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REPORT

2021 Construction As-Built Report

IVR D-1 Dike Attenuation Pond

Whale Tail Project, Nunavut

Submitted to:

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EXECUTIVE SUMMARY

The 2021 winter construction season at the Whale Tail Project Site occurred from 20 February 2021 to 5 May 2021 and consisted of the construction of the IVR D-1 Dike (IVR Dike) and placement of additional rockfill material for added thermal coverage along the east and west abutments of the dike structure. The IVR Dike is part of the IVR Attenuation Pond design. Construction was completed in accordance with the requirements of the Design and Technical Specifications developed by SNC Lavalin.

The data collected from the quality assurance (QA) and quality control (QC) program during the construction of IVR Dike were used to confirm that the construction of the structure was completed in compliance with the Drawings and Technical Specifications. This includes earthwork construction such as foundation preparation and fill placement as well as the installation of the geosynthetics.

The design of the IVR Dike comprises an impermeable linear low-density polyethylene (LLDPE) geomembrane anchored within the continuous permafrost in a 3 m deep key trench. The LLDPE geomembrane is surrounded by 0.3 m of bentonite amended soil (Zone 2B) to anchor the membrane and provide additional impermeability for the dike. These soils are surrounded by filter-compatible permeable materials (Zone 2A, Zone 3, Zone 4, and rockfill) that provide stability and thermal insulation for the foundation. The design includes a conventional geomembrane-lined emergency spillway to handle extreme precipitation events.

The technical specifications for granular materials placed in the dike regard foundation preparation, grain size distribution, compaction, and bentonite content (for Zone 2B). The technical specifications for the geomembranes concern thickness and shear strength.

The key trench foundation was originally required to be ice-poor glacial till or bedrock, grouted if required to seal fractures. However, foundation conditions differed from those reported in the geotechnical investigations and ice-rich soils were present in a large section of the dike foundation (Station 0+230 to 0+300). These soils were accepted as-is due to the impracticability of removing them without further impacting the thermal regime of the foundation and the fact that they are at least 3 m below ground surface and expected to remain frozen year-round, and structurally non-weight-bearing. The bedrock encountered in the key trench foundation was found to be highly competent and grouting was deemed unnecessary given the absence of open fractures.

During the work, five RFIs were submitted requesting changes to the design and six field adjustments were applied to take into account the existing site conditions and to optimize construction activities. The most significant design changes are the reduction of bentonite content in the Zone 2B material from 8% by weight to 6% (within the Sta. 0+080 to 0+320 section) and 4% (outside that section) due to limited supplied of bentonite on site.

It is Golder Associés Ltée opinion that the QA/QC program was adequately followed during construction of the IVR Dike and the materials and construction methods used comply with the technical specifications and modified design.

DOCUMENT CONTROL

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1.0 INTRODUCTION

The 2021 winter construction season at IVR D-1 Dike (IVR Dike) occurred from 20 February 2021 to 5 May 2021 and consisted of the construction of dike, emergency spillway and placement of additional rockfill material for added thermal berm protection along the east and west abutments of the dike structure.

This as-built report for the IVR Dike construction presents a summary of the Technical Specifications, the construction activities, the quality assurance/quality control activities, and the overall information used to produce the as-built drawings. This report was prepared in a collaborative effort between Agnico Eagle Mines Limited (AEM) and Golder Associés Ltée (Golder).

1.1 Roles and Responsibilities

The Drawings and Technical Specifications for the IVR Dike were developed by SNC Lavalin (SNC) and reviewed by the AEM Engineering Team and by the Meadowbank Dike Review Board. Kivalliq Contractors Group (KCG), was contracted by AEM to complete the 2021 IVR Dike construction scope of work. The Owner Representative from AEM was responsible for managing and planning the construction. Golder was responsible for the quality assurance (QA) program and provided technical review of the work to ensure that the structures were constructed according to the Technical Specifications and Construction Drawings (Drawings). The quality control (QC) program (except for aspects related to geosynthetics) was carried out by Tetra Tech Ltd. (Tetra Tech), under the direction of AEM. Tetra Tech monitored the construction to ensure that the work and materials met the Technical Specifications. Drilling and blasting of the key trench excavation was executed with collaboration between AEM Mine Operations and KCG, under the direction of AEM as well as Dyno Nobel Consultants. The geosynthetics were installed by the subcontractor FC Liners under the direction of KCG, geomembrane QC was also done by FC Liners.

Table 1 presents a summary of the general roles and responsibilities for each of the parties involved during the 2021 IVR Dike construction season. This table also includes the key companies and the key personnel that contributed to the various construction activities.

Table 1: Roles, Responsibilities and Key Personnel for the IVR Dike 2021 Construction Season

Company	Role	Responsibility	Key Personnel	Position
Agnico Eagle Mines Meadowbank Division	Owner	Act as Owner's Representative Manage and plan the construction Identify changes to be made in the design, collect information, and share it with the Designer Provide survey and as-built drawings	Thomas Lepine	Engineer of Record (Nunavut)
			Alexandre Lavallée	Responsible Person
			Mark Long	Construction Superintendent
			Marc-André Beaudet	Construction Assistant Superintendent
			Jennifer Pyliuk	Construction Civil Lead

Company	Role	Responsibility	Key Personnel	Position
			Anthony Stewart Stephane Gionet	Construction General Foreman
			Frédérick L. Bolduc	Geotechnical Coordinator
			Patrice Gagnon Laurier Collette	Geotechnical Engineer/Specialist
			Yanick Hamel Jean-François Landreville	Surveyor
Kivalliq Contractors Group (KCG)	Contractor	Execute 2021 dike construction activities	Nicolas Tremblay	Project Manager
			Dany Pageau Sabin Larouche	Superintendent
SNC Lavalin	Designer	Issue design changes and confirm deviations to design	Anh-Long Nguyen	Designer and Project Manager
Golder Associés Ltée	Quality Assurance	QA program during construction Technical review of construction work	Yves Boulianne	Project Director
			Marion Habersetzer	Project Manager
			Shai Spilberg Brandon Gray	QA Representative
Tetra Tech Ltd.	Quality Control	Carry out QC program and construction monitoring	Fai Ndofor	Project Manager
			Ryan Okkema Doug Yokoyama Chantal Pawlychka John Carnegie	QC Representative
FC Liners	Liner subcontractor to KCG	Geosynthetics installation and QC testing	Francis Salois-Long	Project Manager
			René Rheault Simon Jodoin	Site Foreman
			Florent Vaillant Patrick Langlois	QC Representative (geosynthetics)

1.2 Definitions of Terms Used in this Document

The following table presents the definition of the terms used in this report.

Table 2: Definition of Terms

Term	Definition
AEM	Agnico Eagle Mines, Owner.
As-built drawing	Document showing no new concept. It is the graphical representation of a built structure showing the real measurements, installed instruments and objects. Can be seen as an inventory of what was built for reference.
ASTM	American Society for Testing and Materials.
Approval	A written engineering or geotechnical opinion, related to the progress and completion of the Work.
BGM	Bituminous geomembrane satisfying Technical Specifications.
Coarse Filter – Zone 3	Material produced from processing of NON-AG rockfill and meeting the Technical Specifications.
Contractor	Kivalliq Contractors group (KCG). On-site representative of the construction company contracted by the Owner to successfully carry out the scope of work as defined in the Technical Specifications.
Designer	SNC Lavalin.
Dike	Earthwork structure made of rockfill and natural soil to retain water.
Downstream and Upstream	The downstream direction represents the downward direction of water flow in a valley or in the direction of a slope. Upstream is defined as the opposite of downstream. For a dike, downstream is the direction of flow from the dike and upstream represents what is retained by the structure.
Esker – Zone 4	Naturally occurring well-graded material consisting of silt, sand and gravel, having relatively low permeability and satisfying the Technical Specifications.
Field Laboratory	Area and facilities provided for QC and QA testing at Amaruq.
FFAB– Zone 2A	Fine filter amended with bentonite (FFAB). FFAB material produced from mixing fine filter processed NON-AG rockfill and bentonite material and satisfying Technical Specifications.
Fine Filter – Zone 2B	Material produced from processing of NON-AG rockfill and satisfying Technical Specifications.
Geotextile	Non-woven geotextile, minimum 16 oz/yd^2, Tencate Mirafi 1600 or equivalent.
Ice-Poor Soils	Frozen soils that contain less than 10% visible ice volume or moisture having a water content of less than 30% or ice lenses thinner than 10 mm.

Term	Definition
Ice-Rich Soils	Frozen soils that contain more than 10% visible ice volume or moisture having a water content of more than 30% or ice lenses thicker than 10 mm.
Liner Installer	FC Liners, subcontractor under the responsibility of the Contractor and responsible for the installation of geosynthetic material.
LLDPE Geomembrane	Linear low-density polyethylene geomembrane satisfying Technical Specifications.
Owner	Agnico-Eagle Mines Limited, Meadowbank Division (AEM)
Owner's Representative	Person(s) employed by the Owner in order to oversee the project works and the Owner's interests. The primary point of contact for the Designer and the Contractor.
NON-AG	NON-AG: A material that has been geochemically classified as not being acid generating.
QA Representative	Responsible for QA activities.
Quality Assurance (QA)	A planned system of inspection and testing, to the satisfaction of the Owner, the Designer, other stakeholders and regulators, that the Work complies with the design, Drawings and Technical Specifications. Quality Assurance comprises inspections carried out during Quality Control that include verifying and assessing materials and workmanship necessary to determine and document the quality of the constructed facility. Quality Assurance refers to the measures taken by the Quality Assurance organization to assess whether the Contractor is in compliance with the design, Drawings and Technical Specifications.
QC Representative	Person or company hired by the Owner and under the supervision of the Owner's Representative to collaborate with the Contractor to ensure QC testing and inspection of all work done by the Contractor.
Quality Control (QC)	A planned system of inspection, testing and documentation carried out by the Contractor during construction to ensure that the Work is being performed and completed in a manner that complies with the Drawings and Technical Specifications.
Rockfill – Zone 1	NON-AG rockfill, expected to be run-of-mine material requiring little to no processing and satisfying the Technical Specifications.
Suitable Fill Materials	Materials free from organic or other deleterious matter, having a gradation which permits compaction or placement to a stable state, and having the characteristics specified for the particular materials after handling, re-handling, processing and reprocessing have taken place.
Till	Naturally-occurring well-graded material consisting of particle sizes ranging from clay to boulders.
Unsuitable Fill Materials	Materials containing oversized or segregated particles, organic or other deleterious matter such as ice or snow or having poor characteristics which may result in an undesirable settlement or otherwise not meeting the requirements of the Technical Specifications.

Term	Definition
Work	All activities associated with the construction of IVR Dike.
Working Platform	Surface of fill and/or excavated surface from which the work is conducted.

1.3 Description of the Built Structures

The IVR Dike is located northeast of the existing Whale Tail Dike at AEM's Amaruq site. Figure A shows a general site layout in plan view of the IVR attenuation pond and IVR D-1 Dike structure.

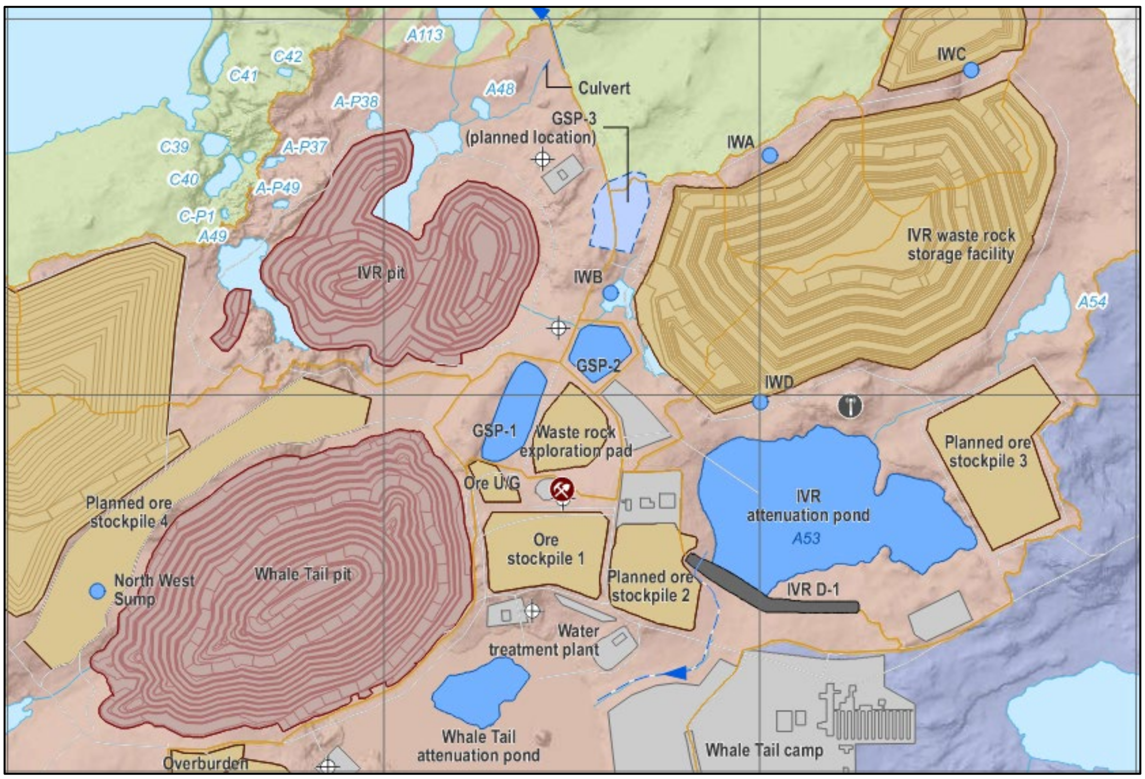

Figure A: General plan view layout of the IVR D-1 Dike at the Amaruq Site

The IVR Dike is designed and constructed as a zoned rockfill dam with filter zones, an impervious upstream liner, and a liner tie-in key trench cut-off wall. The IVR Dike was constructed in three months from February to May 2021.

