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Harvesting rainwater for the home

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Introduction

After an initial investment, collecting water from the home roof will provide "free" water and a level of personal security from drought or water outages. This fact sheet will provide the basic requirements for a safe and maintainable rainwater harvesting system.

There are multiple features to a rainwater harvesting system. Simply put, the roof catches rainwater. Gutters and downspouts transport the water to the storage tank. Then, gravity or a pump system transports the water to an area where it can be properly filtered for complete household use or drinking and cooking.

Before we take a detailed look at each component of a rainwater harvesting system, let's begin by figuring out how much water is currently used and how much rainfall Guam receives. Answers will help determine if installing a rainwater harvesting system is a worthwhile choice.

Household water usage

To find the right water storage capacity for household needs, look at the household's monthly water bills. For complete home usage, take a typical monthly water bill and multiply the gallons used by 12 (months). For drinking water (and perhaps cooking) usage, estimate the amount bought monthly from the water store and multiply by 12 (months). Certainly, if rainwater is desired for household, lawn, and landscape use, water tanks will need to be significantly larger than those used just for drinking and cooking use. Table 1 shows the estimated roof area needed to collect the amount of water needed based on monthly usage for the entire year.

CAUTION: NO DOMESTIC CATCHMENT MAY BE CONNECTED TO A HOME WATER SYSTEM THAT IS ALSO CONNECTED TO THE GWA WATER SYSTEM WITHOUT A PROPER BACK-FLOW PREVENTER INSTALLED WITH GWA WRITTEN APPROVAL AND INSPECTION. GWA support and assistance with this requirement may be obtained by contacting GWA's Permits office in the GWA Engineering offices. Contact information: 300-6058/6054 or permits@guamwaterworks.org

Table 1. Estimated roof square footage needed to collect the amount of water used monthly/annually.

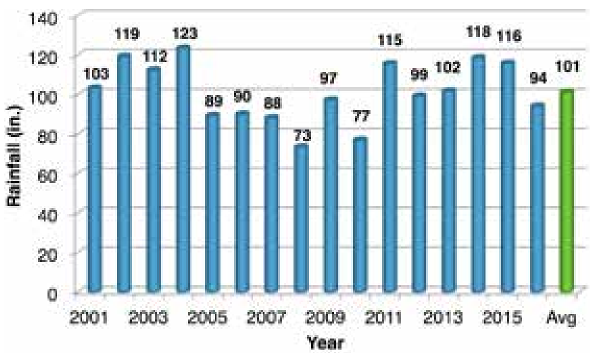
Roof Square Footage	Harvest Potential (gallons)	Monthly Usage Limit (gallons)	Daily Usage Limit (gallons)
800	50,000	4,165	136
900	56,250	4,687	154
1,000	62,500	5,208	171
1,100	68,750	5,729	188
1,200	75,000	6,250	205
1,300	81,250	6,770	222
1,400	87,500	7,291	239
1,500	93,750	7,812	256

Source: Guidelines on Rainwater Catchment Systems for Hawaii and National Weather Service Forecast Office data.

Annual rainfall

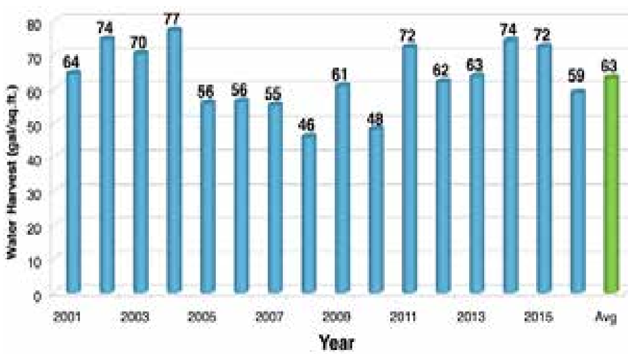
Graph 1 shows that the least amount of rain on Guam for the past 15 years was in 2008; 73 inches. The most amount of rain for the past 15 years was 123 inches in 2004. For the past 15 years, Guam has had an average of 101 inches of rain per year. With an annual average of 101 inches of rain, each square foot of collection surface can harvest about 63 gallons per year. Graph 2 illustrates the annual potential gallons of water harvested per ft^2. Graph 3 and Table 2 show the annual potential of gallons harvested based on the roof area.

