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Technical Memorandum

To:	Karyn Lewis, Project Manager Lupin Project Mandalay Resources Corporation, Suite 330, 76 Richmond Street Toronto, ON M5C 1P1	From:	Alvin Tong Stantec Consulting Ltd., 1100 – 111 Dunsmuir Street Vancouver, BC V6B 6A3
File:	Lupin Gold Project - 129500081	Date:	November 14, 2019

Reference: 2 AM-LUP Technical Meeting Commitment Number 6 Response – Geotechnical Review on the Long-Term Stability of TCA Dams

INTRODUCTION

Lupin Mine Incorporated (LMI), a wholly owned subsidiary of Mandalay Resources Corporation is requesting the renewal and amendment of their existing Type "A" Water License No: 2AM-LUP1520, to allow for Final Closure and Reclamation of the Lupin Mine Project (Lupin). The Nunavut Water Board (NWB or Board) Water License Application No. 2AM-LUP1520 Technical Meeting was held June 6-7, 2019 in Kugluktuk, Nunavut. Appendix D of the June 18, 2019 Pre-Hearing Conference Decision Report outlines the agreed upon List of Commitments (Commitments). Stantec Consulting Ltd. (Stantec) was retained by LMI to support the responses to select commitments and this technical memorandum provides the responses to fulfill Commitment No. 6, shown below, which relates to conducting a geotechnical stability review of the Tailings Containment Area (TCA) dams to ensure long term stability and erosion control.

6	LMI	CIRNAC	Geotechnical details of engineered structures (e.g. which dams will the rip-rap material be taken from to change slope and which dams will be enhanced, cross sections and details) to ensure long term stability and erosion control.	15-Nov-19	Technical Schematics

This memorandum presents the design basis, stability analyses results, and recommendations to satisfy long term stability and erosion control for all the dams at Lupin.

DESIGN BASIS AND CRITERIA

As-built configurations were generated using 2019 bathymetry and surface survey data. The analyses focus on long-term loading conditions which is appropriate for closure design. Permafrost was assumed to remain at its current level and the remaining cover in Cell 3 and 5 is assumed to be completed. Closure water levels are as follows (if not listed, the area will be dry for closure):

- Pond 1 at 480 meters above sea level (masl),
- Pond 2 at 481 masl, and
- Cell 4 at 485 masl.

Factor of Safety (FOS) criteria are based on Canadian dam safety guidelines for mining dams (CDA, 2014) and are presented in Table 1.

Reference: **2 AM-LUP Technical Meeting Commitment Number 6 Response – Geotechnical Review on the Long-Term Stability of TCA Dams**

Table 1: Summary of Stability Criteria

Failure Mode	Condition	Factor of Safety (Limit-Equilibrium)
Local	Static	1.3
Global		1.5
Global	Seismic	1.1

Two stability scenarios have been considered for all dams:

1. As-built Scenario (Where permafrost is present at a 2m depth below ground surface).
2. Seismic Condition (PGA of 0.05g at a probability of 2%/50 years, based on the Natural Resources of Canada 2015 Seismic hazard map (NRC 2015)) with a 50% reduction using the Hynes-Griffin method (Hynes-Griffin, 1984).

The assessment also considers local and global stability failure modes. Local failure consists of shallow failure that would not release tailings, such as sloughing, of minimum 1m thickness. The global failure mode considers a deep, large rotational failure that could result in a dam breach and uncontrolled release of stored water and tailings.

STABILITY ANALYSES

Slope stability analyses have been completed for the closure condition of the Lupin dams. The dam cross-sections are based on the historical design sections presented in the dam safety review report (SRK, 2016). A plan view with cross-section locations is shown on Figure 1. Material properties used in the analyses are based on previous work experience with similar materials and are presented in Table 2. The analyses have been completed using the limit equilibrium software, SLOPE-W, from GeoStudio 2018 (Version 9.0.4). The FOS values were calculated using the Spencer method in SLOPE/W.

Reference: **2 AM-LUP Technical Meeting Commitment Number 6 Response – Geotechnical Review on the Long-Term Stability of TCA Dams**

Figure 1: Tailings Containment Area Stability Section Locations

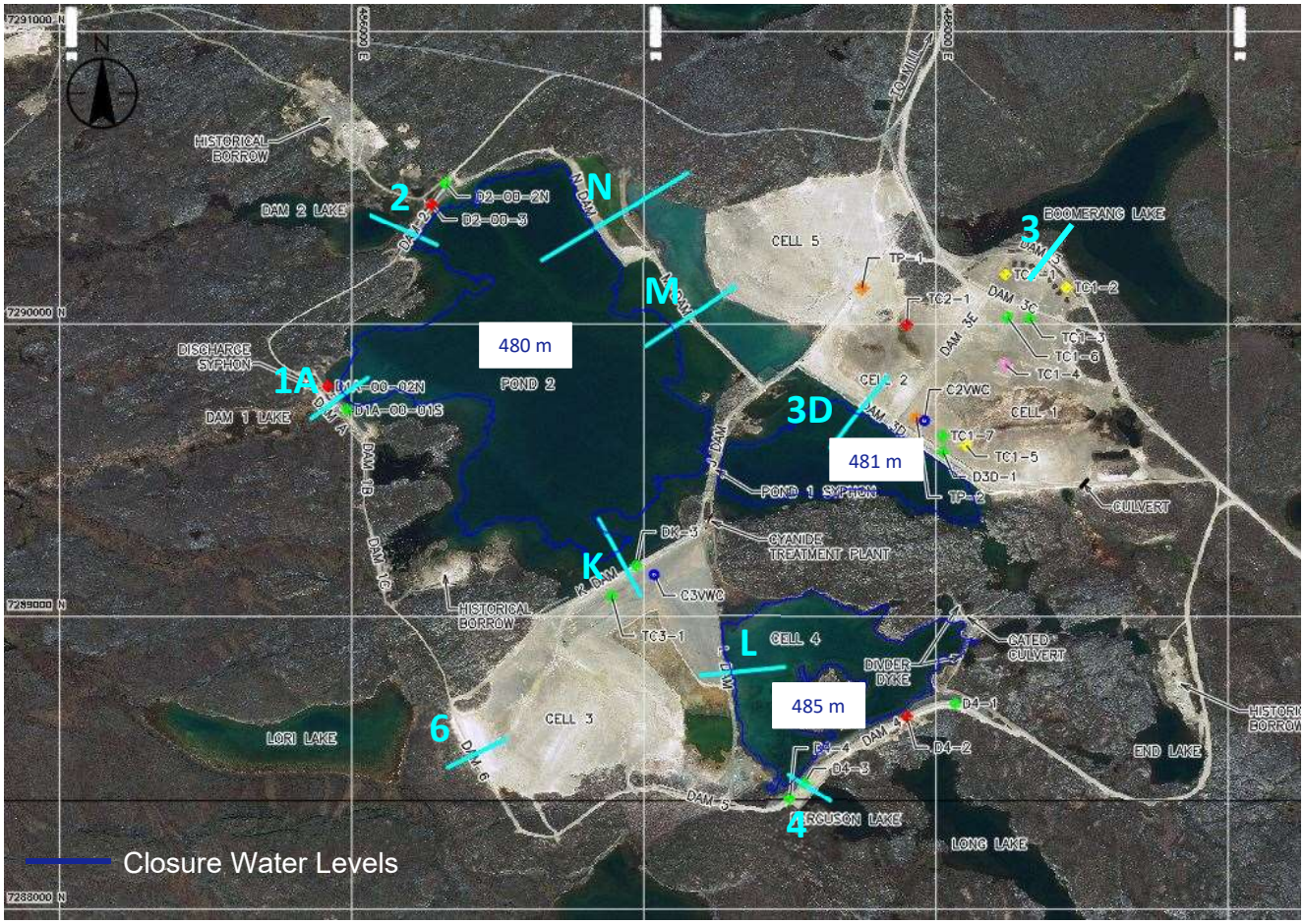

Table 2: Material Properties

Material	Unit Weight (kN/m^3)	Effective Stress Parameters
Esker (dam and cover fill)	30	c' = 0, φ' = 35°
Gravelly Sand	30	c' = 0, φ' = 35°
Rockfill	20	c' = 0, φ' = 39°
Tailings (Drained)	18	c' = 0, φ' = 30°
Tailings (Undrained)	18	Minimum strength: 20 kPa, Su/σ'v = 0.24
Till	18	c' = 0, φ' = 30°
Bedrock	Impenetrable	
Permafrost	Impenetrable	

Reference: **2 AM-LUP Technical Meeting Commitment Number 6 Response – Geotechnical Review on the Long-Term Stability of TCA Dams**

A summary of FOS results for each scenario is presented in Table 3 and the SLOPE/W outputs are attached in Appendix A. If the as-built condition does not satisfy the stability criteria, the dam(s) will be re-sloped to meet the criteria.

Table 3: Summary of Stability Analyses Results

Cross-section	Configuration	Scenario		
		Static		Seismic
		Local	Global	Global
2	As-built	1.3	2.6	2.3
3	As-built	4.0	8.3	6.2
3D	As-built	1.3	3.7	3.3
4	As-built	2.9	3.3	2.9
6	As-built	1.3	2.4	2.4
1A	As-built	2.6	3.6	3.5
K	As-built	0.8*	1.8	1.5
	Re-sloped	1.3	1.8	1.6
L	As-built	1.6	2.1	1.9
M	As-built	1.0*	3.0	2.6
	Re-sloped	1.3	3.1	2.7
N	As-built	1.6	2.6	2.5
FOS Acceptance Criteria		≥ 1.3	≥ 1.5	≥ 1.1

*FOS value does not meet design criteria for as-built configuration, repair and re-sloping is required for closure.

Results in Table 3 show that the existing as-built dams meet the target FOS criteria except for dams M and K. Modifications to these dams are required and details are discussed below.

STABILITY CONCLUSIONS

Most of the Lupin dams (2, 3, 3D, 4, 6, 1A, L and N) meet target closure FOS criteria in their current as-built conditions. Dams M and K require re-sloping to satisfy acceptable FOS criteria, as follows:

- Dam M: re-slope to 2.1H:1V;
- Dam K: re-slope to 2.1H:1V

Once dams M and K have been re-sloped as listed above, all of the Lupin dams will satisfy the design closure criteria and will be performing as licensed.

Reference: **2 AM-LUP Technical Meeting Commitment Number 6 Response – Geotechnical Review on the Long-Term Stability of TCA Dams**

SURFACE WATER MANAGEMENT

As part of the final closure and reclamation plan (FCRP), surface water management will be incorporated into the Cell 3 and 5 tailings cover to manage long term erosion potential. It is recognized that the existing topographies of the Cell 3 and 5 covers would have surface water flow over the dams that could cause erosion. The FCRP would incorporate surface water management into the to-be-constructed cover to minimize potential erosion of the dams. The to-be constructed tailings covers will be engineered and contoured to allow surface water to flow passively away from the face of the dam and into an engineered outflow structure. Both Cell 1 and 2 do not have significant gradient toward the dams and additional cover regrading is not required based on current information available. The design criteria for the surface water management on the covers are shown in Table 4.

Table 4: Surface Water Management Design Criteria

Parameter	Value
Design Event	1 in 100-year
Design maximum flow	0.8 m^3/s
Design maximum velocity	1.9 m/s
Cover maximum grade	0.5%
Outflow channel side slopes	Min. 3H:1V
Outflow channel bottom	5m
Outflow channel maximum grade	10%
Outflow channel armoring size	D_{50} = 0.26m

The Cell 3 engineered cover design is shown on Figure 2 and Cell 5 engineered cover design is shown on Figure 3. These should mitigate long term erosion potential over the dam face.

Stantec Consulting Ltd.

Alvin Tong P. Eng.
Senior Geotechnical Engineer

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alvin.tong@stantec.com

Attachment: Figure 2 – Cell 3 Engineered Cover Design
Figure 3 – Cell 5 Engineered Cover Design
Appendix A – Stability Analyses Results

c.

