ARCADIS Design & Consultancy for natural and built assets

Public Services and Procurement Canada (PSPC)
on Behalf of Transport Canada

PERFORMANCE & LONG TERM MONITORING PLAN (LTM), FORMER METAL DUMP AND COMMUNITY LANDFILL

Iqaluit, Nunavut

August 3, 2017

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EXECUTIVE SUMMARY

Arcadis Canada Inc., was retained by Public Services and Procurement Canada (PSPC), Environmental Services on behalf of Transport Canada (TC) to complete a Performance and Long Term Monitoring (LTM) Plan for the Transport Canada Iqaluit Former Metal Dump and Community Landfill (referenced as "the site" throughout this document). A detailed monitoring plan is also a requirement of Part K, condition 1 of Water Licence 1BR-MDR1721, issued by the Nunavut Water Board on July 31, 2017.

The Iqaluit Former Metal Dump/Community Landfill is located 1.7 km southwest of the City of Iqaluit, Nunavut on the border of the Sylvia Grinnell Territorial Park and the Sylvia Grinnell River. The site covers an area of approximately 72,500 m^2. The United States Air Force (USAF) used the site from 1955 to 1963 as a metal dump for vehicles, truck bodies, barrels and scrap metal. The majority of materials were deposited in 1963 when the US Military left Frobisher Bay. The debris was scattered over a large area and consisted of vehicles, equipment, barrels, and scrap metal. Shops, buildings, and other materials were simply bulldozed over the cliff.

Four areas of environmental concern were identified at the site in the Environmental Site Assessments conducted from 2008-2009; three of these areas are noted as having moderate to significant impacts to water quality, sediment and/or soils. The site is being remediated from July 2017 to November 2017. Remediation activities include but are not limited to the consolidation of non-hazardous debris into the main landfill, off-site disposal of selected soils and sediments, off-site disposal of hazardous materials, construction of an engineered landfill at the main landfill site for disposal of on-site waste in support of remediation, and surface water management. After remediation, the only structures that will remain at the site are a constructed single use landfill, which will be covered with an aggregate cap, and the associated drainage swales.

There are two separate but related monitoring plans included in this document; one for Remedial Performance Monitoring during active remediation and one for Long Term Monitoring post-closure. During active remediation, on-going performance monitoring will be conducted at the site to ensure mitigation measures implemented to reduce additional impacts from remediation efforts are performing as anticipated. The LTM Plan will be implemented post-closure to monitor the long-term performance of site remediation efforts. The long-term monitoring plan has been developed with consideration of INAC's Abandoned Military Site Remediation Protocol (2008). Long Term Monitoring will include visual, water quality, sediment and natural environmental monitoring. Seepage and soil sampling will be completed as required based on landfill performance.

The goal of this Performance and LTM Plan is to ensure that present and future risks to human health and the environment from the site conditions during and post remedial work are negligible and that monitoring, at some point in the future, could be terminated with confidence, based on findings of no risk and no depreciation of site environmental status.

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ACRONYMS AND ABBREVIATIONS

AEC	Areas of Environmental Concern
AMSRP	Abandoned Military Site Remediation Protocol
BTEX	benzene, toluene, ethylbenzene, and xylenes
CALA	Canadian Association of Laboratory Accreditation
CCME	Canadian Council of Ministers of the Environment
COC	contaminants of concern
CSedQG	Canadian Sediment Quality Guidelines
CSQG	Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health
CWS-PHC	Canada-Wide Standards for Petroleum Hydrocarbons in Soil
CWQG	Canadian Water Quality Guidelines
DOC	dissolved organic carbon
DO	dissolved oxygen
ESA	Environmental Site Assessment
EQG	Environmental Quality Guidelines
INAC	Indigenous Affairs and Northern Development Canada
LTM	Long Term Monitoring
MDL	method detection limit
NWB	Nunavut Water Board
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PHC	petroleum hydrocarbons
PSPC	Public Services and Procurement Canada
QA/QC	quality assurance/quality control
RAP	Remedial Action Plan
RPD	relative percent difference
TC	Transport Canada
TDS	total dissolved solids
TOC	total organic carbon
USEPA	United States Environmental Protection Agency
VOC	volatile organic compounds

1 INTRODUCTION

Arcadis Canada Inc. (Arcadis), was retained by Public Services and Procurement Canada (PSPC) Environmental Services on behalf of Transport Canada to complete a Performance and Long Term Monitoring (LTM) Plan for the Transport Canada Iqaluit Former Metal Dump and Community Landfill (referenced as “the site” throughout this document).

The goal of the performance and long-term monitoring program is to ensure that present and future risks to human health and the environment from the site conditions during and post remedial work are negligible and that monitoring, at some point in the future, could be terminated with confidence, based on findings of no risk and no depreciation of site environmental status.

The site is being remediated from July 2017 to November 2017. Remediation activities generally include but are not limited to the consolidation of non-hazardous debris into the main landfill, off-site disposal of selected soils and sediments, off-site disposal of hazardous materials, construction of an engineered landfill at the main landfill site for disposal of on-site waste in support of remediation, and surface water management. The landfill will be constructed with a final cap after this remedial work.

The performance monitoring component of this plan outlines the monitoring that will be undertaken during active remediation (Section 5.0). The LTM Plan outlines the post-closure monitoring program (Section 6.0).

1.1 Regulatory Framework

1.1.1 Nunavut Regulatory Context and Water Licence Requirements

The *Nunavut Waters and Nunavut Surface Rights Tribunal Act* grants the Nunavut Water Board (NWB or Board) the authority to regulate the use of water and deposit of wastes through issuance of water licences to proponents. The objective of the Board is to provide for the conservation and utilization of waters in Nunavut in a manner that will provide optimal benefit for the residents of Nunavut and Canadians in general (Section 35 of the Act).

As stated on the NWB website, the Board operates at arm's length from government and other parties. The Board is part of a larger management regime in Nunavut constituted of other Institutions of Public Government, including the Nunavut Surface Rights Tribunal, the Nunavut Impact Review Board and the Nunavut Planning Commission. Other land and resource management bodies in Nunavut include the Nunavut Wildlife Management Board, regional wildlife organizations and local hunter and trapper organizations.

The NWB holds the authority to regulate the remediation of the site through the conditions set forth in Water Licence 1BR-MDR1721. Part K, conditions 1 through 8 identify requirements for inclusion in this monitoring plan. Part B, condition 1 outlines annual reporting requirements (Section 7.3.1).

The performance and long-term monitoring program is being developed in accordance with Park K, Item 1 of Water Licence 1BR-MDR1721. This monitoring plan:

a) details on-going site monitoring (i.e., the performance monitoring program, Section 5.0);

b) identifies monitoring program stations (Figure 3; Section 5.1 and 6.2);
c) addresses effluent discharge criteria (Section 6.3);
d) summarizes monitoring data collected thus far (Section 3.0); and
e) includes an assessment of how the facilities are expected to perform in the long-term (Section 4.1).

No effluent discharge is anticipated with this site clean-up (Park K, condition 1(c)). Recommendations for improvements to this monitoring plan will be made in future annual reports (Part K, Item 1e and Part B, Item 1(e)).

1.1.2 Contaminated Sites Management

The Contaminated Sites Management Working Group for federal government departments has defined a contaminated site as a site at which substances occur in concentrations that either: 1) are above background levels and pose, or are likely to pose, an immediate or long-term hazard to human health or the environment; or 2) exceed levels specified in policies and/or regulations. For the latter, the Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines (CCME, 1999 and annual updates), including the Canada-Wide Standards for Petroleum Hydrocarbons in Soil (CCME, 2001 and updates) are applied in the numerical comparison of laboratory data to determine whether the site should be deemed a contaminated site. The guidelines are numerical limits intended to maintain, improve, or protect environmental quality and human health at contaminated sites.

The Government of Nunavut Department of Environment Guideline for the Management of Contaminated Sites (revised December 2014) has adopted the federal CCME Guidelines for the management of contaminated sites within its jurisdiction.

The chemical data obtained during the Franz (2009 & 2010c) Phase I/II and Phase III Environmental Site Assessments (ESA) and during the 2016 surface water and sediment testing conducted by Arcadis as part of the Arcadis 2017 Remedial Action Plan (RAP) update were compared to established guidelines from the federal CCME. The federal guidelines, referred to in this report as environmental quality guidelines (EQG) are relevant since the site(s) is currently federally managed and Nunavut has adopted the CCME approach (Section 1.2 and 6.4).

1.2 Environmental Quality Guidelines

The federal EQG are based on the level of risk a contaminant poses to humans, plants and wildlife. The EQG are used in the RAP to identify the areas where mitigation of exposure to chemicals of concern is required and are also incorporated as site-specific remedial objectives.

The specific guidelines that will be used to evaluate the impact to surface water, sediment and soil are as follows:

- Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQGs) (CCME, 1999, with updates).
- Canada-Wide Standards for Petroleum Hydrocarbons in Soil (CWS-PHC) (CCME, 2008).
- Canadian Soil Quality Guidelines (CSQG) Polycyclic Aromatic Hydrocarbons factsheet (CCME, 2010).

- Canadian Environmental Quality Guidelines. Canadian Sediment Quality Guidelines (CSedQG) for the Protection of Aquatic Life (CCME, 2007, with updates).
- Canadian Environmental Quality Guidelines. Canadian Water Quality Guidelines (CWQG) for the Protection of Aquatic Life (CCME, 2007, with updates).

The soil EQGs are further categorized by land use (i.e., agricultural/wildland, residential/parkland, commercial and industrial) and soil properties (i.e., fined or coarse grained soil).

Samples collected during the Phase III ESA were compared against these guidelines (Section 3.0). Water, soil and sediment, sampling completed as part of the LTM Plan will also be compared against these EQG (Section 6.4).

2 BACKGROUND

2.1 Site Overview and Location

Iqaluit (formerly named Frobisher Bay) is located on the southern tip of Baffin Island. The Iqaluit Former Metal Dump/Community Landfill (UTM84, Zone 19 coordinates of E521904.94, N7067812.69) is located at the West 40 area on the border of Sylvia Grinnell Territorial Park and the Sylvia Grinnell River, 1.7 km southwest of the City of Iqaluit (Figure 1). The site covers an area of approximately 72,500 m^2. The site is situated on an escarpment leading to the Sylvia Grinnell River and has several shallow ravines and coulees partially filled with metal debris. Historically, the site has been referred to as Sylvia Grinnell Park Dump and West 40 – Dump Site #1 and Vehicle Dump and Community Landfill or simply “site” or “landfill”.

Two main areas of waste are present at the site as a result of former land use activities (Figure 2):

1) the main debris/community landfill area located in the central portion of the site and spanning the top, side and toe of a bedrock escarpment that runs northwest/southeast; and
2) the vehicle dump located approximately to the south and parallel with the main landfill.

The United States Air Force (USAF) used the site from 1955 to 1963 as a metal dump for vehicles, truck bodies, barrels and scrap metal. The majority of materials were deposited in 1963 when the US Military left Frobisher Bay. The debris was scattered over a large area and consisted of vehicles, equipment, barrels, and scrap metal. Shops, buildings, and other materials were simply bulldozed over the cliff. The area to the north side of the slope was used by the USAF and to a lesser degree the community of Iqaluit as a landfill site for household garbage until sometime in the 1970’s.

The site is being remediated from July 2017 to November 2017. Remediation activities include but are not limited to the consolidation of non-hazardous debris into the main landfill, off-site disposal of selected soils and sediments, off-site disposal of hazardous materials, construction of an engineered landfill at the main landfill site for disposal of on-site waste in support of remediation, and surface water management. After remediation, the only structures that will remain at the site are a constructed single use landfill, which will be covered with an aggregate cap, and associated drainage swales.

2.2 Climate

Iqaluit is located within an arctic climatic zone despite being well outside of the Arctic Circle. The average daily temperature range is -28˚C to 7.7˚C. The area is characterized by very cold winters and short summers that permit the growth of very small, stunted trees. The average monthly temperature is below freezing for eight months of the year. The average annual precipitation is 412.1 mm, which is much wetter than many other localities in the Canadian Arctic islands. There is 198.3 mm annual rainfall and 235.8 mm annual snowfall (www.climate.weatheroffice.ec.gc.ca).

2.3 Ecological Characterization of the Site

Although the landscape appears to be barren, the flora of Iqaluit is abundant. As reported by Franz (2009 & 2010c), the area is characterized by a combination of bare rocky outcrops, grasses, and lichens.

To determine if the site is part of or is near to a critical wildlife habitat, the network of protected areas administered by Environment Canada was reviewed. The network, which includes migratory bird sanctuaries, national wildlife areas, and marine wildlife areas, represents diverse habitats protected under federal legislation. In addition, a territorial search for information related to critical wildlife habitat was also conducted. The distribution data provided by Environment Canada and the Government of Nunavut are based on limited available information. Due to the dynamic nature of species distribution, the data provided in Table 2-1 does not represent an exhaustive and comprehensive inventory of a species' current distribution.

Table 2-1: Ecology of Iqaluit, Nunavut

Vegetation and Terrestrial Mammals	Aquatic Wildlife and Birds
Vegetation	**Aquatic Wildlife**

• Arctic Fireweed (*Epilobium angustifolium)*
• flowers and berries
  o Crowberry (*Emporium*),
  o Poppy (*Papaver*)
  o Saxifrage (*Saxifraga)*
• numerous mushroom species
• lichens
  o Pixie-cup (*Cladonia asahinae)*
Scurvy-grass (*Cochlearia sp.)*
	• Seal (Pinnipedia)
	• Walrus (Odobenus rosmarus)
	• Beluga (Delphinapterus leucas)
	• Humpback Whale (Megaptera novaeangliae)
	• Arctic Char (Salvelinus alpinus)

Terrestrial Mammals	**Birds**
• Wolverine (rare) (*Gulo gulo*), • Lynx (*Lynx lynx*) • Mice • Marmot (*Marmota monax)* • Muskox (*Ovibos moschatus)* • Arctic Hare (*Lepus arcticus*) • Lemming (*Dicrostonyx torquatus)*	• Canada Goose (Branta canadensis) • Ptarmigan (Lagopus muta) • Arctic Tern (Sterna paradisaea) • Common Eider (Somateria mollissima) • Glaucous Gull (Larus hyperboreus) • Herring Gull (Larus argentatus) • Snowy Owl (Bubo scandiacus)

Vegetation and Terrestrial Mammals	Aquatic Wildlife and Birds
• Caribou (*Rangifer tarandus*) • Grey Wolf (*Canis lupus nubilus)* • Arctic Fox (*Alopex lagopus)* • Red Fox (*Vulpes vulpes*) • Polar Bear (*Ursus maritimus*)	

Sylvia Grinnell Territorial Park, the oldest of Nunavut's territorial parks, borders the site to the north-western extent (Figure 1). Sylvia Grinnell Park is divided in two by the Sylvia Grinnell River. The park plays a vital role in the community of Iqaluit by providing an important fishing ground for Arctic Char.

During the 2009 site visit, Arcadis (former Franz) personnel did not observe any wildlife. According to the Species at Risk web mapping application and the Nunavut Department of Environment website, no species are listed as threatened within the Killiniq region. Based on the Nunavut Wild Species 2000 report, the subject sites are within the range of three sensitive species: the wolverine, grey wolf and the polar bear.

Sylvia Grinnell Territorial Park is also home to Arctic Hare, Arctic Fox, Caribou, lemmings and other small mammals. Polar Bear have even been sighted on occasion, although they do not frequent the area. The park also plays a significant role in bird migration and over 40 species have been recorded in the park at different times of the year. The park is also the most southern breeding ground for the Ringed Plover. The local vegetation above and below the cliff consists of wet grassland tundra species including mosses, grasses and sedges. On the cliff and bedrock outcrops vegetation is sparse and consists of lichens with patches of grasses and mosses.

