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Rainwater Harvesting Systems- Public Review Draft 2

Note: This draft is under development and subject to change; it should not be used for reference purposes.

Public comments are requested on this Second Public Review Draft beginning November 1, 2016 and are due by January 2, 2017. Public comments must be submitted on using the CSA Group Public Review site at http://publicreview.csa.ca/Home/Details/2350

Please note that only those sections of the document that were changed substantively from the First Public Review Draft are subject to public comment during this Second Public Review Period. The sections of the document that underwent change and are therefore eligible for comment are denoted in yellow highlighting. If comments are submitted on sections that were not changed, they will not be accepted. If you wish to view the First Public Comment Draft for comparison purposes, click here.

Questions regarding the public review process or comment submission process can be directed to the committee secretariats Paul Gulletson (paul.gulletson@csagroup.org), Shawn Martin (smartin@iccsafe.org).

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Preface

This is the second public review edition of CSA/ICC B805-201x, Rainwater Harvesting Systems. This draft standard is intended solely for use by CSA Group and ICC joint committee members and to solicit comments on the draft from the public. This draft may not be reproduced or redistributed, in whole or in part, by any means whatsoever without the prior permission of CSA Group and ICC.

The Standard was developed through the collaboration of many knowledgeable experts and representatives from Canada and the United States of America. This Standard was developed by the Joint Technical Committee on Rainwater Harvesting Systems under the jurisdiction of the CSA Strategic Steering Committee on Construction and Civil Infrastructure and the ICC Codes and Standards Committee, and will be formally approved by the Joint Technical Committee.

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Notes:

(1) Use of the singular does not exclude the plural (and vice versa) when the sense allows.

(2) Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

(3) This Standard was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all sections of this Standard.

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(a) define the problem, making reference to the specific section, and, where appropriate, include an illustrative sketch;
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(c) where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.
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(a) Standard designation (number);
(b) relevant section, table, and/or figure number;
(c) wording of the proposed change; and
(d) rationale for the change.

0 Introduction

This Standard addresses roof surface rainwater and stormwater (i.e., rainwater that has come in contact with the ground) being used as the source water. This Standard addresses rainwater intended for use in non-potable applications (e.g., irrigation, fire suppression, toilet and urinal flushing, clothes washing, hose bibs, decorative fountains, and vehicle washing) as well potable applications (e.g., human consumption, oral care, food preparation, dishwashing, and bathing). The term rainwater harvesting is used generically in this Standard and can refer to harvesting of either roof runoff or stormwater.

Recognizing that risk to public health increases with the number of persons using a treated water system, this Standard provides different methods for protecting water based on the influent water quality, the system, and the application. Stormwater runoff is expected to have a higher likelihood of contamination as a result of its flowing overland. Therefore, this Standard specifies additional treatment process requirements for stormwater runoff and does not cover its use for potable water applications.

For single-family dwellings, the Standard does not require sampling and testing of the output rainwater quality to substantiate performance. It recognizes the lower risk to the public and relies on sound treatment system design and verification of the treatment system operation.

In order to ensure the consideration of the wide range of variables associated with each site, location, design, and application, this Standard requires that a water safety plan (WSP) be developed for all rainwater harvesting systems. The WSP considers the specific challenges and risks presented by the site and associated impact on source water quality, operation of system components, and the risk associated with the end use. The complexity of the WSP should be consistent with the level of risk for the application and requires the development of a sound method of verifying that treatment processes are operating effectively and as intended.

Applications for harvested rainwater are separated into four end use tiers that consider the exposure potential through ingestion, inhalation, and skin contact. These four tiers are further separated into two groups which are listed by Tables 6.1 and 6.2: one group for single-family residential and one group for multifamily and commercial and public facilities.

This Standard specifies minimum performance criteria for each end use tier in consideration of the health risk and identifies possible treatment process options to meet the specified performance criteria. While specific treatment technologies are addressed, the use of other treatment processes that meet the required performance criteria are not intended to be restricted by this Standard.

Based on the expected source water quality, this Standard establishes suitable water quality parameters that are used to substantiate that the treatment process is operating as intended to produce safe water for the specified end use.

The water quality parameters established in the Standard that are expected of a rainwater harvesting system and used to substantiate treatment effectiveness differ from typical parameters used in wastewater treatment as the levels of contaminants expected in rainwater and stormwater differ from wastewater.

1 Scope

1.1 Inclusions

1.1.1 Applicability

The provisions of this Standard apply to the design, materials, installation, and operation of rainwater harvesting systems for potable and non-potable applications.

1.1.2 Source waters

This Standard covers the use of rainwater and stormwater as the source water.

Note: *Rainwater includes all forms of water from natural precipitation including but not limited to rain, snowmelt, etc. The term rainwater harvesting is used generically in this Standard and can refer to harvesting of either roof runoff or stormwater.*

1.1.3 Applications

This Standard covers rainwater harvesting systems that provide water for
(a) single-family residential applications;
(b) multi-residential applications; and
(c) non-residential applications.

1.2 Exclusions

This Standard does not cover
(a) rainwater harvesting systems that provide water for
    (i) process water systems for industrial or manufacturing purposes; and
    (ii) water distribution systems for commercial agricultural processes; and
(b) collection of surface water.

1.3 Terminology

In this Standard, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; “should” is used to express a recommendation or that which is advised but not required; and “may” is used to express an option or that which is permissible within the limits of the standard.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

1.4 Units of measurement

The units of record in this Standard are SI units. U.S. customary units are shown in parentheses for information only.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

AASHTO (American Association of State Highway and Transportation Officials)
AASHTO M43-2005 (Reaffirmed 2009)
Standard Specification for Sizes of Aggregate for Road and Bridge Construction

APHA (American Public Health Association)
American Public Health Association. 2014. 22nd edition. *Standard Methods for the Examination of Water and Wastewater*

ASHRAE (**American Society of Heating, Refrigerating and Air-Conditioning Engineers)**
ANSI/ASHRAE 188-2015
Legionellosis: Risk Management for Building Water Systems

ASME (The American Society of Mechanical Engineers)
ASME B16.5-2013
Pipe Flanges and Flanged Fittings

ASME A112.6.9-2005
Siphonic Roof Drains

ASPE (American Society of Plumbing Engineers)
ASPE 45-2013
Siphonic Roof Drainage Systems

ASTM International
ASTM A36-14
Standard Specification for Carbon Structural Steel

ASTM A592-10(2015)
Standard Specification for High-Strength Quenched and Tempered Low-Alloy Steel Forged Parts for Pressure Vessels

ASTM A675-14
Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties

ASTM C1227-13
Standard Specification for Precast Concrete Septic Tanks

ASTM D413-98(2013)
Standard Test Method for Rubber Property--Adhesion to Flexible Substrate

ASTM D471-2016a
Standard Test Method for Rubber Property—Effect of Liquids

ASTM D751-06(2011)
Standard Test Methods for Coated Fabrics

ASTM D1204-14
Standard Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting or Film at Elevated Temperature

ASTM D1621-16
Standard Test Method for Compressive Properties of Rigid Cellular Plastics

ASTM D1998-15
Standard Specification for Polyethylene Upright Storage Tanks

ASTM D2136-02(2012)
Standard Test Method for Coated Fabrics—Low-Temperature Bend Test

ASTM D3389-15
Standard Test Method for Coated Fabrics Abrasion Resistance (Rotary Platform Abrader)

ASTM D4833-07(2013)^{e1}
Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products

ASTM E2727-10e1
Standard Practice for Assessment of Rainwater Quality

AWWA (American Water Works Association)
AWWA D100-11
Welded Carbon Steel Tanks for Water Storage

AWWA D103-09
Factory-Coated Bolted Carbon Steel Tanks for Water Storage

AWWA D107-10
Composite Elevated Tanks for Water Storage

AWWA D115-06
Tendon Pre-stressed Concrete Water Tanks

AWWA D120-09
Thermosetting Fiberglass-Reinforced Plastic Tanks

AWWA D121-12
Bolted Aboveground Thermosetting Fiberglass-Reinforced Plastic Panel-Type Tanks for Water Storage

CSA Group
CSA B64.10-11/B64.10.1-11 (R2016)
Selection and installation of backflow preventers/Maintenance and field-testing of backflow preventers

CAN/CSA B126 Series-13
Water cisterns

CSA C22.1-15
Canadian electrical code, part I (23rd edition), safety standard for electrical installations

DVGW (Deutscher Verein des Gas- und Wasserfaches - German Technical and Scientific Association for Gas and Water)
DVGW W294
UV-Geräte zur Desinfektion in der Wasserversorgung

Federal Test Method
FTM STD. No. 101C (method 2065)

Test Method for Puncture Resistance and Elongation Test (1/8 in. radius probe)

IAPMO (International Association of Plumbing and Mechanical Officials)
IAPMO/ANSI Z1002-2014
Rainwater Harvesting Tanks

ICC (International Code Council)
2015 International Building Code (IBC)

2015 International Fire Code (IFC)

2015 International Green Construction Code (IgCC)

2015 International Mechanical Code (IMC)

2015 International Plumbing Code (IPC)

NFPA (National Fire Protection Association)
NFPA 13-2016
Standard for the Installation of Sprinkler Systems

NFPA 13D-2016
Standard for the Installation of Sprinkler Systems in One and Two-Family Dwellings and Manufactured Homes

NFPA 13R-2016
Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies

NFPA 14-2016
Standard for the Installation of Standpipe and Hose Systems

NFPA 22-2013
Standard for Water Tanks for Private Fire Protection

NFPA 70-2014
National Electrical Code (NEC)

NFPA 1142-2017
Standard on Water Supplies for Suburban and Rural Fire Fighting

NRC (National Research Council Canada)
National Building Code of Canada 2015 (NBC)

National Fire Code of Canada 2015 (NFC)

National Plumbing Code of Canada 2015 (NPC)

NWTI (National Wood Tank Institute)
NWTI Technical Bulletin S-82
Specifications for Wood Tanks and Pipe
Note: *Copies of NWTI Technical Bulletin S-82 are available from wood tank manufacturers.*

NSF International
NSF/ANSI 53-2015
Drinking Water Treatment Units – Health Effects

NSF/ANSI 55-2015
Ultraviolet Treatment

NSF/ANSI 60-2015
Drinking Water Treatment Chemicals – Health Effects

NSF/ANSI 61-2014a
Drinking Water System Components – Health Effects

NSF/ANSI 372-2016
Drinking Water System Components – Lead Content

NSF P151-2014
Health Effects from Rainwater Catchment Systems Components

UL (Underwriters Laboratory)
UL 58
Standard for Steel Underground Tanks for Flammable and Combustible Liquids

UL 142
Steel Aboveground Tanks for Flammable and Combustible Liquids

UL 508
Standard for Industrial Control Equipment

UL 508A
Standard for Industrial Control Panels

UL 1316
Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol-Gasoline Mixtures

ULC (Underwriters Laboratory Canada)
CAN/ULC-S601-14
Shop Fabricated Steel Aboveground Tanks For Flammable and Combustible Liquids

CAN/ULC-S603-14
Standard for Steel Underground Tanks for Flammable and Combustible Liquids

USDA Forest Service (United States Department of Agriculture)
USDA Wood Handbook
Forest Products Laboratory. 2010. Wood handbook—Wood as an engineering material. General Technical Report FPL-GTR-190. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 508 p.

U.S. EPA (United States Environmental Protection Agency)
Office of Water. June 2003. *Ultraviolet Disinfection Guidance Manual.* Washington, D.C. United States Environmental Protection Agency.

3 Definitions and abbreviations

3.1 Definitions

The following definitions shall apply in this Standard.

Accessible: Fabricated to be exposed for cleaning and inspection using simple tools (screwdriver, pliers, open-end wrench).

Readily accessible: Fabricated to be exposed for cleaning and inspection without using tools.

Alarm: A signal indicating a critical component or system failure requiring immediate action.

Alert: A signal or notification indicating a non-critical component or system condition.

Alarm set point: The conditions under which a sensor activates an alarm.

Air gap: The unobstructed vertical distance through the free atmosphere between the outlet of the pipe and the flood level rim of the receptacle into which the pipes is discharging.

Approved: Acceptable to the code official or other authority having jurisdiction.

Backflow: A flowing back or reversal of the normal direction of flow.

Backflow preventer: A device that prevents backflow.

Backwater valve: A device installed in the drainage system that prevents liquid wastes from backing up into a lower level or fixtures.

Catch basin: A ground-level rainwater harvesting system inlet designed to capture surface waters or discharge from a scupper.

Cistern: See "Storage tank."

Cleanout: An access opening in the drainage system utilized for the removal of obstructions.
Note: *Types of cleanouts include a removable plug or cap, and a removable fixture or fixture trap.*

Conveyance subsystem - The portion of a rainwater harvesting system that directs collected rainwater from the collection to the point of untreated rainwater storage.
Note: *Conveyance subsystem components include gutters, downspouts, leaders, roof drains, and conductors.*

Conveyance piping: Unpressurized pipe used within the conveyance subsystem that drains rainwater or stormwater to a storage tank by gravity.

Conductor: A pipe inside a building that conveys rainwater or stormwater from the roof to a storm or combined building drain. See "Leader."

Contaminant: An undesirable organic or inorganic, soluble or insoluble substance in the water.
Note: *Contaminants include microbiological organisms.*

Controls: Manual or automatic devices or algorithms designed to regulate the operation of a system.

Corrosion-resistant: Capable of maintaining original surface characteristics under prolonged contact with the intended end use environment and exposure to cleaning or sanitizing procedures according to the manufacturer's recommendation.

Day tank: A temporary holding tank for a limited volume of treated water to be provided for end use.
Note: *Day tanks are also known as buffer tanks or batch tanks.*

Disinfection: The act of eliminating disease-causing microorganisms from contaminated water either by physical removal or by killing or inactivating them.

Distribution system: Piping and other components that convey rainwater from the end point of treatment to the point of end use.

Evaporative cooling system: An assembly of equipment and appliances that cools air through the evaporation of water.

First-flush diverter: A device or method for removal of sediment and debris from collection surface by diverting initial rainfall from entry into the storage tank.

Leader: An exterior drainage pipe for conveying stormwater from roof or gutter drains to a means of disposal or treatment.
Note: *See "Conductor."*

Multi-barrier approach: A system management approach that includes source water protection, treatment, integrity of the distribution system, and operation and monitoring.

Non-potable water: Water not safe for drinking, personal or culinary utilization.

Non-potable water system: An assembly or equipment that collects and distributes non-potable water.
Note: *Equipment used in non-potable water systems includes pipes, fittings, valves, various appurtenances, storage tanks, pressurization equipment, treatment systems etc.*

Potable water: Water that meets human consumption quality standards, as established by the authority having jurisdiction.
Note: *Potable water is drinking water.*

Rainfall abstraction: A measure of the amount of rainfall that is lost from absorption into roof surfaces or the amount of water that is lost due to the operation of first flush diverters
Note: *First flush diverters usually collect the first 2 mm of rainfall and prevent it from reaching the tank. Rainfall abstraction is usually expressed in mm or inches.*

Rainwater harvesting system: a system intended to collect, convey, store, treat, and distribute rainwater for use.
Note: *Rainwater harvesting systems are also known as "rainwater collection systems" or "rainwater catchment systems."*

Rainwater: Collected water from natural precipitation.

Rainwater inlet: The point of discharge from the conveyance piping into the storage tank.

Rainwater outlet: The point of entrance at the storage tank into the distribution system.

Roof runoff: Rainwater that is intercepted by an elevated impervious roof surface that is not subject to pedestrian access.

Secondary directly-connected water supply: A secondary source of water that serves a distribution system independently from the rainwater harvesting system.
Note: *Secondary directly connected water supplies are typically intended to be used when the rainwater harvesting system is unable to provide sufficient water from the main supply. This water is not intended to be introduced directly to the storage tank, but to the distribution system piping.*

Sewer: A piping system that transports sewage and other liquid wastes to a point of disposal.

