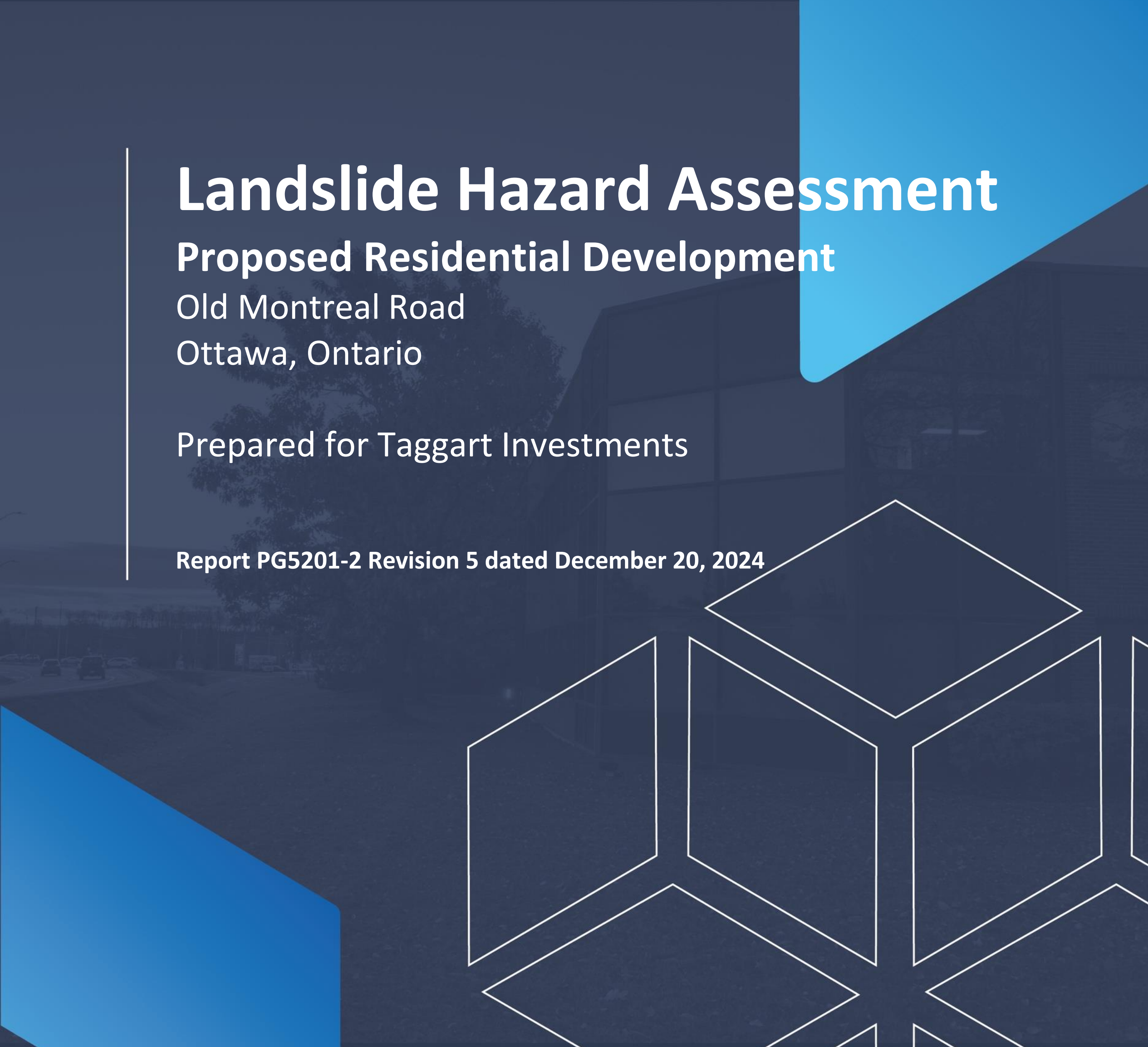

Landslide Hazard Assessment

Proposed Residential Development

Old Montreal Road
Ottawa, Ontario

Prepared for Taggart Investments

Report PG5201-2 Revision 5 dated December 20, 2024

Table of Contents

Appendices

Appendix 1	Soil Profile and Test Data Sheets Symbols and Terms Grain-Size Distribution and Hydrometer Testing Results Atterberg Limits Testing Results Earthquakes Canada Seismic Hazard (NBCC 2015) Table 1 – Summary of Reviewed Landslide Inventory Data
Appendix 2	Figure 1 - Key Plan Figure 6A through 41B – Slope Stability Analysis Cross-Sections Photographs from Site Visits Drawing PG5201-1 – Bedrock Contour Plan Drawing PG5201-2 – Test Hole Location Plan Drawing PG5201-FIG.A – Cross Section A-A’ Drawing PG5201-FIG.B – Cross Section B-B’ Drawing PG5201-FIG.C – Cross Section C-C’

1.0 Introduction

1.1 Purpose of Study and Scope of Work

Paterson Group (Paterson) was commissioned by Taggart Investments to conduct a landslide risk assessment for the proposed residential development considered Cardinal Creek Village South and located south and along Old Montreal Road, in the City of Ottawa, Ontario (reference should be made to Figure 1 - Key Plan in Appendix 2 of this report). The study has been prepared in response to the requirement by the Rideau Valley Conservation Authority (RVCA) as part of the Site Plan Approval process for the City of Ottawa for the subject site.

The objectives of the risk assessment were to:

❑ Demonstrate that any landslide on the sloped areas, including a large "catastrophic landslide", has an annual probability less than 1:10,000.

❑ If the landslide hazard cannot be demonstrated to have an annual probability of less than 1:10,000, it must be demonstrated that the individual risk is <1x10^{-5} per year and group risk falls within the "Acceptable" zone on a suitable group risk chart.

❑ If none of these criteria can be satisfied without mitigation measures, then the mitigation actions required must be demonstrated to reduce the risk below 10^{-5} per year and to "as low as reasonably practicable" (ALARP). If mitigation is required, further discussion with the RVCA will be required to determine what will be acceptable.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as they are understood at the time of writing this report.

1.2 Hazard Assessment Methodology

The methodology of this study was undertaken using a combination of the criteria and requirements set out by the following risk assessment guidelines:

❑ Fraser Valley Regional District's Hazard Acceptability Thresholds for Development Applications dated October 2020

❑ The Association of Professional Engineers and Geoscientists of British Columbia's (APEGBC) Guidelines for Legislates Landslide Assessments for Proposed Residential Developments in BC, dated May 2010

- ❑ Geological Survey of Canada's Open File 7312 - Landslide Risk Evaluation Technical Guidelines and Best Practices, dated 2013

The scope of work used in this assessment included a review of published literature describing local landslides and their associated triggers, geotechnical hazards, inventoried regional landslides and the geological setting of the study area. Desktop review of published topographic mapping, LiDAR imaging, and other geological mapping was also used as part of this assessment.

Field reconnaissance was carried out over several geotechnical field programs that have taken place throughout the subject site, including field review and subsurface investigations. Further, Paterson compensated the subsurface information for the study area with a review of test hole information gathered for nearby sites in close proximity to the subject site which were investigated by Paterson as part of this assessment.

1.3 Proposed Development

Based on the available drawings, it is understood that the proposed development will consist of single and townhouse style residential dwellings with basement or slab-on-grade construction, attached garages, associated driveways, local roadways and landscaped areas. The construction of schools, a park, and a stormwater management pond are also included in the proposed development. It is further anticipated that the proposed development will be serviced by future municipal water, sanitary and storm services.

1.4 Review of Previous Geotechnical Investigations and Associated Studies

For this assessment, subsurface information was collected from a set of site-specific investigations and several previous investigations carried out by Paterson throughout the surrounding area of the subject site. The results of the previous investigations are presented in the following Paterson reports:

- ❑ Report prepared for Tamarack (Queen Street) Corp. - Geotechnical Investigation - Proposed Cardinal Creek Village Residential/Commercial Development - Old Montreal Road, Ottawa, Ontario - PG1796-4 dated September 19, 2014.

- ❑ Report prepared for Taggart Investments - Geotechnical Investigation - Proposed Residential Development Cardinal Creek Village South - Old Montreal Road, Ottawa, Ontario - PG5201-1 Revision 5 dated July 14, 2021.

❑ Memorandum report prepared for Taggart Investments – Slope Stability Assessment of Existing Slope Failure – 1320 Grand-Chene Court, Ottawa, Ontario - PG5201-MEMO.03 dated November 13, 2023.

Relevant test hole information and locations are presented on the Drawing PG5201-2 - Test Hole Location Plan in Appendix 2.

All reviewers of this report should understand that the geotechnical investigation undertaken in support of the proposed development has been undertaken in accordance with the City of Ottawa's *Geotechnical Investigation and Reporting Guidelines for Development Applications in the City of Ottawa*, that the slope stability fieldwork and analysis had been undertaken in accordance with the City of Ottawa's *Slope Stability Guidelines for Development Application in the City of Ottawa*, and that laboratory testing was undertaken in accordance with the above-noted guidelines and the *City of Ottawa's Tree Planting in Marine Clay Soils – 2017 Guidelines*.

It should also be noted that this report also considers the observations and findings provided by GEO Morphix in their report *Fluvial Geomorphological and Erosion Threshold Assessment, Tributary of Cardinal Creek, 1296 and 1400 Old Montreal Road* dated February 23, 2023. It is recommended that this report be read in conjunction with the project fluvial geomorphological report.

2.0 Background of Study Area

2.1 Field Investigation

Field Program

Paterson has undertaken several geotechnical investigations throughout the subject site. The initial portion of the geotechnical investigation for the overall development was carried out between January 22 and 26, 2009. At that time, seven (7) boreholes were advanced within the subject site to depths varying between 0.7 and 9.4 m below ground surface.

Supplemental investigations were completed in April and June 2012, and January and February 2013. At that time, thirty-two (32) additional boreholes were advanced to depths varying between 0.8 and 10.0 m below ground surface.

Additional geotechnical investigations were carried out in December 2012 and between February and March 2021 and consisted of excavating a total of fifty-four (54) test pits. The test holes were advanced within the subject site to depths between 0.7 and 6.5 m below the existing ground surface. A bedrock delineation program consisting of advancing probeholes to the bedrock surface was also carried out in November 2019 to assess the overburden thickness across the subject site.

The test hole locations were placed in a manner to provide general coverage taking into consideration site access, features and underground utilities. The test hole locations were determined by Paterson personnel and surveyed in the field by Paterson or Stantec Geomatics. It is understood that all test hole elevations are referred to a geodetic datum. The test hole locations for the investigations are presented on Drawing PG5201-2 - Test Hole Location Plan included in Appendix 2.

The boreholes and probeholes were completed using a track mounted drill rig operated by a two-person crew. The test pits were excavated using a rubber-tired backhoe or a hydraulic shovel.

All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer from the Geotechnical Division. The testing procedure consisted of augering or excavating to the required depths and at the selected locations sampling and testing the overburden.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon sampler, from the auger flights, or using a 73 mm diameter thin walled Shelby tubes in conjunction with a piston sampler. Grab samples were also collected along the excavated sidewalls of the test pits. All samples were visually inspected and initially classified on site. The auger, grab and split-spoon samples were placed in sealed plastic bags and the Shelby tubes were sealed at both ends on site and protected from disturbances over the entire process.

All samples were transported to our laboratory for further examination and classification. The depths at which the auger, grab, split spoon and Shelby tube samples were recovered from the test holes are shown as AU, G, SS and TW, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

The Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split-spoon samples. The SPT results are recorded as “N” values on the Soil Profile and Test Data sheets. The “N” value is the number of blows required to drive the split-spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

Undrained shear strength testing was carried out in cohesive soils using a field vane apparatus.

Subsurface conditions observed in the test holes were recorded in detail in the field. Reference should be made to the Soil Profile and Test Data sheets presented in Appendix 1 for specific details of the soil profile encountered at the test hole locations.

Groundwater

All boreholes were fitted with flexible polyethylene standpipes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program. The groundwater observations are noted on the Soil Profile and Test Data sheets presented in Appendix 1.

Geotechnical Laboratory Testing

The soil samples recovered from our field investigation were examined in our laboratory to collaborate the field findings. A fully sampled borehole (BH 89-13) was completed in June 2013 located within the north portion of the site. At the time, four (4) samples were submitted for unidimensional consolidation, five (5) samples were submitted for Atterberg limits testing and moisture content testing was completed on all recovered soil samples from BH 89-13.

Gradation and Atterberg limits testing were also completed on select samples obtained from the geotechnical investigations. The results of our testing are presented on Table 1, below, and on Grain Size Distribution and Hydrometer Testing and Atterberg Limit's Results sheets presented in Appendix 1.

Table 1 - Atterberg Limits Results

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)	Classification
TP 1-21	2.0	61	31	30	36.0	CH
TP 3-21	1.85	69	31	38	40.7	CH
TP 4-21	1.11	57	32	25	37.6	MH
TP 5-21	2.1	73	37	36	45	MH
TP 6-21	0.94	63	34	29	42.3	MH
TP 7-21	0.70	59	32	27	38.5	MH
TP 8-21	0.95	70	44	26	49.7	MH
TP 9-21	0.6	58	32	26	23.6	MH
TP 10-21	1.5	60	33	27	35.8	MH
TP 11-21	2.11	65	35	30	43.6	MH
TP 12-21	0.8	75	37	38	37.4	MH
TP 16-21	0.3	57	29	28	36.9	CH
TP 17-21	0.6	65	36	29	39.9	MH
TP 17-21	1.3	57	31	26	35.1	MH
TP 18-21	0.4	66	36	30	35.5	MH
TP 19-21	1.5	61	32	29	32.9	MH
TP 20-21	1.0	76	39	37	39.2	MH
BH 4B TW 1	4.19	61	28	33	70.8	CH
BH 57-12 SS 7	5.33	66	27	39	27.1	CH
BH 58-12 SS 6	4.57	63	23	40	23.2	CH
BH 67-13 SS 6	4.57	75	30	46	29.5	CH
BH 89-13 TW 2	4.97	79	30	48	70.7	CH
BH 89-13 TW 3	8.08	54	26	29	67.0	CH
BH 89-13 TW 4	12.65	46	26	20	70.0	CL
BH 89-13 TW 5	18.74	50	23	27	64.4	CL
BH 89-13 TW 6	24.20	43	20	23	n/a	CL

Notes: LL: Liquid Limit; PL: Plastic Limit; PI: Plasticity Index; w: water content; CH: Inorganic Clay of High Plasticity; CL: Inorganic Clay of Low Plasticity; MH: Inorganic Silts of High Plasticity

The results of the shrinkage limit test indicate a shrinkage limit of 22% and a shrinkage ratio of 1.71.

Grain size distribution (sieve and hydrometer analysis) was also completed on selected soil samples. The results of the grain size analysis are summarized in Table 2 and presented on the Grain-Size Distribution and Hydrometer Testing Results sheets in Appendix 1.

Table 2 - Summary of Grain Size Distribution Analysis

Test Hole	Sample	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
TP 2-21	G4	0.0	0.2	27.3	72.5
TP 7-21	G3	0.0	14.4	29.6	56.0
TP10-21	G4	0.0	14.4	31.2	67.5
TP12-21	G2	0.0	2.7	26.8	70.5
TP18-21	G1	0.0	15.4	34.1	50.5

2.2 Existing Conditions

Surface Conditions

The subject site consists mostly of undeveloped agricultural lands with several areas covered with trees and mature vegetation. The study area was observed to be intersected by a series of tributary ravines, which drain into Cardinal Creek. Piles of granular and crushed material have been observed on the west portion of the property and north of the main tributary ravine.

The ground surface across the subject site slopes downward gradually from east to west, and in general towards the tributary ravines. The slopes of the ravines were noted to be treed and stable based on our most recent site visit. Some signs of toe erosion were noted throughout where the watercourse is in close proximity to the valley corridor wall.

Due to the presence of the tributary ravines within the subject site, a slope stability assessment was carried out considering the slope conditions present in the subject site and along the sidewalls of the aforementioned watercourses. The results of the slope stability analysis are discussed further in Subsection 6.8 of this report.

Subsurface Conditions

Generally, the overburden profile consisted of topsoil, fill and/or asphaltic concrete underlain by a stiff to very stiff silty clay layer followed by a glacial till deposit. The fill was mostly encountered in the boreholes located next to Old Montreal Road.

Where encountered, the existing fill layer was observed to extend to ranges between 0.7 and 1.4 m in depth. The fill generally consisted of crushed stone followed by brown silty sand with clay, gravel, and cobbles.

The surficial layer of topsoil and/or fill was observed to be underlain by a silty clay deposit. The upper portion of the silty clay has been weathered to a brown desiccated crust. In situ shear vane field tests carried out within the silty clay crust yielded peak undisturbed shear strength values between 80 and 249 kPa. These values reflect a stiff to hard consistency in the silty clay crust. Unweathered, grey silty clay was encountered below the brown silty clay crust. The silty clay deposit was observed to present a thickness in excess of 9 m at the west portion of the subject site and thinning out towards the east.

Glacial till was observed underlying the above-noted deposits at most locations at the subject site. The fine matrix of the glacial till generally consisted of silty clay with varying amounts of sand. Gravel, cobbles, and boulders were also present throughout the glacial till deposit and the tributary bed throughout the subject site.

Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Bedrock

Based on available geological mapping, the depth to bedrock across the site generally ranges from ground surface to 25 m. The depth to bedrock throughout the western portion of the tributary creek has been mapped to range between 15 to 25 m. Limestone of the Bobcaygeon formation is located throughout the majority of the subject site, with the exception of the western portion which is underlain by interbedded limestone and dolomite of the Gull River formation.

Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for the details of the soil profiles encountered at each test hole location and Drawing PG5201-1 - Bedrock Contour Plan in Appendix 2 for approximate bedrock contours based on refusal elevations.

Groundwater

Groundwater levels were recorded at each borehole instrumented with a piezometer and as noted upon completion of the test pits. The long-term groundwater can be estimated based on these observations, recovered soil samples' moisture levels, and observed colouring and consistency of the recovered samples. Based on these observations, the long-term groundwater level is anticipated at a depth of approximately **3 to 4 m** below ground surface.

The recorded groundwater levels are noted on the applicable Soil Profile and Test Data sheet presented in Appendix 1. It should be noted that groundwater levels are subject to seasonal fluctuations and could vary at the time of construction.

3.0 Slope Stability Analysis

3.1 Slope Conditions

The existing slope conditions were reviewed by Paterson field personnel throughout multiple site visits. The initial visit was completed on April 18, 2012, to document the conditions of the tributaries to Cardinal Creek (south tributary, Mid Branch 1 and Mid Branch 2). A second site visit was completed on September 10, 2022. At the time, it was concluded that the slopes along the tributaries to Cardinal Creek were observed to be stable. However, some toe erosion was noted throughout the watercourse, close to the valley corridor wall.

A third site visit was completed on July 12, 2023, to compare the current conditions with previous observations made at the subject site. Photos comparing the previous and current conditions have been included in Appendix 2.

The field review completed during the aforementioned visits generally consisted of observing surface conditions along the length of the tributaries, including identifying the presence of vegetation, erosion and other features associated with slope stability. Paterson field personnel verified subsurface information and in-situ shear strength of cohesive soils at select slope sections using a hand-auger and field vane apparatus, respectively, to compare them to the findings from our borehole and test pit test hole observations.

Water levels and flow within the watercourses were generally observed, including identifying signs of recent high-water marks or other signs of previous rises in the water levels.

Overall, a total of twenty-three (23) slope cross sections throughout the above-noted locations were analyzed as part of the slope stability analysis. Topographic surface elevation measured at the selected locations and LiDAR information were used to complete the slope stability analysis.

Based on the results of our field observations and slope stability analysis, a Limit of Hazard Lands was assigned from the top of slope for the above-noted sections of the study areas. The cross-section locations and topographic mapping information are presented on Drawing PG5201-1 - Test Hole Location Plan in Appendix 2.

3.2 Summary of Field Observations

The following section is a summary of our observations during the time of our field review of the subject slopes.

The subject site is intersected by a number of watercourses including the south tributary ravine that drains into Cardinal Creek and two branches opening from the aforementioned tributary designated in this report, from south to north, as Mid Branch 1 and Mid Branch 2. The south tributary was observed to flow in east to west direction throughout the central portion of the subject site and the two branches were observed to flow from a southeast to a northwest direction.

The general slope of the bank was observed to range between 3 to 15 m high and appeared to have a profile generally shaped 5H:1V with local sections with approximate steepness of up to 1H:1V. The watercourses were observed to be up to 6 m wide, with seasonal variations in water flow.

The majority of the slope appeared to consist of stiff, brown silty clay, which was underlain by firm, grey silty clay in close proximity to the water level. Some erosion of the toe of slope had been observed where the watercourse is located in close proximity to the valley corridor wall. This generally consisted of some erosion of the bank face resulting in some undercutting along the channels edge at some locations. Occasional shallow and low slip surfaces restricted to close proximity to the water level were observed in areas with sharp bends in the channel alignment. Overall, vegetation was observed to be intact and mature across the majority of the tributary valley. The bed of the water course generally observed to consist of glacial till and transition to stiff, grey silty clay further downstream along its footprint.

Reference should be made to Drawing PG5201-2 – Test Hole Location Plan in Appendix 2 which depicts the above-noted tributaries and the associated slope stability cross-sections and setback information.

3.3 Slope Stability Analysis

A slope stability assessment has been conducted to determine the applicable geotechnical Limit of Hazard Lands setback along the north bank of the main tributary to Cardinal Creek within the subject site. 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 favoring 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 that 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.

A total of twenty-three (23) slope cross-sections were analyzed under static and seismic conditions. The cross-sections for existing and proposed conditions were analyzed utilizing the latest topographic mapping and proposed grading, respectively, and assuming the worst-case-scenario by assigning cohesive soils under fully saturated conditions.

Subsoil conditions at the sections were determined based on the findings at borehole locations along the top of slope, field observations during site visits and general knowledge of the area's geology. The soil parameters were determined for the slope soils based on subsoil conditions at the boreholes along the top of slope. The analysis was carried out in accordance with the City of Ottawa's standard guidelines prepared by Golder Associates titled Slope Stability Guidelines for Development Applications in the City of Ottawa, dated 2004.

The effective strength soil parameters used for static analysis were chosen based on the subsoil information recovered during the geotechnical investigation. The effective strength soil parameters used for static analysis are presented in Table 3 on the following page.

Table 3 - Effective Soil and Material Parameters (Static Analysis)

Soil Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Brown Silty Clay Crust	17	36	9
Grey Silty Clay	16	36	12
Glacial Till	20	33	1
Bedrock	Impenetrable		

The total strength parameters for seismic analysis were chosen based on the in situ, undrained shear strengths recovered within the test holes completed at the time of our geotechnical investigation and based on our general knowledge of the area's geology. The strength parameters used for seismic analysis at the slope cross-sections are presented in Table 4 below.

Table 4 - Total Stress Soil and Material Parameters (Seismic Analysis)

Soil Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Undrained Shear Strength (kPa)
Brown Silty Clay Crust	17	-	100
Grey Silty Clay	16	-	80
Glacial Till	20	33	N/A
Bedrock	Impenetrable		

Static Conditions Analysis - Existing Conditions

The results for the existing static slope conditions at the slope stability sections are presented in Appendix 2. The slope stability factors of safety were found to be greater than 1.5 at all sections analyzed, except for Sections F and JJ, which require a 4.7 and 17 m setback, respectively from top of slope to obtain a factor or safety greater than 1.5.

Static Conditions Analysis - Proposed Conditions

The results for the analysis of the stability of the slope under proposed conditions are presented in Appendix 2. The slope stability factors of safety were found to be greater than 1.5 at all sections analyzed.

Seismic Loading Analysis - Existing Conditions

An analysis considering seismic loading was also completed as part of our slope stability assessment. A horizontal seismic acceleration, K_h, of 0.21g was considered for the analyzed section and discussed further in Section 4.2.5 of this report.

This acceleration is considered to be higher than half of the peak (horizontal) ground acceleration (PGA) of 0.312g (and near the regional PGA of 0.32g), specified in the National Building Code of Canada (NBCC 2015) Seismic calculator for the subject site. The above-noted specified PGA is considered to have a probability of exceedance of 2% in 50 years (i.e.,1:2,475 years) for the subject site. Based on a trendline considering the PGA values assigned for different probabilities of exceedance, a PGA equal to 0.21g may be approximately estimated to be equivalent to a probability of exceedance of 4% in 50 years (i.e., 1:1,250 years).

A factor of safety of 1.1 is considered to be satisfactory for stability analysis including seismic loading (i.e., pseudo-static) as per the City of Ottawa's Slope Stability Guidelines for Development Applications. The results of the analysis including seismic loading fully saturated conditions (worst-case-scenario) are shown in Appendix 2. The overall slope stability factor of safety at all slope cross-sections when considering seismic loading was found to be greater than 1.1 which is considered to be stable under seismic loading.

Seismic Loading Analysis - Proposed Conditions

An analysis considering seismic loading was completed for the proposed conditions as part of the slope assessment. A horizontal seismic acceleration, K_h, of 0.16g was considered for the slopes. This acceleration is considered as half of the peak (horizontal) ground acceleration (PGA) of 0.32g, specified in the NBCC 2015. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The results of the analysis including seismic loading fully saturated conditions (worst-case-scenario) are shown in Appendix 2. The overall slope stability factor of safety at all slope cross-sections when considering seismic loading was found to be greater than 1.1 which is considered to be stable under seismic loading.

Limit of Hazard Lands

Based on our review, the slopes reviewed as part of this assessment are considered stable from a geotechnical perspective. Since the slopes are in close proximity to an active watercourse, erosion of the toe of slope is considered to be a notable factor in assessing slope stability. The banks abutting the watercourse were observed to be affected by minor signs of erosion. Signs of active erosion were mostly noted in the lower portion of the slopes and consisted of occasional small patches of loss vegetation or exposed root systems along the face of slope.

Generally, subsurface conditions at the toe of slope varied between in-situ, stiff, brown to grey silty clay. Based on the cohesive nature of the soils, the observed current erosional activities and the width and location of the current watercourse, the toe erosion allowance for the valley corridor slopes was determined.

Based on the above-note observations, and in accordance with the City of Ottawa's *Slope Stability Guidelines for Development Applications* (2004) and the Ministry of Natural Resource's *Technical Guide – River and Stream Systems: Erosion Hazard Limit* (2002), it is considered that a toe erosion allowance of 5 m is appropriate for the corridor walls confining the subject tributaries. The toe erosion allowance should be applied from the top of stable slope.

If portions of the slope were to be improved by the use of erosion protection methods, those portions would not be subject to the aforementioned toe erosion allowance as the toe of slope would no longer be susceptible to erosion that would impact the stability of the overlying slopes.

A stable slope allowance in accordance with the requirements outlined for Section F and Section JJ should also be taken from the top of slope, as required.

The limit of hazard lands, including a 6 m erosion access allowance, stable slope allowance (where required) and a 5 m toe erosion allowance, is presented on Drawing PG5201-2 - Test Hole Location Plan in Appendix 2.

3.4 Seismic Design Considerations

Based on the results of the geotechnical investigation, a seismic **Site Class D** is considered applicable for foundation design within the area of the subject site as per Table 4.1.8.4.A of the OBC 2012.

The soils underlying the proposed foundations are not susceptible to liquefaction. Reference should be made to the latest revision of the 2012 Ontario Building Code for a full discussion of the earthquake design requirements.

4.0 Landslide Hazard and Risk Assessment

4.1 General Methodology of Assessment

The methodology for the landside hazard assessment undertaken for this report may be considered as the following:

- ❑ Identify factors that are documented to contribute to the susceptibility for a landslide to occur throughout sloped terrain.
- ❑ Relate the aforementioned factors to the susceptibility for a landslide to occur throughout the subject site.
- ❑ Estimate the probability of a landslide to occur throughout the subject site based on historical regional landslide inventories. A baseline regional probability will be adjusted to a site-specific probability considering the site-specific factors that may promote landslide susceptibility using a Frequency Estimation Method.

If the hazard under consideration cannot be demonstrated to have an annual probability of less than 1:10,000, a group risk assessment estimating the annual probability of loss of lives would be carried out in accordance with the following equation:

$$\text{Risk} = P(H) \times P(S{:}H) \times P(T{:}S) \times V \times E$$

Where R represents the risk or annual probability of loss of life of an individual, P(H) stands for the annual probability that a landslide occurs, P(S:H) indicates the probability of impacting the elements taking into consideration the scale and location of the landslide events, P(T:S) is the temporal spatial probability of the elements being present at the time of a landslide (i.e.- the probability that a person is present at the location at risk), V represents the vulnerability, or likelihood of death or permanent injury of the individual given they are impacted and E represents the number of elements that would be impacted. The variable E can also be considered equal to the number of occupants for grouped areas.

4.2 Factors Affecting Landslide Susceptibility

The following sections discuss factors understood to affect the potential for a landslide to occur. The factors are described briefly and subsequently discussed on their impact to the susceptibility of a landslide throughout the subject site. The study area for the purpose of this discussion is considered as the area bound by the area considered by the Geological Survey of Canada under Open File 5311. The property discussed throughout this report is considered the subject site.

4.2.1 Overburden and Clay Sensitivity

Based on the findings of the geotechnical investigation, the slope profiles throughout the subject site consist primarily of a silty clay deposit inferred to be underlain by bedrock. Based on geological mapping undertaken by the Geological Survey of Canada under Open File 5311, the local deposit is considered to be formed by offshore marine sediments in the form of preserved erosional terraces.

The clay deposit encountered throughout the subject site was observed to consist of a very stiff, weathered, brown clay crust extending to depths between 0.9 and 5.9 m below the ground surface. Shallower (i.e., less than 2.0 m in depth) deposits of clay were typically observed to be underlain by compact to dense deposits of glacial till, and not by unweathered, grey silty clay. Sand, with the exception of imported or re-worked site-generated soil fill material, was not encountered above the clay deposit to form a “sand cap” layer as has been documented throughout the Ottawa Valley.

Average undrained shear strengths for the upper and lower weathered and unweathered portions of the clay deposits were estimated to be approximately 210 and 60 kPa, respectively. The remoulded shear strength for the lower unweathered grey clay deposit ranged between 4 (BH 44-12) and 10 kPa. The clay deposits sensitivity (i.e., ratio between undrained and remoulded shear strength) was estimated to range between 4 and 16.

Review of landslides inventoried under Geological Survey of Canada (GSC) Open Files 5311, 7432 and 8600 document approximately 132 large landslide footprints throughout the Ottawa region. Review of the surficial geology for land adjacent to the landslides inventoried by the above-noted sources indicated approximately 83% (i.e., 109 out of 114 landslides captured by the study area published in OF5311) of these landslides may have originated from marine deposits consisting of clay. The remaining five landslides were considered to have consisted of alluvial sediments and/or organic deposits. Based on this, retrogressive landslides throughout the Ottawa region have historically occurred within clay soils, such as those encountered throughout the subject site.

It has also been documented that the retrogression of landslides might be predicted by the undrained and remoulded shear strength values measured in the silty clay unit. Mitchell & Markell (1974) studied the characteristics of landslides in silty clay soils associated with river valleys. Their study, based on 41 documented landslides located within Eastern and Northern Ontario, indicated that Taylor’s stability number can be used as an indicator to evaluate the susceptibility of landslides to occur. Taylor’s stability number (Ns) is defined as:

$$N_s = yH/S_u,$$

where y represents the bulk unit weight of soil (kN/m^3), H is the slope height (m), and S_u depicts the peak undrained shear strength of the silty clay (kPa). Mitchell & Markell (1974) determined that N_s should be greater or equal to 6 for the potential of retrogression to occur. Based on the in-situ field investigation testing information, the data suggests there is potential for retrogression of a slope failure throughout the subject site if a slope failure was triggered throughout the clay overburden.

It should be noted that remoulded shear strength was not measured to be less than 5 kPa, which is higher than the 1 kPa threshold commonly considered for identifying landslide susceptibility. While plasticity testing has not been complete throughout deeper portions of the clay deposit, there is sufficient information to generally characterize the underlying deposit as “sensitive” given the estimated sensitivity ratios and high Ns factors. The presence of sensitive clay throughout the subject size varies due to the current drift thickness and variable subsoil conditions between the western and eastern portions of the subject site. This is discussed further in subsequent sections of this report.

Based on the above, due to the presence of sensitive glaciomarine clay throughout the majority of the subject site (and along the subject tributary), there is potential for retrogression to occur should a slope failure be triggered. Based on this, the baseline probability discussed in Section 4.3 - Hazard Assessment will be multiplied by a factor of 2.0.

4.2.2 Slope Inclination, Bedrock Depth and Surface Relief

Overburden thickness, surface relief and slope inclination are understood to be significant factors contributing to the potential for a landslide. Landslide susceptibility mapping carried out throughout National Topographic System (NTS) area 31H correlated higher values of drift thickness and surface relief to a higher rate of landslide incidence in Champlain Sea clays (Quinn, 2014). The study considered a weight of evidence approach which assigns a positive or negative weight for the ranges in these parameters with respect to the frequency of landslide occurrence.

A similar review was carried out to understand the relationship between overburden thickness, topographic relief, and angle of slope for landslides that have occurred throughout the study area (area comprised by OF5311). The results of our interpretation of the available information are summarized in Table 5, Table 6, and Table 7 below.

Topographic relief was interpreted using DEM provided by Google Earth. Relief was considered as the difference between the lowest and highest elevations and considering distances extending beyond a landslide footprint. Greater distances were considered where a landslide formed into a slope profile. Significantly large landslides could not be reasonably evaluated due to the highly variable topography beyond their footprint. The measure is considered subjective, however, appropriate based on the available topographic information for each of the landslides identified by OF5311, OF7432 and OF8600 and the purpose of this assessment.

Table 5 – Summary of Drift Thickness Throughout Historic Landslide Footprints

Drift Thickness (m)	Number of Incidences	%
0 to 1	0	0.0
1 to 2	0	0.0
2 to 3	0	0.0
3 to 5	0	0.0
5 to 10	8	7.0
10 to 15	7	6.1
15 to 25	34	29.8
25 to 50	49	43.0
50 to 100	16	14.0
Total Landslides Within Study Area	114	94.2
Total Landslides Documented by Open Files	121	

Note: Drift thickness interpreted using Google Earth and is considered subjective, however, appropriate based on the available information for each of the landslides identified by OF5311, OF7432 and OF8600 and the purpose of this assessment.

In summary, more frequent incidences of landslides occur in areas with more than 15 m of overburden and 10 m of topographic relief throughout the study area. Further, landslides were observed throughout the study area only where slopes ranged between 5 and 30 degrees. In a previous study, Goodings & Schofield (1985) assessed that for slopes with angles up to 30 degrees, slope failures would occur only for slopes with more than 10 m of topographic relief.

Based on the current test hole coverage and slope stability sections, it is anticipated that more than 15 m of overburden may be present west of Slope Stability Cross Section I and north of Cross Section NN. Further, up to 20 m of relief may be observed between the western boundary of the subject site and Slope Stability Cross Section OO. Between 12 to 14 m of relief may be observed between Slope Stability Cross Section O and NN.

Less than 10 m of relief may be observed throughout the remainder of the subject site, including the furthest extension of the tributaries mid-branch extending along the southwestern portion of the subject site (area of Slope Sections L and M). While the majority of the slope analyzed as part of our slope stability assessment yielded factors of safety exceeded local requirements for development purposes, slope geometry throughout the subject site is indicative of terrain that has potential for instability. Based on our review of LiDAR and topographic mapping, slopes are generally rectilinear and locally concave in shape, and range in inclination between approximately 5H:1V (11 degrees) and nearly 1H:1V (45 degrees).

Based on the above, the potential for a landslide as based on the above-noted factors is discussed in further detail in *Section 4.3 – Hazard Assessment* of this report. The baseline probability will be modified for each applicable combination of overburden thickness, topographic relief, and slope inclination understood to be located throughout the subject site in that portion of the report.

Table 6 – Summary of Topographic Relief in Historic Landslide Footprints

Topographic Relief (m)	Number of Incidences	%
<1	0	0.0
1-2	0	0.0
2-3	1	0.9
3-4	2	1.8
4-5	0	0.0
5-6	2	1.8
6-7	0	0.0
7-8	2	1.8
8-9	3	2.7
9-10	3	2.7
10-12	8	7.1
12-14	11	9.7
14-16	16	14.2
16-18	8	7.1
18-20	5	4.4
20-25	21	18.6
25-30	12	10.6
30-40	13	11.5
>40	6	5.3
Total Landslides Within Study Area Capable of Being Measured	113	93.4
Total Landslides Documented by Open Files	121	

Table 7 – Summary of Angle of Slope Throughout Historic Landslide Footprints

Angle of Slope (Degree)	Number of Incidences	%
0-5	0	0.0
5-10	6	5.3
10-15	16	14.0
15-20	20	17.5
20-25	13	11.4
25-30	4	3.5
Total Landslides Within Study Area Capable of Being Measured	59	48.8

4.2.3 Groundwater, Surface Drainage and Toe Erosion

Groundwater

Groundwater is understood to be a factor contributing to landslide susceptibility. Landslides throughout the Ottawa Valley have been understood to generally occur most frequently during the spring thaw, which results in seasonal increases in the depth of the groundwater table and porewater pressure. It has been documented that larger slopes typically fail by a combination of a downward gradient throughout the table lands and an upward gradient (artesian) throughout the bottom of the slope profile and along the channel (Hugenholtz and Lacelle, 2004).

Groundwater regimes with primarily downward gradients from the table lands to the watercourse typically have stronger stability attributes in resisting the potential for a slope failure. Groundwater regimes may be influenced by other factors, such as rising bedrock surfaces (Quinn et al., 2010). The combination of a temporary (seasonal) artesian groundwater table gradient throughout the lower portion of the slope and rising bedrock surface may significantly impact the stability of a slope.

Fully saturated slope conditions have been considered as part of our slope stability assessment in Section 3.1 of this report. Fully saturated slope conditions are anticipated to govern over the downward gradient conditions as a loading case from a slope stability perspective. The slope stability factors of safety were found to be greater than 1.5 at all sections analyzed with the exception of Sections F and JJ. An appropriate stable slope allowance has been incorporated as part of the Limit of Hazard Lands line depicted on Drawing PG5201-2 – Test Hole Location plan in Appendix 2 of this report.

While fully saturated conditions were considered as part of the slope stability analysis, this condition is considered to be a conservative estimate of the slope's stability given that it is interpreted the groundwater table is located at the interface between the weathered and unweathered clay layers for the clay deposit. It is expected a long-term local groundwater table dewatering of up to approximately 0.5 m will take place throughout the subject site as it becomes developed.

This localized long-term dewatering is anticipated as a result of the installation of buried services and a reduction in the amount of permeable surfaces through which surface water may infiltrate as a result of the proposed development. This local dewatering has been considered in our geotechnical report.

Based on this, given that groundwater conditions in the post-development condition are anticipated to be lower than in the pre-development condition, and that pre-development groundwater conditions did not impact the stability of the slopes form a geotechnical perspective, groundwater will not be considered as a factor in modifying the baseline probability discussed in Section 4.3 (i.e., factor of 1.0).

Surface Drainage

Surface drainage, or sheet drainage from the table lands towards the watercourse, can impact the stability of the subject slopes. Currently, in the pre-development condition, surface water generated from rain and snowmelt is handled by either ingress into the subsoils, or sheet drainage following local topography. The majority of the subject site is underlain by silty clay, which is a generally impervious material that does not permit high levels of ingress. Based on this, it is anticipated that the majority of the surface water is handled by sheet drainage, and likely across the table lands, valley corridor and into the watercourse.

In the post-development condition, the majority of the subject site is anticipated to be urbanized by buildings, roads and landscaped areas. The exception to this would be the area encapsulated by the Limit of Hazard Lands designation setback. This area forms an area where development would not be permitted given the nature of the slopes and results of analysis considering erosion potential, stability and temporary access for maintenance. The portion of the site beyond the Limit of Hazard Lands will be graded to promote drainage towards sewer infrastructure and infrastructure would be sized to attenuate peak runoff volumes that are currently handled by the subject site.

Based on this, sheet drainage between urban lots backing onto the Limit of Hazard Lands is expected to result in on-going sheet drainage between the urban area of the subject site and the valley corridor forming the creek. Since the majority of the subject site will be developed and sheet drainage would be primarily handled by the sewer infrastructure, the amount of sheet drainage the slope would handle in the post-development condition would diminish during peak events and normal conditions. However, since surface drainage will persist in the post-development due to the undeveloped nature of the area encapsulated by the Limit of Hazard Lands surrounding the tributary, the baseline probability discussed in Section 4.3 – Hazard Assessment will be multiplied by a factor of 1.5 to account for continued surface drainage in the post-development condition.

Toe Erosion

Landslides throughout the Ottawa Valley have been documented to occur most frequently adjacent to a watercourse. The formation of valley corridors by watercourses results in erosion along the toe of the slope and subsequent downcutting of the bank face by the erosional force of the watercourse. Sufficient downcutting, oversteepening and erosion of the slope can result in the instability of a slope and the potential for a landslide if a slope failure is triggered.

There is a relationship between stream flow (via flow accumulation) and landslide incidence such that larger landslides tend to be associated with larger watercourses (Quinn et al., 2010). In addition, the stream flow of a watercourse can be directly correlated to its stream order. Stream order is the degree of a tributary and branch streams with respect to an artery stream. Larger stream order values indicate the degree of closeness a stream is linked to the principal stream, whereas smaller values indicate the streams are considered to be distant tributaries from an artery stream. In summary, higher values of stream flow are correlated to higher degrees of stream order which are further correlated to older and fully developed watercourses. Smaller values of stream order are correlated to younger and less developed watercourses.

Generally, landslide density throughout the study area undertaken throughout NTS 31H was very low for streams up to order 3 and greater than or equal to order 9 (Quinn, 2009). The findings are similar for flow accumulation such that streams with less flow or smaller stream orders have a negative correlation with landslide incidence (Quinn, 2013). There is some evidence presented by a study area in Norway that younger streams have not fully developed their watercourse morphology and may be more erodible than larger, mature streams. However, the methodology undertaken to assess this for the study area of NTS 31H could not confirm this relationship for local and regional conditions at that time (Quinn, 2013).

Stream sinuosity was also explored as a variable impacting slope stability. Stream sinuosity is defined as the ratio of the total length along a stream segment to the shortest length between its endpoints (Quinn, 2013). Based on the review for the area of NTS 31H, it has been observed that landslides tend to be infrequent along streams with sinuosity lower than 1.338. Furthermore, channels with wider and more tightly spaced meander belts experience higher rates of erosion and are therefore more susceptible to landslides. Preferential occurrence of landslides in slopes situated on the outside of meander belts rather than in streams with low levels of sinuosity was similarly observed by Hugenholtz (2004).

A geomorphic study was undertaken by Geomorphic Solutions in 2007 for the Cardinal Creek watershed. The study considers the east-west running watercourse and its tributaries as part of this study. An excerpt of the study area and watershed footprint are depicted in Figure 1 for reference.

Tributaries TRH1, TRH2, TRH3, TRH4 and TRH5 are located throughout the subject site and are considered the areas of interest with regards to landslide susceptibility. TRH1, TRH2 and TRH4 would be considered the “south tributary”, “mid-branch 1” and “mid-branch 2” portions of the tributary discussed throughout this report, respectively. The study provided the following information with respect to the stream order and sinuosity for these reaches of the tributaries:

Table 8 – Summary of Geomorphic Assessment for Tributary H

Reach	Stream Order	Sinuosity	Length (m)
TRH1	1	1.02	939
TRH2	1	1.02	790
TRH3	2	1.01	827
TRH4	1	1.00	361
TRH5	1	1.03	1285

Note: Results provided by Geomorphic Solutions for Geomorphic Assessment of Cardinal Creek Subwatershed (2007)

The stream order and sinuosity of the south tributary and the mid-branches located throughout the subject site are considered less than values that would indicate an increase to landslide susceptibility.

However, there are notable signs of active erosion throughout the valley corridor during recent site visits by Paterson and GEO-Morphix. This includes active formation of localized slumps along the bank face, over-steepening of the bank and inability for vegetation to establish to reinforce against the active watercourse environment. Detailed observations pertaining to the active erosion and associated bank profile have been discussed in our Geotechnical Report and as noted in the Photographs from Site Visits in Appendix 1 of this report.

It should be understood that previous field reviews have included cursory field review of subsurface conditions by the use of visual observations of apparent subsurface conditions (i.e., areas where bare clay was present in valley floors, bank faces and areas of erosion) and by occasional hand-augers to confirm valley conditions. In general, the conditions observed throughout previous field visits is consistent with the information depicted on our slope stability cross-sections considered based on the subsurface information attained from previous rounds of test holes investigations.

Based on our review of recent and current LiDAR mapping (i.e., compare between 2006 and 2020 LiDAR), small, localized slumps continue to form throughout the valley in response to active erosion of the bank face. In the post-development condition flow conditions throughout the tributary are expected to slightly increase, however, peak flows are anticipated to be restricted and attenuated to minimize potential downstream impacts. Further, natural factors, such as beaver dams, which have formed downstream of the subject site, can result in unforeseen artificial raises in the creek levels and temporary saturation and subsequent draw-down along the bank face. Therefore, it is expected toe erosion will remain a notable factor impacting landslide susceptibility in the post-development condition.

It is expected the outfall area for the proposed stormwater management facility (SWMF) located at the southwestern portion of the northern side of the tributary will be provided with erosion protection for the channel that will be constructed between the headwall and the creek. The erosion protection, which will be advised by Paterson and the project geomorphologist, will be planned to provide sufficiently hydraulically sized to provide protection to the underlying soils from active erosion during peak discharge events, as well as to be provided such that long-term maintenance of the drainage channel would be minimal and be able to remain in place for the service life of the pond.

Since there are notable signs of erosion during each of our site visit, active erosion continues to result in the development of localized slumps, and toe erosion is one of the most common triggers for local slope failures and previous historical landslides, the baseline probability will be multiplied by a factor of 2.0 to consider future toe erosion. This is discussed in further detail in *Section 4.3 – Hazard Assessment* of this report.

4.2.4 Proximity to Landslides

Landslide inventory mapping published by GSC indicates the presence of potentially up to 4 landslides in proximity to the subject site. The proximity of land to previous landslides has been documented as a significant factor in assessing the susceptibility of potential for future landslides. It had been assessed that the likelihood of the nearest adjacent landslides being within a specified distance ranging between less than 50 and 2,000 m being between 49.2 and 96.7% (Quinn et al., 2011).

This pattern explains that future landslides are more likely in areas that have experienced previous landslides than in areas where no past landslides exist. This was observed by Hugenholtz (2004) in their review of Green's Creek and the concentration of landslides to re-occur in concentrated areas along the creek alignment.

It is understood up to potentially five landslides have been documented within 2 km of the subject site. Two of these landslides, Oln17 and Oln18, intersect the southwestern boundary of the subject site. Both Oln17 and Oln18 have been reported by GSC to have retrogressed into their respective sides of the incised valley of a tributary of Cardinal Creek (GSC OF8600, 2019) and are depicted on Figure 2 for reference. Oln15 and Oln16 are located within 500 m of the westernmost boundary of the subject site. Oln15 is considered a "probable landslide" which may have retrogressed into the scarp slope above a terrace surface of the proto-Ottawa River (OF8600, 2019). Cmb1 is located 2 km from the northeastern boundary of the subject site and retrogressed into a scarp slope along the south side of the Ottawa River.

The area of Oln15 and Cmb1 was measured to have approximately 19 to 21 m of topographic relief and a relatively steep (i.e., over 20 degrees) slope along their flank. The areas adjacent to Oln17 and Oln18 were measured to have up to approximately 11 degrees of slope inclination and up to 9 m of relief along their footprints.

Oln16 retrogressed into the western side of the incised valley of Cardinal Creek and has been heavily altered by urban development (OF8600). The area of Oln16 experiences approximately 14 to 16 m of topographic relief and is incised by a creek identified as having a stream order of 4 and sinuosity of 1.39 (Geomorphic Solutions, 2007). Drift thickness throughout the area of Oln15 and Oln16 range between 25 to 50 m. Oln17 and Oln18 has been documented by GSC OF5311 as having a drift thickness ranging between 15 to 25 m.

Based on our review of subsoil information for the area around Oln17 and Oln18, it is not anticipated subsoils conditions throughout those scars is representative of conditions throughout the entirety of the subject site. Based on our current test hole information and associated mapping, drift thickness is higher throughout these scars than throughout the majority of the subject site.

The higher drift thickness is typically characteristic of areas with deeper deposits of sensitive clay, greater depth to bedrock and glacial till (i.e., formations that are not as sensitive to erosion and landslide susceptibility) and greater topographic relief. These conditions are generally only similar for the portion of the subject site located throughout and west of the proposed SWMF and throughout the northern portion of the subject tributary.

While topographic relief may be similar throughout the southern half of the tributary, drift thickness is measured to be decreasing towards the south of the tributary, and consequently results in shallower overburden along the southern half of the tributary. Based on that, surface and subsoil conditions similarities throughout the subject site and areas of previous failures are anticipated to be concentrated throughout the south-western corner of the northern half of the tributary within the subject site.

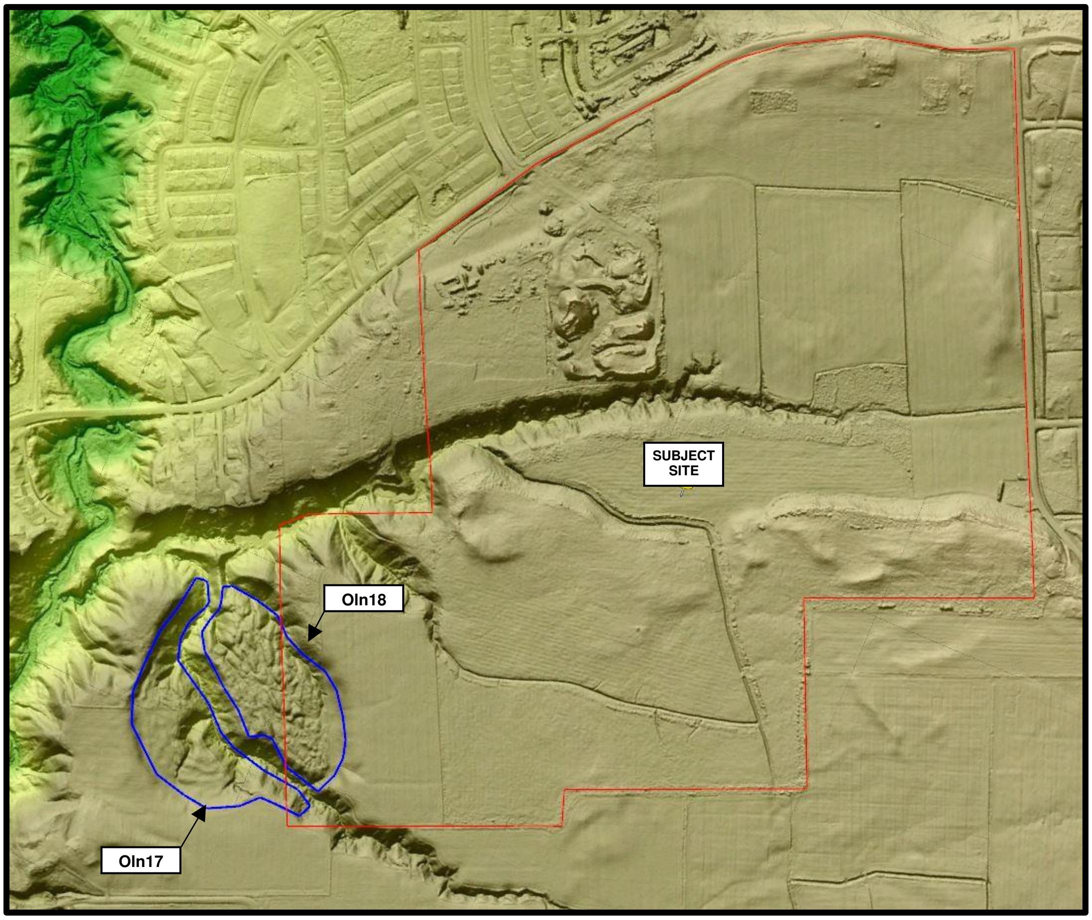

Figure 2 – LiDAR Image of Subject Site and closest landslide and slope failure.

Further to the above-noted large-scale landslides that have occurred within the vicinity of the subject site, recent small-scale and localized slumps have formed in recent years in response to active erosion and sheet drainage. Given the high concentration of local small- and large-scale landslides throughout the area and within the subject site, it is considered appropriate to increase the baseline probability for landslides to occur throughout the subject site by a factor of 2 in *Section 4.3 – Hazard Assessment* of this report.

4.2.5 Earthquakes and Seismic Hazards

Earthquakes are understood to be a major contributing factor in triggering some of the largest landslides inventoried throughout Champlain Sea clay deposits. Many large landslides have been estimated to have occurred approximately 4,550 years before present (BP) and another significant cluster approximately 7,060 years BP (GSC OF7432, 2021; Aylsworth and Lawrence, 2003). The lower bound of these paleo-earthquakes have been estimated to have consisted of M5.9 to M6.0 earthquakes. Several landslides were triggered by the 1663 M7 Charlevoix and 2010 Val-des-Bois M6.2 earthquakes.

The behavior of clay slopes during earthquakes is uncertain and is a topic of current research. Current research suggests that large earthquakes can propagate failures along pre-existing or partially developed planes of weakness along the slope footprint. The critical length of the propagation is understood to be influenced by the sensitivity and fracture toughness, or brittleness, of the clay deposit (Quinn et al. 2012).

The slopes and clay deposit throughout the subject site have been subject to large historic earthquakes that may have triggered significantly large historic landslides throughout the Ottawa Valley. Earthquake-induced landslides generally occur where the potential for slope failures already exists and has generally been assessed as part of our slope stability analysis. Pseudo-static (seismic) loading of the slope profiles considered a PGA of 0.21g and resulted in factors of safety exceeding 1.1 as discussed in Section 3.0 of this report. This PGA is considered equivalent to a 1:1,250-year earthquake event. This value is considered suitable for assessing the stability of the subject slopes when subject to loading that may be associated with earthquakes experienced locally.

Further, larger landslides are understood to be associated with clay deposits with remolded shear strength measurements equal to or less than 1 kPa (Quinn et al., 2011). It would be expected that clay deposits with such low values of remolded strength to be conducive to propagating planes of weakness and unable to resist high earthquake loads. Review of our test hole coverage indicated that remolded shear strength values typically exceed 5 kPa within the subject site and are therefore above the threshold associated with landslide susceptibility. Based on this, it is not expected a significant shear band would propagate throughout the slopes located throughout the subject site that would increase landslide susceptibility due to earthquake loading.

This conclusion may be extrapolated further to the potential for sources of subsurface vibrations such as those associated with building construction, compaction equipment, general earthworks equipment, and installation of temporary shoring. These sources of vibrations are not anticipated to exceed or be close to the magnitude of vibrations associated with the assessed earthquake load of 0.16g. Further, local hazard peak-ground acceleration values for the subject site for a 2% exceedance is considered to be 0.316, which is less than the regionally accepted value of 0.32. This suggests that the area of the subject site has a marginally reduced seismicity than would be considered for the Ottawa region in general.

Given the above, earthquake loading is not anticipated to have a significant impact on local landslide susceptibility and will be considered a slightly notable factor in the calculation of the baseline probability (<u>i.e., multiplied by a factor of 1.1</u>).

4.2.6 Sources of Anthropogenic/Construction Vibrations

It is anticipated that the underlying clay deposit will experience vibrations from several sources during the construction phase of the proposed development. Since the currently proposed development is anticipated to consist of a residential development, foundations for the proposed low- to mid-rise structures are anticipated to consist of conventional spread footing foundations. These types of foundations will be able to be constructed using conventional construction methods and will not require the use of equipment that may cause larger vibrations, such as pile drivers and caissons.

It is expected some higher amounts of vibrations may result from site servicing works that would be located below the bedrock surface throughout portions of the subject site where the bedrock formation is within approximately 2 to 3 m of the existing ground surface. In these areas, Once the excavation reaches the bedrock surface, bedrock removal would be required using a combination of line-drilling, hoe-ramming and blasting. In the City of Ottawa, vibrations resulting from blasting measured at nearby structures is limited to a peak particle velocity of 25 mm/s. Attenuating and limiting vibration potential in accordance with local guidelines is expected to provide limitations against the potential for blasting to generate significantly high magnitudes of vibration that could trigger localized slope failures.

Other sources of vibration throughout the construction phase would be much lower than those associated with blasting and surficial. These would be generated from heavy-truck traffic, operation of heavy-machinery, displacement of material and compaction of fill by vibratory compactors. It is expected the vibrations associated with these efforts would be dampened by the subsoils such that they would not result in a meaningful impact to the stability of slopes along the tributary.

The above-noted peak particle velocity ranges suggest that the vibrations that would be experienced by the clay deposit during the construction program would be comparable to those considered for a seismic hazard with an annual probability of 1% of exceedance. Based on this, the vibrations associated with the construction program would be comparable to an earthquake yielding a horizontal peak ground velocity of 0.025g, and far less than those considered in our slope stability analysis for seismic conditions (considered PGA of 0.21g, over 8 times higher).

There is potential for earthworks to require the use of land located in close proximity to the edge of the table lands, and as has been observed in recent years and as is observable on aerial images taken of the subject site. These types of works are anticipated to consist of occasional and temporary stockpiling of soil fill and other materials.

This type of work will induce stress onto the underlying slope if stockpiling occurs in close proximity to the table lands and would be periodically monitored and advised upon by Paterson during the construction phase to minimize impacts onto the underlying slopes.

