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Joseph Mackenzie, Chair
Wek'èezhìı Land and Water Board
PO Box 32
Wekweètì, NT X1A 3S3
Canada

9 January 2020

Dear Mr. Mackenzie:

Subject: DDMI Request for WRSA-NCRP Cover Modification

Diavik Diamond Mines (2012) Inc. (DDMI) kindly requests that the Wek'èezhìı Land and Water Board (WLWB or Board) distribute the attached Waste Rock Storage Area – North Country Rock Pile (WRSA-NCRP) closure cover modification request for public review and approval by the Board under W2015L2-0001, Part G, Item 2. This modification relates to DDMI's April 18, 2017 submission of the Final Closure and Reclamation Plan (CRP) – Waste Rock Storage Area Version 1.1. DDMI is requesting to reduce the till thickness cover from 1.5m to 1.0m for the top surface of the WRSA-NCRP when the material contains greater than 10% gravimetric water content (GWC). As defined in the Diavik Mine Water Licence, a modification, in respect to an Engineered Structure, means a change, other than an expansion, that does not alter the purpose or function of a structure. As detailed herein, this modification request is not an expansion of the WRSA, nor will it alter the purpose or function of the structure. DDMI is submitting this modification request under Part G, Item 2 rather than Item 1 because DDMI expects the immediate initiation of a public review will assist in expediting the Board's approval process and timeline. Additionally, this submission approach acknowledges that the January 24, 2018 WLWB approval of the WRSA-NCRP CRP included actions to address uncertainties related to the till layer of the WRSA cover and a modification to that till layer is likely to require more detailed consideration by the WLWB. DDMI notes that to prevent a potential impact to progressive reclamation of the WRSA-NCRP a Decision on this request is required by early March 2020.

Background

The closure concept of the WRSA-NCRP requires the construction of a cover layer above the existing extents of Type II or Type III (potentially acid-generating) rockfill placed as waste during mining activities. The design of the cover layer is:

- 1.5 m thick layer of till placed on the crest of the NCRP and along Type II or Type III rockfill slopes which have been re-sloped to 3 horizontal to 1 vertical (3H:1V).
- 3.0 m layer of Type I (non-acid generating) rockfill placed above the till layer.

The design of the cover materials is to promote permafrost aggradation within the Type II and Type III waste rock materials. The moisture content and grain size distribution of the till layer will influence the overall performance of the closure concept. Monitoring the performance of the NCRP cover system will be carried out with the utilization of geotechnical instrumentation. Geothermal design of the cover system was completed by Tetra Tech in (September 27, 2017), geotechnical design completed by Golder Associates (2016) and design accepted by the WLWB in (February 8, 2018)

The A21 pit is the current source of the till material. The till from the deepest location of the former lake contains till and lakebed sediments (LBS) with a higher percentage of fines. The fine-grained lakebed sediments with higher moisture content have been placed on the top of the NCRP to reduce stability concerns with placing the material on the 3H:1V slope. The material has been end-dumped in the horizontal regions 101 to 117 (Figure 1). Due to the end dump placement methodology and high moisture content, the material has settled out to an average thickness of 0.8m to 1.6m.

