Water Efficiency

In the United States, approximately 340 billion gallons of fresh water are withdrawn per day from rivers, streams and reservoirs to support residential, commercial, industrial, agricultural and recreational activities. This accounts for about one-fourth of the nation's total supply of renewable fresh water. Almost 65% of this water is discharged to rivers, streams and other water bodies after use and, in some cases, treatment.

Additionally, water is withdrawn from underground aquifers. In some parts of the United States, water levels in these aquifers have dropped more than 100 feet since the 1940s. On an annual basis, the water deficit in the United States is currently estimated at about 3,700 billion gallons. In other words, Americans extract 3,700 billion gallons per year more than they return to the natural water system to recharge aquifers and other water sources.

On a positive note, U.S. industries today use 36% less water than they did in 1950 although industrial output has increased significantly. This reduction in water use is largely due to the rigorous water reuse strategies in industrial processes. In addition, the Energy Policy Act of 1992 mandated the use of water-conserving plumbing fixtures to reduce water use in residential, commercial and institutional buildings.

Using large volumes of water increases maintenance and life-cycle costs for building operations and increases consumer costs for additional municipal supply and treatment facilities. Conversely, facilities that use water efficiently can reduce costs through lower water use fees, lower sewage volumes to treat energy and chemical use reductions, and lower capacity charges and limits. Many water conservation strategies involve either no additional cost or rapid paybacks. Other water conservation strategies such as biological wastewater treatment, rainwater harvesting and graywater plumbing systems often involve more substantial investment.

Water efficiency measures in commercial buildings can easily reduce water usage by 30% or more. In a typical 100,000-square-foot office building, low-flow fixtures coupled with sensors and automatic controls can save a minimum of 1 million gallons of water per year, based on 650 building occupants each using an average of 20 gallons per day. Non-potable water volumes can be used for landscape irrigation, toilet and urinal flushing, custodial purposes and building systems. Utility savings, though dependent on the local water costs, can save thousands of dollars per year, resulting in rapid payback on water conservation infrastructure.

Overview of LEED™ Credits

WE Credit 1
Water Efficient Landscaping

WE Credit 2
Innovative Wastewater Technologies

WE Credit 3
Water Use Reduction

There are 5 points available in the Water Efficiency category.

SS	WE	EA	MR	EQ	ID
Credit 1.1					

1 point

Water Efficient Landscaping

50% Reduction

Intent

Limit or eliminate the use of potable water for landscape irrigation.

Requirements

Use high-efficiency irrigation technology OR use captured rain or recycled site water to reduce potable water consumption for irrigation by 50% over conventional means.

Submittals

- ❑ Provide the LEED Letter Template, signed by the architect, engineer or responsible party, declaring that potable water consumption for site irrigation has been reduced by 50%. Include a brief narrative of the equipment used and/or the use of drought-tolerant or native plants.

SS	WE	EA	MR	EQ	ID

Credit 1.2

1 point
in addition to
WE 1.1

Water Efficient Landscaping

No Potable Use or No Irrigation

Intent

Limit or eliminate the use of potable water for landscape irrigation.

Requirements

Use only captured rain or recycled site water to eliminate all potable water use for site irrigation (except for initial watering to establish plants), OR do not install permanent landscape irrigation systems.

Submittals

❑ Provide the LEED Letter Template, signed by the responsible architect and/or engineer, declaring that the project site will not use potable water for irrigation. Include a narrative describing the captured rain system, the recycled site water system, and their holding capacity. List all the plant species used. Include calculations demonstrating that irrigation requirements can be met from captured rain or recycled site water.

OR

❑ Provide the LEED Letter Template, signed by the landscape architect or responsible party, declaring that the project site does not have a permanent landscape irrigation system. Include a narrative describing how the landscape design allows for this.

Summary of Referenced Standards

There is no standard referenced for this credit.

Green Building Concerns

Landscape irrigation practices in the United States consume large quantities of potable water. For example, in urban areas of Texas, residential and commercial landscape irrigation accounts for an estimated 25% of total water consumption. Irrigation typically uses potable water, although water volumes of lower quality water (i.e., non-potable water) are equally effective for irrigating landscapes. Sources of non-potable water volumes include captured rainwater from roof runoff as well as graywater from building systems (e.g., sinks and showers) or a municipal recycled water supply system. High-efficiency irrigation systems are another method to reduce potable water use for irrigation. These systems deliver up to 95% of the water supplied versus conventional irrigation systems that are as little as 60% efficient.

Environmental Issues

Native landscapes that have lower irrigation requirements tend to attract native wildlife, including birds, mammals and insects, creating a building site that is integrated with the natural surroundings. In addition, native plantings require less fertilizer and fewer pesticides and, thus, reduce water quality impacts.

Economic Issues

Utility rates for potable water are expected to escalate in future years as a result of overconsumption and finite potable water resources. Currently, the most effective strategy to avoid escalating water costs is simply to use less potable water.

The cost of irrigation systems can be reduced or eliminated through thoughtful irrigation planning. Although the cost for micro-irrigation systems is generally higher than for conventional systems due to additional design costs, the payback period can be rapid due to lower water use and maintenance requirements. Generally, micro-irrigation systems are comprised of fewer materials, rely on less mechanical components for operation, and are easy to repair in the event of breakage.

Initial landscaping costs can be reduced if the existing plants on the site are retained. These plants are typically well-adapted to the project site and reduce landscaping maintenance costs due to minimal water, chemical and energy requirements. Xeriscapes or dry landscapes are another way to reduce landscaping costs by eliminating the need for irrigation.

Community Issues

Water-efficient landscaping helps to conserve local and regional potable water resources. Maintaining natural aquifer conditions is important to providing reliable water sources for future generations. Consideration of water issues during planning can encourage development when resources can support it and prevent development if it exceeds the resource capacity.

Design Approach

Strategies

Perform a soil and climate analysis to determine which plants will adapt best to the site's soil and climate, and specify plants that are most suitable to site conditions. However, do not expect the resulting landscapes to require "no maintenance," as nearly all landscapes require some routine upkeep. Therefore, compile and follow a seasonal maintenance schedule for optimizing a healthy landscape. This schedule should address specific times for pruning, watering and pest inspection. In addition, use techniques such as integrated pest management, mulching, alternative mowing and composting to maintain plant health. These practices conserve water and help foster optimal soil conditions. Develop a landscaping water use baseline as described in the Calculations section.

Synergies

SS Prerequisite 1
Erosion & Sedimentation Control

SS Credit 1
Site Selection

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

SS Credit 7
Landscape and Exterior Design to Reduce Heat Islands

WE Credit 3
Water Use Reduction

EA Prerequisite 1
Fundamental Building Commissioning

EA Prerequisite 2
Minimum Energy Performance

EA Credit 1
Optimize Energy Performance

EA Credit 3
Additional Commissioning

EA Credit 5
Measurement & Verification

EQ Prerequisite 1
Minimum IAQ Performance

EQ Credit 7
Thermal Comfort

EQ Credit 8
Daylight & Views

Design the site landscape with indigenous plants. Also specify and install a diversity of plants that are adapted to site conditions (climate, soils and natural water availability) and that do not need watering from municipal potable water after establishment. It is up to the landscape designer to provide documentation that the species selected will not require permanent irrigation once established. The generally accepted timeframe for temporary irrigation is one to two years.

Specify and install a roof-water or groundwater collection system. Use metal, clay or concrete-based roofing materials and take advantage of gravity water flows whenever possible. Roofs made of asphalt or roofs with lead-containing materials contaminate collected rainwater and render it undesirable for reuse. The filtration of collected rainwater for irrigation can be achieved through a combination of graded screens and paper filters. It is important to check local rainfall quantity and quality as collection systems may be inappropriate in areas with very low rainfall. Also, rainwater that is highly acidic or has high mineral content may damage reuse systems. Conversely, rainwater may have a lower mineral content than the local water supply and may therefore be advantageous for use in appliances such as water heaters and washers.

