Giant Mine Remediation - The First Phase
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Giant Mine is a closed gold mine located in Yellowknife, NWT that operated from 1948 until 2004. Due to Giant’s ore association with arsenopyrite, the process to extract gold generated high amounts of arsenic rich gas as a by-product. As of 1951 several processes were put in place to capture most of this gas in the form of arsenic trioxide dust to be deposited in underground chambers. It is believed that approximately 237,000 tonnes of soluble arsenic dust is currently stored underground.

Giant Mine is currently under care and maintenance by Aboriginal Affairs and Northern Development Canada (AANDC), which, in conjunction with the Government of the Northwest Territories, co-manage the Giant Mine Remediation Project.

In order to protect human health, public safety and the environment Golder Associates Ltd. has begun work to stabilize Giant mine. This paper will discuss Golder’s work within the Giant Mine Remediation Project framework specifically for open pit and underground stabilization.

The underground stabilization component of the mine closure is to backfill underground voids to prevent collapse of portions of the mine that immediate risks to public and worker safety and lead to failure elsewhere.

There is the additional risk that underground collapse could allow surface water to eventually flood the mine. Severe environmental consequences could result from such a flooding event due to the presence of arsenic trioxide dust in the underground stopes. To mitigate risks related to underground stability at the mine site, an innovative short-term advanced remediation backfilling program is underway while the long-term overall remedial plan for the site including the open pits continues to be developed.

AANDC engineers working with Public Works and Government Services Canada, along with industry leaders developed an innovative and efficient approach to stabilizing the underground voids using paste backfill. Paste backfill is commonly used in operating mines to maximize production, but its use in mine mitigation and remediation is limited. The Giant Mine project team utilized thousands of tonnes of tailings that had been deposited on surface as a waste by-product during historical mining as the primary component of the backfill. It is cost-effective to use onsite tailings material for underground backfilling, but its use also reduces the future effort required to remediate surface tailings pond areas.

The presentation will focus on the testing program and system design along with results of the first phase of the remediation work.

Sue Longo, P.Eng, MBA, Senior Project Manager and Associate, Golder Associates Ltd.
Sue Longo, P.Eng., a Senior Project Manager and Associate with Golder Associates Ltd. (Golder), graduated from Queen’s University in 1997 with a B.Sc.Eng. in Mechanical Engineering. Since joining Golder in 2004, she has worked on conceptual, feasibility and detailed plant and mechanical design and associated laboratory testing, equipment specifications, layouts, cost estimating and project scheduling for mine tailings dewatering and backfill projects. She has also been the design lead and QA/QC site supervisor on multiple contracted backfill delivery projects. Sue has managed both underground backfill and surface disposal projects in various locations worldwide which include arid desert, arctic and mountainous regions.

Development and Implementation of Decontamination Standards for the Roaster Complex at Giant Mine

June 3
11:00 am – 11:30 am
Giant Mine is an abandoned gold mine within the city limits of Yellowknife, NT that was operational from 1948 to 1999. Ore processing resulted in the generation of arsenic trioxide as the gold was separated from the mineral arsenopyrite. The Roaster Complex was a series of buildings in which ore processing and arsenic trioxide generation took place. Following mine abandonment, the Roaster Complex buildings were deteriorating to the point of becoming at risk of partial collapse with release to the environment of the process waste and other hazardous materials remaining within. The timely decontamination and demolition of the facility was therefore required. A detailed assessment of the waste types and quantities revealed that: large volumes of arsenic waste remained in process vessels and air handling infrastructure; asbestos insulation covered almost all internal structures and building interiors; asbestos insulation was coated in arsenic-containing dust; asbestos insulation was delaminating and mixed with arsenic-containing dust on floors and other surfaces; and, that in some buildings, sodium cyanide was also present mixed in with process waste and surface dust. In addition to dust and process waste solids, porous structural materials such as wood and brick had become impregnated with arsenic over time, such that they were also contaminated with hazardous levels of arsenic. Given the types, levels, and distribution of hazardous materials requiring decontamination within the complex, multi-faceted work control standards required development to protect the public and the environment, as well as to monitor the health and safety risks to abatement workers. Clear, measurable, and achievable multi-contaminant clean-up standards also needed to be developed to confirm when decontamination was complete, such that remaining structural elements of the buildings could be classified as non-hazardous waste, and that the amount of dust that would be released during building deconstruction had been minimized. The hygiene work control methods selected were based on high risk asbestos abatement air quality monitoring protocols, but were augmented to include monitoring for arsenic and hydrogen cyanide gas as well as asbestos, additional air quality monitoring outside of building enclosures, and additional monitoring for hydrogen cyanide, carbon monoxide, and arsine gas generation. Specific worker monitoring protocols were also adopted to identify exposure hazards for similar exposure groups within each work area. The clean-up standards established for confirming the completion of decontamination included a detailed visual assessment followed by aggressive air-clearance sampling, similar to asbestos abatement procedures. The implementation of the hygiene and air-clearance sampling procedures were particularly challenging at this site because of the high levels of arsenic contamination in soil surrounding the facility, making it difficult to determine the source of measured arsenic impacts outside of building enclosures, and necessitating complete sealing of buildings during air clearance sampling. However, in the end, the selected work control and clean-up standards did prove achievable and effective in protecting the public, environment and workers.

Cathy Corrigan is a senior engineer with AECOM, having worked for the past 17 years on multi-faceted site assessment, design, and remediation of remote contaminated military and mine sites in the north. Her experience spans the areas of: site background geochemical assessments; soil and groundwater contaminant assessment and remediation; acid-rock drainage assessment; geotechnical terrain evaluation; geophysical studies; old landfill environmental and geotechnical assessment and remediation; granular borrow source siting and assessments; new landfill and landfill siting and construction; assessment of demolition requirements, identification of hazardous waste; overseeing facility decontamination and demolition; and gathering and incorporating Aboriginal traditional knowledge and land use in remediation plans. Most recently, she was part of the team completing the assessment and remedial design development for the Roaster Complex at Giant Mine and also served as resident engineer during remediation work.

June 3
11:30 am – 12:00 pm

Establishing a Long-Term Environmental Monitoring Program for the Giant Mine Remediation Project
Brad Overton, Public Works and Government Services Canada

Giant Mine is an abandoned gold mine located just outside the city of Yellowknife that operated for over fifty years. The production process required gold to be extracted from arsenopyrite ore which left behind approximately 237,000 tonnes of arsenic trioxide dust on-site when the mine stopped production. Remediation of the Giant Mine is slated to begin in the near future, following completion of the regulatory process currently underway, which will involve the deconstruction of all on-site buildings and structures and the underground storage of the arsenic trioxide dust.
As a part of the remediation program, a Long-Term Environmental Monitoring Program (LTEMP) is currently under development and planned for implementation early in the 2015/2016 fiscal year. The steps leading up to the implementation of the LTEMP include the identification of data gaps in existing environmental information for the site and surrounding area, completion of scientific studies intended to fill the gaps identified, and consolidation of all monitoring requirements for the remediation project as it is planned and implemented and for the site as a whole. To this end, a large scale environmental baseline data collection study for the site and surrounding has been ongoing for the past few years, including air, soil, water, sediment, fish, birds and habitat assessments at various locations on and adjacent to the Giant Mine site.

Additionally, multiple ongoing environmental monitoring programs underway at the site have been and will continue to be improved upon as the regulatory, engagement and due diligence requirements evolve through the planning, remediation, reclamation and monitoring phases of the GMRP. This presentation will briefly discuss the ongoing and completed baseline studies undertaken in preparation for the implementation of the LTEMP in the 2015/2016 fiscal year, as well as a brief overview of the LTEMP itself.

**Stream 2A - Emerging Issues**

**June 3**

10:30 am – 11:00 am

**Dumps, Landfills and Emerging Contaminants in the Canadian North**

Monica Danon-Schaffer, CH2M HILL

There are numerous problems with landfills and dumpsites across Canada, in particular in the Canadian North (i.e. north of 60° N), because they are unlined, some are adjacent to water bodies, while others are subject to unauthorized dumping and/or uncontrolled access. In addition, northern landfills contain different waste streams than those in southern Canada. Therefore, these dumpsites are expected to have somewhat different contaminants and/or leachate characteristics. Limited research has been done to identify the contaminants across northern dumpsites. Emerging contaminants have been found to be an issue, such as polybrominated diphenyl ethers (PBDEs), originating from many consumer goods (electronics, polyurethane foam, etc.) that end up in dumpsites when their useful life is over. These contaminants degrade and show up in leachate, indicating their persistence in different environmental media.

There is a need to identify problems that are specific to Yukon dumpsites, in order to plan for their eventual decommissioning and remediation. One possible approach is to ensure proper sampling of leachate at the dumpsites; this can be accomplished through the use (and refinement) of the Guidance for the Monitoring of Groundwater at Landfills to guide parties engaged in leachate characterization at Yukon dumpsites. The Yukon government now requires the installation of groundwater monitoring wells at all dumpsites; installation and sampling has started and will occur over the next few years which will facilitate leachate sampling. In order to assist in determining the best course of action for dumpsites with contaminated leachate, it will be important to compare leachate analysis with that of other jurisdictions, whether across Canada or internationally. This paper will look at the nature of the emerging contaminant problem we have or could potentially have at dumpsites in the Yukon and consider some possible approaches to address issues.

Monica Danon-Schaffer, Ph.D., P.Eng., Environment and Nuclear, CH2M HILL

Dr. Monica Danon-Schaffer is a registered P.Eng. in the Yukon, Nunavut and Northwest Territories and has extensive experience dealing with the environmental, social and geologic challenges of the North. Monica has worked extensively in the North since 2004 in support of her PhD research on the fate and transport of polybrominated diethyl ethers (PBDEs), a group of common flame retardant chemicals, in the Canadian Arctic. In addition to her work in the Arctic, Monica has diverse project management experience designing, planning, and executing field programs in remote and sub-Arctic locations, including several programs completed in northern BC and the Prairies. She has extensive project management experience in her many areas of technical expertise including due diligence, compliance and waste audits; impact assessments; site remediation; and environmental forensic investigations within Canada and abroad.

Monica has developed relationships with regulatory and public stakeholders in the course of her Ph.D. project work in the Canadian Arctic. She conducted comprehensive field programs in the western, central, and eastern Arctic in both 2004 and
2006. Each field program involved co-ordination and planning with federal agencies, representatives of territorial
governments, and local community stakeholders, in addition to acquisition of required licenses and approvals.

