APPENDIX 4

HIGH ARCTIC REMEDIATION AND RISK MANAGEMENT PLAN

FINAL REPORT

REMEDIATION AND RISK MANAGEMENT PLAN FOR SIX HIGH ARCTIC OIL AND GAS SITES: Romulus, Lougheed Island L1, Dale Payne, Rea Point, Drake Point and Thor Island, Nunavut

Submitted to:

PUBLIC WORKS GOVERNMENT SERVICES CANADA – ENVIRONMENTAL SERVICES
ATB Place, North Tower
5th Floor – 10025 Jasper Avenue
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Submitted by:

BluMetric Environmental Inc.
4916 49th Street
Yellowknife, NT X1A 1P3

File #: Y-B13360

September 2016

FINAL REPORT

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Submitted to:

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA – ENVIRONMENTAL SERVICES
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File #: Y-B13360

September 2016

EXECUTIVE SUMMARY

BluMetric Environmental Inc. (BluMetric ™) has been retained by Public Works and Govermnent Services Canada (PWGSC), on behalf of Indigenous and Northern Affairs Canada (INAC), to complete a Remediation and Risk Management Plan (RRMP) for Six High Arctic Oil and Gas Sites (Romulus, Lougheed Island, Dale Payne, Rea Point, Drake Point, Thor Island) located in Nunavut, Canada, under the care of INAC as part of the Federal Contaminated Sites Program (CSP).

These sites are former petroleum exploration and development operations, in some cases originating from activities that took place more than fifty years ago. The most common identified impacts at the sites are metals and petroleum hydrocarbons (PHC) in soil. Scattered debris is also present as some sites including drums, wood, scrap metal and asbestos (Dale Payne site).

BluMetric (formerly WESA) completed Phase I/II Environmental Site Assessments (ESAs) for all sites in 2012 and Phase III ESAs in 2015. The data from these assessments was incorporated into Human Health and Ecological Risk Assessments (HHERA) for each of the six sites which were completed by BluMetric in 2016. The results of the HHERAs form the basis of the RRMP for the sites as they identify areas with unacceptable levels of risk to ecological and/or human receptors.

Herein, BluMetric, in consultation with PWGSC and INAC, developed a four step approach by which to identify the most appropriate remediation or risk management measure for the six Sites. The four steps were:

- Regulatory Screening
- Risk Management evaluation matrix
  - Effectiveness
  - Ease of implementation
  - Anticipated socio-economic benefit
  - Duration of commitment
- Cost Evaluation
- Community consultation and input

Based on this process and comments received from the community meeting held in Resolute Bay on May 17, 2016 the following risk management measures are recommended for each site:

Site	Risk Management Measure	Class D Cost Estimate (+/- 50%)
Romulus	Post Signs and Monitor Land Use	$154,000
Lougheed (L1)	Post Signs and Monitor Land Use	$196,800
Dale Payne	Post Signs and Monitor Land Use as well as asbestos abatement and hazmat disposal	$235,200
Rea Point	Post Signs and Monitor Land Use	$147,400
Drake Point	Post Signs and Monitor Land Use	$238,400
Thor Island	Post Signs and Monitor Land Use	$144,400

For all sites the recommended remediation and risk management option is to Post Signs and Monitor Land Use, with the exception of Dale Payne, where an additional abatement task to remove asbestos and other hazmat is warranted. The option to post signs and monitor land use scored high in the Evaluation Matrix because it is effective at reducing and monitoring exposure to human visitors, is relatively easy to implement on a very short timeframe and is cost effective. If land use changes in the region are identified a review of the conceptual site model for the site would be triggered at that time. While some risks will remain present on the sites to ecological receptors, the risk hot spots are relatively small and exposure to these areas would have minimal effects on communities of plants and invertebrates, and migratory receptors would not typically reside on the sites for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach. Implementation of the other options would be more disruptive to the site and surroundings and would require a long field season or several years of monitoring which carry high project financial and safety risks.

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1. INTRODUCTION

BluMetric Environmental Inc. (BluMetric ™) has been retained by Public Works and Government Services Canada (PWGSC), on behalf of Indigenous and Northern Affairs Canada (INAC), to complete a Remediation and Risk Management Plan (RRMP) for Six High Arctic Sites under the High Arctic Sites Assessment project. All sites (Romulus, Lougheed Island, Dale Payne, Rea Point, Drake Point, Thor Island) are located in Nunavut, Canada, under INAC as part of the Federal Contaminated Sites Program (CSP).

These sites are former petroleum exploration and development operations, in some cases originating from activities that took place more than fifty years ago. The most common identified impacts at the sites are metals and petroleum hydrocarbons (PHC).

BluMetric (formerly WESA) completed Phase I/II Environmental Site Assessments (ESAs) for all sites in 2012 and Phase III ESAs in 2015. The data from these assessments was incorporated into Human Health and Ecological Risk Assessments (HHERA) for each of the six sites which were completed by BluMetric in 2016. The results of the HHERAs form the basis of the RRMPs for the sites as they identify areas with unacceptable levels of risk to ecological and/or human receptors.

This report presents the remedial and risk management options for the sites, evaluates them using a standardized process and presents the recommended remedial and/or risk management approach for each of the six sites.

2. REMEDIATION & RISK MANAGEMENT APPROACH (FROM SITE CLOSURE DOCUMENT – FCSAP)

Common approaches to Close or Risk Manage Contaminated Sites according to FCSAP are categorized into three basic approaches:

- Ex Situ Remediation with Offsite Disposal or Treatment – including excavation and off-site disposal of contaminated soils, sediments or other materials.
- On Site In Situ or Ex Situ Remediation – including remediation of contaminated media in place or in treatment cells located on the site to reduce/eliminate contamination to meet clean up criteria. This includes landfarming, bioremediation, groundwater pump and treat, permeable reactive barriers and monitored natural attenuation.
- Risk Management – uses the results of a risk assessment to determine which contaminants may remain in place and identifying the exposure pathways that need to be limited or eliminated for human and ecological receptors. This includes the installation of caps and barrier walls to block exposure as well as long term monitoring.

Several treatment options are available for use on site (in situ) to remediate hydrocarbons. The following table presents a summary of these remedial options. For the purposes of this analysis these options will be considered collectively as "On-site treatment". This is deemed appropriate in consideration of the similar cost, duration, effectiveness and ease (or difficulty) of implementation at any of the 6 high arctic sites.

REMEDIAL OPTION	DESCRIPTION
1. In-situ Chemical Oxidation	Injection of oxidizing agent into the undisturbed impacted soils. • May degrade permafrost at the site. • Migration of chemical into downstream surface water body may occur.
2. Soil Washing and Chemical Oxidation	The contaminated soil would be moved in a phased sequence to a soil washing treatment facility designed and constructed to facilitate desorption of the petroleum hydrocarbons from the soils and into the wash solutions. • Mobilization of soil to a treatment facility is costly for remote sites. • Requires groundwater monitoring during and after treatment.
3. Excavation and Local Disposal – Capping	The contaminated soil would be excavated using heavy equipment and disposed of at the local landfill. • Local landfill is not capable of accepting contaminated soil.
4. Excavation and Southern Disposal	The contaminated soil would be excavated using heavy equipment and transported to a southern landfill for disposal. • Transportation of impacted soils to appropriate southern disposal facilities is costly for remote sites.
5. On-site Low Temperature Thermal Desorption	Low temperature thermal desorption technology is a remediation process that involves an ex-situ means of physically separating volatile and semi-volatile organic contaminants from soils. Contaminated soil is placed in a mobile thermal treatment unit and heated to volatilize the associated hydrocarbons. The clean soil exits the Primary Chamber, where a gas stream is passed through a high-surface area bag house/filtration unit. These gases further travel to a Secondary Chamber (Oxidation Chamber) where the hydrocarbon molecules are turned to carbon dioxide and water. The treated soil is then returned to the original excavation site after it is re-hydrated and cooled. • Mobilization of treatment unit can be costly for remote sites.
6. Bioremediation	Bioremediation through bio-pile management (a modified land farming approach) involves the addition of nutrients and water, and periodic tilling to mix and aerate the impacted soils. • Effectiveness depends on water content, climate, air temperature, nutrient content, microbial colony, and aeration rate. • Requires area for setup of treatment facility. • May require groundwater monitoring during the treatment of impacted soil.

3. OPTION EVALUATION METHODOLOGY

The following flow chart depicts the overall Remedial and Risk Management Option evaluation applied for the Six High Arctic Oil and Gas Sites.

The steps are described in detail in the following paragraphs.

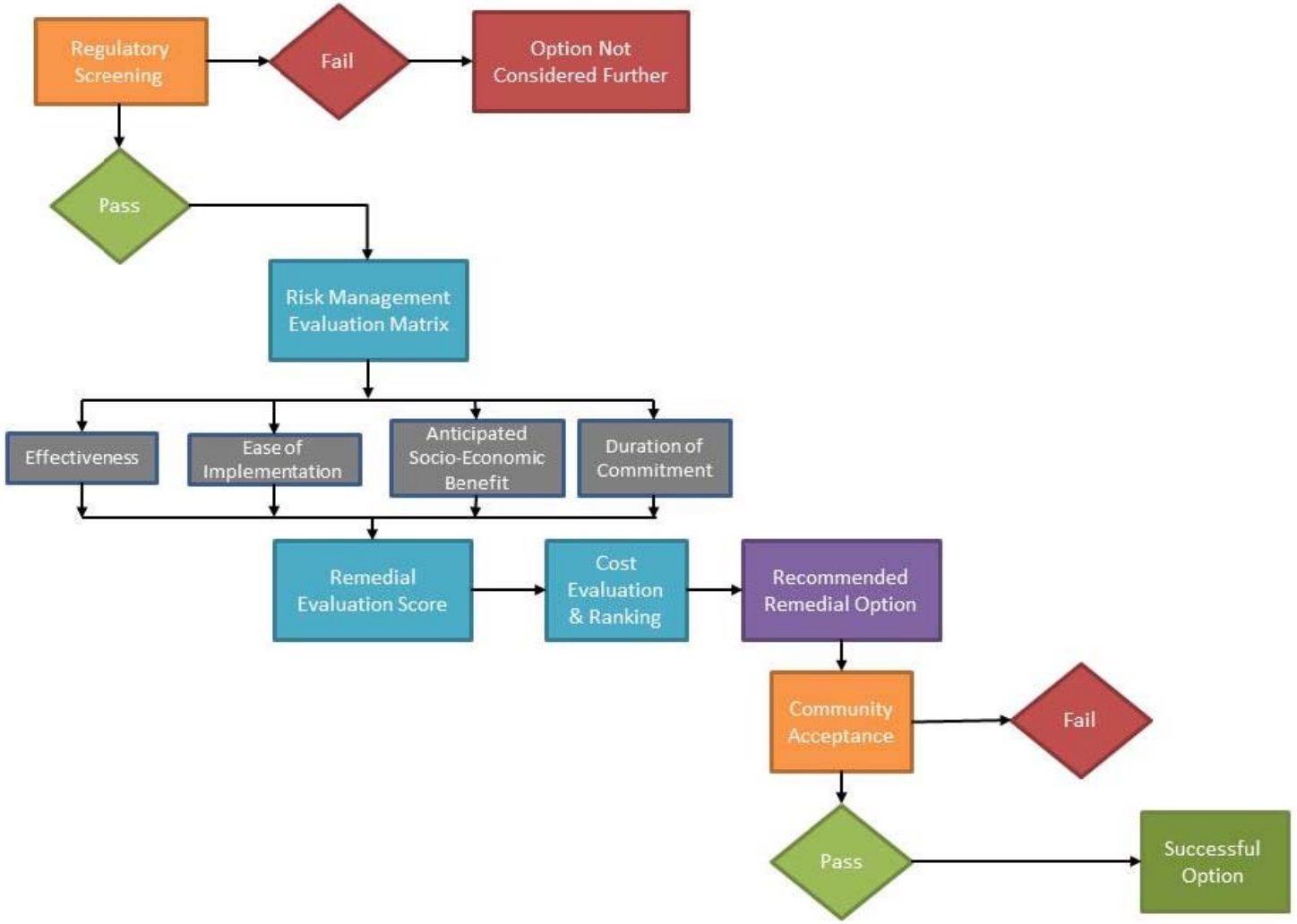
Regulatory Screening: Indicates whether the option would be considered acceptable by applicable regulators (i.e. Nunavut Land and Water Board, Environment Canada). The 'Do Nothing' option is eliminated at this stage of the process as it would not meet regulatory requirements and would not provide a mechanism to reduce environmental liability or monitor any changes in environmental risk at the sites.

Risk Management Evaluation Matrix: Represents the series of qualitative analyses that each option undergoes to evaluate various aspects of the option with respect to how it may be implemented and what impact it may have on the site and nearby communities. A remedial evaluation score is generated from this process to numerically compare each option for a given site.

Cost Evaluation: Site specific costs were developed for each option. The costs are reviewed and given a range based on their level of certainty (Class D). The magnitude of costs calculated are then considered qualitatively in conjunction with the Risk Management Evaluation scores to determine the recommended remedial option for the site.

Recommended Remedial Option: The recommended remedial option is presented to the Community for an evaluation of general acceptance. If the option is accepted, it moves forward as the successful option at which point it will undergo a more detailed costing exercise as well as a consideration on the implementation of this option with other options for the overall remedial program.

Figure 1: Proposed Remedial & Risk Management Option Assessment



3.1 Remediation and Risk Management Evaluation Matrix

The purpose of the comparative analysis was to weigh the relative performance of each option against a particular criterion, and to determine which option performs consistently well or consistently better in relation to the criterion of interest. The options were evaluated according to the following criteria:

1. **Effectiveness:** Determine if the option will be effective at protecting human health and ecological receptors at the respective AECs. Ratings applied:
   a. Expected to be minimally effective = 1
   b. Expected to be somewhat effective = 2
   c. Expected to be moderately effective = 3
   d. Expected to be fully effective = 4
2. **Ease of Implementation:** Assess the level of effort required to implement the option, the availability of needed technologies and services, and the level of logistics and time that will be required to carry out the option. Ratings applied:
   a. Complex logistics and will require more than one season = 1
   b. Moderate logistics and will require more than one season = 2
   c. Complex logistics and attainable in one season = 3
   d. Moderate logistics and attainable in one season = 4
3. **Anticipated Socio-economic Benefit:** Assess the level of economic and social benefit (i.e. employment, capacity building, and training) to the nearest community. Ratings applied:
   a. Limited socio-economic benefit (Local employment of 1-5, 0-10% budget spent locally, minimal training opportunities)= 1
   b. Some socio-economic benefit (Local employment of 5-15, 10-20% of budget spent locally, some training opportunities) = 2
   c. Moderate socio-economic benefit (Local employment of 15-25, 20-30% of budget spent locally, significant training offered) = 3
   d. Significant socio-economic benefit (Local employment of 25-50, > 30% of budget spent locally, significant training offered) = 4
4. **Duration of Commitment:** Rank the options based on the duration of the commitment for work on site. This would be dependent on the duration of treatment/site work as well as any recommended monitoring work. Ratings applied:
   a. Significant duration (7+ years of site work) = 1
   b. Long duration (6-7 years of site work) = 2
   c. Moderate duration (3-5 years of site work) = 3
   d. Short duration (1-2 years of site work) = 4

4. SITE SPECIFIC EVALUATION RESULTS

All six sites included in the scope of this project underwent Human Health and Ecological Risk Assessments (HHERAs) based on the results of the Phase III Environmental Site Assessments (ESAs) for these sites. The HHERAs looked at applicable ecological and human receptors on a site-specific basis and assessed the risks of adverse health effect from exposure to the identified hazards at each site. In cases where exposures to the identified hazards, specifically contaminants of concern (COCs) measured in environmental media (e.g. soil, groundwater, surface water or sediment), were found to be unacceptable, Site Specific Target Levels (SSTLs) were calculated for each COCs. These SSTLs could form the basis of a clean-up or management strategy for the site.

The following sections present a brief summary of the site, the results of the HHERA and provide a detailed remedial and risk management options assessment for each of the sites based on these results. A recommended remedial approach has also been identified for each site based on the options assessment and cost evaluation.

4.1 ROMULUS

4.1.1 Site Summary

The Romulus C-42 well site (herein referred to as the Site or Romulus) is designated as Romulus C-42 well site in the Northwest Territories/Nunavut contaminated sites database. Romulus is located in the Qikiqtaaluk region of Nunavut, on the west side of Ellesmere Island, about 40 km east-southeast of the research station and military facility at Eureka, Nunavut, at approximately 79.85262154 degrees N and 84.3763794 degrees W. The nearest community is Grise Fiord, Nunavut, which is located approximately 400 km south of the Site and has a population of approximately 141 (Statistics Canada 2007). The Site is a former Panarctic Oils Ltd. (Panarctic) site, a Calgary, Alberta, company whose objective was to prove oil and gas reserves in the Canadian Arctic islands.

Panarctic Oils Ltd. (Panarctic) applied for several land use permits (LUPs), N72J040, N72A139 and N72A206 in the early 1970s for work associated with the Romulus. These permits included the creation and use of unpaved roads between Romulus and Slidre Fiord, Cape Lockwood and Halcyon (possibly another exploration site). The airstrip at Romulus and a portion of the Romulus to Cape Lockwood road were used to support the development of the nearby Gemini E-10 well site, including the movement of a drilling rig and other heavy equipment from Romulus to Gemini.

The Site consists of one main area of environmental concern (AEC), which is approximately 250m x 250m (i.e. 0.06km^2). The AEC is subdivided according to the major Site features: the well head (AEC 1a), the burn pit (AEC 1b), the sump and drainage area (AEC 1c), and the camp and rig area (AEC 1d). see Figure 2.

Relevant environmental media (soil, surface water and sediment) has been sampled at AEC 1, during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016 respectively). Levels of metals and PHCs exceeding environmental guidelines were found in soil, surface water and sediment at the Site, warranting further investigation and risk assessment.

A HHERA was conducted on the site to assess the site specific risks to human and ecological receptors. Site Specific Target Levels (SSTLs) were calculated for COCs with unacceptable risks. The results are presented in the following section.

4.1.2 HHERA Results

SSTLs were developed for AECs at the site. The HHRA found no unacceptable risks to humans and no SSTLs were required for Human Receptors.

SSTLs for Ecological Receptors were developed and the estimated areas of impact for these AECs are presented in the table below.

Table 1: HHERA AECs - Romulus

Area of Environmental Concern (AEC)	Impacted Area	Impacted Medium	Contaminant Type	SSTL (µg/g)	Impacted Area (m^2)
AEC 1A – Well Head	R1-2	Soil	Barium	750	111 m^2
AEC 1B – Burn Pit	R1-1	Soil	F2 PHCs	2,500	208 m^2
AEC 1C – Sump and Drainage Area	R1-3	Soil	Barium	750	2,285 m^2

4.1.3 Remediation & Risk Management Options Evaluation

Romulus is located close the Eureka Weather Station on Ellesmere Island, Nunavut. It is assumed that personnel travelling to and from the site will utilize Eureka for accommodations as required. Barges access the weather station with supplies annually and therefore it is assumed that some staging of equipment would occur at Eureka prior to moving equipment overland to the Romulus site.

Heavy equipment is assumed to be transported from Quebec by barge and the backhaul of this equipment at the completion of the work is expected to include any material for off-site disposal as applicable to the remedial/risk management option presented.

A Twin Otter aircraft successfully landed at the site during the 2015 Site Investigation and it is anticipated that larger aircraft may be able to utilize this land area if heavy equipment is used to improve the airstrip conditions.

On-site accommodations in the form of a tent camp would be provided for remedial/risk management options with a duration of more than one week.

Table 2: Summary of Preliminary Evaluation of Risk Management Options - Romulus

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 1: Excavation and Off-site Disposal **Total Rating = 11**	The excavation and off-site disposal option is fully effective at removing soils containing all Contaminants of Concern (COCs), including petroleum hydrocarbons and metals, detected above the SSTLs. The soils would be excavated, placed into either drums or mega bags, and then transported off-site by barge for proper disposal. **Rating = 4**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Eureka and then mobilize overland to the Romulus site. Accommodations would be provided at an on-site camp. The use of barges and overland hauling means that the work will require more than one season to accomplish. If the airstrip is in good condition to land larger airplanes, the process of excavation and off-site disposal would likely require at least 45 days, depending on several factors, including weather. Following the excavation of the impacted soils, confirmatory sampling would need to be completed. Option is considered complex logistically and will require more than one season. **Rating=1**	This option is anticipated to provide a moderate socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refueling, local manpower in the form of wildlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. **Rating=3**	On-site remedial work is expected to be completed within one season (45 days), depending on weather conditions. Barges and overland hauling need to be used to demobilize the equipment and ship out containerized soil. Year 1 – Barge equipment in Year 2- Winter hauling, Summer site work and staging Year 3 – Winter hauling, Summer barging for disposal Total duration is estimated to be 3 years – Moderate Duration. **Rating = 3**
Option 2: On-site In Situ Treatment Options including Landfarming, Low Temperature Thermal Desorption, In-situ Chemical Oxidation, and Soil Washing and Chemical Oxidation **Total Rating = 8**	The on-site treatment options are effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbons, following successful treatment. During the treatment process, the concentrations of petroleum hydrocarbon COCs may be above SSTLs, and as such, a hazard to human and ecological receptors still exists. These options involve the degradation/transformation of petroleum hydrocarbons through the addition of chemicals, tilling and aeration, and/or the application of heat. Samples would be collected and analyzed at the end of the field season to determine the effectiveness of the treatment. It should be noted that all of the on-site treatment options are ineffective against metals contaminants. The timeline for on-site treatment is unknown due to the short field season and unknown effectiveness of the treatment options in the Arctic environment. This option is expected to be 'somewhat effective'. **Rating=2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Eureka and then mobilize overland to the Romulus site. Accommodations would be provided at an on-site camp. The use of barges and overland hauling means that the work will require more than one season to accomplish. If the airstrip is in good condition to land larger airplanes, the on-site treatment process would likely require at least 45 days per year and could take three years to complete the treatment, depending on several factors, including weather. Option is considered complex logistically and will require more than one season. **Rating=1**	This option is anticipated to provide moderate socioeconomic benefit to the community of Resolute. These options will require more than one field season. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required with more than one rotation each year. Some health and safety training would be offered. This option is considered to have a moderate socio-economic benefit **Rating=3**	The implementation of the option is expected to take two seasons due to the use of barges and overland hauling to mobilize and demobilize equipment. The set-up and operation of the on-site in situ treatment would require one season at a minimum and could require three operating seasons depending on the effectiveness of the treatment. Year 1 – Barge equipment to site Year 2 – Winter overland haul, treatment cell construction Year 3 - Summer treatment season 1 Year 4- Summer treatment season 2 Year 5 – Summer treatment season 3, winter overland haul Year 6 – Summer barge to demob equipment This is considered to take 6 seasons. This option is considered to have a long duration (6-7 years). **Rating = 2**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 3: Capping **Total Rating = 7**	The capping option is effective at protecting human and ecological receptors from direct contact with soils detected above the SSTLs for all COCs, including petroleum hydrocarbons and metals. The COCs will remain in the soil beneath the cap and as a result, the potential exists for some migration of contaminants due to cap degradation and/or infiltration of precipitation which could flush contaminants downgradient. As a result, this option is evaluated as somewhat effective. **Rating= 2**	The level of effort required is high as heavy equipment is required and some site improvements such as road construction could be required to reach borrow areas. The logistics of getting the services and equipment required to the site will be extensive and difficult. Barging along with overland hauling would be required to mobilize equipment and would require more than one field season. The process of capping would likely require a 45 day field program, depending on several factors, including weather. A base camp would need to be established at the site to complete the work. The mobilization of some heavy equipment is considered complex logistically. It is anticipated that this option could be achieved within two seasons with the use of barges to demobilize equipment. This option is considered to have complex logistics and would be attainable in more than one season. **Rating=1**	This option is anticipated to provide moderate socio-economic benefits to the community of Resolute. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required and would include 3 – two week rotations. Some health and safety training would be offered. This option is considered to have moderate socio-economic benefit. **Rating=3**	A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Year 1 – Barge equipment to landing area Year 2 – Winter overland haul to site. Summer capping work Year 3- Winter overland haul, Summer barging, Monitoring Year 1 Years 4 to 7 – Monitoring Years 2 to 5 The total duration of commitment for this option is anticipated to be approx. 7 years with the potential for additional monitoring. This option is considered to have a significant duration (7+ years). **Rating = 1**
Option 4: Monitored Natural Attenuation **Total Rating = 5**	The monitored natural attenuation option is minimally effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbon COCs. This option involves the degradation/transformation of petroleum hydrocarbons through biodegradation without human intervention, while periodically monitoring the on-site conditions. Biodegradation is a non-intrusive process that utilizes the natural soil bacteria and nutrients that are already present within the on-site soil. It should be noted that biodegradation is ineffective against metals contaminants. This option is considered minimally effective **Rating=1**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site monitoring can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option. Additionally, heavy equipment will not be required. During each monitoring event, soil samples would be collected within and up- and down-gradient of the AECs. During the first monitoring event, small piezometers would be installed within, and up- and down-gradient of the AECs. These piezometers would be used to collect groundwater samples during subsequent monitoring events. The monitoring events can be completed during the course of one day but will occur for multiple years. This option is considered to have moderate logistics and would require more than one season. **Rating=2**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, limited logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and possibly labourers, and the possible requirement of local general supplies and equipment. This option would have limited socio-economic benefit. **Rating=1**	Due to the non-intrusive nature of this option, and short summer season when the ground is thawed for biodegradation to take place, the timeline for this management strategy is indeterminate. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Due to the indeterminate timeline for treatment, this option is considered to have a significant duration (10 +years). **Rating = 1**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 5: Post Signage & Monitor Land Use **Total Rating = 10**	The posting of signage option is effective at protecting human receptors from direct contact with soils detected above the SSTLs for all COCs. The monitoring of land use would be done through the custodial department by consulting nearby communities, stakeholders and monitoring land use permits and leases in the area. This option is not effective at protecting ecological receptors from soils detected above the SSTLs. This option is considered to be minimally effective. **Rating=1**	The level of effort required is relatively low, and the logistics of getting the services and equipment required to the site can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option, so there is no need for an airstrip check or other considerations associated with a larger airplane. Additionally, heavy equipment will not be required. Personnel will be able to fly to Romulus from Resolute Bay via Eureka. Personnel could install all of the signs during the course of one day. Logistics are considered to be moderate and attainable in one season for this option. **Rating=4**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require a limited amount of overnight stays, meals, logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and labourers, and the possible requirement of local general supplies and equipment. **Rating=1**	This option is considered to have a short duration as it can be accomplished within one year. Minor potential for maintenance or replacement of signs due to damage from weather and wildlife. Periodic inspections efforts to be coordinated in tandem with other travel in the area. No extra costs carried for this. **Rating = 4**

4.1.4 Cost Evaluation & Ranking

The following table provides a summary of the Class D cost estimates for each option evaluated above. Costs assume the work is done as a stand-alone project. Details of the costs estimates are provided in Appendix B.

Table 3: Summary of Cost Estimates for Remedial Options at Romulus

Remedial Option	Class D Cost Estimate
Post Sign & Monitor Land Use	$154,000
Monitored Natural Attenuation	$415,000
Install Soil Cap	$3,977,710
On-Site Treatment	$4,025,350
Excavate and Off-Site Disposal	$8,234,726

Soil Capping, On-Site Treatment and Excavation are capital intensive options with complicated logistics and significant reliance on heavy equipment and associated materials, supplies and shipping.

Posting signs and monitored natural attenuation (MNA) are simpler options requiring fewer and small materials, a small labour force and less complicated logistics. MNA relies on natural processes and is a prolonged duration requiring multiple annual visits. The MNA scenario herein has assume 5 annual inspection and sampling trips, but could require more.

4.1.5 Recommended Remediation & Risk Management Option

The recommended remediation and risk management option is to Post Signs and Monitor Land Use. This option scored second highest in the Options Evaluation Matrix after Excavation and Off-site Disposal, which was approximately 50 times more expensive based on the class D cost estimates prepared for this analysis. Posting Signs and Monitoring Land Use will provide adequate protection to possible human visitors by alerting them to the risks in the area, and if land use changes in the area are identified additional actions can be triggered at that time. While some risks are present on the site for possible ecological receptors the risk hot spots are relatively small and would have minimal effects on communities of plants and invertebrates, and migratory receptors would not typically reside on the site for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach.

The other options would be more disruptive to the site and surroundings and would require long field season or several years of monitoring which carry high project financial and safety risks including:

- Uncertainty of site access from year to year due to weather and sea ice conditions
- Substantial air travel to the remote site
- Complicated logistics

4.2 LOUGHEED L1

4.2.1 Site Summary

The Lougheed Island (L1) Site (herein referred to as the Site or Lougheed Island (L1)) is designated as NB047 – Lougheed Island (L1) in the Northwest Territories/Nunavut contaminated sites database. Lougheed Island (L1) is located in the Qikiqtaaluk region of Nunavut, about 430 km northwest of Resolute Bay, Nunavut, at approximately 77.34953 degree N and 105.30697 degree W (Appendix A - Figure A-1). The Site is a former Panarctic Oils LTD. (Panarctic) site, a Calgary, Alberta, company whose objective was to prove oil and gas reserves in the Canadian Arctic islands. Lougheed Island (L1) acted as a secondary staging point for operations on Lougheed Island and as a well site for Panarctic's oil and gas exploration. Lougheed Island (L1) had very little useful historical information in the INAC records.

The Site is divided into two main areas of environmental concern (AECs) - the main site and the Pat Bay A-72 well site. The two AECs are 3.5 km apart, in the middle of Lougheed Island (Figure A-2). AEC 1 consists of one airstrip (AEC 1A), two drum caches containing 34 and 14 drums (AEC 1B), a burn pit and 5 pallet storage areas suspected to correspond to the remaining pallet laydown areas (AEC 1C), and scattered drums (AEC 1D). AEC 2 consists of the well head & camp disturbed area (AEC 2A), a camp area with burn pit and debris (AEC 2B), and two drill sumps (AEC 2C and AEC 2D). AEC 1 is approximately 200 m x 138 m and AEC 2 is approximately 186 m x 140 m in size. Figure A-4 and Figure A-5 present the site plans for each APEC. See Figures 3 and 4.

Relevant environmental media (soil) has been sampled at AECs 1 and 2, during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016a respectively). Surface water was sampled at AEC 2 during the Phase I/II investigation and the Phase III investigation (WESA 2012 and BluMetric 2016a respectively) and at AEC 1 during the Phase III investigation. Sediment was sampled at AEC 2 and ground water was sampled at AEC 1 during the Phase III investigation (BluMetric2016a). Levels of metals, PAHs, VOCs, BTEX, and PHCs exceeding environmental guidelines were found in soil in both AEC 1 and AEC 2, warranting further investigation and inclusion in the risk assessment.

A HHERA was conducted on the site to assess the site specific risks to human and ecological receptors. Site Specific Target Levels were calculated for COCs with unacceptable risks.
The results are presented in the following section.