Reference: 2 AM-LUP Technical Meeting Commitment Number 6 Response – Geotechnical Review on the Long-Term Stability of TCA Dams

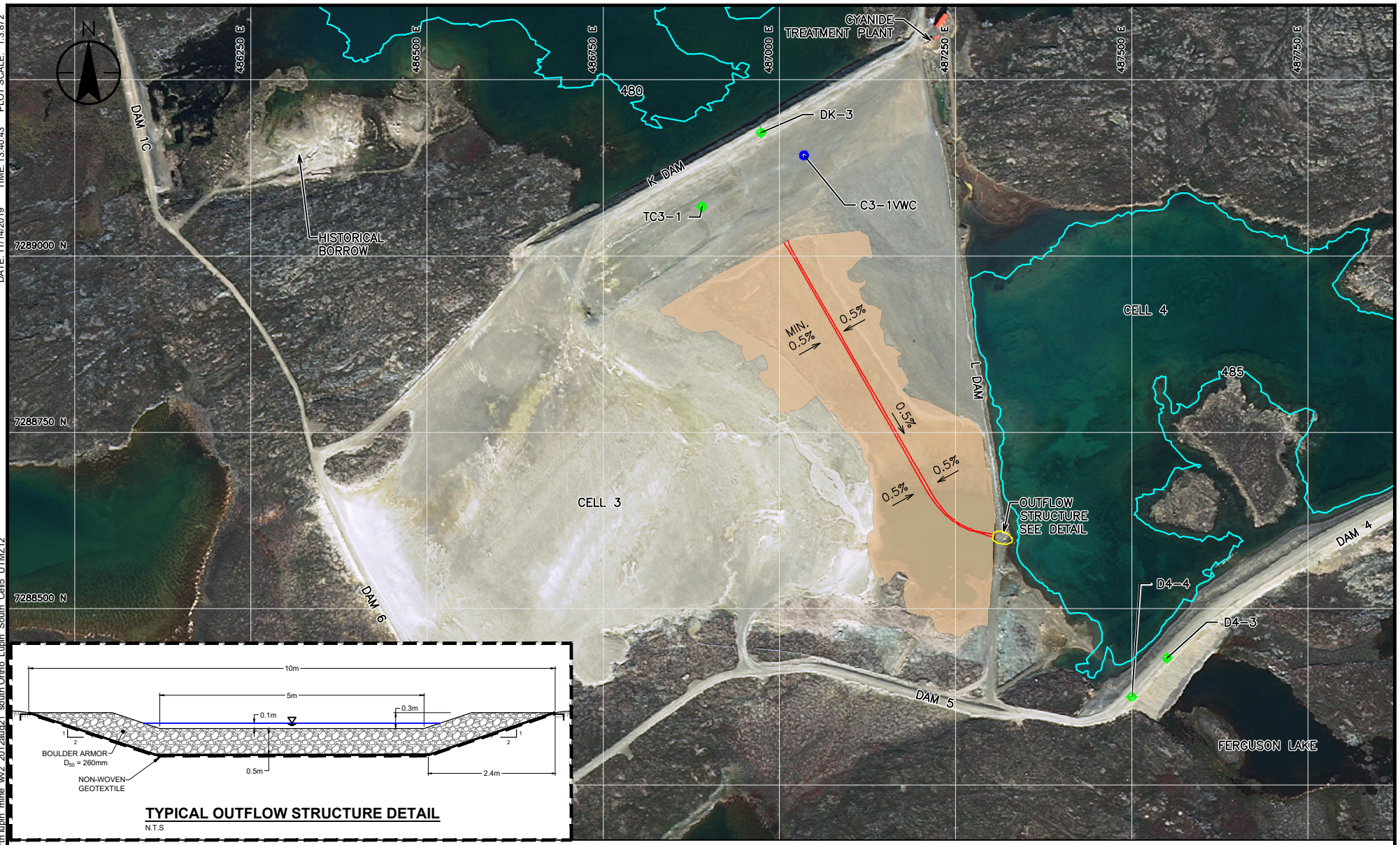
References

CDA, 2014. Canadian Dam Association Publication, Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams.

Hynes-Griffin, 1984. Rationalizing the Seismic Coefficient Method, Department of the Army, Waterways Experiment Station, Corps of Engineers, 1984.

SRK 2016. Lupin Mine Tailings Management Facility, 2015 Dam Safety Review: Final Draft Report submitted to Lupin Mine Inc., 2016

Natural Resources of Canada, 2015. Natural Resources of Canada, PGA Seismic hazard map #10 (of 11)



TYPICAL OUTFLOW STRUCTURE DETAIL
N.T.S

LEGEND

THERMISTORS STATUS

- ACTIVELY MONITORED
- DAMAGED
- MONITORED DURING DSR-NO CALIBRATION DATA
- UNLOCATED-LOCATION ESTIMATED FROM HISTORICAL MAP
- VOLUMETRIC WATER CONTENT SENSOR STRINGS
- TEST PITS
- SHALLOW SURFACE CHANNEL
- NEW TAILINGS COVER
- SURFACE WATER LEVEL

100m 50 0 100 200 300 400 500m

SCALE 1:7500

SCALES INDICATED BASED ON AN 8.5"x11" PLOT CONFIGURATION

LUPIN MINES INC.

PHC COMMENTS RESPONSE

SCALE:	AS SHOWN
DATE:	2019-11-14
CO-ORD. SYS.:	UTM83-12
DRW'N BY:	JL
DSG'N BY:	LK
REV'D BY:	AT
APP'D BY:	PK

TAILINGS CONTAINMENT AREA
CELL 3 COVER AND SURFACE
WATER MANAGEMENT

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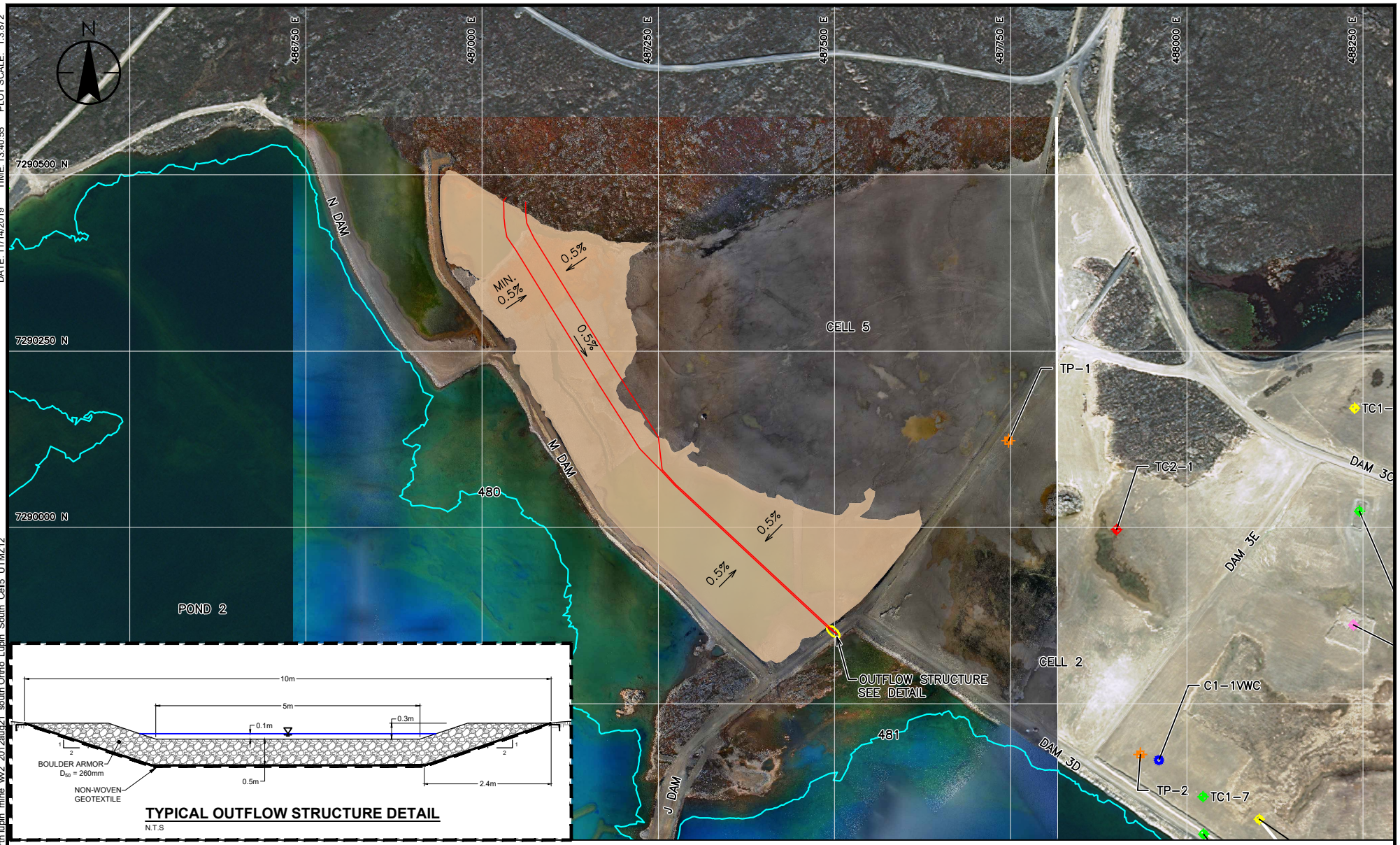
PROJECT NO.:	FIG. NO.:	REV.:
129500081	2	A



LEGEND

THERMISTORS STATUS

- ACTIVELY MONITORED
- DAMAGED
- MONITORED DURING DSR-NO CALIBRATION DATA
- UNLOCATED-LOCATION ESTIMATED FROM HISTORICAL MAP
- VOLUMETRIC WATER CONTENT SENSOR STRINGS
- TEST PITS
- SHALLOW SURFACE CHANNEL
- NEW TAILINGS COVER
- SURFACE WATER LEVEL

100m 50 0 100 200 300 400 500m

SCALE 1:7500

SCALES INDICATED BASED ON AN 8.5"x11" PLOT CONFIGURATION

LUPIN MINES INC.

PHC COMMENTS RESPONSE

SCALE:	AS SHOWN
DATE:	2019-11-14
CO-ORD. SYS.:	UTM83-12
DRW'N BY:	JL
DSG'N BY:	LK
REV'D BY:	AT
APP'D BY:	PK

TAILINGS CONTAINMENT AREA
CELL 5 COVER AND SURFACE
WATER MANAGEMENT

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PROJECT NO.:	FIG. NO.:	REV.:
129500081	3	A

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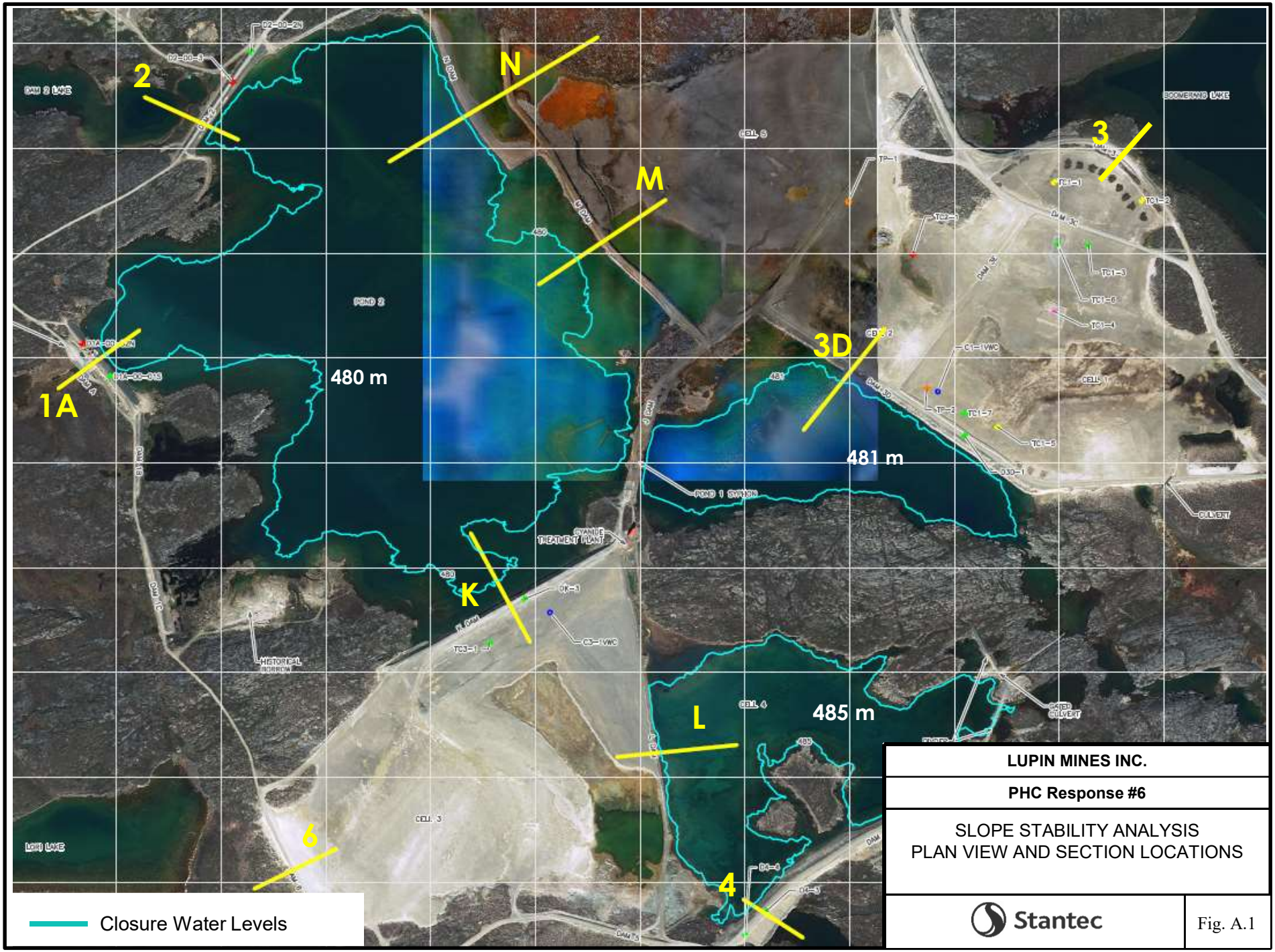
XREF FILE(S): 190924 Topo_cell 3 FIXED 0.5m contours; 03 Merge Design contours 1.0
IMAGE FILE(S): lupin_mine_wv2_2012aug21_north lupin_mine_wv2_2012aug21_south Ortho Lupin South Cell5 UTMZ12
DATE: 11/14/2019 TIME: 13:40:55 PLOT SCALE: 1:3.872

