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FINAL REPORT

Water License Application – Supplementary Information for Hydrocarbon-Impacted Soil Storage and Landfarm Treatment Facilities

BAF-3, Brevoort Island, NU

The Nasittuq Corporation

PROJECT NO. 1043685

PROJECT NO. 1043685.

FINAL REPORT TO

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FOR

BAF-3, Brevoort Island, NU

ON

Water License Application – Supplementary Information for Hydrocarbon-Impacted Soil Storage and Landfarm Treatment Facilities

September 25, 2008

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1.0 INTRODUCTION

1.1 General

On behalf of the Nasittuq Corporation (Nasittuq), Jacques Whitford prepared the following report in satisfaction of the Nunavut Water Board's (NWB) supplementary information for hydrocarbon-impacted soil storage and landfarm treatment facilities in support of Nasittuq's Water License Application for the BAF-3 radar station located on Brevoort Island, NU (refer to Drawing No. 1, **Appendix A**). The purpose of the supplementary information for hydrocarbon-impacted soil storage and landfarm treatment facilities (this report) is to assist Nasittuq in acquiring the Water License for the BAF-3 radar facility.

2.0 BACKGROUND INFORMATION

2.1 Site Description

2.1.1 Subject Property and Surrounding Land Use

The site is situated at an altitude of approximately 366 m above sea level on 2524 acres of land on Brevoort Island, NU. The geographical coordinates are: 63° 20'24" N, 64° 08'40" W. Brevoort is approximately 40 km long and 10 km wide. BAF-3 is located approximately 250 km NE of Iqaluit. A helipad is located on-site, as well as an abandoned airstrip which has been made useable.

The potential for traditional land use by regional Inuit communities was expressed within previous reports (NJW, 2008) – hunting activities on Brevoort Island are considered to be a possibility.

Site details are provided on Drawing No. 2, **Appendix A.**

2.1.2 Site Services

Potable water at the subject site is supplied by an on-site surface water supply located approximately 1.4 km from the site summit.

2.1.3 Topography and Drainage

Due to the large area that the subject site covers, regional topography and drainage is highly variable. Surface drainage slopes away from the site summit in all directions. The terrain at BAF-3 is irregular and hilly with prominent sea cliffs that rise from the water. The local geology consists mostly of igneous or metamorphic bedrock overlain in places by stony, sandy, glacial fill intermixed with fluvial and marine deposits. Water and wind generated erosion move the poorly-developed, thin, mineral soil into valleys and hollows, leaving slopes and hilltops bare. The drainage in the area of the soil remediation facility slopes to the southwest/southeast.

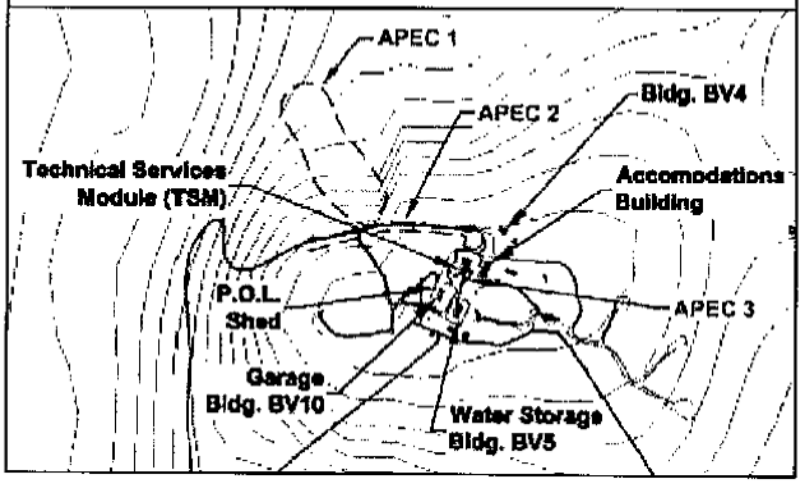
2.2 Sources of Environmental Impacts

A Jet A-1 fuel release was discovered at BAF-3 on January 12, 2007, and reported on January 13, 2007. Reportedly, the fuel release occurred due to a mechanical failure in the threaded end of a one inch fuel pipe supplying the generators from a vertical run of piping in the sub-floor under the Technical Services Module (TSM) Building at the site. It is estimated that approximately 150,000 litres of fuel was accidentally released as a result of the partial pipe break. Additionally, an unrelated water release of approximately 40,000 litres occurred after the fuel release from a water pipe in the same general area underneath the TSM Building.

