# GUIDANCE FOR TREATMENT OF RAINWATER HARVESTED FOR POTABLE USE IN BRITISH COLUMBIA

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## 1. Objective

This guidance document provides a general overview of assessing risks and treatment of rainwater for potable use in British Columbia. It characterizes harvested rainwater as a type of surface water, meaning water from a source which is open to the atmosphere and includes streams, lakes, rivers, creeks and springs, as defined in the Drinking Water Protection Regulation (DWPR). This document is intended to supplement but not replace the existing surface water treatment objectives found in the Ministry of Health's Drinking Water Treatment Objectives (Microbiological) for Surface Water Supplies in British Columbia (referred to herein as the BC Surface Water Treatment Objectives).

## 2. Background and Regulatory Framework

Two documents serve as the primary reference materials for treatment objectives for harvested rainwater: the BC Surface Water Treatment Objectives, and the Rainwater Harvesting Systems standard CSA B805-ICC 805 (produced by the CSA Group and the International Code Council, Inc. and referred to herein as the CSA/ICC Rainwater Standard).

In this guidance document, *rainwater* means: water collected from natural precipitation. Any system used to collect, convey, store, treat and distribute rainwater for use is a *rainwater harvesting system.* This definition is consistent with the CSA/ICC Rainwater Standard.

The British Columbia Building Code and local bylaws may have additional regulatory requirements for the use of harvested rainwater, including its use within single-family dwellings and other buildings. These are not included in this guidance document but should be consulted for reference.

Domestic water systems that serve only one single family residence are exempt from these guidelines, though owners may use them to develop safe systems that protect the health of household water users. The owner of any drinking water supply system servicing more than a single-family residence[1] who wishes to harvest rainwater for domestic use

[1] The term "single-family residence" is not defined in the DWPA. As such, according to the Drinking Water Officers' Guide, it should be given its plain meaning and taken to mean any single residence; i.e., a domestic house. For example, seasonal accommodation for labourers, residences with guest houses and outbuildings would likely fall outside the term "single-family residence" as they are not a single domestic home. Rainwater may be used as a source of drinking water by commercial operations and by owners who rent out their single family residences, so long as it is made potable. A landlord must not rent a

is required as a water supplier under the *Drinking Water Protection Act* (DWPA) and the DWPR to obtain the necessary permits from the local health authority (HA). A water use licence under the *Water Sustainability Act* (WSA) is not required for rainwater harvesting.

Under the DWPA, water suppliers have the responsibility to provide potable water to all users of their systems. As such, rainwater harvested for use as potable water in any drinking water supply system must be disinfected.[2] Schedule A of the DWPR specifies bacteriological water quality standards for potable water for the protection of human health. The DWPA and the DWPR give *Drinking Water Officers*[3] (DWOs) in each health authority the flexibility to address further microbiological, chemical and physical risks through applying site-specific treatment requirements to construction and operating permits. The Drinking Water Officers' Guide (DWOG) contains drinking water policies that must be considered by DWOs when making these statutory decisions, and DWOs must be consulted prior to planning or upgrading drinking water supply systems in the province. The DWOG further suggests best management practices which align with and/or further build on those detailed in the Guidelines for Canadian Drinking Water Quality (GCDWQ) as developed and updated regularly by Health Canada.

Reliability of water volume and quality should be a key consideration during all phases of development, including during the subdivision of land parcels. Given seasonal variations in precipitation, a water supply that relies solely on rainwater may face significant challenges with sufficient storage volume and capacity to cover extended drought periods. Additionally, the costs of using materials that comply with standards for potable water, of implementing sufficient treatment for potable rainwater systems, and of supplementing low volumes with bulk water can be significant. When these factors are considered, in many situations, harvested rainwater may be best suited for non-potable use only, or as a supplementary source to existing water supplies for the purposes of reducing stresses related to water quality and/or quantity.

## 3. Purpose and Scope

### 3.1. Purpose

The intent of this guideline is to assist water suppliers and DWOs in ensuring harvested rainwater is made potable.

### 3.2 Scope

The focus of this guide is on the assessment of risks and appropriate treatment of harvested rainwater for potable use in drinking water supply systems.

This document does not address:

- Non-potable uses of rainwater.

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domestic accommodation rental unit that is not connected to a water supply system unless the landlord can provide the tenant with a supply of potable water for domestic purposes, according to Section 7 of the *Public Health Act*'s Health Hazards Regulation.

[2] See section 5 of the Drinking Water Protection Regulation: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/200_2003#section5.

