Strategies for Improving Potable Water on First Nation Reserves

BREE 655

By: Stefania Mustillo and Kevin Rumsey

For: Professor Jan Adamowski

April 15, 2016.

1.0 Introduction

Providing a safe and continuous supply of potable drinking water requires a functioning treatment system, engineered infrastructure, financial resources, and a supported network of skilled and certified personnel. However, in Canada, these basic requirements remain a significant challenge for many aboriginal communities. Although First Nation governments own and operate their own community drinking water systems, ongoing media coverage reminds us of significant inequality, systemic poverty, poor health conditions, and numerous imposed water advisories on reserves. A recent academic research visit by the authors to various water and wastewater treatment facilities peaked an interest in the use of simple and efficient water treatment technology as a potential solution for the complex challenges in First Nation communities.

This research paper attempts to explore the challenges and some successes of providing potable water in First Nation communities. It is by no means exhaustive due the vast social and political complexities in these communities, but does provide an optimistic view of the situation. The paper describes the rich, cultural, and sacred connection between water and First Nations, provides an overview of some of the ongoing water issues on First Nations reserves, and discusses the confusing roles and responsibilities between different government entities. Through research and personal experience, the paper then focuses on several examples of innovative strategies and programs that appear to be successful in First Nations communities. These examples include experiential training and capacity-building of water operators, facility asset management, maintenance issues, and partnership building. The paper then offers several recommendations that were synthesized from the research and analysis that would aid in continuing efforts to support and improve access to safe water in First Nation communities.

2.0 EXP Consulting and Research Visit

2.1 *EXP: Background*

EXP is a multi-national consulting company with over a century of experience in infrastructure development in six key areas: buildings, earth and environment, energy, industry, infrastructure, and sustainability. This consultancy involves 25 companies employing almost 3000 people globally (EXP, 2016a). Wastewater management is one of the areas in which the firm is committed, and its expertise in this area ranges from “stormwater management, to treatment and distribution of potable water supplies, to the collection and treatment of wastewater” (EXP, 2016, Water + Waste Water, para. 2). It also specializes in the emerging design trends of low impact design for wastewater reuse and stormwater management (EXP, 2016b).

2.2 *Research Visit*

On February 15, 2016, the students of the Integrated Water Resources Management program of McGill University visited four water treatment and filtration sites in Île Perrot, Vaudreuil-Dorion, Coteau-du-Lac, and Salaberry-de-Valleyfield. During this visit, various filtration and treatment methods were explained by Mr. Pierre Beauchamp and his colleagues at the various plants. Mr. Beauchamp is an EXP consultant where he and his team are involved in the design, field supervision, and commissioning of these plants. EXP also oversees plant operations and is also implicated in improvement projects (Pierre Beauchamp, email communication, April 4, 2016).

During this research visit, of interest to the authors was the personal water consumption by residents of the region, with those of Île Perrot described as using 400 litres of water per day. Stress on the water treatment plants is especially high at the peak hours of 6 am to 8 am and 4pm to 8pm, when use of stored water in reserves is necessary in order to meet the demands of citizens (Pierre Beauchamp, personal communication, February 15, 2016). Since citizens expect water on demand, the city does not put any restrictions on water use except for controlling the watering of gardens in the summer. However, it has been noted that generally, residents have become more sensitive towards water use and consumption has decreased overall (Roger Forgues, personal communication, February 15, 2016).

In Salaberry-de-Valleyfield, the mayor of the city, Mr. Denis Lapointe, a professional engineer himself with a background in water treatment, was on hand to provide further information about water consumption trends; it was noted that as residents are surrounded by water in the city, they are of the view that water is in abundance without realizing the expensive and complex mechanisms surrounding the treatment processes required to provide potable water. In the summertime, student volunteers walk around the city, promoting the reduction of water consumption to residents of the city (Denis Lapointe, personal communication, February 15, 2016).

2.3 *DynaSand Filtration Process*

Various types of filtration and treatment technology were used among the four plants visited; however, DynaSand filtration technology had a considerable impact on the authors. DynaSand filtration technology is used at the Coteau-du-Lac site, the first place in Canada to do so. It is a Swedish-patented design that was first used in Canada in the paper mill industry. However, through various testing wherein the filtration system was optimized, it was deemed fit for potable water filtration and began operation in Coteau-du-Lac in 1992. The benefits of the DynaSand filtration method are its low-maintenance requirements and operating costs, and requires no permanent operator; the system needs only one daily check and is serviced once annually (Wang, n.d.). Although its filtration process is effective, the system does not provide disinfection. In Quebec, filtered water alone does not meet health regulations and, therefore, additional disinfection treatment is required, namely chlorination and ozonation (Pierre Beauchamp, personal communication, 2016). The DynaSand filtration method has saved the company 50% in fixed assets costs (Wang, n.d.).

The DynaSand filtration method was also showcased as part of the “Green Cities” initiative in Vietnam due to its simplicity, effectiveness, and relatively low cost. Approximately 50 per cent of Vietnam’s population lacks access to clean drinking water. The DynaSand filtration method was introduced to provide clean drinking water to those without (Pierre Beauchamp, personal communication, February 15, 2016). According to Mr. Beauchamp (Personal communication, February 15, 2016) it is interesting to note that in Vietnam, DynaSand filtered water does not need to be further disinfected before being consumed like it does at Coteau-du-Lac.