The location of the future SWMF is located in an area that is considered favorable with regards to reducing landslide susceptibility throughout the subject site. The SWMF will provide a significant stress reduction to the underlying soils supporting its footprint since it would consist of removing approximately 6 m of soil across the pond's footprint. The area of the proposed SWMF is in an area where drift thickness is in the higher range (i.e., 12 to 15 m) and would result in a condition that is less comparable than in the area of previous failures.

Based on our review of slope stability analysis results considering finished grades and the post-development condition (also considering fully saturated conditions), the post-development condition is not anticipated to result in affecting the stability of the subject slopes or increasing susceptibility for landslides to occur throughout the subject site. Recommendations will be provided in the geotechnical report to limit the types of features rear yards backing onto the table lands may consider (i.e., limiting grade raises, above-ground structures such as pools and decks, drainage features, etc.) and to mitigate enabling conditions that would affect the stability of the subject slopes.

Based on the above-noted discussion, while the construction phase is not anticipated to be a major contributor to landslide susceptibility given the above-noted discussion, <u>the baseline probability will be adjusted by a factor of 2.0</u> to consider unknown potential effects the construction program could impose onto the slopes along the tributary during that phase of the development.

4.3 Hazard Assessment

Frequency Estimation Method

Approximately 132 individual landslides have been identified between GSC files OF8600, OF7432 and OF5311. The study area between these files considers an approximate surface area of approximately 11,800 km^2. This surface area may be decreased to approximately 6,845 km^2 when neglecting the area comprised of bedrock.

The study area was reduced accordingly to consider the absence of Champlain Sea marine deposits throughout areas of bedrock outcrops and where overburden is not present. An average landslide density of 1.9x10^{-2} per km^2 may be extrapolated from this information.

Based on the information provided in OF5311, landslides have not been recorded to have originated from areas comprised of till or glaciofluvial deposits. The study area may be therefore reduced further to approximately 5,354 km^2 and consisting of nearshore and offshore marine deposits, alluvial sediments, organic deposits, and sand dunes. The surficial deposits are considered susceptible to a landslide given their vulnerability to failure by the factors discussed in the preceding sections of this report. Based on this, the baseline landslide frequency, and probability, may be considered as $2.5x10^{-2}$ per km^2 throughout the study area.

The estimated density may vary notably across the study area given that many landslides generally occurred in localized clusters. The distinct clusters of landslides are likely indicative of conditions that are more conducive to landslide hazards in localized zones rather than the entire study area. However, this is considered appropriate as an average density for the purpose of this assessment.

The temporal frequency of landslide occurrence may vary substantially across the study area. OF7432 sought to carbon date 45 separate landslide features throughout the study area. The landslides interpreted by that study documented landslides having occurred potentially between approximately 90 to 7,140 years before present.

The results from the study and approximations provided by OF8600, neglecting the potential deviation and range of uncertainty, are summarized in Figure 3 below.

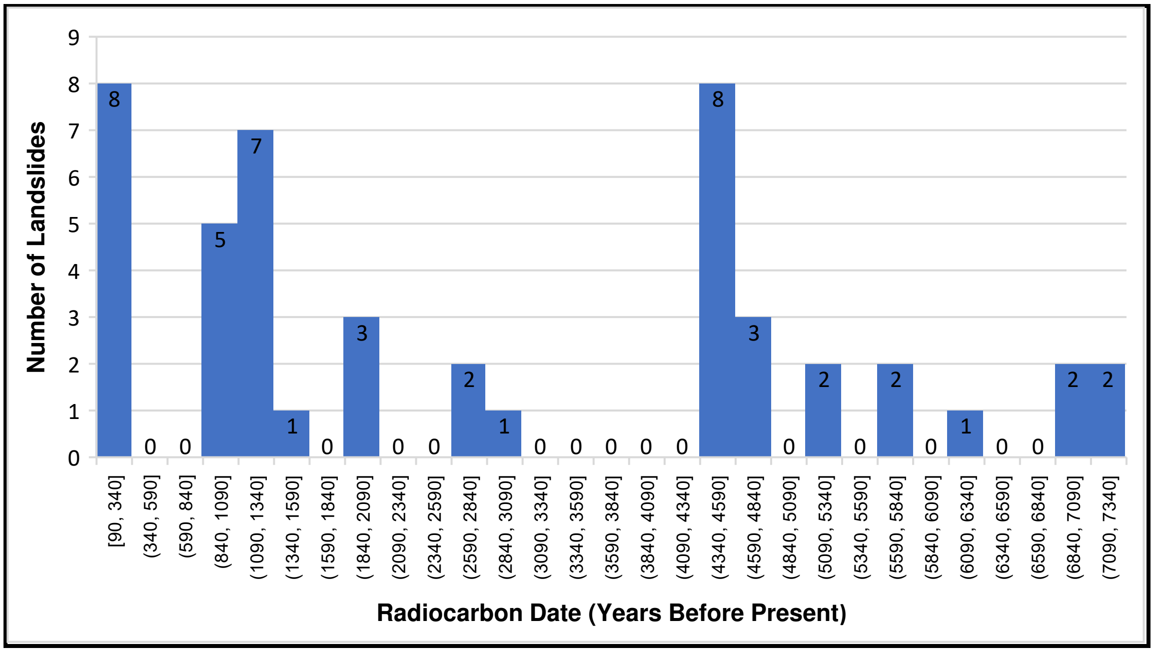

Figure 3 - Summary of Carbon-dated Landslides (GSC OF7432)

Temporal factors such as periods of increased earthquakes and climatic factors affecting these frequencies have been explored by others. Based on the above, more than half of the carbon dated landslides have occurred within the past 3,090 years, and over a quarter within the past 1,090 years.

Quinn et al. (2011) proposed a conservative lower bound of 500 years as a return period for the study area of NTS 31H. This value could be considered appropriate throughout the subject site based on the information presented above. However, the study area of NTS 31H considers a much higher density of landslides (i.e., 1,248 landslides over 75-80,000 km^2) than the study area considered for the subject site.

Based on this, a return period equivalent to the average frequency of landslides (i.e., 132 landslides over 7,140 years) provides a smaller lower bound return period of approximately one large landslide every 54.1 years. An upper bound return period of 2,500 years was indicated in Subsection 4.2 of this report. Then, a 54.1-year return period is within the previously defined range.

With a return period of 54.1 years, a baseline landslide probability of 4.6x10^{-4} landslides per km^2 and annum is calculated over the study area defined by the GSC files. Considering the area of the subject site (approximately 1.2 km^2), this baseline probability may be reduced to a site-specific baseline probability of 5.5x10^{-4} landslide per year. The baseline estimate would be then adjusted based on our assessment of site-specific factors that are known to have resulted in large, catastrophic landslides.

Based on our review of site-specific factors identified throughout this report, additional factors have been considered for adjusting the baseline probability to provide a site-specific landslide probability. Table 9 presents a summary of the above-noted Ottawa-wide probability being reduced to a site-specific probability, omitting the factors associated with drift thickness and topographic relief (which are summarized in the preceding paragraphs).

Table 9 – Summary of Site-Specific Baseline Probability Modification Factors

Baseline Probability for Landslide to Occur Throughout Subject Site	$5.5x10^{-4}$
Section 4.2.1. – Overburden and Clay Sensitivity	2.0
Section 4.2.2. – Inclination, Bedrock Depth and Surface Relief	
Inclination	Estimated Subsequent Tables
Bedrock Depth	
Surface Relief	
Section 4.2.3. – Groundwater, Surface Drainage and Toe Erosion	
Groundwater	1.0
Surface Drainage	1.5
Toe Erosion	2.0
Section 4.2.4. – Proximity to Landslides	2.0
Section 4.2.5. – Earthquakes and Seismic Hazard	1.1
Section 4.2.6. – Sources of Anthropogenic/Construction Vibrations	2.0
Modified Site-Specific Baseline Probability (Not Considering Drift Thickness, Surface Relief and Inclination Factors), $P_{Modified}$	**$1.4x10^{-2}$**

The weight factors for drift thickness, surface relief, and Inclination considered for the subject site are included in Table 10 to Table 12 included below.

Table 10 – Summary of Drift Thickness Weight Factors Applicable to the Subject Site

Drift Thickness (m)	**Weight Factor**
0 to 10	0.01
10 to 15	0.10
15 to 25	0.50
25 to 50	1.00
50 to 100	2.00

Table 11 – Summary of Surface Relief Weight Factors Applicable to the Subject Site

Surface Relief (m)	**Weight Factor**
0 to 8	0.01
8 to 12	0.10
12 to 15	0.50
15 to 20	1.00
20 to 30	2.00
> 30	5.00

Table 12 – Summary of Inclination Weight Factors Applicable to the Subject Site	
Inclination (Degrees)	**Weight Factor**
0 to 10	0.01
10 to 20	0.10
20 to 25	0.50
25 to 30	1.00
30 to 35	1.50

Considering these factors, the tributary may be divided into several areas with distinct attributes associated with the above-noted weight factors and as depicted below:

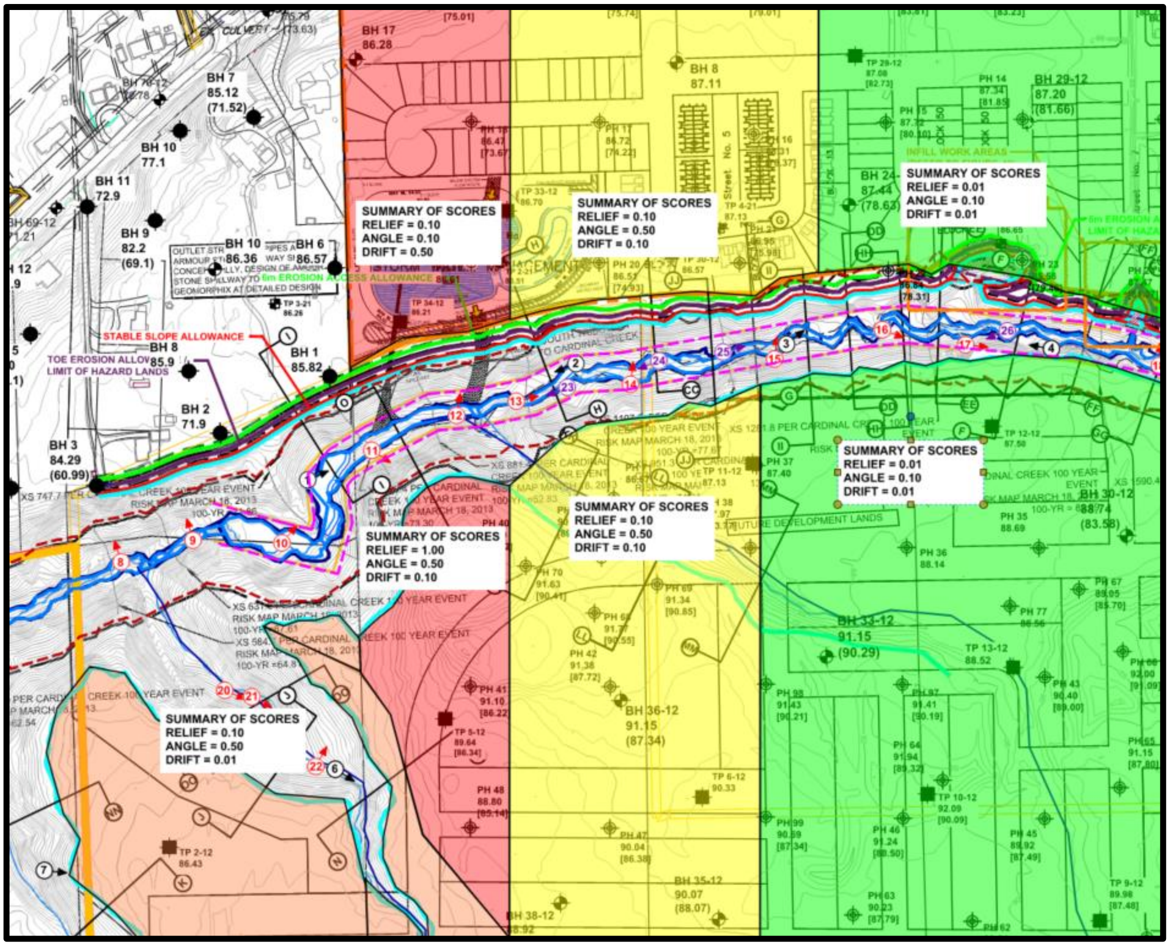

Figure 4 - Summary of Drift Thickness, Surface Relief and Slope Angle Weight Factors

Based on this, the probability for a landslide to occur throughout a portion of the subject site would be the cumulative site-specific probability which has been adjusted for the drift thickness, topographic relief and slope angle weight factors for that portion of the subject site. The probability for the north and south portions of the subject tributary are provided below

Northern Portion of Tributary

For the northern portion of the tributary, the factors for drift thickness, topographic relief and slope angle vary as indicated in Figure 4 above and per Drawing PG5201-1 – Test Hole Location Plan appended to this report. The probability for a landslide to occur throughout this portion of the subject site may be considered as follows:

$$P_{\text{Landslide for North Tributary}} = (P_{\text{Modified}})\text{x}(\text{Factors for Green Area}) + (P_{\text{Modified}})\text{x}(\text{Factors for Yellow Area}) + (P_{\text{Modified}})\text{x}(\text{Factors for Red Area})$$

P_{Modified}, which is $1.4\text{x}10^{-2}$, or 1 in 70 and provided at the end of Table 9, is a modified site-specific probability which has not been further modified to consider the weights associated with drift thickness, topographic relief and slope angle. Since these site attributes vary along the tributary, the associated weight would be modified for those portions of the tributary that are associated with those attributes. These attributes, as discussed in Section 4.2.2. of this report are notable in evaluating the potential for a landslide to occur.

Based on this, the probability for a landslide to occur throughout the northern portion of the subject site may be considered as **1 in 8,626 per year**.

Southern Portion of Tributary

For the southern portion of the tributary, the factors for drift thickness, topographic relief and slope angle vary as indicated in Figure 4 above and per Drawing PG5201-2 – Test Hole Location Plan appended to this report. The probability for a landslide to occur throughout this portion of the subject site may be considered as follows:

$$P_{\text{Landslide for South Tributary}} = (P_{\text{Modified}})\text{x}(\text{Factors for Green Area}) + (P_{\text{Modified}})\text{x}(\text{Factors for Yellow Area}) + (P_{\text{Modified}})\text{x}(\text{Factors for Red Area}) + (P_{\text{Modified for No Toe Erosion}})\text{x}(\text{Factors for Orange Area}) + (P_{\Delta})\text{x}(\text{Factors for Orange Area})$$

It should be noted that since the portion of the subject site identified in orange on Figure 4 and Drawing PG5201-1 – Test Hole Location Plan is not subject to active toe erosion as the remainder of the tributary would be, the toe erosion factor is considered 0.5 rather than 2.0 and as indicated in Table 9 for Toe Erosion. This would result in a $P_{\text{Modified for No Toe Erosion}} = 3.6\text{x}10^{-3}$, or 1 in 277 and ($P_{\Delta}$) for a 1:117 return period.

Based on this, the probability for a landslide to occur throughout the northern portion of the subject site may be considered as **1 in 2,469 per year**.

Landslide Susceptibility Mitigation and Probability Reduction

Reviewing the above-noted parameters affecting susceptibility, the most prevalent trigger in initiating slope failures that can result in landslides and further in retrogressive landslides is considered to be toe erosion.

The remaining factors are considered to be either innate to the property (i.e., sensitivity of clay deposit, depth to bedrock, proximity to landslides and watercourse, sensitivity to vibrations from construction and earthquakes) or uneconomical to sufficiently reduce the hazard probability (i.e., slope inclination and surface relief). Based on this, toe erosion protection could be considered a suitable strategy to reduce erosion potential of the bank face supporting the overlying slope and further reduce the potential for a landslide to be triggered by a slope failure.

Toe erosion protection is commonly used throughout the Ottawa and Gatineau regions for mitigating erosion potential for soils in contact with active watercourses. The implementation of erosion protection would be advised by Paterson and the project geomorphologist to ensure the strategy would be implemented in a manner that is hydraulically compatible with the local drainage features, to mitigate downstream effects in increasing erosion potential to slopes located downstream of the subject site, and to minimize maintenance of the erosion protection measure.

Typically, the erosion protection measure would consist of a relatively thick layer of erosion protection stone, such as “rip-rap”, placed upon a layer of non-woven geotextile fastened directly into the slope profile. The erosion protection would extend between the base of the channel and to a pre-designated elevation (typically considered as 300 mm above the 1:100-year water level within the watercourse) and be dressed with bioengineering features to permit reinstatement of vegetation and naturalization of the channel in conjunction with providing features that would minimize degradation of the control measure over time. The measure would be designed to achieve the “100-year planning horizon” identified in the Ministry of Natural Resource’s *Technical Guide – River and Stream Systems: Erosion Hazard Limit* (2002).

At this time, Paterson has not prepared a detail outlining a site-specific recommendation for erosion protection that would be implemented throughout this subject site. If consideration is given to implementing the detail by the City of Ottawa and RVCA, Paterson can collaborate with GEO-Morphix and associated stakeholders in providing an acceptable solution to mitigating on-going toe erosion and reducing long-term landslide risk throughout the subject site.

In the event that toe erosion measures could be implemented at the base of portions of the subject slopes, hazard probability estimates would be considered to be revised as indicated in Table 15.

Table 15 – Summary of Site-Specific Baseline Probability Modification Factors Considering Implementation of Toe Erosion Measure

Baseline Probability for Landslide to Occur Throughout Subject Site Considering a **100-year Return Period**	**$3.0x10^{-4}$**
Section 4.2.1. – Overburden and Clay Sensitivity	2.0
Section 4.2.2. – Inclination, Bedrock Depth and Surface Relief	
Inclination	Estimated Subsequent Tables
Bedrock Depth	
Surface Relief	
Section 4.2.3. – Groundwater, Surface Drainage and Toe Erosion	
Groundwater	1.0
Surface Drainage	1.5
Toe Erosion	**0.45**
Section 4.2.4. – Proximity to Landslides	2.0
Section 4.2.5. – Earthquakes and Seismic Hazard	1.1
Section 4.2.6. – Sources of Anthropogenic/Construction Vibrations	1.5
Modified Site-Specific Baseline Probability (Not Considering Drift Thickness and Surface Relief Factors), $P_{\text{Modified for Erosion Protection}}$	**$1.8x10^{-3}$**

A return period of 100 years was considered since the most likely triggering factor for slope failure would be resolved by the implementation of an appropriate erosion protection measure. While the previously noted return period of 54.1 years was based on the number of inventoried landslides over several thousand years, the most prevalent trigger in the tributary’s existing condition would be toe erosion given the active nature of this factor.

Based on this adapted probability, the probability for a landslide to occur throughout the subject site would be considered as follows for the north and southern portions of the subject site.

Northern Portion of Tributary

For the northern portion of the tributary, the factors for drift thickness, topographic relief and slope angle vary as indicated in Figure 4 above and per Drawing PG5201-2 – Test Hole Location Plan appended to this report. The probability for a landslide to occur throughout this portion of the subject site may be considered as follows:

$$\begin{gathered}
P_{\text{Landslide for North Tributary}} = (P_{\text{Modified}})\text{x}(\text{Factors for Green Area}) + \\
(P_{\text{Modified}})\text{x}(\text{Factors for Yellow Area}) + \\
(P_{\text{Modified for Erosion Protection}})\text{x}(\text{Factors for Red Area}) + \\
(P_{\Delta})\text{x}(\text{Factors for Red Area})
\end{gathered}$$

The above-noted probability relies on the implementation of erosion protection at the base of the northern portion of the valley corridor of the tributary and meeting the guidelines identified in preceding portion of this report. Based on this, the probability for a landslide to occur throughout the northern portion of the subject site may be considered as **1 in 12,490 per year**.

Southern Portion of Tributary

For the southern portion of the tributary, the factors for drift thickness, topographic relief and slope angle vary as indicated in Figure 4 above and per Drawing PG5201-2 – Test Hole Location Plan appended to this report. The probability for a landslide to occur throughout this portion of the subject site may be considered as follows:

$$\begin{gathered}
P_{\text{Landslide for South Tributary}} = (P_{\text{Modified}})\text{x}(\text{Factors for Green Area}) + (P_{\text{Modified}})\text{x}(\text{Factors} \\
\text{for Yellow Area}) + (P_{\text{Modified for No Toe Erosion}})\text{x}(\text{Factors for Yellow Area}) + (P_{\text{Modified for} } \\
{}_{\text{No Toe Erosion}})\text{x}(\text{Factors for Red Area}) + (P_{\text{Modified for No Toe Erosion}})\text{x}(\text{Factors for Orange} \\
\text{Area}) + (P_{\Delta})\text{x}(\text{Factors for Orange Area, Red Area and Yellow Area})
\end{gathered}$$

The above-noted probability relies on the implementation of erosion protection at the base of the northern portion of the valley corridor of the tributary and meeting the guidelines identified in preceding portion of this report. Based on this, the probability for a landslide to occur throughout the northern portion of the subject site may be considered as **1 in 10,331 per year**.

Additional Discussion for Probability Reduction

In the event that toe erosion protection is not considered as an acceptable solution to reduce the potential for a landslide to occur throughout the subject site, the subject site would be subject to a risk assessment based on the current RVCA guidelines.

Based on this review, Paterson anticipates that the area located downstream of the subject site and west of the area identified in the above-noted figure has higher chances for a landslide to occur. This is based on the trend and expectation for the overburden thickness and slope heights to increase towards the west of the subject site and as the tributary joins the main Cardinal Creek artery.

However, since this area is located beyond the subject site and where site-specific geotechnical information is currently known, additional studies by others would be required to confirm the hazard probability beyond the subject site. Paterson suggests that the western portion of the tributary be investigated further by the City of Ottawa and RVCA, as recommended in our memorandum PG5201-MEMO.03 dated November 13, 2023, given recent failures that have been documented and observed by the City of Ottawa west of the subject site and since estimates provided in this report indicate the probability would be higher throughout those areas. Similar to the subject site, it is suggested that the toe erosion protection measures be explored as a potential solution to minimize the probability for a landslide to occur west of the subject site.

While toe erosion protection will lower the probability for a landslide to occur throughout the subject site it is not considered required throughout the entire length of tributary throughout the subject site. The area east of the red area for the northern portion of the tributary and up to a portion of the yellow area identified on Figure 4 and Drawing PG5201-2 – Test Hole Location Plan is considered to be below the threshold which would require the use of toe erosion protection to reduce the potential for a landslide to occur at this time. The exact portion of the yellow area throughout the southern portion of the tributary that would require this treatment would be limited to up to the portion of the area where relief is less than 8 m (i.e., assuming top of slope is generally an elevation of 86.0 m, this would correspond to where the toe of the slope is higher than an elevation 78.0 m).

Further, since the proposed development will be phased, and likely phased in several sub-phases located on the north and then south side of the tributary, it is not considered a requirement to implement toe erosion protection along the south side of the tributary until consideration will be given to developing the portion of the site located south of the tributary and supported by the red area identified in Figure 4.

At the time of preparing this report, the current area of the proposed development is located on the northern half of the tributary, and the area that would be recommended to be improved upon by toe erosion protection in advance of that development would be the portion of the site downstream of the proposed SWMF. The location of the SWMF is considered suitable given our findings, despite it being in an area that is considered more prone to a landslide occurring.

However, since the area of the SWMF will be constructed by lowering the ground surface around the pond, removing a significant volume of overburden and depth of subsoil (approximately 6 m of soil removal throughout the pond footprint) and providing dedicated erosion-protected outlet channels for pond outflow, the probability for a landslide to occur throughout this area would be improved from the estimates provided herein despite the pre-development drift thickness and topographic relief that exists in this area.

Based on this, Paterson estimates that the post-development condition associated with the currently proposed grading and location of the proposed SWMF would reduce the probability for a landslide to occur as being below the 1:10,000 annual threshold. Therefore, while the area of the SWMF may be located in an area where the pre-development condition results in a probability exceeding the 1:10,000 threshold, the implementation of the currently understood SWMF design would reduce the probability sufficiently such that the currently proposed location is considered as preferential from a landslide-hazard perspective.

4.4 Summary and Conclusion

Based on Peterson's review, the current pre-development landslide hazard probability throughout the northern and southern portions of the tributary bisecting the subject site may be considered to be estimated as **1 in 8,626 per year and 1 in 2,489 per year**, respectively.

However, Paterson has demonstrated that an acceptable solution to lower the probability throughout portions of the site where the hazard probability is greater than 1:10,000 per year could consist of toe erosion protection. Implementing this technique throughout select portions of the base of the valley corridor formed within the tributary in advance of any type of potential development would result in the landslide hazard probability throughout the northern and southern portions of the tributary bisecting the subject site may be considered to be estimated as **1 in 12,490 per year and 1 in 10,331 per year**, respectively.

Based on this, Paterson recommends toe erosion protection be considered as part of maintaining the existing tributary to minimize erosion in areas that are susceptible to a landslide if a slope failure were triggered. Undertaking this measure would yield safer slopes and minimize the risk for a landslide to occur throughout the subject site.

The majority of the subject site is considered to be safe and suitable in consideration of the proposed development, however, some efforts involving enhancing the existing creek are recommended to be undertaken in advance of development-works to improve the safety of the subject slopes and reduce the potential for slope failure to result in a landslide throughout the subject site.

5.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project and the applicable guidelines.

A geotechnical investigation of this nature is a limited sampling of a site. The recommendations are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around the test locations. The extent of the limited area depends on the soil, bedrock, and groundwater conditions, as well the history of the site reflecting natural, construction, and other activities. Should any conditions at the site be encountered which differ from those at the test locations, we request notification immediately in order to permit reassessment of our recommendations.

The assessments provided in this report are intended for the use of design professionals associated with this project. 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 Taggart Investments or their agent(s) is not authorized without review by Paterson Group for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
December 20, 2024
D. J. PETAHTEGOOSE
100568013
PROVINCE OF ONTARIO

Fernanda Carozzi, PhD. Geoph.

Drew Petahtegoose, P. Eng.

Report Distribution:

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6.0 Literature References

[1] APEGBC, 2010, Guidelines for legislated landslide assessments for proposed residential developments in BC: Technical report, Association of Professional Engineers and Geoscientists of British Columbia.

[2] Aylsworth, J., and D. Lawrence, 2002, Earthquake-induced land sliding east of Ottawa; a contribution to the Ottawa Valley landslide project: Presented at the Geohazards 2003, 3rd Canadian Conference on Geohazards and natural Hazards; Edmonton, Alberta; June 9-10, 2003, Canadian Geotechnical Society.

[3] Bélanger, R., 2008, Urban geology of the National Capital area: Geological Survey of Canada, Open File 5311.

[4] Bobrowsky, P., and R. Couture, 2012, Canadian technical guidelines and best practices related to landslides: a national initiative for loss reduction: Geological Survey of Canada, Open File 7312.

[5] Brooks, G., B. Medioli, J. Aylsworth, and D. Lawrence, 2021, A compilation of radiocarbon dates relating to the age of sensitive clay landslide is in the Ottawa valley, Ontario-Quebec: Geological Survey of Canada, Open File 7432.

[6] Fransham, P., and N. Gadd, 1977, Geological and geomorphological controls of landslides in Ottawa valley, Ontario: Canadian Geotechnical Journal, 14, 531–539.

[7] Hugenholtz, Chris., and Lacelle, Denis, 2004, Geomorphic Controls on Landslide Activity in Champlain Sea Clays along Green's Creek, Eastern Ontario, Canada: Géographie physique at Quartenaire, 58(1), 9-23.

[8] Mitchell, R., and Markell, A., 1974, Flowsliding in Sensitive Soils: Canadian Geotechnical Journal, 11, 11-31.

[9] Perret, Didier, 2019, Influence of surficial crusts on the development of spreads and flows in Eastern Canadian sensitive clays: Presented at the 72nd Canadian Geotechnical Conference in St-John's, Newfoundland and Labrador, Canada, Natural Resources Canada, Geological Survey of Canada.

[10] Quinn, Peter Eugene, 2009, Large Landslides in Sensitive Clay in Eastern Canada and the Associated Hazard and Risk to Liner Infrastructure, Queen's University.

[11] Quinn, P.E., Hutchinson, D.J., Diederichs, M.S., Rowe, R.K., 2010, Regional-scale landslide susceptibility mapping using the weights of evidence method: an example applied to linear infrastructure: Canadian Geotechnical Journal,47, 905-927.

[12] Quinn, P.E., Hutchinson, D.J., Diederichs, M.S., Rowe, R.K., 2011, Characteristics of large landslides in sensitive clay in relation to susceptibility, hazard, and risk: BGC Engineering in Ottawa Ontario and Canadian Geotechnical Journal, 48, 1212-1232.

[13] Quinn, Peter E., 2014, Landslide susceptibility in sensitive clay in eastern Canada: some practical considerations and results in development of an improved model: International Journal of Image and Data Fusion, Volume 5, No 1, 70-96.

[14] L'Heureux, J.-S., Demers, D. 2014, Landslides in Sensitive Clays: From Geosciences to Risk Management, Advances in Natural and technological Hazards Research 36, 77-88.

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

BOREHOLE LOGS BY OTHERS

GRAIN-SIZE DISTRIBUTION TESTING RESULTS

ATTERBERG LIMITS TESTING RESULTS

EARTHQUAKES CANADA SEISMIC HAZARD (NBCC 2015)

TABLE 1 - SUMMARY OF REVIEWED LANDSLIDE INVENTORY DATA

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE April 2, 2012

FILE NO. PG1796

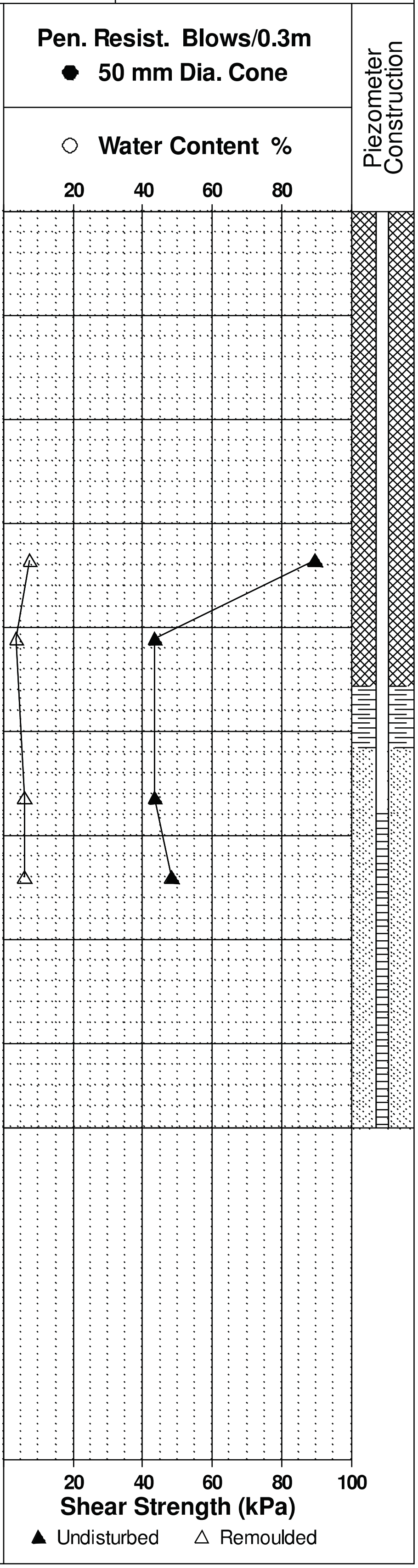
HOLE NO. BH24-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	87.44
Brown **SILTY SAND,** trace clay 0.20		AU	1				
		AU	2				
		SS	3	100	21	1	86.44
		SS	4	100	16	2	85.44
Very stiff to stiff, brown **SILTY CLAY**		SS	5	100	9	3	84.44
- firm and grey by 3.6m depth						4	83.44
		TW	6	100		5	82.44
						6	81.44
6.63							
						7	80.44
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders		SS	7	62	15	8	79.44
8.81							

End of Borehole

Practical refusal to augering @ 8.81m depth

(BH dry - April 13, 2012)



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. PG1796

REMARKS

HOLE NO. BH25-12

BORINGS BY CME 55 Power Auger

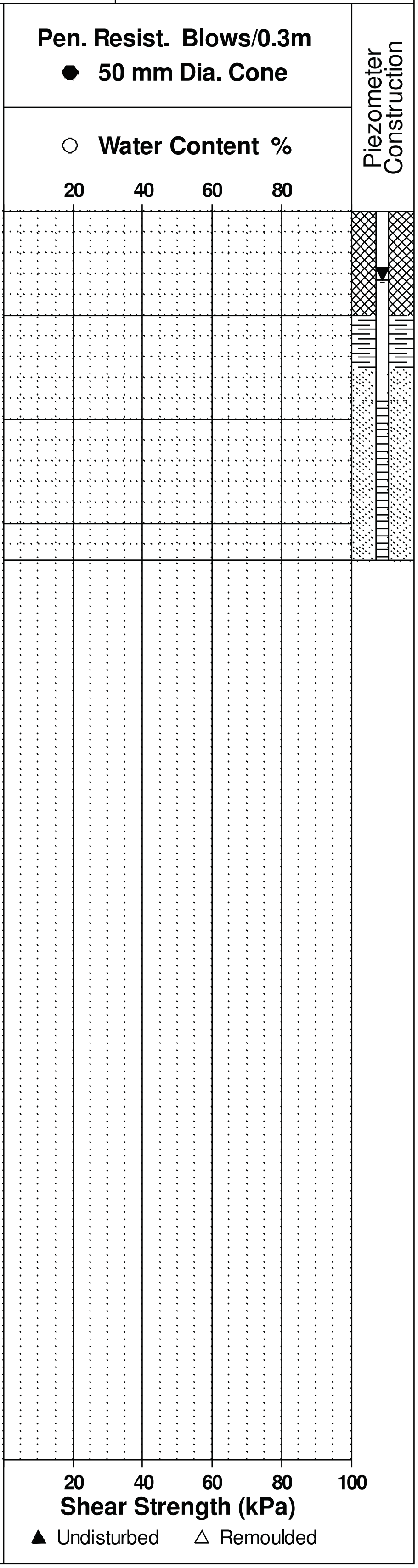
DATE April 2, 2012

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	81.91
TOPSOIL 0.20						
	AU	1				
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders	SS	2	50	25	1	80.91
	SS	3	20	50+		
					2	79.91
	SS	4	67	50+		
					3	78.91
3.35	SS	5	71	50+		

End of Borehole

Practical refusal to augering @ 3.35m depth

(GWL @ 0.66m-April 13, 2012)



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

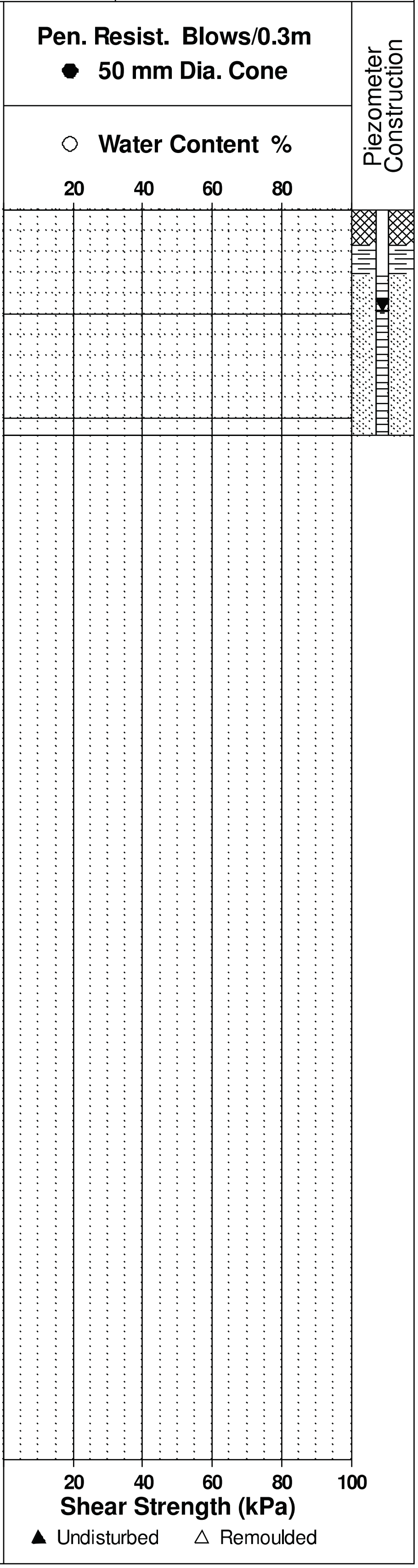
BORINGS BY CME 55 Power Auger

DATE April 3, 2012

FILE NO. PG1796

HOLE NO. BH26-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.45
TOPSOIL 0.30							
Very stiff, brown **SILTY CLAY,** trace sand 1.45		SS	1	100	18	1	88.45
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders 2.16		SS	2	100	50+	2	87.45
End of Borehole Practical refusal to augering @ 2.16m depth (GWL @ 0.97m-April 13, 2012)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE April 9, 2012

FILE NO. PG1796

HOLE NO. BH27-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	96.23		
TOPSOIL 0.20		AU	1						
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders 1.45		SS	2	60	50+	1	95.23		
End of Borehole Practical refusal to augering @ 1.45m depth (BH dry upon completion)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. **PG1796**

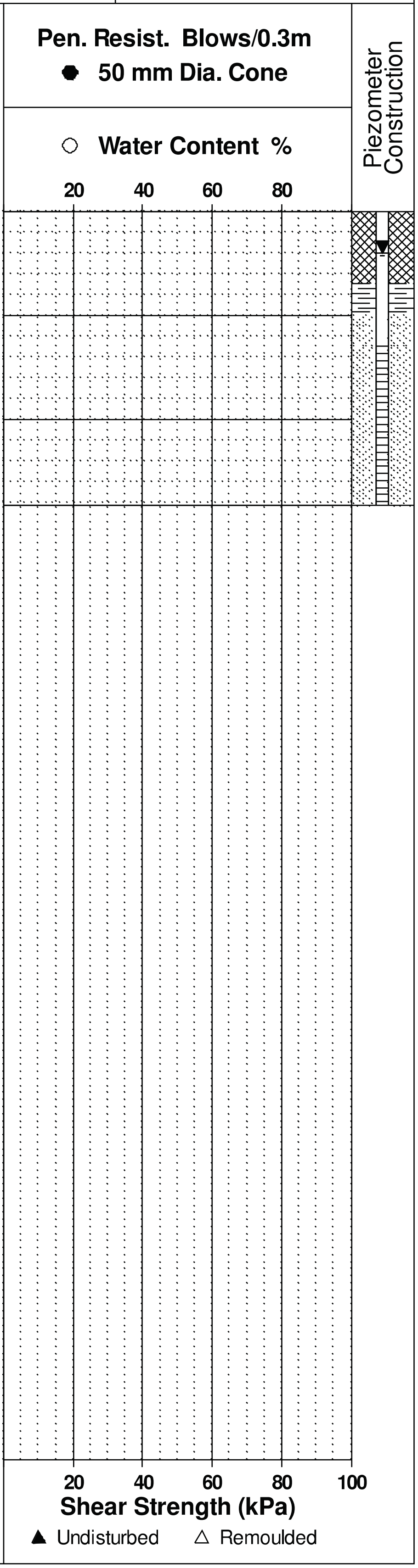
REMARKS

HOLE NO. **BH28-12**

BORINGS BY CME 55 Power Auger

DATE April 3, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	89.10
TOPSOIL 0.30		AU	1				
Very stiff, brown **SILTY CLAY**		AU	2				
		SS	3	100	23	1	88.10
2.21		SS	4	100	15	2	87.10
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders 2.82		SS	5	79	49		
End of Borehole Practical refusal to augering @ 2.82m depth (GWL @ 0.40m-April 13, 2012)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. PG1796

REMARKS

HOLE NO. BH29-12

BORINGS BY CME 55 Power Auger

DATE April 3, 2012

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
TOPSOIL	0.25
Very stiff to stiff, brown **SILTY CLAY**	3.73
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders	5.26
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders	5.54

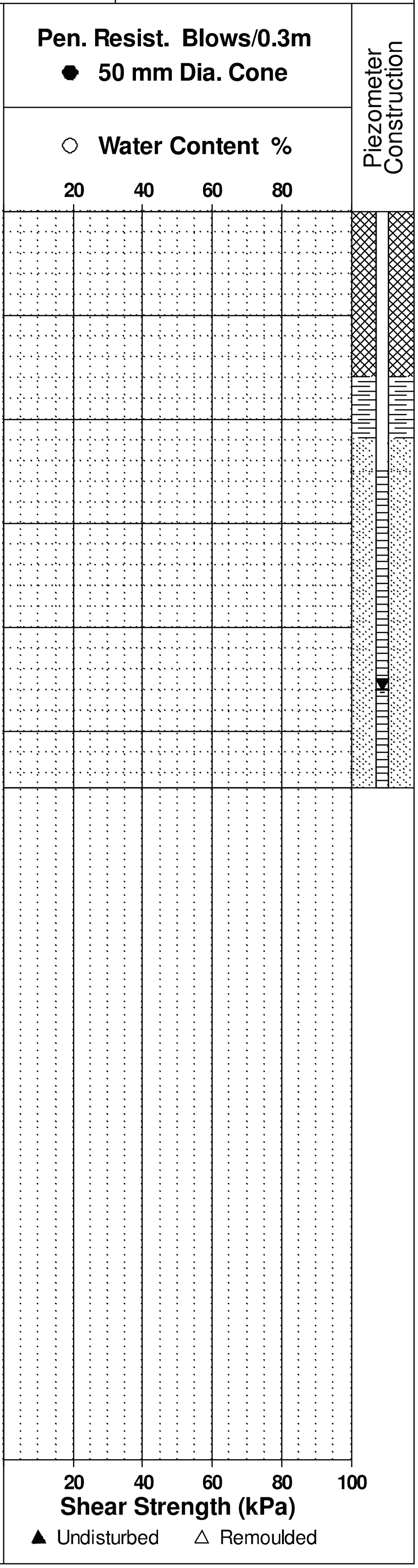
End of Borehole

Practical refusal to augering @ 5.54m depth

(Piezometer damaged - April 13, 2012)

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	100	21
SS	3	100	20
SS	4	100	17
SS	5	100	12
SS	6	50	34
SS	7	4	9
SS	8	100	50+

DEPTH (m)	ELEV. (m)
0	87.20
1	86.20
2	85.20
3	84.20
4	83.20
5	82.20



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. PG1796

REMARKS

HOLE NO. BH30-12

BORINGS BY CME 55 Power Auger

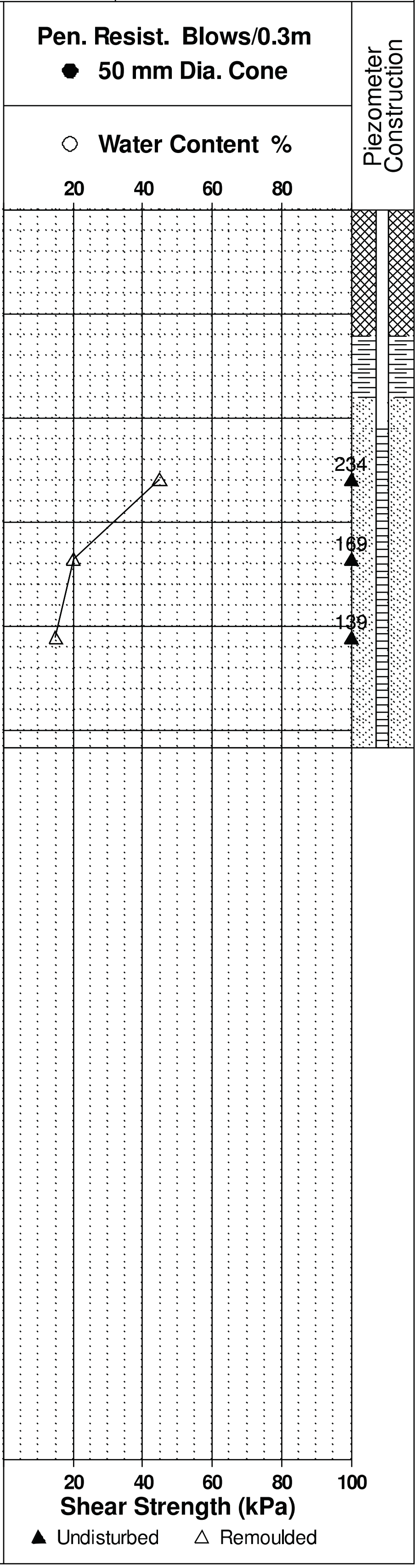
DATE April 3, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.74
TOPSOIL 0.25							
		AU	1				
		SS	2	83	18	1	87.74
Hard to very stiff, brown **SILTY CLAY**		SS	3	75	12	2	86.74
						3	85.74
4.34						4	84.74
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders		SS	4	100	50+		
5.16						5	83.74

End of Borehole

Practical refusal to augering @ 5.16m depth

(Piezometer damaged-April 13,2012)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE April 3, 2012

FILE NO. PG1796

HOLE NO. BH31-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	86.70
TOPSOIL 0.28							
		AU	1				
Very stiff to stiff, brown **SILTY CLAY**		SS	2	100	12	1	85.70
		SS	3	100	19	2	84.70
2.97		SS	4	100	19		
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders 3.76		SS	5	82	50+	3	83.70

End of Borehole

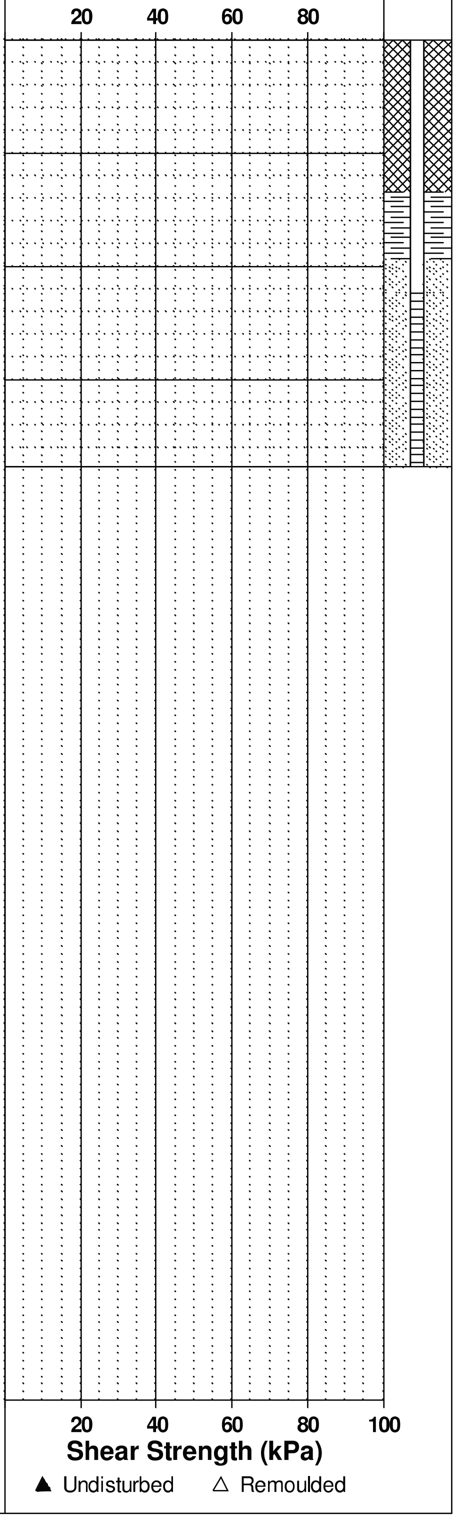
Practical refusal to augering @ 3.76m depth

(GWL @ 1.12m-April 13, 2012)

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

Piezometer Construction



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

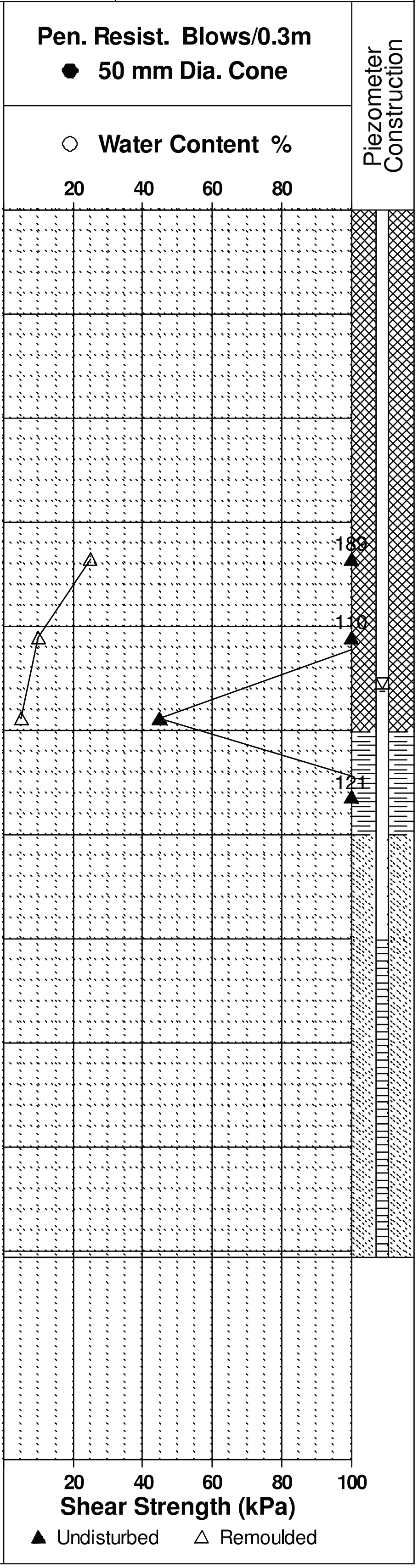
DATE June 26, 2012

FILE NO. PG1796

HOLE NO. BH32-12

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
Very stiff to stiff, brown **SILTY CLAY** - firm by 4.3m depth	SS	1	100	22
	SS	2	100	18
	SS	3	100	13
6.60	SS	4	100	2
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders	SS	5	42	38
	SS	6	67	50+
10.06	SS	7	100	50+
End of Borehole (GWL @ 4.6m depth based on field observations)				

DEPTH (m)	ELEV. (m)
0	87.94
1	86.94
2	85.94
3	84.94
4	83.94
5	82.94
6	81.94
7	80.94
8	79.94
9	78.94
10	77.94



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. PG1796

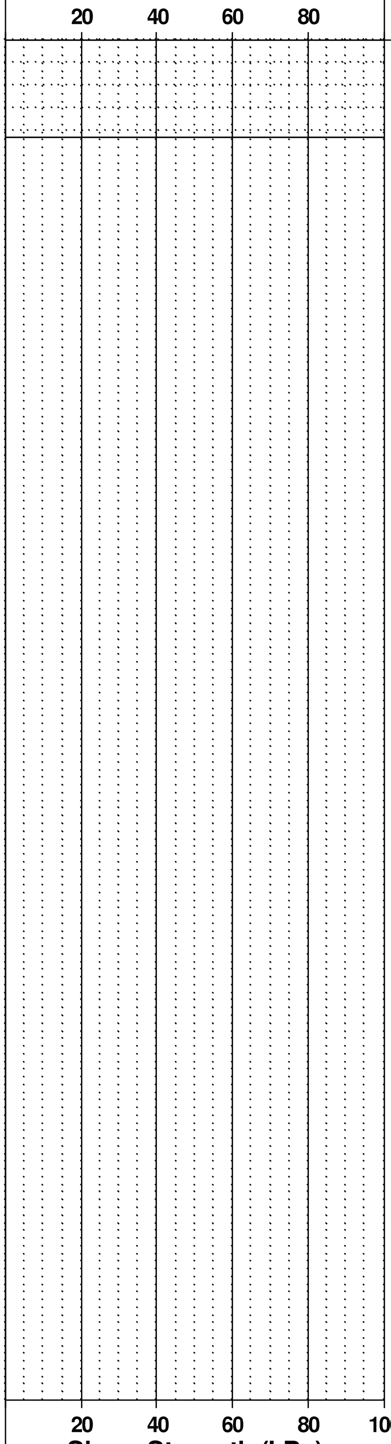
REMARKS

HOLE NO. BH33-12

BORINGS BY CME 55 Power Auger

DATE June 27, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	91.15		
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders	^^^	AU	1						
0.86	^^^	SS	2	33	50+				
End of Borehole Practical refusal to augering at 0.86m depth (BH dry upon completion)									



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

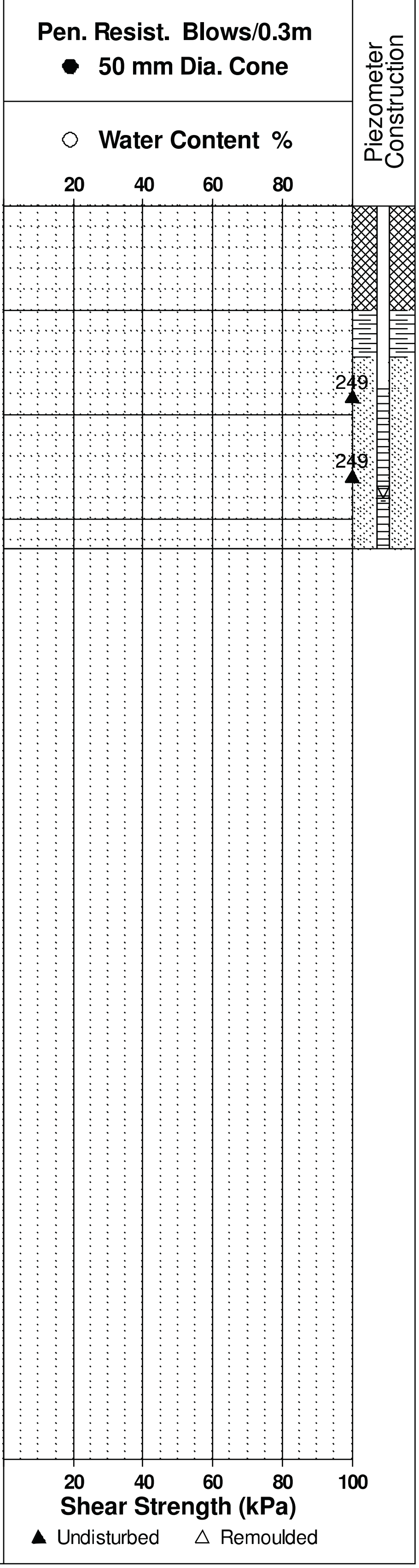
BORINGS BY CME 55 Power Auger

DATE June 26, 2012

FILE NO. PG1796

HOLE NO. BH34-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.99
Hard to very stiff, brown **SILTY CLAY**		AU	1				
		SS	2	100	17	1	88.99
						2	87.99
2.82							
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders 3.28		SS	3	33	50+	3	86.99
End of Borehole Practical refusal to augering at 3.28m depth (GWL @ 2.8m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. **PG1796**

REMARKS

HOLE NO. **BH35-12**

BORINGS BY CME 55 Power Auger

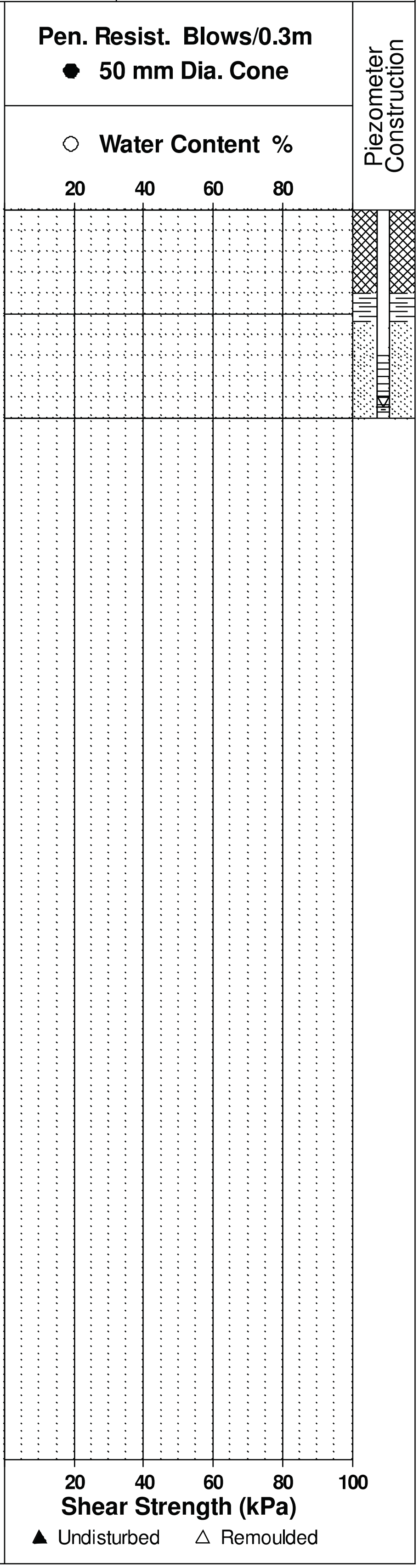
DATE June 27, 2012

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	90.07
Hard, brown **SILTY CLAY**	SS	1	100	23	1	89.07
1.90	SS	2	76	50+		
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders 2.00					2	88.07

End of Borehole

Practical refusal to augering at 2.00m depth

(GWL @ 1.9m depth based on field observations)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. PG1796

