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Geotechnical Engineering
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July 21, 2016
Report: PG3520-LET.01

2325483 Ontario Inc.
9094 Cavanagh Road
Highway 7
Ashton, Ontario
K0A 1B0

Attention: **Mr. Chris Collins**

Subject: **Slope Stability Assessment - Feedmill Creek**
Proposed Development - Kanata West
Palladium Drive at Huntmar Drive - Ottawa

Dear Sir,

Upon your request, Paterson Group (Paterson) has completed our slope stability assessment to determine the limit of hazard lands designation line for the subject alignment of Feedmill Creek adjacent to the aforementioned site. The present letter summarizes our findings and presents our limit of hazard lands recommendations.

1.0 Background Information

A site visit was conducted on June 25, 2016 by Paterson personnel to assess the watercourse and existing slope conditions of the subject section of Feedmill Creek. The subject section of Feedmill Creek borders the north section of the west boundary of the subject site. The shallow watercourse observed at the bottom of the 0.7 to 1.1 m high deep ditch varies between 1.5 to 2 m in width at the bottom and approximately 5.5 to 7.5 m wide at the top. The ditch is mainly grass covered with some bushes and sparse trees. Some of the grass root system was noted to be exposed beyond bank face at the water's edge with some sloughing and minor undercutting along the slope face noted where the watercourse has meandered in close proximity to the slope.

Three (3) slope profiles were completed for the subject site by Paterson personnel.

Boreholes completed as part of a previous geotechnical investigation and hand auger holes competed on June 25, 2016 within the creek alignment indicate the subsurface profile in the area of the subject section of Feedmill Creek consists of a thin layer of topsoil overlying a weathered brown silty clay and/or glacial till consisting of a silty sand with gravel, cobbles and boulders overlying inferred bedrock.

2.0 Slope Stability Analysis

A slope stability analysis was completed by Paterson for the subject slope. Three (3) slope sections were studied based on information obtained by Paterson field personnel and topographical mapping from the City of Ottawa.

The analysis of the stability of the slope was carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including the Bishop's method, which is a widely used and accepted analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favouring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsoil and groundwater conditions, a factor of safety greater than one is usually required to ascertain the risks of failure are acceptable. A minimum factor of safety of 1.5 is generally recommended for conditions where the failure of the slope would endanger permanent structures. Under seismic loading, a minimum factor of safety of 1.1 is considered to be satisfactory.

The sections were analyzed taking into account a groundwater level at ground surface. Subsoil conditions at the cross-sections were inferred based on the findings at nearby borehole locations, hand auger holes and general knowledge of the area's geology.

Static Conditions Analysis

The results for the existing slope conditions at Sections A, B and C are shown in Figures 2a, 3a and 4a, respectively, and are attached to the present report. The results of the slope stability analysis indicate that all sections are considered stable from a geotechnical perspective.

Seismic Loading Analysis

An analysis considering seismic loading was also completed. A horizontal seismic acceleration, K_h, of 0.16G was considered for the analyzed sections. A factor of safety of 1.1 is considered to be satisfactory for stability analysis including seismic loading.

The results of the analysis including seismic loading are shown in Figures 2b, 3b and 4b for the slope sections. The overall slope stability factors of safety for the subject sections when considering a seismic loading were found to be greater than 1.1. Based on these results, the slopes are considered to be stable under seismic loading.

Geotechnical Setback - Limit of Hazard Lands

The geotechnical setback limits (limit of hazard lands) includes the geotechnical stable slope allowance, a toe erosion allowance (where applicable) as well as a 6 m toe erosion access allowance.

The toe erosion allowance for the valley corridor wall slopes was based on the cohesive nature of the soils, the observed current erosional activities and the width and location of the current watercourse. Signs of erosion were noted along the existing watercourse, especially where the watercourse has meandered in close proximity to the toe of the corridor wall. It is considered that a toe erosion allowance of 2 m is appropriate for the corridor walls confining the existing watercourse.

It should be noted that based on our analysis results, the slopes are considered stable. The limit of hazard lands designation line for the subject site is indicated on Drawing PG3520-2 - Limit of Hazard Lands attached to the current report.

The existing vegetation on the slope face should not be removed as it contributes to the stability of the slope and reduces erosion. If the existing vegetation needs to be removed, it is recommended that a 100 to 150 mm of topsoil mixed with a hardy seed or an erosional control blanket be placed across the exposed slope face.

3.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. Should any conditions at the site be encountered which differ from those at the test locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than 2325483 Ontario Inc. or their agents, without review by this firm for the applicability of our recommendations to the altered use of the report.

We trust that this information satisfies your requirements.

Best Regards,

Paterson Group Inc.

Richard Groniger, C. Tech.

David J. Gilbert, P.Eng.

Attachments

- ❑ Soil Profile and Test Data Sheets
- ❑ Figure 1 - Key Plan
- ❑ Figure 2a - Section A - Static Conditions
- ❑ Figure 2b - Section A - Seismic Loading
- ❑ Figure 3a - Section B - Static Conditions
- ❑ Figure 3b - Section B - Seismic Loading
- ❑ Figure 4a - Section C - Static Conditions
- ❑ Figure 4b - Section C - Seismic Loading
- ❑ Drawing PG3520-2 - Limit of Hazard Lands

Report Distribution

- ❑ 2325483 Ontario Inc. (3 copies)
- ❑ Paterson Group (1 copy)

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Consulting Engineers

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Development - Palladium Dr. & Huntmar Dr.
Ottawa, Ontario

DATUM Ground surface elevations provided by Cavanaugh Construction.

FILE NO. PG3520

REMARKS

HOLE NO. BH 6

BORINGS BY CME 55 Power Auger **DATE** June 9, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	107.24
TOPSOIL 0.10		SS	1	75	4		
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders		SS	2	92	34	1	106.24
		SS	3	100	41		
- grey by 2.0m depth						2	105.24
		SS	4	78	59		
						3	104.24
		SS	5	75	33		
3.71							
End of Borehole							
Practical refusal to augering @ 3.71m depth							
(GWL @ 0.13m-June 16, 2015)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone
○ Water Content %
20 40 60 80

Piezometer Construction

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Development - Palladium Dr. & Huntmar Dr.
Ottawa, Ontario

DATUM Ground surface elevations provided by Cavanaugh Construction.

