APPENDIX B

Technical Specifications

PREPARED FOR:
AGNICO EAGLE MINES LIMITED
MEADOWBANK MINE

PREPARED BY:

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S1 GENERAL

S1.1 Tailings Storage Facility

Tailings generated by the mine operation were deposited in the North Cell of the TSF, which was formed by dewatering the northwest arm of Second Portage Lake. The tailings deposition was completely transferred from the North Cell of the TSF to the South Cell in 2015. As of 2019, the North Cell will be receiving tailings produced by milling of ore from the Amaruq Mine, located approximately 55 km north of the Meadowbank mine.

The current Specifications are for construction of the Internal Structure to be built on the existing tailings within the North Cell of the Meadowbank TSF.

The North Cell Internal Structure will be a rockfill structure with coarse and fine filter zones on the upstream side slope. Existing rockfill roads and constructed Internal Structure will be used for construction access, and to create a continuous platform for tailings pipelines and spigots.

The North Cell Internal Structure shall be constructed as shown in the Drawings that accompany these Specifications. Construction of the internal structure can be phased. The configuration to be constructed for each phase will be provided by AEM. As-built information for previous phases will be maintained and made available by AEM.

These Technical Specifications address technical aspects of the construction of the earthworks for the North Cell Internal Structure. They are not intended to address administrative aspects of the construction, nor other aspects such as: piping, barges, electrical, mechanical, structural or other works associated with tailings transport or water reclaim.

S1.2 Definitions

The definitions used in the Specifications are given in Table 1-2.

Table 1-2: Definitions

Accuracy	Degree of approximation of a measurement to the true value of the quantity measured.
AEM	Agnico-Eagle Mines Limited, Owner.
Approval	A written engineering or geotechnical opinion concerning the Work.
AutoCAD	Autodesk CAD program. Drawings should be saved using the .dxf exchange file format.
Bituminous geomembrane	Bituminous geomembrane satisfying the Specifications.
Coarse Filter (processed granular fill)—Zone 2	Material produced from processing of NPAG waste rock and meeting the Specifications.
Contractor	The onsite representative of the construction company contracted by the Owner to successfully carry out the scope of work described herein. For Work performed by mine employees, the Mine Superintendent, an employee of AEM, assumes responsibility for duties and obligations of the Contractor described in the Specifications and in the Drawings.
Contractor's Work Plan	Proposed construction equipment, procedures, schedules, QC plan, environmental management plan, and health and safety plan for all components of work to be completed by the Contractor and any Subcontractor the Contractor may employ to complete the Work.
CSA	Canadian Standard Association.
Designer	Golder Associate Ltd. (Golder), Design Engineer.
EMP	Environmental Management Plan.
Field Laboratory	The area and facilities provided for QC and QA testing at the Meadowbank Gold Project Site.
Fine Filter (processed granular fill)—Zone 3	Material produced from processing of NPAG waste rock and satisfying the Specifications.
Geomembrane Manufacturer	Manufacturer of bituminous geomembrane.
Geotextile	Non-woven geotextile, minimum 340 g/m^2.
Health and Safety (H&S)	A planned set of activities and approaches to provide protection for the health and safety of all persons involved in or potentially affected by construction activities.
Ice-Poor Soil	Frozen soils that contain less than 10% visible ice and having a water content less than 20% (by mass). No visible ice lenses.

Ice-Rich Soil	Frozen soils that contain more than 10% visible ice and/or having a water content greater than 20%. Ice lenses may be present.
Internal Structure	Rockfill structure to be constructed within the North Cell of the TSF.
Liner Installer	Subcontractor under the responsibility of the Contractor, responsible for the installation of geotextile and bituminous geomembrane liners.
Meadowbank	The Meadowbank Gold Mine.
ML	Metal leaching.
NPAG	Non-potentially acid generating.
Owner	Agnico-Eagle Mines Limited, Meadowbank Division (AEM). For the Internal Structure construction, the Owner is the Operations Manager.
Owner's Representative	The engineer of record for the Internal Structure. It is a person(s) employed or retained by the Owner to oversee the project works and the Owner's interests. This role is the primary point of contact for the Designer, the QA Representative, the QC Representative, the Contractor and the Liner Installer. For Work performed by mine employees, the Owner's Representative is to represent the Owner and not act as a representative for the Contractor.
PAG	Potentially acid generating.
QA Representative	Responsible for the Quality Assurance (QA) activities
QC Representative	Person or company hired by the Owner and under the supervision of the Owner's Representative to collaborate with the Contractor to ensure Quality Control (QC) testing and inspection of all work done by the Contractor.
Quality Assurance (QA)	A planned system of inspection and testing that documents, to the satisfaction of the Owner, the Owner's Representative, the Designer, other stakeholders and regulators, that the work complies with the design, drawings and Specifications. Quality assurance forms a subset of the quality assurance program. Quality assurance comprises inspections carried out during quality control and includes verifications, evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Quality assurance refers to measures taken by the quality assurance organization, the QA Representative, to assess if the work is in compliance with the drawings and Specifications. The QA Representative is responsible for performing the QA activities.

Quality Control (QC)	A planned system of inspection, testing and documentation carried out during construction to ensure that the work is being performed and completed in a manner that complies with the drawings and Specifications. Notwithstanding his contractual QC obligations, the Contractor is responsible for collaborating with the QC Representative to ensure the QC of his work. The Contractor is responsible for the QC activities for the work performed by its Subcontractor.
Reproducibility	Degree of approximation to the arithmetic average of each one of a series of similar measurements.
Rockfill—Zone 1	NPAG waste rock, expected to be run-of-mine requiring little to no processing and satisfying the Specifications.
Sensitivity	Minimum unit to be detected by a system of measurement.
Subcontractor	The onsite representative of the construction company contracted by the Contractor to complete a portion of the work.
TSF	Tailings Storage Facility
Work	All activities associated with the construction of the Internal Structure.
Work Completion Report (WCR)	Summary report prepared by the Contractor with the content described in the Specification.
Working Platform	The working platform is the surface of fill and/or excavated surface from which the work is conducted.

S1.3 General Site Conditions

The site is remote, and requires considerable logistic support for transport of materials to site. Climate is described in the associated Design Report, and includes extreme cold weather conditions from October through May.

The current understanding of the condition of the existing tailings, which will be acting as a foundation for the Internal Structure, is based on a limited number of boreholes. The presentation of tailings conditions in the Design Report and Drawings are therefore subject to a large degree of interpretation. The Contractor shall review the Design Report and make his own interpretation of conditions.

S1.4 Drawings

This Specification defines the requirements for performing the work as outlined on the most recent revision of the Drawings presented in Table 1-2. Should a discrepancy or omission be identified the party concerned shall request, in writing, clarification from the Engineer.

TABLE 1-2: List of Drawings

Number	Drawing Title	Revision
001	COVER PAGE	0
002	GENERAL ARRANGEMENT PLAN	0
003	GEOTECHNICAL INVESTIGATION PLAN	0
004	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 1 OF 8	0
005	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 2 OF 8	0
006	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 3 OF 8	0
007	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 4 OF 8	0
008	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 5 OF 8	0
009	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 6 OF 8	0
010	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 7 OF 8	0
011	INTERNAL STRUCTURE AND DITCH PLAN AND PROFILE 8 OF 8	0
012	SECTIONS AND DETAILS OF INTERNAL STRUCTURE AND DITCHES	0
013	DETAILS OF INTERNAL STRUCTURE AND DITCHES	0

S1.5 Scope of Work

Construction of the North Cell Internal Structure and associated water management structures will involve:

- Foundation preparation at the footprint areas of the Internal Structure, Downstream Ditches, and Sumps;
- Excavation of ditches and sumps;
- Fill placement (Rockfill, coarse filter and/or fine filter) at the Internal Structure, Downstream Ditches, and Sumps;
- Installation of geotextile at the Sumps; and
- Installation of bituminous geomembrane in some of the ditches.