Check with local health code departments for guidelines regarding the collection of rainwater, since such collection is not federally regulated. If collected rainwater is to be used for potable or irrigation purposes, certain health code departments might require back-flow prevention devices to avoid the risk of contaminating public drinking water supplies.

Technologies

High-efficiency irrigation strategies include micro-irrigation systems, moisture sensors, clock timers and weather database controllers. These systems are widely available and significantly more water-efficient than conventional irrigation systems.

Graywater systems can be used to recover water volumes from building sewage. Graywater consists of wastewater from lavatories, showers, washing machines and other building activities that do not involve human waste or food processing. These graywater volumes can be stored in cisterns on the site and used in the irrigation system. Also, stormwater volumes can be collected from hardscape surfaces on the site, such as roofing, and used in the landscape irrigation system.

Synergies and Trade-Offs

Landscape design is highly dependent on the site location and design. It may be advantageous to couple the landscape design with water reuse strategies. Landscape plantings may be designed to mitigate climate conditions and reduce overall energy consumption. Plants can be a natural aid to passive solar design, serve as windbreaks, and decrease noise. Irrigation and water reuse schemes will affect building energy performance and typically require commissioning and measurement & verification attention. High-efficiency irrigation systems do not work in the same manner as conventional irrigation systems and it is important to understand system operations. It is often necessary to train maintenance staff and to monitor regularly the irrigation system to ensure that it is working properly. The reuse of an existing building may dictate water reuse strategies. Landscape design may affect ventilation, daylighting and thermal comfort for the building.

Calculations

The following calculation methodology is used to support the credit submittals as listed on the first page of this credit. In order to quantify water-efficient landscaping measures, it is necessary to calculate irrigation volumes for the designed landscape irrigation system for the month of July and compare this with irrigation volumes required for a baseline landscape irrigation system. The resulting water savings is the difference between the two systems. The factors that must be calculated to determine irrigation volumes are explained in detail in the following paragraphs and summarized in **Table 1**.

The Landscape Coefficient (K_L) indicates the volume of water lost via evapotranspiration and is dependent on the landscape species, the microclimate and the planting density. The formula for determining the landscape coefficient is given in **Equation 1**.

The Species Factor (k_s) accounts for variation of water needs by different plant species. The species factor can be divided into three categories (high, average and low) depending on the plant species considered. To determine the appropriate category for a plant species, use plant manuals and professional experience. This factor is somewhat subjective but landscape professionals should have a general idea of the water needs of particular plant species. Landscapes can be maintained in acceptable condition at about 50% of the reference evapotranspiration (ET_0) value and thus, the average value of k_s is 0.5. (Note: If a species does not require irrigation once it is established, then the effective $k_s = 0$ and the resulting $K_L = 0$.)

Equation 1:

$$K_L = k_s \times k_d \times k_{mc}$$

The Density Factor (k_d) accounts for the number of plants and the total leaf area of a landscape. Sparsely planted areas will have lower evapotranspiration rates than densely planted areas. An average k_d is applied to areas where ground shading from trees is in the range of 60-100%. This is also equivalent to shrubs and ground cover shading 90-100% of the landscape area. Low k_d values are found where ground shading from trees is less than 60% or shrub and groundcover is less than 90%. For instance, a 25% ground shading from trees results in a k_d value of 0.5. In mixed landscape plantings where trees cover understory groundcover and shrubs, evapotranspiration increases. This represents the highest level of landscape density and the k_d value should be between 1.0 and 1.3.

The Microclimate Factor (k_{mc}) accounts for environmental conditions specific to the landscape, including temperature, wind and humidity. For instance, parking lot areas increase wind and temperature effects on adjacent landscapes. The average k_{mc} is 1.0 and this refers to conditions where the landscape evapotranspiration rate is unaffected by buildings, pavements, reflective surfaces and slopes. Higher k_{mc} conditions occur where evaporative potential is increased due

Table 1: Landscape Factors

Vegetation Type	Species Factor (k_s)			Density Factor (k_d)			Microclimate Factor (k_{mc})		
	low	average	high	low	average	high	low	average	high
Trees	0.2	0.5	0.9	0.5	1.0	1.3	0.5	1.0	1.4
Shrubs	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.3
Groundcovers	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.2
Mixed: trees, shrubs, groundcovers	0.2	0.5	0.9	0.6	1.1	1.3	0.5	1.0	1.4
Turfgrass	0.6	0.7	0.8	0.6	1.0	1.0	0.8	1.0	1.2

to landscapes surrounded by heat-absorbing and reflective surfaces or are exposed to particularly windy conditions. Examples of high k_{mc} areas include parking lots, west sides of buildings, west and south sides of slopes, medians, and areas experiencing wind tunnel effects. Low microclimate areas include shaded areas and areas protected from wind. North sides of buildings, courtyards, areas under wide building overhangs, and north sides of slopes are low microclimate areas. **Table 1** provides suggested values for k_s, k_{mc}, and k_d.

Once K_L is determined, the evapotranspiration (ET) rate of the specific landscape (ET_L) can be calculated. K_L is multiplied by the reference evapotranspiration (ET_0) to obtain ET_L as shown in **Equation 2**. The **evapotranspiration rate** is a measurement of the total amount of water needed to grow plants and crops. Different plants have different water needs, and thus different ET rates. Irrigation calculations are simplified by using ET_0, which is an average rate for a known surface, such as grass or alfalfa, used as a reference point and expressed in millimeters or inches.

The values for ET_0 in various regions throughout the United States can be found in regional agricultural data (see Resources section). The ET_0 for July is used in the LEED calculation because this is typically the month with the greatest evapotranspiration effects and, therefore, the greatest irrigation demands.

To calculate irrigation volumes, apply the **irrigation efficiency** (IE). **Table 2** lists irrigation efficiencies for sprinkler and drip irrigation systems.

The **Total Potable Water Applied** (TPWA) to a given area (A) is calculated in **Equation 3**.

This equation indicates that a smaller landscape area, a smaller ET_L value, and a larger IE value result in a lower TPWA value. This is sensible because smaller

Equation 2:

$$ET_L\,[in] = ET_0\,[in] \times K_L$$

landscape areas require less water to irrigate, a smaller ET_L value means less water loss due to evapotranspiration, and a higher IE means that irrigation water is being used more efficiently.

To determine the water savings for the designed landscaping irrigation system, perform the above calculations for the **design case** as well as a baseline case.

1. Use **Table 1** to determine the appropriate landscape factors for each specific landscape area in the design case (e.g., k_s, k_{mc}, and k_d). Use a spreadsheet to summarize the different landscape areas and the associated factors.

2. Calculate the landscape coefficient (K_L) for each landscape area using the appropriate landscape factors and Equation 1.

3. Calculate the specific landscape evapotranspiration rate (ET_L) of each landscape area using the corresponding landscape coefficient (K_L) and the ET_L formula in Equation 2.

4. Calculate the TPWA to each landscape area using Equation 3 and the applicable surface area, specific landscape evapotranspiration rate and irrigation efficiency data.

Repeat the above steps for the **baseline case** using conventional plant species and plant densities as determined by the project's landscape consultant. Differences between the two cases result from plant species choices, plant densities and irrigation system choices. Planting types should approximately correspond in both the baseline and design cases (i.e., it is unreasonable to assume that

Table 2: Irrigation Types

Irrigation Type	IE
Sprinkler	0.625
Drip	0.90

Equation 3:

$$TPWA\ [gal] = A\ [SF] \times \frac{ET_L\ [in]}{IE}$$

the baseline is 100% turfgrass if a project clearly intends to include trees, shrubs and planting beds). Do not change the landscape areas, microclimate factors or reference evapotranspiration rates.

