100 Years of Service
Forest Products Laboratory
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Rainwater Harvesting at the Research Demonstration House and Carriage House

The main goal of rainwater harvesting is to keep water on a site so that it will soak into the ground and replenish the water table. An additional goal is to use the rainwater to reduce the strain on municipal water supplies and conserve energy.

The Forest Products Laboratory is collaborating with the University of Arizona to evaluate how rainwater harvesting systems work in a cold climate. The University of Arizona has been involved in rainwater harvesting research for many years and their main focus has been in the southwestern United States. Rainwater harvesting systems at the Research Demonstration (R/D) House and Carriage House are an extension of that research into a cold climate zone.

The rooftops of the R/D House and the Carriage House together collect about 54,000 gallons of rainfall annually – enough water for two people for 1 year, based on 3,200 ft^2 of roof area (R/D House + Carriage House) and a 30-inch average annual rainfall.

Rainwater should not be confused with graywater. Graywater is water that has been used for residential bathing and for washing clothes. It is possible to capture graywater for use as irrigation, but graywater reuse was not included in this demonstration project.

Rain Barrels

Rainwater is an excellent source for irrigation, either for indoor house plants or outdoor flower beds. Rainwater has no mineral salts, is slightly acidic, and has some nitrogen. The municipal water supply has chlorine or other disinfectants and higher mineral content, depending on the source, which makes it less desirable for irrigation.

The easiest way to collect this high-quality water for small irrigation uses is through the installation of the classic rain barrel. Many varieties are now available, from oak barrels, to food-grade plastic barrels, to the ones you see here at the R/D House, which snap together and are made water tight with a plastic bag insert. Rain barrels are only suitable for use in warm weather. They must be drained and water diverted in winter.

Water comes off the roof and down a pipe next to the rain barrels. This pipe is plugged in summer, and water passes over it into the rain barrels. In winter, the pipe is opened and water goes down the pipe and into another pipe that leads to a leach field at the side of the house. Screens on top of the rain barrels keep out mosquitoes that might otherwise breed in the standing water. The pipe coming directly out of the foundation is for the overflow from the non-potable use system in the garage.

Subsurface Irrigation

Because of the complexity of the roof of the R/D House, water from all the downspouts could not be easily captured for reuse. In addition, water in excess of what can be stored and used by the systems being demonstrated needed to be moved away from the building's wood foundation. Therefore, in the area east of the ramp, a drain field was installed to move excess water away from the building so that it could be used in the landscape and infiltrate into the ground. The construction of the drain field is similar to that of a septic leach system. A long perforated plastic pipe is surrounded by heavy gravel, and both are wrapped with fabric to prevent root and soil intrusion.

The downspouts on either side of the chimney and the overflow from the rain barrels and the non-potable use system in the garage flow into a round concrete container. Here any debris is captured, and then the water flows out through the drain field, which parallels the length of the ramp. The water from the drain field leaches into the soil and is available for plants in the immediate area with roots deep enough to reach the moisture, such as trees or shrubs.

Household Non-Potable Rainwater System

A 300-gallon tank located in the garage collects rainwater from part of the R/D House roof. The rainwater comes off the southwestern portion of the roof and into a pipe that enters the garage and empties into a 25-gallon filter box. The initial water that contains debris such as dirt and bird droppings flows into this box; the later, cleaner water bypasses the box and flows into the tank. This is often termed a first flush or foul flush process.

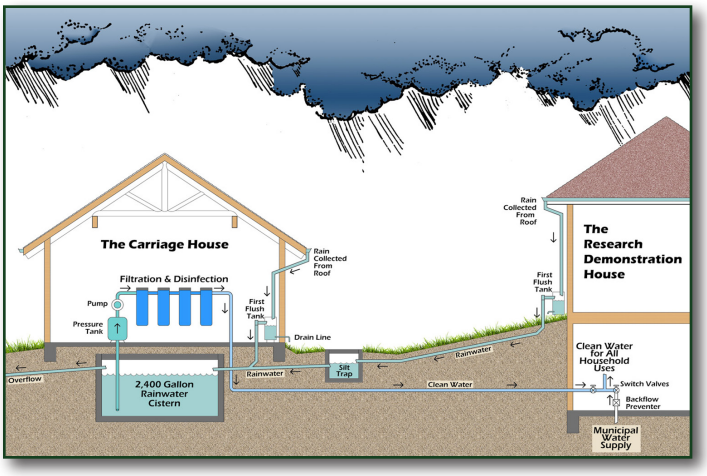
The tank also has a passive overflow in the form of a stand pipe. When rainwater volume exceeds tank capacity, it overflows into the stand pipe and is transported via the outlet pipe in the lower left corner out to the subsurface irrigation system.

The control system includes three main elements:

- Pump, with pressure tank, relay circuitry, and backflow prevention
- Water level sensor (wire near bottom of tank)
- Solenoid valve (to switch to municipal supply)

Rainwater is delivered to non-potable household uses by a secondary plumbing system located adjacent to the laundry and first-floor powder room. When the toilet is flushed, the pump supplies the water. If the water level in the rainwater tank drops

below the low water sensor, a signal is sent to the control system that turns on a low-voltage electrical signal to switch the system from rainwater to the municipal supply. This feeds city water directly to the non-potable uses. Backflow preventers control the direction of flow and prevent rainwater from moving back into the municipal supply.



Potable Use of Rainwater

A key feature of the Carriage House is the large cistern (2,400 gallons) located under the floor (access through an inspection port). Cisterns are large tanks used to store rainwater so that it is available between rainfall events.

Incoming rainwater from the Carriage House roof flows to gutters and then to downspouts, passing through leaf catchers with screens that eliminate large debris and keep mosquitoes from breeding in any standing water. Rainwater then flows into a pipe that empties into a 50-gallon barrel, which serves as a first flush device that diverts a measured volume of roof runoff at the beginning of a rainfall event. This device is designed to reduce contamination in stored rainwater by capturing smaller particles from bird droppings, dust, and other pollutants that have collected on the roof since the last rain. When a certain level of water in the first flush barrel is reached, subsequent cleaner rainwater is diverted to the underground cistern for storage. The first flush barrel drains slowly and the water and

contaminants flow into a subsurface drain field on the south side of the Carriage House, similar to the one on the north side of the R/D House. The barrel is then empty and ready for the next rainfall. Various site conditions may require different volumes and rates of drainage and these can be easily adjusted. If the cistern is full, excess water flows through an outlet port near the top of the tank to the outside drain field.

Rainwater from the cistern is drawn and pressurized by a standard pump and pressurization system and passes through a series of filters . The first two filters remove small particles, then a charcoal filter absorbs residual minerals and metals such as lead. The filtered rainwater finally passes through an ultraviolet purifier that disinfects the water by destroying any remaining microorganisms. Purified rainwater is then piped to the R/D House where it is connected to the water supply system with appropriate backflow prevention and valving so that either the disinfected rainwater or water from the municipal supply can be used. Water quality analysis is ongoing to document system safety and performance.

During excavation for the new cistern, a cistern from the original farm on the site was uncovered. Two bricks from this original cistern are on display in the Carriage House. If they could rely on rainwater a century ago, is it not appropriate that rainwater be considered today… to make our homes more sustainable and to provide water security?

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