APPENDIX 5:

BEAR ISLAND
REMEDIAL ACTION PLAN

Bear Island Mid-Canada Line Radar Station

Remedial Action Plan Revised Sept. 2008

Bear Island, Nunavut

EARTH TECH | AECOM

Remedial Action Plan

Bear Island Mid-Canada Line Radar Station
Bear Island, Nunavut

Revised September 2008

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Remedial Action Plan
Bear Island Mid-Canada Line Radar Site,
Bear Island, Nunavut

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Executive Summary

As the caretaker of federal lands in Canada's north, Indian and Northern Affairs Canada (INAC) is responsible for the care and management of sites that are no longer maintained by the original owner/operator. These sites are often contaminated as a result of mining, oil and gas activities, as well as from government military activities, which took place before environmental impacts were understood. Through the Contaminated Sites Program (CSP), INAC has made it a priority to assess, prioritize and mitigate/remediate the environmental impacts of contaminated sites in Canada's North. As a result, INAC is required to develop a Remedial Action Plan (RAP) for the former Bear Island Mid-Canada Line Radar Station, located at Bear Island, Nunavut.

In support of the Remedial Action Plan, Earth Tech AECOM (Earth Tech), on behalf of Public Works and Government Services Canada (PWGSC) and INAC, has prepared this report which identifies remediation options, critiques potential remediation methods, and provides recommendations for site restoration, as well as a cost estimate to undertake the remedial work.

This RAP for the former Bear Island Mid-Canada Line Radar Station was designed in accordance with the INAC Abandoned Military Site Remediation Protocol (April 2008). This Protocol is designed to address legal requirements, health and safety issues, INAC's Contaminated Sites Management Policy requirements and standard environmental issues. The Protocol identifies financially prudent methodologies that address all the requirements listed above while maintaining a cost effective remediation project.

The table below provides a summary of the environmental issues identified at Bear Island and the proposed remedial action for each.

Environmental Concern	Site Assessment Findings	Recommended Remediation Method
DCC Tier I Contaminated Soils	12.0 m^3 of soils with concentrations of heavy metals (Cd, Cu, Pb and Zn) and PCBs which exceed the DCC Tier I criteria were identified onsite.	Dispose of soils that exceed DCC Tier I soils (12.0 m^3) in an onsite landfill.
DCC Tier II Contaminated Soils	82.3 m^3 of soils with concentrations of heavy metals (Cd, Cu, Pb and Zn) and PCBs which exceed the DCC Tier I criteria were identified onsite. This volume includes 0.8 m^3 of material that is co-contaminated with Tier I metals and 3.5 m^3 of Tier I PCBs.	Excavate, containerize and label soils that exceed DCC Tier II criteria (82.3 m^3) and dispose offsite.
Petroleum Hydrocarbon Contaminated Soils	Approximately 109.8 m^3 of hydrocarbon impacted soil in exceedance of the INAC Abandoned Military Site Remediation Protocol for PHC Soils.	Excavate 77.9 m^3 contaminated soils and place into containers, and ship off site to a licensed disposal facility. Scarify 31.9 m^3 of PHC stained soil.
Surface Debris	Approximately 622.5 m^3 of non-hazardous debris consisting of heavy equipment, barrels, scrap metal, scrap wood, concrete, electrical equipment and plumbing parts, and any remaining buildings.	Consolidate and dispose in a non hazardous landfill constructed onsite.

Environmental Concern	Site Assessment Findings	Recommended Remediation Method
Existing Landfills	Landfill North of Site 413 is considered a Class A landfill and was found to contain hazardous materials. Also, the surrounding soils are being impacted from contaminants located within the landfill. North Landfill is considered to be a Class C landfill and there is no evidence that the surrounding soils are being impacted.	Consolidate and dispose waste debris (14.7 m^3) accordingly. Remediate PHC contaminated soils as described above. Consolidate surface debris, as well as the partially buried debris located on the exposed southwest toe of the landfill, (approx 41.7 m^3 total) and dispose accordingly.
POL Fluids	There are approximately 1.05 m^3 (1,050 L) of Petroleum, Oil and Lubricant fluids.	Incinerate POL fluids that meet incineration criteria (<2 ppm PCBs and Cd and <10 ppm Cr and <100 ppm lead and <1000 ppm Chlorine), otherwise treat as Hazardous Waste.
Water in barrels	With the exception of five barrels, all barrels inspected were found to be empty or rusted through. This fact does not ensure that all barrels on site are empty or contain just rusty water as all (approximately 4300 barrels) were not inspected.	During clean-up, all barrels must be approached using the DLCU barrel protocol.
Lead Painted Products	Approximately 27.0 m^3 of lead amended paint materials were discovered on site	Dismantle lead painted items and ship off site to an appropriate disposal facility.
Hazardous Materials	Approximately 18.0 m^3 of hazardous materials were identified at the site. These materials consisted of lead acid batteries (3 m^3), asbestos containing materials (12.5 m^3), and lead cable and zinc conduit (2.5 m^3).	Asbestos waste to be collected, bagged and disposed of in an on-site landfill. All hazardous materials (such as batteries and hazardous cable/conduit) will be containerized, labeled and shipped to be disposed at a licensed southern facility.
Compressed Gas Cylinders	Approximately 8 compressed gas cylinders were identified onsite.	Vent and dispose of cylinders according to the INAC AMSRP in the non-hazardous landfill.

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1.0 INTRODUCTION

Bear Island, Nunavut is home to two former Mid-Canada Line Radar Stations, which include the main station Site 412 (situated near the south end of the island) and Site 413 (situated near the north end of the island). The island is located toward the central northern end of James Bay and approximately 160 km northwest of Chisasibi, Quebec (**Figure 1.0, Appendix A**). The sites were in operation from the mid-1950s to 1965, after which the site was vacated and left abandoned.

Indian and Northern Affairs Canada (INAC), as the caretaker of federal lands in Canada's north is responsible for the care and management of contaminated sites that are no longer maintained by the original owner/operator. Consequently, in approximately 1965 the site, including all structures, equipment, debris and environmental disturbances, became the responsibility of INAC.

There are four main areas at Bear Island, which include the South Doppler Area (Site 412), North Doppler Area (Site 413), the Beach Area, and the Airstrip Area. Facilities at Site 412 consisted of a Doppler detection building, emergency shelter and garage, as well as a radar tower. Also, located slightly north of Site 412 are the landfill and barrel cache areas. Similar to Site 412, Site 413 consisted of a Doppler detection building and radar tower. After the site was abandoned, facilities at both Site 412 and Site 413 were demolished to their foundations. While the facilities were in operation, the Beach Area was believed to be the area used as the staging area to unload supplies for the operations on the island. Currently there is a large amount of debris stockpiled at the Beach Area, thought to be brought here from Sites 412 and 413 with the intention of removing it from the island.

In 1996, the Environmental Sciences Group (ESG) of the Royal Roads Military College (RRMC) was requested by INAC to conduct a scientific investigation and determine cleanup requirements using the DND DEW Line Cleanup Protocol. The investigation was concentrated on soil, water and plant media to investigate the presence of chemical contamination resulting from previous site activities and the potential for negative impacts on the environment. It was concluded that chemical contamination at Bear Island was minimal and mostly confined to localized areas. On the other hand, physical debris was said to be "ubiquitous and abundant" and "collecting it all will be the main challenge of cleaning up the site". Areas of concern were identified and qualified, however estimates for volume of impacted material was not obtained. In addition, the scope of work of the ESG investigation did not include the assessment of hydrocarbon contamination. The cleanup recommendations included placing non-hazardous debris and DCC Tier I PCBs or Lead contaminated soil in properly designed landfills on site; shipping DCC Tier II contaminated soil to an off-site to an industrial landfill; and crushing and burying the empty barrels with the non-hazardous debris or recycling off-site.

In 2001, Earth Tech conducted an investigation program aimed to delineate soil contamination, inventory materials remaining on the site, locate potential landfill and borrow sites, and generate a topographic survey of the site. Based on the findings, it was estimated that 354 m^3 of soil was contaminated with heavy metals (including all facilities at Site 412, barrel cache area, beach areas, and Site 413) and 86 m^3 of hydrocarbon contaminated soil (at the landfill area). It was also estimated that 1,000 m^3 of non-hazardous material and 35 m^3 of hazardous material exists on site. Also, potential locations for non-hazardous landfills on Bear Island were identified.

Based on information gained from the 1996 and 2001 investigations, and through the Contaminated Sites Program (CSP), INAC has made it a priority to assess, prioritize and mitigate/remediate the environmental impacts of contaminated Sites in Canada's North. Bear Island was classified as a high priority site, which required an additional assessment to accurately quantify the volumes of contaminated soil, as well as identification and assessment of hazardous and non-hazardous materials remaining on site. Earth Tech completed the site investigation activities in late July/early August 2007, which provided the necessary information to complete this Remedial Action Plan (RAP). This RAP was prepared to provide a conceptual remediation design and preliminary specifications for cleanup of the Bear Island Mid-Canada Line Radar Station.

2.0 OBJECTIVES

The main purpose of this Remedial Action Plan was to identify remediation options, critique potential remediation methods, and provide recommendations for site restoration. Based on assessment activities completed by Earth Tech in July/August 2007, a comprehensive site remediation work plan was developed. Remediation options were developed for each waste stream identified at the site, and were critically evaluated to discuss potential risks, advantages, and disadvantages of each remediation option. Based on a number of factors, outlined below, recommendations were made as to the preferred remediation approach. Also, community meetings with PWGSC and INAC in Chisasibi were conducted in February 2008 to incorporate community contribution in selecting the remedial option for each waste stream.

The RAP was designed to meet the following cleanup objectives in accordance with the Indian and Northern Affairs Canada Abandoned Military Site remediation Protocol (April 2008):

1. Restore the site to an environmentally safe condition;
2. Prevent the migration of contaminants into the Arctic ecosystem;
3. Remove physical hazards for the protection of human health and safety; and
4. Implement a cost effective remediation solution.

3.0 SITE DESCRIPTION

As previously shown in **Figure 1.0**, the former Bear Island Mid-Canada Line Radar Station (Sites 412 and 413) is located in the north central portion of James Bay, Nunavut, at 54°20' N, 81°05' W. The communities nearest to Bear Island are Chisasibi, Quebec, which is approximately 160 km southeast, and Sanikiluaq, Nunavut, which is located approximately 300 km north of Bear Island.

The Mid-Canada Line Radar Station was constructed in the mid-1950s and operated until approximately 1965 at which point it was abandoned. In 1965, responsibility for the site was assumed by INAC. The site consists of two Doppler Stations (Sites 412 and 413), a Beach Area and an Airstrip Area, as shown in **Figure 2.0**. Facilities located in each of the main areas are also illustrated in **Figure 2.0**.

The South Doppler Area – Site 412 is located on a hill approximately 17 m above and approximately 300 m west of James Bay. The facilities in the area included; a Doppler detection building, emergency shelter, garage, sewage outfall, one large and two small radar antenna towers, a network of utility poles, as well as numerous waste debris piles. The majority of the facilities at Site 412 have been demolished to their foundations. The concrete garage foundation, wooden timber Doppler detection building foundation and the concrete bunker near the emergency shelter are all that remain in place. Also located in this general vicinity are an existing landfill (approximately 200 m north), and the barrel cache and disturbed area (approximately 400 m north and northwest). It appears that the building construction materials from this area were placed in sorted piles, partially buried or stockpiled at the Beach Area.

The Beach Area is located in a small bay on the east side of Bear Island, approximately 1 km north of the South Doppler Station – Site 412. This area was likely used as the barge staging area when the site was in operation. There is a large amount of stockpiled construction materials and debris in this area (heavy equipment, wooden huts, barrels, etc.), thought to be brought to the beach with the intention of removing it from the island.

Site 413 was the northern, smaller radar facility on Bear Island. Facilities in this area consisted of a control building, an antenna and a set of POL tanks. Like the South Doppler Area, the building has been demolished to its wood frame foundation and the building materials are piled around the area. Also, the antenna was down and the POL tanks were removed.

The airstrip, located on the west side of the island, has a north-south orientation and is approximately 1500 m in length. There is one main debris area at the airstrip, which is located on the east side near the south end of the airstrip. In this area there was a wooden hut, wooden frames of three other huts, as well as domestic debris such as glass bottles, pots and pans, and a few empty barrels. There was also one partially full barrel found lying on its side, which was leaking and causing a small surface stain.

Potential granular borrow source areas were identified at the south end of the island (1.2 km south of Site 412), 0.5 km south of Site 412 and 0.2 km southeast of Site 413, and contain all necessary granular fill types, except Type 4 which is required for the construction of low permeability containment berms.

4.0 BIOPHYSICAL ENVIRONMENT

4.1 Physiographic Description

Bear Island is approximately 1.5 km wide and 5 km long and is located at the northern end of James Bay, approximately 80 km from the nearest shore (Ontario). Bear Island is a low lying black basalt outcrop, covered with small lakes and ponds. Where the surface is not exposed bedrock or covered by water, the surficial materials consists of coarse gravel up to approximately 1.5 m thick. It is understood that Bear Island is located is an area of sporadic discontinuous permafrost (NRC, 1995).

4.2 Climate

The closest weather stations with climate data are the airports at La Grande Riviere, Quebec and Kuujjuarapik, Quebec, which are 240 km east-southeast and 250 km northeast of Bear Island, respectively. Both locations have similar climate normals; however, of the two locations Kuujjuarapik is considered to be in an environment most similar to Bear Island. The daily mean temperatures in the area varies from approximately -23.4ºC in January to approximately 11.4ºC in August, and the average annual temperature is approximately -4.4ºC. The average annual precipitation is approximately 415 mm of rainfall and 241 cm of snow.

4.3 Flora and Fauna

Bear Island is located in the Hudson Bay Lowland ecological region, one of the Earth's largest wetland landscapes. The vast majority of vegetation communities are rich in lichens and mosses, which make up fen wetland types. Because of exposure to wind and wave action, the vegetation communities are all low-lying vegetation and are mostly constrained to the interior areas of the Island around the glacial lakes and ponds. Flora observed on the island includes various species of lichens, willows, berry bushes, grasses, mosses and wildflowers.

General observations regarding wildlife inhabiting Bear Island during the 2007 field program was noted by Earth Tech. Fauna observed in the area includes Polar Bears, arctic foxes, Canada geese, snowy owls (no direct observation, only an abandoned nest), red-throated loons and arctic terns. On July 28, 2007 during preliminary visits to Bear Island to mobilize equipment and supplies to the site in preparation for field activities, approximately nine polar bears were observed on and in the vicinity of Bear Island. The community of polar bears consisted of approximately three mothers with one or more young cubs, and approximately three solo males. Upon returning to the site the following day, there were two sets of mothers with one or more young cub(s), as well as one lone male polar bear. The single male remained in the area for only a short period of time, before leaving the island off the southwest shore; whereas the two sets of mother with cub(s) remained on the island for the duration of the field program. The resident mothers with cubs remained in well sheltered locations on the extreme north portion of the island, which is several hundred metres from the nearest radar site infrastructure. Consequently, interaction and sitings were limited when arriving and departing the island in the airplane. That being said, logistical and work challenges for the future remediation program may prove difficult if bears are present in the work area.

In addition to polar bears, arctic terns and Canadian geese were also found to be nesting on Bear Island during the 2007 field program. A significant arctic tern nesting area was noted on the sandy expanse at the south tip of Bear Island. The terns became highly agitated when field personnel entered this area, and eggs were noted in the sandy soils. Therefore, restricted access to this breeding and nesting area is recommended. The Canadian geese were found to be more widespread than the arctic terns on Bear Island. It should be noted that the young goslings were flightless during the period when the field team was on site. Future remediation activities should consider and respect all wildlife residing on Bear Island.

5.0 INAC SITE REMEDIATION PROTOCOL

5.1 General

Numerous factors affect the suitability of site remediation plans, and must be considered when determining a site specific remediation plan. For this reason, INAC has created the Abandoned Military Site Remediation Protocol (AMSRP, April 2008) to provide a consistent approach for designing RAPs for abandoned military sites. This protocol is designed to address all legal requirements, health and safety issues, INAC's Contaminated Sites Management Policy requirements and standard environmental issues. The protocol identifies financially prudent methodologies that address all the requirements listed above while maintaining a cost effective remediation project. This Remedial Action Plan for the former Bear Island Mid-Canada Line Radar Station was designed in accordance to the INAC Protocol.

The following sections provide an outline of typical environmental issues and their remedial action procedures addressed by the Protocol. These technical aspects are described in greater detail in the INAC Abandoned Military Site Remediation Protocol (**Appendix B**). The following considerations (as outlined in the INAC Protocol) need to be considered in the development and implementation of the remedial action plan for the Bear Island site:

- Respect all historical agreements and obligations in a fair and reasonable manner;
- Ensure consistency with federal guidelines for the management of contaminated sites;
- Apply the Canadian Council of Ministers of the Environment (CCME) environmental protection and management approaches (CCME 1996, 1997, 1999, 2001);
- Apply simple, practical remedial solutions wherever possible, with flexibility as necessary to adjust to site-specific conditions when they are identified;
- Establish cost effective solutions through the use of best practices to ensure appropriate levels of environmental protection for all sites;
- Recognize the concerns of global warming in an Arctic setting; and
- Ensure the long-term effectiveness of the environmental remedial measures.

5.2 Landfills

5.2.1 Landfill Closure

Landfills on INAC abandoned military sites are classified as Class A, Class B or Class C. A Class A landfill is a landfill located in an unstable, high erosion location. These landfills require relocation. If during the relocation process, hazardous materials are noted, the hazardous materials are segregated and disposed of off site. A Class B landfill is a landfill located in a suitable, stable location but there is contaminated leachate being released from the landfill. These landfills require the contaminated leachate to be contained within an engineered containment system. If this is not feasible, the landfill must be relocated to an engineered landfill or the waste must be disposed of off site. Lastly, a Class C landfill is a landfill located in a suitable and stable location with no contaminated leachate being released. These landfills can be left in place and additional granular material can be placed to prevent erosion and promote proper drainage if required.

5.2.2 Landfill Development

The design of landfills at abandoned military sites must give consideration to the type of waste that is to be stored in the landfill, proximity to drainage courses and distance to borrow sources required for landfill construction. Only non hazardous materials and/or non regulated contaminated soils are to be stored in newly constructed on site landfills. All hazardous waste is to be disposed of off site.

Capping of the landfills must include a minimum 0.6 m granular cover, promote run-off, prevent infiltration and minimize erosion. Visual inspection monitoring must be conducted to confirm the integrity of the landfill.

5.3 Physical Debris

Debris throughout the site must be collected and segregated into hazardous and non hazardous waste streams. To reduce volumes, non hazardous material shall be crushed, shredded and/or incinerated prior to placement in the on site landfill. Hazardous materials shall be disposed of off site in accordance applicable guidelines and regulations.

5.4 Contaminated Soils

Soil conditions at Bear Island were assessed using the INAC Abandoned Military Site Remediation Protocol (revised April 2008) as the governing criteria. Heavy metal and PCB concentrations in soils were compared to the DEW Line Cleanup Criteria, which was developed for the Department of National Defence. Petroleum hydrocarbons were evaluated using the process currently utilized on DND DEW Line sites, which was adopted by the INAC AMSRP (revised April 2008).

Heavy metal and PCB contaminated soils identified will be categorized as regulated, hazardous, or contaminated but not hazardous. Soils that are identified as being regulated will be remediated and/or disposed of following applicable regulations. Hazardous soils will be disposed of off-site. Contaminated but not hazardous soils must be remediated to meet DCC DEW Line Clean Up (DLCU) Criteria. Soils classified as contaminated, but not hazardous, are to be remediated based on one of three primary contaminated soil types. Firstly, metal contaminated soils must be disposed off site or encapsulated on site. Secondly, hydrocarbon contaminated soil will be assessed using the evaluation process outlined in the INAC AMSRP. Lastly, PCB contaminated soil must be either disposed off site or encapsulated on site. In cases where co-contamination of soils is present, the most conservative remedial option that addresses both contaminants must be applied.

5.5 Contaminated Water

Surface waters with heavy metal contamination (in exceedance of the CCME Freshwater Aquatic Life Criteria) were observed at Bear Island near the main barrel cache area. It should be noted that considering the shallow depth of the surface water it is unlikely that the pond is fish bearing. It is expected that removal of the source contamination (zinc contaminated soils at the barrel cache) would address the problem and therefore no remedial options for contaminated water are discussed in this remedial action plan.

5.6 Hazardous Materials

In general, all hazardous materials will be shipped off site to a licensed hazardous waste disposal facility. Exceptions include asbestos, which is to be double bagged and disposed in an engineered landfill onsite, in accordance to local regulations. Petroleum products, free of chlorine, PCBs, heavy metals, etc, are to be incinerated. Heavier petroleum products are to be mixed and burned on site, or shipped off site. Compressed gas cylinders, with known contents, are to be vented and subsequently placed in engineered landfills on site. Timbers found suspected to be treated with creosote are to be wrapped in polyethylene and disposed of in an on site landfill. It should be noted that wood samples from the Doppler building framework did not indicate elevated creosote parameters. Lead-based paint considered to be hazardous (leachable lead >5 mg/L) will be collected and transported offsite, whereas painted components not considered hazardous will be disposed in on site landfills. Also, a small volume of zinc coated conduit and lead cable is located on site, which are being classified as hazardous since soil data indicates that both materials have generated soils that are DCC Tier II, hazardous soil.

5.7 Barrels

Barrels located at the site will be addressed in accordance with the DEW Line Cleanup Barrel Protocol (**Appendix B**). With the exception of four barrels located slightly southwest Barrel Cache area, all barrels inspected were found to be empty or contained rusty water. In fact most barrels were rusted right through. In general, empty barrels will be crushed and disposed in on site landfills. This fact does not ensure that all barrels on site are empty or contain just rusty water as all (approximately 4300 barrels) were not inspected. During cleanup activities all barrels must be approached using the DLCU barrel protocol. The contents of filled barrels will inspected and tested, and either be incinerated on site or shipped off site for disposal. The now empty barrels will then be rinsed, crushed and disposed in on site landfills. Depending on the results, the contents will either be incinerated on site or shipped off site for disposal.

5.8 Buildings and Infrastructure

All existing buildings and infrastructure shall be demolished to their foundations. All hazardous material is to be removed prior to or during demolition activities. All removed hazardous material is to be disposed of in accordance with protocol outlined in Section 5.4. Under special circumstances, some buildings may be left place once clear ownership of the building has been outlined.

5.9 Borrow Sources

Borrow sources for granular material will be required for the construction of new landfills and for general site grading purposes. Existing borrow sources, including abandoned gravel pads and road infrastructure, will be fully exhausted prior to exploiting new sources. Upon completing remedial activities, all borrow areas will be recontoured to restore natural drainage and to match surrounding topography. Borrow sources at the south end of the island will be carefully managed to ensure that the arctic tern nesting habitat, as well as the archaeological site, are not impacted by remediation activities.

5.10 Site Grading

Disturbed areas on the site will be graded and shaped to blend in with the natural contours and to eliminate potential hazards for wildlife and humans accessing the site in the future. The disturbed areas include contaminated soils excavations, existing and new landfills, debris areas, disturbed areas resulting from demolition activities; borrow areas, and any areas disturbed as a result of remediation activities.

5.11 Contractor Support Activities

For the completion of remedial activities, a camp will be established on site and will be situated in a previously disturbed location to minimize the extent of new disturbances. Waste generated by the camp will be incinerated and disposed of in on site landfills. Sewage will be treated using an appropriately sized treatment system, and effluent quality will adhere to applicable licenses. Potable water located on site will be tested and used in accordance with the applicable water license. Contingencies for water supply will include filters, and a supply of bottled water. Fuel required to operate the camp and to complete remedial activities will be stored on site in accordance with applicable legislation and licenses.

6.0 COMMUNITY MEETINGS

A community meeting open to the public, was hosted by INAC in Chisasibi, Quebec on February 20, 2008. A copy of the meeting minutes is located in **Appendix C**. To date, no concerns were raised by any of the community members specifically with the proposed Remedial Action Plan for Bear Island. Other historical information was obtained during the community meeting. Several community members present at the meeting expressed a great concern for the radar site at Cape Jones, rather than the Bear Island site. Cape Jones is located in an area frequented by the Cree people for hunting and recreational purposes, whereas Bear Island is not frequently used because of its remote location. That being said, there were community members that visited Bear Island in approximately 1964, after the site was abandoned. Billy Martin Hunter and Billy Weetaltuk reportedly visited Bear Island with members of the Roman Catholic Church, to salvage building materials (metal, wood, etc) to be used in Fort George (former location of Chisasibi). The one time visit to Bear Island was accomplished using a Hudson Bay Barge and took approximately 11 hours (one way). While onsite they noted punctured fuel drums and fuel spills that were impacting the soil. Shore birds were also reportedly contaminated with oil. It was also noted that Eider ducks were breeding on the island, and that polar bears were present. Another community member, William Chiskamish reported that the landfill on the island was constructed by people from Chisasibi and that debris buried included new equipment.

7.0 EVALUATION OF REMEDIAL OPTIONS

7.1 Cleanup Objectives

The following remedial objectives are based on guidance provided from Northern Contaminated Sites, Public Works and Government Services Canada and the Indian and Northern Affairs Canada Abandoned Military Site Remediation Protocol, April 2008.

- Restore the site to an environmentally safe condition;
- Prevent the migration of contaminants into the Arctic ecosystem;
- Remove physical hazards for the protection of human health and safety; and
- Implement a cost effective remediation solution.

7.2 Site Issues

The following sections present a summary of the contaminant and waste disposal issues, as well as the potential remedial methods, for site issues identified from past site assessments. In the cases where more than one remedial method is identified, the options will be evaluated based on the remedial objectives and a recommendation for the favourable remedial method will be provided. Specific issues that need to be addressed at the Bear Island site include;

- Disposal of contaminated soils (PHCs, metals, PCBs),
- Collection and disposal of hazardous materials (POL liquids, asbestos containing materials, lead and zinc materials, batteries),
- Collection and disposal of products coated with lead amended paint,
- Proper disposal for the partially buried debris located near the former Garage, Landfill North of Site 412 and North Landfill Area, and
- Collection and disposal of non-hazardous surface debris piles and dumps (located at Site 412, Beach Area, Site 413, Airstrip Area, Barrel Cache, along roadways and scattered in other areas of the site).

7.3 Contaminated Soils

The following table presents a summary of the contaminated soils and remedial methods recommended to address the contaminated soils at the identified at the Bear Island Mid-Canada Radar Station.

Table 1: Summary of Contaminated Soils at Bear Island

Location	Contaminant Exceeding Criteria (Max ppm)	DCC I m^3	DCC II m^3	PHC Evaluation m^3	Comments
South Doppler Detection Building	**Metals**		1.0		
South Outfall	**Metals** **PCBs**		0.8		Impacted area is co-contaminated
Emergency Shelter	**Metals**		15.8		
Garage	**Metals** **PCBs** **PHC**		24.6	28.8	Impacted area is co-contaminated PHC stained soil requiring scarification to 0.3 m
Landfill North of Site 412	**PHCs**			5.3	PHC contaminated soil requiring excavation to 0.15 m
Main Barrel Cache	**Metals**		5.0		
Small Barrel Cache	**PHCs**			27.3	PHC contaminated soil requiring excavation to bedrock (approximately 0.5m)
POL Storage Area	**Metals** **PHCs**	5.2		40.5	PHC contaminated soil requiring excavation to bedrock (approximately 1.0 m)

Location	Contaminant Exceeding Criteria (Max ppm)	DCC I m^3	DCC II m^3	PHC Evaluation m^3	Comments
Beach Bulldozer	**Metals** **PHCs**		1.7	3.1	PHC stained soil requiring scarification to 0.3 m
Beach Electrical Hut	**Metals**		1.5		
Beach Building Panels	**Metals**		3.2		
Beach Barrel Cache	**Metals**	6.8			
North Doppler Area – ESG-244	**Metals**		4.6		
North Doppler Area – ESG-243	**Metals**		10.9		
Airstrip Area	**PHCs**			4.8	PHC contaminated soil requiring excavation to bedrock (approximately 0.5 m)
Electrical Cable	**Metals**		13.2		Additional sampling along the cable is recommended to confirm impacted areas
TOTAL ESTIMATED VOLUMES		**12.0**	**82.3**	**109.8**	

In accordance with the Indian and Northern Affairs Canada Abandoned Military Site Remediation Protocol, April 2008, the following remedial options are presented for consideration. Bear Island is an abandoned and remote site; therefore the remedial plan must be designed accordingly. Solutions that achieve remedial objectives and minimize site remediation costs will be deemed favourable.

Despite the fact that in-situ technologies reduce contaminant exposure to humans and the environment, in-situ remediation technologies were not researched in detail. In situ remedial technologies are care and maintenance intensive and have not generally proven to be pragmatic technologies for remote, northern site remediation. For this reason in situ technologies were not explored in great detail.

7.3.1 PCB Contaminated Soils

7.3.1.1 Contaminant Issue

The Phase III ESA identified approximately 4.3 m^3 of PCB contaminated soils at the South Outfall and the Garage, as shown in **Figures 4.0** and **6.1** of **Appendix A**. In both cases the PCB contamination plumes identified provide the lateral extent of DCC Tier I contamination for PCBs; however, the soil within these plume areas is also co-contaminated with heavy metals (cadmium, copper, lead and/or zinc) in exceedance of the DCC Tier II criteria. Therefore due to the metal concentrations all PCB contaminated soils are classified as exceeding DCC Tier II.

7.3.1.2 Remedial Method

Due to the limited quantities delineated, the soil shall be excavated, containerized, labelled in accordance with the Transportation of Dangerous Goods Act and shipped off site to a disposal facility that is licensed to accept PCB contaminated soils co-contaminated with heavy metals.

7.3.2 Metal Contaminated Soils

7.3.2.1 Contaminant Issue

The assessment identified a total of 94.3 m^3 of metal contaminated soil at the South Doppler Detection Building (**Figure 3.1**), the South Outfall (**Figure 4.0**), the Emergency Shelter (**Figures 5.1**), the Garage (**Figure 6.1**), the Barrel Cache (**Figure 8.1**), the POL Storage Area (**Figure 10.1**), the Beach Area (**Figure 11.0**), and the North Doppler Area (**Figure 12.0**). As previously indicated in **Table 1**, these soils exceed either DCC Tier I or Tier II criteria. Of the 94.3 m^3, there is approximately 12.0 m^3 of DCC Tier I metal contaminated soil, which includes 4.3 m^3 co-contaminated with DCC Tier I PCB contaminated soil as described in Section 7.3.1.1 above. The other 82.3 m^3 of metal contaminated soil exceeds the DCC Tier II criteria.

7.3.2.2 Remedial Method

Due to the small amounts of metal contaminated soils on site and the large operational and maintenance costs of metal contaminated soil remedial technologies as well as the high costs to construct a hazardous waste landfill, on site remediation or disposal of the soils on site is not recommended. All metal contaminated soils that exceed the DCC Tier I criteria, but are less than DCC Tier II criteria (12.0 m^2) should be buried in the non-hazardous landfill. The metal contaminated soils that exceed the DCC Tier II criteria (82.3 m^3) should be excavated, containerized, labelled in accordance with the Transportation of Dangerous Goods Act and shipped off site to a disposal facility that is licensed to accept metals contaminated soils co-contaminated with PCBs.

7.3.3 Hydrocarbon Contaminated Soils

7.3.3.1 Contaminant Issue

The Phase III site investigation identified approximately 109.8 m^3 of PHC contaminated soil that exceed the INAC Abandoned Military Sites Remediation protocol (DND DEW Line PHC Evaluation Process), which consists of 77.9 m^3 requiring excavation and 31.9 m^3 requiring scarification. It should be noted that soil volumes are likely to increase as a result of bulking during excavation; therefore a 25% contingency should be applied to the total volume of PHC contaminated soil. The hydrocarbon contaminated soils are located at the Landfill North of Site 412 (**Figure 7.1**), the Small Barrel Cache (**Figure 8.1**), the POL Storage Area (**Figure 10.1**), the Beach Bulldozer Area (**Figure 11.0**), and the Airstrip Area (**Figure 13.1**).

7.3.3.2 Remedial Options

<u>Excavation and Off-Site Disposal</u>

The first potential remedial option for the hydrocarbon soils at Bear Island is to excavate the PHC contaminated soils ship them south to a facility licensed to accept hydrocarbon contaminated soils. Since the contamination is completely removed from the site, it meets all of the remedial objectives; however, the major disadvantage of this method is the cost for shipping the material off site and the associated landfill tipping fee.

Bear Island is located in the middle of James Bay, which means that barging to the closest community (i.e. Chisasibi) is the most practical option for removing the contaminated soil. Barging is typically expensive; however, due to the relatively small volume of PHC contaminated soil (81 m^3), this option is favourable because it removes the material from the site, thus prohibiting future site visits for landfarming or monitoring purposes. It is anticipated that the cost of removing the material via sea lift is more cost effective than building, operating and monitoring a landfarm cell or landfill. Also, this remedial option would meet all INAC clean up objectives.

On Site Land Farming

Option 2 for handling the petroleum contaminated soils is the use of a land farm. Land farming is a remediation technique used to reduce the hydrocarbon levels in soil via volatilization, biodegradation and photo degradation. The hydrocarbon soils are spread out on a self contained, lined land farm cell in a lift approximately 0.3 m thick. Chemical amendments (fertilizer) and water are added to the soil to promote biodegradation of the hydrocarbons. The soil is scarified or "turned" using heavy equipment to break up the soil, add oxygen and promote volatilization. Microbes in the soil, (bacteria and fungi) breakdown the hydrocarbon chains converting them into biomass.

Advantages of land farming are that the contamination is eventually eliminated. This eliminates the need for long term inspections and monitoring, and removes any long term liability of the site. Notable disadvantages include the time and effort required for the construction of the land farm cell and the remediation process, as well as monitoring the activity and ensuring the material is remediated to the applicable criteria.

In a northern climate, a minimum of two to three years is required for remediation depending on temperatures, moisture, soil contaminants and fertilizer application/soil turning. Land farming also requires a work crew to visit the site to scarify the contaminated soil, add the chemical fertilizer and monitor the soil contamination levels. Once the soil has been remediated below the applicable criteria, the land farm cell will be decommissioned in place and contoured into natural topography. Due to the time requirement for this method, additional site trips are required after the initial remedial program has been completed.

Land farming of the contaminated soils would meet the INAC Cleanup Objectives one, two and three. Due to the small volume of impacted soils and the cost associated with building, operating and monitoring a landfarm cell, it is not cost effective to landfarm the hydrocarbon contaminated soil.

Landfill On Site

A secure landfill was evaluated as a third option. A landfill containing contaminated soils shall have an engineered clay/synthetic liner to ensure the contaminants within the soil are not allowed to become mobile. Proper design of the landfill will also ensure that permafrost is developed within the landfill to further decrease the mobility potential of the contaminants. The geotechnical evaluation, completed by EBA, identified that Type 4 granular material (well-graded sand and gravel with some fines) which is required for the low permeability containment berms was not found on the island. Consequently, it would necessary to either import suitable material or use a synthetic liner system to meet the containment requirements of a hazardous/PHC landfill.

Advantages of the landfill are that the remedial work can be completed in one season. Disadvantages for this option are similar to the capping option (described below). The main disadvantages of land filling the PHC contaminated soils are that the contamination will remain on site. This requires long term inspections and monitoring of the landfill at a significant extra capital and labour cost to ensure the contamination is contained within the landfill. Also, a synthetic liner or engineered clay must be imported to meet the containment requirements, which would make this option even more costly.

