GREEN BUILDING SERIES

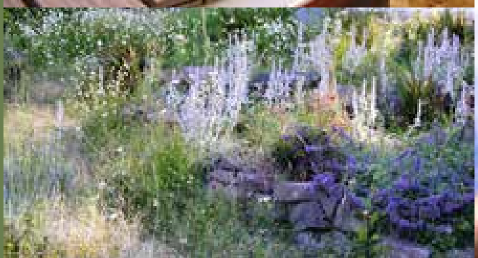
REGIONAL DISTRICT OF NANAIMO

Rainwater Harvesting

BEST PRACTICES GUIDEBOOK

DEVELOPED FOR HOMEOWNERS of the REGIONAL DISTRICT OF NANAIMO

British Columbia, Canada



Residential Rainwater Harvesting Design and Installation

SYMBOLS

Special symbols throughout this guidebook highlight key information and will help you to find your way.


HANDY CHECKLISTS


EXTRA CARE & PRECAUTIONS


CONSULT A PROFESSIONAL


REFER TO ANOTHER SECTION


CLEVER TIPS


CALCULATIONS

MESSAGE FROM THE CHAIR

REGIONAL DISTRICT OF NANAIMO

As one of the most desirable areas to live in Canada, the Regional District of Nanaimo will continue to experience population growth. This growth, in turn, triggers increased demands on our resources. At the same time, residents of the region are extremely focused on protecting our water supplies, and are keen to see progressive and proactive approaches taken to manage water in a sustainable manner. The RDN is committed to protecting the Region's watersheds through water conservation. Conservation will be accomplished by sharing knowledge and supporting innovative actions that achieve more efficient and sustainable water use. One such action is the harvesting of rainwater.

Rainwater harvesting is the collection and storage of rainwater for potable and non-potable uses. With the right controls in place, harvested rainwater can be used for irrigation, outdoor cleaning, flushing toilets, washing clothes, and even drinking water. Replacing municipally-treated water or groundwater with rainwater for these uses alleviates pressure on regional aquifers and sensitive ecosystems, and reduces demands on municipal infrastructure. Stored rainwater provides an ideal source of readily available water, particularly during the long dry summers or in locations facing declining groundwater levels.

This *Rainwater Harvesting Best Practices Guidebook* provides useful information for residents who wish to learn more about the benefits and opportunities of rainwater harvesting for non-potable and potable purposes. As an information source specific to the RDN's location and climate, the *Guidebook* is a valuable resource for RDN residents building their own rainwater harvesting systems or working with professionals to do so.

With this *Guidebook*, the RDN continues to lead the way in protecting watershed health, and in promoting sustainable approaches to the management of water — one of our most precious natural resources.

Joe Stanhope, Chair of the RDN Board

This *Rainwater Harvesting Best Practices Guidebook* has been produced by the Regional District of Nanaimo (British Columbia, Canada), in partnership with the following local organizations specializing in sustainability:

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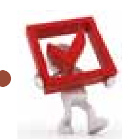
THIS INFORMATION SPECIFIC TO NON-POTABLE (OUTDOOR USE) RWH SYSTEMS

THIS INFORMATION SPECIFIC TO NON-POTABLE (INDOOR USE) RWH SYSTEMS

THIS INFORMATION SPECIFIC TO POTABLE (DRINKABLE) RWH SYSTEMS

3. CALCULATING WATER SUPPLY, DEMAND AND STORAGE REQUIREMENTS

4. THE COMPONENTS OF A RWH SYSTEM



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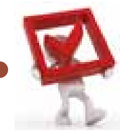


6. APPENDICES

Some studies suggest that when people become involved with their own water supply through harvesting rainwater, they consciously reduce their overall water consumption by 20 to 60 per cent.

...

Australian Rainwater Industry Development Group

2008 Consumer Guide

1. INTRODUCTION

The *Residential Rainwater Harvesting Design and Installation Guidebook* has been produced by the Regional District of Nanaimo (RDN) to encourage the responsible use of rainwater as a safe, sustainable water source for private residences. It has been developed to inform and assist interested homeowners (as well as professionals such as engineers, designers, plumbers, and builders) about methods to capture rainwater as an alternate water source for potable and non-potable use. This *Guidebook* addresses best practices and is a guide for design, installation and maintenance of residential rainwater harvesting (RWH) systems.

1.1 The Importance of Rainwater Harvesting Within the RDN

The *2007 RDN Drinking Water and Watershed Protection Plan* and the subsequent *RDN Watershed Snapshot Report 2010* emphasize the need for promotion of rainwater harvesting within the region, citing increased population, dropping groundwater levels in certain areas, and stressed ecosystems as reasons for the urgency.

Many areas within the RDN are characterized by rock and soil conditions that possess limited ability to store surface and groundwater, while the climate follows an annual cycle of rainy winters and long periods of summer drought. By harvesting and storing the rain that falls during wet winters (when up to 80 per cent of rainwater runs off to the ocean), we reduce the volume of groundwater drawn from aquifers during dry summer months. By maintaining higher groundwater levels, we help to sustain a critical base flow in streams, and therefore protect fish and aquatic health. Reduced groundwater extraction also helps to prevent saltwater intrusion in wells located in coastal areas.

In regions serviced by community water systems, RWH systems can complement existing infrastructure. Widespread adoption of RWH systems can potentially delay, and even reduce, investment in expanding existing or adding additional infrastructure.

Capturing, storing, and using rainwater where it falls can:

- conserve groundwater supplies;
- delay the need for costly water utility expansions by reducing peak summer water demand;
- slow down and even eliminate stormwater runoff; and,
- reduce energy consumption compared to wells.

"Rainwater harvesting does not remove water available to local environments, it simply is gathered from a different part of the water cycle."

...

Rainwater Harvesting on the Gulf Islands, Islands Trust Fund, 2006

1.2 Scope of this Guidebook

RWH systems are capable of producing high quality water that meets or exceeds public utility standards, provided they are correctly designed, constructed, and maintained. Presently, no single set of Provincial or Federal regulations addresses the collection, storage, purification and disinfection of rainwater. This *Guidebook* is a best practices resource for those interested in building a RWH system.

Given widely divergent site-specific considerations and owner maintenance abilities, this *Guidebook* does not present rules and regulations, or a template for any one system. It provides guidance on key considerations for those building their own systems or seeking professionals to help them.

After reading this *Guidebook*, residents and professional practitioners should better understand how different RWH systems are put together, how they function, and the effort required to maintain them. Readers of this *Guidebook* should also emerge with clear expectations about rules and regulations that apply to the construction and installation of RWH systems.

Residents should always consult professionals when planning and constructing their RWH systems, especially for potable RWH systems.

See Section 1.6: Planning & Professionals for information on required or recommended professionals who can guide RWH system installation to ensure safety, efficiency, and compliance with local regulatory requirements.

1.3 Chapter Summary

CHAPTER 1 summarizes the advantages of using rainwater that has been collected from a rooftop for household use, outdoor cleaning and irrigation. It also highlights existing regulations that homeowners must address when designing and installing their residential RWH systems, and introduces the types of professionals who can support you with advice and assistance.

CHAPTER 2 discusses the three categories of RWH systems that are addressed in this Guidebook, including Non-Potable (Outdoor Use), Non-Potable (Indoor Use), and Potable RWH systems.

CHAPTER 3 provides information on annual rainfall throughout the RDN, and teaches you how to calculate the volume you will be able to collect. It also helps you to determine how much water you will need, and the size of storage system required to accommodate that level of demand.

CHAPTER 4 describes each component of the entire RWH system, including considerations pertaining to design, installation, materials, budget, regulations, aesthetics and maintenance. It is presented in an order that mirrors a raindrop's journey, from roof to tap.

CHAPTER 5 presents a practical look at the maintenance responsibilities associated with operating different types of RWH systems. It includes operation and maintenance checklists to guide you in developing your own maintenance schedule.

APPENDICES include data tables, key sources of information, checklists and cases that illustrate details for RWH system installers, water conservation resources, and attributes regarding common roof types and locally utilised cisterns.

Designing and maintaining a RWH system can be enjoyable and educational, and contributes to water conservation in the Region. Non-potable RWH systems can be relatively simple to install and maintain, while potable systems require a greater degree of investment in time and money, as well as involvement of the right professionals. Before committing to install an RWH system, take this quick Self-Assessment, right, to ensure there are no significant barriers to the proper installation and maintenance of the system you choose.

1.4 Quick Self-Assessment: Is Rainwater Harvesting Right for You?

Before committing to the design and installation of a RWH system for your home, review:

- ✓ Section 1.6: Planning & Professionals
- ✓ Sections 4.2.1: Roof and 4.2.2: Gutters
- ✓ Section 5.4: Creating Your Maintenance Schedule and Checklist

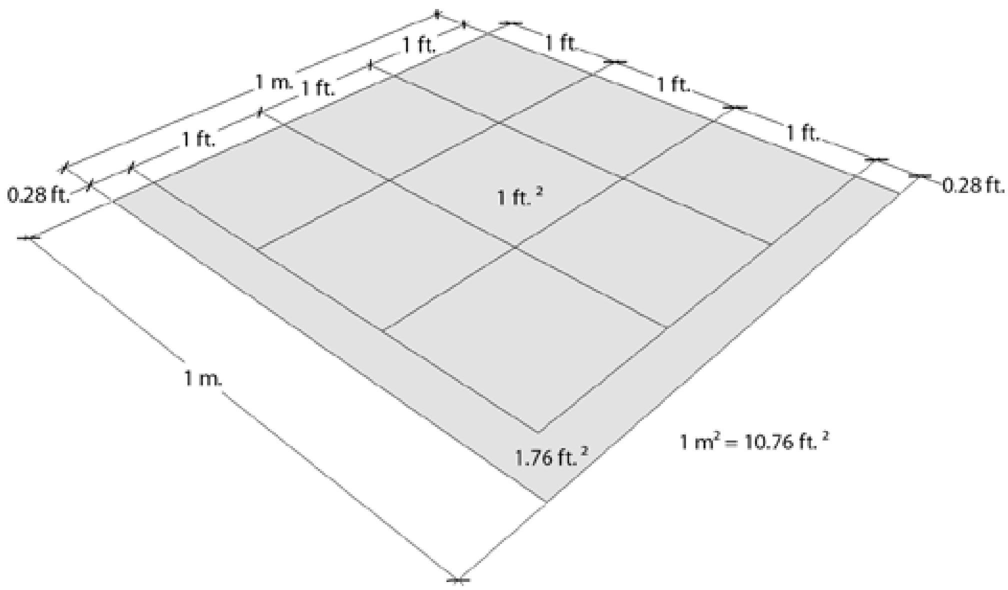
Particularly for potable RWH systems, it's also important to consider the following:

- ? Am I interested in, and physically capable of, cleaning and maintaining my RWH system?
- ? If not, what would be the cost of hiring a professional to conduct regular and seasonal maintenance tasks?
- ? Am I at home often enough (particularly during the winter) to protect my system from freezing?
- ? Can I meet all associated bylaws and regulations?
- ? Am I prepared to invest the capital required for a Potable RWH system?
- ? Are my existing rooftop(s) and gutters made of materials that will not contaminate the rainwater?

For a full list of measurements and conversions see Appendix 6.1: Measurements and Conversions.

1.5 A Note on Units

While metric is the primary system of measure throughout this *Guidebook*, imperial units are included in brackets to reach a wider audience, and because the imperial system remains an industry standard in North America. US gallons have not been included, although rainwater manuals, tanks and pumps produced in the United States often refer to US gallons. Take care to reference the correct calculations for your own equipment.



Metric to Imperial Conversion Table	
Metric Measure	**Imperial Measure**
1 metre	3.28 feet
1,000 millimetres	39.37 inches
1 square metre of roof catchment area	10.76 square feet
10 millimetres (or 1 centimetre) of rain	0.39 inches
25.4 millimetres of rain	1 inch
1 litre (or 1,000 millilitres) of water	0.22 Imperial gallons
4.546 litres of water	1 Imperial gallon
4.5 cubic metres	1,000 Imp gallons of water

Imperial Gallons to US Gallons Conversion Table	
Imperial Measure	**US Measure**
1 imperial gallon	1.2 US gallons
16 imperial gallons per minute (pump rate)	20 US gallons per minute

1.6 Planning & Professionals

RWH systems require careful design, installation and maintenance practices. Although a variety of RWH systems exist in the region (some dating back to the 1920's), advances in rainwater collection techniques and technology can make your system safer, more dependable, and easier to maintain.

Careful planning helps to ensure safety and efficiency. It also determines budgetary projections for installation and maintenance, so that homeowners can realistically commit to their investment.

The choice to collect and use rainwater brings with it the responsibility to maintain your RWH system. It is important to factor in the frequency and cost of parts replacement, and to ensure that each piece of equipment in your system comes with the appropriate operation and maintenance manuals.

The checklists in Section 5.4: Maintenance Checklists may assist you in creating your own detailed maintenance schedule.

Some aspects of RWH systems are regulated by local government regulations and bylaws, while some components must be installed by accredited tradespeople.

1.6.1 Using the Right Professionals

A RWH system integrates the specialized expertise of professionals involved with drainage, plumbing, excavation, construction, electrical, pumps, and water purification and disinfection. Advice about simple, Non-Potable (Outdoor Use) RWH systems can be obtained from home designers, builders, product suppliers, plumbers, irrigation designers and other related contractors.

When installing either Potable or Non-Potable (Indoor Use) systems, expertise may be required from registered plumbers, electricians and water purification and disinfection specialists. For more complex issues, such as assessing the correct size of drainage pipes, or determining the structural integrity of tank pads or underground cisterns, it is advisable to consult an engineer or geoscientist. A growing number of architects, engineers, landscape designers, and water quality testing, purification and disinfection specialists are involved in more complex RWH systems.

The American Rainwater Catchment Systems Association (ARCSA) now offers periodic training and certification in British Columbia for those aiming to become accredited RWH professionals. It is expected that this organization's Canadian counterpart, which is in the early stages of formation, will follow suit with training and certification of its own.

Trained, experienced professionals can help to determine which system is appropriate for your particular site, that it will provide the water security and quality you desire, and that maintenance will be manageable. Because experience can vary in this newly emerging field, it is important to gather references before selecting those who can help.

1.6.2 Compliance with Building Codes, Local Regulations and Bylaws

Like any major household plumbing, electrical work, or renovation, your RWH system must be installed in accordance with applicable codes, regulations and bylaws within various levels of government. Depending on where you live, check carefully with the Regional District of Nanaimo, and with your City/Town or the Islands Trust.

At present, no all-inclusive Federal or Provincial regulation specifically addresses rooftop-collected rainwater for use in private, single family residences. Some regulations and codes do exist, including:

- B.C. Plumbing Code requirements for hydraulic loads from peak storm events, for piping under driveways, for potable water distribution pipes, and for backflow prevention devices;
- B.C. Building Code requirements for building and roof structures, for maximum flow loads of drainpipes, and for drainage away from structures;
- Electrical codes for wiring and pumps;
- International and Canadian certification for potable water tanks, pipes and water purification and disinfection equipment; and,
- Health Canada's Guidelines for Canadian Drinking Water Quality.

For more information about these regulations, consult online resources or a related professional.

Portions of a RWH system may be subject to development permit guidelines or zoning regulations by your local government. For example, most local zoning bylaws describe a water tank as a structure, and lot setback restrictions may limit proximity to side, front or rear property lines. Height restrictions may also apply.

Local planning authorities may request site plans showing the property, subject roofs, tank(s) and other equipment. In some instances, a variance permit may provide exemptions from setback or height restrictions. Check with your planning department for steps to apply for a variance permit.

Even where special regulations do not exist, or where building or plumbing permits are not required, you will lengthen the lifespan and value of your system by building it well from the start.

Professionals can help you to predict the quality of piping, tank fittings, and water purification and disinfection equipment that may be required in future, if not already specified by code. For example, protecting your rainwater storage unit from mosquitoes is not yet a code requirement in British Columbia, but is already mandatory in Australia and in some U.S. states.

Before you finalize your RWH system plans:

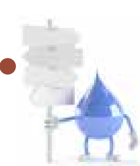
- ☑ inform your local building inspection office of your RWH design;
- ☑ obtain any plumbing or building permits that may be required; and,
- ☑ plan to have the water for a Potable RWH system tested.

Finally, the installation of a RWH system should be treated like any other upgrade or new construction on your property. If you are digging trenches for piping, or excavating holes for tanks, adhere to the rule, "Call before you dig" to ensure safe practices pertaining to hydro and gas line locations.

Call Before You Dig! 1-800-474-6886

1.6.3 Other Sources of Information

Various guidelines, standards, and government sources are listed in Appendix 6.2: Information Sources for Rainwater Harvesting. The internet is also an excellent source of information on RWH.



Visit Appendix 6.2 for other sources of information about rainwater harvesting.

“Arguments over water are resolved by rain.”

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Japanese Proverb

2. AN INTRODUCTION TO RAINWATER HARVESTING

2.1 Rain — A Precious Resource

For the purposes of this *Guidebook*, rainwater is defined as rain that falls on, and is collected from, the roof(s) of a house and/or ancillary building such as a garage or shop.

Rainwater collected from a rooftop can be a high quality water source. Rainwater:

- is nature's watering agent. It contains none of the chlorine found in centralized water supplies, and needs little if any purification or disinfection for use in the garden;
- is the perfect temperature for plants when stored in a tank;
- is naturally soft, which makes it ideal for bathing and washing;
- has no sodium and is virtually mineral-free. It does not produce scale on appliances, and eliminates the need for salt-producing, water-softening devices; and,

Rainwater can also potentially contain bacteria, viruses and cysts collected from the air or from contact with the roof, piping or tank. Therefore, rainwater must undergo a fairly simple disinfection process before use inside the home for potable use.

2.2 What is a Rainwater Harvesting System?

A Rainwater Harvesting (RWH) System is a roof-to-tap combination of components that collects water from the roof and delivers it for use to an outside tap or inside water faucet. The RWH system removes debris, transports it to a storage tank or cistern, and provides an appropriate level of pressurization and post-storage filtration and/or disinfection.

RWH systems and their individual components vary considerably depending on individual site conditions, aesthetics, energy and power constraints, water quality requirements, and budgets.

2.3 Three Categories of RWH Systems

The fundamental distinction between RWH systems is whether they provide Non-Potable Water (Outdoor Use), Non-Potable Water (Indoor Use) for flushing toilets, or Potable Water. Potable means the water is drinkable. This Guidebook addresses all three categories. Each category requires different components, operational requirements and maintenance responsibilities to supply the quality of water designated for the appropriate use and to prevent cross connections between the harvested rainwater and the water in any drinking water system.

2.3.1 Non-Potable (Outdoor Use) RWH Systems

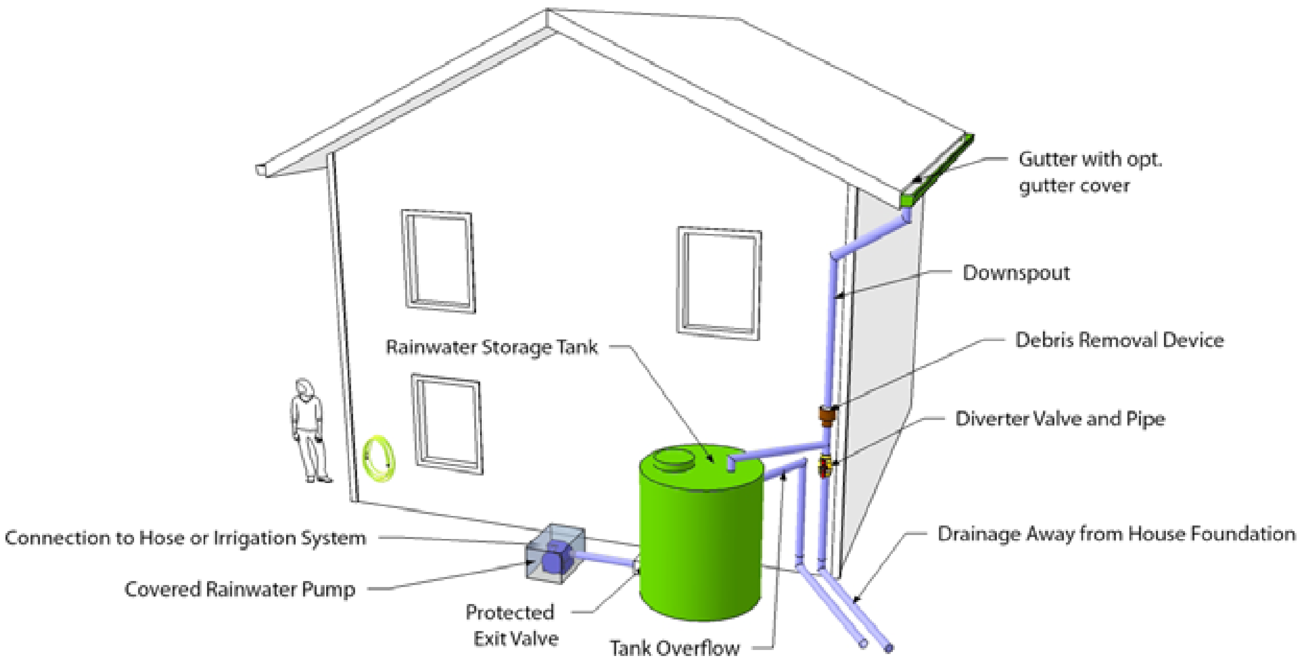
Non-Potable water for outdoor use is non-drinking water that is suitable for outdoor use, including:

- garden watering and irrigation systems;
- pool/hot tub/pond filling;
- water for animals;
- outdoor cleaning/power washing;
- vehicle washing; and,
- fire protection or emergency water.

Compared to other categories of RWH systems, Non-Potable (Outdoor Use) RWH systems often:

- operate seasonally and are shut down in late fall;
- require less debris removal or cleaning en route to storage tanks;
- are easier and less expensive to build and maintain;
- have smaller storage tanks ranging in volume from 4.5m^3 (1000 gal) to 23m^3 (5000 gal);

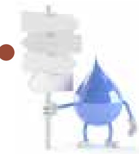
- may require supplemental water from another water source, complete with backflow prevention devices to prevent cross contamination between drinking water and rainwater.
- include little, if any, post-storage treatment such as particle filtration to remove sediment or water disinfection to remove bacteria.



Simplified depiction of a Non-Potable (Outdoor Use) RWH system

Roof, Gutters and Downspouts

See Section 4.2:
Catching the Rain



Most standard roofing types, gutters and downspouts can be used, though for pool filling or irrigation of food crops, you will want to avoid certain roofing materials, particularly those containing lead or other contaminants. Gutter covers are optional. It is often unnecessary to collect from all available rooftops and downspouts, as a sufficient volume of water can usually be collected from a portion of a home's total roof area.

Catchment System

This combination of pipes, gravity filters and/or debris traps collects water from downspouts and gutters, filters debris, and transports it to the tank(s). This filtration or pre-cleaning reduces the frequency of tank cleaning, and helps to prevent algae blooms if the tank is exposed to sunshine.

See Section 2.2.3 regarding First Flush Diverters (FFDs).

Water Diverter

Every rainwater catchment system (even those designed for non-potable, outdoor use) should include a means to divert water from the tank. Diversion is required, for example, when the roof or gutters are being cleaned, when rainwater is contaminated with pollen, or when the tank is full. The simplest form of diverter is a single valve located so that water flows into a diverter pipe when the valve is opened (as shown on the above sketch).The diverter pipe must drain the diverted water away from the home's foundation.

See Section 4.5: Storing the Rain.

Water Storage Tank

The water storage tank may be installed above or below ground. In either case, an overflow is required and the end of the overflow pipe must drain the excess water away from the house.

Water Distribution System

The distribution component of a Non-Potable (Outdoor Use) RWH system delivers the water to its final destination for use. An efficient water delivery system usually requires a pump for pressurization. Distribution piping may run directly to an irrigation system, or may supply hose bibs on the house or throughout the property.

Any hose bib from a Non-Potable (Outdoor Use) RWH system should be clearly marked: **'NOT A SOURCE OF POTABLE WATER — DO NOT DRINK'.** Where an irrigation system is equipped for connection to a drinking water system as a backup or supplementary source, there must be adequate protection against contamination of the drinking water by cross connection with harvested rainwater.. Guidance from an irrigation contractor, a pump supplier, or a trained plumber will help to ensure the installation of an efficient, trouble-free distribution system.

Hose bib containing non-potable water must be labelled clearly.

2.3.2 Non-Potable (Indoor Use) RWH Systems

Non-Potable water for indoor use is non-drinking water that is suitable for use inside the house for toilet flushing.

Compared to other categories of RWH systems, Non-Potable (Indoor Use) RWH systems generally:

- operate year-round;
- require attention to debris buildup in gutters, as well as debris removal en-route to storage tanks (to reduce water discolouration);
- often include post-storage particle filtration to remove sediment, but usually do not include water disinfection equipment to remove bacteria;
- have smaller storage tanks than Potable RWH systems;
- may require supplemental water supply from another water source to the tank (complete with backflow prevention devices to prevent cross connections with the rainwater); and,
- require coloured or labelled piping for rainwater lines inside the house, which reduces the possibility of cross-connection with the potable water supply. This piping must be installed by a registered plumber.

