STANDARDS RESEARCH

Investigating Standards for Small Water and Wastewater Systems in Canada's North

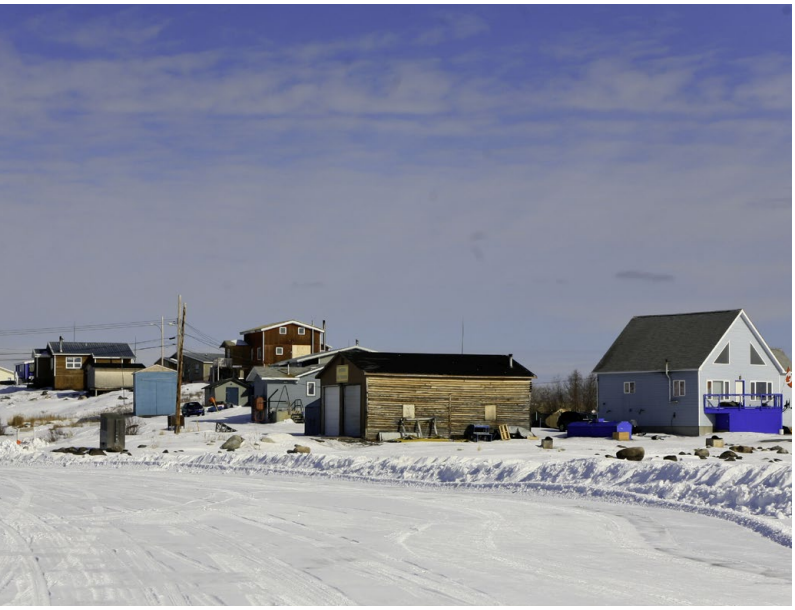
July 2019

Authors

Paul Steenhof, CSA Group (Project Manager, Natural Resources)

Michel Duteau, MSc Biol., Duteau Bioresource Contracting (Owner/Operator, Water Sciences Specialist)

Contents



"Water systems across [Canada's North] have received poor grades in recent years … with risk levels reported to be on the rise – especially in indigenous communities."

1 Introduction

1.1 General

This report builds upon the CSA Group research report entitled *Canada's North: Discovering How Standards Can Contribute to Safety, Sustainability & Economic Growth* [1] by further investigating the possible role of standards and related instruments, such as the training and certification of personnel, for helping to ensure safe, stable, and accessible water and sanitation for the population of Canada's North. For the purpose of this paper, Canada's North is defined to include the three territories and Nunavik in Quebec.

While it is recognized that significant investments have been made in water and wastewater infrastructure in Canada's North, water systems across the region have received poor grades in recent years and are generally below the Canadian average, with risk levels reported to be on the rise — especially in indigenous communities. Northerners have also expressed concerns about the quality of wastewater treatment effluents and the risk of leakage from failing infrastructures. A lack of enforceable standards has been recognized as a significant factor for some jurisdictions, as well as gaps and challenges in capacity building and certification of operators.

The report focuses on small scale water and wastewater systems servicing 500 people. It is estimated that about 500 such systems run across Canada's North (and thus an upper limit of 25,000 people in terms of the potentially affected population) — based on a review of relevant publicly available information, public-owned small systems can be estimated at 50-75 — the 43 small communities have at least one water system and one wastewater system, and some larger communities have split systems serving less than 500 people each. Additionally, an unreported number of systems serving the general public are owned and operated by private interests.

What are Standards?

In Canada, under the accreditation of Standards Council of Canada (SCC), accredited standards are developed by a balanced matrix of stakeholder groups who work together to reach consensus on rules, minimum specifications, performance levels, and technical specifications pertaining to a topic area. They are based on a respective field's collective knowledge and in this way foster its development through dissemination of evaluative benchmarks that reflect best practices, best available technology, etc. Generally, standards are recognized to have far reaching societal benefits, particularly those pertaining to health and safety, environmental protection, the promotion of innovation, and new product development. Many standards are referenced in regulations.

1.2 Objectives and Intended Audience

Three broad objectives underlay the research:

a) To provide an assessment of the situation regarding standardization of small water/wastewater systems in Canada's North, with an overview of standardization documents and their usage;

b) To examine gaps and challenge with these systems;

c) To provide recommendations on where standardization efforts would best be invested and in what form, particularly in terms of how standardization documents can be effectively used.

This paper should be of interest to northern water and wastewater practitioners, especially those authorities, regulators, educators, operators, and related service providers involved with small scale water and wastewater systems.

2 Methodology

2.1 Literature Review

Preliminary information was gathered through a literature review, with an emphasis on identifying gaps and challenges as well as which standardization documents are used or of relevance for Canada's North in terms of small water/wastewater systems. The main sources of information were public authorities' websites, which were thoroughly examined and cross-referenced.

2.2 Engagement Exercise

Following the literature review, an engagement exercise was conducted to survey and then interview water/wastewater stakeholders active throughout Canada's North. This also helped to refine a detailed list of existing standards and related documents used or relevant for small scale water and wastewater systems in Canada's North. This detailed list is provided in Appendix A.

This first involved building a contact list of 906 water/wastewater stakeholders active throughout Canada's North. A survey was sent to the entire contact list, with this followed up with interviews with select key informants. A special effort was made to reach out to and engage with small water and wastewater operators and stakeholders of indigenous identity.

2.2.1 Survey

The survey developed and employed for this project was meant to:

- Reveal current practices related to small water/wastewater systems in Canada's North;
- Generate feedback on gaps and challenges that had already been identified, for instance by rating the relative importance of specific issues with small water/wastewater systems in Canada's North;
- Identify any standardization document that would not have been rendered by the literature review, with a broader objective of helping identify the typical usage of such documents;
- Identify where/how standardization could further play a role.

The specific questions were informed by the literature review process. Some of the suggested gaps and challenges had also been identified by CSA Group [1].

A 22-question electronic survey was built with 53 respondents. It is important to note that the respondents provided significant supplemental information via general comments provided through this survey.

The survey was not designed to be probabilistic. Nonetheless, approximately half of the respondents (25 individuals) declared that they represented/belonged to a small community in Canada's North (with an average population size of 388 people). Yukon was most represented, with 66% of the respondents (35 individuals). Twelve respondents came from the Northwest Territories (NWT), leaving approximately 12% to the other jurisdictions, including three individuals from Northern British Columbia. Twelve respondents declared an indigenous identity.

2.2.2 Key Informant Interviews

Targeted key informant interviews were conducted to drill down in the information obtained from the survey and further inform the recommendations. Specifically, these interviews are meant to help further inform how standardization documents are used in the interviewees' respective territorial/provincial jurisdiction and community and collect their perspective on gaps and challenges with small water/wastewater systems in Canada's North. The interviewees were asked to share any success stories and point out any specific concerns about any aspects of the water/wastewater system. The interviews provided quality feedback and information, complemented by generous supplementary comments from the survey.

3 Current Situation with Small Scale Water/Wastewater Systems in Canada's North

The following provides an overview of the current situation in regard to small scale water/wastewater systems in Canada's North, as informed by both the review of literature, the survey, and key informant interviews. First provided is the overarching governance and legislative context. Specific details are then provided for the various components of the water/wastewater system (e.g., from water sourcing to distribution, water and wastewater testing, certification, etc.).

This material provides the basis for understanding and identifying possible needs and opportunities for standardization or water/wastewater systems in Canada's North, as detailed in sections 4 and 5.

3.1 Governance and Legislative Context

In Yukon and the NWT, the territorial government now has taken on most of the management water and wastewater as part of the devolution process (2003 and 2014, respectively), while the devolution process is ongoing in Nunavut. The federal government, meanwhile, has responsibilities over water and wastewater systems on federal lands and in federal facilities and also plays a key role by leading the development of water and wastewater quality standards.

