



Water Harvesting Guidelines

Irrigating school gardens with rainwater that has been collected from the roof and stored in cisterns is valuable for teaching children about water conservation. When done properly, this practice results in a clean, inexpensive source of irrigation water,¹ fit for all types of crops. At least one Tucson school noted that rainwater use in their garden improved soil pH and enhanced productivity. Keep in mind that standing water can collect contaminants and act as an incubator for a variety of microorganisms, and follow these best practices to keep the water clean and safe.

Roofing materials:

Learn what type of roofing is used at your school.²⁻⁴ Nontoxic, smooth, dense roofing materials, such as metal (but not copper or uncoated galvanized steel) or concrete tile roofs, are ideal.^{2,3}

- Avoid watering your edible plants with the harvested water if you have the following roof types:
 - Asphalt-shingle or tar roofs. Hydrocarbons or copper from these roofs can leach out into the harvested water.^{2,5}
 - Galvanized metal roofs that have NOT been treated with a non-toxic coating.⁴ These can add lead or other metals to the water.²
 - Roofs that contain zinc, lead (which is common in paint on older roofs), asbestos (which can be mixed into concrete tiles), tar, asphalt, or pesticide-treated wood.⁴
 - Copper roofs.^{2,5}
 - Roofs with zinc “antimoss strips” or zinc embedded into the shingles.⁵
 - Roofs with chemicals in the paints, coatings, or treatments that that you would not want entering your garden.
 - Be aware that some roof coatings contain fungicides.⁴
 - Some shingle and shake roofs (which are not recommended for water harvesting) have been treated with chromated copper arsenate, to make them resistant to rot, moss, and algae growth.⁵
 - Roofs with gutters made with toxic construction materials, paints, or coatings.
 - Roofs with copper gutters.⁴
- Non-smooth roofing materials can contribute to unwanted particulate matter in the water.
 - Asphalt or shingle roofs (not recommended) are prone to collecting dust and contaminants.²
 - Shingles can add gravel to the runoff, causing buildup and clogging.²

Cistern construction (See Figure 1):

- Make sure the cistern is constructed with appropriate materials.
 - If a fiberglass or polyethylene tank is used, make sure it meets the NSF/ANSI Standard 61 for drinking water. Although the water is not for drinking, this is important for avoiding materials that could contain hazardous chemicals.
 - If the cistern is not made of a food safe material or if there are leaks, you can use a coating or liner that is food grade or otherwise approved for water storage by the FDA or NSF.⁴
 - Before reusing a container as a cistern, consider its history. Avoid containers that have been used to store garbage or toxic materials in the past.⁶
 - Also, plastics that are not food grade can contain toxic chemicals. For example, some trash cans contain biocides that could leach into the water.⁴
 - Beware of old water storage containers, which often have lead paint.⁴
 - The tank should be opaque to discourage algal growth.^{6,7}
- Install a metal filter (i.e., a **rainhead**) to minimize the entry of organic matter and microorganisms into your storage tank (Fig. 1).
 - A rainhead screen can be custom made at a metal shop for \$65-75.
 - The pipe from the rainhead to the cistern must have at least one bend (90°, ideally), to prevent the entry of sunlight into the tank.
 - Prefabricated plastic screens can be purchased, but they don't wear as well as metal rainheads and can add lead to the water when they break down.
- Include a **first flush device** in the cistern installation to avoid capturing the first 15-20 minutes of rain after a dry spell (Fig. 1).² The **first flush** of roof runoff contains the bulk of pollutants that have accumulated.
 - You can construct a simple first flush device for around \$30, using a long plastic pipe.
 - Commercial devices can be purchased to do this for you, but can be expensive.²
- The **spigot** (which may be attached to a pump) should draw water from 4-6" above the base of the tank.⁸ This will help you avoid drawing settled debris deposits.
- Use an opaque, solid cover on the cistern to keep out dust, debris, animals, and sunlight.
- Any small, remaining openings to the cistern should be covered with a solid cover or fine screen mesh.²
 - All mesh must be fine enough to keep mosquitoes and other insects from passing through.^{5,7}
- Install an **overflow pipe** above the desired water level in the tank to divert overflow into a well-drained place.