An **example** of irrigation calculations is presented below. An office building in Austin, Texas, has a total site area of 6,000 square feet. The site consists of three landscape types: groundcover, mixed vegetation and turf grass. All of the site areas are irrigated with a combination of potable water and graywater harvested from the building. The reference evapotranspiration rate (ET_0) for Austin in July was obtained from the local agricultural data service and is equal to 8.12.

The high-efficiency landscape irrigation case utilizes drip irrigation with an efficiency of 90% and reuses an estimated 9,000 gallons of graywater during the month of July. **Table 3** shows the calculations to determine potable water use for the design case.

The baseline case uses the same reference evapotranspiration rate and total site area. However, the baseline case uses sprinklers for irrigation (IE = 0.625), does not take advantage of graywater harvesting, and uses only shrubs and turf grass. Calculations to determine potable water use for the baseline case are presented in **Table 4**.

The example illustrates that the design case has an irrigation water demand of 23,474 gallons. Graywater reuse provides 4,200 gallons towards the demand, and this volume is treated as a credit in the water calculation. Thus, the total potable water applied to the design case in July is 19,274 gallons. The baseline case has an irrigation demand of 62,518 gallons and reuses no graywater. The difference between the two cases results in potable water savings of 69% for the design case.

It is important to note that the LEED calculation provides an indication of the general efficiency gains provided by the green design. For more accurate under-

Table 3: Design Case (July)

Landscape Type	Area [SF]	Species Factor (k_s)		Density Factor (k_d)		Microclimate Factor (k_{mc})		K_L	ET_L	IE	TPWA [gal]
Shrubs	1,200	Low	0.2	Avg	1.0	High	1.3	**0.3**	2.11	Drip	2,815
Mixed	3,900	Low	0.2	Avg	1.1	High	1.4	**0.3**	2.50	Drip	10,837
Turfgrass	900	Avg	0.7	Avg	1.0	High	1.2	**0.8**	6.82	Sprinkler	9,822
										Subtotal [gal]	23,474
										July Graywater Harvest [gal]	(4,200)
										Net GPWA [gal]	**19,274**

Table 4: Baseline Case (July)

Landscape Type	Area [SF]	Species Factor (k_s)		Density Factor (k_d)		Microclimate Factor (k_{mc})		K_L	ET_L	IE	TPWA [gal]
Shrubs	1,200	Avg	0.5	Avg	1.0	High	1.3	**0.7**	5.28	Sprinkler	10,134
Turfgrass	4,800	Avg	0.7	Avg	1.0	High	1.2	**0.8**	6.82	Sprinkler	52,384
										Net GPWA [gal]	**62,518**

standing of water use and efficiency opportunities, an annual water balance is required. For example, graywater volumes may or may not be consistently available throughout the year because these volumes are dependent on building occupant activities. In a typical office building, graywater volumes will change slightly due to vacation schedules and holidays but should be relatively consistent over the year. In contrast, graywater volumes in a school building will substantially decrease in summer months as a result of reduced building occupancy, and, therefore, graywater volumes may not be available for irrigation. Graywater systems should be modeled to predict graywater volumes generated on a monthly basis as well as optimal storage capacity of the graywater system. It is also important to address possible treatment processes needed for reuse and design of a makeup water system if graywater volume is not sufficient to satisfy reuse demands.

Rain harvest volume depends on the amount of precipitation that the project site experiences and the rainwater collection surface's area and efficiency. See **Equation 4** and consult a rainwater harvesting guide for more detailed instruction. Rainfall data is available from the local weather service (see the Resources section). Within the credit calculations, project teams may either use the collected rainwater total for July based on historical average precipitation, or use the historical data for each month in order to model collection and reuse throughout the year. The latter method allows the project team to determine what volume of water is expected to be in the storage cistern at the beginning of July and add it to the expected rainwater volume collected during the month. This approach also allows the project team to determine the optimal size of the rainwater cistern.

Resources

Web Sites

American Rainwater Catchment Systems Association

www.arcsa-usa.org

Includes a compilation of publications, such as the *Texas Guide to Rainwater Harvesting*.

A Guide to Estimating Irrigation Needs of Landscape Plantings

www.owue.water.ca.gov/docs/wucols00.pdf, (916) 653-1097

Provides detailed methodology for calculating irrigation needs for a wide variety of landscape types. Also includes specific data for California climates.

The Irrigation Association

www.irrigation.org/about_et_list.htm, (703) 536-7080

A nonprofit organization focused on promoting products for the efficient use of water for irrigation applications. This specific Web link is for evapotranspiration data contacts for each U.S. state.

National Climatic Data Center

www.ncdc.noaa.gov/oa/climate/stateclimatologists.html

Useful for researching local climate data, such as rainfall data for rainwater harvesting calculations. Includes links to state climate offices.

Native Plant Societies

Your state or regional native plant society is an excellent resource for identifying climate-appropriate vegetation.

Equation 4:

Rainwater Volume [gal] = collection area [SF] x collection efficiency [%] x average rainfall [in] x 0.6233 gal/in

Texas Evapotranspiration Web Site

texaset.tamu.edu/index.php

An evapotranspiration data Web site for the State of Texas with a discussion of evapotranspiration and sprinkler efficiencies.

U.S. Department of the Interior – Bureau of Reclamation

www.usbr.gov/main/water

The Bureau's Agrimet Data System provides evapotranspiration rates for several regions in the U.S.

WaterWiser: The Water Efficiency Clearinghouse

www.waterwiser.org, (800) 926-7337

A Web clearinghouse with articles, reference materials and papers on all forms of water efficiency.

Water Efficient Landscaping

muextension.missouri.edu/xplor/agguides/hort/g06912.htm, (573) 882-7216

A Web site that has general descriptions and strategies for water efficiency in gardens and landscapes.

Print Media

ASCE Manuals and Reports on Engineering Practice No. 70, "Evapotranspiration and Irrigation Water Requirements," ASCE, 1990.

Estimating Water Requirements of Landscape Plantings, University of California Cooperative Extension, Division of Agriculture and Natural Resources, Leaflet 21493.

Landscape Irrigation: Design and Management, by Stephen W. Smith, John Wiley and Sons, 1996.

Turf Irrigation Manual, Fifth Edition, by Richard B. Choate, Telsco Industries, 1994.

Definitions

Blackwater is wastewater from toilets and kitchen sinks that contains organic materials.

Drip Irrigation is a high-efficiency irrigation method in which water drips to the soil from perforated tubes or emitters.

Evapotranspiration is the loss of water by evaporation from the soil and transpiration from plants.

Graywater is wastewater from lavatories, showers, bathtubs, washing machines and sinks that are not used for disposal of hazardous or toxic ingredients or wastes from food preparation.

Potable Water is water that is suitable for drinking and is supplied from wells or municipal water systems.

Xeriscape or "dry landscape" designs adopt water conservation as the primary objective. Xeriscape landscapes are based on sound horticultural practices and incorporate native plant species that are adapted to local climate conditions.

Case Study

Monsanto Company Life Sciences Incubator
St Louis, Missouri

The Monsanto Company Life Sciences Incubator building is a LEED Version 1.0 Silver Pilot Project that houses research facilities committed to finding solutions to growing global needs for food and health. The building design was inspired by a circular stone Shaker barn in New England and includes two above-ground cisterns to harvest rainwater volumes from the roof for landscape irrigation. Rainwater is collected via a passive gravity-fed collection system and up to 12,000 gallons of water can be stored in the cisterns. This water is then applied manually to the landscape as needed, saving an estimated 28,000 gallons of potable water annually.