3 EXISTING SITE CONDITIONS

Environmental investigations have been carried out at the site dating back to 1988. The work has focused on the presence and impacts of petroleum hydrocarbons (PHCs), inorganic elements, pesticides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCB) contamination in soils, surface water, and sediments. Debris quantification and a designated substances building survey was also undertaken.

Significant reports on the Iqaluit Former Metal Dump and Community Landfill that preceded this LTM include:

- Arcadis Canada Inc., 2017. Remedial Action Plan, Former Metal Dump and Community Landfill. Prepared for Public Works and Government Services Canada on Behalf of Transport Canada. 27 January 2017.
- Franz Environmental Inc., 2010a. Remedial Action Plan, Vehicle Dump and Community Landfill, Iqaluit, Nunavut. Prepared for Public Works and Government Services Canada on behalf of Transport Canada.
- Franz Environmental Inc., 2010b. Ecological and Human Health Detailed Quantitative Risk Assessment (DQRA). Prepared for Public Works and Government Services Canada on behalf of Transport Canada.

- Franz Environmental Inc., 2010c. Phase III Environmental Site Assessment, Vehicle Dump and Community Landfill, Iqaluit, Nunavut. Prepared for Public Works and Government Services Canada on behalf of Transport Canada.
- Franz Environmental Inc., 2009, Preliminary Quantitative Risk Assessment (PQRA) – Human Health, Vehicle Dump and Community Landfill, Iqaluit, Nunavut. Prepared for Public Works and Government Services Canada on behalf of Transport Canada. March 2009.
- Franz Environmental Inc., 2009. Phase I/II Environmental Site Assessment, Vehicle Dump and Community Landfill, Iqaluit, Nunavut. Prepared for Public Works and Government Services Canada on behalf of Transport Canada. February 2009.
- Earth Tech Canada Inc., 2001. Desk Top Review of Scrap Metal Dump Site West of Iqaluit Airport, Iqaluit, Nunavut, Canada. Prepared for Transport Canada, Prairie and Northern Region-Programs;
- Lisa A. Peramaki and Jody F. Decker, School of Planning – University of Waterloo, 1999. Lead in Soil and Sediment in Iqaluit Nunavut, Canada and Links with Human Health;
- Royal Military College – Environmental Sciences Group, Victoria, BC, 1995. Environmental Study of a Military Installation and Six Waste Disposal Sites at Iqaluit, NWT. Prepared for Department of Indian and Northern Affairs Canada & Environment Canada;
- Avati Ltd., 1993. Remediation Options for an Abandoned US Airforce Base and Two Waste Sites at Iqaluit, NWT. October 1993;
- Public Works Canada Literature Review, 1992; and
- Härtling, J., 1988. PCB and Trace Metal Pollution from a Former Military Waste Disposal Site at Iqaluit, Northwest Territories. Master's Thesis.

3.1 Areas of Environmental Concern

The ESAs completed in the field seasons of 2008 (Franz, 2009) and 2009 (Franz, 2010c) identified four areas of environmental (AECs) concern at the site as follows:

AEC 1 – Upgradient Buried Debris

The area of the site directly up gradient from the vehicle dump contains buried metal debris identified during the Phase I/II/III ESA completed by Franz (2009, 2010c). The presence of debris was confirmed during the Arcadis 2016 supplemental assessment.

AEC 2 – Vehicle Dump

The area was referred to as the vehicle dump in the Franz (2009, 2010c) studies and described as containing vehicles, such as trucks, cars, trailers, boilers, tankers, and others. During the Arcadis 2016 supplemental assessment, the area was observed to contain fewer debris because much of the vehicular debris was removed in 2011 during a community wide recycling program. The contractor involved in that recycling program removed the vehicles, crushed them and shipped them south. The removal of this debris has previously been communicated to both PSPC and Transport Canada. The area is located to the east of the main landfill area. A drainage channel runs directly through the center of this debris pile discharging to the ponds, then the river.

AEC 3 – Main Landfill

The main landfill area consists of a mixture of debris spread across a steep graded bedrock slope. The top of the landfill area has been capped with granular material and the toe is left exposed with debris scattered throughout the area.

AEC 4 – Downgradient, Off-site

The downgradient and off-site area is located below the escarpment and includes part of the Sylvia Grinnell Park. This area contains only very few pieces of scattered debris. Some debris is also present in the bottom of the ponds, buried in sediments.

The boundaries of AECs 1 to 4 are presented in Figure 2. Note that these boundaries were revised from the Phase III ESA (Franz, 2010c) to account for the updated information obtained by Arcadis during the 2016 supplemental testing and the selection of the site specific EQG (Section 1.2 and 6.4).

3.2 Summary of Site Impacts Prior to Remediation

The potential contaminants of concern were tested in soil, surface water and sediment in all four AECs in 2008 and 2009. In addition, paint from the vehicles present in AEC 2 was also tested for lead content. Vegetation samples were collected in 2008 and 2009 to further evaluate the presence of the contaminants in the environment. In 2008, grain size samples of soil and sediment were collected and in 2009, total organic carbon (TOC) and dissolved organic carbon (DOC) were analysed in sediment and surface water, respectively, to assist with the interpretation of contaminant results. Limited sampling of surface water and sediment was conducted in 2016 to assess any potential changes in the media since the last sampling round conducted in 2009. The number of samples submitted per year and type of analysis is summarized in Table 3-1.

Table 3-1: 2008, 2009 and 2016 Testing Program

Media	Soil			Surface Water			Sediment			Vegetation			Material Sampling			
Year	08	09	16	08	09	16	08	09	16	08	09	16	08	09	16	Total
PHCs	20	11	-	9	7	7	8	18	7	-	-	-	-	-	-	**87**
Metals	27	13	-	19	31	7	20	25	7	11	11	-	-	2	-	**173**
PCBs	13	6	-	15	9	7	11	18	7	9	2	-	-	-	-	**97**
VOCs	5	11	-	2	7	-	2	4	-	-	-	-	-	-	-	**31**
PAHs	7	5	-	2	5	7	2	3	7	-	-	-	-	-	-	**38**
Pesticides	5	1	-	3	10	7	3	18	7	-	-	-	-	-	-	**54**
TOC	-	-	-	-	-	-	-	25	-	-	-	-	-	-	-	**25**
DOC	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-	**31**
Grain Size	5	-	-	-	-	-	2	-	-	-	-	-	-	-	-	**7**

Media	Soil			Surface Water			Sediment			Vegetation			Material Sampling			
Total number of analyses:	82	47	0	50	100	35	48	111	35	20	13	0	0	2	0	543

The findings indicated significant contamination impacts to soils surrounding the upgradient buried debris (AEC 1), the vehicle dump (AEC 2), and at the landfill (AEC 3). Moderate impacts to sediment were noted in the roadside ditch at AEC 1. Moderate to significant impacts to sediment were noted in the drainage ditch leading to pond 6 in AEC 2, with greatest impact at the height of vehicle debris. Significant surface water quality impacts were noted at AEC 3. Moderate and moderate to significant surface water impacts were noted at AEC 1 and AEC 2, respectively. Contamination at AEC 4 was noted as not significant for sediment and water quality. Soils were not tested at AEC 4 and no sediment was observed at AEC 3.

Overall, the drainage pathways and ponding systems were observed to be in the same condition with no evidence of new or worsening impacts between 2008/2009 and 2016.

A more detailed summary of the contaminant impacts is presented in Table 3-2. The spatial distribution of the impacts is represented in the RAP and included as a figure set in Appendix A: Figure 3 for soil, Figure 4 for sediment and Figure 5 for surface water, respectively (Arcadis, 2017).

Table 3-2: Summary of Contaminant Impacts

Area Identification	Impacted Media	Exceedances of EQG	Elevated Leachate Indicator	Impact Location	Degree of Impact
AEC 1 – Upgradient Buried Debris	Soil	Metals (copper); PHCs (F2, F3)	-	Two discrete areas	Significant
	Sediment	Metal (zinc), DDT, DDD, DDE	Metal (calcium)	Small pond and ditch at road near AEC 1 & AEC 2	Not significant (small pond) to moderate (ditch roadside)
	Surface Water	Metals (aluminum, chromium (IV), copper, iron)	-	Small pond and ditch at road near AEC 1 & AEC 2	Moderate
AEC 2 – Vehicle Dump	Soil	Metals (cadmium, copper); PHCs (F2, F3, F4)	-	Three discrete areas	Significant
	Sediment	Metals (arsenic, cadmium, chromium, copper, lead, zinc); DDT, DDD, DDE; 9 PAHs; PCBs	PHCs (F2, F3, F4); Metals (calcium, iron)	Drainage features leading to pond 6	Moderate to significant (degree of impact increases from north to south and present all across AEC 2)
	Surface Water	Metals (aluminum, cadmium,	Metal (zinc)	Drainage features leading to pond 6	Moderate to significant (degree of impact greatest at the height of vehicle debris)

Area Identification	Impacted Media	Exceedances of EQG	Elevated Leachate Indicator	Impact Location	Degree of Impact
		copper, iron, lead)			
AEC 3 – Main Landfill	Soil	Metals (zinc); 3 PAHs	-	Two discrete areas	Significant
	Sediment	-	-	-	None; no sediment observed
	Surface Water	Metals (aluminum, copper, iron, lead, zinc)	Metal (cadmium)	Water accumulation at toe of the landfill	Significant
AEC 4 – Downgradient and Off Site	Soil	-	-	-	-
	Sediment	Metals (cadmium, chromium, copper, lead, zinc), PCBs, 9 PAHs, DDE, DDD	Metals (calcium, iron), PHCs (F1, F2, F3, F4)	Pond 2 to 6	Not significant (pond 2, 4) to moderate (pond 3, 5) to significant (pond 6)
	Surface Water	Metals (boron, chromium (IV), copper, iron), pH, TCE	Metal (zinc), PCB	Pond 1 to 6	Not significant (pond 1, 2, 3) to moderate (pond 4, 5, 6)

4 SELECTED REMEDIAL STRATEGY

The chosen remedial strategy was selected based on predefined RAP objectives including:

- minimizing human health and safety risks at the site;
- protecting ecological habitats;
- minimizing impacts during remediation;
- minimize long-term care and maintenance; and
- blending the final site conditions with the natural environment where possible while being cost-effective and technically feasible.

The remedial options considered suitable or recommended for the site were compared against the AEC specific issues (Section 3.1 and 3.2) to tailor a remedial strategy best suited to the site conditions and these objectives.

The remedial option selected targets:

a) the offsite disposal of significantly impacted soils and sediments;
b) the offsite removal of selected debris based on their waste stream category;
c) the onsite consolidation of debris and comingling impacted soils;
d) the engineered decommissioning of the site main landfill; and
e) the natural recovery of the remaining surface water and sediment impacts.

The selected strategy for each AEC and media/environmental concern is outlined in Table 4-1 below.

Table 4-1: Outline of Selected Remedial Strategy

AEC Identification	Media/ Environmental Concern	Discussion
AEC 1: Up-gradient Debris	Soil	Targeted hot spot removal of PHC impacted soils exceeding selected EQGs. PHC impacted soils to Iqaluit land treatment unit. Metal impacted soils that are contiguous with debris to be consolidated in the landfill.
	Surface Water	Natural Attenuation with removal of impacted soils.
	Debris	Selected debris removal and disposal according to their waste stream. Only exposed debris would be removed, cut and placed within AEC 3 for permanent landfilling. The remaining debris would be capped in place with an engineered cap (no liner).
AEC 2: Vehicle Dump	Soil	Full removal of all impacted soils. PHC impacted soils to Iqaluit land treatment unit and ship south any PCB impacted soils, if encountered. Any soils impacted with metals only could be included in the construction of the main landfill.
	Sediment	Targeted hot spot removal of sediments in the drainage feature from the top of the vehicle dump, down to the top of Pond 6 (not including Pond 6). This strategy would eliminate and remove the impacts currently contributing to the observed impacts down gradient. In addition, there would be minimal disruption to the natural environment. Mitigation measures would be implemented during the removal to prevent the release of sediment downstream into fish frequented waters. Upon hot spot removal of sediments, large (~5 cm to 30 cm) rip-rap would be placed in the drainage channel to slow the run-off and help mitigate and control future erosion. This would also support the natural recovery of downstream sediments.
	Surface Water	Natural Attenuation with removal of impacted soils and sediments. No alteration to the course of the surface water pathways would be required.
	Debris	Full removal of all debris, staging at AEC 1 and cut and placed into AEC 3 for recycling (non-hazardous and recyclable), permanent landfilling (non-hazardous and non-recyclable) and/or shipment south (hazardous).
	General	No soil would be backfilled and exposed bedrock could be left as is after soil excavation. The area consists of a high quantity of exposed bedrock and this would be similar to naturally occurring conditions, within the AEC 3 boundaries.
	Soil	Minimal impacted soil was identified at the landfill proper and if within the landfill footprint, would be capped in place during final landfill construction.

AEC Identification	Media/ Environmental Concern	Discussion
AEC 3: Main Landfill .	Sediment	No sediment is present within the AEC 3 boundaries.
	Surface Water	Minimal surface water is present within the AEC 3 boundaries (seasonal with melt water only). A high level of effort would be assigned to the design and implementation of surface water swales at the top, sides, and toe of the landfill to reduce water runoff loading and erosion of the landfill face.
	Debris	Scattered debris at the toe of the landfill would be cut down and incorporated into the landfill. Any hazardous material would be removed to the staging area, cut and packaged for shipment south. Only exposed debris would be considered for removal south. No excavations into the existing landfill face or cap would occur.
	General	Arcadis proposes a general cap-in place strategy for AEC 3.
AEC 4: Down-gradient ponds	Surface Water	Natural Attenuation with removal of up-gradient impacted soils and sediments.
	Sediment	Natural Attenuation with removal of up-gradient impacted soils and sediments.
	General	Pond 6 contains the highest exceedances of EQGs; however, Arcadis feels that Pond 6 and, to a lesser degree, Pond 5 acts as contaminant attenuation zones for the upgradient waste load. These two ponds have high organic content and established vegetation. It is proposed to not disturb these ponds but to rather keep their contaminant attenuating function and integrate it with the upstream reconstruction of the drainage feature located in AEC 2.

4.1 Engineered Decommissioning of Landfill (AEC 3)

The only major construction component of the remediation strategy is construction and capping of a landfill at the main landfill site. Materials from around the site will be consolidated at the main landfill site and then the existing main landfill and all consolidated wastes will be covered with an aggregate landfill cap. The landfill design includes:

- an engineered landfill aggregate cap;
- consolidate exposed debris from surrounding areas (AEC 1, AEC 2, AEC 3, and AEC 4) into the main slope of AEC 3; and
- extensive swale designs to divert precipitation and melt water away from the landfill slopes to prevent both erosion and water infiltration.

A high level of effort was assigned to the design and implementation of surface water diversion at the top, sides, and toe of the landfill to reduce water runoff loading and erosion of the landfill face. The landfill will require the implementation of the LTM Plan to monitor performance (i.e., this document). The Engineered

Landfill at this site is designed to displace precipitation and meltwater away from the landfill to a predetermined surface water system through the use of swales at the top of the escarpment and at the base of the landfill. It is imperative to control water, as additional water near or within the landfill could generate excess landfill leachate or erosional effects. With passive water management, the landfill should act as an inert waste body with minimal erosion over time. In addition, as the landfill will have a finite mass of contamination, the leaching potential over time decreases as the leaching production curve diminishes over time.

The performance monitoring will consist of visual monitoring for evidence of settlement, erosion, differential movement, collection of soil and water samples from around the facility to monitor the effectiveness of the containment system, and monitoring of local surface waters near the berms and in the main body of the facility (Section 6.0).