Scupper: A drainage structure from a flat or low-sloped roof that allows rainwater to free-fall to a catch basin below.
Note: *Scuppers are also known as canales.*

Storage tank: a liquid retention tank connected to a plumbing system or irrigation system.
Note: *Storage tanks are also known as "cisterns".*

Stormwater runoff: All rainwater that is not roof runoff.

Surface water: All water naturally open to the atmosphere (e.g., rivers, lakes, reservoirs, ponds, streams, impoundments, seas, and estuaries.)

Third-party certified: Demonstrated by a third-party certification body to conform to specified requirements.

Treatment: The use of biological, physical, or chemical means to make water fit for the intended use.

Ultra Violet Transmittance (UVT): The measure of the fraction of incident germicidal Ultraviolet light remaining after passing through 1 cm of sample water expressed as a percentage of the transmission through pure water.
Note: *This value is a measurement of the water. For example, water from a metal roof after a 350 micron filter might have a UVT of 90%. As water quality changes, the UVT% of said water also changes.*

Vegetative roof: An assembly of interacting components designed to waterproof and normally insulate a building's top surface that includes, by design, vegetation and related landscaping elements.
Note: *Also known as a blue roof, green roof, or bio roof.*

Water distribution system: An assembly of pipes, fittings, valves, and other equipment that conveys water from its source to its intended point of use or destination.

Water Safety Plan (WSP): A plan to ensure the safety of water used for specified purposes through the application of a comprehensive risk and management approach that encompasses all steps from the source water to end use.

3.2 Terms not defined

Terms not defined in Clause 3.1 shall have the ordinary dictionary meaning as implied by the context.

3.3 Abbreviations

The following abbreviations shall apply in this Standard:

BOD_5 – 5-day biochemical oxygen demand
CFU – colony forming units
CMF – commercial/multi-family
COD – chemical oxygen demand
gpd – gallons per day
gpm – gallons per minute
HPC – heterotrophic plate count
NOAA – National Oceanic and Atmospheric Administration
NR – not recommended
NTU – nephelometric turbidity unit
ORP – oxidation-reduction potential
RU – residential use
SF – storage loss factor
SFR – single-family residential
TSS – total suspended solids
U.S. EPA – United States Environmental Protection Agency
UV – ultraviolet
UVDGM –Ultraviolet Disinfection Guidance Manual
UVT – ultraviolet transmittance
WSP – water safety plan

4 Effect of other codes

4.1 Coordination with other codes

Rainwater harvesting systems shall comply with the requirements of the authority having jurisdiction. Where local requirements do not exist, the relevant requirements of the International Building Code, International Fire Code, International Green Construction Code, International Mechanical Code, International Plumbing Code, National Electrical Code (NFPA 70), National Building Code of Canada, National Fire Code of Canada, National Plumbing Code of Canada, or Canadian Electrical Code (CSA C22.1) shall apply, as applicable.

Note: *In this Standard, the term "plumbing code" is used generically to refer to the applicable plumbing code referenced in this Clause.*

4.2 Conflicts with referenced standards

Where conflicts occur between provisions of this Standard and the referenced standards, the provisions of this Standard shall apply.

4.3 Superiority of laws

The provisions of this Standard shall not be deemed to nullify any provisions of local, state, provincial, territorial, or federal law. In the case of a conflict between the provisions of this Standard and those of the applicable regulations, the provisions of the regulations shall govern.

5 General system requirements

5.1 General objectives and requirements

5.1.1 Output water quality

Rainwater harvesting systems shall be designed to treat, maintain, and deliver water at a quality that is fit for the intended use, as specified in Clause 5.2.

Notes:

(1) *Where water is used for public drinking water supplies, the authority having jurisdiction should be consulted for specific regulatory requirements for water quality.*

(2) *Rainwater harvesting systems should employ multi-barrier or a treatment train design approach to reduce accumulation, introduction, and re-introduction of contaminants into the system.*

5.1.2 Water safety plan (WSP)

5.1.2.1 General

A WSP shall be developed for rainwater harvesting systems.

Note: *Guidance on developing a WSP is included in Annex E.*

5.1.2.2 Rationale for a WSP

The WSP should reflect regional, local, and site-specific water quality concerns. A WSP is intended to recognize, address, and improve water quality and water quality concerns for rainwater harvesting systems for potable and non-potable uses. It is important to document the full scope of the rainwater harvesting system in order to identify system components, scope of system supply, parties responsible for system maintenance, and operational guidelines for the rainwater harvesting system.

5.1.2.3 Elements of a WSP

Based on intended uses, the elements of a WSP shall include the following:

(a) Site assessment for source water suitability;

(b) Fit for intended uses;

(c) Hazard identification and risk prioritization;
(d) System design and identification of control points;
(e) Operational monitoring, system verification, and response; and
(f) Supporting programs, measurement procedures, and documentation.

5.1.3 Continuity of supply

Where rainwater harvesting systems serve as a primary supply for a distribution system, a secondary water supply shall be provided when required by the authority having jurisdiction. The secondary supply shall comply with Clause 7.3.7 and the plumbing code.

5.1.4 System sizing

The required storage capacity of the system for the intended system design needs shall be based on
(a) precipitation data generated by Environment Canada, the NOAA National Climatic Data Center, or other acceptable localized data;
(b) available collection area;
(c) anticipated demand; and
(d) applicable code requirements.

Note: *Refer to Annex D for guidance on tank sizing.*

5.1.5 Limited effect on other building systems and structures

Installation of a rainwater harvesting system shall not compromise the site, the structural integrity of the building and related structures, or the safety of the building occupants and general public.

5.1.6 Protection of potable water systems

5.1.6.1 General

Rainwater harvesting systems shall be designed, installed, and maintained to prevent contamination of potable water supplies and the potable water distribution piping.

5.1.6.2 Backflow prevention

Potable water systems connected to rainwater harvesting systems shall be protected against backflow by
(a) an air gap; or
(b) a backflow preventer suitable for the application, in accordance with the plumbing code.

5.1.7 Protection of harvested water from contamination

Harvested rainwater shall be protected from external contamination.

5.1.8 Insect and vermin intrusion control

Rainwater harvesting systems shall be protected to prevent the entrance of insects and vermin into storage tanks, vents, and piping systems in accordance with this Standard and the plumbing code.

5.1.9 Local site conditions

The system design, installation, and materials shall be suitable for local site conditions, including

(a) freezing;
(b) excessive heat;
(c) high wind;
(d) seismic;
(e) extreme rainfall;
(f) contaminants;
(g) elevation of water table;
(h) flooding; and
(i) sunlight exposure.

5.1.10 Access

Access to rainwater harvesting system components shall be restricted in order to minimize contamination, vandalism, and unauthorized access in accordance with this Standard and applicable codes.

5.1.11 System documentation

A manual shall be supplied with all systems and include standard operating procedures under normal operating conditions, such as system start-up and shutdown procedures, as well as contingencies and emergency procedures for system failure, loss of treatment, or other emergency conditions. The manual shall include a system description, detailed system piping and wiring schematics, and locations of all system components as installed, including manufacturer and model numbers. The manual shall provide a maintenance schedule and procedures for all system components requiring periodic maintenance. Consumable parts, including filters, shall be noted along with part numbers.

5.1.12 Permits

5.1.12.1 General

Any owner, or owner's authorized agent who desires to construct, alter, or abandon a rainwater harvesting system shall first make application for required permits, in accordance with the requirements of the authority having jurisdiction. Where the end use of an existing rainwater harvesting system is changed or modified, the system design parameters shall be re-evaluated and all requirements of this Standard shall apply.

5.1.12.2 Construction documents

The following documents shall be provided to the authority having jurisdiction with an application for permit:

(a) system description and design narrative;
(b) list of intended end uses;
(c) site plan;
(d) system specification and bill of materials;
(e) piping diagram;

(f) wiring schematics;
(g) water safety plan (refer to Annex E); and
(h) operations and maintenance manual.

5.1.13 Removal from service

5.1.13.1 Abandonment

Abandoned rainwater harvesting systems shall comply with the requirements of the applicable local codes. In addition, when a rainwater harvesting system is permanently removed from service,

(a) all system piping connecting to a secondary water system shall be removed or disabled;
(b) storage tanks shall be abandoned in accordance with Clause 7.3.6.4;
(c) inlet piping shall be disconnected and redirected to drain systems;
(d) vents, inlets and outlets, and related piping shall be sealed; and
(e) electrical power shall be permanently disconnected.

5.1.13.2 Decommissioning

Rainwater harvesting systems removed from service shall comply with the requirements of the applicable local codes. In addition, when a rainwater harvesting system is seasonally or temporarily removed from service,

(a) all system piping connected to a utility-provided water system shall be locked out or disabled;
(b) the storage tank shall be secured from unauthorized access;
(c) inlet piping shall be redirected to approved drain systems; and
(d) electrical power shall be shut down.

5.2 End use tiers

5.2.1 General

5.2.1.1 End-use tier categorization

The end-use tier categorization shall be as specified in Table 6.1. Each end-use tier is categorized based on the following three elements:

(a) potable or non-potable water quality;
(b) end uses; and
(c) potential for human contact, including ingestion, inhalation, and skin contact.

Each end-use tier comprises common end-use applications and is not intended to be an exhaustive list. Where end uses are not listed, the application shall be categorized based on the criteria specified in Clause 5.2.1.2.

5.2.1.2 End uses and potential for human contact

The potential for human contact through ingestion, inhalation, or skin contact is characterized as low, medium, or high under normal operation for the intended use. A low exposure potential applies to end uses where humans rarely come in contact with the treated rainwater due to the nature of the installation that limits direct or indirect contact under normal operation. A medium exposure potential applies to end uses where human contact with the treated rainwater is indirect or limited under normal operation. A high exposure potential applies to end uses where human contact with the treated rainwater is direct under normal operation.

5.2.2 End use tiers

Rainwater collected shall be categorized in accordance with Table 6.1.

TABLE 5.1
END USE TIERS AND EXPOSURE POTENTIAL WITHOUT MITIGATION MEASURES

End Use Tier	Category	End Uses	Exposure Potential*			
			Ingestion	Inhalation	Skin Contact	Overall
1	Non-Potable	• Trap primers • Spray irrigation (restricted access or exposure) • Surface and subsurface irrigation (drip, bubbler) • Fire suppression • Ice rinks	Low	Low	Low	Low
2	Non-Potable	• Toilet and urinal flushing • Clothes washing • HVAC evaporative cooling† (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling) • Rooftop thermal cooling	Low	Med	Med	Med
3	Non-Potable	• Hose bibbs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access or exposure)	Med	High	High	High
4	Potable	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering, and hand washing • Pools, hot tubs, spas, and splash pads • Misting stations • Swamp coolers	High	High	High	High

** Typical representative outcomes are gastrointestinal illness from ingestion, Legionellosis from inhalation, and bacterial wound infection from skin contact.*

† Exposure potential through inhalation for HVAC evaporative cooling is high.

6 System design and installation - General

6.1 Material compatibility

Rainwater harvesting systems shall be manufactured of materials adequate for the intended applications and compatible with the water treatment processes.

6.2 Materials for potable water systems

With the exception of collection surfaces and conveyance subsystems, materials contacting rainwater collected for potable water applications shall comply with NSF/ANSI 61 and shall have a weighted average lead content of 0.25% or less when evaluated in accordance with NSF/ANSI 372. Solders and fluxes used in rainwater harvesting systems supplying potable water shall not have a lead content greater than 0.2% by mass.

6.3 Pressure and temperature

Components used in rainwater harvesting systems shall be suitable for use at the components' anticipated maximum and minimum operating water temperatures and pressures.

6.4 Seismic considerations

Rainwater harvesting systems and components shall be designed and installed to withstand the anticipated seismic forces in accordance with the building code.

6.5 Buried collection and distribution piping

Except for irrigation piping located outside of a building and downstream of a backflow preventer, buried collection and distribution piping shall

(a) maintain the separation distances from potable water piping specified by the authority having jurisdiction; and

(b) be protected from damage and potential sources of contamination in accordance with the plumbing code.

6.6 Electrical wiring

6.6.1 General

Electrical wiring shall be sized and installed in accordance with the electrical code and the manufacturer's instructions.

6.6.2 Wiring identification

Control circuit wiring and terminals shall be identified in accordance with the electrical code.

6.6.3 Protection of electrical components

Overload and overcurrent protection of electrically operated components shall be consistent with the maximum current rating of the device and the electrical code

6.7 Controls

6.7.1 General

Controls for rainwater harvesting systems shall ensure

(a) effective and safe operation of the system;
(b) continuous supply of water, as applicable;
(c) that operation is within intended design parameters of the system; and
(d) that volume and discharge rates are in compliance with stormwater management requirements as specified by the authority having jurisdiction.

6.7.2 Environmental protection

Controls and associated components shall be suitable for the environment in which they are installed. Wires, connections, sensors, pneumatic lines, and hydraulic lines used to transmit control signals shall be protected from corrosion or signal degradation that would compromise system operations.

6.7.3 Bypass and override

Alarm conditions shall not be capable of being bypassed or overridden except for diagnostic or manual operation of system.

6.7.4 Access and labeling of controls

Control systems and components shall be labeled and accessible for operation and maintenance in accordance with this Standard and applicable codes.

6.7.5 Alerts and alarms

6.7.5.1 Alerts

Alerts shall be provided for critical control points identified by the WSP to indicate when the rainwater harvesting system is operating outside design parameters but not causing a hazard to health or safety, or damage to the system.

6.7.5.2 Alarms

Alarms shall be provided for critical control points identified by the WSP to indicate when the rainwater harvesting system is operating outside the design parameters and potentially causing a hazard to health and safety, or damage the system.

6.7.5.3 Alarm and alert output

Onsite alarms and alerts shall have audible or visible outputs. Visual alarms shall continue to operate for the duration of the alarm or alert condition. A remote alarm or alert system using electronic communication may be used to advise the responsible person that the system has failed or that failure is imminent, in addition to the onsite alarm or alert.

6.7.6 Controls for dedicated firefighting reserves

Controls of rainwater harvesting systems supplying water for fire sprinkler systems or standpipes shall comply with the requirements of the fire code.

6.7.7 Control panels

Control panels for rainwater harvesting systems utilized in commercial occupancies shall comply with UL 508 or UL 508A, as applicable.

6.8 Point of use signage and identification for non-potable water

6.8.1 General

Signage shall be provided at the point of use where non-potable water is used and dispensed in accordance with the requirements of this Standard and the plumbing code.

6.8.2 Non-potable water outlets

Non-potable water outlets, such as hose bibs, open-ended pipes, and faucets shall be identified at the point of use for each outlet in accordance with the requirements of the plumbing code. Where no such requirements exist, non-potable water outlets shall be identified with the words "Non-potable water utilized for [application name]. CAUTION: NON-POTABLE WATER – DO NOT DRINK"*.

The words shall be legibly and indelibly printed on a tag or sign made of corrosion-resistant, fade-resistant, waterproof material or shall be indelibly printed on the fixture. The letters shall be at least 13 mm (0.5 in) in height and shall be of a color that contrasts with the background on which they are printed. In addition to the required words, the pictograph shown in Figure 6.1 shall appear on the required signage.

FIGURE 6.1
POINT OF USE SIGNAGE

**The equivalent French wording is "Eau non potable utilisée pour [application name]. ATTENTION: EAU NON POTABLE – NE PAS BOIRE" and the equivalent Spanish wording is "Agua no potable utilizada para [application name]. ATENCIÓN: AGUA NO POTABLE – NO BEBER".*

7 Subsystem design and installation

7.1 Collection surfaces

7.1.1 Minimization of ponding and retention

Rainwater collection surfaces shall collect and convey rainwater to the inlets of the conveyance subsystem and minimize ponding and retention after the precipitation event.

