APPENDIX B

Design Modification Documents

SNC·LAVALIN	Site Engineering Query (SEQ)	Page 1 of 2	
		Revision	
		No.	Date
	Document No. 668284-5100-64NQ-I-0001	00	2021-02-04

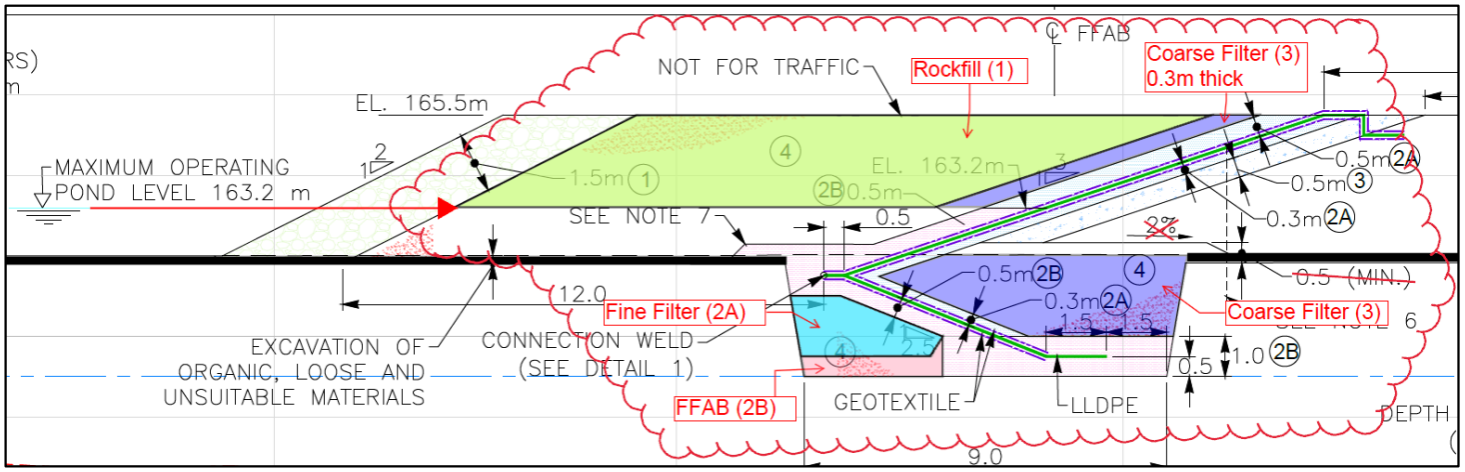
Client Name	AGNICO EAGLE MINES
Project Name	AMARUQ PHASE 2 – IVR D1 DIKE

Contract No.	6127-E-132-003
Contract Name	IVR D1 DIKE CONSTRUCTION
Site Engineering Query Register No.	**RFI-01**
Topic	**ESKER MATERIAL REPLACEMENT**

1. DESCRIPTION OF AGNICO EAGLE'S QUERY (attach documents if needed)

See attached RFI-01.

Reference sketch :



SIGNATURE				
	Title	**Name**	**Signature**	**Date**
Prepared by				
Approved by				

2. RESPONSE BY ENGINEERING (SNC-LAVALIN)

Design Variations Requested	Response
A. <u>Cutoff trench, from 2.5m depth to trench bottom</u>: The low permeability FFAB layer (Fine Filter Amended with Bentonite – Type 2B) will be extended to the full extent of the cutoff trench excavation to improve protection against water infiltration under the liner and to optimize the constructability.	For the 3-m-deep cutoff trench, it was initially proposed to use FFAB in the upstream section of the liner, however, AEM proposed esker material with sufficient fines due to the available quantity of esker on site. Substituting the esker for FFAB (Type 2B) will meet the design requirements. However, the thickness should be a minimum of 0.5 m. This modification is approved.
B. <u>Cutoff trench upstream zone, from upper FFAB layer to bottom FFAB:</u> Esker will be replaced by compacted Fine Filter material (Type 2A). The use of an engineer fill such as fine filter will improve the performance of the key trench by minimizing settlement potential if the key trench would thaw.	For the 3-m-deep cutoff trench, it is initially proposed to use FFAB in the upstream section of the liner, however, AEM proposed esker material with sufficient fines due to the large available quantity of esker material on site. Substituting the esker for fine filter (Type 2A) will meet the design requirements. This modification is approved.

C. <u>Cutoff trench downstream zone, overlaying the FFAB and Fine Filter layers:</u> Esker will be replaced by Coarse Filter material (Type 3) up to the original ground elevation. The surface of this layer will be flat. There will not be any slope towards the downstream side. The use of an engineer fill such as coarse filter will improve the performance of the key trench by minimizing settlement potential if the key trench would thaw.	Due to the coarseness and associated high permeability of the Type 3 material, the use of this material may adversely impact the thermal regime in the cutoff trench and the performance of the dike structure. This modification is not approved.
D. <u>Thermal Berm above operational level (above el 163.2):</u> Esker will be replaced by rockfill material (Type 1 material) to provide an upper layer of erosion protection. An additional 0.3m thick layer of Coarse Filter material (Type 3) will be placed as transition material between the rockfill and fine filter liner protection. The suitable esker will be maximized in this zone with the objective to reach the 1:100 year level (El 164.7 m). The minimum placement limit for the esker material is set at the maximum operational level (El 163.2).	Reduction of the esker material thickness will impact the thermal regime in the upstream section of the dike due to the coarse nature of the rockfill in comparison to the esker material. The performance of the dike may be impacted, especially if the Attenuation Pond water level rises above the maximum operational level (El. 163.2 masl). Additional thermal modelling could allow an estimation of the thermal regime using rockfill material instead of esker but the inherent limitations of the model regarding convective heat transfers would hence affect the level of confidence of the results. This modification is not approved.

SIGNATURE			
	Name	**Signature**	**Date**
Geotechnical Engineer	**Philip Gomes**		2021-02-04
Project Manager	**Anh-Long Nguyen**		2021-02-04

3. FOLLOW-UP BY ENGINEERING (SNC-LAVALIN)

Engineering documents revised	☐ **Yes**	☐ **No**
Explain		

SIGNATURE			
	Name	**Signature**	**Date**
Geotechnical Engineer			
Project Manager			

AGNICO EAGLE

REQUEST FOR INFORMATION

Project	IVR D1 DIKE			RFI No	01
Date	2021-01-28	Project No	6127 (AEM) / 66284 (SNC)	Revision	0
Initiator	AEM	Recipient	Anh-Long Nguyen – SNC Lavalin (Design Engineer)		
Response required by		**2021-02-02**			

REFERENCE DOCUMENTS		
No	*Title*	*Revision*
6127-C-230-003-SPT-001	Technical specifications for the construction of IVR D-1 Dike	0
61-695-230-208	IVR D1 Dike Design sections and details	0
6127-695-132-REP-005	Design Report of IVR Attenuation Pond D-1 Dike	0

REQUEST

Esker material replacement

The amount of quality esker material available on site is limited and potentially less than what is needed for completing the dike construction as per Revision 0 of the drawings issued for construction. Some of the esker stockpiles have been observed to contain significant amounts of chunky frozen material and ice that might impact the performance of the structure. Backfilling the key trench with such unsuitable ice-rich esker is not acceptable as it would increase the risks of settlement under the liner if the foundation was to undergo thawing conditions. AEM prefers backfilling the key trench with the most appropriate engineered material, at an extra cost, to secure the dike performance while using a maximized amount of suitable esker material in the other required zones.

AEM is currently working on sorting out the esker material to separate the good material from the unsuitable one. Ongoing operations and survey indicate that there might not be enough of the acceptable esker material to backfill all the esker zones of the design. The goal of this RFI is to establish accepted equivalence material for the esker and to determine where the good quality esker should be prioritized to ensure an optimal performance of the structure. Esker material that is free of ice, snow and chunk will be used if possible before using the equivalence material.

AEM is proposing the following esker substitutions in these zones. These are listed in the order the substitutions would be done (from first zone where esker would be substituted to last, if required).

A. Cutoff trench, from 2.5m depth to trench bottom: The low permeability FFAB layer (Fine Filter Amended with Bentonite – Type 2B) will be extended to the full extent of the cutoff trench excavation to improve protection against water infiltration under the liner and to optimize the constructability.

B. Cutoff trench upstream zone, from upper FFAB layer to bottom FFAB: Esker will be replaced by compacted Fine Filter material (Type 2A). The use of an engineer fill such as fine filter will improve the performance of the key trench by minimizing settlement potential if the key trench would thaw.

C. Cutoff trench downstream zone, overlaying the FFAB and Fine Filter layers: Esker will be replaced by Coarse Filter material (Type 3) up to the original ground elevation. The surface of this layer will be flat. There will not be any slope towards the downstream side. The use of an engineer fill such as coarse filter will improve the performance of the key trench by minimizing settlement potential if the key trench would thaw.