5 REMEDIAL PERFORMANCE MONITORING PLAN

The water licence application package detailed the potential environmental and resource effects that may be encountered during the execution of remedial activities on site and identified mitigation measures that will be implemented during remediation. Mitigations for dust, soil and sediment erosion, and water quality are identified in the application (see Appendix B for a table of potential impacts and proposed mitigation measures for all valued ecosystem components).

During active remediation, on-going performance monitoring will be conducted at the site to ensure mitigation measures implemented to reduce additional impacts from remediation efforts are performing as anticipated. The proposed performance monitoring plan is outlined in Table 5-1. It identifies the proposed monitoring activity and frequency of monitoring to be completed. Active remediation is anticipated to be completed by November 15, 2017.

Table 5-1: Performance Monitoring: Potential Effects and Mitigative Measures

Potential Effects noted in Application (Appendix B)	Mitigation Measures	Proposed Monitoring	Monitoring Frequency
Dustfall	On-going road watering during dry conditions, as required	Visual Inspections throughout construction period	Multiple times daily
Soil Erosion	Erosion Control measures including silt fencing and graded staging areas.	Visual Inspections of all erosion control measures throughout construction period	Prior to, during and after precipitation events
Sediment Erosion	Erosion Control Measures including Silt Curtains and silt fencing.	Visual Inspections of all erosion control measures throughout construction period	Prior to, during and after sediment removal

Potential Effects noted in Application (Appendix B)	Mitigation Measures	Proposed Monitoring	Monitoring Frequency
Water Quality	Erosion Control Measures including Silt Curtains and silt fencing.	Point sampling and visual inspections during work in or near water. Measure for temperature, turbidity, total dissolved solids using field instrumentation.	Weekly during remedial work, if within 30 m of a waterbody frequency will increase to 3 times per week minimum

5.1 Surface Water Monitoring Station Locations: Performance Monitoring

As part of the performance monitoring at the site, pre-determined surface water sampling stations have been identified and are presented below in Table 5-2.

Table 5-2: Summary of Proposed Monitoring Sample Stations

Performance Monitoring Station #	Surface Water Sample	Easting (UTM83)	Northing (UTM83)	Feature
1	X	521750.251	7067946.256	Pond 1
2	X	521800.108	7067986.503	Pond 2
3	X	521836.893	7067795.774	Pond 3
4	X	521860.124	7067686.315	Pond 4
5	X	521915.011	7067718.731	Pond 5
6	X	521936.764	7067744.086	Pond 6
7	X	522027.627	7067865.856	Culvert

These sample stations correspond with the sample stations to be utilized during the LTM Plan. During the performance monitoring stage (i.e., during active remediation), each station will be monitored on a weekly basis for the field parameters of pH, temperature, conductivity, Dissolved Oxygen (DO), and turbidity using a field calibrated multi-meter (e.g., YSI 556 or similar). In the event of work being conducted within 30 m of a water body, the monitoring frequency will increase to three times per week minimum, assuming active remediation is occurring within the work area. Results from performance monitoring will be reported in the annual report in accordance with Part B, condition 1(c).

Weekly water quality sampling for the field parameters listed in Table 5-1 will commence at all seven stations at the beginning of August 2017, prior to start of remediation work near waterbodies. This sampling information will act as a baseline together with previous water quality data, when analyzing water quality results during active remediation (i.e., this performance monitoring program); this water quality data will be valuable for comparison purposes when completing long term monitoring as well.

Should performance monitoring results identify concerns with the mitigation measures implemented to reduce impacts from active remediation work, corrective action will be taken immediately. This may include improvements to existing measures (e.g., repair or replacement of silt curtains), or implementation of appropriate additional measures to address concerns. This may include:

- development of a dedicated sampling plan for a specified period;
- installation of additional monitoring locations;
- active or passive source risk reduction measures; and
- additional administrative controls.

5.2 Contingency Planning

In the unlikely event that a spill occurs on site during remediation, a Spill Contingency Plan for the site was submitted with the application and was approved by the Board in issuance of the Water Licence (Part I, condition 1). The activities set out in Part I of the Water Licence and the procedures outlined in the Spill Contingency Plan will be adhered to at all times, in the event of a spill. Additional monitoring plans may be developed to monitor areas where a spill has occurred, as needed.

6 LONG TERM MONITORING PLAN

After remediation work at the site is completed, the only structures that will be constructed and remain at the site are the capped single use landfill and its associated drainage swales.

This LTM Plan will be implemented to monitor the long-term performance of site remediation efforts.

6.1 Post-Closure Monitoring Program

Based on a review of other similar sites throughout Nunavut, with consideration given to INAC's Abandoned Military Site Remediation Protocol, AMSRP (2008), the following post-closure monitoring activities are recommended:

- Visual Monitoring
- Seepage Monitoring
- Potential soil sampling (if seepage is observed)
- Surface Water Monitoring
- Sediment Sampling
- Natural Environmental Monitoring

The following sections discuss each of the monitoring components in more detail.

6.1.1 Visual Monitoring

6.1.1.1 Rationale

Visual monitoring is valuable as it provides information on the condition of the isolation cover and associated berms, culverts and tidal zone. Observations shall be documented with photographs. Pre-determined photograph locations will be established in the first year of monitoring, and these will be used to monitor future changes.

6.1.1.2 Monitoring Plan: Visual Monitoring

Regular visual inspections will be conducted to check the physical integrity of the isolation cover and look for evidence of erosion, frost action, animal burrows, vegetation, staining, seepage points, exposed debris, breeches in the cover, condition of monitoring instruments and condition of the warning signs. The tidal zone and tidal periphery should be included in the inspection as well.

Photographs will be taken to document the condition of the isolation cover and substantiate the recorded observations. Pre-determined photograph locations will be established in the first year of monitoring, and these will be used to monitor future changes. At minimum, photos should be taken from each of these locations during each monitoring event.

The physical integrity of the landfill is to be inspected and reported on. A record of all observations will be collected and will include dimensions and location of each feature and its extent using a DGPS unit and note of significant changes and direction. If ponded water is noted in and around the landfill structure (other than naturally occurring ponds), the depth of water will be recorded along with its horizontal extents. Detailed field sketches will be generated and will include a correlation to existing features, monuments and survey identifiers noted on as-built drawings.

A visual inspection checklist will be utilized to compare the magnitude/severity and extent of features over time. A Visual Inspection Checklist is available in Appendix C of this document.

The following site features will be inspected:

- The isolation cover surface;
    - Settlement
    - Erosion
    - Lateral Movement
    - Frost Action
    - Sloughing
    - Cracking
    - Animal Burrows
    - Vegetation Re-establishment
    - Vegetation Stress
    - Seepage points and/or Ponded Water
    - Debris and/or Exposed Geotextile
    - Features of Note/Other Relevant Observations (e.g., signs of activity, ruts, etc.)
- Access Roadway

- Culverts
- Down-gradient Ponds
    - Staining
    - Vegetation Stress

This visual inspection monitoring program will be a significant component of the LTM Plan.

6.1.2 Seepage Monitoring

6.1.2.1 Rationale

Seepage (i.e. surface water seeping through the landfill isolation cover) may be observed at some point during the LTM Plan. Water that contacts unfrozen landfill waste may become acidic and contain elevated concentrations of metals. Seepage monitoring, in combination with visual inspections, will indicate whether long term containment of the landfill waste is maintained or if corrective action may be required.

This seepage monitoring program will be a potential component of the LTM Plan, used in support of the observations made through the visual monitoring program.

6.1.2.2 Monitoring Plan: Seepage Monitoring

Any potential observed areas of seepage on the surface and edges of the landfill isolation cover will be noted during the Visual Inspection. Seepage samples will be collected from these areas, where sufficient volume exists. These samples will be analysed and the results will be compared to baseline/background samples, as well as applicable CCME guidelines (Section 1.2 and 6.4).

Water samples will be analyzed for:

- Petroleum Hydrocarbons (PHCs), F1 to F4 (including BTEX)
- Arsenic, Cadmium, Cobalt, Chromium, Lead, Nickel, and Zinc
- Polychlorinated biphenyls (PCBs)
- Major ions, hardness, total dissolved solids, total suspended solids
- pH, conductivity and temperature

In addition, soil may also be collected at any given potential seepage point as per Section 6.1.3.

6.1.3 Soil Sampling

6.1.3.1 Rationale

Soil sampling would be conducted on an as needed basis in the event of observed seepage through, below, or around the landfill isolation cover. Soil sampling would provide information pertaining to the state of any observed seepage points, including chemical composition and concentrations.

This soil sampling program will be a potential component of the LTM Plan, used in support of the observations made through the visual monitoring and seepage monitoring programs.

6.1.3.2 Monitoring Plan: Soil Sampling

Soil sampling would be conducted on an as needed basis in the event of observed seepage through, below, or around the landfill isolation cover. Soil sampling would be limited to areas where seepage or staining has been identified as part of the visual inspection. When required, soil samples will be collected over the intervals of 0 to 0.15 metres and 0.35 to 0.5 metres depth (where possible). The parameters that will be analysed will include:

- Petroleum Hydrocarbons (PHCs), F1 to F4 (including BTEX)
- Arsenic, Cadmium, Cobalt, Chromium, Lead, Nickel, and Zinc
- Polychlorinated biphenyls (PCBs)

The results will be compared to baseline/background samples, as well as applicable CCME guidelines (Section 1.2 and 6.4).

6.1.4 Surface Water Monitoring

6.1.4.1 Rationale

The natural drainage around the study area is influenced by the bedrock structure and numerous small, elongated ponds that have formed along fault lines and joints. The ponds are shallow (approximately less than 0.5 m deep) and are poorly drained. Six ponds of varying sizes exist on site and were assigned numbers from 1 to 6 (Figure 2). Three of these ponds experience influx of brackish ocean water twice daily (ponds 1, 3, and 4). The other three ponds are considered to be under a freshwater environment (ponds 2, 5 and 6). Two of these ponds (ponds 5 and 6) appear to play a crucial role in naturally attenuating sediment and surface water contaminants prior to discharge into the Sylvia Grinnell River.

Surface water monitoring will provide valuable information on the on-going state of the down-gradient surface water bodies. This plan would effectively provide an early warning system that could be implemented in association with a Contingency Plan and could provide the decision criteria for termination.

6.1.4.2 Monitoring Plan: Surface Water Sampling

Surface water sampling will be conducted at pre-determined LTM sampling stations (Figure 3; Section 6.2) along the down-gradient drainage and pond system. These sample stations were selected to correspond with previous surface water sampling conducted on site in order to maintain consistency and have comparable concentrations.

Additional surface water samples may be warranted based on the results of the visual inspection and identification of any potential seepage points (Section 6.1.1). These samples will be analysed a and the results will be compared to baseline/background samples, as well as applicable CCME guidelines (see Section 1.2 and 6.4).

Surface water samples will be analysed for:

- Petroleum Hydrocarbons (PHCs), F1 to F4 (including BTEX)
- Arsenic, Cadmium, Cobalt, Chromium, Lead, Nickel, and Zinc

- Polychlorinated biphenyls (PCBs)
- Major ions, hardness, total dissolved solids, total suspended solids
- pH, conductivity and temperature

6.1.5 Sediment Sampling

6.1.5.1 Rationale

As with surface water, the natural drainage around the study area is influenced by the bedrock structure and numerous small, elongated ponds that have formed along fault lines and joints. The ponds are shallow (approximately less than 0.5 m deep), and are poorly drained. Six ponds of varying sizes exist on site and were assigned numbers from 1 to 6 (Figure 2). Three of these ponds experience influx of brackish ocean water twice daily (ponds 1, 3, and 4). The other three ponds are considered to be under a freshwater environment (ponds 2, 5 and 6). Two of these ponds (ponds 5 and 6) appear to play a crucial role in naturally attenuating sediment and surface water contaminants prior to discharge into the Sylvia Grinnell River.

Sediment monitoring will provide valuable information on the on-going state of surface water bodies located down-gradient of the former infrastructure and the landfill. This plan would effectively provide an early warning system that could be implemented in association with a Contingency Plan and could provide the decision criteria for termination.

6.1.5.2 Monitoring Plan: Sediment Sampling

Sediment sampling will be conducted at pre-determined LTM monitoring sample stations (Figure 3; Section 6.2) along the down-gradient drainage and pond system and will correspond (i.e., twin) with the LTM surface water stations. These samples will be analysed and the results will be compared to baseline/background samples, as well as applicable CCME guidelines (Section 1.2 and 6.4).

Sediment samples will be analysed for:

- Petroleum Hydrocarbons (PHCs), F1 to F4 (including BTEX)
- Arsenic, Cadmium, Cobalt, Chromium, Lead, Nickel, and Zinc
- Polychlorinated biphenyls (PCBs)

6.1.6 Natural Environmental Monitoring

6.1.6.1 Rationale

Natural environment data will be collected as part of the LTM Plan at the site. This will include observations of animal usage of the site (i.e., direct observation, tracks, scat, etc.) and discussions with locals knowledgeable with the site regarding site usage (i.e., fishing, hunting, gathering, etc.). This information may be helpful for future planning.

6.1.6.2 Monitoring Plan: Natural Environmental

Natural environment data will be collected during site visits as well as during community meetings with people who use or visit the site/area frequently. The purpose of collecting this data is to provide anecdotal information related to the presence of wildlife and changes over time.

The site-specific data to be collected will include:

- wildlife sightings (species, number, gender, juveniles);
- other evidence of recent presence of wildlife (droppings, tracks, feathers/fur, carcass remains, etc.);
- wildlife activity (summering/nesting/denning, migratory/passing through);
- qualitative assessment of relative numbers versus previous years (more, same, less); and
- revegetation of disturbed areas versus previous years (more, same, less).

Information regarding observations of the site by local people may also be collected through consultations with local community members. The type of information that may be collected includes:

- wildlife sightings;
- use by people for traditional activities;
- season(s);
- activities (hunting, fishing, trapping, camping, other harvesting);
- relative frequency versus previous years (more, same, less);
- wildlife species present (sightings or evidence);
- wildlife presence versus previous years (more, same, less);
- health of wildlife observed or harvested (good, average, poor); and
- relative health of wildlife versus previous years (better, same, worse).

6.2 Monitoring Station Locations

Pre-determined surface water and sediment sample station have been identified and are presented below in Table 6-1 and on Figure 3:

Table 6-1: Summary of Proposed Long Term Monitoring Sample Stations

LTM Station #	Surface Water Sample	Sediment Sample	Easting (UTM83)	Northing (UTM83)	Feature
1	X	X	521750.251	7067946.256	Pond 1
2	X	X	521800.108	7067986.503	Pond 2
3	X	X	521836.893	7067795.774	Pond 3
4	X	X	521860.124	7067686.315	Pond 4
5	X	X	521915.011	7067718.731	Pond 5
6	X	X	521936.764	7067744.086	Pond 6

LTM Station #	Surface Water Sample	Sediment Sample	Easting (UTM83)	Northing (UTM83)	Feature
7	X	X	522027.627	7067865.856	Culvert

6.3 Effluent Discharge Limits

No discharge of effluent will occur as part of remediation of the site or during the post remedial stage. Should seepage from the landfill be noted during long term monitoring, it will be tested and compared against the water quality criteria included in Part D, condition 9 of the Water Licence:

Table 6-2: Effluent Discharge Limits as per Part D, condition 9 of Water Licence

Parameter	Maximum Concentration of any Grab Sample (µg/L)
pH	6 to 9
Oil and Grease	5000
Benzene	370
Toluene	2
Ethylbenzene	90
Inorganics (Total)	
Arsenic	100
Cadmium	10
Chromium	100
Cobalt	50
Copper	200
Lead	50
Mercury	0.6
Nickel	200
Zinc	500

Should seepage water quality exceed these allowable concentrations, water will be collected or treated in accordance with Part D, condition 10.

6.4 Selection of EQGs for Evaluation of Soils, Water Quality, and Sediment

Based on a review of the site settings, site usage, municipal zoning and adjacent activities, the site was divided into land use sectors for the purpose of evaluating the soil, water quality and sediment environmental quality against the EQGs.

