Technical Specifications

Earthworks and Geotechnical Engineering

Hope Bay Project, Nunavut, Canada

Revision F – Issue for Construction

Report Prepared for

Hope Bay Mining Ltd.

Report Prepared by

SRK Consulting
Engineers and Scientists

February 2011

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Section 1
General Requirements

1 General Requirements

1.1 Part 1 – General

1.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

1.1.2 Revision Summary

1. Table 1.1 provides a summary of the revision history of this Technical Specification.

Table 1.1: Revision history of this Technical Specification

Revision	Status	Date	Major Changes
A	Water Licence Application	Mar. 2007	-
A	Issued for Construction (IFC)	Mar. 2007	None
B	Issued for Construction (IFC)	Nov. 2007	Removal of payment clauses Revised scope of the Works Revised roles and responsibilities of parties Revised material specifications
C	Issued for Construction (IFC)	May 2010	Revised and added scope of the Works Revised responsible parties
D	Issued for Construction (IFC)	December 2010	Revised all elements related to the construction of the Frozen Core Dam
E	Issued for Construction (IFC)	February 2011	Added Engineers Responsibility Added clarity and detail pertaining to quality control and quality assurance requirements Corrected editorial mistakes
F	Issued for Construction (IFC)	February 2011	Updated Sections 5.3, 5.4, 7.3 and 7.4

1.1.3 Definitions

1. The following definitions and interpretations shall apply to these Technical Specifications:

   (1) PROJECT means the total Hope Bay Project Construction contemplated, of which the Works described in this Document may be the whole or part.

   (2) WORKS is defined as the entire completed construction as defined by this Document, or the various separately identifiable parts thereof, required to be furnished under the Contract Documents. Works is the result of performing services, furnishing labour, and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.

(3) CONTRACT DOCUMENTS are defined as the agreement, addenda (which pertain to the Contract Documents), Contractor's bid (including documentation accompanying the bid and any post-bid addenda submitted) when attached as an exhibit to the agreement, the bonds, the general conditions, the supplementary conditions, these Specifications, the Drawings, together with all Modifications issued after the execution of the agreement.

(4) SPECIFICATIONS are defined as this Document of Specifications prepared by SRK Consulting (Canada) Inc. on behalf of the Owner. These Specifications are to be read, interpreted and coordinated with all Drawings and Modifications, or any other relevant documents produced by the Engineer.

(5) DRAWINGS are defined as all Engineering Drawings, plans, sketches and maps issued with these Specifications, or subsequently, as deemed necessary by the Engineer.

(6) MODIFICATIONS are defined as changes made to the Specifications and/or Drawings, which have been approved by the Engineer in writing. These modifications can be issued at any time, including after issuance of these Specifications and any accompanying Drawings and/or other Modifications.

(7) SUBMITTALS are defined as any documentation, as outlined in this Document, that are used as formal means of communication during execution of the Works, and originated by any of the Responsible Parties.

(8) Responsible Parties:

a) OWNER is defined as Hope Bay Mining Ltd. (HBML), a wholly owned subsidiary of Newmont Mining Company (NMC), or an authorized representative of the company. Hope Bay Mining Ltd., Owner, HBML, Newmont and NMC shall have common meaning.

b) ENGINEER (also, ENGINEER-OF-RECORD) is defined as a representative appointed and authorized by the Owner for those Works described in this Document. The Engineer shall be a registered Professional Engineer in the Territory of Nunavut, or a designated site representative under his direct supervision during construction. At the time of issuing this Document, the Engineer-of-Record is a designated employee of SRK Consulting (Canada) Inc. (SRK). The Engineer has a direct contract with the Owner, and reports to the Owner, either directly, or through the EPCM Manager. The Engineer may not communicate directly with the Contractor and Environmental Monitor, unless approved by the EPCM Manager.

c) EPCM MANAGER is defined as the party or appointed representative of the party that has an agreement with the Owner to act as overall EPCM Manager for executing the Project, including the Works defined in this Document. At the time of issuing this Document, the EPCM Manager is JDS Energy & Mining Inc.

d) CONTRACTOR is defined as the party or appointed representative of the party that has an agreement with the Owner to execute the Works defined in this Document. At the time of issuing this Document, the Contractor is Nuna Logistics Limited (NUNA). The Contractor may not communicate directly with the Engineer or the Environmental Monitor, unless approved by the EPCM Manager.

e) SUB-CONTRACTOR is defined as the party or appointed representative of the party that has an agreement with the Contractor or EPCM Manager to execute specialized components of the Works defined in this Document that cannot be carried out by the Contractor.

f) ENVIRONMENTAL MONITOR is defined as the party or appointed representative of the party that has an agreement with the Owner to act as Environmental Monitor for the Project, including the Works defined in this Document. At the time of issuing this Document, the Environmental Monitor is the Owner. The Environmental Monitor has a direct contract with the Owner, and reports to the Owner directly. The Environmental Monitor may not communicate directly with the Contractor and Engineer, unless approved by the EPCM Manager.

g) SURVEYOR is defined as the party or appointed representative of the party that has an agreement with the Contractor and/or EPCM Manager to act as Site Surveyor for the execution of the Works defined in this Document. The Surveyor shall have equipment and means on site to carry out horizontal and vertical ground surveys with an accuracy of ±2 mm. The Surveyor shall also have the equipment and means to prepare Digital Terrain Models (DTM) and Drawings on site that is compatible with AutoCAD 2007 or later. The Surveyor reports to the Contractor, but will be available for use by the Engineer as required, provided the Engineer has requested such needs through the EPCM Manager.

h) QUALITY CONTROL TEAM is defined as the individual(s) working under the direction of the EPCM Manager and/or Contractor to perform on site Quality Control (QC) for the Works defined in this Document.

i) QUALITY ASSURANCE TEAM is defined as the individual(s) working under the direction of the Engineer to perform on-site Quality Assurance (QA) for the Works defined in this Document.

(9) ON-SITE MATERIAL is defined as borrow materials obtained from within designated on-site facility excavations.

(10) OFF-SITE MATERIAL is defined as material obtained from sources other than on-site.

(11) RECORD DOCUMENTS are defined as the documents prepared and certified by a Land Surveyor, Material Testing Technician, Quality Control and Quality Assurance Personnel, Specialist Professionals, or any other parties documenting any aspect of the Works.

(12) PRODUCTS are defined as processed fill material, machines, components, equipment, fixtures, and systems forming the Works. This does not include machinery and equipment used for preparation, fabrication, conveying, and erection of the Works. Products may also include existing material or components required for reuse.

(13) SLOPES are defined in all instances in these Specifications and on Drawings in terms of horizontal distance to vertical distance (i.e., 2H:1V shall be read as 2 Horizontal to 1 Vertical).

(14) PLANT means all the components and structures used in fill processing, concrete mixing and explosives production.

(15) EQUIPMENT means all construction mobile equipment that will be used for the Works.

1.1.4 Summary of Works

1. The Contractor, with support from the EPCM Manager, will be responsible for ensuring that all the Works defined in this Document be executed in accordance with all appropriate permits and approvals. Furthermore, the Contractor is responsible for ensuring that all the Works are carried out in accordance with the Owners Environmental Management and Procedures Manual (EMPM).

2. The Works covered by this Specification includes, but is not limited to the following:

   (1) Implementation, operation, maintenance and removal of temporary construction sediment and runoff control.

   (2) Construction of permanent surface water management controls, including contour berms, pollution control ponds and sumps.

   (3) Operation and management of permanent surface water management controls up to the time of complete demobilisation.

   (4) Clearing, stripping and excavation in required areas.

   (5) Development of borrow areas and borrow access roads. This includes quarry development, management and closure.

   (6) Production of construction material specified in the Specifications, and on the Drawings.

   (7) Construction of earthworks components of all-weather roads.

(8) Construction of earthworks components of road turnouts and caribou crossings along all-weather roads.

(9) Construction of earthworks components of bridge abutments.

(10) Construction of earthworks components of arch culvert installations.

(11) Construction of earthworks components of all-weather airstrip and aprons.

(12) Construction of earthworks components of laydown areas.

(13) Construction of earthworks components of camp/mill pads.

(14) Construction of earthworks components of permanent explosives storage facility pads.

(15) Construction of earthworks components of waste rock pile pad.

(16) Construction of earthworks components (including liner) of pollution control pond(s).

(17) Construction of earthworks components (including liner) of sedimentation pond(s).

(18) Construction of earthworks components (including liner) of landfarm.

(19) Construction of North and South Dams (frozen core dams).

(20) Construction of spillway.

(21) Construction of earthworks components (including liner) of emergency dump catch basins.

(22) Installation of permanent monitoring instrumentation for the Works, including, thermistors, settlement plates and survey beacons.

(23) Installation of shoreline erosion protection measures around Tail Lake.

(24) Removal of temporary structures used during construction of the Works and clean-up of the construction areas, borrow areas, and stockpile areas.

3. Electrical, instrumentation (other than specified), mechanical, concrete and structural work are excluded from this scope of work.

1.1.5 Contradictions

1. Should any contradiction, either implied or real, exist between the Specifications and the Drawings, the Contractor shall:

(1) Notify the EPCM Manager and the Engineer.

(2) Stop all Works that concern the contradiction until the contradiction is remedied or clarified by the Engineer.

2. The decision of the Engineer is final.

1.1.6 EPCM Manager Responsibilities

1. The EPCM Manager, in the context of the Works defined in this Document, shall:

(1) Act as the Owners representative and be the formal liaison between all parties.

(2) Be responsible for overseeing execution of the Works, in accordance with the Engineers Specifications and Drawings.

(3) Be responsible for procurement of all materials to execute the Works.

(4) Become familiar with all relevant permits, approvals and any other administrative matters which may impact the Works. The Engineer will assume that all appropriate approvals have been obtained and that all conditions have been satisfied when giving technical approvals to proceed with the Works.

(5) Before proceeding with the Works, examine all Drawings and report to the Engineer any apparent discrepancies or interferences. The Engineer shall at all times retain the right to make revisions to the Drawings and the Specifications.

(6) Ensure an appropriate work space, necessary facilities and transportation equipment is available to the Engineer and his representatives to perform their duties on site.

(7) Ensure that the Engineer and his representatives receive appropriate site specific health and safety training and/or orientation whilst on site.

1.1.7 Contractor's Responsibilities

1. The Contractor, in the context of the Works defined in this Document shall:

(1) Comply with Nunavut Worker Compensation Board, Northern Canada Mine Safety Act and any other relevant required health and safety regulations.

(2) Comply with Owner's Environmental Management and Procedures Manual (EMPM).

(3) Provide the EPCM Manager with copy of their Health and Safety Plan, which has been specifically prepared for this Project.

(4) Become familiar with the relevant regional and site-specific conditions that deviates from the Specification and Drawings, and inform the Engineer through the EPCM Manager when a problem or delay is anticipated.

(5) Be responsible for making his own measurements and installing the Works to fit the conditions encountered.

(6) Before proceeding with the Works, examine all Drawings and report to the Engineer via the EPCM Manager any apparent discrepancies or interferences. The Engineer shall at all times retain the right to make revisions to the Drawings and the Specifications.

1.1.8 Engineer's Responsibilities

1. The Engineer, in the context of the Works defined in this Document, shall:

(1) Comply with Owner's Environmental Management and Procedures Manual (EMPM).

(2) Provide the EPCM Manager and Contractor with Drawings and Specifications, including Revisions and Modifications, to be able to conduct the Works defined in this Document.

(3) Provide the EPCM Manager and Contractor with digital Drawing files to facilitate setting out the Works defined in this Document.

(4) Provide full-time site Engineer(s) during construction of the Works as defined in this Document. The Engineer will monitor construction activities to ensure that the Works are constructed in accordance with the Drawings and Specifications.

(5) Ensure timely response as defined in this Document, to Submittals pertaining to the Drawings or Specifications submitted by the EPCM Manager and Contractor.

1.1.9 Codes and Standards

1. The Quality Control and Assurance Program (QA/QC) as described in this Document, shall use testing procedures from, but not limited to the list of American Society of Testing and Materials Standards in Table 1.2.

Table 1.2: List of Codes and Standards

Test	Topic
ASTM D2487	Classification of Soils for Engineering Purposes
ASTM D2216	Water (Moisture) Content in Soil and Rock
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D854	Specific Gravity of Soils
ASTM D698	Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D2922	Density of Soil in Place by Nuclear Methods

1.1.10 Quality Control

1. The Contractor will carry out Quality Control (QC) for the Works defined in this Document, and will undertake testing at a frequency and at the locations specified in the various sections of these Specifications and Drawings, or as defined in their approved Quality Control program.

2. The Contractor shall submit a copy of his QC program for review by the Engineer and EPCM Manager at least seven (7) days prior to commencement of the Works.

3. All QC or other test data, survey data or the like, collected by the Contractor, shall be made available to the EPCM Manager and Engineer on request.

4. The EPCM Manager and Contractor shall provide the all necessary equipment and technicians for material and product testing required to execute the QC program.

