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PROJECT MEMORANDUM

To:	**Nunavut Water Board**	**Fax No.:**	**Via E- Mail**
Attention:	**Joe Murdock, Technical Advisor**	**CC:**	
From:	**Holger Hartmaier (Ext. 113)**	**Date:**	**June 2, 2006**
Subject:	**NWB3CAP0207- Cape Dorset Sewage Lagoon Water Licence Amendment- Geotechnical Review**		
No. of Pages (including this page): 13 Pages		**Project No:**	**0308-003-01**

1.0 Introduction

As requested by the Nunavut Water Board (NWB) in your letter dated May 15, 2006, BGC Engineering Inc. (BGC) has conducted a geotechnical review of the documents filed for an amendment application for the Hamlet of Cape Dorset's water licence (NWB3CAP0207). The following design and tender documents, prepared by Dillon Consulting Limited (Dillon), were reviewed:

- **Final Design:**
  - P Lake Area Sewage Lagoon System, Final Design Report, dated January 2006.
- **Construction:**
  - Construction Tender
  - Construction Contract
  - Geotechnical Investigation Report, prepared by AMEC Earth and Environmental (AMEC) for Dillon.

In addition, NWB requested that BGC consult and comment on remarks filed by Environment Canada (EC) and Indian and Northern Affairs Canada (INAC) during the application review period.

2.0 Background Information

Dillon was retained by the Department of Community and Government Services (C&GS) of the Government of Nunavut (GN) to design a new sewage treatment system for the Hamlet of Cape

Dorset. The community presently uses trucked services for both water delivery and sewage collection. The existing 3-cell sewage lagoon can supply treatment for the short-term. However, it cannot be viably upgraded to provide for a long term sewage treatment system due to a structural failure. Dillon was first retained by the Department of Community Government and Transportation (CG&T) in 2001 when the motion was made to produce a new sewage facility plan for the community. Over the next four years, CG&T and C&GS conducted planning studies, site selection studies and treatment alternatives assessment for a new sewage lagoon. Several site options were identified. Of the options identified, all but two were dismissed for various reasons:

- Use of "P" Lake and wetlands as a sewage lagoon.
- Use of a mechanical system for sewage treatment.

At present, the Hamlet has identified a sewage lagoon and wetlands system at "P" Lake as their preferred sewage treatment option. This is the option presented in Dillon's design report and the option that has been issued for tender and construction.

3.0 Project Description

The proposed sewage lagoon will be located in the valley upstream of P Lake. The annual retention lagoon will be constructed using the natural topography in conjunction with an earthfill berm to create the desired storage volume (96,100 m^3). P Lake downstream will be used as a secondary short retention lagoon. The wetlands downstream of P Lake will provide some nutrient and total suspended solids removal as well.

The maximum height of the berm will be 5 m, based on the following criteria:

- 1 m freeboard,
- 3.5 m operating depth,
- 0.5 m dead area (sludge retention at the base of the lagoon.

The berm construction will include:

- 4 m wide crest to facilitate construction.
- Inside (upstream slope) to have a 2.5:1 (H:V) slope.
- Outside (downstream slope) to have a 2.5:1 (H:V) slope.
- Riprap protection over the inside slope in areas subject to ice and wave action.
- 50 mm minus gravel protection on all exposed areas of fine grained material to prevent wind erosion.
- Emergency spillway to prevent overtopping of the berm.
- Vertical geosynthetic clay liner within the berm anchored 2-m into the sub-base.
- No liner in the lagoon base.

Sewage will be disposed from sewage trucks into the lagoon through a free fall discharge pipe. The effluent from the lagoon will be discharged annually in the fall over a 2 week open water period to P Lake. The sewage discharge system comprises:

- An intake structure to raise the inlet of the pipe above the sludge deposition level.
- A steel pipe through the lagoon berm.
- An access vault located within the berm, with a manhole located in the berm crest.
- A valve installed in the manhole on the discharge pipe.

- A pipe outfall and discharge channel. The outfall area has riprap protection to prevent erosion and to dissipate the energy of the discharge.

