

Northern Territories Water & Waste Association **2021** PART 1

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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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MESSAGE FROM THE EDITOR **KEN JOHNSON**



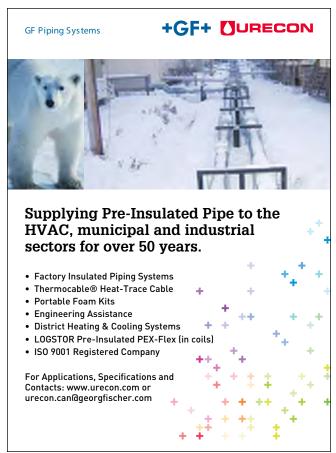
s I stated last year, the Arctic is certainly used to change, but 2020 was a milestone year that presented changing circumstances that remain with us today. The current edition (2021) is the 17th edition of the Journal, which has maintained its importance to the NT-WWA throughout the past 17 years and gained a new importance for communication with, and a deliverable for association members with the cancellation of the NTWWA Annual Conferences over the past two years. The theme for the 2021 issue of the Journal is remediation, with articles on six remediation related projects in the Arctic. Along with the themed articles, there are articles on sewer COVID testing in the NWT and water emergency planning. The current water emergency

situation in Iqaluit has brought to light the critical nature of water emergency planning and the unique responses necessary under Arctic conditions.

I would like to thank Pearl Benyk once again this year for her editorial and plain language review of the Journal articles - this is icing on the cake for my editorial activity of bringing the Journal to press.

If any readers have any questions or comments on the Journal do not hesitate to contact me at EXP (ken.johnson@exp.com or 780.094.9085 [voice or text]). Stay well in the coming year, and with some luck and some good public heath management, I hope to see you in Yellowknife in the fall of 2022.







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Edited from an article by Robert Lacey, Delta Remediation, and Kurtis Trefry, Dominion Diamonds

he Ekati Diamond Mine is located near Lac de Gras in the Northwest Territories, approximately 300 kilometres north of Yellowknife. The mine is only accessible by air, except for the brief period of winter road operation. This remote location comes with many challenges, including limited timeframes for transporting waste materials from the site to a treatment facility, along with the high costs of transporting these materials.

In response to these costs, the Ekati mine management decided to undertake a project which would treat contaminated materials in a self-contained, on-site area. Since Ekati has high environmental standards to meet, all spills and contaminated materials must be treated. Ekati looked for innovative, alternative solutions which could be done on site and become part of the mine's operating practices.

Ekati decided to clean hydrocarbon-contaminated soil by using microbiology, which would make use of bacteria to consume (metabolize) the hydrocarbons. This method would be cost-effective and result in soil that meets the appropriate regulatory criteria (Canadian Council of Ministers of the Environment [CCME] Agricultural Guidelines).

The effectiveness of bacteria at consuming hydrocarbons has been proven in the cleanup of thousands of contaminated sites under a variety of conditions.

However, typically these sites have been located in warmer temperatures than those at Ekati Arctic environment, and these warmer temperatures result in faster cleanup of the hydrocarbon-contaminated soils. Also, it has been shown that soils that have moisture in the range of 10 to 20 per cent have healthier communities of bacteria that consume the hydrocarbons quicker, which are generally conditions not encountered in the cold and dry Arctic climate.

The formal name for using bacteria to clean up soil is called "land farming", and Ekati set out to determine whether this method would be effective with the cold temperatures, the extreme changes in daylight over the course of the year,





and the dry climate conditions. The initial phase of the project was completed in June 2018 using 1,400 cubic metres of hydrocarbon-contaminated soil. The project made use of a "designer" bacteria contained in a product called Biologix, which is a blend of bacteria with a superior ability to consume hydrocarbons and other chemicals.

