Progress report: Small- and medium-scale rainwater harvesting best practices for maximum economic value

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Introduction

This project, funded by HPWD, was proposed and approved in summer 2016 as a joint-research grant with professors at West Texas A&M University and Texas Tech University. Nathan Howell (WTAMU) is an assistant professor of environmental engineering and Ryan Williams (TTU) is an associate professor in agriculture and applied economics.

The project concerns the research on the physical performance of and economic considerations with rainwater harvest (RWH) systems at small and medium scales as they are currently found in the West Texas region. Rainwater harvesting may generally be defined as the capture, storage, and beneficial use of rainwater on the site which it was collected. Most uses of such water are non-potable and include irrigation, landscaping, and gardening. However, it is also a relatively high quality water source with lower levels of pollutants in the water than standard wastewater effluents or septic graywater.

Our hope with this project is that those within the HPWD and the larger region might more readily adopt RWH practices and thereby reap the benefits of increased groundwater conservation. By providing knowledge, obtained by research efforts, on current practices and performance of RWH and providing that information to the broader public, we see a potential for wider spread adoption. To this end, these specific knowledge-discovering objectives are what the project will achieve:

1. Inventory the water quantity and quality of RWH in the HPWD region.
2. Assess the performance and usefulness of RWH as a water supply in current systems in use for residential and commercial settings.
3. Ascertain the economic value that the RWH systems bring to current owner-operators balanced against the costs of purchasing and maintaining the systems.

There are two methods that we are employing towards these objectives. The first is an internet survey that is open for anyone in the West Texas region to take. The survey solicits information on attitudes about RWH generally and also information on the particulars of RWH systems which individuals and institutions currently use. The second method is to determine RWH system owners and operators from the survey who want to participate in 6-12 month monitoring of their RWH system by the project PIs. In that method, we are monitoring the capture efficiency from rain events on individual systems, the use of the water, and the quality of the water over time.

Progress made to date with project

There are two major project activities—(1) the RWH attitudes and use internet survey and associate analyses and (2) the RWH quantity and quality performance monitoring at select HPWD region locations.

Rainwater harvest attitudes-and-use survey

For the internet survey, we designed it, crafted a video introduction of what it is for, and began disseminating through various email chains, social media announcements, and general word-of-mouth. The survey was initially launched in March 2017.

Here are some initial impressions from the survey data. We would like to have 300 respondents in total, and we have received 70 respondents to date (n=70). Some key findings so far:

- Respondent characteristics: Respondents have acquired more education than the average citizen in the High Plains and have a higher income than average.
- Interest in RWH: Respondents indicate that they are most interested in rainwater harvesting for the purposes of environmental benefit and reduced cost water.
- Use of RWH: Respondents use RWH systems primarily for landscape irrigation, with many also using the water for irrigation of fruits and vegetables.
- Barriers: The primary barrier to expanding the scale of rainwater collection is storage capacity, which is viewed as cost-prohibitive.
- Use of tax credits: Most respondents would be willing to install/upgrade their systems given the offer of a tax credit. The degree to which they would invest in installation or improvements is strongly determined by the size of the tax credit offered.

Rainwater harvest system physical performance monitoring

The RWH system field monitoring was originally scheduled to have begun in the late spring of 2017. Some monitoring has indeed begun though it is not as far along as we had originally projected. We have identified one very eager RWH user[1] and have installed water quantity equipment at his RWH system. He would, at a total storage volume of 3100 gallons, be considered a medium-scale RWH system owner. At his location, we have installed equipment that automatically logs rainfall and system water storage volume. This information, combined with his roof drainage area allows us to determine the overall capture efficiency for each rain event that occurs at his greenhouse. Some data we have collected on this is shown in time series in Figure 1. The overall capture efficiency we have observed to date is shown in Table 1. The capture efficiency in this limited dataset has generated rainfall capture efficiencies which are > 100% which indicates that there is an error in some way in which we are conceiving of this rainwater system or a measurement error we have yet to identify.

[1] Jimmy & Teresa Heisler of YWAM Amarillo-Canyon. They operate an urban aquaponics greenhouse in Amarillo which they intend to make entirely sustained on RWH water supply.

