AECOM

Report

Hamlet of Rankin Inlet

Rankin Inlet Solid Waste Site Abandonment and Restoration Plan

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Rankin Inlet Solid Waste Site Abandonment and Restoration Plan

Prepared by:

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Project Number:

108018

Date:

July, 2009

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July 10, 2009 Project Number: 108018

Mr. Paul Waye
Senior Administration Officer
Hamlet of Rankin Inlet
1 Arvinggak (4thStreet)
Rankin Inlet, NU X0C 0G0

Dear Mr. Waye:

Re: Rankin Inlet Solid Waste Site Abandonment and Restoration Plan

We are pleased to present the Abandonment and Restoration Plan for the existing Rankin Inlet solid waste site. The overall objective of the Abandonment and Restoration Plan is to minimize long-term health, safety and environmental risks associated with the existing solid waste site. This report describes the current condition of the site, proposed environmental improvements, and recommendations for ongoing care and maintenance of the site.

We trust the proposed Abandonment and Restoration Plan will be acceptable to both regulators and the residents of Rankin Inlet. Please feel free to contact the undersigned should you have any questions or comments about the proposed Abandonment and Restoration Plan.

Sincerely,
AECOM Canada Ltd.

Darrin Johnson, P.Eng.
Darrin.Johnson@aecom.com

DCJ:dcj
Encl.
cc: Saurabh Dhavale, Government of Nunavut
Phyllis Beaulieu, Nunavut Water Board

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Executive Summary

AECOM was retained by the Hamlet of Rankin Inlet to develop an Abandonment and Restoration Plan for the existing solid waste site. The overall objective of the Abandonment and Restoration Plan is to minimize long-term health and safety and environmental risks associated with the existing solid waste site.

The Abandonment and Restoration Plan provides guidance to the Hamlet of Rankin Inlet and other responsible parties in managing the closure of the existing Rankin Inlet solid waste site by describing the following:

- Activities required to transition the site from an operating landfill to a securely closed state;
- Environmental controls to minimize the environmental impacts in the long-term;
- Post-closure inspection, maintenance and monitoring activities to mitigate any adverse effects.

Abandonment and Restoration of the existing Rankin Inlet solid waste site will involve the following activities:

- Segregation of hazardous waste materials for transport from Rankin Inlet for disposal.
- Consolidation, compaction and contouring of existing solid waste;
- Excavation and relocation of contaminated soil surrounding the landfill onto existing waste;
- Installation of a final cover system over the solid waste footprint;
- Construction of perimeter surface water drainage ditches; and
- Implementation of a post-closure environmental monitoring and inspection program.

The landfill final cover was designed to meet the following criteria:

- Provide a physical barrier to prevent human and wildlife contact with landfilled waste;
- Minimize infiltration of precipitation into the waste and reduce leachate generation;
- Have gentle slopes that minimize hazards to wildlife and all-terrain vehicles;
- At least 2% grade to maintain positive drainage while allowing for some future waste settlement; and
- Maximum slopes of 4H to 1V to minimize erosion and ensure long-term slope stability of the cover.

Post-closure surface water quality sampling will be carried out to verify that contaminants are not migrating from the closed landfill. After five years of post-closure monitoring, the results should be reviewed to determine if extending the post-closure monitoring period is necessary.

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1. Introduction

AECOM was retained by the Hamlet of Rankin Inlet to develop an Abandonment and Restoration Plan (ARP) for the existing Rankin Inlet Solid Waste Site (the Site).

The overall objective of the ARP is to minimize long-term health and safety and environmental risks associated with the Site. This objective will be accomplished by remediating the Site and implementing environmental control measures that are tailored to the northern environment. The ARP will be acceptable to both regulators and the residents of Rankin Inlet.

This report presents a summary of the current status of the Site, proposed environmental improvements, end use plan and recommendations for ongoing care and maintenance of the Site.

1.1 Site Location

Rankin Inlet is the second-largest community in Nunavut and is located on the west coast of Hudson Bay (62°49'N latitude and 92°05'W longitude). The community of Rankin Inlet was first established as a mining centre in 1955 by North Rankin Nickel Mines (Pool, 2008). A mineral processing plant was built in Rankin Inlet in 1956 and started to produce nickel concentrates in 1957 (Pool, 2008). The mineral processing plant was closed in 1962 (Pool, 2008) and Rankin Inlet is now a centre for government, transportation and communications in the North. The economy of Rankin Inlet has recovered with a fishery and an Inuit craft industry. In 2006 the population of Rankin Inlet was 2,358 (CBEC, 2008).

The Rankin Inlet existing solid waste disposal site is located approximately 0.5 km south of the settlement and is approximately 0.5 km from Hudson Bay to the East, South and West. Figure 1 presents a site location plan.

1.2 Site Description

The Site consists of two main areas: a solid waste disposal area and a miscellaneous storage area. The total area of the Site is almost 6 ha. Figure 2 illustrates the general arrangement of the Site. The Site slopes to the south and east with elevated rock outcrops west of the Site.

1.2.1 Solid Waste Disposal Area

The solid waste disposal area occupies a footprint of approximately 4 ha. The waste disposal area is surrounded by a compacted sand and gravel perimeter road and a steel chain link security fence. Solid waste primarily consisting of Municipal Solid Waste (MSW) has been deposited within the fenced disposal area. Photo 1 illustrates the existing condition of the solid waste disposal area.

1.2.2 Miscellaneous Storage Area

Northwest of the waste disposal area there is an area that has been historically used for fire training, drum storage, sewage disposal, and scrap metal storage (hereafter referred to as the miscellaneous storage area). Photo 2 illustrates the existing condition of the miscellaneous storage area. Some hazardous waste materials (i.e., batteries) have been temporarily stockpiled in this area awaiting packaging and transport to suitable disposal or recycling facilities. The miscellaneous storage area is approximately 220 m long from south to north and 150 m wide at the south end. The miscellaneous storage area is approximately 1.7 ha.

1.3 Site History

There are no official records available regarding the start date or early history of the Rankin Inlet solid waste site. The Rankin Inlet solid waste site is not an engineered landfill facility and was never officially commissioned. It is our understanding that the Site has been in operation since the 1950's, when the community of Rankin Inlet was first established. However, waste disposal activities in the vicinity of the Site are not apparent in aerial photos taken in 1962 (obtained from Canada National Air Photo Library) indicating that the majority of the solid waste at the Site has been deposited after 1962.

Rankin Inlet achieved Hamlet status in 1975 and the solid waste site is now owned and operated by the Municipality of Rankin Inlet. We understand from discussions with residents of Rankin Inlet that garbage has been burned and covered at the Site in the past. Burning garbage is no longer considered acceptable and has been discontinued as an operational practice at the Site. However, we understand that fires occur occasionally at the Site, possibly because regular soil cover is not placed over the waste.

The existing solid waste site is the only waste management facility in Rankin Inlet. It currently receives all Municipal Solid Waste (MSW) generated in Rankin Inlet as well as commercial, industrial, institutional, construction and demolition waste. There is a sewage trench (approximately 15 m long and 1.5 m wide) at the Site that receives bagged human faecal waste that is generated from the housing units not equipped with a piped sewage system. A large number of empty fuel drums and other scrap metal have been stockpiled near the Site entrance. Scrap metal (e.g., crushed steel drums and automobiles) was shipped from Rankin Inlet to Churchill, Manitoba for recycled during a pilot recycling project in 2004 and 2005 (GHGM 2006).

Solid waste is transported to the Site by municipal solid waste collection trucks and residents. Typically there is no operator present at the Site to direct and manage waste disposal activities. Bulldozers are occasionally sent to the facility to remove waste from the entrance and perimeter road. No waste compaction or soil cover placement operations are carried out at the Site.

Figure 1. Site Location Plan

Figure 2. Site General Arrangement Plan

1.4 Purpose of Abandonment and Restoration Plan

Municipal Solid Waste (MSW) can continue to produce adverse effects such as leachate and gas generation for decades following closure. The Abandonment and Restoration Plan will provide guidance to the Hamlet of Rankin Inlet and other responsible parties in managing the closure of the existing Rankin Inlet solid waste site by describing the following general activities:

a) Activities required to transition the site from an operating landfill to a securely closed state;
b) Installation of environmental controls to minimize environmental impacts in the long-term;
c) Post-closure inspection and maintenance activities to verify that the environmental controls continue to function as intended.

Implementation of the Rankin Inlet Solid Waste Site ARP will involve the following specific activities:

a) Consolidation, compaction and contouring of existing solid waste;
b) Excavation and relocation of contaminated soil surrounding the landfill;
c) Installation of final cover system and gas ventilation system;
d) Construction of a surface water management (i.e., drainage) system; and
e) Implementation of a post-closure environmental monitoring and inspection program.

The Abandonment and Restoration Plan document is organized as follows:

- Section 2: ..... Physical Setting. A description of adjacent land use, climate, geology and surface water drainage.
- Section 3 ..... Existing Conditions. A description of existing waste characteristics and environmental conditions at the Site.
- Section 4: ..... Regulatory Environment. A summary of applicable regulations and approval requirements.
- Section 5: ..... Abandonment and Restoration Plan. Outline of proposed end use of the Site and recommended environmental controls to address environmental and health and safety issues at the Site.
- Section 6: ..... Risk Management Options. Description of potential options
- Section 7: ..... Design of Environmental Controls. Detailed design of final cover, landfill gas vents and surface water drainage.
- Section 8: ..... Implementation Schedule. Timing for implementation of proposed closure works.
- Section 9: ..... Care and Maintenance: This section outlines post-closure inspection and maintenance requirements.

- Section 10: .....Environmental Monitoring: This section describes the recommended environmental monitoring program to confirm the effectiveness of the ARP.
- Section 11: .....Record Keeping and Reporting Requirements.
- Section 12: .....Contingency Measures. This section identifies potential future problems that may occur and how they could be managed.
- Section 13: .....Emergency Response. This section outlines how emergencies such as a fire or a spill at the landfill should be managed.

2. Physical Setting

2.1 Adjacent Land Use

The Site is approximately 0.5 km south of the Hamlet of Rankin Inlet. Hudson's Bay is about 0.5 km east, south and west of the Site. The community of Rankin Inlet is comprised of residents, local businesses, and government agencies. The Rankin Inlet Airport is located approximately 1 km northwest of the Site. The former Northern Rankin Nickel Mines is north of the community and over 1 km north of the Site. The Rankin Inlet fuel storage facility is approximately 0.5 km northeast of the Site. Seasonal cottages are located east, south and southwest of the Site. An aerial photograph of the Site and surrounding areas are included on Figure 1.

2.2 Climate

The monthly mean temperature in Rankin Inlet ranges from -31.9°C in January to 10.4°C in July and the mean monthly precipitation ranges from 6.6 mm in January to 57.6 mm in August (Environment Canada, 2009). A summary of monthly mean temperature and precipitation is provided in Table 1.

Table 1. Rankin Inlet Monthly Mean Temperature and Monthly Precipitation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Average Temperature (°C)	-31.9	-30.1	-25.2	-16.3	-5.9	4.2	10.4	9.5	3.4	-5.3	-17.8	-26.7
Monthly Precipitation (mm)	6.6	8.9	12.6	14.3	18.4	29.8	39.5	57.6	43.8	34.6	19.8	11.3
Monthly Rainfall (mm)	0	0.1	0	1	7.4	25	39.5	57.3	39.2	11.9	0.1	0
Monthly Snowfall (cm)	6.7	9.3	12.9	13.6	11.5	4.9	0	0.3	4.6	23.1	20.9	11.9
Average Snow Depth (cm)	27	30	36	38	20	1	0	0	0	3	14	23
Snow Depth at Month-end (cm)	28	34	38	33	5	0	0	0	0	8	20	25

Reference: Average climate data between 1971 – 2000 at Rankin Inlet Airport from Environment Canada (2009).

Photo 1. Existing Condition of the Solid Waste Disposal Area inside the Perimeter Fence

Photo 2. Existing Condition of the Miscellaneous Storage Area near the Site Entrance

Photo 3. Ponded Water Near the Miscellaneous Storage Area (facing North)

2.3 Topography and Surface Water Drainage

Perimeter access roads around the waste disposal area extend above the natural ground surface and likely function as a containment berm. Ponded water was observed at the Site during the August 2008 field investigation indicating that the area is not well drained (see Photo 3). Permafrost and a shallow active (i.e., thawed) zone during the summer months likely contribute to poor drainage at the Site. There are no constructed ditches or drainage structures at the Site so drainage is largely controlled by topography. The Site is on a peninsula of land that projects out into Hudson's Bay (see Figure 1). Topography and observations during the August 2008 field investigation indicate that surface water drains from the Site towards Hudson's Bay in a southeast direction. The ocean is approximately 0.5 km east, south and west of the solid waste disposal area.

A natural watercourse exists between the bedrock outcrop west of the Site and the west perimeter road (Photo 4). Surface water drains along this watercourse in a southeast direction. South of the Site, surface water drains toward to the south and southeast towards Hudson Bay (Photo 5). Areas of ponded water were observed south of the Site (Photo 6) that ultimately drains to the ocean. East of the Site, topography appears to drain surface water to the southeast however no defined watercourses are visible (Photo 7). A seepage outfall was observed about 220 m east of the waste disposal area (Photo 8). Seepage at this location appeared to be relatively clear and no staining was observed.

