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MEMORANDUM

To:	**Nunavut Water Board**	**Fax No.:**	**Via Email**
Attention:	**Dave Hohnstein**	**CC:**	**J. Seto**
From:	**Holger Hartmaier**	**Date:**	**November 12, 2010**
Subject:	**Rankin Inlet Landfill- Review of Proposed Abandonment and Restoration Plan (Final)**		
No. of Pages (including this page): 10		**Project No:**	**0308-008-01**

As requested in your email dated June 2, 2010, BGC Engineering Inc. (BGC) has reviewed the documents submitted to the Nunavut Water Board (NWB or "Board")) concerning the proposed Abandonment and Restoration Plan (ARP) of the existing Rankin Inlet solid waste site. Specifically, BGC was requested to review a report prepared by AECOM Canada entitled "Hamlet of Rankin Inlet, Rankin Inlet Solid Waste Site, Abandonment and Restoration Plan", dated July 2009.

The scope of the review focussed on the following major areas of concern:

- Overall design of closure plan.
- Cover design.
- Site drainage.
- Management of contaminated soils.
- Monitoring.

BGC's comments and concerns are highlighted in *italic script* in the sections below to distinguish them from the background information summarized from AECOM Canada's report.

1.0 INTRODUCTION

The existing solid waste site is located approximately 0.5 km south of the settlement on a peninsula into Hudson Bay located about 0.5 km away on the east, south and west sides. The site slopes to the south and east, with bedrock outcrops along the west side.

The site has a total area of about 6 ha and consists of two main parts:

- A solid waste disposal area, and
- A miscellaneous storage area.

The solid waste disposal area is about 4 ha in size, surrounded by a compacted sand and gravel perimeter road and steel chain link security fence. Solid waste, composed of Municipal Solid Waste (MSW) has been deposited within the fenced disposal area. Historical records indicate that the site has been used for waste disposal since the 1950's, although records of active disposal were not apparent until after 1962.

The miscellaneous disposal area, covering a footprint of about 2 ha lies to the northwest of the solid waste disposal area. This area has been historically used for fire training, drum storage, sewage disposal and scrap metal storage. Some hazardous materials (i.e. lead-acid batteries) have been temporarily stockpiled here awaiting packaging and transport to suitable disposal or recycling facilities.

The site is located within the zone of continuous permafrost, with an estimated thickness of permafrost in the Rankin Inlet area of 300 m. The average depth of annual thaw is about 1m but may be up to 2.5 m in well drained granular materials without organic surface cover.

2.0 OVERALL DESIGN OF CLOSURE PLAN

The overall objective of the ARP is to minimize long-term health, safety and environmental risks associated with the existing solid waste site. The report was intended to provide guidance to the Hamlet of Rankin Inlet and other responsible parties in managing the closure by describing the following:

- Activities required transitioning 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.

Implementation of the ARP involves the following activities:

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

BGC understands that the existing landfill will be replaced with new solid waste landfill at another location. In general, AECOM refers to numerous guidelines and regulations that were used to prepare the ARP. However there is no clear rationale presented for the decision that

was taken to abandon and remediate the existing site rather than the option for removing and relocating the waste materials into the new and presumably engineered facility. BGC's scope of review did not include the new landfill, however it is important to point out that the existing landfill was never engineered, operated in an uncontrolled manner, and, is unlined along its base.

No design criteria are presented regarding the integral components of the proposed landfill remediation, such as the cover, gas ventilation system, surface water management system and the monitoring and inspection program. In BGC's opinion, the proposed ARP represents a significant improvement over the existing conditions. However, the potential still exists for leachate to migrate under the cover, as the base of the landfill is unlined. The only potential containment along the base is by permafrost encapsulation or competent bedrock. The test pit logs aren't clear in specifying whether refusal was met in frozen ground when no bedrock was encountered. There is no geothermal design rationale presented to indicate whether permafrost encapsulation was considered. It should be noted that AECOM reported that the Rankin Inlet area was submerged during the post-glacial period with a current land elevation of about 30 m above sea level. The area has been undergoing isostatic rebound at a rate of 1 m/century. It is likely that the ground in the vicinity of the landfill was inundated with seawater and the permafrost may be saline, which would affect the freezing point depression and introduce unfrozen water in the pore ice.

