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Bioremediation at Ekati Mine Site, NWT

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ON THE COVER – *The Ekati Diamond Mine's remote location comes with many challenges, including limiting timeframes for transporting waste materials from the site to a treatment facility, and the high costs of transporting these materials. In response to these costs, the Ekati mine management undertook a project to treat contaminated materials in a self-contained, on-site area.*

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SEWAGE LAGOON SLUDGE REMOVAL IN OLD CROW, YUKON

Completed sludge and vegetation removal at the Cold Crow lagoon – Geotube dewater area in the background.

Edited from an article by Blair Benn, President, Lambourne Environmental Ltd.

Old Crow is the northern-most community in the Yukon Territory, located along the Porcupine River. The community is home to approximately 245 people governed by the Vuntut Gwitchin First Nation. The community is serviced with trucked water and sewer and the sewage is discharged into a sewage lagoon located west of town.

The Old Crow sewage lagoon is now 30 years old and consists of one rectangular primary treatment cell 10,000 square metres in size. Sewage is discharged at the western side of the lagoon, and there is a discharge control valve in a manhole on the eastern side of the lagoon. The total volume of the lagoon is 17,000 cubic metres, and it has an operating depth of 2.2 metres. The lagoon was built on permafrost with berms of coarse sand and small stones, with silt underneath. The original intention of the design was to use permafrost and water frozen inside the berm material to contain the sewage during most of the year, and to do an annual discharge through a pipe installed in the eastern berm.

The warm temperature of the sewage melted most, if not all, of the permafrost under the lagoon, preventing the freeze back of the berms, and the creation of a barrier to leakage from the lagoon. As a result, sewage slowly filters through the bottom of the lagoon and the berms. This flow condition likely provides partial treatment; however, it also resulted in ponding of sewage around the exterior of the berms, except for the north side of the lagoon. The wastewater naturally flows into a wetland on the east side of the lagoon, which provides supplemental natural treatment. A creek moves the water in the wetland toward the Porcupine River, approximately 300 metres away.

In 2019, Lambourne Environmental Ltd. was subcontracted by Wildstone Construction and Engineering Ltd. to remove the thick, muddy waste (sludge) and floating vegetation in the Old Crow sewage lagoon by dredging. There are no roads to the community, so all the equipment had to be flown on one of Summit Air's ATR 72 aircraft. This was challenging because most dredges are too large to be transported by air. The dredge also had to be capable of removing the vegetation floating in the lagoon.

Lambourne designed a dredge which could perform both tasks, and a boat manufacturer designed and built pontoons to float the dredge. The intent was to remove the water from the sludge taken out of the lagoon using Geotubes. Geotubes are large, long "socks" made of a geotextile that allows water to

Operation of the floating sewage lagoon dredge, which removes both sewage sludge and vegetation – Geotube dewatering area in the background.

Loading the floating sewage lagoon dredge on the aircraft in Whitehorse for mobilization to Old Crow.

seep out, while keeping the solid, mud-like waste inside. This was thought to be the best and most portable way of dewatering the sludge in such a remote location.

A small pumping device for adding a chemical (polymer) to the sludge, and all the equipment, chemicals, and other necessary materials, were transported to the site in one plane load in mid-September 2019. A place to lay the Geotubes was needed, so a bermed area, with a plastic liner, was built along one side of the lagoon. The plastic liner captured the liquid (filtrate) flowing out of the Geotubes and allowed it to flow back into the lagoon. Once the site was set up, the crew began pumping the sludge into two Geotubes, each 30 metres long. Cold weather forced the shut down of the project in early October 2019 because the lagoon began to freeze up.

Due to the COVID pandemic in early 2020, the crew did not return to the site until mid-July 2020. The equipment which had been stored in Old Crow was taken to the work site and the crew went to work removing the floating islands of vegetation covering a good portion of the lagoon and dredging the sewage sludge.

The budgetary cost estimate for the sludge dewatering was $790,000, which included a mobilization and demobilization cost of $200,000; $200,000 for the bermed Geomembrane cell; $150,000 for the bermed cell liner and Geotube operation; engineering costs of $80,000; and a contingency of $160,000. The project was successfully completed in August of 2020, having removed approximately 170 dry tonnes of sludge. When the material in the Geotubes has sufficiently dried, it will be removed and used as cover material at the site and at the landfill.