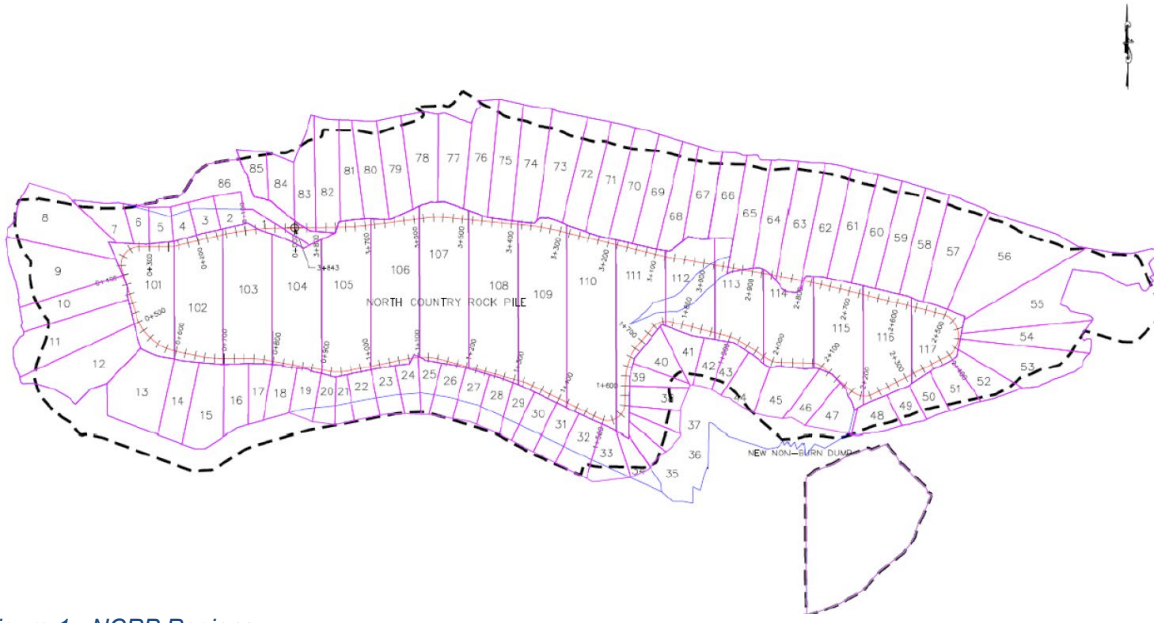

Figure 1 - NCRP Regions

Thermal Analysis

Based on thermal analyses conducted by Tetra Tech (2017), in order to prevent the active layer from propagating into the underlying Type II or Type III rock, a minimum long term gravimetric water content of 10% at a 100% saturation level is required in the till layer, along with a minimum thickness of 1.0m. Based on the memo provided by Leslie Smith March 15, 2018, a minimum of 10% volumetric water content is supported, indicating a level of conservatism in the Tetra tech analysis. The Tetra Tech (2017) thermal analysis indicates that the horizontal areas will require a thinner thickness of till material than the slopes to prevent the thawing of Type II/III material. The thermal analysis predicted a max thaw depth into the top surface cover to range from 3.3m to 4.3m depending on the water content with a 1.5m till layer. The figure below displays a table presented in the Tetra Tech Thermal Analysis report, Figure 2.

Table 9: Summary of Predicted Maximum Thaw Depth for Various Till Water Contents

Case	Water Content (%)	Degree of Saturation (%)	Predicted Maximum Thaw Depth after 100 Years under Projected Mean Climate Change Scenario (m)	
			Top Surface	Side Slope
Case 1	25	100	3.30	3.75
Case 2	22.5	90	3.40	3.95
Case 3	20	100	3.45	4.00
Case 4	18	90	3.60	4.10
Base Case	15	100	3.65	4.10
Case 5	13.5	90	3.70	4.20
Case 6	10	100	3.80	4.30
Case 7	9	90	4.00	4.50
Case 8	8	80	4.30	5.10
: Thawing front penetrating into Type III rock after 100 years under the mean climate change scenario				

Figure 2. Table 9 from the Tetra Tech Thermal Modelling Report. The table presents the maximum thaw depth after 100 years under the projected mean climate change scenario.

The thermal results are presented in Tetra Tech's report in Table 10, Figure 3. The thawing front is retained within the closure cover on the top surface (but not the side slopes) after 100 years under the projected mean climate change scenario. Case 11 predicts that with 15% gravimetric water content, the thaw depth will be 3.65m on the top surface and will not penetrate the Type II/III material. **Case 11 indicates the same thaw depth as the base case; however utilizes a shallower 1.0m till thickness on the top surface indicating reduced sensitivity of thaw on the top surface.**

Table 10: Summary of Predicted Maximum Thaw Depth for Various Cover Thicknesses

Case	Water Content (%)	Degree of Saturation (%)	Predicted Maximum Thaw Depth after 100 Years under the Projected Mean Climate Change Scenario (m)	
			Top Surface	Side Slope
"Base Case" (1.5 m Till and 3.0 m Type I Rock)	15	100	3.65	4.10
Case 11 (1.0 m Till and 3.0 m Type I Rock)	15	100	3.65	4.30
Case 12 (1.5 m Till and 2.0 m Type I Rock)	15	100	3.30	3.80
Case 13 (1.0 m Till and 2.0 m Type I Rock)	15	100	3.50	4.15
: Thawing front penetrating into Type III rock after 100 years under the mean projected climate change scenario				

Figure 3. Table 10 from the Tetra Tech Thermal Modelling Report.