[3] Drinking Water Officer (DWO) is defined in the DWPA as a drinking water officer under Section 3 of the DWPA.

- Stormwater runoff[4] harvested rainwater.
- Assessing collection capacity, storage volumes, reliability nor sustainability of rainwater as a source of domestic water. Annex C of the CSA/ICC Rainwater Standard recommends tank sizing and capacity methodologies.
- Instructions for how to design a rainwater system. Guidance is limited to high level outcomes related to processes for mitigating human health risks and contributing to potability.
- The appropriateness of rainwater sources as basis for subdivision approval.
- Standards for chemical contaminants. As with other sources, rainwater chemical parameters should be reviewed against the GCDWQ.

# 4. Rainwater Harvesting System Design

This section provides an approach to hazard identification, risk assessment and mitigation through system design, as well as determining appropriate treatment objectives to achieve potability.

Application must be made to the local health authority for the issuance of construction and operating permits under the DWPA prior to commencing construction of any system falling under the scope of this document. This process will look at how the water supplier plans to mitigate the risks identified for the proposed system. Treatment systems may be of a complexity that water suppliers might want to consider employing contracted consultants familiar with rainwater as a drinking water source, rainwater catchment and treatment objectives to assist with this process.

The process of designing a rainwater harvesting system should follow a risk assessment and mitigation strategy similar to any other potable water source in British Columbia. The Comprehensive Drinking Water Source-To-Tap Assessment Guideline, Drinking Water Source-To-Tap Screening Tool and the Water System Assessment User's Guide provide risk assessment and mitigation strategies suitable to a harvested rainwater water supply.[5]

## 4.1 Rainwater Harvesting Risks

Harvested rainwater can become contaminated through numerous pathways of exposure including via airborne particles, animal fecal matter, tree litter, and by the materials used to collect and store rainwater.

Harvested rainwater is at risk of contamination prior to reaching a collection point. This can occur through contact with air pollutants that are either regularly occurring or associated with specific events (e.g. forest fire). As these risks will vary between locations and over time, all existing and potential risk should be considered as part of a risk mitigation approach.

At the collection stage, rainwater passes over surfaces (often a roof) which are likely to harbour residual matter, namely airborne contaminants such as dust, fecal matter from birds or mammals, chemical contaminants or other

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[4] Stormwater runoff, as per Section 3.1 of the CSA/ICC Rainwater Standard, is rainwater that is not roof runoff. This includes precipitation runoff from rain or snowmelt that flows over land and/or impervious surfaces (e.g. streets, parking lots, vegetative/green roofs, and roofs with public access).

[5] All three documents are available, along with others, on the **Resources for Water Systems Operators** page at https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality/resources-for-water-system-operators

organic matter (Fewtree & Kay 2008). The source and concentration of contamination may vary depending on conditions, and in some cases with seasons (Zhang et al. 2014).

## 4.2 Materials

Materials used to make collection surfaces and conveyancing systems may have a negative impact on harvested rainwater quality (Ward et al. 2010; Bae et al. 2019). Some roof surface materials are not recommended for potable water applications including those containing asbestos, copper or cedar, since these materials have components capable of leaching into the rainwater. There are some coatings and materials that are NSF/ANSI 61 compliant for potable water applications and components certified for potable water should be used in all conveyancing materials. In some environments, metal roofs, concrete tile and cool roofs (reflective roofs) produce a higher quality of harvested rainwater with lower dissolved organic carbon than shingle and green roofs.

Green roofs may produce discoloured water, as well as high concentrations of dissolved organic carbon which can lead to the formation of disinfection by-products that are harmful to human health if not adequately treated (Mendez et al. 2010; Zhang et al. 2014). The growing medium used in some green roofs is further correlated with a higher concentration of metals (such as arsenic) (Mendez et al. 2010). Green roofs may incur higher costs due to a need for more substantial treatment or costly testing for disinfection by-products. Given that green roofs may also produce a lower volume of water, these factors make green roofs not generally suitable for rainwater harvesting.

## 4.3 Storage

The quality of a harvested rainwater supply is impacted by storage time (stagnation), the environment and the materials in which water is being stored (Crabtree et al. 1996; Ahmed et al. 2010a; 2010b). These factors further interact depending on the quality of harvested rainwater as described in the previous paragraph. Primary filtration should take place before the water storage stage to prevent excessive buildup of organics in the tank. Storage tanks should be completely opaque to prevent algae growth. Thermal-resistant materials are ideal for storage tanks. Lighter colours will reflect sunlight, keeping water cooler on hot days than dark-coloured tanks. In general, storage tanks made of a dark coloured polyethylene are associated with creating a warmer environment for harvested rainwater and may impact microbial contamination of rainwater (Struck 2011).