A FRAMEWORK FOR WATER SYSTEM EMERGENCY PREPAREDNESS IN THE ARCTIC

By Ken Johnson, EXP

In response to a recent water supply emergency in Iqaluit, the residents made use of the potable water available in the adjacent Sylvia Grinell River – boiling of the water was still recommended before drinking the water.

Arctic communities experience situations associated with natural events such as floods, storm surges, permafrost melt, extreme cold weather, and blizzards. The costs arising from many of these common emergency situations and their impact on community infrastructure do not specifically fall under emergency preparedness – they are simply part of the means of maintaining safe, sustainable communities in the Arctic.

In addition to these sorts of natural events, there are always accidents and mishaps caused by human activity. In the Arctic, an emergency event can quickly cascade into a more significant situation because of remoteness, limited transportation and infrastructure, communication options and other factors. In general, system failures (water, power, transportation, and communication) and the events that lead to such failures are perhaps the most critical emergencies faced by many Arctic communities.

Emergency responders, whether local or non-resident, are dependent, in these situations, on supply lines. If transportation and communication systems are disrupted during an emergency event in the Arctic, this can complicate matters. Demands placed on communities that can create or intensify an emergency include accommodation, food, fuel, medical services, specialized or heavy equipment, aircraft, vehicles, human resources, and a host of other factors relating to remoteness and climate.

Given that most emergencies are inherently unpredictable, hazard identification is only a tool to aid preparedness rather than a predictive science. There's considerable variation in the range of perceived hazards in communities as well as across the three Canadian Arctic territories. The sorts of emergency risks that are typically faced by Arctic communities need to be included in any assessment of community preparedness.

Understanding the hazards and risks that Arctic communities face and gathering information from residents, community governments, and other stakeholders is an important step in emergency planning.

When viewing emergency preparedness from an Arctic community perspective, safe communities are far more than the product of the best efforts of any single individual or organization. There is a need to coordinate across many governments and organizations, and this adds considerable complexity to any northern community's pursuit of safety and capacity to respond to emergency situations.

A framework for emergency preparedness as it applies to a water system emergency may have two parts. The first part can be called a Risk and Resilience Assessment (RRA). Through the RRA, procedures and processes are developed which can be used by the management team to identify the major risks and reduce vulnerabilities of critical assets and mitigate the potential consequences of incidents that do occur. It also guides the community by suggesting (or recommending) countermeasures that can reduce the risk from a threat to the utility's assets, equipment backup, power, training, and exercises on emergency response plans.

There are six distinct asset categories that may form part of a water system RRA. These categories are the physical and computer elements of the systems and include water source, water collection from source, water treatment, water storage after treatment, water distribution systems and the electronic, computer, or other automated systems that support these asset categories.

Once the facility management team have completed the RRA, this information may be used to create a document that describes the strategies a community can take to aid in the detection of emergency situations. This Emergency Response Plan

Distributing drinking water during a recent Iqaluit water supply emergency required the set up of fill stations, where potable water was available in plastic containers.

(ERP) must describe a system's strategies, resources, plans, and procedures to prepare for and respond to an incident, natural or man-made, that threatens life, property, or the environment.

The general organization of the ERP can be divided into four sections as follows:

- **Section 1: Resilience Strategies** – strategies and resources to improve the resilience of the system, including the physical security and cybersecurity of the system.
- **Section 2: Emergency Plans & Procedures** – plans and procedures that can be implemented, and identification of equipment that can be utilized, in the event of an incident that threatens the ability of the community to deliver safe drinking water.
- **Section 3: Mitigation Actions** – actions, procedures, and equipment which can significantly lessen the impact of an event on the public health and the safety and supply of drinking water provided to communities and individuals, including the development of alternative source water options, relocation of water intakes, and construction of flood-protection barriers.
- **Section 4: Detection Strategies** – strategies that can be used to aid in the detection of an even natural hazards that threaten the resilience of the system.

The community should review and update their ERP once every five years. The ERP should be thought of as a "living document" with established routine updates, and it must include any revisions to the RRA.