3.0 COVER DESIGN

The proposed end use for the Site is an open space that is safe for passive recreational use by wildlife and people. The surface cover 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 will be posted to discourage the use of All Terrain Vehicles (ATV's) on the closed landfill to minimize erosion and other damage to the final cover. Large rocks will be placed across the site access roads to discourage traffic.

As part of the recommended site improvements, the existing waste will be cleaned up, re-contoured and consolidated into a smaller footprint to minimize voids and total waste volume. Adjacent areas of metals and hydrocarbon contaminated soil will be excavated and placed as an interim cover over the solid wastes beneath the final cover (see further discussion below).

The final cover system will consist of the following:

- 300 mm (1 foot) thick crusher run armour stone (100 mm nominal diameter) layer, over
- 300 mm (1 foot) thick screened sand and gravel (25 mm nominal diameter) cushion layer, over
- 4 mm non-woven geotextile cushion layer, over

- 0.75 mm (30 mil) polyvinyl chloride (PVC) geomembrane, over
- 4 mm non-woven geotextile cushion layer, over
- 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.

No geothermal design basis was presented for the cover. With the proposed cobbley rock cover, there is not much chance for revegetation and the active layer may be close to the 2.5 m quoted by AECOM for well drained gravel with no organic surface cover. Therefore the proposed 1.2 m of cover over the underlying solid waste may be insufficient if permafrost encapsulation of the waste is desired. Permafrost aggradation into the solid waste is desirable to minimize overall potential for leachate and landfill gas generation. No account for the effects of long term climate change were considered, nor is there any provision for monitoring of ground temperatures within the waste. Monitoring of the thermal regime within the landfill is required if permafrost encapsulation is a design necessity.

The design concept appears to minimize surface water infiltration into the landfill. There is no mention of trying to "contain" any leachate water and the anchor design reflects that (see below). If AECOM are not relying on strict containment, this rationale should be fully explained in the report in terms of risk assessment results, expected contamination, etc.

The PVC geomembrane proposed for the cover should have sufficient flexibility to accommodate potential settlements and ground movements without damage. Performance of the cover is not anticipated to be a problem assuming there is good inspection and control during construction and placement of the contaminated soil interim cover that underlies the geomembrane.

One area of concern is the detail shown on the drawings (Figure 9) for the outer edges of the cover. The proposed detail shows the PVC liner being placed flat on top of what is labelled "Natural Ground Surface". This detail should be reviewed by AECOM. In BGC's opinion, the following issues should be addressed:

- *Natural ground means that the surface may be covered with a layer of organics and vegetation, as well as boulders and other unconsolidated materials. This is not considered a proper subgrade for placement of the PVC geomembrane.*
- *The effective depth of cover over the geomembrane at this location is the combined 0.6 m of armour stone and crushed sand and gravel. Therefore the subgrade under the geomembrane liner is within the active zone creating a potential for seepage and leakage of leachate from the landfill along the perimeter of the cover. Furthermore, the seasonal thawing may result in uneven ground settlement or movements that could disturb the contact zone along the liner interface. Freeze-thaw effects could result in the*

development of ice lenses under the liner, which could lead to further problems with the cover.

- *The toe area forms a swale capturing runoff from the cover as well as the surrounding natural ground. The presence of ponding water will further increase problems associated with permafrost degradation and cover integrity. The existing pond near the southeast corner of the landfill may be receiving leachate from the landfill. Water quality samples should be obtained from this area and tested for leachate parameters.*
- *AECOM should consider revising this detail to include an anchor trench for the PVC liner below the natural ground surface, such that at least 1.2 m of cover is provided. If problems develop in the future, the thickness of the granular cover over the PVC liner may have to be increased significantly in order to provide thermal protection in this area.*
- *There is no detail showing how the edge of the cover transitions to the perimeter ditch. This should be shown taking into consideration the above comments, as well as those in the next section.*

AECOM intends to use an existing quarry as the source for the cover materials, as well as the riprap used in the drainage channels. BGC cautions that the use of this material should be confirmed with respect to potential for Acid Rock Drainage (ARD) and Metal Leaching (ML). Presumably, if this quarry has already been approved by regulators, the ARD/ML potential would already have been assessed and passed by regulators, however the Board should verify that this is the case.

