27 August 2018

Assol Kubeisinova
Technical Advisor, NWB
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RE: Response to Comments
Waste Rock Facility Pond Expansion - Modification Request No. 8
Mary River Project, Type 'A' Water Licence - 2AM-MRY1325 - Amend. No. 1

Baffinland Iron Mines Corporation (Baffinland) provides the attached responses to comments received from the Qikiqtani Inuit Association (QIA)[1] and Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC)[2] regarding Water Licence Modification Request No. 8.

We trust that the attached responses provide additional clarification on the proposed work and infrastructure changes at the Project. Please do not hesitate to contact the undersigned should you have any remaining questions or comments.

Regards,

Christopher Murray
Environmental & Regulatory Compliance Manager

Attachments:
Attachment 1: Baffinland Response to Comments
Attachment 2: Waste Rock Facility Pond Expansion - Specification No. 1790951, Rev. 0
Attachment 3: Design Criteria for 2019 to 2019 Waste Rock Management Pile

Cc: Karén Kharatyan (NWB)
Fai Ndofor, Sean Joseph (QIA)
Sarah Forte, Bridget Campbell, Ian Parsons (CIRNAC)
Grant Goddard, Megan Lord-Hoyle, Tim Sewell (Baffinland)

[1] QIA (2018) Re: Mary River Project – Waste Rock Facility Sedimentation Pond Modification Request No. 8. Water Licence 2AM-MRY1325. Letter dated July 16, 2018.
[2] CIRNAC (2018) Re: Crown-Indigenous Relations and Northern Affairs Canada's comments on Baffinland Iron Mines Corporation's Modification Request No. 8 – Waste Rock Facility Pond, Water Licence 2AM-MRY1325 - Amendment No. 1. Letter dated July 16, 2018.

Attachment 1

Baffinland Response to Comments

Table 1-1: Baffinland Response to QIA and CIRNAC Comments RE: Modification Request No. 8

ID	Comment	Baffinland Response
	QIA Comments	
1	Baffinland may not construct the WRF Pond without QIA approved security in place. The joint assessment of security is currently ongoing.	Confirmed, Baffinland is engaged with QIA to ensure adequate reclamation security is in place prior to construction. A Joint Submission to the NWB was presented on July 20, 2018, which encompassed this scope of work.
2	Baffinland to follow the Lease As Built Operations Guide, further detailing expectations of Article 6.4 item c) of the Lease when preparing the As Built Report/Construction Summary Report for the WRF Pond. This does not limit Baffinland's requirements to Part D, item 17 of the Water Licence.	Baffinland will prepare As-Builts and a Construction Summary Report, per the Type A Water Licence Part G, Item 4 required for a Modification Request. Consideration will be given to the requirements outlined in the Draft As-Built Lease Operations Guide, however it is noted that Baffinland and QIA have yet to finalize and implement this document.
3	Baffinland to provide information that explains how this modification has incorporated uncertainties with permafrost depth. The frozen ground assumption used for the original WRF Pond design, which has been the subject of a spill[4] where the lack of depth of permafrost identified in the Construction Summary Report[5] has not been ruled out as the cause of the spill.	The pond berm and pond described in the Civil Design Report and IFC drawings does not rely on permafrost to provide a low permeability barrier as the entire pond is lined with HDPE. The main change from the original design to the current expansion design involves the anchoring of the upstream edge of the liner. The original key trench was identified in the Construction Summary Report as having collapsed due to poor ground conditions. (It was subsequently repaired.) The key trench was identified as a potential location for seepage as ponded water was observed at the key trench in 3 locations. (The key trench was subsequently covered with a till blanket.) The current expansion design involves excavating a key trench within a rockfill berm and in native ground followed by backfilling the key trench. The berm thickness is a minimum of 2 m at the location of the key trench. It is expected the permafrost will aggrade up into the key trench. The key trench is also offset from the pond water edge by a minimum of 10 m. Thus it is not located in the pond thaw zone and is therefore expected to remain stable.
4	Baffinland to provide the outcomes of the detailed inspection discussed in Section 2.0 of the Civil Design Report and any required repair or remediation carried out as part of the construction summary report.	Baffinland will discuss the outcomes of the detailed inspection and any required repair or remediation in the Construction Summary Report, required by Part G, Item 4 of the Type A Water Licence.
5	Baffinland to provide the construction specifications of the WRF Pond.	It is not clear what specifications QIA has identified are absent from the submission. Baffinland has provided signed and stamped IFCs and an accompanying design brief confirming the IFCs.
6	Baffinland to provide a site specific geotechnical investigation. QIA does not consider using boreholes from 2 km away to be standard practice for structures that maintain and withhold water.	As recommended in the Civil Design Report, Baffinland has retained Golder to complete a test pitting program to confirm the foundation conditions. Results of the test pitting program will be provided to QIA and CIRINAC after the investigation.
7	Baffinland to provide the maximum discharge rate out of the WRF Pond allowed to ensure stability. QIA's concern is that the maximum rapid draw down rate in the WRF Pond was assessed to be the treatment rate of the Water Treatment Plant. QIA is concerned that this rate or a higher rate, in the case that the water does not need to be treated could affect the stability of the Waste Rock Sedimentation Pond.	The phreatic surface assumed in the stability model is conservative for a lined rockfill berm. At any expected pumping rate, the stability of the rockfill berm will not be a concern. Due to the high permeability of the rockfill it will drain more quickly than the pond water level will decrease by pumping.
8	Baffinland to provide an Operations, Maintenance, and Surveillance (OMS) Manual/Plan based on requirements of Section 3 of the Canadian Dam Association (CDA) Dam Safety Guidelines[6]. The OMS should provide detailed instrumentation and monitoring plans, including but not limited to sampling locations, parameters measured, and frequencies of sampling to be carried out.	Baffinland considers it is adequately operating the WRF and conducting regular inspections at a satisfactory frequency. The formalization of those processes in a OMS manual will be developed and provided to regulators and stakeholders with the submission of the Construction Summary Report, required by Part G, Item 4 of the Type A Water Licence. Relevant requirements outlined in Section 3 of the CDA Dam Safety Guidelines will be reviewed and included in the OMS manual, as necessary.

Table 1-1: Baffinland Response to QIA and CIRNAC Comments RE: Modification Request No. 8

ID	Comment	Baffinland Response
9	Prior to construction, Baffinland to provide construction QA/QC specifications and geomembrane liner installation specifications required to ensure the construction is completed according to the design intent and to an acceptable standard as detailed in Section 6.9 of the CDA Dam Safety Guidelines[6]. Specifications are to be signed and stamped by a Professional Engineer. The results of said QA/QC monitoring and installation data are to be provided in the construction summary report.	Construction QA/QC specifications are the sole responsibility of Baffinland to commission and implement, and are not a requirement of the Type A Water Licence 2AM-MRY1325 or the Commercial Lease Q13C301. Baffinland retains all risk and liability for the construction of infrastructure at the project, and does not consider QIA review and approval of construction QA/QC to be warranted. In the interest of addressing QIA concerns, the construction QA/QC specifications for the proposed work is detailed in Attachment 2 of this submission, but is provided for information purposes only and shall not be subject to review and comment. Results of any QA/QC monitoring implemented by Baffinland will be provided Construction Summary Report, required by Part G, Item 4 of the Type A Water Licence.
10	Baffinland to provide volume balance to demonstrate that the WRF Pond has sufficient storage capacity and contingency volume.	This is detailed in the Golder Section 5.6. The total storage capacity is 65,000 m3, for a catchment area of 585,000 m2. Maximum predicted pond inflow for a 15 day event is 50,130 m3. Predicted inflow for the 1:10 year 24 hour event (current design criteria) is 12,000 m3. Therefore the pond volume is sufficient.
11	Baffinland to provide the "Design Criteria for 2018 to 2019 Waste Rock Management Pile"[7] and "A hydrological Study to Support Pond Design Calculations at the Mary River Mine, Baffin Island, Nunavut[8] Golder reports from 2018.	Baffinland has retained Golder Associates to provide a detailed design brief for the proposed work, as per the requirements outlined in Part G of the Type A Water Licence. Baffinland does not believe an extensive review by the QIA of the design brief's references and supporting documentation is warranted. To statisfy QIA concerns, the Design Criteria for 2018 and 2019 Waste Rock Management Pile is provided as Attachment 3, for reference only and shall not be subject to review and approval. Additional details on the proposed design of the Waste Rock Facility is discussed in the Interim Waste Rock Management Plan, provided as Appendix E.5 of the 2017 QIA & NWB Annual Report for Operations. The findings of the referenced hydrology study are detailed in Section 3.2 of the design brief provided. To provide additional clarity on waste rock management practices and plans at the Project, Baffinland will be providing to the QIA and regulators an updated Waste Rock Management Plan by the end of December 2018.
12	Baffinland to explain how the Mary River climate station data recommendation will be used to verify the rainfall intensity-duration-frequency statistics in relevant management and monitoring plans.	A reliable correlation between the local climate data and the Environment and Climate Change Canada stations could not be established given the short duration of local data records. The IDF curves developed by KP and presented by Hatch (2013) are considered to still be valid. Therefore there is no need to update design, monitoring or management practices at this time.
	CIRNAC Comments	
1	Baffinland should include a detailed plan to identify the cause(s) of the observed seepage from the WRF sedimentation pond prior to any pond expansion activities so that appropriate mitigation measures can be implemented to prevent any seepage from entering the environment.	Baffinland conducted a dye test and measured a water level decrease below the key trench elevation, without pumping any water out of pond. As result, it is concluded that the seepage observed in August 2017 is likely due to damage of the geomembrane liner. Representatives from Golder and Layfield will inspect the geomembrane liner for damage when the pond water level has been drawn down. The results of this inspection will be provided to CIRNAC.
2	Baffinland should obtain the critical information on the WRF pond berm foundation conditions through boreholes and conduct laboratory testing to verify if the strength parameters used in the model are adequate. At the minimum, Baffinland should implement Golder's recommendations noted in the Civil Design Report.	Baffinland has retained Golder to complete a subsurface investigation to confirm the foundation conditions as recommended in the Civil Design Report. Results of the investigation will be provided to QIA and CIRINAC after the investigation. Based on the proposed height of the berm and the anticipated ground conditions- either bedrock or permafrost within a couple meters of surface- test pitting is appropriate, consistent with the Golder recommendations. Additionally, test pitting allows for better observation of the subsurface conditions whereas a borehole is limited to the diameter of the borehole in a select location.
3	Baffinland should design the diversion ditches by also taking into consideration that any potential seepage from the ditches needs to be prevented as contact water from the WRF could be acidic and contain high level of dissolved metals.	The slope of the west ditch ranges from 0.9% to 6.6% and for the east ditch ranges from 1.1% to 6.6% to promote conveyance of the run-off. Any seepage from the east collection ditch will be inwards toward the pile. To minimize the potential of seepage out of the west collection ditch, potential seepage locations will be identified in the field by the Engineer and the spoil excavated from the ditch will be used to construct a berm on the downstream side of the ditch to raise the permafrost in the native ground such that the expected water level in the ditch is maintained below the permafrost level.

Table 1-1: Baffinland Response to QIA and CIRNAC Comments RE: Modification Request No. 8

ID	Comment	Baffinland Response
4	Baffinland should have management or mitigation measures in place for the appropriate disposal of the sediment in the WRF sedimentation pond.	Due to the difficulties associated with mechanically reclaiming sediment in a containment pond without potentially damaging the pond's underlying geomembrane liner, sediment captured in the Waste Rock Facility Pond will be resuspended and reclaimed using the Facility's dedicated water treatment plant. Resuspended sediment will be captured in the water treatment plant's geotubes. During 2018, Baffinland will further investigate the management of sediment captured within the geotubes and will include a proposed path forward with the submission of the Waste Rock Management Plan update to regulators and stakeholders, planned for the end of December 2018. It should be noted that the disposal of captured sediment is not anticipated to occur prior to the Waste Rock Management Plan update.

Attachment 2

Waste Rock Facility Pond Expansion - Specification No. 1790951, Rev. 0

Baffinland

GOLDER

SPECIFICATION

The document revision number is indicated below. Please replace all revised pages of this document and destroy the superseded copies.