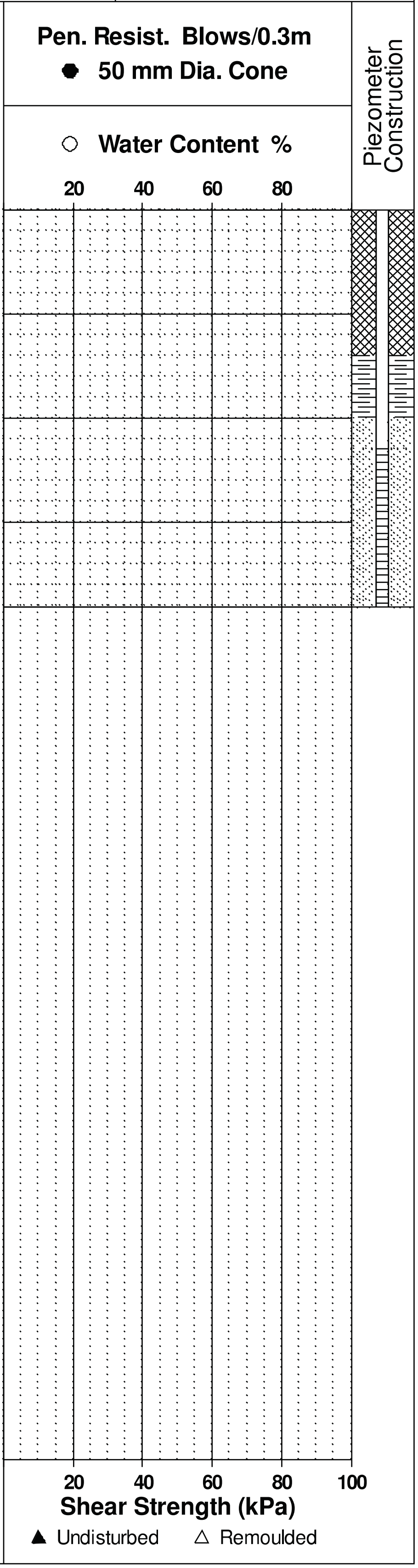
REMARKS

HOLE NO. BH36-12

BORINGS BY CME 55 Power Auger

DATE June 26, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.15
Brown **SILTY SAND** with clay		AU	1				
0.60							
		SS	2	100	6	1	90.15
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders		SS	3	67	16	2	89.15
		SS	4	54	39	3	88.15
		SS	5	56	50+		
3.81							
End of Borehole Practical refusal to augering at 3.81m depth (BH dry upon completion)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. PG1796

REMARKS

HOLE NO. BH37-12

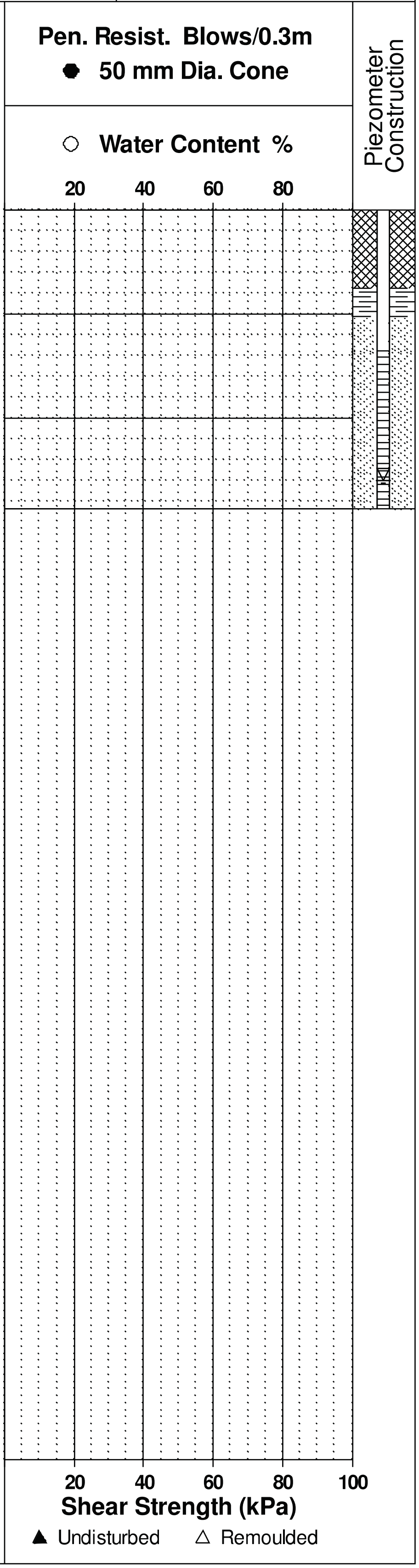
BORINGS BY CME 55 Power Auger **DATE** June 26, 2012

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.42
Hard, brown **SILTY CLAY**		SS	1	100	22	1	88.42
		SS	2	100	16	2	87.42
2.21							
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders		SS	3	75	50+		
2.87							

End of Borehole

Practical refusal to augering at 2.87m depth

(GWL @ 2.6m depth based on field observations)



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SOIL PROFILE AND TEST DATA

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Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

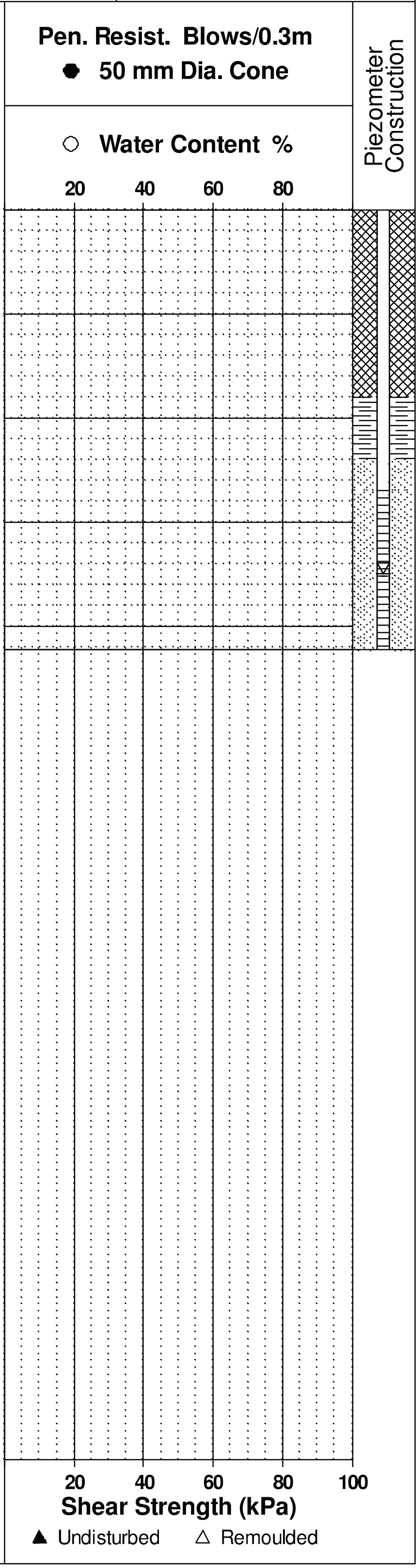
BORINGS BY CME 55 Power Auger

DATE June 26, 2012

FILE NO. PG1796

HOLE NO. BH38-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	88.92
Very stiff to stiff, brown **SILTY CLAY**	▨	SS	1	100	19	1	87.92
		SS	2	100	16	2	86.92
2.97		SS	3	100	20		
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders	^	SS	4	100	50+	3	85.92
4.22		SS	5	50	50+	4	84.92
End of Borehole Practical refusal to augering at 4.22m depth (GWL @ 3.5m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

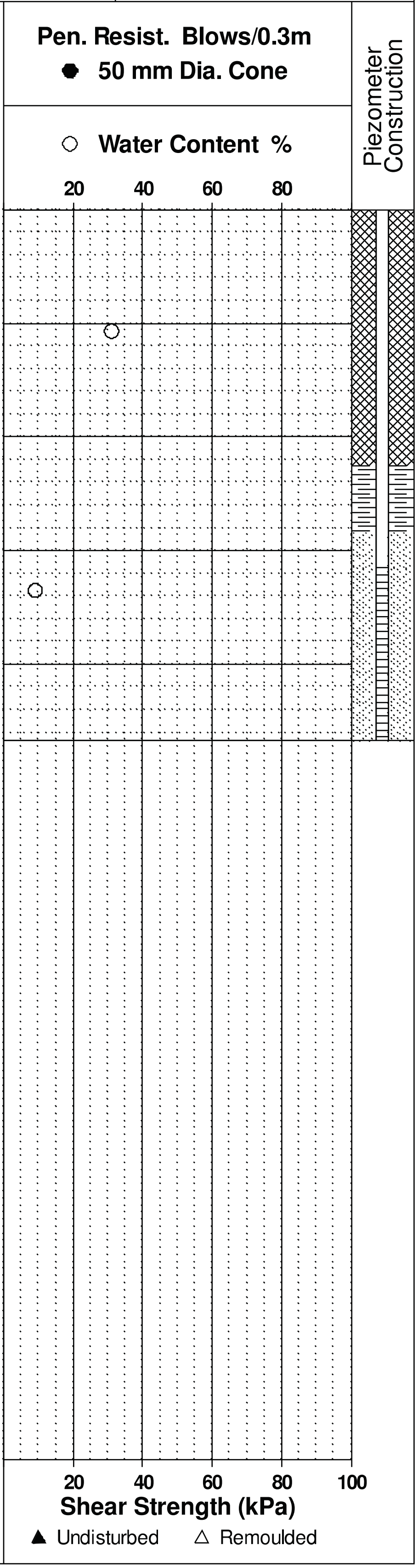
BORINGS BY CME 55 Power Auger

DATE February 4, 2013

FILE NO. PG1796

HOLE NO. BH72-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	77.23
Asphaltic concrete 0.20							
FILL: Crushed stone with sand 0.38		AU	1				
FILL: Brown silty sand with gravel 0.69		AU	2				
Stiff, brown **SILTY CLAY** 1.45		SS	3	50	23	1	76.23
GLACIAL TILL: Brown silty clay with sand, gravel, trace cobbles 2.20		SS	4	67	13	2	75.23
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders		SS	5	43	50+	3	74.23
		SS	6	83	27	4	73.23
4.67		SS	7		50+		
End of Borehole (BH dry upon completion)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

FILE NO. **PG1796**

REMARKS

HOLE NO. **BH73-12**

BORINGS BY CME 55 Power Auger

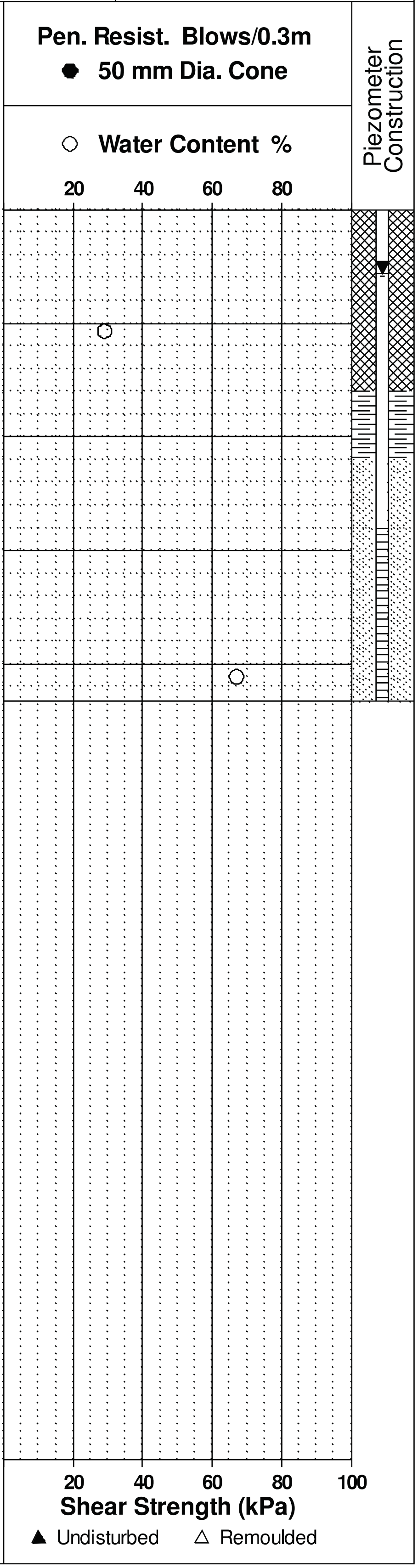
DATE January 31, 2013

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	80.21
FILL: Crushed stone with sand 0.33	AU	1				
FILL: Brown silty sand with clay and gravel 0.69	AU	2				
Very stiff to stiff, brown **SILTY CLAY**	SS	3	33	9	1	79.21
	SS	4	83	13	2	78.21
2.90	SS	5	100	18		
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders 3.73					3	77.21
	SS	6	67	10		
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders, trace clay 4.32	SS	7		21	4	76.21

End of Borehole

Practical refusal to augering at 4.32m depth

(GWL @ 0.56m-Mar. 27, 2013)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 31, 2013

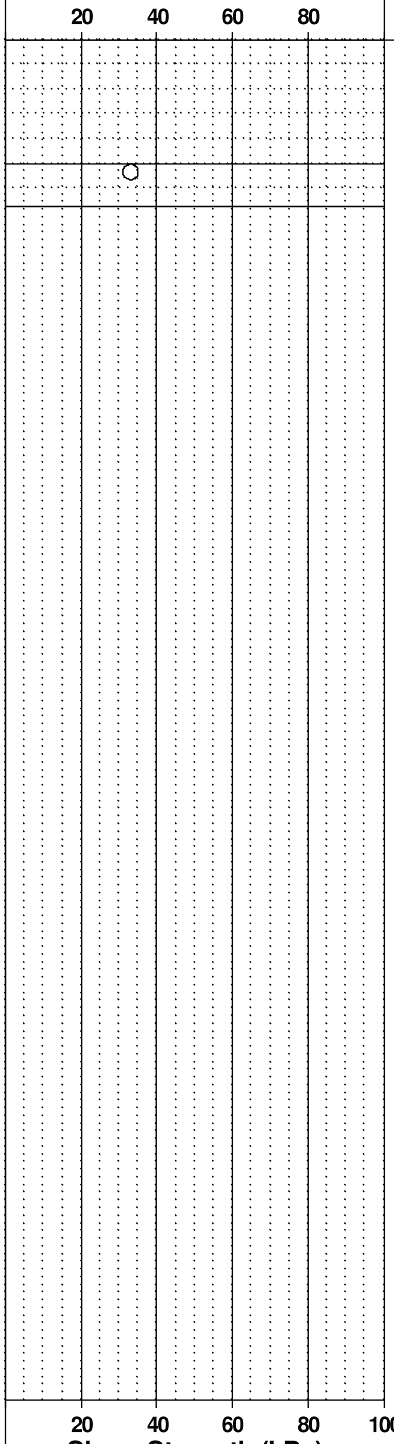
FILE NO. PG1796

HOLE NO. BH74-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	81.02
FILL: Crushed stone with sand 0.30							
FILL: Brown silty sand with gravel 0.69							
Very stiff, brown **SILTY CLAY** 0.99							
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders 1.35		SS	1	80	15	1	80.02
End of Borehole Practical refusal to augering at 1.35m depth (BH dry upon completion)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

Piezometer Construction

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

FILE NO. PG1796

REMARKS

HOLE NO. BH75-12

BORINGS BY CME 55 Power Auger

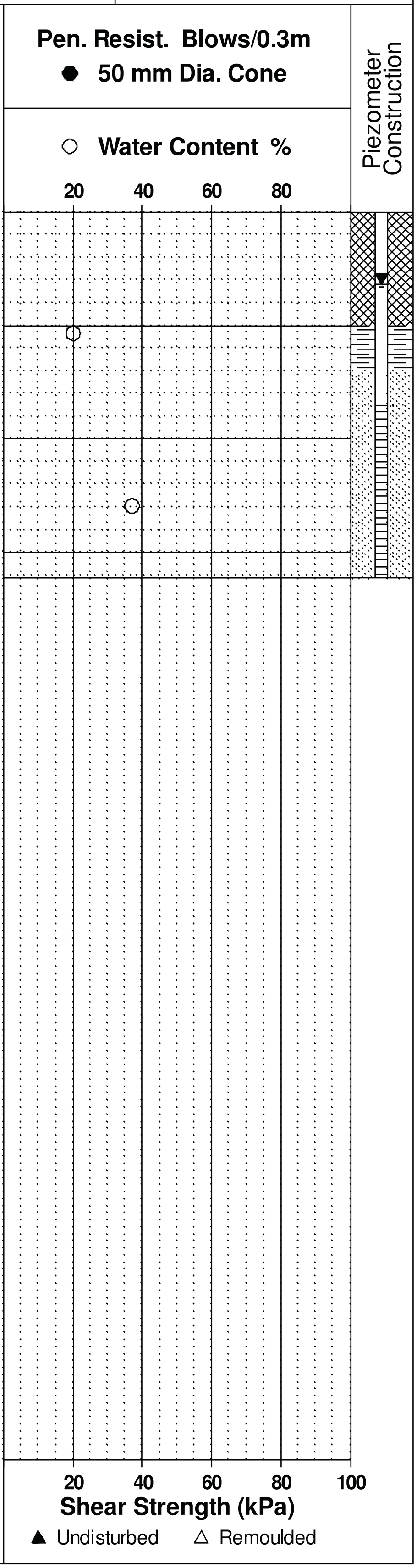
DATE February 1, 2013

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	83.02
Asphaltic concrete 0.20							
FILL: Crushed stone with sand 0.51		AU	1				
FILL: Brown silty sand with gravel 0.81		AU	2				
Compact, brown **SILTY SAND** with gravel 1.45		SS	3	50	10	1	82.02
		SS	4	100	50+		
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders						2	81.02
		SS	5	0	50+		
3.22						3	80.02

End of Borehole

Practical refusal to augering at 3.22m depth

(GWL @ 0.64m-Mar. 27, 2013)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

BORINGS BY CME 55 Power Auger

DATE February 1, 2013

FILE NO. PG1796

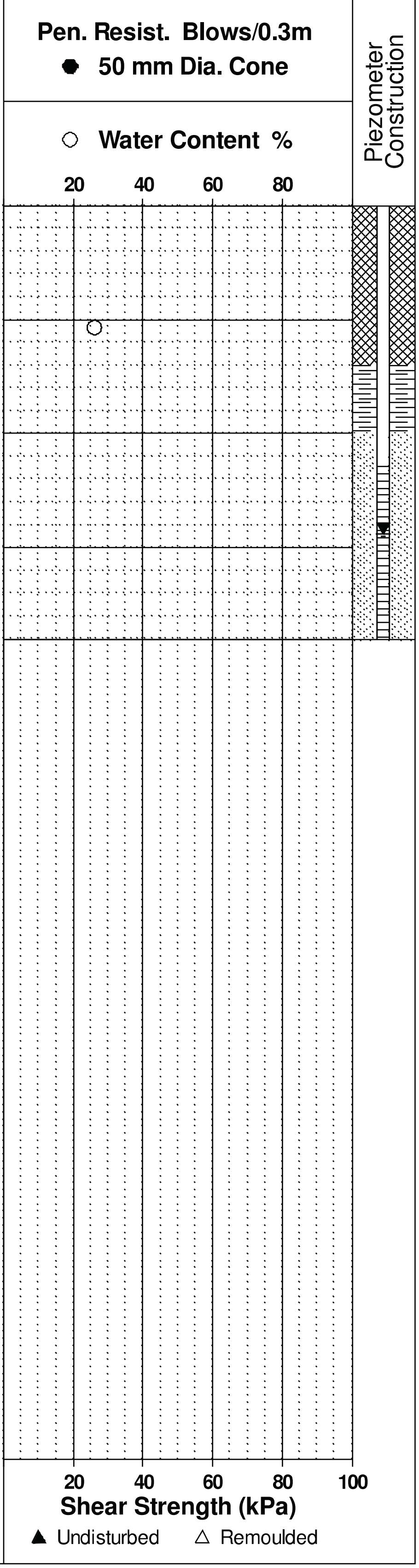
HOLE NO. BH76-12

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	87.83
Asphaltic concrete 0.20						
FILL: Crushed stone with sand 0.46	AU	1				
FILL: Brown silty sand with gravel 0.69	AU	2				
Loose, brown **SILTY SAND** with gravel, trace cobbles 1.45	SS	3	83	6	1	86.83
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders, trace clay	SS	4	100	50+		
					2	85.83
	SS	5	50	1		
- brown silty clay matrix from 1.8 to 3.0m depth					3	84.83
	SS	6	77	50+		
3.81						

End of Borehole

Practical refusal to augering at 3.81m depth

(GWL @ 2.88m-Mar. 27, 2013)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

DATE February 1, 2013

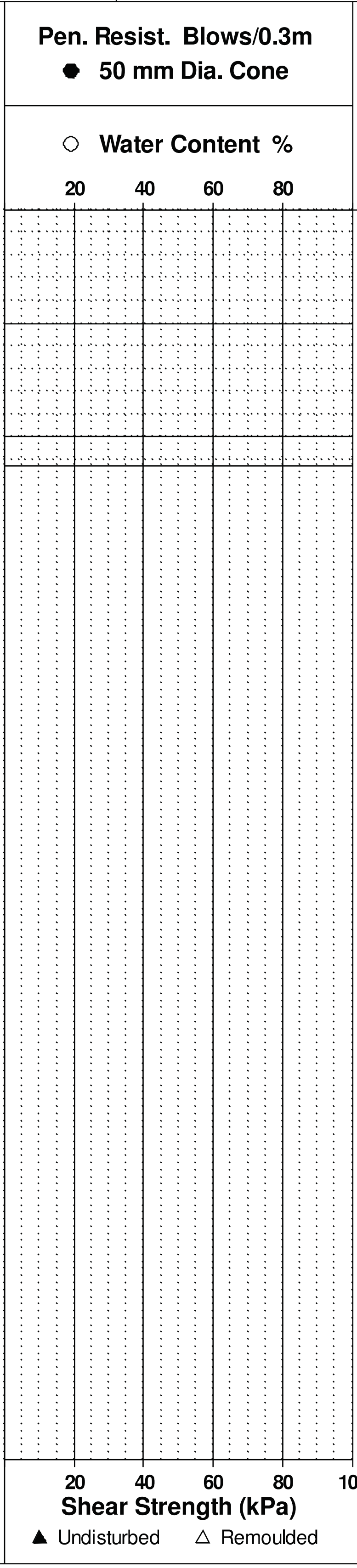
FILE NO. PG1796

HOLE NO. BH77-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.17
FILL: Crushed stone with sand 0.28	▨	AU	1				
FILL: Brown silty sand with gravel 0.69	▨	AU	2				
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders	^ ^ ^	SS	3	33	15	1	87.17
	^ ^ ^	SS	4	0	14	2	86.17
2.26							

End of Borehole

Practical refusal to augering at 2.26m depth



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

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FILE NO. PG1796

REMARKS

HOLE NO. BH77A-12

BORINGS BY CME 55 Power Auger

DATE February 1, 2013

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	88.17		
OVERBURDEN						1	87.17		
2.21						2	86.17		
End of Borehole Practical refusal to augering at 2.21m depth									

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

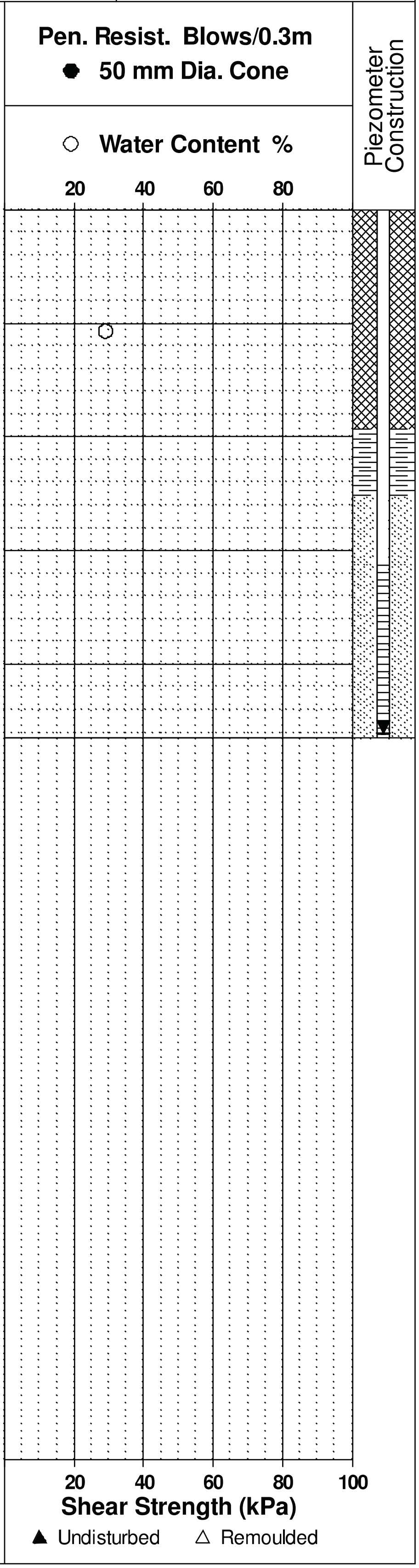
DATE February 1, 2013

FILE NO. PG1796

HOLE NO. BH78-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
FILL: Crushed stone 0.30		AU	1		
FILL: Brown silty sand with gravel 0.69		AU	2		
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders 1.75		SS	3	25	3
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders		SS	4		50+
		SS	5	100	50+
4.65		SS	6	0	50+
End of Borehole (GWL @ 2.88m-Mar. 27, 2013)					

DEPTH (m)	ELEV. (m)
0	91.80
1	90.80
2	89.80
3	88.80
4	87.80



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
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FILE NO. PG1796

REMARKS

HOLE NO. BH79-12

BORINGS BY CME 55 Power Auger

DATE February 1, 2013

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % (20, 40, 60, 80)	Piezometer Construction
GROUND SURFACE						0	94.45		
FILL: Crushed stone 0.28									
FILL: Brown silty sand with gravel 0.69		AU	1						
GLACIAL TILL: Brown silty sand with gravel, trace clay and organics		SS	2	50	8	1	93.45		
1.68		SS	3	100	50+				
End of Borehole Practical refusal to augering at 1.68m depth (BH dry upon completion)									

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

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FILE NO. PG1796

REMARKS

HOLE NO. BH80-12

BORINGS BY CME 55 Power Auger

DATE January 31, 2013

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	96.02
FILL: Crushed stone 0.30		AU	1				
FILL: Brown silty sand with gravel, cobbles, clay 1.07		AU	2				
		SS	3	38	20	1	95.02
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders 1.58		SS	4	100	50+		

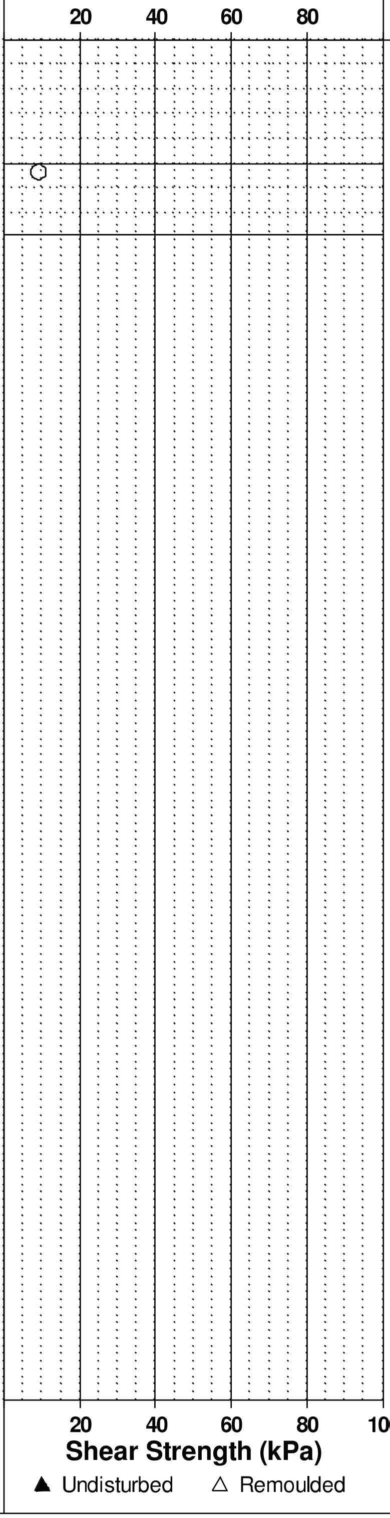
End of Borehole

Practical refusal to augering at 1.58m depth

(BH dry upon completion)

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %



Piezometer Construction

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

REMARKS

BORINGS BY CME 55 Power Auger

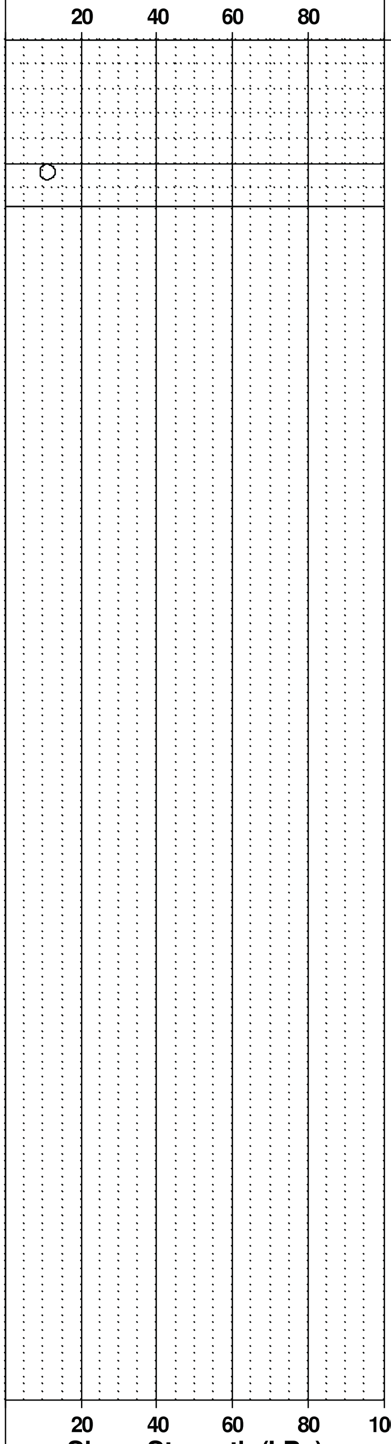
DATE February 1, 2013

FILE NO. PG1796

HOLE NO. BH81-12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	95.77	
FILL: Crushed stone with sand 0.30	▨	AU	1					
FILL: Brown silty sand with gravel 0.69	▨	AU	2					
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulders, trace clay 1.35	^	SS	3	57	15	1	94.77	
End of Borehole Practical refusal to augering at 1.35m depth (Piezometer damaged - March 27, 2013)								

Pen. Resist. Blows/0.3m
● **50 mm Dia. Cone**
○ **Water Content %**



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

FILE NO. PG1796

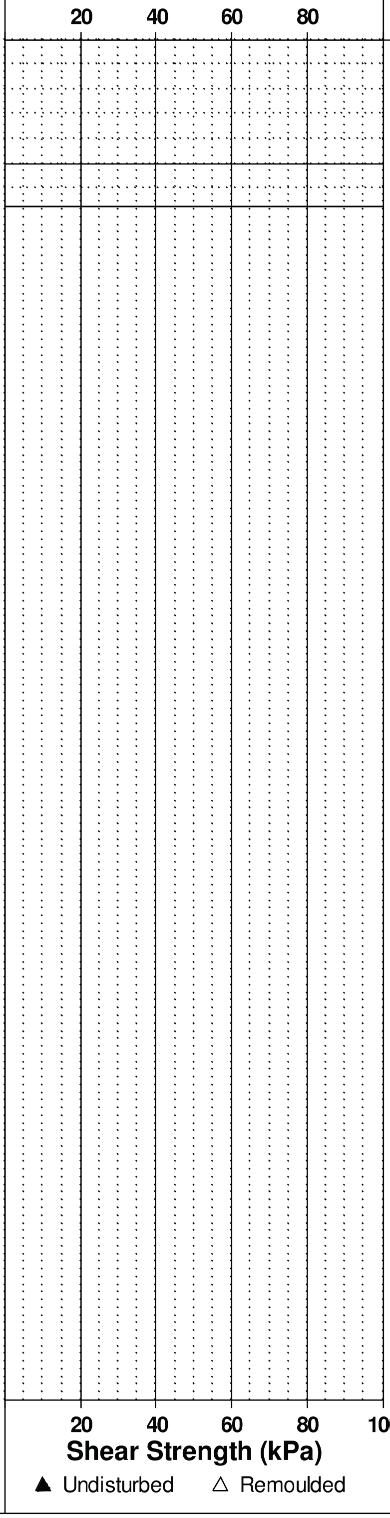
REMARKS

HOLE NO. BH81A-12

BORINGS BY CME 55 Power Auger

DATE February 1, 2013

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD			20 40 60 80	
GROUND SURFACE						0	95.77		
OVERBURDEN 1.35						1	94.77		
End of Borehole Practical refusal to augering at 1.35m depth									



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Limited.

FILE NO. PG1796

REMARKS

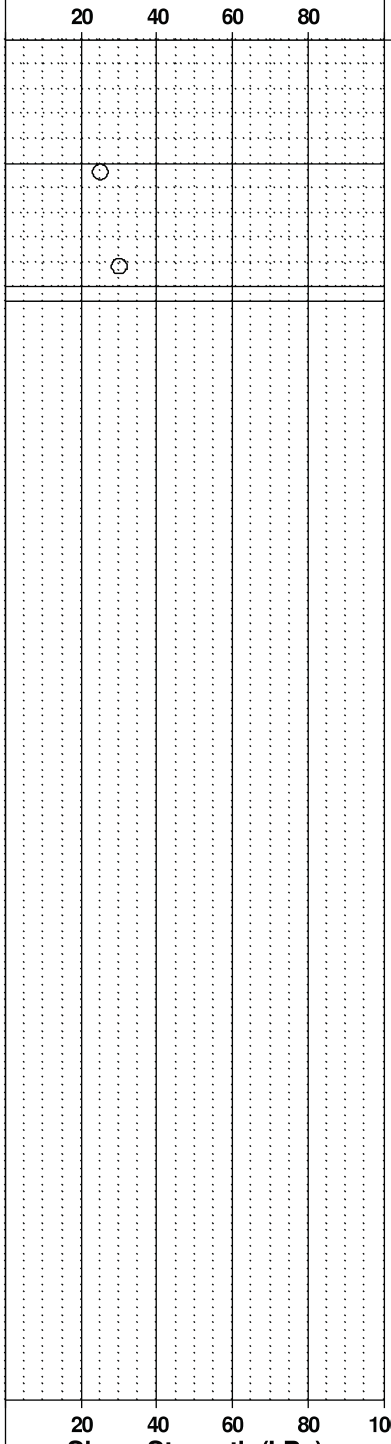
HOLE NO. BH82-12

BORINGS BY CME 55 Power Auger **DATE** January 31, 2013

SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	95.86
FILL: Crushed stone with gravel	0.30	AU	1				
FILL: Brown silty sand with gravel	1.45	SS	2	58	31	1	94.86
GLACIAL TILL: Brown silty sand with gravel, trace clay	2.11	SS	3	78	31	2	93.86
End of Borehole Practical refusal to augering at 2.11m depth (BH dry upon completion)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. **PG1796**

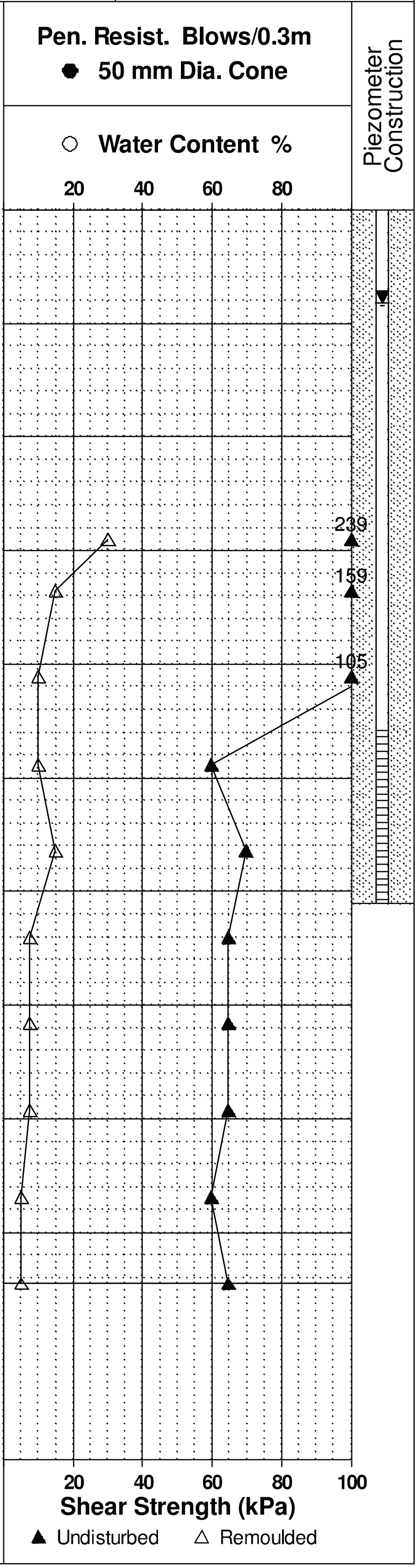
REMARKS

HOLE NO. **BH 8**

BORINGS BY CME 55 Power Auger

DATE January 23, 2009

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	87.11
TIOPSOIL 0.30	AU	1				
	SS	2	42	9	1	86.11
	SS	3	67	5	2	85.11
Hard to very stiff, brown **SILTY CLAY**					3	84.11
					4	83.11
- stiff and grey-brown by 4.3m depth					5	82.11
					6	81.11
					7	80.11
- grey by 7.9m depth					8	79.11
					9	78.11
9.45						
End of Borehole						
(GWL @ 0.82m-Feb. 3/09)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

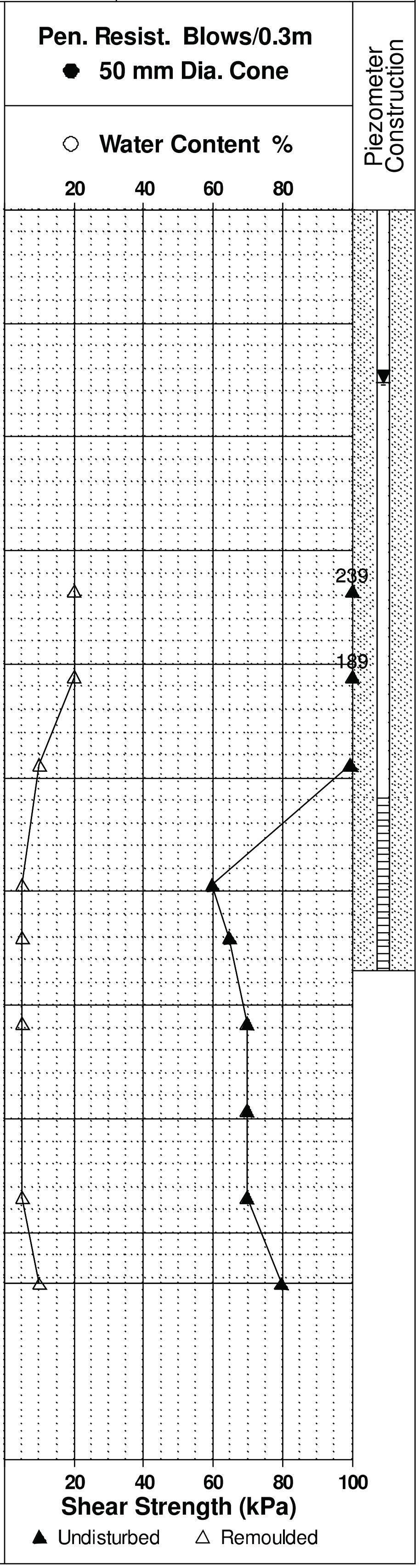
BORINGS BY CME 55 Power Auger

DATE January 22, 2009

FILE NO. PG1796

HOLE NO. BH10

SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	86.36
TOPSOIL	0.20	AU	1				
		SS	2	58	10	1	85.36
		SS	3	75	11	2	84.36
		SS	4	83	8		
Hard to very stiff, brown **SILTY CLAY**						3	83.36
- stiff and grey by 4.3m depth						4	82.36
						5	81.36
						6	80.36
						7	79.36
						8	78.36
						9	77.36
End of Borehole (GWL @ 1.52m-Feb. 3/09)	9.45						



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 23, 2009

FILE NO. PG1796

HOLE NO. BH11

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.75
TOPSOIL 0.30		AU	1				
Very stiff, brown **SILTY CLAY** with organic matter 0.69							
GLACIAL TILL: Compact to dense, brown silty sand with clay, gravel, cobbles and boulders		SS	2	75	8	1	88.75
		SS	3	50	20	2	87.75
2.95		SS	4	80	50+		
End of Borehole Practical refusal to augering @ 2.95m depth							

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. **PG1796**

REMARKS

HOLE NO. **BH13**

BORINGS BY CME 55 Power Auger

DATE January 26, 2009

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	92.03		
TOPSOIL 0.30									
Very stiff, brown **SILTY CLAY**, some sand 0.71		AU	1						
End of Borehole Practical refusal to augering @ 0.71m depth									

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

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SOIL PROFILE AND TEST DATA

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Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 26, 2009

FILE NO. PG1796

HOLE NO. BH14

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
TOPSOIL 0.20		AU	1		
Very stiff, brown **SILTY CLAY** 0.91					
GLACIAL TILL: Very dense, brown silty sand with clay, gravel, cobbles and boulders 2.21		SS SS	2 3	67 33	54 54
GLACIAL TILL: Very stiff, grey silty clay with sand, gravel, cobbles and boulders 7.62		SS SS SS SS SS SS SS	4 5 6 7 8 9 10	50 50 33 38 25 38 42	24 13 16 30 31 44 42
End of Borehole (GWL @ 0.61m-Feb. 3/09)					

DEPTH (m)	ELEV. (m)
0	88.88
1	87.88
2	86.88
3	85.88
4	84.88
5	83.88
6	82.88
7	81.88

Pen. Resist. Blows/0.3m
● **50 mm Dia. Cone**

○ **Water Content %**

20 40 60 80

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

Piezometer Construction

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 26, 2009

FILE NO. PG1796

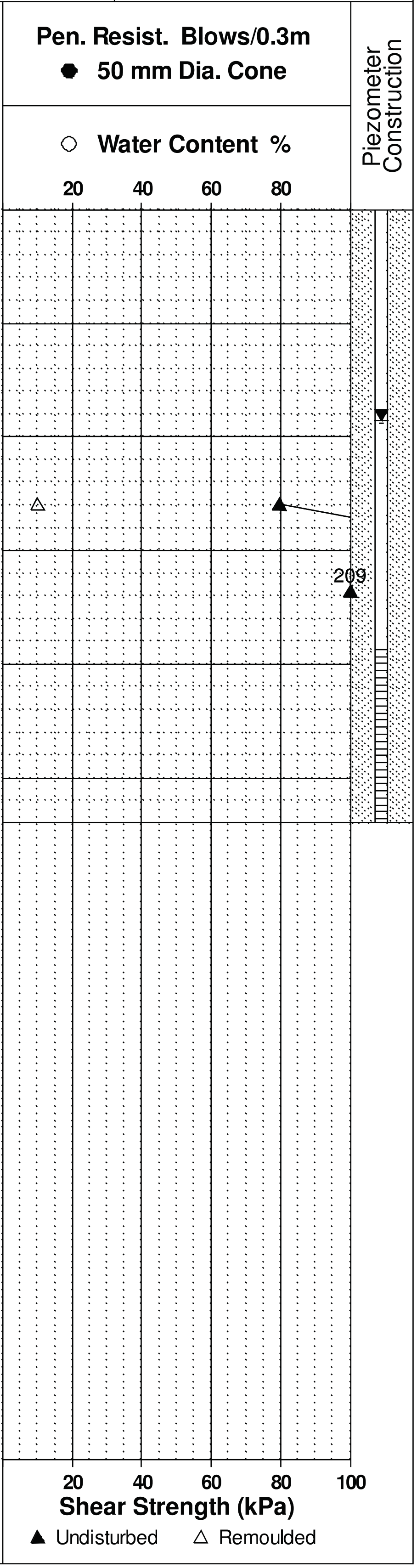
HOLE NO. BH15

SOIL DESCRIPTION		SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.13
TOPSOIL	0.25	AU	1				
Stiff, brown **SILTY CLAY**, some organic matter to 1.4m depth		SS	2	8	9	1	87.13
		SS	3	42	4	2	86.13
	2.82						
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles						3	85.13
		SS	4	100	2		
						4	84.13
		SS	6	42	14	5	83.13
	5.13						
GLACIAL TILL: Compact, grey silty sand with gravel, cobbles and boulders	5.39	SS	7	0	50+		

End of Borehole

Practical refusal to augering @ 5.39m depth

(GWL @ 1.86m-Feb. 3/09)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Queen Street
Ottawa, Ontario

DATUM Ground surface elevations provided by Stantec Geomatics Ltd.

FILE NO. **PG1796**

REMARKS

HOLE NO. **BH17**

BORINGS BY CME 55 Power Auger

DATE January 23, 2009

SOIL DESCRIPTION

GROUND SURFACE

TOPSOIL 0.20

Very stiff, brown **SILTY CLAY**

- stiff and grey-brown by 5.9m depth

- grey by 6.6m depth

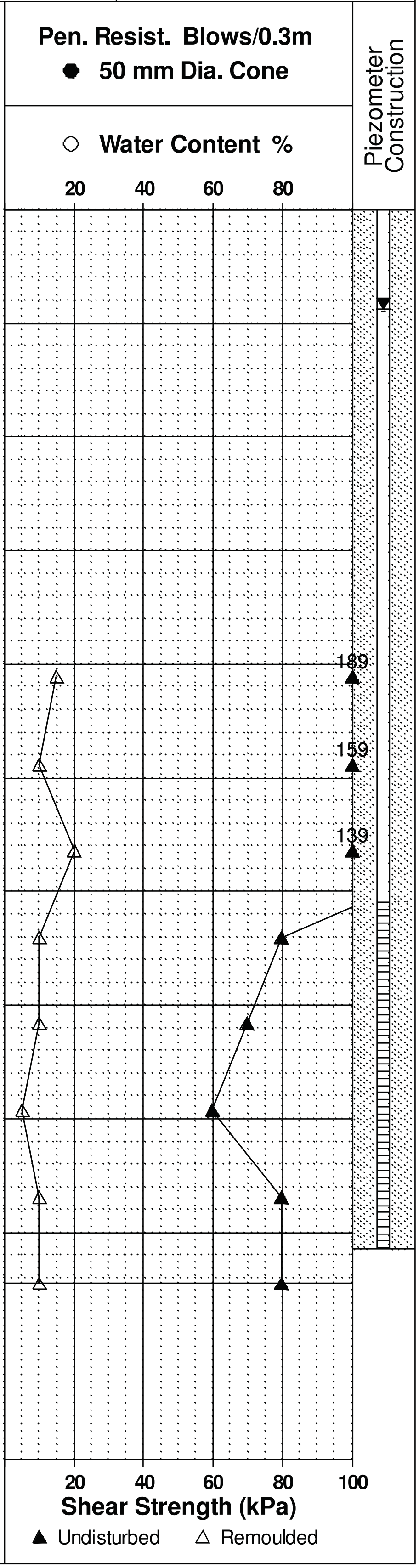
9.45

End of Borehole

(GWL @ 0.88m-Feb. 3/09)

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	54	14
SS	3	50	12
SS	4	71	9
SS	5	75	5

DEPTH (m)	ELEV. (m)
0	86.28
1	85.28
2	84.28
3	83.28
4	82.28
5	81.28
6	80.28
7	79.28
8	78.28
9	77.28



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

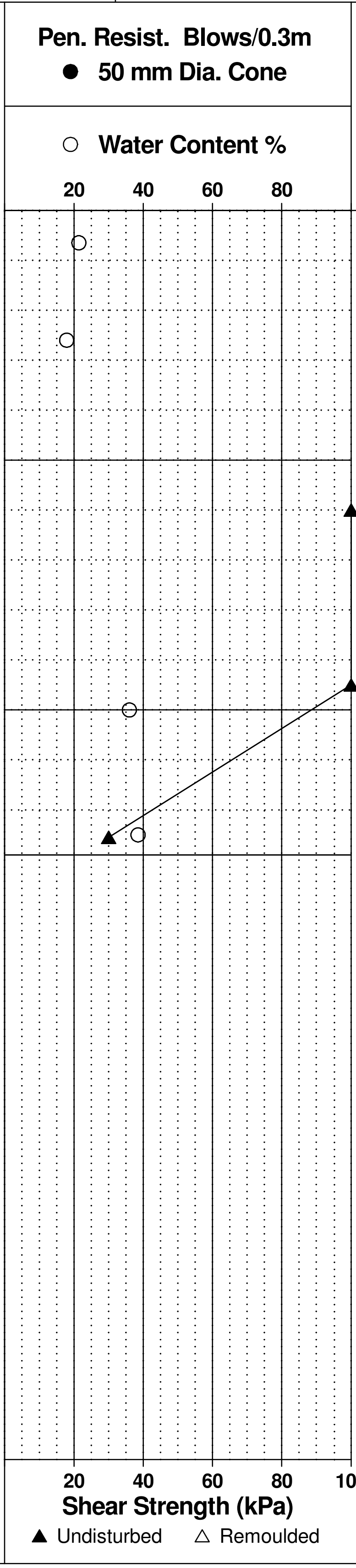
BORINGS BY Excavator

DATE 2021 February 26

FILE NO. PG5201

HOLE NO. TP 1-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	82.71
TOPSOIL 0.13		G	1				
Brown **SILTY CLAY** 0.52		G	2				
Very stiff brown **SILTY CLAY** some silty sand		G	3				
						1	81.71
						2	80.71
		G	4				
2.58		G	5				
End of Test Pit							



Piezometer Construction

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

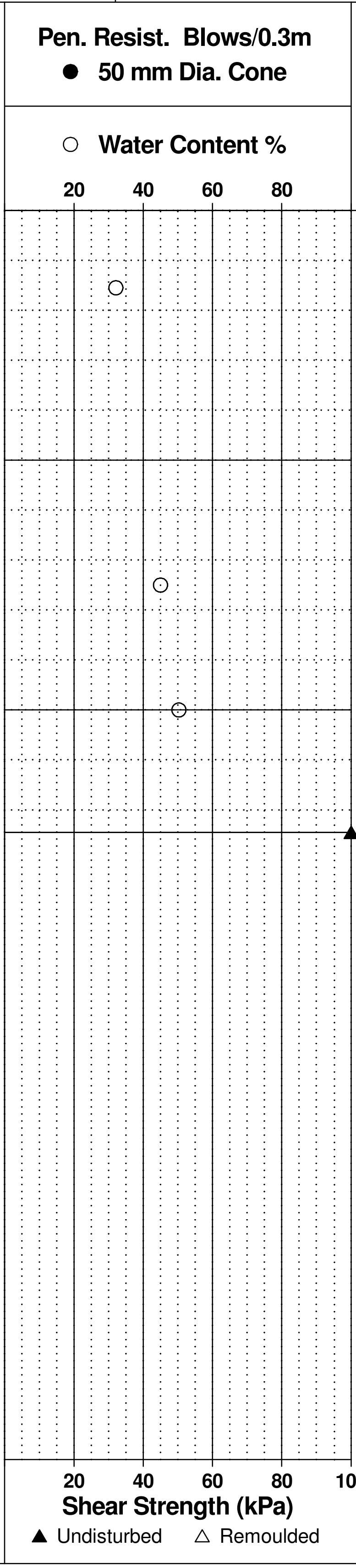
BORINGS BY Excavator

DATE 2021 February 26

FILE NO. PG5201

HOLE NO. TP 2-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.19		G	1			0	86.51
Brown **SILTY CLAY** with sand 0.31							
Very stiff brown **SILTY CLAY**		G	2				
						1	85.51
		G	3				
						2	84.51
2.49		G	4				
End of Test Pit							



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

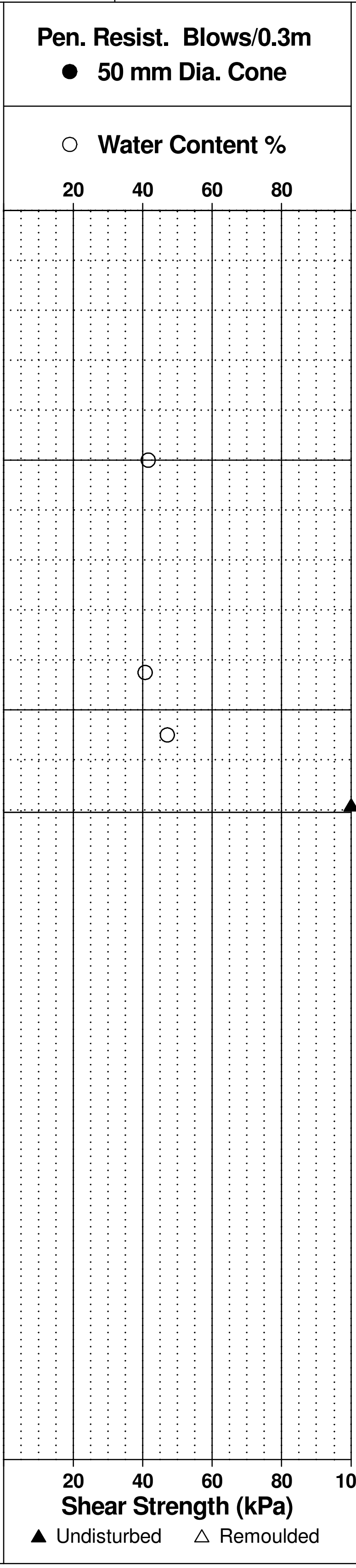
BORINGS BY Excavator

DATE 2021 February 26

FILE NO. PG5201

HOLE NO. TP 3-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	86.26
TOPSOIL 0.14		G	1				
Brown **SILTY CLAY** some sand 0.31							
Very stiff brown **SILTY CLAY**						1	85.26
		G	2				
		G	3			2	84.26
2.38		G	4				
End of Test Pit							



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. **PG5201**

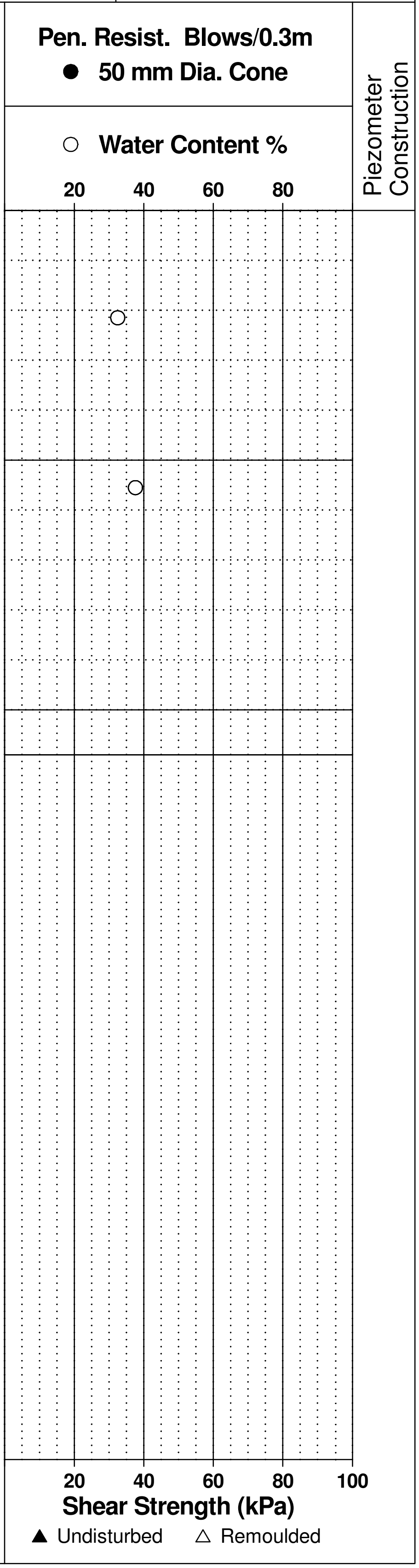
REMARKS

HOLE NO. **TP 4-21**

BORINGS BY Excavator

DATE 2021 February 26

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	87.13
FILL: Brown silty sand with crushed stone, gravel, cobbles and boulders	▩	G	1				
	▩	G	2				
0.98							
Stiff brown **SILTY CLAY**	▨					1	86.13
	▨	G	3				
	▨					2	85.13
2.18	▨	G	4				
End of Test Pit							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5201

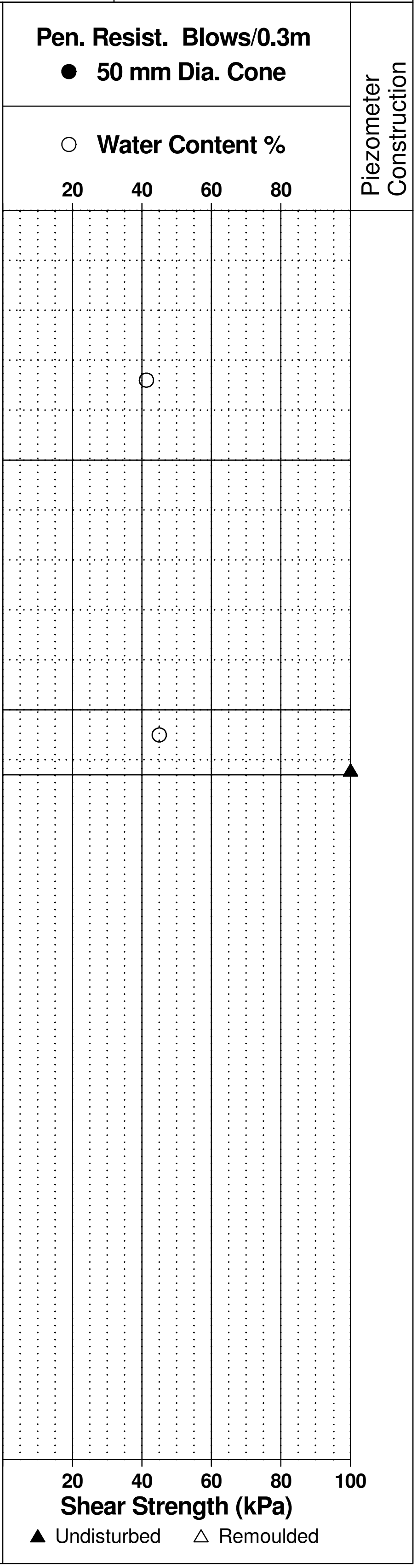
REMARKS

HOLE NO. TP 5-21

BORINGS BY Excavator

DATE 2021 February 26

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	86.65
TOPSOIL 0.15	■	G	1				
Very stiff brown **SILTY CLAY**	▨	G	2				
	▨					1	85.65
	▨					2	84.65
2.24	▨	G	3				
End of Test Pit							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