Through this work, Monica worked intimately with regional remediation criteria, as well as environmental guidelines for all
northern jurisdictions. Monica has also gained extensive experience in logistical planning for mobilisation, site access,
equipment, and support resources. She has worked with employees from eleven government regions, enabling Monica to gain
familiarity with the different project areas. In addition, Monica has worked with the Government of the Yukon, Nunavut
Research Institute, Department of Sustainable Development Government of Nunavut, INAC - Contaminated Sites, City of
Iqaluit, Hamlet of Cambridge Bay, Aurora Research Institute, Town of Inuvik, and local Inuit communities providing her
with an extensive network of support resources across the Canadian territories.

June 3
11:00 am – 11:30 am

Analysis of Seasonal Active Layer Dynamics and Fate, Transport and Transformation of Three Chemical Clusters in
Permafrost Affected Soils
Asish Mohapatra, Regional Health Risk Assessment and Toxicology Specialist, Contaminated Sites, Environmental Health Program,
Prairies Region, Health Canada

Health Canada Contaminated Sites Division funded a project to evaluate current understanding of the fate, transport and
transformation of petroleum hydrocarbons (F2 Arctic diesel), chlorinated solvents (Tetrachloroethylene) and a metalloid (Arsenic) in
three soil great groups (turbic, static and organic) found in continuous, discontinuous, and sporadic permafrost. Further, a critical
evaluation of issues and challenges related to permafrost-affected soil sampling, spatial and temporal requirements of sampling
programs for turbic, static and organic Cryosols was included. Emphasis was also given to chemical fate, transport and transformation
in Cryosols in sporadic, discontinuous and continuous permafrost. Some transport modelling calculations were carried out for the
above three chemical clusters in regosolic Cryosol with point source release over 5 to 100 years. Based on the review of physical and
chemical parameters of permafrost-impacted soils, further emphasis was given to properties such as degree of adsorption, solubility,
volatility, viscosity, gravity, and features such as microstructures of permafrost-impacted soils, thermal regime and active layer depth,
freeze and thaw cycles, clay and organic content, and mineralogy, etc. In light of climate change issues in northern Canada, data gaps
were also identified related to climate forcing mechanisms and their potential impacts on fate, transport and transformation
mechanisms. Various Conceptual Models of Active Layer Dynamics were further reviewed with a focus on seasonal differences and
characteristics. Furthermore, a limited number of peer reviewed publications on climate change impacts related to toxicology and
human health risk assessments were reviewed for potential applications in human health risk assessment projects. Currently, Health
Canada Contaminated Sites is in the process of preparing technical materials to support risk assessments of contaminated sites with
permafrost affected soils.

Disclaimer: This abstract is based on a report that was prepared by Dr. Thomas White of Permafrost Environmental
Consulting, under contract to Health Canada's Contaminated Sites Division; however, this report does not necessarily reflect
the opinion of Health Canada nor is it Health Canada guidance.

Asish Mohapatra, Regional Health Risk Assessment and Toxicology Specialist, Contaminated Sites, Environmental Health Program,
Prairies Region, Health Canada
Asish Mohapatra is a Regional Health Risk Assessment and Toxicology Specialist with Health Canada Contaminated Sites
Program in Prairie region – Alberta office. He has 18 years work experience in chemical toxicology, ecological and human
health risk assessments, soil quality guideline development, surface and groundwater quality risk assessments, indoor and
outdoor air quality risk assessments, dose response and exposure modelling, computational toxicology, and community
health risk assessments, mathematical data fusion framework applications in the context of toxicological and health risk
assessment knowledgebase and big data analytics and high performance informatics platforms. He has peer reviewed
complex risk assessments projects from Northern Canada mine sites, radiological sites, High Arctic Weather Station sites,
Distant Early Warning Sites, active and historical range training areas including chemical warfare agents and energetics
chemicals toxicology reviews. He is currently working on developing technical advice on fate and transport of chemical
contaminants in different permafrost affected soils.
Assessment and remediation of remote northern sites have a whole host of challenges. One of those challenges is characterizing matrices that do not fit into the traditional definition of matrices that are currently classified as water, soil, tissue, or air. Performing an analytical assessment of samples on a suspect contaminated site requires gathering representative samples and performing standardized methodology to determine if a sample is contaminated and if so, to what degree. An analytical method that has been developed for one matrix, such as soil, is not so easily applicable to all different samples that may be classified as that matrix.

Canada has 35% of the world’s peat accumulating wetlands, with a vast majority of it in the north. 11% of Canada’s surface area is covered by peat versus 9% is covered by water bodies. 76% of Canada’s wetlands are comprised of peat. Given those numbers, peat is a significant matrix unto itself. Currently, peat samples are particularly challenging as a matrix as they are classified as soil for the purpose of comparing to many regulations, however peat differs drastically in general characterization from what type of samples are traditionally know as soil samples. More specifically, peat typically contains at least double the moisture content of traditional soil samples and between one to ten times more organic matter. Due to these and other underlying general characteristic differences, applying regulations developed for traditional soil samples to peat samples, may inaccurately characterize a peat site due to the current techniques used to characterize a contaminated site using methodology developed for soil site characterization.

It is currently known and understood that current analytical methods used to meet current regulations over estimate and under estimate the concentrations of certain compounds in peat matrices. For example, as peat is a natural sink for organic compounds, typical organic sample preparation and extraction techniques underestimate organic compound concentrations. Separately, it has been shown that current preparation and extraction techniques for salt characterization in peat, overestimate the concentration of salts present in the sample due to dry weight methodology calculations applied to peat’s very moist nature. Understanding peat as a matrix is an important consideration when performing an analytical characterization of a site.

Synergy Aspen Environmental has worked on many northern peat sites as the environmental consultant and CARO Analytical Services has done many analysis on peat samples as the analytical lab quantifying the concentrations of compounds in peat. Using existing research, historical data, and new data, Synergy Aspen Environmental and CARO Analytical Services will demonstrate the need to develop site and compound specific standards and analysis at peat sites and encourage risk assessors and regulators to examine the need for peat specific regulations and analytical methods.

Patrick Novak, B.Sc., PChem, Vice President and Owner, CARO Analytical Services
Patrick Novak is the owner and the Vice President of CARO Analytical Services and has over 15 years of experience in the environmental analytical laboratory industry, providing a diverse range of chemical and microbiology analysis services for environmental and materials samples. Patrick has particular expertise in project management for soil, water and air analysis for contaminated sites, including sampling, chemical analysis, report preparation, and interpretation of results. He is familiar with Canadian environmental regulations on the national and the regional level, and has extensive knowledge of sampling and analytical test methods. Patrick has also participated in the design, implementation, and management of numerous environmental study programs, process improvement projects and information technology management initiatives. He also served as the President of the Environmental Managers Association of British Columbia, which is responsible for educating and bringing together environmental professionals in British Columbia and has been a board member of the organization for the last 11 years.

Stream 1B - Aboriginal Perspectives
June 3
1:30 pm – 2:00 pm
The Winisk military base (Site 500), used for aerial surveillance, became operational in January 1958 during the Cold War and was shut down in April 1965. The base was named after the Winisk River which flows to the southwest of Hudson Bay.

At the end of 2010, following a series of environmental studies beginning in 1998, the Ontario Ministry of Natural Resources (MNR), mainly sponsored by the Department of National Defence, issued a request for proposals for the site decontamination. The project is part of the Contaminated Site Shared Responsibility Policy Framework program. This type of project requires complex and customized logistics plans as it involves short seasons and limited access to the site. Only small-sized aircrafts, an 800 km winter road or a barge can be used to mobilize or demobilize personnel, equipment and off-site disposal of hazardous waste. No barging has been carried out on the site in the past 20 years.

The project consisted of activities such as the demolition and removal of hazardous waste in the existing buildings. Dismantled demolition materials were placed in a 30,000 m$^3$ landfill cell, constructed onsite according to the MNR’s specifications. During its years of operation, the base required that some of the petroleum products be shipped to the site in drums. As a result, 28,000 contaminated drums were managed during the decontamination work. Several areas with petroleum hydrocarbons and PCB contaminated soils had to be packaged and transported for offsite disposal using the winter road or marine transport. Petroleum, oil and lubricant tanks with 1,000,000 L capacities were also left onsite. The PCB-amended paint (approximately 3,500 m$^2$) present on the tank surfaces was separated with a high-pressure jet system equipped with a recovery system that directs the water and paint towards a specialized treatment unit.

The purpose of the presentation is to summarize the project and to present the critical milestones encountered and the solutions used to complete the mandate. It also addresses the training and involvement of the Cree labourers. The Cree community was involved as part of the workforce (operators and labourers) as well as a heavy equipment supplier for the remediation work. Over 70% of the workforce was represented by the Cree community and social and economical impacts including education and training exceeded the community’s expectations.

Jacques Dion, TSc. A, Vice-President Business Development, Sanexen

Working for Sanexen since 2010 as Vice-President, Business Development, Jacques Dion is an environmental technologist who possesses more than 25 years of field experience related to environmental assessment and clean-up projects, hazardous waste management and transportation, as well as planning of emergency spill response. Jacques also serves as a Board Member of Qikiqtaaluk Environmental, a major Inuit corporation from Baffin Island, as well as of Avataani Environmental Services located in Nunavik. He was involved in four major clean-up projects of DEW Line sites (namely Resolution Island, FOX-C, Cape Christian and Cape Dyer) as Leader for the hazardous waste management team. Moreover, Jacques was the Project Director for the removal, marine transportation and disposal of 9,000 MT of PCB-contaminated soils and wastes stemming from the clean up of the Resolution Island (BAF-5) site. Jacques has led several training workshops and courses for industrial environmental management. He also served as TDG (Transportation of Dangerous Goods) Instructor for road, marine and air transportation of dangerous goods shipped from remote power plants and mining project sites in Nunavut and Nunavik. From July 2013 to May 2014 Jacques was Project Director for the recovery and treatment of oil impacted water following the Lac-Mégantic rail disaster.