Courtesy of Monsanto Company

Owner
Monsanto Company

SS	WE	EA	MR	EQ	ID
Credit 2					

Innovative Wastewater Technologies

1 point

Intent

Reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge.

Requirements

Reduce the use of municipally provided potable water for building sewage conveyance by a minimum of 50%, OR treat 100% of wastewater on site to tertiary standards.

Submittals

- ❑ Provide the LEED Letter Template, signed by the architect, MEP engineer or responsible party, declaring that water for building sewage conveyance will be reduced by at least 50%. Include the spreadsheet calculation and a narrative demonstrating the measures used to reduce wastewater by at least 50% from baseline conditions.

OR

- ❑ Provide the LEED Letter Template, signed by the civil engineer or responsible party, declaring that 100% of wastewater will be treated to tertiary standards on site. Include a narrative describing the on-site wastewater treatment system.

Summary of Referenced Standard

There is no standard referenced for this credit.

Synergies

SS Credit 1
Site Selection

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

WE Credit 3
Water Use Reduction

EA Prerequisite 1
Fundamental Building Systems Commissioning

EA Prerequisite 2
Minimum Energy Performance

EA Credit 1
Optimize Energy Performance

EA Credit 3
Additional Commissioning

EA Credit 5
Measurement & Verification

MR Credit 1
Building Reuse

Green Building Concerns

Conventional wastewater systems require significant volumes of potable water to convey waste to municipal wastewater treatment facilities. However, graywater volumes from sinks, showers and other sources can be substituted for potable water to flush toilets and urinals. Water can also be harvested from roof runoff volumes that would otherwise be absorbed into the ground or released to local water bodies. Low-flow fixtures, automatic controls, and dry fixtures such as composting toilets and waterless urinals can be used to reduce sewage volume generation.

Once wastewater has been conveyed to treatment facilities, extensive treatment is required to remove contaminants before discharging to a receiving water body. A more efficient method for handling wastewater is to treat it on-site. On-site wastewater strategies reduce regional wastewater infrastructure costs as well as provide autonomy from the public treatment works. A variety of on-site wastewater treatment options are available including conventional biological treatment facilities similar to regional treatment plants and "living machine" systems that mimic natural processes to treat wastewater.

Environmental Issues

On-site wastewater treatment systems transform perceived "wastes" into resources that can be used on the building site. These resources include treated water volumes for potable and non-potable use, as well as nutrients that can be applied to the site to improve soil conditions. Reducing wastewater treatment at the local wastewater treatment works minimizes public infrastructure, energy use and chemical use. In rural areas, onsite wastewater treatment systems avoid aquifer contamination problems prevalent in current septic system technology.

Economic Issues

Commercial and industrial facilities that generate large amounts of wastewater can realize considerable savings by recycling graywater. For example, carwashes and truck maintenance facilities generate large volumes of graywater that can be effectively treated and reused. Often, a separate tank, filter and special emitters are necessary for a graywater irrigation system. The dual plumbing lines installed during initial construction will approximately double the cost of plumbing. However, water storage is the highest cost in any rainwater collection system, much greater than costs for the catchment area, water conveyance, filtration and distribution components. Storage tanks and cisterns in a variety of sizes and materials are regionally available. In some systems, there are additional energy costs required for operation.

Water recovery systems are most cost-effective in areas where there is no municipal water supply, where the developed wells are unreliable, or if well water requires treatment. Collecting and using rainwater or other site water volumes reduces site runoff and the need for runoff devices. It also minimizes the need for utility-provided water, thus reducing some initial and operating costs. In some areas with a decentralized population, collection of rainwater offers a low-cost alternative to a central piped water supply.

Wastewater treatment systems and water recovery systems involve an initial capital investment in addition to the maintenance requirements over the building's lifetime. These costs must balance with the anticipated savings in water and sewer bills. This savings can minimize the amount of potable water that a municipality must provide, thereby leading to more stable water rates.

A constructed wetland for wastewater treatment can add value to a development as a site enhancement. Wetlands are beneficial because they provide flood protection and stabilize soils on site. Currently, packaged biological wastewater systems have an initial high cost relative to the overall building cost due to the novelty of the technology.

Community Benefits

By reducing potable water use, the local aquifer is conserved as a water resource for future generations. In areas where aquifers cannot meet the needs of the population economically, rainwater and other recovered water is the least expensive alternative source of water. Reserving potable water only for specific applications benefits the entire community through lower utility rates and taxes.

Design Approach

Strategies

Develop a wastewater inventory and determine areas where graywater can be used for functions that are conventionally served by potable water. These functions might include sinks, showers, toilets, landscape irrigation, industrial applications and custodial applications. Also estimate the demand for these applications and the availability of graywater generated on the site. Finally, determine the amount of wastewater that will require treatment and select the most suitable treatment strategy.

Potable water is used for many functions that do not require high-quality water. Graywater systems reuse the wastewater from sinks, showers and other sources for the flushing of toilets, landscape irrigation, and other functions that do not require potable water. Roof-water or groundwater collection systems harvest water that otherwise would be absorbed into the ground or released to local water bodies. If it is likely that a graywater system will be used in the future, install dual plumbing lines during the initial construction to avoid the substantial costs and difficulty in adding them later.

Figure 1 depicts an example design for rain harvesting reuse. Precipitation volumes are captured on the roof and transported to a basement storage tank via gutters and downspouts. The basement storage tank has an overflow device if the volume of runoff exceeds capacity and potable water makeup (***device?) if the runoff volume is less than the minimum volume required for reuse. The runoff volumes are then filtered and pumped to water closets and washing machines in the building as needed.

Check with the local health department for regulations governing the use of a graywater system and the permits required. Each state has its own standards for graywater irrigation systems. Texas and California, for example, have standards that encourage the use of graywater systems. Other states have regulations that may limit or prohibit graywater use. In many areas, irrigation with graywater must be subsurface, although some regions allow above-ground irrigation.

Consider an on-site wastewater treatment system such as constructed wetlands, a mechanical recirculating sand filter, or an aerobic biological treatment reactor.

Technologies

The construction of artificial wetlands for wastewater treatment can be incorporated on multiple scales to accommodate projects ranging from individual buildings to larger developments. As wastewater moves through the wetlands or bodies of water, plants and microbes naturally remove water contaminants. Another technology involves creating an aquaculture system, where contaminants in the wastewater become food for fish and plants.

Remember to check with local health code departments regarding current regulations governing the use of biological wastewater systems. Most require permits for these systems. Regularly scheduled

