Case Studies

Rainwater Harvesting Systems

Case studies assembled December 2024. The ongoing list will be expanded as more case studies are received.

Note: P = potable and NP = Non-potable

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Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Austin Community College – Highland Campus Garage
Austin, Texas

Rainwater System Designer
Innovative Water Solutions LLC
Austin, Texas

Project Overview

Austin Community College (ACC) converted the old Austin Highland Mall complex into a new campus location. The ACC Highland Parking Garage was constructed as a new structure for the campus. It houses a rainwater harvesting system underneath the structure. Incorporated into the structural design of the garage, a rainwater harvesting cistern was constructed under the garage. The cistern measures 100' x 90' and it is separated into two separate sections with an internal support wall. The ultimate water height in the cistern is 7'. Therefore, the total storage volume is 450,000 gallons. Rainwater is actually harvested from the surrounding existing buildings with a total collection area of approximately 92,000 square feet. In central Texas, this collection area has the potential to harvest 1.75 million gallons of rainwater during an average year of rainfall.

The complete rainwater harvesting system is composed of an underground inlet filter vault that houses three up flow filter units, a poly liner to prevent any future issues with cracks or leaks in the concrete, and a duplex submersible pump system to pressurize the rainwater for use in the irrigation system in a new park that was developed as a campus amenity.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Anodamine, Inc.
Lago Vista, Texas

Rainwater System Designer
Innovative Water Solutions LLC
Austin, Texas

Project Overview

Anodamine is a chemical manufacturing company that produces a non-toxic waterproofing metal protection product. They desired to use harvested rainwater in their manufacturing processes to reduce water costs. IWS designed and installed this system that incorporates six 9,200-gallon storage tanks due to the location constraints. The collection pipe system harvests rainwater from approximately 7,350 square foot of roof area. In central Texas, this will provide a potential collection volume of 140,000 gallons during an average year of rainfall.

The rainwater harvesting system employs an automatic first flush diverter system that will allow the first flush of rainwater off the roof surfaces to be wasted and not collected. The six tanks are connected in series with a 4" equalization pipe. This 4" pipe runs into the building to the rainwater pump system that pressurizes the rainwater for use in their manufacturing processes. If the rainwater level in the cisterns gets below 24" of depth, an auto-fill system will supplement the cisterns with municipal water.

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Carilion New River Valley Medical Center
Christiansburg, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Carilion New River Valley Medical Center (NRVMC), comprising a modern hospital facility and adjacent medical office complex in Christiansburg, VA. The Center is a leading health care provider to the city of Radford, VA and the surrounding seven- county region.

Challenge: Reduce or eliminate the rate and quantity of storm water run-off to neighboring properties. Reduce the use of municipal water in the cooling plant's evaporative cooling towers. Reconstruct the storm discharge swale into a detention pond to act as a supply for the evaporative cooling towers and site irrigation systems.

Application: A Reverse Osmosis system and pre-filter were used to clean and recycle the cooling tower condenser water loop to reduce system blow-down.

Benefits: Reduction of 15,000 gallons of blow-down water and municipal water makeup per day. Reduction in the cost of municipal water of $10.00 per 1000 gallons of water and sewer provided. The return on the system investment is less than two years.

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Climate Pledge Arena Rain to Rink
Seattle, Washington

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

The site selected for Seattle's hockey team, the Kraken, was originally developed for the 1962 World's Fair. It was originally named KeyArena and home to Seattle's NBA Team, Supersonics. Redevelopment of the site began mid-December of 2018. Jeff Bezos purchased the naming rights to the arena with the idea "call to action on climate change" and creating a carbon neutral sustainable building. He ultimately decided on the name Climate Pledge Arena and implemented progressive sustainable practices such as carbon zero energy, zero single use plastics, zero waste, and water conservation.

The Climate Pledge Arena has a total of 740,00 SF, 40,000 SF is used as the collection source for the rainwater harvesting system. A WFF300 Vortex Filter is used to pre-filter the collected rainwater prior to entering the 15,000 gallons below ground fiberglass tank. Submersible pumps were located inside the tank and pumped the water to the 50 gallon per minute filtration skid. The treated water is then stored in a 1,000-gallon day tank, ready for use. The water is then pumped via duplex booster pump system to create ice for rink, toilet flushing, and irrigation.

An unexpected challenge appeared when the ice rink was "too clear" and required additives to create the white ice we're all familiar with. This was due to a reverse osmosis system being required by the jurisdiction for ice creation

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

CODE Building
Charlottesville, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

For the flagship Center of Developing Entrepreneurs (CODE) building which opened in 2021 along the iconic Downtown Mall in Charlottesville, VA, the architect's commitment to sustainability extends to a rainwater harvesting system from Rainwater Management Solutions (RMS). The system prefilters rainwater from rooftop areas, stores the rainwater in a concrete cistern integrated into the building sub-basement level. An RMS treatment skid is housed in a nearby mechanical space where the water is treated and pumped up to nine stories to irrigate rooftop garden spaces on several different levels. RMS utilized a custom-built filtration skid with an integrated high-performance pump specifically used to achieve the height needed to bring the water to the upper terraces. The CODE Building was an exciting project for RMS, as it is not far from RMS headquarters in Roanoke, VA, and it's also a strong statement regarding the commitment to sustainability in the state of Virginia. The CODE Building is Certified LEED Platinum.

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Concho Valley / Master Gardener Demonstration Garden
Tom Green 4-H Center
San Angelo, Texas

Rainwater System Designer
Texas A&M AgriLife Extension
Texas

Project Overview

The Concho Valley Master Gardeners propagate over 6,000 well-adapter and drought-tolerant plants in greenhouses at the Tom Green 4-H Center to sell their annual fundraiser. The rainwater harvesting system consists of three 3,000-gallon tanks, providing water to the greenhouse and demonstration garden beds. Other features include a rain garden, a 50-gallon wildlife guzzler, and a small collection system to divert water from the front awning to a second, plumbed wildlife dripper. The rainwater harvesting system also serves as an educational feature, providing information and inspiration to interested homeowners to start their own rainwater harvesting systems which can help further the conservation of groundwater and surface water in the Concho Valley area.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Deep Eddy Vodka Distillery
Dripping Springs, Texas

Rainwater System Designer
Specified Water Systems
Austin, Texas

Project Overview

Rainwater is captured off the building and conveyed through plumbing to the tank. The rainwater is utilized for irrigation purposes on site. The 4,000 gallon rainwater tank is a CorGal® 0803 WT FS.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Elysian Brewery
Georgetown Seattle, Washington

Rainwater System Designer
Northwest Rain Solutions
Bellingham, Washington

Project Overview

Application: Rainwater Catchment Tanks for Stormwater Retention and Slow Release. Pre-filtration: WISY 6” prefilter. Tanks: 12,000gal Corrugated Steel and 5,000gal Polyethylene Tanks.

Problem: Elysian Brewery located in Georgetown Seattle needed to manage stormwater on-site from the new 33,000 square foot warehouse roof. There was little room to include bioretention or other form of stormwater management onsite, so the best option for managing the runoff was to incorporate rainwater harvesting systems to retain the initial peak flow from rain events. This would be stored in the tanks with the initial rain but slowly drain to the municipal stormwater system over a period of time, emptying the tank for the next rain event.

Three rainwater harvesting systems were designed on the site to retain more than 27,000 gallons of peak flow, which slowly drains through ½” orifices located in each tank. The orifices are located 12” above the floor of the rainwater catchment tanks. This provides “dead storage” where the bottom 12” of rainwater at the bottom of the tank settle additional sediment.

- The downspout from the roof is directed to a 6” WISY vortex pre-filter that removes the large debris from entering the tanks.
- The Corrugated steel tank is assembled on the concrete pad at the entrance of the new building.
  - The corrugated steel tank has a capacity of nearly 12,000 gallons that retains the stormwater runoff from more than 15,000 square feet roof area.
  - Two 5,000-gallon Plastic Tanks located in the back of the warehouse. Manages more than 10,000 square feet of roof area.

  - The Plastic tanks are set side by side and connected at the bottom with a 3” pipe. When one tank fills the rainwater equalizes to the other tank through this pipe
  - There is a ½” orifice at the bottom of each tank 12” up from the bottom to slowly release stormwater before the next rain event.

End Result: Stormwater from the new warehouse roof is managed by retention and slow release to reduce *combined sewer overflow* events during heavy rainstorms.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Horse Farm
Marshall, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: Collect water onsite to supply demands on the sport horse farm.

Application: Installed 35,000 gallons of water storage. Utilized a new modular tank storage system. Wisy vortex fine filter.

Benefits: Reduced municipal and groundwater demands. Determined tank formation (length x width x height) based on terrain due to modular tank system. Supplied water for farm demand.

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Lady Bird Johnson Wildflower Center
Austin, Texas

Rainwater System Designer
Specified Water Systems
Austin, Texas

Project Overview

Rainwater is captured off the pavilion and conveyed through an aqueduct system to the tank. The rainwater is utilized for the watering hole, Dinosaur Creek and Hill Country Grotto Waterfall. The tank is a CorGal ® 1203 WT INV.

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

LCRA Redbud
Austin, Texas

Rainwater System Designer
Specified Water Systems
Austin, Texas

Project Overview

Rainwater is captured off the building and conveyed through plumbing to the tank. The rainwater is utilized for irrigation purposes on site. There are 3-CorGal® 0904 WT CHR's that are 6,700 gallons each.

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Lowertown Ballpark – CHS Field
St. Paul, Minnesota

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Located in St. Paul, Minnesota, the Lowertown Ballpark - CHS Field reduces potable water use by collecting rainwater and stormwater. 33,770 square feet of roof is used to capture the rainwater with the use of vortex filters. The rainwater is then conveyed to a 27,000-gallon cistern and is reused for irrigation and toilet flushing. An estimated 450,000 gallons of potable water is saved with this system annually.

