MSU Extension Service

MontGuide

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Rainwater Harvesting Systems for Montana

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People collect and store rainwater throughout the world. For many island nations, rain is the sole source of domestic water. In portions of the U.S. where groundwater and surface water are scarce, expensive or of poor quality, people use rainwater. Early farm and ranch families throughout the Great Plains routinely collected rainwater to use for laundry and other purposes.

Rainwater harvesting is no longer widely practiced in Montana, but it is a simple technology that offers many potential benefits. Collected rainwater can augment other water sources when they become scarce. It's a good standby in times of emergency, such as during power outages or when the water table lowers and wells go dry. Rainwater is soft and doesn't cause buildup of scale in water heaters, plumbing lines or household humidifiers. It does not compromise the effectiveness of pesticides when mixed in spray rigs, as eastern Montana groundwater often does. Rainwater does not stain laundry and plumbing fixtures (no iron or manganese). And it is better for landscape watering than waters that are naturally alkaline or rich in sodium.

Simple rainwater systems for landscape irrigation or herbicide application can be designed and installed by any homeowner. Systems designed to supply water for in-house use are far more sophisticated, but they too can be laid out by the homeowner. This guide describes the components of a rainwater system and the process of designing the system. The homeowner planning a system for outdoor use will find most of the needed information herein. For potable water systems additional resources must be consulted; these are listed at the end of the guide.

System Components

Each component in the rainwater system serves one of the following functions: rainwater catchment, conveyance, purification, storage or distribution. Figure 1 is a generalized schematic of a rainwater system, showing examples of each system component.

Catchment: In special circumstances, paved patios or decks can be used to collect rainwater. Generally though, the available catchment area is the roof of the home, barn and outbuildings. Any roofing material is acceptable for collecting

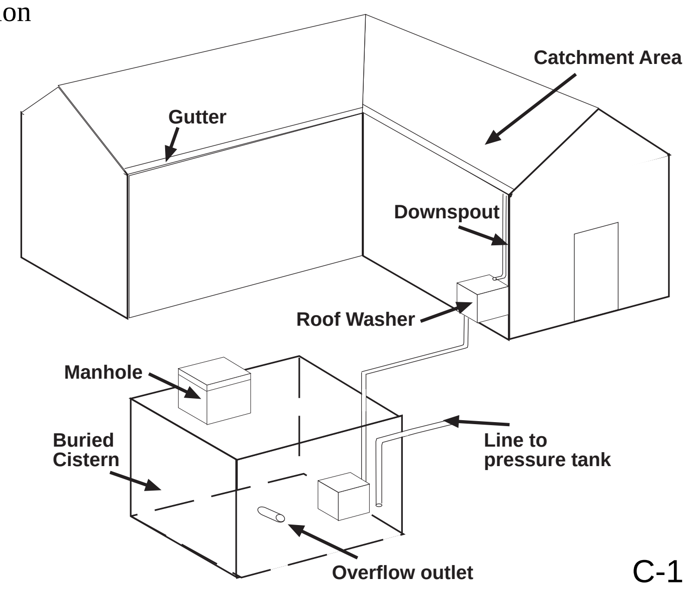

Figure 1. *Basic rainwater harvesting system*

water for non-potable uses. Water to be used for drinking should not be collected from roofs covered with asphalt shingles, and lead flashing should not be used in these systems.

Conveyance: Gutters, downspouts and pipes convey roof runoff to the storage tank, called the cistern. Gutters need to be sloped at least 1/16 inch per foot of run. They should be suspended from hangers no more than three feet apart. Aluminum or galvanized metal are recommended because of their sturdiness, although inexpensive plastic gutters may serve beneath small roof areas. The downspout should be sized to provide at least one square inch of opening per 100 square feet of roof area. Provide a downspout for each 50 feet of gutter run. If there are tall trees near the roof, cover the gutter with 1/2-inch hardware cloth, and place simple wire baskets in each downspout opening to keep leaves and twigs out of the runoff. The pipe leading to the cistern should be a minimum of 4 inches in diameter (assuming the most common layout—gravity flow). It need not be buried beneath the frost line, but must have a slope of at least 1/4 inch per foot. Sharp pipe bends should be avoided, and cleanouts should be incorporated where horizontal runs exceed 100 feet.

