Example 2. Drinking water

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

Example 3. Proximity to a community

In the landfill risk evaluation matrix, human exposure to a landfill is measured in the following way: people can spend time at the landfill (potential dermal exposure), they can drink water from an area near the landfill (potential ingestion), they could live very close to landfills (potential exposure through aerial transport) or they could eat animals that feed near the landfill (potential ingestion). These three considerations form section C.3 of the risk evaluation matrix. If a landfill is located near a community, there is a greater likelihood that people will spend time at the landfill than there is for landfills far from a community. It is not necessarily the case, however, that landfills near communities receive frequent visits; therefore, instead of creating a special section addressing proximity to a community, the risk of human exposure (section C.3.1) is more accurately evaluated by measuring time spent at a landfill. In these cases, however, "special considerations" points may be added to the Receptors category to address a community's specific concerns.

PROPOSED ENVIRONMENTAL RISK EVALUATION MATRIX FOR LANDFILLS IN THE NUNAVUT REGION			
A.	CONTAMINANT SOURCE		Maximum Score
A.1	LANDFILL EXTENT		
	>10 000 m2	10	
	For areas less than 10 000 = Area of Landfill X 10 / 10 000	2-9	
	Minimum Score	1	10
A.2	ESTIMATED DEPTH OF LANDFILL		
	greater than 1.5 m	5	
	less than 1.5 m	2-4	5
A.3	PRESENCE OF LEACHATE		
	Evidence of Leachate	10	
	No Evidence of Leachate	0	10
A.4	PRESENCE OF SURFACE CONTAMINATED SOIL		
	> DCC Tier II Stains	15	
	> DCC Tier I < DCC Tier II Stains	10	
	Contaminated suspected, no surface contamination noted	5	15
A.5	PRESENCE OF SURFACE DEBRIS AT LANDFILL		
	>50% of surface area	10	
	<50% of surface area, pro-rated	1-9	
	No debris observed	0	10
	SPECIAL CONSIDERATIONS		
		+/- 5	
	TOTAL SCORE - CONTAMINANT SOURCE		*50*

PROPOSED ENVIRONMENTAL RISK EVALUATION MATRIX FOR LANDFILLS IN THE NUNAVUT REGION			
B.	PATHWAY/TRANSPORT MECHANISMS		Maximum Score
B.1	AERIAL TRANSPORT OF CONTAMINANTS		
	All Landfills Scored as 2 if Surface Soil Contamination (A.4) or Leachate (A.5) has been identified		2
B.2	WATER MOVEMENT		
B.2.1	TOPOGRAPHY		
	Steeply Slope (>40 % Grade)	12	
	Sloping (10% to 40% Grade)	4-11	
	Subdued to 10% Slope	2-3	
	Flat (< 3%)	1	12
B.2.2	COVER MATERIALS -DEPTH		
	No to little existing cover	4	
	Greater than 50% exposed/surface debris	3	
	Occasional exposed/surface debris	2	
	Existing cover, minimal debris.	1	
	Cover thickness > average active layer thickness	0	4
B.2.3	COVER MATERIAL - TYPE		
	No cover	5	
	Silty/Sandy Material	4	
	Sandy/Gravel Material	3	
	Gravel Material	1-2	5
B.2.4	SURFACE WATER/RUN-OFF POTENTIAL		
	Very High - evidence of erosion, continuing run-off or wave action	12	
	High - evidence of erosion, seasonal, widespread, storm waves	10	
	Moderate - % area affected by erosion	3-9	
	Low - no evidence of erosion, slight slopes	1-2	12
B.2.5	PRECIPITATION		
	> 500 mm annual precipitation	5	
	< 500 mm annual precipitation (pro-rated)	1-4	5
B.2.6	DISTANCE TO DOWNGRADIENT PERENNIAL SURFACE/ SEASONAL DRAINAGE CHANNEL		
	0 to 100 m	10	
	100 to 300 m	7-9	
	300 to 1 km	2-6	
	greater than 1 km	1	10
	SPECIAL CONSIDERATIONS		
		n/a 5	
	TOTAL SCORE - PATHWAYS		*50*

PROPOSED ENVIRONMENTAL RISK EVALUATION MATRIX FOR LANDFILLS IN THE NUNAVUT REGION

C.	RECEPTORS				Maximum Score
C.1	POTENTIAL IMPACT ON RECEIVING FRESHWATER/MARINE HABITAT				
C.1.1	PROXIMITY TO RECEIVING FRESHWATER/MARINE HABITAT				
	0 to 100 m			6	
	100 to 300 m			4-5	
	300 to 1 km			2-3	
	greater than 1 km			1	6
C.1.2	ESTIMATED HABITAT USAGE - FRESHWATER/MARINE				
	High: High Biodiversity/ High Occurrence/Calving or Spawning Area			5-6	
	Moderate: Moderate Biodiversity, Migratory			3-4	
	Low: Low biodiversity, rare sightings			1-2	6
C.2	POTENTIAL IMPACT ON RECEIVING TERRESTRIAL HABITAT				
C.2.1	Extent of Vegetation				
	Extensive vegetation growth: (60 to 100 % ground cover)			6	
	Moderate vegetation growth (40 to 60% ground cover)			4-5	
	Low vegetation growth (20 to 40% ground cover)			2-3	
	Sparse vegetation (<20% ground cover)			1	6
C.2.2	ESTIMATED HABITAT USAGE - TERRESTRIAL/AVIFAUNA				
	High: High Biodiversity/ High Occurrence/Calving, Denning or Nesting Area			5-6	
	Moderate: Moderate Biodiversity, Migratory			3-4	
	Low: Low biodiversity, rare sightings			1-2	6
C.3	POTENTIAL HUMAN EXPOSURE THROUGH LAND USE				
C.3.1	Presence/Occupation	likehood of contact			
	Duration of contact	high	moderate	low	
	High - Numerous visits, summer camp	8	6	4	
	Moderate - occasional summer camp	6	4	2	8
	Low - infrequent visits or winter camp	4	2	1	
C.3.2	Proximity to Drinking Water Source				
	0 to 100 m			6	
	100 to 300 m			5-7	
	300 to 1 km			2-4	
	greater than 1 km			1	8
C.3.3	Food Consumption				
	High quantity of sedentary organisms - marine & plant life			8	
	Moderate quantity of sedentary organisms - marine & plant life			6	
	Low quantity of sedentary organisms - marine & plant life			4	
	No consumption			0	8
	High quantity of migratory organisms			2	
	Moderate quantity of migratory organisms			1	
	Low quantity of migratory organisms			0.5	
	No consumption			0	2
	SPECIAL CONSIDERATIONS				
				+/-5	
	TOTAL SCORE - RECEPTORS				*50*
	TOTAL SCORE				150

Appendix C
Disposal Requirements For Items Potentially Found At Dew Line Sites

Hazardous materials (as defined by federal or territorial legislation) will not be landfilled at the DEW sites.