D. Thermal Berm above operational level (above el 163.2): Esker will be replaced by rockfill material (Type 1 material) to provide an upper layer of erosion protection. An additional 0.3m thick layer of Coarse Filter material (Type 3) will be placed as transition material between the rockfill and fine filter liner protection. The suitable esker will be maximized in this zone with the objective to reach the 1:100 year level (El 164.7 m). The minimum placement limit for the esker material is set at the maximum operational level (El 163.2).

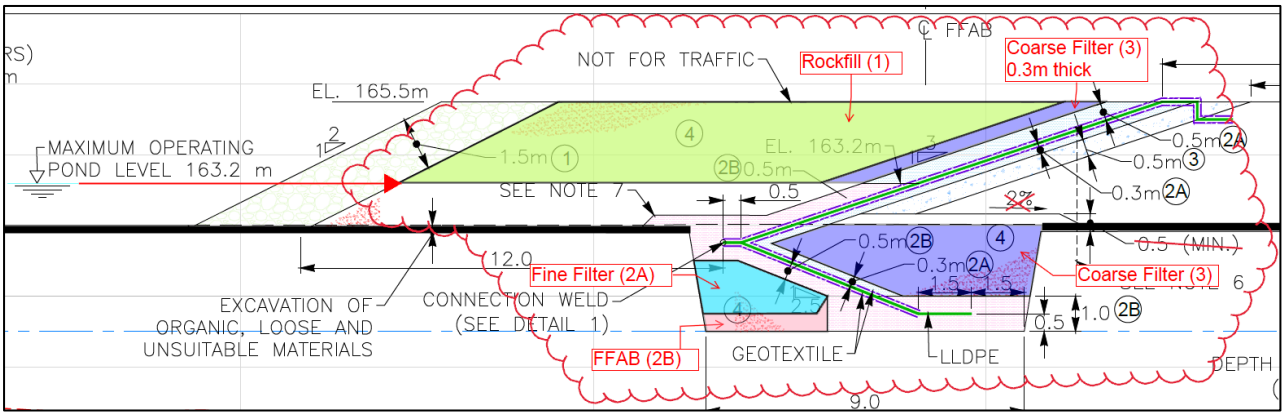


Figure 1 Esker replacement

Each material type will be placed in compliance with their respective technical specifications as detailed in the Design Report (668284-5000-40EF-0001). The changes detailed above will ensure an optimal control on material quality, placement and will therefore ensure the overall dike performance.

Prepared by	Laurier Collette, *Geotechnical Engineer, Site representative*	Signature:	Date: 2021-01-29
Reviewed by	Frederick L.Bolduc, *Geotechnical Coordinator and RP*	Signature:	Date: 2021-01-29

Client Name	AGNICO EAGLE MINES
Project Name	AMARUQ PHASE 2 – IVR D1 DIKE

Contract No.	6127-E-132-003
Contract Name	IVR D1 DIKE CONSTRUCTION
Site Engineering Query Register No.	**RFI-02**
Topic	**CHANGES TO GEOMETRY AND LOCATION OF LINER JOINT**

1. DESCRIPTION OF AGNICO EAGLE'S QUERY (attach documents if needed)

See attached RFI-02.
To improve the performance of the key trench some changes are proposed to its geometry and the location of the liner joint.

The connection weld will be 0.25m above the original ground elevation, embedded in the Fine Filter Amended with Bentonite layer (0.5m of FFAB above the connection weld and 0.25 to 0.5m below the weld depending on the amount of material removed for surface preparation) – Refer to Fig 5. This change will improve the dike performance by allowing a proper installation of the liner at the connection weld and will ensure an optimal protection to avoid water ingress to the key trench.

All the geometry of the cutoff trench with respect to the liner will remain as per design except the distance between the liner and the downstream side of the trench, that will change from 1.5m to 0.6m to keep the excavation 9m wide (Fig 6). Also, because of moving the connected weld 0.75m higher, the excavation will be slightly shifted downstream. This will also be beneficial to the dike performance and will ensure that the engineered cutoff trench extends upstream under the upper liner (from connection weld to elevation 165.2). Such an improved geometry will ensure the integrity of the liner system by minimizing the risks of under-liner settlement

Reference sketch :

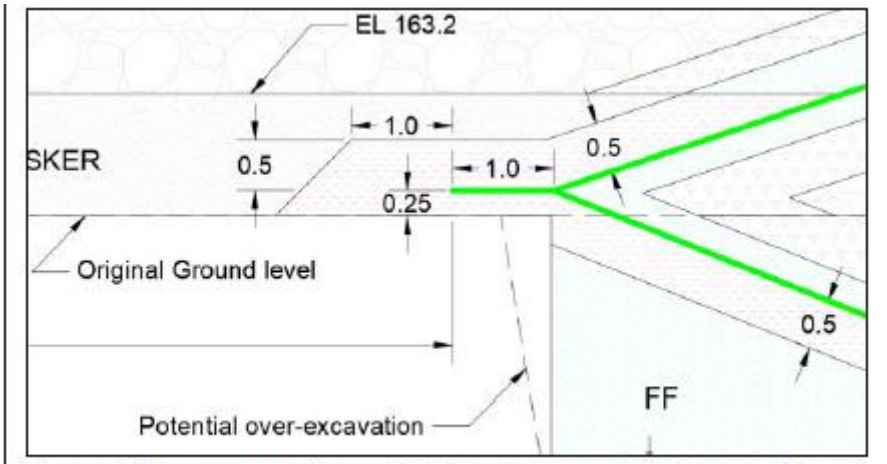


Figure 1 Liner connection weld elevation vs original ground level

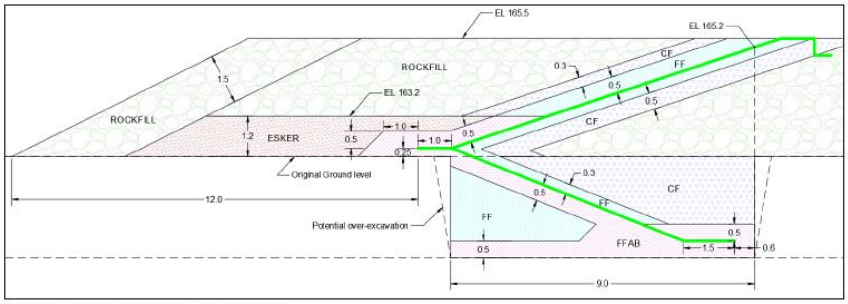


Figure 2 Improved key trench geometry

SIGNATURE				
	Title	**Name**	**Signature**	**Date**
Prepared by				
Approved by				

2. RESPONSE BY ENGINEERING (SNC-LAVALIN)

Response

In the design, the liner connection weld was provided in the cutoff trench for protection and to have a thick FFAB layer above to assist in the thermal protection and to reduce the seepage potential. Raising the connection weld above the original ground will help facilitate construction.
It is recommended that the thickness of the FFAB be a minimum of 0.5 m thick (above the prepared foundation) in the liner connection area to avoid a potential liner puncture at the corner of the cutoff excavation. Also, it is recommended that the liner be extended 1.0 m beyond the potential over-excavation (thus increasing the width of the liner connection (i.e., > 1.0 m)) including the placement of 1.0 m wide FFAB beyond the excavation wall.
This modification is approved in conjunction with the implementation of the recommendations.

SIGNATURE			
	Name	**Signature**	**Date**
Geotechnical Engineer	**Philip S. Gomes**		2021-02-04
Project Manager	**Anh-Long Nguyen**		2021-02-04

3. FOLLOW-UP BY ENGINEERING (SNC-LAVALIN)

Engineering documents revised	☐ **Yes**	☐ **No**

Explain

SIGNATURE			
	Name	**Signature**	**Date**
Geotechnical Engineer			
Project Manager			

AGNICO EAGLE

REQUEST FOR INFORMATION

Project	IVR D1 DIKE			RFI No	02
Date	2021-01-28	Project No	6127 (AEM) / 66284 (SNC)	Revision	0
Initiator	AEM	Recipient	Anh-Long Nguyen – SNC Lavalin (Design Engineer)		
Response required by	20201-02-04				

REFERENCE DOCUMENTS		
No	*Title*	*Revision*
6127-C-230-003-SPT-001	Technical specifications for the construction of IVR D-1 Dike	0
61-695-230-208	IVR D1 Dike Design sections and details	0
6127-695-132-REP-005	Design Report of IVR Attenuation Pond D-1 Dike	0

REQUEST

To improve the performance of the key trench some changes are proposed to its geometry and the location of the liner joint.

The connection weld will be 0.25m above the original ground elevation, embedded in the Fine Filter Amended with Bentonite layer (0.5m of FFAB above the connection weld and 0.25 to 0.5m below the weld depending on the amount of material removed for surface preparation) – Refer to Fig 5. This change will improve the dike performance by allowing a proper installation of the liner at the connection weld and will ensure an optimal protection to avoid water ingress to the key trench.