The simplicity of the patented DynaSand filter method gives it several advantages over other more conventional sand filters (Circuit Water Engineering, n.d.). With a DynaSand filter, the most significant advantage is that it does not require constant backwashes of sand. In conventional sand filters, backwashing of sand is required to remove the accumulated solids that are physically filtered out of the influent. A clogged sand filter will increase head loss and reduce filter efficiencies. Backwashing of sand filters also means there is an interruption of time in the treatment process. Filtering treatment can resume once the sand is cleaned. The company that developed DynaSand has been able to develop sand grains that are highly resistant to the constant abrasion in normal filtration processes. This revolution results in less maintenance needs, cost, and extended life. There is no need for water supply tanks and rinsing pumps, and the units are compact with no moving parts. The DynaSand filter has shown to be effective in reducing the parameters of total suspended solids, nitrogen (denitrification and nitrification), phosphorus, and biological oxygen demand and chemical oxygen demand. The process can also be easily configured with more advanced treatment processes (Circuit Water Engineering, n.d.).

As shown in Figure 1, an air-lift pump located in the center of the up-right freestanding unit (module) draws the water media from the bottom of the filter up into the wash box. As the media is released into the wash box, it falls into the sand washer where the filtered solids are separated from the sand. From there, the filtrate carries the solids out as waste (backwash). This washed sand falls down onto the media bed for continued use (Circuit Water Engineering, n.d.).

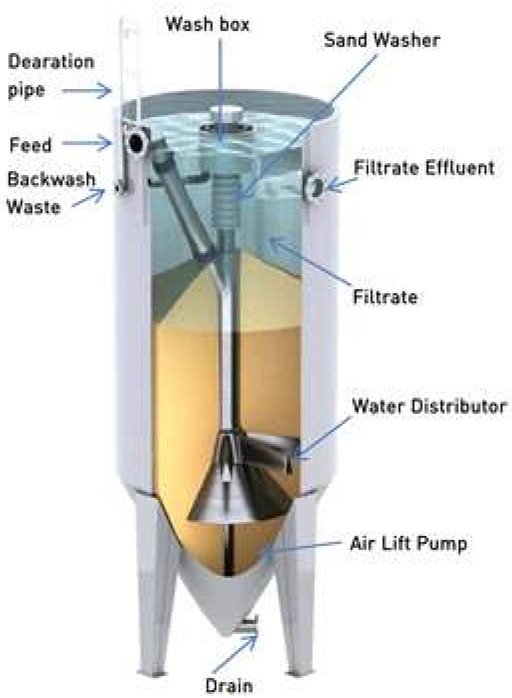

Fig. 1. *Cross-section of DynaSand Filter Module*

It is the simplicity and low maintenance technology of the DynaSand filtration method that inspired the authors to consider this technology as a possible solution to the challenges of providing safe and reliable water in aboriginal communities. Because of its many favourable qualities, the authors believed that the DynaSand filtration system would be in operation on reserves but no evidence of this was found. However, the DynaSand method did motivate the authors to investigate similar simple yet effective solutions that take into account not only technology, but also culture and education, and emphasized approaches that appear to be successful in ensuring improved potable water in First Nations communities.

3.0 First Nations and Water

3.1 *Culture*

The natural environment plays a major role in First Nation identity. In fact, an exact translation of the word 'environment' does not exist in indigenous languages as it alludes to a separation of people and their surroundings, which First Nations consider themselves to be a part (Peigi Wilson, personal communication, October 22, 2015). In western belief systems, nature is deemed as something to be tamed and explained; however, in First Nations culture, nature is crucial to survival. Additionally, the co-existence with the unknowns of natural phenomena is equally respected, meaning that not everything needs precise explanation (Aikenhead, 1996). Knowledge of Earth's systems come through not only physical experiences but also through the spiritual realm of visions and dreams, particularly by an elder in the community; however, as in western science, beliefs in First Nations cultures can also shift through time with newly gained experiences (Aikenhead, 1996). What is acquired through these experiences translates into what is known as 'traditional knowledge' and is linked to the origins of human life (Borrows, 1997). Records of traditional knowledge and experience have historically not been written but passed on to others through the spoken word (Huntington, 2000).

Water, specifically, is vital in First Nation culture; it is considered the life-blood, where rivers and streams are viewed as the veins running through the "Great Mother" (Anderson et al, 2011, p. 14), and where it teaches that what is mighty is also soft and flexible (AFN, n.d.). First Nations depend on water for transport, drinking, cleaning, and must be kept in good health as plants and animals consumed for food and medicine thrive within it (AFN, n.d.). It is also used for purification (AFN, n.d., Anderson et al, 2011) especially through rituals practiced by healers (Anderson et al, 2011). It is sentient with its own conscious and pulse (Anderson et al, 2011).