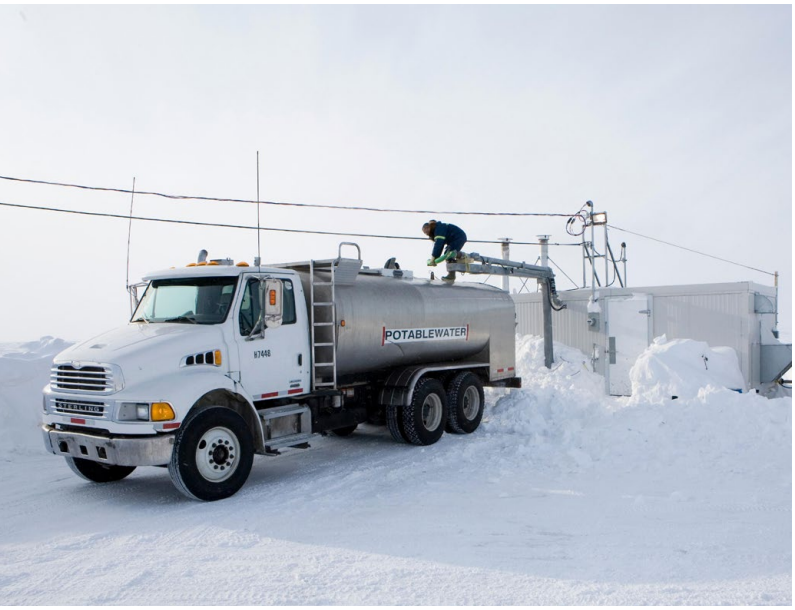
Across the territorial north, water boards are responsible for issuing and rescinding water licenses, which are required to draw water (e.g., drinking water production) and to deposit waste in water (e.g., treatment and release of wastewater). A slightly different model exists in Nunavik/Québec where water licenses are granted by the ministries that relate to the type of undertaking/water usage.

As the bulk of responsibilities fall onto territorial/provincial governments, the main pieces of legislation governing small water and wastewater systems are specific to each territorial/provincial jurisdiction. These regulations typically apply to specific types of administrative divisions (e.g., municipalities, self-governed indigenous community). Nevertheless, gaps still exist where important aspects of small systems are not regulated. For example, not all small water and wastewater systems serving the general public have reporting requirements, water testing criteria, or requirement for certifying operators.

Meanwhile, where a modern treaty has been reached and an indigenous self-government (re)established, the indigenous self-governments have responsibilities similar to those of a provincial/territorial government in regard to water and wastewater systems. Where the local indigenous self-government chooses not to proceed with enacting its own regulations, the provincial/territorial government legislation prevails. With the intention to provide First Nations communities comparable legally-enforceable protections to that of provinces and territories, the federal government enacted the Safe Drinking Water for First Nations Act [2]. This act enables the federal government to develop enforceable regulations based on the referencing of territorial/provincial regulations and recognized technical standards with adaptations to the local realities.

3.2 Water Sourcing

Water sourcing varies with the availability and quality of source water. For example, Yukon generally has favourable geological characteristics that provide an abundance of groundwater that can easily be treated and consistently produces quality drinking water. Other northern regions need to rely on surface water bodies



"Small water systems across Canada's North often involve trucks to deliver drinking water to citizens."

(e.g., lakes and rivers) and groundwater that, generally, has higher organic content. This poses a specific challenge in terms of disinfection/chlorination. These sources also are prone to seasonal fluctuation, such as high turbidity in the spring.

Where groundwater is suspected of potentially being under the direct influence of surface water, legislation typically prescribes the use of a specific standardized assessment method. For instance, Yukon [3] requires the use of an in-house method [4], while Nunavik [3] prescribes another method (i.e., the DRASTIC method [5]).

It is important to note that the traditional collection of water from the land rather than the use of treated tap water is preferred by many people across Canada's North. For example, Martin et al. [6] found that 29% of the residents of Nunavik drank untreated raw water from the land. A number of reasons contributed to this, such as a dislike for chlorinated water or that 'harvest water' is often viewed as an ancestral practice by many. Moreover, many have built a distrust for delivered water — with this sometimes associated with gastrointestinal issues.

3.3 Water Distribution and Wastewater Collection

Small water systems across Canada's North often involve trucks to deliver drinking water to citizens (i.e., bulk water delivery). The same is true for wastewater collection. While operating costs of bulk systems are high, there is also a lower investment in construction and maintenance, often making it the most economical solution in the local conditions. Where a regulation applies, a bulk water delivery truck is typically required to receive an engineering assessment prepared under the seal of an independent professional engineer and cannot be used for any other purpose (as, for example, required in Yukon [7]).

When there is piping, it is sometimes buried (e.g., Rankin Inlet/Kangiqtiniq), but above-ground conduits ('utilidors') also exist in Canada's North. Such utilidor systems are typically restricted to larger communities (e.g., Inuvik, Norman Wells/Tłegǫ̀hłı̨, Iqaluit, Kuujuarapik, Whapmagoostui), but a notable exception to this is Resolute Bay/Qausuittuq.

3.4 Water and Wastewater Treatment

Small water systems across Canada's North use a variety of treatment processes. The design of each system and related treatment approach is based on such criteria as raw water quality, location, required water volume, preference of consumers, and legal requirements. Many small systems use a treatment train, starting with basic particle filtration, possibly followed by a variety of techniques targeting specific water constituents (e.g., ion exchange, activated carbon, ultraviolet (UV)/chlorination/ozone). Generally, legislation requires that any equipment used in the treatment of water must be certified to NSF/ANSI standards. There typically is also a provision that equipment must be installed 'as per manufacturer's recommendations.

Where a regulation applies, one common requirement for small water systems in Canada's North is that supplied water must have undergone a continuous filtration and disinfection treatment if it comes from surface water or from groundwater whose microbiological quality is likely to be altered by surface water. The requirement sometimes extends to all types of raw water. Disinfection must attain the reduction and inactivation requirements (e.g., 99.9% for Giardia — a microscopic parasite that causes the diarrheal illness known as giardiasis or 'beaver fever') and can typically be provided either through chlorination, UV treatment, or ozone. Such primary disinfection is required to happen before/during the distribution, and secondary chlorination treatment is also typically required so as to keep a minimum chlorine residual throughout the distribution system. In exceptional circumstances, regulations will allow disinfection at point-of-use and to forego primary and secondary chlorine treatment. Another common requirement is that chemicals used in the treatment of water intended for human consumption must be certified.

A few communities in NWT and Nunavik use fluoridation. No water system serving the general public uses fluoridation in Yukon.

With regard to the treatment of wastewater, the majority of small communities in Canada's North rely on passive systems, such as wastewater stabilisation ponds, lagoons, and treatment wetlands, and, for the smallest of systems, sometimes a septic field. It is interesting to note that treatment wetlands, and especially wetland treatment areas, are popular in certain regions of Canada's North, especially NWT and Nunavut.

3.5 Operation and Servicing/Maintenance and Repair

While the jurisdictions of Canada's North have strict enforceable legislation that establishes requirements for the operation and maintenance (O&M) of water and wastewater systems, these largely apply to larger systems. Legal O&M requirements for small systems rather tend to be case specific (e.g., through water licensing), and in some cases, nil. For example, not all small systems have legal reporting requirements. The legal requirements are supplemented by case-specific O&M operational and maintenance manuals such as Standard Operating Procedures. Where standards and best practices exist for O&M (see Appendix A), these manuals often refer to them in the same way legislation does. That being said, while there are a multitude of best practices, guidance documents and similar standardization documents for this subject, few technical standards that would be specifically applicable to operation, servicing/maintenance and repair of components of water and wastewater systems in the conditions of Canada's North exist (e.g., [1]).

Proactive maintenance of each water/wastewater system component is especially important in the conditions of Canada's North, with limited expertise to repair them and logistical challenges to deliver replacement parts due to climate, remoteness, and isolation. One common requirement for small water systems in Canada's North is that equipment must be 'kept clean and in good working order and operated & maintained as per manufacturer's recommendations' [8]. Similarly, the O&M requirements for components of wastewater systems (e.g., lagoon, wastewater truck, utilidor) are typically set by the designer/manufacturer. Thus, the standards are in such cases those of the private suppliers. There sometimes also is a legal provision to keep maintenance records in the form of a maintenance log (e.g., replacement of media or filters, replacement of lamps, performance testing, troubleshooting, and professional service events). Where a regulation applies for water tanks maintenance, cleaning and disinfection is typically required at a minimum set frequency (e.g., once per year).

3.6 Testing and Monitoring

3.6.1 Water Sampling, Analysis, and Reporting

All three territories and Nunavik base their water quality requirements on the Guidelines for Canadian Drinking Water Quality issued by the federal government [9]. Routine tests include bacteriological content (presence/absence of total coliforms and *Escherichia coli)*, chlorine, turbidity, and trihalomethanes. Tests are performed to determine whether a system is performing at the

appropriate level based on its design and to manage the risk from hazards that may compromise public health and safety. Such standards define the criteria for drinking water to be considered safe in terms of the presence/absence or concentration of water constituents (e.g., absence of total coliforms; ≤ 0.1 mg/L trihalomethanes).