PROJECT:	MARY RIVER PROJECT		SPECIFICATION NO.: 1790951			REV 0
PROJECT NO:	1790951		GOLDER REFERENCE NO.: 1790951-S			
TITLE:	WRF Pond Expansion					
ISSUED FOR	REV NO.	ORIGIN	DATE		ISSUED-PAGES/SECTIONS	INITIAL
			OUT	IN		
Client Review	A	Golder	7-Aug-18	17-Aug-18	All All	MJT/KAB
Issued for Construction	0	Golder	17-Aug-18		All All	MJT/KAB

New Is

Revised Only Attached

Entire Document Re

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date 17 Aug 2018
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

FINAL DOCUMENT APPROVAL

BAFFINLAND APPROVAL		GOLDER APPROVAL	
Mine Manager:		Senior Review:	
Date:		Date:	August 17, 2018
Environmental Manager:		Project Manager:	
Date:		Date:	August 17, 2018
Engineering Lead:		Originator:	
Date:		Date:	August 17, 2018

Table of Contents

1.0 GENERAL REQUIREMENTS

1.1 Definitions

1. The definition of primary terms used on the Drawings and in the Specification for this contract is listed below:

a)	CONTRACTOR	The party (parties) awarded the contract(s) by the OWNER and all SUBCONTRACTORS and vendors secured by the party (parties) for execution of the work under or related to the Specifications. Work under this Specification includes procurement and supply of materials, equipment, tools, supervision, and labor for performing all parts of work specified in this document. Various portions of the Work described in this Specification may be awarded to multiple CONTRACTORs and, therefore, "CONTRACTOR" does not refer to one sole party. For earthworks activities the OWNER will act as the CONTRACTOR.
b)	CQA	Construction Quality Assurance (CQA) refers to the means and methods utilized by the OWNER to verify conformity to the design intent, the Specifications, and Drawings.
c)	CQC	Construction Quality Control (CQC) refers to the actions taken by the CONTRACTOR to ensure that the materials provided to them, the materials they produce, and their own workmanship, meet the requirements of their construction quality control program, the Specifications, and the Drawings.
d)	Drawings	The Issued for Construction Drawings prepared by the ENGINEER.
e)	ENGINEER	The qualified company or person(s) who is appointed by the OWNER to develop the Specifications and Drawings. The ENGINEER for the Mary River Project- WRF Pond Expansion as identified by these Specifications is Golder Associates Ltd. (Golder). The ENGINEER is an agent of the OWNER.
f)	OWNER	Wherever used in this Specification shall mean Baffinland Iron Mines Corporation, unless otherwise specified.
g)	OWNER'S REPRESENTATIVE	The qualified company or person(s) who is appointed by the OWNER to work as the OWNER's agent in the construction work to perform quality assurance testing and monitoring to verify and document that the CONTRACTOR(s) work is in compliance with the Specifications, Drawings, and CQC/CQA Plan. The OWNER'S REPRESENTATIVE reports to and is a representative of the OWNER.
h)	Project	The Project refers to a combination of the Site, the Work, and all associated people, parties, and products for construction of the Mary River Project- WRF Pond Expansion.

i)	Site	Wherever used in these Specifications shall mean the Mary River Mine.
j)	Specifications	Refers to this document.
k)	Work	The work that is executed by the CONTRACTOR(S) for the OWNER.

1.2 Acronyms and Abbreviations

1. The acronyms and abbreviations commonly used in the Drawings and in the Specification are listed below:

a)	2H:1V	Slope of 2 horizontal units to 1 vertical unit.
b)	ASTM	ASTM International; formerly known as American Society for Testing and Materials.
c)	CSP	corrugated steel pipe.
d)	CSA	Canadian Standards Association.
e)	m	metre.
f)	mm	millimetre.
g)	N	Newton.
h)	SPMDD	Standard Proctor Maximum Dry Density
i)	t	tonne.

1.3 Summary of Work

1. Earthwork shall consist of supplying all labor, supervision, equipment, and materials necessary to construct and protect the earthworks for the WRF Pond and diversion ditches as shown on the Drawings or as required by the OWNER including:
   a) Raising of the WRF Pond Berm will require:
      i) Stripping of deleterious materials from the expanded berm footprint;
      ii) Placing of zoned fill materials layer by layer; and,
      iii) Construction of an emergency spillway channel.
   b) Construction of the diversion ditches will require:
      i) Excavation of the ditch along the design alignment;
      ii) Placement of spoil as a berm on the downstream side of the ditch excavation; and,
      iii) Placement of rip rap (as required).
   c) Geomembrane installation will require:
      i) Inspection of the existing geomembrane condition and identification to repair or replace (to be carried out by the OWNER)
      ii) Preparation of the geomembrane subgrade; and,
      iii) Installation of the geosynthetic materials in accordance with these Specifications.

1.4 Drawings and Specifications

This Specification defines the requirements for performing the Work as outlined on the most recent revision of the Drawings presented in Table 1.

Table 1: Issued for Construction Drawings

Drawing Number	Drawing Title	Revision
G-100	Cover Page	A
G-200	WRF Pond Expansion – General Arrangement	A
C-100	WRF Pond Expansion – Plan & Profile	A
C-120	WRF Pond Expansion – Sections and Details	A
C-130	WRF Pond Expansion – Sections and Details	A
C-200	WRF Pond Expansion – Spillway – Plan, Profile & Sections	A

1.5 Technical Contradictions

1. The general technical requirements specified herein shall apply to all activities and operations relating to carrying out the Work or as required by the OWNER. In the event of a contradiction in the Specifications and Drawings, the CONTRACTOR shall refer all questions to the OWNER for final decision. Work that concerns the contradiction shall not be performed until the contradiction is remedied or explained by the OWNER. In all events, the decision of the OWNER is final.

1.6 Codes and Standards

1. Cited Codes and Standards refer to the newest version of the referenced code. Tests carried out by the ENGINEER, CONTRACTOR, or OWNER will be performed in accordance with the latest principles and methods prescribed by the American Society for Testing and Materials (ASTM) and other such recognized industry standards as approved by OWNER. The tests shall include Control and Record Tests.
2. In carrying out the Work, the CONTRACTOR shall comply with the site Water Licence No. 2AM-MRY 1325.
3. The CONTRACTOR shall carry out the Work in accordance with all environmental regulations and OWNER site policies.

1.7 Continuity of Work

1. The CONTRACTOR shall complete the Work within the Contract period.
2. The CONTRACTOR shall carry out the Work on a continuous basis, without undue delay, unless agreed upon otherwise with the OWNER.
3. In the event that there is a dispute regarding the payment for any part of the Scope of Work, whether completed, in progress, or planned, the CONTRACTOR shall continue to carry out the Work without undue delay. The CONTRACTOR shall not stop the Work progress as a result of any payment dispute.

2.0 CONSTRUCTION QUALITY CONTROL (CQC) AND CONSTRUCTION QUALITY ASSURANCE (CQA)

1. The CQC testing program shall consist of testing of materials used in the Project. The types of materials are defined in the Specifications. All tests shall be performed by the CONTRACTOR on-site and/or at an approved geotechnical testing laboratory.
2. The objective of this plan is to assure that the proper materials, construction techniques, and procedures are followed by the CONTRACTOR, and that the intent of the design is met.
3. The CQC Plan is independent of the CQA programs conducted by the OWNER'S REPRESENTATIVE. The intent of the CQC Plan is to provide verification and testing, to demonstrate that the CONTRACTOR has met its obligations in the supply and installation of the Work according to the Drawings and Specifications.
4. Quality assurance is provided by the OWNER or OWNER'S REPRESENTATIVE and refers to those actions taken by the OWNER or OWNER'S REPRESENTATIVE to verify that the CONTRACTOR has provided materials and workmanship that meet the requirements of the Drawings and Specifications.

2.1 Reference Standards

1. Throughout this Specification, reference is made to the standards published by the ASTM.
2. Materials and workmanship shall comply with the active version of the relevant standard.
3. Standards applicable to earthworks are listed below. If the CONTRACTOR offers services that conform to a standard other than that specified, the standard offered shall be equal to or superior, when tested, to the specified standard and full details of the differences between the standard offered and the standard specified shall be provided to the ENGINEER by the CONTRACTOR.

a)	ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
b)	ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 [600 kN-m/m^3])
c)	ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by Sand- Cone Method
d)	ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft^3 (27,000 kN-m/m^3))
e)	ASTM D2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
f)	ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soil
g)	ASTM D5030	Standard Test Methods for Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit
h)	ASTM D5856	Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter

i) ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Standards related to geotextile are provided under Section 6.0, and for the geomembrane under Section 7.0.

2.2 Inspection and Testing

1. The OWNER will provide CQA measures to monitor for compliance with the Drawings and Specification requirements with input from the ENGINEER.
2. The CONTRACTOR shall perform activites to meet the CQC requirements.
3. Construction checklist forms included at the end of the Specification are required for documenting the CQC and other aspects of construction activities. The checklists included in Section 8.0 shall be finalized and signed off by the CONTRACTOR, the OWNER'S REPRESENTATIVE and THE ENGINEER for acceptance of the construction activities. If the ENGINEER is not on site, the the OWNER'S REPRESENTATIVE is required to provide the information to the ENGINEER.

2.2.1 CQC Requirements

1. During construction, the CONTRACTOR shall coordinate testing of all CQC Samples at a site laboratory or a commercial geotechnical laboratory, to verify that the earthwork construction is in accordance with the Specifications. The CONTRACTOR shall collect samples for testing. The tests to be performed, and the testing frequency, for each material type are listed in Table 2. The testing frequencies shall be increased when the OWNER determines that construction conditions (such as, but not limited to adverse weather, equipment breakdown, improper compaction, excessive lift thickness, improper soil type, improper moisture conditioning, etc.) warrant additional tests. It is important to note that additional requirements for CQC testing are presented throughout this Specification. It is the responsibility of the CONTRACTOR to ensure that all CQC requirements are satisfied.

Table 2: Minimum CQC Testing Frequency for Earthworks Construction

Test Description	Test Designation	Frequency	Applicable Material Types
Visual inspection for ice and boulders	N/A	Continuously	All
Layer thickness	N/A	Continuously	All
Elevation of compacted lift	N/A	Continuously	All
Standard Method of Test For Grain-Size Analysis of Granular Soil Materials	ASTM D422	1 every 5,000 m^3	Intermediate Bedding and Fine Bedding Material
Maximum Particle Size (Visual Inpsection)	N/A	Continuously	500 mm Minus Rockfill

Table 2: Minimum CQC Testing Frequency for Earthworks Construction

Test Description	Test Designation	Frequency	Applicable Material Types
Compaction Effort including number of passes and equipment traffic pattern	N/A	Continuously	500 mm Minus Rockfill, Intermediate Bedding, and Fine Bedding Material

2. CQC requirements related to the geomembrane are under Section 7.0.

2.2.2 CQA Requirements

1. The OWNER will be responsible for carrying out CQA checks to verify that the final constructed product conforms to the Drawings and Specifications. Quality assurance measures undertaken by the OWNER may include but are not limited to:

   a) Visual inspection of the completed works for general design conformance.

   b) Laboratory testing of any construction materials to confirm compliance with the Specifications.

   c) Review of the CONTRACTOR's construction quality control laboratory testing results to confirm compliance with the Specifications.

   d) Verify that the construction fill has been placed to the required standard (i.e., check lift thickness, compaction, moisture content and material gradation).

2. If the laboratory testing results of either the CONTRACTOR or the OWNER indicate that the Work was not completed in accordance with the Specifications, then the CONTRACTOR will be required to repair the work at no cost to the OWNER.

3.0 DEWATERING AND SEDIMENT CONTROL

1. The CONTRACTOR will be responsible for the implementation of any temporary works, including erosion protection and sediment control best management practices to protect the work from stormwater damage.

2. The CONTRACTOR shall use materials, construction practices, mitigation techniques and monitoring of operation at every water crossing in order to prevent harmful alteration, disruption or destruction of fish habitat or the impairment of water quality.

3. The CONTRACTOR shall phase the construction activities to minimize the size of the disturbed area and the duration of soil exposure. All excavations shall have stable side slopes to minimize erosion. Permanent erosion protection shall be provided as soon as is practical.

4. Runoff from the work area shall be channelized and monitored for sedimentation.

5. The CONTRACTOR shall monitor the effectiveness of his sedimentation and erosion control measures and provide additional means to control siltation as required.

6. The CONTRACTOR shall prepare a contingency plan to respond, mitigate and remedy, in a timely manner, the effect due to unforeseen events such as flood and spill contaminants. To implement the contingency plan, the CONTRACTOR shall maintain in standby, adequate supply of material, equipment and the like throughout the duration of construction.