BORINGS BY Excavator

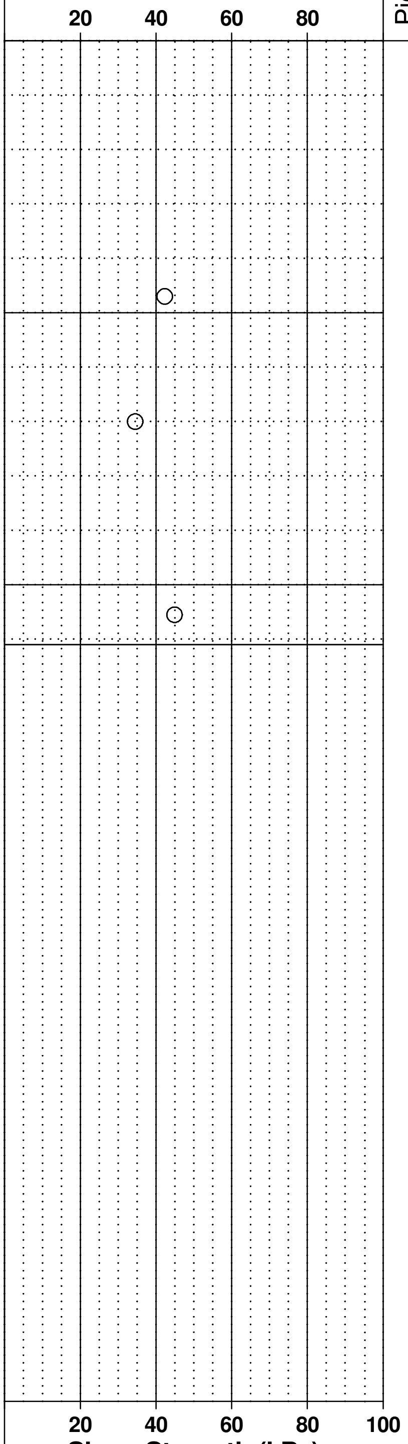
DATE 2021 February 26

FILE NO. PG5201

HOLE NO. TP 6-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.19		G	1			0	87.93
Brown **SILTY CLAY**						1	86.93
		G	2				
		G	3				
1.79							
GLACIAL TILL: Brown silty clay with some sand, gravel, cobbles and boulders						2	85.93
2.22		G	4				
End of Test Pit							

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



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

Piezometer Construction

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

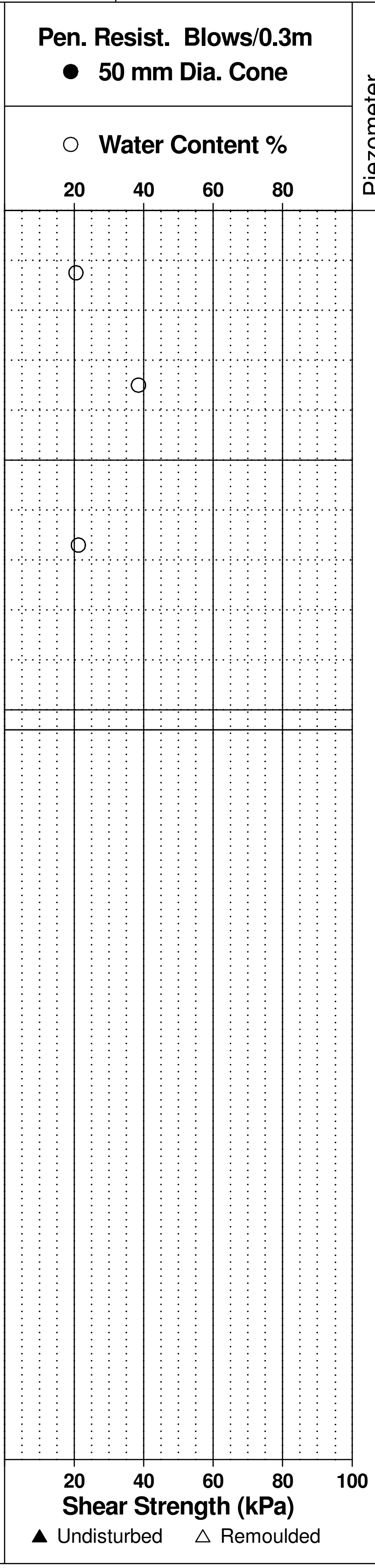
BORINGS BY Excavator

DATE 2021 February 26

FILE NO. PG5201

HOLE NO. TP 7-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.71
TOPSOIL 0.25		G	1				
Brown **SILTY SAND** 0.46		G	2				
Stiff brown **SILTY CLAY** 1.35		G	3			1	87.71
GLACIAL TILL: Brown silty clay, with gravel, cobbles and boulders 2.08		G	4			2	86.71
End of Test Pit							



Piezometer Construction

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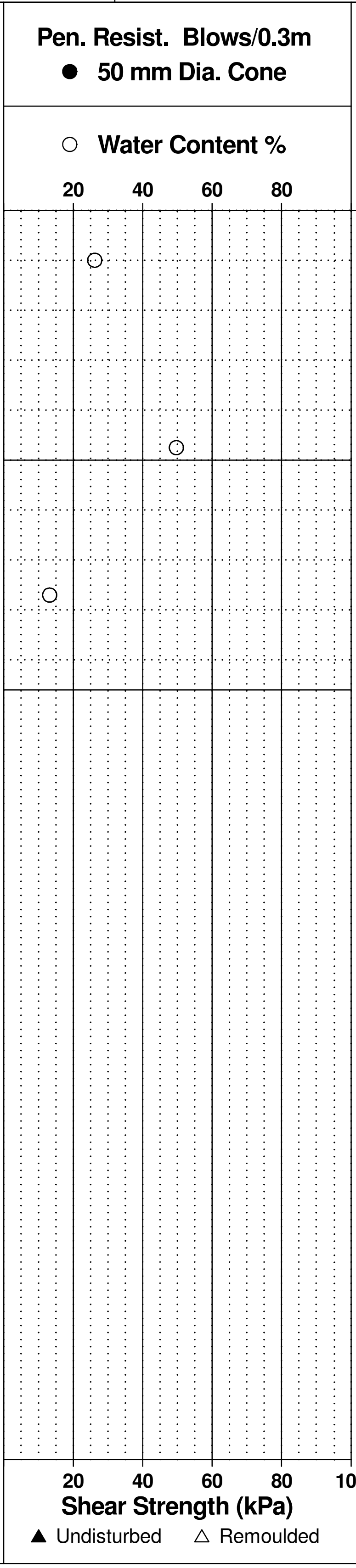
SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic
REMARKS
BORINGS BY Excavator
DATE 2021 February 26
FILE NO. PG5201
HOLE NO. TP 8-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	89.57	
TOPSOIL 0.19		G	1					
Brown **SILTY SAND** 0.95		G	2					
Stiff brown **SILTY CLAY** 1.54		G	3			1	88.57	
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders 1.92		G	4					
End of Test Pit Refusal to excavation on bedrock surface at 1.92 m depth								



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5201

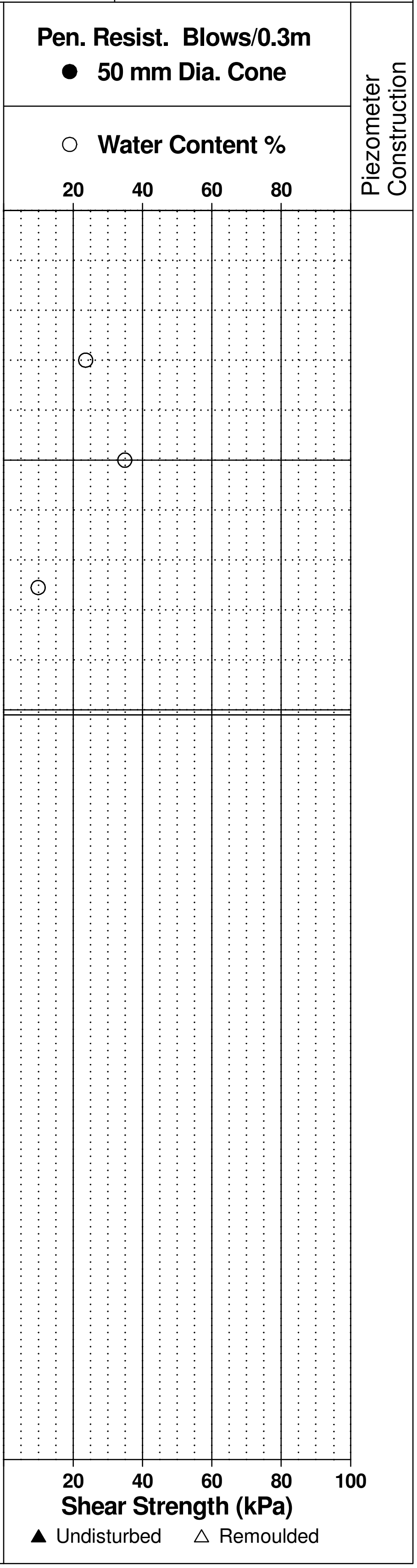
REMARKS

HOLE NO. TP 9-21

BORINGS BY Excavator

DATE 2021 February 26

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE							
TOPSOIL 0.16						0	89.24
Stiff brown **SILTY CLAY**		G	1				
		G	2				
						1	88.24
		G	3				
1.81		G	4				
GLACIAL TILL: Brown silty clay with brown silty sand, gravel, cobbles and boulders 2.02						2	87.24
End of Test Pit Refusal to excavation on bedrock surface at 2.02 m depth							



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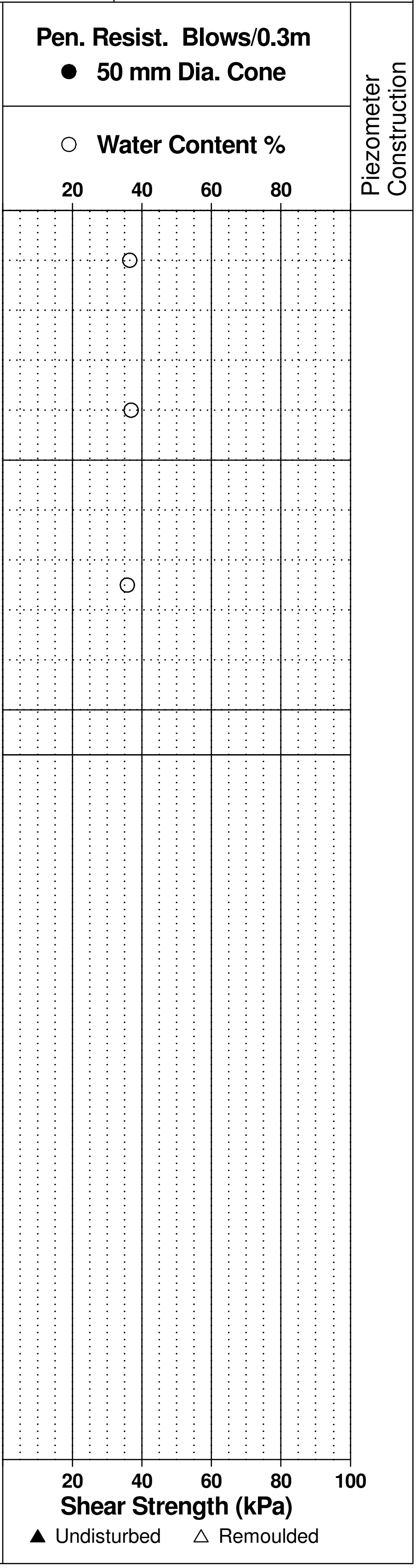
SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic
REMARKS
BORINGS BY Excavator
DATE 2021 February 26
FILE NO. PG5201
HOLE NO. TP10-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.32
TOPSOIL 0.19		G	1				
Brown **SILTY CLAY**		G	2				
		G	3			1	87.32
		G	4			2	86.32
2.18							
End of Test Pit Refusal to excavation on bedrock surface at 2.18 m depth							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

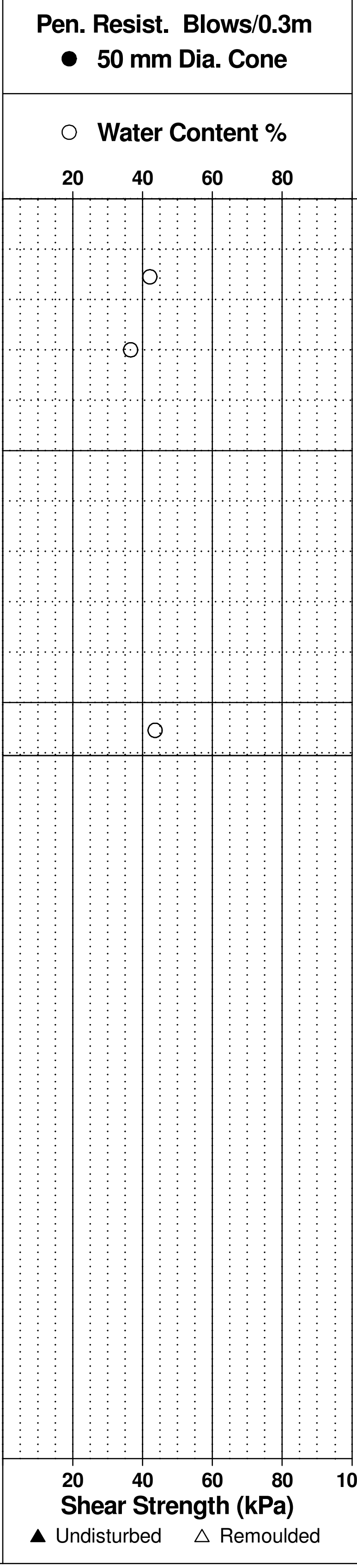
BORINGS BY Excavator

DATE 2021 February 26

FILE NO. PG5201

HOLE NO. TP11-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	86.87	
TOPSOIL 0.21	■	G	1					
Brown **SILTY CLAY**	▨	G	2					
	▨	G	3			1	85.87	
	▨					2	84.87	
2.21	▨	G	4					
End of Test Pit								



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5201

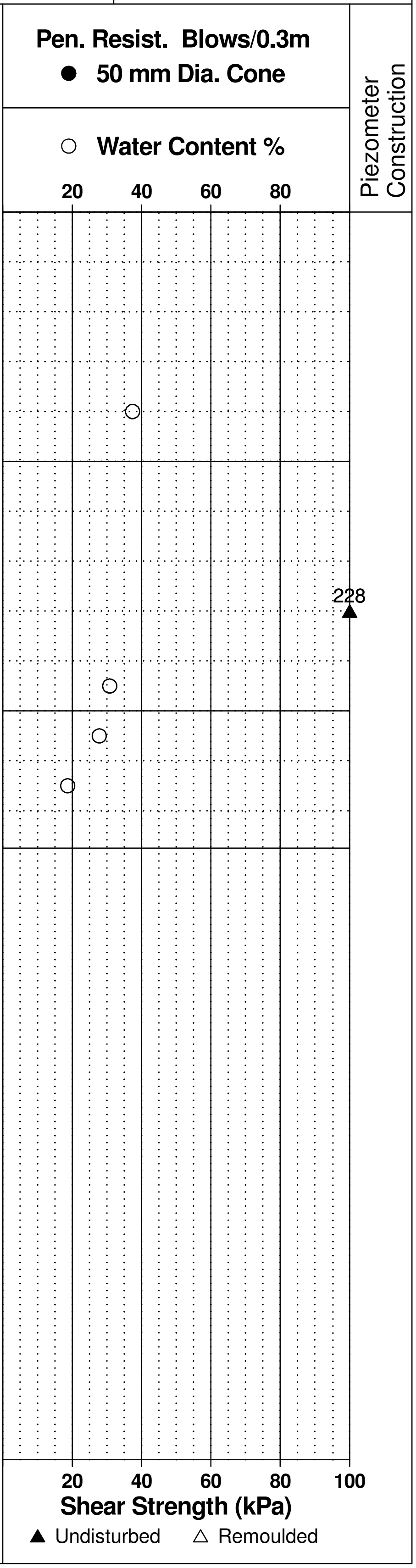
REMARKS

HOLE NO. TP12-21

BORINGS BY Excavator

DATE 2021 March 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	82.56
FILL: Fragmented rock with brown silty sand		G	1				
0.45							
Hard brown **SILTY CLAY**		G	2			1	81.56
		G	3			2	80.56
		G	4				
2.30							
GLACIAL TILL: Brown silty sand, some clay, gravel, cobbles and boulders		G	5				
2.55							
End of Test Pit Refusal to excavation on bedrock surface at 2.55 m depth							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. **PG5201**

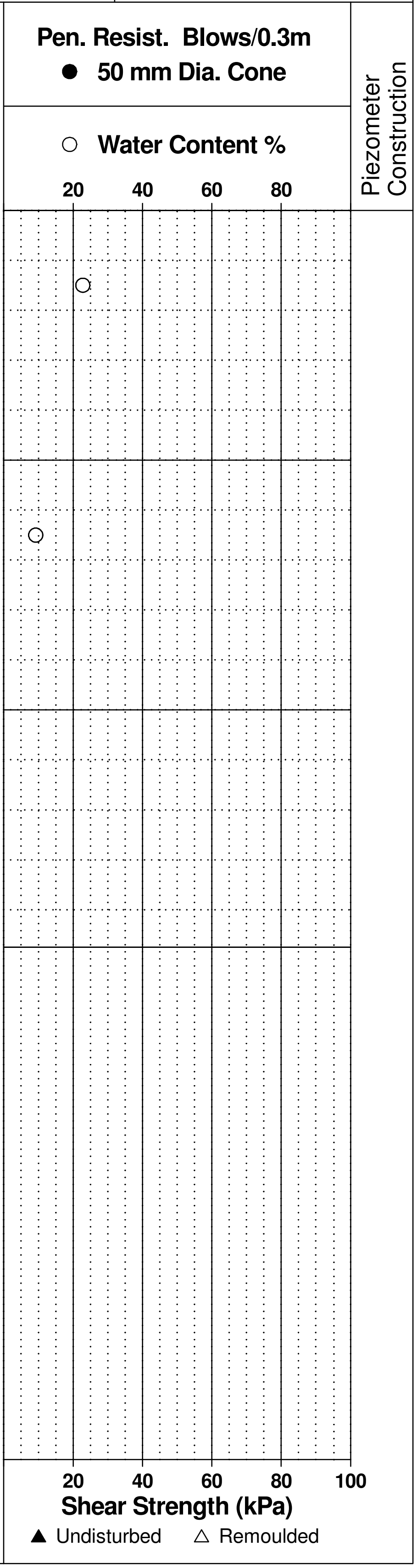
REMARKS

HOLE NO. **TP13-21**

BORINGS BY Excavator

DATE 2021 March 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.22	■					0	87.22
GLACIAL TILL: Brown silty clay some sand, trace gravel, cobbles and boulders 0.60		G	1				
GLACIAL TILL: Brown silty sand some gravel, cobbles and boulders						1	86.22
		G	2				
2.95						2	85.22
End of Test Pit Refusal to excavation on bedrock surface at 2.95 m depth							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. **PG5201**

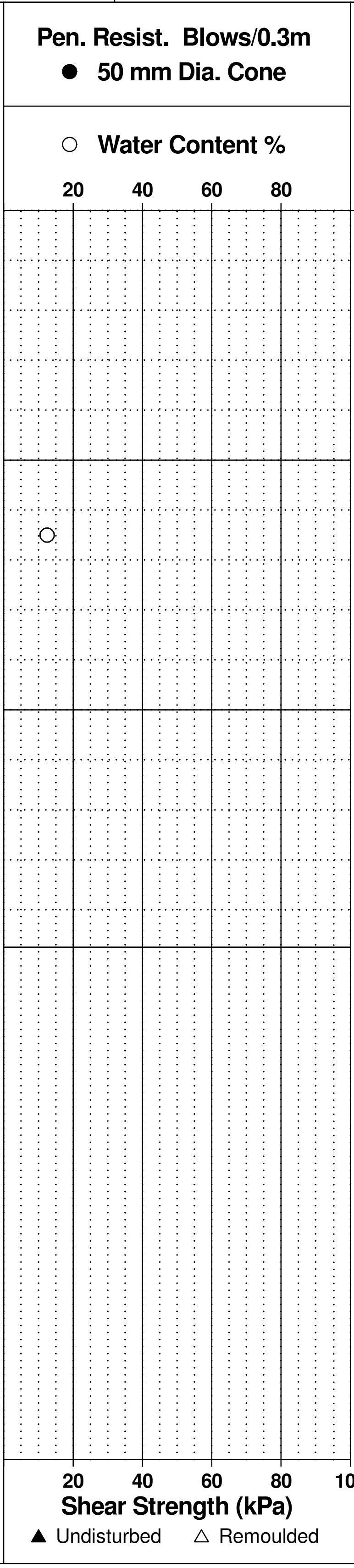
REMARKS

HOLE NO. **TP14-21**

BORINGS BY Excavator

DATE 2021 March 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.44
TOPSOIL 0.25	■	G	1				
GLACIAL TILL: Brown silty sand some gravel, cobbles and boulders 2.95	^	G	2			1 2	92.44 91.44
End of Test Pit Refusal to excavation on bedrock surface at 2.95 m depth							



Piezometer Construction

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

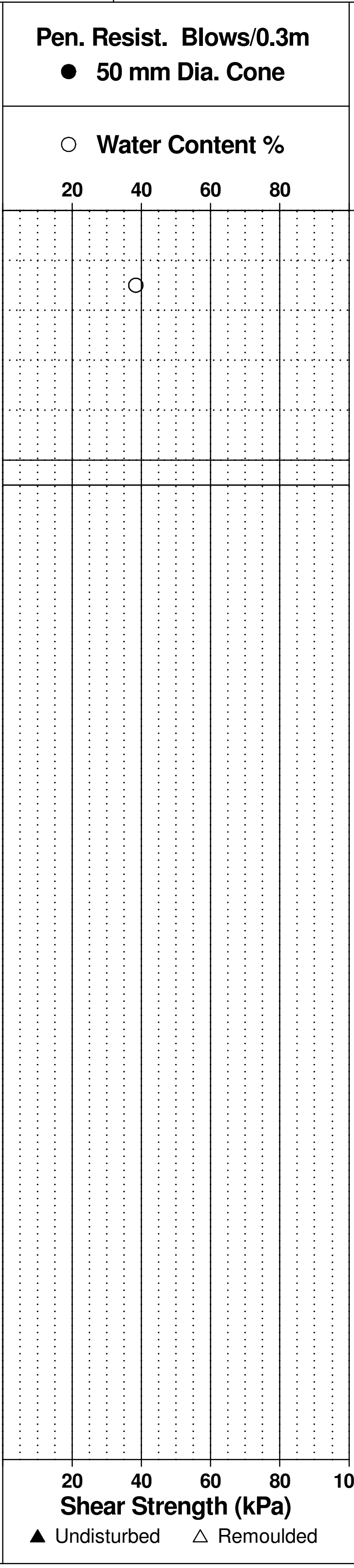
BORINGS BY Excavator

DATE 2021 March 1

FILE NO. PG5201

HOLE NO. TP15-21

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	94.54
TOPSOIL (to 0.27)						
GLACIAL TILL: Brown silty sand some gravel, cobbles and boulders (0.27 to 1.10)	G	1				
					1	93.54
End of Test Pit Refusal to excavation on bedrock surface at 1.10 m depth						



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

REMARKS

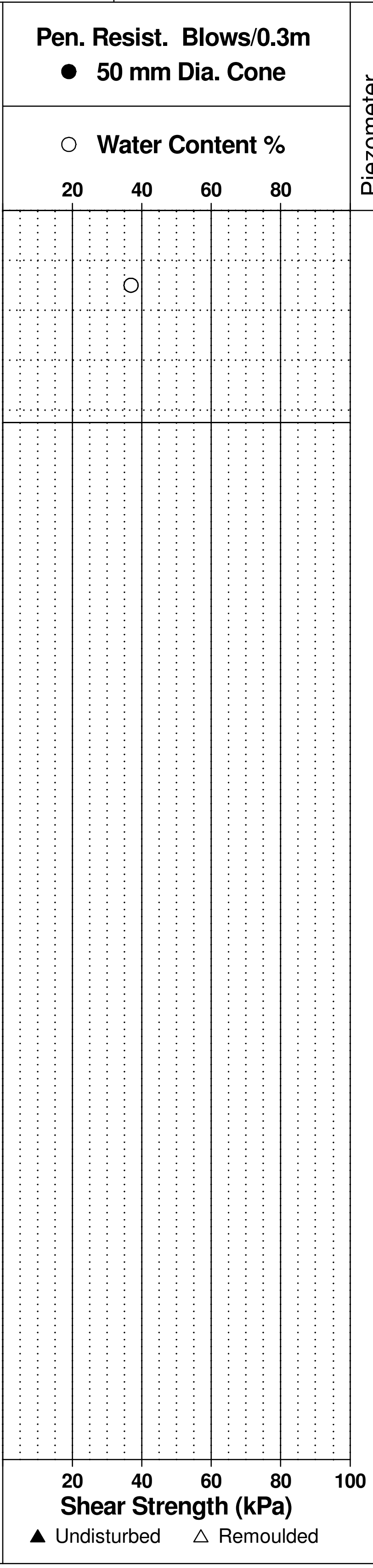
BORINGS BY Excavator

DATE 2021 March 1

FILE NO. PG5201

HOLE NO. TP16-21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	90.42
TOPSOIL							
0.26							
GLACIAL TILL: Brown silty clay, some sand, gravel, cobbles and boulders		G	1				
0.85							
End of Test Pit							



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5201

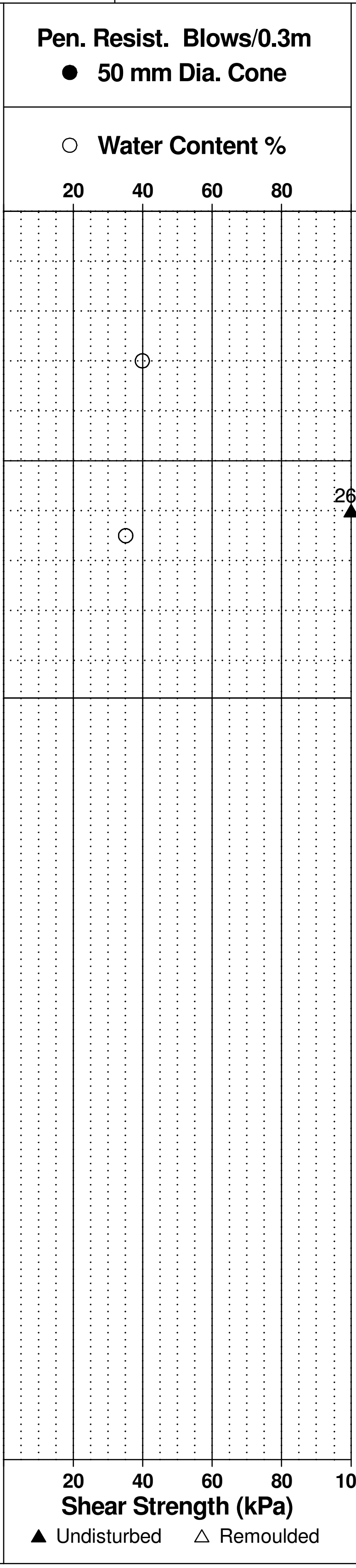
REMARKS

HOLE NO. TP17-21

BORINGS BY Excavator

DATE 2021 March 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL						0	89.57
0.27							
Hard brown **SILTY CLAY**		G	1				
						1	88.57
		G	2				
1.95							
End of Test Pit Refusal to excavation on bedrock surface at 1.95 m depth							



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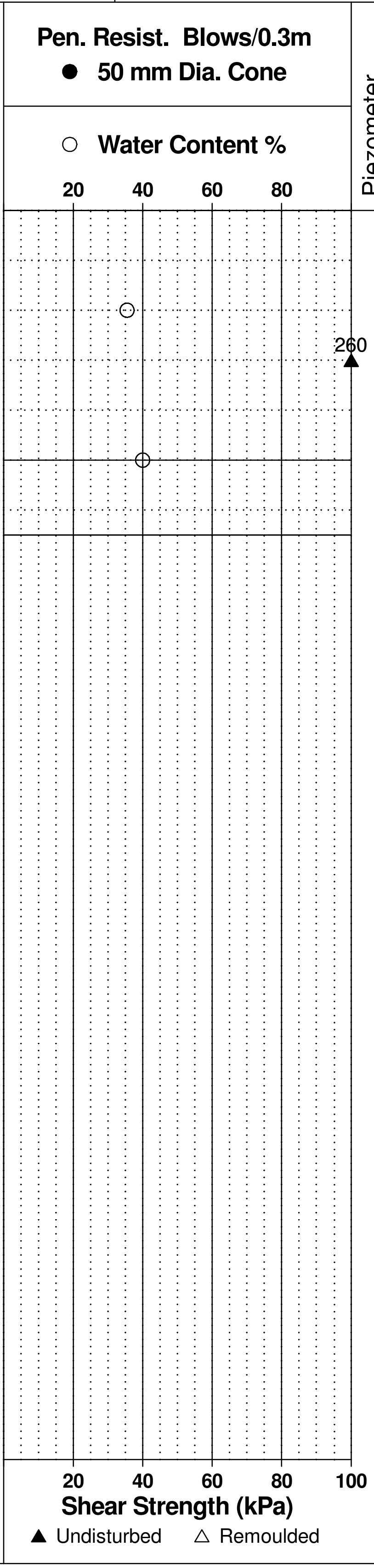
SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic
REMARKS
BORINGS BY Excavator
DATE 2021 March 1
FILE NO. PG5201
HOLE NO. TP18-21

SOIL DESCRIPTION GROUND SURFACE	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
TOPSOIL	■					0	89.96	
0.26								
Hard brown **SILTY CLAY**	▨	G	1					
	▨	G	2			1	88.96	
1.30								
End of Test Pit Refusal to excavation on bedrock surface at 1.30 m depth								



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5201

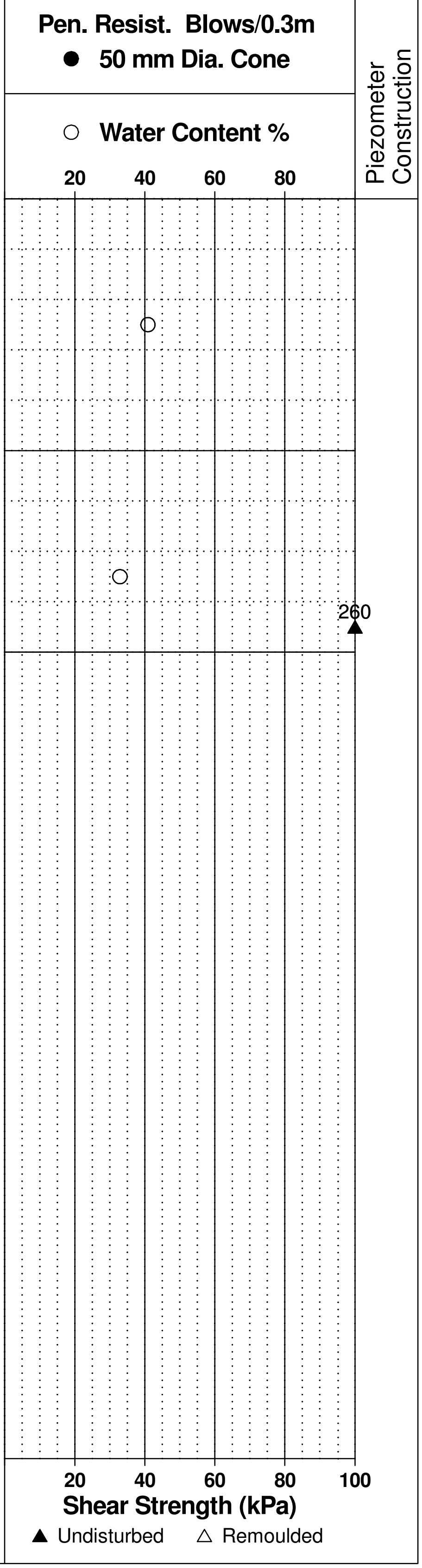
REMARKS

HOLE NO. TP19-21

BORINGS BY Excavator

DATE 2021 March 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	88.27
TOPSOIL							
0.28							
ard brown **SILTY CLAY**		G	1				
						1	87.27
		G	2				
1.80							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development
Cardinal Creek Village South - Ottawa, Ontario

DATUM Geodetic

FILE NO. PG5201

REMARKS

HOLE NO. TP20-21

BORINGS BY Excavator

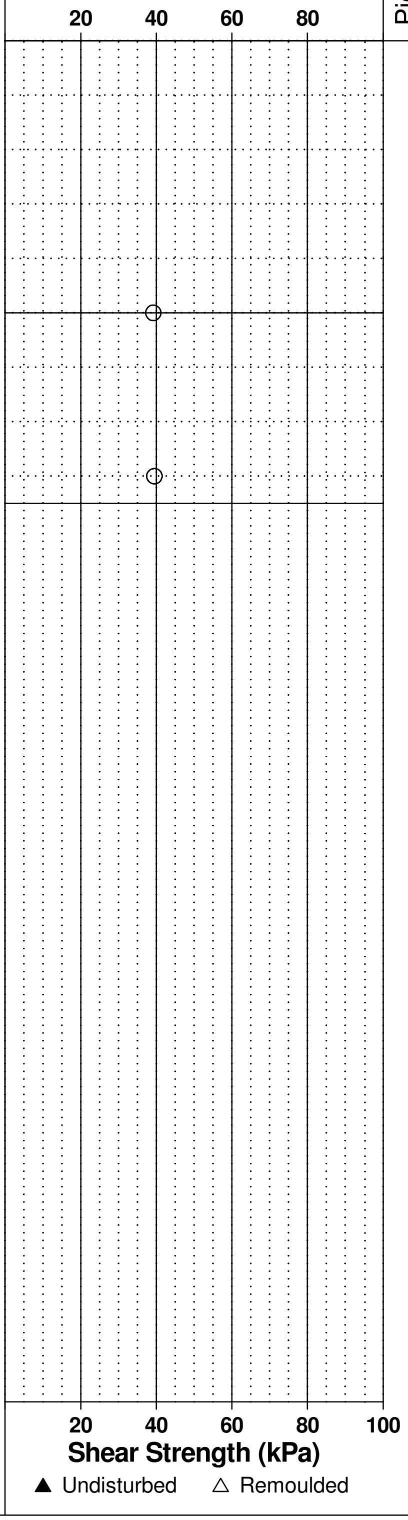
DATE 2021 March 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	87.43
TOPSOIL 0.29	■						
Hard brown **SILTY CLAY**	▨	G	1			1	86.43
1.70	▨	G	2				
End of Test Pit Refusal to excavation on bedrock surface at 1.70 m depth							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

Piezometer Construction



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 relative strength of cohesionless soils is the compactness condition, 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. An SPT N value of “P” denotes that the split-spoon sampler was pushed 300 mm into the soil without the use of a falling hammer.

Compactness Condition	‘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 shear vane tests, unconfined compression tests, or occasionally by the Standard Penetration Test (SPT). Note that the typical correlations of undrained shear strength to SPT N value (tabulated below) tend to underestimate the consistency for sensitive silty clays, so Paterson reviews the applicable split spoon samples in the laboratory to provide a more representative consistency value based on tactile examination.

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, S_t, is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil. The classes of sensitivity may be defined as follows:

Low Sensitivity:	$S_t < 2$
Medium Sensitivity:	$2 < S_t < 4$
Sensitive:	$4 < S_t < 8$
Extra Sensitive:	$8 < S_t < 16$
Quick Clay:	$S_t > 16$

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 NQ or larger size core. However, it can be used on smaller core sizes, such as BQ, 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, generally recovered using a piston sampler
G	-	"Grab" sample from test pit or surface materials
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size BQ, NQ, HQ, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

PLASTICITY LIMITS AND GRAIN SIZE DISTRIBUTION

WC% - Natural water 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 at 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 = $(D30)^2 / (D10 \times D60)$
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)

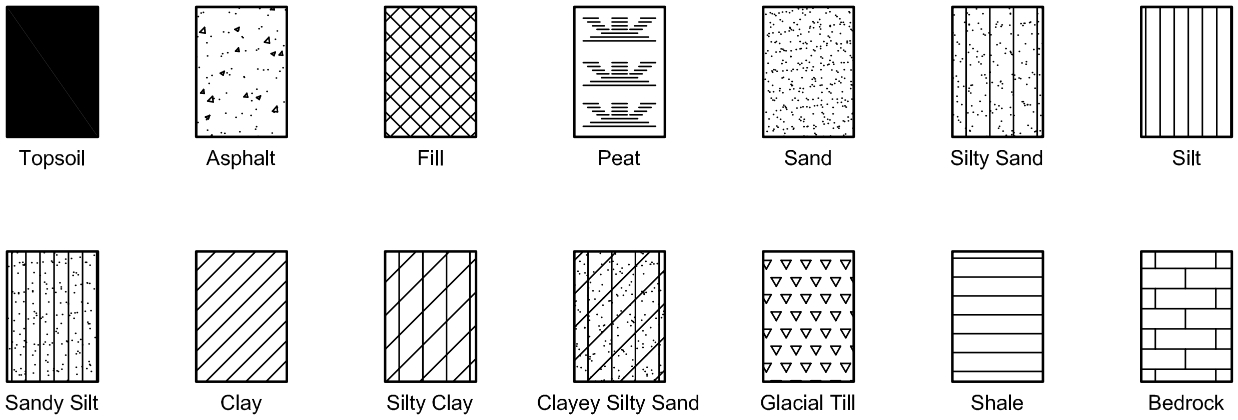
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

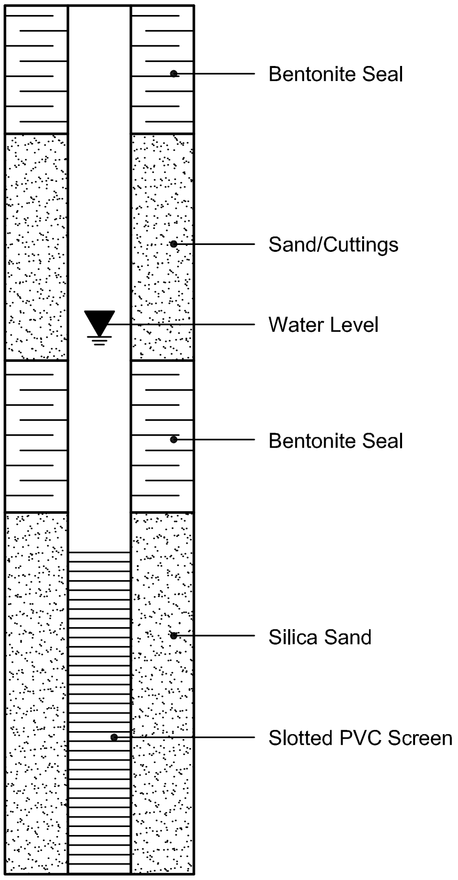
SYMBOLS AND TERMS (continued)

STRATA PLOT

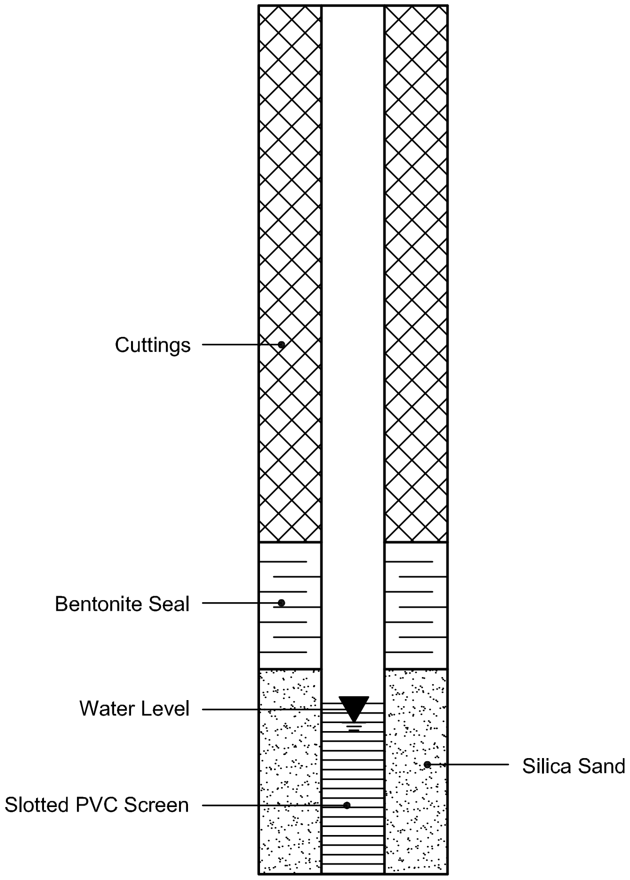


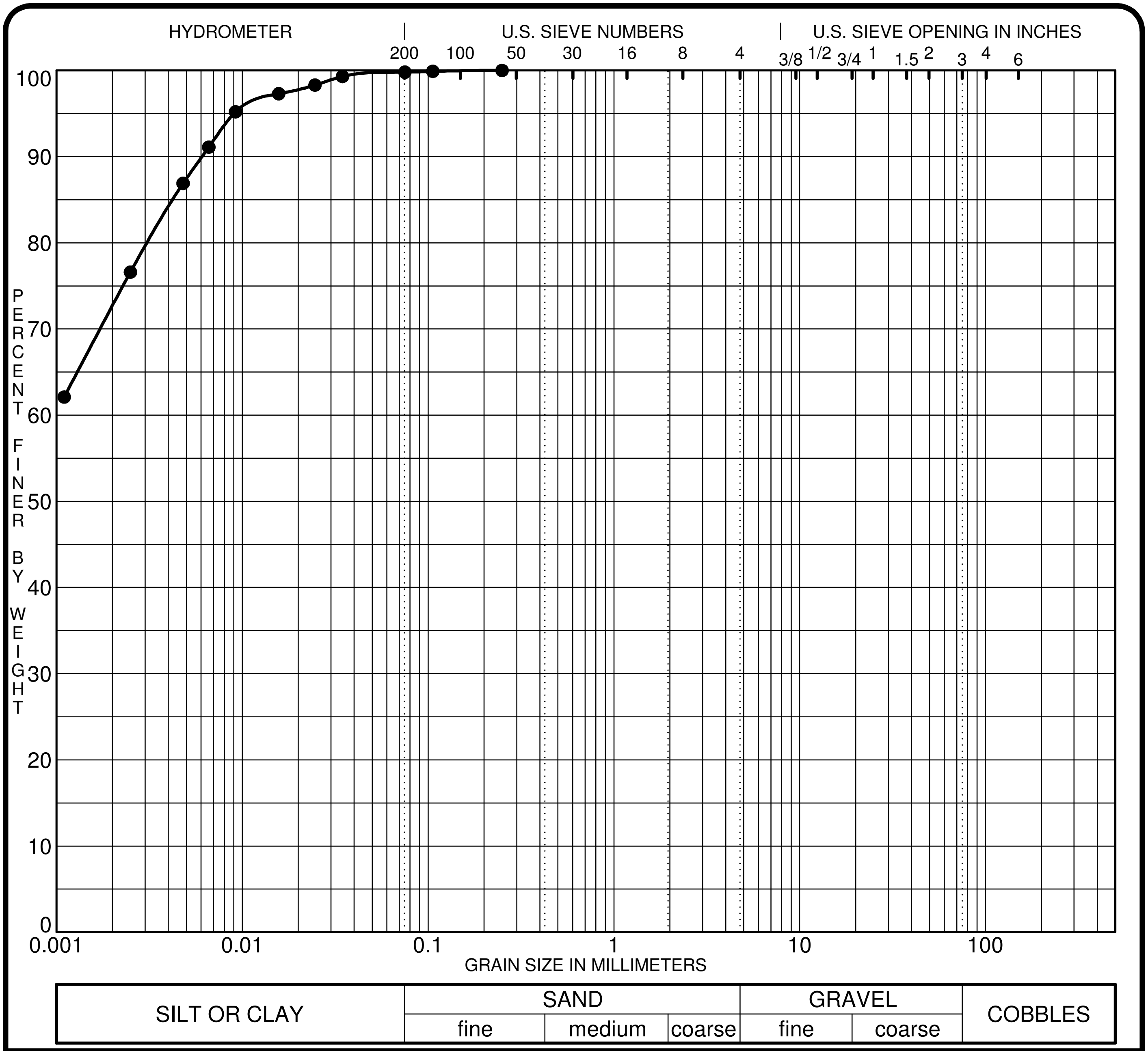
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**TP 2-21 G4**	**CH = Inorganic Clays of High Plasticity**		**71**	**29**	**42**		

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP 2-21 G4**	**0.25**				**0.0**	**0.2**	**99.8**	

CLIENT **Taggart Investments**

FILE NO. **PG5201**

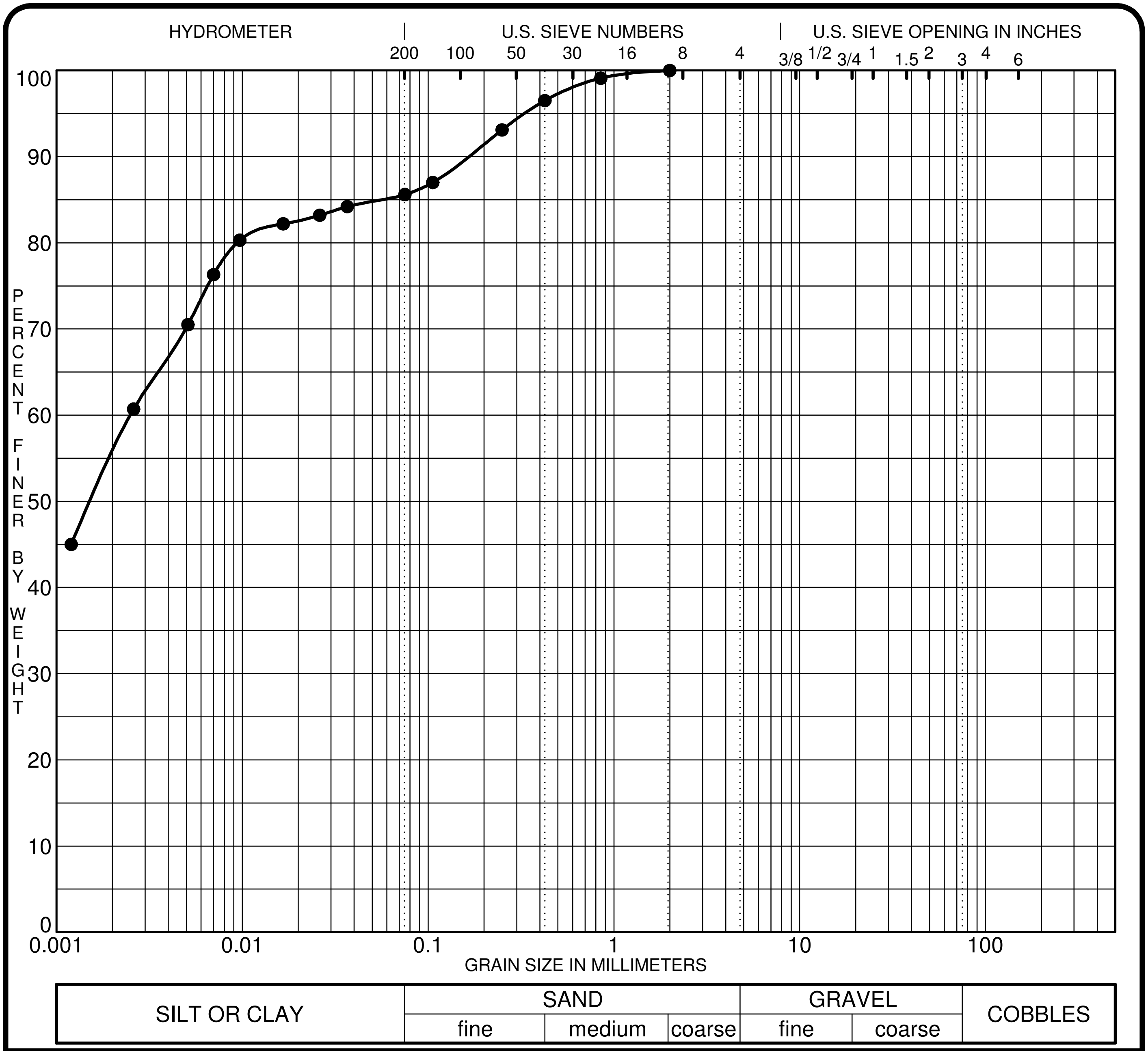
PROJECT **Geotechnical Investigation - Proposed Residential Development**

DATE **26 Feb 21**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

GRAIN SIZE DISTRIBUTION



	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**TP 7-21 G3**	**MH = Inorganic Silts of High Plasticity**		**59**	**32**	**27**		

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP 7-21 G3**	**2.00**	**0.00**			**0.0**	**14.4**	**85.6**	

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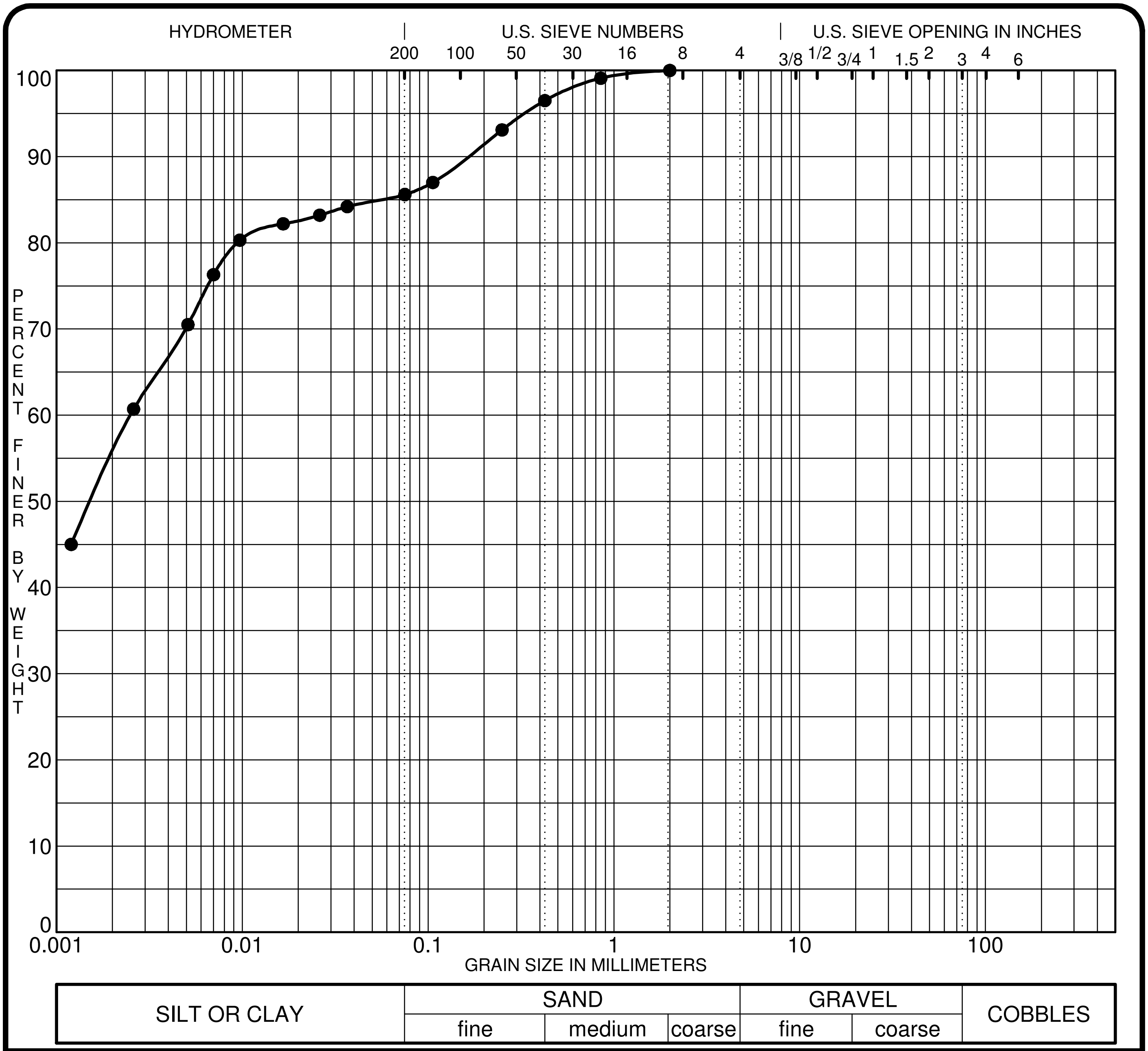
GRAIN SIZE DISTRIBUTION



	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**TP10-21 G4**	**MH = Inorganic SIlts of High Plasticity**		**60**	**33**	**27**		

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP10-21 G4**	**2.00**	**0.00**			**0.0**	**14.4**	**85.6**	

CLIENT **Taggart Investments**

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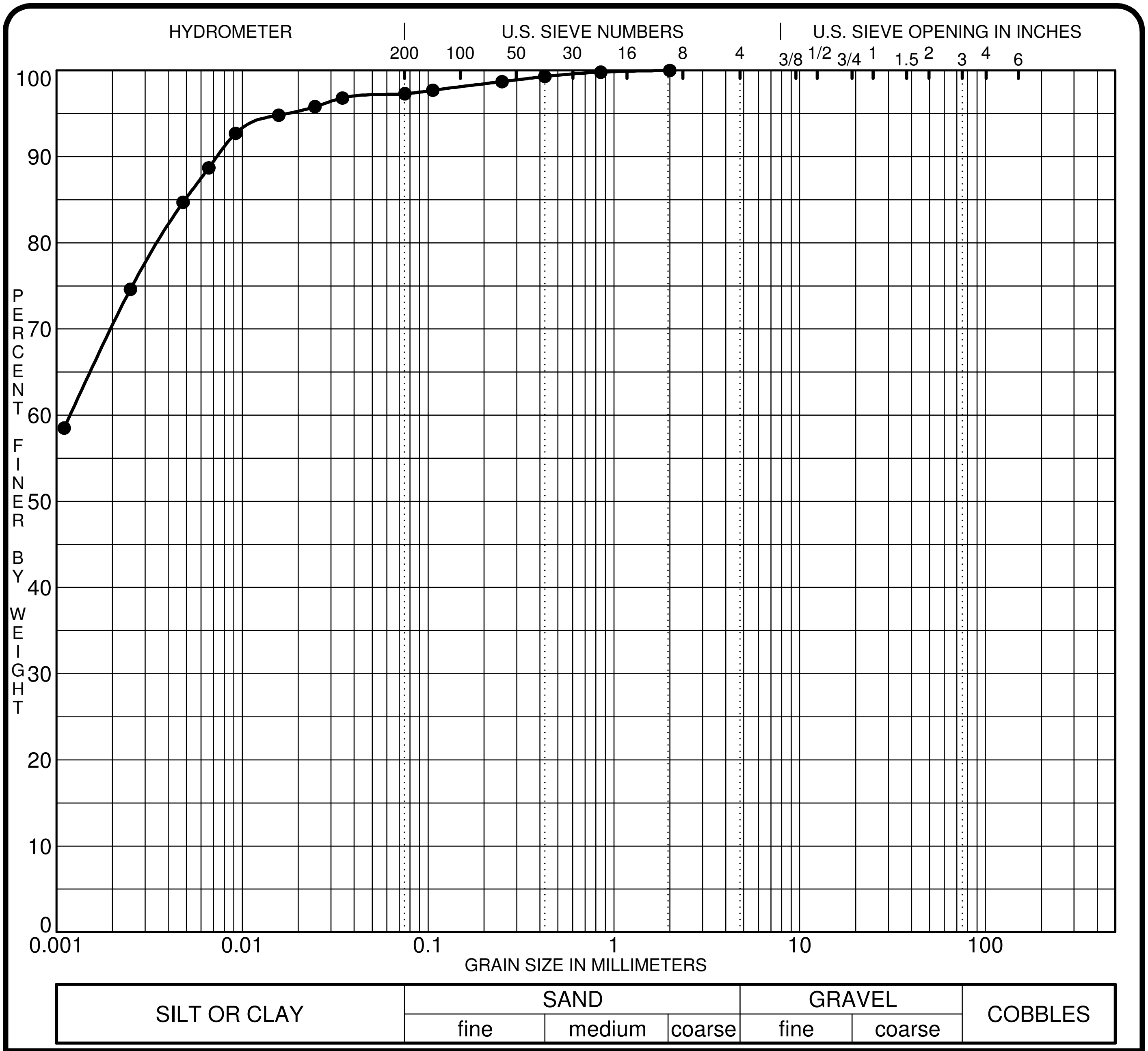
GRAIN SIZE DISTRIBUTION



	Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
●	**TP12-21 G2**	**MH = Inorganic Silts of High Plasticity**		**75**	**37**	**38**		

	Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**TP12-21 G4**	**2.00**	**0.00**			**0.0**	**2.7**	**97.3**	

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DATE **1 Mar 21**

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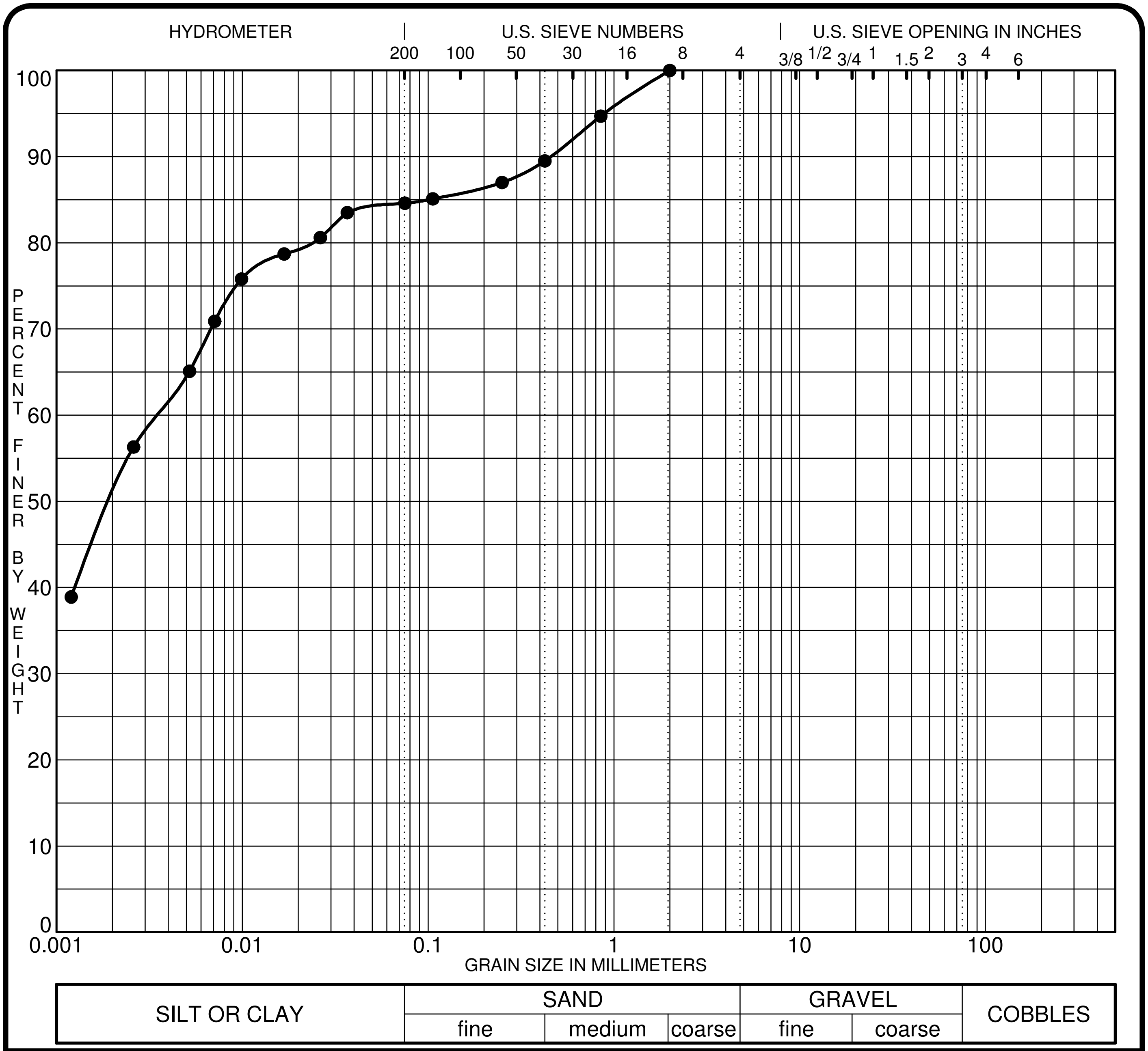
GRAIN SIZE DISTRIBUTION



Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● **TP18-21 G1**	**MH = Inorganic Silts of High Plasticity**		**66**	**36**	**30**		

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● **TP18-21 G1**	**2.00**	**0.00**			**0.0**	**15.4**	**84.6**	

CLIENT **Taggart Investments**

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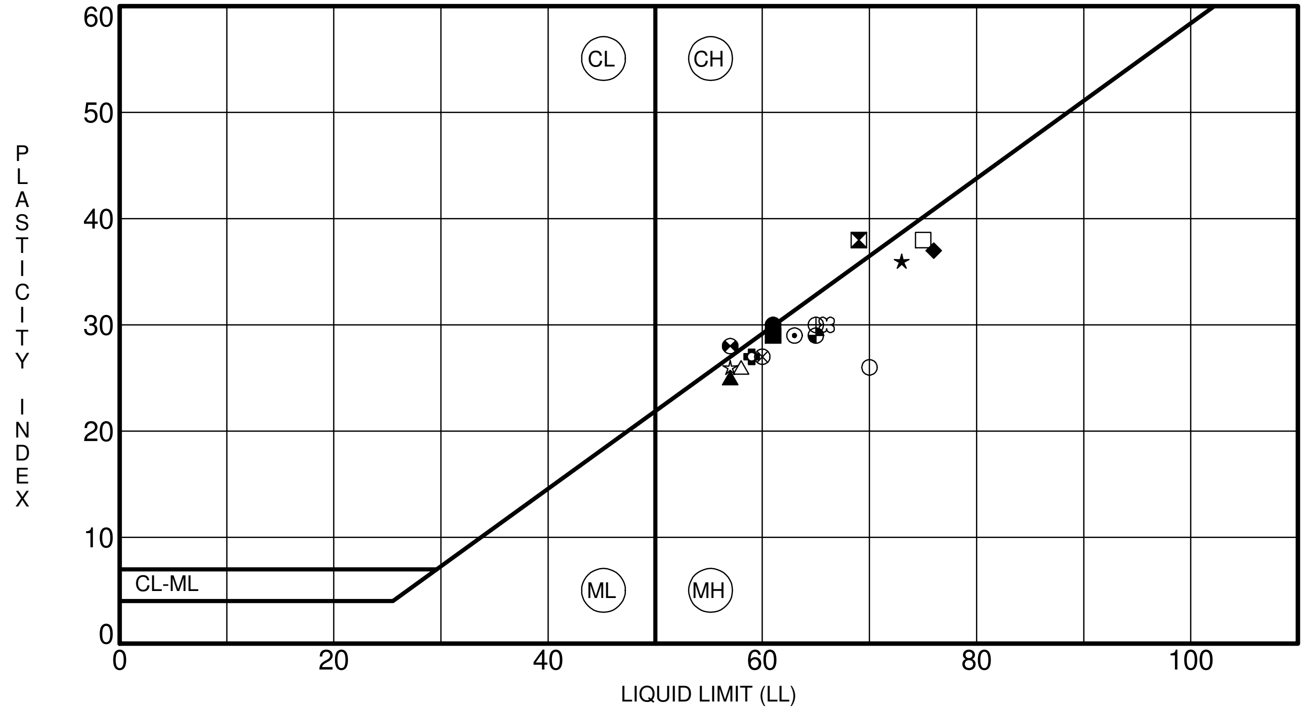
GRAIN SIZE DISTRIBUTION



Specimen Identification		LL	PL	PI	Fines	Classification
●	**TP 1-21 G4**	**61**	**31**	**30**		**CH = Inorganic Clays of High Plasticity**
⧗	**TP 3-21 G3**	**69**	**31**	**38**		**CH = Inorganic Clays of High Plasticity**
▲	**TP 4-21 G3**	**57**	**32**	**25**		**MH = Inorganic Silts of High Plasticity**
★	**TP 5-21 G3**	**73**	**37**	**36**		**MH = Inorganic Silts of High Plasticity**
⊙	**TP 6-21 G2**	**63**	**34**	**29**		**MH = Inorganic Silts of High Plasticity**
✿	**TP 7-21 G3**	**59**	**32**	**27**	**85.6**	**MH = Inorganic Silts of High Plasticity**
○	**TP 8-21 G3**	**70**	**44**	**26**		**MH = Inorganic Silts of High Plasticity**
△	**TP 9-21 G2**	**58**	**32**	**26**		**MH = Inorganic Silts of High Plasticity**
⊗	**TP10-21 G4**	**60**	**33**	**27**	**85.6**	**MH = Inorganic SIlts of High Plasticity**
⊕	**TP11-21 G4**	**65**	**35**	**30**		**MH = Inorganic Silts of High Plasticity**
□	**TP12-21 G2**	**75**	**37**	**38**	**97.3**	**MH = Inorganic Silts of High Plasticity**
◍	**TP16-21 G1**	**57**	**29**	**28**		**CH = Inorganic Clays of High Plasticity**
◕	**TP17-21 G1**	**65**	**36**	**29**		**MH = Inorganic Silts of High Plasticity**
☆	**TP17-21 G2**	**57**	**31**	**26**		**MH = Inorganic Silts of High Plasticity**
⌘	**TP18-21 G1**	**66**	**36**	**30**	**84.6**	**MH = Inorganic Silts of High Plasticity**
■	**TP19-21 G2**	**61**	**32**	**29**		**MH = Inorganic Silts of High Plasticity**
◆	**TP20-21 G1**	**76**	**39**	**37**		**MH = Inorganic Silts of High Plasticity**

CLIENT **Taggart Investments**

FILE NO. **PG5201**

PROJECT **Geotechnical Investigation - Proposed Residential Development**

DATE **1 Mar 21**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 45.497N 75.458W **User File Reference:** PG5201 2022-02-06 21:38 UT

Requested by: Paterson Group

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.523	0.288	0.170	0.049
Sa (0.1)	0.604	0.343	0.211	0.067
Sa (0.2)	0.497	0.287	0.180	0.060
Sa (0.3)	0.373	0.217	0.137	0.047
Sa (0.5)	0.261	0.152	0.096	0.033
Sa (1.0)	0.127	0.074	0.047	0.016
Sa (2.0)	0.059	0.034	0.021	0.006
Sa (5.0)	0.016	0.008	0.005	0.001
Sa (10.0)	0.006	0.003	0.002	0.001
PGA (g)	0.319	0.185	0.114	0.036
PGV (m/s)	0.217	0.121	0.074	0.023

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

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Canada

Table 1 - Cardinal Creek Village South - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Mississippi River	OF8600	Mss1	45.41279	-76.24891	Landslide	Source area with truncated debris field	0.08	Unknown	15.00	65.80	Marine Deposits	15 to 25	Granite
Mississippi River	OF8600	Mss2	45.41224	-76.25685	Landslide	Source area with debris field	0.03	Unknown	11.00	66.46	Marine Deposits	15 to 25	Granite
Mississippi River	OF8600	Mss3	45.40384	-76.24579	Landslide	Source area with debris field	0.11	Unknown	23.00	65.72	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss4	45.40073	-76.25147	Landslide	Truncated source area	0.01	Unknown	14.00	66.25	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss5	45.39957	-76.24593	Landslide	Source area with truncated debris field	0.02	Unknown	20.00	65.82	Erosional Terraces	15 to 25	Marble
Mississippi River	OF8600	Mss6	45.39906	-76.25294	Landslide	Source area with truncated debris field	0.04	Unknown	15.00	66.40	Marine Deposits	15 to 25	Marble
Mississippi River	OF8600	Mss7	45.39121	-76.25506	Landslide	Truncated source area	0.01	Unknown	15.00	66.74	Erosional Terraces	10 to 15	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss8	45.38970	-76.25421	Landslide	Source area with truncated debris field	0.03	Unknown	12.00	66.71	Erosional Terraces	5 to 10	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss9	45.38953	-76.25872	Landslide	Source area with truncated debris field	0.02	Unknown	15.00	67.07	Organic Deposits	5 to 10	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss10	45.38715	-76.25825	Landslide	Source area with truncated debris field	0.01	Unknown	15.00	67.09	Erosional Terraces	5 to 10	Interbedded Limestone and Shale
Mississippi River	OF8600	Mss11	45.37849	-76.26739	Landslide	Truncated source area	0.03	Unknown	13.00	68.04	Erosional Terraces	50 to 100	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss12	45.37130	-76.26864	Landslide	Truncated source area	0.02	Unknown	11.00	68.32	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi Valley	OF8600	Mss13	45.36543	-76.27229	Landslide	Truncated source area	0.02	Unknown	12.00	68.77	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss14	45.36519	-76.27788	Landslide	Source area with truncated debris field	0.02	Unknown	12.00	69.22	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss15	45.36304	-76.27430	Landslide	Source area with truncated debris field	0.03	Unknown	15.00	68.99	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss16	45.36359	-76.26926	Landslide	Truncated source area	0.01	Unknown	17.00	68.57	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss17	45.36075	-76.26736	Landslide	Source area with debris field	0.06	Unknown	20.00	68.50	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss18	45.36124	-76.27193	Landslide	Truncated source area	0.01	Unknown	12.00	68.85	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss19	45.36122	-76.27561	Landslide	Source area with debris field	0.04	Unknown	10.00	69.15	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite

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			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Mississippi River	OF8600	Mss20	45.36267	-76.28135	Landslide	Source area with debris field	0.02	Unknown	10.00	69.57	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss21	45.35604	-76.26640	Landslide	Source area with debris field	0.11	Unknown	15.00	68.55	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss22	45.35416	-76.27441	Landslide	Truncated source area	0.01	Unknown	17.00	69.25	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss23	45.35244	-76.27982	Landslide	Truncated source area	0.01	Unknown	25.00	69.73	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss24	45.35168	-76.28166	Landslide	Truncated source area	0.01	Unknown	25.00	69.90	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Mississippi River	OF8600	Mss25	45.35103	-76.28318	Landslide	Truncated source area	0.02	Unknown	20.00	70.04	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy1	45.35143	-76.26277	Landslide	Source area with truncated debris field	0.01	Unknown	16.00	68.40	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy2	45.35023	-76.26130	Landslide, possibly	Source area with debris field	0.01	Unknown	***	68.32	***	***	***
Cody Creek	OF8600	Cdy3	45.34522	-76.26452	Landslide	Truncated source area	0.01	Unknown	21.00	68.73	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy4	45.34223	-76.26721	Landslide	Truncated source area	0.02	Unknown	17.00	69.04	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy5	45.33939	-76.25827	Landslide	Source area with truncated debris field	0.07	Unknown	17.00	68.42	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy6	45.33979	-76.24991	Landslide	Source area with truncated debris field	0.06	Unknown	13.00	67.74	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy7	45.34175	-76.24524	Landslide, possibly	Source area with truncated debris field	0.10	Unknown	***	67.30	***	***	***
Cody Creek	OF8600	Cdy8	45.33762	-76.24262	Landslide	Source area with truncated debris field	0.03	Unknown	23.00	67.23	Marine Deposits	10 to 15	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy9	45.33822	-76.23647	Landslide	Source area with truncated debris field	0.01	Unknown	17.00	66.73	Marine Deposits	5 to 10	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy10	45.33477	-76.23220	Landslide	Source area with truncated debris field	0.06	Unknown	12.00	66.50	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy11	45.33386	-76.23415	Landslide, probably	Source area with truncated debris field	0.04	Unknown	**	66.69	**	**	**
Cody Creek	OF8600	Cdy12	45.32989	-76.22645	Landslide, probably	Source area with truncated debris field	0.04	Unknown	**	66.22	**	**	**
Cody Creek	OF8600	Cdy13	45.32654	-76.22004	Landslide, probably	Source area with truncated debris field	0.03	Unknown	**	65.83	**	**	**

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			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Cody Creek	OF8600	Cdy14	45.32031	-76.21358	Landslide	Source area with truncated debris field; isolated areas of debris field	0.05	Unknown	24.00	65.56	Marine Deposits	10 to 15	Interbedded Limestone and Dolomite
Cody Creek	OF8600	Cdy15	45.34728	-76.23587	Landslide, probably	Debris field within a narrow stream valley	0.01	Unknown		66.38			
Madawaska Lake reservoir	OF8600	Mdw1	45.40855	-76.35190	Landslide, former site of	Inundated beneath lake waters	**	Unknown	7.00	74.28	Marine Deposits	10 to 15	Marble
Fitzroy	OF8600	Ftz1	45.50319	-76.22097	Landslide	Truncated source area	0.03	Unknown	10.00	62.72	Alluvial Sediments	5 to 10	Interbedded Limestone and Dolomite
Fitzroy	OF8600	Ftz2	45.50437	-76.21394	Landslide	Truncated source area	0.02	Unknown	16.00	62.14	Alluvial Sediments	5 to 10	Interbedded Limestone and Dolomite
Fitzroy	OF8600	Ftz3	45.49835	-76.15980	Landslide	Source area with truncated debris field	0.16	Unknown	27.00	57.68	Erosional Terraces	10 to 15	Interbedded Limestone and Dolomite
Fitzroy	OF8600	Ftz4	45.50664	-76.13974	Landslide	Truncated source area	0.23	Unknown	11.00	56.03	Erosional Terraces	5 to 10	Interbedded Limestone and Dolomite
Buckhams Bay	OF8600	BkB1	45.48572	-76.10521	Landslide	Source area with truncated debris field	0.49	Unknown	34.00	53.20	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Buckhams Bay	OF8600	BkB2	45.48122	-76.10138	Landslide	Source area with truncated debris field	0.13	Unknown	30.00	52.90	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Buckhams Bay	OF8600	BkB3	45.47977	-76.09564	Landslide	Source area with truncated debris field	0.10	Unknown	30.00	52.44	Erosional Terraces	15 to 25	Interbedded Limestone and Dolomite
Carp Creek	OF8600	Crp1	45.34812	-76.04299	Landslide	Source area with debris field	0.10	Unknown	20.00	51.18	Marine Deposits	25 to 50	Interbedded Limestone and Shale
Rideau River	OF8600	Rid1	45.38818	-75.70428	Landslide	Truncated source area	0.05	Unknown	15.00	23.86	Erosional Terraces	5 to 10	Limestone
Rideau River	OF8600	Rid2	45.32436	-75.69166	Landslide	Source area with debris field	0.06	Unknown	30.00	27.86	Alluvial Sediments	15 to 25	Interbedded Dolomite and Sandstone
Rideau River	OF8600	Rid3	45.28377	-75.69606	Landslide, possibly	Truncated source area?	0.01	Unknown		31.72			
Rockcliffe	OF8600	Rkf1	45.45147	-75.67312	Landslide, probably	Truncated source area	0.02	Unknown		18.39			
Gloucester	OF8600	Glt1	45.44963	-75.59729	Landslide	Source area with debris field	0.12	About 1000 cal yr BP	30.00	12.63	Erosional Terraces	25 to 50	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln1	45.45962	-75.55209	Landslide, possibly	Truncated source area?	0.02	Unknown		8.78			
Orleans	OF8600	Oln2	45.45719	-75.54766	Landslide	Debris field within a narrow stream valley	0.11	Unknown	17.00	8.62	Marine Deposits	25 to 50	Shale
Orleans	OF8600	Oln3	45.46016	-75.54108	Landslide	Debris field within a narrow stream valley	0.05	Unknown	5.00	7.97	Marine Deposits	50 to 100	Shale

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			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Orleans	OF8600	Oln4	45.45726	-75.54049	Landslide	Debris field within a narrow stream valley	0.02	Unknown	5.00	8.12	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln5	45.45487	-75.53897	Landslide	Debris field within a narrow stream valley	0.02	Unknown	9.00	8.18	Marine Deposits	50 to 100	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln6	45.45863	-75.53838	Landslide	Debris field within a narrow stream valley	0.01	Unknown	3.00	7.89	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln7	45.45977	-75.53858	Landslide	Debris field within a narrow stream valley	0.00	Unknown	2.00	7.82	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln8	45.46051	-75.53690	Landslide	Debris field within a narrow stream valley	0.01	Unknown	7.00	7.66	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln9	45.46092	-75.53424	Landslide	Debris field within a narrow stream valley	0.02	Unknown	3.00	7.45	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln10	45.46378	-75.53684	Landslide	Truncated source area	0.07	Unknown	20.00	7.45	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln11	45.46497	-75.53146	Landslide	Truncated source area	0.06	Unknown	18.00	7.00	Nearshore Marine	50 to 100	Shale
Orleans	OF8600	Oln12	45.46706	-75.52809	Landslide	Truncated source area	0.05	Unknown	18.00	6.64	Nearshore Marine	25 to 50	Shale
Orleans	OF8600	Oln13	45.47042	-75.52019	Landslide, probably	Truncated source area	0.07	Unknown		5.87			
Orleans	OF8600	Oln14	45.48981	-75.50782	Landslide	Source area with debris field	0.08	Late Holocene?	18.00	4.07	Alluvial Sediments	15 to 25	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln15	45.48871	-75.47487	Landslide, probably	Truncated source area	0.08	Unknown		1.57			
Orleans	OF8600	Oln16	45.48586	-75.47170	Landslide	Debris field within a narrow stream valley	0.07	Unknown	29.00	1.61	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln17	45.48877	-75.46692	Landslide	Debris field within a narrow stream valley	0.04	Unknown	8.00	1.10	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Orleans	OF8600	Oln18	45.49016	-75.46497	Landslide	Debris field within a narrow stream valley	0.03	Unknown	10.00	0.88	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cumberland	OF8600	Cmb1	45.51313	-75.43362	Landslide	Truncated source area	0.14	Unknown	35.00	2.88	Erosional Terraces	15 to 25	Shale
Cumberland	OF8600	Cmb2	45.51302	-75.40335	Landslide	Source area with debris field	0.04	Unknown	24.00	5.00	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
Cumberland	OF8600	Cmb3	45.51737	-75.38140	Landslide	Source area with debris field	0.53	relatively young, less than 2000(?)	30.00	6.87	Erosional Terraces	50 to 100	Dolomite
Cumberland	OF8600	Cmb4	45.51651	-75.33631	Landslide	Source area with debris field	0.02	Unknown	49.00	10.40	Nearshore Marine	25 to 50	Interbedded Limestone and Dolomite

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			Latitude	Longitude			(km2)		(m)	(m)		(m)	
Mer Bleue paleochannel	OF8600	MBu1	45.43409	-75.53765	Landslide	Truncated source area	0.02	Unknown	13.00	9.77	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Mer Bleue paleochannel	OF8600	MBu2	45.43092	-75.51828	Landslide	Source area with debris field	0.12	Unknown	15.00	9.11	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu3	45.42843	-75.51485	Landslide	Source area with debris field	0.01	Unknown	12.00	9.22	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu4	45.42782	-75.51290	Landslide	Truncated source area	0.01	Unknown	**	9.20	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu5	45.42639	-75.50741	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.14	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu6	45.42500	-75.50289	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.14	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu7	45.42364	-75.49702	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.11	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu8	45.42335	-75.49197	Landslide, former site of	Completely altered	N.A.	Unknown	**	9.01	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu9	45.42158	-75.48102	Landslide	Truncated source area	0.03	Unknown	15.00	8.98	Erosional Terraces	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu10	45.42089	-75.47444	Landslide	Truncated source area	0.03	Unknown	15.00	8.97	Nearshore Marine	25 to 50	Shale
Mer Bleue paleochannel	OF8600	MBu11	45.41891	-75.46077	Landslide	Truncated source area	0.03	Unknown	14.00	9.12	Nearshore Marine	15 to 25	Shale
Mer Bleue paleochannel	OF8600	MBu12	45.41829	-75.45649	Landslide	Truncated source area	0.01	Unknown	15.00	9.20	Nearshore Marine	15 to 25	Shale
Mer Bleue paleochannel	OF8600	MBu13	45.41206	-75.27053	Landslide	Source area with debris field	1.42	about 5200 cal yrBP	19.00	18.46	Nearshore Marine	25 to 50	Interbedded Limestone and Shale
Beta-90881	OF7432	1	45.46110	-75.26110	Landslide	*	*	3050±70	20.00	16.85	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-122473	OF7432	1	45.44170	-75.22220	Landslide	*	*	4590±40	8.00	20.57	Nearshore Marine	25 to 50	Interbedded Limestone and Shale
Beta-122475	OF7432	1	45.44240	-75.19240	Landslide	*	*	2760±50	20.00	22.90	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Beta-127281	OF7432	1	45.54160	-75.24160	Landslide	*	*	5130±60	53.00	18.69	Nearshore Marine	10 to 15	Limestone
Beta-127284	OF7432	1	45.52080	-75.26670	Landslide	*	*	4440±80	21.00	16.12	Erosional Terraces	25 to 50	Interbedded Limestone and Shale
Beta-127244	OF7432	1	45.50000	-75.20280	Landslide	*	*	4570±70	30.00	21.13	Erosional Terraces	25 to 50	Interbedded Limestone and Shale

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Beta-122472	OF7432	1	45.48330	-75.19170	Landslide	*	*	4520±50	30.00	22.10	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-127282	OF7432	1	45.47500	-75.12920	Landslide	*	*	4540±90	24.00	27.31	Nearshore Marine	15 to 25	Interbedded Limestone and Shale
Beta-127283	OF7432	1	45.52500	-75.01110	Landslide	*	*	4530±60	12.00	37.06	Erosional Terraces	10 to 15	Interbedded Limestone and Shale
Beta-122478	OF7432	1	45.51390	-75.00280	Landslide	*	*	4700±50	15.00	37.65	Erosional Terraces	15 to 25	Interbedded Limestone and Shale
Beta-122471	OF7432	1	45.51850	-74.95570	Landslide	*	*	1870±40	26.00	41.55	**	**	**
Beta-127242	OF7432	1	45.51380	-74.93750	Landslide	*	*	4820±70	26.00	43.02	**	**	**
Beta-122474	OF7432	1	45.53610	-75.15830	Landslide	*	*	4470±50	**	25.22	Nearshore Marine	25 to 50	Limestone
GSC-1922	OF7432	2	45.54370	-75.40110	Landslide	*	*	4620±80	81.00	7.33	Marine Deposits	15 to 25	Felsic Intrusive Rocks
GSC-2068	OF7432	4	45.52080	-75.49170	Landslide	*	*	6240±70	59.00	3.90	Marine Deposits	25 to 50	Dolomite
UCIAMS-71217	OF7432	6	45.57980	-75.04260	Landslide	*	*	7105±20	35.00	35.66	Erosional Terraces	50 to 100	Shale
UCIAMS-71211	OF7432	7	45.57020	-75.11560	Landslide	*	*	7140±20	31.00	29.58	Marine Deposits	50 to 100	Interbedded Limestone and Dolomite
GSC-1741	OF7432	10	45.46500	-75.75130	Landslide	*	*	120±150	**	24.33	Marine Deposits	25 to 50	Dolomite
UCIAMS-88796	OF7432	11	45.48290	-75.93490	Landslide	*	*	1125±15	29.00	39.20	Marine Deposits	25 to 50	Felsic Intrusive Rocks

Table 1 - Cardinal Creek Village South - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
UCIAMS-88704	OF7432	11	45.48530	-75.93630	Landslide	*	*	2805±20	29.00	39.30	Marine Deposits	25 to 50	Felsic Intrusive Rocks
GSC-6233	OF7432	11	45.48310	-75.93320	Landslide	*	*	7050±80	25.00	39.05	Marine Deposits	25 to 50	Felsic Intrusive Rocks
UCIAMS-88816	OF7432	11	45.48020	-75.93090	Landslide	*	*	200±15	24.00	38.88	Marine Deposits	15 to 25	Felsic Intrusive Rocks
GSC-6449	OF7432	11	45.47180	-75.91290	Landslide	*	*	1080±70	15.00	37.47	Marine Deposits	15 to 25	Interbedded Limestone and Dolomite
UCIAMS-88703	OF7432	11	45.47990	-75.91740	Landslide	*	*	180±20	26.00	37.77	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6318	OF7432	11	45.47860	-75.91180	Landslide	*	*	1030±70	24.00	37.32	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
UCIAMS-88806	OF7432	11	45.47730	-75.90280	Landslide	*	*	1895±25	12.00	36.59	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6482	OF7432	11	45.48120	-75.90670	Landslide	*	*	1210±50	8.00	36.88	Marine Deposits	25 to 50	Interbedded Limestone and Dolomite
GSC-6433	OF7432	11	45.48540	-75.89640	Landslide	*	*	1440±50	18.00	36.02	Marine Deposits	15 to 25	Felsic Intrusive Rocks
UCIAMS-88818	OF7432	11	45.48520	-75.90600	Landslide	*	*	2755±20	22.00	36.81	Marine Deposits	25 to 50	Felsic Intrusive Rocks
GSC-6355	OF7432	11	45.48250	-75.91180	Landslide	*	*	1170±50	27.00	37.30	Marine Deposits	25 to 50	Felsic Intrusive Rocks
Beta-139135	OF7432	11	45.49650	-75.92780	Landslide	*	*	310±40	10.00	38.57	Marine Deposits	50 to 100	Felsic Intrusive Rocks
UCIAMS-122468	OF7432	12	45.53530	-76.03060	Landslide	*	*	1095±20	21.00	47.24	Marine Deposits	15 to 25	Felsic Intrusive Rocks
UCIAMS-106656	OF7432	13	45.54090	-76.04890	Landslide	*	*	1150±15	22.00	48.81	Marine Deposits	25 to 50	Felsic Intrusive Rocks
UCIAMS-171460	OF7432	14	45.55390	-76.13020	Landslide	*	*	1305±20	9.00	55.62	Nearshore Marine	50 to 100	Felsic Intrusive Rocks
UCIAMS-171459	OF7432	15	45.55130	-76.14060	Landslide	*	*	185±20	9.00	56.44	Nearshore Marine	50 to 100	Felsic Intrusive Rocks
UCIAMS-106587	OF7432	16	45.55190	-76.28630	Landslide	*	*	1180±20	24.00	68.37	Erosional Terraces	15 to 25	Felsic Intrusive Rocks
UCIAMS-106575	OF7432	17	45.61920	-76.37190	Landslide	*	*	955±15	32.00	76.43	**	**	**

Table 1 - Cardinal Creek Village South - Summary of Reviewed Landslide Inventory Data

Location	Source	Site Code	Geographical Coordinate		Feature	Morphology	Scar Area	Age	Relief	Distance from PG5201	Surface Geology	Drift Thicknes	Bedrock
			Latitude	Longitude			(km2)		(m)	(m)		(m)	
UCIAMS-106650	OF7432	18	45.50140	-76.28260	Landslide	*	*	1145±20	52.00	67.79	Nearshore Marine	15 to 25	Felsic Intrusive Rocks
UCIAMS-106581	OF7432	19	45.51700	-76.27470	Landslide	*	*	5830±20	34.00	67.17	Nearshore Marine	15 to 25	Felsic Intrusive Rocks
UCIAMS-122453	OF7432	20	45.54620	-76.52600	Landslide	*	*	5745±20	**	87.99	**	**	**
UCIAMS-137113	OF7432	21	45.72570	-75.89150	Landslide	*	*	4525±20	52.00	44.56	**	**	**
UCIAMS-137101	OF7432	22	45.69440	-75.89960	Landslide	*	*	90±20	23.00	43.01	**	**	**
UCIAMS-122455	OF7432	23	45.80960	-75.95980	Landslide	*	*	940±15	25.00	55.15	**	**	**

'*' - Indicates information not provided by source (Geological Survey of Canada Open File 7432)

'' Indicates information could not be interpreted from available mapping.**

APPENDIX 2

FIGURE 1 – KEY PLAN

FIGURES 6A THROUGH 41B – SLOPE STABLITY ANALYSIS CROSS-SECTIONS

PHOTOGRAPHS FROM SITE VISITS

DRAWING PG5201-1 – BEDROCK CONTOUR PLAN

DRAWING PG5201-2 – TEST HOLE LOCATION PLAN

DRAWING PG5201-FIG.A – CROSS SECTION A-A’

DRAWING PG5201-FIG.B – CROSS SECTION B-B’

DDRAWING PG5201-FIG.C – CROSS SECTION C-C’

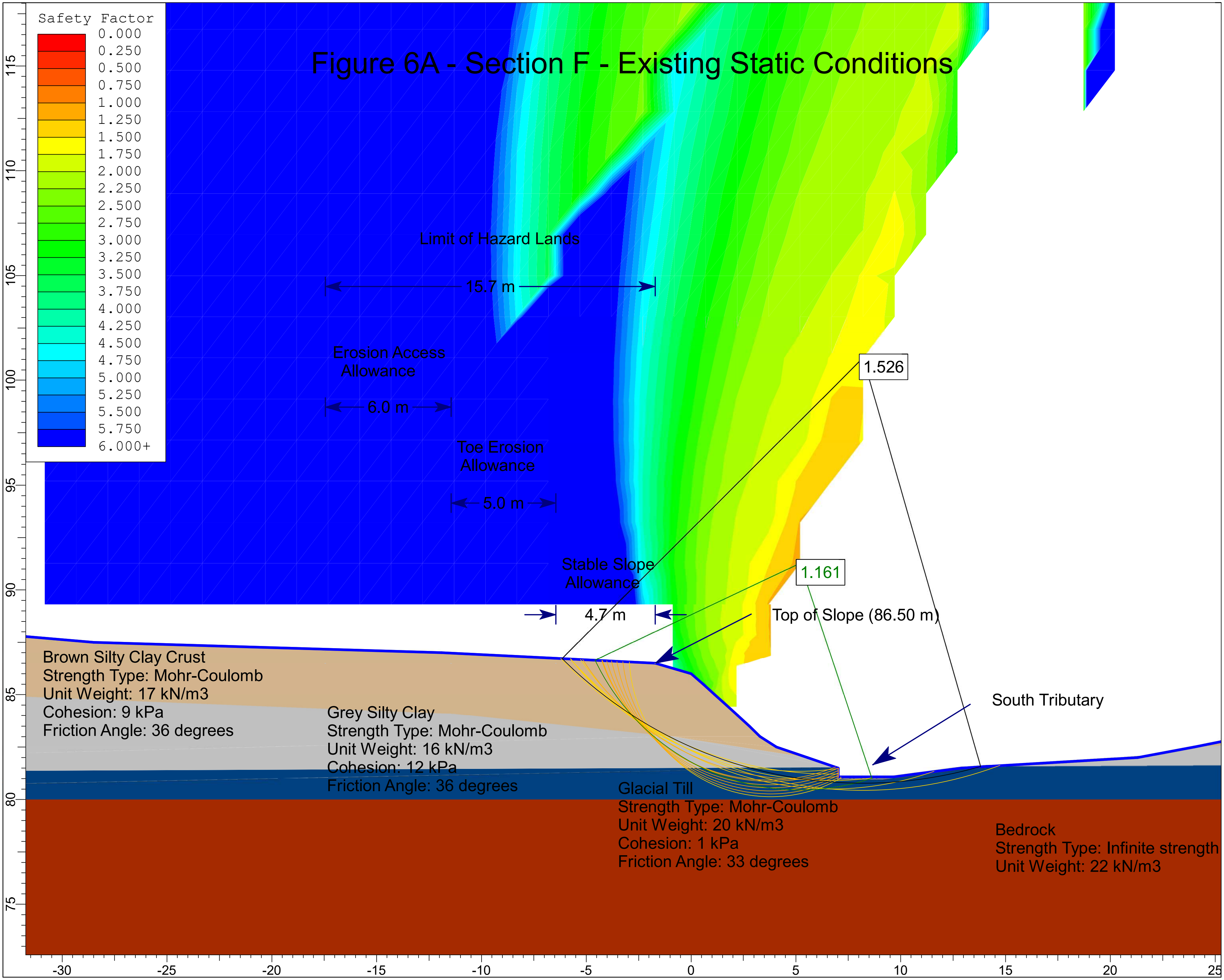
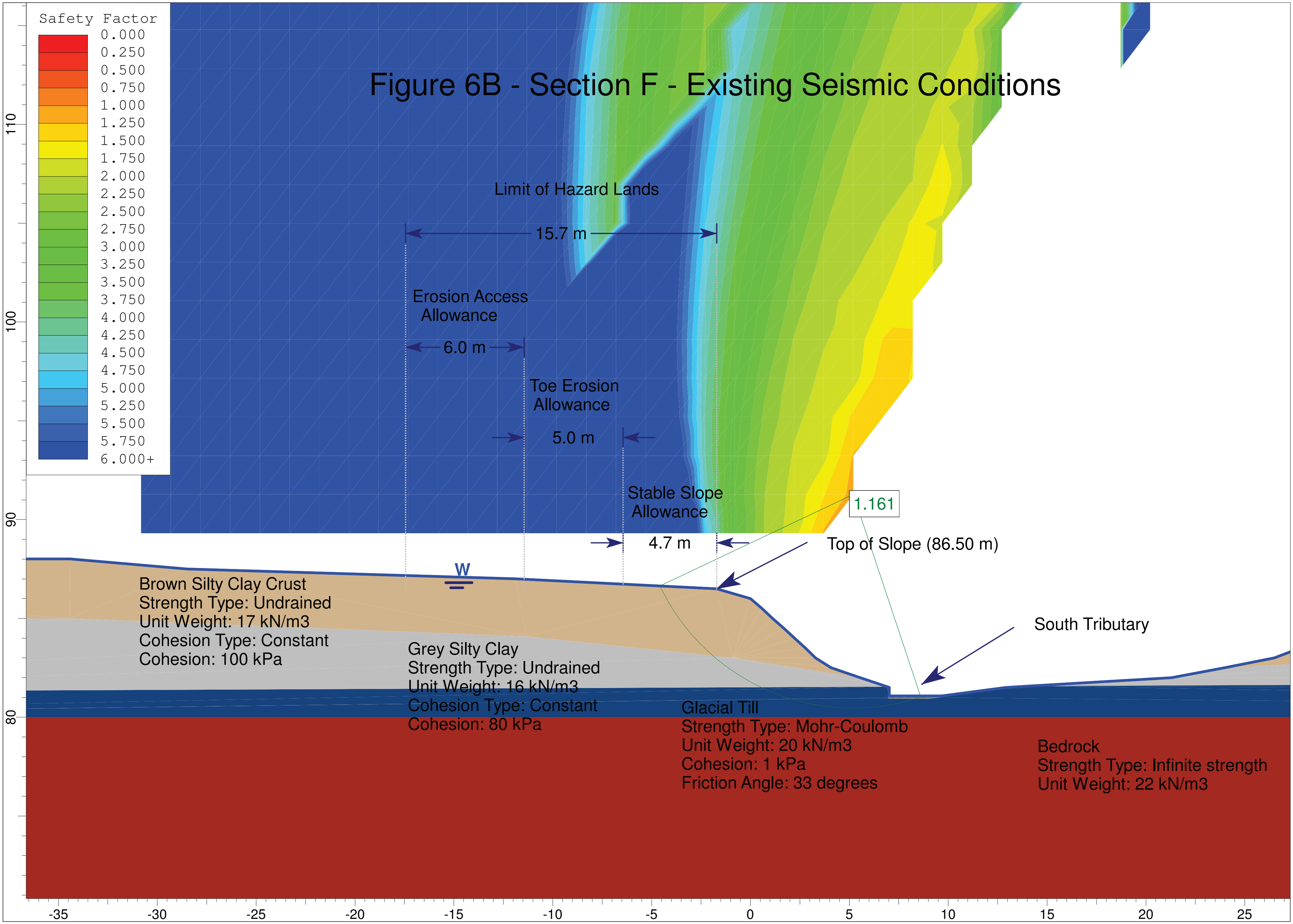


Figure 6A - Section F - Existing Static Conditions

Figure 6B - Section F - Existing Seismic Conditions



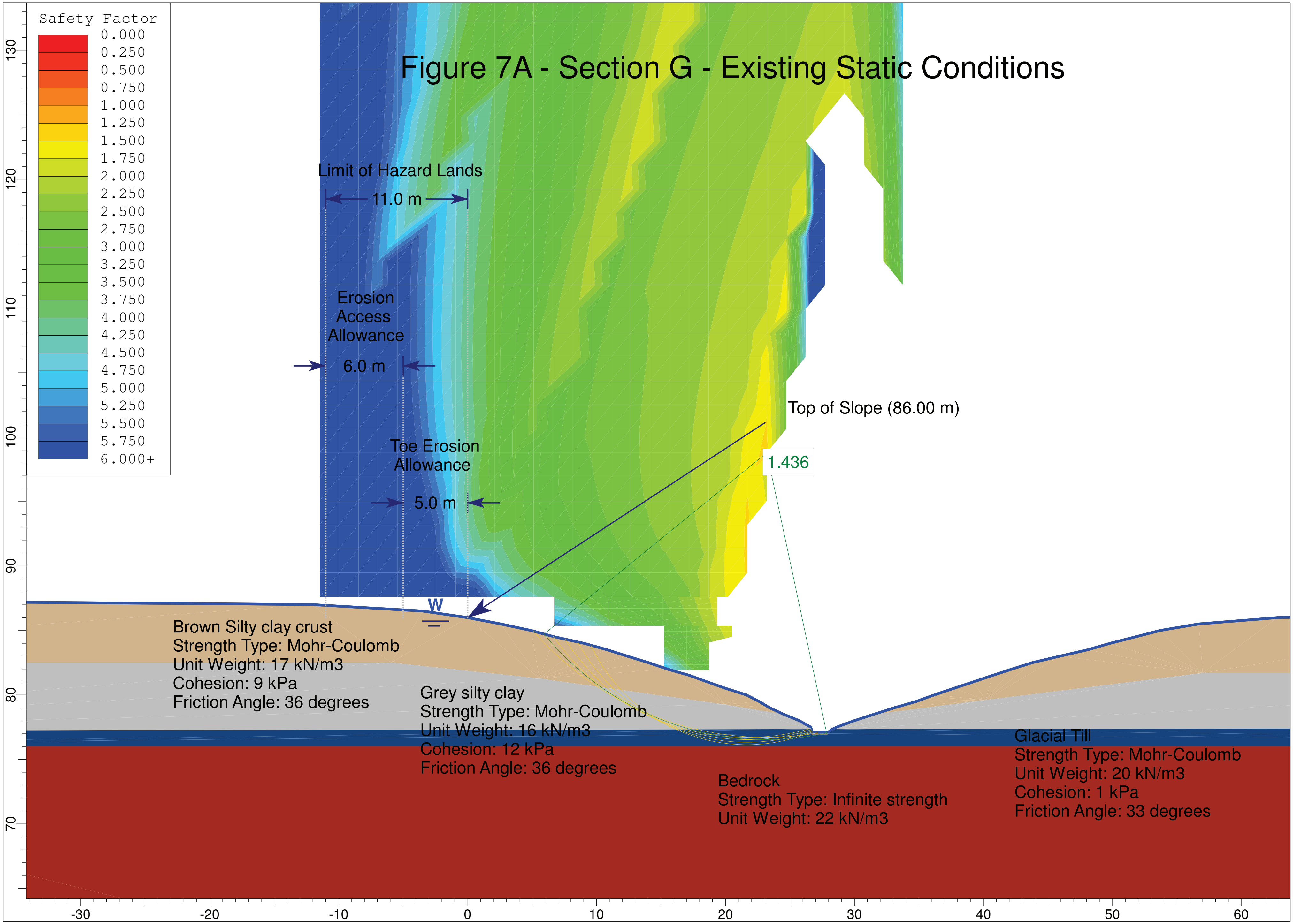


Figure 7A - Section G - Existing Static Conditions

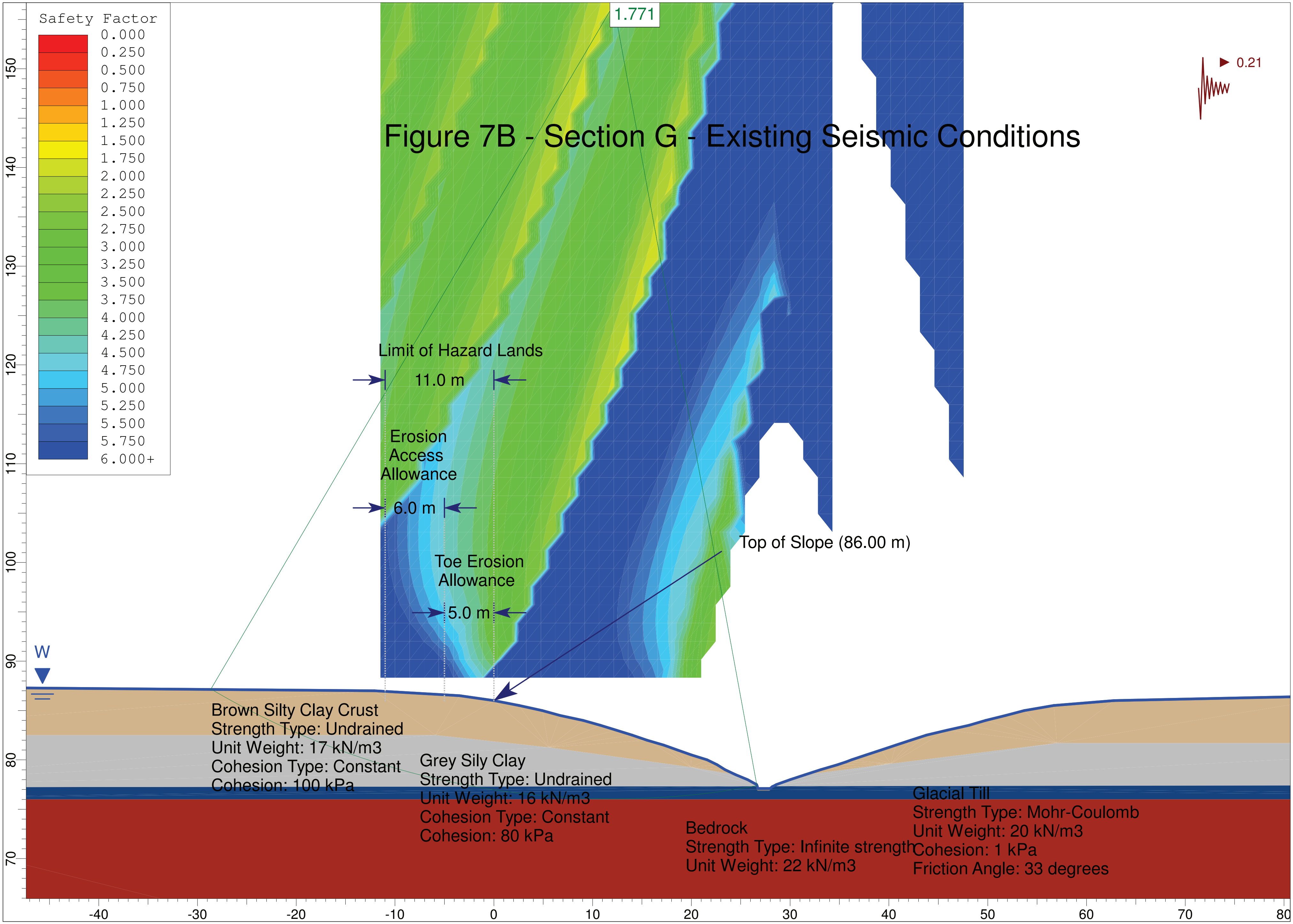
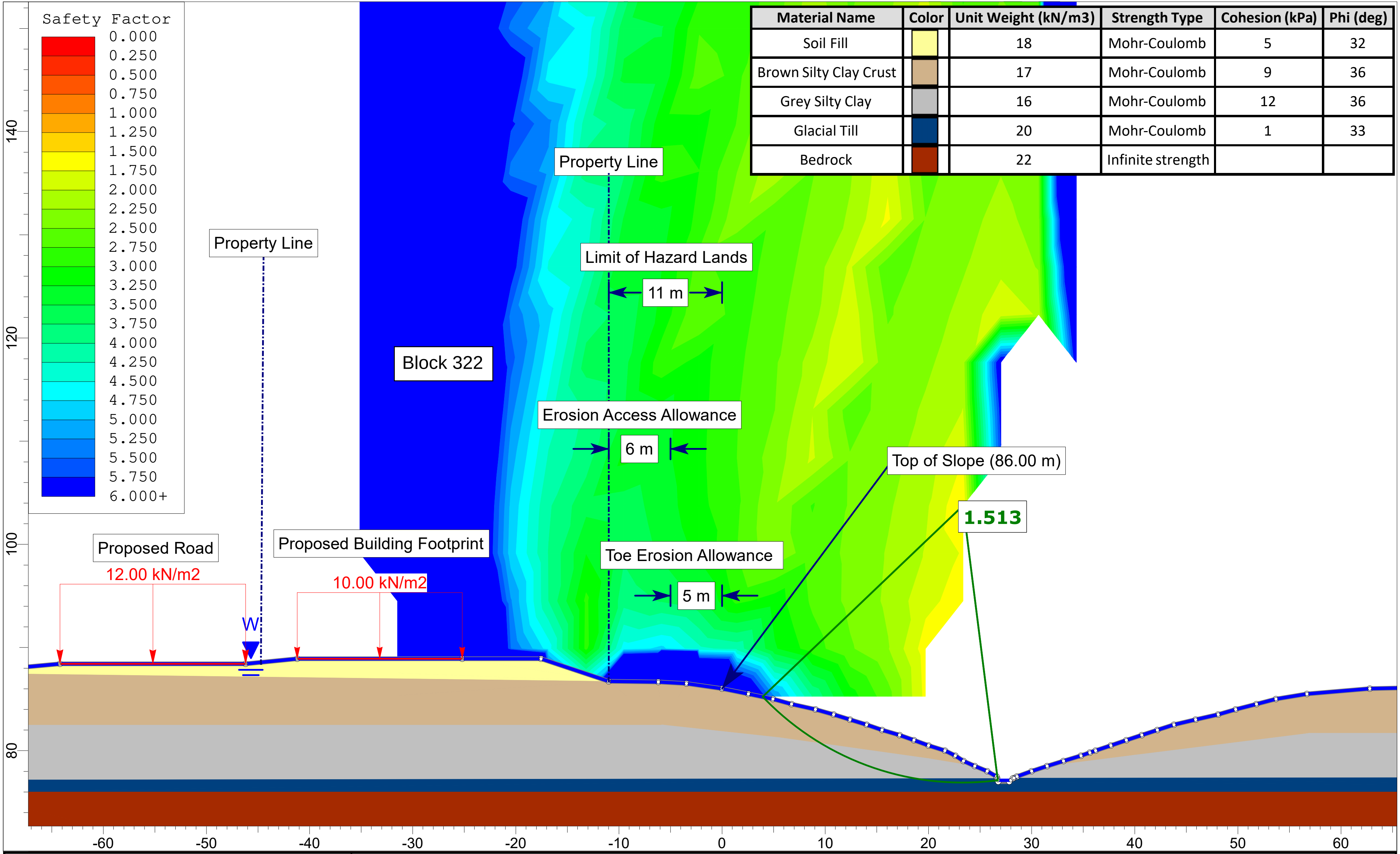


Figure 7B - Section G - Existing Seismic Conditions

Figure 7C - Section G - Proposed Static Conditions



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Mohr-Coulomb	9	36
Grey Silty Clay	⬜	16	Mohr-Coulomb	12	36
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

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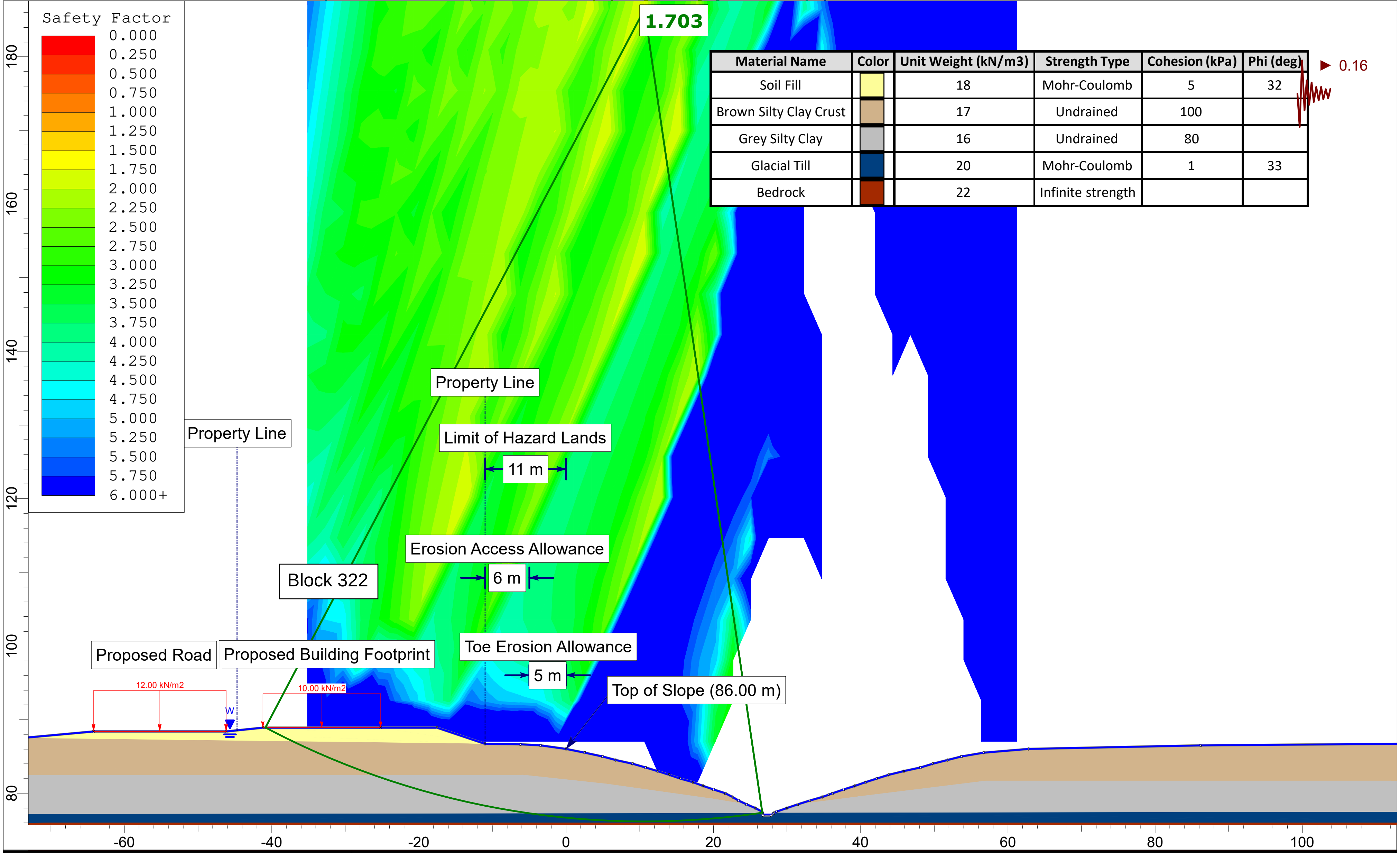
Project PG5201 - Proposed Residential Development - Cardinal Creek Village South
Old Montreal Road, Ottawa, Ontario

Cross Section	G	*Scenario*	Static - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/18/2023	*File Name*	Geotechnical Investigation

Figure 7D - Section G - Proposed Seismic Conditions



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Undrained	100	
Grey Silty Clay	⬜	16	Undrained	80	
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

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SLIDEINTERPRET 9.025

Project	PG5201 - Proposed Residential Development - Cardinal Creek Village South Old Montreal Road, Ottawa, Ontario		
Cross Section	G	*Scenario*	Seismic - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/18/2023	*File Name*	Geotechnical Investigation