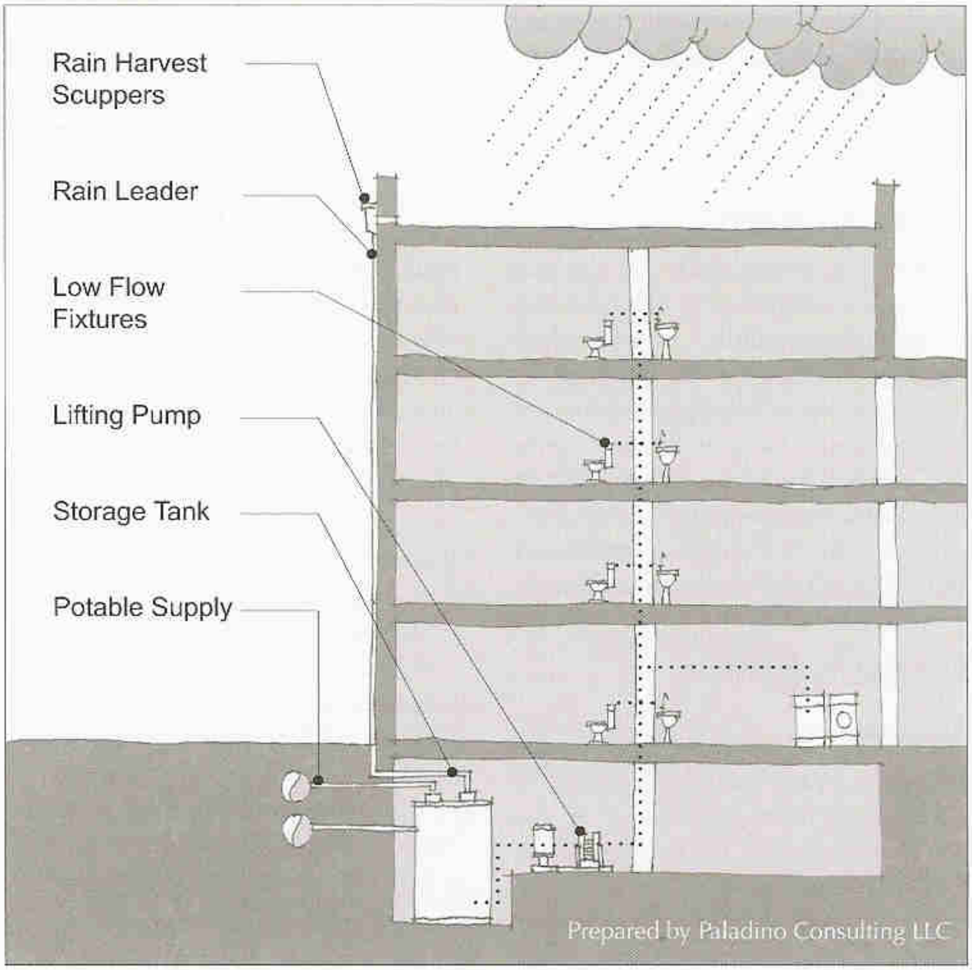


Figure 1: An Illustration of a Rain Harvesting System

maintenance on these systems will increase their lifetimes and reduce operations problems. An EPA study found that ecological systems are comparable in cost to conventional wastewater treatment only for volumes of 50,000 gallons per day or less. An aquaculture system is usually a high-cost and high-maintenance system, yet it can yield food and fertilizer in return.

Modular wastewater treatment systems can be purchased to remove wastewater contaminants including TSS and TP. Some systems imitate natural ecosystems to treat wastewater volumes biologically while other systems are designed with physical, chemical and biological technologies similar to publicly owned treatment works. Both types of systems produce effluents that can be used for non-potable applications such as irrigation and toilet flushing.

Synergies and Trade-Offs

The necessity and availability of wastewater reuse and treatment strategies is heavily influenced by the building location. In remote locations, it may be cost-effective to use an on-site wastewater treatment system.

Conversely, a project located in a dense area with little site area, and with limited wastewater treatment, graywater or stormwater reuse facilities, may not be able to capture this credit. This credit has close ties to water efficiency efforts because a greater amount of potable water saved often results in less blackwater generated. For instance, water efficient water closet and urinal fixtures not only reduce potable water demand but also reduce blackwater volumes created. Thus, performance results will often overlap with those of WE Credit 3.

Energy use may be needed for treatment plant operation or for reuse strategies. These systems also require commissioning and measurement & verification attention. Reuse of an existing building could hinder adoption of an on-site wastewater treatment facility.

Calculations

The following calculation methodology is used to support the credit submittals listed on the first page of this credit. Wastewater calculations are based on the annual generation of blackwater volumes from plumbing fixtures such as water closets and urinals. The calculations compare the design case with a baseline case. The steps to calculate the **design case** are as follows:

1. Create a spreadsheet listing each type of blackwater-generating fixture and frequency of use data. Frequency-of-use data includes the number of female and male daily uses, and the sewage generated per use. Using these values, calculate the total sewage generated for each fixture type and gender (see **Equation 1**).

2. Sum all of the sewage generation volumes used for each fixture type to obtain male and female daily sewage generation volumes.

3. Multiply the male and female sewage generation volumes by the number of male and female building occupants and sum these volumes to obtain the daily total sewage generation volume (see **Equation 2**).

4. Multiply the total daily sewage volume by the number of workdays in a typical year to obtain the total annual sewage generation volume for the building (see **Equation 3**).

5. If rainwater harvest or graywater reuse strategies are employed in the building, subtract these annual volumes from the annual sewage generation volume. The result shows how much potable water is used for sewage conveyance annually.

Repeat the above calculation methodology for the **baseline case**. Use Energy Policy Act of 1992 fixture flow rates for the baseline case (see WE Credit 3, Table 1). Do not change the number of building occupants, the number of workdays, or the frequency data. Do not include graywater or rainwater harvest volumes.

Table 1 shows **example** potable water calculations for sewage conveyance for a two-story office building with a capacity of 300 occupants. The calculations are based on a typical 8-hour workday. It is assumed that building occupants are 50% male and 50% female. Male occupants are assumed to use water closets once and urinals twice in a typical work day. Fe-

Equation 1:

$$\text{Sewage Volume [gal]} = \text{Uses} \times \text{Duration [mins or flushes]} \times \frac{\text{Water Volume [gal]}}{\text{Use [min or flush]}}$$

Equation 2:

$$\text{Daily Sewage Generation [gal]} = \text{Male Occupants} \times \text{Male Sewage Generation [gal]} + \text{Female Occupants} \times \text{Female Sewage Generation [gal]}$$

Equation 3:

$$\text{Annual Sewage Generation [gal]} = \text{Total Sewage Generation} \left[\frac{\text{gal}}{\text{day}}\right] \times \text{Workdays [days]}$$

Table 1: Design Case

Fixture Type	Daily Uses	Flowrate [GPF]	Occupants	Sewage Generation [gal]
Low-Flow Water Closet (Male)	0	1.1	150	0
Low-Flow Water Closet (Female)	3	1.1	150	495
Composting Toilet (Male)	1	0.0	150	0
Composting Toilet (Female)	0	0.0	150	0
Waterless Urinal (Male)	2	0.0	150	0
Waterless Urinal (Female)	0	0.0	150	0
			Total Daily Volume [gal]	495
			Annual Work Days	260
			Annual Volume [gal]	128,700
			Rainwater or Graywater Reuse Volume [gal]	(36,000)
			TOTAL ANNUAL VOLUME [gal]	**92,700**

male occupants are assumed to use water closets three times.

First, the design case is considered to determine annual potable water usage for sewage conveyance. The designed building has fixtures that use non-potable water for sewage conveyance (i.e., rainwater) or no water for sewage conveyance (i.e., waterless urinals and composting toilets). **Table 1** summarizes the sewage generation rates and indicates that 92,700 gallons of potable water are used annually for sewage conveyance.

When using graywater and rainwater volumes, calculations are required to demonstrate that these reuse volumes are sufficient to meet water closet demands. These quantities are then subtracted from the gross daily total because they reduce potable water usage. In the example, 36,000 gallons of rainwater are harvested and directed to water closets for flushing.

Next, the baseline potable water usage for sewage conveyance is developed using conventional fixtures that comply with the Energy Policy Act of 1992. Toilets are 1.6 gallons per flush (GPF) and urinals are 1.0 GPF. All fixtures drain to the existing municipal sewer system.

Table 2 provides a summary of baseline calculations. The baseline case estimates that 327,600 gallons of potable water per year for sewage conveyance.

Comparison of the baseline to the designed building indicates that a 72% reduction in potable water volumes used for sewage conveyance is realized (1 – 92,700/327,600). Thus, this strategy earns one point for this credit. When developing the baseline, only the fixtures, sewage generation rates and the water reuse credit are different from the designed building. Usage rates, occupancy and number of workdays are identical for the designed case and the baseline case. See **Table 3** for sample fixture flow rates.