In British Columbia, we use approximately 490 litres (108 gal) of water per person, per day — almost 50 per cent higher than the national average.
In the home, toilet flushing alone accounts for approximately 30 per cent of our water usage.

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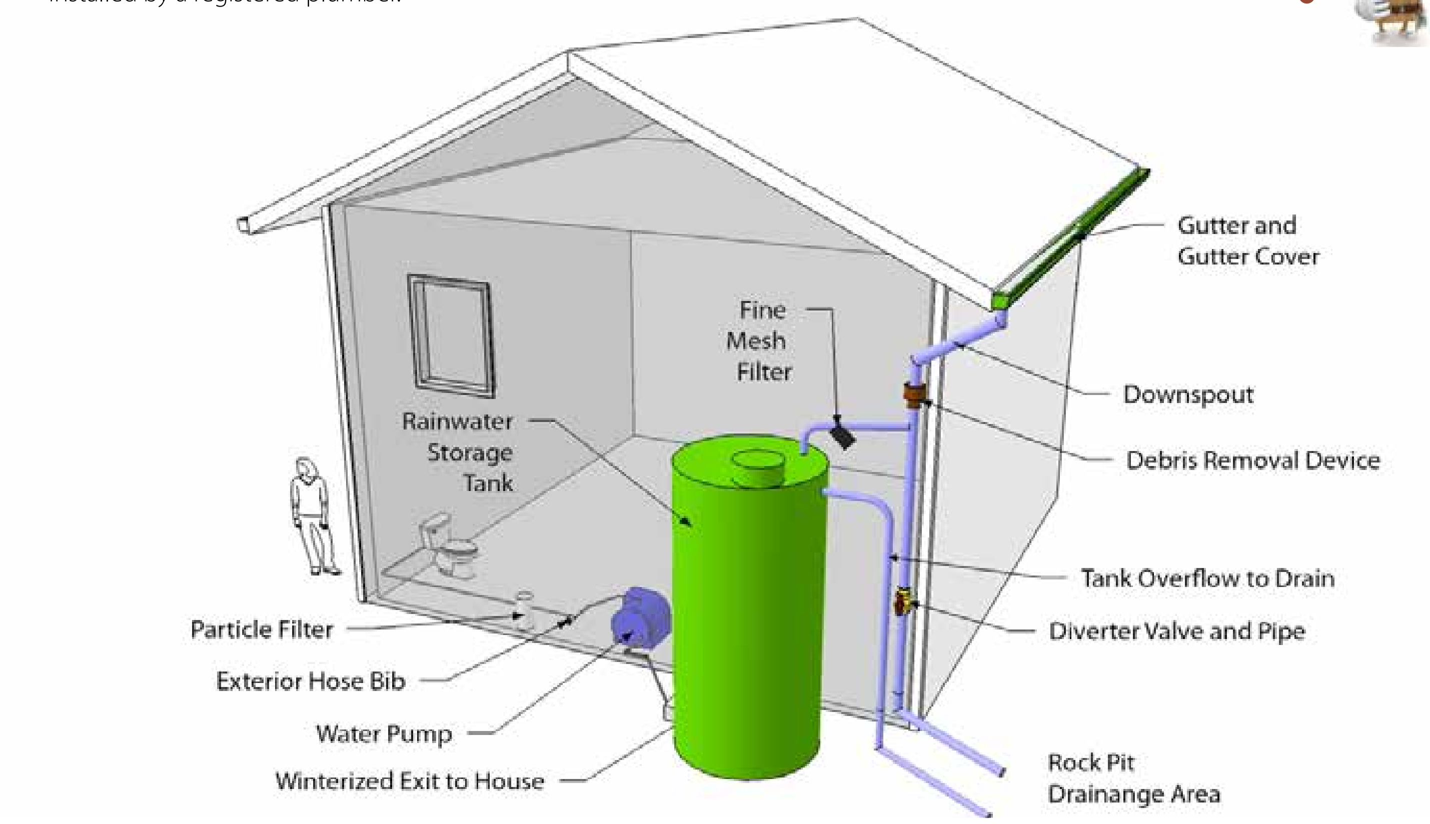
B.C. Living Water Smart website



Simplified depiction of a Non-Potable (Indoor Use) RWH system.

Roof, Gutters, and Downspouts

Most roofing types can be used; however, cedar shingles or shakes should be avoided due to toxicity and to prevent water discolouration. Standard gutters and downspouts are appropriate. Gutter covers are often used to reduce debris build-up in the gutters that can discolour the water. It is often unnecessary to collect from all available rooftops and downspouts.

See Section 4.2: Catching the Rain.

Catchment System

Extra attention should be paid to cleaning the water before it reaches the tank, using debris traps and gravity filters to remove debris and organic material suspended in the water.

See Section 4.4.2: First Flush Diverters (FFDs).

Water Diverter

A diverter valve or First Flush Diverter (FFD) prevents water from entering the tank at times when it would be inconvenient, such as when the water is of poor quality during pollen season, when the roof is being cleaned, or when the tank is already full. The diverter pipe must drain the water away from the home's foundation. FFDs are more effective than simple diverter valves to improve the colour and quality of the water used for toilet flushing.

Water Storage Tank

The water storage tank may be installed above or below ground. In either case, an overflow is required and the end of the overflow pipe must drain the excess water away from the house.

Water Distribution System

The water distribution component of a Non-Potable (Indoor Use) RWH system requires the services of a qualified plumber. It includes pressurization from a pump, and distinctly coloured or labelled distribution piping inside the house to the toilet to reduce the possibility of cross-connection with the potable water supply.

A particle filter is often added after the pump to reduce the size of water-borne particles that could interfere with flush mechanisms within the toilet.

2.3.3 Potable RWH Systems

Potable water is water that is **safe to drink** and meets Health Canada's *Guidelines for Canadian Drinking Water Quality*. Water colour, acidity, and freedom from pathogens must be addressed in Potable RWH systems. Potable water uses include:

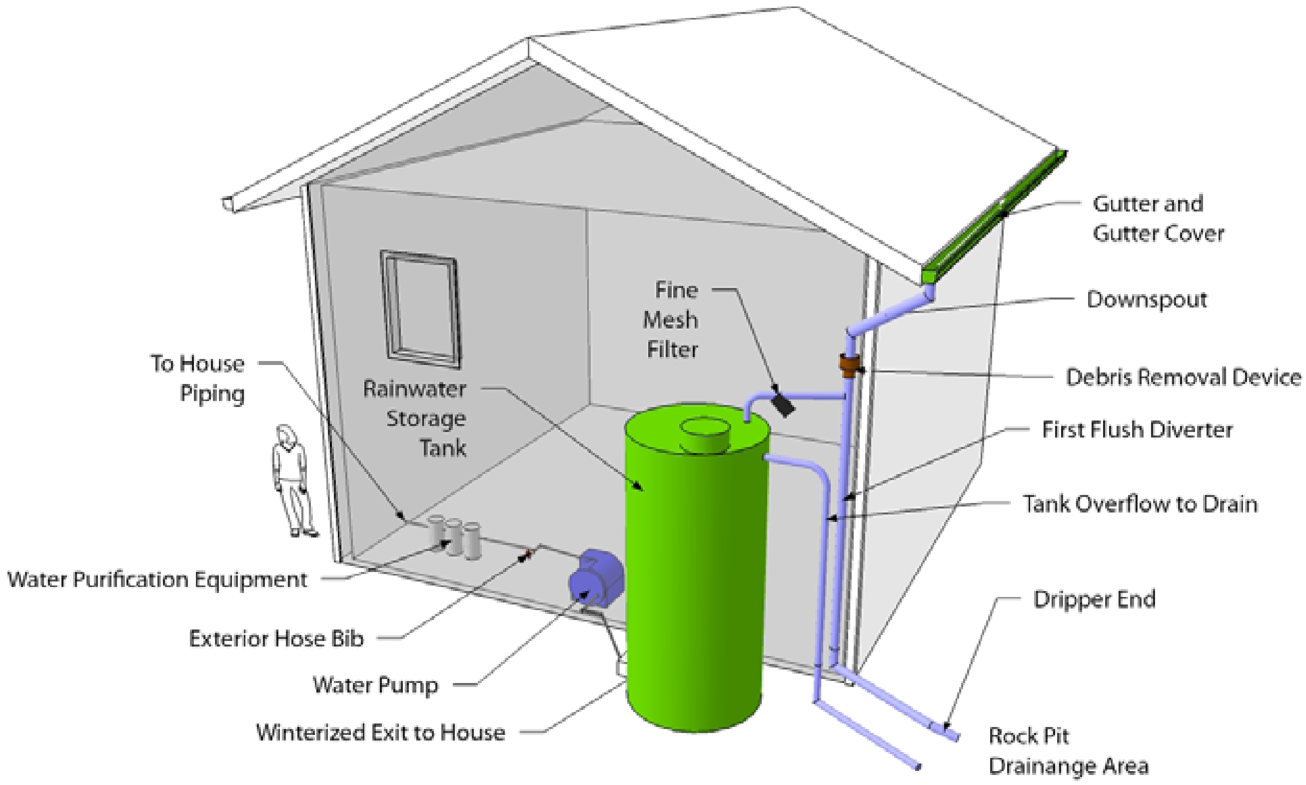
- drinking water;
- household laundry;
- bathing and showering;
- cooking; and,
- dishwashing.

In comparison to its Non-Potable water counterparts, Potable RWH systems generally:

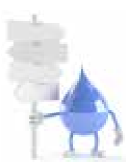
- operate year-round;
- collect from most or all of available rooftops;
- are more complex and costly to design and build;
- incorporate a higher degree of pre-cleaning before water enters the storage tank;
- provide more storage capability, typically ranging in size from 36–68m^3 (approximately 8000–15,000 imp. Gal.);
- require post-storage water disinfection; and,
- require more careful attention to maintenance.

Typically, homeowners would consider Potable RWH systems if:

- they reside in an area not serviced by a water supply;
- well water quality is too poor for consumption;
- the quantity of well water is insufficient to support household use;
- well-drilling would be prohibitively expensive; or,
- the homeowner is committed to taking complete responsibility for water self-sufficiency with minimal environmental impact



Simplified version of a Potable RWH system, which highlights the additional cleaning and purification features that should be included.



See Section 4.2: Catching the Rain.

Roof, Gutters and Downspouts

Tile, slate or metal rooftops are the best options. Standard gutters and downspouts are appropriate. Potable systems often include a high quality gutter cover, or specialized gutters, to reduce prolonged contact between water and debris within the gutters.

Avoid lead flashings and copper solder as it could be leached into the system by the relatively low pH of rainwater.

Learn more about micron sizes in Appendix 6.8: How Big is a Micron?

Debris Removal Devices

One or more devices should be used in the catchment system to remove debris (normally particles larger than 200-500 microns) suspended in the rainwater. Devices range from very fine gutter covers, to debris traps on the wall, to underground filters capable of cleaning all the rainwater from the entire roof at one point.

First Flush Diverter (FFD)

First Flush Diverters (FFDs) reject the first, poorest quality, and most polluted water at the beginning of any rain event, including water that is either discoloured or acidic because of contact with gutter debris, heavy metals, acidity in the rain, or bacteria that has formed on the roof. FFDs are a requirement for Potable RWH systems.

Potable Water Rated Components

Tanks, piping and pumps must be certified specifically for potable water.

Water Disinfection Equipment

Water disinfection equipment includes fine filtration filters (to a minimum of five microns) and one or more disinfection devices to inactivate viruses, bacteria and cysts. All equipment must be certified for potable water and appropriately sized to handle the volume of water required within the home.

Consult a RWH or water purification and disinfection professional to ensure that your system will be safe, reliable and easy to maintain.

"Less than three per cent

of municipally-treated water

is actually used for drinking.

The rest goes down the drain,

down the toilet,

or on our gardens."

...

Environment Canada

3. CALCULATING WATER SUPPLY, DEMAND AND STORAGE REQUIREMENTS

3.1 Supply: How Much Rainwater Can I Collect?

The amount of rainwater you can collect depends on three things:

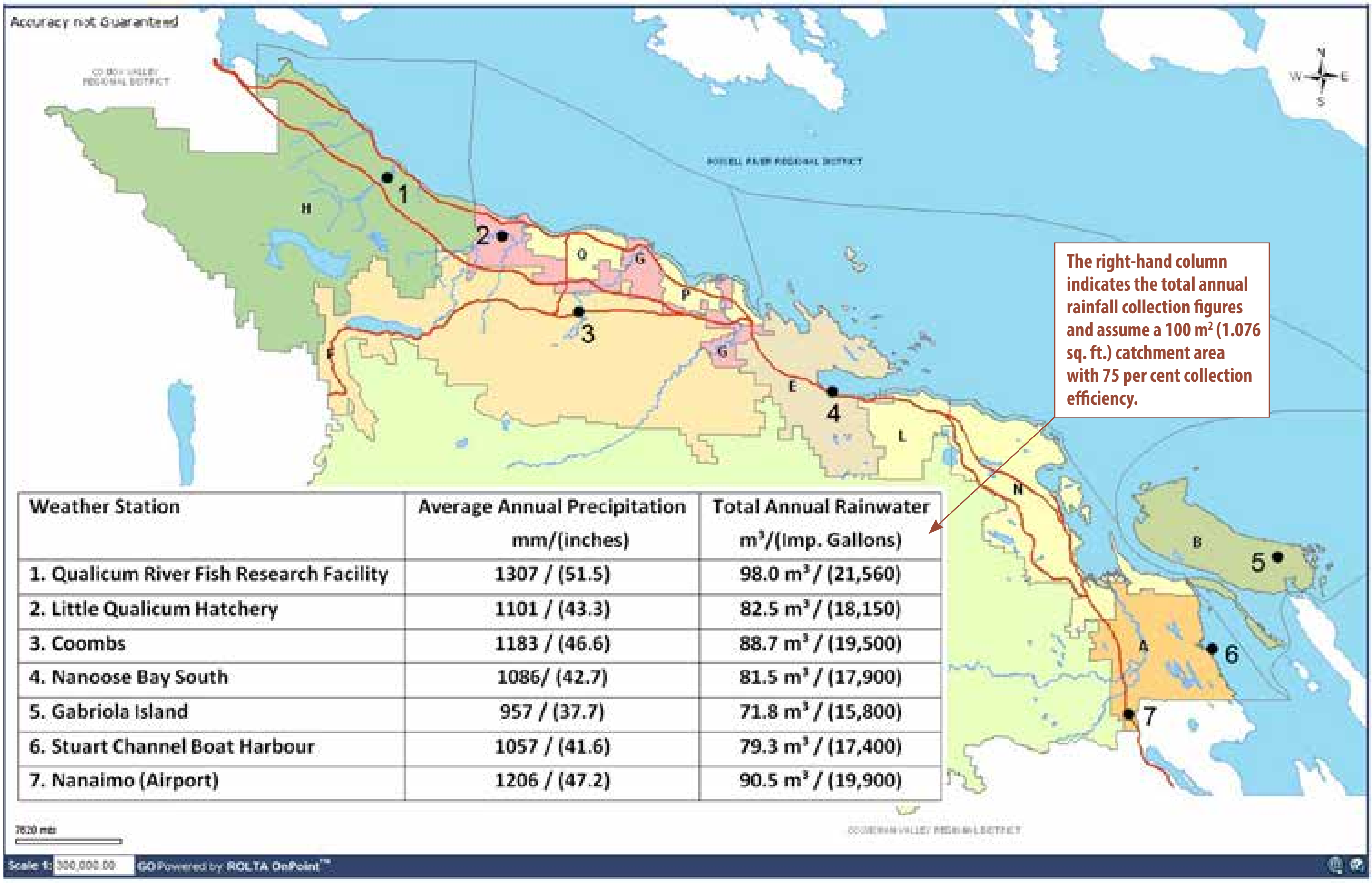
1. The amount of precipitation in your area;
2. The size or catchment area of your roof; and,
3. The proportion of total rainfall you can collect.

3.1.1 Amount of Precipitation in Your Area (Potential Rainwater)

From year to year, the amount of precipitation from rain and snow can vary by as much as 25 per cent above or below average. Therefore, you should review average precipitation data for at least 10 years. This data includes both rain and snow, and is available from Environment Canada's National Climate Data and Information Archive:

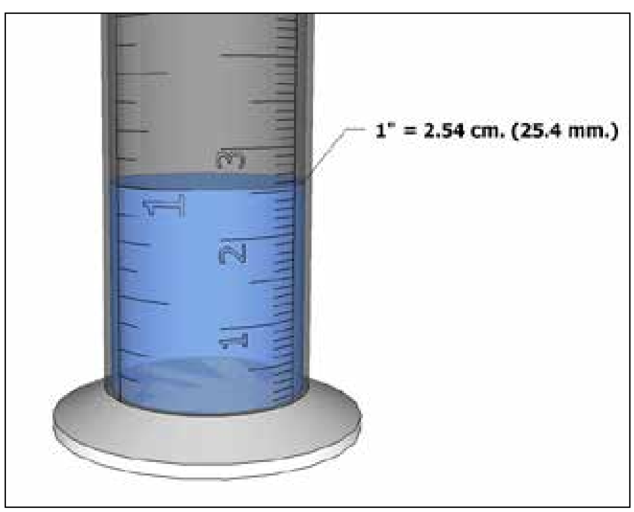
http://climate.weatheroffice.gc.ca/climateData/canada_e.html

Annual precipitation amounts also vary by more than 30 per cent within different parts of the RDN, from 957mm (37.7 inches) in south coastal areas like Gabriola Island, to 1307mm (51.5 inches) in north inland regions like the Qualicum River Fish Research Facility, as shown in the table on page 20.



Weather Station	Average Annual Precipitation mm/(inches)	Total Annual Rainwater m³/(Imp. Gallons)
1. Qualicum River Fish Research Facility	1307 / (51.5)	98.0 m³ / (21,560)
2. Little Qualicum Hatchery	1101 / (43.3)	82.5 m³ / (18,150)
3. Coombs	1183 / (46.6)	88.7 m³ / (19,500)
4. Nanoose Bay South	1086/ (42.7)	81.5 m³ / (17,900)
5. Gabriola Island	957 / (37.7)	71.8 m³ / (15,800)
6. Stuart Channel Boat Harbour	1057 / (41.6)	79.3 m³ / (17,400)
7. Nanaimo (Airport)	1206 / (47.2)	90.5 m³ / (19,900)

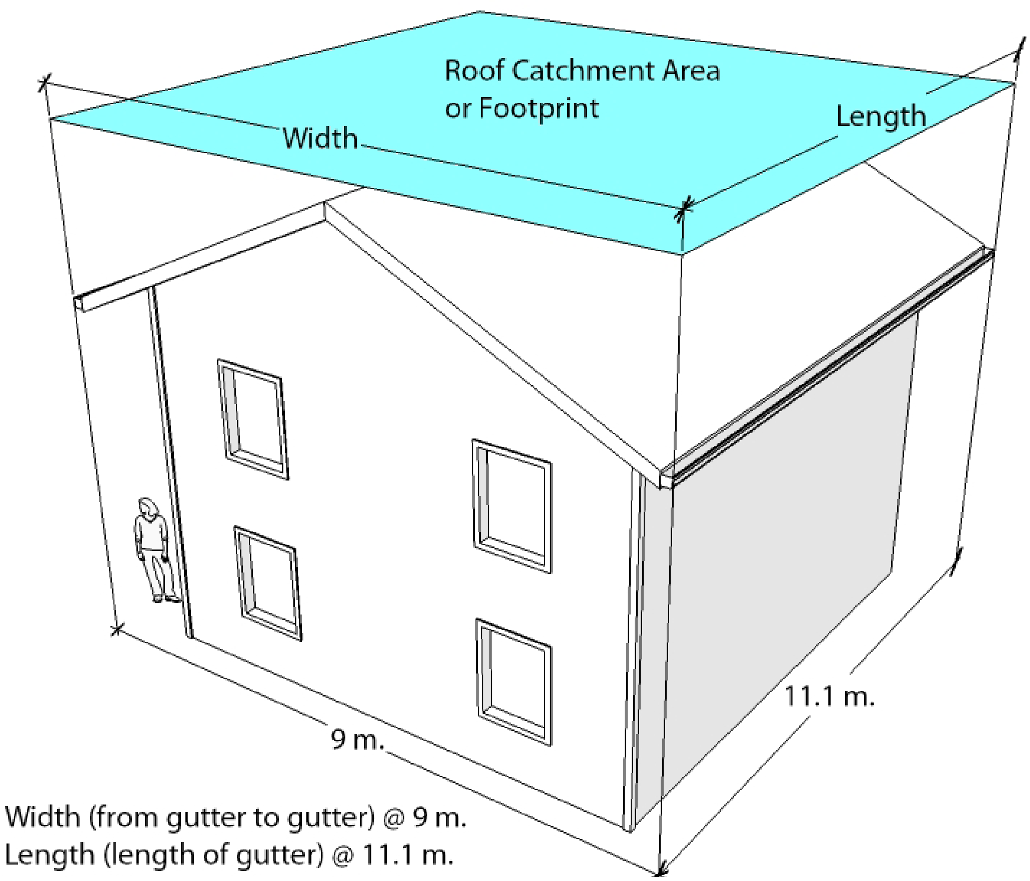
Annual precipitation and water collection for seven RDN locations.



Rainwater gauge

3.1.2 Size or Footprint of Your Roof (Roof Catchment Area)

The roof catchment area refers to the footprint or horizontal plane under the eaves, rather than the actual surface area of the roof. Catchment area is not affected by roof slope. Determining the roof catchment area will allow you to calculate the total amount of water you can collect for a given rainfall event.



Calculating the roof catchment area

Width (from gutter to gutter) multiplied by Length (length of gutter) equals Catchment Area

9m (29.5ft) x 11.1m (36.5ft)
= 100m^2 (1,076 sq.ft)

Therefore, if the roof footprint is 9m wide by 11.1m long, the catchment area equals 100m^2 (1,076 sq.ft)

Calculating the roof catchment area.

3.1.3 Proportion of Total Rainfall You Can Collect (Collection Efficiency)

Collection Efficiency, defined as the percentage of rainfall landing on the roof that will find its way to the storage tank, depends on several site-specific and seasonal factors. As a general rule of thumb, you can expect to collect an average of 75–80 per cent of the actual precipitation. Common reasons for water loss include:

- Site-specific water losses that are affected by roof material, overhanging branches, and prevailing winds;
- Collection system losses such as overflow and spillage from undersized piping and inefficient filters; and,
- Seasonal factors that decrease the proportion of the rain collected such as snowfall that does not melt, light shower rainfalls in the summer, the need to divert water during spring pollen season, and the need to shut down and clean the system after pollen season.

3.1.4 Calculating Actual Annual Rainwater Collection

Calculating potential annual rainwater collection.

Step 1: Potential Annual Rainwater Collection

Potential water collection or catchment is based on the following formula:

1m^2 of catchment area x 1mm of rain will produce 1 litre of water
therefore
Roof Catchment Area (in m^2) multiplied by Annual Precipitation (in millimeters) equals potential water collection (in litres)

For the sample calculations in this section, an area with moderate rainfall has been selected. The 17-year average annual precipitation at the Little Qualicum Hatchery weather station is 1101mm (43.3 inches). Accordingly, a house near the Little Qualicum Hatchery weather station with a catchment area of 100m^2 would capture 100m^2 X 1,101mm = 110,100 litres (110m^3) of water each year, if 100 per cent collection efficiency were possible.

Step 2: Actual Annual Rainwater Collection

Calculating actual annual rainwater collection.

Actual Rainwater Collection equals Potential Rainwater Collection multiplied by the Collection Efficiency

In this example, if the collection efficiency is 75%, the actual water collected annually would be 110m^3 X 75% = 82.5 m^3, or 82,500 litres.

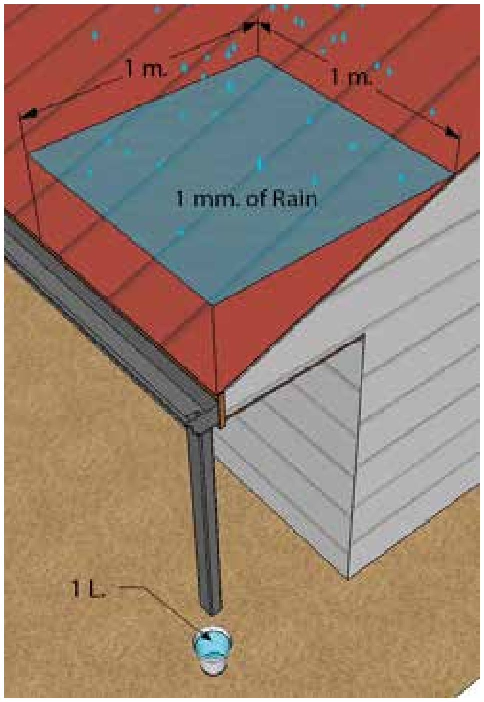
For imperial gallons use the formula:

Calculating actual annual rainwater collection with imperial gallons.