Appendix A

Lupin Mines Inc.
PHC Response #6
Tailings Containment Area

Slope Stability Analysis
(Rev 0)

November 13, 2019



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SLOPE STABILITY ANALYSIS
PLAN VIEW AND SECTION LOCATIONS

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Fig. A.1

Fig. A1	Plan View Section Locations
Fig. A2	List of Analyses
Fig. A3	Section 2 – Permafrost Conditions, Static Case - Local Failure
Fig. A4	Section 2 - Permafrost Conditions, Static Case - Global Failure
Fig. A5	Section 2 - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A6	Section 3 - Permafrost Conditions, Static Case - Local Failure
Fig. A7	Section 3 - Permafrost Conditions, Static Case - Global Failure
Fig. A8	Section 3 - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A9	Section 3D - Permafrost Conditions, Static Case - Local Failure
Fig. A10	Section 3D - Permafrost Conditions, Static Case - Global Failure
Fig. A11	Section 3D - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A12	Section 4 - Permafrost Conditions, Static Case - Local Failure
Fig. A13	Section 4 - Permafrost Conditions, Static Case - Global Failure
Fig. A14	Section 4 - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A15	Section 6 - Permafrost Conditions, Static Case - Local Failure
Fig. A16	Section 6 - Permafrost Conditions, Static Case - Global Failure
Fig. A17	Section 6 - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A18	Section 1A - Permafrost Conditions, Static Case - Local Failure
Fig. A19	Section 1A - Permafrost Conditions, Static Case - Global Failure
Fig. A20	Section 1A - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A21	Section K - Permafrost Conditions, Static Case - Local Failure
Fig. A22	Section K - Permafrost Conditions, Static Case - Global Failure
Fig. A23	Section K - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A24	Section L - Permafrost Conditions, Static Case - Local Failure
Fig. A25	Section L - Permafrost Conditions, Static Case - Global Failure
Fig. A26	Section L - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A27	Section M - Permafrost Conditions, Static Case - Local Failure
Fig. A28	Section M - Permafrost Conditions, Static Case - Global Failure
Fig. A29	Section M - Permafrost Conditions, Pseudo-Static - Global Failure
Fig. A30	Section N - Permafrost Conditions, Static Case - Local Failure
Fig. A31	Section N - Permafrost Conditions, Static Case - Global Failure
Fig. A32	Section N - Permafrost Conditions, Pseudo-Static - Global Failure

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SLOPE STABILITY ANALYSIS
LIST OF ANALYSES

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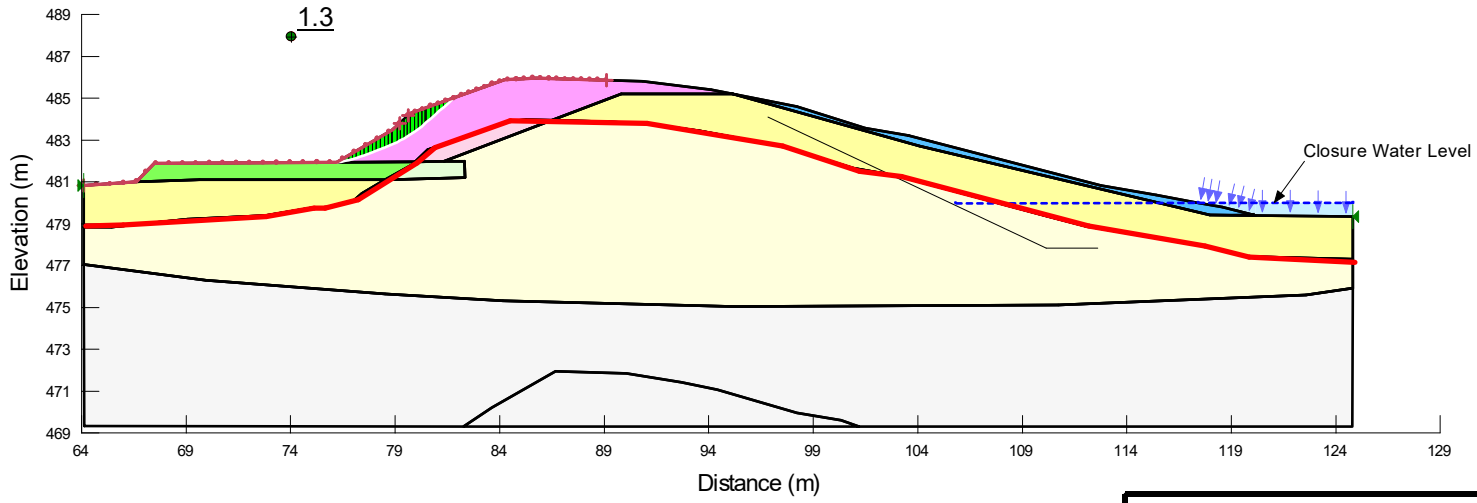
Fig. A.2

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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SLOPE STABILITY ANALYSIS
SECTION 2 – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

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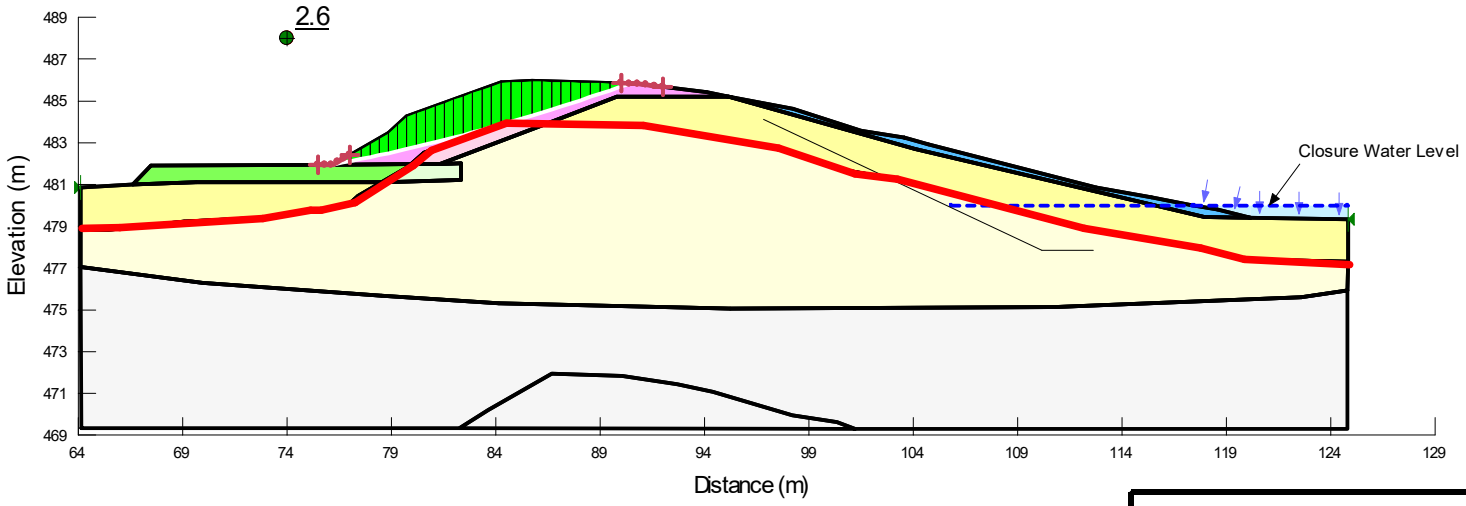
Fig. A.3

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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SLOPE STABILITY ANALYSIS
SECTION 2 – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

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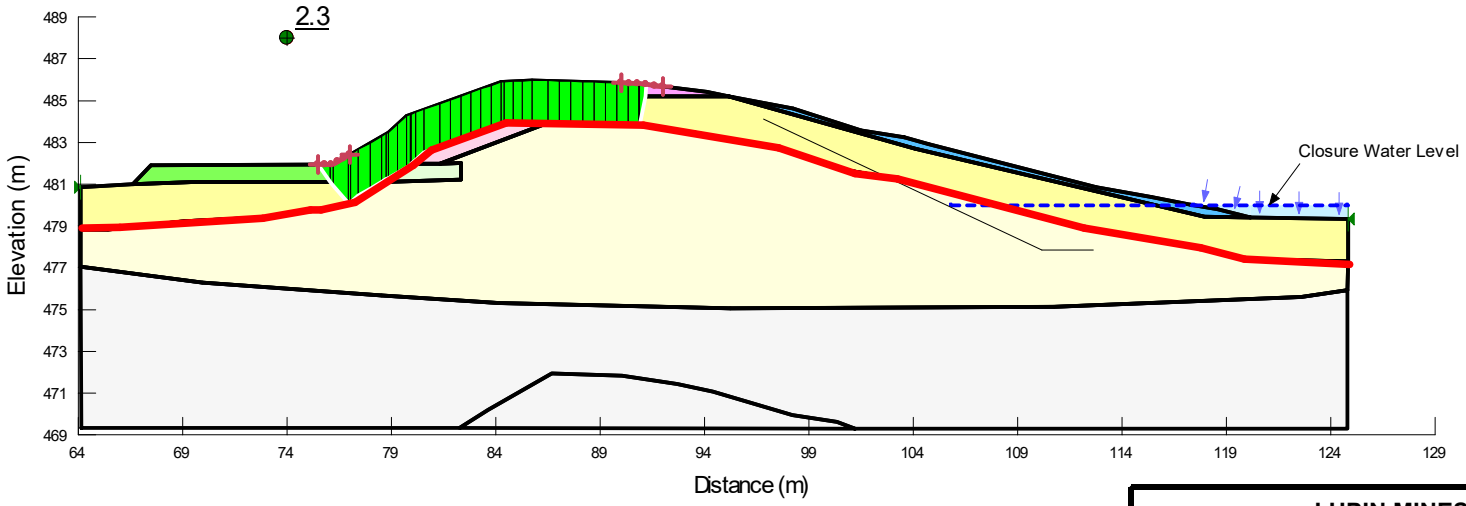
Fig. A.4

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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SLOPE STABILITY ANALYSIS
SECTION 2 – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

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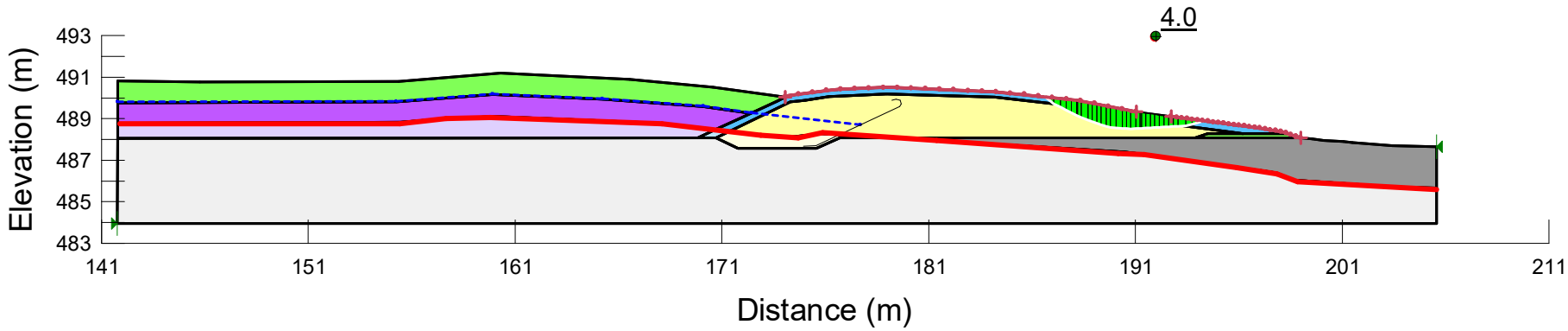
Fig. A.5