Photo 4. Natural Drainage Along the West Side of the Site (facing southeast)

Photo 5. Topography and Drainage South of the Site (facing northwest)

Photo 6. Ponded Water Southeast of the Site (facing northwest)

Photo 7. Topography and Drainage East of the Site (facing east)

Photo 8. Seepage Outfall and Drainage East of the Site

2.4 Geologic Setting

Rankin Inlet is located in the continuous permafrost zone as shown in Figure 3 (NRC, 2009). In the continuous permafrost zone, permafrost occurs everywhere except beneath large bodies of water. Permafrost depth in the Rankin Inlet area ranges from 100 m to 500 m below ground surface (NRC 2009) with an estimated permafrost depth of about 300 m in Rankin Inlet (Judge *et al.,* 1991).

Rankin Inlet is part of the Kazen Upland and is underlain by Precambrian volcanic and sedimentary rock (Judge *et al.,* 1991). The Rankin Inlet area was submerged during the post-glacial period with a current land elevation of about 30 m above sea level and relatively low relief. Post-glacial iso-static rebound is causing the ground elevation around the coast of Hudson Bay to rise at a rate of about 1 m per century. Bedrock in the area is very irregular and surficial materials are generally thin (i.e., glacial veneer) but can vary significantly in thickness.

Surficial soils in the Rankin Inlet area consist of organic material, sand, gravel and fines. Tundra vegetation is typical of the area. Surficial soils are immature and typical of the arctic reflecting the presence of permafrost and effects of frost processes in the active layer (James, 1970). The average depth of thaw in Rankin Inlet is about 1 m but can be as deep as 2.5 m in well-drained gravel without organic surface cover (Judge *et al.,* 1991).

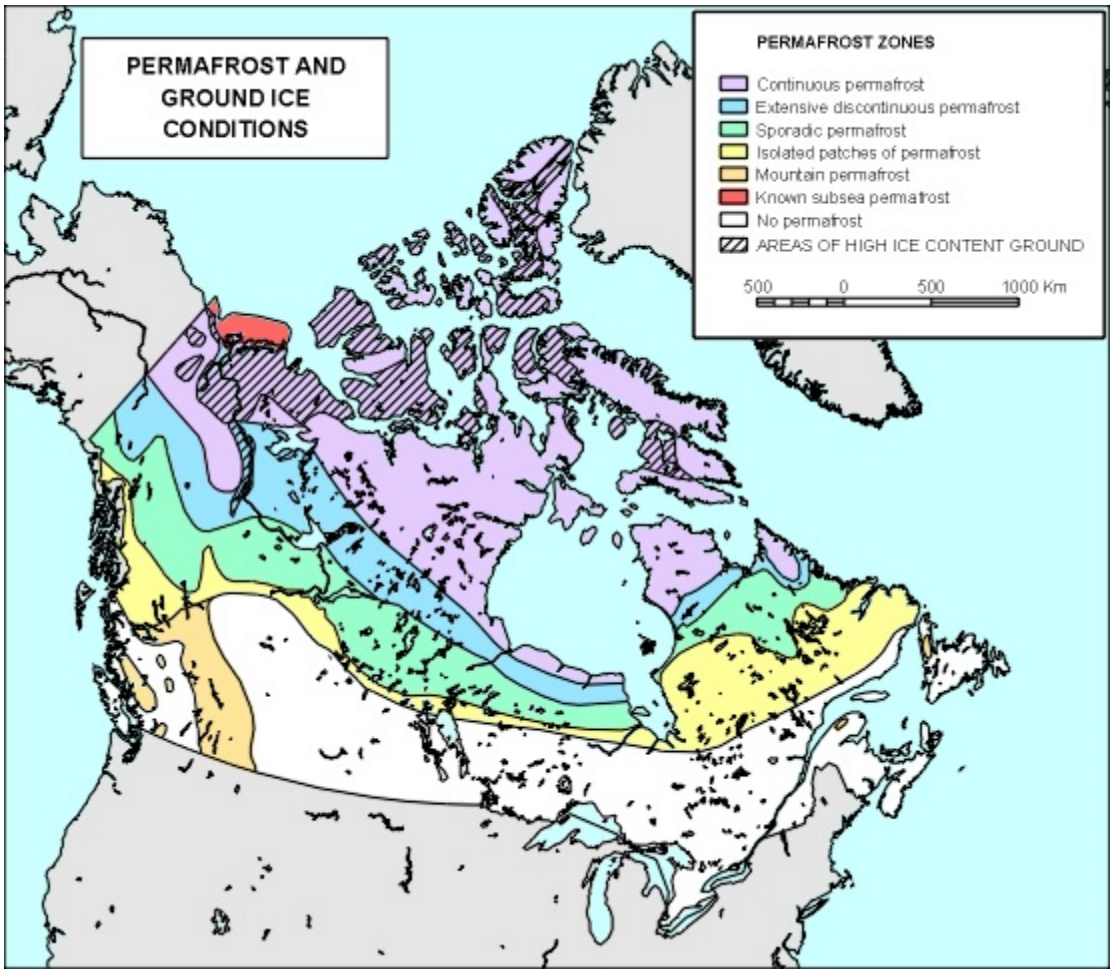

Figure 3. Permafrost Zones in Canada

(Source: Natural Resources Canada, 2009)

3. Existing Conditions

3.1 Estimated Quantity of Solid Waste Disposed

An estimate of waste generation in Rankin Inlet over the operating life of the Site has been calculated based on the population of Rankin Inlet and estimated per capita waste generation rates. The historical population of Rankin Inlet was obtained from various government and historical references. Average annual waste generation rates (in tonnes per person) for Rankin Inlet were estimated from published waste generation rates for similar northern and remote communities. Typical per capita annual waste generation rates for Canada, United States, Denmark and northern communities in Canada are presented in Table 2.

Table 2. Typical Waste Generation Rates

	Yellowknife, NWT (2006)[1]	Fort McPherson, NWT (1982)[2]	Fort Smith, NWT (1982)[3]	Gordon Indian Reserve, Saskatchewan (1979)[4]	Canada Average (2002)[5]	Alaska (1975)[6]	US Average (1999)[7]	Denmark (1982)[8]
Annual Per Capita Waste Generation, tonnes/person·year	0.5	0.44	0.29	0.07	0.76	1.02	0.77	0.27

References:

1. *Estimated residential and commercial per capita waste generation (GLL, 2007).*
2. *Estimated based on reported per capita generation rate of 0.006 m^3/day (Smith, 1987) assuming a waste bulk density of 0.2 tonne/m^3.*
3. *Estimated based on reported per capita generation rate of 0.004 m^3/day (Smith, 1987) assuming a waste bulk density of 0.2 tonne/m^3.*
4. *. Reported per capita generation rate of 0.001 m^3/day (0.19 kg/day) (Smith, 1987).*
5. *Average per capita waste (including residential and non-residential) generation rate for 10 provinces in Canada (Statistics Canada, 2005).*
6. *Reported per capita generation rate of 2.8 kg/day (Smith, 1987).*
7. *Reported per capita annual waste generation in US (Pichtel, 2005).*
8. *Reported per capita generation rate of 0.74 kg/day (Smith, 1987).*

The per capita waste generation rate in Yellowknife is lower (0.5 tonnes/person year) than the Canada average (0.76 tonnes/person year). For the purposes of this assessment we have assumed that Rankin Inlet has the same waste generation rate as Yellowknife (e.g., northern community with significant government services), although Rankin Inlet has a lower average family income than Yellowknife. Per capita waste generation in Canada has increased steadily over the past two decades, with an average annual increase of about 1.8% between 1980 and 2005 (Conference Board of Canada, 2009). An average annual waste generation increase of 1.8% has been assumed for the calculation of historical annual waste generation rates (from 1955 to 2008) in Rankin Inlet. Population growth and annual waste generation in Rankin Inlet from 1955 to 2008 are presented in Figure 4. The total estimated quantity of waste generated in Rankin Inlet since 1955 is estimated to be about 27,000 tonnes. However, organic waste decomposition and burning of waste have probably contributed to a reduction in waste mass and volume.

Based on field observations it is estimated that the height of solid waste deposited onto the ground piles is up to 3 m at some locations with an average depth of 2.5 m over the entire Site (see Photo 9). Based on a disposal area footprint of about 33,500 m^2 there is approximately 83,750 m^3 of solid waste on the ground in the waste disposal area. This translates to about 21,000 tonnes of waste assuming an average bulk density of 0.25 tonnes per cubic meter, which is the average bulk density of waste dumped from a compactor truck (Smith, 1987). The additional 6,000 tonnes of waste (i.e., difference between 27,000 tonne and 21,000 tonne estimates) may have been buried, burned or decomposed. These estimates help understand the scale of historic solid waste disposal operations at the Site.

Photo 9. Solid Waste Pile near TP14

Photo 10. Recyclable Scrap Metal in Disposed Solid Waste

Figure 4. Rankin Inlet Population and Waste Generation with Time

3.2 Solid Waste Sources and Composition

Because of the remoteness of Rankin Inlet all solid waste disposed at the Site was likely generated in the community. Sources of solid waste in Rankin Inlet include residential, commercial (e.g., hotels, restaurants, stores, airport, businesses, etc.) and institutional (e.g., schools, hospital, etc.). The North Rankin Nickel Mines operated from 1957 to 1962 (Pool, 2008) but mine waste (e.g., tailings and waste rock) was not observed at the Site during the August 2008 field investigation. The former mine operation was located approximately 1 km north of the solid waste disposal area so it is considered unlikely that mine waste would have been transported to the Site. Table 3 provides a summary of published waste composition for communities that are considered similar to Rankin Inlet. Paper and food (i.e., organic) waste typically accounts for approximately 60% to 80% of the total waste stream and recyclable materials (i.e., plastic, glass and metal) can comprise 15% to 30% of the total waste stream. However, it should be noted that recycling typically does not occur in remote northern communities because of high transportation costs. Significant quantities of scrap metal were observed in the solid waste disposal area at the Site (see Photo 10).

Table 3. Typical Waste Composition for Remote Northern Communities

%	Yellowknife, NWT (2006)[1]	Gordon Indian Reserve, Saskatchewan (1979)[2]	Anchorage, Alaska [2]	Denmark (1982)[2]
Paper	37.1	46	43.7	34.7
Food Waste	23.9	37	15.2	35.0
Yard Waste	2.2		6.5	12.5
Wood	2.9		1.2	2.5
Textiles	5		2.1	2.0
Rubber and Leather	0.1		0.9	
Plastics	12.4	3	4.1	4
Glass and Ceramics	2.4	6	14.5	10
Metals	3.9	8	10	9
Inerts (Dirt)	2.7		1.7	3
Household Hygiene	5.1			
Bulky items	2.3			
Total	100	100	99.9	100

References:

1. *City of Yellowknife Solid Waste Composition Study and Waste Reduction Recommendations (GLL, 2007).*
2. *Cold Climate Solid Waste Management Guidelines (Smith, 1987).*

Waste materials that were observed at the Site during the August 2008 investigation include:

- Scrap metal and white goods (appliances, drums, vehicles, boilers, sheet metal, steel pipes, etc.);
- Wood (pallets, furniture, plywood, etc.);
- Plastic (bottles, containers, packaging, film, etc.);

- Cardboard and paper;
- Used tires;
- Glass;
- Textiles;
- Organic waste (food waste, dead animals, etc.);
- Electronic waste;
- Construction and demolition waste (insulation, shingles, concrete, gypsum board, etc.)

There is a sewage disposal trench northeast of the solid waste disposal area (see sewage trench location note on Figure 2) for bagged human waste (i.e., honey buckets) from housing units not serviced by the community sewage system. There is also a designated area for disposal of dead animal carcasses, however animal carcasses were observed throughout the solid waste disposal area.

3.3 Waste Placement History and Filling Methods

The area filling method appears to have been the primary method of waste placement utilized at the Site. Waste has essentially been placed within or on the perimeter roads of the Site with no apparent cell construction, designated active tipping area or soil cover placement. We understand that a bulldozer is used to push solid waste off the perimeter roads of the Site into the central waste disposal area. No compaction of disposed solid waste is carried out.

3.4 Soil Cover

Solid waste has not been covered with regular or interim soil cover at the Site. Some solid waste materials have been buried at the Site in the past. However, it appears that buried waste accounts for only a small portion of the total waste volume disposed at the Site.

3.5 Leachate Generation

Because soil cover has not been placed over disposed waste at the Site, all precipitation that falls on the waste is assumed to discharge from the waste disposal area as leachate. Total average annual precipitation in Rankin Inlet is almost 300 mm so potentially up to 10,000 m3 of leachate could be generated each year at the Site (conservative estimate assuming no evapotranspiration). A water balance was carried out for existing conditions at the Site using the Hydrologic Evaluation of Landfill Performance (HELP) computer model developed by the US Environmental Protection Agency (EPA). A 100-year simulation was carried out using site-specific climate data (see Table 1) and the HELP model to estimate average evapotranspiration and leachate generation at the Site. Evapotranspiration is estimated to be about 80% of the total precipitation or about 8,000 m3 per year. Leachate generation at the Site is estimated to be about 20% of the total precipitation or about 2,000 m3 per year. Note that this calculation is for existing conditions (i.e., no cover) and conservatively assumes that all runoff contacts waste and is discharged as leachate.