The IVR Dike cross-section consists of a minimum 3.0 m deep key trench blasted into overburden or bedrock and filled with compacted Fine Filter/FFAB (Zone 2A/2B) material and Coarse Filter (Zone 3). The downstream face of the IVR Dike is comprised of a rockfill (Zone 1) embankment constructed from run-of-mine waste rock placed to Elev. 165.5 m with a downstream slope at a 2H:1V.

The upstream face of the IVR Dike comprises two rockfill filter zones, Fine Filter (Zone 2A) and Coarse Filter (Zone 3), and a linear low-density polyethylene (LLDPE) liner extending along the key trench to a depth 2.5 m below ground surface (mbgs). The filter zones act as the bedding surface to prevent damage to the liner and as a filter designed to prevent internal erosion. Esker (Zone 4) material is placed upstream of the liner to Elev. 164.5 m to minimize convective heat transfer and water infiltration from the pond towards the cut-off wall. The upstream shell consists of rockfill (Zone 1) placed to Elev. 165.5 m with an upstream slope at a 2H:1V. A spillway structure is constructed along the west abutment of the IVR Dike at invert Elev. 164.8 m.

1.4 Construction Drawings and Technical Specifications

The Construction Drawings and Technical Specifications for the IVR Dike were developed by SNC in 2020 prior to the beginning of construction.

Table 3, Table 4, and Table 5 present the available versions of the Design Reports, Technical Specifications, and Drawings in chronological order.

Table 3: List of Design Reports for IVR D-1 Dike

Document Number	Date	Rev	Title
Client Ref. 6127-695-132-REP-005	23/12/2020	0	Detailed Report of IVR Attenuation Pond D-1 Dike

Table 4: List of Technical Specifications for IVR D-1 Dike

Document Number	Date	Rev	Title
Client Ref. 6127-C-230-003-SPT-001	21/12/2020	0	Technical Specifications for the Construction of IVR D-1 Dike

Table 5: List of Construction Drawings for IVR D-1 Dike

Drawing Number	Date	Rev	Title
61-695-210-200	22/12/2020	0	General Arrangement
61-695-230-204	22/12/2020	0	Location Map and Drawing Index
61-695-230-205	22/12/2020	0	Field Investigation Location Plan and Soil Stratigraphic Section
61-695-230-206	22/12/2020	0	Plan and Section IVR Attenuation Pond D1
61-695-230-207	22/12/2020	0	Excavation Plan and Sections
61-695-230-208	22/12/2020	0	Design Sections and Details
61-695-230-209	22/12/2020	0	Spillway Plan Sections and Details
61-695-230-210	22/12/2020	0	Instrumentation Plan
61-695-230-211	22/12/2020	0	Construction Sequence Sections

1.5 As-Built Drawings

Table 6 presents the as-built drawings for the 2021 construction season of the IVR Dike. The surveying and the as-built drawings were done by AEM and verified by Golder. The as-built drawings for the 2021 construction of the IVR Dike are included in Appendix A.

Table 6: List of As-Built Drawings for the IVR D-1 Dike.

Drawing ID	Date	Rev	Title
6127-IVR-Typ. Section	28/05/2021	0	Typical Cross Sections: West Abutment @ 0+080 & 0+320 @ 0+445 (outside MOL) 0+080 @ 0+320 (inside MOL) 0+445 @ East Abutment (outside MOL)
6127-IVR-As Built	25/07/2021	0	As Built Cross Sections: 0+046 @ 0+050 0+060 @ 0+090 0+100 @ 0+130 0+140 @ 0+170 0+180 @ 0+210 0+220 @ 0+250 0+260 @ 0+290 0+300 @ 0+330 0+340 @ 0+370 0+380 @ 0+410 0+420 @ 0+450 0+460 @ 0+490 0+500 @ 0+530
6127-IVR-Plan View	31/07/2021	0	As Built Plan View
6127-IVR-AB_Liner	28/05/2021	0	As Built – Liner
6127-IVR-AB-SPILLWAY	21/07/2021	0	As Built Spillway Profile & Cross Sections

MOL = maximum operation level.

1.6 Technical Memoranda – Design Changes

Design changes and field adjustments occurred during the 2021 IVR Dike construction season to adapt the initial design to material availability on site and field conditions encountered during construction. These design changes were implemented by the Designer in partnership with AEM. Five requests for information (RFIs) were submitted during the 2021 construction campaign. Table 7 summarizes the list of RFIs that discuss field adaptation or modification from the initial Technical Specifications and Drawings relevant to the 2021 IVR Dike construction Season listed in chronological order. The RFIs issued during the 2021 IVR Dike construction season, including details about the background and recommendations for each one, can be found in Appendix B. Other field changes and adjustments are documented in Section 5.0

Table 7: List of RFIs Issued During the 2021 Construction Season of IVR Dike

Doc Number	Date	Rev	Title
668284-5100-64NQ-I-0001	04/02/2021	0	Esker Material Placement
668284-5100-64NQ-I-0002	04/02/2021	0	Changes to Geometry and Location of Liner Joint
668284-5100-64NQ-I-0003	11/02/2021	0	Surface Preparation
668284-5100-64NQ-I-0004	09/18/2012	0	12 m Wide Upstream Berm Modification (partially implemented)
668284-5100-64NQ-I-0005	04/24/2014	0	Bentonite Quantity Optimisation

RFI-01 - Esker Material Placement:

Replace esker by compacted Fine Filter material (Zone 2A) compacted Fine Filter (Zone 2A), FFAB (Zone 2B), Coarse Filter (Zone 3) or Rockfill (Zone 1) depending on location due to a lack of suitable esker material on site.

RFI-02 - Changes to Geometry and Location of Liner Joint:

Relocate liner connection weld above key trench to improve performance of the dike.

RFI-03 - Surface Preparation:

Clarify that unsuitable foundation material outside the key trench will be removed but without systematic excavation to fixed depth.

RFI-04 - 12 m Wide Upstream Berm Modification (partially implemented):

Have the rockfill protection layer be included in the 12 m of rockfill placed on the upstream side of the dike, thus reducing the total width of upstream side of dike from 15 m to 12 m from liner connection weld. Place esker material up to the maximum operation level (MOL) elevation and rockfill above to reduce esker material quantities.

Note that only part of this design change, regarding the esker elevation within the upstream berm, was implemented, while the original upstream berm width was respected.

RFI-05 - Bentonite Quantity Optimisation:

FFAB material (Zone 2B) eliminated from select locations and mix ratio modified to complete the construction with available bentonite quantities on site.

2.0 SUMMARY OF TECHNICAL SPECIFICATIONS REQUIREMENTS

The Technical Specifications and Requirements for the main work activities at the IVR Dike are summarized below.

2.1 Excavation and Foundation Preparation

The technical requirements for the foundation preparation at the IVR Dike include:

- Key trench blasting to a minimum depth of 3.0 mbgs into overburden ice-poor till or bedrock.
- Stripping of the footprints to provide suitable surface for rockfill and granular fill placement, such as removal of boulders, snow, ice and organics where present.
- Bedrock cleaning including the removal of soil and rock fragments in all pockets, cracks and depressions and grouting of cracks and joints as required.
- Preparation of foundation surfaces for LLDPE geomembrane installation, where applicable.

Stripping and excavation must be carried out in accordance with their respective Drawings and Technical Specifications.

Foundation approvals must be completed and documented before placing granular material above the foundation.

2.2 Fills Materials and Placement

The IVR Dike is made of five different fill materials zones. The general Technical Specifications for each fill material zone are described in Section 2.2.1 through Section 2.2.5. The material gradation limits are summarized in Table 8.

Table 8: Material Gradation Limits for IVR Dike

Grain Size (mm)	Percent Passing by Mass (%)				
	Rockfill (Zone 1)	Fine Filter (Zone 2A)	Bentonite	Coarse Filter (Zone 3)	Esker (Zone 4)
1000	100	-	-	-	-
500	80-100	-	-	-	-
200	10-100	-	-	-	100
150	-	-	-	100	-
100	0-60	-	-	60-100	85-100
56	-	-	-	-	79-100
31.5	-	-	-	-	59-93
30	0-25	-	-	20-57	-
19	-	100	-	-	47-86

Grain Size (mm)	Percent Passing by Mass (%)				
	Rockfill (Zone 1)	Fine Filter (Zone 2A)	Bentonite	Coarse Filter (Zone 3)	Esker (Zone 4)
13		65-100	-	-	-
10	-	-	-	5-32	-
4.75	-	30-65	-	0-24	27-71
2.00	-	17-41	100	0-17	20-62
0.850		11-27	60-100	-	-
0.475	0-15	-	-	-	-
0.425	-	9-18	-	0-10	10-45
0.150	-	7-13	-	-	-
0.075	-	6-10	0-20	0-5	7-20

2.2.1 Zone 1 – Rockfill

Rockfill shall consist of sound, hard, durable, NON-AG, well graded rock fragments free from any possible effect by water or elements. It shall be free from snow, ice, frozen chunks, organic matter, debris, and other unsuitable material. Rockfill must have a maximum particle size of 1.0 m. All rockfill shall be geochemically classified by the Owner prior to placement.

The maximum loose lift thickness for rockfill is 1.5 m. Placement equipment shall traffic the material uniformly parallel and perpendicular to the lift front advancement to aid with compaction. Rockfill shall be placed and compacted to avoid disturbance of the underlying materials. Compaction of rockfill shall be carried out using a 10-tonne smooth-drum roller with a minimum of six passes. Compaction shall be to the satisfaction of the Owner's Representative.

2.2.2 Zone 2A – Fine Filter

Fine filter is made of crushed NON-AG rockfill processed to satisfy the gradation limits. Fine filter shall be free of organic material, debris, cinders, ash, refuse, snow, ice, and other deleterious material subject to the satisfaction of the Owner's Representative.

The maximum loose lift thickness of fine filter is 0.3 m on the downstream side of the liner and 0.5 m on the upstream side of the liner. Compaction of fine filter must be carried out using the bucket of the excavator to the satisfaction of the Owner's Representative.

2.2.3 Zone 2B – Fine Filter Amended with Bentonite (FFAB)

The FFAB is to be mixed homogeneously, and powdered sodium bentonite shall be added mechanically to the fine filter or by other methods approved by the QC and QA representatives. The bentonite shall be free flowing, high swelling, powdered sodium bentonite and satisfy the gradation limits.

The ratio of bentonite in the FFAB shall be at least 6% of the fine filter by weight after mixing, loading, hauling, unloading and placement but before compaction. The initial ratio of bentonite (when mixing) may be higher than 6% to meet this requirement. The FFAB shall be mixed in an area protected from prevailing winds. No FFAB mixing, loading, hauling and placement shall occur when weather conditions promote excessive loss of fines based on judgment of QC and QA personnel.

The maximum loose lift thickness of FFAB is 0.3 m. FFAB under the liner must be compacted with the optimum number of passes which will be determined following the completion of the test pad in order to achieve 98% maximum dry density using the Standard Proctor compaction procedure on a sample at its in situ water content. Compaction of FFAB over the liner must be carried out using the bucket of the excavator to the satisfaction of the Owner's Representative. The FFAB shall be placed and compacted within 24 hours after mixing or before weather conditions deteriorate.

2.2.4 Zone 3 – Coarse Filter

Coarse filter is made of crushed NON-AG rockfill processed to satisfy the gradation limits. Coarse filters shall be free of organic material, debris, cinders, ash, refuse, snow, ice, and other deleterious material.

The maximum loose lift thickness of the coarse filter upstream and downstream of the liner is 0.5 m and is 0.3 m everywhere else. Coarse filter shall be placed and compacted to avoid disturbing the underlying materials. Compaction of the coarse filter shall be carried out using a 10-tonne smooth-drum vibratory roller compactor with a minimum of six passes parallel to the axis of the structure and to the satisfaction of the Owner's Representative.

2.2.5 Zone 4 – Esker

The Esker material is sourced from naturally occurring soil and constituted of silty sand and gravel. The material must be well-graded with a maximum particle size of 200 mm and satisfy the gradation limits. Esker shall be free of ice, snow, frozen chunks, organic matters, debris, or other unsuitable materials.