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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SLOPE STABILITY ANALYSIS
SECTION 3 – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

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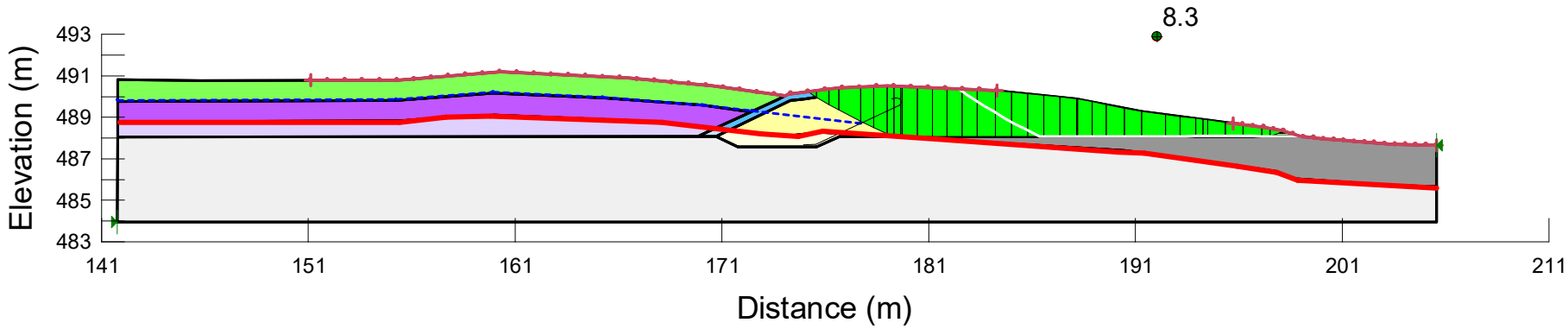
Fig. A.6

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 3 – PERMAFROST CONDITIONS
STATIC CASE – GLOBAL FAILURE

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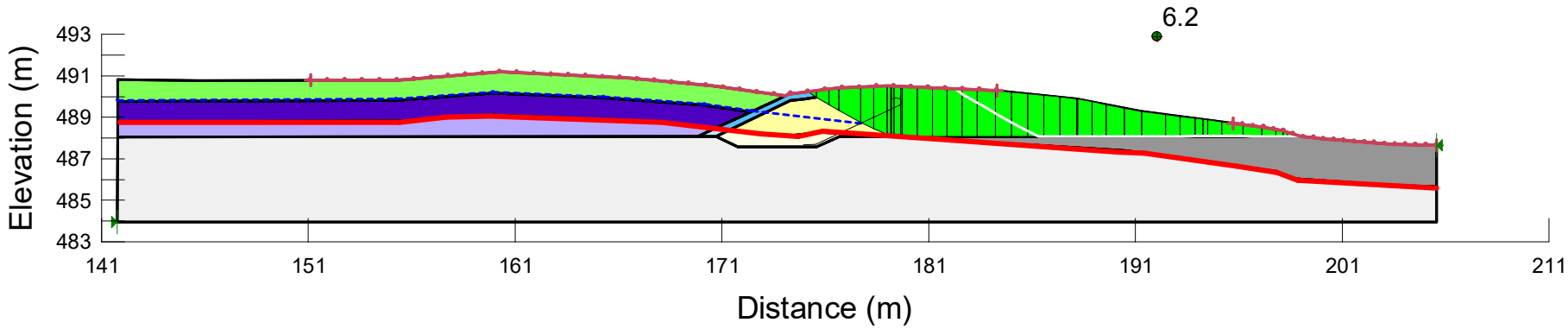
Fig. A.7

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 3 – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

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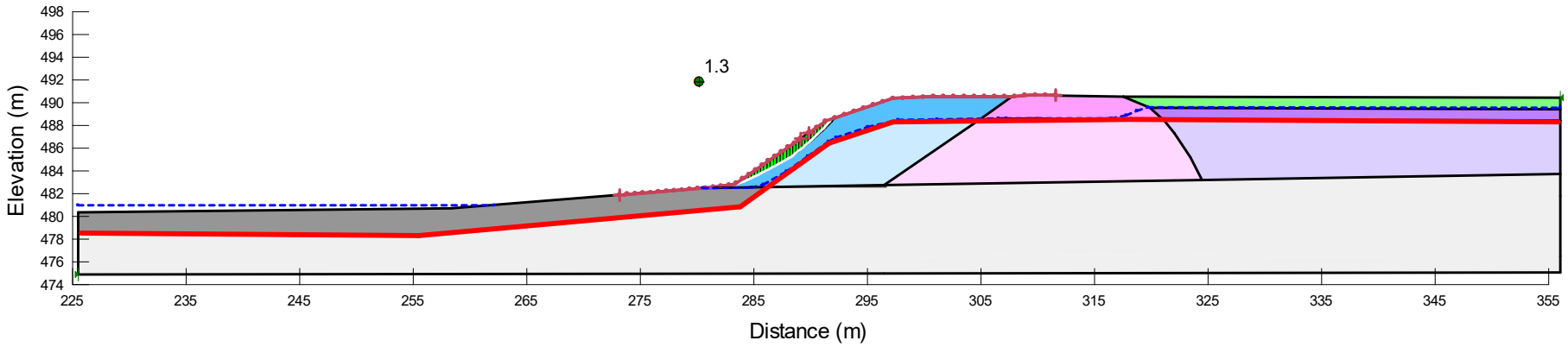
Fig. A.8

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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SLOPE STABILITY ANALYSIS
SECTION 3D – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

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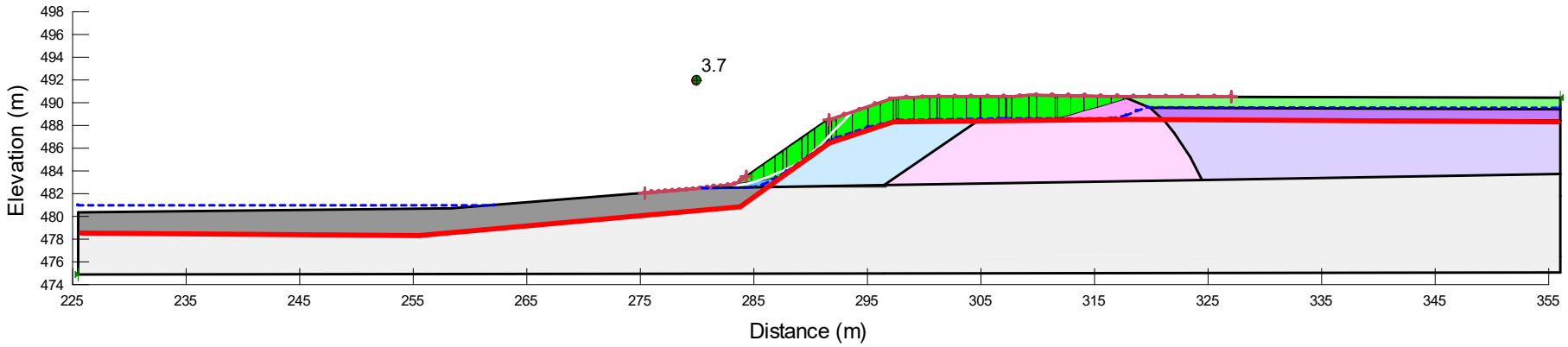
Fig. A.9

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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SLOPE STABILITY ANALYSIS
SECTION 3D – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

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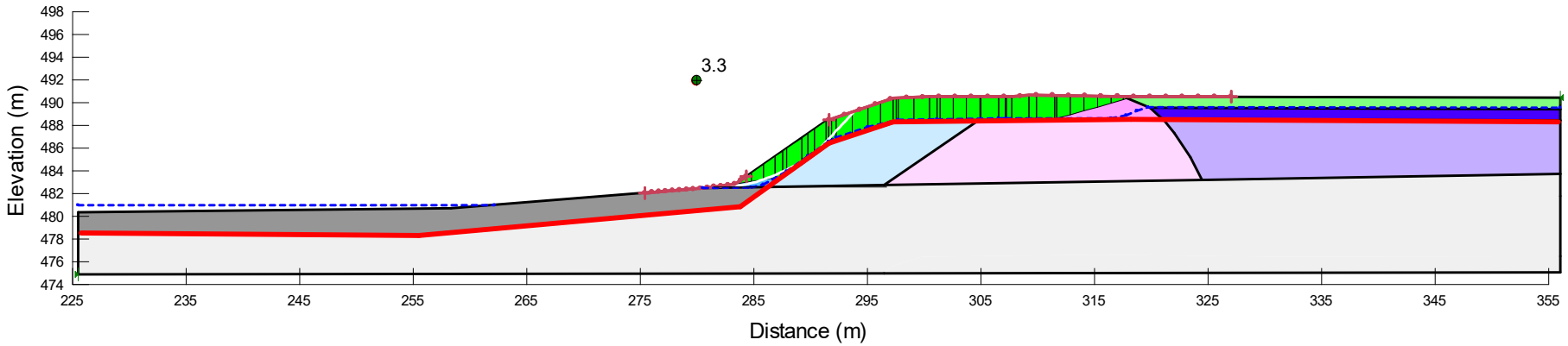
Fig. A.10

Details:

Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:

1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 3D – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

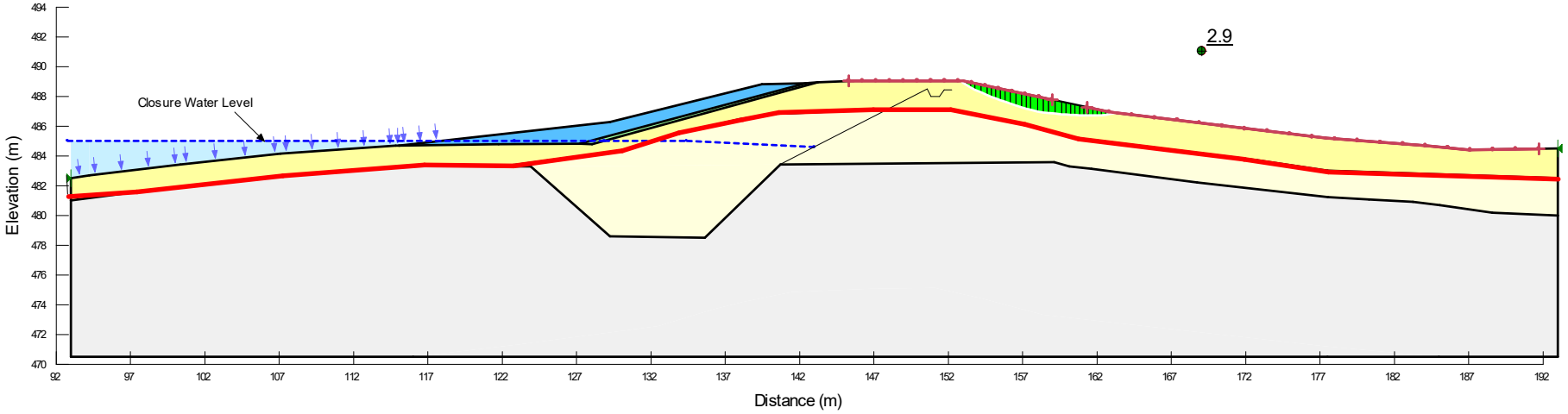
Stantec

Fig. A.11

Details:

Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:

1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 4 – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