Approximately 40% of the precipitation that falls at the Site is snow that accumulates through the winter months and may be subject to blowing and drifting. Existing stockpiles of waste may increase accumulation of snow within the waste disposal area resulting in increased leachate generation. Construction of a relatively flat final cover should reduce the accumulation of drifted snow on the landfill and contribute to a reduction in leachate generation.

3.6 Landfill Gas

Typical landfill gas is composed of approximately 50% methane and approximately 50% carbon dioxide with small concentrations of other constituents typically referred to as Non-Methane Organic Compounds (NMOCs). It is likely that some landfill gas is being generated at the Site. However, solid waste has been deposited at the Site in a thin pile over a large area and is uncovered so anaerobic conditions (required to generate methane) are not likely present. Any landfill gas generated from the decomposition of waste at the Site is currently being released to the atmosphere. Figure 5 presents a conservative estimate of potential landfill gas generation with time based on estimated waste generation rates using the Landfill Gas Emissions Model (LandGEM) computer model also developed by the US EPA. Figure 5 presents waste generation and potential landfill gas generation over time for the Site.

3.7 Site Security

The Site is unsupervised with no dedicated operator or manager. The waste disposal area is enclosed by perimeter security fence; however there are no functioning gates at the three entrances to the waste disposal area. Furthermore, the perimeter fence has been damaged at several locations. The site is accessible at all times, however waste placement primarily occurs during the day.

3.8 Birds and Animals

A significant number of birds were observed at the Site during the August 2008 field investigation. No other animals such as bears or dogs were observed. The waste site is located approximately 1 km southeast of the Rankin Inlet Airport therefore the birds may create a safety hazard for airplanes. Because the Site is not operated as a sanitary landfill (i.e., no regular application of soil cover) there are likely rodents (e.g., sik siks) and/or other scavengers living at the Site.

3.9 Environmental Condition of the Site

3.9.1 Soil and Water Quality Sampling

Soil and water sampling was carried out in August 2008 to assess the environmental condition of the Site and surrounding land and water. Test pit excavation and shallow soil sample collection (i.e., in the active

layer above permafrost) was carried out to determine if leachate has impacted soil quality and to assess the distribution of contaminants that may have migrated from the landfill. Test pit excavation was also carried out to confirm the lateral extent and depth of buried solid waste at the Site. Records of test pit excavation are included in Appendix A. Soil samples were submitted to an accredited analytical lab for metals (ICP) and hydrocarbon (CCME F1-F4) analyses. Four soil samples were submitted for polycyclic aromatic hydrocarbon (PAH) analysis to identify if historic burning of waste or fire training has resulted in PAH impacts to soil quality. Four soil samples were submitted for polychlorinated biphenyl (PCB) analysis to identify if any PCB impacted waste materials have been landfilled at the site. Water samples were collected from a test pit and surface water ponds downstream of the landfill to determine if leachate is impacting downgradient water quality. Water samples were submitted for general chemistry (alkalinity, ammonia, pH, conductivity, etc.), metals (ICP/MS), and hydrocarbon (CCME F1-F4) analyses. Soil and water quality sample analytical results are included in Appendix B. Analytical results were compared to generic standards set out in the following guidelines:

- Canada Wide Standards for Petroleum Hydrocarbons in Soil ("PHC CWS"), CCME 2008; and
- Canadian Environmental Quality Guidelines ("CEQG"), CCME 2007.

The sampling program focussed on soils surrounding the landfill that may have been impacted by landfill leachate to identify areas requiring remediation. Soil and water quality around the landfill can also be used to infer what waste materials have been disposed at the Site. Sampling of disposed solid waste was not carried out because of potential health and safety risks and because waste samples would likely exceed applicable standards (i.e., provide limited information).

3.9.2 Contaminants of Potential Concern

The following screening for Contaminants of Potential Concern (COPCs) was carried out based on the above referenced *Canadian Council of Ministers of the Environment (CCME) Environmental Quality Guidelines*.

Contaminants that exceeded CCME Canadian Water Quality Guidelines in water samples collected at the site include (note that this standard is conservative for the site because freshwater aquatic life are more sensitive than marine or saltwater aquatic life):

- Cadmium
- Chromium
- Copper
- Iron
- Selenium
- Silver

Mercury was below the 0.0001 mg/L detection limit, however the laboratory detection limit exceeds the 0.000026 mg/L CCME standard for the protection of freshwater aquatic life. No volatile organic compound (VOCs) or petroleum hydrocarbons were detected in water samples collected downgradient of the landfill indicating that these organic contaminants are not migrating from the landfill, are being adsorbed onto soil particles or are undergoing natural bioremediation.

Contaminants that exceeded CCME Canadian Soil Quality Guidelines for the protection of Environmental and Human Health (Residential/Parkland) or CCME Canada-Wide Standards for Petroleum Hydrocarbons (Residential/Parkland) include (note that this standard may be conservative for the site if Commercial land use standards are acceptable):

- Arsenic (Residential/Parkland and Commercial)
- Chromium (Residential/Parkland and Commercial)
- Copper (Residential/Parkland and Commercial)
- Lead (Residential/Parkland only)
- Nickel (Residential/Parkland and Commercial)
- Selenium (Residential/Parkland only)
- Zinc (Residential/Parkland only)
- Benzene (Residential/Parkland only)
- F2 and F3 Hydrocarbons (Residential/Parkland only)

It should be noted that it is not always practical or necessary from an environmental risk perspective to remediate contaminated sites to pristine conditions. Generic guidelines do not take into account regional differences in geology, soil, or climate, nor do they account for site-specific factors that may influence bioavailability or toxicity of contaminants. It should be noted that some of the above metals (e.g., arsenic) may be naturally present in soils around Rankin Inlet at the concentrations detected (see Section 6 below for a discussion on natural background levels). Furthermore, generic guidelines are set to be protective of the most sensitive receptors (ecological or human) that may be exposed to the contaminant. Because of their conservatism, an exceedance of the guideline values does not necessarily imply that risks to humans or the environment exist.

Figure 5. Rankin Inlet Waste Generation and Landfill Gas Generation with Time

4. Regulatory Framework

4.1 Guidance on Remediation of Contaminated Sites in Northern Canada

The following federal guidance documents on remediation of contaminated sites in Northern Canada were referenced during development of the ARP:

- A federal approach to Contaminated Sites (CSMWG, 2000);
- Northern Affairs Program Contaminated Sites Management Policy (INAC 2002); and
- Treasury Board Federal Contaminated Sites Management Policy (Treasury Board 2002).

4.2 Other Federal Guidelines

The following other federal guidelines were referenced during development of the ARP.

Code of Good Practice on Dump Closing or Conversion to Sanitary Landfill at Federal Establishments outlines the guidelines to improve operation and properly close existing dumps. It is intended to promote a consistent approach to the clean up of existing dumps to prevent contamination of water, air, and land and to ensure that the best particular control technology is used.

Canadian Environmental Quality Criteria for Contaminated Sites, compiled by the Canadian Council of Ministers of the Environment (CCME) provide numerical limits for contaminants in soil and water intended to maintain, improve, or protect environmental quality and human health at contaminated sites. The criteria are intended to provide general technical and scientific guidance to provincial, federal, territorial and nongovernmental agencies in the assessment and remediation of contaminated sites across Canada. They serve as benchmarks against which to access the degree of contamination at a site.

4.3 Federal Acts and Regulations

The following federal acts and regulations may apply during implementation of the ARP.

The **Canadian Environmental Protection Act** regulates toxic substances from their production or import, to consumption, storage and disposal. This act identifies materials, such as hazardous waste, that cannot be disposed at the Site.

The **Transportation of Dangerous Goods Act and Regulations** promotes public safety in the transportation of dangerous goods. The Act applies to all handling, offering for transport and transporting of dangerous goods by any means of transport whether or not the goods originate from or are destined for any place or places in Canada. This act will apply to hazardous waste that needs to be transported to a southern disposal facility.

The **Fisheries Act** protects fish and fish habitat from pollution, harmful alteration, disturbance and destruction, and impediments to fish movement. This act prevents discharge of landfill leachate to surface water and the ocean.

The **Arctic Waters Pollution Prevention Act and Regulations** govern development and shipping activity in Arctic waters of the Canadian Arctic to ensure the continuing welfare of the residents of the areas, and to protect the ecological balance in water, ice and land areas. Applies if any equipment will be brought to site for closure activities, or if hazardous materials are shipped from the Site.

The **Migratory Birds Convention Act** provides for the protection of designated migratory species, their habitats, and the regulated harvest of certain species. This act may apply if there are any migratory birds which use the site.

The **Canada Wildlife Act** provides for the involvement of the Government of Canada in cooperative research and management programs involving wildlife species normally the responsibility of provinces or territories. This is particularly relevant to rare and endangered species or species such as the Peary caribou, which seasonally move across various regulatory boundaries. Applies if there is wildlife at the site.

The **Species at Risk Act** aims to protect wildlife from becoming extinct or lost from the wild, with the objective of helping the numbers recover. The act covers all wildlife species listed as being at risk nationally and their critical numbers. Applies if there is wildlife at the site.

The **Canada Shipping Act** regulates shipping activities under the jurisdiction of Canada. Regulations cover technical standards of operation safety and pollution aspects related to shipping activities in Canadian waters. May apply if any equipment will be brought to site for closure activities, or if any hazardous materials need to be shipped off the site.

The **Navigable Water Protection Act** pertains to the erection of structures or facilities used to support or impede navigation in waters under the jurisdiction of Canada. Applies if there are any water bodies close to the landfill that could be impacted by having construction activities in the water during closure.

The **Nunavut Land Claim Agreement Act** provides for the use, management and conservation of land, water, and resources of Nunavut.

The **Nunavut Waters and Surface Rights Tribunal Act** provides the Nunavut Water Board with the power to issue water use licenses. The NWB evaluates the potential for detrimental effects occurring because of the use of water or a deposit of waste in water on other users.

Atomic Energy Control Act and Regulations describe the packaging requirements and approvals needed for the transportation of radioactive materials. A nuclear densometer may be needed for construction of the final landfill cover, which would have to be shipped to site.

The **National Fire Code** (NFC) established the standard for fire prevention, fire fighting and life safety in buildings in use, including standards for the conduct of activities causing fire hazards, maintenance of sire safety equipment and egress facilities, standards for fire extinguishers, etc. In addition, the NFC established the standard for prevention, containment and fighting of fires originating outside buildings which may present a hazard to a nearby community, and sets the standards for the storage and handling of dangerous goods, flammable liquids and combustible liquids.

4.4 Nunavut and Northwest Territory Acts, Regulations and Guidelines

The following Nunavut and Northwest Territory acts, regulations and guidelines were referenced during preparation of the Rankin Inlet Solid Waste Site ARP.

Guidelines for the Discharge of Domestic Wastewater in Nunavut, by the Nunavut Water Board, outlines the requirements for water quality effluent from facilities in Nunavut.

Environmental Guidelines for Industrial Waste Discharges establish standards that should be followed when discharging waste from an industrial operation on Commissioners Land or lands administered by municipal governments in Nunavut.

The **Nunavut Wildlife Act** provides for the protection of wildlife and wildlife habitats as well as regulated harvest of selected species.

The **Nunavut Environmental Protection Act** provides for the protection of the environment from the discharge of contaminants, clean up of contaminants and unsightly premises. In addition, the powers of inspectors as well as offences and penalties are defined. The Act applies only to situations not authorized by other Canadian Acts in the Nunavut Territory. The following guidelines under the Nunavut Environmental Protection Act may be applicable to the Rankin Inlet Solid Waste Site ARP:

- Contingency Planning and Spill Reporting
- Disposal Guidelines for Fluorescent Light Tubes
- Guideline: Dust Suppression
- Guidelines for the Management of Waste Asbestos
- Guideline for the Management of Waste Antifreeze
- Guideline for the Management of Waste Paint
- Guideline for the Management of Waste Solvents
- Guidelines for the General Management of Hazardous Waste in Nunavut

The **Nunavut Environmental Rights Act** provides the people of Nunavut the right to access information concerning the release or potential release of contaminants into the environment, and also the right to prevent the release or potential release of contaminants into the environment.

The **Spill Contingency Planning and Reporting Regulations** outline requirements for filing a spill contingency plan and for reporting spills.

The **Nunavut Territorial Archaeological Sites Regulations**, pursuant to the Nunavut Act, protects archaeological sites in Nunavut from disturbance and prohibits the removal of archaeological specimens, except under permit.

The **Safety Act: Occupational Health Regulations** outline the health and safety standards to be maintained at workplaces to ensure the health and safety of persons.

Guidelines for the Removal of Materials Containing Friable Asbestos outlines the procedures for the removal of friable asbestos.

4.5 Approvals

A Land Use Permit is not required from either the Kivalliq Inuit Association (KIA) or Indian and Northern Affairs Canada (INAC) because the Hamlet of Rankin Inlet is the landowner of the Rankin Inlet Solid Waste Site.

