



Stream E: Assessment and Remediation in Special Environments

Fox-C Ekalugad Fjord Lobe B Dump “Excavation”

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The FOX-C Intermediate Distant Early Warning (DEW) Line Site was constructed in 1957 and subsequently abandoned in 1963. It is located on the Northeast coast of Baffin Island, Nunavut on the south shore of Ekalugad Fjord. It is approximately 240 kilometres northwest of Qikiqtarjuaq and 260 kilometres south of Clyde River.

At the conclusion of the 2007 season a thorough review of the remaining work was completed and it was determined that if site conditions in 2008 were the same as those encountered in previous years then the methodology being used to excavate the Lobe B dump would not allow for the completion of the work in one extra year. To increase our chances of completing the remaining work in 2008 a new methodology would have to be developed.

The original plan for the Lobe B dump was to excavate and segregate it using heavy equipment. This was to be completed in steps by removing the surface materials and scraping down to the frozen area, allowing it to thaw, and then repeating the process. The progress made in 2007 projected that the work remaining at Lobe B would take around 90 days to complete using this methodology. Since the typical field season at FOX-C lasts around 60 days an alternative methodology would be required if we wanted to increase the probability of completing the project in 2008.

A number of alternative approaches to Lobe B were discussed during off-season meetings. These options were reviewed and discussed with consideration given to the site characteristics and other factors (limited access, available equipment, cost, permitting, scheduling). Upon completing the review it was decided that the use of explosives to loosen the material would give us the best opportunity to complete the project in 2008.

The change in the approach to Lobe B was just to the methodology used to excavate the material. Once the material is removed it was to be segregated and handled as described in the original approach. In order to expedite the excavation process a certified explosives contractor was hired to come to the site and strategically place charges to loosen up the material. This allowed us to excavate the loosened material and move it to the lower site processing area where it could thaw quickly and be segregated and properly handled.

The new methodology successfully loosened the material and it was excavated and moved to either the non-hazardous waste landfill (debris) or the material processing area where it was placed in piles and sampled. Confirmatory sampling of Lobe B indicated that the area was successfully cleaned. The use of explosives to loosen a frozen dump proved to be successful methodology.

Control, Mitigation, Assessment, and Remediation of a Significant Hydrocarbon Release in a Heavily Sloped Discontinuous Permafrost Environment, BAF-3, Brevoort Island, Nunavut

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In March 2007, Stantec was retained by the Nasittuq Corporation to assist in the emergency response, assessment, and clean-up, following a 150,000 L Jet A-1 fuel spill that occurred at the summit of a Department of National Defence (DND) Long Range Radar (LRR) site (BAF-3); a part of the North Warning System (NWS), on Brevoort Island, Nunavut. This multi-faceted project included a step-wise approach to the assessment and remediation in consideration of the environmental and logistical challenges imposed by weather, topography, isolation, and discontinuous permafrost.

Prior to initiating a “traditional arctic Phase II Environmental Site Assessment (ESA)”, Stantec (formerly under the Jacques Whitford banner) conducted a preliminary investigation (visual and olfactory) to delineate the PHC impacts in the surface snow and ice (the PHC release was complicated by a 40,000 L water line break on top of the PHC plume). This assessment, completed by the end of March 2007, allowed for the development of a control and mitigation strategy requested by an INAC Order. The plan needed to address the potential uncontrolled flow of PHC impacts, temporarily halted in the winter environment, throughout the spring freshet to mitigate potential flow of free product to the Arctic Ocean. The plan resulted in the construction of control structures (underflow dams) and the installation of a water treatment system to treat approximately one million litres of PHC-impacted water in year one. During the Phase II/III ESA completed by September 2007, information was collected to perform a Human Health and Ecological Risk Assessment (HHERA). Two hundred and eighty one samples were collected throughout the Phase II/III ESA. Screening based on soil vapour concentrations, field observations, and PetroFLAG™ test kit, resulted in 86 soil samples submitted for laboratory analysis of Benzene, Toluene, Ethylbenzene, Xylenes (BTEX) and Petroleum Hydrocarbon Contaminants (CWS PHCs – Fractions F1 to F4). Soils were also submitted to the National Research Council Biotechnology Research Institute (NRC BRI) to optimize the microbial nutrient approach for sustained bioremediation on site. The ESA and HHERA, as well as the microcosm study results from the NRC BRI, allowed the development of a point-rated remedial options analysis to select the most appropriate treatment train approach to deal with multiple media: impacted water, soils, and waste adsorbent materials (boom and pads). The resulting Remedial Action Plan (RAP) includes remedial excavation and placement of soils in an engineered landfarm (on-site, licensed by a Nunavut Water Board Application), soil flushing to mobilize PHCs that are inaccessible due to infrastructure and utilities, continued operation of a water treatment system and continued control and mitigation efforts (2008, 2009, and 2010) to deal with sporadic subsurface PHC migration (free product) affected by the discontinuous permafrost. The site is expected to be remediated by the end of the 2010 field season, with continued landfarming and site monitoring up to 2012.

This paper will outline the step-wise strategic field approach developed for this complex site and provide early results from the biostimulation in the landfarm as well as from the soil flushing component of the project. It will further outline the logistical challenges imposed by the nature of the site (schedule constraints exacerbated by extreme weather conditions (fog and high winds), logistical and equipment constraints from working in a remote location, steep and uneven terrain being assessed, and significant scrutiny from stakeholders), and discuss the impacts of the rapid thaw of the discontinuous permafrost in consideration of “observed” climate change.

Reaching Cam-F, Cam-5 and Fox-3 DEW Line Sites: Challenges and Lessons Learned

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The Distant Early Warning (DEW) Line is a network of 63 radar stations (42 in Canada) built in the mid-1950s, at the peak of the Cold War. It took three years of intensive work to the United States to build this system in the Arctic. It was designed to detect any aircraft approaching from the North Pole. It was operated jointly by the Canadian

Department of National Defence and the USA Airforce. The DEW Line was composed of six main sites, 26 auxiliary sites and 31 intermediate sites.

CAM-F, one of the intermediate sites, closed in 1963 and was transferred to INAC in 1976, along with 20 other stations. CAM-5 and FOX-3, both auxiliary sites, closed in the early 1990's. The stations were comprised of the following infrastructure: module trains, garages, warehouses, sheds, communication towers, POL tanks and storage facilities, etc. Wastes and contaminants present on site included: PCBs (present in soil, oil and painted material), hydrocarbon (present in soils), metals present in soils, asbestos, etc.

CAM-F and CAM-5 are both located on the Melville Peninsula. The closest communities are Hall Beach and Igloolik, which are located approximately 100 km from CAM-F and 225 km from CAM-5. FOX-3 is located on Baffin Island, approximately 200 km west of Clyde River. All three sites can only be accessed by plane or helicopter in the summer and via snowmobiles in the winter.

Biogénie was awarded the CAM-F Cleanup Project contract in 2005, the CAM-5 contract in 2006 and the FOX-3 contract in 2007. All projects required heavy equipment, material and a construction camp to be mobilized on each site in order to perform the remediation work. Winter/over tundra transportation is a challenging expedition requiring a specific logistic and knowledge of the area.

This paper will present some challenges and issues encountered during the mobilization to each site. Topics such as fluctuating winter conditions, special permit and aboriginal content requirements will be addressed and discussed.

Rapid Assessment and Remediation Approach: Mercury Contamination at Hydrometric Stations in British Columbia

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The Water Survey of Canada (WSC), a branch of Environment Canada (EC) operates a network of up to 3,000 hydrometric stations across the country for the purpose of collecting water level and river flow data. These stations typically consist of a small walk-in shelter containing monitoring and communication equipment. Between the early 1970s and the mid-1990s mercury servo-manometers coupled to chart recorders were used to collect and record data. During this period, mercury releases from the servo-manometers occurred nationally at up to 1,300 locations due to freezing of the system hoses causing mercury overflow and release, spillage during regular maintenance of the equipment, and/or vandalism.

A national program to assess and remediate the mercury contamination has been underway since 1999. In British Columbia, upwards of 70 stations were assessed on a yearly basis in a variety of urban and remote locations around the province. Project management challenges that were overcome included obtaining appropriate site access agreements from property owners for each of the sites (including First Nations, federal and provincial owners), gaining access to remote sites via use of helicopters and off-road vehicles, and establishing appropriate health and safety guidelines and communication protocols with the remote field team working extended hours (including use of a SPOT satellite transponder to track crew position throughout day and developing emergency response procedures in the event of an emergency message sent or missed call-in).