Applicable regulations also establish requirements for water sampling and testing, including the manner of sampling, transport, as well as testing methods and the laboratories to be used. Typically a provision exists that samples must be collected, stored, transported, and tested in accordance with methods described in 'Standard Methods for Examination of Water and Wastewater' (e.g., [10]) and also using certified devices typically exists. Similarly, there is a provision that results, other than spot-readings (e.g., chlorine, turbidity), can only be accepted if the laboratory is accredited. A variety of well-established technical standards and other standardization documents exist for those aspects of testing and monitoring, which are sometimes referred in legislation.

Water licenses and other regulatory instruments also often establish the frequency and sampling location requirements for each parameter of the water sample, as well as recording and reporting requirements. The requirements are as diverse as there are pieces of legislation, types and sizes of facilities, and parameters. Although case-specific best practices and guidance documents exist for such aspects, technical standards hardly exist for frequency and location of sampling and recording/reporting of results.

3.6.2 Wastewater Monitoring

Across Canada's North, wastewater quality criteria (e.g., maximum allowable concentration) developed by the federal government currently apply only in Yukon and only on systems producing at least 100 m^3 of wastewater per day, which thereby excludes most small systems. Where applicable, wastewater quality requirements are otherwise dictated by the individual water license, which is case-specific. These often refer to best practices and other related standardization documents (e.g., [10]). No technical standard, however, exists for wastewater quality requirements. Where legislation (including water licence) applies, sampling must typically be carried out at designated 'Surveillance Network Program' (SNP) sites throughout the wastewater treatment system. The SNP sites are specific to each wastewater treatment system and are determined as part of the water license.

A limited number of accredited laboratories exist at the moment in Canada's North. For instance, public authorities operate laboratories that can analyze bacteriological content in Whitehorse (Environmental Health Services), Yellowknife (Taiga), and Kuujjuak (Ungava Tulattavik Health Centre). Taiga laboratory is also accredited for a wide range of organic and inorganic chemical analyses on water. No accredited laboratory exists in Nunavut at the moment. In Nunavik, accredited labs exist in the Northern Villages that can perform bacteriological analysis [3]. For all other analyses, samples must be shipped to private accredited laboratories located in southern Canada.

3.7 Certification of Water and Wastewater System Practitioners

3.7.1 General

The territorial/provincial governments across Canada's North are responsible for establishing and enforcing operator certification requirements. They are also responsible for recognizing certification/classification agencies. In turn, a certifying agency may require classification of facilities where certified operators are/will be working. Certification exam prerequisites (e.g., formal education, work experience, training) and requirements to upkeep a certification (e.g., periodic re-examination, continuing education, periodic dues) are determined by the certifying agency and are specific to each certification level.

However, contrary to most other jurisdictions across Canada, no other water/wastewater-related personnel are required to be certified in Canada's North; this includes chlorine handler, cross connection control tester and inspector, septic system installer, well driller, well pump installer, urban/agricultural runoff infrastructure maintenance worker, and industrial/mining-impacted water treatment operator.

3.7.2 Requirements for Operators to be Certified and Facilities to be Classified

Where provincial/territorial legislation exists, operators are typically required to hold a 'valid' certification for regulated facilities. Although encouraged, certification is voluntary for operators working at any other water/wastewater facility, including all wastewater facilities and most small water facilities across Canada's North.

3.7.3 Certification/Classification

Unless stated otherwise in legislation, any certifying agency signatory to Canadian Water and Wastewater Operator Certification Committee's (CWWOCC) Best Practices can be recognized [11]. For instance, the British Columbia Environmental Operators Certification Program (EOCP) [12] is active and recognized for certification of water and wastewater operators and classification of their facilities in Yukon. In the NWT, it is the NWT government [13] through its Municipal and Community Affairs Department that fulfils this role [14]. No certifying/classification agency currently is active or recognized in Nunavut. Similar to the NWT, a governmental agency fulfils the role in Nunavik — Government of Quebec's Ministry of Work, Employment and Social Solidarity [14]. It is worth noting that in Nunavut, as much as in Nunavik, local public authorities are currently developing certification/classification programs that would apply to their specific jurisdictions.

The type of training activities that are necessary to prepare for a certification exam and continuing education activities required to fulfil continuing education requirements are typically offered by institutions other than the legislator, certifying agency, or water/wastewater facility owner. In Canada's North, such opportunities are offered by post-secondary academic institutions, professional associations, and sometimes by governments. Some activities are offered in the communities, and online options exist. As a mobile complement, private companies contracted through the Circuit Rider Training Program of Crown-Indigenous Relations and Northern Affairs Canada (CIRNA) can provide on-the-job continuing education activities in First Nation communities [15].

4 Identified Gaps, Challenges, and Potential Needs for Standardization

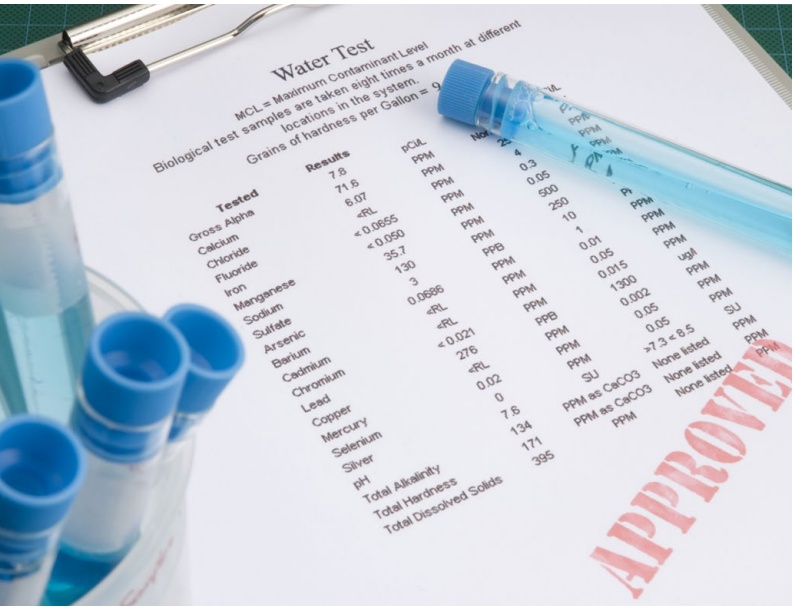
The following summarizes feedback received through the survey and key informant interview process on the gaps, challenges, and potential needs for standardization as related to small drinking water and wastewater systems in Canada's North. This is organized around six key themes that emerged from the research.

4.1 Engagement and Involvement of Indigenous Peoples and Indigenous Perspectives

One consistent message heard throughout was that opportunities to improve the engagement and involvement of indigenous peoples into each lifecycle phase of water/wastewater systems exist. This could help ensure that the management, design, and types of systems as well as related procedures better reflect both the population being serviced and those likely to be involved in the O&M of these assets.

For instance, concerns over the Safe Drinking Water for First Nations Act have been widespread and consistent since its proposal and adoption, including that it is inconsistent with a Reconciliation approach [16] [17]. While recent international declarations and efforts from the federal government have recognized human rights to water and sanitation, it was heard that not just the violation of rights was the problem, but also "the removal of the ability to fulfil indigenous responsibilities as stewards of the land and water", as embedded in the United Nations Declaration on the Rights of Indigenous Peoples [29].

An example of where respondents indicated that perspectives can be important is with the mere concept of what "water" and "wastewater" is. Traditional indigenous views typically include that water is much more than a commodity to be managed. Seen through a traditional indigenous lens, water is rather "a sacred relation and a transcendent gift" [16]. Moreover, indigenous peoples typically refer to water as a stratification of a larger, more important concept, individual, and community health and wellbeing, which also includes housing and energy [16].



"Given the sheer distances and transportation logistics involved, there are difficulties in accessing laboratory services in a timely manner for testing water samples across Canada's North."

An example of cultural specificities that respondents underscored is with languages. For instance, courses and certification exams are in most cases only available in English, doing little to recognize the cultural specificities of the populations of Canada's North. More technically, one sentiment heard through the research was that a significant proportion of the indigenous community did not like the taste of chlorinated water and questioned its potential impact on health. Removal of chlorine or UV disinfection at point of use might be preferred options. Over and above the development and use of technical standards for these innovations (see Appendix A), adoption of these might require accommodation of current regulations, which in some cases prescribes blanket chlorination in all instances.