4.0 SITE DRAINAGE

The proposed final cover slopes are at least 2% to encourage drainage from the final cover surface and it allows for future waste settlement to occur while maintaining positive drainage. The maximum cover slopes will be 4H to 1V to prevent excessive erosion of the cover materials. The contour plan has gentle slopes that mimic surrounding natural topography and minimizes hazards to wildlife.

The proposed surface water drainage system includes a perimeter drainage ditch with an open channel design, lined with a 0.3 m thick layer of 150 mm nominal diameter riprap (i.e. crusher run) to minimize erosion and accommodate potential ground settlement.

The drainage swale detail shown in Figure 9 of AECOM's drawings does not indicate whether the ditch is excavated or placed on top of natural ground. BGC would prefer that no ground excavation take place to create ditches. AECOM's Figure 6 shows excavation around the perimeter of the proposed landfill from 0.6 to 1.0 m deep (to bedrock in some cases). Disturbance of the natural ground cover in this area could lead to degradation of the permafrost in the underlying soils and consequent erosion problems. Surface water may be diverted to

natural swales by the use of berms, rather than ditches. The use of excavated ditches should be minimized, or at least restricted to thaw-stable soils (i.e. granular soils or bedrock).

A significant deficiency in the report is the lack of any details that describe how the area will be re-graded and what drainage and erosion protection measures will be implemented for the large areas where contaminated soils were removed as part of the site remediation.BGC is aware that some of the ditches are located within the zones where contaminated soils will be removed. Further commentary on the remediation of the contaminated soils is provided below.

5.0 MANAGEMENT OF CONTAMINATED SOILS

A minimum excavated soil volume of 20,000 m^3 is required to provide the 0.6 m thick soil cushion layer above the waste and beneath the geomembrane liner. Approximately 30,000 m^3 of contaminated soil was estimated by AECOM to be the amount placed into the landfill. This would result in a thicker soil cushion and provide additional protection to the overlying geomembrane.

Four areas of contaminated soil were identified by AECOM. The depths of excavation ranged from 0.6 to 1.0 m based on samples obtained from test pits. The total potential volume of contaminated soils, based on the affected area and depth is 55,000 m^3. However, AECOM's estimate of 30,000 m^3 to be placed into the landfill was based on the assumption that bedrock refusal would be reached in many of the areas before reaching the maximum target depth.

The contaminated soil areas include a hydrocarbon impacted area north (upgradient) of the main landfill, a leachate impacted soil along the east perimeter of the main landfill and two leachate impacted areas along the drainage courses downgradient of the landfill.

After removal of the impacted soils, AECOM intends to place the new riprap lined drainage ditches to divert the surface water around the main landfill area.

It was not clear from the test pit logs presented by AECOM why the test pits were stopped at each of the respective depths. In many cases, the base of the test pit was in soil, indicating that perhaps refusal was reached on top of frozen ground before reaching bedrock. It is not clear if the target depths given in the report table (page 29) are based on excavation to the top of the permafrost. In any case, it is BGC's experience that contamination will migrate down through the soil column to the permafrost table and potentially spread laterally in response to natural seepage and dispersion gradients. The Board should obtain clarification from AECOM that the estimated soil volumes are based on removing all the soil to the top of the permafrost table or bedrock.