These views stem from water's association to birth, connected to the breaking of water just before a baby is born (Anderson et al, 2011). It is because of this that women are the traditional stewards and keepers of water in most aboriginal cultures, a sacred role which becomes an intrinsic part of their identity (Anderson et al, 2011). Through their roles as water keepers, women become the intermediary between Earth and the spirit world (Anderson, 2011). Furthermore, sharing knowledge with others of the community is a responsibility that falls upon them, but where learning must also continue through community elders (Native Women's Association of Canada, n.d.). This profound connection makes women's observations of water more acute and therefore they are usually the first to notice changes that arise within it (Native Women's Association of Canada, n.d.).

3.2 Water and First Nations Reserves in Canada

In Canada, while most enjoy high quality and readily available drinking water, many on First Nations reserves do not. The reasons for such disparity are complex and highly contextualized. Certainly, their low population size and the remoteness of many communities cause for immense economies of scale for providing services, and efficient operations, where maintenance of water treatment systems tends to be difficult and expensive to operate. As of January 31, 2016, there were 86 First Nations communities under a water advisory, excluding those in British Columbia. There, on-reserve water issues are overseen by the First Nations Health Authority (Health Canada, 2016) and, as of March 31, 2016, there were 25 advisories on First Nations reserves in that province. (First Nation Health Authority, 2016) There are three types of water advisories that can be issued: boil water advisories, do not consume advisories, and do not use advisories. Boil water advisories are the most common and are issued when drinking water is suspected or confirmed to be contaminated with disease-causing micro-organisms such as parasites or viruses (Environment and Climate Change Canada, 2016). In these instances, water must be boiled before consumption in order to avoid becoming ill. Twenty-one and 19-year long boil water advisories plague the reserves of Neskantaga in northern Ontario and Shoal Lake 40 at the border of Manitoba and Ontario respectively, the two longest standing advisories in the country (Health Canada, 2016). This aboriginal tragedy in Canada has been well documented by the media and sensationalized to some degree, but it does beg the question as to why these issues persist, what innovative methods are being used, and what kind of research is being undertaken to help resolve this tragedy.

3.3 Roles and Responsibilities for Providing Safe Drinking Water

Roles and responsibilities for ensuring potable water in First Nation communities involves a confusing shared approach that may be contributing to the overall challenges that First Nations have regarding safe drinking water (Morrison, 2015; Mitchell, 2012). Although First Nations become the owners and operators of their water and wastewater systems on reserves, the Government of Canada and the three federal departments of Indigenous and Northern Affairs Canada (INAC), Health Canada, and Environment Canada remain extremely influential over the operations and management of water systems (Mitchell, 2012). The primary responsible department is INAC which provides the total funding and guidance for water system design, and is also responsible for the construction, operation, maintenance, and training of the operators of these facilities. INAC (2016) also sets the standards through various national protocols and has developed a First Nations Water Quality Act, with the intent of having enforceable standards under forthcoming regulations. Meanwhile, Health Canada's role is to undertake drinking water quality monitoring programs (except for those north of the 60-degree latitudes, as this responsibility was transferred to the Territorial governments), and to set national guidelines for drinking water quality both on and off reserve. Environment Canada has a role in source water protection planning for First Nations and the regulation of the treatment of wastewater discharged to receiving waters. As First Nations are the owners and operators of these water systems, they are tasked with the daily responsibility of ensuring their community has access to safe and reliable water and wastewater systems. They are responsible for the actual facility design, the construction, maintenance and operation of the water systems in accordance with federally established protocols and standards. First Nations must also undertake the routine of continuously monitoring water quality through sampling, testing, and reporting. In addition, they must undertake the role of system operators, purchase system supplies, and maintain the infrastructure's integrity (Mitchell, 2012).

4.0 Examples of Success for On-reserve Water Treatment

4.1 *Circuit Rider Training Program*

Trained water operators in the First Nations community are essential for ensuring the prevention of risk to their drinking water supply. To assist aboriginal water operators across Canada in their training needs, the Government of Canada invests over $10 million per year in a national joint initiative between INAC and Health Canada (Mitchell, 2012). To help mentor First Nation' directly, INAC established the *Circuit Riders Training Program* (CRTP) which is a long-term, capacity building initiative that provides training and mentoring services to aboriginal water operators of drinking water and wastewater systems (INAC, 2016). Qualified water utility professionals, usually non-aboriginal, are retained across Canada, and rotate through a regular circuit of First Nation communities, training the operators in the many technical and reporting requirements. These water experts are called 'Circuit Rider Trainers' whose roles are to mentor First Nation operators and provide general technical support to perform various functions such as obtaining and maintaining their required certification, increasing the reliability of their systems, ensuring efficient operations and maintenance, confirming standards for health and safety are met, and reducing the number of boil water advisories (INAC, 2016). The CRTP offers 24-hour access in case of emergencies. The CRTP is available for every First Nation community with a drinking water system or wastewater system at no expense. The benefits of the CRTP are numerous; for the federal government, the CRTP helps maintain the assets of which the government has invested billions. In addition, the program reduces maintenance costs, ensures minimal interruption of services, helps to retain operators thus reducing turnover, and promotes higher operator self-confidence and self-esteem (INAC, 2016).

