Rainwater Catchment for Skagit County

Project Report

Fall 2017 - Spring 2018

Report No. 18-01 April 2018

About SCP

Western's Sustainable Communities Partnership (SCP) program focuses the expertise, energy, and ideas of faculty and students upon the issues that communities face as our society transitions to a more sustainable future. SCP partners with communities each academic year, facilitating a program in which many Western courses complete community engaged learning projects that address problems identified by the partner.

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SCP Partner for Academic Year 2017 – 2018: Skagit County, WA

SCP is proud to partner with Skagit County, Washington, during the program's second year. Six Western courses and three student interns will tackle eight projects identified in collaboration with county staff.

Acknowledgement

The Association of Washington Cities (AWC) has provided invaluable assistance as SCP has grown and developed in its second year. AWC has provided advice on program development, and has assisted in promoting the program.

SCP is housed within Western's Office of Sustainability

PREFACE

A student intern, Joseph Kuljis, prepared a rainwater catchment design template in the 2017-2018 academic school year under the supervision of Robert Mitchell, PhD, a licensed hydrogeologist and professor in the Geology Department at Western Washington University. Skagit County sought a rainwater catchment template with the goal of offering the template to homeowners as a response to constraints on new well use. This report contains a summary of the importance of proper rainwater catchment and provides step-by-step instructions on how to set up a functioning catchment system.

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POTABLE RAINWATER CATCHMENT SYSTEM DESIGN FOR RESIDENTIAL WATER SYSTEMS IN SKAGIT COUNTY, WASHINGTON

By Joseph Kuljis

WARNING!

Potable water system design is a matter of human health. Improper rainwater catchment system design or maintenance can result in a water source that poses health risks for users. The following design guidelines are intended to insure the production of water that meets Skagit County's potable water standards for captured rainwater.

Rainwater catchment, also known as rainwater harvesting, refers to the collection and storage of rainwater for irrigation, drinking, or other uses. Rainwater is typically captured from a roof, then diverted into a storage tank before purification and usage. A properly-designed rainwater catchment system may be able to fulfill a household's potable water needs. This makes rainwater a practical alternative when wells and water lines are not available options. Potable rainwater catchment systems require special care in their design to make them permittable drinking water sources. Non-potable rainwater catchment systems, such as rainwater stored in rain barrels to be used for garden irrigation, are not subject to the same rigorous standards of purification and design.

Skagit County has adopted Appendix B of the 2012 Green Plumbing and Mechanical Code Supplement for designing potable rainwater catchment systems. The specifics of this code are incorporated into the following guidelines intended to streamline this design process while emphasizing safety, simplicity, and cost-effectiveness. Please refer to the 2012 Green Plumbing and Mechanical Code Supplement, Appendix B for more information. Further questions regarding potable rainwater catchment systems should be directed towards Skagit County Planning and Development Services.

The following page is a diagram of a potable rainwater catchment system. This diagram lists key recommendations for designing a rainwater catchment system, divided into six steps. These six steps are elaborated upon in the remainder of the document.

POTABLE RAINWATER CATCHMENT SYSTEM DESIGN

A Design Template For Skagit County

① ROOF

- Roof material: asphalt shingles or other non-restricted material
- For asphalt shingles:
  - Not excessively old/worn
  - No algae treatment
  - No chlorine purification
- Roof must be sloped
- The larger the roof area, the better

② CONVEYANCE

- Gutter material: schedule 40 PVC or other non-restricted material
- Downspouts/piping material: Schedule 40 PVC
- Downspouts connect to single pipe before pre-filtering
- Pre-filtering: first-flush diverter and vortex filter

③ STORAGE

- Tank material: polyethylene
- Size according to Rainwater Harveting Calculator
- Primary inlet: includes calming inlet
- Primary outlet: floating intake w/filter
- Vent: min 1.5 in diameter, 3/32 in mesh screen cover

④ PUMP

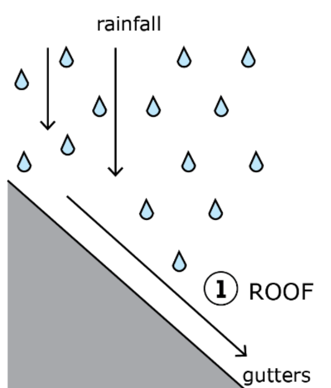
- Pump must be listed for potable water use
- Pressure should not exceed 80 psi