Most of the construction will be carried out by AEM with some work to be carried out by a Contractor.

S1.6 Standards

The work shall conform to, but not necessarily be limited to, the requirements of the standards, acts and regulations listed in Table 1-3. The work included in these Specifications shall conform to the applicable provisions of these publications, except as modified by the requirements specified herein or as indicated in the Drawings. Each publication shall be the

most recent revision, including applicable addenda in effect at the date of issue of the Specification.

It is important to note that additional standards may be referenced by those listed in Table 1-3; it is the responsibility of the user of this document to be familiar with all the applicable standards.

Table 1-3: Standards

AEM	Safety Handbook 2008
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3 (600 kN-m/m3))
ASTM D792	Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D1004	Test Method for Initial Tear Resistance of Plastic Film Sheeting
ASTM D1238	Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D3895	Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
ASTM D4218	Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils
ASTM D4354	Standard Practice for Sampling of Geosynthetics for Testing
ASTM D4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus
ASTM D4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632	Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
ASTM D4833	Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
ASTM D5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles
ASTM D5323	Standard Practice for Determination of 2 % Secant Modulus for Polyethylene Geomembranes
ASTM D5596	Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
ASTM D5617	Standard Test Method for Multi-Axial Tension Test for Geosynthetics
ASTM D5721	Standard Practice for Air-Oven Aging of Polyolefin Geomembranes
ASTM D5885	Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry

ASTM D5994	Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
ASTM D6392	Standard Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D6693	Standard Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes
GRI GM 9	Cold Weather Seaming of Geomembranes.
GRI GM 11	Accelerated Weathering of Geomembranes using a Fluorescent UVA-Condensation Exposure Device
GRI GM19	Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

AEM: Agnico-Eagle Mines Limited; ASTM: ASTM International; originally known as American Society for Testing and Materials; CEBTP: *Centre Expérimental de Recherches et D'Études du Bâtiment et des Travaux Public;* DGS: European Commission Research Directorate-General; EN: European Standard (European Committee for Standardization); NFP : *Norme française (French Standard); GRI:* Geosynthetic Research Institute.

S2 FOUNDATION PREPARATION

S2.1 Scope

This section of the Technical Specifications provides the technical requirements for foundation preparation for the North Cell Internal Structure and associated water management structures, including:

- Removal of snow from within the footprint of the Internal Structure and associated ditches and sumps to provide suitable surfaces for rockfill and filter placement;
- Excavation of existing ground including blasting for ditches and sumps; and
- Preparation of surfaces for liner placement.

S2.2 Work Sequence

The work shall be started following inspection, as-built survey and approval of pre-work conditions.

S2.3 General

Stripping and excavation shall be carried out in accordance with the Drawings and Specification, using ground support and water control measures required for safe and effective operation.

Foundation preparation is subject to inspection and approval by the Owner's Representative.

S2.3.1 Waste Soil and Rock

Waste soil and rock includes soft soils/tailings, frozen tailings and other materials, organic materials and other rejected materials removed from the Internal Structure, ditches and sumps footprints.

Waste soil and rock shall be disposed of within the TSF but outside of the footprints of the Internal Structure. Waste soil and rock shall not be disposed of outside of these areas unless approved in writing by the Owner's Representative.

Waste soil and rock materials shall not be piled higher than the crest of the Internal Structure.

Waste soil and rock materials shall not be spoiled in any manner which, in the opinion of the Owner's Representative, could adversely affect future deposition of tailings into the TSF.

Waste soil and rock materials shall not be deposited into any riverbed, lake, or other water channel.

S2.3.2 Dimensional Tolerances

All excavations shall be completed to be within 300 mm horizontally and vertically of specified lines and grades, except that the finished invert of ditches shall be completed to within 100 mm vertically, unless otherwise specified by the Owner's Representative.

S2.4 Execution

S2.4.1 Internal Structure Foundation

Foundation preparation shall be carried out within the footprint of the North Cell Internal Structure, as indicated on the Drawings, and includes removal of snow from the existing tailings surface.

No excavation and tailings removal are required within the Internal Structure footprints.

S2.4.2 Excavation for Ditches and Sumps

The excavation shall meet the minimum dimensions shown on the Drawings. Method of excavation and stability of the excavation shall be the responsibility of the Contractor, with method reviewed by the Owner’s Representative. The ditch construction may require an open cut excavation through frozen foundation soils using excavation, hoe-ramming, ripping or drilling and blasting methods as required to establish a ditch.

All necessary precautions shall be taken to obtain regular and stable excavation surfaces, which follow the boundary lines and grades shown on the Drawings.

Alternative methods such as mechanical cutting of rock surfaces and frozen ground are allowed.

S2.4.3 Subgrades Supporting Liners

In some areas, liner will be placed directly on top of subgrade surfaces excavated into tailings. Such surfaces shall be smooth, firm, free of loose material, shall not contain protruding particles that may damage the liner, and shall not be steeper than the slopes shown in the Construction Drawings. Subgrades supporting liners are subject to inspection and approval by the Owner’s Representative. The Contractor is responsible for preparation of the

bedding surface, and for excavation of the ditches. The Contractor must drain and dry the site when required.

The Contractor and the Owner's Representative shall inspect the surface of the bedding material prior to placing the liner, to ensure that it is free of protrusions or surface irregularities that could cause stress in the liner.

S2.4.4 Blasting

Where required, blasting will be carried out by the Owner. The Contractor shall be responsible for the excavation and disposal of the blasted rock material.

All operations in connection with transporting, storage and the use of explosives shall be subject to the Mine Health Safety Act and Regulations of Nunavut. Blasting shall be performed by experienced and licensed personnel.

S3 FILL PLACEMENT

S3.1 Scope

This Specification describes requirements for fill placement and compaction for construction of the North Cell Internal Structure.

S3.2 Work Sequence

Construction shall not begin until completion of inspection, as-built survey and approval of pre-work conditions by the Owner's Representative.

S3.3 General

Fill placement shall be to the lines, grades and cross-sections shown on the Drawings and in accordance with the Specification.

S3.3.1 Access

The Owner shall provide access to the Internal Structure and associated water management structures. The Contractor shall establish and maintain temporary access roads and ramps throughout the construction period.

S3.3.2 Borrow Sources

Borrow sources shall be tested prior to the start of construction and through construction.

The QC Representative shall be responsible for the following tasks:

- Ensure materials meet Specifications;
- Surface water management; and
- Control material segregation.

The QA Representative shall be responsible for the following tasks:

- Perform QA testing including gradations, moisture content;
- Perform visual inspection of materials;
- Approve suitability of borrow material and storage area for construction;
- Approve quantities; and
- Documentation including photographic records.

S3.3.3 Rockfill Material

Rockfill material for construction of the North Cell Internal Structure shall be NPAG material.

S3.3.4 Filter Material Handling

Filter materials shall be stockpiled in areas designated by the Owner's Representative. The storage areas for the Filter materials shall be inspected prior to storage. Handling, stockpiling, and sampling of Filter materials shall be carried out in a manner which prevents segregation and contamination.

S3.4 Fill Materials

S3.4.1 NPAG Waste Rock (Rockfill – Zone 1)

The NPAG waste rock material shall be run of mine material consisting of well graded rock fragments free from ice, frozen chunks, organic matter, debris and other deleterious materials.

