Rainwater Management Solutions
Siphonic Roof Drainage And Rainwater Harvesting

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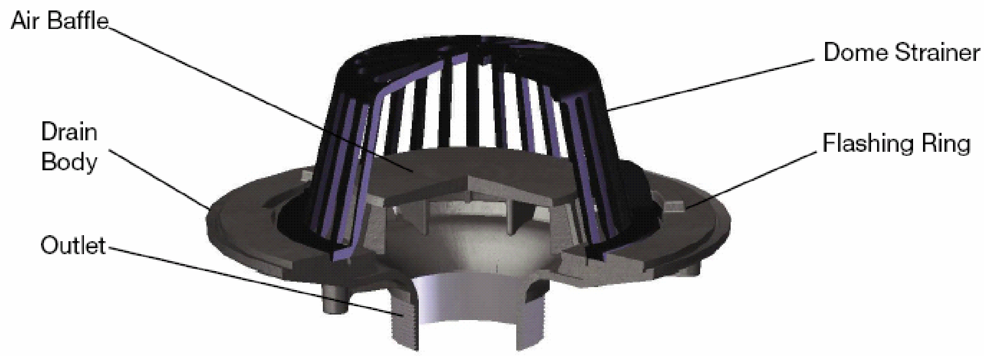
Background

Rainwater Management Solutions developed the design for siphonic roof drain, patent pending, and entered into a licensing agreement with Jay R. Smith Mfg. Co. to develop, manufacture and distribute the siphonic roof drains. In addition, Rainwater Management Solutions developed engineering software for the design of siphonic roof drainage systems.

The Siphonic Roof Drainage System

Siphonic Roof Drain Anatomy



Components of a Siphonic Roof Drain

A siphonic roof drain looks much like a traditional roof drain. The distinguishing feature of a siphonic roof drain is the air baffle. This air baffle is engineered and tested to prevent air from entering the piping system at peak flows.

Other than the baffle, a siphonic roof drain has the same features as a traditional roof drain including a cast iron drain body, flashing ring, dome strainer, and fastening hardware.

In contrast to traditional roof drains, siphonic roof drains are not designed with a large diameter or deep sump bowl because their operation is by means of sub-atmospheric pressure generated at the under side of the baffle and outlet. The depth of water maintained on the roof is dependent only on the resistance value of the drain assembly while operating under siphonic conditions. Any viscous weir effects of the drain body become minor and the flow is determined by simple inertial hydraulic effects of flow from a high pressure (atmospheric pressure at the roof surface) to low pressure (within the piping system).

Unlike traditional roof drain systems, a siphonic system is designed to operate with the piping completely filled with water during a rainstorm. Several drains tie into a horizontal collector that is routed to a convergent point where it transitions into a vertical stack. This stack, once it reaches the ground, is piped to a vented manhole or inspection-chamber where the water is discharged at atmospheric pressure and low velocity into the storm system.

The following three pages are from the Jay R. Smith Mf. Co's. Brochure "Siphonic Roof Drains – The level approach to roof drainage ™.

How Traditional Gravity Drainage Works

As seen in illustration 1, a traditional gravity drainage system consists of a network of roof drains connected by open outlet to a vertical downpipe. The pitch in the piping allows rain water to flow to a discharge point. This configuration necessitates relatively large diameter downpipes which connect into an even larger underground drainage network.

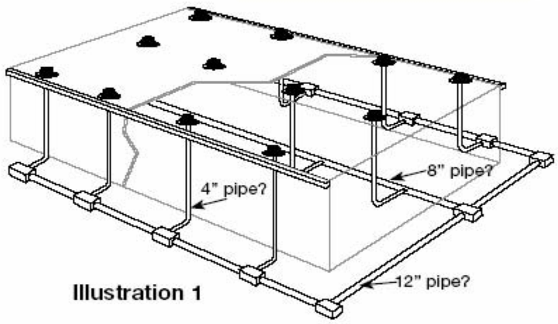


Illustration 1

A traditional system is sized and pitched to be at atmospheric pressure throughout. Since pressure is constant from inlet to outlet, the only thing inducing flow is the pipe pitch. In horizontal pipe segments, illustration 2,

