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Adapting to Climate Change Through Source Water Protection: Case Studies from Alberta and Saskatchewan, Canada

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Abstract

The protection of drinking water sources continues to gain momentum in First Nation communities on the Canadian Prairie. Through the identification of potential threats to drinking water sources communities are taking action to mitigate those threats. This article explores the extent to which climate change has been taken into consideration in recent source water protection planning community exercises. In addition, this article describes how source water protection planning has potential to enhance community adaptation strategies to reduce the impacts of climate change on source water and drinking water systems. Results are based on six case studies from Alberta and Saskatchewan.

Keywords

climate change, Saskatchewan, Alberta, source water protection, First Nations, Canada

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Adapting to Climate Change Through Source Water Protection in First Nation Communities: Case Studies from Alberta and Saskatchewan, Canada

In Canada, access to safe drinking water in many First Nation communities remains a challenge (Bradford, Bharadwaj, Okpalauwaekwe, & Waldner, 2016; Galway, 2016;). Today, approximately 1 in 5 First Nation communities is on a boil water advisory, with some advisories lasting a decade or longer (Bharadwaj, 2014; Patrick, Machial, Quinney, & Quinney, 2017). There are many factors contributing to this problem, including poor raw water quality, insufficient water treatment technology, inadequate water distribution systems, as well as local and regional water contamination by land users. Institutional factors also contribute to the drinking water quality problem, such as inadequate design standards for wastewater disposal, difficulty with retention of qualified water treatment plant operators, as well as insufficient federal funding for water system upgrades (Patrick et al., 2017). Notwithstanding these challenges, First Nation communities are dedicated to overcome these and other contributing factors to unsafe drinking water through the sustained efforts of water treatment plant operators, environmental health officers, circuit riders, and First Nation leadership. However, a further challenge is now at play. Climate change is poised to exacerbate the current drinking water quality challenges in many First Nation communities within the Prairie region (Bharadwaj, 2014; Patrick et al., 2017). The prevalence of extreme weather, unpredictable weather patterns, as well as fluctuation in climate trends is now contributing to unanticipated levels of community risk, including both flood and drought with variable impacts on water quality and quantity (Bonsal, Cuell, Wheaton, Sauchyn, & Barrow, 2017; Pomeroy, Stewart, & Whitfield, 2016; Shook, 2016). Research has shown that extreme weather will continue to produce not only seasonal fluctuations but also annual extremes in weather cycles that include rain-on-snow events, higher than normal summer rainfall, as well as prolonged periods of drought with variable, yet significant, impacts on the hydrological regime (Buttle et al., 2016; Dumanski, Pomeroy, & Westbrook, 2015; Pomeroy et al., 2016).

This article explores the impact of climate change on drinking water quality within First Nation communities in the Canadian Prairie region and the role of source water protection planning as a means toward community adaptation. While climate change poses very real threats to the quantity of water supply across the Prairie region, the focus of this article is on the quality of that supply.

The principle of source water protection is prevention of contamination at the source of a drinking water supply, either groundwater or surface water. Source water protection is operationalized through a planning process that first identifies land use activities, human practices, and natural processes that pose some level of risk to a drinking water source. Next, specific management actions are assigned to each identified risk with the intent of reducing, or eliminating, each risk. Implementation of the management actions and periodic review of the full source water protection plan complete the plan-making process. This article undertakes an assessment of management actions to determine the utility of source water protection planning as a form of community adaptation to climate change. Data for this article has emerged from a cross-sectional analysis of six recently completed First Nations source water protection plans in the Canadian Prairie region. The case study communities are all located in Alberta and Saskatchewan across Treaty 4, 5, 6, and 7 territories (see Figure 1). The names of the individual communities will not be identified in this article for privacy reasons.

