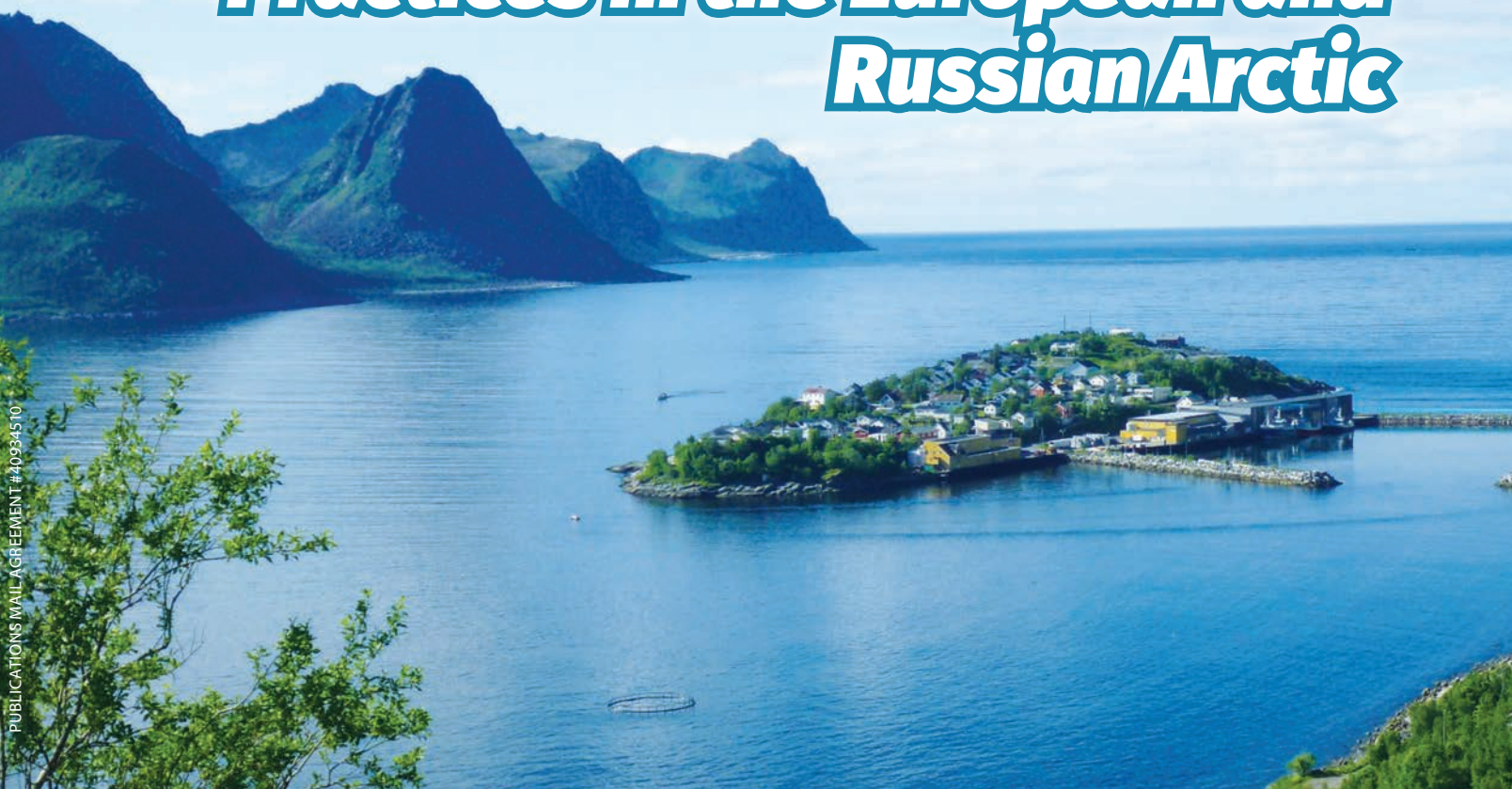


# *Journal*

**2019**

**of the Northern Territories  
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## ***Water & Sanitation Practices in the European and Russian Arctic***



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## ON THE COVER

July 2019 Photo by Ken Johnson. ♦

*Husøy, Senja, Norway, 69 degrees, 32 minutes North Latitude*

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## Editor's Notes

# KEN JOHNSON

The European and Russian Arctic theme of the *Journal* developed from personal contacts I have made over the past several years during my travel, tours, presentations, and research in Greenland, Alaska, and Finland, as well as a week-long graduate course teaching opportunity in Tromso, Norway in July 2019. Travel to Tromso, Norway was a rare opportunity to experience the geography and climate of the European Arctic and share knowledge and experiences with cold region water experts from Norway, Denmark, China, Russia, and Alaska, as well as 50 students from a dozen different countries around the world. The European and Russian Arctic do things differently than we do in the Canadian Arctic, but the fundamental challenges remain the same. A very odd example of these differences is the photo of me with a \$500,000 (Canadian) Norwegian tourist outhouse in the background. The similarities we experience in the north offer a tre-



mendous chance for northern Canadian water professionals to gain perspectives and knowledge that could influence how we might do things in the future.

Thanks to Pearl Benyk for her annual editorial input to the *Journal*, which makes great articles even greater. Additional cold region water information is available at [issuu.com/cryofront](http://issuu.com/cryofront) and at [Twitter.com/cryofront](https://twitter.com/cryofront). If you need any more information or help with your water, wastewater, solid waste, drainage, or planning related projects, please do not hesitate to contact me at [ken.johnson1@aecom.com](mailto:ken.johnson1@aecom.com) or [cryofront@shaw.ca](mailto:cryofront@shaw.ca), or by text/cell at 780.984.9085. 💧



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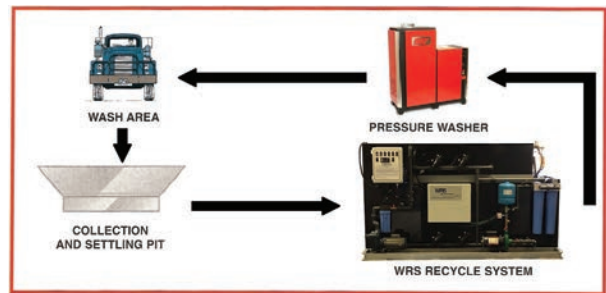


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*Above-ground water, sewer, and district heat systems in Longyearbyen*

# THE WATER SUPPLY IN LONGYEARBYEN, SVALBARD, NORWAY

*Edited from a presentation by Einar Olsen, Longyearbyen, Spitsbergen, Norway; and an article by Aga Nowak and Andy Hodson, University Centre, Svalbard.*

Longyearbyen is a small coal-mining town on Spitsbergen Island, in Norway's Svalbard archipelago, 2,000 kilometres north of Oslo. The Svalbard archipelago may be best known as the home of the "doomsday" global seed vault established in 2008 as a repository of seed samples from around the world that could survive a global catastrophe. Longyearbyen was founded by American John Longyear, who started a coal mining operation there in 1906. The settlement was then known as Longyear City, before being changed to its Norwegian form Longyearbyen. About 2,100 people live in Longyearbyen, which, like the rest of the Svalbard archipelago, sits on permafrost ranging from 10 to 40 metres deep. The average winter temperature is minus 14 degrees Celsius and the average temperature in summer is six degrees Cel-

sus. The Svalbard archipelago is, overall, an Arctic desert with an average annual precipitation of 200 to 300 millimetres.

