Rainwater Catchment as an Alternative WATER SOURCE

The increasing need for potable water free of water-borne disease is a growing problem worldwide. Locally, increasing water costs improve the attractiveness of rainwater. The changing climate conditions causing weather extremes and putting increased demand on storm systems combined with increased government scrutiny on pollution of water resources; all point toward taking a closer look at rainwater catchment as an alternative source of water.

Not Just a Problem In Other Countries

Worldwide groundwater contamination and loss are growing environmental calamities. The U.N. estimates that one-fifth of all people currently lack access to safe drinking water, and more than half lack adequate sanitation, which further pollutes the available fresh water. By 2025, the United Nations predicts that 35 percent of the world will face serious water shortages.[1] Even with the highest feasible water use efficiency and productivity, many countries will not have sufficient water resources to meet their agricultural, domestic, industrial and environmental needs.[2] Closer to home, water shortage issues now plague the seven western states relying on the Colorado River for their water needs, according to a recent front page article in the New York Times.[3] In the midwest, Indianapolis increased rates 26 percent in February, north Chicago has proposed a 15 percent increase, Northern Kentucky is looking at a 25 percent hike over the next two years and the Cleveland Water Department wants to increase rates a whopping 82 percent over the next 4½ years for city residents.

Due to increasing demand from worldwide population growth and the decreasing supply of accessible water sources, the outlook for potable fresh water availability looks grim. Clearly, extending the supply of potable fresh water is one of the most critical challenges facing us today.

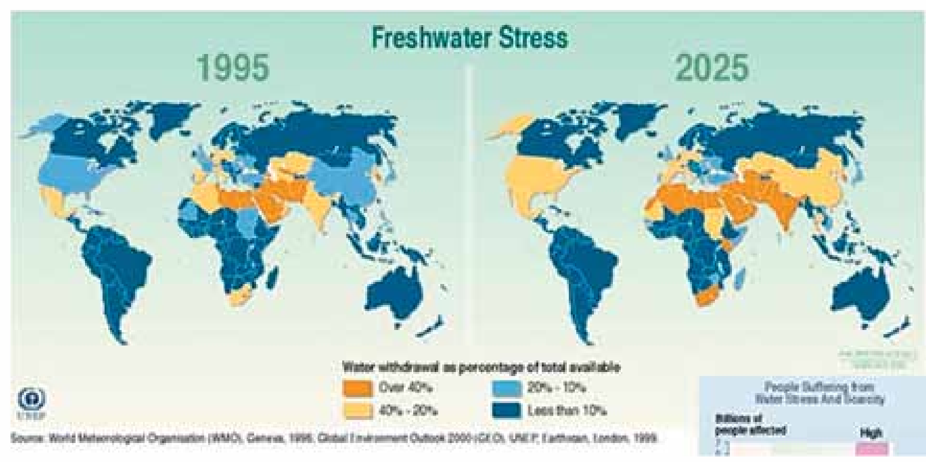

Fig. 1: World Meteorological Organization forecasts freshwater stress in the year 2025.

Saving What We Have

Rainwater catchment is the harvesting of rainwater for reuse before it reaches the aquifer. This makes sense if there is a shortage of water, the water quality is not good or there is concern about combined sewer overflows into the water supply. The concept requires three components; a surface where rain can be captured and collected; a storage device, or cistern, to store the water and piping for moving the collected water. The key challenge for engineers designing rainwater catchment systems is matching water demand with the amount of stored rain.

Demand: How Much Water Does a Person Need?

The average U.S. citizen uses an estimated 100 gallons (378 liters) per day for drinking, bathing, waste removal (i.e. toilets), and washing clothes. By comparison, United Kingdom citizens use 87 gallons (329 liters) per day; Asians use 22 gallons (83 liters) per day; and Africans use 12 gallons (45 liters) per day.[4] At a minimum, we need about ⅔ gallons (2.4 liters) of water per day to survive, which represents a vast gulf between water needs and traditional water usage. How much water is the correct amount to provide?

The engineer's challenge is to calculate a water demand estimate that integrates a cost/benefit analysis with a facility's minimum water needs. With a rainwater catchment system, you can exercise some control over water usage. Rather than depending on standardized tables that imply an unlimited water supply, you can perform your own demand calculations that reflect the use of low-flow fixtures and your specific application's usage patterns. This begins by understanding the facility's usage and occupancy.