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Metropolitan Atlanta Rapid Transit Authority (MARTA)
Atlanta, Georgia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

We helped MARTA become better environmental stewards by implementing a rainwater harvesting system that effectively reduces the impacts of stormwater runoff onsite and provides irrigation for the grounds without using potable water. The rainwater is harvested from train stations to supply water for irrigation plant material onsite and utilizes our WISY WFF150 filters and is stored in 3,100-gallon tanks.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Naples Children's Museum
Naples, Florida

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

We assisted Naples Children's Museum in implementing a rainwater harvesting system to provide irrigation to their grounds without using potable water in addition to supplying their toilets and water features and helping them become environmental stewards. The rainwater is collected from the roof and is pre-filtered by a WISY WFF300 vortex filter and then flows into one 10,000-gallon cistern, which remove particulates greater than 380 microns from the collected rainwater.

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Nike
Byhalia, Mississippi

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

The Nike Distribution Facility located in Byhalia, MS set out to reduce the environmental impact of their distribution facility by collecting and reusing rainwater runoff. Rainwater Management Solutions was selected to help turn their goal of collecting and reusing the water runoff from the facility into a reality. After further analysis, Nike was able to reuse the collected water runoff for toilet fixtures accounting for up to 500 gallons per day of water demand. The water runoff is diverted into a larger vortex filter to separate debris greater than 380 microns from entering the collection tank. The water is stored in a 4,200-gallon underground HDPE tank from Advanced Drainage Systems (ADS). The water is then pumped up through the RMS packaged filtration and purification system so that it is ready for reuse at the toilet fixtures.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Port of Gray's Harbor
Aberdeen, Washington

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

To assist Port of Gray's Harbor in Aberdeen, Washington in their desire to become environmental stewards, RMS helped them implement rainwater harvesting to provide irrigation to their grounds without using potable water. To harvest rainwater from this incubator facility, rainwater is collected, pre-filtered using two WISY WFF300 vortex filters, and then collected into two 8,700-gallon corrugated steel rainwater tanks.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Scheels Eden Prairie Center
Eden Prairie, Minnesota

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

The rainwater harvesting system for the Eden Prairie Center was designed according to ARCSA/ASPE/ANSI Standard 63. Rainwater is collected from 130,680-square foot rooftop and stored in four below ground storage tanks with a combined capacity of 52,000 gallons. The collected water is reused for toilet flushing and irrigation. It is estimated to save 405,840 gallons per year for toilet flushing alone and up to 1.2 million gallons per year in irrigation demand.


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The Journal for Surface Water and Erosion Control Professionals
Coronavirus
How the industry is weathering the storm
A National Standard for Permeable Pavers
Rainwater Capture and Harvesting
Whitewater Park Provides Stormwater Benefits

A rendering of the completed retail store.

Saving a Rainy Day

Rainwater capture at a Minnesota shopping center supports conservation and stormwater management goals

BY KATHY GEE

The Eden Prairie Shopping Center in Eden Prairie, MN, which originally opened in 1976, offers shopping, dining, and entertainment options to residents throughout the southwest suburbs of Minneapolis and St. Paul. A recent renovation project involved the redevelopment of an empty retail store and associated parking areas to accommodate a new 250,000-square-foot Scheels retail store. Environmental sustainability was a primary objective of this redevelopment project and was evident in numerous design components, including the reduction of impervious surfaces to the maximum extent practicable, the reuse of stormwater collected onsite, and the preservation of existing drainage patterns (i.e., low impact development principles were employed whenever possible). This project serves as an excellent example of how potable water conservation and stormwater management can be integrated to maximize sustainability and environmental benefits despite challenging site constraints.

The 22.7-acre site is comprised primarily of paved parking, an existing mall building, and small landscaped areas. Post-development impervious area totaled 19.57 acres, or roughly 86% of the total site; this was a decrease of 0.66 acres compared to pre-development conditions. Site constraints including low permeability soils, soil contamination, and minimal usable area presented unique challenges when designing the site layout and stormwater control measures. Geotechnical reports revealed that underlying soils are primarily clay or clayey sand with a hydrologic soil group (HSG) rating of "D." Additionally, contaminated soils were discovered in the project area. Per state guidelines and recommendations made by the geotechnical engineer, stormwater infiltration was not permitted within 100 feet of the known source of contamination, and mounding calculations were performed to help ensure groundwater contamination would not occur as a result of the stormwater control measures (SCMs) used onsite.

Grading, layout, and SCMs for the site were carefully designed by LHB Inc. to meet jurisdictional stormwater requirements, reflect low impact development concepts, and conform to the various site constraints. The primary stormwater mitigation goals were to minimize peak flow, total suspended solids

All images: LHB Inc.

(TSS) loading, and total phosphorus (TP) to the maximum extent practicable. A total of seven SCMs were implemented to mitigate stormwater on the site: three infiltration basins, three sand filters, and one rainwater harvesting and reuse system. Though limited due to the poor-draining clayey subsoils, infiltration practices were used as much as possible to maximize stormwater volume reduction; these practices were located a minimum of 120 feet away from soil contamination and within the boundaries of planned disturbance.

The infiltration basins and sand filters, as traditional stormwater control measures, provided stormwater mitigation for a large portion of the site; however, a unique component of the overall development plan was the rainwater harvesting and reuse system. A large non-potable water demand, coupled with the need for reducing stormwater volumes, created an ideal situation for implementing this practice.

The rainwater harvesting and reuse system, designed by Rainwater Management Solutions (lead system designer), LHB Inc. (civil, mechanical, landscape architecture), MLC Irrigation Consultants (irrigation design), and Vareberg Engineering (electrical), was designed according to the specifications set forth in the ARCSA/ASPE/ANSI Rainwater Harvesting Standard 63 and accepts runoff from the 130,680-square-foot rooftop of the retail store. Water stored in the system is used to flush toilets and urinals within the retail store and for landscape irrigation. Water demand was estimated based upon an average of 95,000 customers per month, resulting in an estimated annual toilet water demand of 1,110 gallons per day, or 405,840 gallons per year. The irrigation system designer provided volume estimates that varied by time of year and totaled 1.2 million gallons per year.

The size of the storage tank was selected based upon input to the tank via precipitation from the roof area and the water used from the tank to meet onsite demands. A time-series modeling analysis was performed to identify the minimum volume beyond which increasing tank size resulted in only a minimal increase in the water supplied for use (in other words, to identify the point of diminishing returns); the ideal storage volume for this system was determined to be 52,000 gallons.

Four 13,000-gallon underground storage tanks, hydraulically connected and thus acting as a single system, were installed below the loading dock area adjacent to the store building. Runoff from the store's roof first enters a series of parallel vortex filters that provide filtration to remove large particulate matter greater than 380 microns as well as aeration to reduce anaerobic bacteria and enhance the precipitation of heavy metals such as iron. These filters are virtually self-cleaning and are able to handle large flow rates, although if the flow exceeds the design capacity of the filter it will overflow to the existing stormwater system. Filtered water then enters the storage tanks via smoothing inlets, directing it upwards, to prevent the resuspension of sediment and debris that accumulates on the bottom of the tank. These smoothing inlets also effectively mix the water within the tank, providing aeration and discouraging the development of low-oxygen zones. When the inflow of runoff exceeds the storage capacity, the tanks overflow through skimming overflow siphons that prevent backup from the stormwater system into the tank or any introduction of debris. The skimming nature of the overflow remove any floating debris, such as pollen, from the water surface. This overflow is directed to an infiltration basin for further treatment and volume reduction.

The four underground storage tanks can hold a combined total of 52,000 gallons of rainwater.

Water is extracted from the storage tanks via a floating intake connected to a submersible pump. The intake pulls water from just below the water surface to avoid floating particulate matter and debris that has settled to the bottom of the tank, thus minimizing the potential for clogging. The submersible pump is controlled by a float switch, thus preventing the pump from

A large non-potable water demand and the need to reduce stormwater volumes made rainwater harvesting an ideal solution.

running when the tanks are empty by triggering domestic water from the city as the back-up source. Water from the tanks is pumped through a series of filtration components, then to a purified water holding tank (day tank). The treatment process for extracted water begins with a 5-micron sediment filter to reduce turbidity and allow for effective disinfection. Water then passes through a carbon filter to remove organics and water and is this disinfected by ultraviolet (UV) light. The day tank stores 1,000 gallons of purified water to allow the system to meet peak flow demands from the building. Once the day tank is full, a float switch deactivates the submersible pump in the storage tanks and prevents the introduction of anymore water. A domestic backup line is plumbed to the day tank with an air gap to prevent contact between the domestic water and the treated rainwater. A booster pump located within the day tank, activated/deactivated via a float switch, distributes treated water into the building (for toilets and urinals) or to the outdoor irrigation system. The system is equipped with flow meters at multiple locations to measure the volume of water used for irrigation, the volume used for toilets/urinals, and the volume of domestic water used for backup. Additionally, an interactive control panel allows system operators to view water levels within the storage tanks and day tank, access water usage data, and view the system alarm history, among other things.

Installation of the system. The ends of the buried storage tanks can be seen on the right.

Because stormwater mitigation provided by the system relies on the usage of stored rainwater, the system was designed with a unique backup option for years when precipitation or system operation deviates from normal enough to affect stormwater mitigation performance. A pipe connects the rainwater storage tanks to the nearby infiltration basin and water can be pumped from the tanks to the infiltration basin. The system allows for the pump to be manually operated or operated via a float switch that is set at a pre-determined level (i.e. if the tank is at a high level for an extended period of time, the float switch activates the pump to deliver a certain volume of water to the infiltration basin). This feature—as well as manual operation of the pump—can be conveniently accessed via the system's control panel. An example of when this option would be utilized might be during an abnormally wet year; if irrigation is not meeting the estimated designed demand, system operators can program the system to pump the equivalent volume to the infiltration basin so as to maintain the stormwater mitigation performance required by jurisdictional stormwater requirements.

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Rainwater harvesting can reduce stormwater volumes and provide a reliable source of water for meeting onsite demands, reducing demand on local potable water sources.

Hydraulic modeling indicates that the rainwater harvesting and reuse system will accommodate at least 62% of the yearly demand for toilet/urinal flushing and irrigation while simultaneously reducing runoff volume from the contributing drainage area by 3 acre-feet (130,680 cubic feet). Additionally, it is expected to remove 3.7 pounds of phosphorus and 493 pounds of total suspended solids annually via volume reduction. The linked infrastructure of the rainwater harvesting system and other SCMs allow the site to meet not only the regulatory requirement of stormwater volume and peak flow rate reduction but also includes cost savings in municipal water use as well as substantial stormwater water quality improvement (great than 90% and 60% removal efficiency for TSS and TP, respectively).

This site exemplifies how several low impact development concepts can be combined to achieve significant sustainable benefits. While stormwater volume mitigation can be achieved by various SCMs, rainwater harvesting is the only one that can concurrently provide a reliable source of water for meeting onsite demands, thereby reducing demand on local potable water sources. And while the overall design principle of a rainwater harvesting system is standard, simple design modifications, such as the option to pump stored rainwater to another SCM, can ensure required stormwater mitigation occurs despite varying precipitation and usage patterns without significant added cost. It is likely that a majority of development projects, both new development and re-development, could benefit from the incorporation of a rainwater harvesting and reuse system such as the one implemented at the new Scheels store of the Eden Prairie Center. For more information regarding the design and use of rainwater harvesting systems, visit the website of the American Rainwater Catchment Systems Association (ARCSA) at *www.arcsa.org*.

Dr. Kathy Gee *joined Dr. Bill Hunt's Stormwater team at NC State University in 2008 as an Extension Associate and earned her PhD under Dr. Hunt in 2013. Kathy joined Longwood University in 2013, where she earned tenure as an Associate Professor in 2019. Her research efforts focus on characterizing the hydrologic, water quality, and social benefits of rainwater harvesting systems and other stormwater management practices.*

Rainwater Harvesting Case Study: Seagate Media Research Center

by David Crawford, T.J. Smith, and Casey Richey

Data storage company Seagate decided to integrate a rainwater harvesting system at its Media Research Center in Fremont, California to reduce demand on the municipal water supply and the impacts of stormwater runoff.

FACILITY BACKGROUND

The facility is the former home of solar-panel manufacturer Solyndra, but Seagate purchased it in 2013 to house research and development projects. The facility has more than 62,000 square feet of roof area from which rainwater can be collected. With an average annual rainfall total of about 16 inches in Fremont, the facility has the potential to collect more than 580,000 gallons of rainwater each year (see Figure 1).

Steven Deason, the Executive Director of Facilities for Seagate, wanted to reduce municipal supply demand and create a sustainable environment for the software company's research facility.

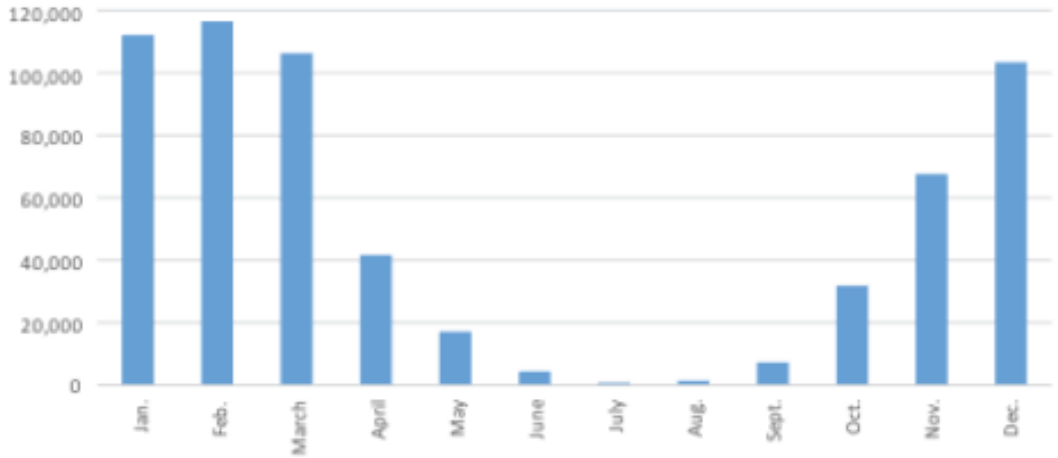
RAINWATER SYSTEM DESIGN

The collected rainwater is used to supply nonpotable uses such as toilet and urinal flushing, scrubber makeup, and cooling tower makeup.

The rainwater collected from the roof is filtered by two WISY WFF300 vortex filters (see Figure 2), which remove particulates greater than 380 microns from the collected rainwater. The clean water then flows into one of two 29,700-gallon storage tanks, and the debris exiting the filter is carried to the storm drain. The clean water enters each tank through an 8-inch smoothing inlet that directs the water flow upward, preventing any disturbance of the healthy biofilm that has developed at the bottom of the cistern as well as oxygenating the tank. Any particulate that

FIGURE 1: RAINWATER COLLECTION POTENTIAL

(from roof size based on average monthly precipitation in Fremont, CA)



has passed through filtration will either sink to the bottom of the tank or float on the surface of the water.

Should the water reach a high enough level, an overflow line (see Figure 3) will prevent the storage tank from overflowing into the building as well as siphon small particulates floating on the water surface. The water is drawn by a 3-horsepower booster pump through a 2-inch WISY floating filter that takes water from 6 to 8 inches below the surface level. This prevents any intake of floating particulates at the top of the water level and ensures that the cleanest water is being used.

FIGURE 2: WISY WFF300 VORTEX FILTERS

FIGURE 3: OVERFLOW LINE

FIGURE 4: DAY TANK

FIGURE 5: DUPLEX BOOSTER PUMP SKID

The pumped rainwater then passes through a custom-fabricated purification skid provided by Rainwater Management Solutions. The first stage of skid filtration is a bag filter that will eliminate particles larger than 1 micron. The water then goes through a carbon filter to eliminate any discoloration or odors. Finally, the water passes through an ultraviolet light that will disinfect it and eliminate any harmful bacteria.

The water is then stored in a 500-gallon day tank (see Figure 4), where it is then drawn by a duplex booster pump skid (see Figure 5) and sent through the facility as needed. The duplex booster pump skid incorporates a variable-frequency drive to lessen power demands and prolong pump life.

The rainwater harvesting system integrates a domestic backup water line for use when rainwater levels are low. The domestic line has a solenoid valve (see Figure 6) that is controlled by the RMS-200 controller interpreting a digital input from a float switch inside the day tank to the right.

The three post-tank filtration elements are mounted on a skid (see Figure 7) along with an RMS Series 200 Controller, which monitors inputs and controls pump operation as well as enables the domestic backup system. A normally closed solenoid valve is opened when a float switch in the day tank falls below a set level, indicating that there is not enough water in the system.

CHALLENGES

Michael Shaw, the Startup General Foreman with Therma Corporation of San Jose, California, shared responsibilities for retrofitting the former Solyndra facility to meet Seagate's needs. One of the challenges faced was adapting the existing piping to accommodate the rainwater system.

The original roof drainage had to be identified, disassembled, and re-routed to the WISY WFF300 vortex filters, and the piping following the final stage of filtration had to be adapted.

"The recycled water supply line installation and its integration with the existing restrooms posed the biggest challenge," Shaw explained. "The water supply line to the existing urinals and toilets had to be separated from lavatories. It required some major in-wall exploration to locate the point of connection in some areas."

One of the other challenges for the rainwater harvesting system is the months with low rainfall totals. Due to the decreased collection of rainwater, the domestic backup integration proved to be essential for the dry summer months.

FIGURE 6: SOLENOID VALVE AND AIR GAP

FIGURE 7: PURIFICATION SKID

David Crawford is the CEO and Founder of Rainwater Management Solutions in Salem, Virginia and the current President of the American Rainwater Catchment Systems Association (ARCSA). T. J. Smith is the Director of Technical Support and Sales and Casey Richey is an Inside Sales Representative with Rainwater Management Solutions. rainwatermanagement.com

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Seagate Media Research Center
Fremont, California

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Seagate decided to integrate a rainwater harvesting system at its Media Research Center in Fremont, California to reduce demand on the municipal water supply and the impacts of stormwater runoff. To make this possible, we retrofitted their existing plumbing to accommodate a rainwater harvesting system. The facility has more than 62,000 square feet of roof area from which rainwater can be collected. The collected rainwater is used to supply non potable uses such as toilet and urinal flushing, scrubber makeup, and cooling tower makeup. The rainwater collected from the roof is pre-filtered by two WISY WFF300 vortex filters and then flows into one of two 29,700-gallon storage tanks.

Challenge: Retrofitting existing plumbing system to accommodate rainwater harvesting system.

Application: Collecting from 62,000 square feet. Prefiltered with (2) WISY Vortex Fine Filter WFF300

Benefits: For non-potable rainwater reuse to flush toilets, cooling tower makeup, and scrubber makeup.
See the Case Study published in the American Society of Plumbing Engineers (ASPE) journal

ARCSA INTERNATIONAL

Case Study

Non-Potable

Agricultural

Rainwater Harvesting Systems

Retired State Senator Truban
Culpeper, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: The area around the barn was extremely wet from run off and cattle waste. Some of the cattle were developing hoof rot. Also, there was no water at the barn for watering.

Application: Drain a 5,000-gallon storage system that harvested rainwater from the barn and carried the water to a pasture-watering cooler. The system requires no electricity.

Benefits: By collecting the water that was running off the barn, the area around the barn started to dry up.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

SerVaas Laboratories, Inc.
Indianapolis, Indiana

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

SerVaas Laboratories, the parent company of Bar Keepers Friend, installed a rainwater capture system at the BKF facility. Fifty percent of the water in BKF liquid products is rainwater from the roof of their facility. (BKF triple filters and UV sterilizes the rainwater before use.) BKF believes they might be the largest user of recycled rainwater in Indiana. As an organization, Bar Keepers Friend strives to use as few resources and as little energy as possible when manufacturing its products. Collecting rainwater and storing it for later use is one way BKF accomplishes this.

Bar Keepers Friend began harvesting rainwater in 2018. BKF has six tanks that hold 3,500 gallons each for a total of 39,000 gallons and prior to adding on to their building in 2020, they captured ~500,000 gallons per year. After adding more roof for capturing water they are up to about 750,000 gallons per year."

The rainwater harvesting system for SerVaas Laboratories uses a total of three WFF300 Vortex Filters. The water is used as process water for creating the BKF cleaners. Rainwater represents approximately 43% of the water used and has saved 1,552,200 gallons of municipal water in the system's lifetime thus far.

Case Study

Non-Potable
Commercial

Rainwater Harvesting Systems

Sonora Bank
New Braunfels, Texas

Rainwater System Designer
Innovative Water Solutions LLC
Austin, Texas

Project Overview

The rainwater harvesting system collects rainwater from approximately 6,750 square feet and harvests it into a 20,243-gallon water storage tank via a wet conveyance system. The system can harvest approximately 4,200 gallons per inch of rainfall. With the annual average rainfall amount of 31″ in central Texas, this system can potentially capture and reuse 130,000 gallons of rainwater.

Once collected in the tank, the rainwater is pumped to the irrigation system via a submersible pump system that includes inline filters to prepare the rainwater before entering the irrigation system. If the rainwater level in the cistern gets below 12” of depth, an auto-fill system will supplement the cistern with municipal water.

A Pioneer brand corrugated metal liner tank was used for the water storage tank. After the tank was installed, a mortared rock wall was constructed around the tank to blend it into the aesthetics of the bank building.

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

SRMKCCA Google Office Building
Kirkland, Washington

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

SRMKCCA Google Office Building collects rainwater from the roofs using two WFF300 Vortex Filters to ensure high-quality water in the cisterns. The water is then filtered down to 5 microns before entering an ultraviolet light for disinfection. The water is reused inside the buildings for toilet and urinal flushing.

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

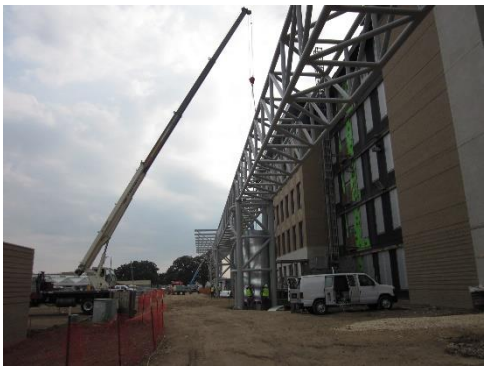
Texas A&M University Agriculture and Life Sciences Complex
College Station, Texas

Rainwater System Designer
Innovative Water Solutions LLC
Austin, Texas

Project Overview

The Agriculture and Life Sciences Complex consists of multiple buildings which houses the Office of the Vice Chancellor and Dean for Agriculture and Life Sciences and the headquarters for the Texas A&M AgriLife Extension Service, Texas A&M AgriLife Research, and the College of Agriculture and Life Sciences.

The rainwater harvesting system consists of four 12,000-gallon corrugated metal cisterns that were incorporated into the Canopy structure that connects the buildings. The rainwater from the roofs of the buildings is first collected into the Canopy cisterns. When these cisterns overflow, the rainwater then is captured in a 40,000-gallon underground fiberglass cistern. From this cistern, a pump system pressurizes the rainwater to be used in the landscape irrigation system for the complex. When the water level in the underground cistern reaches a depth of 2', rainwater from the Canopy cisterns will be released into the underground cistern by way of an actuated valve. At a water depth of 1', municipal water will flow into the cistern to keep a minimum amount of water in the cistern.



ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

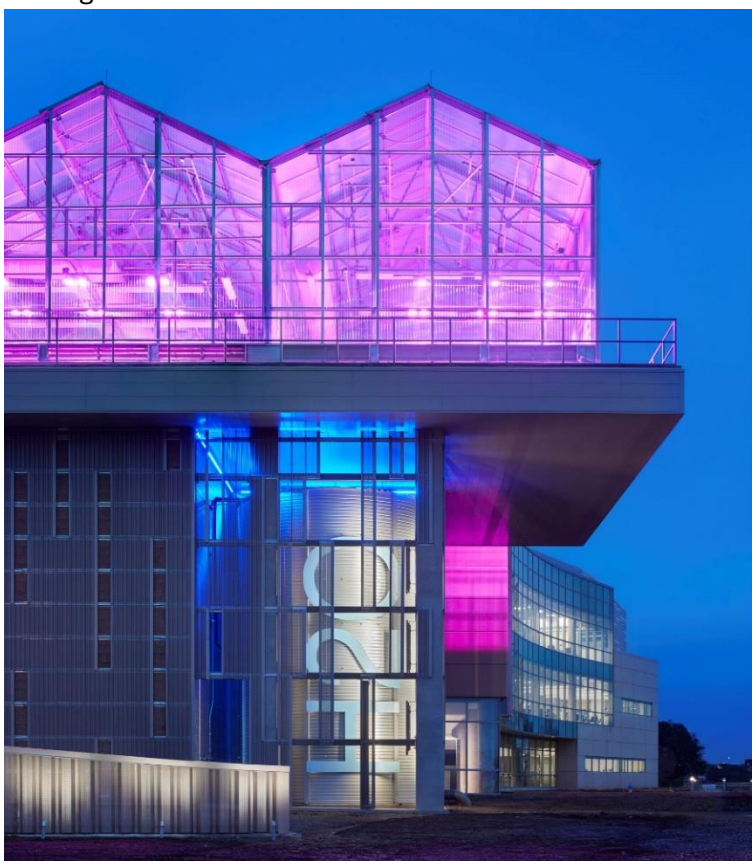
Texas A&M AgriLife Research and Extension Center
Dallas, Texas

Rainwater System Designer
Innovative Water Solutions LLC
Austin, Texas

Project Overview

This project consists of a state-of-the-art research facility for the Texas A&M AgriLife Research Division housing research and development for sustainable urban agriculture and ecology. The new, environmentally sustainable headquarters stands alongside upgraded existing buildings, overhauled infrastructure and new public teaching facilities. The new additions transformed the Dallas campus over roughly two-year duration of the project. The center focuses on producing agricultural solutions for improved sustainability in urban and suburban living.

The rainwater harvesting system collects rainwater from the roof into a 33,582-gallon corrugated metal liner tank. The incoming rainwater is filtered through a vortex filter. A floating filter in the tank provides additional filtration opportunity before the rainwater is pulled into the Grundfos centrifugal pump system. The rainwater passes through a Viqua UV disinfection system prior to being used for toilet flushing in the building and for irrigation use outside the building.



ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

TD Ameritrade Headquarters
Omaha, Nebraska

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

We supplied the TD Ameritrade Headquarters with a rainwater harvesting system consisting of a 30,000-gallon rainwater storage tank and the RMS Day Tank System which provides rainwater to the toilets and urinals throughout the entire facility. Two WISY Vortex Filters are installed prior to the storage tank to remove particulate larger than 380 microns from almost 60,000 square feet of roof area.

Case Study

Non-Potable
Commercial

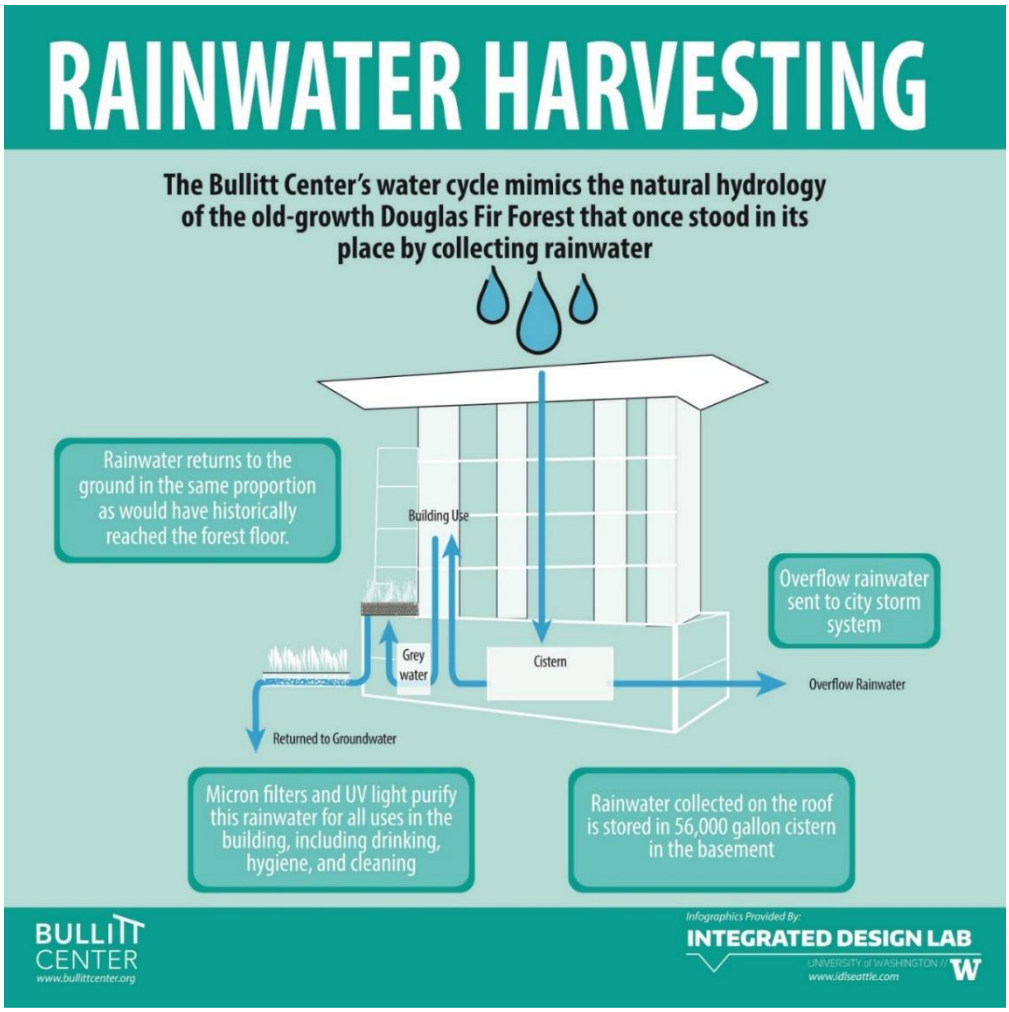
Rainwater Harvesting Systems

The Bullitt Center
Seattle, Washington

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

The Bullitt Center, located in Seattle, Washington, collects and reuses graywater. Water is collected from showers and hand sinks, filtered and disinfected, then reused for irrigation. This system was designed to treat up to 1,000 gallons per day, thus reducing potable water use for non-potable applications.



Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Virginia Tech Carilion Biomedical Research Expansion
Roanoke, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Rainwater was collected through WFF300 Vortex Filters from the roof and conveyed to a 25,000-gallon poured-in-place concrete cistern. Water is being used for toilet flushing and irrigation in the surrounding green space.

ARCSA INTERNATIONAL

Case Study

Non-Potable

Commercial

Rainwater Harvesting Systems

Williamson Road Fire-EMS Station
Roanoke, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: Reduce the use of municipal water for non-potable water needs.
Reduce stormwater runoff from the site to protect the environment.
Attain LEED certification through the USGBC

Application:9,000 sq.ft. roof collection area
10,000 gallons of storage
Two Wisy WFF 150 vortex filters
Two Wisy smoothing inlets
Two Wisy coarse 2" floating filters
UV light filtration system

Benefits: Harvested rainwater used to wash vehicles and flush toilets. Promote green infrastructure for fire stations and public service buildings as well as prevent stormwater runoff.

The construction for the Williamson Road Fire Station finished in January 2009. The fire station is located in Roanoke, Virginia and is the city's first LEED certified fire station. With the addition of this fire station, emergency response times will be improved for the North side of the city.

Non-Potable

Case Study *Commercial - Zoos*

Rainwater Harvesting Systems

A Michigan zoo collects rainwater to irrigate its gardens, reducing reliance on treated water and promoting sustainable resource use. This initiative supports the zoo's broader commitment to eco-friendly practices. Learn more https://potterparkzoo.org/earth-month-conservation-initiatives/

A zoo located in the UK uses a rainwater harvesting system beneath its elephant house, capable of collecting over 55,000 liters at a time, to sustainably clean enclosures, provide showers for elephants, operate sprinklers, and fill pools. Installed in 2017 as part of the Project Elephant facility, the system has conserved 2.7 million liters of water, reducing environmental impact and supporting the zoo's sustainability goals. Learn more https://www.blackpoolzoo.org.uk/blog/rainwater-system

A zoo in Ohio has conserved over 2 billion gallons of water through rainwater harvesting and other green initiatives. Advanced stormwater systems under the Africa exhibit reduce sewer overflow by 15 million gallons annually, mitigating pollution in the Ohio River and saving taxpayer costs. These measures highlight the zoo's role as a leader in sustainability and resource conservation. Learn more https://cincinnatizoo.org/zoo-saves-one-billion-gallons-of-water/

This Nebraska zoo employs a rainwater harvesting system connected to the Desert Dome, the world's largest indoor desert. Gutters on the dome collect rainwater, storing it in two underground tanks with a capacity of 20,000 gallons each. This water is used for irrigating plants within the dome, supporting sustainable practices. Learn more https://journalistsforrwh.blogspot.com/2014/02/rain-water-harvesting-in-henry-doorly.html

An Indiana zoo features rainwater-harvesting pavilions designed to resemble a lush rainforest. These pavilions capture rainwater, which is then used for irrigation and supporting the zoo's gardens, helping to conserve resources and reduce the facility's environmental impact. The design integrates sustainability with educational elements, showcasing innovative ways to manage water while enhancing the visitor experience. Learn more details on this initiative on Inhabitat's website.https://inhabitat.com/rainwater-harvesting-pavilions-mimic-a-lush-rainforest-at-the-indianapolis-zoo/

The gigantic rainwater harvesting system underneath an elephant house has saved more than enough water to fill an Olympic swimming pool.

Case Study

Potable

Commercial

Rainwater Harvesting Systems

Shield Ranch
Austin, Texas

Rainwater System Designer
Specified Water Systems
Austin, Texas

Project Overview

Rainwater is captured off the rooftops and conveyed via a wet system to catchment tanks to supply a potable Public Water System. The tanks are (2) CorGal ® 2702 WT CHR's that are 30,000 gallons each.

Case Study

Potable

Commercial

Rainwater Harvesting Systems

UA Local 130
Chicago, Illinois

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

The Local 130 Plumber's Union wanted to provide an exceptional training facility while showcasing water conservation. RMS was selected to provide a graywater reuse system alongside a rainwater reclamation system. Water is collected from hand sinks and showers and reused for toilet flushing and irrigation around the facility alongside the collected rainwater.

Case Study

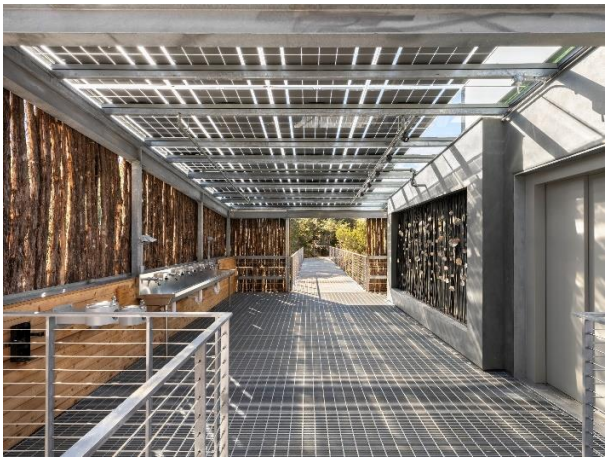
Rainwater Harvesting Systems

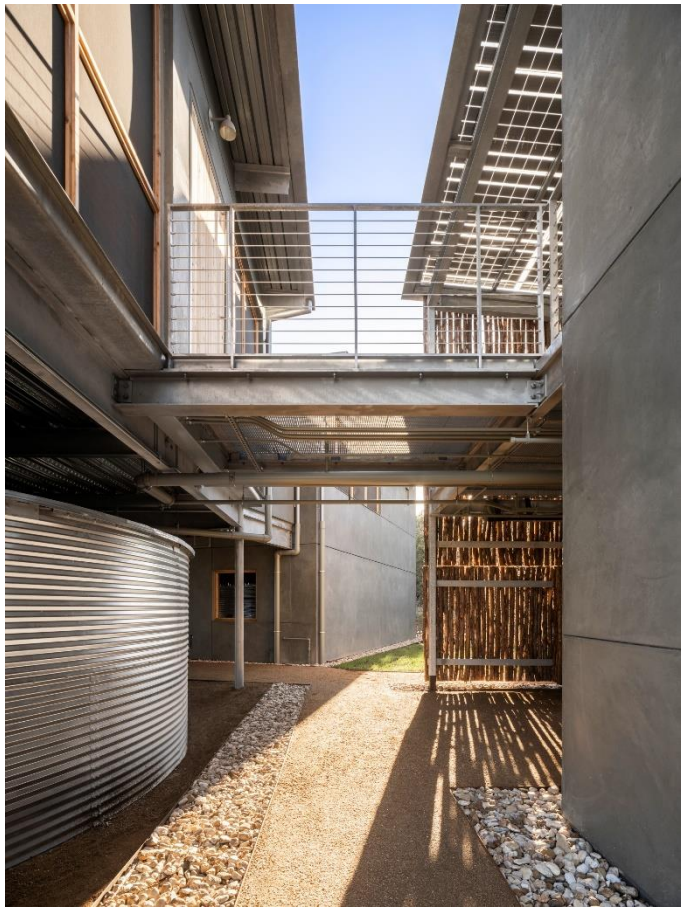
The Campsite at Shield Ranch
New Braunfels, Texas

Rainwater System Designer
Venhuizen Water Works
Texas

Project Overview

The Campsite at Shield Ranch is a completely off-grid nature immersion camp that provides lessons in sustainability and conservtion. The Campsite's rainwater havebesting systen has a storage capacity of 67,800 gallons that consists of tow reservoirs and two cisterns. As a pilot project, the primary goal of the Campsite's rainwater systen was to demonstrate alternatives and pave a permitting process for other Texans to construct more sustainably. The system also serves as a living, learning model that draws community and sustainability-focused tour groups to the Campsite to learn about rainwater harvesting.





Case Study

Non-Potable

Educational

Rainwater Harvesting Systems

Alexandria Center for Agtech
Durham, North Carolina

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

The Alexandria Center collects and stores rainwater in two 20,000-gallon fiberglass below ground tanks. The water is used for their greenhouse and outdoor irrigation. Thus, saving an exceptional amount of potable water each year.

Case Study

Non-Potable

Educational

Rainwater Harvesting Systems

Claude Moore Education Complex
Roanoke, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

We assisted the Claude More Education Complex in Roanoke, VA in implementing a rainwater harvesting system to reduce potable water demands for non-potable needs in addition to reducing stormwater runoff. We used a Siphonic roof drain system to effectively move water from rooftop to storage tanks, using the diverted water to use in flushing toilets. We collected water in two 2,500-gallon storage tanks and pre-filtered water using two Wisy vortex fine filters.

Case Study

Non-Potable

Educational

Rainwater Harvesting Systems

CODE Technology Center
Charlottesville, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Rainwater is collected and pre-filtered using a custom-made High-Volume Separator. The water is pumped from the cistern, through the RMS filtration skid, and to irrigation. The filtration skid housed the flooded suction pump, variable frequency drive, self-cleaning backwash filter, and RMS 200 Controller.

Case Study

Non-Potable

Educational

Rainwater Harvesting Systems

Federal Way Public Schools Service Center
Federal Way, Washington

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: Reduce the use of municipal water for non-potable water needs.
Reduce stormwater runoff from the site to protect the environment

Application: (8) 8 Wisy Vortex 150 Filters
(8) 1,400-gallon vertical storage tanks
2 inch coarse floating filter & hose
(8) 4" smoothing inlets

Benefits: Harvested rainwater used to wash cars and trucks.
Promote green infrastructure for schools.
Prevent stormwater runoff.

This public school's service center located in Federal Way, Washington, was looking for ways to reuse rainwater and not to depend on a municipal supply for washing cars and trucks.

Case Study

Non-Potable

Education

Rainwater Harvesting Systems

LiUNA The Laborers School
El Monte, California

Rainwater System Designer
Rainwater Management Solutions (RMS) and ARCSA

Project Overview

RMS paired with ARCSA (American Rainwater Catchment System Association) to create a rainwater harvesting system that is used for hands-on training. The system included a below ground tank, WFF300 Vortex Pre-Filter, post-tank filtration, and backup water supply equipment. The system is used to train laborers how to install and maintain rainwater catchment systems.

Case Study

Non-Potable
Educational

Rainwater Harvesting Systems

Oscar Smith Middle School
Virginia Beach, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

This middle school in Virginia Beach, Virginia is situated in the sensitive Chesapeake Bay Watershed. The existing school was replaced with a more environmentally sound school.

Challenge: Reduce the use of municipal water for non-potable water needs.
Reduce stormwater runoff from the site to protect the environment.
Educate students on water conservation and stewardship.

Application: 220,00 sq. ft. roof collection area
9 Wisy WFF 300 vortex filters
9 Wisy coarse floating filters

Benefits: Harvested rainwater used to flush toilets and irrigate.
Promote green infrastructure for schools.
Prevent stormwater runoff

ARCSA INTERNATIONAL

Case Study

Non-Potable

Educational

Rainwater Harvesting Systems

Villanova University
Center for Engineering Education and Research (CEER) Building
Villanova, PA 19085

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

To reduce municipal water use, Villanova University implemented a rainwater harvesting system to be used for toilet and urinal flushing. Rainwater is collected from the rooftop and pre-filtered through a horizontal High-Volume Filter before entering two 20,000-gallon fiberglass reinforced plastic storage cisterns. The rainwater is then pumped through a treatment skid before being stored in a polyethylene tank. From there, the treated water is repressurized for distribution to the toilets and urinals when demand is signaled.

FEMP
Federal Energy Management Program

Potable Rainwater Harvesting System

Introduction

Located in San Juan, Puerto Rico, the U.S. Army Garrison Fort Buchanan was first established in the 20th century, with its name designated by 1940. Since 2006, Fort Buchanan has been under the direction of Installation Management Command and is the headquarters of the U.S. Army Reserve, 1st Mission Support Command and the Puerto Rico National Guard. Fort Buchanan's primary mission is to *"deliver base support and services to enable holistic readiness for the total force"*.[1] This mission includes approximately 130,000 people working together across three municipalities (San Juan, Guaynabo, and Bayamon), while also serving surrounding communities. The municipal water supplier to Fort Buchanan is the Puerto Rico Aqueduct and Sewer Authority (PRASA).[2] Additionally, Fort Buchanan produces water from an on-site well.

Fort Buchanan faces water system challenges including aging infrastructure, natural hazards, and long-term drought. For example, after Hurricane Maria devastated the entire island of Puerto Rico in 2017, Fort Buchanan had to rely on reverse osmosis water purification units to meet potable water needs. A key lesson learned from this disruption was Fort Buchanan's susceptibility to water disruptions that impact the installation's ability to perform its mission.

To help address these challenges, Fort Buchanan has worked to implement water resilience projects including replacing its water distribution system's main pipelines and installing high efficiency water consuming fixtures and equipment. Additionally, Fort Buchanan has installed potable rainwater harvesting systems, an alternative water source and method of resilience, to offset the use of PRASA supplied potable water.

Figure 1. Fort Buchanan welcome gate

Defined Terms

Potable water is water that is permitted and treated to levels safe for human consumption.

Non-potable water is untreated water that is not safe for human consumption but can be used for other purposes, such as toilet flushing and fire suppression.

Alternative water is water sourced from sustainable supplies, serving to mitigate the reliance on fresh surface water and groundwater.

Rainwater System Pilot Demonstration

In 2018, Fort Buchanan was awarded funding from the Army's Integrated Technology Transition Program (ITTP) to demonstrate a potable rainwater harvesting system. Through the ITTP project, a private contractor was tasked with building, installing, and maintaining the pilot rainwater harvesting system. The installations first fully off-grid potable rainwater harvesting system was installed at the Fort Buchanan Welcome Center. The solar panels and batteries allow the treatment and pumping components to remain functional in the event of a long-term power loss. The intention behind the initial pilot was to demonstrate the effectiveness of the system and determine whether such shipping container mounted systems would be suitable for other buildings at Fort Buchanan. As such, the initial pilot provided an opportunity to create methods for installation, maintenance, and operation of a potable rainwater harvesting system for future successful expansion.

What is Rainwater Harvesting?

Rainwater harvesting collects precipitation from above ground hard surfaces (e.g. building roofs and parking canopies) for later use. This water can be stored as non-potable and used for approved applications such as landscaping, toilet flushing, and emergency fire response. At Fort Buchanan, additional filtration and disinfection treats the raw rainwater to potable levels. This potable water is then pressurized and piped into adjacent buildings for all water demands, including toilet flushing, faucets, lavatories, showers, hand washing and water fountains.

Pilot Equipment Description

The main components of the rainwater harvesting system are represented in Figure 2 and indicated by the below numbering:

1. First Flush Diverter: screens for large debris, such as leaves or sticks
2. Raw Water Storage Tank: collects rainwater prior to treatment
3. Overflow: allows for water to drain from the raw water storage tank when it reaches capacity
4. Meters: measures flow rate and consumption
5. Filtration system: filters particulates through carbon and micron filters

[1] Information was obtained from U.S. Army Fort Buchanan website: https://home.army.mil/buchanan/about/mission
[2] Information was obtained by Pacific Northwest National Laboratory (PNNL) for ITTP proposal in 2018
[3] Photos taken by PNNL February 2024

6. Treated water and hydropneumatics bladder tank: adds chemicals for disinfection to potable water standards and pressurizes water to distribute to the building
7. Solar power batteries: stores energy from solar panels to power the system
8. Solar panels and communication network: generates electricity as an off-grid energy source and communicates data using a cellular-based network for system data logging

Figure 2. The main components of the pilot potable rainwater harvesting system

Pilot Results and Lessons Learned

Overall, the pilot rainwater harvesting system is considered a success. In the first year of operation, the system collected over 22,000 gallons of water and met the potable water demand of the Welcome Center.[4] Some key lessons learned from the demonstration project include:

Consistent maintenance is vital: The contractor initially provided all the operations and maintenance of the system. After the first year, the system operation was turned over to the installation. With staffing constraints, the solar batteries were not maintained properly, and the system went offline but became operational after the maintenance contract was re-issued. Although the system treatment components were fully functional, loss of power led to system degradation.

Ample room for accessing equipment is important: The pilot system was skid mounted, for ease of shipping; however, that system configuration left little space for accessing or modifying the equipment. The newer treatment systems are housed in a standard shipping container.

Rainwater System Expansion

With the lessons learned from the Welcome Center pilot, Fort Buchanan moved forward with establishing additional systems onsite. As of December 2023, Fort Buchanan has 20 potable water harvesting units in use, serving a variety of building types: health clinic, data center, bowling alley, and administration.[5] These systems are currently operated and maintained by a contractor, ensuring proper water treatment and system function.

Larger Scale Applicability for Future Systems

The solar powered potable rainwater harvesting systems at Fort Buchanan can largely be considered a success story and an example for a variety of buildings and campuses seeking ways to attain resilient water infrastructures. If your agency is interested in implementing rainwater harvesting, the Federal Energy Management Program (FEMP) Rainwater Harvesting Tool is a way to assess the viability across the United States. This tool allows users to determine the potential of harvesting rainwater at their installation. Following this, installation managers can work with private contractors to determine what rainwater harvesting system would satisfy their water resiliency needs.

For More Information

FEMP alternative water sources

FEMP best management practices for water efficiency

Fort Buchanan website

Figure 3. Newest model of rainwater system

Pacific Northwest NATIONAL LABORATORY

FEMP Federal Energy Management Program

[4] System water storage was obtained by PNNL from metered data collected in 2019
[5] Number and type of rainwater harvesting units in use obtained during PNNL February 2024 site visit

September 2024 · PNNL-SA-203721

ARCSA INTERNATIONAL

Non-Potable

Case Study

Governmental

Rainwater Harvesting Systems

Alabama-Coushatta Tribe of Texas
Livingston, Texas

Rainwater System Designer
Pioneer Water Tanks
San Marcos, Texas

Project Overview

The rainwater harvesting system installed by the Alabama-Coushatta Tribe of Texas harvests and stores 65,000 gallons of rainwater to be used for wildfire mitigation, irrigation of a community garden, and dust abatement. As prescribed burns are a way of life for the tribe, refilling trucks with rainwater rather than from area lakes and wells relieves dependency on local water resources and cuts the expense of hauling water from other areas. Through outreach events, the project also provided education and demonstration of assembly and installatin of smaller-scale systems for houshold rainwater harvesting. The project generated interest among other tribes in Oklahoma, New Mexico, South Dakota, and Louisiana.

Non-Potable

Case Study *Governmental – U.S. Department of Defense*

Rainwater Harvesting Systems

United States Defense and Intelligence Facilities
United States of America

Rainwater System Designer
Rainwater Management Solutions
Roanoke, Virginia

Minnesota National Guard Maintenance Facility, New Ulm, MN.

Rainwater is harvested from the rooftop and stored in a 20,000-gallon below-ground fiberglass tank. A single, three horsepower submersible pump delivers water to a 25 GPM water filtration skid. Treated rainwater is reused on site for equipment washing.

Project Overview

1. **Camp Lejeune Marine Corps Base, North Carolina**
    - Facilities at Camp Lejeune reuse both rainwater and graywater for irrigation and toilet flushing, reducing municipal water demand and improving drought resilience.
2. **Moody Air Force Base, Georgia**
    - This U.S. Air Force base utilizes a rainwater harvesting system to reuse water onsite for toilet flushing, helping to reduce the facility's potable water demand.
3. **Minnesota National Guard Maintenance Facility, Minnesota**
    - Opened in 2022 as a significant upgrade from the previous facility, the new Minnesota National Guard Maintenance Facility harvests rainwater for vehicle and equipment washing.
4. **Redstone Arsenal, Alabama**
    - An FBI facility at Redstone Arsenal harvests rainwater for cooling towers are other non-potable indoor use.
5. **Aviation Classification Repair Activity Depot, Mississippi**
    - This National Guard aircraft maintenance facility captures rainwater from one of its hangars to be reused for toilet flushing and equipment washdown.
6. **Quantico FBI Academy, Virginia**
    - Located at the Quantico Marine Corps Base, this FBI training facility reduces potable water demand though the use of harvested rainwater for toilet flushing and other non-potable applications.
7. **Intelligence Community Campus, Maryland**
    - This facility is a state-of-the-art office campus that hosts staff from over a dozen executive agencies and organizations. The campus harvests and reuses rainwater on-site for toilet flushing.

Non-Potable

Case Study *Governmental - U.S. Department of Defense*

Rainwater Harvesting Systems

United states Military Bases
United States of America

Rainwater System Designer
Various Designers

Project Overview

Fort Hood's Tactical Vehicle Wash Rack captures rainwater for use and also treats off-wash for reuse

The Tactical Vehicle Wash Rack at Fort Hood was originally installed in 1987. The wash rack was designed to treat off-wash through a series of grit chambers and settling basins for re-use while capturing and using rainwater in the primary lagoon.

1. **Fort Bragg, North Carolina**
    - Fort Bragg has implemented rainwater harvesting systems as part of its sustainability efforts. They have used rainwater for landscape irrigation and to reduce potable water usage.
2. **Camp Pendleton, California**
    - This U.S. Marine Corps base has utilized rainwater harvesting systems in multiple locations to conserve water, especially during drought conditions. It also helps to irrigate landscapes and reduce reliance on municipal water supplies.
3. **Naval Base San Diego, California**
    - This base has incorporated rainwater collection systems for various uses, including irrigation and industrial applications. The project aims to conserve water and enhance sustainability efforts.
4. **Joint Base Lewis-McChord, Washington**
    - Located in the Pacific Northwest, this base has utilized rainwater harvesting systems to support landscaping and reduce dependence on treated water.
5. **Davis-Monthan Air Force Base, Arizona**
    - In Arizona, water scarcity is a concern, and Davis-Monthan Air Force Base has implemented rainwater harvesting for irrigation and cooling systems, contributing to the base's water conservation initiatives.
6. **Vandenberg Space Force Base, California**
    - Known for its environmental stewardship, Vandenberg Space Force Base has adopted rainwater harvesting systems to reduce the use of potable water for irrigation and other base operations.

Non-Potable

Case Study *Governmental - U.S. Army Corps of Engineers*

Rainwater Harvesting Systems

Fort Sill
Oklahoma

Rainwater System Designer
Unkown

Project Overview

At Fort Sill, Okla. the U.S. Army Corps of Engineers is taking positive steps to increase energy efficiency and preserve resources by harvesting rain and sunlight.

The design and construction of some of the new facilities at the Army post includes innovative systems for collecting rainwater and using sunlight to improve energy efficiency. In a region with little rain and abundant sunshine it makes sense to hoard one and exploit the other.

The 30-thousand-gallon rainwater collection tank at the Reception Complex under construction at Fort Sill.

“The idea behind it is great,” said Brant Purdum, Tulsa District USACE mechanical engineer, E&C, Fort Sill Area Office. “You are conserving energy, conserving water, and conserving resources.”

The rainwater collection system harvests water from the building’s roof to water the grass. The gutter system feeds into giant fiberglass tanks stored underground preventing evaporation, which happens to be a real threat to water supplies in this region. A first check filter flushes out things like bird waste and sticks, whatever is on the roof, to keep it from getting into the system. Each tank has a pump tied into the irrigation system so that water from the underground tanks serves the sprinkler heads.

“We can capture the rain when we get it and use it when it’s needed,” said Paul Panter, mechanical technician, USACE Fort Sill Area Office. “There is a formula to use to calculate the amount of rain that can be harvested. For instance, in a two-inch rainfall event six thousand gallons of water runs off a four thousand square foot roof.”

Moreover, Panter said rainwater is better for the landscape than treated water because it is softer water.

The Energy Monitoring and Control System (EMCS) at Ft. Sill monitors the collection system. EMCS is a computer software system that monitors water, gas, and electricity usage mainly through the management of the HVAC systems. Operators can track tank levels and filter alarms, watch the pump operation and verify that everything is in working order. If something does go wrong, it sends an alarm and operators can check on the problem.

The buildings with the rainwater collection systems are the Thermal High Altitude Air Defense (THAAD) project, Reception Battalion Complex, and the Tactical Equipment Maintenance Facility (TEMF). The THAAD has two 50 thousand gallon tanks, the Reception Complex has one 30 thousand gallon tank, and the TEMF has two 25 thousand gallon tanks.

Eventually the system could be connected to other buildings.

“The system on the TEMF is designed with this in mind,” said Purdum. “It could pull water from all four buildings around it. It could be the beginnings of a beneficial system.”

In a small way, the rainwater collection system will assist with cooling the building. It ties into the building’s cooling tower water supply so that it would start utilizing rainwater first rather than pulling from the building’s water supply.

The first rainwater system should go online this summer.

At the Mission Training Complex, photovoltaic panels on the roof collect sunlight and turn it into electricity. The big solar panels charge batteries in the building’s inverter room and those batteries assist with the building’s power. This helps to shave off the peak demand loads so the Army isn’t paying premium rates.

“You don’t have to burn fossil fuels to use it,” said Purdum. “As the sun moves the panels track the sun; they are designed to always be in the sun and to catch light from both sides.”

Purdum said even though there is an initial high cost to install both systems, ultimately they pay for themselves. The lifecycle for the rainwater system is about 25 to 30 years, and about 15 years for the photovoltaic panels.

Both systems are an example of how creative thinking about energy efficiency and conservation can help preserve resources and save the U.S. Army money.

Case Study

Non-Potable
Residential

Rainwater Harvesting Systems

Elevate at Southwest Station Apartments
Eden Prairie, Minnesota

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Elevate Apartments collect rainwater using a WFF300 prefilter to ensure a high-quality of water is initially obtained. The water is conveyed to two 2,500-gallon tanks located in the basement. The water is filtered and reused for surrounding irrigation.

Case Study

Non-Potable
Residential

Rainwater Harvesting Systems

Residence
Charlottesville, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: Collect rainwater from the rooftop to supply irrigation demands on the landscaped grounds without relying on potable water supplies.

Application: 5,000-gallon belowground storage. Wisy WFF 150 vortex filter. Wisy smoothing inlet. Wisy coarse floating filter.

Benefits: Offer a reliable source of high-quality water. Reduce reliance on potable water.

Case Study

Non-Potable
Residential

Rainwater Harvesting Systems

Residence
Franklin County, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: To collect rooftop runoff for landscape irrigation and prevent water from running down the hill and contaminating the pond. The collected rainwater is used for irrigation at a rate that does not exceed infiltration rate, thus preventing runoff.

Application: 3- 1,500 gallon belowground storage tanks providing 4,500 gallons of storage. The Wisy WFF150 Vortex Fine Filter is used to pre-filter the collected rainwater, preserving the water quality inside the tanks. A submersible 1 HP pump with a floating suction intake is used to irrigate the landscape.

Benefits: Reduced onsite runoff and protected nearby lake and provides irrigation to the landscape without using municipal or well water.

ARCSA INTERNATIONAL

Case Study

Non-Potable

Residential

Rainwater Harvesting Systems

Gabbay Residential
Lockhart, Texas

Rainwater System Designer
Unknown

Project Overview

The Gabbay residence uses a 10,000-gallon rainwater harvesting system for a vegetable garden, fruit orchard, and flower garden on their on-acre lot. The surface area of the gardens and their use of Hügelkultur beds, a technique that uses sloped and raised planting beds filled with topsoil: rotted wood stumps and limbs; and other organic matter; helps redirect and hold water on the property to reduce runoff and eliminate flooding. The collected rainwater provides all the water necessary for irrigating the gardens throughout the year, reducing dependency on municipal water.

Case Study

Non-Potable
Residential

Rainwater Harvesting Systems

Residence
Nebo, North Carolina

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: Collect rainwater from a 3,000 square foot roof to supply potable water to the residence for exterior uses such as hose bibs, car washing, and building washing.

Application: 2 above-ground storage tanks,1 Wisy WFF 150 vortex filter Sediment, Carbon, and UV Light filtration

Benefits: Reduce reliance and demand on potable water supplies for outdoor uses

Case Study

Potable
Residential

Rainwater Harvesting Systems

Residence
Afton Mountain, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: To build a home following the US Green Building residential building program's guidelines. Rainwater harvesting is considered a green building approach and qualifies for LEED points.

Application: Two 1,700-gallon belowground tanks. Wisy vortex filters. Potable water treatment system.

Benefits: Construct a green residential building. Reduce groundwater reliance and conserve groundwater resources.

Case Study

Potable
Residential

Rainwater Harvesting Systems

Allen Shreeman Residence
Unknown

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: The home's original well went dry in 2001. A second well was drilled to a depth of 900 feet, but only produced a half gallon per minute. This was inadequate to provide an ample water supply for peak demand.

Application: Six 400-gallon storage tanks were placed in the crawl space, providing the customer with a 2,400-gallon capacity of stored rainwater. The harvested rainwater was filtered and sterilized for potable use. The project was coordinated with local officials, who issued a potable water permit for the rainwater harvesting system.

Benefits: An additional well was not required. The system provides an average of 34,000 gallons of water per year. A continuous source of high quality, soft potable water is available from the system.

Case Study

Potable

Residential

Rainwater Harvesting Systems

Bayview Residence
Southwest Watcom County, Washington

Rainwater System Designer
Gary Kitching LLC & Seattle Rainwater
Ferndale, WA

Project Overview

Water Scenario: The site is situated in an area where the owner of property is prohibited from connecting to the local public water system. Drilling on-site wells and trucking water to the site are also prohibited. Therefore, the only option for obtaining potable water is utilizing a rainwater harvesting system. The property owner then sought permission from the County to install a rainwater catchment system.

Rainwater harvesting system Design: The property owner hired Gary Kitching, a certified designer and installer of Rainwater Catchment Systems to design and install his system. Although the property owner lives alone, the local jurisdiction requires all rainwater harvesting systems for potable water be sized for a minimum number of two users. The system was designed in accordance with Standard 63 per ARCSA manual.

Operation and Maintenance: The rainwater catchment system was installed on-site adjacent to the new home. The filters, pressure tank, UV light, and associated controls were installed in the new garage (see Exhibits). The property owner was shown how to operate the RWH system. He was also provided with an Operation and Maintenance Manual which includes a list of components that may eventually need to be repaired or replaced. The property owner has contracted with the designer/installer to periodically inspect the system.

Conclusion: The designer/installer returned to the site approximately six weeks after startup of the system. The water storage tanks were full due to the recent rainfall. The designer/installer reviewed the operation and maintenance requirements with the property owner. The property owner is delighted with his system. The RWH system is functioning as expected and the property owner is confident that he has a sufficient supply of safe drinking water. Below is the water filtration system with UV light and pressure tank Inside garage.

Case Study

Potable
Residential

Rainwater Harvesting Systems

Bow Residence
Bow, Washington

Rainwater System Designer
Northwest Rain Solutions
Bellingham, Washington

Project Overview

Application: Rainwater Catchment for Potable Use Indoors, Irrigation & Fire Protection
System: 2,000sf Metal Roof, Fine Mesh Screen Prefilter, Wet Conveyance with WaterFrog Drip Emitter, Pump, Filter & Treatment Board
Tanks: 54,000-gal Corrugated Steel
Challenge: Situated on a rural hillside, the site has restricted access to groundwater. The property location is far from the local fire district. The project's goal was to establish a dependable water source for cultivating food for the local food bank, while preserving a sufficient water reserve.
System Features: Rainwater is collected from the metal shop roof through a pre-filter and is then transferred using the wet conveyance method of gravity and hydrostatic pressure to the storage tank. The conveyance piping is equipped with a WaterFrog Emitter for freeze protection and First-Flush, additional pre-filtration, and components to meet the requirements of the Four-Step process outlined in ARCSA/ASPE/ANSI Std 63.

There are 44,000 gallons of stored rainwater for irrigation for a large field and series of greenhouses for growing food for the local food bank. The irrigation system is designed with micro sprayers, drip, and other water conserving technology to maximize the use of the stored rainwater and reduce reliance on the low producing well.

There is a filtration and treatment board that allows the owner to use the stored rainwater for potable use in the house as a backup to the well.

The storage tank has a separate outlet that is connected to a dry hydrant, so water can be drafted from the tank by the local fire department in an emergency. There are 10,000 gallons of water stored at the bottom of the tank at all times for fire protection.

Filter and treatment board.

Corrugated steel tank with bladder liner

Case Study

Potable
Residential

Rainwater Harvesting Systems

Residence
Glasgow, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: Collect water from residential roof line to supply water for two-yard hydrants, as well as sink, shower, and toilet.

Application: Three 1,500-gallon tanks for 4,500 gallons of storage, Wisy vortex fine filter.

Benefits: Supply a reliable water source for horses. Reduce reliance on potable water for non-potable needs. Save money on water costs.

Case Study

Potable
Residential

Rainwater Harvesting Systems

Residence
Hillsville, Virginia

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: The residents relied on well-water for a water source in the mountains of Virginia. The well did not supply a continual source of water for all their needs. The residents sought a rainwater harvesting system to replace the well. Installing the system was comparable in price to drilling a new well, which may or may not have supplied sufficient water.

Application: 5,000-gallon belowground tank, Wisy WFF 150 vortex filter. Potable system to serve all of the household's needs.

Benefits: Offer reliable source of high-quality, soft, potable water. Protect groundwater resources Unnecessary to drill additional well.

Case Study

Potable
Residential

Rainwater Harvesting Systems

Residence
Kirkland, Washington

Rainwater System Designer
Rainwater Management Solutions (RMS)
Roanoke, Virginia

Project Overview

Challenge: Collect rainwater from the rooftop to supply potable water to the residence for daily needs and also to the irrigation system.

Application: 4 below ground storage tanks, 1 Wisy WFF 150 vortex filter.

Benefits: Offer a reliable source of high-quality water. Reduce reliance on potable water supplies for indoor use. Provides water to the irrigation system that also reduces costs of using municipal water.

Case Study

Potable

Residential

Rainwater Harvesting Systems

North County Residence
North County, Washington

Rainwater System Designer
Gary Kitching LLC & Seattle Rainwater
Ferndale, WA

Water storage tanks with manifold.

Project Overview

Water Scenario: Whatcom County, the local jurisdiction, prioritizes water sources. Property owners are required to connect to public water systems if available. If public water is not available then property owners are required to explore options for installation of a private well. If a public water system is not available and a private well is not an option then the property owner may pursue the option of installing a rainwater catchment system. Here, the 5-acre property owner drilled two separate wells for the purpose of obtaining a source of potable water. Both wells were drilled to a depth of 440' as neighboring properties had successfully obtained water from wells at that depth. Unfortunately, both of the subject wells were dry. The property owner then sought permission from the County to install a rainwater catchment system.

Rainwater harvesting system Design: The property owners hired Gary Kitching, a certified designer and installer of Rainwater Catchment Systems to design their system. The property owners requested a system to meet the needs of two users. It was agreed that Gary Kitching would install the system, however, the property owner agreed to construct the pumphouse and assist with the installation of the system and components as he wanted to learn how the system functions. The system was designed in accordance with Standard 63 per ARCSA manual.

Operation and Maintenance: The rainwater catchment system was installed as shown on the site plan. Although the property owner constructed the pumphouse, he was unavailable to help with the installation of the system itself. Operation of the rainwater catchment system commenced in October during the beginning of the rainy season. The property owners were shown how to operate and maintain the system. They were also provided with an operation and maintenance manual including a list of components that may eventually need to be repaired or replaced. The rainwater catchment system functioned as intended for approximately six months. During the month of April, the property owners contacted the designer/installer of the system because they were out of water. The designer/installer visited the site to determine why the system was not supplying sufficient water. During the site visited the following concerns were noted:

- All five storage tanks were empty. The storage tanks hold approximately 15,000 gallons of water. At that time of year, the tanks should have been full due to the prior heavy rain.
- Although the rainwater catchment system was designed for two users, the property owners had a total of four individuals living onsite and using the water.
- The pre-filter between the downspouts and the storage tanks had never been cleaned. The clogged pre-filter was causing a

significant loss of water due to bypass.
• The pumphouse which contains the controls, filters, pressure tank, and UV light was being used as a chicken coop. Virtually everything in the pumphouse was covered with chicken feces.

Site construction of RWH system with pumphouse.

During the site visit, the designer/installer reiterated to the property owners the importance of following the operation and maintenance manual which includes instructions on cleaning the pre-filter. The property owners were also reminded that the system was designed for two users—not four. Therefore, the property owners need to immediately conserve their water usage. It was also explained to the property owners that using the pumphouse as a chicken coop poses significant health risks. The pumphouse must be kept as sanitary as possible when providing potable water. It was recommended to the property owners that they hire the designer/installer to provide the necessary maintenance, nonetheless, the property owners declined. They promised to address the concerns and make the necessary changes. The designer/installer scheduled a follow-up site visit in six months.

Conclusion: The designer/installer returned to the site six months after the inspection to verify that the corrections had been made. The following issues were noted:

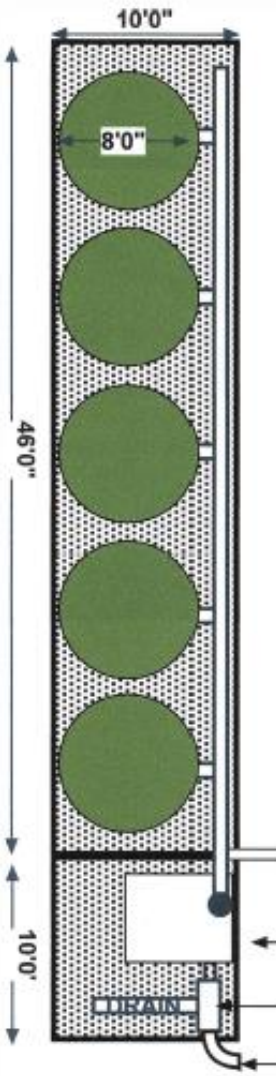
• The storage tanks contained water for operating the system, however, the property owners had arranged for tanker trucks to deliver water to the on-site storage tanks.
• The number of users of the system had increased to eight individuals despite repeated reminders that the system was designed for two users and stores a finite amount of water.
• The pre-filter remained clogged. It did not appear that it had ever been properly cleaned. The property owners admitted that they had not cleaned the filter because they were too busy.
• The clutter from chickens in the pumphouse had increased from the prior visit. The building was inaccessible because of the feed containers.
• A new issue: The property owners complained about the low flow of water inside the house. The designer/installer learned that the property owners purchased replacement filters from an online source to save money. The replacement filters had absolutely no certifications.

The designer/installer informed the property owners that he could no longer assist them with their rainwater catchment system because they continue to ignore the instructions for operation and maintenance of the system. The property owners were reminded that failing to follow the operation and maintenance instructions poses health risks. This case study demonstrates the need for follow-up by local jurisdictions with policies in place for enforcement—especially when the RWH System is the sole source of water.



Water Filtration System Located inside Pumphouse. Plumbing of Viqua Pro 10 UV light system inside Pumphouse.

North County RWH System



RAINWATER CATCHMENT SYSTEM for Potable Water

Components include:

5 - 3,000 gallon Poly Storage Tanks

Pre-filter system

Piping, miscellaneous fittings, drain

Gravel Pad

PUMP HOUSE Provided by owner

Components include:

81 gallon Pressure Tank
3/4 HP Jet Pump
Disinfection Filter System
Control System

500 Gallon Pump Tank with Pump

VFI Volume Filter by 3P Technik

From Downspout Drains