When reusing graywater volumes from the building, it is necessary to model the system on an annual basis to determine graywater volumes, generated storage capacity of the system and any necessary treatment processes before reusing the water volumes. Graywater volumes may or may not be consistently available throughout the year because these vol-

Table 2: Baseline Case

Fixture Type	Daily Uses	Flowrate [GPF]	Occupants	Sewage Generation [gal]
Water Closet (Male)	1	1.6	150	240
Water Closet (Female)	3	1.6	150	720
Urinal (Male)	2	1.0	150	300
Urinal (Female)	0	1.0	150	0
			Total Daily Volume [gal]	1,260
			Annual Work Days	260
			TOTAL ANNUAL VOLUME [gal]	**327,600**

Table 3: Sample Fixture Types and GPFs

Fixture Type	[GPF]
Conventional Water Closet	1.6
Low-Flow Water Closet	1.1
Ultra Low-Flow Water Closet	0.8
Composting Toilet	0.0
Conventional Urinal	1.0
Waterless Urinal	0.0

umes are dependent on building occupant activities. For instance, in a typical office building, graywater volumes will change slightly due to vacation schedules and holidays but should be relatively consistent over the year.

In contrast, graywater volumes in a school building will substantially decrease in summer months due to the school calendar, and, therefore, graywater volumes may not be available for irrigation.

If the project uses rainwater volume as a substitute for potable volumes in water closets or urinals, it is necessary to calculate water savings over a time period of one year. Rain harvest volume depends on the amount of precipitation that the project site experiences and the rainwater collection surface's area and efficiency. See **Equation 4** and consult a rainwater harvesting guide for more detailed instruction. Rainfall data is available from the local weather service (see the Resources section). Rainwater volume depends on variations in precipitation, and, thus, it is necessary to model the reuse strategy on an annual basis. A model of rainwater capture based on daily precipitation and occupant demand is helpful to determine the rainwater volumes captured and storage tank size. Subtract annual rainwater use for sewage conveyance in the design case calculations.

Resources

Web Sites

American Rainwater Catchment Systems Association

www.arcsa-usa.org

Includes a compilation of publications, such as the *Texas Guide to Rainwater Harvesting*.

Equation 4:

Rainwater Volume [gal] = collection area [SF] x collection efficiency [%] x average rainfall [in] x 0.6233 gal/in

How to Conserve Water and Use it Wisely

www.epa.gov/OW/you/chap3.html

A U.S. EPA document that provides guidance for commercial, industrial and residential water users on saving water and reducing sewage volumes.

National Climatic Data Center

www.ncdc.noaa.gov/oa/climate/stateclimatologists.html

Useful for researching local climate data, such as rainfall data for rainwater harvesting calculations. Includes links to state climate offices.

Print Media

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat: 17 Case Studies, EPA 832/B-93-005, 1993.

Mechanical & Electrical Equipment for Buildings, Eighth Edition, by Benjamin Stein and John Reynolds, John Wiley and Sons, 1992.

Sustainable Building Technical Manual, Public Technology, Inc., 1996 (www.pti.org).

Definitions

Aquatic Systems are ecologically designed treatment systems that utilize a diverse community of biological organisms (e.g., bacteria, plants and fish) to treat wastewater to advanced levels.

On-Site Wastewater Treatment uses localized treatment systems to transport, store, treat and dispose of wastewater volumes generated on the project site.

Potable Water is defined as water that meets drinking water quality standards and is approved for human consumption by the state or local authorities having jurisdiction.

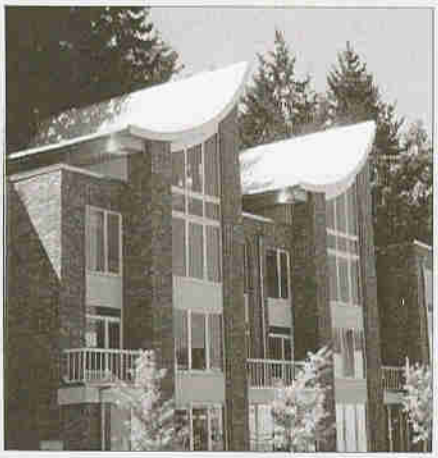
Tertiary Treatment is the highest form of wastewater treatment and includes removal of organics, solids and nutrients as well as biological or chemical polishing, generally to effluent limits of 10 mg/L BOD_5 and 10 mg/L TSS.

Also see WE Credit 1 definitions.

Case Study

C.K. Choi Building for the Institute of Asian Research
Vancouver, British Columbia

The C.K. Choi Building for the Institute of Asian Research at the University of British Columbia is a campus research building. The building incorporates two strategies to reduce wastewater generation. All toilets in the building are composting toilets that function without water and transform human wastes into compost that can be applied to the site landscape. Liquid wastes from the composting toilets and other building sources (lavatories, kitchen sinks and urinals) are directed through a simulated wetland system. This system doubles as a landscape feature next to the building and treats the liquid wastes before application to the site landscape. These strategies allow for the building to be disconnected from the existing sanitary sewer infrastructure.



Courtesy of Paladino Consulting LLC

Owner
University of British Columbia

SS	WE	EA	MR	EQ	ID
Credit 3.1					

Water Use Reduction

20% Reduction

1 point

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements.

Submittals

- ❑ Provide the LEED Letter Template, signed by the MEP engineer or responsible party, declaring that the project uses 20% less water than the baseline fixture performance requirements of the Energy Policy Act of 1992.
- ❑ Provide the spreadsheet calculation demonstrating that water-consuming fixtures specified for the stated occupancy and use of the building reduce occupancy-based potable water consumption by 20% compared to baseline conditions.

SS	WE	EA	MR	EQ	ID

Credit 3.2

1 point
in addition to
WE 3.1

Water Use Reduction

30% Reduction

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 30% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements.

Submittals

- ❑ Provide the LEED Letter Template, signed by the MEP engineer or responsible party, declaring that the project uses 30% less water than the baseline fixture performance requirements of the Energy Policy Act of 1992.
- ❑ Provide the spreadsheet calculation demonstrating that water-consuming fixtures specified for the stated occupancy and use of the building reduce occupancy-based potable water consumption by 30% compared to baseline conditions.

Summary of Referenced Standard

The Energy Policy Act (EPAct) of 1992

This Act was promulgated by the U.S. government and addresses energy and water use in commercial, institutional and residential facilities. The water usage requirements of the Energy Policy Act of 1992 are provided in **Table 1**.

Table 1: EPACT Fixture Ratings

Fixture	Energy Policy Act of 1992 Flow Requirement
Water Closets [GPF]	1.6
Urinals [GPF]	1.0
Showerheads [GPM]*	2.5
Faucets [GPF]*	2.5
Replacement Aerators [GPM]*	2.5
Metering Faucets [gal/CY]	0.25

*At flowing water pressure of 80 pounds per square inch (psi)

Green Building Concerns

The Energy Policy Act of 1992 established water conservation standards for water closets, shower heads, faucets and other uses to save the United States an estimated 6.5 billion gallons of water per day. Toilet flushing uses the most water in residential and commercial buildings, accounting for approximately 4.8 billion gallons per day. Older toilets use 4 to 8 gallons of water per flush, while all new toilets must have a maximum flush volume of 1.6 gallons.

While the EPAct is a good starting point, there are many ways to exceed this standard and achieve even greater water savings. Effective methods to reduce potable water use include reusing roof runoff volumes for non-potable applications, installing sensors and flow restrictors on water fixtures, and installing dry fixtures such as composting toilets and waterless urinals.

Environmental Issues

The reduction of potable water use in buildings for toilets, shower heads and faucets reduces the total amount withdrawn from rivers, streams, underground aquifers and other water bodies. Another benefit of potable water conservation is reduced energy use and chemical inputs at municipal water treatment works.

Economic Issues

Reductions in water consumption minimize overall building operating costs. Reductions can also lead to more stable municipal taxes and water rates. By handling reduced water volumes, water treatment facilities can delay expansion and maintain stable water prices.