7. The CONTRACTOR shall report to the OWNER any unexpected discharge of silt, sediment or other deleterious substance to a watercourse.

8. The CONTRACTOR shall be responsible for providing temporary surface water controls during construction and shall be responsible for, and shall repair at his own expense, any damage to any part of the work caused by storm water runoff, or failure of any temporary surface water controls.

9. All temporary surface water controls not part of the permanent facility shall be removed, leveled, and graded by the CONTRACTOR after completion of the Work.

10. The CONTRACTOR shall have full responsibility for the adequacy of the temporary surface water controls. The sizing for temporary surface water controls should consider the duration of the construction activities, the time of the year of construction, characteristics of the storms during the construction seasons, cost of possible damage, cost of delay to the construction completion of the work, and the safety of workers.

11. The CONTRACTOR shall dewater any stormwater from the construction areas during the time required to complete construction. Acceptable dewatering measures include, but are not limited to, pumping, construction of dewatering sumps, and temporary diversion of surface flows.

4.0 FUEL AND OIL SPILLS

1. The CONTRACTOR shall work in accordance with all environmental regulations and the OWNER's site policies regarding spills of fuels and oils. In the event of an accidental spill on land or into a watercourse, the OWNER's spill response and reporting procedures shall be strictly adhered to.

2. Corrosive, toxic, flammable or otherwise polluting fluids shall not be discharged. Spills of such fluid shall be contained and cleaned in accordance with the spill response and reporting procedures.

3. Portable fuel tanks and fuel cans shall not be left at locations near a watercourse of any kind. All fuel tanks must be double walled and equipped with 360° vehicle protection. A list of emergency contact numbers for key personnel must be provided by the CONTRACTOR to the OWNER at the start of construction.

5.0 EARTHWORKS

This specification describes the requirements for placement and compaction of earth fill and rock fill zones for construction of the WRF Pond Berms, and diversion ditches.

5.1 Excavation

1. Excavation shall be carried out as required to achieve the lines, grades and dimensions shown on the Drawings and/or required to expose suitable subgrade materials. The suitability of the subgrade materials shall be subject to inspection and approval by the OWNER.
2. At the East and West Diversion Ditches, spoil from the ditch excavation shall be used be used for construction of a berm to prevent clean run-off from entering the ditch, as shown on the Drawings.

5.2 Subgrade Preparation

1. The WRF Pond Berm subgrade shall be prepared, inspected, and approved by the OWNER prior to any fill placement for the WRF Pond Berm construction.
2. Subgrade preparation shall involve removal of all unsuitable and deleterious materials (e.g. saturated materials, organics, etc.) from the WRF Pond Berm foundation.
3. The prepared subgrade shall be nominally compacted by heavy equipment traffic prior to fill placement.

5.3 Construction Tolerances

1. All excavations and fill shall be completed to be within (+/-) 0.3 m horizontally and plus (+) 0.05 m vertically of specified lines and grades unless otherwise approved by the OWNER. The CONTRACTOR shall provide and have available at all times during their working hours, the necessary staff and equipment to ensure that proper and correct setting out of the Works is continually maintained during construction. Should any errors in setting out the Works occur, such errors shall be corrected and any necessary adjustment to previously placed fill materials resulting from such errors shall be made good to the satisfaction of the OWNER prior to further placement of fill materials, at no additional cost to the OWNER.
2. Slopes shall not be steeper than those shown on the Drawings unless otherwise approved by the ENGINEER.
3. Temporary excavation and fill slopes shall be in compliance with local health and safety regulations.
4. Finished grades and slopes shall be in general conformance with the Drawings. Deviations from finished grades or slopes are subject to approval by the ENGINEER and shall not result in low spots, non-uniform slopes or contours, or result in slopes that are steeper than design, unless approved in writing by the OWNER.

5.4 Fill Materials

The following sections describe the fill material requirements.

5.4.1 General Requirements

1. Fill materials shall not be frozen and shall be free from organic and other unsuitable matter. They shall be composed of sound, hard, durable particles that will not be affected by the addition of water or by the elements. Materials such as shale or thinly bedded limestone which may break upon exposure or freezing is not acceptable.
2. Fill materials shall generally be well-graded within the specified limits. Material placement and spreading techniques shall prevent segregation of the fill.
3. All fill materials are to be placed in the dry. No fill shall be placed through standing water or under adverse weather conditions (e.g. rain, snow, etc.) that prevent the performance of satisfactory work. In the event that the prepared surface becomes damaged or loosened due to exposure to frost, rain or any other cause, the CONTRACTOR shall remove all affected material, at no additional cost to the OWNER, to the satisfaction of the OWNER prior to further fill placement.
4. The OWNER shall be allowed access to all sampling locations (stockpiles and embankments) and reserves the right to take CQA samples at any time without notice to the CONTRACTOR.
5. Materials furnished by the CONTRACTOR that do not conform to the requirements of the Specifications shall be considered as defective. All defective materials, whether in place or not, will be rejected and shall be removed from the site of the Work or shall be substantially corrected and approved by the OWNER.
6. All fill materials shall be free from organic matter, debris, or other deleterious matter.
7. The placement of frozen fill will not be permitted.
8. The fill materials shall be free from lenses, pockets or layers of materials which are significantly different in gradation from the surrounding materials within the same zone.
9. Dumping of material on slopes will not be permitted.

5.4.2 500 mm minus Rock Fill

The 500 mm minus rock fill shall be obtained from an approved construction material source, as required under Water Licence No. 2AM-MRY 1325-Amendment No.1. The material shall be well graded within the limits defined in Table 3 below:

Table 3: 500 mm Minus Rock Fill Gradation

Sieve (mm)	Percent Passing by weight	
	Lower Bound	Upper Bound
500	100	100
150	100	50
75	40	20
37.5	23	15
19	15	8
4.75	5	0
2	5	0
0.075	5	0

Nests of cobble size material will not be permitted and any segregation which might result in discrete zones of coarse material occurring within the fill will also not be permitted

The maximum compacted lift thickness shall be 1.0 m.

5.4.3 Intermediate Bedding Material

Intermediate Bedding Material shall be placed as a transition material between the geomembrane bedding material, and the underlying rock fill. The bedding material shall be provided by the OWNER from an approved construction material source as required under Water Licence No. 2AM-MRY 1325-Amendment No.1.
The material shall be well graded within the limits defined in Table 4 below:

Table 4: Intermediate Bedding Material Gradation

Sieve (mm)	Percent Passing by weight	
	Lower Bound	Upper Bound
32	100	100
19	100	85
13.2	100	70
9.5	100	50
4.75	70	30
1.18	40	10
0.3	22	5
0.075	8	0

5.4.4 Fine Bedding Material

Fine Bedding Material shall be placed as a transition material between the geomembrane and underlying Intermediate Bedding Material. The Fine Bedding Material shall be provided by the OWNER from an approved construction material source as required under Water Licence No. 2AM-MRY 1325-Amendment No.1.
The material requirements are defined below:

1. The material shall be well graded
2. The maximum particle size shall be 2.0 mm
3. The fines content (percent passing the #200 sieve) shall not exceed 5%.

With approval from the ENGINEER and OWNER, the Fine Bedding Material can be replaced by a non-woven geotextile meeting specifications in Section 6.0.

5.4.5 Rip Rap D_{50} = 300 mm

Rip rap shall be placed as erosion protection at the emergency spillway and within the East and West Diversion Ditches (as required). Rip rap within the spillway channel shall be sourced from an approved construction material source as required under Water Licence No. 2AM-MRY 1325-Amendment No.1. Rip rap placed within the East and West Diversion Ditches can be produced from waste rock. The rip rap gradation requirements are defined as follows:

1. The material shall be well graded;
2. The maximum rip rap particle gradation shall not exceed 600 mm
3. At least 50% of the particles shall exceed 300 mm.
4. The fines content (percent passing the #200 sieve) shall not exceed 5%.

The requirement for rip rap at the East and West Diversion Ditches will be assessed by the OWNER based on performance monitoring. The rip rap requirements will be communicated to the CONTRACTOR as required.

5.4.6 Rip Rap D_{50} = 200 mm

Rip rap shall be placed as erosion protection at the emergency spillway and within the East and West Diversion Ditches (as required). Rip rap within the spillway channel shall be sourced from an approved construction material source as required under Water Licence No. 2AM-MRY 1325-Amendment No.1. Rip rap placed within the East and West Diversion Ditches can be produced from waste rock. The rip rap gradation requirements are defined as follows:

1. The material shall be well graded;
2. The maximum rip rap particle gradation shall not exceed 400 mm
3. At least 50% of the particles shall exceed 200 mm.
4. The fines content (percent passing the #200 sieve) shall not exceed 5%.

The requirement for rip rap at the East and West Diversion Ditches will be assessed by the OWNER based on performance monitoring. The rip rap requirements will be communicated to the CONTRACTOR as required.

5.5 Fill Compaction

5.5.1 500 mm Minus Rockfill

1. Compaction shall be provided by heavy equipment traffic (e.g. dozer tracking) as approved by the OWNER and ENGINEER. Each lift shall be compacted and approved by the OWNER prior to placement of the subsequent lift.
2. Compaction shall be as uniform as practicable over the entire lift surface.
3. Where compaction equipment causes rutting, uneven surfaces, or excessive cross-slope, the surface shall be flattened with additional compaction, or through smoothing with construction equipment.
4. Each lift shall be compacted with a minimum 6 passes by heavy equipment traffic.

5.5.2 Other Materials

1. Compaction of the Intermediate and Fine Bedding Materials placed on the WRF Pond Berm slope shall be provided by excavator bucket. The material shall be nominally compacted.
2. Compaction of the Intermediate and Fine Bedding Materials placed on the WRF Pond floor shall be provided by dozer. The material shall be nominally compacted.
3. Rip Rap shall be knuckled in place by excavator bucket to produce a tightly interlocked mass.

5.6 Survey Control

1. Survey benchmarks to be provided by the OWNER.
2. The CONTRACTOR shall be responsible for establishing temporary construction benchmarks. Benchmarks shall be established on immobile objects or bedrock. Benchmarks shall not be established on ground susceptible to movement.
3. The CONTRACTOR shall carry out a pre-construction as-built survey prior to any fill placement or excavation. The survey shall be submitted to the OWNER for review and approval prior to any fill placement.
4. Survey points shall be appropriately coded such that the intention of the collected survey can be understood.
5. The CONTRACTOR shall provide the OWNER with an accurate ground survey of the completed works for as-built documentation and quantities. The survey shall include sufficient detail to define all breaklines, fill boundaries, and the full extent of any work carried out.
6. Sufficient survey control and records shall be maintained to provide the following:
   a) Layout of the work.
   b) Measurement of in-place quantities of each product placed
   c) Verification of the accuracy of the work.

6.0 GEOTEXTILE

This section describes the requirements for the manufacturing, supply, and installation of nonwoven geotextile to be placed as a bedding between the HDPE liner and underlying bedding material.

6.1 Reference Standards

a)	ASTM D4354	Practice for Sampling Geosynthetics for Testing.
b)	ASTM D4355	Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
c)	ASTM D4491	Test Method for Water Permeability of Geotextiles by the Permittivity Method.
d)	ASTM D4533	Test Method for Trapezoid Tearing Strength of Geotextiles
e)	ASTM D4632	Test Method for Breaking Load and Elongation of Geotextiles (Grab Method).
f)	ASTM D4751	Test Method for Determining Apparent Opening Size of a Geotextile

g) ASTM D4833 — Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

h) ASTM D4873 — Guide for Identification, Storage and Handling of Geotextiles

i) ASTM D5262 — Standard Test Method for Measuring Mass per Unit Area of Geotextiles

j) ASTM D 6241 — Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50-mm Probe.

6.2 Products

1. Geotextile to be nonwoven, needle-punched polypropylene or polyester material meeting or exceeding the criteria specified in Table 5 of this specification.
2. Geotextile manufacturer(s) to be approved by the OWNER.
3. Provide test results from the manufacturer for the geotextile product, as well as a certification that the material properties meet or exceed the specified values.