1 inch of rain on 1 sq. ft. of roof catchment area will potentially produce 0.52 imperial gallons of water

In this example, potential annual rainfall collection is 43.3 inches of rain multiplied by 0.52 (imp gal/inch of rain) and multiplied again by 1,076 (sq.ft catchment area) equals 24,227 imp gal.].

If the collection efficiency is 75%, the actual water collected annually would be 24,227 imp. gal. x 75% = 18,170 imp. gal.]



Calculating potential water collection (in litres).

3.1.5 Calculating Monthly Rainwater Collection

For larger Non-Potable (Indoor Use) and all Potable RWH systems with no other water source, tracking monthly precipitation will aid in estimating the required amount of storage. Monthly data can also help to estimate the proportion of total water demand that can be supplied by rainwater.

Minor inconsistencies in quantities that appear in the table result from rounding errors in the water balance table software.

MONTHLY RAINWATER SUPPLY TABLE - LITTLE QUALICUM HATCHERY WEATHER STATION

SCENARIO:	Roof Catchment Area:	100m2 (1,076 sq. ft.)
	Assumed Precipitation Level:	Average
	Location:	House near Little Qualicum Hatchery Weather Station
	Roof Type:	Metal Roof - Relatively clear site

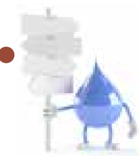
	Assumed Precipitation		Assumed Collection Efficiency	Rainfall Collected	
Month	Inches	Millimeters		Litre	Gal
October	4.7	118	75%	8,770	1,930
November	7.1	181	85%	15,227	3,350
December	6.5	165	85%	13,924	3,063
January	7.0	178	85%	15,035	3,307
February	4.4	112	85%	9,403	2,068
March	4.0	102	85%	8,579	1,887
April	2.4	62	50%	3,086	679
May	1.8	46	65%	2,959	651
June	1.7	44	75%	3,277	721
July	0.9	22	65%	1,391	306
August	1.4	36	65%	2,359	519
September	1.4	36	75%	2,588	569
TOTAL	43.3	1,101		86,598	19,050
Average Annual Collection Efficiency = 78%					

TABLE 1 — Monthly Rainwater Supply Table for the Little Qualicum Hatchery Weather Station.

Table 1 summarizes monthly rainwater supply for a house near the Little Qualicum Hatchery, with a 100m^2 (1,076 sq. ft) roof catchment area. The precipitation figures describe a year with average precipitation. Collection efficiency figures (second column from the right) are typical for homes in the RDN that have metal roofs, and are located in relatively open sites. The low collection percentages in April and May assume that the system is shut down and cleaned after pollen season. The figures in the far right column represent the actual amount of rainwater that could be collected each month. Note that this monthly calculation results in actual annual rainwater collection of 86.6m3 (19,050 imp gal) or about 78 per cent of the potential water collection.

3.2 Demand (How Much Water, and for Which Purposes?)

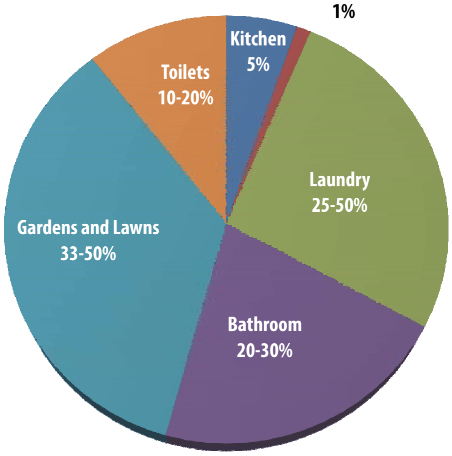
Decisions about water usage will affect how much water you need to collect and store, and how you will design your entire RWH system, from roof to tap. These choices are best made at the outset of your planning. Committing to lower water demand will help to preserve local groundwater levels and to reduce the amount of rainwater storage you need to provide.



Appendix 6.8: Information Sources for Water Conservation provides tips and resources to determine water usage and ways it can be reduced.

3.2.1 Water Conservation

Before investing in a RWH system, water conservation measures should be thoroughly explored. Reduce water consumption as much as possible before relying on rainwater as a primary supply. Incorporating native, drought-tolerant plants, or installing drip irrigation systems, can reduce outdoor water usage by 30–50 per cent. Introducing fixtures such as dual-flush toilets, low-flow showers, and high-efficiency washing machines and dishwashers can reduce indoor water consumption by at least 30 per cent. Fixing faucet leaks can reduce indoor water consumption by 10 per cent[1].



Typical household water use (indoor and outdoor) in summer.

This pie chart indicates typical indoor and outdoor summertime household water usage. It assumes low flush toilets are used, and that there are no leaks in taps or piping.[2] This chart also demonstrates the impact of indoor versus outdoor water usage during summer months. It is important to factor in all key water uses when deciding where collected rainwater would have the most impact on your overall water use.

[1]CMHC Household Guide to Water Efficiency

[2]The Australian Rain Industry Development Group (ARID) 2008 Consumer Guide

Appendix 6.4: Indoor and Outdoor Water Use Information provides more detail about the amount of water your garden will require.

Garden Watering

Large gardens and lawns can consume more water than all other indoor uses combined during the summer months, precisely when regional aquifers and streams are most stressed. Within water service areas administered by the RDN, summer water use is more than double winter water demand. Even an average-sized garden with an efficient drip irrigation system can require 10m^3 (2,200 imp gal) of water per month in July and August. Lawn watering can double or triple that amount.

Outdoor Cleaning and Hot Tubs

Diverting non-potable water for outdoor cleaning and filling the hot tub has a year-round impact. These uses combined can amount to as much as 4.5m^3 (1,000 gal) per month in peak months. Using non-potable water instead could save 23m^3 (5,000 gal) of water per year.

Toilet Flushing

Using rainwater to flush all the toilets in a home can save 10 to 20 per cent of annual water consumption[3]. A three-person household that uses rainwater for toilet flushing is estimated to save as much as 2.2m^3 (480 gal) per month for a three-person household, or 26.2 m^3 (5,800 gal) per year.

Refer to Appendix 6.4: Indoor and Outdoor Water Use Information for data about water usage in districts administered by the RDN.

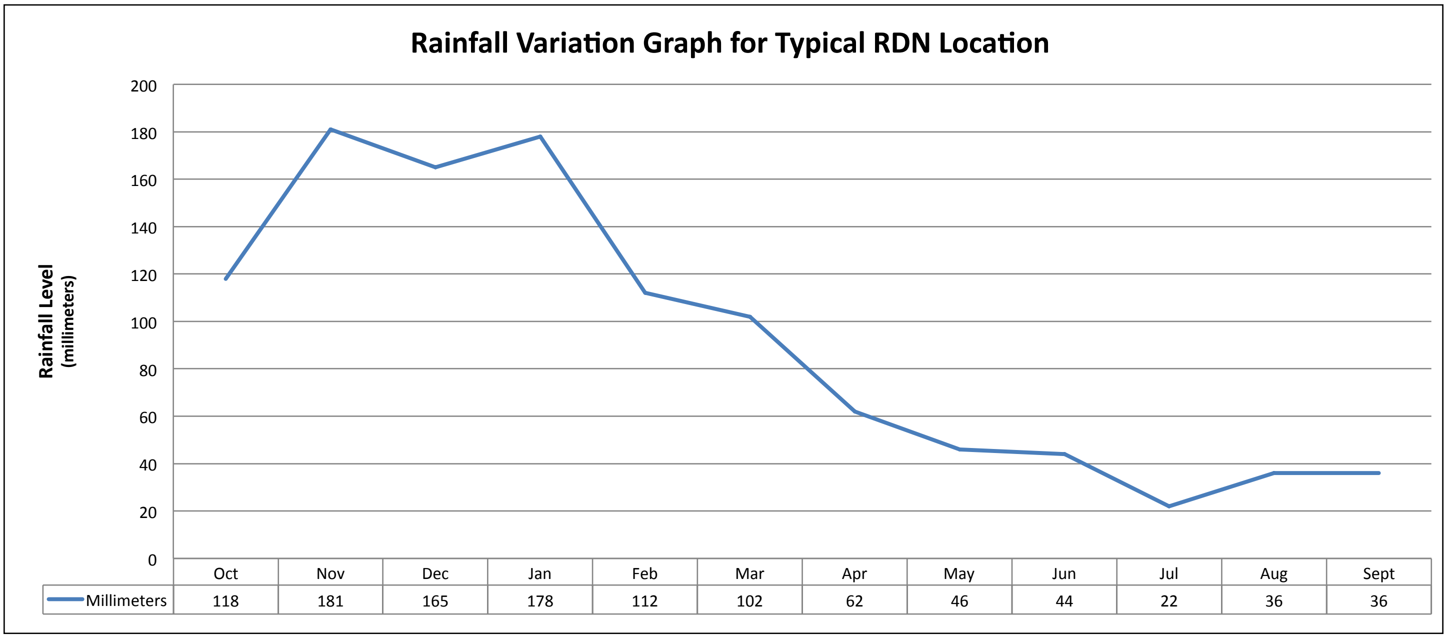
Other Indoor Water Uses

Total annual indoor water usage for a three-person, water conserving (efficient) household is approximately 175m^3 or 38,500 gal. This volume assumes 160 litres/person/per day (35 imperial gallons/person/day).

[3]CMHC Household Guide to Water Efficiency and Rainwater Connection.

3.3 Storage: How Much Rainwater Do I Need to Store?

On the east coast of Vancouver Island, the majority of annual precipitation falls during the winter, with almost half of total annual rainfall occurring between November and January.



Rainfall variation graph typical to the RDN.

3.3.1 Determining Tank Size Using Water Balance Tables

On the west coast, large RWH systems designed for year-round use require larger storage tanks to offset our seasonal rain patterns. In parts of Canada that have more consistent precipitation patterns, smaller tanks often suffice. To help determine optimal, cost effective tank size, many people consult a water balance table. A water balance table compares rainwater supply against total water demand to determine the volume of water that would be left in the storage tank at the end of each month. This calculation helps to estimate what size of tank would provide for projected demands without running dry during the summer.

Two examples of water balance tables are described in this section: one for a seasonal, Non-Potable (Outdoor Use) RWH system; the other for a Potable RWH system that supports a three-person household.

3.3.2 Case Example: Water Storage — Non-Potable (Outdoor Use) RWH System

WATER BALANCE TABLE FOR A NON-POTABLE (OUTDOOR USE) RWH SYSTEM

SCENARIO:	Roof Catchment Area:	100m^2 (1,076 sq. ft.)
	Assumed Precipitation Level:	Average
	Location:	Near Little Qualicum Hatchery Weather Station
	Roof Type:	Metal Roof - Relatively clear site
	Operational Storage Capacity:	25,000 Litres or 25m^3 (5,500 imp. Gal.)

Month	Outdoor Usage		Assumed Precipitation		Assumed Collection Efficiency	Rainfall Collected		Alternate Supply	Month-end Storage Volume	
	Litre	Gal	Inches	mm.		Litre	Gal		Litre	Gal
October	5,000	1,100	4.7	118	75%	8,770	1,930	0	3,770	829
November	0	0	7.1	181	85%	15,227	3,350	0	18,996	4,179
December	0	0	6.5	165	85%	13,924	3,063	0	25,000	5,500
January	0	0	7.0	178	85%	15,035	3,307	0	25,000	5,500
February	0	0	4.4	112	85%	9,403	2,068	0	25,000	5,500
March	0	0	4.0	102	85%	8,579	1,887	0	25,000	5,500
April	0	0	2.4	62	50%	3,086	679	0	25,000	5,500
May	5,000	1,100	1.8	46	65%	2,959	651	0	22,959	5,050
June	5,000	1,100	1.7	44	75%	3,277	721	0	21,236	4,671
July	10,000	2,200	0.9	22	65%	1,391	306	0	12,628	2,778
August	10,000	2,200	1.4	36	65%	2,359	519	0	4,987	1,097
September	5,000	1,100	1.4	36	75%	2,588	569	0	2,575	566
TOTAL	40,000	8,800	43.3	1,102		86,598	19,050			
	(Demand)					**(Supply)**				

TABLE 2 — Water Balance Table for a Non-Potable (Outdoor Use) RWH System.

The water balance table for garden irrigation water, shown on the previous page, describes a scenario where an efficient Non-Potable (Outdoor Use) RWH system is collecting water from a roof catchment area of 100m^2 (1,076 sq.ft.) on a house located close to the Little Qualicum Fish Hatchery weather station. Collection efficiency figures assume that the house has a metal roof and no trees nearby.

In this case, the owner needs water to irrigate a small garden and residential landscape using a drip irrigation system. The monthly outdoor water usage (second column from left) is a conservative estimate of water demand for this type of garden watering system.

The table shows that installation of a cistern with an operating capacity of 25m^3 (5,500 gal) would provide for all of the water demand (40m^3 or 8,800 gal) in a year with average rainfall. The table also shows that the tank would overflow during much of the winter, so the catchment system could be closed down in early winter and reopened in the spring.

This scenario does not integrate any supplemental water supply during the summer when rainwater replenishment is low. Water from a supplemental source (a well, piped-water or water truck) during the summer would reduce the required storage amount.

Budget constraints? Start with half the storage, and plan the tank layout for future expansion and inter-tank connections.

Two 1660 gal (7,550L) poly tanks with interconnecting piping and protective valve boxes (before final backfill).

Two poly tanks storing water from a small pump house building.

3.3.3 Case Example: Water Storage — Potable RWH System for a Three-Person Household

While winter rainfall can more than provide for a household's water needs over the fall and winter seasons, rooftop supply falls short for the balance of the year. Potable RWH systems, where all indoor water usage is supplied by rainwater, rely on water storage to bridge this shortfall. For these systems, a water balance table can determine:

- What cistern size is required to meet household water needs through the dry summer months?
- Is the roof sufficiently large to fill that size of cistern?

SCENARIO:		
	Roof Catchment Area:	210m2 (2,260 sq. ft.)
	Assumed Precipitation Level:	Average
	Location:	Near Little Qualicum Hatchery Weather Station
	Roof Type:	Metal Roof - Relatively clear site
	Operational Storage Capacity:	62,000 Litres or 62m^3 (13,600 imp. Gal.)

Month	Indoor Usage		Assumed Precipitation		Assumed Collection Efficiency	Rainfall Collected		Month-end Storage Volume	
	Litre	Gal	Inches	mm.		Litre	Gal	Litre	Gal
October	14,600	3,210	4.7	118	75%	18,419	4,052	3,819	840
November	14,600	3,210	7.1	181	85%	31,982	7,035	21,201	4,664
December	14,600	3,210	6.5	165	85%	29,246	6,433	35,847	7,885
January	14,600	3,210	7.0	178	85%	31,579	6,947	52,826	11,620
February	14,600	3,210	4.4	112	85%	19,749	4,344	57,975	12,753
March	14,600	3,210	4.0	102	85%	18,019	3,963	61,394	13,505
April	14,600	3,210	2.4	62	50%	6,481	1,426	53,275	11,719
May	14,600	3,210	1.8	46	65%	6,216	1,367	44,890	9,875
June	14,600	3,210	1.7	44	75%	6,883	1,514	37,174	8,177
July	14,600	3,210	0.9	22	65%	2,922	643	25,496	5,608
August	14,600	3,210	1.4	36	65%	4,955	1,090	15,851	3,487
September	14,600	3,210	1.4	36	75%	5,436	1,196	6,687	1,470
TOTAL	175,200	38,520	43.3	1,102		181,887	40,010		
	(Demand)					**(Supply)**			

TABLE 3 — Water balance table for a Potable Water RWH system.

This Water Balance Table for a Potable RWH System describes a scenario where all indoor water for a three person household is supplied by rainwater. The water demand figures (left column) are realistic for a full-time, three-person, water conserving household, where each of the three residents have an average daily water consumption rate of 160 litres (35 gal). Note: These demand figures do not account for variances in consumption rate that are impacted by visiting houseguests, outdoor watering, or reduced usage during out-of-town holidays.

The table shows that a cistern with an operating capacity of 62m^3 (13,600 gal) would provide sufficient water to get through the dry summer months, and would still provide a 6.69m^3 (1,470 gal) emergency water reserve at the end of September. This table also shows that the roof catchment area must be at least 210m^2 (2,260 sq. ft.) to produce sufficient water to fill a cistern of this size in a year with average precipitation. The right-hand column shows the amount of water in the cistern at the end of each month. In this scenario, in a year with average rainfall, the cistern would almost fill by the end of March. Drier conditions would require a larger roof.

A water balance table for a Potable RWH system supplied by both a well and rooftop rainwater collection is described in Appendix 6.5: Case Example — Water Balance Table for a combined RWH/Well Water System.

This scenario does not factor in any alternate supply water being added to compensate for low rainwater replenishment during the summer. For example, adding water from a low producing well during the spring and early summer would reduce the required storage amount and/or allow for a smaller roof catchment area.

3.3.4 Fire and Emergency Water Reservoirs

Additional water storage capacity can be added to the rainwater storage tank to provide a reservoir for fire and emergency uses. This emergency water can be accessed from the tank in case of a fire, prolonged power outage or earthquake.

Determining Your Emergency Water Storage Requirement for Fire Suppression

Calculating emergency water storage requirement for fire suppression.

205L/Minute (45gal/Min) [the output of a high capacity gasoline fire pump]
multiplied by
the number of minutes until the Fire Dept. can be expected to arrive

For example: 205L/minute x 30 minutes = 6.2m^3 (2,800gal) of water reserved for fire suppression.

Note: This formula is just one simple way to calculate reservoir size. You may also have a fire sprinkler system that determines your required water storage.

"Without the rain,

there would be

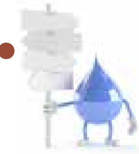
no rainbow."

...

Gilbert K. Chesterton,

British writer

4. THE COMPONENTS OF A RWH SYSTEM



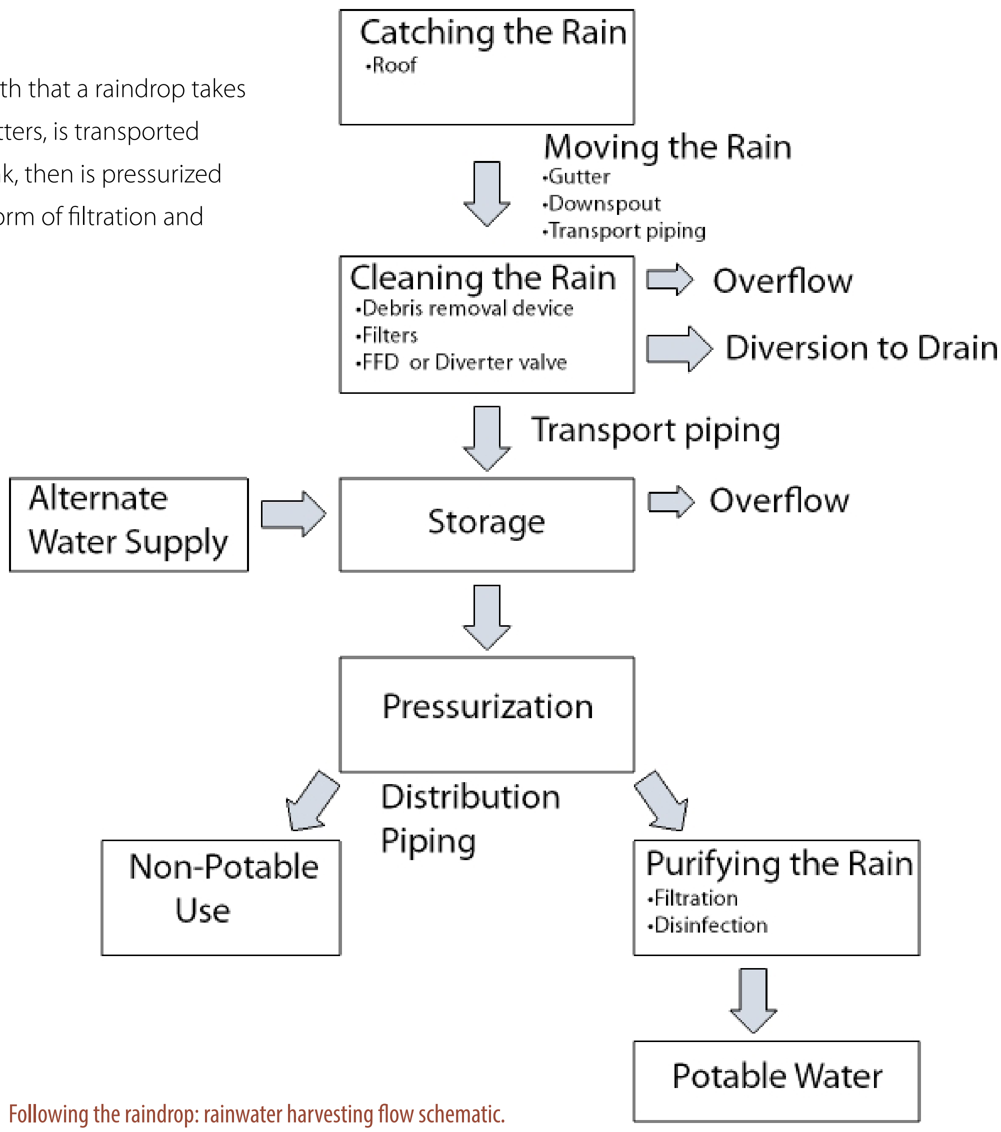
Other information resources to help design your RWH system are listed in Appendix 6.2: Information Sources for Rainwater Harvesting.

This chapter focuses on the design and installation of a RWH system. Parameters, materials, installation and maintenance vary significantly between Non-Potable and Potable systems. Both categories are referenced in this document.

Every RWH system will include features to suit the water requirements and the individual site. This Guidebook does not attempt to cover all possible approaches or component details.

4.1 From Roof to Tap

This chapter is organized to follow the path that a raindrop takes as it lands on your roof, collects in the gutters, is transported and cleaned on its way to the storage tank, then is pressurized to its final destination (often with some form of filtration and disinfection before reaching the tap).



Following the raindrop: rainwater harvesting flow schematic.

4.2 Catching the Rain

A variety of common roof types and their attributes are listed as a guide in Appendix 6.6: Common Roof Types and their Attributes.

4.2.1 Roof

Selection of roof material is an important first step in designing a RWH system. Some roofing materials produce toxins that prevent potable water use, and sometimes even non-potable outdoor water. Some roof surfaces are less efficient for collection, and some are difficult to keep clean.

At present, no water quality standards for roofing types exist, and few roofing products carry water quality test information. Individual roof products vary; it is important to check if toxins may leach from any particular roof product.

Factory-coated enamelled steel, terracotta, concrete tile and properly glazed slate are the safest materials for a RWH system and the easiest to maintain. Zinc-coated, galvanized metal is the next best choice.

Modern asphalt and fibreglass shingles are often heavily infused with anti-fungal chemicals to prevent moss growth. Given the lack of information available about concentrations of moss inhibitors or chemicals (such as copper) contained in roofing materials, best practice would be either to avoid collecting rainwater for potable use from roofs comprised of these materials, or to treat the drinking water with a Reverse Osmosis or distillation process. Gardeners have raised some concern that moss inhibitors may be harmful to plants.

Avoid cedar shakes, cedar shingles, Bitumen, or composition roofing (for flat or low-slope roofs). Acidity and potential toxins make these roofs unsuitable for potable water and are a low quality water source for gardens. Copper or lead roof or flashing materials should be avoided, especially for Potable RWH systems.

Snow rails can help to prevent gutter damage.

Snow Rails on Roofs

On metal roofs, snow rails help to prevent gutter damage by slowing the slide of melting snow that can cause this damage. They can also protect entryways and planting beds located under eaves. For rainwater harvesters, snow rails increase the efficiency of winter rainwater collection by holding more snow on the roof that will be collected as water during the thaw.

4.2.2 Gutters

Gutters are the first part of the rainwater transport system that move the rain from the roof to the storage tank. Gutter design and installation affects the amount and quality of collected rainwater, as well as the maintenance required. Clean and properly constructed gutters are essential for good quality water, and also reduce fire risk and mosquito breeding in summer.

Materials

Use appropriate materials approved for their structural integrity and water quality. Coated aluminum and vinyl are rated for use in Potable RWH systems. Always avoid copper and lead. Galvanized steel can be used for Non-Potable RWH systems, and, with properly functioning first flush diversion, is suitable for potable water collection as well.

Size

Gutters are sized to handle peak water flows from the roof. Usually, a 12.5 cm (5") wide gutter will suffice.

Consult your contractor or building inspector for larger roofs.