Graph 1: Annual rainfall data for the past 15 years.



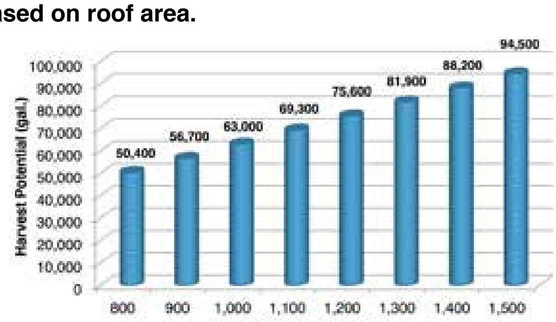
Source: National Weather Service Forecast Office data.

Graph 2: Annual potential gallons of water harvested per square foot for the past 15 years.



Source: National Weather Service Forecast Office data & Guidelines on Rainwater Catchment Systems for Hawaii.

Graph 3: Annual potential gallons of water harvested based on roof area.



Source: National Weather Service Forecast Office data & Guidelines on Rainwater Catchment Systems for Hawaii.

Table 2. Annual potential gallons of water harvested based on roof area.

Monthly Usage (gallons)	Annual Amount (gallons)	Roofing Needed to Harvest Monthly Usage (ft^2)
1,000	12,000	192
2,000	24,000	484
3,000	36,000	576
4,000	48,000	768
5,000	60,000	960
6,000	72,000	1,152
8,000	96,000	1,536
10,000	120,000	1,920

Source: National Weather Service Forecast Office data & Guidelines on Rainwater Catchment Systems for Hawaii.

Roofing surfaces suitable for water collection and their upkeep

Roofing must be made of materials that do not contaminate runoff water with harmful chemicals. Roof paint should not contain any fungicides or other poisons that could get into the catchment drinking water. This is a trade-off: the roof could get moldy and the fungicide in the paint can slow mold growth down, but harvested water could contain fungicide. A safe option available on Guam is silicone roof coating.

With newer home roofs, there should be no paint containing lead. If the house was built in the mid 80's or prior, it would be worth having the roof surface tested for lead. Lead test kits can be purchased at local hardware stores for under $10, while complete water analysis kits are less than $30.

Other roofing materials to avoid are asbestos, tar, asphalt, pesticide-treated wood, zinc, and uncoated galvanized metal. Table 3 shows roof materials available on Guam that can be used to safely harvest rainwater for consumption and other home uses.

In addition to making sure the water collection surface is safe, any trees above the roof should be trimmed so as not to hang over the roof. This reduces the amount of debris that can clog the drain and water catchment system. Roofs should also be cleaned on a regular basis. Maintaining a roof used for water collection requires a washing about every 3-6 months or as experience dictates. In some cases, cleaning the roof once a year is sufficient.

Table 3. Roof materials that allow for safe water collection.

Material	Cost ($)	Additional Material Needed	Additional Cost ($)	Lifespan (years)
Concrete	Current Roofing	None	N/A	50+
Fiberglass	Unavailable	None	N/A	25+
Galvanized Metal	Current Roofing	Nontoxic Paint	Unavail-able	15+
Slate	Unavailable	None	N/A	40+
Terracotta Tiles	Unavailable	None	N/A	20+

Source: Hardware stores on Guam, 2017.

Gutters That Collect and Transport Drinkable Water

Roofing gutters, as shown in Figure 1, or drains are essential for the harvest of rainwater. Figure 2 shows a simple form of filtration with a downspout debris screen. Most homes on Guam have flat, concrete roofs with drain holes and do not need roof-edge gutters. There are strainers that can be used on the roof entry point, which is shown in Figure 3. However, gutters and downspouts are important in order to move water from the roof into a catchment system. The second most common home type on Guam is an A-framed, galvanized steel homes where gutters are typically attached at the base of the roofline. Gutter materials that are safe for drinking water consumption are shown in Table 4.

Table 4. Gutter and downspout materials considered safe for water collection.