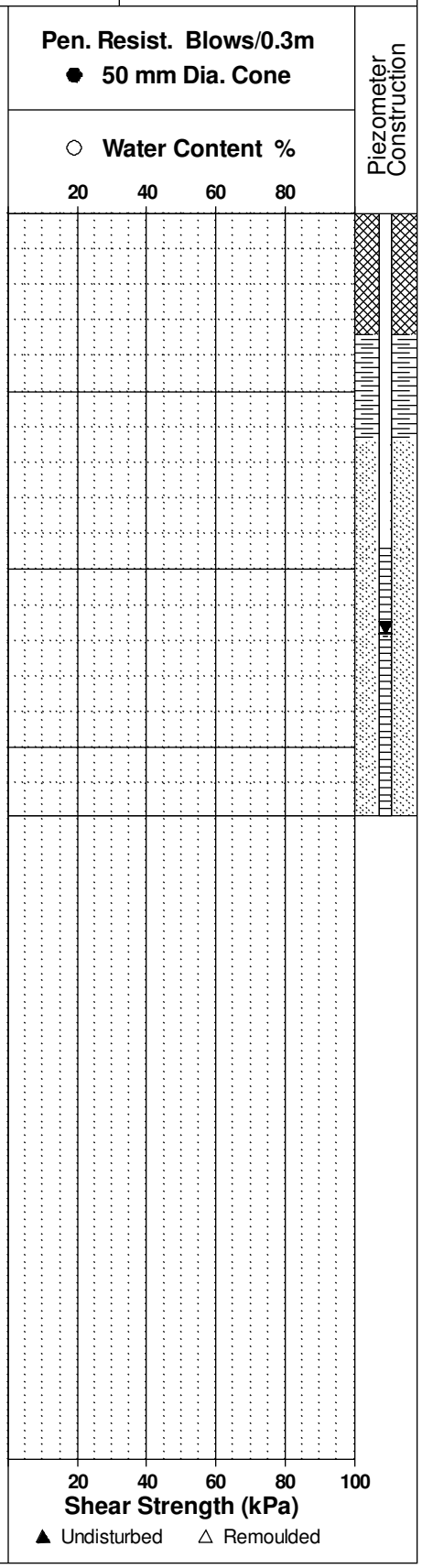
FILE NO. PG3520

REMARKS

HOLE NO. BH 7

BORINGS BY CME 55 Power Auger **DATE** June 9, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	105.77
TOPSOIL 0.30		AU	1				
Brown **SILTY CLAY,** some sand		SS	2	58	24	1	104.77
1.30							
GLACIAL TILL: Grey silty sand with clay, gravel, cobbles and boulders		SS	3	42	8	2	103.77
		SS	4	100	2		
		SS	5	100	50+	3	102.77
3.38							
End of Borehole							
Practical refusal to augering at 3.38m depth							
(GWL @ 2.36m-June 16, 2015)							



SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	'N' Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	ROCK QUALITY
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC%	-	Natural moisture content or water content of sample, %
LL	-	Liquid Limit, % (water content above which soil behaves as a liquid)
PL	-	Plastic limit, % (water content above which soil behaves plastically)
PI	-	Plasticity index, % (difference between LL and PL)
Dxx	-	Grain size which xx% of the soil, by weight, is of finer grain sizes These grain size descriptions are not used below 0.075 mm grain size
D10	-	Grain size at which 10% of the soil is finer (effective grain size)
D60	-	Grain size at which 60% of the soil is finer
Cc	-	Concavity coefficient = $(D30)^2$ / (D10 x D60)
Cu	-	Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay
(more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

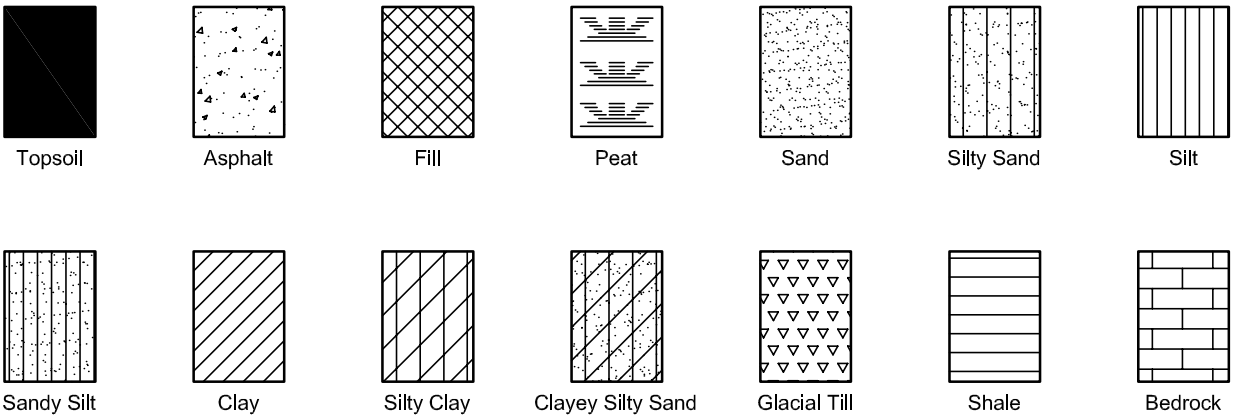
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void Ratio		Initial sample void ratio = volume of voids / volume of solids
Wo	-	Initial water content (at start of consolidation test)

PERMEABILITY TEST

k	-	Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

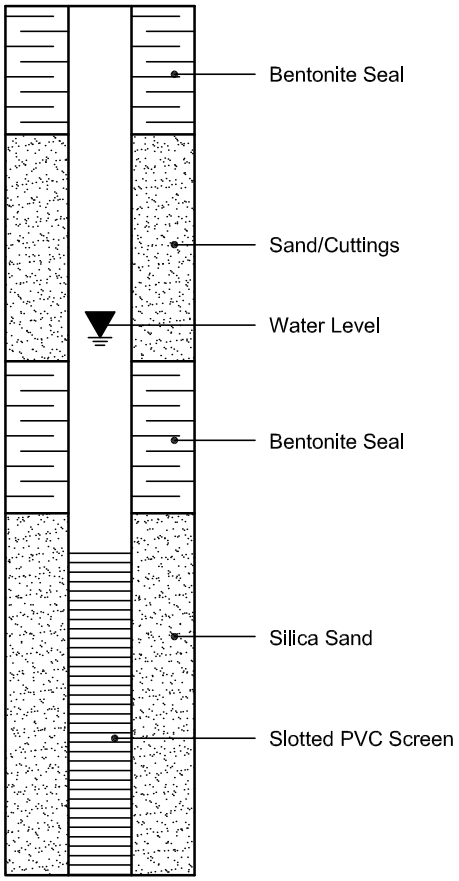
SYMBOLS AND TERMS (continued)

