Rainwater Harvesting (RH)

Cistern at Little River Canyon; Mentone, AL

Synonyms: Rooftop runoff management, stormwater collection system

Rainwater harvesting is the collection of rainwater for reuse, typically from a rooftop, and can be used as a form of rooftop runoff management to reduce runoff from impervious surfaces. Rooftop systems typically collect stormwater through a connection to a rain gutter system. Rainwater harvesting systems may be above or below ground systems and can be large or small depending on the site, application, and intended use. When designed and used properly, these systems are an excellent way of saving water, energy, and money.

Rain barrels: Rain barrels are systems used for small-scale applications such as residential areas.

Rain barrels are generally 50 – 60 gallons and can be connected to one another to collect larger volumes of water. Rain barrels work well for a residential homeowner as a stormwater collection system, but due to their limited volume collection, rarely contribute to sizeable watershed-wide runoff reductions. However, targeted promotion of rain barrel use raises awareness of stormwater runoff issues, and can also help homeowners to reduce localized stormwater runoff issues and erosion in their yards.

Cisterns: Cisterns are larger storage tanks that are better suited to commercial or agricultural settings where large volumes of water need to be collected.

Cisterns are discussed in this handbook and can be used above or below ground to collect rainwater and store it for later use. Cisterns may range from less than 100 gallons to over 10,000 gallons in size and the water is intended for non-potable water uses. Water collected by these systems may be used for flushing toilets, irrigation, vehicle washing, and laundry. It is recommended that the harvesting system be labeled and identified as non-

Site Selection

Quantity Control	✔
Drainage Area	small
Space Required	small-med
Works with:	
Steep Slopes	---
Shallow Water Table	✔
Poorly Drained Soils	✔

General Significance

Construction Cost	med
Maintenance	med
Community Acceptance	med-high
Habitat	---
Sun / Shade	---

More information about rain barrels can be found on the Alabama Rain Barrel Project page at www.alabamarainbarrelproject.com.

Connected Rain Barrels Capture More Rainwater; Auburn, AL

potable water to prevent any confusion and to deter anyone from consuming collected water.

Large cisterns typically need to be purchased directly from a supplier, and due to their size and weight, freight charges can be costly.

Site Selection

Above Ground Cisterns: Above ground cisterns are easier to install and maintain, are comparatively less expensive, but can be regarded as unsightly.

Below Ground Cisterns: The primary benefit of a below ground cistern is that it is out of sight and does not take up valuable land. However, below ground cisterns require the addition of a pump, can be harder to maintain after installation, and are generally more difficult to install because they require excavation and significant structural support. Underground cisterns should not be sited adjacent to buildings due to intensive construction and excavation during installation, which can damage foundations.

Downspouts: The cistern should be located near gutter downspouts to make installation modifications easier.

Evaluating Soils: Use the USDA Web Soil Survey to identify soil map units and to make initial interpretations for potential uses and limitations of a site. However, since most soil map units have inclusions of other soils that may be quite different, detailed evaluations should be made at the proposed site by a professional soil scientist or soil classifier. On-site evaluations should properly identify a soil or the hydrologic soil group (HSG) and the final decision for use should be made based on the detailed determination of soil series or HSG. For a detailed list of HSG properties, see Table A.3 in Appendix A on Stormwater Hydrology.

In-situ Soils: Cisterns should not be sited where underlying soils are unstable.

Underground Utilities: Cisterns should not be sited over underground utilities or septic systems.

Water Use: Cistern location should also be in the vicinity of where the harvested rainwater will be used; this will alleviate the need to transport water over long distances.

Call 811 to locate utilities before you begin any type of excavation (www.al1call.com)

Rainwater Harvesting System at Boykin Community Center; Auburn, AL

Rainhead and First Flush Diverter system; Summerdale, AL

Design

It is important that cisterns are designed to capture the correct volume of stormwater for on-site needs and the available collection area. When harvested rainwater goes unused, cisterns overflow and can no longer reduce runoff or collect stormwater.