The maximum loose lift thickness of the Esker is 0.5 m everywhere outside of the cut-off trench, where the original design prescribed 0.3 m thick lifts (no longer relevant in the cut-off trench after design change). Esker shall be placed and compacted to avoid disturbance of the underlying materials and to limit particle segregation. Esker must be compacted with the optimum number of passes which will be determined following the completion of the test pad in order to achieve 95% maximum dry density using the Standard Modified compaction procedure on a sample of Esker material at its in situ water content.

2.3 Liner Tie-In Key Trench

The Technical Specifications for the construction of the liner tie-in key trench of the IVR Dike include the following activities:

- Excavation of the liner tie-in key trench will involve blasting to a minimum depth of 3.0 mbgs in overburden ice-poor till or until bedrock. Bottom of cut-off trench must be established on or below the glacial till surface or bedrock, if the surficial gravel cobbles and boulders layer is encountered the excavation must continue until this material has been completely removed.
- Preparation of the bedrock surface at the base of the liner tie-in key trench. Bedrock preparation includes removal of loose material and ice, bedrock mapping and the sealing of exposed cracks and joints at the bottom of the cut-off trench as required.

- Preparation of liner tie-in key trench surfaces for geosynthetic placement.
- Backfilling of the liner tie-in key trench with compacted FFAB, fine filter and coarse filter materials.

2.4 Geosynthetics

The geotextile installed at the IVR dike must be Tencate Mirafi 1600 or an approved equivalent. The work covered by the Technical Specifications includes the purchase, fabrication (if needed), supply, transport, storage, testing, and installation of the geotextile.

The LLDPE geomembrane installed at the IVR Dike must be a double-sided textured LLDPE (1.5 mm thick). The work covered by the Technical Specifications includes the purchase, supply, transport, storage, installation, and testing of the LLDPE geomembrane.

The bituminous geomembrane (BGM) placed in the spillway channel must be Coletanche ES2 elastomeric geomembrane (4 mm thick) or an approved equivalent. The work covered by the Technical Specifications includes the purchase, supply, transport, storage, installation, and testing of the bituminous geomembrane.

3.0 SUMMARY OF CONSTRUCTION ACTIVITIES AND SCHEDULE

This section describes the construction steps performed during the 2021 construction season to build the IVR Dike. This section also includes the schedule for the work done.

3.1 IVR Dike– Schedule and Construction Steps

The construction of the IVR Dike took place from 20 February 2021 to 5 May 2021, and was comprised of the following major work items:

- Site preparation (removal of snow along key-trench and downstream shell of dike, construction of temporary access roads);
- Drilling and blasting for key trench and bulk excavation (to a minimum depth of 3.0 mbgs);
- Foundation preparation and approval of base of key trench (cleaning of rock fragments and loose material, bedrock preparation);
- Key trench fill placement, compaction, and slope profiling (coarse filter, fine filter and FFAB material placement);
- Geotextile and LLDPE geomembrane installation in key trench (2.5H:1V slope from original ground to 2.5 mbgs);
- Foundation preparation and approval of downstream shell (removal of snow and ice);
- Downstream shell fill placement, compaction, and slope profiling (rockfill, fine and coarse filter material placement);
- Geotextile and LLDPE geomembrane installation along upper slope (3H:1V slope from original ground to Elev. 165.5 m);
- Foundation preparation and approval of upstream shell (removal of snow and ice);

- Upstream shell fill placement, compaction, and slope profiling (rockfill and esker material placement);
- Spillway fill placement, compaction, and slope profiling (coarse filter and fine filter material placement);
- BGM installation along spillway channel at invert Elev. 164.8 m.
- Thermal berm construction along east and west abutments (rockfill placement).

The work procedures followed during the construction of these work items are discussed in the following subsections.

Selected photographs of the work progress taken throughout the construction season are shown in Appendix C. Table 9 presents the construction schedule for the main work items regarding the preparation of the IVR Dike.

Table 9: Schedule of Construction Activity at the IVR Dike

Activity	Beginning	End
Site preparation (removal of snow along key-trench and downstream shell of dike)	14 February 2021	23 February 2021
Drilling and blasting for key trench and bulk excavation (to a minimum depth of 3.0 mbgs)	23 February 2021	23 March 2021
Foundation preparation and approval of base of key trench (cleaning of rock fragments and loose material, bedrock preparation)	24 February 2021	10 April 2021
Key trench fill placement, compaction, and slope profiling (coarse filter, fine filter and FFAB material placement);	4 March 2021	16 April 2021
Geotextile and LLDPE geomembrane installation in key trench (2.5H:1V slope from original ground to 2.5 mbgs);	15 March 2021	16 April 2021
Foundation preparation and approval of downstream shell (removal of snow and ice)	26 March 2021	16 April 2021
Downstream shell fill placement, compaction, and slope profiling (rockfill and filter zones placement)	26 March 2021	22 April 2021
Geotextile and LLDPE geomembrane installation along downstream shell (3.0H:1V slope from original ground to Elev. 165.5 m);	15 April 2021	22 April 2021
Foundation preparation and approval of upstream shell (removal of snow and ice);	17 April 2021	29 April 2021
Upstream shell fill placement, compaction, and slope profiling (rockfill and esker zones placement); and	17 April 2021	2 May 2021

Activity	Beginning	End
Spillway fill placement, compaction, and slope profiling (rockfill and filter zones placement)	22 April 2021	23 April 2021
BGM installation along spillway channel at invert Elev. 164.8 m.	23 April 2021	24 April 2021
Thermal berm construction along east and west abutments (rockfill placement).	27 April 2021	3 May 2021

The delay in completing Geotextile and LLDPE geomembrane installation in key trench is because FC Liner was scheduled off site on 2 April 2021 and did not return until 11 April 2021 to complete the remaining installation of geosynthetic material.

3.1.1 Site Preparation

Temporary access roads were constructed at the west entrance of the IVR Dike to allow access for haul truck and heavy equipment traffic. Snow was removed from the footprint of the key trench cut-off wall and downstream shell in advance of drill and blast operations for the key trench. Temporary access roads were also constructed at the east entrance of the IVR Dike to allow for continuous flow of traffic from the west to the east entrances during construction.

3.1.2 Drilling and Blasting

Blasting of the overburden material was required during construction of the key trench cut-off wall to a minimum depth of 3.0 mbgs. Drilling activities were conducted by KCG with stemming and blasting operations being executed by AEM Mine Operations. Blast mats were used for all blasts to preserve infrastructure within the blast radius. In total 13 blasts were conducted during construction of the IVR Dike.

The key trench cut off wall was blasted to an average depth of 3.5 mbgs along the approximately 9 m wide key trench. The width of the key trench incorporating back break and removal of loose overhanging overburden material can be seen in the as-built cross-sections in Appendix A.

Bulk excavation of the key trench was then executed with an excavator down to rough design grades.

3.1.3 Key Trench: Foundation Preparation

The foundation preparation consisted of the removal of snow, ice, boulders and any other deleterious materials or soft/loose pockets of material. Before the placement of fill materials over the dike foundation, the foundation surface was inspected and then accepted by the Owner’s Representative, and the QC and QA representatives.

In areas where the foundation of the key trench consisted of till (Sta. 0+130 to 0+312), the surface was carefully cleaned using an excavator and all soft/loose pockets of material were removed. The foundation was then subjected to a final cleaning using high-pressured air compressors. The QA Representative obtained in-situ samples along the base of the key trench at approximate intervals of 20 m for moisture and ice content testing to evaluate ice-poor or ice-rich quality of the soils as defined in the Technical Specifications. A summary of moisture and ice content testing results can be found in Table 10.

In areas where the overburden surface was identified as ice rich based on visual observations and laboratory testing the foundation of the key trench was approved by the QA Representative and other stakeholders after the following procedure was followed:

- Survey verification that the key trench excavation was excavated below 3.0 mbgs as the permafrost is not expected to thaw at this depth.
- Visible ice was removed from the trench floor by scraping with an excavator bucket. If ice was still visible after scraping down a minimum of 10 cm, the ice was left in place.

Table 10: Summary of moisture and ice content samples of overburden foundation soil samples

Sample ID	Date Sampled	Location	Moisture Content (%)	Ice Content (%)	Comments[1]
QA21-07	3 March 2021	Sta. 0+145	18.4	9.9	Ice poor zone
QA21-08	5 March 2021	Sta. 0+180	9.4	5.2	Ice poor zone
QA21-09	5 March 2021	Sta. 0+190	26.5	5.2	Ice poor zone
QA21-10	5 March 2021	Sta. 0+200	17.3	6.8	Ice poor zone
QA21-13	10 March 2021	Sta. 0+230	36.0	13.7	Ice rich zone
QA21-14	10 March 2021	Sta. 0+240	24.7	5.8	Ice rich zone
QA21-15	11 March 2021	Sta. 0+260	26.6	19.9	Ice rich zone
QA21-16	12 March 2021	Sta. 0+280	79.5	56.9	Ice rich zone
QA21-17	13 March 2021	Sta. 0+300	29.1	15.9	Ice rich zone
QA21-18	14 March 2021	Sta. 0+320	12.9	1.7	Ice poor zone
QA21-22	7 April 2021	Sta. 0+465	18.3	1.2	Ice poor zone

Notes:

1. Moisture content testing conducted in accordance with ASTM D4959.
2. Ice content calculated through measuring mass of supernatant water in soil sample: Ice Content (%) = ($M_{ice\text{-}water}/M_{dry\text{-}soil}$) x 100%.
3. Based on visual observation and laboratory testing results.

In areas where the foundation of the key trench consisted of bedrock (from Sta. 0+045 to 0+130 and from Sta. 0+312 to 0+526), the foundation was carefully cleaned using high-pressured air compressors. All pockets, cracks and depressions filled with soil and rock fragments were cleaned to the satisfaction of the QC and QA representatives. During key trench excavation, bedrock was mostly encountered outside of the MOL footprint (except between Sta. 0+100 and 0+130) and was identified to be competent, and moderately to heavily jointed in some areas; joint aperture was observed to be tight to very tight. As indicated in FC21-03 in Section 5.0, bedrock grouting was not required along the bedrock surface in areas where the bedrock is sound, of high quality, with closed joints, and outside of the MOL footprint. No bedrock grouting was performed during the construction of the IVR Dike, although bedrock was encountered in the key trench within the MOL footprint between Sta. 0+100 and 0+130. This section was not grouted, which is not compliant with FC21-03. However, due to the proximity of this section to the MOL footprint limit, thus exposed to a low hydraulic gradient, the good quality of the bedrock, which was sound with tightly closed joints, and the low-permeability FFAB material placed over it over the entire width of the key trench, the lack of grouting in this limited section is deemed acceptable. The QA Representative manually mapped the critical bedrock features using a Brunton or Silva Ranger compass. To facilitate the construction process AEM at times assisted in mapping bedrock using a Maptek laser scanning system.

The approved foundation area was then surveyed by AEM or KCG surveyors and provided to the QA Representative for review. The as-built trench data was reviewed to verify the footprint of the liner would be installed over ice-poor overburden soil as identified in the excavation side walls or within the excavation of the key trench. The liner footprint was fully within the excavation of the key trench for the entirety of the IVR Dike. Some ice-rich soils were left in place in the key trench walls, as only components not sensitive to settlement (i.e., rockfill shell that is easy to repair) were placed on top of these areas (see Section 3.1.5).

A total of 19,442 m^3 of overburden and blasted rock was removed from the key trench to construct the IVR Dike.