Nunami Jacques Whitford (NJW) was retained by Nasittuq to perform a preliminary assessment/inspection of the BAF-3 fuel release, which comprised a visual and olfactory delineation of the extents of fuel migration. The initial preliminary delineation occurred between March 9 and March 11, 2007.

Based on the collection of visual and olfactory evidence, the following Areas of Potential Environmental Concern (APECs), as presented in Drawing No. 2 (**Appendix A** – see detail in Figure 1), were identified by NJW at BAF-3 during the March, 2007, site visit:

Figure 1. Detail from Drawing 2 showing APEC areas



APEC 1 is the slope north of Culvert 2 (CV-2) (Drawing No. 2, **Appendix A**). This area was designated as an area of potential environmental concern due to the potential migration of the fuel to the marine environment (Arctic Ocean). This area is characterized by a steep slope (>40%) covered with boulders, snow, and ice (at the time of delineation). Based on topographic information, and the site reconnaissance, melt-water and groundwater is expected to travel to the north until it reaches the slope bottom. Once water reaches the bottom of the slope it is anticipated to travel west to a channel that feeds an inland lake, which in turn outfalls to the sea.

APEC 2 is the drainage ditch on the south side of the main road to the site summit and the slope to the west of the station from Culvert 1 (CV-1) towards Culvert 3 (CV-3) (Drawing No. 2, **Appendix A**). This area was designated as an area of potential environmental concern due to the potential eventual migration of the fuel to the marine environment and the potential migration of fuel to the freshwater lake that is used as a multi-purpose water supply for the BAF-3 station.

APEC 3 is the area under the TSM Building (Drawing No. 2, **Appendix A**). Fuel-impacted ice was observed within the footprint of the TSM building. This area was designated as an area of potential environmental concern due to the potential human health risk from exposure to the product and potential for subsequent migration to the environment. Since APEC 3 is upgradient from APEC 1 and APEC 2, impacts at APEC 3 could potentially be a source of impact to APEC 1 and APEC 2.

A detailed site assessment was performed in August 2007 to fully delineate impacts from the spill and to allow the development of an extensive remedial action plan (RAP) and supporting risk assessment. The RAP and risk assessment concluded that the most cost effective and environmentally sustainable approach to deal with soils that exceeded the target site remediation levels (DEW line Clean Up criteria) was to remediate the soils in an engineered biopiles in a soil remediation facility (landfarm) on site.

3.0 SITE LOCATION CONSIDERATIONS

Considerations which were assessed with respect to the soil remediation facility location include site topography, probability of future monitoring and sampling of the soil/groundwater, facility access routes, adjacent water bodies, site drainage patterns, and the location of the contaminated soil in relation to the soil remediation facility.

The area directly north of the current on-site airstrip was selected for the soil remediation facility based on the following factors:

Ease of accessibility – The soil remediation facility can be accessed by ATV, truck, or snow mobile from the main roadway connecting the site summit to the beach. It is well graded for accessibility, and is routinely maintained due to the vicinity of the airstrip (see Drawings No. 3 and 4, **Appendix A** for the facility access routes).

Its location in relation to surface water bodies – The freshwater lake is located up gradient of the soil remediation facility with a hydraulic divide separating them, and the Davis Straight is located locally cross gradient and ultimately down gradient of the soil remediation facility (see Drawing No. 2, **Appendix A** for adjacent surface water bodies).

Site topography and drainage patterns – the area in the vicinity of the soil remediation facility is relatively flat and has been continually graded and maintained for air strip accessibility reasons. It has an established slope/drainage pattern which will be maintained once the biopiles are constructed in the soil remediation facility (see Drawings No. 2 and 4, **Appendix A** for site drainage patterns).

Surface and Subsurface monitoring – the easy accessibility of the biopiles within the soil remediation facility enables an effective scheduled soil monitoring program. Monitoring wells are also proposed within the vicinity of the soil remediation facility to enable the monitoring and sampling of groundwater in this area (see Drawing No. 4, **Appendix A** for biopile locations and proposed monitoring well locations).