Slope

The gutter must be installed with sufficient slope towards the downspout to ensure that the gutter drains dry between rains. Gutters that dry completely between rains are estimated to last three times longer than those that have ponds or wet areas. The minimum required slope of 1:200 (1/16" per linear foot) should be increased where possible to assist debris to flow out of the gutter. Greater slope reduces the ponding of water and debris that cause organic matter to decay and discolour the water, increase its acidity, and promote bacterial growth and mosquito breeding. Where aesthetics are not a concern, some rainwater harvesters use slopes of 1:100 or 1:50 (1/8-inch or ¼-inch per linear foot).

Part 7 of the B.C. Plumbing Code addresses hydraulic loads used to size gutters, rainwater leaders, building drains and sewers.

Shape

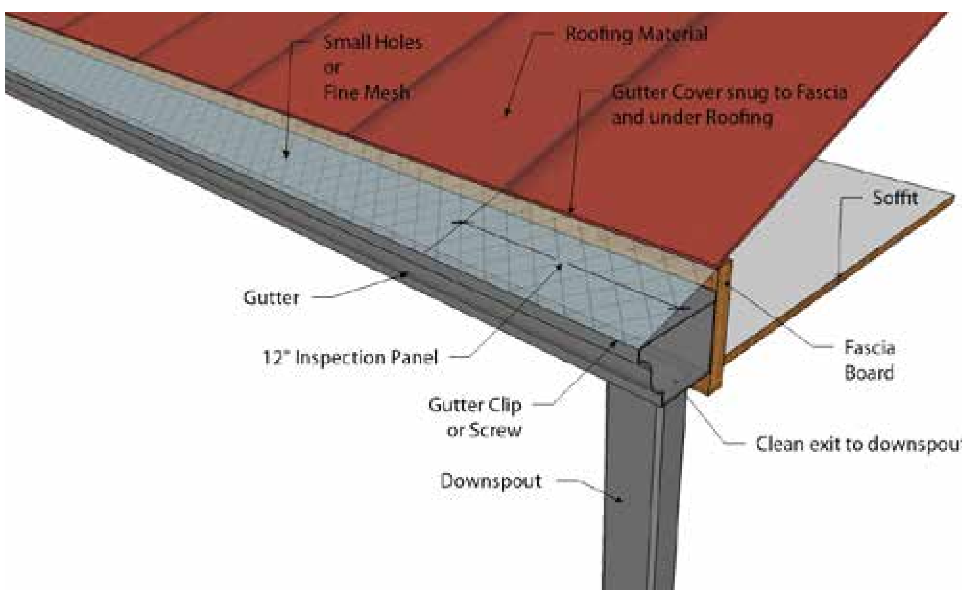
Gutter shape should facilitate the flow of water to aid in self cleaning. Half-round gutters are ideal, but fascia gutters with smaller bottoms than tops are also effective.

Regardless of shape, the gutter must be smooth and evenly sloped (no dips or valleys) toward the downspout. Professionally-installed, continuous aluminum gutters achieve this objective because they are seamless, and contain no joins or ridges to block water flow.

Flushing of the gutters or hand cleaning may be necessary. An unobstructed opening to the downspout that prevents buildup of debris at its edge is particularly important for Potable RWH systems. For example, a 6mm (¼-inch) plastic lip will contribute to debris and water buildup.

4.2.3 Gutter Covers

Gutter covers or debris screens over gutters are highly recommended for any Potable RWH system to improve water quality and to reduce the need for frequent gutter cleaning.

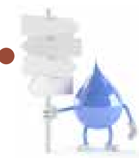


Typical gutter cover detail.

Whether your gutter covers are made of a fine mesh or holes in a plastic or aluminum cover, the type of gutter cover you select will impact the amount of debris that collects in the gutter and therefore the time spent on gutter cleaning.

In the RDN, the greatest challenge to clean gutters is fir needles. Fir needles are light enough to be carried long distances in the wind, and small enough to find their way through almost anything. They are highly acidic and impart colour with prolonged contact with water. To effectively block fir needles, gutter cover screens or holes must be very small, and the cover surface should be sloped. However, if the gutter cover mesh is small enough to prevent any needle from entry, it can become clogged with fine debris and require surface cleaning to allow enough water to pass through.

All gutter covers require maintenance to work effectively. Periodic cleaning of the top surface is required to prevent roof water from flowing over the gutter edge. Maintenance is particularly important in the spring after pollen season, and again in late fall when the fir trees have shed the majority of their needles. Check gutter conditions under the gutter cover, at the entry to the downspouts, where the majority of debris will accumulate. It may be necessary to remove debris either by flushing gutters with water or by removing the covers and cleaning gutters by hand.



See Chapter 5: Operational and Maintenance of a RWH System for more information on pollen season and frequency of gutter cleaning.

4.2.4 Splash Guards

Splash guards are added to the outside edge of a gutter to prevent fast flowing rooftop water from overshooting the gutter. They are typically placed where a roof valley joins the inside corner of a gutter, and where a gutter cover is being used. A variety of splashguard options are available from gutter installers who are familiar with RWH systems.

4.2.5 Downspouts

Downspouts are usually constructed of coated aluminum or vinyl. It is not recommended to use ABS or PVC sewer piping unless painted to protect the piping from sunlight.

Rectangular 50mm x 75mm (2" x 3"), or square 75mm (3") downspouts, constructed of aluminum or round vinyl, are most common in this region. These sizes should be adequate for most roof surfaces feeding into one downspout; check with your contractor or building inspector if your roof catchment area requires a gutter larger than 125mm (5 inches).

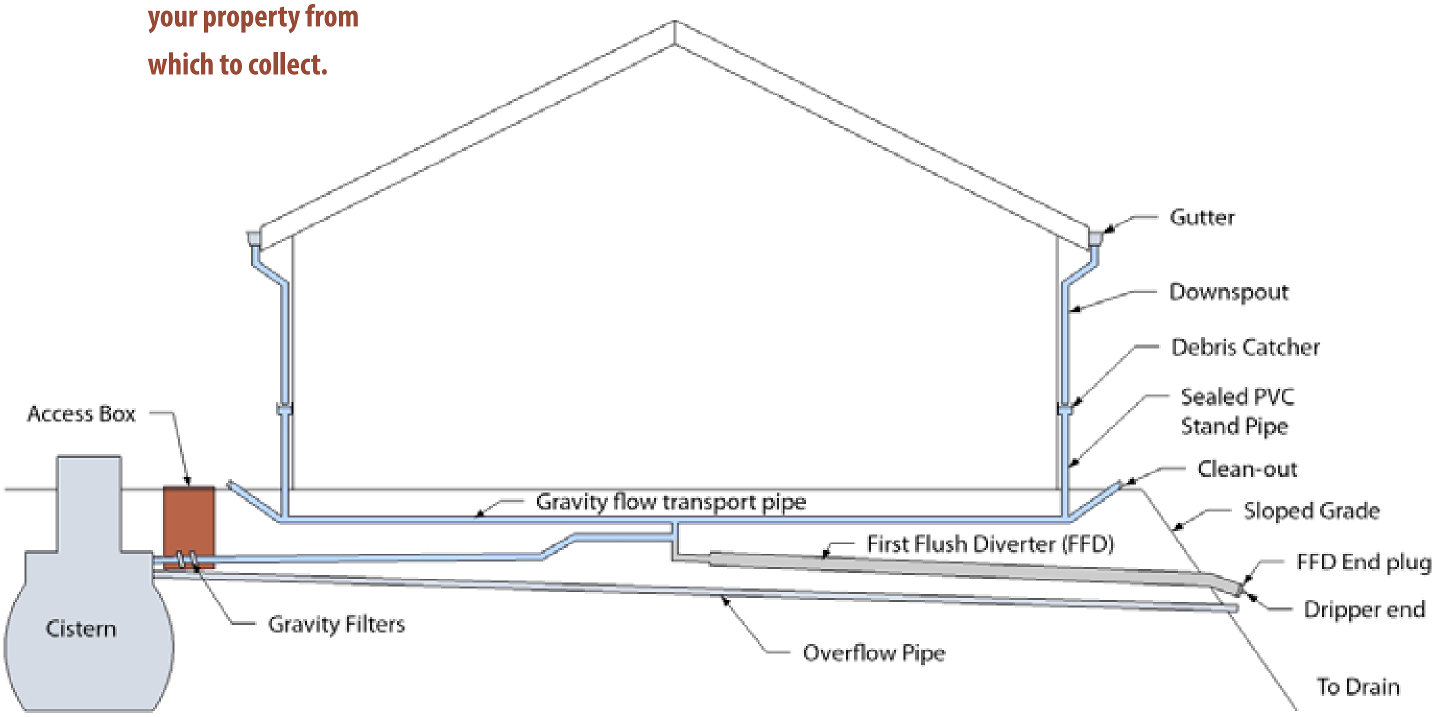
All debris exiting gutters travels through the downspouts. Avoid elements that could cause debris buildup, such as sharp corners or screws protruding into the interior. A clogged downspout will reduce collection efficiency, and could cause blocked water to back-up onto the exterior walls of the house.

4.3 Moving the Rain – from Roof to Tank

DESIGN TIP: Save money on transport piping by deciding how much water you need, and selecting the easiest roofs on your property from which to collect.

4.3.1 Transport Piping Systems

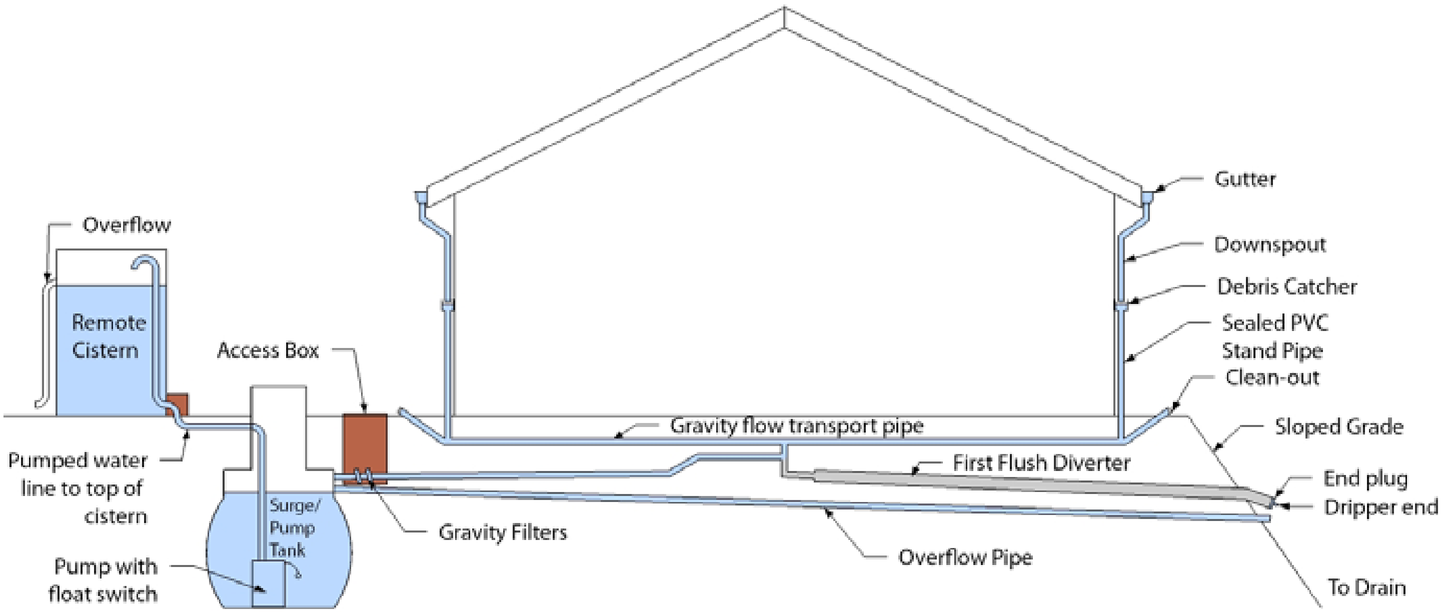
The Transport Piping System refers to pipes and other devices used to move collected rainwater from gutters to storage tank(s). When water is collected from downspouts on two or more sides of a house, transport piping must be installed around the house perimeter. There are three types of rainwater transport or conveyance systems: dry, surge/pump tank, and wet.



A dry rainwater transport system.

Dry Systems

A Dry Rainwater Transport System is a pipe system where the water runs downhill by gravity to the top of the cistern. A dry system is the simplest method to transport rainwater in a RWH system. No pockets of water can collect to grow bacteria or freeze. No power, and very little maintenance beyond occasional brushing and flushing, is required.



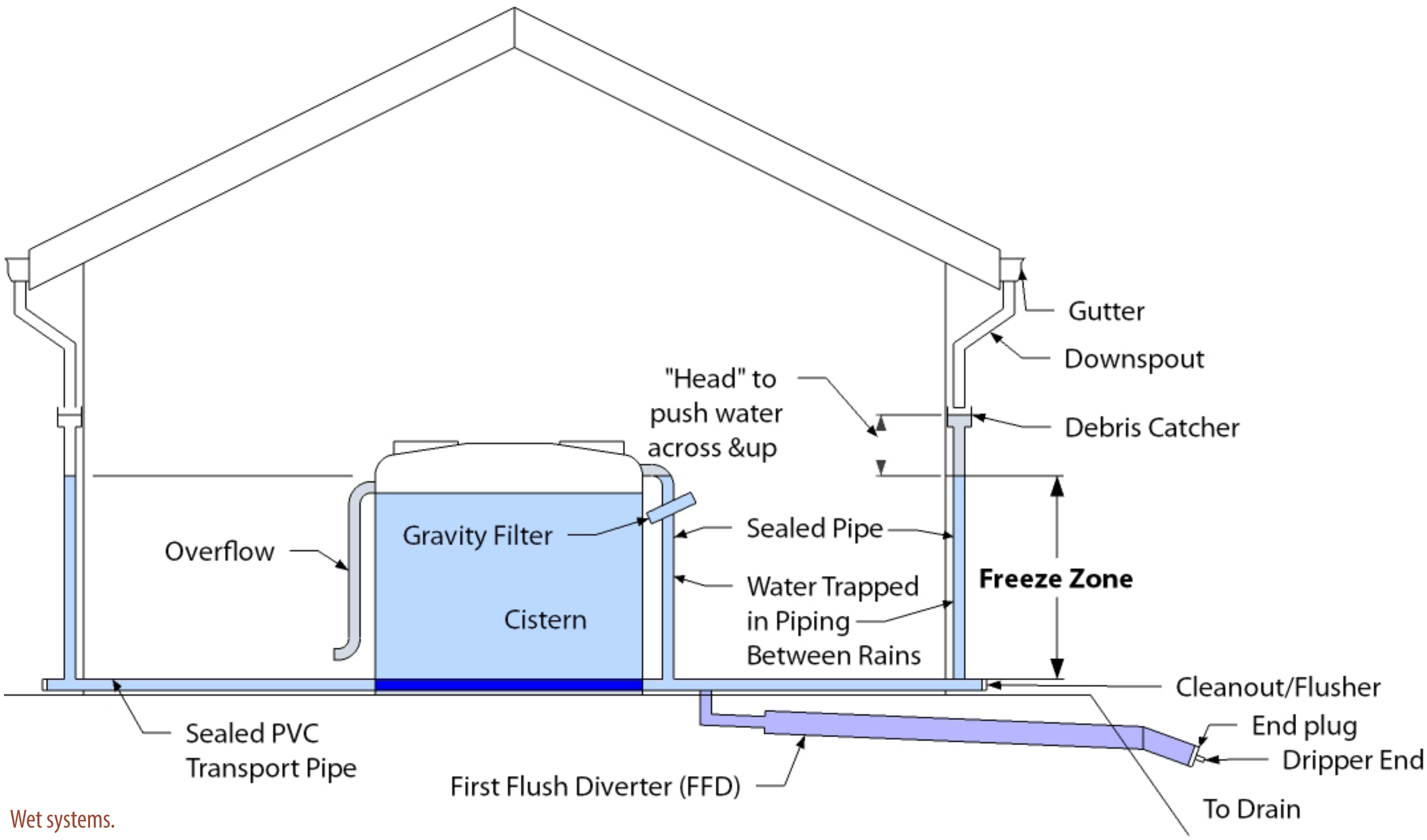
A surge/pump tank system.

Surge/Pump Tank Systems

A Surge/Pump Tank Rainwater Transport System is a pipe system with direct gravity flow to a surge/pump tank; from there, water is pumped to the cistern. These systems are commonly used when the storage tank is uphill and some distance away from the building, or when the owner wants to hide all collection pipes below grade.

Piping is similar to a dry system. Typically, the surge/pump tank is relatively small: 180 to 400 litres (40 to 90 imp. gal), but is large enough for the pump to manage peak rainwater flows. This tank must be equipped with an overflow. The pump (referred to as a Transfer Pump) is equipped with a float switch to turn the pump on and off automatically.

While a surge/pump tank may be preferable for logistic or aesthetic reasons, the extra capital cost could be as much as $2000 and there are additional maintenance requirements such as periodic tank cleaning and pump and float switch servicing. Note that these systems do not work during power outages.



Wet systems.

Wet systems

In a Wet Rainwater Transport System, the water is contained in sealed pipes that typically form a U shape: water travels down, across, and back up into the cistern. A section of sealed pipe is installed above the top of the tank to create a head of water that pushes water across and back up into the tank. Large amounts of water can potentially become trapped in the pipes between rain events. Unless frequently flushed or emptied with a First Flush Diverter (FFD), this water can freeze in winter or become stagnant in summer.

These wet systems are the most difficult to maintain and have the lowest rates of collection efficiency. They are useful where there is no power supply, or for a homeowner who is interested in accepting responsibility for more maintenance in exchange for lower capital and operating costs.

4.3.2 Pipe Size and Slope

The required size and slope of the transport pipe (considered a drain) is stipulated in the B.C. Building and Plumbing Codes. Sizes are intended to ensure that debris is carried away to avoid water backups. Minimum pipe diameter depends on pipe slope and on the size of the water catchment surface. The larger the water catchment surface, the larger the pipe must be to transport the water.

As a general rule, for a roof catchment area of 200m^2 (2,150 sq. ft.) the following pipe size and slope would be adequate:

- a 75mm (3-inch) pipe at a slope of 1:50 (2%), or
- a 100mm (4-inch) pipe at a slope of 1:100 (1%)

A 1:100 slope means a 1cm fall for every 1m of length, which is referred to as a one per cent slope. In imperial units, a one per cent slope is a 1 ft (12-inch) fall for 100 ft, or approximately 1/8th–inch per foot.

If in doubt, consult your contractor or local building inspector to select the appropriate pipe diameter for your particular RWH system.

Calculating slope.

4.3.3 Rainwater Transport Pipe Types

The type of pipe selected depends on where it is located, and whether it is being used to transport potable water. Three types of piping are most commonly used.

- For below-grade piping, a PVC sewer-grade pipe that is stamped as CSA B182.1 320 kPa is common. ABS sewer pipe can also be used if care is taken that the joints are carefully cemented to avoid groundwater infiltration. These types of pipes can also be used above grade, but they should be painted to reduce deterioration in sunlight.
- When installing piping under areas that are subject to vehicle loading such as driveways which have less than a 600mm (2 ft) cover on well-compacted soil, PVC SDR or Solid Core ABS should be used.
- For above-grade installations where the pipe is exposed to sunlight, it is recommended to use the thicker-walled PVC DWV pipe.
- For Potable RWH systems, potable water-rated PVC Schedule 40 piping is recommended. This type of pipe does not contain recycled plastics that could contain contaminants from a previous use. All piping installed downstream of the disinfection system must be either Schedule 40 or certified for potable water.

4.4 Cleaning the Rain

Rainwater quality is a measure of the physical, chemical, and microbiological properties of the water, and includes the pH, metals and bacteria. Rainwater is impacted by airborne pollutants such as smoke, heavy metals, contaminants on the roof such as bird droppings and pollen, and toxins leaching from the roofing material. To improve the quality and safety of the stored rainwater, employ debris-removal devices and First Flush Diverters as pre-cleaning tools. Pre-storage purification reduces contaminant buildup, bacterial growth in the tank, and frequency of tank cleaning. All RWH systems should provide some means of pre-cleaning the water en route to the tank.

Why clean rainwater before it reaches the tank?

- ✓ Improve the quality and freshness of the water.
- ✓ Eliminate many water-borne particles that carry bacteria and consume oxygen from the water as they decompose.
- ✓ Reduce the nutrients in the water that foster mosquito growth and algae blooms when subjected to sunshine.
- ✓ Decrease the frequency of tank cleaning from annually to as rarely as every 15 years.

Pre-storage purification in Potable RWH systems is particularly important to maintain water freshness and to simplify the disinfection process. Table 2, on the following page, illustrates various pre-cleaning strategies depending on water use, storage type, and maintenance requirements.

Dry triple-cleaning system to surge/pump tank, downspout to debris box, and a pair of Banjo screen mesh gravity filters.

Table 2: Pre-Cleaning and Maintenance Required Based on Water Use and Storage Type

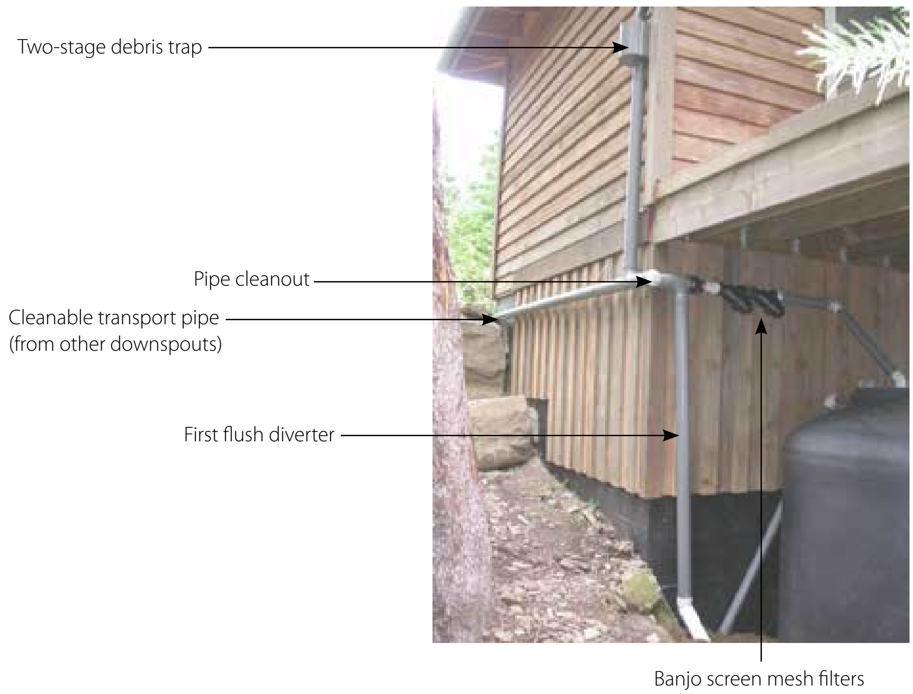
Water Use and Storage Type	Water Pre-Cleaning Recommended	Maintenance Requirements
Emergency water storage and outdoor cleaning, and — if stored out of strong sunlight — below-grade irrigation .	Coarse screens or debris traps required to remove large debris particles that could damage pumps.	Tank must be cleaned annually to avoid anaerobic conditions, which could occur if sediment were to reach a depth of more than 13mm (½ inch).
Above-ground irrigation and hand-watering, OR water stored in above-ground tanks that are subject to direct sun	One coarse, and one finer debris removal device to reduce the volume and size (600-800 microns) of solid debris and soluble pollutants that enter the tank	Tank must be cleaned every three to five years; pre-cleaning minimizes the possibility of summer algae blooms and anaerobic bacterial growth.
Non-Potable (Indoor Use), for toilet flushing.	One coarse, and one finer debris removal device to reduce the volume and size (600-800 microns) of solid debris and soluble pollutants that enter the tank. Increased concern with clean gutters to prevent discolouration.	Tank must be cleaned every three to five years; pre-cleaning minimizes the possibility of summer algae blooms and anaerobic bacterial growth. Gutter cleaning reduces discolouration and toilet bowl staining.
Potable water indoor use.	Debris free gutters (fine gutter cover or frequent cleaning). One or more debris pre-cleaning devices to prevent debris larger than 200-500 microns.	With sediment this fine the chance of anaerobic bacteria growth is virtually eliminated, and a biologically active layer of sediment can form. Water stays "fresh" for over a year. No taste or odours. Tank cleaning frequency reduced to every 10-15 years.

To understand more about microns and their sizes, flip to Appendix 6.8: How Big is a Micron?

Water flowing into filter basket of whole house; combined filter and pump chamber.

4.4.1 Debris Removal Devices

Debris Removal Devices remove both organic and inorganic particles suspended in the water, as opposed to substances or pathogens that are dissolved in the water. Debris removal devices include very fine gutter covers, debris traps, rain screens, roof washers and super filters, which clean rainwater from the entire roof at one point.