Purification: Dust, leaves and bird droppings accumulate on roof surfaces between rainstorms. A simple device known as a roof washer is often used to filter the largest material from the roof runoff. The roof washer diverts the first flush of runoff (containing most of the contaminants) away from the cistern. Various devices can be constructed by the homeowner or purchased commercially for this purpose. A common design is shown in Figure 2. Not until the barrel has filled to the level of the outlet pipe does runoff begin to flow to the storage tank. Between storms the barrel empties slowly through the trickle drain. A roof washer should always be incorporated into potable water systems, but it may not be needed otherwise. Potable water systems should also incorporate a sand filter at the inlet of the storage tank, and a disinfection device within the home. This could be either a point-of-use device serving the cold-water tap, or an in-line unit treating all of the household water.

Storage: The cistern can be of nearly any size and material. A wood, metal or plastic barrel placed beneath a downspout during the warm months is all that's necessary for watering the front flowerbed. Conversely, a tank that is to hold the household water supply throughout the year may need a capacity of 10,000 gallons. Any cistern to be used throughout the year in Montana must be buried, preferably with its top beneath the frost line. Any watertight tank of non-toxic material will serve: bulk milk tanks, never-used, lined fuel tanks, or precast fiberglass, polyethylene or concrete tanks, including those designed as septic tanks. As in any application, only tanks designed to be installed underground should be buried. Large cisterns are often made of concrete cast in place. Lined concrete-block vaults are not recommended, as it is very difficult to make them waterproof. The cistern inlet and outlet should be designed to minimize stirring the solids settled on the tank bottom, and the tank should include a manhole, a vent, a cleanout sump and an overflow pipe. If the cistern is to store potable water, a vertical fill pipe for use by water haulers is also desirable. Consult the listed references for design details.

Distribution: Except on steeply sloping sites, a pressurized system is needed to distribute the water from the cistern. A 1/3 or 1/2 horsepower pump, coupled with a pressure tank, usually suffices. The outlet line from the cistern should be buried beneath the frost line.

Rainwater is naturally acidic, and corrosive to metal tanks and household plumbing. In homes where the water lines are copper, joined with lead-containing solder, the rainwater should be neutralized before it enters the water lines to prevent mobilizing lead and copper into drinking water. This can be done with a commercially-available "neutralizing filter," or by using crushed limestone as the filter media in the cistern's sand filter. Sacks of crushed limestone used to

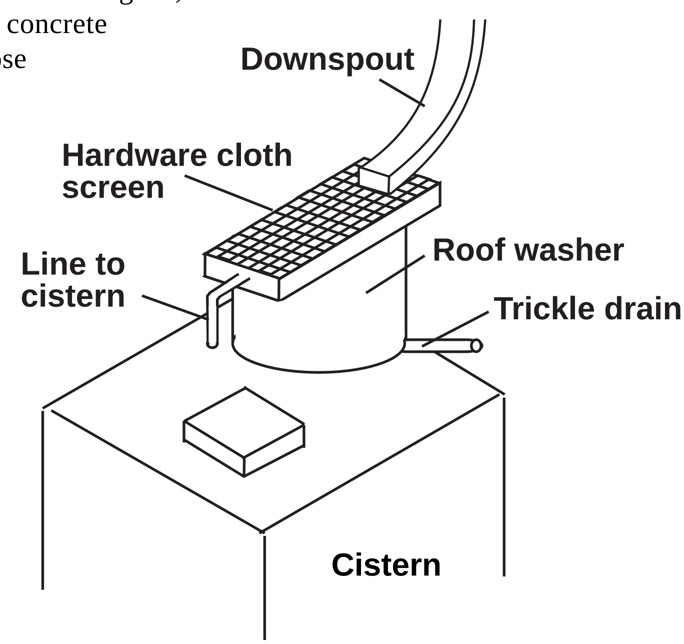

Figure 2. Example of a roof washer. Water doesn't begin to flow into the cistern until the washer has filled. The first flush drains out slowly via the trickle drain.

anchor the inlet pipe in the cistern serve the same purpose.