The risk of opportunistic pathogens (e.g. Legionella) exists where water temperatures will be stored at a temperature at above 25 degrees Celsius. Therefore, tanks should be stored out of direct sunlight, and storage should be in-ground if there is a risk of temperatures exceeding 25 degrees Celsius. Best practice for the location of a storage tank recommends it not be located directly under sanitary, waste or storm drain pipes or in any other location that may increase the risk of contamination or microbial growth, such as a location subject to direct mid-day sun or above an onsite sewage disposal system (see the CSA/ICC Rainwater Standard). For systems without another potable source of water, it should be possible for storage tanks to be filled by bulk water haulers during drought periods. However, water collection, conveyancing and storage areas should not be accessible to the public.

Tanks and all associated components, including but not limited to sealants, fittings and linings contacting collected water, should comply with NSF/ANSI 61 and have a weighted average lead content of 0.25% or less when evaluated in accordance with NSF/ANSI 372. Solders and fluxes used in potable use rainwater harvesting systems should not exceed lead content greater than 0.2% by mass (see the CSA/ICC Rainwater Standard).

## 4.4 Risk Identification and Assessment

Identifying hazards and implementing control measures to mitigate potential health hazards is an essential aspect of any potable water supply system. A risk assessment process, such as the one outlined in Figure 1 below, serves as a tool for water systems to develop a more comprehensive understanding of the risks to drinking water safety and availability, designing risk mitigation measures, operating more effectively, and ensuring the best possible water quality. Understanding threats and vulnerabilities to drinking water supplies and the interdependency of their components equips water suppliers with the ability to make informed decisions about reducing or mitigating risks.

**Figure 1: Flow Diagram for Rainwater Harvesting Risk Assessment Process**

**Site Visit**

Identify potential off-site source contaminants that could impact catchment area such as:

- Air pollutants, agricultural chemicals and land use practices
- Waste disposal sites, industrial complexes or farming practices
- Local zoning, historical and current property use
- Rural vs urban landscapes

**Hazard Identification**

Identify potential on-site contaminants that could impact water quality such as:

- Fecal pathogens from animals or natural reservoirs of disease
- Chemical contamination from on-site air pollutants
- Leaching from roofing, conveyance or storage materials
- Debris or pests
- Pathogen proliferation caused by water stagnation or storage siting in direct sun
- Human activities or access

**Source Water Quality Study**

Assess the proposed treatment technology's effectiveness in providing potable water:

- Collect and analyze raw water samples to determine baseline water quality
- Identify constituents that can adversely affect treatment technologies
- Collect samples during initial portion of a storm event following arid conditions
- DWOs can require suppliers to complete a source assessment

A thorough evaluation should be done on land use in vicinity of the collection surface for both human and natural activity. Hazards identified should be documented to inform risk analysis, application of risk mitigation measures, and for measuring successes over time. The process may include surveys of potential sources of contamination and the frequency of occurrence of contamination events. A period of sampling for microbiological and/or chemical quality to characterize typical nature of the water quality may be valuable to ensuring that the design and treatment objectives (see section 5 in this guideline) applied are appropriate. It may be appropriate to sample in different seasons to obtain a robust representation of water quality throughout the year. Existing studies of raw rainwater collected directly from the air in close proximity to the site may be considered as a source of information for risk assessment at the discretion of the DWO; this can be helpful for systems that have not been constructed yet. For systems that will be using components that are already installed, baseline studies should involve sampling water that has come in contact with the existing components where possible.

Several tools exist to assist with the above-described process. The Comprehensive Drinking Water Source-To-Tap Assessment Guideline, Drinking Water Source-To-Tap Screening Tool and the Water System Assessment User's Guide are intended to help water suppliers develop a better understanding of the risks to drinking water safety and availability. Ongoing assessment and evaluation of potential offsite and onsite sources of contamination, as well as water quality, will be important in mitigating risks over the long term.

### 4.5 Design Considerations

Central to the risk assessment process is the implementation of control measures to ensure appropriate and effective risk mitigation. Table 1 below identifies some of the essential design considerations that can be administered in a rainwater harvesting system.