Components

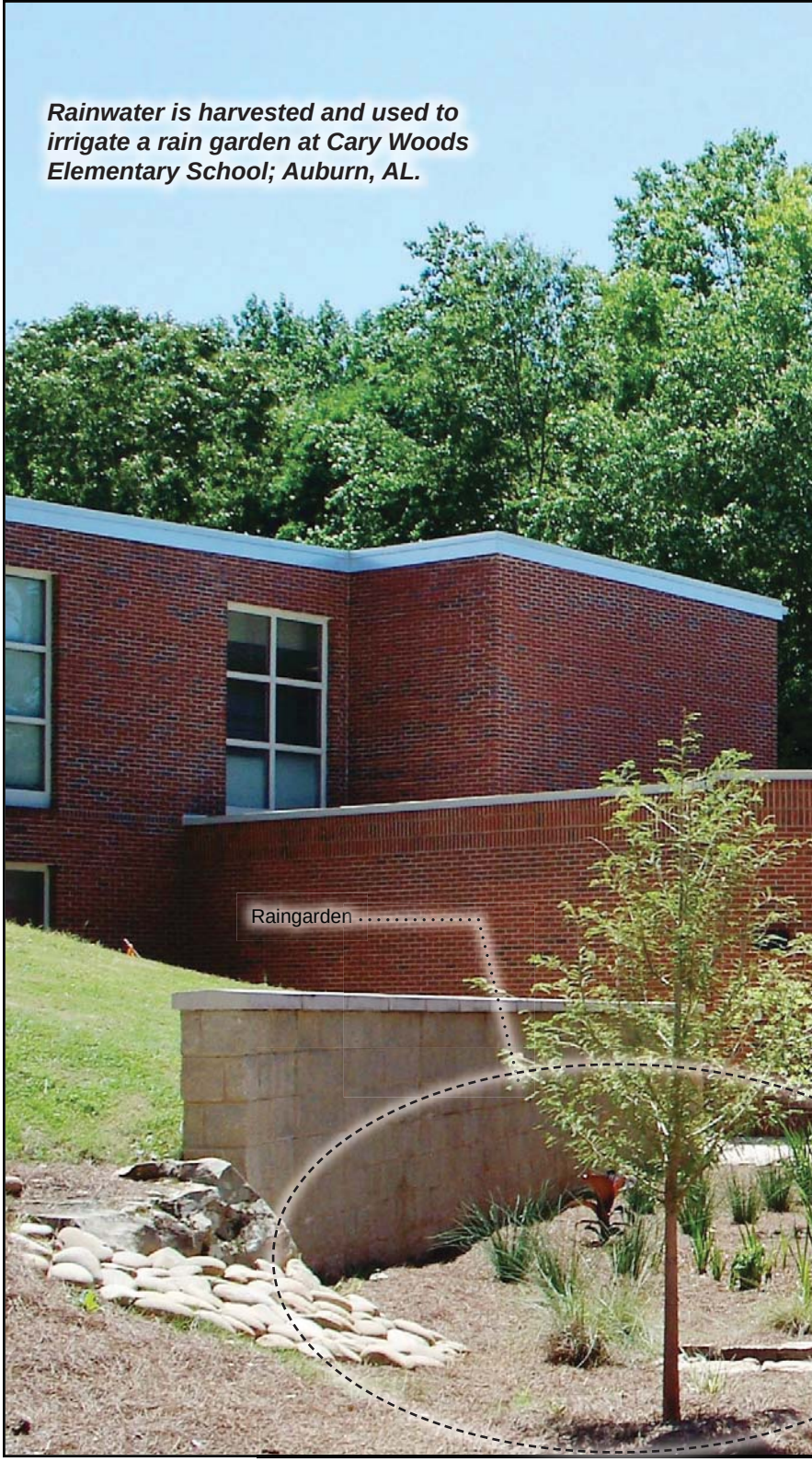
First Flush Diverter: A first flush diverter is a pretreatment device designed to collect and dispose of the first inch of runoff from a rooftop system. The first inch of runoff has the highest concentration of pollutants from atmospheric deposition and other contaminants collected in the runoff process. Once capacity is met, a valve closes to allow the remaining runoff to move through the routing system and into the cistern. In many cases, the first flush diverter valve is made up of a ball and choked section of pipe. The first flush chamber fills, which causes a ball to float and restrict flow into the first flush chamber. The collected water is slowly released from a check valve at the bottom of the chamber. The rate at which the first flush is released is determined by the size of the check valve opening. The diverter should discharge to a stormwater control measure (SCM) or vegetated area for treatment. First flush diverters are especially beneficial when rainwater collected is to be used to irrigate edible plants or crops.

Rainheads: Rainheads can be attached to the gutter system to filter debris before water enters the cistern. These devices have mesh screening so that water passes easily through them, while blocking leaves and other particulate matter. The mesh screening sits roughly at a 45° angle so that debris can be easily discarded to the ground. Incorporating a rainhead can help to reduce cistern maintenance. Rainheads are also useful for the prevention of mosquitoes when 1 mm or smaller screen is used.

Cistern: Cisterns are made of hard plastic, galvanized metal, concrete, or fiberglass. White or light colored cisterns are not recommended due to their propensity to foster algae growth, however, these can easily be painted. Cistern selection should be based on material, size, and whether it will be located above or below ground. Plastic cisterns are lightweight, aesthetically appealing, have minimal assembly, and any modifications can be made using standard tools. Metal cisterns are usually constructed of corrugated or galvanized metal, are commonly made from discarded grain bins, and may require an internal waterproof bladder to minimize leaks.

Structural Support: Gravel, concrete, or stone foundations are recommended as structural support of cisterns especially in situations where underlying soils cannot support the weight.

Underground Cisterns: Underground cisterns will most likely require anchoring by backfilling sand or gravel



Rainwater is harvested and used to irrigate a rain garden at Cary Woods Elementary School; Auburn, AL.

Rainhead clean of debris

around the cistern.