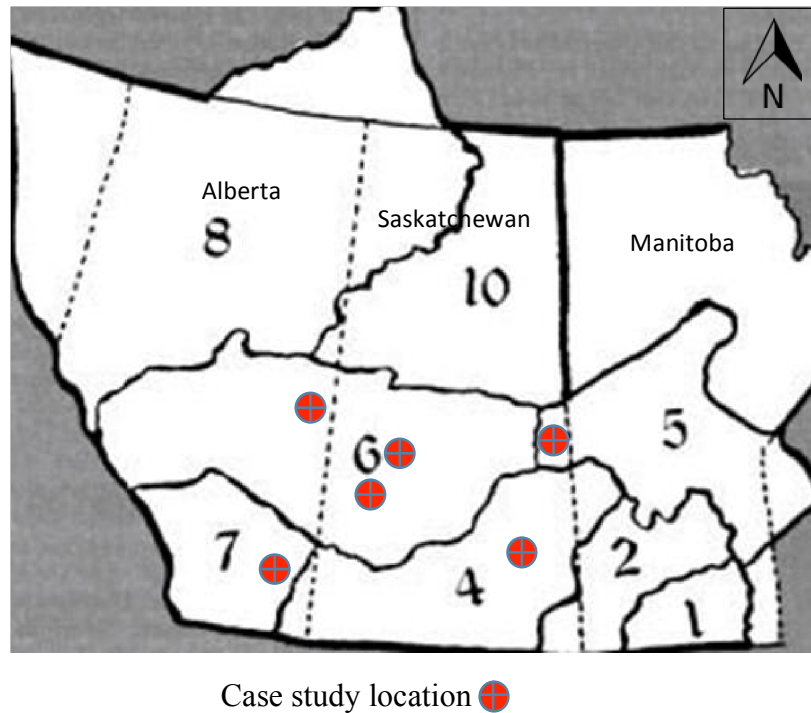


Figure 1. Numbered treaties and case study locations, Canadian Prairie

Extensive academic literature is dedicated to the impacts of climate change on Indigenous communities in the Canadian Arctic where rates of global warming are most pronounced. Less extensive literature exists for southern Canada, and includes work describing climate change interplay between Western science and traditional knowledge (Sanderson et al., 2015), climate change adaptation planning (Reid et al., 2014), water vulnerability assessment in First Nations (Plummer, de Grosbois, Armitage, & de Loë, 2013), as well as methodological approaches to community health impacts (Bradford et al., 2016). With the exception of work by Bharadwaj (2014), there is limited attention to climate change impacts on drinking water quality in the Prairie region. Specific water-related human health impacts caused by climate change include adverse skin conditions and intestinal illness from consumption of contaminated drinking water (Bharadwaj, 2014). In other regions of North America, the spread of wildfire caused by drought has resulted in the disruption of water service and negatively impacted source water quality. In a post-wildfire watershed, increased levels of turbidity in surface water may compromise disinfection treatment while also producing trihalomethanes, a disinfection by-product and proven carcinogen (Emelko, Silins, Bladon, & Stone, 2011; Hohner, Cawley, Oropeza, Summers, & Rosario-Ortiz, 2016; Murphy, Writer, McCleskey, & Martin, 2015). Under a drier Canadian Prairie-region climate the potential for similar impacts to surface water reservoirs is a concern.

This article focuses on the nexus of climate change and source water protection planning in First Nation communities with emphasis on the identification of adaptation strategies to protect sources of drinking water. Under a changing climate, source water protection planning provides both a practical means of managing land use activities as well as a potentially useful tool for community-based climate change

adaptation. The focus of this research is at the local scale to answer calls for “a more nuanced understanding of factors contributing to vulnerability, as well as sources of capacity for adaptation” (Plummer et al., 2013, p. 761). The term *vulnerability* to describe First Nation communities with respect to climate change and access to safe water will not be used in this article. The vulnerability label presents a negative messaging of weakness, frailty, and inability to adapt (Haalboom & Natcher, 2012). To the contrary, First Nation communities have survived myriad impositions over time—culturally and ecologically—resulting in a continued display of resilience, strength, and the ability to thrive (Golden, Audet, & Smith, 2015; Howitt et al., 2013; McGregor, 2012). Instead, opportunities for community adaptation will be explored.

The article begins with an overview of the challenges facing First Nation communities regarding the provision of safe drinking water followed by a description of source water protection planning and the multi-barrier approach to safe drinking water. A range of perceived threats to source water from six completed source water protection plans are discussed followed by a description of how these existing threats may be exacerbated by climate change. The article concludes by identifying a range of climate change adaptation strategies to help protect source water in First Nation communities.