Longyearbyen has an above-ground water and sewer system with 30 kilometres of water pipe and 24 kilometres of sewer pipe. The water distribution system contains four pressure booster stations and a freeze protection system provided by insulated and heated pipes. Since 1999, a water treatment plant with a sand filter and UV disinfection process has been providing the community with 300,000 cubic metres of treated water annually. The sewage receives no treatment before it is discharged into the ocean.

The earliest pipelines serving Longyearbyen were above ground and supported on wood and steel frames with the pipes for a district heating system running alongside them. The pipes were pre-insulated high-density polyethylene (HDPE) with internal heating cables. This system was phased out because of the limited service life span of the heating cables and high maintenance and operating costs. The next generation of pipes installed were also pre-insulated HDPE pipes, but these have a glycol heating loop inside the pipes. This glycol heating system was first installed in 2004 and has had only limited problems. The source of heat for the glycol system is waste heat from a coal-fired power station. The water and sewer pipes are installed on the surface of the ground, which is graded to provide good sewage drainage and covered with gravel to provide some limited protection of the pipes.

Longyearbyen's water comes from two surface water sources, both of which depend on glacial and snow meltwater. The winter water supply (September to July) comes from Isdammen Lake, which is 2,000 metres long and 500 metres wide and located on the east edge of the community. This lake has an accessible volume of 2.5 million cubic metres of water, with a maximum depth of 4.5 metres. The intake pipe is located at a depth of four metres. Winter ice is up to two metres thick. Work has been underway to increase the capacity of Isdammen Lake with a dam. Isdammen Lake becomes very turbid in summer, so when this happens, usually in July, the community switches to its alternate source of water, the watershed of Gruvedalen.

This source of water in the Gruvedalen watershed, which is also beside the community, is used until September. It consists of a four-square-kilometre drainage basin which is fed by meltwater.

The Longyearbyen Community Council is working to establish a reserve water source as a back-up to the water supplied by Lake Isdammen and the Gruvedalen watershed. Finding a safe and dependable water source for Longyearbyen is a multi-disciplinary problem requiring engineering, glaciological, geomorphological, and hydrological expertise. The initial step taken was to complete snow surveys on the existing watersheds to establish snow accumulation and the volume of water available from snowmelt. This information was supple-



*Location of community of Longyearbyen in Svalbard*



Construction of dam at Isdammen Lake to increase water supply

mented with information from monitoring the amount of sediment suspended in the water from Isdammen Lake and the Grudvedalen watershed, as well as from an alternate water supply in the Endalen watershed.

The watershed studies indicated the importance of rainfall on sustainable runoff. The relative significance of water from rain and snow is likely to become more variable from year to year, and related studies suggest that the amount of winter rainfall might be a major reason for this variability.

Acidified water draining from the nearby coal mines is becoming a water quality issue for Longyearbyen. This water carries both fully dissolved substances and heavy metals in suspension which have leached out of the waste rock as the water passes through it. Poor water quality is expected at the beginning and end of summer. Contami-

nants are leached from both the snowpack and the underlying mine waste rock in early summer. By the end of summer, the reduced amount of water flowing from the mines and the extended time the water has been in contact with the waste rock contribute to its level of contamination.

The Endalen watershed is filled by snow, melted ice, and rainwater and is only moderately affected by the presence of mines. Glacial meltwater entering the Endalen watershed is an important buffer as it dilutes the contaminants. The contamination is most pronounced at the end of summer when the glacier runoff is low and therefore unable to dilute the mine runoff. Water quality is also similarly influenced by the end-of-summer rainfalls that, when they are heavy, deliver contaminants from the hillsides.



The studies also identified crucial periods when poor water quality can be expected and an alternate source of water should be used. The importance of glacial melt as a freshwater source was also proven and it should be appropriately considered in the planning for Longyearbyen's water supply.

Thanks to Nicolas Ashbolt, University of Alberta, for the photo of the Longyearbyen system. 💧



Water sources serving Longyearbyen



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*Community of Anadyr, capital of Chukotka*

# WATER AND SANITATION IN THE RUSSIAN ARCTIC

*Edited from a technical paper by Alexey A. Dudarev, Northwest Public Health Research Center, Saint Petersburg, Russia*

Bounded by the Chuckchi Sea to the north and the Bering Strait and Alaska to the east, in the eastern-most region of the Russian Arctic, sits Chukotka Okrug ("Ok-rug" is Russian for "region"). The shortest distance between Chukotka and Alaska is only 90 kilometres. Chukotka is a semi-independent region of Russia, with an area of 740,000 square kilometres, which is about one-third the size of Nunavut. The population of Chukotka Okrug is 50,000 people, and the largest community is Anadyr on

the east coast, with a population of 15,000. Chukotka contains 44 established communities with 34,700 people (70 per cent) living in the established communities (urban), and 15,500 people (30 per cent) living outside the established communities (rural).

The transportation systems in Chukotka are like those in Nunavut, where travel between communities is possible in the summer only by air or water (with the exception of few short gravel roads), and in the winter by air or ice roads. A unique transpor-

tation feature of the region is the Ugolny Airport, which is a 3,700-metre military and civilian airfield located 10 kilometres east of Anadyr, separated from the community by an inlet. The airfield was constructed during the Cold War, originally as a staging base for long-range bombers, and since then has become the primary hub for civilian flights in the Chukotka region.

Twenty-five of the communities in Chukotka have water delivered to homes and offices with a piped distribution system, and eight of the communities have water provided with trucked delivery systems. The remaining 11 communities have no organized water delivery system. A piped sewage collection system is available in only 10 of the communities.

Water treatment facilities are available in only four communities, with the remaining communities having no mechanized water treatment system. Most of the water for domestic use in the small Chukotka settlements is taken from the nearest lake or river, and the only treatment used is the addition of chlorine to the water truck tanks or the individual household storage tanks.

The water delivered by trucks to the individual households is typically pumped into 200-litre barrels in the home, using a hose, which is often routed through a nearby window. These water barrels generally have no attached pipes or drains, and water

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*Water distribution system in Anadyr*



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is taken from them with ladles. For washing their hands and dishes, most people use a five-litre water dispenser (called in Russian a “rukomojnik”) attached to the wall over the sink. The wastewater from sink drains into a bucket under the sink, which is usually dumped on the ground outside the home.

The poor quality of drinking water is due to many factors, including a lack of any water treatment (including disinfection), the use of obsolete technologies, and the contamination of water sources by improper disposal of sewage. It is also common for contamination of water to occur because of the deterioration and corrosion of the pipes in the distribution systems. It is estimated that 40 to 80 per cent of the water supply systems in Chukotka communities need replacing. Another issue is the number of dead-end lines in the water distribution systems which hold stagnant water, increas-

ing the opportunity for corrosion to occur.

There are no sewage treatment facilities in all of Chukotka, and untreated sewage, totalling approximately five million cubic metres per year, is discharged directly into rivers, lakes and the ocean. In the capital city of Anadyr, 1.8 million cubic metres of sewage is discharged annually into the adjacent Kazachka River, which flows into Anadyr Bay and then to the Bering Sea. In some of the communities, the sewage is dumped or pumped into small lagoons. However, in most cases, the sewage tank trucks pump their contents onto the ground in an area beside the community or into the nearest body of water.

The use of outdoor toilets and self-haul sewage collection systems are common, including the use of indoor honey buckets, which are emptied in an area near the homes. Plastic bags to contain waste are

not used because there are no services in the communities for collecting and disposing of bagged sewage. In-ground sewage disposal systems are not very common because most of the region has permafrost. Many different types of sewage collection and disposal are often in use in a single community.