7.1.2 Roof runoff versus stormwater runoff

Rainwater that is intercepted by roof material and

(a) not subject to pedestrian access, except for maintenance purposes, shall be considered roof runoff; and

(b) subject to pedestrian access, or intercepted by ground level surfaces (e.g., vegetative roofs, pedestrian surfaces, porous pavement, landscape runoff, paved parking, and street, freeway and shoulder areas on roadways) shall be considered stormwater runoff.

7.1.3 Collection surface types for end use tiers

7.1.3.1

Subject to the assessment of the WSP, based on the prescriptive approach, collection surfaces shall only supply water for the end-use tiers specified in Table 7.1 Where a system supplies multiple end uses, the collection surface shall comply with Table 7.1 for each end use.

7.1.3.2

Colder climate regions subject to some degree of snowfall during the year and use of salt for de-icing shall not collect stormwater runoff for reuse unless appropriate treatment is undertaken to address salt content.

Note: *Water end use tiers are specified in Clause 5.2.*

TABLE 7.1

COLLECTION SURFACES PER WATER END USE TIER FOR THE PRESCRIPTIVE APPROACH

Collection Surface		End Use Tier
Roofing material*	Asbestos cement	None
	Asphalt	1, 2, 3, 4
	Asphalt felt and bituminous and tar membranes	1, 2, 3
	Ceramic	1, 2, 3, 4
	Clay	1, 2, 3, 4
	Concrete	1, 2, 3, 4
	Copper	1, 2, 3
	Fiberglass	1, 2, 3, 4
	Glass	1, 2, 3, 4
	Polyethylene membrane	1, 2, 3, 4
	Polymer and acrylic	1, 2, 3
	Rubber/Butyl /EPDM membrane	1, 2, 3
	Steel - Coated	1, 2, 3, 4
	Steel - Stainless	1, 2, 3, 4
	Tin	1, 2, 3, 4
	Wood - Untreated	1, 2, 3
	Wood - Treated	1, 2, 3
Public pedestrian accessible roofs		1, 2
Vegetated roofs		1, 2§
Pedestrian and parking surfaces (e.g. sidewalks, courtyard, driveways, parking areas, pervious surfaces)		1, 2§
Landscaped runoff		1, 2§
Street, freeway, shoulder areas, paved parking		None
Subsurface collection†		1, 2
Surface waters and stormwater detention ponds		None

** Roofing products used within rainwater harvesting systems collecting water for use as drinking water can be third-party certified to NSF P151-1995 Health Effects from Rainwater Catchment System Components unless the water collected is treated to address the constituent contaminants.*

† Subsurface water shall not be collected from sites which contain contaminated soils.

§ HVAC evaporative cooling applications not included.

7.1.4 Collection surfaces for potable water applications

Paints or coatings applied to surfaces used for collection of rainwater for potable applications shall be third-party certified to NSF P151 or NSF/ANSI 61, and applied in accordance with manufacturer's installation instructions. Lead, chromium, or zinc-based paints and coatings shall not be used on surfaces used for collection of rainwater for potable applications.

7.1.5 Equipment and appliances mounted on collection surfaces

Except where potential discharge of equipment and appliances is limited to potable water or clear water waste and the collection surface supplies rainwater harvesting systems utilized exclusively for Tier 1 or 2 applications (excluding evaporative cooling), equipment and appliances mounted on collection or runoff surfaces shall have a means of preventing the introduction of contaminants into the rainwater harvesting system. Equipment and appliances containing toxic fluids or other potentially harmful substances shall not be installed on collection surfaces.

7.2 Conveyance subsystems

7.2.1 General

Conveyance subsystems and components shall be designed and installed to facilitate the transport of collected rainwater with minimal loss and contamination and without degradation of any associated structure.

7.2.2 Roof drains

Where rainwater harvesting conveyance systems serve as all or a portion of the primary roof drainage for a structure, the system shall be sized, designed and installed in accordance with the building code and the plumbing code, as applicable. Secondary roof drains and roof drains that connect to a combined primary and secondary roof drainage system shall not discharge to a rainwater harvesting conveyance system.

7.2.3 Stormwater management

Conveyance subsystems that also function as elements of stormwater management systems for the site shall be designed and installed in accordance with requirements of the authority having jurisdiction.

7.2.4 Materials

Conveyance subsystems shall be constructed of materials that fit for the intended use. Collection devices shall be constructed of materials that are compatible with the collection surfaces, anticipated rainwater quality, and the treated water quality required for the intended end use.

7.2.5 Joints

Joints between components in the conveyance system shall be watertight.

7.2.6 Cleanouts

Cleanouts shall be provided in the water conveyance system to allow for cleaning and clearing of blockages in pipes, leaders, and downspouts.

7.2.7 Access

Inlets, debris excluders, filters, first flush diverters, cleanouts, and any conveyance system components requiring service shall be accessible.

7.2.8 Vermin control

Conveyance systems and inlets shall be protected to prevent the entrance of insects and vermin.

7.2.9 Slope

Gutters and collection piping that use gravity to produce flow shall have a slope along their entire length and shall not permit the collection or pooling of water at any point. Siphonic roof drain systems shall be installed in accordance with Clause 7.2.12 and shall not be sloped.

7.2.10 Conveyance system inlets

7.2.10.1 Conveyance inlet sizing

Inlets to conveyance subsystems that also serve as primary or secondary roof drains or stormwater management systems shall comply with the minimum size requirements specified by the authority having jurisdiction.

7.2.10.2 Pre-filtration

Inlets accepting water from collection surfaces shall be protected with a debris excluder or equivalent device to prevent the entry of large contaminants and debris into the conveyance system (e.g., leaves, sticks, pine needles, tree fruit, bark, and moss).

7.2.11 First-flush diverters

First-flush diverters shall operate automatically and not rely on manually operated valves or devices. Diverted rainwater shall be discharged in a manner consistent with the stormwater runoff requirements of the authority having jurisdiction and shall not drain onto rainwater collection surfaces.

7.2.12 Gutters

Roof gutters used to convey captured rainwater shall be installed and sized in accordance with the requirements of the authority having jurisdiction. In the absence of such requirements, installation and sizing shall be in accordance with the applicable code.

7.2.13 Roof drain systems

The collection and conveyance of rainwater shall not adversely impact the function of roof drain systems. Roof drain systems shall be designed and installed in accordance with the requirements of the applicable codes and manufacturer’s requirements. Siphonic roof drains and drainage systems shall be designed in accordance with ASME A112.6.9 and ASPE 45.

7.2.14 Vertical conveyance

7.2.14.1 General

Leaders, vertical conductors, and other devices conducting captured rainwater from elevated collection surfaces shall be designed, sized and installed in accordance with the requirements of the applicable code.

7.2.14.2 Scuppers and catch basins

Scuppers used with elevated collection surfaces shall allow for the free fall of water to a catch basin without obstructions in the path of travel. Scuppers and catch basins shall be designed to prevent water from splashing the exterior of the structure. Catch basins used in conjunction with scuppers shall comply with Clause 7.2.

7.2.15 Conveyance piping

7.2.15.1 General

To convey captured rainwater, rainwater harvesting systems shall use drainage piping suitable for use within plumbing drainage or pressure systems.

7.2.15.2 Design and installation of conveyance piping

Collection piping conveying captured rainwater shall be designed, sized and installed in accordance with the requirements of the authority having jurisdiction. The size of a drainage pipe shall not be reduced in the direction of flow.

7.3 Storage tanks

7.3.1 Compliance

7.3.1.1 General

Tanks shall comply with the applicable requirements of Annex C or the applicable requirements of at least one the following standards:

(a) ASTM C1227;
(b) ASTM D1998;
(c) AWWA D100;
(d) AWWA D103;
(e) AWWA D107;
(f) AWWA D115;
(g) AWWA D120;
(h) AWWA D121;
(i) CSA B126 Series;
(j) IAPMO/ANSI Z1002;
(k) NFPA 22;
(l) UL 58;
(m) UL 142;
(n) UL 1316;

(o) ULC S601; or
(p) ULC S603.

7.3.1.2 Fire supression tanks

Tanks used for fire suppression shall comply with the fire code.

7.3.2 Sizing

The minimum capacity of the rainwater storage tank shall consider the output water demand, dedicated fire reserve volume, stormwater or detention (management) volume, and storage loss factors and shall be in accordance with the requirements of the authority having jurisdiction. See also Annex D for guidance on tank sizing methodologies and calculations.

7.3.3 Materials

7.3.3.1 General

Tanks, liners, coatings, pipes, pipe fittings, and appurtenances shall be constructed of durable, non-absorbent materials. Storage tank materials shall be compatible with disinfection agents or processes that come in contact with the tank, the water to be stored and the intended end use. Seams and joints shall be watertight.

7.3.3.2 Material compatibility for potable end use

Storage tanks, liners, coatings, pipes, pipe fittings, and appurtenances contacting collected rainwater intended for potable end uses shall comply with NSF/ANSI 61 and NSF/ANSI 372.

7.3.3.3 Environmental compatibility

Storage tanks and materials shall be constructed to withstand local environmental conditions. Storage tanks pipes and pipe fittings and appurtenances designed to be installed in a location subject to direct sunlight shall be constructed from a material designed to be stable under the UV light exposure anticipated during the life of the system.

7.3.4 Storage tank foundation and supports

7.3.4.1 General

Storage tanks shall be properly supported on a base capable of withstanding the weight of the storage tank when filled to capacity. Storage tanks shall be supported and restrained to prevent lateral movement. Support and restraint devices shall be placed in a manner that will not obstruct access for testing and maintenance. Support and restraint shall be in accordance with the building code, the manufacturer's installation instructions, and any applicable standards related to the end use.

7.3.4.2 Tanks subject to buoyancy uplift conditions

Where there is high ground water or a risk of flooding, storage tanks shall be
(a) ballasted or otherwise secured to prevent them from floating or moving; and

(b) designed to withstand structural stresses caused by hydrostatic pressure and buoyancy.

7.3.4.3 Underground structural support

7.3.4.3.1 General

The design of buried or partially buried tanks shall consider the

(a) external loads on the tank including the weight of the backfill together with hydrostatic, overburden, and live loads; and

(b) soil type at the site and the tank loading when the tank is either full and empty.

7.3.4.3.2 Surface loads

Underground tanks subject to vehicular traffic shall be installed in accordance with manufacturer's installation instructions and applicable codes and standards and shall be capable of withstanding anticipated loads as defined by the American Association of State Highway and Transportation Officials (AASHTO).

7.3.5 Storage tank location

7.3.5.1 Restricted locations

Storage tanks and their access openings shall not be located directly under sanitary, waste, or storm drainage piping, or any potential source of contamination. Storage tanks shall not be installed above onsite sewage disposal systems.

7.3.5.2 Protection of water from direct sunlight

Water contained within storage tanks shall be protected from direct sunlight through the use of opaque, UV-resistant materials.

7.3.6 Access

7.3.6.1 General

Access openings shall be located to facilitate the pumping and cleaning of tanks and the servicing and inspection of inlets and outlets. At least one access opening shall be provided to allow inspection and cleaning of the interior of each tank. Access openings shall be secured to prevent unauthorized access. Openings shall be watertight and weatherproof and shall be constructed to prevent entry of vermin and insects and ingress of contaminants.

7.3.6.2 Access openings

Where installed, openings intended for human access shall have a minimum dimension of 0.50 m (20 in) and an area of at least 0.20 m^2 (314 in^2). Access openings shall extend at least 100 mm (4 in) above ground or shall be designed to prevent water infiltration. Finished grade shall be sloped away from the access opening to divert surface water. Access openings and covers shall be secured to prevent unauthorized access and vandalism.

7.3.6.3 Covers

Covers shall be installed over service ports and access openings. Penetrations for wiring or piping shall not be installed on covers.

7.3.6.4 Tank abandonment

When permanently removed from service,

(a) below-ground storage tanks shall be removed or filled with inert material; and

(b) above-ground tanks shall be removed or secured to prevent unauthorized access.

7.3.7 Secondary water supply

7.3.7.1 General

Where an uninterrupted water supply is required for the intended application, a secondary source shall be provided. When installed, secondary water may be supplied by means of a makeup water system to refill the storage tank(s) or a bypass system that provides water directly to the distribution system.

7.3.7.2 Availability and minimum quality

Secondary sources of water supply shall have sufficient capacity to meet the anticipated demand supplied by the rainwater harvesting system. Secondary sources of water shall meet the minimum quality for the intended use as required in Clause 8. Where rainwater harvesting systems supply water for potable uses, secondary water supplies shall be potable.

7.3.7.3 Protection against backflow

The secondary water supply shall be protected against backflow in accordance with the plumbing code.

7.3.7.4 Pipes, valves, and fittings

Valves shall be accessible for inspection and maintenance. A full-open manual valve shall be installed on secondary water supply lines upstream of automatic level control or diverter valves for servicing and maintenance. Secondary water piping, joints, fittings, and valves shall be designed and installed in accordance with the plumbing code for the intended end use.

7.3.7.5 Makeup water supply systems

Where makeup water is utilized, it shall be provided to rainwater harvesting systems to maintain minimum water levels within the storage tank. Makeup water supply systems shall use automatic level control valves to maintain the minimum water level in the tank for uninterrupted operation. The automatic level controls shall limit the makeup water level below the tank overflow.

7.3.7.6 Secondary directly-connected water supply

Secondary directly-connected water supplies shall be connected to the distribution system to maintain the water supply and sized to meet the maximum anticipated demand of the end use. Where an automatic secondary directly-connected water supply is utilized, an alert shall be provided in accordance with Clause 6.7.5 indicating when the secondary directly-connected water supply system is in operation.

7.3.8 Tank overflows

7.3.8.1 General

Storage tanks shall be equipped with an overflow not less than the capacity of the inlet(s). No single overflow pipe shall be less than 50 mm (2 in) in diameter.

7.3.8.2 Insect and vermin control

Tank overflow pipes shall be protected from insects and vermin.

7.3.8.3 Distance and direction

Tank overflow pipes shall discharge directed away from the tank and in accordance with the plumbing code. Drainage from tank overflow pipes shall be directed to prevent a hazardous condition.

7.3.8.4 Shutoff valves

Shutoff valves shall not be installed in tank overflow piping.

7.3.8.5 Cleanouts

Cleanouts shall be provided on each tank overflow pipe in accordance with the plumbing code.

7.3.8.6 Backwater valves

Tank overflows directly connected to sanitary or storm drainage systems shall have a means to prevent backflow.

7.3.9 Tank connections and penetrations

7.3.9.1 General

All inlets and outlets on storage tanks shall be installed and supported in accordance with the manufacturer's instructions. Flanged connections, when used, shall be at least Class 150 as specified in ASME B16.5.

7.3.9.2 Rainwater inlets

Rainwater inlets shall be constructed and arranged to minimize turbulence and disturbance of sediment within the storage tank.

7.2.3.9.3 Rainwater outlets

Rainwater outlets and pump suction shall be located at least 100 mm (4 in) above the bottom of the storage tank and shall not skim water from the surface. Floating outlets, when used, shall be tethered to the top of the tank to prevent the intake from coming within 100 mm (4 in) of the bottom of the tank with changes to the water level.

7.3.9.4 Controlled flow outlets

Where rainwater harvesting systems are used for stormwater management and detention, a controlled flow outlet shall be provided utilizing an orifice or flow restrictor sized to control the release rate from the rainwater harvesting system in accordance with the plumbing code. Controlled flow outlets shall not supersede the overflow requirements specified in Clause 7.3.8.

