



MANAGING WET WEATHER WITH
GREEN INFRASTRUCTURE

MUNICIPAL HANDBOOK

RAINWATER HARVESTING POLICIES

Managing Wet Weather with Green Infrastructure

Municipal Handbook

Rainwater Harvesting Policies

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The Municipal Handbook is a series of documents to help local officials implement green infrastructure in their communities.

December 2008



EPA-833-F-08-010



Front Cover Photos

Top: rain garden; permeable pavers; rain barrel; planter; tree boxes.

Large photo: cisterns in the Wissahickon Charter School's Harmony Garden in Philadelphia



Rainwater Harvesting Policies

Introduction

From the last half of the 20th century, the U.S. has enjoyed nearly universal access to abundant supplies of potable water. But as witnessed by the recent serious and sustained droughts in the Southeast and Southwest, this past luxury is not something that can be expected for the long term. Future population growth will exert more demand on water systems while climate change is predicted to decrease available supplies because of decreased snow pack and drier regional climatic patterns. The U.S. has been identified as a country that faces imminent water shortages and a Government Accountability Office (GAO) survey found that water managers in 36 states anticipate water shortages during the first two decades of this century.¹ These challenges will require a more sustainable approach to using water resources, looking at not only how much water is used, but also the quality of water needed for each use.

The overwhelming majority of the water used in the U.S. comes from freshwater supplies of surface and groundwater. Water extracted for public systems is treated to potable standards as defined by the Safe Drinking Water Act. Access to high quality water has greatly benefited public health, but it has also resulted in our current system that utilizes potable water for virtually every end use, even when lesser quality water would be sufficient. In addition to conservation methods, using alternative sources of water will be necessary for more efficient use of water resources.

Rainwater harvesting, collecting rainwater from impervious surfaces and storing it for later use, is a technique that has been used for millennia. It has not been widely employed in industrialized societies that rely primarily on centralized water distribution systems, but with limited water resources and stormwater pollution recognized as serious problems and the emergence of green building, the role that rainwater harvesting can play for water supply is being reassessed. Rainwater reuse offers a number of benefits.²

- Provides inexpensive supply of water;
- Augments drinking water supplies;
- Reduces stormwater runoff and pollution;
- Reduces erosion in urban environments;
- Provides water that needs little treatment for irrigation or non-potable indoor uses;
- Helps reduce peak summer demands; and
- Helps introduce demand management for drinking water systems.

Rainwater harvesting has significant potential to provide environmental and economic benefits by reducing stormwater runoff and conserving potable water, though several barriers exist that limit its application. The U.S. uses more water per capita than any other country, with potable water delivered for the majority of domestic and commercial applications. Typical domestic indoor per capita water use, shown in Table 1, is 70 gallons per day (gpd); however outdoor water use can constitute 25% to 58% of overall domestic demand, increasing per capita domestic use up to 165 gpd.

Table 1. Typical Domestic Daily per Capita Water Use.³

Use	Gallons per Capita	% of Daily Total
Potable indoor uses		
• Showers	11.6	7.0%
• Dishwashers	1.0	0.6%
• Baths	1.2	0.8%
• Faucets	10.9	6.6%
• Other uses, leaks	11.1	6.7%
Subtotal	35.8	21.7%
Non-potable indoor uses		
• Clothes washers	15.0	9.1%
• Toilets	18.5	11.2%
Subtotal	33.5	20.3%
Outdoor uses	95.7	58.0%

While potable water is used almost exclusively for domestic uses, almost 80% of demand does not require drinkable water. Similar trends exist for commercial water use. Table 2 provides examples of daily commercial water usage.

Table 2. Typical Daily Water Use for Office Buildings and Hotels.⁴

Use	Office Buildings % of Daily Total	Hotels % of Daily Total
Potable indoor uses		
Showers	---	27%
• Faucets	1%	1%
• Kitchen	3%	10%
• Other uses	10%	19%
Subtotal	14%	57%
Non-potable indoor uses		
• Toilets/urinals	25%	9%
• Laundry	---	14%
• Cooling	23%	10%
Subtotal	48%	33%
Outdoor uses	38%	10%

Both the domestic and commercial water use statistics show that potable water is often being utilized for end uses that could be satisfied with lesser quality water. The statistics also indicate that nearly all water is used in a one-time pass through manner, with little attempt at reuse. Rainwater harvesting offers an alternative water supply that can more appropriately match water use to the quality of water supplied.