3.1.4 Key Trench: Zone Placement

Due to sodium bentonite material shortages on site, FFAB (Zone 2B) material was placed along the base of the key trench at various design widths and bentonite concentrations. As indicated in RFI '668284-5100-64NQ-I-0005' in Appendix B, to optimize bentonite quantities the FFAB material was placed in three different zone configurations as seen in Figure 2 below:

- **ZONES I to III:** From Sta. 0+080 to Sta. 0+320 (within MOL footprint) @ 6% FFAB
- **ZONES I to III:** From Sta. 0+320 to Sta. 0+435 @ 4% FFAB
- **ZONES I to II:** From Sta. 0+435 to Sta. 0+523 @ 4% FFAB

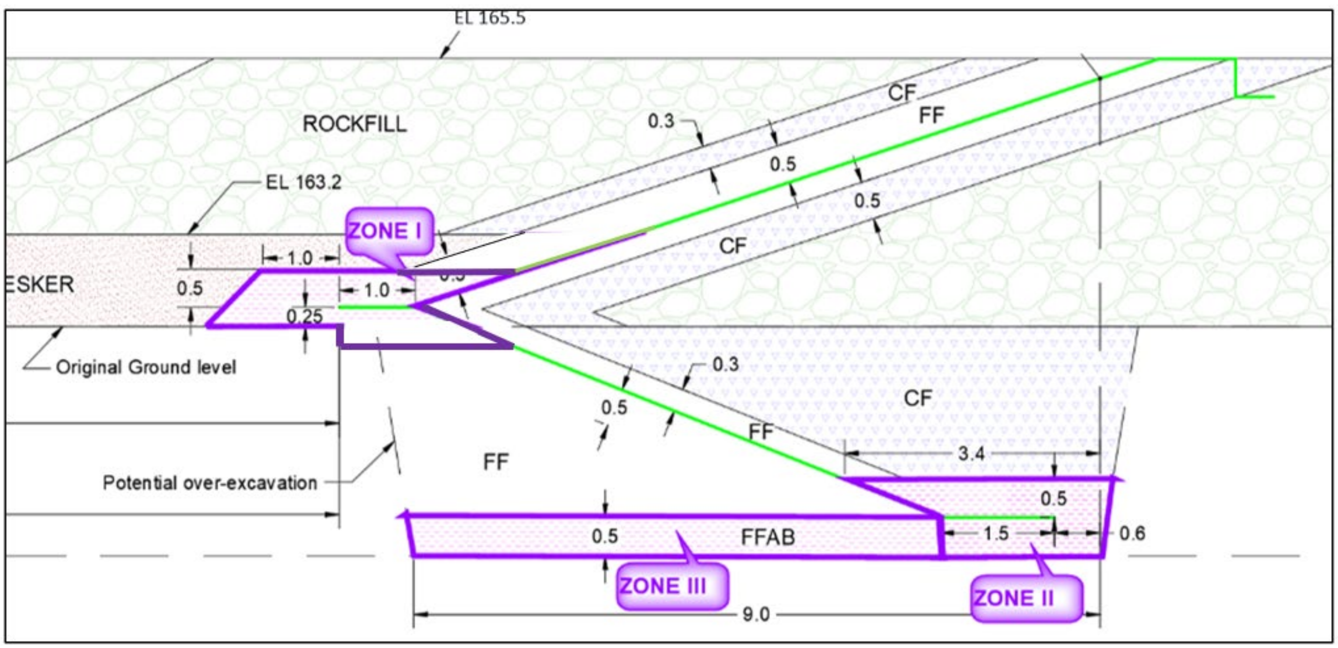

Figure B: IVR Dike FFAB (Zone 2B) material placement

The FFAB material was placed from the floor of the key trench to 2.5 mbgs and from 0.25 mbgs to 0.0 mbgs to construct the under-liner slope. The FFAB was composed of fine filter mixed with various concentrations of sodium bentonite as summarized above. The material was end dumped from the edge of the excavation and levelled by excavator in 0.3 m loose lifts.

FFAB placed under liner in deeper pockets along the base of the key trench was compacted using a 1-tonne plate tamper, outside these areas the FFAB material was compacted with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. Minimum number of passes was established following results of test pad constructed at the start of construction; results of test pad further discussed in Section 4.3.2. Lifts of FFAB material were compacted to 98% standard proctor dry density at in-situ moisture and accepted by the QC and QA representatives prior to additional material placement. Results of QC compaction testing are further discussed in Section 4.0. FFAB placed over the installed liner was compacted using the excavator bucket in 0.3 m loose lifts and accepted by the QC and QA representatives prior to additional material placement.

The fine filter (Zone 2A) material was placed between 2.5 mbgs and 0.25 mbgs to construct the under-liner bedding at a slope of 2.5H:1.0V. In addition, fine filter material was placed along the base of the key trench in areas where FFAB material did not extend the full design width of Zone III as seen in Figure 2. The fine filter was composed of processed NON-AG rockfill. The material was end dumped from the edge of the excavation and levelled by excavator in 0.3 m loose lifts.

Fine filter placed under liner in deeper pockets along the edge of the key trench was compacted using a 1-tonne plate tamper, outside these areas the fine filter was compacted with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. Minimum number of passes was established following results of test pad constructed at the start of construction; results of test pad further discussed in Section 4.3.2. Lifts of fine filter material were compacted to 98% standard proctor dry density at in-situ moisture content and accepted by the QC and QA representatives prior to additional material placement. Results of QC compaction testing are further discussed in Section 4.0. After compaction, the slope of the lift was profiled with an excavator. The downstream key trench slope was profiled with a 2.5H:1V slope. Fine filter placed over installed liner was compacted using bucket of excavator in one lift of 0.3 m thickness and accepted by QC and QA representatives prior to additional material placement.

Due to limited supplies of good quality Esker (Zone 4) material on site, Coarse Filter (Zone 3) material was placed over liner for backfill of the key trench excavation between 2.5 mbgs and 0.0 mbgs. This design change is documented in RFI '668284-5100-64NQ-I-0002' found in Appendix B but was not formally approved by the designer (refer to Appendix B for details on this design change and the communication between AEM and the designer). The coarse filter was composed of processed NON-AG rockfill. The material was end dumped from the edge of the excavation and levelled by excavator in 0.5 m loose lifts. Coarse filter placed over liner was compacted by the excavator bucket until fill elevation above the installed liner exceeded 2.0 m. Above this elevation, coarse filter was compacted with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. Lifts of coarse filter were accepted by the QC and QA representatives prior to additional material placement.

Prior to changing material types, the surface was inspected and then accepted by the Owner's Representative, and the QC and QA representatives before additional fill placement.

A total of 7,689 m^3 of Fine Filter (Zone 2A), 6,083 m^3 of FFAB (Zone 2B) and 6,191 m^3 of Coarse Filter (Zone 3) material was placed in the key trench excavation.

3.1.5 Dike Shell: Foundation Preparation

The foundation preparation for the upstream and downstream shell of the dike consisted of the removal of snow, ice, boulders and any other deleterious materials or soft/loose pockets of material. As indicated in FC21-02 in Section 5.0 organics and ice-rich overburden soil were not removed within the footprint of the rockfill shell of the dike, given that the rockfill shell can be easily repaired in case of settlement-induced deformations. The foundation surface was inspected and then accepted by the Owner's Representative, the QC and QA representatives before placement of fill materials. The dike shell foundation was not approved at the extremities of the dike, from Sta. 0+080 to 0+170 and from Sta. 0+400 to 0+527 due to these areas being backfilled while

Golder was not present on site during night shifts. The risk to the performance of the dike is limited due to the downstream location of these areas, where only rockfill is placed, provided that AEM is prepared to repair the rockfill shell as needed in case of deformation of the foundation and overlying fill.

The approved foundation area was then surveyed by AEM or KCG surveyors.

3.1.6 Dike Shell: Material Placement

Downstream of Liner

The Rockfill (Zone 1) material was placed first from original ground to Elev. 165.5 m. The rockfill material was composed of run-of-mine NON-AG rockfill. The material was dumped by rock truck and spread by dozer in 1.0 m loose lifts. Rockfill material was compacted with a minimum of six passes with a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. The downstream slope was profiled with an excavator to a 2H:1V slope, the upstream under-liner slope was profiled with an excavator to a 3H:1V slope.

Fine Filter (Zone 2A) and Coarse Filter (Zone 3) zones were placed in tandem to construct the under-liner slope above the key trench. The fine filter and coarse filter materials were placed by excavator in 0.3 m loose lifts. The first lift of fine filter and coarse filter placed above the installed liner extending below the key trench was compacted using excavator bucket. Outside the first lift, fine filter and coarse filter materials were compacted with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. Lifts of fine filter material were compacted to 98% standard proctor dry density at in-situ moisture content and accepted by the QC and QA representatives prior to additional material placement. Following compaction, the fine filter slope was profiled to a 3H:1V slope.

Upstream of Liner

Following liner installation FFAB (Zone 2B) material was placed over the installed liner hinge by excavator in one lift of 0.3 m. The material was compacted using the bucket of the excavator. Following the placement of FFAB, Fine Filter (Zone 2A) was placed in one 0.5 m (perpendicular thickness) lift over the installed liner from the previously placed FFAB material to Elev. 165.5 m. The material was compacted using the bucket of the excavator.

Due to limited amounts of Esker (Zone 4) material available on site, esker material was placed to a reduced width and elevation at the IVR Dike. Esker material was placed upstream of the liner to a width of approximately 7.0 m between stations Sta. 0+080 and Sta. 0+414 to elev. 164.5 m. The added benefit of this design change, beyond quantities optimization, is to increase air cooling of the core of the structure through the rockfill with a wider rockfill section than initially planned while preserving the low-permeability upside of the esker berm within normal operating levels. This design change is documented in RFI ‘668284-5100-64NQ-I-0004’ and can be found in Appendix B. Although this RFI also discussed reducing the overall width of the upstream berm from 15 m to 12 m, the original width of 15 m was constructed and only the esker section geometry was changed from the original design.

The esker material was dumped by rock truck and spread by excavator in 0.5 m loose lifts. The first lift of esker material placed over the installed liner was compacted by the excavator bucket. Outside this area, esker was compacted with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. Lifts of esker material were to be compacted to 95% standard modified proctor dry density, however QC field-testing results were highly variable and inconsistent due to the frozen nature of the material. Results of QC compaction testing are further discussed in Section 4.0. Lifts of esker were accepted by the QC and QA representatives following visual confirmation of compaction effort with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor prior to additional material placement. After compaction, the slope of the lift was profiled with an excavator. The upstream esker slope was profiled with a 2H:1V slope.

The Rockfill (Zone 1) material was placed last from original ground to elev. 165.5 m. The material was dumped by rock truck and spread by dozer in 1.0 m loose lifts. Rockfill material was compacted with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. The upstream slope was profiled with an excavator to a 2H:1V slope.

Prior to changing material types, the surface was inspected and then accepted by the Owner's Representative, the QC and QA representatives before additional fill placement.

There were 2,045 m^3 of fine filter, 2,221 m^3 of coarse filter, 2,531 m^3 of esker and 10,356 m^3 of rockfill placed for construction of the dike shell at the IVR Dike.

3.1.7 Geosynthetics Installation

Geosynthetics installation included the placement of non-woven geotextile and LLDPE geomembrane from 2.5 mbgs to Elev. 165.5 m and the placement of BGM through the spillway channel at the IVR Dike. The geosynthetic materials were installed by the subcontractor, FC Liners.

Before installation of the geosynthetics at the IVR Dike, the geosynthetics bedding surface was prepared.

All geosynthetic material was installed over Fine Filter (Zone 2A) material. The surface of the fine filter was sloped to design lines by an excavator and compacted using bucket compaction to create a smooth surface. The bedding surface was then inspected and approved by the Owner's Representative, the QC Representative, and the QA Representative prior to placement of geosynthetic material.

The geotextile and the LLDPE geomembrane were keyed in a 0.5 m deep anchor trench excavated into the upstream side of the rockfill crest within the coarse filter. The anchor trench was backfilled after the installation of the geosynthetics once all QC tests passed. Approximately 0.1 m of fine filter was placed over the installed geotextile and liner followed by 0.4 m of coarse filter, and material was compacted using bucket of excavator.

The geotextile panels were bonded with a heat gun using a minimum overlap of 0.15 m. The geotextiles were visually inspected during installation to make sure that the overlap was sufficient and that the panels were not damaged.

The LLDPE geomembrane panels were mostly seamed with the dual hot wedge welding equipment using a minimum overlap of 0.15 m. When wedge seams were not practical (such as for seaming the liner hinge), the LLDPE geomembranes were bonded with extrusion fillet seams. The LLDPE geomembranes were visually inspected during installation to ensure that the overlap was sufficient and that the panels were not damaged.

The LLDPE geomembrane installation included air channel testing and vacuum box testing as part of the continuous QC program. In conformity with the Technical Specifications, an air channel test was conducted on each fusion seam, and vacuum testing was conducted on each extrusion weld, patch and repair. No air channel test failed during this construction project. When a vacuum box test indicated a leak, the extrusion material was grinded off and the weld was remade until vacuum test results were compliant with the specifications. The QA team was present for most air channel tests and at minimum observed one in five vacuum box tests, in compliance with the design requirements. Test details and results are presented in the Liner Installers QC report in Appendix I-2.

As part of the QA supervision of the LLDPE liner installation, the following destructive samples were taken, tested, and kept by the Owner's Representative:

Table 11: Details of the Destructive Testing at the IVR Dike

Name	Description	Station	Location	Comment
DT1	IVR Dike (key trench section)	Sta. 0+238	Seam P10/P11	Destructive test, compliant
DT2	IVR Dike (key trench section)	Sta. 0+321	Seam P23/24	Destructive test, compliant
DT3	IVR Dike (key trench section)	Sta. 0+136	Seam P39/P40	Destructive test, compliant
DT4	IVR Dike (key trench section)	Sta. 0+075	Seam P48/P49	Destructive test, compliant
DT5	IVR Dike (key trench section)	Sta. 0+451	Seam P63/64	Destructive test, compliant
DT6	IVR Dike (key trench section)	Sta. 0+274	Seam P74/P75	Destructive test, compliant
DT7	IVR Dike (upper liner slope)	Sta. 0+239	Seam P86/P87	Destructive test, compliant
DT8	IVR Dike (upper liner slope)	Sta. 0+314	Seam P99/98	Destructive test, compliant
DT9	IVR Dike (upper liner slope)	Sta. 0+153	Seam P108/109	Destructive test, compliant
DT10	IVR Dike (upper liner slope)	Sta. 0+178	Seam P118/P119	Destructive test, compliant

As part of the QA supervision of the LLDPE liner installation, the following repairs were made during installation of liner at the IVR Dike.

Table 12: Details of the liner repairs at the IVR Dike

Name	Description	Station	Location	Comment
R1-R3	IVR Dike (key trench section)	Sta. 0+265	Panel P14	Repaired with extrusion weld, vacuum tested and compliant.
R4	IVR Dike (key trench section)	Sta. 0+283	Seam P16/17	Repaired with extrusion weld, vacuum tested and compliant.

Name	Description	Station	Location	Comment
R5	IVR Dike (key trench section)	Sta. 0+310	Seam P20/21	Repaired with extrusion weld, vacuum tested and compliant.
R6	IVR Dike (key trench section)	Sta. 0+150	Seam P1/P29	Removed smooth part of liner at tie-in due to damage caused during snow removal
R7-R11	IVR Dike (key trench section)	Sta. 0+114	Panel P43	Patched holes made by forklift. Vacuum tested and compliant.
R12	IVR Dike (key trench section)	Sta.0+047	Seam P53/P54/P55	Vacuum box tested and compliant.
R13	IVR Dike (key trench section)	Sta.0+049	Seam P52/P53/P55	Vacuum box tested and compliant.
R14-R17	IVR Dike (key trench section)	Sta. 0+420	Panel 59	Patched holes made by forklift. Vacuum tested and compliant.
R18-R22	IVR Dike (key trench section)	Sta. 0+427	Panel 60	Patched holes made by forklift. Vacuum tested and compliant.
R23	IVR Dike (key trench section)	Sta. 0+450	Seam P63/P64	Patched hole made by destructive testing at bottom of slope. Vacuum tested and compliant.
R24	IVR Dike hinge weld repair	Sta. 0+197 to 0+217	P86/P89 to P8/P4	Repair visually inspected to satisfaction of QC and QA representatives.
R25	IVR Dike (key trench section)	Sta. 0+522	Seam P82/P84/P85	Vacuum box tested and compliant.
R26	IVR Dike (key trench section)	Sta. 0+525	Seam P82/P83/P85	Vacuum box tested and compliant.
R27	IVR Dike (upper liner slope)	Sta. 0+290	Seam P93/P94/P95	Vacuum box tested and compliant.
R28	Hole from forklift damage	0+330	Panel P101	Vacuum box tested and compliant.

After its installation, the LLDPE geomembrane surface was visually inspected and approved by the Owner's Representative, and the QC and QA representatives.

A total of 9,908 m^2 of LLDPE geomembrane and 1,182 m^2 of BGM geomembrane was installed during the construction of the IVR Dike. A total of 18,792 m^2 of geotextile was installed under and above the LLDPE and BGM geomembranes.

3.1.8 Thermal Berm Construction

Additional rockfill material was added along the east and west abutments of the IVR Dike at the end of the project for added thermal cover. The rockfill material was placed to ensure 2.5 m of fill above original ground elevation between Sta. 0+435 to Sta. 0+526 (east abutment) and from Sta.0+045 to Sta. 0+065 and Sta. 0+085 to Sta.

0+100 (west abutment on either side of the spillway). The material was dumped by rock truck and spread by dozer in 1.5 m loose lifts. Rockfill material was compacted with a minimum of six passes with a 10-tonne smooth-drum vibratory roller compactor on the entire surface of the lift. The upstream and downstream slopes were profiled with an excavator to a 2H:1V slope.

Prior to placement of rockfill material 0.3 m of Fine Filter (Zone 2A) followed by 0.3 m of Coarse Filter (Zone 3) was placed over the installed liner along the dike crest. Material was compacted using bucket of the excavator and accepted by the QC and QA representatives prior to additional material placement.

Refer to Section 5.0 for details regarding thermal berm design.

A total of 7,299 m^3 of rockfill, 95 m^3 of Fine Filter (Zone 2A), and 169 m^3 of Coarse Filter (Zone 3) was placed for construction of the thermal berms at the IVR Dike.

4.0 QA/QC PROGRAM AND RESULTS

4.1 General

During the 2021 construction season of the IVR Dike, a daily construction meeting was held at 16:00 at the AEM construction trailer with all parties present on site (AEM, KCG, Golder, TetraTech). This meeting was used to review daily progress, plan for the next 24 hours and to discuss and resolve problems encountered during construction. Minutes from these meetings were taken by Golder and are presented in the daily reports in Appendix D-2.

The QA program was carried out by Golder during construction of the IVR Dike. The content of the QA program is defined in the Technical Specifications and includes foundation preparation, fill placement, and geosynthetics installation. The QA team consisted of two QA representatives working on approximately two-week rotations. A QA Representative was present full-time on site from 20 February to 4 May 2021. No QA activities were performed during night shifts. Daily and weekly reports were prepared by the QA personnel to document the QA activities performed during the construction of the IVR Dike. These QA daily and weekly reports are presented in Appendix D.

TetraTech carried out the QC program defined in the Technical Specifications for all construction activities except for the geosynthetics installation. The TetraTech QC team worked under the supervision of AEM and consisted of a QC Representative on day shift from 16 February to 27 April 2021 and a QC Representative on night shift from 4 March to 27 April 2021. The daily reports prepared by the on-site QC day shift and night shift representatives to document the QC activities are presented in Appendix E. The geosynthetics installation QC activities were carried out by the geosynthetics installation crew (FC Liner) under the supervision of KCG.

The Owner’s Representative and the QA Representative routinely conducted visual inspection of the work done during the construction of the IVR Dike. Review of the work procedures was done on a daily basis and corrections were made as necessary. Photographs of the work progress and activities were taken every day. A selection of photographs taken throughout the construction season is presented in Appendix C.

4.2 Foundation Approval

As part of the QA/QC program, the foundations were approved before placing any material over natural soil and before the installation of geosynthetics on a bedding surface. The objective of the foundation approval process was to ensure that the foundation was prepared as per the Technical Specifications. The approval was prepared by the QA Representative and reviewed by the Owner's Representative and the QC Representative.

It was verified that the foundation to be approved was competent, dry, free of contamination or ice, and also that:

- The clearing and stripping were adequate.
- The foundation excavation and the removal of unsuitable foundation materials was adequate.
- The preparation of the bedrock surface was adequate.

For each foundation approval, the limit of the approved area was surveyed, and a foundation approval form was signed by the Owner's Representative, and the QA and QC representatives. Each foundation approval form included a picture of the approved foundation area as well as the filled inspection item checklist. Table 13 and Table 14 present a summary of the key trench and dike shell foundation approvals done during the 2021 construction season at the IVR Dike. Individual foundation approval forms are presented in Appendix F-1.

Table 13: Summary of Key Trench Foundation Approval for the 2021 Construction Season of the IVR Dike

Foundation Approval Form	Stations	Foundation Approval Form	Stations
20210331-DS-01	Sta. 0+045 to 0+065	20210313-DS-01	Sta. 0+280 to 0+312
20210329-DS-02	Sta. 0+065 to 0+090	20210316-DS-02	Sta. 0+312 to 0+340
20210327-DS-03	Sta. 0+090 to 0+105	20210317-DS-02	Sta. 0+340 to 0+377
20210325-DS-06	Sta. 0+105 to 0+130	20210318-DS-01	Sta. 0+377 to 0+408
20210304-DS-01	Sta. 0+130 to 0+160	20210320-DS-01	Sta. 0+408 to 0+423
20210305-DS-01	Sta. 0+160 to 0+180	20210330-DS-01	Sta. 0+423 to 0+442
20210308-DS-02	Sta. 0+180 to 0+205	20210401-DS-04	Sta. 0+442 to 0+465
20210310-DS-01	Sta. 0+205 to 0+227	20210407-DS-01	Sta. 0+465 to 0+482
20210311-DS-01	Sta. 0+227 to 0+248	20210410-DS-01	Sta. 0+482 to 0+526
20210312-DS-02	Sta. 0+248 to 0+280	**Total Approval Forms:**	**19**

Table 14: Summary of Dike Shell Foundation Approval for the 2021 Construction Season of the IVR Dike

Foundation Approval Form	Footprint	Stations
20210326-DS-02	Downstream Rockfill Shell	Sta. 0+170 to 0+385
20210328-DS-02	Downstream Rockfill Shell	Sta. 0+355 to 0+400
20210425-DS-01	Upstream Esker Shell	Sta. 0+080 to 0+414
20210501-DS-01	Upstream Rockfill Shell	Sta. 0+025 to 0+527
20210422-DS-01	Spillway	Sta. 0-010 to 0+050

Foundation Approval Form	Footprint	Stations
	Total Approval Forms:	**5**

Note that no foundation approval was issued for the downstream shell areas between Sta. 0+080 and 0+170, and between Sta. 0+400 and 0+527 due to Golder not being present on site when the foundation was prepared and backfilled (refer to Section 3.1.5 for more details).

4.3 Material Placement

During material placement, the quality of the material and the placement technique were routinely reviewed. It was ensured that the placement technique limited segregation, that the material quality was visually acceptable, and that the maximum allowable lift thickness was not exceeded.

During placement of fine filter and coarse filter over liner installed at the crest of the dike along the east and west abutments, it was visually verified that the coarse filter completely wrapped the fine filter so that the fine filter did not come in direct contact with the rockfill thermal berm.

During rockfill placement, it was verified by the QC and QA representatives that the rockfill was well graded, did not contain oversized particles and was placed in the correct area of the dike. In addition, the QC and QA representatives verified placement of rockfill was compacted with a minimum of six passes with a 10-tonne smooth-drum roller prior to additional material placement.

A fill placement approval form was completed prior to changes in material zones during construction at the IVR Dike. For each fill placement approval, the limit of the approved area was surveyed, and an approval form was signed by the Owner's Representative, the QA Representative, and the QC Representative. Each fill placement approval form included a picture of the approved foundation area as well as the filled inspection item checklist. In total 44 fill placement approval forms were prepared during construction of the IVR Dike. Individual approval forms are presented in Appendix F-2.

4.3.1 Laboratory Testing

Samples of fine filter, FFAB, coarse filter and esker were obtained by the QC and QA representatives during construction per the sampling intervals defined in the Technical Specifications. The QA Representative reviewed the QC Representative sampling technique and laboratory procedures to ensure that proper techniques were being used. The QA Representative took and tested one sample for every five samples taken by the QC Representative.

The volumes of material (fine filter, FFAB, coarse filter and esker) placed daily were communicated by KCG to the QC Representative, and samples were taken accordingly to ensure that the sampling frequency was compliant with the Technical Specifications. The sampling frequencies defined in the specifications are summarized in Table 15 below.

Table 15: QC sampling frequencies for the construction of the IVR Dike

Material	Sampling frequency in stockpile (prior to start of construction)	Sampling frequency in place
Fine Filter (Zone 2A)	3	1 sample in 1,000 m^3
FFAB (Zone 2B)	3	1 sample in 1,000 m^3
Coarse Filter (Zone 3)	3	1 sample in 1,000 m^3
Esker (Zone 4)	3	1 sample in 1,000 m^3

The Fine Filter, FFAB, Coarse Filter and Esker samples were tested for particle size distribution (ASTM C136) and water content (ASTM D2216) to ensure that requirements set out in the Technical Specifications were met.

A one-point standard proctor test was performed on frozen fine filter and FFAB materials at in situ moisture content to define the maximum in situ dry density following the standard proctor test procedure. These values were used to determine the minimum number of passes with a 10-tonne smooth-drum roller required to achieve 98% in-situ dry density.

A one-point modified proctor test was performed on both frozen and thawed esker materials at in-situ moisture content to define maximum in-situ dry density following the modified proctor test procedure. Originally these values were to be used to determine the minimum number of passes with a 10-tonne smooth-drum roller required to achieve 95% in-situ dry density. However, due to the frozen nature of the material, compaction was unattainable in the field and a minimum compaction effort of six passes were required for esker material placement. Frozen optimum values were achieved. Thaw-induced settlement of the esker material in the upstream berm is possible as a result. However, the upstream berm is still expected to perform its intended use of insulating the foundation upstream of the cut-off trench. If settlement is observed to be significant enough to lower the esker elevation below the MOL elevation, causing the esker to be overtopped by water, AEM should consider exposing the esker zone by removing the rockfill cover, re-establish the esker elevation, and place back the rockfill cover to ensure that water does not pond against the liner.

Two samples of FFAB material at 4% and 6% bentonite by weight were sent to Golder's Mississauga laboratory for constant head permeability tests (ASTM 2434) to obtain the hydraulic conductivity of the FFAB material at various bentonite concentrations. The tests were performed inside triaxial cells at natural water content and the material was consolidated to its expected in-situ vertical confinement pressure within the key trench prior to performing the conductivity test.

The saturated conductivity at standard temperature (20 C) was found to be 2.45E-08 m/s for the 4% sample and 2.19E-11 m/s for the 6% sample; however, the inflow and outflow across the latter sample were not equal and conductivity was calculated by taking the average of both. The inflow quantities for that sample were initially negative (flowing out of the sample) becoming positive towards the end of the test. A falling head test may be more appropriate for this material.

Based on these results, the FFAB mixes have hydraulic conductivities within the typical range for silty clay to clay, which is considered acceptable for the FFAB purpose of providing a low permeability anchor to the liner, provided that it remains frozen as intended per the design.

The results of gradation testing on fine filter indicate that the material was well graded but slightly coarser than design. The fine filter was deemed suitable for its intended use (liner bedding, filter compatibility with coarse filter, matrix for the bentonite in FFAB), refer to Section 5.0 for field adjustment documentation. Results of QC and QA gradation testing are summarized on Figure 1.

The results of gradation testing on FFAB (Zone 2B) indicate that the material was well graded and deemed suitable for use by the QA Representative. No gradation limits were provided for the FFAB material in the Technical Specifications. The results of QC and QA gradation testing are summarized on Figure 2.

The results of gradation testing on coarse filter indicate that the material was well graded and satisfied the requirements set out in the specifications. One QC sample (PSD-8-AMQ-CF) was slightly coarser than allowed by the Technical Specifications below the 9.5 mm fraction. The material was still accepted by the QA Representative and AEM as it was visually adequate, and it was judged that this difference would not negatively impact the performance of the coarse filter. Results of QC and QA gradation testing are summarized on Figure 3.

The results of gradation testing on esker material indicate that the material was well graded and satisfied the requirements set out in the specifications. Three samples were slightly coarser than allowed by the Technical Specifications between the 100 mm and 31.5 mm fraction. The material was still accepted by the QA Representative and AEM as it was visually adequate, and it was judged that this difference would not negatively impact the performance of the esker. Results of QC and QA gradation testing are summarized on Figure 4.

The results of gradation testing on sodium bentonite indicate that the material satisfied the requirements set out in the technical specifications. Results of QC and QA gradation testing are summarized on Figure 5.

The individual results of QC and QA laboratory testing on material used during the construction of the IVR Dike are provided in Appendix G and Appendix H. Table 16 summarizes the number of samples tested by QC and QA representatives during the 2021 construction season of the IVR Dike. The sampling requirements of the Technical Specifications were met during the 2021 construction season.

Table 16: Summary of Laboratory Testing During IVR Dike Construction

Sample Location	Material	# Samples QC[1]	QC Sampling Frequency[2]	# Samples QA[1]
Stockpile	Fine Filter (Zone 2A)	3 PSD 3 WC	3	1 PSD 1 WC
	FFAB (Zone 2B)	3 PSD 3 WC	3	1 PSD 1 WC
	Coarse Filter (Zone 3)	2 PSD 2 WC	2	1 PSD 1 WC
	Esker (Zone 4)	2 PSD 2 WC	2	1 PSD 1 WC

Sample Location	Material	# Samples QC[1]	QC Sampling Frequency[2]	N° Sample QA[1]
IVR Dike	Fine Filter (Zone 2A)	11 PSD 11 WC 1 SSP	1 sample in 885 m^3	3 PSD 3 WC
	FFAB (Zone 2B)	9 PSD 9 WC 2 SSP	1 sample in 719 m^3	2 PSD 2 WC 2 Perm.
	Coarse Filter (Zone 3)	8 PSD 8 WC	1 sample in 1,052 m^3	2 PSD 1 WC
	Esker (Zone 4)	5 PSD 5 WC 3 SMP (2 frozen)	1 sample in 506 m^3	1 PSD 1 WC
Mixing Station	Sodium Bentonite	1 PSD	-	1 PSD

Notes:
1. Particle size distribution (PSD) testing per ASTM C136-06, Water Content (WC) testing per ASTM D2216, Standard Proctor (Proctor) testing per ASTM D698 and Soil Permeability (Perm.) testing per ASTM 2434. Single point standard proctor (SSP) and single point modified (SMP) per technical specification.
2. Material quantities provided by AEM survey.

4.3.2 Field Testing

The QC Representative was always present during material compaction to supervise the process. The compaction of the fine filter, FFAB, coarse filter, esker and rockfill was visually observed by the QC Representative and verified the minimum compaction effort was achieved prior to additional material placement. The overlap of the passes and the compactor speed was continuously verified by the QC Representative.

Fine Filter

The compaction of each lift of fine filter placed as backfill in the key trench excavation was controlled by the QC Representative in the field with a portable nuclear gauge. The number of compactor passes was adjusted in the field until 98% of the maximum dry density at in-situ moisture content was reached. The overlap of the passes and the compactor speed were verified by the QC Representative.

The maximum in-situ dry density was determined through single point standard proctor testing on the frozen material at in-situ moisture. The maximum in-situ dry density of the fine filter was 2,131 kg/m^3 at a water content of 1.8%.

At the start of construction, a test pad made of compacted fine filter was constructed in the field and compacted by the 10-tonne smooth-drum compactor in vibratory mode. After each pass of the compactor, the dry density and water content was measured with the portable nuclear gauge. This method was used to determine the minimum number of passes required to achieve 98% maximum in-situ dry density. It was determined six passes with the 10-tonne smooth-drum compactor in vibratory mode would be the minimum compaction effort used during placement of fine filter.

FFAB

FFAB was prepared by mixing bags of bentonite to a stockpile of fine filter. The mixing was done in an area protected from the winds by stacked up seacans and supervised by the QC Representative to ensure good quality of the mix. Swell tests were performed on FFAB samples to confirm the presence of bentonite. Care was taken to use the prepared FFAB material as soon as possible (within less than 24 hours) to avoid loss of bentonite through wind erosion. No FFAB that had been stockpiled for a prolonged period of time in the wind was allowed to be placed in the key trench.

The compaction of each lift of FFAB placed as backfill in the key trench excavation was controlled by the QC Representative in the field with a portable nuclear gauge. The number of compactor passes was adjusted in the field until 98% of the maximum dry density at in-situ moisture was reached. The overlap of the passes and the compactor speed were verified by the QC Representative.

The maximum in-situ dry density was determined through single point standard proctor testing on the frozen material at in-situ moisture. The maximum in-situ dry density of the FFAB was 2,038 to 2,111 kg/m^3 at a water content of 5.8% and 3.3% respectively. For the majority of construction, the maximum in-situ dry density of 2111 kg/m^3 at a water content of 3.3% was used.

At the start of construction, a test pad made of compacted fine filter was constructed in the field and compacted by the 10-tonne smooth-drum compactor in vibratory mode. After each pass of the compactor, the dry density and water content was measured with the portable nuclear gauge. This method was used to determine the minimum number of passes required to achieve it to achieve 98% maximum in-situ dry density. It was determined six passes with the 10-tonne smooth-drum compactor in vibratory mode would be the minimum compaction effort used during placement of FFAB.

Esker

The compaction of each lift of esker placed as backfill for the upstream shell was controlled by the QC Representative in the field with a portable nuclear gauge. The overlap of the passes and the compactor speed were verified by the QC Representative.

The maximum in-situ dry density was determined through single modified standard proctor testing at in-situ moisture. The maximum in-situ dry density of the esker was 2,014 kg/m^3 at a water content of 11.4%. Single modified standard proctor testing was also conducted on the esker material under frozen conditions. The maximum in-situ dry density of the esker under frozen conditions ranged from 1,510 to 1,585 kg/m^3 at a water content of 12.1% and 11.5% respectively. Note, the standard test method for laboratory compaction of soil (ASTM 1111) specifies soil samples should contain a maximum of 30% material retained on the 19.0 mm sieve. As the Esker material used during construction and during the single modified standard proctor tests had greater then 30% material retained on the 19.0 mm sieve maximum in-situ dry density values achieved in the lab versus the field may be variable.

During construction in-situ portable nuclear gauge (PNG) testing results were variable and unable to achieve 98% maximum in-situ dry density of 2,014 kg/m^3 due to the frozen nature of the material, but achieved the maximum in-situ dry density under frozen conditions of 1,585 kg/m^3. Lifts of Esker were accepted by QC/QA representatives following visual confirmation of compaction effort with a minimum of six passes of a 10-tonne smooth-drum vibratory roller compactor prior to additional material placement.

QC field-testing results of dry density and water content are summarized in Table 17. Refer to Appendix G-3 for individual QC compaction density test forms.

Table 17: Summary of Portable Nuclear Gauge Field Testing during IVR Dike Construction

Material	Water Content (%)	Water Content Mean (%)	Dry Volumetric Density (kg/m^3)	Dry volumetric density Mean (Kg/m^3)	Compaction Rate (%)	Compaction Rate Mean (%)
Fine Filter (Zone 2B)	3.0 to 5.3	3.9	2,014 to 2,250	2126	95 to 108	100
FFAB (Zone 2A)	5.9 to 9.4	3.3 to 6.5	2,113 to 2,228	2093	97-105	100
Esker (Zone 4)	7.7 to 10.1	9.3	1,562 to 1,682	1599	98-106 (of frozen in-situ optimum)	100 (of frozen in-situ optimum)

4.4 Geosynthetics Installation

QC testing of the geosynthetics installation was done by FC Liners under the supervision of the QA Representative. QC testing was done during the assembly and the installation of geosynthetic materials. QC testing during installation included welding calibration, air pressure tests on every seam, vacuum box testing of each extrusion weld, and destructive weld integrity tests every 150 m of welding. The QA Representative was present for most air channel tests and at minimum observed one in five vacuum box tests, in accordance with the Technical Specifications.

Prior to installation of geosynthetic material during construction the subgrade was accepted by FC Liners and signed by KCG and the QC and QA representatives. The completed subgrade acceptance forms submitted by FC Liners is included in Appendix I-1. Note, the geosynthetic approval forms prepared by the QA Representative also incorporated the acceptance of the subgrade prior to placement of geosynthetic material.

The QC report from FC Liners summarizing results of field-testing conducted during construction is presented in Appendix I-2. All installed LLDPE geomembrane passed the QC testing requirements set out in the technical specifications.

After the completion of the geomembrane installation, the Owner's Representative, the QA Representative, and the FC Liners QC Representative completed an inspection to approve the installation. The inspection was done to ensure that:

- The geomembrane was not damaged (cracks or rips) and was smooth and flat.

- The welding and patches were done properly.
- The QC testing was completed and passed all tests.

After each geosynthetic approval, the limit of the approved area was surveyed and a geosynthetic approval form was signed by the Owner's Representative, and the QA and QC representatives. Each geosynthetic approval form included a picture of the approved area and the filled-out inspection item checklist. Table 18 presents a summary of the geosynthetic approvals completed during the 2021 construction season at the IVR Dike. The completed geosynthetic installation approval forms for the construction of are included in Appendix F-3.

Table 18: Summary of Geosynthetic Approval for the 2021 IVR Dike Construction

Geosynthetic Approval Form	Footprint	Stations	Geosynthetic Approval Form	Footprint	Stations
20210316-DS-01	Key Trench	Sta. 0+169 to 0+239	20210401-DS-03	Key Trench	Sta. 0+89 to 0+045
20210317-DS-01	Key Trench	Sta. 0+239 to 0+269	20210416-DS-04	Key Trench	Sta. 0+403 to 0+526
20210322-DS-01	Key Trench	Sta. 0+269 to 0+318	20210419-DS-01	Dike Slope	Sta. 0+140 to 0+369
20210324-DS-03	Key Trench	Sta. 0+318 to 0+355	20210420-DS-02	Dike Slope	Sta. 0+140 to 192 & Sta. 0+360 to 0+385
20210324-DS-04	Key Trench	Sta. 0+170 to 0+150	20210421-DS-01	Dike Slope	Sta. 0+385 to 0+483
20210325-DS-07	Key Trench	Sta. 0+355 to 0+405	20210422-DS-02	Dike Slope	Sta. 0+080 to 045 & Sta. 0+485 to 0+523
20210328-DS-03	Key Trench	Sta. 0+150 to 0+120	20210423-DS-02	Spillway	Sta. 0+048 to 0+015
20210331-DS-04	Key Trench	Sta. 0+120 to 0+89	20210424-DS-02	Spillway	Sta. 0+015 to 0-010
				Total Approval Forms:	**16**

Data sheets for geosynthetic material used during construction at the IVR Dike can be found in Appendix J.

5.0 FIELD ADJUSTMENTS

Field changes and adjustments were implemented during the construction of the IVR Dike. Field adjustments were documented in the QA weekly and daily reports found in Appendix D and are summarized in this section.

Six field adjustments were made during construction of the IVR Dike when the encountered conditions were different than the expected conditions. These local adjustments were discussed with the QA Representative and implemented by the Owner's Representative without requiring a change to the design.

Field Adjustment (FC21-01) – Fine Filter (Zone 2A): Grain Size Specification

The results of gradation testing on Fine Filter (Zone 2A) indicated that the material was well graded but slightly coarser than design with 10% to 20% of particles being retained on the 19.0 mm sieve. The QA team provided the opinion that fine filter is deemed suitable for its intended use as liner bedding, filter compatibility with coarse filter and as a matrix for the bentonite in FFAB material. The QA team also provided the opinion that for slightly coarse material AEM to ensure good mixing of the fine filter and potentially increase bentonite mass to 8% (this was not done due to limited supplies of bentonite). Care was taken to avoid segregation of the material during handling, hauling and placement.

Field Adjustment (FC21-02) – Foundation Preparation in Rockfill Shell Footprint

Foundation preparation for the rockfill shell in the design requires removal of organics and ice-rich soil. The QA team provided the opinion that in the key trench and foundation area within the vertical limits of the LLDPE liner-bearing slope must be excavated to ice-poor soil or bedrock. This was achieved on the field. Frozen organics was therefore left in place in the foundation in rockfill shell footprint downstream of the liner limit, but snow, ice and loose materials are removed.