7.3.9.5 Pipe penetrations

Pipe penetrations through tank walls shall be watertight and shall comply with the plumbing code. Piping penetrations shall not impede access to the tank.

7.3.9.6 Interconnection of multiple tanks

Where multiple tanks are interconnected, piping connections shall be made with compliant fittings and installed in a manner that provides adequate flexibility to allow for tank settlement or movement.

7.3.9.7 Electrical penetrations

Electrical penetrations through tank walls shall
(a) be made above the highest water level in the tank (i.e., above the highest overflow);
(b) be watertight;
(c) comply with the electrical code; and
(d) not impede access to the tank.

7.3.10 Venting

7.3.10.1 General

Tanks shall be vented
(a) through a vent or overflow piping; and
(b) directly to the atmosphere.

7.3.10.2 Vent pipes

Vent pipes shall
(a) be protected from contamination by means of a cap or U-bend installed with the opening directed downward;
(b) extend not less than 150 mm (6 in) above grade or as necessary to prevent surface water from entering the storage tank;
(c) be protected against the entrance of vermin and insects in accordance with Clause 5.1.8; and
(d) not have air admittance valves installed.

7.3.11 Draining of tanks

All tanks shall be provided with a means to drain or empty the tank utilizing a gravity drain or pump. Where tanks are provided with a gravity drain, tank drain pipe(s) shall discharge as required for the overflow pipe(s). The gravity drain or pump discharge shall not be less than 50 mm (2 in) in diameter.

7.3.12 Tank marking and signage

7.3.12.1 Markings

Tanks for rainwater harvesting systems shall have at least the following markings:

(a) the rated capacity;

(b) for storage tanks containing non-potable water, the words "CAUTION: NON-POTABLE WATER - DO NOT DRINK"*.;

(c) where openings allow for the entry of personnel, the words "DANGER - CONFINED SPACE" † and a warning indicating the need for procedures for safe entry into confined spaces.

**The equivalent French wording is "ATTENTION: EAU NON POTABLE – NE PAS BOIRE" and the equivalent Spanish wording is "ATENCIÓN: AGUA NO POTABLE – NO BEBER".*

†The equivalent French wording is "DANGER - ESPACE CONFINÉ" and the equivalent Spanish wording is "PELIGRO - ESPACIO REDUCIDO".

7.3.12.2 Marking characteristics

Markings shall be indelibly printed on exterior tank walls or on a tag or sign constructed of a corrosion-resistant, waterproof material mounted on the tank in a visible location.

7.3.12.3 Letter size

The letters of the labels and markings shall be at least 13 mm (0.5 in) in height and shall be of a color that contrasts with the background on which they are printed.

7.3.13 Ladders, balconies, and platforms

Interior and exterior ladders, platforms, and balconies on tanks shall comply with NFPA 22.

7.4 Treatment and disinfection subsystems

7.4.1 General

Potable water systems shall be equipped with a fail-safe mechanism that will trigger an alarm in accordance with Clause 6.7.5 and turn the supply off should the treatment system malfunction.

7.4.2 Sampling ports

Sampling ports shall be installed to facilitate verification of the operation of each filtration and disinfection process.

7.4.3 Filtration systems

Collected rainwater shall be filtered as required for the intended end use as specified in Clause 8. Filters shall

(a) be installed in accordance with the plumbing code;

(b) be accessible for inspection and maintenance;

(c) utilize a pressure gauge or other acceptable method to provide indication when it requires servicing or replacement; and
(d) have shutoff valves installed immediately upstream and downstream to allow for isolation during maintenance.

7.4.4 Disinfection systems

Where the intended end use requires disinfection, rainwater shall be disinfected to ensure that the required water quality is delivered at the point of use, as specified in Clause 8. Disinfection systems shall be designed and installed in accordance with manufacturer's instructions and the plumbing code.

7.4.4.1 UV disinfection systems

7.4.4.1.1 General

UV disinfection systems shall treat water for distribution downstream of the storage tank and upstream of the point of end use. For potable water applications, UV disinfection systems shall be certified to Class A of NSF/ANSI 55.

Where low UVT precludes the use of NSF/ANSI 55 compliant devices, alternative UV treatment systems shall be used as approved by the authority having jurisdiction.

Where rainwater harvesting systems employ day tanks, UV disinfection may be applied upstream of the day tank, provided measures are taken to maintain the required water quality.

7.4.4.1.2 UV Disinfection system sizing

UV disinfection systems shall be sized based on the required dose taking into consideration the design flow and minimum UVT that is required for the disinfection specified for the end uses.

7.4.4.1.3 Filtration for UV systems

Filtration of 5 µm or less shall be installed upstream of the UV disinfection system.

7.4.4.2 Chemical disinfection systems

7.4.4.2.1 General

Rainwater harvesting systems that employ chemical disinfection shall produce treatment levels in accordance with the requirements specified in Clause 8. Chemical feed and dosing systems shall be installed in accordance with the manufacturer's specifications.

7.4.4.2.2 Filtration for chemical disinfection systems

Filtration shall be installed upstream of the chemical disinfection system and in accordance with manufacturer's installation requirements.

7.4.4.2.3 Measurement and control for chemical disinfection systems

Chemical disinfection systems shall have means to measure and control the disinfection and oxidation levels within the treated water to comply with the treatment levels specified in Clause 8. Chemical feed pumps shall be controlled to prevent operation unless there is flow through the system.

7.4.4.2.4 Chlorine disinfection systems

Chemicals used in chlorine disinfection systems shall comply with NSF/ANSI 60.

7.4.4.2.5 Free chlorine residual

When provided, free chlorine residual in the distribution system shall be maintained between 0.5 and 4.0 mg/L.

7.4.5 Microfiltration and ultrafiltration systems

When used, microfiltration or ultrafiltration systems shall be installed between the storage tank and the point of end use. Microfiltration and ultrafiltration systems shall be sized based on the design flow and installed in accordance with Clause 7.4.3 and the manufacturer's installation requirements.

7.5 Distribution systems

7.5.1 General

Distribution systems shall be designed and installed in accordance with the plumbing code for the intended application. Distribution piping shall be identified and marked in accordance with the plumbing code.

Note: *Irrigation piping is excluded from the scope of this Standard.*

7.5.2 Water pressure-reducing valves or regulators

Where the water pressure supplied by the pumping system exceeds 550 kPa (80 psi) static, a pressure-reducing valve shall be installed to reduce the pressure in the rainwater distribution system piping to 550 kPa (80 psi) static or less. Pressure-reducing valves shall be specified and installed in accordance with the plumbing code.

7.5.3 Materials, joints, and connections

Distribution piping, fittings, joints and connections shall comply with the plumbing code.

7.5.4 Pumps

7.5.4.1 General

Pumps used in distribution systems shall be sized for the maximum anticipated end use demand and in accordance with the requirements of the applicable code. Pumps used for potable water applications shall comply with NSF/ANSI 61.

7.5.4.2 Pump controls

The pump controller shall be designed to ensure that pumps shall not operate when there is a low water level or low suction pressure condition. Pump failure alarms or alerts, when provided, shall be in accordance with Clause 6.7.5.

8 Water quality

8.1 Treatment

8.1.1 Minimum performance criteria

Treatment shall comply with Table 8.1, 8.2, 8.3, or 8.4, as applicable based on the end use and source water. Treatment options shall include one of the options listed within each applicable table or another method acceptable to the authority having jurisdiction. Equipment used shall be validated to meet the minimum performance criteria.

8.1.2 Multiple end uses

Where multiple end uses are supplied from a single system, the applicable performance criteria shall be satisfied for each end use.

8.1.3 Multiple sources

Where a rainwater harvesting system uses a combination of roof runoff and stormwater runoff as the source water, either Table 8.2 or 8.4 shall be followed, as applicable.

8.1.4 Control of growth of opportunistic pathogens

Rainwater harvesting systems whose water temperature is anticipated to be between 25 °C and 55 °C (77 °F and 131°F) shall have a means to control the growth of opportunistic pathogens (e.g., *Legionella*, *Pseudomonas aeruginosa*, *Mycobacterium avian* complex). Water supplied for multi-residential and commercial applications shall maintain a chlorine residual of 0.5 mg/L in accordance with Tables 8.3 and 8.4.

Note: *Opportunistic pathogens (e.g.,* Legionella pneumophila*,* Pseudomonas aeruginosa*, and* Mycobacterium avian *complex) grow on storage and plumbing internal surfaces and sediments when water is between 25 °C and 55 °C (77 °F and 131°F). Opportunistic pathogens should be controlled with a point-of-use disinfection device or through a chlorine residual in the water. Regular flushing-out of storage sediments is also good management practice to remove the growth niche of opportunistic pathogens. In-ground storage of water can also reduce opportunistic pathogen growth by keeping stored water at temperatures below 25 °C (77°F).*

8.1.5 Multi-barrier approach

Rainwater harvesting systems shall employ a multi-barrier approach to reduce accumulation, introduction, and re-introduction of contaminants into the system.

TABLE 8.1

ROOF RUNOFF WATER TREATMENT REQUIREMENTS FOR SINGLE-FAMILY RESIDENTIAL APPLICATIONS

Application				Minimum Performance Criteria				Minimum Prescriptive Requirements				
				Log Reduction (% reduction)				Options for post-storage treatment before end use				
								UV††		Chemical-based disinfectants‡‡		
End Use Tier	**Category**	**Potential for Human Contact**	**Examples of Uses**	**Viruses**	**Bacteria****	**Protozoa**	**pH**	**Filtration**	**Disinfection**	**Filtration**	**Disinfection**	**Microfiltration or Ultrafiltration**
1	Non-Potable	Low	• Trap Primers • Spray irrigation (restricted access or exposure) • Surface and subsurface irrigation (drip, bubbler) • Fire suppression • Ice rinks	0	0	0	-	None§				
2	Non-Potable	Medium	• Toilet and urinal flushing • Clothes washing • HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling) • Rooftop thermal cooling	0*	2 (99%)	2 (99%)	-	5 µm	16 mJ/cm^2	NR†**	NR†**	0.5 µm‡
3	Non-Potable	High	• Hose bibbs	0*	3	3	-	5 µm	30 mJ/cm^2	NR†**	NR†**	0.5 µm‡

			• Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access or exposure)		(99.9%)	(99.9%)						
4	Potable	High	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering, and hand washing • Pools, hot tubs, spas, /splash pads • Misting stations • Swamp coolers	0*	6 (99.9999%)	4 (99.99%)	7-10	5 µm	40 mJ/cm² and third-party certified to Class A of NSF/ANSI 55	NR†**	NR†**	0.2 µm‡ third-party certified to NSF/ANSI 53

** It is unlikely that human infectious viruses are present in harvested rainwater sourced from elevated surfaces. If below-ground tanks are used where there is a potential for sewage contamination, a 4 log reduction shall be required in accordance with the WSP.*

† Due to complexity of operation and design, chemical-based disinfection is not recommended for single-family dwellings.

‡ Pre-filters of 5 to 100 µm are recommended to extend the life of the filter.

§ For operational purposes only, it is recommended to use filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm.

*** Due to potential for growth of opportunistic pathogens in plumbing systems (e.g.,* Legionella, Pseudomonas aeruginosa, *and* Mycobacterium avian *complex), water stored at temperatures higher than 25 °C (77°F) for extended periods shall not be used for tiers 2, 3, and 4 unless a chlorine residual of at least 0.5 mg/L is maintained. If chlorine is used, consideration should be given to the potential formation of disinfection by-products.*

†† Filtration and disinfection are both required. Filtration of at least 5 µm is required upstream of the UV disinfection device.

‡‡ Filtration and disinfection are both required.

Note: *A figure depicting the particle size spectrum for filtration is shown in Annex A.*

TABLE 8.2
STORMWATER RUNOFF TREATMENT REQUIREMENTS FOR SINGLE-FAMILY RESIDENTIAL APPLICATIONS

Application				Minimum Performance Criteria				Minimum Prescriptive Requirements				
				Log Reduction (% reduction)				Options for post-storage treatment before end use				
								UV††		Chemical-based disinfectants‡‡		
End Use Tier	Category	Potential for Human Contact	Examples of Uses	Viruses	Bacteria**	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	Microfiltration or Ultrafiltration
1	Non-Potable	Low	• Trap Primers • Spray irrigation (restricted access or exposure) • Surface and subsurface irrigation (drip, bubbler) • Fire suppression • Ice rinks	0	0	0	-	None§				
2	Non-Potable	Medium	• Toilet and urinal flushing • Clothes washing • HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling) • Rooftop thermal cooling	4*	2 (99%)	2 (99%)	-	5 µm	16 mJ/cm^2	NR†**	NR†**	0.5 µm‡
3	Non-Potable	High	• Hose bibbs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access or exposure)	4*	3 (99.9%)	3 (99.9%)	-	5 µm	30 mJ/cm^2	NR†**	NR†**	0.5 µm‡
4	Potable	High	• Human consumption	Not in the scope of this Standard								

			• Oral care • Food preparation • Dishwashing • Bathing, showering, and hand washing • Pools, hot tubs, spas, and splash pads • Misting stations • Swamp coolers	

***** *It is unlikely that human infectious viruses are present in harvested rainwater. For below-ground tanks where there is a potential for sewage contamination, a 4 log reduction shall be required in accordance with the WSP.*

† *Due to complexity of operation and design, chlorine-based disinfection is not recommended for single-family dwellings.*

‡ *Pre-filters of 5 to 100 µm are recommended to extend the life of the filter.*

§ *For operational purposes only, it is recommended to use filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm.*

** *Due to potential for growth of opportunistic pathogens in plumbing systems (e.g.,* Legionella, Pseudomonas aeruginosa*, and* Mycobacterium avian *complex), water stored at temperatures higher than 25 °C (77°F) for extended periods shall not be used for tiers 2, 3, and 4 unless a chlorine residual of at least 0.5 mg/L is maintained. If chlorine is used, consideration should be given to the potential formation of disinfection by-products.*

†† *Filtration and disinfection are both required. Filtration of at least 5 µm is required upstream of the UV disinfection device.*

‡‡ *Filtration and disinfection are both required.*

Note: *A figure depicting the particle size spectrum for filtration is shown in Annex A.*

TABLE 8.3
ROOF RUNOFF WATER TREATMENT REQUIREMENTS FOR MULTI-RESIDENTIAL AND NON-RESIDENTIAL APPLICATIONS

Application				Minimum Performance Criteria				Minimum Prescriptive Requirements				
				Log Reduction (% reduction)				Options for post-storage treatment before end use				
								UV‡‡		Chemical-based disinfectants§§		
End Use Tier	Category	Potential for Human Contact	Examples of Uses	Viruses	Bacteria**	Protozoa	pH	Filtration	Disinfection	Filtration	Disinfection	Microfiltration or Ultrafiltration
1	Non-Potable	Low	• Trap primers • Spray irrigation (restricted accessor exposure) • Surface and subsurface irrigation (drip, bubbler) • Fire suppression • Ice rinks	0	0	0	-	None§				
2	Non-Potable	Medium	• Toilet and urinal flushing • Clothes washing • Rooftop thermal cooling	0*	2 (99%)	2 (99%)	-	5 µm	16 mJ/cm^2	1 µm absolute**	CT for 2 Log reduction for bacteria and at least 0.5 mg/L chlorine residual**	0.5 µm‡ with at least 0.5 mg/L chlorine residual
			• HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray cooler, direct and indirect evaporative cooling)	Treatment shall consider equipment manufacturer water quality requirements and designed in accordance to ANSI/ASHRAE 188								

3	Non-Potable	High	• Hose bibbs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access or exposure)	0*	3 (99.9%)	3 (99.9%)	-	5 µm	30 mJ/cm^2 with at least 0.5 mg/L chlorine residual	1 µm absolute**	CT for 3 Log reduction for bacteria and at least 0.5 mg/L chlorine residual**	0.5 µm‡ with at least 0.5 mg/L chlorine residual
4††	Potable	High	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering, and hand washing • Pool/hot tubs/spas/splash pads • Misting stations • Swamp coolers	0*	6 (99.9999%)	4 (99.99%)	7-10	5 µm	40 mJ/cm^2 and third-party certified to Class A of NSF/ANSI 55 or validated to U.S. EPA UVDGM or DVGW W294 with at least 0.5 mg/L chlorine residual	1 µm absolute**	CT for 6 Log reduction for bacteria† and at least 0.5 mg/L chlorine residual**	0.2 µm‡ third-party certified to NSF/ANSI 53 with at least 0.5 mg/L chlorine residual

** It is unlikely that human infectious viruses are present in harvested rainwater. For below-ground tanks where there is a potential for sewage contamination, a 4 log reduction shall be required in accordance with the WSP.*

† Depending on source water quality, consideration should be given to the potential formation of disinfection by-products.

‡ Pre-filters of 5 to 100 µm are recommended to extend the life of the filter.

§ For operational purposes only, it is recommended to use filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm.

*** Due to potential for growth of opportunistic pathogens in plumbing systems (e.g.,* Legionella, Pseudomonas aeruginosa, *and* Mycobacterium avian *complex), a chlorine residual of at least 0.5 mg/L shall be maintained.*

†† The authority having jurisdiction might specify additional requirements for public drinking water supplies.

‡‡ Filtration and disinfection are both required. Filtration of at least 5 µm is required upstream of the UV disinfection device.

§§ Filtration and disinfection are both required.

Notes:

(1) *CT = disinfectant concentration times the contact time.*

(2) *A figure depicting the particle size spectrum for filtration is included in Annex A.*

TABLE 8.4

STORMWATER RUNOFF TREATMENT REQUIREMENTS FOR MULTI-RESIDENTIAL AND NON-RESIDENTIAL APPLICATIONS

Application: End Use Tier	Application: Category	Application: Potential for Human Contact	Application: Examples of Uses	Minimum Performance Criteria: Log Reduction (% reduction): Viruses	Minimum Performance Criteria: Log Reduction (% reduction): Bacteria**	Minimum Performance Criteria: Log Reduction (% reduction): Protozoa	Minimum Performance Criteria: pH	Minimum Prescriptive Requirements (Options for post-storage treatment before end use): UV††: Filtration	UV††: Disinfection	Chemical-based disinfectants‡‡: Filtration	Chemical-based disinfectants‡‡: Disinfection	Microfiltration or Ultrafiltration
1	Non-Potable	Low	• Trap primers • Spray irrigation (restricted access or exposure) • Surface and subsurface irrigation (drip, bubbler) • Fire suppression • Ice rinks	0	0	0	-	None§				
2	Non-Potable	Medium	• Toilet and urinal flushing • Clothes washing • Rooftop thermal cooling	4 (99.99%)	4 (99.99%)	3 (99.9%)	-	5 µm	40 mJ/cm² and third-party certified to Class A of NSF/ANSI 55 or validated to U.S. EPA UVDGM or DVGW W294 with at least 0.5 mg/L chlorine residual	1 µm absolute**	CT for 4 Log reduction for bacteria and at least 0.5 mg/L chlorine residual**	0.5 µm‡ with at least 0.5 mg/L chlorine residual
			• HVAC evaporative cooling (e.g., cooling tower, evaporative condenser, spray	Treatment shall consider equipment manufacturer water quality requirements and designed in accordance with ANSI/ASHRAE 188								

			cooler, direct and indirect evaporative cooling)									
3	Non-Potable	High	• Hose bibbs • Pressure washing • Decorative fountains • Vehicle washing • Spray irrigation (non-restricted access/exposure)	4 (99.99%)	4 (99.99%)	3 (99.9%)	-	5 µm	40 mJ/cm^2 and third-party certified to Class A of NSF/ANSI 55 or validated to U.S. EPA UVDGM or DVGW W294 with at least 0.5 mg/L chlorine residual	1 µm absolute**	CT for 4 Log reduction for bacteria and at least 0.5 mg/L chlorine residual**	0.5 µm‡ with at least 0.5 mg/L chlorine residual
4	Potable	High	• Human consumption • Oral care • Food preparation • Dishwashing • Bathing, showering, and hand washing • Pools, hot tubs, spas, splash pads • Misting stations • Swamp coolers	Not in the scope of this Standard								

‡ *A pre-filter of 5 to 100 µm is recommended to extend the life of the filter.*

§ *For operational purposes only, it is recommended to use filters smaller than 500 µm, or, for drip irrigation only, filters smaller than 100 µm.*

** *Due to potential for growth of opportunistic pathogens in plumbing systems (e.g.,* Legionella, Pseudomonas aeruginosa, *and* Mycobacterium avian *complex), a chlorine residual of at least 0.5 mg/L shall be maintained.*

†† *Filtration and disinfection are both required. Filtration of at least 5 µm is required upstream of the UV disinfection device.*

‡‡ *Filtration and disinfection are both required.*

Notes:

(1) *CT = disinfectant concentration times the contact time.*

(2) *A figure depicting the particle size spectrum for filtration is included in Annex A.*

8.2 Water quality verification and substantiation

8.2.1 General

To ensure the rainwater harvesting system equipment is operating effectively and as intended to meet the minimum performance criteria specified in Table 8.1, 8.2, 8.3, or 8.4, a water quality verification and substantiation program shall be implemented as required by the WSP (see Clause 5.1.2). The water quality verification and substantiation program shall include at least the following elements:

(a) inspection and monitoring of equipment, processes, and controls to verify effective system operation;
(b) inspection, monitoring, and cleaning of collection surfaces, conveyance piping, equipment, and storage tanks; and
(c) for multi-residential and non-residential only, a water quality monitoring program.

8.2.2 Single-family residential applications

Any filter, UV lamp, or other consumable component shall be replaced in accordance with the manufacturer's recommendations. If output water changes in clarity or odour, filters should be replaced and any sediment in the storage tank should be flushed or pumped out.

8.2.3 Multi-family residential applications

Any filter, UV lamp or other consumable component shall be replaced in accordance with the manufacturer's recommendations. Water quality monitoring shall include weekly measurement of turbidity and UVT of water leaving the treatment system, chlorine residual at the point of use and, for systems serving 500 or more people, grab samples for HPC and culturable enterococci to ensure treatment processes are operating within control limits. Where treatment processes are not operating within control limits, corrective action shall be taken.

8.2.4 Commercial applications

Any filter, UV lamp, or other consumable component shall be replaced in accordance with the manufacturer's recommendations. Water quality monitoring shall include weekly measurement of turbidity and UVT of water leaving the treatment system, chlorine residual at the point of use and grab samples for HPC, and culturable enterococci to ensure treatment processes are operating within control limits. Where treatment processes are not operating within control limits, corrective action shall be taken.

8.2.5 Water quality substantiation

Water quality results that meet the limits outlined in Table 8.5 or 8.6, as required by the end use and source, shall substantiate that hazards are being effectively controlled. Corrective action shall be taken if output water quality requirements are not met.

The values in Table 8.5 or 8.6 are provided only as suitable indicator parameters to substantiate system performance and shall not be used as the only or primary criteria for the design of a treatment system.

TABLE 8.5

OUTPUT WATER QUALITY REQUIREMENT FOR APPLICATIONS USING WATER SOURCED FROM ROOF COLLECTION SURFACES

End Use Tier	Parameter	Turbidity (NTU)	HPC (CFU/100 mL)	Enterococci (CFU/100 mL)	pH‡	Chlorine§	
						CMF (mg/L)	SFR (mg/L)
1	Median		NT				-
	Maximum		-		-		-
2*	Median	<1	<500§	≤5		0.5 – 2§	
	Maximum	5	-	<15			-
2†	Median	-	<500§	NT	7-8.2		-
	Maximum	-	-	-	-		-
3	Median	≤1	<500§	<5		0.5 – 2	
	Maximum	5	-	<15	-		-
4	-	Refer to applicable drinking water standards and guidelines from the authority having jurisdiction					

** Excluding evaporative cooling.*

† Evaporative cooling only.

‡ A pH of less than 7 can be a concern for piping, fittings, and other equipment but a required value is not set for most uses.

§ For systems supplying water to less than 25 people, UV disinfection can be used instead of chlorine.

Notes:

(1) *For systems serving a single-family dwelling, there is no requirement to undertake microbiological testing, however the system must be physically examined upon installation and periodically thereafter.*

(2) *Methods shall follow* APHA Standard Methods for the Examination of Water and Wastewater *or U.S. EPA-approved methods.*

TABLE 8.6
OUTPUT WATER QUALITY REQUIREMENTS FOR APPLICATIONS USING WATER SOURCED FROM GROUND LEVEL COLLECTION SURFACES

Tier	Parameter	Turbidity (NTU)	HPC (CFU/100 mL)	*E. coli* (CFU/100 mL)	Enterococci (CFU/100 mL)	*Bacteroides* HF183 & HumM2 Markers (GE/100 mL)	pH‡	Chlorine	
								CMF (mg/L)	SFR (mg/L)
1	Median	-	-					-	-
	Maximum		-				-	-	-
2*	Median	≤2	<500	≤10	≤5	<60		0.5 – 2	0.5 – 2
	Maximum	5	-	<200	<70	<100		-	-
2†	Test Ave.	-	<500	NT	NT	NT	7-8.2	-	-
	Maximum	-	-	-	-	-	-	-	-
3	Test Ave.	≤1	<500	<100	<35	<60		0.5 - 2	0.5 - 2
	Maximum	5	-	<200	<100	<100	-	-	-
4	-	Not permitted							

** Excluding evaporative cooling.*
† Evaporative cooling only.
‡ A pH of less than 7 can be a concern for piping, fittings, and other equipment but a required value is not specified for most uses.

9 Rainwater system tests and inspections

9.1 Testing for non-potable water distribution system cross-connection

9.1.1 General

Potable water distribution systems supplying water to rainwater harvesting systems shall be tested for cross-connections in accordance with Clauses 9.1.2 and 9.1.3, upon construction and after any modifications.

9.1.2 Cross-connection testing for water distribution systems

Water distribution systems shall be tested for cross-connection as follows:
(a) Fill the water storage tank with sufficient potable water to conduct the test.
(b) Ensure the water supply from the storage tank remains active.
(c) Deactivate and drain the water in the potable water system.
(d) Confirm that potable water is no longer supplied after the system has been drained.

Note: *If a potable outlet keeps running, then it might not be connected to the correct water supply system and the plumbing system should be reconfigured.*

(e) Activate the non-potable water system outlets and confirm that water from the storage tank is provided continuously.

Note: *If a non-potable outlet does not flow, then it might not be connected to the proper water supply system and the plumbing system should be reconfigured.*

9.1.3 Post-test reconnection

After conducting the test specified in Clause 9.1.2,

(a) all potable and non-potable outlets shall be closed;

(b) the water system shall be restored to normal operation; and

(c) any air trapped in the water system shall be purged.

9.2 First-flush diversion test

First-flush diverters shall be inspected and tested by introducing water into the device. Proper diversion of the first quantity of water shall be verified.

9.3 Collection pipe and vent test

Drain, waste, and vent piping used for rainwater collection and conveyance systems shall be tested in accordance with the plumbing code.

9.4 Tank test

Storage tanks shall be tested as follows:

(a) Tanks shall be filled with water to the overflow outlet prior to and during inspection. All seams and joints shall be left exposed and the tank shall remain watertight without leakage for at least 24 h before completing subsequent tests;

(b) Overflow systems shall be inspected for proper operation. Additional water shall be introduced for a period of 15 min at a rate similar to the anticipated influent flow to verify proper drainage through the overflow system without leaks;

(c) Tank drains shall be inspected and tested for proper operation; and

(d) Makeup water systems, when provided, shall be inspected and tested for proper operation of the automatic control valves, level controls, and alarms.

9.5 Water supply system test

The testing of makeup water supply piping and distribution piping shall be conducted in accordance with the plumbing code.

9.6 Inspection and testing of backflow prevention assemblies

The testing of backflow preventers shall be conducted in accordance with the plumbing code. In the absence of code requirements, backflow preventers shall be tested in accordance with CSA B64.10.1.

9.7 Inspection of vermin and insect protection

Inlets and vents to the system shall be inspected to verify each is protected to prevent the entrance of insects and vermin into the storage tank and piping systems in accordance with Clause 5.1.8.

9.8 Water quality

Water supplied to an end use shall be verified to meet the minimum water quality requirements for the intended application as specified in Clause 8. The quality of the water for the intended application shall be verified at the point of use in accordance with the requirements of this Standard and the applicable codes.

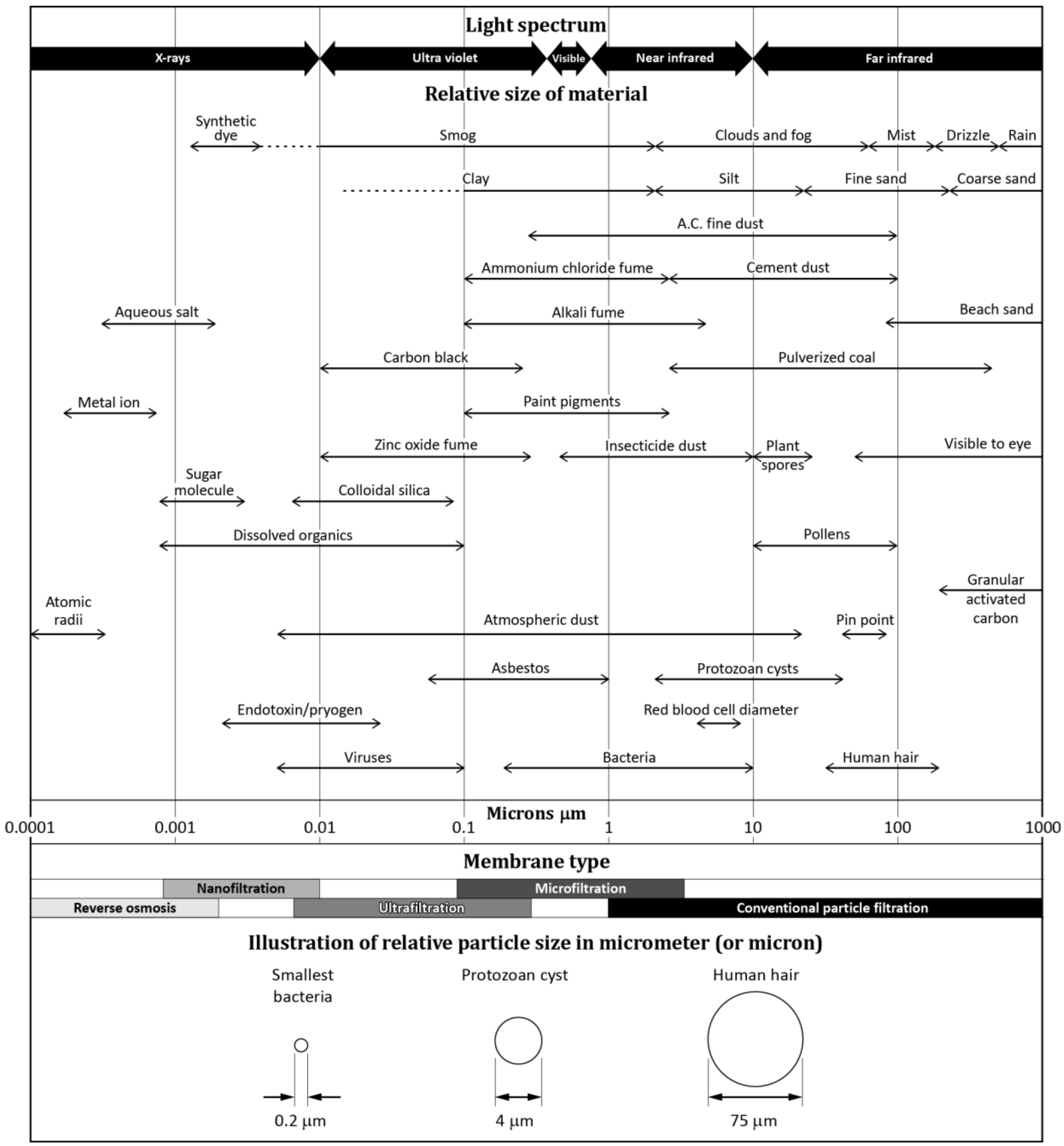
Annex A
Particle Size Spectrum

Note: *This Annex is an informative (non-mandatory) part of this Standard.*

A.1 Particle size spectrum for filtration

Figure A.1 shows a comparison of particle sizes for different substances.