Using a commercial building as an example, you can eliminate drinking water from the calculation if it comes from a bottled-water provider. The statistical inclusion of ultra-low-flush toilet fixtures, urinals with electronic flush valves that control flush frequency and amount, and kitchen water needs (if applicable) creates a more manageable estimated load than provided by traditional calculation techniques.

Special-purpose facilities such as hotels add some complexity to the calculations due to the inclusion of showers in the water demand load. When you add laundry needs, spas, swimming pools, landscape irrigation and other recreational options, accurate water demand calculations become more challenging. However, remember that these latter loads can use lower-quality water and can be separated from the facility's domestic water system. It is also important to remember that water demand must be matched with the corresponding seasonal rain pattern – rainy season may not be tourist season

Estimating the Rainwater Supply

The next step is to determine the amount of potential rainwater that will be available to supply a catchment system. Two excellent sources of rainwater data are the National Oceanic and Atmospheric Administration's National Climatic Data Center (www. ncdc.noaa.gov/oa/ncdc.html) and National Weather Service (www.nws. noaa.gov).

As a rule of thumb, you should analyze at least seven years of monthly rainfall records at a location close to the project site. While average and median rainfall amounts provide some guidance, rainwater availability extremes are the most important.

After determining the available rainwater density, you can calculate the water that can be collected by multiplying rainfall density (in inches) by the collection surface area (in sq. ft.). A 35 percent buffer is commonly added to this amount to account for evaporation and system leakage.

Sizing the Storage Tank

It is not crucial to collect water for 100 percent of demand if replacement water from an alternative source (well, water delivery service, utility) is available. The actual safety factor is a decision that depends on replacement water availability and the consequences of running out of fresh water. Due to a number of factors, it may not be feasible to provide for 100 percent of demand without water rationing during periods of low rainfall.

With some iteration, the storage tank can be sized using the following formula:

V = D - G + L where
V = Tank volume (gallons)
D = Water demand out
G = Available rainwater in
L = Leakage of tank

Often the controlling factor on the cistern size is budget and consequences of the cistern running dry. If the facility is near a utility water loop to which the cistern can be connected, you can use an automatic float valve to maintain a minimum water level. If no nearby water supply is available, trucking in water to supplement a dry cistern may be an option. If no alternative sources exist, the tank size must be increased accordingly. However, if the tank is oversized, the water can become stagnant if not regularly replaced. Balancing these two extremes – running out or causing stagnation – is the art in sizing the cistern storage volume.

Fiberglass tanks, with capacities of approximately 2,000 gallons or less, are usually the most economical and easily maintained tanks available. Concrete, used for larger tanks, is generally more expensive. One way to greatly reduce a cistern's cost is to integrate it into the building's design rather than construct it as a separate additional system. With below-grade tanks, the surrounding surfaces need to be graded away from the cistern so surface water runoff will not contaminate the water supply. Cisterns must be water tight and have washable surfaces, with a low point for residue (mud) to collect for easy cleaning. A thorough cleaning with a chlorine solution should be part of the final installation before putting the cistern to use. While research shows that maintaining the biofilm in the tank is actually beneficial to water quality, keeping sunlight from entering the cistern is essential for keeping algae from growing in the tank.