We also understand that the Hamlet has a new quarry that can provide sufficient quantity of aggregate for construction of the final cover. Accordingly, a quarry permit will not be required from INAC for development of a new quarry.

Approvals are required from the Nunavut Water Board (NWB) and the Nunavut Impact Review Board (NIRB). A NWB Water Use License Application and NIRB Project Proposal Summary will be submitted to NWB and NIRB with the ARP and stamped design drawings for review and approval. We understand that NWB will circulate a copy of the ARP to INAC, Environment Canada, and Department of Fisheries and Oceans (DFO) for review.

5. Abandonment and Restoration Plan

5.1 Proposed End Use

The proposed end use for the Site is open space that is safe for passive recreational use by wildlife and people. Following implementation of the ARP the Site will consist of an armour stone protective layer over a low-permeability final cover with gentle slopes that do not present a hazard to wildlife. Signage should be posted to discourage the use of All Terrain Vehicles (ATVs) on the closed landfill to minimize erosion and other damage to the final cover. Large rocks could be placed across site access roads to discourage traffic.

5.2 Recommended Site Improvements

Minimizing long-term risk to the environment and to human health and safety is the primary objective of the ARP. To achieve this objective the following site improvements and environmental control measures are proposed. Detailed design of the recommended site improvements is discussed in Section 7 below.

5.2.1 Cleanup of Blown and Dispersed Litter

Loose and blown garbage that is dispersed beyond the perimeter fencing of the existing solid waste site should be collected and transferred to the existing waste pile. All solid waste at and around the Site should be consolidated beneath the proposed final cover footprint.

5.2.2 Management of Scrap Metal and Empty Steel Drums

A pilot project was carried out in 2004 and 2005 where scrap metal was collected, baled and shipped from Rankin Inlet, Nunavut to Churchill, Manitoba for transport by rail to a recycling end user. We understand that this pilot project was supposed to lead to the development of a longer-term initiative that would establish Churchill, Manitoba as a staging point for recycling in the Hudson Bay region. However, a regional recycling program has not been implemented therefore collection and stockpiling scrap metal for transport to Churchill for recycling is not presently an option. It is recommended that scrap metal and steel drums be crushed and placed within the solid waste disposal area. Smaller waste pieces should be placed around larger steel pieces to minimize voids and reduce the total waste volume as much as practicable. Steel pieces and crushed drums should be covered with a 0.3 m thick (minimum) layer of compacted municipal solid waste to protect the overlying final cover from damage.

5.2.3 Hazardous Material Collection and Disposal

In general, hazardous materials appear to have been segregated at a designated location near the Site entrance. All hazardous materials should be gathered and temporarily stored in a secure compound for subsequent transportation to a licensed treatment and/or disposal facility. Examples of hazardous materials that should not be disposed in a Municipal Solid Waste (MSW) landfill include waste fuel, waste oil, toxic chemicals, batteries and PCB-containing fluorescent light ballasts. Waste paint and waste solvents should

also be considered hazardous waste and not disposed in the landfill. Although hazardous wastes have been actively segregated from MSW, the existing solid waste disposal area should be scanned for visible hazardous materials by conducting a "walk-over" of the solid waste disposal area. Any hazardous materials identified during the "walk-over" should be flagged and relocated to a temporary hazardous waste storage compound. Hazardous wastes should be handled, stored, and transported in compliance with applicable regulations including the Canadian Environmental Protection Act and the Transportation of Dangerous Goods Act. The Nunavut Environmental Protection Act provides guidance on management and disposal of fluorescent light tubes, paint, solvents and other hazardous waste in Nunavut. Liquid hydrocarbons may be burned with an appropriate waste oil burner. Residue from burning hydrocarbons should be transported off-site for disposal at a licensed facility.

Appropriate health and safety precautions should be implemented (e.g., personal protective equipment and spill containment) prior to relocating waste materials, opening drums and sampling contents. Compatible hazardous waste materials should be bulked and containerized for transportation and shipped to a registered recycling or disposal facility.

For more information on hazardous waste material handling, transport and disposal contact:

Environmental Protection Service
Department of Sustainable Development
P.O. Box 1000, Station 1195
Iqaluit, Nunavut, X0A 0H0
Phone: (867) 975-5900; Fax: (867) 975-5990

5.2.4 Contaminated Soil Excavation and Relocation

A soil remediation plan has been developed based on the soil sampling results. Contaminated soil will be relocated to the landfill for use as interim cover beneath the final cover. Figure 6 is a site map illustrating test pit locations with soil exceedances and areas of proposed soil excavation. The proposed soil remediation plan identifies four areas with target remedial excavation depths as follows:

Area	Description	Area (m2)	Target Depth (m)	Approximate Volume (m3)
A	Hydrocarbon impacted area east and west of site access road; north of the main landfill area.	26,243	1	26,243
B	Potentially leachate impacted area along east perimeter of main landfill area.	2,190	0.6	1,314
C	Leachate drainage area southeast of main landfill.	25,833	0.6	15,500
D	Leachate drainage area southwest of main landfill.	12,349	1	12,349
Total Potential Volume of Contaminated Soil				**55,406**

The soil remediation areas outlined above and illustrated on Figure 6 will be excavated to the target depth or bedrock refusal. Bedrock outcrops are extensive around the landfill and appear to have provided topographic containment of landfill leachate and related impacts. The proposed soil remediation plan provides for excavation of hydrocarbon impacted soil north (i.e., upgradient) of the main landfill related to historic fuel drum storage and fire training (i.e., Area A). An allowance has been made for excavation of potentially leachate impacted soil along the east perimeter of the main landfill area (i.e. Area B) where a new rip-rap lined drainage ditch will be constructed to divert surface water around the landfill. In general, surface water from the site drains towards the south (i.e., ocean) along two watercourses from the southeast and southwest corners of the main landfill area. These drainage courses and adjacent soil that may have been impacted by landfill leachate (i.e., Areas C and D) will be remediated and new rip-rap lined drainage ditches will be constructed.

Although the above calculation identifies approximately 55,000 m^3 of potential contaminated soil to be excavated the actual volume of soil available for excavation is expected to be significantly less than this due to bedrock refusal during remedial excavation (estimate 30,000 m^3 or just over half of the above estimate). Excavated soil will be relocated to the solid waste disposal area, spread over the solid waste and compacted to construct an interim cover or cushion layer beneath the final cover geomembrane. If buried waste is encountered during remedial excavations in the miscellaneous storage area (i.e., outside of the waste disposal area) this waste will be excavated and relocated to the waste disposal area that will be covered.

Relocating contaminated soil beneath the final cover of the existing solid waste disposal area is preferred over disturbing a clean area for construction of a new landfill or soil treatment cell. Disposal of metal and hydrocarbon contaminated soil beneath an engineered final cover with a low-permeability liner is considered acceptable because the final cover is designed to minimize leachate generation and provide a high-level of long-term environmental protection.

5.2.5 Final Cover Construction

Disposed solid waste will be covered with an impermeable geomembrane final cover system that will prevent infiltration of precipitation into the waste. The final cover system will consist of an armour stone protective layer over a low-permeability geomembrane over a relocated soil cushion layer. A minimum excavated soil volume of 20,000 m^3 is required to provide a 0.6 m thick soil cushion layer above the waste and beneath the geomembrane. However, should additional contaminated soil be available (e.g., estimated 30,000 m^3) this would result in a thicker soil cushion providing improved protection to the overlying geomembrane. The final cover will be graded to encourage runoff from the cover and prevent ponding on the cover. The final cover will minimize leachate generation by encouraging precipitation to runoff and evaporate rather than draining into the waste. Grading and final cover construction to encourage surface water runoff will significantly reduce infiltration into the waste and leachate generation. The final cover will also be a physical barrier to prevent access to the waste by humans and animals and have gentle slopes that do not present a hazard to wildlife or safe movement of ATVs (although as discussed above use of ATVs on the final cover should be discouraged).

5.2.6 Surface Water Diversion and Drainage Ditches

A perimeter surface water drainage ditch around the solid waste disposal area is proposed to collect and divert clean surface water around the landfill. The surface water drainage system will utilize natural topography to direct surface water runoff from the final cover surface and adjacent land to the ocean.

5.2.7 Landfill Gas Ventilation

Explosion risks can occur at landfills where landfill gas can migrate through the subsurface and accumulate inside adjacent buildings. However, this risk does not exist at the Rankin Inlet Solid Waste Site because the community (or nearest residential building) is over 500 m away and permafrost prevents the migration of landfill gas through the subsurface. Therefore, the main concern at the Site is the potential for combustible gas impacts to accumulate beneath the final cover potentially causing damage to the cover (i.e., bubbles in the geomembrane) and/or the potential for an explosion during an abrupt release of landfill gas.

A passive landfill gas ventilation system is proposed to prevent accumulation of landfill gas beneath the final cover. Based on the quantity and age of waste deposited at the existing Rankin Inlet Solid Waste Site, collection and utilization of landfill gas is not considered technically feasible or warranted. Furthermore, flaring of vented landfill gas is also not considered necessary based on the quantity of waste deposited.

No buildings should ever be constructed on the former landfill site without implementation of landfill gas monitoring and management measures.

Figure 6. Proposed Soil Remediation Plan

6. Potential Risk Management Options

Some exceedences of CCME guidance values were detected in both soil and surface water at the periphery of the solid waste disposal area. The proposed soil remediation plan allows for excavation of all detected exceedances with conservative allowances for additional excavation beyond sample locations and depths with observed exceedances. Bedrock outcrops are extensive around the landfill boundary and appear to have provided topographic containment of landfill leachate and related impacts. As a result, it is expected that all waste and contaminated soil will be contained beneath the final cover after implementing the ARP. Confirmatory soil samples will be collected after remedial soil excavation to confirm this assumption.

The following risk management options may be required should confirmatory sampling indicate that soil exceeding applicable guidance values remains beyond the landfill footprint and final cover. If contaminant concentrations exceed applicable guidance values in some of the confirmatory samples then one of two risk management strategies may be required.

1) Conduct a background study; or
2) Conduct a screening level ecological and human health risk assessment to derive site-specific criteria.

A potential decision tree related to this scenario is shown in Figure 7. Each of these risk management strategies are discussed in more detail in the following sections.

6.1 Background Study

A background study could be conducted to determine whether the elevated metal concentrations in soil and surface water are natural or anthropogenic (i.e., caused by man). As a first step, a literature and local information study would be conducted to determine whether any other historic soil or water quality analysis has been completed in the area. Such a search would examine available literature, referenced papers, and government documents and utilize local knowledgeable people. Soil and surface water would be collected at a variety of sampling sites that are remote from the landfill area yet similar in terms of topography and geology. Soil sampling locations should be selected using judgement to find areas that are unlikely to have historic contamination and are similar to the area of interest in terms of soil type and elevation. Surface water sampling sites should be located upsteam from the landfill area and be located in areas that are not influenced by other sources of contaminant inputs. Soil samples should be collected according to the guidelines set out in *CCME Guidance Manual on Sampling, Analysis and data Management for Contaminated Sites (December, 1993)*.

6.2 Screening Level Risk Assessment

If the results of the confirmatory sampling and the background study indicate that following implementation of the ARP, contamination related to the landfill remains beyond the final cover then a screening level Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) could be considered. A HHRA and ERA would help determine if the COPC(s) at the site pose a risk to ecological or human receptors. A risk assessment of this type would likely be a desktop exercise using existing soil and surface water quality data (i.e., likely no additional sample collection required). The risk assessment process would develop site-specific clean up values using a scientifically defensible procedure. It is possible that a HHRA and ERA would confirm that existing contaminant concentrations do not pose a risk to humans or the environment. The process would: identify the relevant exposure pathways that exist at the site; identify any data gaps; develop a source/pathway/receptor conceptual model; and determine if any further sampling is required. The results of a risk assessment would assist with developing further risk management options, if required.