S3.4.2 Coarse Filter (Zone 2)

Coarse Filter shall be from crushed and screened ultramafic rockfill, processed to meet the design Specification. Coarse Filter shall fall within the gradation limits in place on the upstream side of the Internal Structure, as shown in Table 3-1. Coarse Filter shall be free of clay, organic matters, debris, refuse, snow, ice and other deleterious material, subject to the satisfaction of the Owner's Representative.

TABLE 3-1: Coarse Filter Gradation Limits

Size (mm)	%Passing	%Passing
200		100
152		86
76	100	42
25	52	14
12.7	35	10
4.76	23	5
2	15	3
0.425	10	1
0.075	7	0

S3.4.3 Fine Filter (Zone 3)

Fine Filter shall be from crushed and screened ultramafic rockfill, processed to meet the design Specification. Fine Filter shall fall within the gradation limits in place on the upstream side of the Internal Structure, as shown in Table 3-2. Fine Filter shall be free of clay, organic matters, debris, cinders, ash, refuse, snow, ice and other deleterious material, subject to the satisfaction of the Owner's Representative.

TABLE 3-2: Fine Filter Gradation Limits

Size (mm)	%Passing	%Passing
38.1		100
19.05		65
12.7	100	50
4.76	60	28
2	40	16
0.425	23	6
0.075	10	0

S3.5 Examination

Prior to commencing construction, the Contractor shall thoroughly examine the site conditions upon which his Work is dependent and he shall report any deficiencies to the Owner's Representative in writing.

S3.6 Survey and Initiation

Before the Work starts, a survey of the surface work areas shall be carried out to establish the base plans for layout, as-built quantities, and for quality control.

The Owner is responsible for providing reference bench marks and the Contractor is responsible for the layout of his work, and for the correctness and exactness of their work.

S3.7 Execution

Foundation preparation to be completed. No fill material or liner is to be placed on prepared foundation surface without prior foundation approval in writing from the Owner's Representative, QC and QA Representatives.

Construction of the North Cell Internal Structure shall be to the lines, grades and cross-sections shown on the Drawings using only suitable materials approved prior to placement by the Owner's Representative.

Equipment suitability, methods of working, rate of progress and quality of work shall be demonstrated during the initial stages of the Work. In the event that the work performance is unsatisfactory for either quality or schedule requirements, there shall be immediate implementation of such changes as are required to ensure the required quality and scheduled completion of the Work.

Accumulation of water, snow, ice or other deleterious material(s) shall be prevented on the surface of the fill or foundations.

Material placement shall cease when satisfactory work cannot be carried out due to rain, snow, unsatisfactory materials or any other unsatisfactory conditions.

During placement of materials, mixing of the materials from adjoining zones shall be prevented. Segregation during transportation, dumping and spreading of material shall be avoided so that the material placed meets the Specifications.

S3.8 Dimensional Tolerances

All placement of fill material shall be completed to be within 0.3 m horizontally and vertically of specified lines and grades unless otherwise approved by the Engineer. The placement of fill materials in the inverts of ditches shall be within 0.1 m vertically of the specified lines and grades unless otherwise approved by the Owner's Representative.

The thickness of all layers of Coarse Filter and Fine Filter material shall be greater than or equal to the minimum thickness as shown on the Drawings, unless otherwise approved by the Owner's Representative.

S3.9 Fill Compaction

All fill materials shall be placed in lifts and each material lift shall be compacted before placement of the subsequent lift.

The compaction shall be carried out by rolling over large surfaces and executing turns carefully to obtain uniform compaction. One passage of the roller over the entire area being

compacted will constitute a pass and successive passes shall horizontally overlap the previous pass by at least 600 mm.

If the compaction of a lift or a portion of lift is insufficient due to either lack of overlapping or rolling, or due to excessive lift thickness, or to excess or deficient moisture content, improve the condition of the fill in accordance with the requirements specified herein and re-compact the lift. If the additional work cannot provide satisfactory results, remove and waste such lift, or its portion, and provide new material.

If compaction of a material cannot be achieved due to the use of improper compaction equipment, immediately replace such equipment with equipment suitable for compaction of the material.

Any fill that has become saturated, softened, loosened or has undergone a reduction in density due to precipitation, ponded water, construction traffic or frost action shall be treated to restore the required density. Alternatively, the material shall be excavated and disposed of and replaced. Such work shall subject to the approval of the Owner's Representative.

The compaction methodology and degree of compaction achieved in the field will be monitored by the QC Representative.

S3.9.1 Fine Filter

The maximum un-compacted lift thickness of Fine Filter shall be 500 mm.

On the face of the Internal Structures, the compaction of the Fine Filter shall be carried out using a 10 tonnes smooth drum vibratory roller compactor with a minimum of 4 passes, subject to review of performance. Fine filter placed into ditches shall be compacted using hand guided compactors or other method approved by the Owner's Representative.

S3.9.2 Coarse Filter

The maximum un-compacted lift thickness of Coarse Filter shall be 500 mm.

Compaction of the Coarse Filter shall be carried out using a 10 tonne smooth drum vibratory roller compactor with a minimum 4 passes.

S3.9.3 Rockfill

Compaction of Rockfill for the Internal Structure shall meet the following requirement:

a) The maximum un-compacted horizontal lift thickness shall be 2.0 m as shown on the Drawings;

b) Compaction of the rockfill shall be carried out using a 10 tonnes smooth drum roller vibratory compactor with a minimum 4 passes;

c) The Contractor shall avoid nesting of oversize stones; and

d) The upstream slope of the rockfill zone shall be trimmed, free of oversized stones and compacted along the slope prior to placement of the Coarse Filter.

S4 GEOMEMBRANE LINER

S4.1 Work Sequence

A Subcontractor shall be retained by the Contractor for installation of the Liner. The work shall be started upon receipt of approval to proceed from the Owner's Representative following inspection, as-built survey and approval of pre-work conditions.

S4.2 General

This section of the Specifications defines the technical requirements for installation of the Bituminous Geomembrane Liner for the North Cell ditches. Golder will provide a different technical requirements if AEM wishes to use other types of geomembrane liner such as HDPE and LLDPE.

The Work covered by this Specification shall include:

By Owner:

- Ordering the liner;
- Handling and transport of the liner to the mine site;
- Receiving and unloading rolls of the liner at the mine site;
- Preparing a suitable temporary storage area for the rolls of the liner, and protecting the rolls from damage or environmental degradation while in temporary storage.

By Contractor & Subcontractor (Liner installer)

- Transporting the rolls of the liner from the temporary storage area to the installation sites;
- Placing the liner in accordance with the Manufacturer's instructions and this technical Specification, to the lines, grades and dimensions shown on the Drawings, or as directed by the Engineer;
- Providing all materials, equipment and labour required to position and assemble the liner, as shown on the Drawings;

- Carrying out all the non-destructive and destructive tests required in the technical Specifications, employing industry standard techniques and equipment;

- Clean up of the site; and

- Preparation of pre-installation and as-built panel layout Drawings, in digital AutoCAD drawing format, as described in detail within this Specification.

S4.3 Manufacturer's Qualifications

The manufacturer of the bituminous geomembrane sheet shall be approved by the Owner's Representative and have satisfactory experience and reputation for producing a high quality product.

S4.4 Subcontractor's Qualifications

The Subcontractor installing the liner shall employ qualified personnel, experienced in deploying, welding, testing and patching the liner material. Qualified personnel shall be certified annually by the liner Manufacturer with a non-transferable letter.