Till Material Analysis

Ten till samples have been collected from in-place till on the top of the NCRP. Approximately 20 kg of material per sample was manually collected with shovels and pails. Till samples have been collected from regions 101 to 105 and 114 to 117, and a summary of locations and results are presented in Table 1.

Tetra Tech (2017) specifies a minimum long term gravimetric moisture content (GWC) of 10% for the till. The samples of the placed till have undergone moisture content testing. Moisture contents of the placed till varying from a minimum of 5.9%GWC to a maximum of 31.7%GWC with an average of 17.4%GWC, Table 1.

Table 1. Moisture content and gradation of placed lakebed sediments in regions 101 to 105 and 114 to 117.

Region	Sample ID	% Passing (0.425 mm) Specified Criteria	% Fines (passing 0.075 mm	Gravimetric Moisture Content %	Volumetric Moisture Content %
117	Sample 77	52.18	30.64	7.75	17.58
116	Sample 78	39.46	21.91	5.87	13.31
114	Sample 79	47.97	29.80	7.70	17.46
111	Sample 80	60.93	41.36	12.11	27.47
104	Sample 81	48.08	27.12	19.15	43.43
102	Sample 82	52.61	36.03	8.62	19.55
104	Sample 83	71.67	59.71	27.91	63.30
105	Sample 84	78.51	67.96	23.40	53.07
103	Sample 85	91.43	85.37	31.70	71.90
101	Sample 86	82.92	70.18	30.16	68.40

For the till layer to retain moisture, a content of 30 to 70% passing the 0.425 mm sieve is required. The till placed to date has between 40% and 90% passing the 0.425 mm sieve. A summary of grain size distribution plots for each tested sample is presented in Figure 4. The relationship between grain size and moisture content is shown in Figure 5 which indicates higher moisture content with higher percent passing the 0.425mm sieve.