Accelerated installation of high-efficiency plumbing fixtures, especially 1.6 gallon per flush (GPF) toilets, through incentive programs has become a cost-effective way for some municipalities to defer, reduce or avoid capital costs of needed water supply and wastewater facilities.

For example, New York City invested $393 million in a 1.6 GPF toilet-rebate program that has reduced water demand and wastewater flow by 90.6 million gallons per day (MGD), equal to 7% of the city's total water consumption. The rebate program accomplished a net present value savings of $605 million from a 20-year deferral of water supply and wastewater treatment expansion projects. Another successful water efficiency program was instituted in Santa Monica, where the toilet replacement program achieved permanent reductions in water usage and wastewater flows of over 1.9 MGD, representing a 15% reduction in average total water demand and a 20% reduction of average total wastewater flow. The cost of the rebate program was $5.4 million. The program will have a net savings of $6 million in the year 2002 due to avoided costs of water imports and wastewater treatment.

Water-conserving fixtures that use less water than requirements in the Energy Policy Act of 1992 may have higher initial costs. Additionally, there may be a longer lead time for delivery because of their limited availability.

The first cost of composting toilets is significantly higher than conventional water closets and they may initially require additional maintenance attention. Some composting toilets also carry an ongoing energy cost to run fans and other system equipment. Nonetheless, significant operational savings are realized through eliminated potable water use and sewage generation.

Community Issues

Water use reductions, in aggregate, allow municipalities to reduce or defer the capital investment needed for water supply and wastewater treatment infrastructure. These strategies protect the natural water

Synergies

SS Credit 1
Site Selection

SS Credit 5
Reduced Site Disturbance

SS Credit 6
Stormwater Management

WE Credit 1
Water Efficient Landscaping

WE Credit 2
Innovative Wastewater Technologies

EA Prerequisite 1
Fundamental Building Systems Commissioning

EA Prerequisite 2
Minimum Energy Performance

EA Credit 1
Optimize Energy Performance

EA Credit 3
Additional Commissioning

EA Credit 5
Measurement & Verification

cycle and save water resources for future generations.

Design Approach

Strategies

Develop a water use inventory that includes all water-consuming fixtures, equipment and seasonal conditions according to the methodology outlined in the Calculations section. Consider developing the inventory in conjunction with WE Credit 2. Use this to identify significant potable water demands and determine methods to minimize or eliminate these demands.

Specify water-conserving plumbing fixtures that exceed the fixture requirements stated in the Energy Policy Act of 1992. Consider ultra-high efficiency fixture and control technologies, including toilets, faucets, showers, dishwashers, clothes washers and cooling towers. A variety of low-flow plumbing fixtures and appliances are currently available in the marketplace and can be installed in the same manner as conventional fixtures.

Technologies

Water-efficient shower heads are available that require less than 2.5 GPM. Bathroom faucets are typically used only for wetting purposes and can be effective with as little as 1.0 GPM. Water-saving faucet aerators can be installed that do not change the feel of the water flow. Specify self-closing, slow-closing or electronic sensor faucets, particularly in high-use public areas where it is likely that faucets may be carelessly left running.

Water closets are a significant user of potable water. There are a number of toilets that use considerably less than 1.6 GPF, including pressure-assisted toilets and dual flush toilets that have an option of 0.8 GPF or 1.0 GPF. Unfortunately, it is currently difficult to obtain these fixtures in North America.

Consider dry fixtures such as waterless urinals and composting toilets. These technologies use no water volumes to cope with human waste. Waterless urinals use advanced hydraulic design and a buoyant fluid instead of water to maintain sanitary conditions. Composting toilets mix human waste with organic material to produce a nearly odorless end product that can be used as a soil amendment. These fixtures have been used successfully but to a limited extent in commercial settings. Composting toilets may not be acceptable by health code departments in some areas, and, thus, it is important to check with the local health code department to uncover regulations governing the use of both composting toilets and waterless urinals. Also, if the building allows for public access to restroom facilities, it is important to educate users about system operation and purpose. Signage in restrooms is a good way to educate users, and signs should include instructions and a brief description of how the system functions. This is especially true for composting toilets that do not function in the same manner as conventional water closets.

Consider specifying water-efficient cooling towers that use delimiters to reduce drift and evaporation. Couple cooling towers with water recovery systems to operate with graywater or stormwater volumes. However, keep in mind that delimiters may require larger fans in the cooling tower system, resulting in increased energy use.

Synergies and Trade-Offs

Water use strategies depend on the site location and site design. Project sites with no access to municipal potable water service typically use groundwater wells to satisfy potable water demands. Sites with significant precipitation volumes may determine that reuse of these volumes is more cost-effective than creating stormwater treatment facilities. Potable water use is significant for irrigation applications and is directly correlated with the amount of wastewater generated on-site. Strategies and performance results may overlap with those of WE Credit 2.

Some water-saving technologies impact energy performance and require commissioning and measurement & verification attention. Reuse of existing buildings may hinder water efficiency measures due to space constraints or existence of plumbing fixtures.

Calculations

The following calculation methodology is used to support the credit submittals listed on the first page of this credit. To calculate the potable water savings for a building, the design case must be compared with a baseline case. The steps to calculate the **design case** are as follows:

1. Create a spreadsheet listing each water-using fixture and frequency-of-use data. Frequency-of-use data includes the number of female and male daily uses, the duration of use, and the water volume per use. There are no set criteria for determining daily use or duration of use. Applicants can estimate both of these items based on the project's program requirements. With these values, calculate the total potable water used for each fixture type and gender (see **Equation 1**).

2. Sum all of the water volumes used for each fixture type to obtain male and female total daily potable water use.

3. Multiply male and female potable water volumes by the number of male and female building occupants and sum these volumes to obtain the daily total potable water use volume (see **Equation 2**).

4. Multiply total daily potable water volume by the number of workdays in a typical year to obtain the total annual potable water volume use for the building. If rainwater harvest or graywater reuse strategies are employed in the building, subtract these annual volumes from the total potable water use (see **Equation 3**).

Repeat the above calculation methodology for the **baseline case**. Use EPAct fixture flow rates for the baseline case. Do not change the number of building occupants, the number of workdays or the frequency data. Do not include graywater or rainwater harvest volumes. Sample flush and flow fixture flow rates are provided in **Table 2** and **Table 3**.

An **example** potable water use calculation is included for a two-story office building with a capacity of 300 persons. Occupant fixtures that use potable water include water closets, urinals, lavatories, kitchen sinks and showers. Calculations are based on a typical 8-hour workday and 260 workdays per year.

It is assumed that building occupants are 50% male and 50% female. Male occupants are assumed to use water closets once

Equation 1:

$$\text{Potable Water Use [gal]} = \text{Uses} \times \text{Duration [mins or flushes]} \times \frac{\text{Water Volume [gal]}}{\text{Use [min or flush]}}$$

Equation 2:

$$\text{Daily Potable Water Volume [gal]} = \text{Male Occupants} \times \text{Male Sewage Generation [gal]} + \text{Female Occupants} \times \text{Female Sewage Generation [gal]}$$

Equation 3:

$$\text{Total Potable Water Use [gal]} = \frac{\text{Water Use}}{\text{Occupant} \cdot \text{Day}}\left[\frac{\text{gal}}{\text{day}}\right] \times \text{Occupants} \times \frac{\text{Workdays}}{\text{Year}} - \text{Annual Graywater or Rainwater Harvest [gal]}$$

and urinals twice in a typical work day.

Female occupants are assumed to use water closets three times. All occupants in this example are assumed to use lavatories for each restroom use for 15 seconds and kitchen sinks once for 15 seconds. An estimated 10% of the building occupants use showering facilities on a typical day.