3.1 Site Topography

The topography of the soil remediation facility was graded in preparation for the individual biopiles and the lay down area. A uniform and consistent topography was desired with minimal slope. Prior to the recent grading activities, the soil remediation facility topography was generally flat (graded due to air strip activities), sloping southwest/southeast. This flow direction was maintained when the area was re-graded for the biopiles. See Drawing No. 4, **Appendix A** for the general surface drainage patterns of the soil remediation facility.

3.2 Site Assessment Considerations

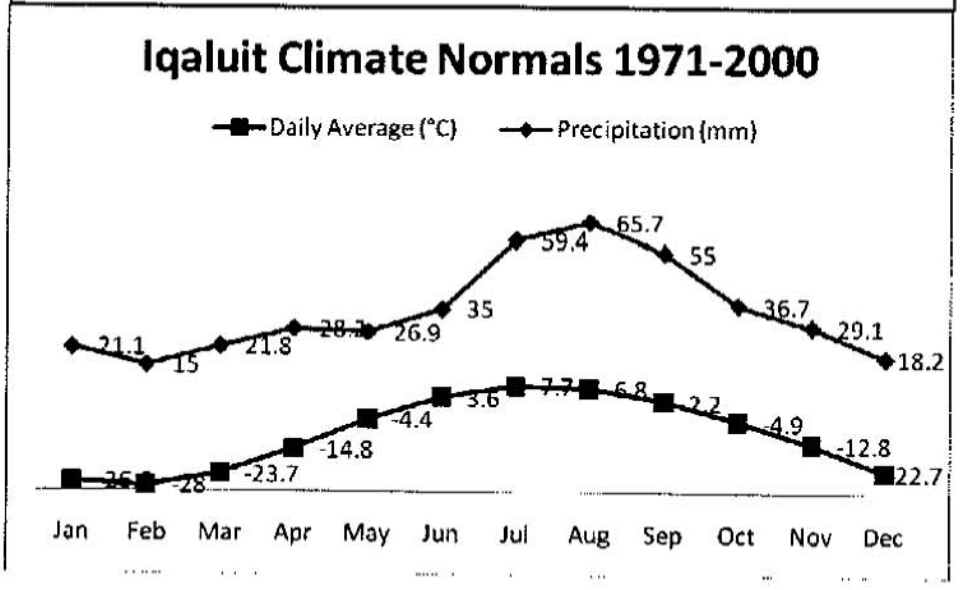
As part of Site Assessment Considerations, the following details are provided.

3.2.1 Hydrological/Climate Assessment

In general terms, the climate of the site is consistent with remote station sites in northern Canada. The climate is classified as Maritime Arctic (ESG, 2006), and the site is located within the Pangnirtung Upland of the Northern Arctic Ecozone (EC, 2005). Mean temperatures measured at BAF-3 are 4.2°C in July and -22.3 °C in January, and average rainfall is 600 mm a year. The heaviest precipitation is from July to November, and least from December to March (ESG, 2006). On average, frost occurs 322 days a year, and fog occurs 150 days a year (most common in the spring and summer). The site is subjected to heavy winds and blowing snow during the winter months (ESG, 2006).

The nearest meteorological survey station with Canadian climate normals (1971 - 2000) is Iqaluit (Latitude: 63° 45' N Longitude: 68° 33' W), which can provide the necessary data needed to produce predictions of the extreme precipitation events that could result in flood-type conditions at the site. The figure below shows the climate normals for Iqaluit – as can be seen in Figure 2, extreme precipitation events that could result in maximum flooding are most likely to occur during the period June-September.

Figure 2. Iqaluit Climate Normals 1971-2000 (MSC)



Site topography largely precludes any significant concentration of runoff, given the fact that it is built atop a local hilltop feature. The closest bodies of water include a freshwater lake (the camp water supply), which is located approximately 900 m southwest from the main station buildings and delineated fuel impacts (APECs 1-3), and the Davis Strait, which is located approximately 700 m north and east of the site. Local hilltop drainage is generally outward radially, with several runoff channels intersecting the freshwater lake. The lake in turn drains into Davis Strait to the south – lake outlet levels are below and hydraulically separated from any facilities. An active remediation program is underway in controlling impacts in APECs 1-3.

Regarding seepage potential, overburden material in the area is typically well to poorly drained, thin, and discontinuous. Materials consist of sandy gravel with some cobble and boulders over Precambrian Archean and/or Proterozoic bedrock.

3.2.2 Chemical Storage

There are several solid and liquid chemicals used as part of the soil remediation program stored on-site, as follows:

- Solid:

Fertilizer: bags stored in the Air Terminal Building

Bentonite and grout: bags stored in the Garage Building BV10

- Liquid:

IvySol™ soil flushing additive (emulsifier) stored in 45 gal. drums in Garage Building BV10

Sample bottle and test kit preservatives/fixers stored in various small containers in Technical Services Module

3.3 Site Stratigraphy

Regionally, the geology of Brevoort Island has been described as follows:

"*The bedrock at Brevoort Island is entirely composed of crystalline rocks of the Canadian Shield, providing a mildly acidic terrain (Miller et al., 1999). The island is largely underlain by Precambrian (Proterozoic) biotite-quartz feldspar gneiss, with well-graded glacial silt and sand at surfaces. The angular cobbles and boulders suggest a nearby bedrock source, and the overburden is consistent across the site (WESA, 2005). The igneous or metamorphic bedrock is overlain in places by stony, sandy, glacial fill intermixed with fluvial and marine deposits. Brevoort Island lies in the zone of continuous permafrost. Water- and wind-generated erosion moves the poorly developed, thin, mineral soil into valleys and hollows, leaving slopes and hilltops bare.*"

The stratigraphy in the immediate vicinity of the airstrip at the location of the biopile construction has been graded mechanically over several years as the area was used for a laydown or staging area in the construction of the new station. In general, the site consists of a sand and gravel fill which was, in all likelihood, produced from local crushed rock and placed over the existing insitu glacial till and igneous bedrock. A total of approximately 1.2 m of fill consisting of fine silty sand and gravel with some cobbles and boulders exists below the biopile area, from present grade to the glacial till surface. A thin veneer (0.30 m) of glacial till consisting mainly of dense silty medium sand-gravel underlies the surficial fill and extends to the bedrock surface. Bedrock consisting of medium to coarse grain, crystalline gneiss was encountered from the surface (outcrops just to the northeast of the biopile area), to a depth of 1.5 m from grade below the treatment cell locations under the surficial fill and till.

3.3.1 Permafrost

In general, the permafrost layer on station was encountered at a depth of 1.5 to 1.8 m from the surface of the active zone. At the location of the biopile treatment area, the permafrost layer is located within the bedrock. The glacial till and fill making up the active zone is frozen from the last week in September until late July, with melt beginning in the first week of June. During the test pit investigation for this area in June and July of this year no ice lenses or permafrost boils or heaves were noted in the area. The permafrost is located within the bedrock regime and as such does not affect the overlying soil significantly. The active zone melt is managed with drainage ditches running along the exterior perimeter of the treatment cell area and the interior area is graded to the ditches with a general flow to the south.

3.4 Municipal Zoning or Land-Use Planning

The biopile/soil remediation undertaking does not have any conformity issues regarding its applicability to Municipal zoning and/or land use planning regulations on Brevoort Island, as there are no municipal regulations in place.

4.0 SOIL STORAGE AND LANDFARM TREATMENT DESIGN CONSIDERATIONS

4.1 Biopile Design Details

Each biopile constructed on-site is composed of two sub piles, each 28.5 metres long, 2.0 metres high and 3.5 metres wide. The lay down area, used to stockpile soils prior to biopiling, is approximately 30 metres long and 30 metres wide (Drawing No. 5, **Appendix A**). Overall biopile volume at completion is estimated to be 5,500 m^3. The area underlying the biopiles and lay down area was graded in preparation for the 34 millimetre linear low density poly ethylene (LLDPE) reinforced liners that underlie the base and sides of the piles. See Drawing No. 4, **Appendix A**, for the layout of the soil remediation facility. Gravel berms were also constructed around the perimeter of each biopile and the lay down area (and covered with the same LLDPE lining the base) in order to contain any precipitation collected within the biopiles/lay down area, as well as to contain the soils placed within the areas. A 22 millimetre HDPE liner will be placed over each completed biopile to keep precipitation from saturating the piled soils.

At present, as the landfarm area is being completed, overland runoff is collected at the outlet and monitored to see if concentration exceed guideline values – should exceedance occur, then precipitation collected within the lining of the biopiles and the lay down area will be pumped out and forced through a granular activated carbon water treatment unit modeled after the units already in use on-site within the water treatment facility at the site summit. It is proposed that during operation of the system, water samples will be collected from the outlet of the carbon unit at monthly intervals during the summer period to monitor the water quality prior to its release down the slope.

Ditches were dug along the northern, eastern, and southern boundaries of the soil remediation facility in order to facilitate drainage of the area down the eastern slope (Drawing No. 4, **Appendix A**).

Background soil samples were collected from the soil remediation facility area prior to its construction. These background samples will act as a guide in future sampling events of the same locations upon site decommissioning. It is proposed that background samples taken from outside of the actual laydown footprint of the biopliles and laydown area will be collected annually in order to monitor the soil quality of the area. This will enable Jacques Whitford to proactively plan the maintenance of the soil remediation facility in order to maintain the soil quality of the area throughout its operation.

4.2 Barriers and Outside Site Access

The soil remediation facility is located on Brevoort Island, a remote location with access only granted to persons associated with Nasittuq and the Department of National Defence. As such, barriers will not be erected around the perimeter of the facility as persons associated with the site are briefed daily on the health and safety concerns associated with the soils in biopiles/lay down area. In addition, erecting any barriers around the facility could obstruct the airstrip, and encroach on the landing / take off area.

As a precautionary measure for the soil remediation facility, a sign outlining the purpose, potential risks, and projected duration of the facility is proposed to further enhance the safety of the area.

4.3 Facility Location on Site

The closest bodies of water include the aforementioned freshwater lake (the camp water supply) located 1.28 kilometres northwest upgradient, and the Davis Straight, located approximately and 860 metres south downgradient of the soil remediation facility. Drainage pathway distances to and from these two water bodies are longer than the horizontal distances mentioned above.

4.4 Alternative Remediation

In the event that the soil remediation facility does not succeed in lowering the concentration of petroleum hydrocarbon contaminants (PHC) within the biopiled soils to less than 2500 parts per million (ppm) as outlined in the Dew Line Clean-up Criteria (DLCU criteria), the soil will be remediated with an alternative remedial option to achieve the approved clean up objective. The soil may have to be shipped off-site (most likely on large barge or other sea faring vehicle) to an approved disposal facility or a more aggressive on site approach, such as low temperature thermal oxidation or ex-situ chemical oxidation would be applied.

Based on the early results of the biotreatability study being performed by the National Research Council (NRC) Biotechnology Research institute (BRI), the biopiles should allow for the degradation of the PHCs to the desired levels under proper management and monitoring without concern for the consideration of alternative treatment technologies.

5.0 OPERATIONS AND MAINTENANCE CONSIDERATIONS

5.1 Soil Quality

Soil quality on-site is monitored via two separate analyses.

PetroFlag™ Total Petroleum Hydrocarbons (TPH) test kits are used to screen the impacted soil in the field. Soils with concentrations of TPH in excess of the DLCU criteria of 2,500 ppm are stockpiled and transported by truck to the biopiles/lay down area. Soils with TPH concentrations below the DEW Line Clean-Up Criteria are temporarily stockpiled and are used as backfill for the excavated areas. Prior to transportation to the biopiles, contaminated soil are screened using an excavator to remove large rocks (>30-cm diameter).

As mentioned above, background soil quality samples were collected from the area occupied by the soil remediation facility. Based on soil vapour concentrations, field observations, and PetroFLAG ™ test kit results, select soil samples were submitted to Paracel Laboratories for analysis of Benzene, Toluene, Ethylbenzene, Xylenes (BTEX) and Petroleum Hydrocarbon Contaminants (PHCs – Fractions F1 to F4).

Paracel is accredited by the Standards Council of Canada (SCC) in cooperation with the Canadian Association for Environmental Analytical Laboratories (CAEAL) for specific environmental tests listed in the scope of accreditation approved by the SCC and registered with the association. Paracel is accredited to the ISO/IEC 17025 standard and employs in-house quality assurance and quality control programs to govern sample analysis including the analysis of method blanks, spiked blanks, and the analysis of duplicates (10%) for each sample batch.

With regards to the soil quality within the biopiles themselves, a 6 kilogram composite soil sample (providing an average sample of the contaminated material at the site) was collected by Jacques Whitford personnel. The soil sample was then sent to the National Research Council of Canada (NRC) – Biotechnology Research Institute (BRI) for a number of laboratory analyses concerning bacterial populations. NRC-BRI will continue to monitor soil conditions data from the composite soil samples that Jacques Whitford will provide from the biopiles, and they will recommend amendments to the soil conditions, as required.