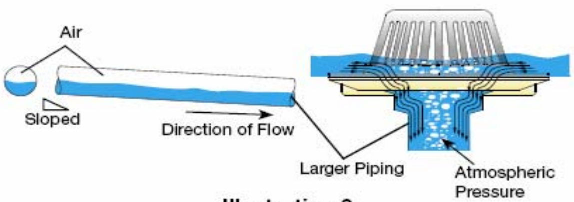


Illustration 2

water cascades along the invert of the pipe. About 1/2 of the pipe cross section is used to convey water and the remaining 1/2 is air at the maximum expected rainfall rate. Conceptually, if air can be removed, you need only 1/3 of the traditional pipe size to drain the same amount of water. Since the air is not removed, it works at only a fraction of its design capacity. This reduced capacity results in low flow velocities and poor internal cleansing of debris. This type of design is inherently inefficient in materials since large pipe sizes are specified to handle a rainfall event that may occur only a few times during the life span of a building.

How Full-Bore Siphonic Action Works

Siphonic systems induce flow by creating a full-bore continuous path of water making pitch unnecessary, illustration 3. The full-bore flow in a siphonic roof drainage system is achieved through natural hydraulic action and is not produced by any sort of mechanical element, special fitting or control. There is no need for any utilities such as electricity, compressed air, vacuum, etc.

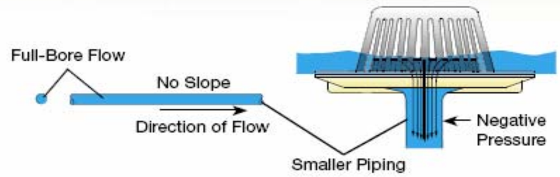


Illustration 3

Siphonic systems do not require any special installation kit or procedure. The pipe materials and fittings used with siphonic roof drains are the same as those required for traditional drainage systems. Siphonic roof drainage is not so much a 'system' in terms of a pre-engineered product or package; it is instead a technique of no-pitch pipe design used to achieve desired flow from roof drains to point(s) of discharge. With a flat, level design, long horizontal runs above overhead ceilings are possible, as shown in illustration 4. This reduces or even

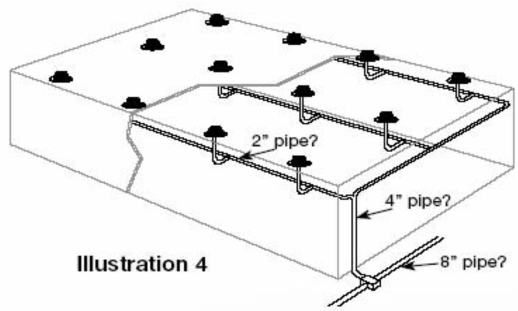


Illustration 4

eliminates the need for buried pipe and the associated costs with trenching, bedding, and backfilling. Siphonic systems are designed to operate under sub-atmospheric pressure when primed full. The horizontal piping in the system can have higher velocities than the terminal velocity that can be achieved in a traditional vertical stack. This means rain water in moved off the roof faster during the heavy but infrequent storms. During light rainfall events, that are more common, the piping still drains but in the traditional open channel flow mode. Therefore, siphonic roof drainage systems are more efficient in materials since smaller pipe diameters can be specified to handle a wide range of rainfall events.

