Draft Updates to the Protocol for Centralised Drinking Water Systems in First Nations Communities

FOR REVIEW

Standards for Design, Construction, Operation, Maintenance, and Monitoring of Centralised Drinking Water Systems

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Background

The Centralised Drinking Water Protocol first came into effect March 21, 2006, under the name *Protocol for Safe Drinking Water in First Nations Communities*. It was subsequently updated and renamed the *Protocol for Centralised Drinking Water Systems in First Nations Communities* on April 10, 2010. This draft updated document reflects proposed changes to address preliminary feedback from First Nations technical representatives, consulting engineers, Circuit Rider Trainers, the First Nations Health Authority in British Columbia and regional and headquarters staff of the Regional Operations Sector and the First Nations and Inuit Health Branch (FNIHB) of Indigenous Services Canada.

The purpose of this draft document is to obtain feedback from First Nation leadership, technical representatives (water Operators, public works managers, etc.) and other individuals that are responsible for centralised drinking water systems on First Nation lands and in First Nations communities in Yukon. This draft document will be revised following a review of comments received, and a final document will be prepared.

If interested in sharing your comments or setting up an individual or group engagement session to discuss the draft protocol, please contact us at: protocolsh2o-protocolsh2o@sac-isc.gc.ca.

1.0 Introduction

The *Protocol for Centralised Drinking Water Systems in First Nations Communities* (Centralised Drinking Water Protocol) contains minimum treatment standards, as well as standards for the operation, maintenance, and monitoring of centralised drinking water systems on First Nation lands and in First Nations communities in Yukon. It also provides guidance on risk management, system design, commissioning and asset management to improve public health protection.

For the purposes of the Centralised Drinking Water Protocol, a centralised water system is a communal water system with a centralised treatment facility from which drinking water is delivered to users by a piped or trucked distribution system.

This document is intended for use by First Nation staff responsible for drinking water systems. It is also intended for use by Indigenous Services Canada (ISC) staff and all others involved in providing advice, assistance, or support to First Nations related to centralised drinking water systems in their communities.

As outlined in the Centralised Drinking Water Protocol, First Nations' responsibilities as they relate to ensuring that residents are provided with clean, safe, and reliable drinking water are divided between two main groups in First Nations communities: 1. First Nation leadership, and 2. Water Treatment and Distribution System Operators:

1. First Nation leadership (e.g., Chief and Council, Clan and Spokesperson), with support from First Nation administration, utility directors, infrastructure managers, public works supervisors, and Operators, are responsible for ensuring that drinking water systems are designed, constructed, upgraded and operated in accordance with the Centralised Drinking Water Protocol. They are also responsible for organizing training to ensure that their system's primary and secondary Operators are trained and certified to the classification level of the system.
2. Water Treatment and Distribution System Operators (referred to as 'Operator') are responsible for operating and maintaining drinking water systems as well as for implementing effective sampling and testing to continuously monitor drinking water quality, as outlined in Section 3.8. They should also keep complete records to fully document maintenance activities, monitoring, and corrective action, as outlined in Section 5.4. It is highly recommended that Operators be involved in the design and construction of new or upgraded systems.

More information on partners' responsibilities as they relate to the operation of water systems in First Nations communities is outlined in Appendix A.

First Nations are responsible for the design, construction, operation, maintenance, monitoring and management of their drinking water systems, in accordance with the policies and protocols from ISC, or provincial/territorial regulations. ISC staff will provide advice and support to First Nations regarding meeting the requirements of the Centralised Drinking Water Protocol.

The Centralised Drinking Water Protocol is intended to provide First Nations with a set of requirements and best practices that, when followed, can be used to demonstrate that due diligence is being applied to their drinking water systems. The requirements in this Protocol should be carefully considered to ensure that public health is appropriately protected at all times. Using a risk management approach, corrective action plans to address the highest risk deficiencies should be developed (as necessary) for existing systems that do not meet the requirements of the Centralised Drinking Water Protocol. First Nations may apply for funding support to address deficiencies from ISC through their Regional office under the Capital Facilities and Maintenance Program.

2.0 Application

Any centralised water system that produces drinking water that is funded in whole or in part by ISC, and serves five or more household service connections, or that serves a public facility should meet the requirements of the Centralised Drinking Water Protocol.

Specifically, the Centralised Drinking Water Protocol and its requirements apply to the following types and sizes of drinking water systems:

- Community System – A Community System is a drinking water system that serves five or more household service connections.

- System serving a Public Facility – A Public Facility is a non-commercial, ISC-funded facility that is owned or operated by the First Nation and serves a public function (such as a school, First Nation office, or community centre).

Alternatively, First Nations may choose to meet the requirements outlined in drinking water regulations and standards in the province or territory where the First Nation is located. Where provincial/territorial regulations do not exist, the Centralised Drinking Water Protocol still applies.

Under the Centralised Drinking Water Protocol, a distribution system can consist of a system of water mains, reservoirs, pumping stations, valves, and other appurtenances used to supply drinking water. In addition, trucked systems that use tank trucks to deliver drinking water to consumers are also considered part of a distribution system. For the purposes of this document, the cisterns to which water is delivered are not included as part of a centralised system. Cisterns are covered under the *Protocol for Decentralised Water and Wastewater Systems in First Nations Communities* (INAC, 2010), as household cisterns are considered part of the premise plumbing.

The Centralised Drinking Water Protocol does not apply to drinking water systems that serve four or fewer household service connections. Drinking water systems with four or fewer household service connections are covered in the *Protocol for Decentralised Water and Wastewater Systems in First Nations Communities* (INAC, 2010).

The Centralised Drinking Water Protocol does not apply to water supplied to a First Nation community via a municipal type service agreement (MTSA) unless otherwise stipulated in contracts or the terms and conditions of funding agreements between the First Nation and ISC related to the provision of the service. ISC will follow a proposal-based model to support infrastructure improvements and MTSA negotiation processes to ensure water systems are compliant with the responsible authorities and terms of service are sustainable and satisfactory to the First Nation.

The Centralised Drinking Water Protocol does not apply to facilities funded in full, or operated by, other government departments.

The Centralised Drinking Water Protocol may not be applicable to eligible recipients that receive Capital Facilities and Maintenance Program (CFMP) funding associated with the ratification of a Service Delivery Transfer Agreement. Service delivery transfer is intended to support Indigenous self-determination and accountability for the way in which services and assets are being planned, prioritized, funded, managed and delivered in participating First Nations. As such, eligible recipients will be responsible for the prioritization and management of their projects, as per the specific terms and conditions of their funding agreement.

These agreements reflect Transfer Partner-specific governance systems and funding models that have been validated by ISC. For additional information, please consult ISC regional offices or the Infrastructure Partnerships and Transfer team at infrastructuretransfer-transfertinfrastructure@sac-isc.gc.ca.

In addition, the Centralised Drinking Water Protocol may not apply to First Nation public water systems in the Yukon if they are subject to Yukon's *Drinking Water Regulation* which applies to large public drinking water systems with 15 or more connections and bulk delivery of drinking water for 5 or more trucked connections.

In the case that the Centralised Drinking Water Protocol does not apply, the water system should follow industry best practices for producing safe drinking water.

3.0 Risk Management Approach

Drinking water systems should implement a preventive risk management approach, such as a source-to-tap or water safety plan approach, to assess, prioritize, and manage risks in order to protect public health. An effective risk management approach focuses on local system knowledge, proactive hazard identification and risk mitigation and should be cyclical and adaptive so that incremental improvements to the safety of the water supply can be made. Successful risk management approaches are team-based and include all those who share responsibility for a drinking water system and include Operator training and support (WHO, 2012; WHO, 2014; WHO, 2023).

Additional key principles that should be considered when developing a risk management approach include but are not limited to the following:

- The greatest risk to drinking water safety is contamination from disease-causing microorganisms;
- Sudden or extreme changes in water quality, environmental conditions, or any component of the system should result in an investigation to assess the safety of the drinking water and determine if corrective actions need to be undertaken; and,
- Complaints about illness, taste, colour or smell require follow-up to ensure that drinking water continues to be safe.

An effective risk management approach must also consider climate-related risks and mitigation measures. Understanding the potential impacts of climate change is an important consideration in the planning, design and operation of water supply systems. Key considerations should include changes to water temperature, precipitation, sea-level, and the nature and frequency of extreme weather events. Potential impacts to a drinking water system from climate change should at least be considered in the feasibility and design phases of drinking water system projects, such that appropriate mitigation measures can be integrated into the system.

Several documents are available to assist First Nations in considering potential climate change impacts to their drinking water systems. Climate change impacts and adaptation measures specific to First Nations communities can be found in the Assembly of First Nations' *Climate Change and Water* guidance document (AFN Environmental Stewardship Unit, 2008). Information on the potential impacts of climate change to drinking water distribution systems is available in the National Research Council's *Water Distribution Systems: Climate Change Risks and Opportunities* (Roshani et al., 2022).

For more information on risk management approaches for drinking water, please refer to the World Health Organization's *Water Safety Plan Manual* (WHO, 2023) and the Canadian Council of the Ministers of the Environment's (CCME) *From Source to Tap: Guidance on the Multi-Barrier Approach to Safe Drinking Water* (CCME, 2004).

3.1 Water Safety Planning

Water Safety Planning (WSP) is an international risk management framework developed by the World Health Organization (WHO) that is recognized as an effective tool for improving and maintaining drinking water safety. It has been demonstrated to reduce risks in small community water systems (WHO, 2023).

The purpose of developing and implementing a WSP is to more effectively protect a drinking water system against risks to public health or infrastructure. Potential risks are identified at all stages of the drinking water system and prioritized based on likelihood, impact, and the effectiveness of applicable proactive control measures.

Considerations in developing a water safety plan should include:

- Assembling a knowledgeable and representative team to formulate the plan;
- Conducting a complete assessment of the drinking water system including identification and prioritization of potential risks;
- Establishing control measures to mitigate and reassess risk;
- Continuous monitoring and assessment of the system to ensure compliance to the WSP and any applicable guidelines;
- Development of corrective action plans for immediate response to an incident or emergency;
- Clear channels of communication between Operators, end users, and other stakeholders; and,
- Ensuring systems are in place to revise and update the WSP on a regular basis, for planned upgrades, and in the case of an incident or emergency.

More information on developing and implementing water safety plans can be found on the World Health Organization's *Water Safety Portal* (wsportal.org/resources/key-wsp-resources). Resources available specific to small drinking water systems can be found in WHO's *Water Safety Planning for Small Community Water Supplies* (WHO, 2012) and *Water safety plan: a field guide to improving drinking-water in small communities* (WHO, 2014).

3.2 Multi-Barrier Approach

A key principle of risk management is that multiple barriers should be in place to control the risks to a drinking water system. It recognizes that each individual barrier may not be able to completely remove or prevent contamination but that together the barriers work to minimize risk to public health. The five main components of a multiple barrier approach include:

- Protection of raw water sources;
- Effective treatment of drinking water;
- Maintenance of a clean distribution system;
- Monitoring of control measures (e.g., barriers preventing contamination); and,
- Response plans for adverse conditions/events.

Details on the requirements of each of the barriers that should be in place in a drinking water system are provided below.

3.3 Source Water Protection

Source water protection, designed to preserve source water quality and quantity, is the first layer of defense in a multi-barrier approach to water protection. First Nation authorities responsible for drinking water systems covered by the Centralised Drinking Water Protocol should participate where possible with local stakeholders (such as conservation authorities and neighbouring municipalities) in the development and implementation of a local watershed and aquifer protection plan, which includes consideration of potential climate change impacts. First Nations communities should also develop and implement community-specific Source Water Protection Plans (SWPP) to prevent, minimize, or control potential sources of contaminants in or near the community's raw water sources. Development of an implementation strategy including establishing a monitoring program to measure if the SWPP is having its intended impacts and to make necessary adjustments is critical to the success of source water protection.

It is highly recommended to develop a SWPP as part of all ISC funded water projects, with prioritization given to new and high-risk water systems. Please refer to ISC's *First Nations On-Reserve Source Water Protection Plan* (2014) document for more information regarding source water protection plans. Your province may also have guidance available.

3.4 Source Water Characterization

Source water characterization is a critical component of drinking water system assessments that form part of source-to-tap and water safety plan risk management approaches (Health Canada, 2019a, b; Government of B.C, 2010; WHO, 2023). A source water characterization should include:

- Delineating the source water area including the contributing watershed or groundwater capture zone;
- Identifying threats and risks to source water including those from natural conditions and human activities and the conditions that can lead to changes (e.g., precipitation events, drought, fire); and,
- Conducting source water monitoring to assess the presence and concentration of contaminants of concern.

Monitoring of contaminants should be conducted over an extended period of time (e.g., more than a year) so that seasonal and annual variations in the source water quality and quantity can be assessed (Government of B.C., 2010; Nova Scotia Environment, 2022). Conditions that can lead to significant changes in water quality, such as rainfall events, drought and fire, should also be identified and their risk assessed. A source water characterization is often done during feasibility assessments and should be carried out for any new water system or substantial upgrade to an existing water system. The data collected is critical for determining the type and level of treatment needed. It also forms the basis of the development of a monitoring plan, including which physical, chemical and microbiological parameters should be routinely monitored. In addition, trends in data over time should be analyzed to consider the potential for climate-related impacts to a water resource (WHO, 2016).

3.5 Groundwater Under the Direct Influence of Surface Water

Groundwater under the direct influence of surface water (GUDI), also referred to as groundwater at risk of containing pathogens (GARP), is generally considered to be a subsurface water source (groundwater) that is vulnerable to contamination by large diameter pathogens including enteric protozoa such as *Giardia* and *Cryptosporidium*.

Links to provincial/territorial resources with procedures for determining if a subsurface water supply is GUDI or GARP are provided in Appendix C. It is the responsibility of First Nation leadership to obtain a determination of whether or not a subsurface water supply is GUDI. Obtaining this determination requires the services of a qualified hydrogeologist. If an assessment is needed, it should be done as part of feasibility or design studies for new and upgraded systems or for any existing wells when GUDI is suspected. Drinking water systems supplied by existing groundwater wells that have not previously undergone a GUDI assessment should conduct more frequent microbiological testing (total coliforms, *E. coli*) of the raw water while a GUDI assessment is being undertaken. If monitoring indicates that the water supply is subject to fecal contamination, then appropriate corrective measures should be taken (regardless of pending GUDI assessment results).