4.2 Ensuring Consistent Use and Accessibility to Best Practices

This study highlighted that numerous guidance documents exist for small water and wastewater systems across Canada's North. However, users noted some difficulties in accessing these, as well as possible inconsistencies among existing guidance documents — for instance, those identified were in terms of operations and maintenance of water and wastewater systems across Canada's North, such as for tank cleaning, sampling frequency, and recordkeeping and reporting. Also, different approaches regarding important aspects of management of small water/wastewater systems and projects (e.g., planning, engagement, risk assessment, decision-making) exist out there. It was heard too that, in some cases, there had been ineffective adaptation or design of drinking and wastewater systems to reflect local realities. Mohseni [18] illustrated this with the following example: "many water plants fail because they're over-designed for local needs or require complicated technology to operate".

The use and referencing of standards has also been found to be well advanced in Canada's North for design and build. Nonetheless, whereas there might be sufficient guidance available for design and build, it was identified that additional guidance may be needed for the management and operation of small water/wastewater systems. While many participants observed a general trend of low adaptation to local conditions for existing technical standards, as discussed in Section 4.1, they were clear that solutions for the North must be based on Northern circumstances and emanate from northerner's perspectives and peoples, rather than the historical tendency to impose solutions developed in the southern context or by southern stakeholders.

4.3 Managing Challenging Environmental Conditions

A number of challenges were identified with respect to dealing with the impacts of extreme cold temperatures and climate change on water/wastewater systems. In particular, shipping and handling of water samples can be challenging due to both geographical and

environmental factors, with the potential for samples to be compromised. Notably, given the sheer distances and transportation logistics involved, there are difficulties in accessing laboratory services in a timely manner for testing water samples across Canada's North. This situation is compounded by extreme cold temperatures, where samples can be compromised if exposed to freezing temperatures. This is especially true for bacteriological analysis (e.g., coliforms), which is sensitive to freezing. Similarly, there are unique cold-related health and safety considerations for water/wastewater practitioners that need to be accounted for since their work can often involve a significant amount of time in very cold temperatures while performing maintenance or other detailed tasks. Although not entirely universal, much of the soil is locked in permafrost (permanently frozen ground), posing major challenges to construction and build, especially for underground infrastructures such as water wells, aqueducts, and sewers.

Science and traditional knowledge both attest to major climatic changes happening in Canada's North, with these changes happening at a faster rate than southern regions. Changes include higher temperatures, melting permafrost, alteration of precipitation patterns, and an increase in occurrence of extreme climatic events. Some of the most serious impacts of climate change include structural failures in water and wastewater system components due to permafrost degradation [1]. For example, Norman Wells, NWT, had to replace its water reservoir in 2008 due to structural cracks that had been caused by ground settlement [19]. The risk is especially high with components that have been designed to rely on permafrost to maintain their structure. A recent example is in Old Crow and Umiujaq where permafrost degradation and changes in precipitation patterns contributed to the recent failure of wastewater treatment infrastructures, leading to an increased risk for contamination from wastewater effluents. Permafrost melt may also alter the composition of source water. For example, surface water might see an increase in humic acids and turbidity levels, which subsequently can escalate maintenance costs and require more chlorine to adequately disinfect water [19]. Water/wastewater systems are particularly sensitive to climatic extremes. When an exceptional event such as a major snowstorm or particularly intense cold spell causes a breakdown in a water or wastewater system component in Canada's North, it has the potential to disrupt the life of the community not just for a few days, but for months [20]. With the occurrence of these extreme events bound to increase in the coming decades, this poses yet another major challenge.

4.4 Capacity Building/Training and Continuing Education

Capacity building, training, and continuing education are key to ensuring a workforce that is adequate and capable of building, operating, and maintaining/servicing water and wastewater systems and infrastructure. While the feedback received indicated that the level of knowledge/information contained in the courses currently offered throughout Canada's North were appropriate, a number of challenges and opportunities for advancement, including costs, a general lack of local opportunities, and some inconsistency in the capacity building methods being used, were also noted. For example, respondents felt that in-class and web-conferenced training courses can sometimes be 'too intense', with a lot of theoretical notions covered while sitting for 4-5 days consecutively. Much like what was identified by ECO Canada [21], respondents were clear that hands-on and on-the-job training and continuing education was the optimal method; unfortunately; however, such opportunities are not always available in Canada's North and are expensive. The interest to develop cross-training between roles, communities, and systems that was identified by the Yukon Government [22] was also confirmed in this study.

The study participants also expressed that local capacity building opportunities were generally insufficient for the workers to acquire and maintain validity of their certification, with limited ability to travel long distances or for long periods of time to attend classes where they were offered — typically only in the capital, which often is at a great distance and sometimes requires air travel. Web-conferenced options are only good in so far as the attendee already has the necessary skills (e.g., computer proficiency).

"Certification is voluntary for most small water/wastewater operators working in Canada's North, and not all jurisdictions have a water/wastewater operator certification legal requirement."

Another key consideration raised was the lack of redundancy/replacement opportunities when a team member must leave for a few days to attend training or continuing education. This was identified as critical in smaller teams, especially when alternative workers lacked certification and operation of the facility legally required valid certification. It was suggested that certification of a higher proportion of the team members could contribute to alleviating this irritant, as well as access to temporary, mobile certified workers. While praising the efforts already imparted (e.g., CIRNA support for Yukon Water and Wastewater Operator Program), it was felt that support by public instances for capacity building of small water and wastewater operators was uneven and could be improved across Canada's North.

As discussed in Section 4.1, there may also be language barriers given that training and continuing education courses only are available in English, whereas many more languages have official status (e.g., 11 languages in NWT, 4 languages in Nunavut, and French and Inuktitut in Nunavik), and even more traditional languages being spoken.

4.5 Certification of Water and Wastewater Practitioners

Participants acknowledged that certification was often challenging to obtain. Some of the challenges included costs and insufficient opportunities, especially at the local level, for the same reasons as mentioned for capacity building in the previous section. Although online options exist in some cases, an invigilator must typically be present, and it was found that personnel to fulfil that role was not always available.

While participants noted that the three certifying agencies active in Canada's North strived to follow the Canadian Water and Wastewater Operator Certification Committee (CWWOCC)'s Best Practices [11], their programs vary considerably, with no inter-jurisdiction transferability. For instance, although most signatories to CWWOCC's Best Practices have reciprocity agreements, there are no reciprocity agreements between certifying agencies active in Canada's North. Moreover, although standardized exams seem to be an avenue of choice for some certifying/classification agencies for systems servicing more than 500 people, there currently are no standardized exam for small water or small wastewater Operator certification, no more than for bulk water delivery. This situation is similar to what once prevailed across North America and which led to the creation of the Association of Boards of Certification (ABC) [23] and later the CWWOCC [11] and the Certification Commission for Environmental Professionals (C_2EP) [24].

It was also heard that a lack of legal requirements for certification effectively posed a barrier to training and continuing education of operators in that efforts and costs related to certification are not as evidently justifiable and warrantable financially. For instance,

although encouraged, certification is voluntary for most small water/wastewater operators working in Canada's North, and not all jurisdictions have a water/wastewater operator certification legal requirement. This, in turn, is seen as contributing to the risk imparted to small water and wastewater systems. By comparison, all southern Canada provincial legislations have a mandatory operator certification requirement, albeit not always applicable to small operators.

Certification programs are the result of decades of hard work and consensus-building efforts. Recognizing the challenges inherent to building and maintaining a personnel certification program, especially for a thin population scattered over a large territory, respondents pointed out that not all certifying agencies active in Canada's North respected the independence criteria as set out by the industry (i.e., 'third-party attestation', see Appendix A). Independence is seen as an important tool in ensuring autonomy and impartiality and in warding against inappropriate influence, potential conflict of interest, and unintentional self-serving bias, as well as for controlling the risk imparted to small water and wastewater systems [25] and [11].

Similar to training and continuing education, mixed comments were heard regarding the cultural adaptation of certification schemes, as discussed in Section 4.1. Contrastingly, participants noted that the certifying agency active and recognized in Nunavik was somewhat culturally and linguistically flexible, with documents and communication being available in First Languages such as Inuktitut and usage languages such as English, over and above the official French language.