5.2 Biopiling Procedure

5.2.1 Lay Down and Aeration

Approximately 5,500 m^3 of impacted soil will be placed within the biopiles and lay down area of the soil treatment facility. The soil originates from APEC 1, 2, and 3. As mentioned above in section 4.1, each biopile consists of two sub piles. The area underneath the biopiles is lined with LLDPE reinforced liner, and the tops are tarped with HDPE to prevent saturation of the soils within each biopile. See Drawing No. 4, **Appendix A** for an illustration of the current soil remediation facility layout.

Biopiles will be aerated mechanically, using an excavator to turn the soil. Soils will be monitored for moisture, nutrient, and microbial populations of hydrocarbon degraders. To facilitate the creation of optimal biopile conditions, the NRC-BRI will monitor soil conditions data, and recommend amendments to the soil conditions, as required.

5.2.2 Dust Control and Training

The hazard associated with soil dust is very low, due to its lack of mobility (coarse material with moisture levels from 12% - 18%). Dust masks are available for both heavy equipment operators as well as environmental staff during operations, should the need arise. Jacques Whitford staff is trained in the proper use of Personal Protective Equipment (PPE), and provide input to Nasittuq staff during each day's morning health, safety and operations meeting relating to environmental operations.

5.3 Regulatory Framework

5.3.1 Canadian Environmental Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines (CEQG) (latest update 2006) provide guideline limits for contaminants in soil and water and is intended to maintain, improve, and/or protect environmental quality and human health at contaminated sites in general. These guideline criteria include numerical values for the assessment and remediation of soil and water in the context of agricultural, residential/parkland, commercial, and industrial land uses. Environmental soil and water quality guidelines are derived using toxicological data to determine the threshold level to key receptors. These criteria include the Recommended CCME Soil Quality Guidelines (SQG), and the Canadian Water Quality Guidelines (CCME CWQG). The latest update of these CCME guidelines is dated July 2006.

5.3.2 DEW Line Clean-Up Criteria

The DLCU criterion was also used to compare PHC impacts in soil for the Phase II Environmental Site Assessment of BAF-3 with respect to the recent fuel release. The DLCU criteria, as defined in the *Agreement Between Nunavut Tunngavik Incorporated and Her Majesty in the Right of Canada as Represented by the Minister of National Defence for the Clean-Up and Restoration of Distant Early Warning Sites Within the Nunavut Settlement Area* (1998), provides an ecologically protective numerical guideline for hydrocarbon contamination in soil. Hydrocarbon contamination is based on the measurement of TPH where the TPH value is greater than or equal to 2500 ppm (µg/g).

5.4 Decommissioning and Reclamation Plan

Following the successful treatment of the soil in the biopiles to below the DLCU criteria, the soils within the lay down area and the biopiles will be recycled on-site as fill material in areas of existing residual TPH impacts below the DLCU criteria.

6.0 SURFACE AND GROUNDWATER MONITORING PROGRAMS

The Site Monitoring Plan is presented in Appendix B.

7.0 CLOSURE

This report has been prepared for the sole benefit of the Nasittuq Corporation. The report may not be used by any other person or entity without the express written consent of Jacques Whitford and the Nasittuq Corporation.

Any use that a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Jacques Whitford accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgment of Nunami Jacques Whitford based on the data obtained from the work. The conclusions are based on the site conditions observed by Nunami Jacques Whitford at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction and other activities. In addition, analyses have been carried out for a limited number of chemical parameters, and it should not be inferred that other chemical species are not present. Due to the nature of the investigation and the limited data available, Nunami Jacques Whitford cannot warrant against undiscovered environmental liabilities.

Where information has been supplied to Jacques Whitford from other consultants, whether presented in this report or not, it has not been used in interpretation leading to conclusions and recommendations, unless that information has been verified through investigations carried out by Jacques Whitford.

If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

This report was prepared by Rob McCullough, Nathaniel Novosad, Sarah Montesano, and David Wilson, and was reviewed by Francois Lauzon and Ted Hergel (Mr. Hergel is a Professional Engineer registered in the Northwest Territories).

Respectfully submitted,

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