The main objective of conducting a GUDI assessment is to determine whether or not treatment beyond a minimum level of disinfection to inactivate viruses and bacteria is needed (i.e., whether treatment for enteric protozoa is required). Since enteric protozoa (*Giardia* and *Cryptosporidium*) are resistant to commonly used chlorine-based disinfectants, filtration or other forms of disinfection such as ultraviolet light (UV) are needed to achieve the required level of treatment when protozoa are present in source water.

3.6 Minimum Treatment Requirements

At the point where it is delivered to consumers at the tap, drinking water should meet the health-based water quality criteria and treatment requirements set out in Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ). More information on the GCDWQ is provided in Appendix B.

The minimum type of treatment required to make drinking water microbiologically safe depends on the quality and type of water source:

- Groundwater sources – minimum treatment is disinfection; and,
- Surface water and GUDI – minimum treatment is filtration combined with disinfection.

The appropriate type and level of treatment should take into account potential fluctuations in water quality, including short-term degradation, and variability in treatment performance. When needed, pilot testing or optimization processes can be useful for assessing factors that can reduce treatment effectiveness (Health Canada, 2019b).

As most surface water and GUDI sources are subject to fecal contamination, a combination of filtration and disinfection technologies should be in place to remove and/or inactivate enteric protozoa and viruses (Health Canada, 2019a). Groundwater sources are generally not subject to contamination from enteric protozoa due to natural filtration processes, however they are vulnerable to contamination from enteric viruses. Enteric viruses can survive and travel hundreds to thousands of meters in certain subsurface environments therefore, unless the risk of contamination from enteric viruses is determined to be negligible, the minimum treatment for groundwater should be disinfection (Health Canada, 2019b).

Minimum health-based treatment goals for enteric protozoa (*Giardia* and *Cryptosporidium*) and enteric viruses have been established by Health Canada using a risk assessment approach. As outlined in sections 3.6.1 and 3.6.2, these health-based treatment goals are based on the minimum level of log reduction (removal and/or inactivation) that should be achieved by the treatment processes in place. Guidance on determining if higher levels of log reduction are needed is available in Health Canada's *Guideline Technical Document – Enteric Protozoa: Giardia and Cryptosporidium* and *Guideline Technical Document – Enteric Viruses* (Health Canada, 2019a; Health Canada 2019b). Treatment technologies are assigned a log removal or inactivation credit depending on the type of technology and specific operational parameters. More information is provided on log reduction credits for filtration and disinfection in Appendices D and E, respectively.

Physical removal barriers (filtration) are assigned a "log removal" credit towards reducing enteric protozoa (*Giardia* and *Cryptosporidium*) and virus levels when they achieve specified individual filter effluent turbidity limits as discussed in Appendix D. "Log inactivation" credits are calculated using the primary disinfection concepts described in Appendix E. Credits are determined based on contact time at specified temperatures and pH (chemical disinfectants) and intensity time (UV). The log removal and/or log inactivation credits are summed to calculate the overall enteric protozoa or enteric virus log reduction for the treatment process being assessed (Health Canada 2019a; Health Canada, 2019b).

Filtration processes include a variety of engineered technologies including chemically assisted, slow sand, diatomaceous earth and membrane filtration as well as natural in-situ filtration processes such as riverbank filtration. The physical removal of viruses (e.g., natural or engineered filtration) can be challenging due to their small size and variations in their surface charge. Therefore, disinfection is a critically important barrier in achieving the appropriate level of virus reduction in drinking water (Health Canada, 2019b).

The Centralised Drinking Water Protocol recognizes that primary disinfection and secondary disinfection are separate treatment processes designed to provide different outcomes:

- ***Primary disinfection*** is a drinking water treatment process that is intended to achieve the necessary inactivation (render non-infectious) of pathogenic microorganisms that may be present in source water through the application of a disinfectant(s) at the drinking water treatment plant before water reaches the first consumer. Primary disinfection processes include chlorine, ultraviolet (UV) light, ozone and chlorine dioxide.
- ***Secondary disinfection*** (distribution system disinfection) is a drinking water treatment process intended to protect against microbial (re)growth in the distribution system by achieving and maintaining an appropriate disinfectant residual. A disinfectant residual can also serve as a sentinel to detect problems with the drinking water system such as inadequate treatment, pipe leaks, excessive water age and the presence of cross connections. Chlorine is the most commonly used water disinfectant for secondary (residual) disinfection. Chloramines can also be used. If primary disinfection is capable of providing the required chlorine residuals within the distribution system, then a separate secondary disinfection system is not required.

Chemical additives used for drinking water treatment should be certified to and used in accordance with NSF/ANSI Standard 60: *Drinking Water Treatment Chemicals – Health Effects* (NSF, 2021). Products, components and materials used in drinking water systems such as filter media, joining and sealing materials, pipes, plumbing devices and other materials that come into contact with drinking water should be certified to and used in accordance with NSF/ANSI Standard 61: *Drinking Water System Components – Health Effects* (NSF, 2022). Copies of these standards may be purchased from NSF International (www.nsf.org).

3.6.1 Minimum Treatment Requirements for Groundwater Sources

A raw water supply that is classified as groundwater means water that it is located in an aquifer where the overburden acts as a filter that reduces the risk of the presence of larger sized microbial pathogens (i.e., enteric protozoa). For a groundwater source that supplies drinking water to a distribution system serving five or more households or one or more public facility, the minimum required treatment design is:

- A health-based treatment goal of a minimum 4-log (99.99 percent) removal and/or inactivation of enteric viruses. Depending on the source water quality, a greater log reduction may be required.

Water treatment plants can achieve a minimum 4-log (99.99 percent) inactivation using a variety of disinfection processes (e.g., chlorine, UV, chlorine dioxide, ozonation etc.). If filtration is in place, depending on the type of technology, it may also achieve partial credit towards achieving an overall minimum 4-log reduction of viruses.

All groundwater supplies should have secondary disinfection in place to maintain a disinfectant residual in the distribution system. However, if a comprehensive risk assessment demonstrates negligible risk of potential contamination or deterioration of water quality in a distribution system, and where acceptable based on provincial/territorial regulations, a community may choose to not employ secondary disinfection of a groundwater supply. In this case, a plant should have the equipment in place to provide a disinfectant residual, through chlorination or chloramination, for use when needed.

3.6.2 Minimum Treatment Requirements for Surface Water and Groundwater under Direct Influence

Surface water, which is susceptible to microbiological contamination from enteric protozoa, viruses and bacteria requires more treatment than groundwater. For surface water or GUDI/GARP sources that supply drinking water to a distribution system serving five or more households or one or more public facility, the minimum required treatment is:

- A health-based treatment goal of a minimum 3-log (99.9 percent) removal and/or inactivation of enteric protozoa *Giardia lamblia* and *Cryptosporidium parvum* and a minimum 4-log (99.99 percent) removal and/or inactivation of enteric viruses. Depending on the source water quality, a greater log reduction may be required.

In order to achieve the necessary removal and/or inactivation of enteric protozoa and viruses, a combination of filtration and disinfection should be employed. A combination of physical removal (i.e., filtration) and inactivation barriers (i.e., UV or ozone disinfection) is the most effective way to reduce enteric protozoa in drinking water, because of their resistance to commonly used chlorine-based disinfectants. Depending on the source water quality, a multi-disinfectant strategy involving two or more primary disinfection steps can also be effective for inactivating protozoa, along with other microorganisms in drinking water. For example, the use of UV and free chlorine are complementary disinfection processes that can inactivate protozoa, viruses and bacteria (Health Canada, 2019a).

Where possible, routine monitoring of source water for *Giardia* and *Cryptosporidium* should be conducted including monitoring during specific events (e.g., rainfall, snowmelt, low flow in rivers receiving wastewater discharge) in order to establish system-specific log reduction treatment goals. Where monitoring is not feasible (e.g., small community water supplies), other approaches, such as implementing a water safety plan approach, can provide guidance on identifying and implementing necessary risk management measures (e.g., source water protection, adequate treatment, operational monitoring, standard operating procedures and contingency plans) (Health Canada, 2019a).

While the filtration of all surface water and GUDI sources is a critical step in the treatment of drinking water it is possible to meet the minimum log reduction requirements through the use of at least two disinfection technologies for systems with high quality source water (demonstrated through historical and ongoing monitoring data). More information can be found in Health Canada's *Guideline Technical Document – Turbidity* (Health Canada, 2012).

3.6.3 Concentration - Time (CT) Requirements

The water system designer should ensure that an appropriate contact time between drinking water and disinfectant(s) is provided before the water reaches the first consumer in the distribution system during periods of peak flow. The period of contact time required, calculated at peak flow rates, is based on a variety of factors including the microbiological contaminant, type of disinfectant, source water quality, and baffling factors. The Operator, in turn, should ensure that adequate disinfectant is added, as per water system design requirements, such that an adequate disinfectant residual is maintained in the system.

References for calculating the required disinfection concentration and contact time and the corresponding concentration-time (CT) tables for the inactivation of enteric protozoa and enteric viruses by chlorine, chlorine dioxide and ozone at various temperatures and pH values can be found in Appendix E. A similar approach is used for disinfection using UV light through the concept of intensity-time (IT). References for determining IT are provided in Appendix E.

3.7 Distribution System Requirements

A well maintained and operated distribution system is a critical component of providing safe drinking water. It is the responsibility of the Operator to ensure that the appropriate operations and maintenance are conducted to prevent drinking water quality from deteriorating after it leaves a treatment plant (whether by a piped distribution network or by a trucked water delivery system).

Treated water within a distribution system can undergo numerous biological, physical and chemical interactions and reactions, which can lead to the deterioration of water quality. Deteriorated water quality can lead to direct health risks as well as aesthetic issues. Waterborne disease outbreaks have been attributed to distribution system deficiencies. In order to proactively prevent the deterioration of drinking water quality in a distribution system, appropriate management strategies should be implemented in addition to providing a disinfectant residual (Health Canada, 2022). These management strategies include, but are not limited to:

- Ensuring biologically stable water enters the distribution system;
- Designing storage facilities with turnover rates capable of maintaining a residual disinfection;
- Preventing the stagnation of water in storage facilities and at watermain dead ends;
- Conducting regular inspection, cleaning, and maintenance of storage facilities;
- Flushing and sampling of watermains;
- Using biologically stable materials in the construction and replacement of distribution systems; and,
- Implementing backflow and cross-connection prevention programs to ensure hydraulic integrity.

All drinking water distribution systems should have a persistent residual disinfectant throughout the system. The appropriate residual concentration should be determined on a system-specific basis to ensure that it can be maintained, while minimizing disinfection by-product formation and aesthetic concerns. In general, a free chlorine residual of 0.2 mg/L (or 1.0 mg/L combined chlorine) is considered a minimum level for the control of bacterial (re)growth (Health Canada, 2009). However, Health Canada recently reported that higher minimum disinfectant residual concentrations, on the order of 1.0 mg/L of free chlorine and 1.8 mg/L total chlorine, are typically required to control (re)growth (Health Canada, 2022).

The presence of adequate chlorine residuals should be confirmed when sampling for microbial indicators (total coliforms and *E. coli,* see Table 1). These indicators are used to indicate potential unsanitary conditions, physical integrity issues and (re)growth in the distribution system. The presence of *E. coli* in any distribution and/or storage system sample is unacceptable and should result in further action (see section 3.8.6). Detection of total coliforms from consecutive samples from the same site or from more than 10% of the samples collected in a given sampling period should also be investigated.

3.7.1 Piped Water Systems

In piped water systems, all water should be chlorinated or chloraminated and should have a minimum free chlorine residual of no less than 0.2 mg/L (or a minimum of 1.0 mg/L combined chlorine) at all points throughout the distribution system. Water that originates from a third-party provider under a municipal type service agreement (MTSA) should have a free chlorine residual of no less than 0.2 mg/L at all points throughout the distribution system. It is the responsibility of First Nation leadership, and their project designer, to determine if booster chlorination is required to maintain an acceptable chlorine residual within the portion of the distribution system that is located within their community. As discussed above, a higher minimum disinfectant residual concentration is needed to control microbial (re)growth in many systems.

Guidance on maintaining and monitoring water quality in piped distribution systems can be found in Health Canada's *Guidance on Monitoring the Biological Stability of Drinking Water in Distribution Systems* (Health Canada, 2022).

3.7.2 Trucked Water Systems

The quality of water provided by trucked systems may be affected by the quality of the water source, contact with the transportation equipment, transfer into the storage container (cistern) and storage in the cistern. Hauled water to be used as a drinking water supply should meet the health-based GCDWQ (Health Canada, 2021) at the time of delivery.

When operating a trucked water system, appropriate measures need to be taken to protect the water source, the storage tank, and all other equipment from contamination during filling, storage, transportation and delivery (Manitoba Health, 2013). The sanitary condition of the transportation equipment should be maintained at all times including the tank or container used to carry drinking water as well as the pumps, hoses, and other equipment used in the supply or delivery of the drinking water. The container should allow easy access for cleaning and be disinfected at least weekly. The tank must not be used to transport other materials, as these are likely to contaminate the water. In addition, backflow prevention is needed when cisterns are being filled or emptied (Health Canada, 2021). For monitoring of cisterns please refer to the

Protocol for Decentralised Water and Wastewater Systems in First Nations Communities (INAC, 2010).

In trucked water systems, all water should be chlorinated and should have a free chlorine residual of no less than 0.2 mg/L (or a minimum of 1.0 mg/L combined chlorine) at the time of delivery. All data should be recorded in a register containing the data and results of the measurements and the name of the person who took them (Health Canada, 2021).

No person shall operate a trucked drinking water distribution system without first obtaining adequate training including provincial/territorial bulk water delivery certification if available.

3.8 Monitoring Requirements

Monitoring of control points from source to tap within a drinking water system (e.g., entering a treatment plant, following treatment and within the distribution system) is essential for supporting risk management by demonstrating that the control measures (e.g., barriers preventing contamination) for the system are effective. When changes in water quality are detected, actions can be taken in a timely manner to prevent the system from being compromised (WHO 2009; WHO 2014).