4.2.2 HHERA Results

The HHERA found minor unacceptable risk for both human and ecological receptors from exposure to Ba, Pb, PHC F1, PHC F3, 2- and 1-methylnaphthalene,

The remedial efforts that would be required to remove impacted soil on the basis of the protection of plant and invertebrate health are likely to cause significant damage to the surrounding thriving environments. Natural re-vegetation following remediation is uncertain and will be slow at best due to the short growing season at that latitude.

Human use in the area, as a whole, is extremely limited and this risk assessment is likely to over-estimate the actual risk posed by contaminants on Site. Risk management options such as the requirement of personal protective equipment to cover exposed skin while on-site may be employed by INAC to further decrease any potential impacts for human receptors.

The estimated areas of impact for the AECs based on human health and ecological SSTLs are presented in the table below.

Table 4: HHERA AECs – Lougheed L1

Area of Environmental Concern (AEC)	Impacted Area	Impacted Medium	Contaminant Type	SSTL (µg/g)	Impacted Area (m²)
AEC 1 – Main Site	R1-2	Soil	F2 PHCs	2,500	315 m²
	R1-4	Soil	F2 PHCs	2,500	194 m²
AEC 2 – Pat Bay A-72 Well Head	R2-1	Soil	F2 PHCs, Ba and Pb	2,500, 750, 200	121 m²
	R2-2	Soil	F2 PHCs	2,500	446 m²
	R2-3	Soil	F2 PHCs	2,500	218 m²

4.2.3 Remediation & Risk Management Options Evaluation

Lougheed L1 is located inland on Lougheed Island. The assumptions used in the remediation/risk management option evaluation include using barges to mobilize heavy equipment to Lougheed Island and then to use overland hauling during the winter to access the site. This could be achieved via the beach near Lougheed Island Airstrip to the east, or from the western coastline. This would require an additional season of work on either end of the remediation/risk management to demobilize equipment by winter haul back out to the coast.

Heavy equipment is assumed to be transported from Quebec by barge and the backhaul of this equipment at the completion of the work is expected to include any material for off-site disposal as applicable to the remedial/risk management option presented.

Rotary aircraft were utilized to access the site during the 2015 Site Investigation. It is anticipated that fixed wing aircraft may be able to land at the site if heavy equipment is used to improve the airstrip conditions.

On-site accommodations in the form of a tent camp would be provided for remedial/risk management options with a duration of more than one week.

A total of 50 drums are present on the site which would be backhauled with soil and/or heavy equipment as applicable to the remediation/risk management options presented.

Table 5: Summary of Preliminary Evaluation of Risk Management Options – Lougheed L1

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 1: Excavation and Off-site Disposal **Total Rating = 11**	The excavation and off-site disposal option is fully effective at removing soils containing all Contaminants of Concern (COCs), including petroleum hydrocarbons and metals, detected above the SSTLs. The soils would be excavated, placed into either drums or mega bags, and then transported off-site by barge for proper disposal. **Rating = 4**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge on Lougheed Island and then be mobilized overland to the site during the winter. If an airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of excavation and off-site disposal would likely require at least 45 days of site work, depending on several factors, including weather. Following the excavation of the impacted soils, confirmatory sampling would need to be completed. This option is considered complex logistically and will require more than one season. **Rating=1**	This option is anticipated to provide a moderate socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refueling, local manpower in the form of willdlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. **Rating=3**	On-site remedial work is expected to be completed within one season (45 days), depending on weather conditions. Barges and winter trails would need to be used to mob/demob the equipment and ship out containerized soil which would take 2 to 3 seasons. Year 1 – Barge equipment to Lougheed Strip landing area Year 2 – Winter hauling to site, Summer site work Year 3 – Winter hauling to Lougheed Strip barge landing area, Summer Barging Total duration is estimated to be 3-5 years – a moderate duration. **Rating = 3**
Option 2: On-site In Situ Treatment Options including Landfarming, Low Temperature Thermal Desorption, In-situ Chemical Oxidation, and Soil Washing and Chemical Oxidation **Total Rating = 8**	The on-site treatment options are effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbons, following successful treatment. During the treatment process, the concentrations of petroleum hydrocarbon COCs may be above SSTLs, and as such, a hazard to human and ecological receptors still exists. These options involve the degradation/transformation of petroleum hydrocarbons through the addition of chemicals, tilling and aeration, and/or the application of heat. Samples would be collected and analyzed at the end of the field season to determine the effectiveness of the treatment. It should be noted that all of the on-site treatment options are ineffective against metals contaminants. The timeline for on-site treatment is unknown due to the short field season and unknown effectiveness of the treatment options in the Arctic environment. This option is expected to be 'somewhat effective'. **Rating=2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge on Lougheed Island and then be mobilized overland to the site during the winter. If an airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of on-site treatment would likely require at least 45 days of site work, depending on several factors, including weather. This option is considered complex logistically and will require more than one season. **Rating=1**	This option is anticipated to provide moderate socioeconomic benefit to the community of Resolute. These options will require more than one field season. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required with more than one rotation each year. Some health and safety training would be offered. This option is considered to have a moderate socio-economic benefit **Rating=3**	The set-up and operation of the on-site in situ treatment would require one season at a minimum and could require three operating seasons depending on the effectiveness of the treatment. Barges and winter trails would need to be used to mob/demob the equipment. Year 1 – Barge equipment to site Year 2 – Winter overland haul, treatment cell construction Year 3 - Summer treatment season 1 Year 4 - Summer treatment season 2 Year 5 – Summer treatment season 3, winter overland haul Year 6 – Summer barge to demob equipment Total duration is estimated to be 6-7 years – a long duration. **Rating = 2**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 3: Capping **Total Rating = 7**	The capping option is effective at protecting human and ecological receptors from direct contact with soils detected above the SSTLs for all COCs, including petroleum hydrocarbons and metals. The COCs will remain in the soil beneath the cap and as a result, the potential exists for some migration of contaminants due to cap degradation and/or infiltration of precipitation which could flush contaminants downgradient. As a result, this option is evaluated as somewhat effective. **Rating= 2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge on Lougheed Island and then be mobilized overland to the site during the winter. If an airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of capping would likely require at least 45 days of site work, depending on several factors, including weather. This option is considered complex logistically and will require more than one season. **Rating=1**	This option is anticipated to provide moderate socio-economic benefits to the community of Resolute. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required and would include 3 – two week rotations. Some health and safety training would be offered. This option is considered to have moderate socio-economic benefit. **Rating=3**	The implementation of the option is expected to take one season to construct and implement the capping and 2-3 seasons to mobilize and demobilize equipment. Barges and winter trails would need to be used to mob/demob the equipment. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Year 1 – Barge equipment to Lougheed Strip landing area Year 2 – Winter hauling to site, Summer site work Year 3 – Winter hauling to Lougheed Strip landing area, Summer Barging, Monitoring Year 1 Years 4 to 7 – Monitoring Years 2 to 5 Total duration is estimated to be 7 years – a significant duration. **Rating = 1**
Option 4: Monitored Natural Attenuation **Total Rating = 5**	The monitored natural attenuation option is minimally effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbon COCs. This option involves the degradation/transformation of petroleum hydrocarbons through biodegradation without human intervention, while periodically monitoring the on-site conditions. Biodegradation is a non-intrusive process that utilizes the natural soil bacteria and nutrients that are already present within the on-site soil. It should be noted that biodegradation is ineffective against metals contaminants. This option is considered minimally effective **Rating=1**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site monitoring can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option. Additionally, heavy equipment will not be required. During each monitoring event, soil samples would be collected within and up- and down-gradient of the AECs. During the first monitoring event, small piezometers would be installed within, and up- and down-gradient of the AECs. These piezometers would be used to collect groundwater samples during subsequent monitoring events. The monitoring events can be completed during the course of one day but will occur for multiple years. This option is considered to have moderate logistics and would require more than one season. **Rating=2**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, limited logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and possibly labourers, and the possible requirement of local general supplies and equipment. This option would have limited socio-economic benefit. **Rating=1**	Due to the non-intrusive nature of this option, and short summer season when the ground is thawed for biodegradation to take place, the timeline for this management strategy is indeterminate. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Due to the indeterminate timeline for treatment, this option is considered to have a significant duration (10 +years). **Rating = 1**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 5: Post Signage & Monitor Land Use **Total Rating = 10**	The posting of signage option is effective at protecting human receptors from direct contact with soils detected above the SSTLs for all COCs. This option is not effective at protecting ecological receptors from soils detected above the SSTLs. The monitoring of land use would be done through the custodial department by consulting nearby communities, stakeholders and monitoring land use permits and leases in the area. This option is considered to be minimally effective. **Rating=1**	The level of effort required is relatively low, and the logistics of getting the services and equipment required to the site can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option, so there is no need for an airstrip check or other considerations associated with a larger airplane. Additionally, heavy equipment will not be required. Personnel will be able to fly to Lougheed Island directly from Resolute Bay and can install all of the signs during the course of one day. Logistics are considered to be moderate and attainable in one season for this option. **Rating=4**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require a limited amount of overnight stays, meals, logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and labourers, and the possible requirement of local general supplies and equipment. **Rating=1**	This option is considered to have a short duration as it can be accomplished within one year. Minor potential for maintenance or replacement of signs due to damage from weather and wildlife. Periodic inspections efforts to be coordinated in tandem with other travel in the area. No extra costs carried for this. **Rating = 4**

4.2.4 Cost Evaluation & Ranking

The following table provides a summary of the Class D cost estimates for each option evaluated above. Costs assume the work is done as a stand-alone project. Details of the cost estimates are provided in Appendix B.

Table 6: Summary of Cost Estimates for Remedial Options at Lougheed L1

Remedial Option	Class D Cost Estimate
Post Sign & Monitor Land Use	$196,800
Monitored Natural Attenuation	$676,300
Install Soil Cap	$4,008,740
On-Site Treatment	$4,063,676
Excavate and Off-Site Disposal	$6,063,956

Soil Capping, On-Site Treatment and Excavation are capital intensive options with complicated logistics and significant reliance on heavy equipment and associated materials, supplies and shipping. If the airstrip cannot be improved, personnel transport for staff rotations and annual monitoring would be exclusively by helicopter, which is much more expensive and risky.

Posting signs and MNA are simpler options requiring fewer and small materials, a small labour force and less complicated logistics. MNA relies on natural processes and is a prolonged duration requiring multiple annual visits. The MNA scenario herein has assumed 5 annual inspection and sampling trips, but could require more.

4.2.5 Recommended Remediation & Risk Management Option

The recommended remediation and risk management option is to Post Signs and Monitor Land Use. This option scored second highest in the Options Evaluation Matrix after Excavation and Off-site Disposal, which was approximately 30 times more expensive based on the class D cost estimates prepared for this analysis. Posting Signs and Monitoring Land Use will provide adequate protection to possible human visitors by alerting them to the risks in the area, and if land use changes in the area are identified additional actions can be triggered at that time. At the time of sign installation the few drums scattered around the site should be consolidated into one area and as aircraft cabin capacity allows should be removed and properly disposed off site.

While some risks are present on the site for possible ecological receptors the risk hot spots are relatively small and would have minimal effects on communities of plants and invertebrates, and migratory receptors would not typically reside on the site for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach.

The other options would be more disruptive to the site and surroundings and would require long field season or several years of monitoring which carry high project financial and safety risks including:

- Uncertainty of site access from year to year due to weather and sea ice conditions
- Substantial air travel to the remote site
- Complicated logistics

4.3 DALE PAYNE

4.3.1 Site Summary

The Dale Payne Site is designated as NB045 – Lougheed Island (Dale Payne) in the Northwest Territories/Nunavut contaminated sites database. Dale Payne is located in the Qikiqtaaluk region of Nunavut, about 410 km west-northwest of Resolute Bay, Nunavut, at approximately 77.436699 degree N and 105.444878 degree W.

Land Use Permit (LUP) N80J193 was granted by Indian and Northern Affairs Canada (INAC) Land Administration in 1980 to PR Exploration (Dale Payne & Associates was named as the field supervisor) for the storage of bulk fuel and heavy equipment as well as for the use of a nearby airstrip. Specific equipment included in this LUP included three D-7 crawler tractors, seven sleigh mounted camp units, three sleigh mounted geophones, ten 500 gallon sleigh mounted steel metal fuel tanks, and eleven track mounted line vehicles and ice drills. It is suspected that the equipment at the current NB045 – Dale Payne site originated from LUP N80J193.

Lease 79 D/7-2 was granted by INAC Lands Administration for a term lasting from July 1, 1986 to June 30, 1989 for the storage of the Dale Payne equipment. The lease was for a 140 m by 140 m square plot of land (19,600 m^2) located on Lougheed Island. The lease stated that the land was to be returned in restored condition and that all buildings or structures on the land were to be removed within three months of the lease termination or expiration date.
A renewal of the lease 79 D/7-2 was drafted in July 1989. Dale Payne & Associates refused to sign the lease on the basis of wanting more time to remove the equipment from the Site and that 60% of the Site was owned by Lorne H. Reed and Associates Ltd.

In June 1992, INAC wrote to Dale Payne advising that they contact Panarctic Oils to co-ordinate clean-up of the NB045 Dale Payne site. Panarctic Oils was contacted, but refused to aid in the clean-up due to the proposed work being too expensive to pursue. It was requested by Dale Payne & Associates that the site be left as is.

The Site is grouped into one area of environmental concern (AEC 1) related to the storage of buildings and fuel tanks moved from another oil and gas exploration site. The AEC is subdivided according to the major Site features: the former landfill area (AEC 1a), the main site (AEC 1b), the drum laydown area (AEC 1c), and the Site buildings (AEC 1d). The Site area is approximately 140 m by 200 m. See Figure 5.

Relevant environmental media (soil) has been sampled at AEC 1, during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016 respectively). Surface water was sampled at AEC 1 during the Phase I/II investigations (WESA 2012). Levels of metals, PHCs, benzene, toluene, ethylbenzene, xylene (collectively referred to as BTEX), polycyclic aromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs) exceeding environmental guidelines were found in soil within AEC 1, warranting further investigation and inclusion in the risk assessment.

Building materials were also assessed in the trailers on site. Asbestos-containing materials were found inside the trailers. Batteries and small quantities of other hazardous materials were also found including some residual petroleum liquids. The exterior orange paint on the trailers were sampled and found to contain elevated concentrations of lead. Paint was well adhered at the time of the 2015 site visits.

A HHERA was conducted on the site to assess the site specific risks to human and ecological receptors. Site Specific Target Levels were calculated for COCs in environmental media with unacceptable risks. The results are presented in the following section.

4.3.2 HHERA Results

The COCs assessed in the human health risk assessment included PHC F2 and 2-and 1-methylnaphthalene. Exposures associated with incidental ingestion of soil, inhalation of soil particulates, dermal contact with soil, and inhalation of outdoor air vapours were assessed. No unacceptable risks were found for human receptors.

For ecological receptors, unacceptable risk was found for plant species from elevated PHC-F2, PHC-F3, xylene, 1-1-biphenyl, 2-and 1- methylnaphthalene, and naphthalene concentrations in soil. Unacceptable risk was found for soil invertebrate species from elevated PHC-F1, PHC-F2, PHC-F3, xylene, and 2-and 1-methylnaphthalene concentrations in soil. Risk estimates for higher trophic level organisms were not included in the ERA as no COCs exceeded the applicable ecological screening guidelines.

Based on the small spatial scale of impacts, the loss of some individual sensitive plant and invertebrate species will likely have negligible effects to the community as a whole and their ecological function as food for wildlife. Any sort of remedial works to address the contamination found in the worked areas has a high potential to disturb the surrounding natural environment and cause environmental damage in these areas.

SSTLs for Ecological Receptors were developed and the estimated areas of impact for these AECs are presented in the table below.

Table 7: HHERA AECs – Dale Payne

Area of Environmental Concern (AEC)	Impacted Area	Impacted Medium	Contaminant Type	SSTL (µg/g)	Impacted Area (m^2)
AEC 1A – Former Landfill Area	R1-1	Soil	F2 PHCs, and 2- and 1-methylnaphthalene	2,500, 8.8	327 m^2
	R1-2	Soil	F2 PHCs, naphthalene, and 2- and 1-methylnaphthalene	2,500, 8.8	17 m^2
	R1-4	Soil	F2 PHCs	2,500	24 m^2
AEC 1C – Drum Laydown Area	R1-5	Soil	Xylenes, naphthalene, and 2- and 1-methylnaphthalene	95, 8.8, 8.8	7 m^2
AEC 1D – Site Buildings	N/A	Building Materials	Lead based paint exceeding criteria	Not applicable	445 m^2
	N/A	Flooring	Asbestos containing materials - chrysotile	0.5 % by dry weight	70 m^2
	N/A	3 thermostats, 30 fluorescent light tubes	Mercury containing materials	Not applicable	N/A
	N/A	Refrigerator containing R-12	Halocarbons	Not applicable	N/A

Asbestos-containing materials and other hazmats inside the trailers pose a minor risk to potential occupants if disturbed. The exterior paint was well adhered to the structures and was not deemed to be a concern at the time of the site investigation. The physical structures appeared in good condition at the time of the Phase III ESA site visit and were not deemed to be a concern.

4.3.3 Remediation & Risk Management Options Evaluation

Dale Payne is located inland on Lougheed Island. The assumptions used in the remediation/risk management option evaluation include using barges to mobilize heavy equipment to Lougheed Island and then to use overland hauling during the winter to access the site. This could be achieved via the beach near Lougheed Island Airstrip to the east or from the western coastline.

This would require an additional season of work on either end of the remediation/risk management to haul equipment over land between the coast and the site.
Dale Payne is the only High Arctic site that includes a significant amount of hazardous and non-hazardous waste requiring transport off-site. This is included in the evaluation of options which include the use of heavy equipment where a backhaul can be utilized for waste disposal off-site.

Heavy equipment is assumed to be transported from Quebec by barge and the backhaul of this equipment at the completion of the work is expected to include any material for off-site disposal as applicable to the remedial/risk management option presented.

Rotary aircraft were utilized to access the site during the 2015 Site Investigation. It is anticipated that fixed wing aircraft may be able to land at the site if heavy equipment is used to improve the airstrip conditions.

On-site accommodations in the form of a tent camp would be provided for remedial/risk management options with a duration of more than one week.

Table 8: Summary of Preliminary Evaluation of Risk Management Options – Dale Payne

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 1: Excavation and Off-site Disposal – Contaminated Soil **Abatement and Disposal of Asbestos, Batteries, Mercury Switches and Liquids** **Total Rating = 11**	The excavation and off-site disposal option is fully effective at removing soils containing all Contaminants of Concern (COCs), including petroleum hydrocarbons and PAHs, detected above the SSTLs. The soils would be excavated, placed into either drums or mega bags, and then transported off-site by barge for proper disposal. Abatement, packaging and disposal is fully effective at eliminating risk of exposure and possible spread into the environment. **Rating = 4**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge on Lougheed Island and then be mobilized overland to the site during the winter. If an airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of excavation and off-site disposal would likely require at least 45 days of site work, depending on several factors, including weather. Following the excavation of the impacted soils, confirmatory sampling would need to be completed. This option is considered complex logistically and will require more than one season. Hazardous materials would be packaged and shipped off site with other equipment. Abatement will required a small amount of additional specialized equipment and training for personnel. **Rating=1**	This option is anticipated to provide a moderate socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refueling, local manpower in the form of wildlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. Abatement and disposal work will require asbestos awareness training and equipment handling. **Rating=3**	On-site remedial work is expected to be completed within one season (45 days), depending on weather conditions. Barges and overland hauling need to be used to demobilize the equipment and ship out containerized soil and waste. Year 1 – Barge equipment into Lougheed Strip landing area Year 2- Winter hauling to site, Summer site work and staging Year 3 – Winter hauling, Summer barging for disposal Total duration is estimated to be 3 years – Moderate Duration. **Rating = 3**
Option 2: On-site In Situ Treatment Options including Landfarming, Low Temperature Thermal Desorption, In-situ Chemical Oxidation, and Soil Washing and Chemical Oxidation **Abatement and Disposal of Asbestos, Batteries, Mercury Switches and Liquids** **Total Rating = 9**	On-site treatment options are effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbons and PAHs following successful treatment. During the treatment process, the concentrations of petroleum hydrocarbon COCs may be above SSTLs, and as such, a hazard to human and ecological receptors still exists. These options involve the degradation/transformation of petroleum hydrocarbons through the addition of chemicals, tilling and aeration, and/or the application of heat. Samples would be collected and analyzed at the end of the field season to determine the effectiveness of the treatment. The timeline for on-site treatment is unknown due to the short field season and unknown effectiveness of the treatment options in the Arctic environment. This option is expected to be 'moderately effective'. Abatement, packaging and disposal is fully effective at eliminating risk of exposure and possible spread into the environment. **Rating=3**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge on Lougheed Island and then be mobilized overland to the site during the winter. If an airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of on-site treatment would likely require at least 45 days of site work, depending on several factors, including weather. This option is considered complex logistically and will require more than one season. Hazardous materials would be packaged and shipped off site with other equipment. Abatement will required a small amount of additional specialized equipment and training for personnel. **Rating=1**	This option is anticipated to provide moderate socioeconomic benefit to the community of Resolute. These options will require more than one field season. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required with more than one rotation each year. Some health and safety training would be offered. This option is considered to have a moderate socio-economic benefit Abatement and disposal work will require asbestos awareness training and equipment handling. **Rating=3**	The set-up and operation of the on-site in situ treatment would require one season at a minimum and could require three operating seasons depending on the effectiveness of the treatment. Barges and winter trails would need to be used to mob/demob the equipment. Year 1 – Barge equipment to Lougheed Strip Barge landing Year 2 – Winter overland haul, Summer construction of treatment cell Year 3 - Summer treatment season 1 Year 4- Summer treatment season 2 Year 5 – Summer treatment season 3, winter overland haul to Lougheed Strip Barge Landing Year 6 – Summer barge to demob equipment Total duration is estimated to be 6-7 years – a long duration. **Rating = 2**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 3: Capping **Abatement and Disposal of Asbestos, Batteries, Mercury Switches and Liquids** **Total Rating = 7**	The capping option is effective at protecting human and ecological receptors from direct contact with soils detected above the SSTLs for all COCs, including petroleum hydrocarbons and PAHs. The COCs will remain in the soil beneath the cap and as a result, the potential exists for some migration of contaminants due to cap degradation and/or infiltration of precipitation which could flush contaminants downgradient. As a result, this option is evaluated as somewhat effective. Abatement, packaging and disposal is fully effective at eliminating risk of exposure and possible spread into the environment. **Rating= 2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge on Lougheed Island and then be mobilized overland to the site during the winter. If an airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of capping would likely require at least 45 days of site work, depending on several factors, including weather. This option is considered complex logistically and will require more than one season. Hazardous materials would be packaged and shipped off site with other equipment. Abatement will required a small amount of additional specialized equipment and training for personnel. **Rating=1**	This option is anticipated to provide moderate socio-economic benefits to the community of Resolute. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required and would include 3 – two week rotations. Some health and safety training would be offered. This option is considered to have moderate socio-economic benefit. Abatement and disposal work will require asbestos awareness training and equipment handling. **Rating=3**	Implementation is expected to take one season for mob and cap construction. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Barges and winter trails would need to be used to mob/demob the equipment and ship out containerized soil & hazmats which would take 2 to 3 seasons. Year 1 – Barge equipment to Lougheed Strip landing area Year 2 – Winter hauling to site, Summer site work Year 3 – Winter hauling to Lougheed Strip barge landing area, Summer Barging, Monitoring Year 1 Years 4 to 7 – Monitoring Years 2 to 5 Total duration is estimated to be 7 years – a significant duration. **Rating = 1**
Option 4: Monitored Natural Attenuation **Abatement and Disposal of Asbestos, Batteries, Mercury Switches and Liquids** **Total Rating = 5**	Monitored natural attenuation is minimally effective at protecting human and ecological receptors from soils detected above the SSTLs for PHC and PAHs. This option involves the degradation/transformation of PHC and PAHs through biodegradation without human intervention, while periodically monitoring the on-site conditions. Biodegradation is a non-intrusive process that utilizes the natural soil bacteria and nutrients that are already present within the on-site soil. It should be noted that biodegradation is ineffective against metals contaminants. This option is considered minimally effective. Abatement, packaging and disposal is fully effective at eliminating risk of exposure and possible spread into the environment. **Rating=1**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option. Additionally, heavy equipment will not be required. During each monitoring event, soil samples would be collected within and up- and down-gradient of the AECs. During the first monitoring event, small piezometers would be installed within, and up- and down-gradient of the AECs. These piezometers would be used to collect groundwater samples during subsequent monitoring events. The monitoring events can be completed during the course of one day but will occur for multiple years. This option is considered to have moderate logistics and would require more than one season. Hazardous materials would be packaged and shipped off site with other equipment by plane. Abatement will required a small amount of additional specialized equipment and training for personnel. **Rating=2**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, limited logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and possibly labourers, and the possible requirement of local general supplies and equipment. This option would have limited socio-economic benefit. Abatement and disposal work will require asbestos awareness training and equipment handling. **Rating=1**	Due to the non-intrusive nature of this option, and short summer season when the ground is thawed for biodegradation to take place, the timeline for this management strategy is indeterminate. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Due to the indeterminate timeline for treatment, this option is considered to have a significant duration (7+ years). Abatement and disposal can occur in season, approx. 6 days. **Rating = 1**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 5: Post Signage & Monitor Land Use **Abatement and Disposal of Asbestos, Batteries, Mercury Switches and Liquids** **Total Rating = 12**	The posting of signage option is effective at protecting human receptors from direct contact with soils detected above the SSTLs for all COCs as well as hazardous materials present at the site. This option is not effective at protecting ecological receptors from soils detected above the SSTLs. The monitoring of land use would be done through the custodial department by consulting nearby communities, stakeholders and monitoring land use permits and leases in the area. This option is considered to be minimally effective. Hazardous materials abatement (e.g. Asbestos, batteries, mercury, liquids), packaging would be carried out. Hazmat would be removed from the site and properly disposed. Abatement would be fully effective for the materials removed. **Rating=2**	The level of effort required is relatively low, and the logistics of getting the services and equipment required to the site can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option, so there is no need for an airstrip check or other considerations associated with a larger airplane. Additionally, heavy equipment will not be required. Personnel will be able to fly to Lougheed Island directly from Resolute Bay and can install all of the signs during the course of one day. Logistics are considered to be moderate and attainable in one season for this option. Hazardous materials would be packaged and shipped off site with other equipment by plane. Abatement will required a small amount of additional specialized equipment and training for personnel. **Rating=4**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require a limited amount of overnight stays, meals, logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and labourers, and the possible requirement of local general supplies and equipment. Abatement and disposal work will require asbestos awareness training and equipment handling. **Rating=2**	This option is considered to have a short duration as it can be accomplished within one year. Minor potential for maintenance or replacement of signs due to damage from weather and wildlife. Periodic inspections efforts to be coordinated in tandem with other travel in the area. No extra costs carried for this. Abatement and disposal can occur in season, approx. 6 days. **Rating = 4**
Option 6: Post Signage & Monitor Land Use **Total Rating = 10**	The posting of signage option is effective at protecting human receptors from direct contact with soils detected above the SSTLs for all COCs. This option is not effective at protecting ecological receptors from soils detected above the SSTLs. The monitoring of land use would be done through the custodial department by consulting nearby communities, stakeholders and monitoring land use permits and leases in the area. No abatement and hazmat disposal is carried out in this option. This option is considered to be minimally effective. **Rating=1**	The level of effort required is relatively low, and the logistics of getting the services and equipment required to the site can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option, so there is no need for an airstrip check or other considerations associated with a larger airplane. Additionally, heavy equipment will not be required. Personnel will be able to fly to Lougheed Island directly from Resolute Bay and can install all of the signs during the course of one day. Logistics are considered to be moderate and attainable in one season for this option. **Rating=4**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require a limited amount of overnight stays, meals, logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and labourers, and the possible requirement of local general supplies and equipment. **Rating=1**	This option is considered to have a short duration as it can be accomplished within one year. Minor potential for maintenance or replacement of signs due to damage from weather and wildlife. Periodic inspections efforts to be coordinated in tandem with other travel in the area. No extra costs carried for this. **Rating = 4**

4.3.4 Cost Evaluation & Ranking

The following table provides a summary of the Class D cost estimates for each option evaluated above. Cost of each option at Dale Payne includes abatement and disposal of asbestos, batteries, mercury switches and liquids unless specified. Costs assume the work is done as a stand-alone project. Details of the cost estimates are provided in Appendix B.

Table 9: Summary of Cost Estimates for Remedial Options at Dale Payne

Remedial Option	Class D Cost Estimate
Post Sign & Monitor Land Use	$235,200
Monitored Natural Attenuation	$709,700
Install Soil Cap	$4,055,730
On-Site Treatment	$4,445,480
Excavate and Off-Site Disposal	$4,645,980
ONLY Post Signs & monitor Land Use (No Abatement work)	$192,200

Soil Capping, On-Site Treatment and Excavation are capital intensive options with complicated logistics and significant reliance on heavy equipment and associated materials, supplies and shipping. If the airstrip cannot be improved, personnel transport for staff rotations and annual monitoring would be exclusively by helicopter, which is much more expensive and risky.

Posting signs and MNA are simpler options requiring less material, a small labour force and less complicated logistics. Both approaches rely on natural processes for contaminant degradation and have a prolonged duration requiring multiple annual visits. The MNA scenario herein has assumed 5 annual inspection and sampling trips, but could require more. The added benefit of posting signs is that there is a direct warning and deterrent for people to avoid the contaminated areas.

While the lead content in the orange paint on the exterior of the trailers is elevated, the paint is well adhered and does not currently pose a risk to the environment. Removing the paint would require sandblasting or chemical removal inside an enclosure, which is not logistically feasible at the site and would likely results in more contamination in the soil around the buildings, thus it is recommended to leave the paint as is. Potential physical hazards posed by infrastructure and waste are minor and are not considered a concern.

Each cost estimate includes a task for asbestos abatement and removal of batteries and mercury switches inside the trailers, and residual petroleum liquids, and packaging and transport of these materials from the site for off-site disposal. The incremental cost of this abatement and hazmat disposal task is estimated at $43,000. Costs for travel, logistics and administration were captured

elsewhere. Once the asbestos is removed from the buildings the physical hazards will be minimal. Options 6 is provided as an example of the added benefit to removing the these hazardous wastes from the site compared to leaving them in place.

4.3.5 Recommended Remediation & Risk Management Option

The recommended remediation and risk management option is to Post Signs and Monitor Land Use as well as asbestos abatement and hazmat disposal. This option scored second highest in the Options Evaluation Matrix after Excavation and Off-site Disposal, and was approximately 20 times less expensive based on the class D cost estimates prepared for this analysis. Posting Signs and Monitoring Land Use will provide adequate protection to possible human visitors by alerting them to the risks in the area, and if land use changes in the region are identified additional actions can be triggered at that time. While some risks are present on the site for possible ecological receptors the risk hot spots are relatively small and would have minimal effects on communities of plants and invertebrates, and migratory receptors would not typically reside on the site for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach. The other options would be more disruptive to the site and surroundings and would require long field season or several years of monitoring which carry high project financial and safety risks including:

- Uncertainty of site access from year to year due to weather and sea ice conditions
- Substantial air travel to the remote site
- Complicated logistics

4.4 REA POINT

4.4.1 Site Summary

The Rea Point Site is designated as NB062 – Rea Point (1)/Melville Island and NB063 – Rea Point (2)/Melville Island in the Northwest Territories/Nunavut contaminated sites database. Rea Point is located in the Qikiqtaaluk region of Nunavut, about 320 km west-northwest of Resolute Bay, Nunavut, at approximately 75.3609885 degree N and 105.72743 degree W (Appendix A - Figure A-1).