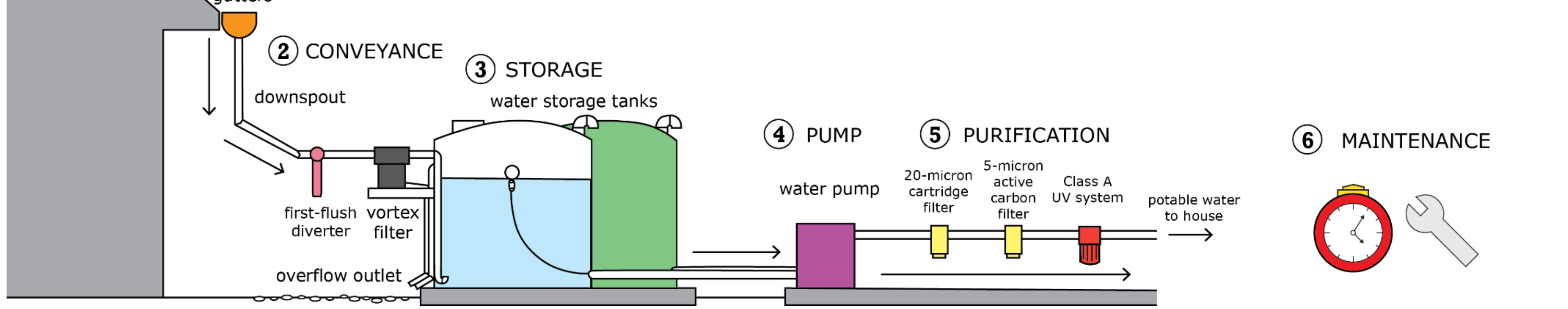
⑤ PURIFICATION

- 20-micron cartridge filter
- 5-micron activated carbon filter
- Class A UV disinfection system
- The order of these devices matters

⑥ MAINTENANCE

- Perform all maintenance activities listed in Table 1
- Keep a maintenance log





Who Can Use a Rainwater Catchment System?

Current Washington State Department of Ecology (Ecology) policy states that water rights permits are not required for rainwater catchment systems. Ecology specifies the following conditions for rainwater catchment systems:

- Rainwater use is restricted to the property where it was collected.
- Rainwater must be collected from structures that have purpose besides rainwater collection.
- The ability to use rainwater as a property's primary water source is governed by the local county.
- If the Department of Ecology finds that rainwater collection is negatively affecting existing water rights, further restrictions may be developed.

Designing a Potable Rainwater Catchment System

Step One: Catchment Area

Figure 1: Traditional asphalt fiberglass shingle roofing makes suitable potable rainwater catchment surfaces. However, users should avoid algae-resistance treatment and purifying their water with chlorine. [By FASTILY [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], from Wikimedia Commons]

Catchment area refers to the surface from which rainwater is collected, typically rooftops. Ecology has determined that water right permits are not required to collect rainwater from rooftops on a user's property.

Roof Material

- Asphalt fiberglass shingles are recommended as effective potable rainwater catchment surfaces.
- This material is recommended over other choices because of their popularity and cost-effectiveness. Asphalt fiberglass shingles are already the most popular roof material in the Puget Sound area (Winters & Graunke, 2014). Asphalt shingles are also particularly low-cost.
- Despite many rainwater catchment professionals expressing a preference towards metal roofing for potable systems, in experimental testing modern asphalt shingles do not leach notable amounts of harmful contaminants into rainwater runoff compared to most metal roofs (Winters & Graunke, 2014).
- When using asphalt fiberglass shingles in a potable rainwater catchment system, a number of considerations should be taken into account:
    - Older varieties of asphalt shingles may contain excessive impurities and are not suitable for potable rainwater catchment (Winters & Graunke, 2014).
    - Asphalt fiberglass shingles with algae-resistance treatment included are not recommended, as this treatment increases the amount of copper leached into water runoff (Winters & Graunke, 2014). This can be hazardous if consumed. In general, be cautious with any roof treatments while harvesting rain for potable purposes.
    - When asphalt roofing is used, chlorine should not be used in the water purification process. Dissolved organic carbons from the roofing (which are not harmful to humans on their own) can react with chlorine to form hazardous chemical byproducts (Mendez et al., 2010). For this reason, it is recommended to purify harvested rainwater with a combination of filters and UV disinfection instead of chlorine. See Step Five: Purification.
- Metal roofs are not required for rainwater catchment but can still be good choices. Some metals and paints are not recommended for potable water collection because of their potential to leach hazardous chemicals. Check with other resources for more details on roofing alternatives.