The Liner Installer shall provide the following:

• Resumes of supervisors and master seamers that will work on this project.

• Proposed installation schedule.

• Information on equipment and personnel.

• Samples of field welds of the same type geomembrane specified for this project from each type of weld proposed to be seamed at this project.

• A list of completed facilities, for which the Subcontractor has installed the same type(s) geomembrane specified for this project. For each installation listed, the following information shall be provided as a minimum: name and purpose of the facility, the location of the facility, the date of the installation, the name of the Owner, the name of the geomembrane Manufacturer, the type, thickness and total surface area of geomembrane installed, type of seaming, patching, and QC testing used during the installation.

S4.5 Sampling, Testing and Reporting

The Subcontractor shall provide representative samples of the liner material for QA testing, allow access for QA review of the QC testing, and provide results of QC testing in a prompt manner.

The Contractor must provide laboratory equipment and facilities that are sufficient for the QC testing required within the Specifications.

S4.6 Bituminous Geomembrane Liner Supply

S4.6.1 Supplier Requirements

The Supplier shall ensure that the Manufacturer has provided labels on each roll of the liner which shall include the following information:

- Name of manufacturer;
- Type of liner;
- Roll identification number and shipping weight;
- Thickness, length and width;
- Manufacturer's approved QC stamp, QC test results, and technician's signature;
- Location and type of any flaws; and
- Asqual certification.

Liner labels must be durable to be able to withstand shipping, unloading and temporary storage.

The Supplier shall provide a summary document of all the information listed above, including Manufacturer QC certificates to the Construction Manager. The QC certificates shall include results from all QC tests listed in Table 4-1.

TABLE 4-1: Required QC Testing of Liner in Manufacturer's Factory

Type of Test	Testing Standard [1]	Frequency of Testing	Specified Value
			ES2
Nominal Thickness	ASTM D5199	1 per 10 rolls	4.0 mm
Density	ASTM D792	1 per 10 rolls	1.244g/cm³
Static puncture	ASTM D4833	1 per 10 rolls	601 N (min)
Dimensional stability Longitudinal	ASTM 1204-02	1 per 10 rolls	-0.04% longitudinal (max)

Type of Test	Testing Standard [1]	Frequency of Testing	Specified Value
			ES2
Dimensional stability Transverse			-0.06% transverse (max)
Stress Relaxation with Time	CEBTP 6327.7.390	1 per 10 rolls	70% in 3 hours
Stress Cracking Susceptible	ASTM D1693	1 per 10 rolls	No
Coefficient of Thermal Expansion	ASTM D696	1 per 10 rolls	1×10^{-6} cm/cm/°C (max.)

Liner rolls delivered with defects such as holes, blisters, undispersed raw materials, or any signs of contamination by foreign matters, shall -not be used.

The Supplier shall warrant the liner material meets the requirements covered by these Specifications. The warranty shall provide for the total and complete replacement of any defective materials that may be identified at any time, upon written notification and demonstration by the Owner of the non-conformance of the liner material with these Specifications.

The Supplier must guarantee the liner material according to these Specifications for a period of ten (10) years, starting from the date of delivery of the liner to site.

S4.7 Transportation and Handling

Transportation of the geomembrane liner shall be the responsibility of the Owner. All handling on-site is the responsibility of the Owner.

At any time during delivery and/or upon arrival at site, the Contractor must allow the QA Representative or Construction Manager, or designated representative to be present when the liner is handled outside of the sea containers or off loaded from a transport vehicle. This requirement includes any off-site handling of the liner required for its transport to site.

When the liner arrives at site, the Owner shall unload all the rolls at a location where only one handling step is required to take each roll to its position for storage. The rolls must be handled in such a way to prevent damage to the liner.

All handling of the rolls shall be done using a beam or with a full length pin inserted in the liner's steel roll mandrel. ***The use of forklifts or other means is forbidden.***

S4.7.1 Mandrels

The Contractor is responsible to collect and dispose the steel roll mandrels.

S4.8 Temporary Storage and Protection

Upon the arrival of the liner rolls on site the Owner shall:

- Prepare a suitable temporary storage area for the sea containers or the liner rolls in a secure location agreed to with the -Owner's Representative; and
- Prepare an 'As-Received' inventory of the rolls of the liner and materials, a copy of which must promptly be provided to Owner's Representative and the Contractor.

The Contractor shall be responsible for:

- Protection of the rolls and materials on site prior to placement; and
- Transportation of the rolls and materials from a temporary storage location to the North Cell area.
- Mandrels shall be sent to landfill after the liner is removed.

The Owner shall assume responsibility for the protection and handling of the rolls and materials from the time of unloading upon arrival at site to their installation at the North Cell. Any rolls or materials found damaged upon unloading from the container shall be reported to the Owner's Representative.

While in temporary storage, rolls shall be strapped so that no damage occurs to the outer wraps on each roll, and that straps do not damage adjacent rolls. Rolls shall be supported so that no penetrating stresses are induced in the liner, and the rolls cannot move.

Rolls shall be stacked no more than 3 rolls high, on a smooth, dry, clean, flat surface, and covered. Rolls shall be protected from heat sources, solvents, dirt, debris, rodents, and other conditions which could affect the performance of the materials. Manufacturer's labels shall be maintained intact. Labels shall be clearly visible and legible after rolls have been stored on site.

S4.9 Products

S4.9.1 Liner

The required liner material shall be Coletanche ES2 elastomeric bituminous geomembrane liner or approved equivalent. The geomembrane liner must meet or exceed the characteristics indicated by the properties listed in Table 4-2.

TABLE 4-2: Properties of Coletanche ES2 Geomembrane

Material Property	Qualifier	Unit	ES2 Specified Value	Standard
Characteristics of Roll	Length Width	m m	80 5.10	- -
Unit Weight of Incorporated Non-Woven Geotextile	-	g/m^2	250	n/a
Thickness	nominal	mm	4.0	ASTM D5199
Density	typical	g/cm^3	1.247	ASTM D-792
Bitumen	-	n/a	Elastomeric bitumen	n/a
Tensile Stress at break				
Longitudinal	minimum	kN/m	26.80	ASTM D4595
Transverse	minimum	kN/m	22.90	ASTM D4595
Elongation at break				
Longitudinal	minimum	%	71	ASTM D4595
Transverse	minimum	%	73	ASTM D4595
Tensile Tear Resistance				
Longitudinal	minimum	N	902	ASTM D4073
Transverse	minimum	N	835	ASTM D4073
Static puncture	minimum	N	601	ASTM 4833
Puncture by aggregates (20/40)	minimum	kN	25	NFP84507
Dimensional Stability				
Longitudinal	maximum	%	-0.04	ASTM D1204
Transverse	maximum	%	-0.06	ASTM D1204
Permeability	maximum	cm/sec	$<1x10^{-13}$	-
Stress relaxation with time	-	% in 3 hours	70	CEBTP No. 6327.7.390
Stress cracking susceptible	-	-	No	ASTM D1693
Coefficient of Thermal Expansion	maximum	cm/cm/°C	1×10^{-6}	ASTM D696
Cold bending	minimum	°C	-25	ASTM D746

S4.9.2 Mastic

The mastic used in the liner installation shall be Sopramastic or approved equivalent. The mastic shall be a solvent-based mastic containing SBS-modified bitumen, fibers and mineral fillers. Characteristics of the required material are shown in Table 4-3.