4.6 Recruitment, Retention and Advancement of Operators

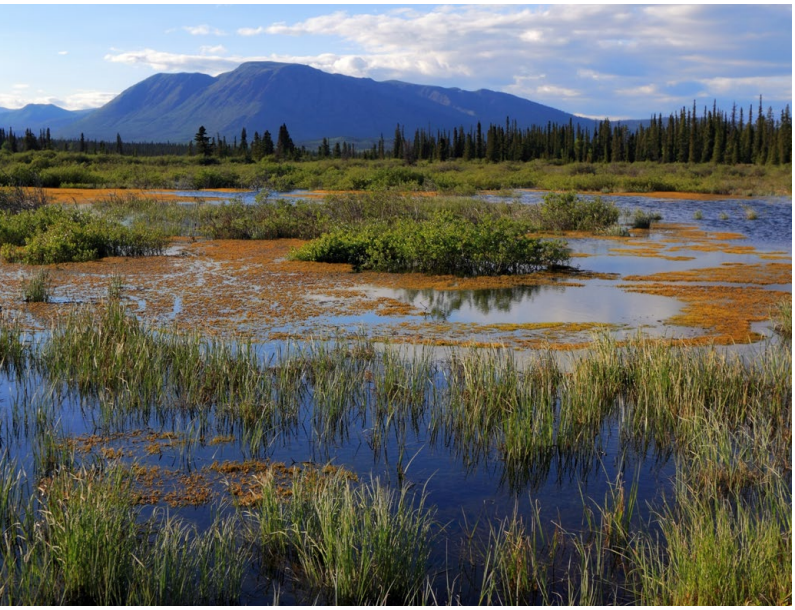
As previously noted by ECO Canada [26] for Canada, by CSA Group [1] for Canada's North, and by the Yukon Government [22] for Yukon specifically, respondents reinforced that the recruitment and retention of workforce necessary to help operate and maintain water/wastewater systems can be a major challenge in Canada's North.

It was particularly emphasized that the region's remoteness and the smaller labour supply pool to draw from can limit the availability and attraction of potential Operators. This is often exacerbated by competition for employees from other economic sectors. Smaller communities also tend to lose talent to larger municipalities that offer greater career growth and better pay.

Respondents indicated that challenges inherent to capacity building and certification/classification heavily impacted recruitment, retention, and advancement. The fact that small system operators often must cover more tasks than with larger system operators increases the training, certification, and continuing education development requirements of each individual. In addition to these factors, the need to be certified before being hired as an Operator was noted as being a challenge in cases where the certifying/classification agency required hands-on work experience at a water and wastewater facility. Such positions are very limited and often require experience to start with.

It was also highlighted that the compartmentalization and limited harmonization of the three Operator certifying programs active across Canada's North (see subsection 4.5 above) was a major challenge to recruitment, retention, and advancement of the operators in that it effectively hampered the mobility of skilled trades and the sharing of knowledge and best practices inter-jurisdictionally. Respondents also mentioned that many small water and wastewater practitioners lacked training in leadership, communication, and computer skills to enable them to advance in the workforce, much like that identified by the Yukon Government [22].

Respondents were clear that the fact that current typical formal education levels in Canada's North were not on par with the southern reality affects community-based recruitment, retention, and advancement of operators. It was heard that this was most critical in small communities. Identified challenges and barriers to formal education included incompatibilities of education systems with the lifestyles and living conditions of northerners, lack of coordination among relevant stakeholders, and other systemic issues. Similar to what was identified by the



"A wide variety of best practices and guidance documents exist (in Canada's North) as related to water and wastewater systems generally. These could form the basis for more widely useable and referable standards specific to small scale water and wastewater systems in Canada's North."

Yukon Government [22], participants were insistent that such social challenges as lack of opportunity for adult graduation (pursue Grade 12 equivalency) in Canada's North and unconventional limitations to what was recognized as Grade 12 'equivalent' were major compounding barriers to recruitment, retention, and advancement of skilled operators.

It was identified that it would be beneficial to have more mentoring, improved training/continuing education of more junior staff, better formal education systems, greater clarity over what constitutes equivalent to Grade 12, as well as better succession planning generally, all of which represent standardization opportunities.

5 Recommendations

The following recommendations are based on an analysis of the survey responses and the feedback from the interviewees, particularly with respect to the identified gaps, challenges, and potential needs for standardization as detailed in the previous chapter. Some recommendations call for harmonizing/streamlining and improving the usage of existing standardization documents, while others call for the development of new standards. Where possible, recommendations are presented on how to present the content in standards and related documents so that these can be effectively used in small communities.

Nonetheless, it is emphasized that while this is presented for the North overall, the situation in the North in regard to water and wastewater systems differs significantly from jurisdiction to jurisdiction.

The recommendations include the following, with details provided in the subsections that follow:

a) Engagement of Indigenous Nations and Peoples;

b) Promote / sell / facilitate the use of existing standardization documents;

c) Mainstreaming of existing best practices into standards;

d) Analysis of water/wastewater across Canada's North;

e) Training, certification, and continuing education of the operators.

5.1 Engagement of Indigenous Nations and Peoples

CSA Group [1] Canada's North report identified a number of fundamental elements of success for the mainstreaming of best practices for the engagement of Indigenous and non-Indigenous northerners, such as acknowledgement and inclusion of the variety of perspectives, conceptions and cultural/societal specificities, as well as the value of traditional knowledge and inclusion of elders. A number of key aspects concerning how standards and related instruments

(such as guidance) for various phases of the water/wastewater lifecycle could help support this were gathered through the literature review and heard through the engagement process involved with this research project.

For instance, promotion of well-established and successful engagement models such as RÉS'EAU/WaterNET's "Community Circle" approach [27] could do much in advancing engagement processes. This model has a strong track record in small indigenous communities by conducting research and testing on promising new solutions under real-world conditions and integrating community feedback into the refinement process. Such success stories involved, for example, the implementation of point-of-entry (POE) treatment systems to meet site-specific needs and the installation of a mobile water treatment unit.

It was also emphasized and reinforced that it was important to formally recognize the values of traditional knowledge as well as cultural/societal specificities in any document involving the topic of indigenous engagement, such as incorporation of worldview, language, history, customs, values, traditional economic roles, infrastructures, governance, and differences across indigenous populations and peoples was critical. Any effort to develop guidance on this topic area should also consider the ethics of the decolonization of science as well as the Truth and Reconciliation Commission of Canada final report that calls for commitment to meaningful consultation and building of respectful relationships and conformity with existing relevant international legal frameworks and related documents such as:

- the United Nations Declaration on the Rights of Indigenous Peoples [28];
- the United Nation Declaration on the Rights to Water [29];
- Garma International Indigenous Water Declaration [30].

5.2 Promote/Facilitate the Use of Existing Standardization Documents

As identified through the literature review as well as the stakeholder consultation process, there are many relevant and existing standardization documents that could be utilized for the purpose of small scale water and wastewater systems (see appendix A for a detailed listing).

Where relevant for small systems and with due consideration for local conditions, efforts should be made to have these referenced within operational and maintenance manuals (e.g., Standard Operating Procedures) and referenced/required as part of tendering documents. For instance, there are opportunities to reference well-established standards in product specifications, procurement documents, and sourcing requirements to help improve asset management and accessibility to the parts and equipment used and needed by small water and wastewater system practitioners in the North.

Efforts should be made to have these referenced in relevant legislation. Opportunities exist for indigenous self-governments to reference such technical standards as they (re)build their own governance structures and institutions, such as their unique sets of regulations over water and wastewater systems.

Special efforts should also be made to see well-established standards being used and referenced with technical topics for which referencing is not as well-advanced, such as management (e.g., emergency plans), operations, maintenance/servicing, and repair (e.g., tank cleaning), and testing and monitoring (e.g., reporting and recordkeeping).

Referencing standards in tendering documents, legislation, etc., could help facilitate accountability and could be used to enforce circumstances where procedures are not followed. This would require and benefit from the involvement of key stakeholders, notably regulatory authorities that could raise the profile

of any related standard and heighten their potential use and applicability.

Examples of technical standards as per the entire lifecycle of small scale water and wastewater systems are presented in Appendix A.

5.3 Mainstreaming Existing Best Practices and Developing New Standards

There is an opportunity to mainstream existing guidance documents, procedures, and best practices in the form of technical standards. Specifically, a wide variety of best practices and guidance documents exist as related to water and wastewater systems generally. These could form the basis for more widely useable and referable standards specific to small scale water and wastewater systems in Canada's North. These could allow for the broader application of best practices, encourage consistency in approach across these regions, and allow for the use of standards for reference in tendering documents and in regulation more broadly.

Efforts could be undertaken to adapt existing technical standards (such as any of those listed in Appendix A) to be more applicable to Canada's North and for northern stakeholders.

Nonetheless, important topics where best practices or similar standardization documents are limited and which could benefit from the development of technical standards include emission and rescinding of boil water advisories, assessment of groundwater that is under the direct influence of surface water, freeze prevention in water distribution lines, treatment of pharmaceuticals, point-of-use dechlorination, POE UV treatment, ozone treatment (pre-distribution and POE), stabilized hydrogen peroxide treatment (pre-distribution and POE), remote sensing/monitoring and process control, as well as water delivery trucks technical specifications and O&M more generally.

