

Alternative Stormwater Management Practice

CISTERNS

Description

Cisterns capture and store stormwater runoff to be used later for irrigation systems or filtered and reused for household activities such as toilet flushing and clothes washing. Cisterns can be constructed of any water-retaining material and their size can vary from hundreds of gallons for residential uses to tens of thousands of gallons for commercial and/or industrial uses. They can be located either above or below ground and can be constructed on-site or pre-manufactured.

The basic components of a cistern include: a secure cover, a leaf/mosquito screen, a coarse inlet filter with clean-out valve, an overflow pipe, a manhole or access hatch, a drain for cleaning, and an extraction system (tap or pump). Additional features might include a water level indicator, a sediment trap, or an additional tank for extra storage volume.

Recommended Application of the Practice

Cisterns can be used in most areas (residential, commercial, and industrial; Figure 1) due to their minimal site constraints relative to other stormwater management practices. They can be applied to manage almost every land use type from very dense urban to more rural residential areas. The sizes of cisterns are directly proportional to their contributing drainage areas and intended use.

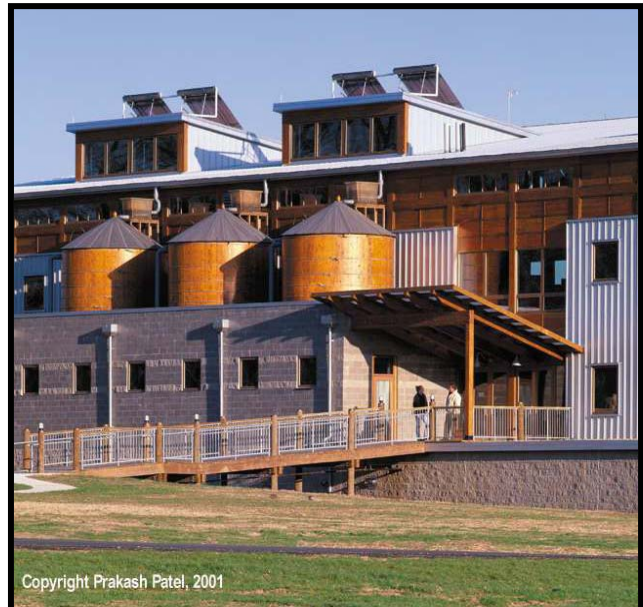


Figure 1: Cisterns can be designed for smaller residential uses (left) or for large business operations (right).

Benefits

Cisterns provide many stormwater management benefits, among them:

- Cisterns can reduce stormwater runoff volumes, and delay and reduce peak runoff flow rates.
- Stored water from cisterns can help reduce water consumption, which ultimately reduces the demand on municipal water systems. Water from cisterns, if managed correctly, can be used for drinking, bathing, and cooking as well as for garden irrigation (Kessner, 2000).
- Cisterns can also be used in urban redevelopment scenarios to reduce runoff volumes in areas where soils are compacted, groundwater levels are high or hot-spot conditions exist that preclude infiltration.

Feasibility/Limitations

The biggest limitation to the installation and use of cisterns to capture and reuse stormwater is the need for active management/maintenance and initial capital cost. Generally, the ease and efficiency of municipal water supply systems and the low cost of water prevent people from implementing on-site water conservation and reuse systems. Specific limitations include:

- Cisterns require periodic maintenance and cleaning to ensure effective stormwater treatment. If water from a cistern is intended for household use, adequate design and maintenance on the part of the homeowner are necessary to ensure all water is appropriately treated before use.
- A supplementary water source may be needed if water captured in a cistern does not fulfill the intended water demand. Alternatively if captured water is not used as anticipated, the extra water entering the cistern will need to be managed to prevent overtopping.
- To achieve significant community wide acceptance, an active community education program and a high profile public site demonstration will likely be necessary.
- In cold climates specific design or maintenance strategies will need to be considered to prevent freezing such as providing insulation or disconnecting the system.

Sizing and Design Guidance

Depending on the intended use, cistern sizing is a function of the impervious area that drains to the device and the amount of water required for the reuse activity (e.g., laundry or toilet flushing). The basic equation for sizing a cistern based on the contributing area is as follows:

$$\text{Vol} = \text{WQv} * 7.5 \text{ gals/ft}^3$$

where:

Vol = Volume of cistern [gallons]

WQv = Water Quality Volume [cubic feet], as defined in Chapter 4 of the New York Stormwater Management Design Manual

7.5 = Conversion factor [gallons per cubic foot]

A simple example for sizing cisterns using WQv is presented in Table 1.