Table 5: Property Specifications for Non-Woven Geotextile

Material Property	Qualifier	Unit	Specified Value	Test Method
Mass	minimum	g/m^2	237	ASTM D5261
Grab Tensile Strength	minimum	N	800	ASTM D4632
Grab Elongation	minimum	%	50	ASTM D4632
Tear Resistance	minimum	N	333	ASTM D4533
CBR Puncture Strength	minimum	N	2000	ASTM D6241
Apparent Opening Size	maximum	mm	0.212	ASTM D4751
Permittivity	minimum	sec^{-1}	1.4	ASTM D4491
Water Flow Rate	minimum	$L/min/m^2$	4,074	ASTM D4491
UV Resistance	minimum	% @ 500 hr	70	ASTM D4355

6.3 Mill Certificates

At least two (2) weeks prior to start of work, furnish the OWNER with copies of mill test data and a certificate indicating that the geotextile delivered to the site meets the requirements of this Specification.

6.4 Labelling, Delivery, and Storage

1. Geotextile labelling, shipment and storage shall follow ASTM D 4873.
2. Product labels shall clearly show the manufacturer or supplier name, style name and roll number.
3. Each geotextile roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight and contaminants.
4. 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.

6.5 Installation

1. Place material by unrolling onto the prepared surface in a manner consistent with the manufacturer's instructions for placement of the geotextile. Any snow and/or debris accumulated on the surface must be removed prior to placement of the geotextile.
2. Geotextile may be retained in place with sandbags during placement and during periods of wind. Pins or stakes will not be permitted.
3. Place panels to minimize any folds or wrinkles especially along overlaps prior to seaming.
4. Geotextile panels to be either:
   a) overlapped a minimum of 0.5 m on the sides and 1.0 m at the end and securely fastened to prevent any movement or slipping during placement of Fill materials.
   b) sewn or bonded in an approved manner, with an overlap of at least 150 mm.
5. Place geotextile such that factory sewn seams remain visible to facilitate inspection after deployment.
6. Protect geotextile and prepared surfaces from damage during installation.
7. Do not permit passage of any vehicle directly on the geotextile at any time. A minimum thickness of 300 mm of granular fill shall be maintained between rubber tire equipment and the geotextile.
8. Remove and replace damaged or deteriorated geotextile as directed by the OWNER. Remove deleterious materials from geotextile prior to covering.
9. Testing of any field samples ordered by the OWNER and conducted by a geosynthetics CQA laboratory company to be at OWNER's cost, except that costs of "failed" tests shall be deducted from monies owing to the CONTRACTOR.
10. Overlaps shall be arranged in the direction of slopes. Horizontal overlaps running across slopes are not acceptable.

6.6 Repair

1. Repair any holes or tears in the geotextile by heat bonding in place a patch made from the same geotextile, with a minimum of 600 mm overlap in all directions.
2. Take care to remove any soil or other material which may have penetrated the torn geotextile.

7.0 HDPE GEOMEMBRANE SUPPLY AND INSTALLATION

This section describes the requirements for the manufacturing, supply, and installation of 60 mil Layfield Enviroliner 6060 as the low permeability element for the WRF Pond.

7.1 Reference Standards

a) ASTM D792 — Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

b) ASTM D1004 — Test Method for Initial Tear Resistance of Plastic Film and Sheeting.

c) ASTM D1238 — Test Method for Flow Rates of Thermoplastics by Extrusion Plastomer.

d) ASTM D1505 — Test Method for Density of Plastics by the Density-Gradient Technique.

e) ASTM D1603 — Test Method for Carbon Black in Olefin Plastics.

f) ASTM D3895 — Test Method for Oxidative Induction Time of Polyolefins by Thermal Analyses.

g) ASTM D4833 — Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.

h) ASTM D 5199 — Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes.

i) ASTM D5397 — Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test.

j) ASTM D5596 — Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.

k) ASTM D5721 — Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.

l) ASTM D5885 — Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.

m) ASTM D5994 — Standard Test Method for Measure Core Thickness of Textured Geomembranes.

n) ASTM D6392 — Standard Test Method for Determining the Integrity of Non-reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

o) ASTM D6693 — Standard Test Method for Determining Tensile Properties of Non-reinforced Polyethylene and Non-reinforced Flexible Polypropylene Geomembranes.

p) GRI Standard GM13 (Revision 10) Geosynthetics Research Institute December 14, 2012

q) GRI Standard GM19 (Revision 6) Geosynthetics Research Institute October 3, 2011.

7.2 Products

7.2.1 Raw Materials

1. Geomembrane to be manufactured from virgin, first-quality polyethylene resin, designed and manufactured specifically for use in HDPE geomembrane and meeting the requirements of the GRI Standard GM13.
2. Reclaimed polymer or reprocessed geomembrane not to be added to the virgin resin, however, the use of edge trimmings recycled during the manufacturing process of the same batch of geomembrane is permitted if recycled polymer does not exceed 10% by weight.
3. Resin raw material specifications are:

Minimum Density (ASTM D1505)	0.932 g/cm^3
Maximum Melt Index (ASTM D1238, Condition 190/2.16)	1.0 g/10 min

4. The manufacturer to provide a certificate stating the name of the resin supplier, complete with product description, properties and certification that the resin product has not been produced from a blend of resins.
5. Extrudate rod and/or bead to be produced from the same resin used in the manufacture of the geomembrane rolls.
6. At least two (2) weeks prior to delivery of the geomembrane to the job site, the manufacturer is to provide written certification and supporting documentation / test results to the OWNER that all raw materials used to manufacture geomembrane and extrudate rod and/or bead meet or exceed the requirements given in this specification.

7.2.2 Manufactured Geomembrane

1. Material specifications for the double-sided textured, white-surfaced (on top side only) HDPE geomembrane to meet or exceed those listed in Table 2b of the GRI Standard GM13 for 1.5 mm (60 mil) textured geomembrane (attached).
2. Geomembrane shall have one side in white colour. White side shall be exposed following installation.
3. Geomembrane to be free of pinholes, blisters, undispersed raw material, striations or any sign of contamination by foreign matter.
4. Rolls to consist of a continuous width seamless panel.
5. The minimum length of each roll shall be the manufacturer's standard length for the specified thickness such that seaming requirements are minimized.
6. Each roll to be clearly marked at two separate locations on the roll, with the following information:
   a) Manufacturer
   b) Product Type
   c) Thickness
   d) Resin Lot Number
   e) Roll Number
   f) Length and Width

7. At least two (2) weeks prior to delivery of the geomembrane to the job site, the manufacturer is to provide written certification and supporting documentation/test results to the OWNER that the geomembrane sheet is in compliance with the specification given in Table 2b of the GRI Standard GM13 for 1.5 mm textured geomembrane (attached).

7.2.3 Geomembrane Manufacturer and Installer Qualifications

1. The Geomembrane manufacturer and installer shall be recognized and well established with proven ability with HDPE geomembrane.
2. Each geomembrane installation crew shall include a Master Seamer in both extrusion and fusion welding, who has served in this capacity on the installation of at least 500,000 m^2 of polyethylene geomembrane over the three years prior to this project.
3. All welding technicians shall have project experience amounting to at least 100,000 m^2 of HDPE welding.

7.3 Material Warranty

The geomembrane manufacturer to provide OWNER with a written warranty against manufacturing defects for a period of ten (10) years from the date of installation.

7.4 Guarantee

The CONTRACTOR to guarantee and provide OWNER with a written guarantee against defects in installation and workmanship for a period of two (2) years from the date of final acceptance, including the services of qualified technicians and materials necessary for repairs, at no cost to the OWNER.

7.5 Storage

1. Protect geomembrane from direct sunlight, excessive heat, mud, debris, dust, snow and deformation.
2. Geomembrane shall not be stored on a coarse granular surface that may puncture the geomembrane.
3. Temporary storage of HDPE geomembrane rolls in the field shall not result in crushing of the core or flattening of the rolls.

7.6 Installation

1. At least two (2) weeks prior to installation of the geomembrane, the installer shall provide proposed panel layout drawings to the OWNER for approval. The locations of the geomembrane seams shall be approved by the OWNER.
2. The identification of each roll of geomembrane required by Section 7.2.2 shall be checked against the manufacturer's submittals for consistency prior to installation. Any damaged rolls shall be rejected and replaced.
3. Prior to installation, the installer to inspect the subgrade and provide written certification to the OWNER stating that the prepared surface is suitable for the geomembrane installation.
4. Geomembrane shall be installed in the dry. No panels shall be deployed through standing water.
5. Maintain the subgrade surface at a suitable condition throughout the geomembrane installation period.
6. Placement of the geomembrane is to be done in accordance with the sequence on the approved shop drawings, and/or as may be revised on site (with the approval of the OWNER), to suit field conditions.
7. All seams within the key trenches are to be oriented down slope and not across slope.

8. Equipment used to handle and weld the geomembrane shall not cause any damage to the geomembrane or the subgrade due to handling, trafficking, leakage of hydrocarbons or any other means.
9. No vehicles are allowed to travel directly on the geomembrane liner except for All Terrain Vehicles (ATV's) provided the following criteria and practices are adhered to:
   a) Maximum tire pressure of 40 kPa (6 psi);
   b) 90 degrees entrance and exits into the liner area;
   c) No driving over wrinkles;
   d) No abrupt starting or stopping of ATV's (i.e., use rolling stops);
   e) One person per vehicle;
   f) Maximum 50lbs of equipment/supplies allowed on the ATV;
   g) No ATV's on key trench slopes;
   h) No refueling of ATV's over the liner area
   i) ATV use will be limited to work either exclusively on the liner or off the liner, but not a mix of both; and
   j) Any ATV used off the liner surface shall be thoroughly cleaned and inspected with signoff by the OWNER and CONTRACTOR before being allowed on the liner surface
10. Any damage caused to the Geosynthetics by the use of ATV's shall be immediately rectified at no additional cost to the owner.
11. Personnel to not engage in activities or wear footwear which could damage the geomembrane.
12. Apart from approved welding equipment, no mechanical equipment will be allowed on the geomembrane. Electrical generator equipment required for powering the welding equipment shall be placed on a geotextile cushion at all times while working on the geomembrane surface. Appropriate measures must be taken to avoid any damage to the geomembrane when moving the generator equipment. Precautions must be taken to ensure no hydrocarbon spills occur on the liner.
13. Sufficient material slack shall be provided to allow for thermal expansion and contraction of the material.
14. Place panels in such a way as to minimize scratches, crimps and other damage to the geomembrane. Minimize wrinkles and "fishmouths" along seams.
15. Do not deploy geomembrane panels if moisture prevents proper placement or seaming.
16. Do not allow geomembrane to "bridge over" voids or low areas in the subgrade. Repair subgrade if required and place geomembrane such that it rests entirely on the subgrade surface.
17. At the end of each day or installation segment, all unseamed edges to be anchored by sand bags or other approved device. Staples, U-shaped rods or other penetrating anchors are not to be used to secure the geomembrane. Any damage to the liner due to inclement weather to be the sole responsibility of the installer.
18. The OWNER must be made aware of any incident that occurs that could have damaged the liner (e.g., vehicle going off the road where liner has been placed and bulldozer tracks contacting the liner during spreading of the cover soil layers). Any panel or part thereof which has been seriously damaged shall be replaced at no additional cost to the OWNER. Such damaged 'panels' shall be removed from the site immediately. Minor damage such as crimps, wrinkles, small punctures etc., to be repaired as described in Section 6.6.

7.7 Seaming

1. All seaming to be performed under the direct supervision of the "Master-Seamer".
2. At least two weeks prior to liner installation, the installer shall provide to the OWNER the proposed method of performing seaming operations including the equipment to be used.
3. Seams to have Minimum Seam Shear Strength and Peel Strength (force per unit width at yield) as given in the GRI Standard GM19 (Table 1b) for 1.5 mm textured geomembrane (attached).
4. Approved seaming methods are double hot wedge fusion welding and extrusion welding on repairs and pipe penetration details only.
5. All geomembrane seams are to be welded.
6. Seaming to be a continuous operation along the entire seam, with a minimum number of interruptions.
7. Fusion welder to be equipped with gauges which indicate the temperatures and speeds during welding.
8. Extrusion welding equipment to be equipped with gauges indicating barrel and nozzle temperatures. Extruder to be purged of all heat degraded extrudate prior to commencement of each seaming sequence.
9. Minimum overlap shall be 75 mm (3 in) for extrusion welding and 125 mm (5 in) for fusion welding. Sufficient overlap must be provided on both sides of the double fusion weld to allow for destructive testing.
10. Methods used to temporarily bond adjacent rolls are not to result in any damage to geomembrane. Solvents and/or adhesives are not to be used.
11. If hot air leisters are used to provide temporary bonding, no damage to the geomembrane will be permitted. If damage is noted upon visual inspection and/or destructive testing, it shall be repaired to the satisfaction of the OWNER.
12. Align seams to provide minimum wrinkles and "fishmouths". Seam area to be free of dirt, dust, moisture, debris or any other foreign matter.
13. If grinding is required along the seam, do so according to manufacturer's recommendations.
14. Seaming procedures described in this Section relate to ambient temperatures between 5°C and 40°C. Do not perform seaming when ambient temperatures are greater than 40°C.
15. Welding may be permitted below 5°C subject to approval of the OWNER, and provided that the seam is protected from excessive cooling by wind or other adverse conditions.
16. Keep seam areas clean, dry and sheltered from wind during seaming operation.