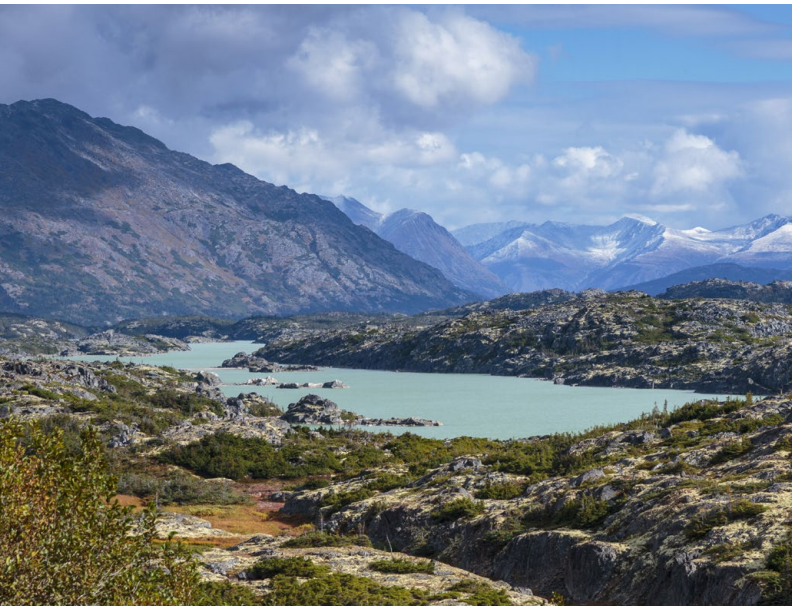
5.4 Analysis of Water/Wastewater across Canada's North

Recognizing that the presence of laboratories is mostly market-driven, there appears to be a need and opportunity to help bolster the analysis of water across Canada's North in order to help ensure the quality of both drinking water and wastewater effluents and the operational integrity of water/wastewater infrastructures. This should be done in collaboration with public authorities (governments). For instance, an avenue might be to engage health authorities, operators, and couriers in better identifying and coordinating delivery and shipping schedules, along with flexible frequency options. There might also be an opportunity for the establishment and support of laboratories accredited for proficiency, quality assurance, quality control, and accountability according to already existing laboratory conformity assessment standards or other standards developed specifically for the topic (Appendix A). This could include the training of local health practitioners (e.g., at local nursing stations) to perform such standardized analysis as Colilert™ for bacteriological content.

5.5 Training, Certification, and Continuing Education of the Operators

Northerners involved in this project were clear that there are opportunities to standardize certification schemes inter-jurisdictionally, making transferability possible, for example through reciprocity agreements. As mentioned by ABC [23], "this call for standardization and collaboration between operator certification programs is not merely for the sake of uniformity, but also to provide the opportunity for greater assurances of public health and environmental protection." Standardization of certification schemes can also foster synergies between jurisdictions sharing similarities in terms of governance, culture, geography, and environment. For instance, standardization of certifying models can bring savings through economy of scale and deduplication (removing some redundancy). Most importantly, standardization of models across Canada's North could give rise to a better representation of the societal/cultural, environmental and geographical specificities of Canada's North in terms of capacity building and certification/classification. Harmonization could also help recruitment and stimulate recognition and transferability outside the region.

Well-recognized standards and relating documents applicable to training, certification, and continuing education of water and wastewater operators in Canada's North are presented in Appendix A.



"A better alignment of certification programs with conformity assessment and quality assurance standards could do much to alleviate unnecessary systemic risks imparted to small water and wastewater systems across Canada's North."

Standards exist that can help certifying/classification agencies harmonize their practices. Basic ones include ABC [23] and CWWOCC [11]. For instance, the collaborative development and adoption of standard examination for small water, wastewater, and bulk water delivery operators could do much for inter-jurisdiction transferability as well as recruitment, retention, and career advancement. The adoption of a common, standard, and consistent definition of what constitutes Grade 12 equivalent could also have a significant impact. The adoption of a standardized requirement for bulk water delivery operators to attend subject-specific training and commit to continuing education like other certified water/wastewater operators could enhance safety and reliability of the systems while fostering public health. A further elaborated alternative could be for Canada's North stakeholders to call on a common certifying agency active and recognized in multiple jurisdictions such as EOCP [31] and C_2EP [24].

Another option could be for northerners to develop a cross-jurisdiction certifying agency specific to Canada's North. This would require broad stakeholder representation and a significant commitment. As with other topic areas, this could be specific to small water/wastewater systems or broader, and while it could be limited to the typical definition of water/wastewater operators, it could also be applicable to other legislated and related professions involved with each lifecycle component of the water/wastewater systems (e.g., laboratory analyst, well driller, etc.). Such a certification program as well could be designed to serve all of Canada's North or only specific intentional jurisdictions. This could be an opportunity to better align the qualification process to that of traditional trades such as Red Seal.

A better alignment of certification programs with conformity assessment (e.g., independence criteria) and quality assurance standards (e.g., continuous improvement) could do much to alleviate unnecessary systemic risks imparted to small water and wastewater systems across Canada's North.

Diversity in capacity building approaches and topics is essential to fulfil its purpose of exposing operators to new and rapidly evolving water treatment technologies, legislation, and health risks. The adoption of common requirements that would address the specificities of small systems across Canada's North would however support standardization efforts in certification/classification, while keeping and respecting the unicity and independence of each training and continuing education institution and the people they cater to. This could also be an opportunity to better represent the cultural/societal specificities of the populations of Canada's North, for instance through licensing under ECO Canada's Building Environmental Aboriginal Human Resources program or another technical standard developed specifically for the situation.

Other key factors that should be considered for the success of such potential standardization projects for training, certification, and continuing education include:

a) Accessibility with respect to cost;

b) Consideration of the fact that acquisition of hands-on working hours can take much longer with small systems as the work shifts are short and often sporadic;

c) Use of a common, standard, and consistent definition of what constitutes Grade 12 equivalent;

d) Provide for the integration of new operators (e.g., internship) and encourage mentoring / hands-on training;

e) Consider current typical level of formal education (e.g., Grade 12) in the application area;

f) Reflect the current and prospective physical environment realities in the application area;

g) Utilize a multi-barrier approach (source to tap), with emphasis on source water protection;

h) Other factors for the success of engagement of indigenous peoples (see subsection 5.1).

6 Conclusions

A research project investigating the potential of standards for the build, operation, and maintenance phases of small water and wastewater systems in Canada's North was conducted to identify opportunities for standards to help ensure safe, accessible, and high-quality drinking water and sanitation for all northerners. In order to meet this objective, a literature review was conducted, followed by an engagement exercise through a survey and targeted interviews to gather northerners' perspective.

An important contextual element is that water governance in Canada's North is inherently complex. The situation is rapidly evolving in Canada's North, and important pieces of legislation have been put in place in recent years where high requirements have been established, especially for larger systems.

Small water and wastewater systems in Canada's North also differ in many ways from their southern Canada counterparts. For instance, bulk delivery and collection systems are more common than in southern Canada, and wastewater is mainly treated through passive systems including constructed/tundra wetlands. This study highlights a general trend of low adaptation to local conditions for standardization documents on many technical topics in Canada's North. It is worth noting that in Canada's North, standardization seems to be more advanced with drinking water systems, compared to wastewater treatment systems, and with the 'Design & Build' phase of these systems, compared to other lifecycle phases.

A number of major themes and corresponding recommendations have been drawn from this research project with respect to potential for standardization efforts. This includes the engagement and involvement of indigenous peoples and indigenous perspectives, ensuring consistent use and accessibility to best practices, managing challenging environmental conditions, capacity building/training and continuing education, certification of water and wastewater practitioners, and the recruitment, retention and advancement of operators.

Of the themes identified, training and certification/classification were identified as a key area that has many gaps, challenges, and potential opportunities with respect to the use of standardized procedures for small scale water and wastewater systems. For instance, the lack of harmonization seems to undermine inter-jurisdiction transferability of skills, knowledge, etc. Subsequently, this is also identified as the area where standardization efforts may have the broadest social benefit, urgency, as well as potential feasibility.

Reference

[1] CSA Group, "Canada's North: Discovering How Standards Can Contribute to Safety, Sustainability & Economic Growth," Toronto, 2017.