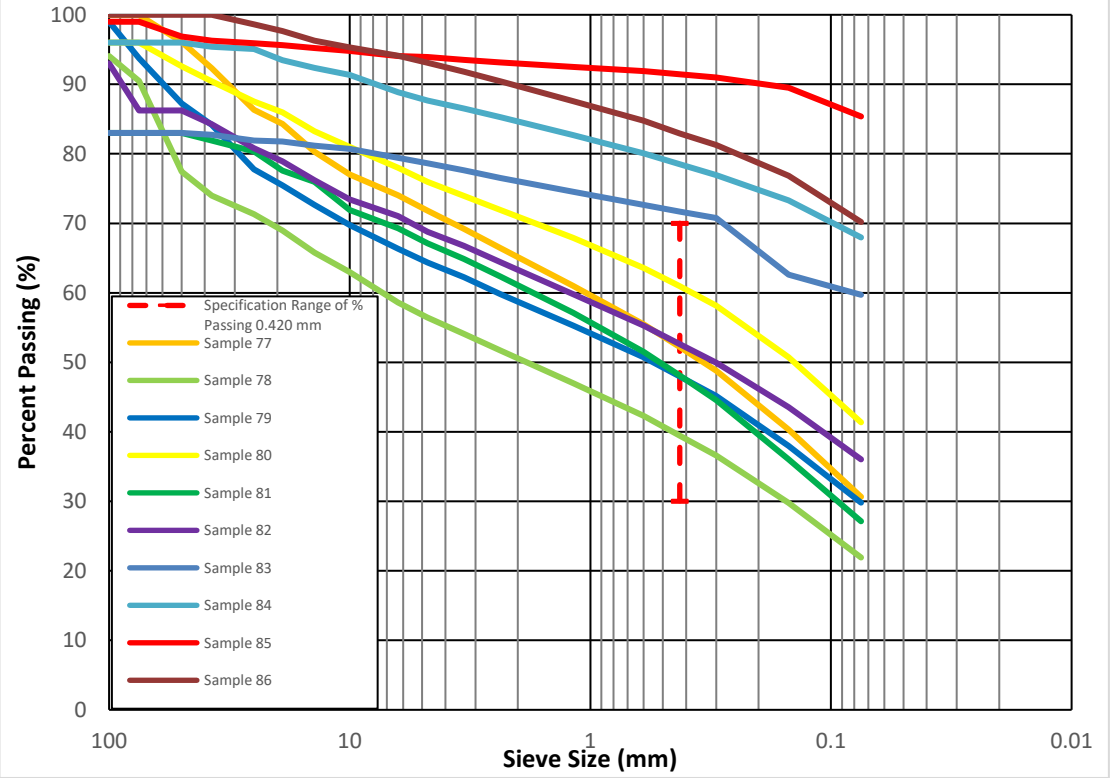

Figure 4. Gradation Curve for the sample collected from the top region 101 to 117. The red dash line is the specification range of percent passing the 0.425mm sieve.

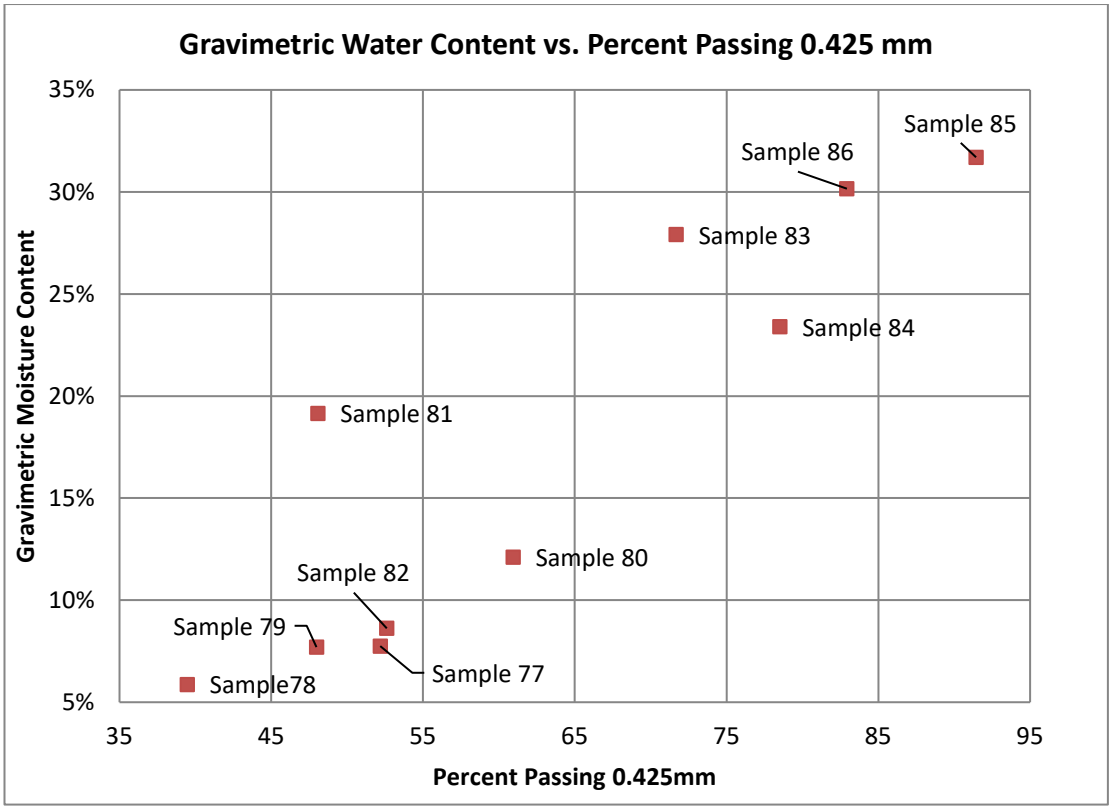

Figure 5. Gradation results. Gravimetric water content versus percent passing 0.425mm sieve.

The material in regions 101 to 105 contains a significant amount of fines, resulting in an average gravimetric moisture content of 23%GWC. The thermal analysis supports the till thickness reduction to 1.0m as this is significantly greater than the 10% minimum and the 15% used in the thickness scenarios (Figure 3).