TABLE 4-3: Properties of Sopramastic

Property	Unit	Value
Specific gravity at 20 °C	kg/l	1.12
Application temperature	°C	-10 to 35
Solids by weight	%	83
Flash point (ASTM D-93)	C	25
Setting time	Hours	4 to 24 depending on temperature and thickness

S4.10 Liner Bedding

Surfaces for liner bedding shall meet the Foundation Preparation Specification for Liner Bedding.

S4.11 Execution

S4.11.1 Liner Bedding Surface Preparation

The liner bedding shall be to the lines and grades as shown on the Drawings and in accordance with the Fill Placement Technical Specification. No liner shall be placed until the Owner's Representative and QA Representative has given written approval of the liner bedding surface.

Before beginning installation of the liner, a surface acceptance form, as prepared by the QA and QC Representatives, must be signed by the liner installer first and then by the Owner's Representative. This acceptance may be segmented in order to cover only localized areas of the liner placement at any one time. No roll shall be installed before the surface preparation acceptance form has been signed.

S4.11.2 Installation

The Contractor is in charge of the transportation of the rolls of the liner to the work site. Subcontractor (Liner Installer) is in charge of installation of the liner, QC testing and document preparation.

The Subcontractor shall install the liner using personnel experienced in the deployment and welding of bituminous liners. The Subcontractor shall submit a list of proposed personnel to the Owner's Representative for approval at least two weeks prior to the liner deployment, and specifically identify the experience of the personnel that will install the liner.

The Subcontractor shall install the liner in accordance with the Manufacturer's instructions, and these Specifications. The Contractor is responsible to prevent any damage that may be caused due to the liner cover placement or other construction activities.

In order to minimize mechanical damage to the liner during installation:

- Using brooms, maintain the liner surface free of stones;
- the equipment used shall not damage the liner;
- personnel working on or near the liner shall wear boots that will not damage the liners; and
- only all-terrain vehicles (ATV) with low pressure tires may traffic on the uncovered surface of the liner.

Following the installation, each in-place liner panel shall be visually inspected by the Contractor, QA Representative and Owner's Representative in order to identify any damaged surfaces or abnormal appearance. Any defect must be repaired promptly by the Subcontractor. Additionally, the Subcontractor shall carry out required QC testing and sampling as specified in the QC/QA Specification.

The QA Representative will inspect and approve the liner installation only upon receiving all required QC documentation.

S4.11.3 Deployment of Rolls

The surface of the bedding material must be smoothed, free of protruding stones, clean, and dry. When deploying the rolls the Contractor shall ensure that the liner panels are properly aligned, with a minimum overlap of 200 mm. Chalk marks 200 mm from the panel edges shall be used to lay out the panels.

S4.11.4 Flaws in Membrane

Flaws, which shall be repaired, shall not exceed one per 500 m^2, unless otherwise approved by the Owner's Representative. Edge flaws will only be accepted if they do not interfere with the seaming process. Defects such as holes, blisters, undispersed raw materials, or any signs of contamination by foreign matters, shall result in rejection of the roll.

S4.11.5 Torch Welding

The liner shall be welded using propane torches. The torch-welds must be performed according to these Specifications, and the instructions of the Manufacturer.

Liner panel ends and overlaps must be welded on a homogeneous and continuous basis, leaving a 6 to 10 mm bitumen bead along the seam.

Seams shall be aligned and welded so that a smooth surface is created with minimal wrinkles. The area in the immediate vicinity of the seam shall be free of moisture, dust, dirt, debris or any other foreign material. Seams shall be welded directly following deployment of the liner.

To the extent possible, welding of seams should be done from the bottom to the top of the slope. No horizontal welds shall be allowed on slopes of greater than 10% incline, except on small, localized patches required to repair defects. All seams shall be completed by a welding reviewer, who has not been a part of the welding team for that seam, completing visual checking and trowel testing of the entire seam length.

The Contractor shall note the following information for each weld performed:

- Weld identification number;
- Date and time of start and finish of welding;
- Corresponding roll identification numbers of welded sheets; and
- Welder's name and his certification number.

A copy of this information shall be provided to the Owner's Representative and QA Representative for approval.

S4.11.6 Installation Temperature

The ES2 liner may be installed in ambient air temperatures as low as -20 °C (or -30 °C including wind chill factor). The Contractor shall not install ES liner when the

ambient air temperature is lower than -25°C (including wind chill factor) without prior written approval of the Owner's Representative.

S4.11.7 Quality Control

The Subcontractor shall provide on-site supervision, equipment and QC testing during the installation period, for inspection of the completed liner and seaming of the liner, as required to warrant the entire liner assembly. The Subcontractor shall maintain and clean all equipment on a regular basis to ensure that it is in good working order.

S4.11.8 Repairs

Seams and defective areas identified during the QC testing and inspections shall be repaired, and the areas re-inspected and re-tested until approved by the Owner's Representative.

S4.12 Warranty

Without limiting the provisions of any Contract with the Owner, the Contractor shall warrant the liner assembly meets the requirements covered by these Specifications.

The warranty shall provide for the total and complete repair or replacement of any defective seams that may be identified at any time, upon written notification and demonstration by the Owner of the non-conformance of the liner installation with these Specifications. The Contractor shall correct defects within thirty (30) days of notification of defect.

The Contractor shall guarantee the liner assembly according to these Specifications for a period of ten (10) years, starting from the date of completion of the installation of the liner. This guarantee shall cover repair of defective liner seams. The guarantee shall also cover all defects consequent to inappropriate preparation, levelling, compaction or surfacing of the stratum, anchorage or subsequent back-filling.

S4.13 Site Clean-up

The Contractor shall ensure that all excess or waste materials, debris, sand bags or any other extraneous materials are removed from the site whenever they are no longer required. Upon completion of work in any given area, the Contractor and the QA Representative shall examine that area to determine whether all waste and extraneous materials have been removed and that the area has been left in a satisfactory clean condition to allow placement of materials on top of the liner.

The polyethylene film and kraft paper which comes off the liner when it is installed must be collected and disposed of away from the construction works area following site procedures.

S4.14 Completion of Work

The installation of the liner shall be considered as totally complete when: all required deployment, field seaming, testing and repairs, and site clean-up have been completed by the Contractor; the Contractor has submitted all the required quality control documentation to the Owner's Representative; and the QA Representative is satisfied that the liner has been installed in accordance with the above Specifications.

S4.14.1 Work Completion Report

The Work Completion Report prepared by the Contractor and forwarded to the Owner's Representative within 30 days following the end of the installation of the liner shall include:

- As-built panel layout drawings, in AutoCAD and hardcopy formats;
- Roll deployment record;
- Seaming record;
- Repair record;
- QC testing summary, and
- Warranty.

S5 NON-WOVEN GEOTEXTILE

This Specification covers handling and installation of non-woven geotextile as shown on the Drawings.

S5.1 Geotextile Properties

- Material shall be a needle punched non-woven polypropylene or polyester geotextile with minimum mass unit area of 340 g/m^2.

- The geotextile shall be used to wrap around the fine filter (Zone 3) and underlying the riprap.

- The geotextile shall meet or exceed all material properties listed in Table 5-1.

Table 5-1: Required Properties of the Geotextile Fabrics

Material Property	Qualifier	Units	Values	Test Method
Structure	-	-	Needle Punched Non-Woven	-
Polymer Composition	Minimum	%	95% by wt. Polypropylene or Polyester	-
Mass per Unit Area	MARV	g/m^2	340	ASTM D 5261
Grab Tensile Strength	MARV	kN	1.02	ASTM D 4632
Grab Elongation	MARV	%	50	ASTM D 4632
Puncture Strength	MARV	kN	0.7	ASTM D 4833
Trapezoidal Tear Strength	MARV	kN	0.42	ASTM D 4533
UV Resistance	Minimum	%	70	ASTM D 4355

Notes:
1. MARV – Minimum Average Roll Value (QA Testing quality shall meet or exceed the minimum average roll value).
2. Manufacturers Quality Assurance (MQA) sampling shall be in accordance with ASTM D 4354
3. Required values given in this Table are based on GRI Test Method GT12 (a) (Table 1b) dated February 18, 2002.