TECHNIQUES AND TECHNOLOGIES FOR ARCTIC LAGOON ASSESSMENT

By Renata Klassen, EXP

The Kugluktuk lagoon was constructed in 2008 consisting of a 240-metre and 200-metre cell lined with an HDPE liner. A major issue o ccurred with the formation of "whales" in the liner, seepage from the base of the lagoon and subsidence in the top of the lagoon.

An extensive field program was initiated in 2021 to investigate the potential causes of the lagoon issues and form the basis for remedial work. Site reconnaissance was completed focusing on settlement and drainage issues (See subsidence in top of fence line). Topographic elevations were recorded to help quantify the historical subsidence any continuing subsidence in the berms.

A drilling program was completed consisting of boreholes around the lagoon perimeter to a maximum depth of 10 metres using an air track drill. Samples were collected during drilling of the cuttings returned to the surface. Laboratory testing on the samples collected included determination of natural moisture content, particle size distribution (gradation), Atterberg limits, and salinity.

Above right: Five of the 11 boreholes were instrumented with thermistor cables to measure ground temperatures and slotted standpipes to measure water levels. The thermistor cables installed in the berms consisted of one ground temperature cable (GTC) and three variable thermistor strings. The installations were temporary by lowering the cables into one-inch solid PVC pipes installed in advance in the boreholes. The five thermistor cables were connected to dataloggers for continuous temperature measurements. Water levels were measured with a water level tape.

Another part of the program was collecting water samples around the lagoon to identify possible sewage leaks. Water samples were collected from the anticipated seepage at the toe of the east berm, from and adjacent stream and from a ponded area west of the lagoon.

A permeability test was conducted in the borehole drilled from the western sideslope. A levelogger was programmed and lowered into the one-inch slotted standpipe. The standpipe was filled with water, and the water level versus time was logged. A water level tape was used as a backup measurement. The data has been compiled to provide a comprehensive picture of the ground conditions within the lagoon system to development schematic designs for remediation work.

COVID EARLY WARNING IN THE ARCTIC WITH WASTEWATER SAMPLING

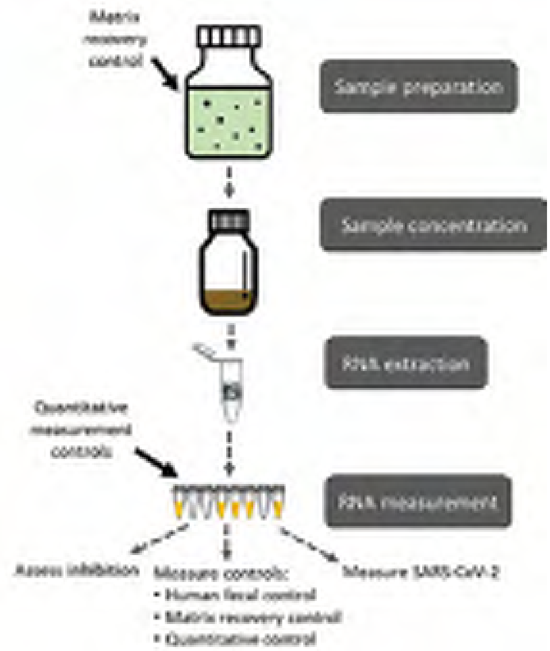
Wastewater testing has a history of being a source of information for action on public health-related issues. Wastewater testing has been used to monitor health threats such as polio, illegal drug use in populations, and, most recently, the virus that causes COVID-19.

The COVID-19 virus has characteristics which makes it challenging to detect. These include a high rate of transmission by symptomatic, non-asymptomatic, and pre-symptomatic individuals that leads to missed detection, which can in turn lead to the virus being passed on before it is detected. These characteristics of the infection – along with the fact that traces of the virus are excreted in feces during all phases of the infection – has led authorities to call for early wastewater testing to complement surveillance based on clinical tests and identifying cases of Covid-19 infection in the community. Wastewater surveillance is also a cost-effective way of detecting COVID-19 in a population.

This way of detecting the presence of Covid-19 in a community alerts the health system five to 10 days earlier that there are Covid-19-infected people there than testing could do, especially if the population includes individuals who are infected but have no symptoms or have not yet developed symptoms.