All the geometry of the cutoff trench with respect to the liner will remain as per design except the distance between the liner and the downstream side of the trench, that will change from 1.5m to 0.6m to keep the excavation 9m wide (Fig 6). Also, because of moving the connected weld 0.75m higher, the excavation will be slightly shifted downstream. This will also be beneficial to the dike performance and will ensure that the engineered cutoff trench extends upstream under the upper liner (from connection weld to elevation 165.2). Such an improved geometry will ensure the integrity of the liner system by minimizing the risks of under-liner settlement.

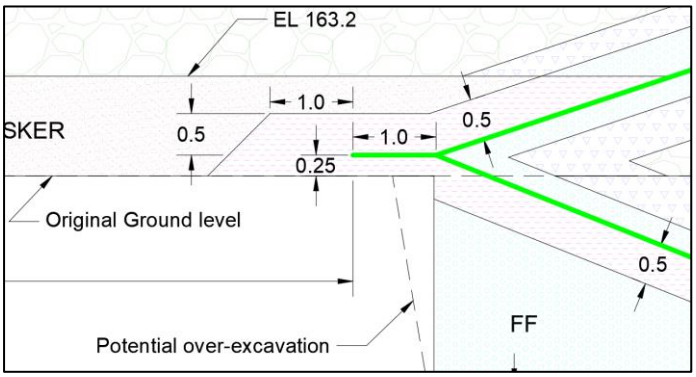


Figure 1 Liner connection weld elevation vs original ground level

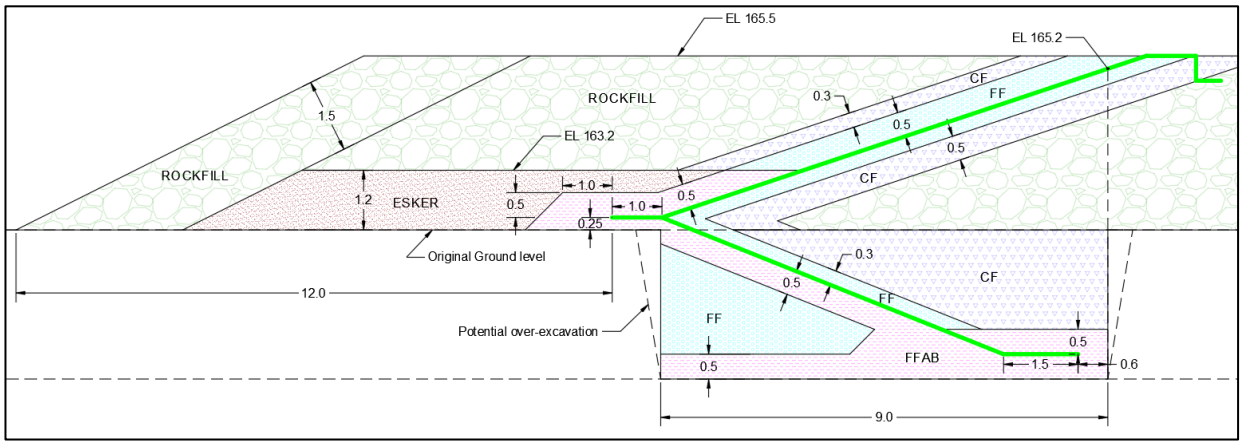


Figure 2 Improved key trench geometry

Prepared by	Laurier Collette, *Geotechnical Engineer, Site representative*	Signature:	Date: 2021-01-29
Reviewed by	Frederick L.Bolduc, *Geotechnical Coordinator and RP*	Signature:	Date: 2021-01-29

Client Name	AGNICO EAGLE MINES
Project Name	AMARUQ PHASE 2 – IVR D1 DIKE

Contract No.	6127-E-132-003
Contract Name	IVR D1 DIKE CONSTRUCTION
Site Engineering Query Register No.	**RFI-03**
Topic	**SURFACE PREPARATION**

1. DESCRIPTION OF AGNICO EAGLE'S QUERY (attach documents if needed)

See attached RFI-03.

Surface preparation

The construction drawings mention the need for excavation of organic, loose and unsuitable material and show an excavation cut without indicating any excavation dimension.

To simplify the construction in the field it is proposed that the surface preparation outside of the key trench include removal of organic material, boulders, snow, ice, loose and unsuitable materials (Fig. 3 and 4). As a results material will be stripped and removed but without a systematic excavation at a fixed depth. To ensure a suitable dike performance the foundation condition will be inspected prior to material placement and approved by the QA and QC representative.

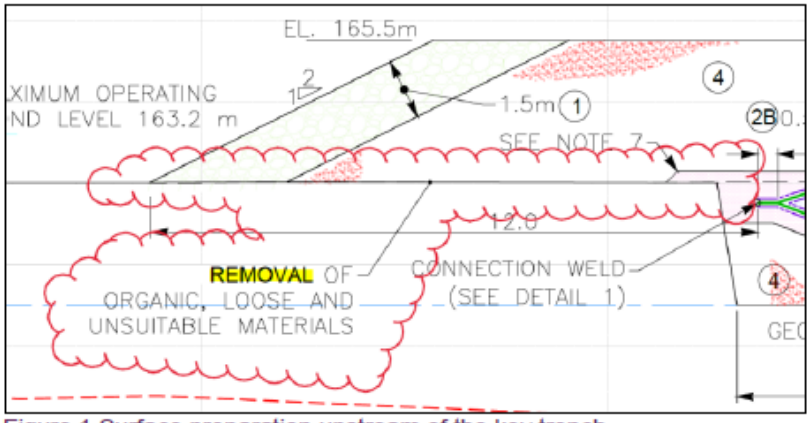


Figure 1 Surface preparation upstream of the key trench

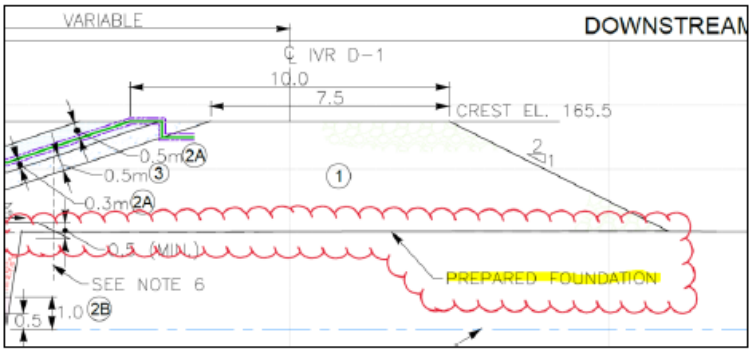


Figure 2 Surface preparation downstream of the key trench

SIGNATURE

	Title	Name	Signature	Date
Prepared by				
Approved by				

2. RESPONSE BY ENGINEERING (SNC-LAVALIN)

Response

The proposed approach is acceptable.

SIGNATURE			
	Name	**Signature**	**Date**
Project Manager	**Anh-Long Nguyen**		2021-02-11

3. FOLLOW-UP BY ENGINEERING (SNC-LAVALIN)

Engineering documents revised	☐ **Yes**	☐ **No**

Explain

SIGNATURE			
	Name	**Signature**	**Date**
Geotechnical Engineer			
Project Manager			

AGNICO EAGLE

REQUEST FOR INFORMATION

Project	IVR D1 DIKE			RFI No	03
Date	2021-01-28	Project No	6127 (AEM) / 66284 (SNC)	Revision	0
Initiator	AEM	Recipient	Anh-Long Nguyen – SNC Lavalin (Design Engineer)		
Response required by	2021-02-05				

REFERENCE DOCUMENTS		
No	*Title*	*Revision*
6127-C-230-003-SPT-001	Technical specifications for the construction of IVR D-1 Dike	0
61-695-230-208	IVR D1 Dike Design sections and details	0
6127-695-132-REP-005	Design Report of IVR Attenuation Pond D-1 Dike	0

REQUEST

Surface preparation

The construction drawings mention the need for excavation of organic, loose and unsuitable material and show an excavation cut without indicating any excavation dimension.

To simplify the construction in the field it is proposed that the surface preparation outside of the key trench include removal of organic material, boulders, snow, ice, loose and unsuitable materials (Fig. 3 and 4). As a results material will be stripped and removed but without a systematic excavation at a fixed depth. To ensure a suitable dike performance the foundation condition will be inspected prior to material placement and approved by the QA and QC representative.