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Collecting It Clean

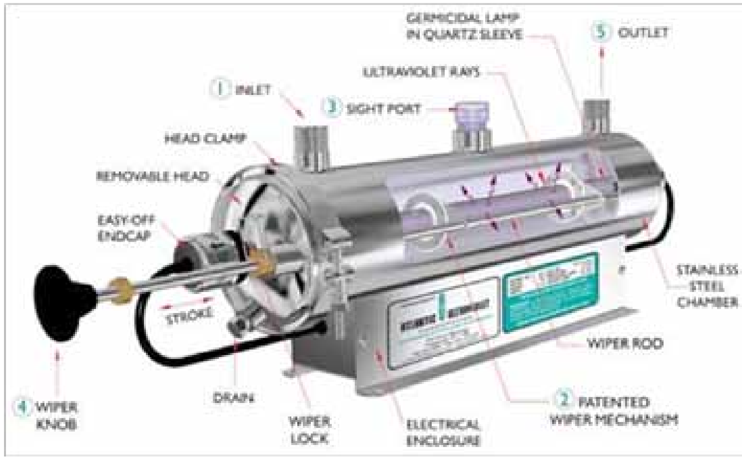
Any collection surface will have dirt and other undesirable substances, such as bird residue and leaves. To prevent this contamination from entering the cistern, the use of a roof washer to filter the initial rain volume is recommended. A number of field-constructed and commercial roof washers are available with varying techniques for filtering pollutants. Roof washers clean the collection surface by wasting the first of the rainwater collected. The roof washer tank should be sized to catch about 15 to 30 minutes of rain time, or approximately 10 gallons for every 1,000 sq. ft. of collection surface. When the roof washer tank is full, thus the collection surface and piping system presumed to be clean, rainwater overflows from the roof washer into the cistern. A small (⅜-inch) bleed hole in the bottom of the roof washer collection tank allows the collected dirty water to slowly drain, thus emptying the tank and carrying most of the debris to waste.

Water Distribution Design Inside the Building

The final step in creating a rainwater catchment system is designing the building distribution system. For a cistern installed below floor grade, a shallow-well pump system commonly is used to pressurize the system. This presumes that a ready source of electricity is available. For remote locations where power is not reliably available, a manual hand pump or solar powered pump can be included with the system design

The best water to collect from the cistern is just below the water surface. At the surface there is an abundance of undesirable bacteria thanks to the oxygen interface at the surface. On the bottom, where all things eventually settle, is the anaerobic zone where the debris begins to ferment in the absence of oxygen. Products of anaerobic digestion include SO_2, and methane, the same as develops in an outdoor privy. So if the water is to be used inside the building, or for potable applications, the best quality water, free of odors and coloring, will be gotten with the water pickup floating just below the water surface.

For higher levels of purification, such as for personal consumption, an ultraviolet water purifier to kill bacteria is the most popular device to use. To minimize this purifier's size and resultant cost, the potable water line intended for human consumption, should be run separately from the non potable water to plumbing fixtures. An example of an ultraviolet water purifier can be seen below in Figure 2.



Fighting Fires with Rainwater

Dual use of a cistern is commonplace in many areas. For example, San Francisco uses an alternative water supply for emergencies. To provide for fire protection, a fire reserve is needed in addition to the calculated domestic water demand. This reserve is drawn from the lowest part of a tank and pumped into the sprinkler system with a fire booster pump. Therefore, the cistern is designed so the domestic water is drawn from a level above the designated fire reserve. It is important and highly recommended, that you consult the local fire authorities regarding the necessary fire reserve requirements.

Cistern Maintenance

Cistern maintenance requires a regular system of inspections. Opinions are mixed regarding the ongoing use of chlorine to occasionally treat the water supply. Concerns include health problems associated with possible chlorine overdosing and chlorine-tolerant bacteria development. In practice, omitting chlorine use and following regular maintenance of periodic cleaning of the collection surface and flushing out settled debris in the cistern has been shown to be adequate.

Like any standing body of water, a cistern is often a source of mosquito breeding and attendant mosquito-born diseases. All vents and overflows need to be properly screened for flying insects and vermin.

Storm Water Management

Collecting rainwater serves to buffer the immediate load on the storm water drainage system. By collecting the water for use later, it reduces the immediate demand on a combined sewer system, which is of interest to many municipalities looking at undersized sewers across the county. Another way to manage storm water is to retain the storm water on site in the form of a rain garden. This serves to delay the runoff into the storm sewer until after the ground on site is saturated. This serves the purpose of replenishing the aquifer which in turn serves to maintain moisture in the soil for better landscape growth.

Always a Need for Clean Water

The increasing need for potable water free of water-borne disease does not just occur in desert areas or in third world countries. It is a problem that affects many people around the world and will increasingly affect Americans over the next decade. With costs for clean water rising dramatically, it only makes sense for businesses to look to alternative methods for their water needs. Capturing and collecting rainwater for use can save money and help preserve a dwindling resource.

References

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