Expert Review

DDMI engaged experts with Golder Associates Ltd. (Golder) (Attachment 1) and Tetra Tech Canada Inc. (Tetra Tech) (Attachment 2) to ensure that the proposed modification was acceptable from a design perspective. Golder completed additional slope analysis and confirmed that a reduction in till thickness on the top surface of the NCRP will not affect the overall stability of the cover system. Tetra Tech completed additional thermal modelling and confirmed that when the material contains greater than 10%GWC the thawing front would be at depths between 3.90 m to 4.00 m after 100 years under the projected mean climate change scenario, which is still within the modified cover system. Both assessments confirmed that this modification would not prevent the cover from performing the designed purpose or function.

Monitoring and Maintenance

In order to verify thermal performance of the modified cover DDMI will install a vertical thermistor within the thinnest cover region with the lowest moisture content to monitor the worst-case scenario. The vertical thermistor will penetrate at least 10m into the WRSA-NCRP cover and have sufficient bead spacing to verify thermal performance of the cover material. If monitoring of the modified cover identifies that the cover is unable to perform, an additional 1m of run of mine Type I (non-acid generating) waste rock will be added to the cover in the affected region. DDMI believes the NCRP maintenance holdback proposed in Diavik's December 17, 2019 Reclaim Estimate submitted with the interim Closure and Reclamation Plan (CRP) as Version 4.1 addressed this potential cost.

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Summary

- DDMI is requesting to reduce the required till thickness from 1.5m to 1.0m for the top of the NCRP when the material contains greater than 10%GWC. This material is expected to be contained within regions 101 to 105.
- Till material results in regions 101 to 105 contains a high percentage of fines and water content, average of 23%GWC.
- DDMI engaged technical experts and confirmed this modification would not prevent the cover from performing the designed purpose or function.
- DDMI will install a vertical thermistor in the modified cover to verify performance.
- If the cover is unable to develop an active zone contained within the cover, an additional 1m of Type I waste rock will be added to the cover.
- The NCRP maintenance holdback provided in DDMI's Reclaim Estimate addresses this risk/cost.

DDMI thanks the Board in advance for considering our request. Please do not hesitate to contact the undersigned if you have any questions related to this submission.

Yours sincerely,

Gord Macdonald
Closure Manager

Gord Stephenson
Projects Manager

Attachment: 1 – Request for Information from Golder
2 – Request for Information from Tetra Tech

cc: Anneli Jokela, WLWB
Kassandra DeFrancis, WLWB

Diavik Diamond Mines Inc.
REQUEST FOR INFORMATION

RFI NUMBER:	**DDMI-4110-005**
Date Created:	**9/October/2019**

Project: NCRP Closure Construction	**Area/Location: N.C.R.P.**

Originator:	**DDMI**
To:	Golder Associates Ltd. (Golder)
Forwarded to:	**Adam Pfitzenmaier, Ben Wickland.**

Date response required by:				**Contract Number:**
Priority:	☐ **High**	☐ **Medium**	☒ **Low**	**Number of Pages:** **1 of 1**
Query:	☒ **Technical**	☐ **Contractual**		

A) Instruction Request / Question:

DDMI request confirmation that the proposed reduction in material thickness on the top face of the NCRP will not affect the stability of the cover system.

RFI Impact: Cost ☒; Time/Schedule ☒
Remarks:

Drawings Affected:	**Document #**	**Title**	**Print Name: Eamonn Goggin**
			Originator Signature:
			Date: Oct/9/2019

B) Response:

Based on DDMI's internal memo titled Proposed North Country Rock Pile Crest Till Thickness Design Modification (3 October 2019), Golder understands DDMI has proposed to reduce the thickness of the till layer for the closure cover system from 1.5 m to 1 m on the top surface of the North Country Rock Pile (NCRP). Golder understands that this proposed change will be for the top surface of the NCRP only (Regions 101 to 117 shown in Figure 1), and the thickness of the till layer of the cover to be placed over the side slopes of the NCRP, including areas re-sloped to 3H:1V, will remain unchanged at 1.5 m thickness measured perpendicular to the slope.