6.4.1 Soils

For soils evaluation, the site was divided into two land use sectors (Figure 6-1). The coarse grained EQG were applied to both sectors since they are the most stringent of the set and considering that both fine and coarse grained soils were observed at the site.

Wildland Sector

The lower sector below the escarpment and encompassing ponds 1 to 6 and part of the Sylvia Grinnell Territorial Park was considered to be a wildland sector. This sector is outlined as Area of Environmental Concern 4 (AEC 4) in Figure 6-1.

The Sylvia Grinnell Territorial Park plays a significant role in bird migration and over 40 species have been recorded in the park at different times of the year. CCME agricultural/wildland use is defined as "*Land on which the primary activity is related to the productivity capability of the land and includes lands that provide habitat for wildlife and birds*". Based on this definition and on significance of the park's habitat, the CCME wildland guidelines are applicable to the northern section of AEC 4 which is part of the park.

The southern portion of the AEC 4 presents similar geomorphological/biological features and the presence of equivalent wildlife habitat can be expected throughout AEC 4. The wildland soil EQG are protective of the more sensitive ecological habitats expected in the area while protecting for the recreational usage observed and permitted by the municipal zoning (i.e., Iqaluit by-law 704 Open Area Zone (OR) which permits the use of the area as cultural interpretation centre, dog area, park, beach shack, temporary camping structures and utility installation).

Commercial Sector

The upper sector including the vehicle dump, the landfill and the upper debris was considered to be a commercial sector. This sector is outlined as AECs 1, 2, and 3. This sector is predominantly located within Iqaluit by-law 704, zone M2 and is regulated for heavy industrial usage. This sector also already includes a zoning allowance for a former waste disposal site (Iqaluit by-law, zone MR, exclusion 1).

The local residents are known to use the area for social activities (e.g., bonfire) and for accessing the Sylvia Grinnell River and Park. It is assumed that this behavior will continue following the remediation of the site and that no residential dwellings will be installed in the sector.

The CCME commercial guidelines would be protective of the site users and ecological receptors because they are calculated based on 10 hours a day, 5 days a week, 48 weeks a year, exposure assumptions that include site usage by all members of the public, including children (toddlers) and that consider the different potential exposure routes such as direct soil contact (ingestion and dermal contact), vapour inhalation and ecological soil contact.

6.4.2 Surface Water and Sediment

Surface water and sediment EQG are further refined into freshwater or marine environment. The commercial sector including AECs 1, 2, and 3 contains drainage features and small ponds that act as headwater to the wildland sector. Surface water and sediment from this sector is not affected by the tides and the freshwater EQG are applicable. Similarly, the eastern portion of the wildland sector (AEC 4) including ponds 2, 5 and 6 is not considered to be significantly affected by the tides and the freshwater EQG are applicable.

The western portion of the wildland sector (AEC 4) including ponds 1, 3 and 4 is replenished by the upstream freshwater features and intruded with saline water twice daily during high tide. Sodium concentrations measured in these ponds are generally less than the 1000 mg/L freshwater threshold; however, since it was observed that marine water intrudes the ponds and in the absence of sufficient information on resident species and environmental conditions, the water quality guideline protecting the most sensitive condition should be applied (CCME, 2007; *A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life 2007*). As such, the ponds are considered a brackish water environment and the lowest of the freshwater or marine surface water/sediment guidelines are applicable.

Federal groundwater EQG have been published by the CCME and under the Federal Contaminated Sites Action Plan (FCSAP); however, they have not been used in developing this monitoring plan. Exposure to contaminated groundwater is considered not applicable to the site (i.e., groundwater exposure pathway non-operable) for the following reasons:

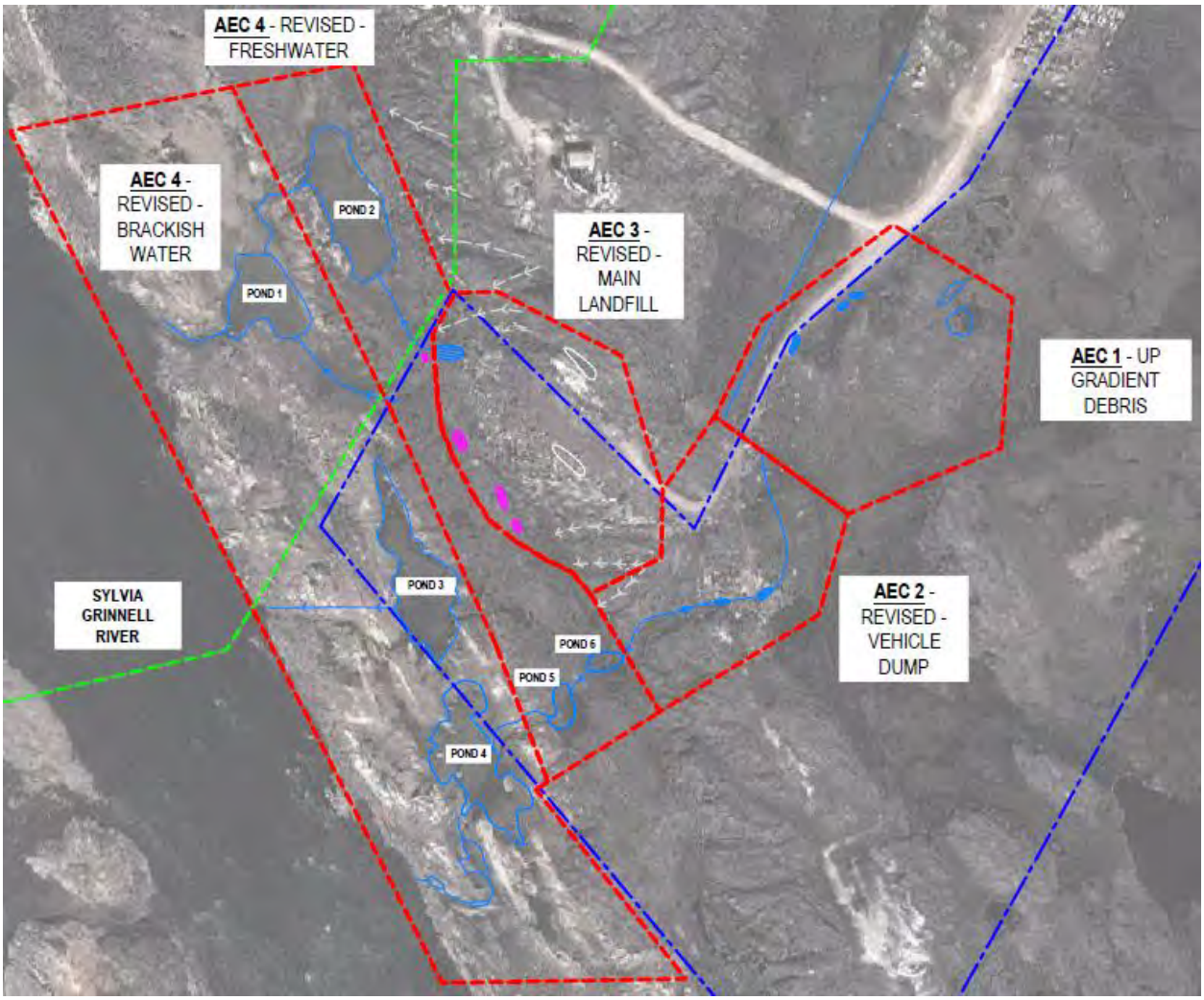
1) overland flow is the primary mode of water transport in the area;
2) groundwater associated with fractures in the bedrock and through the thin overburden would likely be minor;
3) groundwater is not used as a drinking water source in the area; and
4) the site lies within the continuous permafrost zone (Franz, 2010c).

The site specific EQG are summarized in Table 6-3 for the different sectors.

Table 6-3: Summary of Site Specific Environmental Quality Criteria

Sector	AEC	EQG
Upper	1, 2, 3	Commercial, Freshwater, Coarse grained soil
Lower – Eastern portion	4	Wildland, Freshwater, Coarse grained soil
Lower – Western portion	4	Wildland, Lowest of Marine or Freshwater, Coarse grained soil

Figure 6-1: AEC Boundaries



6.5 Quality Assurance and Quality Control Plan

Sample collection, preservation and analyses will be conducted in accordance with methods prescribed in the current edition of “Standard Methods for the Examination of Water and Wastewater” in accordance with Part K, condition 2 of the Water Licence. Analyses will be performed in a Canadian Association of Laboratory Accreditation (CALA)- certified Laboratory and will conform to ISO/IEC Standard 17025 (Part K, condition 3). A letter from Maxxam Analytics is included in Appendix D, in accordance with Part K, condition 6 of the Water Licence. This letter confirms acceptance of this proposed QA/QC Plan by an accredited laboratory.

6.5.1 Sample Methodologies

6.5.1.1 Solids

Solids, for the purpose of this project, refer to soil and sediment samples. Samples will be collected from test pits or sediments manually excavated with hand tools (pick/shovel or Eckman dredge) which will be decontaminated between locations using Alconox and distilled water. Field personnel will use a new pair of Nitrile gloves for each sample station. Each solid sample will be collected in either laboratory supplied zip-top plastic bags and/or 125 mL clear glass jars, which will be filled with soil such that no headspace remains in the jars. Samples collected for analysis of volatiles (i.e., VOCs and/or BTEX) will be collected in two 40 mL clear glass vials with methanol for preservation.

All soil sampling locations will be backfilled after the collection of soil samples. All locations will be photographed during sampling and after backfilling is completed, these photographs will be included in the photographic records (Section 6.1.1).

6.5.1.2 Aqueous

Surface water samples will be collected by dipping laboratory supplied sample containers with the appropriate preservative (e.g., NAHS04 for F1/BTEX) directly into the water body. Care will be taken not to disturb any sediments in order to minimize sediment entrainment in the sample matrix. Surface water sampling will be conducted prior to any sediment sampling activities. Field personnel will use a new pair of Nitrile gloves for each sample station.

The following parameters will be monitored in the field using a calibrated multi meter: pH, temperature, conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), and total dissolved solids (TDS). The field meter will be decontaminated using Alcanox and water between each sample station.

6.5.2 Sample Duplicates

Quality assurance/quality control (QA/QC) will be consistent with CALA regulations and guidelines. At least 10% of samples will be taken and analyzed in duplicate and appropriate QA/QC data will be generated and reported. All samples will be given sequential alphanumerical coding before submitting to the analytical laboratories; this coding method will mask any information concerning site location, sample type or possible concentrations in the samples.

Sampling procedures and laboratory analytical precision will be evaluated by calculating the relative percent difference (RPD) for a sample and duplicate pair according the following equation:

$$RPD = | X_1 - X_2 | / X_{avg} \times 100$$

where: x_1 and x_1 are the duplicate concentrations and x_{avg} is the mean of these two values.

The duplicate results were evaluated using criteria developed by Zeiner (1994), which draws from several data validation guidelines developed by the United States Environmental Protection Agency (USEPA). According to these criteria, the RPD for duplicate samples should be less than 40% for aqueous samples, and less than 60% for solid samples. In addition, the newly developed CCME Guidance manual –

PN1551; 2016 indicates the use of RPD values of less than 40% for aqueous samples, and less than 60% for soils. RPDs can only be calculated when the compound is detected in both the original and the duplicate sample at concentrations of five times above the reportable detection limit (or method detection limit - MDL), or greater. Alternative criteria are used to evaluate duplicate pairs where one or both of the results are less than five times the MDL, or where one or both of the results is less than the MDL (i.e. nd or 'not-detected'). The alternative criteria used for the evaluation of the data, adapted from Zeiner (1994), are presented in the table below. When both concentrations are less than the MDL, no calculation/evaluation criterion is required.

Table 6-4: Criteria for the Evaluation of Blind and Duplicate Sample Results

Scenario	Result A	Result B	Criteria for Acceptance	
			Aqueous (water)	Soil (Soil)
A	nd	nd	Acceptable precision; no evaluation required	
B	nd	positive	result B – 0.5 x MDL < MDL	result B – 0.5 x MDL < 2 x MDL
C	positive and > 5 x MDL	positive and > 5 x MDL	RPD < 40% (Zeiner)	RPD <60% (Zeiner)
D	positive and < or = 5 x MDL	positive	|result B – result A| < MDL[1]	|result B – result A| < 2 x MDL[1]

Source(s):

Zeiner, S.T., Realistic Criteria for the Evaluation of Field Duplicate Sample Results, Proceedings of

Superfund XV, November 29-December 1, 1994, Sheraton Washington Hotel, Washington, D.C. – modified to use Method Detection Limit (MDL) or Reportable Detection Limit (RDL) in lieu of the Quantitation Limit (QL), the Instrument Detection Limit (IDL) and/or Laboratory Reporting Limit (LRL).

Notes:

nd – not detected

RPD – relative percent difference, |result A - result B| / |(result A + result B)/2|

1. When result reported are less than half the quantitation limit, half the limit will be used in the equation.

The precision is considered acceptable when the evaluation criteria are met or when both results are below the MDL. When the evaluation criteria are not satisfied, the following apply:

- nd vs. positive – unacceptable precision: the positive result is considered an estimate and the nd result is considered inconclusive.
- Positive vs. positive – unacceptable precision: the results are considered an estimate.

7 LONG TERM MONITORING SCHEDULE AND REPORTING

7.1 Schedule

Based on other landfill sites throughout the arctic and upon review of INAC's Abandoned Military Site Remediation Protocol, AMSRP (2008), Arcadis identifies that a three phase approach to monitoring is commonly implemented for remediation of landfill sites:

- Phase I: Years 1 through 5; sampling every other year (for a total of 3 sampling events).

- Contingency -Phase II: up to year 25, with progressively reduced sampling frequencies (for a total of four sampling events).
- Contingency -Phase III: beyond 25; frequency as determined.

At the end of each of Phase I, II, and III an evaluation of results is commonly completed and recommendations for termination of monitoring or continuation into the next monitoring phase are presented.

The RAP for the site indicates that monitoring will continue to December 2020. In consideration of the proposed timeline, the Board issued Water Licence 1BR-MDR1721, for a period of four years, expiring July 31, 2021.

To align this proposed monitoring plan with the RAP and the current Water Licence timelines and reporting requirements, Arcadis recommends the post-closure monitoring program outlined in Section 6.0 be undertaken on an annual basis from 2018 to 2020; this allows three sampling events to be completed prior to Licence expiry, conforming to the number of sampling events AMSRP recommends be undertaken in the first Phase of post-closure monitoring, while accommodating the current Water Licence timeline.

Each of the monitoring activities discussed above (Section 6.0) will be conducted during each of the three site monitoring events (i.e., visual inspection, surface water monitoring, sediment monitoring, and natural environment monitoring – with the possibility of seepage monitoring and/or soil monitoring on an as needed basis). A site monitoring event would be conducted once each monitoring year between the dates of July 15th and September 1st to account for the maximum permafrost thaw conditions.

An evaluation and review of the monitoring data will then be conducted at the end of 2020 once three years of monitoring data have been collected, to re-evaluate the monitoring requirements for any future phases.

A final report with recommendations for any future monitoring will be provided to the Board in the 2020 Annual Report, to be submitted on March 31, 2021 (Part B, Condition 1). Should evaluation identify that additional long-term monitoring is required beyond the term of the Licence, the Board will be notified that a Water Licence application for renewal will be submitted.

The Water Licence Annual Reporting timelines allow enough time for submission of a renewal licence application within the Board's recommended timelines (a minimum of three months prior to Licence expiry on July 31, 2021). Any recommended updates to the monitoring program would then be discussed in consideration of the water licence renewal application, as necessary.

Table 7-1 below summarizes the proposed monitoring schedule.