4.2 *Yukon Example: Liard First Nation*

From the author's personal knowledge (Rumsey) of the regional area and understanding the issues from past employment, an example is offered of what the authors believe is working in one First Nations community. The Liard First Nation is a small community of 300 members located in Yukon Territory, just north of the town of Watson Lake at the British Columbia and Yukon border. The community is a non-self-governing First Nation, with significant reliance on INAC as its sole funding source. This First Nation community is burdened by low income and under-development, and currently has few economic opportunities other than associations with the mineral exploration industry and small scale timber harvesting. The Liard First Nation water treatment plant is equipped for treatment using greensand filtration to reduce hardness, iron, manganese, and turbidity, and uses chlorine disinfection to ensure safe drinking water as identified in the Canadian Drinking Water Quality Guidelines (2012). The water treatment plant included boreholes, a water treatment facility, a truck bay garage, a truck filling station, and emergency power supply. The plant was constructed at a cost of $4 million. Funding for the plant came from the First Nations Water and Wastewater Action Plan government program (Indigenous and Northern Affairs Canada, 2013).

To undertake the role of a water operator, candidates need to have completed a grade 12 education, combined with additional training in water safety, followed by the legal requirement to pass a certification exam from an independent certification board (Government of Yukon, 2016). From the personal knowledge of the author (Rumsey), in the Liard First Nation, education levels among the population is generally low, contributing to challenges such as recruiting and retaining qualified water operators for the water treatment plant. In addition, there is a general lack of interest in becoming a water operator in the community.

4.2.1 *Standard Operating Procedures*

Routine maintenance on the Liard First Nation water treatment plant was often not performed to standards and there was high staff turnover of water plant operators; once trained, plant operators sought better paying opportunities outside of the Liard community (Nick Wozniewski, personal communication, March 28, 2016). Routine maintenance on water treatment systems is essential; INAC requires that maintenance management plans (MMPs) be developed for every water treatment and distribution system. INAC has also developed a guide and templates for the development of MMPs that First Nations can use to create their own plan. The implementation of an MMP can reduce risks within the water system by improving the effectiveness of various preventative maintenance activities by decreasing service troubles and by extending life of the asset (INAC, 2014N). However, it has been the author's (Rumsey) experience that the INAC guide and template for MMPs are too generic, merely a simple base to work from. First Nations water managers in the Yukon had difficulty developing their own MMPs and standard operation procedures (SOPs) for their water treatment systems. In 2012, to assist with improved routine maintenance on the Liard water system, INAC suggested that a tailored MMP be completed for their system with the addition of video SOPs. The leadership of Liard First Nation agreed and INAC retained the engineering consulting services of Urban Systems from Vancouver, BC, to work with the First Nation to develop the MMP. In time, video SOP's for the routine maintenance of their individual water treatment systems were produced. Every maintenance task for each component of the water treatment system had their own individual DVD containing a three to four minute video clip. A total of 14 DVDs were produced explaining the SOPs required to maintain individual components. Illustrated manuals that support the DVD instruction were also available (Nick Wozniewski, personal communication, March 28, 2016).

On March 25, 2016, the author, Rumsey, contacted Mr. Robert Greenway, Director of Housing, Liard First Nation, by phone to enquire about the use of the MMPs and the video SOPs[1]. Mr. Greenway confirmed that the dedicated MMPs and SOP videos were very beneficial to them. He stated, "The advantage of the video SOP was that that almost anyone could watch the video DVDs and then perform the maintenance task required, including me, in the absence of a water operator. We've had big challenges retaining operators here and when they leave, they

---

[1] Rumsey explained to Mr. Greenway that he was a McGill University graduate student researching First Nations on-reserve water issues for a school assignment and he agreed to a brief informal interview.

take the knowledge of the maintenance procedures with them." The success of the video SOPs has spread and another First Nation community in Yukon has requested the same assistance from INAC for MMP planning (Nick Wozniewski, personal communication, March 28, 2016).

4.2.3 *Remote Water Monitoring: Liard First Nation*

In addition to the developed MMP's for Liard First Nation, the installation of a real-time remote monitoring system is underway (Robert Greenway, personal communication, March 25, 2016). Most of the water treatment plants in Yukon do not report information on plant operations in a timely manner, thus when issues occur such as poorly treated water quality by way of system failure, the period to process such events becomes prolonged (Nick Wozniewski, personal communication, March 28, 2016). A real-time remote water monitoring system can identify water quality problems (chlorine residual, turbidity, nitrates, and organic substances) quickly and notify the operator or other involved parties. The real-time remote monitoring system uses a patented "s::can spectrometer", which is a product from a company named S::Can, located in Austria with distribution outlets around the world. The manufacturer states that their submersible spectrometers with optical multi-parameter probes are "reliable and simple" (S::Can, 2016, para. 3) and require little to no maintenance. They are robust and durable with no moving parts or consumables, and measures data 24 hours a day (S::Can, 2016).

Another real time monitoring method used in the Liard water treatment plant is SCADA, an acronym that refers to Supervisory Control and Data Acquisition, which is software commonly used in industrial control systems that manage the automation of large and complex processes including water and wastewater treatment plants, over a large geographical area. Real time automation and control of the industrial process is accomplished by electronic equipment located remotely near the process equipment. Computers at the central command center communicate with those at remote locations. Data is presented on a computer screen to operators at a central command center where they monitor and control the process at the supervisory level. The acronym is applied both as an umbrella for an entire system and to the specific software that implements the supervisory control capability (Robertson, 2015).