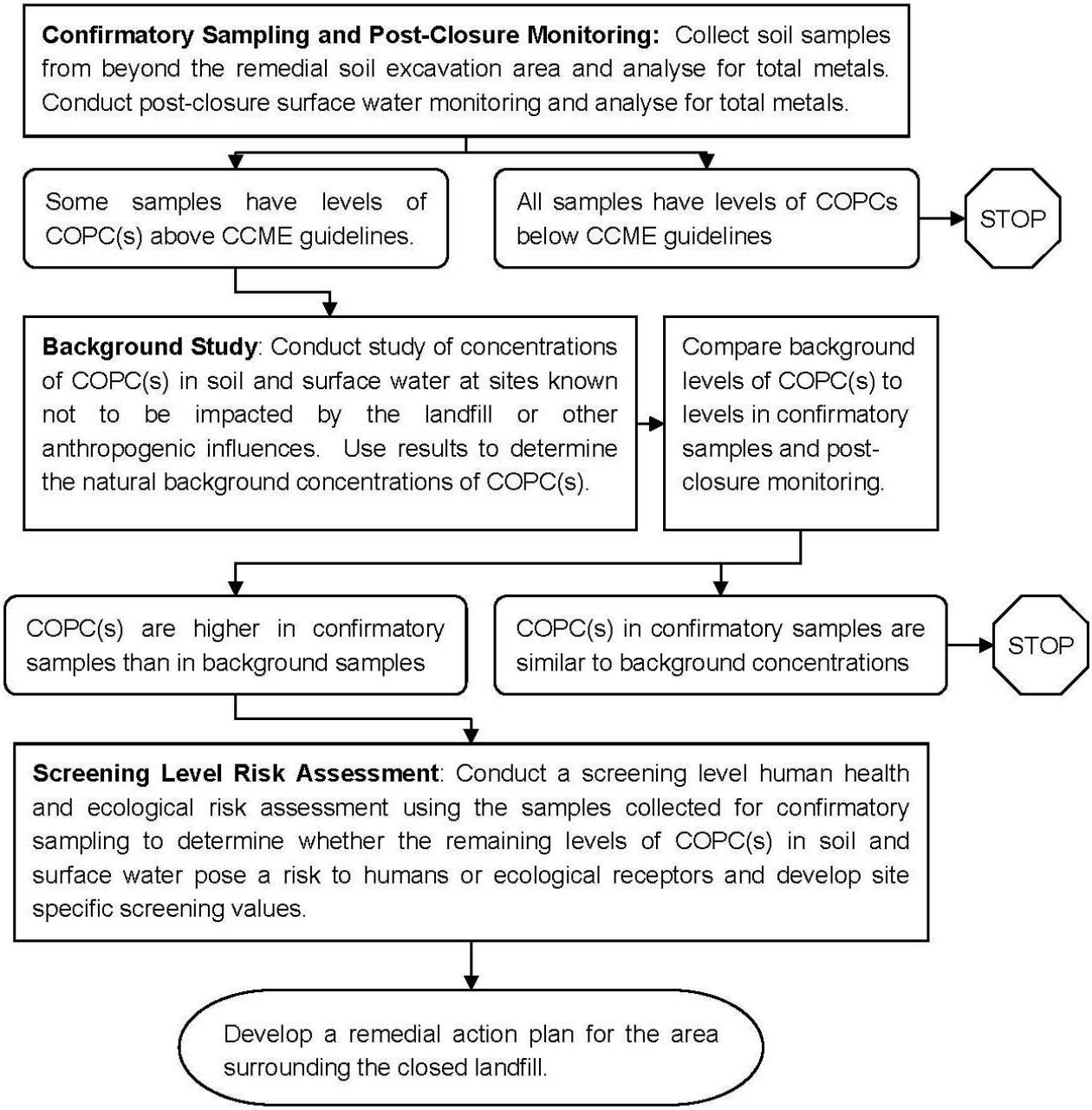

Figure 7. Risk Management Decision Tree

7. Design of Environmental Controls

7.1 Proposed Final Cover Design

The proposed final cover contour plan for the landfill is shown in Figure 8. Design criteria for the final cover contour plan include:

a) All final cover slopes are at least 2% to encourage drainage from the final cover surface. This is considered a minimum grade that allows for future waste settlement to occur while maintaining positive drainage.
b) The maximum final cover slopes will be 4H to 1V. This is considered a maximum slope to ensure that excessive erosion of the final cover surface does not occur.
c) The contour plan has gentle slopes that mimic surrounding natural topography and minimize hazards to wildlife.

The cross-section of the final cover is illustrated on Figure 9 and will consist of the following:

a) 300 mm (1 foot) thick crusher run armour stone (100 mm nominal diameter) layer, over
b) 300 mm (1 foot) thick screened sand and gravel (25 mm nominal diameter) cushion layer, over
c) 4 mm non-woven geotextile cushion layer; over
d) 0.75 mm (30 mil) polyvinyl chloride (PVC) geomembrane; over
e) 4 mm non-woven geotextile cushion layer; over
f) 600 mm (2 foot) minimum thick soil cushion layer composed of relocated contaminated soil from the remedial soil excavation. The soil cushion layer will be placed in two lifts each 300 mm thick and compacted to a minimum density of 95% of the Standard Proctor Dry Density (SPDD) within ±2% of the optimum moisture content.

Prior to placement of the final cover layers, the existing solid waste will be regraded and compacted. Ideally a specially designed landfill waste compactor with steel-wheels and pegged-feet is best suited for waste compaction but such a specialized piece of heavy equipment may not be available in Rankin Inlet. A large (i.e., heavy) tracked excavator (e.g., Caterpillar 345 or equivalent) or bull dozer (Caterpillar D8 or equivalent) will provide some compactive effort but several passes will be required to achieve adequate compaction. Final waste contours will be achieved by cutting existing high points and relocating waste to low points with a bull dozer and/or excavator. Regrading the existing waste will provide an opportunity to fill voids in the waste and rearrange pieces of waste into a more solid mass. In addition, all waste will be compacted by completing at least 4 passes of the tracked heavy equipment over the entire regraded waste surface. Equipment used to regrade and compact the waste should be fitted with guards for the radiator, engine compartment, crankcase (belly), and cylinder lines to provide protection for critical machine components. Debris protection guards for the idler seals, pivot shaft seals, and final drive seals would also help prevent damage to the equipment and related construction delays.

Existing waste should be graded to have approximately the same contours as the proposed final cover (see Figure 8) with elevations approximately 1.2 m below the final cover surface. Note that the as-built thickness of the interim soil layer (and final cover contours) may vary slightly from those shown on Figure 8; however the approximate grades should be achieved to encourage runoff of precipitation from the final cover.

7.2 Proposed Surface Water Drainage System Design

The layout of the proposed surface water drainage system is illustrated in Figure 8. The perimeter drainage ditches will be designed and constructed as follows:

a) The perimeter drainage ditches will be an open channel design with a trapezoid shaped cross section.

b) The perimeter drainage ditches will be lined with a 0.3 m thick layer of 150 mm nominal diameter rip-rap (i.e., crusher run) to minimize erosion and accommodate any potential ground settlement.

A detail of the proposed ditch cross-section is included on Figure 9.

7.3 Proposed Passive Landfill Gas Vent Design

A total of four passive landfill gas vents will be constructed at locations illustrated in plan on Figure 8. The gas vents will consist of a 100 mm (4 inch) diameter steel pipe that penetrates the geomembrane with a slotted screen section embedded in a gravel column within the waste. A detail of the gas vent is included on Figure 9. The vent pipes will be field welded to the geomembrane cover with a flexible boot to allow settlement of the underlying waste without damaging the cover and prevent infiltration of water into the waste. The top of the vent pipe will have a 180 degree gooseneck to prevent precipitation from entering the vent and the vent opening will be fitted with a metal screen to prevent animals from entering vent pipe. The bottom of the vent pipe will be anchored in concrete to prevent the vent pipe from being jacked out of the waste by freeze-thaw action. The landfill gas ventilation pipes are designed to passively vent landfill gas generated by the waste over the long-term with little to no maintenance required. It is recommended that bright coloured (e.g., fluorescent orange) flags on an extension pole be attached to the gas vent pipes to make them more visible and prevent collisions with All-Terrain Vehicles (ATVs).

Figure 8. Proposed Final Cover Contour Plan

Figure 9. Cross-Section of Proposed Final Cover Design

8. Post-Closure Inspection and Maintenance

Implementation of the ARP for the existing Rankin Inlet Solid Waste Site is scheduled to commence in 2009. After the ARP is implemented the Site will require post-closure inspection and maintenance to verify the integrity and performance of the final cover and other environmental controls. Tables 4 through 6 identify the recommended inspection and maintenance activities and suggested frequencies.

Table 4. General Site Inspection and Maintenance

Frequency	Inspection	Maintenance
Biannually (Spring and Fall)	Visual inspection of: ➢ Evidence of illegal dumping of waste at entrance and on property; ➢ Signage (lettering clear and unobscured); ➢ Access road barriers (functional); and ➢ Passive landfill gas vents (undamaged).	➢ Maintenance or repair as needed based on inspections.

Table 5. Final Cover Inspection and Maintenance

Frequency	Inspection	Maintenance
Annually (Summer)	Visual walk-over inspection of covered landfill surface for: ➢ presence of significant erosion; ➢ exposure of geomembrane; ➢ exposure of waste; ➢ settlement areas; ➢ damaged or blocked landfill gas vents; and ➢ leachate seepage from cover slopes or toe.	Maintenance or repair as needed based on inspections. Specific requirements may include: ➢ regrading/repair of erosion areas; and ➢ infilling of settlement depressions or erosion areas with additional aggregate.

Table 6. Surface Water Drainage System Inspection and Maintenance

Frequency	Inspection	Maintenance
Biannually (Spring and Fall)	Visual inspection of surface water controls as follows: ➢ sediment accumulation in perimeter ditches; ➢ evidence of leachate impacts (staining along drain sides and any natural channels on site); ➢ condition of culverts (sediment accumulation within and around culvert openings, confirmation of structural integrity); ➢ condition of erosion protection (disturbance, erosion beneath armouring, sediment accumulation); and ➢ Inspections should be timed, if possible, to follow significant runoff events (e.g. after spring thaw and/or following major storm events).	Maintenance or repair as needed based on inspections. Specific requirements may include: ➢ sediment removal from ditches or culverts; ➢ culvert improvement or replacement; ➢ removal of trash and debris accumulated in ditches; and/or ➢ erosion repairs (placement of additional granular material or rip-rap).

9. Environmental Monitoring Program

Environmental monitoring is a required element of the closure plan to assess and monitor the effectiveness of the ARP. A post-closure environmental monitoring program will verify that the implemented ARP effectively prevents landfill contaminants from leaching into the surrounding environment. If post-closure environmental monitoring indicates that contaminants are not migrating from the closed landfill then there is little long-term risk to ecological or human receptors. Impact to surface water quality is the primary concern therefore surface water monitoring is the primary component of the proposed environmental monitoring program.

After implementation of the ARP at least five years of follow-up environmental monitoring is recommended. At the end of the five-year post-closure monitoring period (i.e., in 2015) the monitoring program and results should be reviewed to determine if additional monitoring (i.e., extending the monitoring period) is necessary.

9.1 General Environmental Monitoring Recommendations

The following recommendations apply to environmental monitoring in general:

1. All sampling work shall be conducted by appropriately trained personnel supervised by a Professional Engineer of Professional Geoscientist experienced in landfill environmental monitoring. Significant sources of error can be introduced to monitoring results from improper sampling protocols and procedures, thereby negating the value of any such work.

2. All sampling shall be conducted in accordance with environmental industry standard sampling protocols.

3. Sample analysis shall be completed by a certified commercial laboratory using acceptable international standards for environmental chemical analysis and quality control. All analysis shall be conducted with sufficient analytical precision to allow for comparison of the results with applicable guidance values (e.g. CCME criteria).

4. Samples shall be filtered and preserved, as specified by the analytical laboratory, in the field immediately following sample collection. All samples shall be kept on ice and in a cooler at all times between collection and delivery to the laboratory.

5. Calibration results of all field meters shall be recorded on the day of sample collection.

6. Only clean, laboratory provided sample bottles shall be used for sample collection.

7. One randomly selected location shall be collected and analyzed in duplicate during each sampling event (e.g. two samples collected from the same location, collected sequentially). This is a quality control measure that documents variability and repeatability in sampling and laboratory analysis.

8. All sample results shall be reviewed by a Professional Engineer or Professional Geoscientist experienced in landfill environmental monitoring. An annual monitoring report shall be prepared by such a professional. The report shall also include an assessment of quality control, including reporting of quality control samples. The scope of the monitoring program should be reviewed on a regular basis by the qualified environmental professional and adjustments to the program made in light of interpretation of water quality trends. This could include addition or reduction in sampling parameters, locations and frequency.

9.2 Surface Water Monitoring

Surface water monitoring is recommended at four locations as shown on Figure 10. Proposed surface water monitoring locations include:

- SW1 – Downstream drainage ditch southeast of landfill
- SW2 – Downstream drainage ditch southwest of landfill
- SW3 – Ocean outfall from drainage ditch southeast of landfill
- SW4 – Ocean outfall from drainage ditch southwest of landfill

It is recommended that surface water monitoring be carried out once per year in late August (i.e., at full thaw). The recommended monitoring parameter list is outlined in Table 7. It may be possible to discontinue annual surface water sampling and/or reduce the parameter list if analytical results consistently indicate no impact to surface water quality after 5 years of monitoring.

9.3 Landfill Gas Monitoring

Given the size of the landfill and distance to the nearest structures, generation and accumulation of landfill gas has been assessed not to be a significant concern. However, as a proactive measure, it is recommended that the concentration of methane or Lower Explosive Limit (LEL) at the passive landfill gas ventilation pipes be measured once per year (at the same time as the surface water sampling event) during the five-year post-closure monitoring period.