The GCDWQ list many parameters relevant for drinking water supplies. Many of these may not be a concern depending on the quality of the raw water and the potential sources of contamination in the watershed or aquifer. It is recommended that baseline chemical monitoring, which includes analysis of all GCDWQ health-related parameters (i.e., with a MAC), be conducted on raw and treated water. Where appropriate, baseline monitoring would also include monitoring for other parameters (e.g., operational guidance values, aesthetic objectives) and/or screening for radiological parameters (Health Canada, 2021). Generally, baseline monitoring is conducted once every five years to ensure that a water supply does not exceed any MACs and to periodically assess if any parameters should be added or removed from routine monitoring programs.

Routine drinking water quality monitoring programs should be site-specific using an approach that considers risks from all potential contaminants (microbiological, chemical and radiological) in a water supply. Monitoring programs should be developed based on the hazards that are specific to each system and include the parameters, frequencies and locations where monitoring should be conducted. They should include source water monitoring, operational and verification monitoring and should demonstrate that water quality goals are consistently being met for microbial risks, chemical risks such as disinfection by-products (DBPs), as well as biological stability and corrosion control in the distribution system (Health Canada, 2021). Monitoring should be performed at each barrier of a multi-barrier approach. Four types of monitoring are required for First Nation drinking water systems:

- Source water quality monitoring;
- Operational monitoring;
- Quality assurance & quality control; and,

- Verification & third-party monitoring.

Several individuals conduct monitoring of First Nation drinking water systems including Operators, Community-based Drinking Water Quality Monitors (CBWM) and certified Environmental Public Health Officers (EPHO). Monitoring of drinking water quality at the tap conducted by EPHOs and CBWMs is completed through ISC's FNIHB, or other organizations providing environmental public health services such as the British Columbia First Nations Health Authority (FNHA). Monitoring programs should be developed by a team of qualified professionals including engineers, Operators, CRT, EPHOs, and CBWMs.

Operators are responsible for performing operational water quality monitoring, using water quality tests of source (raw), treated and distribution system water as per the drinking water quality monitoring program for the system(s) under their responsibility. The frequency and location of the monitoring will depend on the water quality parameter and may be conducted daily, weekly, monthly or quarterly. Operational monitoring includes but is not limited to microbiological parameters (e.g., *E. coli* and total coliform) and treatment process parameters (e.g., chlorine residual, turbidity, pH, temperature, etc.). In addition, specific chemical, physical and radiological parameters may also need to be monitored as part of a system-specific water quality monitoring program.

In addition to the operational monitoring conducted by Operators, CBWMs and/or certified EPHOs perform drinking water verification monitoring in the distribution system to provide a final check on the water quality at the tap. In some cases, baseline monitoring by CBWMs and EPHOs may also be conducted on treated water leaving the treatment plant. Any monitoring conducted by CBWMs and EPHOs is considered to be third-party monitoring from a public health perspective and is not intended to replace monitoring conducted by the Operator.

3.8.1 Source Water Quality Monitoring

Source water quality monitoring should be included in routine monitoring programs. Depending on the parameter and the likelihood of changes in water quality, source water may be monitored continuously (i.e., turbidity), daily, or as little as once every 5 years. While rapidly changing parameters (e.g., turbidity, temperature) should be monitored more frequently, parameters not identified in the source water characterization, which are not expected to contaminate the water source, can be monitored less frequently. This will be based on a risk management approach and the overall site-specific monitoring plan. Source water monitoring plans can be designed to provide insight on long-term trends in the system, including changes to source water due to climate change.

Source water monitoring is also part of operational monitoring for key parameters that need to be monitored frequently (e.g., turbidity, microbiological parameters, chemical/physical parameters that change seasonally). It is important for Operators to have an understanding of source water quality because it determines the treatment needed and rapid, significant changes in water quality can have an impact on the ability of the water treatment plant to perform optimally (Government of B.C., 2010; WHO 2009; WHO 2014).

3.8.2 Operational Monitoring

The purpose of ongoing ***operational*** monitoring is to verify water quality and system performance and is conducted by the Operator (or a qualified person supervised by the Operator) under the direction of First Nation leadership. Operational monitoring is generally established based on the source water quality and treatment process and distribution system characteristics. Operational monitoring uses water quality tests of raw, treated, and distribution system water to check and confirm that the control measures that are in place in a drinking water system are working properly. Monitoring of specific parameters after each unit treatment process is also needed to verify and optimize ongoing treatment performance.

The Operator should keep an up-to-date log in which the dates and results of all required operational testing are recorded along with the name of the person who conducted the testing. The data collected for the log should be kept for a minimum of five (5) years.

3.8.2.1 Microbiological and Process Monitoring

The minimum microbiological and treatment process (e.g., chlorine residual and turbidity) monitoring for water systems is summarized in Table 1. Microbiological monitoring should include the indicator organisms *E. coli* and total coliforms. *E. coli* is an indicator of fecal contamination and that microorganisms capable of causing illness may also be present. *E. coli* monitoring is used to provide information on the quality of the source water, the adequacy of treatment and the safety of the drinking water distributed to the consumer. Total coliforms can be present in human and animal feces but are also naturally occurring in water, soil and vegetation. Total coliforms are used as a tool to determine how well the drinking water treatment system is operating and as an indicator of water quality changes in the distribution system (Health Canada 2020a; Health Canada 2020b).

The team of qualified professionals that develops the site-specific monitoring program (as described above) should consider if the minimum monitoring outlined in Table 1 is sufficient. Health Canada indicates that best practice commonly involves monitoring more frequently than the minimum monitoring in Table 1. The need for increased monitoring will depend on the size of the system, the number of consumers, the history of the system and site-specific considerations such as source water quality. Additional monitoring should also be conducted during events that lead to an increased risk of fecal contamination (e.g., spring runoff, storms or wastewater spills) (Health Canada 2020a).

In addition to the monitoring outlined in Table 1 there are a number of water quality parameters that are adjusted or monitored throughout the treatment process to ensure the efficacy of the treatment process such as pH, temperature, alkalinity, etc. Monitoring for these parameters should be established based on the treatment processes in place and are particularly important for systems that use chlorine-based disinfectants. Similarly, for piped water systems additional parameters including but not limited to conductivity, pressure, temperature, and pH are important for assessing the biological stability of drinking water in distributions systems (Health Canada, 2022).

For the purpose of establishing monitoring frequencies and locations:

- Small Community Systems have been defined as systems serving between five and 100 household service connections;
- Large Community Systems serve more than 100 household service connections; and,
- A Public Facility is a non-commercial, ISC-funded facility that is owned or operated by a First Nation and serves a public function (such as a school, First Nation leadership office, or community centre).

Table 1: Minimum Required Microbiological and Process Monitoring[1]

System Type	Source	Minimum Operational Monitoring[1] by Water Treatment and Distribution System Operator
Small Community Systems (5 to 100 service connections) and Public Facilities	Surface water (SW) or GUDI	***Microbiological[2]*** – One raw water sampling event[3] per month (SW) or one raw water sampling event per well per month (GUDI), one treated water sampling event per week and one distribution sampling event per week. ***Chlorine residual[2]*** – One treated water sampling event per day at locations where the minimum required chlorine contact time has been completed and one distribution system sampling event per week. ***Turbidity*** – one raw water sampling event per month combined with continuous treated water monitoring on each filter effluent line for filtered surface water and GUDI.
	Ground-water	***Microbiological*** – One raw water sampling event per well per month and one treated water sampling event per week and one distribution sampling event per week. ***Chlorine residual*** – One treated water sampling event per day at locations where the minimum required chlorine contact time has been completed and one distribution system sampling event per week. ***Turbidity*** – One raw water sampling event per well per month.
Large Community Systems (more than 100 service connections)[1]	Surface water (SW) or GUDI	***Microbiological*** – One raw water sampling event per week (SW) or one raw water sampling event per well per week (GUDI) , and one treated water sampling event per week, and eight distribution system samples per month (with at least one in each week). ***Chlorine residual*** – Treated water to have continuous monitoring equipment with alarm and one distribution system sampling event per week.

System Type	Source	Minimum Operational Monitoring[1] by Water Treatment and Distribution System Operator
		Turbidity – One raw water sampling event per month, combined with continuous treated water monitoring on each filter effluent line for filtered surface water or GUDI.
	Ground-water	***Microbiological*** – One raw water sampling event per well per week, one treated water sampling event per week, and eight distribution system samples per month (with at least one in each week). ***Chlorine residual*** – Continuous monitoring of treated water and at least one distribution system sampling event per week. ***Turbidity*** – One raw water sampling event per well per month.
Trucked Water Systems	Water treatment plant	***Chlorine residual*** – One sample per truck per delivery day, in a water sample collected at the outlet of the tank. ***Microbiological -*** One sample per month or, if this is not feasible, at least four samples per year, from each water tank's fill and delivery hoses.

[1] Drinking water systems should have site-specific monitoring plans. These may require more frequent monitoring and/or additional monitoring parameters.

[2] Samples that are to be tested for microbiological parameters and chlorine residual are to be collected at the same time and location. For treated water obtained under a municipal type service agreement (MTSA), results of chlorine residual testing should be obtained from the treated water provider, but samples should still be collected and tested for chlorine residual, *E. coli* and total coliforms.

[3]A sampling event typically includes collecting several samples at various locations within a drinking water system particularly at critical control points. Guidance on how to determine the number of samples and locations can be found in Health Canada's Guideline Technical Documents for *E. coli*, Total Coliforms, Chlorine and Turbidity.

3.8.2.2 Chemical Monitoring

Water quality monitoring programs should include chemical and radiological parameters that are present in source water that are naturally occurring as well as from human activities, treatment additives, disinfection by-products, corrosion products and other chemicals identified during a source water characterization and hazard or vulnerabilities assessment. The monitoring program established for a water system should list which chemical and radiological parameters to test for routinely including the frequency and at which sampling locations.

Drinking water systems that have a treatment process in place to remove a specific contaminant (i.e., manganese, uranium, arsenic, nitrate, etc.) need to conduct frequent monitoring of raw and treated water, in order to make necessary process adjustments and to ensure that treatment processes are effectively removing the contaminant to concentrations below the MAC. Guidance on monitoring considerations can be found in Health Canada's Guideline Technical Documents for the respective parameter.

Monitoring programs should also consider parameters that may be present in treated water as a result of the treatment process itself such as disinfection by-products and treatment additives. Depending on the disinfection process being used several parameters such as trihalomethanes (THMs), haloacetic acids (HAAs), chlorite, chlorate, bromate and N-nitrosodimethylamine (NDMA) may need to be monitored. At a minimum, quarterly monitoring of treated water should be conducted for both THMs and HAAs, if applicable. Additional parameters to consider for monitoring depending on the treatment process include but are not limited to aluminum and manganese.

Monitoring within the distribution system and at the tap is also recommended for metals that can increase within piping and plumbing systems as a result of corrosion or deposition and release of metals including but not limited to lead, copper, iron, manganese, uranium and arsenic.

The Operator is responsible for the operational monitoring of chemical and radiological parameters that are identified in the site-specific monitoring plan. If a community is concerned about an emerging (new) contaminant that may be found in drinking water, Health Canada's *Prioritization process for the development of Guidelines for Canadian Drinking Water Quality* can be consulted to determine if a guideline may be developed in the future.

3.8.2.3 Sampling Considerations

Proper procedures for collecting samples should be followed to ensure that samples are representative of the system's water quality. Guidance on collecting samples for bacteriological analysis can be found in the Health Canada's *Guideline Technical Document – Escherichia coli* and *Guideline Technical Document – Total Coliforms* (Health Canada, 2020a; Health Canada, 2020b). Sampling for microbiological analysis requires good technique to prevent the introduction of contamination from external surfaces (e.g., hands, the tap) during sampling. Details on the appropriate storage temperature and chain of custody procedures for submitting samples to an accredited laboratory are also found in the GCDWQ.

Analyses of samples for microbiological parameters may be conducted by the trained Operator onsite using appropriate analytical equipment and field kits (e.g., Colilert). In the absence of appropriate onsite testing equipment and for QA/QC purposes, analyses of samples for microbiological parameters should be conducted by an accredited laboratory. Operators should use a laboratory accredited by one of the following: Canadian Association for Environmental Analytical Laboratories (CAEAL), the Standards Council of Canada (SCC), or, in Quebec, the Programme d'accréditation de laboratoires d'analyse environnementale (PALAE). SCC/CAEAL defines accreditation as the formal recognition of the competence of a laboratory to carry out specific tests. Accreditation is awarded to a laboratory for each individual test (e.g., the analysis of pesticides in drinking water).

Because chlorine is not stable in water, the chlorine content of samples will decrease with time and may decrease during transportation to the laboratory and while in storage. Therefore, chlorine residual should be tested immediately upon sample collection. For samples collected in the distribution system, it is preferable to conduct analyses in the field using a field test kit. Several portable field instruments are available for this purpose, typically using a colorimetric method (Health Canada, 2009).

All field measurements of chlorine in the distribution system should be carried out at a free-flowing or flushed sampling location according to appropriate sampling procedures, in order to achieve a fresh sample that is reflective of the system water quality.

3.8.3 Quality Assurance & Quality Control

Quality assurance and quality control (QA/QC) refers to an approach that verifies that sampling and monitoring are being performed correctly. To ensure reliable results, a quality assurance (QA) program, which incorporates quality control (QC) practices, should be in place. QA/QC programs typically include field blanks, field duplicates, verification of in-plant sampling by an accredited laboratory and calibration standards (Nova Scotia Environment, 2022). In addition to the QA/QC program, any test kits used should meet minimum requirements for accuracy, detection (sensitivity), and reproducibility, and be used according to the manufacturer's instructions (Health Canada, 2020b).

For QA/QC purposes, not less than ten percent of all field or portable laboratory samples for microbiological parameters should be submitted to an accredited laboratory (or equivalent) for comparison purposes. Depending on the location of the community and access to laboratories this may not be possible in all cases, and a reliable alternative method should be used for QA/QC purposes.

The Operator should keep an up-to-date log in which the dates and results of all required QA/QC testing (including trucked water test results) are recorded along with the name of the person who conducted the testing. The data collected for the log should be kept for a minimum of five (5) years.