Rapid assessment and remediation techniques were developed to allow for the quick identification of potentially impacted areas, assessment of impacted materials on-site using portable mercury analytical equipment (mercury vapour concentrations inside the hydrometric station shelters and mercury concentrations in soil), remediation of impacted areas and removal of impacted material off-site, and confirmation sampling – usually within a single day. Multiple stage QA/QC procedures were developed to confirm the correlation of analytical results obtained from portable field equipment with results from off-site laboratories. Assessment procedures were modified as the project progressed to account for site observations and individual site characteristics such as sampling and analysis of high organic content and high moisture content soil and assessing and remediation of impacted soil on flood plains. Rarely was mercury contamination observed to extend beyond 15 cm depth, even when the contamination was > 20

years old in high precipitation coarse-grained environments. The mercury appeared to bond to soil particles strongly minimizing vertical migration into the subsurface despite its “liquid” metallic state.

Assessment and Remediation of a Coastal Wetland Ecosystem

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In 1999, the Department of National Defence conducted a surface soil investigation and identified the presence of petroleum hydrocarbon impacts in the wetland area and along the coastal beach area of the DCD Fire Training Centre, near Halifax Nova Scotia. The wetland area is located in the central portion of the DCD school site, southeast of the former fire fighting training area (FFTA). An initial remedial program was completed in 2002 using in-situ application of oxygen releasing material (ORM) to remediate impacted wetland soil and sediment. However, after several years of monitoring soil/sediment hydrocarbon residuals, the treatment method was deemed ineffective and alternative remediation methods were required.

This paper presents a summary of the unique site conditions associated with this impacted wetland, management and assessment of complex issues associated with the wetland and coastal region, and special requirements for post-clean-up restoration to a fully functional wetland habitat.

Giant Mine Remediation Project: Environmental Assessment and Regulatory Processes

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The Giant Mine is located in Yellowknife, Northwest Territories, and produced gold from 1948 until 1999. Gold in the Giant Mine ore is associated with an arsenic-bearing mineral known as arsenopyrite. The roasting process used to liberate the gold from the arsenopyrite led to production of arsenic trioxide dust. Approximately 237,000 tonnes is stored in sealed underground storage areas on the Giant Mine site. The arsenic trioxide dust is hazardous to both people and the environment.

After the mine owner went into receivership in 1999, the mine was transferred to the Department of Indian and Northern Affairs Canada (INAC). INAC and its Technical Advisor developed a remediation plan for Giant Mine. The remediation plan outlines the clean up of the entire mine site, including the long-term management, containment and storage of the arsenic trioxide dust. The remediation plan was submitted to the Mackenzie Valley Land and Water Board for regulatory approval in October 2007.

In February 2008, the Mackenzie Valley Land and Water Board released its decision to not refer the Giant Mine Remediation Plan to environmental assessment under the *Mackenzie Valley Resource Management Act* and instead move straight to the permitting process required for the project. In March 2008, however, the City of Yellowknife, under the *Mackenzie Valley Resource Management Act*, referred the remediation plan to environmental assessment. INAC is currently participating in the environmental assessment for the Giant Mine Remediation project as the proponent for the project.

This presentation will provide an overview of the environmental assessment process for a large-scale remediation project. The presentation will focus on the steps taken by INAC and Public Works and Government Services Canada (PWSGC) to effectively participate in the environmental assessment while simultaneously completing care and maintenance activities on the site. Both the challenges and lessons learned by INAC and PWSGC will be explored.

Faro Mine Complex Remediation Project: Options and Decision Making for Closure

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The Faro Mine Complex is a very large abandoned lead-zinc mine in the Yukon Territory, Canada. In 1998, all mining operations stopped at the Faro Mine Complex after the last owner, Anvil Range Mining Corporation, was placed into receivership. Due to the nature and magnitude of the contamination there will be no walk-away solution to remediating the site. The potential for acid rock drainage is widespread in the waste rock piles and tailings impoundment. Significant impact will occur in the fish bearing rivers downstream of the site if not controlled. The provincial and federal governments have entered into a joint agreement with the local First Nation to work together on the development of a closure plan for the Faro Mine Complex. To ensure support for the preferred closure option, there was a need to involve a wide range of stakeholders/interested parties in the assessment.