4.3 *Math Training: Yukon*

Because water operators need to be certified to the same classification level of the water treatment plants (Small, I, II, III, IV), INAC also provides assistance to operators in becoming certified. The author (Rumsey) has direct experience in this training initiative as he funded the program and the following observations are his own. There is a math component to all the certification exams which has resulted in many First Nation operators failing the exam due to limited math skills. In Yukon Territory, long distances can inhibit travel by potential operators to the capital city of Whitehorse for training. Therefore, creative initiative was required to help operators upgrade their math competences in order to pass the certification exam. As a result, in early 2008, INAC partnered with Yukon College and funded audio-visual equipment installation on small, satellite campuses or in administrative buildings in First Nations communities to allow for video-conferenced instruction. These lessons were given once a week by an instructor based in Whitehorse who provided basic math skills for on-reserve plant operators. This ten week program was successful in improving the project's objectives; the passing rate among water operators for certification increased by almost 50 percent in 2008. Despite the success rate and the author’s personal promotion of this success, the program was cancelled in 2010 due to funding reductions by the federal government.

4.4 *Lytton First Nation, BC*

The Lytton First Nation, near Cache Creek, BC, has a population of 2000 members distributed among many individual reserves along the Fraser River. Most of the reserves have access to basic water treatment and a piped water system (Government of British Columbia, 2016). The Nickeyeah Reserve, recently benefited from an innovative public-private-institutional partnership that assisted the First Nation to find the most appropriate water treatment technology to meet their needs. The community required an upgrade of their aging water system, including the river intake structure, storage reservoir, and treatment plant (Thorpe, 2014). In the summer of 2014, a strategic visit was made to the Nickeyeah Reserve by the research institution *RES’EAU*, whereby they took research out of the laboratory and brought it into First Nation community.

The *RES’EAU-WaterNET* project is a five-year, $7 million program that is 30% funded from a partnership among 24 public and private organizations, and 70% funded by the Natural Sciences and Engineering Research Council. In addition, the program leverages over $5 million in human and technological capital from other partner organizations. RES’EAU is increasingly working with First Nations in BC to improve their potable water supply and operations capacity. Recently, First Nations water operators in BC and the Yukon have started their own network to support each other (RES'EAU, 2016).

The research innovation was a mobile water treatment pilot plant, constructed within a specially designed dual axle cargo trailer measuring 6.4 metres in length. The mobile plant contained several different water treatment systems such as various filtration options, ion exchange units, and activated carbon options including ultraviolet and chlorine for disinfection. The mobile treatment trailer was a unique partnership between *RES’EAU*, the Government of Canada, and two private companies, BI Pure Water and Kerr Wood Leidal (Thorpe, 2014). A water sampling program was undertaken to assess raw water quality and determine seasonal variability within the river. Prior consultations were held with the operators and other personnel regarding the existing treatment system, and the future system’s operation. As part of community consultations, it was determined that residents disliked the odour and taste of increased chlorine residual in the drinking water, which corresponded to seasonal water quality changes in the river. The results of the raw water quality sampling, which was collected over a year, in addition to the communities concerns, were used to design their new treatment plant. The new treatment system was comprised of various types of filtration including UV for primary disinfection and chlorine for secondary disinfection. The First Nation water operators were then trained in the operation and maintenance of the systems in the mobile unit (Thorpe, 2014). In this case, collaboration towards improved potable water, aboriginal capacity building, and creating positive networks across different sectors were instrumental in the success of this project.

5.0 Recommendations

1. Appropriate water treatment system technology and consultation: Economical and relatively simple treatment plants like DynaSand and that of RES'EAU need to be considered for and by First Nations governments as they may best suit the needs, population sizes, remoteness, and general capacity of the community. The selection and construction of expensive, over-engineered, and complicated larger treatment plants are difficult to manage, operate, and maintain if reliable capacity does not exist in the community. This is especially true when considering the recent Liberal government's budget which allocates $1.8 billion to the operation and maintenance of plants and $141.7 million to the monitoring and testing of water (Kirkup, 2016). As shown with the RES'EAU project in British Columbia, consultation with First Nations is important especially in the choosing of water systems that meet the needs of the community, both technologically and socially. Effective consultation also leads to relationship building and trust which can help achieve project success.

2. Ongoing water operator training and off-site support: Once treatment plants are built, water operators must be trained for the water treatment plant on their reserve by a Circuit Rider Trainer. This will ensure that if any problem arises in their water system, an operator will be there on-site to repair or mitigate the problem, as waiting for outside assistance can result in delays that can exacerbate the issue. Furthermore, all water operators need to be independently certified to the level of the facility. Once trained and certified, the government needs to provide ongoing support and financial incentives to help retain the operator in the community. It's important that any training offered should be conducted in a culturally sensitive manner in which First Nations-specific learning is accounted for and where traditional knowledge can be incorporated for a more holistic approach to water management. Training operators on-reserve has socio-economic benefits as well as it creates employment in areas where it is scarce. In fact, according to Statistics Canada (2006), on-reserve employment rate is 51.8% compared to 81.6% for the non-aboriginal population. Therefore, this kind of employment can bring promise and optimism to communities.