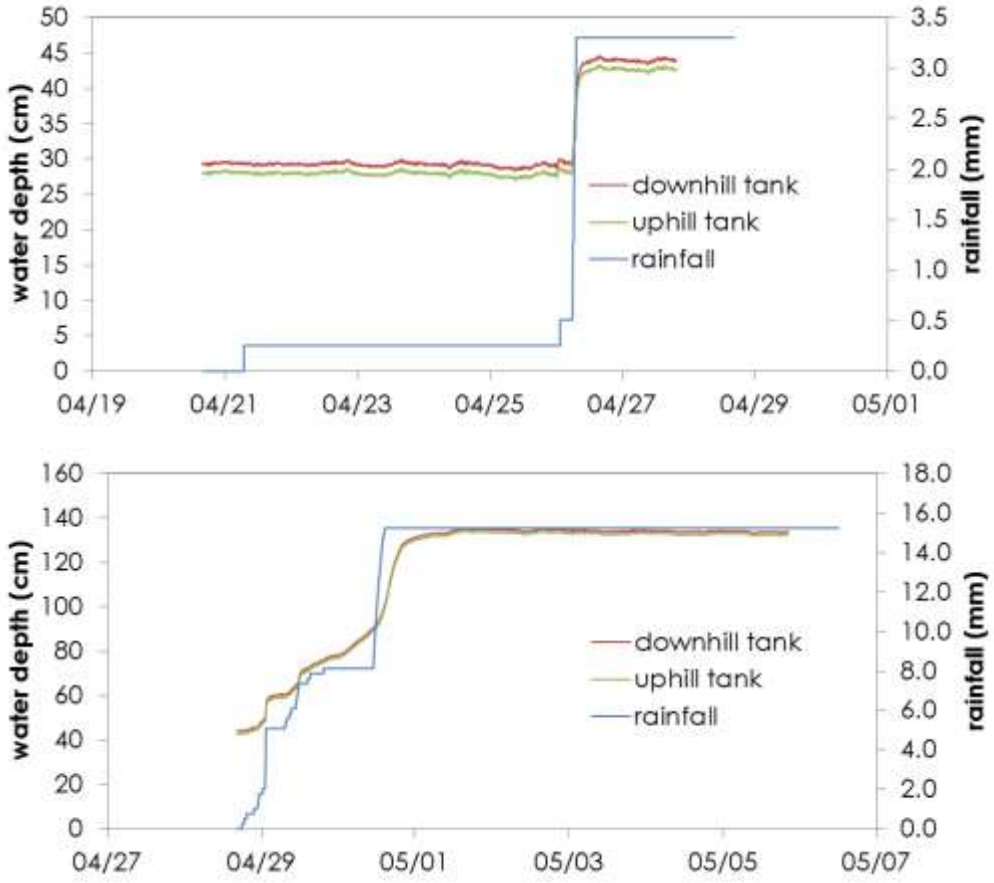

Figure 1. Rainfall depth during two different periods in April and the response in two rainwater storage tanks that receive the captured water from downspout. Each of the two tanks in this RWH system has a total storage volume of 1550 gallons.

Table 1. Summary of water quantity in rainwater storage tanks and from rainwater building drainage area at greenhouse. Total storage capacity of two-tank system is 3100 gallons.

date-time (gmt-5)	depth in downhill tank (cm)	depth in uphill tank (cm)	total water in tanks (gallons)	accumulated rainfall (mm)	accumulated rainfall (gallons)	change in tank water (gallons)	change in rainfall (gallons)	instantaneous capture efficiency
04/20/2017 15:41	29.4	28.1	599	0	0	-	-	-
04/26/2017 07:07	37.8	36.5	774	3.3	245	175	245	71%
04/29/2017 01:24	56.1	54.8	1155	8.4	622	381	377	101%
04/30/2017 14:28	100.9	99.6	2089	18.5	1376	934	754	124%

In the area of water quality monitoring of RWH sites, we have not made as much progress as water quantity. We collected some water samples which are currently being analyzed at the Commercial Core Lab housed at WTAMU. That analysis will yield us the major and minor ions that are present in the water, which is used to generally characterize the water quality and interpret things which are influencing it.