This paper describes the site closure objectives, issues and the remediation options to reduce site liability and risk to human health and the environment. Other objectives are to reduce impact to traditional land use and to support socioeconomic activity for First Nations and Yukoners. A multi-attribute analysis was developed and used with stakeholder representatives to assess closure options against objectives and a cost-benefit analysis was performed with the results.

Colomac Mine Remediation Project: Project Overview

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Colomac Site History and Project Background

Colomac is located 220 km north of Yellowknife with site access via airlift and winter road. The site is upstream of the Indin Lake watershed within the traditional lands of the Tlicho people. The Bathurst caribou herd, which migrates annually through the area, are critical to the Tlicho not only as a primary food source but also as an integral part of their spiritual and cultural identity.

Mineral exploration in the area started in the 1930s and the mine operated from about 1990 through 1997. The site was abandoned by Royal Oak Mines Inc. in April 1999, leaving behind contaminated tailings, hydrocarbon impacts, open pits and quarries, waste rock dumps, hazardous materials and mine infrastructure. The most pressing issue was the management of contaminated water and, by the end of 1998, Tailings Lake was threatening to overtop Dam 1. An emergency amendment granted under Section 39 of the *Northwest Territories Waters Act* allowed for the transfer and safe storage of tailings water to the Zone 2.0 Pit.

Through comprehensive risk characterization and risk assessment, Indian and Northern Affairs Canada (INAC) worked closely with the Tlicho Elders and Executive and developed the Colomac Remediation Plan in March 2004, which was approved by the Mackenzie Valley Land and Water Board. Colomac has been undergoing full remediation since that time.

Site Risks and Mitigations

Tailings and Tailings Water Management

Water management (diversion ditch program), water treatment (Enhanced Natural Removal program using fertilizer) and construction of Dam 1B, tailings cap and spillways within the Tailings Containment Area (TCA) have effectively mitigated these risks.

Hydrocarbon Remediation

Full-scale hydrocarbon remediation commenced in 2004 with decommissioning of the former Tank Farm, soil treatment and free product recovery. Enhanced free product recovery, Steeves Lake shoreline remediation, human health and ecological risk assessment and post-closure containment planning are in progress and will form the Final Hydrocarbon Remedial Action Plan.

Major Demolition

Select mill equipment has been removed from the mill for re-use in other gold mining projects and mill decontamination and demolition will continue with the removal of residual tailings and demolition of the mill facilities, maintenance shop and camp complex. All demolition wastes will report to the non-hazardous waste landfill and salvaging options will be pursued to the extent possible.

Site Restoration

A number of stream crossings will need to be restored across the site as well as the reconstruction of a fish passage channel between Truck Lake and Steeves Lake.

Site Clean up and Non-hazardous Waste Consolidation

Almost 10,000 tonnes of clean scrap steel, tires and tailings pipe have been placed in the non-hazardous landfill (located in Zone 2.5 Pit) to date. While addressing safety hazards (loose rock and residual unexploded ordinances), the site operator, Tlicho Logistics, brought down enough rock to provide a one metre cover and address the safety hazards at the same time.

Colomac and the Tlicho Community

Fence Project

The 2008 TCA soil and vegetation survey confirmed that contaminant levels in the soil and vegetation were greatly reduced since the 2003 survey and are once again safe for the caribou. The caribou fence has been since been decommissioned.

Youth Employment and Apprenticeship Program

One of the Tlicho participants in the 2007 Youth Science Workshop was hired on as an Assistant Environmental Technician for the 2008 TCA survey. Tlicho Logistics has successfully established and maintained training priorities for Tlicho community members through the Colomac Apprenticeship Program and many of the apprentices have transferred their skills to operating mines.

Elders' Support

Tlicho Elders identified the Colomac Mine Site as a major concern early in the Tlicho Land Claim negotiation process and were instrumental in the development of the Colomac Remediation Plan. The Elders are still very much involved with Colomac and tour the site twice annually to check on wildlife issues and remediation progress.

Final Demob and Post Closure

Final demob is scheduled for March 2012 and project closure planning has started.