Material	Cost ($)	Additional Material Needed	Additional Cost ($)	Lifespan (years)
Aluminum Alloy-Coated Steel	Unavailable	Nontoxic Paint	Unavailable	25-30
Copper	Unavailable	None	None	60+
Extruded PVC	Unavailable	None	None	50+
Galvanized Steel	Gauge 26, 18in. x 10ft. - $21	Nontoxic Paint	Unavailable	7+
Stainless Steel	Unavailable	None	None	50+

Source: Hardware stores on Guam, 2017.

Leaf guards and screens

Leaf guards are installed over gutters to keep large debris from clogging gutters and downspouts. Additionally, a leaf screen can be added to the downspout to strain out even more debris. For a flat roof, some sort of straining device should be placed over the drain hole(s).

Figure 1. Roof gutter with a leaf guard that prevents leaves and other debris from clogging the drain.
Source: https://www.ctahr.hawaii.edu/hawaiirain/Library/Guides&Manuals/HI_Guidelines_2010.pdf

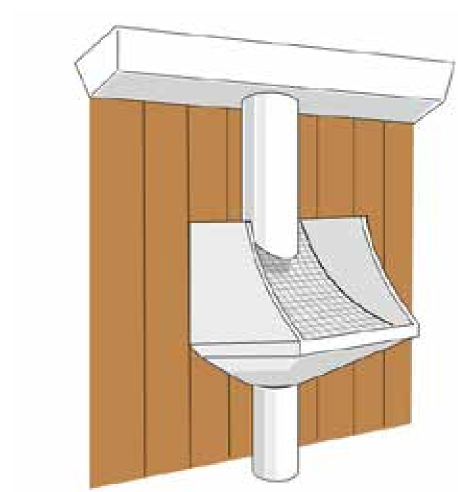
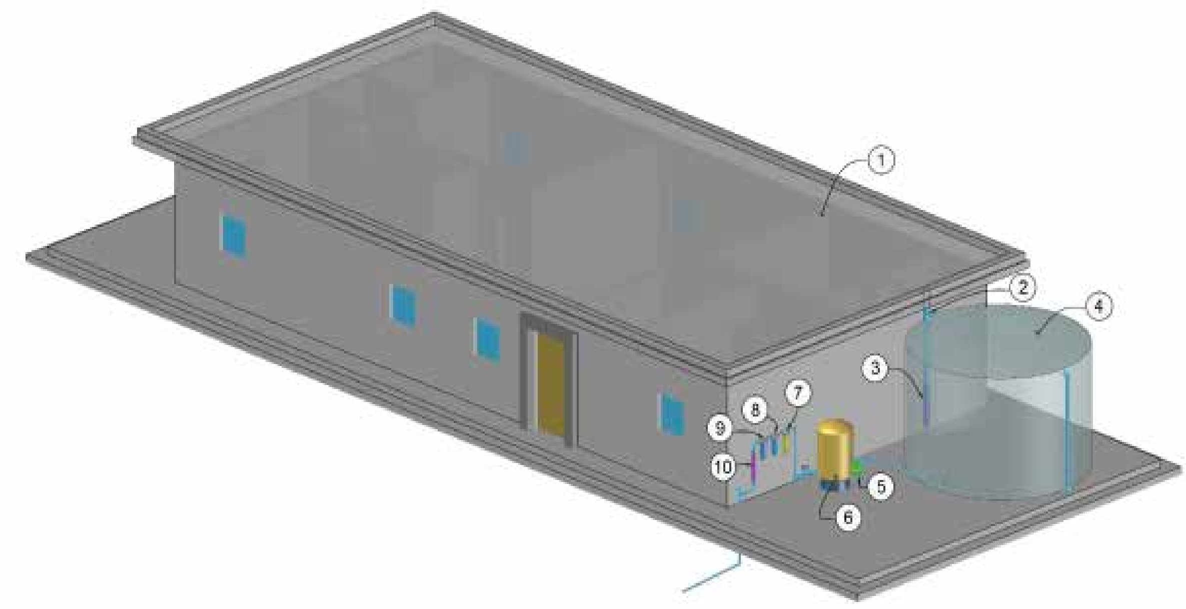


Figure 2. Downspout leaf/ debris screen that filters smaller materials that might pass through initial screens.
Source: https://www.ctahr.hawaii.edu/hawaiirain/Library/Guides&Manuals/HI_Guidelines_2010.pdf

Diagram of a water catchment system

This illustration is of a 1,256-ft^2 home with a water catchment system that can hold 5,000 gallons of rainwater. The household size is a family of four (4). The household water usage is 4,000 gallons a month, which totals to 48,000 gallons of water annually. Table 5 offers a cost range of what is seen in this illustration. Tables 6 and 7 assist in understanding the importance of associating the household water usage with the needed tank capacity.