Benefits of a Siphonic Roof Drain System

Smaller pipe diameters (reduced material cost).	Full-bore flow within the piping reduces pipe diameter as compared to open-channel, traditional gravity flow. The smaller pipe size equates to savings in material. For example, a traditionally designed system calls for an eight (8") inch pipe, a siphonic system of equal drainage capacity may need only a four (4") inch or six (6") inch pipe to drain the same quantity of water.
Siphonic action is independent of pipe pitch or gradient. No pitch is required. The invert coordination is eliminated.	Traditional systems are designed to be atmospheric throughout and rely on pipe gradient or pitch to induce flow to the point of discharge. This pitch necessitates the pipe to become increasingly lower as it runs laterally. Full-bore flow is achieved independently of pipe gradient in a siphonic system. The piping can be installed flat like any other mechanical system such as sprinklers and it simplifies coordination with other building elements. With siphonic piping being horizontal, the building height can be reduced by 3 to 4 feet, saving on construction costs.
Driving head of the system is up to 100 times that of a traditional system (i.e. height of building vs. depth on roof).	Siphonic roof drainage systems make full use of a building's height to drive the drainage capacity. The resulting higher operating velocities (3 ft/sec up to 30 ft/sec) of a siphonic system further reduce pipe size and promotes self-cleaning of debris.
Below-slab installation is minimized (reduces excavation, backfill costs and exterior underground piping).	Level installation allows for longer lateral runs overhead thereby reducing or eliminating pipe installed below slab and the associated costs of excavation, bedding and backfill. If overhead, traditional drainage pipe has to quickly drop vertically to avoid a conflict with the ceiling, structural elements or HVAC systems. If below grade, the longer the horizontal run, the deeper the pipe trench must go to accommodate pitch, siphonic systems reduce or eliminate these issues. This means there are lower site preparation costs.
Stack and horizontal pipe locations are highly flexible.	Level installation and freedom of placement of vertical stacks reduces buried pipe depths and the associated costs of trenching, bedding, shoring, and dewatering. The flexibility of stack placement also facilitates on-site rainwater harvesting systems by allowing flexibility for cistern location as well as below ground and above ground options.
Allows maximum use of open space without intrusion of drainage piping.	Smaller diameter piping conforming to structural and architectural lines present a less intrusive presence in an open area. Level installation and freedom of placement of vertical stacks reduces the size of exterior storm sewer infrastructure. The point of discharge for the roof can be concentrated to one corner typically rather than out the building in several points.

These benefits enable significant savings in terms of time and money. Experts predict that siphonic roof drainage will soon be the standard in large-roof construction similar to those found on factories, warehouses, airports, convention centers, stadiums and "big-box" retailers. However, all buildings regardless of size or height can realize the economic and technical benefits offered by siphonic roof drainage.

LEED / Green Building Design

The LEED (Leadership in Energy and Environment Design) Green Building Rating System™ was devised as a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. LEED was initially created by the U.S. Green Building Council (USGBC) to establish a common measurement to define "green building." It has since grown into a program aimed at raising awareness of and promoting integrated "green" building projects.

How does a building become a "green" building? Through design and construction that concentrates on:

- Conserving water;
- Reducing energy consumption;
- Reducing the depletion of natural resources and materials;
- Creating a sustainable site;
- Use of innovative design;
- Improving indoor environmental quality.

To become LEED certified, the building is rated by these six categories. Within each category, points are awarded based on the LEED Green Building Rating System™.

LEED awards points to building designs for a variety of energy-efficient and environmentally friendly features, from the installation of radiant heating to reduction of energy consumption, to grey water recycling, to the use of local building materials that require less energy to transport. LEED points are not given to individual products, but to an aggregate of the building system that saves water, energy, and contributes to a healthy indoor environment. An example of this is Wal-Mart's use of green building designs on a prototype store in Dallas, Texas, one feature of the design is the capture of rainwater for use throughout the building and grounds; i.e. Rainwater Harvesting.

