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Rainwater Harvesting Systems

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What is Rainwater Harvesting?

Rainwater harvesting is the process of collecting, storing, and later reusing rainwater from surfaces such as roofs. Rainwater harvesting has long been used for agricultural irrigation and as a source of drinking water, and allowed ancient civilizations to flourish in semi-arid and arid regions. Rainwater harvesting systems are in use today in many water-limited locations, especially in the western US. As the population growth increases pressure on water resources in the more humid eastern US, rainwater harvesting is being considered to reduce the demand for potable water.

Why Harvest Rainwater?

Harvesting and storing rainwater can reduce the use of municipal and well water. Roofs are often the largest impervious surfaces on a residential lot. Intercepting rainwater that falls on roofs can reduce stormwater runoff and the need for downstream stormwater management and treatment. Rainwater is itself very clean, although contaminants that are present on roof surfaces should be appropriately addressed.

How Can Harvested Rainwater be Used?

Strictly speaking, harvested rainwater can replace tap water for any use. In practice, harvested rainwater is most often used (and permitted for use) for certain designated purposes such as landscape irrigation and toilet flushing. When used for landscape irrigation many states do not require a permit to install a rainwater harvesting system.

Some locations, such as the U.S. Virgin Islands, Bermuda, and other Caribbean islands require all new building construction to provide for self-sustaining water supply systems and use harvested rainwater for potable and non-potable uses (United Nations Environment Programme, 2007).

Rainwater Harvesting Systems

There are six basic components of a rainwater harvesting system:

- Catchment surface
- Gutters and downspouts
- Screens, first-flush diverters, and roof washers
- Cisterns
- Delivery system
- Treatment system

CATCHMENT SURFACE

The quantity of rainwater that can be captured from a catchment surface such as a roof is a function of its size and texture. Roofs that are made of textured or porous material, such as clay tile, will retain more rainwater compared to smoother materials such as metal. The catchment material will also control the type and potential for leaching of small amounts of toxins. For example, rainwater harvested from wood, asphalt, and tar shingled roofs may only be suitable for irrigation.

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GUTTERS AND DOWNSPOUTS

Gutters and downspouts for rainwater harvesting systems are essentially no different than conventional gutters and downspouts. The only added consideration for a rainwater harvesting system is the number of screens and first-flush diverters that will be needed, since each downspout should have its own.

SCREENS, FIRST-FLUSH DIVERTERS, AND ROOF WASHERS

There are several different types of screens that can be used, determined both by the amount of debris that accumulates on the catchment surface, and the intended use of the water. For example, a drip irrigation system may require finer screens that are maintained more regularly to prevent clogging of emitters. To prevent leaves from entering the system, leaf guards can be installed along the entire length of a roof gutter. Filter screens can also be installed on downspouts to handle rainwater prior to entering the cistern or distribution system. These offer the advantage of easy access.

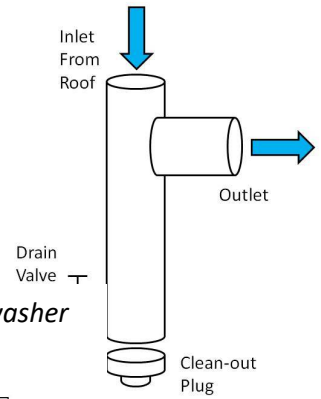
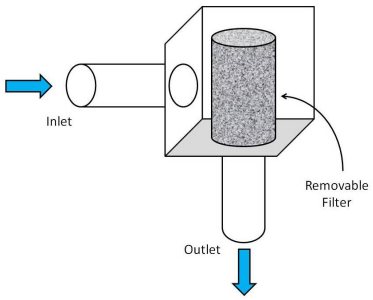


Figure 1. A simple stand-pipe first flush diverter. The drain valve is kept slightly open to allow the first flush water to slowly drip out.

Figure 2. A box-type roof washer with removable filter.



A first-flush diverter, usually a standpipe (Figure 1), allows this debris-containing water to be diverted from entering the cistern. The suggested volume ranges from 10 to 50 gallons for every 1,000 ft^2 of catchment surface; this will depend on the amount and type of debris that accumulates, the number of dry days since the last rainfall, and the intended use of the water. Each downspout will require its own first-flush diverter and the diverter should be sized according to the portion of the catchment that contributes to that downspout.

Roof washers (Figure 2) are something of a misnomer since they don't actually wash the roof. A roof washer consists of a tank with a strainer and filter (typically 30-micron) that is installed immediately upstream of the cistern and downstream of the downspouts. Sometimes roof washers and first-flush diverters are combined into a single unit. Many are equipped with a baffle at the inlet to capture any remaining debris before the water moves through the filter. Canister filters are usually used for the purpose since they need to be replaced periodically.

CISTERNS

The cistern, or storage tank, stores the collected rainwater for later use and is usually the most expensive component of the system. Cisterns are typically constructed from materials such as fiberglass, polypropylene, concrete, or metal. If cisterns are not made of non-reactive material, it should be lined. Cisterns should also be opaque, to inhibit algal growth; cisterns constructed from translucent material are often painted prior to use. Any vents should be screened to discourage mosquito breeding. Cisterns should be periodically cleaned to remove any accumulated sediments and to discourage algal growth. Cisterns can be located above or belowground; belowground cisterns should be adequately reinforced.

DELIVERY SYSTEM

Depending on the location of the cistern and the intended use of the water, a pump and/or pressure tank may be installed to achieve the desired water pressure. Pump and pressure tank combinations will also require a one-way check valve between the pump and cistern to prevent backflow and loss of pressure. Alternately, an on-demand pump can be used, eliminating the need (and space) for a pressure tank.

TREATMENT SYSTEM

For systems designed for non-potable uses such as irrigation and toilet flushing, leaf guards, first-flush diverters, and roof washers should provide sufficient treatment. However, drip irrigation systems may benefit from additional sediment removal to prevent clogging of emitters. Potable use of the captured rainwater (where permitted) will require treatment to remove sediments and disinfection for human pathogens.

Sediment removal is usually accomplished using multiple cartridge filters; those used for potable systems are much finer than units used in the roof washer, and are often used in series. For example, a common setup is to use a 5-micron filter to remove suspended material and dust, followed by a 3-micron activated charcoal filter to remove microscopic particles and absorb organic contaminants. Cartridge filters must be replaced regularly according to manufacturers' recommendations.

Disinfection of rainwater for potable use can be accomplished by ultraviolet (UV) light, ozonation, or chlorination. UV lamps available for disinfection are rated in gallons per minute. Ozone (O_3) generators can be used to generate O_3, a reactive molecule of oxygen. Ozone oxidizes any organic molecules in the water and then quickly converts to unreactive O_2. If using chlorination, a separate injection pump must be installed. Sufficient contact time should be designed into the system to ensure bacteria are killed. Chlorination alone is not sufficient to kill Giardia or Cryptosporidium cysts, so a 1-micron filter is also needed. Many find the taste and smell of chlorine objectionable and choose to use an activated carbon filter prior to using the water.

Summary and Conclusion

A properly designed, constructed, and maintained rainwater harvesting system can provide supplemental water in water-stressed areas and reduce downstream management and treatment. Approved uses of harvested rainwater and permitting of rainwater harvesting systems varies from state to state. Local regulations should be consulted when considering a rainwater harvesting system.

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