The NWT government has undertaken regular surveillance of wastewater in some communities within the territory to identify the presence – or absence – of the coronavirus.

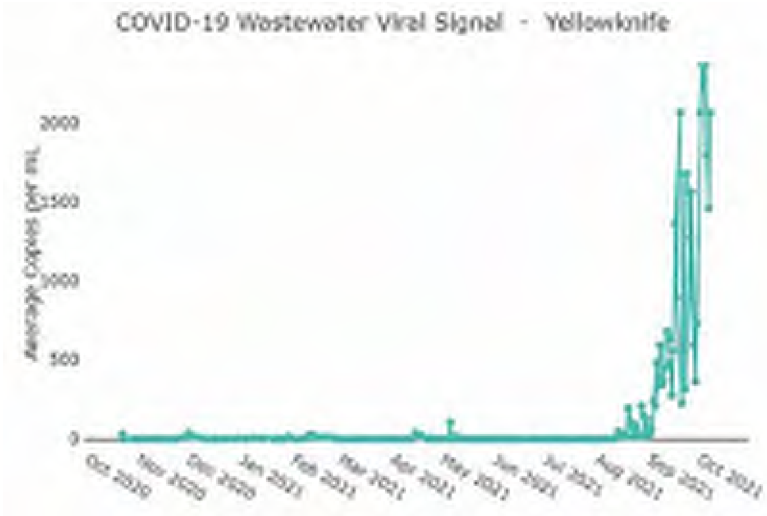
Laboratory method for testing for viral signal.

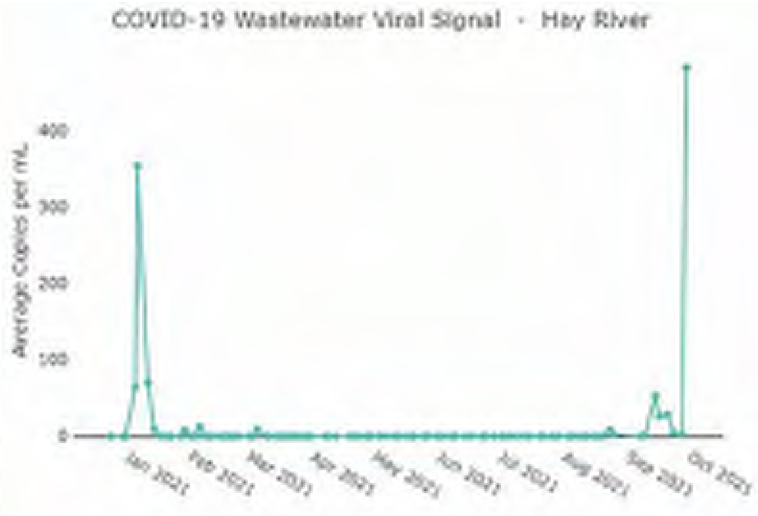


Wastewater testing is especially useful for the NWT because it allows public health officials to know there are Covid-19-infected individuals in the community and to take early actions to control the virus from spreading. Wastewater testing can't identify the individuals who are sick, how many people are infected, their vaccination status, or how sick each person is. Unlike swab testing that requires people to sign up, sewage samples include nearly everyone, and if anyone has the virus, it will show up in their waste even before they have symptoms.

The presence of COVID-19 in wastewater samples doesn't necessarily mean there is active COVID-19 transmission in the community. However, collecting this information can serve as an early-warning system for the territory and help the health and social services system target advice to affected communities.

On the flip side, just because there





are no positive results from wastewater testing in a community doesn't necessarily mean there are no COVID-positive people there. But the wastewater test gives health authorities useful information to pair with information from tests of individual residents and visitors to the community.

The effort has been led by the Office of the NWT's Chief Public Health Officer in partnership with the Government of the Northwest Territories Departments of Municipal and Community Affairs, and Environment and Natural Resources. As a key partner, the Public Health Agency of Canada's National Microbiology Laboratory is providing in-kind support of testing costs.

Establishing an early-warning system using wastewater samples provides the opportunity to have a much better idea of whether COVID-19 is present in the territory, and the opportunity to give communities advice and get people tested if they need it.