7.8 Repairs

1. Entire geomembrane surface to be examined to confirm it is free of damaged areas, defects, pinholes, blisters, undispersed raw material or contamination by foreign matter.
2. If necessary, the installer shall clean the surface of the geomembrane to enable inspection by the OWNER.
3. Gouges or scratches associated with grinding or from other sources whose depth is in excess of 10% of the geomembrane thickness, to be classified as defects and will require appropriate repairs.
4. Small tears, wrinkles or pinholes are to be repaired by seaming or patching. Other areas are to be patched or capped.
5. Patches to be round or oval, of the same material and thickness, and shall extend a minimum of 150 mm beyond the damaged or faulty area in all directions.
6. Cut and repair any large wrinkles or "fishmouths" identified by the OWNER.
7. All repairs to be non-destructively tested using a vacuum box. Vacuum box testing requirements to be agreed on with the OWNER.

7.9 Disposal of Scrap Material

1. Remove scrap material and trash from the site and recycle or dispose of as approved by the OWNER. No scrap material shall be left on the geomembrane surface.

7.10 Documentation

1. Provide the necessary field assistance, notes, test results, etc. necessary for the OWNER to prepare an "As-Built" Drawing which documents the location of all panels, seams, repairs, and other pertinent data.
2. The installer shall provide all CQC documentation to the OWNER within 2 weeks of completion of the geomembrane installation.

7.11 Quality Control

This section describes the requird CQC activites to be carried out by the Installer and CONTRACTOR.

7.11.1 Quality Control Certificates

At least two (2) weeks prior to delivery of materials to job site, furnish the OWNER with copies of quality control certificates as detailed below:

1. Origin of resin, brand name, number and production date;
2. Certificate that all resin used in the manufacture of the geomembrane for this project complies with the requirements of the GRI Standard GM13;
3. Quality Control certificates issued by the resin supplier;
4. Quality control certificates and certification that the geomembrane supplied complies with the project requirements of the GRI Standard GM13 for 1.5 mm textured geomembrane (Table 2b of GM13, attached); and,
5. Certification that the geomembrane and extrudate rod have the same properties.

7.11.2 Test Seams

1. Each seamer and his welding unit to produce two test seams per day per welding apparatus, one made at the beginning of each shift and one at mid-shift, as directed by the Owner. If a seamer is required to use a different welding unit, a new test seam will be required prior to seaming operations with each new unit.
2. Test seams to be made on a piece of geomembrane identical to that being installed. Sample to measure a minimum of 1 metre long by 0.3 metres wide with the seam centred lengthwise and overlapped as specified in Section 7.7. Test seam welding to be carried out under ambient conditions that replicate actual field conditions.
3. Four adjoining 25 mm wide specimens from the test seam sample to be tested by the installer, in shear and in peel using a field tensiometer. Each specimen must not fail in the seam. If a specimen fails in the seam, a second seam is to be produced and tested. The seam shear strength and peel strength to meet requirements of the GRI Standard GM19 (Tables 1b, attached) for 1.5 mm textured geomembrane. A second failure will result in rejection of either the seamer and/or equipment until the deficiency has been corrected. This will be verified by the production and successful testing of two consecutive test seams.

7.11.3 Non Destructive Testing

1. All seams to be subject to non-destructive testing for their full length (air pressure test for fusion welds, vacuum box testing of extrusion welds). Perform non- destructive testing concurrently using equipment and methods approved by the OWNER.
2. Provide all equipment and manpower required for non-destructive testing. All testing to be witnessed by the OWNER.
3. All defects shall be clearly marked for repair.
4. Repair and test again any seam failing a test.
5. Ensure that all repairs and associated testing is complete prior to requesting final checking by the OWNER.

7.11.4 Destructive Testing

1. Destructive seam testing to be performed concurrent with seaming.
2. Samples to be taken for testing at a minimum average frequency of one sample per 150 metres of seam. Locations to be predetermined by the OWNER, however, the installer shall not be informed of pre-selected locations.
3. Testing frequency may be increased by the OWNER if there is reason to suspect the presence of excess crystallinity, contamination, offset welds or any other potential defect. Poor test results may also result in an increased testing frequency.
4. Samples to be cut by the installer under the direction of the OWNER. Each sample shall be numbered and its location recorded by the OWNER on the shop drawings.
5. Each sample to be 0.3 metres wide by 1.2 metres long with the seam centred lengthwise. One 25 mm wide sample to be taken from each end for shear and peel testing by the installer.
6. Remainder of sample to be cut by the installer into three equal portions: one for the Installer and two for the OWNER. Results of field laboratory tensiometer testing by OWNER will determine acceptability. In case of disputes, samples are to be sent to a pre- determined geosynthetics CQA laboratory for confirmation verification testing and the results will determine acceptability. The cost for the geosynthetics CQA laboratory testing is to be paid by the OWNER unless the results do not meet the specifications, in which case the cost will be deducted from monies owing to the CONTRACTOR.
7. The OWNER to cut and test ten (10) 25 mm wide replicate specimens from his sample and shall test 5 specimens for seam shear strength and 5 for peel strength. To be acceptable, the strength of 4 out of the 5 replicate samples must pass for each mode of testing. The fifth must meet or exceed 80% of the values given in Table 1b of the GRI Standard GM19 for 1.5 mm thick textured HDPE geomembrane attached). In addition, the shear percent elongation and the peel separation must satisfy the values given in the GRI Standard GM19 (see Table 1b, attached).
8. The test method and procedures to be used employ a grip separation rate of 50 mm/min for peel and shear and shall be in accordance with ASTM D6392. A calibrated field tensiometer is to be provided by the Installer.
9. Area of test strip to be repaired as described in this Section. All seams created by repair to be non-destructively tested.

7.11.5 Acceptance of Seams

1. A seam will be considered acceptable only when it is bounded by two destructive test locations which meet the specified criteria.
2. A double hot wedge fusion seam will be considered acceptable only when both outside and inside track welds are destructively tested and meet the specification criteria.
3. If a seam fails the destructive test, the Installer may reconstruct the seam between the point of failure and any previously accepted test. Alternatively, the installer may trace the extent of unacceptable seam by taking 25 mm samples at minimum 3 metre distance on each side of failed section. Test in both shear and peel. If one or both tests fail, continue along seam at minimum 3 metre increments. Continue until tests indicate pass results. Then take large samples for field laboratory tensiometer testing. If field laboratory tests pass, make repairs - if fail, continue.
4. Reconstruction or repair of failed seam lengths to be either by capping of the failed seam (extrusion or fusion weld) or, in the case of a double fusion weld, by extrusion fillet welding the overlap to the bottom sheet. Cutting off the overlap and topping the failed fusion weld with extrudate will not be permitted.
5. If the overlap of the outside (i.e. visible) weld is less than 30 mm, extrusion welding of the overlap to the bottom sheet in the failed section will not be permitted.
6. Continuity of all reconstructed seams to be subject to non-destructive testing. If reconstructed length exceeds 50 metres, sample shall be taken for destructive testing.
7. All trial seam welding as well as non-destructive and destructive testing of field seams carried out by installer are to be at no additional cost to the OWNER.

7.12 Completion of Work

The installation of the geomembrane shall be considered totally complete when all required deployment, seaming, repairs, testing and site clean-up, including sand bags, have been completed by the Installer; the Installer has submitted all the required certifications to OWNER; and the OWNER is satisfied that the geomembrane has been installed in accordance with the above Specifications.

GRI – GM19 Specification – Table 1b

Table 1(b) – Seam Strength and Related Properties of Thermally Bonded **Smooth and Textured** High Density Polyethylene (HDPE) Geomembranes **(S.I. Units)**

Geomembrane Nominal Thickness	0.75 mm	1.0 mm	1.25 mm	1.5 mm	2.0 mm	2.5 mm	3.0 mm
Hot Wedge Seams[1]							
shear strength[2], N/25 mm	250	350	438	525	701	876	1050
shear elongation at break[3], %	50	50	50	50	50	50	50
peel strength[2], N/25 mm	197	263	333	398	530	661	793
peel separation, %	25	25	25	25	25	25	25
Extrusion Fillet Seams							
shear strength[2], N/25 mm	250	350	438	525	701	876	1050
shear elongation at break[3], %	50	50	50	50	50	50	50
peel strength[2], N/25 mm	170	225	285	340	455	570	680
peel separation, %	25	25	25	25	25	25	25

GRI – GM13 Specification –Table 2b

Table 2(b) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness mils (nom. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.)	D 7466	0.40 mm	0.40 mm	0.40 mm	0.40 mm	0.40 mm	0.40 mm	0.40 mm	every 2nd roll *(1)*
Formulated Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties (min. ave.) *(2)* • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	11 kN/m 8 kN/m 12% 100%	15 kN/m 10 kN/m 12% 100%	18 kN/m 13 kN/m 12% 100%	22 kN/m 16 kN/m 12% 100%	29 kN/m 21 kN/m 12% 100%	37 kN/m 26 kN/m 12% 100%	44 kN/m 32 kN/m 12% 100%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	200N	267 N	333 N	400 N	534 N	667 N	800 N	20,000 kg
Stress Crack Resistance *(3)*	D 5397 (App.)	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	per GRI GM10
Carbon Black Content (range)	D 4218 *(4)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	9,000 kg
Carbon Black Dispersion	D 5596	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(6)* (a) Standard OIT — or — (b) High Pressure OIT	D 3895 D 5885	100 min 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(6), (7)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	55% 80%	per each formulation
UV Resistance *(8)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(10)*	D 7238 D 3895 D 5885	N.R. *(9)* 50%	N.R. *(9)* 50%	N.R. *(9)* 50%	N.R. *(9)* 50%	N.R. *(9)* 50%	N.R. *(9)* 50%	N.R. *(9)* 50%	per each formulation

(1) Alternate the measurement side for double sided textured sheet

(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(3) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(4) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(10) UV resistance is based on percent retained value regardless of the original HP-OIT value.

8.0 CONSTRUCTION CHECKLISTS

The following construction checklist forms documenting CQA and CQC and other aspects of the construction activities, by work activity, are attached:

- WRF Pond Site Checklist –Embankment Construction
  - Subgrade Inspection
  - Fill Inspection
- WRF Pond Site Checklist – Liner Placement
  - Pre-Liner Inspection
  - Completion of Liner Inspection

The CONTRACTOR may propose alternative forms for approval by the OWNER'S REPRESENTATIVE and the ENGINEER.

The checklists are to be signed by all parties prior to acceptance of each activity within the defined work area.

WRF Pond Site Checklist – Embankment Construction -Subgrade Inspection

CONTRACTOR:	DATE:	SHIFT: DAY - NIGHT
LOCATION:		WEATHER:

No.	ITEMS TO BE INSPECTED	INSPECTED BY CONTRACTOR	INSPECTED BY OWNER's REPRESENTATIVE
1	Survey lines and layout conform to the Drawings.		
2	Unsuitable Materials, snow, ice and loose or saturated materials removed.		
3	Dewatering measures provided, if required.		
4	Required compaction of subgrade materials performed.		
5	Surface of subgrade compacted, smooth, and graded to promote drainage at end of every fill operation or the end of each shift, whichever occurs sooner.		
6	As-built survey conducted pre- and post- construction. Final work photographed.		