The Site is a former Panarctic Oils Ltd. (Panarctic) site, a Calgary, Alberta, company whose objective was to prove oil and gas reserves in the Canadian Arctic islands. Panarctic Oils Ltd. (Panarctic) received their first lease for the Rea Point parcel of land on June 5, 1974. The Rea Point camp was shut down on May 17th, 1997.

Rea Point was the main basecamp location and was the staging point for all Panarctic camps. The 150-person camp consisted of a big warehouse, storage in sea cans, drills, oil barrels, and two one-million watt generators. Heat from the generators was piped to the shop and hangar for the Twin Otters. Fuel was shipped to Rea Point and then flown to other camps by Hercules aircraft. The bay at Rea Point was deep enough so that the fuel ship could come within a few metres of the shore. Fuel was stored primarily in bladders (containing several million gallons), and some tanks near the end of operations. One fuel barge was left at Rea Point. Some steel was buried at Rea Point, the rest was flown out. Panarctic was fined approximately half a million dollars for dumping steel at sea without a proper permit. At closure, most of the camp, including generators, was "landfilled" on-site. Machinery (some almost new) from King Christian Island and the Bent Horn Site on Cameron Island were moved to Rea Point; items were steam cleaned, drained of fluids, and buried in the early 1990s.

The Site is divided into three main areas of environmental concern (AECs):

- AEC 2: Camp, Storage Area, Airstrip, Sump
  - AEC 2A: Sump
  - AEC 2B: Camp – Structure 1
  - AEC 2C: Camp – Structure 2
  - AEC 2D: Generator Building
  - AEC 2E: Camp – Structure 4 & 5
  - AEC 2F: Storage Area
  - AEC 2G: Airstrip
  - AEC 2H: Anomaly
  - AEC 2I: Staining near dammed creek
- AEC 3: Landfills
  - AEC 3A: Landfill North
  - AEC 3B: Landfill South
- AEC 4: Pumping Station, Bladder Farm, Docking & Unloading Area
  - AEC 4A: Pumping Station
  - AEC 4B: Docking & Unloading Area
  - AEC 4C: Bladder Farm

The Camp, Storage Area, Airstrip and Sump (AEC 2) are located at beginning of two main drainage channels. The Landfills (AEC 3) are located approximately 200 m south of AEC 2. The Pumping Station, Bladder Farm, Docking & Unloading Area (AEC 4) are located approximately 1,000 m south of AEC 3 and are found at the southern boundary of the Site along the coastline. AEC 2, AEC 3, and AEC 4 are approximately 750,000 m^2, 93,750 m^2, and 140,625 m^2 in size, respectively. See Figures 6 – 8.

Relevant environmental media (soil) has been sampled at AECs 2, 3 and 4, during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016, respectively). Surface water was sampled at AEC 3 and 4 during the Phase I/II investigations and the Phase III investigations (WESA 2012 and BluMetric 2016, respectively). Surface water was also sampled at AEC 2 during the Phase I/II investigation (WESA 2012). Groundwater was sampled at AEC 2 during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016 respectively). Groundwater was also sampled at AEC 4 during the Phase I/II investigation (WESA 2012). Sediment was sampled at AEC 4 during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016 respectively). Sediment was also sampled at AEC 3 during the Phase III investigations
(BluMetric 2016).

Levels of PHCs, PAHs, VOCs, and boron exceeding environmental guidelines were found in soil at Rea Point. A HHERA was conducted on the site to assess the site specific risks to human and ecological receptors. Site Specific Target Levels were calculated for COCs with unacceptable risks. The results are presented in the following section.

4.4.2 HHERA Results

Potential risk associated with elevated on-Site soil concentrations of Ba, PHC F1-F3 fractions, and 2- and 1-methylnaphthalene has been found for ecological receptors. Risk to human receptors is acceptable based on current site conditions.

For ecological receptors, risk was found for plant species from elevated PHC F2 and F3 fractions and 2- and 1-methyl Naphthalene in soil. Risk was found for invertebrate species from elevated Ba, PHC F1-F3 fractions and 2- and 1-methyl Naphthalene. Higher trophic level terrestrial organisms are not expected to be at risk from the CoPC concentrations at the Site.

Site Specific Target Levels were developed for AECs at the site. The HHRA found that no SSTLs were required for applicable Human Receptors.

SSTLs for Ecological Receptors were developed and the estimated areas of impact for these AECs are presented in the table below.

Table 10: HHERA AECs – Rea Point

Area of Environmental Concern (AEC)	Impacted Area	Impacted Medium	Contaminant Type	SSTL (µg/g)	Impacted Area (m²)
AEC 2E – Camp Structure 4 & 5	R2-1	Soil	F2 PHCs, and 2- and 1-methylnaphthalene	2,500, 8.8	1,102 m²
AEC 2D – Camp Structure	R2-3	Soil	Barium	750	89 m²
	R2-4	Soil	F2 PHCs	2,500	335 m²
AEC 2F – Storage Area	R2-7	Soil	Barium	750	1,074 m²
AEC 2I – Staining Near Dammed Creek	R2-8	Soil	F2 PHCs	2,500	354 m²
AEC 3A – Landfill North	R3-1	Soil	F2 PHCs	2,500	1,282 m²
AEC 4A – Pumping Station	R4-1	Soil	F2 PHCs, and 2- and 1-methylnaphthalene	2,500, 8.8	1,114 m²

4.4.3 Remediation & Risk Management Options Evaluation

Rea Point is located on the eastern shoreline of Melville Island which allows for barge access directly to the site. Historical operations at the site used large ships to mobilize equipment so the potential effectiveness of barges for mobilization and demobilization of equipment is high.

Heavy equipment is assumed to be transported from Quebec by barge and the backhaul of this equipment at the completion of the work is expected to include any material for off-site disposal as applicable to the remedial/risk management option presented.

The airstrip at Rea Point accommodated Hercules aircraft during historical site operations. In order to mobilize the camp and supplies for the 2015 investigation, a Dash 7 aircraft was utilized. The airstrip was found to be a bit soft for anything larger, but it is anticipated that some recondition of the airstrip could occur once heavy equipment is on site.

General site access in late July-August at Rea Point was good with the site consisting of mainly sand with no significant features noted that would bar access to the AECs to be remediated/risk managed.

On-site accommodations in the form of a tent camp would be provided for remedial/risk management options with a duration of more than one week. It should be noted that there are not significant quantities of freshwater for drinking available adjacent to the airstrip at the site. A small freshwater stream was utilized to the north of the airstrip but water levels may fluctuate depending on the proximity to freshet.

Table 11: Summary of Preliminary Evaluation of Risk Management Options – Rea Point

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 1: Excavation and Off-site Disposal **Total Rating = 13**	The excavation and off-site disposal option is fully effective at removing soils containing all Contaminants of Concern (COCs), including petroleum hydrocarbons, PAHs and metals, detected above the SSTLs. The soils would be excavated, placed into either drums or mega bags, and then transported off-site by barge for proper disposal. **Rating = 4**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Rea Point. If the airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land with requirement materials and supplies. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of excavation and off-site disposal would likely require at least 45 days of site work, depending on several factors, including weather. Following the excavation of the impacted soils, confirmatory sampling would need to be completed. This option is considered to have moderate logistics and will require more than one season. **Rating=2**	This option is anticipated to provide a moderate socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refueling, local manpower in the form of wildlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. This option is considered to have a moderate socio-economic benefit **Rating=3**	On-site remedial work is expected to be completed within one season (45 days), depending on weather conditions. Barges would need to be used to mob/demob the equipment and ship out containerized soil. Year 1 – Barge equipment to Rea Point Year 2 – Summer site work, barge equipment and soil off-site Total duration is estimated to be 2 years – a short duration. **Rating = 4**
Option 2: On-site In Situ Treatment Options including Landfarming, Low Temperature Thermal Desorption, In-situ Chemical Oxidation, and Soil Washing and Chemical Oxidation **Total Rating = 10**	The on-site treatment options are effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbons and PAHs following successful treatment. During the treatment process, the concentrations of petroleum hydrocarbon and PAH COCs may be above SSTLs, and as such, a hazard to human and ecological receptors still exists. These options involve the degradation/transformation of petroleum hydrocarbons through the addition of chemicals, tilling and aeration, and/or the application of heat. Samples would be collected and analyzed at the end of the field season to determine the effectiveness of the treatment. It should be noted that all of the on-site treatment options are ineffective against metals contaminants. The timeline for on-site treatment is unknown due to the short field season and unknown effectiveness of the treatment options in the Arctic environment. This option is expected to be 'somewhat effective'. **Rating=2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Rea Point. If the airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land with requirement materials and supplies. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of on-site treatment would likely require at least 45 days of site work, depending on several factors, including weather. This option is considered to have moderate logistics and will require more than one season. **Rating=2**	This option is anticipated to provide moderate socioeconomic benefit to the community of Resolute. These options will require more than one field season. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required with more than one rotation each year. Some health and safety training would be offered. This option is considered to have a moderate socio-economic benefit **Rating=3**	The set-up and operation of the on-site in situ treatment would require one season at a minimum and could require three operating seasons depending on the effectiveness of the treatment. Barges would need to be used to mob/demob the equipment. Year 1 – Barge equipment to Rea Point, Landfarm construction Year 2 – Summer treatment season 1 Year 3- Summer treatment season 2 Year 4 – Summer treatment season 3, barge to demob equipment Total duration is estimated to be 4 years – a moderate duration. **Rating = 3**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 3: Capping **Total Rating = 8**	The capping option is effective at protecting human and ecological receptors from direct contact with soils detected above the SSTLs for all COCs, including petroleum hydrocarbons, PAHs and metals. The COCs will remain in the soil beneath the cap and as a result, the potential exists for some migration of contaminants due to cap degradation and/or infiltration of precipitation which could flush contaminants downgradient. As a result, this option is evaluated as somewhat effective. **Rating= 2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Rea Point. If the airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land with requirement materials and supplies. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of capping would likely require at least 45 days of site work, depending on several factors, including weather. This option is considered to have moderate logistics and will require more than one season. **Rating=2**	This option is anticipated to provide moderate socio-economic benefits to the community of Resolute. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required and would include 3 – two week rotations. Some health and safety training would be offered. This option is considered to have moderate socio-economic benefit. **Rating=3**	The implementation of the option is expected to take one season to construct and implement the capping and 2 seasons to mobilize and demobilize equipment. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Barges would need to be used to mob/demob the equipment. Year 1 – Barge equipment to Rea Point, initial capping work Year 2 – Finish capping work, Summer Barging Years 3 to 7 – Monitoring Years 1 to 5 Total duration is estimated to be 7 years – a significant duration. **Rating = 1**
Option 4: Monitored Natural Attenuation **Total Rating = 5**	The monitored natural attenuation option is minimally effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbon and PAH COCs. This option involves the degradation/transformation of petroleum hydrocarbons through biodegradation without human intervention, while periodically monitoring the on-site conditions. Biodegradation is a non-intrusive process that utilizes the natural soil bacteria and nutrients that are already present within the on-site soil. It should be noted that biodegradation is ineffective against metals contaminants. This option is considered minimally effective **Rating=1**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site monitoring can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option. Additionally, heavy equipment will not be required. During each monitoring event, soil samples would be collected within and up- and down-gradient of the AECs. During the first monitoring event, small piezometers would be installed within, and up- and down-gradient of the AECs. These piezometers would be used to collect groundwater samples during subsequent monitoring events. The monitoring events can be completed during the course of one day but will occur for multiple years. This option is considered to have moderate logistics and would require more than one season. **Rating=2**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, limited logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and possibly labourers, and the possible requirement of local general supplies and equipment. This option would have limited socio-economic benefit. **Rating=1**	Due to the non-intrusive nature of this option, and short summer season when the ground is thawed for biodegradation to take place, the timeline for this management strategy is indeterminate. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Due to the indeterminate timeline for treatment, this option is considered to have a significant duration (10 +years). **Rating = 1**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 5: Post Signage & Monitor Land Use **Total Rating = 10**	The posting of signage option is effective at protecting human receptors from direct contact with soils detected above the SSTLs for all COCs. This option is not effective at protecting ecological receptors from soils detected above the SSTLs. The monitoring of land use would be done through the custodial department by consulting nearby communities, stakeholders and monitoring land use permits and leases in the area. This option is considered to be minimally effective. **Rating=1**	The level of effort required is relatively low, and the logistics of getting the services and equipment required to the site can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option, so there is no need for an airstrip check or other considerations associated with a larger airplane. Additionally, heavy equipment will not be required. Personnel will be able to fly to Rea Point directly from Resolute Bay and can install all of the signs during the course of one day. Logistics are considered to be moderate and attainable in one season for this option. **Rating=4**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require a limited amount of overnight stays, meals, logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and labourers, and the possible requirement of local general supplies and equipment. **Rating=1**	This option is considered to have a short duration as it can be accomplished within one year. Minor potential for maintenance or replacement of signs due to damage from weather and wildlife. Periodic inspections efforts to be coordinated in tandem with other travel in the area. No extra costs carried for this. **Rating = 4**

4.4.4 Cost Evaluation & Ranking

The following table provides a summary of the Class D cost estimates for each option evaluated above. Costs assume the work is done as a stand-alone project. Details of the costs estimates are provided in Appendix B.

Table 12: Summary of Cost Estimates for Remedial Options at Rea Point

Remedial Option	Class D Cost Estimate
Post Sign & Monitor Land Use	$147,400
Monitored Natural Attenuation	$458,400
Install Soil Cap	$3,935,730
On-Site Treatment	$4,195,938
Excavate and Off-Site Disposal	$8,474,630

Soil Capping, On-Site Treatment and Excavation are capital intensive options with complicated logistics and significant reliance on heavy equipment and associated materials, supplies and shipping.

Posting signs and MNA are simpler options requiring fewer and small materials, a small labour force and less complicated logistics. MNA relies on natural processes and is a prolonged duration requiring multiple annual visits. The MNA scenario herein has assume 5 annual inspection and sampling trips, but could require more.

4.4.5 Recommended Remediation & Risk Management Option

The recommended remediation and risk management option is to Post Signs and Monitor Land Use. This option scored second highest in the Options Evaluation Matrix after Excavation and Off-site Disposal, which was approximately 50 times more expensive based on the class D cost estimates prepared for this analysis. Posting Signs and Monitoring Land Use will provide adequate protection to possible human visitors by alerting them to the risks in the area, and if land use changes in the area are identified additional actions can be triggered at that time. While some risks are present on the site for possible ecological receptors the risk hot spots are relatively small and would have minimal effects on communities of plans and invertebrates, and migratory receptors would not typically reside on the site for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach.

The other options would be more disruptive to the site and surroundings and would require long field season or several years of monitoring which carry high project financial and safety risks including:

- Uncertainty of site access from year to year due to weather and sea ice conditions
- Substantial air travel to the remote site
- Complicated logistics

4.5 DRAKE POINT

4.5.1 Site Summary

The Drake Point Site is designated as NB023 – Drake Point/Melville Island and NB067 – Sabine Peninsula/Melville Island in the Northwest Territories/Nunavut contaminated sites database. Drake Point is located in the Qikiqtaaluk region of Nunavut, about 420 km northwest of Resolute Bay, at approximately 76.4128351 degree N and 108.485761 degree W. The Site is a former Panarctic Oils Ltd. (Panarctic) site, a Calgary, Alberta, company whose objective was to prove oil and gas reserves in the Canadian Arctic islands.

The Site consists of thirteen disturbed areas previously used during the exploration and extraction activities by Panarctic. All areas were investigated by aerial reconnaissance and or intrusive testing. The following Areas of Environmental Concern were identified and carried forward in to the risk assessment. See Figures 9 – 13.

- AEC 1 Collingwood K-33
- AEC 3 Drake Point D-68
- AEC 4 Airstrip
- AEC 7 Drake F-78 (E-78)
- AEC 9 "Drake F-76 (off shore) Main Drilling Camp Site"
    - AEC 9a Landfill
    - AEC 9b Fabrication Shop
    - AEC 9c Generator Building
    - AEC 9d Camp
    - AEC 9e Warehouse/Shop
    - AEC 9f Outwash Area
    - AEC 9g Pipeline
    - AEC 9h Airstrip
    - AEC 9i Beach

The following sections provide a brief description of each AEC that was evaluated during the 2016 Risk Assessment.

AEC 1

Collingwood K-33 well drilled in 1974 was the northern most well of Drake Point. The site features included an airstrip, a camp, access roads, fuel storage and sumps. In 1975, drilling fluid overflowed the sump at K-33 and was drained toward a flare pit. In 1977, the final inspection was satisfactory and the final clearance was recommended. During an aerial reconnaissance of APEC 1 in 2011, there was no obvious sign of debris or disturbance at the suspected coordinates of this location. However, in 2015, the well marker, sumps, drums and buried debris were found. Relevant environmental media (soil, ground water, surface water and sediment) were sampled at this AEC during Phase III investigations (BluMetric 2016).

AEC 3

Drake Point D-68 well drilled in 1973 is located south of Drake Point K-79. The site features included an airstrip, a camp, access roads, fuel storage, dam for water and sumps. A pipeline was installed in 1973 between Drake Point D-68 and F-16. In 1974, drilling fluid overflowed the sump so a second sump was constructed. In 1978, the final inspection was satisfactory and the final clearance was recommended. During aerial reconnaissance of AEC 3 in 2011, a well marker and some debris were observed in this area. Relevant environmental media (soil, surface water and sediment) was sampled at this AEC during Phase III investigations (BluMetric 2016).

AEC 4

An airstrip was built in the 1960s west half-way between Drake Point D-68 and the camp. Due to fuel and weather constraints, it was not inspected aerially during the 2011 site investigation program. During the aerial reconnaissance of AEC 4 in 2015, a significant amount of site debris, sump and drums were observed at the suspected coordinates. Relevant environmental media (soil, surface water and sediment) was sampled at this AEC during Phase III investigations (BluMetric 2016).

AEC 7

In 1974, Drake Point F (or E)-78 well drilled in 1974 is located north of Drake-Point F-76, along the coastline. Abandonment was completed in 1993. Due to fuel and weather constraints, it was not inspected aerially during the 2011 site investigation program. During the aerial reconnaissance of AEC 7 in 2015, a well marker and partially buried drums were observed at the

suspected coordinates. Relevant environmental media (soil) was sampled at this AEC during Phase III investigations (BluMetric 2016).

AEC 9

Drake Point F-76 well drilled offshore in 1978 is located north-east of Caribou Lake, along the coastline. The site features included an airstrip, a camp, access roads, fuel storage, sumps a quarry and a pipe fabrication shop. The Drake Point site was used year-round. The main airstrip was located on a delta to north. In 1982, the camp was in general disarray and an additional camp sump was constructed. That year, the camp supported the operations for Marryatt K-71. A 1984 inspection revealed drums and debris in camp sump which were cleaned out in 1985. In 1992, the airstrip was not in use and the abandonment was completed the following year. In 1997, Drake F-76 site was inspected and all material had been removed. Relevant environmental media (soil, surface water and sediment) has been sampled at AEC 9, during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016 respectively).

A HHERA was conducted on the site to assess the site specific risks to human and ecological receptors. Site Specific Target Levels were calculated for COCs with unacceptable risks. The results are presented in the following section

4.5.2 HHERA Results

For human health, no further action is necessary in AEC 4, 7 and 9. In AEC 1, risk is driven by one sample exceeding the SSTL for PHC-F2 for the toddler receptor. In AEC 3, risk is driven by two soil samples exceeding the SSTL for Pb for the toddler receptor. The human health SSTLs for Drake Point developed in this risk assessment for PHC F2 and Pb are based on two human receptors (the toddler and an adult remediation worker). The SSTL for the toddler is the lowest value for the protection of human health.

The ecological SSTLs for Drake Point developed in the risk assessment are based on plant and soil invertebrate communities. For As, Ba, Cr, Cu, Pb, Zn, xylene, naphthalene and 2-and 1-methylnaphthalene, the SSTLs for plant communities are the lowest values for the protection of ecological health. For Ba and PHC F1 to F3, the SSTLs for soil invertebrate communities are the lowest values for the protection of ecological health. Although the localized areas of contamination present potential risk to individual wildlife, plant and soil invertebrate species, there is low risk to communities as a whole.

SSTLs were developed for AECs at the site and the estimated areas of impact for these AECs are presented in the table below.

Table 13: HHERA AECs – Drake Point

Area of Environmental Concern (AEC)	Impacted Area	Impacted Medium	Contaminant Type	SSTL (µg/g)	Impacted Area (m²)
AEC 1 – Collingwood K-33	R1-1	Soil	F2 PHCs, xylenes, and naphthalene	2,500, NV, 0.6	337 m²
AEC 3 – Drake Point K-79	R3-1	Soil	Naphthalene	0.6	335 m²
	R3-2	Soil	F2 PHCs	2,500	222 m²
	R3-4	Soil	As, Ba, Cr, Cu, Pb, Zn	30, 750, 250, 100, 200, 500	10,345 m²
AEC 4 – Suspected Airstrip, Well Head, and Camp	R4-1	Soil	F2 PHCs, naphthalene, and 2- and 1-methylnaphthalene	2,500, 0.6, NV	2,750 m²
	R4-2	Soil	F2 PHCs, naphthalene, and 2- and 1-methylnaphthalene	2,500, 0.6, NV	8,299 m²
AEC 7 – Well Head E-78	R7-1	Soil	Barium	750	69 m²
AEC 9 – F-76 Main Drilling Camp Site	R9-1	Soil	F2 PHCs and naphthalene	2,500, 0.6	868 m²
	R9-2	Soil	F2 PHCs and naphthalene	2,500, 0.6	11,405 m²
	R9-3	Soil	F2 PHCs and naphthalene	2,500, 0.6	46 m²
	R9-4A	Soil	F2 PHCs and naphthalene	2,500, 0.6	375 m²
	R9-4B	Soil	F2 PHCs and naphthalene	2,500, 0.6	396 m²
	R9-5	Soil	F2 PHCs	2,500	647 m²

Note:
NV – no value

4.5.3 Remediation & Risk Management Options Evaluation

Drake Point is a challenging site to access due to the wet conditions observed during the Site Reconnaissance and Site Investigation work performed in 2015. In addition, the AECs in question are spread out across a large geographic area. Fixed wing aircraft were unable to access the site at all in 2015 but it is known that historically a Twin Otter strip was present at AEC 9.

The main assumption for the work at Drake Point is that a camp would be established at AEC9 as it has the volumes of soil to remediate/risk manage. AEC 9 is located near to the coastline which would allow for barge access for the mobilization of heavy equipment and supplies.

The construction of roads between AEC9 and the other AECs is not feasible due to the distance (10 to 40km) and the lack of good borrow sources as the site soils are predominantly wet and tend to be fine-grained. As a result, if an AEC requires heavy equipment for a remedial/risk

management option, winter hauling of equipment and materials must occur in order to facilitate work during the short summer season.

Sites requiring heavy equipment are assumed to rely on the following timeline:

- Year 1 – Barge equipment and supplies to AEC9
- Year 2 – AEC 9 work plus winter mob to AEC7
- Year 3 – AEC 7 work plus winter mob to AEC4
- Year 4 – AEC4 work plus winter mob to AEC3
- Year 5 – AEC 3 work plus winter mob to AEC 1
- Year 6 – AEC 1 work plus winter mob back to coastline
- Year 7 – Demob of equipment and materials by barge

A helicopter would need to be utilized to move equipment and personnel from the base camp at AEC9 to whichever AEC is being remediated/risk managed each year as fixed wing access is not feasible for all other AECs.

For the on-site treatment option, it is assumed that treatment cells would have to be constructed at each AEC due to the geographic distance between locations. If one central treatment area was utilized, additional years of treatment would be added in order to account for the winter mobilization of soils from distant AECs to the central treatment site.

Table 14: Summary of Preliminary Evaluation of Risk Management Options – Drake Point

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 1: Excavation and Off-site Disposal **Total Rating = 10**	The excavation and off-site disposal option is fully effective at removing soils containing all Contaminants of Concern (COCs), including petroleum hydrocarbons, PAHs and metals, detected above the SSTLs. The soils would be excavated, placed into either drums or mega bags, and then transported off-site by barge for proper disposal. **Rating = 4**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Drake Point and then would mobilize to a new AEC each year during the winter via CAT train. Airstrip conditions were observed to be poor so overland travel with helicopter support is assumed. Accommodations would be provided at an on-site camp. The use of barges and overland transport means that the work will require 7 years to accomplish. The process of excavation and off-site disposal would likely require at least 45 days of site work per season depending on several factors, including weather. Following the excavation of the impacted soils, confirmatory sampling would need to be completed. This option is considered to have complex logistics and will require more than one season. **Rating=1**	This option is anticipated to provide a significant socio-economic benefit to the community of Resolute as the work would be spread over 7 years. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refuelling, local manpower in the form of wildlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. This option is considered to have a significant socio-economic benefit **Rating=4**	On-site remedial work is expected to be completed over 7 seasons (45 days each season), depending on weather conditions. Barges and overland hauling would need to be used to mob/demob the equipment and ship out containerized soil. Total duration is estimated to be 7+ years or a long duration. **Rating = 1**
Option 2: On-site In Situ Treatment Options including Landfarming, Low Temperature Thermal Desorption, In-situ Chemical Oxidation, and Soil Washing and Chemical Oxidation **Total Rating = 8**	The on-site treatment options are effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbons and PAHs following successful treatment. During the treatment process, the concentrations of petroleum hydrocarbon and PAH COCs may be above SSTLs, and as such, a hazard to human and ecological receptors still exists. These options involve the degradation/transformation of petroleum hydrocarbons through the addition of chemicals, tilling and aeration, and/or the application of heat. Samples would be collected and analyzed at the end of the field season to determine the effectiveness of the treatment. It should be noted that all of the on-site treatment options are ineffective against metals contaminants. The timeline for on-site treatment is unknown due to the short field season and unknown effectiveness of the treatment options in the Arctic environment. This option is expected to be 'somewhat effective'. **Rating=2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Drake Point and then would mobilize to a new AEC each year during the winter via CAT train. Airstrip conditions were observed to be poor so overland travel with helicopter support is assumed. Accommodations would be provided at an on-site camp. The use of barges and overland transport means that the work will require 7 or more years to accomplish, depending on the effectiveness of the treatment at each APEC. The process of on-site treatment would likely require at least 45 days of site work per season, depending on several factors, including weather. This option is considered to have complex logistics and will require more than one season. **Rating=1**	This option is anticipated to provide a significant socio-economic benefit to the community of Resolute as the work would be spread over 7 years. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refuelling, local manpower in the form of wildlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. This option is considered to have a significant socio-economic benefit **Rating=4**	On-site remedial work is expected to be completed over a minimum of 7seasons (45 days per season), depending on weather conditions and the effectiveness of the on-site treatment. Barges and overland hauling would need to be used to mob/demob the equipment from the AECs. Total duration is estimated to be 7+years or a long duration. **Rating = 1**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 3: Capping **Total Rating = 8**	The capping option is effective at protecting human and ecological receptors from direct contact with soils detected above the SSTLs for all COCs, including petroleum hydrocarbons, PAHs and metals. The COCs will remain in the soil beneath the cap and as a result, the potential exists for some migration of contaminants due to cap degradation and/or infiltration of precipitation which could flush contaminants downgradient. As a result, this option is evaluated as somewhat effective. **Rating= 2**	The level of effort required is high, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Drake Point and then would mobilize to a new AEC each year during the winter via CAT train. Airstrip conditions were observed to be poor so overland travel with helicopter support is assumed. Accommodations would be provided at an on-site camp. The use of barges and overland transport means that the work will require 7 years to accomplish. The process of capping would likely require at least 45 days of site work per season depending on several factors, including weather. This option is considered to have complex logistics and will require more than one season. **Rating=1**	This option is anticipated to provide a significant socio-economic benefit to the community of Resolute as the work would be spread over 7 years. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refuelling, local manpower in the form of wildlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. This option is considered to have a significant socio-economic benefit **Rating=4**	The implementation of the option is expected to take one season per APEC to construct and implement the capping. With overland mobilization of equipment, it is anticipated that the capping will take 7 years to complete. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. The duration of commitment for this option is anticipated to be 12 years. This option is considered to have a significant duration (7+ years). **Rating = 1**
Option 4: Monitored Natural Attenuation **Total Rating = 5**	The monitored natural attenuation option is minimally effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbon and PAH COCs. This option involves the degradation/transformation of petroleum hydrocarbons through biodegradation without human intervention, while periodically monitoring the on-site conditions. Biodegradation is a non-intrusive process that utilizes the natural soil bacteria and nutrients that are already present within the on-site soil. It should be noted that biodegradation is ineffective against metals contaminants. This option is considered minimally effective **Rating=1**	The level of effort required is moderate, and the logistics of getting to the AECs for monitoring can be completed with relative ease. A helicopter will be sufficient for this option but fuel caching will need to be set up to facilitate the use of the helicopter. Additionally, heavy equipment will not be required. During each monitoring event, soil samples would be collected within and up- and down-gradient of the AECs. During the first monitoring event, small piezometers would be installed within, and up- and down-gradient of the AECs. These piezometers would be used to collect groundwater samples during subsequent monitoring events. The monitoring events can be completed during the course of one day but will occur for multiple years. This option is considered to have moderate logistics and would require more than one season. **Rating=2**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, limited logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and possibly labourers, and the possible requirement of local general supplies and equipment. This option would have limited socio-economic benefit. **Rating=1**	Due to the non-intrusive nature of this option, and short summer season when the ground is thawed for biodegradation to take place, the timeline for this management strategy is indeterminate. The annual monitoring is expected to take 5-7 days per year. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Due to the indeterminate timeline for treatment, this option is considered to have a significant duration (10 +years). **Rating = 1**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 5: Post Signage & Monitor Land Use **Total Rating = 10**	The posting of signage option is effective at protecting human receptors from direct contact with soils detected above the SSTLs for all COCs. This option is not effective at protecting ecological receptors from soils detected above the SSTLs. The monitoring of land use would be done through the custodial department by consulting nearby communities, stakeholders and monitoring land use permits and leases in the area. This option is considered to be minimally effective. **Rating=1**	The level of effort required is moderate, and the logistics of getting to the AECs for the installation of signage can be completed with relative ease. A helicopter will be sufficient for this option but fuel caching will need to be set up to facilitate the use of the helicopter. Additionally, heavy equipment will not be required. Personnel will be able to fly to Drake Point directly from Resolute Bay and can install all of the signs during the course of one to two days. Logistics are considered to be moderate and attainable in one season for this option. **Rating=4**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require a limited amount of overnight stays, meals, logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and labourers, and the possible requirement of local general supplies and equipment. **Rating=1**	This option is considered to have a short duration as it can be accomplished within one year. Minor potential for maintenance or replacement of signs due to damage from weather and wildlife. Periodic inspections efforts to be coordinated in tandem with other travel in the area. No extra costs carried for this. **Rating = 4**

4.5.4 Cost Evaluation & Ranking

The following table provides a summary of the Class D cost estimates for each option evaluated above. Costs assume the work is done as a stand-alone project. Details of the costs estimates are provided in Appendix B

Table 15: Summary of Cost Estimates for Remedial Options at Drake Point

Remedial Option	Class D Cost Estimate
Post Sign & Monitor Land Use	$238,400
Monitored Natural Attenuation	$888,400
Install Soil Cap	$14,412,850
On-Site Treatment	$16,121,046
Excavate and Off-Site Disposal	$74,082,326

Soil Capping, On-Site Treatment and Excavation are capital intensive options with complicated logistics and significant reliance on heavy equipment and associated materials, supplies and shipping. Further, due to the disparate nature of the AECs from the barge landing area, winter hauling would be required to access the work sites and remediation by these approaches would take several years.