Field Adjustment (FC21-03) – Bedrock Grouting: Key Trench

The Technical Specifications indicate that areas of exposed bedrock within the key trench should be grouted as required. The QA team provided the opinion that foundation bedrock grouting can be omitted in areas where the bedrock is sound, of high quality, with closed joints AND where water does not pond directly against the dike at maximum operating level (MOL). During key trench excavation, bedrock was encountered in the foundation within the MOL footprint only between Sta. 0+100 and 0+130 but was not grouted. This is still deemed acceptable due to the low hydraulic gradient over this section, the good quality of the bedrock and the presence of low-permeability FFAB over its entire width (refer to Section 3.1.3). As a result, no bedrock grouting was done at IVR Dike.

Field Adjustment (FC21-04) – Increase in Thermal Berm Thickness Near Abutments

An additional thickness over the thermal berm cover was placed along the east abutment from Sta. 0+435 to Sta. 0+526 and along the west abutment on either side of the spillway from Sta. 0+045 to 0+065 and Sta. 0+085 to Sta. 0+100. In addition, the crest of the thermal cover was extended 15 m beyond the end of the key trench on either abutment. The thermal berm is placed to an elevation of 2.5 m above original ground surface. The downstream crest of the thermal capping was shifted to the downstream in order to align with the downstream crest of the key trench.

In addition, the exposed liner crest at these locations will is topped with 0.3 m of Fine Filter (Zone 2A) and 0.3 m of Coarse Filter (Zone 3) to protect the liner prior to placement of rockfill. The thermal berm design drawings are included in Appendix B; however, they do not show Zones 2A and 3 in the thermal berm.

Field Adjustment (FC21-05) – Thickness of FFAB (Zone 2B) over Liner Hinge

Inside the MOL (Sta. 0+100 to 0+280), the Zone 2B (FFAB) is 0.3 m thick over LLDPE liner hinge and the crest of the FFAB shall be 0.5 m beyond the end of the liner. The liner hinge overlap is of 1 m. The bentonite content is of 6%. Outside the MOL (Sta. 0+045 to 0+100; Sta. 0+280 to 0+529), the Zone 2B (FFAB) is 0.25 m thick over LLDPE liner hinge and the crest of the FFAB is 0.5 m beyond the end of the liner. The liner hinge overlap is 1 m. The bentonite content is 4%.

Field Adjustment (FC21-06) – Spillway Installation of Geotextile under BGM

Geotextile was installed prior to placement of BGM over the full footprint of the spillway channel between Sta. 0+048 and Sta. -0+012 (spillway chainage). The original design did not plan for installation of geotextile through this area. BGM was extended beyond placement of geotextile at spillway inlet at Sta. -0+012. QA is of the opinion additional geotextile will not significantly impact the design intent but should have been stopped short from -0+012 to the connection between the BGM and installed LLDPE, as an added precaution to minimize the seepage potential upstream and through the non-welded connection by promoting contact between the liners. QA does not consider the extension of geotextile through the spillway area will significantly impact the performance of the structure in the event the spillway is activated.

Signature Page

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PERMIT TO PRACTICE
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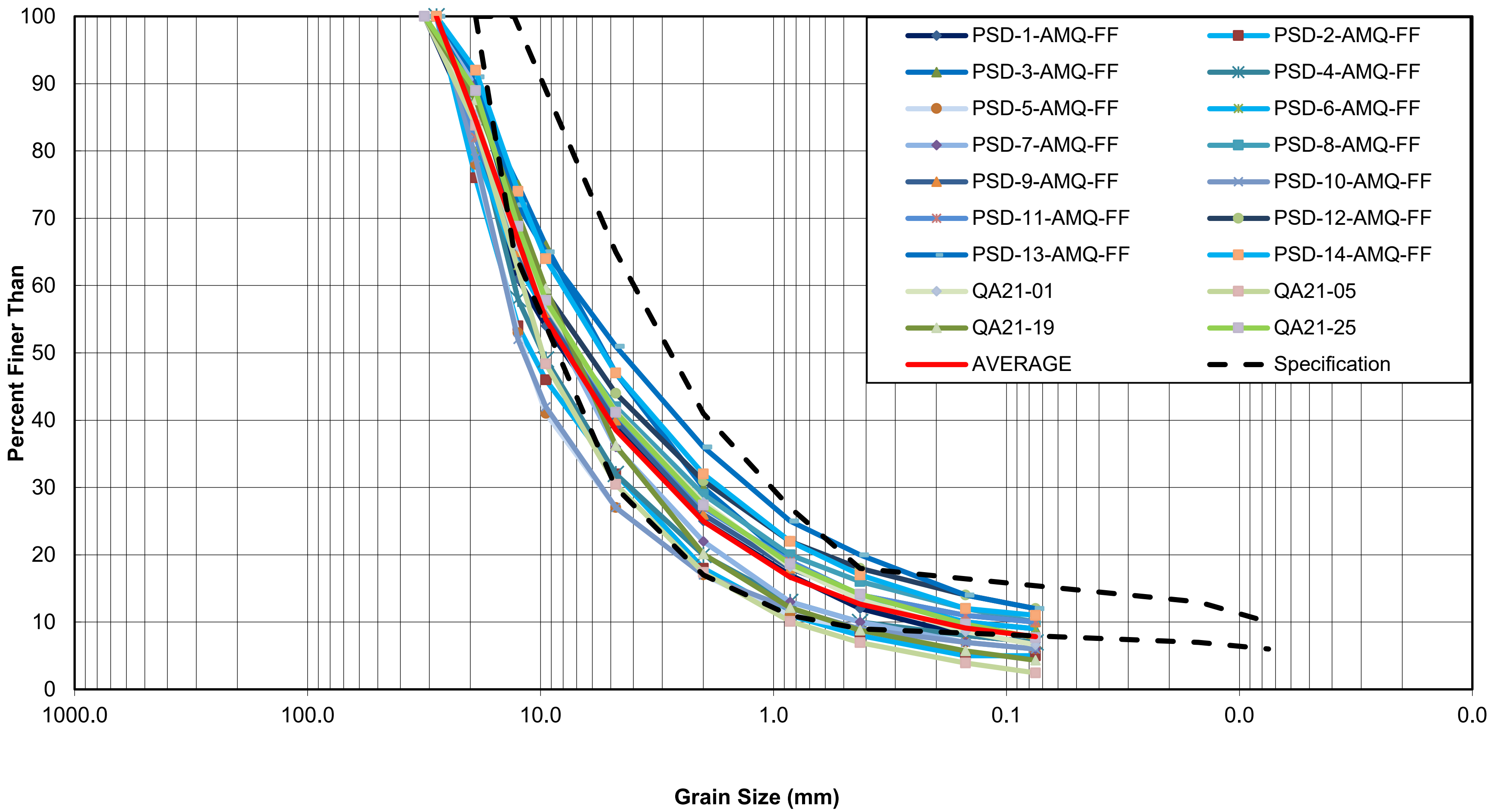
Figures

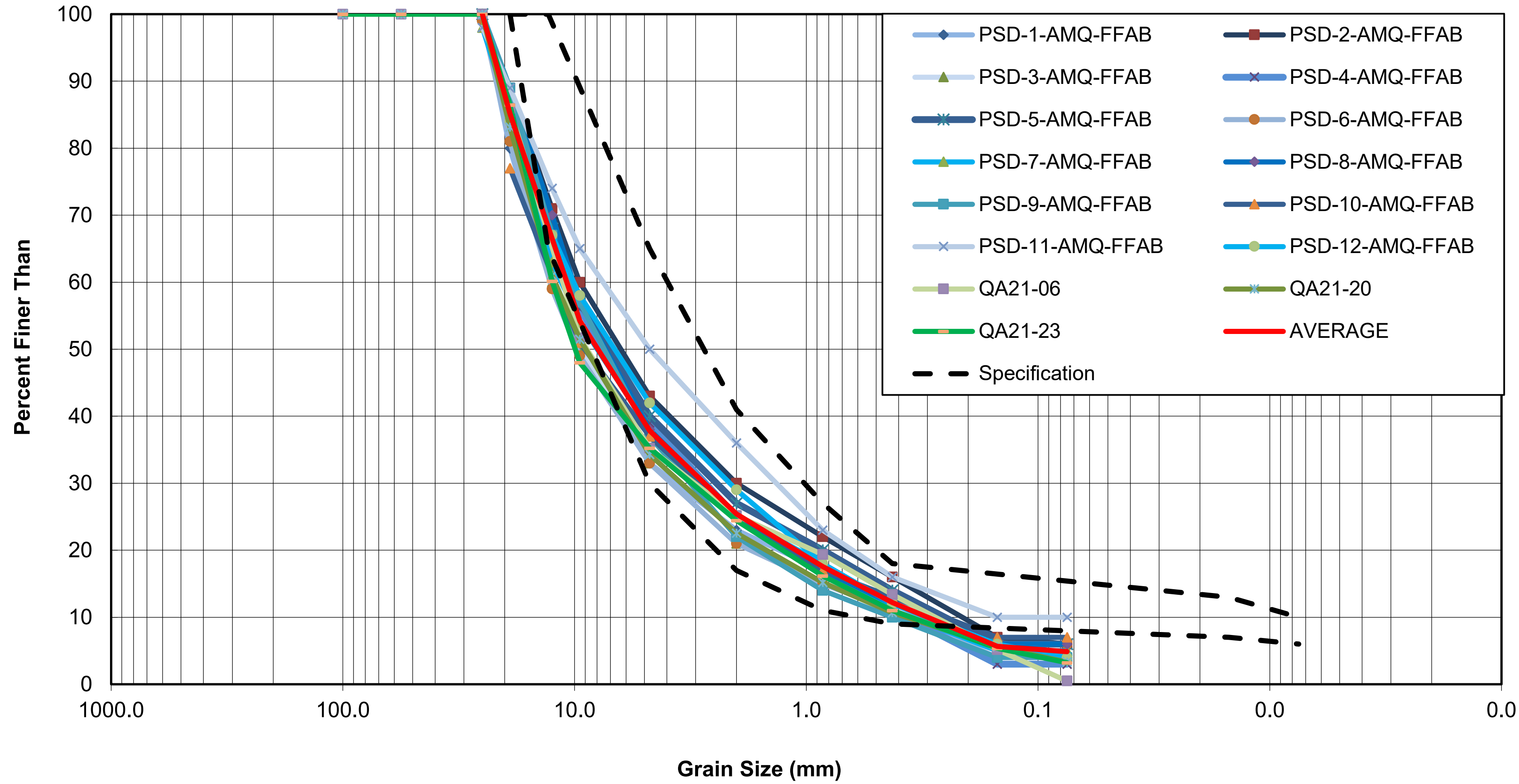


BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

QC/QA GRAIN SIZE DISTRIBUTION: ZONE 2A - FINE FILTER

PROJECT NO:	21452873	DATE:	May-2021
BY:	BG	Review:	MH

Figure 1



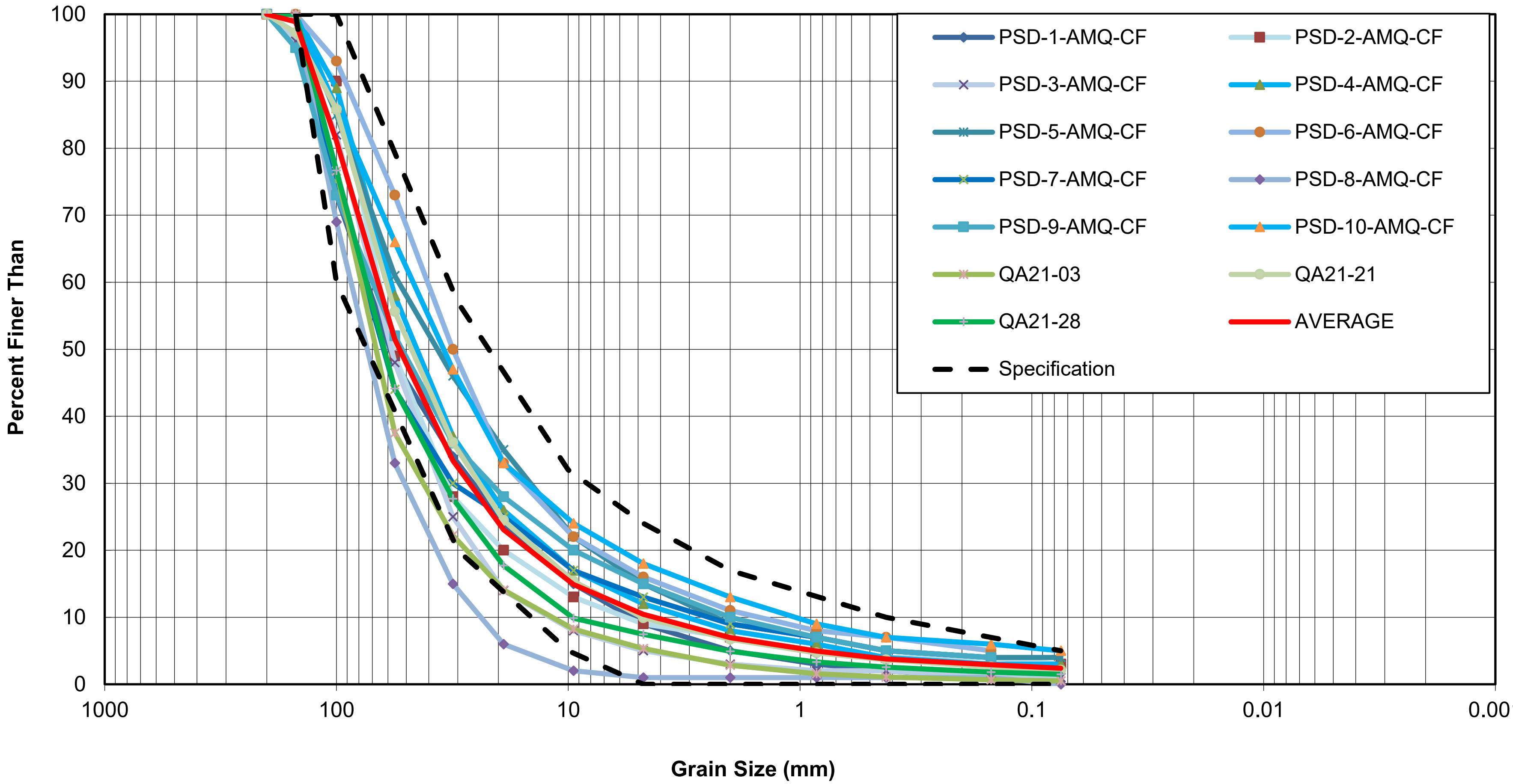
BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