STRATA PLOT

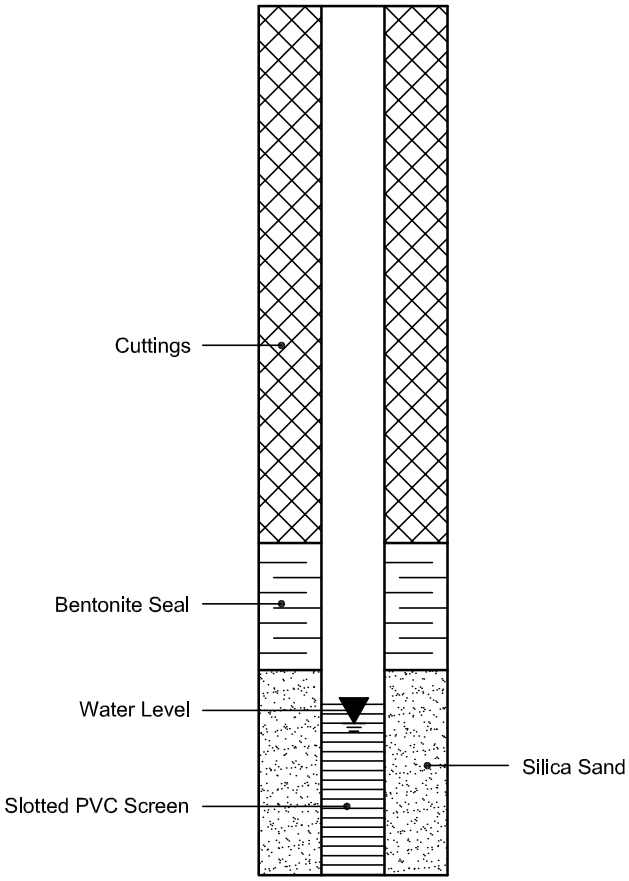


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



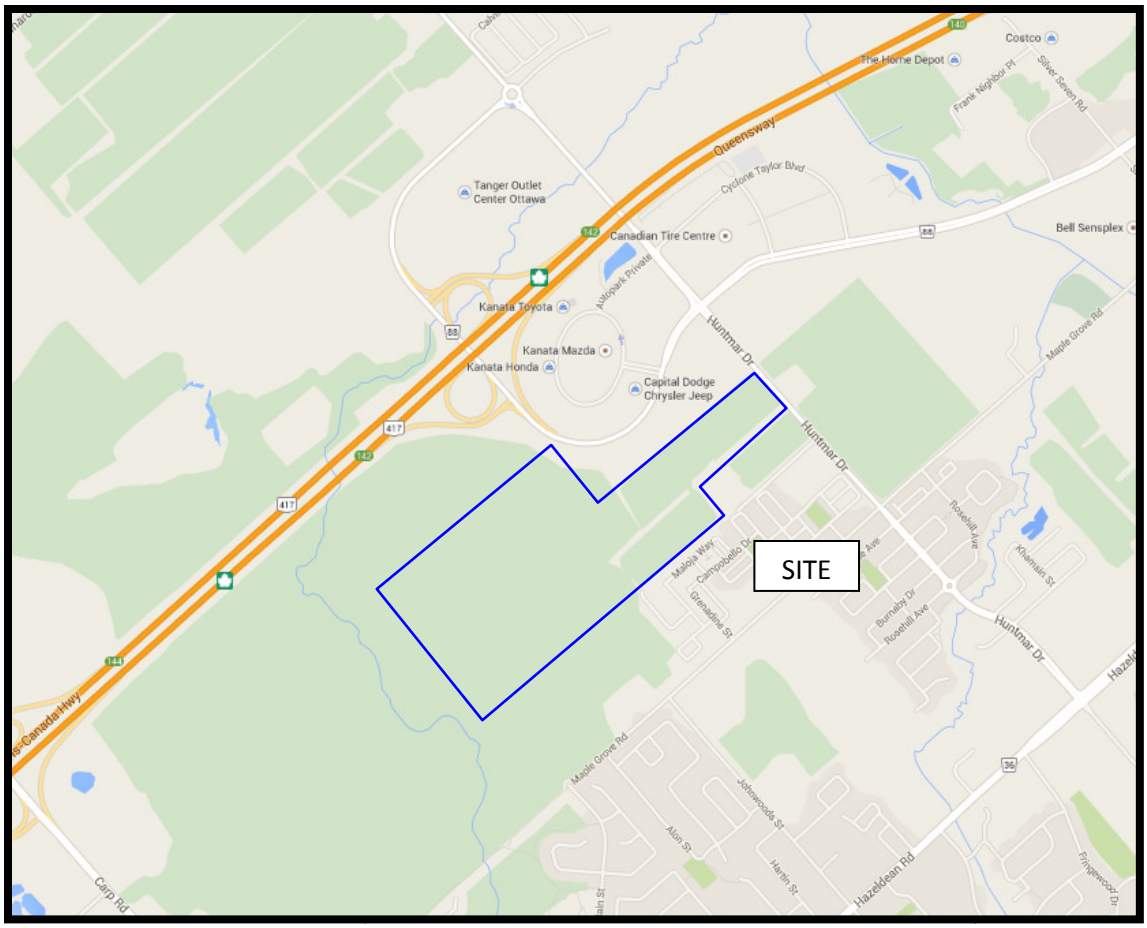
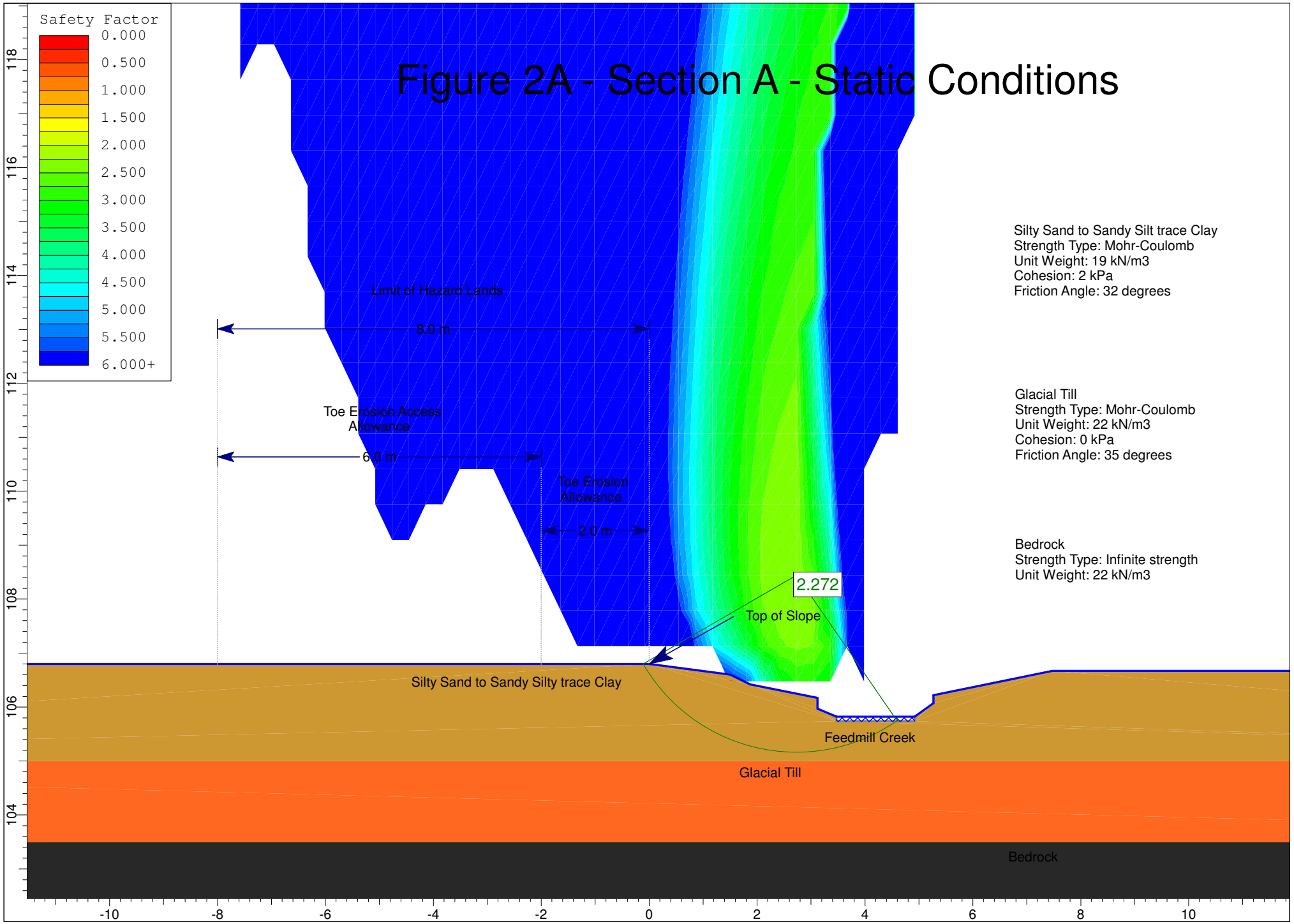


