Water Conservation Technology

Rainwater Harvesting in Greater Victoria

Overview

Rainwater harvesting is the practice of collecting rainwater for beneficial use. Usually this refers to collection of rainwater from a rooftop and storing it in tanks and cisterns for later use in or near the point of collection. The use of rain barrels is a simple form of rainwater harvesting, although larger storage systems are required to serve most uses.

In the Gulf Islands near Victoria, where reliable surface water or groundwater supplies are not always available, several homes and businesses rely on rainwater harvesting as their only source of water. In Greater Victoria, rainwater harvesting is emerging as one of many sustainable development strategies to reduce the ecological impacts of development.

Applications

Harvested rainwater may be used for virtually any purpose, provided suitable collection, storage and treatment for the desired use. Although rainwater may be treated for use as drinking water, the most cost-effective applications of rainwater harvesting in areas served by municipal drinking water infrastructure are usually outdoor uses such as irrigation or vehicle washing, and indoor uses that do not require potable water.

Rainwater used outdoors usually needs no treatment, although screens in the collection system are necessary to protect pumps and prevent accumulation of debris in tanks. Fine screens or filters may be required for micro-drip or spray irrigation applications. Screened, untreated rainwater (non-potable water) may also be used for toilets and laundry where buildings are fitted with dedicated non-potable water supply plumbing[1]. Treatment, such as filtration and ultraviolet radiation, is typically required for indoor uses, and may also be required for irrigation of fruits or vegetables.

Components of a Rainwater Harvesting System

Rainwater harvesting systems are simple in design, consisting of a collection system, storage tank or cistern, and pump and treatment systems.

The collection system includes the roof, gutters and downspouts of a building, and a network of pipes that collect the rainwater to a cistern that is usually located to allow collection by gravity. The collection system also includes screens or traps to prevent debris from entering the cistern. For potable systems, a diversion device that prevents the first 0.5mm of rainwater in a rainfall event from entering the cistern, called a first flush diverter, is also usually included. Collection system components are generally simple and inexpensive. The most costly component of the collection system is the roof itself, which is usually enamel coated steel for potable systems. Other roofing materials are generally acceptable for non-potable systems; however, cedar shakes and asphalt shingles treated with moss inhibitors should be avoided.

A storage tank or cistern for an urban rainwater harvesting system should be sized and configured to achieve a substantial reduction in municipal water use and a substantial reduction in peak rainwater discharge to the sewer. The installed cost of storage tanks is typically in the range of $250-500 per cubic

[1] Some authorities may require water used for laundry to be treated to potable standards, although König and Stubbs consider untreated rainwater acceptable for laundry use. König (p.66) cites a German court ruling in favour of the use of untreated rainwater for laundry on the basis of lack of evidence of risk, and the fact that pathogens are more likely to be introduced to laundry by dirty clothing than by rainwater. Stubbs (p.11) states that “raw, screened rainwater may be used for irrigation, water closets, urinals, laundry, outdoor cleaning and water features.”

metre. There are several options for storage tanks, depending on site conditions, and whether the system is installed at the time of building construction or as a retrofit:

- *Pre-cast concrete* tanks may be cost-effective in smaller sizes (2-12 cubic metres), where they can be buried and access is available for a crane truck.
- *Polyethylene* tanks are cost-effective for retrofits to existing buildings, or where site access is limited; however, they must be protected from direct sunlight.
- For larger tanks (more than 15 cubic metres), site-assembled, *polypropylene lined galvanized steel* tanks are cost-effective and durable.
- *Cast in place concrete* tanks may be cost-effective for new construction, if constructed concurrently with building foundations.
- Other possibilities include *flexible water bladders* or *fibreglass* tanks

Pump and treatment systems are similar to those used for well water, although the pumps needed for rainwater systems are simpler and less expensive to purchase and operate. A pressure tank is usually required, and as a minimum a fine screen should be fitted to non-potable systems. Specially marked, dedicated non-potable distribution piping must be installed in buildings where non-potable rainwater is used for toilets or laundry, and signs must be posted wherever non-potable water is used. The standard for non-potable piping systems in Canada is CSA B128. Potable systems generally require filtration and disinfection, which is often provided by simple cartridge filters and a small ultraviolet lamp. Finally, where a rainwater supply is connected to a distribution system that also has a municipal water connection, a backflow prevention assembly must be installed in conformance with CRD Bylaw No. 3337. The total cost of pump and treatment systems ranges from a few hundred dollars for the simplest systems used for landscape irrigation, to a thousand dollars or more for a potable system.