Water catchment parts key

1. **Roof** The water catchment surface area. Safe roof materials/paint is required if water consumption is intended. Each square foot can harvest 63 gallons of rainwater annually.
2. **Downspout** 4" pipe that channels water from the catchment surface to the water storage tank.
3. **First-Flush Diverter** 4" pipe collects the initial harvest where most contaminants exist. The water collected is then released and flushed out into a designated area on the property.
4. **Concrete Water Storage Tank** The tank stores all harvested rainwater. Storage size depends on the intended use of rainwater and size can vary from 500-15,000 galllons. Attachments include a drainage valve for cleaning purposes and an overflow pipe in case the water harvested reaches above tank capacity.
5. **Water Pump** The pump moves water from the storage tank and sends it throughout the household with a normal water pressure, which is 40psi (pounds per square inch). Purchasing a higher voltage water pump such as a 220-volt pump, rather than a 110-volt creates energy cost savings.
6. **Pressure Tank** The pressure tank keeps water pressure steady and keeps the pump from turning on every time water is used within the household. This creates energy cost savings and water pump life longevity. The larger the tank size, the less electricity is consumed.
7. **Sediment Filter** Sediment filter can only filter debris, sand, and sediment. This can be placed in the pipe before water enters the storage tank. A filter can also be placed before the water pump to ensure that no debris or sediment goes into the pump; which could cause pump breakage.
8. **Carbon Block Filter** The carbon block filter can filter chemicals and some bacteria.
9. **Ceramic Filter** The ceramic filter can filter most microbes within the water. Many models are combined with activated carbon filters and serve a dual purpose of filtering many chemicals and most microbes.
10. **Ultra Violet Light Filter** The UV filter kills off 99.9% of the microbes and ensures all water that passes through is safe for consumption.

Table 5. Cost Range of Water Catchment System.

Part	Amount	Cost ($)
Ball Valve, 1"	2	$4-6
Ball Valve, 1"	1	$6-8
Check Valve, 1"	1	$6-8
Diverter Cap, 4"	1	$6
Elbow 90°, 1"	8	$5
Elbow 90°, 1½"	1	$2
Elbow 90°, 2"	2	$8
Filter, Ceramic	1	$150-200
Filter, Sediment	1	$90-200
Hose Bib, 1 in.	1	$8
Line, 1" x 20'	1	$10
Line, 2" x 10'	1	$6
Line, 4" x 10'	1	$19-59
Pressure Tank, 42 Gallon	1	$205
Tees, 1"	5	$5-8
Tees, 4"	1	$5-14
Unions,1"	6	$30
UV Filter	1	$100-120
Water Pump,¾ HP	1	$237-309
Water Tank, 5,000 Gallon	1	$2,275-5,500
Total Cost Range		$3,177-6,712

Source: Hardware stores on Guam, 2017.

Table 6. Household water catchment annual usage cycle. The blue cells indicate the tank capacity. The red columns indicate months of water shortage.

Month in 2016	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Inches of Rain	8	7	21	16	13	10	9	3	4	2	1	2
Harvest Potential	6,261	5,484	16,889	12,677	10,643	8,205	7,031	2,122	4,099	1,320	1,061	1,458
Gallons Diverted	16	16	16	16	16	16	16	16	16	16	16	16
Gallons in Tank	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,106	3,188	492	(2,463)	(5,021)
Gallons Used	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Gallons Left	1,000	1,000	1,000	1,000	1,000	1,000	1,000	(894)	(812)	(3,508)	(6,463)	(9,021)

Source: National Weather Service Forecast Office data, 2017.

Table 7. Household water catchment annual usage cycle with sufficient tank capacity to have access to water year round.