Roof Pitch

- Roofs used for rainwater collection need to be pitched or sloped. In other words, the roof should not be flat. Flat roofs are not acceptable for potable rainwater catchment systems as they allow for pooling and stagnation of water, resulting in the growth and collection of contaminants.

Roof Sizing

In general, the larger the roof size the better. The amount of catchment area affects the volume of water captured in a given rainfall event, and hence the volume of water that can be stored. Roof size for calculations should be measured as the length times the width of the house, or the projected area of the roof. The surface area of the roof is not equivalent. See Figure 5 for an illustration of this concept.

Step Two: Conveyance System

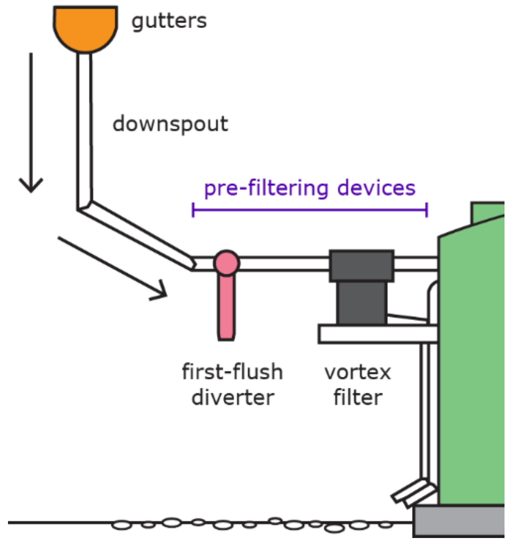


Figure 2: A schematic of a conveyance system. This system runs from the gutters of the roof to the connection with water storage. Pre-filtration devices remove debris and contaminants from the captured rainwater before storage.

The conveyance system is what carries rainwater from the catchment area to the storage tank. It consists of gutters, piping, and any pre-tank filters. Although the water will be further filtered and purified before use, pre-tank filtering is an effective way to reduce wear and need for maintenance on catchment system components.

- Gutters
  Definition: The troughs along a roof's edge that capture and direct roof runoff.
  - Material: Schedule 40 PVC is a readily available and easy-to-clean material for potable rainwater catchment.
  - Gutters should be sized appropriately for the local climate and roof size. Either have a professional size them or utilize an online calculator, such as [SMACNA's Downspout and Gutter Sizing Calculator](https://www.smacna.org/news/latest/archives/2017/07/06/introducing-smacna-s-downspout-and-gutter-sizing-calculator). (https://www.smacna.org/news/latest/archives/2017/07/06/introducing-smacna-s-downspout-and-gutter-sizing-calculator)
- Downspouts
  Definition: The vertical pipes that carry water out of the gutter system.
  - Schedule 40 PVC pipe is a cheap and safe choice in potable water systems. However, any kind of piping certified for potable water use can be used.
  - All downspouts will be connected to a single pipe connected to the pre-filtering devices.
  - As with gutters and downspouts, Schedule 40 PVC is a reasonable choice for the pipes used within a potable rainwater catchment system.

- First-Flush Diverter
  Definition: A device used to capture and divert early runoff.
  - A first-flush diverter is a necessary pre-tank filtration device for potable rainwater catchment systems because early runoff in a rain event contains the most contaminants (during dry periods these contaminants build up on roofs and gutters).
  - First flush diverters capture a set volume of water and keep it from entering storage. After the diverter becomes full, further water captured will be carried to storage.
  - Diverter inlets should have corrosion-resistant debris screen with maximum openings of 1/2 inch.
  - Water from a diverter should not go to a storage tank and should instead be disposed of in a way that does not erode or damage the property.
  - First-flush diverters need to allow for manual draining (as opposed to automatic).
  - Western Washington weather is dominated by low intensity but frequent rainfall events. This makes emptying a first-flush diverter after every rainfall event very wasteful. Manually empty the first flush diverter only after extended dry periods that allow contaminants to build up on outdoor surfaces.
- Vortex Filter
  - Potable rainwater systems should utilize a vortex filter to remove sediment and debris from rainwater before being sent to storage. This filter system requires minimal maintenance compared to gutter and downspout screens, which are prone to clogging.
  - Vortex filter specifications typically describe the total roof area they are capable of filtering. Pick one that is appropriate for your roof size.
  - Some vortex filters include first-flush diverter capabilities and may be used in place of a dedicated diverter, assuming they meet the requirements for diverters listed above.