The landfill option meets INAC Cleanup Objectives one, two and three, however long term monitoring and inspections of the landfill are required as the contamination will remain on site. Consequently, the cost for building and monitoring a landfill is likely offset by the cost to excavate the material and dispose of it off site.

Engineered Cap in Place

Option 4 for dealing with the hydrocarbon contamination at the Bear Island site is to grade and cover the contaminated areas with an engineered cap. The cap would consist of a 1.0 m thick layer of compacted engineered fill, graded to promote drainage.

A cap would reduce the amount of rain and surface water coming into contact with the contamination and prevent further dispersion of the hydrocarbon contamination. The cap would also eliminate the possibility of humans and/or fauna from coming into contact with the contamination. This remedial option has a relatively low cost and a minimal level of effort. The capping of the hydrocarbon contaminated soils could easily take place during other site remedial activities.

In addition to the engineered cap a chemical amendment can be added to the contaminated soil. The chemical amendment (fertilizers, nutrients, nitrogen etc.) promote biodegradation of the hydrocarbons by providing the necessary chemicals and nutrients required by the microbes for the degradation to occur. The hydrocarbon impacted soils are excavated and the chemical amendment would be mixed into the soils and the soils would be replaced and capped as noted above. The additional costs for the chemical amendment include the costs for the excavation of the impacted areas; the addition of the amendment, the amendment itself and the cost to replace and compact the soils after the amendment is added.

The main disadvantage of this option is that the engineered fill must be imported. Other disadvantages associated with this remedial option are that it would require further monitoring events to ensure the capping system remains in good condition (no erosion, frost heaving) and that the hydrocarbons do not become mobile. The capping would also greatly reduce the natural occurring bioremediation of the soils by limiting the amount of oxygen reaching the contaminated soil. Less oxygen reduces the rate of aerobic degradation of the hydrocarbons. There would be little to no control over the bioremediation process and ongoing monitoring of the contaminated area would be required.

In Situ Soil Vapour Extraction

Vapour extraction is a remedial method used to remediate hydrocarbon contaminated soils. Air is pushed or drawn through the contaminated soils and the lighter end hydrocarbons volatilize into the air. The air is then released into the atmosphere or run through carbon filters to remove the hydrocarbons. Contamination favouring this option is light end hydrocarbons (F1 Fractions). Heavier fractions of hydrocarbons are less likely to volatilize and require different remediation methods. The soils must also be porous, freely allowing the air to move through the soil and volatilize the hydrocarbons. Poorly graded dry sands and gravels are ideal for vapour extraction. Saturated well graded soils are not favourable for Soil Vapour Extraction.

Vapour Extraction systems rely on powered blowers and require frequent adjustments and maintenance during the extraction process. Since Bear Island is a remote unmanned site the cost of instituting this remedial measure is not cost effective. The soils and type of hydrocarbon contamination at Bear Island are not compatible with vapour extraction remediation methods. The contamination at the Bear Island site is the larger fractions of hydrocarbons (F2 and F3). Vapour extraction will not be explored further as a remedial option.

Biopile

A biopile is a remediation technology used to remediate hydrocarbon contaminated soils. The PHC contaminated soils are collected into piles and wrapped in synthetic liners to promote anaerobic degradation of the hydrocarbons and retain heat to promote the bioactivity. Temperatures measured within an active biopile are often much higher than ambient temperatures. Biopiling has had limited success as an effective remediation technique at remote and unmanned northern sites due to low ambient temperatures and the care and maintenance involved with operating the biopile system. Biopiles will not be explored further as a remedial option.

Scarification

In accordance with the DND Evaluation process, Type A (non-mobile) hydrocarbon impacted soil with TPH concentrations less than 20,000 mg/kg and located a localized area with a slope less than 10% must be scarified to a depth of 0.3 m.

7.3.3.3 Recommendation

Based on the evaluation of the remedial options in the context of the remedial objectives, it is recommended that the 77.9 m^3 of hydrocarbon contaminated soils be excavated and shipped off site for disposal. Also, it is recommended that the 3.1 m^3 of Type A impacted soil at the Beach Bulldozer be scarified (area of 10.4 m^2 to a depth of 0.3 m) to address hydrocarbon stained soils in that area.

7.4 Site Materials

7.4.1 Non-Hazardous Materials

Approximately 727 m^3 of non-hazardous materials are estimated to be left on site at Bear Island, which includes 622.5 m^3 of surface debris, 14.7 m^3 at the existing landfill, and 41.7 m^3 in the west toe of Landfill A. The following table presents a summary of the non-hazardous materials. It should be noted that 48 m^3 of concrete structures, such as antenna bases and the emergency shelter, are not included in the **Table 2** because it is likely the surrounding soil will be re-contoured and the concrete structures will be left in place. A detailed inventory of the non-hazardous materials is provided in **Table D1** (**Appendix D**).

The 2007 Phase III ESA included the collection and analysis of a concrete sample collected from the Garage foundation. As reported, the analysis indicated PCBs concentrations less than 50 ppm in all the samples. Consequently, concrete products are classified as non-hazardous waste.

All buildings/infrastructure shall be demolished to their foundations in accordance with the INAC, Abandoned Military Site Remediation Protocol, April 2008. All barrels shall be addressed using the Department of National Defence (DND) DEW Line Clean up Barrel Protocol (**Appendix B**). A detailed summary of the non-hazardous materials located at the Bear Island site is provided in **Table D1** (**Appendix D**). Remedial options for non-hazardous materials are described below.

Table 2 – Summary of Non-Hazardous Materials

Location	Volume (m3)	Weight (tonnes)	Percentage of Total (% by weight)	Comments
South Doppler Area	446.8	1413.7	69.0	Includes barrels in the west toe of the North Landfill Area, as well as assumes concrete emergency vault and antenna bases will remain in place
Beach Area	104.3	311.9	15.2	Located on ground surface
North Doppler Area	101.7	263.6	12.9	Located on ground surface, and assumes concrete antenna bases will remain in place
Airstrip Area	26.1	59.3	2.9	Located on ground surface
Total	**678.9**	**2048.5**		

7.4.1.1 Remedial Options

Buried in Place

Once all the structures have been demolished to their foundations, the site materials can be buried in place. The debris would be flattened and covered with compacted engineered fill or placed in a nearby excavation or low spot in the surrounding terrain and then covered with compacted fill. The cover of compacted fill must be engineered to promote positive drainage and the cap must also be graded to match surrounding terrain. Advantage of this method is that it is less expensive as the contractor does not have to remove, transport and place material in a landfill some distance away. The disadvantages of this method is that the material is not placed in a secure engineered landfill and that a large contractor effort would be required to move fill to cover the debris piles that are scattered around the site. In the event that additional debris is discovered on site, the debris shall be addressed using the INAC Abandoned Military Site Remediation Protocol, April 2008. In the event that the materials are buried onsite, future monitoring would be required.

Consolidate Wastes and Place in On Site Non Hazardous Waste Landfill

Once all the structures have been demolished to their foundations, the demolished materials as well as the non-hazardous materials from the surface debris piles that are scattered around the site would be transported to an engineered landfill. This option is more cost intensive, but it gathers all the site material into one secure area reducing future monitoring inspection efforts. Placing the non hazardous demolition waste in an on-site engineered landfill is in accordance with the INAC Abandoned Military Site Protocol, April 2008.

Off Site Disposal

Once all the structures have been demolished to their foundations, the demolished material can be collected and transported off site. As Bear Island is located 140 km off-shore from the nearest community of Chisasibi, a sea lift would be required to deliver the material for disposal at another location. Due to the large costs associated with hauling demolition material via barging, off site disposal is deemed too expensive and not cost effective.

7.4.1.2 Recommendation

It is recommended that an engineered non-hazardous waste landfill be constructed on site using the available borrow sources. It is recommended that all non-hazardous waste materials be collected, consolidated and deposited in one central landfill. This landfill should be large enough to place all of the non-hazardous debris plus the disposable Tier I soils, as well as the bagged asbestos waste and vented compressed gas cylinders.

Since the debris piles that are scattered around the site are located on the ground surface and are not buried the collection of these materials and disposal in a common landfill is recommended over burial in-place as the remedial option. Although the North Landfill Area is classified as a Class C Landfill (located in a suitable, stable location with no evidence of contaminated leachate), it is also recommended that all non-hazardous wastes be recovered from the exposed toe along the southwest perimeter of the North Landfill Area (**Figure 9.0**). This material should also be placed into the common landfill. All non-hazardous material on site is to be placed in the landfill and compacted and capped in accordance with the landfill design. Taking the results of the Ecological Site assessment, as well as the location of the majority of the debris onsite, it is recommended to use landfill location #1, as identified in the EBA Geophysical and Geotechnical report (Figure 1 in the EBA report).

7.4.2 Hazardous Materials

Hazardous materials are known to be present at the former Bear Island Mid-Canada Line Radar Station based on assessment work completed in 2007, and previously in 2001. A detailed inventory of hazardous waste is provided in **Table D2** (**Appendix D**). All hazardous materials (with the exception of Asbestos Containing Materials and empty compressed gas cylinders) will be containerized and labelled in accordance with the Transportation of Dangerous Goods act in Accordance with the INAC Abandoned Military Sites Remediation protocol and disposed of offsite.

Approximately 27.0 m^3 of Lead painted materials and 18.8 m^3 of hazardous materials (asbestos materials and lead-acid batteries, gas cylinders) were identified during the 2007 Earth Tech site assessment. A detailed description of the hazardous / non-hazardous samples is provided in **Table D3** (**Appendix D**). It should be noted that additional paint samples from the materials where the paint was applied to a metal substrate (i.e. electrical cabinets at the Beach Area) should be collected at the commencement of remediation activities to avoid any uncertainties with the proper method to handle these paint products. The paint samples must include the substrate as well as the paint, and are to be submitted for leachable lead analysis. Also, paint samples collected during the 2007 investigation program were only analyzed for lead consequently it is recommended that the painted media be resampled and analyzed for PCB content. It should be noted however that the only paint product not found to be hazardous (i.e. lead contaminated) was the white and orange antenna paint. If the antennas (two large and three small) are found to contain PCB contaminated paint the volume of hazardous materials will increase by as much as 75 m^3.

According to the AMSRP the Landfill North of Site 412 is classified as a Class A Landfill (unstable, high erosion location with contaminated soil downgradient) and consequently debris within this landfill must be sorted and disposed of accordingly.

Remedial options for hazardous materials are described below.

7.4.2.1 Petroleum Oil and Lubrication (POL) Fluids and Collected Water

Incinerate on Site

Preliminary results for barrel samples found to contain product at Bear Island is provided in **Table D4** (**Appendix D**). Some of the product samples collected during the 2007 investigation were compromised during transport to the lab; consequently results for chlorine and chromium were not available for some of the barrel samples. These barrels at the small barrel cache must be re-sampled and analyzed for chlorine and chromium content. The fluids can be burned if the levels of the previously listed parameters are below the criteria for incineration as listed in the Department of Defence DEW Line Clean up Barrel Protocol (the POL fluid contains <1000 ppm Cl and <10 ppm Cr; **Appendix B**). If the POL fluid analysis indicates any of these contaminant levels have been exceeded, the fluid will be classified as a hazardous material and must be treated in accordance with Section 7.4.2 (Hazardous Material) of this document. There is approximately 1.05 m^3 of POL liquids stored onsite.

Disposal on Ground

As a general note, all barrels inspected at Bear Island were found to be empty or rusted through, with the exception of approximately four barrels at the Small Barrel Cache and one at the Airstrip (described above). This fact does not ensure that all barrels on site are empty or contain just rusty water as all (approximately 4300 barrels) were not inspected. During cleanup activities all barrels must be approached using the DLCU barrel protocol. A copy of the DEW Line Clean-up protocol is provided in **Appendix B**.

7.4.2.2 Asbestos

Asbestos Containing Materials (ACM) at the Bear Island site includes to green and brown 9"x9" floor tiles and asbestos cement board, which were found at both the South and North Doppler Areas, as well as at the Beach Area. A detailed description of the asbestos samples in provided in **Table D4** (**Appendix D**). Asbestos is located throughout the remaining structures, within the surface debris piles and scattered in the region of the above mentioned areas. All asbestos is to be properly abated, in accordance with applicable Federal and Territorial Asbestos regulations, prior to any demolition activities.

Asbestos Abatement, Place in On Site Landfill

All asbestos is to be abated in accordance with applicable Federal and Territorial Asbestos regulations and guidelines. All asbestos debris shall be abated and placed in a sealed, airtight container, clearly labelled "ASBESTOS". The asbestos is then placed in the engineered landfill constructed onsite. The location of the asbestos material located within the landfill should be noted for future reference. This method is in accordance with the INAC Abandoned Military Site Remediation Protocol. Due to the transport costs associated with transport of materials from the Bear Island site, off site disposal is not recommended for the asbestos waste.

7.4.2.3 Lead Contaminated Paint

Paint Removal, Off Site Disposal

Paint abatement consists of physically removing the lead contaminated paint from the substrate. This is accomplished by physical scrapping, chemical stripping, sand blasting and various other abrasive physical removal techniques. As the paint being removed contains lead, abatement methods must be conducted in a manner that protects the worker and the environment from lead contamination. Abatement methods generating dust must be conducted in a sealed, negative pressure environment with the area exhaust filtered with a certified High Efficiency Particulate Air (HEPA) Filter. Misted water is also used to control the paint dust, requiring the waste water to be filtered to remove the contaminated paint or collected and treated as hazardous waste. These required mitigation measures increase costs dramatically. This option would meet the INAC cleanup objectives for restoring the site to an environmentally safe condition and preventing the migration of the contaminants as all of the lead containing paint would be removed from site. The abatement process; however, is involved and costly. The abatement costs combined with the disposal costs make this option less cost effective.

Remove Painted Materials, Off Site Disposal

As an alternative to paint abatement, building materials painted with contaminated paint can be dismantled and disposed of as hazardous materials, bypassing the requirement for the paint to be abated. The transport and disposal costs are higher due to the fact that the painted building materials are disposed of along with the paint; however these additional costs are smaller than the additional costs of paint abatement. As there is minimal scrapping and abrasion during the dismantling activities, negative air enclosures and filtration systems are not required. Dismantled material volumes can be minimized by cutting and compacting. This option meets the INAC Abandoned Military Site Clean up Protocol Cleanup Objectives one, two and three. This option is also less expensive than the abatement options making it more cost effective than the other options proposed.

7.4.2.4 Recommendations

During cleanup activities all barrels must be approached using the DEW Line Clean-up barrel protocol (**Appendix B**). If the petroleum products meet the incineration guidelines, the waste products may be incinerated adhering to an approved method, otherwise POL fluids must be shipped off-site and disposed of accordingly. Rusty barrels found to contain water must be handled according to the barrel protocol.

It is recommended that all compressed gas cylinders (after they are vented), as well as asbestos waste, be disposed in the constructed landfill.

It is recommended that the lead amended paint materials be dismantled and disposed off site. This remedial method is in accordance with the INAC Abandoned Military Site Remediation Protocol, April 2008. Care is to be taken during the dismantling to prevent dust and paint chips from being released into the environment and to protect the workers that are conducting the dismantling from PCB and lead contamination. All dismantled lead contaminated paint material shall be packaged, transported and disposed of in accordance with the current regulations governing the handling and disposal of hazardous materials.

7.5 Recommended Remediation Methods

The following table presents a summary of the recommended remedial methods.

Table 3: Summary of Recommended Remediation Methods

Environmental Concern	Site Assessment Findings	Recommended Remediation Method
DCC Tier I Contaminated Soils	12.0 m^3 of soils with concentrations of heavy metals (Cd, Cu, Pb and Zn) and PCBs which exceed the DCC Tier I criteria were identified onsite.	Dispose of soils that exceed DCC Tier I soils (12.0 m^3) in an onsite landfill.
DCC Tier II Contaminated Soils	82.3 m^3 of soils with concentrations of heavy metals (Cd, Cu, Pb and Zn) and PCBs which exceed the DCC Tier I criteria were identified onsite. This volume includes 4.3 m^3 of material that is co-contaminated with Tier I PCBs.	Excavate, containerize and label soils that exceed DCC Tier II criteria (82.3 m^3) and dispose offsite.
Petroleum Hydrocarbon Contaminated Soils	Approximately 109.8 m^3 of hydrocarbon contaminated soil in exceedance of the INAC Abandoned Military Site Remediation Protocol for PHC Soils.	Excavate 77.9 m^3 contaminated soils and place into containers, and ship off site to a licensed disposal facility. Scarify 31.9 m^3 of PHC stained soil.
Surface Debris	Approximately 622.5 m^3 of non-hazardous debris consisting of heavy equipment, barrels, scrap metal, scrap wood, concrete, electrical equipment and plumbing parts, and any remaining buildings.	Consolidate and dispose in a non hazardous landfill constructed onsite.
Existing Landfills	Landfill North of Site 413 is considered a Class A landfill and was found to contain hazardous materials. The surrounding soils are being impacted from debris located within the landfill. North Landfill is considered to be a Class C and there is no evidence that surrounding soils are being impacted.	Consolidate and dispose waste debris (14.7 m^3) accordingly. Remediate PHC contaminated soils as described above. Consolidate surface debris, as well as the partially buried debris located on the exposed southwest toe of the landfill, (approx 41.7 m^3 total) and dispose accordingly.
POL Fluids	There are approximately 1.05 m^3 (1,050 L) of Petroleum, Oil and Lubricant fluids.	Incinerate POL fluids that meet incineration criteria (< 2 ppm PCBs and Cd and < 10 ppm Cr and <100 ppm lead and <1000 ppm Chlorine), otherwise treat as Hazardous Waste (**Appendix C**)

Environmental Concern	Site Assessment Findings	Recommended Remediation Method
Water in barrels	With the exception of five barrels, all barrels inspected were found to be empty or rusted through. This fact does not ensure that all barrels on site are empty or contain just rusty water as all (approximately 4300 barrels) were not inspected.	During clean-up, all barrels must be approached using the DLCU barrel protocol (**Appendix C**).
Lead Painted Products	Approximately 27.0 m^3 of lead amended paint materials were discovered on site.	Dismantle contaminated paint items and ship off site to an appropriate disposal facility.
PCB Painted Products	If the orange and white painted antennas are found to contain PCB contaminated paint, there is potentially an additional 75 m^3 of hazardous materials on site.	Dismantle contaminated paint items and ship off site to an appropriate disposal facility.
Hazardous Materials	Approximately 18.0 m^3 of hazardous materials were identified at the site. These materials consisted of lead acid batteries (3 m^3), asbestos containing materials (12.5 m^3), and lead cable and zinc conduit (2.5 m^3).	Asbestos waste to be collected, bagged and disposed of in an on-site landfill. All hazardous materials (such as batteries and hazardous cable/conduit) will be containerized, labeled and shipped to be disposed at a licensed southern facility.
Compressed Gas Cylinders	Approximately 8 compressed gas cylinders were identified onsite.	Vent and dispose of cylinders according to the INAC AMSRP in the non-hazardous landfill.

8.0 REMEDIAL DESIGN AND IMPLEMENTATION

8.1 Remedial Objectives

The remedial design for the Bear Island Mid-Canada Line Radar Station has been developed in accordance with the Indian Affairs and Northern Development, Abandoned Military Site Protocol, April 2008. The following section outlines the general design and implementation of the preliminary draft Bear Island Remedial Action Plan (RAP).

Remedial Design and Implementation Objectives:

1. Ensure safety of workers on site;
2. Prevent further contamination at the Bear Island Mid-Canada Line Radar Station;
3. Minimize impact to environment, fauna, flora and
4. Achieve remedial objectives.

The contractor shall have a site specific, Health and Safety Plan (HASP) in place and understood by all involved workers prior to work starting on the site. Contractor shall also have a spill contingency plan in place to deal with any unforeseen and accidental releases of contaminants.

8.2 Camp/Contractor support

Due to the high costs for a contractor to commute to the site on a daily basis, and due to the potential that the contractor may not be able to access the site during poor weather, it is recommended that an onsite construction camp be utilized. The camp must be large enough to support approximately 30 site workers and approximately 3-5 camp staff. If possible, the camp will be located in a previously disturbed area, such as the disturbed area west of the Barrel Cache (**Figure 2.1A**), to minimize any new disturbances in accordance with applicable licenses.

The camp shall include a potable water source, sewage collection and treatment in accordance with all applicable guidelines and regulations, bear safety measures, emergency rations and an emergency rescue contingency plan. A water sample was collected by Earth Tech from the water reservoir, located south of the north of Site 412 (as shown in **Figure 2.1A**). Although the results for total metals, PCBs, PHCs and PAHs are below the CCME Guideline for Canadian Drinking Water Quality, the sample was not analyzed for routine water potability. Consequently, the water reservoir should be resampled prior to setting up the camp to determine if the water source can be used to support the camp requirements. It should also be noted that additional testing would be required on an on-going basis for potable use during remediation.

Domestic waste generated by the camp will either be disposed off-site or incinerated on-site with the ash placed in the on-site landfill or shipped off-site. Sewage will be treated using an approved sewage treatment system, in accordance with applicable legislation and licenses.

It is recommended that mobilization to the site be achieved using sealift rather than airlift. It should be noted that the proposed barge landing area, located at the Beach Area in a bay on the east side of the island, has not been inspected by a sealift contractor. It is recommended that an inspection be completed to ensure the sealift can be land on the island. In the event that the sealift can be landed on Bear Island, it is recommended that consideration be given to truck all the contractor equipment and supplies to the James Bay community of Chisasibi. Potentially a sealift contractor would be able to load up in Chisasibi and transfer the materials to Bear Island. The other option for mobilization is to sealift the entire contractor's equipment from Montreal via sealift. It is also recommended that the contractor charter aircraft in the community of La Grande or Chisasibi in order to re-supply the camp and move personnel.

As described in Section 4.3 above, Polar Bears were residing on Bear Island. It is likely that Polar Bear are commonly observed on the island in the summer season. Due to terrain and topographic features of the island, there are numerous locations where bears could approach the camp and work areas without being noticed. Due to the high potential for bear encounters, it is recommended that a safety plan be developed by the contractor to maximize the protection of all workers onsite. The plan should provide guidance on how to respond in a manner that is safe to both humans and polar bears. The plan should also outline methods of deterrents, waste disposal requirements as well as the proper procedures to follow should a bear be encountered. During the field season activities, numerous polar bear wildlife monitors should be used to provide 24 hour surveillance for the camp and crew members. To add an additional level of protection, the main camp should be surrounded with a 2 m high, 10,000 volt electrical fence. Each of the wildlife monitors should be equipped with rifles as well as two-way radios to allow them to be in continual communication with all field and camp staff. It is recommended that a wildlife specialist be involved in the design and follow through of the contractors Polar Bear mitigation plan.

In addition to mitigation measures being in place during the field activities, measures must be taken during the off-season to minimize Polar Bears being attracted to infrastructure associated with clean-up activities. It will be necessary to leave heavy equipment and tools, as well as potentially hard-sided camp infrastructure, over the winter. It is recommended to remove all kitchen supplies (stoves, fridges, food, etc.) and other infrastructure that can be removed from the site during the winter/off-season to reduce the attraction of Polar Bears and other wildlife.

8.3 Infrastructure/Roads

8.3.1 Airstrip

As was presented in the EBA report, the airstrip is susceptible to becoming oversaturated during spring thaw or during periods of heavy rain. If contractors are preparing to use the airstrip at Bear Island, it is recommended that the contractor evaluate the runway condition prior to use. The contractor shall utilize the airstrip at its own risk. The airstrip must be continually evaluated by the operational pilots and staff at the Bear Island site. If and when excessive erosion and/or rutting are noted, the airstrip shall be repaired immediately as required and to the satisfaction of the operational pilots. Further assessments and the use of a Boeing Penetrometer shall be employed before larger aircraft are taken under consideration for landing on the airstrip at Bear Island. It is recommended that the contractor maintain the airstrip on a regular basis to allow for camp resupply and personnel transfer. Once remediation activities have been completed it is recommended that the airstrip be left in place. This practice is consistent with most other site clean-up programs (DEW Line and otherwise), because the airstrip is currently referenced on aviation maps and is available to be used in the event of an emergency. Removing the airstrip is therefore considered to be a safety hazard.

8.3.2 Existing Roads

Due to lack of upkeep and erosion, some of the existing roads to be utilized during remedial activities will require minor repair and upgrading. The settlements and washout areas shall be patched and compacted using borrow material from the most suitable borrow source (identified in the EBA report). Upon completing the remediation program, with the exception of removing culverts and any other fabricated materials, it is recommended that the existing roads will be left in place. The only amendments recommended are slight modifications to allow natural drainage patterns to continue.

8.4 Borrow Source Development

Borrow sources shall be developed in accordance with the Indian and Northern Affairs Canada Abandoned Military Site Remediation Protocol. Required borrow material shall be drawn from one of the three borrow sources identified in the EBA report. It should be noted that the tern nesting habitat and archaeological sites located at the south borrow source should be identified and remain undisturbed during site activities.

Once the borrow source requirements for the Bear Island remediation have been satisfied all borrow sources will be recontoured to restore natural drainage and to match surrounding topography and minimize changes to the existing permafrost.

8.5 Non-Hazardous Waste Landfill Engineering and Construction

The landfill location was selected based on the required landfill size, distance to material to be landfilled and distance to borrow sources. The landfill location (shown in **Figure 2.1A**) just north of Site 412 requires the least amount of transportation for the majority of the waste and it is on the crest of a hill, minimizing the probability of erosion and infiltration. It was identified in an Ecological Assessment, completed by Earth Tech in 2007, that this area provides an important vegetation resource. It should be noted that other areas on the island provide equal vegetation resources and more importantly, it is recommended that the landfill design includes planting native vegetation to re-establish the vegetation resource currently located in this area. Another suitable location for the non-hazardous landfill is within the disturbed area, although this option was not investigated by EBA during the 2007 investigation. Other potential landfill areas were identified south of Site 412; however, Landfill Area #3 was located in close proximity to the sensitive arctic tern nesting area at the south end of Bear Island, and Landfill Area #2 was sited near fox dens. Therefore, it is not recommended to use either Landfill Areas #2 or #3.

The landfill shall be constructed in a controlled manner with minimal lifts to control compaction and settlement. Surface water run-on and run-off will be controlled through proper grading to positively shed water and to prevent ponding and seepage into the landfill. Consideration to the landfill cap angles must be designed as to not to encourage erosion of capping material.

Leachate control should be accomplished by control measures (rather than containment and collection such as synthetic liner cover). Control measures include placing only dry and stable material in the landfill and preventing water infiltration into the landfill to prevent leachate generation. Fill material shall be "frost stable" and placement outside of high groundwater or constant surface water area recharge area. Settling of the landfill surface shall be avoided by placing thin lifts (0.15 m) and compacting/vibrating to fill voids.

Outside berms shall be constructed at 3H:1V and inside berms at 1.5H:1V. The top of the berm should have a minimum width of 2 m. Since the berm material will be erodible, the berms should have a minimum 0.5 m thick cover of gravel and cobbles.

The reduction of surface settlement over the landfill should be completed by ensuring all debris voids are filled in and the total debris thickness in the landfill does not exceed 3 m. The landfill cap shall be compacted to 95% of the maximum density.

8.6 Waste Handling Facility Construction

A Waste Handling Facility (WHF) will be required at the Bear Island site to receive and sort various waste items. The fluids handling area within the WHF shall be lined with an engineered clay/synthetic liner to prevent the migration of contaminants resulting from any accidental spills. The fluids handling area is to be bermed and the engineered liner should have some fill cover to protect the liner integrity. The waste handling facility shall have applicable safety items and PPE which include but are not limited to; fire extinguisher, first aid kit, eye wash station, emergency spill kit etc. Materials to be received and sorted at the WHF include but are not limited to:

- Barrels (Barrel Protocol)
  - Empty
  - Unknown fluids
  - POLs
  - Cleaning, rinsate, crushing

- Batteries
- Compressed Gas Cylinders
- Items painted with Lead Paint
- Soils for off Site Removal
- Creosote Treated timbers (wrap in poly, on site landfill).

The WHF area shall be located near the proposed landfill location (**Figure 2.1A**) and it is recommended that the WHF be surrounded by a temporary road to provide access to vehicles and equipment required in the delivery, sorting and transport of the site waste. Upon decommissioning of the WHF the area beneath the facility shall be sampled for confirmatory purposes.

8.7 Schedule

8.7.1 Schedule

Based on the scope of work of the project, it is assumed that one complete construction season would be needed to complete the project; however due to the delay in the arrival of the sealift to this site (approximately late July) and the time required to construct an onsite camp, it is expected that 2 field seasons will be required to complete all onsite activities. It is assumed that remedial activities would not commence until mid-August and would continue until the end of September of the first construction year.

Assuming the project is tendered in the Fall 2008, the following is a proposed schedule for the remediation of this site:

- Community meetings (Spring 2008)
- Permitting (Summer/Fall 2008)
- Bidders site meeting (Fall 2008)
- Contract tender (Winter 2008)
- Contract award (Spring 2009)
- Mobilization (Summer 2009)
- Year 1 Remedial Activities (Summer 2009)
- Year 2 Remedial Activities (Summer 2010)
- Demobilization (Fall 2010).

9.0 PROJECT AND LONG TERM MONITORING

The purpose of project and long term monitoring is to confirm compliance of the remedial activities with the specified clean up objectives and clean up criteria. During the remedial program, quantities of all site materials should be estimated, tracked and measured. Contaminated areas that have been excavated shall be confirmed clean by field screening methods and then samples shall be taken for laboratory confirmation.

As all dumps are recommended to be excavated, long term monitoring of these areas will not be required. However, any newly constructed non-hazardous landfill will be inspected visually. This visual inspection will look for any settling, ponding, erosion or frost action that may have occurred. If there are signs of instability at these landfills such that buried material becomes exposed, then remedial action will be implemented. Visual monitoring will be conducted at all constructed landfills in approximately mid-August. The frequency of the program will be on an annual basis for the first five years, then if no problems area encountered year 7, 10, 15 and 25. A full review of data will be completed in the fifth year.

10.0 REFERENCES

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An Environmental Assessment of Two Mid-Canada Line Sites at Bear Island, Environmental Sciences Group, Royal Roads Military College, March 1996.

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A Federal Approach to Contaminated Sites, Contaminated Sites Management Working Group, November 1999.