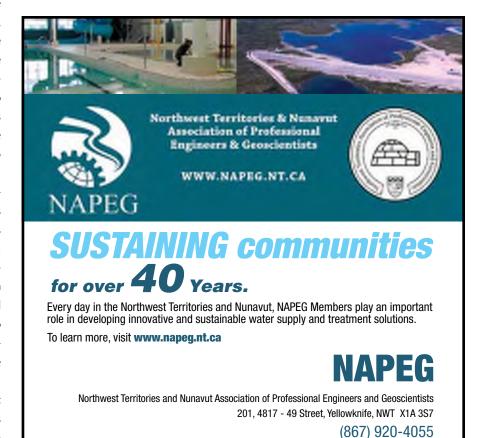
Biologix was added to the landfarm soil and evaluated to determine if it was appropriate for the conditions at the mine site (cold temperatures, hours of daylight, and moisture content of the soil). The evaluation was completed by testing the number of hydrocarbons in the soil before and after the bacteria were added to the landfarm. The landfarm also requires the occasion aeration by excavating the pile to hasten the transfer of oxygen into the landfarm soil.

The hydrocarbon-consuming bacteria also need nitrogen and phosphorous nutrients to complete the job, and it was found that the contaminated soil at Ekati did not contain enough nutrients to support the Biologix bacteria. Therefore, in addition to the bacteria, nitrogen and phosphorous were added to the soil to provide the bacteria with all the necessary ingredients to thrive and consume the hydrocarbons.

By September 2019, the 1,400 cubic metres of contaminated soil that was treated by the bacteria and clean enough to meet the regulatory criteria. This proved that it was not necessary to haul the contaminated soil to a treatment facility in Yellowknife. Another hydrocarbon cleanup project was initiated at the land farm for 1,000 cubic metres of contaminated soil that will ultimately be used as a cap on the landfill site when it reaches capacity.

The project has successfully proven that using bacteria to clean up hydro-

carbon-contaminated soils can be effective in the Canadian Arctic. This method reduces the costs and greenhouse gas emissions associated with screening, bagging, and hauling hydrocarbon-contaminated soils to Yellowknife for cleanup. Using the Biologix process resulted in a savings of \$200 per cubic metre of soil over hauling it to Yellowknife for treatment.



TUNDRA MINE REMEDIATION PROJECT

By John Mackenzie, AECOM



he Tundra Mine site is located approximately 240 kilometres northeast of Yellowknife, NWT. on the east side of Matthews Lake, and ultimately discharges into the east arm of Great Slave Lake. The site is remote and lies within the Akaitcho Territory, the Wek'eeshii and Monwhi Goga De Nittaee areas of the Tlicho Land Claim Agreement and North Slave Métis traditional lands.

Tundra Mine, owned by Royal Gold, was operated as an underground gold

mine from 1964 until 1968 and supported operations at the nearby Salmita Mine from 1983 to 1987. During its lifetime, Tundra Mine produced some 3,250 kg (104,480 troy ounces) of gold. In 1987, the mine was permanently closed, and in 1999, it reverted to the Crown when the mine's owner went into receivership. Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) is currently the custodian of the site.

The Canadian government is responsible for numerous orphan mine sites Tundra Mine features of site cleanup.

across the Arctic. Historically, mining operations were started with no closure plan in place or funding set aside for site remediation and reclamation when mining stopped. As in many cases, as the profitability of the mines decreased, the owners declared bankruptcy and abandoned the mine, along with all the associated contamination, equipment, and buildings.

After the site became the responsibility of CIRNAC, it was assessed, and a plan was made for the cleanup. The initial phase of the cleanup was started over a decade ago, with tailings and hydrocarbon contamination remediation work completed in the initial phase. During this phase of the project, it was found that two tailings ponds on the site were reaching precariously high levels and the dams were at risk of failing. This failure would result in the release of millions of litres of arsenic-contaminated water, as well as tailings that could potentially contaminate the surrounding watershed for hundreds of kilometres.

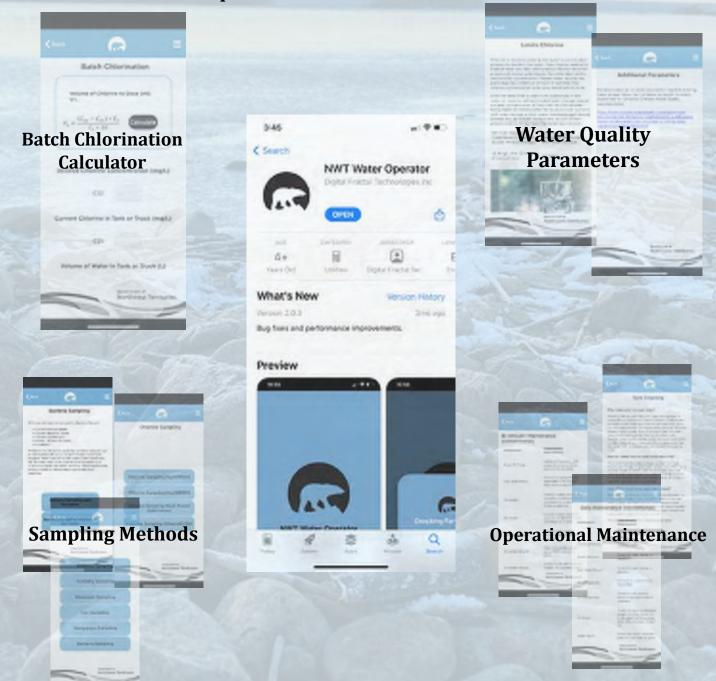
This critical situation meant it was urgent to reduce the volume of arsenic-contaminated water in the tailings ponds to reduce the risk of dam failure to manageable and acceptable levels. At this point, 100,000 cubic metres of tailings water was treated so that the contaminant levels were reduced to well below acceptable background levels in the discharge streams. At the same time, this activity eliminated the risk of a dam failure and a discharge of contaminated water into the environment (See article titled "Tundra Mine Emergency Treat-





NWT Water Operator App

The Water & Sanitation Section of the Department of Municipal & Community Affairs recently developed a smartphone App to assist water treatment plant operators with their day to day regulatory and maintenance tasks. Available for both iOS and Android the free App can be found in the App store with a quick search for "NWT Water Operators"



ment Challenge" in the 2010 NTWWA Journal).

During this phase, work was also done on the tailings area, which originally included two tailings ponds. In total, over 10,000 cubic metres of hydrocarbon contaminated soils were collected from the two tailings ponds, in addition to debris and waste rock which could potentially acidify rain and snow melt water. These soils were moved into a central tailings area, which was covered with layers of geomembrane and covered with gravel and sand to protect the liner and control erosion. Placing all the tailings and other contaminated materials into the one tailings area will reduce the potential for surface water to become contaminated, thereby keeping "clean water clean". Consolidating the materials into one place also limits the actual footprint where contaminated materials still exist on site. Later, the tailings ponds were covered with erosion protection material, and they continue to serve as drainage and flow-through areas for clean surface water.

An important part of the design of the new consolidated tailings area was the installation, through the cover material and tailings, of ground temperature sensors and instruments to measure the underground water pressure. These monitoring instruments were placed in several locations so the information collected from them would give a good representation of the conditions, in various places and at various depths, of the area holding the tailings. The data collected by these instruments can be recorded at daily or hourly intervals so the conditions of the ground, tailings and ground water can be assessed throughout the seasons.

When the mine was established in the 1960s, the natural drainage path between Mill Pond and Hambone Lake was cut off. Restoring this drainage path, which was done during the latter part of the project, added tremendous value for the natural environment and First Nations' stakeholders.

When the remedial work was completed in 2018, the Tundra Mine remediation project shifted to a management phase, during which monitoring, and assessments will determine whether the remediation works will withstand the environmental conditions at this site and are performing as expected. This determination will include assessment of both

the remedial work done and the environment downstream from this area.

The accomplishments in each phase of this remediation project at the Tundra Mine site resulted in significant improvements to the site and the surrounding environment. Removing and disposing of hazardous materials off site, as well as the demolition and on-site landfilling of non-hazardous materials and derelict buildings, was a necessary and critical first task to ensure safe work conditions for the public and for following phases of the work.

With the completion of the Tundra Mine remediation project, the immediate risks to the public have been eliminated and the environment is protected in a manner consistent with the Water Licence and Land Use Permit. The design of the project deliberately considered the low maintenance of the entire site in the future, along with the appropriate level of monitoring for the low maintenance framework.

The Tundra Mine Remediation project was an award-winning submission to the Consulting Engineers of Alberta at the 2019 Showcase Awards.



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ld Crow, Yukon, is a community accessible yearround only by air. Without an all-weather road, construction costs are very high and access logistics are complicated. When unexpected events like hydrocarbon spills occur, the logistical challenges are many and the costs high, not only for assessment of the spill, but also for the cleanup of the spill.

Old Crow is also in an area with complicated geology, including continuous permafrost and associated issues within the active layer. There are no land farms for soil remediation (bioremediation) in the community or nearby. The cold climate limits the biological activity of bacteria activity needed for land farming, and there are various legal requirements regarding land farms in the community.

Microbes will work for food

These various constraints in the community made it necessary to find new and innovative remediation methods to use at sites needing cleanup (referred to as in situ bioremediation). In situ bioremediation uses bacteria already in the local ground to treat the hydrocarbon contaminants in the soil and groundwater. The local bacteria can be used to treat hydrocarbons in the process of their biological activity because they can adapt to consuming hydrocarbons to obtain the energy to grow and reproduce.

The bacteria get energy from the hydrocarbons by using oxygen to break down chemical bonds in the hydrocar-

Rather than taking microbes out of the soil in Old Crow and testing them in a laboratory, a different process was used.

bons. The bacteria "invest" this energy and the carbon from the spill to produce more cells. This process of breaking down hydrocarbon contaminants with the help of oxygen is called aerobic respiration. In aerobic respiration, some of the carbon molecules are broken down to form carbon dioxide and the rest of the carbon is used to produce new cells.

One of the challenges with in-situ bioremediation is that the available oxygen is often quickly used up, and additional oxygen must be added. Fortunately, there are many bacteria that don't need oxygen to break down hydrocarbons. These microorganisms need nutrients like nitrate, sulfate, and use iron instead of oxygen to break down the hydrogens. Groundwater can provide these nutrients, but unfortunately, most of the hydrocarbons in a spill sit above the groundwater in the soil. Hydrocarbon breakdown under these circumstances can take much longer to complete.

Part of the solution to this problem is to provide the necessary conditions for the local microorganisms to consume the hydrocarbons. This selection of the right combination of biochemical conditions for the bacteria living in the permafrost soils of Old Crow required some study.

Bio-stimulating northern microbes and tracking their metabolic activity

Rather than taking microbes out of the soil in Old Crow and testing them in a laboratory, a different process was used. Radioactive substances known has radiotracers were used to measure changes in the biological activity (biostimulation) of the microorganisms in samples of soil taken from the location of the contamination. These changes were encouraged by the number of hydrocarbons that were available.

How well did bio-stimulation work?

Measurements revealed that small amounts of nutrients added to the contaminated soil tripled the rate at which the hydrocarbons were broken down compared to the rate in the soil to which nothing had been added. Even with the short warm season in Old Crow, using a bio-stimulatory solution can be predicted to clean up the contaminated site within one to two years, compared to the six to 35 years (depending on which

hydrocarbon is present) that would be required for degradation of the hydrocarbons to occur naturally, with no help.

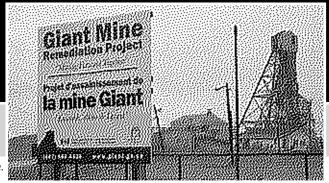
For a site the size of a small building (3,800 cubic metres), this means that bioremediating the contaminated soil where it is, by introducing nutrients for the microorganisms, would mean more than eight metric tonnes of contaminated soil would not have to be added to the landfill, and this would prevent the emission of more that 30 kilotonnes of carbon dioxide equivalents—as well as reducing costs by 30 to 70 per cent compared to solutions in which the contaminated soil is removed. This led to the opinion that successful and sustainable bio-stimulation processes, in areas where the local ground water contains low levels of organic matter, can be used to remediate hydrocarbon contaminated soils, without moving the soil, even where the temperatures are low.



GIANT MINE WATER MANAGEMENT

Update to 2010 NTWWA Journal article entitled "Giant Mine Water Management System"

Giant Mine Remediation project sign.



he history of Yellowknife is intrinsically linked to its start as a mining town. The two most longstanding and productive mines, the Con and Giant Mines, were a result of the original exploration. Both mines closed underground operations in the early part of the new millennium, but both mines have left extraordinary contaminant legacies on the shores of Great Slave Lake.

The rock mined at Giant was rich in gold and arsenopyrite, a mineral with a

high arsenic content. Extracting the gold from the ore produced by Giant Mine required a "roasting" process to extract the gold from the arsenopyrite rock. Arsenic trioxide dust was created during the production of more than seven million ounces of gold over a 50-year period. When the ore was roasted to release the gold, arsenic was also released as a gas. Much of the arsenic gas escaped into the air, but as the remainder cooled, it became arsenic trioxide dust.

Pollution-control hardware installed in the late 1950s prevented most of the arsenic gas from going up the stack, but that created a new problem of storage of the dust. The solution to this storage issue was to make use of the mined out underground chambers. Over a 50-year period, 237,000 tonnes of toxic arsenic trioxide were produced, which is still being stored to depths of nearly 250 metres (800 feet) below ground in various chambers.

Arsenic trioxide dust is water soluble and contains approximately 60 per cent arsenic. It is therefore critical to maintain the stored material "high and dry" to ensure that arsenic is not released into the environment. This effort requires that the ground water level be maintained below the arsenic trioxide dust storage level.

The arsenic trioxide at Giant Mine is stored in 15 underground chambers behind one-metre-thick concrete bulkheads, constructed after the mine closed, which act as plugs to the chambers. Permafrost around the chambers was expected to provide a seal around

the chambers. However, the mining activity thawed the permafrost, and water began seeping into the chambers, becoming contaminated with arsenic, with the potential of leaking into the groundwater around the mine. In response to this new issue, the groundwater has been pumped from the mine to a treatment facility on the surface since 2008.

Over the years since 2008, the contaminated water was temporarily stored in a decommissioned tailings pond over the course of a year and during the summer, the water was pumped into a water treatment plant. The water treatment plant removes arsenic and other contaminants. Once treated, water goes into additional settling ponds for further treatment before being discharged into Baker Creek and ultimately into Yellowknife Bay.

This original treatment system is approaching the end of its operating life, and a plan has been developed to replace the water treatment plant and settling ponds as part of a current remediation phase of the entire Giant Mine site. Once a new water treatment plant is completed in the next several years, the original water treatment plant along with the settling and polishing ponds will no longer be needed.

This site water will continue to be collected and processed at a new water treatment plant when it replaces the existing water treatment system, with the target of ensuring the water is drinkable - containing no more than 10 micrograms per litres (10 parts per billion). The objective is for the new water treatment plant



to reduce arsenic to a concentration well below the "Guidelines for Canadian Drinking Water Quality".

The \$900-million Giant Mine Remediation Project is a job of tremendous scope and complexity, and a 13-year-long consultation process provided the framework for the remediation work, which will include monitoring for a full century into the future.

Most of the details of the cleanup plans have already been reviewed by stakeholders and discussed at length during two technical sessions and a "closure criteria" workshop.

The current phase of the Giant Mine Remediation project began in 2021. ♦