Month in 2016	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Inches of Rain	8	7	21	16	13	10	9	3	4	2	1	2
Harvest Potential	6,261	5,484	16,889	12,677	10,643	8,205	7,031	2,122	4,099	1,320	1,061	1,458
Gallons Diverted	16	16	16	16	16	16	16	16	16	16	16	16
Gallons in Tank	6,245	7,713	15,000	15,000	15,000	15,000	15,000	13,106	13,188	10,492	7,537	4,979
Gallons Used	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Gallons Left	2,245	3,713	11,000	11,000	11,000	11,000	1,000	9,106	9,188	6,492	3,537	979

Source: National Weather Service Forecast Office data, 2017.

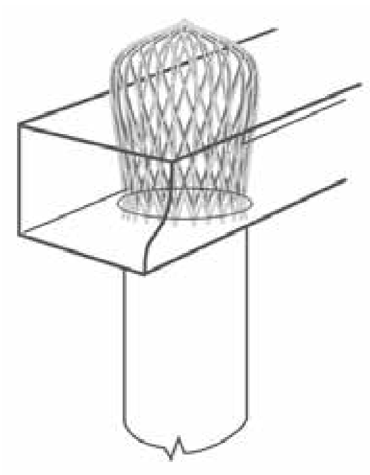


Figure 3. Aluminum strainer that can be used in gutters or roof drain entry point.
Source: https://www.smgov.net/uploadedFiles/Departments/OSE/Categories/Urban_Runoff/Clean_WaterTips.pdf

First-flush diverter

When rain hits a collection surface for the first few minutes, collected water can have insects, feces, leaves and sticks, paint chips, dust, and soil, etc. It is important to keep as much of these materials out of the water storage tank.

A first-flush diverter is an optional element attached to the downspout system that collects and diverts the first few gallons of water away from the holding tank. Table 8 shows the cost in creating a first-flush diverter for the home. In Figure 4, the diverter pipe collects the initial 20-50 gallons of rainwater. As the pipe fills up, a float rises to the top. Once the pipe is full, the float will seal the diverter pipe and the clean rainwater channels into the water tank. Figure 5 shows a side view of a small first-flush diverter. The amount of water that should be diverted with the first-flush device is dependent on the square footage of the collection surface. The recommended amount of water to be diverted by the first-flush diverter is $0.5gal/100ft^2$ to $1.25gal/100ft^2$.

Table 8. First-flush diverter materials that are safe for contact with drinking water.

Material	Cost ($)	Lifespan (years)
ABS Cap 4"	$6	50+
ABS Elbow 90° x 4"	$10	50+
ABS Elbow 45° x 4"	$6	50+
ABS Pipe 4" x 20'	$59	50+
ABS Tee 4"	$14	50+
ABS Wye 4"	$12	50+
First Flush Diverter	Unavailable	20+

Source: Hardware stores on Guam, 2017.

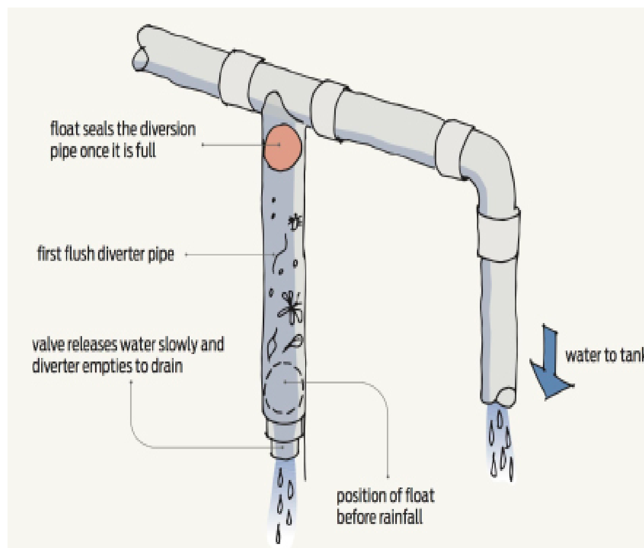


Figure 4. Diagram of how a first-flush diverter works.
Source: http://www.buildmagazine.org.nz/assets/Uploads/Build-151-26-Build-Right-Collecting-Drinking-Water-From-Roofs.pdf

