

# Rain Water Harvesting

## PURPOSE

Rainwater harvesting is a means to capture runoff from rooftops and store it for non-potable uses such as irrigation and greywater plumbing. In addition to reducing the demand on public water supplies by replacing potable water with rainwater, rainwater harvesting can reduce peak stormwater flows, potentially reducing combined sewer overflows and other pollution associated with stormwater runoff.

Rainwater harvesting – collecting rainwater from impervious surfaces and storing it for later use – is gaining in popularity as communities, businesses, and homeowners seek ways to affordably manage stormwater, and address the potential for increasingly limited water resources caused by climate change. The many benefits of rainwater harvesting and reuse include:

- » Provides inexpensive supply of water for outdoor water use and non-potable indoor uses
- » Reduces stormwater runoff and associated pollution by reducing peak flows
- » Helps reduce peak summer water use demand by creating alternative water supplies

## RAINWATER HARVESTING SYSTEMS

Rainwater harvesting systems typically divert and store runoff from residential and commercial roofs. Often referred to as ‘clean’ runoff, roof runoff does contain pollutants (metals or hydrocarbons from roofing materials, nutrients from atmospheric deposition, bacteria from bird droppings), but they are generally in lower concentrations and absent from many of the pollutants present in runoff from other impervious surfaces. Installing a rainwater collection system requires diverting roof downspouts to cisterns or rain barrels to capture and store the runoff. Collection containers are constructed of dark materials or buried to prevent light penetration and the growth of algae.

From the storage container, a dual plumbing system is needed for indoor uses and/or connection to an outdoor irrigation system.

## DESIGN CONSIDERATIONS

Every rainwater harvesting system, from a single 60-gallon rain barrel to a 1,400-gallon underground cistern, is custom tailored to site features, intended water use, budget, whether it is new construction or a retrofit, and how much space is available for storage capacity. Points toward LEED project certification are also available for a properly designed rainwater harvesting system.

Some general design considerations for every project include:

- » The earlier rainwater harvesting is incorporated into a new building design process, the more efficient and cost effective-it will be.
- » The largest and often most expensive system feature will be the storage tank, also called a cistern.
- » Storage tanks can be installed above or below ground.
- » Storage located high on the building or the site saves energy and costs (no pumps = zero energy use).
- » Elevated storage requires structural and seismic engineering.
- » Above ground storage structures can serve additional beneficial purposes as shade or privacy structures, and as heat sinks.
- » If space permits, size the cistern to capture the occasional really large storm, and have water available for extended dry periods.
- » Cisterns designed for full time domestic water use should be sized based upon a minimum of 30 gallons per day per person. <http://www.saveourh2o.org/water-use-calculator>
- » Underground storage tanks must be anchored to keep from floating when empty.
- » Use gravity as much as possible for the movement of water in the system.
- » Plumbing, backflow, overflow, and air gaps are important design features, and may require a licensed plumber depending on local code requirements.
- » Above ground tanks must be drained completely before freezing temperatures, and thus are seasonal applications.
- » Maintenance depends on intended reuse of water. Typical maintenance includes keeping gutters and cistern screens clean as well as periodic inspection and replacement of any water treatment components and equipment, including pumps and backflow prevention devices. The tank will require cleaning annually for potable water sources.
- » Rain barrel costs, including installation, range from \$60-\$150.
- » Underground storage systems range in cost depending on the size of the cistern and the water reuse application. For example, a buried 1,800 gallon storage tank with overflow directed to a drywell recharge area, including submersible pump for supply to an irrigation system, costs \$5,000-\$6,000, including installation.

## How to Size a Rain Barrel

Rain barrel volume can be determined by calculating the roof top water yield for any given rainfall, using the following general equation:

$$V = A2 \times R \times 0.90 \times 7.5 \text{ gals./ft.}^3$$

V = volume of rain barrel (gallons)

A2 = surface area of roof (square feet)

R = rainfall (feet)

0.90 = losses to system (no units)

7.5 = conversion factor (gallons per cubic foot)

Example: One 60-gallon barrel would provide runoff storage from a rooftop area of approximately 215 square feet for 0.5 inch (0.042 ft.) of rainfall.