**Table 1: Rainwater Harvesting Water System Design Considerations**

| Design Consideration | Reasoning |
|---|---|
| **Collection Potential** | Amount of available precipitation in the area |
| **Output Demand** | Required storage volume for intended use |
| **NSF/ANSI 61, NSF/ANSI 372 and NSF P151 Materials (or third party certification)** | Ensures materials adhere to minimum established health effects requirements for any chemical contaminants or impurities that are imparted to the water[6] |
| **Air Gap or Backflow Preventer** | Prevent potential cross contamination with other water supply system(s)[7] |
| **Inlet Pre-Filter and Inlet Cover** | Prevent entry of debris, roof contaminants and pests into water supply |
| **First Flush Diverter[8]** | Reduce contaminants in the harvested water supply |
| **Food-Grade Plastic Storage** | Retains acidic nature of harvested rainwater which can inhibit microbial growth |
| **Covered or Shaded Storage** | Retains cool temperatures of stored water which can slow microbial growth |
| **Calmed Inlet** | Brings oxygenated water to lower levels of tank, preventing stagnation and disturbance of debris at bottom of tank |
| **Floating Intake** | Extracts water from the tank where it is cleanest, just below the surface |
| **Alarm Systems** | Systems to monitor, alert or shut-off supply when intake or output water quality standards not being achieved due to power failure or other incident |
| **Secured Access** | Prevents unauthorized access to water supply |

[6] USEPA (2002) *Permeation and Leaching. Distribution System Issue Paper.* https://www.epa.gov/sites/production/files/2015-09/documents/permeationandleaching.pdf

[7] The DWPR prohibits the mixing of potable and non-potable water systems to protect human health.

[8] First flush diverter, as per Section 3.1 of the CSA/ICC Rainwater Standard, is a device or method for removal of sediment and debris from collection surface by diverting initial rainfall from entry into the storage tank. NSF/ANSI 61 provides further guidance on how to perform an effective flush. First flush diverters must be installed correctly and maintained regularly to work properly.

## 5. Treatment Objectives

Drinking water treatment objectives provide a minimum performance target for water suppliers to treat water to produce potable water from harvested rainwater. The actual amount of treatment required will depend on the risks identified (see Section 4.1 and 4.2) and may require levels of treatment over and above those outlined below.

### 5.1 Treatment Objectives (Microbiological)

As this document has categorized rainwater as a surface water supply, most of the treatment objectives and the supporting reference material for this section can be found in the BC Surface Water Treatment Objectives. Further reasoning and explanation is provided when necessary within each sub-section where the treatment objectives differ or expand in the BC Surface Water Treatment Objectives.

This section outlines the following treatment objectives for the following pathogenic microbes: enteric viruses, bacteria, enteric protozoa in harvested rainwater for potable use:

- 4-log reduction or inactivation of viruses.
- 4-log reduction or inactivation of *Giardia* and *Cryptosporidium*.
- Two methods of treatment (dual treatment) for harvested rainwater.
- Less than or equal to (≤) one nephelometric turbidity unit (NTU) of turbidity.
- No detectable *E. coli*, fecal coliforms and total coliform.

#### 5.1.1. 4-log Inactivation of Viruses

**A minimum 4-log reduction of enteric viruses is recommended for all potable rainwater harvested systems.** This is consistent with requirements for surface water in the BC Surface Water Treatment Objectives. Depending on the results of testing and ongoing monitoring, a greater than 4-log reduction may be necessary, as per the Surface Water Treatment Objectives.

While the CSA/ICC Rainwater Standard assumes that elevated collection surfaces are unlikely to become contaminated with human viruses and recommends this level of reduction only where a water supply system includes a below-ground tank (where there is potential for sewage contamination), this guideline takes a more precautionary approach to ensure air transported human viruses, or viruses that are capable of cross-species transfer are inactivated.

#### 5.1.2. 4-log Inactivation of *Giardia* and *Cryptosporidium*

Protozoa such as *Giardia* and *Cryptosporidium* can be responsible for severe and, in some cases, fatal gastrointestinal illness. Local climate, the rate of pathogen occurrence, and the potential for higher pathogen concentrations increase the risks to human health associated with harvested rainwater for potable use (Ahmed et al. 2013; Schoen et al. 2017). As reliable and ongoing monitoring remains a challenge with a water supply such as harvested rainwater, the measures in place to ensure protection should aim to reduce the level of risk as much as possible.