If there is a positive result from the testing of a community's wastewater, guidance and outreach may be targeted at those in the community who have arrived in the NWT after travel outside the territory since the last negative wastewater result, as well as those who have developed symptoms of COVID-19.

The detection of COVID-19 in wastewater samples alone won't result in aggressive containment measures, as it could be connected to imported travel cases being appropriately isolated. However, public health measures like putting limits on large-scale gatherings or making mandatory masking rules for indoor public spaces may be considered.

Currently, the communities which are having their wastewater tested for traces of Covid-19 are Fort Liard, Fort Simpson, Fort Smith, Hay River, Inuvik, Norman Wells, and Yellowknife. With these currently participating communities, over 67 per cent of the NWT's population is being tested for COVID-19 two to three times per week.

The territory's wastewater samples are analyzed at the National Microbiology Laboratory in Winnipeg, and at the GNWT's Environment and Natural Resources' (ENR) Taiga Laboratory in Yellowknife.

An investment of $100,000 from Indigenous Services Canada allowed the territory to purchase the necessary testing equipment and to coordinate the delivery of this program.

BRINGING ARCTIC MINE REMEDIATION TO THE COMMUNITY CLASSROOM

Edited from an article by Guillaume Nielsen, Yukon University

In Eliza Van Bibber School classroom.

In the field with Nacho Nyak Dun students - Keno Hill mine, 2016.

The Yukon's mining industry has been an important part of the Yukon economy since the Klondike Gold Rush 125 years ago. Whether or not a mining operation would leave behind a legacy of damage was not part of the planning for mines in days past, and the Yukon and NWT have been left with many legacy projects that pose serious threats to public health and the environment. The mining industry in the Arctic today recognizes the need for remediation planning at all stages of a mine's life, along with the need to engage with Indigenous communities that have been impacted by mines.

The newly established Yukon University shares the commitment for remediation planning at all stages of a mine's life, along with the need to engage with mine-impacted Indigenous communities. YukonU is committed to working with Indigenous communities and building partnerships to support research that may be applied in a practical context.

YukonU hosts a Natural Sciences and Engineering Research Council of Canada Industrial Research Chair for Colleges (IRCC) in Northern Mine Remediation (NMR). This research program partners with all Yukon's active mines and focuses on solving environmental challenges the mining industry faces in the North. The program focuses on water treatment by passive or semi-passive technologies, mine waste management, and mine revegetation.

In order to introduce the research program to First Nation communities and build impactful research projects, workshops were held for First Nation summer students, youth, and environmental teams multiple times each summer between 2018 and 2020. The workshops were hands-on and visually based, focusing on the mine life cycle, as well as mine contamination and solutions to mine contamination. The workshops included experiments performed in the classroom, which helped students explore acid mine drainage, toxicity, and the difference between active and passive water treatment. Some of these workshops were followed by mine site tours with the support of partnering mining companies.

Following one of the workshops presented in the Selkirk First Nation community of Pelly Crossing, a teacher at the community's Eliza Van Bibber School suggested that the team develop a course that could be offered as part of the science program for the school's high school students.

With the school's support and in partnership with Minto Explorations Ltd., the research program team developed a course that highlights the importance of what is referred to as "passive treatment". Passive treatment systems rely on "mother nature" to provide the means of treating contaminants, with enhancements added to allow mother nature to work better. Passive systems are important for the north because non passive systems require technologies that may require ongoing operation and maintenance attention, including the need for power supply.

Selkirk First Nation students visiting Minto Mine.

The course became part of the credited curriculum offered to students through the Science for Citizens 11 course. The course was built around a class-based experiment where students constructed a small passive-waste treatment system that used Yukon native bacteria and mine-impacted water from the Minto Mine near the community of Pelly Crossing. Sampling, monitoring and discussing heavy metals removal rates were part of each module.

Guest speakers were an added benefit to the course, and they presented information on Arctic research projects, including the impacts of climate on northern mine remediation. Discussions took place around how potentially affected First Nations and communities imagine mine revegetation success in the North.

The course lectures were also designed to present different career paths available in the environmental monitoring field, including a presentation from a Na-Cho Nyak Dun citizen working as an environmental technician at Eagle Gold mine (200 kilometres north of Pelly Crossing) who discussed what she had to do to qualify for the position she has.

Students also heard from a Minto Mine Environmental Officer who spoke about the different groundwater and surface water monitoring techniques and the science behind the mine's set-up. To explore educational opportunities available to students to prepare them for such careers, students were introduced to the Environmental Monitoring Program at YukonU and this was complemented by a tour of the research lab to introduce students to laboratory equipment.

The students also explored why involving First Nation communities in research projects is important. This discussion was led by a Selkirk First Nation citizen working at YukonU as a First Nation Engagement Advisor. Another lecture detailed the exploration-to-development process at Minto Mine to teach students more about the operations at a working mine. Finally, to come back to passive treatment system, a module focused on Minto Mine's constructed wetland treatment system and its role in post-closure reclamation of the site.

The focus of the course on remediation and restoration, in alignment with the focus of the Northern Mine Remediation research program, has provided a pathway for building relationship with students at the Eliza Van Bibber School. Both remediation and restoration are relevant to students, emerging areas of interest for the industry, and support advancement of research tools and outcomes that are impactful in the Yukon.

SEWER MAIN REPLACEMENT IN IQALUIT PERMAFROST

By Chris Keung, EXP

Example of sewer pipe crushing in Iqaluit.

Project area of Iqaluit sewer replacement.

Background

The construction of the accommodation and sealift area of the Crystal II Air Base, now known as the City of Iqaluit, was completed in 1941 as part of the original series of airfields used for ferrying aircraft from North America to Europe. The original service for this area was trucked water and sewage until 1985, when shallow-buried piped services were installed. Shallow-buried sewer pipes are commonly used in Iqaluit. At the time of the installation of the original buried sewer and water system, placing buried pipes in the active layer) was thought to be appropriate. However, with time, it was found the shallow-buried service lines could significantly deteriorate from the freeze-thaw forces in the dynamic active layer. In several cases, the forces destroyed the pipe by crushing it.

In 1996, the service pipes between Access Vaults 207 and 208 were replaced. During this project, it was noted that the ground conditions in the active layer were poor. Changes in the design would be needed for any future construction in the neighbourhood. These would include removing surface and groundwater in the construction trench and installing extra insulation to make sure that warmer temperatures in the pipes would not affect the existing freeze and thaw changes in the active layer.

Sewer depth and alignment

Iqaluit's municipal guidelines recommend a minimum cover of at least three metres of fill from the top of the pipes to the finished grade of the surface. This is intended to reduce the influence of thawing of the active layer on the pipe, which can cause pipe deformation and complete collapse because of the pressure on the pipe when the thawed active lay re-freezes. Climate change and associated impacts on the active layer may further influence the stability of buried services in Iqaluit in the future.

The current sewer lines have only between two to 2.5 metres of cover between the top of the pipe and the ground surface. One major problem that affects the possibility of burying this sewer line deeper in the ground is that this sewer line connects to AV211, which then connects to the wastewater treatment facility. Presently, this sewage line crosses over a 2.3-metre diameter culvert. Going under this culvert is not an option because then there wouldn't be sufficient grade for gravity feed of the sewage at the point where it connects to AV 211. Therefore, to maintain minimum grades and hydraulic flow, the necessary pipe elevation at the AV 211 connection dictates how deep the upstream sewer line must be buried.

The existing water and sewer mains are located at the south edge of Mivvik Street. Replacing the sewer lines in this location raises many issues since this requires working in a very wet area with existing water supply, water recirculation, and sewer mains, as well as multiple service connections to adjacent buildings. If a new sewer main was placed, in its own separate trench on the north edge of the street, several of these construction problems could be avoided, as well as reducing construction costs and cross contamination risk.

Pipe zone and general backfill

In situations where there are ice-rich or silty soils within a half metre below the specified pipe base, it may be necessary to remove the ice-rich or silty soil below the pipe as the ice could thaw and possibly allow the pipe to move. The recommended type of material for this area below the pipe should be

Example of wet excavation in Iqaluit.