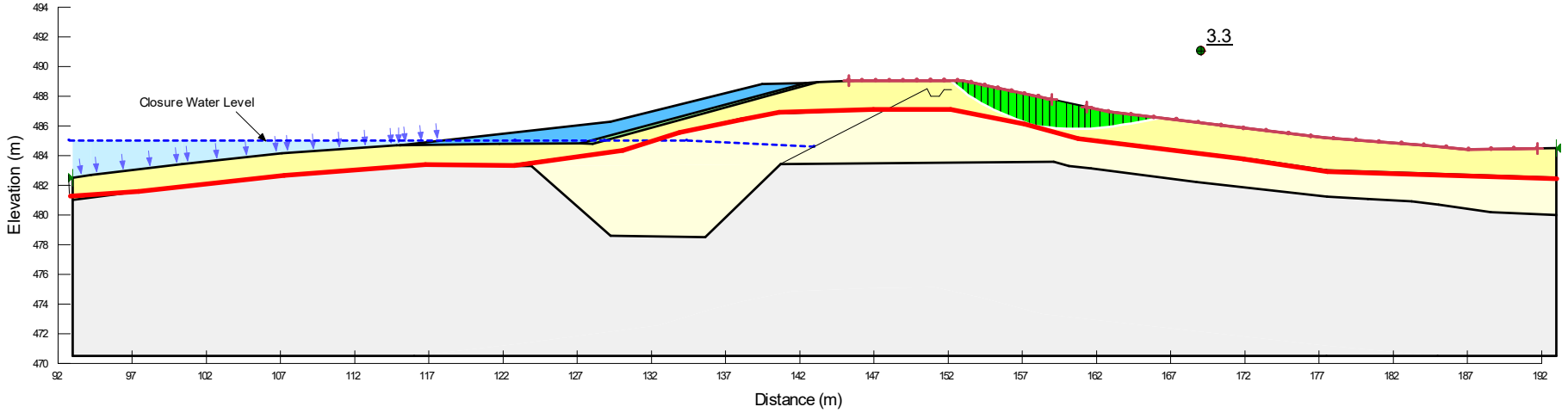
Stantec

Fig. A.12

Details:

Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:

1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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2019 DAM SAFETY REVIEW

SLOPE STABILITY ANALYSIS
SECTION 4 – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

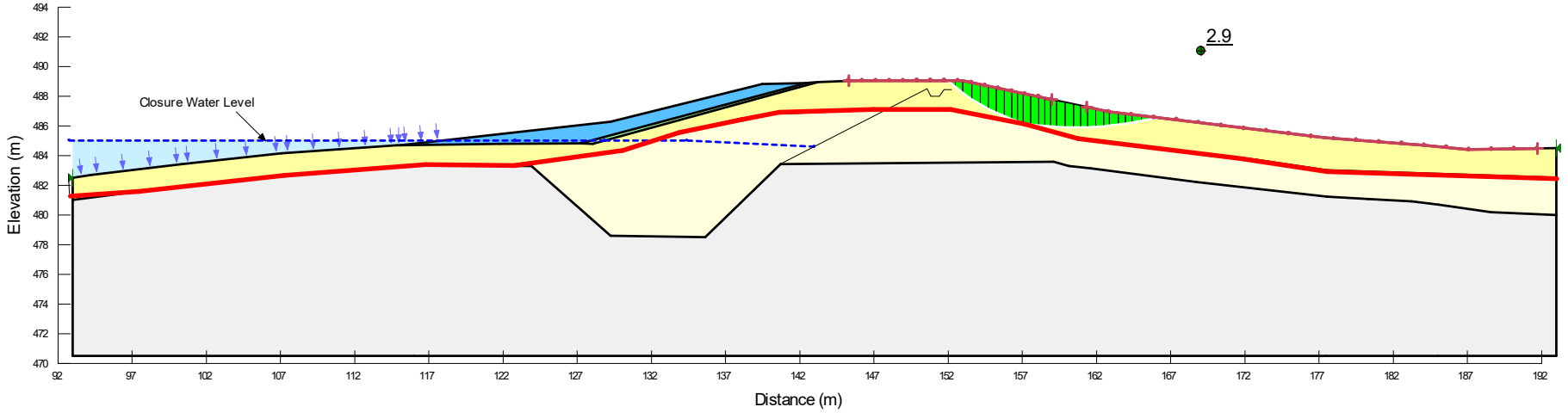
Stantec

Fig. A.13

Details:

Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:

1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

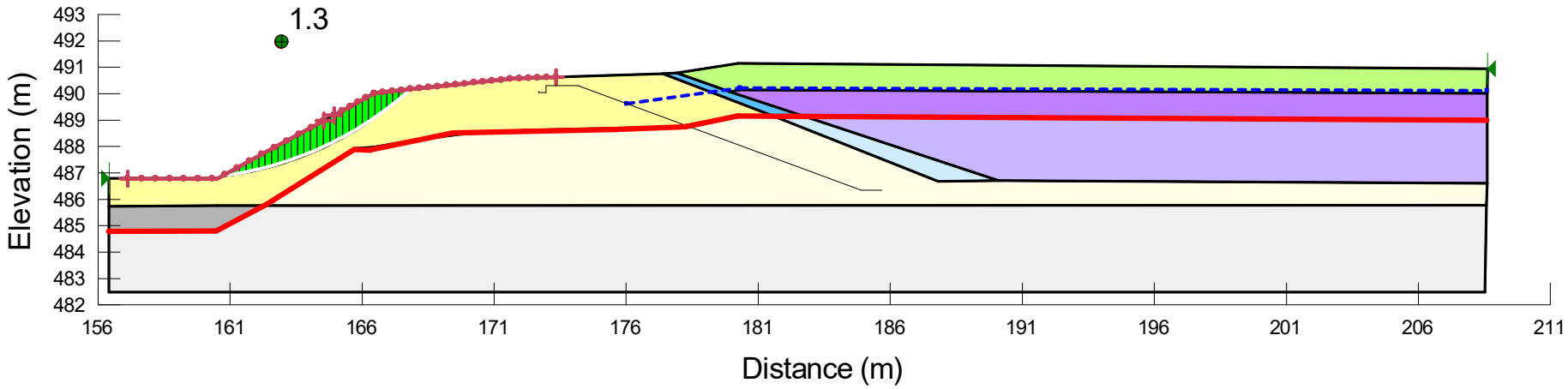
SLOPE STABILITY ANALYSIS
SECTION 4 – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

Stantec

Fig. A.14

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

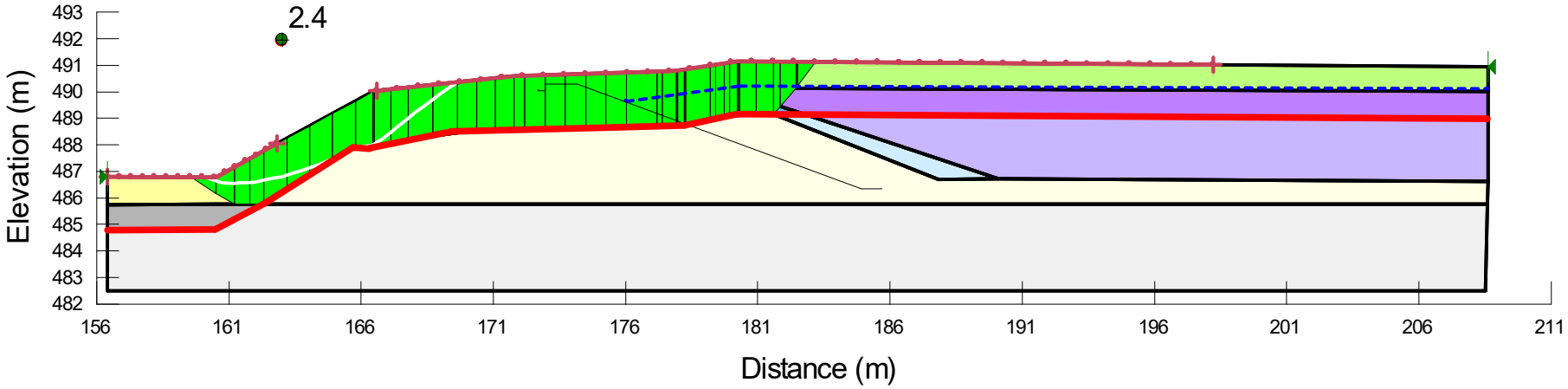
SLOPE STABILITY ANALYSIS
SECTION 6 – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

Stantec

Fig. A.15

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

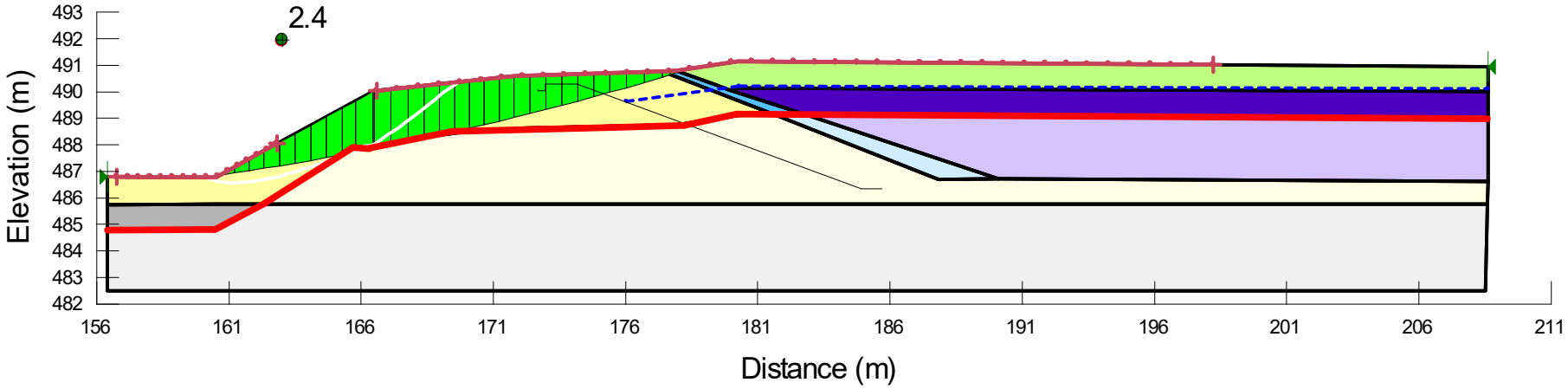
SLOPE STABILITY ANALYSIS
SECTION 6 – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

Stantec

Fig. A.16

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 6 – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

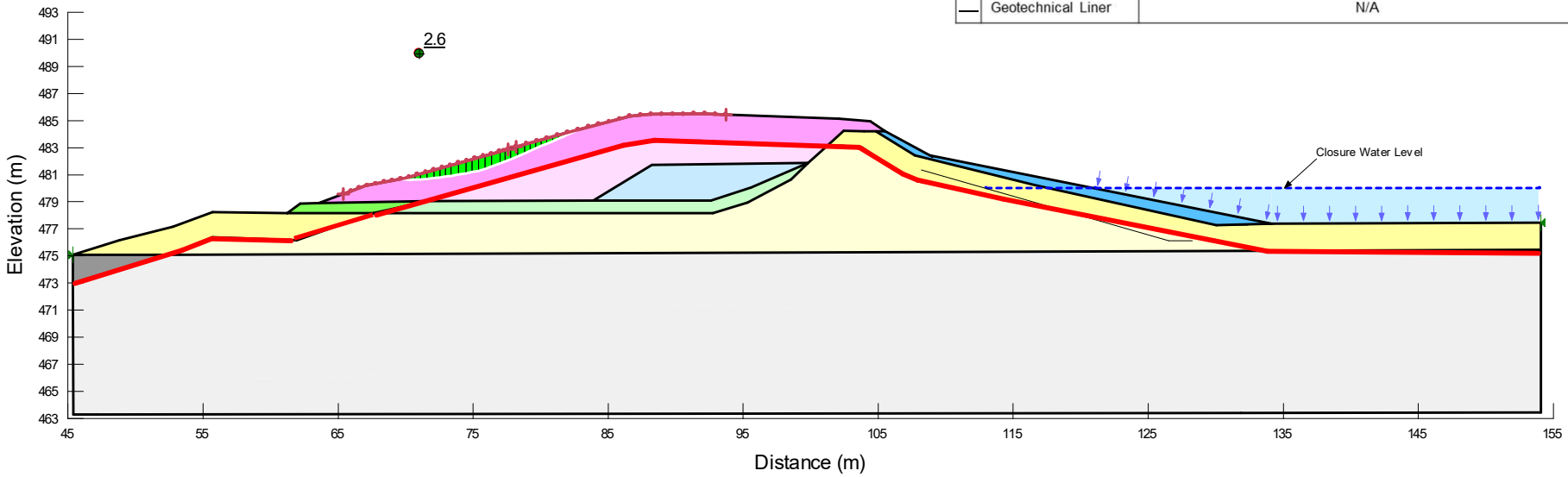
Stantec

Fig. A.17

Details:

Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:

1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 1A – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