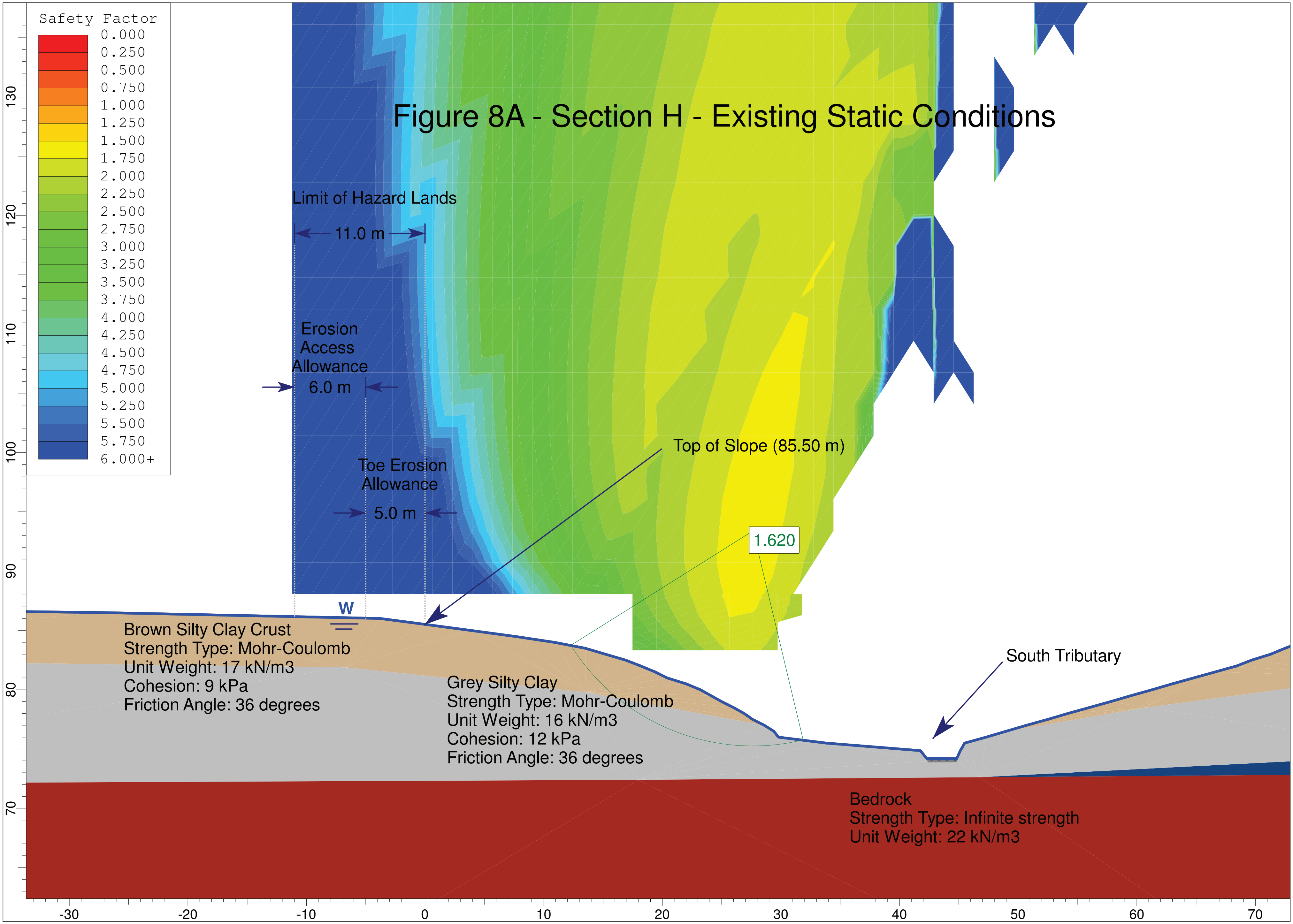


Figure 8A - Section H - Existing Static Conditions

Figure 8B - Section H - Existing Seismic Conditions

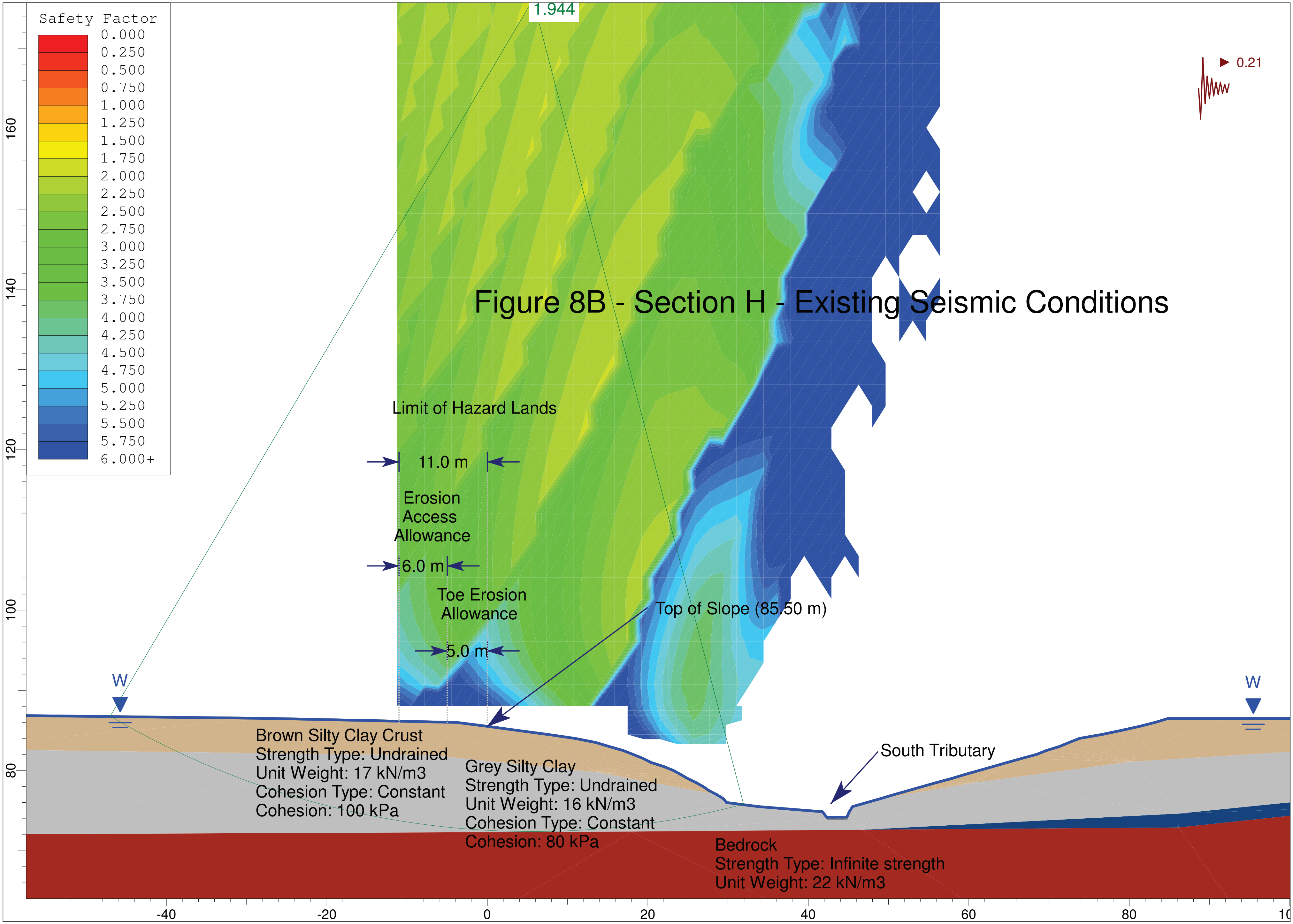


Figure 9A - Section I - Existing Static Conditions

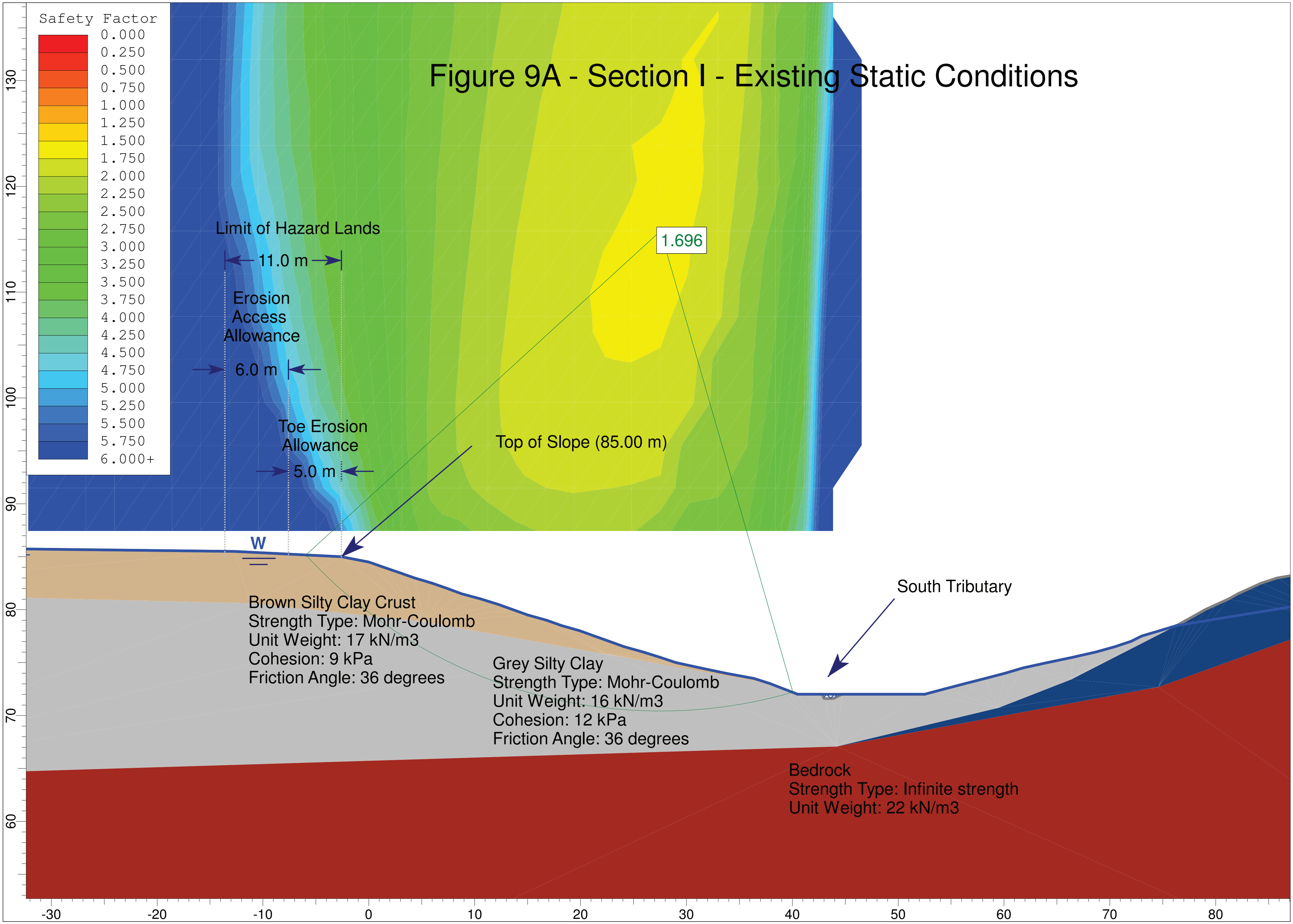


Figure 9B - Section I - Existing Seismic Conditions

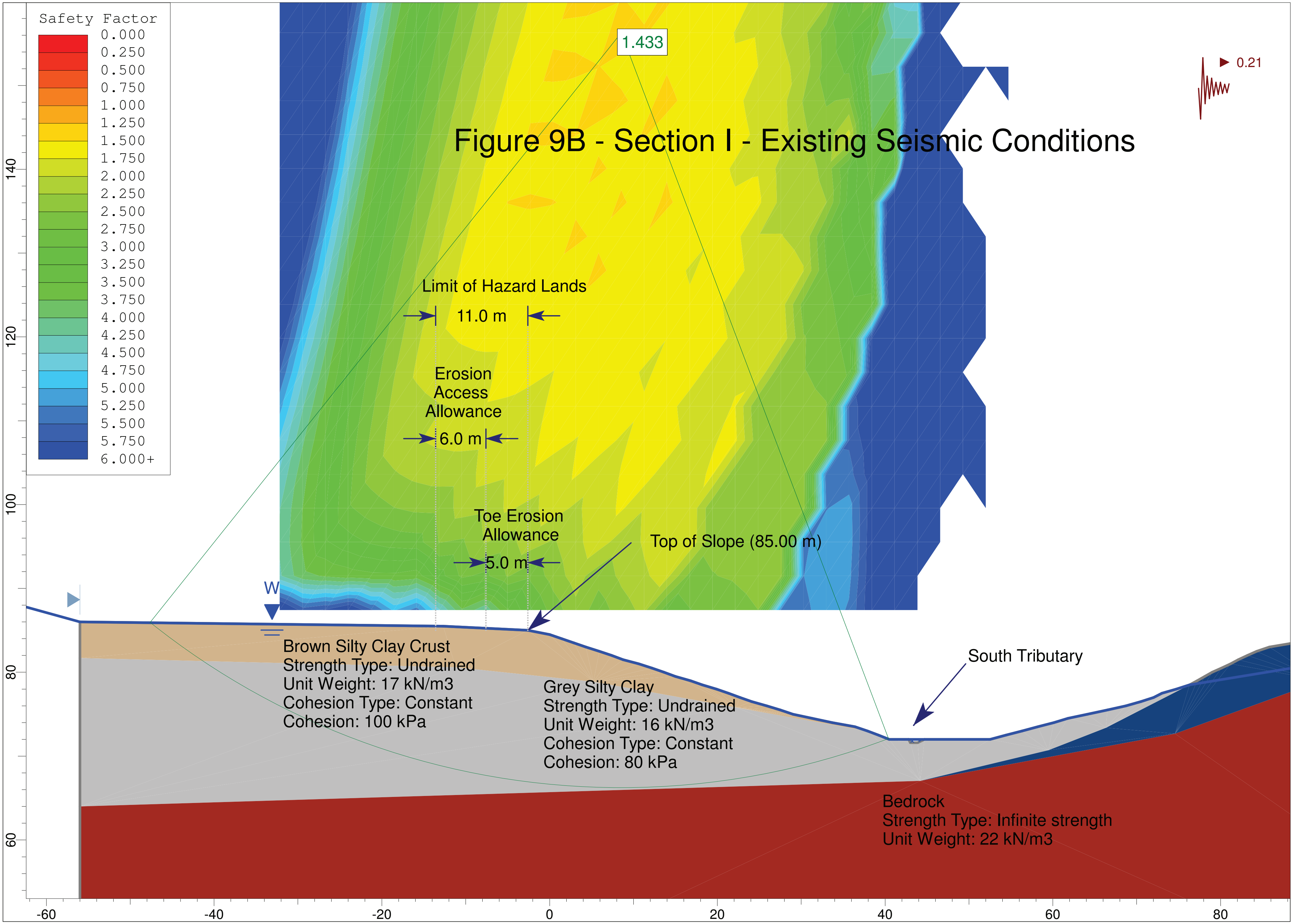
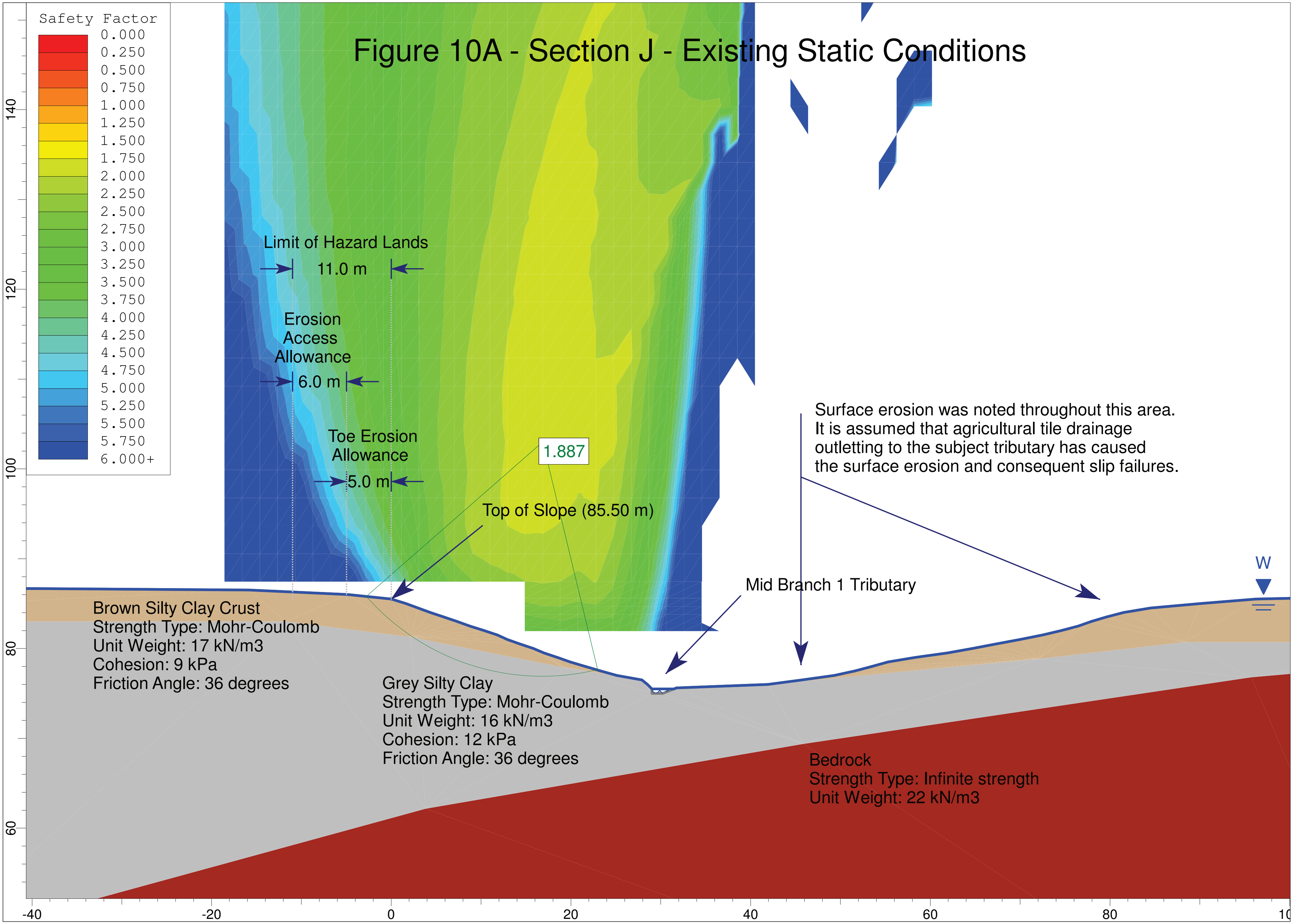


Figure 10A - Section J - Existing Static Conditions



Surface erosion was noted throughout this area. It is assumed that agricultural tile drainage outletting to the subject tributary has caused the surface erosion and consequent slip failures.

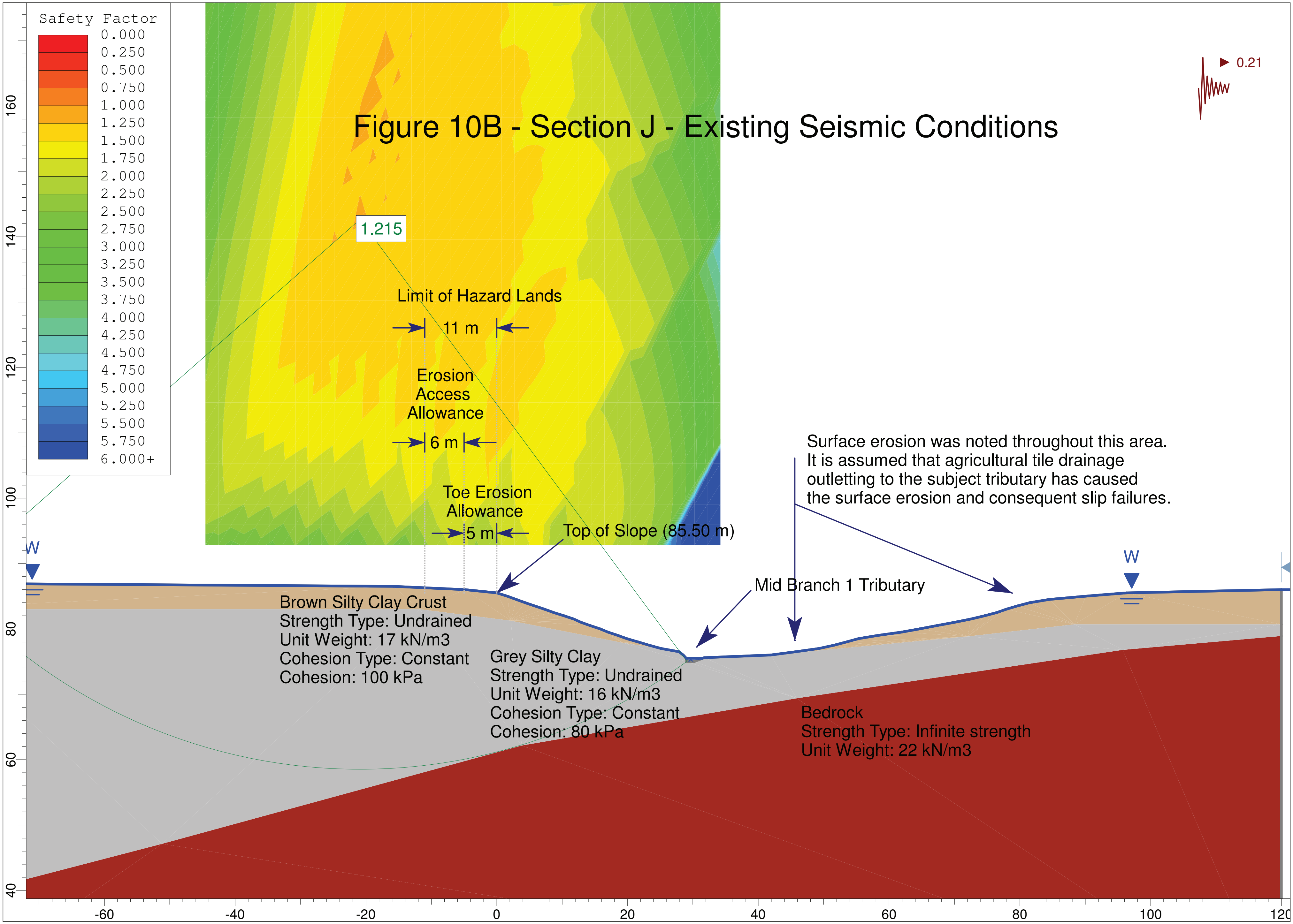
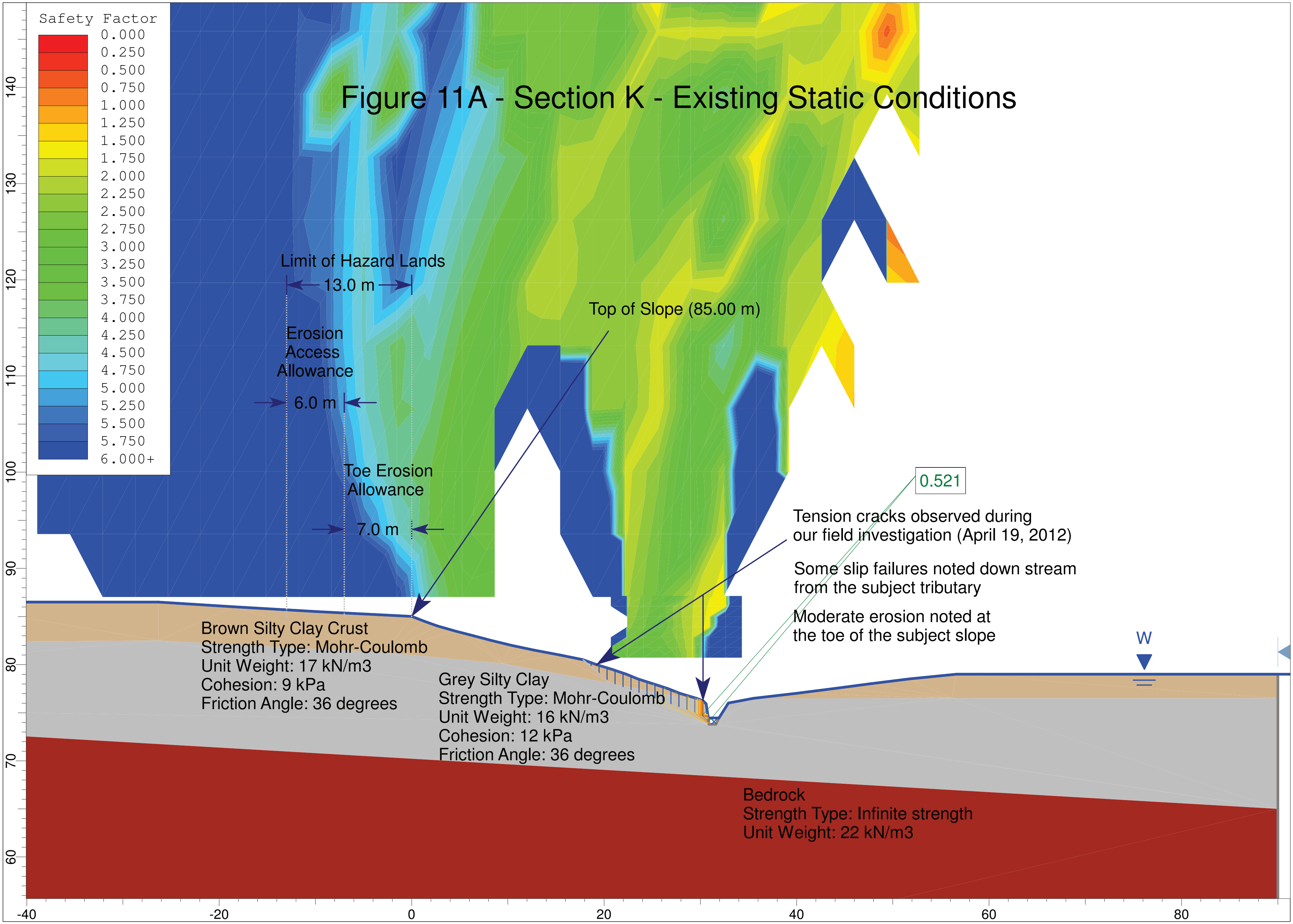


Figure 10B - Section J - Existing Seismic Conditions

Figure 11A - Section K - Existing Static Conditions



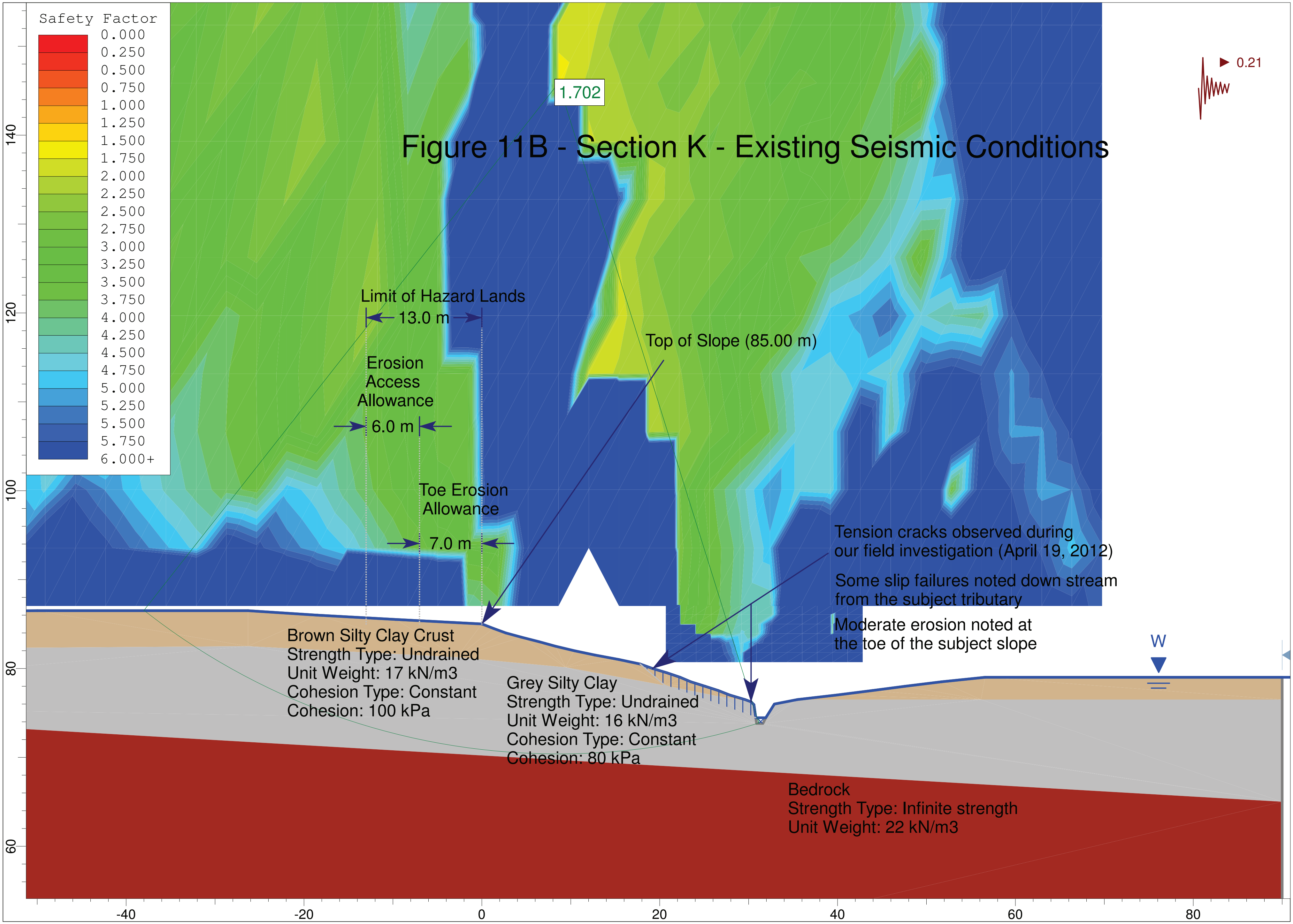


Figure 11B - Section K - Existing Seismic Conditions

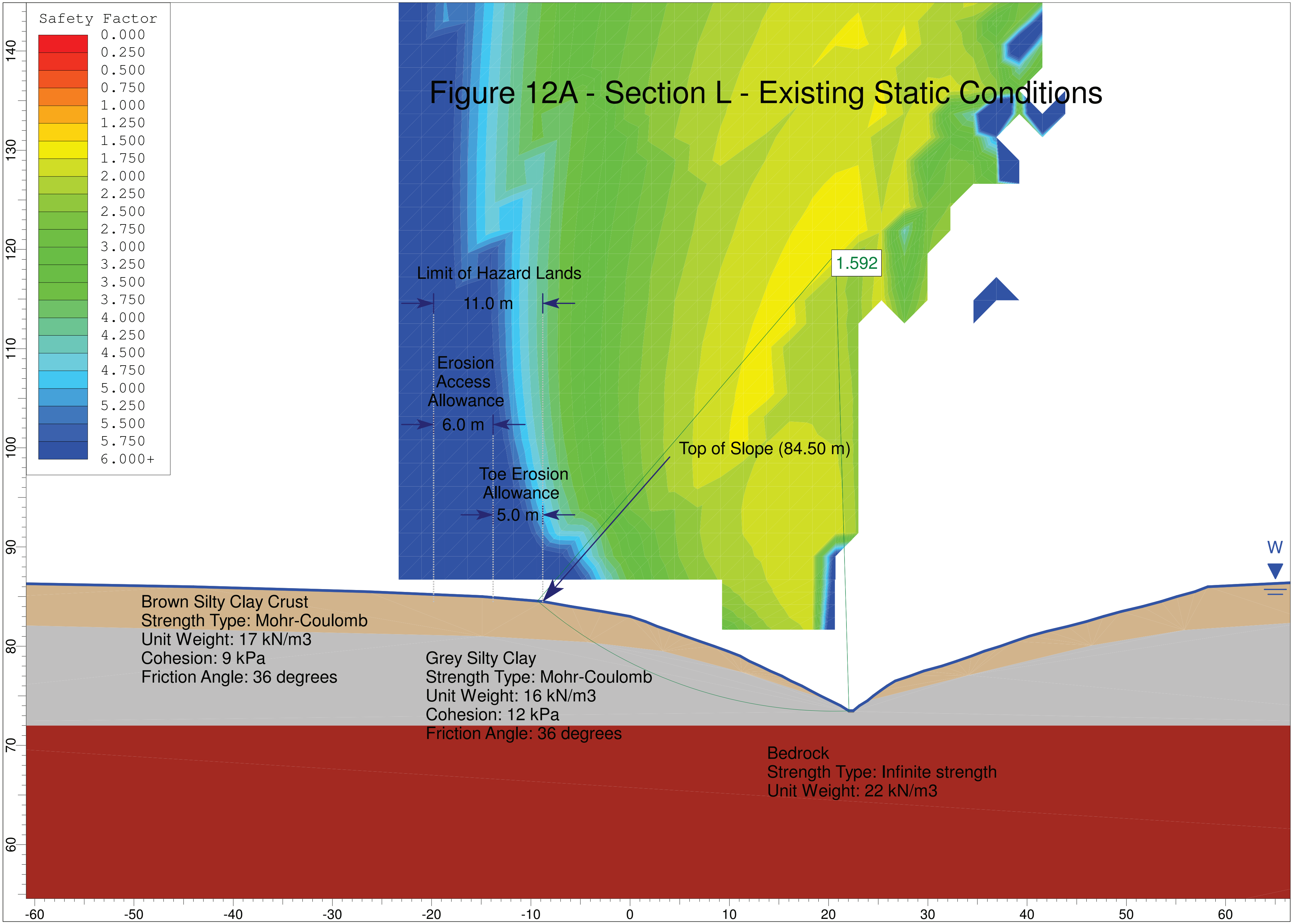


Figure 12A - Section L - Existing Static Conditions

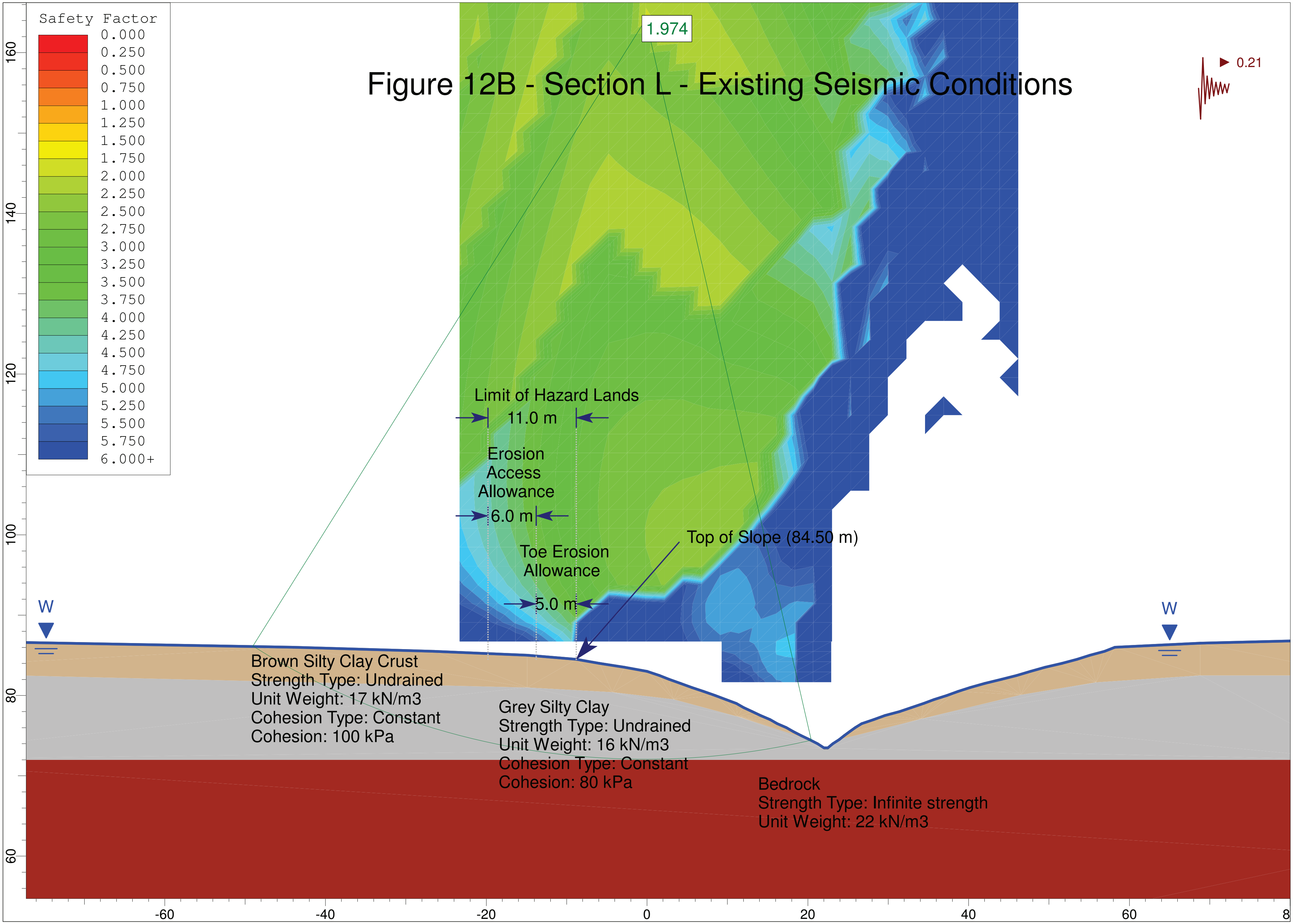


Figure 12B - Section L - Existing Seismic Conditions

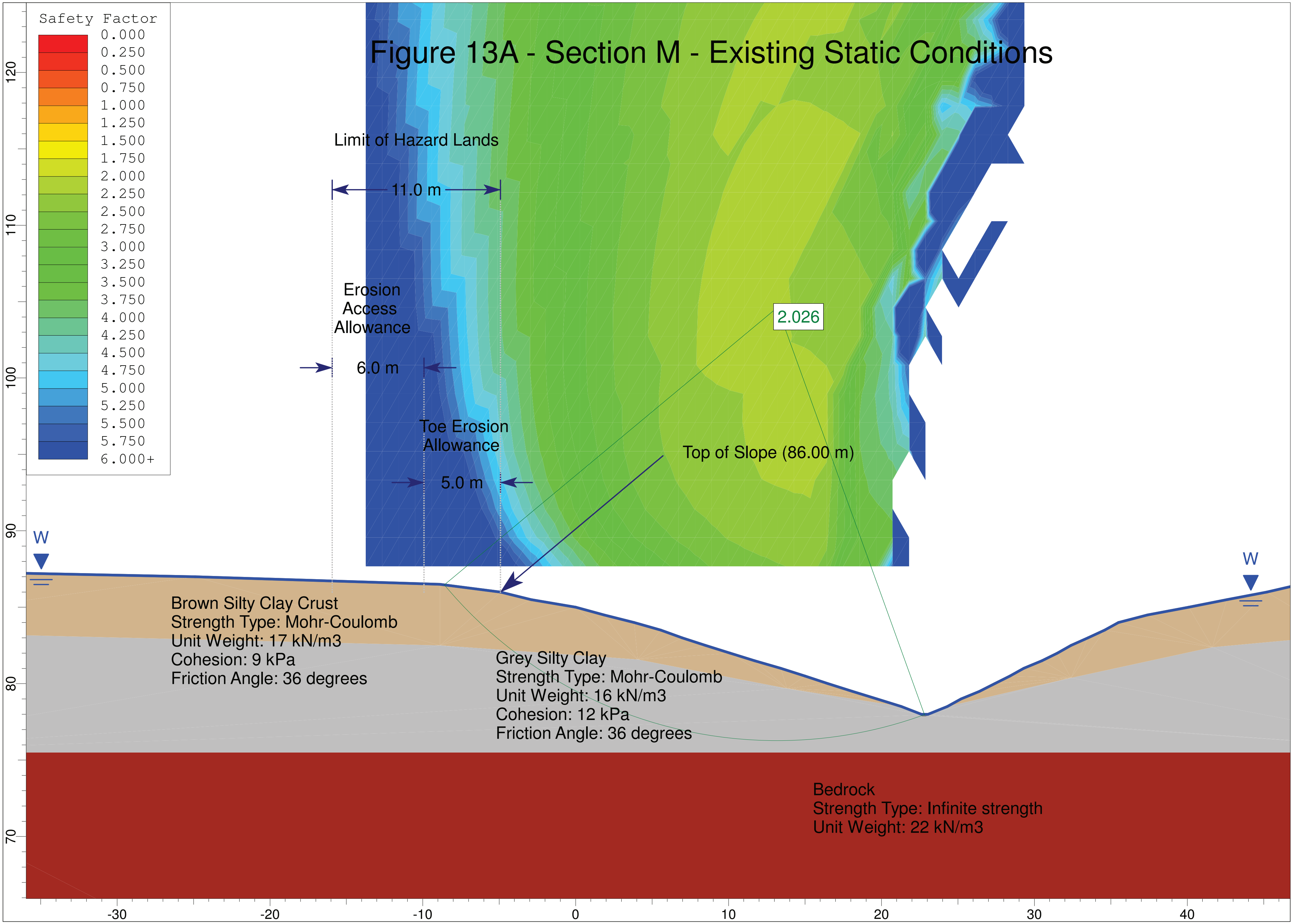
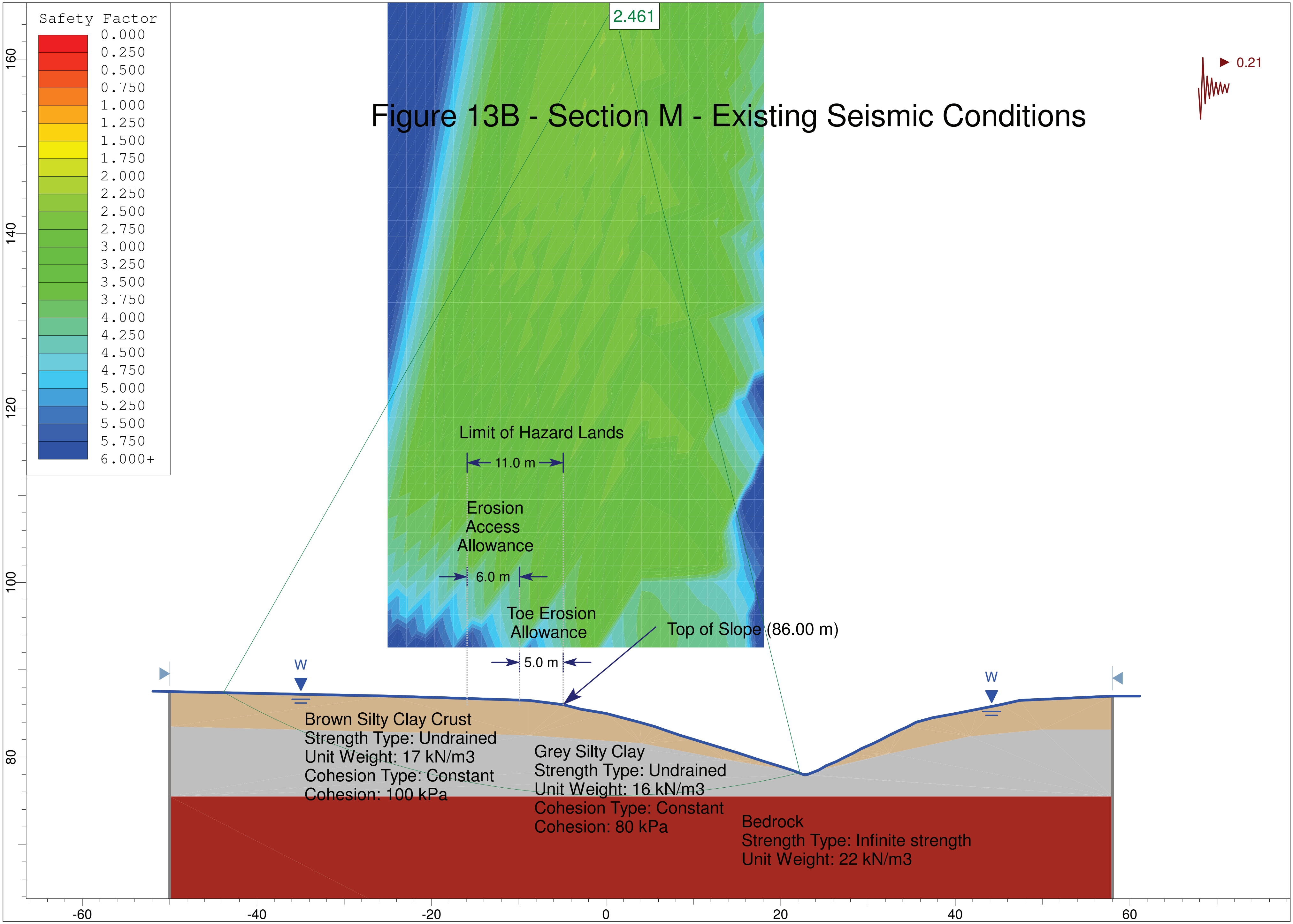


Figure 13A - Section M - Existing Static Conditions

Figure 13B - Section M - Existing Seismic Conditions



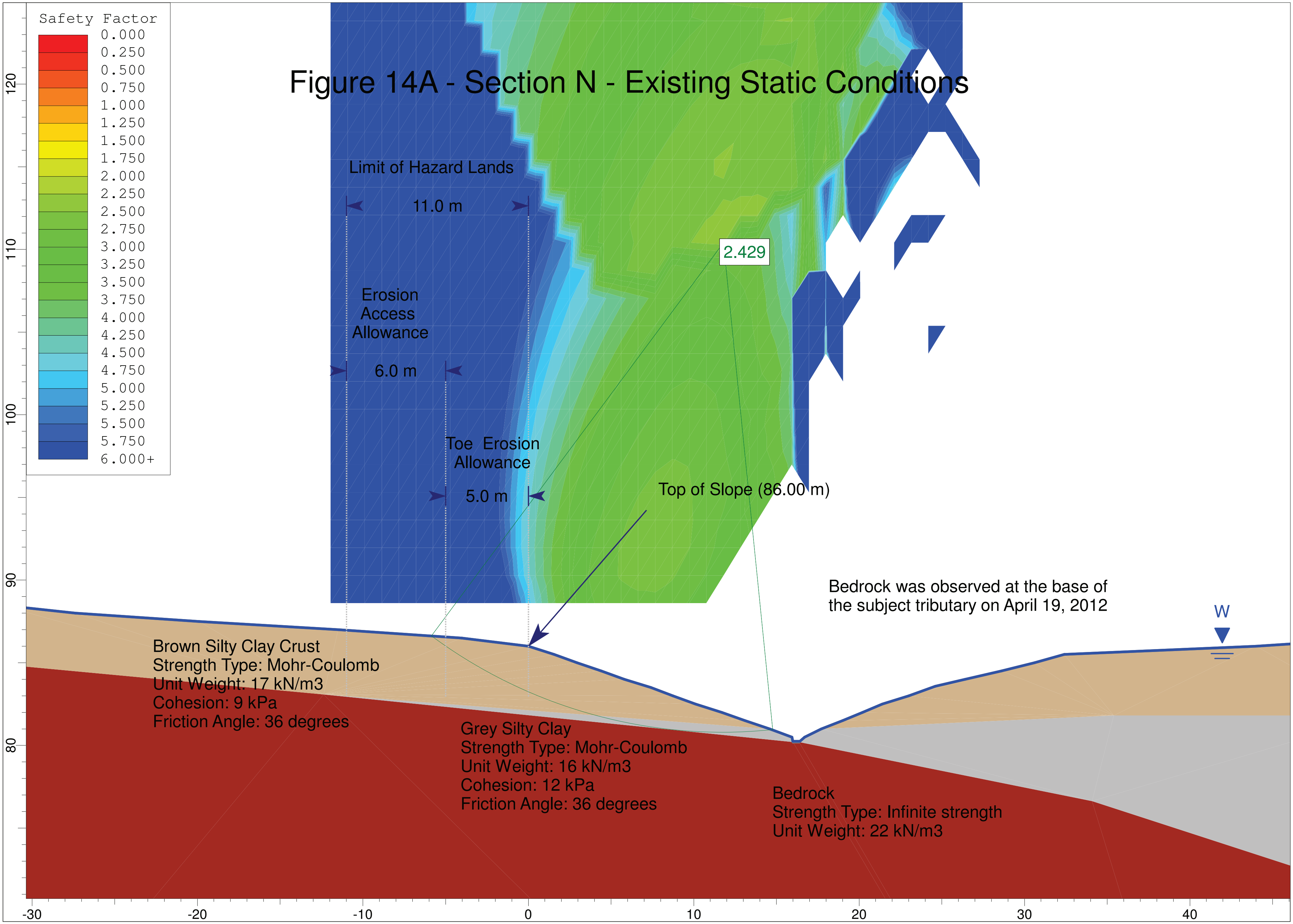


Figure 14A - Section N - Existing Static Conditions

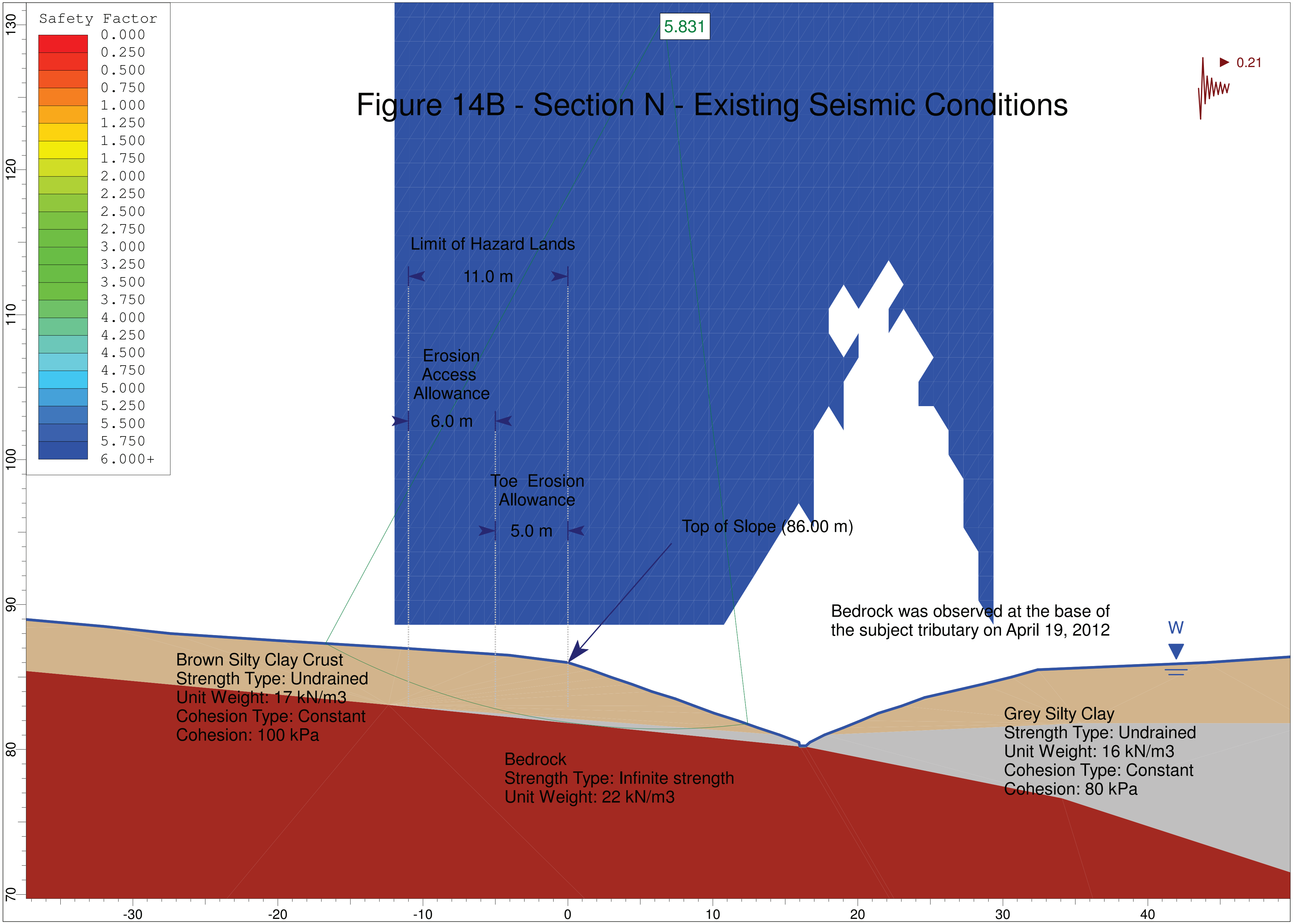
Bedrock was observed at the base of the subject tributary on April 19, 2012

Brown Silty Clay Crust
Strength Type: Mohr-Coulomb
Unit Weight: 17 kN/m3
Cohesion: 9 kPa
Friction Angle: 36 degrees

Grey Silty Clay
Strength Type: Mohr-Coulomb
Unit Weight: 16 kN/m3
Cohesion: 12 kPa
Friction Angle: 36 degrees