4.0 Geotechnical Review Comments

4.1 General Comments

The documents submitted by Dillon to the NWB are deficient in the following major areas that prevent BGC from completing a full geotechnical review of the project:

- The figures included in the design report were marked “Preliminary Only, Not for Construction”.
- There was no discussion of the geotechnical design aspects of the sewage lagoon in the design report prepared by Dillon. Although Appendix G contained the Geotechnical Investigation report prepared by AMEC, the geothermal analysis was carried out for a different liner detail than the one shown in the Dillon drawings.
- The Tender documents did not include any of the construction drawings listed in the List of Tender Documents- Appendix A of the Construction Tender.

On the basis of these deficiencies alone, BGC would recommend that the NWB reject the submission until a complete set of documentation is provided. The following sections provide specific comments with respect to the information that was available for review by BGC.

4.2 Design Report

- On the title page there is an inconsistency with respect to the type of report. The report is “Final Design Report” in the title, but “Preliminary Design Report” remains in the subsequent sub-title.
- The enclosed covering letter makes it clear that, this is, in fact the final report, including all comments received from C&GS, as well as the geotechnical assessment (was not included with filed copy). The intent of the report is to develop the Class “C” cost estimate for the construction phase.
- In Section 1.1, first paragraph, it is stated that “This document outlines the preliminary design plans for a new sewage lagoon treatment system…”.
- There should be some reference in the design report to tie this document to the construction specifications and construction drawings.
- The climate data in the third paragraph of Section 1.1 needs to be qualified. What is the source (i.e. Canada Climate Normals from Year _ to Year _), are the temperatures mean monthly or daily max./min. ?
- In the last paragraph of Section 1.1, the required service life of 20 years + is given. Environment Canada has expressed concerns with the existing system. Subsequently in Section 1.2, first paragraph, it was noted that there was a structural failure with the existing three-cell lagoon. It would be useful for Dillon to provide some information on both the nature of the structural failure and the Environment Canada concerns, so that these can be assessed with respect to the proposed sewage treatment system. If structural failure occurred within a similar design to that proposed, previous lessons should be of critical importance.

- In Section 3.3 there are some minor inconsistencies noted in the maximum depth of P Lake. In the first paragraph, the maximum depth is 2.5 m. In the second paragraph, it is 2.75 m. Drawing C shows bathymetric contours down to 2.8 m.
- Section 3.6.1 Ground Water Movement in Permafrost, does not mention taliks as another mechanism of ground water flow in permafrost. The Geotechnical Investigation report (Appendix G) did not check for the presence of a talik by means of a thermistor in the vicinity of P Lake.
- In Table 4.4, it should be noted that the pH value of 10.1 is believed to be in error and should be re-measured.
- There should be a geotechnical design section in the report prior to Section 5- Lagoon Construction to cover off the geotechnical design of the major lagoon components, such as:
    - Selection of berm alignment and location.
    - Selection of embankment materials and type of structure.
    - Foundation conditions- soil and bedrock, surficial geology plan. Longitundinal and cross- sections through upstream and downstream berms.
    - Assessment of depth and extent of frost-affected bedrock (FAB) unit.
    - Ground ice conditions.
    - Ground temperatures and taliks.
    - Permeability of active zone soils, especially in the abutment and foundation areas of the upstream and downstream berms.
    - Design of seepage cutoff and justification for selected liner option and configuration and decision for not using a lagoon liner.
    - Foundation preparation requirements.
    - Slope stability assessment and justification of upstream and downstream slopes.
    - Riprap design based on hydraulic design criteria.
    - Geothermal analysis for selected central GCL cutoff option.

It should be noted that the AMEC geotechnical investigations were insufficient to provide this information, as discussed in Section 4.2.1.

- There should be a section in the report to describe the hydrological and hydraulic design of the major lagoon components, such as:
    - Site hydrology.
    - Determination of design flood.
    - Design flood routing.
    - Design of spillway and discharge facilities.
    - Establishing operating water levels and freeboard requirements (validating the 1 m freeboard value used in setting the height of the berm).

- In Section 5.2, Berm Construction, the height of the berm does not mention any allowance for flood handling. For this facility, the design event would likely be based on an extreme precipitation event generating rainfall that falls directly into the lagoon as the surrounding berms have effectively diverted surface water runoff from entering the lagoon.
- Slope stability analysis should be carried out to demonstrate the stability of the slopes under all operating conditions, especially rapid drawdown on the upstream slope due to annual pumping of the lagoon. Due to the lack of site investigations, there is no information on the potential ground ice content of the foundation soils, which could lead

to excessive settlement or foundation instability when the lagoon is impounded on the upstream toe of the slope.

- The spillway is an overflow weir located on the crest of the downstream berm, at the maximum berm section. This arrangement is not recommended due to the potential for uncontrolled erosion of the berm and loss of lagoon containment. An alternative spillway arrangement is recommended, preferably in the abutments, through or on rock. As noted above, spillway design criteria need to be presented and discussed.
- The impermeable liner proposed by Dillon will be placed vertically on the inside of the berm. The geothermal analysis done by AMEC was for a liner on the upstream face of the berm. This option showed that the foundation cutoff trench would remain frozen for the life of the structure. With the vertical liner, this may not be the case. The warm lagoon water would saturate the upstream half of the berm and may result in thawed conditions around the cutoff trench. This may lead to seepage around the liner.
- From BGC's experience, the installation of a vertical liner, as proposed by Dillon, is impractical and without precedent in northern Canada.
- Since there is no design assessment presented that shows that the base of the lagoon is impervious, the proposed liner arrangement cannot be justified. Dillon incorrectly interprets AMEC's conclusions. The AMEC report (Section 8.4), last bullet "…AMEC has not assessed whether the proposed 2 m deep cut-off system under the dyke is sufficient, although thermal modelling suggests that the subgrade will remain frozen." AMEC is referring to the subgrade under the dam, in the vicinity of the cutoff trench, not the lagoon floor. The geothermal analyses clearly show that the lagoon floor will become thawed to a depth of over 6 m after thirty years of operation. The consequences of this will depend on the existing thermal regime, which has not been determined by actual measurements. Therefore, the validity of the geothermal analyses may also be called into question, since they are based on assumed site parameters, as no thermistors have yet been installed on site.
- Section 5.5 describes the lagoon discharge structure. The proposed structure is a pipe through the berm at the maximum head section. The design report states that this will be a steel pipe, however the drawings (Drawing 111, Detail 6) shows a 300 mm HDPE pipe. There are several concerns with this arrangement:
    - Constructing a pipe or any conduit through an embankment dam is considered to be poor practice from a dam safety and stability perspective due to the potential for concentrated seepage flow, deformation or cracking of the pipe and inability to inspect its condition.
    - The pipe is composed of HDPE, which would be even less capable of withstanding imposed loads than the steel pipe mentioned in the design report.
    - There is no information on ground ice content in the foundation soils, which may lead to differential settlement if thawing occurs. This has not been taken into account in the design of the pipe.
    - The pipe may freeze up due to the cold ground temperatures at the dam toe.

- Dillon should provide some information concerning the performance of the gravity discharge system used at other Nunavut locations, with respect to the above concerns.
- In Section 5.6, the design report indicates that natural materials will be used to construct the lagoon berms. No discussion is presented on how these natural, permafrost affected materials will be excavated and processed for use in the berm.
- No details are provided as to the construction of the lagoon berms in terms of:
    - Foundation preparation measures.

  - Cut-off trench depth and excavation.
  - Liner installation procedures in conjunction with fill placement.

- The upstream berm is located on topographic saddle. The lagoon containment limit is at elevation 122.5 m, resulting in a head of about 4.5 m through the berm to the downstream side. There is no liner shown on the drawings for this section of the lagoon, even though this structure has to retain almost as much head as the downstream berm.
- The cutoff trench detail assumes there is 2 m of overburden. There is no detail for the liner if bedrock is encountered in the foundation, or the details for the liner configuration at the abutment ends of the structure.
- Since the drawings included in the Design Report are not issued for construction, there are no further comments at this time.

4.2.1 AMEC Geotechnical Report (Appendix G)

BGC has reviewed the AMEC report for information purposes only. The investigations were carried out at the request of Dillon, and as such, it is Dillon's responsibility to assess the adequacy or inadequacy of the information provided.

AMEC was requested to conduct a geotechnical investigation and geothermal modelling of the proposed sewage treatment system. Based on discussions with Dillon, AMEC's scope of work included:

- Conduct a review of available aerial photographs and relevant geotechnical information.
- Conduct a review of the climatic and permafrost historical data.
- Conduct a site reconnaissance and hand auger drilling program across the proposed lagoon site.
- Conduct a hand auger drilling program at select local borrow sources.
- Conduct a laboratory analysis on select samples obtained during the drilling program.
- Conduct a geothermal analysis of the proposed berm configuration to assess the potential effectiveness of a frozen core liner concept.
- Prepare geotechnical report that summarizes the results of the geotechnical investigation that includes:
  - Discussions of subsurface conditions encountered at the borehole locations.
  - Recommendations for the development of low permeability lagoon walls including geothermal analysis of the berm structures.
  - Development of design requirements for lagoon wall stability.
  - Discussion of borrow source materials, and
  - Recommendations for site grading and drainage, if required.

The following points are raised by BGC with respect to the information provided by AMEC and how it was applied by Dillon:

- The source of information regarding the permafrost conditions was not provided by AMEC. It would appear that it was estimated from the mean annual air temperature data. No thermistors were installed at the site to provide site specific temperature data for design purposes.
- Due to fractured rock covering the site, only one hand auger borehole was able to be drilled to a depth of about 0.15 m. Therefore, no site-specific subsurface data was

obtained for the lagoon foundations. The extent of the frost affected bedrock is critical for design of any water retaining structure.

- Borrow materials investigations comprised one disturbed sample obtained from each of the proposed borrow areas. No drilling was undertaken at the prospective borrow area locations to estimate soil composition. No information was provided as to the in situ condition of these areas in terms of frozen ground and ice conditions that may affect quantities available, time required for excavation and processing required to render them suitable for dyke construction.
- Subsurface conditions were inferred from air photos and the field reconnaissance observations. The values of overburden depth, overburden stratigraphy, mean annual permafrost temperature and active zone thickness have not been confirmed by drilling.
- No information was provided regarding the ground ice content and potential behaviour of foundation materials under thawed conditions.
- There is no discussion provided regarding the design requirements to ensure stability of the lagoon slopes.
- AMEC did not carry out any seepage analysis to justify the design of the liner and cutoff trench.
- The liner configuration used in the geothermal analysis is not what Dillon is proposing. With the vertical liner, there will be a greater potential for thaw around the cut off trench that has not been evaluated.
- The geothermal analysis assumed that there was a 0.5 m thick layer of coarse rockfill protecting the dyke core. This detail is missing from the Dillon drawings ((Drawing 111) and significantly affects the depth of thaw within the berm.
- The geothermal analysis did not include any component of global warming, which is typically applied to all northern designs.
- The predicted ground temperatures at the base of the dyke are a function of the initial temperature conditions, the physical and thermal soil properties and the boundary conditions, all of which were based on assumptions. AMEC did not assess whether the 2 m deep cut-off system under the dyke is sufficient. If actual conditions differ from the assumed parameters, then the actual temperatures in the dyke could vary from the predicted temperatures.

4.3 Tender and Construction Specifications

4.3.1 General

The construction tender was issued by the Department of Community and Government Services, Government of Nunavut. Various dates appear on the document, that require some explanation and updating:

- On the cover of the Construction Tender, “Revised: April 2000”
- On the addendum footer, “January 19, 2004”.
- Within the addendum, the text refers to changes taking effect “April 1, 2004”.
- Table of Contents, “August 2003”.
- Instructions to Tenderers footer, “August 2003”
- Tender form footer, “April 2000”.
- List of Tender Documents- Appendix A- footer “April 2000”.
- NNI Policy Forms footer- Appendix B, “March 2001”.

- Appendix B-1 General Contractors and Sub-Contractors Dollar Amount footer- "April 2000".
- Schedule of Values- Appendix C footer, "February 2006".
- List of Unit Prices- Appendix D footer, "April 2000".
- Transportation of Materials- Appendix H footer, "August 2003".
- Contractor's Certificate of Insurance- Appendix I footer, "April 2000"
- NNI Policy- Appendix J, dated "March 17, 2000".
- Contractor's Obligation to Provide Inuit Content- Appendix K footer, "March 2, 2001".
- Construction Contract cover page, "Revised: April 2000".
- Articles of Agreement footer, "August 2003".
- Terms of Payment footer, "March, 2003".
- General Conditions Table of Contents, page 1 is dated "August, 2003" and page 2 is dated "February 2000".
- General Conditions footer, August, 2003".
- Special Provisions footer, "February 2006".
- Specifications are generally dated "November 2005".

Rather than using a footer date to identify a particular revision of the contract document or form, it is preferred that the contract documents all be consistently dated with the same date to identify that they are all part of the same tender package. This would indicate that some effort was made by the tendering authority, to ensure that all the contractual components are internally consistent and up to date.

4.3.2 General Conditions and Specifications

These need to be read in conjunction with the construction drawings. Since no construction drawings were filed, BGC can only comment on the adequacy of the specifications. In general, the specifications appear to be generic in nature and have not been specifically written for this project. As a result, the specifications contain some irrelevant provisions that don't pertain to this project and leave out some important provisions that are required for execution of this work.

- GC34 Changes in Soil Conditions and Neglect or Delay by Owner:
    - Since no sub-surface investigations were carried out, there is a good chance that the soil conditions assumed by Dillon will differ from the actual conditions. The contractor will likely claim additional expense related to type of material encountered, presence or absence of ground ice, depth to rock, volume of rock excavation required and volume of excavation required.
- Section 01110 Summary of Work:
    - The items listed do not include all the work that is required, such as mobilization and demobilization, provision of temporary utilities and construction facilities, site surveys and layout, borrow area permitting and development, disposal of soil and rock waste materials, commissioning, training and preparation of an operation and maintenance manual.
    - The contract method is a single fixed price contract. There is insufficient information provided in these documents to allow a contractor to prepare a fixed price contract that will cover all the potential unknowns associated with the work.
- Section 01410 Regulatory Requirements:
    - The references and codes listed that the contractor should meet or exceed should already be incorporated into the design and contract specifications. It is

up to the Engineer (GN) to ensure that the work is carried out according to the design and specifications. It is the Engineer's responsibility to ensure that the design and specifications are in accordance with the National Building Code and other standards listed, not the Contractor's.

- Section 01450 Quality Control:
  - Under a fixed price lump sum contract, the Engineer has no opportunity to direct the Contractor to achieve the desired end product while the work is in progress.
  - There is insufficient information provided in this section regarding the basis upon which the Engineer will reject defective work. These details are also not adequately covered in the individual specifications.

- Section 01561 Environmental Protection:
  - There is nothing covering stockpiling and disposal of waste soil and rock.
  - There should be a separate specification to cover drainage and dewatering works associated with construction of the lagoon.

- Section 01-31 Operations and Maintenance Manual:
  - It appears that this specification is generic in nature and not specifically written for this project. It seems to be written for a mechanical type sewage treatment plant, rather than for the lagoon design being proposed. The areas that need to be covered include pond operating levels, procedures for flood handling and routing, what to do in case of overtopping, pond drainage procedures (i.e. rates to prevent instability of slopes), inspection of berm slopes, dealing with seepage through the berm, etc.
  - In order to drain the lagoon during an emergency, someone has to drive up the road, cross the berm, access the manhole and manually open the valve. An Emergency Preparedness Manual is also required to address contingency requirements associated with operating this facility at this location.

- Section 02072 Geotextiles:
  - In the Special Provisions section of the contract, the Contractor is informed of the surplus Bentomat ® panels that are available at the C&GS warehouse in Iqaluit. Presumably these panels meet the requirements of this specification. If so, then C&GS should provide the material warranty because they are no longer directly supplied from the manufacturer. For instance, the panels should have been protected from hydration and damage.
  - If the Contractor elects to use these panels, he should only be responsible for the installation guarantee regarding defects and workmanship, which are under his direct control.
  - Part 3 Execution is a generic specification only. It does not provide details for installation of the vertical liner in the cut-off trench or within the body of the dyke. There are no details regarding abutment treatment or difference in installation in (or on) rock versus soil in the cut-off trench.

- Section 02315 Excavating, Trenching and Backfilling:
  - No information has been provided in the contract regarding the volumes of rock, common and waste materials to be excavated. Since the contract is fixed price/lump sum, the need to define the various classes of excavation is not

necessary, as the contractor will have to carry out all excavation at the same price.
    - There is nothing in the specifications that prevents the Contractor from mixing all classes of excavation together and hauling to the designated disposal area.
    - The specification does not provide details on the number of samples, the materials to be sampled or the sampling protocol. Section 01330- Submittal Procedures covers shop drawings only.
    - Although no construction drawings were filed, it is important to note that the lines, grades and elevations shown on the drawings were based on assumed conditions, without the benefit of subsurface exploration. Since the Engineer will be required to establish the final lines and grades based on actual conditions exposed in the field, the Contractor can claim additional costs.
    - The specifications do not state what the quality of the dyke foundation has to be. Provisions should include the need to remove organics, compressible materials, ice lenses, boulders etc. Since frozen ground (permafrost) may be encountered, the provisions in 3.5.2, backfilling not on frozen ground, does not seem relevant.

- Section 02316 Rock Removal:
    - This specification does not adequately address the need for removal of frost affected bedrock under the footprint of the berms and dykes. Excavating only to the lines and grades shown on the drawings may result in frost affected bedrock being left under the water retaining structures. Since no subsurface investigations were carried out, the depth of the frost affected bedrock has not been determined for this site. In some areas, it may be in excess of 5 m thick. This contingency has not been addressed by these specifications.

- Section 02317 Roadway Excavation Embankment and Compaction:
    - The classes of excavation are not consistent with those used in the Excavating, trenching and Backfilling specification (02315).
    - Not sure what the difference is between Common and Unclassified excavation according to the definitions given in the specification.

- Section 02371 Rip-rap:
    - The specification has not included any durability testing to assess the quality of the rip-rap. Laboratory testing of the proposed rip-rap materials should be carried out, including freeze-thaw, absorption and slake durability.

- Section 02661 Sewage Storage Lagoons:
    - This is the only specification that covers the construction of the dykes. No detail is given regarding the concurrent construction of the vertical liner and fill placement that is required to execute the proposed design.
    - The dam construction materials specifications are not described.
    - Section 3.5 seems to imply that the impervious liner will be placed on the bottom and sides of the lagoon. This is not what was presented in the Dillon design report.

5.0 Comments by Intervenors

NWB requested BGC to comment on the following intervenor remarks filed during the application review period:

5.1 Environment Canada

BGC was requested by NWB to comment on the following remarks filed by EC:

- **Hydrology:**
  - Section 3.4 of the "Cape Dorset Sewage Treatment System" report indicates that there is significant recharge from P Lake in June and July. It is stated that the use of P Lake for sewage treatment is not practical unless the recharge water is directed away from the proposed lagoon, and that diversion ditches will be implemented as part of the design. However, the 95% Review Drawings included in the submission do not seem to include diversion ditches around either the new lagoon cell or P Lake. In order to prevent failure of the berms due to spring freshet flows, EC strongly recommends that diversion ditches be included in the design to redirect recharge around the lagoon and P-Lake.

BGC is not in favour of excavating ditches in permafrost for the purpose of water diversion. The preliminary design drawings in the Dillon report show that the berms will divert water from entering the lagoon. BGC recommends that Dillon review the design of the berms to ensure that they will remain stable when subject to freshet flows. This may require armouring the outside slopes with rip-rap to prevent erosion. In addition, they need to be properly thermally designed to ensure the subsurface remains frozen. BGC is not aware of any reason why natural runoff into P-Lake should be prevented.

- Environment Canada requests confirmation that there is no talik or fault beneath P Lake that would facilitate the movement of contaminants into the groundwater.

BGC has expressed a similar concern in our comments above. No subsurface investigation has been carried out at the site. As a minimum, BGC would recommend that Dillon consider installing a thermistor into an inclined borehole, on the downstream side of the dyke, oriented parallel to the dyke axis. The purpose of the hole is to check for the presence of a fault zone and to measure ground temperatures to confirm the absence of a talik. These actual ground temperatures would then be used as input into the geothermal assessment of the final design.

5.2 Indian and Northern Affairs Canada

BGC was requested by NWB to comment on the following remarks by INAC:

- The Nunavut Water Board should note that the geotechnical study referred to in Section 5.2, "Berm Construction", of the Final Design Report was not included in the document's appendices. This study was submitted by AMEC Earth & Environmental (AMEC) in October 2005 and was obtained by INAC after contacting Dillon Consulting Ltd. INAC is concerned that this information was not made available to the Board's reviewers and that the Final Design Report inaccurately states that AMEC advises that a liner is not needed under the base of the lagoon (refer to section 5.2). INAC recommends that the Board review this geotechnical study as part of the proponent's Final Design Report.

BGC has reviewed the AMEC report and has pointed out this discrepancy in our comments.

- INAC recommends that the proponent seriously consider the value of placing an impermeable synthetic liner under the base of the lagoon in addition to the interior of retention berms. AMEC's geotechnical investigation noted that the proposed lagoon site consists of fractured bedrock and that the ground temperature below the lagoon will likely rise due to the warming effect of the sewage effluent. Having an impermeable synthetic liner placed under the lagoon can prevent the contamination of ground water from effluent flowing through porous rock.

BGC has noted that the AMEC investigation failed to obtain subsurface data at the site. The actual foundation conditions and ground temperatures are not known, but have been assumed based on reconnaissance observations and climate data respectively.

- INAC recommends that the proponent address the need to establish water diversion measures in the vicinity of the proposed lagoon site so as to protect the integrity of its retention berms.

As noted in Section 5.1 above, BGC recommends that Dillon review the design of the retention berms so that are geothermally adequate and capable of withstanding surface runoff flows without erosion or instability. Avoid excavating ditches in permafrost affected ground.

6.0 Closure

BGC considers that the Dillon submission for the water licence amendment of the Cape Dorset sewage lagoon is inadequate and prevents BGC from completing a full geotechnical review of the project, for the following reasons:

- The figures included in the design report were marked "Preliminary Only, Not for Construction".
- There was no discussion of the geotechnical design aspects of the sewage lagoon in the design report prepared by Dillon. Although Appendix G contained the Geotechnical Investigation report prepared by AMEC, the geothermal analysis was carried out for a different liner detail than the one shown in the Dillon drawings.
- No actual site specific geotechnical information was collected by AMEC. Only "inferred subsurface conditions" are provided. This is not adequate for the final design and construction of a 5 m high dam.
- The Tender documents did not include any of the construction drawings listed in the List of Tender Documents- Appendix A of the Construction Tender.

On the basis of these deficiencies alone, BGC would recommend that the NWB reject the submission until a complete set of documentation is provided. We have included comments related to the documents filed so that these may be responded to by Dillon in the course of re-submitting the design and construction documents for NWB approval. The above noted deficiencies relate to the overall water containment capability of the proposed sewage lagoon and the potential impacts on surface and ground water resources, which are the within the mandate of the NWB.

We trust that this information meets with your requirements at this time. Should you have any questions or require additional information, please do not hesitate to contact me.

Yours truly,
BGC Engineering Inc.

Holger Hartmaier, M.Eng., P.Eng.
Senior Geotechnical Engineer

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