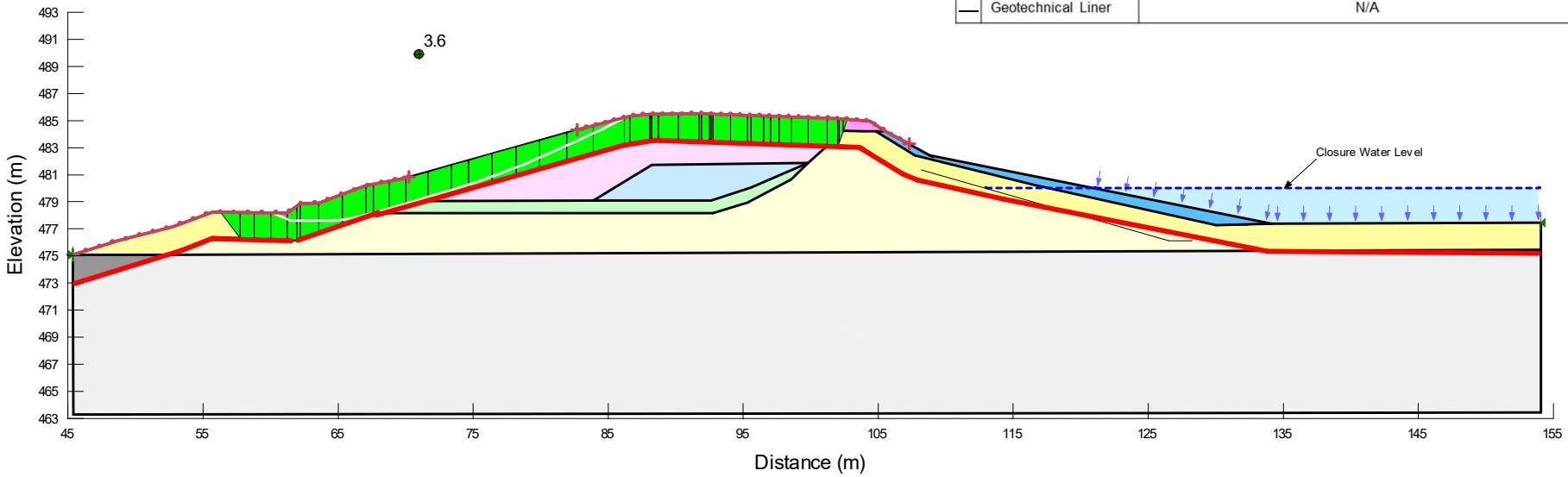
Stantec

Fig. A.18

Details:

Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:

1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 1A – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

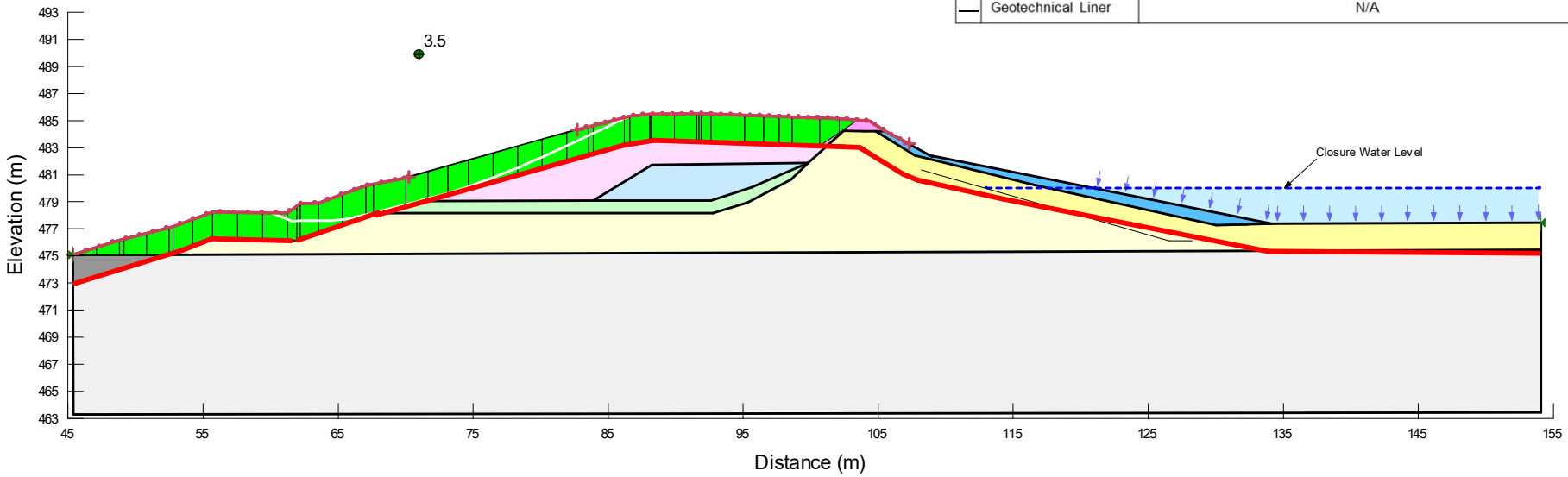
Stantec

Fig. A.19

Details:

Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:

1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION 1A – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

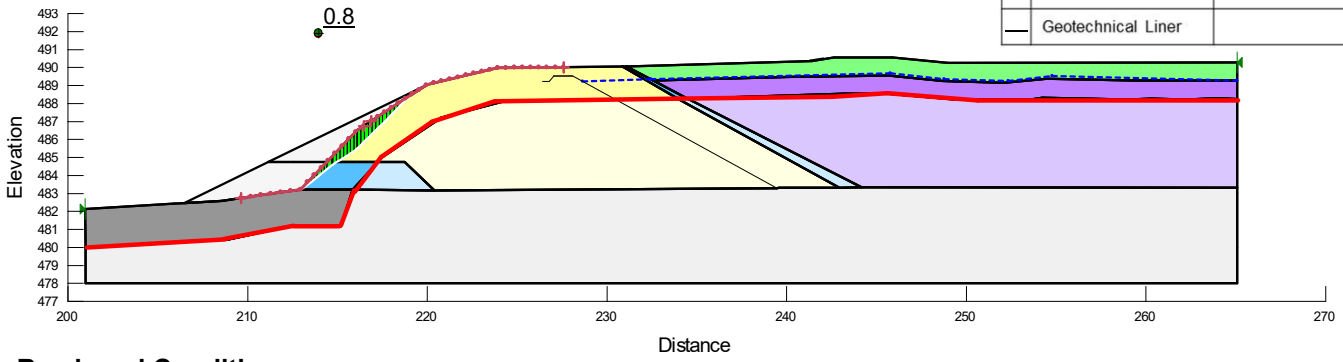
Stantec

Fig. A.20

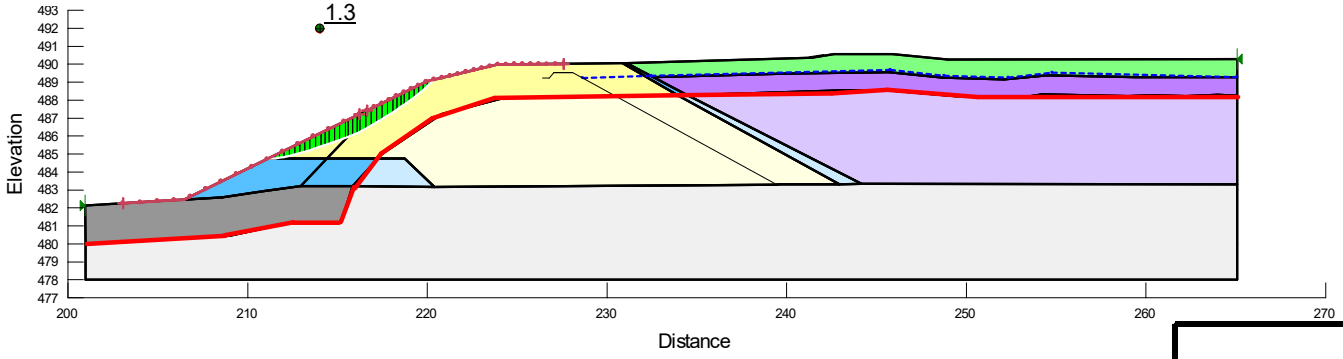
Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface
Re-sloped Conditions: regraded to 2H:1V to reach minimum FOS criteria

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				

As Built Conditions



Re-sloped Conditions



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION K – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

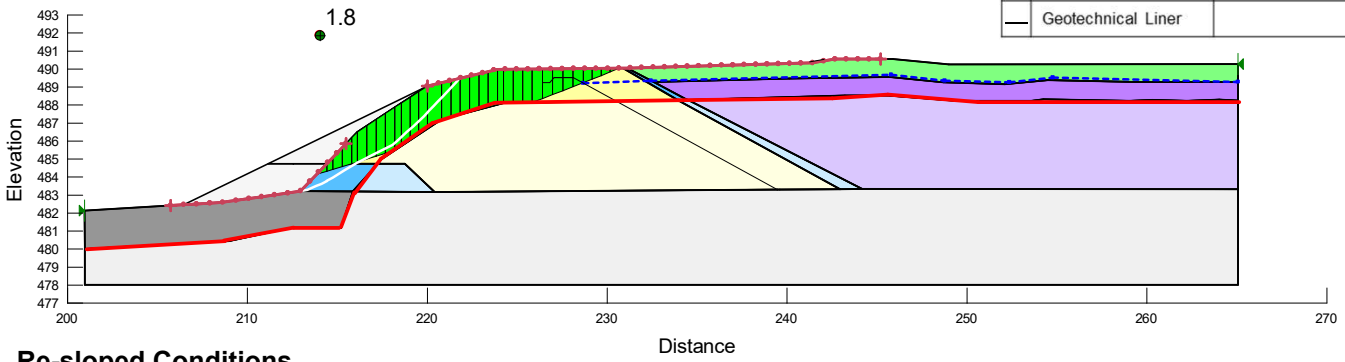
Stantec

Fig. A.21

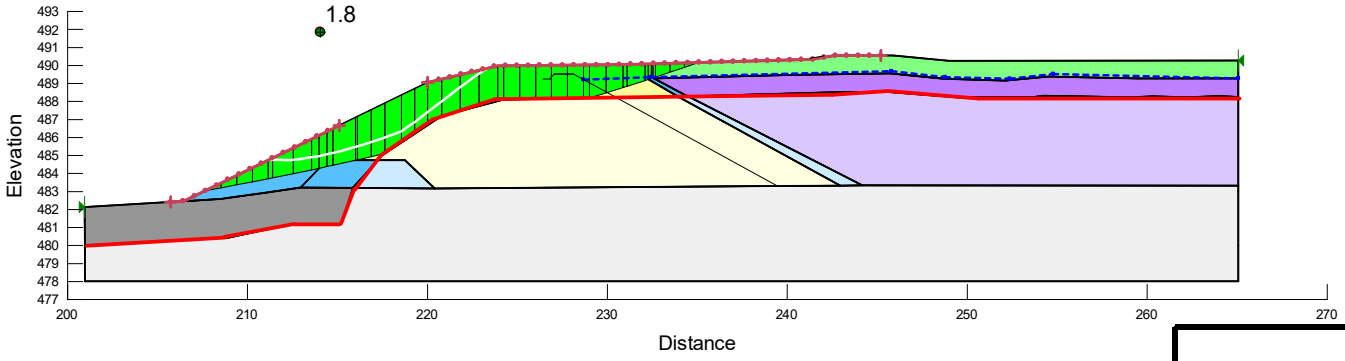
Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface
Re-sloped Conditions: regraded to 2H:1V to reach minimum FOS criteria

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				

As Built Conditions



Re-sloped Conditions



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION K – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