The following table includes items that could be found at DEW sites and provides the treatment of these items as part of the clean-up.

Item	Disposal
Waste oil	Treat as per the DLCU Barrel Protocol/GNWT criteria
PCB-containing equipment (e.g. transformers/capacitors)	Treat as per federal regulations
Asbestos	Bag and bury according to GNWT regulations
Sewage-liquid	Treat as per wastewater discharge criteria
Sewage-solid	Treat as soil
Lead and PCB based paints	Treat as per federal regulations
Radioactive tubes	Not suitable for landfill
Scrap metal	Bury in engineered landfill on site
Radar components	Bury in engineered landfill on site
Fuel barrels	Treat as per the DLCU Barrel Protocol/GNWT criteria
Lime	Not suitable for landfill
Antifreeze	Treat as per the DLCU Barrel Protocol/GNWT criteria
Wood	Bury in engineered landfill on site
AVGAS (aviation fuel)	Treat as per the DLCU Barrel Protocol/GNWT criteria
Sulfamic acid	Not suitable for landfill.
Cathode-ray tubes and screens	Bury in engineered landfill on site
Filtron tubes	Not suitable for landfill
Oscillators	Bury in engineered landfill on site
Meters	Not suitable for landfill if PCB- or mercury-containing
Copper wire	Bury in engineered landfill on site
Transmission fluid	Treat as per the DLCU Barrel Protocol/GNWT criteria
1,1,1-trichloroethane	Not suitable for landfill
PBX telephone equipment	Bury in engineered landfill on site
Mercury vapour rectifier tubes	Not suitable for landfill
Paint thinners	Treat as per the DLCU Barrel Protocol/GNWT criteria
Batteries	Not suitable for landfill
Chlorinated hydrocarbons	Treat as per the DLCU Barrel Protocol/GNWT criteria
Corrosion inhibitors	Not suitable for landfill
Lye	Not suitable for landfill
Corrosives	Not suitable for landfill

Item	Disposal
Plastic	Bury in engineered landfill on site
Solvent	Treat as per DLCU Barrel Protocol/GNWT criteria
Dynamite	Not suitable for landfill
RF Interference filters	Bury in engineered landfill on site
Generators	Clean and bury in engineered landfill on site
Scopes	Bury in engineered landfill on site
Vehicles	Clean and bury in engineered landfill
Rubber fuel bladders	Clean and bury in engineered landfill on site
Creosote-treated poles	Bag and bury in engineered landfill on site
Compressed gas cylinders	Vent, puncture and bury in engineered landfill on site
Refrigeration equipment	Recover freon and bury in engineered landfill on site
Paper	Bury in engineered landfill on site

Appendix D

Sample Questions For Community Consultations

Habitat Considerations

- Are there fish/birds/clams in the pond/lake/bay immediately down hill of the landfill?
- Are there many different types of fish/birds/clams in the pond/lake/bay? What species have you observed in that water body?
- Does spawning or nesting occur in the pond/lake/bay?
- Do the animals in the pond/lake/bay stay all year round or are they migratory?
- Have you observed any land animals such as caribou, fox or bear at the DEW Line site? How many? Was the wildlife feeding/calving/nesting/burrowing on site or near a landfill?

Exposure Considerations

- Does the community fish in the pond/lake/bay down hill of the landfill? Where does the community fish?
- Does the community collect clams/sculpins/urchins from the lake/bay?
- Does the community hunt seal, walrus or whales from the bay?
- Does the community pick berries or use the vegetation down gradient of the landfill?
- Does the community hunt at the DEW Line site? What do they hunt?
- How often do the community residents visit the site? Do you camp there seasonally? Where is the camp located?
- Where is drinking water taken from on-site?

Special Considerations

- Is the community aware of this landfill? Are there any special considerations?

Appendix E

Tier I and Tier II
DEW Line Clean-up Criteria

Substance	Units	DCC Tier I	DCC Tier II*
Arsenic	ppm	-	30
Cadmium	ppm	-	5.0
Chromium	ppm	-	250
Cobalt	ppm	-	50
Copper	ppm	-	100
Lead	ppm	200**	500
Mercury	ppm	-	2.0
Nickel	ppm	-	100
Zinc	ppm	-	500
PCB's	ppm	1.0***	5.0

* concentrations exceeding this limits are classified as Tier II Soils except where the concentrations exceed federal regulations (referred to herein as "CEPA" soils)

** concentrations between 200 and 500 ppm are classified as Tier I Soils

*** concentrations between 1.0 and 5.0 ppm are classified as Tier I Soils

Appendix F

Confirmatory Testing Protocol

Confirmatory Testing Grid Sizes

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

Where the excavation has an irregular shape, samples from the perimeter of the excavated area are to be collected following the shape of the excavation, rather than the grid if the grid points do not fall on the edge of the excavation.

Samples at the grid intersections will be point samples (as opposed to composite samples from each cell on the grid),to ensure simplicity of sampling and clarity of the result.

Appendix G

Barrel Contents Criteria and Disposal

Introduction

In order to determine the correct disposal method for barrels and their contents, the contents must first be identified. All barrel contents will be sampled and analyzed. Analytical data obtained for the samples collected from barrels located at the site will be compared to the criteria included in Table 1, below. Barrel contents are identified as organic or aqueous and the concentrations of glycols, alcohols, PCBs, chlorine, cadmium, chromium and lead are determined. Uncontaminated aqueous phases can be disposed of on the land; uncontaminated organic phases can be incinerated; contaminated aqueous material should be scrubbed free of organic material; and contaminated organic material should be disposed of as hazardous material.