3.8.4 Verification & Third-Party Monitoring

Any sampling and testing of water by FNIHB or other organizations providing environmental public health services (either by certified EPHOs or CBWMs) is for the purposes of verification and third-party monitoring from a public health perspective and does not replace the operational monitoring requirements outlined above (of the raw water, treated water, and distribution system water) that should be conducted by the trained Operator.

EPHOs work with First Nations communities to protect public health by assuring verification monitoring programs are in place to provide a final check on the quality of drinking water at the tap. The CBWM and/or the EPHO perform microbiological and chemical monitoring of drinking water at the tap to verify the water quality being delivered to consumers. EPHOs also perform periodic baseline chemical monitoring of treated drinking water at the treatment plant to complement existing operational monitoring.

Details of FNIHB's verification, microbiological, chemical, baseline and routine monitoring, QA/QC program can be found in FNIHB's *Drinking Water Program Manual, 1st edition* (2014). A copy of the manual can be obtained from FNIHB.

3.8.5 Monitoring of Trucked Water Systems

The delivery truck operator should have adequate training and certification, if available, in operating a bulk (trucked) water delivery system. The truck operator or person(s) in charge of a trucked water system should, at least once per delivery day, measure the quantity of free residual chlorine present in a water sample collected at the outlet of the tank. In addition, it is recommended that trucked water be monitored at the outlet of the tank for microbiological indicators (*E. coli* and total coliforms) on a monthly basis.

The person(s) in charge of a trucked water system should keep an up-to-date log in which the dates and results of required testing are recorded along with the name of the person who conducted the testing. The data collected for the log should be kept for a minimum of five years.

3.8.6 Reporting and Corrective Action for Adverse Results

Adverse water quality results (including inadequate chlorine residual) are to be reported immediately by the designated individual (e.g., Operator or Environmental Public Health Officer) to First Nation leadership, ISC (FNIHB and RO), and, where appropriate, the Provincial/Territorial Medical Officer of Health. Corrective action by First Nation leadership, including notification to consumers (where appropriate) and follow-up sampling, should be performed promptly and in accordance with the community's emergency response plan.

An adverse water quality result is defined here as any health-related parameter that does not meet the acceptable concentration set out in the latest edition of Health Canada's Guideline for Canadian Drinking Water Quality. This includes the health-based treatment limits for turbidity and the health-based treatment goals for enteric protozoa and enteric viruses. Recommendations regarding corrective action may be provided to the First Nation leadership (or chief administrative officer) by the Environmental Public Health Officer, as well as other qualified persons such as the Operator or those performing Annual Performance Reviews. Similarly, corrective actions may be defined in the plant's Emergency Response Plan.

3.9 Emergency Response Plan Requirements

First Nation leadership should have in place an emergency response plan (ERP) in the event of any situation where there is a threat to the health of consumers.

First Nation leadership should ensure that the ERP is kept up to date and developed in consultation with an emergency response consultant or other qualified professional, if available, as well as the Operator. In addition, the water system's ERP should be incorporated into the First Nation's community-wide ERP and could include a communication plan, system information, mitigation strategies as well as potential emergency situations.

ERPs can also include mitigation and response strategies to natural hazards, climate change events, and other emergencies. While the rectification of these situations is out of the Operator's control, systems can be in place to mitigate damage to infrastructure and notify consumers.

The ERP should be reviewed annually. Reviewing the ERP and ensuring that emergency contact phone numbers are fully updated is the responsibility of First Nation leadership. ISC's *Emergency Response Plan for Drinking Water Systems in First Nations Communities (2014)* is available online, containing a template and guidance on the development of an ERP for a specific system.

3.10 Guidance on Addressing Drinking Water Advisories

To be effective, Drinking Water Advisories (DWAs) need to be fully understood by the community in which they are issued. In addition, DWAs should be dealt with quickly. A prolonged DWA can lose effectiveness over time and thus can become a threat to public health.

The *Guidance on Addressing Drinking Water Advisories (2021)* developed by FNIHB replaces the *Procedure for Addressing Drinking Water Advisories in First Nations Communities South of 60 (2007).* It is intended to support and provide guidance to community-based teams who do not have their own procedures in place for addressing Drinking Water Advisories (DWAs), are in the process of developing their own procedures, or who may want to update existing procedures. It is meant to complement and not replace established and proven procedures, guidelines or tools for addressing DWAs.

The document identifies key players that could be part of a Community Based Water Team and their roles and responsibilities; discusses elements of best practices; explains the importance of communication; and provides a suggested review cycle.

The intention of the document is to support communities by providing a possible team-based approach to addressing DWAs that identifies various key individuals to involve and lays out potential roles and responsibilities. The guidance is meant to support communities, should they wish to use it, and identify decision makers and processes related to addressing DWAs.

A printed copy of the *Guidance on Addressing Drinking Water Advisories (2021)* can be obtained from FNIHB.

3.11 Waste Residuals Management Requirements

All ISC-funded drinking water treatment plants should have a system for the treatment and safe disposal of treatment process residuals. Process wastewater treatment systems should meet applicable federal or provincial/territorial rules for the management and ultimate disposal of raw water rejects, backwash discharges, and process residuals.

For more information, consult Section 9 of the ISC *Design Guidelines for First Nations Waterworks (2010)*.

4.0 System Design

The microbiological treatment requirements established under the Centralised Drinking Water Protocol supersede any requirements stipulated in ISC's *Design Guidelines for First Nations Water Works (2010)* (Design Guidelines). A copy of the most current version of the Design Guidelines can be obtained at https://www.sac-isc.gc.ca/eng/1100100034922/1533666798632.

For other design parameters and requirements, First Nation leadership may choose to meet the ISC Design Guidelines or the provincial/territorial design guidelines in the province or territory where the First Nation is located.

Water treatment plants should be designed to enable the facility to be operated in the event that any single piece of critical process equipment fails or needs to be taken offline for servicing. Critical equipment includes any individual component without which the treatment plant would not be able to produce the design treated water flows and quality. Examples of critical equipment for which redundancy is likely required includes raw and treated water pumps, filters, and disinfection units (ACWWA, 2022). A reliability and redundancy analysis should be conducted to define the effect on treated water quality and quantity in the event of a failure, to ensure appropriate levels of redundancy and storage are included in the system.

The key consideration in the design of new or upgraded treatment plants is the protection of public health. Design engineers may also give consideration to the impacts that the recommended treatment processes will have on Operators in terms of operational complexity.

4.1 Treatment Plants

Treatment systems should be designed and constructed based on the results of a source water characterization in terms of quality and quantity of a source, as well as current and future water demands, and they should be reviewed regularly. Operators should be involved in the design or upgrade of their treatment plants. In addition, EPHOs and ISC engineers are available to work with First Nations communities to support reviews of design documents.

Operators, Circuit Rider Trainers and other individuals involved in Annual Performance Reviews (APRs) and Asset Condition Reporting System (ACRS) inspections can provide checks on the status of treatment plant infrastructure and operations and adjustments can be made as needed.

Items to consider in designing effective treatment systems include the treatment processes required, treatment components (including redundancies), equipment design, chemicals used, treatment efficiency, operating and monitoring procedures, process water and waste management, the health and safety of Operators, climate change impact mitigation and adaptation measures, operational complexity, energy requirements and local conditions. In assessing these components, potential hazards and their causes should be identified along with their associated health risks so priorities for risk management can be established. Adaptations in the design, construction, operation and maintenance of treatment plants as a result of potential climate change impacts may also be needed. It is advised that Operators are aware of, and adequately trained to deal with, any potential climate change impacts identified and the effects on the treatment plant.

Comprehensive, scientifically defensible, and achievable performance standards - based on industry-recognised principles - are essential to ensuring the effectiveness and reliability of treatment technologies. Decision makers should balance the desire to use the latest technologies against site-specific economic realities (including life cycle costing analyses). Public health goals should be at the forefront of any treatment-related decision.

For systems with piped water distribution with fire protection, fire flow requirements should be based on a Fire Service Assessment. An evaluation of fire protection options including the use of community building and residential fire sprinklers, and development of related community bylaws, should be included to minimize fire flow and fire storage requirements. An analysis of fire flows according to applicable national and provincial/territorial guidance should be conducted to determine the most appropriate pipe size and storage volume. In all cases, water potability should be prioritized.

4.2 Distribution Systems

Piped distribution systems should be designed, constructed, and upgraded as necessary to eliminate dead-ends (where dead-ends cannot be avoided they should be designed to facilitate flushing), prevent cross-connections, prevent unauthorised access, allow for adequate disinfection, and ensure that water system capacity is sufficient to meet domestic demand and fire protection flows when provided.

Because it has been shown that a significant number of waterborne disease outbreaks are caused by breakdowns in the distribution system, active cross-connection control programs should be developed and implemented for all drinking water systems.

Treated water reservoirs and distribution systems will be designed, constructed, reviewed and upgraded as necessary, to take the following into account: best water management practices, and regulations; prevention of access by wildlife and unauthorised personnel; system capacity; emergency water storage; contact time required for disinfection; minimization or elimination of dead ends, and cross-connection potentials.

4.3 Trucked Water Systems

Tank trucks employed to deliver drinking water in a trucked water system are to be considered as an extension of the water distribution system.

Under the Centralised Drinking Water Protocol, drinking water that is transported in delivery trucks should be obtained only from a public drinking water system that fully meets the requirements of the Centralised Drinking Water Protocol. All surfaces and equipment which come in contact with drinking water including fill point equipment, the drinking water truck's tank, caps, valves, fittings, and other plumbing attachments must meet NSF/ANSI Standard 61: *Drinking Water Components - Health Effects* (NSF, 2020).

The tank must not be used to transport other materials, as these are likely to contaminate the water.

First Nations will operate trucked water systems to effectively protect public health, through the application of industry best practices.

4.4 Code Requirements

Buildings and infrastructure should comply with the more stringent of either the applicable provincial/territorial or federal regulation or codes of practice for all building trades:

- Structures – Comply with the more stringent of applicable provincial/territorial or federal building codes and fire codes;
- Piping – Comply with the more stringent of either the applicable provincial/territorial or federal plumbing codes; and,
- Electrical and mechanical components - Comply with the more stringent of either the applicable provincial/territorial or federal codes.

4.5 Commissioning Plans

Prior to any new or upgraded community water system being placed into service, it should undergo commissioning as set out in a commissioning plan. The terms and conditions of contract documents related to design and construction of the plant and distribution system should state that:

- A detailed, site-specific commissioning plan will be created for the water system.
- The commissioning plan will include performance requirements to be met for a full year of continuous, uninterrupted operation after commissioning begins. Performance requirements will include ensuring that the system reliably produces water at its design capacity and that the water produced by the system meets quality requirements as set out in the Centralised Drinking Water Protocol.
- The warranty for the plant will cover the cost to remedy all deficiencies identified during the commissioning process and for one full year after successful completion of the commissioning process.
- A holdback for commissioning will be set aside to be paid upon successful completion of the commissioning process set out in the commissioning plan.

4.6 As-built or Record Documents

First Nation leadership and the Operator will be provided with as-built documents (as-built or record plans, design brief, etc.) to be kept permanently in the water treatment plant's records. The terms and conditions of construction contract documents should include provision of acceptable quality as-built or record documents.

4.7 Operation and Maintenance Manuals

First Nation leadership and the Operator should be provided with a Water System Operations and Maintenance (O&M) Manual produced by the Consulting Engineer that provides an in-depth description and step by step procedures on how to safely operate and maintain the overall water supply system. In addition, it is highly recommended that a training program led by the consultant, and supported by CRTP if needed, be included with the delivery of O&M manuals particularly for complex systems.

The General Contractor should assemble and provide vendor produced O&M manuals for each piece of equipment installed. The Engineer will use the Vendor's information in the preparation of the Water System O&M Manual. The Manual should also include troubleshooting guidance for commonly encountered issues. A detailed list of the information that should be included in the Water System O&M Manual is provided in ISC's *Design Guidelines for First Nations Waterworks (2010)*. Contract documents should stipulate that the O&M Manuals should be of an acceptable quality to the First Nation and its Operator.

5.0 Asset Management and Record Keeping

Asset management planning promotes cost-effective, proactive, and preventative maintenance and management of water infrastructure. A proactive asset management plan incorporates standard operating procedures, maintenance management plans, emergency response plans and regular inspections of the treatment system components to ensure ongoing performance (CCME, 2004; WHO, 2023). The effective implementation of an asset management plan can lead to increased operator confidence, knowledge retention, efficiency, and uniformity in treatment performance (WHO, 2023).

To protect public health and safety and prolong the service life of a water system, the water system's assets should be inspected regularly to monitor their physical condition, identify maintenance deficiencies, and monitor ongoing system performance in providing safe drinking water.

To ensure efficient planning, operations, maintenance, and emergency troubleshooting, First Nation leadership and the Operator are responsible for the safe-keeping and accessible storage of documents pertaining to the system's design and construction, monitoring logs, and emergency planning.

5.1 Maintenance Management Plans

A functioning Maintenance Management Plan (MMP) must be developed and implemented for the water system. In the context of this requirement, the term "functioning" means that the MMP is in continuous use, all regular maintenance is executed as per the MMP's schedule for maintenance, and records are kept for all maintenance work. MMPs can be developed by Operators and/or in collaboration with qualified professionals such as Circuit Rider Trainers (CRTs), technical Regional HUBs (Ontario), or consulting engineers.

MMPs for water systems are integral to ensuring effective and continuous system performance. Specifically, an MMP is a compilation of records that formalizes the planning, scheduling, documentation and reporting of preventative maintenance activities, and provides a method of recording unscheduled or corrective maintenance activities. The development and implementation of an MMP reduces overall system management risks by improving the effectiveness of preventative maintenance activities, minimizing service disruptions, and extending asset life. An MMP should be site-specific and can be as simple as a wall calendar (or Excel spreadsheet) tracking the annual maintenance required for a single asset or as complex as software with a scanning system to track equipment, inventory, and parts for multiple community assets (e.g., water systems, wastewater systems, community facilities, etc.).

Once developed, it is the responsibility of the Operators who use the MMP to carry out and monitor maintenance procedures. The MMP should be accessible and up to date, as the information should be regularly referenced by Operators to plan, schedule, conduct, and track all routine maintenance activities.