3. Involving youth and women in water projects: Encouraging First Nations youth and women to participate in operator training and water issues can be socio-economically beneficial. For youth, training and employment can create a more positive outlook for the future. For instance, 23-year old Poplar Hill First Nations member Nico Suggashie expressed feeling "withdrawn and depressed" when he couldn't find employment upon graduating from high school (Wilson, 2015, para. 21). Now a trainee at the plant in his home community, he feels "pride and value" and is confident in his newly acquired skills (Wilson, 2015, para. 28). Considering the high suicide rates of First Nations youth, with some communities recently declaring states of emergencies (Puxley, 2016; Thompson, 2016, Curtis & Fidelman, 2016), it is possible that creating opportunity can aid in curbing such dire realities by giving youth a sense of purpose.

   Moreover, the involvement of women in this type of training should be encouraged as well as they are traditionally the stewards of this resource. This involvement would create an opportunity to return to ancestral roles where their traditional knowledge can be used in conjunction with the technical elements of water treatment. Furthermore, water quality does not only affect physical health, but also the spiritual health of the community since water is considered a sacred life source (Anderson, 2011). Therefore restoring the traditional roles of women would also positively impact the traditional culture of the community.

4. Supporting traditional knowledge and an aboriginal approach to learning***:*** Especially in training, but also generally speaking, there needs to be a better understanding of and more willingness to learn about First Nations culture and traditional knowledge by the non-aboriginal community. Unless this happens, any attempt of co-operation will fail. Aboriginal people learn in ways which are not aligned with current western academic models (Ningwakwe, 2008). Rather, a holistic approach is used, one that uses the body (physical skills), the mind (mental knowledge), the heart (emotions/perceptions) and the spirit (intuition/faith), which are all constantly in flux while also being connected to each other. The learning begins in the mother's womb and eventually becomes inter-generational. The process is holistic and fluid instead of being the end result of something. Learning is not about filling the mind with facts but through harmony with peers. It becomes a human development exercise that is culturally relevant (Ningwakwe, 2008). Despite several hundred years of contact and relations, gaps remain in cross-cultural understanding between First Nations and non-aboriginal Canadians. The biggest gap is a fundamental difference in worldview. In many cases, it is the inability to explain matters in a way that is understandable or an unwillingness to listen (Assembly of First Nations, 2012).

5. Bridging communities for learning and networking: For two consecutive days in February of 2008, a conference on Anishinabek Traditional Knowledge and Water Policy was held on the Garden River First Nation reserve in Ontario (AORMC Water Working Group, 2009). The conference brought together those from many disciplines in the water field including representatives of "26 First Nation communities, provincial government ministries, non-governmental organizations, industry, youth, consultants, academia, water plant operators, and other provincial territorial organizations" (AORMC Water Working Group, 2009, p. 2). This conference allowed for community members and professionals to share knowledge, express concerns, and share opinions on how to improve the quality of on-reserve drinking water (AORMC Water Working Group, 2009). Conferences like these can empower communities with knowledge and understanding, and allow for inter-reserve communication and unity on projects that are working and those that are not, and ideally should be held regularly across Canada. It also allows for First Nation and non-First Nation communities to come together and learn from each other while also creating mutual trust and understanding. Rather than each entity working separately, cohesion between concerned parties creates an environment where co-operation can lead to real improvement and change.

   Furthermore, the creation of a report post-conference as was done in this case (Anishinabek Traditional Knowledge and Water Policy Report, March 2009) gives weight and importance to such events. Each speaker's presentation was summarized and included, as was commentary expressed by the attendees through surveys (AORMC

Water Working Group, 2009). They can also guide and aid in the organization of future conferences, whether it be a follow-up conference of the one reported or for similar conferences held in different regions.

To be sure, conferences can be difficult and costly to organize. Furthermore, long distances to travel by those who live in remote communities may inhibit participation. This is where webinars, video-conferencing, and interactive websites can be useful tools when a full scale, in-person seminar becomes logistically too difficult. The use of this technology can promote effective outreach, learning, and participation from various people concerned about water treatment and the well-being of on-reserve communities, where people can share ideas and gain knowledge in real time.

6. Clear government roles: Because water governance falls under provincial jurisdiction while First Nations reserves are of federal jurisdiction, and because of the multiple governmental departments with responsibilities to First Nations communities, there is a repeated sense of confusion as to who is ultimately responsible for on-reserve water issues (AORMC Water Working Group, 2009; Morrison, 2015; von der Porten & de Loë 2010). Therefore, clearly defined roles and responsibilities must be outlined in order to better manage water issues among First Nations communities. It may also be necessary to streamline all responsibilities under one single federal department, rather than being spread among INAC, Health Canada, and Environment Canada. In this manner, clear leadership can be ascertained by both First Nations and governmental bodies, wherein the said chosen department will be fully responsible for First Nations water issues with the general support of the federal government. This would allow for the congregation of experts in the field and government members under a single department to strengthen their relationships with First Nations communities and help achieve water-related objectives.