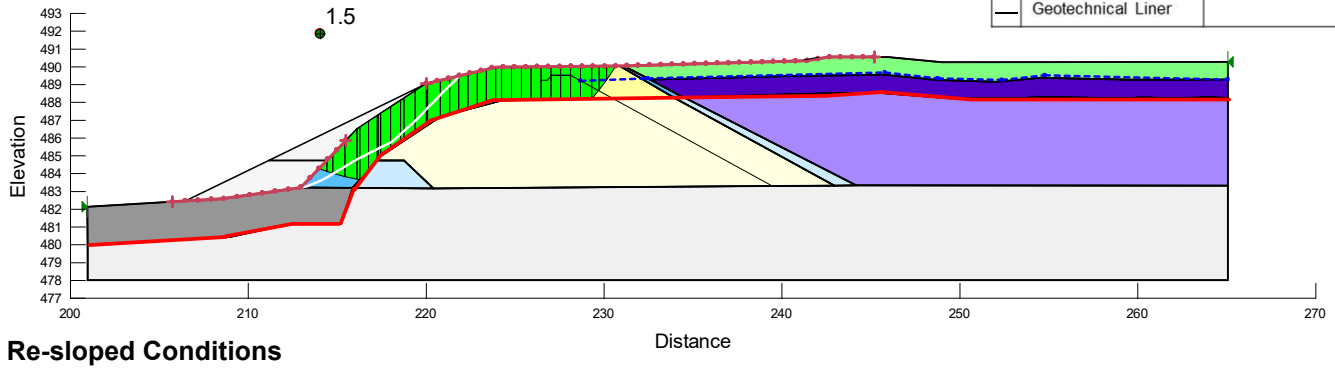
Stantec

Fig. A.22

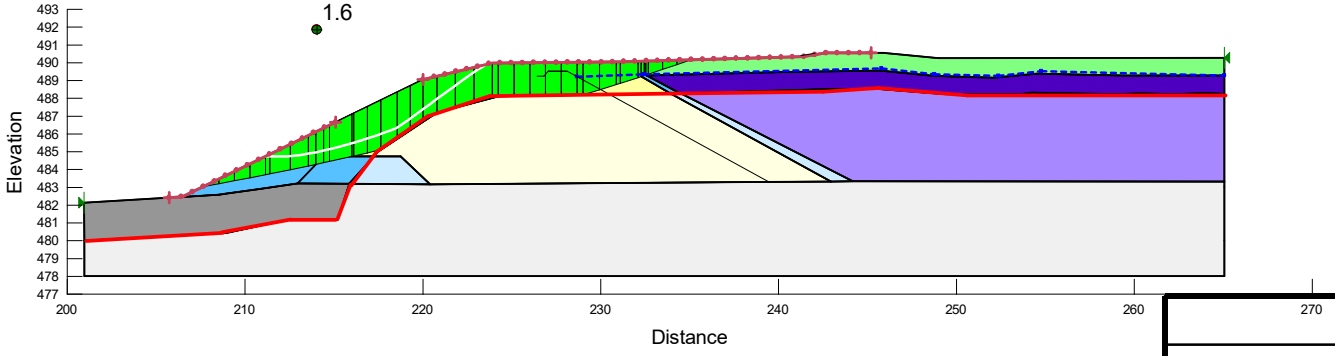
Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface
Re-sloped Conditions: regraded to 2H:1V to reach minimum FOS criteria

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				

As Built Conditions



Re-sloped Conditions



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

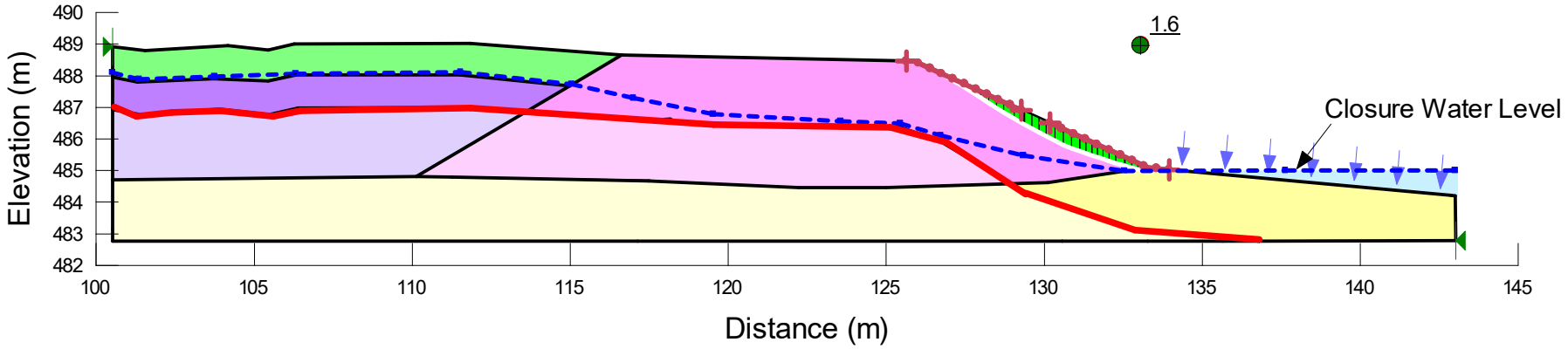
SLOPE STABILITY ANALYSIS
SECTION K – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

Stantec

Fig. A.23

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

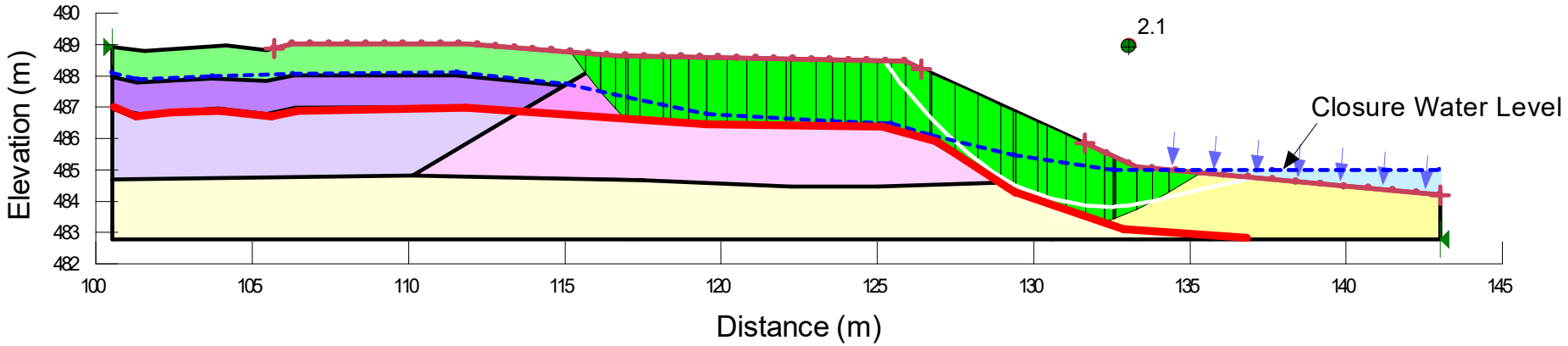
SLOPE STABILITY ANALYSIS
SECTION L – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

Stantec

Fig. A.24

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

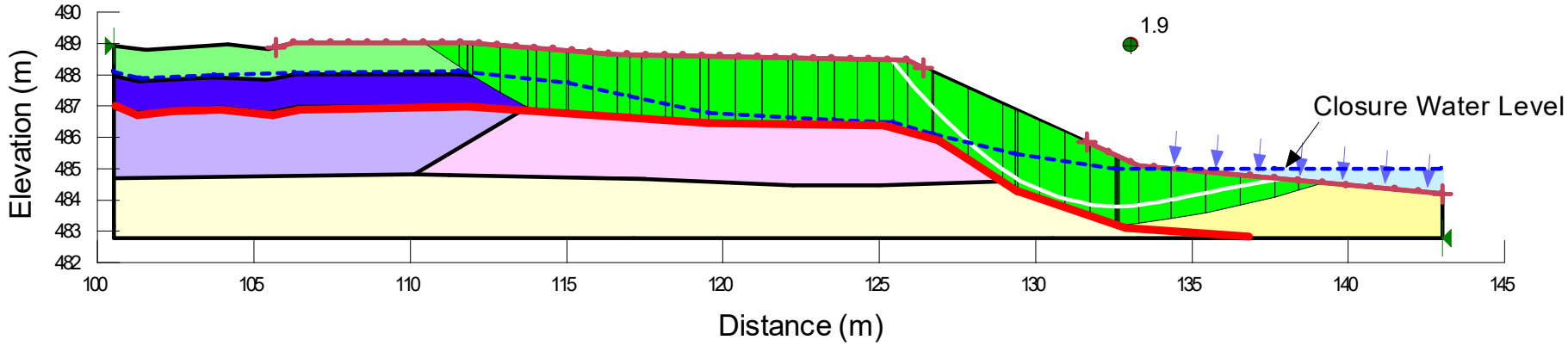
SLOPE STABILITY ANALYSIS
SECTION L – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

Stantec

Fig. A.25

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

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PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION L – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

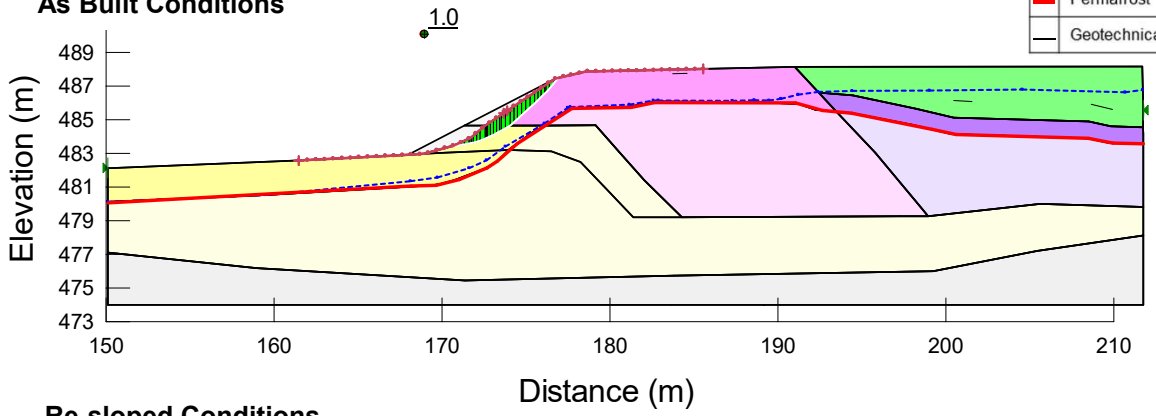
Stantec

Fig. A.26

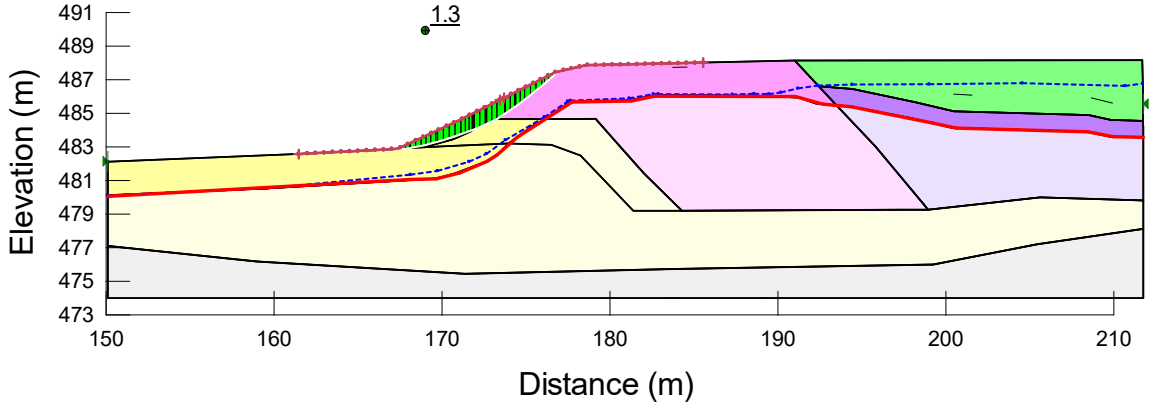
Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface
Re-sloped Conditions: regraded to 2H:1V to reach minimum FOS criteria

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				

As Built Conditions



Re-sloped Conditions



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION M – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