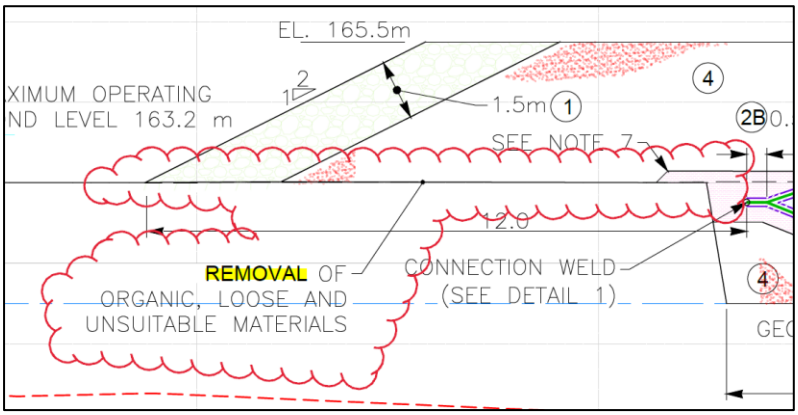


Figure 1 Surface preparation upstream of the key trench

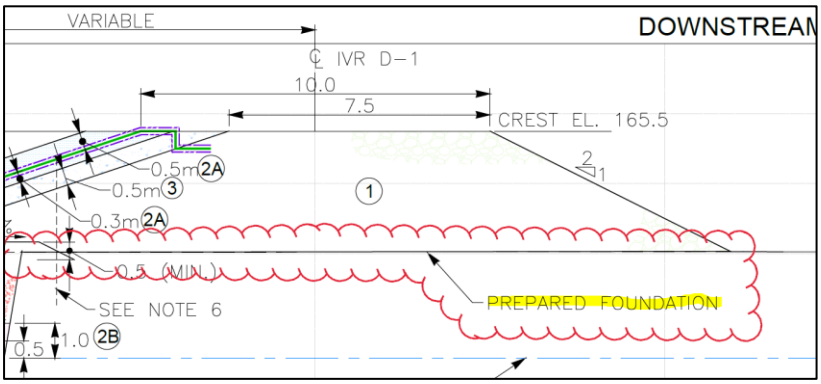


Figure 2 Surface preparation downstream of the key trench

Prepared by	Laurier Collette, *Geotechnical Engineer, Site representative*	Signature:	Date: 2021-01-29
Reviewed by	Frederick L.Bolduc, *Geotechnical Coordinator and RP*	Signature:	Date: 2021-02-05

SNC·LAVALIN	Site Engineering Query (SEQ)	Page 1 of 2	
		Revision	
		No.	Date
	Document No. 668284-5100-64NQ-I-0004	00	2021-03-09

Client Name	AGNICO EAGLE MINES
Project Name	AMARUQ PHASE 2 – IVR D1 DIKE

Contract No.	6127-E-132-003
Contract Name	IVR D1 DIKE CONSTRUCTION
Site Engineering Query Register No.	**RFI-04**
Topic	**12m WIDE UPSTREAM BERM MODIFICATION**

1. DESCRIPTION OF AGNICO EAGLE'S QUERY (attach documents if needed)

See attached RFI-04.

The 12m wide upstream thermal berm will include the 1.5m thick upstream rockfill shell of the thermal berm. The 12m will extend from the upstream toe of the dike to the liner connection weld (Fig. 1). Within the 12m, the rockfill shell remains 3.35m wide and the esker fill will be 8.65m wide. As per the thermal model report this change is not expected to impact the performance of the structure. This change is requested to optimize the dimension of the thermal berm and is not expected to impact the dike performance as per the available thermal modeling results.

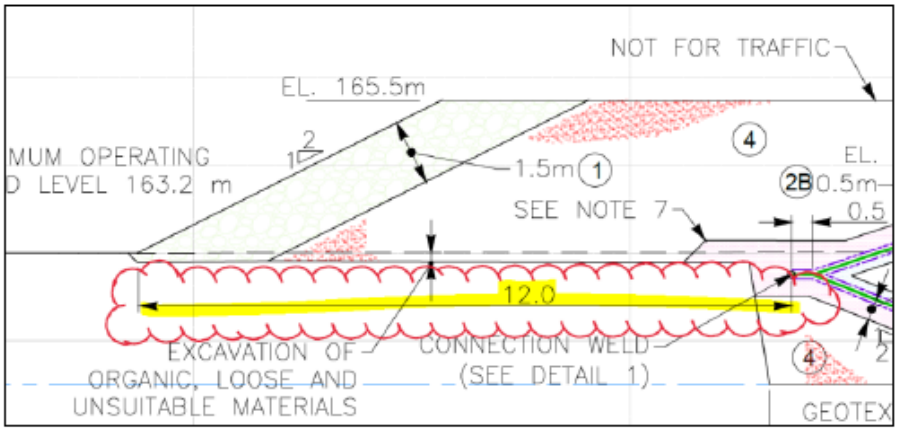


Figure 1. Thermal Berm width

SIGNATURE				
	Title	**Name**	**Signature**	**Date**
Prepared by				
Approved by				

2. RESPONSE BY ENGINEERING (SNC-LAVALIN)

Response

As highlighted in the thermal analyses technical note, the thermal effect of reducing the width of the berm relies on a phenomenon that is not taken into consideration in the study, that is convective heat transfer. A narrower berm, especially when in conjunction with using rockfill material, could lead to higher water ingress close to the cutoff trench, which will bring some heat in this area. The actual thermal modelling of this proposed modification of the dike design cannot be conducted with certainty for the reason mentioned previously; that is why a 12-m-wide esker berm, excluding the 1.5-m-thick rockfill in the upstream slope, was proposed in the initial design. The results from the thermal modelling also shown that

the construction of a wider berm would promote cooling of the upstream foundation (especially close to the cutoff trench), thus reducing possibility of thawing of the foundation and development of potential seepage pathways towards the cutoff trench.

SNC-Lavalin recommends keeping the same thermal berm width as initially designed. However, if AEM decides to proceed with reducing the overall width, proper monitoring points (temperature and elevation) should be put in place to follow the performance of the structure and that an appropriate mitigation plan and measures be developed in case there is any issue with the performance of the dike.

SIGNATURE			
	Name	**Signature**	**Date**
Project Manager	**Anh-Long Nguyen**		2021-03-09

3. FOLLOW-UP BY ENGINEERING (SNC-LAVALIN)		
Engineering documents revised	☐ **Yes**	☐ **No**
Explain		

SIGNATURE			
	Name	**Signature**	**Date**
Geotechnical Engineer			
Project Manager			

AGNICO EAGLE

REQUEST FOR INFORMATION

Project	IVR D1 DIKE			RFI No	04
Date	2021-01-28	Project No	6127 (AEM) / 66284 (SNC)	Revision	0
Initiator	AEM	Recipient	Anh-Long Nguyen – SNC Lavalin (Design Engineer)		
Response required by	2021-02-08				

REFERENCE DOCUMENTS		
No	*Title*	*Revision*
61-695-230-208	IVR D1 Dike Design sections and details	0
6127-695-132-REP-005	Design Report of IVR Attenuation Pond D-1 Dike	0

REQUEST

The 12m wide upstream thermal berm will include the 1.5m thick upstream rockfill shell of the thermal berm. The 12m will extend from the upstream toe of the dike to the liner connection weld (Fig. 1). Within the 12m, the rockfill shell remains 3.35m wide and the esker fill will be 8.65m wide. As per the thermal model report this change is not expected to impact the performance of the structure. This change is requested to optimize the dimension of the thermal berm and is not expected to impact the dike performance as per the available thermal modeling results.

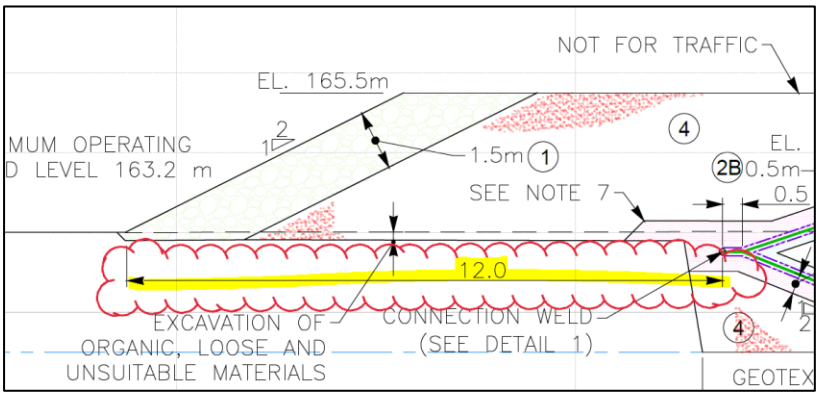


Figure 1. Thermal Berm width

Prepared by	Laurier Collette, *Geotechnical Engineer, Site representative*	Signature:	Date: 2021-01-29
Reviewed by	Frederick L.Bolduc, *Geotechnical Coordinator and RP*	Signature:	Date: 2021-01-29

SNC·LAVALIN	Site Engineering Query (SEQ)	Page 1 of 2	
		Revision	
		No.	Date
	Document No. 668284-5100-64NQ-I-0005	00	2021-03-25

Client Name	AGNICO EAGLE MINES
Project Name	AMARUQ PHASE 2 – IVR D1 DIKE

Contract No.	6127-E-132-003
Contract Name	IVR D1 DIKE CONSTRUCTION
Site Engineering Query Register No.	**RFI-05**
Topic	**BENTONITE QUANTITY OPTIMISATION**

1. DESCRIPTION OF AGNICO EAGLE'S QUERY (attach documents if needed)

See attached RFI-05 for details.

Summary

AEM's proposal is to place FFAB material only in the prioritized zones described above.

Project Manager

Also, as per a phone meeting held on March 22nd 2021 involving SNC-Lavalin (Anh-Long Nguyen – [redacted]), AEM (Thomas Lepine – Engineer of Record Nunavut, Laurier Collette – Geotechnical Engineer), Golder (Yves Boulianne, Marion Habersetzer), all parties agreed that outside of the MOL, FFAB material will be specifically placed in zone I and zone II only, from station 0+435 to the East abutment and from the West abutment to station 0+080. This is to further optimize FFAB placement because of a limited amount of bentonite available on site. Figure 3 illustrates where the FFAB will be placed in this specific part of the key trench. As of 2021-03-22, the remaining of the key trench outside the MOL is already backfilled (from 0+320 to 0+435).

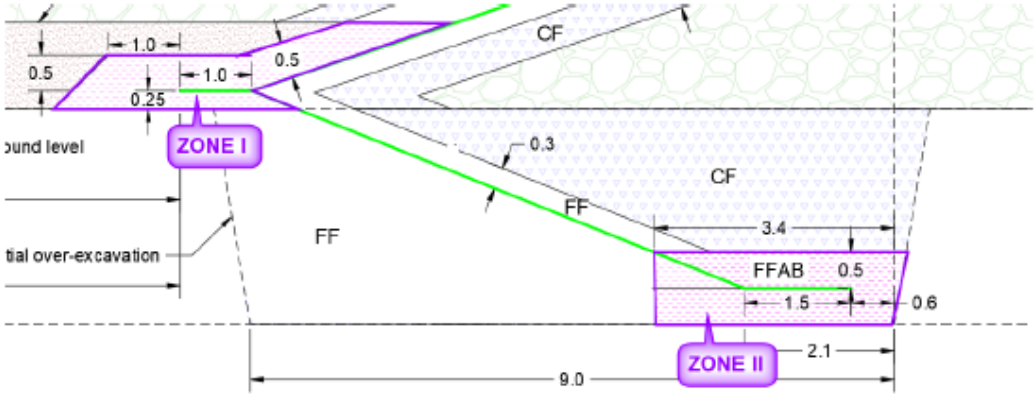


Figure 3 – FFAB placement from station 0+435 to the East abutment and from the West abutment to station 0+080, **only**

SIGNATURE				
	Title	**Name**	**Signature**	**Date**
Prepared by				
Approved by				

2. RESPONSE BY ENGINEERING (SNC-LAVALIN)

Response

Considering the limited quantity of bentonite on site, the proposed modifications is acceptable.

Note that the layer of FFAB upstream of the liner has also been removed. This is still acceptable since the liner will remain the primary barrier to infiltration in the key trench as per design. AEM will have to ensure the liner is properly installed and have all of the relevant testings and QC/QA reports to demonstrate this.

SIGNATURE			
	Name	**Signature**	**Date**
Project Manager	**Anh-Long Nguyen**		2021-03-25

3. FOLLOW-UP BY ENGINEERING (SNC-LAVALIN)

Engineering documents revised	☐ **Yes**	☐ **No**

Explain

SIGNATURE			
	Name	**Signature**	**Date**
Geotechnical Engineer			
Project Manager			

AGNICO EAGLE

REQUEST FOR INFORMATION

Project	IVR D1 DIKE			RFI No	05
Date	2021-03-22	Project No	6127 (AEM) / 66284 (SNC)	Revision	0
Initiator	AEM	Recipient	Anh-Long Nguyen – SNC Lavalin (Design Engineer)		
Response required by					

REFERENCE DOCUMENTS		
No	*Title*	*Revision*
6127-C-230-003-SPT-001	Technical specifications for the construction of IVR D-1 Dike	0
61-695-230-208	IVR D1 Dike Design sections and details	0
6127-695-132-REP-005	Design Report of IVR Attenuation Pond D-1 Dike	0
RFI-01	Esker Equivalence	0
RFI-02	Key Trench Configuration	0

REQUEST

In August 2020, during the Design phase of IVR Dike D1, 768 metric tons (768,000 kg) of bentonite were ordered to fulfill the needs of the Design. Since such a quantity of bentonite can only be delivered to site using boat transportation during the open water season, the order had to take place during that time frame. At the time of placing the order, a contingency volume was considered to provide security and to allow for field adjustments or future design changes. The quantity of bentonite to order was calculated as follows:

- 3,690 m^3 of FFAB required for the design of a dike with a 3 m wide key trench
- 30% contingency (grand total of 4,797 m^3 of FFAB);
- 8% bentonite mix ratio
- fine filter compacted density of 2,000 kg/m^3

Further work was done on the Design after the 2020 barge season order, with a final IFC design approved in December 2020, including a key trench 9m wide and a 6% bentonite mix ration in the FFAB. In February 2021, the FFAB material quantities were also slightly affected by the changes captured in RFI 01 (esker equivalence) and RFI-02 (Key trench configuration). All considered, the required compacted FFAB volume is 5,480 m^3. as a result, the total amount of bentonite required is 798,317 kg based on the following assumptions:

- 6% mix ratio (per design)
- Compacted FFAB density of 2,100 kg/m^3 (based on QC testing)
- 15% contingency

In order to build a performing structure with the amount of bentonite available on site, an optimization scenario of the FFAB zones within the dike is proposed. It has been discuss internally between the all concerned stakeholders and with the QA representative. The scenario retained and agreed between the parties is the subject of the current RFI. AEM is proposing to modify the zone where FFAB will be placed to optimize the available quantity while ensuring a good performance of the structure.

The water retention performance of IVR Dike relies on its impermeability system. The primary impermeable element of this system is the LLDPE liner. As a second line of defense, the expected thermal regime of the structure is such that the foundation is to remain frozen year-round (refer to the design report and thermal modeling sections for further details). AEM is of the opinion that the low permeability FFAB material placed within the structure adds robustness to the design and suggests to optimize the available bentonite as follows. The proposal complies with the quantity of bentonite remaining on site, as of March 10th, 2021.

ZONE I – Liner connection weld

The liner connection weld shall be properly protected as it is the weakest points of the impermeable element. It is suggested to maintain FFAB in this zone as per design to ensure a proper weak point protection and to minimize seepage infiltration to the key trench in the case where the zone would undergo thawing conditions.

ZONE II – Downstream bottom end of the liner

Based on the dike design and its operational strategy, the onset of significant thawing conditions in the foundation is considered unlikely. If such conditions were to take place, the liner is expected to prevent seepage across the structure as it remains the primary impermeable element of the dike. However, the weakest zone for seepage in the excavated foundation is at the bottom of the foundation at the downstream end of the liner where there is no liner (over a 0.6m length as per revised key trench geometry - RFI 01). It is suggested to maintain FFAB in this zone as per design to minimize the magnitude of potential seepage in the cut-off trench between the end of the liner and the trench downstream wall, in the low-probability event of unfrozen conditions at depth (2.5 below natural ground surface, about 0.5-1m below the active layer before construction).

ZONE III – Cut-off trench bottom

AEM suggests that the remaining available bentonite to be placed at the bottom of the cut-off trench to minimize potential seepage underneath the engineered fill of the cut-off trench, in the unlikely event of the onset of unfrozen conditions at depth.

Bentonite mix ratios

In addition to prioritizing the FFAB zones described above, AEM also proposes to optimize bentonite quantities based on two general areas of the dike:

A. Within the Maximum Operating Pond Level (MOL)
   - Between stations 0+080 and 0+320 (include a 25m buffer beyond the MOL)

B. Outside the MOL
   - From west abutment to station 0+080
   - From station 0+320 to the east abutment

AEM suggests keeping the FFAB bentonite mix ratio at 6% within the MOL zone as per design specification and using a 4% mix ratio outside of the MOL zone. This change of bentonite mix ratio outside of the MOL is not expected to affect the structure performance. The likelihood of having water above the MOL for a sustained period of time is quite low and such a high water level would most probably occur at freshet when the structure and foundation will be at its coldest temperature.

The tables and figure below summarize the FFAB zones detailed above. For all other areas throughout the dike where the design was requiring FFAB, fine filter without bentonite will be placed.

Table 1 - FFAB zones summary

	Within MOL 0+080 to 0+320	**Outside MOL <0+080 and >0+320**
ZONE I – Liner connection weld	Bentonite mix ratio = 6%	Bentonite mix ratio = 4%
ZONE II – Downstream bottom end of the liner	Bentonite mix ratio = 6%	Bentonite mix ratio = 4%
ZONE III – Cut-off trench bottom	Bentonite mix ratio = 6%	Bentonite mix ratio = 4%

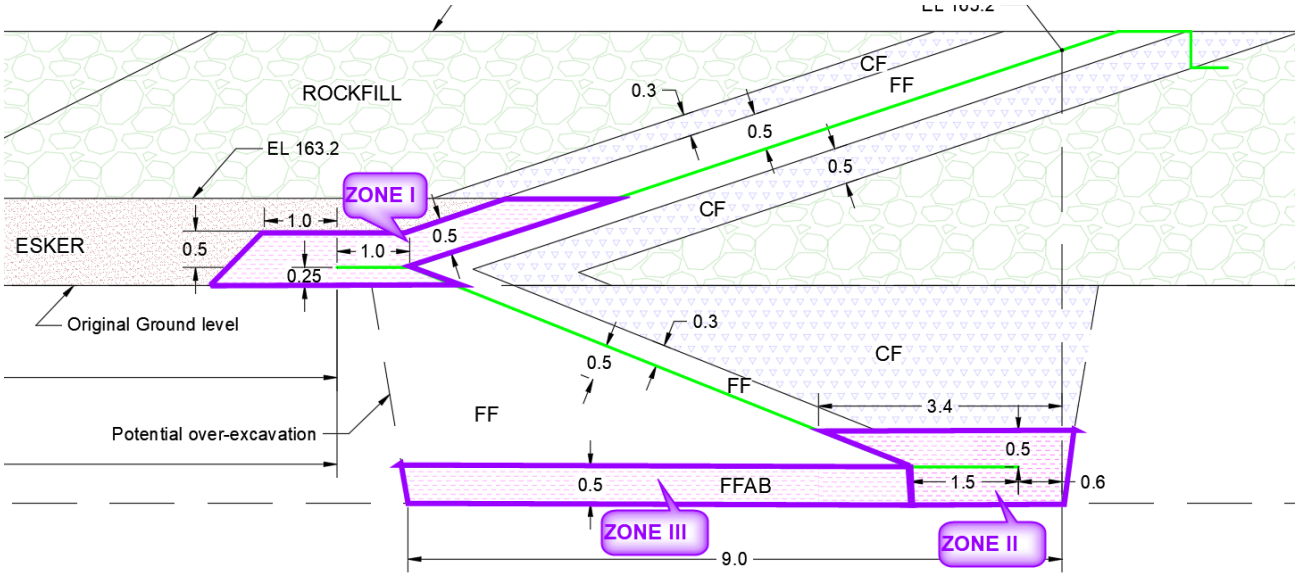


Figure 1 - Location of the optimal areas, in purple, to place FFAB within the IVR D1 Dike cross section. Areas are described as the liner connection weld (Zone I), the downstream bottom end of the liner (zone II) and the cut-off trench bottom (Zone III).

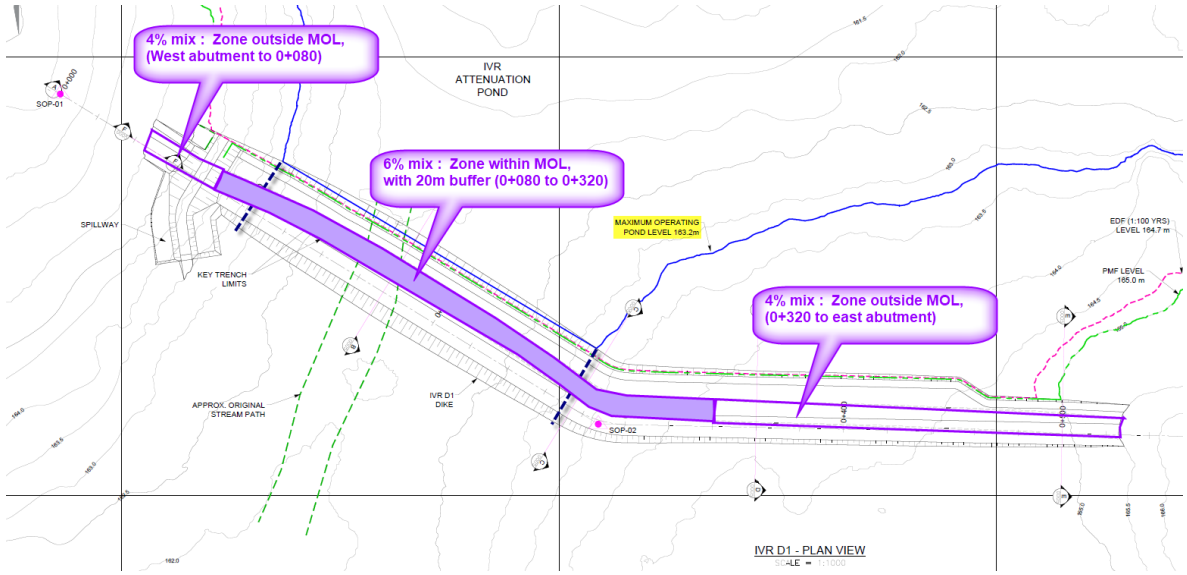


Figure 2 - Identification of the cut-off trench footprint in the zone within the Maximum Operating Pond Level

Summary

AEM's proposal is to place FFAB material only in the prioritized zones described above.

Also, as per a phone meeting held on March 22nd 2021 involving SNC-Lavalin (Anh-Long Nguyen – Design Engineer), AEM (Thomas Lepine – Engineer of Record Nunavut, Laurier Collette – Geotechnical Engineer), Golder (Yves Boulianne, Marion Habersetzer), all parties agreed that outside of the MOL, FFAB material will be specifically placed in zone I and zone II only, from station 0+435 to the East abutment and from the West abutment to station 0+080. This is to further optimize FFAB placement because of a limited amount of bentonite available on site. Figure 3 illustrates where the FFAB will be placed in this specific part of the key trench. As of 2021-03-22, the remaining of the key trench outside the MOL is already backfilled (from 0+320 to 0+435).

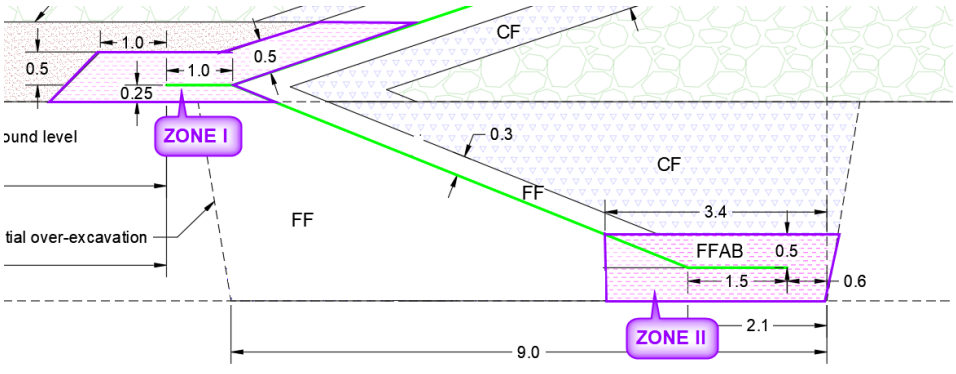


Figure 3 – FFAB placement from station 0+435 to the East abutment and from the West abutment to station 0+080, **only**

Prepared by	Patrice Gagnon, *Geotechnical Specialist, Site representative*	Date: 2021-03-12
	Laurier Collette *Geotechnical Engineer, Site representative*	Date: 2021-03-22
Reviewed by	Thomas Lepine *Engineer of Record*	Date: 2021-03-23

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IVR Dike D1 RF-1, RFI-4 & RFI-5 responses to SNC Lavalin

To: Anh-Long Nguyen, Project Manager

From: Patrice Gagnon, Geotechnical Specialist

CC: Thomas Lépine, Engineer of Record

Date: June 6th, 2021

AEM is constructing the IVR Dike D1 at the Whale Tail Project. To date, five (5) Design changes were identified and managed through the form of a Request for Information to the Designer. There are still some items that are outstanding and that AEM want to clarify.

RFI-1, part C, Cutoff trench downstream zone, overlaying the FFAB and Fine Filter layers

AEM initial proposition:

Esker will be replaced by Coarse Filter material (Type 3) up to the original ground elevation. The surface of this layer will be flat. There will not be any slope towards the downstream side. The use of an engineer fill such as coarse filter will improve the performance of the key trench by minimizing settlement potential if the key trench would thaw.

SNC Lavalin answer:

To limit the amount of water that could accumulate on the downstream side of the key trench, we recommend that the esker be replaced with fine filter material (zone 2A) with the gradation specified by SNC instead of coarse filter.
If there is insufficient zone 2A material on site, put in place proper monitoring points (temperature and elevation) to follow the performance of the structure and that an appropriate mitigation plan and measures be developed in case there is any issue with the performance of the dike.

AEM additional comments:

It is to be noted that, from the beginning of the Design phase, the usage of esker material was presented as an opportunity in certain areas of the infrastructure if the material quality and availability on site were met. After further site investigation, only a small quantity of the esker material available met quality standards for its planned usage, therefore AEM intent is to use it in the most effective way as possible.

AEM believes that the usage of coarse filter will offer an improved protection against the settlement of the backfill material of the key trench in a case of thawing conditions taking place in the foundation. Therefore, AEM maintains its proposition and will place coarse filter in replacement of the esker on the downstream of the liner in the key trench. A good monitoring program of the structure thermal behavior and settlement will be implemented at freshet onwards.