REMARKS:

DEVIATIONS: (Attach list if necessary)

DATE OF RECTIFICATION:

ACCEPTED BY ENGINEER	ACCEPTED BY CONTRACTOR	ACCEPTED BY OWNER'S REPRESENTATIVE
NAME: _____	NAME: _____	NAME: _____
SIGNATURE: _____	SIGNATURE: _____	SIGNATURE: _____
DATE: _____	DATE: _____	DATE: _____

WRF Pond Site Checklist – Embankment Construction – Fill Inspection

CONTRACTOR:	DATE:	SHIFT: DAY - NIGHT
LOCATION:		WEATHER:

No.	ITEMS TO BE INSPECTED	INSPECTED BY CONTRACTOR	INSPECTED BY OWNER'S REPRESENTATIVE
1	Survey lines and layout conform to the Drawings.		
2	Required assessment of Fill Material before placement (visual inspection, laboratory tests).		
3	Unsuitable Materials, snow, ice and loose or saturated materials removed prior to placement.		
4	Dewatering measures provided, if required.		
5	Fill lift thickness according to Specifications.		
6	Fill materials contain no frozen lumps or Unsuitable Material.		
7	Segregation of fill materials controlled during placement.		
8	Required visual inspection of placed materials performed and photographed.		
9	Required compaction of fill materials performed.		
10	Surface of fill left compacted, smooth, and graded to promote drainage at end of every fill operation or the end of each shift, whichever occurs sooner.		
11	As-built survey conducted pre- and post- construction. Final work photographed.		

REMARKS:

DEVIATIONS: (Attach list if necessary)

DATE OF RECTIFICATION:

ACCEPTED BY ENGINEER	ACCEPTED BY CONTRACTOR	ACCEPTED BY OWNER'S REPRESENTATIVE
NAME: _____	NAME: _____	NAME: _____
SIGNATURE: _____	SIGNATURE: _____	SIGNATURE: _____
DATE: _____	DATE: _____	DATE: _____

WRF Pond Site Checklist – Ditch Excavation

CONTRACTOR:	DATE:	SHIFT: DAY - NIGHT
LOCATION:		WEATHER:

No.	ITEMS TO BE INSPECTED	INSPECTED BY CONTRACTOR	INSPECTED BY OWNER'S REPRESENTATIVE
1	Survey lines and layout conform to the Drawings.		
2	Spoil disposal area or spoil berm locations identified.		
3	Dewatering measures provided, if required.		
4	Preconstuction condition photographed.		
5	Unsuitable materials, snow, ice and saturated materials removed from area.		
6	Visual inspection during excavation performed and photographed.		
7	Surface competent and free of major protrusions and photographed.		
8	Final surface conditions meet the Specifications and photographed.		
9	As-built survey conducted pre- and post- excavation and disposal of removed materials or downstream berms.		

REMARKS:

DEVIATIONS: (Attach list if necessary)

DATE OF RECTIFICATION:

ACCEPTED BY ENGINEER	ACCEPTED BY CONTRACTOR	ACCEPTED BY OWNER'S REPRESENTATIVE
NAME: _____	NAME: _____	NAME: _____
SIGNATURE: _____	SIGNATURE: _____	SIGNATURE: _____
DATE: _____	DATE: _____	DATE: _____

WRF Pond Site Checklist – Ditch Construction

CONTRACTOR:	DATE:	SHIFT: DAY - NIGHT
LOCATION:		WEATHER:

No.	ITEMS TO BE INSPECTED	INSPECTED BY CONTRACTOR	INSPECTED BY OWNER'S REPRESENTATIVE
1	Survey lines and layout conform to the Drawings.		
2	Visual inspection of existing conditions before Fill Material placement.		
3	Required assessment of Fill materials before placement (visual inspection of maximum particle size).		
4	Unsuitable materials, snow, ice and loose or saturated materials removed prior to placement.		
5	Dewatering measures provided, if required.		
6	Fill lift thickness according to Specifications		
7	Fill material contain no frozen lumps or unsuitable material.		
8	Segregation of Fill materials controlled during placement.		
9	Required visual inspection of placed materials performed and photographed.		
10	As-built survey conducted pre- and post- subgrade preparation. Final work photographed.		

REMARKS:

DEVIATIONS: (Attach list if necessary)

DATE OF RECTIFICATION:

ACCEPTED BY ENGINEER	ACCEPTED BY CONTRACTOR	ACCEPTED BY OWNER'S REPRESENTATIVE
NAME: _____	NAME: _____	NAME: _____
SIGNATURE: _____	SIGNATURE: _____	SIGNATURE: _____
DATE: _____	DATE: _____	DATE: _____

WRF Pond Site Checklist – Liner Placement - Pre-Liner Installation

CONTRACTOR:	DATE:	SHIFT: DAY - NIGHT
LOCATION:		WEATHER:

No.	ITEMS TO BE INSPECTED	INSPECTED BY CONTRACTOR	INSPECTED BY OWNER'S REPRESENTATIVE
1	Survey lines and layout conform to the Drawings.		
2	Required assessment of Fill Material before placement (visual inspection of particle size Intermediate Bedding, Fine Bedding (if applicable) maximum particle size).		
3	Unsuitable Materials, snow, ice and loose or saturated materials removed prior to placement.		
4	Dewatering measures provided, if required.		
5	Liner bedding surface is acceptable and contains no potentially damaging materials		
6	Fill materials contain no frozen lumps or Unsuitable Material.		
7	Required visual inspection of placed materials performed and photographed.		
8	Written certification from the CONTRACTOR stating the prepared surface is suitable for the geomembrane installation.		
9	Weather conditions meet requirements during fill placement and compaction.		

REMARKS:

DEVIATIONS: (Attach list if necessary)

DATE OF RECTIFICATION:

ACCEPTED BY QA REPRESENTATIVE	ACCEPTED BY CONTRACTOR	ACCEPTED BY OWNER'S REPRESENTATIVE
NAME: _____	NAME: _____	NAME: _____
SIGNATURE: _____	SIGNATURE: _____	SIGNATURE: _____
DATE: _____	DATE: _____	DATE: _____

WRF Pond Site Checklist – Liner Placement – Completion of Liner Inspection

CONTRACTOR:	DATE:	SHIFT: DAY - NIGHT
LOCATION:		WEATHER:

No.	ITEMS TO BE INSPECTED	INSPECTED BY CONTRACTOR	INSPECTED BY OWNER'S REPRESENTATIVE
1	Survey lines and layout conform to the Drawings.		
2	Required visual inspection of condition of completed Liner.		
3	Dewatering measures provided, if required.		
4	Liner installed as per Specifications.		
5	All defects addressed.		
6	All seams and patches tested.		
7	QC Testing and documentation completed.		
8	Site cleaned of waste materials.		
9	As-built survey conducted post- construction. Final work photographed.		

REMARKS:

DEVIATIONS: (Attach list if necessary)

DATE OF RECTIFICATION:

ACCEPTED BY QA REPRESENTATIVE	ACCEPTED BY CONTRACTOR	ACCEPTED BY OWNER'S REPRESENTATIVE
NAME: _____	NAME: _____	NAME: _____
SIGNATURE: _____	SIGNATURE: _____	SIGNATURE: _____
DATE: _____	DATE: _____	DATE: _____

END OF SECTION: 1790951

https://golderassociates.sharepoint.com/sites/22103g/technical work/phase 2000/2003 pond upgrade/1790951_design brief/specifications/final/1790951-s-doc029_final-wrfpondearthworks_aug172018.docx

golder.com

Attachment 3

Design Criteria for 2019 to 2019 Waste Rock Management Pile

GOLDER

TECHNICAL MEMORANDUM

DATE August 24, 2018

Project No. 1665556-1000/ 1790951-2000

TO Trevor Brisco, Engineering & Geology Superintendent
Baffinland Iron Mines Corp.

Document No. 025 Rev 0

FROM Brian Andruchow, Michelle Tyldesley,
Ken Bocking

EMAIL mtyldesley@golder.com

DESIGN CRITERIA FOR 2018 TO 2019 WASTE ROCK MANAGEMENT PILE, MARY RIVER PROJECT

1.0 INTRODUCTION

Baffinland Iron Mines Corporation (Baffinland) Mary River Project is an operational iron mine on Baffin Island in Canada's Nunavut territory. Based on the current mine plan an estimated 640 Mt of waste rock will be generated from the mining of Deposit No. 1 (Baffinland, 2014). Ore is mined from the open pit, crushed onsite, and hauled to the Milne Port (approximately 100 km from site) where it is stockpiled and shipped off-site for processing. Ore is currently transported from the Mine site to the Milne Port by B-train trucks. In future years, Baffinland plans to construct a rail line and ship from Steensby Port. Waste rock from the open pit is disposed of at the Mine site to the north of the open pit.

The Phase 1 Waste Rock Management Plan (Baffinland, 2017) was developed for 2014 to 2018 to accommodate the lower tonnage of waste rock produced in the early years of operation. A revision to the Waste Rock Management Plan is now required to address the unexpected water quality observed at the Waste Rock Facility Pond (WRF Pond) in 2017. The existing Life of Mine (LOM) Waste Rock Management Plan (Baffinland, 2014) currently remains in effect.

Baffinland and Golder Associates Ltd. (Golder) are currently in the process of updating the waste rock management plan until end of 2022. This document summarizes the design criteria that will be used to carry out the Waste Rock Facility (WRF) and WRF Pond detailed design.

2.0 DESIGN CRITERIA FOR YEARS 2018 TO 2022 WASTE ROCK MANAGEMENT PLAN

2.1 Waste Rock Facility

The current proposed WRF expansion is limited to the end of April 2019. Expansion of the WRF beyond April 2019 has not been considered as there is a possibility of constructing a new sedimentation pond in a different location to manage the seepage/runoff. This new pond cannot be efficiently located or designed at this time due to uncertainties regarding Baffinland's mining plan and the WRF long-term geochemistry. As discussed under Section 2.2, the existing WRF Pond can be expanded to accommodate a short-term increase in the WRF footprint.

It is recommended that the WRF expansion design beyond April 2019 be assessed at a future date when the WRF geochemistry and results of the recent actions undertaken to improve the seepage and runoff water quality are both better understood. An instrumentation program is currently being planned for 2018, and this instrumentation is expected to provide critical data required to review the performance of the WRF and mechanisms contributing to the observed water quality issues.

2.1.1 WRF Design Criteria

The following design criteria have been established, with input from Baffinland, for the WRF expansion through to April 2019:

- The WRF footprint will be expanded within the existing permitted boundary;
- It is assumed that treatment of the WRF seepage/runoff will be required in the near-term (i.e. all runoff and seepage will be collected to the extent practicable) and will be managed at the existing WRF Pond. The requirement for ongoing treatment will be reviewed prior to carrying out the design for further expansion.
- Expansion of the WRF will be carried out in a manner conducive to permafrost aggradation, to the extent practicable; and,
- WRF Geometry considerations:
  - Overall side slopes of 2H:1V.
  - Minimum crest width of 25 m (40 m will be used in plans beyond April 2019).
  - Inter bench slopes at angle of repose.
  - Bench width as required to achieve 2H:1V overall side slopes.

2.1.2 Waste Rock Quantities 2018 to 2022

The waste rock production schedule provided by Baffinland on March 2, 2018 is summarized in Table 1, for the years 2018 through 2022.

Table 1: Estimated Waste Rock Volumes

Year	Season	Non-PAG Volume (m^3)	PAG* Volume (m^3)	Total Waste Rock (m^3)
2018	Winter	277,102	94,248	607,402
	Summer	208,151	27,901	
2019	Winter	1,506,530	221,111	2,649,699
	Summer	787,337	134,720	
2020	Winter	3,734,796	468,999	6,305,692
	Summer	1,867,398	234,500	

Year	Season	Non-PAG Volume (m^3)	PAG* Volume (m^3)	Total Waste Rock (m^3)
2021	Winter	4,587,398	363,308	7,426,119
	Summer	2,293,719	181,654	
2022	Winter	5,197,358	347,198	8,316,834
	Summer	2,598,679	173,599	
			Total:	**25,305,745**

*PAG – Potentially Acid Generating

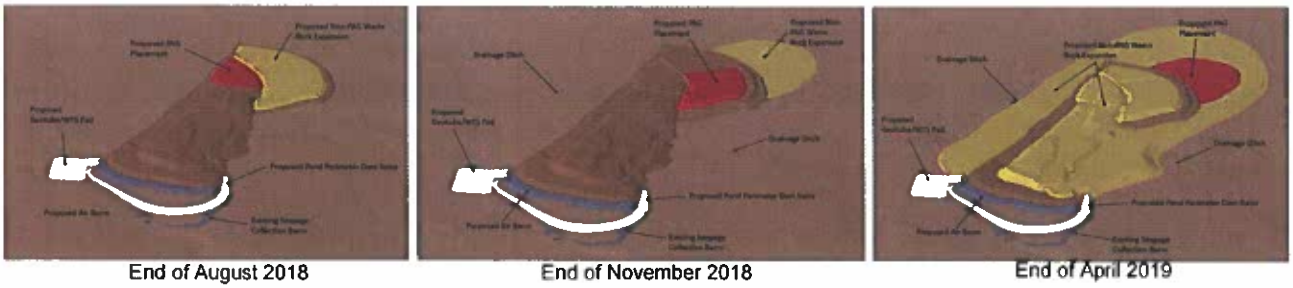
The tonnages have been converted to a volume using a specific gravity of 2.82 (Non-PAG rock) and 3.82 (PAG rock). The specific gravities have been provided by Baffinland. Through discussion with Baffinland, a waste rock swell factor of 1.30 has been used.

For waste rock deposition planning, the production schedule is split into winter and summer seasons. Winter production, defining the time period when the ambient temperatures are typically below freezing, is assumed to be October through April. Summer deposition is assumed to be May through September. For 2018, monthly waste rock quantities were provided; for 2019 quarterly waste rock quantities were provided; for 2020 to 2022 annual quantities were provided by Baffinland. Where monthly quantities were not provided, it was assumed that the quarterly and annual waste rock tonnages will be produced at a uniform rate throughout the period.

2.1.3 2018 – 2019 WRF Expansion

The WRF expansion progression for summer 2018 through April 2019 is provided in Figure 1 below. Key aspects of the final geometry include:

- Surface area contributing to the WRF Pond: 432,000 m^2
- Maximum WRF elevation: 614.0 m
- Maximum WRF height: 24.4 m
- Total capacity: 1.5 Mm^3 (for summer 2018 to April 2019)



End of August 2018 End of November 2018 End of April 2019

Figure 1: Progression of WRF Expansion until April 2019

It is our understanding that permafrost aggradation within the WRF is required for geochemical stability. As a result, the waste rock deposition strategy varies by season. During winter, Non-PAG waste rock will be used to expand the WRF footprint over frozen native ground. After snow clearing, the Non-PAG waste rock will be spread at a minimum 2.0 m thickness, raising the active permafrost zone to within the waste rock and creating a foundation for future summer waste rock placement. During summer months, waste rock placement will be limited to within the existing WRF footprint (i.e. with no waste rock placement directly on native ground). The total thickness of material placed during summer months should be reduced to the extent practical (i.e. to maximize area of coverage) to better promote freezing of the WRF during winter months. Waste rock should be placed in lifts of approximately 3.0 m and spread by dozer to prevent segregation, which will promote permafrost aggradation and reduce the extent of air movement within the stockpile. Placement of PAG waste rock will be limited to locations at a minimum of 25 m from the WRF extents; this applies in both summer and winter.

The LOM Waste Rock Management Plan (Baffinland, 2014) specifies triple benching to a total height of 30 m. Attention is drawn to the requirement for the WRF to be constructed in lifts (approximately 3.0 m) specifically around the perimeter of the WRF. End dumping and advancement of thick lifts can lead to significant particle segregation. The accumulation of segregated coarse material at the toes of slopes is known to exacerbate air flow within the WRF. The rate of acid generation is controlled by the flux of oxygen to the reactive surfaces on PAG rock; therefore the accumulation of coarse rock particles at the toes of dumped perimeter slopes would contribute to the overall geochemical instability of the WRF.

The WRF bench and slope design criteria remains unchanged from the LOM Waste Rock Management Plan (Baffinland, 2014) as no further geotechnical information has been collected to update/verify the design. A geotechnical investigation near the perimeter of the expanded WRF footprint should be completed within the next year to provide input to the detailed design and stability analysis of the WRF.

2.1.4 Future Expansion of WRF

Although future expansion beyond April 2019 has not yet been planned, it is possible that drainage from the expansion will be temporarily directed to the existing WRF Pond, until a new pond is constructed. The maximized WRF footprint that could drain to the existing WRF Pond based on the natural topography (i.e. watershed area) is shown in Figure 2 below. The footprint results in a surface area of 584,000 m^2. Depending on the mine planning, future expansion of the WRF may be within this footprint.

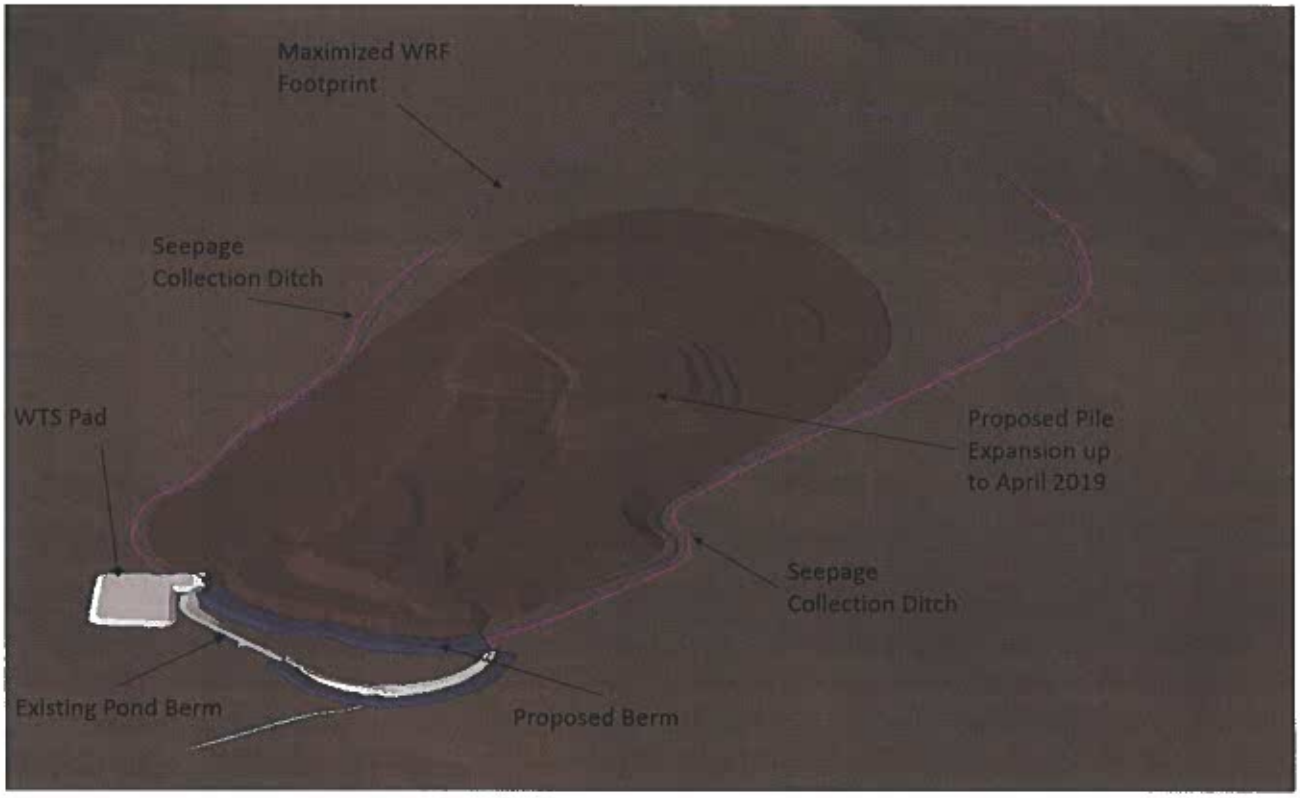


Figure 2: Maximized WRF Footprint for Existing WRF Pond Location

2.2 Existing WRF Pond

Surface runoff and seepage from the WRF are diverted to the WRF Pond through a network of ditches. The WRF Pond was originally designed to contain the 1:10 year 24 hour return event (Hatch, 2013). It is our understanding that this design basis was developed with the intention that the WRF Pond would act as a sedimentation pond, and that, following sedimentation, the clarified flows could be discharged directly to the environment without further treatment.

Baffinland has identified that the WRF is currently generating acid rock drainage (ARD). As a result, flows collected in the WRF Pond currently require treatment prior to environmental discharge. While actions are currently being undertaken to improve the geochemical stability of the WRF (Golder, 2018a), the effectiveness of the remedial works and the timeline for water quality improvement are currently uncertain. It is recommended that future planning of the WRF Pond operation and expansion consider that ongoing collection and treatment of the WRF seepage/runoff will be required, until such time that site water quality data are available to indicate otherwise.

The existing WRF Pond was constructed over the period of September 2015 through May 2016. The pond was constructed on sloping ground, with a containment provided by a crescent shaped outer berm. The outer berm was constructed to a crest elevation of 577.0 m. The pond floor and upstream slope of the outer berm were lined with a geomembrane to elevation 575.8 m, providing a pond capacity of approximately 9,200 m^3 (Hatch, 2017a).

Baffinland has documented the presence of seepage from the WRF Pond outer berm. In September 2017, the seepage was inspected by Hatch (Hatch, 2017b). Hatch identified that the seepage may have resulted from infiltration entering the ground upstream of the WRF Pond liner (i.e. seepage which is bypassing under the liner), from flow through damage in the pond liner, or from the pond being operated at a level above the top of liner. The exact source of the seepage was not identified. Hatch did not observe any physical damage to the liner. It is our understanding that the seepage source has not yet been identified.

2.2.1 WRF Pond Capacity

As discussed under Section 2.2, the existing WRF Pond was designed for the 1:10 year 24 hour event. It is recommended that the pond sizing be reviewed as the operational requirements now differ from those discussed under Hatch 2013 (i.e. water retention and treatment is currently required).

It is our understanding that the existing WRF Pond is temporary. Construction of the LOM run-off collection ponds (Baffinland, 2014) is still required, and should be carried out prior to further expansion of the WRF beyond the footprint presented under Section 2.1.3.

It is recommended that the pond be sized to manage (by a combination of storage and pumping/treatment) the runoff from a 1:10 year return period event. The rationale for using a 1:10 year return period for design is that, given a design life of approximately 2 years, the probability of the capacity being exceeded during its operating life is only 20%. Furthermore, the consequence of a longer return runoff event would be a spillway discharge of pond water that had been diluted by high runoff. The estimated WRF Pond capacity requirements for the 1:10 year is shown in Figure 3 (footprint of 584,000 m^2). The pond sizing in Figure 3 corresponds to the WRF footprint discussed under Section 2.1.4.The pond capacity calculations account for continuous water treatment and discharge at a rate of 280 m^3/h. Where the required pond sizing is shown as 0 m^3, the predicted the pond inflow rate is less than the treatment rate. Note that all ponds require a certain dead storage capacity to collect and feed the water treatment system.

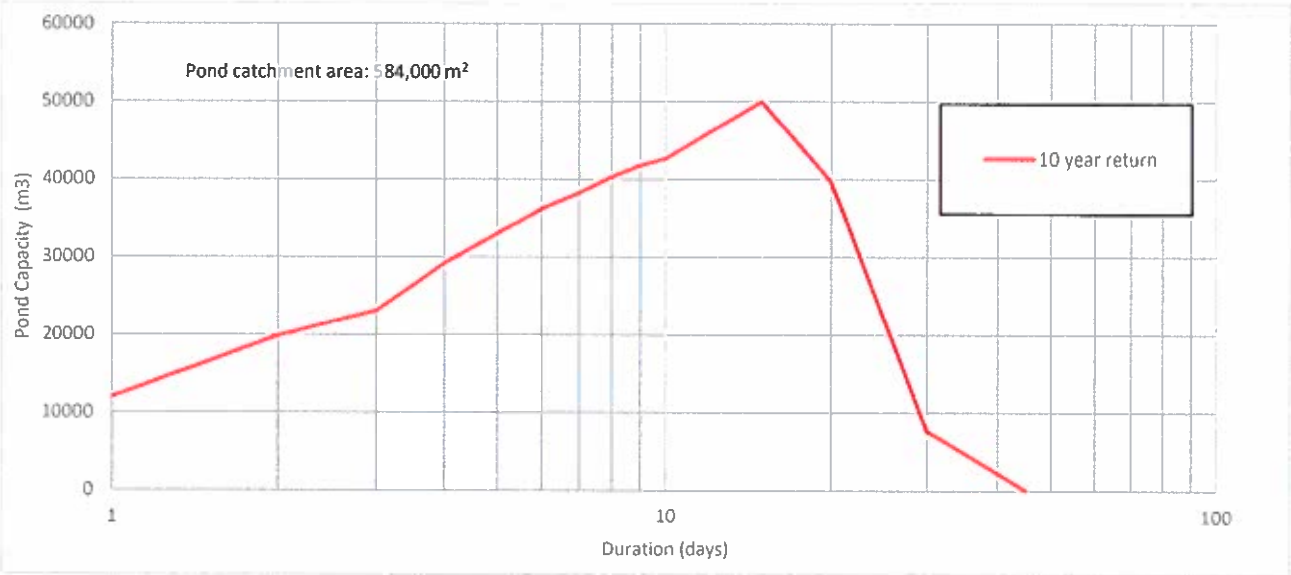


Figure 3: WRF Pond Storage Capacity for Catchment Area of 584,000 m^2

The return period flows were assessed based on a frequency analysis of the available data from meteorological station H07. Refer to the Hydrological Study (Golder, 2018b) for a detailed discussion on the frequency analysis and data source. As the return period flows were assessed based on actual measured stream-flow data, the flow values presented in Figure 3 account for varying hydrological events (i.e., they address both rainfall events and freshet events (combined rainfall and snowmelt) flows).