FIGURE A.1
PARTICLE SIZE SPECTRUM



Annex B

Suggested Evaporative Cooling Water Quality Control Levels

Note: *This Annex is an informative (non-mandatory) part of this Standard.*

B.1 General

The suggested evaporative cooling water quality control levels are specified in Table B.1. Where an evaporative cooling equipment manufacturer specifies a different water quality control level, it should take precedence over the suggested water quality control levels provided in Table B.1

TABLE B.1

SUGGESTED EVAPORATIVE COOLING WATER QUALITY CONTROL LEVELS

Parameter	Unit	Suggested Limits
BOD_5	mg/L	<50
TSS	mg/L	<25
Alkalinity, as $CaCO_3$	mg/kg (ppm)	75-400
Total Hardness, as $CaCO_3$	mg/kg (ppm)	<1000
Chlorides	mg/kg (ppm)	<250
Silica	mg/kg (ppm)	<150
Copper	mg/kg (ppm)	<10
Iron	mg/kg (ppm)	<3
TDS	mg/kg (ppm)	<3000
Conductivity	µS/cm	<3000
pH	--	7-8.8
Total Coliform	per 100 mL	<10,000

Annex C

Prescriptive Tank Requirements

Note: *This Annex is a normative (mandatory) part of this Standard.*

C.1 Precast concrete tank requirements

C.1.1 Materials

C.1.1.1 Freeze-thaw

Concrete for tanks exposed to freeze-thaw conditions shall be mixed with 4% to 7% entrained air.

C.1.1.2 Sulphate soils

Concrete for tanks exposed to moderate or high sulphate soils shall be rated for resistance to sulphate exposure, as appropriate.

C.1.1.3 Potable water applications

, Tanks intended for potable water applications and all associated components (e.g., sealants, fittings, and linings contacting collected water), shall comply with the applicable requirements of NSF/ANSI 61. Non-toxic form release agents shall be used in the production of all molded components installed on tanks for potable water applications.

C.1.2 Field testing

Field testing shall be in accordance with the tank manufacturer's instructions.

C.2 Modular plastic tanks

C.2.1 Materials

Tanks intended for potable and non-potable water applications shall be manufactured with recycled or virgin polymers complying with the applicable requirements of NSF/ANSI 61 and ASTM D1998, respectively. Injection molded products shall use polymer material tested in accordance with ASTM D1621.

C.2.2 Design life

The design life of a polymer tank shall be determined in accordance with the life expectancy of the specific project.

C.2.3 Below-ground tanks

Where water is introduced into the tank through infiltration, the soil mix and plant material shall be selected to provide required infiltration rates and shall not contain contaminants.

C.3 Flexible tanks

Note: *Flexible tanks are known as "pillow tanks" and "bladder tanks".*

C.3.1 Materials

Materials for flexible tanks shall comply with the requirements specified in Table C.1. Flexible tanks used for potable water applications shall comply with NSF/ANSI 61.

TABLE C.1
REQUIREMENTS FOR FLEXIBLE TANK MATERIALS

Property	Requirements	Test Conditions	Test Method
Tear strength	Minimum 133/133 N (30/30 lbf)		ASTM D751 Trap Tear
Breaking yield strength	Minimum 1110/890 N (250/200 lbf)		ASTM D751 Grab tensile
Hydrostatic resistance	Minimum 2.07 MPa (300 psi)		ASTM D751, Procedure A
Low temperature resistance	Pass -32 °C (-25°F)	1/8 in mandrel, 4 h	ASTM D2136
Dimensional stability	Maximum 5% in each direction	100 °C (212°F), 1 h	ASTM D1204
Bursting strength	Minimum 1557 N (350 lbf)		ASTM D751, Ball Tip
Blocking resistance	Maximum #2 Rating	82 °C (180°F)	ASTM D751
Adhesion-ply	Minimum 2.1 kN/m (12 lbf/in)		ASTM D413, Type A
Abrasion resistance	Minimum 2,000 cycles before fabric exposure and maximum weight loss of 50 mg/100 cycles	H-18 Wheel, 1 kg load	ASTM D3389
Water absorption	Maximum $0.05\ kg/m^2$ at 21 °C (70°F) and $0.28\ kg/m^2$ at 100 °C (212°F)	7 d	ASTM D471, Section 12
Wicking	Maximum 3.2 mm (0.125 in)		ASTM D751
Puncture resistance	Minimum 225 N (50 lbf)		ASTM D4833
	Minimum 912 N (205 lbf)		FTM STD. No. 101C (Method 2065)

C.3.2 Seams

Seams shall be made watertight using radio frequency, heat bonding, or equivalent methods and shall comply with the applicable requirements specified in Table C.2, depending on the fabric and seam type.

TABLE C.2
MINIMUM REQUIREMENTS FOR FLEXIBLE TANK SEAMS

Test	Minimum Requirements	Test Method
Adhesion heat welded seam	1.75 kN/m (10 lbf/in)	ASTM D751, Dielectric Seam
Dead load seam strength	17.5 kN/m (100 lbf/in) at 21 °C (70°F) and 8.75 kN/m (50 lbf/in) at 70 °C (160°F)	ASTM D751
Bonded seam strength	1,112 N (250 lbf)	ASTM D751, Grab Test Method, Procedure A

C.3.3 Fittings

C.3.3.1 Reinforcement patches

Fitting ports shall be reinforced with patches made of the same material used in the manufacture of the flexible tank. Patches shall be thermally welded to the flexible tank.

C.3.3.2 Location

Fittings shall be located at least 200 mm (8 in) from seams.

C.3.3.3 Bulkhead fittings

Bulkhead fittings shall be bolt-on.

C.3.3.5 Flexible piping or tubing

Side and top fittings shall be connected to a section of flexible pipe or tubing that is sufficiently long to compensate for tank flexing without imparting excessive stress on the piping or tank.

C.3.4 Installation

Flexible tanks shall be installed on level and smooth surfaces.

C.4 Wooden tanks

C.4.1 Materials

Lumber for wood bottoms and wood staves for the manufacturing of wooden tanks shall be of decay resistant species, untreated, and as specified in the USDA Wood Handbook or the NWTI Technical Bulletin S-82. Acceptable lumber species are as follows:

(a) Western Red Cedar;

(b) Alaskan Yellow Cedar;
(c) Atlantic White Cedar;
(d) Coast-Type Douglas Fir;
(e) White Oak;
(f) Red Cypress; and
(g) Other wood species, including imported species may be used provided they comply with the requirements of NWTI Bulletin S-82.

C.4.2 Binding elements

Binding elements (e.g., reinforcing hoops, hoop lugs, and nuts), shall meet the strength requirements of ASTM A36, ASTM A592, or ASTM A675, as applicable, and shall be made of ductile iron, mild steel, hot dipped galvanized steel, or stainless steel. Different materials shall be acceptable provided that they comply with the ultimate strength design for the intended application.

C.4.3 Liners

Wooden tanks subject to prolonged periods without water shall utilize a flexible liner appropriate for the application. Liners for tanks intended for potable water applications shall comply with NSF/ANSI 61.

C.4.4 Installation

Wooden tanks shall be installed aboveground and rest on timbers at least of 100 x 150 mm (4 x 6 in) in a structural or dense grade adequate to support the weight of the tank when full. The timbers (dunnage) shall provide at least a 19 mm (0.75 in) air space below the bottom of the staves and the ground to provide air circulation under the tanks. Wooden tanks shall not be used for underground installations.

C.4.5 Testing

Wooden tanks shall be tested with water and verified to be watertight for a period of at least 48 h without adjustments. The tank shall be allowed to continue swelling for an additional six days. Moisture on the outside surface of a wood tank that disappears or evaporates without forming a drip shall not be considered a leak.

Annex D

Tank Sizing and Capacity Calculation Methodologies

Notes:

(1) *This Annex is an informative (non-mandatory) part of this Standard.*

(2) *This informative (non-mandatory) Annex has been written in normative (mandatory) language to facilitate adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.*

D.1 Minimum capacity of storage tank

The minimum capacity of rainwater storage tanks shall be determined in accordance with the requirements of the authority having jurisdiction and calculated using the following equation with all values in consistent units:

$$TC = OWD + FR + EI + SW + SLV$$

where:

TC = minimum tank capacity, L (gal)

OWD = output water demand storage, L (gal)

FR = dedicated fire reserve storage volume, L (gal)

EI = environmental initiative storage, L (gal)

SW = stormwater detention (management) volume, L (gal)

SLV = storage loss volume, L (gal)

Note: *If the peak monthly rainwater yield or the peak rainwater event yield volume is less than the minimum tank capacity required, the tank capacity may be reduced to the peak monthly rainwater yield volume without compromising the storage required for a dedicated fire reserve, when applicable.*

D.2 Output water demand storage volume

D.2.1 General

D.2.1.1 Water storage volume determination

The output water demand storage volume shall be determined in accordance with the applicable code or in accordance with the requirements of the authority having jurisdiction, and in accordance with the periodic end use demand for the site. In the absence of requirements specified by the code or the authority having jurisdiction, the output water demand storage volume can be determined by first determining the annual rainwater yield for the site, the end use and its demand (monthly, daily, or hourly), and by verifying whether a secondary water supply will be required.

D.2.1.2 Rainwater yield evaluation

The rainwater yield for the site shall be evaluated for the average annual rainfall and for the peak rainfall, both measured monthly and at any one instance.

D.2.1.3 Output water demand determination

The output water demand shall be determined as required for the project site including potable and non-potable domestic water, irrigation, cooling tower makeup, and grey water uses.

D.2.1.4 Empirical weather data sourcing

The empirical weather data shall be sourced from a nationally-recognized agency providing weather data over a period of at least ten years.

D.2.2 Site rainwater yield

D.2.2.1 Annual and peak rainwater data

The following data shall be utilized to determine the site rainwater yield:

(a) Average annual rainfall data, expressed in mm (in)

(b) Peak monthly rainfall event, expressed in mm (in), noting the month of the year of the event.

Note: *Monthly peaks can differ depending on the location.*

(c) Peak rainfall event in the last five years, measured as total rainfall and rainfall per hour, expressed in mm and mm/h (in and in/h).

The rainfall data fields in Items (a) to (c) shall be compared to the actual output water demand in order to determine the most efficient tank volume required for the project.

D.2.2.2 Annual rainwater yield

Annual rainwater yield shall be determined in accordance with the method(s) specified by the authority having jurisdiction. In absence of such requirements, the annual rainwater yield shall be calculated using the following equation:

$$ARY = (AAR - F_{abs})AC_w$$

where:

ARY = annual rainwater yield, m^3 (ft^3)

AAR = average annual rainfall, m (ft)

F_{abs} = rainfall abstraction associated with pre-storage filtration or first-flush diverter, m (ft)

A = catchment area, m^2 (ft^2)

C_w = weighted runoff coefficient, based upon the surface on which it is collected

When rainwater is collected from surfaces with more than one runoff coefficient, the equation in Clause D.4.5 shall be used to determine the weighted runoff coefficient.

Note: *F_{abs} is the amount of rainfall that is lost from absorption into roof surfaces or the amount of water that is lost due to the operation of first-flush diverters (i.e., it will collect the first 2 mm of rainfall and prevent them from reaching the tank). It is usually expressed in millimetres or inches. The manufacturer or supplier should be consulted to obtain F_{abs}.*

D.2.2.3 Peak monthly rainwater yield

Peak monthly rainwater yield shall be determined in accordance with the method(s) specified by the authority having jurisdiction. In the absence of such requirements, the peak monthly rainwater yield shall be calculated using the following equation:

$$PMRY = (PM - F_{abs})AC_w$$

where:

PMRY = peak monthly rainwater yield, m^3 (ft^3)

PM = peak monthly rainfall, m (ft)

Note: *The peak monthly rainfall should be based on the month with the heaviest rainfall.*

F_{abs} = rainfall abstraction associated with pre-storage filtration or first-flush diverter, m (ft)

A = catchment area, m^2 (ft^2)

C_w = weighted runoff coefficient, based upon the surface on which it is collected

When rainwater is e collected from surfaces with more than one runoff coefficient, the equation in Clause D.4.4 shall be used to determine the weighted runoff coefficient.

D.2.2.4 Peak rainfall event yield

Peak rainfall event yield shall be determined in accordance with the methods specified by the authority having jurisdiction. In the absence of such requirements, peak rainfall event yield shall be calculated using the following equation:

$$PRE = (PR - F_{abs})AC_w$$

where:

PRE = peak rainfall event, m^3 (ft^3)

PR = peak rainfall, m (ft)

F_{abs} = rainfall abstraction associated with pre-storage filtration or first flush diverter, m (ft)

A = catchment area, m^2 (ft^2)

C_w = weighted runoff coefficient, based upon the surface on which it is collected

When rainwater is collected from surfaces with more than one runoff coefficient, the equation in Clause D.4.5 shall be used to determine the weighted runoff coefficient.

D.2.2.5 Monthly output water demand

The output water demand shall be determined in accordance with the requirements specified by the authority having jurisdiction and in accordance with requirements specified by the manufacturer or the system designer. In the absence of such requirements, the output water demand shall be determined using the following equation:

OWD = RU + CU + IU + EC + OU

where:

OWD = output water demand storage, L (gal) per month

Note: *Add each use to the total output water demand equation as required for the desired end use*

RU = residential use, L (gal) per month

Note: *When meeting both potable and non-potable water demand, residential use is determined by using the population of the household and estimated daily water demand determined by historical data for*

(a) high use: 285 L (75 gal) per day per person; or

(b) low use: 115 L (30 gal) per day per person.

$$RU = Household\ Population\ x \frac{gal}{day\ person} x\ 31\ d$$

CU = commercial use, L (gal per month

Note: *Commercial use is determined by using the population of the building and estimated daily water demand determined by historical data, as follows:*

(a) commercial office, 38 L (10 gal) per day per person;

(b) restaurant, 7.5 L (2 gal) per meal per persn); and

(c) hotel, 115 L (30 gal) per day per person).

$$CU_{Office} = Population\ x \frac{water\ demand}{day\ person} x \frac{days}{month}$$

$$CU_{Restaurant} = \frac{water\ demand}{meal} x \frac{meals}{day} x\ monthly\ days\ of\ operation$$

$$CU_{Hotel} = \frac{water\ demand}{person} x \frac{Avg. population}{room} x\ monthly\ room\ rental$$

IU = irrigation use, L (gal) per month

Note: *Irrigation use is determined by the maximum monthly irrigation demand during the year, usually the demand for July or August. This is based upon regional weather data and evapotranspiration rates of the species being irrigated.*

EC = evaporative cooling use, or L (gal) per month

Notes:

(1) *Evaporative use is determined by using the evaporation rate, drift (i.e., windage) and blowdown rate of the cooling towers or equipment being served.*

$$EC_{Cooling\ Tower} = Evaporation\ Rate + Blowdown + Drift$$

and

$$Evaporation\ Rate = \frac{Condenser\ Water\ Flow\ Rate}{Condenser\ Water\ \Delta T} = CT\ Tonnage\ x\ 3\%$$

$$Blowdown\ = \frac{Evaporation\ Rate}{(Cycles\ of\ Concentration) - 1}$$

$$Drift = Blowdown\ x\ 10\%$$

(2) *For the evaporation rate equation in Note (1), use the following:*

(a) ΔT = 7.5 L/min (2 gpm) per cooling ton when the condenser water temperature change is 8 °C (15°F); or

(b) ΔT = 11.4 L/min (3 gpm) per cooling ton when the condenser water temperature change is 6 °C (10°F).