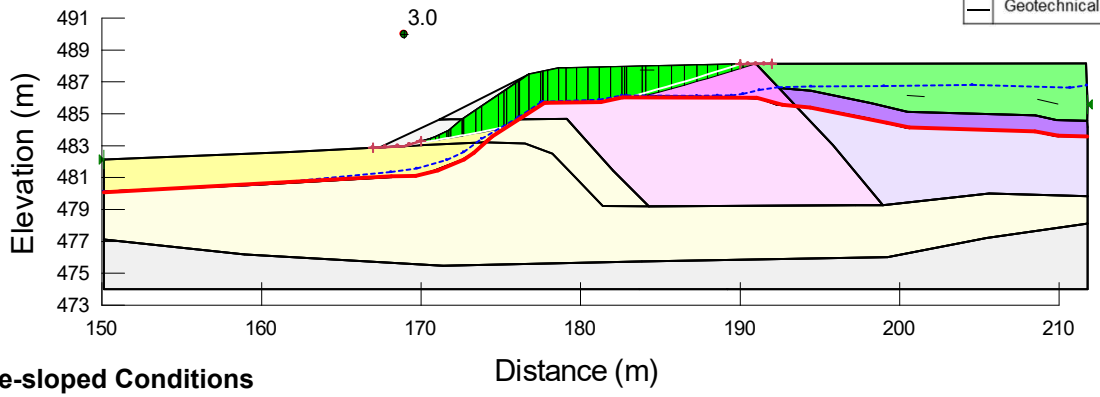
Stantec

Fig. A.27

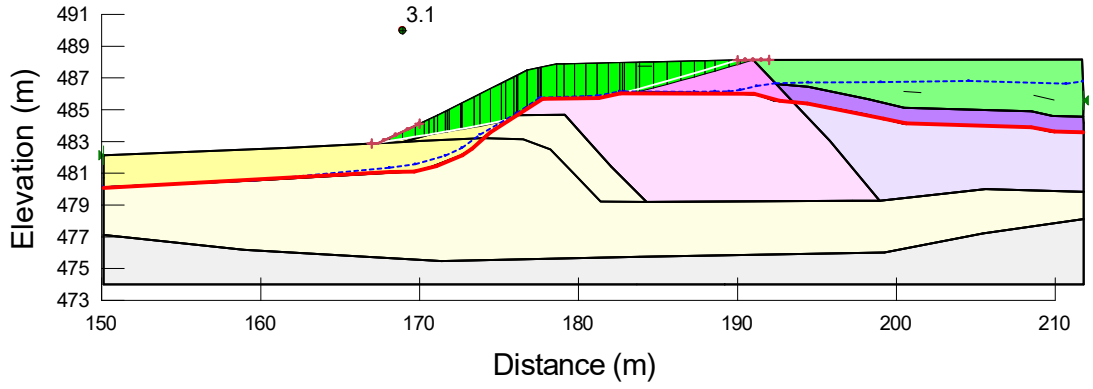
Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface
Re-sloped Conditions: regraded to 2H:1V to reach minimum FOS criteria

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				

As Built Conditions



Re-sloped Conditions



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION M – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

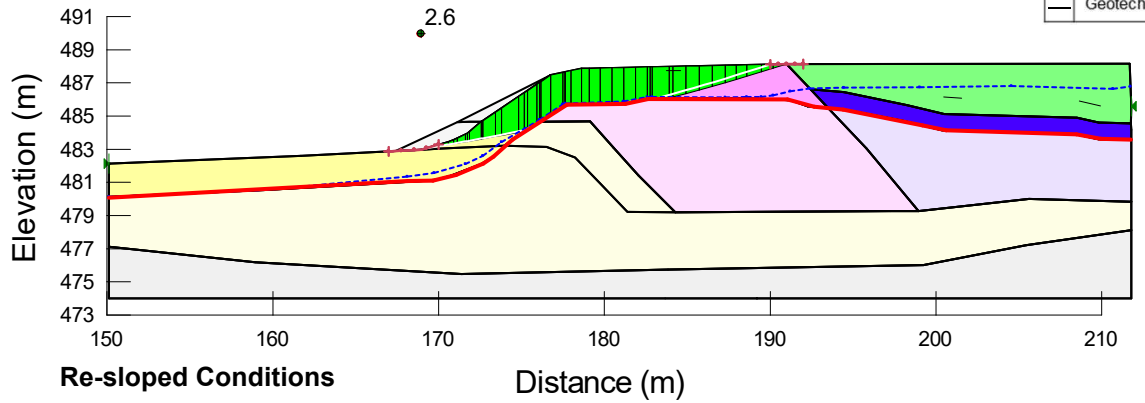
Stantec

Fig. A.28

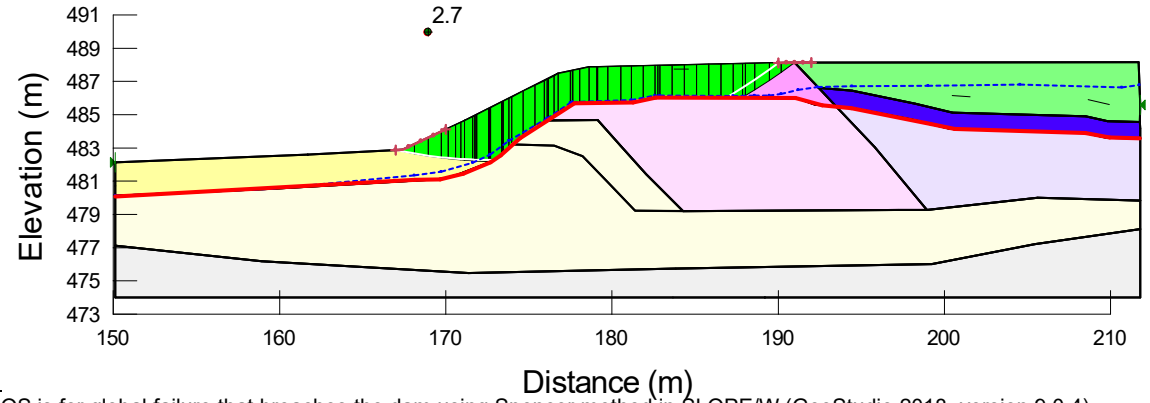
Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface
Re-sloped Conditions: regraded to 2H:1V to reach minimum FOS criteria

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				

As Built Conditions



Re-sloped Conditions



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

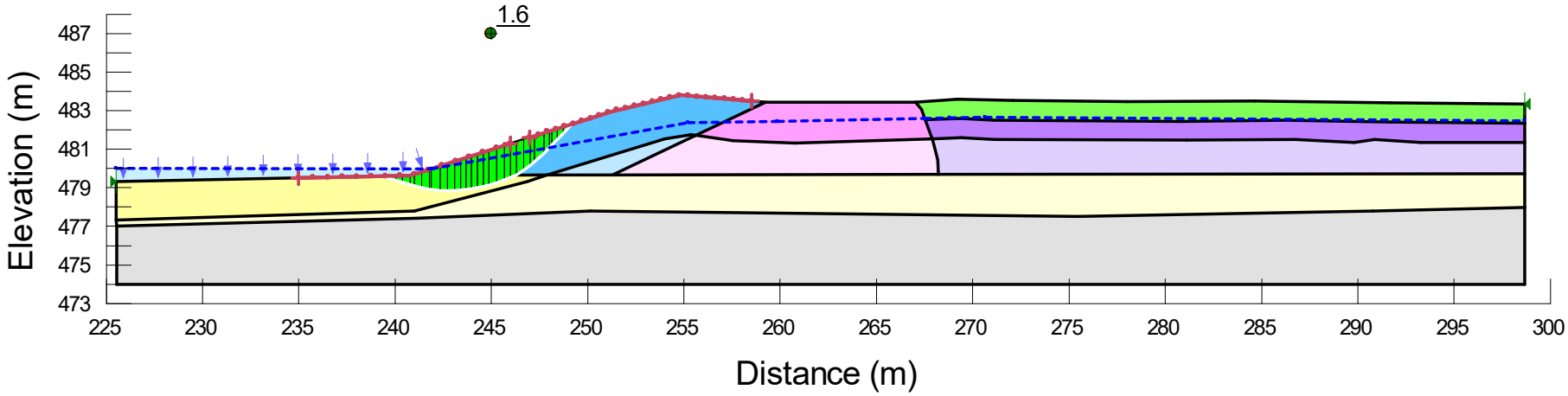
SLOPE STABILITY ANALYSIS
SECTION M – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

Stantec

Fig. A.29

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for optimized slip surface using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

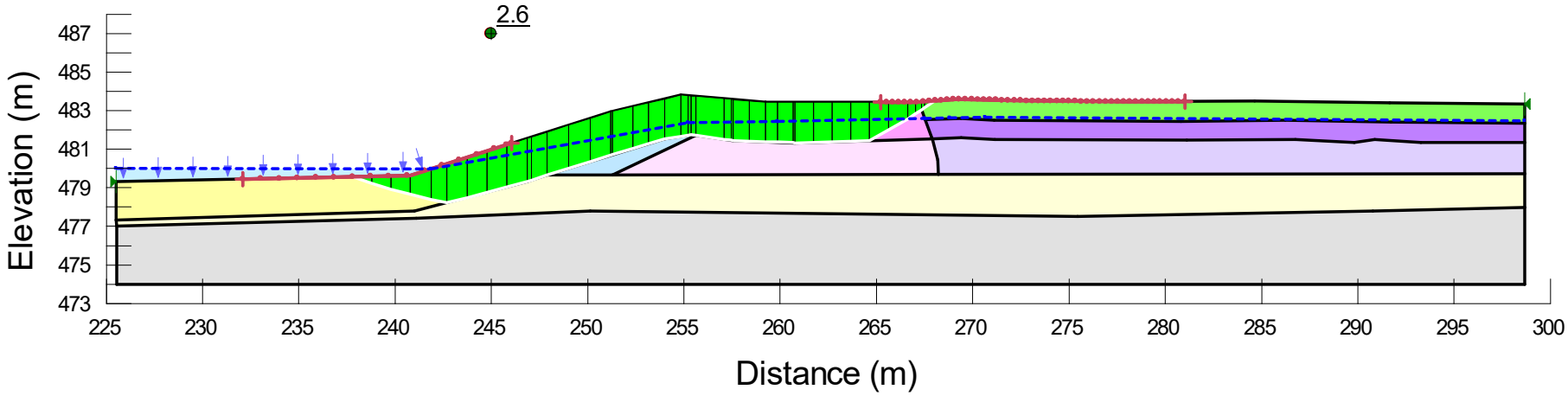
SLOPE STABILITY ANALYSIS
SECTION N – PERMAFROST CONDITIONS
STATIC CASE – LOCAL FAILURE

Stantec

Fig. A.30

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

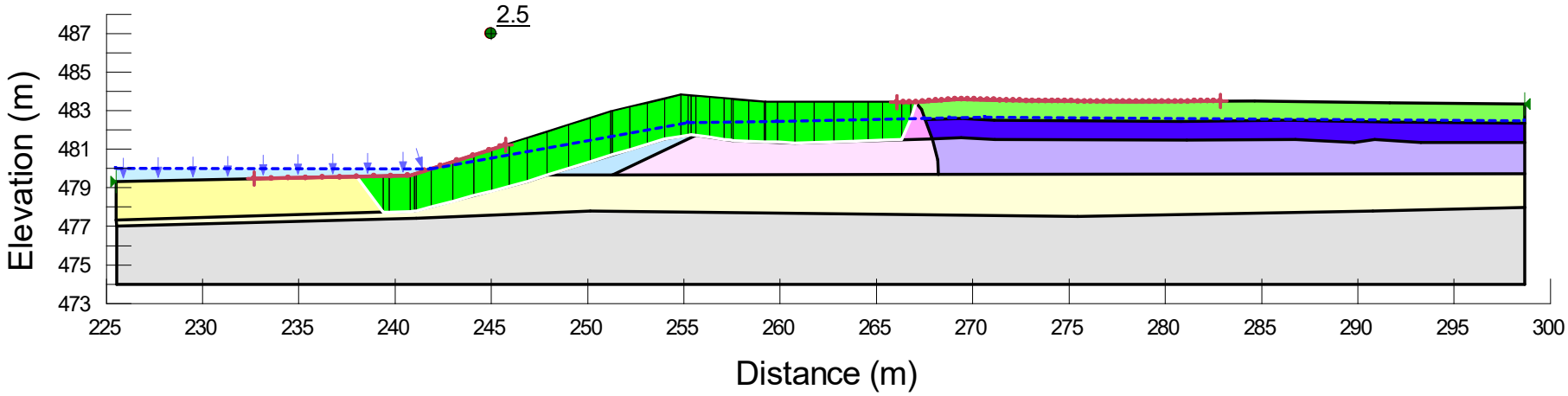
SLOPE STABILITY ANALYSIS
SECTION N – PERMAFROST CONDITIONS
STATIC CASE - GLOBAL FAILURE

Stantec

Fig. A.31

Details:
Current Permafrost Conditions: permafrost is present at depth 2m below ground surface

Material	Unit Weight (kN/m³)	Drained Parameters		Undrained Parameters	
		Friction Angle (°)	Cohesion (kPa)	Minimum Strength (kPa)	Tau/Sigma Ratio
Esker	30	35°	0	N/A	
Gravelly Sand	30	35°	0	N/A	
Rockfill	20	39°	0	N/A	
Tailings (Drained)	18	30°	0	N/A	
Tailings (Undrained)	18	N/A		20	0.24
Till	18	30°	0	N/A	
Bedrock	Impenetrable				
Permafrost	N/A				
Geotechnical Liner	N/A				



Notes:
1. FOS is for global failure that breaches the dam using Spencer method in SLOPE/W (GeoStudio 2018, version 9.0.4).

LUPIN MINES INC.

PHC Response #6

SLOPE STABILITY ANALYSIS
SECTION N – PERMAFROST CONDITIONS
PSEUDO-STATIC CASE – GLOBAL FAILURE

Stantec

Fig. A.32