Rainwater harvesting systems typically divert and store runoff from residential and commercial roofs. Often referred to as ‘clean’ runoff, roof runoff does contain pollutants (metals or hydrocarbons from roofing materials, nutrients from atmospheric deposition, bacteria from bird droppings), but they are generally in lower concentrations and absent many of the toxics present in runoff from other impervious surfaces. Installing a rainwater collection system requires diverting roof downspouts to cisterns or rain barrels to capture and store the runoff. Collection containers are constructed of dark materials or buried to prevent light penetration and the growth of algae.⁵ From the storage container, a dual plumbing system is needed for indoor uses and/or a connection to the outdoor irrigation system.

Regulations

Although a few states and local jurisdictions have developed standards or guidelines for rainwater harvesting, it is largely unaddressed by regulations and codes. Neither the Uniform Plumbing Code

(UPC) nor International Plumbing Code (IPC) directly address rainwater harvesting in their potable or stormwater sections. Other reuse waters are covered by codes. The UPC’s Appendix J addresses reclaimed water use for water closets and urinals and the IPC’s Appendix C addresses graywater use for water closets and urinals along with subsurface irrigation.⁶ Both sections focus on treatment requirements, measures necessary to prevent cross-contamination with potable water, and appropriate signage and system labeling. However, because of a general lack of specific rainwater harvesting guidance some jurisdictions have regulated harvested rainwater as reclaimed water, resulting in more stringent requirements than necessary. These issues have led to confusion as to what constitutes harvested rainwater, graywater, or reclaimed water.⁷

The confusion among waters for reuse and the lack of uniform national guidance has resulted in differing use and treatment guidelines among state and local governments and presents an impediment to rainwater reuse. Texas promotes harvested rainwater for any use including potable uses provided appropriate treatment is installed; Portland, like many other jurisdictions, generally recommends rainwater use to the non-potable applications of irrigation, hose bibbs, water closets, and urinals.

To develop general or national guidance for rainwater harvesting, several factors must be considered. While potable use is possible for harvested rainwater, necessary on-site treatment and perceived public health concerns will likely limit the quantity of rainwater used for potable demands. Irrigation and the non-potable uses of water closets, urinals and HVAC make-up are the end uses that are generally the best match for harvested rainwater. A lesser amount of on-site treatment is required for these uses and, as seen from the use statistics presented above, these uses constitute a significant portion of residential and commercial demand. Focusing harvested rainwater on irrigation and selected non-potable indoor uses can significantly lower demand while allowing a balance and public comfort level between municipal potable water and reused rainwater.

Guidance for the reuse of harvested stormwater will be similar to reclaimed water and graywater but will differ because of lower levels of initial contamination and targeted end uses. The primary concerns of indoor rainwater reuse are cross-contamination of the potable supply and human contact with bacteria or pathogens that may be present in the collected rainwater. Portland’s Rainwater Harvesting One and Two Family Dwelling Specialty Code provides a good example of specific rainwater reuse stipulations. Although the code doesn’t address multi-family residential or non-residential applications, rainwater reuse is permitted for these facilities, but due to the unique design of each system, commercial reuse systems are considered on a case by case basis. In addition, multi-family residential units and sleeping portions of hotels are allowed to use rainwater for irrigation only; non-residential buildings are permitted to use rainwater for irrigation, water features, water closets and urinals. In these applications, water provided for water closets and urinals must be treated with filters and UV and/or chlorinating.⁹

UPC Definitions – Waters for Reuse⁸

- *Graywater* – untreated wastewater that has not come in to contact with black water (sewage). Graywater includes used water from bathtubs, showers, lavatories, and water from clothes washing machines.
- *Reclaimed water* – water treated to domestic wastewater tertiary standards by a public agency suitable for a controlled use, including supply to water closets, urinals, and trap seal primers for floor drains and floor sinks. Reclaimed water is conveyed in purple pipes (California’s purple pipe system is one of the better known water reclamation systems).
- *Harvested rainwater* – stormwater that is conveyed from a building roof, stored in a cistern and disinfected and filtered before being used for toilet flushing. It can also be used for landscape irrigation.

Tucson Rainwater Harvesting Requirements

Tucson, Arizona became the first city in the country to require rainwater harvesting for landscaping use. Beginning June 1, 2010, 50% of a commercial property’s irrigation water must be supplied from rainwater. In addition to cisterns, the regulations allow berms and contoured slopes to be used to direct rainwater to trees and landscaped areas.