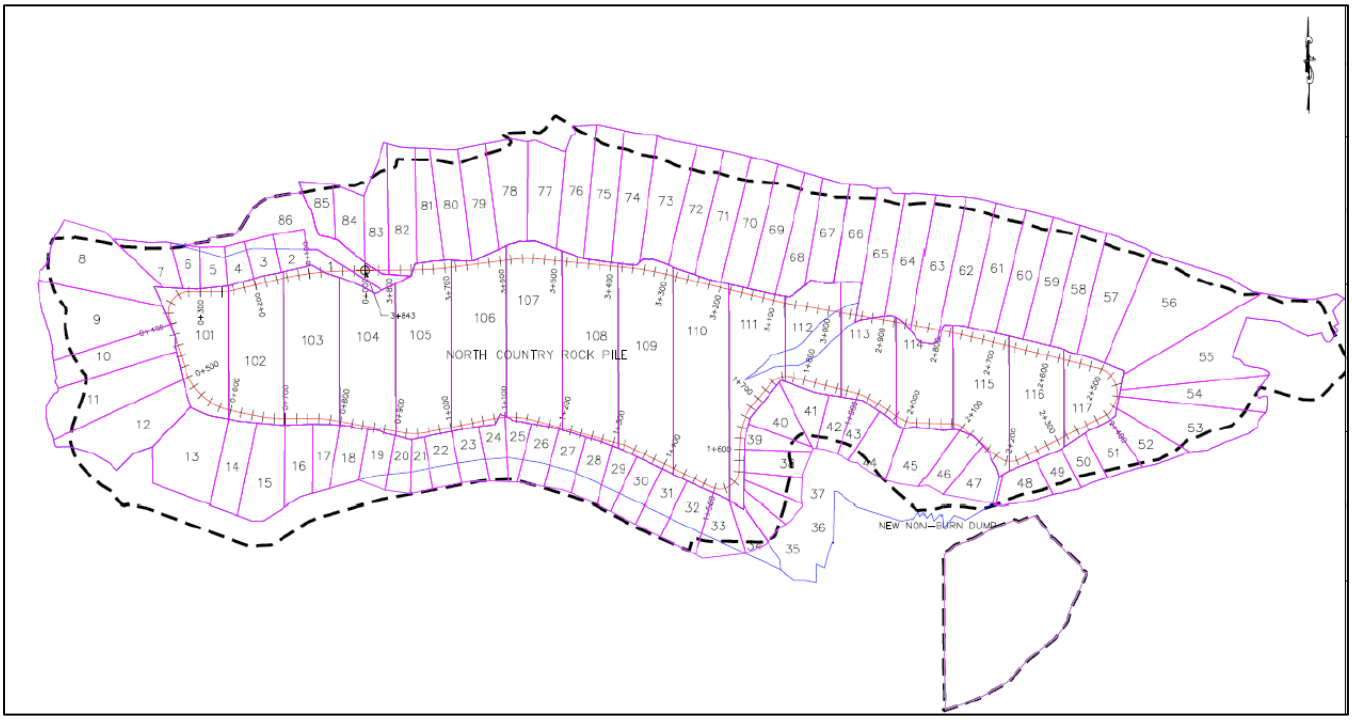

Figure 1: North Country Rock Pile Construction Region Plan

<u>Regarding the question of stability of the cover under the proposed change:</u>

The upper portion of the pile is relatively flat, and does contain locally sloped areas with the potential for solifluction, skinflows, and bimodal flows where frozen soil within the active layer thaws faster than pore water pressure is dissipated, generating excess pore water pressures in the soil layer (till layer). High pore water pressures increase the potential for slippage of the till cover placed on a slope.

To confirm the proposed change in till thickness will not adversely impact the stability of the top of the NCRP, the stability of the reduced to 1 m till thickness in the cover system was assessed and compared to the NCRP design with 1.5 m till thickness in the cover system.

The design is presented in Golder (2018) (North Country Rock Pile Closure Design Report (1521339-1471-R-Rev5-7000) dated 20 February 2018). Golder (2018) presents an assessment of the physical stability of the till layer in the cover system using infinite slope analyses. The two cases considered were:

- Case 1: Stability of the 1.5 m till layer on a 3H:1V slope before placement of the Type 1 ROM capping layer (short-term condition).

- Case 2: Stability of the 1.5 m till layer on a 3H:1V slope after placement of the 3 m thick Type 1 ROM capping layer (long-term condition).

Case 1 and Case 2 were re-analysed using a 1.0 m till layer using the same properties and conditions reported in Golder (2018). Table 1 presents the results.