June 3
2:00 pm – 2:30 pm

First Nations Stakeholder Engagement and Capacity Building to Facilitate Positive Outcomes for an Ex-Situ Remediation Program at a Remote First Nations Site in Northern, BC

Chris McDonald$^1$, John Taylor$^2$, Brad Klave$^3$ and Ellen Sedlack$^4$

$^1$Franz Environmental
$^2$Core 6 Environmental Ltd.
$^3$Public Works and Government Services Canada
$^4$Aboriginal Affairs and Northern Development Canada
This topic will highlight the positive impacts of early engagement with First Nation stakeholders and capacity building with the use of traditional knowledge for an ex-situ remediation project in Lower Post, BC. Aside from the benefit of remediating a contaminated site, there were several other successes resulting from the remediation project. Awareness of cultural sensitivities and traditions were exemplified by the request for a grieving period during remediation, the community was consulted in the overall planning and design of the project which helped with community acceptance of the project. Finally, a local First Nation contractor won the remediation contract, which provided the benefit of first-hand knowledge of the site, as well as employing local First Nations throughout the project. Each of the successes are presented to exemplify how incorporating local First Nations stakeholders and contractors in the remediation process can lead to positive outcomes for the social and economic goals of a project in remote northern communities.

Chris McDonald, B.Sc., A.Ag., EP., Environmental Scientist, Franz Environmental
Chris McDonald has over five years of experience as project manager and project scientist on environmental and geotechnical projects. Chris has designed and supervised the operation of numerous ex-situ remediation programs in British Columbia and the Yukon, which treat various hydrocarbon (gasoline, diesel, fuel oil, bunker C and high lead aviation fuel) contaminants. He has worked on Phase I, II and III ESA's for gas retail and service stations, petroleum bulk plants, metals processing sites, dumpsites and tank farms; mining sites; and municipal landfills.

June 3
2:30 pm – 3:00 pm

The Engagement of Aboriginal Peoples in Contaminated Sites Decision-making
Viviane Paquin, Nick Battye, Megan Lord-Hoyle, Dr. Ken Reimer, Dr. Kela Weber
Environmental Sciences Group, Royal Military College of Canada

The assessment and remediation of contaminated sites often requires involvement of the public, particularly the communities and individuals who will be directly affected and are most at risk. Involving the public in contaminated sites decision-making builds trust in the assessment and remediation process and builds support for remediation and risk management decisions. This has many benefits, including reduction of the potential for conflict and greater likelihood of successful project outcomes because of an increased knowledge base in the affected community. In land claims areas, public engagement is not only needed but required. The Environmental Sciences Group (ESG), based at the Royal Military College of Canada, has conducted assessment and remediation activities in many northern and remote locations where the meaningful involvement of Aboriginal peoples was critical for understanding a site and its challenges and achieving project outcomes that address the needs of both the community affected and the project proponent.

There are many ways to involve Aboriginal peoples in the assessment and remediation of contaminated sites. Involvement in contaminated sites management activities can occur at many levels and stages of the assessment and remediation process. This presentation will describe case studies in which ESG has engaged Aboriginal peoples from communities in the Arctic and other areas of Canada in contaminated sites management activities. The case studies will include a discussion of approaches used to engage Aboriginal peoples to help identify and clarify the site-specific issues for better-informed decision-making and to determine how these issues can best be managed or mitigated to achieve long-term support for the project within the community. The presentation will also discuss how involving Aboriginal peoples in the assessment and remediation of contaminated sites can support local capacity-building initiatives through the provision of training opportunities as well as supporting the local economy through the use of local labour and skills in site assessment and remediation activities.

There is not one right approach to a successful community involvement process; when and how to involve the community members will depend on the particular circumstances of a project and the expectations of the community, but their involvement should always be an important component of any contaminated sites project.

Viviane Paquin, Manager and Program Facilitator, Environmental Sciences Group, Royal Military College of Canada
Viviane Paquin holds an MSc in Biology from Queen’s University. She currently holds the position of Manager and Program Facilitator at Environmental Sciences Group, based out of the Royal Military College of Canada. In this role she works alongside a professional team of chemists, geologists, biologists, engineers and environmental scientists, providing management support to the development and execution of a broad range of contaminated sites projects. Many of these
projects are located in remote and northern environments and include a strong public involvement component at different stages of the contaminated sites management process.

June 3
3:00 pm – 3:30 pm

Environmental Assistant Training and Work Experience Program – Effecting Longer Term Benefits in Remote Communities

Sam Bird, WorleyParsons

Many projects near remote communities are in part measured and judged by the economic benefits they bring to local communities. The metrics used to measure these benefits typically only last for the duration of the project. While these metrics may be applicable for measuring significant and sustainable community benefits that can be built up over time from large-scale developments lasting many years, the benefits available from short-term projects fluctuate and require ready and able local resources that may or may not exist. The demand for local skills and resources is often turned on and off as short-term project cycles progress.

During a 2014 Environmental Site Assessment conducted at a former gas field in the Northwest Territories, a client and WorleyParsons worked to implement a technical training and work experience program that might have benefits beyond the short-term environmental work planned for the site.

The goals of the program were to develop a mechanism that could deliver longer-term benefits and build capacity within WorleyParsons and the local community by:

• Building connections with individuals within the community;
• Develop useful skills in individuals that could be employed during project work near the community over the next 3-5 years so that community members could benefit from activities on their land base; and,
• Have skilled employees that could maintain and transfer their skills with employment in other regions on a longer-term basis.

The training program was developed to provide a basic knowledge of environmental site assessment field skills for students who attended a three-day hands-on course in the community. An open invitation to attend the course was provided in the community with extensive communications and organization support provided by the local Band office. Ten people successfully completed the course, including 4 minors, and all of the students over 18 were invited to apply for a work experience program. Three applicants were selected as environmental assistants for the work experience program that took place during the environmental site assessment.

Several employment models were considered as options to deliver the goals of the program. Options to hire individuals through third party suppliers such as the Band or local contracting companies were rejected because that would not maximize networks with individuals. An option to hire individuals as independent contractors was rejected based on procurement hurdles. An option to directly hire individuals as contract employees within WorleyParsons was selected as the preferred option.

The process, challenges and successes of the initiative included:

• Identifying opportunities through community and client discussions;
• Developing an objective;
• Building on past examples that had been stalled mid-program;
• Co-operation with the community to get the logistics right;
• Choosing not to subcontract through a third party but on-boarding individuals as staff;
• Various internal corporate process and attitude adaptations to hiring outside of the box;
• Identification of additional training holes during the program (WHMIS, H2S, ground disturbance) and implementation of mitigations; and,
• On-going work and employee relationships, financial benefits enduring beyond the initial project.

The program would not have been successful without the dedication, flexibility and cooperation of all its participants.

Sam Bird, B.Sc., Intermediate Environmental Scientist, Liability Management & Remediation, WorleyParsons
Sam Bird is an Intermediate Environmental Scientist working as a project manager, technical and team lead. Sam has nine years of experience conducting Phase I, II and III environmental site assessments, remediation projects and environmental monitoring programs at oil and gas facilities, mines, industrial sites and former defence sites in the Northwest Territories, Yukon, Nunavut, BC and Alberta. Specializing in Arctic and sub-Arctic project sites, Sam has provided expertise as a technical lead, site supervisor, project manager and regulatory advisor on multi-disciplined projects for clients in Northern Canada. His areas of expertise are contaminants in permafrost and cold climate environments; and demolition and remediation of abandoned operations bases. The project sites are typically remote with limited resources and have required close community relationships, detailed planning for complex logistics, transportation and safety solutions.

**Stream 2B - Real-time Technology Application**

June 3

1:30 pm – 2:00 pm

**Respiratory Protection Level Selection for Contaminated Site Remediation Work Based on Real-Time and Rapid Turnaround Air Monitoring Methods**

*Todd Irick, WESA, a Division of BluMetric Environmental Inc.*

Validated (prescribed by regulation) sampling and analytical methods for occupational exposure assessments typically require air sample collection followed by submission of exposed media to a laboratory for analysis. These traditional methods can have lengthy turnaround times and/or add extra costs to the project. Regular turnaround times for lab analysis are generally 3 to 5 days (in some instances this can be reduced to next day however the costs will also double). Turnaround times can be significantly longer for work at remote locations that require a few to several days for sample shipment from worksite to lab – regardless of the amount of money available to expedite shipment, physical logistical constraints are sometimes fixed, causing delays in availability of analytical results.

Strategies for overcoming these constraints include:

- The use of direct reading instruments as surrogate indicators for the contaminant of concern (e.g. arsenic, lead, silica estimated from particulate matter concentrations determined with direct reading optical scattering devices together with contaminant composition data previously analyzed within soil and/or other worksite materials),
- The actual determination of contaminant air concentrations such as TVOCs by photoionization detection, and
- Same/next day on-site or nearby project dedicated lab facility (e.g. Asbestos fibres by phase contrast microscopy and X-Ray Fluorescence for arsenic in air analysis).

Contaminant air concentrations must be determined to allow the appropriate selection of respiratory protection, particularly for the higher risk contaminants. Examples of remediation projects where real-time and rapid project dedicated lab turnaround time techniques were used to select and/or validate appropriate level of respiratory protection will be discussed, including the appropriate use of respirator protection factors to select the right type of respirator based on contaminant air concentrations. Challenges and limitations of the techniques will be discussed in the context of decision-making and project efficiencies. Quality control including external lab verification of field results is important. Correlation of arsenic air concentrations determined by rapid turnaround portable XRF versus remote site lab analysis by ICP will be presented, using data from a large-scale arsenic remediation project.

*Todd Irick, M.Sc., CIH, Senior Industrial Hygienist and Safety Specialist with WESA, a Division of BluMetric Environmental Inc.*

Todd Irick is a Senior Industrial Hygienist and Safety Specialist with WESA, a Division of BluMetric Environmental Inc. He is a Certified Industrial Hygienist (American Board of Industrial Hygiene). He holds a Bachelor of Science (Chemistry) degree from the College of William and Mary in Virginia, a Master of Science (Chemical Toxicology) from Carleton University in Ottawa, and an Applied Master of Science (Occupational Health Science) from McGill University in Montreal. Todd has over 25 years experience as an Environmental, Health and Safety (EHS) professional serving as an internal company resource and external consultant for large multinational organizations. He has consulted on and conducted air monitoring (industrial hygiene and ambient environmental) at the Giant Mine Remediation project in Yellowknife, NWT during Roaster complex deconstruction and drilling operations for underground arsenic trioxide storage stabilization and maintenance. Parameters evaluated include arsenic (inorganic compounds and arsine gas), asbestos, particulate matter, silica, hydrogen cyanide and others. He has conducted ambient environmental and occupational exposure monitoring for lead and VOCs at other contaminated site remediation projects. He has extensive experience with evaluating occupational exposures with a wide variety of exposure guidelines across various jurisdictions and determining appropriate levels of protective
equipment based on the monitoring results (e.g. selecting respirators with appropriate assigned protection factors based on workplace airborne contaminant concentrations).

