Rainwater Harvesting System

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Introduction

Water is a crucial resource for the survival of life on earth. Unfortunately, with the increasing threat of climate change fresh water is expected to become a pressing issue in the future for many countries, including the southeastern region of the United States (EPA 2013), refer to figure 1. According to the EPA, water management is likely to become a challenging issue, due to rising temperatures, and demand due to economic and population growth (EPA 2013). Increased temperatures are likely to lead to longer, more intense, and more frequent droughts in the Southeast, putting more stress on water resources (EPA 2013). There is also a concern that saltwater may mix with shallow aquifers of groundwater in coastal areas, due to expected rise in sea level, contaminating the groundwater (EPA 2013). One way to adapt to the changing climate and rain patterns, is to start harvesting rainwater.

Background

In 2007 President Ayers signed the American College and University Presidents Climate Commitment (ACUPCC). The plan is committed towards measuring the carbon footprint of the University. Updates and changes to the Climate Action Plan occur every two years to ensure the University of Richmond will reach its goal of becoming carbon neutral by 2050 (Climate Action Plan 2012). The University of Richmond has made great efforts to address climate change and water conservation. For example the University has implemented conservation techniques by irrigating some fields, such as the baseball field, with water from the Westhampton Lake (Glass). Other notable water conservation practices include installing water efficient shower heads and the use of drought tolerant landscaping at several LEED certified buildings (Glass). A potential new project for the University to explore is a rainwater irrigation system. Rainwater would be collected from the roof of Booker Hall. The water would then be transported through gutters into rain barrels, and used to irrigate flowerbeds around campus.

Study Site

Booker Hall would be a great building to test a rainwater harvesting and irrigation project because of its large roofs, and there is a storage area for the rain barrels (figures 2, 3, and 4). On the Westhampton Way side of Booker Hall there is a large rectangular cement floor. This cement floor is hidden from the view of pedestrians, and receives little to no walking traffic. No one will see the rain barrels unless they enter Booker Hall from the basement entrance by Westhampton Way. Also, there are five gutters that extend downward from the roof to the cement floor. Once the rain is collected in the barrels, facilities will drive their trucks up to the rain barrels and siphon the water from the barrels into an irrigation tank on the back of their trucks for further use (Glass 2014). Facilities already have irrigation tanks on their trucks that they use to irrigate flowerbeds around campus (Glass 2014). Our goal is to help facilities switch from using city water to rainwater for irrigation.

Methodology and Calculations

Booker Hall's roof is a complex structure, which makes calculating the amount of rainwater collected difficult to determine. From aerial pictures of Booker Hall on Google Maps and ArcGIS we struggled to determine where the rain would drain after falling on the roof, as there are many drainage points (figure 4). Therefore we took a conservative approach to estimate, which roofs would drain to our rain barrels, and how much rain would be collected from one inch of rain. We estimate the designated sections of Booker Hall will capture 1,113 gallons of water per inch of rain.

First step: We calculated 1,113 gallons of rainwater by first observing aerial pictures of Booker Hall and determining the area of the roof that our project would be receiving water from (figure 4).

Second step: Next we calculated the square footage for our designated rooftops, by using the draw tool in ArcGIS Maps. We determined the dimensions to be 91.38 ft by 15.76 ft and 15.56 ft by 27.76 ft.

Third step: We then plugged the dimensions of the roofs into a USGS calculator, which calculated the amount of rainfall that could be collected from one inch of rainfall on the designated areas of Booker Hall (Pearlman). We calculated 1,113 gallons of rainwater that could be collected.

Fourth step: Since we calculated the number of gallons that would be produced from one inch of rain on Booker Hall, we were able to determine how many gallons of rainwater could be collected each month based on monthly rainfall averages (figure 5).

Fifth step: Our conservative calculations suggest that with the exception of April, the 200-gallon rain barrels would fill up at least twice, therefore justifying the purchase of ten rain barrels.

Rain Barrels

After researching websites such as Amazon.com, Homedepot.com, and rainharvestingsupplies.com, we found that the latter offers the best barrels in terms of capacity and pricing. We propose to use ten 200 gallons barrels for $285.95 per barrel (figure 6). Figures 6, 7, 9, and 9 are examples of all the different rain barrels designs for aesthetic purposes, as well as different capacity levels.

Figure 6: Rain Harvesting Tank, holds 200 gallons, priced at $285.95.

Figure 7: Upcycle Wooden Rain Barrel, holds 54 gallons, priced at $285.99 - $305.99.

Figure 8: Madison Rain Catcher, holds 40 gallons, priced at $219.99.

Figure 9: Tree Bark Rain Barrel, holds 90 gallons, priced at $215.99.

Figure 2: Cement floor where the rain barrels will be stored.

Figure 3: Ground view of Booker Hall.