With regard to the estimated volume of contaminated soils to be handled, BGC has the following comments:

- *In general, it is BGC's experience that the volume of contaminated soil ultimately remediated significantly exceeds the volume estimated from exploratory investigations. The reasons for this are varied and may include such factors as:*
  - *Actual spread of contamination is greater than originally interpreted (i.e. lateral spreading on permafrost table or bedrock).*
  - *Inability of excavating equipment to avoid removal of adjacent uncontaminated soil while excavating the zone of contaminated soil.*
  - *New areas of contamination not identified in original exploration are found as a result of remedial work activities.*
- *AECOM has not accounted for the bulking of the excavated material placed into the landfill. Even if their estimate of 30,000 m^3 of contaminated soil turns out to be correct, the material is expected to bulk by at least 20%. The Board may have a concern regarding how much contaminated soil is ultimately placed into this landfill, as it is not a fully lined, engineered facility intended to store contaminated soils. Other options for remediation, such as landfarming may have to be considered by AECOM as a backup plan.*
- *Hydrocarbon contaminated soils containing free phase hydrocarbons should be prohibited from being placed into the landfill.*

BGC also has the following concerns regarding the overall soil excavation and relocation plan:

- *There is no provision for dealing with surface water flows and containment and treatment of water contaminated during the excavation of the contaminated soils, some of which are located within drainage courses.*
- *Some of the soils will be excavated below the water table and may require provisions to allow drainage, as well as collection and treatment of the seepage water.*
- *There is no provision or contingency for dealing with free phase hydrocarbons or other potential liquid contaminants which may be encountered, especially near the bedrock or permafrost interfaces.*
- *There are no provisions shown for covering or protecting the exposed soil within the excavations after the contaminated soils have been removed. AECOM notes that some of the excavations will be formed into the drainage swales around the perimeter of the reclaimed landfill, however the excavated areas extend beyond the immediate perimeter of the landfill and need to be covered with erosion protection. BGC has a concern that permafrost degradation may occur in these areas, unless a thermal cover is placed.*

6.0 POST-CLOSURE INSPECTION, MAINTENANCE AND MONITORING

After the ARP is implemented, a program of post-closure inspection, maintenance and monitoring will be required to verify the integrity and performance of the final cover and other environmental controls. AECOM has provided several tables outlining the recommended inspection and maintenance activities and suggested frequencies.

Environmental monitoring is required to assess and monitor the effectiveness of the ARP. Primarily, the environmental monitoring program should verify that contaminants are not leaching into the surrounding environment and impacting surface water quality. AECOM recommended at least 5 years of follow-up environmental monitoring, after which the results of the program should be reviewed to determine if additional monitoring is recommended.

AECOM recommended four surface water monitoring locations located within the two downstream drainage ditches and respective ocean outfalls. Surface water sampling would take place once per year in August. The samples would be analyzed for total metals, general chemistry (geared to potential landfill leachates), hydrocarbons and various field measurements including pH, temperature and conductivity.

Landfill gas monitoring at the passive landfill gas ventilation pipes would be carried out once per year. This would comprise measurements of methane concentration and Lower Explosive Limit (LEL) at the same time as the surface water sampling event.

BGC recommends to the Board to request that AECOM add a surface water quality sampling site that is upgradient of the landfill to obtain measurements of what would be considered "background" levels for the parameters analyzed at the four surface water monitoring locations.

BGC noted that there was no provision for monitoring ground temperatures within the landfill. BGC's recommendation would be that AECOM consider installing at least one thermistor array within the landfill to monitor temperatures within the subgrade, solid waste, interim cover below the geomembrane and within the protective cover above the geomembrane. The reasoning for this is because the landfill base is unlined and there is a strong likelihood that permafrost aggradation will take place, helping to mitigate the potential for leachate generation. By monitoring the ground temperatures, further confidence will be established that the landfill will not be a source of contamination in the future. Increases in ground temperature should be checked, as they may be related to development of seepage zones. Additional remedial measures can then be undertaken, as required. Thermistors may detect potential leachate migration problems well before they are detected by water quality changes in the surface water quality sampling stations located further downstream.

An as-built drawing of the completed facility should be provided to the Board upon completion of construction. The drawings should show the final contours of the landfill cover, the alignment and grades of the drainage ditches, the locations of the passive landfill gas ventilation pipes and the locations of all instrumentation and monitoring stations. The survey should be tied to a permanent benchmark, if available.

7.0 CLOSURE

We trust that this information meets with your requirements. Should you require any further information or have any questions, please do not hesitate to contact the undersigned at your convenience.

Yours truly,
Per BGC Engineering Inc.

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The Association of Professional Engineers, Geologists and Geophysicists of NWT/NU