**June 3**

**2:00 pm – 2:30 pm**

**Sä Dena Hes Mine Closure: Application of XRF Technology to Delineate Metals-Contaminated Soils**  
*Andrew Bruemmer, Golder Associates Ltd.*

The Sä Dena Hes mine is a former lead-zinc mine located approximately 70 km by road, north of Watson Lake YT. The mine is currently owned by a joint venture between Teck Resources Ltd. and Korea Zinc. The mine operated for an eighteen month period in the early 1990’s by Curragh Resources and closed after a decline in metals prices. The joint venture purchased the mine property in 1994 and the property remained closed under care and maintenance.

In January 2013, the mine entered a “Permanent Closure” phase, in accordance with the requirements of the mine’s Water License. The overall closure plan for the mine is outlined in the document entitled Sä Dena Hes Mine – Detailed Decommissioning and Reclamation Plan (DDRP) (March 2013 Update) and is being implemented by Teck.

As part of the DDRP, Teck retained Keyeh Nejeh Golder – a joint venture company between the Liard First Nation Development Corporation and Golder Associates Ltd. – to undertake environmental site assessment (ESA) activities at the mine site. The field program and reporting work was completed by Golder between 2012 and 2014, with assistance from LFN environmental monitors.

A portion of Golder’s site assessment work included the use of X-Ray fluorescence (XRF) analyzer to delineate metals contaminated soils. The XRF analyzer uses x-ray emissions to provide real-time measurements of metals concentrations within the soil matrix. Field staff and LFN field assistants were trained in the proper use of the XRF prior to using the instrument in the field.

Golder developed a sampling program to establish the correlation between analytical laboratory data and XRF results. Accompanying XRF software was used to download readings on a daily basis, screen against applicable criteria, and re-assess delineation objectives.

XRF and laboratory data showed a strong correlation and XRF technology was used to laterally and vertically delineate metals-contaminated soil at the mine site. In 2014, approximately 10% of samples were submitted to the laboratory for analytical testing, while remaining samples were analyzed with XRF only.

Due to the remote location of the project, field engineers were able to discuss daily results with the project manager in order to determine if additional step-out samples were required, which increased the overall efficiency of the ESA field work, reduced downtime associated with laboratory analyses turnarounds and costs, and reduced costs associated with mobilization to and from the mine site.

*Andrew Bruemmer, P.Eng., Environmental Engineer, Golder Associates Ltd.*

Andrew Bruemmer is an Environmental Engineer in Golder Associates Ltd.’s Vancouver office and is a licensed Professional Engineer under the Association of Professional Engineers and Geoscientists of British Columbia. Andrew has over six years of experience planning, managing, and undertaking Environmental Site Assessment (ESA) and remediation projects in British Columbia, Yukon Territory, Quebec, and New York State. Andrew has experience working at a variety of sites, including active and former commercial and industrial facilities, dormant mine sites, and emergency spill response sites. He has performed a variety of field tasks including borehole logging and soil sampling, monitoring well installation, groundwater sampling, and soil vapour sampling to help complete environmental site assessments, investigations, and remediation projects. Andrew has developed and implemented health and safety plans for remote project locations, monitored and documented contractor activities (hydro-excavation, drillers, excavator operators, and remediation contractors) and supervised technicians. He has also provided quality assurance and quality control reviews of analytical data associated with environmental projects and prepared reports based on field investigation results and historical data review. Andrew holds a Bachelor of Engineering degree from McGill University in Civil and Environmental Engineering (2008) and is fluent in French.
New Methods to Assess and Support Monitoring: Natural Source Zone Depletion

Liz van Warmerdam, Tom Palaia¹, Ellen Porter¹, Fiona D’Arcy², Ian Clark², Ruth Hall³

¹CH2M HILL
²University of Ottawa, Ontario, Canada
³Yukon Government, Site Assessment and Remediation Unit

Two new methods are available to monitor and assess carbon dioxide production related to biodegradation of petroleum hydrocarbon. The methods are derived from nearly a decade of university research and are currently being used on several sites in Canada.

The first new method uses the LICOR 8100A automated soil flux system (LI-COR, Inc., Lincoln, Nebraska) - an infrared analyzer and pump unit to measure CO₂ and water vapour collected from the headspace of a hood set on a shallow soil collar embedded into the ground surface. The soil CO₂ efflux is calculated using a theoretical curve fit of the CO₂ concentration versus time data series. CO₂ efflux measurements are collected at various locations above and outside the footprint of contamination.

Results from outside the footprint of contamination are used to estimate the background CO₂ efflux from non-hydrocarbon sources (shallow vegetation and biodegradation of natural organic matter). The background efflux is subtracted from results collected in the area of contamination to estimate the fraction of CO₂ generated by depleting the petroleum hydrocarbon. Site-specific petroleum hydrocarbon biodegradation stoichiometry is used to quantify the depletion rate. LICOR measurements at each location can be performed within a timeframe of ten minutes and efflux results are obtained immediately. The rapid results allow for a real-time assessment of CO₂ efflux and depletion rates. The research indicates that petroleum biodegradation can be effectively estimated by converting CO₂ efflux measurements with the LICOR soil flux system.

The second new method uses stable carbon isotopic analysis of soil gas (completed by the University of Ottawa). These analyses are performed on soil samples collected from both active layer and permafrost soil cores. The samples are collected using field analysis jars that trap soil gas for later analysis. Isotopic analysis to establish ¹⁴C content of the CO₂ is completed by accelerator mass spectrometry at the Lalonde AMS Laboratory at the University of Ottawa, complemented by analyzing the d¹³C of the samples to trace the source of CO₂ (determining the ratio of CO₂ resulting from degradation of petroleum hydrocarbons versus CO₂ from ambient air).

By comparing carbon ratios of samples collected from contaminated areas to samples collected from background areas (i.e. non-contaminated areas), the CO₂ generated by natural degradation of petroleum hydrocarbon is calculated. The data show that the CO₂ attributed to biodegradation of petroleum hydrocarbons accounts for the majority of the total CO₂ in the soil. These isotopic measurements have been used to confirm that petroleum hydrocarbon degradation is in fact occurring at permafrost sites affected by petroleum hydrocarbon contamination, and may be used to calculate the rate at which biodegradation takes place.

This presentation will discuss the results of the two new methods from two petroleum hydrocarbon contaminated sites in the Yukon: one site with discontinuous permafrost; the second site in continuous permafrost. It will provide information on the advantages and disadvantages of the methods, with a brief discussion about applying the results to estimate the petroleum hydrocarbon degradation rates at contaminated sites.

Liz van Warmerdam, Project Manager, CH2M HILL

Liz van Warmerdam is a professional geologist and project manager with CH2M HILL in Vancouver, British Columbia. She has over 20 years of experience in the environmental industry, completing environmental site assessments, selecting and implementing appropriate remediation solutions at contaminated sites. She’s worked on remote and urban industrial and government owned sites in Yukon, BC, Alberta and Ontario. Liz works with diverse technical teams to evaluate sites, identifying the source contamination, through to developing and executing groundwater sampling and monitoring programs designed to support assessment and eventual implementation of remediation at sites with soil, groundwater, soil vapour and sediment contamination. Remediation options implemented at various sites have included soil and/or groundwater treatment, excavation, and risk assessment/risk management, including monitored natural attenuation.
Considerations for the Use of Real-time Measurement Technologies for Expedited Site Characterization in the North
François Lauzon and Marc Bouchard
Stantec Consulting Ltd.

This presentation will summarize information on the potential uses, benefits and constraints of using real-time measurement technologies for expedited site characterization. Two significant considerations need to be understood for the effective use of real-time technologies: the sampling approach, and; statistical analysis. The Triad approach developed in the US minimizes uncertainty, optimize data collection and accelerate decision-making, and as such, proves to be the most up-to-date and most suited for real-time decision-making as it proactively exploits recent advancements in data-collection technologies and measurement systems, and incorporates the learnings and best features of its predecessors. Statistical tools and methods are used in modern sampling approaches to understand and manage decision uncertainty. Statistical tools combined with a proper approach can effectively support integrated site management and rapid site characterization. Real-time measurement technologies will be outlined and categorized by their potential level of precision and accuracy within the context of an adaptive sampling program.

The real-time measurement methods and technologies are comparatively summarized the technologies reviewed will include analytical tests, physical sensors and geophysical assessment technologies. Each of the reviewed technologies has the potential to achieve cost-savings, greater data density, and faster characterization of sites compared to conventional techniques, especially when applied using an adaptive sampling approach, such as the Triad approach. However, each tool has unique limitations in terms of its application and suitability for site and contaminant-specific characterization. Other supporting technologies and methodologies that allow for supplemental measurements, simplified data management, and comprehensive analysis of gathered data complement the data collected from real-time measurement technologies.

Recommendations and lessons learned from Stantec’s firsthand experience implementing several of the summarized technologies and methodologies will be presented.

François Lauzon, Senior Principal and Sector Leader, Environmental Services Group, Stantec Consulting Ltd.
François Lauzon is a fully bilingual senior environmental engineer with over 28 years of experience in the fields of municipal and environmental engineering, with unique federal expertise, currently working in the Stantec Consulting Ltd. Ottawa office as a Senior Principal and Sector Leader for the Environmental Services group. François has gained in-depth expertise in environmental engineering and management as a senior officer in National Defence Headquarters and as a senior manager in the environmental consulting industry. In these roles he has gained extensive experience in providing senior project management leadership as well as senior QA/QC for all aspects of environmental projects, performing and providing senior oversight for contaminated sites assessments, critically compiling and assessing environmental data, evaluation of contaminant fate and transport, and development of Remedial Options Analyses and Remedial Action Plans. François has performed senior consulting in support of industry, First Nations Groups, and for provincial and particularly federal departments and Crown corporations. He has extensive experience in training delivery, workshop facilitation, and in federal policy development in relation to the Federal Contaminated Sites Action Plan (FCSAP), leadership and facilitation of various federal interdepartmental committees including the Federal Contaminated Sites Management Working Group (co-chair 2000-2002), The Federal Regulatory Gap Committee and the Interdepartmental Storage Tank Working Group (1998-2002).