FIGURE 1

KEY PLAN


Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Figure 2A - Section A - Static Conditions
Silty Sand to Sandy Silt trace Clay
Strength Type: Mohr-Coulomb
Unit Weight: 19 kN/m3
Cohesion: 2 kPa
Friction Angle: 32 degrees
Limit of Hazard Lands
8.0 m
Toe Erosion Access Allowance
6.0 m
Toe Erosion Allowance
2.0 m
Glacial Till
Strength Type: Mohr-Coulomb
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
2.272
Top of Slope
Silty Sand to Sandy Silty trace Clay
Feedmill Creek
Glacial Till
Bedrock
118
116
114
112
110
108
106
104
-10
-8
-6
-4
-2
0
2
4
6
8
10

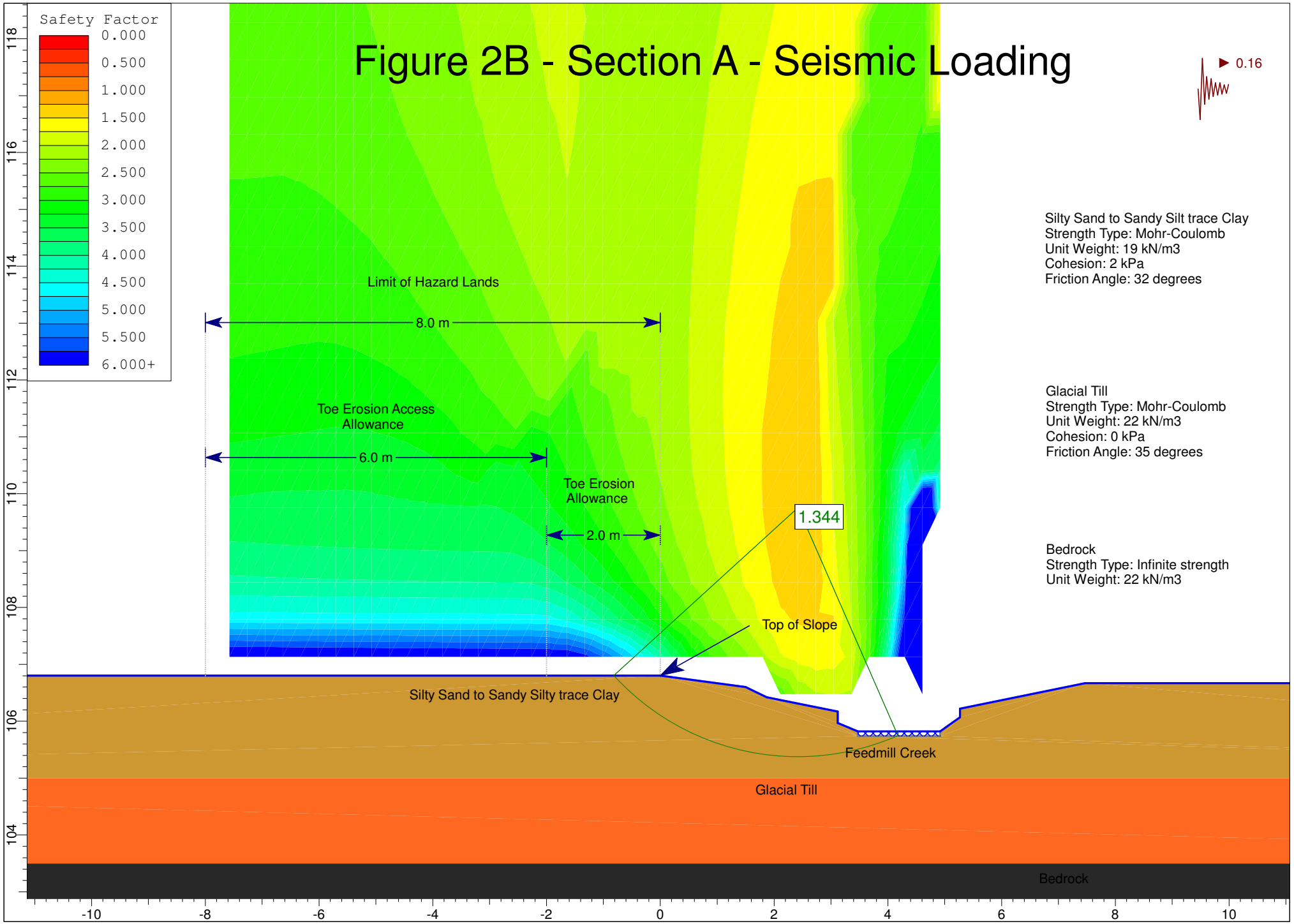


Figure 2B - Section A - Seismic Loading
Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
0.16
Limit of Hazard Lands
8.0 m
Toe Erosion Access Allowance
6.0 m
Toe Erosion Allowance
2.0 m
1.344
Top of Slope
Silty Sand to Sandy Silty trace Clay
Feedmill Creek
Glacial Till
Bedrock
Silty Sand to Sandy Silt trace Clay