- The pipe must be the same diameter or larger than the inflow pipe.
- The end of the overflow pipe should contain a one-way flap if it is sitting on the ground, to prevent flooding events from contaminating the stored water.⁸
- To make the best use of overflow, it should be directed to one or more passive (earthen) water harvesting basins to support native vegetation.
- A **cleanout** pipe (note: *not* shown in Fig. 1) should be installed at the very bottom of the cistern to completely empty the tank during cleanings. We recommend the following features:
 - A ball valve to allow opening and closing.
 - A wide 1.5-2" diameter to avoid clogging.
 - It can be connected to the overflow pipe for easy draining.
- Label your tank with a "do not drink the water" sign.

Cistern placement:

- Place the cistern in a well-drained area that is not vulnerable to flooding.²
- Always locate all on-site utilities before installing the cistern.
 - Arizona Bluestake will locate some utilities on school properties, but be sure to check with the school district's facilities department as well before digging.
 - Avoid placing the cistern within the serviceable area of underground utilities.
 - If using an underground cistern, consider distancing it far from any septic systems.
- Avoid connecting the cistern to a sewer system. Instead, use an overflow pipe (see above) to divert overflow to an area where excess water will not cause erosion.^{5,7}
- When full, the cistern will become quite heavy, which could cause it to collapse if it is not placed on a solid foundation.⁶
 - Make sure the ground beneath the cistern is solid, level and unlikely to erode.⁶
 - In areas with uneven ground, fine sand spread evenly can be used to create a level base for a polyethylene tank. Use a leveling tool to ensure a flat surface.
 - Route overflow away from the base of the cistern.^{6,7}

First flush:

- Be sure to empty the first flush device between rainfall events.

Cistern and roof upkeep:

- If your roof receives extensive leaf drop, consider cleaning the gutters on a regular basis.² If there are tree branches over the rooftop, they will contribute to this problem.^{2,4}
 - Organic contaminants can cause discoloration, odor, and buildup of microorganisms in the water.⁴

- If leaves and animal droppings are an ongoing problem, consider covering the gutters with a screen.^{2,4}
- Make sure there are no places on the roof or gutters where water can pool.⁵
- Thoroughly inspect the whole system for leaks once per year and make necessary repairs.² Leaks can act as entry points for contaminants.⁴
- Make sure all filters are kept clean and maintained. An unclean filter can act as a breeding ground for bacteria.² Remove debris from the top of all filters and screens often, to prevent clogging, sagging, and overflow.²
- Check for deposits at the bottom of your tank at least once per year, and remove deposits once they have nearly reached the level from which water is drawn (i.e., 4-6" from the bottom).
- Consider completely emptying the cistern and rinsing it with city water annually as an added sanitation measure.
 - Allow it to dry completely after the cleaning.
 - Avoid rinsing the debris deposits into your garden area.
 - A bleach solution can be used if desired,² but should not be allowed to drain out into the landscape.
- Clean the cistern if it appears dirty after repair work.²

A note about irrigation

- Drip irrigation reduces the direct contact between the water and the edible portion of above-ground crops in the garden, such that EPA considers it a low risk practice as far as rainwater is concerned.⁹
- If the water from a poorly designed or maintained system is applied through spray irrigation form, foliar applications, or hand watering that may result in direct contact with the plant, we recommend a representative water sample from you harvesting system be tested annually for contaminants, including coliform bacteria and lead.⁴ The specific thresholds recommended by EPA are as follows:
 - E. coli: 126 CFU/100mL⁹
 - Lead: 10mg/ L¹¹
- Other agents to consider testing for:
 - Enterococcus: 35 CFU/100mL⁹
 - Zinc: 10 mg/L¹¹
 - Cadmium: 0.05 mg/L¹¹
 - Copper: 5.0 mg/L¹¹
- Maintain records of any water tests performed.¹⁰
- If the cistern will be attached to an irrigation system, additional filtration is advisable to make sure deposits in the cistern won't clog the pump and irrigation emitters.