Table 7. Surface Water Monitoring Parameters

Analysis Suite	Rational/Description	Recommended Minimum List of Parameters	
Total Metals	Major cations including potential landfill leachate indicator parameters and potential natural background metals. *NOTES: Metal samples must be preserved in the field. Surface water samples do not have to be field filtered.*	♦ Arsenic ♦ Cadmium ♦ Chromium ♦ Copper ♦ Iron ♦ Lead ♦ Magnesium ♦ Manganese	♦ Mercury (detection limit less than 0.000026 mg/L) ♦ Nickel ♦ Selenium ♦ Sodium ♦ Silver ♦ Zinc
General Chemistry	Major anions and nutrients including potential landfill leachate indicator parameters.	♦ Alkalinity ♦ Ammonia ♦ Chloride ♦ Hardness ♦ Lab pH ♦ Lab conductivity	♦ Sulphate ♦ Nitrate ♦ Nitrite ♦ Turbidity ♦ Total dissolved solids (TDS)
Field Measurements	Physical conditions at time of sampling and measurement of field parameters that may change with time.	♦ Weather (current and past 24 hours) ♦ Visual observations (sheen, odour, etc.) ♦ Water depth and/or flow rate estimate	♦ Field pH ♦ Temperature ♦ Field conductivity
Hydrocarbons	Potential fuel impacts.	♦ CCME F1-F4 hydrocarbon fractions	

NOTE: Most analytical laboratories provide packages that include these parameters; ensure the above minimum parameters are included in the selected analytical package.

Figure 10. Proposed Surface Water Monitoring Locations

10. Record Keeping and Reporting Requirements

Records shall be maintained of all environmental monitoring, post-closure inspections and maintenance. A sample landfill inspection and maintenance record form is included in Appendix C.

Post-closure reporting is required to assess the performance of the closed landfill and identify any required changes in post-closure care. An annual report should be prepared that includes the following:

a) A summary of environmental monitoring results and interpretation;

b) Any recommended modifications to the monitoring program;

c) A summary of inspections and maintenance;

d) Any contingency measures implemented and their adequacy;

e) A summary of any public complaints and the responses to those complaints; and

f) Recommendations on the scope and frequency of future reporting.

Following implementation of the ARP and demonstration that the environmental control systems are effective, the frequency of the reporting should be reviewed and potentially decreased as appropriate.

11. Implementation Schedule and Cost Estimate

11.1 Implementation Schedule

This section describes the required activities and expected timing to implement the ARP. After the ARP is implemented, there will be a post-closure period of inspection, maintenance, and environmental monitoring as outlined above.

Abandonment and Reclamation Plan Implementation

The following tasks are required to implement the ARP:

Task 1. Advise community and waste haulers of the existing Site closure and new landfill location by advertising in the local newspaper;

Task 2. Site cleanup (e.g., collection of wind blown litter) and waste regrading/compaction;

Task 3. Remedial soil excavation and placement/compaction over waste;

Task 4. Perimeter drainage ditch construction;

Task 5. Final cover construction;

Task 6. Place access road barriers to discourage traffic on final cover; and

Task 7. Establish environmental monitoring stations.

Task 1 should be completed prior to initiating the other ARP tasks. Collection of wind blown litter and scattered waste and relocation of contaminated soil from around the landfill (i.e., Tasks 2 and 3) could potentially be carried out by municipal forces and/or a local contractor as soon as weather permits in advance of final cover construction. Tasks 2, 3 and 4 should be completed before construction of the final cover commences.

Post-Closure Period

After implementing the ARP completion of the following tasks will be required on an ongoing basis throughout the post-closure period:

Task 1. Inspect and maintain access road barriers;

Task 2. Inspect and maintain final cover;

Task 3. Inspect and maintain perimeter drainage ditches;

Task 4. Maintain records of inspections and maintenance;

Task 5. Carry out surface water and landfill gas monitoring (2010 through 2015 minimum);

Task 6. Maintain monitoring data and prepare an annual report (2010 through 2015 minimum); and

Task 7. Address any recommendations identified during inspections or in the annual report.

11.2 Estimated Capital and Annual Post-Closure Costs

Estimated capital costs to implement the Abandonment and Restoration Plan at the Rankin Inlet solid waste site are almost $1.5 million. Table 8 presents estimated quantities and unit rates used to develop the capital costs estimate. Estimated post-closure costs are $50,000 per year to carry out inspections, maintenance and environmental monitoring at the closed site. Table 9 provides a breakdown of estimated annual post-closure costs.

Table 8. Rankin Inlet Solid Waste Site ARP Capital Cost Estimate

Item	Qty	Units	Unit Cost1	Item Cost
Hazardous waste segregation for transport/disposal (2 person crew)[2]	40	Hours	$100	$4,000
Collection of wind blown litter and scattered waste (2 person crew)	120	Hours	$100	$12,000
Removal of existing perimeter fence and gates	1	Allowance	$5,000	$5,000
Blocking access to site and perimeter roads	1	Allowance	$5,000	$5,000
Excavation of ditches and placement of rip-rap lining[3]	1200	m	$50	$60,000
Grading and compaction of existing waste	32,000	m^2	$3	$96,000
Excavation, relocation and spreading of contaminated soil/waste	30,000	m^3	$10	$300,000
Supply and place geomembrane and geotextile layers	32,000	m^2	$15	$480,000
Haul and place 0.3 m thick screened sand & gravel cushion layer[3]	9,600	m^3	$30	$288,000
Haul and place 0.3 m thick crusher run armour stone layer[3]	9,600	m^3	$25	$240,000
Supply and install passive landfill gas vents	4	Each	$1,000	$4,000
Site Information Signs	1	Allowance	$2,000	$2,000
Total ARP Capital Costs (in 2009 dollars)				**$1,496,000**

Notes:

1) Estimated unit costs include supply and placement of materials, if applicable.

2) Transport and disposal of hazardous waste costs not included in above estimate.

3) Aggregate supplied from municipality owned quarry.

Table 9. Estimate of Annual Post-Closure Maintenance and Monitoring Costs

Item	Qty	Units	Unit Cost	Item Cost
Perimeter Drainage Ditch Maintenance (by local contractor)	1	Allowance	$5,000	$5,000
Final Cover Maintenance (by local contractor)	1	Allowance	$5,000	$5,000
Annual Landfill Inspection (including travel and report)	1	Allowance	$20,000	$20,000
Environmental Monitoring (including travel, analysis and report)	1	Allowance	$20,000	$20,000
Total Annual Post-Closure Costs (in 2009 dollars)				**$50,000**

12. Contingency Measures

If deficiencies in the performance of the proposed existing environmental controls are observed at the Site, or if environmental conditions are found to be degrading, they should be investigated and mitigated as soon as possible. In all cases the deficiency or occurrence should be thoroughly investigated and documented for future reference. Potential courses of action should be identified and evaluated according to their feasibility, expected effectiveness and cost. Finally, an appropriate level of design should be carried out prior to implementation. This section identifies potential deficiencies that may occur at the Site and possible contingency measures that could be undertaken.

12.1 Final Cover Integrity

Localized damage to the final cover may occur through erosion, settlement, human or animal activity. The cover is the primary component of the leachate control system and it is important that it be maintained, as best as possible, as a continuous low-permeability barrier. Any erosion of the gravel cover over the geomembrane can be repaired by placing additional gravel cover material and/or regrading. Any suspected damage to the geomembrane should be investigated and repaired.

12.2 Landfill Settlement

Settlement of landfilled waste materials will continue through the post-closure period. Where settlement creates a depression that ponds water, the situation should be rectified by placing additional gravel cover material and/or regrading the effected area to maintain positive drainage and minimize infiltration of precipitation into the landfill. Any suspected damage to the geomembrane should be investigated and repaired.

12.3 Landfill Gas

If unacceptable landfill gas concentrations (i.e., explosive conditions) are consistently measured at ground surface (i.e., near the passive vent outlets), then improvements to the passive venting system may be required. Improvements may include constructing additional passive vents or increasing the capacity of the existing vents by installing fans.

12.4 Blockage of Surface Drainage Pathways

If the surface water perimeter ditches erode or become filled with sediment they should be reconstructed, repaired and/or cleaned out to re-establish positive drainage. Ponding of water on the landfill final cover is not desirable and depressions should be graded to prevent ponding of water on the final cover.

12.5 Leachate Seepage Detected by Surface Water Monitoring

Should surface water quality monitoring downstream of the closed landfill indicate that leachate may be seeping from the landfill the source of the leachate should be identified. Staining around the perimeter of the final cover could be an indication of leachate seepage. An assessment of the extent and cause of the leachate seepage should be carried out and potential mitigation measures evaluated. A potential mitigation measure could involve increasing final cover thickness in the area to raise the elevation of the active thaw layer and create a containment barrier with frozen ground (i.e., permafrost). Another potential mitigation measure is construction of a geomembrane cut-off trench that ties into the final cover. The assessment and mitigation measure design should be carried out by a Professional Engineer experienced in landfill design in northern climates.

13. Emergency Response

13.1 Fire

Should fire or smoke be detected at the closed landfill the following actions should be taken immediately:

1. Notify the Rankin Inlet fire department and RCMP.
2. Attempt to put out the fire by smothering it with water or soil, if appropriate and safe to do so. Landfill fires should be contained/smothered by placing soil cover over the effected area.
3. Any suspected damage to the geomembrane final cover should be investigated and repaired.

13.2 Spills

In the event of a spill or unlawful discharge onto the ground on or near the closed landfill the following actions should be taken immediately:

1. Identify and/or characterize the spilled material.
2. Put on personal protective equipment appropriate for the spilled material and stop the source of the leak/spill, if safe to do so.
3. Contain the spilled material with absorbent materials and/or containment booms, if safe to do so. Take every reasonable precaution to prevent spilled material from discharging to ditches and surface water.
4. Spills of contaminants in excess of quantities listed in Schedule B of the Spill Contingency Planning and Reporting Regulation (Regulation R-068-93 dated July 15, 1998) must be reported to the 24-hour Nunavut Spill Report Line (867-920–8130 or 403-920-8130). Report a spill immediately and do not delay reporting a spill because of lack of knowledge.
5. Notify the Hamlet of Rankin Inlet, fire department and RCMP, if public safety is at risk.
6. Clean up the spill using absorbent materials and/or excavation of contaminated soil. It may be necessary to retain a specialist contractor to clean up the spill.
7. Temporary barriers such as snow fencing and/or caution tape should be erected around any areas that are unsafe.
8. Some hydrocarbons and solvents can damage the geomembrane liner in the final cover. Any suspected damage to the geomembrane final cover should be investigated and repaired.

13.3 Illegal Dumping of Solid Waste

If solid waste is deposited at the Site or near any of the Site entrances, the waste should be transferred to the operating landfill. The Hamlet of Rankin Inlet should make every effort to determine who placed the waste illegally at the Site and take action to correct this from occurring again.

14. References

CBEC, 2008. *Rankin Inlet 2008.* CBEC Web Site.

CCME, 1999. *Canadian Environmental Quality Guidelines*. Canadian Council of Ministers of the Environment. 1999.

CCME, 2001. *Canada-Wide Standards for Petroleum Hydrocarbons in Soil*. Canadian Council of Ministers of the Environment. 2001.

Conference Board of Canada, 2009. *Environment: Municipal Waste Generation.* http://www.conferenceboard.ca/HCP/Details/environment/municipal-waste-generation.aspx#way

CSMWG, 2000. *A federal approach to Contaminated Sites*.

Environment Canada, 2009. *Canadian Climate Normals 1971 – 2000 - Rankin Inlet.* http://www.climate.weatheroffice.ec.gc.ca/climate_normals/results_e.html?StnID=1721&autofwd=1

EPEC Consulting Western Limited, 1981. *Community Water and Sanitation Services Northwest Territories.* Prepared by EPEC Consulting Western Limited under the authorization and direction of the Water and Sanitation Section, Department of Local Government. Government of the Northwest Territories. pp 329 – 334.

GHGM, 2006. *Greenhouse Gas Measurement and Reporting Plan, Project Title: Pilot Project to Demonstrate Cost-Effective Ways of Recycling Scrap Metal form Northern Communities.* Greenhouse Gas Measurement.

GLL, 2007. *City of Yellowknife Solid Waste Composition Study and Waste Reduction Recommendations.* Gartner Lee Ltd. (GLL).

INAC, 2002a. *Northern Affairs Program Contaminated Sites Management Policy.*

James, P.A. 1970. *The Soils of the Rankin Inlet Area, Keenwatin, N.W.T., Canada.* Arctic and Alpine Research, Vol. 2, No. 4, pp293-302.

Judge, A.S., Tucker, C.M., Pilon, J.A., and Moorman, B.J., 1991. *Remote Sensing of Permafrost by Ground-Penetrating Radar at Two Airports in Arctic Canada.* Arctic, Vol. 44, Supp. 1, pp 40-48.

NRC, 2008. *Surficial Materials. Natural Resources Canada (NRC).* http://atlas.nrcan.gc.ca/site/english/maps/environment/land/surficialmaterials

NRC, 2009. *Geological Survey of Canada. Natural Resources Canada (NRC).* http://gsc.nrcan.gc.ca/permafrost/wheredoes_e.php

Pichtel, J., 2005. *Waste Management Practices: Municipal, Hazardous, and Industrial.* CRC Press, Taylor & Francis Group, Boca Raton, FL.

Pool, A., 2008. *Rankin Inlet, the Canadian Encyclopedia.* Historic Foundation Web Site.

Quinn Duffy, R., 1987. *The Road to Nunavut: The Progress of the Eastern Arctic Inuit Since the Second World War.* McGill-Queen's Press – MQUP.

Smith, W.D., 1987. *Cold Climate Solid Waste Management Guidelines.* World Health Organization (WHO), Copenhagen, Denmark.