**A minimum 4-log reduction of enteric protozoa is recommended for all potable rainwater harvested systems.** This is a higher level of reduction than recommended in the BC Surface Water Treatment Objectives but is aligned with the CSA/ICC Rainwater Standard (see Table 8.1). The 4-log reduction is based on the United States Environmental Protection Agency (USEPA) health based target of an annual risk of less than 1/10,000 persons per year ($10^{-4}$ ppy) (USEPA 1989). The higher level of reduction is recommended based on the potential for rainwater harvested systems to harbour significantly higher concentrations of protozoa, as well as the potential for such water sources to experience an unpredictable rate of pathogen occurrence, when compared to other surface water sources.

#### 5.1.3. Two Methods of Treatment (Dual Treatment)

To provide the most effective protection, the GCDWQ and the BC Surface Water Treatment Objectives recommend that filtration and one form of disinfection be used to meet the treatment objectives. The CSA/ICC Rainwater Standard also supports dual treatment and recommends filtration and disinfection of harvested rainwater supplies used for potable purposes. It is possible that a water supply system may be permitted to operate without filtration if certain conditions are met, as described in the BC Surface Water Treatment Objectives.

**It is recommended that dual treatment should be applied to all rainwater harvested potable water supply systems.** This is consistent with requirements for surface water in the BC Surface Water Treatment Objectives.

#### 5.1.4. ≤1 NTU in Turbidity

Turbidity of treated harvested rainwater should be maintained at less than 1 NTU. Turbidity levels should comply with the GCDWQ on turbidity, as referenced in the BC Surface Water Treatment Objectives, and the same exceptions apply (see section 4.4).

#### 5.1.5. No Detectable *E. Coli*, Fecal Coliform and Total Coliform

Schedule A of the DWPR requires that the treatment target for all potable water systems is to contain no detectable *E. coli* or fecal coliform per 100 ml. Total coliform objectives are also zero based on one sample in a 30-day period. For more than one sample in a 30-day period, at least 90% of the samples should have no detectable total coliform bacteria per 100 ml and no sample should have more than 10 total coliform bacteria per 100 ml. The DWO may require increase the frequency of testing within the operating permit if deemed necessary.

### 5.2. Treatment Objectives (Physical and Chemical)

This document does not outline the required treatment mechanisms or equipment to remove chemical/physical contaminants but recognizes that such contaminants can reduce the effectiveness of disinfection methods (e.g., by increasing the chlorine demand or by blocking/absorbing UV irradiation). Where the risk assessment or subsequent monitoring identifies potential concerns due to the presence of chemicals or turbidity, appropriate treatment technologies should be applied. The GCDWQ should be consulted for further guidance.

## 6. Operation, Monitoring, Maintenance and Training

Operational monitoring is critical for ensuring the treatment objectives and control measures in place are effective, and that a system is supplying potable water. Identifying and monitoring critical control points in a water system allows opportunities for corrective actions to be taken. As part of any operation, maintenance plans, monitoring and record keeping are required.

Water quality should be monitored for all parameters identified in the risk assessment, which may be over and above the minimum required by the DWPA. If there is uncertainty about how water quality from a new supply may vary over time, the DWO may establish different sampling frequencies and parameters than those specified in section 8 of the DWPR. Additional parameters could include a comprehensive combination of microbial indicators (e.g., heterotrophic plate count (HPC) bacteria, Pseudomonas and Aeromonas). Testing and monitoring protocols should take into account that different rainwater collection surfaces in close proximity to each other can have vastly different bacteriological counts.

Rainwater harvesting systems require ongoing maintenance and cleaning. Maintenance activities could include: cleaning and sanitizing the collection, conveyance and storage systems; inspecting and verifying inlet pre-filters and first flush diverters are in working order; and removing overgrown foliage, accumulated debris and pest harborage locations.

Water system operators need to ensure sufficiently trained and qualified people are available to maintain the system. In B.C., the level of training and certification required for operators is tied to the size of the system and classification level assigned to a drinking water system by the Environmental Operator's Certification Program (EOCP) or as required by the DWO through conditions on the operating permit. Many small water systems are exempt from training as per the DWPR, however a DWO may impose training requirements through conditions on permit when deemed necessary. Training specific to rainwater harvesting systems are listed (based on availability) on the EOCP Customer Relationship Management System, under the Career Management tab. The EOCP website and training guides are available to and recommended for anyone in the water industry.

Unforeseen circumstances that fall outside of an owner/operators' control will always pose a risk to the quality of water produced within any drinking water system. Water suppliers are required, as per Section 10 of the DWPA with requirements outlined under Section 13 of the DWPR, to have an Emergency Response Plan (ERP). The Ministry of Health's Emergency Response and Contingency Planning for Small Water Systems is a useful tool for developing an ERP. Water suppliers are encouraged to engage with their local DWO on ERP planning.

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