The Department's detailed guide to developing a *Maintenance Management Plan for Drinking Water and Wastewater Systems in First Nations Communities*, including sample templates, is available online at: https://www.sac-isc.gc.ca/eng/1398350727577/1533667365874.

5.2 Extended-Asset Condition Reporting System (E-ACRS/ACRS) Inspections

For Community Systems and systems serving a Public Facility, an E-ACRS/ACRS inspection of the water system's infrastructure is to be performed once every three (3) years by a qualified person (consulting engineer, Tribal Council engineer), who is not from the First Nation involved, to assess the condition of the assets, adequacy of maintenance efforts, needs for additional maintenance work and, with E-ACRS, a 35-year forecast of component replacement needs. The E-ACRS/ACRS inspection report will be discussed with and submitted to First Nation leadership and the ISC regional office. Inspections will be conducted in accordance with the *E-ACRS/ACRS Manual* and *E-ACRS Terms of Reference*, the latest versions of which can be obtained from the ISC office in your region.

5.3 Annual Performance Reviews

For systems defined in Section 2.0 (Community Systems and systems serving a Public Facility), a performance review will be completed annually to verify the performance of the system and update some of the information provided by ACRS inspections. The Annual Performance Review is a collaborative process between the Operator, First Nation leadership, ISC and third parties such as Circuit Rider Trainers that conduct the reviews. Performance reviews are a tool used to provide a periodic assessment of the risks associated with a drinking water treatment and distribution system from source to tap, including its operation, to determine an overall system risk score. The risk associated with the source water, treatment plant and distribution system design, operation and maintenance, record keeping and reporting as well as operator capacity and qualifications is assessed. The reviews also include identification of system deficiencies and recommendations to mitigate risk. The results of these reviews can be used by Operator and First Nation leadership to take actions to avoid critical system failures and strive for continual system improvement.

Annual performance reviews will be conducted by qualified personnel such as a Circuit Rider Trainer, a licensed engineer, a licensed Tribal Council engineer, a provincial/territorial water system inspector, or an Operator who has been, at a minimum, certified to the level of the system to be inspected and has an appropriate understanding of the system being reviewed. Inspectors should be "independent" from the system to be inspected. For example, an inspector cannot belong to the First Nation that owns the system to be inspected, or a Circuit Rider Trainer cannot inspect the systems that are under his responsibility under the Circuit Rider Training Program. Water quality testing results from the Operator (operational results as defined in Section 3.8.2) and from FNIHB (third party monitoring results as defined in Section 3.8.4) for the previous year along with follow-up action reports will be given to the inspector for review and inclusion in the annual inspection report. The annual report will be discussed with and submitted to First Nation leadership and to the ISC regional office.

The list of data required to be collected during an annual inspection can be found in ISC's Integrated Capital Management Systems (ICMS). Inspection forms are generated from ICMS by ISC's regional offices. Data is then collected in the field to complete the inspection forms, which are returned to ISC regional offices for input into ICMS. For a copy of the Annual Inspection form or information on ICMS, contact the ICMS coordinator at the ISC office in your region.

More information regarding the Annual Performance Review process and timelines can be found in the Operating Instructions, the latest version of which can be obtained from the ISC office in your region.

5.4 Documents Management and Record Keeping

First Nation leadership and the Operator are responsible for the management and record keeping of all documents that are essential to the planning, construction, operations, maintenance, and emergency troubleshooting of the water system. Project consultants and contractors should be required through contractual obligation to deliver the appropriate documents to First Nation leadership and the Operator in a timely manner.

5.4.1 Documents Management

First Nation leadership will keep permanently on file, in electronic format, when possible, the following documents:

- Feasibility studies;
- Environmental assessments;
- Design reports and drawings;
- Contract documents;
- Commissioning plan and report; and,
- As-built drawings.

First Nation leadership should engage the appropriate professionals (Operator, CRT, EPHO, licensed engineer) to maintain, revise, and keep up to date the following documents:

- Water Safety Plan (or equivalent Risk Management Documentation);
- Standard operating procedures;
- Maintenance Management Plan; and,
- Emergency Response Plan.

The Water Treatment and Distribution System Operator will keep on hand copies of the following documents:

- Standard operating procedures;

- Maintenance Management Plan;
- Maintenance manuals for each piece of equipment in the plant and the distribution system;
- Emergency response plan;
- Commissioning manual;
- As-built drawings;
- WHMIS documentation (Material Safety Data Sheets); and,
- Water quality results.

5.4.2 Record Keeping

The purpose of record keeping and reporting is to document, review, and improve all aspects of the risk management of the system continually over time. Analysis of operational and water quality records are essential to ensure that the water system is meeting the requirements of the Centralised Drinking Water Protocol and that proper procedures are being followed for treatment and distribution processes. Tracking data over prolonged periods provides insight into the operational trends of a water system, allowing Operators to identify treatment steps reaching operational or critical limits. Reviewing trends can also be critical in identifying plant inefficiencies, providing Operators with better information while making operational adjustments.

In addition to Operator duties outlined in Section 5.4.1, the Operator should keep an up-to-date register in which the dates and results of all required operational sampling and testing (as outlined in Section 3.8.2 of this document) are recorded along with the name of the person who conducted the sampling and testing. The data collected for the registers should be kept for a minimum of five years. In addition, the Operator should keep on file all records related to water quality monitoring, operations, and system maintenance (including laboratory analyses, ACRS reports, annual reports, and consultant reports) for a period of not less than five years. The Operator's daily and weekly record keeping will include:

- Logbook of daily plant checks;
- Logbook of daily and weekly water quality checks;
- Log sheets for calibrating analyzers (chlorine, turbidity, pH);
- Log sheets for disinfectant volumes used (liquid or gas);
- Log sheets for sodium or potassium chloride used for softeners;
- Log sheets for coagulant volumes used;
- Log sheets for chlorine delivered;
- Sign-in sheet for visitors; and,
- Maintenance performance logs for all equipment (pumps, compressors, valves, UV equipment, generators, etc.).

6.0 Operator Certification Requirements

Operator certification requirements should match the requirements of the applicable provincial/territorial system. Thus, Water Treatment and Distribution System Operators should be certified to the level specified by provincial/territorial operator certification requirements for the classification of system they operate. If an Operator lacks the certification or experience required to operate the system, their work should be overseen by an Operator with the required qualifications.

Managers of trucked water systems should ensure that each Operator of the delivery truck possesses adequate training (or a provincial/territorial Operator Certificate for distribution systems, where applicable).

Provincial/territorial requirements for certification of Operators are provided in Appendix F. Information provided in Appendix F is subject to change by the Provincial/territorial department/agency responsible. The latest information should be obtained directly from the respective provincial/territorial department/agency.

Ongoing learning and training are key to the continued success of Operators. Continued training can help maintain skills and ensure up-to-date knowledge, which in turn, helps reduce and prevent operational risks and contributes to the long-term sustainable operation and maintenance of water systems. For some provinces/territories, continued learning is a requirement for maintaining Operator certification, where Continuing Education Units (CEUs) must be completed on an annual basis (additional details in Appendix F). ISC also provides regular on-the-job training and learning opportunities for Operators through the Circuit Rider Training Program (CRTP) and Ontario Regional Water and Wastewater Hubs.

The Circuit Rider Training Program (CRTP) provides on-site training and mentoring to Operators. Qualified experts, known as Circuit Rider Trainers, rotate through a circuit of First Nations communities and provide training for the people responsible for operating, monitoring, and maintaining water systems. Trainers can also assist operators in obtaining and maintaining their Operator certifications. The program supports Operators in developing and maintaining capacity to manage their water systems; increasing reliability of systems; ensuring efficient operations; ensuring that health and safety standards are met; decreasing the number and duration of drinking water advisories; and maximizing the use of existing infrastructure. In some regions, the program provides 24-hour access to qualified experts in case of emergencies. In Ontario, the hands-on technical support is delivered by Regional Water and Wastewater Hubs, and the CRTP offers Continuing Educations Units (CEUs) for operators to achieve and maintain their certification.

7.0 Public Reporting

To help community members stay informed as to the quality of drinking water provided by their water system, it is strongly encouraged that all First Nation water system operating authorities make available to community members a copy of the most recent Annual Inspection Report as well as copies of up-to-date annual summaries of water quality monitoring results. These records should be made available in printed format in an accessible location in the First Nation community such as the First Nation administration office.

8.0 References

Alberta Environment and Parks. *A Guidance Framework for the Production of Drinking Water Safety Plans*. Government of Alberta. (http://environment.alberta.ca/apps/regulateddwq/DWSP.aspx)

AFN Environmental Stewardship Unit (2008). *Climate Change and Water: Impacts and Adaptations for First Nations Communities*. Assembly of First Nations. Climate Change and Water: Impacts and Adaptation Program. (https://www.afn.ca/uploads/files/env/08-03-27_climate_change_and_water_research_paper_final.pdf)

ACWWA (2022). *Atlantic Canada Water Supply Guidelines*. Atlantic Canada Water and Wastewater Association. (https://www.acwwa.ca/resources/water-wastewater-guidelines/kmp/design-guidelines)

Government of B.C (2010*) Comprehensive Drinking Water Source-to-Tap Assessment Guidelines Version 1.0*. Ministry of Healthy Living and Sport. (https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality/resources-for-water-system-operators#source-to-tap-assessment)

CCME (2004). *From Source to Tap: Guidance on the multi-Barrier Approach to Safe Drinking Water*. Canadian Council of Ministers of the Environment, Winnipeg, Manitoba. (http://publications.gc.ca/site/eng/9.690085/publication.html)

Health Canada (2009). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Chlorine*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-lead.html)

Health Canada (2012). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Turbidity*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-turbidity.html)

Health Canada (2019a). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Enteric Protozoa: Giardia and Cryptosporidium*. Water and Air Quality Bureau,
Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/enteric-protozoa-giardia-cryptosporidium.html)

Health Canada (2019b). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Enteric Viruses*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario.

(https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-enteric-viruses.html)

Health Canada (2020a). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Escherichia coli*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-escherichia-coli.html)

Health Canada (2020b). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Total Coliforms*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-total-coliforms.html)

Health Canada (2020c). *Guidance on Natural Organic Matter in Drinking Water*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-enteric-viruses.html)

Health Canada (2021). *Guidance on Providing Safe Drinking Water in Areas of Federal Jurisdiction, Version 3*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-providing-safe-drinking-water-areas-federal-jurisdiction-version-3.html)

Health Canada (2022). *Guidance on Monitoring the Biological Stability of Drinking Water in Distribution Systems.* Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-monitoring-biological-stability-drinking-water-distribution-systems.html)

INAC (2010*). Protocol for Decentralised Water and Wastewater System in First Nations Communities (Decentralised Protocol)*. Indian and Northern Affairs Canada. (https://www.sac-isc.gc.ca/eng/1100100034991/1533666283450)

Manitoba Health (2013). *Bulk water hauling guidelines*. Health Protection Unit, Manitoba Health. (www.gov.mb.ca/health/publichealth/environmentalhealth/protection/docs/bulkwater.pdf)

Nova Scotia Environment (2022). *Nova Scotia Treatment Standards for Municipal Drinking Water Systems, Appendix B-G*. Government of Nova Scotia. (www.novascotia.ca/nse/water/publicwater.municipal.supply.asp)

NSF/ANSI (2021). *Standard 60: Drinking Water Treatment Chemicals – Health Effects*. NSF International. (https://www.nsf.org/knowledge-library/nsf-ansi-standard-60-drinking-water-treatment-chemicals-health-effects)

NSF/ANSI (2022). *Standard 61: Drinking Water Components - Health Effects*. NSF International. (https://www.nsf.org/knowledge-library/nsf-ansi-standard-61-drinking-water-system-components-health-effects)

Roshani, E; Kleiner, Y; Colombo, A; Salomons, E (2022). *Water Distribution Systems: climate change risks and opportunities*. National Research Council of Canada, Construction. (https://doi.org/10.4224/40002739).

WHO (2012). *Water Safety Planning for Small Community Water Supplies.* World Health Organization, Geneva, Switzerland. (https://apps.who.int/iris/handle/10665/75145)

WHO (2014). *Water Safety Plan: A field guide to improving drinking-water safety in small communities*. World Health Organization, Geneva, Switzerland. (https://apps.who.int/iris/handle/10665/329537)

WHO (2017). *Climate-resilient Water Safety Plans: managing health risks associated with climate variability and change.* World Health Organization, Geneva, Switzerland. (https://apps.who.int/iris/handle/10665/258722)

WHO (2022). *Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda.* World Health Organization, Geneva, Switzerland. (https://apps.who.int/iris/handle/10665/352532)

WHO (2023). *Water Safety Plan Manual: Step-by-Step Risk Management for Drinking Water Suppliers. Second Edition.* World Health Organization, Geneva, Switzerland. (https://apps.who.int/iris/handle/10665/75141)

Appendix A: Roles and Responsibilities

Responsibility for safe drinking water is shared between First Nations communities and the Government of Canada. Stakeholder roles and responsibilities are outlined below.

- ***First Nations*** **–** First Nations' responsibilities are divided into two main groups: First Nation leadership, and Water Treatment and Distribution System Operators. The roles of these two groups are defined in Section 1.0 of the Centralised Drinking Water Protocol.

- ***Tribal Councils*** – are organisations mandated by First Nations to provide various services to member First Nations, including technical support. First Nations that lack the required human resource capacity to manage and provide their own public works and technical services, including water treatment and distribution services, should contact their Tribal Council for assistance.

- ***Circuit Riders*** **–** Under ISC's Circuit Rider Training Program (CRTP), funding is provided to engage circuit riders (third party water system experts who provide Operators with on-site mentoring, training, and emergency assistance). The third-party service may also provide Operators with a 24/7 emergency hotline. To participate in the Circuit Rider Training Program, First Nations representatives should contact the CRTP coordinator at the ISC office in their region.