In the Hydrological Study (Golder, 2018b) it was recommended that a factor of safety of 1.2 be applied to the frequency analysis results, to allow for uncertainties in the analysis. The pond sizing presented in Figure 3 does not have this factor of safety explicitly applied. Instead, contingency on the pond capacity has been provided in the form of 0.6 m of freeboard as lined storage capacity (see Section 2.2.2) above the predicted maximum WRF Pond level, corresponding to 20% additional capacity beyond the predicted requirement.

Considering the 1:10 year return event, the WRF Pond capacity required to manage the 15 day duration event is approximately 50,000 m^3 for the footprint area of 584,000 m^2.

2.2.2 WRF Pond Design Criteria

The following design criteria have been established for the WRF Pond:

- Total operating capacity at maximum operating water level of 50,000 m^3;
- Normal operating volume: 450 m^3 (assumed 0.5 m minimum water depth requirement for treatment system intake);
- Berm side slopes of 3H:1V (Hatch, 2017a);
- Berm crest width of 8.4 m (Hatch, 2017a);
- Use of a geomembrane for the low permeability element (existing pond lined with Layfield 6000 HD);
- Spillway Inflow Design Flood (IDF): 1:200 year event (based on a "significant" dam classification as per the 2014 Canadian Dam Association Guidelines.
- Liner freeboard above maximum operating water level: 0.6 m (provides containment of 65,000 m^3, a 1.2 factor of safety on inflow); this will be at the spillway invert elevation of 578.9 m.;
- Dam crest freeboard above IDF water level: 0.60 m; the liner freeboard above the IDF water level is 0.2 m.

The existing WRF Pond design concept (exposed geomembrane) is proposed to be utilized for the expansion. If inspection of the condition of the existing liner indicates that the observed seepage is related to ice damage, then the liner may require supplemental protection measures (such as a sacrificial top liner or erosion protection).

Figure 4 below provides the plan view for the expanded WRF Pond footprint.

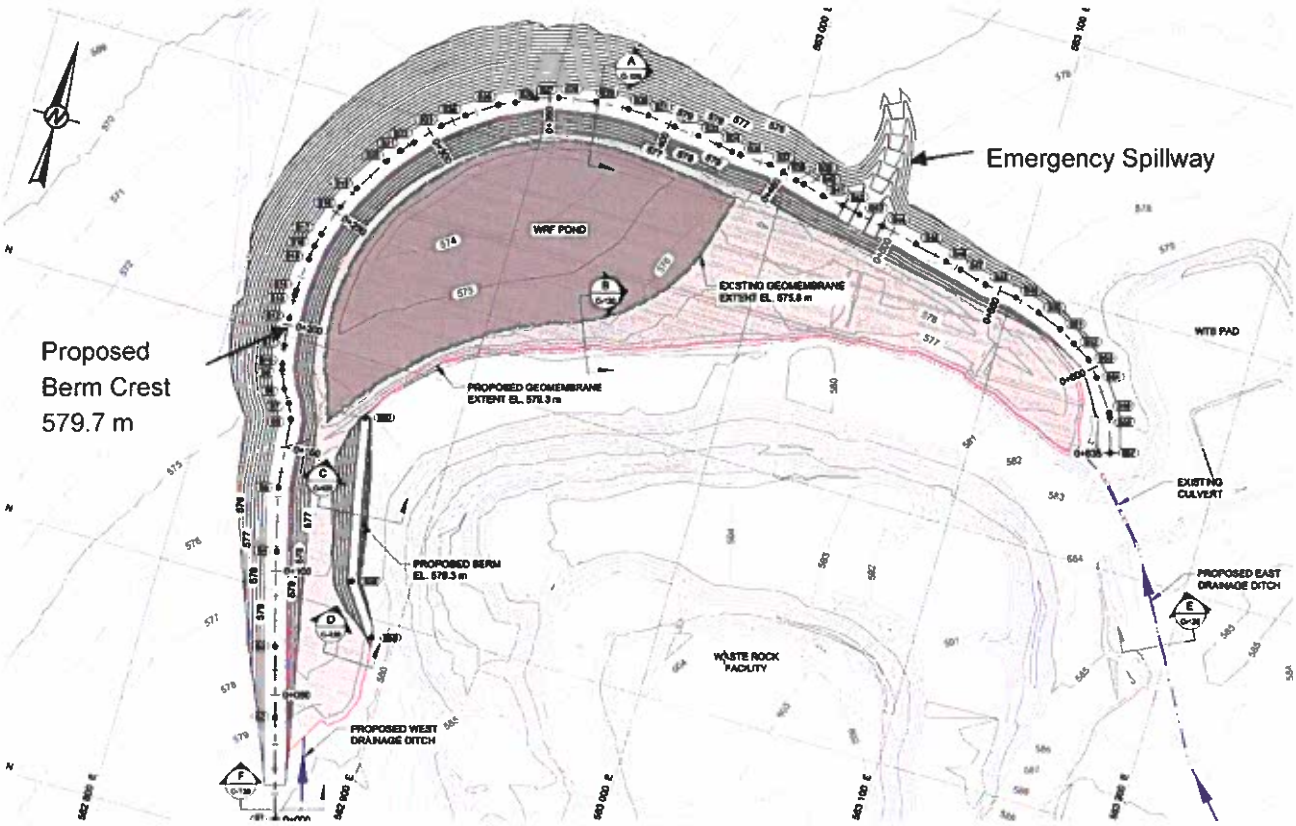


Figure 4 – Conceptual WRF Pond Expansion Plan View

Re-alignment of the existing ditches on the east and west side of the WRF will be required.

Figure 5 below provides the conceptual detail for raising of the WRF Pond outer berm (Section A) and tie-in of the geomembrane with the WRF toe berm (Section B).

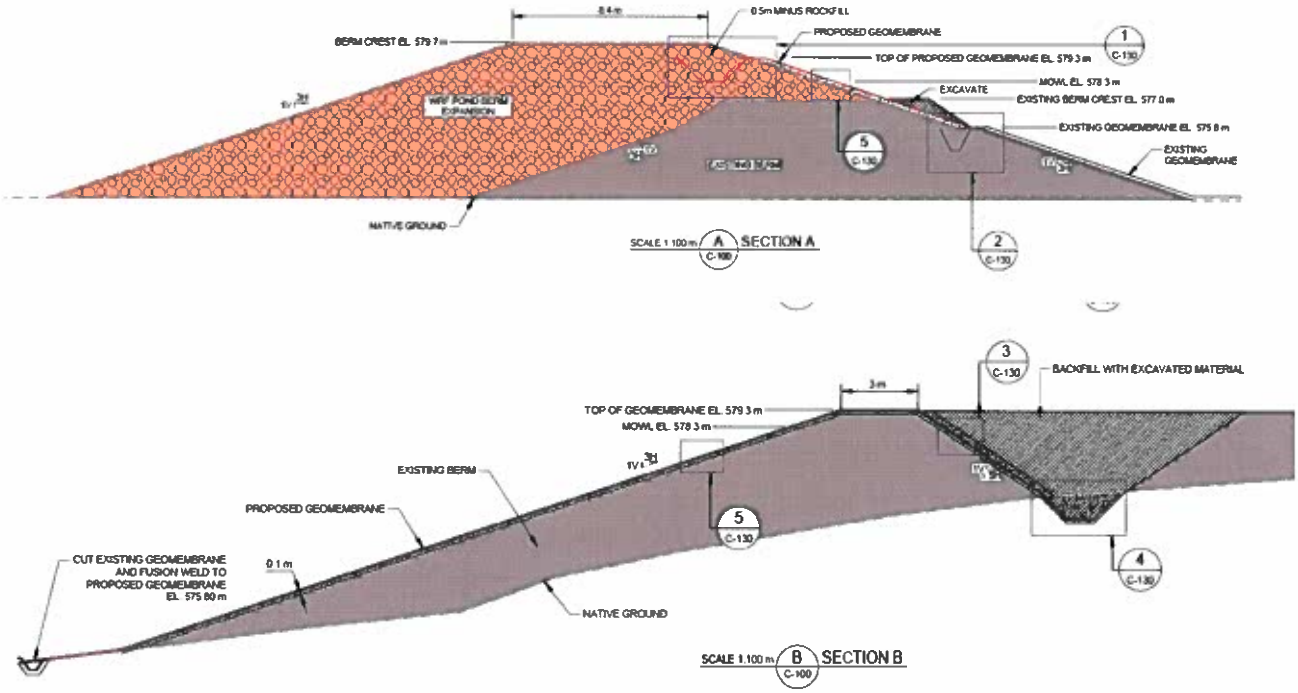


Figure 5 – WRF Pond Conceptual Cross Sections

The cross sections presented in Figure 5 are intended to present the design concept. The dimensions and elevations will be refined as part of the WRF Pond detailed design. The concept does not present the bedding details required to interface the geomembrane with the bulk fill materials.

The expanded design proposes to tie-in the WRF Pond geomembrane with the native till below the WRF toe berm proposed under Golder, 2018a. Anchoring the geomembrane within permafrost will reduce the potential for the WRF seepage to bypass under the WRF Pond geomembrane.

The WRF toe berm and WRF Pond outer berm expansions should be constructed in 1 to 2 m thick lifts, from well graded rockfill and have a maximum particle size of 0.3 m. If significant oversize material is placed within the WRF toe berm, then excavation and preparation of the geomembrane subgrade may be difficult, and require significant volume of bedding materials to create a suitable interface with the geomembrane. The bedding material is anticipated to be 9.5 mm minus crusher fines, placed 100 mm thick on either side of the geomembrane at all locations. All geomembrane will be underlain by a non-woven geotextile.

It is noted that the elevations provided in Figure 5 are preliminary. The freeboard required to contain the EDF generated over the 2019 WRF footprint has not yet been calculated. This will be carried out as part of detailed design. The elevations provided are conservatively based on the EDF inflow calculations from Golder, 2017a, which considered a larger pond catchment area of 62 ha.

The pond elevation corresponding to a 50,000 m^3 volume is 578.30 m. It is noted that the pond volume at the top of the existing liner (elevation 575.80 m) is 12,500 m^3 compared to the aforementioned as-built volume of 9,200 m^3. The 12,500 m^3 volume was calculated from as-built files provided by Baffinland.

The estimated incremental fill volume required to construct the outer berm raise is 56,000 m^3. This figure is considered a high level estimate as the survey data provided for the existing berm are incomplete (incomplete data supplemented with the design geometry). The total area of geomembrane required is estimated as 35,000 m^2. This area allows for complete replacement of the existing liner. If a sacrificial top liner is required, it may be possible to re-use some of the existing liner for that purpose.

3.0 PATH FORWARD

The following steps are required in support of the design:

- Carry out flood routing to determine the freeboard required for the EDS requirement;
- Carry out flood routing to set the spillway invert and to estimate the operating head associated with the IDF event;
- Inspect the existing liner to determine if the seepage is related to ice damage to the existing liner; and
- Develop the details of the liner bedding requirements.

4.0 CLOSURE

We trust the above meets your current requirements. If you have further queries or require additional information, please do not hesitate to contact the undersigned.

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