Table 1: Barrel Protocol Criteria and Disposal Summary

Phase	% glycols or alcohols	PCB	Cl	Cd	Cr	Pb	Disposal
Organic	-	<2	<1000	<2	<10	<100	Incineration
Organic	-	>2	>1000	>2	>10	>100	Ship south
Aqueous	>2 %	>2	>1000	>2	>10	>100	Ship south
Aqueous	>2 %	<2	<1000	<2	<10	<100	Incineration
Aqueous	<2%						Scrub and discard

A. Inspection

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

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

B. Sampling

1. Barrels shall not be transported until it has been determined that they are not under pressure, do not leak, and are sufficiently sound for transport.
2. Barrels to be sampled should be set in an upright position, provided that this does not cause them to leak and that it is physically possible.
3. Barrels should only be opened using heavy equipment, according to accepted procedures and under qualified supervision.
4. Once open, barrels will be sampled by personnel wearing proper personal protective gear. Samples of the contents of all barrels shall be extracted using a drum thief.
5. In instances where there are a large number of barrels with obviously similar contents, these can be grouped together and 30 to 40% of the barrels in the group sampled. Barrels containing less than 50 mm of liquid may be combined with compatible material prior to sampling; samples inferred to contain only water on a visual examination shall be tested prior to this consolidation. Barrel contents, which consist of black oil, shall not be consolidated.
6. All barrels shall be clearly numbered using spray paint or other suitable marker. The number on this label should be the only sample coding provided to the laboratory.
7. The barrel locations and barrel sample descriptions should be recorded.
8. Samples should be kept at ambient temperatures and shipped by guaranteed freight to laboratories where they should be kept cold pending analysis.

C. Testing

1. Liquid samples shall be inspected and classified as either containing water or organic materials. Samples thought to contain water shall be analyzed to confirm that they are indeed water, and contain less than 2% glycols or alcohols.
2. The contents of barrels containing organic materials, including aqueous samples which contain more than 2% glycols or alcohols, shall be tested for PCBs, total

chlorine, cadmium, chromium and lead, in addition to identification of the major components e.g. fuel oil, lubricating oil.

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

D. Disposal of Barrel Contents

1. Barrels containing only rust and sediment shall be treated as empty barrels.
2. Barrel contents comprising water only (less than 2% glycols or alcohols) shall be transferred to an open vessel such as a utility tub or half-barrel and any organic material removed by agitation with a pillow or segment of oil absorbent material. The water may then be discarded on to the ground that is a minimum of 30 meters distance from natural drainage courses. Used oil absorbent material shall be treated as described in below (D.5.).
3. Barrel contents which are composed of water with glycols and/or alcohols or organic phases, and which contain less than 2 ppm PCBs, 1000 ppm chlorine, 2 ppm cadmium, 10 ppm chromium, and 100 ppm lead, may be disposed of by incineration. Alternatively these contents may be disposed of off-site at a licensed disposal facility. The solid residual material resulting from incineration shall be subjected to a leachate extraction test. Material found to be not leachate toxic shall be disposed of as DCC Tier II contaminated soil. Leachate toxic material shall be treated as hazardous waste and disposed of off-site at a licensed disposal facility.
4. Barrel contents, which contain greater than 2 ppm PCBs, 1000 ppm chlorine, 2 ppm cadmium, 10 ppm chromium or 100 ppm lead shall be disposed of off-site at a licensed disposal facility. Contents may be combined with compatible materials for shipping purposes. Flash points may be required to be determined if they cannot be inferred from the product identification.
5. Used oil absorbent material should be treated as hazardous waste and disposed of off-site at a licensed disposal facility. If it is shown to be uncontaminated with PCBs (< 2 ppm), chlorine (< 1000 ppm), cadmium (< 2 ppm), chromium (< 10 ppm) and lead (< 100 ppm), it may be incinerated on-site.

E. Disposal of Barrels

1. Empty barrels may be crushed or shredded and landfilled on-site as non-hazardous waste after they have been cleaned in an appropriate manner. The barrels shall be

crushed in such a manner so as to reduce their volume by a minimum of 75%. Shredded barrels may be disposed of off-site as recycled metals.

Appendix H

Post Construction Landfill Monitoring Regime

1.0 Types of Landfills

There are four types of landfills that require monitoring:

- New landfills for non-hazardous materials and Tier I soil;
- Landfills to be closed by the addition of granular fill and regraded;
- Landfills to be closed with leachate containment; and
- Tier II soil disposal facilities.

2.0 Monitoring

New landfills are to be constructed for the disposal of non-hazardous demolition wastes, site debris and Tier I soil. These landfills, constructed according to specifications, are considered to pose low potential environmental risks as the contents and placement of the materials in the landfill are known. The monitoring of these landfills will be limited to a visual inspection program to evaluate the stability of the landfill.

Existing landfills that are to be regraded will be monitored for leachate periodically by the collection of soil and/or water samples from test pits at the toe of the landfill, in addition to visual inspection.

For existing landfills that have been classified as moderate potential environmental risk, and proposed Tier II soil disposal areas, the design in both cases is to incorporate a leachate containment system, consisting of synthetic liners (geocomposite clay liners, and/or geomembrane liners) and promotion of permafrost aggradation through the landfill contents. The monitoring program for these landfills will include thermal monitoring of the ground temperatures in and around the landfill, collection and analysis of soil samples, collection and analysis of water from wells around the landfill, and visual inspection.

3.0 Description of Monitoring Components

3.1 Visual Inspection

The physical integrity of the landfill will be inspected and reported using photographs (from the air as well as ground level) and hand drawn sketches. Documented observations should include:

- Signs of damage from settlement, ponding, frost action, erosion, and lateral movement.
- Sloughing of berms, thermal contraction cracks etc.

3.2 Soil and Water Sampling

Soil and water samples, representing background as well as baseline conditions, will be collected. Results of analyses of samples from landfills will be compared to these baseline and background samples as this is indicative of changing environmental conditions at the site.

In general, one monitoring well will be placed upgradient and three will be placed downgradient. This allows the assessment of hydraulic gradient and evaluation of potential impacts. Soil samples will be collected from the toe of the landfill, and will generally be taken from the same locations as the wells. Soil samples at the toe of the landfill reflect chronic input from water and are a very important indicator of leachate.