Overflow: As the cistern reaches capacity, it will need a mechanism to release excess water collected. The overflow should accommodate the same flow rate as the gutter system, which is a 100 year, 1 hour storm event. For Alabama, this can range between 3.25” to 4.5” of rain depending on location within the state (see Appendix A on Stormwater Hydrology for more information). It is recommended that the cistern be sized such that overflow is no more than 14% of annual average historical rainfall. Overflow is ideally directed into another SCM, but should always discharge to a vegetated or natural area, not to an impervious surface where it will create more runoff. As a general recommendation, overflow pipes for 1000 ft^2 of rooftop should be a minimum of 2.5” diameter and rooftops > 3000 ft^2 should have overflow pipes with a minimum diameter of 4”.

Outlet: A faucet or outlet pipe should be installed at the bottom of an above ground cistern so that water can be easily retrieved. The outlet should be approximately 6” from the bottom of the cistern to allow for sediment collection in the

cistern base. A bulkhead fitting should be installed to prevent leaks since the faucet will experience high water pressure. The bulkhead fitting should be installed from the inside of the cistern and for this reason, it is generally cost effective and safer for the cistern vendor to install it.

Gutters: Larger quantities of water can be collected when multiple downspouts contribute to the cistern. In this case, some gutters may need to be piped to the cistern. If piping is not an option, gutters can be tied together and directed to a single downspout. However, this can lead to structural failure and unintended overflows during heavy storms.

EQN 4.6.1

$$V_{req} = SA_{roof} * R_d$$

SA_{roof} = Surface area of roof or flat plane (ft^2)

R_d = Rainfall depth (in) or 1-yr storm event

EQN 4.6.2

$$V = V_{req} * FoS$$

Pumps: The addition of a pump will help draw water from the cistern and can increase utilization in cases where constant pressure is needed. If the cistern is housed below ground, it will require a pump to move the water. Recommended pumps for cisterns are usually low-head and high-flow centrifugal pumps. These pumps are generally inexpensive, available in various flow rates and heads, and are easy to install. The pump should be submersed in the bottom of the cistern to make the priming process easier.

Pump Selection: A pump should be selected based on the flow rate and total head desired. The flow rate is the rate at which the water moves through the pipe and it is usually expressed in gallons per minute (gpm). Total head is the amount of energy needed to push the water through the pipe and is measured in pounds per square inch (psi).

Secondary Water Supply: A secondary water supply may be set up to provide supplemental water to the system during drought conditions, if desired for irrigation.

Design Guidance

The design calculation of a rainwater harvesting system volume is quite simple. Additional design will be required if the system is underground (e.g. buoyancy calculations are needed) and may be necessary for overflow sizing, pump sizing, and irrigation purposes.

The **cistern volume required (V_{req})** to capture rooftop runoff can be estimated using EQN 4.6.1.

Often a **factor of safety (FoS)** is also added to the equation to ensure critical volumes are captured. A **FoS of 1.2** is suggested.

Maintenance

Sediment and Debris: The most common maintenance concern is keeping debris and sediment out of the cistern. Roof maintenance is imperative to minimize sediment and debris loads such as roof shingle particles from entering the cistern. It is important to maintain gutters to minimize debris entering or clogging the inlet of the cistern. Sediment will build up in the bottom 6” of the cistern, and may need to be cleaned out after a few years. A valve can be installed at the cistern base to regularly drain away built up sediment.

Rainhead: Use of a rainhead will aid in reducing sediment and debris in the cistern and the rainhead should be cleaned periodically so that flow into the first flush diverter and cistern is not inhibited. Mosquito screens should also be cleaned of blocked debris, especially during warm weather conditions when mosquito breeding is likely to occur.

First Flush Diverter: The first flush diverter may clog and cause water to remain in it for long periods of time. As this occurs, it may be necessary to remove the bottom portion of the diverter and discard any built up debris.

Pump: Check pump function regularly and perform any pump maintenance based on the manufacturer’s recommendations.

Safety: The cistern should never be entered for any type of maintenance due to risks associated with drowning and toxic gas exposure.

Table 4.6.1
Maintenance Schedule

Task	How Often	Comments
Clean Out First Flush Diverter	Routinely	Should be performed regularly, preferably after each rainfall event.
Clean Rainhead	Routinely	Should occur frequently to prevent clogging.
Inspection of Gutter Connections	Quarterly or after heavy rainfall events	Check for any damage and remove any trash or vegetation debris.
Unclog Gutters	Routinely	When gutters become clogged, water may back up and inhibit flow into the cistern. Gutter screens can be installed to prevent future clogging.
Check System for Clogging	When unnecessary overflows occur	The system may be clogged when the cistern overflows following a rain event less than or equal to the design rainfall.
Inspection	After 0.5” or greater rainfall event	Visually inspect all components of the rainwater harvesting system for damage or clogging. This is especially important for any pipes or gutters used in the system.
Sediment Removal from Cistern	Every 3 years or as needed	Remove sediment from the bottom 6” of the cistern.

Pollutant Removal

Rainwater harvesting can reduce flooding and stream erosion problems due to the reduction in stormwater volume entering stormwater conveyance networks. The cistern captures rooftop runoff that contains nutrients from rain and atmospheric deposition, which aids in reducing nonpoint source pollution.

References

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