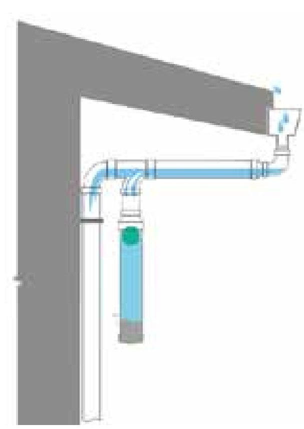


Figure 5. Side view first flush diverter attached to gutter.
Source: https://www.smgov.net/uploadedFiles/Departments/OSE/Categories/Urban_Runoff/Clean_WaterTips.pdf

Pre-tank filters

A pre-tank filter is an option that can remove the last remaining sediment and debris before the catchment water enters the water storage tank. Typically, a 10 or 5-micron carbon filter is suitable. These filters ensure that no particles enter the storage tank but they do not filter any potential pathogens. Research product details to know exactly what they can and cannot filter. These filters should be cleaned every 1-4 weeks. Filters should be changed as directed by the manufacturer's instructions.

Water storage tanks

Storage tanks are usually the most expensive element of a water catchment system. There are a variety of materials that can be used for water storage, but if one plans to drink the water from the tank, the tank material must be safe for long-term storage of drinkable water, i.e. the materials that make up the tank should not leach harmful chemicals into the water.

Budget will also impact choice of tank materials and size. The availability and variety of storage tanks on Guam are few. Larger systems require multiple smaller tanks or a larger tank constructed out of concrete, wood, or other water-safe materials.

Whatever the tank materials, once installed, the tank should be rinsed thoroughly before its first use. Follow all manufacturers' recommendations for maintaining the tank and keeping the water as sanitary as possible. Table 9 shows tanks that are made of safe materials and are available on Guam.

Once a storage tank has been chosen, placement of the tank must be planned. There are many things to consider and they may conflict with one another. The storage tank must be close enough to run a pipe downward from roof to storage tank. Overflow and drainage should not be in an area that will affect the foundations of any structures. The slope of the land should have a major influence on where to place the tank. It is important to prevent any chance of flooding from the collapse of a water storage tank for any reason. Placing the storage tank on the higher end of the slope can eliminate the need for a water pump system, but there must be some level of expertise as getting proper water pressure throughout the household without a pump is a very complex goal.

Construction of a water storage tank for Micronesia

In 1983, Guam Community College's environmental engineer Ralph L. Hogge wrote how to plan, design, and construct a water storage tank and elements. He describes a step-by-step process to build a 350- 10,000-gallon water storage tank. He reports that the Federated States of Micronesia built over 300 more tanks since World War II that are used as the main water source on dozens of islands. He shows the estimated cost for building a tank in 1983. The savings are significant and should be considered, especially if a very large water storage tank is desired. This study is at: http://www.weriguam.org/rainwater-catchment-systems.html . This page has the GCC publication and a few more done in Saipan and the FSM.

Table 9. Water storage tank materials that are safe for drinkable water.

Material	Cost ($)	Capacity (gallons)	Maintenance	Structural Integrity	Lifespan (years)
Cement	$250-600	550	Little to none- only checking for leaks from fittings is needed quarterly	Excellent	50+
Clay	Resource Based	550	N/A	N/A	N/A
Polyethylene	$499	550	Little to none- only checking for leaks from fittings is needed quarterly	Very Good	25+
Stainless Steel	Unavailable	550	Fair- Corrosion possible in the tropics which could lead to early repairs or replacement.	Fair	5-20+

Source: Hardware stores on Guam, 2017.

Water pump system

A water pump system is only required for water usage throughout the household. Harvesting water directly from the water storage tank does not require a pump.

A typical water pump system is composed of a pump, a pressure tank, a pressure switch, and a check valve. The purpose of a water pump system is to receive water from the storage tank and send it throughout the household with a normal water pressure, preferably above 40psi (pounds per square inch).

From the storage tank, there needs to be a pipe that connects to the pump. Just before the pump, along the pipeline, a coarse filter should be installed to prevent any potential debris from clogging the pump system. An optional pressure tank is installed directly after the pump. A pressure tank keeps water pressure high during water use and greatly reduces continuous work for the pump.

Considerations for pump longevity and energy cost savings.

- Supply line diameter from tank to pump
- Changing cycle of the coarse filter
- Pump voltage
- Pressure tank size

The diameter of the supply line should be no size less than 1 (one) inch and an even larger diameter will reduce strain on the pump. A larger diameter promotes both pump longevity and reduced electricity consumption.

The changing cycle of the filter is important because a dirty filter will cause stress to the pump and increase electricity consumption. Cleaning and changing the filter on a regular basis is important to ensure pump longevity and savings. A typical pump voltage for water catchment systems is 110 volts, but purchasing a higher quality, such as a 220-volt pump, will reduce electricity consumption.

The size of the pressure tank also influences pump longevity and energy cost savings. The larger the tank, the less electricity is consumed per gallon. There are more technical factors that are important to know that should be researched to ensure the pump system does not overheat or become damaged. If the pump malfunctions or is inoperable for any reason, seek advice from a licensed plumber. Table 10 shows water pumps available on Guam.

Table 10. Water pump materials suited for home use.

Material	Cost ($)	Optional Material	Optional Material Cost ($)	Lifespan (years)
½ HP 230V Pump	$197	Water Tank	$62-197	10+
¾ HP 230V Pump	$237	Water Tank	$62-197	10+
1 HP 230V Pump	$271	Water Tank	$62-197	10+

Source: Hardware stores on Guam, 2017.

Water Treatment

The most widely used form of water treatment to reduce pathogens is chlorination, the addition of the chemical, chlorine, to water at a holding area. Proper disinfection can be done by maintaining a 1 part per million concentration of chlorine in the water stored in the tank. There are chlorine products with higher concentrations for disinfection, but household chlorine will be used here as an example. If products with higher concentrations are to be used, proper conversions to this example must be made.

To reach a proper 1 part per million concentration, add 2.5 ounces of household chlorine (containing 5.25% available sodium hypochlorite) for every 1,000 gallons of water during rainy periods and 5 ounces per 1,000 gallons during dry periods. During the dry season, water within the tank sits inside for longer periods of time and pathogens have a greater chance of multiplying in these conditions. Therefore, a higher amount of chlorine is suggested during the dry season. Generally, chlorine dissipates within 12-24 hours without filtration. Chlorination can be done once a month, but a weekly dosage is recommended since chlorine dissipates over time. Proper filtration can remove chlorine from the water used for consumption. If chlorination is not desirable, there are filtration treatments that can create safe drinking water without chlorination. More information about these options is available in the CNAS publication, Making Guam's Safe Tap Water Taste Better with Home Filters (2017).

Harvesting water with rain barrel systems
Water captured by simple rain barrels can be used to wash the driveway, outside living area, or car. The savings can definitely add up.

Rainwater harvesting also benefits plants because they love rainwater much more than water from the tap. Rainwater doesn't contain any added chemicals that can cause a build up of chlorine or chlorine by-products, for example, within the soil. Rainwater can also help clean up any chemicals built up that was caused by water from the tap, which will promote root growth.

To establish a rain barrel system, choose an area, preferably where a downspout is already installed. If necessary, dig out a few inches of soil in an area that is the length and width of the cinder blocks that will be placed under the barrels as its base. Fill the area with some pea gravel or small, uniform rocks. This helps keep the area dry and drains water away from the foundation of the building. Place the needed amount of cinder blocks down and make the area as level as possible. The cinder blocks provide sufficient room to use a can under the spigot. Also, the blocks raise the level of the rain barrels and increase water pressure. The higher the rain barrels are placed, the more water pressure is added to the water flow. Cut a hole at the top of the rain barrel large enough for the water from the downspout to enter the rain barrel without excessive spilling. Modify the downspout by cutting it in order to place the barrel directly underneath. Install a mesh over the hole in the barrel to act as a filter for leaves and other debris. If mosquitoes are a problem, install a very fine mesh to avoid the harvested water from becoming a breeding site. Additional barrels can be added for greater storage. Figure 6 shows a diagram of a rain barrel system. For tools and materials needed and more detailed information about installation visit: http://www.gardengatemagazine.com/52droughttolerant/