Step Three: Storage Tanks

Storage tanks are where harvested rainwater is kept between capture and use. Many storage tanks are constructed explicitly for potable water and for outdoor use and can be purchased in a variety of sizes at local vendors or online.

- Multiple Tanks
  - Households depending on rainwater as their only potable water source need to have multiple water storage tanks. Water tanks require periodic cleaning and maintenance that can only happen when a tank is not in use. With multiple tanks, one tank can be emptied for maintenance while another is kept active to maintain a water supply. Multiple tanks are also useful as a safety precaution in the case one tank unexpectedly fails.
  - There are many ways that multiple water tanks can be incorporated into a system. A valve at the end of the conveyance section (Step Two) that allows the destination of the incoming water to be manually changed is recommended. Connecting conveyance to a single tank, then connecting the tanks near their bottoms so that water is free to

distribute equally across the tanks is also an option. Just make sure this connection can be closed when a tank is being serviced.

- Tank Material and Coating
    - Polyethylene is recommended for storage tank material.
    - It is the most common, effective, and economical material for potable water tanks.
    - If the tanks are kept outdoors, they will need to be opaque to block sunlight. Either find opaque tanks approved for use in sunlight (this will be explicitly labeled) or modify non-opaque tanks with multiple layers of dark paint for the same result.
- Storage Sizing
    - Correct storage sizing is a crucial aspect of rainwater catchment design.
    - Water tanks vary in sizes from hundreds to tens of thousands of gallons. The volume of storage a system needs depends on factors such as expected household water use, catchment area, and average precipitation rates. Please see the upcoming section "Using the Rainwater Harvesting Calculator to Size System Storage."

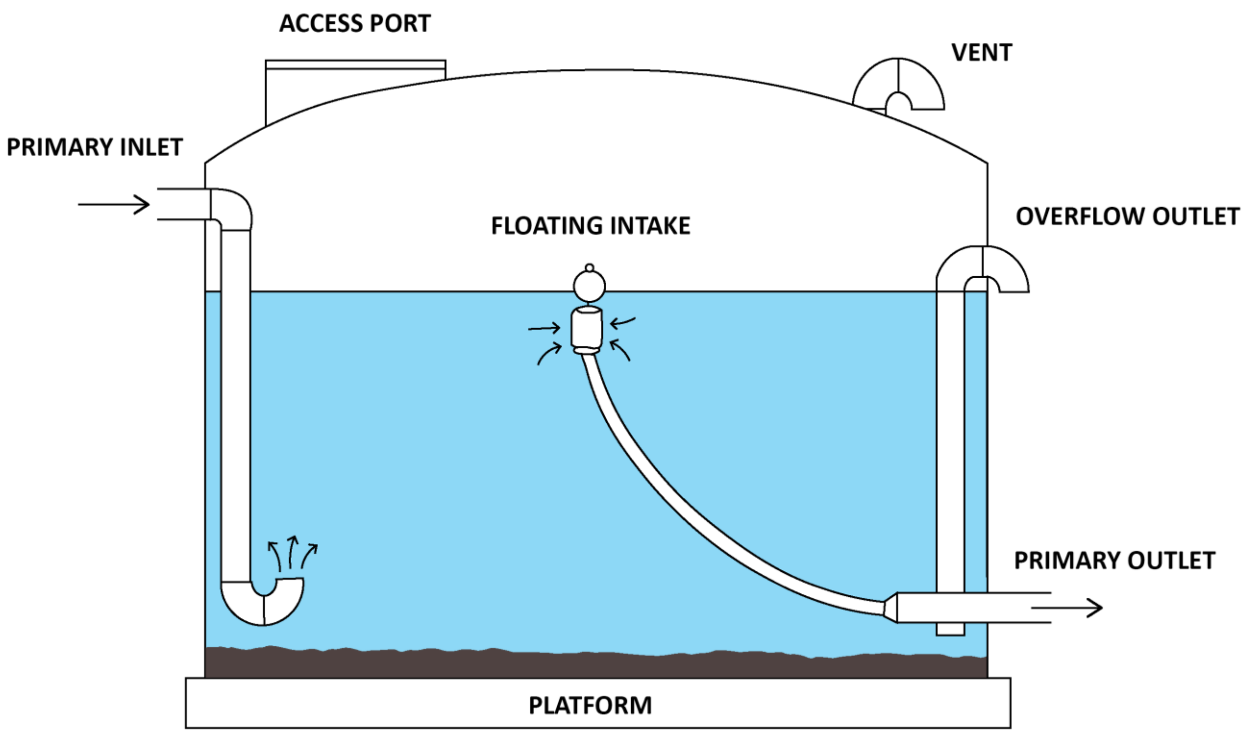


Figure 3: A schematic of a water storage tank.