Table 7-1: Proposed Monitoring Schedule

Year	Years After Construction	Site Monitoring Event	Reporting Action
2017	0	Remediation and Landfill Construction	

Year	Years After Construction	Site Monitoring Event	Reporting Action
2018	1	X	Remediation and Landfill Construction results reported in 2017 Annual Report
2019	2	X	Year 1 monitoring results reported in 2018 Annual Report
2020	3	X	Year 2 monitoring results reported in 2019 Annual Report
2021	4	-	Year 3 monitoring results reported in 2020 Annual Report, including recommendations from the program re-evaluation

7.2 Reduction or Termination of Site Monitoring

As part of the monitoring plan, a reduction or termination of specific locations will be developed and any recommendations for changes will be presented in the annual monitoring report. Results of the site monitoring would be compared against the regulatory limits to provide continuous feedback for hazard identification and compliance with the data analysis and response actions.

The reduction or termination of the site monitoring could be evaluated against the following criteria (as examples):

1) Outside of the source area, are the chemical results consistently below the appropriate Regulatory Limit over the predefined monitoring period?
2) Outside of the source area, do the chemical results demonstrate a trend of reduced, non-detectable or steady state concentrations over a predefined sampling period?
3) Do the natural attenuation processes at the site remain consistent and predictable with previous interpretations
4) Have the pathways and/or receptors identified been modified or eliminated?

If these criteria have been met then the site monitoring could be reduced or terminated despite the fact that concentrations of contaminants of concern (COCs) within the source area could still remain above the Regulatory Limits.

7.3 Reporting

7.3.1 Nunavut Water Board Annual Reporting

Annual reporting will be submitted to the Nunavut Water Board in accordance with Part B, Section 1 of the Water Licence and will include:

1. A summary report of water use activities;
2. A summary of any construction work, modification and major maintenance work (includes as-built diagrams) carried out;
3. Tabular summaries for all data and information generated under the Monitoring Program;
4. A review and analysis of data collected during the Monitoring Program and a brief description of any future studies planned;

5. The results of any review conducted and any recommendations regarding any changes to the monitoring program and/or remediation requirements;
6. A summary of any remediation work undertaken during the year and an outline of any work anticipated for next year;
7. A list of unauthorized discharges and summary of follow-up actions taken;
8. Any updates or revisions for manuals and places as required by changes in operation and/or technology;
9. If applicable, a description of any trenches and sumps excavated, including the following; GPS coordinates, dimensions, depth below active layer, and secondary containment features;
10. A brief summary of work done to address any concerns of deficiencies listed in the inspection reports and/or compliance reports prepares by the Inspector;
11. An executive summary in English and Inuktitut of all plans, reports, or studies conducted under this Licence; and
12. Any other details on Water use or deposit of Waste requested by the Board by 1st of November of the year being reported.

7.3.2 Long Term Monitoring Annual Report

In addition to NWB Reporting, upon completion of each monitoring event, as outlined above in Section 7.1, a Long Term Monitoring report will be created as per contractual agreements with PSPC and TC. One annual monitoring report will be created for each monitoring event and will include:

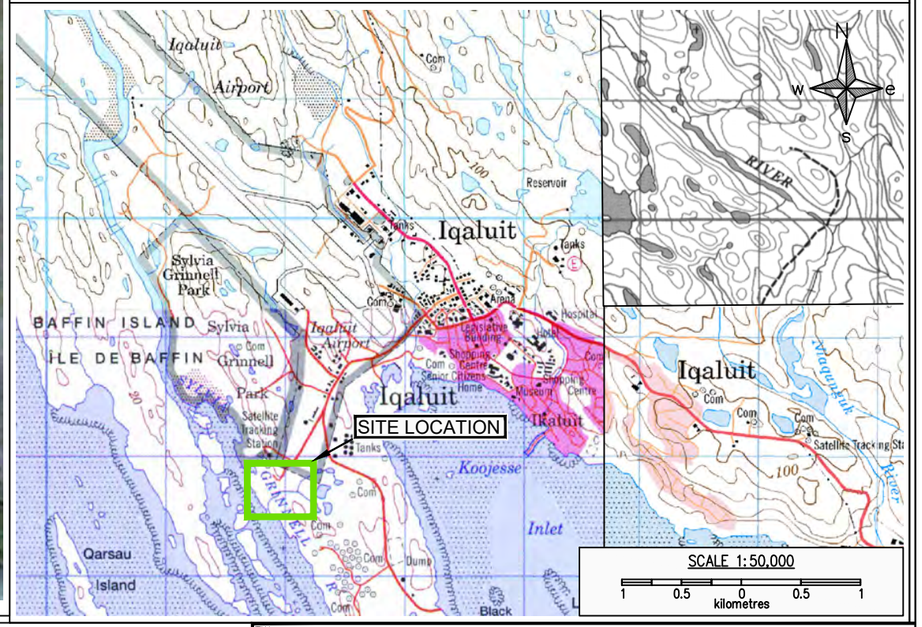
- An executive summary describing the main observations, assessment and conclusion (visual inspection results, assessment and conclusions) and any items to be addressed during subsequent site visits;
- A brief (max two to four pages) outline for the site with work objectives and scope of work, location map, site plan, timing of and weather conditions during field work, field staff and schedule, approach/methodology and equipment used for each monitoring component, and any deviations from the monitoring plan;
- The main landfill inspection section will include:
    - A landfill description;
    - Completed visual inspection checklist;
    - A geotechnical stability assessment (including severity rating for each feature of note). This must provide an overall performance rating for the landfill;
    - A discussion on any items identified during the visual and stability assessment assessed as “significant” or “unacceptable”;
    - A photolog outlining all of the sample locations/stations, overview viewpoints of the landfill, details of any features of note, and any changes from year to year;
    - Annotated drawings of the landfill area showing all visual inspection features, photospot viewpoints, chemical monitoring sample points and surface water flow directions;
    - Analytical data from any chemical testing will be tabulated in excel format and presented. Formal laboratory certificates will be included as an appendix;
    - A discussion and comparison of chemical data to both historical and background concentrations, as well as to the selected EQGs (Section 6.4);
    - A discussion on QA/QC relative to the analytical results;

- An analysis of the overall performance of the Landfill base on a combination of current and historical (when available) visual, geotechnical, and chemical values;
- Review concentrations and trends to determine future monitoring requirements and
- Recommendations for future action and conclusions.

8 REVISIONS

If updates to the frequency or activities included in the monitoring plan are required based on results of monitoring completed, PSPC will be notified and provided with an updated monitoring plan. In addition, should monitoring results indicate a reduction in the frequency, number, or location of samples is possible, proposed changes will be submitted to PSPC and the NWB for approval.

FIGURES



References:

(above) Google Earth satellite image, 2008.

(upper right) "*Canada Road Map*", MapArt Publishing, 2003.

(lower right, composite)
Natural Resources Canada NTS Sheet: 25-N/9 Burton Bay, Nunavut, Edition 3, NAD 83, Series A 713, 2001.
Natural Resources Canada NTS Sheet: 25-N/10 Hill Island, Nunavut, Edition 2, NAD 83, Series A 713, 2001.
Natural Resources Canada NTS Sheet: 25-N/15 Iqaluit, Nunavut, Edition 2, NAD 83, Series A 713, 2001.
Natural Resources Canada NTS Sheet: 25-N/16 [No Title] Nunavut, Edition 2, NAD 83, Series A 701, 2001.
(Note: ground elevations shown in metres above mean sea level).

Title: SITE LOCATION

ARCADIS

Project: LONG TERM MONITORING PLAN
LANDFILL - IQALUIT, NUNAVUT

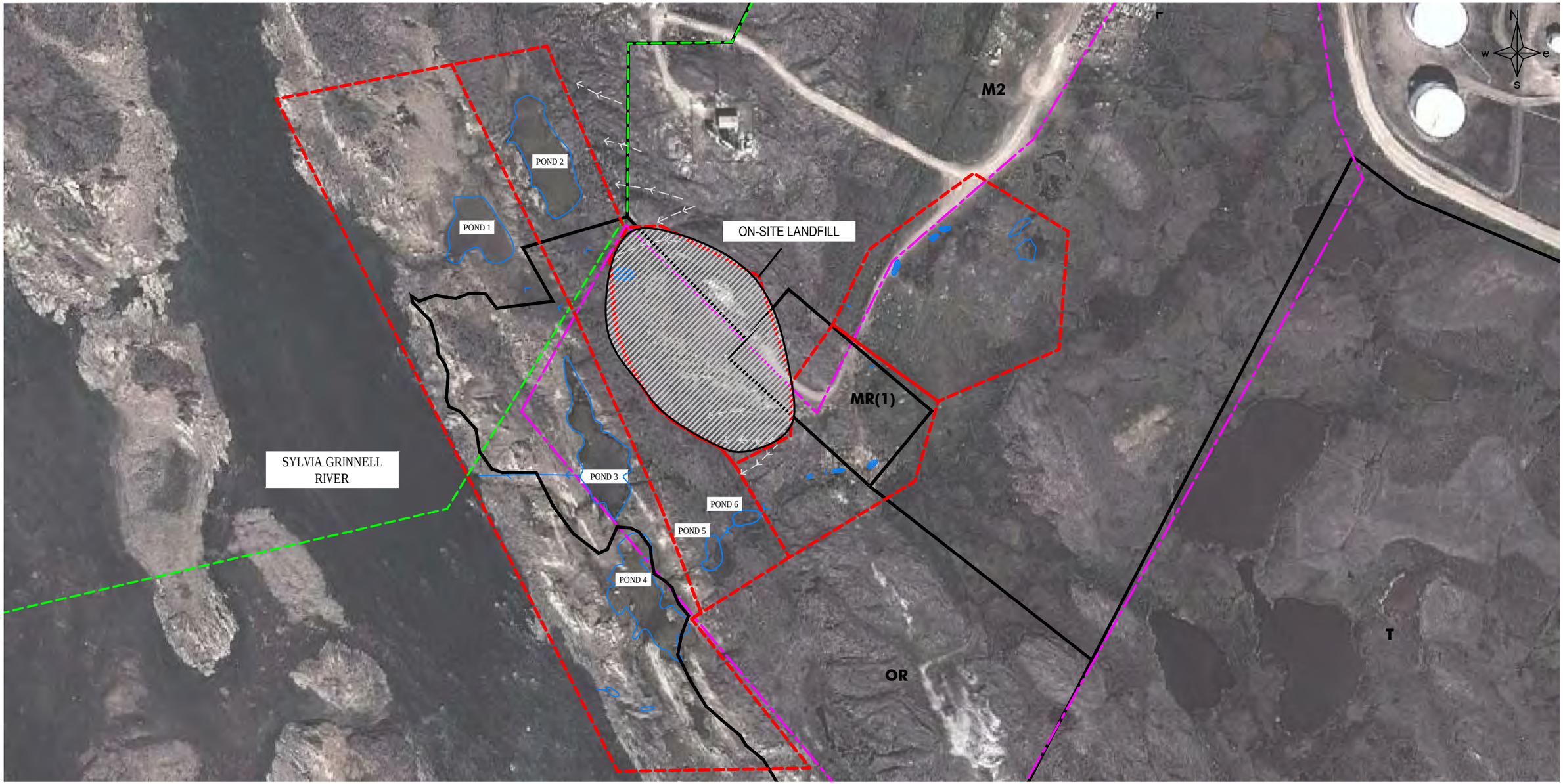
Date: JULY 2017

Client: PWGSC - TRANSPORT CANADA

SCALES AS SHOWN

FIGURE 1

Z:\Projects\2009\1584-0901 TC Iqaluit Landfill\Figures\TC-IQALUIT-LOCATION.dwg



LEGEND:

- PROPERTY BOUNDARY
- PARK BOUNDARY
- IQALUIT ZONING OVERLAY
  - OR = OPEN AREA ZONE
  - MR1 = MUNICIPAL RESERVE ZONE (FORMER DISPOSAL SITE ALLOWANCE)
  - M2 = HEAVY INDUSTRIAL ZONE
  - T = TRANSPORTATION ZONE
- WATER
- APPROXIMATE EXTENT OF COMPLETED LANDFILL
- ADJUSTED FORMER AREAS OF ENVIRONMENTAL CONCERN (AEC)

REFERENCE: BACKGROUND IMAGE OBTAINED FROM GOOGLE EARTH, 2008

SCALE 1: 3000

75 60 45 30 15 0 metres 75 150

Title: LONG TERM MONITORING
FORMER AEC BOUNDARIES AND SITE PLAN

Project: FORMER VEHICLE DUMP & COMMUNITY
LANDFILL - IQALUIT, NUNAVUT

Client: PWGSC - TRANSPORT CANADA

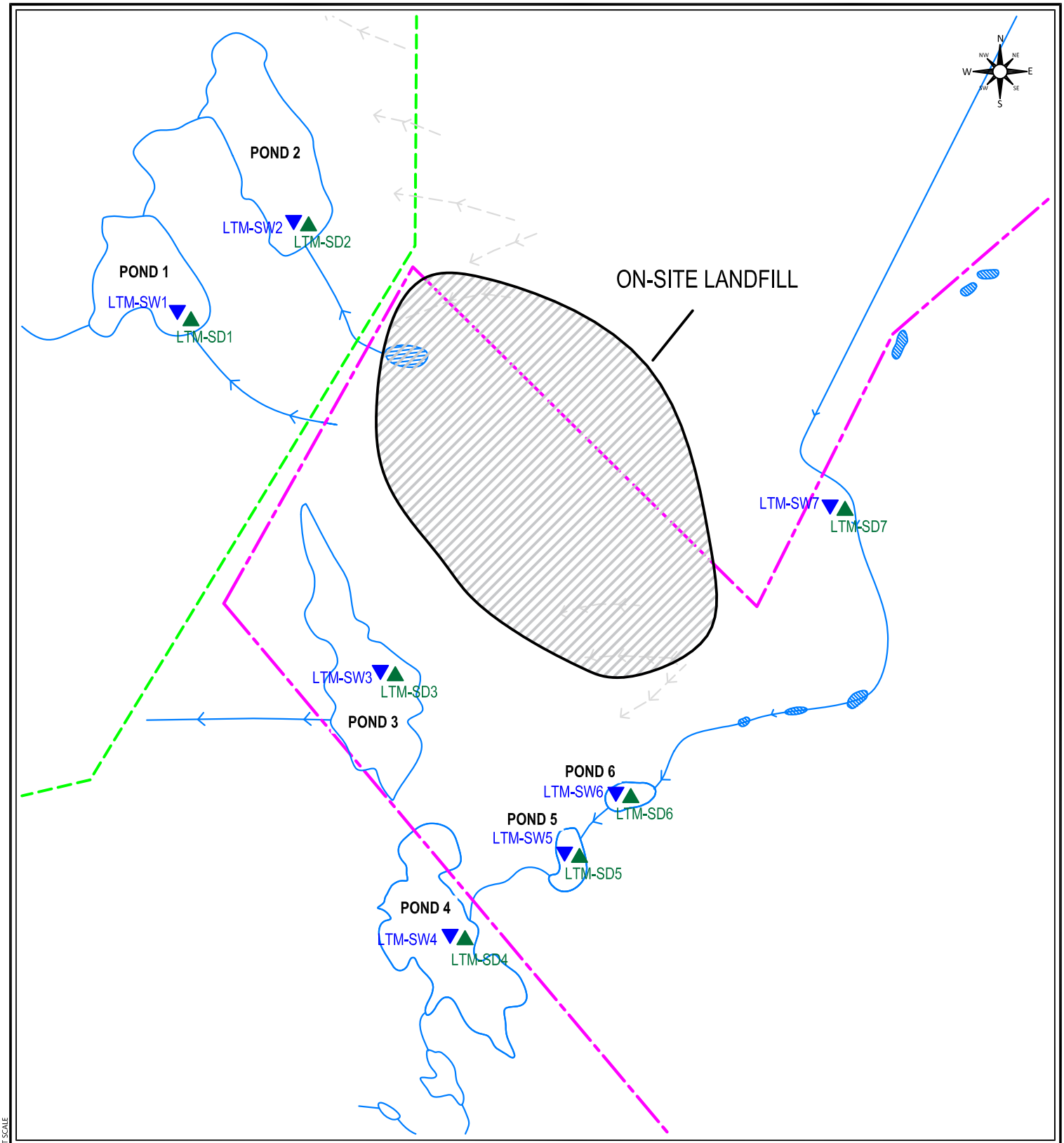
ARCADIS

Date: AUGUST 2017

FIGURE 2

*Original in colour

Z:\Projects\2009\1584-0901 TC Iqaluit Landfill\Figures\102153-000_TC IQALUIT_LTM Program.dwg