Assessment and Remediation of Petroleum Hydrocarbons in Fractured Bedrock at the Colomac Mine

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The Colomac mine is currently undergoing significant remedial work under the oversight of Indian and Northern Affairs Canada. As part of this effort, fuel tanks have been deconstructed and the impacted overburden from the tank farm area excavated for treatment in a biopile. Residual contamination is present in the underlying bedrock. Remediation of petroleum hydrocarbons in fractured bedrock is a difficult challenge in temperate climates, and is more complicated by the presence of permafrost and deep seasonal freezing and thawing.

To better understand the flow field and groundwater geochemistry detailed sampling and testing has been conducted since 2005 including:

- Water level measurements in approximately 35 monitoring wells;
- Water samples to measure inorganic and organic chemical concentrations as the active layer thawed and the water depth changed;
- Periodic bail tests to determine free product recovery in select wells;
- Packer tests conducted over intervals to obtain hydraulic conductivity versus depth profiles; and,

- Installation of thermistor cables and data loggers in a number of boreholes to determine the thermal regime at the site.

Remedial activities have also been undertaken including removal of free product from existing monitoring wells, excavation of a large trench in one of the most heavily contaminated areas for free product collection, and applying vacuums to some wells to enhance product recovery.

The active layer depth in the monitoring wells was highly variable, with thaw depths in excess of 20 m measured in some wells. There also exists a talik beneath a heated warehouse. Hydraulic conductivities in the bedrock ranged from 3×10^{-5} m/s to being too tight to measure at depths greater than approximately 4.5 m in some wells, but not others. Median values were approximately 4×10^{-6} m/s.

Total dissolved solids in the groundwater ranged from 100-1200 mg/L, with an average value of 600 mg/L. The groundwater is dominated by calcium, sulphate, and bicarbonate, with minor amounts of sodium, potassium, iron, manganese, and small amounts of chloride. The iron and manganese were obtained from field filtered and acidified samples, and indicate a reducing environment even up gradient of the contamination, which was surprising given the shallow nature of the site. Dissolved hydrocarbons were found in all wells sampled but one. However, many of the wells had contained free product, so concentrations obtained from these wells are questionable. In wells with no free product in 2005, CCME F1 fractions (n-C₆ to n-C₁₀) varied from 30 ug/L to a high of approximately 3500 ug/L, with a median value of approximately 400 ug/L. These geochemical indicators suggest that intrinsic bioremediation is ongoing.

Free product recovery in the fractured bedrock was very difficult. Despite thicknesses in some wells of metres of free product in the winter when the water table was at its lowest, recovery of free product after initial product removal was very slow. A large trench blasted and excavated into the bedrock in the most contaminated area had more success, however was very costly. Vacuum application to monitoring wells to enhance free product recovery was met with limited success.

5 Wing Goose Bay Remediation Project

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Department of National Defence

The Department of National Defence (DND) is currently managing over 100 suspected and confirmed contaminated areas at 5 Wing Goose Bay (located in central Labrador) and is developing a comprehensive remediation plan that will reduce or eliminate the potential risks posed by the contamination.

Environmental contamination at the Wing can be attributed to several sources. Major hydrocarbon plumes can be attributed to leaking underground and aboveground storage tanks, leaking or ruptured pipelines, and historical management and containment practices. Heavy metals and other chemical contamination (i.e., PCBs, VOCs) are due to historical waste disposal practices and the existence of numerous dumpsites.

5 Wing Goose Bay is considered a remote site, due to the limited ways of getting to the area. The Wing itself covers over 5,400 hectares, access to which is mostly unrestricted, and approximately 20% of which is comprised of wetlands. This creates a considerable habitat for aquatic and terrestrial receptors, along with human receptors from people working on the Wing and those who use the land for recreational purposes.

The challenge will be to plan and execute the remediation project in such a way as to minimize disturbance to the various impacted areas, while remediating or risk managing the contamination in accordance with Government of Canada policies related to the management of contaminated sites.

DND is taking a holistic management approach to develop and implement a comprehensive, multi-phase remedial action plan for the Wing. Instead of independently assessing each contaminated site, DND is collectively considering all the sites to achieve economies of scale, address cumulative effects (positive and negative), and optimize logistical considerations. The planned remediation completion date for this project is 2020.

This paper will present the challenges faced by DND to manage, plan and execute a large-scale remediation project in a remote area.

MOE's Pottersburg Site Decommissioning: Site Specific Remediation Challenges in an Urban Setting

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The Ontario Ministry of the Environment (MOE) owns and manages a PCB waste storage site in London, Ontario. The MOE contracted Quantum Murray LP (QMLP) to safely excavate and transport for offsite destruction approximately 36,000 cubic metres of PCB contaminated soils, sediment and debris from four landfill cells that make-up the storage site. QMLP subcontracted CH2M HILL to oversee the monitoring and provide other consulting services for the project. This project is to comply with federal Environment Canada PCB Regulation (SOR/2008-273), which requires that stored PCB waste be removed and sent to an authorized destruction facility by December 31, 2009.

This project has numerous designs and monitoring components that are unique as a result of the site's urban location. Two temporary structures were erected so that the secure PCB waste materials could be excavated under cover to prevent contaminants from making contact with rainwater and to control dust generation; one of the structures is equivalent to the length of three football fields. Over a kilometre of on-site roadways were paved for dust control and suppression.

The project monitoring includes on-site monitoring of soil, air, dust, surface water, and groundwater and off-site monitoring of air and dust. A network of off-site air monitoring equipment is being used as an early detection system so that the team can take appropriate remedial actions to protect the public and the environment. A dust control and suppression plan has been implemented to monitor and minimize the generation of dust and airborne particulates on-site. A storm water and erosion control plan is in place to control surface water quality and groundwater sentry monitoring is being completed to verify that the activities have no influence over local environmental conditions. Within the first several months of the project, over 500 dust particulate data points were measured and interpreted; approximately 250 soil samples, 36 dust swab samples from neighbouring properties; 50 PCB samples from off-site air stations; and, 10 on-site dust swab samples from trucks and other surfaces have been collected, analyzed and interpreted. Results indicate that control measures are working to satisfaction.

The construction progress and monitoring program results were shared with the community. Sensitive receptors are present adjacent and near the property and include an active day care nursery within 500 m. An extensive community outreach program is integral to the execution of the project and involves:

- Public information centres;
- Community liaison group meetings;
- Meetings with local health and safety committees, municipal and local agencies;
- Quarterly project newsletters;
- A complaints response procedure;
- A web site with project and contact information; and,
- A voicemail hotline for upcoming events and to leave a comment, question, or suggestion.

The focus of the presentation will be on components and activities to protect the public and environment and will include: the secure design features and unique remediation challenges overcome by the team, the monitoring network to provide an early warning system for public and environment protection, monitoring results and the community outreach and engagement program.

Feasibility Testing and Performance Monitoring of the Bioremediation of Contaminated Sites in the Canadian Arctic

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Polar soils are typically characterized as nutrient poor and limited in available water. In the Canadian Arctic, the bioremediation of hydrocarbon-contaminated soils is further complicated by the low temperature, which has an impact on the bioavailability of hydrocarbon substrates to bacteria and the activity of the degrading bacteria in the soil. This study describes the initial bioremediation feasibility testing and the subsequent on site treatment and monitoring of diesel fuel contaminated soils originating from several fuel spills at Canadian Forces Station (CFS)-Alert.

An initial laboratory biotreatability study evaluated the presence of hydrocarbon degrading viable bacterial populations, the genetic potential of the indigenous soil bacteria to degrade fuel hydrocarbons, and the degradation and mineralization activity of soils with and without fertilizer amendments. The results demonstrated good hydrocarbon degradation activity by the indigenous microbial population following nutrient amendment, and this activity was sustained at 4°C. Chemical analysis of the treated soil after three months of incubation showed a reduction in residual hydrocarbons of 90% and 30% at 22 and 4°C, respectively. During the spring months an on-site biopile was constructed in a bermed area at the station, and the contaminated soil was mixed with fertilizer and tilled into windrows ranging from 1-2 meters in height. Following a period of two months of on site treatment, soil samples from the treatment area showed a considerable increase in the indigenous microbial population and in the hydrocarbon degrading activity, resulting in a reduction of more than 60% of residual hydrocarbons. Soil samples taken after slightly more than one year of on site treatment showed a reduction of more than 70% of the residual hydrocarbons and substantial increases in the numbers of key bacterial genes involved in hydrocarbon degradation. These results demonstrated that a simple treatment design that includes controlled fertilizer amendment and soil tilling resulted in an effective treatment for fuel hydrocarbon contaminated soil under ambient climatic conditions at CFS-Alert.