Statistics Canada, 2005. Human Activity and the Environment, Annual Statistics 2005, Feature Article: Solid Waste in Canada. Statistics Canada, Ottawa.

Treasury Board 2002. *Treasury Board Federal Contaminated Sites Management Policy*. June 2002.

Appendix A

Records of Test Pit Excavation

Table A-1. Summary of Test Pit Locations

ID	Co-ordinates (UTM Zone 15, NAD 83)	
	Easting	Northing
TP1	0547197	6963662
TP2	0547150	6963613
TP3	0547138	6963613
TP4	0547120	6963624
TP5	0547113	6963599
TP6	0547191	6963651
TP7	0546969	6963844
TP8	0546998	6963851
TP9	0546983	6963863
TP10	0546914	6963914
TP11	0546935	6964009
TP12	0546885	6964016
TP13	0547001	6963890
TP14	0547139	6963686
TP15	0547247	6963897
TP16	0547448	6963601
TP17	0547394	6963564
TP18	0546928	6964022
TP19	0547241	6963692
TP20	0547242	6963702
TP21	0547069	6963600
TP22	0547077	6963591
TP23	0547088	6963566
TP24	0547102	6963557
TP25	0547112	6963544
TP26	0547102	6963511
TP27	0547123	6963501
TP28	0547098	6963506
TP29	0547353	6963669
TP29-1	0547422	6963678
TP30	0547432	6963698
TP31	0546914	6963947
TP32	0546931	6963906
TP33	0546970	6963934
TP34	0547014	6963928
TP35	0546994	6963934
TP36	0547029	6963890

Table A-2. Record of Test Pit Excavations

Test Pit ID	Location	Depth from Surface, m	Soil Description
TP1	Within the perimeter road	0-0.05 0.05-0.9	Some grass on the surface. Moist, brown organic matter and plant material mixed with sand, silt and gravel. Moist, yellowish-brown sand, silt, some gravel and cobbles. Little garbage was found.
TP2	Within the perimeter road	0-0.1 0.1-0.6	Grass on the surface. Moist, brown organic matter and plant material mixed with sand, silt and some gravel. Very moist, brown sand, silt, some gravel and cobbles; roots to 50 cm; Grey sand and silt at bottom. A lot of garbage (metals and plastics) was found at approximately 30 – 40 cm; strong stink smell.
TP3	Within the perimeter road	0-0.1 0.1-0.3 0.3-0.6 0.6-0.9	Grass on the surface. Moist, brown organic matter and plant material mixed with sand, silt and some gravel. Moist, brownish-yellow sand, silt, gravel and some boulders. A lot of garbage (typical domestic); dark brown colour associated with some garbage. Moist, greyish-yellow gravel, sand, and some silt.
TP4	Within the perimeter road	0-0.1 0.1-0.4 0.4-1.2 1.2	Grass on the surface. Moist, brown organic matter and plant material mixed with sand, gravel and some silt. Old garbage layer with yellow, black, white and rust-coloured stains. Moist to wet, yellow/rust-coloured sand and silt mixed with gravel and cobbles. Some seepage with oil sheen on water surface.
TP5	Within the perimeter road	0-0.1 0.1-0.5 0.5-1.3 1.3	Grass on the surface. Moist, brown organic matter and plant material mixed with sand, gravel and some silt. Typical domestic garbage including plastic, metal, electrical cables, etc. Moist to wet, grey sand and silt with some gravel. Some groundwater seepage into test pit.
TP6	Within the perimeter road	0-0.1 0.1-0.9 0.9	Some grass on the surface. Moist, brown organic matter and plant material mixed with sand, silt and some gravel. Moist to wet, yellowish-brown sand, silt, gravel; and cobbles. Some seepage with grey coloured water.
TP7	Fire training area	0-0.1 0.1-0.7	Moist, black silt, clay, and sand associated with ash; some gravel found. Moist, yellowish-brown sand and silt with some clay and gravel; brown colour observed at the bottom. Compacted drums and metals were found.
TP8	Fire training area	0-0.2 0.2-0.3 0.3-0.7 0.7-0.9	Moist, yellowish-brown sand, silt and some gravel. Black old garbage. Moist, light brown sand, gravel and some silt; some garbage. Black old garbage.
TP9	Fire training area	0-0.3	Moist, brown sand, silt and gravel. Rusty fuel drum found at the bottom.
TP10	Close to the drum storage and crusher area (North of the site)	0-0.1 0.1-0.6 0.6-0.9	Grassed surface. Moist, brown organic matter mixed with sand, silt, gravel and occasional cobble. Moist, dark brown to black organics, silt, sand and gravel; occasional plastic. Wet, grey clay and silt with some sand and gravel.
TP11	Close to the 45 gallon drum storage area (North of the site)	0-0.5	Moist, brown sand and gravel, some cobbles and trace silt. Strong fuel smell. Big rock/bed rock at bottom.
TP12	Close to the site entrance (west to the access road)	0-0.9	Moist, brown sand and gravel with some silt and cobbles.
TP13	Metal scrap area	0-0.3	Moist, brown sand and gravel; excavation stopped at concrete pieces (demolition waste).
TP14	Approximately in the middle of the landfill site	0-0.6	Some grass on the surface. Moist, brown sand and gravel, some silt and cobbles. No garbage found.

Table A-2. Record of Test Pit Excavations

Test Pit ID	Location	Depth from Surface, m	Soil Description
TP15	150 m east to the landfill site	0-0.8 0.8-0.9	Moist, greyish-brown sand and gravel, some cobbles; grey clay at bottom Wet, brown sand and gravel; some grey clay at bottom.
TP16	250 m southeast to the landfill	0-0.1 0.1-1.0	Some grass on the surface. Moist, brown organic matter and plant remains mixed with sand, silt and gravel. Moist, brown sand and gravel, some cobbles and silt.
TP17	200 m southeast to the landfill	0-0.2 0.2-0.6	Some grass on the surface. Moist, dark brown organic matter and plant material mixed with sand, silt and some gravel. Moist, brown and grey sand and gravel with trace silt.
TP18	Close to the site entrance (east to the access road)	0-0.4 0.4-0.5 0.5-0.6	Moist, brown sand and silt, some dark grey gravel and cobbles; fuel smell. Wet, brown sand and silt, some dark grey gravel and cobbles. Seepage observed.
TP19	20 m southeast to the landfill	0-0.1 0.1-0.5 0.5-1.2 1.2	Some grass on the surface. Moist, sand and gravel with roots and some organic matter. Moist gravel and cobbles with some sand; fuel smell. Moist to wet sand and grave with some cobbles; fuel smell. Seepage with fuel sheen on the surface.
TP20	25 m southeast to the landfill	0-0.1 0.1-1.2	Some grass on the surface. Moist, sand and gravel with roots and some organic matter. Moist sand, gravel, some cobbles and silt.
TP21	10 m south to the landfill	0-0.25 0.25-1.0	Some grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Moist to wet gravel, sand, silt and some greyish-yellow clay.
TP22	10 m south to the landfill	0-0.2 0.2-0.3	Some grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Grey gravel and cobbles; large boulder or bedrock at bottom.
TP23	20 m south to the landfill	0-0.2 0.2-0.3	Some grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Grey gravel and cobbles; bedrock possibly encountered at the bottom.
TP24	25 m south to the landfill	0-0.2 0.2-0.6	Grass on surface. Moist, dark brown organic matter and plant material mixed with sand, gravel and silt. Grey gravel and cobbles; some greyish-yellow clay; some sand and silt; bedrock possibly encountered at the bottom.
TP25	40 m south to the landfill	0-0.2 0.2-0.6	Grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Moist to very moist sand, gravel, cobbles and some silt; bedrock possibly encountered at the bottom.
TP26	50 m south to the landfill	0-0.2 0.2-0.8 0.8	Grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Moist to wet sand, gravel, cobbles and some silt; bedrock possibly encountered at the bottom. Seepage observed.
TP27	80 m south to the landfill	0-0.2 0.2-0.7 0.7-1.2	Grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Moist to wet sand, silt, clay, gravel, and some cobbles; seepage observed from depth of 0.7 m. Wet sand, silt, clay, gravel, and some cobbles; seepage observed.
TP28	75 m south to the landfill	0-0.2 0.2-0.5	Some grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Moist to wet sand, silt, clay, gravel, and some cobbles; grey clay on the bottom.
TP29	130 m southeast to the landfill	0-0.2 0.2-0.3	Some grass on surface. Moist, brown organic matter and plant material mixed with sand, gravel and silt. Moist to wet sand, gravel and silt; seepage observed. Bedrock or large boulder at the bottom.
TP29-1	200 m southeast to the landfill	0-0.1 0.1-0.2	Some grass on surface. Moist, brown organic matter, sand, gravel and some silt. Gravel, sand and some silt; bedrock at bottom.
TP30	210 m southeast	0-0.1	Trace grass on surface. Moist, brown organic matter, plant material, sand,

Table A-2. Record of Test Pit Excavations

Test Pit ID	Location	Depth from Surface, m	Soil Description
	to the landfill	0.1-0.3	gravel and silt. Moist to wet, sand, gravel, silt and clay; some cobbles.
TP31	Located at north of the site; close to drum storage area and diesel contaminated soil stockpile	0-0.2 0.2-0.3 0.3-0.6	Grass on surface. Moist, brown organic matter, sand, gravel and silt. Moist, dark brown organic matter, sand, and silt. Moist to wet, grey gravel, sand, silt and clay; seepage at the bottom.
TP32	Located at north of the site	0-0.2 0.2-0.3 0.3-0.6 0.6-0.9	Grass on surface. Moist, brown organic matter, sand, gravel and silt. Moist, black sand, gravel and silt. Moist to wet, light brown gravel, sand, and silt. Seepage observed at 0.6m depth; trace fuel sheen observed on the surface of the water. Garbage (e.g., metal, plastic, and wood waste) observed.
TP33	Located at north of the site	0-0.05 0.05-0.1 0.1-0.3	Trace grass on surface. Moist, brown organic matter, sand, gravel and silt. Moist, grey clay and silt. Gravel, sand and some silt.
TP34	North of the site	0-0.3	Gravel, sand, silt and some cobbles; fuel drum observed.
TP35	North of the site	0-0.6	Gravel, cobbles, sand and some silt.
TP36	North of the site; close to sewage trench	0-1.2	Slightly moist gravel, sand, silt and some clay and cobbles.