The following detail the parts of a potable water tank, which are also shown in the above diagram.

- Tank Inlet

  Definition: The interior tank piping where tank inflow meets the body of water resting in the tank.

  - Inlets need to be fitted in a way that minimizes the disturbance of sediments resting at the tank's bottom. The simplest way to accomplish this is with an upward-aimed inlet (see Figure 3), also called a calming inlet.
- Primary Outlet

  Definition: The piping that connects the storage tank to the next processing stage.

  - For a potable system, the best option is a floating pump intake (see Figure 3) that rests within the storage tank at water level. These should and typically are coupled with filters to reduce the amount of sediment in the following water pump.
- Overflow Outlet

  Definition: Where surplus water overflows from a filled tank.

  - Should be equipped with a backwater valve to prevent backflow into the tank.
  - Should not be equipped with a shut off valve.
  - Discharge from this outlet needs to meet the requirements of the plumbing code as related to storm drains.
  - Outlet pipe cross-sectional area should be equal to the cross-sectional area of all inflow pipes.
- Vent

  Definition: The opening on the tank's top that allows air exchange between the inside and outside of the tank that keeps a vacuum from forming when water level changes.

  - The vent should be a minimum of 1.5 inches in diameter.
  - Vent terminal should be directed downwards and covered with a 3/32-inch mesh screen.
- Platform

  Definition: The foundation on which a water tank sits upon.

  - Filled tanks can become very heavy. They may require the construction of a concrete base to hold them. These platforms should be flat, level, and be constructed on compacted ground so that sinking does not occur.

Step Four: Pumps

There needs to be some force to move water from your tank to its place of use. With careful planning, water can be moved to the house through gravity. However, an electronically-driven pump will allow for easier installation and system design.

- Water Pump
  - Water pumps pressurize water to cause movement through a system.
  - Any pumps used should be specifically listed for potable water use.

- Within a building, pressure should be managed so as to not exceed 80 psi. If exceedance occurs, a pressure reducing valve should be used.

Step Five: Purification

Before water can be considered potable, it needs to be purified. A combination of a filter series and a UV disinfection system is recommended. This purification setup is relatively easy to maintain while also being capable of purifying to the water quality standards required by Skagit County.

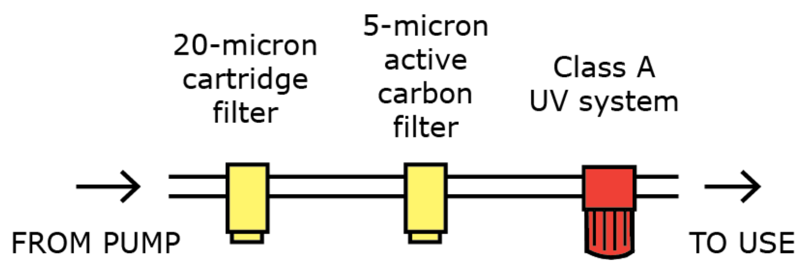


Figure 4: Schematic of the recommended water purification setup.
The order of the purification devices is important.

- Filters
    - A series of filters of decreasing size are necessary for removing particulate matter from rainwater before UV disinfection occurs. A series of two filters is recommended:
        - 20-micron cartridge filter
        - 5-micron activated carbon filter
    - Filters should be installed so that water within the system encounters increasingly fine filter sizes, as shown in the above diagram.
    - Activated carbon filters have the added bonus of removing odors and tastes from water. Incorporating one into your purification system is desirable for this reason.
    - Smaller filters will not be necessary, as the primary purpose of the filter series is to remove sediment that will interfere with the UV disinfection and not to remove all pathogens through filters alone.
    - Filters needed to be replaced regularly to maintain effectiveness. See the following section on maintenance for details.
- UV Disinfection
    - UV disinfection systems use ultraviolet light to sterilize pathogens in the water, rendering them harmless.
    - To be effective on untreated rainwater, UV systems should meet NSF Class A specifications.
    - To ensure proper function, the flow rate of the UV system should match the rate of the water pump used.
    - UV disinfection system should be placed after the filter sequence (see Figure 4). The more material removed from the water, the more effective the disinfection.