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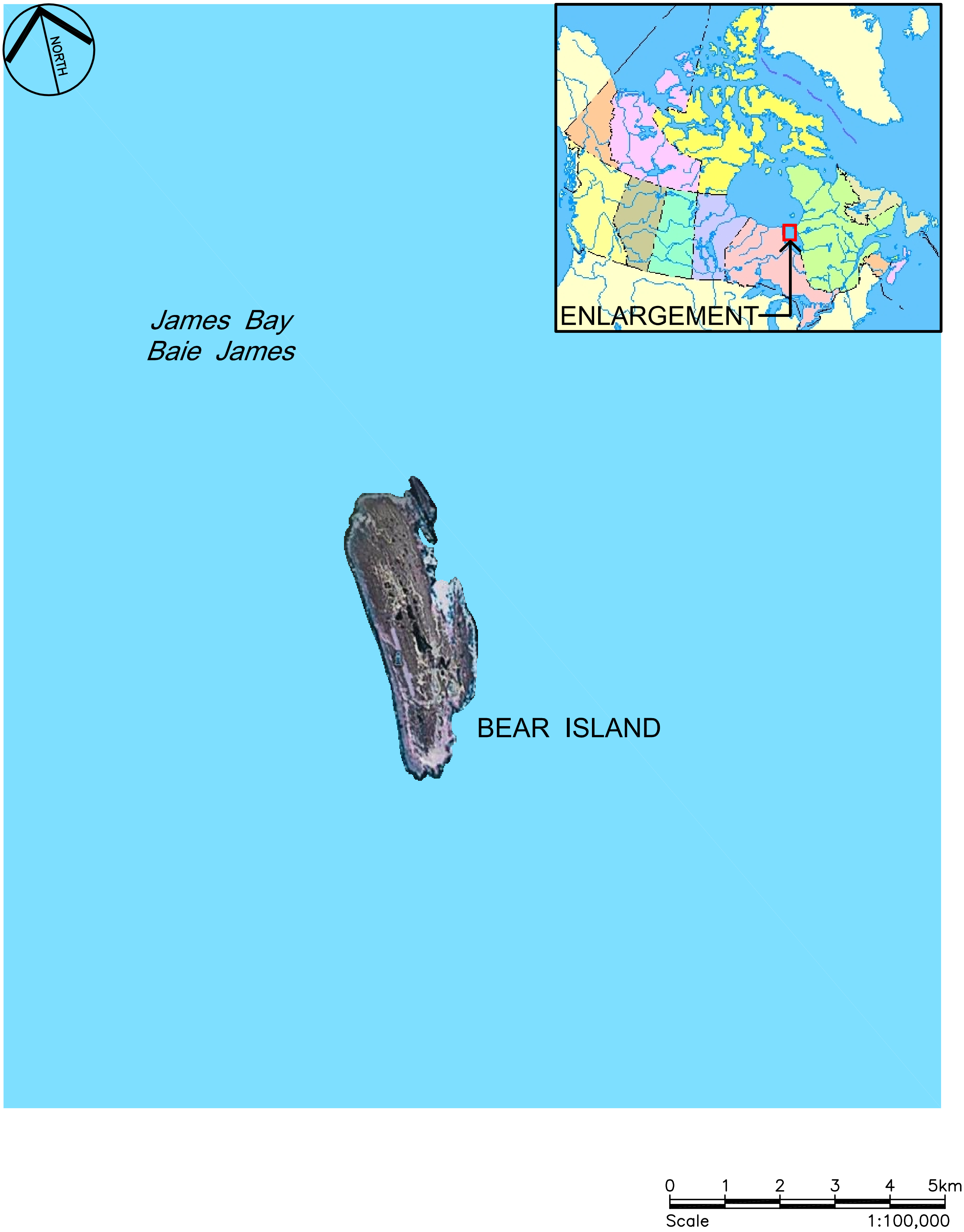
APPENDIX A

FIGURES

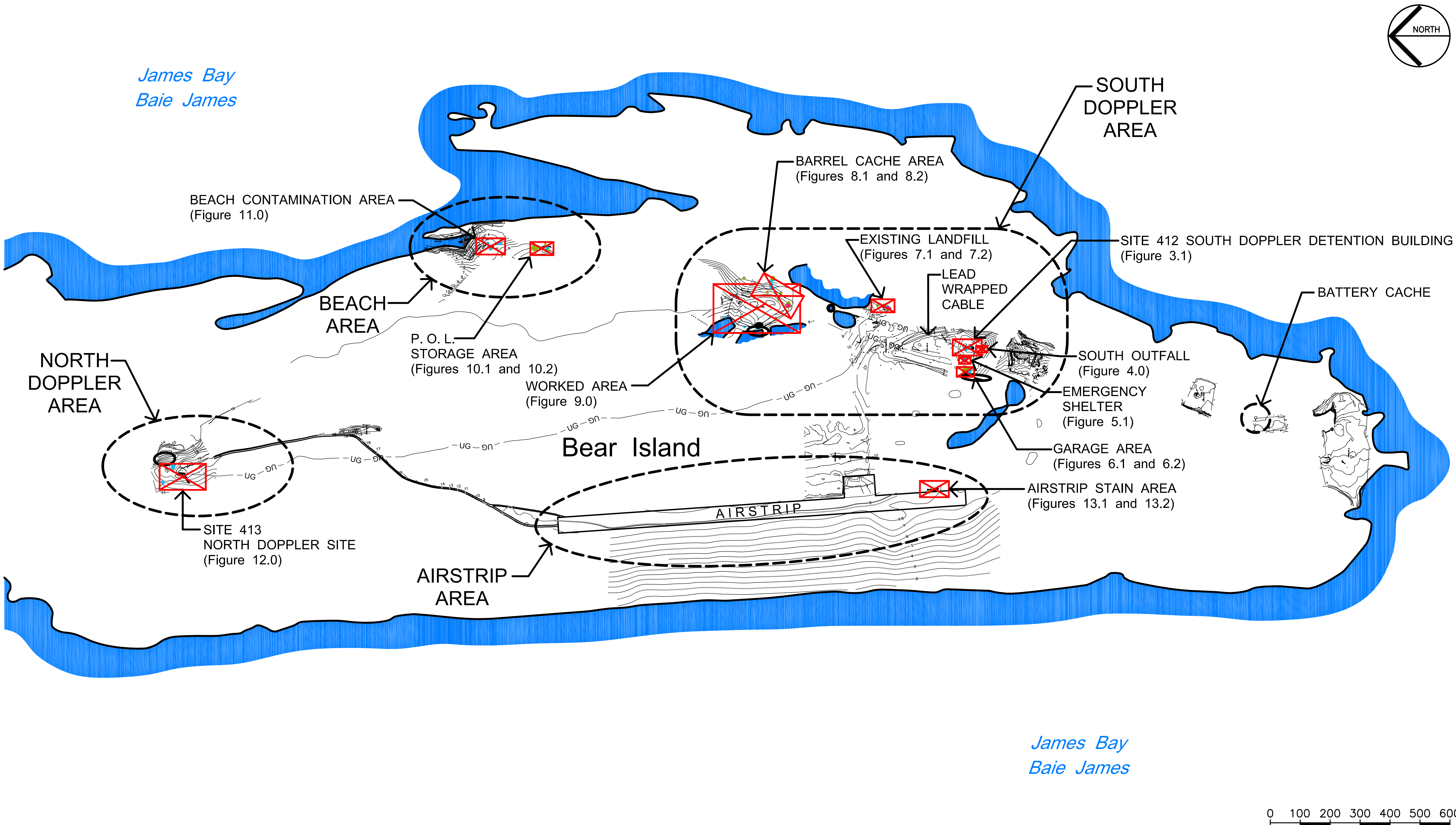


Earth Tech
A tyco International Ltd. Company

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

designed GTW	scale As Noted	yy-mm-dd 2008-08-15
drawn SB/RJH	E.T. project no. 101610	
checked GTW	drawing no. FIGURE 1.0	
approved		

BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
SITE LOCATION

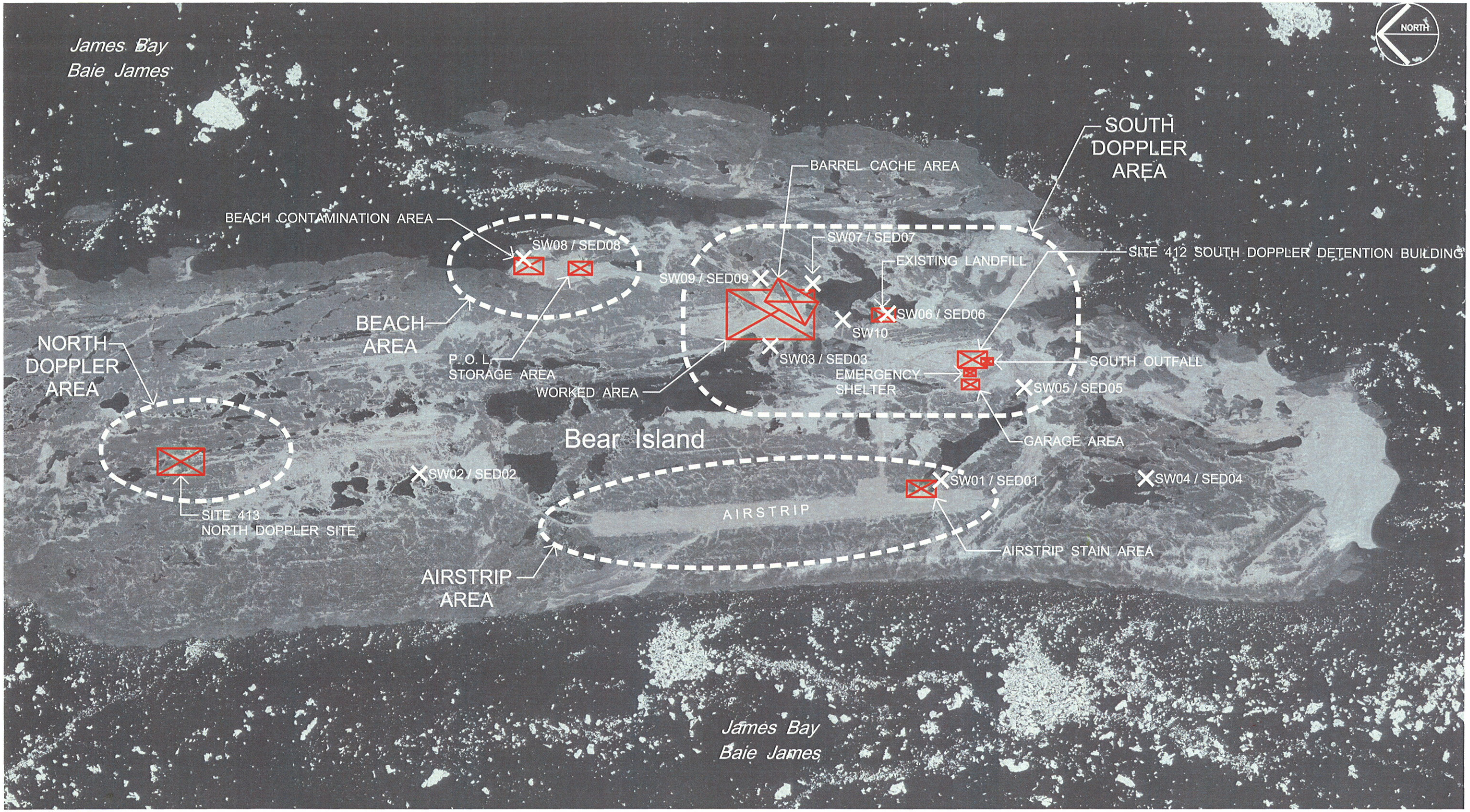


Legend

FIGURE OUTLINE

SURFACE WATER

EarthTech A tyco International Ltd. Company	Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada	designed GTW	scale As Noted	yy-mm-dd 2008-08-15
		drawn SB/RJH	E.T. project no. 101610	
BEAR ISLAND MID - CANADA LINE SITE Remedial Action Plan SITE LAYOUT		checked GTW	drawing no. FIGURE 2.0	
		approved		



Legend

- FIGURE OUTLINE
- SAMPLE LOCATION
- SW04 WATER SAMPLE
- SED04 SEDIMENT SAMPLE

0 100 200 300 400 500 600m
Scale 1:12,500

EARTH TECH | AECOM

Indian and Northern Affairs Canada — Affaires indiennes et du Nord Canada

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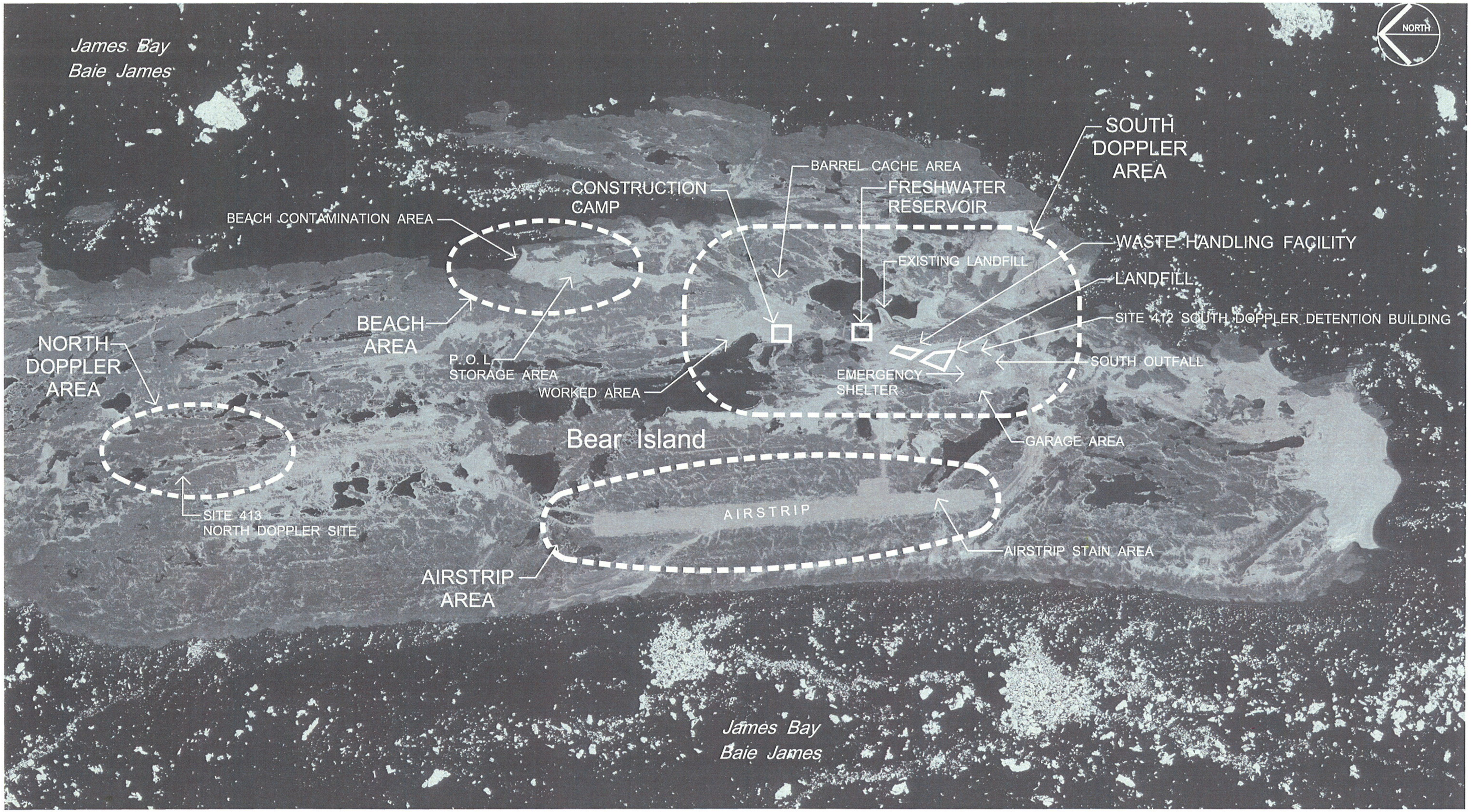
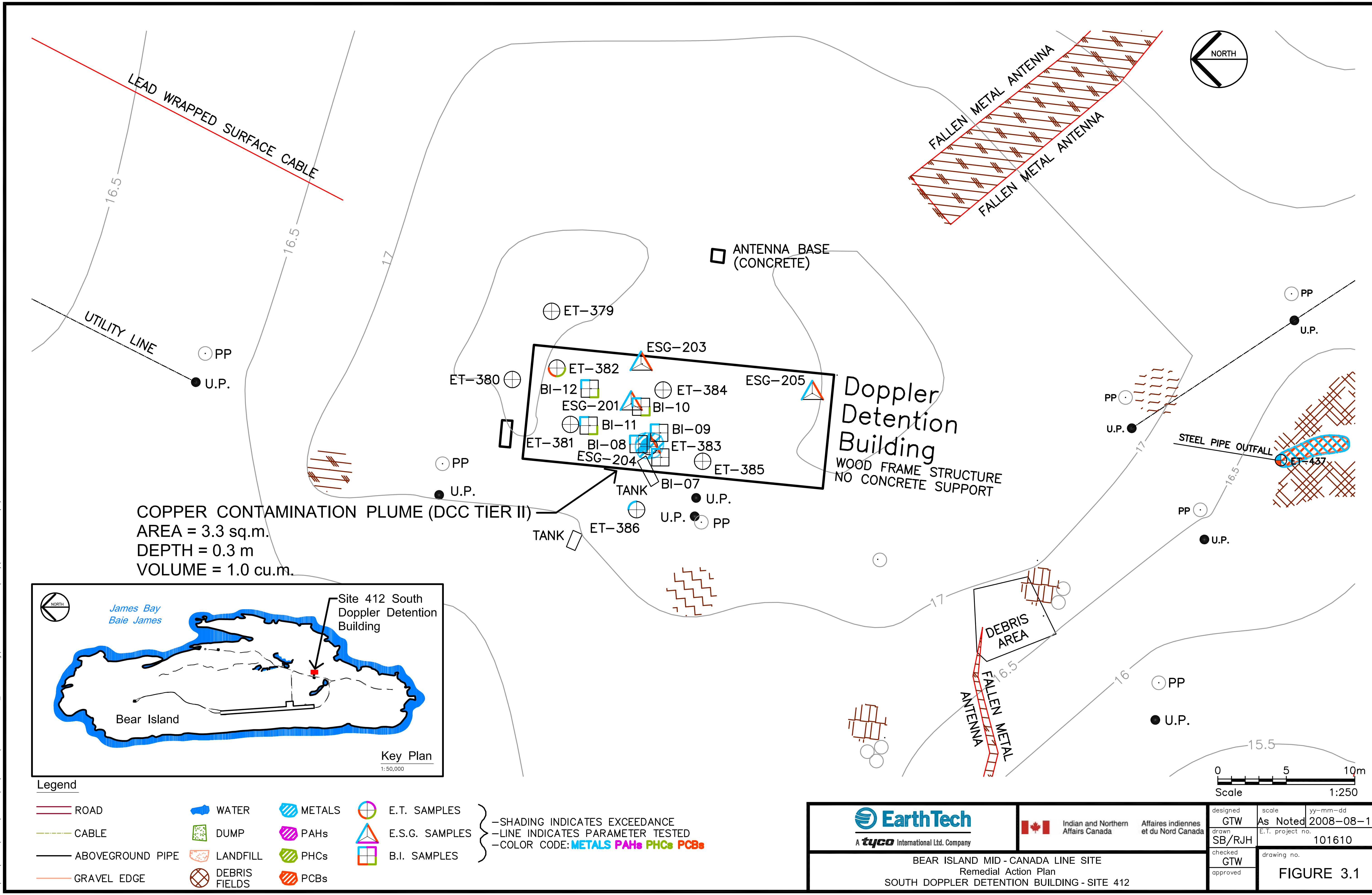
drawn SB/RJH	E.T. project no. 101610	
checked GTW	drawing no.	
approved	FIGURE 2.1	

BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
SITE LAYOUT - SURFACE WATER and SEDIMENT SAMPLE LOCATIONS



0 100 200 300 400 500 600m
Scale 1:12,500

EARTH TECH | AECOM	Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada	designed GTW	scale As Noted	yy-mm-dd 2008-03-14
		drawn SB/RJH	E.T. project no. 101610	
BEAR ISLAND MID - CANADA LINE SITE Phase III Environmental Site Assessment and Materials Audit SITE LAYOUT		checked GTW approved	drawing no. FIGURE 2.1A	



NORTH
LEAD WRAPPED SURFACE CABLE
UTILITY LINE
16.5
17
16
15.5
PP
U.P.
FALLEN METAL ANTENNA
ANTENNA BASE
(CONCRETE)
ET–379
ESG–203
ET–382
ET–380
BI–12
ET–384
ESG–205
ESG–201
BI–10
BI–11
BI–09
ET–381
BI–08
ET–383
ESG–204
ET–385
TANK
BI–07
ET–386
Doppler
Detention
Building
WOOD FRAME STRUCTURE
NO CONCRETE SUPPORT
STEEL PIPE OUTFALL
ET–437
DEBRIS
AREA
COPPER CONTAMINATION PLUME (DCC TIER II)
AREA = 3.3 sq.m.
DEPTH = 0.3 m
VOLUME = 1.0 cu.m.
James Bay
Baie James
Site 412 South
Doppler Detention
Building
Bear Island
Key Plan
1:50,000
Legend
ROAD
CABLE
ABOVEGROUND PIPE
GRAVEL EDGE
WATER
DUMP
LANDFILL
DEBRIS
FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
–SHADING INDICATES EXCEEDANCE
–LINE INDICATES PARAMETER TESTED
–COLOR CODE: METALS PAHs PHCs PCBs
0
5
10m
Scale
1:250
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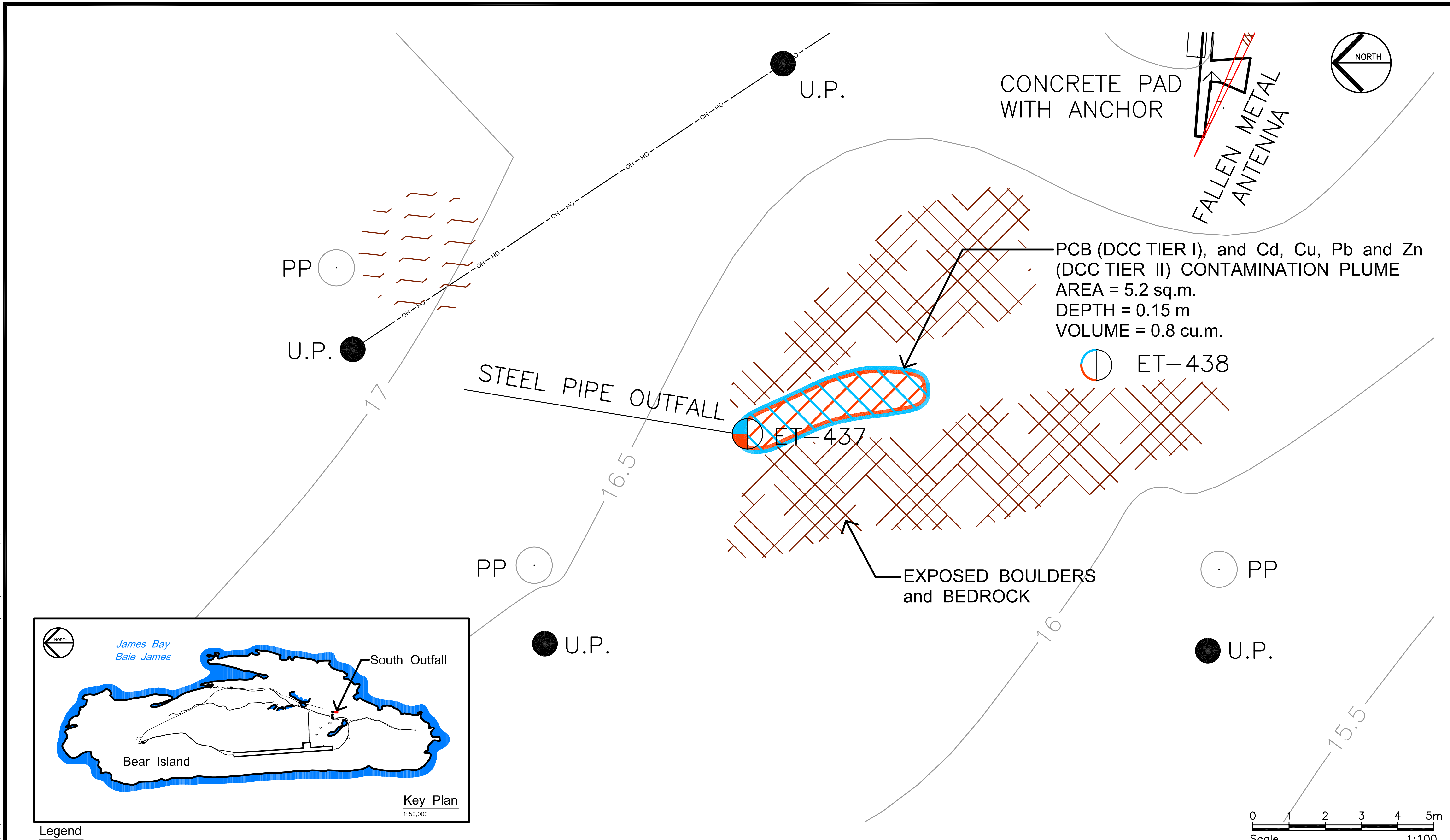
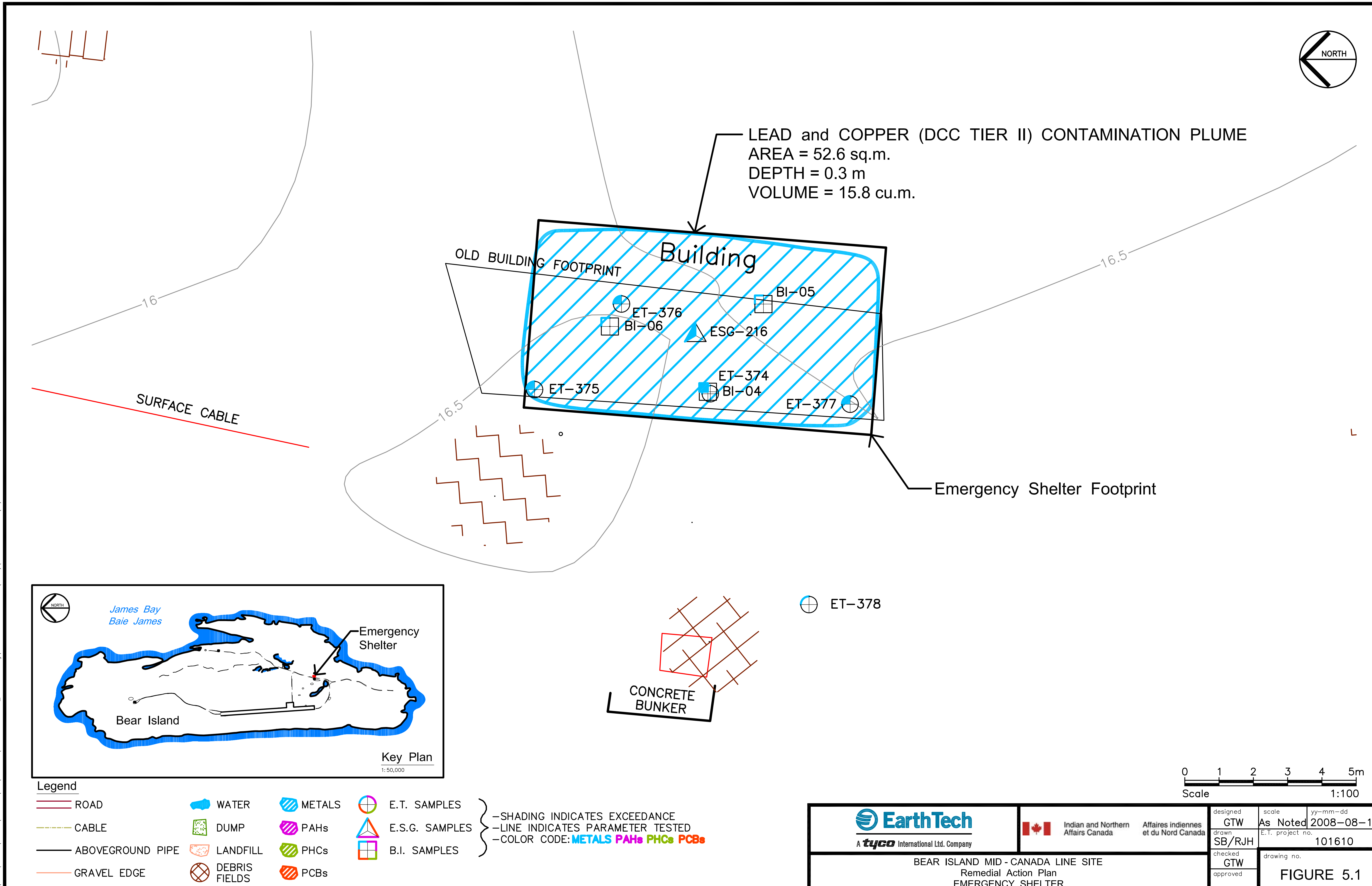
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
designed
GTW
scale
As Noted
yy–mm–dd
2008–08–15
drawn
SB/RJH
E.T. project no.
101610
checked
GTW
approved
drawing no.
BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
SOUTH DOPPLER DETENTION BUILDING - SITE 412
FIGURE 3.1



EarthTech A tyco International Ltd. Company	Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada	designed GTW	scale As Noted	yy–mm–dd 2008–08–15
		drawn SB/RJH	E.T. project no. 101610	
BEAR ISLAND MID-CANADA LINE SITE Remedial Action Plan SOUTH OUTFALL		checked GTW	drawing no. FIGURE 4.0	
		approved		



NORTH
LEAD and COPPER (DCC TIER II) CONTAMINATION PLUME
AREA = 52.6 sq.m.
DEPTH = 0.3 m
VOLUME = 15.8 cu.m.
OLD BUILDING FOOTPRINT
Building
BI–05
ET–376
BI–06
ESG–216
ET–374
BI–04
ET–375
ET–377
16
16.5
16.5
SURFACE CABLE
Emergency Shelter Footprint
ET–378
CONCRETE BUNKER
James Bay
Baie James
Emergency Shelter
Bear Island
Key Plan
1:50,000
Legend
ROAD
CABLE
ABOVEGROUND PIPE
GRAVEL EDGE
WATER
DUMP
LANDFILL
DEBRIS FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
–SHADING INDICATES EXCEEDANCE
–LINE INDICATES PARAMETER TESTED
–COLOR CODE: METALS PAHs PHCs PCBs
0 1 2 3 4 5m
Scale 1:100
EarthTech
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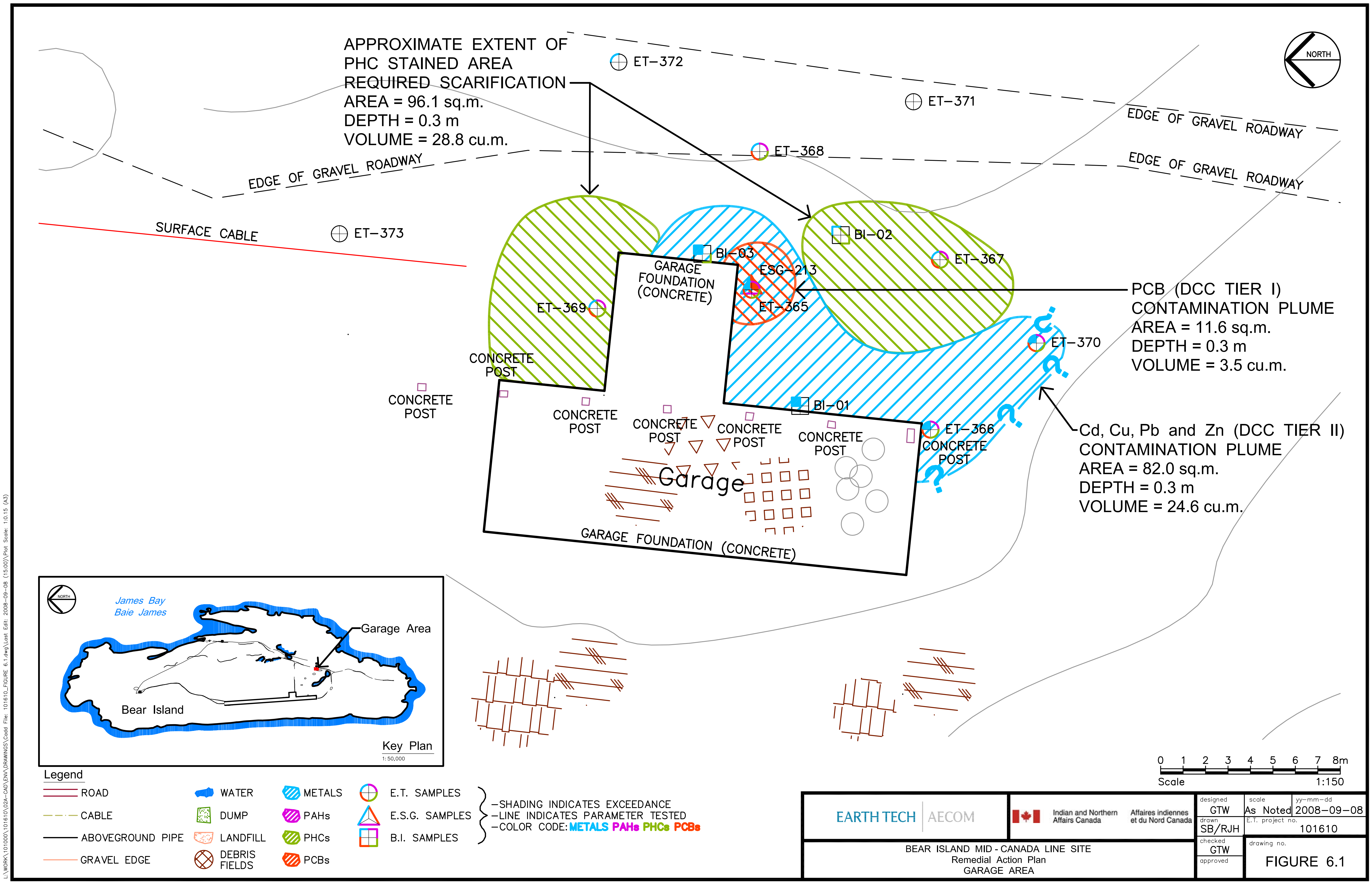
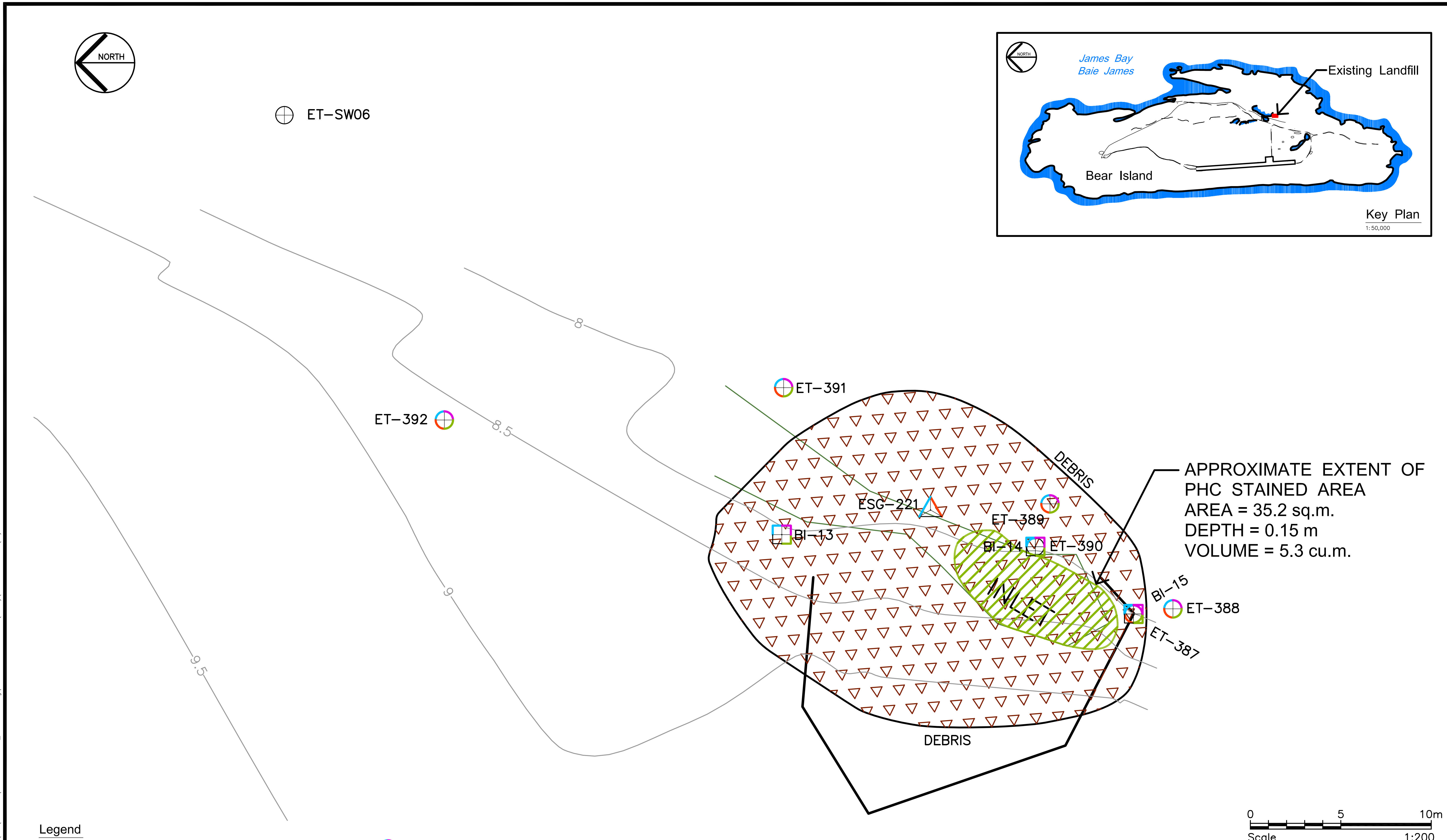
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
designed GTW
scale As Noted
yy–mm–dd 2008–08–15
drawn SB/RJH
E.T. project no. 101610
checked GTW
approved
drawing no. FIGURE 5.1
BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
EMERGENCY SHELTER



APPROXIMATE EXTENT OF
PHC STAINED AREA
REQUIRED SCARIFICATION
AREA = 96.1 sq.m.
DEPTH = 0.3 m
VOLUME = 28.8 cu.m.
ET–372
ET–371
EDGE OF GRAVEL ROADWAY
EDGE OF GRAVEL ROADWAY
EDGE OF GRAVEL ROADWAY
ET–368
SURFACE CABLE
ET–373
BI–02
BI–03
ESG–213
ET–365
ET–367
GARAGE
FOUNDATION
(CONCRETE)
ET–369
PCB (DCC TIER I)
CONTAMINATION PLUME
AREA = 11.6 sq.m.
DEPTH = 0.3 m
VOLUME = 3.5 cu.m.
ET–370
CONCRETE
POST
CONCRETE
POST
CONCRETE
POST
CONCRETE
POST
CONCRETE
POST
CONCRETE
POST
CONCRETE
POST
BI–01
ET–366
Cd, Cu, Pb and Zn (DCC TIER II)
CONTAMINATION PLUME
AREA = 82.0 sq.m.
DEPTH = 0.3 m
VOLUME = 24.6 cu.m.
Garage
GARAGE FOUNDATION (CONCRETE)
NORTH
James Bay
Baie James
Garage Area
Bear Island
Key Plan
1:50,000
0 1 2 3 4 5 6 7 8m
Scale 1:150
Legend
ROAD
CABLE
ABOVEGROUND PIPE
GRAVEL EDGE
WATER
DUMP
LANDFILL
DEBRIS FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
–SHADING INDICATES EXCEEDANCE
–LINE INDICATES PARAMETER TESTED
–COLOR CODE: METALS PAHs PHCs PCBs
EARTH TECH
AECOM
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
designed GTW
scale As Noted
yy–mm–dd 2008–09–08
drawn SB/RJH
E.T. project no. 101610
checked GTW
approved
drawing no.
BEAR ISLAND MID-CANADA LINE SITE
Remedial Action Plan
GARAGE AREA
FIGURE 6.1



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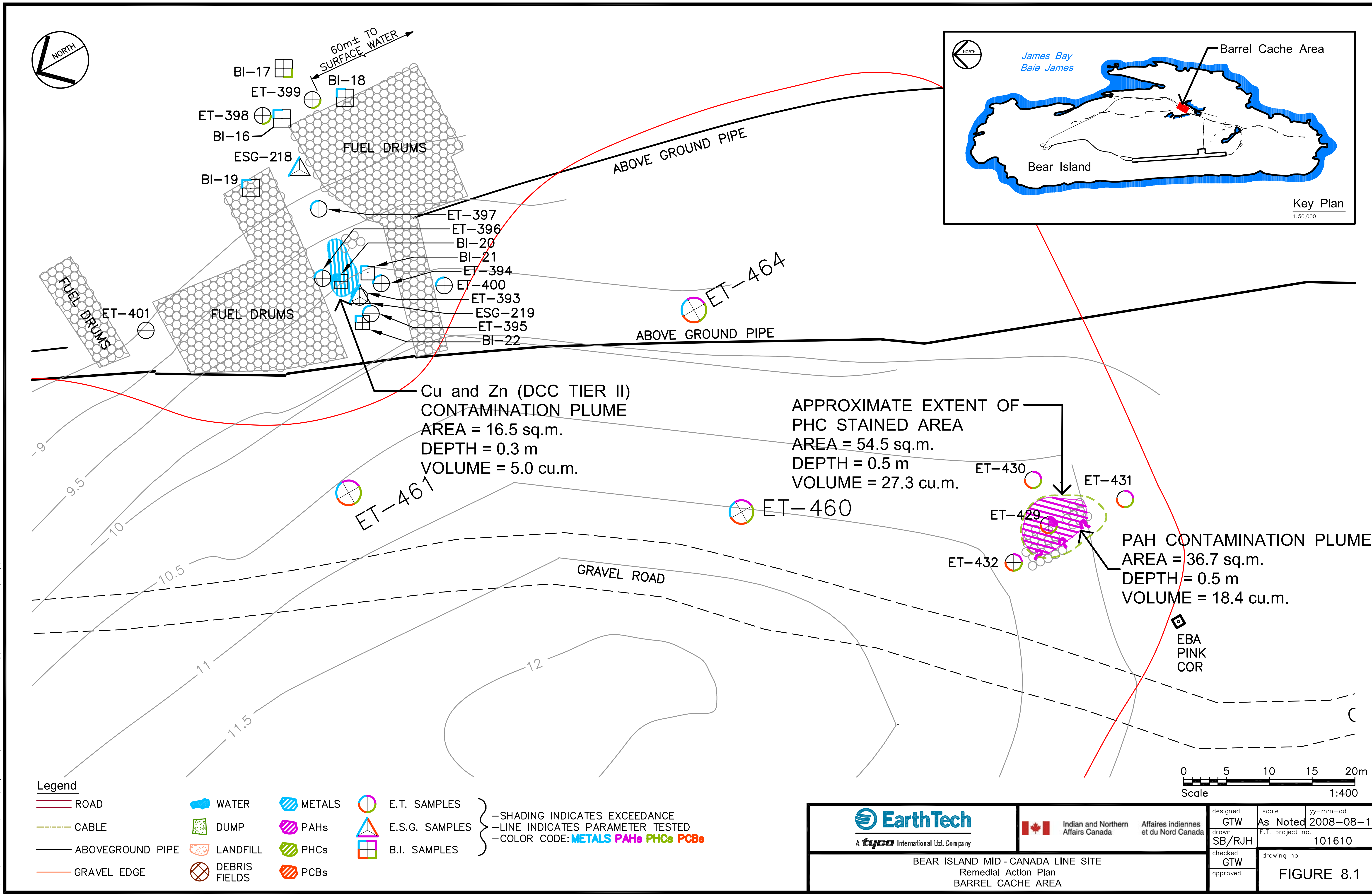
BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
EXISTING LANDFILL

designed GTW	scale As Noted	yy–mm–dd 2008–08–15
drawn SB/RJH	E.T. project no. 101610	
checked GTW	drawing no. FIGURE 7.1	
approved		

L:\WORK\101000\101610\02A–CAD\ENV\DRAWINGS\Cadd File: 101610_FIGURE 7.1.dwg\Last Edit: 2008–08–15 (15:00)\Plot Scale: 1:0.2 (A3)


NORTH
60m± TO SURFACE WATER
BI–17
BI–18
ET–399
ET–398
BI–16
ESG–218
BI–19
FUEL DRUMS
ABOVE GROUND PIPE
ET–397
ET–396
BI–20
BI–21
ET–394
ET–400
ET–393
ESG–219
ET–395
BI–22
ET–401
FUEL DRUMS
FUEL DRUMS
ET–464
ABOVE GROUND PIPE
Cu and Zn (DCC TIER II)
CONTAMINATION PLUME
AREA = 16.5 sq.m.
DEPTH = 0.3 m
VOLUME = 5.0 cu.m.
APPROXIMATE EXTENT OF
PHC STAINED AREA
AREA = 54.5 sq.m.
DEPTH = 0.5 m
VOLUME = 27.3 cu.m.
ET–430
ET–431
ET–429
ET–432
ET–461
ET–460
PAH CONTAMINATION PLUME
AREA = 36.7 sq.m.
DEPTH = 0.5 m
VOLUME = 18.4 cu.m.
EBA
PINK
COR
GRAVEL ROAD
9
9.5
10
10.5
11
11.5
12
James Bay
Baie James
Barrel Cache Area
Bear Island
Key Plan
1:50,000
0
5
10
15
20m
Scale
1:400
Legend
ROAD
CABLE
ABOVEGROUND PIPE
GRAVEL EDGE
WATER
DUMP
LANDFILL
DEBRIS FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
–SHADING INDICATES EXCEEDANCE
–LINE INDICATES PARAMETER TESTED
–COLOR CODE: METALS PAHs PHCs PCBs
EarthTech
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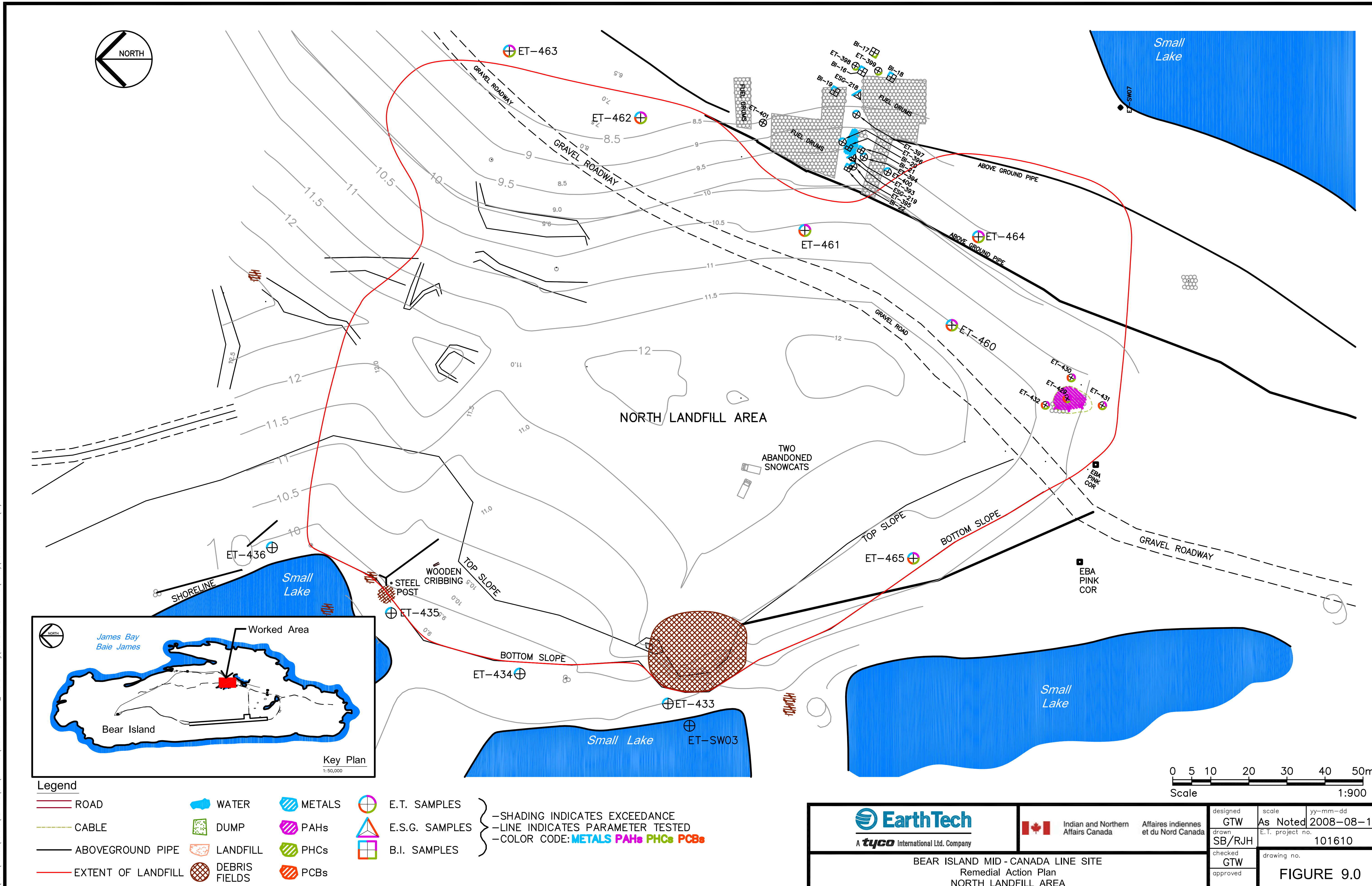
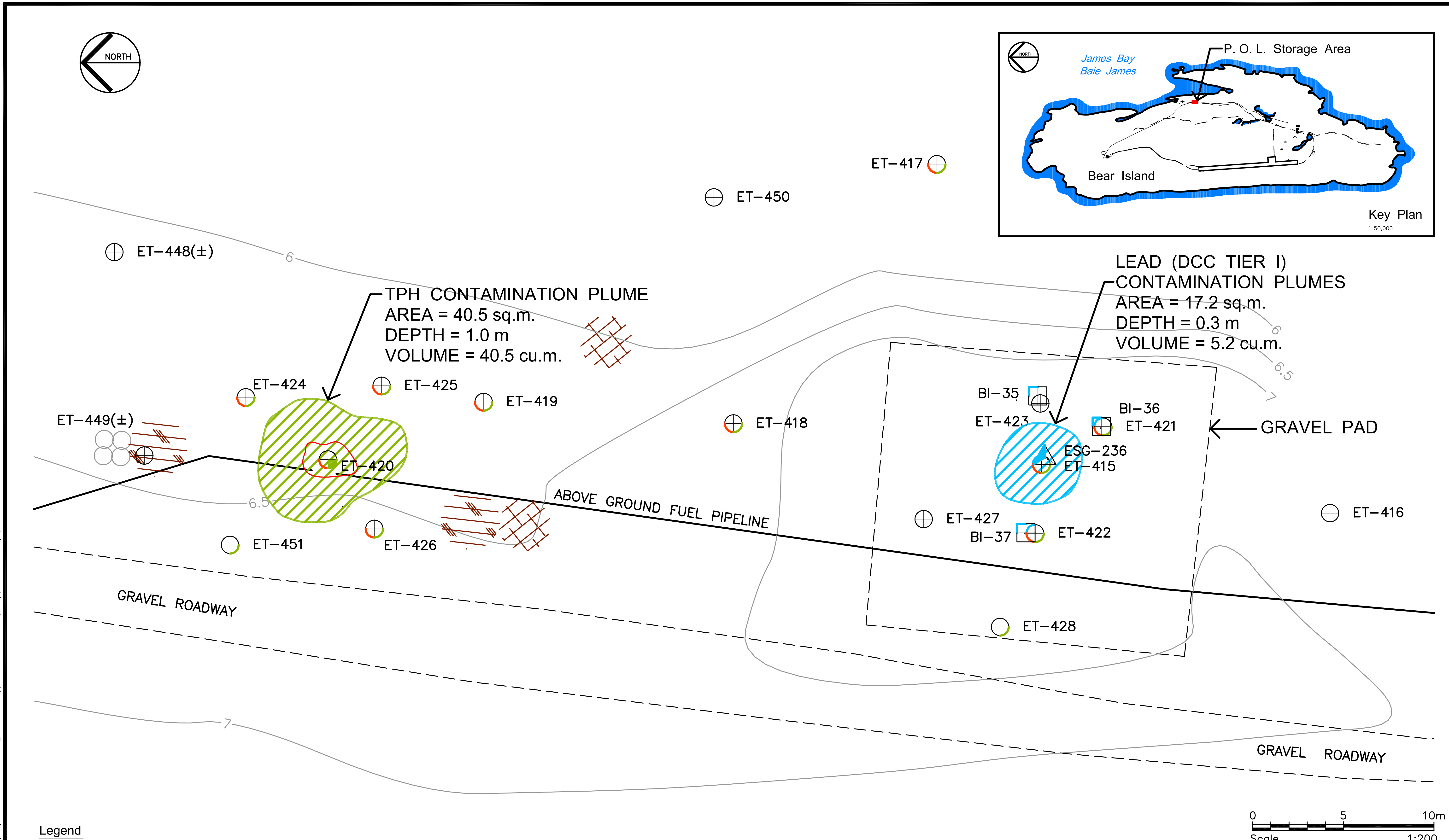
scale As Noted
yy–mm–dd 2008–08–15
drawn SB/RJH
E.T. project no. 101610
checked GTW
approved
drawing no.
BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
BARREL CACHE AREA
FIGURE 8.1


NORTH
ET-463
ET-462
GRAVEL ROADWAY
FUEL DRUMS
ET-401
BI-17
ET-398
ET-399
BI-18
ESG-218
BI-19
ET-397
ET-396
ET-400
ET-393
ESG-219
ET-395
BI-22
ABOVE GROUND PIPE
Small Lake
ET-SW07
ET-461
ET-464
ET-460
GRAVEL ROAD
ET-430
ET-431
ET-432
NORTH LANDFILL AREA
TWO ABANDONED SNOWCATS
EBA PINK COR
GRAVEL ROADWAY
TOP SLOPE
BOTTOM SLOPE
ET-465
ET-436
SHORELINE
WOODEN CRIBBING
STEEL POST
ET-435
ET-434
ET-433
ET-SW03
Small Lake
James Bay
Baie James
Worked Area
Bear Island
Key Plan
1: 50,000
0 5 10 20 30 40 50m
Scale
1:900
Legend
ROAD
CABLE
ABOVEGROUND PIPE
EXTENT OF LANDFILL
WATER
DUMP
LANDFILL
DEBRIS FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
-SHADING INDICATES EXCEEDANCE
-LINE INDICATES PARAMETER TESTED
-COLOR CODE: METALS PAHs PHCs PCBs
EarthTech
A tyco International Ltd. Company
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
designed GTW
scale As Noted
yy-mm-dd 2008-08-15
drawn SB/RJH
E.T. project no. 101610
checked GTW
approved
drawing no. FIGURE 9.0
BEAR ISLAND MID-CANADA LINE SITE
Remedial Action Plan
NORTH LANDFILL AREA



Legend

- ROAD
- CABLE
- ABOVEGROUND PIPE
- GRAVEL EDGE
- WATER
- DUMP
- LANDFILL
- DEBRIS FIELDS
- METALS
- PAHs
- PHCs
- PCBs
- E.T. SAMPLES
- E.S.G. SAMPLES
- B.I. SAMPLES

–SHADING INDICATES EXCEEDANCE
–LINE INDICATES PARAMETER TESTED
–COLOR CODE: METALS PAHs PHCs PCBs

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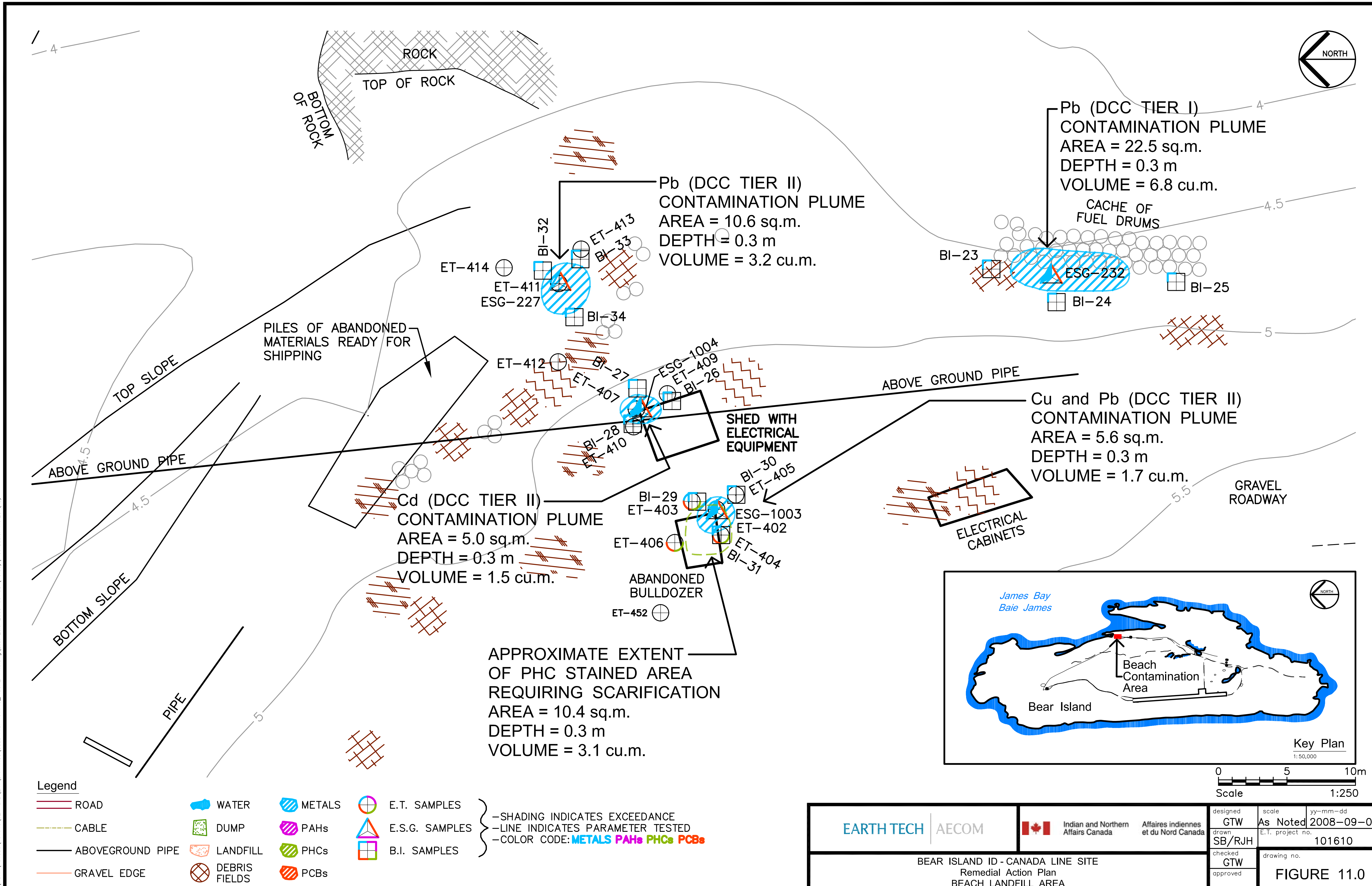
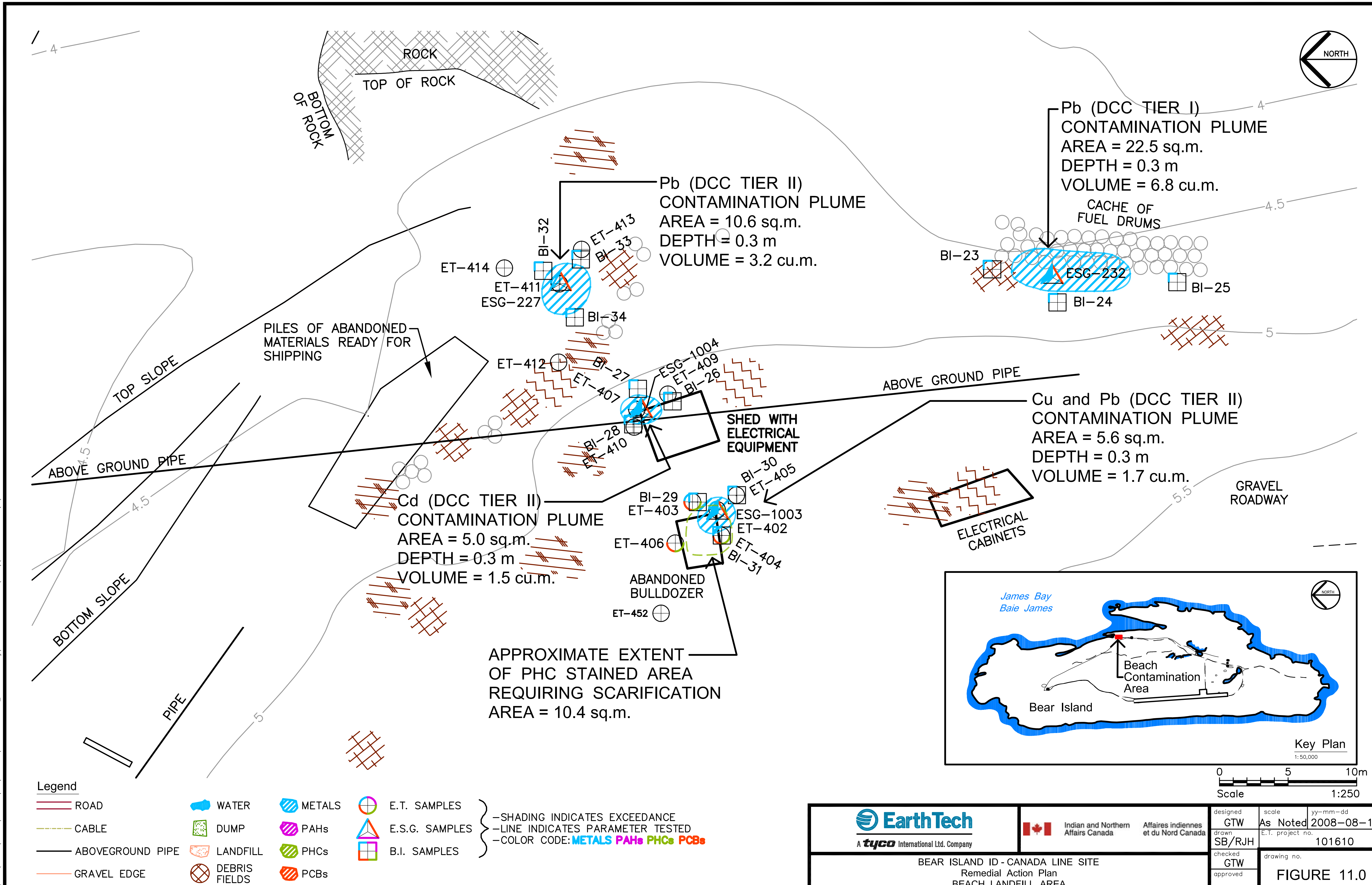
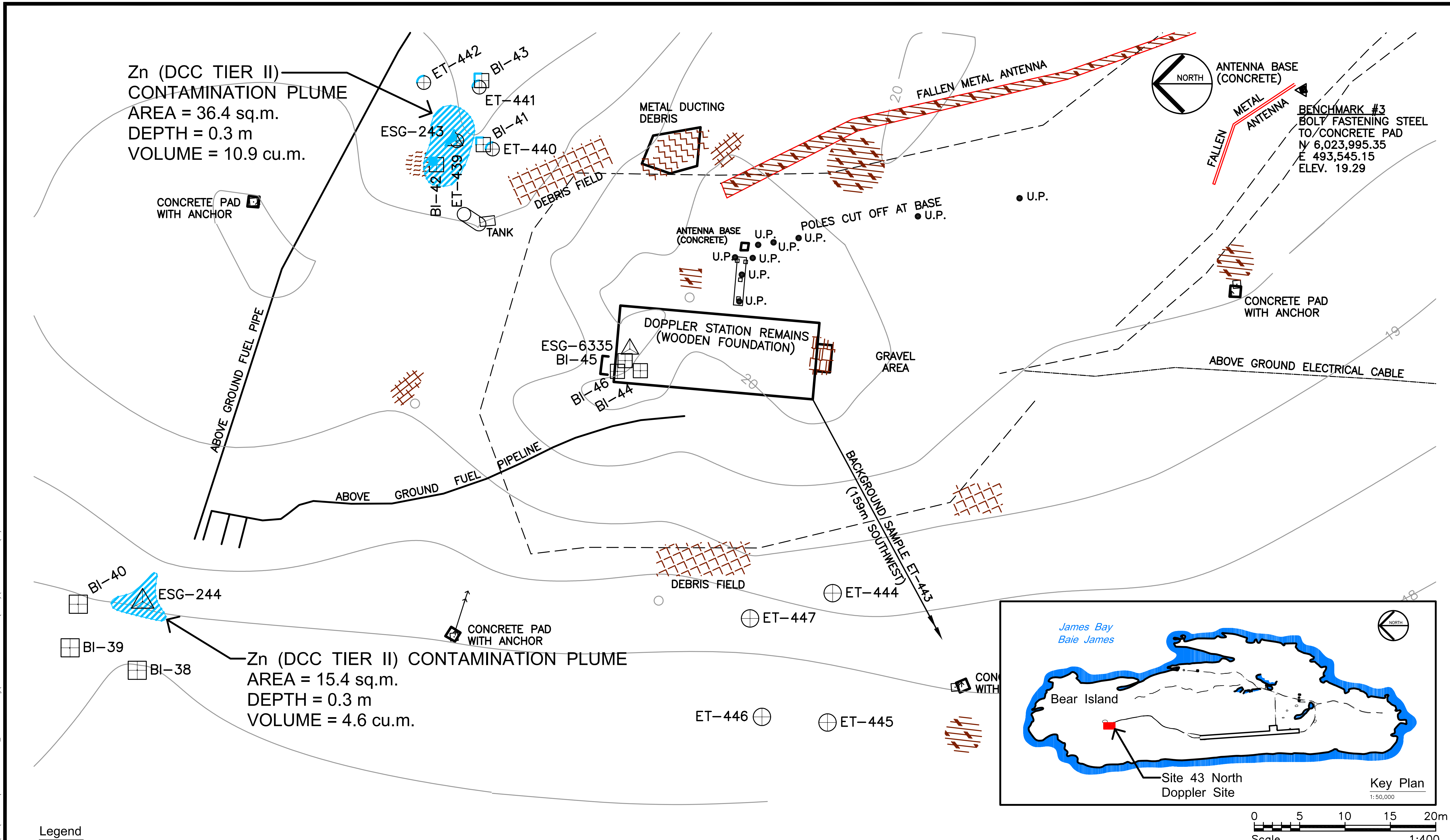
designed GTW	scale As Noted	yy–mm–dd 2008–08–15
drawn SB/RJH	E.T. project no. 101610	
checked GTW	drawing no. FIGURE 10.1	
approved		

BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
P.O.L. STORAGE AREA


ROCK
TOP OF ROCK
BOTTOM OF ROCK
Pb (DCC TIER I)
CONTAMINATION PLUME
AREA = 22.5 sq.m.
DEPTH = 0.3 m
VOLUME = 6.8 cu.m.
CACHE OF FUEL DRUMS
BI–23
ESG–232
BI–24
BI–25
Pb (DCC TIER II)
CONTAMINATION PLUME
AREA = 10.6 sq.m.
DEPTH = 0.3 m
VOLUME = 3.2 cu.m.
BI–32
ET–413
BI–33
ET–414
ET–411
ESG–227
BI–34
PILES OF ABANDONED MATERIALS READY FOR SHIPPING
TOP SLOPE
ET–412
BI–27
ET–407
ESG–1004
ET–409
BI–26
ABOVE GROUND PIPE
SHED WITH ELECTRICAL EQUIPMENT
Cu and Pb (DCC TIER II)
CONTAMINATION PLUME
AREA = 5.6 sq.m.
DEPTH = 0.3 m
VOLUME = 1.7 cu.m.
BI–28
ET–410
ABOVE GROUND PIPE
Cd (DCC TIER II)
CONTAMINATION PLUME
AREA = 5.0 sq.m.
DEPTH = 0.3 m
VOLUME = 1.5 cu.m.
BI–29
ET–403
BI–30
ET–405
ESG–1003
ET–402
ET–406
ET–404
BI–31
ELECTRICAL CABINETS
GRAVEL ROADWAY
ABANDONED BULLDOZER
ET–452
BOTTOM SLOPE
PIPE
APPROXIMATE EXTENT
OF PHC STAINED AREA
REQUIRING SCARIFICATION
AREA = 10.4 sq.m.
DEPTH = 0.3 m
VOLUME = 3.1 cu.m.
NORTH
James Bay
Baie James
Beach Contamination Area
Bear Island
Key Plan
1:50,000
0 5 10m
Scale 1:250
Legend
ROAD
CABLE
ABOVEGROUND PIPE
GRAVEL EDGE
WATER
DUMP
LANDFILL
DEBRIS FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
–SHADING INDICATES EXCEEDANCE
–LINE INDICATES PARAMETER TESTED
–COLOR CODE: METALS PAHs PHCs PCBs
EARTH TECH | AECOM
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
designed GTW
scale As Noted
yy–mm–dd 2008–09–08
drawn SB/RJH
E.T. project no. 101610
checked GTW
approved
drawing no.
FIGURE 11.0
BEAR ISLAND ID - CANADA LINE SITE
Remedial Action Plan
BEACH LANDFILL AREA



ROCK
TOP OF ROCK
BOTTOM OF ROCK
Pb (DCC TIER II) CONTAMINATION PLUME
AREA = 10.6 sq.m.
DEPTH = 0.3 m
VOLUME = 3.2 cu.m.
Pb (DCC TIER I) CONTAMINATION PLUME
AREA = 22.5 sq.m.
DEPTH = 0.3 m
VOLUME = 6.8 cu.m.
CACHE OF FUEL DRUMS
BI-23
ESG-232
BI-24
BI-25
BI-32
ET-413
BI-33
ET-414
ET-411
ESG-227
BI-34
PILES OF ABANDONED MATERIALS READY FOR SHIPPING
TOP SLOPE
ET-412
BI-27
ET-407
ESG-1004
ET-409
BI-26
SHED WITH ELECTRICAL EQUIPMENT
ABOVE GROUND PIPE
Cu and Pb (DCC TIER II) CONTAMINATION PLUME
AREA = 5.6 sq.m.
DEPTH = 0.3 m
VOLUME = 1.7 cu.m.
BI-28
ET-410
BI-30
ET-405
BI-29
ET-403
ESG-1003
ET-402
ET-406
ET-404
BI-31
Cd (DCC TIER II) CONTAMINATION PLUME
AREA = 5.0 sq.m.
DEPTH = 0.3 m
VOLUME = 1.5 cu.m.
ELECTRICAL CABINETS
GRAVEL ROADWAY
ABANDONED BULLDOZER
ET-452
BOTTOM SLOPE
PIPE
APPROXIMATE EXTENT OF PHC STAINED AREA REQUIRING SCARIFICATION
AREA = 10.4 sq.m.
NORTH
4
4.5
5
5.5
James Bay
Baie James
Beach Contamination Area
Bear Island
Key Plan
1:50,000
0
5
10m
Scale
1:250
Legend
ROAD
CABLE
ABOVEGROUND PIPE
GRAVEL EDGE
WATER
DUMP
LANDFILL
DEBRIS FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
-SHADING INDICATES EXCEEDANCE
-LINE INDICATES PARAMETER TESTED
-COLOR CODE: METALS PAHs PHCs PCBs
EarthTech
A tyco International Ltd. Company
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
designed GTW
scale As Noted
yy-mm-dd 2008-08-15
drawn SB/RJH
E.T. project no. 101610
checked GTW
approved
drawing no.
FIGURE 11.0
BEAR ISLAND ID - CANADA LINE SITE
Remedial Action Plan
BEACH LANDFILL AREA



Legend

ROAD	WATER	METALS	E.T. SAMPLES
CABLE	DUMP	PAHs	E.S.G. SAMPLES
ABOVEGROUND PIPE	LANDFILL	PHCs	B.I. SAMPLES
GRAVEL EDGE	DEBRIS FIELDS	PCBs	

-SHADING INDICATES EXCEEDANCE
-LINE INDICATES PARAMETER TESTED
-COLOR CODE: METALS PAHs PHCs PCBs

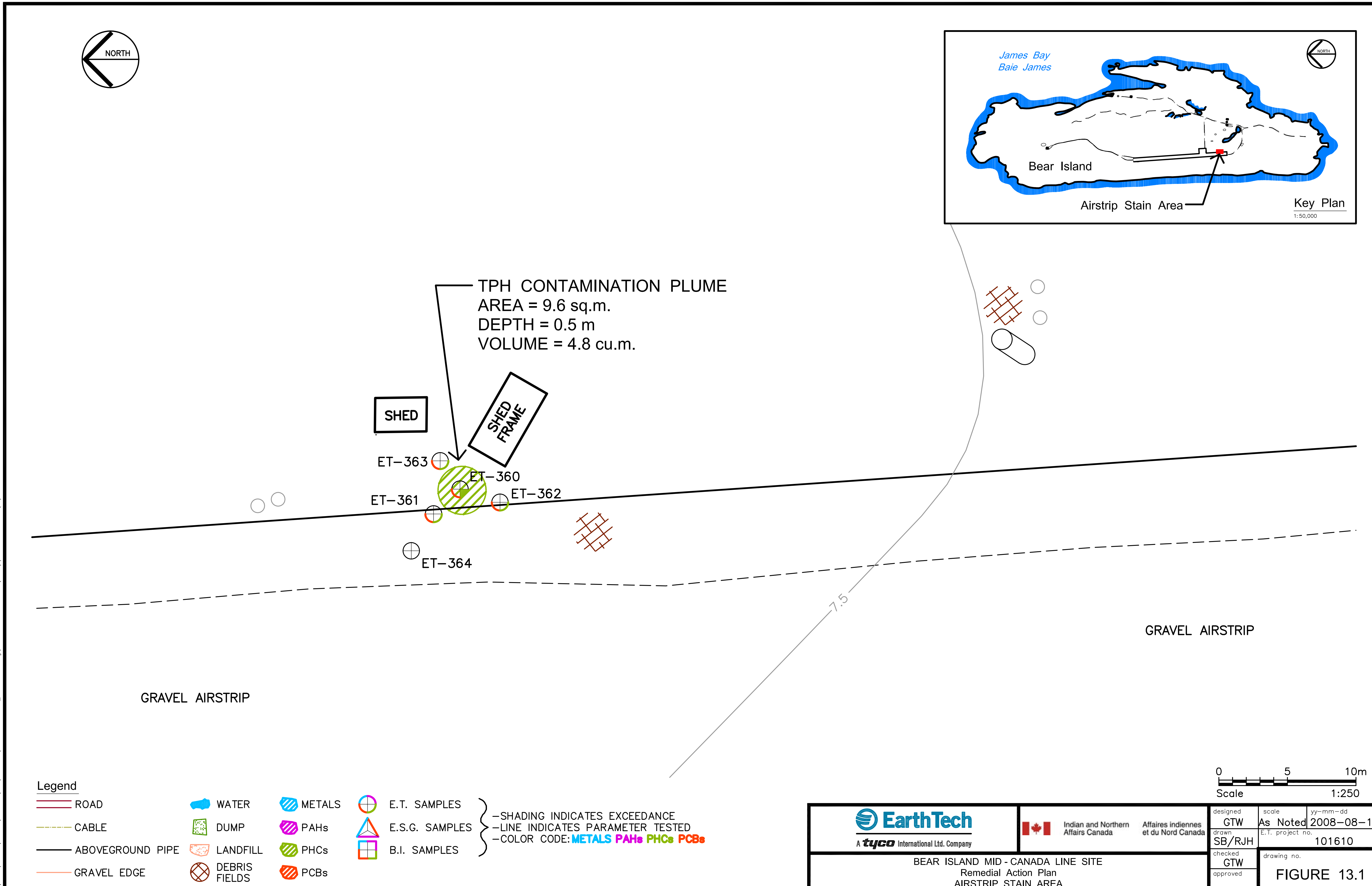
EarthTech
A tyco International Ltd. Company

Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

BEAR ISLAND MID-CANADA LINE SITE
Remedial Action Plan
SITE 413 - NORTH DOPPLER SITE

designed GTW	scale As Noted	yy-mm-dd 2008-08-15
drawn SB/RJH	E.T. project no. 101610	
checked GTW	drawing no. FIGURE 12.0	
approved		

L:\WORK\101000\101610\02A-CAD\ENV\DRAWINGS\Cadd File: 101610_FIGURE 12.0.dwg\Last Edit: 2008-08-15 (15:00)\Plot Scale: 1:0.4 (A3)



NORTH
James Bay
Baie James
Bear Island
Airstrip Stain Area
Key Plan
1:50,000
TPH CONTAMINATION PLUME
AREA = 9.6 sq.m.
DEPTH = 0.5 m
VOLUME = 4.8 cu.m.
SHED
SHED FRAME
ET–363
ET–360
ET–361
ET–362
ET–364
7.5
GRAVEL AIRSTRIP
GRAVEL AIRSTRIP
0 5 10m
Scale 1:250
Legend
ROAD
CABLE
ABOVEGROUND PIPE
GRAVEL EDGE
WATER
DUMP
LANDFILL
DEBRIS FIELDS
METALS
PAHs
PHCs
PCBs
E.T. SAMPLES
E.S.G. SAMPLES
B.I. SAMPLES
–SHADING INDICATES EXCEEDANCE
–LINE INDICATES PARAMETER TESTED
–COLOR CODE: METALS PAHs PHCs PCBs
EarthTech
A tyco International Ltd. Company
Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada
designed GTW
scale As Noted
yy–mm–dd 2008–08–15
drawn SB/RJH
E.T. project no. 101610
checked GTW
approved
drawing no.
BEAR ISLAND MID - CANADA LINE SITE
Remedial Action Plan
AIRSTRIP STAIN AREA
FIGURE 13.1

APPENDIX B

INAC ABANDONED MILITARY SITE REMEDIATION PROTOCOL

Indian and Northern Affairs Canada Affaires indiennes et du Nord Canada

Abandoned Military Site Remediation Protocol

April 2008

Indian and Northern Affairs Canada

Abandoned Military Site Remediation Protocol

November 2007

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1 INTRODUCTION

In the 1950s, at the height of the Cold War, the Distant Early Warning (DEW) Line, a series of radar stations, was constructed across the Canadian Arctic and Alaska to provide surveillance of northern approaches to the continent. In total, 63 stations were constructed of which 42 were located in Canada. In 1963, due to advances in technology, installations at 21 of the sites were considered redundant and these Intermediate or I-Sites were abandoned. All buildings, vehicles, Petroleum Oil Lubricant (POL) storage tanks and miscellaneous debris were left in place. The administration of these sites was transferred to Indian and Northern Affairs Canada (INAC) (Fletcher 1989; INAC 2002). The locations of the INAC military sites in the Canadian Arctic are indicated on Figure 1. The remainder of the installations on the DEW Line continued to operate until the early 1990s, at which point most of them were converted to the North Warning System (NWS). Decommissioning and cleanup of these 21 sites, excluding facilities that are required for the operation of the NWS, is the responsibility of the Department of National Defence (DND).

Several environmental issues have been identified at DEW Line sites, based on previous preliminary and detailed assessments at the INAC and DND sites (ESG 1991, 1993). These issues include physical hazards related to unconsolidated debris and aged structures, as well as environmental impacts associated with soil contamination. In 1996, DND initiated remediation of the DEW Line sites under its jurisdiction, and cleanup of these sites is on-going. The cleanup follows the conditions of the DEW Line Cleanup Protocol (ESG, 1993 and ESG/UMA, 1995) and the co-operation agreements between DND and Nunavut Tunngavik Inc. (NTI) (DGE 1998) and DND and the Inuvialuit Regional Corporation (IRC) (DGE 1996).

INAC has completed the remediation of a number of sites across the Canadian Arctic namely Iqaluit Upper Base, Resolution Island (BAF-5), Horton River (BAR-E), Sarcpa Lake (CAM-F), and Pearce Point (PIN-A). The approach adopted for the remediation of these sites has generally been consistent with the methodology applied at the DND DEW sites (PWGSC references here). Due to the Federal Governments commitment to future funding of contaminated site clean up, INAC recognizes the need for a consistent protocol for abandoned military site cleanup (INAC 2002).

A number of factors must be considered when determining the most suitable approach to site remediation for remote sites in the Arctic environment. The Abandoned Military Site Remediation Protocol is based on an approach that addresses legal requirements, INAC's Contaminated Sites Policy (including risk management requirements) and standard environmental management practices (INAC 2002). This Protocol also takes into consideration financially prudent methodologies that address the site environmental issues while striking a balance with remedial cost. An over-arching principle has been to balance the environmental benefits of remediation activities with potential negative physical impacts to the Arctic environment.

The primary objectives of this document are to provide sufficient background information to understand the environmental issues present at these sites, and to describe the guiding principles for their assessment and remediation. Additional supporting technical information is provided in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008).

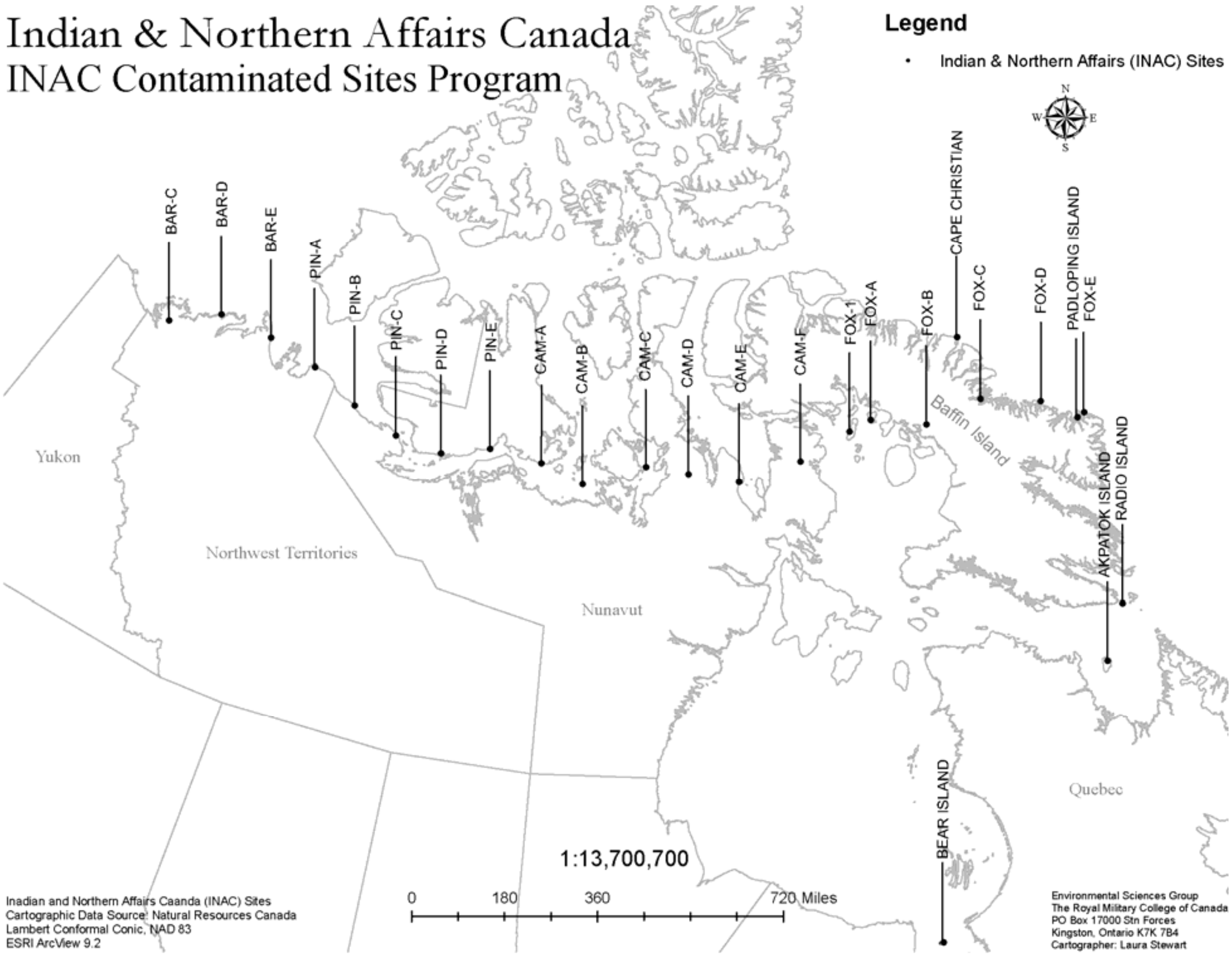


Figure 1 Location of INAC Military Sites

1.1 *Scope of Document*

This document has been structured in a manner generally consistent with the steps outlined in the Federal Contaminated Sites Action Plan (Figure 1 (sic)) as shown in Figure 2. As previously indicated, issues of environmental concern have been identified at the INAC DEW Lines (Step 1). Extensive historical data (Steps 2 and 3) from initial environmental assessments, as well as detailed information collected through the assessment of the DEW sites under the jurisdiction of DND, has been used to develop the requirements for the detailed assessment of the INAC sites (Step 5), as described in Section 4 of this document – Assessment Protocol. Guidelines for the development of a remediation strategy (Step 7) are provided in Section 5 of this document. Implementation related issues, such as confirmatory sampling, waste manifesting, construction quality assurance/quality control measures (Step 9) are described in Section 6. Post-implementation monitoring requirements are described in Section 7 (Step 10).

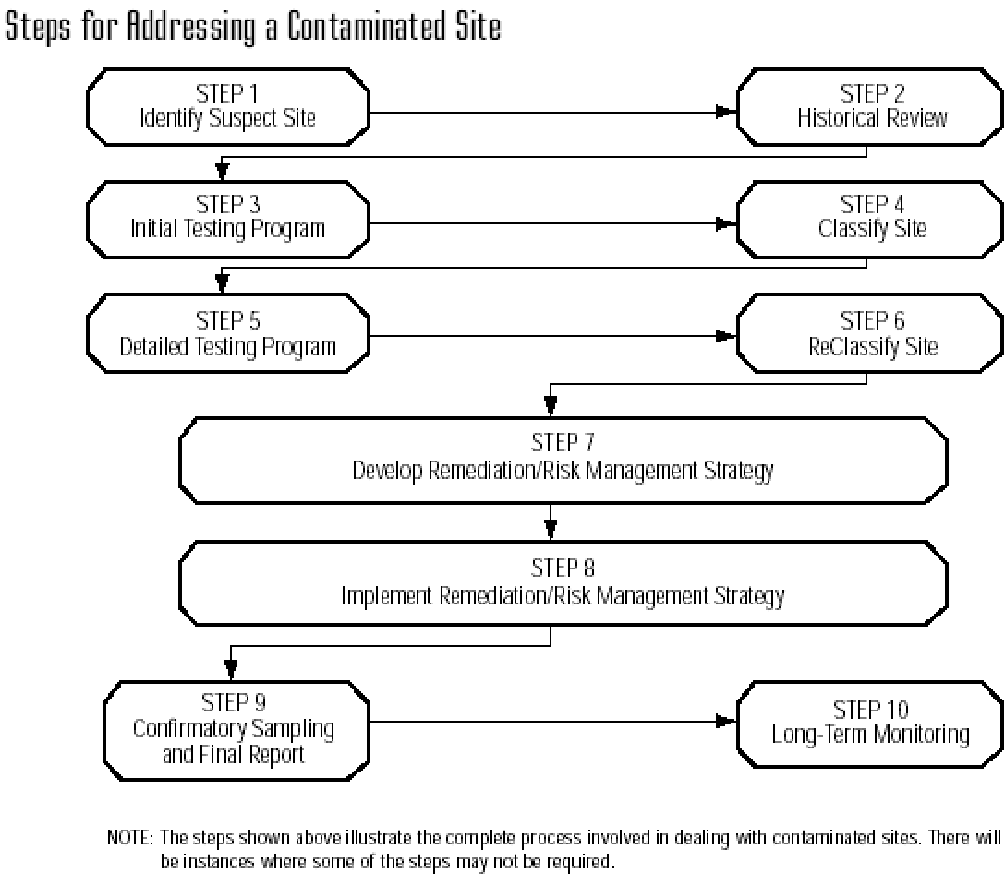


Figure 2 Steps for Addressing a Contaminated Site

2 BACKGROUND

2.1 CCME Environmental Quality Guidelines

Where remediation of federal real property is undertaken, departments and agencies are to set remediation objectives in accordance with the most applicable of the three methods developed by the Canadian Council of Ministers of the Environment (CCME) (CCME 1997):

CCME Tier 1: Follow CCME Environmental Quality Guidelines (CCME 1997, 1999), as amended from time to time, and, where applicable, the *Canada-wide Standard for Petroleum Hydrocarbons in Soil* (CCME 2001), as amended from time to time. To the extent that such guidelines do not exist for a particular type of contamination, or are technically or economically inappropriate for a particular situation, departments and agencies may follow equivalent guidelines or standards (e.g. provincial);

CCME Tier 2: Follow modified CCME Environmental Quality Guidelines where site conditions, land use, receptors, or exposure pathways differ only slightly from the protocols used in the development of the guidelines; and

CCME Tier 3: Develop site-specific remediation objectives based on a site-specific risk assessment, as outlined by the CCME, or equivalent, where site conditions are unique or particularly sensitive.

Although the CCME Environmental Quality Guidelines are broad in application and address a wide variety of land uses and potential contaminants from diverse sources, they do not necessarily address the environmental conditions representative of the Arctic.

2.2 Department of National Defence (DND) DEW Line Cleanup (DLCU) Protocol

The initial environmental assessment of the DEW Line sites under the jurisdiction of DND was one of the first major contaminant investigations in the Arctic related to point source contaminants. Following these assessments in the early 1990s, a remedial protocol was developed by DND in consultation with other government agencies and stakeholders (ESG 1991, 1993), and is referred to as the DEW Line Cleanup (DLCU) Protocol. This Protocol was developed at a time when no remediation standards and criteria specific to the Canadian Arctic existed but remedial criteria for contaminants were developed using a contaminant source and pathway targeted approach, consistent with CCME's Tier 3 method. A broad suite of chemicals was investigated and the contaminants of concern at DEW Line sites were identified as those contaminants that were consistently elevated relative to the site background levels and the available Canadian federal or provincial guidelines (CCME 1991). The rationale for selection of contaminants of concern is provided in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008). Engineering input with respect to remediation strategies was used to refine the cleanup protocol (ESG/UMA 1995), prior to its implementation at the first DND sites in 1996.

The cleanup of Arctic sites presents a number of unique challenges, including but not limited to:

- Remote site location, with access limited to sea-lift and small aircraft during the summer months, and over-land during winter;
- Short construction season, typically from July to September, which may limit the technical feasibility of remedial options;
- Lack of centralized waste disposal facilities;
- High costs associated with mobilization of equipment and personnel to the sites, both during the site assessment and remedial phases; and
- Sensitivity of the Arctic ecosystem to changes in the physical habitat.

Experience gained since 1996 at the DND sites has been reviewed annually to evaluate lessons learned and to incorporate new information and methodologies as they become available. The DLCU protocol therefore is the culmination of scientific and engineering expertise that has been applied across the Arctic at the DND sites.

Although there are many similarities between INAC and DND DEW sites, the INAC sites were in operation for a significantly shorter period of time, and environmental issues tend to differ in scale. In addition, there may have been other land use subsequent to the DEW Line activities. INAC sites and known land uses are summarized in Table 1.

**Table 1	Summary of INAC Military Sites and Historic Land Use**

Site Designation/Name	Location	Other Historic Land Use/ or Issues
BAR-C Tununuk Camp	NWT	Imperial Oil as Lessee
BAR-D, Atkinson Point	NWT	Canadian Marine Drilling (CANMAR) Canadian Reindeer Ltd. (note: cleanup on-going)
BAR-E Horton River	NWT	SRR, (note: cleanup completed, monitoring on-going)
PIN-A Pearce Point	NWT	Biological Research Station (note: cleanup completed, monitoring ongoing)
PIN-B Clifton Point	Nunavut/Kitikmeot	
PIN-C Bernard Harbour	Nunavut/Kitikmeot	
PIN-D Ross Point	Nunavut/Kitikmeot	
PIN-E Cape Peel	Nunavut/Kitikmeot	
CAM-A Sturt Point	Nunavut/Kitikmeot	
CAM-B Hat Island	Nunavut/Kitikmeot	Short Range Radar (SRR) as part of North Warning System
CAM-C Matheson Point	Nunavut/Kitikmeot	
CAM-D Simpson Lake	Nunavut/Kitikmeot	SRR (module train gone)
CAM-E Keith Bay	Nunavut/Qikiqtaaluk	Module train gone/some evidence of burning
CAM-F Sarcpa Lake	Nunavut/ Qikiqtaaluk	Research Station (note: cleanup completed, monitoring ongoing)
FOX-1 Rowley Island	Nunavut/Qikiqtaaluk	SRR (large burn area, module train gone)
FOX-A Bray Island	Nunavut/Qikiqtaaluk	SRR (module train gone)
FOX-B Nudluardjuk Lake	Nunavut/Qikiqtaaluk	SRR
FOX-C Ekalugad Fiord	Nunavut/Qikiqtaaluk	
FOX-D Kivitoo	Nunavut/Qikiqtaaluk	Fire destroyed main building train in 1963
FOX-E Durban Island	Nunavut/Qikiqtaaluk	Partially burned building
Cape Christian	Nunavut/Qikiqtaaluk	LORAN Site
Padloping Island	Nunavut/Qikiqtaaluk	Navigational aid and weather station
Radio Island	Nunavut/Qikiqtaaluk	Navigational aid and weather station (note: cleanup completed, monitoring ongoing)
Akpatok Island	Nunavut/Qikiqtaaluk	Exploratory oil well drilling in the 1970s
Bear Island	Nunavut/Qikiqtaaluk	Mid-Canada site
BAF-5 Resolution Island	Nunavut/Qikiqtaaluk	Pole-Vault site (note: cleanup completed, monitoring ongoing)

Based on these cleanup objectives were set for the INAC sites, and the INAC protocol was developed as outlined in the following sections.

3 CLEANUP OBJECTIVES

Cleanup objectives, which are consistent with the Federal Contaminated Sites Management Working Group (CSMWG) objective to “integrate sustainable development and pollution prevention principles while meeting environmental regulations and protecting public health” (CSMWG, 2000, TB 1998, 2000, 2002), have been identified as follows:

- To restore sites to meet the environmental objectives established for the northern sites;
- To prevent migration of contaminants into the Arctic ecosystem;
- To remove physical hazards for the protection of human health and safety; and
- To implement a cost effective remediation solution.

These objectives are consistent with those applied in the remediation of DEW Line sites under the jurisdiction of DND (DGE 1996, 1998). The following considerations need to be taken into account when developing and implementing a Remedial Action Plan for the INAC sites:

- Respect all historical agreements and obligations in a fair and reasonable manner;
- Ensure consistency with federal guidelines for the management of contaminated sites;
- Apply the Canadian Council of Ministers of the Environment (CCME) environmental protection and management approaches (CCME 1996, 1997, 1999, 2001) as applicable;
- Apply simple, practical remedial solutions wherever possible, with flexibility as necessary to adjust to site-specific conditions when they are identified;
- Establish cost effective solutions through the use of best practices to ensure appropriate levels of environmental protection for all sites;
- Recognize the concerns of climate change in an Arctic setting; and
- Ensure the long-term effectiveness of the environmental remedial measures.

It is Canadian government policy that all federal departments and agencies ensure sound environmental stewardship with respect to property in their care by avoiding contamination and managing contaminated sites in a consistent and systematic manner that recognizes the principle of risk management and results in the best value for the Canadian taxpayer (TBRP 1998, 2000, 2002). The following section identifies the primary factors that have been taken into consideration in developing a remediation approach.

3.1 *Biophysical Environment*

The INAC abandoned military sites are located across the Arctic in the Southern Arctic Ecozone in the western Arctic, in the Northern Arctic Ecozone in the central and eastern Arctic and Arctic Cordillera along the east coast of Baffin Island. The majority of the sites are located along the coastline.

Mean annual temperatures are in the range of -11^{0}C in the western Arctic and tend to be colder in the central and eastern Arctic. Accordingly, all of the sites are located within the zone of continuous permafrost. Much of the Arctic region is classified as polar desert as annual precipitation, predominantly as snow, is generally within the range of 100 to 300 mm. One exception is the eastern coastline of Baffin Island near Cumberland Peninsula, where precipitation can be in the order of 400 to 600 mm annually.

As indicated, the Arctic ecosystem is characterized by extreme environmental conditions, including cold temperatures, large seasonal fluctuations in incoming solar radiation, extensive snow and ice cover, and short growing seasons. These conditions affect the productivity, species diversity, wildlife behaviour (e.g., migration), and food chain characteristics of Arctic ecozones. For example, productivity in terrestrial, freshwater, and marine environments is reduced due to limited nutrient availability, low light, low temperatures, ice cover, and short growing seasons. Compared to most other ecosystems, the Arctic is characterized by relatively low reproductivity, organisms that are slower to reach sexual maturity and are generally longer lived, lower species diversity; and distinctive sub-ice biological communities. Relatively short food chains, which are characteristically known for their dominance of marine mammals and birds, are associated with simple predator-prey relationships (e.g. phytoplankton-zooplankton-fish-seal-polar bear or phytoplankton-zooplankton-whale). The combination of all these physical factors affect the sparse distribution and number of Arctic biological communities and makes them very sensitive to physical disturbances such as habitat destruction (AMAP 1998, CACAR 2003).

The assessment and remedial protocols that have been developed are cognizant of striking a balance between the physical disturbances of existing impacted areas versus the physical disturbances of developing new areas required to support remediation activities.

4 ASSESSMENT PROTOCOL

The elements of the assessment protocol have been developed through the review of previous work at related sites (eg. PWGSC 2001, 2001b, 2001c, 2002, 2002b, 2002c, 2002d, 2002e, 2002f, 2003, IEG 2001, EWG 1998 & 1999, UMA 1994) and taking into consideration information of particular relevance to the unique character of the INAC sites. Typical environmental issues at abandoned military sites include:

- Contaminated Soils
- Existing landfills/dump sites
- Debris on surface and in waters near the sites
- Debris associated with the demolition of structures/facilities
- Hazardous waste

The objective of the environmental assessment of these sites is to collect sufficient information to allow the development of a Remedial Action Plan.

Issues related to implementation, including but not limited to: environmental screening, permitting, and construction, also require information to be collected at the assessment stage. These information requirements include:

- Geotechnical site information relating to potential development areas for landfills and/or hydrocarbon contaminated soil treatment area, available borrow sources;
- Site access, such as condition of roadways, the airstrip, barge landing areas, requirements for winter roads or CAT train routes;
- Potable water supply and seasonal fluctuations of potable water supply;
- Siting of camp facilities and temporary storage areas;
- Natural Environment Assessment;
- Traditional Knowledge Surveys/Assessment; and
- Archaeological Assessment

This section of the protocol provides guidance related to conducting an environmental site assessment that meets the requirements of the INAC cleanup objectives.

4.1 Background Geo-Chemical Assessment

Application of remedial criteria must take into account background concentrations of inorganic elements, as naturally elevated concentrations of a select number of inorganic elements may impact assessment and subsequent remedial activities. High natural variability in concentrations of inorganic elements on the local scale has been observed at several DND DEW Line sites (PIN-1, DYE-M, FOX-2, FOX-3). Based on a desk-top study of the geochemistry and surficial and bedrock geology, a detailed investigation of background concentrations is required in conjunction with the environmental site assessment of the following sites:

- Nadluarjuk Lake (FOX-B),
- Kivitoo (FOX-D),
- Durban Island (FOX-E) and
- Padloping Island.

A statistically valid approach must be used to design a sampling program for the collection of representative samples from background areas. Guidance for the background geochemistry investigation is provided in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008).

4.2 Contaminated Soils

4.2.1 Inorganic Elements and PCBs – DCC Criteria

The contaminants of concern for INAC abandoned military sites, where historic land use is limited to former DEW Line operations, is based on a detailed review of data collected to date from DND and INAC site assessment and delineation programs. The DEW Line Cleanup (DLCU) Protocol, that includes criteria for a specific, limited set of contaminants, is considered appropriate for the INAC sites. Supporting documentation for selection of these criteria is provided in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008).

This provides a consistent approach across all sites, and is generally considered protective of the Arctic ecosystem as described in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008). The parameters and criteria are identified in Table 2.

Table 2 DEW LINE CLEANUP CRITERIA (DCC) FOR SOIL (see Note a)

Parameter in Soil	CRITERIA[b] mg/kg	
Inorganic Elements	*DCC Tier I* [c]	*DCC Tier II*[d]
Arsenic (As)		30
Cadmium		5.0
Chromium		250
Cobalt		50
Copper	-	100
Lead	200	500
Mercury	-	2.0
Nickel		100
Zinc		500
Polychlorinated biphenyls		
PCBs	*1.0*	*5.0*

a. These criteria were adopted specifically for the cleanup of Arctic DEW Line Sites from the 1991 versions of the Quebec Soil Contamination Indicators and the Canadian Council of Ministers of the Environment Interim Canadian Environmental Criteria for Contaminated Sites. They were validated by an assessment of the soil concentration at which the substance was taken up by vascular plants and thereby constituted an input to the Arctic ecosystem.

b. Soil criteria are given in parts per million, ppm.

c. Soils containing lead and/or PCBs at concentrations in excess of DCC Tier I, but less than DCC Tier II, may be landfilled in an Inert Waste Landfill,

d. Soils containing one or more substrates in excess of DCC Tier II are to be treated/disposed of in a manner that precludes contact with the Arctic ecosystem.

A review of data collected on INAC sites with land use other than DEW Line activities indicated that the likelihood of other parameters occurring systematically in concentrations exceeding applicable criteria in the absence of other contaminants of concern is low (INAC 2008).

Based on historic patterns of waste disposal and contamination observed at other former DEW Line sites, soils contaminated in excess of the DCC criteria are typically found in the following locations:

- In the vicinity of buildings;
- Former sewage discharge areas;
- Former open storage areas;
- In areas, where surface debris is present;
- Landfill or dump areas; and
- Petroleum, Oil, Lubricant (POL) bulk storage areas and along fuel lines and transfer locations.

Delineation of the lateral extent and depth of contamination is required to determine quantities of sufficient accuracy to develop a Remedial Action Plan and the subsequent Contractual Drawings and Specifications. A detailed sampling plan shall be developed for each potential area of concern identified as part of historic review, and shall include the following information:

- Description of the objective for each potential area of concern
- Sampling locations
- Sampling methods
- Proposed number of samples and media
- Parameters for analyses,
- Sampling methodology, analytical requirements, Quality Assurance/Quality Control measures.

Delineation shall be achieved by sampling in a grid pattern over the affected area. The grid spacing is determined by the estimated size of the area: the larger the estimated area, the larger the grid spacing. A number of test pits shall be excavated to determine the depth of contamination. Test pits shall also be excavated outside the area of surface contamination, to evaluate whether sub-surface migration of the contaminants has occurred. Greater sample density may be warranted based on site specific conditions; in particular in areas where soils contaminated with PCB concentrations in excess of 50 ppm are suspected; such as at garages and module trains. Consideration shall be given to the cost-benefit of the cost for analyses versus the cost of disposal of contaminated soils. It is recommended that over-sampling and an iterative approach to analyses be employed to provide greater confidence that closure is achieved during the assessment phase.

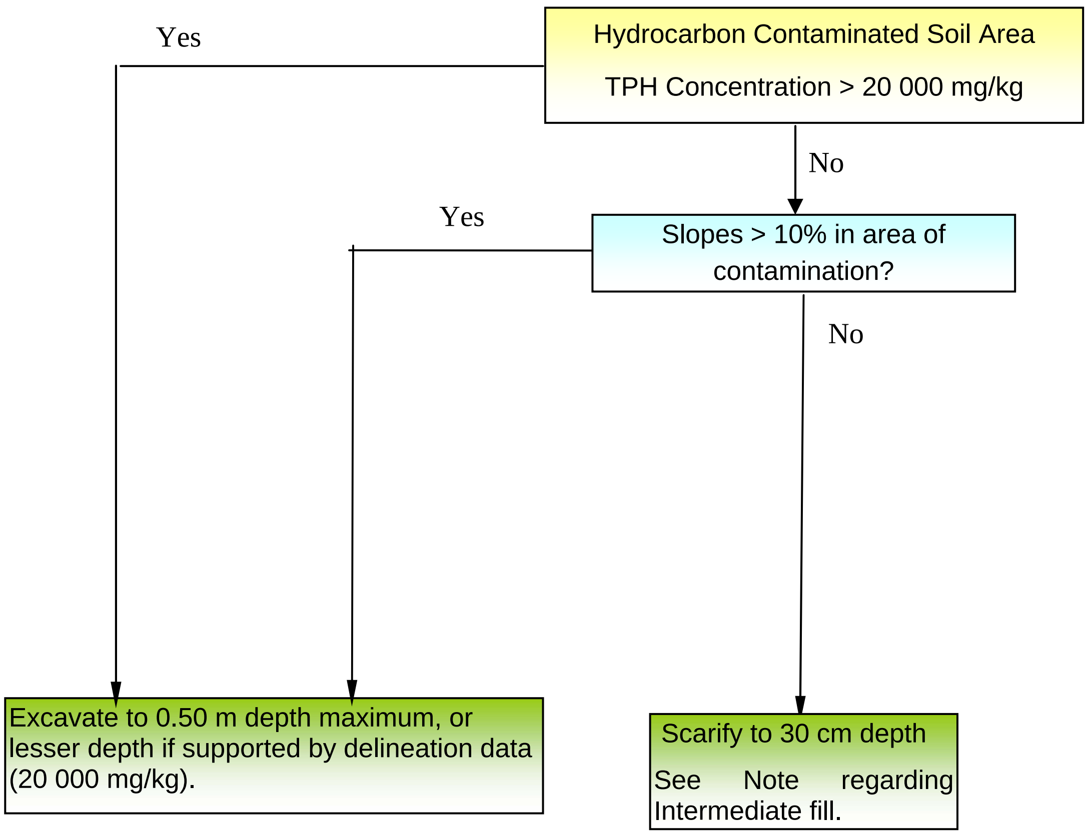
Additional samples shall be collected and analysed to determine transport and disposal requirements should off-site disposal of contaminated soils be required.

4.2.2 Hydrocarbon Contaminated Soils

Where free product is encountered, the free phase liquid will be addressed prior to the application of a qualitative risk assessment method for establishing remediation requirements.

A review of the assumptions used for the derivation of the CCME CWS for Petroleum Hydrocarbons, as well as the need to minimize physical disturbance suggests that direct application of criteria for the protection of all receptors may not be appropriate at the INAC sites (INAC 2008). Therefore, based on a review of the CCME Method, the process currently utilized on DND DEW Lines sites, and the quantitative risk assessments carried out to date, a revised set of criteria are provided, as summarized in the following flowcharts. Supporting documentation is provided in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008)

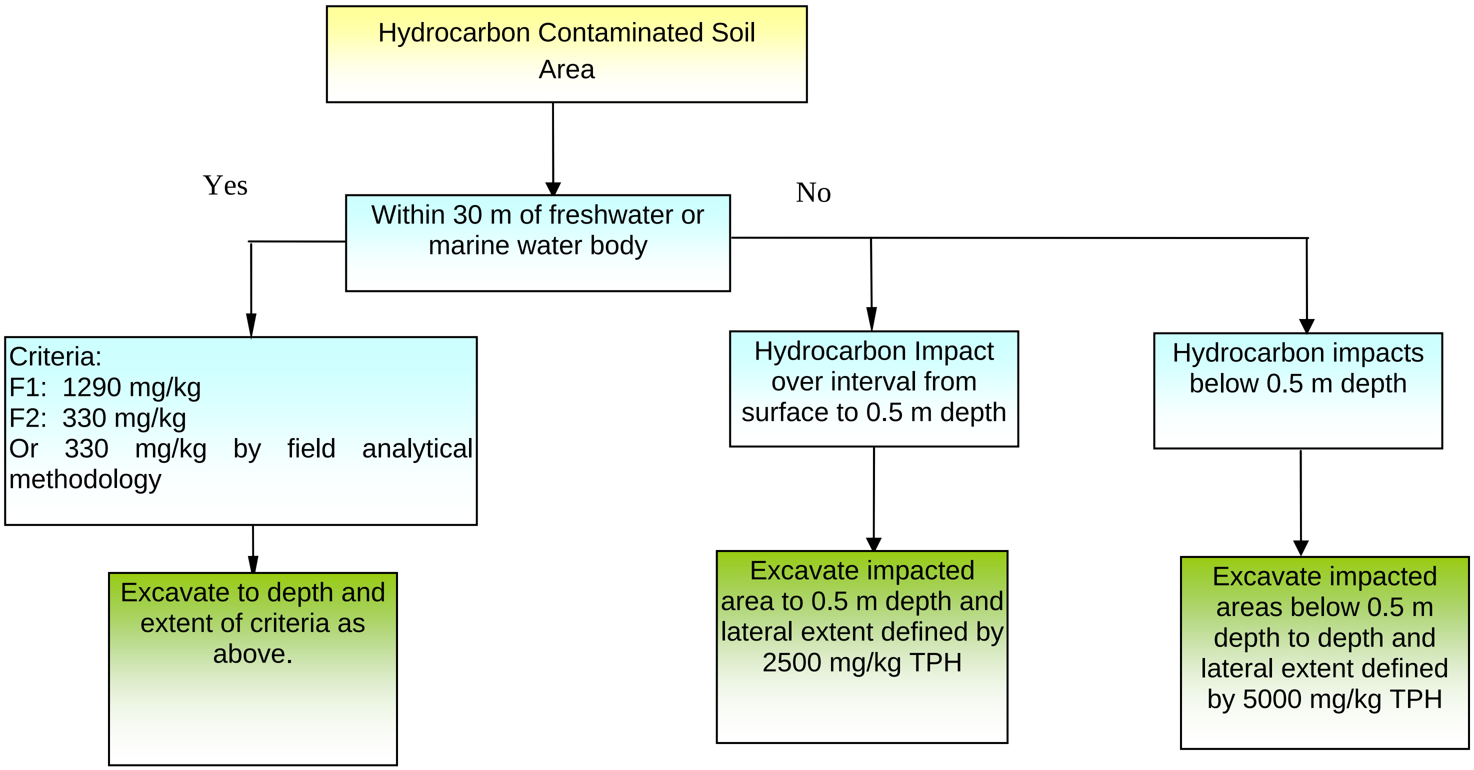
Figure 3 Type A (Non-Mobile) Hydrocarbon Contaminated Soil – Evaluation Process



Notes:

Type A is defined as the sum of F3 and F4
20 000 mg/kg criterion based on residual formation.
Presence of co-contaminants to be confirmed or disproved. Most stringent requirements apply.
F3 and F4 are essentially insoluble and migration of dissolved phase in active layer groundwater is not applicable.
Criteria for topography to mitigate against sediment/contaminant transport through surface water run-off.

Figure 4 **Type B (Mobile) Hydrocarbon Contaminated Soil – Evaluation Process**



Based on historic patterns of contamination observed at other former DEW Line sites, soils contaminated with hydrocarbons are typically found in the following locations:

- In the vicinity of buildings near fuel distribution lines, fuel dispensing tanks;
- Former open storage areas and/or debris areas where barrels may be present;
- Petroleum, Oil, Lubricant (POL) bulk storage areas; and
- Landfill or dump areas

Delineation of the lateral extent and depth of contamination is required to determine quantities of sufficient accuracy to develop a Remedial Action Plan and the subsequent Contractual Drawings and Specifications. A detailed sampling plan shall be developed for each potential area of concern identified as part of historic review, and must include the following information:

- Description of the objective for each potential area of concern;
- Sampling locations;
- Proposed sampling methods for shallow and depth samples, where the depth sampling should achieve a depth consistent with the estimated active layer thickness;
- Proposed number of samples and media;
- Parameters for analyses in accordance with Table 3;
- Sampling methodology, analytical requirements, Quality Assurance/Quality Control measures.

At minimum, the information requirements as outlined in Table 3 shall be incorporated into the Sampling Plan.

Table 3 Hydrocarbon Contaminated Soil Information Requirements

Item	Comments
Hydrocarbon Contaminated Soils – Stained Soils (F3/F4 fraction) – Type A	
Areal Extent -Visible surface staining	Topographic survey and location/coordinates of stained areas and sample locations Provide sketches with measurements
Topography	Provide survey of area to confirm slopes, Examine for evidence of erosion (drainage channels)
Soil Description	Include description of grain size distribution Fine grained, coarse grained, maximum particle size Well graded or poorly graded.
Sampling	Collect soil samples for analyses of F1 to F4 fractions to characterize contamination, analyses for presence of co-contaminants such as PCBs.
Confirm Depth of Staining	Testpit to extent of stain, collect soil sample for PHC analyses at 0.5 m depth.
In areas of multiple staining	Identify and survey extent of stains Collect individual samples from most visibly stained areas to represent "worst" case. Focus on stained areas larger than 4 m^2
Evidence of residual or free product	
Hydrocarbon Contaminated Soils – Near Fuel Storage, Distribution or Dispensing Areas (F1-F3 fraction) Type B	
Within 30 m of **water body supporting aquatic life**	
Describe surrounding environment	Confirm fish bearing waters if possible, differentiate from tundra ponds. Consulting locals and elders who use the area may prove to be useful.
Sampling – Hydrocarbons	Delineate **laterally and at depth** to 330 mg/kg as per on-site analytical capabilities Collect sufficient samples for laboratory analyses of hydrocarbon fractions to confirm correlation with on-site analytical results. Oversampling and iterative analyses may be required where there is poor correlation with test-kits (organic materials)
Sample groundwater in Testpit excavation in source zone.	Collect groundwater samples and analyze for dissolved hydrocarbons (F1, F2) and wastewater discharge criteria (Section 6). Measure water levels, and presence of free product, if applicable
Greater than 30 m distant of water body supporting aquatic life	
Sampling – Hydrocarbons	Delineate **laterally and at depth** to 2500 mg/kg as per on-site analytical capabilities. Collect sufficient samples for laboratory analyses of hydrocarbon fractions to confirm correlation with on-site analytical results For the purposes of comparison, use the summation of F1 to F3 concentrations.
Collect soil samples for grain size distribution	Representative samples should be taken of soils within and downgradient of the source zone for determination of grain size distribution, and water content.
All Hydrocarbon Contaminated Soil Areas	
Topography	Survey sample locations and topography of source zone and surrounding area. Include min. 25 m buffer zone around contaminated areas. Document seepage zones (toe of embankments), if applicable. Evidence of erosion
Evidence of impacted vegetation	Note presence and extent of vegetation; identify areas of stressed vegetation if applicable.
Wildlife	Note presence or evidence of wildlife (nests, burrows, etc.) within impacted and surrounding area area. Review in context with overall Natural Environment Survey (Section 4.9)

Additional representative samples shall be collected and analysed to assist in the determination of treatment requirements. These analyses shall include, but not be limited to:

- Water content
- Total Available Nutrients
- Total Organic Carbon
- Treatability tests to assess bioremediation potential

4.3 *Landfills*

Landfills on INAC abandoned military sites are generally smaller in extent than those located on DND DEW Line sites, and in some cases, may be more appropriately referred to as buried debris areas or dumps. As part of the historic review, areas of ground disturbance/landfill activity will be identified for further investigation. A detailed investigation/sampling plan shall be developed for each area, and must include the following information:

- Description of the objective for each potential area of concern
- Methodology for determining extent of buried debris using non-intrusive geophysical surveys, such as Electro-Magnetic Surveys (EM) or Ground Penetrating Radar (GPR), and associated ground-truthing.
- Identification of sampling locations both up- and down-gradient of the landfill or dump.
- Proposed sampling methods for shallow and depth samples, where the depth sampling should achieve a depth consistent with the estimated active layer thickness.
- Proposed number of samples and media
- Parameters for analyses
- Sampling methodology, analytical requirements, and Quality Assurance/Quality Control measures.

In addition, general site information shall be collected as outlined in Section 4.9 and 4.10, as well as landfill/dump specific information as described below to support the evaluation of the potential environmental risk associated with the landfill (Annex A).

Physical Characteristics:

- Landfill/Dump Extent
- Landfill/Dump Depth
- Contaminant Characterization (concentrations/extent)
- Volume and extent of exposed debris, where exposed debris is defined as surface and/or partially buried debris within 0.5 meters of the surface.

Pathway/Transport Mechanisms

Surface expressions of contaminated soil and/or leachate.

- Grades/Topography
- Surface cover materials type and depth
- Evidence of erosion
- Precipitation
- Distance to downgradient perennial surface water bodies

Receptor Characteristics

- Distance to freshwater/marine habitat and habitat usage.
- Terrestrial Habitat
- Traditional Land Use

The evaluation matrix prepared by the DND/NTI Environmental Working Group (EWG 1998), was adopted for this protocol with minor modifications for the assessment of potential environmental risk (Annex A). These modifications included:

- Addressing remedial requirements for debris areas (generally smaller in size than landfills)
- Modifying contaminant characterization to include leachate migration and the presence of contaminants as one category.
- Including consideration of snow pack as well as annual precipitation.

Additional detail regarding the evaluation of landfills/dumps is provided in Annex A.

4.4 *Surface Debris*

Surface debris is present on many of the sites, and may consist of a variety of waste materials including:

- Scrap metal and wood wastes (painted/unpainted);
- Barrels, potentially containing product; and
- Asbestos, batteries, electrical equipment.

All areas of debris shall be inventoried to the extent possible to provide volume estimates and characterization of waste materials. Site debris shall be classified as inert, non-hazardous wastes or hazardous wastes in accordance with the following regulations.

- Federal Transportation of Dangerous Goods Act and Regulations
- The Canadian Environmental Protection Act

- The Nunavut or Northwest Territories Environmental Protection Act

The number of barrels containing product shall be inventoried where it is safe to do so. However, it is impractical to sample and analyse contents of all barrels on site during the assessment phase. To provide information required for the Remedial Action Plan, a statistically relevant number of barrels shall be sampled and analysed for parameters in accordance with the barrel protocol, and as summarized below:

Organic Phase: Total Chlorine, PCBs, Cadmium, Chromium, Lead

Aqueous Phase: % Alcohols and Glycols, Total Chlorine, Cadmium, Chromium, Lead

If the aqueous phase is less than 2% alcohols or glycols, water shall be analysed in accordance with waste water discharge criteria. See Annex B for further information on the Barrel Protocol.

4.5 *Submerged Debris*

Debris may be present in the near shore marine environment and/or lakes that are present on the site. Observations of debris in water shall be recorded to the extent possible and supplemented with local and anecdotal knowledge. Previous studies have confirmed that such debris is primarily a risk to navigation in shallow waters (INAC 2008).

4.6 *Buildings/Structure Inventory*

The existing buildings and infrastructure at a site will be demolished to their foundations as part of the cleanup. To assist in the development of the Remedial Action Plan, an inventory of building contents and building/structure construction materials and dimensions is required. Building contents, where present, shall be inventoried and classified as non-hazardous or hazardous wastes. Hazardous building materials may include, but not be limited to: PCB and lead-amended paint, asbestos containing materials (ACMs), fluorescent lights, and mercury containing switches.

Painted building materials shall be tested for total lead and PCBs, and leachable lead and PCBs in order to determine disposal requirements. Samples of concrete, excluding paint, shall be collected and analysed for PCBs. As part of the assessment, a detailed waste inventory shall be prepared that includes: dimensions, building materials, foundation materials (concrete slab, timber piles, timber crib), estimated volume and mass of wastes, and the basis of any assumptions used in the estimate. Painted materials must be specifically identified and the extent of paint coverage and adherence quantified.

4.7 *Geotechnical Requirements*

4.7.1 Potential Development Areas

New engineered landfills and hydrocarbon treatment areas may be required during cleanup. Potential locations shall be identified and surveyed during the site assessment phase. Guidelines for the siting of potential development areas include:

- Avoidance of permafrost sensitive areas, vegetated areas and archaeological features.

- Avoidance of contaminated areas.
- Maintain a distance of 300 m or more from downgradient permanent water features
- Ground surface topography with grades of 6% or less.
- Proximity to borrow sources, waste materials.

The INAC sites are all located within the zone of continuous permafrost. The sensitivity of permafrost to climate warming consists of two components, the thermal response to warming and the impact of thaw (physical response) (Smith, Burgess, 2004) as cited in EBA (2007). The physical response of the terrain to permafrost degradation is mainly dependent on the ice content of the frozen material (Dyke et al., 1997). Warming of ice-rich perennially frozen ground would eventually lead to its thawing and the resultant thaw settlement, slope instability, thaw slumping, thermokarst, and other permafrost degradation-related processes. Excess ground ice can be identified by landforms at surface, such as patterned ground. An evaluation of the potential for impacts due to climate change is provided in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008).

Potential development areas shall be surveyed to provide detailed topographic information to allow generation of ground contours. In previously disturbed areas, soil sampling and analyses shall be carried out to confirm or disprove the presence of any historic contamination using a targeted approach. Additional sampling should be carried out over a grid with spacing of approximately 50 m x 50 m.

4.7.2 Borrow Sources

Borrow material is required during cleanup for the construction of new landfills, development of treatment areas, backfilling of contaminated soil excavation, closure of existing landfills, regrading of areas disturbed during cleanup and for road construction.

Available existing sources of borrow material should be exhausted before exploiting new areas. Areas of excess ground ice or of biophysical significance (denning/nesting areas) should be avoided. Use of abandoned gravel pads and road infrastructure as granular source material is preferable, wherever possible. Given the potential for impacts due to historic activities, existing gravel pads shall be screened for the presence of contaminants during the assessment phase.

Borrow sources shall be identified and characterized and estimated quantities developed. Test-pits shall be excavated to confirm subsurface stratigraphy, seepage, depth to permafrost table or bedrock, and ground ice conditions. Select soil samples shall be retained for geotechnical laboratory testing to assist in the development of Specifications. Testing shall include, but not be limited to water content, grain size distribution, and moisture density relationships. At sites where background inorganic element concentrations are elevated, additional samples shall be taken to characterize the borrow material.

4.7.3 Site Access

Access to the sites is typically by barge/ship and aircraft and on the sites by existing access roads. A limited number of sites are land-locked. The use of the airstrip is essential to mobilize materials and equipment required for site activities. An inspection and sampling of the airstrip fill materials shall be completed during the assessment phase to determine the load capacity to support a variety of aircraft. Drainage and erosion features shall be documented.

As heavy equipment will be required for the site restoration, potential CAT Train and/or other equipment mobilization options shall be investigated. The suitability of the beach for barge landing/sea lift access shall also be assessed. Local knowledge and TK may prove useful in evaluating potential CAT train routes as well as suitable barge landing sites.

4.7.4 Siting of Camp Facilities and Temporary Storage areas.

Laydown areas are required for temporary camp structures, equipment and storage during the cleanup. Potential locations shall be identified during the site assessment phase. Where possible, these will be located in previously disturbed areas such as borrow or storage areas, to minimize any new disturbances.

4.8 Potable Water Supply

A suitable water supply shall be identified during the site assessment phase. Consideration shall be given to the flow rates at the time of the site assessment, as water withdrawal rates may not exceed 10% of the flow volume. Water samples shall be collected and analysed for criteria in accordance with the latest edition of the CCME Guidelines for Drinking Water Quality.

4.9 Natural Environment Assessment

A thorough assessment of the natural environment of the site and surrounding area shall be conducted as part of the detailed environmental site assessment. This assessment shall be carried out mainly by a biologist with input from a local traditional knowledge (TK) consultant, where appropriate. This study shall consist of describing the regional and local setting, local ecosystems, species assemblage as well as potential impacts to vegetation and wildlife from cleanup activities and proposed mitigation measures. Additional information requirements are outlined in the following subsections.

4.9.1 Regional and Local Setting

The report should address the following information requirements.

- Location (site coordinates, main natural and man-made features present);
- Ecosetting (ecozones and ecoregions);
- Climate (mean temperature and precipitation data);
- Vegetation;
- Landforms and soils (main land features, soil types, general topography);
- Human usage and disturbance (TK input will be valuable to assess human usage of the area).

4.9.2 Local Ecosystems

This subsection should describe 1) the various inland ecosystems; 2) the ecosystems present in the former operational areas (*i.e.*, disturbed areas and areas with infrastructure); as well as, if applicable, 3) the shore/coastline ecosystem; and the 4) open ocean ecosystem.

Each identified ecosystem should be described in terms of the various terrestrial and freshwater habitats, the vegetation and wildlife species present in those habitats, as well as past and current impacts and disturbances to habitats. Local and traditional knowledge from people who use these areas for hunting and fishing may provide useful information on plant and wildlife species present as well as ecosystem health.

4.9.3 Species Assemblage

This subsection should describe the various species at risk (*i.e.*, extirpated, endangered, threatened, or special concern) according to the Species at Risk Act (SARA) that occur in the general vicinity of the site.

All species (*i.e.*, birds, mammals, fish, and plants) observed or known to use the site and surrounding areas should be documented. Observations should be described in terms of numbers and behaviour during sighting (*e.g.*, migrating, nesting/breeding, feeding, etc.). Species not observed on site but known to use the area may be documented by consulting local TK holders as well as various studies and reports.

4.9.4 Impacts and Mitigation

Potential impacts to vegetation and wildlife from site investigation and remediation activities should be clearly identified. Proposed mitigation measures and other recommendations should also be presented as part of the Natural Environment Assessment.

4.10 Traditional Knowledge Surveys/Assessment

Traditional Knowledge (TK) forms an integral part of the development of the Remedial Action Plan. Incorporating TK during the assessment phase can provide guidance on targeting specific areas of concern to local residents. The qualitative knowledge provided by local residents can be used to complement and enhance the largely quantitative information provided by the physical studies completed during the site assessments.

TK can be efficiently obtained through a local community representative (*i.e.*, local TK consultant) who can liaise between the Consultant and the various TK holders in the community. The local TK consultant may either be an Elder or someone else who knows the site well (*e.g.*, hunter, ranger). The ideal local TK consultant possesses some TK, but more importantly knows who to consult in the community to obtain relevant site information and TK.

4.10.1 Typical TK and Local Knowledge

TK gathered on site may be grouped in four (4) main categories:

1. Historical and Archaeological Features
2. Wildlife Use
3. Land Use
4. Site Specific Information

Historical and archaeological features provide information on traditional land use of the area. These features, often hidden from the untrained eye, will be identified by local TK holders as to their use and relative age, and can complement the work of the archaeological assessment.

Wildlife use of the land in and around the site includes migration routes, mating and calving grounds, as well as summer and winter-feeding areas of large land mammals. Nesting, moulting, and summer feeding grounds of migratory birds such as geese and ducks, as well as migration routes and feeding areas of sea mammals must also be identified.

Land use relates to traditional usage of the land and sea for hunting, fishing, camping, and harvesting products on land (*e.g.*, berries, eggs, medicine, tea, drinking water), and harvesting of sea products (*e.g.*, clams, kelp).

Site-specific information about the military site while it was under construction or in operation, including events (spills, accidents), waste management practices (storage, dumping), as well as natural occurrences, should also be documented.

4.11 *Archaeological Assessment*

The overall purpose of the archaeological assessment is to obtain the necessary archaeological regulatory approval at the assessment stage as required to implement the remediation program. The scope of the archaeological assessment shall include:

- Preparation and submission of permit applications to the Department of Culture, Language, Elders and Youth.
- Completion of an Overview for each site, which would include file searches to determine the number, nature and terrain associations of previously recorded sites.
- Completion of a field inventory and assessment of each site;
- Completion of a heritage features or structures evaluation for consideration of heritage value;
- Provision of a heritage resource impact assessment for each site
- Implementation of more detailed investigations at key sites and appropriate mitigation at significant sites affected by proposed projects (if required); and
- Preparation of a final permit report for each site and, if required, provides a summary of these results suitable for inclusion in a screening document.

Areas of high and moderate archaeological potential for containing cultural material will require detailed examination during the assessment phase, to ensure the protection and if required, development of mitigation measures to be implemented prior to or during cleanup.

5 REMEDIATION PROTOCOL

The elements of the remediation protocol have been developed through the review of previous work at related sites by DND and INAC, and take into consideration information of particular relevance to the unique character of the INAC sites.

The primary components of cleanup on the INAC abandoned military sites includes:

- Treatment/Disposal of Contaminated Soil
- Disposal of Debris/Demolition Waste
- Closure of Existing Landfills or Dumps
- Construction of New Landfills
- Development of Borrow Sources and Site Grading Activities

The goals of a Remedial Action Plan are to reduce the environmental liabilities present at the site, maximize benefits to local communities and ensure good value to the Crown. More specifically, the Remedial Action Plan is to identify and evaluate options applicable to the treatment and/or disposal of waste materials present at a site. These waste materials typically include:

- Soil contaminated with inorganic elements, PCBs and/or petroleum hydrocarbons;
- Non-hazardous and hazardous wastes associated with building/facility demolition;
- Visible/accessible debris including barrel contents; and
- Buried debris/landfills as identified by geophysical surveys

The estimated volume of waste materials in each stream shall be determined and options evaluated on the basis of effectiveness to reduce and/or mitigate environmental risks in the short and long term, long term liability or residual risks, relative costs, monitoring costs and community acceptance. The costs associated with implementing remedial solutions include, but are not limited to: resources, such as materials, equipment, and human resources, and site logistics. Mobilization and site access constitute a significant cost for remote site cleanups, and can have significant impact on selection of the preferred remedial option. The evaluations shall be summarized and preferred remedial options identified for each waste stream. Options shall be integrated to finalize the recommended approach for site remediation.

During remediation planning public community consultations are conducted in surrounding communities to obtain feedback on the draft Remedial Action Plan.

5.1 *Contaminated Soils*

Contaminated soils are considered in three primary categories; soils that are regulated, soils that are classified as hazardous and soils that are classified as contaminated but not hazardous waste. Contaminated soils that are regulated shall be remediated and/or disposed of in compliance with the applicable regulations. Volumes of contaminated soil that are not regulated or hazardous shall be excavated to the depth and extent to meet the DCC (see section 4.2.1). Hydrocarbon contaminated soil remediation levels shall be established through the application of the Petroleum Hydrocarbon (PHC) Evaluation Process.

Three primary contaminated soil types have been identified; inorganic element contaminated soil, PCB contaminated soil and hydrocarbon contaminated soil (Type A and Type B, see section 4.2.2). Where multiple contaminants are present in the soils, the most conservative remedial option that addresses all contaminant types shall be applied. A summary of remedial options for contaminated soils is presented in Table 4.

Table 4 Summary of Remedial Options – Contaminated Soil

Contaminated Soil	Remedial Options
DCC Tier I	• Excavate and place in an on-site engineered landfill or • Cap in place under 0.3 m of clean fill if in a stable location
DCC Tier II	• Excavate and dispose of in an on-site Tier II facility or • Containerize for off-site disposal[1]
Inorganic Elements Leaching	• Transport in accordance with the TDGA for disposal at an off-site facility
PCB Contaminated Soil in excess of CEPA	• Store in accordance with Storage of PCB Material Regulations pending a decision regarding disposal
Type A TPH (Non-Mobile Hydrocarbon Contaminated Soil)	• Excavate and place in an on-site engineered landfill • Scarify surficial stains that meet PHC criteria.
DCC Tier I -Type A TPH	• Excavate and place in an on-site engineered landfill or • Cap in place under 0.3 m of clean fill if in a stable location
DCC Tier II -Type A TPH	• Excavate and place in an on-site Tier II disposal facility or • Containerize for off-site disposal[1]
Type B TPH (Mobile Hydrocarbon Contaminated Soil)	• *In-situ* or *ex-situ* treatment to reduce environmental risk to meet guidelines
DCC Tier I -Type B TPH	• Ex-situ treatment to meet guidelines and place in an on-site engineered landfill or cap under 0.3 m of clean fill in a stable location after treatment. • Small areas of contamination may be excavated and disposed of in a Tier II disposal facility
DCC Tier II -Type B TPH	• Excavate and place in an on-site Tier II Facility or • Containerize for off-site disposal[1]
Hazardous Soil	• Dispose in compliance with applicable regulations

[1] Decision of whether to dispose of on or off-site is based on cost analyses (see section 5.2.6, Table 6).

5.2 *Debris – Site Debris and Demolition Wastes*

Site debris shall be collected and segregated into hazardous and non-hazardous waste streams for disposal:

Non hazardous waste: The volume of the non-hazardous materials shall be minimized through crushing, shredding, or incineration, prior to their placement in an on-site engineered landfill. If there is no existing landfill on-site, and no suitable location for a new engineered landfill, the non-hazardous materials shall be disposed of off-site; and

Hazardous waste: These materials shall be disposed of off-site, in accordance with the current regulations governing the handling and disposal of hazardous materials.

Hazardous materials referred to in this section are defined as any materials, which are, designated "hazardous" or "dangerous goods" under Territorial or Federal legislation. Generally, all hazardous materials identified at the site shall be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act (TC 2002), to a licensed hazardous waste disposal facility.

Some hazardous materials that are typical of abandoned military sites and require special consideration include the following:

PCB Contaminated Concrete: PCB contaminated concrete (excluding paint) with concentrations in excess of 50 ppm is regulated under the CEPA, and shall be collected and transported off-site, in accordance with the Transportation of Dangerous Goods Act and CEPA to a licensed hazardous waste disposal facility.

PCB Paint on Building Components: PCB paint and PCB painted components that are regulated under the CEPA, shall be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act and CEPA, to a licensed hazardous waste disposal facility. PCB painted materials are considered regulated under CEPA when the component, (paint and substrate) contain greater than 50 ppm PCBs total. Accordingly, knowledge of the thickness and density of the paint, and substrate material is required to calculate total PCB concentrations. Loose paint materials/paint chips are regulated under CEPA when PCB concentrations in the paint are greater than 50 ppm.

Lead-Based Paint on Building Components: Lead-based painted components that are classified as hazardous material shall be collected and transported off site, in accordance with the Transportation of Dangerous Goods Act to a licensed hazardous waste disposal facility. Painted components that exceed the relevant federal or Territorial criteria but are not considered hazardous shall be collected and disposed in an on-site engineered landfill. Lead-based painted materials are considered hazardous when the lead leachate concentrations from a test of the component (paint and substrate) exceed 5 mg/L or the concentration as provided in the latest schedule of the TDGA.

Additional discussion related to the classification of painted material is provided in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008).

There are also a few exceptions, which are described below:

Asbestos: Asbestos waste shall be collected, double bagged and disposed of in an on-site engineered landfill, in accordance with the appropriate legislation. Where no on-site facility is available, asbestos waste shall be shipped off-site for disposal. Where asbestos materials are painted, disposal requirements shall be based on paint analyses.

Petroleum Products: Petroleum products, such as gasoline or diesel, which do not contain other hazardous products (chlorine, PCB, metals, etc.) will be incinerated on-site under appropriate emissions controls. Heavier petroleum products such as lubricating oil will be disposed of off-site or mixed with lighter petroleum products and incinerated on-site under appropriate emissions controls in accordance with the Barrel Protocol provided in Annex B.

Compressed Gas Cylinders: Compressed gas cylinders with known contents shall be vented. Once empty, the metal cylinder shall be disposed on-site in an engineered landfill. . Where no on-site facility is available, compressed gas cylinders shall be shipped off-site for disposal.

Creosote Treated Timbers: Timbers shall be wrapped in polyethylene sheets and disposed on-site in an engineered landfill. Where no on-site facility is available, creosote treated timbers shall be shipped off-site for disposal.

5.2.1 Submerged Debris

Submerged debris shall be removed from the near-shore environment to a depth of 2 metres or 30 metres off-shore, whichever is encountered first. Work in marine and freshwater environments shall be in accordance with all stipulations as provided by the Department of Fisheries and Oceans. Debris, once removed shall be classified as hazardous or non-hazardous and disposed of as indicated in the previous sub-section.

5.2.2 Barrels

Barrels identified at the site shall be handled according to the Barrel Protocol (see Annex B) and as outlined below:

Empty Barrels: Empty barrels shall be crushed and disposed in an on-site engineered landfill;

Filled or Partially Filled Barrels: Barrel contents shall be inspected and tested if necessary and disposed of appropriately (off-site or incinerated). The empty barrel shall be rinsed, crushed and disposed on-site in an engineered landfill. The spent rinse liquid shall be tested and disposed of appropriately. Absorbent materials used as part of this process shall be disposed as hazardous material, as required; and

Buried Empty Barrels: Areas containing buried empty barrels will be inspected to determine if any of the barrels contain material and characterized through a geophysical survey. If the barrels are found to be empty the area will be stabilized through compaction to crush any corroded barrels. A cover of borrow material shall be placed over the area and compacted.

The criteria used to determine the acceptability of product for on-site incineration are summarized in Table 5 as follows:

Table 5 Barrel Protocol Criteria and Disposal Summary

Phase	% Alcohol or Glycols	PCBs	Chlorine ppm	Cadmium ppm	Chromium ppm	Lead ppm	Disposal
Organic		<2	<1000	<2	<10	<100	On-Site Incineration
Organic		>2	>1000	>2	>10	>100	Ship South
Aqueous	>2		>1000	>2	>10	>100	Ship South
Aqueous	>2		<1000	<2	<10	<100	On-Site Incineration
Aqueous	<2						Discard in accordance with wastewater discharge criteria

5.2.3 Buildings and Infrastructure

The existing buildings and infrastructure at a site shall be demolished to concrete foundations. Above-grade timber foundations shall be removed. Exposed timber piles shall be removed to 0.3 m below ground surface. All hazardous materials shall be segregated prior to or during demolition. Non-hazardous demolition materials and asbestos shall be collected and disposed in an on-site engineered landfill. Hazardous demolition materials shall be disposed off-site.

PCB amended painted material shall be containerized in accordance with the Transportation of Dangerous Goods Act, and transported off-site to a licensed treatment disposal facility.

Only in exceptional circumstances will existing buildings remain intact on site following the remediation program. These structures may remain as emergency shelters once clear transfer of ownership has been established.

5.3 *Landfill Closure*

The following section will apply to landfills, dumps and debris areas. For ease of reading the term ‘landfill’ will be used throughout this section. Using the landfill/dump and debris area evaluation matrix (Annex A), landfills can be classified into one of three broad categories. Actions associated with each category of landfill have been identified. Where a landfill exists on INAC abandoned military sites, the condition of the landfill shall be evaluated to determine the most appropriate action;

If the landfill is located in an unstable, high erosion location, it shall be relocated to a properly engineered landfill. During the relocation process, any identified hazardous materials shall be segregated for off-site disposal (Class A landfill);

If the landfill is located in a suitable, stable location, but there is evidence of contaminant migration, potential remedial solutions include excavation or provision of a suitably engineered containment system.

The remedial solution selected shall be based on a cost-benefit analyses that includes consideration of construction costs and long-term monitoring costs. (Class B).

If the landfill is located in a suitable, stable location, with no evidence of contaminant migration it may be left in place. If required, additional granular fill shall be placed to ensure erosion protection and proper drainage (Class C Landfill). Consideration must be given to surrounding topography (to blend into existing terrain) and long term monitoring costs.

5.4 *Landfill Development*

New engineered landfills may be required for the disposal of non-regulated contaminated soils and non-hazardous debris collected or generated during cleanup. Two classes of landfills are provided:

- Inert Waste Landfill.
- Tier II Contaminated Soil Landfill

5.4.1 Inert Waste Landfill

An Inert Waste Landfill is a new landfill constructed for the disposal of non-hazardous debris and building demolition waste. Tier I contaminated soils may also be disposed of in these landfills. The landfills constructed to date at the DND DEW sites are predominately above ground facilities. The landfills do not rely on permafrost for containment nor do they include a geosynthetic liner.

The general design parameters include a perimeter berm and landfill cover constructed of a well graded sand and gravel. Clay is generally not available at the abandoned military sites. The sand and gravel should have a minimum of 8% fines (<0.08 mm) and be compacted to a minimum of 95% maximum dry density (ASTM D698). The landfill should have a maximum debris thickness of 3 m and minimum cover thickness of 1.0 m.

To reduce settlement and ground subsidence, the debris should be placed in maximum 0.5 m thick lifts with a granular intermediate graded over each lift of debris to fill the voids. The intermediate fill should be a minimum of 0.15 m thick and worked into the underlying debris. The final landfill surface must be graded such that water ponding does not occur. Ponding and infiltration could increase the seasonal thaw depth or contribute to leachate generation. The landfill surface must not be so steep that it promotes erosion of the cover materials that could expose debris.

The fill material for landfill cap should a well-graded material that is relatively erosion resistant and will have moderate water infiltration. Alternative designs or surface treatments are required if erosion resistant materials are not present on site. The alternatives include importing coarser gravels and cobbles, vegetation covers at sites where it is possible to vegetate the sites, roller compacted concrete or other synthetic surfaces.

The final landfill design parameters including granular fill specifications, side slopes, cover thickness, and maximum height of landfill are dependent on site specific ground conditions and borrow availability. Designs must be reviewed by a geotechnical engineer with permafrost experience.

5.4.2 Tier II Contaminated Soil Landfill

As outlined below and as detailed in Abandoned Military Site Remediation Protocol, Technical Supporting Documentation (INAC 2008) the decision as to whether to construct a Tier II Contaminated Soil Landfill on site is based on a number of factors. The decision criteria related to volumes of contaminated soil were based on relative cost estimates and may not accurately reflect site specific conditions and are provided as a guideline only.

Table 6 Decision Criteria Tier II Contaminated Soil Landfill

▪ Is the site landlocked?	▪ For landlocked sites, off-site transport costs increase significantly. ▪ Consideration should be given to on-site disposal facility.
▪ Is landfill excavation required.	▪ Landfill excavations pose contracting risks due to unknown quantities of waste material. To mitigate risks, an on-site Tier II disposal facility should be considered.
▪ Are known contaminated soil volumes less than 300 to 500 m^3.	▪ If yes, evaluate contingency factors and potential over-runs. If significant risk of quantity overrun is present, construct landfill on-site. ▪ If volume of contaminated soil estimated to be below these values, ship off-site for disposal.
▪ Are known volumes of contaminated soil between 500 and 1000 m^3	▪ Evaluate site specific conditions, and develop preliminary design and cost estimate for an on-site disposal facility using site specific information. ▪ Confirm availability and quality of borrow material.
▪ Are known volumes of contaminated soil greater than 1000 m^3.	▪ If yes, confirm availability and quality of granular borrow. ▪ If granular borrow sufficient, develop preliminary design and cost estimate for an on-site disposal facility, using site specific conditions. ▪ Re-evaluate on-site disposal costs versus off-site disposal and confirm cost-benefit.

The Tier II Contaminated Soil Landfill design is based on the containment of contaminated soil with a lined landfill provided with sufficient granular fill cover to maintain the contaminated soil in a frozen condition. The required fill thickness is a function of the climatic conditions selected as the design criteria.

Geothermal analyses are required to substantiate the use of permafrost as a means of containment for the landfills. Analyses are carried out to predict the short-term and long-term ground temperatures for the Tier II Contaminated Soil Landfill to determine:

- Length of time for landfill freezeback;
- Short-term and long-term thermal regime in the landfill; and
- Depth of annual thaw (active layer) in the cover material.

Geothermal analyses should be carried out for the landfills using two-dimensional finite element computer models. The models simulate transient, two-dimensional heat conduction with a change of phase for a variety of boundary conditions. The heat exchange at the ground surface should be modeled with an energy balance equation considering air temperatures, wind velocity, snow depth, and solar radiation. The models should include the temperature phase change relationships for saline soils, such that freezing depression and unfrozen water content variations can be explicitly modeled.

The soil thermal properties required to carry out geothermal analyses include: porewater composition, latent heat, specific heat (frozen and unfrozen), and thermal conductivity (frozen and unfrozen). These properties are determined indirectly from well-established correlations with soil index properties, moisture content, grain size distribution, bulk density, salinity, etc. (Farouki, 1986; Johnston, 1981). Soil index properties are based on information collected during the site investigations.

Climatic data required for the thermal model include monthly mean air temperature, wind speed, solar radiation, and snow cover. The thermal analysis should be calibrated to measured temperatures and/or observed active layers thicknesses. The landfill designs include analyses for mean temperature conditions, warm conditions and long-term climate change. Statistical analyses are carried out to determine mean monthly temperatures representative of a 1 in 100 warm year. The freezing index and thawing index for each year are calculated from the recorded air temperature data. The index for each year is ranked in ascending order and plotted. A "best-fit" line is drawn through the set of points to estimate the 1 in 100 warm year index. Mean monthly air temperatures are increased by the ratio of the 1 in 100 warm year freezing or thawing index to the mean year freezing or thawing index to estimate the mean monthly temperatures of a 1 in 100 warm year. The influence of climate change should be evaluated by similar methods presented in ACIA 2005. This includes the average estimated of season temperature changes by various Global Circulation models.

Given the uncertainties in climate change and the cost of returning to a site at a future date, it is recommended that the Soil Disposal Facility be designed for 100 years of long-term climate warming (average of four GCMs) as a minimum. With this design condition, the active layer could penetrate the contaminated soil if a warm year occurred. Containment during this condition would be provided by the thick soil cover and the geomembrane liner. Additional factors of safety can also be applied to account for uncertainties in the geothermal model, soil input parameters, and climate input parameters, or the facilities can be design for climate change plus one 1 in 100 warm year. Some modifications to this section may be made following the FMEA.

5.5 *Borrow Source Development*

Granular borrow material will be required for the development of new landfills and general site grading purposes.

5.5.1 Site Grading

Grading operations generally consist of the shaping and regrading of disturbed areas to blend in with the natural contours, in accordance with all applicable licenses. The disturbed areas may include:

- contaminated soil excavation areas,
- existing and new landfill areas,

- debris areas,
- areas disturbed during demolition activities,
- granular borrow areas, and
- any area disturbed during the establishment and operation of the camp, equipment storage and maintenance activities.

5.6 *Contractor Support Activities*

For the implementation of the remedial activities, a Contractor will establish a camp and storage areas on-site, where required. Where possible, these will be located in previously disturbed areas such as borrow or storage areas, to minimize any new disturbances, in accordance with all applicable licenses.

Domestic refuse generated by the camp shall be incinerated and disposed of on-site in an engineered landfill. Sewage shall be handled by an appropriately sized sewage treatment system, in accordance with applicable legislation and all applicable licenses.

Potable water supplies at the site will be tested and used, only if they meet the Canadian Drinking Water Quality Standards (CCME 2002), in accordance with all applicable licenses.

Fuel required for the operation of the camp will be stored on-site in accordance with applicable legislation and licenses.

All hazardous materials shall be segregated prior to or during demolition. Non-hazardous demolition materials and asbestos shall be collected and disposed in an on-site engineered landfill. Hazardous demolition materials shall be disposed off-site.

Only in exceptional circumstances shall existing buildings remain intact on site following the remediation program. These structures may remain as emergency shelters once clear transfer of ownership has been established.

6 CONSTRUCTION RELATED IMPLEMENTATION REQUIREMENTS

Consistent with Step 9 of the Federal Contaminated Sites Action Plan, confirmation that the objectives of the Remedial Plan have been met is required. Based on the issues typically associated with the remediation of the INAC sites, confirmatory testing encompasses a wider range of activities. These include, but are not necessarily limited to:

- Confirmatory testing of contaminated soils;
- Quality Assurance testing of earthworks associated with the remediation and construction of landfills;
- Testing as required for waste manifesting to allow for shipment and disposal of materials off-site; and
- Testing as required to meet the requirements of Land Use Permits, and/or other Licences/Permits issued for the cleanup program.

The requirements and/or guidelines for these testing programs are outlined in the following sub-sections.

6.1 *Confirmatory Testing Contaminated Soils*

Following excavation of contaminated material confirmatory samples shall be collected and analyzed to ensure that cleanup objectives have been met. Sampling will be conducted by a third party qualified to carry out such work. A detailed sampling plan shall be developed for each area of concern identified for excavation in the Remedial Action Plan, and must include the following information:

- Description of the objective for each potential area of concern
- Sampling locations
- Sampling methods
- Proposed number of samples and media
- Parameters for analyses
- Sampling methodology, analytical requirements, and Quality Assurance/Quality Control measures.

6.1.1 Tier I contaminated soils:

Tier I criteria were developed to address aerial transport of contaminants; excavation and backfilling precludes this pathway. If, during the site assessment, sufficient evidence has been collected to demonstrate that soils at depths of greater than 0.3 m below surface do not exceed Tier II levels for inorganic elements or PCBs, confirmatory sampling will not be required.

6.1.2 Tier II contaminated soils:

Confirmatory sampling shall be carried out using a systematic grid sampling design following the DND DLCU Confirmatory Sampling Protocol as summarized in Table 7. This design provides a practical and simple method for designating sample locations and ensures uniform coverage of a site. Discrete samples should be collected at every point on the grid. For small areas, all samples shall be analyzed, whereas for larger areas only a fraction of the interior grid samples shall be analyzed. When choosing sample locations for analysis, consideration shall be given to areas of previously high concentrations. No single sample result or the mean of a duplicate/replicate sample shall exceed the cleanup objectives. In cases where field analytical methodology is used, 10-20% of the samples analyzed in the field should also be analyzed in the laboratory for quality control purposes.

Table 7 Confirmatory Testing Grid Sizes

Size of area	Grid size	# Perimeter samples analyzed	# Interior grid samples analyzed
<100 m^2	3x3 m	all	all
>100 m^2, <2500 m^2	6x6 m	50%	40%
>2500 m^2	12x12 m	50%	40%

6.1.3 Hazardous Soils

Confirmatory sampling following excavation of soils considered hazardous according to CEPA (PCBs >50 ppm) or the TDGA may require a more closely spaced grid than outlined in Table 7 to minimize the overall volume of materials requiring off-site disposal.

6.1.4 Type B TPH (Fractions F1 to F3)

Confirmatory sampling following excavation of petroleum hydrocarbon impacted soils within 30 m of a water body supporting aquatic life will follow the confirmatory sampling protocol outlined in section 6.1.2. The remedial solution for petroleum hydrocarbon impacted soils further removed from surface water bodies involves excavation of source areas. In cases where field analytical methodology is used, 10-20% of the samples analyzed in the field should also be analyzed in the laboratory for quality control purposes. For comparison purposes, total petroleum hydrocarbons (TPH) data obtained by hexane extraction can be compared to data generated using the CCME analytical procedure for PHC in soils by summing fractions F1 to F3. The presence of residual petroleum hydrocarbon contamination is expected following excavation to design limits as outlined in the Remedial Action Plan. Representative samples from the base of the excavation will be collected and analyzed for record keeping purposes using the CCME analytical procedure for PHC in soils.

6.1.5 Ex-situ Confirmatory Sampling

Soils excavated from landfills and dumps will be classified ex-situ. The excavated soils will be placed in windrows or stockpiles with a maximum stockpile size of 20 m^3 (B.C. Environment, 1995. Contaminated Site Statistical Applications. March, 1995). Debris is separated from the soil and sorted as potentially hazardous and non-hazardous under the supervision of the Hazardous Materials Specialist. Stained soil and soil associated with potentially contaminated debris such as battery waste or barrels must be stockpiled separately from other soil to prevent dilution and facilitate disposal.

As part of the sampling protocol, two types of soil samples shall be collected from stockpiles: discrete and composite. Sample locations are selected at various surface and depth locations at each stockpile to obtain samples that are representative of the entire pile. Five discrete samples are collected and analyzed for the first 20 stockpiles and every 20th stockpile thereafter. Composite samples shall be collected and analyzed at all stockpiles. Composite samples consist of approximately equal volumes of soil collected from the five discrete sample locations.

The standard deviation for each stockpile shall be calculated based on discrete sample results. These standard deviations are then used to calculate the average standard error for all stockpiles (Equation 1). Twice the average standard error is added to the analytical result for the composite sample to provide a 95% upper confidence limit (Equation 2).

$$SE_{avg} = \frac{\sum_{1}^{m}\left(\frac{SD}{\sqrt{n}}\right)}{m} \qquad \textbf{(Equation 1)}$$

$$UCL = \left[Composite_x\right] + 2\left(SE_{avg}\right) \qquad \textbf{(Equation 2)}$$

n represents the number of sample values,

SE_{avg} represents the average standard error,

SD represents the standard deviation of the sample values,

m represents the number of stockpiles,

UCL represents the upper confidence limit and

x represents the stockpile number.

Classification of stockpiles for disposal is based on a comparison of the 95% upper confidence limit values and the relevant clean up objectives.

The first 20 stockpiles shall be analyzed for the nine inorganic elements for which the DCC criteria are applicable and PCBs. Analysis for petroleum hydrocarbon will be based on visual and/or olfactory evidence. This process shall be repeated for every 20th stockpile thereafter. All the remaining stockpiles will be tested for copper, lead and zinc and any other analyte that exceeded the DCC criterion previously until it is no longer present (Table 8). Field analysis can provide adequate detection limits for statistical classification of certain contaminants (PCBs and PHC), while others (inorganic elements) must be analyzed in CAEAL accredited laboratories for more precise results.

Table 8 Analytical Requirements for Stockpile Sampling

Stockpile No.	Samples Collected	Analytical Suite	Samples for Analyses
1 through 20	**5 discrete** 1 composite	**PCBs, Cu, Ni, Co, Cd, Pb, Zn, Cr, As** PHC and Hg where evident	All discrete and all composite samples are analyzed for first 20 stockpiles
Every 20th thereafter	**5 discrete** 1 composite	**PCBs, Cu, Ni, Co, Cd, Pb, Zn, Cr, As** PHC and Hg where evident	All discrete and all composite samples are analyzed
Remaining stockpiles	**1 composite**	**PCBs, Cu, Pb, Zn** PHC, Hg and other inorganic elements where evident	Every composite sample is analysed.

Once the excavation is complete, the base of the landfill excavation must be sampled in accordance with confirmatory sampling protocol for Tier II soils.

6.1.6 Confirmatory Sampling of Material Processing Areas

Residual contamination may be present at barrel processing areas, hazardous materials processing areas, and stockpile lay down areas after clean up activities are complete. Once an area is no longer in use, a detailed inspection for evidence of staining and other indicators of contamination such as visible debris or paint flakes shall be carried out. Samples must be collected in these areas in a grid pattern based on the size of the area (see Table 7). In cases where field analytical methodology is used, 10-20% of the samples analyzed in the field should also be analyzed in the laboratory for quality control purposes.

6.2 Quality Assurance Testing of Earthworks

At most sites, earthworks will be carried out as part of the construction of new landfills, remediation of existing landfills, and/or development of hydrocarbon contaminated soil treatment areas. Contract Specifications developed for the project will identify specific requirements for fill gradation and compaction standards. As part of the testing to be carried out during cleanup, quality assurance (QA) testing is required to confirm that the earthworks are in conformance with the Specifications. The number and type of testing will be dependent on the volume of fill to be placed and the number of different material types employed in the cleanup. A QA program shall be developed in conjunction with the design engineer to determine the optimal number of tests required.

6.3 Testing Related to Permits/Regulatory Requirements

in progress

7 LANDFILL MONITORING

Under review

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A Annex A – Landfill / Dump And Debris Area Evaluation Process

A.1 Introduction

In 1997, the DEW Line Cleanup Environmental Working Group (EWG), comprised of members representing Nunavut Tungaavik Inc. (NTI) and the Department of National Defence (DND) / Defence Construction Canada (DCC), was formed to address environmental issues associated with the DEW Line sites under the jurisdiction of DND. One of their tasks was the development of a matrix to assess potential environmental risk associated with existing landfills at the DEW Line sites. The evaluation matrix considered three primary categories, contaminant source, exposure pathways and potential receptors. In the development of the matrix, landfills typical of the DND DEW Line sites were considered. The DND DEW Line sites were in operation for nearly 40 years, and landfill activity was generally extensive. By comparison, the INAC DEW Line sites or I-sites, were only operational for a period of approximately five to six years. Accordingly, waste disposal practices were different. At many sites, waste materials were not consolidated in a single area, and isolated areas of partially buried debris are common.

This current document presents a Landfill/Debris Area Evaluation Matrix that considers conditions more specific to INAC DEW Line and other northern abandoned military sites.

A.2 Background

To address the varied nature of DEW Line landfills, a consistent method for the assessment of their potential risk to the arctic environment, in the form of a risk evaluation matrix, was developed by the DND/NTI EWG in 1997. Since that time, the matrix has been utilized to develop recommendations for landfill remediation at DND DEW Line sites. This document provides a modified evaluation matrix to address the landfills/buried debris areas more typical of the DEW Line and other abandoned military sites under the jurisdiction of INAC.

The DND/NTI evaluation matrix was based on the CCME National Classification System for Contaminated Sites, and adapted to address the particular concerns of the Arctic environment. This revised version also references the Federal Contaminated Site Action Plan (FCSAP) Contaminated Site Classification Guidance Document. The matrix is divided into three categories of equal weight: contaminated source, pathways, and receptors. The interaction of these three elements results in environmental risk. Each category is assigned 50 points, which are distributed among several factors. Each of these factors has been made as specific as possible in order to reduce the subjectivity of the matrix to a minimum. In addition, each of the three main categories is assigned a highly subjective “special considerations” factor according to the method described in the CCME Classification System. As it is unlikely that any classification system could address all possible factors, a special considerations factor allows the user to increase or decrease the score “to emphasize important concerns about a site and should be used as an **exception rather than as a rule**” (CCME 1992, p.6-7).

The intended purpose of the matrix is to evaluate the potential environmental risk posed by landfills in their current condition. It is not considered suitable for assessing environmental risk posed by a landfill post-closure. Specific elements of the landfill closure design that mitigate against the potential risk posed by the landfill are not considered in the matrix evaluation process.

Two conservative assumptions are made during the evaluation of all landfills/buried debris areas.

- The contents of landfills/buried debris areas are unknown and all potential contaminants may be present.
- If contaminants come into contact with receptors, they could have adverse effects on the receptors.

A.3 MATRIX FACTORS

A. Contaminant Source

Four factors were considered under Contaminant Source to describe specific landfills/debris areas as follows:

A.1 Landfill Extent

A.2 Estimated Depth of Landfill

A.3 Contaminant Characteristics – combined presence of leachate and surface contaminated soil.

A.4 Presence of Surface Debris

Contaminant characteristics were assigned the greatest weighting in this category as it is a strong indicator of potential environmental risk associated with the landfill. The volume of a landfill is considered to be related to its potential to be contaminated – the greater the volume, the greater the risk that the landfill contains contaminants. The volume of the landfill is divided into two parameters, area and depth. The area is relatively easy to measure; the estimated depth of the landfill is given less weight in the matrix as it is difficult to measure using non-intrusive techniques.

A.1: Landfill Extent

The larger the area of the landfill, the greater the potential for contaminants to be present exists. Landfill areas are based on the results of geotechnical/geophysical site surveys and visual observations. The value of 10 000 m^2 is an area approaching the size of the largest landfills on the DEW Line; scoring for all other landfills is prorated based on their areal extent relative to 10000 m^2. Areas less than 1000 m^2 are referred to as debris areas.

Scores are provided for all landfills/debris areas following the detailed field investigations that are carried out prior to cleanup/construction. The objectives of these investigations are to delineate the extent of known contamination, and confirm existing site and landfill conditions.

A.2: Estimated Depth

The depth of a landfill/debris area is estimated by visual inspection of surrounding topographic features. The average depth of the active layer is used as a qualifier for the description of landfill depth, as this is generally the maximum depth of investigation. The depth of the active layer may range from one to two meters at these sites, depending on material type; therefore an average depth of 1.5 meters was used in the rating. Landfills with estimated depths of greater than 1.5 meters were scored higher than those with estimated depths of less than 1.5 meters. For the majority of INAC DEW Line landfills, it is anticipated that the depth of buried waste is 1.5 metres or less based on the relatively short duration of operation. Exceptions to this may include dumping within ravine areas or other natural depressions.

A.3: Contaminant Characteristics

Contamination associated with landfills and/or debris areas may be elevated with respect to background concentrations, but less than applicable criteria. In this case, elevated concentrations may be indicative of chronic low levels of contaminants leaching from the landfill, as a result of infiltration and percolation of surface water, or flow of active layer groundwater through the landfill. In some cases, contamination on the surface or near the toe of the landfill may exceed applicable criteria as a result of direct spills or leaking containers.

With consideration of the FSCAP Hazard Ranking of contaminants and the DEW Line Cleanup Criteria, all contaminants included in the DEW Line Cleanup Criteria are considered high concern, with the exception Petroleum Hydrocarbon Fractions F3 and F4. In the scoring of this category, four categories are provided:

- Concentrations not elevated with respect to background; however, the potential for contamination is considered possible.

- Concentrations elevated with respect to background; but less than DEW Line Cleanup guidelines. Elevated with respect to background refers to a concentration in excess of the three times the mean background concentration.

- Concentrations in excess of Tier I guidelines.

- Concentrations in excess of Tier II guidelines.

A.4: Presence of surface debris

At some landfills, surface debris is very extensive, while at others there is almost no debris. Scoring needs to be quantitative; therefore the percentage of the surface area of the landfill that is covered with debris is used as the basis for scoring. A landfill that has surface debris covering more than 50% of its surface receives a full score. Debris areas, as implied by the designation, generally receive full score for this category.

B. Pathways

The primary transport mechanisms for contaminants from the DEW Line landfills are considered to be:

- Aerial transport of fine particles; and
- Dissolved phase and/or colloidal transport in water, both as surface water run-off or subsurface water flow.

B.1: Aerial Transport of Contaminants

All contaminants can be transported as particles. Windblown debris is not considered in this category, as debris pickup is inherent in any cleanup. Surface contamination or surface expressions of leachate impacted soils imply the potential for aerial transport. This factor is given a low weight because the quantity of contaminated soil on the surface of a landfill is generally low relative to the quantity of contaminated soil at the site as a whole. In addition, it is anticipated that relative to the effect of water movement, aerial transport contributes less to the transport of contaminants away from a landfill.

B.2: Water Movement

Dissolved phase and/or colloidal transport in water includes movement of surface water and subsurface water within the active layer. "Groundwater" is not addressed as an issue separate from surface water, as the movement of water within the active layer is subject to the same driving forces or gradients as surface water. The intent of this sub-category is to examine factors that affect migration away from the landfill – slope, runoff, extent and type of cover on the landfill, annual precipitation and distance to surface water. Among these factors, topography, runoff potential and proximity to surface water are given the greatest weight.

B.2.1 Topography

The degree of the slope on which the landfill is located is one of the major factors contributing to transport of contaminants. Scoring is carried out on a progressive scale. In cases where there are different slopes across the landfill, a weighted average is used.

B.2.2 Cover Material – Depth

The extent to which contaminants are available for transport is also dependent on the depth and type of cover material. The potential for leachate generation and correspondingly, leachate migration, is related to the infiltration of water into the landfill. Cover over the landfill helps mitigate infiltration of water into the landfill contents. As the thickness of the landfill cover increases, the likelihood that potential contaminants will be released from the landfill decreases. If the active layer is contained in the cover material above the debris, then the potential for surface water infiltration into the landfill is small; this circumstance is assigned the lowest score.

B.2.3 Cover Material – Type

The erosion potential of a landfill is partly based on the type of cover material. Erosion can eventually lead to the exposure of the landfill contents. Some cover materials are more susceptible to erosion than others; well graded gravels are the least susceptible, and silty materials are the most susceptible. In cases where there is no cover, this factor is assigned the highest score. Where the cover materials consist of a combination of soil types, the scoring should reflect the more conservative or higher score.

B.2.4 Surface Water/Run-Off Potential

This factor aims to describe the destructive potential of water action on the landfill, which could take the form of waves; streams, rivers or lakes; or seasonal drainage. Where there is significant seasonal drainage, the run-off potential is high. "Significant seasonal drainage" is defined as run-off that has the potential to transport large quantities and concentrations of contaminants to surface water courses over a short period of time (CCME 1992, p.23). Significant seasonal drainage also includes consideration of major snow drifting on a landfill.

B.2.5 Precipitation

The amount of precipitation received, either as rain or snow fall, affects the amount of surface water infiltration or run-off, and potentially erosion. The majority of the DEW Line sites receive less than 500 mm of precipitation annually, with the exception of sites on the lower east coast of Baffin Island. Typically, the amount of precipitation at any site is relatively low. Any given rainfall event is unlikely to generate major run-off; however, spring thaw and corresponding run-off may be significant at some sites. Detailed precipitation data is not available for the INAC sites; therefore data was interpolated from the Hydrological Atlas of Canada Maps, as summarized below.

Sites	Annual Precipitation (mm)	Annual Snowfall (cm)	Average Maximum Snow Pack depth (cm)
PIN-B	100-200	100	30
PIN-C, D, E, CAM-A, B, C	100-200	80	30
CAM-D, E, F	150-200	100	50
FOX-1,A,	150-200	100	60
FOX-B	200-300	100	60
FOX-C	200-300	200	70
FOX-D	350	240	100
FOX-E	+400	240	100

As spring run-off likely represents the maximum precipitation event, scoring is provided relative to the maximum snow pack depth, with a score of 4 allotted to snow pack depth of 100 cm. If site specific factors, such as drifting in the landfill area are present, the score may be increased to 5, the maximum allotted to this category.

B.2.6 Distance to Down-gradient Perennial Surface Water/Seasonal Drainage Channel

The distance to surface water will affect the probability of contaminants reaching the watercourse. This factor can include streams, seasonal or perennial, running directly through the landfill or streams and lakes downgradient from the landfill, but it is intended to exclude small ponds with no outflow. On very steep slopes, this distance should consider the horizontal distance to the water body rather than the vertical drop. The impact of drainage with respect to contaminant exposure is not considered in this category (it is considered under Receptors); this factor determines whether there is a drainage pathway from the landfill.

C. Receptors

This section addresses the potential for impact on receptors, specifically, aquatic and terrestrial habitats, as well as human exposure. Impact on humans is the primary consideration; however, it should be recognized that impact on humans is implicit in the scoring of factors addressing ecosystem impact. The scoring within each category is to be based on recorded data, as well as local knowledge of the land use in the area, and therefore requires local input.

C.1: Potential Impact on Receiving Freshwater/Marine Habitat

Selection of the water body in this category is based on potential effects on the receiving habitat. Consideration must be given to the regional drainage patterns. For example, where the drainage from a landfill is overland (i.e. there is no direct connection between the landfill and the downgradient water body), water bodies beyond two kilometers should not be used in the evaluation. This is based on the premise that natural attenuation of any potential contamination will occur with overland flow. Where a direct connection between a landfill and a downgradient water body exists, via a stream or interconnected ponds, the two-kilometre limit should not be used.

C.1.1 Proximity to Receiving Freshwater/Marine Habitat

"Receiving habitat" is considered to be a significant body of water near the toe of the landfill where contaminants are likely to have an impact. The water body may support freshwater or marine life and/or may be used by avifauna and/or terrestrial mammals as a water source. It is not necessarily the seasonal drainage course or perennial water body closest to the landfill toe. **The objective is to select a habitat that supports receptors rather than identify the closest body of water.** It is assumed that only habitat downgradient from the landfill is to be considered (given that aerial transport of contaminants to habitat upgradient from the landfill will be addressed by the remediation of contaminated soil).

C.1.2 Estimated Habitat Usage – Freshwater/Marine

The score within this category is based on the frequency of usage within the selected receiving environment and considers the level of biodiversity and the occurrence of calving/spawning grounds. Freshwater and/or marine wildlife are potentially more at risk compared with terrestrial wildlife or avifauna, the latter which are exposed through water ingestion. Thus, when terrestrial wildlife or avifauna are the primary receptor, the score for this factor should fall into the moderate or low category based on the potential frequency of usage. Otherwise, when the selected water body sustains freshwater and/or marine wildlife, the level of biodiversity should be used to evaluate the score. It should be noted that the most conservative approach - in the selection of the receiving water body - must be used when scores from section C.1.1 and C.1.2 are combined. Finally, "Biologically sensitive" areas such as bird sanctuaries and/or endangered, threatened or vulnerable populations should be considered as "special considerations".

C.2: Potential Impact on Receiving Terrestrial Habitat

C.2.1 Extent of Vegetation

The extent of vegetation considers the area within 300 metres downgradient of the landfill. Within this distance, vegetation is expected to be most susceptible to uptake of contaminants if they are leaching from the landfill. However, topography and the potential for run-off must be considered and a greater or lesser distance could be considered.

C.2.2 Estimated Habitat Usage – Terrestrial/Avifauna

The same criteria as for usage of aquatic habitat are to be applied.

C.3: Potential Human Exposure Through Land Use

C.3.1 Presence/Occupation

This factor addresses strictly dermal exposure and inhalation; consumption of food and water from the area are dealt with in subsequent factors. The risk of dermal exposure or inhalation is much lower when soil is frozen; therefore winter occupation of the site is assigned a low risk. “Summer” in this factor is intended to include the spring, summer and fall periods when the ground surface is not frozen. Within this factor, the scoring takes into account the likelihood and the duration of contact. Using this method, proximity to a community is considered (high likelihood of contact), although proximity to a community does not necessarily trigger a high score if visits are infrequent (low duration of contact).

The likelihood of contact considers proximity to community or to a camp, as well as proximity to “travel routes”. The duration of contact considers full time residences (i.e. permanent community for high, summer camp for moderate, winter camp or travel routes as low). Scores may be interpolated between the allocated points, according to Table 1-1 below.

Table 1-1 Scoring Guide for Section C.3.1

	High Likelihood of Contact	Moderate Likelihood of Contact	Low Likelihood of Contact
High Duration of Contact	8	6	4
Moderate Duration of Contact	6	4	2
Low Duration of Contact	4	2	1

Different landfills on a site may need to be considered individually.

C.3.2 Proximity to Drinking Water Source

Regardless of whether the source is seasonal or perennial, an established community or a summer camp water source located downgradient of the landfill is to be considered in this factor.

C.3.3 Food Consumption

Sedentary organisms are more susceptible to local inputs as their exposure is greater if they are downgradient from the landfill. These organisms can include bottom-dwellers such as sculpins, mussels, sea urchins etc., as well as terrestrial vegetation, which can be used for medicinal purposes. This kind of contamination "is quite localized when considered on a broad regional scale" (DIAND 1997, pg. 5). Migratory marine animals may have body burdens of contaminants; these are not directly attributable to local contaminant sources, as the vast majority of organochlorines, for instance, arrive in the Arctic via long range transport. Caribou living in the general area of DEW Line sites do not have elevated levels of contaminants, as they feed over a very wide area. The Canadian Arctic Contaminant Assessment Report (DIAND, 1997) describes these results in more detail.

It is recognized, however, that sources such as DEW Line sites do contribute contaminants to the Arctic ecosystem. For the purpose of scoring the matrix, therefore, a high consumption of animals from the area surrounding the DEW Line sites has the potential to pose a higher risk than a low consumption, **although in general the risk remains low.**

This factor is divided into two sub-sections, and the score is the sum of the score for each of the two sub-sections.

Special Considerations

As indicated in the introduction to the matrix, each of the three main categories includes a "*special considerations*" factor. The proposed value of the special considerations factor is a maximum of ten percent of the overall score for each category. It is intended that no circumstance will allow a user to assign a special considerations score that will cause the score for that category to exceed the maximum allotted. To avoid undue bias, it is also suggested that the user should complete the entire evaluation form and score a site before addressing special considerations in the total score.

The Environmental Working Group (EWG) based the landfill risk evaluation matrix on the CCME model which defines three categories: contaminant source, pathways and receptors. Within those three categories, the EWG tried to address all of the possible factors contributing to risk. Recognizing that even a thorough matrix could never address all possible risk factors, special considerations were included to address specific risk factors that are not general to all of the DEW Line sites.

As noted in the CCME document, the special considerations factor is not intended to be applied on a regular basis, as it addresses very site-specific risk factors. In fact, if the special consideration factor was being consistently applied in the scoring of landfills, it would indicate that the matrix itself was incomplete. Special considerations should be site-specific characteristics that can be documented.

Three examples of how special considerations could be applied are provided to clarify the use of such a classification:

Example 1. Wildlife on site

It may be that "special considerations" points would be assigned to the Receptors category when endangered, threatened and/or vulnerable species (COSEWIC, 1997) are known to visit the DEW Line landfill.

Example 2. Drinking water

The risk associated with landfill impact on a drinking water source is addressed in section C.3.2. In that section, the distance from a landfill to a known drinking water source, permanent or seasonal, is used as an indicator of the risk that the contaminants in the landfill could have an impact on the drinking water source. If a landfill is close to a drinking water source, then section C.3.2 would be assigned the maximum score (8 points). In the case of Pelly Bay, however, where the landfills are far from the drinking water source and therefore receive a relatively low score in section C.3.2, "special considerations" points may be added to address concerns that the landfills are located in the watershed for the community drinking water supply.

Example 3. Proximity to a community

In the landfill risk evaluation matrix, human exposure to a landfill is measured in the following way: people can spend time at the landfill (potential dermal exposure), they can drink water from an area near the landfill (potential ingestion), they could live very close to landfills (potential exposure through aerial transport) or they could eat animals that feed near the landfill (potential ingestion). These considerations form section C.3 of the risk evaluation matrix. If a landfill is located near a community, there is a greater likelihood that people will spend time at the landfill than there is for landfills far from a community. It is not necessarily the case, however, that landfills near communities receive frequent visits; therefore, instead of creating a special section addressing proximity to a community, the risk of human exposure (see Table 1-1) is more accurately evaluated by measuring time spent at a landfill. In these cases, however, "special considerations" points may be added to the Receptors category to address a community's specific concerns.

A.4 Traditional Knowledge

The matrix for the evaluation of potential environmental risk associated with landfills was developed recognizing that local input would be relied upon in the scoring of landfills. Additional guidance on the collection of Traditional Knowledge is provided in of the protocol.

A.5 Interpretation of Scores

The score obtained through the application of the matrix is intended to represent the potential environmental risk posed by a given landfill in its current state. The objective of landfill remediation is to mitigate the risk associated with a landfill by preventing the migration of contaminants that may be present in the landfill.

Landfills scoring 105 points or more are classified as potentially high risk (Class A) and require excavation. The high score accorded to these landfills is generally a result of the ecological sensitivity of the area and the geometry and surrounding topography of the landfill, which precludes the development of a cost-effective and long-term design solution such as pathway intervention and/or stabilization of the landfill. Landfills with a score of 100-104 points must be considered on a case by case basis – some may require complete excavation while others may be considered Class B landfills.

Landfills with a score in the range 75 to 99 points are classified as moderate potential environmental risk (Class B). An engineered leachate containment system will be provided for these landfills to mitigate against potential environmental risks. In specific cases where an engineered leachate containment system cannot be constructed, an evaluation of excavation will be carried out with the objective of determining whether complete excavation or partial excavation with a leachate containment system is required.

Landfills with scores of 75 or less are classified as low potential environmental risk (Class C). In general, the remediation approach for these landfills includes placement of an engineered cover, following collection, sorting, and appropriate disposal of debris from the surface, and excavation and disposal of any surface contaminated soils from the area. Some of the factors to be considered in the design of the cover include: thickness and type of the existing cover materials; slopes on the landfill; surrounding topography and available granular fills.. The cover is designed to promote surface water run-off (i.e. no areas of standing water), prevent erosion, and mitigate against settlement. Where required, the slope of the landfill may be modified and/or geotextiles may be incorporated into the granular cover to provide a long-term solution. Generally, the final thickness of cover material is approximately 0.75 metres, and may be greater dependent on site specific conditions. The granular cover material is to be placed in layers and compacted before the placement of the next layer of granular fill, until the design thickness is reached.

Debris areas scoring a total of 89 points or more are classified as potentially high risk and require excavation to the full extent/depth of the debris. In addition, if a debris area scores greater than 23 points in the contaminant source category, complete excavation of the debris area is recommended.

For debris areas scoring less than 89 points, it is considered unlikely that leachate containment will be cost-effective when compared to excavation and removal of debris. Consideration must therefore be given to the level of contamination present. If contaminants are present in excess of criteria, it is recommended that the debris area be excavated to its full extent. If contamination does not exceed criteria, debris should be cut-off and removed within the upper 0.5 metres of the ground surface.

Debris areas are classified as being of low environmental risk if the overall score is less than 63. These areas may be covered in place once surface accessible debris is removed. However, consideration must be given to surrounding topography, such that the cover must blend in with existing grades.

Overall, it is to be stressed that the matrix is to be used in the assessment of potential environmental risks associated with a specific landfill. It is not intended to be used as the sole criterion in determining the remediation solution for a landfill. The results of the matrix, both total score and the score from each major category, are to be considered in conjunction with the engineering evaluation of site conditions, to determine appropriate design solutions. Review of the individual category scores relative to the total score will highlight particular areas of concern that are to be addressed during the design process.

The potential impacts of climate change are also to be considered in evaluating remedial solutions.

It should be emphasized that the total score has an error associated with it of approximately 5 points; there is inevitable subjectivity in the scoring process and scores that fall near decision points should be considered on a case by case basis.

A.6 References

BC Environment. June 1996. Guideline #1 Contaminated Sites: Site Characterization and Confirmation Testing. Draft.

CCME. 1992 National Classification System for Contaminated Sites.

COSEWIC, 1997, Categories of the Committee on the Status of Endangered Wildlife in Canada, Canadian Wildlife Service, Environment Canada.

DIAND, 1997. Canadian Arctic Contaminants Assessment Report.

B Annex B – Barrel Protocol

B.1 Introduction

In order to determine the correct disposal method for barrels and their contents, the contents must first be identified. All barrel contents should be sampled and analyzed according to DND DEW Line Cleanup standard procedures, as described in this section.

Analytical data obtained for the samples collected from barrels located at the site should be compared to the criteria included in Table 1, below. Barrel contents are identified as organic or aqueous and the concentrations of glycols, alcohols, PCBs, chlorine, cadmium, chromium and lead are determined. The flash point of organic waste and aqueous waste (> 2% glycols/alcohols) must also be determined. Uncontaminated aqueous phases can be disposed of on the land according to the discharge criteria; uncontaminated organic phases can be incinerated; contaminated aqueous material should be scrubbed free of organic material; and contaminated organic material should be disposed of as hazardous material.

During the delineation phase of the site investigation, an inventory of the number and locations of barrels at the site is to be compiled. This inventory should include buried or partially buried barrels that will be taken out of the landfills during excavation. Where significant numbers of barrels are present on a site, and if safe to do so, representative samples shall be collected to provide a preliminary indication of whether on-site incineration is a viable alternative. Otherwise, barrels are only sampled during the cleanup phase and as such, the handling, transportation and opening of barrels is the responsibility of the site Contractor.

Other waste fuels and oils are also sampled according to this protocol. These may come from a variety of sources including, but not necessarily limited to, old generators, fuel tanks and pipelines, and transformers.

B.2 Inspection

All barrels are to be inspected to address the following items which shall be recorded and used as a guide prior to opening barrels.

- Symbols, words, or other marks on the barrel that identify its contents, and/or that its contents are hazardous: e.g. radioactive, explosive, corrosive, toxic, flammable.
- Symbols, words, or other marks on the barrel that indicate that it contains discarded laboratory chemicals, reagents, or other potentially dangerous materials in small-volume containers.
- Signs of deterioration or damage such as corrosion, rust, or leaks at seams, rims, and V grooves, or signs that the barrel is under pressure such as bulging and swelling.
- Spillage or discoloration on the top and sides of the barrel.

B.3 Sampling

Barrels shall not be transported until it has been determined that they are not under pressure, do not leak, and are sufficiently sound for transport.

Barrels to be sampled should be set in an upright position, provided that this does not cause them to leak and that it is physically possible.

Barrels should only be opened according to accepted procedures and under qualified supervision, preferably using remotely operated, non-sparking equipment.

Once open, barrels will be sampled by personnel wearing proper personal protective equipment as described below (B.7). Samples of the contents of all barrels shall be extracted using a drum thief and placed into a pre-labelled glass vial. The number and type of liquid phases, and their respective thickness, and the size of each barrel are to be recorded.

In instances where there are a large number of barrels with obviously similar contents, these can be grouped together and 30 to 40% of the barrels in the group sampled. Barrels containing less than 50 mm of liquid may be combined with compatible material prior to sampling; samples inferred to contain only water on a visual examination shall be tested prior to this consolidation. Barrel contents, which consist of black oil, shall not be consolidated.

All barrels shall be clearly numbered using spray paint or other suitable paint marker. The number on this label should be the only sample coding provided to the laboratory.

The barrel locations and barrel sample descriptions should be recorded.

Samples should be kept at ambient temperatures and shipped by guaranteed freight to laboratories where they should be kept cold pending analysis.

B.4 Testing

Liquid samples shall be inspected and classified as either containing water or organic materials. Samples thought to contain water shall be analyzed to confirm that they are indeed water, and contain less than 2% glycols or alcohols.

The contents of barrels containing organic materials, including aqueous samples which contain more than 2% glycols or alcohols, shall be tested for flash point, PCBs, total chlorine, cadmium, chromium and lead following the targeted barrel testing approach presented in Figure 1. Analyses will be conducted on a rush basis where indicated. In addition, major organic components should be identified e.g. fuel oil, lubricating oil.

If on site incineration of waste is not planned, waste samples need only be tested for flash point, PCB, and pH (at regular turnaround time) in order to classify the waste for transport and disposal options.

Contents of barrels which contain two or more phases shall have all phases analyzed; the organic phases as described above and the aqueous phase to ascertain whether it contains less than 2% organic substances. In addition, the aqueous phase shall be tested for any components found in the organic phases above the criteria provided in the protocol.

B.5 Disposal of Barrel Contents

Barrels containing only rust and sediment shall be treated as empty barrels.

Barrel contents comprising water only (less than 2% glycols or alcohols) shall be transferred to an open vessel such as a utility tub or half-barrel and any organic material removed by agitation with a pillow or segment of oil absorbent material. The water shall be tested prior to discharge in accordance with wastewater discharge criteria. Where water meets criteria, it may be discharged to the ground a minimum of 30 meters distance from natural drainage courses. Used oil absorbent material shall be treated as described in the following subsection.

Barrel contents which are composed of water with glycols and/or alcohols or organic phases, and which contain less than 2 ppm PCBs, 1000 ppm chlorine, 2 ppm cadmium, 10 ppm chromium, 100 ppm lead, and that have a flash point between 25°C and 225°C, may be disposed of by incineration. Alternatively these contents may be disposed of off-site at a licensed disposal facility. The solid residual material resulting from incineration shall be subjected to a leachate extraction test. Material found to not be leachable shall be disposed of as DCC Tier II contaminated soil. Leachable material shall be treated as hazardous waste and disposed of off-site at a licensed disposal facility.

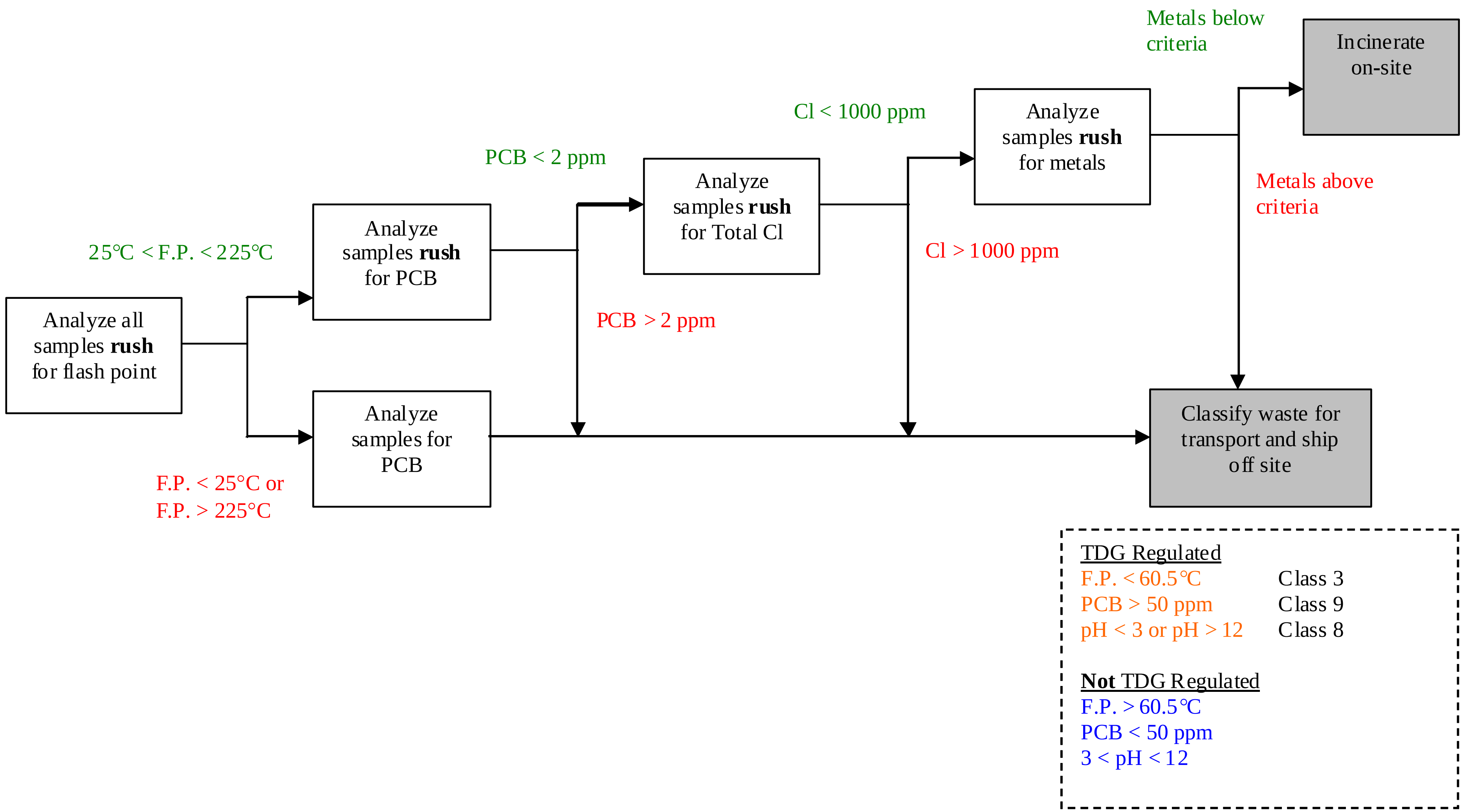

Figure 1 Targeted Barrel Testing Approach

Barrel contents, which contain greater than 2 ppm PCBs, 1000 ppm chlorine, 2 ppm cadmium, 10 ppm chromium or 100 ppm lead, or that have a flash point below 25°C or greater than 225°C shall be disposed of off-site at a licensed disposal facility. Contents may be combined with compatible materials for shipping purposes.

Used oil absorbent material should be treated as hazardous waste and disposed of off-site at a licensed disposal facility. If it is shown to be uncontaminated with PCBs (< 2 ppm), chlorine (< 1000 ppm), cadmium (< 2 ppm), chromium (< 10 ppm) and lead (< 100 ppm), it may be incinerated on-site.

B.6 Disposal of Barrels

Empty barrels may be crushed or shredded and landfilled on-site as non-hazardous waste after they have been cleaned in an appropriate manner. The barrels shall be crushed in such a manner so as to reduce their volume by a minimum of 75%. Shredded barrels may be disposed of off-site as recycled metals.

B.7 Personnel Protective Equipment

Safety equipment required includes a respirator with organic vapour cartridges, safety glasses, a hard hat, rubber safety boots, double gloves (chemically resistant on the outside, and latex or vinyl on the inside) and disposable Syranex-coated coveralls.

A decontamination procedure should be established at the barrel sampling area(s) to prevent tracking potentially contaminated liquids outside of the sampling area(s).

It is advisable to have one person outside of the sampling area to observe the sampler(s) in case of unexpected hazards, and also to record the samplers' observations.

APPENDIX C

MEETING MINUTES

Bear Island Mid-Canada Radar Site
2008 Community Consultation regarding the draft Remedial Action Plan

Chisasibi, Quebec
February 20, 2008
7:00 – 9:00 pm (presentation)
9:00 – 10:00 (questions)

Introductions:
Sonia Nobrega (INAC)
Lisa Dyer (PWGSC/TPSGC)
Greg Wright (Earth Tech

Presentation:
Sonia – draft Remedial Action Plan

Attendees: 46 (Eddie Rupert, Translator)

Sonia made a presentation about the work completed at Bear Island.

- Bear Island was a Mid-Canada Line Radar Station
- The purpose of this meeting is to share information, communicate plans and to seek community input
- Objectives for Bear Island
    - Minimize environmental impact
    - Comply with legal requirements
    - Follows all Federal policies
    - Increase public awareness about remediation activities
    - To provide employment opportunities to local work force
- Bear Island is located 160 km Northwest of Chisasibi
- Site includes the North and South Dopler Stations, an airstrip, roads and Beach Area
- The radar sites were built in the 1950s
- Workers lived at the North Dopler station
- Most of the buildings have been demolished
- 2 radio towers have collapsed on site
- Roads connect all the areas
- History
    - 1950 to 1965 Radar Stations
    - 1965 to present under the care of INAC
    - 1996 Environmental Site Assessment
    - 2001 Environmental Site Delineation
    - 2007 Phase 3 Environmental Site Assessment, Archaeological Impact Assessment and Remedial Action Plan
- Bear Island Clean Up Objectives

- Protect human health and safety
- Protect the environment
- Employ proven Northern Technologies
- Use long term solutions
- Minimize the environmental impact of clean up activities
- Minimize time spent on site
- Minimize long term monitoring requirements
- Employ cost effective solutions

- Bear Island Non-Hazardous Wastes
    - Heavy equipment, radar towers, metal waste, concrete, empty barrels, wood
    - Approximately 730 m^3 or 91 dump trucks

- Clean Up Options for Non Hazardous Wastes
    - Leave waste where it is and cover with gravel
    - Ship Material Off site
    - Build a new secured landfill and place waste inside
- Bear Island Hazardous Waste
    - Includes batteries, lead amended paint, asbestos, lead cable and zinc conduit and gas cylinders
    - Petroleum Product volume is around 1,500 litres
- Options for cleaning up Hazardous Waste
    - Build a hazardous waste landfill and place material inside
    - Place in a non hazardous landfill
    - Ship off site
- Asbestos
    - Place in plastic bags and dispose of in an engineered landfill
- Lead Amended Paint, Batteries, Lead Cable and Zinc Conduit
    - Remove off site for disposal at a licensed facility
- Petroleum Product
    - Incinerate on site if possible
- Compressed Gas Cylinders
    - Vent and dispose of in the site landfill

- Contaminated Soils at Bear Island
    - Comes from batteries, paint, electrical equipment
    - Heavy metals such as cadmium, copper, lead and zinc found on site
    - Approximately 92 m^3
    - Enough to fill 11 dump trucks
    - Clean Up Options
        - Place material in a non hazardous landfill on site
        - Ship off site
        - Build a new hazardous waste landfill and place material inside
    - Recommendation
        - Low level contaminated soils to be placed in a non hazardous landfill on site
        - 13 m^3 or 1.5 dump trucks
        - High level contaminated soils to be put in containers and disposed of off site
        - 79 m^3 or 9.5 dump trucks

  - PCB Contaminated Soils
    - PCBs used in transformers, capacitors, hydraulic fluids, flame retardants and paints
    - High level contaminated soils – $4m^3$
    - Low level contaminated soils – $1m^3$
    - Clean Up Options
      - Place waste in a non hazardous landfill
      - Ship material off site
      - Build a new hazardous waste landfill and place material inside
    - High level contaminated soils are to be removed from site – $4m^3$
    - Low level contaminated soils to be placed in an engineered landfill on site – $1m^3$

  - Hydrocarbon contaminated soils
    - 295 m^3 of contaminated soil
    - Same as 37 dump trucks
    - 102 m^3 of non mobile contamination
    - 193 m^3 of diesel fuel contaminated soils
    - Clean Up Options
      - On site land farming
      - Place a gravel cap on top
      - In situ soil vapour extraction
    - Non mobile contamination to be placed in a secure landfill
    - Diesel contaminated soils to be removed from site

- Archaeological Impact Assessment
  - A single heritage resource site was identified at Bear Island
  - A 20 m buffer has been created around the site to protect it

- Remediation Schedule
  - Summer 2008 – bidders tour
  - Fall 2008 – permitting
  - Winter 2008 – contract tender
  - Spring 2009 – Contract Award and Community Consultation
  - Summer 2009 – Mob equipment to site
  - Summer 2009 & 2010 – Clean up activities
  - Spring 2010 – Community Consultation
  - Fall 2010 – Demob from site

- Future consultations and monitoring
    - During remediation – one meeting per year
    - After remediation – one meeting during monitoring years
    - Annual inspections of landfill for first five years after construction
    - Then once every 5 years until 2030
    - The monitoring requirements will be reevaluated in 2035

- Potential Aboriginal Involvement
    - Business opportunities
    - Sub contractors
        - Camp supply
        - Provision of equipment
    - Labour opportunities
        - Equipment operators
        - Mechanics
        - Surveyors
        - Trades
        - Labourers
        - Cook/Housekeepers
        - Wildlife Monitors
        - Interpreters
        - Health and Safety Officer
        - Opportunities for Sampling Scientist

- Project Procurement
    - Bidder's conference
    - Use of a request for proposal
    - Posted on MERX the government electronic tendering service
    - www.merx.com
    - The proposals are evaluated for socio economic benefit, technical content and cost
    - If the proposal is technically sound the contract can be awarded for the higher cost as long as it is no more than 15 percent higher
    - Training – funding will be made available
    - Incentive/Penalty Clause
        - Aboriginal commitment must be met by the contractor
        - There is a bonus for contractors that exceed the guaranteed aboriginal employment commitment
    - Work could also be contracted through Standing Offer Agreements with the government or through Contribution Agreements

- Contacts
    - Sonia Nobrega/Mark Yetman from INAC (867) 975-4733
    - Lisa Dyer from PWGSC at (867) 766-8377

Comments & Questions and Answers:

Comment: (Jimmie Neacappo) These sites have been around for many years. The contamination may have spread over the years. The oil drums started to leak and ended up in wider spread contamination.

Question: Joint effort between the US and Canadian Armies. There were no regulations that forced the Military to clean up the site. Were there any rules for clean up? Why did it take so long to clean up the site?
Answer: (Sonia Nobrega) Does not know the history behind why the site was not cleaned up sooner. However, funding is available now and the site will be cleaned up.

Question: (Samson Snowboy) Wanted to know about the clean up for Cape Jones
Answer (Sonia Nobrega) This site is outside the Nunavut Territory and Sonia believes that DND is responsible for this site along with Grey Goose Island. Sonia will find out who is responsible for Cape Jones and the schedule for clean up of this site.

Question: (James Stewart) Venting of gas cylinders. Why are you not burning the gas cylinders? Why vent?
Answer: (Sonia Nobrega) Venting is safer than burning for health and safety reasons

Question: (Daisy House) How far away is Sanikiluaq away and are they being consulted?
Answer :(Sonia Nobrega) Sanikiluaq is 300 km away. Bear Island is not part of the land claim agreement but part of Nunavut. Authorities in Nunavut were contacted to determine who should be consulted.

Question: (Samson Snowboy) Cape Jones probably has the same types and concentration of contaminates as Bear Island
Answer: (Sonia Nobrega) Not familiar with the site. Contamination issues can be similar at Military sites.

Comment: (Jimmie Neacappo) Bear Island might be part of the Cree Land Claims Negotiations
Comment: (Sonia Nobrega) Is aware of the Land Claims Negotiations and all parties are aware of the activities on Bear Island.

Comment: (Harry Scipio) The reason why radar sites were put on the island was the threat from the Russians. This Elder worked at the site. The Radar stations were not very effective and only were in place for a short period of time.
Comment: (Sonia Nobrega) – The Bear Island station was operated for less than 10 years to monitor for Russian activity.

Comment: (Harry Scipio) The work that is to be done on Bear Island is not important to the Cree people as they do not frequent the area. They are more concerned about the site at Cape Jones because this area is used for hunting. Would like to see efforts put into cleaning up Cape Jones.

Comment: There were some people that went to the Island. Billy visited the island.
Comment: (Sonia Nobrega) Sonia will try and find information regarding Cape Jones.

Comment: (Billy Martin Hunter) Went to site in 1964 after the site was abandoned. The Roman Catholic Church gathered material from the site. The material from site was brought back to Fort George and used to build the residential school. It took 11 hours to get there by boat.
When they were on site they saw that the soil was damaged, punctured fuel drums and fuel spills. Eider Ducks were breading on the island and there were polar bears. It would be a very good idea to clean up the island. It is a beautiful spot and could be used for tourism in the future.

Comment: (Billy Weetaltuk) Also went to the Island with Billy Martin Hunter. Saw the contamination and saw that shore birds were contaminated with oil. The material salvaged included metal, wood and what ever was useful. They only went there once. A Hudson Bay Barge bought back materials to Fort George.

Comment: (Sonia Nobrega) Earth Tech conducted the most recent environmental investigation of the Island. The cost to clean up the site is estimated to be 8 to 15 million. Are interested in learning from people about what the best route to Bear Island would be. The contractor will determine how to access the site.

Question: (William Chiskamish) The landfill on the island was constructed by some people from Chisasibi. Brand new equipment was buried on site. Will the landfill be removed from site?
Answer: (Sonia Nobrega) The landfill at site and the area around it was tested and no contamination was found to be migrating from the landfill. Greg Wright from Earth Tech tested the site and it has been determined that the best option is not to dig up the site.

Question: (Moses Snowboy) Is this the only site being worked on? Are any sites on the Quebec mainland being remediated?.
Answer: (Sonia Nobrega) Not aware of what sites are being remediated in Quebec.

Comment: (Moses Snowboy) The material from sites found on the main land has had a great affect on hunting and wildlife. He wants to talk about the radar station at Cape Jones and the Point. Believes there are impacts from this site affecting wildlife. At Cape Jones they found the carcass of a polar bear soon after they dismantled the buildings. Feels that the death was related to contamination at the site.

Comment: (Sonia Nobrega) Greg and Lisa are taking notes and recording your questions. Sonia will find out what is happening at Cape Jones.

Comment: (Moses Snowboy) Wants to see the area around Cape Jones cleaned up because this area is visited by Elders and youth. Material was buried on site and they don’t know what it is.

Question: (Sonia Nobrega) How far is Cape Jones from Chisasibi?
Answer: (Moses Snowboy) The site is 80 miles North of Chisasibi. Can travel there by boat in the summer and snowmobile in winter. Cape Jones was abandoned in 1962, 1963.

Question: (Sonia Nobrega) Is Chisasibi the main user of Cape Jones?
Answer: (Eddie Rupert) Yes, there are three radar stations at Cape Jones

Sonia thanked everyone for coming out and asking good questions. The meeting was closed.

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APPENDIX D

SUMMARY TABLES

Table D1: Detailed Summary of Non-Hazardous Materials

Location		Items	Material	Quantity	Comments	In Situ Volume[1] (m^3)	Crushed or Cut Volume[2] (m^3)	Weight[3] (tonnes)[4]	Percentage of Total Non-Hazardous Materials (by weight)
South Doppler Area - Site 412	Doppler Detection Building (DDB)	Wooden structure	Wood	lump sum	165 linear m of 0.3x0.3 beams, joists and flooring	15	15.0	3.6	0.17
		Concrete foudation pillars	Concrete	40	approx 1.5x0.3x0.3 (m)	5.5	5.5	9.9	0.46
		Power poles	Wood	20	approx 5 m tall 0.3 m diameter	7	7.0	1.7	0.08
		Antenna bases	Concrete	7	approx 3 m^3 each	21	21.0	37.8	1.77
		Antennas	Steel	3	1 large, 2 small		40.0	157.0	7.35
		HVAC ducting	Steel/Iron	lump sum	east of building	10	5.0	19.6	0.92
		Scrap metal	Steel/Iron	lump sum	wire, cable, piping, scrap metal scattered in vicinity of DDB		25.0	98.1	4.60
		Scrap wood	Wood	lump sum	scattered in vicinity of DDB		8.0	1.9	0.09
		Domestic debris	Tin	lump sum	domestic debris south of DDB		0.5	0.3	0.01
		Glass Products	Glass	lump sum	domestic debris south of DDB		0.5	0.4	0.02
		Barrels	Steel/Iron	10		1.6	0.5	1.9	0.09
		Fuel/Water/Sewage Tanks	Steel/iron	2		4	2.0	7.8	0.37
	Emergency Shelter (ES)	Emergency vault	Concrete	1		20	7.0	12.6	0.59
		Barrels	Steel/Iron	5	within and surrounding ES	0.8	0.2	0.9	0.04
		Scrap metal	Steel/Iron	lump sum	bed frames, rubber-wrapped cables, nails, piping, misc metal		6.0	23.5	1.10
		Scrap wood	Wood	lump sum	lumber and misc wood within and surrounding ES footprint		4.0	1.0	0.05
	Garage	Foudation	Concrete	lump sum	approx 165 m^2 and 0.3 m thick		50.0	90.1	4.22
		Concrete pillars	Concrete	15	2.0x0.5x0.5 (m) with rebar		7.5	13.5	0.63
		Barrels	Steel/Iron	20		3.2	1.0	3.8	0.18
		Scrap metal	Steel/Iron	lump sum	vehicle parts, ducting, piping, snow removal blade, wires, misc metal		15.0	58.9	2.76
		Scrap wood	Wood	lump sum	lumber and misc wood scattered in vicinity of garage		6.0	1.4	0.07
	Road to south end of Island	Barrels	Steel/Iron	8		1.28	0.4	1.5	0.07
		Glass Products	Glass	lump sum	bottles, jars, etc	2	0.5	0.4	0.02
		Domestic debris	Tin	lump sum	cans	2	0.5	0.3	0.01
		Scrap wood	Wood	lump sum		2	2.0	0.5	0.02
		Scrap metal	Steel/Iron	lump sum	vehicle parts, piping, scrap metal	3	3.0	11.8	0.55
	Landfill North of Site 412	Barrels	Steel/Iron	50		8	2.4	9.4	0.44
		Scrap metal	Steel/Iron	lump sum	metal strapping, ducting, vehicle parts, wires, misc metal	10	10.0	39.2	1.84
		Scrap wood	Wood	lump sum		2	2.0	0.5	0.02
		Glass Products	Glass	lump sum	bottles, jars, etc	0.5	0.3	0.2	0.01
	Barrel Cache	Barrels	Steel/Iron	3800	also includes barrels at the small barrel cache area which contain product requiring disposal	608	182.4	715.9	33.53
		Scrap metal	Steel/Iron	lump sum	wires, misc metal	1	1.0	3.9	0.18
		Scrap wood	Wood	lump sum	misc lumber and wood	2	2.0	0.5	0.02
	North Landfill Area	Barrels	Steel	35		5.6	1.7	6.6	0.31
		Snow vehicles	Steel	2		35	20.0	78.5	3.68
		Scrap Wood	Wood	lump sum	lumber and misc wood	8	8.0	1.9	0.09
		Scrap Metal	Steel	lump sum	vehicle parts (incl rubber tracks for snow vehicles), piping, pumping equipment, scrap metal	12	12.0	47.1	2.21
Beach Area	Beach Area	Heavy Equipment	Steel/Iron	lump sum	bulldozer	10	8.0	31.4	1.47
		Fire Fighting Carts	Steel/Iron	lump sum		4	2.0	7.8	0.37
		Fire Fighting Hose	Rubber	lump sum		0.5	0.5	0.2	0.01
		Barrels	Steel/Iron	140		22.4	6.7	26.4	1.24
		Machinery Parts	Steel/Iron	lump sum	heavy equipment parts, snow removal blade	4	3.0	11.8	0.55
		Scrap Metal	Steel/Iron	lump sum	metal strapping, nails, wiring, piping, misc scrap metal	15	15.0	58.9	2.76
		Scrap wood	Wood	lump sum	misc lumber and wood (not incl drift wood)	9	9.0	2.2	0.10
		Electrical Building	Wood	lump sum	includes building skeleton and wood framing of electrical cabinets	40	5.0	1.2	0.06
	POL Area	Wood	Wood	550	wood supports along pipeline (approx two 0.15x0.15x0.4 wood support every 6 m)	9.9	10.0	2.4	0.11
		Barrels	Steel/Iron	45	including 30 barrels east of POL pad area	7.2	2.2	8.5	0.40
		Pipeline	Steel/Iron	lump sum	pipe extends from POL pad to North and South Doppler Areas (approx 3,300 m total)	40	40.0	157.0	7.35
	Road to Beach Area	Barrels	Steel/Iron	20		3.2	1.0	3.8	0.18
		Wood	Wood	lump sum	misc scrap wood	2	2.0	0.5	0.02

Table D1: Detailed Summary of Non-Hazardous Materials

Location		Items	Material	Quantity	Comments	In Situ Volume[1] (m^3)	Crushed or Cut Volume[2] (m^3)	Weight[3] (tonnes)[4]	Percentage of Total Non-Hazardous Materials (by weight)
North Doppler Area - Site 413	North Doppler Detection Building	Wooden structure	Wood	lump sum		30	30.0	7.2	0.34
		Building foundation/pads	Concrete	lump sum		4	4.0	7.2	0.34
		Power poles	Wood	7	approx 5 m tall 0.3 m diameter	2.5	2.5	0.6	0.03
		Antennas	Steel/Iron	2	1 large, 1 small		35.0	137.4	6.43
		Antenna bases	Concrete	8	approx 2.5 m^3 each	20	20.0	36.0	1.69
		Scrap Metal	Steel/Iron	lump sum	ducting, wire, piping, cables, metal strapping, misc metal	10	10.0	39.2	1.84
		HVAC ducting	Steel/Iron	lump sum	west and north of the building	6	6.0	23.5	1.10
		Steel wrapped Cable	Steel/Iron	lump sum	2,880 m length from Site 413 to Site 412	10	10.0	39.2	1.84
		Barrels	Steel/Iron	25	including barrels along road from airstrip	4	1.2	4.7	0.22
		Fuel/Water/Sewage Tanks	Steel/iron	1		2	1.0	3.9	0.18
		Scrap Wood	Wood	lump sum		2	2.0	0.5	0.02
Airstrip Area	Airstrip Area	Terminal buildings	Wood	3	1 complete, 2 partial huts	50	6.0	1.4	0.07
		Fiberglass insulation	Fiberglass	lump sum	in walls of terminal hut	0.5	0.1	0.1	0.00
		Shingles	Tar/Asphalt	lump sum	roof of former terminal hut	0.25	0.3	0.2	0.01
		Glass Products	Glass	lump sum	bottles, jars, etc	0.25	0.3	0.2	0.01
		Domestic debris	Tin	lump sum	tin cans, pots and pans, etc	0.25	0.3	0.1	0.01
		Barrels	Steel/Iron	120		19.2	5.8	22.6	1.06
		Antenna	Steel/Iron	1		0.5	0.5	2.0	0.09
		Machinery Parts	Steel/Iron	lump sum	airstrip grading equipment, snow removal blade	4	3.0	11.8	0.55
		Fuel/Water/Sewage Tanks	Steel/iron	2		4	2.0	7.8	0.37
		Scrap Metal	Steel/Iron	lump sum	cable, wire, wind sock support, misc scrap metal	3	3.0	11.8	0.55
		Scrap Wood	Wood	lump sum		5	5.0	1.2	0.06
	Totals						**726.9**	**2135**	

Notes:
1 - volume of each material was determined based on field measurements and observations
2 - crushed volume based on volume reduction from crushing with excavator bucket or crushing in landfill with bull dozer; cut volume reduction based on torch cutting scrap metal and sawing scrap wood to manageable sizes
3 - weights of materials obtained from *Pocket Ref* (T.J.Glover, 2005) and *Standard Volume to Weight Conversion Factors* (USEPA, 2008)
Wood (based on average of soft woods and assuming 50% voids when cut/crushed/stacked) = 480.6 kg/m^3
Scrap metal (based on weight of steel and assuming 50% voids when crushed) = 3924.9 kg/m^3
Concrete (based on gravel type concrete and 25% voids when crushed) = 1802.1 kg/m^3
Rubber (based on ground scrap and assuming 25% voids when cut/ground) = 480.6 kg/m^3
Glass (based on semicrushed) = 889.1 kg/m^3
Tin cans (based on manual compaction) = 503.8 kg/m^3
Fibreglass (assumed to be saturated with water, therefore weight of water was used for calculation) = 999.6 kg/m^3
Asphalt shingles (based on weight of tar and assuming 25% voids) = 861.4 kg/m^3
4 - tonnes = 10^3 kg

Table D2: Detailed Summary of Hazardous Materials

Location		Items	Material	Quantity	Comments	Material Volume[1] (m^3)	Weight[2] (tonnes)[3]	Percentage of Total Hazardous Materials (by weight)
South Doppler Area Site 412	Site 412 Area	Brown floor tile	Asbestos	lump sum	5-10 % Chrysotile; piled south of DDB and scattered around the South Doppler Area	1	0.6	1.4
		Green floor tile	Asbestos	lump sum	5-10 % Chrysotile; piled south of DDB and scattered around the South Doppler Area	1	0.6	1.4
		Asbestos cement board	Asbestos	lump sum	25-50 % Chrysotile; piled south of DDB and scattered around the South Doppler Area	8	8.7	18.6
		Lead acid batteries	Lead	14	piled at Garage (6) and on road (8) approx 300 m south of Site 412	1.5	0.3	0.7
	Landfill North of Site 412	Lead acid batteries	Lead	10	piled at the existing landfill	1	0.2	0.5
	Barrel Cache and North Landfill Area	Barrels with Product	Waste Oil	800 L	approx 4 partially full barrels at the Small Barrel Cache (may require shipment to a disposal facility)	0.8	0.7	1.5
		Lead cable	Lead	lump sum	373 m length from Site 412 to water reservoir, and stockpiled at the Disturbed Area	2	11.3	24.2
Beach Area		Building Panels	lead in paint	lump sum	70.2 mg/L leachable lead	7	1.7	3.6
		Electrical Cabinets	lead in paint	lump sum	15.2 mg/L leachable lead	10	39.2	83.8
		Brown floor tile	Asbestos	lump sum	5-10 % Chrysotile; scattered around the Beach Area	0.5	0.3	0.7
		Green floor tile	Asbestos	lump sum	5-10 % Chrysotile; scattered around the Beach Area	0.5	0.3	0.7
		Lead acid batteries	Lead	3	piled near bulldozer	0.5	0.1	0.2
		Compressed Gas Cylinders	Compressed Gas	8	compressed gas cylinders for fire fighting equipment	0.8	1.6	3.4
		Boat	lead in paint	lump sum	9.9 mg/L leachable lead	10	2.4	5.1
North Doppler Area Site 413		Brown floor tile	Asbestos	lump sum	5-10 % Chrysotile; scattered around the North Doppler Area	0.6	0.4	0.8
		Green floor tile	Asbestos	lump sum	5-10 % Chrysotile; scattered around the North Doppler Area	0.2	0.1	0.3
		Asbestos cement board	Asbestos	lump sum	5-10 % Chrysotile; scattered around the North Doppler Area	0.2	0.2	0.5
		Zinc coated conduit	Zinc	lump sum	stockpiled north of the building	0.5	1.8	3.8
Airstrip Area		Asbestos cement board	Asbestos	lump sum	25-50 % Chrysotile; scattered near the terminal huts	0.5	0.5	1.2
		Barrel with Product	Fuel	250 L	1 partially full barrel which requires shipment to a disposal facility	0.25	0.2	0.4
Totals						**47**	**71.5**	

1 - volume of each material was determined based on field measurements and observations
2 - weights of materials obtained from *Pocket Ref* (T.J.Glover, 2005) and *Standard Volume to Weight Conversion Factors* (USEPA, 2008)
Floor Tiles (no weight found in reference material, used asphalt shingles to approximate) = 861.4 kg/m^3
Asbestos Cement Board (based on lightlweight concrete with expanded clay aggregate) = 1089 kg/m^3
Batteries = 24.18 kg/battery
Waste Oil (lube oil = 910 km/m^3; petroleum oil = 881 kg/m^3; transformer oil = 880 kg/m^3) = 900 kg/m^3
Lead cable (based on cast lead and 50% voids when compressed) = 5670 kg/m^3
Lead paint (based on weight of substrate) = 480.6 kg/m^3 (wood) and 3924.9 kg/m^3 (metal)
Zinc conduit (based on cast zinc and 50% voids when compressed/cut) = 3524.1 kg/m^3
4 - tonnes = 10^3 kg

Table D3: Inventory of Asbestos, Paint, Concrete and Wood Samples

Sample ID	Item	Description	Location	Lead Leachate	Total PCBs	Asbestos Content	Color	Substrate	Condition	Comments
Building Panels	paint	buidling panels stockpiled	Beach Area	**70.2**		-	yellow/green	wood	flakey	ET 2007 investigation
Electrical Cabinet	paint	electrical cabinets in hut	Beach Area	**15.2**		-	blue	steel	good	ET 2007 investigation
Brown 9x9 Tile	ACM	brown 9x9 floor tile	Site 412, 413 and Beach Area	-		**5-10 %**	light brown	chrysotile	good	ET 2007 investigation
Garage Foundation	concrete	southeast corner of foundation	Garage	-	< 0.05	-	grey	concrete	fair	ET 2007 investigation
Orange Tower	paint	orange paint from radar antenna	Site 412	<0.5			orange	steel	weathered	ET 2007 investigation
White Tower	paint	white paint from radar antenna	Site 412	<0.5			white	steel	weathered	ET 2007 investigation
Green Tile	ACM	green 9x9 floor tile	Site 412, 413 and Beach Area	-		**5-10 %**	green	chrysotile	good	ET 2007 investigation
Asbestos Board	ACM	asbestos cement board	Site 412, 413, Beach Area and Airstrip	-		**25-50 %**	grey	chrysotile	good	ET 2007 investigation
Boat Paint	paint	hull of boat near beach area	Beach Area	**9.9**	-		white	wood	flakey	ET 2007 investigation
N Doppler Floor	wood	treated lumber from Site 413	Site 413	non-detect for PAHs and metals			brownish grey	wood	weathered	ET 2007 investigation

Notes: ACM indicates potential asbestos containing material

Criteria:
- 5 mg/L Lead leachate in paint
- 50 ppm PCBs
- 1% Asbestos content

Table D4: Summary of Barrel Analysis

Identifier	Location	Estimated Volume	Aqueous or Organic	PCB (ppm)	Cl (ppm)	Cd (ppm)	Cr (ppm)	Pb (ppm)	Disposal Method	Comments
				>2 ppm?	>1000 ppm?	>2 ppm?	>10 ppm?	>100 ppm?		
BAR-01	Small Barrel Cache	200 L	Organic	<1		<1	**<50**	8	refer to comment	Confirm Cl and Cr concentrations. If < 1000 and < 10, suitable for incineration. Otherwise ship south for disposal
BAR-02	Small Barrel Cache	200 L	Organic	<0.05	2	<1	**<50**	5	refer to comment	Confirm Cr concentrations. If < 1000, suitable for incineration. Otherwise ship south for disposal
BAR-03	Small Barrel Cache	200 L	Organic	<1		<1	**<50**	21	refer to comment	Confirm Cl and Cr concentrations. If < 1000 and < 10, suitable for incineration. Otherwise ship south for disposal
BAR-04	Small Barrel Cache	200 L	Organic	<1		<1	**<50**	16	refer to comment	Confirm Cl and Cr concentrations. If < 1000 and < 10, suitable for incineration. Otherwise ship south for disposal
BAR-05	Airstrip Area	250 L	Organic	<0.3	32	**6**	**220**	**540**	ship south for disposal	