## REGULATIONS

Massachusetts has no statutes or regulations concerning rainwater harvesting. Consequently, greywater requirements are often used to govern rainwater harvesting systems, resulting in requirements that are more stringent than necessary for outdoor water use. In 2010, the International Association of Plumbing and Mechanical Officials (IAPMO) published the first of its kind Green Plumbing and Mechanical Code Supplement (GPMCS). The supplement is a separate document from the Uniform Plumbing and Mechanical Codes and establishes requirements for green building and water efficiency applicable to plumbing and mechanical systems. In addressing “Non-potable Rainwater Catchment Systems”, the GPMCS specifically identifies provisions for collection surfaces, storage structures, drainage, pipe labeling, use of potable water as a back-up supply (provided by air-gap only), and a wide array of other design and construction criteria. It also refers to and incorporates information from the ARCSA/ASPE Rainwater Catchment Design and Installation Standard, a document published in 2008 under a joint effort by the American Rainwater Catchment Systems Association (ARCSA) and the American Association of Plumbing Engineers (ASPE). (EPA, 2013)

## CROSS-CONNECTIONS WITH MUNICIPAL WATER SUPPLY AS BACKUP SOURCE

State code allows the direct plumbing of municipal water supply to a RWH system as a back-up water supply provided an approved reduced pressure backflow preventer (RPBP) is installed and included under a required maintenance plan. These fixtures have a physical air gap internal to the device that separates “unregulated” harvested water from the municipal supply. A standards model of an RPBP is approved by MA DEP for use in cross-connections.



## WATER RATES

Water rates are perceived as irresponsibly low by many water sustainability professionals and researchers, and seldom reflect the true costs of its use. Many communities also have a decreasing block rate structure wherein water becomes cheaper on a unit basis the more one uses. Low rates are perhaps the largest impediment to rainwater harvesting systems, since under current rate structures one would never build a harvesting system to save money on water usage, except in a rare case where a site is particularly water constrained.

## TREATMENT REQUIREMENTS

Since no standards exist for secondary exposure to contaminants or bacteria from use of harvesting systems (e.g spray irrigation, toilet use, etc.), municipalities often use primary exposure thresholds (e.g drinking the water) to set water quality requirements for harvesting systems since no scientific basis for assessing risk exposure exists today. Or, greywater reuse code provisions are applied which are not necessarily appropriate and are typically considered over treatment which results in increased costs to a project limiting implementation of these systems.

## CONSIDERATIONS FOR ESTABLISHING A MUNICIPAL RAINWATER HARVESTING PROGRAM

- » **Establish specific codes or regulations for rainwater harvesting** – Local codes should define rainwater harvesting and establish its position as an acceptable stormwater management and water conservation practice.
- » **Identify acceptable end uses and treatment standards** – Consider and identify acceptable uses for harvested rainwater and the required treatment for specific uses. Rainwater is most commonly used for non-potable uses and segregated by indoor and outdoor use.
- » **Detail required system components** – Delineate between rain barrels and cisterns. Needed system requirements include: pre-filtration (screens, etc.), storage containers, back-flow prevention, dual piping system, cross-connection prevention, and signage for locations of potable and non-potable water within the system. Refer to the UPC's Green Plumbing and Building Code Supplement for guidance.
- » **Permitting** – Rain barrels should not require local permitting. A building permit may be required for cistern systems used for non-potable water uses. If harvested rainwater is used for potable water, the collection and treatment system should be inspected and approved by the local Board of Health.
- » **Maintenance** – Adequate design and maintenance of the cistern and piping system is the responsibility of the cistern owner.

- » **Rates of use** – To be used efficiently for maximum stormwater retention, rainwater needs to be used in a timely manner to ensure adequate storage capacity for subsequent rain events. Municipalities should engage in outreach and education about best practices. Harvesting programs targeting combined sewer areas should promote post-storm slow draw down of rain barrels and cisterns to delay stormwater release to the sewer system and ensure maximum storage for the next storm.



## LOCAL RAINWATER HARVESTING PROJECTS

### Center-Pepin School, Easthampton, MA

A 305-gallon storage tank collects rainwater from a 670 square foot roof and serves as a source of irrigation water for the school yard garden. The cistern does not fully capture the first one inch storm, and overflow is directed to an existing ground level concrete channel along the building which drains to the municipal storm sewer. The system cost \$308 plus \$125 for delivery, and was installed by volunteers at the school.

### MassMutual Financial Group, Springfield, MA

Roof water reclamation serves as a reservoir for on-site irrigation. 60-inch diameter HDPE piping provides 200,000 gallons of storage. An independent pumping system pressures water for irrigation system. There is automated conversion to domestic water during dry periods, and a smaller infiltration system for winter.



A similar system to the one in the photo was installed at MassMutual.

## REFERENCES AND RESOURCES

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