By using Smith Siphonic Roof Drains in a siphonic design, LEED points can be awarded by for using recycled material (cast iron), reducing site preparation (less buried pipe), and extra points can be awarded by using "Innovation and Design" concepts. Additional points can be awarded if the siphonic system is used for rainwater harvesting. For more information on how siphonic systems can be used in rainwater harvesting, see page A.6

Environmental Design Credits

The benefit of using Smith Siphonic Roof Drains in a siphonic design is that this concept helps achieve the ultimate goal of USGBC: to promote buildings that are environmentally responsible, profitable and a healthy place to live and work. Here's how to get design credit:

❒ **SS Credit 5.1 "Reduced Site Disturbance" – 1 Point (14 possible points under Sustainable Sites)**

Reduced, shallower trenching – *"On greenfield sites, limit site disturbance including earthwork and clearing of vegetation..."*

Did you know that a siphonic roof drain system requires less site preparation?
In a siphonic system there is a de-pressured flow (a higher flow capacity since pipe is a full-bore) which means there is much more flexibility where pipe routing is concerned – thus the pipe work can be run just horizontally below the roof rather than below ground; this means there is less need for groundwork such as site trenching, bedding, and backfilling.

❒ **SS Credit 6.1 "Stormwater Management, Rate and Quantity" – 1 Point (14 possible points under Sustainable Sites)**

Controlled flow roof drainage – *"Limit disruption of natural water flow by minimizing stormwater runoff, increase on-site infiltration and reducing contaminants."*

Did you know that a siphonic roof drain system can reduce stormwater runoff from the roof?
In a siphonic system several roof drain outlets can be connected to a single vertical discharge pipe reducing the number of discharge points. And fewer discharge points mean the water can be easily routed for storage and reuse. This in turn controls the amount of rainwater being fed into the stormwater systems or runoff area. Once the water is stored it can be used for landscaping irrigation, toilet and urinal flushing, and custodial uses.

❒ **WE Credit 3.1 & 3.2 "Water Use Reduction" – 1-2 Points (5 possible points under Water Efficiency)**

Rainwater harvesting

Sewage conveyance and landscape irrigation – *"Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater system."*

Did you know that a siphonic roof drain system can be used successfully with water harvesting?
A siphonic system allows for piping to a water harvesting system so that it can be stored and used for non-potable applications such as toilet and urinal flushing, mechanical systems, and custodial uses.

❒ **MR Credit 4.1 & 4.2 "Recycled Content" – 1-2 Points (13 possible points under Material & Resources)**

Products incorporate recycled content materials – *"During construction, ensure that the specified recycled content materials are installed and quantify the total percentages of recycled content materials installed."*

Did you know that most cast iron is "green?"
Most cast iron drainage products use 100% post-consumer recycled materials and can be re-melted and recycled after their useful life. Such is true with all Jay R. Smith Mfg. Co., cast iron, plumbing and drainage products and our siphonic roof drains.

❒ **ID Credit 1.1 "Innovation in Design" – 1-2 Points (5 possible points under Innovation &Design Process)**

Reduction in construction materials – *"Award points for exceptional performance above the requirements set by the LEED Green Building Rating System™."*

Did you know that a siphonic roof drain system is an innovative design?"
A siphonic roof drain system allows for smaller diameter piping and more flexibility where pipe routing is concerned. These characteristics enable significant savings, of time and money, in the construction of large industrial or commercial buildings. The need for vertical rainwater piping inside a building can be eliminated, saving approximately .5 m2 per absent down piping. This allows greater flexibility in the use of space within open-plan buildings, permitting larger uncluttered areas in large public structures.

Siphonic Roof Drain Technical Standards

Technical Standards have been issued by the American Society of Plumbing Engineers (ASPE) for Siphonic Roof Drainage System Design.

This standard eliminates the requirement to seek approval for installation of an alternative roof drainage system as a variance to the conventional gravity based roof drainage system standard.

John Rattenbury, P.E., was Chairman of the committee drafting the standards

The American Society of Mechanical Engineers developed a standard for siphonic roof drains (A112.6.9 ”Siphonic Roof Drains”) which was approved by the American National Standards Institute (ANSI) 0n July 8, 2005.