Three-stage gravity pre-cleaning for Potable RWH system.

Select a debris removal device that:

- is sized to handle peak water flow from your roof. Oversized devices require less frequent cleaning;
- is fine enough to meet your needs. Some rainwater harvesters install two consecutive filters with decreasing mesh sizes to prevent the filters from becoming clogged;
- is constructed of durable materials to withstand sun and freezing temperatures;
- is designed with sufficient height between the water entry and exit points to operate effectively; and,
- matches your maintenance expectations. Some devices are virtually self cleaning.

Debris pail above standpipe to underground transport piping.

Low steel debris pail.

Wall-mounted pipe to 1660 gallon tank.

Banjo gravity strainer with 180-micron screen.

4.4.2 First Flush Diverters

A First Flush Diverter (FFD) is a pipe or other device that rejects the first, poorest quality, and most polluted water collected from the roof at the beginning of any rain event. Its primary function is to prevent soluble pollutants or very fine suspended solids (e.g. pollen) from entering the water storage tank. Materials eliminated can include dissolved bacteria or cysts, heavy metals and other toxins from the roof, and acidic tannins or polluted water from ponds of debris in the gutters. The first rain arriving on the roof contains the highest concentrations of these soluble pollutants. Research suggests that up to 80 per cent of pollutants are found in the first 0.5 to 0.75 mm (0.02 to 0.03 inch) of a rain event.[4] Depending on its location in the transport piping system, a FFD can also capture larger, heavier suspended debris particles.

How Does a FFD Work?

The simplest FFD is a pipe that exits from the bottom of a horizontal section of transport piping. The first water from the roof enters and fills this diverter pipe. This pipe backs up when filled completely, allowing the remaining rainwater to flow over it and continue to the tank. A dripper valve allows the trapped water to drain slowly from the diverter pipe. Within one or two days the diverter pipe is empty, and is prepared to reject the first portion of the next rain event.

Self cleaning leaf trap between downspout and underground transport piping.

[4] Bertrand-Krajewski et al., 1998

Downspouts to catchment pipe and into tank.

Custom-designed debris catchment box.

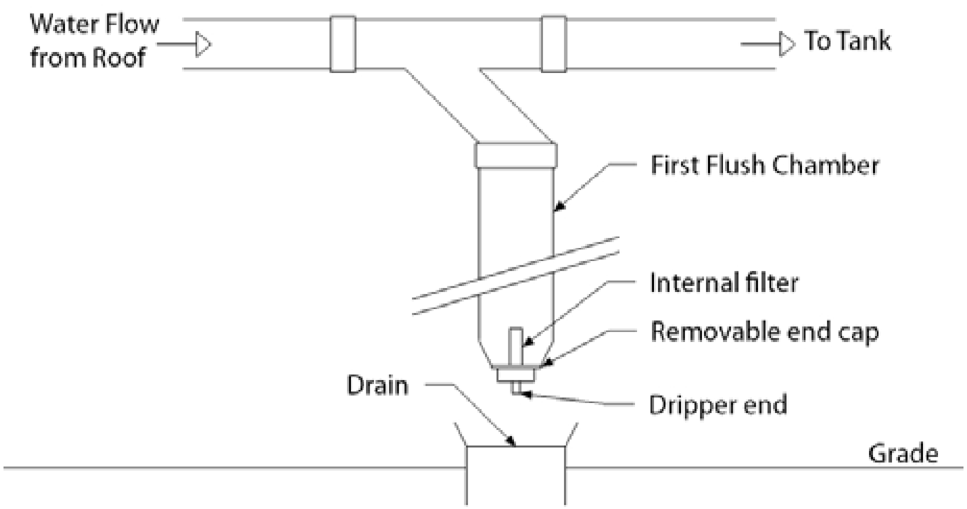
When to Use a FFD

FFDs should be included in any Potable RWH system. They reduce fine sediment and concentrations of bacteria in stored water, and therefore minimize demand on post-storage disinfection equipment.

While FFDs are less critical for Non-Potable RWH systems, they are popular among gardeners to reduce water acidity and the leaching of fungicides that are often added to modern fibreglass or asphalt shingles.

Water Rejection Quantities

The amount of water rejected in the FFD varies according to the roof and site conditions. Recommended rejection amounts vary widely around the world. The following chart is a guide for typical properties in the Regional District of Nanaimo.



FFD dripper end and plug with many holes.

Large, underground FFD pipe partly backfilled.

Table 2 — Typical FFD Water Rejection Quantities.

Level of Roof Contamination	Rejection Amount
High Contamination Environment • High organic waste from animals, birds, or adjacent trees • Areas of high airborne contamination (close to roads, pulp mills, open wood burning) • Rough roof surfaces such as asphalt shingles	First 1.0 mm (0.04 inch) Total rejected* = 100L (21.8 gal)
Medium Contamination Environment • Normal levels of organic waste collection • Medium expectation of airborne contamination • Rough roof surfaces such as shingles	First 0.75mm (0.03 inch) Total rejected* = 75L (15.6 gal)
Low Contamination Environment • Relatively clear site Low expectation of airborne contamination • Smooth roof surface such as metal	First 0.5 mm (0.02 inch) Total rejected* = 50 litres (10.4 gal)

* Rejection quantities assume a 100m² roof (for litres) or a 1,000 sq.ft roof (for gallons)

Pipe-style FFDs also function as full diverters for the RWH system. By removing the entire dripper end, the FFD diverts all roof water away from the tanks, which is useful during pollen season and when the roof and gutters are being cleaned. The dripper end must be located where adequate drainage and erosion protection can accommodate the full volume of roof water for limited periods.

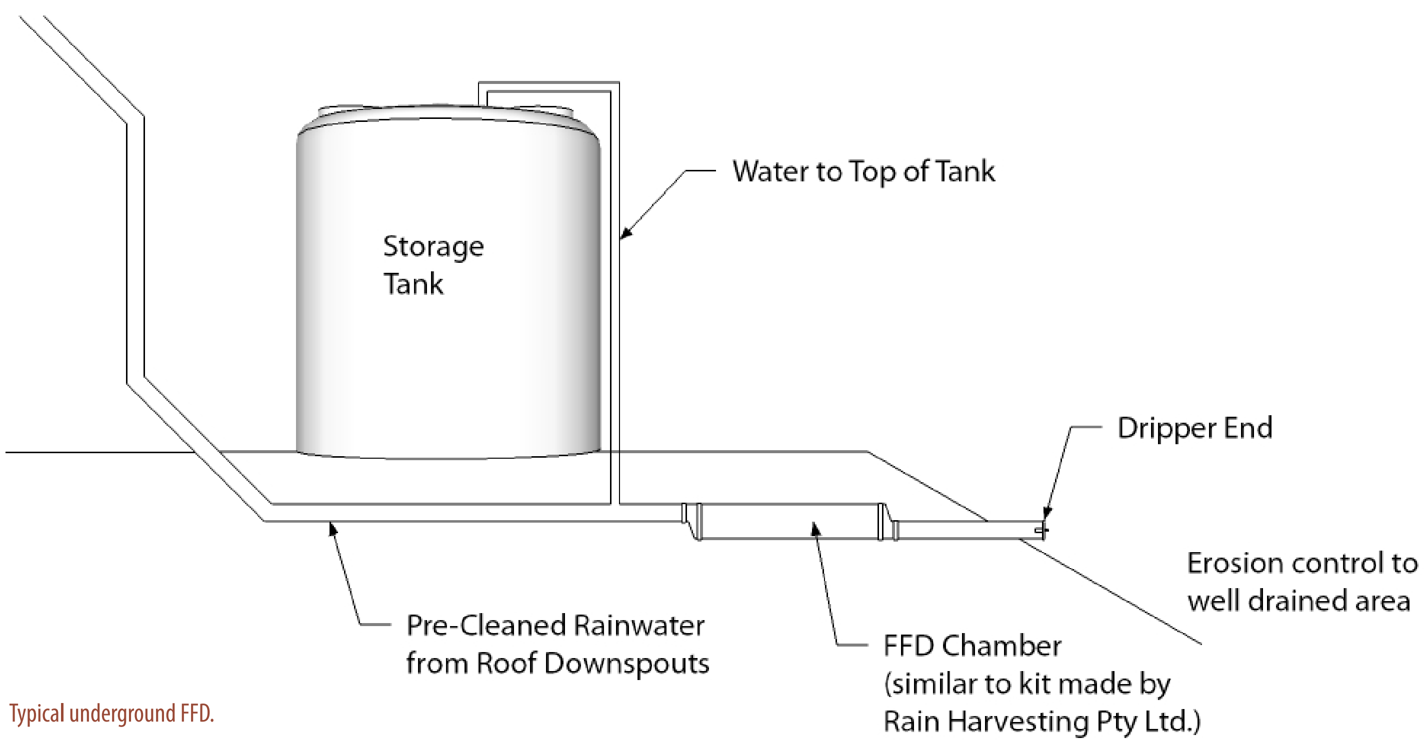
Types of FFDs

Wall Mounted Pipe

The simplest and most common type of FFD is a wall-mounted pipe running vertically down a wall. Larger pipe diameters will increase the reject volume. A good drain is required below. Wall-mounted pipe FFDs can freeze if the dripper end plugs before or during a period of cold temperatures. Some models have a built-in floating ball valve. The ball floats up and seals the joint of the pipes to prevent any possibility of the water mixing. Other models have a wall-mounted debris rain head combined with an automatic valve to reject the first water entering the filter assembly.

Underground FFD Pipes

If aesthetics are a concern or if protection from freezing is important, pipe-style FFD's can be built underground. Smaller FFDs are often handmade, while kits are available for those with a larger diameter (305m or 12").



Typical underground FFD.

Box or Barrel FFDs

FFDs may be constructed of a plastic box or barrel with the water flowing past it. A drip valve at the bottom empties the vessel between rain events, and a second, larger valve provides the full diversion function. These box-style FFD's are subject to freezing, and require regular cleaning to prevent the growth of bacteria.

Dripper Ends

The dripper end or drip valve is the most important component of any FFD. If the flow-rate is too fast, the FFD will reject more water than required and therefore will reduce collection efficiency. If the flow-rate is too slow, the FFD pipe will not empty fast enough to reject the first flush from the next rain event.

A dripper end can be as simple as a small hole in a sewer plug end. A small valve or an adjustable sprinkler head fitted into the pipe end are also effective. However, these dripper ends can clog easily, and require inspection and cleaning as often as weekly. Some RWH system manufacturers produce a plastic dripper end that incorporates one or two large filters to minimize clogging. The end component removes for easy cleaning, and for the FFD to function as a full diverter.

FFD Pipe Sizing

The reject volume of a FFD depends on the size of the box, or on the length and diameter of the pipe. For example, a 100mm diameter pipe contains 7.855 litres of water per metre (a 4-inch diameter pipe has a capacity of 0.543 imp gal per linear foot). That means that a 100mm diameter FFD pipe for a 100m^2 roof in a low contamination environment should be 6.365m long. In imperial measure, 19 linear feet of 4" pipe would be required to reject 10.4 imp gal from a 1,000 sq.ft. roof.

Rainwater Harvesting Ltd. brand dripper end with optional SS debris screen.

In this *Guidebook*, the term cistern describes one or more installed rainwater storage tanks, but does not include single or combined rain barrels.

4.5 Storing the Rain

Storage is at the heart of every RWH system in coastal B.C., where the majority of annual rainfall arrives in winter and summers are dry. It is also the most expensive component in the system. Your own preferences, water requirements, location, and budget will influence your choice of tank.

Prior to investment, consider: the tank's durability (including warranty and potential lifespan); protection from sunlight penetration; certification for potable water; and, retail, transportation, and site preparation costs. Also, be sure to note whether the tank size is being quoted in US or Imperial gallons.

When selecting, installing, and maintaining a rainwater storage tank, carefully consider the type of cistern, cistern size, cistern site placement, neighbourliness, and future expansion.

4.5.1 Types of Cisterns

Three types of tanks are available to suit various locations:

- **Outdoor Above-Ground Tanks**

  Outdoor, above-ground poly tanks are usually the simplest and least expensive option. For small systems, a tank can often be located behind a house or garage, under a deck, and close to a downspout. Many shapes and colours are available. They are, however, subject to sunlight penetration that can compromise water quality. Tank outlets require frost protection.

- **Outdoor Below-Ground Tanks**

  Outdoor, below-ground tanks are usually more expensive than above-ground tanks to purchase, transport and install, but they provide a concealed alternative and are not affected by sunlight or freezing temperatures. Installation costs can be reduced if the tanks are installed at time of building construction. Some versions are load-bearing and can be placed under driveways.

- **Indoor Tanks**

  Indoor tanks are smaller and can be placed in garages or basements. Adequate drainage for overflow and leakage is essential.

72,700 L (16,000 gal) steel tank behind trellis.

Four poly 11,365 L (2500 gal) tanks, partly backfilled.

1546 L (340 gal) Slimline rainwater tank.

Consult your building inspector regarding seismic restraints or the need for approval by a structural engineer.

4.5.2. Cistern Size

The tank size quoted by tank suppliers refers to its Nominal Capacity, which refers to the volume of water if the tank was filled completely to the top. The Operational Capacity refers to the actual volume of water that can be contained in the tank after the fittings and overflow have been added. Generally you should not count the 75-150mm (3-6 inches) of space above the overflow, and at least 75mm (3 inches) of trapped, inaccessible water at the bottom of the cistern.

Be sure to check whether the tank you are purchasing is sized for the United States (US gallons) or for Canada (imperial gallons). A conversion table is found in Appendix 6.1: Measurements & Conversions.

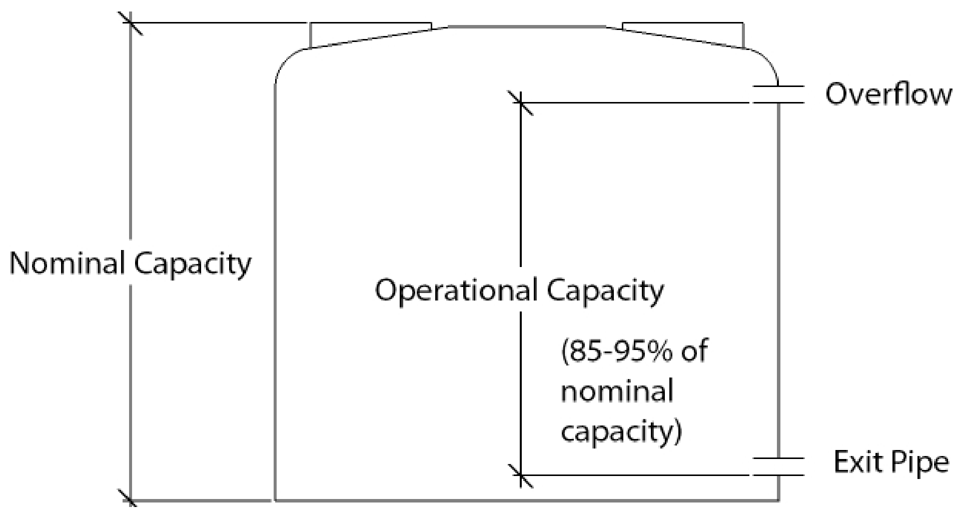
Calculating U.S. versus imperial gallons.

Calculating U.S. versus Imperial Gallons

One US gallon equals 4/5ths (0.83) of an imperial gallon.
One imperial gallon equals 4.546 litres equals 1.2 US gal.

For example, a Norwesco 2500 gallon tank (made in the US) has a nominal capacity of 2,082 imperial gal. (9,465 L)

Refer to Appendix 6.7 for a summary of common cisterns on Vancouver Island.



Tank Size: Nominal vs. Operational Capacity.

Refer to Section 3.3: Storage — How Much Rainwater do I need to Store?

Select a tank size depending on how much water you require to last through the dry spring and summer months, when rainfall is minimal. Chapter 3 helped you to determine the quantity you need to store. In rural areas, tank sizes are often larger to accommodate emergency water. Optional fire connections, specified by your local fire department, can be installed at the tank.

Budget and site are also important considerations. If your budget is tight, a minimum-sized tank can be installed above-ground, with provisions made to add others in future. Plan for how you will transport and install your tank, as well as for overhanging trees, narrow or winding roads, tight corners, overhead wires and other features that could present challenges when moving large cisterns. In cases where water supply is crucial, two smaller tanks (instead of one larger one) provide system redundancy and therefore increased water security in cases of either tank failure or contamination.

Compacted tank pad for steel cistern.

Two-inch tank exit valve.

Tank with valve box (on left) backfilled with 10-inch fill.

Tank manifold pipe and valve boxes after backfilling.

How big is my tank going to be? A typical 4,500L (1,000 gal) tank is 1.8m (6 ft) in diameter and 2m (80 inches) tall. A 10,900L (2,400 gal) tank measures about 2.4m (8 ft) in diameter by 2.4m (8 ft) tall.

Partially backfilled valve boxes.

4.5.3 Cistern Site Placement

Once situated, plumbed, and filled with water, a tank is essentially impossible to move. Consider the following issues carefully while designing the storage component of your RWH system.

Leveraging Gravity

Take advantage of gravity flow: locate the tank near a downspout, or downhill from the house where multiple downspouts can feed by gravity. Gravity-filled systems are the least expensive, are easiest to maintain, and still collect water during power outages.

Aesthetics

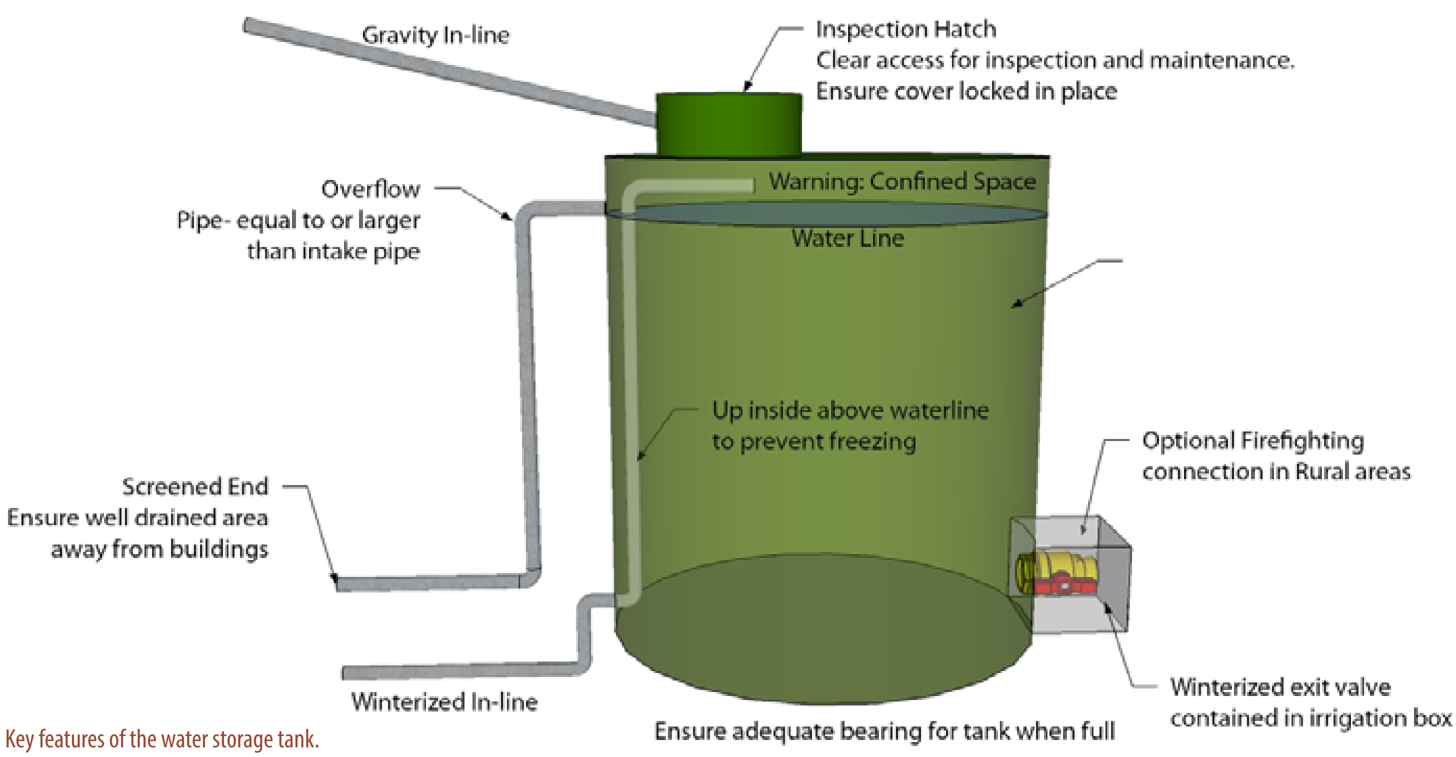
Aesthetics on your site are important, and there is no need for your tank to be unattractive. It can be painted to match adjacent buildings, tucked under a deck, fenced with wood, encircled with lattice work on which plants can climb, or installed discreetly behind a larger structure.

Neighbourliness

You're not the only one who lives with your cistern: don't forget to exercise consideration toward your neighbours. Select your tank shape, size and placement to conform to local regulations regarding height restrictions and setbacks from property lines. These bylaws are in place to minimize negative noise and visual disturbance to those who live closest to you. Appropriate screening with trees, plants or a fence can all help to ensure that your system is designed to be respectful of your neighbours. In addition, the tank and its overflow pipe should be placed where excess water will not drain onto a neighbouring property.

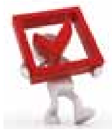
Allowing for Future Expansion

Plan ahead for tanks you may wish to add in future. Set aside adequate space, and ensure the tops of all tanks will be at the same elevation. Install a valved pipe-end that will connect to the next tank.



Key features of the water storage tank.

4.5.4 Tank Installation Checklist



Following these guidelines will help to ensure your tank runs efficiently for many years to come. Make sure your tank:

- ❒ can be transported to the site, despite overhanging trees, narrow or winding roads, tight corners, overhead wires or other features that could present challenges;
- ❒ is installed according to the manufacturer's installation instructions, or is certified by a professional engineer;
- ❒ complies with the B.C. Building Code, and with the administrative policies of your local building department. It may be necessary to obtain certification from a professional engineer, especially if your cistern does not contain the manufacturer's certification;
- ❒ includes an inspection hatch for servicing and cleaning, and is located to allow clear access;
- ❒ has an overflow pipe located near the top of the cistern that is of equal or greater diameter than the intake pipe. The end of the overflow must be directed away from the base of the tank and from house foundations, and to an area protected from erosion where it will not flow onto a neighbouring property;
- ❒ is placed on level ground;
- ❒ is, if above-ground, opaque, painted, or located within a building to limit the entry of sunlight;
- ❒ is ventilated to accommodate pressure changes when water enters or exits the tank. Larger vents increase the oxygen supply to the stored water;
- ❒ has properly sealed openings, inlets and outlets (such as the overflow) to prevent mosquitoes, rodents, groundwater, and other sources of contamination from entering the tank;
- ❒ has been freeze-protected at exit fittings and water entries;
- ❒ is sitting on a tank pad or foundation that is capable of supporting the cistern when full (water weighs 1 kg per litre, or 10 pounds per imperial gallon). The pad should consist of a compacted soil layer, covered by a level layer of sand so that the tank load will be distributed evenly. The sand layer should be smooth, containing no sharp objects that could puncture the tank. While the underlying soil layer will shift, swell, and shrink, the sand will help to absorb this movement. Engineering approval may be required for tank pads located on steep or unstable sites or close to buildings, or for underground tanks in areas with high groundwater.
- ❒ is not installed in the path of surface water runoff;
- ❒ is not installed in a concave area where water could collect around the base and compromise its foundation; and,
- ❒ is not installed in an area prone to high winds, which could topple an empty tank (especially if constructed of a lightweight poly material).

4.5.5 Tank Safety Checklist

Like swimming pools, water tanks can be dangerous for children. They also qualify as a confined space, and the air inside may not contain sufficient oxygen to allow a human to maintain consciousness. Several guidelines and precautions apply for the responsible rainwater harvester.

Check that your storage tank:

❒ clearly displays the label DANGER — CONFINED SPACE. NEVER enter a tank. There are specific guidelines for entering a confined space, and only those with specific qualifications, training, and equipment should do so;

❒ is fitted with safety devices or locked lids to prevent tampering or unintended entry, especially if it is large enough for a child to fit inside and drown. As an added precaution, do not leave a ladder where it could provide easy access to the roof of the tank and inspection hatch;

❒ is never left open and unattended;

❒ never contained a toxic substance, and that the interior surface of the tank is CSA or NSF approved for potable water; and,

❒ is certified by the manufacturer for its intended application.

4.5.6 Optional Tank Features

There are a variety of other features that you may wish to install on your tank. Optional tank accessories can include:

- water level indicators available in simple, mechanical tank-mounted or remote-controlled, electronic versions;
- floating exit assemblies that collect water from approximately 25mm (10”) below the water surface;
- aeration devices on water entry to add oxygen;
- water-entry smoothing inlets to prevent the disturbance of sediment; and,
- flexible connecting fittings to allow for tank movement with natural shifts of the earth (these are especially important for multiple underground tanks).

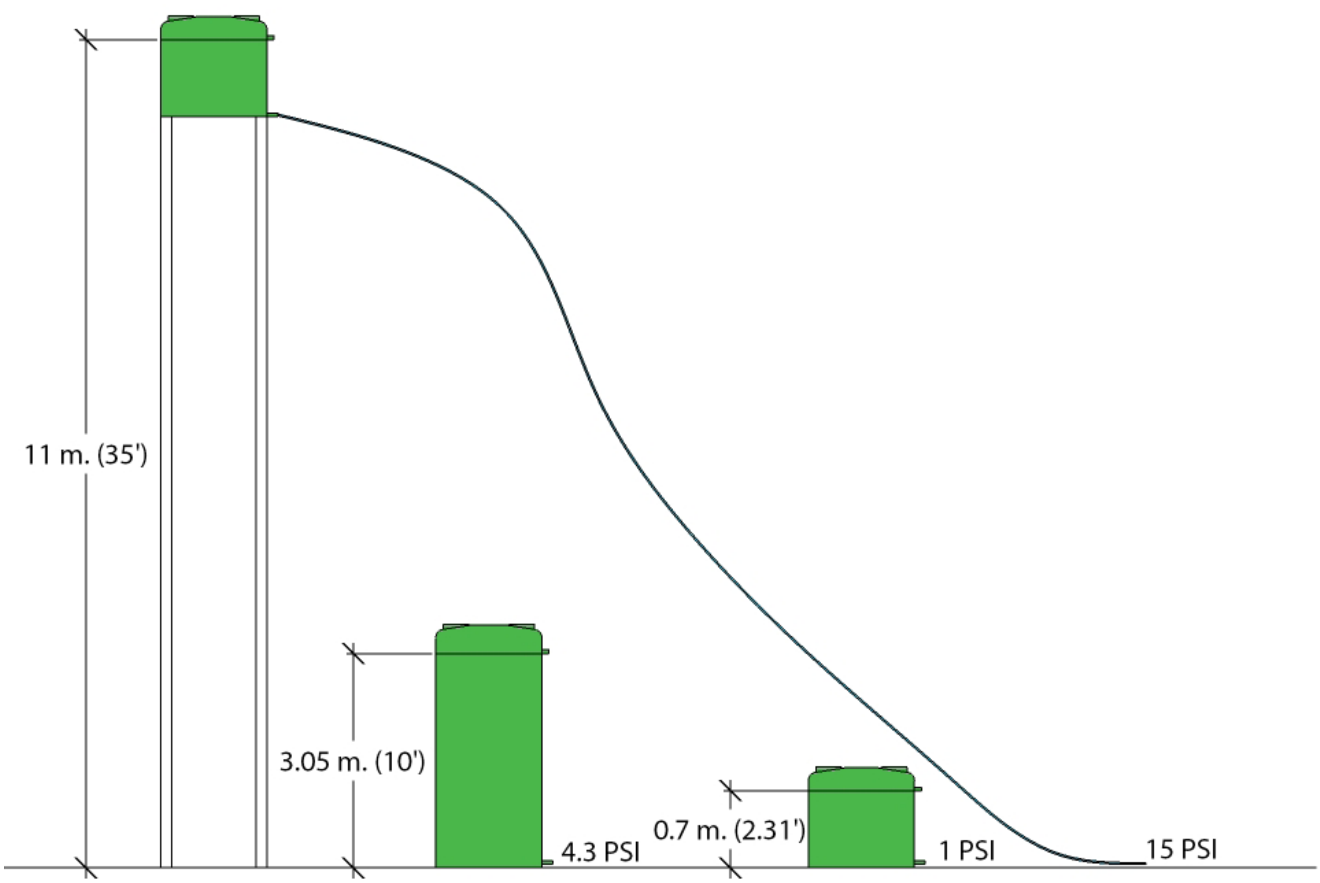
4.6 Pressurizing the Rain

Because gravity pressure is often insufficient, most RWH systems rely on some form of mechanical pump to deliver stored water to its end use. For example, water must be stored almost 11m (35 ft) above a garden to provide a gravity head pressure of 15psi (pounds per square inch), which is the minimum requirement for an efficient drip irrigation system.

The technical information in this section is included as a guide to the owner in selecting a pump supplier or contractor to supply and install the appropriate equipment.

4.6.1 Pump Pressure or Head

Water pressure is usually measured in pounds per square inch (psi), but pump size is often measured in feet of head or Head Pressure (HD, which stands for Head). The term feet of head originated because a column of water 2.31ft. (0.7m) high will exert a pressure of 1psi, or 1 vertical foot will exert a pressure of 0.43psi. For example, a 10ft (3.05m) high column of water exerts 10 X 0.43= 4.3psi of head pressure.



Head pressure created by gravity.

4.6.2 Selecting the Appropriate Type of Pump

Several questions will help you to choose the right pump:

- How often the pump will be used?
- How often will you need to turn the pump on and off?
- Will the pump be required to run for long periods (for example, to accommodate some irrigation systems)?
- How important is pump reliability? What are the repercussions if the pump fails while you are away?
- Is pump noise a concern for you or for your neighbours?
- Is the pump a component of a Potable RWH system? All pumps in a Potable RWH system, along with attachments such as float switches, must be approved for potable water or fish-safe use. A potable water pump cannot contain oil, and mercury float switches cannot be used.

4.6.3 Types of Pump Systems

There are three basic pump types or pumping systems:

- External Constant Speed Pumps;
- On-Demand Pumps; and
- Submersible Pumps.

Newer Variable Speed Drive (VSD)/Variable Frequency Drive (VFD)-style pumps have become common despite their higher initial cost compared to constant speed models. They maintain more constant pressure and are more energy efficient than traditional models.

External Constant Speed Pump with a Pressure Tank

The most common pumping system combines a constant speed pump (often a shallow well jet pump) that draws water from the storage tank and pushes it into a pressure tank. This pressure tank stores the pressurized water so that minor demands like flushing a toilet do not require the pump to turn on. A pressure tank can prolong the lifespan of your pump by decreasing the number of times it cycles on and off.

These pumps are equipped with a one-way check valve to prevent pressurized water from returning to the tank. They also include a pressure switch that regulates pressure tank operation. This system is a good choice when the pump is elevated above tank water level. Some pumps are self-priming to easily begin drawing water up and out of the tank.

A safety float switch inside the tank is often used to ensure that the pump does not overheat if the tank runs dry.

Simple pond pump in transfer tank.

Eco Booster on-demand pump.

On-demand Pumps

New on-demand pressure pumps are well suited for use in average sized homes and irrigation systems, provided they are not required to lift water long distances from the storage tank. They can sense a pressure drop in water lines, and turn on when there is a demand for water. Some versions start slowly to meet initial demand, and accelerate to accommodate additional water requirements. On-demand pumps eliminate the need for a pressure tank. They contain their own motor control system and check valve, and are often self-priming. They often use less energy than traditional constant speed pumps, and 115–volt plug-in models are available.

Several on-demand pumps are designed specifically for RWH systems, and provide reliable overheating and dry run protection. Some are extremely quiet, and have an easy-to-use electronic control panel. Like modern automobiles, the disadvantage of these pumps is that their complex design can make them challenging for your plumber to rebuild, and often must be returned to an authorized service centre if they break down.

Small leaks (even a dripping tap) can cause on-demand pumps to cycle on and off; thus reducing their lifetime. If leaks are a possibility in your garden system it is advisable to add a pressure tank to the pump.

12 volt, solar charged on-demand pumps are available for gardeners who want to reduce energy consumption.

Tip: No pump will last forever. Install it so it can be easily removed for servicing.

Submersible Pumps

Variable speed (VSD/VFD style) submersible pumps are submerged within the storage tank rather than externally. On-demand versions exist specifically for RWH systems; they are equipped with protective electronics or float switches if the tank runs empty. Submersible pumps are more efficient and reliable than external pumps when tank elevation is substantially lower than house elevation, because pumps are designed to push, rather than to pull, water. Use of a submersible pump saves space in the home, and reduces noise levels associated with external pumps. They use less energy, and have proven to be as reliable as the deep well, multi-stage pumps that have been used for years. However, they are more expensive than other pump types, and are more difficult to remove for servicing.

4.6.4 Pump Safety Checklist

Rainwater harvesters may use this checklist of basic precautions to ensure the safety and longevity of their pump.

- ❒ An external pump must be supplied with its own dedicated electrical circuit to ensure ample and consistent power.
- ❒ An external pump must be located in a frost-free, dry, and well-ventilated location.
- ❒ Submersible pumps must be supplied with a ground fault-protected electrical circuit.
- ❒ Your pump should possess either reliable run-dry electronics (such as those found with on-demand pumps) or a safety float switch installed near the bottom of the cistern. Either device turns off the pump when the water level runs low.

Connect your pump to generator circuits to provide water during a power outage.

Safety Precaution! Before touching it, disconnect the power supply to your pump.

4.7 Purifying the Rain

As noted in Section 4.4: Cleaning the Rain, purification of rainwater before it enters the tank is highly recommended for all RWH systems to reduce organic debris buildup that can lead to discolouration, odour, and bacterial growth. Purification is especially important for Potable systems. Generally, Non-Potable RWH systems (Outdoor or Indoor Use) do not require post-storage water disinfection or sanitation when the water comes out of the tank. However, post-storage water filtration and/or disinfection is important if safety could be an issue. For example:

- if dirty water in a sun-exposed tank contains an algae bloom that could be toxic;
- if a deep layer (more than 13mm or ½ inch) of sediment at the bottom of a tank has triggered a rotting or septic smell that indicates anaerobic bacteria growth; and,
- if (in an irrigation or toilet water supply system) tank water appears cloudy and suspended particles are sufficient to clog pumps or drip water emitters.

In any of these cases, the water should be filtered and/or disinfected using the techniques described for potable water, as in the next section.

4.7.1 Rainwater Purification for Potable RWH Systems

Potable Water: Private versus Public Consumption

The Vancouver Island Health Authority (VIHA) does not set requirements for private, residential potable water systems that supply water to a single family dwelling. In such cases, the responsibility to ensure safe water quality rests with the system owner, and (to a lesser extent) with those who assist in the selection, installation, and maintenance of the system.

By contrast, any system that supplies potable water to the public, or to more than one single connection or household, is considered by VIHA to be a Water Supply System and is subject to the provisions of the Drinking Water Protection Act and Drinking Water Protection Regulation. Some residential buildings such as duplexes, secondary suites single family homes occupied by tenants or Bed & Breakfast accommodations may fall into this category.

The purpose of this *Guidebook* is to assist residents with understanding and developing RWH systems for personal, private residential use, rather than for public use. If you wish to install a RWH system for multiple dwellings, public or commercial use (i.e. workplace, store, and business), paying guests or tenants, you will bear responsibility for their health and wellbeing. This significant responsibility is not recommended for the average homeowner. Design and treatment requirements for such public systems are beyond the scope of this Guidebook. Contact VIHA, as well as highly experienced RWH practitioners, to discuss RWH systems intended to provide potable water for public consumption.

Two Stages of Potable Water Cleaning

Potable water must be purified in two stages: before it reaches the tank, and when it emerges from the tank en route to the tap.

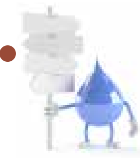
Extreme caution must be exercised when selecting the components of a Potable RWH system; roof materials and vents, debris cleaning fixtures, piping, pumps and the storage tank must not impart harmful metals or toxins into the water. NSF or CSA certification for pipes, tank interiors, pumps and related equipment is a reliable guarantee of quality and safety.

Pre-storage Purification

Purifying potable rainwater begins on the roof surface and in the gutters. As noted earlier in Section 4.4: Cleaning the Rain, three steps should be taken before water is stored in a cistern:

- The gutters must be fitted with appropriate gutter covers, and maintained to minimize water contact with fir needles, cedar fronds and other debris. This debris contains tannins that impart colour, increase acidity, and complicate disinfection;
- Debris removal devices must be installed and maintained beyond the gutter to remove all suspended particles larger than 500 microns; and,
- A First Flush Diverter (FFD) must be integrated to reject the majority of dissolved toxins and acidic, discoloured water before it enters the tank.

Post-Storage Disinfection



See Appendix 6.8: How Big is a Micron?

The second and final step in the water purification process is located after the water leaves the storage tank and pump. In most parts of Vancouver Island (provided the roof is constructed of appropriate materials and no obvious contamination sources exist such as agricultural chemicals, road dust or industrial air pollution) it is only necessary to install post-storage treatment equipment that deals with cysts, bacteria and viruses.

A post-storage potable water disinfection system includes particle filtration to at least five microns, which reduces the amount and size of suspended organic particles. It also includes at least one disinfection method or device to eliminate bacteria, viruses and Cryptosporidium and Giardia cysts associated with bird, rodent and racoon feces. The most common ways to eliminate these contaminants are described in the guidelines below. In order to effectively remove biological contaminants from their water supply, many RWH system owners apply two stages of disinfection between the cistern and the tap.

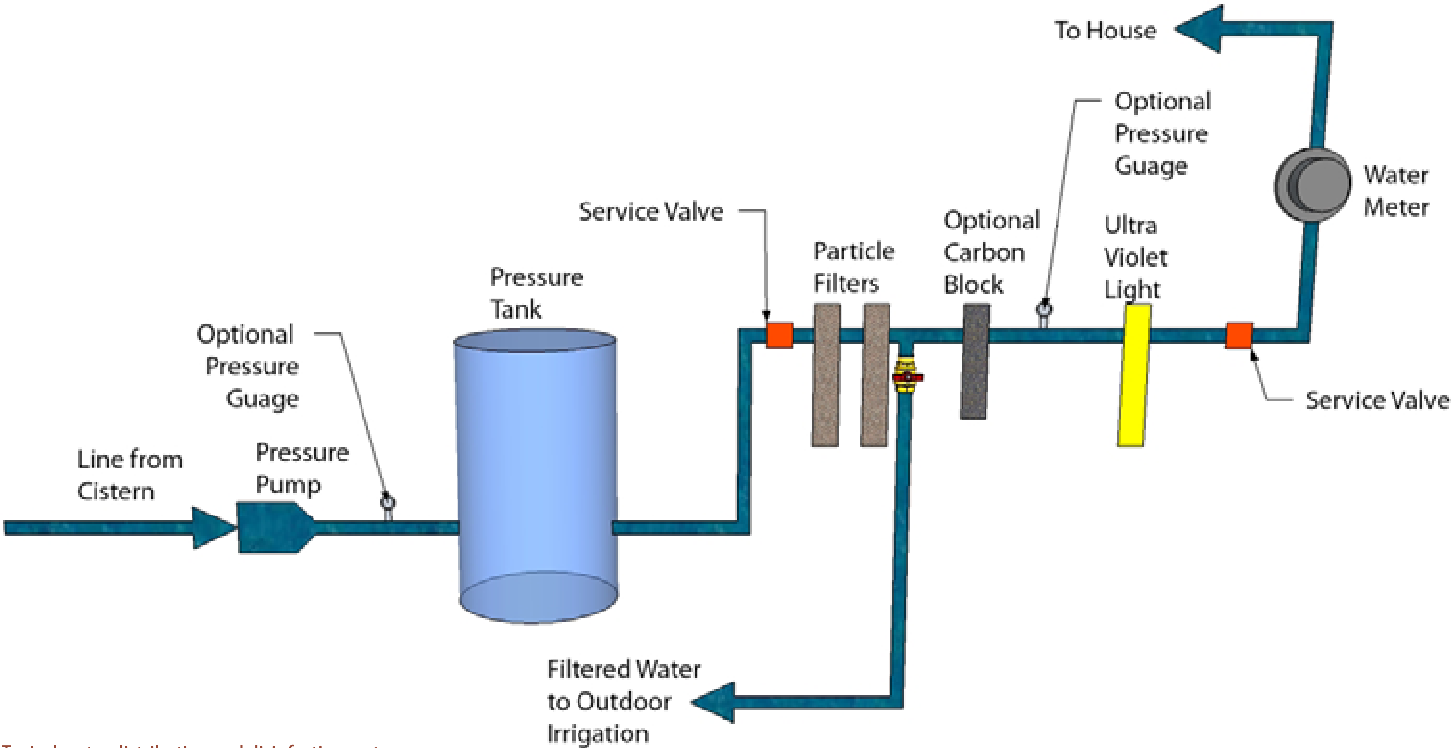
Guidelines for Selecting Post-Storage Disinfection Methods and Equipment

Consult trained professionals such as plumbers, RWH firms, or water treatment equipment suppliers to select the right disinfection method, and to ensure the equipment is properly sized and suited for your environment.

A range of methods is available to purify, freshen, and improve the taste of rainwater after it comes from the tank. The subject matter is expansive, and new information is introduced regularly. This section provides a simple overview for those considering various water purification options.

As a general guideline, post-storage disinfection equipment for private residential potable RWH systems should be:

- ❒ certified for potable water use (CSA or NSF 61 for contact equipment; NSF/ANSI 42 & 53 for filtration, and NSF/ANSI 55 for UV treatment);
- ❒ rated to process the volume of water, or the flow rate, in your RWH system (often marked in US gal per minute);
- ❒ designed for easy replacement of components (e.g. the UV light bulb or the filter cartridge);
- ❒ supplied with an easy-to-read maintenance schedule; and,
- ❒ located in close proximity to the house distribution piping system, and to the end-use taps – ideally in a utility room or easily-accessible crawl space of the home.



Typical water distribution and disinfection system.

A filter certified as one micron absolute will block particles of one micron almost 100 per cent of the time, versus a one micron nominal filter that blocks them 95 per cent of the time.

Sediment Filtration

Sediment filters are installed consecutively, usually decreasing in size, to trap and remove particles. For example, a 25 micron filter is followed by a five micron filter. This system must remove all particles larger than five microns, which could hide or shadow bacteria and cysts from the UV light. Filters from one-half to three microns effectively block bacteria, and those certified as one micron absolute or finer reliably remove cysts.

Sediment filters are disposable cartridges that slide in to permanent casings. Many types and qualities are available. Lower cost cartridges need more frequent replacement; higher priced ones include features that make them easier to service.

The pressure gauges in the above sketch can be used to determine the pressure drop as the water flows through the filters. When the filters are clean the difference in pressure should be minimal. Filters must be changed when the pressure differential has increased to 10–15psi.

Chlorination

Chlorine is the most common disinfectant because of its dependability, water solubility and availability. Another advantage of chlorine is that the system owner can easily confirm the presence of chlorine at the tap and monitor its concentration using a chlorine test kit. Chlorine is generally recognized as the most effective barrier to viruses and bacteria while UV is more effective for cysts. VIHA considers a combination of these two methods to provide the best protection from microbiological contaminants.

Avoid pool chemicals because they often contain a stabilizer that is not approved for human consumption.

Chlorine can be added manually to the water storage tank, either as bleach, as slow-release tablets of Calcium Hypochlorite, or as another form of chlorine certified for potable water use.

Concern about chlorine use leads some homeowners to select alternative equipment to sanitize their potable water. Most health authorities believe that by-products of chlorination present minimal risk compared to the consumption of inadequately disinfected water, and that harmful residuals can be controlled effectively with appropriate pre-storage water purification.

Ultraviolet (UV) Light

Ultraviolet (UV) light disinfection is a physical process that inactivates microbiological organisms when they pass in front of a high-intensity light in the disinfection chamber. The UV light should be equipped with a timer to warn when the bulb needs replacement or the bulb should be replaced annually as per manufacturer's operating instructions. Some models include a light intensity sensor that sounds an alarm or shuts down the water supply if the water does not receive adequate levels of UV radiation. This safety feature is a requirement on all NSF-validated systems accepted by VIHA for public water consumption, but is not a requirement for a single family house.

When selecting a UV light, check that:

- ❒ it is large enough to operate at peak performance during peak water flow rates in your house.
- ❒ the bulb can be removed easily for cleaning or replacement.
- ❒ adjacent downstream piping will not be compromised by concentrated UV light at the exit.
- ❒ There is no piping to bypass the UV light, which would allow the water to pass by the UV system untreated.

Biosand jet pump pressure tank and particle filters.

Smaller capacity sediment filers and UV light.

Dual-particle filters and U.V. light with water metre.

Activated Carbon Filters

Disposable carbon filter cartridges are made from a range of carbon-based materials from coal to coconut husks, and are manufactured to create surfaces full of microscopic holes that trap larger particles. Smaller organic particles are absorbed by the activated surface. Carbon filters are used in water purification systems to address aesthetic issues like taste and odour; they effectively remove the smell and taste of residual chlorine in water. Common jug-sized tap water filters consist of carbon. Some finer carbon filters (0.5 micron) are CSA approved to remove bacteria and cysts; these models typically contain silver to slow bacteria growth. Most carbon filters provide an ideal environment for the growth of bacteria and therefore should only be used when the water is disinfected, or after chlorination to remove the chlorine.

Ozone

Ozone can be an effective disinfection method, but should be used only with an approved delivery system that ensures sufficient contact time with the water, and provides for off-gassing to a safe environment. Ozone concentration cannot be easily verified at the tap.

Micro Filtration

Micro-filtration includes particle filters that are one micron or less. A one micron absolute filter will remove many bacteria and virtually all cysts, and therefore can be used as an alternative to UV irradiation when combined with chlorination or other method of disinfection.

Reverse Osmosis

Reverse osmosis, or nanofiltration, provides for very fine filtration by forcing water though a membrane at extremely high pressure. This process removes dissolved metals, salts, and cysts. A proportion of the water is lost in this process, which can be a disadvantage for scarcely supplied RWH systems. A reverse osmosis disinfection unit for an entire house would be relatively expensive, but affordable versions that fit under a kitchen sink counter are available for small quantities of drinking water, where the quantity of rejected water would be minimized. Effluent produced by the reverse osmosis process may impact septic systems.

Other Water Purification Methods

Many other water disinfection and taste-enhancing alternatives exist, including bubbling oxygen through storage tanks, slow sand filters large enough to service a whole house, distillation machines, and numerous jug-sized filters. Some of these methods can also enhance taste. Check carefully to ensure they are certified for the water protection you require.

Maintenance of the Water Purification Components

Careful operation and maintenance of your water purification system is critical. Three things are required:

1. The Owner's Instruction Manual

The Owner's Instruction Manual for each water disinfection device will contain important safety warnings and information on water quality, recommended maintenance, and parts replacement. System operators should read all supplied manuals before operating the equipment. For example, particle filters generally need replacement every six to 12 months (carbon filters more often), and UV bulbs must be replaced annually or after 10,000 hrs of operation.

2. Water Testing

Water testing is an important part of taking responsibility for the safety of your Potable RWH system. An initial test should be undertaken when the RWH system is first installed, and again before the water is used. In some cases, your building inspector will require this test before issuing final approval.

Water tests must be conducted by a government-approved lab, and must reflect the requirements of the B.C. Drinking Water Protection Act and Health Canada's Guidelines for Canadian Drinking Water Quality The lab will advise from where the water sample should be drawn and how much is required. The water testing lab, or a water purification, disinfection or RWH specialist, can also recommend test parameters for your home and location.

Minimal test parameters for a single family home include E. coli, Total Coliform Bacteria, Total Plate Count (TPC), pH (recommended 6.5 to 8.5 to reduce scaling/corrosion issues), and a limited metal scan (usually for lead and zinc). It is important to undertake a full metal scan for chemicals and other parameters in the initial water test, which will indicate unknown air-borne pollutants in your area, or pollution sources in your collection and storage system. Keep the results of this initial test as a baseline for future test results and all subsequent results to track changes over time. During the first year of operation, quarterly follow-up tests should be undertaken for E. coli and Total Coliform Bacteria. Thereafter, annual tests for these bacteria normally suffice. Repeat the initial full test for chemicals and other parameters every three to five years.

3. Periodic System Disinfection

Your water disinfection specialist or local Environmental Health Officer can provide advice for your particular situation.

System disinfection refers to the disinfection of all the components of the entire RWH system, from roof to tap. Disinfection should be performed when the system is first launched (approximately one week before the initial water test), and annually thereafter or anytime contamination is detected at the most remote test location, which is normally at the tap. Disinfection is also required if the raw tank water becomes contaminated by a failure in upstream rainwater collection components, and becomes too cloudy for the water disinfection devices to function properly.

To disinfect your system, first conduct a manual cleaning of the gutters, all pre-tank debris removal devices, and the catchment or transport piping. Then, flush each of these pre-tank cleaning components with chlorine, hydrogen peroxide, or another disinfectant that is certified for potable water. Allow sufficient contact time for the solutions to work. Chlorine is often recommended because of its effectiveness, and because its concentration can be measured easily.

Post-storage disinfection filters and equipment should be cleaned in accordance with their manuals. Finally, water delivery pipes should be filled with chlorinated water and left for at least one hour to destroy any accumulated pathogens.