Stream 3A - Lessons Learned & Guidelines
June 4
9:00 am – 9:30 am
Cleaning up the Former DEW Line Radar Station at Dewar Lake, Nunavut

Eric Thomassin-Lacroix, Biogénie, a division of Englobe Corp.

In 2011, Biogénie, a division of Englobe Corp., successfully completed the restoration of the Dewar Lake site (FOX-3); a former radar station located on Baffin Island, Nunavut, 300 km north of the Arctic Circle. This site was part of the Distant Early Warning Line (known as the DEW Line) which was composed of a string of 63 radar sites stretching 5,000 kilometers from western Alaska to Iceland. Its purpose at the time was to act as an impenetrable radar fence, intercepting any potential Soviet attack launched from the Canadian north.

Biogénie’s mandate included demolishing the existing building structures, excavating the contaminated soil, and buried debris, managing the hazardous materials (PCBs, asbestos and lead), the biological treatment of hydrocarbon-contaminated soil as well as the off-site shipment of the untreated contaminated soil down south for final disposal.

The site restoration, notwithstanding the harsh climatic conditions and the logistical challenges, was completed in three years due to the invaluable participation and support from the local Inuit communities and workers.

Eric Thomassin-Lacroix, General Manager, Site Assessment and Remediation, Northern Canada, Biogénie, a division of Englobe Corp.

Eric Thomassin-Lacroix is General Manager, Northern Canada, for Biogénie, a Division of Englobe Corp. His main tasks are to lead the company's operations throughout Northern Canada and remote sites. He holds a Bachelor's degree in Microbiology obtained from University Laval and a Master’s degree in Environmental Sciences obtained from the Royal Military College of Canada. Eric combines 16 years of experience in the field of characterization and remediation of contaminated sites, having worked on several projects in Nunavik, Nunavut and the Northwest Territories. His participation in large-scale remediation projects made him aware of the challenges of working in the Arctic and the importance of close collaboration with local communities.

June 4
9:30 am – 10:00 am

Tununuk Point (BAR-C) Remediation

Ramy Rahbani\(^1\) and Warren Bebeau\(^2\)

\(^1\)Imperial Oil Ltd.
\(^2\)AECOM

The Tununuk Point (BAR-C) project site is approximately 80 km north of Inuvik, NT and located within the Inuvialuit Settlement Region on the uninhabited low plateau on the south tip of Richards Island just north of the treeline. The site is accessible by boat/barge along the Mackenzie River for approximately 4 months per year or via ice road during the winter months. The site was originally developed as BAR-C, an Intermediate Distant Early Warning (DEW Line) site in 1957. Operations ceased in 1963 and Imperial Oil (IOL) used the site as a logistics base. The facility supported year-round on-shore and off-shore oil and gas exploration activities from 1972 to 1984. After the program ceased, extensive demobilization of infrastructure occurred. Following a Phase II Environmental Site Assessment (ESA) led by AANDC, above ground infrastructure was dismantled and 44,000L of fuel was removed in 2012. In December 2013, a Remedial Action Plan (RAP) was approved by the Inuvialuit Lands Administration (ILA) for the remaining underground remediation and restoration work.

AECOM and IOL set out to complete the required site closure work in 2014 with the removal of remaining on-site infrastructure associated with IOL site tenure, on-site treatment of Type B impacted soils, removal of impacted soil (Type A, PCBs and Tier I/II) and hazardous wastes, capping of landfills and waste disposal areas in accordance with the Abandoned Military Site Remediation Protocol (AMSRP) standards, and restoration of excavation areas (borrow areas and impacted soil excavation areas). The work was scheduled for one construction season (July to October) with access to the site on water only. A successful 2014 campaign using local expertise including First Nation personnel was underlined by no recordable injuries with approximately 60,000 person hours worked at this remote site including wildlife monitoring, heavy civil construction, and water-based activity. Logistical planning is already underway for the final steps to realize the remedial and reclamation efforts at this site, expected to be completed by August 2015.
This presentation highlights the challenges and successes surrounding the execution of such a dynamic project at a remote site with limited windows of time for remediation.

_Ramy Rahbani, Project Manager, Environmental Services, Imperial Oil Ltd._

Ramy Rahbani graduated with a degree in Mechanical Engineering from McGill University. He joined Imperial Oil Ltd. two years ago in the Environmental Services department. In his role, he has mainly worked in North of 60 areas (notably Norman Wells and Tununuk Point) managing former upstream sites assessments and remedial activities. Ramy has been working on this project since its planning stages and is following through until its final execution.

June 4
10:00 am – 10:30 am

**Looking Beyond the Mine Footprint – Impacts and Risks from the Associated Pine Point Rail Bed**

_Meagan Gourley\(^1\), Charlotte Lessard\(^2\), Susan Winch\(^3\), Emma Pike\(^2\), Erin Shankie\(^3\)\(^\text{1}\)**

\(^1\)Franz Environmental, a division of ARCADIS Franz Canada Inc.

\(^2\)Aboriginal Affairs and Northern Development Canada

\(^3\)Public Works and Government Services Canada

Mine closure activities primarily focus on the main mine footprint, and for good reason. However the ancillary infrastructure also needs to be considered and evaluated in terms of impact, risk, and potential remediation. One example is from the Pine Point Mine in the Northwest Territories where the mine and townsite were remediated, however the potential impacts of transporting lead/zinc ore along the associated rail line were not assessed at the time of closure. As the Pine Point rail bed is a long linear feature (approximately 80 km), the usual step-wise approach to assessment was not financially feasible. A screening level risk assessment was completed after the Phase II Environmental Site Assessment (ESA) rather than after a Phase III ESA. The goal of the risk assessment was to aid in scoping further site assessment and/or remedial and risk management actions, via identification of contaminants, media, and rail bed areas driving risks to human and ecological receptors.

The human health and ecological risk assessment was supported by biological observations, interviews with local residents and aboriginal people, field sampling of soil, sediment, surface water, and vegetation, onsite and in local background areas.

Human exposure pathways evaluated in the risk assessment included fugitive dust inhalation during recreational ATV use on the rail bed, as well as consumption of country foods harvested from the local area. Respirable dust samples were collected during ATV activities onsite, with the resulting contaminant data applied in the human health risk assessment. Surveys conducted with local residents and aboriginal people helped define human activity areas and exposure scenarios, as well as identify site specific ecological receptors. Potential risks to onsite adults and toddlers were identified to be driven mainly by exposure to lead via consumption of seasonal berries, and in the case of the toddler, inadvertent soil ingestion.

Major exposure pathways for wildlife receptors included direct ingestion of contaminants in soil and food items. Hazard quotients from food web modelling identified potential risks for small mammals, birds, and ungulates, mainly driven from exposure to soil concentrations of cadmium, lead and zinc. Calculated elevated risks to plants and soil invertebrates were identified as driven by direct contact with cadmium, lead and zinc soil concentrations, limited to the rail bed.

Risk assessment results supported development of a “next steps” remedial options analysis, and focused Phase III assessment recommendations to validating risk assessment assumptions and confirming options for long-term risk management of the property, if required.

_Meagan Gourley, M.E.T., EPt., Environmental Scientist, Franz Environmental, a division of ARCADIS Franz Canada Inc._

Meagan Gourley has over five years of experience conducting ecological and human health risk assessments, environmental site assessments (Phase I, II, III) and toxicological assessments, for a variety of human use areas (e.g., former rail lines, abandoned mine sites and dump sites, wetlands, effluent lagoons, operational and abandoned landfills, active federal institutional, industrial, and commercial properties). Meagan has conducted vegetation and wildlife surveys, and prepared environmental management plans for work around ecologically sensitive areas. She has designed, coordinated, and executed various multi-media terrestrial and aquatic field sampling programs in support of risk assessment, ex-situ remediation, and
Completing spill response, assessment and remediation programs during the Canadian winter can be a challenging exercise, particularly in some of the coldest and remote locations of the Canadian Arctic. This presentation will discuss a case study of a large gasoline release to the land in Resolute Bay, Nunavut (NU), demonstrating the challenges, potential solutions, lessons learned and best practices to conducting assessment and remediation programs in remote northern environments. The unique elements discussed in this presentation include conducting a forensic assessment and locating a free phase product plume in permafrost fractures, use of hydrocarbon fingerprinting to determine the age/type of impacts, adapting southern technologies for water and on-site treatment to extreme northern conditions, and constructing/operating effective remedial systems to meet remediation targets.

The Project was the result of an estimated 87,000 litres (L) of gasoline released from the community tank farm located approximately 5 km from Resolute, NU, in October of 2011. Phases of the project included working with the Government of Nunavut (GN) to identify potential origins of the release, assessing fate and transport, determining the extent of impacts to soil, surface water and groundwater, and subsequently the removal and treatment of impacted soil and water associated with the release.

Known as “Qausiuttuq” in Inuktitut, meaning “place with no dawn”, Resolute presents a multitude of challenges which were encountered during the Project. Blizzard conditions, heavy snow and almost total darkness hampered initial investigative efforts. Investigations conducted shortly after the release were not able to identify a release footprint (i.e., flow paths, ponding, odours, etc.), typically associated with releases. Evidence of the spill was not seen until the spring of the following year once the snow melt had begun. Further investigative efforts, including a dye tracer test, were completed to determine the flow path of the product. To intercept product and impacted water associated with the release, Nunami Stantec constructed a series of collection and cut-off trenches, keyed into the permafrost. Water collected in these trenches was treated in a water treatment system, consisting of a carbon filtration system, constructed on-site. Permafrost and cold ambient temperatures provide for their own unique challenges when remediating contaminants to the subsurface in addition to working in close proximity to a river and the shoreline and marine environment of Resolute Bay.