S5.2 Submittals

- The Contractor shall provide the Owner's Representative a certificate stating the name of the geotextile manufacturer, product name, style, chemical composition and other pertinent information to fully describe the geotextile.

- Manufacturing Quality Assurance testing for the geotextile shall be performed at a frequency in accordance with ASTM D4354. Manufacturing Quality Control test results shall be provided upon request.

S5.3 Temporary Storage, Protection and Handling

- Geotextile shall be supplied in rolls wrapped in protective covers and marked or tagged with the following information: Manufacturer's name, Product identification; Lot number; and Roll number and dimensions.

- During the shipment and storage, the geotextile shall be kept in its wrapping and protected from exposure to sunlight, mud, dirt, dust, puncture, cutting, or other damaging or deleterious conditions. Wrappings shall be removed from a roll only when being handled in preparation for placement.

- The Owner shall store the geotextile rolls received on site according to the Manufacturer's written instructions. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from site construction damage, extended exposure to ultra violet (UV) radiation, precipitation, chemicals, flames, sparks, temperatures in excess of 71°C and any other environmental condition that might damage the geotextile.

S5.4 Installation

- The Contractor shall handle the geotextile in a manner to ensure it is not damaged.

- Material damaged during storage and handling may be rejected by the QA Representative, in which case it shall be removed from site and replaced at the Contractor's expense.

- Prior to installation, the QA Representative shall inspect the subgrade surface to ensure that the prepared surface is suitable for the geotextile cushion installation.

- Do not allow geotextile to "bridge over" voids or low areas in the subgrade. Subgrade shall be repaired by the Contractor where required such that the geotextile rests uniformly on the subgrade surface.

- Minimize disturbance of the subgrade surface by the geotextile installation activities.

- The geotextile shall be installed in accordance with the Drawings or as directed by the Owner's Representative.

- During placement, care shall be taken not to entrap soil, stones, excessive dust, or moisture that could damage the geotextile, or clog the geotextile or hamper subsequent seaming or joining.

- The geotextile shall be placed by unrolling geotextile onto subgrade surface according to the Manufacturer's instructions.

- All geotextile shall be cut using an approved cutting method and approved equipment only.

- The geotextile sheet shall be installed with sufficient tension to preclude folds and wrinkles and the entire geotextile sheet shall be weighted with sandbags or equivalent to avoid wind damage. Pins or stakes will not be permitted.

- Remove and replace damaged or deteriorated geotextile as directed by the QA Representative. Geotextile contaminated by mud, dust or dirt may require washing or removal and replacement as directed by the QA Representative. Remove deleterious materials from geotextile prior to covering, as directed by the QA Representative.

- Passage of any vehicle directly on the geotextile cushion shall not be permitted at any time.

- If weather damage should occur, the QA Representative will determine if the geotextile shall be repaired or replaced. Weather damage to the geotextile will include tears and dirty fabric.

- Repair or replacement of the weather-damaged geotextile shall be completed by the Contractor at no additional cost to the Owner.

- Adjoining panels of geotextile shall overlap by a minimum of 0.6 m. Greater overlaps shall be provided if there is potential for the overlap to move. To the extent practicable, placement shall be accomplished by advancing the geotextile in the upslope direction only, such that each upstream panel overlaps the adjoining downstream panel.

S5.5 Seaming

- All geotextile seams shall be continuously sewn or heat bonded. Geotextile panels to be overlapped a minimum of 0.6m prior to seaming. All seams alongside slopes shall be oriented downslope. Areas to be seamed shall be clean and free of foreign matter.

- All sewing of geotextile seams shall be carried out using polymeric thread with chemical resistance properties equal to or exceeding those of the geotextile. All heat bonded geotextile seams shall be carried out with a welder specifically designed for geotextile seaming.

- Seams shall be sewn to provide a flat (prayer) seam, “J” seam, or “butterfly-folded” seam, having 3 to 6 stitches per 25 mm. The stitch type to be a double-locking chain stitch or other if approved by the QA Representative.

- When sewing a flat seam, stitching shall be approximately 38 mm (+/- 6 mm) from the outside edge of the fabric (not in the selvage or at the selvage edge). The “J” fold and Butterfly fold seams require a fold 30 mm to 50 mm from the fabric edge with the stitching approximately 25 mm from the folded edge.

- Place geotextile such that factory sewn seams remain visible to facilitate inspection after deployment.

S5.6 Repairs

- Repair any holes or tears in the geotextile by sewing in place a patch made from the same geotextile, with a minimum of 0.6m overlap in all directions.

- In the event of damage to the geotextile cushion, immediately make all repairs and replacements necessary, to the approval of the QA Representative, at no additional cost to the Owner.

- Atmospheric exposure of the geotextile cushion to the elements following lay down shall be limited to 14 days to prevent damage, unless the Manufacturer specifies otherwise.

S6 QUALITY CONTROL (QC) AND QUALITY ASSURANCE (QA) PLAN

S6.1 Scope

This Specification defines the requirements for the Quality Control and Quality Assurance for construction of the Internal Structure.

The Specification includes:

- Equipment list for the field laboratory;
- Minimum QC site inspections and testing requirements;
- Minimum QA site inspections and testing requirements;
- Documentation requirements for QC and QA activities;
- Checklists for QC/QA of the major construction activities; and
- Corrective action procedures for non-conforming materials.

S6.2 Site Inspection and Testing

The tasks of the Owner's Representative, the QA Representative, the QC Representative the Contractor and the Liner Installer for QA and QC construction activities are listed in Table 6-1.

Table 6-1: Construction Activities and QC/QA Responsibilities

Activities	Tasks			
	Contractor (incl. Liner Installer)	**QC Representative**	**QA Representative**	**Owner's Representative**
Borrow Materials, Sources, and Storage	• Documentation; • Surface water management; and • Prevent material segregation; • Provide assistance to QC/QA during material sampling.	• Perform QC testing including gradations and water content; • Perform visual inspection of materials; • Documentation including photographic records.	• Perform QA testing including gradations, water content and density; • Perform visual inspection of materials; and • Documentation including photographic records.	• Perform QC testing during crushing operations; and • Classify PAG and NPAG materials. • Approve suitability of borrow material and storage area for construction; • Approve quantities.
Foundation Preparation and Excavations	• Propose removal methods for unsuitable materials; • Surface water management; • Prepare sumps, pumps, and lines for dewatering; • Care of water; • Report unusual conditions; • Survey lines conform with Drawings; • Plan excavation and waste material disposal; • Provide excavation records; • All in situ material loosened from excavation removed from trench; • Excavation stability; • Prepare foundation material for direct placement of geomembrane, as indicated in the drawings.	•Report unusual conditions; •Inspection of foundation preparation and excavation of material •Inspection of foundation area prior to fill placement.	• Observe foundation preparation; • Documentation including photographic records; • Review survey lines and locations; • Review proposed excavation methods and blasting methods/pattern; • Observe foundation excavation; • Inspect excavation and prepared foundation area prior to fill placement; • Map bedrock and exposed surfaces for geologic features and to determine ground ice conditions; • Inspect and approve bedrock surface; • Report non-conformities; and • Review as-built survey report.	• Identify storage areas for waste materials.