EXAMPLES OF PRIOR ENGINEERING DESIGN SERVICES

Siphonic Roof Drainage Systems:
Designed by Engineer – John Rattenbury, P.E., LEED ap

Ikea Stores:
Atlanta, Georgia
Westchester, New York
Portland, Oregon
Round Rock, Texas
Toledo, Ohio

Target Stores:
Richfield, Minnesota
Bronx, New York
Currently Providing Design Services for Target Corporation

Western Virginia Regional Jail

The Art Museum of Western Virginia

Warehouse at JFK Airport in New York

General Motors Building, Toledo, Ohio

Oscar Smith Middle School, Chesapeake, Virginia

Dance Studio, Richmond, Virginia

Rainwater Harvesting Systems, Commercial Applications:

Portsmouth Naval Hospital Laundry, Portsmouth, Virginia

Carilion Health Systems Hospital, Radford, Virginia

Western Virginia Regional Jail

The Art Museum of Western Virginia

Oscar Smith Middle School, Chesapeake, Virginia

SIPHONIC ROOF DRAINAGE DESIGN SERVICE REFERENCES

John Bemben	Greenberg Farrow Architect www.greenbergfarrow.com	732-537-0811
Carlos Burbano	Glickman Engineering, PC www.gepc.net	212-643-8006
Todd Pugh	John E. Green, Contractor www.johnegreen.com	313-868-2400
Julius Ballanco	JMB Engineering www.jmbengineering.com	219-922-6171
Tom Peterson	SSOE, Inc. Architects and Engineers www.ssoe.com	419-255-3830

Rainwater Harvesting

Rainwater harvesting may be utilized for recycling the rainwater for numerous applications including: irrigation, fire suppression, toilet flushing, chilling tower water makeup, potable uses in non – public spaces, commercial laundry water supply, car washing, roof cooling, and water features.

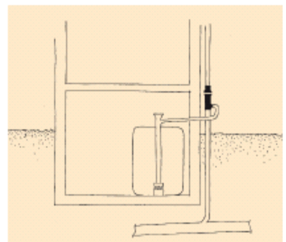
Rainwater harvesting may be used in conjunction with siphonic roof drainage systems or independent of the siphonic system.

Rainwater Management Solutions utilizes the Wisy products for first flush of the rainwater and floating filters in the cisterns. The first flush filters are vortex filters and require little maintenance. The following pages, 10 through 12, contain pictures of the Wisy rainwater harvesting components and the Vortex filters.

Page 13 illustrates a rainwater harvesting system utilizing a siphonic roof drainage system.

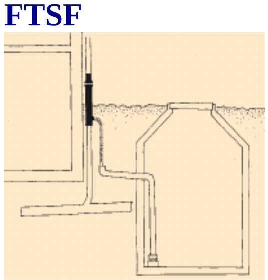
Rainwater Harvesting System Components

Filter Collector SF



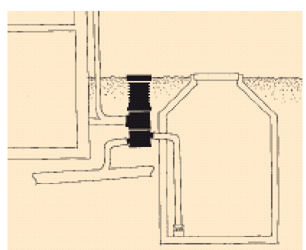
For installation round down pipes with connection to interior storage tanks.

Standpipe Filter Collector FTSF



For installation round down pipes with connection to in ground storage tanks.

Vortex Fine Filter WFF 150

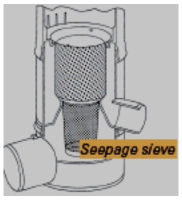


To be connected to standard storm water pipes below ground, for roof areas up to 5,500 sq ft,

Vortex Fine Filter WFF 300

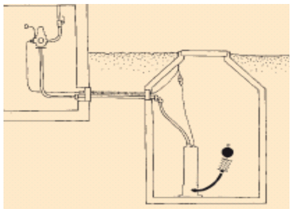
For roof areas up to 33,000 sq ft. May be configured, with a steel cap, for vehicle loads of 12 tons and 60 tons.