- Water Quality Guidelines
    - Water quality is a high priority when it comes to potable water systems. There are minimum requirements that post-purified water need to meet to be considered safe.
    - Before occupancy permits are granted for a property with rainwater as its primary potable water source, the treated water needs to pass an intensive quality test using an accredited lab. See [Skagit County's Water Testing Handout](https://www.skagitcounty.net/PlanningAndPermit/Documents/forms/Water/Water%20Testing.pdf) for those requirements. (https://www.skagitcounty.net/PlanningAndPermit/Documents/forms/Water/Wate %20Testing.pdf)
    - The following are water quality guidelines given by the 2012 Uniform Plumbing and Mechanical Code Supplement. These can be performed by the homeowner with self-administered tests.

With the initial system startup, water quality should meet the following guidelines:

Escherichia coli (fecal coliform)	99.9% reduction
Protozoan Cysts	99.99% reduction
Viruses	99.99% reduction
Turbidity	<0.3 NTU

System testing should occur every 3 months and should meet the following guidelines:

Escherichia coli (fecal coliform)	99.9% reduction
Turbidity	<0.3 NTU

If a system fails a water test, the system will need to be thoroughly cleaned and retested before use is continued.

After purification, the processed rainwater is ready for use as potable water within household plumbing. It can now be moved to a household water tank to await usage.

Step Six: Maintenance

After assembly, a rainwater catchment system requires maintenance to keep it functional and safe for use. The following table is a general guide to scheduling maintenance activities.

DESCRIPTION	MINIMUM FREQUENCY
Inspect and clean filters and screens, and replace (if necessary)	Every 3 months.
Inspect and verify that disinfection, filters and water quality treatment devices and systems are operational.	In accordance with the manufacturer's instructions
Perform applicable water quality tests to verify minimum water quality compliance (see tables in Step Five).	Every 3 months.
Perform applicable water quality test for E. Coli, Total Coliform, and Heterotrophic bacteria. For a system where 25 different people consume water from the system over a 60 day period, a water quality test for cryptosporidium shall also be performed.	After initial installation and every 12 months thereafter
Inspect and clear debris from rainwater gutters, downspouts, and roof washers.	Every 6 months.
Inspect and clear debris from roof or other aboveground rainwater collection surface.	Every 6 months.
Remove tree branches and vegetation overhanging roof or other above-ground rainwater collection surface.	As needed.
Inspect pumps and verify operation.	After initial installation and every 12 months thereafter.
Inspect valves and verify operation.	After initial installation and every 12 months thereafter.
Inspect pressure tanks and verify operation.	After initial installation and every 12 months thereafter.
Clear debris and inspect storage tanks, locking devices, and verify operation.	After initial installation and every 12 months thereafter.

Table 1: Minimum potable rainwater catchment system testing, inspection, and maintenance frequency modified from Appendix B of 2012 Green Plumbing & Mechanical Code Supplement

A maintenance log for the system will need to be kept up-to-date and available for inspection. The purpose of the log is to record any tests, system inspections, or maintenance activities performed on the rainwater catchment system along with the dates the activities were performed. A record of any required water quality tests should be retained for no less than two years.

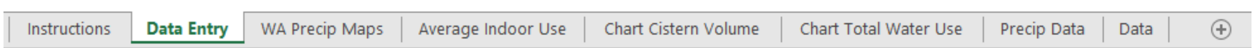
Other Remarks about Design

- All components of the system should be approved for potable water use.
- Water in a rainwater catchment system cannot be allowed to freeze. This includes water in storage tanks, pipes, and water pumps. If the system cannot be designed in such a way as to prevent freezing, consider implementing a heat pump into the system.
- Rainwater pH can be an issue in some areas. If rainwater is too acidic, its corrosiveness will cause wear on your plumbing system. A pH neutralizer filter can be added into the purification series to reduce water acidity before entering home plumbing. Typically, pH neutralizer filters are installed after the UV system in the purification series.

Using the Rainwater Harvesting Calculator to Size System Storage

The Washington State Department of Ecology Rainwater Harvesting Calculator is a useful tool for determining an adequate volume of water storage for one's system.