[2] Government of Canada, "Safe Drinking Water for First Nations Act.," 2013. [Online]. Available: https://laws-lois.justice.gc.ca/eng/acts/S-1.04/index.html

[3] Government of Quebec, "Regulation Respecting the Quality of Drinking Water (RRQDW)/Règlement sur la qualité de l'eau potable [Q-2, r. 40]," 2001. [Online]. Available: http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/Q-2,%20r.%2040

[4] Yukon Government, "Assessment of Well water or groundwater under the direct influence of surface water (GUDI)," 2006. [Online]. Available: http://www.hss.gov.yk.ca/pdf/well_ground_guidelines.pdf

[5] United States Environmental Protection Agency, "DRASTIC: A standardized system for evaluation groundwater pollution potential using hydrogeologic settings," 1985. [Online]. Available: https://nepis.epa.gov/

[6] D. Martin, "Drinking water and potential threats to human health in Nunavik: adaptation strategies under climate change conditions.," *Arctic Journal,* vol. 60, no. 2., pp. 195-202, 2007.

[7] Yukon Government, "Drinking Water Regulations (DWR) – last amended in 2009. Under the Public Health and Safety Act," 2009.

[8] Yukon Government, "Small Drinking Water Systems in Yukon – Information for Owners and Operators.," 2013. [Online]. Available: http://www.hss.gov.yk.ca/pdf/smalldrinkingwatersystems.pdf

[9] Government of Canada, "Guidelines for Canadian Drinking Water Quality," 2017. [Online]. Available: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html

[10] E.W. Rice, R.B. Baird, and A.D. Eaton (eds.), *Standard Methods for the Examination of Water and Wastewater (23rd Edition),* Washington, DC: American Public Health Association, 2017.

[11] Canadian Water and Wastewater Operator Certification Committee (CWWOCC), "Canadian Best Practices for Water and Wastewater Operator Certification. In cooperation with the Association of Boards of Certification.," 2014. [Online]. Available: https://owwco.ca/wp-content/uploads/2015/10/Canadian-Best-Practices.pdf

[12] Environmental Operator Certification Program, "Operator Certification and Facility Classification Program," 2018.

[13] Northwest Territories Government, "Water/Wastewater Certification/Classification Program. Municipal and Community Affairs (MACA)," 2018. [Online]. Available: https://www.maca.gov.nt.ca/en/services/drinking-water-operators-corner/training.

[14] Emploi-Québec, "Wastewater Operator Qualification and Water System Worker Certification Programs," [Online]. Available: http://www.emploiquebec.gouv.qc.ca/citoyens/developper-et-faire-reconnaitre-vos-competences/qualification-professionnelle/qualification-obligatoire/liste-des-certificats/certifications-dans-le-domaine-de-leau-potable/.

[15] Crown-Indigenous Relations and Northern Affairs Canada, "Circuit Rider Training Program," [Online]. Available: https://www.aadnc-aandc.gc.ca/eng/1313424571273/1313424692733.

[16] C. Behn, "What Does Reconciliation Mean for Safe Water Governance?," Water Canada , vol. 15, no. 1, 2019.

[17] A. A. Thornton, "Safe Drinking Water for First Nations Act –An Unsafe Foundation for Safe and Sustainable Drinking Water in First Nation Communities," in *AFN Water Symposium,* Vancouver, British Columbia, 2018.

[18] M. Mohseni, "Improving Drinking Water in Canada's First Nations: Time to Embrace Complexity," RÉS'EAU/WaterNet., 2016.

[19] S. Ripley, "Navigating the Waters of Change: Strengthening the Capacity of NWT Communities to Respond to the Impacts of Climate Change on Municipal Water and Wastewater Systems," Ecology North, 2009.

[20] D. Martin, "Drinking water and potential threats to human health in Nunavik: adaptation strategies under climate change conditions.," *Arctic Journal,* vol. 60, no. 2, pp. 195-202, 2007.

[21] Environmental Labour Market Research, "Municipal Water and Waste Management Labour Market Study; Planning for Today, Preparing for Tomorrow," 2010. [Online].Available: https://www.eco.ca/wp-content/uploads/2010-Municipal-Water-Waste-Management-Labour-Market-Study.pdf.

[22] Yukon Government, "Yukon Water and Wastewater Sector Profile Report," [Online]. Available: http://yukonwater.ca/docs/default-source/default-document-library/water-sector-profile-report_final.pdf?sfvrsn=2.

[23] Association of Boards of Certification, "Model Standards of Operator Certification," Ankeny, Iowa (USA), 2013. [Online]. Available: http://www.abccert.org/pdf_docs/ModelStandardsofOperatorCertification.pdf

[24] Certification Commission for Environmental Professionals (C2EP), "Professional Operator Certification Program," Association of Board of Certification, [Online]. Available: http://www.professionaloperator.org/.

[25] Association of Boards of Certification, "Model Standards of Operator Certification," Ankeny, Iowa (USA), 2013. [Online]. Available: http://www.abccert.org/pdf_docs/ModelStandardsofOperatorCertification.pdf

[26] EcoCanada, "Municipal Water and Waste Management Labour Market Study; Planning for Today, Preparing for Tomorrow. Prepared by Environmental Labour Market (ELM) Research.," 2010.

[27] RÉS'EAU/WaterNET, "An NSERC Small Water System Strategic Network.," 2018. [Online]. Available: http://www.reseauwaternet.ca/list.aspx?gp=8.

[28] United Nations, "United Nations Declaration on the Rights of Indigenous Peoples.," 2007. [Online]. Available: https://www.un.org/esa/socdev/unpfii/documents/DRIPS_en.pdf.

[29] United Nations, "The Right to Water," 2010. [Online]. Available: https://www.ohchr.org/Documents/Publications/FactSheet35en.pdf.

[30] United Nations University – Institute of Advanced Studies Traditional Knowledge Institute , "Garma International Indigenous Water Declaration. In collaboration with North Australian Indigenous Land and Sea Management Alliance.," 2008. [Online]. Available: https://www.afn.ca/uploads/files/env/garma-international.pdf.

[31] Environmental Operator Certification Program, "Customer Relationship Management System (CRM). Website.," 2018. [Online]. Available: https://crm.eocp.ca/.

[32] Government of Quebec, "Regulation Respecting the Quality of Drinking Water (RRQDW)/Règlement sur la qualité de l'eau potable [Q-2, r. 40]. Under the Environment Quality Act (GQ, 1978).," 2001. [Online]. Available: http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/Q-2,%20r.%2040

[33] Association of Boards of Certification, "Reciprocity Solution for Operator Certification Programs," Ankeny, Iowa (USA), 2014.

Appendix A: Existing Standards Applicable to Small Scale Water and Wastewater Systems

Well-established standards applicable to various phases of small water and wastewater systems lifecycles of Canada's North are provided below.

Category	Name of Standard/Program	Standards Development Organization	Standards Number/ Program	Year
Certification/ Classification	General Requirements for Bodies Operating Certification of Persons	International Organization for Standardization (ISO)	17024	2012
	Conformity Assessment—Requirements for Bodies Certifying Products, Processes and Services	International Organization for Standardization (ISO)	17065	2012
	Conformity Assessment—Vocabulary and General Principles	International Organization for Standardization (ISO)	17000	2004
Design & Build	Ultraviolet Disinfection Systems for Drinking Water	American Waste Water Association	F110-16	2016
	Water Wells	American Waste Water Association	A100-15	2015
	Bolted Aboveground Thermosetting Fiberglass-Reinforced Plastic Panel-Type Tanks for Water Storage	American Waste Water Association	D121-12	2012
	Thermosetting Fiberglass-Reinforced Plastic Tanks	American Waste Water Association	D120-09	2009
	Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings	ASTM	F2620-13	2013
	Wastewater Treatment in Northern Communities Using Lagoon and Wetland Systems	Canadian Standards Association	CAN/CSA W203	2018
	Water Cisterns	Canadian Standards Association	CAN/CSA-B126 SERIES-13 (R2018)	2018
	Drinking Water Treatment Systems	Canadian Standards Association	CAN/CSA-B483.1-07 (R2017)	2017
	Selection and Installation of Backflow Preventers/ Maintenance and Field Testing of Backflow Preventers	Canadian Standards Association	CSA B64.10-17/B64.10.1-17	2016
	Water and Wastewater Treatment Plant Design	Canadian Standards Association	CSA S900	2016
	Installation Code for Decentralized Wastewater Systems	Canadian Standards Association	CSA B65-12 (R2016)	2016
	Design, Material, and Manufacturing Requirements for Prefabricated Septic Tanks and Sewage Holding Tanks	Canadian Standards Association	CSA B66-16	2016