Posting signs and MNA are simpler options requiring fewer and small materials that could be mobilized by air, a small labour force and less complicated logistics. However, MNA relies on natural processes and has a prolonged duration requiring multiple annual visits. The MNA scenario herein has assume 5 annual inspection and sampling trips, but could require more. Posting signs could likely be completed at all AECs in one field season.

4.5.5 Recommended Remediation & Risk Management Option

The recommended remediation and risk management option is to Post Signs and Monitor Land Use. This option scored highest in the Options Evaluation Matrix, tied with Excavation and Off-site Disposal, but was approximately 300 times less expensive based on the class D cost estimates prepared for this analysis. Posting Signs and Monitoring Land Use will provide adequate protection to possible human visitors by alerting them to the risks in the areas, and if land use changes in the region are identified additional actions can be triggered at that time. While some risks are present on the site for possible ecological receptors the risk hot spots are relatively small and would have minimal effects on communities of plants and invertebrates, and migratory receptors would not typically reside on the sites for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach. The other options would be more disruptive to the site and surroundings and would require long field season or several years of monitoring which carry high project financial and safety risks including:

- Uncertainty of site access from year to year due to weather and sea ice conditions
- Substantial air travel to the remote site
- Complicated logistics (winter hauling between sites; helicopter access only).

4.6 THOR ISLAND

4.6.1 Site Summary

The Thor Island Site is designated as NB058 - Panarctic Oils/Thor H-28 Well in the Northwest Territories/Nunavut contaminated sites database. Thor is located in the Qikiqtaaluk region of Nunavut, approximately 440 km northwest of Resolute Bay, Nunavut, at approximately 78.1236777 degrees N and 103.1777136 degrees W. The Site is a former Panarctic Oils Ltd. (Panarctic) site, a Calgary, Alberta, company whose objective was to prove oil and gas reserves in the Canadian Arctic islands.

Supplies, equipment and fuel for the Site were brought by sealift to Panarctic's Rea Point site on Melville Island and then were delivered by plane to the closest accessible location on Thor Is. and then transported by helicopter to the well sites or camp.

The Site is divided into two main areas of environmental concern — the two well survey sites, Thor P-38 and Thor H-28. Thor H-28 (AEC 3) is located on the southern boundary of the Site along the coastline, with Thor P-38 (AEC 2) to the northwest of AEC 3 as the northern extent of the site. The AECs are approximately 2 km apart and both are approximately 200 m by 200 m (40,000 m^2) in size. See Figures 14 and 15.

An airstrip was identified as an area of potential environmental concern (APEC 1) in the ESAs. APEC 1 has been inspected visually for debris or other evidence of environmental contamination related to site use. No evidence of contamination has been reported in WESA 2012 or BluMetric 2016. Further investigation of this APEC is not warranted and it is not identified as an AEC in this risk assessment.

Relevant environmental media (soil) has been sampled at AECs 2 and 3, during the Phase I/II and Phase III investigations (WESA 2012 and BluMetric 2016 respectively). Surface water was sampled at AEC 2 during the Phase I/II investigations (WESA 2012) and at AEC 3 during the Phase I/II and Phase III investigations (BluMetric 2016). Levels of metals and PHCs exceeding environmental

guidelines were found in soil and surface water in both AEC 2 and AEC 3, warranting further investigation and inclusion in the risk assessment.

4.6.2 HHERA Results

Potential risk associated with elevated on-site soil concentrations of Ba, Pb, PHC-F2, PHC-F3, and 2- and 1- methylnaphthalene has been found for ecological receptors and for PHC-F3 for human receptors.

For the human receptors, elevated risk was found in both AEC 2 and AEC 3, for the toddler receptor and for the remediation worker through exposure by incidental soil ingestion and dermal contact due to concentrations of PHC fraction F3.

For ecological receptors, risk was found for plant species from elevated Pb, PHC-F2, PHC-F3, and 2- and 1-methylnaphthalene concentrations and for soil invertebrate species from elevated Ba, PHC-F2, and PHC-F3 concentrations. Higher trophic level organisms are not expected to be at risk from the concentrations of contaminants at the Site. Elevated Pb and 2- and 1-methylnaphthalene concentrations have been identified in AEC 3 only, while Ba, PHC-F2, and PHC-F3 concentrations exceed HQs in both AEC 2 and 3.

SSTLs were developed for AECs at the site and the estimated areas of impact for these AECs are presented in the table below.

Table 16: HHERA AECs – Thor Island

Area of Environmental Concern (AEC)	Impacted Area	Impacted Medium	Contaminant Type	SSTL (µg/g)	Impacted Area (m²)
AEC 2 – P-38 Well Site	R2-1	Soil	F3 PHCs	20,000	348 m²
	R2-2	Soil	F2 PHCs and barium	2,500, 750	313 m²
	R2-3	Soil	F2 PHCs	2,500	785 m²
AEC 3 – H-28 Well Site	R3-1	Soil	F2 PHCs	2,500	196 m²
	R3-2	Soil	F3 PHCs	20,000	113 m²
	R3-3A	Soil	F2 PHCs, Ba and Pb	2,500, 750, 200	598 m²
	R3-3B	Soil	Barium	750	527 m²
	R3-4	Soil	F2 PHCs	2,500	154 m²

4.6.3 Remediation & Risk Management Options Evaluation

Thor Island is located adjacent to the shoreline which allows for barge access to the site. The assumptions used in the remediation/risk management option evaluation include using barges to mobilize heavy equipment to Thor Island.

Heavy equipment is assumed to be transported from Quebec by barge and the backhaul of this equipment at the completion of the work is expected to include any material for off-site disposal as applicable to the remedial/risk management option presented.

Rotary aircraft and Twin Otter fixed wing aircraft were utilized to access the site during the 2015 Site Investigation. It is anticipated that larger fixed wing aircraft may be able to land at the site if heavy equipment is used to improve the airstrip conditions. Also, a historical airstrip is present at APEC 1 which previously accommodated large aircraft such as a Hercules.

On-site accommodations in the form of a tent camp would be provided for remedial/risk management options with a duration of more than one week.

Table 17: Summary of Preliminary Evaluation of Risk Management Options – Thor Island

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 1: Excavation and Off-site Disposal **Total Rating = 13**	The excavation and off-site disposal option is fully effective at removing soils containing all Contaminants of Concern (COCs), including petroleum hydrocarbons and metals, detected above the SSTLs. The soils would be excavated, placed into either drums or mega bags, and then transported off-site for proper disposal. **Rating = 4**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Thor Island. If the airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land with requirement materials and supplies. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of excavation and off-site disposal would likely require at least 45 days of site work, depending on several factors, including weather. Following the excavation of the impacted soils, confirmatory sampling would need to be completed. This option is considered to have moderate logistics and will require more than one season. **Rating=2**	This option is anticipated to provide a moderate socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, logistical support, such as flights to and from Resolute, refueling, local manpower in the form of wildlife monitors and labourers with bi-weekly rotations, and some health and safety training would be offered. **Rating=3**	On-site remedial work is expected to be completed within one season (45 days), depending on weather conditions. Barges would need to be used to mob/demob the equipment and ship out containerized soil which would take 2 seasons. Year 1 – Barge to equipment to Thor, some site work Year 2 – complete site work, demob equipment by barge from site Total duration is estimated to be 2 years – a short duration. **Rating = 4**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 2: On-site In Situ Treatment Options including Landfarming, Low Temperature Thermal Desorption, In-situ Chemical Oxidation, and Soil Washing and Chemical Oxidation	The on-site treatment options are effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbons, following successful treatment. During the treatment process, the concentrations of petroleum hydrocarbon COCs may be above SSTLs, and as such, a hazard to human and ecological receptors still exists. These options involve the degradation/transformation of petroleum hydrocarbons through the addition of chemicals, tilling and aeration, and/or the application of heat. Samples would be collected and analyzed at the end of the field season to determine the effectiveness of the treatment. It should be noted that all of the on-site treatment options are ineffective against metals contaminants. The timeline for on-site treatment is unknown due to the short field season and unknown effectiveness of the treatment options in the Arctic environment. As the impacted soil will remain present, likely without a barrier to human or ecological receptors, signage would be posted during the first treatment event to warn human visitors of the presence and danger of the AECs. This option is expected to be 'somewhat effective'.	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Thor Island. If the airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land with requirement materials and supplies. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of on-site treatment would likely require at least 45 days of site work, depending on several factors, including weather. The logistics are considered moderate and the work will require more than one season.	This option is anticipated to provide moderate socioeconomic benefit to the community of Resolute. These options will require more than one field season. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required with more than one rotation each year. Some health and safety training would be offered. This option is considered to have a moderate socio-economic benefit	The set-up and operation of the on-site in situ treatment would require one season at a minimum and could require three operating seasons depending on the effectiveness of the treatment. Barges would need to be used to mob/demob the equipment which would take 2 seasons. Year 1 – Barge equipment to site, Year 2 - Construct treatment cells Year 3 –Summer treatment season 1 Year 4- Summer treatment season 2 Year 5 – Summer treatment season 3, Summer barge to demob equipment This is considered to take 5 seasons. This option is considered to have a moderate duration (3-5 years).
Total Rating = 10	**Rating=2**	**Rating=2**	**Rating=3**	**Rating = 3**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 3: Capping **Total Rating = 8**	The capping option is effective at protecting human and ecological receptors from direct contact with soils detected above the SSTLs for all COCs, including petroleum hydrocarbons and metals. The COCs will remain in the soil beneath the cap and as a result, the potential exists for some migration of contaminants due to cap degradation and/or infiltration of precipitation which could flush contaminants downgradient. As a result, this option is evaluated as somewhat effective. **Rating= 2**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site, will be extensive and difficult. Heavy equipment would need to arrive by barge at Thor Island. If the airstrip at the site can be improved it could simplify access by enabling a larger aircraft to land with requirement materials and supplies. Accommodations would be provided at an on-site camp. The use of barges means that the work will require more than one season to accomplish. The process of capping would likely require at least 45 days of site work, depending on several factors, including weather. The logistics are considered moderate and the work will require more than one season. **Rating=2**	This option is anticipated to provide moderate socioeconomic benefit to the community of Resolute. These options will require more than one field season. Community benefits include overnight stays, meals, logistical support, such as flights to and from Resolute, refueling and some procurement of local supplies. Local manpower in the form of wildlife monitors and labourers will be required with more than one rotation each year. Some health and safety training would be offered. This option is considered to have a moderate socio-economic benefit **Rating=3**	The implementation of the option is expected to take one season. Barges would need to be used to mob/demob the equipment. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Year 1 – Barge equipment to site Year 2 – Capping and demob by barge Years 3 to 7 – Monitoring years 1 to 5 The duration of commitment for this option is anticipated to be 7 years with the potential for additional monitoring. This option is considered to have a significant duration (7+ years). **Rating = 1**
Option 4: Monitored Natural Attenuation **Total Rating = 5**	The monitored natural attenuation option is minimally effective at protecting human and ecological receptors from soils detected above the SSTLs for petroleum hydrocarbon COCs. This option involves the degradation/transformation of petroleum hydrocarbons through biodegradation without human intervention, while periodically monitoring the on-site conditions. Biodegradation is a non-intrusive process that utilizes the natural soil bacteria and nutrients that are already present within the on-site soil. It should be noted that biodegradation is ineffective against metals contaminants. This option is considered minimally effective **Rating=1**	The level of effort required is moderate, and the logistics of getting the services and equipment required to the site monitoring can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option. Additionally, heavy equipment will not be required. During each monitoring event, soil samples would be collected within and up- and down-gradient of the AECs. During the first monitoring event, small piezometers would be installed within, and up- and down-gradient of the AECs. These piezometers would be used to collect groundwater samples during subsequent monitoring events. The monitoring events can be completed during the course of one day but will occur for multiple years. This option is considered to have moderate logistics and would require more than one season. **Rating=2**	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require overnight stays, meals, limited logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and possibly labourers, and the possible requirement of local general supplies and equipment. This option would have limited socio-economic benefit. **Rating=1**	Due to the non-intrusive nature of this option, and short summer season when the ground is thawed for biodegradation to take place, the timeline for this management strategy is indeterminate. A five year monitoring plan is recommended at which point data would be reviewed for applicable trends to determine if further monitoring is required. Due to the indeterminate timeline for treatment, this option is considered to have a significant duration (10 +years). **Rating = 1**

Risk Management Option	Effectiveness	Ease of Implementation	Anticipated Socio-economic Benefit	Duration of Commitment
Option 5: Post Signage & Monitor Land Use	The posting of signage option is effective at protecting human receptors from direct contact with soils detected above the SSTLs for all COCs. This option is not effective at protecting ecological receptors from soils detected above the SSTLs. The size of the impacted area is somewhat limited which lowers the potential for exposure of ecological receptors. The monitoring of land use would be done through the custodial department by consulting nearby communities, stakeholders and monitoring land use permits and leases in the area. This option is considered to be minimally effective.	The level of effort required is relatively low, and the logistics of getting the services and equipment required to the site can be completed with relative ease. A smaller airplane (i.e., Twin Otter) will be sufficient for this option, so there is no need for an airstrip check or other considerations associated with a larger airplane. Additionally, heavy equipment will not be required. Personnel will be able to fly to Thor Island from Resolute Bay and install all of the signs during the course of one day. Logistics are considered to be moderate and attainable in one season for this option.	This option is anticipated to provide a limited socio-economic benefit to the community of Resolute. This option will require a limited amount of overnight stays, meals, logistical support, such as flights to and from Resolute, limited local manpower in the form of wildlife monitors and labourers, and the possible requirement of local general supplies and equipment.	This option is considered to have a short duration as it can be accomplished within one year. Minor potential for maintenance or replacement of signs due to damage from weather and wildlife. Periodic inspections efforts to be coordinated in tandem with other travel in the area. No extra costs carried for this.
Total Rating = 10	**Rating=1**	**Rating=4**	**Rating=1**	**Rating = 4**

4.6.4 Cost Evaluation & Ranking

The following table provides a summary of the Class D cost estimates for each option evaluated above. Costs assume the work is done as a stand-alone project. Details of the cost estimates are provided in Appendix B.

Table 18: Summary of Cost Estimates for Remedial Options at Thor Island

Remedial Option	Class D Cost Estimate
Post Sign & Monitor Land Use	$144,400
Monitored Natural Attenuation	$308,400
Install Soil Cap	$3,794,930
On-Site Treatment	$3,832,880
Excavate and Off-Site Disposal	$6,355,966

Soil Capping, On-Site Treatment and Excavation are capital intensive options with complicated logistics and significant reliance on heavy equipment and associated materials, supplies and shipping. If the airstrip cannot be improved, personnel transport for staff rotations and annual monitoring may rely substantially on helicopters, which is much more expensive and risky.

Posting signs and MNA are simpler options requiring fewer and small materials, a small labour force and less complicated logistics. MNA relies on natural processes and is a prolonged duration requiring multiple annual visits, while signs can be erected in one short field visit. The MNA scenario herein has assumed 5 annual inspection and sampling trips, but could require more.

4.6.5 Recommended Remediation & Risk Management Option

The recommended remediation and risk management option is to Post Signs and Monitor Land Use. This option scored second highest (tied with On-Site Treatment) in the Options Evaluation Matrix, after Excavation and Off-site Disposal. Posting signs is 25 times less expensive than On-Site treatment and about 50 times less expensive than Excavation and Off-Site Disposal based on the class D cost estimates prepared for this analysis. Posting Signs and Monitoring Land Use will provide adequate protection to possible human visitors by alerting them to the risks in the area, and if land use changes in the region are identified additional actions can be triggered at that time. While some risks are present on the site for possible ecological receptors the risk hot spots are relatively small and would have minimal effects on communities of plants and invertebrates, and migratory receptors would not typically reside on the site for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach. The other options would be more disruptive to the site and surroundings and would require long field season or several years of monitoring which carry high project financial and safety risks including:

- Uncertainty of site access from year to year due to weather and sea ice conditions
- Substantial air travel to the remote site
- Complicated logistics

5. COMMUNITY MEETING AND CONSULTATION

Representatives from the BluMetric project team and INAC held an open community consultation meeting in Resolute Bay on May 17, 2016 to inform residents of the outcomes of site investigation work and risk assessments, as well as seek community input. The proposed remediation and risk management options were also described and the process of evaluation and selection was explained.

Fifteen members of the community attended the meeting. The meeting sign-in pages is attached in Appendix D. Several constructive comments were received from the community. Appendix C shows the list of questions and comments brought forward from the community during the weekend. The recommended management option of posting signs and monitoring land use was well accepted. The community re-affirmed that the sites are too far from town to be used for hunting and gathering, and are generally not visited. It was requested that fencing not be installed as it would interfere with wildlife migration and could possible ensnare and harm animals.

6. SUMMARY AND CONCLUSIONS

BluMetric, in consultation with PGWSC and INAC, developed a four step approach by which to identify the most appropriate remediation or risk management measure for six High Arctic Oil and Gas Sites in Nunavut. The four steps were:

- Regulatory Screening
- Risk Management evaluation matrix
    - Effectiveness
    - Ease of implementation
    - Anticipated socio-economic benefit
    - Duration of commitment

- Cost Evaluation
- Community consultation and input

Based on this process and comments received from the community meeting held in Resolute Bay on May 17, 2016 the following risk management measures are recommended for each site:

Table 19: Summary of Recommended Risk Management Measures

Site	Risk Management Measure	Class D Cost Estimate (+/- 50%)
Romulus	Post Signs and Monitor Land Use	$154,000
Lougheed (L1)	Post Signs and Monitor Land Use	$196,800
Dale Payne	Post Signs and Monitor Land Use as well as asbestos abatement and hazmat disposal	$235,200
Rea Point	Post Signs and Monitor Land Use	$147,400
Drake Point	Post Signs and Monitor Land Use	$238,400
Thor Island	Post Signs and Monitor Land Use	$144,400

For all sites the recommended remediation and risk management option is to Post Signs and Monitor Land Use, with the exception of Dale Payne, where an additional abatement task to remove asbestos and other hazmat is warranted. This option scored high in the Evaluation Matrix because it is effective at reducing exposure to human visitors by warning them of risks at the site and monitors regional land uses, is relatively easy to implement on a very short timeframe and is cost effective. If land use changes in the region are identified additional actions can be triggered at that time. While some risks are present on the sites for possible ecological receptors the risk hot spots are relatively small and would have minimal effects on communities of plants and invertebrates, and migratory receptors would not typically reside on the sites for long enough to achieve adverse effects.

Other benefits to Posting Signs and Monitoring Land Use are that it can be completed in one field trip with minimal labour required and is a minimally invasive approach. The other options would be more disruptive to the site and surroundings and would require long field season or several years of monitoring which carry high project financial and safety risks.

7. CLOSING AND LIMITING CONDITIONS STATEMENTS

These Remediation and Risk Management Plans and Options Analyses have been conducted using industry-standard best methods and practices. All data incorporated in the risk assessment were collected or assembled by BluMetric Environmental Inc. The RRMPs have been prepared following the scope of work developed by Procurement and Contracting Services Canada and

Indigenous and Northern Affairs Canada and information provided by Public Works and Government Services Canada and Aboriginal Affairs and Northern Development Canada regarding site use and the findings of the Phase I/II ESAs (WESA, 2012a - f), Phase III ESAs (BluMetric, 2016a - f) and Risk Assessments (BluMetric, 2016g - l). The RRMP is valid for the intended site uses and practices at the time of writing. The RRPM assumptions were based on the finding and conclusions of the Phase III ESAs and recent Risk Assessments and should be validated accordingly with any intended or actual site use changes.

The observations and results obtained during the investigation are representative of the conditions encountered at the sampling locations and at the time of the investigation only. No information presented in this report should be interpreted as being indicative of conditions elsewhere on the property. The statements made in this report are based solely on the information obtained to date as part of the above referenced investigations. BluMetric has used its professional judgment in analyzing this information and formulating its conclusions. No other warranty or representation, expressed or implied, as to the accuracy of the information or recommendations is included or intended in this report.

BluMetric Environmental Inc. makes no warranty as to the accuracy or completeness of the information provided by others, or of conclusions and recommendations predicated on the accuracy of that information.

This report has been prepared for Public Works and Government Services Canada and Aboriginal Affairs and Northern Development Canada. Any use a third party makes of this report, any reliance on the report, or decisions based upon the report, are the responsibility of those third parties unless authorization is received by BluMetric Environmental Inc. in writing. BluMetric Environmental Inc. accepts no responsibility for any loss or damages suffered by any unauthorized third party as a result of decisions made or actions taken based on this report.

Respectfully submitted,
BluMetric Environmental Inc.

Paul Bandler, M.Sc.
Environmental Scientist

Wayne Ingham, Ph.D.
Project Principal

8. REFERENCES

BluMetric, 2016a. Phase III Environmental Site Assessment Report at Rea Point. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016b. Phase III Environmental Site Assessment Report at Drake Point. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016c. Phase III Environmental Site Assessment Report at Dale Payne. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016d. Phase III Environmental Site Assessment Report at Lougheed (L1). Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016e. Phase III Environmental Site Assessment Report at Thor Island. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016f. Phase III Environmental Site Assessment Report at Romulus. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016g. Human Health and Ecological Risk Assessment Report at Rea Point. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016h. Human Health and Ecological Risk Assessment Report at Drake Point. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016i. Human Health and Ecological Risk Assessment Report at Dale Payne. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016j. Human Health and Ecological Risk Assessment Report at Lougheed (L1). Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016k. Human Health and Ecological Risk Assessment Report at Thor Island. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

BluMetric, 2016l. Human Health and Ecological Risk Assessment Report at Romulus. Prepared for: Public Works Government Services Canada, Edmonton, Alberta, Final Report.

Canadian Council of Ministers of the Environment (CCME), 2008. Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil.

Environment Canada, 2012. Federal Contaminated Sites Action Plan (FCSAP): Ecological Risk Assessment Guidance. Prepared by Azimuth Consulting Group for Environment Canada, March 2012.

Health Canada, 2010a. Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. September 2010. Prepared by the Contaminated Sites Division, Safe Environments Directorate.

Indian and Northern Affairs Canada (INAC), 2009. Abandoned Military Site Protocol. Volumes I and II. Northern Affairs Organization, Contaminated Sites Program. Final March 2009.

WESA, 2012a. Phase I/II Environmental Site Assessment – Drake Point. Prepared for Aboriginal Affairs and Northern Development Canada, Contaminated Sites Directorate, Iqaluit, Nunavut. February 2012.

WESA, 2012b. Phase I/II Environmental Site Assessment – Dale Payne. Prepared for Aboriginal Affairs and Northern Development Canada, Contaminated Sites Directorate, Iqaluit, Nunavut. February 2012.

WESA, 2012c. Phase I/II Environmental Site Assessment – Lougheed (L1). Prepared for Aboriginal Affairs and Northern Development Canada, Contaminated Sites Directorate, Iqaluit, Nunavut. February 2012.

WESA, 2012d. Phase I/II Environmental Site Assessment – Thor Island. Prepared for Aboriginal Affairs and Northern Development Canada, Contaminated Sites Directorate, Iqaluit, Nunavut. February 2012.

WESA, 2012e. Phase I/II Environmental Site Assessment – Romulus. Prepared for Aboriginal Affairs and Northern Development Canada, Contaminated Sites Directorate, Iqaluit, Nunavut. February 2012.

WESA, 2012f. Phase I/II Environmental Site Assessment – Rea Point. Prepared for Aboriginal Affairs and Northern Development Canada, Contaminated Sites Directorate, Iqaluit, Nunavut. February 2012.

APPENDIX A

Project Map Showing High Arctic Site Locations

Eureka

ROMULUS
C-42 Well Site

THOR
ISLAND

DALE PAYNE

LOUGHEED ISLAND (L1)

DRAKE POINT

REA POINT

Grise
Fiord

Resolute
Bay

LEGEND

- Phase III ESA
- Community
- Inuit Owned Land
- National Wildlife Area
- Proposed National Park
- Site Location

REFERENCES

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CLIENT

Public Works Government Services Canada

PROJECT

Remediation and Risk Management Plans – High Acitic Sites

TITLE

Site Location Map

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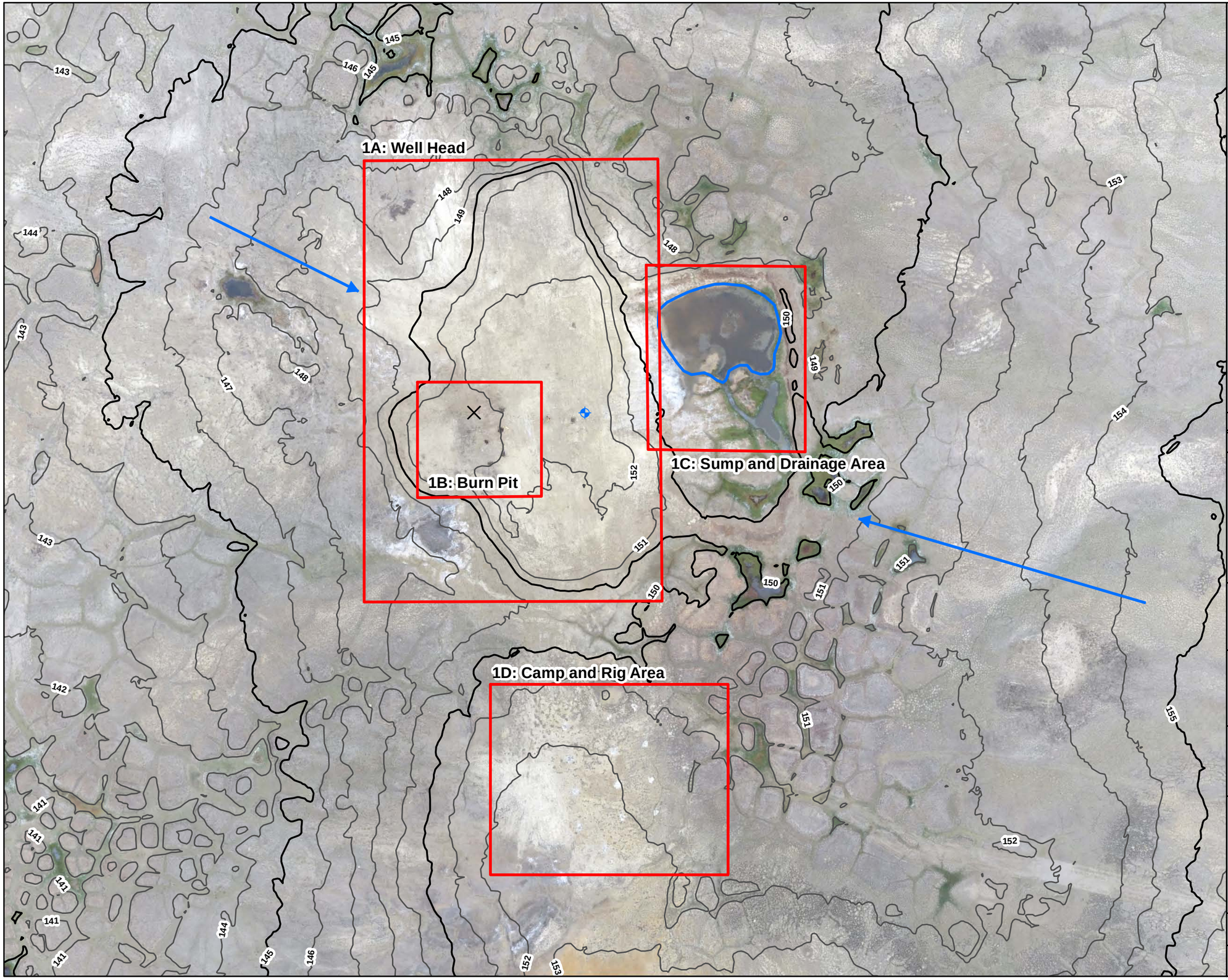

LEGEND

- Burn Pit
- Debris
- Well
- Debris Area
- Structure Footprint
- Sump
- APEC
- Inferred Ground and Surface Water Flow Direction
- Major Contour
- Minor Contour

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
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REFERENCES

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Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Romulus APEC 1: C-42 Well Site Plan

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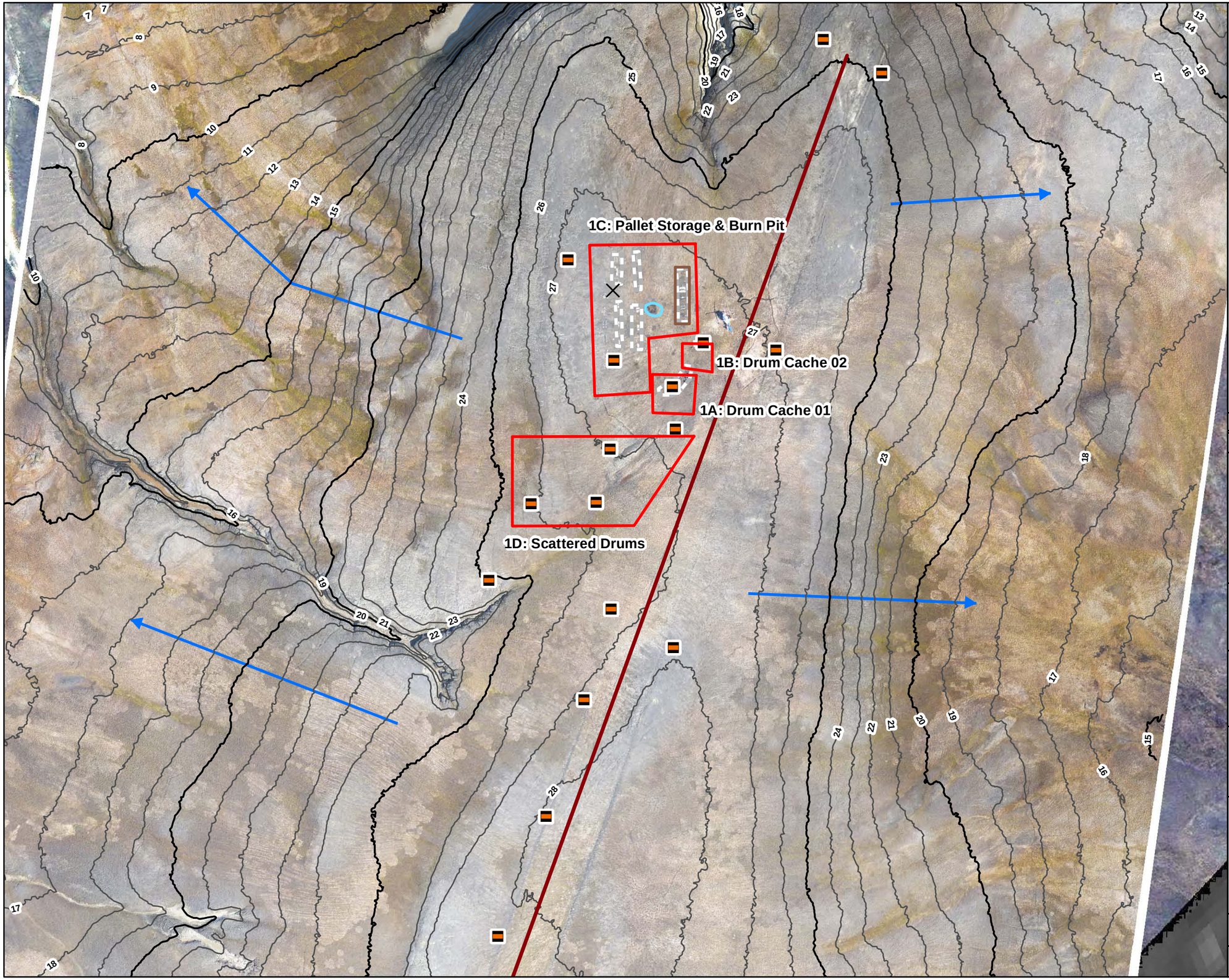

LEGEND

- Burn Pit
- Drum
- Well
- Surface Water
- Debris Area
- Structure Footprint
- Sump
- Stain
- AEC
- Inferred Ground and Surface Water Flow Direction
- Major Contour
- Minor Contour

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Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Lougheed AEC 1
Site Plan

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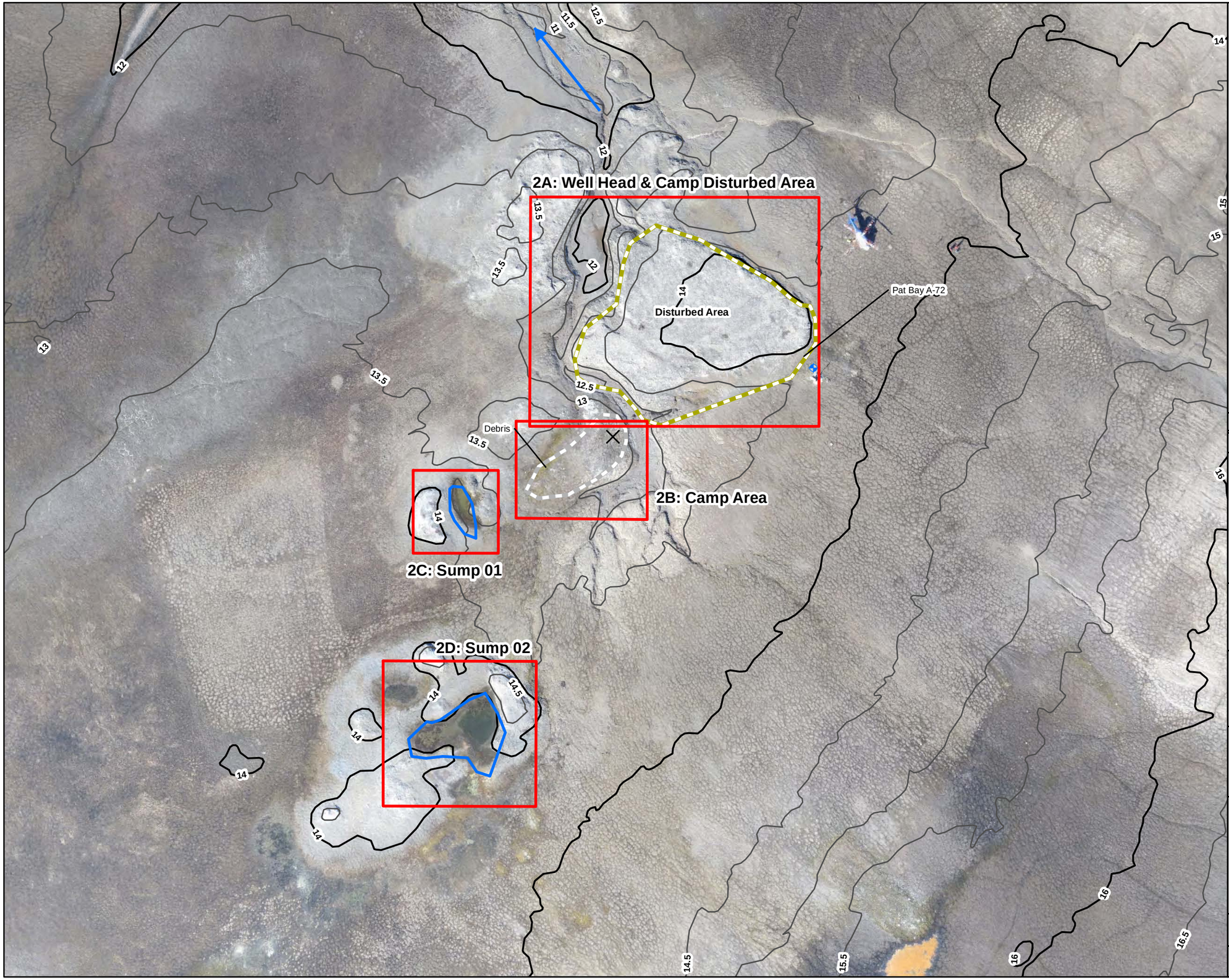

LEGEND

- Burn Pit
- Debris
- Drum
- Well
- Debris Area
- Disturbed Area
- Structure Footprint
- Sump
- AEC
- Inferred Ground and Surface Water Flow Direction
- Major Contour
- Minor Contour

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REFERENCES

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PROJECT

Risk Assessment for High Arctic Sites

TITLE

Lougheed AEC 2 Site Plan

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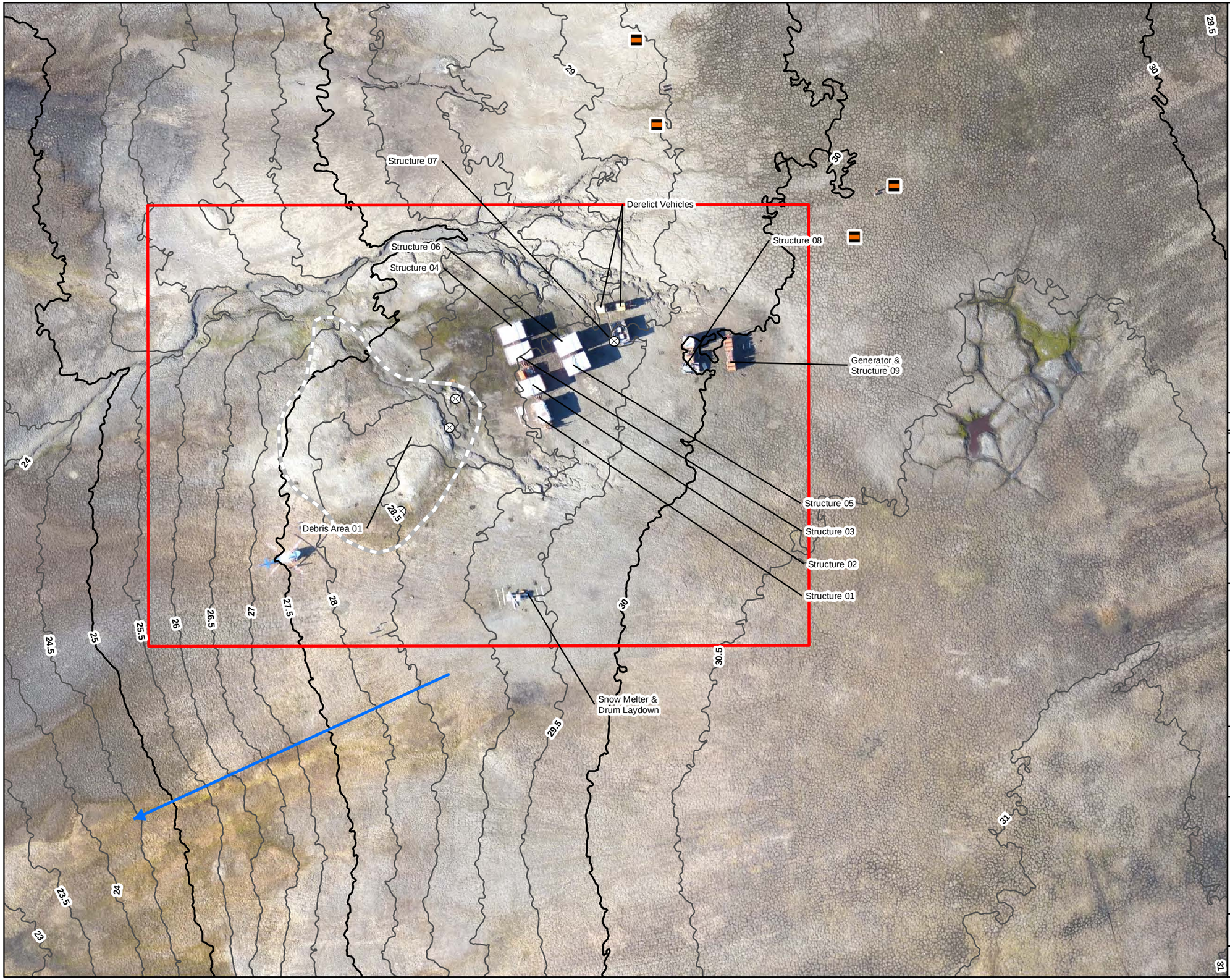

LEGEND

- Burn Pit
- Debris
- Drum
- Well
- Debris Area
- Structure Footprint
- APEC
- Inferred Ground and Surface Water Flow Direction
- Major Contours
- Minor Contours

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
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PROJECT

Risk Assessment for High Arctic Sites

TITLE

Dale Payne APEC 1: Site Plan

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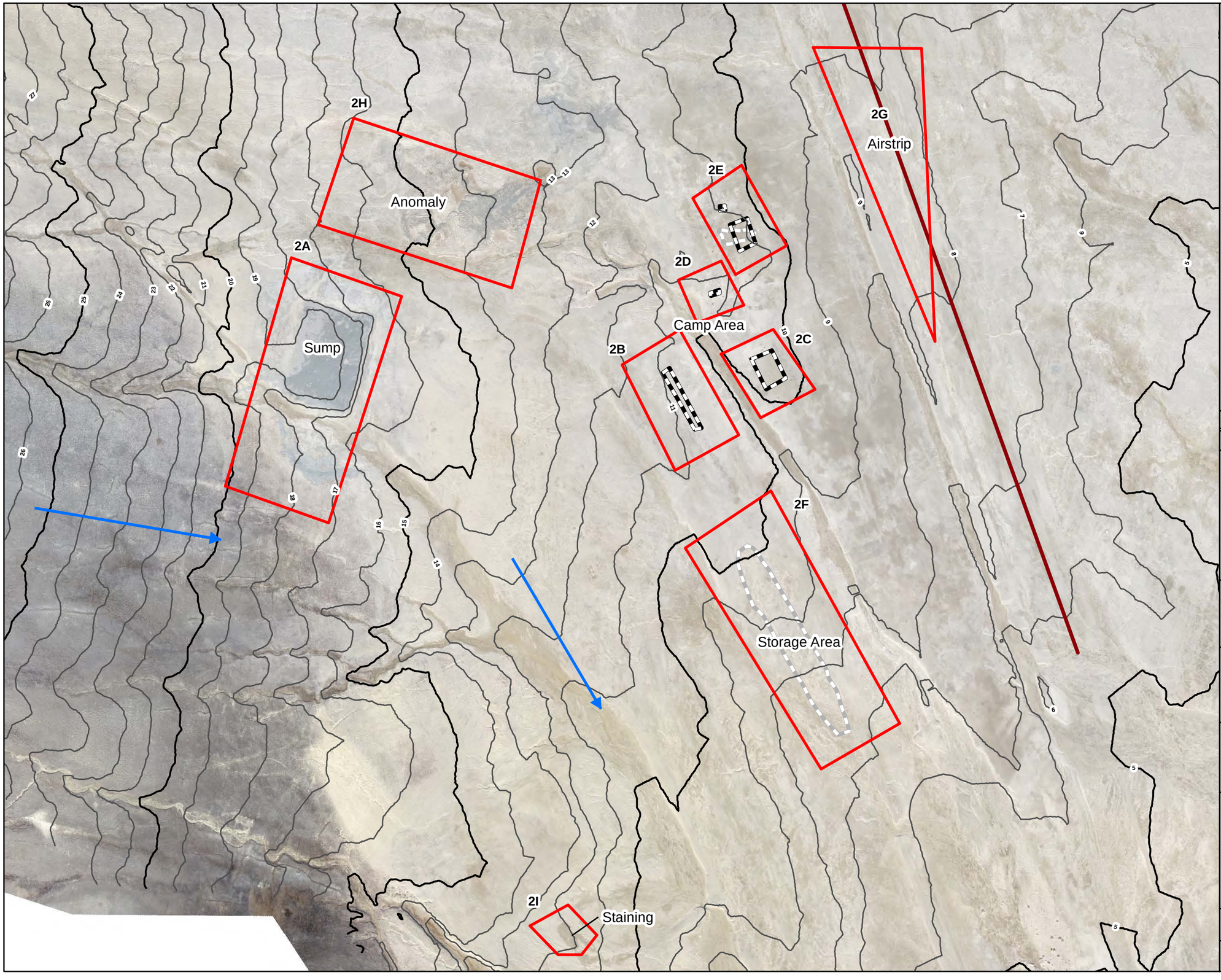

LEGEND

- AEC
- Debris Area
- Structure Footprint
- Inferred Ground and Surface Water Flow Direction
- Major Contour
- Minor Contour

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
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REFERENCES

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CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Rea Point AEC 2 Site Plan

BluMetric Environmental
4916 49th Street,
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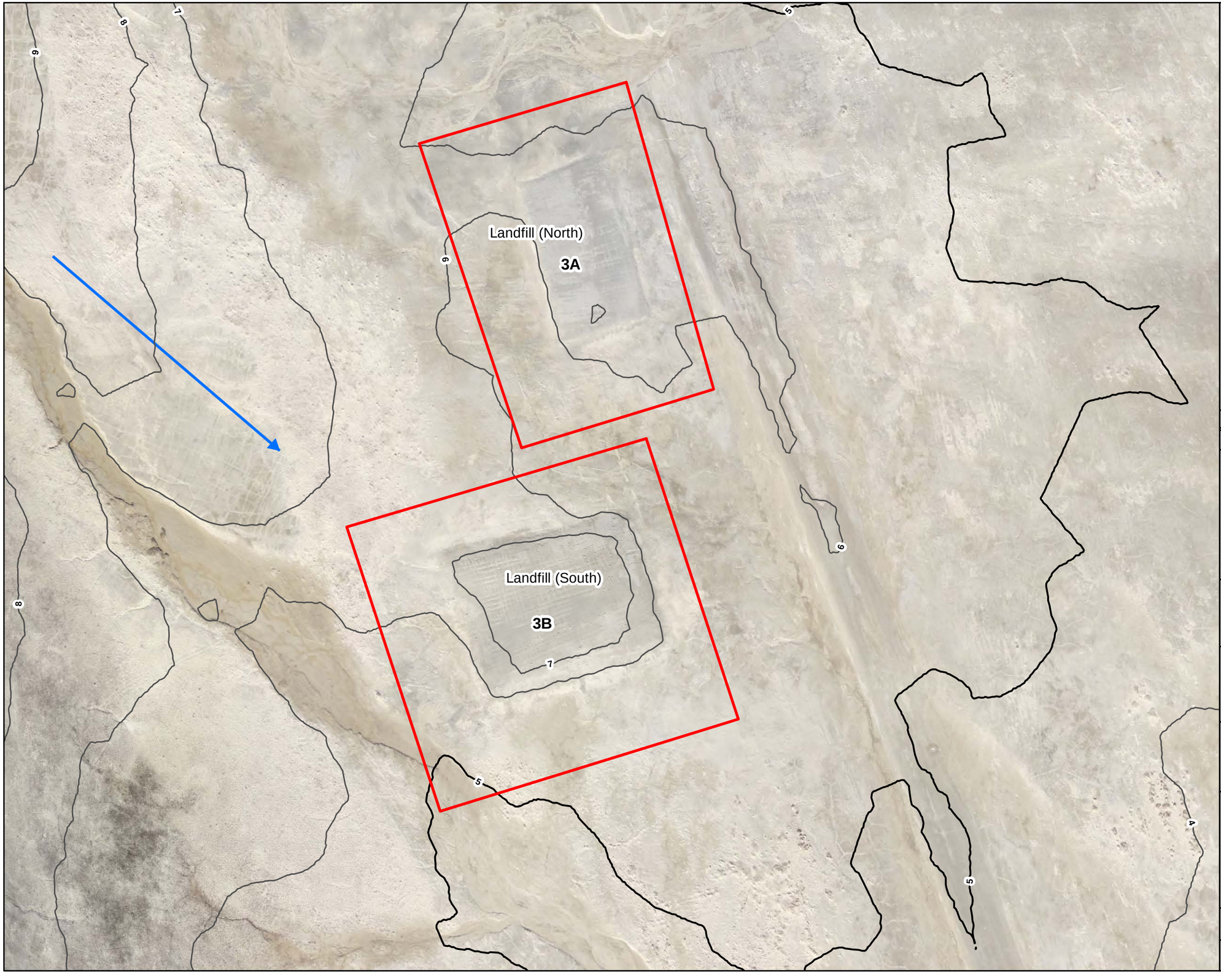

LEGEND

- AEC
- Inferred Ground and Surface Water Flow Direction
- Major Contour
- Minor Contour

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 50 100 Meters

CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Rea Point AEC 3
Site Plan

BluMetric Environmental
4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
Y-B13360	March 10, 2016		
DRAWN	CHECKED	FIG NO.	REV
IB	LF	7	0

LEGEND

- AEC
- Minor Debris Area (2 Drums)
- Structure Footprint
- Odor
- Inferred Ground and Surface Water Flow Direction
- Major Contour
- Minor Contour

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 20 40 Meters

CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Rea Point AEC 4 Site Plan

BluMetric Environmental
4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
Y-B13360	March 10, 2016

DRAWN	CHECKED	FIG NO.	REV
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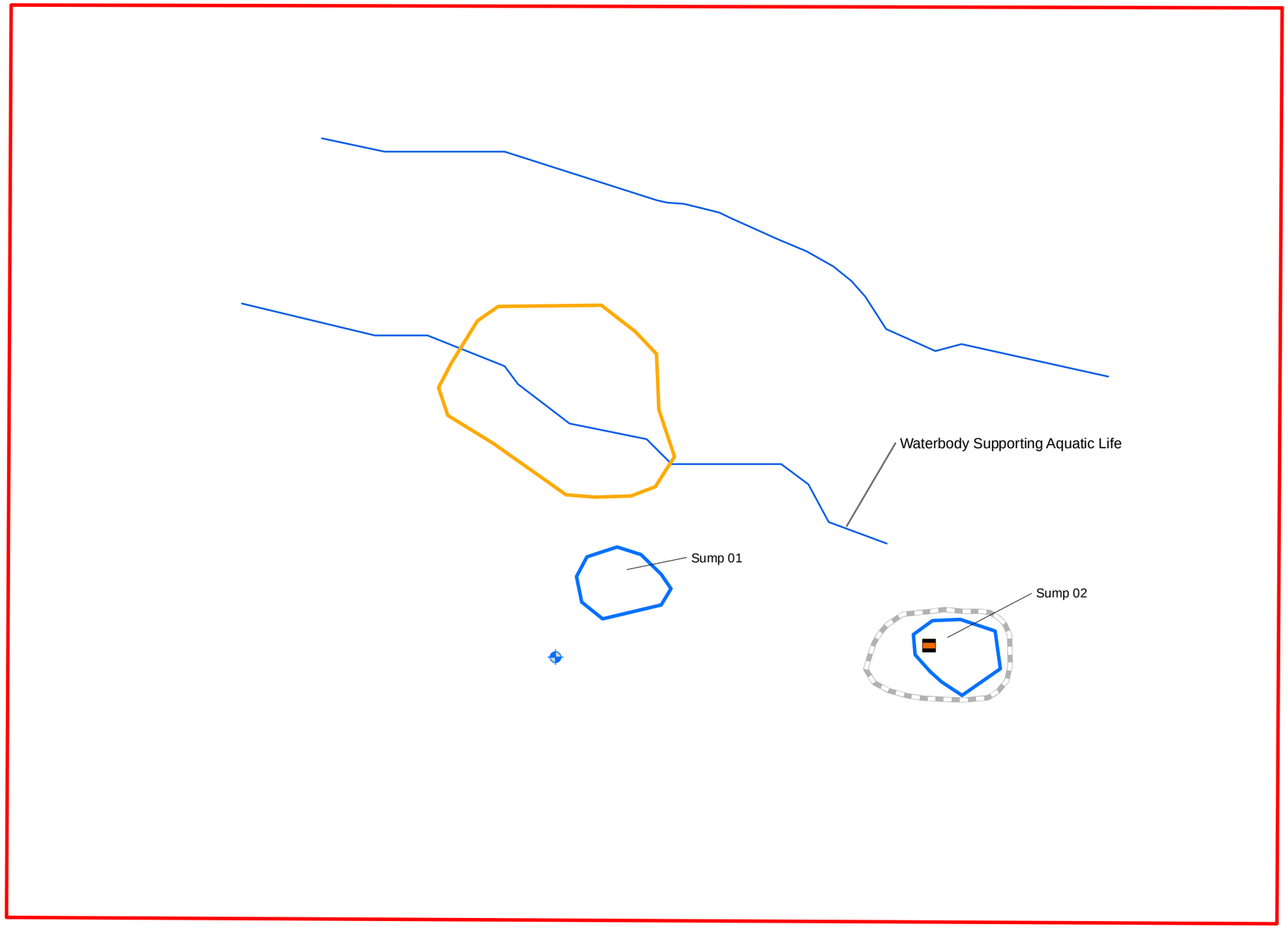
AEC 1 - Collingwood K-33



LEGEND

- Burn Pit
- Debris
- Drum
- Well
- Drainage Pathway
- Debris Area
- Pond
- Solvent Odor Area
- Sump
- AEC

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 10 20 Meters

CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Drake Point AEC 1 Site Plan

BluMetric Environmental

4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
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PROJECT #	DATE
Y-B13360	March 07, 2016

DRAWN	CHECKED	FIG NO.	REV
IB	LF	9	0

LEGEND

- Well
- Drum
- Inferred Ground and Surface Water Flow Direction
- Debris Area
- Disturbed Area
- Pond
- Sump
- AEC

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

DO NOT SCALE DRAWING.
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N W E S

0 20 40 Meters

CLIENT

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PROJECT

Risk Assessment for High Arctic Sites

TITLE

Drake Point AEC 3
Site Plan

BluMetric Environmental
4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
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PROJECT #	DATE		
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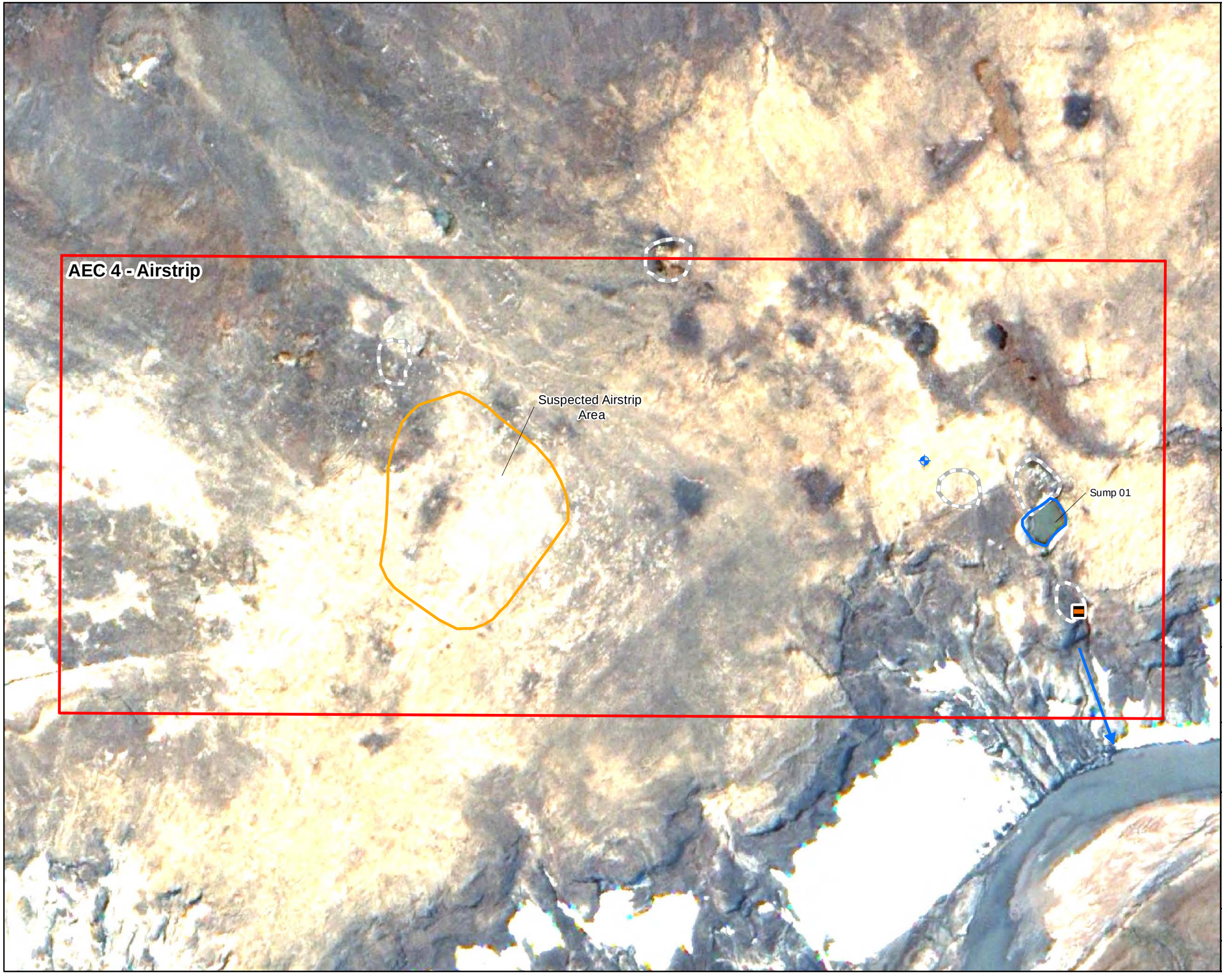

LEGEND

- Drum
- Well
- Inferred Ground and Surface Water Flow Direction
- Debris Area
- Pond
- Solvent Odor Area
- Sump
- AEC

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

DO NOT SCALE DRAWING.
THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N

0 50 100 Meters

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Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Drake Point AEC 4 Site Plan

4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
Y-B13360	March 07, 2016		
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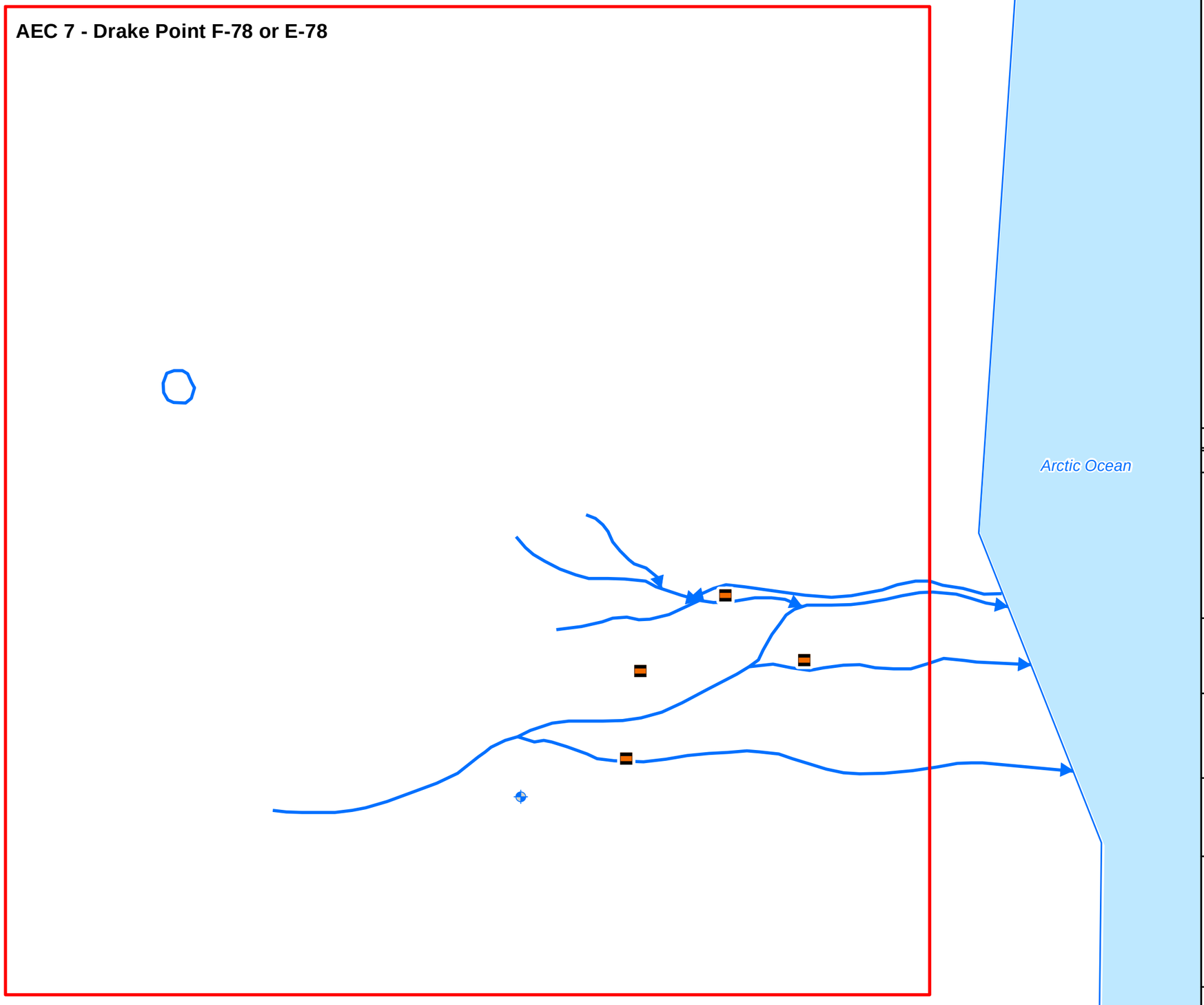

LEGEND

- Burn Pit
- Debris
- Drum
- Well
- Inferred Ground and Surface Water Flow Direction
- AEC

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 10 20 Meters

CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Drake Point AEC 7 Site Plan

BluMetric Environmental
4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
Y-B13360	March 07, 2016

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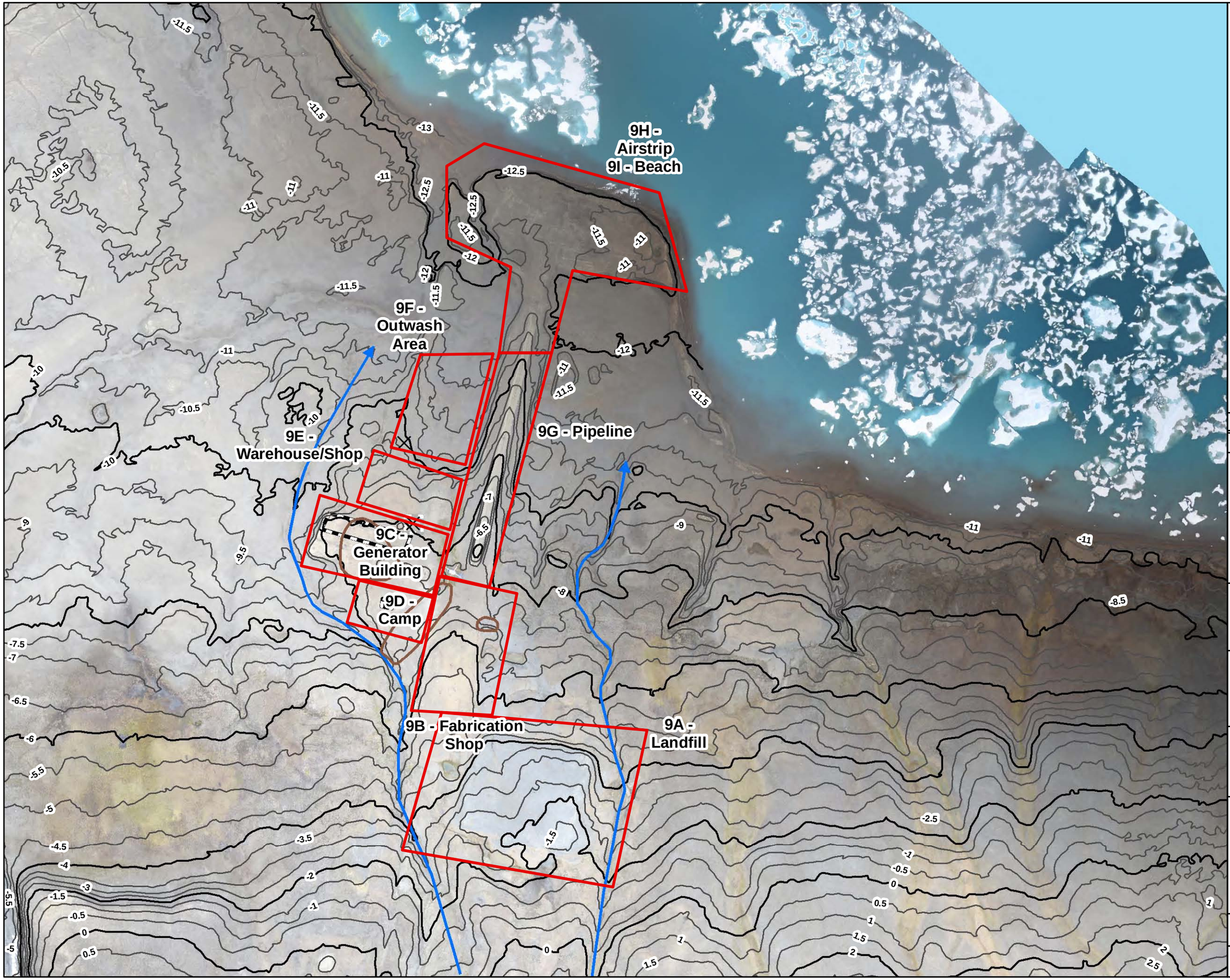

LEGEND

- Burn Pit
- Debris
- Drum
- Well
- AEC
- Debris Area
- Structure Footprint
- Stain
- Inferred Ground and Surface Water Flow Direction
- Major Contour
- Minor Contour

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 50 100 Meters

CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Drake Point
AEC 9 Site Plan

BluMetric Environmental
4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
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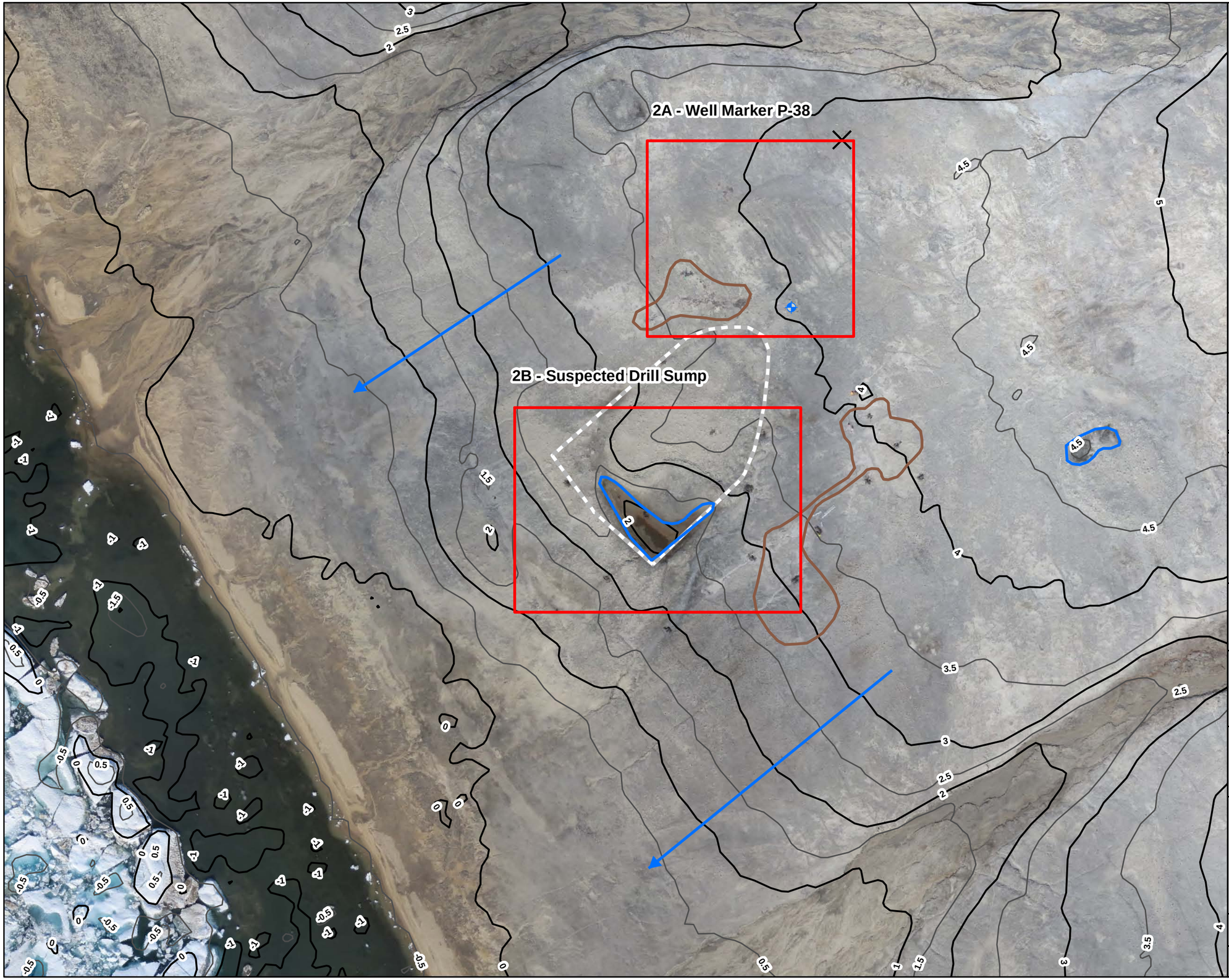

LEGEND

- Burn Pit
- Drum
- Well
- Stain
- Sump
- AEC
- Debris Ares
- Structure Footprint
- Inferred Ground and Surface Water Flow Direction
- Major Contours
- Minor Contours

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

N W E S

0 20 40 Meters

CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Thor Island AEC 2: P-38 Well Site Plan

BluMetric Environmental
4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
Y-B13360	April 07, 2016		
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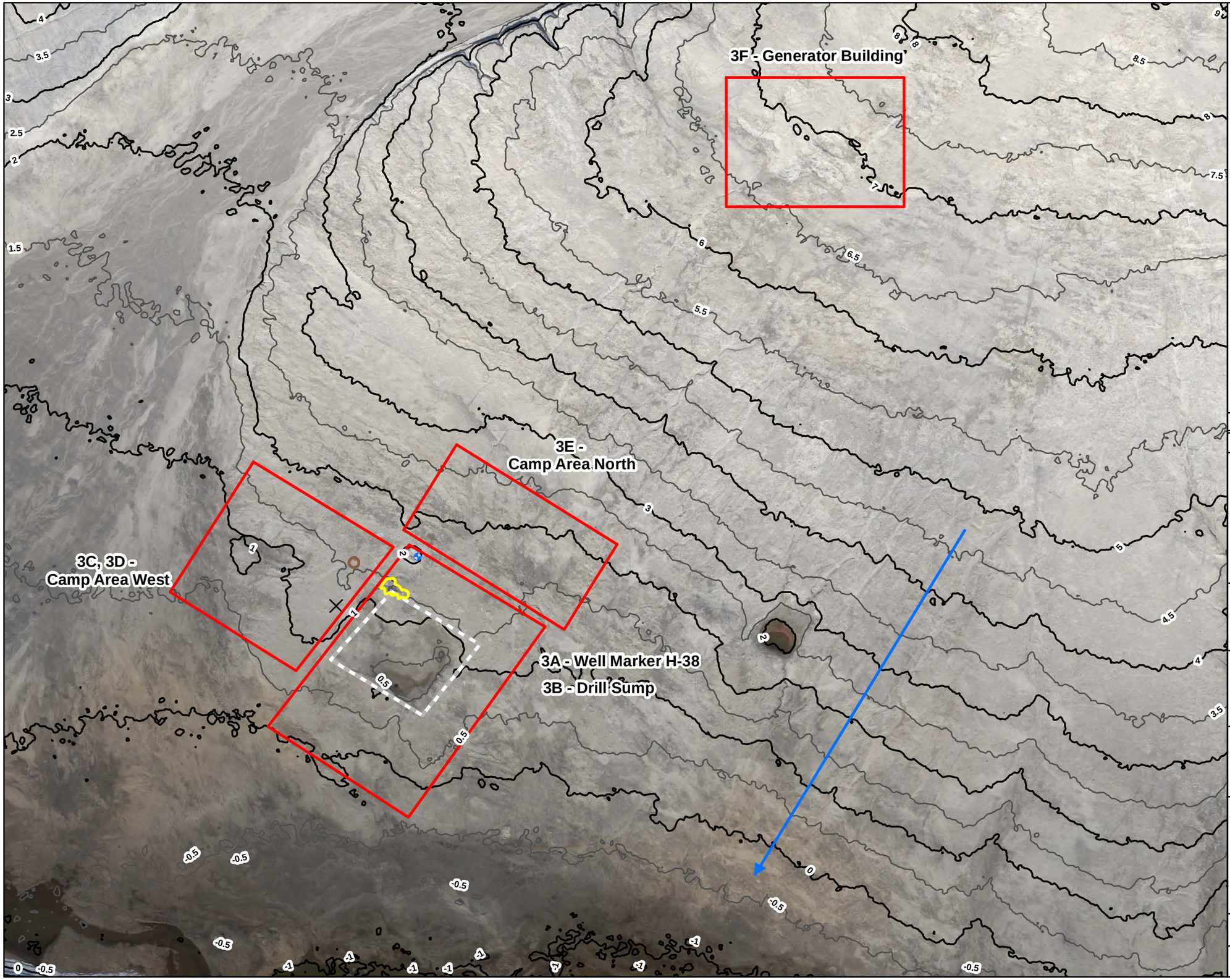


LEGEND

- Burn Pit
- Drum
- Well
- Drill Cutting Pile
- Stain
- AEC
- Debris Ares
- Structure Footprint
- Inferred Ground and Surface Water Flow Direction
- Major Contours
- Minor Contours

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 20 40 Meters

CLIENT

Public Works Government Services Canada

PROJECT

Risk Assessment for High Arctic Sites

TITLE

Thor Island AEC 3: H-28 Well Site Plan

BluMetric Environmental

4916 49th Street,
PO Box 11086
Yellowknife, NT, X1A 1P3
TEL: (867) 873-3500
FAX: (867) 873-3499
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
Y-B13360	April 07, 2016

DRAWN	CHECKED	FIG NO.	REV
IB	LF	15	0

APPENDIX B

Detailed Cost Tables for Remedial Options

Appendix B: Detailed Cost Tables for Remedial Options
Class "D" (+/- 50%) Cost Estimate 2016
Dale Payne (NB045)

Total Number of AECs:	1
Total Square Meters of Soil at AECs:	375
Total Cubic Meters of Soil at AECs:	300
Hazardous Materials (Lead Paint, Asbestos) m^2	530
Distance from Resolute Bay (km):	410

Item	Cost	
Post Signage		
Project Management, Administration & Logistics	$	149,200
Capital Cost	$	46,000
Operations and Maintenance	$	40,000
Subtotal	**$**	**235,200**
Minimum Projected Cost (-50%)	$	117,600
Maximum Projected Cost (+50%)	$	352,800
Monitored Natural Attenuation		
Project Management, Administration & Logistics	$	149,200
Capital Cost	$	48,000
Operations and Maintenance	$	512,500
Subtotal	**$**	**709,700**
Minimum Projected Cost (-50%)	$	354,850
Maximum Projected Cost (+50%)	$	1,064,550
Install Soil Cap		
Project Management, Administration & Logistics	$	2,278,980
Capital Cost	$	1,746,750
Operations and Maintenance	$	30,000
Subtotal	**$**	**4,055,730**
Minimum Projected Cost (-50%)	$	2,027,865
Maximum Projected Cost (+50%)	$	6,083,595
On-Site Treatment		
Project Management, Administration & Logistics	$	2,278,980
Capital Cost	$	1,764,500
Operations and Maintenance	$	402,000
Subtotal	**$**	**4,445,480**
Minimum Projected Cost (-50%)	$	2,222,740
Maximum Projected Cost (+50%)	$	6,668,220
Excavation and Off-Site Disposal		
Project Management, Administration & Logistics	$	2,278,980
Capital Cost	$	2,367,000
Operations and Maintenance	$	-
Subtotal	**$**	**4,645,980**
Minimum Projected Cost (-50%)	$	2,322,990
Maximum Projected Cost (+50%)	$	6,968,970

Post Signage

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Site-Specific Permitting & Management Plans		$5,000	1	$5,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$15,000	1	$15,000.00
Rotatry Wing (for installation program) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 12 flight hrs to access the 2 AECs)	lump sum	$67,000	1	$67,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	18	$7,200.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 1 sign per Impacted Area (1 time event) -personnel time and supplies	Impacted Area	$3,000.00	1	$3,000.00
Debris Packaging and Disposal				
Hazardous Materials -Asbestos abatement, packaging and disposal	tonne	$3,000.00	3	$9,000.00
Hazardous Liquids	drum	$3,400.00	10	$34,000.00
Annual Operation and Maintenance				
Annual Site Inspection and monitoring -site inspection by fixed wing fly over (no landing)	Per Visit	$30,000.00	1	$30,000.00
Reporting	Lump Sum per yr	$10,000.00	1	$10,000.00
Option Total				**$235,200.00**

NOTES and ASSUMPTIONS:

- All work completed in 1 day site visit. One flight to transport personnel and supplies for the work.
- No suitable fixed wing landing condition at the Site

·is would remain on site as is

Monitored Natural Attenuation

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$20,000	1	$20,000.00
Rotatry Wing (for installation program) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 12 flight hrs to access the 2 AECs)	lump sum	$67,000	1	$67,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	18	$7,200.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Construction / Installation Cost				
Install 3 piezometers per Impacted Area -personnel time and supplies	Impacted Area	$5,000.00	1	$5,000.00
Debris Packaging and Disposal				
Hazardous Materials -Asbestos abatement, packaging and disposal	tonne	$3,000.00	3	$9,000.00
Hazardous Liquids	drum	$3,400.00	10	$34,000.00
Annual Operation and Maintenance				
Sampling (rotary wing access only) -site inspection -well development and sampling -laboratory analysis	Per Visit	$50,000.00	5	$250,000.00
Rotatry Wing (per sampling year) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 5 flight hrs)	per year	$42,500.00	5	$212,500.00
Reporting	Lump Sum per yr	$10,000.00	5	$50,000.00
Option Total				**$709,700.00**

NOTES and ASSUMPTIONS:

- All work completed in 1 day site visit. One flight to transport personnel and supplies for the work.
- No suitable fixed wing landing condition at the Site
- Derelict equipment, sleighs and debris would remain on site as is

Install Soil Cap

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$103,590
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$103,590
Mobilization barge from Montreal OR Hay River to Basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies to basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	1	$182,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE basecamp small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Capping and covering, regrading area -0.5m thick soil cap over each impacted area	per m2	$50.00	375	$18,750.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Debris Packaging and Disposal				
Hazardous Materials -Asbestos abatement, packaging and disposal	tonne	$3,000.00	3	$9,000.00
Hazardous Liquids	drum	$3,400.00	10	$34,000.00
Non-Hazardous Materials -sleighs, trailers, tanks - haul out to L1 strip and load out intact by bardge -transport and disposal in Montreal	tonne	$2,000.00	20	$40,000.00
Annual Operation and Maintenance				
Periodic Inspection of Cap integrity and site condition -aerial inspection by fly over in fixed wing aircraft -travel, room, board -cap inspection	Per Inspection	$30,000.00	1	$30,000.00
Option Total				**$4,055,730.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Winter cat train to deliver equipment to site and return to coast for Demob
- No suitable fixed wing landing condition at the Site
- Soil cap only (no liners). Soil Cap 0.5 m thick to be adequately protective against direct soil contract pathway and potential burrowing
- Site inspections carried out on 2 - 5 year basis to assess cap integrity and signs of activity/visitation (1 inspection visit included in cost)
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations

On-site Treatment

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	5 % of technical work	5 % of technical work	5%	$103,590
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	5 % of technical work	5 % of technical work	5%	$103,590
Mobilization barge from Montreal OR Hay River to Basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies to basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	1	$182,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Construct treatment Cell Includes: -Materials -oversight -confirmatory sampling (1 sample / 10m ^ 2)	cubic metre	$65.00	300	$19,500.00
Excavate and move soil to treatment cell	cubic metre	$40.00	300	$12,000.00
Install 3 piezometers around treatment area -personnel time and supplies	Impated Area	$5,000.00	1	$5,000.00
Debris Packaging and Disposal				
Hazardous Materials -Asbestos abatement, packaging and disposal	tonne	$3,000.00	3	$9,000.00
Hazardous Liquids	drum	$3,400.00	10	$34,000.00
Non-Hazardous Materials -sleighs, trailers, tanks - haul out to L1 strip and load out intact by bardge -transport and disposal in Montreal	tonne	$2,000.00	20	$40,000.00
Annual Operation and Maintenance				
Annual treatment cell operation: -nutrient addition -aeration/tilling -surface water management -assumed 5-day operation per visit	per year	$60,000.00	3	$180,000.00
Rotatry Wing (per sampling year) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 12 flight hrs)	per year	$67,000.00	3	$201,000.00
Groundwater monitoring: -sampling and laboratory analysis	per year	$7,000.00	3	$21,000.00
Option Total				**$4,445,480.00**

Excavation and Off-Site Disposal

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$103,590
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$103,590
Mobilization barge from Montreal OR Hay River to Basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies to basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	1	$182,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Excavate and containerize soil Includes: -equipment/Labour -materials -oversight -confirmatory sampling (1 sample / 10m^2)	cubic metre	$65.00	300	$19,500.00
Backfill, placement and compaction	cubic metre	$65.00	300	$19,500.00
Non-haz soil transport and disposal: -winter cat train haul from AEC to coast @ Lougheed Strip -barge to Montreal	cubic metre	$2,000.00	300	$600,000.00
Debris Packaging and Disposal				
Hazardous Materials -Asbestos abatement, packaging and disposal	tonne	$3,000.00	3	$9,000.00
Hazardous Liquids	drum	$3,400.00	10	$34,000.00
Non-Hazardous Materials -sleighs, trailers, tanks - haul out to L1 strip and load out intact by bardge -transport and disposal in Montreal	tonne	$2,000.00	20	$40,000.00
Option Total				**$4,645,980.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Winter cat train to deliver equipment to site and return to coast for Demob
- No suitable fixed wing landing condition at the Site
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Impacted soil placed in 1 cu m mega bags; barge to Montreal; ground transport to non-haz waste landfill in QC.

Appendix B: Detailed Cost Tables for Remedial Options
Class "D" (+/- 50%) Cost Estimate 2016
Drake Point

		Disitance from Drake Base (AEC 9)
Total Number of AECs:	5	
Distance from Resolute Bay (km):	440	
Total Square Meters of Soil at AEC 1:	337	40km
Total Cubic Meters of Soil at AEC 1:	270	40km
Total Square Meters of Soil at AEC 3:	10902	30km
Total Cubic Meters of Soil at AEC 3:	8722	30km
Total Square Meters of Soil at AEC4:	11049	20km
Total Cubic Meters of Soil at AEC4:	8839	20km
Total Square Meters of Soil at AEC 7:	69	10km
Total Cubic Meters of Soil at AEC 7:	55	10km
Total Square Meters of Soil at AEC9:	13737	0 km
Total Cubic Meters of Soil at AEC9:	10990	0 km

Item	Cost	
Post Signage		
Project Management, Administration & Logistics	$	183,400
Capital Cost	$	15,000
Operations and Maintenance	$	40,000
Subtotal	**$**	**238,400**
Minimum Projected Cost (-50%)	$	119,200
Maximum Projected Cost (+50%)	$	357,600
Monitored Natural Attenuation		
Project Management, Administration & Logistics	$	188,400
Capital Cost	$	25,000
Operations and Maintenance	$	675,000
Subtotal	**$**	**888,400**
Minimum Projected Cost (-50%)	$	444,200
Maximum Projected Cost (+50%)	$	1,332,600
Install Soil Cap		
Project Management, Administration & Logistics	$	6,783,150
Capital Cost	$	7,599,700
Operations and Maintenance	$	30,000
Subtotal	**$**	**14,412,850**
Minimum Projected Cost (-50%)	$	7,206,425
Maximum Projected Cost (+50%)	$	21,619,275
On-Site Treatment		
Project Management, Administration & Logistics	$	6,783,150
Capital Cost	$	8,851,896
Operations and Maintenance	$	486,000
Subtotal	**$**	**16,121,046**
Minimum Projected Cost (-50%)	$	8,060,523
Maximum Projected Cost (+50%)	$	24,181,569
Excavation and Off-Site Disposal		
Project Management, Administration & Logistics	$	6,783,150
Capital Cost	$	67,299,176
Operations and Maintenance	$	-
Subtotal	**$**	**74,082,326**
Minimum Projected Cost (-50%)	$	37,041,163
Maximum Projected Cost (+50%)	$	111,123,489

Post Signage

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Site-Specific Permitting & Management Plans - 5 disparate AECs to be considered	lump sum	$10,000	1	$10,000
Purchasing and Mobilization (consider mobing to Lougheed strip as Base) Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$15,000	1	$15,000.00
Rotatry Wing (for installation program) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 20 flight hrs to access the 5 AECs)	lump sum	$95,000	1	$95,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	0	$0.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	21	$8,400.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 1 sign per Impacted Area (1 time event) -personnel time and supplies rotary wing travel to AECs from Base	Impacted Area	$3,000.00	5	$15,000.00
Annual Operation and Maintenance				
Annual Site Inspection and monitoring -site inspection by fixed wing fly over (no landing)	Per Visit	$30,000.00	1	$30,000.00
Reporting	Lump Sum per yr	$10,000.00	1	$10,000.00
Option Total				**$238,400.00**

NOTES and ASSUMPTIONS:

- Installation work completed in 5 day-site visits. One rotary wing flight to transport personnel and supplies for the work.
- No suitable fixed wing landing at any AECs - inspection by fly over only

Monitored Natural Attenuation

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Site-Specific Permitting & Management Plans - 5 disparate AECs to be considered	lump sum	$10,000	1	$10,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$20,000	1	$20,000.00
Rotatry Wing (for installation program) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 20 flight hrs to access the 5 AECs)	lump sum	$95,000	1	$95,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	21	$8,400.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 3 piezometers per Impacted Area -personnel time and supplies	Impacted Area	$5,000.00	5	$25,000.00
Annual Operation and Maintenance				
Sampling (rotary wing access only) -site inspection -well development and sampling -laboratory analysis	Per year	$30,000.00	5	$150,000.00
Rotatry Wing (per sampling year) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 20 flight hrs)	per year	$95,000.00	5	$475,000.00
Reporting	Lump Sum per yr	$10,000.00	5	$50,000.00
Option Total				**$888,400.00**

NOTES and ASSUMPTIONS:

- All work completed in 5 day site visit per AEC. One flight to transport personnel and supplies for the work.
- Rotary wing access only; assumed one AEC per day
- One year of monitoring included in cost scenario

Install Soil Cap

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$308,325
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$308,325
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Winter Cat Train - One AEC per year - mob, equipment commissioning, road push, transport	per year	$100,000.00	5	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$30,000	5	$150,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup (5 seasons) -soft sided tents	per year	$200,000.00	5	$1,000,000.00
Camp Operation (5 seasons) -support staff, food, fuel -10 person team (7500 / day) - Estimated 30 days per season -15 person team (12,000 / day)	per year	$225,000	5	$1,125,000.00
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	5	$912,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community Room and Board for contractor ($400/ night) NON-LOCAL staff contractor = 2 custodian = 1 estimated 22 preson days per season	per year	$8,800.00	5	$44,000.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$2,500.00	300	$750,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	110	$550,000.00
Survey	Lump sum	$25,000.00	5	$125,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 1 seasons (min 2 seasons due to barge schedules)	Lump Sum	$810,000.00	7	$5,670,000.00
Capping and covering, regrading area -0.5m thick soil cap over each impacted area	per m2	$50.00	36094	$1,804,700.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	5	$125,000.00
Annual Operation and Maintenance				
Periodic Inspection of Cap integrity and site condition -aerial inspection by fly over in fixed wing aircraft -travel, room, board -cap inspection -photo log	Per Inspection	$30,000.00	1	$30,000.00
Reporting	Lump Sum per yr	$10,000.00	1	$10,000.00
Option Total				**$14,412,850.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 7 yrs due to barge schedules
- yr 1 mob equipment to Site(AEC9); yr 2 cap AEC9 + winter mob to AEC7; yr3 cap AEC7+ winter mob to AEC4; yr4 cap AEC4 + mob to AEC3;
- Rotary wing access to sites only for personnel and miscilaneous equipment
- Soil cap only (no liners). Soil Cap 0.5 m thick to be adequately protective against direct soil contract pathway and potential burrowing
- Site inspections carried out on 2 - 5 year basis to assess cap integrity and signs of activity/visitation (1 inspection visit included in cost)
- 30 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations

On-site Treatment

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	5 % of technical work	5 % of technical work	5%	$308,325
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	5 % of technical work	5 % of technical work	5%	$308,325
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Winter Cat Train - One APEC per year - mob, equipment commissioning, road push, transport	per year	$100,000.00	5	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$30,000	5	$150,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup (5 seasons) -soft sided tents	per year	$200,000.00	5	$1,000,000.00
Camp Operation (5 seasons) -support staff, food, fuel -10 person team (7500 / day) - Estimated 30 days per season -15 person team (12,000 / day)	per year	$225,000	5	$1,125,000.00
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	5	$912,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community Room and Board for contractor ($400/ night) NON-LOCAL staff contractor = 2 custodian = 1 estimated 22 preson days per season	per year	$8,800.00	5	$44,000.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$2,500.00	300	$750,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	110	$550,000.00
Survey	Lump sum	$25,000.00	5	$125,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 1 seasons (min 2 seasons due to barge schedules)	Lump Sum	$810,000.00	7	$5,670,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	5	$125,000.00
Construct treatment Cell Includes: -Materials -oversight -confirmatory sampling (1 sample / 10m ^ 2)	cubic metre	$65.00	28875	$1,876,888.00
Excavate and move soil to treatment cell	cubic metre	$40.00	28875	$1,155,008.00
Install 3 piezometers around treatment area -personnel time and supplies	Lump Sum	$5,000.00	5	$25,000.00
Annual Operation and Maintenance				
Annual treatment cell operation: -nutrient addition -aeration/tilling -surface water management -assumed 2-day operation per visit	per year	$60,000.00	3	$180,000.00
Rotatry Wing (per sampling year) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel	per year	$95,000.00	3	$285,000.00
Groundwater monitoring: -sampling and laboratory analysis	per year	$7,000.00	3	$21,000.00
Option Total				**$16,121,046.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- yr 1 mob equipment to Site(AEC9); yr 2 AEC9 + winter mob to AEC7; yr3 AEC7+ winter mob to AEC4; yr4 AEC4 + winter mob to AEC3;
- Rotary wing access only
- 30 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- All work completed in 1 day site visit per AEC. One flight to transport personnel and supplies for the work.
- Treatment cell not lined. 0.75m high berms. Impacted soil placed 0.5 m thick in berm.
- 3 additional years of treatment included; includes purchase/shipping/application of nutrients; tilling by hand or with roto-tiller, monitoring samples
- Treatment cell to be decommissioned in place; MWs left in place in case additional monitoring is desired

Excavation and Off-Site Disposal

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$308,325
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$308,325
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan	lump sum	$500,000.00	1	$500,000.00
Winter Cat Train - One APEC per year - mob, equipment commissioning, road push, transport	per year	$100,000.00	5	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$30,000	5	$150,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup (5 seasons) -soft sided tents	per year	$200,000.00	5	$1,000,000.00
Camp Operation (5 seasons) -support staff, food, fuel -10 person team (7500 / day) - Estimated 30 days per season -15 person team (12,000 / day)	per year	$225,000	5	$1,125,000.00
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	5	$912,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community Room and Board for contractor ($400/ night) NON-LOCAL staff contractor = 2 custodian = 1 estimated 22 preson days per season	per year	$8,800.00	5	$44,000.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$2,500.00	300	$750,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	110	$550,000.00
Survey	Lump sum	$25,000.00	5	$125,000.00
Construction / Installation Cost				
Heavy Equipment -rental per seasons (min 2 seaons due to barge schedules)	Lump Sum	$810,000.00	7	$5,670,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	5	$125,000.00
Excavate and containerize soil Includes: -equipment/Labour -materials -oversight -confirmatory sampling (1 sample / 10m^2)	cubic metre	$65.00	28875	$1,876,888.00
Backfill, placement and compaction	cubic metre	$65.00	28875	$1,876,888.00
non-haz soil transport and disposal: -winter cat train haul from AEC to coast @ AEC9 -barge to Montreal	cubic metre	$2,000.00	28875	$57,750,400.00
Option Total				**$74,082,326.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- yr 1 mob equipment to Site(AEC9); yr 2 AEC9 + winter mob to AEC7; yr3 AEC7+ winter mob to AEC4; yr4 AEC4 + winter mob to AEC3;
- Rotary wing access only
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Impacted soil placed in 1 cu m mega bags; barge to Montreal; ground transport to non-haz waste landfill in QC.

Appendix B: Detailed Cost Tables for Remedial Options
Class "D" (+/- 50%) Cost Estimate 2016
Lougheed Island (L1)

Total Number of AECs:	2
Total Square Meters of Soil at AECs:	1294
Total Cubic Meters of Soil at AECs:	1035
Drums:	50
Distance from Resolute Bay (km):	430

Item	Cost	
Post Signage		
Project Management, Administration & Logistics	$	150,800
Capital Cost	$	6,000
Operations and Maintenance	$	40,000
Subtotal	**$**	**196,800**
Minimum Projected Cost (-50%)	$	98,400
Maximum Projected Cost (+50%)	$	295,200
Monitored Natural Attenuation		
Project Management, Administration & Logistics	$	150,800
Capital Cost	$	10,000
Operations and Maintenance	$	512,500
Subtotal	**$**	**673,300**
Minimum Projected Cost (-50%)	$	336,650
Maximum Projected Cost (+50%)	$	1,009,950
Install Soil Cap		
Project Management, Administration & Logistics	$	2,278,980
Capital Cost	$	1,699,760
Operations and Maintenance	$	30,000
Subtotal	**$**	**4,008,740**
Minimum Projected Cost (-50%)	$	2,004,370
Maximum Projected Cost (+50%)	$	6,013,110
On-Site Treatment		
Project Management, Administration & Logistics	$	2,278,980
Capital Cost	$	1,763,696
Operations and Maintenance	$	21,000
Subtotal	**$**	**4,063,676**
Minimum Projected Cost (-50%)	$	2,031,838
Maximum Projected Cost (+50%)	$	6,095,514
Excavation and Off-Site Disposal		
Project Management, Administration & Logistics	$	2,213,980
Capital Cost	$	3,849,976
Operations and Maintenance	$	-
Subtotal	**$**	**6,063,956**
Minimum Projected Cost (-50%)	$	3,031,978
Maximum Projected Cost (+50%)	$	9,095,934

Post Signage

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Site-Specific Permitting & Management Plans		$5,000	1	$5,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$15,000	1	$15,000.00
Rotatry Wing (for installation program) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 12 flight hrs to access the 2 AECs)	lump sum	$67,000	1	$67,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 1 sign per Impacted Area (1 time event) -personnel time and supplies	Impacted Area	$3,000.00	2	$6,000.00
Consolidate drums and surface debris - periodic removal as allowable by capacity in charter	Lump Sum	$3,000.00	1	$3,000.00
Annual Operation and Maintenance				
Annual Site Inspection and monitoring -site inspection by fixed wing fly over (no landing)	Per Visit	$30,000.00	1	$30,000.00
Reporting	Lump Sum per yr	$10,000.00	1	$10,000.00
Option Total				**$199,800.00**

NOTES and ASSUMPTIONS:
- All work completed in 2 day site visit. One flight to transport personnel and supplies for the work.
- No suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- Site inspections carried out on 2 - 5 year basis to assess site and Sign integrity and signs of activity/visitation (1 inspection visit included in cost)

Monitored Natural Attenuation

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$20,000	1	$20,000.00
Rotatry Wing (for installation program) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 12 flight hrs to access the 2 AECs)	lump sum	$67,000	1	$67,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Consolidate drums and surface debris - periodic removal as allowable by capacity in charter	Lump Sum	$3,000.00	1	$3,000.00
Install 3 piezometers per Impacted Area -personnel time and supplies	Impacted Area	$5,000.00	2	$10,000.00
Annual Operation and Maintenance				
Sampling (rotary wing access only) -site inspection -well development and sampling -backhaul waste as capacity allows for disposal in Resolute -laboratory analysis	Per Visit	$50,000.00	5	$250,000.00
Rotatry Wing (per sampling year) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 5 flight hrs)	per year	$42,500.00	5	$212,500.00
Reporting	Lump Sum per yr	$10,000.00	5	$50,000.00
Option Total				**$676,300.00**

NOTES and ASSUMPTIONS:
- All work completed in 2 day site visit. One flight to transport personnel and supplies for the work.
- No suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment

Install Soil Cap

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$103,590
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$103,590
Mobilization barge from Montreal OR Hay River to Basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies to basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	1	$182,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE basecamp small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Capping and covering, regrading area -0.5m thick soil cap over each impacted area	per m2	$50.00	1035	$51,760.00
Consolidate drums and surface debris -Backhaul as alloable by capacity in charter for disposal in Resolute	Lump Sum	$3,000.00	1	$3,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Annual Operation and Maintenance				
Periodic Inspection of Cap integrity and site condition -aerial inspection by fly over in fixed wing aircraft -travel, room, board -cap inspection -photo log	Per Inspection	$30,000.00	1	$30,000.00
Option Total				**$4,008,740.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Winter cat train to deliver equipment to site and return to coast for Demob
- No suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- Soil cap only (no liners). Soil Cap 0.5 m thick to be adequately protective against direct soil contract pathway and potential burrowing
- Site inspections carried out on 2 - 5 year basis to assess cap integrity and signs of activity/visitation (1 inspection visit included in cost)
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations

On-site Treatment

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	5 % of technical work	5 % of technical work	5%	$103,590
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	5 % of technical work	5 % of technical work	5%	$103,590
Mobilization barge from Montreal OR Hay River to Basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies to basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	1	$182,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Construct treatment Cell Includes: -Materials -oversight -confirmatory sampling (1 sample / 10m^2)	cubic metre	$65.00	1035	$67,288.00
Excavate and move soil to treatment cell	cubic metre	$40.00	1035	$41,408.00
Install 3 piezometers around treatment area -personnel time and supplies	Impacted Area	$5,000.00	2	$10,000.00
Consolidate drums and surface debris -Backhaul as alloable by capacity in charter for disposal in Resolute	Lump Sum	$3,000.00	1	$3,000.00
Annual Operation and Maintenance				
Annual treatment cell operation: -nutrient addition -aeration/tilling -surface water management -assumed 5-day operation per visit	per year	$60,000.00	3	$180,000.00
Rotatry Wing (per sampling year) -Mob/demob - Resolute Bay ($25,000) -$3500/hr rotary rate includes fuel (estimated 12 flight hrs)	per year	$67,000.00	1	$67,000.00
Groundwater monitoring: -sampling and laboratory analysis	per year	$7,000.00	3	$21,000.00
Option Total				**$4,313,676.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Winter cat train to deliver equipment to site and return to coast for Demob
- No suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Treatment cell not lined. 0.75m high berms. Impacted soil placed 0.5 m thick in berm.
- 3 additional years of treatment included; includes purchase/shipping/application of nutrients; tilling by hand or with roto-tiller, monitoring samples
- Treatment cell to be decommissioned in place; MWs left in place in case additional monitoring is desired

Excavation and Off-Site Disposal

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$71,090
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$71,090
Mobilization barge from Montreal OR Hay River to Basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies to basecamp at Lougheed Strip -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Rotatry Wing for personnel transport to site (Daily) - Mob/demob - Resolute Bay ($25,000) - $3500/hr rotary rate includes fuel (estimated Daily minimum 2hrs) - 45 day program	lump sum	$182,500.00	1	$182,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Excavate and containerize soil Includes: -equipment/Labour -materials -oversight -confirmatory sampling (1 sample / 10m^2)	cubic metre	$65.00	1035	$67,288.00
Backfill, placement and compaction	cubic metre	$65.00	1035	$67,288.00
Non-haz soil transport and disposal: -winter cat train haul from AEC to coast @ Lougheed Strip -barge to Montreal	cubic metre	$2,000.00	1035	$2,070,400.00
Consolidate drums and surface debris -Winter backhaul to Lougheed String; fixed wing backhaul for disposal in Resolute	Lump Sum	$10,000.00	1	$10,000.00
Option Total				**$6,073,956.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Winter cat train to deliver equipment to site and return to coast for Demob
- No suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Impacted soil placed in 1 cu m mega bags; barge to Montreal; ground transport to non-haz waste landfill in QC.

Appendix B: Detailed Cost Tables for Remedial Options
Class "D" (+/- 50%) Cost Estimate 2016
Thor Island (NB058)

Total Number of AECs:	2
Total Square Meters of Soil at AECs:	3034
Total Cubic Meters of Soil at AECs:	2427
Distance from Resolute Bay (km):	440

Item	Cost	
Post Signage		
Project Management, Administration & Logistics	$	98,400
Capital Cost	$	6,000
Operations and Maintenance	$	40,000
Subtotal	**$**	**144,400**
Minimum Projected Cost (-50%)	$	72,200
Maximum Projected Cost (+50%)	$	216,600
Monitored Natural Attenuation		
Project Management, Administration & Logistics	$	98,400
Capital Cost	$	10,000
Operations and Maintenance	$	200,000
Subtotal	**$**	**308,400**
Minimum Projected Cost (-50%)	$	154,200
Maximum Projected Cost (+50%)	$	462,600
Install Soil Cap		
Project Management, Administration & Logistics	$	1,968,230
Capital Cost	$	1,796,700
Operations and Maintenance	$	30,000
Subtotal	**$**	**3,794,930**
Minimum Projected Cost (-50%)	$	1,897,465
Maximum Projected Cost (+50%)	$	5,692,395
On-Site Treatment		
Project Management, Administration & Logistics	$	1,968,230
Capital Cost	$	1,663,650
Operations and Maintenance	$	201,000
Subtotal	**$**	**3,832,880**
Minimum Projected Cost (-50%)	$	1,916,440
Maximum Projected Cost (+50%)	$	5,749,320
Excavation and Off-Site Disposal		
Project Management, Administration & Logistics	$	1,968,230
Capital Cost	$	4,387,736
Operations and Maintenance	$	-
Subtotal	**$**	**6,355,966**
Minimum Projected Cost (-50%)	$	3,177,983
Maximum Projected Cost (+50%)	$	9,533,949

Post Signage

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Site-Specific Permitting & Management Plans		$5,000	1	$5,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$15,000	1	$15,000.00
Air Charter to Site (Twin Otter) -FOB Resolute Bay	round trip	$15,000	1	$15,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
Camp Startup -soft sided tents	per year	$200,000.00	0	$0.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	0	$0.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	21	$8,400.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$2,500.00	0	$0.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 1 sign per Impacted Area (1 time event) -personnel time and supplies	Impacted Area	$3,000.00	2	$6,000.00
Annual Operation and Maintenance				
Annual Site Inspection and monitoring -site inspection	Per Visit	$30,000.00	1	$30,000.00
Reporting	Lump Sum per yr	$10,000.00	1	$10,000.00
Option Total				**$144,400.00**

NOTES and ASSUMPTIONS:

- All work completed in 1 day site visit. One flight to transport personnel and supplies for the work.
- Assumes suitable fixed wing landing condition at the Site
- Site inspections carried out on 2 - 5 year basis to assess site and Sign integrity and signs of activity/visitation (1 inspection visit included in cost)

Monitored Natural Attenuation

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$20,000	1	$20,000.00
Air Charter to Site (Twin Otter)	round trip	$15,000	1	$15,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	21	$8,400.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$2,500.00	0	$0.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 3 piezometers per Impacted Area -personnel time and supplies	Impacted Area	$5,000.00	2	$10,000.00
Annual Operation and Maintenance				
Sampling -site inspection -well development and sampling -laboratory analysis	Per Visit	$30,000.00	5	$150,000.00
Reporting	Lump Sum per yr	$10,000.00	5	$50,000.00
Option Total				**$308,400.00**

NOTES and ASSUMPTIONS:

- All work completed in 1 day site visit. One flight to transport personnel and supplies for the work.
- Assumes suitable fixed wing landing condition at the Site

Install Soil Cap

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$89,465
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$89,465
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Capping and covering, regrading area -0.5m thick soil cap over each impacted area	per m2	$50.00	3034	$151,700.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Annual Operation and Maintenance				
Periodic Inspection of Cap integrity and site condition -travel, room, board -cap inspection -photo log -Inspection report	Per Inspection	$30,000.00	1	$30,000.00
Option Total				**$3,794,930.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- Soil cap only (no liners). Soil Cap 0.5 m thick to be adequately protective against direct soil contract pathway and potential burrowing
- Site inspections carried out on 2 - 5 year basis to assess cap integrity and signs of activity/visitation (1 inspection visit included in cost)
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations

On-site Treatment

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	5 % of technical work	5 % of technical work	5%	$89,465
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	5 % of technical work	5 % of technical work	5%	$89,465
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Construct treatment Cell Includes: -Materials -oversight -confirmatory sampling (1 sample / 10m^2)	cubic metre	$65.00	130	$8,450.00
Excavate and move soil to treatment cell	cubic metre	$40.00	130	$5,200.00
Install 3 piezometers around treatment area -personnel time and supplies	Lump Sum	$5,000.00	1	$5,000.00
Annual Operation and Maintenance				
Annual treatment cell operation: -nutrient addition -aeration/tilling -surface water management -assumed 2-day operation per visit	per year	$60,000.00	3	$180,000.00
Groundwater monitoring: -sampling and laboratory analysis	per year	$7,000.00	3	$21,000.00
Option Total				**$3,832,880.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Treatment cell not lined. 0.75m high berms. Impacted soil placed 0.5 m thick in berm.
- 3 additional years of treatment included; includes purchase/shipping/application of nutrients; tilling by hand or with roto-tiller, monitoring samples
- Treatment cell to be decommissioned in place; MWs left in place in case additional monitoring is desired

Excavation and Off-Site Disposal

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$89,465
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$89,465
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$25,000.00	1	$25,000.00
Excavate and containerize soil Includes: -equipment/Labour -materials -oversight -confirmatory sampling (1 sample / 10m^2)	cubic metre	$65.00	2427	$157,768.00
Backfill, placement and compaction	cubic metre	$65.00	2427	$157,768.00
Non-haz soil transport and disposal: -Montreal	cubic metre	$1,000.00	2427	$2,427,200.00
Option Total				**$6,355,966.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Impacted soil placed in 1 cu m mega bags; barge to Montreal; ground transport to non-haz waste landfill in QC.

Appendix B: Detailed Cost Tables for Remedial Options
Class "D" (+/- 50%) Cost Estimate 2016
Rea Point

Total Number of AECs:	6
Total Square Meters of Soil at AECs:	5350
Total Cubic Meters of Soil at AECs:	4280
Distance from Resolute Bay (km):	440

Item	Cost	
Post Signage		
Project Management, Administration & Logistics	$	98,400
Capital Cost	$	9,000
Operations and Maintenance	$	40,000
Subtotal	**$**	**147,400**
Minimum Projected Cost (-50%)	$	73,700
Maximum Projected Cost (+50%)	$	221,100
Monitored Natural Attenuation		
Project Management, Administration & Logistics	$	128,400
Capital Cost	$	30,000
Operations and Maintenance	$	300,000
Subtotal	**$**	**458,400**
Minimum Projected Cost (-50%)	$	229,200
Maximum Projected Cost (+50%)	$	687,600
Install Soil Cap		
Project Management, Administration & Logistics	$	1,968,230
Capital Cost	$	1,937,500
Operations and Maintenance	$	30,000
Subtotal	**$**	**3,935,730**
Minimum Projected Cost (-50%)	$	1,967,865
Maximum Projected Cost (+50%)	$	5,903,595
On-Site Treatment		
Project Management, Administration & Logistics	$	1,968,230
Capital Cost	$	2,026,708
Operations and Maintenance	$	201,000
Subtotal	**$**	**4,195,938**
Minimum Projected Cost (-50%)	$	2,097,969
Maximum Projected Cost (+50%)	$	6,293,907
Excavation and Off-Site Disposal		
Project Management, Administration & Logistics	$	1,968,230
Capital Cost	$	6,506,400
Operations and Maintenance	$	-
Subtotal	**$**	**8,474,630**
Minimum Projected Cost (-50%)	$	4,237,315
Maximum Projected Cost (+50%)	$	12,711,945

Post Signage

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Site-Specific Permitting & Management Plans		$5,000	1	$5,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$15,000	1	$15,000.00
Air Charter to Site (Twin Otter) -FOB Resolute Bay	round trip	$15,000	1	$15,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	21	$8,400.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 1 sign per Impacted Area (1 time event) -personnel time and supplies	Impacted Area	$3,000.00	3	$9,000.00
Annual Operation and Maintenance				
Annual Site Inspection and monitoring -site inspection	Per Visit	$30,000.00	1	$30,000.00
Reporting	Lump Sum per yr	$10,000.00	1	$10,000.00
Option Total				**$147,400.00**

NOTES and ASSUMPTIONS:

- All work completed in 1 day site visit. One flight to transport personnel and supplies for the work.
- Assumes suitable fixed wing landing condition at the Site

Monitored Natural Attenuation

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$20,000	1	$20,000.00
Air Charter to Site (Twin Otter)	round trip	$15,000	3	$45,000.00
Demobilization from community Excludes waste disposal	lump sum	$5,000.00	1	$5,000.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	21	$8,400.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 3 piezometers per Impacted Area -personnel time and supplies	Impacted Area	$5,000.00	6	$30,000.00
Annual Operation and Maintenance				
Sampling -site inspection -well development and sampling -laboratory analysis	Per Visit	$50,000.00	5	$250,000.00
Reporting	Lump Sum per yr	$10,000.00	5	$50,000.00
Option Total				**$458,400.00**

NOTES and ASSUMPTIONS:

- All work completed in 3 day site visit. One flight to transport personnel and supplies for the work.
- Assumes suitable fixed wing landing condition at the Site

Install Soil Cap

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$89,465
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$89,465
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Capping and covering, regrading area -0.5m thick soil cap over each impacted area	per m2	$50.00	5350	$267,500.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$50,000.00	1	$50,000.00
Annual Operation and Maintenance				
Periodic Inspection of Cap integrity and site condition -travel, room, board -cap inspection -photo log -Inspection report	Per Inspection	$30,000.00	1	$30,000.00
Option Total				**$3,935,730.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- Soil cap only (no liners). Soil Cap 0.5 m thick to be adequately protective against direct soil contract pathway and potential burrowing
- Site inspections carried out on 2 - 5 year basis to assess cap integrity and signs of activity/visitation (1 inspection visit included in cost)
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations

On-site Treatment

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	5 % of technical work	5 % of technical work	5%	$89,465
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	5 % of technical work	5 % of technical work	5%	$89,465
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$50,000.00	1	$50,000.00
Construct treatment Cell Includes: -Materials -oversight -confirmatory sampling (1 sample / 10m ^ 2)	cubic metre	$65.00	3350	$217,724.00
Excavate and move soil to treatment cell	cubic metre	$40.00	3350	$133,984.00
Install 3 piezometers around treatment area -personnel time and supplies	Lump Sum	$5,000.00	1	$5,000.00
Annual Operation and Maintenance				
Annual treatment cell operation: -nutrient addition -aeration/tilling -surface water management -assumed 2-day operation per visit	per year	$60,000.00	3	$180,000.00
Groundwater monitoring: -sampling and laboratory analysis	per year	$7,000.00	3	$21,000.00
Option Total				**$4,195,938.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Treatment cell not lined. 0.75m high berms. Impacted soil placed 0.5 m thick in berm.
- 3 additional years of treatment included; includes purchase/shipping/application of nutrients; tilling by hand or with roto-tiller, monitoring samples
- Treatment cell to be decommissioned in place; MWs left in place in case additional monitoring is desired

Excavation and Off-Site Disposal

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$89,465
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$89,465
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$800.00	60	$48,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$50,000.00	1	$50,000.00
Excavate and containerize soil Includes: -equipment/Labour -materials -oversight -confirmatory sampling (1 sample / 10m^2)	cubic metre	$65.00	4280	$278,200.00
Backfill, placement and compaction	cubic metre	$65.00	4280	$278,200.00
non-haz soil transport and disposal: -Montreal	cubic metre	$1,000.00	4280	$4,280,000.00
Option Total				**$8,474,630.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Impacted soil placed in 1 cu m mega bags; barge to Montreal; ground transport to non-haz waste landfill in QC.

Appendix B: Detailed Cost Tables for Remedial Options
Class "D" (+/- 50%) Cost Estimate 2016
Romulus C-42 Well Site

Total Number of AECs:	3
Total Square Meters of Soil at AECs:	2604
Total Cubic Meters of Soil at AECs:	2083
Distance from Resolute Bay (km):	640

Item	Cost	
Post Signage		
Project Management, Administration & Logistics	$	110,000
Capital Cost	$	4,000
Operations and Maintenance	$	40,000
Subtotal	**$**	**154,000**
Minimum Projected Cost (-50%)	$	77,000
Maximum Projected Cost (+50%)	$	231,000
Monitored Natural Attenuation		
Project Management, Administration & Logistics	$	100,000
Capital Cost	$	15,000
Operations and Maintenance	$	300,000
Subtotal	**$**	**415,000**
Minimum Projected Cost (-50%)	$	207,500
Maximum Projected Cost (+50%)	$	622,500
Install Soil Cap		
Project Management, Administration & Logistics	$	2,127,510
Capital Cost	$	1,800,200
Operations and Maintenance	$	50,000
Subtotal	**$**	**3,977,710**
Minimum Projected Cost (-50%)	$	1,988,855
Maximum Projected Cost (+50%)	$	5,966,565
On-Site Treatment		
Project Management, Administration & Logistics	$	2,127,510
Capital Cost	$	1,696,840
Operations and Maintenance	$	201,000
Subtotal	**$**	**4,025,350**
Minimum Projected Cost (-50%)	$	2,012,675
Maximum Projected Cost (+50%)	$	6,038,025
Excavation and Off-Site Disposal		
Project Management, Administration & Logistics	$	2,127,510
Capital Cost	$	6,107,216
Operations and Maintenance	$	-
Subtotal	**$**	**8,234,726**
Minimum Projected Cost (-50%)	$	4,117,363
Maximum Projected Cost (+50%)	$	12,352,089

Post Signage

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Site-Specific Permitting & Management Plans		$5,000	1	$5,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$15,000	1	$15,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	0	$0.00
Return person Transportation - Contractor's Charter Base to REMOTE site	person-trips	$2,500.00	0	$0.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 1 sign per Impacted Area (1 time event) '-Site is compact; impacts in close proximity; 1 sign needed -personnel time and supplies	Impacted Area	$4,000.00	1	$4,000.00
Annual Operation and Maintenance				
Annual Site Inspection and monitoring -site inspection	Per Visit	$30,000.00	1	$30,000.00
Reporting	Lump Sum per yr	$10,000.00	1	$10,000.00
Option Total				**$154,000.00**

NOTES and ASSUMPTIONS:

- All work completed in 1 day site visit. One flight to transport personnel and supplies for the work.
- Assumes suitable fixed wing landing condition at the Site
- Site inspections carried out on 2 - 5 year basis to assess site and Sign integrity and signs of activity/visitation (1 inspection visit included in cost)

Monitored Natural Attenuation

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	$10,000	1	$10,000
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	$10,000	1	$10,000
Purchasing and Mobilization Staging in Community & ship supplies -$5000 / tonne (air transport) -$9000/20' seacan (sealift)	lump sum	$10,000	1	$10,000.00
Demobilization from community Excludes waste disposal	lump sum		1	$0.00
In Community Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	9	$3,600.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$2,500.00	0	$0.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	3	$15,000.00
Survey	Lump sum	$15,000.00	1	$15,000.00
Construction / Installation Cost				
Install 3 piezometers per Impacted Area -personnel time and supplies	Impacted Area	$5,000.00	3	$15,000.00
Annual Operation and Maintenance				
Sampling -site inspection -well development and sampling -laboratory analysis	Per Visit	$50,000.00	5	$250,000.00
Reporting	Lump Sum per yr	$10,000.00	5	$50,000.00
Option Total				**$415,000.00**

NOTES and ASSUMPTIONS:

- All work completed in 1 day site visit. One flight to transport personnel and supplies for the work.
- Assumes suitable fixed wing landing condition at the Site

Install Soil Cap

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$96,705
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$96,705
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00

Item (& assumptions)	Unit	Rate	Quantity	Total
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00
In Community (RESOLUTE) Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
In EUREKA Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$1,400.00	60	$84,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Capping and covering, regrading area -0.5m thick soil cap over each impacted area	per m2	$50.00	2604	$130,200.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$50,000.00	1	$50,000.00
Annual Operation and Maintenance				
Periodic Inspection of Cap integrity and site condition -travel, room, board -cap inspection -photo log -Inspection report	Per Inspection	$50,000.00	1	$50,000.00
Option Total				**$3,977,710.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- Soil cap only (no liners). Soil Cap 0.5 m thick to be adequately protective against direct soil contract pathway and potential burrowing
- Site inspections carried out on 2 - 5 year basis to assess cap integrity and signs of activity/visitation (1 inspection visit included in cost)
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations

On-site Treatment

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	5 % of technical work	5 % of technical work	5%	$96,705
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	5 % of technical work	5 % of technical work	5%	$96,705
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport - demob equipment back to cost in following winter	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In Community (RESOLUTE) Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
In EUREKA Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$1,400.00	60	$84,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$50,000.00	1	$50,000.00
Construct treatment Cell Includes: -Materials -oversight -confirmatory sampling (1 sample / 10m ^ 2)	cubic metre	$65.00	208	$13,520.00
Excavate and move soil to treatment cell	cubic metre	$40.00	208	$8,320.00
Install 3 piezometers around treatment area -personnel time and supplies	Lump Sum	$5,000.00	1	$5,000.00
Annual Operation and Maintenance				
Annual treatment cell operation: -nutrient addition -aeration/tilling -surface water management -assumed 2-day operation per visit	per year	$60,000.00	3	$180,000.00
Groundwater monitoring: -sampling and laboratory analysis	per year	$7,000.00	3	$21,000.00
Option Total				**$4,025,350.00**

NOTES and ASSUMPTIONS:
- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Treatment cell not lined. 0.75m high berms. Impacted soil placed 0.5 m thick in berm.
- 3 additional years of treatment; includes purchase/shipping/application of nutrients; tilling by hand or with roto-tiller, monitoring samples
- Treatment cell to be decommissioned in place; MWs left in place in case additional monitoring is desired

Excavation and Off-Site Disposal

Item (& assumptions)	Unit	Rate	Quantity	Total
Balance of Project Costs including but not limited to: - Any variable indirect costs for overhead and administration, - Costs for Expeditors, - Closeout Submittals, - CGL Insurance, - WCB Costs, - Business Expenses, - Contractor's Portion of Training Expenses, - EMT, - Ancillary Equipment	lump sum	5 % of technical work	5%	$96,705
-Worker Orientation/training Seminar -Planning & community meetings -Work Management Plans -Health & Safety Plan -permitting -communications links -wildlife monitor	lump sum	5 % of technical work	5%	$96,705
Mobilization barge from Montreal OR Hay River -$500 / tonne -$9000/20' seacan -1 dozer, 1 excavator, 1 rock truck	lump sum	$500,000.00	1	$500,000.00
Mobilization from Community & ship supplies -$500 / tonne -$9000/20' seacan	lump sum	$50,000	1	$50,000.00
Mobilization Winter Cat Train - Site is approx 10km inland from coast - mob, equipment commissioning, road push, transport	per year	$100,000.00	1	$100,000.00
Demobilization barge to Montreal OR Hay River -$400 / tonne -$7000/20' seacan Excludes waste disposal	lump sum	$500,000.00	1	$500,000.00
Demobilization from community Excludes waste disposal	lump sum	$10,000.00	1	$10,000.00
Camp Startup -soft sided tents	per year	$200,000.00	1	$200,000.00
Camp Operation -support staff, food, fuel -10 person team (7500 / day) -15 person team (12,000 / day)	per day	$7,500	45	$337,500.00

Item (& assumptions)	Unit	Rate	Quantity	Total
In RESOLUTE Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
In EUREKA Room and Board for contractor NON-LOCAL staff contractor = 2 custodian = 1	Person-day	$400.00	22	$8,800.00
Return person Transportation - Contractor's Charter Base to REMOTE site small site = 10 med site = 15 large site = 20	person-trips	$1,400.00	60	$84,000.00
Return person Transportation - Commercial travel to community contractor = 2 custodian = 1	person-trips	$5,000.00	22	$110,000.00
Survey	Lump sum	$25,000.00	1	$25,000.00
Construction / Installation Cost				
Heavy Equipment -rental for 2 seasons (due to barge schedules)	Lump Sum	$1,620,000.00	1	$1,620,000.00
Site Access -Landing strip improvements -road / trail construction	Lump Sum	$50,000.00	1	$50,000.00
Excavate and containerize soil Includes: -equipment/Labour -materials -oversight -confirmatory sampling (1 sample / 10m ^ 2)	cubic metre	$65.00	2083	$135,408.00
Backfill, placement and compaction	cubic metre	$65.00	2083	$135,408.00
Non-haz soil transport and disposal: -winter cat train haul from AEC to coast @ Lougheed Strip -barge to Montreal	cubic metre	$2,000.00	2083	$4,166,400.00
Option Total				**$8,234,726.00**

NOTES and ASSUMPTIONS:

- Heavy Equipment sourced from Montreal or NWT; assumed dedicated to the site for minimum 2 yrs due to barge schedules
- Assumes suitable fixed wing landing condition at the Site - potential for improvement/expansion with heavy equipment
- 45 day season includes site ramp-up, work implementation, and complete Demob by barge; 2 week personnel rotations
- Impacted soil placed in 1 cu m mega bags; barge to Montreal; ground transport to non-haz waste landfill in QC.

APPENDIX C

Summary of Community Meeting in Resolute Bay – Public Comment and Slide Deck

ᐃᓂᐊᓗᒃ ᐅᑎᖅᑭᖢᓂᖅ ᐋᐅᓚᑦ ᑎᕿ ᔪᑎᓗᒃ ᐸᕐ ᓇᐅᑎᖕ
ᖁᑭᑉ ᑐᕐ ᒥᐅᑦ ᐅᖅᓱᐊᓂ ᐊᒻᒪᓗᒑᓯᑦ ᐃᓂᖕᒋ, ᓄᓇᕗᑦ
ᓄᓇᓕᖕᓂᑲᑎᒪᓂᖅ ᖃᐅᔨᑎᖕ ᑎᕿ ᔪᑕᐅᔪᓗᒃ ᑐᑭᓯᑎᐊᕈᑎᖕ - ᖃᐅᔨᐃᑦ ᑐᖅᕼᐋᓚ ᓚᒃ ᑯᑦ ᑲᑎᒪᔨᖕᒋ

ᓄᓇᓕᖕᓂᑲᑎᒪᓂᖅ ᐅᓪ ᔫᖕᑲᐊᐃᐹ, ᒪᐃ17, 2016
ᖃᔅ ᓱᒧᐊᖅᐸᑦ: 7-ᓂᑦ 9-ᒧᑦ ᐅᓐᓄᒃᑯᑦ
ᓇᓃ: ᓄᓇᓕᖕᓂ ᐃᓚᓐᓂᐊᕐ ᕕᒃ ᐱᖕᖑᐊᕐ ᕕᖕᒐᖅᑲᐅᔨᐃᑦ ᑐᖅ

ᐃᓂᖅ ᐱᖁᑎᔭᐅᔪᖅ: ᐃᓄᓐᓂᓯᑐᖅᑯᑦ ᑲᓇᑕ
ᐱᓕᕆᐊᖑᔪᒧᑦ ᐅᖃ ᕕᐅᑉ ᑐᑦ: ᐳᓛᒥᑐᓪ ᐊᑲᑦᓕᓐᓯᒃ ᑯᑦ ᑎᒥᖓ[Blumetric]

ᐱᓕᕆᐊᖑᔪᖅ ᑭᓱᓕᕐᓂᐊᕐ ᓂᖕᒐ ᐃᓄᓐᓂᓯᑐᖅᑯᑦ ᑲᓇᑕᒥ ᐱᔭᒃ ᓴᖅᑲᖅᑐᑦ ᑕᒪᐃᓐᓂᒃ ᒐᕙᒃ ᑯᑦ ᓄᕐᖁᖓᖕᖏᓂᒃ ᐅᑭᐅᖅᑕᖅᑐᒥ. ᑕᒪᐅᓇ ᐅᑭᐅᖅᑕᖅᑐᒥ ᓱᕋᖅᓯᒪᔪᓗᒃ ᐱᓕᕆᕝᕕᖕ ᑎᕿ ᔪᑕᐅᔪᖅ ᐃᓂᖕᒋᑦ, ᑖᒃ ᑯᐊ ᐋᐅᓚᑦ ᓯᔩᑦ ᑲᒪᒋᔭᖅᑲᖅᑐᑦ ᐊᒥᓱᓂᒃ ᓱᕋᖅᓯᒪᕕᐅᔪᓂᒃ ᐃᓄᖕᒍᓐᓂᖅᑲᖅᑐᓂᒃ. ᓱᕋᖅᓯᒪᔪᑦ ᐅᑯᐊ ᑕᐃᒪᓐᓇᐃᓚᖕᒐᖅᑐᑦ ᐃᒻ ᒥᒃᑯᖅᑐᓂᑦ ᐅᔭᕋᖕᓂᐊᕐ ᑎᓂᑦ ᐊᒻᒪᓗ ᐅᖅᓱᐊᓗᓐᓂᕕᐅᔪᑦ ᒫᓯᓐᓂᕕᐅᔪᑦ ᐊᒻᒪᓗ ᒐᕙᒃ ᑯᓂᑦ ᐅᓇᓖᖅᑐᓴᖅᑲ ᕕᐅᔪᑦ ᑕᐃᒪᓗ ᐊᑲᐅᖕᒋᑦ ᐊᐅ ᑐᖅᑕᐅᓯᒪᔪᖅ ᖃᓄᖅ ᑐᑭᓯᐅᒪᔭᐅᓇᓂᓯᑦ.

ᑐᑭᓴᐅᑎᑕᐅᖕᖑᐊ ᓚᐊᓂᐊᖅᑐᑦ ᑖᒃ ᑯᓇᖕᒍ ᐅᑭᐅᖅᑕᖅᑐᒥ ᓱᕋᖅᓯᒪᔪᓗᒃ ᐱᓕᕆᕝᕕᖕ ᑎᕿ ᔪᑕᐅᔪᖅ ᐋᐅᓚᑦ ᑎᒃᑯᖕ ᒧᑦ ᐱᓕᑦ ᑎᒃᑯᖕ ᒧᑦ ᓱᕋᖅᓯᒪᔪᖅᑲᖅᑐᑦ ᐃᓂᖕᒋ ᐊᑭᑐᔪᖕᖏᒧᑉ ᐊᒻᒪᓗ ᒪᓕᑦ ᑎᒃᑯᖅᑐᒥᒃ. ᐅᓇ ᐱᓕᕆᕝᕕᖕ ᑎᕿ ᔪᑕᐅᔪᖅ ᑐᑦᖅᑐᖅ ᐊᑦ ᑎᑉ ᓯᓯᒪᑎᖕᓇᓱᐊᖕ ᒧᑉ ᐊᒻᒪᓗ ᓄᖕᖑ ᑎᒃᑯᖕ ᒧᑦ, ᑕᐃᑲᓂᐊᕐᖅ ᓇᖕᒋᑎᕐ ᒧᑦ, ᐊᑦ ᑕᖅ ᓇᖅᑐᑦ ᐃᓅᓗᒃ ᐊᒻᒪᓗ ᐊᑲᖏ ᑎᓗᒃ ᐋᓂᐊᓚᕈᑕᐅᔪᓐᓇᖅᑐᑦ, ᐊᑭᓚᑉ ᓴᖕᑰᓇᖅᑐᑦ ᓱᕋᖅᓯᒪᔪ ᐃᓅᖕᑎᐅᑭᐅᖅᑕᖅᑐᒥ. ᓯᕗᓪ ᓚᖅᐋᐅᑎᕝ ᒧᑦ ᐅᑯᐊ ᐃᓅᓯᔭᐅᔪᑦ ᐊᑦ ᑕᖅ ᓇᖅᑐᖅᑲᓪᓚᖕᖑᔪᑦ.

ᑕᐃᑲᓂ ᔪᓚᐃ ᐊᒻᒪᓗ ᐋᒍᓯ 2015-ᒥ, ᐃᖅᑲᓇᐃᔭᖅ ᑎᖕᒋ ᐳᓛᒥᑐᓪ ᐊᑲᑦᓕᓐᓯᒃ ᑯᑦ ᐳᓛᓚᐅᖅᑐᑦ ᐅᑯᓄᖕᒐ 6 ᓱᕋᖅᓯᒪᔪᖅᑲᖅᑐᓗᒃ ᐃᓅᓯᔭᐅᔪᓗᒃ, ᑕᒪᖅ ᒥᒃ ᑕᐃᒪᓐᓇᐃᓚᖕᒐᖅᑐᑦ ᑭᖕᒍᓂᑦ ᑎᓂᐅᖅᓱᐊᓗᓐᓂᔪᓂᑦ ᐊᒻᒪᓗᒫᓯᓐᓂᔪᓂᑦ:

- ᐅᓚᐃ ᓄᕗᐊ - ᐅᖅᓱᑎᓐᓇᑉ ᖁᐱᖅᑕᖕᒐ
- ᑐᓚᐃᒃ ᓄᕗᐊ - ᐅᖅᓱᑎᓐᓇᑉ ᖁᐱᖅᑕᖕᒐ
- ᓚᕼᐋᑦ (L1) ᐃᓅᕙ ᓚᕼᐋᑦ ᖁᐱᖅᑕᖅ
- ᑕᐃᔪ ᐸᐃᓐ ᐃᓅᕙ ᓚᕼᐋᑦ ᖁᐱᖅᑕᖅ
- ᑐᐊ ᖁᐱᖅᑕᖅ
- ᐲᒧᑐ - ᑐᔾ ᔮᓂ ᖁᐱᖅᑕᖕᒐ ᖃᓂᔮᓂ ᐅᓛᑲ

ᐃᖅᑲᓇᐃᔭᖅ ᑎᖕ ᓄᐊᑦ ᑎᓚᐅᖅᑐᑦ 850 ᐃᔾ ᔪᖅ ᐊᒻᒪᓗ ᐃᒥᖕᒋᓂᒃ ᖃᐅᔨᓴᕐᑖᖅᓱᒋᑉ ᖃᐅᔨᓂᐊᕐ ᒪᑕ ᖃᓄᖕᒋᔪᖅ ᓱᕋᖅᓯᒪᖕᒪᖕᑖ ᓇᓗᓇᐃᖅᑕᐅᓚᐅᖅᓯᒪᔪᑦ ᐃᓚᑕᐅᓇᓱᒃ ᑐᓂ ᑭᖕᒍᓂᑦ ᑎᓂ. ᐅᑯᐊ ᖃᐅᔨᓴᕈᑎᓚᑦ ᖃᐅᔨᔭᐅᑦ ᑎᒃᑯᖕ ᒧᑉ ᐊᒻᒪᓗ ᖃᐅᔨᔭᖕᒋ ᑕᐃᒪ ᐅᖅᓱᐊᓗᕐᖅᑐᑦ ᓱᕋᖅᑕᐅᓯᒪᔪᑦ ᐊᒻᒪᓗ ᓴᕕᖁᔭᒃ ᓴᓂᑦ ᓱᕋᖅᑕᐅᓯᒪᔪᑦ ᐱᑕᖅᑐᑦ ᐃᔾ ᔪᖅ ᒥ ᑕᒪᐃᓐᓂ ᐃᓅᓯᔭᐅᔪᓂ. ᐅᑯᐊ ᓱᕋᖅᓯᒪᔭᖕᒋ ᑕᐃᒪᓐᓇᐃᓚᖕᒐᖅᑐᑦ ᐃᒻ ᒪᑲᓪᓚᒃ ᐅᖅᓱᐊᓗᓐᓂᕕᐅᔪᕕᓂᐅᓂᖕᒪ ᐊᒻᒪᓗ ᒫᓯᓐᓂᕕᐅᓂᒍᓐᓂᖕᒪᓗ ᐃᓅᖕᖏᓂ.

ᓄᓇᓕᖕᓂ ᑲᑎᒪᓂᖅ ᖁᐱᖅ ᕿᐊᖕ ᒧᑉ ᐊᑐᓂ ᐊᒻᒪᓗ ᑐᓂᔪᓯᒪᓂᖅ ᐊᑐᕈᓐᓇᖅᑕᖕᖏᓂᒃ ᓂᕈᐊᓂᒧᑦ ᖃᐅᔨᓴᕐᑖᖅ ᑎᒃᑯᖕ ᒪᓂᓚᓪ ᓗᒍ ᐃᓄᓐᓂᑦ ᐅᐸᒃ ᑕᐅᕙᒍᓐᓃᖅ ᒧᑉ ᐊᑦ ᑕᖅ ᓇᖅᑐᖅᑲᓪᓚᒃ ᑕᒪᑕ, ᓂᖅ ᔪᑎᓗᒃᓗ ᐊᒻᒪᓗ ᐱᕈᖅᑐᓗᒃ ᐃᓅᕙᓂ. ᐅᓇ ᐊᑐᓕᖅᑕᐅᔪᖅ ᐊᑦ ᑕᖅ ᓇᖅᑐᓅᓂᕐᒪᓗ ᐋᐅᓚᑕᐅᑦ ᑎᒃᑲᓕᐊᖅ ᓂᖕᒐᐅᖅᑲᐅᓯᐅᓂᐊᖅᑐᖅ. ᑲᑎᒪᑎᕝ ᑎᓂᐊᖅᑐᒧᑦ ᓄᓇᓕᖕᓂ ᑭᐅᔭᐅᔭᓪᓚᒃ ᐊᑐᓐᓇᖅᑕᑦ ᑎᓂᑉ ᐊᒻᒪᓗᐊᐱᖅᓱᖅ ᒧᑉ ᐱᖦ ᒧᑦ ᑖᒃ ᑯᐊ ᐃᓅᓯᔭᐅᔪᑦ.

ᑳᐱᑐᖅ ᕕᖅᑲ ᓂᐊᖅᑐᖅ ᐊᒻᒪᓗᐊᕐᑎ ᓂᑉ ᐊᐅᓯᒧᑉ ᓵᓚᒃ ᓴᐅᓯᐊᖅ ᑎᕿ ᑎᓂᐊᖅᑐᑦ.

ᐊᐱᖅᑯᑉ ᓴᖅᑳᕕᑦ ᐊᔪᖕᒋᓂᑉ, ᐅᖅᑲᐅᒋᓗᒍ ᒍᐃᓐ ᐃᖕᒐᒻ ᑖᒃ ᑯᓇᓂ ᐳᓛᒥᑐᓪ ᐊᑲᑦᓕᓐᓯᒃ ᑯᑦ (wingham@blumetric.ca ᐅᖃᓗᒻᒥᑦ 613-329-5363) ᐅᖃᓗᒻᒥᑦ ᒫᒃ ᔨᑦᒪᓐ ᐃᓄᓐᓂᓯᑐᖅᑯᑦ ᑲᓇᑕᒥ (mark.yetman@aandc-aadnc.gc.ca ᐅᖃᓗᒻᒥᑦ 819-934-1188).

Remedial & Risk Management Plans
High Arctic Oil and Gas Sites, Nunavut
Community Meeting Background Information – Resolute Bay Hamlet Council

Community Meeting Date: Tuesday May 17, 2016
Time: 7-9pm
Location: Community Gym, Resolute Bay

Site Custodian: Indigenous and Northern Affairs Canada (INAC)
Project Consultants: BluMetric Environmental Inc.

Project Background: Indigenous and Northern Affairs Canada (INAC) is responsible for most Federal lands in the North. Through the Northern Contaminated Sites Program (CSP), the Department manages a number of contaminated properties abandoned by their previous occupants. The contamination of these properties is the result of private sector mining and oil and gas activities and government military activity that occurred over a half a century ago, when environmental impacts were not fully understood.

The objective of the CSP is to manage contaminated sites in a cost-effective and consistent manner. The program aims to reduce and eliminate, where possible, risks to human and environmental health, and liability associated with contaminated sites in the North. Priority is given to those sites posing the highest risks.

In July and August 2015, personnel from BluMetric Environmental visited the following six contaminated sites, all of which were associated with past high Arctic oil and gas activities:

- Rea Point – Melville Island
- Drake Point – Melville Island
- Lougheed (L1) Site – Lougheed Island
- Dale Payne Site – Lougheed Island
- Thor Island
- Romulus – Ellesmere Island, near Eureka

Personnel collected 850 soil and water samples to determine the extent of contaminants that were identified in previous studies. These samples were analysed and the results found that fuel contamination and metal contamination is present in pockets of soil at all of the sites. This contamination is likely associated with the historical oil and gas operations at the sites.

The Community Meeting will review the results for each site and will present the options evaluated to reduce the risk to humans, wildlife and plants at the sites. The recommended risk management option will be presented. This meeting will be a forum for local residents to provide feedback and ask questions about the sites.

Refreshments and door prizes will be provided.

If you have any further questions, please contact Wayne Ingham of BluMetric Environmental (wingham@blumetric.ca or 613-329-5363) or Mark Yetman of Indigenous and Northern Affairs Canada (mark.yetman@aandc-aadnc.gc.ca or 819-934-1188).

High Arctic Oil and Gas Sites - Community Consultation Summary -

DATE:	May 17, 2016
TIME:	19:00-21:20
LOCATION:	Resolute Bay Hamlet Office Gym
REPRESENTATIVES:	Wayne Ingham (BluMetric) Mark Yetman (INAC) Michael Westlake (INAC)
ATTENDANCE:	15
NOTES:	There were 15 adults in attendance but only 11 signed the attendance sheet. There were also a few children present.

QUESTIONS & ANSWERS	
Q1) Have you done detailed sampling of wildlife from end of oil and gas operations to present?	A1) No sampling of wildlife has been done, but it's important to note that the size of the sites are small and the exposure of any wildlife to contaminants is low due to the short amount of time that they would be in contact.
Q2) I'm especially concerned about the exposure of caribou and muskox to contaminants as they travel long ranges.	A2) With respect to the High Arctic sites, the sites are small and there is no reason for them to stay in the area for long periods of time as there isn't much vegetation and the sites are small. Furthermore, the contaminants of concern are largely petroleum based and as they age they naturally break down.
Q3) There is not enough studies done on marine mammals. The water moves around a lot. Mammals move around a lot. And then there's also migratory birds.	A3) Marine mammals were not looked at as part of our site investigations as we did not find evidence to suggest that mammals would have been impacted from the contaminants found on the 6 sites. These sites contained minimal amounts of water and there was no evidence found to suggest contaminants were traveling via this mechanism. With respect to the question about migratory birds and exposure to contaminants, these species don't stay in an area long enough to be exposed.

High Arctic Oil and Gas Sites - Community Consultation Summary -

QUESTIONS & ANSWERS	
Q4) Where do the samples get sent to to be tested?	A4) All samples are sent to an accredited laboratory in the South.
Q5) How can we get copies of the sampling data and the results?	A5) The data and results are public information. If you would like copies you can talk to INAC.
Q6) How long will it take to clean up the sites?	A6) There is at least 4 months of work, albeit most of the work is at Dale Payne. With this being said, there isn't a concrete schedule until the project goes to tender.
Q7) What will happen to the soils at Dale Payne that are of high contaminant concentrations?	A3) This will be up to the contractor, but soil could be bagged and put into the building to be shipped, or could be shipped in a separate container.
Q8) Wayne: Do you know anybody that goes to these sites?	A8) The only people that we know of that go to these sites are the military. You should warn them about the contaminants. "We are too old!"
Q9) Question on procurement process and local/aboriginal employment.	A9) When we evaluate proposals from individual companies we look at the amount of local employment and involvement in the project. We want local people from the community to be involved in the project and encourage local employment. Only people from Resolute would count in this evaluation.
Q10) How can you tell where buried landfills and areas of contaminants are?	A10) You can tell where the sites are based on areas of disturbances. We typically sample around the outer exterior of these areas of disturbance until we don't find anything.
Q11) How do you know where the sites are? Comment: "we don't want to see fences put up to disturb the wildlife."	A11) Sites are initially identified through historical records. We know where the sites are but haven't put markers. We do not plan to put any fences on the sites so wildlife movement will not be restriced. We will post signage so people are aware of the presence of contaminants.

High Arctic Oil and Gas Sites - Community Consultation Summary -

QUESTIONS & ANSWERS	
Q12) Where do the contaminateds soils go when they are removed from the sites?	A12) Soils that are removed from the sites will be shipped down South and be treated at a licenced disposal facility.
Q13) Discussion on other contaminants sites in the area	Devon Island: - there could be a lot more contaminants sites on Devon Island due to known military, and exploration/development activities. (mention of a site where there was more than 100 fuel drums). Resolute: - there are a number of old military sites around the community that could hold contaminants.
FOLLOW UP ACTIONS:	Look into the issues mentioned in Q13; Ensure no fences in remediation design and Specs
MEDIA INQUIRIES:	

* A copy of the Presentation and the Attendance Sheet is attached

Remedial & Risk Management Plans

High Arctic Oil and Gas Sites, Nunavut

Wayne Ingham, Ph.D. – BluMetric Environmental Inc.
Michael Bernardin – Public Works and Government Services Canada
Mark Yetman - Indigenous and Northern Affairs Canada

www.blumetric.ca

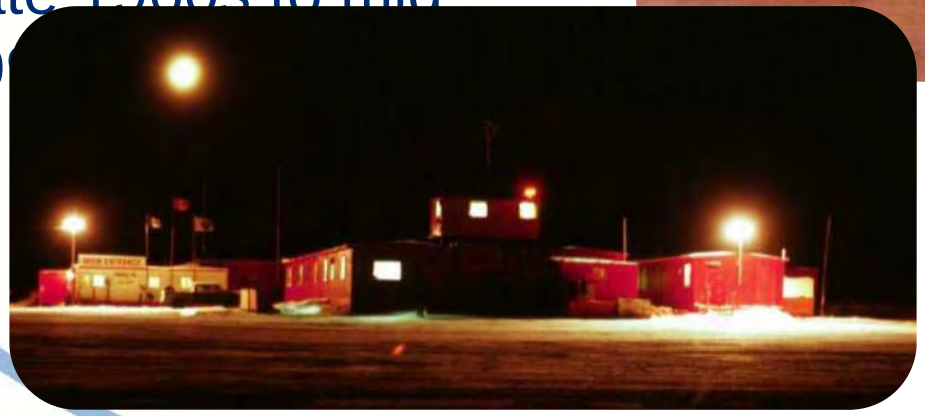
Presentation Outline

- Project Background
- Site Summary
- Site Assessment Results
- Risk Assessment
- Risk Management Options
- Recommended Next Steps

Project Background

Six Sites

- High Arctic Oil & Gas
- Exploration & production
- Late 1960s to mid-19



Rea Point – 1975-1980
Photos by Don Smith

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High Arctic Sites

- Rea Point – Melville Island
- Drake Point – Melville Island
- Lougheed (L1) Site – Lougheed Island
- Dale Payne Site – Lougheed Island
- Thor Island
- Romulus – Ellesmere Island near Eureka

Preliminary site assessments conducted in 2011 to collect information.

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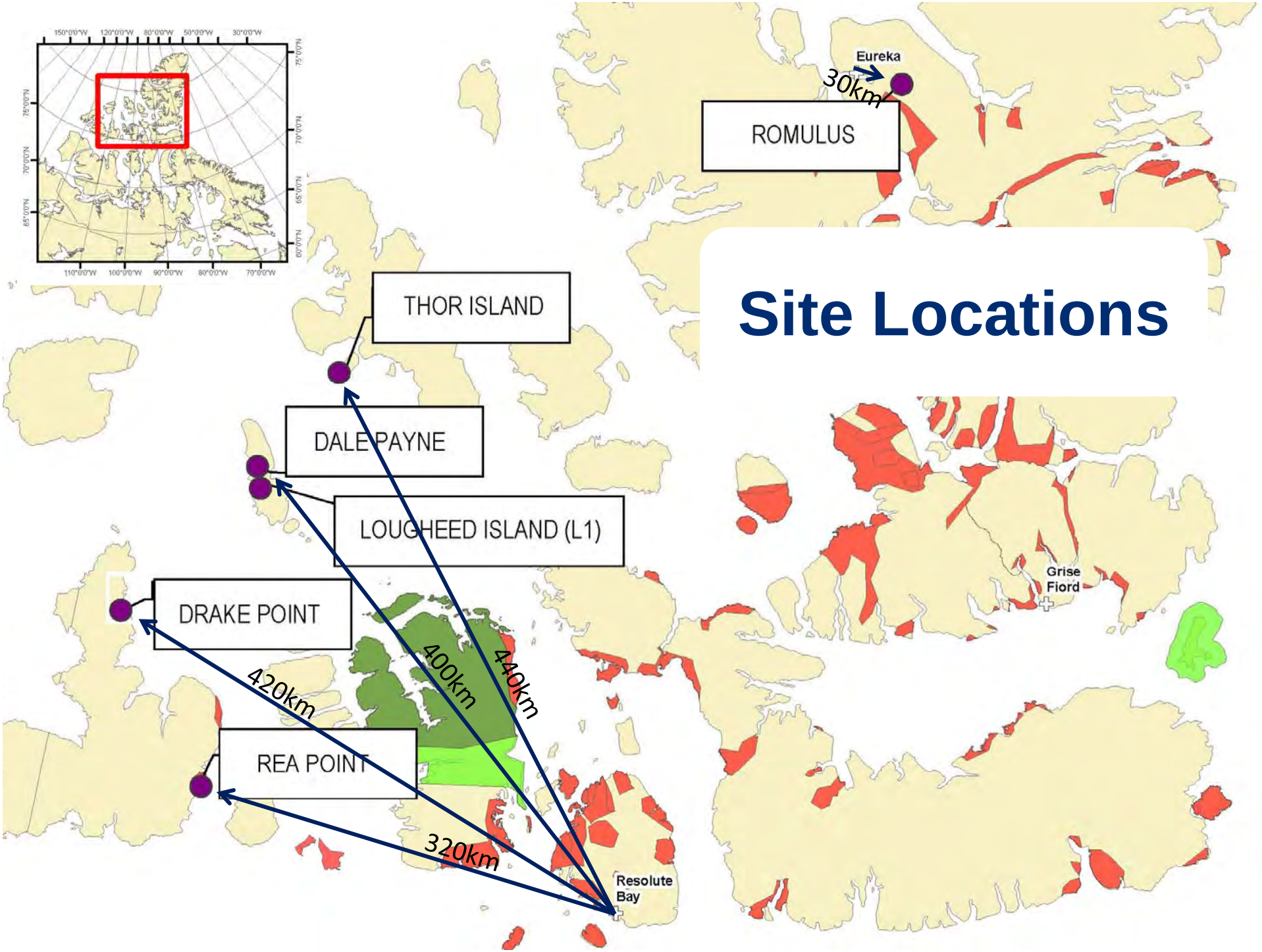

Site Locations

Project Scope

Completion of the following on each site:

- Detailed Environmental Site Assessment
- Human Health And Ecological Risk Assessment (People, Plants & Animals)
- Remediation And Risk Management Plan (Clean-up Plan)
- Environmental Impact Assessment

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The Project Team

- Client: Public Works and Government Services Canada (PWGSC) – Michael Bernardin – Project Manager
- Site Custodian: Indigenous and Northern Affairs Canada (INAC) – Mark Yetman – Project Contact
- Consultants: BluMetric Environmental Inc.
- Sub-Contractors:
  - Air Charters: Summit Air, Kenn Borek Air
  - Camp Outfitter: Matrix Aviation Solutions
  - Lab: AGAT Laboratories
  - Local Wildlife Monitors
  - ATCO, 994458 Nunavut Ltd.

Detailed Site Assessments

Site Work:

- Collect soil and water samples to measure amount of contaminants identified in previous work.

Program Details:

- Program based out of Rea Point camp
- Wildlife Monitors from Resolute Bay
- Site work occurred from July 27-August 19, 2015
- Used Twin Otter aircraft and helicopter to travel to sites
- 850 soil and water samples collected by hand & sent for analysis

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Assessment Results - Rea Point

Assessment Results – Rea Point

- All buildings, drums and major debris were buried or removed from the site when it was abandonned
- 5 Areas Investigated – North Quarry, Camp & Airstrip Area, Landfills, Pumping Station & Loading Area and South Quarry
- Samples:
  - 272 soil
  - 10 water
  - 2 sediment samples
- Fuel and metal contamination in soil from material storage and handling

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Assessment Results – Drake Point

Assessment Results – Drake Point

- All buildings, drums and major debris were buried or removed from the site when it was abandonned
- 5 Areas Investigated: Collingwood K-73, K-79 Well, Airstrip & Camp, Well EE-78 and F-76 Drill Camp,
- Samples:
  - 156 soil
  - 10 water
  - 4 sediment samples
- Fuel and metal contamination in soil from material storage and handling

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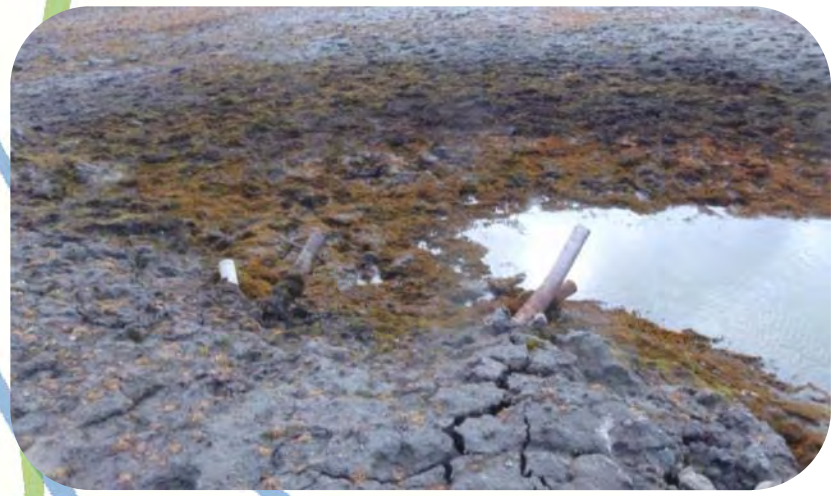
Assessment Results – Lougheed Island (L1)

Assessment Results – Lougheed (L-1)



- All major debris was removed when it was abandoned - drums and minor debris remain
- 2 Areas Investigated – Main Site and Pat Bay A-72 Well Site
- Samples:
  - 77 soil
  - 7 water
  - 2 sediment
  - 2 drum

- Fuel and metal contamination in soil from material storage and handling

Assessment Results – Dale Payne

Assessment Results – Dale Payne

- Currently 6 sleigh mounted structures, sleigh mounted fuel tanks, 2 tracked machines and scattered drums and debris
- 4 Areas Investigated – Former Landfill, Main Site, Drum Area & Site Buildings

Assessment Results – Dale Payne

- Samples:
  - 79 soil
  - 2 water
  - 1 drum
  - 9 building material
  - 7 paint samples
- Fuel and metal contamination in soil from material storage and handling
- Buildings have lead-based paints, asbestos floor tiles and mercury containing materials

Assessment Results – Thor Island

Assessment Results – Thor Island

- Minor debris, 2 wells sumps, trails and 2 well markers
- 3 Areas Investigated – Airstrip, P-38 and H-28 Well Sites
- Samples:
  - 92 soil
  - 3 water
- Fuel and metal contamination in soil from material storage and handling

Assessment Results - Romulus

Assessment Results – Romulus

- Major debris removed when site was abandoned – only minor debris remains
- 3 Areas Investigated – Well Head, Burn Pit and Sump Area
- Samples:
  - 34 soil
  - 3 sediment
  - 3 water
- Fuel and metal contamination in soil from material storage and handling

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Risk Assessment Process

Risk Management

Risk Characterization

Exposure

Hazard

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Risk Assessment – Who Might Use the Sites?

Humans:

- Workers checking the site – including wildlife monitors
- Local residents – have you been to these sites?

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Risk Assessment – Who Might Use the Sites?

Plants & Wildlife:

- Wildlife: Muskox, Polar Bear, Wolves, Birds, Marine mammals
- Vegetation: sparse due to sandy conditions at most sites

Risk Assessment Results

Human Health:

- Considered a child (toddler) visiting site as well as an adult as either a visitor or site worker
- No unacceptable risk to humans was found
- Site workers can use personal protective equipment and hygiene to reduce any risk

Insert Conceptual Model Graphics

Risk Assessment Results

Ecological Receptors – Wildlife, Invertebrates & Plants

- Considered wildlife, plants and invertebrates on the sites
- Contaminants may harm a few plants and invertebrates living directly in the contaminated area
- Sites are sparsely vegetated

Insert Conceptual Model Graphics (break into two slides)

What can be done to minimize risk to humans, wildlife & vegetation at the sites?

Risk Management Options Considered

- Excavation and Offsite Disposal
- Onsite Treatment
- Capping of Soil
- Monitored Attenuation
- Post Signage and Monitor Land Use

Criteria Used for Evaluating the Options

1. How well will the option work?
2. How hard will the option be to put in place?
3. What benefits does the option bring to the Community of Resolute Bay? (economic, social, training, employment)
4. How long will it take to complete this option?

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Recommended Risk Management Option

- Post signs so visitors are aware of the site's history and the presence of contaminated soil
- Monitor any changes in land use over time
  - Potentially used for mineral or oil and gas development again?
  - Potentially used for hunting by local residents?

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Site Specific Risk Management - Dale Payne Site

- Only site with known hazardous building materials on site
- Recommend removing hazardous materials from site, posting signage and monitoring land us

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Thank You

The Project Team would like to thank:

- The Community of Resolute Bay
- Matrix Aviation Solutions
- Summit Helicopters
- Kenn Borek Air

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Questions?

APPENDIX D

List of Attendees of the Community Meeting in Resolute Bay, NU

Indigenous and Northern Affairs Canada | Affaires autochtones et du Nord Canada

HIGH ARCTIC OIL & GAS SITES

#	NAME (Please Print)	SIGNATURE	TELEPHONE #
1	Philip Manik Sr		[redacted]
2	Alice Sallurniq		
3	Mark Amarualik		
4	Peter AMARUALIK		
5	NANCY AMARUALIK		
6	Tabitha Mullin		
7	Mike Stephens		
8	Sarah Sallurniq		
9	Saroomie Manik		
10	Ulurtak Amarualik		
11	Philip Clubbs		
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