7. Increased funding and technical support to First Nations to develop source water protection plans: All First Nation water treatment facilities are required to develop and implement a source water protection plan under the INAC Drinking Water Protocols (INAC, 2012). Although, the benefits of developing a source water protection plan are accepted and recommended, many First Nations unfortunately lack the capacity and resources to develop their own source water protection plans, which potentially puts their source water at risk (Patrick, 2010). Protection of drinking water supply, whether ground or surface water, is required as part of a multi-barrier approach. The process of developing a source water protection plan offers an opportunity for stakeholders, governments, and community to come together and become aware of risks to their water supply. By coming together and increasing awareness, collaborative efforts can increase First Nations capacity in order to develop solutions to reduce potential risks such as inventory of risk factors, determination of water flow and travel time, improved coordination of land use activity, and enacting regulation or by-laws with enforcement provisions.

6.0 Conclusion

Aboriginal communities in Canada are unique, culturally rich, and diverse with complex socio-cultural, economic, political and technological issues. They have been largely shut out of technological progress enjoyed by larger urban centers, yet at the same time, they are often challenged by the same technology. Many of the First Nation water treatment systems are underfunded, aging and difficult to staff with experienced and certified operators (Edward McBean, personal communication, April 4, 2016).

With a new Liberal federal government in power with ambitious goals for First Nations communities of Canada, it will be with interest to observe what changes will unfold throughout this party's term concerning water quality improvements on-reserve. Prime Minister Justin Trudeau promised while campaigning for 2015's election that there would be no First Nations reserve under a water advisory by 2020 (excluding those in British Columbia) (Beaumont, 2015). It is the hope that critical changes be made not only in what infrastructure is being built to provide clean water, but in the processes and planning that are involved in such an endeavour as well. Holistic approaches that encompass First Nations culture, traditional knowledge, co-operation among aboriginal and non-aboriginal communities, and meaningful research into smart water treatment and filtration has the potential to create true change that can have a lasting effect for future generations to come.

References

Aikenhead, G. S. (1997). Toward a First Nations cross-cultural science and technology curriculum. *Science Education*, *81*(2), 217-238.

Anderson, K., Clow, B., & Haworth-Brockman, M. (2013). Carriers of water: Aboriginal women's experiences, relationships, and reflections. *Journal of Cleaner Production*, *60*, 11-17.

AORMC Water Working Group (March 2009). *Anishinabek traditional knowledge and water policy report*. North Bay, ON: Ministry of Natural Resources. Retrieved from http://www.onwa.ca/upload/documents/water-report.pdf

Assembly of First Nations (n.d.). *Honouring water*. Retrieved from http://www.afn.ca/en/honoring-water

Assembly of First Nations. March, 2012. *Education, Jurisdiction, and Governance: Supporting First Nations Learners - Transitioning to Post-Secondary*. Retrieved from http://www.afn.ca/uploads/files/education2/postsecondarytransitionsreport.pdf

Beaumont, H. (October 6, 2015.). Canada's Liberals vow to end rampant boil water advisories on reserves. *Vice News*. Retrieved from https://news.vice.com/article/canadas-liberals-vow-to-end-rampant-boil-water-advisories-on-reserves

Borrows, J. (1997). Living between water and rocks: First Nations, environmental planning and democracy. *The University of Toronto Law Journal*, *47*(4), 417-468.

Health Canada (2012). *Canadian drinking water quality guidelines*. Retrieved from http://hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php

Canadian Council of Learning. (November 2008) *Aboriginal Adult Literacy: Nourishing Their Spirit, by George Ningwakwe.* Saskatoon, SK: University of Saskatchewan. Retrieved from https://www.google.ca/?ion=1&espv=2#q=abbreviation+for+saskatchewan

Circuit Water Engineering (n.d.). *DynaSand™ continuous filters*. Nordic Water Products, Sweden. Retrieved from http://www.circuit.co.za/wp-content/uploads/2015/12/DynaSand_Product_Brief_IFAT-120419.pdf

Curtis, C. & Fidelman, C. (March 22, 2016). Special Report: A First Nations community's legacy of traumas and abuse. *Montreal Gazette*. Retrieved from http://montrealgazette.com/news/local-news/beyond-grief-part-2-a-history-of-violence

EXP (2016). *About*. Retrieved from http://www.exp.com/en/ataglance

EXP (n.d.). *Filtration plant in Coteau-du-Lac*. Coteau-du-Lac, QC: Hui Wang, P. Eng, M. Ing.

EXP (2016b). *Water + waste water*. Retrieved from http://www.exp.com/en/service&s=1221

First Nations Health Authority (2016). *Drinking water safety program*. Retrieved from http://www.fnha.ca/what-we-do/environmental-health/drinking-water-safety-program

Government of British Columbia. (n.d.). *Lytton First Nation*. Retrieved from http://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-first-nations/first-nations-negotiations/first-nations-a-z-listing/lytton-first-nation

Government of Yukon. (November 3, 2015). *Drinking water: Environmental Health*. Retrieved from http://www.hss.gov.yk.ca/environmentaldrinkingwater.php

Health Canada (March 16, 2016.). *First Nations and Inuit Health*. Retrieved from http://www.hc-sc.gc.ca/fniah-spnia/promotion/public-publique/water-dwa-eau-aqep-eng.php

Huntington, H. P. (2000). Using traditional ecological knowledge in science: methods and applications. *Ecological applications, 10*(5), 1270-1274.