- ***Indigenous Services Canada (ISC)*** – Two branches of ISC provide support to First Nations in relation to their drinking water systems:
    - *Regional Operations (ISC-RO)*: Provides First Nations with financial assistance and technical advice for designing, constructing, commissioning, upgrading, operating, and maintaining water facilities in accordance with relevant policies and protocols. ISC-RO also provides funding and can provide advice for the provision of services shared between First Nations communities and municipalities through municipal-type service agreements (MTSA).
    - *First Nations and Inuit Health Branch (FNIHB)* – FNIHB works in partnership with First Nations communities South of 60º (with the exception of British Columbia, see the *First Nations Health Authority* below) to identify environmental public health risks and recommend actions through qualified engineers to ensure that drinking water quality meets the *Guidelines for Canadian Drinking Water Quality*. In order to build local capacity, FNIHB Environmental Public Health Officers (EPHOs) facilitate the training of Community-Based Drinking Water Quality Monitors (CBWM). EPHOs and public health engineers review data from CBWMs to assess trends and provide recommendations to protect the health and safety of First Nations. FNIHB also reviews water infrastructure proposals from a public health perspective and is actively involved in the development of educational and awareness programs, tools, and materials on drinking water safety issues. All monitoring activities conducted by FNIHB

personnel (EPHOs, CBWMs, etc.) are in addition to the operational monitoring conducted by a Drinking Water Treatment and Distribution System Operator. In First Nations communities where Environmental Health Programs are transferred, the First Nations stakeholders are responsible for community-based drinking water quality monitoring.

- ***First Nations Health Authority (FNHA)*** – The First Nations Health Authority has taken on the responsibility of providing independent public health advice and guidance to First Nations communities in BC. FNHA's Drinking Water Safety Program provides technical advice and funding to enable the effective development and implementation of drinking water quality monitoring. Similar to FNIHB, all monitoring activities conducted by FNHA personnel is in addition to the operational monitoring conducted by a Drinking Water Treatment and Distribution System Operator.

- ***Environment Climate Change Canada (ECCC)*** – ECCC is responsible for enforcing federal legislation related to wastewater, both on and off First Nation lands. This mandate includes the enforcement of regulations related to the disposal of water treatment process residuals where applicable, as regulated under the Wastewater Systems Effluent Regulations (WSER).

Appendix B: Summary of Guidelines for Canadian Drinking Water Quality

The Guidelines for Canadian Drinking Water Quality (GCDWQ) are established by Health Canada in collaboration with the Federal-Provincial-Territorial Committee on Drinking Water (CDW) and other federal government departments. The Guidelines are based on a review of the known health effects associated with each contaminant, on exposure levels and on the availability of treatment and analytical technologies. Aesthetic objectives (e.g., for taste or odour) are provided when they play a role in determining whether consumers will consider the water drinkable. Operational guidance values are provided when a substance may interfere with or impair a treatment process or technology or adversely affect drinking water infrastructure (e.g., corrosion of pipes).

Guideline technical documents provide detailed information on the health risk assessment and how the maximum acceptable concentration (MAC) or treatment requirements were determined for each Guideline for Canadian Drinking Water Quality.

A summary of the values and key information from each of the guidelines is also published in the Guidelines for Canadian Drinking Water Quality Summary Table. Health Canada updates the summary table regularly, however, individual guideline technical documents and guidance documents available on the website Water Quality - Reports and Publications should be consulted for the most current information. It is recommended that the water system manager and Operator review the most current version of the Summary Table annually.

Appendix C: Definition of Groundwater under Direct Influence of Surface Water

All water supply wells serving community systems or public facilities should be screened to determine if they could potentially be classified as groundwater under the direct influence of surface water (GUDI). If the wells fail the initial screening criteria, then a more detailed GUDI assessment is required. Some provinces use the terminology groundwater at risk of pathogens (GARP). The purpose of the evaluation is to determine if the water supply contains particulates and large diameter pathogens such as enteric protozoa which impacts the type of treatment required (e.g., filtration or equivalent technology). GUDI is defined as (U.S.EPA, 1991), "any water beneath the surface of the ground with:

i. significant occurrence of insects or other macro-organisms, algae, organic debris, or large-diameter pathogens such as *Giardia lamblia* or *Cryptosporidium*; or
ii. significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH which closely correlate to climatological or surface water conditions."

A GUDI evaluation should include, at a minimum, an assessment of the raw water quality and hydrogeology, a physical evaluation of the well and well-casing, and a survey of activities and physical features in the area. Microscopic Particulate Analysis (MPA) can be used to quantify the risk of contamination by potential surface water organisms (e.g., algae, organic debris, insects or other macro-organisms). The presence of chlorophyll-containing algae is considered unequivocal evidence of surface water contamination and should be included in any MPA assessment. GUDI assessments should be conducted by a person with hydrogeological training and experience that is registered to practice as a Professional Geoscientist or Engineer. It is important that water supply wells be properly classified as numerous waterborne outbreaks have been linked to consumption of untreated well water contaminated with enteric protozoa (Health Canada, 2019a).

Some provinces/territories have procedures in place to define discrete levels of vulnerability within a GUDI classification (e.g., high-, medium-, low-risk GUDI). This process is used to determine the level of treatment required in provincial standards/regulations including determining if natural filtration credits can be applied for enteric protozoa removal. Regardless of designation, all water supply wells should be properly classified to implement the most effective control measures to protect public health (Alberta Environment and Parks, 2021; Ministry of Health, British Columbia, 2017; Nova Scotia Environment, 2022).

As there is no federal procedure for determining whether a groundwater source is under the direct influence of surface water, please consult the following provincial/territorial guidance for procedures on assessing if a water supply well is GUDI/GARP.

British Columbia and Yukon:

Ministry of Health, British Colombia (2017). *Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP) Version 3*. Health Protection Branch, Ministry of Health, British Columbia. (Available at: www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality/resources-for-water-system-operators#garp-at-risk)

Alberta:

Alberta Environment and Parks (2021*). Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems Part 1: Standards for Municipal Waterworks, Appendix 1-E Assessment Guideline for Groundwater Under the Direct Influence of Surface Water (GWUDI)*. Government of Alberta. (Available at: open.alberta.ca/publications/5668185)

Saskatchewan:

Saskatchewan Ministry of Environment and The Water Security Agency (2002). *Groundwater Under the Direct Influence of Surface Water (GUDI) Assessment Guideline EPB 284*. Saskatchewan Ministry of Environment. (Available at: publications.saskatchewan.ca/#/products/113236)

Manitoba:

Manitoba Environment, Climate, and Parks (2007). The Drinking Water Safety Act, MB Regulation 40/2007: Drinking Water Safety Regulation, Section 2. Manitoba Environment, Climate, and Parks. (Available at: Man Reg 40/2007 | Drinking Water Safety Regulation | CanLII)

Ontario:

Ontario Ministry of the Environment, Conservation and Parks (2001). *Terms of Reference for Hydrogeological Study to Examine Groundwater Sources Potentially Under Direct Influence of Surface Water*. (Available at: www.publications.gov.on.ca/terms-of-reference-for-hydrogeological-study-to-examine-groundwater-sources-potentially-under-direct-influence-of-surface-water-october-2001)

Prince Edward Island:

PEI does not currently have a GUDI assessment protocol. It is recommended that the Nova Scotia protocol for assessing a potentially GUDI water source be consulted.

Québec:

Direction Générale des Politiques de l'Eau (2019). *Guide de Conception des Installations de Production d'Eau Potable, Volume 1, Chapitre 6.6 Protocole d'évaluation de l'influence directe de l'eau de surface sur les eaux souterraines et de la susceptibilité à la contamination microbiologique*. Québec, Ministère de l'Environnement et de la Lutte contre les Changements Climatiques. (Available at: https://www.environnement.gouv.qc.ca/eau/potable/guide/index.htm)

New Brunswick:

New Brunswick Department of Environment and Local Government (2022). *Protocol for Determining Groundwater Under the Direct Influence of Surface Water (GUDI Protocol)*. (Please contact the New Brunswick Department of Environment or Local Government to obtain a copy of their GUDI Protocol.)

Nova Scotia:

Nova Scotia Environment (2022). *Nova Scotia Treatment Standards for Municipal Drinking Water Systems, Appendix A: Protocol for Determining Groundwater under Direct Influence of Surface Water*. Nova Scotia Environment (Available at: https://novascotia.ca/nse/water/docs/Treatment_Standards_for_Municipal_Drinking_Water_Systems_Appendix%20A.pdf)

Newfoundland and Labrador:

AECOM (2012). *Groundwater Under Direct Influence of Surface Water (GUDI) – an Evaluation for Public Water Supplies in Newfoundland and Labrador*. Government of Newfoundland and Labrador, Department of Environment and Conservation, Water Resources Management Division. (Available at: www.gov.nl.ca/ecc/files/waterres-cycle-groundwater-nl-gudi-aecom.pdf)

Appendix D: Guidance on Filtration, Turbidity and Log Removal Credits

Filtration is an important step in the treatment of drinking water for the physical removal of particulates such as clay and silt, microorganisms, natural organic matter, and inorganic precipitates. Removal of particulate matter is essential to minimize the potential for interference during disinfection processes and improve disinfection efficacy. It is also important to minimize particulate loading to effectively operate distribution systems. In general, all surface water and GUDI source water should be filtered prior to disinfection (Health Canada, 2012).

Filtration processes include a variety of engineered technologies including chemically assisted (conventional), direct, slow sand, diatomaceous earth and membrane filtration. These processes can be effective for the removal of microorganisms and are a particularly important treatment barrier for enteric protozoa. Since enteric viruses and protozoa cannot be routinely measured in filtered water, turbidity is used as in indicator of the effectiveness of filtration processes.

Depending on the type and performance of the filtration process(es) in place, log removal credit(s) for the removal of enteric viruses and enteric protozoa (*Giardia* and *Cryptosporidium*) can be assigned to a drinking water system. Log removal credits are based on the ability of the filtration process to achieve specified levels of turbidity in the filtered water. For filtration systems that use conventional, direct, slow sand, diatomaceous earth or membrane technologies, Health Canada has established health-based treatment limits based on the turbidity from individual filters or units for each type of filtration technology. Details on the health-based treatment limits and the associated log removal credits can be found in Health Canada's Guideline Technical Document - *Turbidity* (Health Canada, 2012).

Health Canada's Turbidity guideline is provided below. Guidelines are periodically updated, and this information is subject to change. Readers should consult the link above for the latest version of the guideline.

Turbidity levels are an important consideration for the effective design and operation of a variety of treatment processes and as an indicator of water quality changes in drinking water systems. For filtration systems that use conventional, direct, slow sand, diatomaceous earth or membrane technologies, the turbidity from individual filters or units should meet the following treatment limits in order to achieve health-based pathogen removal goals:

1. *For **conventional and direct filtration**, less than or equal to **0.3 nephelometric turbidity units (NTU)** in at least 95% of measurements either per filter cycle or per month and never to exceed 1.0 NTU;*
2. *For **slow sand or diatomaceous earth filtration**, less than or equal to **1.0 NTU** in at least 95% of measurements either per filter cycle or per month and never to exceed 3.0 NTU; and*
3. *For **membrane filtration**, less than or equal to **0.1 NTU** in at least 99% of measurements per operational filter period or per month. Measurements greater than 0.1 NTU for a period of greater than 15 minutes from an individual membrane unit should immediately trigger an investigation of the membrane unit integrity.*

Appendix E: Guidance on Concentration-Time (CT) and Intensity-Time (IT) Concepts

Chemical-based disinfectants (chlorine, chlorine dioxide and ozone) can be used for primary disinfection of drinking water due to their strong inactivation of a broad range of microbial contaminants. The efficacy of a chemical disinfectant varies based on the specific microorganism and a variety of design and operational factors. Water quality parameters such as low temperature, high pH, and high turbidity can significantly reduce the efficacy of chemical disinfection and must be considered in the design and operation of these drinking water treatment processes (Health Canada, 2019b; U.S. EPA, 2020).

Reactions between chemical disinfectants and natural organic matter (NOM) can form disinfection by-products (DBPs), some of which can pose human-health risks (Health Canada, 2020c; U.S. EPA, 2020). Inorganic compounds that enhance the reactivity of NOM with disinfectants should be characterized (i.e., ammonia, bromide, iodide, and sulfur) (Health Canada, 2020). Ozone and chlorine dioxide also have the potential to form inorganic DBPs (i.e., bromate and chlorite/chlorate, respectively). When selecting a chemical disinfectant, the potential impacts of DBP formation should be considered, and minimized, without negatively impacting the disinfection process (Health Canada, 2019b; Health Canada 2020c).

Ultraviolet (UV) radiation is an alternative to chemical disinfectants that can be used for primary disinfection of drinking water and is especially effective for inactivating protozoa. UV is usually applied after filtration, to reduce the effects of particle shielding (Health Canada, 2019b; U.S. EPA, 2003). Minimal DBP formation is expected from the use of UV light, although chlorate and bromate formation has been reported with advanced oxidation processes using UV and chlorine (U.S. EPA, 2003).

Disinfection requirements for drinking water systems use the Concentration-Time (CT) concept for chemical disinfection and the Intensity-Time (IT) concept for UV disinfection. The CT and IT values needed to achieve various levels of log inactivation based on a target microorganism and specific design and operational parameters can be found in CT and IT tables that are available in the references provided below. The Drinking Water Treatment and Distribution System Operator should ensure that the minimum required CT and/or IT is achieved at all times, as determined for the specific system.

Details on determining CT for chlorine disinfection and IT for UV disinfection are provided below. Details on determining CT for ozone and chlorine dioxide can be found in Health Canada (2019a), Health Canada (2019b), US EPA (1999) and US EPA (2020).

Chemical Disinfection: Guidance on Concentration x Time (CT) Concept

The efficacy of chlorine disinfection for a specific microorganism can be predicted based on knowledge of the residual concentration and factors that influence its performance, mainly temperature, pH, and contact time (Health Canada, 2019a). This relationship is referred to as the CT concept, where CT is the product of:

- *C* - the residual concentration of disinfectant, measured in mg/L, and
- *T* – the time that water is in contact with the disinfectant in minutes.

To account for disinfectant decay, the residual concentration is usually determined at the exit of the contact chamber rather than using the applied dose or initial concentration. The contact time T is typically calculated using a T_{10} value, which is defined as the detention time at which 90% of the water meets or exceeds the required contact time. The T_{10} value can be estimated by multiplying the theoretical detention time (i.e., tank volume divided by flow rate) by the baffling factor of the contact chamber. Alternatively, tracer tests can be conducted to measure the contact time of a specific chamber (Health Canada, 2019a).