1. Download the calculator from the Skagit County Planning and Development website.
   This version of the calculator has precipitation data for Skagit County locations built in. A more general version of the calculator is available with locations from around Washington State.
2. Open the calculator on your computer.
   A warning may appear explaining that macros have been disabled. If so, click 'Enable Content.' Otherwise the calculator may not work.
3. Navigate to the 'Data Entry' sheet in the calculator spreadsheet.



This bar present at the bottom of the spreadsheet allows you to navigate to other sheets by clicking on their titles.

You will input the following information:

Location: Location affects expected average precipitation rates for the household. Click on the green box (Anacortes by default) and find the closest city or town to your location in the drop-down menu (see Figure 6). Since precipitation rates do not usually change drastically across short distances, this approach is generally accurate enough for estimating a storage volume. See the 'WA Precip Maps' sheet in the calculator to see representations of precipitation rates across the state.

In some situations, you may want to input your own precipitation data into the calculator. To do this, navigate to the 'Precip Data' sheet of the calculator. You can edit the monthly precipitation values in the 'CUSTOM DATA' row with new data. The 'Total' column should fill-in automatically with the sum of the twelve months of precipitation averages. **Keep in mind that this calculator works in units of inches of rain.** If your data is in another unit, you will need to convert before putting the numbers into the calculator. After adding the custom data, return to the 'Data Entry' page and select 'CUSTOM DATA' from the location drop-down menu. Your custom data should now be incorporated and you can continue using the calculator as normal.

Rainwater Harvesting Water Usage & Storage (gallons)	
Select the city nearest where you live. This determines your precipitation and irrigation duties so try to choose a city with a similar climate.	Marblemount
Estimate household or building daily water use in gallons per day (gpd)	60
Enter rainwater harvesting cistern storage capacity (gallons)	2,500
Enter roof size in s.f. (assumes 100% roof dedicated to catchment and 80% or rain/snow that falls on roof is captured)	1,200
Are you concerned if your cistern goes dry during the summer (is rainwater your sole source or is it a source augmentation)? If you are concerned, click yes. If not, click no. A yes entry will trigger a reduce/resize message below under Desired Use below if your cistern runs dry - this ensures your needs can be met.	(•) Yes ( ) No

Figure 5: An example of a filled-in data entry table in the rainwater calculator.

Average water usage: This is the volume of water you expect the household will use in gallons-per-day. Around 60 gallons per day per person is a good rule of thumb, but we recommend making more specific estimates. See the 'Average Indoor Usage' sheet within the calculator spreadsheet on how to calculate a reasonable estimate or use an online water usage calculator. Given your water usage habits, you should be able to come up with a rough gallons-per-day estimate.

When transitioning to rainwater as a primary water source, we recommend reviewing water conservation guidelines. Installing high-efficiency appliances, doing extra maintenance to keep pipes and fixtures leak-free, and being aware of practices to reduce water usage when reserves get low. See the WA State Department of Ecology webpage on Water Conservation for a helpful guide. (https://ecology.wa.gov/About-us/Get-involved/What-you-can-do/Water-conservation)

Roof size: This is the square footage of your catchment area. A rectangular roof will have a roof area equal to the length of the roof times the width. The size here IS NOT the same as the surface area of the roof (see Figure 5).

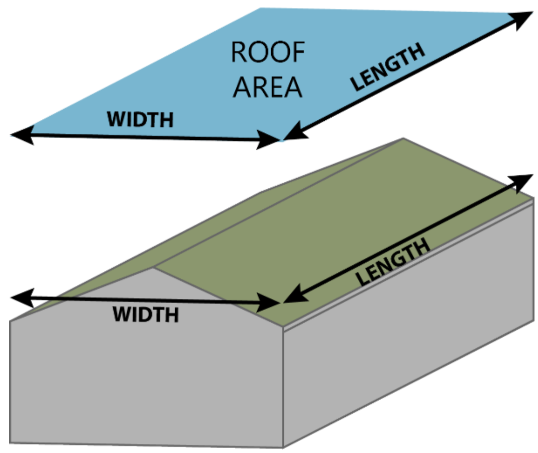


Figure 6: Roof Area as referred to in the rainwater harvesting calculator is the actual area of the roof, and not the surface area. For a standard shaped roof, this will be the length times the width of the building.

If you are using rainwater catchment as your primary water source, you need to check 'Yes' where the calculator asks if you are concerned about your cistern going dry during the summer.