Soil and water samples will be tested for:

- PCBs (polychlorinated biphenyls);
- TPH (total petroleum hydrocarbons),; and;
- Inorganic elements: arsenic, cadmium, chromium, cobalt, copper, lead, nickel and zinc.

If the landfill is close to a drinking water source and has the potential to have an impact on it, the water samples will be analyzed for the following parameters in addition to the compounds and elements listed above:

- inorganic elements by ICP scan;

- major ions, hardness, and total dissolved solids,; and;
- pH and conductivity.;

The intent of the additional analyses is to provide added information to evaluate the potential impacts related to the landfill, and not necessarily to provide an assessment of the potability of the water source. In this latter case, the results of the analyses of these drinking water samples will be compared to the most current version of Canadian and/or Territorial standards for drinking water for the parameters analysed, in addition to comparison with background and baseline data.

3.3 Thermal Monitoring

As indicated previously, one component of the leachate containment system incorporates aggradation of the permafrost through the landfill contents such that the active layer does not penetrate the waste materials. Geothermal analyses were carried out to predict the length of time for freezeback of the landfill; long-term and short-term thermal regime in the ground; and the depth of the active layer in the cover material. The analyses have shown that it takes several years for the landfill temperatures to equilibrate and stabilize.

A thermal monitoring system provides measurement of sub-surface ground temperatures, which allows comparison to and verification of the predicted ground temperatures. The thermal monitoring system consists of installation of thermistor strings, with "thermistor beads" at select intervals to provide ground temperature profiles at various locations within the landfill. The thermistor strings are attached to automated data-loggers which allow for remote data collection. In general, a minimum of three thermistors will be placed; the actual number will be evaluated on a landfill-specific basis. Thermistor installation will be in accordance with standard engineering practice.

Checklists for the collection of monitoring data are presented in Appendix I.

4.0 Monitoring Frequency

Generally, the post-construction monitoring program would have three phases, each with a different objective.

4.1 Phase I: Monitoring of conditions to confirm that equilibrium is achieved.

During Phase I, sites where leachate containment and/or Tier II soil facilities have been constructed, monitoring will take place on an annual basis, for an estimated period of five years following construction. The five-year term was selected on the basis that ground-temperature thermal regimes at these specific landfills would require three to five years to reach equilibrium.

At other locations, where existing landfills have been regraded and new landfills have been constructed, Phase I monitoring will be carried out on in the first, third and fifth years following construction.

An evaluation of the Phase I data will be carried out at the end of five years to confirm that thermal and chemical equilibrium had been achieved, and that no stability issues have been identified. The Phase I monitoring program may be extended, if required.

4.2 Phase II: Verification of equilibrium conditions established during Phase I.

The monitoring frequency in Phase II be downgraded from Phase I, and be carried out according to the following schedule: year 7, year 10, year 15 and year 25. Year 25 would mark the end of Phase II monitoring.

4.3 Phase III: Monitoring for long term issues such as liner integrity, permafrost stability, and significant storm events.

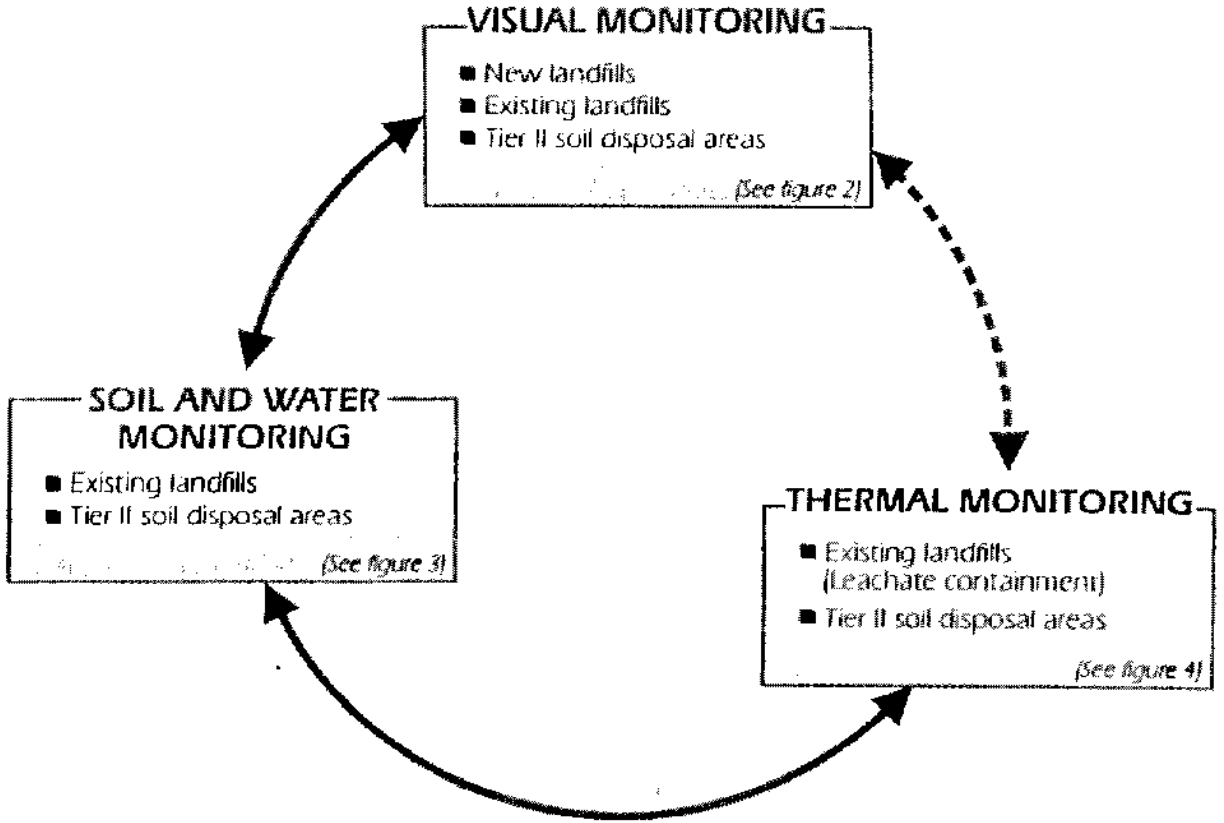
At the end of Phase II, 25 years after implementation of the remedial actions for a given landfill, a major re-evaluation of the monitoring program will be carried out prior to initiating Phase III. It is difficult to predict beyond 25 years how world events and improvements in technology may impact on monitoring requirements. Based on current technology and knowledge, a Phase III program should be implemented at 10 year intervals. The duration of the Phase III program will be estimated at the outset of the program and be subject to re-evaluation as new technologies are developed and new information becomes available.

5.0 Interpreting Monitoring Results

Monitoring results (thermal, chemical and visual) have to be interpreted in concert with one another. An increase in chemical concentrations, for instance, from one year to the next does not necessarily trigger action if there are no other signs of landfill instability. Stability problems would have to be established by a geotechnical engineer with northern experience. Action will be taken based on trends in chemical data rather than isolated results.

Normally, the first step to be taken when a potential problem is identified is to intensify the monitoring program. If a problem has been confirmed, then remedial action will be undertaken.

The flowcharts in Figures 1 to 4 illustrates the decision-making process to be applied to monitoring data. The following section outlines actions to be taken if the monitoring program indicates a deficiency in a landfill.



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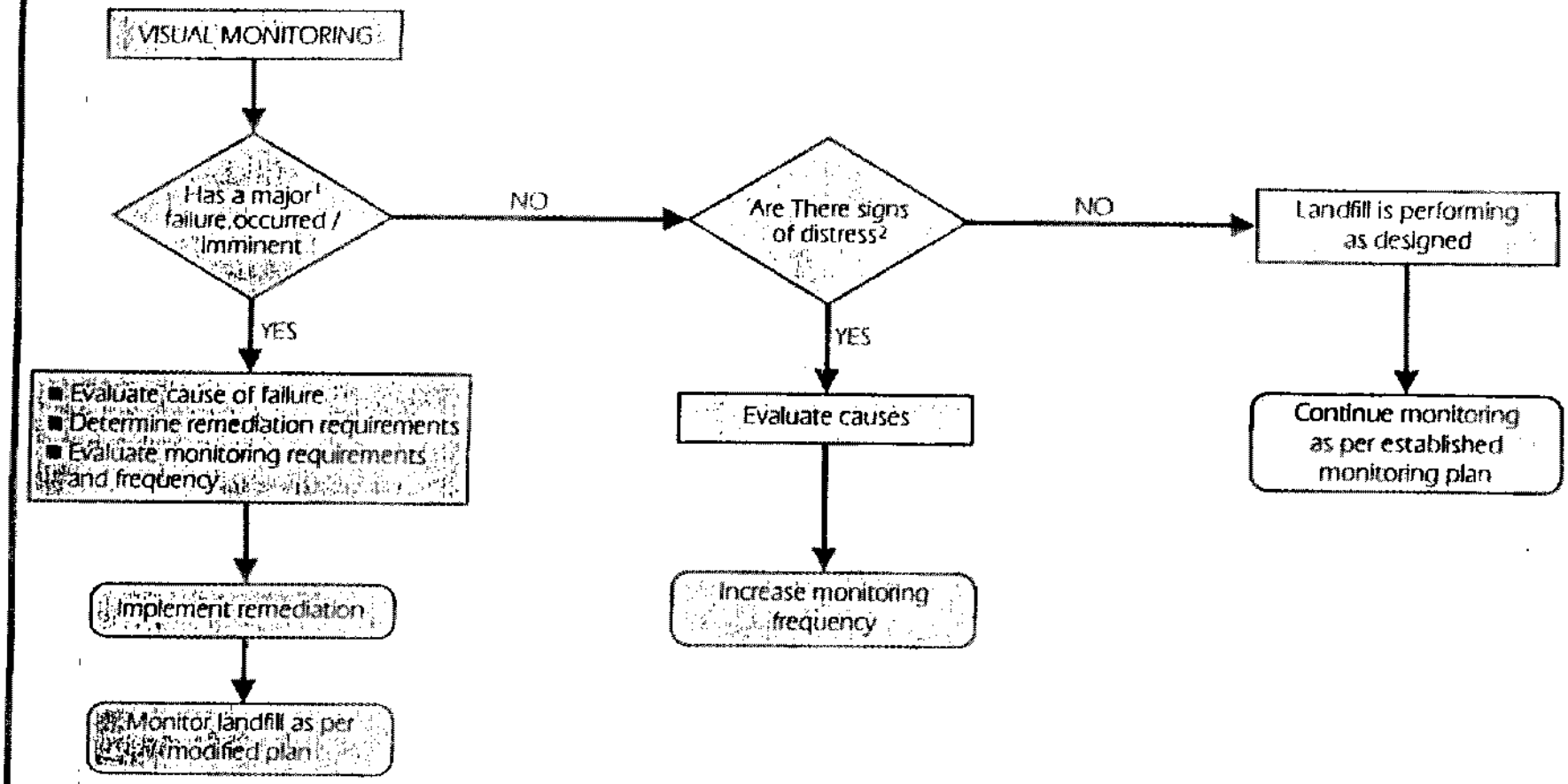
SUMMARY FLOW CHART

Figure



Notes:

1 Major Failure: significant exposed debris (>25% of surface area) due to erosion, settlement, frost action; berm failure (slope stability)

2 Signs of Distress: Voids due to settlement, ponding on surface, and/or tension cracks, and/or erosion.

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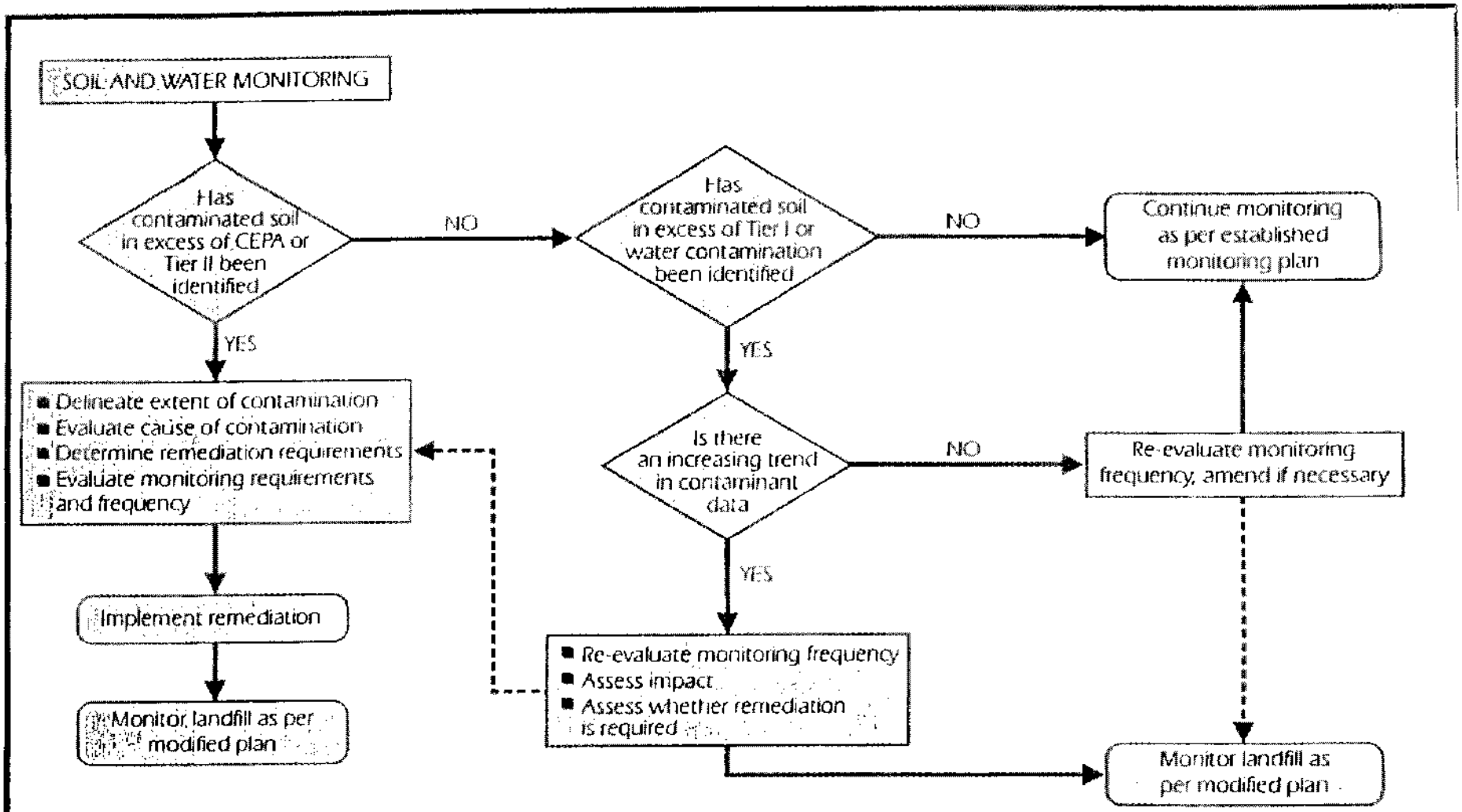
VISUAL MONITORING FLOW CHART

Figure



Note:
Water contamination to be evaluated relative to baseline and background concentrations.

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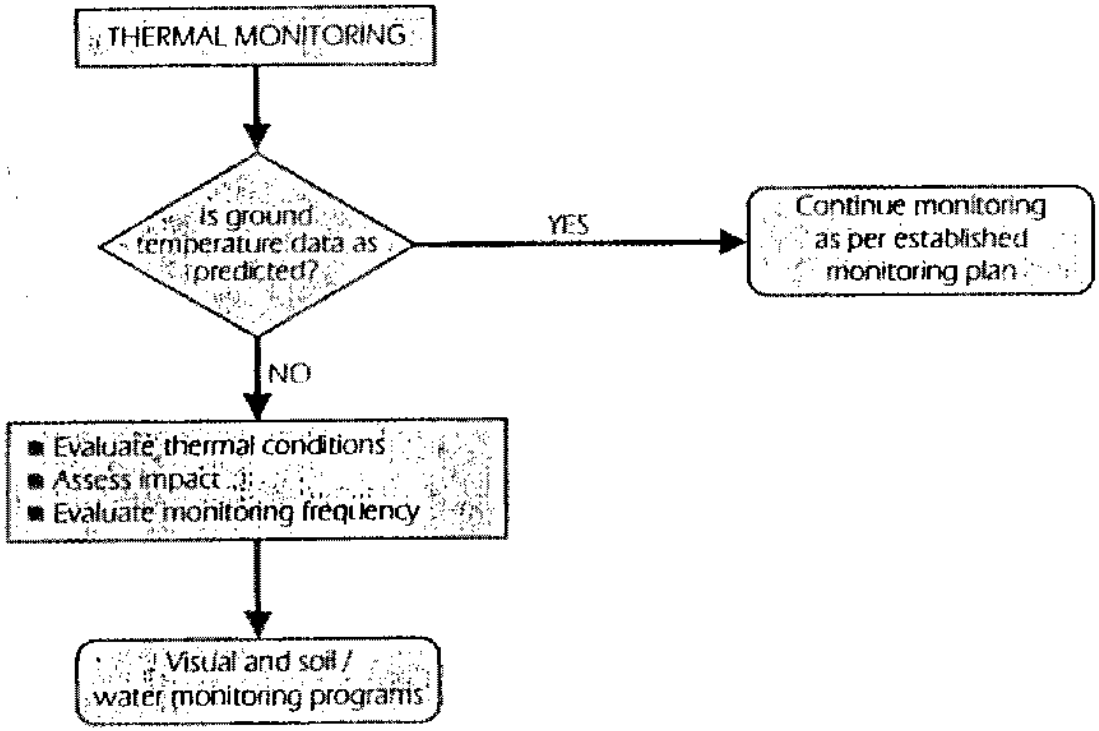
SOIL AND WATER MONITORING FLOW CHART

Figure



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THERMAL MONITORING FLOW CHART

Figure

6.0 Impact of Monitoring Results

The possible results and the associated potential mitigation requirements for the landfill monitoring components are described in the following subsections. For all instances, the mitigation requirements are dependent on the severity of the deficiency, and will be assessed by a professional geotechnical engineer with northern engineering design and construction experience. In addition, the assessment and implementation of resulting remediation requirements will be carried out in a staged approach to ensure that the proposed solutions address the specific requirements in a logical and cost effective manner.

6.1 Visual Inspection

If the results of the visual inspection program indicate evidence of significant settlement, ponding, or frost jacking, it may be necessary to implement one or more of the following mitigative measures:

- increase the frequency of the visual monitoring program
- place erosion protection material such as riprap, vegetation mats, etc.
- recompact existing debris material and existing granular material
- place additional granular fill
- regrade, as required, to promote positive drainage away from the deficient landfill area.

It should be noted that settlement of the landfill surface may not necessarily result in failure of the landfill. Settlement (typically differential settlement) that results in ponding and infiltration of surface water could lead to erosion and frost jacking problems.

If the visual monitoring program results indicate evidence of sloughing of landfill perimeter berms and thermal contraction cracks, it may be necessary to implement one or more of the following mitigative measures:

- flatten granular berm slopes
- compact existing granular slopes
- place and compact additional granular fill material

6.2 Soil and Groundwater Monitoring

The results of the soil and groundwater monitoring program will be compared against baseline data established prior to the initial landfill development or remediation program. Results of the analysis of soil and groundwater samples that show decreasing trends of contamination at the perimeter of landfills typically indicate that the implemented landfill remediation has been effective. Conversely, if the results indicate increasing levels of contamination, then it may be necessary to implement one or all of the following:

- Increase the frequency of the monitoring program.
- Carry out a review and evaluation of the nature and extent of the contamination, including the incorporation of the results of the visual monitoring program. The major objective of this evaluation will be to determine the cause of the contaminant migration problem, and in particular to determine if it is the result of ineffective design, material (e.g. liner) failure, improper compaction, selection and use of inadequate granular material, poor grading, etc. This evaluation may require intrusive investigation into and around the landfill.
- Depending on the results of the above, it may be necessary to remove and replace liner material, reconstruct containment berms, etc.
- Assess the requirement to excavate and dispose of the contaminated soil; this would include the delineation of the vertical and areal extent of the contamination.
- Excavate and dispose of contaminated soil and/or excavate all or part(s) of the landfill, as required.

The requirement for the specific scope and extent of remediation, as outlined above, will also incorporate an risk evaluation of the potential impacts of the contamination based on the principles defined in the Landfill Risk Evaluation Matrix. The need for the risk evaluation is predicated on the understanding that not all affected sites pose the same risk to the environment, and consequently remediation requirements will vary.

6.3 Thermal Monitoring

The results of the thermal monitoring program will be compared against the parameters for freezeback that were incorporated into the geothermal design of the landfills. It is important that the overall assessment of these results consider the results of both the visual and soil/groundwater monitoring programs. If the thermal monitoring results indicate ground temperatures that are significantly higher (greater than 2° C) than

predicted during the geothermal analyses carried out as part of the design, then it may be necessary to implement one or more of the following:

- Increase the frequency of the recording and assessment of results from the thermal monitors.
- Establish, based on the results of the soil and groundwater monitoring programs, if groundwater and/or soil contaminant levels beyond the perimeter of the landfill have increased. Incorporate the results of a risk assessment. Assess the impacts, as outlined above, to determine the appropriate remediation requirements.
- If it established that a slower than expected freezeback period has resulted in the migration of contamination beyond the landfill and depending on the results of the above risk assessment, then it may be necessary to implement one or more of the following:

    - determine if the rate of the freezeback progress is continuing, or if freezeback within the landfill has terminated; is at steady-state;
    - excavate and dispose of contaminated soil and/or excavate all or part of the landfill, as required;
    - place additional granular cover material or other insulating material (styrofoam insulation, vegetation) over the landfill to provide an increased insulation barrier over the landfill;
    - reconstruct and/or re-saturate the perimeter berms of the landfill.

Appendix I

Landfill Monitoring Checklist

DEW LINE CLEANUP
LANDFILL MONITORING CHECKLIST

MONITORING PROGRAM

LANDFILL TYPE	Visual	Soil and Water	Thermal
New Landfill (Non-Hazardous Wastes)	X		
Landfill requiring Regrading	X	X	
Landfill requiring Leachate Containment	X	X	X
Tier II Soil Disposal Facilities	X	X	X

SITE: _____

LANDFILL DESIGNATION: _____

LANDFILL TYPE: _____

DATE: _____

MONITORING EVENT NO.: _____

NAME: _____

WEATHER CONDITIONS: _____

VISUAL INSPECTION CHECKLIST

Carry out a visual inspection of the landfill surface, berms, toe of berms and identify potential areas of distress as follows:

1. Settlement:
   - a) Is there differential settlement occurring on the surface?
     - i) low areas or depressions;
     - ii) voids forming
   - b) What is the extent of settlement?
     - i) percent of surface area affected;
     - ii) localized areas or continuous;
     - iii) how deep;
   - c) Where is the settlement occurring?
     - i) near berms, center of facility, etc.
   - d) Explain?
     - i) evidence of significant surface infiltration,
     - ii) water ponding on surface
     - iii) snow drifting

32. Erosion
   - a) Is there erosion occurring on the surface or berms of the landfill?
     - i) preferred drainage channels;
     - ii) sloughing of material;
   - b) What is the extent of erosion?
     - i) percent of surface area affected;
     - ii) localized areas or continuous;
   - c) Where is the erosion occurring?
     - i) along the toe, on the surface, through the berms;
   - d) Explain?
     - i) evidence of significant surface water run-off ;
     - ii) poor material type;

34. Frost Action

a) Is there frost action/damage to the landfill?
   i) exposure of debris due to uplift;
   ii) tension cracking along berms;
   iii) sorting of granular fill;

b) What is the extent of frost action?
   i) percent of surface area affected;
   ii) localized areas or continuous;

c) Where is the cracking, frost heaving occurring?
   i) along the toe, on the surface, through the berms;

d) Explain?
   i) poor material gradation;
   ii) poor compaction;
   iii) high water content, silt content in cover material;

45. Condition of Other Monitoring Instruments:

56. Provide detailed sketch and photographic record of landfill.

PRELIMINARY STABILITY ASSESSMENT

SOIL AND GROUNDWATER MONITORING FIELD CHECKLIST

1. Soil Samples:

Sample No:	
Field Measurements: VOC	
Soil Description:	
Analyses Requested	

2. Water Samples

Sample No: Well No.:	
Field Measurements :	pH Conductivity Temperature
Well Processing	Water level
	Purged well or standing water sampled
	Recovery Rates
Analyses Requested	

Comments:

Additional surface water samples: where, why, describe areas of stressed vegetation

THERMAL MONITORING CHECKLIST

Thermistor Number:
Location:

1. Download data
2. Replace battery pack
3. Check condition of connections and instrumentation
4. Save data to hard-drive and disk,.
5. Relock cap

Appendix J

Hydrocarbon Contamination Checklist

General

Date:

Name of Assessor:

Site Name:

Hydrocarbon Spill/Stain Location:

Hydrocarbon Source

What type of hydrocarbon is present in this stain? Consider the following:

Toxicity (Lubrication Oil, Diesel, Gasoline/Avgas)
Fluidity
Solubility
Volatility

What is the concentration of total petroleum hydrocarbons in parts per million (ppm)? Is it above 2500 ppm?