Activities	Tasks			
	Contractor (incl. Liner Installer)	**QC Representative**	**QA Representative**	**Owner's Representative**
Fill Placement	• Ensure placement and extent as per Drawings; • Confirm topography; • Plan material storage and waste material disposal; • Report any unusual conditions; • Survey extent of any unusual conditions; • Surface water management; • QC survey during the Work.	•QC testing of placed material gradations, water content, and density •Report any unusual conditions; •Inspect fill surfaces prior to subsequent fill placement; •Ensure fill materials conform to Specifications; •Ensure placement and extent as per Drawings.	• Review survey lines and locations; • Inspection of liner bedding surfaces; • Inspect fill surfaces prior to subsequent fill placement; • Perform QA testing of placed material including gradations, water content, and density; • Confirm the QC results, including whether the specified fill placement, construction grades and limits are being attained and construction materials are meeting the required Technical Specifications; • Observe fill placement; • Inspect fill quality and extents; • Approval of suitability of fill materials prior to placement; • Report non-conformities; and • Documentation including photographic records.	• QC of fill gradations at crusher and as-placed; and • Review as-built survey report and approve quantities.
Geomembrane Installation	• Ensure placement and extent as per Drawings; • Perform QC testing on the Liner and provide results; • Report any unusual conditions or problems and provide resolutions; • Provide liner panel layout plan; • Inspect liner bedding material conforms to Specification and suitable for liner placement; • Provide liner panel as-built drawings.	•	• Perform QA testing; • Select samples for destructive testing; • Observe QC testing; • Inspect excavation and prepared foundation area prior to Liner placement; • Report non-conformities; • Documentation including photographic records; and • Inspect all seams and liner material prior to covering.	• Receive liner at Meadowbank, storage and inventory. • Review as-built survey report and approve quantities.
Geotextile Installation	• Ensure placement and extent as per Drawings; • Perform QC testing and provide results; • Report any unusual conditions or problems and provide resolutions; • Inspect bedding material conforms to Specification and suitable for geotextile placement.		• Review of required documentation; • Review QC testing results; • Report problems; • Approval of geotextile rolls for deployment; • Observation of unrolled material for damage; • Observation of seaming procedure, overlaps, and completed seams; and • Documentation including photographic records.	• Receive geotextile at Meadowbank, storage and inventory. • Review as-built survey report and approve quantities.

S6.2.1 Field Laboratory

The Owner shall provide a proper facility/location for performing the required testing in addition to suitable testing equipment, maintained in good repair, properly calibrated at all times.

The following should be provided in the field laboratory as a minimum:

- Heating, lighting, and power;
- ASTM Gradation Sieves and shaker;
- Hydrometer and appurtenant equipment;
- Oven suitable for soils testing;
- Running water;
- Aluminum moisture boxes- 4;
- Stainless steel mixing bowls – 3 large round and 3 large rectangular;
- Scale for density and water content;
- Sample splitter – 1 large and 1 standard;
- Split standard Proctor mould with hammer and straight edge;
- Tool set including screwdrivers, chisels, hammers, etc.;
- Brush, soft bristle;
- Wash bottle;
- Mortars and pestles – 2;
- Round bottom scoops – 1 large and 1 small;
- Timers – 2 – 1s resolution to 24 hours, electronic;
- Mechanical analysis stirrer for hydrometer testing;
- 10 L Sample buckets and lids;
- Crates for shipping samples;
- pH tape – 1 set;
- Sand Cone and/or nuclear densometer; and
- Rigid walled compaction mould permeameter.

In addition, the Owner shall provide calibration certificates to the Contractor and QA Representative.

S6.2.2 Minimum Field Testing and Frequency for QA/QC

The quality assurance and quality control minimum testing requirements and frequency are listed in Table 6-2. At a minimum, all the required testing to document the construction quality shall be performed.

Characterization of different rock types with respect to geochemistry is the responsibility of the Owner.

Table 6-2: QC/QA Activity with Testing and Frequency

Work	Quality Control (QC)				Quality Assurance (QA)		
	Responsible	Type of Test or Monitoring	Test Frequency	Requirement	Responsible	Type of Testing or Monitoring	Test Frequency
Borrow Material Storage	Contractor / QC Representative	Visual Observation	Continuously		Owner's Representative	Visual Observation	Periodically
Foundation preparation							
On-land location and extents	Contractor	Survey for QC	Before and after foundation preparation, excavation.		Owner's Representative	Survey for QA and as-built following the work.	Before and after foundation preparation, excavation.
Foundation Preparation Inspection	QC Representative	Visual Observation	Continuously		QA Representative	Visual observation and photographs	Periodically during work; fully over area prior to fill placement
Inspection Placement Surface for Geotextile and liner	Liner Installer	Visual Observation	Continuously		QA Representative	Visual Observation	Periodically during work; fully over area prior to geotextile and liner installation
Fills							
Rockfill (Zone 1)	Contractor	Visual Gradation	Continuously		QA Representative	Visual Gradation	Periodically
	Owner	Geochemical Classification of Rockfill	As Required				
	Contractor	Placement - Visual Inspection	Continuously	Max. 500 mm loose lift thickness;	QA Representative	Visual Inspection	Periodically
		Compaction - Visual Inspection	Continuously	4 passes w/ 10 t smooth drum vibratory roller;	QA Representative	Visual Inspection, count compaction passes.	Periodically
Coarse Filter (Zone 2)	Owner	Gradation (in stockpile)	1 every 5,000 m^3		QA Representative	Gradation	1 in every 5 QC tests
	QC Representative	Gradation (as placed)	1 every 5,000 m^3		QA Representative	Gradation as placed	1 in every 5 QC tests
		Compaction - Visual Inspection	Continuously		QA Representative	Visual Inspection	Periodically
		Compaction – Visual Inspection	Continuously	4 passes w/ 10 t smooth drum vibratory roller;	QA Representative	Visual Inspection, count compaction passes.	Periodically
Fine Filter (Zone 3)	Owner	Gradation (in stockpile)	1 every 1,000 m^3		QA Representative	Gradation	1 every 5 QC tests
	QC Representative	Gradation (as placed)	1 every 1,000 m^3		QA Representative	Gradation as placed	1 every 5 QC tests
		Placement - Visual Inspection	Continuously	Max. 0.5 m loose lift thickness;	QA Representative	Visual Inspection	Periodically
		Compaction - Visual Inspection	Continuously	4 passes w/ 10 t smooth drum vibratory roller;	QA Representative	Visual Inspection, count compaction passes.	Periodically
Geotextile							
Sample Collection for Conformance Testing	Contractor	Collect sample of Geotextile	At the request of the Engineer	1 m wide sample, cut across width of roll, not within 1 m of roll end. Label roll number, machine direction, date and name of sampler.	QA Representative	Visual Inspection of sampling	As requested
Placement	Contractor	Visual Observation of Seams and Panels	Continuously	Visually inspecting seams. Ensuring they are properly sewn or that a minimum	QA Representative	Visual Observation	Periodically

Work	Quality Control (QC)				Quality Assurance (QA)		
	Responsible	Type of Test or Monitoring	Test Frequency	Requirement	Responsible	Type of Testing or Monitoring	Test Frequency
				overlap of 450 mm is achieved.			
Liner Installation							
Sample Collection for Conformance Testing	Liner Installer	Collect sample of the liner	At the request of the QA Representative	1 m wide sample, cut across width of roll, not within 1 m of roll end. Label roll number, machine direction, date and name of sampler.	QA Representative	Visual Inspection of sampling, Determination of Conformance Testing to be Performed	As requested
Rolls	Liner Installer	Visual inspection of the unrolled panels for holes, blisters, undispersed raw materials and marking for repair or rejection.	Each Roll		QA Representative	Visual Inspection	Each Roll
Test Welding Equipment	Liner Installer	Calibration Test Seams	Each welder and piece of equipment that will be seaming, at the beginning of each day, and a minimum of once during the middle of the shift.	Load at failure for all samples meets requirements for peel and shear.	QA Representative	Visual Inspection, Oversee Testing	1 every 5 QC tests
Testing	Liner Installer/Contractor	Table 6-3			QA Representative	Table 6-4	

Increased testing frequencies shall be instituted by the Owner's Representative if observations of normal testing frequencies result indicate potential problems. Additional testing may be warranted when:

- The material repeatedly fails to meet Specifications;
- The degree of compaction is doubtful;
- The materials appear to differ from those specified;
- Less than the required number of compaction equipment passes are made;
- The material water contents differ from those specified;
- The lift thicknesses differ from those specified; or
- Adverse weather conditions occur.