4.8 Supplementing the Rain

There are three reasons that many rainwater harvesters choose to add water from an on-site well or other water utility to a RWH storage tank:

1. **To augment the capacity of a seasonal, Non-Potable (Outdoor Use) RWH system**
   By adding water from another source to the storage tank of an irrigation system, you may be able to use your RWH system throughout dry summer months, even when the tank is not being replenished with rainwater. If the alternate water supply for the RWH system is a public utility, adding water slowly at night can reduce peak demand, which can reduce or defer the need for infrastructure upgrades. If the alternate source is a private well, night time filling reduces stress on the well by taking water when other groundwater demands are minimal. Plants also benefit from being watered with stored water, as water warms in the tank and chlorine has time to evaporate.

2. **To reduce storage requirements of Non-Potable Indoor Use (toilet flushing), or Potable RWH systems.**
   Seasonal rainfall patterns in the RDN create the need for substantial water storage to last through the dry spring and summer periods. Adding water during the spring and early summer (from a public, piped water supply, or from a private well), can reduce storage requirements by as much as 60 per cent; which, in turn, reduces the cost of the system significantly.

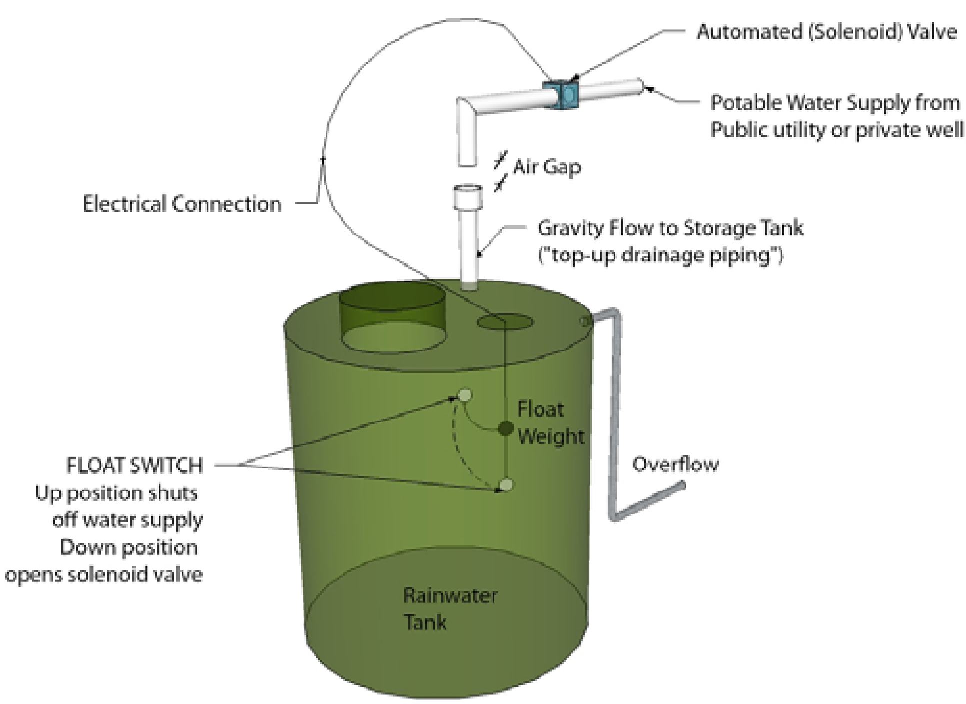
3. **To allow homes with smaller roof areas to use rainwater for most domestic uses.**
   Smaller homes often do not have sufficiently large roof catchment areas to fill a tank that is large enough to last through dry summers. Adding water in the spring and summer replenishes the tank to meet summer demand.

4.8.1 Backflow Prevention

Whenever your RWH system is connected to a potable water source, backflow prevention is required. A backflow prevention device eliminates the possibility of rainwater flowing back into the pressurized water line of a public utility, or returning to a private well. Backflow can occur if the utility line loses pressure and draws potentially contaminated rainwater into the public system. Regulations apply in all jurisdictions to prevent this cross-connection; your building inspector will require one or more backflow prevention devices wherever a cross-connection could occur.

Air Gap Backflow Prevention Devices

Air gap backflow prevention devices are simple and require little maintenance. As shown in the illustration below, the air gap method provides physical separation between the two water sources. The water entry can be controlled manually with a simple timer, or controlled automatically with a float switch and an electronic solenoid valve.



Automated tank top-up system with air gap.

Consult your building inspector for the requirements in your area, and for your situation. For example, if a separate Non-Potable, Indoor Use rainwater line were installed for toilet flushing, the rainwater pipes would have to be coloured or clearly labelled to prevent possible cross-connection between these pipes and publicly-supplied potable water. It may also be necessary for an approved, cross-connection control valve to be installed, inspected independently and serviced annually. A similar mechanism or approved air gap device may be required when publicly-supplied water supplements a storage tank.

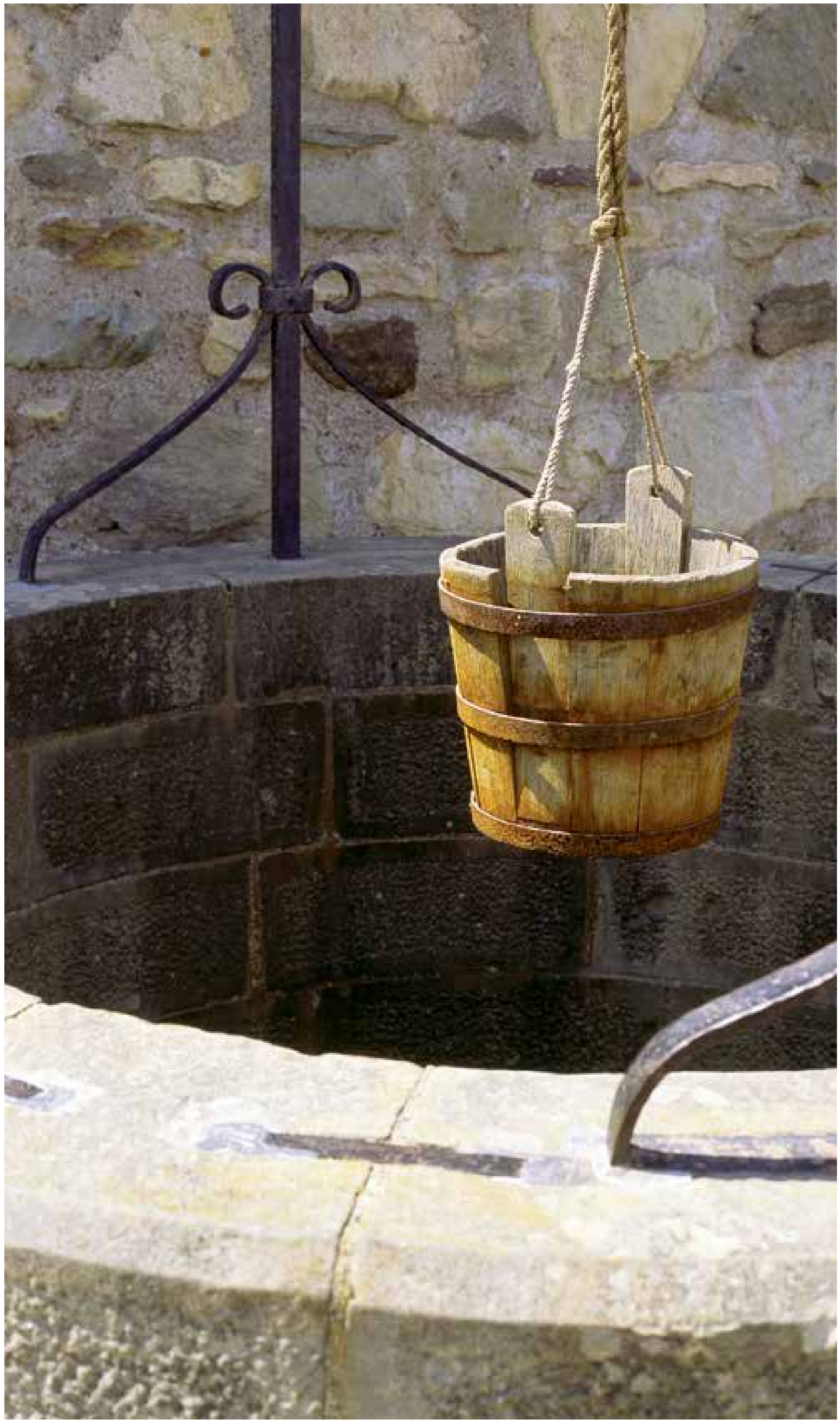
"When the well is dry,

we learn the

worth of water."

...

Benjamin Franklin



5. OPERATION AND MAINTENANCE OF A RWH SYSTEM

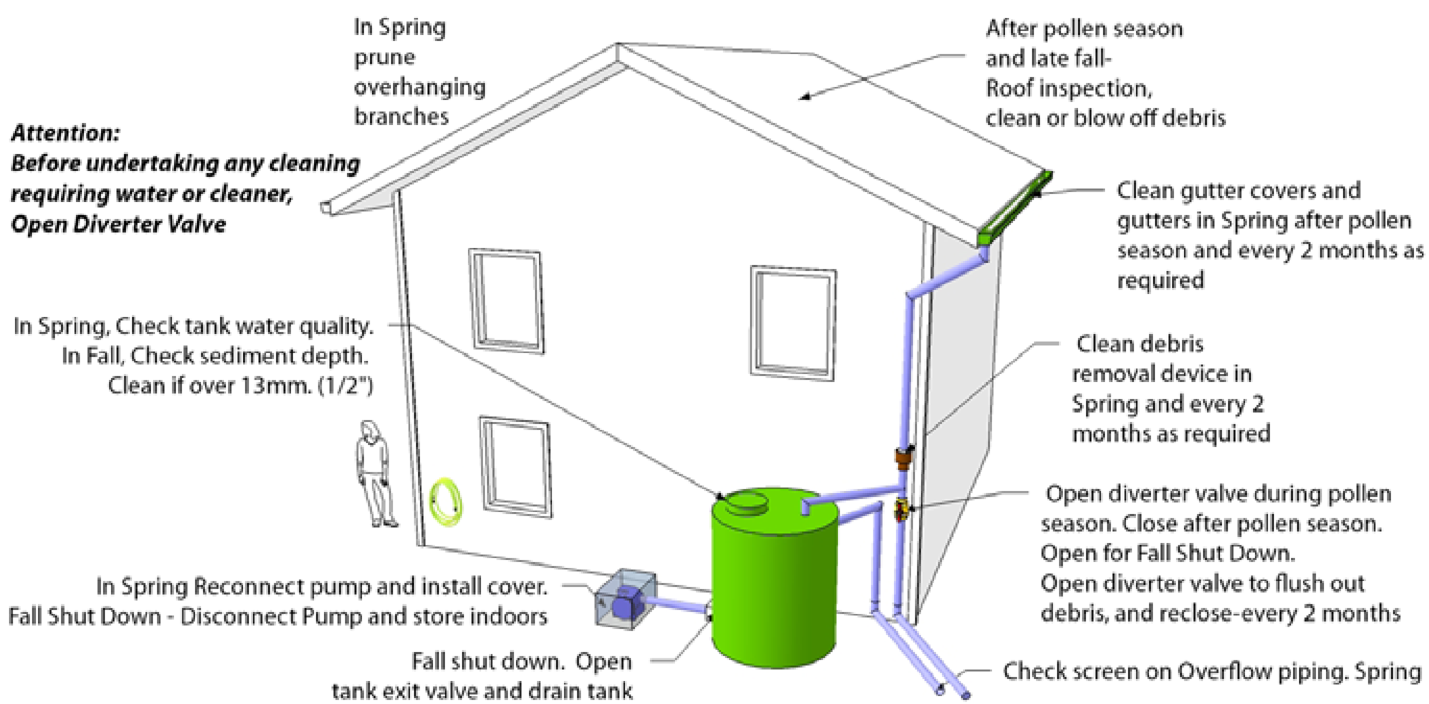
Rainwater harvesting systems are generally LOW maintenance, but not NO maintenance. A few simple steps regularly taken will protect your investment and ensure that your system will provide years of trouble-free service, providing the quality of water suitable for its intended purpose. The following section summarizes key maintenance tasks for Non-Potable and Potable RWH systems.

Safety First! If you plan to maintain your own system, take all necessary safety precautions.

Be prepared to take responsibility for all steps outlined in this chapter, or hire a professional contractor who is qualified for the work.

5.1 Maintenance Tasks for a Non-Potable (Outdoor Use) RWH system

Non-Potable Outdoor Use RWH systems have fewer components and require less maintenance than Potable (Indoor Use) systems. They do not, for example, include water purification equipment to ensure the water is safe for drinking. However, even the simplest Non-Potable Outdoor Use RWH systems require attention. Even if the water is used outdoors, it still comes into human contact with tasks like washing the dog or hand-watering the garden. Therefore, this water should be relatively odour-free and should not contain harmful organisms such as those produced by an algae bloom in the storage tank.



Basic maintenance tasks for a Non-Potable (Outdoor Use) RWH system.

5.2 Maintenance Tasks for a Non-Potable (Indoor Use) RWH system

For Non-Potable (Indoor Use) RWH systems, include all tasks in the Non-Potable (Outdoor Use) system maintenance regime. In addition, gutters should be cleaned more often to prevent debris buildup that could discolour the water. Winterizing tasks will be more important, as these systems typically run year-round. If a filter is installed after the pump, service it according to the maintenance steps for filters in a Potable RWH system.

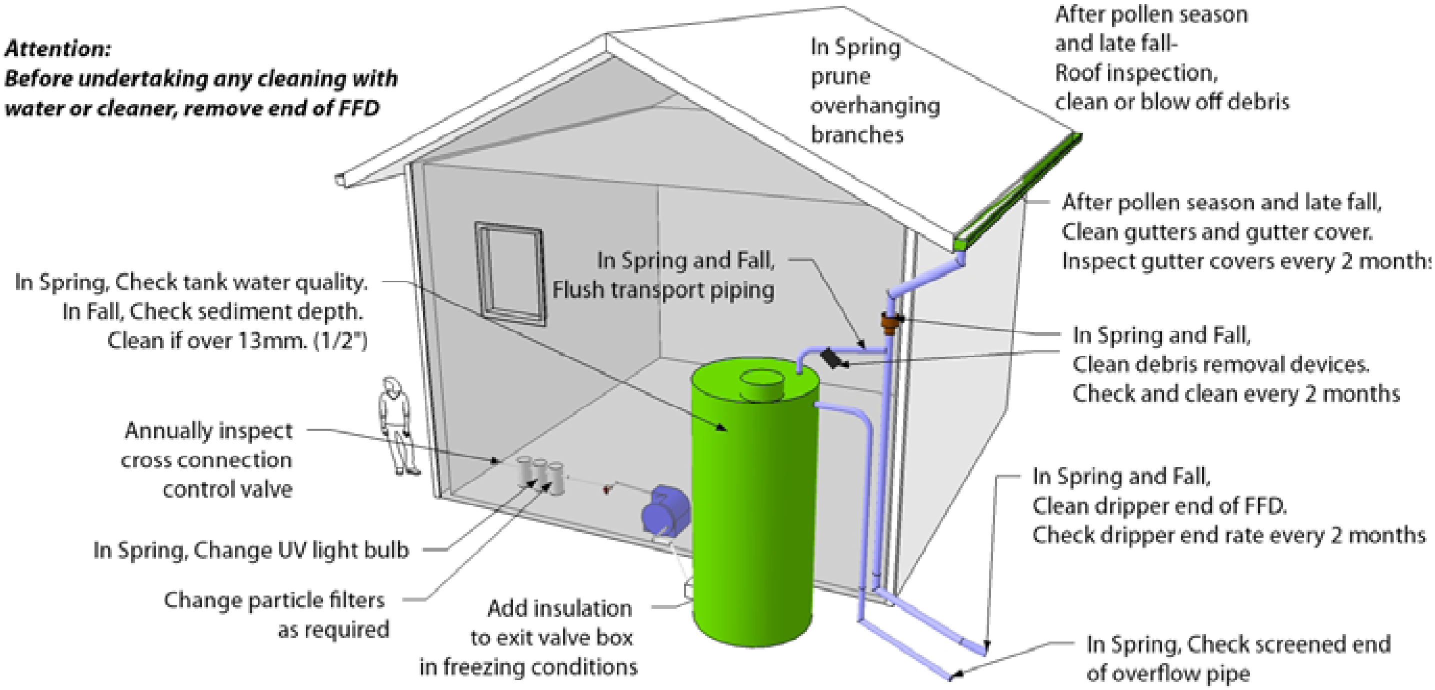
5.3 Maintenance Tasks for Potable RWH systems

Potable RWH systems have more components and require more maintenance than Non-Potable RWH systems. For example, gutter cleaning is critical to prevent your water from absorbing coloured and acidic tannins from contact with gutter debris. Potable RWH systems also have water purification equipment that requires regular maintenance to ensure safe drinking water.

Proper upkeep and routine maintenance are directly related to water quality and safety for Potable RWH systems. Each system is unique; the system operator must become very familiar with all maintenance procedures, and must understand the manuals for each device in the system. The water itself must be tested periodically for bacteria and other pathogens.

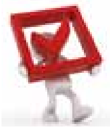
A well-designed RWH system requires about one hour per month of routine maintenance, plus time for regular gutter, roof and seasonal pipe cleaning. Before deciding to build a Potable RWH system, consider whether you can, and wish to, undertake the required maintenance. Ask yourself:

- ❐ Am I physically capable and interested in cleaning and maintaining my RWH system?
- ❐ If not, what would be the cost to hire a professional to conduct regular and seasonal maintenance?
- ❐ Am I at home often enough, particularly during the winter, to protect my system from freezing?



Maintenance tasks for a Potable RWH System.

5.4 Creating Your Maintenance Schedule & Checklist



Establishing your Maintenance Schedule & Checklist is the best guarantee of a properly-functioning RWH system. It should be prepared while you are designing and installing your system. Mark all key events on your household calendar, and store the details safely with your system's manuals and warranties.

For best results:

- ✓ start immediately, and if a contractor has installed the system, insist on a start-up demonstration and tour;
- ✓ as a practice run, clean the whole system and check all components before the water is used;
- ✓ designate one person to take overall responsibility for all maintenance; and,
- ✓ use a calendar and mark dates for major events including the start of pollen season, and for monitoring, maintenance, water testing and the replacement of parts such as particle filters and UV bulbs.

The checklist will include regular maintenance requirements that should be addressed each month or two. It should also address maintenance tasks that are related to the seasons: pollen season in the spring; leaf and needle shedding in the fall; and, freezing weather during the winter.

Most people who collect rainwater in southern British Columbia stop collecting and divert rainwater during the pollen season. When pollen has stopped falling, they undertake their annual spring cleaning of roofs, gutters and the catchment system. This strategy is particularly important in heavily forested rural areas.

5.4.1 Pollen Season in Southern British Columbia

Each spring as the trees bud, they release pollen — a fine particulate that is carried on the wind for considerable distances. Each species of tree has unique characteristics for its pollen, flowers, seeds, berries, and release times. In southern British Columbia, alder and maple pollen typically arrive first (from mid to late March). The fir pollen that follows at the end of March and early April is more dense and sticky.

The amount of pollen varies each year, and the volume that lands on a particular roof depends on proximity of trees, prevailing winds and amount of rain. The amount of pollen in the air can be determined by laying a flat, shiny surface (such as piece of glass) horizontally on a table, and by observing the residue that collects. This simple test also helps to determine the stickiness of pollen in your area.

Extremely fine pollen particles coat the roof and catchment pipe interiors, and can clog gravity filters. In most systems, some pollen can find its way through the catchment system and into the cistern; therefore, rigorous prevention is preferred.

5.4.2 Fall Cleaning

Most trees in coastal British Columbia shed needles or leaves in September and October. A dry summer can trigger increased shedding of fir needles and dry cedar fronds. Maple, alder and Garry Oak leaves fall in October and early November. It is important to clean roofs and gutters more frequently between September and November, when the rainy season begins. For year-round RWH systems, this schedule also prepares catchment surfaces for the winter rainwater collection season, when ongoing maintenance is more difficult.

Spring pollen and debris in open gutter.

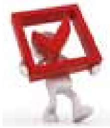
5.4.3 Maintenance Checklist for a Seasonal Non-Potable (Outdoor Use) RWH System

This checklist relates to a seasonal, Non-Potable (Outdoor Use) system that does not collect water during the winter. A seasonal system is cheaper to build and requires less maintenance. Many systems can start collecting rainwater in February or March and fill the tank prior to summer.

This checklist is intended to guide in the development of your own maintenance checklist that meets your particular needs. Use a new checklist each year as a way to document the present condition of each component of the system, anything unusual that you have observed, parts you have replaced, and all maintenance and repairs you have completed. Include a column to record the date of each action taken.

Some maintenance procedures can be a safety hazard. See the list of safety warnings in Section 5.5: Safety Warnings for Operation and Maintenance.

Maintenance Checklist for a Seasonal Non-Potable (Outdoor Use) RWH System



DATE OR SEASON	ACTION REQUIRED	DONE ☑	NOTES	DATE COMPLETED
Spring start-up	Inspect roof			
Spring start-up	Prune overhanging branches			
Spring start-up	 ATTENTION: Open diverter valve before doing any cleaning with water or a cleansing agent			
Spring start-up	Clean gutter covers and/or gutters			
Spring start-up	Clean debris removal device(s)			
Spring start-up	Close diverter valve			
Spring start-up	Check screen end on tank overflow pipe			
Spring start-up	Reconnect pump, and install cover			
Spring start-up	Replace any post-pump filters			
During pollen season (late March/early April)	 ATTENTION: Open the diverter valve to shut down the catchment system			
After pollen season	Clean roof			
After pollen season	Clean gutter covers			

Checklist continued on page 78.

Checklist continued from page 77.

Maintenance Checklist for a Seasonal Non-Potable (Outdoor Use) RWH System (cont.)

DATE OR SEASON	ACTION REQUIRED	DONE ☑	NOTES	DATE COMPLETED
After pollen season	Clean debris removal device(s)			
After pollen season	Flush piping if pollen has accumulated in horizontal sections			
After pollen season	Inspect warning labels on tank and the security of the locking system			
After pollen season	Check tank water quality. Add bleach if necessary			
After pollen season	Close diverter valve to start collecting water			
Annually	If a cross-connection control valve is installed, have it inspected			
Every two months	Check and clean gutters			
Every two months	Check and clean debris removal device(s)			
Every two months	Open diverter valve to flush out debris, then re-close diverter valve			
Fall shutdown	Clean gutters for winter			
Fall shutdown	Open diverter valve			
Fall shutdown	Open tank exit valve and drain tank			
Fall shutdown	Check sediment depth in tank.			
Fall shutdown	Clean tank if sediment is more than 13mm (½ inch) deep			
Fall shutdown	Disconnect pump and store indoors			

5.4.4 Maintenance Checklist for a Year-Round Potable RWH System

This checklist relates to a year-round Potable RWH system. It is intended to guide in the development of your own maintenance checklist that meets your particular needs. Use a new checklist each year as a way to document the present condition of each component of the system, anything unusual that you have observed, parts you have replaced, and all maintenance and repairs you have completed. Include a column to record the date of each action taken.

Some maintenance procedures can be a safety hazard. See the list of safety warnings in Section 5.5: Safety Warnings for Operation and Maintenance.

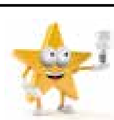
Maintenance Checklist for a Year-Round Potable RWH System

DATE OR SEASON	ACTION REQUIRED	DONE ☑	NOTES	DATE COMPLETED
During pollen season (late March/early April)	Open diverter valve or remove dripper end of First Flush Diverter (FFD) to shut down catchment system and divert water			
After pollen season/ spring cleaning	Inspect roof			
After pollen season spring cleaning	Prune any overhanging branches			
After pollen season spring cleaning	 ATTENTION! Ensure the FFD end is still open to divert water, then clean roof			
After pollen season spring cleaning	Clean gutter covers			
After pollen season spring cleaning	Inspect gutters, then clean or flush pollen from gutters if required			
After pollen season spring cleaning	Clean debris removal device(s) or gravity filters			
After pollen season spring cleaning	Add disinfectant and flush transport piping if pollen has accumulated in horizontal sections			
After pollen season spring cleaning	Inspect warning labels on tank and the security of the locking system			

Checklist continued on page 80.

Checklist continued from page 79.

Maintenance Checklist for a Year-Round Potable RWH System (cont.)

DATE OR SEASON	ACTION REQUIRED	DONE ☑	NOTES	DATE COMPLETED
After pollen season spring cleaning	Check tank water quality and add bleach if necessary			
After pollen season spring cleaning	Thoroughly clean dripper end assembly on FFD			
After pollen season spring cleaning	Re-install FFD dripper end			
After pollen season spring cleaning	Check screen end on tank overflow pipe			
As required by the service manual	Change particle filters in the water disinfection system			
Annually	If a cross-connection control valve is in your system, have it inspected			
Annually	Change UV bulb			
Annually	Conduct water test			
Every two months	Clean gutter covers and/or gutters (more frequently in fall)			
Every two months	Clean debris removal device(s) or gravity filters if required in service manual			
Every two months, or after a major rain event	Check debris removal devices			
Every two months, or after a major rain event	Check drip rate of FFD dripper end and clean if required			
Fall cleaning	 Clean gutter covers and gutters if required. ATTENTION: Open diverter valve before doing any cleaning with water or a cleansing agent			
Fall cleaning	Check transport piping and flush if required			

Checklist continued on page 81.

Checklist continued from page 80.

Maintenance Checklist for a Year-Round Potable RWH System (cont.)

DATE OR SEASON	ACTION REQUIRED	DONE ☑	NOTES	DATE COMPLETED
Fall cleaning	Clean debris removal device (s), or gravity filters if required in service manual			
Fall cleaning	Check sediment depth in tank and clean tank if sediment is more than 13mm (½ inch) deep			
Fall cleaning	Check drip rate of FFD dripper end and clean if required			
Fall cleaning	Install frost protection on FFD if required			
Extreme winter conditions	Add insulation bags in tank exit valve boxes			
Extreme winter conditions	Check for freezing in the transfer tank (if one is used) and remove the pump if the water is freezing			
Extreme winter conditions	Drain any trapped water out of the FFD dripper end assembly			
Extreme winter conditions	Loosen plugs on any filters to drain the casing			

5.4.5 Maintenance when the System is Not in Use

If your house remains vacant and the RWH system is not being used for more than two or three days, it is recommended that the pump be turned off and the tank exit valve be closed. If the house remains vacant for more than two months, or for extended periods during the winter, it is recommended that someone be assigned to undertake the maintenance tasks described above.

If you are away from your home for short or extended periods of time, be sure to take the necessary precautions.

See Section 4.5.7: Tank Safety Checklist for other important precautions related to your storage tank.

5.5 Safety Warnings for Operation and Maintenance

When planning for any type of maintenance task, consider all safety issues to protect those who are doing the work.

5.5.1 Roof and Gutter Cleaning

Falling from the roof is always a danger. When cleaning the roof and gutters, wear proper footwear, stay well away from skylights, and use caution when working near the edges. Always be harnessed and secured by a rope, and ensure someone is nearby to spot you.

5.5.2 Storage Tanks

Never enter a tank to clean it, or for any other purpose. Water tanks are designated as a confined space, and only those with specific qualifications, training, and equipment should enter them.

5.5.3 Cleaning Agents

- Use either a heavy duty cleaning solution of hydrogen peroxide (according to the manufacturer's instructions) OR a solution of 10 to 20 per cent household bleach diluted in water.
- Use extreme caution when using either hydrogen peroxide or chlorine. Read and follow the manufacturer's instructions on the container. Harmful if swallowed.
- Never mix bleach and hydrogen peroxide together because they can react to form a noxious gas.
- With either cleaner avoid contact with eyes or skin. In case of contact, flush promptly with abundant water.
- Either solution can discolour clothing.
- DO NOT use any other type of household cleaner that may contain soap or other chemicals, and could therefore affect the quality of the water or react with chlorine.
- DO NOT use any cleaner containing ammonia, or any household bleaches that contain whitening or scented additives.

DO NOT attempt to service the float switches; call your maintenance professional instead.

5.5.4 Electrical Components and Float Switches

Unplug any pump or other system component before touching or servicing it.

“To understand water
is to understand the cosmos,
the marvels of nature,
and life itself.”

...

Dr. Masaru Emoto

6. APPENDICES

APPENDIX 6.1: Measurements and Conversions

The following conversions list measurement units and formulas commonly used in designing a RWH system, including a table to help you convert imperial units to metric and US gallons to imperial Gallons.

Imperial to Metric Conversion

- One imperial Gallon = 4.546 litres
- One litre = 0.22 imperial Gallons
- One foot = 0.305 metres
- One square foot = 0.093 sq. metres
- One cubic metre = 220 Imperial Gallons

Area to Volume Measurements

- One cubic foot = 6.23 imperial Gallons
- One inch of water over one square foot = 0.52 imperial Gallons
- One cubic metre = 1,000 litres
- One millimeter of water over one square meter = One litre

Volume to Weight

- One imperial gallon of water weighs 10 pounds
- One litre of water weighs one kilogram

Water Pressure Created by Gravity

- One pound per square inch (psi) created for every 2.31 vertical feet of drop
- One foot of vertical drop produces 0.435 psi

Flow Rate

- ½-inch of rain in one hour on 1,000 square feet = 4.3 gpm (gallons per minute)

Area of a Circle

- Measure the diameter and divide by 2 to find the radius, then apply the formula:
  Area = R2 x pi (3.14159)

Circumference of a Circle

- Pi (3.14159) x Diameter

US Gallons to Imperial Gallons

US gallons are referenced in many rainwater manuals; most tanks and pumps manufactured in the United States refer only to US gallons.

- One US gallon is 4/5ths (0.83) of an Imperial gallon. One imperial gallon is 1.2 US gal.
  For example, a 1,000–US gal tank contains only 830 imp gallons.
- A U.S. pump with a pumping rate of 20gal/min. provides a pump rate of only 16 imp gal per minute.

Conversion Calculation Guide

IF YOU KNOW:	MULTIPLY BY:	TO FIND:
inches	25.4	millimetres
inches	2.54	centimetres
feet	0.3048	metres
yards	0.9144	metres
fluid ounces	28.4	millilitres
imperial gallons	4.546	litres
centimetres	0.39	inches
metres	3.281	feet
metres	0.836	yards
millilitres	0.039	inches
litres	.22	imperial gallons
imperial gallons	0.16054	cubic feet
cubic feet	6.23	imperial gallons
imperial gallons	.004546	cubic metres
cubic metres	220	imperial gallons

Some useful conversions between metric and imperial

- 1 metre (1,000mm) equals 3.28 ft. or 39.4 inches
- 1m^2 (sq. metre) of roof catchment area equals 10.76 sq. ft.
- 10mm (or 1 cm) of rain equals 0.39 inches, or
- 1 inch of rain equals 25.4mm
- 1 litre (1,000ml) of water equals 0.22 imp gal
- 1 imp gal of water equals 4.546 litres so
- 1,000 imp gal of water equals 4,546 litres or 4.5m^3 (cubic metres)

APPENDIX 6.2: Information Sources for Rainwater Harvesting

The following sources listed below include interesting articles, guidance when planning a rainwater harvesting system, standards to follow, and FAQ's about harvesting the rain. This list is for information only and is not intended as an endorsement or approval of any products or services by the RDN.

Publications

Rainwater 2009 Consumer Guide & 2008 Consumer Guide
Australia Rainwater Industry Development Group (ARID)
www.arid.asn.au

Thinking Beyond Pipes and Pumps:
Top Ten Ways Communities Can Save Water and Money
The Polis Project
www.polisproject.org

Rainwater Harvesting on the Gulf Islands — Frequently Asked Questions
Dick Stubbs, Islands Trust Fund
www.islandstrustfund.bc.ca/projects/pdf/itfrainwaterfaq.pdf

Rainwater Harvesting on the Gulf Islands — Guide for Regulating the Installation of Rainwater Harvesting Systems – Potable and Non-Potable Use
Dick Stubbs, Islands Trust Fund
www.islandstrustfund.bc.ca/projects/pdf/itfrainwaterinstallationregulatingguide.pdf

Books

Design for Water
Heather Kinkade-Levario (2007)
New Society Publishers
www.newsociety.com

Rainwater Collection for the Mechanically Challenged
Suzy Banks with Richard Heinichen (2004)
www.rainwatercollection.com

Rainwater Harvesting Manuals

The Texas Manual on Rainwater Harvesting
Texas Water Development Board (2005)
http://www.twdb.state.tx.us/home/404.asp

Virginia Rainwater Harvesting Manual
Compiled by The Cabell Brand Centre (August 2007)
www.cabellbrandcentre.org

***Residential Rainwater Harvesting Design and Installation Best Practices Manual* (Version 2.0)**
City of Guelph (July 2011)
www.guelph.ca/rainwater

Rainwater Catchment Design and Installation Standards
American Rainwater Collection Systems Association (ARCSA), 2009 (Revised Dec. 15, 2010)
www.arcsa-usa.org

Rainwater Harvesting System Planning
Texas AgriLife Extension Service, 2010
(used in the current ARCSA Level 200 Accredited Professional Training Course)

***Health Effects from Rainwater Catchment System Components* (Listings)**
http://www.nsf.org/Certified/Protocols/Listings.asp?TradeName=&Standard=P151

Alberta Guidelines for Residential Rainwater Harvesting Systems
http://www.municipalaffairs.alberta.ca/documents/ss/STANDATA/plumbing/AlbertaHandbook2010.pdf

Websites

Regional District of Nanaimo
www.rdn.bc.ca
An excellent resource for rainwater harvesting, water conservation, Team WaterSmart, Outdoor and Indoor Water Use, Incentives, FAQ's and Upcoming Workshops and Events. Use the site's search engine to conduct your keyword search.

Environment Canada
http://climate.weatheroffice.gc.ca/climateData/canada_e.html
National Climate Data and Information Archive (weather and precipitation data).

Vancouver Island Health Authority
www.viha.ca
Provider of Vancouver Island's health care network of hospitals, clinics, centres, health units, and residential facilities.

One Minute Water Calculator
http://goblue.zerofootprint.net
Calculate how much water you use per year.

Ruby Alton Nature Reserve
www.islandstrustfund.bc.ca/projects/rainwaterphotos.cfm
Photos and installation of a rainwater harvesting system

IDUS Controls
www.iduscontrols.com
Water re-use technology.

Oasis Design
www.oasisdesign.net
Sustainable living systems.

APPENDIX 6.3: Information Sources for Water Conservation

A Simple Way to Calculate Summer Irrigation Water Demand

The following extract from the *Mayne Island Rainwater Feasibility Study*, commissioned by the Islands Trust in 2006 (Madrone Environmental Services and The Rainwater Connection), provides a simple mathematical formula to estimate garden water demand based on 1-inch of rain per week during peak summer demand and average soils.

NOTE: The calculations utilize a nursery standard, assuming that during peak dry summer months a flower or vegetable garden or orchard requires 1-inch of water per week to size fruit and maximize blooming. The shoulder months (May, June and Sept) require one half of this amount. Required water volumes are calculated by measuring the size of garden/ orchard in sq. ft. dividing by 12 to change this into cubic feet, and multiplying the number of cu feet by 6.23 (the number of gallons in a cu. ft.).

Summer Irrigation Water Use Scenarios

Scenario A

30 deck pots hand- or drip-watered 180 gal/month (820 L)

Assumes 1.5 gallon per week: (glazed pot) X 30 = 45 imp gal X 4 weeks

Scenario B

Flower planting bed around patio or front entry 310 gal/month (1,410 L)

Assumes 50 linear feet X 3 feet average width = 150 sq ft.

At 1-inch of water per week: 150 divided by 12 = 12.5 cu ft X 6.23 = 78gal X 4

Scenario C

Small Vegetable Garden with four raised beds 200 gal/month (910 L)

Assumes 4 beds each measuring 3ft X 8 ft = 24sq.ft. X 4 = 96 sq.ft.

At 1-inch of water per week: 96 divided by 12 = 8 cu ft X 6.23 = 50 gal X 4

Scenario D

Small Orchard 1,860 gal/month (8,450 L)

Assumes 4 semi-mature trees spaced 15 feet apart

Watering area 30X30 = 900 sq.ft.

At 1-inch of water per week: 900 divided by 12 = 75 ft3 X 6.23 = 465 gal X 4

Monthly Irrigation Water Use for Typical Small Gardens

Scenario	May	June	July	Aug	Sept	TOTAL Summer
A + C Deck Pots & Vegetable Garden	190	190	380	380	190	1,330 (6,050 L)
A + B Deck Pots and Flower Beds	245	245	490	490	245	1,715 (7,800 L)
A + B + C Flowers and Vegetable Garden	345	345	690	690	345	2,415 (11,000 L)
A + B + C + D Flowers, Vegetables and Orchard	1,2751	1,275	2,550	2,550	1,275	8,925 (40,500 L)

Useful Websites

Regional District of Nanaimo
www.rdn.bc.ca
The Regional District of Nanaimo has produced the *Landscape Guide to Water Efficiency* with useful tips on water conservation inside the house and outdoors. This document is available for download online at http://goo.gl/0QqMH

www.rdnrebates.ca
This site also contains information on the Region's Toilet Rebate Program and RWH Incentive Program:

- 2012 Toilet Replacement Rebate Program
- 2012 Rainwater Harvesting Incentive Program

Team Water Smart
www.teamwatersmart.ca
Team WaterSmart is the website for water conservation tips, resources, and workshops.

The Islands Trust
www.islandstrust.bc.ca
The Islands Trust Fund has posted links to a useful publications and websites on its rainwater harvesting links page.

CMHC
www.cmhc-schl.gc.ca
CMHC has produced a *Household Guide to Water Efficiency*. This guide for residential consumers covers information on water efficient fixtures and appliances, shows how to test for and repair leaks, makes the most efficient use of water when doing daily chores, and helps to plan residential landscapes with water efficiency in mind. Search for *Household Guide to Water Efficiency*, also published in paper at a cost of $7.95.

The Partnership for Water Sustainability in British Columbia
www.waterbucket.ca
Good information on storm water management, rain gardens, courses and workshops.

Irrigation Industry Association of British Columbia (IIABC)
www.irrigationbc.com
Courses available throughout British Columbia.

Every Little Drop
www.everylittledrop.com
The Steps to Saving Water section provides useful information on plant types and soil types to reduce water demand.

APPENDIX 6.4: Indoor and Outdoor Water Use Information

The following data presents some examples of water use and the experience of households relying entirely on rooftop-collected rainwater.

Information from the Regional District of Nanaimo (RDN) Water Services

The following information highlights indoor and outdoor water use figures for seven of the eight water systems operated by the RDN. These households typically do not use rainwater to supplement their piped water supply.

- A 28% decline in average annual consumption (per connection or household) from 2001 to 2011.
- Year-round average household use of 735 L (162 gal) per day (based on five-year average annual consumption for indoor and outdoor water combined).
- 306 litres (67gal) per person per day (based on the above number and assuming 2.4 people per household). This rate compares favourably to the provincial average of 440L/person/day, or the national average of 326.
- Summer combined indoor/outdoor water consumption is almost 2.5 times higher than winter use (504L (111gal)/person/day in summer compared to 204L (45 gal)/person/day during the winter). Based on average figures over the past five years.

Preliminary information from the Englishman River Water Services (Parksville) suggests a similar summer demand increase. Summer Peak day consumption is reported as about 2.5 times the annual average day demand. Average per capita use is similar to the RDN at approx. 300L (66 gal) per capita.

Typical Water Consumption of Rainwater Harvesting Households

The following data is based on information from more than 100 households that have either had systems designed by Rainwater Connection or that have volunteered usage information. The systems rely entirely on rainwater (or a combination of well and rainwater from a common storage tank) for all potable water consumption. The figures are based on average monthly consumption for all indoor uses, including an allowance for houseguests.

- 205L (45gal)/person/day without water-saving appliances (up to 10% higher in summer)
- 160L (35 gal)/person/day with water efficient showers, toilets, dishwasher and clothes washer.
- 114L (25 gal)/person/day for households with water conserving habits as well as fixtures. For example, persons who are very water conservative report daily consumption totals of less than 90L (20 gal)/person/day.

Indoor uses can be divided as follows:

- Bath/showers 35%
- Toilets 30%
- Laundry 20%
- Kitchen Faucet & Dishes 10%
- Other washing 5%

Outdoor water use is usually provided or metred separately. In some rainwater households, summer outdoor water demand is equal to, or as much as double, indoor consumption.

The City of Guelph (Ontario) has estimated that water-efficient households using rainwater for all of their toilet and outdoor water requirements could consume as little as 112L (25gal)/person/day. (Source: City of Guelph, Water Conservation Efficiency Strategy, 2009 (sourced from American water Works Association, Region of Durham).

APPENDIX 6.5: Case Example — Water Balance Table for a Combined Rainwater/Well Water System

The following water balance table demonstrates that adding well water during the spring and early summer would reduce the water storage requirement to 6,000 gal ($27.3m^3$). It also shows that a smaller roof area would provide sufficient water for a three-person household.

Location	Little Qualicum Hatchery (17 year data, 1990–2006
Property	House with metal roof on quite clear site
Scenario	Rainwater Supplemented by well water. Rainwater from $210m^2$ (2,260 sq.ft.) roof, and tank with operational capacity of 6,000 imp. Gal. ($27.2m^3$) Full time use, three-person household. Average rainfall.
Max Storage Capacity	$27.3m^3$ (6,000 gal)
Collection Area #1 (sqft)	2,260
Collection Area #2 (sqft)	0
Collection Area #3 (sqft)	0
TOTAL Collection Area	2250 sqft ($210m^3$)
Volume Units	gal
Assumed Rainfall Level	(Average)

Note: The rainfall figures in this table are slightly different than those in the Potable RWH System table in Section 3.3.3 because of rounding errors in translating mm to inches.

Month	Indoor Usage		Assumed Precipitation		Rainwater Collected		Alternate Supply		Month-end Storage Volume	
	gal/month	litre/month	Inches	mm.	gal/month	litre/month	gal/month	litre/month	gal/month	litre/month
October	3,210	14,593	4.6	117	4052	18,420	0	0	842	3,828
November	3,210	14,593	7.0	178	7035	31,981	0	0	4,667	21,216
December	3,210	14,593	6.4	163	6433	29,244	0	0	6,000	27,276
January	3,210	14,593	7.0	178	6947	31,581	0	0	6,000	27,276
February	3,210	14,593	4.3	109	4344	19,748	0	0	6,000	27,276
March	3,210	14,593	4.0	102	3964	18,020	0	0	6,000	27,276
April	3,210	14,593	2.4	61	1426	6,483	2,000	9,092	6,000	27,276
May	3,210	14,593	1.8	46	1387	6,305	2,000	9,092	6,000	27,276
June	3,210	14,593	1.7	43	1514	6,883	2,000	9,092	6,000	27,276
July	3,210	14,593	0.8	20	643	2,923	2,000	9,092	5,433	24,698
August	3,210	14,593	1.4	36	1090	4,955	0	0	3,313	15,061
September	3,210	14,593	1.4	36	1196	5,437	0	0	1,299	5,905
TOTAL	38,520	175,112	42.8	1,087	40,031	181,981	8,000	36,368		
Demand:	**38,520 gallons**	**175,112 litres**		**Supply:**	**40,031 gallons**	**181,981 litres**				

TABLE 4 — Water Balance Table for a Combined Rainwater/Well Water System

APPENDIX 6.6: Common Roof Types and their Attributes

At present, no water quality standards exist for roofing types, and very few roofing products carry water quality test information. Individual roof products vary, and it is important to check the toxins that may leach from any particular roof product. The following table summarizes some of the commonly accepted information about roofing types used in British Columbia.

Roof Type	Attributes
• Factory-coated enamelled steel • Terracotta or concrete tiles • Slate	Safest materials. Most efficient. Easiest to clean but check the type of sealant or grout used with tile or slate installations.
• Galvanized (zinc-coated metal)	Zinc concentrations can usually be kept below the Guidelines for Canadian Drinking Water Quality by using a high volume First Flush Diverter (FFD) in the catchment system. Quite efficient and easy to clean.
• EPDM and other flat-roof products	Many are NSF approved for potable water collection. Lower water production in summer. Difficult to keep clean.
• Asphalt or fibreglass shingles	Shingles that contain moss inhibitors can give off unknown quantities of chemicals that could harm plants. First Flush Diverters should be used, and Reverse Osmosis treatment is recommended for potable water use. Lower water production in summer. Difficult to keep clean.
• Bitumen or composition roofing (for flat or low slope roofs)	There is generally more concern with flat composition roofs than with asphalt shingles – dependent partly on age, condition and amount of ponding in flat spots. Use FFD for outdoor water and both FFD and reverse osmosis for potable water. Lower water production in summer. Very difficult to clean.
• Wood/Cedar Shake or shingle roofing	Not approved for potable water use. Untreated water can be too acidic for some plants. Concern about chemical toxins in some cedar shingles. Very inefficient in summer. Very difficult to clean.
• Copper roofs and lead flashings or plumbing vents	Not to be used for any rainwater harvesting system.

Appendix 6.7: Summary of Common Cisterns on Vancouver Island

DESCRIPTION	PROS AND CONS	DURABILITY	COST
Above Ground Poly • Most commonly used. • Made of polyethylene or polypropylene. • Typically installed above ground. • Made from a food grade plastic resin that is U.V. (ultra violet) treated to slow down deterioration of the tank structure in the sun.	• Wide range of shapes and sizes. • Light weight, easily transported. • Most are NSF potable water rated or CSA approved.	• 5–8 year warranties. • Possible 25–30 year lifespan in shade.	• Least expensive. • Mid-size (2,400 gal) about $0.85 per gal. • Up to $1.30/gal, for small, large or specialty tanks.
Below Ground Poly Tanks • Heavier and more structured than the above ground poly tank versions. • Most are potable water rated. • Most commonly about 1,500 gal (6,800 litres) in size.	• Underground installation prevents sun penetration. • Irregular interior makes them hard to clean. • Anchoring or ballast required in wet sites.	• Generally very robust for installation. • Long lasting (some warranties for up to 100 years).	• More expensive than above ground. • Typically $1.50/gal for 1500 gal size and up to $3/gal for smaller ones.
Fibreglass • Most commonly used for larger industrial or commercial applications. • They require an interior lining or interior layer of food grade resin if used for potable water.	• Versatile and can be installed above or below ground. • Opaque to block sun. • Relatively salt water resistant.	• Very durable, and can be painted with normal house paints.	• More expensive than underground poly tanks.
Pre-cast Concrete • Factory manufactured as either septic or water quality. • Range of sizes from 1,000 – 14,000 litres (200 to 3,000 gallons).	• Concrete additives can be used to decrease permeability and add to potability. • Some types can be driven over. • May require expensive gravel backfill for wet sites.	• Long anticipated lifetime. • Are prone to cracking and leaking in poor soil conditions, but can be repaired from the inside.	• Approx $1.40 per gallon for larger ones, but expensive to transport and place on site due to heavy weight. • Full costs including transport and installation as high as $2.50 per gallon.

Continued on page 98.

Appendix 6.7: Summary of Common Cisterns on Vancouver Island, continued from page 97.

DESCRIPTION	PROS AND CONS	DURABILITY	COST
Poured in Place Concrete • Above or below grade, built on site, custom cisterns. • Often built under garages or exterior decks. • Concrete additives can be used to decrease permeability and increase potability.	• Special features can be designed in to facilitate maintenance. • Requires the services of a structural engineer to determine the structural requirements. • Not recommended for placing under habitable spaces (water condensation issues).	• Can be expected to be very long lasting if well designed and constructed. • Can be engineered to a high seismic standard.	• As much as $2.50 per gal for stand-alone tank – more where concrete prices are high. • As little as $1/per gallon incremental cost if constructed as part of a garage.
Galvanized steel tanks with a potable water rated liner • High quality above ground storage option where large storage capacities are required, 45m^3 to 90m^3 (10,000 -20,000 gal.). • Roof types vary from grain bin style sloped to flat.	• Liners are NSF 61 rated for potable water. • Can be transported and assembled on difficult to access sites. • Can be constructed on evenly compacted dirt and sand pad.	• Extremely durable with 50 year plus lifetime on steel and liner. • High probability of surviving an earthquake.	• $1.80 -$2.20/ gal depending on size. • Prices typically include delivery and installation on site.

Note: All costs are approximate 2011 figures in major centres and do not include transportation.

Appendix 6.8: How Big is a Micron?

MICRON SIZE	AS SMALL AS	US MESH NUMBER	OPENING SIZE MM (IN)
1 micron	one-millionth of a metre (25,400 microns per inch) Slightly smaller than a giardia cyst or anthrax	n/a	n/a
5	Generally recognized standard for proper functioning of a UV light	n/a	n/a
37	The smallest particle that can be seen by the human eye, such as fine plant pollen, silt, small dust	400	0.037mm (0. 0015 in)
177	Dust mites	80	0.177mm (0.0070 in)
250	Fine sand Mist (70-350 microns)	60	0.25mm (0.0098 in)
354	Coffee (5-400 microns)	45	0.354mm (0.0138 in)
500	Human hair (60-600 microns) Saw dust (30-600 microns)	35	0.5mm (0.0197 in)
707	Beach sand	25	0.707mm (0.028 in)
1,000 microns	Eye of a needle	18	1.0mm (0.0394 in)

SOURCES:

- www.engineeringtoolbox.com
- www.showmegold.org/news/mesh.htm

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