Typical access vault in Iqaluit.

well-graded, sand and/or fine gravel to maintain a dry trench for the pipe. For wet trench conditions, a coarser material such as a well-graded, rounded or partially rounded gravel is preferred as it will help stabilize the trench.

As new sewer lines require pipe diameters of at least 450 millimetres, there may not be enough space in the existing trench to maintain the required spacing requirements between the proposed sewer and the existing watermains. Also, in situations where there are water supply, water recirculation, and sewer mains all in the same trench, it's best to lay the sewer main on the outside edge of the trench to further reduce the risk of cross contamination.

Access vault considerations

Access vaults (AVs) are prefabricated, double walled, insulated metal units, installed at least half a metre below the base of the pipes. The typical temperature in the AVs will be between 5 and 10°C, because of the radiated heat from the sewer main going through the AV. Although the AV bases are insulated to prevent thawing of the materials below the AV, the above-freezing temperatures in the AV may cause some long-term thaw below it. If this happens, the stability of the AV may be compromised because of movement in the surrounding soil which can put additional stresses on the pipe connections outside the vaults. Breaks in the piping connected to the AVs have been observed in the past. To counter this effect, the thaw stability of the soils under the AVs must be considered.

Two additional things to consider relating to potential movement of the AVs are insulation beneath the steel base of the AV to protect the permafrost below the AV from thawing and the use of flexible couplings to connect the pipes to the AVs to accommodate movement caused by thawing and freezing.

AVs are essential structures that may cost more than $125,000 each. Therefore, finding ways to maintain the existing AVs could provide potential substantial savings. However, considering hydraulic performance, existing conditions of the AVs, and construction factors the installation of new AVs, installing the sewer in a new location as part of the work may be necessary.

Construction considerations

As the site is in the downtown core of Iqaluit, this project becomes significantly more challenging. The contractor will be required to safely deal with maintaining access and service to existing businesses, overhead electrical wires, excavation around existing roadways, managing heavy vehicle and pedestrian traffic, and limited workspace within the right-of-way.

If the desired alignment of the new sewer is along the existing sewer alignment, this will require removal and replacement of the existing sewer and likely the watermain pipes. This would significantly increase the project challenges, anticipated construction duration, and construction costs due to the necessity of designing and maintaining a continuous sewer bypass and temporary water supply.

Alternatively, constructing a separate trench for the sewer main on the north side of Mivvik Street would significantly reduce the project complexity, construction duration, service disturbances, and costs. It is estimated that installing the sewer main on the north side of Mivvik Street will result in savings of up to 50 per cent of the project costs.

AL REIMER AWARD WINNER
ALAN HARRIS – HAMLET OF FORT LIARD

Fort Liard Deputy Mayor Eva Hope presents Alan Harris with the Al Reimer Award.

I am honoured and feel very privileged to have received the nomination and the award in the memory of Al Reimer. In fact, knowing my name was put forward by my fellow NTWWA board members is an honour unto itself.

I would like to thank my employer, the Hamlet of Fort Liard, for their trust and direction in having involved me in this field of work. The training and knowledge I have received over the years has led to my success in the water and wastewater field of operations. Working with the great people I do, their hard work in the provision of municipal services in my own community, and other communities of the NWT, has also, I believe, contributed to my success. The water and wastewater services that we are all involved with are instrumental to the strength and health of everyone around us. Thank you all.

SACHS HARBOUR WATER INTAKE INSTALLATION

By Ken Johnson, EXP, and Michel Lanteigne, AECOM

Sachs Harbour is located along the Beaufort Sea, on the southwestern shore of Banks Island, at 71o 59’ N latitude, and 125o14’ W longitude. It is the most northerly community in the Northwest Territories, 520 kilometres northeast of Inuvik. This small, traditional community has an estimated population of 100 (2016), which is serviced by water and sewage trucks.

Installing concrete anchors on insulated HDPE intake pipeline – anchors secured with stainless steel bolts.

Preparation for intake installation with removal of ice and excavation of the lake bottom.

Installation of insulated and anchored HDPE using strategically placed heavy equipment – ice platform used for intake installation.

Water intake structure with intake screen, 45-degree bend, bolted connections for fish screen and bend.

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