Water closets use graywater volumes captured from showers, sinks and lavatories in the building. Waterless urinals are used in male restrooms and these fixtures use no water. Showers, lavatories and kitchen

Table 2: Sample Flush Fixture Types

Flush Fixture Type	Water Use [GPF]
Conventional Water Closet	1.6
Low-Flow Water Closet	1.1
Ultra Low-Flow Water Closet	0.8
Composting Toilet	0.0
Conventional Urinal	1.0
Waterless Urinal	0.0

Table 3: Sample Flow Fixture Types

Flow Fixture Type	Water Use [GPM]
Conventional Lavatory	2.5
Low-Flow Lavatory	1.8
Kitchen Sink	2.5
Low-Flow Kitchen Sink	1.8
Shower	2.5
Low-Flow Shower	1.8
Janitor Sink	2.5
Hand Wash Fountain	0.5

Table 4: Design Case

Flush Fixture	Daily Uses	Flowrate [GPF]	Duration [flush]	Occupants	Water Use [gal]
Ultra Low-Flow Water Closet (Male)	0	0.8	1	150	0
Ultra Low-Flow Water Closet (Female)	3	0.8	1	150	360
Composting Toilet (Male)	1	0.0	1	150	0
Composting Toilet (Female)	0	0.0	1	150	0
Waterless Urinal (Male)	2	0.0	1	150	0
Waterless Urinal (Female)	0	0.0	1	150	0
Flow Fixture	**Daily Uses**	**Flowrate [GPM]**	**Duration [sec]**	**Occupants**	**Water Use [gal]**
Conventional Lavatory	3	2.5	12	300	450
Kitchen Sink	1	2.5	12	300	150
Shower	0.1	2.5	300	300	375
				Total Daily Volume [gal]	1,335
				Annual Work Days	260
				Annual Volume [gal]	347,100
				Graywater Reuse Volume [gal]	(36,000)
				TOTAL ANNUAL VOLUME [gal]	**311,100**

sinks are conventional fixtures and use 2.5 GPM. Motion sensors and electronic controls are used on lavatories, sinks and water closets. These devices are estimated to reduce lavatory and sink use duration by 20% but do not reduce the flow of water closets. These fixtures' duration data have been correspondingly adjusted from 15 seconds to 12 seconds. All of the above data is specific to the design case.

Table 4 provides a summary of the design case. The calculations indicate annual potable water use of 311,100 gallons.

The baseline case is calculated in the same manner as the design case except that ALL fixtures are assumed to be standard fixtures that comply with the Energy Policy Act of 1992. Also, automatic sensors are not used on any fixtures and there is no graywater reuse. Usage rates, occupancy and annual workdays are identical for the baseline and the designed building. **Table 5** provides a summary of the baseline case. The calculations estimate an annual potable water use of 620,100 gallons.

Comparison of the design case to the baseline case indicates that a potable water savings of 309,000 gallons is realized by using low-flow water closets, waterless urinals, auto controls on lavatories and sinks, and graywater reuse. This equates to a savings of 50% over the baseline case.

Other building equipment that uses potable water can also be considered for water efficiency. For instance, water-efficient cooling towers can be specified instead of conventional cooling towers. Fire suppression systems and irrigation systems are not applicable to this credit. Building equipment should be included in the design case calculations as well as in the baseline calculations.

When reusing graywater volumes from the building, it is necessary to model the system on an annual basis to determine graywater volumes generated, storage capacity of the system and any necessary treatment processes before reusing the water volumes. Graywater volumes may

Table 5: Baseline Case

Flush Fixture	Daily Uses	Flowrate [GPF]	Duration [flush]	Auto Controls N/A	Occupants	Water Use [gal]
Conventional Water Closet (Male)	1	1.6	1		150	240
Conventional Water Closet (Female)	3	1.6	1		150	720
Conventional Urinal (Male)	2	1.0	1		150	300
Conventional Urinal (Female)	0	1.0	1		150	0
Flow Fixture	**Daily Uses**	**Flowrate [GPM]**	**Duration [second]**	**Auto Controls N/A**	**Occupants**	**Water Use [gal]**
Conventional Lavatory	3	2.5	15		300	563
Kitchen Sink	1	2.5	15		300	188
Shower	0.1	2.5	300		300	375
					Total Daily Volume [gal]	2,385
					Annual Work Days	260
					TOTAL ANNUAL VOLUME [gal]	**620,100**

or may not be consistently available throughout the year because these volumes are dependent on building occupant activities.

For instance, in a typical office building, graywater volumes will change slightly due to vacation schedules and holidays but should be relatively consistent over the year. In contrast, graywater volumes in a school building will substantially decrease in summer months due to the school calendar, and, therefore, graywater volumes may not be available for non-potable applications.

If the project uses rainwater volume for non-potable uses, it is necessary to calculate water savings over a time period of one year. Rain harvest volume depends on the amount of precipitation that the project site experiences and the rainwater collection surface's area and efficiency. See **Equation 4** and consult a rainwater harvesting guide for more detailed instruction. Rainfall data is available from the local weather service (see the Resources section). Rainwater volume depends on variations in precipitation, and, thus, it is necessary to model the reuse strategy on an annual basis. A model of rainwater capture based on daily or monthly precipitation and occupant demand is helpful to determine the rainwater volumes captured and storage tank size. Subtract annual rainwater use as budgeted for flush and flow fixtures in the design case calculations.

Resources

Web Sites

American Rainwater Catchment Systems Association

www.arcsa-usa.org

Includes a compilation of publications, such as the *Texas Guide to Rainwater Harvesting*.

Composting Toilet Reviews

www.buildinggreen.com/features/mr/waste.html, (802) 257-7300

An *Environmental Building News* article on commercial composting toilets.

National Climatic Data Center

www.ncdc.noaa.gov/oa/climate/stateclimatologists.html

Useful for researching local climate data, such as rainfall data for rainwater harvesting calculations. Includes links to state climate offices.

Terry Love's Consumer Toilet Reports

www.terrylove.com/crtoilet.htm

This Web site offers a plumber's perspective on many of the major toilets used in commercial and residential applications.

Water Efficiency Article

home.earthlink.net/~wliebold

An opinion survey addressing various brands of water-efficient toilets and showerheads.

WaterWiser: The Water Efficiency Clearinghouse

www.waterwiser.org, (800) 926-7337

The American Water Works Association's clearinghouse includes articles, reference materials and papers on all forms of water efficiency.

Print Media

Water, Sanitary and Waste Services for Buildings, Fourth Edition, by A. Wise and J. Swaffield, Longman Scientific & Technical, 1995.

Equation 4:

Rainwater Volume [gal] = collection area [SF] x collection efficiency [%] x average rainfall [in] x 0.6233 gal/in

Definitions

A **Composting Toilet** is a dry plumbing fixture that contains and treats human waste via microbiological processes.

Fixture Sensors are applied to lavatories, sinks, water closets and urinals to sense fixture use and automatically turn on and off.

A **Waterless Urinal** is a dry plumbing fixture that uses advanced hydraulic design and a buoyant fluid instead of water to maintain sanitary conditions.

Also see WE Credit 1 definitions.

Case Study

King Street Center
Seattle, Washington

Courtesy of King County

Owner
King County

The King Street Center is an office building that houses several departments of the King County government. To reduce potable water use and harvest site resources, the building was designed to collect rainwater from 44,000 square feet of roof area and store it in three 5,400-gallon tanks in the basement. The water is pumped from the tanks through a filtration system and into a graywater piping system that services water closets on each floor of the eight-story building. Rainwater provides 1.4 million gallons of graywater or about two-thirds of the total water closet demand, the remainder of which is made up by potable water volumes. As a result, stormwater volumes leaving the site are reduced by about two-thirds.