Strength Type: Mohr-Coulomb
Unit Weight: 19 kN/m3
Cohesion: 2 kPa
Friction Angle: 32 degrees
Glacial Till
Strength Type: Mohr-Coulomb
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
118
116
114
112
110
108
106
104
-10
-8
-6
-4
-2
0
2
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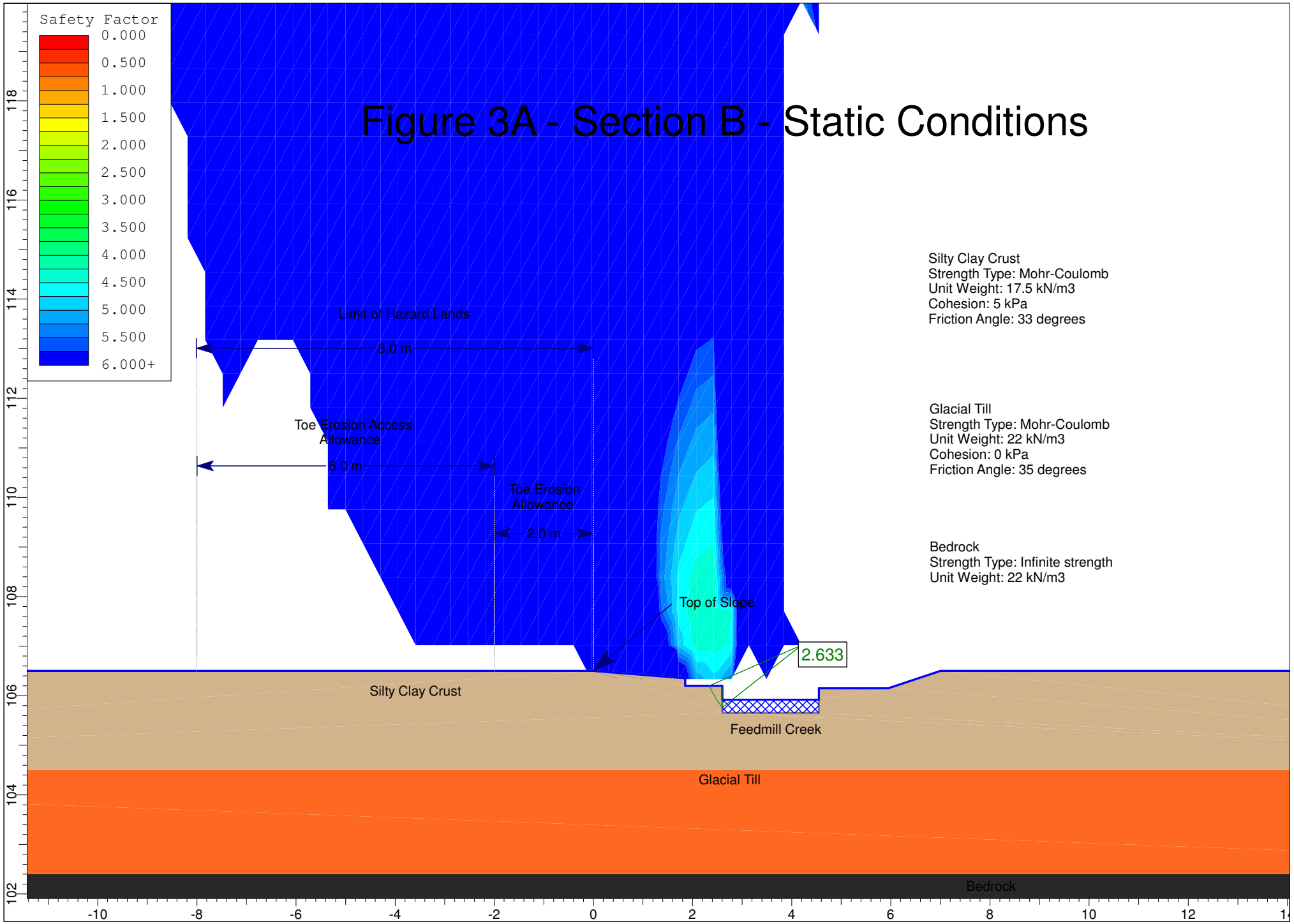
Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Figure 3A - Section B - Static Conditions
Silty Clay Crust
Strength Type: Mohr-Coulomb
Unit Weight: 17.5 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Glacial Till
Strength Type: Mohr-Coulomb
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
Limit of Hazard Lands
8.0 m
Toe Erosion Access Allowance
6.0 m
Toe Erosion Allowance
2.0 m
Top of Slope
2.633
Silty Clay Crust
Feedmill Creek
Glacial Till
Bedrock
118
116
114
112
110
108
106
104
102
-10
-8
-6
-4
-2
0
2
4
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12