The assessment program completed at the site identified widespread hydrocarbon impacts associated with the gasoline release as well as a number of historic contaminants given the site’s long history of fuel storage since the 1950s. Nunami Stantec worked with the GN and regulators to examine the extent of the GN’s liability and to focus on remediating areas that the GN was ultimately responsible for. Once the extent of impacts related to the 2011 release were determined, Nunami Stantec supervised the excavation of approximately 5,000 cubic metres (m³) of impacted soil and placement in two treatment cells constructed within the footprint of the tank farm facilities. In addition, during remediation approximately 423,000 L of impacted water was collected and treated to applicable guidelines and discharged.

Limited heavy equipment and fluctuating availability of contractors in addition to the remote nature of the site and the inability to procure many of the normal spill response equipment and supplies are discussed.

Rob McCullough, Stantec Consulting Ltd.

Rob McCullough is Principal and Senior Scientist for Stantec Consulting Ltd. He is chiefly involved with Environmental Remediation, management, co-ordination and facilitation of large contaminant release across Canada and in the Arctic. He has carried out numerous projects located in remote areas and has overseen many complex oil and gas projects across Canada from Fort McMurray to Sable Island. He has over 30 years of experience in the Canadian Arctic both in the Northwest Territories and Nunavut. He has worked extensively in South America and Indonesia and has been involved in all aspects of detailed site assessment work and remediation. Rob has worked most of his career in remote areas and in the Arctic in addition to large contaminant releases in the south. Rob supervised the clean-up of the MK Airline 747B crash at Halifax.
International Airport. Rob was senior technical lead for assessment of JET A-1 fuel and Arctic diesel contamination, 2007 to 2010 at DND DEW Line BAF-3, NU, and former Colomac Gold Mine in the NT for Aboriginal Affairs and Northern Development Canada. Since 2010 Rob has been the senior technical lead for major oil spill response projects in Alberta, Ontario, Nunavut and the Northwest Territories.

June 4
11:30 am – 12:00 pm

Lessons Learned in Remediating Legacy Uranium Mine and Mill Sites in Northern Saskatchewan
David Sanscartier, Dianne E. Allen, Ian Wilson
Saskatchewan Research Council

The Saskatchewan Research Council (SRC) is managing Project CLEANS (Cleanup of Abandoned Northern Sites), a multi-year, multi-million dollar environmental remediation project on provincial Crown land. On behalf of the Saskatchewan provincial government, the objective of the project is to remediate legacy nuclear sites and transfer them to the provincial Institutional Control Program for long-term maintenance and monitoring. Project CLEANS includes the former Gunnar uranium mine and mill, the former Lorado uranium mill and 35 legacy uranium mines near Uranium City in northern Saskatchewan.

The northern location provides a short field season and the remoteness presents logistical challenges. The objectives of the provincial government for Project CLEANS also include maximizing local economic benefits from the project; which has led to an emphasis by SRC on engaging the seven Athabasca Basin region communities.

Since beginning this large remediation project in 2008, SRC has accumulated lessons learned applicable to environmental remediation projects in remote northern locations. These can be applied at the planning stage of remediation projects and include opportunities to improve Aboriginal involvement, stakeholder and regulatory engagement, site characterization, setting objectives and endpoints, resource planning, risk management, procurement of engineering and contracting services and sustainability. Lessons learned and innovative initiatives will be shared during this presentation.

David Sanscartier, P.Eng., Ph.D., Saskatchewan Research Council, Saskatoon, Saskatchewan, Canada
David Sanscartier, Ph.D., P.Eng., works at the Saskatchewan Research Council. He is involved in the rehabilitation and closure of legacy uranium mines in northern Saskatchewan. In the past 10 years, he has been involved in multi-disciplinary applied research and environmental engineering projects.

June 4
12:00 pm – 12:30 pm

Case Study of the Remediation of the Padloping Island and FOX-E, Durban Island Sites in Nunavut
Rebecca Morley and Caitlin Moore
AECOM

AECOM was retained in 2011 by Public Works and Government Services Canada (PWGSC), on behalf of Aboriginal Affairs and Northern Development Canada (AANDC), to conduct a site investigation and complete a Remedial Action Plan (RAP) along with design drawings, specifications and construction cost estimates for the remediation of the Padloping Island and FOX-E, Durban Island sites. The remediation work at these sites was tendered and awarded in 2012 and AECOM was further retained to provide site supervision, construction and contract administration and geotechnical and environmental services during clean-up construction activities.

FOX-E was constructed as an Intermediate Distant Early Warning (DEW) Line site in 1957 and was abandoned in 1963. The site is located approximately 2.3 km off the coast of Baffin Island. The FOX-E site consisted of a module train, water reservoir building, warehouse and garage, POL tanks, buried debris areas, barrels, contaminated soil, hazardous materials and scattered debris.

At Padloping Island, the American Military constructed a United States Air Force (USAF) weather station in 1943. This weather station was initially operated by the USAF and later operated by the Canadian Department of Transport until its abandonment in 1956.
A long history of Inuit settlement near the Padloping Island site predates the weather station. The Padloping Island site consisted of abandoned buildings in various states of advanced disrepair, buried debris areas, fuel tanks, barrels, contaminated soil, hazardous materials and extensive scattered debris. The Padloping Island site is located approximately 24 km southwest of the FOX-E site.

To allow for work efficiencies and cost savings, a combined contract was implemented for the Padloping Island and FOX-E sites. The contract for the overall remediation of FOX-E and Padloping Island was awarded to Biogenie, A Division of Englobe Corp. The remediation of the site primarily occurred over two summer construction seasons and was substantially completed in 2014.

The scope of work for the remediation contract for the FOX-E and Padloping Island sites included:

• Demolition of on-site infrastructure and collection of demolition and site debris for off-site disposal.
• Excavation of buried debris areas at Padloping Island and regrading of low environmental risk buried debris areas at FOX-E, Durban Island.
• Excavation, containerization and off-site disposal of hazardous and inorganic contaminated soils.
• Excavation and on-site treatment of hydrocarbon contaminated soils.
• Segregation, containerization and off-site disposal of hazardous demolition debris and hazardous contaminated soil.

This presentation focuses on the unique challenges and lessons learned associated with these isolated remediation sites, including:

• Working in a remote location with harsh weather conditions.
• Difficult on-site access conditions at FOX-E due to the mountainous terrain.
• Challenging access and working conditions on poorly drained muskeg areas underlain by continuous permafrost at Padloping Island.
• Provision of on-site design changes resulting from additional contaminated soils and hazardous demolition materials identified during remediation construction activities.
• Protection of archeological resources at Padloping Island.
• Administration of a combined remediation contract for sites located on separate islands with limited inter-site access.

Rebecca Morley, E.I.T., Environmental Engineer, AECOM
Rebecca Morley is an Environmental Engineer-in-Training who has been working with AECOM since 2011. Over the last four years, Rebecca has been involved in multiple assessment and remediation projects at sites across the Canadian Arctic. Responsibilities have included preparation of remedial options, design, specifications and cost estimates, resident engineering during site remediation, as well as planning and completing environmental site assessments and monitoring programs. Rebecca had both environmental inspection and resident engineer roles for the Padloping Island and FOX-E Durban Island remediation projects in 2013 and 2014.

Stream 4A - Innovative Remedial Techniques

Phytoremediation of Salt and Petroleum Hydrocarbon Impacted Soil: An Innovative Technology for Treating Remote and Northern Sites

Elizabeth W. Murray¹, Bruce Greenberg², Ben Poltorak¹, Kent Cryer¹, Perry Gerwing¹,
¹Earthmaster Environmental Strategies Inc.
²Department of Biology, University of Waterloo

We have successfully developed and implemented advanced phytoremediation systems for removal of petroleum hydrocarbons (PHCs), polycyclic aromatic hydrocarbons, and salt from soils at a fraction of the cost of traditional landfilling. Our plant growth promoting rhizobacteria (PGPR) enhanced phytoremediation systems (PEPS) create large amounts of root biomass in impacted soils, which stimulates exponential growth of rhizosphere microorganisms. This facilitates effective and rapid partitioning of contaminants out of the soil, where uptake and metabolism by the microorganisms and plants results in degradation of PHCs and sequestration of salt into the plant foliage resulting in complete remediation, usually with two to three years of treatment. PEPS has been successfully deployed in seven Canadian Provinces/Territories in the remediation of sites contaminated with PHC and salt. More than 20 sites containing PHC impacted soil have been treated with PEPS. Eleven sites have met generic provincial soil remediation standards and
the remaining active sites are on target to meet remediation goals within a two to three year treatment period. PEPS has also been deployed at numerous salt impacted sites (containing ECe levels up to 25 dS/m) and has greatly enhanced plant growth and salt uptake. Salt remediation to regulatory and/or client targets has been achieved at nine sites. PEPS is effective for remediation of contaminated soil in inclement weather, when permafrost is present, where sites are remote, where roads are non-existent or impassable, and when getting heavy equipment to sites for treatment or removal of soil is not possible. PEPS has recently been deployed at three locations in the Northwest Territories to remediate PHC and salt contaminated soils. Location 1 is a PHC and salt contaminated wellsite constructed on a gravel/clay pad and is located 30 km southeast of Norman Wells. Contaminated soil from drilling activities has been treated in ‘lifts or layers’ across the site using PEPS. Currently 2 of 4 lifts have completed treatment and successful remediation was achieved for both PHC and salt in three years or less for each lift. Locations 2 and 3 are situated approximately 170 km northeast of Norman Wells. PEPS was deployed at these two locations in 2013. By the fall of 2014, plants were well established on both sites for which conventional re-vegetation attempts in the past by the client were unsuccessful. Following one year of phytoremediation, PHC fractions F2 and F3 concentrations were remediated below generic guideline values, and salt levels (ECe and SAR) were showing decreasing trends on both sites. Field results from these three treatment locations have proven that the PEPS technology is effective at re-vegetating and remediating both salt and PHC impacted soil in Northern environments. Regulators are supportive of this green and sustainable technology. Further, clients have adopted it as a cost effective method for remediation of contaminated sites in remote areas where off-site landfill disposal or other equipment intensive remediation technologies are not feasible.

Elizabeth W. Murray, Ph.D., P.Biol., Technical Reporting-QA/QC Manager, Earthmaster Environmental Strategies Inc.
Elizabeth Murray is the Technical Reporting-QA/QC Manager for Earthmaster Environmental Strategies in Calgary, Alberta. Her background is in human genetics and she has worked for more than 20 years in medical related research and in plant based biotechnology, developing biologics as treatments for human diseases. Elizabeth has worked in environmental sciences for over three years and plays a lead role in the analysis and reporting of phytoremediation results.