Portland’s code permits rainwater reuse for potable uses at family dwellings only through an appeals process. In addition, rainwater used only for outdoor irrigation is not covered by the code and needs no treatment prior to use. Acceptable indoor non-potable uses are hose bibbs, water closets, and urinals. The code illuminates several important issues that need to be considered when developing rainwater harvesting code.

- *Water quality* – Water quality and its impact on human health is a primary concern with rainwater harvesting. This issue is comprised of two components: end use of the rainwater and treatment provided. Rainwater used for residential irrigation (on the scale of rain barrel collection) does not typically require treatment. Commercial applications and non-potable indoor uses require treatment but the type of use will determine the extent of treatment. Each jurisdiction will need to assess the level of treatment with which it is comfortable, but limiting rainwater reuse to water closets, urinals and hose bibbs presents little human health risk. Each system will require some level of screening and filtration to prevent particles and debris from traveling through the plumbing system, and most jurisdictions require disinfection with UV or chlorination because of bacterial concerns. Table 3 provides an example of minimum water quality guidelines and suggested treatment methods for collected rainwater.

<p>Excerpts of General Requirements Portland Rainwater Harvesting Code Guide</p>
<p>General</p> <ul style="list-style-type: none"> • Harvested rainwater may only be used for water closets, urinals, hose bibbs, and irrigation. • Rainwater can only be harvested from roof surfaces. • The first 10 gallons of roof runoff during any rain event needs to be diverted away from the cistern to an Office of Planning & Development Review (OPDR) approved location.
<p>Rainwater Harvesting System Components</p> <ul style="list-style-type: none"> • Gutters – All gutters leading to the cistern require leaf screens with openings no larger than 0.5 inches across their entire length including the downspout opening. • Roof washers – Rainwater harvesting systems collecting water from impervious roofs are required to have a roof washer for each cistern. Roof washers are not required for water collected from green roofs or other pervious surfaces. The roof washer is required to divert at least the first 10 gallons of rainfall away from the cistern and contain 18 inches of sand, filter fabric, and 6 inches of pea gravel to ensure proper filtration. • Cisterns – Material of construction shall be rated for potable water use. Cisterns shall be able to be filled with rainwater and the municipal water system. Cross-contamination of the municipal water system shall be prevented by the use of (1) a reduced pressure backflow assembly or (2) an air gap. Cisterns shall be protected from direct sunlight. • Piping – Piping for rainwater harvesting systems shall be separate from and shall not include any direct connection to any potable water piping. Rainwater harvesting pipe shall be purple in color and labeled “CAUTION: RECLAIMED WATER, DO NOT DRINK” every four feet in length and not less than once per room. • Labeling – Every water closet or urinal supply, hose bibb or irrigation outlet shall be permanently identified with an indelibly marked placard stating: “CAUTION: RECLAIMED WATER, DO NOT DRINK.” • Inspections – Inspections are required of all elements prior to being covered. • Maintenance – Property owner is responsible for all maintenance.

A review of treatment standards among various jurisdictions shows a wide range of requirements from minimal treatment to reclaimed water standards. A recent memorandum of understanding from the City and County of San Francisco allows rainwater to be used for toilet flushing without being treated to potable standards. Texas requires filtration and disinfection for non-potable indoor uses, and Portland requires filtration for residential non-potable indoor uses, but requires filtration and disinfection for multi-family and commercial applications. Treatment requirements ultimately come down to risk exposure with risk of bacterial exposure determining the most stringent levels of treatment. However, San Francisco’s Memorandum of Understanding indicates a belief in a low exposure risk with rainwater when used for toilet flushing. Likewise, testing conducted in Germany demonstrated that the risk of *E. coli* contact with the human mouth from toilet flushing was virtually non-existent, resulting in the

recommendation that special disinfection measures were unnecessary for rainwater dedicated to non-potable uses.¹⁰

The level of treatment required by each municipality can influence the number of harvesting systems installed. Filtration and disinfection are not expensive treatment requirements but each treatment requirement adds a cost to the system. Simplifying the treatment requirements when there is not a threat to public health lowers the cost for private entities to install systems and encourages broader adoption of the practice.