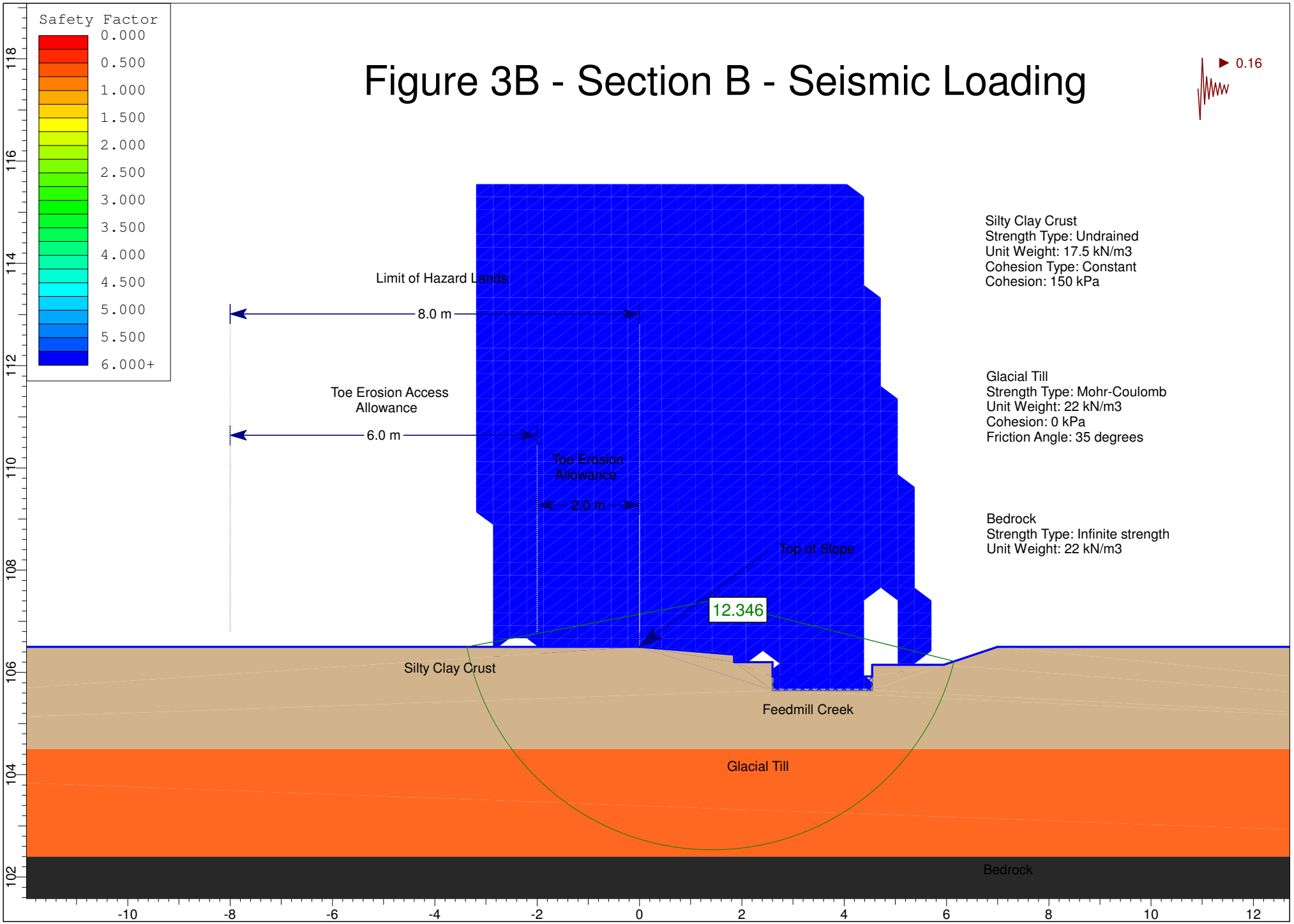
Figure 3B - Section B - Seismic Loading
Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
0.16
Limit of Hazard Lands
8.0 m
Toe Erosion Access Allowance
6.0 m
Toe Erosion Allowance
2.0 m
Top of Slope
12.346
Silty Clay Crust
Strength Type: Undrained
Unit Weight: 17.5 kN/m3
Cohesion Type: Constant
Cohesion: 150 kPa
Glacial Till
Strength Type: Mohr-Coulomb
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
Silty Clay Crust
Feedmill Creek
Glacial Till
Bedrock
118
116
114
112
110
108
106
104
102
-10
-8
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-4
-2
0
2
4
6
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12