Table 1: Stability Analysis Results of the Cover System

Case Analysed	Calculated Factor of Safety	
Till Layer Thickness	**1.5 m (Golder 2018)**	**1.0 m (new)**
Case 1: Till cover layer only on 3H:1V slope before placement of Type 1 ROM capping layer – (short-term condition)	1.0	1.0
Case 2: Stability of the till layer on a 3H:1V slope after placement of the 3 m thick Type 1 ROM capping layer (long-term condition).	2.2	2.3

The results indicate that a reduction in till thickness to 1 m will not reduce the stability of the cover. For the long term condition, the Factor of Safety against solifluction, skinflows, and bimodal flows increases slightly, indicating an increase in stability.

As stated in Golder (2018), if the till cover is left uncapped and allowed to go through freeze-thaw cycling, then some minor slippage of the till layer is expected to occur due to frost action (regardless of till layer thickness).

Based on the results presented above, Golder can confirm that a reduction in till thickness on the top surface of the NCRP will not affect the overall stability of the cover system.

As stated in Golder (2018), should water pond on the till layer on the surface of the NCRP, and the active layer fully penetrate the till, then loss of finer particles from the till into the underlying waste rock is possible due to filter incompatibility. A reduction in the till thickness from 1.5 to 1.0 m will reduce resistance to this failure mode.

This response considers failure modes related to construction of the cover. Other evaluations, such as thermal performance, are excluded.

Drawings Issued:	**Document #**	**Title**	**Print Name:** Adam Pfitzenmaier
			Responder Signature:
			Date: 24 October 2019

RFI Response Reviewed by DDMI Representative:	**Print Name:** Sarah Greenop
	DDMI Signature:
	Date: October 24, 2019

Diavik Diamond Mines Inc.
REQUEST FOR INFORMATION

RFI NUMBER:	**DDMI-4110-007**
Date Created:	**25/October/2019**

Project: NCRP Closure Construction.	**Area/Location: N.C.R.P**

Originator:	**DDMI**
To:	Tetra Tech Canada Inc
Forwarded to:	**Hongwei Xia, Chantal Pawlychka**

Date response required by:				**Contract Number:**
Priority:	☐ **High**	☒ **Medium**	☐ **Low**	**Number of Pages:** **1 of 1**
Query:	☒ **Technical**	☐ **Contractual**		

A) Instruction Request / Question:

DDMI requests confirmation that the justification used for the proposed reduction in material thickness on the top face of the NCRP is accurate. Please review the attached memo PROJ-008-1019-Proposed North Country Rock Pile Crest Till Thickness Design Modification.

RFI Impact: Cost ☒; Time/Schedule ☒
Remarks:

Drawings Affected:	**Document #**	**Title**	**Print Name: Sarah Greenop**
	1521339-1470-SP-Rev3-7000-NCRP Construction 20FEB_18	**North Country Rock Pile Closure Construction Technical Specifications**	**Originator Signature:**
			Date: October 26, 2019

B) Response:

Tetra Tech understands that DDMI is planning to request a modification to the approved closure cover design of the North Country Rock Pile (NCRP). The current approved closure cover design for the NCRP consists of a 4.5 m cover layer with: 1.5 m of till and 3.0 m of overlying Type I waste rock. DDMI would like to reduce the till cover thickness from 1.5 m to 1.0 m at the top of the NCRP, in areas where till contain high percentage of fines and gravimetric water content (GWC) is greater than 10%. The proposed change would only affect select regions at the top of the NCRP. The till cover thickness on the slopes will remain unaffected (1.5 m).

After discussion with DDMI, Tetra Tech completed an additional thermal modelling to evaluate the proposed modification to the cover design. The additional thermal modelling assumes:
a) the closure cover on the top of the NCRP consists of 1.0 m till with 3.0 m of overlying Type I waste rock;
b) the long-term GWC of till is 10%; and
c) other assumptions have been maintained the same as reported in Tetra Tech's thermal evaluation report (Tetra Tech 2017).

The thermal results demonstrate that the thawing front would be at depths between 3.90 m to 4.00 m after 100 years under the projected mean climate change scenario, which is still within the cover system, but nearly penetrates to Type III rock layer underneath.

Drawings Issued:	**Document #**	**Title**	**Print Name: Hongwei Xia**
			Responder Signature: Hongwei Xia
			Date: November 5, 2019

RFI Response Reviewed by DDMI Representative:	**Print Name:**
	DDMI Signature:
	Date: