# *PROPOSED LANDFILL MONITORING PLAN*
# *NUNAVUT SETTLEMENT AREA - DEW LINE SITES*
# *DRAFT - REVISION 4*

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| | |
|---|---|
| CCME | Canadian Council of Ministers of the Environment |
| DCC | DEW Line Cleanup Criteria |
| DCL | Defence Construction Canada Ltd. |
| DEW | Distant Early Warning |
| DIAND | Department of Indian Affairs and Northern Development |
| DLCU | DEW Line Clean Up |
| DND | Department of National Defence |
| ESG | Environmental Sciences Group @ Royal Military College |
| EWG | Environmental Working Group |
| ICP | Inductively Coupled Plasma |
| LRR | Long Range Radar |
| NWS | North Warning System |
| NSA | Nunavut Settlement Area |
| NTCL | Northern Transportation Company Ltd. |
| NTI | Nunavut Tunngavik Incorporated |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PCBs | Polychlorinated Biphenyls |
| POL | Petroleum Oil Lubricants |
| SRR | Short Range Radar |
| TEH | Total Extractable Hydrocarbons |
| TPH | Total Petroleum Hydrocarbons |
| UMA | UMA Engineering Ltd. |
| USAF | United States Air Force |

# 1. INTRODUCTION

The Distant Early Warning (DEW) Line was constructed across the Arctic coastline during the 1950s to provide radar surveillance of northern military approaches. A total of 42 sites were constructed in Canada, 21 of which were shut-down and abandoned in the early 1960s due to advances in radar technology. These sites were transferred to the jurisdiction of the Department of Indian Affairs and Northern Development (DIAND).

The remaining 21 sites continued to be operated until the early 1990s when they were replaced with the automated North Warning System (NWS). Eight DEW Line sites were converted to NWS Long Range Radar site, eight sites have a Short Range Radar located on or near the original reserve, and the five remaining sites are no longer required. The location of the DND DEW Line sites is shown on Figure 1.1.

Between 1996 and 2008, the Department of National Defence (DND) is carrying out the cleanup and restoration of these 21 DEW Line sites. It is intended that the majority of cleanup and restoration work to be completed at each individual site will be performed in a general contract spanning two to three years, supplemented with separate specialty contracts such as for the disposal of hazardous materials, as appropriate. Cleanup requirements for the sites are based on a risk management approach, and were developed by the Environmental Sciences Group, Royal Military College over the period 1989 to 1992, in consultation with various government agencies and Aboriginal Land Claims Organizations. In general, the cleanup requirements address demolition of facilities and structures, removal and disposal/treatment of contaminated soils and debris, and remediation of existing landfills.

This document addresses the landfill monitoring guidelines for the fifteen DEW Line sites located in the eastern and central Arctic within the Nunavut Settlement Area. An Agreement has been established between Nunavut Tunngavik Incorporated and the Department of National Defence, regarding the cleanup of the DEW Line Sites. Within this Agreement, the Environmental Provisions address the restoration and cleanup of these DEW Line sites, as well as the issue of future landfill monitoring. Consistent with the risk management approach adopted for the project, DND has committed to post-construction monitoring of existing and new landfills, remediated or constructed during the cleanup.

Post cleanup management includes three aspects: quality assurance certification that the site is clean; properties action (if required) and landfill monitoring.

The overall schedule for cleanup of the 21 sites under the jurisdiction of DND was developed based on environmental priorities, geographic location, and consultation with aboriginal groups. It was also included in the Treasury Board submission for approval of funding for the DLCU project. DND, through their contracting agency, Defence Construction Canada (DCL), initiated cleanup of the DEW Line sites in 1996.

Further to a Memorandum of Understanding signed between DIAND and DND in 1989, it is the intent of DND to return DEW Line site property, surplus to NWS requirements, to DIAND (for military reservation on Crown land). However, DND intends to retain landfills to be monitored and access thereto, within the future military reservations. Property action is to include a disclosure document, which includes a site-specific Post Cleanup Management Plan. This Plan addresses future requirements related to the landfills, specifically, monitoring and corrective action as required. Therefore the property transfer considers future activity by DND related to monitoring of the landfills.

Section 2 of this document describes in general terms, the types of landfills and monitoring requirements. Section 3 provides an overview of the landfill monitoring requirements at the DEW Line sites in the Nunavut Settlement Area. The remainder of the document has been organized by site, and provides general information relative to the landfill assessment and design, and details of the landfill monitoring program. These annexes include:

- PIN-2 Cape Young
- PIN-3 Lady Franklin Point
- PIN-4 Byron Bay
- CAM-M Cambridge Bay
- CAM-1 Jenny Lind Island
- CAM-2 Gladman Point
- CAM-3 Shepherd Bay
- CAM-4 Pelly Bay
- CAM-5 Mackar Inlet
- FOX-M Hall Beach
- FOX-2 Longstaff Bluff
- FOX-3 Dewar Lakes
- FOX-4 Cape Hooper
- FOX-5 Broughton Island
- *DYE-M Cape Dyer (not included in this draft)*

**Figure 1-1 Location of 21 DND DEW Line Sites**

INUVIALUIT SETTLEMENT REGION

NUNAVUT SETTLEMENT AREA

BAR-1 (1999) Komakuk Beach

BAR-2 (2000) Shingle Point

BAR-3 (1996,1999) Tuktoyaktuk

BAR-4 (1998) Nicholson Point

PIN-M (1997) Cape Parry

PIN-1 (2001) Clinton Point

PIN-2 (2007) Cape Young

PIN-3 (2006) Lady Franklin Point

PIN-4 (2005) Byron Bay

CAM-M (1998) Cambridge Bay

CAM-1 (2004) Jenny Lind Island

CAM-2 (2003) Gladman Point

CAM-3 (2002) Shepherd Bay

CAM-4 (2001) Pelly Bay

CAM-5 (2003) Mackar Inlet

FOX-M (2002) Hall Beach

FOX-2 (2004) Longstaff Bluff

FOX-3 (2004) Dewar Lakes

FOX-4 (1996) Cape Hooper

FOX-5 (2001) Broughton Island

DYE-M (2003) Cape Dyer

Clyde River

Broughton Island

Inuvik

Tuktoyaktuk

Paulatuk

Coppermine

Gjoa Haven

Cambridge Bay

Taloyoak

Pelly Bay

Hall Beach

Cape Dorset

Iqaluit

Yukon

Norman Wells

Northwest Territories

Yellowknife

British Columbia

Alberta

Saskatchewan

Manitoba

National Defence / Défense nationale

DEW Line Clean Up Project

# LOCATION OF 21 DND DEW LINE SITES IN CANADA, AND CLEAN UP SCHEDULE

Figure 1.1

# 2. LANDFILL CLASSIFICATIONS AND MONITORING REQUIREMENTS

## 2.1 Landfill Classifications

### 2.1.1 Existing Landfills

Environment Canada developed a list of potential waste materials that may be present in a landfill (ref: Environmental Protection Service Report No. W&NR-86/87-CP(EP)-16) based on information obtained from U.S.A.F. records. These materials may include:

- waste oil*
- PCB transformers/capacitors*
- asbestos*
- sewage
- lead based paints
- radioactive tubes
- scrap metal*
- radar components
- fuel drums*
- lime
- antifreeze*
- wood*
- AVGAS (aviation fuel)
- sulfamic acid
- cathode ray tubes & screens
- filtron tubes
- oscillators
- meters*
- copper wire
- transmission fluid*
- 1-1-1-trichloroethane
- PBX telephone equipment
- mercury vapour rectifier tubes
- paint thinners
- batteries*
- chlorinated hydrocarbons
- corrosion inhibitors
- lye
- corrosives
- paper*
- plastics*
- solvent
- dynamite
- RF interference filters
- generators*
- scopes
- vehicles*
- rubber fuel bladders

Those items marked by an asterisk have been observed in existing landfills/dump sites at the DEW Line Sites.

The remediation requirements for existing landfills, potentially containing the materials as identified above, were based on a qualitative assessment of potential environmental risk, as well as site specific geotechnical and topographical factors which could influence the closure design. The need to carry out a qualitative risk assessment was predicated on the understanding that not all landfills pose the same risk to the environment, and correspondingly remediation requirements will vary. In addition, consideration was given to the potential environmental risks arising as a result of landfill excavation.

In general, the potential environmental and human health risks associated with the majority of existing landfills are considered less than the potential risks associated with landfill excavation. For example, during excavation, risks include disturbance of previously encapsulated materials as a result of degradation of the permafrost, and/or uncontrolled release of materials during removal.

The qualitative assessment of potential environmental risk will be carried out for each landfill using the Environmental Risk Assessment Matrix developed by the Environmental Working Group (EWG). This assessment will include review of data obtained during the pre-tender site investigation, as well as the data obtained during the initial environmental investigations over the period 1989 to 1992. From this assessment, three classes of landfills are defined: Class A, B and C, corresponding to high, moderate, and low potential environmental risk, respectively. These classifications are consistent with the definitions of types of landfills outlined in the DLCU protocol (April, 1994). The following paragraphs provide a summary of the remediation requirements for each class of existing landfill.

*Existing Landfills - High Potential Environmental Risk - Class A:* Landfills, designated as Class A, are generally located in high erosion areas and cannot be stabilized in place using engineered controls. These landfills will be excavated and confirmatory testing carried out, and therefore, no post-construction monitoring program is required.

*Existing Landfills - Moderate Potential Environmental Risk - Class B*: Landfills classified as moderate potential environmental risk generally have been identified as being a source of contaminated leachate. The remediation design is based on leachate containment, where double synthetic liners are installed over the toe of the landfill, and keyed into the underlying existing permafrost, and granular fill material of sufficient thickness to promote aggradation of permafrost through the landfill contents is placed and compacted over the surface and toe of the landfill.

*Existing Landfills - Low Potential Environmental Risk - Class C*: The remediation design for these landfills includes placement and compaction of granular fill as a cover, following collection, sorting, and appropriate disposal of debris from the surface, and excavation and disposal of any surface contaminated soils from the area.

### 2.1.2 New Landfills

New landfills will be constructed on site, as required, for the disposal of non-hazardous demolition wastes and site debris, and Tier I contaminated soil. Landfills for the disposal of DCC Tier II soil are referred to as Tier II Soil Disposal Areas, as described in subsequent paragraphs. Hazardous materials, collected or generated during cleanup, will be containerized for transport off site to a licensed disposal facility. A brief description of the design components for these two types of landfills follows.

*New Landfills for Non-Hazardous Wastes*: As part of the cleanup, facilities and structures associated with the DEW Line operation will be dismantled and disposed of on site in new landfills, or extensions to existing landfills. The design for these landfills includes granular fill perimeter berms, placement and compaction of waste materials in maximum one metre lifts with granular fill material placed between lifts, and a granular cover of minimum thickness of 0.75 metres. In the design and construction of some landfills, segregation of waste materials is required, specifically to address materials, which are coated with paint containing non-regulated levels of PCBs. The details of these specific landfills are provided on Record Drawings that are prepared after construction completion.

*Tier II Soil Disposal Areas*: As part of the DLCU protocol, DEW Line Cleanup Criteria (DCC) Tier I and Tier II were defined specifically to address contamination in soil. These criteria were developed based on the results of a series of environmental assessments at all the DEW Line sites and address persistent contaminants, which have the potential to impact the Arctic ecosystem. These contaminants include a select subset of inorganic elements and organic compounds, as described in the following table.

**Table 2-1 DEW Line Cleanup Soil Criteria (DCC)**

| Parameter | DCC Tier I (ppm) | DCC Tier II (ppm) |
|---|---|---|
| Arsenic | --- | 30 |
| Copper | --- | 100 |
| Cadmium | --- | 5 |
| Cobalt | --- | 50 |
| Chromium | --- | 250 |
| Nickel | --- | 100 |
| Lead | 200 | 500 |
| Mercury | ---- | 2 |
| Zinc | --- | 500 |
| PCBs[1] | 1 | >5,<50 |

1. Soils containing PCB concentrations in excess of 50 ppm are regulated under the Canadian environmental Protection Act.

Total Petroleum Hydrocarbons (TPH) are not included in the original DLCU protocol but have subsequently been added to the cleanup requirements as a result of negotiations between DND and the NTI. The evaluation of the cleanup requirements for each hydrocarbon contaminated area, where measured concentrations of TPH are in excess of 2500 ppm, is carried out using a risk management approach on a case by base basis.

Soils with contaminants in excess of Tier I criteria, but less than Tier II are classified as DCC Tier I soil and in accordance with the DLCU protocol, will be disposed of on site in conjunction with other non-hazardous wastes in an engineered landfill.

DCC Tier II soil is classified as soil containing contaminants in excess of Tier II. A separate landfill or disposal area will be constructed for the disposal of DCC Tier II contaminated soil, at sites where significant volumes of Tier II soil are present, (generally greater than 1000 $m^3$ ). Consideration will also be given to geotechnical parameters such as quality and quantity of granular fill, where quality must meet the specifications required for construction of the facility. DCC Tier II contaminated soil excavated from sites where a DCC Tier II soil disposal facility will not be constructed, will be transported to an alternate site, with the location dependent on proximity and construction schedule.

A DCC Tier II Soil Disposal facility design incorporates the use of synthetic liners in the base and cover, as well as placement of sufficient granular fill to promote freezeback through the contaminated soil.

## 2.2 Landfill Monitoring Requirements

The specific components of the landfill monitoring program are based on the type of landfill, and the remediation or closure design. For any specific landfill, these components may include:

*Visual Monitoring*: The physical integrity of the landfill will be inspected and reported using hand drawn sketches. Additional detail is provided in the Annex to this section. Documented observations will include:

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

Photographic Records will be provided from ground and air, to document the general condition of the landfill and to substantiate all recorded observations. The location of all photographic viewpoints will be referenced to existing monuments.

*Soil and Active Layer Water Monitoring*. The soil and active layer water monitoring program will consist of baseline/background assessment, as well as contaminant evaluation. Background conditions represent soil and water quality from an area not impacted by the landfill. Background (naturally occurring) values will be obtained from samples collected from areas that have not been directly influenced by activities at the DEW Line site, but are indicative of the prevailing geochemistry. These samples are taken hydraulically upgradient and at some distance from the landfill. Baseline conditions refer to existing soil and water quality at the landfill area, prior to any remediation and/or construction work being carried out. These samples are generally collected from areas both up and downgradient of the landfill.

Soil and active layer water samples (where required) will be collected prior to construction/closure of a landfill, to represent background as well as baseline conditions. The results of subsequent landfill monitoring events will be compared to these baseline and background values to evaluate any potential changes in environmental conditions.

In general, one monitoring well will be installed upgradient and two to three wells will be installed downgradient of the landfill during the construction phase. Using water elevation data from a minimum of three wells allows assessment of the hydraulic gradient and flow velocities. Review of analytical data from water samples collected from wells up and down gradient allows evaluation of potential impacts associated with the landfill. Soil samples will be collected from the toe of the landfill, generally from the same locations as the monitoring wells. Contamination in soil samples at the toe of the landfill reflects chronic input from water that may have infiltrated the landfill, and is an important indicator of contaminated leachate.

Soil samples will be transported to a CAEAL[1] accredited laboratory. Parameters for analyses include:

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

Prior to collection of samples from a monitoring well, the well will be purged and allowed to reach equilibrium. Physical measurements shall be collected prior to and after purging and shall be referenced to the top of the monitoring well pipe. Parameters include:

- water elevation;
- total depth of water ;
- presence of hydrocarbons; and
- hydrocarbon layer thickness (if appropriate).

Following withdrawal of a water sample, other physical measurements to be recorded include:

- color, odor;
- pH;
- conductivity; and
- temperature.

[1] CAEAL accredited laboratories must comply with Canada's National Standard, called the Requirements for the Competence of Environmental Laboratories, which is based on ISO Guide 25 and addresses specific quality and technical aspects related to environmental laboratories.

The water sample will be filtered, as required for specific analyses, and transferred into appropriate containers, for transport to a CAEAL accredited laboratory for analyses. Parameters for analyses include:

- Inorganic elements: arsenic, cadmium, chromium, cobalt, copper, lead, nickel and zinc (total and dissolved concentrations)
- PCBs (polychlorinated biphenyls)
- TPH (Total Petroleum Hydrocarbons)

If the landfill is in close proximity and hydraulically upgradient of a drinking water source, the water samples will be analyzed for the following parameters in addition to the compounds and elements listed above:

- inorganic elements with low detection limits (ppb); and
- major ions, hardness, and total dissolved solids.

The supplementary analyses provide additional information on the potential impacts related to the landfill, but do not necessarily 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.

*Thermal Monitoring:*. Geothermal analyses were carried out as part of the design to predict the length of time required for permafrost aggradation through landfills requiring leachate containment, as well as DCC Tier II soil disposal facilities. These analyses also provided information on the long and short-term thermal regime in the ground, and the depth of the active layer in the cover material.

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 that allow for remote data collection. In general, a minimum of three thermistors will be installed at each landfill where permafrost aggradation through the landfill contents is an integral part of the design..

The following table provides a summary of the post-construction monitoring requirements for each of the landfill classifications.

**Table 2-2 Landfill Monitoring Requirements**

| Landfill Classification | Visual | Active Layer Groundwater Sampling | Soil Sampling | Thermal |
|---|---|---|---|---|
| Class A – Existing Landfills | Not required, as landfill to be excavated. | | | |
| Class B – Existing Landfills | ✓ | ✓ | ✓ | ✓ |
| Class C – Existing Landfills | ✓ | | ✓ | |
| New Landfills: Non-Hazardous Wastes [1] | ✓ | ✓ | ✓ | |
| Tier II Soil Disposal Facility | ✓ | ✓ | ✓ | ✓ |

1. Groundwater sampling is required at new landfills in which painted materials, where the paint contains PCB additives, have been disposed of.

## 2.3 Landfill Monitoring Frequency

The landfill post-construction monitoring program consists of three phases:

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

The frequency of monitoring events during Phase I is dependent on the closure or remediation design at specific landfills. At sites where a leachate containment system is part of the landfill closure, and/or DCC Tier II soil disposal 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 will require three to five years to reach equilibrium.

At other sites, where existing landfills have been regraded and new landfills containing non-hazardous wastes have been constructed, the Phase I monitoring may be carried out over a reduced frequency in the first, third and fifth years following construction.

An evaluation of all 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 had been identified. The Phase I monitoring program may be extended, if required, to provide sufficient data to establish equilibrium conditions.

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

The monitoring frequency in Phase II will be downgraded from Phase I, and is anticipated to 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.

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

At the end of the Phase II program, 25 years after construction, a re-evaluation of the landfill monitoring program will be carried out prior to initiating any Phase III program. The scope of the Phase III monitoring program is not included in this document, but is anticipated to be based on a 10 year monitoring interval.

The following table provides a summary of the landfill monitoring frequency for each of the landfill classifications.

**Table 2-3 Landfill Monitoring Frequency**

| Landfill Classification | Phase I | Phase II |
|---|---|---|
| Class A - Existing Landfills | Not required, as landfill to be excavated. | |
| Class B - Existing Landfills | Year 1, 2, 3, 4, 5 | Year 7, 10, 15, 25 |
| Class C - Existing Landfills | Year 1, 3, 5, | Year 7, 10, 15, 25 |
| New Landfills: Non-Hazardous Wastes | Year 1, 3, 5, | Year 7, 10, 15, 25 |
| Tier II Soil Disposal Facility | Year 1, 2, 3, 4, 5 | Year 7, 10, 15, 25 |

## 2.4 Interpretation of Landfill Monitoring Results

To effectively assess follow-up action requirements, it is necessary that monitoring results (thermal, chemical and visual) be interpreted in concert with one another. An increase in chemical concentrations, for instance, from one year to the next does not necessarily trigger remedial action if there is no other evidence of landfill instability.

Should potential problems be identified during the landfill monitoring program, the frequency and scope of the monitoring program will be increased. Following verification of the cause and extent of the problem, the scope of any remedial action will be reviewed, and implemented, as appropriate.

Figure 2.1 illustrates schematically the monitoring results evaluation process where results have indicated a deficiency or problem with the landfill. The possible results and the associated potential mitigation requirements for the landfill monitoring components are described in the following paragraphs.

In all cases, the mitigation requirements are dependent on the severity of the deficiency, and are to be assessed by a professional geotechnical engineer with northern engineering design and construction experience. In addition, it is recommended that the assessment and implementation of resulting remediation requirements be carried out in a staged approach to ensure that the proposed solutions address the specific requirements in a logical and cost effective manner.