June 4
9:30 am – 10:00 am

Bioremediation with Fungal Mycelia
Roland Treu, Athabasca University

Fungi have the potential to degrade a wide variety of toxins ranging from polycyclic aromatic hydrocarbons (PAH) to dioxins, DDT, polychlorinated biphenyls (PCB), pesticides and other contaminants. White rot fungi in particular are considered as useful candidates for bioremediation because of their complex phenol peroxidase systems that causes the break-down of the highly resistant lignin molecule as well as other complex organic toxins. In many remediation situations fungal systems may be superior to bacteria due to their flexible mycelial networks extending in the soil.

The Athabasca University Bioresource Collection currently includes cultures of 100 strains of native fungi from Alberta including many white rot fungi. We tested some of these strains (from the genera *Trametes*, *Bjerkandera*, *Ganoderma* and *Pleurotus*) for their bioremediation potential by exposing artificially contaminated water to fungal mycelia. Toxicity was measured with the Microtox system and a significant toxicity reduction of was obtained for most strains within 7-10 days of fungal exposure.

A large number of past studies on the bioremediation potential of fungi were carried out exclusively in-vitro. For our experiments we developed a wood based inoculation system that has the potential for application in-situ. The inoculated wood substrates were successfully tested for water contamination and we are currently testing the feasibility of the approach for contaminated soils.

Roland Treu, Associate Professor, Faculty of Science and Technology, Athabasca University

June 4
10:00 am – 10:30 am

In-situ Remediation of Hydrocarbon Impacted Groundwater in Permafrost Terrain at a Remote Site in the Northwest Territories
Stephen B Mailath, Tetra Tech EBA
In March 2008, an estimated 14,000 L diesel spill occurred from a transport truck roll over at Portage 32 of the Tibbitt to Contwoyto Winter Road, approximately 100 m up-gradient of a freshwater lake. Emergency responses included excavation and removal of most highly impacted snow and soils (based on visual staining) over an area approximately 10 m by 5 m by 1 m deep, where excavation was halted due to frozen ground conditions. Due to the remote location, access is by winter road from January to March and helicopter during summer. Natural drainage is southeast, towards the nearby lake.

From 2008 to 2011, 37 monitoring wells and four well points were installed to assess and delineate groundwater impacted with hydrocarbons. In 2011, a risk assessment indicated potential receptors include freshwater aquatic life (FAL) via surface water/groundwater and wildlife via soil contact. A remediation options evaluation was conducted that suggested in-situ chemical oxidation would be a viable option given the remote location. An evaluation of candidate chemical oxidants suggested PermeOx Plus calcium peroxide oxygen releasing compound was suitable and was subsequently injected in 2012 and 2013 into wells containing detectable concentrations of hydrocarbons.

Prior to the injection of PermeOx in July 2012, a total of 12 wells contained concentrations of hydrocarbons (benzene, toluene and ethylbenzene), exceeding guidelines in the July or September sampling that was conducted each season. Following the injection of PermeOx, hydrocarbon concentrations significantly reduced in the wells and in September 2013 only 6 wells contained concentrations of toluene, naphthalence and/or pyrene slightly exceeding guidelines.

The remediation performance was evaluated by comparing the theoretical decrease (decay) of hydrocarbons (toluene and ethylbenzene) based upon natural processes to the observed concentrations after the application of PermeOx. The observed concentrations were significantly less than theoretical concentrations suggesting the addition of PermeOx was effective at reducing hydrocarbon concentrations.

An assessment was conducted to estimate the potential concentration of toluene that could potentially be reached at the nearby lake based upon the residual concentrations measured in 2013. The results of the assessment indicated that concentrations of toluene could reach the lake on the order of ten orders of magnitude less than guidelines.

The remediation program is anticipated to reduce concentrations to below guidelines in the next year or two. The outcome of the work shows effective in-situ remediation of hydrocarbons can be achieved in remote northern areas.

*Stephen B Mailath, M.Sc., P.Geo., Senior Hydrogeologist, Tetra Tech EBA*

Stephen Mailath is a Senior Hydrogeologist at Tetra Tech EBA with over thirty years of experience in the environmental consulting and oil and gas industries. He specializes in soil and groundwater contamination, migration processes, contaminant fate, contaminated groundwater remediation and management, groundwater resource evaluation, management and exploitation, analytic and numeric groundwater modelling, and remediation technology development. He has prepared industry guidelines and instructed at workshops and courses on contaminant assessment, remediation and environmental impact assessment.

**Stream 4B - Site Assessment Considerations**

June 4
11:00 am – 11:30 am

*Health Risk Characterization for Intermittent and Short-term Exposures to Chemicals at Northern Sites*

*Lindsay Smith-Munoz, Alicja Wierzbicka and G Mark Richardson Stantec*

At remote Northern Contaminated Sites, where human exposure is often seasonal, intermittent or infrequent, available regulatory toxicity reference values (TRVs), developed for continuous chronic exposures, are a poor fit for human health risk characterization. Amortizing short duration exposure over a lifetime in order to use the chronic TRVs is not defensible from a scientific viewpoint. However, assuming continuous lifetime exposure, when the actual exposure is far less, could result in resources being used to manage and remediate sites where there is no current existing health risk.
Using available guidance from Health Canada and position papers from Toxicology Excellence for Risk Assessment, toxicologists at Stantec have developed a protocol for incorporating information about exposure duration and recurrence into the toxicity assessment. This protocol considered the exposure duration, the toxicokinetics and the toxicodynamics of the contaminants of concern. The final outcome determines whether the exposure should be treated as chronic with no amortization, or short-term. It also provides information for selecting appropriate short-term toxicity benchmarks, and determining whether an intermittent exposure can be treated as chronic or short-term.

The issue of what duration of annual on-site occupation can be considered “chronic”, with associated amortization of dose for comparison to chronic TRVs, will also be discussed, and compared to accepted commercial and industrial scenarios.

Chemicals will need to be assessed on an individual basis; however, since northern sites may fall into certain categories, exposure profiles will be developed to match certain types of site use. As chemical evaluations are completed, they can be maintained and used at other similar sites.

Lindsay Smith-Munoz, M.Sc., EP, Senior Environmental Risk Assessor/Toxicologist, Stantec

June 4
11:30 am – 12:00 pm

Advancements in Managing Uncertainty in Remedial Options Analysis and Remedial Action Plan Development for Northern Sites

David Wilson¹, François Lauzon¹, Jessie Hoyt² and Michael Bernardin²
¹Stantec Consulting Ltd.
²Public Works and Government Services Canada

Invariably, the starting position for undertaking remedial options analysis (ROA) and developing remedial action plans (RAP) for remote northern sites includes significant areas of uncertainty. These uncertainties arise from many sources: short field seasons and costly logistics lead to less field data than would otherwise be available, resulting in poor characterization of impacts and background conditions; multiple small investigations, often by different consultants, lead to orphaned data and inconsistent analyses and conclusions; and physical constraints render some accepted remedial options as invalid while necessitating significant modification to others. Methods for identifying and characterizing these types of uncertainties, and for quantifying their associated risks, have seen significant development over the past several decades in many industry sectors, however the environmental remediation sector has been slow to adopt and apply such methods. As a result, risks are often insufficiently characterized and communicated to stakeholders, and ROA and RAP efforts are insufficiently improved by risk reduction efforts – ultimately, remediation costs end up being higher than they would be with sound application of risk management.

In this presentation, uncertainties that hamper the development of ROA/RAPs for northern sites are described. Necessary distinction is made between technical risks and project risks, while methods for risk characterization, mitigation and management in each case are outlined. Methods considered include statistical methods, sensitivity analysis, scientifically-derived extrapolation factors, use of proxy data, use of models, and scenario analysis and Monte Carlo simulation. Examples and case studies are used to demonstrate application of these methods, and to suggest improvements to the current practice or ROA/RAP development within the environmental remediation sector for northern sites.

David Wilson, CD, M.A.Sc., P.Eng., Senior Project Manager, Stantec Consulting Ltd.

David Wilson, CD, M.A.Sc., P.Eng., is a Senior Project Manager with Stantec Consulting Ltd. in Ottawa. He has over 20 years’ experience managing teams: unit leadership positions in the Canadian Army, project team positions in NDHQ and national and international consulting firms, and service team positions in national consulting firms. David has early experience in systems engineering and modeling, which was reinforced through his first Master’s degree in Defence Technology. He continued his education with an Environmental Engineering Master’s degree at the University of Ottawa wherein he undertook a three year research effort aimed at developing an integrated modeling environment for watersheds. David has managed projects both within the public and private sector, with values up to $125 million, covering fields of environmental engineering, contaminated sites, water resources, training, environmental data analysis and management, ecological systems, Safety Management Systems (SMS), and building systems. He is a past Service Director for Water
Resources for Stantec Ltd., and presently acts as Specialist for that service in the Ottawa office. His areas of expertise include environmental site assessment and remediation, water resources, Geographic Information Systems, surface and groundwater modelling and software design, OH&S/SMS, and integrated risk management.

June 4  
12:00 pm – 12:30 pm

Successes and challenges: An overview of ongoing assessment and remediation activities at Environment Canada’s High Arctic Weather Stations

Darryl Roberts  
Environment Canada

June 4  
2:00 pm – 2:30 pm

Programmatic Approaches to Identification and Management of Federal Sites Potentially Impacted with Perfluorinated Compounds

William DiGuiseppi  
CH2M HILL

June 4  
2:30 pm – 3:00 pm

An Introduction to Biogenic Hydrocarbon Issues at Federal Contaminated Sites

Alison Street  
Amec Foster Wheeler

Stream 3B - Long-term Monitoring  
June 4  
2:00 pm – 2:30 pm

The Remediation and Long Term Monitoring of Colomac Mine, NWT

Caitlin Moore and Jessica Ham  
AECOM

The Colomac Mine, located 220 kilometres north of Yellowknife, NWT was an open pit gold mine, in operation between the years 1988 and 1998. Aboriginal Affairs and Northern Development Canada (AANDC) assumed responsibility for the site in 2000 after the mine operator was placed in receivership and abandoned the site.