References:

- ¹ Lee, et al., 2010. Comparison of the microbiological and chemical characterization of harvested rainwater and reservoir water as alternative water resources. *Science of the Total Environment* (408).
- ² T. Younos et al., 1998. Evaluation of Rooftop Rainfall Collection Cistern Storage Systems in Southwest Virginia, Virginia Tech. <http://vwrrc.vt.edu/pdfs/specialreports/sp031998.pdf>
- ³ C.B. Mendez et al. 2011. The effect of roofing material on the quality of harvested rainwater. *Water Research* 45(5): 2049-59.
- ⁴ P.S.H. Macomber. 2010. Guidelines on Rainwater Catchment Systems for Hawaii. College of Tropical Agriculture and Human Resources, University of Hawaii. http://www.ctahr.hawaii.edu/hawaiirain/Library/Guides&Manuals/HI_Guidelines_2010.pdf
- ⁵ Seattle Conservation Corps, City of Seattle, 2011. Seattle Rain Barrel User Guide. http://www.seattle.gov/util/groups/public/@spu/@conservation/documents/webcontent/cos_004351.pdf
- ⁶ Texas Water Development Board, 2005. The Texas Manual on Rainwater Harvesting. http://www.twdb.state.tx.us/publications/reports/rainwaterharvestingmanual_3rdedition.pdf
- ⁷ A.A. Phillips. 2005. City of Tucson, Water Harvesting Guidance Manual. <http://cms3.tucsonaz.gov/files/transportation/2006WaterHarvesting.pdf>
- ⁸ Technicians for Sustainability, LLC. Parts of an aboveground gravity culvert cistern. <http://tfssolar.com/residential/rain-water/how-it-works-2/parts-of-an-aboveground-gravity-culvert-cistern/>
- ⁹ Information from webinar led by Dr. Dennis Lye, microbiologist at the EPA. Webinar was held by American Rainwater Catchment Systems Association on June 18, 2013.
- ¹⁰ U.S. Department of Agriculture. Food Safety tips for [school gardens](http://www.fns.usda.gov/cnd/guidance/foodsafety_schoolgardens.pdf). http://www.fns.usda.gov/cnd/guidance/foodsafety_schoolgardens.pdf
- ¹¹ 2004 Guidelines for Water Reuse. United States Environmental Protection Agency. <http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=30006MKD.PDF>