### 2.4.1 Visual Monitoring

If the results of the visual inspection program indicate evidence of significant settlement, erosion, 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;
- mitigate the cause of erosion or settlement by regrading, 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. However, 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 of more of the following mitigative measures:

- flatten granular berm slopes;
- compact existing granular slopes;
- place and compact additional granular fill material;
- collect soil and water samples to monitor contaminant migration.

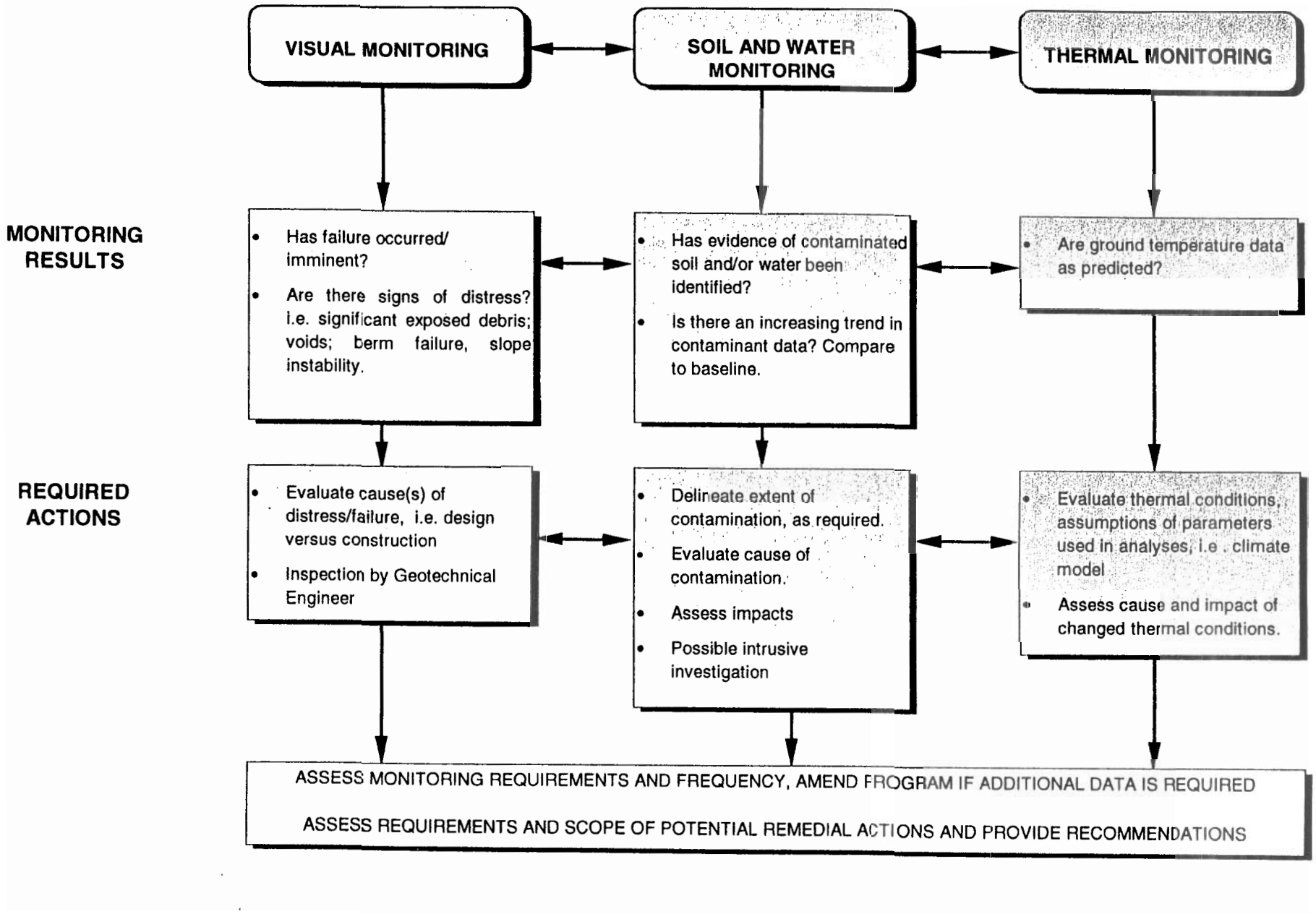


**FIGURE 2.1 - DLCU LANDFILL MONITORING PLAN - ASSESSMENT PROCESS**