First Nations Water Progress

In the Prairie region, the protection of drinking water has moved beyond words and into action with the completion of source water protection plans in numerous First Nation communities (Patrick, 2017). These plans, and the planning process that guides them, have produced tangible action on the ground while empowering individuals and communities to take greater control over past and present land use practices that have compromised source water quality. Source water protection planning, while a modern tool of Western science, is consistent with Indigenous traditional knowledge and value systems pertaining to water (Lavalley, 2006). While source water protection introduces a “formal” planning activity, it is certainly not the first planning activity ever practiced by Indigenous Peoples. First Nations have long been planners on the land, both pragmatically for decision-making around food gathering, settlement, and migration, and as long-term visionary planners represented by the Seven Generation model (Jojola, 2008; Porter, 2010). Present day source water protection planning often plays a corrective role, identifying past and present land use activities that may pose a threat to a drinking water source. Source water protection planning also has potential to re-connect community members, particularly youth, to the importance of clean water, Indigenous values and beliefs, as well as Elder knowledge (Lavalley, 2006).

The Multi-Barrier Approach and Source Water Protection

The multi-barrier approach (MBA) to safe drinking water gained attention in the water resources literature in the aftermath of the water contamination events in Walkerton and North Battleford (Laing, 2004; O’Connor, 2002). Within the water industry, the MBA is an effective means of safeguarding potable water delivery (Canadian Council of Ministers of the Environment [CCME], 2004). The MBA is a series of operational redundancies, or barriers, that protects against full system failure should a single barrier fail. Source water protection, often referred to as the first barrier in the MBA, is vital to the protection of a water supply. The other key barriers include drinking water treatment such as chlorination and filtration, maintenance of the water distribution system, testing and monitoring, as well

as emergency planning (CCME, 2004). However, there are two limitations to the multi-barrier approach. First, the MBA concept is designed around municipal water service systems with a central water treatment plant, piped distribution system, and coordinated monitoring oversight. The water distribution system in most First Nation communities is unlike municipal water service systems, and instead features a mix of piped water, trucked water, private wells, or no household water service. Second, the impacts of climate change on a drinking water system were never envisioned within the MBA concept. This omission enables communities to develop source water protection plans without due consideration of climate change impacts on their water system. Arguably, the most appropriate place for climate change consideration is within the first barrier of the multi-barrier approach, source water protection. This article will identify climate change adaptation measures that may be applied at the time of source water protection planning.

Methods

Data for this article were extrapolated from six source water protection plans completed by First Nation communities in the Canadian Prairie region between 2013 and 2017. Selection of the communities was based on a combination of existing relationships between a community member and the author, willingness of the communities to participate, and emerging water quality problems. Each of the source water protection plans followed the planning process as shown in Figure 2 based on a planning template developed for the federal government (Aboriginal Affairs and Northern Development Canada [AANDC], 2013).

Each source water protection plan was developed by a working committee from each community. The author assisted each working committee in the form of group work facilitation as well as administrative and technical support. The planning process in each community began with an introductory meeting, or meetings, between the plan facilitator, in this case the author, and representatives from the community, including leadership, management, and staff. The introductory meeting was at the invitation of the community to explain the source water protection planning purpose and process. After the introductory meeting(s), and with expression to proceed from leadership in the community, the first task was to establish a working committee of key individuals from the community (Stage 1). Working committee make-up was reasonably consistent across all communities, normally consisting of an Elder, water treatment plan operator, Band Councillor, land manager, health representative, other staff, and any interested community members. The size of each working committee was relatively consistent across all the communities, ranging from 6 to 10 persons. Approximately eight meetings, each lasting five to six hours, enabled completion of each plan. Protocol in each community was respected for all working committee meetings, often with an opening and closing prayer from the Elder, a mid-day meal, and other protocols as deemed appropriate including gifting tobacco and other items.

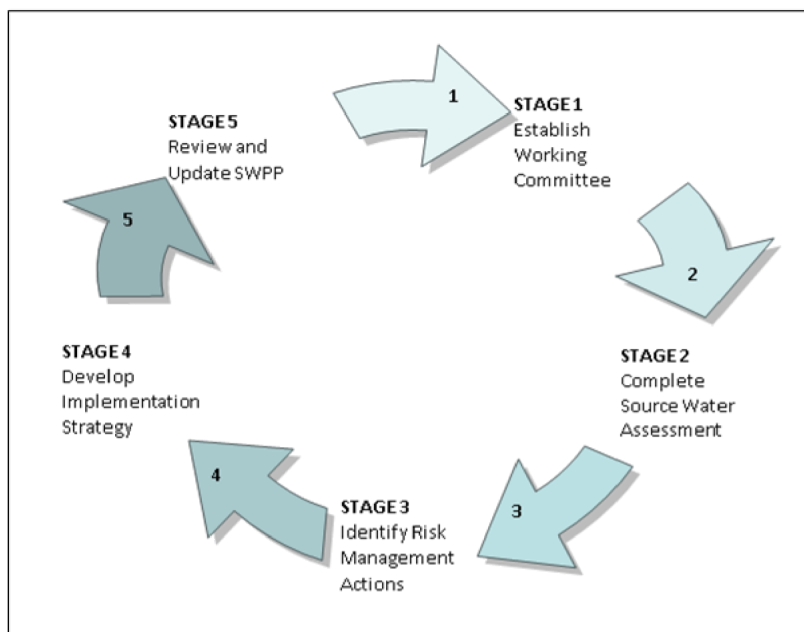


Figure 2. Source water protection planning process (AANDC 2013)

Stage 2 in the planning process saw completion of a source water assessment to inventory the water source (surface or groundwater), water treatment methods, type of water distribution system (piped or trucked), number of water cisterns, type of water users (residential, commercial, industrial), and number of piped connections to households. The source of information for the water system assessment was taken from technical reports or previously completed engineering reports on file in each community. Next, the working committee listed all potential threats to the water source using a brainstorming exercise or small group discussions. The location of each potential threat was noted on a map for future reference. Following threat identification, a risk matrix assessment was applied to each of the identified threats as a means of ranking each of the threats on a scale of 1 (*low threat*) to 25 (*high threat*). The risk matrix uses two indices: likelihood of a contamination event and human health consequence of a contamination event. Each water contamination threat previously identified by the working committee is tested against the risk rank matrix (see Figure 3) to produce a relative risk ranking score.

Stage 3 of the planning process matches management actions to each of the identified risks. Management actions include structural and non-structural activities aimed at reducing the identified threat. A structural activity includes the relocation of a landfill or fencing to provide well-head protection. A non-structural activity includes information posters or household newsletters and education programming in the local school. Stage 4 of the planning process focuses on plan implementation. The estimated time to completion of each management action, associated costs and funding sources, and required partnerships and stakeholders were recorded in Stage 4. Stage 5 is a procedural stage requiring an annual review of the source water protection plan. This annual review process provides the opportunity to celebrate plan implementation success, but also a time to adjust the plan in light of any new information.

Likelihood of Occurrence	Impact of Occurrence				
	Insignificant 1	Minor 2	Moderate 3	Severe 4	Catastrophic 5
Most Unlikely 1	1 Lower Risk	2	3	4	5
Unlikely 2	2	4	6	8	10
Likely 3	3	6	9	12	15
Probable 4	4	8	12	16	20
Almost Certain 5	5	10	15	20 Higher Risk	25

Figure 3. Risk assessment score analysis matrix (based on AANDC, 2013)

Results

An aggregated list of threats to source water from the six communities is shown in Table 1. All recorded data represents the direct input of the working committee from each of the plans. For the purpose of this study, only those threats reported consistently across four or more communities are reported in Table 1. The risk ranking for each threat is listed.

The highest risk reported across all six communities was evenly tied between sewage lagoons and illegal dump sites. Past construction of sewage lagoons in First Nation communities lacked impermeable liners. Instead, sewage lagoons were dug into the ground and, depending upon local soil conditions, there remains potential for groundwater contamination. Sewage lagoon capacity was reported to be a major concern in all six case study communities. Unauthorized on-reserve dump sites were also consistently reported as a very high risk to source water. Unknown solid waste materials and their potential cumulative effects on water sources were consistently reported across all six communities. Uncapped private wells and agricultural runoff of fertilizer and pesticides were another source of concern for a majority of First Nation communities. Uncapped and therefore unsecured large diameter wells pose both a human safety risk from drowning as well as a human health risk from water contamination. Small bore diameter wells are commonly reported as scattered throughout all six communities, a legacy of early farms and abandoned household wells after conversion to community piped water or trucked water systems.

Table 1. Local Source Water Threats and Concerns

Threat (Average Risk Ranking) ^a	Number of First Nations Reporting^b	Concern
Sewage lagoons (25)	6	Threat of overcapacity lagoons; aging facilities; some lagoons failing; few with industrial liners; potential groundwater contamination; susceptible to overflow; flooding from rivers, lake bodies.
Illegal dump sites (25)	6	Aesthetic concerns; threat of unknown contaminants to surface and groundwater sources; potential impacts on drinking water and ecosystem; cumulative impacts from dump sites.
Uncapped private wells (abandoned)	5	Threat of groundwater contamination.
Agriculture pesticides, fertilizer	5	Threat of pesticide contamination; excess fertilizer increasing nitrogen and algae blooms of surface water sources; downstream or downslope impacts; biomagnification.
Household septic “shoot-outs”	5	Threat of raw sewage deposition of ground surface outside residential homes; land and wetland areas becoming saturated; dangerous to health; potential for infiltration to water cistern or to groundwater, surface water supply sources.
Cattle and livestock encroaching	5	Threat of nutrient and E. coli contamination to source water. Lack of riparian protection, free range of livestock into surface water source, groundwater contamination.
Contaminated industrial land, fuel, & material wastes	5	Threat of petroleum product spills, contaminated soils, leaching to source water supply. Legacy of railroad activity, in-ground fuel tanks, work yards.
Solid waste landfills	5	Threat of groundwater contamination in unlined landfill, unregulated landfill, lack of waste separation, unknown landfill products, cumulative impacts. Poorly constructed landfills waste materials. Groundwater contamination.
Well-head exposure	4	Main water wells unprotected; land contour slopes to well-head; no fencing or barriers around wells; aging well-head and well casing.
Hazardous goods transport	4	Threat of railway or highway accident; toxic spills (petroleum, etc.) with surface and groundwater contamination.
Potable water cisterns	4	Cistern damage is caused by both human and climate-related impacts. Freeze–thaw cycles impart damage to the concrete shell of a cistern. Frost heave and uneven ground temperature adds potential damage.

Note. ^a 25 = highest; 1 = lowest risk ranking. ^b N = 6

Agricultural fertilizers and pesticides were another identified threat in many communities. While farm lease agreements often state that responsible fertilizer and herbicide practices would be followed, there was little or no means of confirming lease-holder practices. Septic shoot-outs, or the discharge of liquid waste directly onto the ground adjacent to a home, were consistently reported as a major concern across all case studies. The combined problem of groundwater or surface water contamination and the immediate human health issue of untreated sewage discharge outside a home is a common concern in all case study communities. Solid waste landfills, most at full capacity, with no waste separation, recycling, or monitoring programs in place was also voiced as a concern. Other high risk concerns included contaminated former industrial lands, damaged water cisterns, hazardous goods transport, and livestock encroachment into surface water sources.

Exacerbated Threats

Threats to drinking water sources with potential to be exacerbated by climate change are described in Table 2 along with adaptation strategies. The exacerbated threats represent an extension of the concerns previously listed by each working committee in all six communities. Community members reported an increase in sudden and violent rainfall events. In late winter, these events may be rain-on-snow events. More frequent flooding or extreme high water was reported to have a negative impact on existing water management infrastructure. For example, sewage lagoons were reported to be at or near capacity. The addition of flood waters from sudden storm events, either as rainfall or as rain-on-snow events, will only exacerbate the current sewage lagoon capacity problem.

Other climate change impacts that will exacerbate existing threats include the mobilization of land-based contaminants such as landfill leachate and other industrial wastes caused by localized flooding. Climate warming is driving increased incidence of freeze–thaw cycles, exacerbating threats to drinking water sources. For example, concrete manufactured water cisterns were reported to be suffering internal cracks and breakage from more frequent cycles of freeze-thaw events. This situation is allowing surface water drainage and organic contaminants to contaminate household cisterns.

Adaptation Strategies

The source water protection planning process enabled the working committee to match adaptation strategies, identified as management actions in the planning framework (Figure 2), to each of the identified risks. During this process, the working committee focused discussion on specific adaptation strategies.

Table 2. Climate Change Adaptation Strategies

Threat (Number of First Nations Reporting) ^a	Accelerated Climate Change Impacts	Adaptation Strategies
Sewage lagoons (6)	Increased rainfall; rain-on-snow; seasonal storms all may cause flooding; river and lake flooding into lagoons; pothole region of poor drainage.	Develop new lagoons under current regulations; develop new <i>lined</i> lagoons to protect groundwater.
Illegal dump sites (6)	Mobilization of potential contaminants from flooding, increased summer rainstorm events; rain-on-snow events, poor land drainage.	Written notification to all contractors; community education, schools, radio, newsletters, website; coordinate with community clean up; community clean-up initiative; educational campaigns; community hazardous waste pick-up days; develop regular schedule for pick up; education signage; repair road access to main landfill; investigate transfer station; enforce Land Management Act.
Uncapped private wells (abandoned) (5)	Uncapped wells allow direct pathway for groundwater contaminants; rain and flood events increase likelihood of contaminant entry.	Map and identify all uncapped wells; decommission all abandoned wells.
Agriculture pesticides, fertilizer (5)	Overland flow from heavy seasonal rain events, mobilization of pesticides and fertilizers.	Make use of lease agreements to enforce better management practices; obtain full information about chemical usage; restrict fertilizer and pesticide use near the community; as buffer encourage crop cover that does not need fertilizers or community gardens; talk to farmers; hold community workshops on proper product application.
Household septic shoot-outs (5)	High water tables, flooding, violent summer storms, increased incidence of dry periods followed by large rain events have potential to mobilize shoot-out sewage waste, or cause localized (backyard flooding).	Extend pipe further from house; upgrade to in-ground septic system; extend community sewer system; education; bylaws requiring regular tank pump out.

Note. ^a N = 6

Table 2. Climate Change Adaptation Strategies (continued)

Threat (Number of First Nations Reporting)	Accelerated Climate Change Impacts	Adaptation Strategies
Cattle and livestock encroaching (5)	Increased frequency of extreme dry and wet periods, flooding of land mobilizing manure waste.	Confine livestock at the farm property; keep horses and cattle away from village centre and well-head areas; fence to protect wells-heads; keep livestock and domestic animals out of drinking water sources; talk to farmers working Treaty Land Entitlement (TLE) lands, educational brochures; fencing; dugouts; bylaws.
Contaminated industrial land, fuel & material wastes (5)	Flooding, mobilization of contaminants, soluble soils, percolation of contaminants in flood events.	Collect all fuel tanks no longer in use; site remediation by professionals; decommission former industrial sites.
Solid waste landfills (5)	Old and abandoned sites (legacy issues). Rainfall, rain on snow, saturation of landfill waste material, mobilization of waste materials. Groundwater contamination.	Decommission old and abandoned landfill sites. Initiate waste separation of main landfill. Repair road access to landfill. Fence landfill, hire a landfill operator, waste separation. Longer term, consider conversion of landfill to a transfer station.
Well-head exposure (4)	Flooding, rain on snow; Ponding of water in area of well-heads; long, dry periods broken by sudden large summer rain events.	Protect well-head from flooding, contamination, by extending well casing 1 metre above ground; mound fill and gravel material around casing, slope away from casing. Fence around well-head to keep people, livestock, and domestic animals away.
Hazardous goods transport, oil pipelines (4)	Climate change impacts on roads, railways, reduced stability of land surface; road potholes, railway washouts. Subsurface land subsidence causing pipeline fractures.	Railway and highways not in First Nation jurisdiction. Need for communication, partnership, collaboration with rail company and highways to maintain, repair; response plan for hazardous spills. Pipeline mapping on First Nations, greater awareness.
Potable water cisterns (4)	Increased incidence of local flood conditions (spring runoff and summer rains) adds to threat of water contamination; increased freeze–thaw with climate change damaging to concrete cisterns; damage by truck haulers with thawing ground.	Annual cleaning and repair program; cistern replacement program; install distribution system; grading and landscaping around cistern; testing schedule; improve, repair cistern collars, caps, and covers; move to a low pressure system.

Note. ^a N = 6

In the case of sewage lagoons, noted as high risk in all communities, there was little evidence of adaptation. In one Alberta First Nation, a large sewage lagoon was re-built on the same site as the previous lagoon, which was destroyed in the 2013 Bow River flood, despite calls from the community directed at Indigenous and Northern Affairs Canada (INAC) to re-build the lagoon on higher ground. The 2013 Bow River flood is well documented as a flood event typical of a changing climate (Pomeroy et al., 2016). Given that many lagoons are gravity fed, moving existing lagoons to higher ground away from rivers and lakes initiates a long-term cost for pumping and hauling. Additionally, to control lagoon overflow conditions the operation of these lagoons requires a release of liquid waste into an adjacent water body during late spring. Relocating sewage lagoons to higher ground would not only add an additional cost to pipe wastewater over a greater distance for storage in the lagoon and discharge back into a waterbody. In several communities, overcapacity lagoons were leading to localized flooding within the community.

Unauthorized community solid waste sites were targeted with specific adaptation strategies in all six communities ranging from education regarding appropriate waste disposal, scheduling regular garbage pick-up, site reclamation, and establishing a waste transfer station.

Uncapped wells were identified in all but one community as posing a high risk to groundwater contamination. Adaptation measures to help reduce risk of contamination included mapping uncapped or abandoned groundwater wells to be followed by well decommissioning. Federal and provincial funding sources are available for well decommissioning in First Nation communities.

Several case study communities have already taken advantage of these funding opportunities. Mobilization of fertilizer as the result of more frequent summer rainstorm events has the potential to elevate nitrate levels in groundwater sources. Adaptation measures include information sharing with the farm community, lease agreement restrictions on fertilizer application, as well as establishing buffer strips adjacent to community water sources.

Household sewage shoot-outs were identified as a threat with potential risk to source water and human health. Shoot-outs consist of piped raw sewage from a home into a backyard area. Adaptation strategies includes emergency repair of shoot-outs. Longer term adaptation strategies include extension of the community sewer system and local area bylaws requiring regular septic tank pump-outs.

Livestock enclosures and other means of restricting both domestic and farm animals away from surface water sources, well-head areas, and water treatment facilities will help protect water quality. These adaptation strategies will be new to many communities where free-range livestock is a more common practice. Well-head protection will increasingly be an effective, low cost solution to protect well-water supplies that are increasingly subject to seasonal flooding, which is common in many communities.

The legacy of former industrial sites including gas stations, in-ground fuel tanks, and other hazardous material has potential to contaminate water sources under a changing climate. Adaptation strategies include commercial and industrial site remediation. In addition, landfills are a concern in most communities. In all but one community, the active landfills were open to the public with no attendant, no community recycling, and no waste separation program in place. Recent increases in localized flooding have raised concerns over groundwater and surface water contamination. As a result, all case study communities voiced concern for the long-term viability of existing unmanaged landfill operations.

In all case study communities, landfills consisted of large, unlined excavations to be filled with all forms of domestic, commercial, and industrial waste. In a wetter climate, these landfill pits are at risk of filling with water thus mobilizing potentially toxic materials.

Climate change is currently impacting the integrity of water cisterns in First Nations. Flooding and more frequent freeze–thaw events will continue to threaten water quality and quantity in cisterns. Adaptation will require more frequent cistern cleaning and repair programs. Cistern replacement programs have begun in several case study communities. Moving toward a low pressure water system to replace cisterns is an additional adaptation strategy that requires serious consideration and funding from the federal government.

Discussion

Source water protection planning serves as an effective tool to identify climate change adaptation strategies respecting safe drinking water in First Nation communities. Source water protection aids in the protection of drinking water sources through a deliberate, focused planning process (Patrick, 2011; Patrick et al., 2017). Through identification of threats to a water supply, it is possible to produce a risk ranking followed by management actions to reduce those risks (AANDC, 2013). In the Prairie region, First Nation communities are now engaged in source water protection planning to produce plans that have led to the implementation of management actions.

The source water protection planning process has traditionally provided a means by which threats to source water may be identified, ranked in terms of risk, and mitigated through appropriate management actions. The impacts of climate change add another dimension to source water protection by introducing new threats (spread of wildfire) and by exacerbating existing threats (sewage lagoon flooding).

Policy Recommendations

It is recommended that the practice of source water protection be modified to include greater consideration of climate change impacts. With greater focus on climate change, source water protection planning will be more responsive to local conditions. The federal government, through agencies such as INAC, is encouraged to fund source protection planning in First Nation communities, particularly the implementation of completed source water protection plans. It is recognized that single-purpose planning, such as source water protection planning, must become multi-dimensional to include climate change impacts and adaptation strategies. To that end, a more robust source water protection planning framework that includes climate change impacts will provide a higher degree of relevant information to First Nations. Source water protection planning may be the best means of responding to climate change impacts affecting drinking water sources in First Nation communities.

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