Rainwater Availability in Greater Victoria

The maximum available rainwater supply is a function of the amount and patterns of precipitation, the area of roof used to collect precipitation, the roof material, and the amount of water diverted in the beginning of each rainfall event. In Greater Victoria, average annual precipitation ranges from 600mm at Gonzales Heights (Oak Bay) to 1,200mm at Victoria Marine (Sooke)[2]. Figure 1 shows the range of average monthly precipitation in Greater Victoria. A residential roof with an area of 200m^2 would receive 120-240m^3 of rainwater in an average year in Greater Victoria, depending on the location.

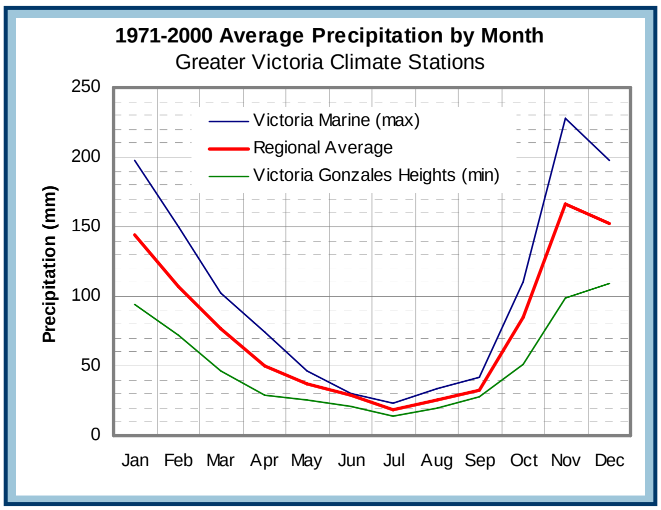

Figure 1. Greater Victoria Precipitation

Some of this precipitation is lost to evaporation on the roof surface or to a first-flush diverter. Generally, collection systems are estimated to be 75-90% efficient, with higher efficiencies in winter due to lower temperatures and longer, more frequent rainfall events. Steel roofs are also more efficient than asphalt or tile roofs. A system that collects water from an asphalt roof for non-potable use may be 85% efficient on average since no diversion is required, resulting in a maximum of 100-200m^3 of available rainwater, or about 0.5-1m^3/m^2/year.

[2] Environment Canada

Rainwater Harvesting in Greater Victoria

The usable portion of this rainwater depends on storage capacity, patterns of precipitation, and patterns of end use of the harvested rainwater. Storage makes rainwater available when it is needed, and collects rainwater for later use during rainfall events when the rate of supply exceeds the rate of use. Indoor uses of water such as toilet flushing and laundry are relatively consistent throughout the year. Outdoor (irrigation) uses in Greater Victoria typically occur between May and October, peaking in July or August; however, almost all of the precipitation occurs between October and April. Since the largest end uses of water during the time rainwater is abundant are indoor uses, the climate in Greater Victoria is better suited to indoor uses of rainwater than outdoor uses.

Value of Rainwater Harvesting in Greater Victoria

The value of rainwater harvesting depends on the availability and quality of water from other sources, the site and building characteristics, and the cost of managing rainwater that is not harvested for beneficial use. In Greater Victoria, the availability of municipal water and high-quality groundwater at a current (2007) cost in the range of $0.50-2.00 per m^3 (including volumetric sewer charges where applicable) limits the range of cost-effective applications of rainwater harvesting. At a capital cost of over $200 per cubic metre for storage, the cost of storing winter rains strictly for irrigation use far outweighs the direct benefit: The simple payback period is over a century at current water rates.

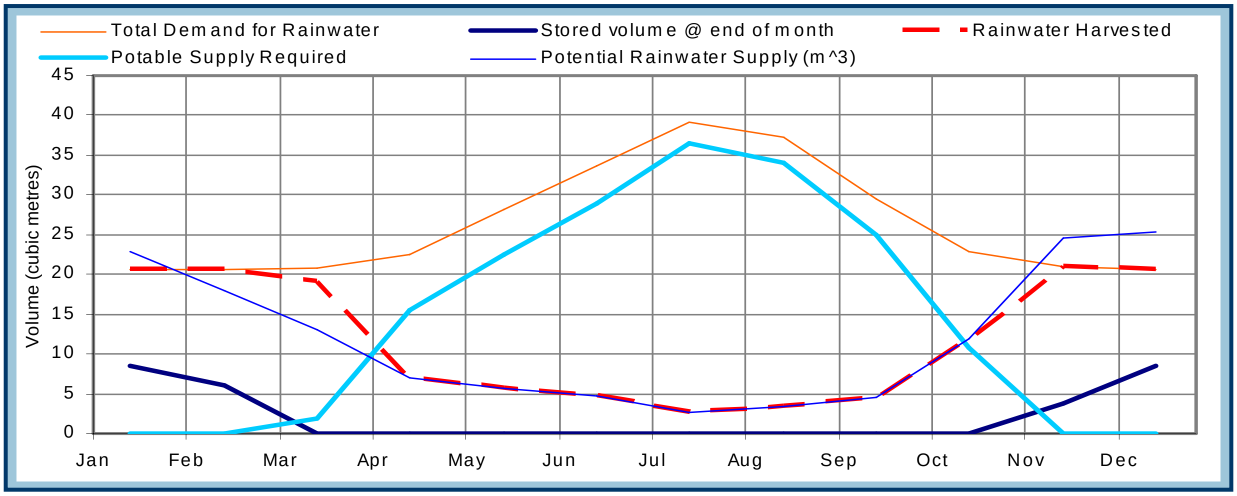

Figure 2. Rainwater harvesting for all end uses at a typical Greater Victoria home: 200 m^2 roof area, 8 m^3 storage

Figure 2 shows the balance of water supply and demand for a typical single family residence in Greater Victoria, with a rainwater tank sized to augment all end uses of water as cost-effectively as possible. The annual water demand is about 315m^3, of which 70m^3 is landscape irrigation between April and October. With a roof area of 200 m^2 (roughly 2,000 square feet) and 7.7m^3 (2,000 US gallons) of effective rainwater storage serving all end uses, 900mm/year of precipitation would supply 140 m^3, or 45% of the annual demand. Based on an estimated capital cost of $5,000, an annual operating cost of $100 and an amortization period of 25 years at a real discount rate of 4% per annum, the cost of rainwater collected by this system would be about $3.00/m^3.

If the rainwater system is designed only to supply toilets and laundry, cost-effectiveness can be improved although significantly less rainwater would be harvested. A system with a 5m^3 cistern would supply about 90 m^3/year for toilets and laundry, roughly one quarter of the overall annual demand. The capital and operating costs may be reduced to $3,000 and $25 per year by eliminating treatment components, and the unit cost of rainwater harvested improves to about $2.50 per m^3.

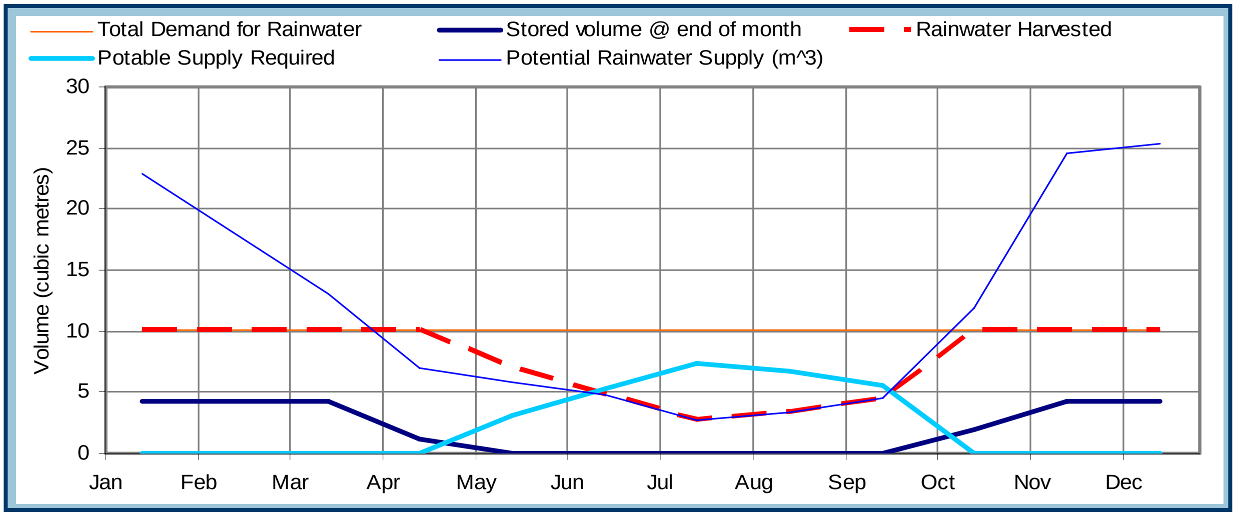

Figure 3. Rainwater harvesting for toilets and laundry: 200 m^2 roof area, 5 m^3 storage

Rainwater harvesting may be more cost-effective where:

- precipitation is significantly more than 900mm/year (Most of the western communities)
- available roof area is large relative to water demand
- winter end uses are relatively large and constant
- capital costs can be minimized by avoiding complex treatment or plumbing retrofits

The cost of harvested rainwater may be lower than \$2.00/m^3, and possibly lower than \$1.50/m^3, where several of these factors combine and the system is designed for indoor non-potable use only.

The only means to reduce the cost of harvested rainwater to within the current range of municipal water rates in Greater Victoria would be to eliminate tanks altogether, and divert roof leaders directly to a simple network of distribution pipes for landscape irrigation. Where this could be accomplished with reasonable distribution uniformity and soils and plants are reasonably drought-tolerant, as much as half of the landscape irrigation demand (20-40 m^3/year from a 200 m^2 roof) could be supplied by harvested rainwater at a unit cost as low as \$1.00/m^3. Simple or natural means of storage such as ponds, or soils with high moisture capacity, may be employed to make roof runoff available for plants during longer dry periods. These strategies have proven cost-effective in local agriculture, maximizing the benefit of rainwater, groundwater and municipal water for irrigation.

There are several benefits of harvesting rainwater in addition to reduced use of municipal water. Rainwater systems that supply toilets and laundry would act as rainwater detention systems to eliminate more than half of the total roof runoff to storm or combined sewers, and a significantly greater proportion of peak flows. This reduction could substantially reduce combined sewer overflows and winter peak flows through future wastewater treatment plants connected to combined sewers. Also, rainwater used for landscape irrigation, or in buildings connected to onsite wastewater systems, infiltrates into the ground near where it falls, replenishing groundwater while minimizing surface runoff. These benefits are not realized directly by property owners that harvest rainwater, but could be reflected in future pricing structures for wastewater, or incentives to install rainwater harvesting systems. The higher volumetric sewer rates that will be required to pay the cost of wastewater treatment in Greater Victoria will strengthen the economic case for rainwater harvesting over the next 5-10 years, particularly where systems are installed at the time of building construction.

Conclusions

Where municipal water is available in the Greater Victoria area, rainwater harvesting using tanks or cisterns is currently cost effective only in limited applications. The most cost-effective rainwater systems have cisterns sized to provide 7-10 days of indoor, non-potable uses (toilets and laundry) between rainfall events. In Greater Victoria, a cost-effective cistern would be roughly 2m^3 (500 US gallons) for a smaller home with efficient toilets and washing machine, and 4-6m^3 (1,000-1,500 US gallons) for a larger home with higher occupancy. Such systems would not require treatment, but would require dedicated non-potable indoor plumbing for toilets and laundry, typically including a small water heater for laundry. For this reason, rainwater harvesting will be most cost-effective where non-potable plumbing is installed during construction of a new building. If a system can be installed at a total cost of $1,500 for a small home or $3,000 for a larger home, harvested rainwater could reduce municipal water use by 30%, at a cost of $2.00-2.50/m^3. The additional cost of treating water for potable use generally outweighs the benefit of harvesting additional rainwater in winter.

In Sidney, where the marginal cost of water used indoors (including sewer charges) is $2.29 at 2007 rates, rainwater harvesting for toilets and laundry may already be cost-effective. As sewage treatment is implemented for the core area and other municipalities adopt volumetric pricing for sewage collection and treatment, marginal prices of water used indoors are likely to increase beyond $2.00/m^3 in most municipalities and rainwater harvesting will become cost-effective for most homeowners in the region.

Harvesting winter rain in tanks for summer irrigation use is highly cost-prohibitive. However the use of simple distribution systems that direct rainfall during the irrigation season from roof leaders to plants without the use of pumps or cisterns may make beneficial use of 20-40m^3/year of rainwater at an average cost in the range of $1.00/m^3.

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