Appendix B

Summary of Soil and Water Sampling Results

Table B-1. Summary of Analytical Results for Soil Samples

Parameters	Units	CCME CSQG - Coarse Soil		CCME PHC CWS - Coarse Soil		TP7 - 0	TP7 - 60	TP9-0	TP11-0	TP11-30	TP12-60	TP15-90	TP17 - 0	TP18-30	TP19-0	TP19- 60	TP20-60	TP21 - 30	TP21 - 90	TP23- 0	TP24 - 0	TP25 - 30	TP26 - 30	TP27 - 30	TP28 - 30	TP28- 30 R	TP29-30	TP30-30	TP30-30 R
		Residential/ Parkland	Commercial	Residential/ Parkland	Commercial	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	22-AUG-08	22-AUG-08	22-AUG-08
Metals																													
Antimony (Sb)	mg/kg	20	40			<0.07	0.10	<0.07	<0.07	<0.07	<0.07	<0.07	0.09	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
Arsenic (As)	mg/kg	12	12			4.08	13.3	14.6	16.7	9.63	15.7	7.73	1.83	9.37	9.39	6.20	7.10	6.75	2.35	8.40	6.45	8.56	14.8	5.89	7.04	7.63	7.15	9.63	7.68
Barium (Ba)	mg/kg	500	2000			70.0	78.0	99.2	94.8	82.1	92.0	64.7	104	92.2	84.0	70.5	84.1	45.9	53.4	56.9	59.5	64.9	60.3	32.5	58.7	55.2	74.9	54.0	53.6
Beryllium (Be)	mg/kg	4	8			0.21	0.12	0.16	0.17	0.12	0.11	0.10	<0.06	0.12	0.10	0.11	0.12	0.12	0.13	0.14	0.11	0.16	0.12	0.11	0.10	0.10	0.11	0.11	0.10
Cadmium (Cd)	mg/kg	10	22			0.43	0.57	0.19	0.09	0.07	0.06	0.06	0.21	0.05	0.08	0.03	0.05	0.06	0.22	0.07	0.06	0.05	0.07	0.03	0.03	0.03	0.03	0.06	0.04
Chromium (Cr)	mg/kg	64	87			50.4	61.7	60.1	65.9	52.4	51.3	46.4	3.5	56.6	59.4	53.1	61.9	93.3	145	89.9	58.2	68.2	53.7	53.1	52.9	50.5	50.2	80.3	64.7
Cobalt (Co)	mg/kg	50	300			6.44	16.1	16.5	18.7	10.3	14.0	11.5	3.73	21.1	13.5	10.7	13.7	16.3	27.4	16.2	11.5	12.4	15.9	9.11	12.4	11.5	10.4	13.9	14.4
Copper (Cu)	mg/kg	63	91			48.3	77.0	64.5	55.8	61.7	46.7	46.1	42.7	34.2	233	38.0	71.5	45.9	146	43.5	57.6	53.3	125	45.4	38.8	36.9	68.7	88.1	64.9
Lead (Pb)	mg/kg	140	260			156	24.7	58.3	6.17	4.38	5.78	3.59	1.47	3.95	4.89	3.35	3.72	2.68	1.14	4.57	3.11	3.64	3.38	2.38	2.92	2.90	3.10	3.08	3.39
Mercury (Hg)-Total	mg/kg	6.6	24			<0.02	0.04	<0.02	<0.02	<0.02	<0.02	<0.02	0.16	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Molybdenum (Mo)	mg/kg	10	40			1.19	1.13	0.67	0.85	0.54	0.81	0.55	0.43	0.68	0.72	0.55	0.51	0.39	0.09	0.42	0.44	1.62	0.73	0.32	0.42	0.44	0.42	0.37	0.55
Nickel (Ni)	mg/kg	50	50			26.0	40.0	38.1	36.6	26.6	28.1	27.1	25.7	23.6	27.3	23.2	29.8	33.4	69.8	31.9	25.5	29.8	27.0	20.9	24.1	23.5	24.3	39.5	32.8
Selenium (Se)	mg/kg	1	2.9			<0.1	0.3	0.2	0.2	<0.1	0.1	<0.1	1.3	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	0.2	<0.1
Silver (Ag)	mg/kg	20	40			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Thallium (Tl)	mg/kg	1	1			<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Tin (Sn)	mg/kg	50	300			<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Uranium (U)	mg/kg	23	33			0.81	0.63	0.59	0.58	0.57	0.60	0.49	0.26	0.55	0.58	0.49	0.46	0.37	0.10	0.61	0.48	0.51	0.60	0.48	0.47	0.49	0.45	0.40	0.47
Vanadium (V)	mg/kg	130	130			22.4	33.6	38.4	45.0	32.2	38.1	25.9	3.72	37.3	34.5	31.9	38.5	38.3	35.5	41.0	30.1	37.1	36.1	25.4	26.8	26.8	30.8	35.4	30.9
Zinc (Zn)	mg/kg	200	360			328	200	58	49	37	34	26	32	38	36	32	38	34	50	41	31	42	33	29	32	32	31	33	29
Hydrocarbons																													
Benzene	mg/kg	0.011	0.03			<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ethylbenzene	mg/kg	0.082	0.082			<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Toluene	mg/kg	0.37	0.37			<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
o-Xylene	mg/kg					<0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Xylenes, m+p	mg/kg					<0.04	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.06	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Xylenes	mg/kg	11	11			<0.06	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
F2-Naphth	mg/kg					74	-	70	-	-	-	-	-	-	<5	-	-	5	-	-	-	-	-	-	-	-			
F3-PAH	mg/kg					410	-	320	-	-	-	-	-	-	60	-	-	21	-	-	-	-	-	-	-	-			
F2 (C10-C16)	mg/kg			150	260	74	100	70	21	170	<5	<5	<5	<5	<5	<5	<5	5	6	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F3 (C16-C34)	mg/kg			300	1700	410	1300	320	290	460	<5	21	1600	<5	60	5	32	21	120	32	15	32	15	30	32	10	<5	<5	<5
F4 (C34-C50)	mg/kg			2800	3300	23	290	100	91	54	<5	<5	660	<5	35	<5	<5	<5	7	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Hydrocarbons (C6-C50)	mg/kg					510	1700	490	400	680	<5	21	2300	<5	95	5	32	26	130	32	15	32	15	30	32	10	<5	<5	<5
F1-BTEX	mg/kg					<10	<5	<5	<5	<5	<5	<5	<20	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
F1 (C6-C10)	mg/kg			30	320	<10	<5	<5	<5	<5	<5	<5	<20	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Polycyclic Aromatic Hydrocarbons																													
Acenaphthene	mg/kg					<0.01	-	<0.05	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Acenaphthylene	mg/kg					<0.01	-	<0.05	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Acridine	mg/kg					<0.05	-	<0.05	-	-	-	-	-	-	<0.05	-	-	<0.05	-	-	-	-	-	-	-	-	-	-	-
Anthracene	mg/kg					<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)anthracene	mg/kg	1	10			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	mg/kg	0.7	0.7			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	mg/kg	1	10			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Benzo(ghi)perylene	mg/kg					<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	mg/kg	1	10			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Chrysene	mg/kg					<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Dibenzo(ah)anthracene	mg/kg	1	10			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	mg/kg					<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Fluorene	mg/kg					<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3 cd)pyrene	mg/kg	1	10			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
1-Methyl Naphthalene	mg/kg					0.05	-	<0.05	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
2-Methyl Naphthalene	mg/kg					0.06	-	<0.05	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	mg/kg	0.6	22			0.08	-	<0.05	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	mg/kg	5	50			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Pyrene	mg/kg	10	100			<0.01	-	<0.01	-	-	-	-	-	-	<0.01	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-
Quinoline	mg/kg					<0.05	-	<0.3	-	-	-	-	-	-	<0.05	-	-	<0.05	-	-	-	-	-	-	-	-	-	-	-
Polychlorinated Biphenyls																													
Aroclor 1016	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1221	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1232	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1242	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1248	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1254	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1260	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1262	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Aroclor 1268	mg/kg					-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-
Total PCBs	mg/kg	1.3	33			-	-	-	<0.1	-	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-

Notes:

1. Yellow denotes exceedancees above CCME Canadian Soil Quality Guidelines for the Environmental and Human Health (CSQG) -**Residential/Parkland** (Last Updated 2007) or CCME Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil (PHC CWS) -**Residential/Parkland** (Last Updated 2008).
2. Green denotes exceedancees above CCME Canadian Soil Quality Guidelines for the Environmental and Human Health (CSQG) -**Residential/Parkland and Commercial** (Last Updated 2007) or CCME Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil (PHC CWS) -**Residential/Parkland and Commercial** (Last Updated 2008).
3. Orange denotes results with detection limts that are higher than CCME guidelines.

Table B-2. Summary of Analytical Results for Surface Water and Seepage Samples

Parameters	Units	CCME CWQG	TP19-120	SW 1	SW2	SW3	SW4	SW4 R
		Aquatic Life - Freshwater	21-AUG-08	21-AUG-08	21-AUG-08	21-AUG-08	22-AUG-08	22-AUG-08
Physical Tests								
Conductivity	umhos/cm		485	811	922	260	1600	1610
Hardness (as CaCO3)	mg/L		236	281	189	99.9	436	438
pH	pH units	6.5-9.0	7.64	8.06	7.35	8.29	7.83	7.84
TDS (Calculated)	mg/L		302	479	538	139	1040	1240
Turbidity	NTU		95	2.0	0.65	0.90	5.3	3.8
Anions and Nutrients								
Alkalinity, Total (as CaCO3)	mg/L		114	158	144	88	199	199
Bicarbonate (HCO3)	mg/L		140	193	175	107	243	242
Carbonate (CO3)	mg/L		<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Chloride (Cl) - Dissolved	mg/L		20	125	145	24	245	246
Fluoride (F) - Dissolved	mg/L		0.2	<0.1	0.1	0.1	0.2	0.2
Hydroxide (OH)	mg/L		<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Nitrate+Nitrite-N - Dissolved	mg/L		1.60	0.013	0.569	0.016	0.977	0.972
Sulphate (SO4) - Dissolved	mg/L		109	101	129	14	348	346
Total Metals								
Aluminum (Al)-Total	mg/L		0.987	0.024	0.019	0.036	0.029	0.032
Antimony (Sb)-Total	mg/L		0.001	0.001	0.001	<0.001	0.001	0.002
Arsenic (As)-Total	mg/L	0.005	0.0033	0.0025	0.0012	0.0071	0.0020	0.0021
Barium (Ba)-Total	mg/L		0.0381	0.0797	0.0186	0.0228	0.0379	0.0393
Beryllium (Be)-Total	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bismuth (Bi)-Total	mg/L		<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Boron (B)-Total	mg/L		0.09	<0.03	0.33	<0.03	0.89	0.97
Cadmium (Cd)-Total	mg/L	0.000017	0.00002	0.00002	0.00003	0.00001	0.00016	0.00016
Calcium (Ca)-Total	mg/L		70.4	84.4	47.7	31.2	145	153
Cesium (Cs)-Total	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (Cr)-Total	mg/L	0.0089(III), 0.001(VI)	0.004	0.001	<0.001	<0.001	0.002	0.003
Cobalt (Co)-Total	mg/L		0.0026	0.0004	0.0004	0.0003	0.0041	0.0047
Copper (Cu)-Total	mg/L	0.002-0.004	0.043	0.020	0.035	0.008	0.024	0.023
Iron (Fe)-Total	mg/L	3.00	28.7	0.18	0.09	0.25	0.90	0.91
Lead (Pb)-Total	mg/L	0.001-0.007	0.0009	<0.0005	<0.0005	0.0006	0.0007	0.0006
Magnesium (Mg)-Total	mg/L		7.24	14.7	11.0	4.20	22.3	23.6
Manganese (Mn)-Total	mg/L		0.376	0.0227	0.0117	0.0114	0.273	0.306
Mercury (Hg)-Total	mg/L	0.000026	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum (Mo)-Total	mg/L	0.073	0.0014	0.0012	0.0006	0.0003	0.0014	0.0016
Nickel (Ni)-Total	mg/L	0.025-0.15	0.015	0.009	0.006	0.004	0.024	0.026
Phosphorus (P)-Total	mg/L		0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Potassium (K)-Total	mg/L		6.4	5.9	10.9	1.6	20.6	21.9
Rubidium (Rb)-Total	mg/L		0.0091	0.0110	0.0018	0.0023	0.0058	0.0062
Selenium (Se)-Total	mg/L	0.001	0.002	0.002	0.005	0.002	0.008	0.008
Silver (Ag)-Total	mg/L	0.0001	0.0004	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium (Na)-Total	mg/L		13.8	52.5	106	12.5	158	168
Strontium (Sr)-Total	mg/L		0.216	0.378	0.244	0.0876	0.776	0.837
Tellurium (Te)-Total	mg/L		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium (Tl)-Total	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0001
Tin (Sn)-Total	mg/L		<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Titanium (Ti)-Total	mg/L		0.0341	0.0016	<0.0009	0.0009	0.0021	0.0015
Tungsten (W)-Total	mg/L		<0.0002	<0.0002	<0.0002	<0.0002	0.0003	0.0009
Uranium (U)-Total	mg/L		0.0011	0.0014	0.0005	0.0002	0.0012	0.0012
Vanadium (V)-Total	mg/L		0.003	<0.001	<0.001	<0.001	<0.001	0.001
Zinc (Zn)-Total	mg/L		0.02	0.02	0.02	0.01	0.08	0.08
Zirconium (Zr)-Total	mg/L		0.0009	<0.0004	<0.0004	<0.0004	0.0010	0.0004
Dissolved Metals								
Calcium (Ca)-Dissolved	mg/L		79.3	86.1	54.2	32.2	139	142
Iron (Fe)-Dissolved	mg/L		5.95	0.15	0.08	0.24	0.49	0.46
Magnesium (Mg)-Dissolved	mg/L		9.13	16.0	13.1	4.73	21.6	20.2
Manganese (Mn)-Dissolved	mg/L		0.162	0.0207	0.0130	0.0151	0.219	0.223
Potassium (K)-Dissolved	mg/L		7.65	6.18	12.9	1.87	19.3	22.5
Sodium (Na)-Dissolved	mg/L		14.8	55.6	126	14.1	143	138
Volatile Organic Compounds								
Benzene	mg/L	0.37	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Ethyl Benzene	mg/L	0.09	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Toluene	mg/L	0.002	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
o-Xylene	mg/L		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
m+p-Xylenes	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Xylene, (total)	mg/L		<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
Hydrocarbons								
F2 (C10-C16)	mg/L		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
F3 (C16-C34)	mg/L		<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
F4 (C34-C50)	mg/L		<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Total Hydrocarbons (C6-C50)	mg/L		<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
F1-BTEX	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
F1 (C6-C10)	mg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

Notes:

1. Yellow denotes exceedancees above CCME canadian Water Quality Guidelinesfor the Protection of Aquatic Life - Freshwater. Last Updated 2007.
2. Orange denotes results with detection limts that are higher than CCME guidelines.

Appendix C

Landfill Inspection and Maintenance Record Form

Record of Inspection
Closed Rankin Inlet Solid Waste Site

Inspected By: _____

Date: _____

Weather: _____

Instructions:

1. Circle OK if condition is satisfactory or NO if no action required, as appropriate.
2. Describe any maintenance requirements, if applicable.

Site Access

Site Access and Perimeter Roads:	OK	
Information Signage at Entrances:	OK	

Surface Water Drainage

East Drainage Ditch:	OK	
West Drainage Ditch:	OK	
Erosion of Ditch Slopes/Invert:	NO	
Sediment in Ditches:	NO	
Condition of Culverts:	OK	

Final Cover

Erosion of Granular Cover:	NO	
Geomembrane Exposed:	NO	
Waste Protruding:	NO	
Leachate Seepage:	NO	
Ponded Water on Cover:	NO	
Settlement or Sinkholes:	NO	
Landfill Gas Vents (4):	OK	

Comments and/or Maintenance Recommendations

_____

_____

_____

_____

_____