Water treatment, storage and truckfill facility in Cambridge Bay, Nunavut.

EMERGING CLIMATE CHANGE ISSUES AND CHALLENGES FOR WATER SYSTEMS IN THE ARCTIC

Introduction

Many factors influence the engineering practices associated with water infrastructure in the Canadian Arctic. These factors include the extreme cold conditions that infrastructure must withstand, ground-related conditions, extreme construction, operation and maintenance costs, the short construction season, challenges of transporting construction material, delays in procuring specialized equipment, and an undersupply of labour.

It has been observed that Arctic water is abundant, but in short supply for communities that require a clean source of water year-round. Ten-month winters, by themselves, limit water supply because water can freeze to a depth of two metres. The Arctic is also a desert with some most regions receiving less than 250 millimetres of annual precipitation, falling mostly as snow.

Water treatment processes have become complex with the application of membrane technology, which involves high capital and operation and maintenance costs. This technology is generally designed for "targeted" treatment, which may not be easily adjusted to accommodate changes in the source water quality.

Ongoing research is showing that climate change is altering the fragile thermodynamic relationships of northern ecosystems by shifting the seasonal transitions, and altering precipitation regimes, including the rainfall events and the snowfall accumulations. Snowmelt is a crucial source of water for shallow Arctic lakes, and snowfall is projected to decrease in some regions. What this means is

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that the targeted treatment systems may be unable to achieve the required water treatment because of changing conditions.

A recent compilation of specific occurrences potentially related to climate change issues for water and sewer systems (NWT and Nunavut) identified 17 occurrences. Of these 17 occurrences, 11 were associated with water supply and treatment, and seven of the 11 were associated with water quality.


Water treatment, storage and truckfill facility in Cape Dorset Nunavut

Attributes of water infrastructure not suited to change

The water infrastructure in the Arctic has three significant attributes which cause limitations for climate change adaptation. The attributes are design life, a non-portable configuration, and complexity. The design life limits the infrastructure because it is designed to last a generation (20 to 30 years), which means that a community is burdened with whatever infrastructure is built for a 20- to 30-year period, with limited or no opportunity for changing the infrastructure. The non-portable attribute limits the infrastructure because it has a fixed location with a limited possibility for relocation.

The final attribute is associated with the complexity of the design, and operation and maintenance. With these complexities, issues may develop with time that may be expensive and time consuming to correct. This is particularly true with the "modern" water infrastructure that has emerged which requires the application of complex technologies.

These three attributes do not align well with climate change because by its very nature climate change is creating an increasingly dynamic natural environment that the water infrastructure must respond to. Water infrastructure operation and maintenance in the Arctic can be difficult enough with "normal" day-to-day functioning, and quite likely very difficult, to impossible, with the anticipated changes in the quality and quantity of water.

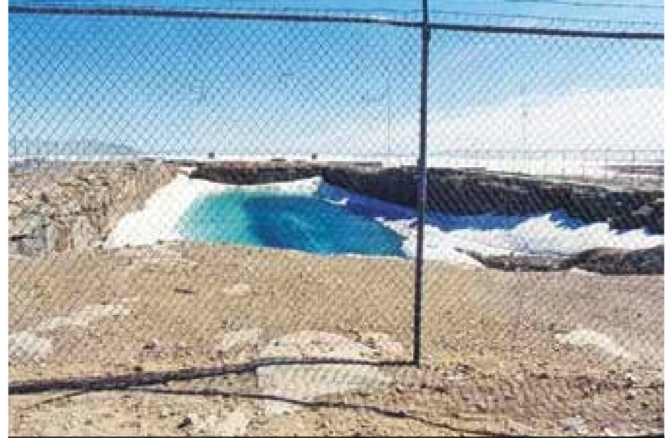
A changing climate presents additional challenges to the design, development, and management of water infrastructure in the Arctic. Water infrastructure is "climate sensitive" because it is designed, built, and operated so as to provide useful service over decades within a range of site-specific criteria. The current water infrastructure – and the infrastructure that will be built in the next few decades – will be subject to climate conditions outside of historical experience, with changes likely intensifying over time. All infrastructure systems carry some risk of failure. However, unanticipated, and rapid, changes in the operating environment may increase this risk and overwhelm systems' coping capacity, with related financial losses, and health and safety risks.

Water engineering practices associated with climate change

The lack of system "redundancies" or backups, and the isolation of Arctic communities are key features that differentiate infrastructure systems in the Arctic from systems in the south. In the event of infrastructure failure, northern communities may not have access to the benefits of options that many southern communities take for granted, such as simple and convenient community access, piped and looped water systems, and local problem-solving resources.

This lack of options in emergency situations may require the mobilization of considerable resources, at great expense, to address an issue. For example, Arviat, Nunavut had a significant leak in the water reservoir, which prompted the need for an emergency water supply because a winter repair was not possible. After the consideration of alternate freshwater sources, it was concluded that seawater was the only reliable solution. This required the quick and expensive mobilization of a reverse osmosis treatment system.

A northern water engineering manual Good Engineering Practice (GEP) for Northern Water and Sewer Systems was originally published in 2004 by the Government of the Northwest Territories' Department of Public Works and Services. GEP highlights the conditions for Arctic water infrastructure which often require a different approach to design than what is commonly applied in the south. GEP has been revised and published as a second edition, and the revision includes a list of climate change influences associated with the engineering of water systems in the Arctic, along with several reference documents for further consideration.



Water storage reservoir in Chesterfield Inlet, Nunavut.

There are planning reports addressing climate adaptation that have been developed for many Arctic communities, but water infrastructure is only highlighted in the context that change will likely occur, and adaptation will be needed. Ultimately the adaptation of water systems to a changing climate will be the responsibility of the individual communities, with the support available from the senior governments.

Closure

It is anticipated that the warming Canadian Arctic climate will influence the quantity and quality of community water. A significant number of Arctic communities are already experiencing water issues that may be related to climate change. The most recent climate change report stated that the entire Arctic Ocean could be largely ice free, in the summer, as early as 2030. Arctic temperatures are rising twice as fast as temperatures in the rest of the world, and, in the fall of 2016, mean temperatures in the Arctic were six degrees higher than average.

In response to climate impacts on water infrastructure, resiliency may be more appropriate than redundancy. Historically, the application of redundancy has meant having "more of the same" in order to be in a position to respond to critical facility issues, whereas "resiliency" refers to the ability of such infrastructure systems (including the interconnected systems and social systems) to absorb disturbance and still retain their basic function and capacity.

Most Arctic communities currently have a limited capacity for dealing with water issues, whether they are technical, financial, administrative, or human resources. Contrary to this limited capacity are the increasing demands on these same resources which are being driven by increasing regulatory demands and increasing sophistication in the technology associated with water in the Arctic. Climate change will demand new approaches to juggle these contrary issues.