Successes or setback observed with the project

The following issues and successes are worth noting at this point in our project with less than one year of actual work involved.

- *Challenge*: The survey response rate is reasonable given it has been available for about four months. However, we will likely need to find additional means to distribute it if we are to reach the goal of 300 total respondents.
- *Success*: Several individual have identified themselves as willing to talk to us concerning us installing equipment to monitor their location. When the physical monitoring protocol for RWH sites is better tested, this means we will be able to coordinate with these individuals to efficiently monitor their systems' performance.
- *Challenge*: The Institutional Review Board (IRB) (i.e., ethical treatment of human subjects) certification took longer than we expected. We had to proceed in this process due to the fact that we are giving out surveys. At this point, nearly all certifications are complete meaning that as long as we follow all of the IRB procedures, there should be no issue with data collected from surveys in how we use and interpret it.
- *Challenge*: The total organic carbon (TOC) instrument housed in Nathan Howell's lab has suffered some repair issues. We are currently troubleshooting it so that we can measure TOC. This parameter is essential to characterize the water quality of any water source. TOC should be fairly low in order for the water to be potable but can be a significant amount higher for many non-potable uses.
- *Success*: We have shown that we can leave remotely logging instruments at rainwater harvest location and collect reasonable water quantity information at a relatively high data frequency (once every 5 minutes).
- *Challenge*: At the first test location for physical site monitoring, somehow we are measuring > 100% capture efficiency which is impossible. So we need to do some work on troubleshooting where errors in data interpretation or measurement lie so that we can correct this problem and thus truly assess how well the quantity of rainfall capture is going per rain event.

Conservation impacts to the district

At this point, in the project there is still much data from the surveys and physical site measurements that we need to collect. However, there are some positive trends that speak to potential conservation impacts to HPWD.

1. *Identified active RWH owner-operators*: Simply identifying more owner-operators, establishing relationships with them, and understanding their motivations and backgrounds will help this project as research with respect to the adoption of RWH generally. This survey data will help us to understand what circumstances the district can promote in municipalities and rural areas that will increase the total amount of RWH users. If there are more RWH users, much of the water that they capture will directly translate to water which is not taken from the Ogallala Aquifer.
2. *Examined the use of incentives*: The survey data we have gathered thus far provide valuable insight into how incentives may move more people to adopt RWH especially in terms of how much the financial incentive (e.g., a tax credit) might be. This data will give HPWD the authority to advocate to cities, counties, and the state the use of a tax credit to encourage RWH use. The adoption rate of RWH is currently not that high in Texas generally. We will be able to estimate this rate from our survey, which may also help HPWD and others set targets for adoption rates. They may then use education and incentives to increase the adoption rate.
3. *Physical measurements tell a necessary story*: These early measurements, though exhibiting challenges in interpretation, demonstrate that we will be able to capture data to show physical performance of RWH systems in terms of both water quantity and quality. We believe that we can use this information to craft communication tools with and for the district that will demonstrate the potential of RWH practice for those who doubt its utility relative to its cost. Eventually we will combine the physical data collected by Nathan Howell with economic valuation tools of Ryan Williams to demonstrate the cost-benefit and the water savings in time so that those considering RWH can quantify the real risk and reward to them.

Budget expense report and remaining grant fund balance

Our total budget allocated for this project is $13969.00. The amount is split between Nathan Howell at WTAMU and Ryan Williams at TTU. Thus far, not much has been spent to obtain the results we have obtained. We have spent $738.94 on some supplies use to measure water quantity and quality leaving still $13,230.06. We anticipate spending more on laboratory costs and student labor in this coming year, which represents the bulk of the budget when it was first proposed.

Final thoughts

We hope that this report has given HPWD confidence that we are making strong efforts to meet the research objectives that we set out to investigate. We certainly welcome any thoughts the district has which will streamline and improve our efforts. As well, we will provide more information to the district on any specifics that they need, and we will respond towards any feedback or criticism that they have.