Design Approach

The design of an individual rainwater harvesting system depends on the planned water use, the layout of the yard or farmstead, and the reliability of the water supply that is needed. Different approaches are taken in different parts of the country. For Montana homeowners, the following steps are suggested: estimate whether rainwater could satisfy the identified need; decide on the needed reliability of the supply; size and locate the catchment area; size and design the cistern; select, locate and size the appurtenances.

Estimate Rainwater Availability: Roughly 35 percent of the precipitation that falls on a Montana roof is unavailable for use because of evaporation, leakage or diversion by the roof washer. Based on this yield estimate, Equations 1 and 2 (below) show the amount of water that can be harvested from a given roof area for a given amount of precipitation. As the equations show, one inch of precipitation falling on one square foot of roof area yields four-tenths of a gallon of usable water (the factors 0.4 and 2.5 convert among inches, feet and gallons). The first step is to estimate the annual water need in gallons, and use Equation 2 to decide whether the available catchment area could meet the need. For making up herbicide solution, base your estimate on your own experience. Estimate landscape irrigation-water requirements from Extension Service guidance. In-home water use ranges from 25 gallons per person per day (low-flow plumbing fixtures, laundering of full loads only, no use of a garbage grinder, showers rather than baths) to 50 gallons per person per day (no consideration given to water conservation).

Establish Needed Reliability: If rainwater is to be used only as a high-quality supplement to plentiful groundwater, it is not crucial to collect a rainwater volume equal to the water need every single year. In this case you can size your system based on your average annual precipitation. Each year the precipitation is less than average, you'll need to use some groundwater.

The reason for designing a system that you know will not meet your needs every year is to save money—large cisterns are very expensive. Conversely, if the rainwater is to be the sole source of drinking water for your family, you must size the system so that it collects and stores enough water even during drought years. In this case, basing your design on an annual precipitation value of 50% of average is suggested.

Size and Locate Catchment Area: The pertinent catchment area is calculated from Equation 2 as the horizontal projection of the collecting roof surface —the "building footprint." Use roof surfaces as near as possible to the planned cistern location, to shorten pipe runs. If you have the option, you may wish to avoid roofs with a northern aspect: ice buildup may make it very difficult to maintain gutters there (heat tape may prevent this problem).

Size and Design the Cistern: Because precipitation and water demand are very uneven over the course of the year (except for in-home demand), the cistern cannot be sized on the basis of annual precipitation and demand. Instead, the total demand during the dry months must be estimated; this is the volume that must be in storage at the beginning of the dry season (generally July 1). Monthly average precipitation values are needed for this exercise; these can be obtained from MSU Extension Bulletin 113, *Climate Atlas of Montana*.

If the needed storage volume is 5000 gallons or less, a lightweight fiberglass, metal or polyethylene tank will be possible. Their advantage is that they can be transported to your site and lowered into place by smaller, lighter equipment, and they do not leach alkalinity into the water, as concrete does. On the other hand, they do not have the bearing strength of concrete tanks. This is important if the tank is to be buried deeply, or beneath the driveway or farmyard.

Select, Locate and Size Appurtenances: A 1-inch or 1.25-inch pipe is generally used for conducting water from the cistern to the service pump and pressure tank. The cistern's overflow pipe should be as large as the inlet pipe from the downspouts.

If the rainwater is to be used within the house, special care must be taken to prevent its contamination. The cistern itself, as well as each fitting, must be leak-proof. Manhole risers and vent pipes emerging from a buried system should end at least eight inches above the ground surface, so that surface water can never flow down into the cistern. The cistern should be located uphill and at least 100 feet from the nearest point of the septic system. Avoid potential cross-connections: never plumb any part of the rainwater system

$G = 0.4 \times R \times A$	**Equation 1**	where	G = gallons of water harvested R = precipitation, inches of water
$A = 2.5 \times G/R$	**Equation 2**		A = roof area, square feet

(including the cistern overflow) into the wastewater lines so that suction could draw sewage into the system.