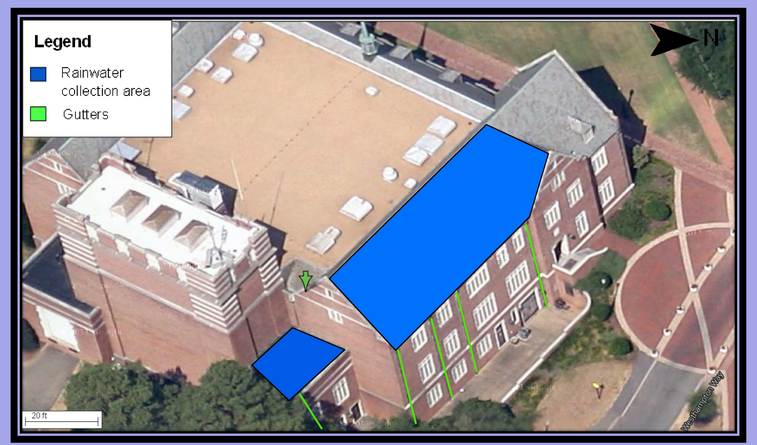

Figure 4: Aerial view of Booker Hall. Blue area is our collection area and the green lines are the gutters (Google Maps).

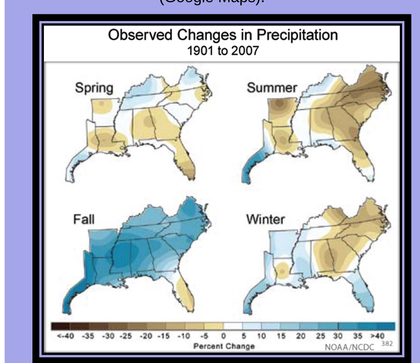

Figure 1: The average precipitation in the Southeast has increased, however the summer and winter precipitation has declined by 10 percent. The percentage of areas covered in droughts in the region has also increased (U.S. Global Climate Change Impacts in the United States 2009).

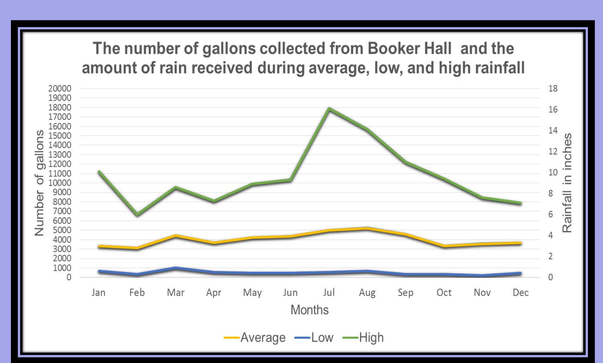

Figure 5: Graph shows the number rainwater gallons captured by Booker Hall for each month, based on average, low and high rainfall.

Payback

The payback period for average, low, and high rainfall is shown in figure (10). The expected payback period is approximately sixteen years. Typically, payback is calculated through dividing the initial investment by cash inflow per period. Our calculations are based on the assumption that we will buy ten 200 barrels, with the initial investment of $2,859.50. The yearly cash flows were estimated to be $177.10 using average rainfall figures. These cash flows represent the amount the University will save by not using the city water which costs $2.73 per CCF (Souleret 2014).

Average	Low	High
16	130	6

Figure 10: Payback period for ten 200 gallon rain barrels is shown for high, low, and average rainfall projections. The payback period is represented in years.

Conclusion

As climate change continues to threaten parts of the world, individuals and organizations must take micro steps to make an impact on the macro level. In order to combat climate change and scarcer rainfall we believe that rainwater harvesting is a small but monumental step to create a greener university and ultimately a greener world. Due to monetary and time constraints our pilot project must start on a small scale. Two small sections of roof from Booker Hall is our only collection area, but as we have shown this can yield relatively significant rainwater capture. Based on our calculations we have determined that collecting water using rain barrels can be effective economically, but most importantly a sustainable way of using water.

The American College and University Presidents Climate Commitment signed by President Ayers in 2007 committed this University to strive for carbon neutrality and increased sustainability. The conservation of water on our campus is just one way we can extend our scope of sustainability. In order to capture the optimal amount of rain in our designated area at Booker Hall we are requesting the purchase and use of ten 200 gallon rain water barrels seen in Figure 5. Our data indicates that in all but one month the barrels will be filled at least twice to be used for irrigation around campus. This results in a payback period of approximately sixteen years. In addition, the barrels will be placed out of view so as to ensure that the campus remains aesthetically pleasing. In figure 2 and figure 3 it is possible to see that the barrels will be hidden by a brick wall and a difference of elevation between the observable sidewalk and the actual placement of the barrels.

It is important to understand that this is a pilot project and our calculations are all theoretical. The actual rainfall of each month is impossible to determine, as there could easily be drought periods, or times of intense rainfall. In these circumstances the efficiency of our barrels will be compromised, but based on the average rainfall of each month then the collection from our barrels should even out and the accuracy of our predictions will be relatively close. In addition, we cannot predict the displacement of rainwater as it strikes the roof of Booker Hall. Assuming the rain does not act sporadically then the utilization of the five gutters highlighted in figure 4 will be the most effective way to collect the most rainfall we can from our section of Booker Hall. The number one goal of our pilot project is to initiate the conservation of water on campus and to promote sustainability. This type of project has been seen to be effective at other Universities and that the range of use can go well beyond irrigation. We believe rainwater barrels is an excellent starting point, and will hopefully spur further sustainability practices around campus.

Acknowledgments

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