Bedrock
Strength Type: Infinite strength
Unit Weight: 22 kN/m3

Figure 14B - Section N - Existing Seismic Conditions



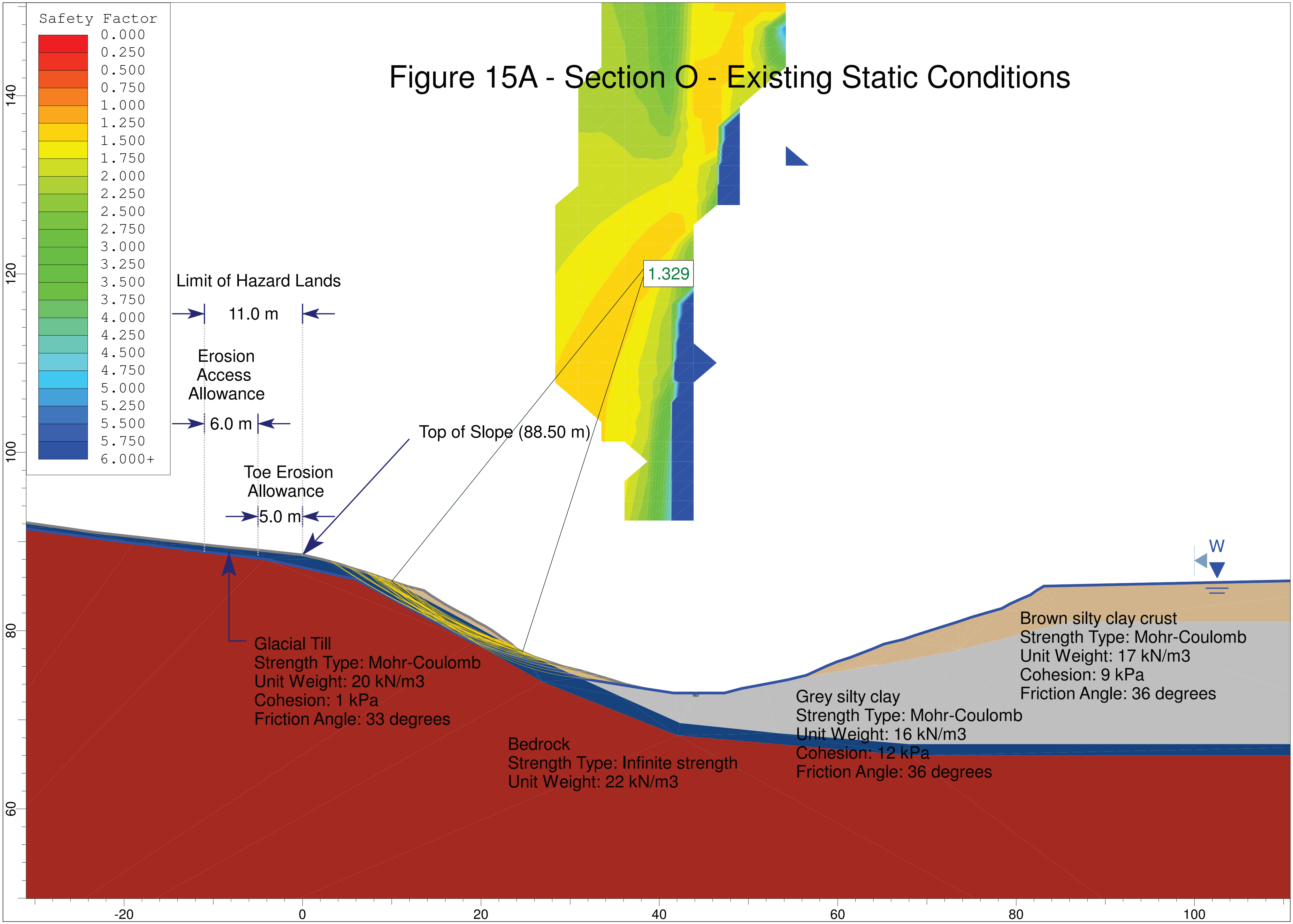


Figure 15A - Section O - Existing Static Conditions

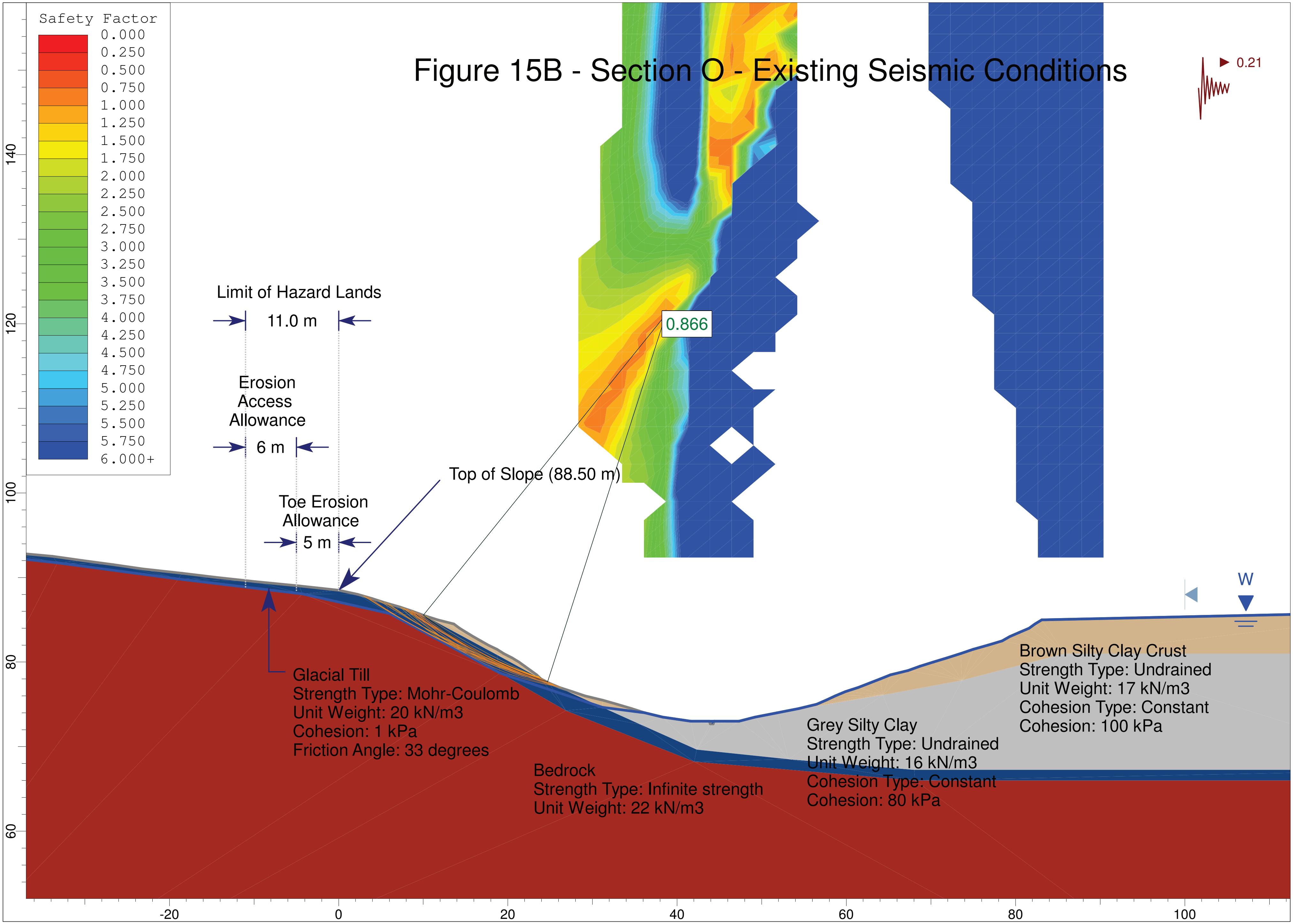


Figure 15B - Section O - Existing Seismic Conditions

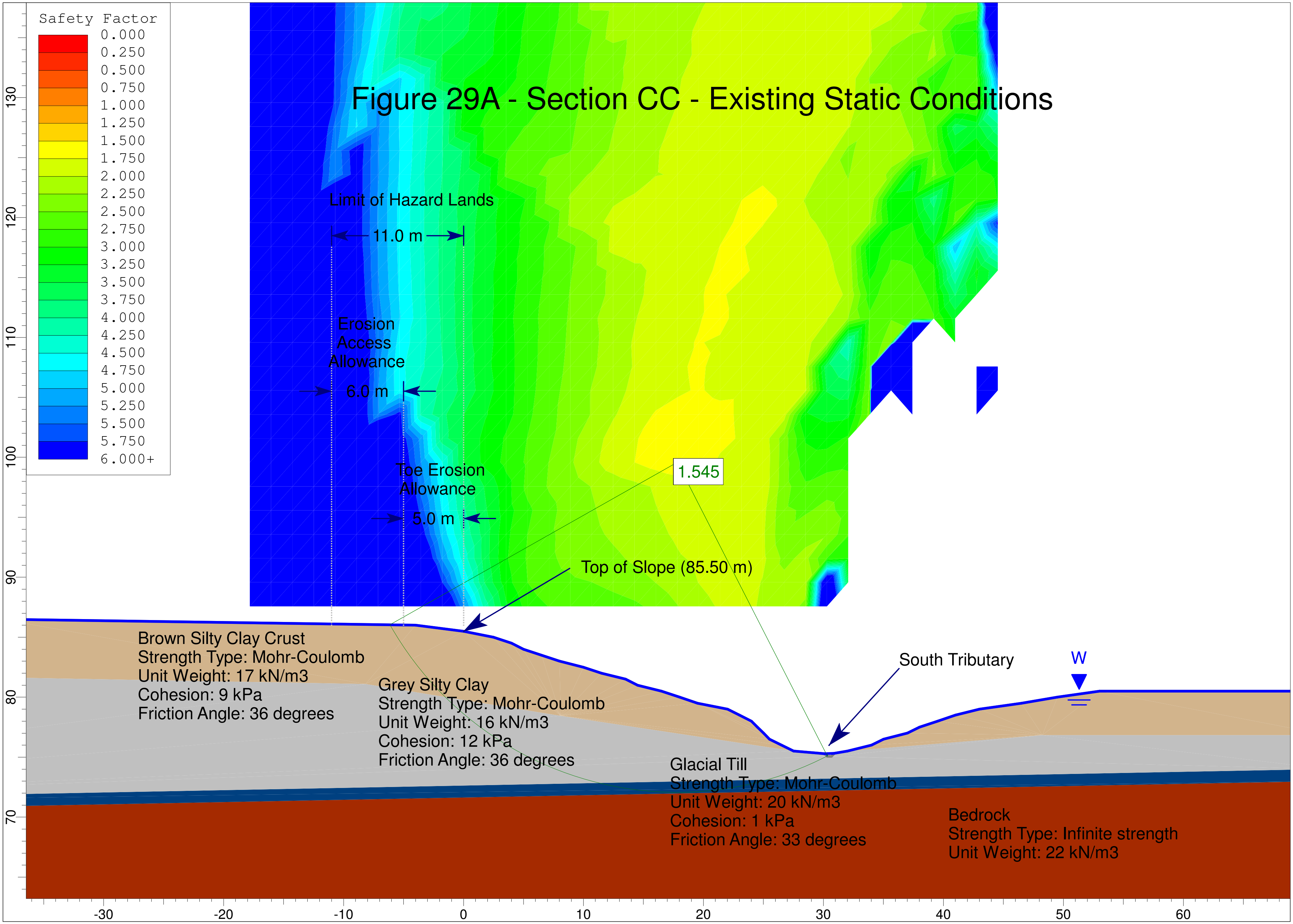


Figure 29A - Section CC - Existing Static Conditions

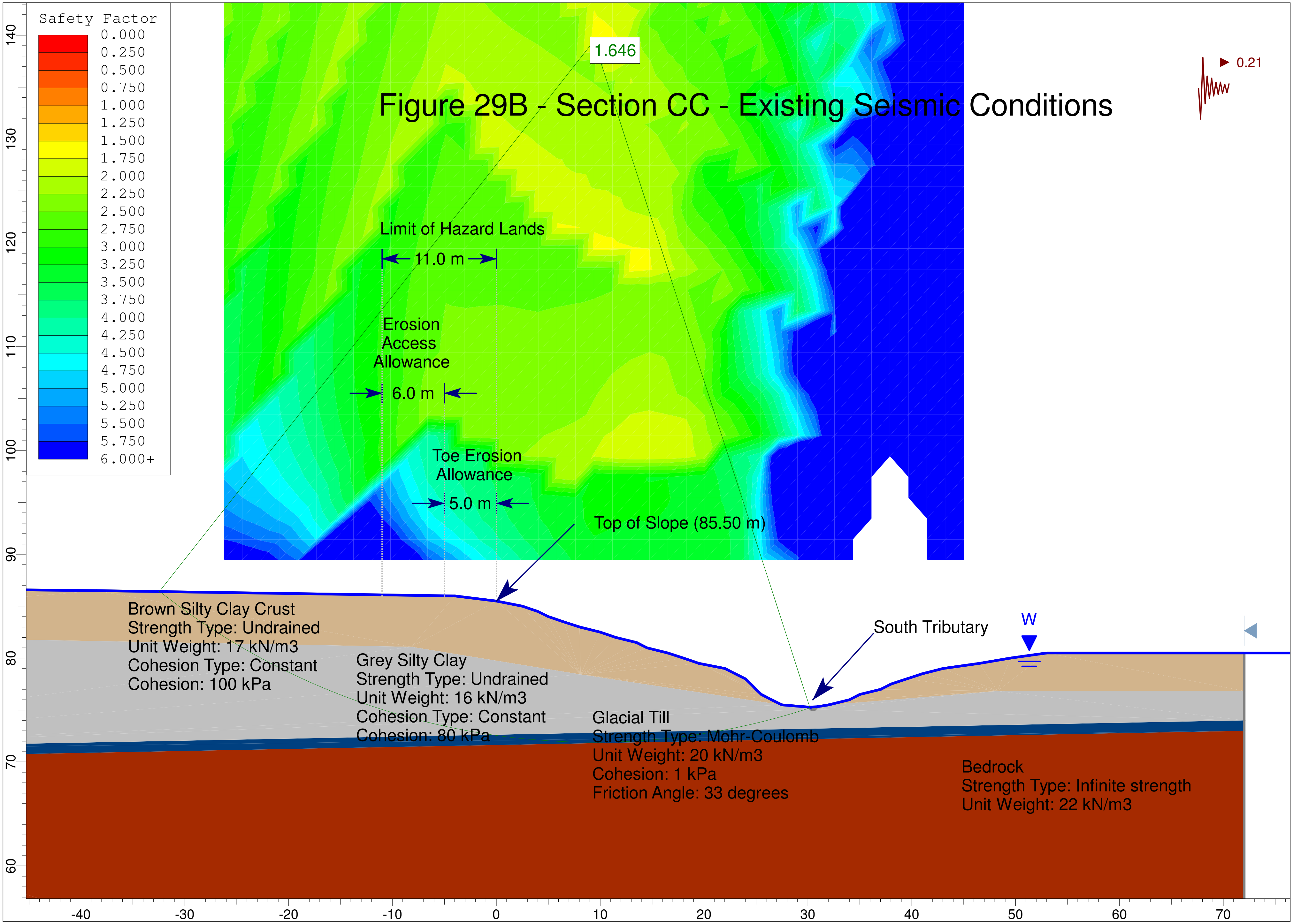
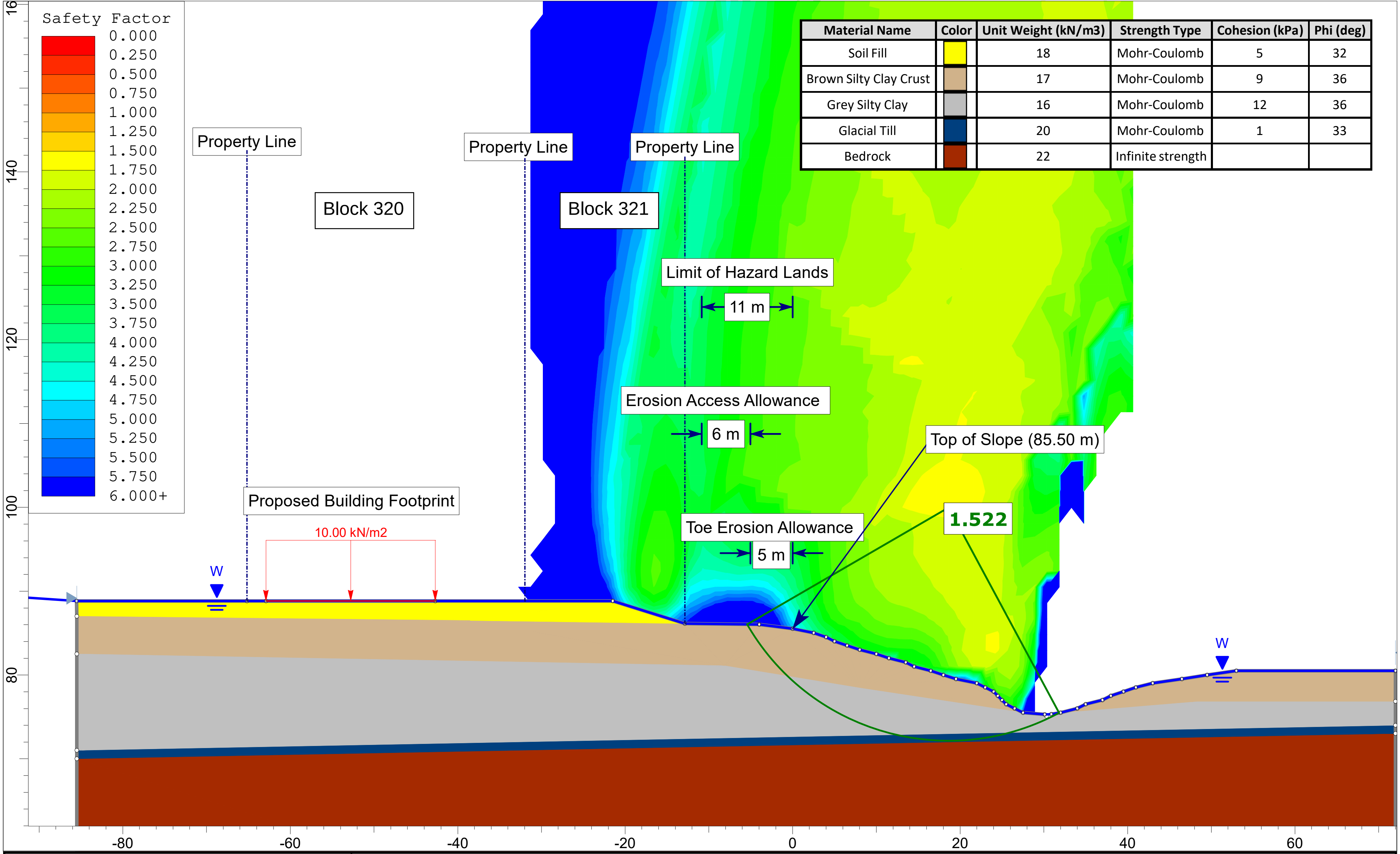


Figure 29B - Section CC - Existing Seismic Conditions

Figure 29C - Section CC - Proposed Static Conditions



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Mohr-Coulomb	9	36
Grey Silty Clay	⬜	16	Mohr-Coulomb	12	36
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

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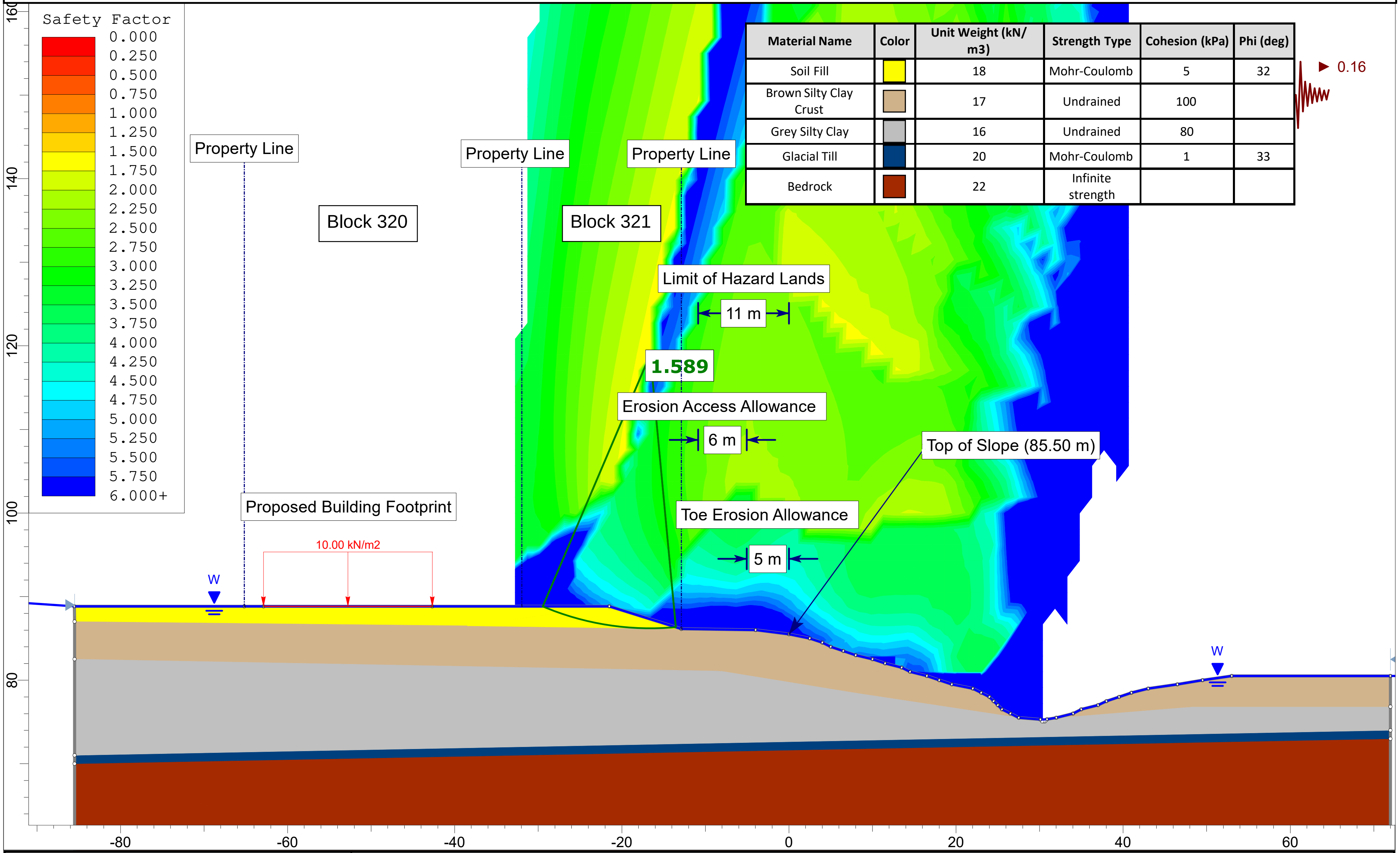
SLIDEINTERPRET 9.025

Project	PG5201 - Proposed Residential Development - Cardinal Creek Village South Old Montreal Road, Ottawa, Ontario

Cross Section	CC	*Scenario*	Static - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/15/2023	*File Name*	Geotechnical Investigation

Figure 29D - Section CC - Proposed Seismic Conditions



Material Name	Color	Unit Weight (kN/ m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Undrained	100	
Grey Silty Clay	▨	16	Undrained	80	
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

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SLIDEINTERPRET 9.025

Project	PG5201 - Proposed Residential Development - Cardinal Creek Village South Old Montreal Road, Ottawa, Ontario		
Cross Section	CC	*Scenario*	Seismic - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/15/2023	*File Name*	Geotechnical Investigation

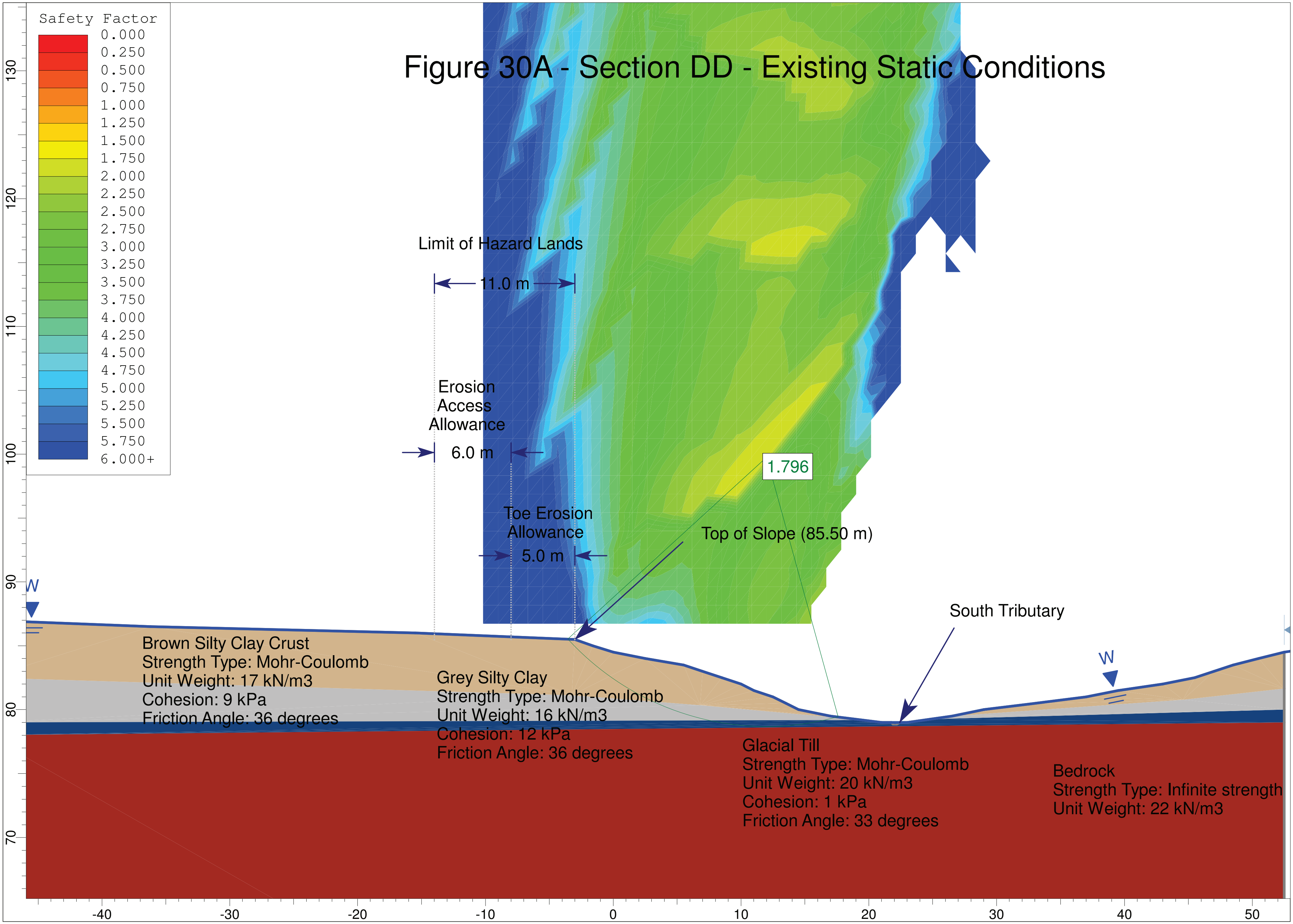


Figure 30A - Section DD - Existing Static Conditions

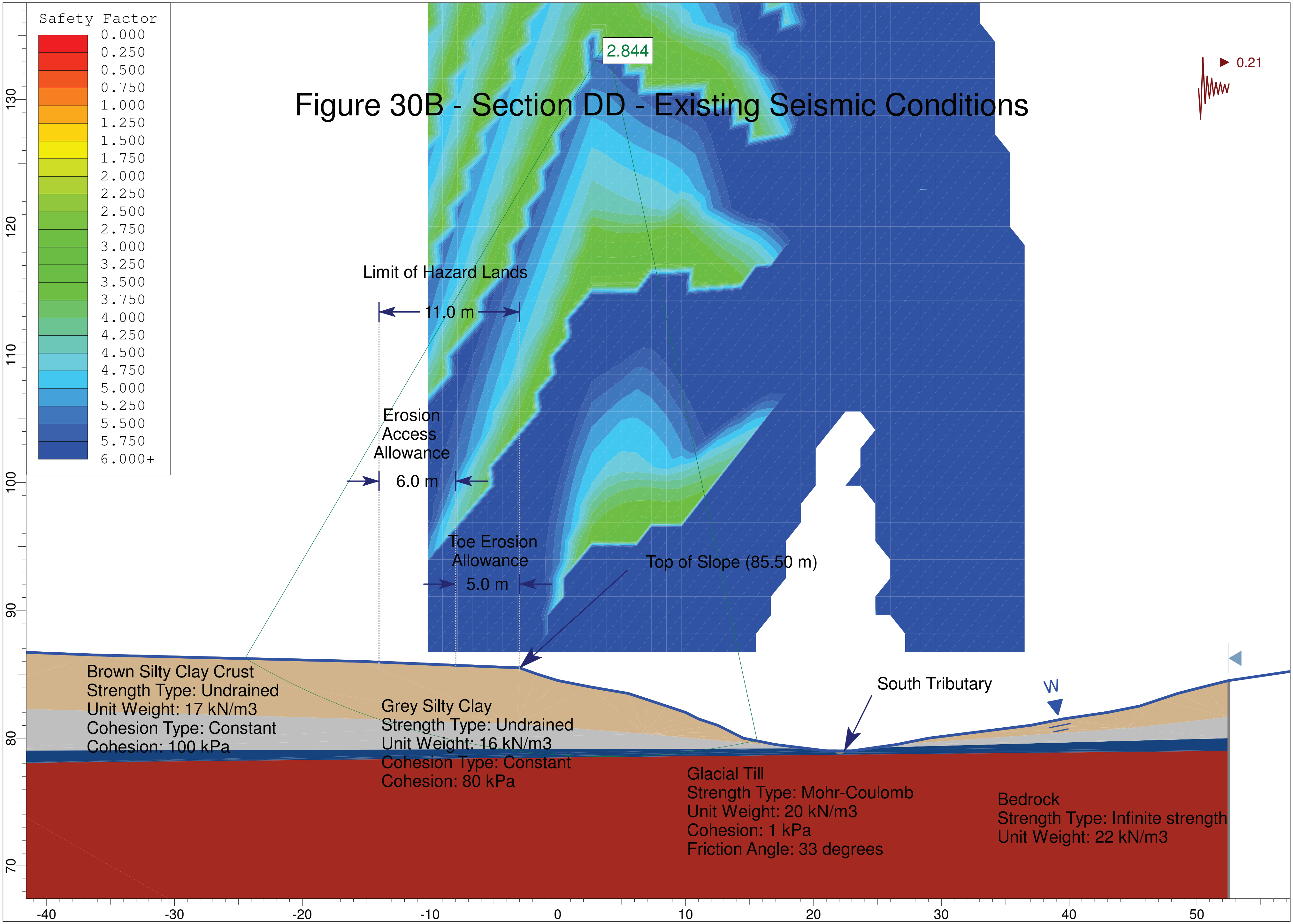
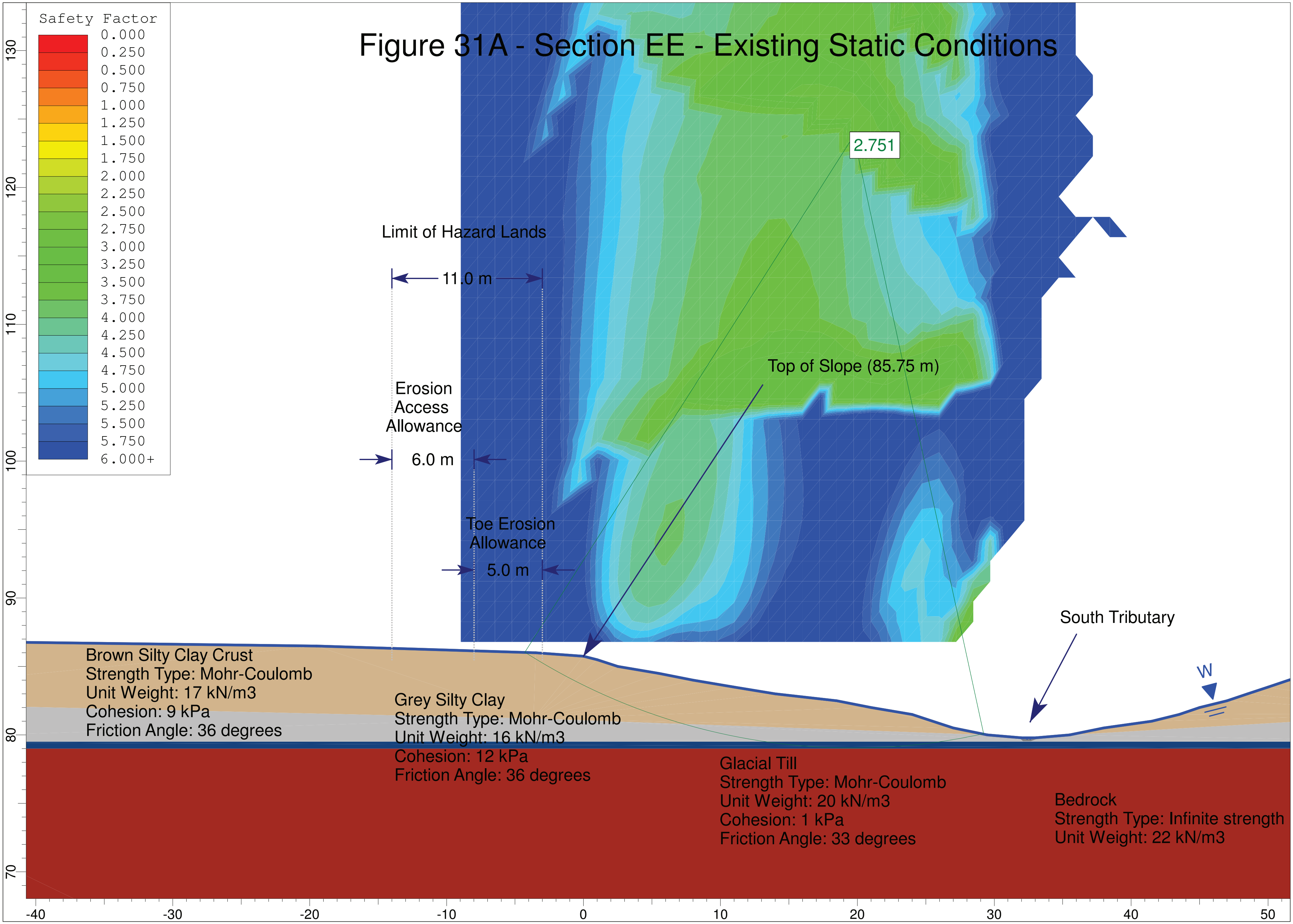


Figure 30B - Section DD - Existing Seismic Conditions

Figure 31A - Section EE - Existing Static Conditions



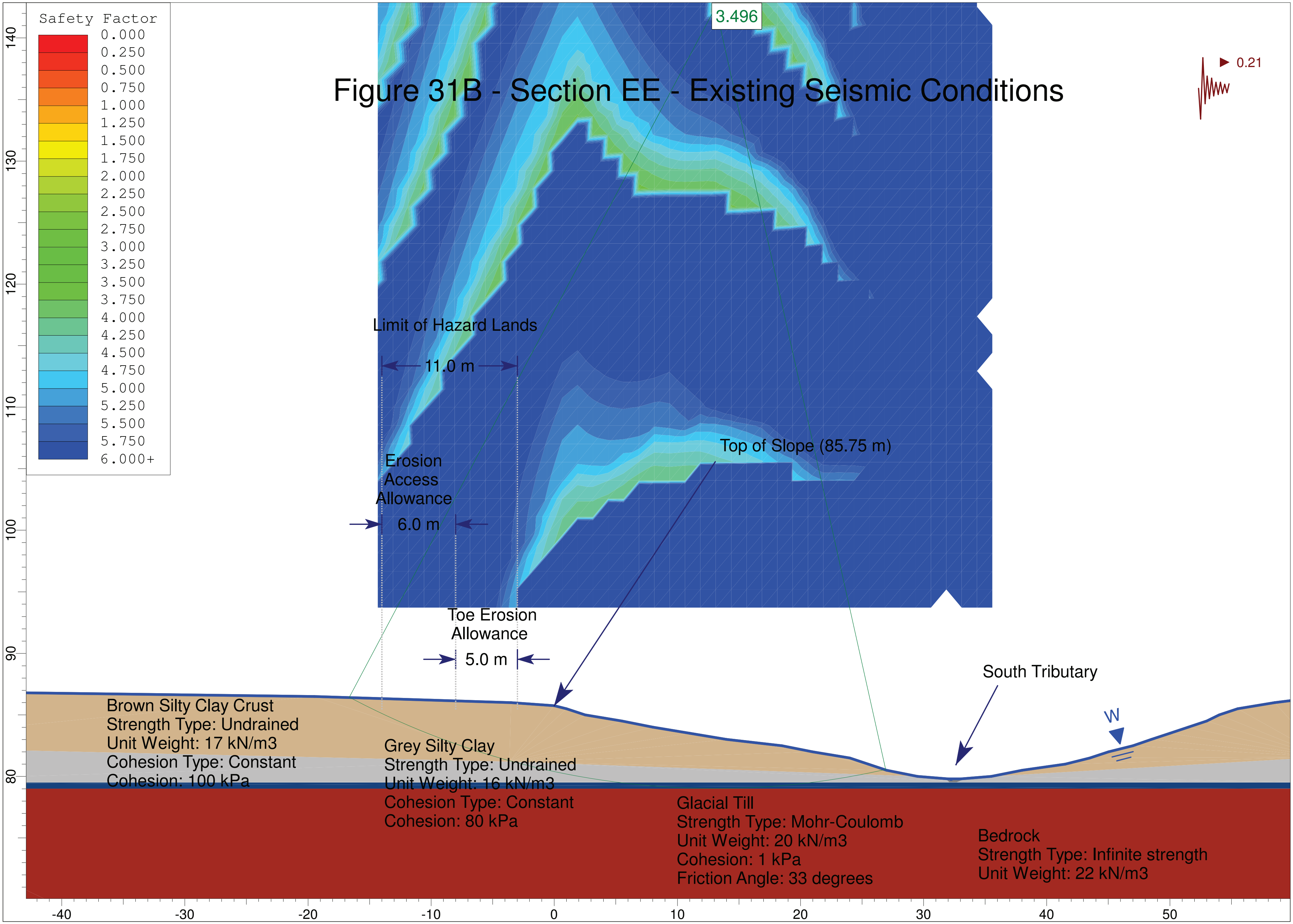
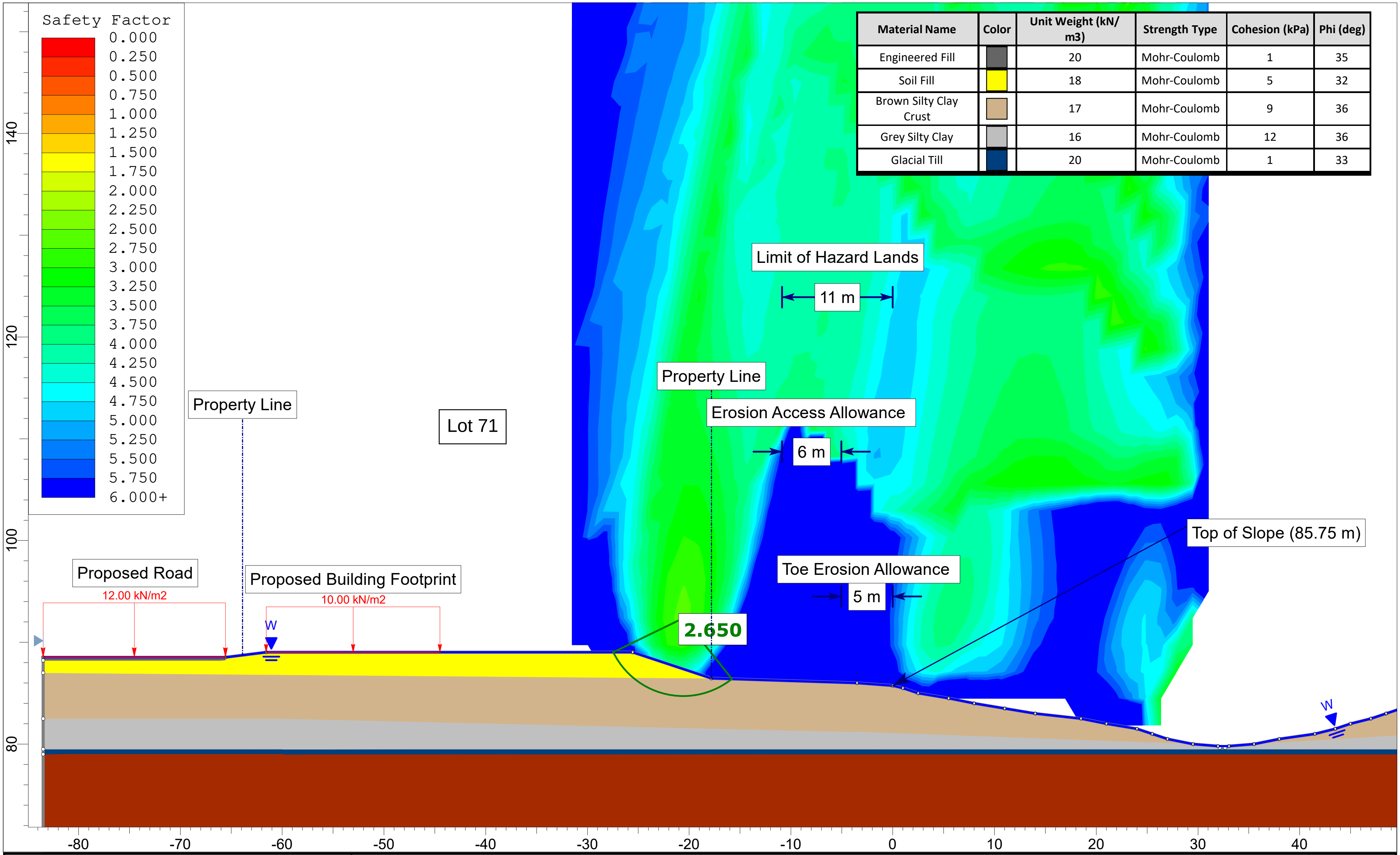


Figure 31B - Section EE - Existing Seismic Conditions

Figure 31C - Section EE - Proposed Static Conditions



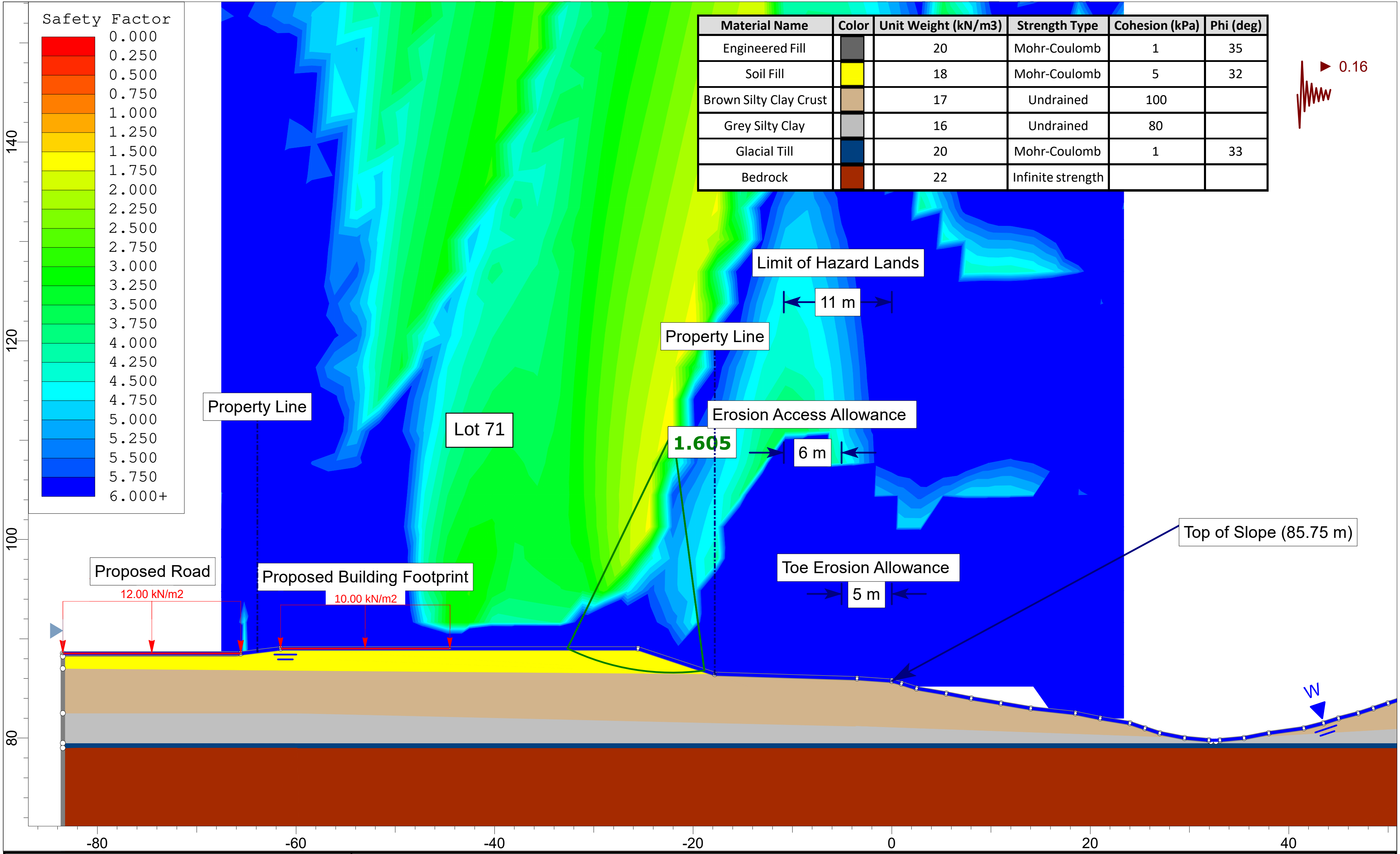
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Engineered Fill	⬛	20	Mohr-Coulomb	1	35
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Mohr-Coulomb	9	36
Grey Silty Clay	⬜	16	Mohr-Coulomb	12	36
Glacial Till	🟦	20	Mohr-Coulomb	1	33

PATERSON GROUP

SLIDEINTERPRET 9.025

Project	PG5201 - Proposed Residential Development - Cardinal Creek Village South Old Montreal Road, Ottawa, Ontario		
Cross Section	EE	*Scenario*	Static - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/15/2023	*File Name*	Geotechnical Investigation

Figure 31D - Section EE - Proposed Seismic Conditions



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Engineered Fill	⬛	20	Mohr-Coulomb	1	35
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Undrained	100	
Grey Silty Clay	⬜	16	Undrained	80	
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

SLIDEINTERPRET 9.025

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Project
PG5201 - Proposed Residential Development - Cardinal Creek Village South
Old Montreal Road, Ottawa, Ontario

Cross Section EE

Scenario Siesmic - Proposed Condition

Drawn By EA

Company Tamarack Homes

Date 8/15/2023

File Name Geotechnical Investigation

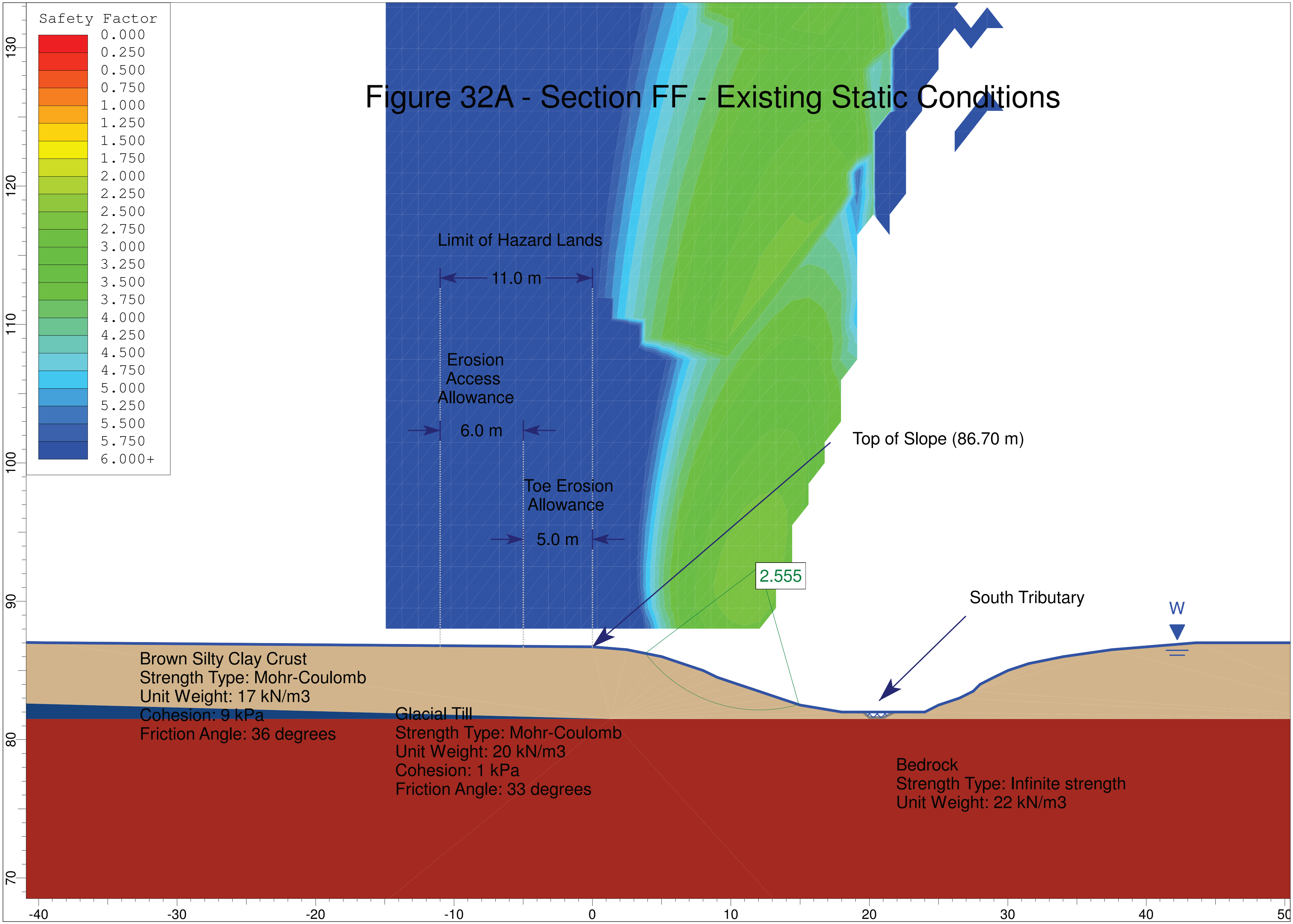


Figure 32A - Section FF - Existing Static Conditions

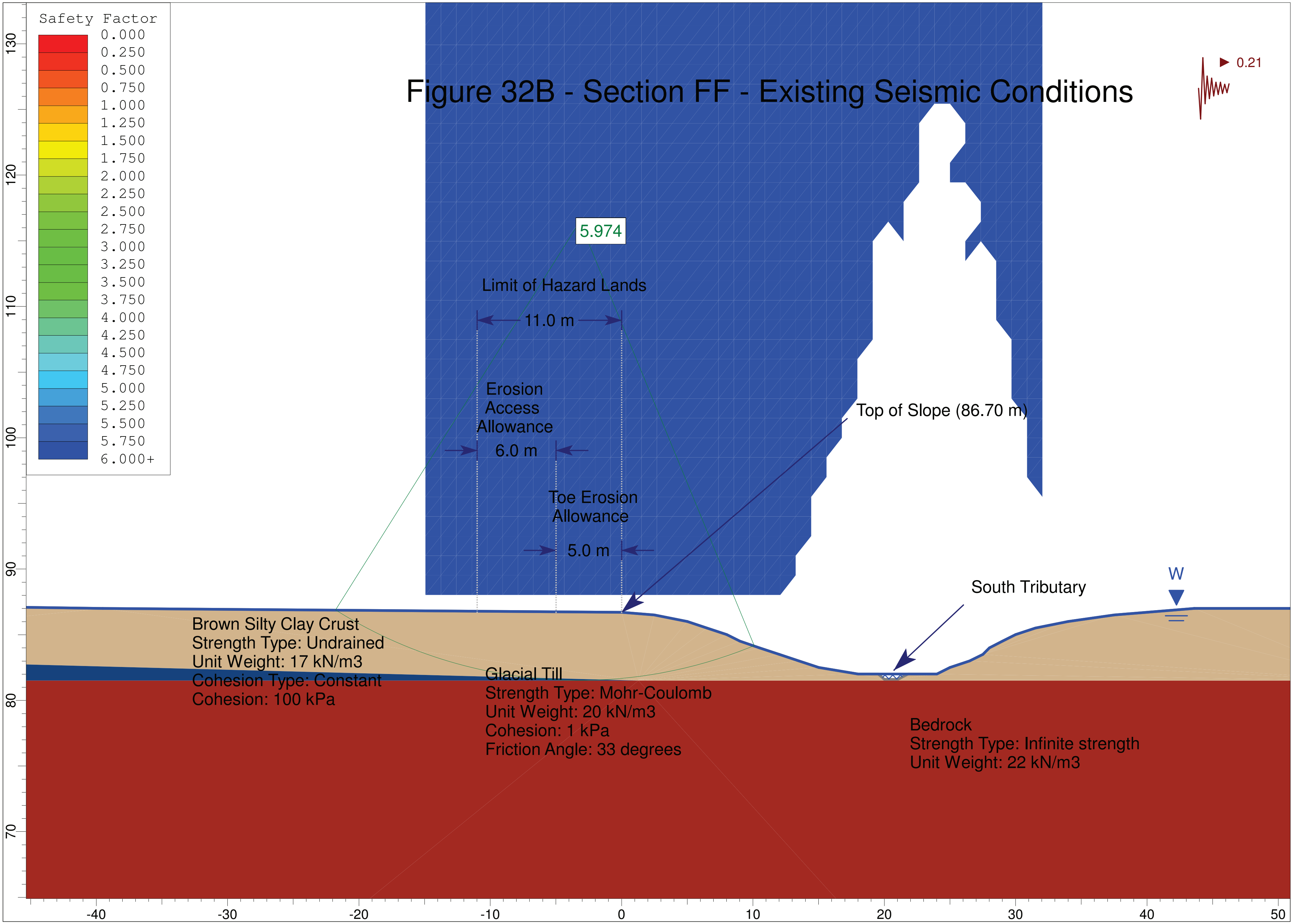
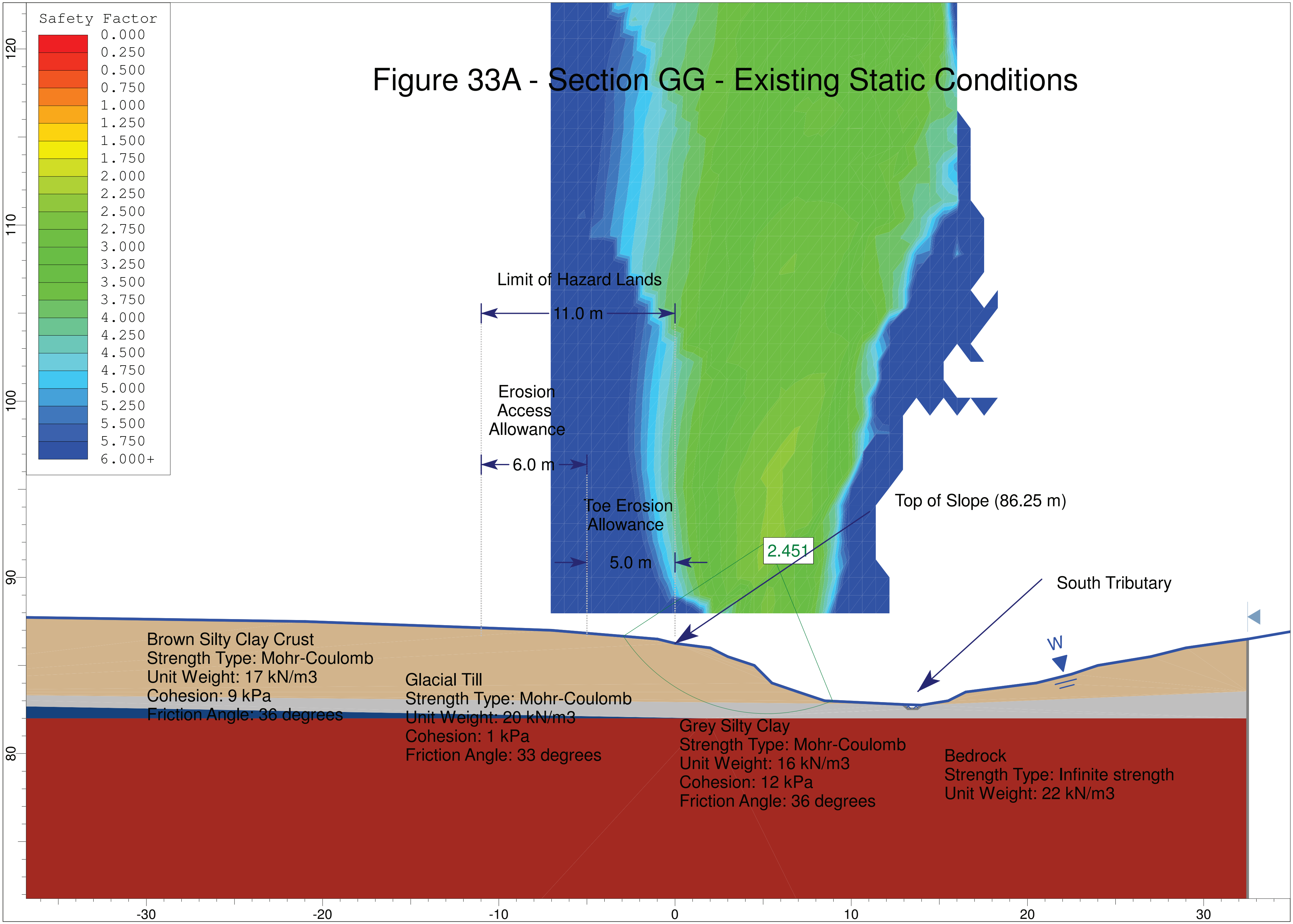


Figure 32B - Section FF - Existing Seismic Conditions

Figure 33A - Section GG - Existing Static Conditions



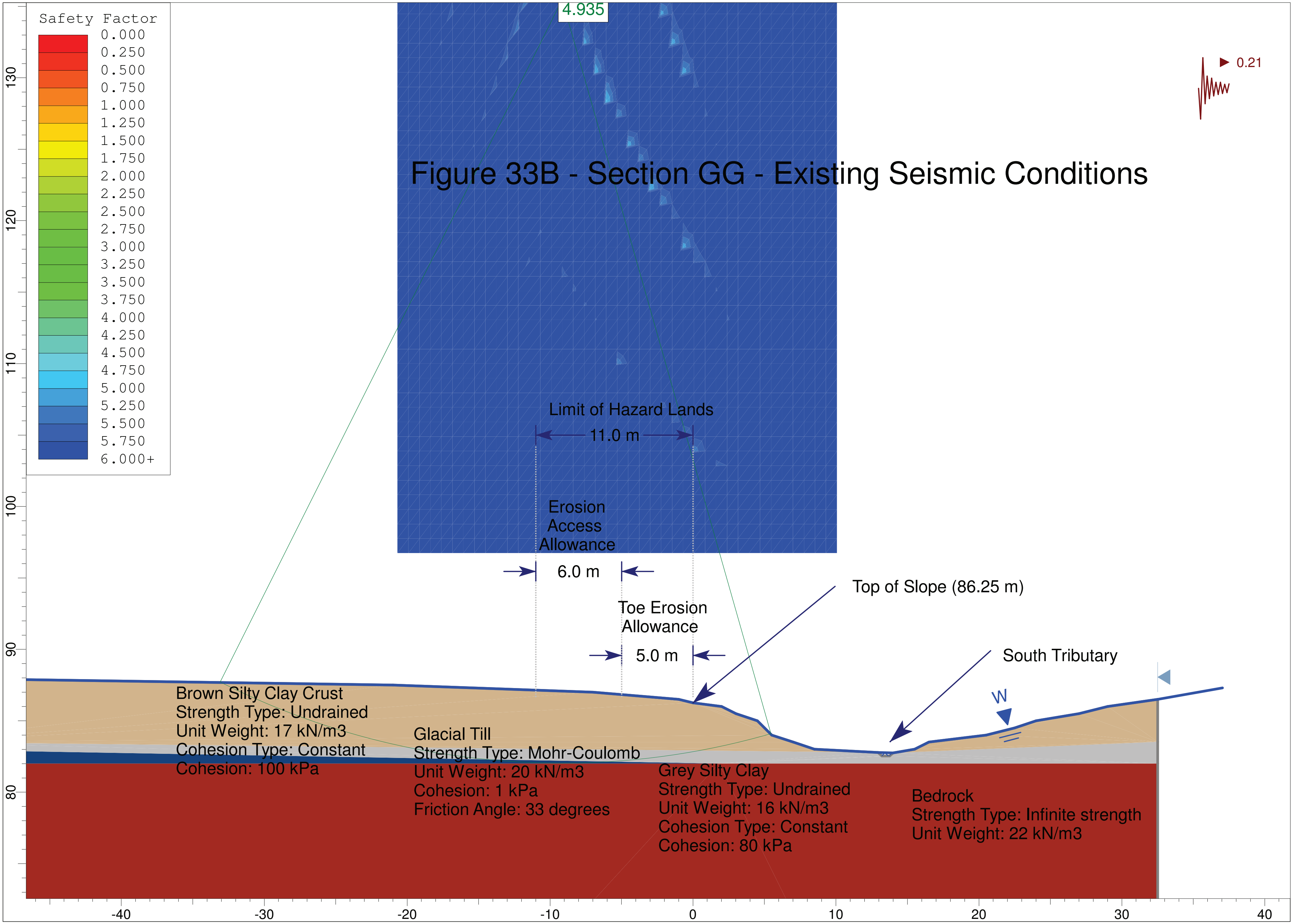
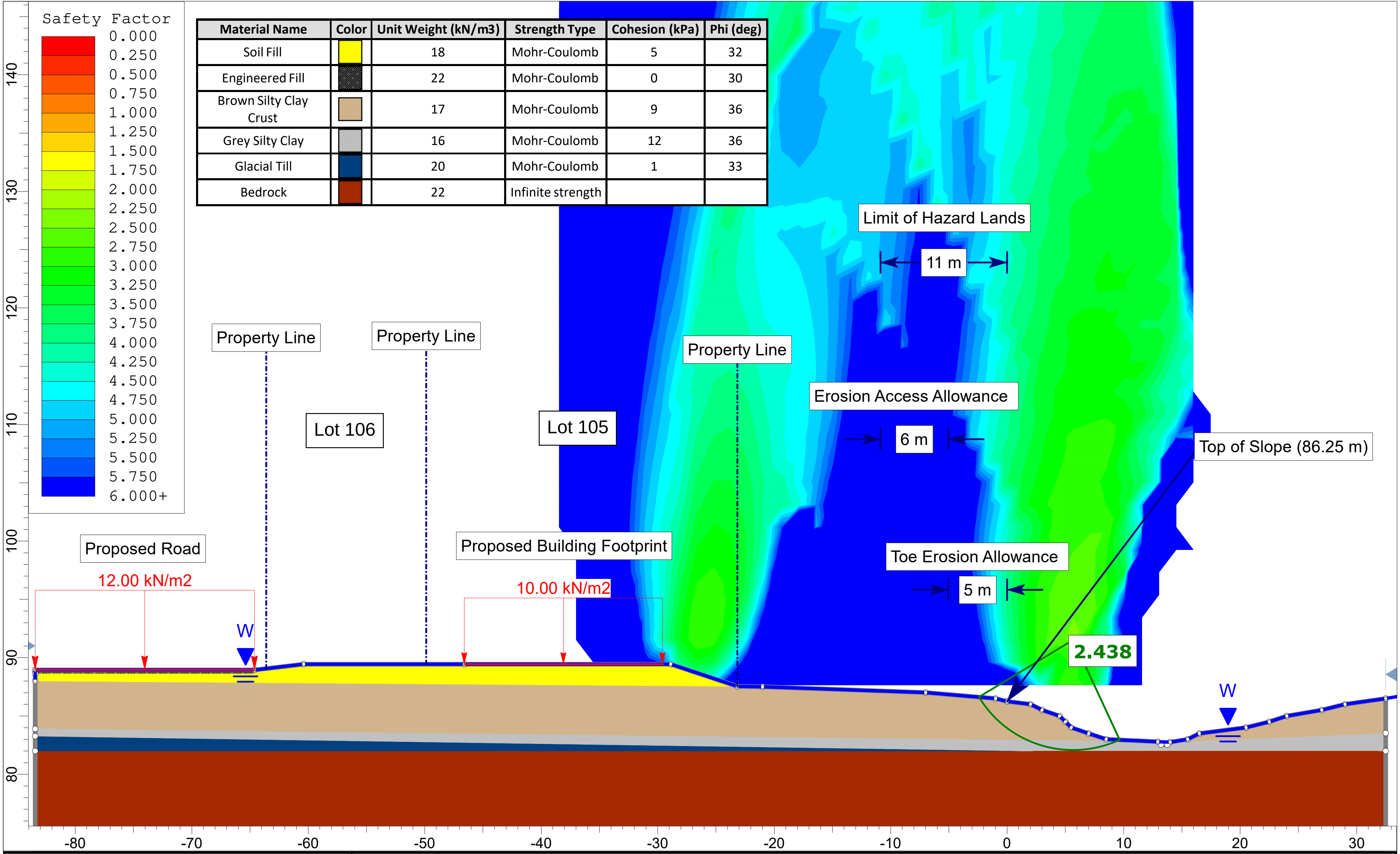