Table 1: Simple Cistern Sizing Example
<i>Given a 3,000 square foot impervious surface area draining to a cistern, calculate the water quality volume and required cistern volume.</i>
<p>Step 1: Calculate water quality volume using the following equation:</p> $\text{WQv} = \frac{(P)(Rv)(A)}{12}$ <p>where:</p> <p>P = 90% rainfall number = 0.9 in</p> <p>Rv = 0.05+0.009 (I) = 0.05+0.009(100) = 0.95</p> <p>I = the percentage of impervious area draining to site = 100%</p> <p>A = the Area Draining to Practice = 3,000 ft²</p> $\text{WQv} = \frac{(0.9)(0.95)(3,000)}{12} \quad \text{WQv} = 213.75 \text{ ft}^3$
<p>Step 2: Calculate cistern volume using equation above: Vol = (WQv) (7.5 gals/ft³)</p> $\text{Vol} = \text{WQv} \times 7.5 \text{ gals/ft}^3$ <p>Vol = 1603 gal</p>
<i>Therefore, to treat the water quality volume for the area draining to the practice, a 1,650-gallon cistern is required.</i>

Siting

A cistern can be located beneath a single downspout or one large cistern can be located such that it collects stormwater from several sources. Due to the size of rooftops and the amount of contributing impervious area, increased runoff volume and peak discharge rates for commercial and industrial sites may require large capacity cisterns. Cisterns designed to capture small, frequent storm events need to be either actively or passively drained to provide storage for subsequent storm events or located in an area where overflow runoff can be conveyed to a suitable area such as open yard, swale, a rain garden or the storm drain system.

In cold climates where cisterns are designed for use throughout the year, cisterns placed on the ground require extra insulation on the exposed surfaces (Stensrod, *et al.*, 1989). For cisterns placed on rock, the bottom surface will also need to be insulated. For underground systems it may be cost-prohibitive to place the cistern below the freezing depth, so alternatively, insulation

can be placed below the surface and above the underground cistern to prevent freezing. Other methods to prevent freezing include lining the intake pipe and cistern with heat tape and closing the overflow valve (Stensrod, *et al.*, 1989). Water levels should also be lowered at the beginning of winter to prevent possible winter damage and provide needed storage for spring snow melt.

Environmental/Landscaping

An effort should be made to meet property owners' preferences in providing attractive above ground cisterns. The likelihood of continued use of the cistern is increased if they are an attractive part of the landscape (Figure 3). Landscaping should be used to shade cisterns to reduce algae growth and to provide visual screening.

Maintenance

Maintenance requirements for cisterns vary depending on if the water will be used domestically or only for irrigation. Depending on the design and use of the cistern, winterization maintenance may also be necessary. Generally, cisterns inspections should be conducted semi-annually and the following components inspected and either repaired or replaced as needed:

- Roof catchments should be inspected to ensure that no particulate matter or other parts of the roof are entering the gutter and downspout to the cistern.
- Gutters and downspouts should be inspected to ensure that no leaks or obstructions are occurring.
- Roof washers, cleanout plugs, screens, covers, and overflow pipes should be inspected and replaced as needed.
- Inspections should also include inflow and outflow pipes as well as any accessories, such as sediment traps.



Figure 3: Cisterns can be incorporated into the overall landscaping of the site.

Cost

The cost for cisterns can vary greatly depending on its size, material and location (above or below ground). Costs range from a low of about \$0.50 per gallon for large fiberglass tanks to up to \$4.00 per gallon for welded steel tanks (TWDB, 2005). The following are representative costs for pre-manufactured cisterns, not including labor and accessory costs (Table 2).

Table 2: Cost Guide – Pre-manufactured Cisterns (LID Center)

Material	Cost (small system)	Cost (large system)
Galvanized Steel	\$225 for 200 gallons	\$950 for 2,000 gallons
Polyethylene	\$160 for 165 gallons	\$1,100 for 1,800 gallons
Fiberglass	\$660 for 350 gallons	\$10,000 for 10,000 gallons
Fiberglass/Steel Composite	\$300 for 300 gallons	\$10,000 for 5,000 gallons

References

Kessner, K., 2000. How to Build a Rainwater Catchment Cistern. The March Hare, Summer 2000, Issue 25, <http://www.dancingrabbit.org/building/cistern.html>

Low Impact Development Center, Inc. (LID). Accessed 2005.
<http://www.lid-stormwater.net/intro/sitemap.htm>

Stensrod, O. and Gosback, J. September 1978. translated May 1989, Johansen, J. and Seifert R.. *Water Cistern Construction for Small Houses*. Alaska Building Research Series, HCM-01557.

Texas Water Development Board (TWDB). 2005. *The Texas Manual on Rainwater Harvesting 3rd Edition*.
http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf

The Urban Garden Center (UGC)
<http://www.urbangardencenter.com/products/rainbarrel/index.html>