S6.3 Geomembrane Liner

The Contractor shall conform to the minimum Quality Control/Quality Assurance Program detailed in this section.

S6.3.1 Schedule of QC Testing

The Contractor shall perform testing of the type and frequency indicated in the following table.

TABLE 6-3: Schedule of QC Testing by Contractor

Type of Test	In-situ or sample extraction	Testing Standard [1]	Frequency of Testing	Specified Value
Tensile Shear Strength of Bituminous Seams	Sample extraction	D 7056	1 per 1000 m of seam length	ES 15 kN/m (min.)
Vacuum Box Testing [2]	In-situ	-	1 per 30 m of seam length	No defects permitted
Ultrasonic Testing of Seams [2]	In-situ	-	1 m per 300 m of seam length	No defects permitted
Visual [3]	In-situ	-	Along entire seam	-

Notes: *1.* Standard is ASTM unless otherwise noted.
2. Vacuum box testing shall be done a minimum of once per shift when liner is being placed.
3. Visual inspection, including trowel testing, of seam to be completed by someone who was not a part of the welding team.

The Contractor shall extract samples for the QA testing at the request of the QA Representative to perform the following QA testing.

TABLE 6-4: Schedule of QA Testing by QA Representative

Type of Test	Testing Standard [1]	Frequency of Testing	Specified Value
			ES2
Oversee vacuum box test	In-situ	1 every 10 QC tests	Pass
Oversee ultrasound tests	In-situ	1 every 5 QC tests	Pass
Thickness	D5199	1 per 1000 m of seam length	4.0 mm (min.)
Density	D792	1 per 1000 m of seam length	1.244 g/cm³
Tensile Shear Strength of Bituminous Seams	D7056	1 for every 5 QC tests	15 kN/m (min)
Tensile Shear Strength of Bituminous Liner Material	D4595-86	1 per 2000 m of seam length	26.8 kN/m longitudinal 22.9 kN/m transverse

Note: 1. Standard is ASTM unless otherwise noted

S6.3.2 Documentation and Reporting

The Subcontractor shall prepare and submit the following Liner QC documentation, in electronic and hardcopy formats:

The Final Report shall include:

- Summary of work completed;
- list of equipment working on project;
- number of personnel in each trade;
- results of QC field and laboratory testing and test data sheets;
- repair records (including documenting the location of all repairs on layout plan);
- description of incidents and problems, and steps to solve them and prevent re-occurrence; and
- additional information for cold weather seaming (defined as temperatures below 0°C, including wind chill), which includes:
  - Ambient air temperature measured 1 m above the liner;
  - Method of removing frost from area to be seamed, as well as drying and cleaning of surface;
  - Condition of subgrade beneath seamed area;
  - Identification of seaming system used, including preheat, seaming rate and use of enclosure; and
  - Unusual conditions with respect to personnel, equipment, sampling and testing attributes to cold weather.

S6.3.3 Field Inspection of Liner and Testing of Seams

a) By Subcontractor:

Carry out inspection of membrane after installation and perform destructive and non-destructive testing of seams in accordance with the Specifications. Extract samples for QA destructive testing as requested by the QA Representative.

b) By QA Representative:

The QA Representative will inspect the liner installation and periodically audit the Contractor's QC test procedures and documentation and will collect samples for QA testing. Any deficiencies identified by the QA Representative shall be corrected promptly by the Liner Installer.

The Contractor shall cooperate with the QA Representative, and shall extract QA field samples as requested by the QA Representative. The Contractor shall allow the QA Representative to oversee QC testing and inform the QA Representative of planned QC testing. The Contractor shall also give a minimum of 4 hours' notice to the QA Representative when liner seams are ready for inspection when QC testing is complete. The liner shall not be covered before the QA Representative has performed tests and given written approval of material and seams.

APPENDIX C

Hazard Classification

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

September 29, 2017

Site: 65.04 N, 96.08 W User File Reference: Meadowbank Gold Mine

Requested by: Kebreab Habte, Golder Associates Ltd

National Building Code ground motions: 2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.05)	Sa(0.1)	**Sa(0.2)**	Sa(0.3)	**Sa(0.5)**	**Sa(1.0)**	**Sa(2.0)**	**Sa(5.0)**	**Sa(10.0)**	**PGA (g)**	**PGV (m/s)**
0.064	0.087	**0.083**	0.069	**0.055**	**0.032**	**0.015**	**0.0035**	**0.0015**	**0.049**	**0.042**

Notes. Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC 2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are specified in **bold** font. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. ***These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.***

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.05)	0.0061	0.021	0.035
Sa(0.1)	0.010	0.032	0.051
Sa(0.2)	0.012	0.034	0.051
Sa(0.3)	0.011	0.030	0.044
Sa(0.5)	0.0079	0.024	0.036
Sa(1.0)	0.0039	0.014	0.021
Sa(2.0)	0.0015	0.0057	0.0096
Sa(5.0)	0.0004	0.0012	0.0020
Sa(10.0)	0.0003	0.0007	0.0010
PGA	0.0055	0.018	0.029
PGV	0.0045	0.016	0.026

References

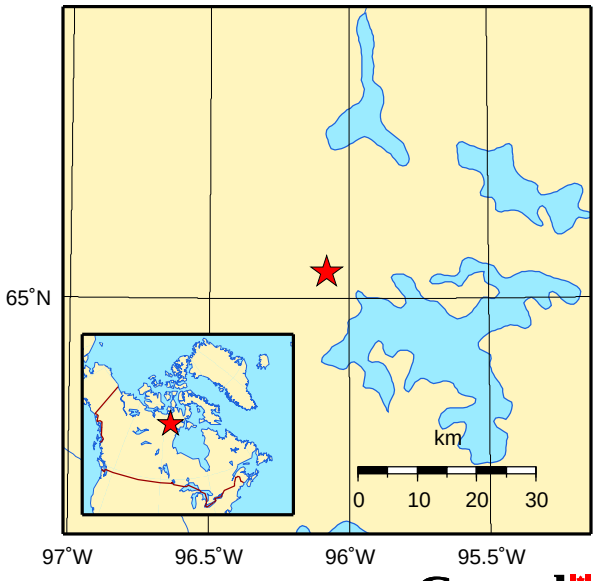
National Building Code of Canada 2015 NRCC no. 56190;
Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

User's Guide - NBC 2015, Structural Commentaries NRCC no. xxxxxx (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites *www.EarthquakesCanada.ca* and *www.nationalcodes.ca* for more information

Aussi disponible en français



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