Category	Name of Standard/Program	Standards Development Organization	Standards Number/ Program	Year
Design & Build	Valves (Standards Development Program)	International Organization for Standardization (ISO)	ISO/TC 153	2019
	Plastics Pipes, Fittings and Valves for the Transport of Fluids (Standards Development Program)	International Organization for Standardization (ISO)	ISO/TC 138	2019
	Ferrous Metal Pipes and Metallic Fittings (Standards Development Program)	International Organization for Standardization (ISO)	ISO/TC 5/SC 2	2019
Lab Conformity	General Requirements for the Competence of Testing and Calibration Laboratories	International Organization for Standardization (ISO)	17025:2017	2017
	Conformity Assessment—Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies	International Organization for Standardization (ISO)	17011:2017	2017
Management	Utility Management System (Water and Wastewater)	American Waste Water Association	G400-18	2018
	Business Practices for Operation and Management (Water and Wastewater)	American Waste Water Association	G410-18	2018
	Emergency Preparedness Practices: Utilities in the Water Sector	American Waste Water Association	G440-17	2017
	Water Treatment Plant Operation and Management	American Waste Water Association	G100-17	2017
	Wastewater Collection System Operations and Management	American Waste Water Association	G520-17	2017
	Distribution Systems Operation and Management	American Waste Water Association	G200-15	2015
	Source Water Protection	American Waste Water Association	G300-14	2014
	Risk and Resilience Management of Water and Wastewater Systems	American Waste Water Association	J100-10(R13)	2013
	Encouraging the Hiring, Retention and Return to Work of Experienced Workers—A Guide to Good Practices	Bureau de normalisation du Québec (BNQ)	BNQ 9700-811	2018
	Product, Process and Service Certification; General Rules of Procedure	Bureau de normalisation du Québec (BNQ)	9902-001	2017
	Geotechnical Site Investigations for Building Foundations in Permafrost	Bureau de normalisation du Québec (BNQ)	CAN/BNQ 2501-500	2017
	Psychological Health and Safety in the Workplace —Prevention, Promotion, and Guidance to Staged Implementation	Bureau de normalisation du Québec (BNQ)	CAN/CSA-Z1003-13/BNQ 9700-803	2013
	Climate Change Adaptation for Wastewater Treatment Plants	Canadian Standards Association	CSA S900-1	2018
	Infrastructure in Permafrost: A Guideline for Climate Change Adaptation and the Concurrent Development of Complementary Technical Guidance, Directed Towards Highly Technical Users	Canadian Standards Association	CSA PLUS 4011	2018
	Mapping of Underground Utility Infrastructure	Canadian Standards Association	CSA S250-11 (R2016)	2016
	Activities Relating to Drinking Water and Wastewater Services—Guidelines for the Management of Drinking Water Utilities and for the Assessment of Drinking Water Services (Adopted)	Canadian Standards Association	CAN/CSA-Z24512-10 (R2014)	2014

Category	Name of Standard/Program	Standards Development Organization	Standards Number/ Program	Year
Management	Activities Relating to Drinking Water and Wastewater Services—Guidelines for the Management of Wastewater Utilities and for the Assessment of Wastewater Services (Adopted)	Canadian Standards Association	CAN/CSA-Z24511-10 (R2014)	2014
	Activities Relating to Drinking Water and Wastewater Services—Guidelines for the Assessment and for the Improvement of the Service to Users (Adopted)	Canadian Standards Association	CAN/CSA-Z24510-10 (R2014)	2014
	Moderating the Effects of Permafrost Degradation on Existing Building Foundations	Canadian Standards Association	CAN/CSA-S501-14	2014
	Technical Guide: Performance Improvement for Small & Medium Sized Water Utilities	Canadian Standards Association	CSA PLUS 4010	2009
	Asset Management—Management Systems—Guidelines for the Application of ISO 55001	International Organization for Standardization (ISO)	55002	2018
	Guidelines for the Management of Assets of Water Supply and Wastewater Systems—Part 2: Waterworks	International Organization for Standardization (ISO)	24516-2	2018
	Guidelines for the Management of Assets of Water Supply and Wastewater Systems—Part 4: Wastewater Treatment Plants, Sludge Treatment Facilities, Pumping Stations, Retention and Detention Facilities	International Organization for Standardization (ISO)	24516-4	2018
	Service Activities Relating to Drinking Water Supply Systems and Wastewater Systems—Crisis Management—Good Practice for Technical Aspects	International Organization for Standardization (ISO)	24520	2017
	Guidelines for the Management of Assets of Water Supply and Wastewater Systems—Part 3: Wastewater Collection Networks	International Organization for Standardization (ISO)	24516-3	2017
	Guidelines for the Management of Assets of Water Supply and Wastewater Systems—Part 1: Drinking Water Distribution Networks	International Organization for Standardization (ISO)	24516-1	2016
	Quality Management Systems—Fundamentals and Vocabulary (Definitions)	International Organization for Standardization (ISO)	9000	2015
	Quality Management Systems—Requirements	International Organization for Standardization (ISO)	9001	2015
	Activities Relating to Drinking Water and Wastewater Services—Crisis Management of Water Utilities	International Organization for Standardization (ISO)	24518	2015
	Asset Management—Management Systems—Requirements	International Organization for Standardization (ISO)	55001	2014
	Asset Management—Overview, Principles and Terminology	International Organization for Standardization (ISO)	55000	2014
	Guidelines for Auditing Management Systems	International Organization for Standardization (ISO)	19011	2011
	Risk Management—Risk Assessment Techniques	International Organization for Standardization (ISO)	31010	2009
	Risk Management—Vocabulary	International Organization for Standardization (ISO)	73	2009

Category	Name of Standard/Program	Standards Development Organization	Standards Number/ Program	Year
Management	Quality Management Systems—Managing for the Sustained Success of an Organization (Continuous Improvement)	International Organization for Standardization (ISO)	9004	2009
	Activities Relating to Drinking Water and Wastewater Services—Guidelines for the Assessment and for the Improvement of the Service to Users	International Organization for Standardization (ISO)	24510	2007
	Activities Relating to Drinking Water and Wastewater Services—Guidelines for the Management of Wastewater Utilities and for the Assessment of Wastewater Services	International Organization for Standardization (ISO)	24511	2007
	Activities Relating to Drinking Water and Wastewater Service—Guidelines for the Management of Drinking Water Utilities and for the Assessment of Drinking Water Services	International Organization for Standardization (ISO)	24512	2007
Operations, Maintenance/ Servicing & Repair	Sodium Chloride	American Waste Water Association	B200-17	2017
	Calcium Chloride	American Waste Water Association	B550-17	2017
	Encoder-Type Remote-Registration Systems for Cold-Water Meters	American Waste Water Association	C707-10 (R16)	2016
	Disinfecting Water Mains	American Waste Water Association	C651-14	2014
	Wastewater Treatment Plant Operations and Management	American Waste Water Association	G510-13	2013
	Liquid Oxygen for Ozone Generation for Water, Wastewater, and Reclaimed Water Systems	American Waste Water Association	B304-13	2013
	Disinfection of Wells	American Waste Water Association	C654-13	2013
	Disinfection of Water Treatment Plants	American Waste Water Association	C653-13	2013
	Disinfection of Water-storage Facilities	American Waste Water Association	C652-11	2011
	Hypochlorites	American Waste Water Association	B300-10	2010
	Liquid Chlorine	American Waste Water Association	B301-10	2010
	Sodium Chlorite	American Waste Water Association	B303-10	2010
	Field Dechlorination	American Waste Water Association	C655-09	2009

Category	Name of Standard/Program	Standards Development Organization	Standards Number/ Program	Year
Testing & Monitoring	Online Turbidimeter Operation and Maintenance	American Waste Water Association	C671-16	2016
	Online Chlorine Analyzer Operation and Maintenance	American Waste Water Association	C670-15	2015
	Water Quality Standards (Standards Development Program)	International Organization for Standardization (ISO)	ISO/TC 147	2019
	Water Quality—Selection and Application of Ready-to-Use Test Kit Methods in Water Analysis	International Organization for Standardization (ISO)	ISO 17381:2003-R2014	2014
	Managing Risk in Projects—Application Guidelines	International Organization for Standardization (ISO)	15839	2003

CSA Group Research

In order to encourage the use of consensus-based standards solutions to promote safety and encourage innovation, CSA Group supports and conducts research in areas that address new or emerging industries, as well as topics and issues that impact a broad base of current and potential stakeholders. The output of our research programs will support the development of future standards solutions, provide interim guidance to industries on the development and adoption of new technologies, and help to demonstrate our on-going commitment to building a better, safer, more sustainable world.

CSA GROUP™