Costs

The most expensive part of a rainwater system is usually the cistern itself. Water tanks with a capacity of 2000 gallons or less cost between $0.45 and $1.00 per gallon of storage; concrete tanks are more expensive than equivalent synthetic tanks. Larger-volume concrete tanks cost roughly $1.25 per gallon of storage. Hiring a contractor to install a large, heavy tank on a remote farmstead is also expensive. This cost is very specific to the site; call local contractors for estimates. The other major expense that may be incurred for some systems is concrete work, for a cast-in-place cistern. For large cisterns, this approach may be cheaper than bringing a precast tank onto the site.

Maintenance

If the rainwater is to be used for drinking water, the inside of the finished cistern should be scrubbed down with a 10 percent bleach solution and rinsed thoroughly before the system is put in use. The cistern will need to be drained and emptied of accumulated sediment every few years. At that time, cracks should be patched with a non-toxic sealant. Be sure to employ vigorous, positive ventilation when working inside the tank.

Other system maintenance is straightforward: keep gutters and downspouts clean and in good repair; clean the roof washer or sand filter at least once a year; replace clogged sand as needed; and service pumps periodically.

Example

John Riley wishes to collect precipitation to water a young shelterbelt that covers 1500 square feet. The county Extension agent tells him the shelterbelt should get an inch of water every week between June 15 and Sept. 15, and that the average total rainfall during that time is two inches. John calculates that he will need to collect 9,350 gallons (see example calculation below) to water the shelterbelt each summer. After pricing cistern options, he decides he only wishes to buy 6000 gallons of storage capacity, and will use well water for the rest of his irrigation water. For a catchment area, he will need at least

A = 2.5 x 6000 gallons / R-annual (Equation 2)

where R-annual is the total average annual precipitation, in inches. If he only collects from this area, he'll be storing an entire year's precipitation to use during the 3-month irrigation season. The average annual precipitation on the Riley place is 15 inches, so John will need to collect from a roof area with a horizontal projection of at least 1000 square feet (2.5 x 6000/15). He decides to collect from the south side of his barn, which has 1200 square feet of roof area and is just above where he wishes to install his cistern.

Resources

General

Harvested Rainwater. 1996. Austin, Texas Green Builder's Sourcebook. Website http://www.greenbuilder.com/sourcebook/rainwater.html

Yard and Garden Water Management. 1993. MontGuide 8915AG. MSU Extension Service, Bozeman, MT.

Drinking Water Systems

Private Water Systems Handbook, MWPS-14. 1979. Midwest Plan Service, Ames, IA.

Captured Rainfall; Small-Scale Water Supply Systems. 1981. California Dept. of Water Resources Bulletin 213. $1 from CA DWR; PO Box 942836; Sacramento, CA. 94236-0001.

Rainwater Cisterns: Design, Construction and Water Treatment. 1989. E.S. Young and W.E. Sharpe. Penn State College of Agriculture Cooperative Extension, Circular 277. University Park, PA. (814) 865-7685.

Household Drinking Water Protection and Treatment. 1991. M. Vogel. MSU Extension Bulletin EB 102. ($3.50) Bozeman, MT. (406) 994-3273.

Product Literature

Alternative Water Sources for Rural Areas - Using Ponds, Lakes, Springs and Rainwater Cisterns. 1990. Water Filtration Company, Marietta, OH. (800) 733-6953.

Example calculation for watering a 1500-square foot shelterbelt

$$\underbrace{([12 \text{ weeks} \times 1 \text{ inch/week}]}_{\text{Total water needed}} - \underbrace{2 \text{ inches})}_{\text{Rainfall on shelterbelt}} \times \underbrace{(1 \text{ ft}/12 \text{ in})}_{\text{Conversion to feet}} \times \underbrace{1500 \text{ ft}^2}_{\text{Shelterbelt area}} \times \underbrace{(7.48 \text{gal/ft}^3)}_{\text{Conversion to gallons}} = \underbrace{9350 \text{ gallons}}_{\text{Total water John must collect for shelterbelt, gallons}}$$

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