What is the approximate volume of contaminated soil in cubic metres?

Pathways

1. Is the contaminated soil in a stable location or on a slope?

2. What is the estimated organic matter in the contaminated soil? (ie. <0.1%, <5%, >5%)

3. What is the estimated grain size of the contaminated soil? Consider the following:

   Coarse (D_{50} > 75 micron)
   Fine (D_{50} < 75 micron)

4. What is the distance from the contaminated soil to a marine or freshwater environment?

5. What is the annual precipitation of the site?

6. What is the mean summer temperature?

Potential Impacts on Receptors

1. What is the distance to the nearest down gradient marine or freshwater habitat?

2. Is this a potential or known drinking water source for terrestrial animals or humans?

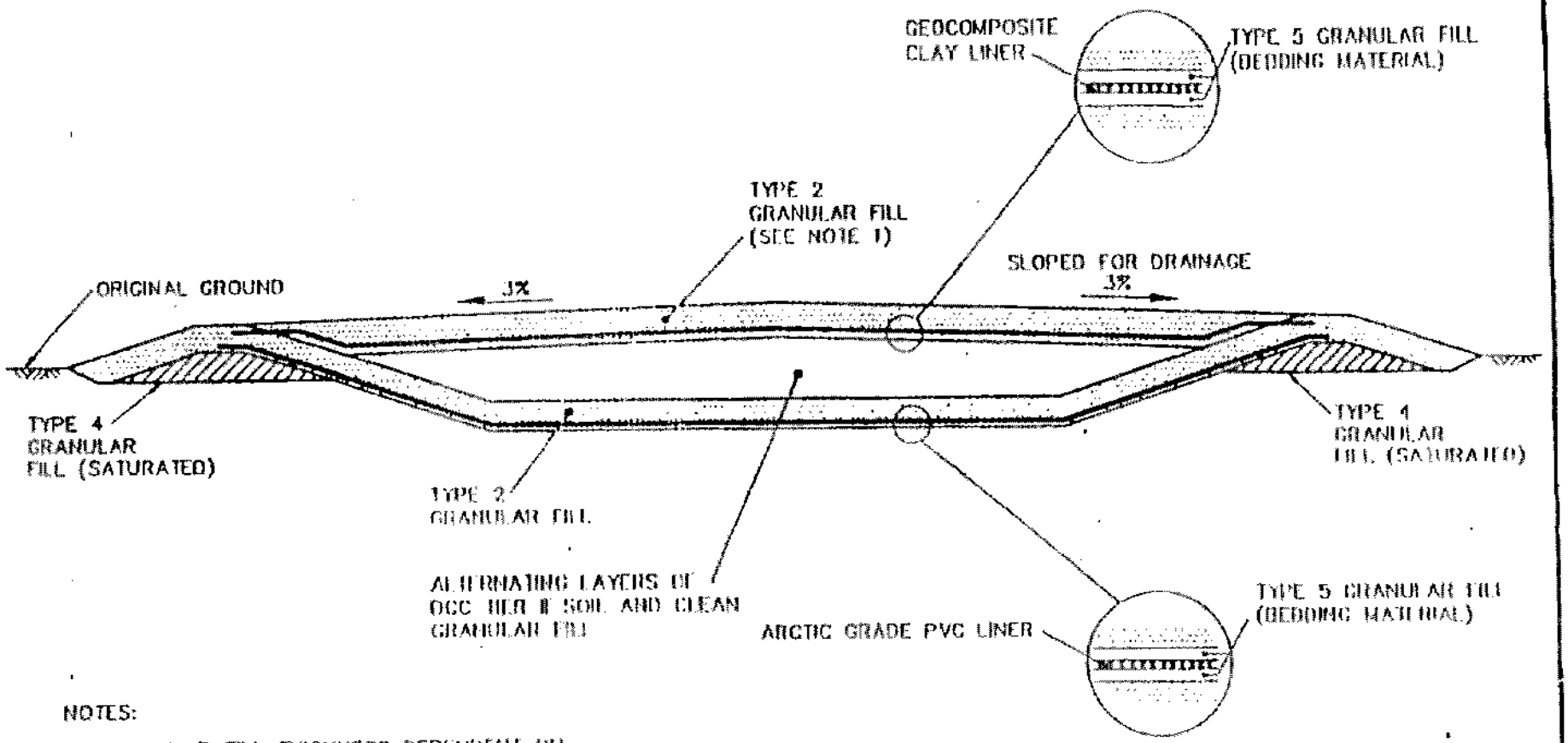
3. What is the down gradient habitat usage? Consider the following:

   Grazing, nesting, denning, spawning, calving
   High, medium, or low number of sitings.
   High, medium or low biodiversity.

4. Is this area visited frequently by humans for hunting, fishing, gathering or camping purposes? What is consumed and from where is it obtained?

Appendix K

Tier II Disposal Facility



NOTES:

1. GRANULAR FILL THICKNESS DEPENDENT ON SITE SPECIFIC CONDITIONS.
2. GRANULAR FILL GRADATIONS ARE SITE SPECIFIC.

TIER II DISPOSAL FACILITY

TYPICAL CROSS SECTION

AGREEMENT BETWEEN

Nunavut Tunngavik Incorporated

And

Her Majesty In The Right Of Canada,

Represented By

The Minister Of National Defence

With Respect To Economic Benefits For Inuit

In The Clean-Up And Restoration Of

Distant Early Warning Sites

Within The Nunavut Settlement Area

(NTI-DND Economic Agreement)

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