Cross Section Vortex Fine Filter WFF 150



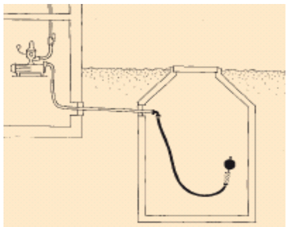
Floating Filter Connection to Sump Pump

Basket to capture debris if overflow is to be used



Configured with either a fine .3mm mesh filter or a coarse 1.3mm mesh filter

Floating Filter Connection to Vacuum Pump



Configured with either a fine .3mm mesh filter or a coarse 1.3mm mesh filter

WISY
VORTEX FINE FILTERS

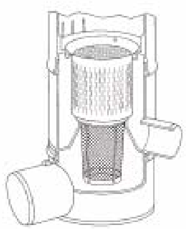
- Clean water for domestic, industrial and commercial applications
- Fit to rainwater drainage system
- Meet completely drainage standard 1986
- Unique fine filtration separates both coarse and fine debris, diverting it into sewerage or soakaway
- High efficiency
- Easy cleaning of filter insert

WISY®

Products For Rainwater Harvesting

VORTEX FINE FILTER

WISY Vortex Fine filters:
3 different sizes available.
WFF100 for up to 200 m²
WFF150 for up to 500 m²
WFF300 for up to 3000 m²



Should the WFF have to lead the excess water to a soakaway - instead of a drain - this sieve will be installed additionally in the filter insert. It catches the larger dirt particles and as a result it must often be emptied and cleaned.

Improvement of filtration through perforated surface

The unique WISY filtration provides highly clean rainwater to store it in a tank. Thus ensuring durability and reliability of the whole system.

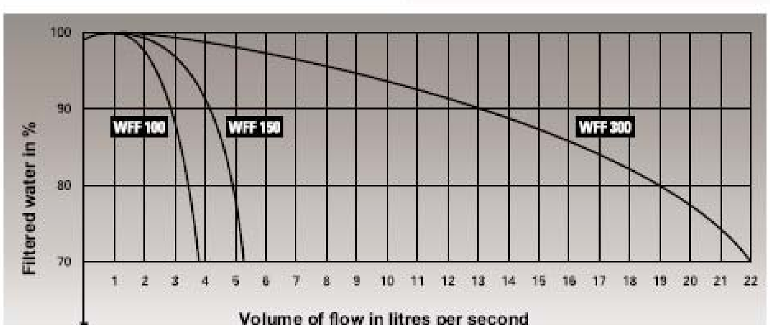
The simple but high precision WISY filters use surface tension (adhesoin) in conjunction with a fine stainless steel filter mesh which exclude all unwelcome particles. By this process about 90 % of the rainwater is captured, filtered and diverted into a storage tank, while the remaining water carrying leaves and other debris is redirected into the sewer or soakaway.

The full cross-section of the rainwater drainage system remains continously open in these filter devices. No contamination and no danger of blockages. This is especially important in hail storms and torrential rainfall.

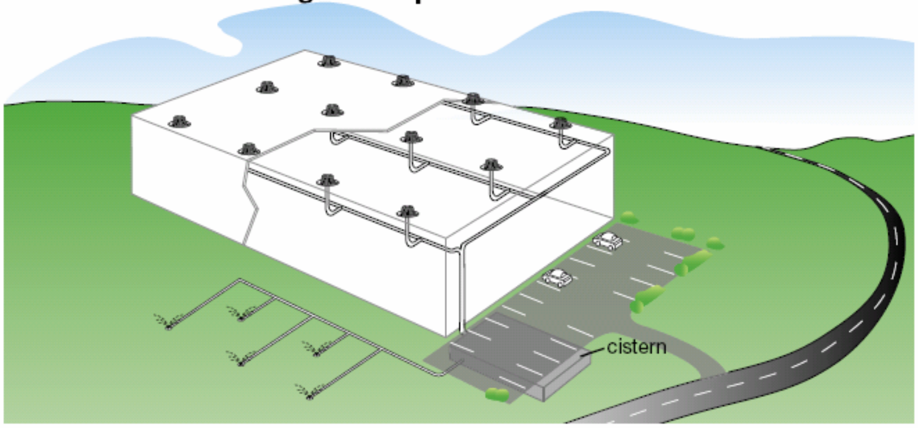
The filter inserts require only little maintenance, cleaning from time to time is recommended depending on the environment

Ideally collecting roofs should be of tile or slate. Green roofs due to high evaporation are less recommendable.
Asbestos or heavily soiled roofs should not be used for rainwater collection.