Mine operations had left the Colomac site with environmental and physical hazards. Upon assuming control, AANDC undertook care and maintenance of the site, and completed a site-wide assessment to identify the extent of environmental and physical risks. An overall conceptual site remedial plan was developed in 2004 based on studies and stakeholder consultation. The plan identified key remedial components and the remedial methods to be implemented.

In 2009, AECOM was retained by Public Works and Government Services Canada (PWGSC), on behalf of AANDC, to prepare engineering design drawings and specification documents for the final site remediation contract, as well as resident engineering services, construction contract administration, and technical support during the implementation of the remediation contract. The final remediation contract was awarded to Tlicho Engineering and Environmental Services Ltd., in joint venture with Aboriginal Engineering Ltd. (TEES-AEL). The final remediation of the site occurred over an 18-month period and was completed in 2011. The final remediation of the site included decontamination and demolition, construction of a non-hazardous waste landfill, disposal of nonhazardous, hazardous and contaminated debris and demolition waste, improvement of drainage pathways and shorelines, excavation and treatment of hydrocarbon soil and rehabilitation of hydrocarbon contaminated sediments in Steeves Lake.

Following the remediation, a comprehensive long term monitoring program was initiated which includes:
2015 RPIC Federal Contaminated Sites Regional Workshop
Assessment and Remediation on Remote or Northern Sites
June 3-4, 2015 at the Westin Edmonton
10135 100 St NW, Edmonton, Alberta

- Terrestrial Monitoring
- Aquatic Monitoring
- Water Quality Monitoring
- Hydrology Monitoring
- Geotechnical and Post-Construction Monitoring
- Adaptive Hydrocarbon Monitoring Program

The adaptive hydrocarbon monitoring program (AHMP) was developed to quantify the potential impact of residual hydrocarbons in the fractured bedrock below the mine site and monitor the impact on the surrounding environment – specifically on the adjacent Steeves Lake. The AHMP program started in 2011, and includes regular site visits during the summer months and continuous monitoring through instrumentation. The results of the program are reviewed annually by the Colomac Hydrocarbon Advisory Group (CHAG) and the monitoring activities and objectives are revised based on the review.

This presentation will include:
- An overview of the remediation of the mine site
- The establishment of this comprehensive and large scale long term monitoring program
- The initiation of the AHMP and the activities included in the monitoring program
- The unique nature of the AHMP and the processes that shape the adaptive program
- Results, successes and lessons learned from the AHMP and overall long term monitoring programs
- End points for the ongoing monitoring

Caitlin Moore, P.Eng., Environmental Engineer, AECOM
Caitlin Moore is an environmental engineer with 5 years of experience in northern and arctic remediation. Caitlin’s responsibilities include completing remedial designs and specifications, environmental inspection, resident engineering and contract management. She has been involved with the remediation of many northern sites including several DEW Line sites, high arctic weather stations and abandoned mine sites, including Colomac Mine.

June 4
2:30 pm – 3:00 pm

Long-term Monitoring Approach for an Extremely Remote Site
Nick Battye¹, Jeff Donald¹, Dr. Tamsin Laing¹, Dr. Daniela Loock¹, Dr. Ken Reimer¹ and Jane Chisholm²
¹Royal Military College of Canada
²Parks Canada Agency

Fort Conger is an extremely remote northern site located in Quttinirpaaq National Park (QNP) on Ellesmere Island in Nunavut. Located on the shore of Discovery Harbour, the site was used as a base by three early Arctic expeditions associated with George Strong Nares, Adolphus Greely and Robert Peary. Greely established a semi-permanent scientific research camp there during the first International Polar Year, 1882–1883, and in 1900, the research camp was transformed into a base camp for Peary’s attempts to reach the North Pole. The site has also been visited by early-twentieth-century expeditions, government and military personnel, researchers, Inughuit hunters and tourists. Many artifacts, including the foundation of the Greely expedition house and Peary’s wooden huts, are still present. Because of the site’s historical significance and wealth of artifacts, it has been given several heritage designations.

Unfortunately, the presence and weathering of certain artifacts has led to a significant amount of inorganic element (i.e., metals and metalloids) and some polycyclic aromatic hydrocarbon soil contamination. Terrestrially, there is evidence of contaminant uptake by the plants that are growing on the site, with potential impacts to those ecological receptors that might consume them. The soil contamination is located next to the marine environment and the adjacent coastal bank is actively eroding through wave action and slumping. The human health risk was determined to be low. Under the Federal Contaminated Sites Action Plan (FCSAP) National Classification System for Contaminated Sites (NCSCS), Fort Conger was categorized as a Class 1 site (High Priority for Action).
Any remedial solution for the contamination at Fort Conger has to balance the maintenance of ecological integrity with the preservation and promotion of the cultural resources as per the Canada National Parks Act, the Nunavut Land Claims Agreement and Parks Canada's policies. At this time, remediation is considered neither practical nor feasible because of the extreme remoteness of the location. The issue was thoroughly discussed and debated by a Technical Advisory Group that consisted of contaminated sites specialists, archaeologists and Parks Canada managers, with input by FCSAP expert support representatives. The resulting risk management strategy and long-term monitoring plan for Fort Conger consists primarily of measuring the rate of coastal erosion, which is presently unknown, as this is the single most important factor that is expected to cause significant changes to the site in terms of contaminant movement and potential exposure. Reviews of the human health and ecological risk assessment assumptions, climate change data and feasibility of completing remedial actions will be conducted every five years. A brief overview of the long-term monitoring plan and the methods of data collection through remote and on-site means will be presented.

Nick Battye, M.Sc., P.Geo., Project Leader, Environmental Sciences Group, Royal Military College of Canada

Nick Battye holds a Bachelor’s degree in Geology and a Master’s degree in Earth Sciences from the University of Ottawa. Over the past 13 years, he has been working with the Environmental Sciences Group at the Royal Military College of Canada in Kingston, Ontario, on a variety of projects involving contaminated site assessment, risk assessment, risk communication, remedial action planning and long-term monitoring. As one of the scientific advisors on the BAR-B, Stokes Point clean-up project, in 2011 he was one of the recipients of the Parks Canada CEO Award of Excellence in the category of "Engaging Partners".

Use of Unmanned Aerial Vehicle (UAV) Technology for High-Resolution Mapping in the High Arctic

David G. Pritchard, Golder Associates Ltd.

Obtaining suitable mapping information for managing sites in the High Arctic can prove challenging. The scales of traditional government topographic mapping can be too small to be useful. Free satellite imagery often does not have the resolution necessary to identify site features and to provide adequate base mapping. Commercially-available high-resolution satellite imagery can be sufficient, but may not be available for the particular area of interest, or may be constrained by cloud or snow cover. The costs of custom tasking of high-resolution satellites can be prohibitive, as can the cost of ground topographic survey.

Over the past few years, small-scale unmanned aerial vehicle technology has expanded rapidly. Systems that allow for the collection of high-resolution still and video aerial imagery are becoming simple and cheap to operate. Post-processing capabilities allow for the creation of products ranging from simple two-dimensional maps to complex three-dimensional images. This presentation will discuss the application of small-scale unmanned aerial vehicle technology for collection of high-resolution aerial imagery, and the development of detailed orthophotographs and digital elevation models.

A case study of the use of small-scale unmanned aerial vehicle technology for collection of geo-referenced aerial imagery and subsequent production of high-resolution orthophotography on an abandoned industrial site in Canada’s High Arctic will be presented.

David G. Pritchard, P.Geol., Principal and Senior Geoscientist, Golder Associates Ltd.

David Pritchard, P.Geol. is a Principal and Senior Geoscientist with Golder Associates Ltd., and has over twenty-five years experience undertaking contaminated site assessment and regional hydrogeological baseline studies throughout Canada and abroad. David has extensive experience in the design, implementation, analysis and interpretation of environmental site assessment and remedial programs for oil and gas production, treatment and refining facilities, gas transmission facilities, military installations, mine sites and commercial/industrial facilities. Dave has a passion for working in Canada’s North, and has completed site assessment and remediation projects related to active and abandoned mine sites, power generating plants, High Arctic Weather Stations, DEW Line sites, and abandoned oil and gas facilities throughout the Western Arctic.
Mine Closure Design and Performance Monitoring, Nanisivik Mine, Nunavut

Jim Cassie and Geoff Claypool
BGC Engineering Inc.

Nanisivik Mine was opened in 1976 at the northern end of Baffin Island in Canada’s North, in arguably one of the remotest and harshest environments in the world. With very little high Arctic mining experience, the mine staff and related consultants developed a design for sulphidic tailings that used the natural topography, the accessible construction materials and the cold climate to its maximum advantage. As the operations proceeded, design and construction practices were amended to reflect site experiences and knowledge that was gained. For years, test covers were monitored to collect site specific performance data to assess the proposed closure cover design for the tailings. In 2002, the economic ore reserves were depleted and the mine entered the closure and reclamation phase. As part of this process, the natural process of permafrost aggradation was incorporated into the construction of engineered covers over the sulphidic tailings, waste rock and the landfill. Portals and mine openings were plugged and buildings and infrastructure was demolished and landfillfilled.

Reclamation has been substantively complete since 2007 and results from on-going monitoring indicate that the closure measures are performing as designed; the deposits are physically stable and no negative environmental impacts have been noted. Post-closure performance monitoring results, including the mine waste covers, talik freezeback and water quality parameters will be reviewed.

Jim Cassie, Principal Geotechnical Engineer, BGC Engineering Inc.

Jim Cassie is a Principal Geotechnical Engineer with BGC Engineering in Calgary with 29 years of experience in a variety of civil and mining projects. During this time, he has specialized in the design, construction, operation and closure of mining projects located in cold regions and permafrost conditions. His areas of expertise include permafrost characterization, foundation input, dam design and inspection, tailings management planning and water balance, geothermal assessments, water management, soil cover design and mine closure planning, design and permitting. In addition, he was located in the BGC office in Santiago, Chile for three and a half years and worked on numerous high altitude mining projects in the Andes mountains. As such, he has worked on projects in all three northern Canadian territories, Alaska, Far East Russia, Bolivia, Chile and Argentina. Jim was also formerly the Chair of the Cold Regions Geotechnology Division (CRGD) of the Canadian Geotechnical Society (CGS) and served on its Board of Directors. He has been involved with closure of numerous northern mining projects including Nanisivik Mine (NU), Discovery Mine (NT) and Faro Mine (YT).