While operators have greater control of disinfectant concentration on an operational basis, contact time at peak flow is dependent on the hydraulics related to the construction of the treatment plant. Plant design should be optimized (i.e., increasing baffling factor) to maximize contact time and reduce the quantity of disinfectant needed. When designing and operating a chlorine disinfection system, the most appropriate control factors include the disinfectant concentration and the contact time at peak flow (Nova Scotia Environment, 2022; U.S. EPA, 2020). More information on determining baffling factors and optimizing contact time is provided in the resources below.

The CT value for any plant should be determined based on a 'worst-case' scenario encountered during treatment operations. For chlorine, this typically includes highest pH, lowest temperature, highest turbidity, and peak flow (Health Canada, 2019a). Standards of procedure should indicate minimum and maximum design ranges for achieving CT specific to the disinfection process (Nova Scotia Environment, 2022; U.S. EPA, 2020).

UV Disinfection: Guidance on Intensity x Time (IT) Concept

UV disinfection can be achieved using low pressure lamps (LP) which emit UV light primarily at a single wavelength of ~254 nm or using medium-pressure (MP) lamps which use light across a broader spectrum. All UV applications should be expressed in a common equivalent dose (e.g., 254 nm) (Health Canada, 2019b; U.S. EPA, 2003).

The amount of UV light delivered to pathogens in a reactor is referred to as the UV dose. The UV dose depends on a number of factors including the UV intensity, UV transmittance (UVT) and the water flow rate and hydraulics in the reactor. Validation testing should be conducted to determine the operating conditions under which the reactor will deliver the required UV dose (Health Canada, 2019b). The operating conditions include flow rate, UV intensity, UV lamp status, and account for UV absorbance of the water, lamp fouling and aging, inlet and outlet piping configuration of the UV reactor and measurement of the uncertainty of on-line sensors (Nova Scotia Environment, 2022).

UV dosage is a measure of the energy incident over a surface area, and acts as a function of the UV Transmittance (UVT) of the water, lamp output intensity, and flow rate (exposure-time).

For UV disinfection, the product of light intensity and time results in a computed dose (fluence) in mJ/cm^2 for a specific microorganism. This relationship is commonly referred to as the IT concept, where IT is the product of:

- *I* - the incident power of the lamp, measured in W/m^2 or W/cm^2, and
- *T* - the exposure time for water under the lamp, measured in seconds.

A typical minimum dose of 40 mJ/cm^2 is considered sufficient to achieve 4-log inactivation of most enteric viruses using LP lamps with the exception of adenovirus which is especially resistant to UV inactivation and requires a significantly higher dose for an equivalent log-inactivation (Health Canada, 2019a; Nova Scotia Environment, 2022; U.S. EPA, 2020). It is possible to combine LP UV at a dose of 40 mJ/cm^2 with other inactivation technologies, such as chlorine disinfection, to provide 4-log reduction of adenovirus. UV systems should be designed to achieve the required log inactivation for the appropriate target microorganism (e.g., adenovirus or rotavirus) for specific 'worst-case' conditions, typically lowest UVT, and peak flow rate (Health Canada, 2019b; U.S. EPA 2003).

UV system design should consider the specific operational ranges of the system (UVT, intensity, flow rate), redundancy and reliability of equipment, and scaling and fouling (U.S. EPA 2003). Continuous monitoring should be conducted to ensure the reactor remains within the validated conditions and an automatic shut off and alarm should be installed to indicate failure to meet any of the specifications. Systems should also be in place to prevent inadequately treated water from being distributed, including during lamp cleaning and warm-up. Scaling, fouling, and physical damage to the sleeve decrease the UVT, meaning a greater lamp output or exposure time is required for the same level of treatment (U.S. EPA, 2003). For this reason, sleeves should be cleaned on a regular basis, with attention to care, in accordance with the standard operating procedures.

Resources

A compilation of resources including CT and IT tables from federal, provincial, and international entities, with brief descriptions of each document, is provided below.

Health Canada (2019a). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Enteric Protozoa: Giardia and Cryptosporidium*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (Available at www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-enteric-protozoa-giardia-cryptosporidium.html)

- Health Canada's Enteric Protozoa document provides guidance on calculating the CT/IT value for chlorine, chlorine dioxide, UV, and ozone disinfection systems as well as CT/IT tables to help determine the required values to achieve various levels of log-inactivation of select protozoa– See section 7, Appendix A, and Appendix B

Health Canada (2019b). *Guidelines for Canadian Drinking Water Quality: Guideline Technical Document — Enteric Viruses*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (Available at: https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-enteric-viruses.html)

- Health Canada's Enteric Virus document provides guidance on calculating the CT/IT value for chlorine, UV, and ozone disinfection systems as well as CT/IT tables to help determine the required values to achieve various levels of log-inactivation of select viruses– See section 7

Health Canada (2020c). *Guidance on Natural Organic Matter in Drinking Water*. Water and Air Quality Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontario. (Available at: https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-natural-organic-matter-drinking-water.html)

- Guidance on how NOM affects drinking water treatment and distribution systems, techniques to measure NOM, its role in the formation of DBPs, and strategies to minimize DBP formation

Nova Scotia Environment (2022). *Nova Scotia Treatment Standards for Municipal Drinking Water Systems, Appendix B-G*. (Available at: www.novascotia.ca/nse/water/publicwater.municipal.supply.asp)

- Nova Scotia's Drinking Water Treatment Standards provide detailed guidance on determining and calculating CT/IT-values to achieve various levels of log-inactivation, and guidance on system design to improve baffling. See Appendix C through Appendix G

U.S. EPA (1999). *Alternative Disinfectants and Oxidants Guidance Manual*. U.S. EPA, Office of Water, Washington, DC. (Available at: nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=2000229L.txt)

- This manual provides additional guidance for ozone and chlorine dioxide in sections 3 and 4, respectively. The disinfection chemistry, primary uses, disinfection by-products, and operational considerations are presented for each disinfectant.

U.S. EPA (2003). *Ultraviolet Disinfection Guidance Manual*. U.S. EPA, Office of Water, Washington, D.C. (Available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=901T0000.TXT)

- The U.S. EPA's UV Disinfection Guidance Manual provides technical information and guidance on the selection, design, and operation of UV disinfection systems including tools for evaluating and calculating the effectiveness of UV systems.

U.S. EPA (2020). *Disinfection Profiling and Benchmarking Guidance Manual*. U.S. EPA, Office of Water, Washington, DC. (Available at: www.epa.gov/system/files/documents/2022-02/disprof_bench_3rules_final_508.pdf)

- The U.S. EPA's Disinfection Guidance Manual provides guidance on calculating the CT/IT value for chemical and UV disinfection systems as well as CT/IT tables to help determine the required values to achieve various levels of log-inactivation of select microbiological contaminants.

Appendix F: Guidance on Provincial Operator Certification Requirements

Operator certification requirements for First Nations water systems will match applicable provincial requirements. Thus, operators of water treatment plants and distribution systems must be certified to the level required for their respective drinking water system as specified by the appropriate provincial operator certification program. Managers of trucked water systems should ensure that the operators of the delivery truck possess adequate training (or a provincial operator certificate for distribution systems where applicable). The table below includes links for operator certification information. For the most up-to-date information on requirements, exams, and certification visit these links.

Province	Operator Certification Information Links
AB	Water and wastewater operator certification | Alberta.ca
BC	How to Become an Operator | EOCP
MB	Environment, Climate and Parks | Province of Manitoba (gov.mb.ca)
NB	Water and Wastewater Operator - Apprenticeship and Occupational Certification (gnb.ca)
NL	Operator Certification - Environment and Climate Change (gov.nl.ca)
NS	Operator Certification | Water: Operator Certification (novascotia.ca)
ON	Drinking water operations: training and certification | ontario.ca
PEI	Obtaining a Water and Wastewater Operator Certificate | Government of Prince Edward Island
QC	Water System Worker Certification (ccq.org)
SK	Operator Certification - SaskOCB
YK	How to Become an Operator | EOCP

The following table includes options for operator training in each province. Free and Indigenous-focused courses are listed separately below.

Province	Organizations	Links to Training for Operator Certification
AB	Alberta Onsite Wastewater Management Association	Alberta Onsite Wastewater Practitioner Training
	Alberta Water and Wastewater Operators Association (AWWOA)	AWWOA Training
	ATAP Infrastructure Management Ltd.	ATAP courses
	Northern Alberta Institute of Technology	NAIT – Water and Wastewater Technician Certificate
	Northern Lakes College	Water And Wastewater Operator Preparation
	Portage College	Water and Wastewater Treatment Courses
	Southern Alberta Institute of Technology	Water and Wastewater Treatment Operations Certificate
BC	BC Institute of Technology	BCIT program
	BC Water & Waste Association	BCWWA Course Catalogue
	Coastal Water Suppliers Association	Operator Training Courses
	Environmental Operators Certificate Program (EOCP)	Program Guide
	Maintenance Training Systems INC	MTS courses
	Okanagan College	Water Engineering Technology Diploma
	Thompson Rivers University	Indigenous Operator Training

	Western Canada Onsite Wastewater Management Association	Onsite Wastewater Practitioner Training
MB	Manitoba Onsite Wastewater Management Association (MOWMA)	Onsite Wastewater Practitioner Training
	Apprenticeship Manitoba	Advanced Education, Skills, and Immigration MB - Technical Training
	Assiniboine Community College	Courses - Water and Wastewater Refresher Courses
	ATAP Infrastructure Management Ltd.	ATAP courses
	Manitoba Water & Wastewater Association	Manitoba Water & Wastewater Association - Training (mwwa.net)
	Parkland College	Water and Wastewater Training Courses
	Red River College (RRC) Polytech	Manitoba Water and Wastewater Training
NB	NB Community College (NBCC)	Water & Wastewater Management (nbcc.ca)
NL	NL Operator Education, Training and Certification (OETC) Program	Operator Education
NS	Maritime Provinces Water and Wastewater Association (MPWWA)	Workshops
	Nova Scotia Community College (NSCC)	Environmental Engineering Technology – Water Resources | Programs | NSCC
	Waste Water Nova Scotia Society	Professional Training Programs
ON	Conestoga	Water Treatment and Distribution System Operations Program
	George Brown College	Water Treatment and Distribution System Operations Program
	OCWA	Training Services
	Ontario Colleges (various institutes)	Water/Wastewater Programs List
	Seneca College	Water Treatment and Distribution System Operations Program
	Walkerton Clean Water Centre	Course catalogue First Nations Courses
	Water First	Indigenous Schools Water Programs
	World Water Operator Training	Course Catalogue
PEI	Environmental Training Institute (PEI)	Environmental Training Institute (etivc.org)
	Holland College (PEI)	Small Water Systems Training
QC	Cégep de Saint-Laurent	Traitement des eaux (Attestation d'études Collégiales (AEC)) Technologie de l'eau: programme unique au Québec (Diplôme d'études collégiales (DEC))
	Cégep de Shawinigan	Techniques de gestion des eaux Formations en assainissement des eaux usées
	Centre de formation professionnelle Paul-Gérin-Lajoie	Conduite de procédés de traitement de l'eau - Inforoute FPT
	Centre de services scolaire des Trois-Lacs	Programme de qualification des opérateurs en eau potable
	Commission de la Construction du Québec	Certification de manœuvre à l'Aqueduc
	Mastera Formation Continue - Cégep de Jonquière	Gestion et assainissement des eaux (attestation d'études collégiales (AEC))
	Université Laval	Génie des eaux | Baccalauréat (ulaval.ca)
SK	Great Plains College	Water and Wastewater Training Courses
	Prince Albert Grand Council	Training upon request

	Saskatchewan Polytechnic	Water and Wastewater Courses
	Saskatchewan Water and Wastewater Association (SWWA)	Training (membership registration required)
	SaskWater Corporation	First Nations Training Program - SaskWater
	Southeast College	Wastewater Treatment & Collection Class 1
YK	Environmental Operators Certificate Program (EOCP)	Program Guide
	Yukon University	Yukon Water and Wastewater Operator Program

Free Courses

Province	**Organization**	**Link**
AB & MB	Saskatchewan First Nations Water Association Inc. (Online)	CEU Classes and Workshops
BC	Thompson Rivers University	Indigenous Operator Training
ON	Walkerton Clean Water Centre	First Nations Courses
SK	Saskatchewan First Nations Water Association Inc. (Online)	CEU Classes and Workshops

Indigenous-Focused Courses

Province	**Organization**	**Link**
BC	Thompson Rivers University	Indigenous Operator Training
SK	SaskWater Corporation	First Nations Training Program - SaskWater
ON	Walkerton Clean Water Centre	First Nations Courses

Appendix G: Definitions

Aesthetic objective (AO): Aesthetic objectives are parameters that may affect consumer acceptance of drinking water such as taste, odour and colour.

Alkalinity: A measure of the capacity of water to neutralize acids. It is influenced by the presence of the conjugate bases of inorganic carbon (HCO_3^- and CO_3^{2-}) and organic acids, as well as orthophosphate ($H_2PO_4^-$, HPO_4^{2-}, and PO_4^{3-}), ammonia and silicate, all of which consume acid (H^+) when it is added to the water. Alkalinity is usually expressed as the equivalent concentration (mg/L) of calcium carbonate ($CaCO_3$).

Aquifer: A geological formation of permeable rock, sand or gravel that conducts groundwater and yields significant quantities of water to springs and wells.

Bacteria (plural), bacterium (singular): Microscopic living organisms usually consisting of a single cell. Some bacteria are pathogenic and may cause human, animal and plant health problems.

Centralised water system: For the purposes of the Centralised Drinking Water Protocol, a centralized water system is any water treatment and distribution system which serves five (5) or more households and/or one or more public facilities.

Contact Time: The contact time is the theoretical amount of time water is exposed to a disinfectant and is highly dependent on the hydraulics of the contact chamber. Contact time can be estimated using a T_{10} concept which considers the geometry and flow characteristics of the system or can be modelled more accurately using tracer tests.

Chloramine: A chemical compound resulting from the interaction of chlorine and ammonia, or other amines. Chloramines can be found in drinking water intentionally, as a result of treatment, or unintentionally, as a result of chlorine disinfection in the presence of ammonia. Chloramines are not as strong of a disinfectant as chlorine, but they are more stable and provide longer-lasting disinfection.

Chlorine: Chlorine is used in most Canadian drinking water treatment and distribution systems as a primary or secondary disinfectant. Chlorine can inactivate most microorganisms in drinking water, virtually eliminating waterborne diseases, but will also interact with other compounds in water to form disinfection by-products (DBPs).

Contaminant: Any physical, chemical, microbiological, or radiological substance or matter that may be found in water that may be harmful to human health, impact consumer acceptance of water, or affect the operations of drinking water treatment systems.

Cryptosporidium: *Cryptosporidium* is a protozoan parasite found in the gut of humans and other mammals and can be found in water following direct or indirect contamination by the feces of humans and other animals. It is commonly found in surface waters and can survive for long periods of time in the environment. Individuals infected with *Cryptosporidium* may develop symptomatic illness including diarrhea, cramping, nausea, vomiting (particularly in children), low-grade fever, anorexia and dehydration.

Disinfectant: A disinfectant is a chemical (commonly chlorine, ozone, chlorine dioxide) or physical process (e.g., ultraviolet light) that inactivates microorganisms such as bacteria, viruses, and protozoa.

Disinfection by-products (DBP): Chemical disinfectants react with Natural Organic Matter (NOM) in the treatment and distribution system to form DBPs. Health Canada has established health-based maximum acceptable concentrations (MACs) for the most common DBPs (THMs, HAAs, chlorite/chlorate, bromate and N-nitrosodimethylamine). DBP formation is dependent on the chemical disinfectant used, the NOM fractions present, physical characteristics of the water (e.g., temperature and pH), and the presence of other reactive species (e.g., bromide, iodide, ammonia, and sulfur).

Distribution System: The part of a drinking water system that is used in the distribution, storage or supply of water and that is not part of a treatment system or household/premise plumbing.

Drinking Water: Water that is safe to drink as it meets the health-based Guidelines for Canadian Drinking Water Quality, set out by Health Canada.

Drinking water treatment and distribution system operator (Operator): A system's Operator is a First Nation employee or a third party under contract to a First Nation who is tasked with the operation and maintenance of a water system.

Escherichia coli: *Escherichia coli* (E. coli) is a species of bacteria that is naturally found in the intestinal system of humans and animals. It is present in feces in high numbers and can be easily measured in water, which makes it a useful indicator of fecal contamination for drinking water providers. There are several pathogenic types of E. coli, like E. coli O157:H7 serotype, which have acquired traits that make them harmful to humans. These pathogenic *E. coli* can be important causes of waterborne enteric illness if they are introduced into drinking water supplies through contaminated human or animal feces.

First Nation lands: First Nation lands means lands of a First Nation that are referred to in Class 24 of section 91 of the Constitution Act, 1867, and source water on, in or under those lands. It does not include lands over which Aboriginal title is claimed by a First Nation or has been confirmed by a court.

Giardia: *Giardia* is a flagellated protozoan parasite found in the gut of humans and other mammals and can be found in water following direct or indirect contamination by the feces of humans and other animals. It is commonly found in surface waters and can survive for long periods of time. Typically, *Giardia* is non-invasive and results in asymptomatic infections. Symptomatic giardiasis can result in nausea, diarrhea (usually sudden and explosive), anorexia, an uneasiness in the upper intestine, malaise and occasionally low-grade fever or chills.

Groundwater: A raw water supply that is classified as groundwater means water that is located in an aquifer where the overburden acts as a filter that reduces the risk of the presence of larger sized microbial pathogens (i.e., bacteria and enteric protozoa).

Groundwater at risk of containing pathogens (GARP): Terminology used mainly in British Columbia to refer to groundwater that is vulnerable to contamination by enteric protozoa, viruses, and other pathogens.

Groundwater under the direct influence of surface water (GUDI): Is generally considered to be a subsurface water source (groundwater) that is vulnerable to contamination by large diameter pathogens including enteric protozoa such as *Giardia* and *Cryptosporidium*.

Haloacetic acid (HAA): HAAs are a common DBP, formed when chlorine (or chlorine-based disinfectants) used to control microbial contaminants in drinking water reacts with naturally occurring organic matter in water. Total Haloacetic Acids refers to the total of monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid and dibromoacetic acid. Health Canada has established a MAC for total HAAs.

Hardness: Hardness is a measure of calcium and magnesium in water. These elements precipitate with carbonate in boilers and pots to form scale. Hardness also makes it difficult to form lather, requires more soap, and creates a soap scum. Softeners can be used to treat hardness by removing some of the mineral ions.

Inactivate: A term used in water disinfection, that refers to the process by which a disinfectant renders pathogenic microorganisms harmless by damaging them enough that they can no longer reproduce and are, thus, no longer infectious.

Maximum acceptable concentration: A Maximum Acceptable Concentration (MAC) is a drinking water guideline value that is determined based on a comprehensive review of the known health effects associated with a contaminant, exposure levels of the population to a contaminant and the availability of treatment and analytical technologies.

Microorganisms: Microorganisms, also known as microbes, are tiny living organisms that can be seen only with the aid of a microscope. Some microbes can cause acute health problems when consumed in drinking water.

Ozone: Ozone is produced when oxygen (O_2) molecules are dissociated by an energy source into oxygen atoms and subsequently collide with an oxygen molecule to form an unstable gas, ozone (O_3). It can be used as a treatment method for oxidizing and eliminating contaminants.

Pathogen: Pathogen is a term applied to any disease-causing organism.

pH: pH is a measure of the acidity/basicity of water. Water with a pH of 0 to less than 7 is acidic. A pH of 7 is neutral, neither acidic nor basic. Water with a pH greater than 7 to 14 is termed basic. In Canada, the operational guideline for pH is a range of 7.0 to 10.5 for finished drinking water.

Premise plumbing: Premise plumbing is the portion of a water system including piping and fixtures (e.g., showers and faucets) that are located within a home that is connected to a piped or trucked water system via service lines or a cistern.

Public facility: A non-commercial, ISC-funded facility that is owned or operated by a First Nation and serves a public function (such as a school, band office, or community centre).

Radiological contaminants: Radionuclides are naturally present in the environment, and they may also enter the environment as a result of human activities. Maximum acceptable concentrations in drinking water have been established for three natural (210Pb, 226Ra, and total uranium in chemical form) and four artificial (tritium, 90Sr, 131I, and 137Cs) radionuclides. These represent the natural and artificial radionuclides that are most commonly detected in Canadian water supplies.

Raw water: Water that enters a drinking water system prior to any drinking water treatment process.

Service connection: Any point where a drinking water treatment and distribution system connects to a building's plumbing or, in the case of a trucked system, a holding cistern.

Source water: Water in its natural state (surface water or groundwater) prior to any introduction into the drinking water treatment and distribution system.

Surface water: Raw water that is obtained from sources such as lakes, rivers, and reservoirs that are open to the atmosphere.

System designer: A system designer is a person, such as an engineer, who is qualified to design a water system.

System manager: A system manager is an employee of the First Nation or a third party under contract to the First Nation who is tasked with managing a water system.

Total coliform(s): Total coliforms are a group of bacteria that are naturally found on plants and in soils, water, and the intestines of humans and warm-blooded animals. It refers to three groups of coliforms whose presence may indicate contamination by disease-causing microorganisms. All three groups contain various species of the genera Escherichia, Klebsiella, Enterobacter, Citrobacter, Serratia, and many others. Total coliforms are naturally found in both fecal and non-fecal environments, so they are commonly present in both surface water and groundwater under the direct influence of surface water (GUDI) sources. The degree of response to the presence of total coliforms (in the absence of E. coli) should be discussed with the appropriate authorities and will depend on system specific factors.

Trihalomethanes (THM): THMs are a common DBP, formed when chlorine (or chlorine-based disinfectants) used to control microbial contaminants in drinking water reacts with naturally occurring organic matter in water. Trihalomethanes refers to the total of chloroform, bromodichloromethane, dibromochloromethane and bromoform in a water supply. Health Canada has established a combined MAC for THMs (including dibromochloromethane) and a separate MAC for dibromochloromethane.

Trucked system: A drinking water system that uses tank trucks to deliver potable water to consumers. For the purposes of this document, the cisterns to which water is delivered are not included as part of the centralised system.

Turbidity: A measure of the relative clarity or cloudiness of water. Turbidity is usually measured in nephelometric turbidity units (NTU), using a device called a turbidimeter. Turbidity is not a direct measure of suspended particles, but rather a general measure of the scattering and absorbing effect that suspended particles have on light.

UV: Ultraviolet (UV) light is a disinfection process that uses radiation to penetrate an organism’s cell walls and disrupt genetic material, making reproduction impossible.

Water quality: The term used to describe the chemical, physical, radiological, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Watershed: A land catchment area, typically bounded by a natural divide, that directs water and potential contaminants to a particular water course or body of water.

WHMIS: The Workplace Hazardous Materials Information System (WHMIS) is Canada's national hazard communication standard. The key elements of the system are hazard classification, cautionary labelling of containers, the provision of (Material) Safety Data Sheets ((M)SDS) and worker education and training programs.

Appendix H: Summary of Material Changes between this Version and the Previous Version of this Document

This document will evolve over time to reflect feedback from First Nations and other partners as well as operational or policy changes at Indigenous Services Canada. This appendix lists material changes between this document, and the second version released in April of 2010. The numerous minor edits that were made to improve clarity and organization of the document are not listed.

1. The text in Section *1 Introduction* was revised to clarify the definition of a centralised system.
2. Section *2 Application* was updated to remove the Small Community Systems classification and to add information on the option for First Nations to either follow the Centralised Drinking Water Protocol or provincial/territorial regulations. Information on the application of the Centralised Drinking Water Protocol in the case of systems associated with a Service Delivery Transfer Agreement was also added.
3. Section *3 Risk Management Approach* (previously titled Multi-Barrier Approach) was largely revised based on newer resources from Health Canada, WHO, and provincial/territorial partners. The subsections under section 3 have been reordered, with some additions.
4. A new section was added (Section *3.1 Water Safety Planning* in this version) to outline the components and benefits of Water Safety Planning.
5. Section *3.2 Multi-Barrier Approach* (previously Section 3.0) was revised.
6. Section *3.3 Source Water Protection Requirements* (previously Section 3.1) was revised.
7. A new section was added (Section *3.4 Source Water Characterization* in this version) to outline considerations for conducting a source water characterization.
8. A new section was added (Section *3.5 Groundwater Under the Direct Influence of Surface Water* in this version) to clarify the purpose of assessing whether a groundwater source is under the direct influence of surface water (GUDI/GARP).
9. Section *3.6 Minimum Treatment Requirements* (previously Section 3.2) was revised to include additional guidance on the use of filtration and disinfection, to achieve the minimum log-reduction.
10. Section *3.6.1 Minimum Treatment Requirements for Groundwater Sources* was revised to reflect Health Canada's most up-to-date Guidelines for Canadian Drinking Water Quality. The health-based treatment goal was increased from a minimum of 2-log (99%) to 4-log (99.99%) removal and/or inactivation of enteric viruses for systems using chlorine disinfection. The requirement for 2-log removal or inactivation of *Giardia* and *Cryptosporidium* was removed. Enteric protozoa should not be present in groundwater sources.

11. Section *3.6.2 Minimum Treatment Requirements for Surface and Groundwater Under the Direct Influence* was revised to reflect Health Canada's most up-to-date Guidelines for Canadian Drinking Water Quality and to provide additional guidance on the considerations for achieving the required log reduction using filtration and disinfection. The health-based treatment goal was increased from a minimum of 2-log (99%) to 3-log (99.9%) removal and/or inactivation of *Giardia* cysts. The treatment goals for *Cryptosporidium* cysts and enteric viruses remain unchanged at 3-log (99.9%) and 4-log (99.99%) removal and/or inactivation, respectively.
12. Section 3.7 *Distribution System Requirements* was revised to include new guidance from Health Canada on distribution systems.
13. Section 3.7.2 *Trucked Water Systems* was updated to include additional guidance on operating, maintaining and monitoring trucked systems.
14. Section *3.8 Monitoring Requirements* (previously Section 3.4) was revised to include considerations in the development of site-specific monitoring programs using a risk management approach and to clarify the roles and responsibilities of individuals that conduct monitoring.
15. A new section was added (Section *3.8.1 Source Water Quality Monitoring* in this version) to outline considerations in the development of source water quality monitoring programs.
16. Section *3.8.2 Operational Monitoring* (previously within Section 3.4) was revised to provide additional information on monitoring for microbiological parameters, chlorine and turbidity as well as new information on consideration for monitoring chemical parameters. Information on sampling considerations was also added.
17. Section *3.8.3 Quality Assurance & Quality Control* and Section *3.8.4 Verification & Third-Party Monitoring* were updated to clarify components to include in a QA/QC program and the roles and responsibilities for monitoring of drinking water.
18. Section *3.9 Emergency Response Plan Requirements* (previously Section 7.0) was moved to section 3, as an ERP is a component of a risk management strategy.
19. Section *4.0 System Design* was updated to include information on considering provincial/territorial design guidelines when applicable and considerations for equipment redundancy.
20. Section *4.7 Operation and Maintenance Manuals* (previously titled *4.7 Operator's Manual*) was revised to include more complete information on the necessary requirements of an O&M manual.
21. Section *5.0 Asset Management and Record Keeping* (previously titled *5.0 Quality Assurance*) was revised to outline the components and benefits of asset management planning.

22. Section *5.3 Annual Performance Review* (previously titled Annual Performance Inspection) was revised to clarify the purpose of reviews and provide details on the types of qualifications of individuals conducting the reviews.
23. Section *5.5 Compliance Assurance* was removed from this version of the Centralised Drinking Water Protocol. For guidance on monitoring and remedial actions, see Section 3.8 through 3.10.
24. A new section was added (Section 5.4 *Documents Management and Record Keeping* in this version) to highlight the importance of record keeping.
25. Section *6.0 Operator Certification Requirements* was revised to include guidance on ongoing learning and support for Operators and an overview of the Circuit Rider Training Program.
26. All appendices were revised to include up-to-date information from Health Canada and provincial/territorial guidance and resources.