5. QC shall be done continuously, as specified in this Document, to ensure the quality of products and Works.

6. The Contractor's QC shall be done independently from the Engineer's Quality Assurance (QA).

7. QA, or any other form of performance testing by the Engineer or EPCM Manager, shall in no way relieve the Contractor of its sole responsibility for completing the Works in accordance with the specified requirements.

8. Geochemical testing of any construction material will be the responsibility of the Owner, and will be controlled by the EPCM Manager. The Contractor is however responsible to ensure that any applicable testing has been carried out and that any construction material has been approved for use.

1.1.11 Quality Assurance

1. The Engineer will carry out Quality Assurance (QA) for the Works defined in this Document, and will undertake testing at a frequency and at the locations specified in the various sections of these Specifications and Drawings. The Engineer may undertake any additional testing which he deems necessary on any part of the Works.

2. This Document, and the Drawings outline the Engineer's QA program, and is subject to review by the EPCM Manager and Contractor.

3. All QA or other test data, collected by the Engineer, shall be made available to the EPCM Manager and Contractor on request.

4. The Contractor and EPCM Manager shall render such assistance as is necessary to enable QA sampling and testing to be carried out expeditiously, and provide the all necessary equipment, including an adequately equipped on-site laboratory.

5. The Engineer's QA shall be done independently from the Contractors QC.

6. QA, or any other form of performance testing by the Engineer or EPCM Manager, shall in no way relieve the Contractor of its sole responsibility for completing the Works in accordance with the specified requirements.

7. Geochemical testing of any construction material will be the responsibility of the Owner, and will be controlled by the EPCM Manager. The Contractor is however responsible to ensure that any applicable testing has been carried out and that any construction material has been approved for use.

1.1.12 Submittals

1. The Contractor shall submit information as specified and requested from the Engineer through the EPCM Manager. All submittals required by the Engineer will be requested through the EPCM Manager.

2. The Engineer has the right to request as a Submittal any other information deemed necessary throughout execution of the Works. This includes information not currently defined as Submittal information on the Drawings and Specifications.

1.1.13 Construction Schedule

1. Construction scheduling is the responsibility of the EPCM Manager; however, the Contractor and EPCM Manager is reminded of the following very important facts:

   (1) Construction of the North and South Dam can ONLY be carried out in the winter, when the constant ambient outside air temperature is a maximum of -10°C. This ambient air temperature must be maintained from the time the foundation base is cleared and stripped, until the entire Run-of-Quarry shell has been placed in accordance with the Specifications and Drawings.

   (2) The Core material placement must be conducted when air temperatures will freeze a lift of key trench material within 24 hours of placement. Experience has shown that a 250 mm thick lift freezes back within 24 hours when air temperatures are below -15ºC. The time to freeze back will depend on the moisture content, wind speed, air temperature and solar radiation.

   (3) The Contractor and EPCM Manager must submit a detailed schedule of the dam construction to the Engineer at least 14 days prior to commencement of construction. The Engineer reserves the right to halt the start of construction of the dams, if in his opinion there is any risk that the construction cannot be completed under the required ambient air temperatures.

1.1.14 Construction Drawings

1. Drawings will be issued by the Engineer specific to construction needs prior to commencement of the Work. Drawings shall be reviewed by the EPCM Manager and Contractor to ensure all aspects of the construction needs are covered, and report to the Engineer any discrepancies and interferences. The EPCM Manager shall notify and inform the Engineer of construction progress and Drawing requirements four (4) weeks prior to commencement of any Works.

2. Only Drawings specifically marked with the following words are considered acceptable for Construction: ISSUED FOR CONSTRUCTION, or IFC.

1.1.15 Construction Specifications

1. Specifications will be issued by the Engineer specific to construction needs prior to commencement of the Work. Specifications shall be reviewed by the EPCM Manager and Contractor to ensure all aspects of the construction needs are covered, and report to the Engineer any discrepancies and interferences. The EPCM Manager shall notify and inform the Engineer of construction progress and Specification requirements four (4) weeks prior to commencement of any Works.

2. Only Specifications specifically marked with the following words are considered acceptable for Construction: ISSUED FOR CONSTRUCTION, or IFC.

---------- END OF SECTION 1 ----------

Section 2
Clearing and Stripping

2 Clearing and Stripping

2.1 Part 1 – General

2.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

2.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:

   (1) CLEARING means Works involved in the removal of snow and ice on natural ground or subgrade surface to the satisfaction of the Engineer.

   (2) STRIPPING means Works involving excavation and removal of unsuitable material including but not limited to organics and ice rich materials.

2.1.3 Description

1. The Works covered by this section consists of supplying all labour, materials, and equipment, and performing all Works necessary for clearing and striping.

2. The Contractor shall clear or clear and/or strip the Works areas as required including, but not limited to; borrow areas, disposal areas, stockpile areas, laydown areas, water management areas, foundation zones and between individual lifts of fill placement, as shown on the Drawings, or inferred by these Specifications or as directed by the EPCM Manager with express approval from the Engineer.

3. Clearing and stripping in all areas shall require approval by the Engineer before such Works begins.

4. It is the EPCM Manager's responsibility to identify and acquire all necessary permissions and approvals for stockpiling and storage of materials removed through the process of clearing and/or stripping.

2.1.4 Submittals

1. At least seven (7) days prior to clearing, striping, or clearing and stripping in any specific area, the Contractor shall submit to the Engineer and EPCM Manager, for approval, a Clearing and Stripping Work Plan describing the schedule, locations and extent of the clearing and striping, and the proposed methods for disposal of clearing and stripping products.

2. Work shall not start until applicable approvals are obtained from the EPCM Manager in writing.

3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

2.1.5 Permits and Regulations

1. The EPCM Manager shall conduct his work in accordance with the Owner's and all applicable Federal, Territorial, local or landowner regulations and licences regarding the disposal of materials from clearing and stripping.

2. It is the EPCM Managers responsibility to be familiar with all said regulations, conditions and permits.

2.1.6 Protection

1. Unless otherwise instructed, the Contractor is to take all necessary precautions to prevent damage to natural and man-made features, including, but not limited to monuments, survey marks, archaeological sites, monitoring instrumentation and the sensitive tundra landscape.

2. The Contractor may not perform any Works outside of the permitted and pre-approved construction area.

2.2 Part 2 – Execution

2.2.1 Preparation

1. The Contractor shall confirm the clearing or stripping limits by having his surveyor lay out and flag the extents at all areas of work, prior to commencement of clearing or stripping. The Engineer will inspect these demarcated areas and confirm all clearing or stripping limits before giving approval to proceed to the EPCM Manager. The EPCM Manager will in turn authorize the Contractor to proceed with the Works.

2. The Contractor shall inspect the Works site and verify with the Engineer and the EPCM Manager, any restrictions within or adjacent to the clearing limits.

3. Unless specifically instructed otherwise, the Contractor shall locate and protect natural and man-made features, including, but not limited to monuments, survey marks, archaeological sites, monitoring instrumentation and the sensitive tundra landscape.

2.2.2 Clearing

1. Snow and ice shall be removed from all construction footprint areas, prior to undertaking any work in that area, with a maximum tolerance of 10 cm of snow material left above natural ground, or otherwise approved by the Engineer.

2. Should snow fall on previously cleared or stripped surfaces that have been prepared and approved for construction, including between individual lifts of fill placement, the Contractor will carry out any additional clearing as requested by the Engineer.

3. The Contractor shall take all necessary precautions to prevent damage to natural and frozen ground, unless otherwise specified by the Engineer.

2.2.3 Stripping

1. Where required and as a minimum in areas to be excavated, areas subjected to clearing shall undergo stripping to the depth necessary to remove all soil, including permafrost and other organic material necessary to expose bedrock, or other suitable foundation conditions as directed by the Engineer.

2. Should blasting be required of permafrost soils, the Contractor will comply to all Specifications associated with blasting, in addition to those listed in this Section.

2.2.4 Finished Surface

1. The Contractor shall leave the cleared and/or stripped surface clear, smooth, debris- and snow-free, in a condition suitable for inspection by the Engineer.

2.2.5 Disposal

1. Snow and ice cleared off the construction area shall be stockpiled downstream and outside of the construction area where it will not affect the construction or any constructed elements during thaw. The stockpile area shall be proposed by the Contractor and approved by the EPCM Manager. A water management plan, prepared by the Contractor, and approved by the EPCM Manager, must be in place prior to stockpiling snow and ice in the specified area.

2. Soil and organic material stripped off the construction areas shall be stockpiled in designated areas approved by the EPCM Manager with proper sediment control as instructed in permit requirements.

2.3 Part 3 – Quality Control

1. Submit a Clearing and Stripping Work Plan as defined in Section 2.1.4 of this Document.

2. Confirm with EPCM Manger that all Permits and Approvals are in place prior to commencing any work.

3. Physically demarcate, for review and approval by the EPCM Manager and Engineer, the Works area that will be cleared and/or stripped using proper survey control. Within this zone clearly identify natural and man-made features that require protection as defined in this Document.

4. Implement measures, including spotters as needed, to allow visual inspection of clearing and/or stripping activities during execution to ensure it is done in accordance with the Specifications as defined in this Document.

5. Conduct field surveys, and submit As-built Drawings, in electronic format of any cleared and/or stripped areas, as requested by the Engineer or EPCM Manager.

2.4 Part 4 – Quality Assurance

1. Review the Contractor's Clearing and Stripping Work Plan as defined in Section 2.1.4 of this Document and submit review comments back to the Contractor via the EPCM Manager.

2. Visually inspect the demarcated zone prepared by the Contractor for clearing and/or stripping and inform the Contractor via the EPCM Manager if changes are required.

3. Visually inspect the cleared and/or stripped areas and inform the Contractor via the EPCM Manager if changes are required.

4. Review As-built Drawings submitted by the Contractor of cleared and/or stripped areas and inform the Contractor via the EPCM Manager if any changes are required.

---------- END OF SECTION 2 ----------

Section 3
Excavation and Water Control

3 Excavation and Water Control

3.1 Part 1 – General

3.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

3.1.2 Description

1. The excavation Works entails excavation of soil and other materials below original ground surface to neat lines and grades as indicated on the Drawings.

2. The Works to be done under this Section consists of furnishing all labour, material, plant and equipment, and the performance of all Works necessary to carry out rock, soil and permafrost excavation as shown on the Drawings, and as specified herein.

3. The Works shall also include the loading, transportation and permanent disposal of all excavated materials which are deemed by the Engineer to be surplus, or unsuitable for use as construction material, and the loading, transportation and possible temporary stockpiling and re-handling of acceptable materials to locations where they can either be used as part of the temporary or permanent structures, or stockpiled in readiness for future temporary or permanent use.

4. The EPCM Manager and Contractor will be responsible to locate suitable stockpile locations for any excavated material, whether temporary or permanent. The Engineer will however have the right to reject any identified sites, if in his opinion it may interfere with any of the Works.

3.1.3 Exclusions

1. The Contractor is responsible for quarry development. The Engineer does however reserve the right to request modifications to the quarry development plan if the materials being produced do not meet Specifications. Any such requests must be submitted through the EPCM Manager.

3.1.4 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:

   (1) SOIL and OVERBURDEN meaning is interchangeable and means general overburden material including glacial marine clays, silty clays, sand, gravel, till and any combination of these materials, which can be used in part as Bedding material for liners or concrete aggregate if they are free of contaminants, snow, ice and organic material, and if approved by the Engineer.

(2) PERMAFROST means soil that is permanently frozen, in accordance with the appropriate normal geotechnical definitions.

(3) ROCK means quarried material from a designated quarry site, or from a designated foundation excavation.

(4) UNSUITABLE MATERIAL means any soil, permafrost or rock that does not meet the Specifications for the use of this project.

(5) BLASTED MATERIAL means any material produced by production blasting at all quarry or excavation sites that is deemed to be suitable for construction material.

(6) NEAT LINE means the final line or grade to which excavation is to be performed.

(7) QUARRY and BORROW areas meaning is interchangeable.

(8) COMMON EXCAVATION means excavation of all materials, including rock, weathered bedrock, soil, permafrost and unsuitable material by mechanical means.

3.1.5 Procedures

1. The details of the surface excavations shown on Drawings represent an engineered design encompassing drainage under particular assumed conditions. Variations in site conditions may require adjustments to the excavation shape, slope reinforcement and drainage under the Engineer's discretion.

2. If, in a specific area, a plan that has been previously adopted does not fit the site conditions in accordance with the requirements of these Specifications, the Engineer shall submit a revised plan to the EPCM Manager before continuing excavation in identified areas.

3. All earthworks that will potentially disturb original ground shall be constructed during the winter season to prevent damage to the tundra. All construction Works and traffic shall be within the constructed footprint during summer months.

4. Water management measures shall be constructed and implemented during the winter months as directed by the EPCM Manager, and only emergency adjustments can made during the following spring and summer as approved by the EPCM Manager.

3.1.6 Submittals

1. The Contractor shall submit a detailed excavation plan to the EPCM Manager and the Engineer outlining his intended methods for excavation within a given area at least seven (7) days prior to the commencement of Works including, but not limited to the following details:

(1) Typical equipment deployment.

(2) Sediment and runoff control around the intended Works area.

(3) Water control and dewatering plan for Works where inflow of ground water or surface runoff could occur.

(4) Typical blast method including hole size, depth, spacing, burden and loading details for production, buffer, pre-split holes, if required.

2. The Contractor's excavation plan must be approved by the EPCM Manager and the Engineer.

3. Work shall not start until applicable approvals are obtained from the EPCM Manager in writing.

4. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

3.2 Part 2 – Execution

3.2.1 Preparation

1. Prior to beginning a grading or excavation operation in any area, all necessary clearing and/or stripping in that area shall have been performed in accordance with the Specifications.

2. The Contractor shall satisfy himself as to the character, quantity, and distribution of all the material to be excavated.

3. The Contractor shall have a contingency plan for sudden unforeseeable change of weather conditions in place prior to excavation commencement. The Contractor shall have a daily Works plan in relation to the weather conditions, equipment, operator availability, area of Works, and schedule.

4. The Contractor shall be responsible for sediment and runoff control around the construction area to ensure there is minimal impact on the natural state of the surrounding environment in accordance to all issued regulations, licenses and permits.

5. The Contractor shall be responsible for all dewatering and water control to allow for fill placement in a dry, ice free environment.

3.2.2 Common Excavation Methods

1. Common excavation of weathered bedrock and soil, including permafrost, shall be performed as indicated on the Drawings, or as directed by the Engineer to the lines, grades, and elevations, and shall be finished to a reasonable smooth and uniform surface.

2. Should the Contractor, through carelessness or other fault, excavate beyond the designated grades, he shall replace the excavation in an approved method, in accordance with the Specification, or any modification thereof as directed by the Engineer.

3. All excavated material determined unsuitable by the Engineer shall be disposed of as directed by the EPCM Manager.

4. At all times during construction, the Contractor shall adopt excavation procedures such that at no time shall the stability of any slope be impaired. The Engineer reserves the right to stop work if he deems the conditions to be unsafe.

3.2.3 Excavation in Quarry Areas

1. Borrow excavation shall be performed as indicated on the Drawings or as directed by the Engineer to the lines, grades, and elevation.

2. Borrow development will be the responsibility of the Contractor in accordance with staged plans submitted to the EPCM Manager and Engineer for approval prior to undertaking the Works.

3. Methods of access and excavation in the borrow areas will be determined by the Contractor, unless otherwise directed by the EPCM Manager or Engineer.

4. The Contractor shall use appropriate blasting methods to control the height of each bench and associated material gradation. The Contractor is responsible for fragmentation and throw of the material to ensure ease of excavation.

5. Excavation in the borrow area should be optimized by the Contractor for safety of equipment operation, water control, and bench stability.

6. Prior to excavation of the material, certified personnel must inspect the blast pattern to ensure all blasting agents were ignited and none were left behind.

3.2.4 Control of Water

1. Surface water flows during the melting seasons shall be directed away from the Works by means of diversion berms, ditches or other acceptable means and, in any case, all surface flows on the Works area shall be satisfactorily controlled, and to the environmental standards specified.

2. Any inflow of ground water or surface runoff water into the key trench or dam footprint must be controlled using suitably placed and sized sumps and pumps.

3. Any water collected in the sumps must be discharged in an approved manner to a designated area away from the construction activities. A pump and discharge contingency plan should be discussed with and submitted to the Engineer and EPCM Manager for approval prior to construction.

4. The construction, operation, and maintenance of the sump(s) and pump(s) are the responsibility of the Contractor.

3.2.5 Scaling, Slope Stability and Safety

1. Immediately following excavation and at any time during the Works, all loose material on slopes, which appears to be unsafe or to endanger workmen, structures or equipment, shall be scaled and removed.

2. All slope stability measures will be considered incidental to the Works, and will be the responsibility of the Contractor with inspections done by the EPCM Manager and Engineer.

3.2.6 North Dam Key Trench Excavation

1. The key trench must be excavated into ice saturated, permanently frozen soil as determined by the Engineer. The base of the excavation must have no natural or excavation related open voids or joints.

2. The depth of excavation will be confirmed in the field by the Engineer. The depth of the key trench may be increased in some areas at the discretion of the Engineer to confirm the suitability of the foundation soils beneath the key trench.

3. The key trench can be excavated using mechanical or drill and blast means.

4. Final cleaning of the key trench must be conducted with hand excavation, brooms and compressed air or other appropriate equipment such as rippers, jack hammers etc. to remove all loose, broken or altered material from the base of the key trench. Snow and ice must be removed from the key trench prior to fill placement.

5. Ice rich soils exposed on the upstream face of the key trench excavation shall be removed from areas underlying the liner system. Additional excavation beyond the limits of the key trench excavation may be required at the Engineer's discretion.

6. Any inflow of water into the key trench excavation shall be controlled by sumps and pumps in a manner that minimizes thaw and erosion of the key trench base.

3.3 Part 3 – Quality Control

1. Submit an Excavation Plan (including a water management and dewatering plan, if required) as defined in Section 3.1.6 of this Document.

2. Confirm with EPCM Manger that all Permits and Approvals are in place prior to commencing any work.

3. Physically demarcate, for review and approval by the EPCM Manager and Engineer, the Works area that will be excavated using proper survey control.

4. Implement measures, including spotters and frequent survey control as needed, to allow visual inspection of excavation activities during execution to ensure it is done in accordance with the Drawings and Specifications as defined in this Document.

5. Implement measures to ensure adequate water management and dewatering as necessary.

6. Advise the Engineer and EPCM Manager when an excavation has been completed and is ready for inspection and/or approval. Interim survey control may be requested by the Engineer via the EPCM Manger to confirm lines and grades have been met.

7. Conduct a field survey, and submit As-built Drawings, in electronic format of any excavated area, for submittal to the Engineer and EPCM Manager.

3.4 Part 4 – Quality Assurance

1. Review the Excavation Plan (including a water management and dewatering plan, if required) as defined in Section 3.1.6 of this Document and submit review comments back to the Contractor via the EPCM Manager.

2. Visually inspect the demarcated zone, and any associated survey files prepared by the Contractor for excavation, and inform Contractor via the EPCM Manager if changes are required.

3. Visually inspect the excavated area, and any associated survey files, and inform the Contractor via the EPCM Manager if changes are required.

4. Visually inspect water management and dewatering if required, and inform the Contractor via the EPCM Manager if changes are required.

5. Review As-built Drawings submitted by the Contractor of excavated areas and inform the Contractor via the EPCM Manager if any changes are required.

---------- END OF SECTION 3 ----------

Section 4
Drilling and Blasting

4 Drilling and Blasting

4.1 Part 1 – General

4.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

4.1.2 Description

1. All blasting operations must be performed in accordance with the Owners EMPM and all Federal and Territorial Regulations and Licences.

2. Blasting near water bodies frequented by fish, will require lower powder factors, as determined by Guidelines issued by the Department of Fisheries and Oceans.

3. The Contractor will be responsible to familiarize himself with all appropriate conditions that would apply to blasting.

4. The Works to be done under this Section consists of supplying all labour, materials, plant and equipment, and performing all Works necessary to carry out drilling and blasting with certified personnel and chemical agents as shown on Drawings and specified herein.

5. The Works shall include; but is not limited to:

    (1) Provide a typical list of safety protocols, chemical blasting agents, blast patterns and powder factors that will be suitable for carrying out the Works, and for producing the specified construction materials.

    (2) Drilling with appropriate equipment, to appropriate depth and grade to execute the Works, develop rock quarries and any other common excavation as shown on the Drawings, or as directed by the Engineer.

    (3) Provide suitably qualified personnel, with current blasting certificates to carry out all required safety protocols for blasting regulations prior to ignition.

4.1.3 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:

(1) CERTIFIED PERSONNEL means a suitably qualified person that hold current blasting certificates issued by all necessary Territorial and Federal Regulatory agencies for the Project.

(2) CHEMICAL BLASTING AGENTS means any form of agents, and components that are suitable for use in the Project.

4.1.4 Submittals

1. The Contractor shall submit a Drilling and Blasting Plan to the Engineer and EPCM Manager describing the schedule, and proposed methods for borrow development and common excavation, at least seven (7) days prior to the commencement of Works.

2. Work shall not start until applicable approvals are obtained from the EPCM Manager in writing.

3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

4.2 Part 2 – Products and Personnel

1. The Contractor is responsible to procure all necessary supplies and equipment for drilling and blasting operations, excluding the chemical blasting agents, detonators and detonator cords, which will be supplied by the Owner.

2. The Contractor is responsible to acquire all required licenses and notifications from Territorial and Federal Regulatory Agencies.

3. The Contractor is responsible to have appropriately qualified and certified persons to handle all aspects of the drilling and blasting Works, including, but not limited to management of inventory, mixing of explosives, storage of explosives, transportation of explosives, placing of charges, ignition of explosives, and clearing of explosives after ignition.

4. The Contractor is responsible for management, maintenance and security of the Explosives Facility, whether temporary or permanent.

4.3 Part 3 – Execution

4.3.1 Drilling

1. The Contractor will lay out the appropriate blast pattern for the specified material grade required, at appropriate locations.

2. The Contractor will drill blast holes in accordance with the blast pattern requirements, taking due care to prevent over-breaking.

3. The Contractor will ensure that the appropriate surface water containment and management procedures are followed when drilling.

4.3.2 Blasting

1. The Contractor's Health and Safety Plan, list of blasting agents, technician's certificates, and proposed methods of blasting will be provided by the Contractor prior to blasting operation, for EPCM Mangers approval.

2. The Contractor will provide appropriately qualified and certified personnel to manage all aspects of the blasting.

3. The Contractor will be responsible for notifying all air and land traffic of the time and location of any blast at least 24 hours in advance.

4. The Contractor will be responsible for putting in place all protocols and physical barriers to warn and prevent land and air traffic from entering the designated blast zone, according to all applicable Territorial and Federal Regulations and the Contractors Health and Safety Plan.

5. The Contractor should use controlled blasting methods to ensure production of specified materials, ease of excavation and to minimize processing requirements.

6. Certified Personnel must inspect the blast pattern post blasting to ensure there are no unexploded agents and explosives left behind prior to excavation. If unexploded material is found in the pattern, Certified Personnel must remove the danger material according to normal practice and the Contractor's Health and Safety Plan.

4.3.3 North Dam Key Trench Drilling and Blasting

1. The Contractor must use excavation methods that minimize fracturing beyond excavation limits.

2. Care must be taken in locating the drill holes, orienting the drills, and during drilling so that accurate positioning and alignment of the drill holes is achieved.

3. The method of excavation must produce a key trench base that is free of abrupt changes in elevation.

4. Controlled blasting techniques must be used to satisfy the excavation requirements stated herein. The initial explosive type and quantity, blasting sequence, and delay pattern must be flexible in order to meet these requirements.

5. The Contractor shall submit complete details of any proposed blast to the EPCM Manager and the Engineer. Submitted data shall include the following:

   (1) The location, depth and area of the blast;

(2) The type, strength, quantity, column load, and distribution of explosives to be used per hole, per day, and per blast;

(3) The sequence and pattern of the delay; and

(4) The description and purpose of any special methods to be adopted.

6. If, in a specific area, a plan that was previously adopted does not produce conditions in accordance with the requirements stated herein, the Contractor must submit a revised blasting plan to the EPCM Manager and Engineer before continuing with drilling and blasting in adjacent areas.

4.4 Part 3 – Quality Control

1. Submit a Drilling and Blasting Plan as defined in Sections 4.1.4 and 4.3.3 of this Document.

2. Confirm with EPCM Manger that all Permits and Approvals are in place prior to commencing any work.

3. Physically demarcate, for review and approval by the EPCM Manager and Engineer, the Works area that will be drilled and blasted using proper survey control.

4. Implement and follow appropriate established protocols prior to and immediately following any Blast in compliance with all appropriate Rules and Regulations.

4.5 Part 4 – Quality Assurance

1. Review the Drilling and Blasting Plan as defined in Sections 4.1.4 and 4.3.3 of this Document and submit review comments back to the Contractor via the EPCM Manager.

2. Visually inspect the demarcated zone, and any associated survey files prepared by the Contractor for drilling and blasting, and inform the Contractor via the EPCM Manager if changes are required.

---------- END OF SECTION 4 ----------

Section 5
Fill Material Specifications

5 Fill Material Specifications

5.1 Part 1 – General

5.1.1 Documents

1. This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.

5.1.2 Description

1. The sources and borrow areas of all fill are shown on the Drawings or as designated by the Engineer. For the types of material and related Specifications, refer to the Drawings. The material types required for completion of the Works are labelled as:

   (1) Riprap;

   (2) Run-of-Quarry;

   (3) Transition;

   (4) Surfacing;

   (5) Bedding; and

   (6) Core.

2. All construction materials shall be non-acid generating, free of organic matter or similar impurities, as well as snow and ice.

3. The Contractor is responsible for supplying, installing, operating and maintaining all the necessary plant, equipment, materials, labour and supervision to produce and test the suitability of the specified construction material on site.

4. The Contractor must process all materials to meet the gradations specified herein.

5.1.3 Submittals

1. The Contractor shall submit the information requested in the Quality Control program listed in Section 5.3 to the Engineer and EPCM Manager in a timely manner, understanding that approvals to proceed with the Works may be contingent on review and approval of these submittals.

2. Work shall not start until applicable approvals are obtained from the EPCM Manager in writing.

3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

5.2 Part 2 – Product

5.2.1 General

1. Quarry areas

   (1) Fill, required for the Works, shall be obtained and manufactured by the Contractor from designated borrow areas as shown on the Drawings, and from the excavation of select foundations.

   (2) The parent rock sources for all fill materials must be inspected by the Engineer throughout the material processing and construction activities to ensure the requirements stated herein are being met.

   (3) Unsuitable material from an excavation for the Works shall be disposed of in a designated onsite disposal area as directed by the EPCM Manager.

   (4) If the Contractor proposes to obtain fill from an area not within the excavations or designated areas shown on the Drawings, he shall communicate his intention to the EPCM Manager. The EPCM Manager then shall first obtain the necessary approvals and permits to carry out such sub-surface investigation and obtain and submit such samples, as are required, to enable the Engineer to assess the suitability of the fill for the Works.

   (5) The Contractor shall keep accurate exploration records of any test pit, trench or drill hole which it makes for the purpose of investigating borrow material, and a copy of such records shall be submitted to the EPCM Manger and to the Engineer within seven (7) days of the completion of exploration Works.

   (6) The Contractor shall give the EPCM Manager not less than 14 days' notice, of his intention to develop any potential borrow area not shown on the Drawings.

   (7) The Contractor shall make his own determination of the adequacy of any borrow source he intends to exploit.

2. Foundation excavation

   (1) Fill acquired from foundation excavation shall meet the Specifications; otherwise it will be considered as unsuitable material and disposed of accordingly.

   (2) Unsuitable material from the excavation for the Works shall be disposed of in a designated onsite disposal area as directed by the EPCM Manager.

(3) Fill shall be used in place with minimum handling to minimize degradation and segregation.

3. Core material handling

(1) The Contractor shall supply, operate and maintain all necessary plant to ensure that the appropriate moisture conditioning, placement and compaction of the Core material can be carried out as specified.

(2) Special care must be taken to minimize material handling to minimize segregation.

5.2.2 Riprap

1. Riprap material shall be competent non-acid generating rock sourced from the quarries or foundation excavations, and that is free from organic matter, snow and ice.

2. Riprap shall be clean with no fine grained material and a minimum boulder size of 1,000 mm and maximum boulder size of 1,500 mm or as specified of the Drawings.

3. Basic screening or manual selection may be used to achieve the desired gradation.

4. The Riprap material shall be washed to remove blast residue and/or fines, unless otherwise directed by the Engineer.

5.2.3 Run-of-Quarry Material

1. Run-of-Quarry (ROQ) material shall consist of competent non-acid generating material sourced from the quarries or foundation excavations, and that is free of organic matter, frozen soil, snow and ice.

2. ROQ material shall be well-graded, containing sufficient quantities of unfrozen gravel, sand and silt sized material to allow the material to be compacted. In areas where the overall ROQ fill thickness is less than 0.85 m, the maximum boulder size shall not exceed 500 mm, as measured in any direction. In areas where the overall ROQ fill thickness is greater than 0.85 m, the maximum boulder size shall not exceed 900 mm as measured in any direction.

3. Basic screening, or crushing and screening may be used to achieve the desired gradation.

4. The ROQ material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.4 Transition Material

1. The Transition material shall consist of competent non-acid-generating material from the quarries or foundation excavations, and that is free of organic matter, frozen soil, snow and ice.

2. The Transition material shall have a particle size distribution falling within the limits presented in Table 5.1.

Table 5.1: Transition material particle size distribution limits

Particle Size (mm)	% Passing
200	100
100	60-100
50	40-70
20	20-50
10	0-30
5	0-10

3. Crushing and screening will be required to meet the Specification.

4. The Transition material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.5 Surfacing Material

1. Surfacing material shall consist of competent non-acid-generating material from the quarries or foundation excavations, and that is free of organic matter, frozen soil, snow and ice.

2. The Surfacing material shall have a particle size distribution falling within the limits presented in Table 5.2.

Table 5.2: Surfacing material particle size distribution limits

Particle Size (mm)	% Passing
38.0	100
25.0	60-100
12.5	25-100
5.0	10-50
0.63	2-20
0.08	1-15

3. Crushing and screening will be required to meet the Specifications.

4. The Surfacing material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.6 Bedding Material

1. Bedding material shall consist of competent non-acid-generating material from the quarries or foundation excavations, including unfrozen soil, and that is free of organic matter, frozen soil, snow and ice.

2. The Bedding material shall have a particle size distribution falling within the limits presented in Table 5.3.

Table 5.3: Bedding material particle size distribution limits

Particle Size (mm)	% Passing
25.0	100
20.0	90-100
12.5	50-100
10.0	30-100
5.0	10-80
0.63	2-35
0.08	1-15

3. Crushing and screening will be required to meet the Specifications.

4. The Bedding material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.7 Core Material

1. Core material shall consist of competent, non-saline, non-acid generating material from the quarries or foundation excavations, and that is free of organic matter, frozen or unfrozen soil, snow and ice.

2. The Core material shall have a particle size distribution falling within the limits presented in Table 5.4.

Table 5.4: Core material particle size distribution limits

Particle Size (mm)	% Passing
20.0	100
12.5	65-100
5.0	45-70
0.63	15-35
0.08	4-10

3. Crushing and screening of the Core material will be required to meet the Specification.

4. The Core material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.3 Part 3 – Quality Control

1. The Contractor shall carry out Quality Control testing during the production of construction materials as outlined in Table 5.5.

Table 5.5: Required QC testing during production of construction materials

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
Riprap	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (General)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (North Dam)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Surfacing	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 1,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Maximum Density (ASTM D698)	On Site	24-hrs	One per 2,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Water Content (ASTM D2216)	On Site	24-hrs	One per 2,000 m^3	Test Certificate
Core	At Crusher	Grab	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per 500 m^3	Test Certificate
Core	At Crusher	Grab	Moisture Content (ASTM D2216)	Site Lab	24-hrs	One per 2,000 m^3	Test Certificate
Core	At Crusher	Grab	Maximum Density (ASTM D698 - Proctor)	Site Lab	24-hrs	One per 2,000 m^3	Test Certificate
Core	At FCP Outlet	n/a	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	At FCP Outlet	Grab	Aggregate Temperature (Concrete Thermometer or Temperature Gun)	At Source	Immediate	Ongoing	None

5.4 Part 4 – Quality Assurance

1. The Engineer shall carry out Quality Assurance testing during the production of materials as outlined in Table 5.6.

Table 5.6: Required QA testing during production of construction materials

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Riprap	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (General)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (North Dam)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (North Dam)	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One on upstream slope; One on downstream slope	Test Certificate
Surfacing	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 6,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 2,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Maximum Density (ASTM D698)	On Site	24-hrs	One per 4,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Water Content (ASTM D2216)	On Site	24-hrs	One per 4,000 m^3	Test Certificate
Core	At Crusher	Grab	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per 1,000 m^3	Test Certificate
Core	At Crusher	Grab	Moisture Content (ASTM D2216)	Site Lab	24-hrs	One per 4,000 m^3	Test Certificate
Core	At Crusher	Grab	Maximum Density (ASTM D698 - Proctor)	Site Lab	24-hrs	One per 4,000 m^3	Test Certificate
Core	At Crusher	Grab	Specific Gravity (ASTM D854)	Off Site Lab	7-days	One per 8,000 m^3	Test Certificate
Core	At Crusher	Grab	Salinity	Off Site Lab	7-days	One per 8,000 m^3	Test Certificate
Core	At FCP Outlet	n/a	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	At FCP Outlet	Grab	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per 500 m^3	Test Certificate
Core	At FCP Outlet	Grab	Moisture Content (ASTM D2216)	Site Lab	Immediate	One per 50 m^3	Test Certificate
Core	At FCP Outlet	Grab	Bulk Density and Air Content (EBA Method adapted from CSA A23.2-6C)	Site Lab	Immediate	One per 500 m^3	Test Certificate
Core	At FCP Outlet	Grab	Aggregate Temperature (Concrete Thermometer or Temperature Gun)	At Source	Immediate	Ongoing	None

---------- END OF SECTION 5 ----------

Section 6
Geosynthetics

6 Geosynthetics

6.1 Part 1 – General

6.1.1 Documents

1. This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.

2. This section specifies requirements for the supply and installation of the following geosynthetic products:

   (1) Textured High Density Polyethylene (HDPE) Liner;

   (2) Non-Woven Geotextile Fabric;

   (3) Woven Geotextile Fabric;

   (4) Geosynthetic Clay Liner (GCL);

   (5) Extrusion rods; and

   (6) Bentonite powder.

6.1.2 Description

1. The Works to be done under this Section consists of furnishing all labour, materials and equipment and the performance of all Works necessary to carry out geosynthetic installations as shown on the Drawings and as specified herein.

6.2 Part 2 – Products

6.2.1 Submittals

1. The EPCM Manager will submit the following information at least 14 days prior to material arrival at the designated marshalling area:

   (1) Manufacturer's written certification that the geosynthetic products to be used, meet the Specifications, and have been continuously inspected.

   (2) The certification shall identify the origin and the manufacturer of any resin used in manufacturing of the geotextile.

2. Work shall not start until applicable approvals are obtained from the EPCM Manager in writing.

3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

6.2.2 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:

   (1) GEOSYNTHETICS includes textured HDPE liner, GCL, geotextile and other supplies used in liner, geotextile or GCL deployment.

   (2) HDPE Liner means textured High Density Polyethylene liner, as specified.

   (3) GCL means Geosynthetic Clay Liner, as specified.

   (4) GEOTEXTILE means woven or non-woven geotextile, as specified.

   (5) EXTRUSION RODS means HPDE rods that are fed into an apparatus for extrusion welding.

   (6) BENTONITE POWDER means sodium montmorillonite clay used as a high swelling soil sealant, as specified.

6.2.3 Product Specifications

1. The High Density Polyethylene (HDPE) liner shall be textured, and have a nominal thickness of at least 1.4mm (57 mil). The basic liner requirements are listed in Table 6.1.

Table 6.1: HDPE liner specifications (typical product)

Parameter	Standard	HDPE 60 Textured
Nominal Thickness	ASTM D5199	1.42 mm (57 mil)
Density (Untextured)	ASTM D792	0.94
Tensile Strength Modified Type IV Die	ASTM D638 (Stress at Yield)	22.0 kN/m (126 ppi)
	ASTM D638 (Stress @ Break)	15.8 kN/m (90 ppi)
	ASTM D638 (Strain @ Yield 33mm Gauge)	12%
	ASTM D638 (Strain @ Break 50mm Gauge)	100%
Tear Resistance	ASTM D1004	187 N (42 lbs)
Dimensional Stability	ASTM D1204 (Max Cng).	± 2%
Notched Constant Load ESCR	ASTM D5397	200 Hours
Punctured Resistance	ASTM D4833	400N (90 lbs)
Carbon Black Content	ASTM D1603	2.0 – 3.0%
Carbon Black Dispersion	ASTM D5596	CAT 1 or 2

Parameter	Standard	HDPE 60 Textured
Bonded Seam Strength Test Temp 23°C, 73°F	ASTM D6392	21 N/mm (120 ppi)
Peel Adhesion Test (FTB) Test Temp 23°C, 73°F	ASTM D6392	14 N/mm (78 ppi)

2. The Geosynthetic Clay Liner (GCL) shall consist of sodium bentonite between two non-woven geotextiles which are bonded by needle punching and shall satisfy the Specifications as listed in Table 6.2.

Table 6.2: GCL specifications (typical product)

Parameter	Standard	GCL VN
Bentonite Mass per Unit Area[1]	ASTM D5993	3.67 kg/m^2 (0.75 lb/ft$^{2)}$
Grab Tensile Strength[2]	ASTM D4632	420 N (95 lbs)
Peel Strength	ASTM D4632	66 N (15 lbs)
Hydraulic Conductivity[3]	ASTM D5321	5x10^{-9}cm/sec max.
Internal Shear Strength (Typical) at 200 psf normal stress (10 kPa)	ASTM D5321	24 kPa (500 psf)
Geotextile Component Properties		
Mass per Unit Area	ASTM D5261	non-woven 200 g/m^2 (6.0 oz/yd^2)
Bentonite Component Properties		
Swell Index	ASTM D5890	24 ml/2 g min.
Moisture Content	ASTM D4643	12% max.
Fluid Loss	ASTM D5891	18 ml max.

[1] Oven-dried measurements
[2] Measured in weakest principal direction
[3] De-aired tap water @ 5 psi effective stress and 2 psi head

3. The geotextile shall be a non-woven needle-punched fabric with a nominal weight of at least 385g/m^2 (12 oz), and must satisfy the Specifications listed in Table 6.3:

Table 6.3: Geotextile specifications (typical product)

Parameter	Standard	LP12
Grab Tensile	ASTM D4632	1,330 N
Elongation	ASTM D4632	50%
Tear	ASTM D4533	510 N
Puncture	ASTM D4833	775 N
Mullen Burst	ASTM D3786	3,995 kPa
AOS	ASTM D4751	150 microns
Permittivity	ASTM D4491	0.9 sec-1
Water Flow	ASTM D4491	2,648 l/min/m^2

Parameter	Standard	LP12
Weight	ASTM D5261	385 g/m^2 (Nominal)
Thickness[1]	ASTM D5199	3.0 mm (Nominal)
UV (500 hrs)	ASTM D4355	70%
Roll Size	n/a	4.57 X 91.4 m
Roll Weight[1]	n/a	181 kg

[1] Typical values. All other values are minimum average roll values (MARV)

4. Extrusion rods and other welding supplies shall conform to the following Specifications:

   (1) Extruded material shall be made from same type resin as the HDPE liner.

   (2) The extrusion rod has compatible diameter for proposed apparatus.

   (3) Contractor shall submit product certificates for the EPCM Manager and the Engineer's approval prior to deployment.

   (4) Additives shall be thoroughly dispersed.

   (5) Material shall be free of contamination by moisture or foreign matter.

5. Bentonite powder specification:

   (1) The bentonite supplied as a soil sealant shall be high swelling sodium montmorillonite clay.

   (2) High swelling is defined as the ability of 2 grams of bentonite, when mechanically reduced to a minus 0.15 mm particle size, to swell in water to an apparent volume of 1.6 cm^3 when added to 100 cm^3 of water.

   (3) The dry fineness of the soil sealant shall be 98% minimum passing 4.75 mm mesh and 5% maximum passing 0.85 mm mesh.

   (4) The bentonite shall be stored in a dry area, and shall not be used if hydrated.

   (5) Contractor shall submit the manufacturer's product specification for approval by the EPCM Manager and the Engineer, 14 days prior to procurement.

6.2.4 Equipment

1. The EPCM Manager shall ensure the Contractor supplies proper handling equipment, as recommended by the manufacturer, for the geosynthetic installation, which does not pose any danger to installation personnel or risk damage or deformation of the geosynthetics. Examples of suitable handling equipment include, but is not limited to:

   (1) Spreader bar assembly;

(2) Stinger;

(3) Roller cradles; and

(4) Straps.

2. Equipment for welding HDPE:

(1) A self-propelled fusion wedge welder and an extrusion welding apparatus from a recognized manufacturer.

(2) The fusion wedge welder shall have certified working gauges showing working temperature and speed.

(3) An adequate number of extrusion welding apparatus shall be available to maximize production.

(4) The Contractor must supply an adequate power source, capable of providing constant voltage under combined line load.

(5) The Contractor must provide a suitable shelter and heater to ensure that a suitable environment can be created for completion of seams according to the Specifications.

6.2.5 Delivery Storage and Handling

1. Delivery, storage and handling shall conform to the requirements of the manufacturer and shall be carried out in a manner which shall protect the geosynthetics from damage or water penetration during shipment.

2. Packing and shipping shall as a minimum conform to the following:

(1) Supply geosynthetics in rolls with straps for unloading.

(2) Supply geosynthetics marked or tagged with the following information:

a) Manufacturer's name

b) Product information

c) Roll number

d) Batch or lot number

e) Roll dimensions

(3) Ensure that geosynthetics are properly loaded and secured to prevent damage during transit.

(4) Protect geosynthetics from excessive cold, heat, puncture, cutting, or other damaging or deleterious conditions.

(5) Ensure personnel responsible for loading, transport and unloading of geosynthetics are familiar with the handling and transport constraints imposed by the manufacturer.

3. Acceptance at Works site shall as a minimum conform to the following:

(1) Engineer may perform inventory and surface inspection for defects and damage of geosynthetic rolls upon delivery.

(2) The Engineer will unroll and inspect any geosynthetic roll that may appear to be damaged below surface layers.

(3) The Contractor will repair damage resulting from handling and transport of geosynthetics. If irreparable, in the opinion of the Engineer, the EPCM Manager will replace damaged materials.

4. Storage and protection shall as a minimum conform to the following:

(1) Storage of geosynthetics shall be in a secure location that will minimize exposure. It is absolutely essential that GCL rolls are protected from exposure to water.

(2) Contractor will provide on-site area for storage of geosynthetic rolls from time of delivery until installation with the approval from the Engineer.

(3) Prepare storage area so that the geosynthetic products are stored off the ground and protected from the elements (e.g. ultraviolet light, water, moisture, etc.).

(4) After removing material from storage area, protect geosynthetics from puncture, dirt, groundwater, moisture, mud, mechanical abrasion, excessive heat and cold, ultraviolet light exposure, and other sources of damage. Keep geotextile and GCL rolls in relatively opaque and water tight wrappings.

(5) Preserve integrity and readability of the geosynthetics roll labels, and store such that Engineer shall have access to the package slips or roll labels for each roll to verify roll acceptance.

6.3 Part 3 – HDPE Liner Installation

6.3.1 Installation

1. Deployment

(1) The Contractor must submit a proposed liner layout 14 days prior to deployment for Engineer's approval through the EPCM Manager.

(2) An anchor trench shall be excavated or weight ballast constructed by the Contractor to the lines and grades shown on the Drawings or as directed by the Engineer.

(3) The liner should cover the depth and width plus minimum 200 mm slack beyond the width of the trench.

(4) The liner shall not be excessively dragged across the subgrade.

(5) Assign each panel a simple and logical identifying code. The coding system shall be subject to Engineer's approval.

(6) Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.

(7) Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

a) Unroll the geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage.

b) Unroll the geomembrane with the textured surface on top. Its purpose for this Project is to provide some slip resistance for workers, as opposed to structural integrity.

c) Place ballast on geomembrane which will not damage or puncture the geomembrane to prevent wind uplift.

d) Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage the liner. Smoking will not be permitted on the geomembrane.

e) Do not allow heavy vehicular traffic directly on geomembrane. Low bearing vehicles under 42 kPa might be permitted with Engineer's approval.

f) Protect geomembrane in areas of heavy traffic by placing protective cover over the liner. The protective cover should as a minimum consist of 300 mm of approved fill material. This thickness is subject to change by the Engineer depending on site conditions.

(8) The Contractor shall determine to his own satisfaction that sufficient extra material for anchor embedment, seams, slack, thermal expansion and contraction of the material and waste are included on top of the neat area given.

2. Field seaming

(1) Fusion weld seams shall meet the following requirements:

a) To the maximum extent possible, orient seams parallel to line of slope.

b) Minimize number of field seams in corners, odd-shape geometric locations and outside corners.

c) Slope seams shall extend a minimum of 1.5m beyond the grade break into the flat area.

d) Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the Engineer.

e) Align seam overlaps consistent with the requirements of the welding equipment being used. A minimum 150 mm overlap is recommended to ensure proper welding.

f) Use manufacturer's recommended temperature and speed for the wedge welders.

g) Clean seam area of dust, mud, moisture and debris immediately ahead of wedge welder.

h) Protect against moisture build-up between sheets due to condensation.

(2) Extrusion welding

a) Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.

b) Clean and roughen geomembrane surfaces by disc grinder or equivalent.

c) Purge extrusion welding apparatus of heat-degraded extrudate before welding.

(3) Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. Contractor shall demonstrate that acceptable seaming can be performed by completing a weld and obtaining approval by the Engineer.

(4) Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available to the Engineer.

6.3.2 Seam Testing and Repair

1. Non-destructive testing may be carried out as the seaming progresses.

(1) Vacuum testing shall be performed in accordance with ASTM D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.

(2) Air pressure testing shall be performed in accordance with ASTM D 5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembrane.

2. Destructive Testing procedures

(1) One sample per 450m liner seam length or at Engineer's request.

(2) Contractor shall cut samples at locations designated by the Engineer as the seaming progresses in order to obtain field laboratory test results.

(3) Destructive testing shall be performed in accordance with ASTM D 6392, Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

3. Failed seam procedures

(1) Reconstruct the seam between any two passed test locations. Or,

(2) Trace the weld to intermediate location at least 3 m minimum, or where the seam ends in both directions from the location of failed test.

(3) Extrude weld or cap the failed section tying into passed seam.

4. Repair procedure

(1) Contractor shall be responsible for repair of defective areas.

(2) Remove damaged geomembrane and replace with acceptable geomembrane material if damage cannot be satisfactorily repaired.

5. All repairs shall be verified by the Engineer.

6.3.3 Liner Cover

1. All exposed HDPE liner will be covered with minimum 300 mm of Bedding material unless stated otherwise. The material shall be deployed with care to ensure that the liner will not be damaged during the operation. The material is to be spread evenly without any compaction. Traffic shall not be permitted directly on the geomembrane.

2. Unless specifically indicated by the Engineer, HDPE liner shall at all times be placed between two geotextiles.

6.4 Part 4 – GCL Installation

6.4.1 GCL Deployment

1. The key trench shall be excavated as shown on the Drawings. The surface for the GCL shall be smooth with all protrusions and angular particles larger than 20 mm removed.

2. The installation of the GCL shall not begin until a proper subbase has been prepared and approved by the Engineer.

3. The GCL shall be placed in the key trench in a manner that will prevent damage to the liner. The method of deployment shall be discussed with and approved by the Engineer.

4. The Contractor shall submit a proposed panel lay out plan for Engineer's approval 14 days prior to deployment through the EPCM Manager.

5. The GCL panels should be placed perpendicular to the dam axis.

6. The Contractor shall have sufficient amount of ballast weights, such as sand bags, during the deployment to hold and keep panels in place as protection against wind.

7. The GCL shall be temporarily anchored to prevent movement while backfilling.

8. The GCL should not be deployed during any form of precipitation, or in periods of high wind.

9. GCL shall not be excessively dragged across the subgrade.

10. The GCL in the key trench shall be carefully covered with the saturated Core material. The Core material should be mixed and placed as described in Section 7.

11. The upstream of the core slope GCL subgrade should be uniformly compacted and graded and free of loose material.

6.4.2 GCL Lapping and Joining

1. Unless shown otherwise on the Drawings, the GCL shall have a minimum overlap of 500 mm.

2. Each overlap should be treated with powdered bentonite comprised of the same bentonite as used in the manufacture of the GCL. The bentonite shall be applied at the minimum rate of 0.4 kg/m of seam.

3. All joints shall be placed so the higher liner overlaps the lower liner.

6.4.3 GCL Cover

1. The cover material refers to the material upstream and on top of the upper GCL placed on the upstream slope and over the crest of the frozen Core material.

2. The cover material shall be placed in such a manner that it is pushed across the seams from the overlap roll to the underlap roll. Care must be taken to not push aggregate between the seam overlap. Equipment shall push the cover material ahead of the equipment, and never travel directly on the GCL.

3. The cover material shall comprise Core material as specified in Section 5.

4. Uncovered edges of GCL panels shall be protected with a waterproof sheet adequately secured with ballast, if the GCL installation sequence is delayed for a period in excess of 12 hours or the edges remain exposed for a period in excess of 12 hours.

5. The cover material shall be placed with the minimum thickness of 300 mm over the GCL.

6. The cover material shall be placed with low ground pressure equipment. Care should be taken to avoid damaging the GCL by not making sharp turns or pivots with equipment as well as sudden starts or stops.

7. A minimum thickness of 500 mm to 900 mm of cover, as determined by the Engineer, shall be kept between heavy equipment and the GCL at all times, except during final-grading. Heavy vehicles should not be driven directly on the GCL until the proper thickness of cover has been placed.

8. The first fill of Cover material over the GCL shall be compacted to a maximum of 90% of the maximum dry density (ASTM D698) or as specified by the Engineer to prevent damage to the GCL. Subsequent lifts, if required, of the Cover material over the GCL shall be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.

9. The cover material should be pushed up-slope to minimize tension on the GCL when covering GCL on sloped areas.

10. Precautions shall be taken to prevent damage to the GCL by restricting the use of heavy equipment over the GCL.

6.4.4 GCL Damage

1. The Engineer shall record all areas requiring repair due to damage during shipping, handling, or deployment, or manufacturing flaws. The Engineer shall prescribe the method of repair to be used.

2. The Contractor shall report to the Engineer all areas where the GCL is damaged or suspected to be damaged. The Engineer shall prescribe the method of repair to be used.

3. All repairs made by the placement of a patch of the same material over the damage shall extend at least 500 mm beyond the flaw or damage in every direction.

6.5 Part 5 – Geotextile Installation

6.5.1 Geotextile Deployment

1. The Contractor shall submit a proposed panel layout 14 days prior to deployment for Engineer's approval through the EPCM Manager.

2. The Contractor shall have sufficient amount of ballast weights, such as sand bags, during the deployment to hold and keep the deployed panels in place as protection against wind.

3. The geotextile shall be unrolled as smoothly as possible on the prepared subgrade in the direction of construction traffic.

4. Geotextile rolls shall be overlapped in the direction of sub-base placement.

5. The geotextile shall be 200 mm minimum overlapped and stitched or heat bonded together. The Engineer will inspect the stitching or heat bonding to ensure quality of Works.

6. On curves, the geotextile may be folded or cut and overlapped to conform to the curve.

7. The fold or overlap shall be in the direction of construction and shall be held in place as prescribed above.

8. The geotextile shall not be excessively dragged across the subgrade.

9. Damaged geotextile, as identified by the Engineer, shall be repaired immediately. The damaged area plus an additional 1m around the damaged area shall be cleared of all fill material. A geotextile patch extending 1m beyond the perimeter of the damage shall be installed as directed by the Engineer.

10. A method of attaching the geotextile patch may be required over soft subgrade as directed by the Engineer.

6.6 Part 6 – Quality Control

1. The EPCM Manager and Contractor must ensure that all geosynthetic manufacturers have an internal product QC program that meets contract requirements.

2. The EPCM Manager and Contractor are responsible to ensure that all geosynthetic material delivered to site meet the Specifications.

3. Geosynthetics that do not meet the Specifications will be rejected. The EPCM Manager and Contractor will replace any rejected material with new material that meets the Specifications.

4. The EPCM Manager and Contractor must ensure that the geosynthetic installations are carried out by a suitably qualified and experienced team or subcontractor.

5. The Contractor shall supply a QC program for installation of the geosynthetics for review and approved by the EPCM Manager and the Engineer.

6. The Contractor shall supply all testing technicians and equipment required in the QC program.

7. The Contractor, or his designated Subcontractor's testing technicians shall be responsible for panel labelling, destructive testing, repair labelling and inspections, overall QC of Works, as outlined in the QC program, and record keeping.

8. The Contractor shall generate, and submit for review to the Engineer and EPCM Manager, an As-built QC report that includes:

   (1) Record of material deployment.

   (2) As-built panel layout with panel number and associated roll number finalized in AutoCAD 2007 or later format.

   (3) All destructive test results with panel numbers and associated roll numbers.

6.7 Part 7 – Quality Assurance

1. The Engineer will confirm that all geosynthetic material delivered to site meet the Specifications. This will be done through visual inspection, and through review of product certificates.

2. Geosynthetics that do not meet the Specifications will be rejected. The EPCM Manager and Contractor will replace any rejected material with new material that meets the Specifications.

3. The Engineer will review the Contractor's QC program for installation of the geosynthetics and inform the Contractor via the EPCM Manager if changes are needed.

4. The Contractor shall supply all testing technicians and equipment required in the QC program, and make the personnel and equipment available to the Engineer for QA testing, over and above continuous visual inspection.

5. The Engineer shall review the Contractor's an As-built QC report and inform the Contractor via the EPCM Manager if changes are needed.

---------- END OF SECTION 6 ----------

Section 7
Fill Placement

7 Fill Placement

7.1 Part 1 – General

7.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

7.1.2 Description

1. The Works specified in this section includes furnishing all supervision, labour, materials, tools and equipment for placement of fill material to the lines and grades shown on the Drawings and specified herein.

2. The Works shall include, but is not limited to the following:

   (1) Foundation preparation to receive fill.

   (2) The supply, hauling, placing, and compacting of the specified fill materials as shown on the Drawings.

   (3) All related surveys for layout and control of the Works.

   (4) The Contractor shall assist Engineer when necessary while Engineer is performing QA testing. In addition, the Contractor shall submit copy of Contractor's QC results.

   (5) Maintenance of haul roads (as applicable) including snow and ice removal.

   (6) The development, maintenance, and restoration of fill material borrow areas.

   (7) Any other related Works not covered elsewhere.

3. Fill material required to be placed include, but are not limited to the following:

   (1) Haul, place and compact Run-of-Quarry (ROQ) material as base layer, as a thermal protection layer, as an erosion protection layer, or as a dam shell material.

   (2) Haul, place, and compact Surfacing material as final trafficking surfaces.

   (3) Haul and place Riprap as an erosion protection or wave energy dissipation layer.

   (4) Haul, place and compact Bedding material as a liner bedding material.

(5) Haul, place compact moisture conditioned Core material as an impermeable permanently frozen water retaining barrier.

(6) Haul, place and compact Transition material as a filter layer between Core and ROQ material.

7.1.3 Submittals

1. The Contractor shall submit the information requested in the Quality Control Plan listed below in Section 5.3 to the Engineer and EPCM Manager in a timely manner, understanding that approvals to proceed with the Works may be contingent on review and approval of these submittals.

2. Work shall not start until applicable approvals are obtained from the EPCM Manager in writing.

3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

7.2 Part 2 - Execution

7.2.1 Compaction Equipment

1. The compaction equipment shall be the appropriate size and type to achieve the specified densities of the respective fill materials.

2. Where compaction procedures (lift thickness, number of passes compactor type) are specified the Contractor shall provide compactors that meet or exceed those described in the Specification.

3. A vibratory plate tamper, or other suitable equivalent hand operated compactor will be required for compaction around instrumentation, or in confined spaces. The hand compactor shall be rated to provide sufficient pressure to meet compaction requirements.

4. Notwithstanding the requirements stated above, the equipment and compaction procedures employed by the Contractor shall be subject to approval from the Engineer.

7.2.2 Snow Removal Equipment

1. Care shall be taken when clearing snow above or adjacent to previously placed compacted material to avoid ripping and subsequent damage. Any material, which, in the opinion of the Engineer, has been damaged, shall be removed and replaced.

2. Care shall be taken when clearing snow from original ground to prevent damage to the tundra.

3. If deemed necessary by the Engineer, the Contractor shall use hand labour to clear snow.

7.2.3 Foundation Preparation

1. The Contractor shall prepare an acceptable foundation surface to receive the specified fill material. An acceptable foundation surface is a surface, which is clean, sound and firm, and which does not contain any loose, softened or disturbed foundation material as determined by the Engineer.

2. Riprap, ROQ, Surfacing, Bedding, Core and Transition materials shall be graded in accordance with the Drawings, compacted in lifts and be free of snow, ice, and any other loose or deleterious material.

3. Dense foundation surfaces to receive fill shall be free from noncompacted fill, snow, ice or other unsuitable materials. The surfaces shall be inspected by the Engineer, who may direct proof rolling with a loaded haul truck, and/or local over excavation and backfilling with approved material. Placement shall be completed as outlined in the applicable sections of these Specifications.

4. Where depressions or holes exist in the foundation material, acceptable fill shall be placed in depressions, as directed, and compacted as specified herein. Special techniques, handwork and the like shall be required as necessary.

5. Fill shall not be placed on the prepared foundations until they have been inspected and approved by the Engineer.

7.2.4 Fill Placement (General – All Products)

1. Construction must be performed in accordance with the best modern practice and with equipment best adapted to the work being performed. Materials must be placed so that each zone is homogenous, free of stratifications, ice chunks, lenses or pockets, ruts, and layers of material with different texture or grading not conforming to the requirements stated herein.

2. No fill material shall be placed on any part of the foundation until it has been prepared as specified herein and approved by the Engineer. The placement of fill material must conform to the lines, grades and elevations shown on the Drawings, as specified herein or as per the direction of the Engineer. Fill placement must be conducted in such a manner that mixing of fill materials with fill materials in the adjacent zones is avoided.

3. Embankment construction shall not proceed when the work cannot be performed in accordance with the requirements of the Specifications. Any part of the embankment that has been damaged by the action of rain, snow or any other cause must be removed and replaced with the appropriate material conforming to the requirements stated herein before succeeding layers are placed.

4. Stockpiling, loading, transporting, dumping, and spreading of all materials shall be carried out in such a manner to avoid segregation or any other condition that does not meet the requirements stated herein. Segregated materials must be removed and replaced with materials meeting the requirements stated herein and receiving the Engineer's approval.

5. The Contractor must remove all debris, vegetation or any other material not conforming to the requirements stated herein. The Contractor must dispose of these materials in an area approved by the Owner.

6. The compaction operations for fill shall be conducted within the same work day to provide a smooth compact surface. Adjacent individual passes of the compactor shall overlap by approximately 1/3 of the width of the compactor's drum. New fill shall be "keyed" into existing approved fill. Keying in is by placing new fill adjacent to exposed compacted fill. The Contractor is responsible to repair all damages on unfinished work from the previous work day.

7. Unless otherwise specified construction material maximum lift thicknesses and compaction requirements shall be as indicated herein or otherwise specified on the Drawings.

7.2.5 Riprap Material Placement

1. The Riprap material must be placed in accordance with the Drawings, or otherwise directed by the Engineer.

7.2.6 Run-of Quarry Material Placement

1. The Run of Quarry material must be placed in lifts not exceeding 0.85 m thickness if the total fill thickness is less than 0.85 m. The ROQ material must be placed in lifts not exceeding 1.85 m thickness if the total fill thickness is greater than 1.85 m. The placement method must ensure that segregation and nesting of coarse particles is avoided.

2. Compaction Trials (see Section 7.2.12) shall be used to develop a site specific Method Specification for compaction of ROQ material.

3. Unless otherwise defined by a Method Specification, the ROQ material (each lift) shall be compacted in accordance with either of the following standards:

   (1) Compacted with a smooth drum vibratory compactor weighing no less than 10 tonnes, with at least eight passes of the compactor (back and forth being two passes). Rolling patterns must be used throughout construction to optimize the number of passes, and vibration frequency for compaction of the ROQ material.

   (2) Compacted by ensuring that loaded haul truck traffic is routed over the entire surface of each lift with a minimum of 4 passes (back and forth being two passes).

7.2.7 Transition Material Placement

1. The Transition material must be placed in lifts not exceeding 500 mm thickness. The placement method used must ensure that segregation and nesting of coarse particles is avoided.

2. Compaction Trials (see Section 7.2.13) shall be used to develop a site specific Method Specification for compaction of Transition material.

3. Unless otherwise defined by a Method Specification, the Transition material (each lift) shall be compacted in accordance with either of the following standards:

   (1) Compacted with a smooth drum vibratory compactor weighing no less than 10 tonnes, with at least six passes of the compactor (back and forth being two passes). Rolling patterns must be used throughout construction to optimize the number of passes, and vibration frequency for compaction of the Transition material.

   (2) Compacted by ensuring that loaded haul truck traffic is routed over the entire surface of each lift with a minimum of 4 passes (back and forth being two passes).

7.2.8 Surfacing Material Placement

1. The Surfacing material must be placed in lifts not exceeding 200 mm thickness. The placement method used must ensure that segregation and nesting of coarse particles is avoided.

2. Compaction Trials (see Section 7.2.12) shall be used to develop a site specific Method Specification for compaction of Surfacing material.

3. Unless otherwise defined by a Method Specification, the Surfacing material (each lift) shall be compacted in accordance with either of the following standards:

   (1) Compacted with a smooth drum vibratory compactor weighing no less than 10 tonnes, with at least four passes of the compactor (back and forth being two passes). Rolling patterns must be used throughout construction to optimize the number of passes, and vibration frequency for compaction of the Surfacing material.

   (2) Compacted by ensuring that loaded haul truck traffic is routed over the entire surface of each lift with a minimum of two (2) passes (back and forth being two passes).

7.2.9 Bedding Material Placement

1. Bedding material underlying geosynthetic products must be placed in lifts not exceeding 300 mm thickness. The placement method used must ensure that segregation and nesting of coarse particles is avoided.

2. Bedding material overlying geosynthetic products must be placed in lifts no less than 300 mm thickness, if low ground pressure equipment is used. The Contractor must submit a work plan outlining his Bedding material placement strategy to the Engineer and EPCM Manager for review approval prior to covering geosynthetics, to allow this specification to be modified to suit.

3. Bedding material underlying geosynthetic products must be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.

4. The first lift of bedding material overlying geosynthetic products shall be compacted to a maximum of 90% of the maximum dry density (ASTM D698) or as specified by the Engineer to prevent damage to the geosynthetic products. Subsequent lifts, if required, of the Bedding material over the geosynthetic products hall be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.

5. The Contractor must ensure that the integrity of the geosynthetic products is not compromised during construction.

6. Any damage to geosynthetic products must be immediately reported to the Engineer and EPCM Manager. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the geosynthetic products has been compromised. Excavation of fill surrounding the damaged geosynthetic products, to allow repairs to be made, must be done without further damaging the integrity of the products. Hand excavation may be required.

7.2.10 Core Material Placement

1. The Core material shall be placed in a near-saturated state to achieve an impermeable dam core after freeze back. The dam core comprises the bedding layer, key trench backfill, and core structure. A near-saturated condition is not required for the Core material that lies between the upstream face of the GCL and below the Transition material.

2. The key trench foundation must be cleared of all deleterious materials as described in Section 3. The foundation area must be inspected and approved by the Engineer before fill placement proceeds.

3. Snow and ice must be removed from the base of the key trench excavation before Core material can be placed in that area.

4. The Core material placement must be conducted when air temperatures will freeze a lift of core material within 24 hours of placement. Experience has shown that a 250 mm thick lift freezes

back within 24 hours when air temperatures are below -15ºC. The time to freeze back will depend on the moisture content, wind speed, air temperature and solar radiation.

5. The lift thickness must be varied to achieve 100% freeze back prior to placement of the next lift. Freeze back is defined as maximum temperature of -2ºC. The lift thickness may be adjusted depending on the placed moisture content and climatic conditions and results of fill temperature monitoring. Individual lifts must have uniform thickness.

6. The Core material from the stockpile must be mixed with heated water using a method approved by the Engineer to create a homogeneous mix that is fully thawed and does not contain interstitial ice. The mix must not freeze until after it is placed and compacted. The temperature of the mix water required to meet the requirements stated herein may vary depending on the air temperature, wind speed and solar radiation.

7. The placed Core material must have a moisture content no less than 2% above the optimum moisture content (OMC) determined from density testing (ASTM D698).

8. The placed Core material shall have a minimum degree of saturation of 85% with no results falling below 80%. The moisture content shall be adjusted so that the material shall be saturated and flow easily, but shall not produce free water when placed. The optimum moisture content shall be determined by undertaking a test fill pad prior to beginning the main fill placement. The established moisture content may be adjusted from time to time during construction based on results of the QC/QA tests.

9. The Core material must be spread and levelled immediately upon placement. The material must not be reworked, disturbed or rutted after compaction. Extra care should be taken by the Contractor to ensure the surface of the first lift before liner placement is as smooth and even as possible. Additional work, described in Section 6, may be required if the lift surface is rough or uneven.

10. The Core material placed shall be compacted with a smooth drum vibratory compactor weighing not less than 10 tonnes. The material shall be compacted with at least six passes (back and forth being two passes) to achieve the maximum density possible at the placed moisture content. The number of passes may be adjusted at the Engineer's discretion to suit varying conditions.

11. A test fill pad shall be constructed when the air temperature is low enough as specified by the Engineer.

    (1) The following test fill characteristics shall be evaluated:

        a) Optimum moisture content;

        b) Optimum lift thickness;

c) Bonding with the foundation and between lifts;

d) Freeze back time for a lift given the ambient climatic conditions; and

e) Contractor's placement methodology.

(2) The test fill pad shall be a minimum 4 m wide and 4 m long. A minimum of two lifts of material shall be placed.

(3) Test fill properties shall be evaluated from core samples and percolation tests.

(4) Test fill should be removed if it is within the core footprint and has been judged unsuitable by the Engineer.

12. The fill area must be cleared of snow, ice and loose material before a new lift is placed. The surface area of each lift must be approved by the Engineer before it is covered by a subsequent lift.

13. Small batches of the Core material may be required to provide localised levelling and smoothing of the first lift surface to ensure the liner system has a level, even subgrade beneath it. Localised frozen high points on the surface of the first lift that the Engineer believes may cause puncture or stressing of the liner system must be removed without disturbing the surrounding surface. Equipment suitable for this task may include, but not be limited to, an excavator with a toothless bucket or jackhammer. Smoothing and patching with the Core material must be done if the lift surface is rough or pocketed after the high points are removed.

14. The Contractor must ensure that the integrity of the GCL and thermosyphon system is not compromised during construction. Precaution the Contractor may take to avoid damaging the GCL and thermosyphons may include, but will not be limited to: avoiding turning tracked vehicles on the first two lifts after liner system installation, providing light plants in the work area to improve operator visibility, or using pylons to mark the lift/liner interface or any other sensitive areas.

15. Any damage to the must be immediately reported to the Engineer. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the GCL has been compromised.

16. Any damage to GCL and thermosyphons must be immediately reported to the Engineer and EPCM Manager. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the GCL or thermosyphons has been compromised. Excavation of fill surrounding the damaged GCL or thermosyphons, to allow repairs to be made, must be done without further damaging the integrity of the products. Excavation methods suitable for this task may vary depending on the degree of freezing that may have already taken place.

7.2.11 Core Material Placement (GCL Cover)

1. The Core material on the upstream GCL slope shall be placed as described in Section 6. The placement method used must ensure that segregation and nesting of coarse particles is avoided.

2. The first lift of cover material over the GCL shall be compacted to a maximum of 90% of the maximum dry density (ASTM D698) or as specified by the Engineer to prevent damage to the GCL. Subsequent lifts, if required, of the Cover material over the GCL shall be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.

3. The Contractor must ensure that the integrity of the GCL is not compromised during construction. The precautions the Contractor may take to avoid damaging the GCL may include, but will not be limited to: providing light plants in the work area to improve operator visibility or using pylons to mark the lift/GCL system interface.

4. Any damage to the GCL must be immediately reported to the Engineer and EPCM Manager. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the GCL has been compromised. Excavation of fill surrounding the damaged GCL, to allow repairs to be made, must be done without further damaging the integrity of the products. Hand excavation may be required.

7.2.12 Tolerances

1. Fill shall be placed in horizontal lifts to the lines and levels shown on the drawings or as directed herein.

7.2.13 Compaction Trials

1. Compaction trials shall be performed upon production of fill material to determine site specific parameters such as density and compaction standards. The trials shall be carried out as part of the fill placing operation.

2. The Engineer may request through the EPCM Manager to periodically conduct field trials to optimize moisture conditioning, lift thickness and compaction effort.

3. The compaction trials on the material in question shall be done using a survey method according to the general procedure listed below, and as specified by the Engineer:

   (1) A pad made with the approved material in approximate 7 m by 20 m with specified thickness associated with the specified material with placement method according to this Specification.

   (2) A set of survey points with accuracy of ±5 mm shall be laid out as specified by the Engineer in a grid pattern.

(3) The elevations of each survey points shall be recorded immediately after placement and after each compaction effort.

(4) The compaction be done upward of 10 passes in accordance with this Specification or otherwise specified by the Engineer and survey recorded after each pass.

(5) This process shall be repeated to simulate construction as directed by the Engineer.

4. The EPCM Manager and or the Contractor shall obtain the Engineer's approval before implementing any change to the Specifications.

7.2.14 Restrictions Due To Weather and Suspension of Operations

1. The Contractor shall not place any fill when conditions for such operations are unsatisfactory due to heavy snowfall, extraordinarily freezing conditions, or any other reason determined by the Engineer.

2. Where operations have been discontinued by the Contractor or suspended by the Engineer, the effects of adverse conditions shall be assessed by the Engineer and the surficial layers of fill treated or replaced to the satisfaction of the Engineer before resumption of fill placement.

3. Before suspension of operations each day, or each construction shift, as described in this Section, and before suspension due to inclement weather, Core material fill in place shall be:

   (1) Surface shaped to drain excess water.

   (2) Rolled smooth to seal against ice lens development.

   (3) The Engineer will examine the quality of surficial fill to determine if rework is required to meet requirements.

4. In freezing conditions, the Contractor shall:

   (1) Provide satisfactory snow and ice removal from subgrade surface.

   (2) Provide heating capabilities to condition the Core material to the specified moisture content during placement and compaction.

5. In conditions that is warmer than -10°C during the Core material placement, the Contractor shall:

   (1) Prove to the Engineer that a satisfactory uniformly frozen core without free ice lenses can be constructed.

7.2.15 Sediment and Runoff Control

1. The EPCM Manager is responsible to provide to the Contractor with the locations and methods to construction facilities such as diversion berms, sediment ponds, and other measures as are required to prevent the discharge of fines from construction areas and from entering any natural water courses downstream of the Works during the spring melt season immediately following construction.

2. In general, when placing fill material, the Contractor shall slope the surfaces toward collection channels for surface water management.

3. The Contractor shall not excavate any ditches in the original ground, especially in permafrost overburden. Diversion berms will be the preferred method to re-route surface water.

7.3 Part 3 – Quality Control

1. The Contractor shall be responsible for the quality of fill as described in Section 5.

2. The Contractor shall conduct regular topographic surveys to demonstrate the placement of fill to the specified lines, levels, grades and tolerances. The Engineer may from time to time conduct check surveys. Survey results shall be reported to the Engineer and EPCM Manager within 24 hours of the completion of each survey.

3. The Contractor shall carry out Quality Control testing during fill placement as outlined in Table 7.1.

Table 7.1: Required QC testing during placement of construction material

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
Riprap	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Riprap	In-Place	n/a	Visual and Survey Controlled	n/a	24-hrs	Ongoing	Survey Report
Run-of-Quarry	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Run-of-Quarry	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Transition (General)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (North Dam)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
Transition	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Transition	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Surfacing	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Surfacing	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Surfacing	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Bedding	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 1,000 m^3	Test Certificate
Bedding	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Bedding	In-Place	n/a	Compaction (ASTM D2922)	On Site	Immediate	One per 100 m^2/Lift	Test Certificate
Core	During placement, but before freeze-back	Grab	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report

7.4 Part 4 – Quality Assurance

1. QA testing shall be carried out across the full length, width and depth of the various fill zones so as to fully represent the overall quality of the structure.

2. The Contractor shall conduct regular topographic surveys to demonstrate the placement of fill to the specified lines, levels, grades and tolerances. The Engineer may from time to time conduct check surveys. Survey results shall be reported to the Engineer and EPCM Manager within 24 hours of the completion of each survey.

3. The compacted density of the Core material must be evaluated by coring samples for laboratory testing and in situ compaction testing. Samples of the placed fill will be obtained using a concrete coring machine. The core sample will be used to determine if the lift of key trench backfill is completely frozen and to determine the soil properties.

4. Samples of placed Core material must be taken once freeze-back is completed by means of a concrete coring machine. The core must extend through the lower contact of the lift. All cored samples must be evenly distributed over the lift surface. All holes must be thoroughly washed with clean water to remove any remaining drilling fluid, and backfilled with saturated Core material immediately after extraction of the core.

5. Each cored sample of core key trench fill shall be split in half longitudinally and transversely and then examined and photographed by the Engineer. The bonding between layers, ice-saturation, and ice bonding will be evaluated.

6. The method of determining bulk density of cored samples will depend on the quality of the sample. The sample volume can be determined from the dimensions if the core has uniform dimensions. The Engineer will rely on in situ measurements of core and key trench fill density with a nuclear densometer if core recovery is poor or if the recovered cores are non-uniform.

7. The degree of saturation for cored samples will be determined, when possible, from the measured moisture content, bulk density, and measured specific gravity.

8. Final acceptance of earthworks will be made only after fill materials have been dumped, spread, moisture conditioned, and compacted, and tests and surveys have demonstrated compliance with the Specifications.

9. If on the basis of the sampling and testing, or if in the opinion of the Engineer, an area of the fill does not meet the specified requirements; such fill shall be removed and replaced with conforming material. Rejection of fill material by the Engineer may be made at source, in transporting vehicles, or in place.

10. The Engineer can re-inspect previously approved areas for damages and instruct the Contractor to repair said damages in accordance with the Specifications.

11. The Engineer shall carry out Quality Assurance testing during fill placement as outlined in Table 7.2. Additional testing may be conducted at the discretion of the Engineer.

Table 7.2: Required QA testing during placement of construction materials

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Riprap	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Riprap	In-Place	n/a	Visual and Survey Controlled	n/a	24-hrs	Ongoing	Survey Report
Run-of-Quarry	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Run-of-Quarry	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Transition (General)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (North Dam)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Transition	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Surfacing	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 6,000 m^3	Test Certificate
Surfacing	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Surfacing	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Bedding	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 2,000 m^3	Test Certificate
Bedding	In-Place	Grab	Maximum Density (ASTM D698)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Bedding	In-Place	Grab	Water Content (ASTM D2216)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Bedding	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Bedding	In-Place	n/a	Compaction (ASTM D2922)	On Site	Immediate	One per 400 m^2/Lift	Test Certificate
Core	During placement, but before freeze-back	Grab	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Compaction (ASTM D2922 - Nuclear Densometer)	In-Situ	Immediate	One per 225 m^2/Lift	Test Certificate

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Core	During placement, but before freeze-back	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Core	After freezeback (from "cored" sample)	Drilled Core	Ice Saturation and Bulk Density (EBA Method on "Cored" Sample)	Site Lab	Hold Point - Before Next Lift is Placed	4 "cores" per lift or 2 per day	Test Certificate
Core	After freezeback (from "cored" sample)	Drilled Core	Moisture Content (ASTM D2216)	Site Lab	24-hrs	75% of "cores" collected per lift/per day	Test Certificate
Core	After freezeback (from "cored" sample)	Drilled Core	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per lift (use aggregate of "cores")	Test Certificate
Core	After freezeback (from "cored" sample)	Drilled Core	Specific Gravity (ASTM D854)	Off Site Lab	7-days	One from 2nd lift and one from last lift	Test Certificate
Core	After freezeback (from "cored" sample)	Drilled Core	Salinity	Off Site Lab	7-days	One per 8,000 m^3	Test Certificate
Core	During freezeback	n/a	Freeze back (Thermistor)	In-Situ	Hold Point - Before Next Lift is Placed	2 (beads) per lift, equally spaced	Data Report

---------- END OF SECTION 7 ----------

Section 8
Horizontal Thermosyphons

8 Horizontal Thermosyphons

8.1 Part 1 –General

8.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

8.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (1) THERMOSYPHON means a passive heat transfer system using a combination of evaporator pipes and radiators to ensure that the base of the key trench remain frozen for the design life of the frozen core dam.

   (2) RADIATOR means a manufactured product with fins to enhance heat transfer from the evaporator pipes to ensure efficient working of the thermosyphon.

   (3) EVAPORATOR PIPE means the steel pipe installed at the base of the dam key trench to transfer heat from the ground to the atmosphere via the radiator.

8.1.3 Materials

1. The horizontal thermosyphons shown on the drawings will be manufactured, supplied and installed by a specialist contractor.

2. The thermosyphons shall be two-phase, liquid-vapour type thermosyphons charged with carbon dioxide refrigerant.

3. The thermosyphons shall be constructed with A53B Schedule 40 steel pipe.

4. The radiators shall be 75 mm O.D. pipe with 32 mm high x 0.012 mm nominal thickness carbon steel fins. Fin density shall be four (4) rows of fins per 25 mm of pipe.

5. Standard of Acceptance: Thermosyphons as manufactured by Arctic Foundations of Canada Inc., Winnipeg, Manitoba, or an approved equal.

6. The evaporator and radiator sizes shall be as shown on the Drawings.

7. All welds shall meet ASME boiler and pressure vessel Code B31.3.

8.2 Part 2 – Execution

8.2.1 Installation

1. The evaporator pipes shall be installed as specified on the Drawings.

2. The radiators shall be erected plumb.

3. All piping shall be tested by the installer prior to burial.

8.2.2 Monitoring

1. The operation of the thermosyphons shall be monitored with a contact thermometer or an infrared surface temperature measuring device to verify operation. Operation is generally indicated by a thermosyphon temperature being a few degrees warmer than the air temperature. Monitoring shall be carried out twice a month during the first three months in which the thermosyphons are expected to be operational. The thermosyphons will only be operational during the period when the air temperatures are colder than the ground temperatures.

2. Performance of the thermosyphons shall be evaluated with ground temperature cables as shown on the Drawings and as described in Section 9 of this document.

8.3 Part 3 – Quality Control

1. Physically demarcate, for review and approval by the EPCM Manager and Engineer, the Works area where the thermosyphons will be installed using proper survey control.

2. Conduct field surveys, and submit As-built Drawings, in electronic format of the installed thermosyphons.

3. Conduct a pressure test on each individual completed thermosyphon, and submit the results of the test to the Engineer and PECM manager for review.

8.4 Part 4 – Quality Assurance

1. Visually inspect the demarcated zone prepared by the Contractor for installing the thermosyphons and inform the Contractor via the EPCM Manager if changes are required.

2. Visually inspect the installed thermosyphons and inform the Contractor via the EPCM Manager if changes are required.

3. Review As-built Drawings submitted by the Contractor of installed thermosyphons and inform the Contractor via the EPCM Manager if any changes are required.

4. Review the results of the pressure tests conducted on the thermosyphons and inform the Contractor via the EPCM Manager if any changes are required.

5. Monitor the thermosyphon temperatures and inform the Contractor and EPCM Manager is trends emerge suggesting non-performance of the system.

---------- END OF SECTION 8 ----------

Section 9
Instrumentation

9 Instrumentation

9.1 Part 1 –General

9.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

9.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (1) GROUND TEMPERATURE CABLE means a manufactured cable with thermistor beads that allows in-situ ground temperature measurement.

   (2) THERMISTOR BEAD means an instrument capable of measuring in-situ ground temperature.

   (3) SETTLEMENT MONUMENT means an instrument capable of measuring in-situ ground deformations.

9.1.3 Materials

1. The ground temperature cables shown on the Drawings will be manufactured and supplied by a specialist contractor.

2. Ground temperature cables, casings, and datalogger housings will be supplied by the Contractor and EPCM Manager, with express direction provided by the Engineer.

3. The settlement monuments will be supplied and installed by the Contractor, with express direction provided by the Engineer.

4. The Contractor shall be responsible for providing protection for all instruments installed before construction of the dam is complete. The method of protection must be approved by the Engineer. The Contractor may be held responsible (at the Engineer's discretion) for replacement or repair of instruments damaged during construction.

9.1.4 Procedures

1. Ground temperature cables must be installed as shown on the Drawings to measure ground temperature during construction and operation of the dams.

2. Single bead ground temperature cables will be used to monitor the freeze back of individual lifts of the key trench backfill.

3. Settlement monuments must be installed as shown on the Drawings to allow any settlements of the dams to be measured.

9.1.5 Submittals

1. At least seven (7) days prior to installation of the ground temperature cables, the Contractor shall submit to the Engineer and EPCM Manager, for approval, the Manufacturers Calibration Certificates for each ground temperature cable.

9.2 Part 2 – Execution

9.2.1 Ground Temperature Cable Installation

1. Horizontal and vertical ground temperature cables must be installed during construction. The locations and orientation of the ground temperature cables are shown in the Drawings.

2. Drill holes for ground temperature cable installation must be 100 mm diameter or greater. Drill holes must be drilled in the presence of the Engineer to the depths shown on the Drawings.

3. The drill hole with the installed ground temperature cable must be backfilled with slurry as described in Section 11 to prevent air voids around the ground temperature cable.

4. The portion of the cable extending beyond the dam fill must be protected with a steel pipe extending 1 m above the final elevation of the dam. The steel pipe must be painted with fluorescent paint.

5. The location of the installed instruments must be surveyed.

9.2.2 Settlement Monuments Installation

1. Settlement monuments must be supplied and installed by the Contractor according to the Drawings as directed by the Engineer.

9.3 Part 3 – Quality Control

1. Physically demarcate, for review and approval by the EPCM Manager and Engineer, the Works area where the instrumentation will be installed using proper survey control.

2. Conduct field surveys, and submit As-built Drawings, in electronic format of the installed instrumentation.

9.4 Part 4 – Quality Assurance

1. Visually inspect the demarcated zone prepared by the Contractor for installing the instrumentation and inform the Contractor via the EPCM Manager if changes are required.

2. Visually inspect the installed instrumentation and inform the Contractor via the EPCM Manager if changes are required.

3. Review As-built Drawings submitted by the Contractor of installed instrumentation and inform the Contractor via the EPCM Manager if any changes are required.

4. Review the manufacturers Calibration certificates for the ground temperature cables and inform the Contractor via the EPCM Manager if any changes are required.

5. Confirm that each ground temperature cable is functioning prior to installation, and throughout the construction stage.

---------- END OF SECTION 9 ----------

Section 10
Percolation Testing

10 Percolation Testing

10.1 Part 1 –General

10.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

10.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (1) PERCOLATION TEST means a test within the footprint of the North Dam key trench prior to excavation to confirm the base of the key trench is founded within saturated frozen soil.

10.2 Part 2 – Execution

10.2.1 Test Procedure

1. Survey and layout percolation test holes within the footprint of the proposed key trench area.

2. Drill the percolation test holes using an air-track drill and air flush with a minimum hole diameter of 100 mm. The depth of the test holes will depend on the local geotechnical conditions as defined by the Engineer. For the Doris North Dam the percolation holes should be a minimum of 8 metres deep.

3. Drill cutting samples should be collected and bagged every 1,000 mm during drilling. A board or shovel placed near the test hole during drilling may be used to collect samples of the drill cuttings.

4. The samples collected during drilling of the percolation holes should be logged using geotechnical and permafrost logging procedures to develop a soil profile log.

5. Moisture content determinations should be completed on all the samples collected. Salinity testing should be carried out on approximately 30% of the samples collected or as directed by the Engineer. The samples for salinity testing should be determined based on varying depths and material type changes.

6. Upon completion of drilling, the top of the percolation hole should be insulated until ready for testing. Typically insulation can be pink fibreglass insulation which should penetrate about 600 mm down the percolation hole.

7. When ready for testing, remove the insulation and fill the percolation hole with water that has a temperature of approximately 15°C (holes are filled only once). Where possible, record the volume of water required to fill the hole.

8. Records the change of the water level in the percolation hole using a measuring tape. Readings should be undertaken at suitable time intervals to determine the rate of water level change and at which level there is no further change of the water level. For example, the reading schedule can be: 0 min, 1 min, 2 min, 5 min, 10 min, 15 min, 30 min, 45 min, 60 min, 2 hrs, 8 hrs, 16 hrs, 24 hrs, and 36 hrs.

9. Keep the percolation holes insulated between water level readings.

10. All percolation holes should be back filled with 20 mm crush and water and allowed to freeze back after percolation testing is completed.

10.3 Part 3 – Quality Control

1. The Contractor shall carry out Quality Control testing during percolation testing, including, but not limited to:

   (1) Survey control of the percolation test hole locations.

   (2) Survey control of the percolation test hole diameter and final depth.

10.4 Part 4 – Quality Assurance

2. The Engineer shall carry out Quality Assurance testing during percolation testing, including, but not limited to:

   (1) Recording of percolation test conditions as specified in this document.

   (2) Logging of percolation test holes, including completion of moisture content testing every 1,000 mm, and conducting two (2) to three (3) salinity tests per percolation test hole.

---------- END OF SECTION 10 ----------

Section 11
Adfreeze Piles

11 Adfreeze Piles

11.1 Part 1 –General

11.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

11.1.2 Definitions

2. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (2) ADFREEZE PILES means steel pipes required to support the thermosyphon radiators.

11.2 Part 2 – Execution

11.2.1 Installation

1. A minimum 4” (102 mm) nominal Schedule 80 pipe is recommended. The pile installation holes shall be drilled to a diameter at least 100 mm larger than the outside diameter of the pipe.

2. The pile shall penetrate a minimum of 6.0 m below grade.

3. Holes shall be cut on opposite sides of the pile to ensure the sand slurry fills the annulus between the steel pipe pile and the wall of the borehole. The holes also provide a mechanical interlock between the frozen sand backfill and the steel which contributes to the specified allowable bond strength. The holes shall be spaced at 500 mm and be approximately 50 mm wide by 100 mm long. Each pile shall have a minimum of sixteen holes within the frozen bond length. No holes shall be placed within the top 2 m of the pile embedment.

4. After drilling, the hole shall be free of water, mud, slough and any other delirious material. The procedure is very important for obtaining a suitable bond between the slurry and the pile, and between the slurry and the permafrost or rock. Loose material and oil and grease shall be completely cleaned off the pile immediately before installation. These operations shall be monitored by the Engineer.

5. It is recommended that the pile be placed in the hole first and slurry placed down the centre of the pile. The slurry shall consist of approximately 15% to 35% water by volume. The water content shall be moist enough to attain a workable and fully saturated mixture but shall be minimized to facilitate freeze back. A pencil vibrator or a pile vibrator shall be used to densify the slurry.

6. Aggregate used for slurry shall consist of mineral soils conforming to the following gradation limits listed in Table 11.1.

Table 11.1: Typical Gradation of Slurry Sand for Backfill

Sieve Size (mm)	Percent Passing by Weight
10	100
5	85-100
2	60-100
0.63	20-65
0.08	0-15

7. Water used for slurry production shall be fresh potable water. The temperature of the slurry when placed shall not exceed 10°C to minimize permafrost disturbance and freeze back time.

8. Accurate records of slurry volumes placed down the hole shall be kept. This is to identify that there are no voids between the pile and the side of the hole.

11.3 Part 3 – Quality Control

1. Physically demarcate, for review and approval by the EPCM Manager and Engineer, the Works area where the adfreeze piles will be installed using proper survey control.

2. Conduct field surveys, and submit As-built Drawings, in electronic format of the installed piles.

11.4 Part 4 – Quality Assurance

1. Visually inspect the demarcated zone prepared by the Contractor for installing the adfreeze piles and inform the Contractor via the EPCM Manager if changes are required.

2. Visually inspect the installed piles and inform the Contractor via the EPCM Manager if changes are required.

3. Review As-built Drawings submitted by the Contractor of installed piles and inform the Contractor via the EPCM Manager if any changes are required.

4. Record the slurry temperature and collect for testing one (1) sample per pile of the slurry mix. Conduct a particle size distribution (ASTM C136) and Moisture Content (ASTM D2216) test per sample.

---------- END OF SECTION 11 ----------