Aboveground Gravity Culvert Cistern

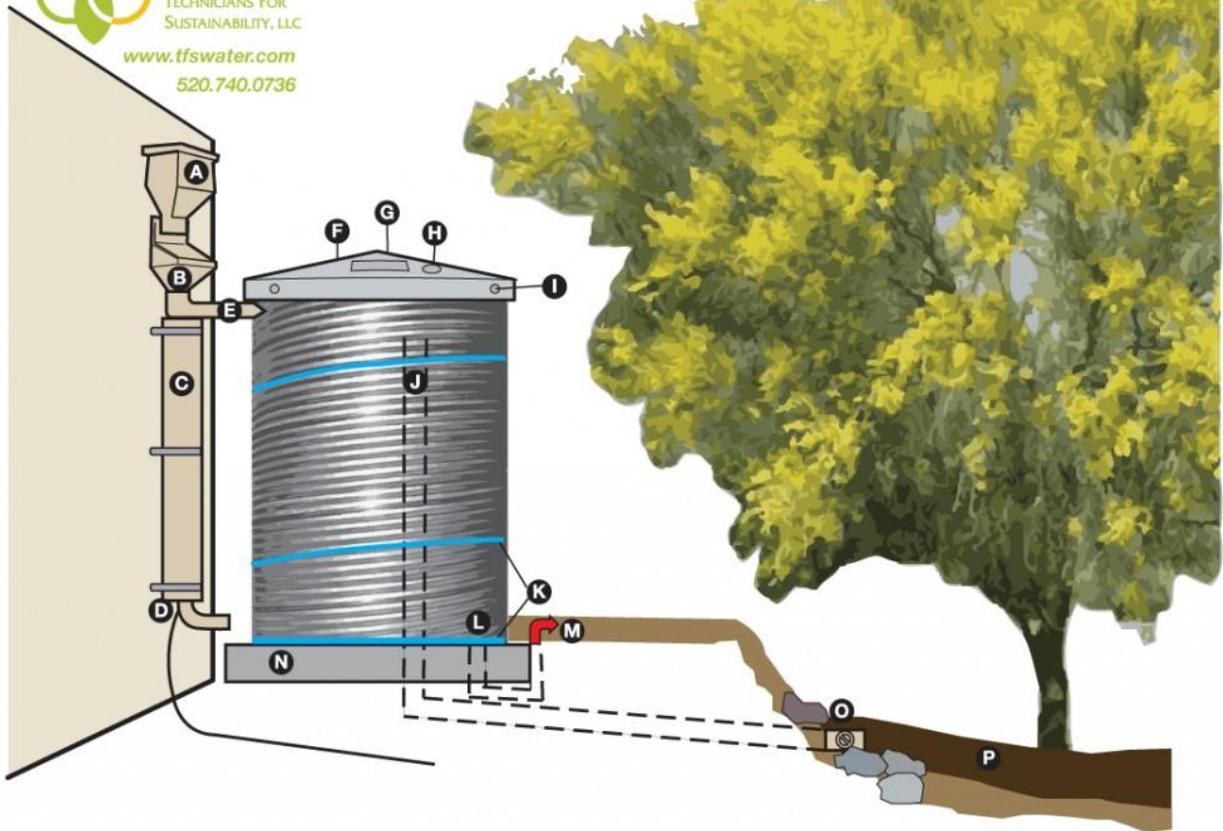


Figure 1 (<http://tfssolar.com/residential/rain-water/how-it-works-2/parts-of-an-aboveground-gravity-culvert-cistern>):⁸

- A) Header box (for flat roofs): Metal collector to collect rainwater from roof drain/canale/scupper and direct it to rainhead screen
- B) Rainhead screen: 1/8" screen mesh catches leaves and other roof debris, screen slopes at a 45 degree angle so that debris falls away
- C) First flush diverter: Wall-mounted pipe sized to catch the dirtiest water- the first 1% of roof runoff at the start of each storm

- D) First flush end cap: Pipe ends at elbow with threaded cleanout cap, with irrigation tube run to vegetation nearby to slowly empty first flush pipe after storms
- E) Inflow pipe: Rainfall enters either directly from rainhead screen or once first flush diverter is filled. Typical pipe is painted plastic and sized based on expected rainwater flow calculated from roof area
- F) Pitched metal lid: Includes interior foam gasket to ensure tank remains free of algae, bacteria, and insects
- G) Observation port: Latched door to allow easy visual access to your stored rainwater at any time
- H) Vent: Ensures airflow, prevents a vacuum effect in heavy rain
- I) Screws: Lid is secured on tank
- J) Overflow pipe: ABS pipe in the tank interior, directs water away when the tank is full during a storm
- K) Interior tank sealant: The concrete floor, edge of culvert, pipe connections, and steel seams are coated with a potable-rated liquid rubber formulated for water storage
- L) Supply line: Interior 1" PVC pipe extends 4" above the floor of the cistern to avoid sourcing sediment settled on the tank floor
- M) Spigot: A full-port (3/4" opening) ensures maximum gravity pressure. The supply line can also be extended to provide spigots in various parts of the yard, or to a pump for greater pressure/ longer distances
- N) Concrete foundation: We use a circular form to minimize concrete use, which extends 6" from the culvert on all sides. The culvert is set into the concrete while it is wet, and supported on bricks above a reinforcing steel mesh in the pad
- O) Backwater valve: On the end of the overflow pipe, this one-way flap valve ensures that water can exit but nothing can enter the tank
- P) Mulched, vegetated basin (recommended): Overflow should be used as a resource, and directed to an area with the capacity to accept predicted cistern overflow and native plants to use it efficiently