Legend

- POOLING WATER
- PROPERTY BOUNDARY
- PARK BOUNDARY
- STREAM/DRAINAGE
- APPROXIMATE EXTENT OF COMPLETED LANDFILL

PROPOSED LONG TERM MONITORING SAMPLES

- LTM-SW4 ▼ PROPOSED SURFACE WATER SAMPLE STATION
- LTM-SD4 ▲ PROPOSED SEDIMENT SAMPLE STATION

0 50 100 Meters

1:1250

Title: LONG TERM MONITORING SAMPLE LOCATIONS

Project: FORMER VEHICLE DUMP & COMMUNITY LANDFILL - IQALUIT, NUNAVUT

Client: PWGSC - TRANSPORT CANADA

ARCADIS

Date: AUGUST 2017

FIGURE 3

TO BE PRINTED IN COLOUR ON 8.5"X11" PAPER ONLY - DO NOT SCALE

updated on:1-Aug-17 by rfletcher

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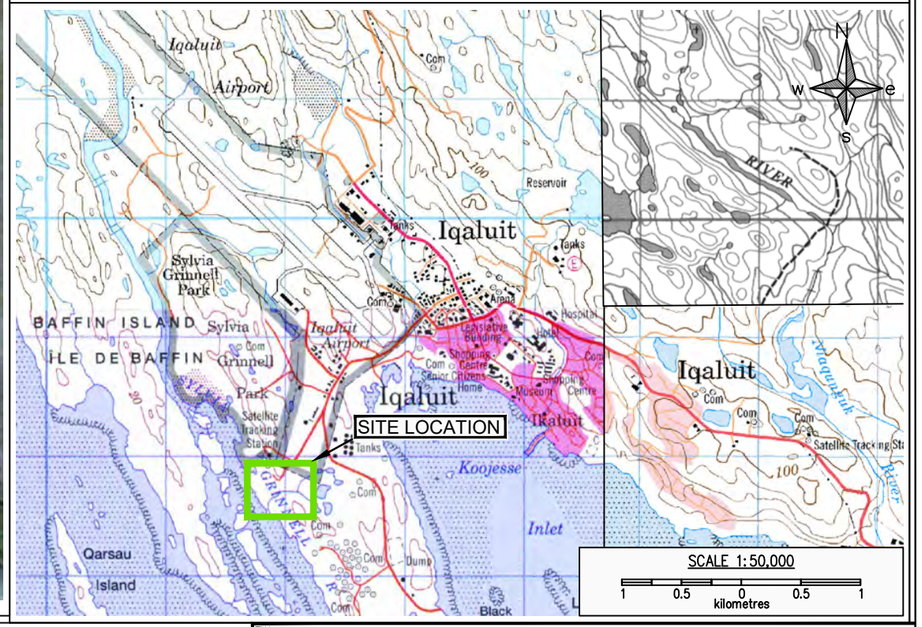
APPENDIX A

Remedial Action Plan Figures



References:

(above) Google Earth satellite image, 2008.

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(lower right, composite)
Natural Resources Canada NTS Sheet: 25-N/9 Burton Bay, Nunavut, Edition 3, NAD 83, Series A 713, 2001.
Natural Resources Canada NTS Sheet: 25-N/10 Hill Island, Nunavut, Edition 2, NAD 83, Series A 713, 2001.
Natural Resources Canada NTS Sheet: 25-N/15 Iqaluit, Nunavut, Edition 2, NAD 83, Series A 713, 2001.
Natural Resources Canada NTS Sheet: 25-N/16 [No Title] Nunavut, Edition 2, NAD 83, Series A 701, 2001.
(Note: ground elevations shown in metres above mean sea level).

Title: SITE LOCATION

ARCADIS

Project: LANDFILL - IQALUIT, NUNAVUT

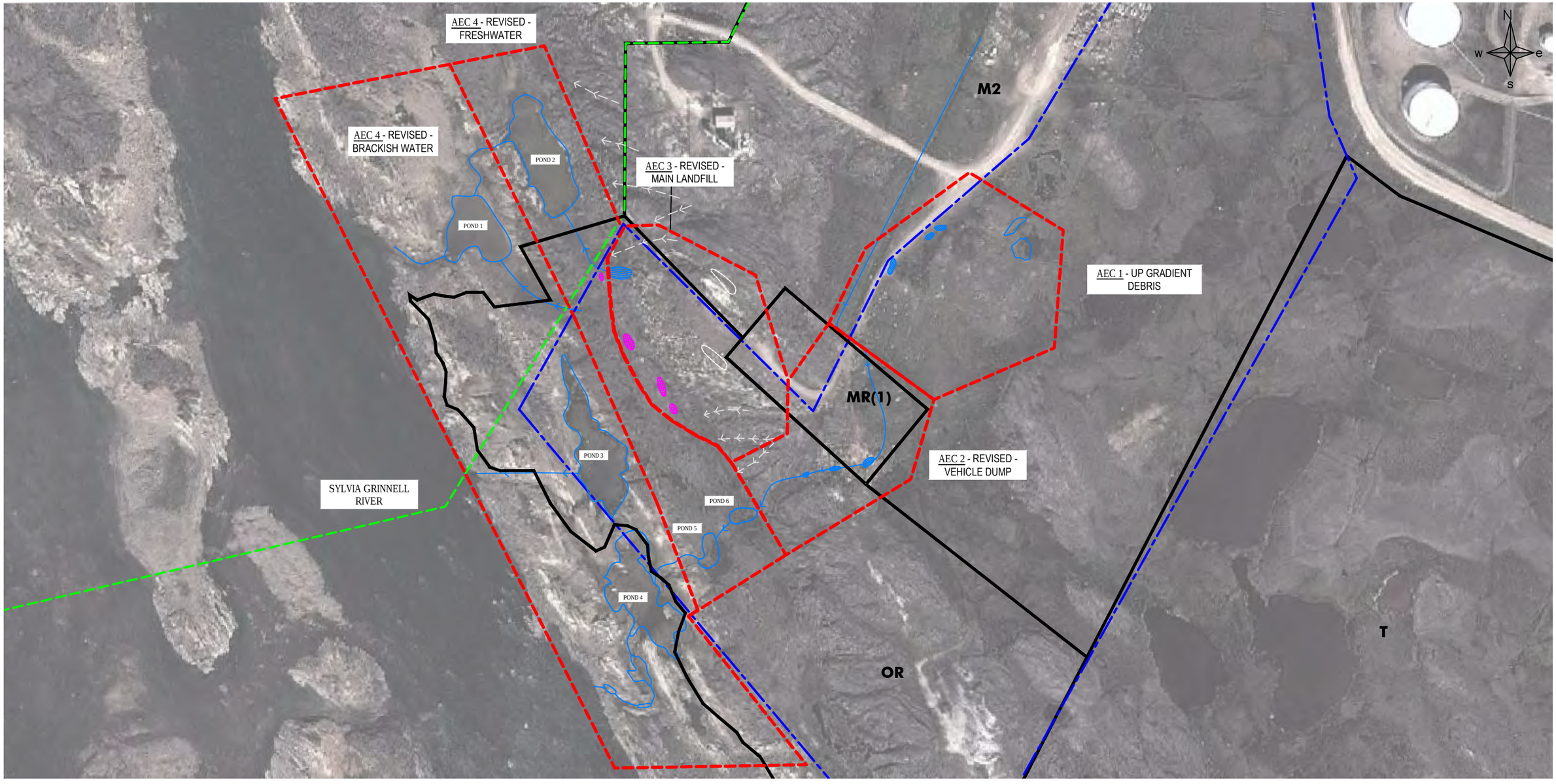
Date: JANUARY 2017

Client: PWGSC - TRANSPORT CANADA

SCALES AS SHOWN

FIGURE 1

Z:\Projects\2009\1584-0901 TC Iqaluit Landfill\Figures\TC-IQALUIT-LOCATION.dwg



LEGEND:

- POOLING WATER
- PROPERTY BOUNDARY
- PARK BOUNDARY
- ADJUSTED AREA OF ENVIRONMENTAL CONCERN (AEC)
- BURN AREA
- DRUMS
- SEEPAGE/GULLY
- STREAM/DRAINAGE

IQALUIT ZONING OVERLAY

OR = OPEN AREA ZONE
MR1 = MUNICIPAL RESERVE ZONE (FORMER DISPOSAL SITE ALLOWANCE)
M2 = HEAVY INDUSTRIAL ZONE
T = TRANSPORTATION ZONE

REFERENCE: BACKGROUND IMAGE OBTAINED FROM GOOGLE EARTH, 2008

SCALE 1:3000

75 60 45 30 15 0 metres 75 150

*Original in colour

Title: REVISED AEC BOUNDARIES AND SITE PLAN

Project: VEHICLE DUMP & COMMUNITY LANDFILL - IQALUIT, NUNAVUT

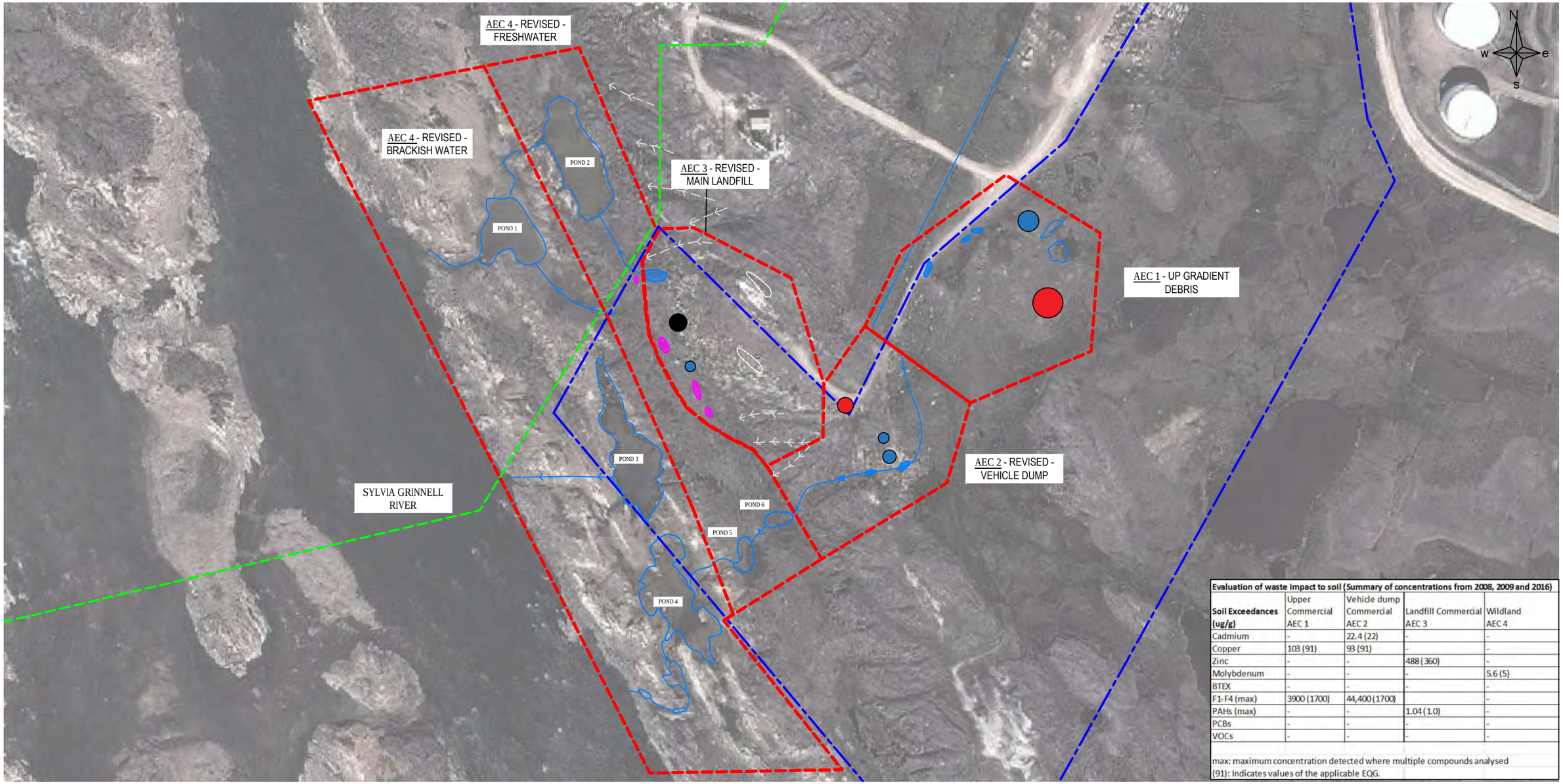
Client: PWGSC - TRANSPORT CANADA

ARCADIS

Date: JANUARY 2017

FIGURE 2

Z:\Projects\2009\1584-0901 TC Iqaluit Landfill\Figures\102153-000_TC IQALUIT_2016_RAP.dwg



Evaluation of waste impact to soil (Summary of concentrations from 2008, 2009 and 2016)

Soil Exceedances (ug/g)	Upper Commercial AEC 1	Vehide dump Commercial AEC 2	Landfill Commercial AEC 3	Wildland AEC 4
Cadmium	-	22.4 (22)	-	-
Copper	103 (91)	93 (91)	-	-
Zinc	-	-	488 (360)	-
Molybdenum	-	-	-	5.6 (5)
BTEX	-	-	-	-
F1-F4 (max)	3900 (1700)	44,400 (1700)		-
PAHs (max)	-	-	1.04 (1.0)	-
PCBs	-	-	-	-
VOCs	-	-	-	-

max: maximum concentration detected where multiple compounds analysed
(91): Indicates values of the applicable EQG.

LEGEND:

- POOLING WATER
- PROPERTY BOUNDARY
- PARK BOUNDARY
- ADJUSTED AREA OF ENVIRONMENTAL CONCERN (AEC)
- BURN AREA
- DRUMS
- SEEPAGE/GULLY
- STREAM/DRAINAGE
- PHC IMPACTED SOIL > COMMERCIAL EQG (LANDFARM)
- METAL IMPACTED SOIL TO BE PLACED IN AEC 3 LANDFILL
- PAH IMPACTED SOIL > COMMERCIAL EQG (LANDFARM OR PLACEMENT IN LANDFILL)

REFERENCE: BACKGROUND IMAGE OBTAINED FROM GOOGLE EARTH, 2008

SCALE 1:3000

75 60 45 30 15 0 metres 75 150

*Original in colour

Title: SOIL IMPACT SUMMARY

Project: VEHICLE DUMP & COMMUNITY LANDFILL - IQALUIT, NUNAVUT

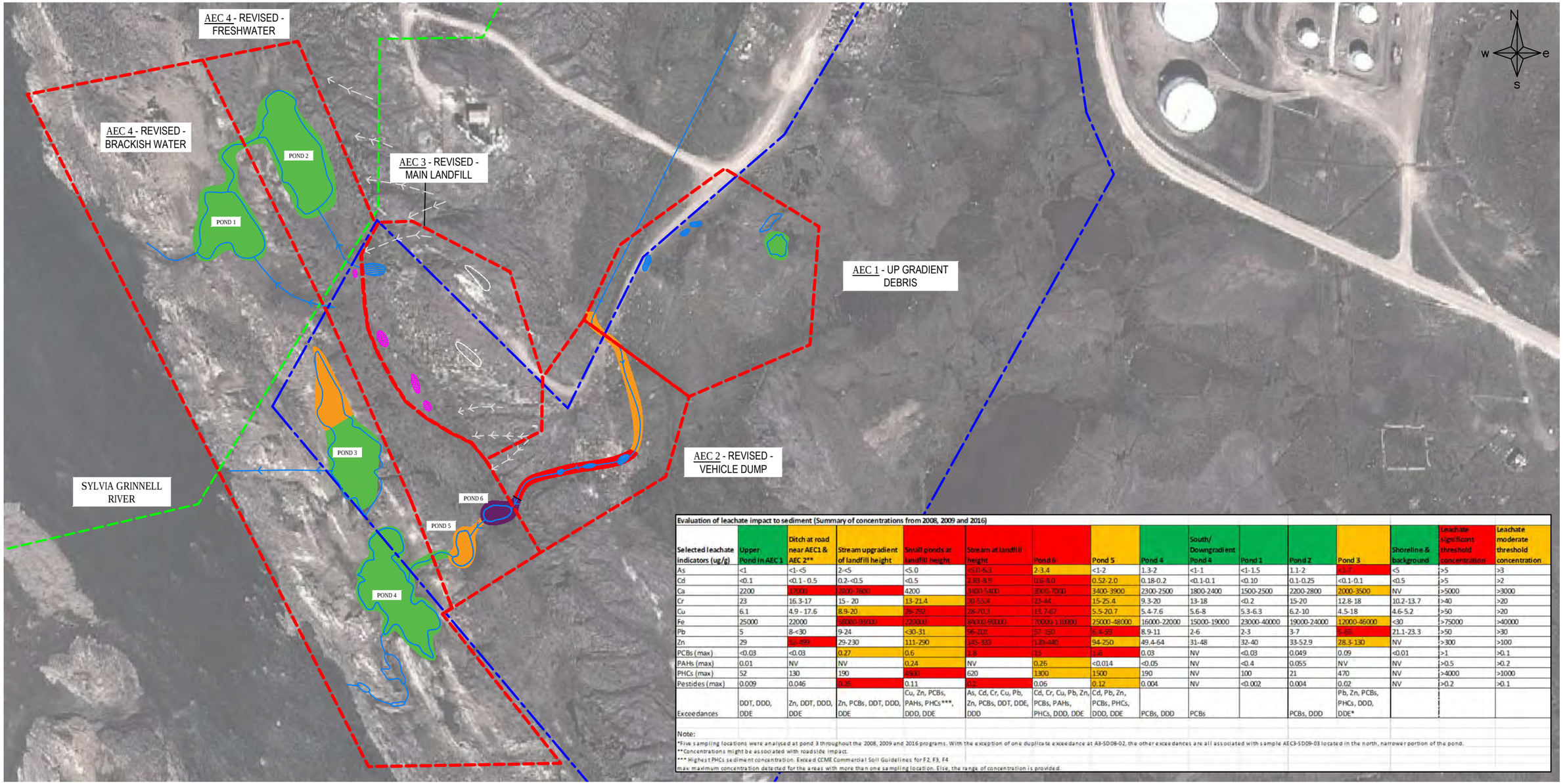
Client: PWGSC - TRANSPORT CANADA

ARCADIS

Date: JANUARY 2017

FIGURE 3

Z:\Projects\2009\1584-0901 TC Iqaluit Landfill\Figures\102153-000_TC IQALUIT_2016_RAP.dwg



Evaluation of leachate impact to sediment (Summary of concentrations from 2008, 2009 and 2016)

Selected leachate indicators (ug/g)	Upper Pond in AEC 1	Ditch at road near AEC1 & AEC 2**	Stream upgradient of landfill height	Small ponds at landfill height	Stream at landfill height	Pond 6	Pond 5	Pond 4	South/ Downgradient Pond 4	Pond 1	Pond 2	Pond 3	Shoreline & background	Leachate significant threshold concentration	Leachate moderate threshold concentration
As	<1	<1-<5	2-<5	<5.0	<5.0-5.3	2-3.4	<1-2	1.3-2	<1-1	<1-1.5	1.1-2	<1-7	<5	>5	>3
Cd	<0.1	<0.1 - 0.5	0.2-<0.5	<0.5	2.83-8.9	0.6-3.0	0.52-2.0	0.18-0.2	<0.1-0.1	<0.10	0.1-0.25	<0.1-0.1	<0.5	>5	>2
Ca	2200	10000	26000-76800	4200	3400-5400	3900-7000	3400-3900	2300-2500	1800-2400	1500-2500	2200-2800	2000-3500	NV	>5000	>3000
Cr	23	16.3-17	15 - 20	13-21.4	30-55.4	23-44	15-25.4	9.3-20	13-18	<0.2	15-20	12.8-18	10.2-13.7	>40	>20
Cu	6.1	4.9 - 17.6	8.9-20	26-292	28-70.3	13.7-67	5.5-20.7	5.4-7.6	5.6-8	5.3-6.3	6.2-10	4.5-18	4.6-5.2	>50	>20
Fe	25000	22000	58000-93000	220000	84000-90000	70000-110000	25000-48000	16000-22000	15000-19000	23000-40000	19000-24000	12000-46000	<30	>75000	>40000
Pb	5	8-<30	9-24	<30-31	56-202	57-150	6.4-59	8.9-11	2-6	2-3	3-7	5-68	21.1-23.3	>50	>30
Zn	29	52-899	29-230	111-290	145-333	139-440	94-250	49.4-64	31-48	32-40	33-52.9	28.3-130	NV	>300	>100
PCBs (max)	<0.03	<0.03	0.27	0.6	1.8	15	1.6	0.03	NV	<0.03	0.049	0.09	<0.01	>1	>0.1
PAHs (max)	0.01	NV	NV	0.24	NV	0.26	<0.014	<0.05	NV	<0.4	0.055	NV	NV	>0.5	>0.2
PHCs (max)	52	130	190	4500	620	1300	1500	190	NV	100	21	470	NV	>4000	>1000
Pestides (max)	0.009	0.046	0.35	0.11	0.3	0.06	0.12	0.004	NV	<0.002	0.004	0.02	NV	>0.2	>0.1
Exceedances	DDT, DDD, DDE	Zn, DDT, DDD, DDE	Zn, PCBs, DDT, DDD, DDE	Cu, Zn, PCBs, PAHs, PHCs***, DDD, DDE	As, Cd, Cr, Cu, Pb, Zn, PCBs, DDT, DDE, DDD	Cd, Cr, Cu, Pb, Zn, PCBs, PAHs, PHCs, DDD, DDE	Cd, Pb, Zn, PCBs, PHCs, DDD, DDE	PCBs, DDD	PCBs		PCBs, DDD	Pb, Zn, PCBs, PHCs, DDD, DDE*			

Note:
*Five sampling locations were analysed at pond 3 throughout the 2008, 2009 and 2016 programs. With the exception of one duplicate exceedance at A3-SD08-02, the other exceedances are all associated with sample AEC3-SD09-03 located in the north, narrower portion of the pond.
**Concentrations might be associated with roadside impact.
*** Highest PHCs sediment concentration. Exceed CCME Commercial Soil Guidelines for F2, F3, F4
max: maximum concentration detected for the areas with more than one sampling location. Else, the range of concentration is provided.

LEGEND:

- POOLING WATER
- PROPERTY BOUNDARY
- PARK BOUNDARY
- ADJUSTED AREA OF ENVIRONMENTAL CONCERN (AEC)
- BURN AREA
- DRUMS
- SEEPAGE/GULLY
- STREAM/DRAINAGE
- SIGNIFICANTLY IMPACTED TO BE REMOVED
- SIGNIFICANTLY IMPACTED TO REMAIN IN PLACE AS A SETTLING POND
- MODERATELY IMPACTED TO NATURALLY ATTENUATE
- NO SIGNIFICANT IMPACTS

REFERENCE: BACKGROUND IMAGE OBTAINED FROM GOOGLE EARTH, 2008

SCALE 1: 3000

75 60 45 30 15 0 metres 75 150

Title: SEDIMENT IMPACT SUMMARY

Project: VEHICLE DUMP & COMMUNITY LANDFILL - IQALUIT, NUNAVUT

Client: PWGSC - TRANSPORT CANADA

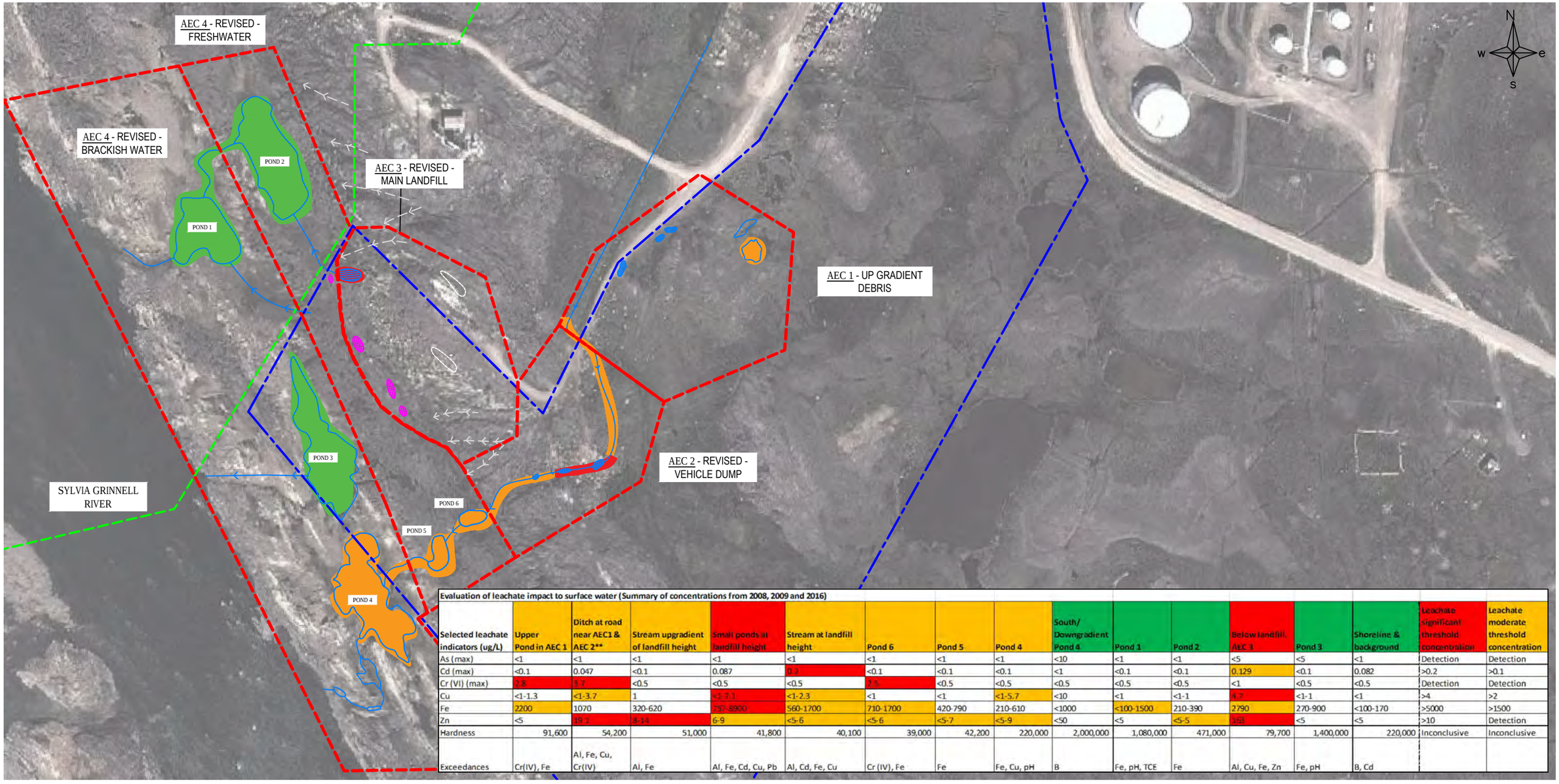
ARCADIS

Date: JANUARY 2017

FIGURE 4

*Original in colour

Z:\Projects\2009\1584-0901 TC Iqaluit Landfill\Figures\102153-000_TC IQALUIT_2016_RAP.dwg



Evaluation of leachate impact to surface water (Summary of concentrations from 2008, 2009 and 2016)

Selected leachate indicators (ug/L)	Upper Pond in AEC 1	Ditch at road near AEC1 & AEC 2**	Stream upgradient of landfill height	Small ponds at landfill height	Stream at landfill height	Pond 6	Pond 5	Pond 4	South/ Downgradient Pond 4	Pond 1	Pond 2	Below landfill AEC 3	Pond 3	Shoreline & background	Leachate significant threshold concentration	Leachate moderate threshold concentration
As (max)	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	<5	<5	<1	Detection	Detection
Cd (max)	<0.1	0.047	<0.1	0.087	0.3	<0.1	<0.1	<0.1	<1	<0.1	<0.1	0.129	<0.1	0.082	>0.2	>0.1
Cr (VI) (max)	2.8	3.7	<0.5	<0.5	<0.5	2.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1	<0.5	<0.5	Detection	Detection
Cu	<1-1.3	<1-3.7	1	<1-7.1	<1-2.3	<1	<1	<1-5.7	<10	<1	<1-1	4.7	<1-1	<1	>4	>2
Fe	2200	1070	320-620	757-8900	560-1700	710-1700	420-790	210-610	<1000	<100-1500	210-390	2790	270-900	<100-170	>5000	>1500
Zn	<5	19.1	8-14	6-9	<5-6	<5-6	<5-7	<5-9	<50	<5	<5-5	163	<5	<5	>10	Detection
Hardness	91,600	54,200	51,000	41,800	40,100	39,000	42,200	220,000	2,000,000	1,080,000	471,000	79,700	1,400,000	220,000	Inconclusive	Inconclusive
Exceedances	Cr(IV), Fe	Al, Fe, Cu, Cr(IV)	Al, Fe	Al, Fe, Cd, Cu, Pb	Al, Cd, Fe, Cu	Cr (IV), Fe	Fe	Fe, Cu, pH	B	Fe, pH, TCE	Fe	Al, Cu, Fe, Zn	Fe, pH	B, Cd		

LEGEND:

- POOLING WATER
- PROPERTY BOUNDARY
- PARK BOUNDARY
- ADJUSTED AREA OF ENVIRONMENTAL CONCERN (AEC)
- BURN AREA
- DRUMS
- SEEPAGE/GULLY
- STREAM/DRAINAGE
- SIGNIFICANTLY IMPACTED
- MODERATELY IMPACTED
- NO SIGNIFICANT IMPACTS

REFERENCE: BACKGROUND IMAGE OBTAINED FROM GOOGLE EARTH, 2008

SCALE 1:3000

75 60 45 30 15 0 metres 75 150

Title: SURFACE WATER IMPACT SUMMARY

Project: VEHICLE DUMP & COMMUNITY LANDFILL - IQALUIT, NUNAVUT

Client: PWGSC - TRANSPORT CANADA

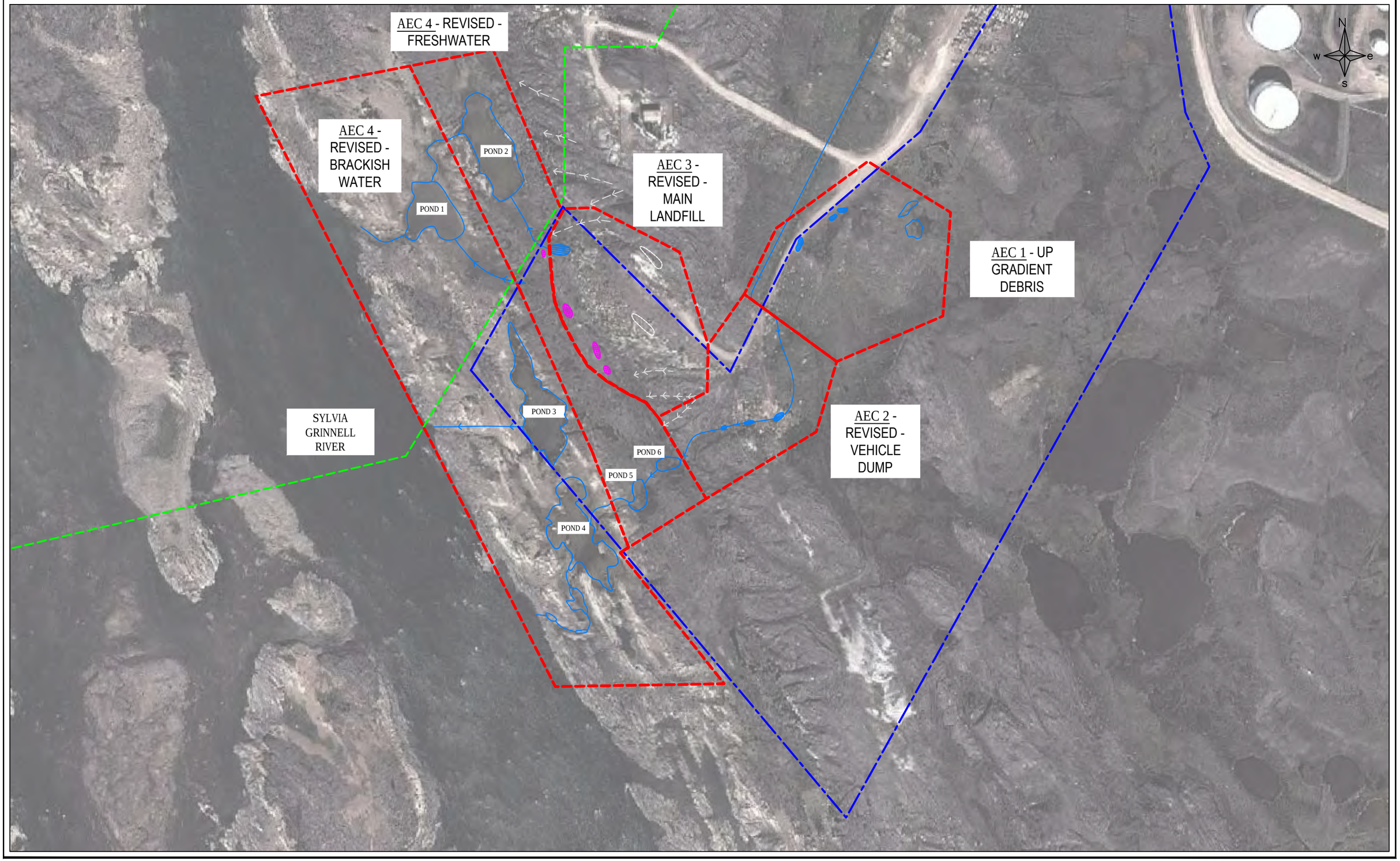
ARCADIS

Date: JANUARY 2017

FIGURE 5

*Original in colour

Z:\Projects\2009\1584-0901 TC Iqaluit Landfill\Figures\102153-000_TC IQALUIT_2016_RAP.dwg


AEC 4 - REVISED - FRESHWATER
AEC 4 - REVISED - BRACKISH WATER
POND 2
POND 1
AEC 3 - REVISED - MAIN LANDFILL
AEC 1 - UP GRADIENT DEBRIS
POND 3
SYLVIA GRINNELL RIVER
AEC 2 - REVISED - VEHICLE DUMP
POND 6
POND 5
POND 4
N
w
e
S

APPENDIX B

Identification of Potential Environmental and Resource Impacts

Value Ecosystem Component	Activity	Description of Impact	Proposed Mitigation Measure
Air Quality	Hydrocarbon Contaminated Soil/Sediments Removal	Air quality may be impacted by the removal of hydrocarbon contaminated soil/sediment. Soil volume to be excavated is expected to be minimal and localized and have low potential for dust generation. Sediment will be moist to wet and have a low potential for dust generation.	Execute work by methods to minimize raising dust (e.g., minimize height of waste release from excavator bucket into trailers). Stockpiles will be covered and refuse will be covered when not being excavated. Work may be suspended if conditions of high dust generation can not be controlled.
	Site Grading	The extraction of granular materials and grading activities has the potential to create dust and impact air quality.	Implement dust control measures, if required. Only water will be used for dust control. Work may be suspended if conditions of high dust generation can not be controlled. Access roads will have hard-packed surfaces to reduce dust generation. The speed limit for on-site traffic will be 15 km/hr.
	Emission	Emissions from equipment used on site during remediation.	No unnecessarily idling.
Soil Quality	Site Remediation/Landfill & Vehicle Dump Closure	Contaminated soils, sediments and waste at the site are contributing to the release of contaminant in the environment. The remediation and landfill closure activities will limit the migration of contaminants to the soil. If not completed properly, contaminants may continue to leach out of the landfill following the remediation program and impact soil quality.	Accessible hazardous material containing debris will be removed from the site. The waste and co-mingling impacted soils/sediments will be consolidated in the landfill which will undergo engineered decommissioning that will include extensive swale designs to divert precipitation and melt water away from the landfill slopes to prevent both erosion and water infiltration.
	Fuel Handling	Refuelling of equipment during remediation could lead to accidental release of fuel in the environment.	No storage tanks and hazardous materials are to be stored on site. No refuelling equipment is allowed on site other than at a staging area away from the work site. Spill response kit to be available on-site at all time. Spill contingency plan developed for the site

Value Ecosystem Component	Activity	Description of Impact	Proposed Mitigation Measure
			and to be available on-site at all time.
	Transport of Hazardous Material, Fuel and Contaminated Soil/Sediment	The potential exists for accidental release of hazardous materials, contaminated soil/sediments and/or fuels during transport, which could impact soil quality.	Proper handling, storage, and transportation procedures for hazardous materials to be implemented as per TDGA regulations. All contaminated soil/sediment, landfill waste and liquid waste, if encountered, shall be separated and managed on-site at the staging area to prevent contamination of uncontaminated material or migration to non-contaminated areas. All workers to be trained in proper handling procedures for all hazardous materials on-site. Workers to follow the spill contingency plan. All materials and equipment to implement contingency plan to be available on-site.
Water Quality	Contaminated Soil/Sediment and Hazardous Materials Removal	Contaminated soils, sediments and waste at the site are contributing to the release of contaminant in the environment. The remediation and landfill closure activities will limit the migration of contaminants to the water. If not completed properly, contaminants may continue to leach out of the landfill following the remediation program and impact water quality.	Accessible hazardous material containing debris will be removed from the site. The waste and co-mingling impacted soils/sediments will be consolidated in the landfill which will undergo engineered decommissioning that will include extensive swale designs to divert precipitation and melt water away from the landfill slopes to prevent both erosion and water infiltration.
	Fuel Handling	Refuelling of equipment during remediation could lead to accidental release of fuel in the environment.	No storage tanks and hazardous materials are to be stored on site. No refuelling equipment is allowed on site other than at a staging area away from the work site.

Value Ecosystem Component	Activity	Description of Impact	Proposed Mitigation Measure
			Spill response kit to be available on-site at all time. Spill contingency plan developed for the site and to be available on-site at all time.
	Removal of Debris near the Sylvia Grinnell River and removal of debris/impacted sediment/soil near/within the upstream drainage features	Sediment release and associated sedimentation in ecologically productive aquatic habitat may occur during removal.	Prevent sediments from entering waterbodies by use of berms and/or silt fences.
		Potential inadvertent release of harmful substances such as fuels and lubricating oils when completing removal of debris.	Proper handling, storage, and transportation procedures for hazardous materials to be implemented as per TDGA regulations. All workers to be trained in proper handling procedures for all hazardous materials on-site. All contaminated soil/sediment, landfill waste and liquid waste, if encountered, shall be separated and managed on-site at the staging area to prevent contamination of uncontaminated material or migration to non-contaminated areas. Workers to follow the spill contingency plans. All materials and equipment to implement contingency plans to be available on- site. Implement mitigation measures to prevent deleterious substances from entering the aquatic environment. Implement water control measures such as maintain excavation areas (if produced) free of water, protect site from standing or running water, prevent surface
	Stockpiling of debris and soil/sediment in the staging area	Potential release of contaminants from surface water runoff leaving the staging area.	

Value Ecosystem Component	Activity	Description of Impact	Proposed Mitigation Measure
			water runoff from leaving work areas, prevent precipitation from infiltrating or from directly running off stockpiled waste materials where practical and provide, operate, and maintain necessary equipment appropriately sized to keep excavations, staging pads, and other work areas free from water.
Terrain	Site Regrading	Terrain and drainage will be improved as a result of grading disturbed areas. Previously disturbed areas will blend into the natural environment.	N/A
	Contaminated Soil Excavation	The excavation of contaminated soil has the potential to degrade the permafrost.	Minimize the time permafrost is exposed. Minimize surface area of exposed permafrost or active zone.
	Importation of Fill and/or Other Material	Site could be re-contaminated by poor quality fill.	The contractor will be responsible for providing documentation pertaining to the environmental quality of the material, including analytical results (where required) and to disclose the location of origin for the material. The contractor will also be responsible for removing any excess imported materials from the site.
Noise	Heavy machinery at the site	Increased noise level during operation of machinery	Site is away from populated area and the general population is not likely to be impacted. On site workers will be required to follow the health and safety procedures as outlined in the project health and safety plan to mitigate risks associated with noise and odours.
Odour	Moving impacted soil/sediment and debris	Temporary release of odour	
Terrestrial Animals	General Remediation Activities and Landfill Decommissioning	The use of heavy equipment during the remediation has the potential to disturb wildlife.	Avoid areas of known wildlife colonies or bird nesting areas. Employ minimum distance requirements for transportation activities around the site.

Value Ecosystem Component	Activity	Description of Impact	Proposed Mitigation Measure
Aquatic Habitat and Aquatic Life	General Remediation Activities and Landfill Decommissioning	The removal of debris, soil/sediment has the potential to release material into the aquatic environment and disturb aquatic habitat and aquatic life.	During excavation, implement mitigation measures to prevent deleterious substances from entering the aquatic environment. Prevent siltation by use of berms and/or silt fences. Do not operate equipment within the wetted perimeter. Disturbed areas adjacent to water are to be stabilized, if required.
Health and Safety	General Clean Up Activities	The excavation of potentially hazardous materials from the landfills, the collection and disposal of potentially hazardous debris, the removal of hazardous materials from the facilities and the general handling of hazardous materials has the potential to impact the health and safety of workers.	Transportation of any hazardous materials is to be in accordance with the TDGA Regulations. Workers must wear and use appropriate personal protective equipment. Workers are to be trained in the use of personal protective equipment and proper handling procedures for hazardous materials. Proper procedures for working around heavy equipment to be implemented.

APPENDIX C

Visual Inspection Checklist

POST-CONSTRUCTION - LANDFILL MONITORING

VISUAL INSPECTION CHECKLIST

SITE NAME:
DATE OF INSPECTION:
WEATHER CONDITIONS:
DATE OF PREVIOUS INSPECTION:
INSPECTED BY (name and signature):
REPORT PREPARED BY (name and signature):
The inspector represents to the best of their knowledge that the following statements and observations are true and correct and that no material facts have been suppressed or misstated.

Notes:

- *All Features must have UNIQUE and consistent identifiers:*
  - *If a Feature is identified as Feature 'A' in 2018; then this same Feature 'A' must be followed up on as Feature 'A' in 2020 and all subsequent years. If it is not observed in a year, than it must be described as 'not observed'; Feature 'A' cannot be replaced to become a different Feature in later years.*
  - *If a Feature was noted in a previous year, but in the Geotechnical Engineer's opinion is not relevant; you can explain why in your opinion it is not relevant.*
  - *A new Feature must get its own unique identifier, in alphabetical order from where the previous list of Features left off; It should also be described as 'NEW' in the description column;*
  - *New Features can only be grouped together if they are very similar and located in close proximity;*
  - *Feature names must be consistent in the Tables, Figures, Photos and text; All Feature referencing must be verified for consistency.*
- *All measurements must be metric units;*
- *GPS is in UTM coordinates (NAD83).*

VISUAL INSPECTION CHECKLIST - INSPECTION REPORT – PAGE 2 OF 3

Checklist Item	Present Yes/No	Feature Number (Feature A, B, C – Keep name from historical observations, where appropriate)	Location (Describe relative to existing monuments/ features and relative to landfill design i.e. surface, berms, toe)	GPS coordinates (Taken at each 0.5m to 1m interval, and at any significant change in direction and around circumference of feature) Also take centre of feature (where feasible, and call c) Easting/ Northing/Zone	Length	Width	Depth	Extent relative to Area of Landfill (%)	Description	Comparison with historical observations	Additional Comments	Photographic Records Photo Reference, Focal length, location, view point & direction (relative to magnetic north) Feature of note Scale
Settlement												
Erosion												
Lateral Movement												
Frost Action												
Sloughing												
Cracking												
Animal Burrows												

VISUAL INSPECTION CHECKLIST - INSPECTION REPORT – PAGE 3 OF 3

Checklist Item	Present Yes/No	Feature Number (Feature A, B, C – Keep name from historical observations, where appropriate)	Location (Describe relative to existing monuments/ features and relative to landfill design i.e. surface, berms, toe)	GPS coordinates (Taken at each 0.5m to 1m interval, and at any significant change in direction and around circumference of feature) Also take centre of feature (where feasible, and call c) Easting/ Northing/Zone	Length	Width	Depth	Extent relative to Area of Landfill (%)	Description	Comparison with historical observations	Additional Comments	Photographic Records Photo Reference, Focal length, location, view point & direction (relative to magnetic north) Feature of note Scale
Vegetation Establishment												
Staining												
Vegetation Stress												
Seepage Points (or) Ponded Water												
Debris and/or Liner Exposed												
Presence & Condition of Monitoring Instruments												
Features of Note/ Other Relevant Observations (e.g. signs of activity, ruts…)												

APPENDIX D

QA/QC Plan - Approval Letter from Maxxam Analytics

maxxam.ca

MAXXAM ANALYTICS
6740 Campobello Rd
Mississauga, ON L5N 2L8

Office 905 817 5700
Toll Free 800 563 6266
Fax 905 817 5777

August 8, 2017

Ryan Fletcher
Arcadis Canada Inc.
329 Churchill Ave N.
Ottawa, ON K1Z 5B8

RE: Performance & Long Term Monitoring Plan (LTM), Former Metal Dump and Community Landfill, Iqaluit, Nunavut (as provided by Arcadis Canada Inc.)

Dear Ryan;

We have completed a thorough review of the sampling plan you've provided in support of your project listed above for water licence #1BR-MDR1721.

Maxxam is a Standards Council of Canada accredited laboratory to ISO/IEC 17025:2005. While Maxxam cannot provide approval for field sampling plans, we can comment that the indicated planned frequency of field QC samples, as applicable to soil and groundwater related parameters in general, is in line with the frequency of analysis of QC samples (for soil and groundwater analyses) in our laboratories.

Should you require anything further, please feel free to contact me at your convenience.

Sincerely,

Maxxam Analytics International Corporation
Susan Bigg, Certified Auditor
Senior QA Manager, Ontario and Manitoba

Arcadis Canada Inc.

329 Churchill Avenue North

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Ottawa, Ontario K1Z 5B8

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