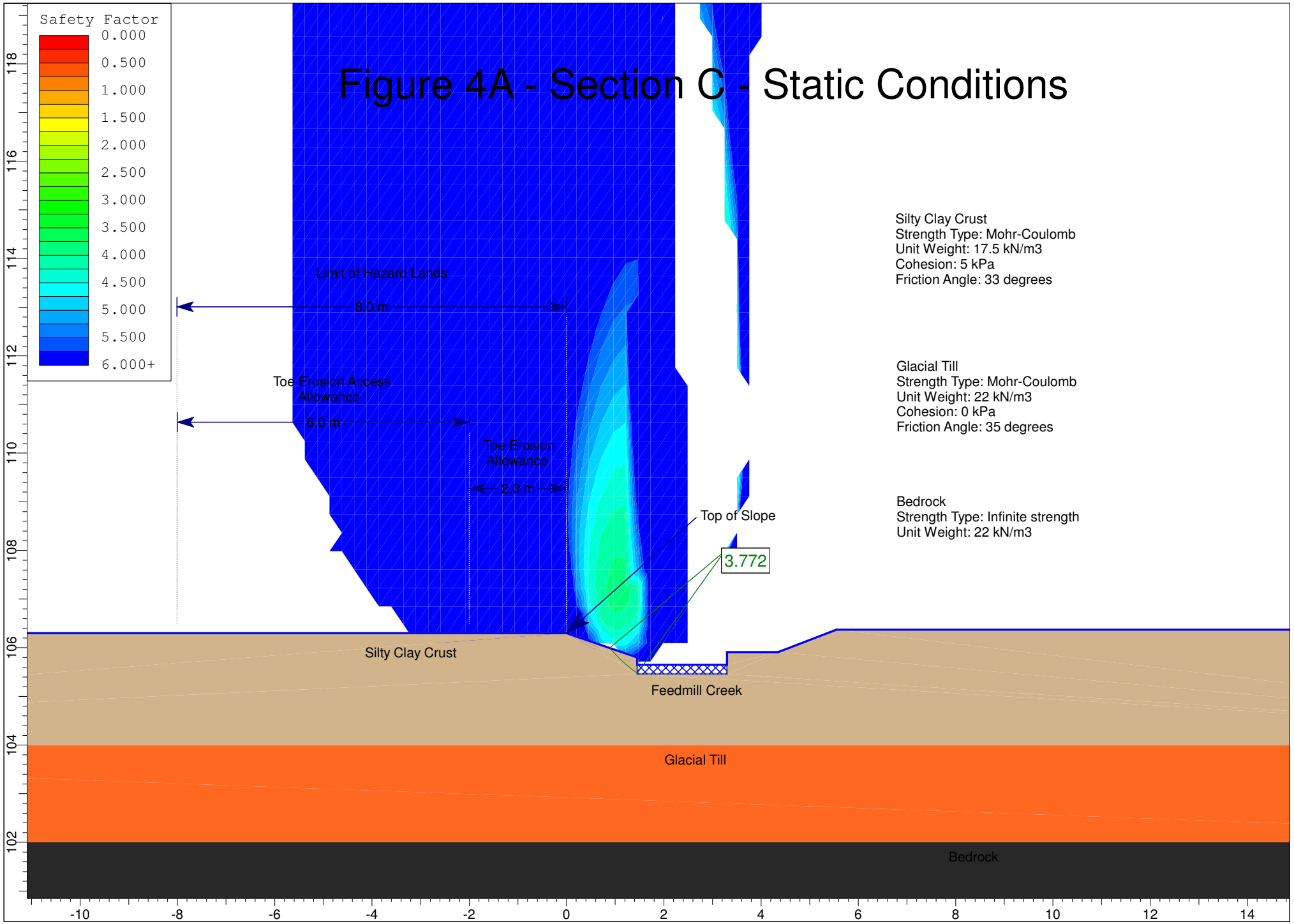
Figure 4A - Section C - Static Conditions
Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
Limit of Hazard Lands
8.0 m
Toe Erosion Access Allowance
6.0 m
Toe Erosion Allowance
2.0 m
Top of Slope
3.772
Silty Clay Crust
Strength Type: Mohr-Coulomb
Unit Weight: 17.5 kN/m3
Cohesion: 5 kPa
Friction Angle: 33 degrees
Glacial Till
Strength Type: Mohr-Coulomb
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
Silty Clay Crust
Feedmill Creek
Glacial Till
Bedrock
118
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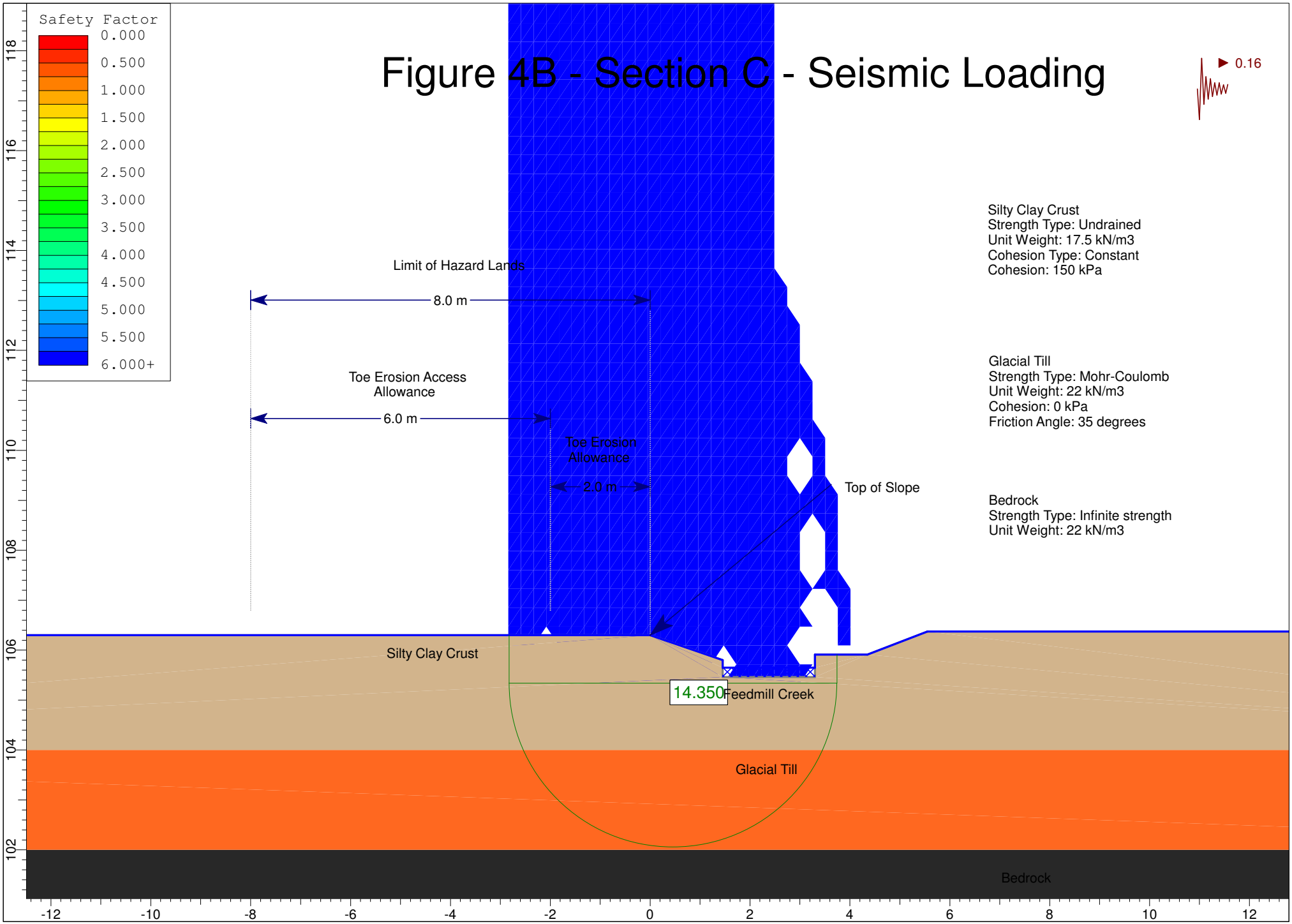
Figure 4B - Section C - Seismic Loading
Safety Factor
0.000
0.500
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000+
0.16
Limit of Hazard Lands
8.0 m
Toe Erosion Access Allowance
6.0 m
Toe Erosion Allowance
2.0 m
Top of Slope
Silty Clay Crust
Strength Type: Undrained
Unit Weight: 17.5 kN/m3
Cohesion Type: Constant
Cohesion: 150 kPa