GOLDER

QC/QA GRAIN SIZE DISTRIBUTION: ZONE 2B - FFAB

PROJECT NO:	21452873	DATE:	May-2021
BY:	BG	Review:	MH

Figure 2



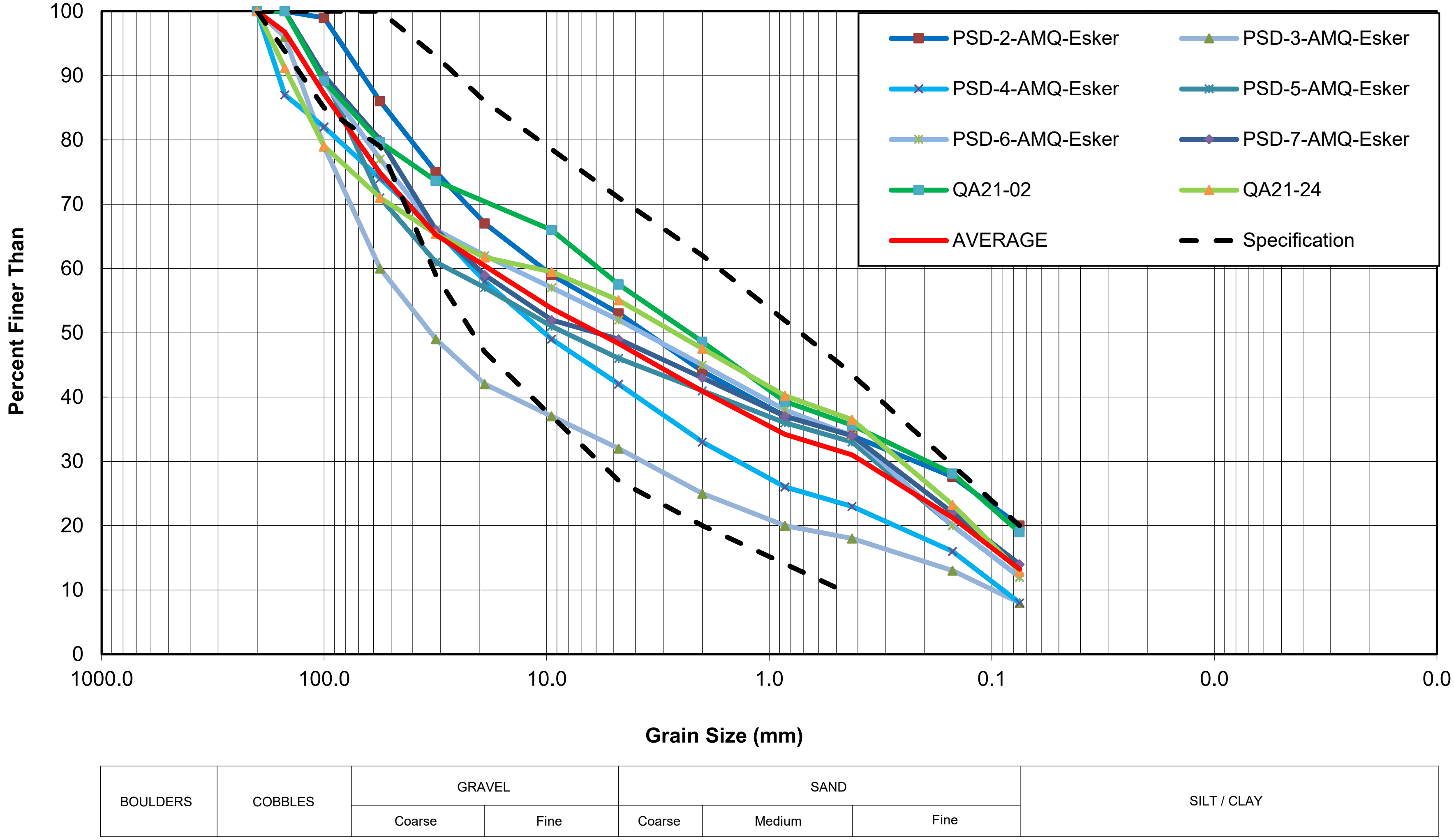
BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

GOLDER

QC/QA GRAIN SIZE DISTRIBUTION:
ZONE 3 - COARSE FILTER

PROJECT NO:	21452873	DATE:	May-2021
BY:	BG	Review:	MH

Figure 3

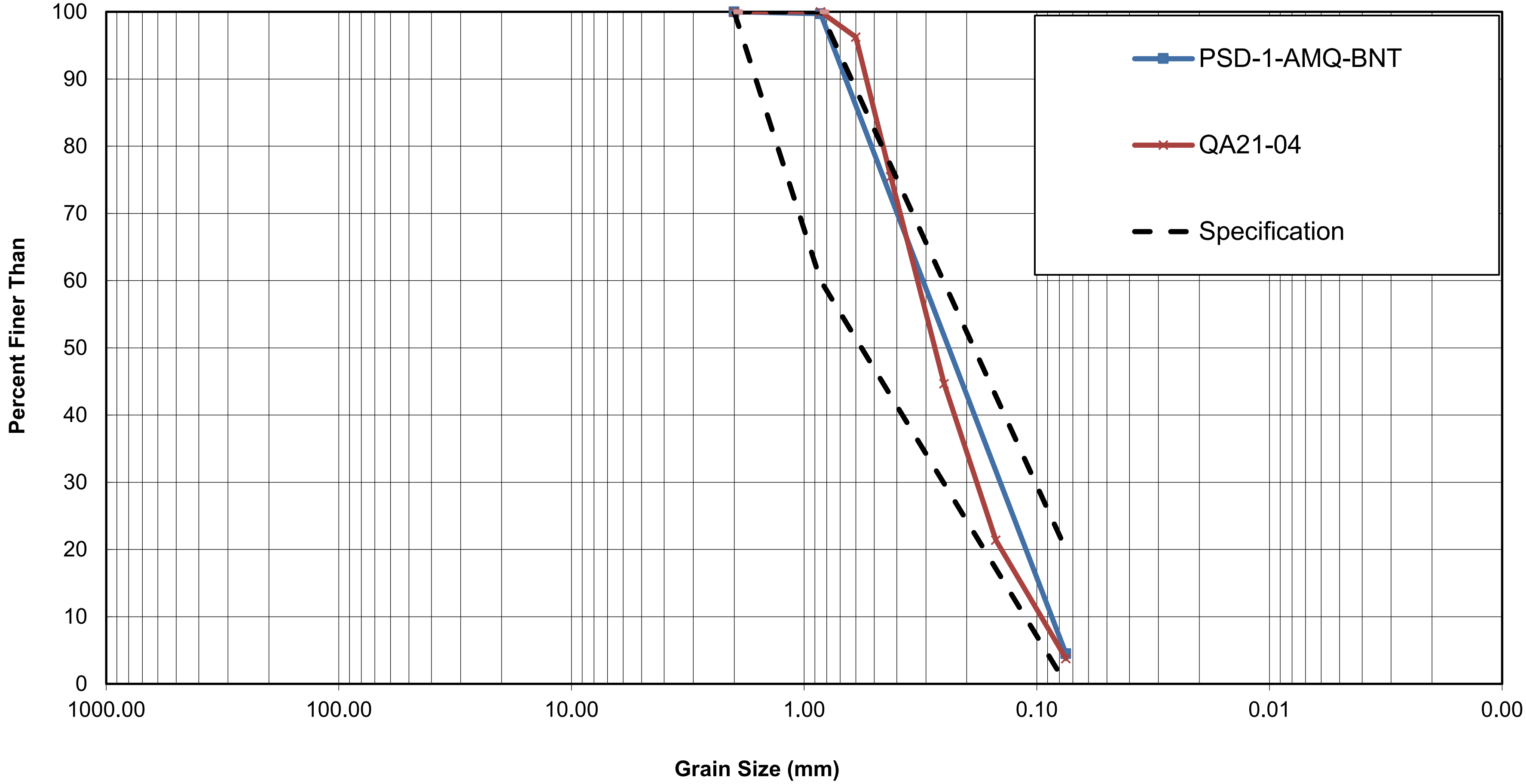


GOLDER

QC/QA GRAIN SIZE DISTRIBUTION: ZONE 4 - ESKER

PROJECT NO:	21452873	DATE:	May-2021
BY:	BG	Review:	MH

Figure 4



BOULDERS	COBBLES	GRAVEL		SAND			SILT / CLAY
		Coarse	Fine	Coarse	Medium	Fine	

GOLDER

QC/QA GRAIN SIZE DISTRIBUTION: BENTONITE

PROJECT NO:	21452873	DATE:	May-2021
BY:	BG	Review:	MH

Figure 5

APPENDIX A

As-built drawings

APPENDIX B

Design Modification Documents

APPENDIX C

Construction Photographs

APPENDIX D

QA Reporting

APPENDIX D-1

QA Weekly Reports

APPENDIX D-2

QA Daily Reports

APPENDIX E

QC Daily Reports

APPENDIX F

Approval Forms

APPENDIX F-1

Foundation Approval Forms

APPENDIX F-2

Fill Placement Approval Forms

APPENDIX F-3

Geosynthetic Installation Approval Forms

APPENDIX G

QC Laboratory and Field Testing Results

APPENDIX G-1

Stockpile QC Laboratory Results

APPENDIX G-1A

QC Laboratory Results – Zone 2A Fine Filter Material

APPENDIX G-1B

QC Laboratory Results – Zone 2B FFAB Material

APPENDIX G-1C

QC Laboratory Results – Zone 3 Coarse Filter Material

APPENDIX G-1D

QC Laboratory Results – Zone 4 Esker Material

APPENDIX G-1E

QC Laboratory Results – Bentonite Material

APPENDIX G-2

IVR Dike QC Laboratory Results

APPENDIX G-2A

QC Laboratory Results – Zone 2A Fine Filter Material

APPENDIX G-2B

QC Laboratory Results – Zone 2B FFAB Material

APPENDIX G-2C

QC Laboratory Results – Zone 3 Coarse Filter Material

APPENDIX G-2D

QC Laboratory Results – Zone 4 Esker Material

APPENDIX G-3

IVR Dike QC Field Results

APPENDIX G-3A

QC Field Results – Zone 2A Fine Filter Material

APPENDIX G-3B

QC Field Results – Zone 2B FFAB Material

APPENDIX G-3C

QC Laboratory Results – Zone 4 Esker Material

APPENDIX H

QA Laboratory Testing Results

APPENDIX H-1

Stockpile QA Laboratory Results

APPENDIX H-1A

QA Laboratory Results – Zone 2A Fine Filter Material

APPENDIX H-1B

QA Laboratory Results – Zone 2B FFAB Material

APPENDIX H-1C

QA Laboratory Results – Zone 3 Coarse Filter Material

APPENDIX H-1D

QA Laboratory Results – Zone 4 Esker Material

APPENDIX H-1E

QA Laboratory Results – Bentonite Material

APPENDIX H-2

IVR Dike QA Laboratory Results

APPENDIX H-2A

QA Laboratory Results – Zone 2A Fine Filter Material

APPENDIX H-2B

QA Laboratory Results – Zone 2B FFAB Material

APPENDIX H-2C

QA Laboratory Results – Zone 3 Coarse Filter Material

APPENDIX H-2D

QA Laboratory Results – Zone 4 Esker Material

APPENDIX I

Geomembrane QC Documentation

APPENDIX I-1

Installation Acceptance Certificates

APPENDIX I-2

QC Field Testing Results

APPENDIX J

Manufacture Specifications

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