- *Cross-contamination* – Cross-contamination of the potable water system is a critical concern for any water reuse system. Cross-contamination measures for rainwater reuse systems will be similar to those for reclaimed and graywater systems. When rainwater is integrated as a significant supply source for a non-potable indoor use, a potable make-up supply line is needed for dry periods and when the collected rainwater supply is unable to meet water demands. The make-up supply to the cistern is the point of greatest risk for cross-contamination of the potable supply. Codes will require a backflow prevention assembly on the potable water supply line, an air gap, or both. In addition to backflow prevention, the use of a designated, dual piping system is also necessary. Purple pipes, indicating reused water, are most often used to convey rainwater and are accompanied by pipe stenciling and point-of-contact signage that indicates the water is non-potable and not for consumption.
- *Maintenance and inspection* – The operation and maintenance of rainwater harvesting systems is the responsibility of the property owner. Municipal inspections occur during installation and inspections of backflow prevention systems are recommended on an annual basis. For the property owner, the operation of a rainwater harvesting system is similar to a private well. Especially for indoor uses annual water testing to verify water quality is recommended as well as regular interval maintenance to replace treatment system components such as filters or UV lights. The adoption and use of rainwater harvesting systems will add to the inspection responsibilities of the municipal public works department, but the type of inspection, level of effort, and documentation required will be similar to those of private potable water systems and should be readily integrated into the routine of the inspection department.

Table 3. Minimum Water Quality Guidelines and Treatment Options for Stormwater Reuse.¹¹

Use	Minimum Water Quality Guidelines	Suggested Treatment Options
Potable indoor uses	<ul style="list-style-type: none"> • Total coliforms – 0 • Fecal coliforms – 0 • Protozoan cysts – 0 • Viruses – 0 • Turbidity < 1 NTU 	<ul style="list-style-type: none"> • Pre-filtration – first flush diverter • Cartridge filtration – 3 micron sediment filter followed by 3 micron activated carbon filter • Disinfection – chlorine residual of 0.2 ppm or UV disinfection
Non-potable indoor uses	<ul style="list-style-type: none"> • Total coliforms < 500 cfu per 100 mL • Fecal coliforms < 100 cfu per 100 mL 	<ul style="list-style-type: none"> • Pre-filtration – first flush diverter • Cartridge filtration – 5 micron sediment filter • Disinfection – chlorination with household bleach or UV disinfection
Outdoor uses	N/A	Pre-filtration – first flush diverter

*cfu – colony forming units

*NTU – nephelometric turbidity units

Institution Issues and Barriers

Although stormwater reuse offers environmental and economic benefits, its use has remained relatively limited. This is caused by a number of perceived and actual barriers. The high rate of water consumption in the U.S. is coupled with water cost rates that are among the lowest. For example, U.S. water use is approximately twice that of Europe, but the annual cost of household water bills are roughly equal. The cost of water in the U.S. ranges from \$0.70 to \$4 per thousand gallons, with the national average cost

slightly more than \$2 for a thousand gallons. Price, therefore, creates little incentive for conservation or the use of alternative sources.¹²



Residential rain barrels are an inexpensive and easy retrofit that reduces stormwater runoff and provides irrigation water. Photo at left: District of Columbia Water & Sewer Authority; Photo at right: Ann English.

San Francisco Rainwater Harvesting MOU

In 2008, San Francisco's Public Utilities Commission (SFPUC), Department of Building Inspection (DBI), and Department of Public Health (DPH) signed a Memorandum of Understanding for the permitting requirements for rainwater harvesting systems located within the City and County of San Francisco. The MOU encourages rainwater harvesting and its reuse for non-potable applications without requiring treatment to potable water standards. It also defines the roles of the participating agencies. From the MOU:

- The SFPUC will create and distribute guidance and material on rainwater harvesting. The material will cover system design, system components, allowable uses, owner responsibilities, and permitting requirements. The SFPUC will encourage all rainwater harvesters to notify the SFPUC with the design specifications of their systems for research purposes.
- DBI will issue permits for construction of properly designed rainwater harvesting systems for non-potable uses that meet the minimum criteria described in the MOU and in guidance materials prepared by the SFPUC. DBI will be responsible for review of permit applications and inspection of rainwater harvesting systems that require permits.
- DPH will review rainwater harvesting projects that propose any residential indoor uses of rainwater other than toilet flushing to assure the protection of public health.

It also stipulates that system design, maintenance, and use are the responsibility of the system owner.

The MOU classifies rain barrels and cisterns and defines the allowable uses of harvested rainwater. Water from rain barrels may be used for irrigation and vehicle washing; it is prohibited to connect rain barrels to indoor or outdoor plumbing. Water from cisterns connected to indoor plumbing may be used for irrigation, vehicle washing, heating and cooling, and toilet flushing. If a cistern is not connected to indoor plumbing it cannot be used for toilet flushing.

The MOU also includes safety and maintenance requirements, required system components, labeling requirements, and DBI permit requirements.

To better manage natural resources and water infrastructure, EPA has advocated four pillars of sustainable infrastructure, one of which is full cost pricing of water. Full cost pricing would result in water rates that reflect the entire suite of costs associated with water delivery: past, present, and future capital costs and operations and maintenance. Full cost pricing would ideally also include the external costs associated with the environmental damage and resource depletion created by water use.^{13, 14} However, user fees and other funding sources are insufficient in 29% of water utilities to cover the cost of providing service, let alone including external costs.¹⁵ Insufficient pricing is a significant barrier to collection and reuse.

Water needed for sanitation, cleaning, and cooking is less responsive to price than discretionary uses such as landscaping, but overall, water generally displays inelastic demand. A 10% increase in domestic prices decreases demand 2 to 4%; a 10% increase in commercial prices decreases demand 5 to 8%.¹⁶ While studies show that price has limited effect on demand, they also do not consider the option of a low-cost alternative source of water. Increased prices may not significantly diminish water use, but may be sufficient to encourage the use of lower cost alternatives. When faced with sufficiently priced potable water, the investment in a low cost alternative that provides continued savings becomes increasingly favorable.

Regulations and codes also inhibit rainwater collection. Plumbing codes have been identified as a common barrier. Whether they make no provisions for rainwater reuse or require downspouts to be connected to the stormwater collection system, thereby eliminating the possibility of intervening to intercept roof runoff, code changes are often a necessary first step to enabling rainwater harvesting. Other regulations complicate the implementation of rainwater harvesting. Western water rights and the doctrine of “first in time, first in line” access to water can present a barrier to rainwater harvesting. Colorado interprets its Western water rights laws as prohibiting rainwater harvesting. The state’s interpretation that cisterns and rain barrels prevent runoff from reaching rivers and thereby decrease a downstream user’s allotted water right has been questioned, but it currently prohibits rainwater capture and reuse.

Albuquerque-Bernalillo County Building Standards

In 2008, the Water Utility Authority of Albuquerque-Bernalillo County instituted new standards that require rainwater harvesting systems for new homes. Buildings larger than 2,500 square feet are required to have a cistern and pump, while smaller buildings can use cisterns, rain barrels, or catchment basins. All rainwater harvesting systems need to capture the runoff from at least 85% of the roof area.

The standards also include a requirement for high efficiency toilets and prohibitions against installing turf on slopes steeper than 5:1 and sprinkler irrigating areas smaller than 10 feet in any dimension.

Rainwater Harvesting in the West

Western water rights can be an impediment to rainwater harvesting efforts because the doctrine of prior appropriation has created ambiguity about the legality of intercepting and storing rainwater. In the strictest interpretation, diverting rainwater to a collection system is a taking of a water previously appropriated.

This issue has been overlooked for many community rain barrel initiatives, because the individual storage units are relatively small. The City of Seattle, however, obtained a citywide water-right permit to ensure the legality of water harvesting efforts.

State legislation may ultimately be necessary to ensure the legality of rainwater harvesting and establish the upper capacity limit for rainwater systems. Any efforts should fully assess the watershed impacts of rainwater harvesting efforts. Colorado law, for instance has assumed that all rainfall eventually reaches groundwater or surface waters and is therefore appropriated. In the dry regions of the state, however, a study has found that the majority of rainfall on undeveloped lands is lost to evaporation and transpiration and only a small fraction actually reaches surface waters.

Likewise, rainwater harvesting is a water conservation practice which will reduce the overall withdrawal and use of water, making a greater quantity of water available for downstream users. Harvested rainwater used for irrigation or other outdoor uses reapplies the water in a manner similar to normal precipitation. Rainwater used for non-potable indoor uses is collected in the sanitary system and eventually returned to receiving streams and available for downstream use.

Energy and Climate

In addition to the natural resources impacts that water use imparts, water collection, treatment, and distribution has energy and climate consequences. The connection between water and energy is often overlooked but the process of extracting water from surface or groundwater supplies, bringing it to treatment facilities, treating it to drinking water standards, and delivering it to residential and commercial customers expends energy primarily because of pumping and treatment costs. The water sector consumes 3% of the electricity generated in the U.S. and electricity accounts for approximately one-third of utilities' operating costs.¹⁷ Reducing potable water demand by 10% could save approximately 300 billion kilowatt-hours of energy each year.¹⁸ Water reuse systems, like rainwater harvesting, supplant potable water and reduce demand. The reduced water demand provided by rainwater harvesting systems translates directly to energy savings. Table 4 presents estimates of the energy required to deliver potable water to consumers.

Table 4. Estimated Energy Consumption for Water Treatment and Distribution.¹⁹

Activity	Energy Consumption kWh/MG
Supply and conveyance	150
Water Treatment	100
Distribution	1,200
Total	1,450

Decreasing potable water demand by 1 million gallons can reduce electricity use by nearly 1,500 kWh. An inch of rainfall produces 600 gallons of runoff per 1,000 square feet of roof. Coordinated residential applications and large-scale non-residential rainwater harvesting systems offer an alternative method of reducing energy use.

Limiting energy demand is significant but the impact that decreased energy demand has on carbon dioxide emissions is critical. Carbon dioxide emissions associated with electricity generation vary according to the fossil fuel source. Rough estimates suggest that reducing potable water demand by 1 million gallons can reduce carbon dioxide emissions 1 to 1½ tons when fossil fuels are used for power generation (Table 5).

Table 5. Carbon Dioxide Emissions from Electric Power Generation.²⁰

Fuel Type	CO₂ Output Rate Pounds CO₂/kWh	CO₂ Output per MG Water Delivered (x 1,450 kWh)
Coal	2.117	3,070 lbs
Petroleum	1.915	2,775 lbs
Natural gas	1.314	1,905 lbs

The carbon reductions associated with rainwater harvesting are admittedly not on the order of magnitude required to significantly impact climate change. However, the connection between potable water use and energy demand is important to recognize in the broader context of sustainable water management. It is critical to assess water use not only from a resource availability and protection standpoint, but also with the aim of improving overall sustainability of which energy is a critical component. As municipalities are faced with the anticipated CO₂ reductions that will be required over the coming decades, decreased potable water demand (along with other measures such as increased energy efficiency and conservation) represent the “low hanging fruit” that may provide the quickest and easiest reductions. Rainwater harvesting along with graywater and reclaimed water reuse represent an integrated water management approach that can not only limit contributions to climate change, but also protect and conserve limited water resources developing resiliency to the uncertain effects of climate change.

Conclusions and Recommendations

Encouraging rainwater harvesting and reuse requires enabling the practice through codes and regulations and providing incentives. State or municipal codes need to address public health concerns by stipulating water quality and cross-contamination requirements. Similar to reclaimed and graywater, specific rainwater harvesting codes need to be developed. Codes should establish acceptable uses for rainwater and corresponding treatment requirements. Disinfection of rainwater for reuse has been the standard, but recent research and policies should encourage jurisdictions to evaluate lesser requirements for non-potable uses in water closets and urinals. The simplification of the on-site treatment process and associated cost savings could broaden the use of rainwater harvesting without increasing exposure risks.

In addition to code development, incentives for rainwater harvesting should be instituted. The incentives should recognize that rainwater is a resource and that the use of potable water carries an environmental and economic cost. Current water policies and rates do not promote sustainability, with a structure that inadequately accounts for the value of water and does not promote conservation. Municipalities should review their water rates to see if they appropriately account for the full cost of water. Pricing alternatives such as increasing block rates, which increase the price of water with increased use, create an incentive to conserve potable water. An increased price of potable water would encourage investment in rainwater harvesting systems because they offer a long-term inexpensive supply of water after the initial capital investment. The combined actions of establishing certain requirements for rainwater harvesting systems and increasing the currently underpriced cost of water creates a complementary system that can encourage the use of alternative water sources.



Commercially sized cistern at the Chicago Center for Green Technology. *Photo: Abby Hall, EPA.*

Considerations when Establishing a Municipal Rainwater Harvesting Program

1. Establish specific codes or regulations for rainwater harvesting
 - Building and plumbing codes are largely silent on rainwater harvesting. Consequently, graywater requirements are often used to govern rainwater harvesting systems, resulting in requirements that are more stringent than necessary. Codes should define rainwater harvesting and establish its position as an acceptable stormwater management/water conservation practice.
2. Identify acceptable end uses and treatment standards
 - Each municipality will need to consider and identify acceptable uses for harvested rainwater and the required treatment for specified uses. Rainwater is most commonly used for non-potable applications and segregated by indoor and outdoor uses.
 - Typical outdoor uses:
 1. Irrigation; and
 2. Vehicle washing.
 - Typical indoor uses:
 1. Toilet flushing;
 2. Heating and cooling; and
 3. Equipment washing.
 - Non-potable uses typically require minimal treatment. Outdoor uses normally need only prescreening to limit fouling of the collection system. Indoor non-potable uses do not necessarily require treatment beyond screening, although some municipalities have adopted a conservative approach and require filtration and disinfection prior to reuse.
 - Harvested rainwater can be used for potable applications although a special permitting process should be established to ensure that proper treatment (e.g., filtration and disinfection) is provided and maintained.
3. Detail required system components
 - Jurisdictions often delineate between rain barrels and cisterns because of the size and potential complexity of the systems. Rain barrels collect relatively small quantities of water and generally only require mosquito prevention, proper overflow, and an outlet for outdoor uses. Cisterns can be 100 to several thousand gallons in size and may be connected to various indoor plumbing and mechanical systems. Needed system requirements include:
 - Pre-filtration – Filtration prior to the rain barrel or cistern should be provided to remove solids and debris.
 - Storage containers – Rain barrels and cisterns should be constructed of a National Sanitation Foundation approved storage container listed for potable water use.
 - Back-flow prevention – For cisterns that require a potable water make-up for operation, back flow prevention in the form of an air gap or backflow assembly must be provided.
 - Dual piping system – a separate piping system must be provided for harvested rainwater distribution. The pipe should be labeled and color coded to indicate non-potable water. Purple piping indicating reclaimed water is often used for rainwater harvesting systems. Cross connections with the potable water supply system are prohibited.
 - Signage – permanent signage should be provided at every outlet and point of contact indicating non-potable water not for consumption. In addition, biodegradable dyes can be injected to indicate non-potable water.
4. Permitting
 - Rain barrels should not need to be permitted provided that they are installed correctly and direct overflow to a proper location. A permit application process should be instituted for cistern systems used for non-potable uses. If harvested rainwater is used for potable water, the collection and treatment system should be inspected and approved by the public health department.
5. Maintenance
 - Adequate design and maintenance of the cistern and piping system is the responsibility of the cistern owner.
6. Rates of reuse
 - For harvesting systems to be efficient stormwater retention systems, the collected rainwater needs to be used in a timely matter to ensure maximum storage capacity for subsequent rain events. Cistern systems generally supply uses with significant demands, ensuring timely usage of the collected water. Outreach and education is a critical component of rain barrel programs, however, because of the more episodic and less structured use of this collected water. Municipalities should inform homeowners of the steps needed to maximize the effectiveness of their rain barrels. Harvesting programs targeting susceptible combined sewer areas have used slow draw down of the rain barrels to delay stormwater release to the sewer system, yet ensure maximum storage capacity for subsequent rain events.

Case Studies

King Street Center, Seattle

The King Street Center in Seattle uses rainwater for toilet flushing and irrigation. Rainwater from the building's roof is collected in three 5,400 gallon cisterns. Collected rainwater passes through each tank and is filtered prior to being pumped to the building's toilets or irrigation system through a separate piping system. When needed, potable makeup water is added to the cisterns. The collection and reuse system is able to provide 60% of the annual water needed for toilet flushing, conserving approximately 1.4 million gallons of potable water each year.²¹

The Solaire, Battery Park City, New York

The 357,000 square foot, 27 floor building was the first high-rise residential structure to receive LEED® Gold certification. The Solaire was designed to comply with Battery Park City's progressive water and stormwater standards; more than 2 inches of stormwater must be treated on site to meet the standards. Rainwater is collected in a 10,000 gallon cistern located in the building's basement. Collected water is treated with a sand filter and chlorinated according to New York City Standards prior to being reused for irrigating two green roofs on the building. Treated and recycled blackwater is used for toilet flushing and make-up water. Water efficient appliances and the rainwater and blackwater reuse system have decreased potable water use in the building by 50%.²² Because of its innovative environmental features, the Solaire earned New York State's first-ever tax credit for sustainable construction.^{23, 24}

Philip Merrill Building, Annapolis, MD

The Chesapeake Bay Foundation's headquarters is a LEED® Version 1 Platinum certified building. Rainwater from the roof is collected in three exposed cisterns located above the entrance.²⁵ Roof runoff passes through roof washers before entering the cisterns; following the cisterns the water is treated with a sand filter, chlorination, static mixer, and carbon filter prior to reuse. The building uses composting toilets, so the reused water is used for bathroom and mop sinks, gear washing, irrigation, fire suppression, and laundry. The building's design allows for a 90% reduction in potable water use with 73% of the water used within the building supplied by the cistern collection system.^{26, 27, 28}



Cisterns at CBF headquarters. Photo: Chesapeake Bay Foundation.

Alberici Corporate Headquarters, Overland, Missouri

Alberici Corporation, a construction company, chose to relocate its corporate headquarters to a 14-acre site in the St. Louis suburbs in 2004. The site renovation included refurbishing a 150,000 square foot former metal fabrication facility into a LEED® platinum certified office building. The building design includes a rainwater collection and reuse system. Rainwater is collected from 60% of the garage roof area and stored in a 38,000 gallon cistern. The collected water is filtered and chlorinated and used for toilet flushing and the building's cooling tower. The stormwater reuse system saves 500,000 gallons of water each year, reducing potable water demand by 70%.^{29, 30}

Lazarus Building, Columbus, Ohio

After Federated Department Stores closed the 750,000 square foot retail store in 2002, it donated the building to the Columbus Downtown Development Corporation. The building renovation completed in 2007 achieved LEED® Gold certification and the building's largest tenant is Ohio EPA. The renovated building includes a rainwater collection and reuse system. The system makes use of an existing 40,000

gallon tank on the building's roof and a new 50,000 gallon tank installed in the basement. The collected rainwater is used for toilet flushing, irrigation, and HVAC makeup. A biodegradable blue dye is added to the water used for toilet flushing to visually identify it as non-potable water. The system reduces potable water use in the building by several million gallons a year.^{31, 32}

Stephen Epler Hall, Portland State University

PSU's 62,500 square foot mixed-use student housing facility (classrooms and academic office space are located on the first floor) was completed in 2003 and is LEED® Silver Certified. The stormwater management system was designed to be engaging to the public; rain from the roofs of Epler Hall and neighboring King Albert Hall is diverted to several river rock "splash boxes" in the public plaza.³³ The water then travels through channels in the plaza's brick pavers to planter boxes where it infiltrates and is filtered before being collected in an underground cistern. UV light is used to treat the water prior to its reuse for toilet flushing in the first floor restroom and irrigation. Placards located in the water closets indicate that the non-potable toilet flushing water is not for consumption. The stormwater collection and reuse system conserves approximately 110,000 gallons of potable water annually, providing a savings of \$1,000 each year.^{34, 35}

Natural Resources Defense Council's Robert Redford Building, Santa Monica

NRDC's renovation of a 1920s-era structure in downtown Santa Monica achieved LEED® New Construction, Version 2 Platinum certification. The innovative water systems in the 15,000 square foot



Rainwater cistern at NRDC's Santa Monica Office (inset photo after planter planting). Photo: NRDC.

building are a key component of the project's sustainability. The plumbing system delivers potable water only to locations where drinking water is needed, such as faucets and showers. Water from the showers and sinks is collected in graywater collection tanks and treated on-site. The treated graywater is reused for toilet flushing and landscaping. Rainwater from the building is collected in outdoor cisterns, which were installed beneath planters adjacent to the building. The collected rainwater is filtered prior to being added to the graywater collection tank as part of the water reuse system. The graywater/rainwater reuse system and high-efficiency features such as dual-flush toilets, waterless urinals, and drought-tolerant plants reduce potable water demand by 60%. Each waterless urinal, for instance, saves 40,000 gallons of water each year.³⁶

The City's plumbing code complicated the installation of many of the building's water features. The plumbing code prohibited waterless toilets or urinals, requiring a resolution that allowed the waterless urinals to be installed with water supply stubbed out behind the wall if needed for future use. The City is now seeking a change to

City Code to allow for waterless urinals to be installed without an available water supply. Similarly, California's graywater ordinance did not contain a provision for rainwater collection; an agreement was negotiated with the County Health Department after which the City's Building and Safety Division agreed to sign off on the plans.^{37, 38}

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