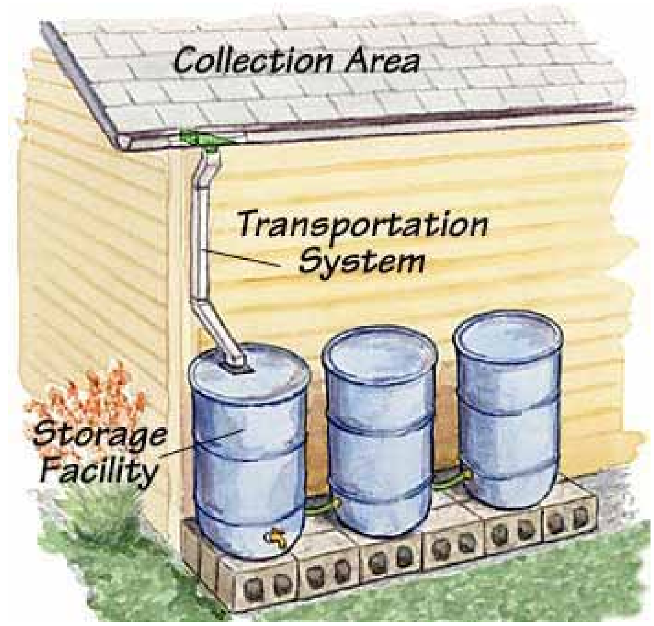


Figure 6. Diagram of a rain barrel system.
Source: http://www.gardengatemagazine.com/52droughttolerant/

Historical fresh water use on Guam: an exploratory study (1979)
Rebecca A. Stephenson led a collaborative effort to show the importance of freshwater for Guam's people throughout their history. The project explained the various methods that ancient Chamorus used to catch and harvest rainwater along with gathering water from caves and rivers. Survey results showed that many Chamorus did not believe that water was a limited resource. The main aspect of this project dealt with using the Chamoru language to survey elder Chamorus and find their perception of water from natural resources before World War II. The overwhelming evidence showed that water from natural resources was greatly preferred over tap water, which was installed in 1950. However, the researchers saw with the youngest participants that there was a change in perception of tap water brought on after WW II. The study shows that water has been collected for over 2,000 years and tap water has been our primary resource for just over 70 years. See the study here: http://www.weriguam.org/docs/reports/8.pdf

Summary
Guam receives more than enough rainwater to explore the option of harvesting rainwater for the home. Take the time to find out how much water is required to store for the usage desired. Catchment systems can provide for drinking, for only outside use, or for complete household use. An installation plan should fit the needs of how the water will be used. A sufficient plan consists of: a roof suitable for water collection, gutters, leaf guards and screens, a first-flush diverter, a water storage tank, a water pump system if needed, and water treatment if water consumption is intended.

There are many additional sources available to help gain more information about home rainwater catchment systems. Gather as much information as needed to make the most informed choice and follow manufacturer's instructions for installation and maintenance.

References
Elkink, A. 2016. Collecting Drinking Water From Roofs. http://www.buildmagazine.org.nz/assets/Uploads/Build-151-26-Build-Right-Collecting-Drinking-Water-From-Roofs.pdf. (Accessed March 31, 2017).

Hren, R. 2009. Free Your Water: Fundamentals of a Rainwater Harvesting System. http://www.chelseagreen.com/blogs/free-your-water-fundamentals-of-a-rainwater-harvesting-system/. (Accessed March 10, 2017).

Macomber, P. 2010. Rainwater Catchment Systems for Hawaii. https://www.ctahr.hawaii.edu/hawaiirain/Library/Guides&Manuals/HI_Guidelines_2010.pdf. (Accessed February 27, 2017).

National Weather Forecast Office. 2017. https://www.weather.gov/climate/index.php?wfo=guam. (Accessed March 12, 2017).

Pushard, D. 2013. Rainwater Harvesting- Pumps or Pressure Tanks. http://www.harvesth2o.com/pumps_or_tanks.shtml#.WUJ_FVJ7Gn4. (Accessed June 14, 2017).

Pushard, D. 2016. Comparing Rainwater Storage Options. http://www.harvesth2o.com/rainwaterstorage.shtml. (Accessed February 28, 2017).

University of Hawai‘i at Mānoa. Clean Water Starts Before Your Tank. https://www.smgov.net/uploadedFiles/Departments/OSE/Categories/Urban_Runoff/Clean_WaterTips.pdf. (Accessed March 5, 2017).

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