OU = other uses, L (gal) per month

D.2.3 Complex method

D.2.3.1 General

The output water storage volume shall be determined by assessing rainwater collection and output water use on a monthly basis using the following equation:

$OWD_t = OWD_{t-1} + (MRY - MOWD)$

where:

OWD_t = volume of rainwater available in the storage tank to meet output water demand at the end of each month, L (gal)

OWD_{t-1} = volume of excess rainwater carried over each month, L (gal)

MRY = monthly rainwater yield, mm (in)

MOWD = monthly output water demand, L (gal)

D.2.3.2 Monthly rainwater yield

The monthly rainwater yield shall be determined in accordance with the method specified by the authority having jurisdiction. In the absence of such requirements, the monthly rainwater yield shall be calculated using the following equation:

$MRY = (AMR – C_{abs} – F_{abs})\ A\ C\ F$

where:

MRY = monthly rainwater yield, mm (in)

AMR = average monthly rainfall, mm (in)

C_{abs} = rainfall abstraction associated with absorption and wetting of surfaces, mm (in)

Note: *C_{abs} typical values are between 2 and 6 mm (0.08 and 0.24 in) per month.*

F_{abs} = rainfall abstraction associated with pre-storage filtration, mm (in)

A = catchment area, m^2 (ft^2)

C = runoff coefficient, %

F = efficiency of the pre-storage filter, %

Note: *F is typically 90%; however, the manufacturer or supplier should be consulted.*

When rainwater is collected from surfaces with more than one runoff coefficient, the equation for the MRY shall be modified to use a weighted runoff coefficient (C_w) calculated in accordance with the equation in Clause D.4.5.

D.2.3.3 Monthly output water demand

The monthly output water demand shall be determined in accordance with the requirements specified by the authority having jurisdiction and in accordance with the requirements specified by the manufacturer or system designer. In the absence of such requirements, the output water demand shall be determined using the following equation:

$MOWD = RU + CU + IU + EC + OU$

where:

MOWD = monthly output water demand, L (gal)

Note: *Monthly output water demand can vary based on a variety of factors (e.g., irrigation use can vary with seasonal demand). The appropriate monthly output water demand should be used for each month.*

RU = residential use, L (gal) per month

CU = commercial use, L (gal) per month

IU = irrigation use, L (gal) per month

EC = evaporative cooling use, L (gal) per month

OU = other uses, L (gal) per month

D.2.4 Calculation method

D.2.4.1 General description

This method calculates the volume of rainwater available in the storage tank to meet the output water demand on a monthly basis for a period of one year. The equation [$OWD_t = OWD_{t-1} + (MRY – MOWD)$] is repeated for each month to identify whether sufficient rainwater remains in the storage tank to meet monthly output water demands throughout the year based on the maximum storage capacity available to meet output water demands (OWD) and monthly rainwater yield (MRY) as follows:

(a) To begin, from the nearest available average monthly rainfall record for the site, identify the month with the greatest amount of average monthly rainfall. This is the start month from which to begin calculations;
(b) For the first month, assume that the volume of rainwater carried over from previous months is 0 L, so that $OWD_{Month\ 1} = 0 + (MRY - MOWD)$;
(c) Estimate a volume of rainwater available in the storage tank to meet the output water demand. If the value calculated for OWD_t exceeds the estimated volume, then the excess is assumed to overflow from the rainwater storage tank: $OWD_{t\text{-}max}$ is less than the assumed output water demand storage capacity;
(d) For month two, use the value for $OWD_{Month\ 1}$ for OWD_{t-1}; therefore, $OWD_{Month\ 2} = OWD_{Month\ 1} + (MRY - MOWD)$;
(e) Perform the OWD_t calculation for all of the months; and

    Note: *Positive values indicate that there is excess rainwater remaining at the end of a month, whereas negative values indicate a deficit.*
(f) Repeat these calculations using varying storage capacities to meet output water demands.

D.2.4.2 Storage capacity

The storage capacity shall be modified until OWD_t is no longer negative for any month for the rainfall record utilized, indicating that there is enough supply each month to meet the demands.

D.2.4.3 Adjustments to met output demands

If it is not possible to obtain positive values of OWD_t, then this indicates that the output water demand is too high or the monthly rainwater yield too low to capture sufficient water to meet the demands. Under such conditions, either output water demand should be adjusted or provisions put in place to ensure that alternate water supplies are available to meet the output water demands.

D.2.5 Computational method

The output water storage volume can be determined by a computational method utilizing continuous daily modelling. Continuous daily modelling shall take into consideration at least the following factors:

(a) estimated tank capacity,
(b) daily or continuous rainfall,
(c) catchment area, runoff coefficient,
(d) filter efficiency,
(e) low water cut-off volume,
(f) daily output water demand use,
(g) stormwater detention (management) volume,
(h) dedicated fire reserve storage volume,
(i) storage loss volume, and
(j) tank overflow volume.

D.3 Dedicated fire reserve storage volume

The dedicated fire reserve storage volume for automatic sprinkler and fire systems shall be determined in accordance with the requirements of the authority having jurisdiction and the applicable code. In the absence of such requirements, the dedicated fire reserve storage volumes shall be determined in accordance with Annex C of this Standard and one of the following standards: NFPA 13, NFPA 13D, NFPA 13R, NFPA 14, or NFPA 1142.

D.4 Stormwater detention

D.4.1 General

The stormwater detention (management) volume for the purpose of controlling the stormwater release rate from the site shall be determined in accordance with the requirements of the authority having jurisdiction. In the absence of such requirements, the stormwater detention (management) volume shall be determined by calculating the difference between the inflow and outflow hydrographs utilizing local weather data.

D.4.2 Detention system design

D.4.2.1 General

The detention system shall be designed using

(a) a detention tank with a variable release rate with an orifice or controlled-flow drains (see Clause D.4.8);
(b) a detention tank with constant release rate with a pump (See Clause D.4.9);
(c) series detention with multiple tanks with variable release rate (See Clause D.4.10); or
(d) a combination of controlled-flow drains and a detention tank.

D.4.2.2 Equations used

Depending on the system design, the equations in Clauses D.4.3 to D.4.12 shall be used to determine the tank volume, duration of the storm event whose water is to be detained, weighted runoff, and orifice size and location, as applicable.

D.4.3 Stormwater detention (management) volume

The stormwater detention (management) volume shall be determined using the following equation:

$$SW = \int_{t0}^{t} (Qin - Qout)\ \Delta t$$

where:

SW = stormwater detention (management) volume, m^3 (ft^3)
t = total time detention is required, s
Q_{in} = inflow rate to the detention tank, m^3/s (ft^3/s)
Q_{out} = outflow rate to the sewer or surrounding area, m^3/s (ft^3/s)

D.4.4 Inflow rate

The inflow rate to the detention tank shall be calculated using the following equation with the design rainfall event intensity:

$$Q_{in} = C_w i A_t$$

where:

Q_{in} = average inflow rate, m^3/s (ft^3/s)

C_w = weighted runoff coefficient for the catchment area

i = rainfall intensity, mm/h (in/h)

A_t = catchment area tributary to the detention facility, ha (acres)

When rainwater is collected from surfaces with more than one runoff coefficient, the equation for Q_{in} shall be modified to use a weighted runoff coefficient (C_w) calculated in accordance with the equation in Clause D.4.5.

D.4.5 Weighted runoff coefficient

The weighted runoff coefficient for the catchment area for the detention tank shall be calculated using the following equation:

$$C_w = \frac{C_1 A_1 + C_1 A_2 + C_3 A_3 + \cdots}{A_t}$$

where:

C_w = weighted runoff coefficient for the catchment area

C_1 = runoff coefficient for a given catchment area

A_1 = catchment area classified as a given type, m^2 (ft^2)

A_t = total catchment area, m^2 (ft^2)

D.4.6 Rainfall intensity

The rainfall intensity shall be calculated for a storm with a ten-year return frequency using the following equation:

$$i_{10} = \frac{140}{t + 15}$$

where:

i_{10} = intensity of rainfall for a storm with a ten-year return frequency, mm/h (in/h)

t = duration of the rainfall event, h

D.4.7 Detention release rate

The detention release rate (restricted flow rate) shall be determined on a case-by-case basis as a portion of the inflow rate to the detention tank using the following equation:

$$Q_{DRR} = Q_{in}R$$

where:

Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)
Q_{in} = average inflow rate, m^3/s (ft^3/s)
R = release rate, %

D.4.8 Variable-release detention system storm duration and detention volume

D.4.8.1 Storm duration

The storm duration for variable-release detention systems where the outflow is controlled by an orifice or controlled-flow drains shall be calculated using the following equation using a storm with a ten-year return frequency.

$$t_v = 0.27\sqrt{\left(\frac{C_w A_t}{Q_{DRR}}\right)} - 15$$

where:

t_v = duration of the rainfall event for variable-release detention systems, min
C_w = weighted runoff coefficient for the catchment area
A_t = total catchment area, m^2 (ft^2)
Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)

D.4.8.2 Detention volume

The maximum detention volume for variable-release detention systems where the outflow is controlled by an orifice or controlled-flow drains shall be calculated using the following equation:

$$V_v = \left[\frac{0.19 C_w A_t}{(t_v + 15)} - 40 Q_{DRR}\right] t_v$$

where:

V_v = maximum detention volume for variable-release detention systems, m^3 (ft^3)
t_v = duration of the rainfall event, min
C_w = weighted runoff coefficient for the catchment area
A_t = total catchment area, m^2 (ft^2)
Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)

D.4.9 Constant-release detention system storm duration

D.4.9.1 Storm duration

The storm duration for constant-release detention systems where the outflow is controlled by a pump or a narrow head range shall be calculated using the following equation using a storm with a ten-year return frequency.

$$t_c = 0.23\sqrt{\left(\frac{C_w A_t}{Q_{DRR}}\right)} - 15$$

where:

t_c = duration of the rainfall event for constant-release detention systems, min

C_w = weighted runoff coefficient for the catchment area

A_t = total catchment area, m^2 (ft^2)

Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)

D.4.9.2 Detention volume

The maximum detention volume for constant-release detention systems where the outflow is controlled by a pump with a constant flow shall be calculated using the following equation:

$$V_c = \left[\frac{0.19 C_w A_t}{(t_c + 15)} - 57 Q_{DRR}\right] t_c$$

where:

V_c = maximum detention volume for constant-release detention systems, m^3 (ft^3)

t_c = duration of the rainfall event for pump-controlled detention systems, min

C_w = weighted runoff coefficient for the catchment area

A_t = total catchment area, m^2 (ft^2)

Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)

D.4.10 Variable release series detention

The weighted effective runoff for detention systems where the outflow is restricted utilizing controlled-flow drains or multiple detention tanks discharging into a sub-surface detention tank (i.e., series detention) before discharging to the sewer, shall be calculated using the following equation:

$$C_{WE} = \frac{311 Q_{DRR}(t_v + 15)}{A_t}$$

where:

C_{we} = weighted effective runoff for the area restricted by controlled-flow drains or series detention, m^3 (ft^3)

Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)

t_v = duration of the rainfall event, min
A_t = total catchment area, m^2 (ft^2)

C_{we} shall be used for calculating the maximum required detention volume for the area with runoff restricted to the detention facility (i.e., substitute C_w with C_{we}).

D.4.11 Outlet orifice size for variable-release detention

The outlet orifice size for variable-release detention tanks where the outflow is restricted by an orifice shall be determined using the following equation:

$$Q_{DRR} = C_D A_o (2gh)^{0.5}$$

where:
Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)
C_D = coefficient of discharge for the type of orifice tube, (i.e., 0.52 for re-entrant and 0.61 for flush)
A_o = area of the orifice tube, m^2 (ft^2)
g = gravity acceleration, i.e., 9.8 m/s^2 (32.2 ft/s^2)
h = maximum head or storage on the orifice tube, m (ft)

D.4.12 Maximum storage depth

D.4.12.1 Re-entrant tube

Where tank height is limited, the maximum storage depth shall be determined to verify the elevation of the outlet and full-size overflow. Where outflow is restricted by a re-entrant tube orifice, the maximum storage depth to limit the flow shall be calculated using the following equation:

$$S_{DR} = \frac{1930Q^2}{(d_o)^4} + d_o/24$$

where:
S_{DR} = maximum storage depth for a re-entrant orifice tube outlet, m (ft)
Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)
d_o = nominal orifice tube diameter, mm (in)

D.4.12.2 Flush tube

Where outflow is restricted by a flush tube orifice, the maximum storage depth to limit the flow shall be calculated using the following equation:

$$S_{DR} = \frac{1400Q^2}{(d_o)^4} + d_o/24$$

where:

S_{DR} = maximum storage depth for a flush orifice tube outlet, m (ft)

Q_{DRR} = detention tank maximum release rate, m^3/s (ft^3/s)

d_o = nominal orifice tube diameter, m (in)

D.5 Storage loss volume

Storage loss volume shall be calculated to determine the volume of the storage tank lost from freeboard, sediment layer, and other physical restraints. The storage loss volume shall be calculated using the following equation:

$$SLV = D + F$$

where:

D = dead storage volume, L (gal)

Note: *Dead storage is the volume of water lost from the mud layer or level below the pump intake, which cannot be used to meet output water demand, and may be expressed in percentage, in which case it is calculated using the following equation:*

$$D = (OWD + FR + EI + SW)PD$$

where:

OWD = output water demand, L (gal)

FR = dedicated fire reserve storage volume, L (gal)

EI = environmental initiative storage, L (gal)

SW = stormwater detention (management) volume, m^3 (ft^3)

PD = dead space, % (typically 5 to 10%)

F = freeboard volume, L (gal)

Note: *Freeboard is the volume of water above the flood level rim or bottom of the overflow piping for the rainwater storage tank.*

D.6 Day tank sizing

Day tanks, where used, shall be sized based on the average demand or peak daily or hourly demand required for the end use as determined by the system designer.