RFI-1, part D, Thermal Berm above operational level (above el 163.2):

AEM initial proposition:

Esker will be replaced by rockfill material (Type 1 material) to provide an upper layer of erosion protection. An additional 0.3m thick layer of Coarse Filter material (Type 3) will be placed as transition material between the rockfill and fine filter liner protection. The suitable esker will be maximized in this zone with the objective to reach the 1:100 year level (El 164.7 m). The minimum placement limit for the esker material is set at the maximum operational level (El 163.2).

SNC Lavalin answer:

In terms of seasonal frost penetration, no major change is expected as the geothermal properties of the esker material and rockfill are similar. However, as noted in the thermal analyzes technical note, the cutoff above El. 163.2 m solely relies on the geomembrane performance as there is no FFAB above this elevation. This is particularly true since there is no esker with some fines placed on the upstream above El. 163.2 m that could reduce any flow of water coming from the Attenuation Pond, when the water level rises to a higher elevation than the maximum operational water level. The geomembrane installation becomes a critical part of the construction as it does not benefit from the composite liner system with FFAB. To account for potential settlements and construction imponderables, SNC-Lavalin recommends increasing the esker level up to El. 163.5 m and increasing the FFAB layer up to the EDF level (164.7 m).

For RFI-1, item D: The proposed modifications is conditionally approved with the following recommendations:

a) Increase the height of the esker layer to 163.5 m to provide a 0.3 m freeboard.
b) Increasing the FFAB layer along the liner up to EDF level (164.7 m) to provide a composite liner effect.
c) Put in place proper monitoring points (temperature and elevation) be put in place to follow the performance of the structure and that an appropriate mitigation plan and measures be developed in case there is any issue with the performance of the dike.

AEM additional comments:

Similar to several structures at sites, the IVR dike D1 is a rockfill shell dike with a liner anchored in a key trench contained within permafrost. The main impervious element of the infrastructure is therefore the LLDPE geomembrane that is wrapped within two robust layers of geotextile. Furthermore, a specialized and certified firm has been hired to install the LLDPE following a stringent QA and QC program.

Given the amount of quality esker material available on site, the esker zone part of the thermal berm will be built up to the elevation 164.5. To accommodate this raise, the longitudinal extent of the esker zone will be at least 6m upstream. As for everything related to FFAB, please consult the RFI-5. As per our standard practices, an adequate monitoring program will be implemented at freshet and onwards.

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RFI-4, Reducing the upstream thermal berm total width

AEM initial proposition:

The 12m wide upstream thermal berm will include the 1.5m thick upstream rockfill shell of the thermal berm. The 12m will extend from the upstream toe of the dike to the liner connection weld. Within the 12m, the rockfill shell remains 3.35m wide and the esker fill will be 8.65m wide. As per the thermal model report, this change is not expected to impact the performance of the structure. This change is requested to optimize the dimension of the thermal berm and is not expected to impact the dike performance as per the available thermal modelling results.

SNC Lavalin answer:

As highlighted in the thermal analyze technical note, the thermal effect of reducing the width of the berm relies on a phenomenon that is not taken into consideration in the study, that is convective heat transfer. A narrower berm, especially when in conjunction with using rockfill material, could lead to higher water ingress close to the cutoff trench, which will bring some heat in this area. The actual thermal modelling of this proposed modification of the dike design cannot be conducted with certainty for the reason mentioned previously; that is why a 12-m-wide esker berm, excluding the 1.5-m-thick rockfill in the upstream slope, was suggested in the initial design. The results from the thermal modelling also shown that the construction of a wider berm would promote cooling of the upstream foundation (especially close to the cutoff trench), thus reducing possibility of thawing of the foundation and development of potential seepage pathways towards the cutoff trench. SNC-Lavalin recommends keeping the same thermal berm width as initially designed. AEM will increase the elevation of the esker layer against the structure. The rest of the thermal berm will be constructed with rockfill.

SNC-Lavalin recommends keeping the same thermal berm width as initially designed per the advantages described above. However, if AEM decides to proceed with in reducing the overall width, proper monitoring points (temperature and elevation) should be put in place to follow the performance of the structure and that an appropriate mitigation plan and measures be developed in case there is any issue with the performance of the dike.

AEM additional comments:

In line with the RFI-5 delineating the changes in bentonite quantities that were already discussed and approved by SNC, AEM will go ahead with the building of the full extent of the upstream berm as per IFC drawings.

AEM believes that the monitoring program planned for the structure will prove to be effective in following the performance of the structure and thermal berm. For the first year of operation, AEM will also manage the pond water level in a way to keep water away from the structure. If the performance is not satisfactory after the first months of operation, a remediation plan will be implemented to correct the situation.

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RFI-5 BENTONITE QUANTITIES

AEM initial proposition

AEM's proposal was to place FFAB material only in the prioritized zones described in the RFI-05 documentation provided.

As further detailed in RFI-05, upon a phone meeting held on March 22nd 2021 involving SNC-Lavalin (Anh-Long Nguyen – Design Engineer), AEM (Thomas Lepine – Engineer of Record Nunavut, Laurier Collette – Geotechnical Engineer), Golder (Yves Boulianne, Marion Habersetzer), all parties agreed that outside of the MOL, FFAB material will be specifically placed in zone I and zone II only, from station 0+435 to the East abutment and from the West abutment to station 0+080. This is to further optimize FFAB placement because of a limited amount of bentonite available on site. The shortage is caused by the greater amount of FFAB placed so far to fill the bedrock overbreak of the key trench floor (about 100% of additional FFAB required). Figure 1 illustrates where the FFAB will be placed in this specific part of the key trench. As of 2021-03-22, the remaining of the key trench outside the MOL is already backfilled (from 0+320 to 0+435).

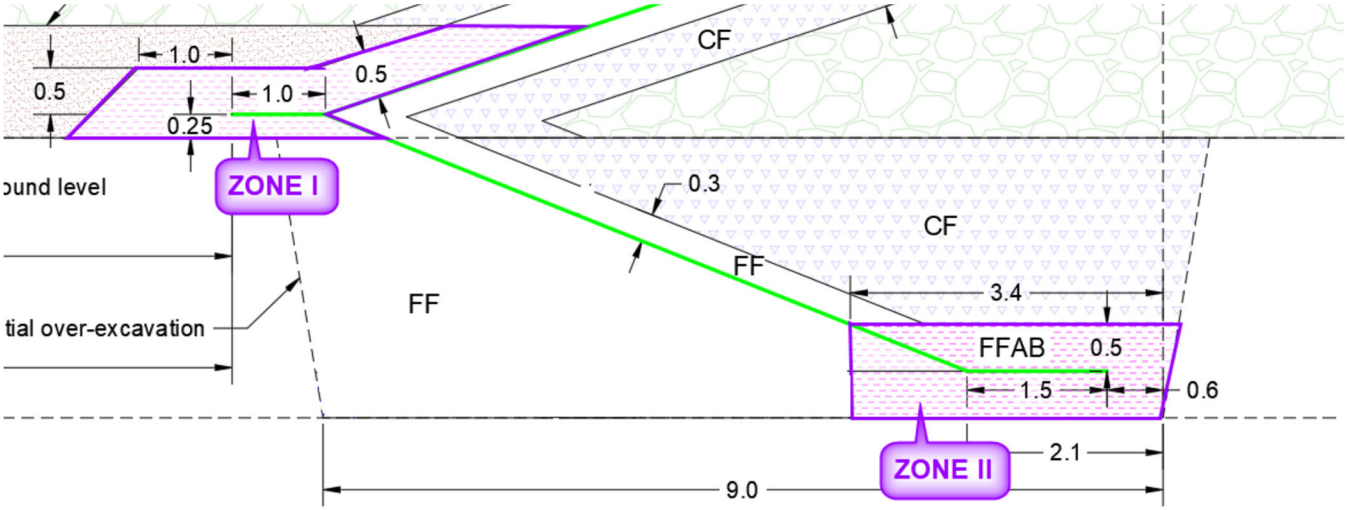

Figure 1 – FFAB placement from station 0+435 to the East abutment and from the West abutment to station 0+080, only

SNC Lavalin answer:

Considering the limited quantity of bentonite on site, the proposed modifications is acceptable.

Note that the layer of FFAB upstream of the liner has also been removed. This is still acceptable since the liner will remain the primary barrier to infiltration in the key trench as per design. AEM will have to ensure the liner is properly installed and have all of the relevant testings and QC/QA reports to demonstrate this.

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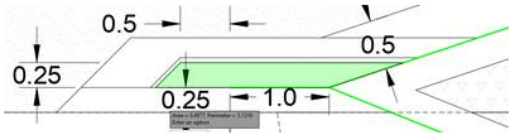
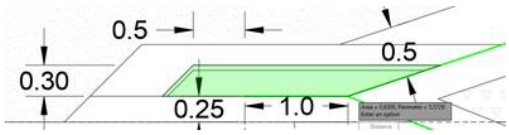
AEM Additional comments

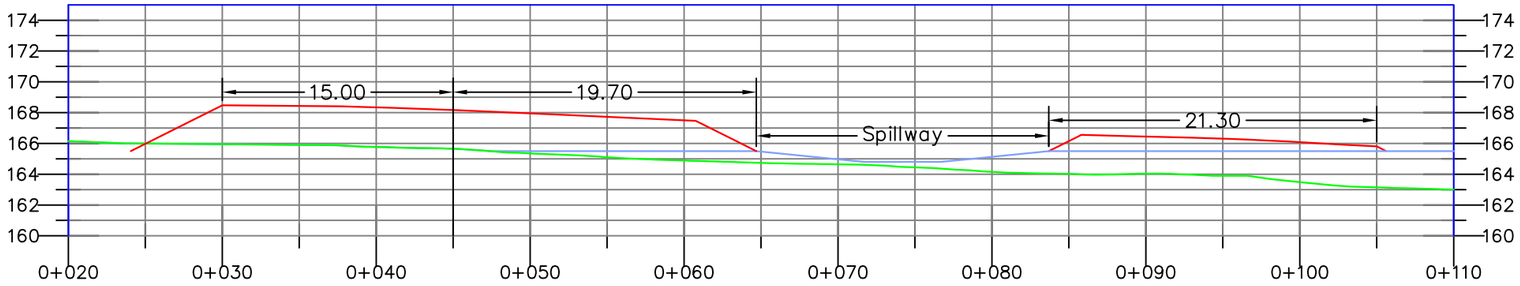
As placement of FFAB progressed per RFI-05, the conditions at the key trench bottom (overbreak in bedrock), along with losses at the mixing station and upon placement, were such that more bentonite was required to finish the dike construction than the remaining inventory available on site. Therefore, more bentonite had to be ordered from another mine site to finalize the construction. More optimization was also required with the new bentonite inventory on site. The following table presents the four scenarios evaluated.

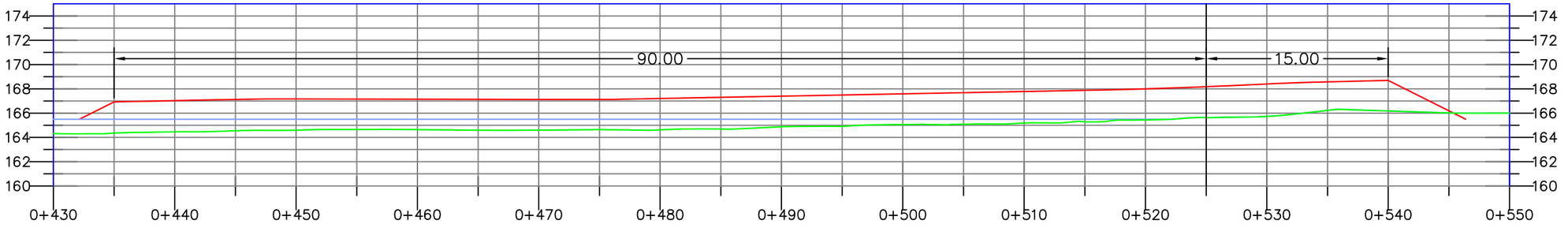
	Scenario 1	Scenario 2	Scenario 3	Scenario 4
FFAB thickness over liner connection weld	**0.25m**		**0.3m**	
Horizontal extent of FFAB beyond the liner	0.5m			
Bentonite mixing ratio within the MOL (from sta 0+100 to 0+300)	6%	**4%**	6%	4%
Section area (m2)	0.4977	0.4977	0.63	0.63
Required Bentonite (tons)				
Within MOL	12.4	8.4	15.7	10.7
West of MOL	2.3	2.3	2.9	2.9
East of MOL	9.6	9.6	12.2	12.2
TOTAL	**24.4**	**20.4**	**30.8**	**25.8**
sketch				

*assumption of 2200 Kg/m3 for compacted FFAB density – from average measure in the field.

Scenario #3 was the preferred option as discussed and agreed between AEM site representatives, AEM Engineer of Record and QA representatives. Therefore, a 0.3 m thick layer of FFAB with a 6% mix ratio was used to cover the LLDPE at the hinge section in the area comprised within the Maximum Operating Level (MOL). Following snow removal at hinge location after a blizzard, more FFAB was removed and replaced in the MOL area, affecting the quantities of remaining bentonite. Therefore, to cope with the remaining quantity available, the thickness of the lift that was used to cover the liner outside the MOL needed to be readjusted to 0.25m with a mix ratio kept at 4%.

Patrice Gagnon, Geotechnical Specialist





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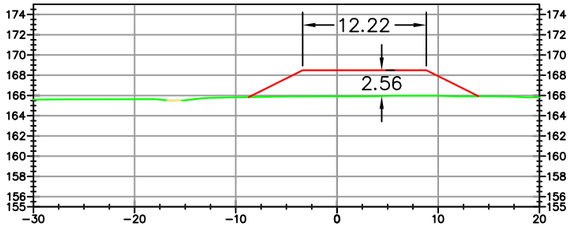

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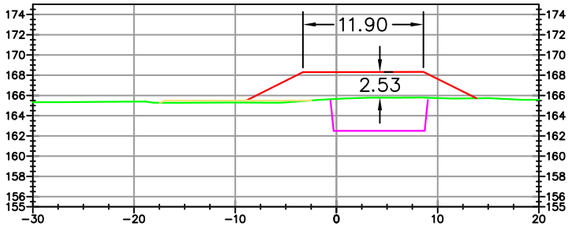

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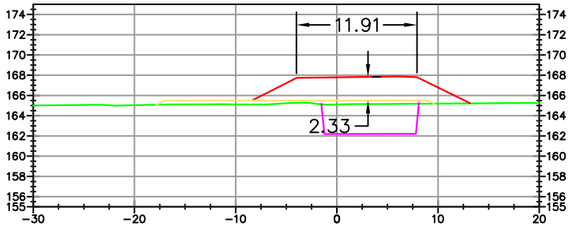

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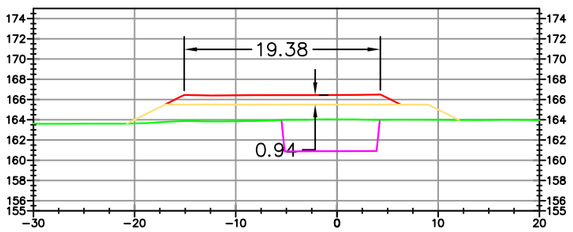

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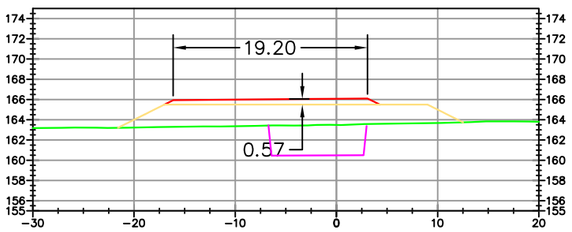

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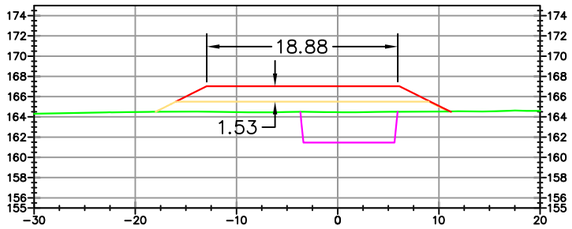

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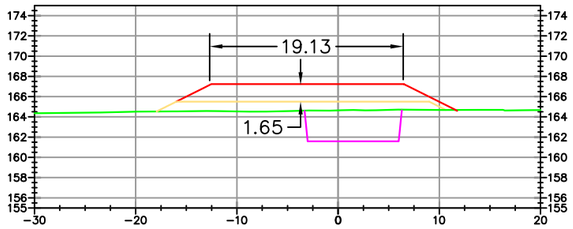

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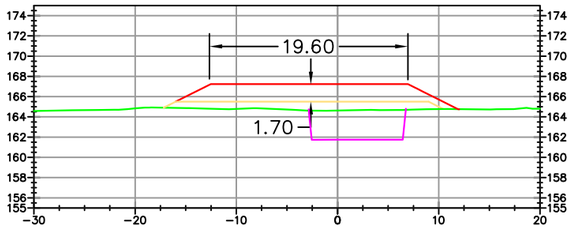

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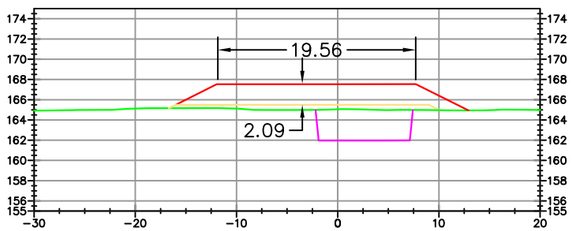

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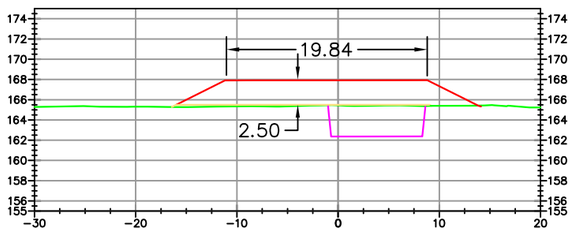

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