Efficiency ratio Vortex Fine Filter, tested with brandnew filters.



Rainwater Harvesting and Siphonic Roof Drains



Benefits of Siphonic Roof Drains in Rain-water Harvesting

- Water is collected below grade in more convenient location
- Cistern depth is minimized by level siphonic pipes
- Water is available for beneficial use in and around building
- Water overflows to swale or storm drain.
- Valuable roadside property is avail-able at cistern below ground

A siphonic roof drainage system is one of the most effective technologies offered for capturing rainwater from a building roof top to aid in implementing rainwater harvesting. In a siphonic system several roof drain outlets can be connected to a single vertical discharge pipe. Fewer discharge points and no requirement for pitch in the piping means the rainwater can be easily routed horizontally below the roof to a storage tank or cistern. The stored rainwater is now available for use in non-potable applications such as toilets and urinal flushing, mechanical systems, custodial uses, and for site irrigation.

One of the major benefits of designing a building with siphonic roof drainage and rainwater harvesting systems is reduced overall construction and facility operation costs.

Additional benefits include reduced discharge of rainwater to lakes, stream, rivers and sanitary systems, and decreased dependence on municipal water supplies.

Benefits of Rainwater Harvesting:

1. Industrial and Commercial Use

   a. Water Conservation
      i. Site irrigation,
      ii. Toilet and urinal flushing,
      iii. Janitorial use, and
      iv. Fire protection.

   b. Reduced Municipal Water Consumption and Industry Uses
      i. Car washes,
      ii. Commercial laundry,
      iii. Process water (e.g., microelectronics, metal molds, electroplating, printing, etc.),
      iv. Evaporative cooling tower make-up,
      v. Mechanical equipment make-up water, and
      vi. Evaporative cooling of roof surface (reduction in A/C load).

   c. Stormwater runoff reduction
      i. Assists storm water NPDES permitting,
      ii. Allows for better use of property (e.g., less area used for on-site detention),
      iii. Above ground and below ground storage (cisterns) reduce mosquito nuisance on site,
      iv. Decreases soil erosion and local flooding by reducing run-off rate and quantity,
      v. Improves water quality to near by streams, rivers, and water sheds.

   d. Can offset "Roof Top Taxes" imposed by local and state authorities.

   e. Promotes good public relations (i.e., showing a positive environmental concern by eliminating run-off).

2. Military Use

   a. Can be used for all industrial/commercial uses listed above,
   b. Decreases dependency on delivered water supplies, and
   c. Can serve as reserve source if primary water supply is contaminated.

3. Residential Use

   a. Water Conservation
      i. Lawn and garden irrigation,
      ii. Toilet flushing,
      iii. Laundry,
      iv. Car washing,
      v. Filling pools and hot tubs, and
      vi. Residential fire protection supply (can reduce insurance premiums).

   b. Reduced dependency on strained municipal water supplies
      i. Reduce monthly water bill by reducing municipal water needs,
      ii. Avoid water restrictions by collecting your own water,
      iii. Reduce or eliminate need for water treatment systems (e.g., softeners),
      iv. Adds sale/resale value to homes with reduced water bills and fewer water restrictions.

4. Supplement or replace well sources of low yield or water quality

   a. Rainwater is naturally soft (low in mineral content)
      i. Reduces/eliminates water softening equipment, and
      ii. Reduce the amount of detergent needed for laundry.

   b. Can be used to supplement low volume wells instead of drilling additional or deeper wells.
   c. Can enable development in areas without sufficient municipal or well water sources.
   d. Can enable development adjacent to wetland areas and streams due to reduction in rainwater discharge rate and quantity to surrounding waters.
   e. In many cases can be used as potable water supply (can be completely "off the grid" where necessary).