Glacial Till
Strength Type: Mohr-Coulomb
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 35 degrees
Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3
Silty Clay Crust
14.350
Feedmill Creek
Glacial Till
Bedrock
118
116
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112
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-12
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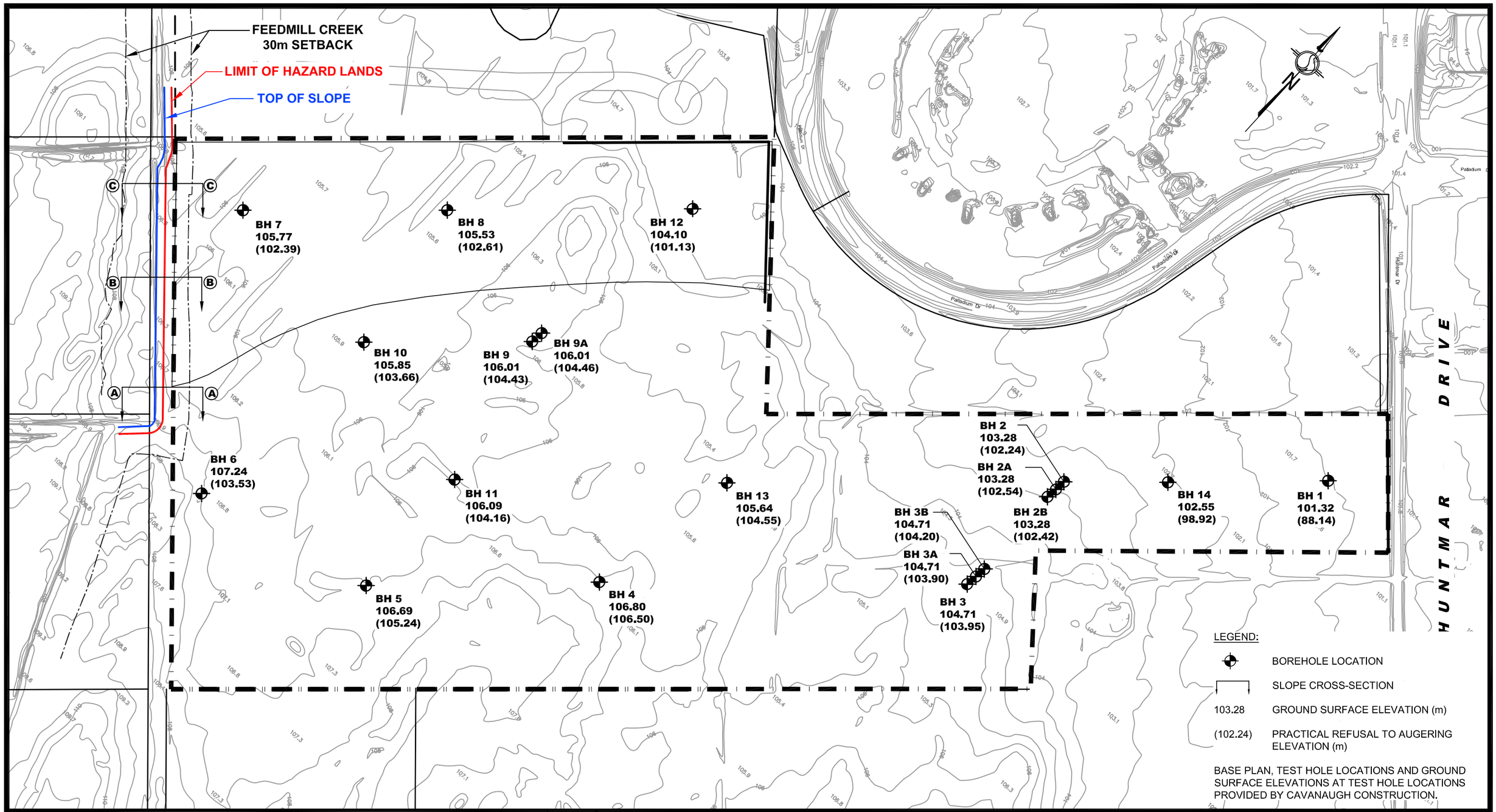

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consulting engineers

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NO.	REVISIONS	DATE	INITIAL

2325483 ONTARIO INC.

SLOPE STABILITY ASSESSMENT
PROP. DEVELOPMENT - PALLADIUM DRIVE AT HUNTMAR DRIVE

OTTAWA, ONTARIO

Title:

LIMIT OF HAZARD LANDS

Scale: 1:4000	Date: 06/2015
Drawn by: RCG	Report No.: PG3520-1
Checked by: RG	Drawing No.: PG3520-2
Approved by: DJG	Revision No.:

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