The combination of a lack of water treatment, the discharge of untreated sewage into the environment, and the use of nearby surface water bodies for both a drinking water supply and sewage disposal all pose ongoing threats to public health in the region. Added to these issues is the deteriorated condition of most of the water and sewer systems. The history of water-borne disease outbreaks in the region suggests that these issues pose a serious public health concern. ♦

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Typical five-litre wall-hung water dispenser (called "rukomojnik" in Russian)



Location of Chukotka in Russia.



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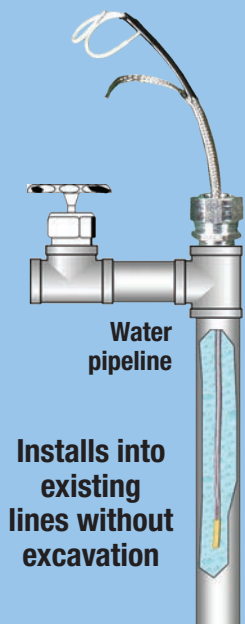
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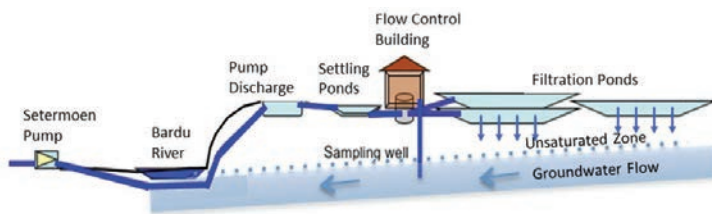
# COMMUNITY WASTEWATER INFILTRATION SYSTEM AT SETERMOEN, TROMS COUNTY, ARCTIC NORWAY



*Satellite image of Setermoen filtration system*

Arctic Norway is warmer than most other places in the world located at the same latitude due to the influence of the Gulf Stream. These warmer temperatures allow for the use of sewage disposal by discharging the wastewater into an engineered pond and allowing it to soak into the ground. This process is referred to as sewage “filtration” through soil. The largest of these systems has been constructed in the community of Setermoen, 100 kilometres south of Tromsø.

The Setermoen filtration system is in a large sand and gravel deposit, and serves a total population of approximately 5,000, located in the community of Setermoen and an adjacent army camp. The wastewater is pumped into two settling ponds which allow the larger solids to settle out by gravity (called “primary treatment”). The remaining liquid from the settling ponds then flows into filtration ponds. If settling ponds were not used to remove the larger solids, the solids would settle and block the flow of sewage into the sand and gravel under of the filtration ponds. The three filtration ponds



*Flow diagram of Setermoen filtration system*

*Edited from a technical paper by P. Jenssen, T. Krogstad, and K. Halvorsen, Norwegian University of Life Science*

are two metres deep, and each has a surface area of 2,000 square metres.

The Setermoen sewage discharge system has been able to achieve the complete removal of fecal coliforms, removal of up to 95 per cent of the biodegradable material, removal of up to 85 per cent of the nitrogen (ammonia), and removal of up to 98 per cent of the phosphorous. The filtration ponds are operated by pumping sewage into them until they are full, and then allowing the sewage to completely soak into the ground before refilling the pond. By doing this, the sand and gravel below the pond has a period when no sewage is filtering through it, which allows small pockets of air to be maintained in the soil (called the “unsaturated zone”). Air in the soil promotes good treatment efficiency with aerobic conditions.

The average depth of the sand and gravel under the filtration ponds is about 20 metres, with the first seven metres containing small pockets of air (unsaturated zone). The unsaturated zone is the key process of this system because it efficiently and effectively treats sewage.

Soil filtration of wastewater uses Mother Nature to treat wastewater, where different treatment processes occur to remove the contaminants in sewage. Coliforms and other organisms that cause diseases are removed by filtering, and “die off” as a result of the harsh environment of the soil.

Biodegradable material in the sewage is removed by the bacteria in the soil and the bacteria in the sewage, both of which consume this material (biodegradation) as it flows downward through the sand and gravel. Ammonia in the sewage is changed by several chemical reactions that, using the oxygen in the soil, transforms the ammonia to other nitrogen compounds. Phosphorous compounds are “retained” by soil particles because of an adsorption reaction, where the phosphorous compounds stick to the soil particles.

The degree of biodegradation in the Setermoen system is measured by chemical oxygen demand (COD). The amount removed has been consistently above 85 per cent and this demonstrates the ability of a sand and gravel deposit in a cold climate to treat sewage.

The alternative to the filtration system used at Setermoen would have been a mechanical wastewater treatment system such as the ones in Pangnirtung, Iqaluit, Fort Simpson, and Dawson City. This plant would have discharged the wastewater, after it was treated, directly into the Bardu River, without achieving the same level of treatment that is achieved with the sand and gravel filtration system.

Another reason for choosing a filtration system over a mechanical plant was the investment cost. The filtration system was less than 50 per cent of the investment cost compared to the alternative mechani-

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## In Memoriam

### Ben Grieco, P.Eng.



**The cold regions engineering community lost one of its finest on June 28, 2019. Ben Grieco passed away at the age of 78 years.**

Ben was an original member of the group of cold region's engineers who advanced the first generation of innovations to water and sanitation engineering in the Canadian Arctic. He was instrumental in developing the looped/circulating/heated water system infrastructure that he first applied to the Arctic community of Resolute, Nunavut and later in Whitehorse, Yukon. Ben was the lead in the conceptual design and predesign of Copper Ridge Expansion area, which ultimately built out to 5,000 lots.

Ben's legacy continues with all new expansion areas in Whitehorse being developed with the same piping configuration, which is based upon his original concept.



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One of the three infiltration ponds at the Setermoen filtration system



Effluent sample from Setermoen filtration system

cal plant. The estimated total savings over the past 30 years has been estimated to be \$10 million (Canadian) due to the lower investment and lower operation costs for the filtration system. The operation cost has also been extremely low since there are no mechanical parts to the system, except for the pump that transports the wastewater across the river from Setermoen. It also does not use any chemicals. The main operational cost, in addition to electricity for the pumps, is the cost of removing the solids from the sedimentation ponds.

By comparison, in northern Canada, the use of filtration ponds for treating wastewater from an entire community has been very limited. The only filtration systems being used in northern Canada are in the communities of Fort Good Hope, NWT, and Watson Lake, Ross River and Mayo in the Yukon. None of these systems were “engineered” for filtration but have operated successfully because the lagoons allow the sewage to flow into the surrounding ground, which consists of a large deposit of sand and gravel. The first engineered filtration sewage treatment system in northern Canada is anticipated to be part of the Tlicho road construction near Behchoko, with a system which will serve the construction camp at kilometre 20 of the road. 💧

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Three of the rotating belt microscreens in the Tomasjord treatment plant

# WASTEWATER TREATMENT SYSTEMS SERVING COMMUNITY OF TROMSO, ARCTIC NORWAY

*Edited from an article by Jan Stenersen, Water and Sewage Department, Tromsø, Norway.*

Tromsø is a community of 75,600 people in northern Norway. It is located on the island of Tromsøya, which is 350 kilometres north of the Arctic Circle and 1,200 kilometres north of Oslo. The 22-square-kilometre island, which is the main part of the community, is connected to the mainland with two bridges and a tunnel. The entire municipality covers 2,521 square kilometres and is the 18th-largest municipality, by area, of the 422 municipalities in Norway. Tromsø is also the ninth-largest community by population, and the third-largest urban area north of the Arctic Circle anywhere in the world after Murmansk and Norilsk in Russia.

The municipality is warmer than most other places located at the same latitude, due to the warming effect of the Gulf Stream. Tromsø is even milder than places much farther south of it elsewhere in the world, such as on Hudson Bay and in Far Eastern Russia, with the warm-water current causing both relatively mild winters and significant tree growth despite its very high latitude.

Tromsø has piped water and sewer systems, and until 15 years ago, all the sewage was untreated and discharged directly into the ocean. In 2004, the Norwegian national authorities started a project called “Primærrens” with the goal of determining if the raw sewage in Norway could be appropriately treated with micro-screening technologies. The project evaluated different screening methods and their efficiency at removing total suspended solids and or-

ganic materials in the sewage.

One of the significant findings of the project was that the performance of the micro screening treatment methods could be significantly changed by altering how the equipment was operated. The change in operating methods and targets increased the rate at which suspended solids and organic materials could be removed by as much as 20 per cent. The study identified the maximum flow rates achievable with each of the screens, which allowed the municipality to compare the different screens and their maximum expected capacities to remove the suspended solids and organic materials.

To meet the requirements of the national wastewater treatment regulations for urban wastewater, a wastewater treatment plant was required to reduce total suspended solids by at least 50 per cent and organic matter by at least 20 per cent. These demands had never been carried out before in Norway, and the available information on the efficiency of the available technologies was poor.

As a result of the Primærrens project, Tromsø built or upgraded five wastewater treatment plants between 2004 and 2009 by installing micro-screening equipment. These five wastewater treatment plants serve a total population of 80,000 people.

The project findings showed that it is possible to treat sewage with mechanical micro screens, which is a much more sustainable method of wastewater treat-

ment than the more complicated and costly biological wastewater treatment processes. The equipment to treat wastewater with the micro-screens does not take up very much space because the equipment is housed in compact metal boxes. The metal boxes easily fit inside a building. The screens that are used have openings of 0.35 and 0.2 millimetres, but by changing the way the screens are operated, the openings are reduced to 0.06 to 0.07 millimetres. This process is called “screening through the sludge”, and it creates a finer screen because a layer of the particles that are in the sewage remain on the surface of the screen.

Tomasjord, one of the wastewater treatment plants in Tromsø Municipality serving 40,000 people, was designed to remove a minimum 60 to 70 per cent of total suspended solids, which is a level of treatment well above the standards set by the European Union’s Directive for Primary Treatment of Wastewater. To achieve this level of treatment, eight rotat-



ing Salnes Brand micro-screen belt filters were installed to treat 1,600 cubic metres of wastewater per hour. The screens are rotated at a speed that achieves the screening through the sludge operation.

To make sure that the Norwegian regulations are met, Tromsø was also required to complete environmental surveys of the waters around the community that the wastewater was released into after it was treated. Before the project to upgrade the existing wastewater treatment systems or build new facilities with micro-screen pro-

cesses, the fjords around Tromsø - into which the wastewater had been released - were showing the effects of sewage pollution. Since the upgrading or building of new facilities, the water quality in the fjords has been improving.

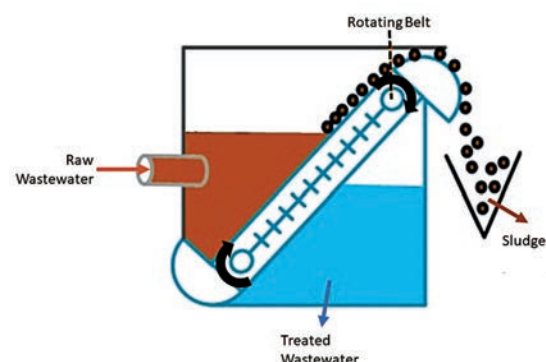
Another project was started in the period between 2013 and 2015, which focused on the use of electric energy to run the facilities. Research was conducted on the highest energy consumption by each of the facilities. Full-scale studies were done at one of the wastewater treatment plants, where the air blowers that were used to remove the sludge from the screen were replaced with mechanical scrapers. This was done in 2014 and was followed by full-scale testing in 2015. The result was a 90 per cent reduction in energy used, with no reduction in the amount of sludge removed or the ease of doing this.

The work in Norway over the past 15 years concerning wastewater treatment equipment, and reducing their energy consumption, has also resulted in better working conditions for the operators. Aerosols have been reduced through ventilation,



*Tomasjord wastewater treatment plant in the Tromsø Municipality*

there is less dust in the air, and the amount of maintenance of equipment required has been reduced. Norway has demonstrated that there are ways and means to apply appropriate technologies and to achieve improvements in the environmental impacts of wastewater. 💧



*Rotating belt microscreen*

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*Waste site cleanup in progress*

# WASTE MANAGEMENT IMPROVEMENTS IN GREENLAND

*Edited from an article by Zenica Gosvig Larsen*

Waste management in Greenland is, in many ways, like waste management in Denmark – and yet, not at all. As in Denmark, the backbone of waste management is incineration, but the vast differences in the physical conditions, settlement patterns, and infrastructure mean that many solutions that are the obvious best choices in Denmark do not work in Greenland. From time to time, stories have surfaced in the Danish media about waste management in Greenland which paint a bleak picture of Greenland as a developing country regarding waste. If you base your perception only on what these stories say about what is going on in Greenland, regarding waste, the picture looks much worse than it actually is. There is room for improvement, but there is also plenty that is working, and in some areas, the way we do things in Greenland inspires other Arctic communities.

The waste sector has been developing rapidly in recent years, with a fundamental shift from local to central processing underway. In other words, waste is an incredibly exciting area to work in when you are a geographer in Greenland working a field in which things are continually moving. There are challenges in Greenland that are not en-

countered in Denmark. The distance from north to south Greenland is about the same as the distance from Denmark to southern Italy. Greenland's total population is equivalent to that of a medium-sized provincial Danish town, and it is scattered among settlements located along most of the coast with no road links between them. In some cases, it is only possible for ships to dock at the communities for a short period during the summer due to winter ice conditions. Finally, the transport distance to Europe's markets from Greenland is more than 3,000 kilometres, which causes certain challenges that are not encountered in Denmark.

When the number of residents in the settlements can also vary from less than 100 in the smallest ones to about 18,000 in Nuuk, you have to think creatively and come up with individual solutions. The intuitive environmental choice between recycling and incineration/landfilling does not, for example, always result in the best solution (either environmentally or economically) – a waste pyramid concept will not work as the default in Greenland. For instance, it does not make sense to sort paper and cardboard from households for recycling; the quantities are so small and scat-

tered that local processing is not realistic, and to transport it to Denmark is neither economically nor environmentally viable. However, burning the paper and cardboard in incineration plants increases the heating value of household waste and provides better and cleaner incineration, resulting in district heating which can replace oil with waste as fuel.

However, this does not mean ruling out sorting waste in Greenland. Commercial waste is especially subject to requirements that it be sorted so that the waste can be shipped to Denmark for recycling. Projects investigating the local use of resources or alternative ways of utilizing waste are ongoing. There is a constant assessment of how to best manage the types of waste entering municipal waste facilities. Since 1996, Greenland has had a national Waste Management Plan, which sets out the overall framework for waste management in the country. Municipalities have municipal waste management plans outlining the specific objectives for their settlements. The waste management plans are updated regularly. In most settlements, collection schemes for hazardous waste have been established, including boxes set up for collect-



*Waste site before cleanup began*



*Waste site after cleanup completed*

ing batteries. Hazardous waste is shipped to the big towns to be further processed, to a greater or lesser extent, before being shipped to receiving stations in Denmark that are approved for handling hazardous waste. In some towns, there are recycling bins for the collection of glass and metal, but in most communities, household waste is not sorted, and all waste is burned, with the surplus heat being used in many areas of the district heating network.

There are currently "regional" incineration plants in six towns in Greenland. The largest, located in the capital Nuuk, has a capacity of 1.6 tonnes per hour, and it runs at maximum capacity 24 hours a day. In comparison, the Vestforbrændingen incineration plant in Glostrup, Denmark, incinerates over 60 tonnes per hour. The waste system in settlements and smaller towns typically consists of a "dump" and a settlement incinerator, as well as a separate system for the collection of hazardous waste. The dumps have traditionally been used for all types of waste, and many of these dumps are currently environmental burdens. Many municipalities are in the process of cleanup efforts in which the waste in the old dumps is sorted and shipped to either one of the regional incineration plants and back to Denmark for recycling. After the waste is removed, the area is covered, but it will be a long time before the dumps no longer pose environmental problems. The settlement incinerators that were established in the late 1990s were an improvement over the previous system of open incineration at the dumps, but there's a big variation in how well settlement waste incineration is functioning in the various communities.

Many places are now working to replace the smaller and outdated plants with transport solutions, with the waste sorted and packed locally, then sent by ship to the incineration plant in the nearest town. Many challenges have arisen - waste is not easy to transport! However, trials with, among other things, dedicated containers with built-in compactors and the sorting of organic waste plus balers adapted to the amount of waste in the individual settlements have proven to work.

The future was charted at a meeting of the Government of Greenland (Naalakkersuisut), and all the country's mayors regarding a crucial decision about the future of waste management in Greenland. It was unanimously decided at this meeting to replace the current six regional incineration plants and the many outdated incinerators in the small settlements with two central incineration plants at Sisimiut and Nuuk, so the management of waste suitable for incineration in the future will come to be based on transport solutions. Shortly,



there must be work done toward establishing a common public waste company that will be responsible for waste management in the whole country. The waste sector in Greenland is entering an extremely exciting time. 💧

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# WATER SEWER SYSTEM RETROFIT IN FORT SMITH, NWT

By Rob Osborne, Resident Inspector,  
AECOM Canada.

Fort Smith, Northwest Territories is currently undertaking a significant retrofit of their existing buried water system, which is approximately 60 years old. Doing retrofits of water and sewer systems is very different than installing new systems because of the need to complete the work while maintaining services to all of the buildings, and in spite of the best as-built information, unexpected surprises will be encountered when the existing infrastructure is dug up. 💧



*To maintain water services, temporary water lines are run to each building, and gravel ramps were needed at every driveway to maintain vehicular access to the buildings.*



*Since the water system is pressurized, concrete thrust blocks are needed to brace the water main at every bend, valve, or change in diameter to ensure that the pipe connections do not separate.*



*The contractor must closely monitor the excavation of the existing water system, and a significant amount of hand excavation is required to make sure the existing system is not damaged by the large equipment.*

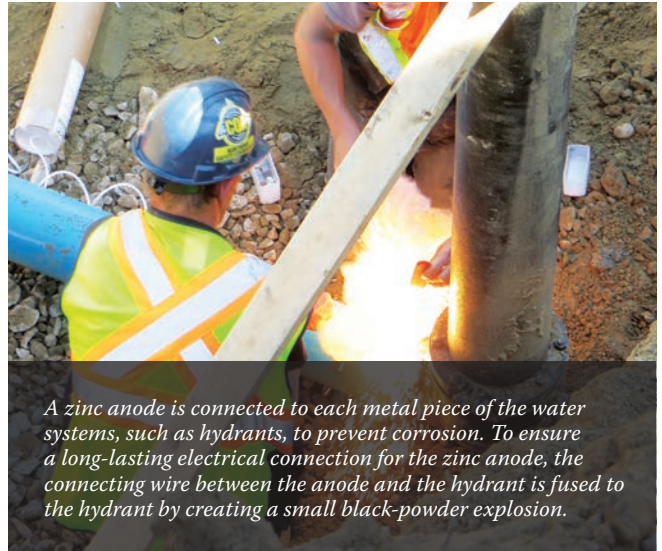


*New valves are installed on the water system to replace the existing valves that are worn out. New valves are also installed to improve the Town's capability to isolate sections of the water main for emergency repairs in circumstances such as water main breaks.*

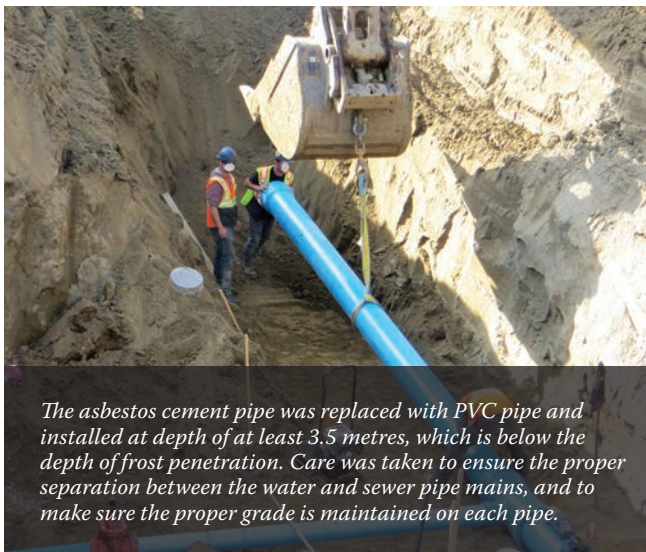




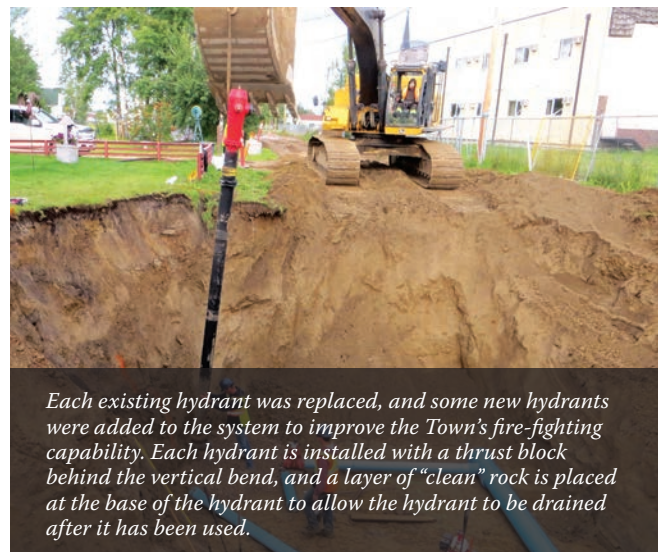
*Removing the old infrastructure was complicated because these and sewer mains were asbestos cement pipe, which is a health concern created when cutting the pipe. The pipe sections must be carefully sealed in plastic before they can be disposed of in a landfill.*



*A zinc anode is connected to each metal piece of the water systems, such as hydrants, to prevent corrosion. To ensure a long-lasting electrical connection for the zinc anode, the connecting wire between the anode and the hydrant is fused to the hydrant by creating a small black-powder explosion.*



*The asbestos cement pipe was replaced with PVC pipe and installed at depth of at least 3.5 metres, which is below the depth of frost penetration. Care was taken to ensure the proper separation between the water and sewer pipe mains, and to make sure the proper grade is maintained on each pipe.*



*Each existing hydrant was replaced, and some new hydrants were added to the system to improve the Town's fire-fighting capability. Each hydrant is installed with a thrust block behind the vertical bend, and a layer of "clean" rock is placed at the base of the hydrant to allow the hydrant to be drained after it has been used.*



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*Lagoon pump mixing and pumping sludge using the GEA brand pump attached to a large horsepower tractor.*

# HAINES JUNCTION, YUKON LAGOON DESLUDGING PROJECT

*By Blair Benn, President, Lambourne Environmental Ltd.*

The community of Haines Junction, Yukon, is located along the Alaska Highway, approximately 150 kilometres west of Whitehorse. The sewage treatment facility consists of two short-term storage cells (primary cells) and three long-term cells (retention cells). The retention cells are emptied annually into a wetland that ultimately flows into the pristine Dezadeash River. The existing lagoons were constructed in 1986 and needed upgrades because the cell berms had deteriorated. As part of the upgrades, the sludge from the primary cells was removed and dewatered.

The two primary cells are 4.5 metres

deep and designed to remove suspended solids (sludge) by allowing the solids to settle to the bottom of the cells. The primary cells in Haines Junction are large enough to hold the wastewater sewage produced about 21 days. The three retention cells, located downstream from the primary cells, provide aerobic treatment to the wastewater before it is discharged into the wetland.

In June 2018, Lambourne Environmental Ltd. of Red Deer, Alberta was selected to “desludge” and dewater the accumulated solids in the primary lagoons. This work was a portion of a much larger project by Norcope Construction to upgrade the lagoon

system in Haines Junction.

To desludge the primary cells, the contractor used two GEA brand pumps, which mixed and pumped sludge from the lagoons. The pumps are power take-off (PTO) units powered through connections to large horsepower tractors. The pumps are 16 metres long with hydraulically articulated mobile undercarriages, which allow them to be backed right into the lagoons and lowered into the sludge. In the Haines Junction lagoons, two tractor/pump units were used – one to continuously mix the contents of the lagoon and clean the sludge from the berms as the level of liquid dropped, and the other to pump the material into “geotubes” on an adjacent, lined dewatering cell.

Geotube dewatering tubes manufactured by Tencate Geosynthetics were used to dewater the sludge geotubes which are made from a woven polypropylene material that is sewn together to create a giant



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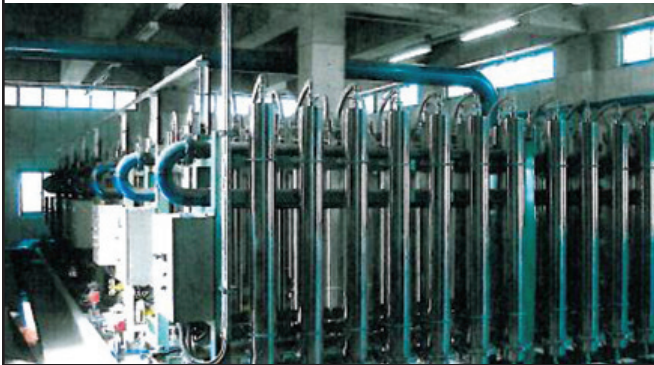


*Geotubes in the process of filling – filtrate is collected in the dewatering cell and pumped back into the lagoon system.*



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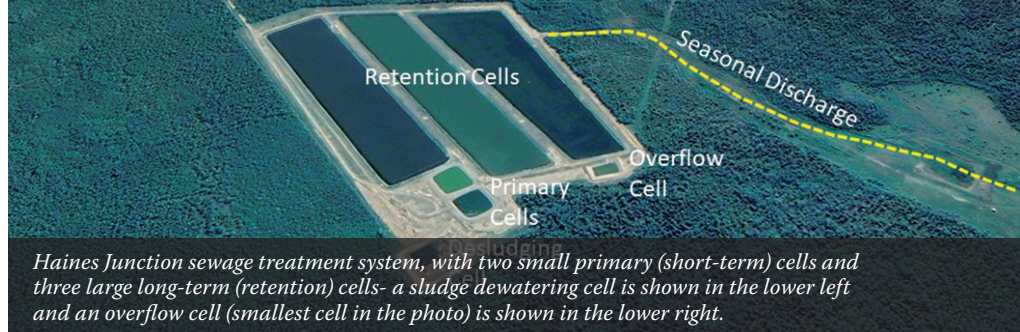
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sock. The pore size of the woven material used for making the geotubes is approximately 450 microns. They are designed to allow the water to drain from the geotube through the pores, while the sludge remains

in the geotube. The efficiency of the geotubes improves with time because a layer of solids forms on the inside of the geotube, creating a smaller pore size and therefore a better filtering performance.

Further improvements in the performance of the geotubes to capture the finer biosolids and to speed up the release of water from the sludge can be achieved by adding a chemical polymer to the sludge as it is being pumped from the lagoon into the geotube. The result of adding the correct amount polymer is a very clean fluid (filtrate) coming out of the geotubes. The filtrate was collected in the laydown area and pumped back into the lagoon.

Typically, the material pumped from a municipal wastewater lagoon contains six to eight per cent solids. The sludge pumped into the geotubes will continue to release water over time, eventually resulting in a greatly reduced sludge volume and a solids content of 20 to 40 per cent. The geotubes also greatly reduce sludge odours, and the contents will not absorb water (rehydrate) from rain or snowmelt. After the initial dewatering has taken place, the geotubes will have additional capacity, and more sludge can be pumped into them multiple times. The geotubes will not deteriorate in direct sunlight for several years, which means there is flexibility when the dried material is eventually removed.

During the project, the contractor removed approximately 2,600 cubic metres of sludge from the two primary cells. Three (sock-like) tubes 30 metres (100 feet) long and 18 metres (60 feet) in circumference were used to contain the sludge. The sludge will continue to lose water as it remains in the geotube for a period of 12 to 24 months. After that, it can be used as a landfill cover material. The ultimate use of the dried material depends upon the level of contamination it contains. In some cases, sludge can be used as a garden fertilizer.

The project took approximately two weeks to complete, including the time needed for initial set up of the site. 💧



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# PROJECT DELIVERY: NEW WATER TREATMENT PLANT IMPACTS CAMBRIDGE BAY, NUNAVUT

*By George Thorpe, BI Pure*

## *The Challenge*

North of the Arctic Circle at 69° 07", Cambridge Bay is a very remote community along the Northwest Passage. To carry out potable water treatment projects in Cambridge Bay, the Government of Nunavut selects an engineering company to oversee the project, and a general contractor, who in turn contracts various subcontractors and suppliers. All must have experience working in the north.

## *The Community*

The population of Cambridge Bay is close to 1,800 people, which has been increasing by approximately 10 per cent every six years. Approximately 80 per cent of the residents are Inuit. With an expanding population comes an increased demand for potable water.

## *The Stages*

Detailed aspects of this design-bid-construct "Project Delivery" process includes planning with the involvement of stakeholders, preliminary and detailed designs, public tendering, awarding of the contract, component sourcing, parts delivery, con-



*The packaged water treatment plant undergoing testing and pre-commissioning in the Surrey factory.*

struction of modular units and pre-testing in the factory. This is followed by loading and shipping, site delivery, assembling on site, commissioning, operator training, and ongoing support.

## *Planning*

Stantec Consulting was chosen by the Government of Nunavut to complete the overall design and manage the project. Stantec determined the design criteria, which included population growth, raw water characteristics, and other design information. From this information, Stantec prepared a tender package that was used as the basis for a public tender of the project.

## *Project Award*

NDL Construction Ltd. was awarded the project in 2014 and partnered with BI Pure Water to manufacture and deliver the packaged water treatment plant in 2015. The project delivery timeline was extended to accommodate the short construction season and other challenges of northern construction.

## *Process Engineering and Construction*

BI Pure Water engineers apply "Design for Resilience" for the process engineering. The objective of this approach is to sustain the required operations during and after the impact of severe disturbances, plus to adapt to longer term influences. The water treatment plants are custom engineered to a specific water quality and available budget. The well-insulated building contains a standby generator, electrical room, boilers, ventilation equipment, process piping, and the treatment system.

## *The Treatment Process*

The water treatment plant has a design flow rate of 20 litres per second (317 USGPM). Raw water turbidity is a significant problem during spring breakup. The water treatment system included three steel vessels with Zeolite filtration media, UV disinfection units, a chlorination unit, a large treated water storage tank, and distribution pumps.



*The shrink-wrapped building was barged North on the MacKenzie River to the Arctic Ocean.*



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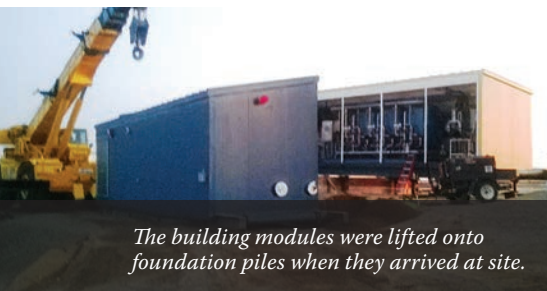
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## Delivery

Four modules of the plant – three metres by 13 metres each – were trucked for shipment by sealift from Surrey, B.C. to the Port at Hay River, NWT in July 2015. The barge then travelled more than 1,800 kilometres from Hay River up the MacKenzie



The building modules were lifted onto foundation piles when they arrived at site.



A view of the treatment portion of the plant showing control panel and filter vessels.



The package treatment plant is shown next to one of the site-built water storage tanks.

River to Tuktoyaktuk, NWT on the Arctic coast, then an equal distance east through the Northwest Passage to Cambridge Bay, Nunavut. The barge arrived on August 22, 2015, and the modules were skidded off the barge and pulled by a bulldozer to the plant site

## Site Work

Local equipment was used to set the building modules on piles, and the sections were bolted together. The storage tanks were set on their pads, but no buried piping was completed in 2015 due to the arrival of winter in September. Work was continued in 2016, and during the long daylight hours, workers installed the piping and access vaults. The outside work was completed in August 2016.

## Commissioning

After the power was on, and raw, waste, and treated water lines were connected to the building, an initial leak test was performed, followed by testing of the controls and equipment operation. Commissioning and test plans for each system were followed. The post-commissioning phase to monitor the facility performance may take up to one year.

## Owner Inspection and Approval

The owner and their technical representative visited the facility to confirm the plant operation. The owner's validation of proper operations triggered the owner acceptance phase, which may include a deficiency list to address.

## Operator Training

Local operators were trained during start-up and commissioning. The plant may be remotely monitored and controlled, which allows remote access of the control system by factory technicians for monitoring and ascertaining the need for further training.

## Ongoing Support

Staff turnover occurs, so there is a continuing need for ongoing training and support of new staff. Remote monitoring assists in the operations when the operator is not available. Remote diagnostics from thousands of kilometres away helps reduce downtime and travel to the site by factory technicians. Issues do occur that need to be resolved, like additional manganese in the raw water from the concentration of water under the ice in late winter. 💧

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# IQALUIT, NUNAVUT SUPPLEMENTAL WATER SUPPLY

*Edited from an article by Matthew Follett, Nunami-Stantec, Matthew Hamp, City of Iqaluit and Kyle Humphrey, Colliers Project Leaders Inc.*



*Lake Geraldine with water level well below capacity.*

Following the spring melt in 2018, the City of Iqaluit observed record low water levels in Lake Geraldine, the city's sole source for potable water. After further investigation, it was estimated that there could be a water shortage of approximately 400,000 cubic metres, which means that Iqaluit could run out of potable water before the lake was replenished in the spring of 2019. By July 2018, the City formed an Emergency Task Force to lead the search for a supplementary source of water. The team worked to identify the best design, get the necessary regulatory approvals and funding, and identify a source for the materials and equipment to construct and operate the system. The team confirmed that pumping overland from the nearby Niaqunngut (Apex) River would be the most appropriate solution.

The City requested and received an amendment to their water licence that would allow them to pump water from the Niaqunngut River for a period of seven years. It was estimated that as much as 500,000 cubic metres of water would be required to "top up" Lake Geraldine, between the months of July and October, every year until 2026. The conditions of the water licence amendment included the requirement for a screen on the intake pump to prevent fish from being sucked up into the pump. The pumping system on the Niaqunngut River needed the capability of adjusting the pumping rate depending on the daily flow of the river.

Lake Geraldine's watershed is made up of a modest area of 3.5 square kilometres, and the reservoir is primarily replenished with snow and ice melt during the spring and early summer. Rain contributes a smaller amount of the total volume of approximately 1.4 million cubic metres. By the early summer, Lake Geraldine should be filled to about 90 per cent of its capacity. Rain and a small amount of overland flow contributes the remaining amount of water volume required to fill the reservoir and satisfy the demand for water in the warmer season.

Temperatures in Iqaluit usually begin dropping below zero degrees centigrade in September, and ice covers nearby lakes by early October. Due to winter temperatures that reach minus 45 degrees centigrade, the top layer of water in Lake Geraldine remains frozen and unavailable for use during the winter months. To meet the winter water demands of the City, Lake Geraldine must be filled to overflowing before the October freeze begins.

Concerns about the capacity of Lake Geraldine to meet the city's needs for

water were noticed in 2013. A water balance assessment study was done and the search for an alternate water supply began. The search included the consideration of the Niaqunngut River and the Sylvia Grinnell River. In June 2018, the depth of Lake Geraldine was nearly 1.5 metres below the historical average. This meant the lake contained approximately 400,000 cubic metres of water less than capacity, triggering the need to find a supplemental water supply.

An options investigation was done, and the conclusion was that there were three available options: pumping water from the Niaqunngut River directly into Lake Geraldine; pumping water from Unnamed Lake either directly into Lake Geraldine or to a point in the Niaqunngut River from which it could be pumped; or installing of a reverse-osmosis treatment system to treat seawater from Koojesse Inlet.

Pumping from the Niaqunngut River was selected as the most feasible option. The remaining options were tabled as possible backup options if the river ran dry or seasonal freeze-up occurred before the reservoir was filled. Calculations were done on the use of two pumping trains, each consisting of a submersible pump, a purpose-built intake structure, and a fish screen, as well as independent shutoff valves to feed the overland supply pipelines to Lake Geraldine. The design and plans for obtaining the materials were made with the contractor selected to carry out the project.

The Niaqunngut River pumping site was in a relatively undeveloped area. Therefore, in order to set up the pumping site, the contractor had to extend the access road, install a generator to power the pumps, and place 10 kilometres of flexible hose.

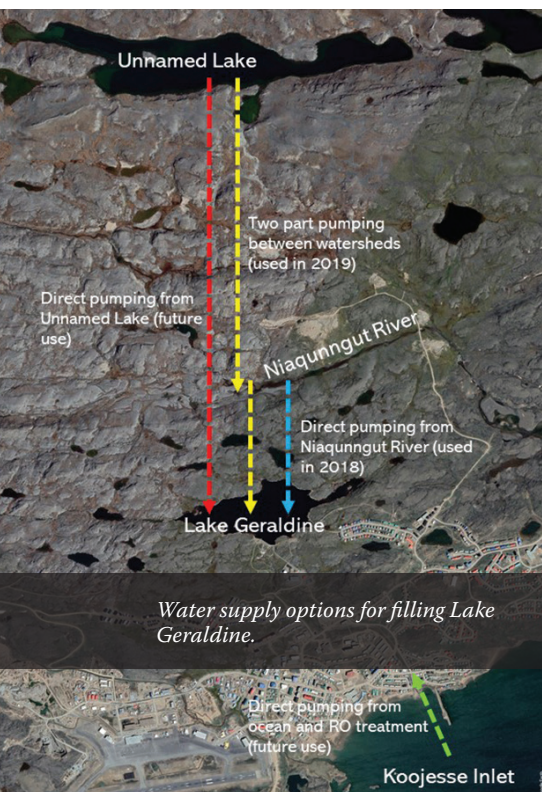
By mid-September 2018, the water in



*Pumping system on the Niaqunngut River.*

Lake Geraldine was very close to overflowing, which meant pumping water from the river and rainfall had successfully put enough water in Lake Geraldine to meet the city's summer demand and brought the reservoir level up to capacity before the seasonal freeze-up.

The Niaqunngut River supplementary pumping project was a successful short-term solution, but the work did not stop here. The project continued and, in the fall of 2019, the Unnamed Lake was the source of an estimated 750,000 cubic metres of water added to Lake Geraldine. 💧



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*Water point in Chefnak, Alaska*

# THE SEARCH FOR LOWER-COST WATER IN THE FAR NORTH

*By Ken Johnson, AECOM*

The search continues for technology with lower costs for water systems in the far north. One of the primary areas of this search is decentralized (individual water and sewage treatment systems in each house) wastewater technology and water re-use technology. The use of decentralized wastewater treatment is not new, and in fact, it has provided a low-cost way of treating wastewater for rural homes in the south since the 1940s. Technical innovations of the past 25 years have facilitated an expanding use of decentralized water systems, and water re-use systems, and even advanced the use of this technology in the urban environment.

In the context of the Canadian far north, climate, ground conditions, and community isolation create expensive problems for piped residential servicing. In the City of Yellowknife, development costs, including roads and drainage, are over \$120,000 per lot. A study in 2001 suggested that a comparable development cost for a water re-use system could be less than \$70,000 per lot.

Considering that approximately 55 per cent, or 10,000 litres, of the water used in a typical Yellowknife household each month is used for laundry and flushing toilets, there is a substantial opportunity to save money on water use by treating it and recycling it for these uses.

The Yellowknife study compared the cost for a typical residential piped water and sewer system, and a water-re-use system over a 20-year period. It concluded that water re-use could save approximately 40 per cent of the overall cost, with the most significant part of this cost reduction associated with the elimination of putting pipes in the ground.

The typical unit processes of the water re-use system considered for Yellowknife included a septic tank for primary treatment, a bio-filter followed by a slow sand filter for secondary treatment, and ozonation for disinfection of the water before it is re-used. The application of a water re-use system in a house would incorporate changes to the plumbing system, the electrical system, and the building structure. The most important part of the system is the plumbing, which must ensure a separation of the drinking and non-drinking water supply systems. Unfortunately, the Yellowknife initiative was not advanced beyond the conceptual design phase.

In Alaska, more than 4,700 rural Alaskan homes lack running water and sewage collection systems. The palette of existing water and sanitation systems includes centralized laundry locations called washeterias, and central water points, individual wells and in-ground systems, water and sewer truck or trailer haul systems, and piped water and sewer systems. All these systems operate on a user-pay principle with no operating subsidies, which is contrary to the con-

siderable operating subsidies provided to water and sanitation systems in the Canadian north.

Decentralized systems with individual wells and septic systems are already in use in Alaska. These make use of the favourable in-situ soil conditions. Trailer haul systems are also used, which are a scaled down version of northern Canadian truck-haul systems. These systems use four-wheel all-terrain vehicles in the summer and snowmobiles in the winter to pull specially designed trailer-mounted water or sewage containers.

Conventional, community-wide piped systems in Alaska are increasingly expensive to construct, maintain and replace. The available capital funding cannot meet the demand for new systems and the rehabilitation of aging systems, which is estimated to cost close to a billion dollars (CA\$). As well, many communities cannot afford the high operation and maintenance costs associated with piped or haul systems.

These emerging realities prompted Alaska to embark on a significant program in 2013 to hire groups of specialists to develop and implement decentralized water and water re-use systems. This program is called the Alaska Water and Sewer Challenge.

The process of selecting the companies to do this work was unusual because it did not include the typical “requests for proposals”, but instead asked for “expressions of interest”. The project also included funding of approximately \$30 million (CA\$) to pay the selected companies to research and develop a useable technology. Six companies – out of an initial 18 that applied in the first phase – advanced to the competition’s second phase, which ended with the presentation of proposals in late 2015.

Phase 3 of the project was completed in 2017 with the development and testing of prototypes of the top three proposals from the second phase. The results of Phase 3 were presented to the project’s steering committee. Planning is now underway to try out the technologies on a pilot project. One of the scenarios for the pilot project is the installation of a system in a student residential building at the University of Alaska in Anchorage.

The program’s ultimate goal is a secure, safe source of at least 55 litres of running water per person, per day in a four-person household, that will cost no more than \$175 (CA\$) per month to run and maintain. Wastewater management is an integral part of the Alaska system design, along with its introduction into existing housing units.

In Canada, there is cautious optimism about the successful outcome of the Alaska Water and Sewer Challenge. Certainly, the successful technology may have applications in northern and remote regions of Canada. Time will tell. 💧

# NTWWA President's Report

## MEGAN LUSTY



I am pleased to report on a successful 2018 conference that was held in Yellowknife from November 12 to 16, with 112 delegates attending. 2018 was special because it was the 25th anniversary of the formation of the NTWWA. Several of the presentations were particularly interesting, including a presentation by the Canadian Standards Association on the "National Standard for Municipal Wastewater Treatment in Northern Communities Using Lagoon and Wetland Systems" and a presentation on the "Iqaluit Emergency Water Resupply" (see article in this edition of the *Journal*).

I would like to welcome Rob Osborne as the new Executive Director of the association. Rob's day job is with AECOM in Yellowknife. I would also like to acknowledge Pearl Benyk for her continuing support as Administrator, and the board of the NTWWA for their continuing involvement in the association.

In closing, the NTWWA membership remains small but constant at around 180 members. We have carried forward in year 26 with an expanding international reputation, which is demonstrated by our returning Greenland delegation, and the international content in the current issue of the *Journal*. 💧

### National Research Council Canada Arctic Program

The NRC/Arctic Research Program is developing a novel approach for the biotreatment of wastewater. The bio-electrochemical anaerobic sewage treatment (BEAST) technology uses microbially-catalyzed electrochemical reactions to achieve a high rate of degradation of organic wastes.

The BEAST technology is efficient, scalable, has low power requirements and is simple to operate and maintain. It produces energy-rich biomethane that may render the entire treatment process energy-positive.

The BEAST technology is presently being piloted in a number of locations.

**For partnership opportunities and to learn more, contact Mr. Mark Murphy at (709) 722-2105 or [mark.murphy@nrc-cnrc.gc.ca](mailto:mark.murphy@nrc-cnrc.gc.ca)**

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