4. Determining tank size

   With location, water usage, and roof size entered into the calculator, you can move on to calculating a reasonable storage volume. This is as simple as entering storage sizes in the calculator and observing the cistern volume carryover in the bottom right chart and the actual use vs desired use in the bottom left chart.

   - If carryover is equal to zero at any point during the year, then the storage volume is too small.
   - If carryover is notably low at any point during the year, then the storage volume is too small. Remember that these results are based on an average precipitation year. In some years you will receive less than average rainfall, so having a reasonable buffer of extra expected water is essential. Keep in mind your average daily water usage value; having weeks of extra water would be a good idea.
   - If carryover volume is zero every month then you are not collecting enough rainwater to outweigh your daily usage. You either need to include more catchment area in your system or lower your daily water demands.

Month	Cistern Volume Carryover (gallons)	Cistern Overflow (gallons)
Jan	1,600	3,533
Feb	1,600	1,426
Mar	1,600	1,451
Apr	1,600	597
May	1,600	19
Jun	1,344	0
Jul	607	0
Aug	0	0
Sep	0	0
Oct	1,600	2,019
Nov	1,600	4,415
Dec	1,600	2,476

RESIZE

Month	Cistern Volume Carryover (gallons)	Cistern Overflow (gallons)
Jan	2,100	3,533
Feb	2,100	1,426
Mar	2,100	1,451
Apr	2,100	597
May	2,100	19
Jun	1,844	0
Jul	1,107	0
Aug	118	0
Sep	26	0
Oct	2,044	0
Nov	2,100	4,415
Dec	2,100	2,476

RESIZE

Month	Cistern Volume Carryover (gallons)	Cistern Overflow (gallons)
Jan	3,000	3,533
Feb	3,000	1,426
Mar	3,000	1,451
Apr	3,000	597
May	3,000	19
Jun	2,744	0
Jul	2,007	0
Aug	1,018	0
Sep	926	0
Oct	2,944	0
Nov	3,000	4,415
Dec	3,000	2,476

SAFE!

Figure 7: Three example cistern forecasts for different storage sizes. The leftmost case (1600 gallons) will not hold water throughout an average precipitation year. The middle case (2100 gallons) will hold water throughout an average precipitation year but lacks enough water to be reliable. The rightmost example (3000 gallons) holds water throughout an average precipitation year by a large margin. It will be more reliable in years with less than expected rainfall.

Given inputted water use, this shows how much water you annually want to use and actually can use	Gallons	
	Actual Use	Desired Use
Total annual use	31,341	Resize/Reduce

If you see a "resize/reduce" message under the Gallons heading, your desired use is too high for the size of your roof/cistern. If you don't care if your cistern goes dry, change that setting above.

Figure 8: The Resize/Reduce warning appears when expected water use exceeds expected water availability.

When the calculator shows Actual Use meeting Desired Use, and when Cistern Volume Carryover is sufficient year-round, you have a volume goal for your storage system. Check tank sizes available through local and online vendors and determine the best combination of tanks that will combine to meet your ideal storage volume. Remember, it is recommended that you utilize multiple storage tanks to allow for easier tank maintenance and as a precaution if one tank fails.

References

2012 Green Plumbing & Mechanical Code Supplement. (2012). Ontario, CA: International Association of Plumbing and Mechanical Officials.

FASTILY. (2017, April 21). [Shingle Roof]. Retrieved from https://commons.wikimedia.org/wiki/File:Shingle_Roof_1_2017-04-21.jpg

Kinkade-Levario, H. (2007). *Design for water rainwater harvesting, stormwater catchment, and alternate water reuse*. Gabriola Island, B.C.: New Society.

Mendez, C., Sungwoo, B., Chambers, B., Farkheddine, S., Gloyna, T., Keithley, S., & Untung, L., Barrett, M.E., Kinney, K. & Kirisits, M.J. (2010). *Effect of Roof Material on Water Quality for Rainwater Harvesting Systems – Additional Physical, Chemical, and Microbiological Data Report Texas Water Development Board*. 10.13140/2.1.2686.4641.

Winters, N. L., & Graunke, K. (2014). *Roofing Materials Assessment: Investigation of Toxic Chemicals in Roof Runoff*(Rep. No. 14-03-003). Retrieved May, 2018, from WA State Department of Ecology website: https://fortress.wa.gov/ecy/publications/SummaryPages/1403003.html