Annex E

Guidance for Developing a Water Safety Plan

Note: *This Annex is an informative (non-mandatory) part of this Standard.*

E.1 General

Note: *This Annex provides guidance to help the user comply with the mandatory requirements specified in Clause 5.1.2.*

E.1.1 Introduction

Water safety plans

(a) require the assessment of hazards, their pathway(s) through the water system and identification of control points and likely concentration and impact on exposed individuals (i.e., the probability of the hazard occurring times the consequence of the hazard exposure);

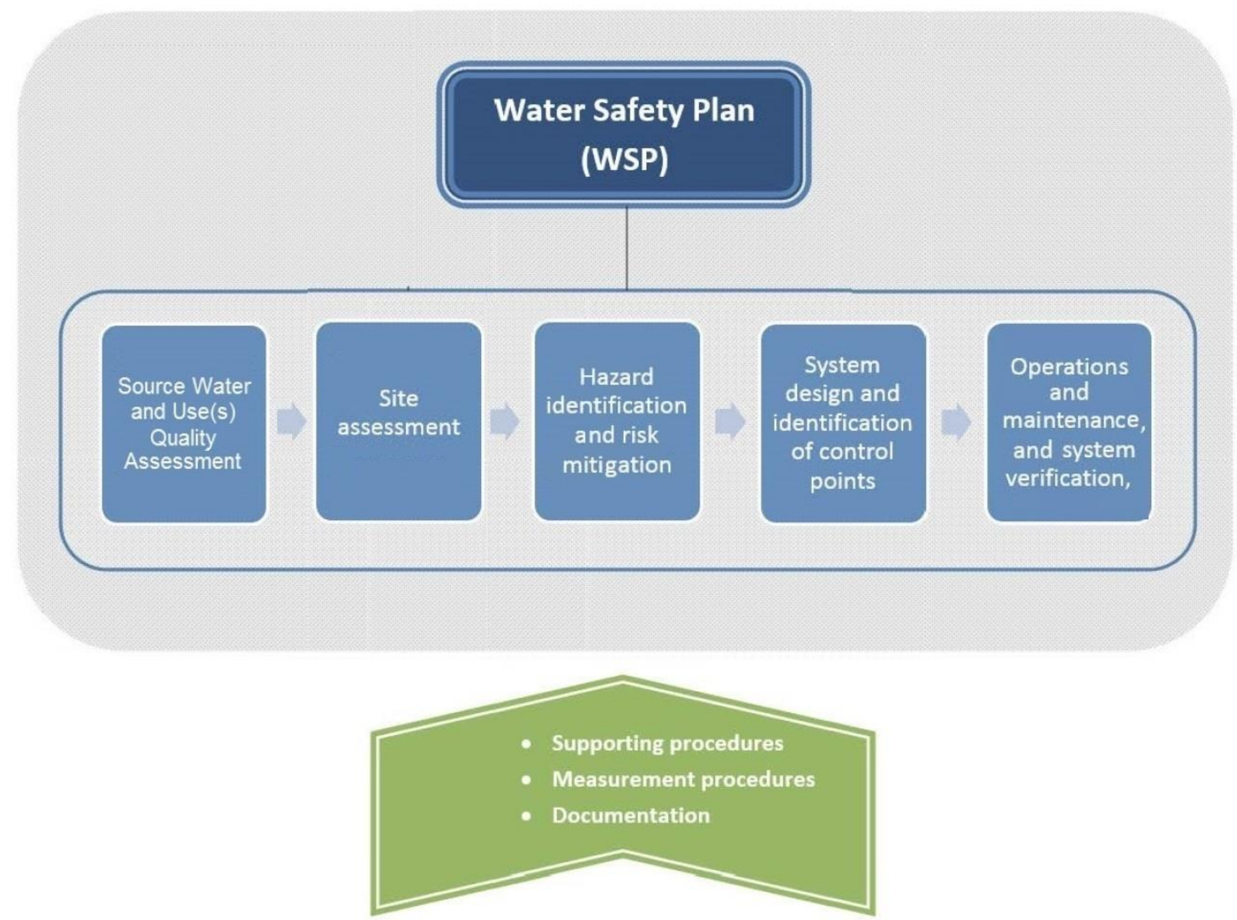
(b) include parameters for monitoring and verifying the rainwater harvesting system to understand if the identified hazards can be mitigated or controlled and, if not, responses to bring the system back into line with the design parameters before unacceptable risk is reached.

(c) have an element for review and revision based on experience and audit.

E.1.2 Elements of a Water Safety Plan (WSP)

An overview of a WSP is illustrated in Figure E.1.

Figure E.1
Water Safety Plan Overview



E.1.3 Scope

WSPs are intended to recognize, address, and improve water quality and water quality concerns for rainwater harvesting systems intended for potable and non-potable uses. This WSP applies to both systems collecting roof surface runoff from residential or commercial structures or stormwater surface runoff from the identified catchment area. It is important to document the full scope of the rainwater harvesting system in order to identify system components, including the system supply, parties responsible for system maintenance, and operational guidelines for the system. The tiered approach within the WSP is designed to address the scale and level of risk that is to be managed (see Figure X).

The rainwater harvesting system information document should be completed in accordance with Clause E.5.

E.1.4 Source water and use(s) quality assessment

E.1.4.1 Baseline water quality

If possible, representative raw-water samples should be collected and analyzed to determine the baseline water quality and identify constituents that can adversely affect the intended use of the water. As it might not be possible to collect a source-water sample for greenfield projects, data from similar locations should be sought. If water samples can be collected, the samples should be collected during the initial portion of a storm event that follows a long dry-weather period that can result in accumulation of contaminants.

E.1.4.2 Samples

The collection of a grab or short-term composite-source water sample is unlikely to provide a comprehensive assessment of potential contaminants of concern, as the source and characteristics of contaminants can vary with seasons and age and condition of materials the rainwater comes into contact with, from collection to distribution. Subsequent source water samples should also be periodically collected and analyzed in conjunction with treated water samples for water quality compliance or system verification monitoring.

E.1.4.2 Asessment of potential contaminants

Whether or not a raw-water sample can be collected and analyzed, the assessment of potential contaminants for a rainwater collection system should not rely on the analyses. It is important that an assessment also be carried out of potential sources of contaminants within the air-shed as well as the solubility characteristics of the surfaces the rainwater will come into contact with during collection, storage, and distribution, and changes in the material characteristics and contaminants that might be released as the surfaces age. Storage temperature (higher than 20 °C [68°F]) and accumulation of sediments are also important considerations for odour generation and potential growth of opportunistic pathogens, (e.g., *Legionella*).

All relevant water quality standards for the authority having jurisdiction for the end water use should be adhered to.

E.2 Site assessment

E.2.1 Initial assessment

An initial site assessment should be conducted to identify potential contaminants that could enter or already exist in the catchment area and impact the water quality of the harvested rainwater. The goal is to assess the impact of the broader environment on the site and the collection surfaces as well as materials considered in the collection system so that the potential for human exposure can be characterized.

All rainwater harvesting systems and associated materials, except those installed on single-family residences using rainwater collected exclusively from a residential roof, should be assessed for suitability in accordance with the requirements of the authority having jurisdiction.

E.2.2 Site assessment elements

The site assessment should provide, at least, a general description of the site, end uses for harvested rainwater and any potential chemical or microbial contamination that could be present. Therefore, the information provided in the site assessment should include at least the following:

(a) Site location and a map showing all the properties within the proposed catchment area.
(b) Sanitary maintenance hole covers on or in close proximity to the site.
(c) Zoning classification of all properties contributing to the catchment area. If the site is zoned as industrial and the proposed catchment area contains surfaces other than the roof area, a more robust baseline investigation should be conducted to determine if chemical or microbial contamination is present.
(d) Total size of the catchment area.
(e) Description of site and surrounding area based on available information and data.
(f) Short narrative of how the property was historically used.
(g) Description of planned future uses of the site.
(h) Summary of any environmental investigation(s).
(i) Surface characteristics of the catchment area (e.g., Is the catchment area subject to vehicular traffic or pedestrian traffic? Are there overflows or bleed-off pipes from roof mounted appliances, flues, or smoke stacks? What is the roofing material? Are there vegetated roof systems?)
(j) Summary of end uses for the harvested rainwater system..

Note: *ASTM E2727 provides useful guidance on site assessment related to rainwater quality.*

E.3 Hazards identification

E.3.1 General

Hazards identification involves determining sources of potential contaminants and assessing its impact to public health based on the likelihood and the consequence of exposure for the intended and unintended end use. Once the hazards are identified, solutions can be reasonably determined to help mitigate or reduce the threat to public health.

Note: *Characterizing the threat to public health is vital to the process as it helps to identify the key issues or hazards that need to be addressed.*

E.3.2 Potential sources of contamination

An evaluation of potential contaminants that could adversely affect runoff water quality should be performed. The following is a non-exhaustive list of potential sources of contaminants:

(a) Fecal pathogens from animals.
(b) Chemical contamination from roofing materials.
(c) Vehicular traffic and de-icing activities.
(d) Organic and nutrient contamination from plant debris, seasonal pollen, and animal excreta.

(e) Elevated salt concentration due to sea spray.
(f) Air pollution in urban, industrialized, or farming areas.
(g) Algae growth on collection and transport surfaces and in collection tanks.
(h) Stagnation of water in collection tanks and in dead-ends of the distribution system.
(i) Piping materials and coatings.
(j) Airborne dust and degrading surface materials.
(k) Infiltration and inflow of surface and groundwater, primarily in situations where the water storage tanks are buried.

E.3.3 Summary and prioritization of risks (qualitative assessment)

E.3.3.1 Level of risk

The level of risk associated with the potential contaminants identified is dependent on the end use, the likelihood for exposure and the consequence of exposure. It is reasonable to assume that where no exposure exists, the level of risk is non-existent or low. Similarly, where a high likelihood for exposure exists, the level of risk can be high, depending on the contaminant(s) of concern and the consequence of exposure associated with the end use. Therefore, assessing the level of risk becomes critical in determining the appropriate and reasonable mitigation and control practice for the site and application.

For larger installations (e.g., those potentially impacting more than 25 people), there is value in prioritizing potential risks associated with each identified hazard and event combination in a risk matrix (i.e., the pathway that can lead the hazard to reach and impact people).

E.3.3.2 Risk matrix

A risk matrix is used during risk assessment to define the various levels of potential risk. It is a function of the likelihood (probability) of the hazard exposure and the consequence from it. While simplistic, the goal is to assist in managing rainwater harvesting risks associated with the rainwater harvesting system, through mitigation and controls (e.g. barriers and treatments). Analysis through a risk matrix should be made for both intended and unintended uses and exposures. The types of individuals who will use the site should also be considered.

The likelihood of harm occurring might be categorized as 'Certain', 'Likely', 'Possible', 'Unlikely' or 'Rare' based on reasonable assumption. For practicality, this qualitative evaluation should assess based on whether it is plausible exposures will occur. However, very low probabilities may not be very reliable, and overall this is a subjective assessment based on local understanding of the rainwater harvesting system. Hence, the assessment is generally best undertaken with more than one person, to reflect on the range of expertise and skills needed to understand and assess the complete system.

The consequence categories to consider are
(a) Catastrophic – major outbreak of disease or poisoning with likely death in a few cases;
(b) Critical – a few severe injuries or illnesses that can lead to death;
(c) Marginal – one severe illness or multiple minor impacts; and

(d) Negligible – minor impact.

The combined evaluation of the likelihood of exposure and consequence of exposure helps characterize the level of risk and the threat to public health, which can be summarized in a risk matrix showing all possible outcomes. See Table E.1.

Table E.1
Risk Matrix

Likelihood	**Consequence**			
	Negligible	**Marginal**	**Critical**	**Catastrophic**
Certain	High	High	Extreme	Extreme
Likely	Moderate	High	High	Extreme
Possible	Low	Moderate	High	Extreme
Unlikely	Low	Low	Moderate	Extreme
Rare	Low	Low	Moderate	High

The party responsible for the WSP should estimate the levels of risk for each hazard-event combination and focus their mitigation and control practices accordingly.

E.4 Risk mitigation

E.4.1 General

An essential component of the incremental improvement plan is to ask questions related to each identified hazard, such as the following:

(a) What is the source of the hazard, and can the likelihood of contamination be eliminated or reduced? (e.g., removal of overhanging branches that could enable animals to access the roof, or the placement of a fake owl to deter birds.)
(b) Where is the hazard located? (e.g., northern quarter of the catchment area.)
(c) How is the hazard assessed? (e.g., visual inspection or water quality testing.)
(d) What system components are impacted by the hazard? (e.g., collection surfaces, downspouts, storage reservoir, or distribution system.)
(e) Who is responsible for inspections and for monitoring the hazard(s)?
(f) How often is the system likely to be inspected for each identified hazard and mitigation measures adjusted?
(g) What mitigation measures can be applied? (e.g., routine cleaning, first flush diversion, removal of overhanging vegetation, bird deterrent systems, exclusion of roof areas from collection.)

E.4.2 Control measures

Control measures include routine verification that mitigation measures are in place and are effective for each identified hazard to minimize the likelihood of adversely impacting water quality, and monitoring treatment operating conditions and water quality (see Section E.3). Once appropriate and effective mitigation measures are identified and implemented, control measures provide the necessary operational inputs to ensure the mitigation measures continue to be effective and performing as expected. Typically for small systems the system owner is responsible for maintaining and monitoring the rainwater harvesting system control measures, but this may also be the responsibility of individuals contracted to operate and maintain the system.

E.5 Operational Monitoring, System Verification and Responses

E.5.1 Rainwater harvesting system operations and maintenance document

An operation and maintenance manual should be provided and a maintenance log kept to record information about the rainwater harvesting system, including flow readings, component condition observations, and any repairs or component replacements. The operation and maintenance manual should be more than just a collation of manufacturers' manuals and should include at least the following information:

(a) Contact information (e.g., names, roles, telephone numbers, and e-mail addresses) for
  - (i) emergency personnel; and
  - (ii) maintenance and operation personnel.

(b) Operating procedures.

(c) Maintenance procedures, including inspection and maintenance schedule.

(d) System identifier (e.g., owner name, street address, building name.)

(e) General narrative of the overall collection, treatment, storage and distribution system, including
  - (i) water uses (e.g., potable, irrigation, laundry);
  - (ii) number of people served by the system;
  - (iii) number and types of fixtures served by the system, including noting whether the fixtures are labeled;
  - (iv) raw and treated water storage volumes;
  - (v) details of any make-up or auxiliary water supply, and the method of connection; and
  - (vi) material and equipment specifications.

(f) Description of hazards, mitigation measures, and controls (based on the risks identified in Clause E.3).

(g) Control measures to mitigate identified risks.

(h) Dates of system construction, installation, and commissioning.

(i) Design drawings.

(j) Permits (if applicable) and local authority contact information.

(k) Warranty and supplier contact information.

(l) Water testing data, if available.

(m) Log section to note
  - (i) dates and times of routine inspections;
  - (ii) equipment condition;

(iii) maintenance and repairs carried out;
(iv) verification of controls being in place and effective; and
(v) new hazards identified.

E.5.2 System technical information

The general narrative of the overall collection, treatment, storage, and distribution system should include the following technical information:

(a) Catchment area size.
(b) Roofing materials.
(c) Vertical conveyance materials.
(d) Conveyance pipe materials.
(e) Storage tank information, including:
  (i) tank volume;
  (ii) tank dimensions;
  (iii) tank construction materials; and
  (iv) location (i.e., above- or below-ground).
(f) Pre-filtration system information, including
  (i) type of pre-filter(s);
  (ii) quantity of pre-filters;
  (iii) filtration particle size; and
  (iv) location (e.g., above- or below-ground).
(g) Pump system information, including
  (i) brand, make, and model of pump(s);
  (ii) capacities and heads; and
  (iii) horsepower.
(h) Water treatment system information, including
  (i) narrative on treatment goal;
  (ii) intended level of disinfection (e.g., not applicable or log reduction of viruses, protozoa and bacteria);
  (iii) type of filtration or disinfection: (e.g., sediment, activated carbon, UV, or chlorine,);
  (iv) make-up water or rainwater harvesting system bypass contingency;
  (v) water treatment components brands, makes, and models; and
  (vi) date of equipment installation.
(i) Distribution piping information, including
  (i) distribution piping material(s); and
  (ii) length of distribution piping system.

E.5.3 Water quality verification

The operations and maintenance document should include the following water quality information:

(a) Frequency of water quality sampling and control and mitigation inspections.
(b) Microbial, chemical, and physical parameters being monitored.
(c) Water sampling locations.

(d) Water quality records.

(e) Log entry to record dates and times of inspections and sampling events and operating conditions at those times.

E.5.4 Audit and reporting

Once the WSP has been completed, the agency responsible should audit it and confirm the reporting needs. Auditing and maintenance checks may be undertaken by a third party, but when and what to report (e.g., a major risk event, annual reporting) shall be confirmed by the authority having jurisdiction.