Indigenous and Northern Affairs Canada. (August 2, 2013). *Backgrounder*. Retrieved from http://news.gc.ca/web/article-en.do?crtr.sj1D=&crtr.mnthndVl=8&mthd=advSrch&crtr.dpt1D=6680&nid=950029&crtr.lc1D=&crtr.tp1D=930&crtr.yrStrtVl=2013&crtr.kw=&crtr.dyStrtVl=1&crtr.aud1D=&crtr.mnthStrtVl=8&crtr.page=1&crtr.yrndVl=2013&crtr.dyndVl=16

Indigenous and Northern Affairs Canada. (November 30, 2015). *Circuit rider training program*. Retrieved from https://www.aadnc-aandc.gc.ca/eng/1313424571273/1313424692733

Indigenous and Northern Affairs Canada. (May 2, 2014). *Maintenance management planning*. Retrieved from http://www.aadnc-aandc.gc.ca/eng/1398350727577/1398350921495

Indigenous and Northern Affairs Canada. (December 19, 2012). *Roles and Responsibilities.* Retrieved from http://www.aadnc-aandc.gc.ca/eng/1314034319353/1314034564208

Indigenous and Northern Affairs. (September 09, 2012) *Protocols for Safe Drinking Water in First Nations Communities, Standards for Design, Construction, Operation, Maintenance, and Monitoring of Drinking Water Systems*. Retrieved from https://www.aadnc-aandc.gc.ca/eng/1100100034913/1100100034920

Kevany, K., Siebel, M., Hyde, K., Nazer, D., & Huisingh, D. (2013). Water, women, waste, wisdom and wealth–harvesting the confluences and opportunities. *Journal of Cleaner Production*, *60*, 4-10.

Kirkup, Kristy. (March 22, 2016). Liberal budget includes billions in new spending for aboriginal people. *CBC News*. Retrieved from http://www.cbc.ca/news/aboriginal/liberal-budget-billions-new-spending-aboriginal-peoples-1.3502942

Mitchell, G. (March 12, 2012). *Conference Presentation*. Retrieved from http://www.afn.ca/uploads/files/water_conference/gailmitchell.pdf

Morrison, A., Bradford, L., & Bharadwaj, L. (2015). Quantifiable progress of the First Nations Water Management Strategy, 2001–2013: Ready for regulation?. *Canadian Water Resources Journal/Revue canadienne des ressources hydriques*, *40*(4), 352-372.

Native Women's Association of Canada (n.d.). *Aboriginal women and aboriginal traditional knowledge (ATK): Input and insight in aboriginal traditional knowledge*. Ottawa: Environment Canada. Retrieved from http://www.nwac.ca/wp-content/uploads/2015/05/2014-NWAC-Aborignal-Women-and-Aborignal-Traditional-Knowledge-Report1.pdf

Patrick, R. J. (2011). Uneven access to safe drinking water for First Nations in Canada: Connecting health and place through source water protection. *Health & place*, *17*(1), 386-389.

Puxley, C. (March 9, 2016) Manitoba First Nation declares state of emergency over suicide epidemic. *CTV News*. Retrieved from http://www.ctvnews.ca/canada/manitoba-first-nation-declares-state-of-emergency-over-suicide-epidemic-1.2810573

RES'EAU. (n.d.). *Highlights of First Nation Partnerships*. Retrieved from http://www.reseauwaternet.ca/lytton-first-nation

Robertson, J. (2015). *SCADA, Industrial Control Systems & PLC Explained*. Retrieved from http://www.jgrobertson.com/SCADA-PLC-Def.html

S::Can. (n.d.). *Spectrometer probes*. Retrieved from http://www.s-can.at/text.php?kat=1&id=11&langcode=

Statistics Canada (November 30, 2015). *Despite labour market improvement, Aboriginal people still less likely to be employed*. Retrieved from http://www.statcan.gc.ca/pub/89-645-x/2010001/employment-emploi-eng.htm

Thompson, N. (April 11, 2016). Northern Ontario First Nations community declares state of emergency after suicide attempts. The Globe and Mail. Retrieved from http://www.theglobeandmail.com/news/national/northern-ontario-first-nations-community-declares-state-of-emergency-after-suicide-attempts/article29582002/

Thorpe, G. (December 9, 2014). Mobile water treatment pilot plant helps determine best process. *Environmental Science & Engineering Magazine*, Retrieved from http://ese.dgtlpub.com/2014/2014-12-31/pdf/Mobile_water_treatment_pilot_plant_helps_determine_best_process.pdf

von der Porten, S. & de Loë, R.C. (December 2010). *Water challenges and solutions in First Nations communities*. Waterloo, ON: Water Policy and Governance Group. Retrieved from http://www.wpgg.ca/sites/default/files/vonderPorten_and_deLoe_2010.pdf

Wilson, T., (October 26, 2015). Bad water: Innovative solution for remote northern Ontario First Nations. *CBC News*. Retrieved from http://www.cbc.ca/news/aboriginal/bad-water-innovative-solution-ontario-first-nations-1.3278480

Yukon Research Centre. (November 12, 2015). *The accessibility, quality, and safety of the Liard First Nation's drinking water supply*. Retrieved from https://www.yukoncollege.yk.ca/research/project/accessibility_quality_and_safety_of_drinking_water_in_watson_lake_upper_lia