Figure 33B - Section GG - Existing Seismic Conditions

Figure 33C - Section GG - Proposed Static Conditions



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Engineered Fill	▩	22	Mohr-Coulomb	0	30
Brown Silty Clay Crust	🟫	17	Mohr-Coulomb	9	36
Grey Silty Clay	⬜	16	Mohr-Coulomb	12	36
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

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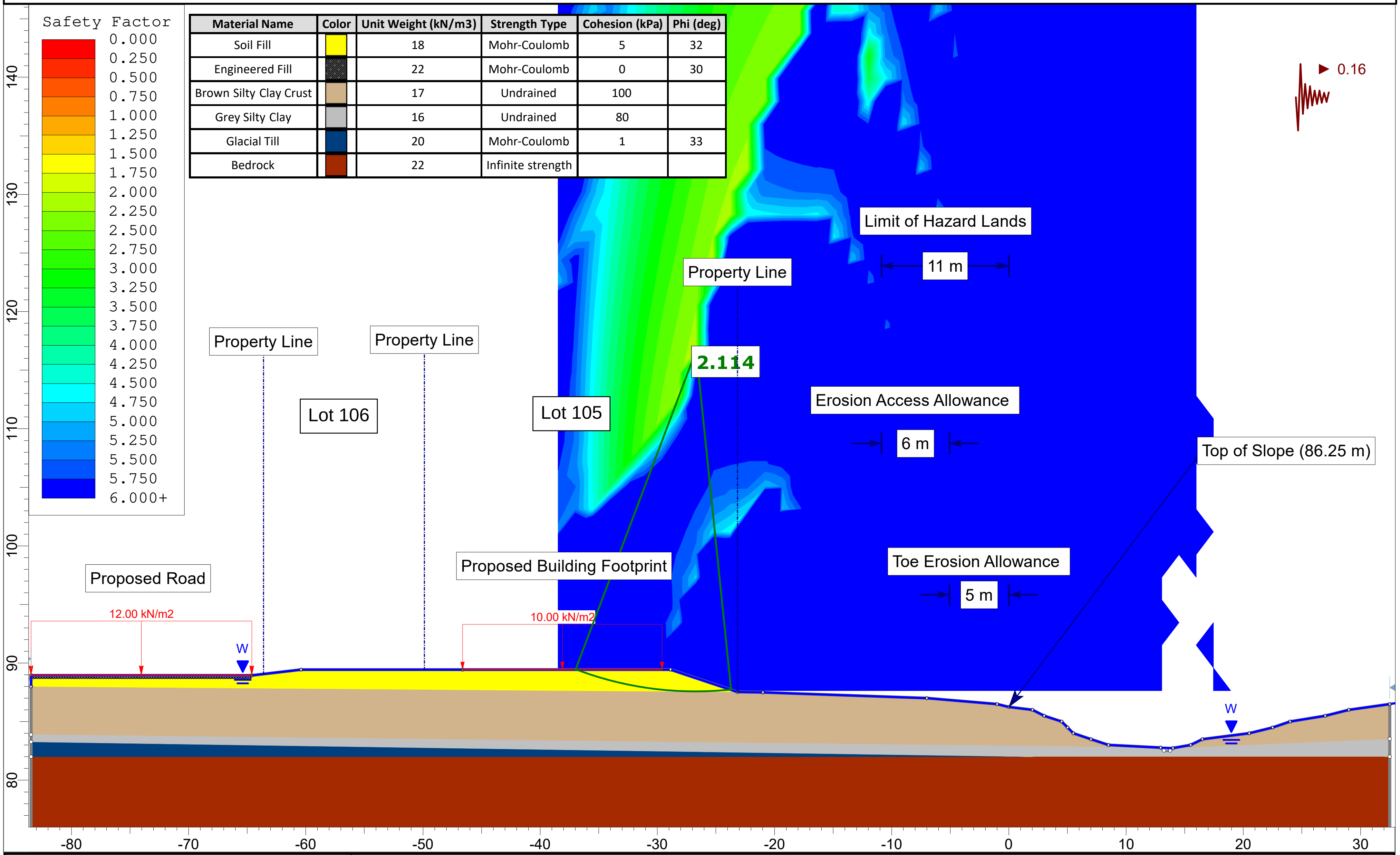
SLIDEINTERPRET 9.025

Project	PG5201 - Proposed Residential Development - Cardinal Creek Village South Old Montreal Road, Ottawa, Ontario		
Cross Section	GG	*Scenario*	Static - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/15/2023	*File Name*	Geotechnical Investigation

Figure 33D - Section GG - Proposed Seismic Conditions



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Engineered Fill	▨	22	Mohr-Coulomb	0	30
Brown Silty Clay Crust	🟫	17	Undrained	100	
Grey Silty Clay	⬜	16	Undrained	80	
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

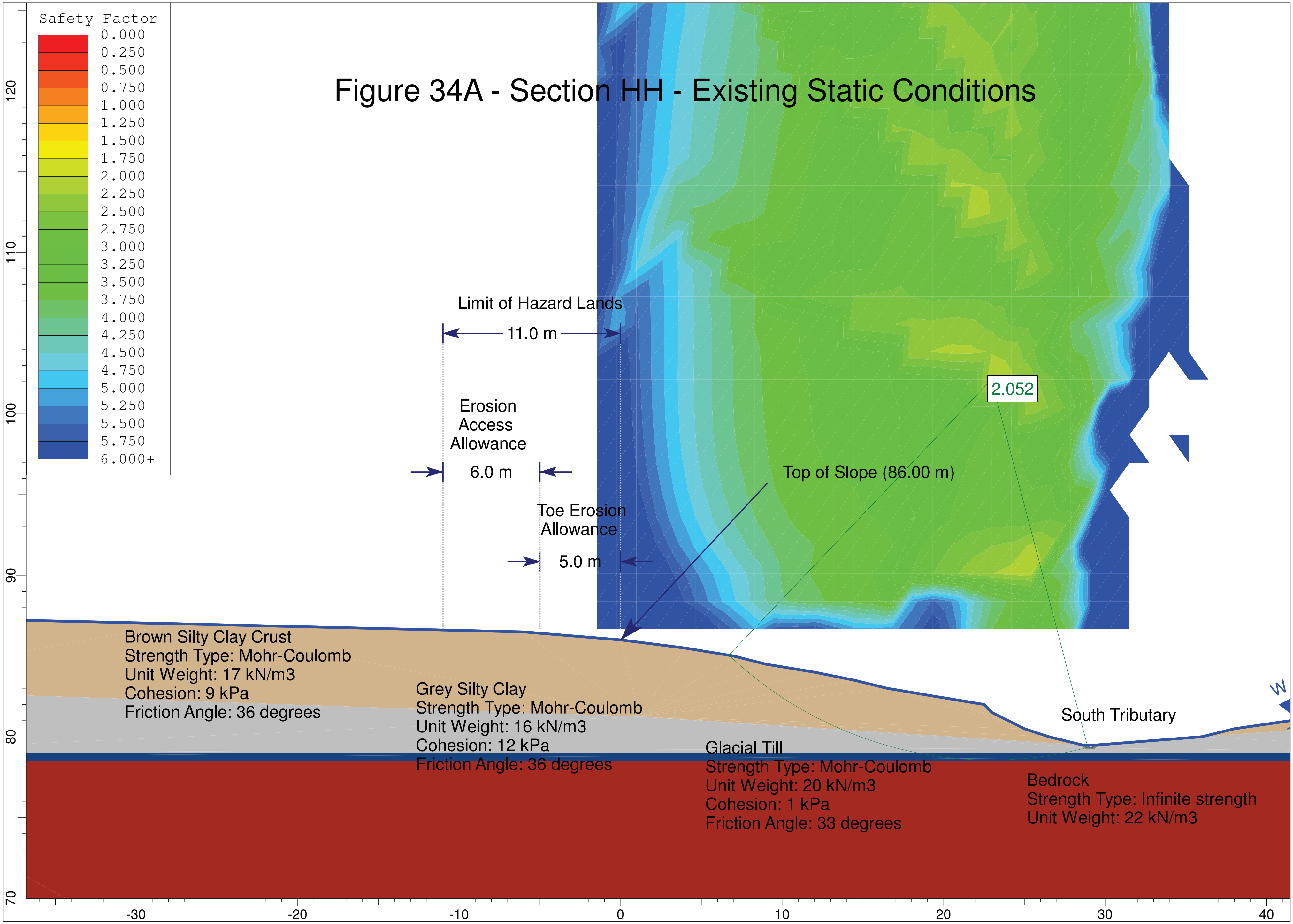
PATERSON GROUP

SLIDEINTERPRET 9.025

Project PG5201 - Proposed Residential Development - Cardinal Creek Village South
Old Montreal Road, Ottawa, Ontario

Cross Section	GG	*Scenario*	Seismic - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/15/2023	*File Name*	Geotechnical Investigation

Figure 34A - Section HH - Existing Static Conditions



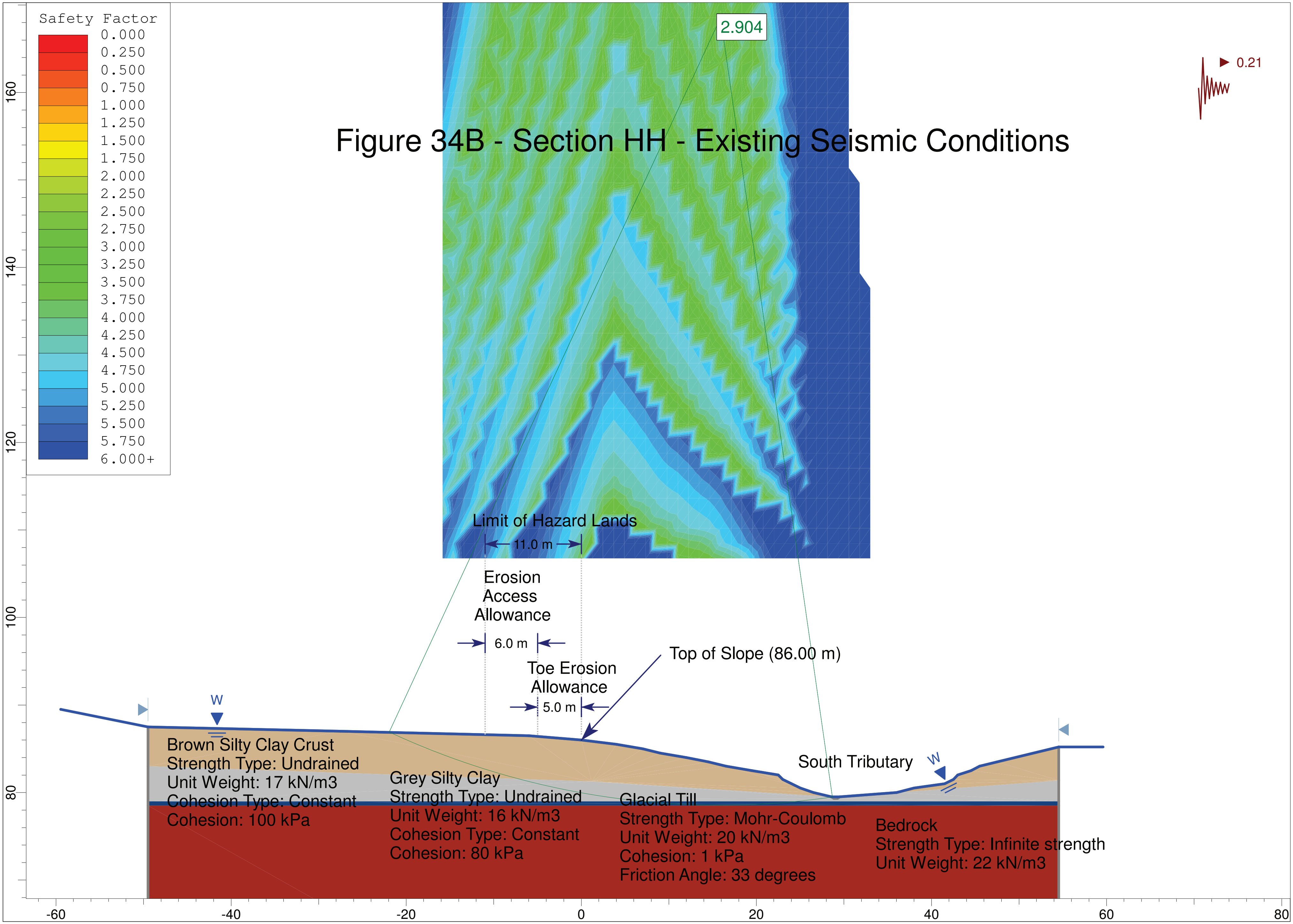
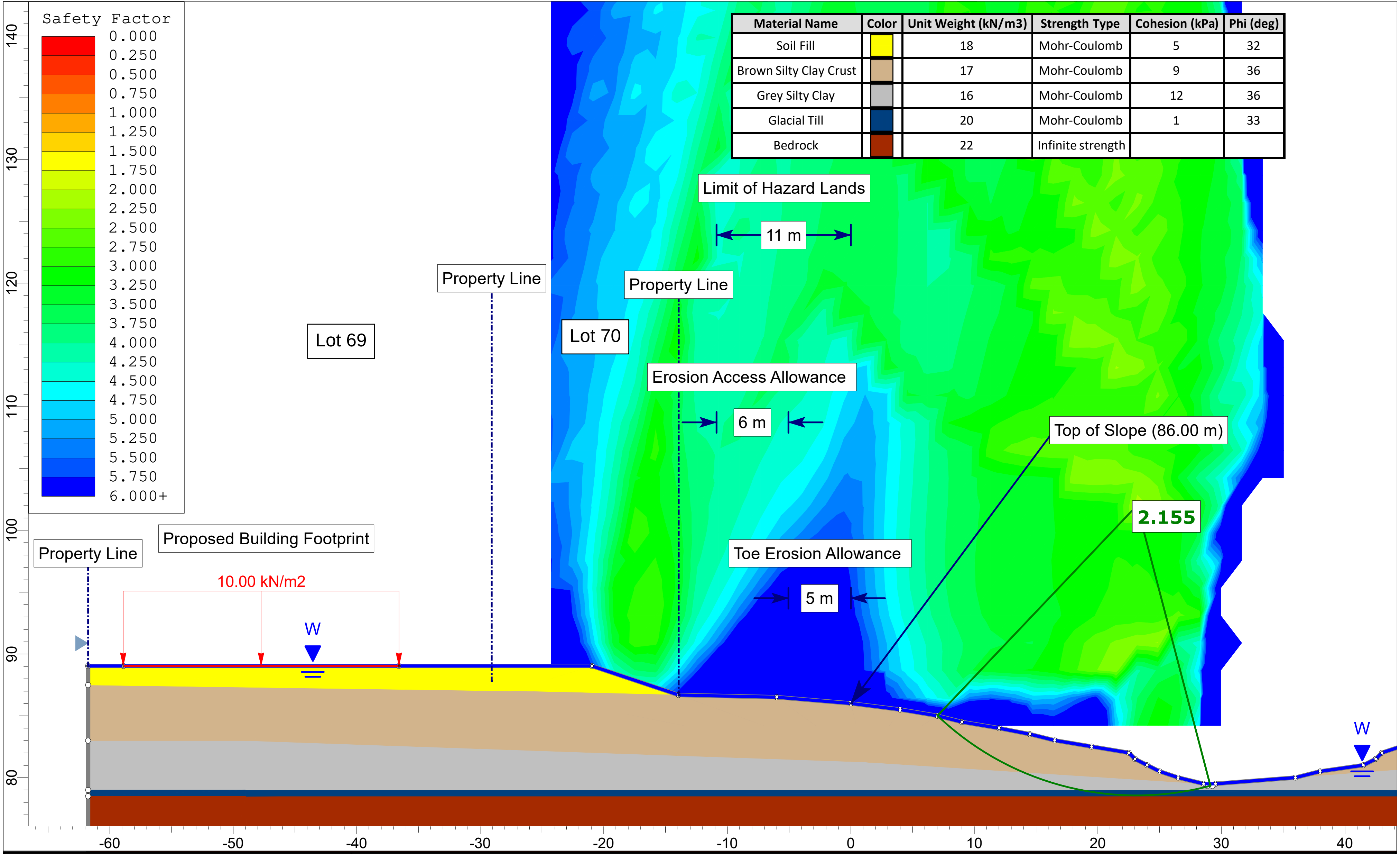


Figure 34B - Section HH - Existing Seismic Conditions

Figure 34C - Section HH - Proposed Static Conditions



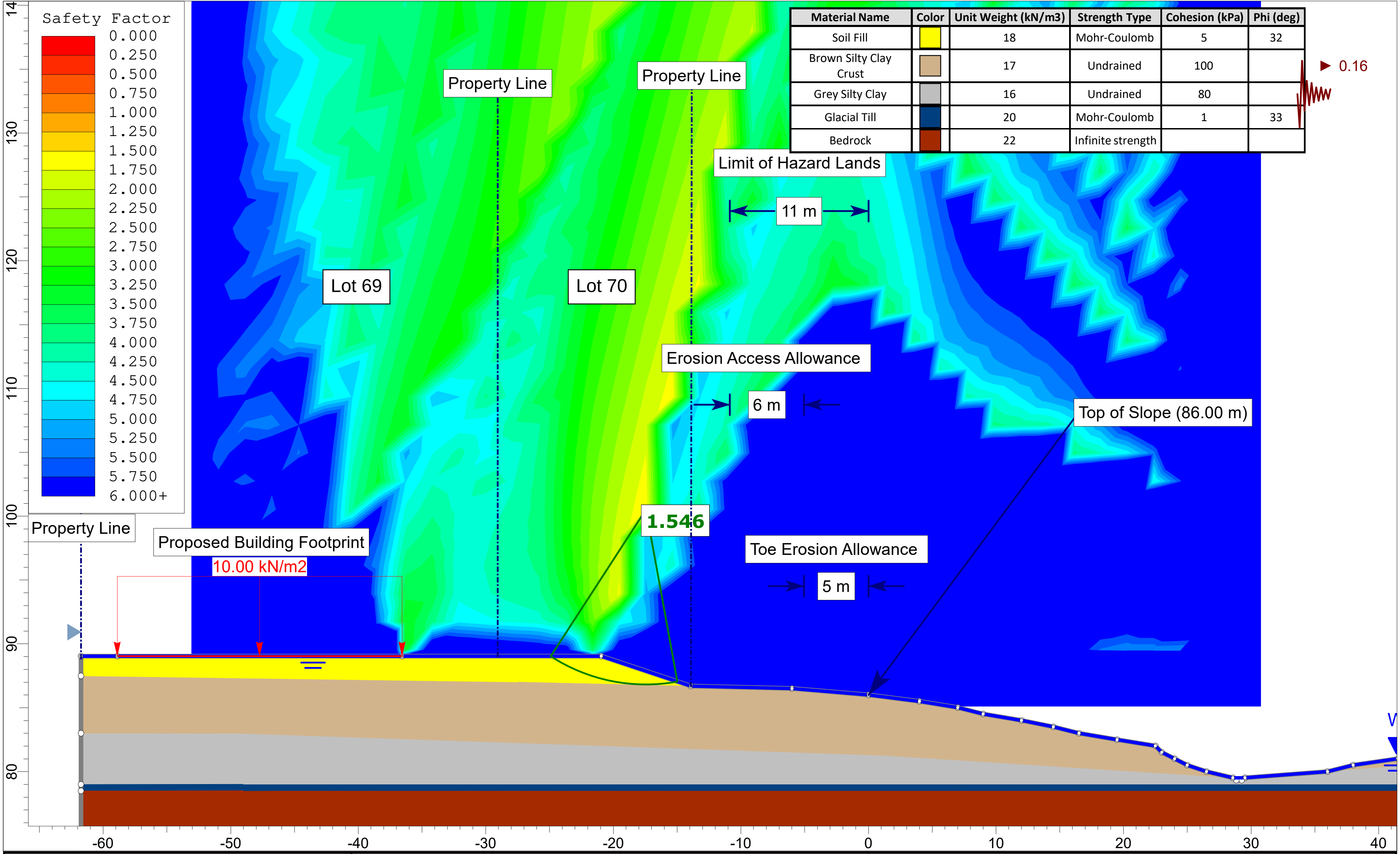
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Mohr-Coulomb	9	36
Grey Silty Clay	⬜	16	Mohr-Coulomb	12	36
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

PATERSON GROUP

SLIDEINTERPRET 9.025

Project	PG5201 - Proposed Residential Development - Cardinal Creek Village South Old Montreal Road, Ottawa, Ontario		
Cross Section	HH	*Scenario*	Static - Proposed Condition
Drawn By	EA	*Company*	Tamarack Homes
Date	8/15/2023	*File Name*	Geotechnical Investigation

Figure 34D - Section HH - Proposed Seismic Conditions



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Soil Fill	🟨	18	Mohr-Coulomb	5	32
Brown Silty Clay Crust	🟫	17	Undrained	100	
Grey Silty Clay	⬜	16	Undrained	80	
Glacial Till	🟦	20	Mohr-Coulomb	1	33
Bedrock	🟥	22	Infinite strength		

PATERSON GROUP

SLIDEINTERPRET 9.025

Project
PG5201 - Proposed Residential Development - Cardinal Creek Village South
Old Montreal Road, Ottawa, Ontario

Cross Section HH

Scenario Seismic - Proposed Condition

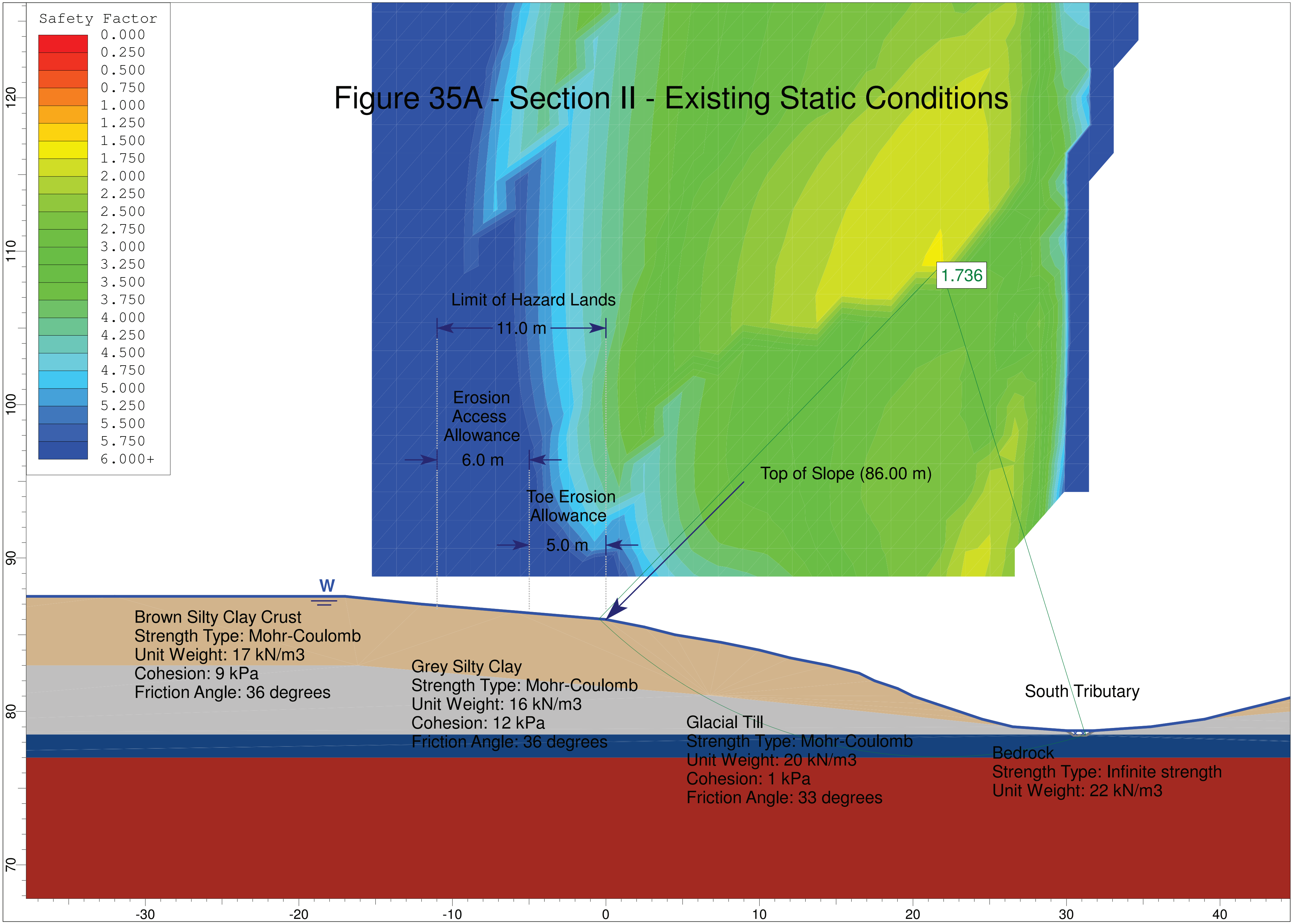
Drawn By EA

Company Tamarack Homes

Date 8/15/2023

File Name Geotechnical Investigation

Figure 35A - Section II - Existing Static Conditions



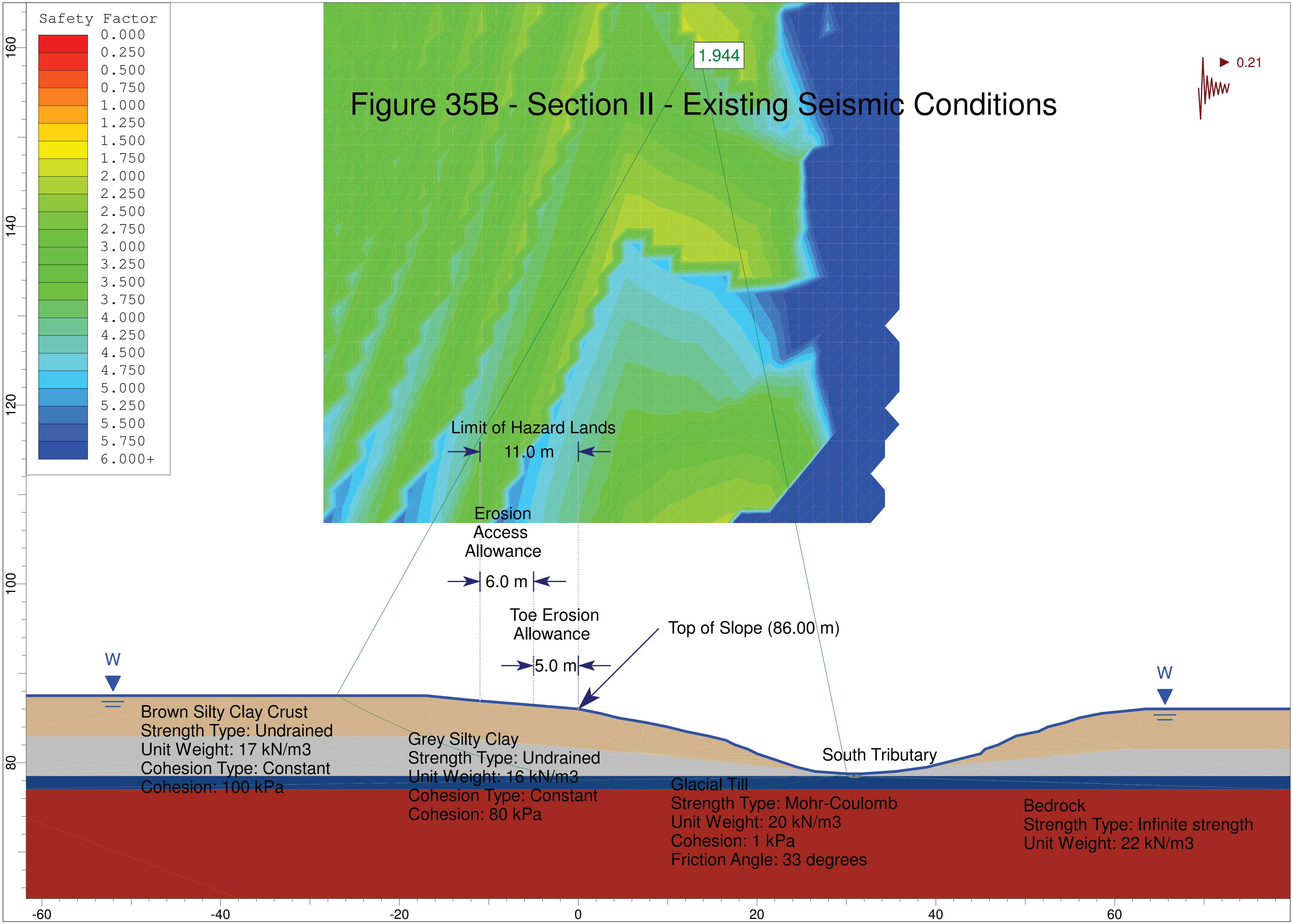


Figure 35B - Section II - Existing Seismic Conditions

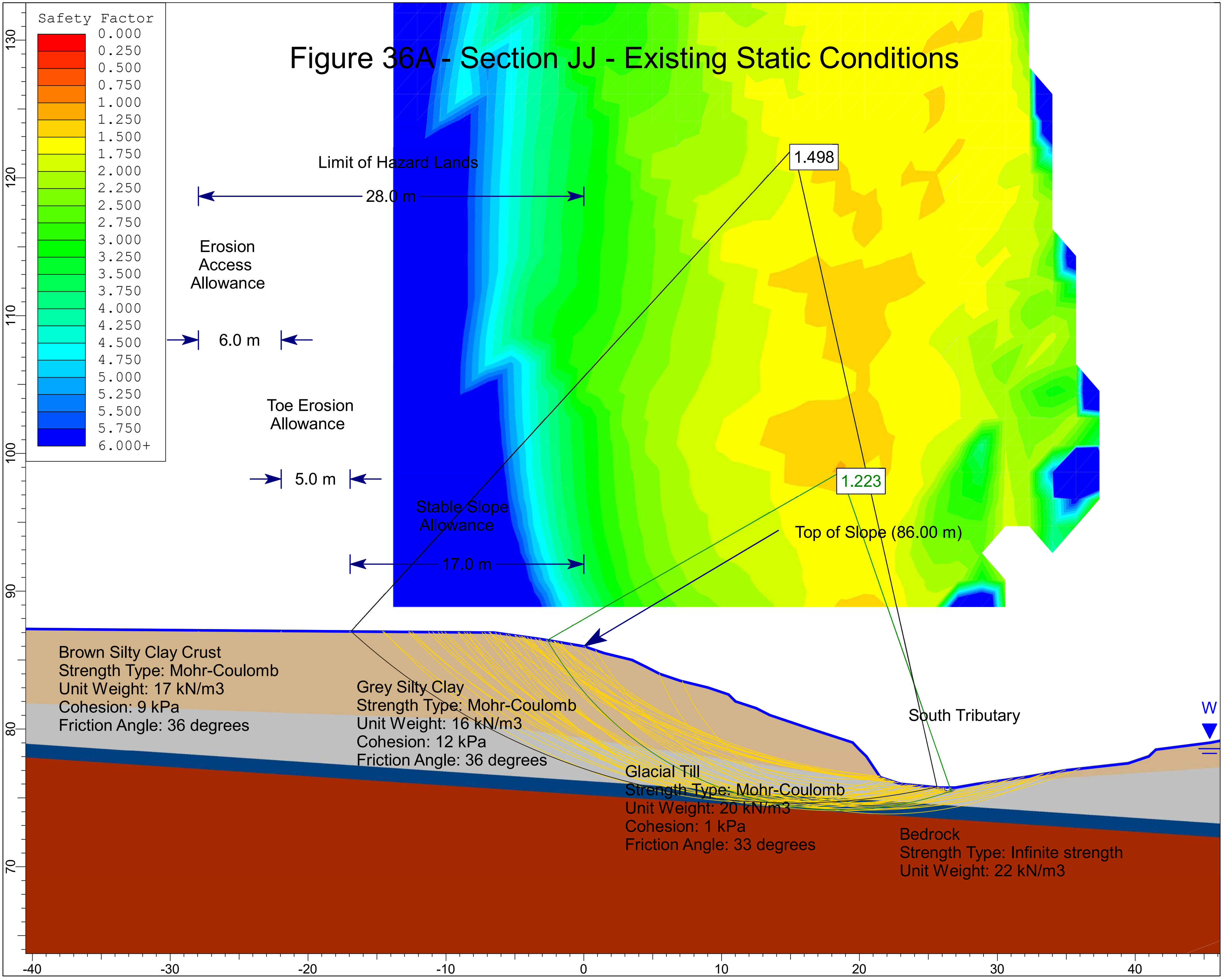


Figure 36A - Section JJ - Existing Static Conditions

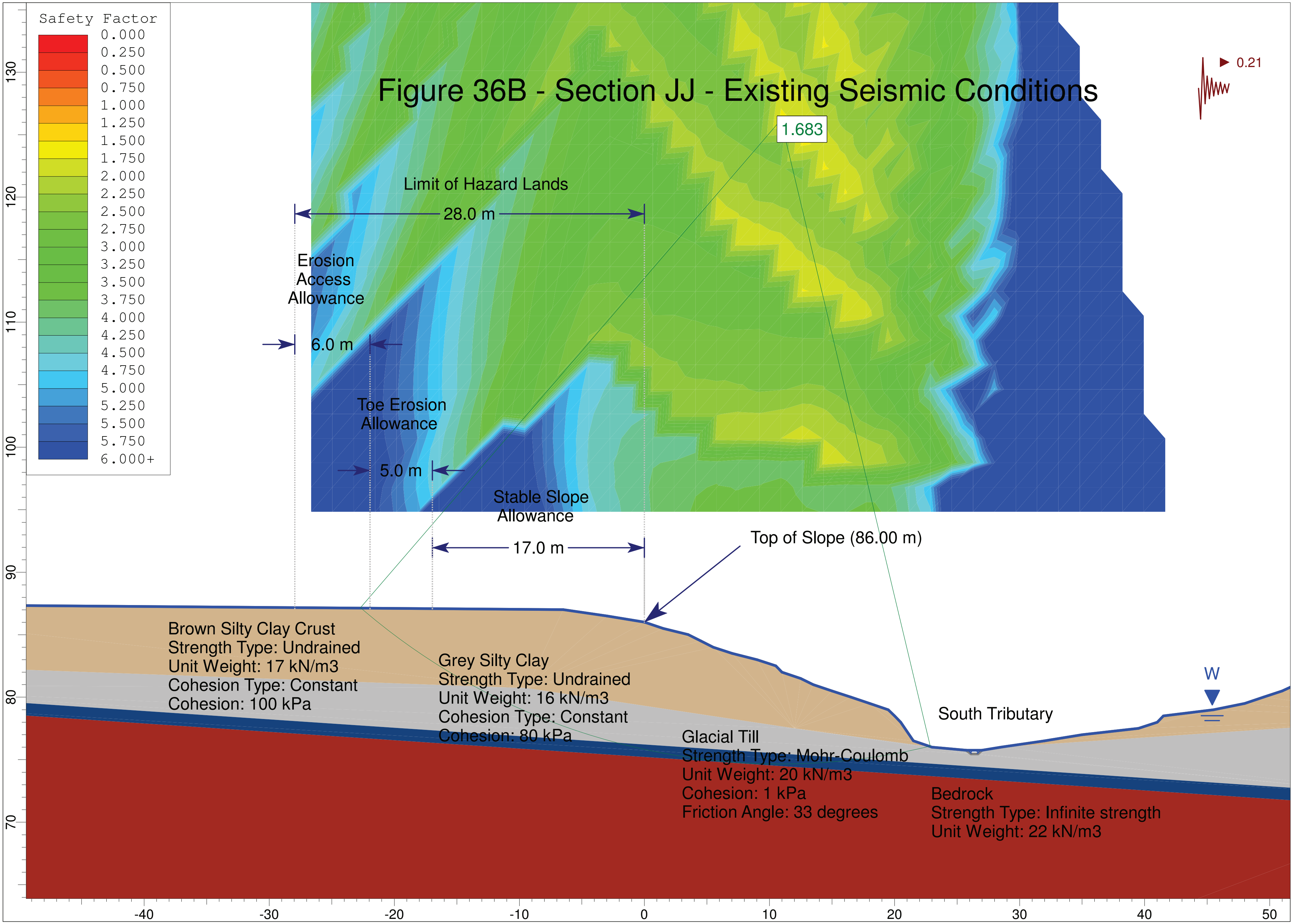


Figure 36B - Section JJ - Existing Seismic Conditions

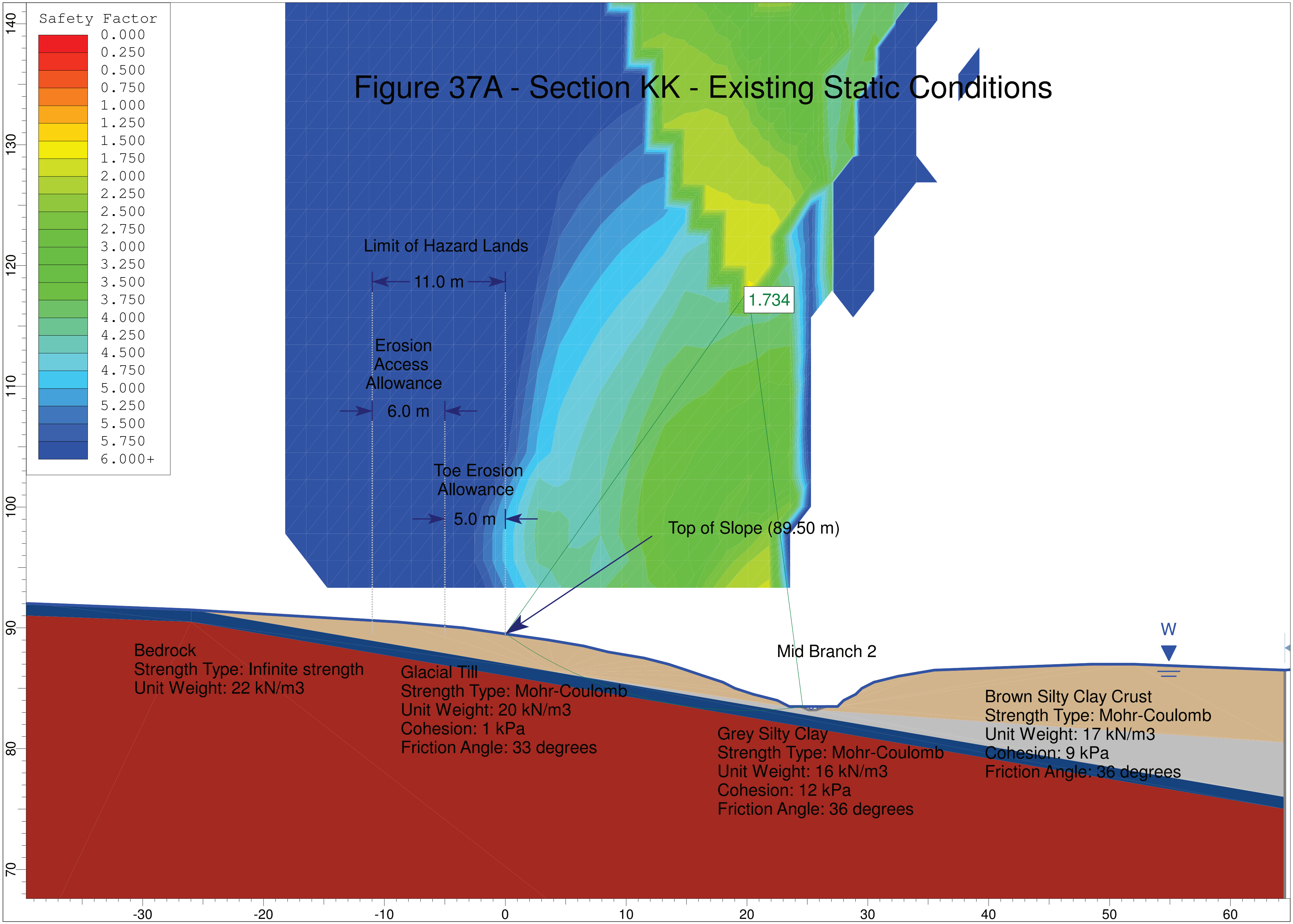
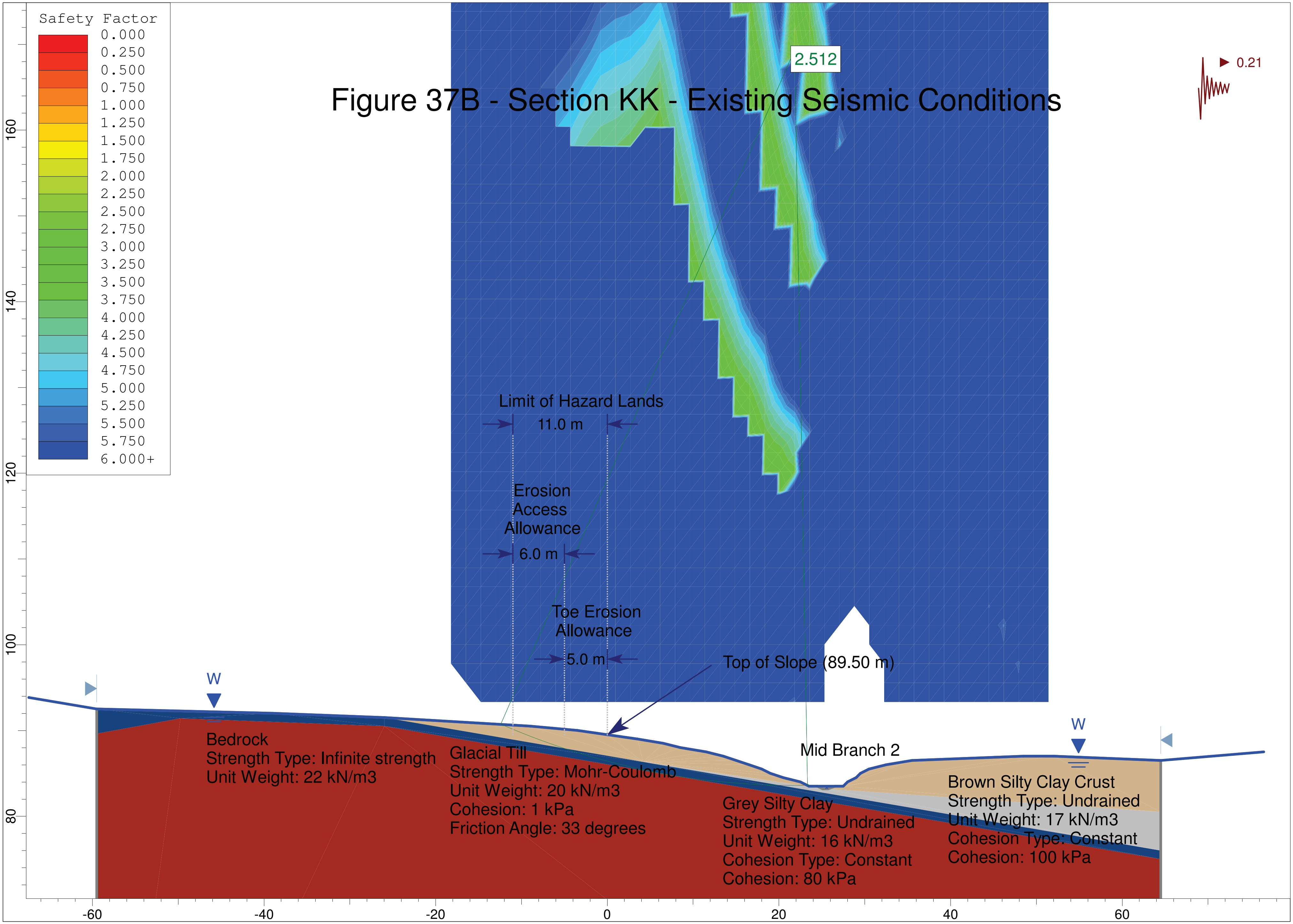


Figure 37A - Section KK - Existing Static Conditions

Figure 37B - Section KK - Existing Seismic Conditions



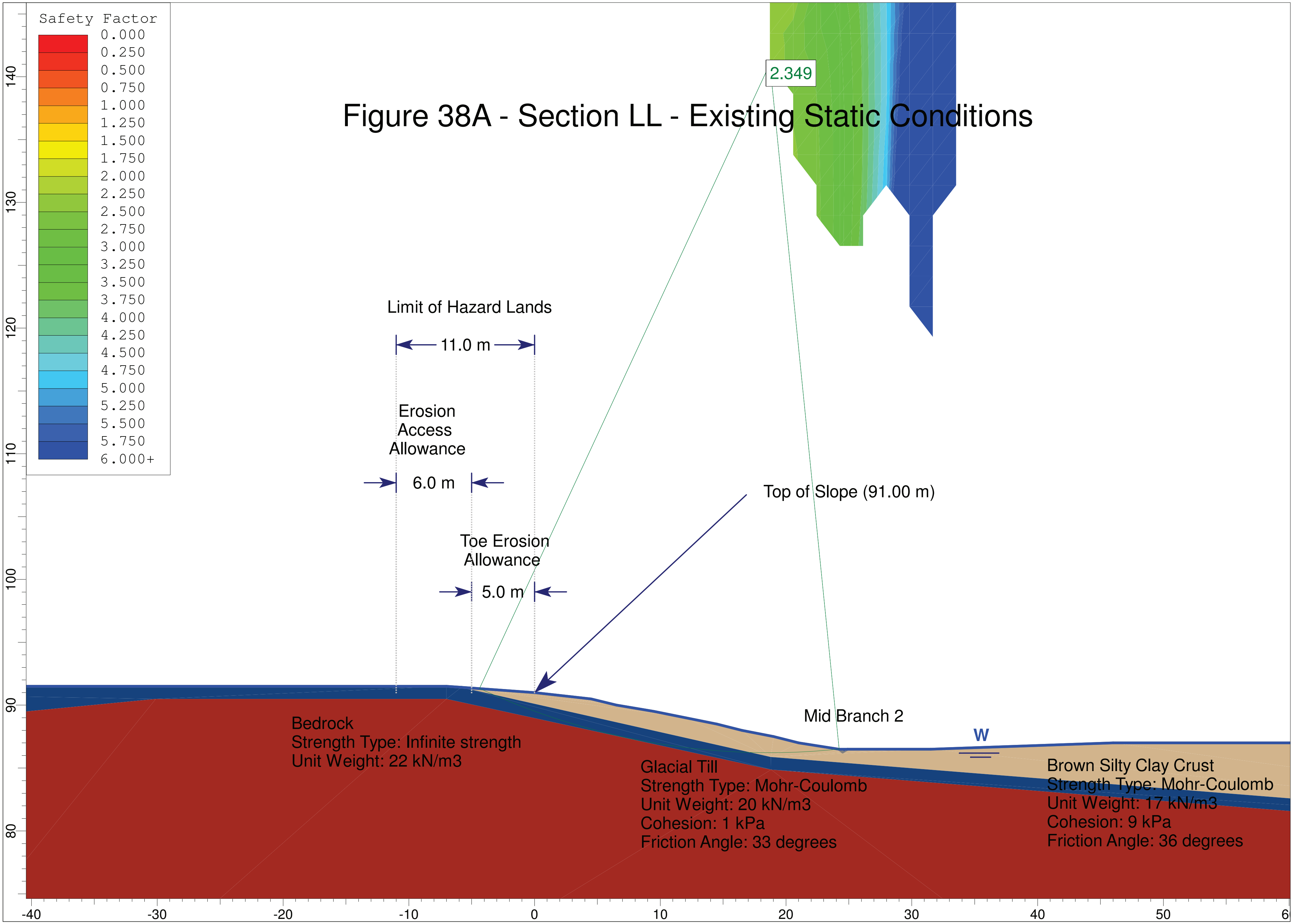


Figure 38A - Section LL - Existing Static Conditions

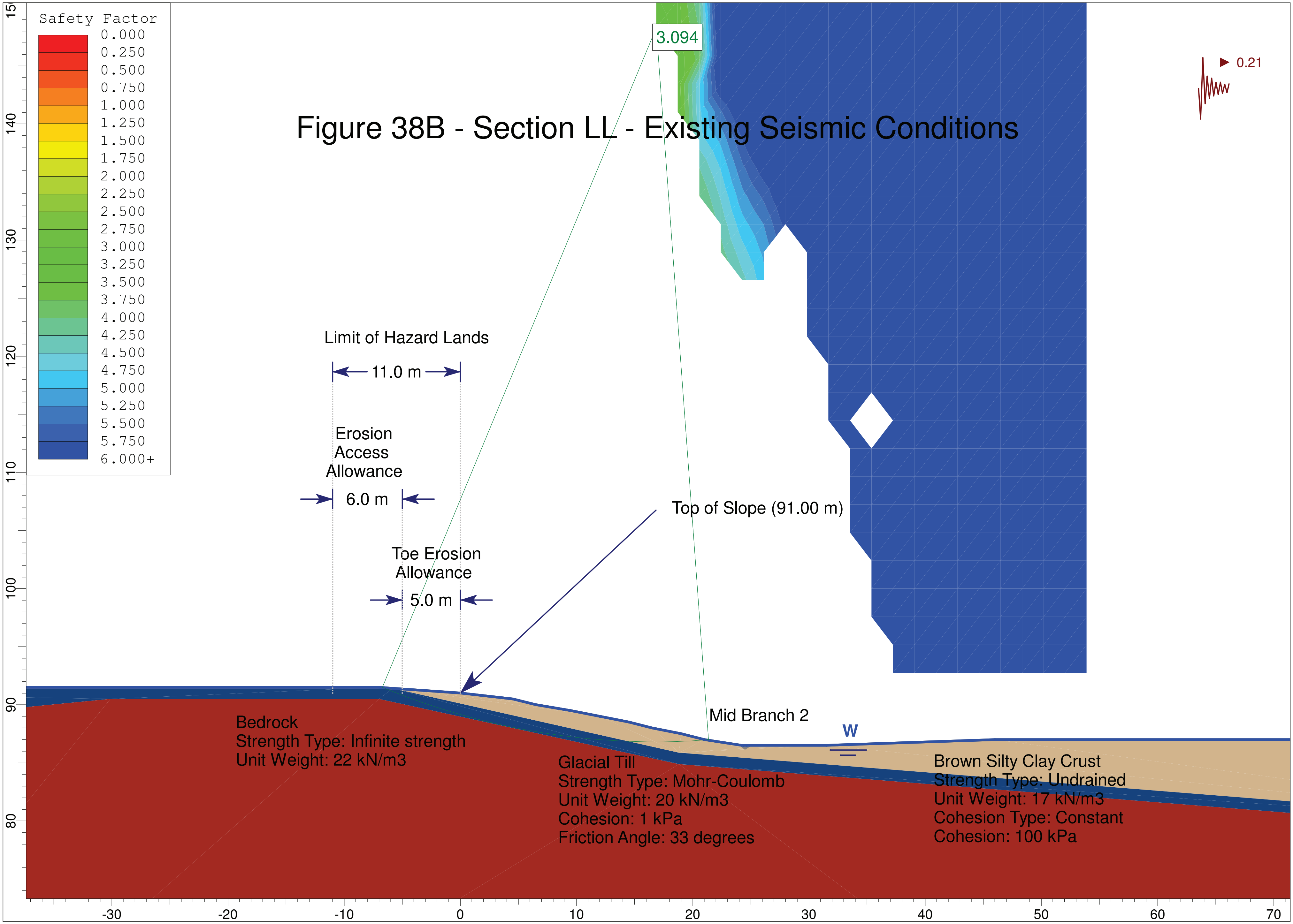


Figure 38B - Section LL - Existing Seismic Conditions

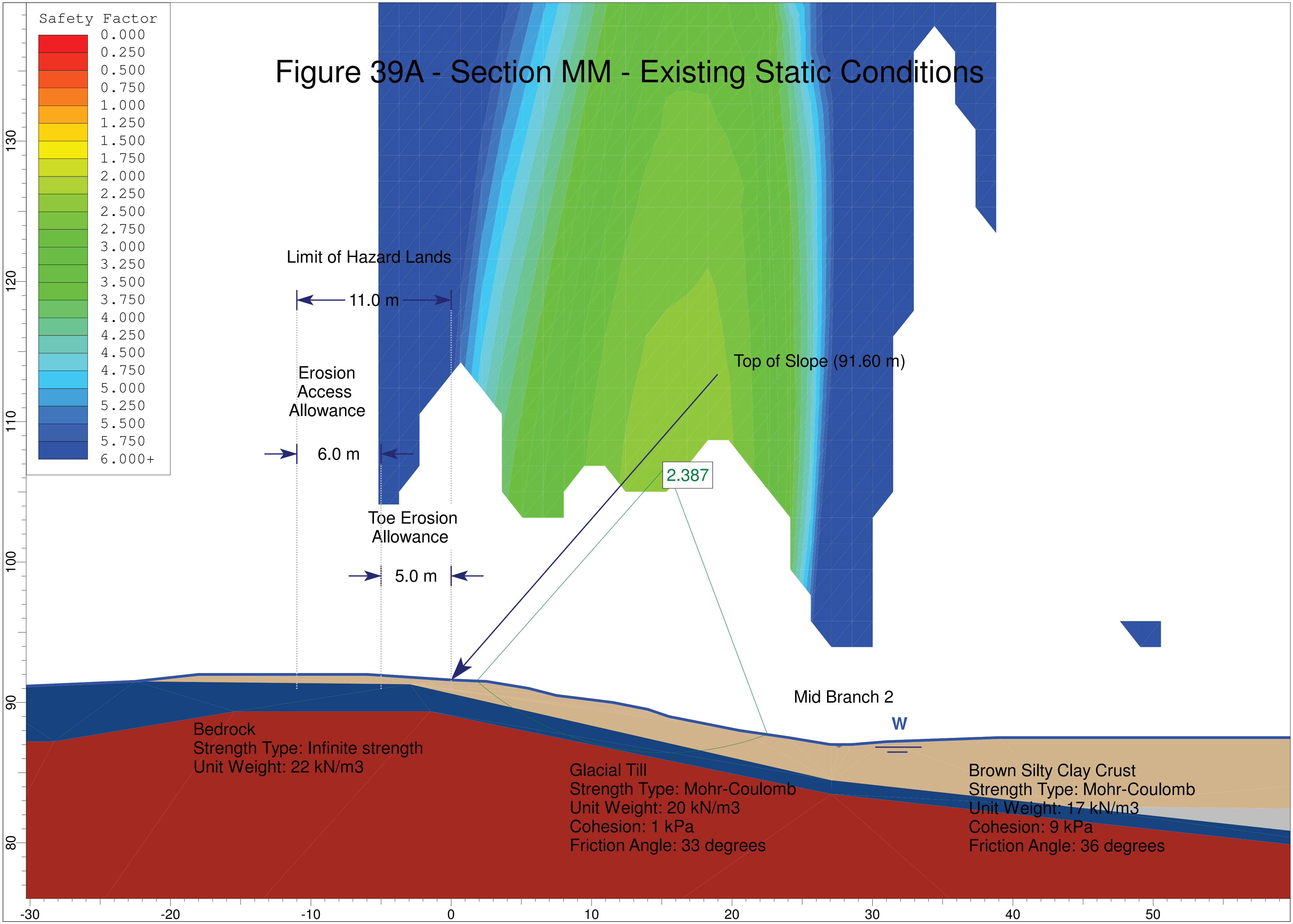


Figure 39A - Section MM - Existing Static Conditions

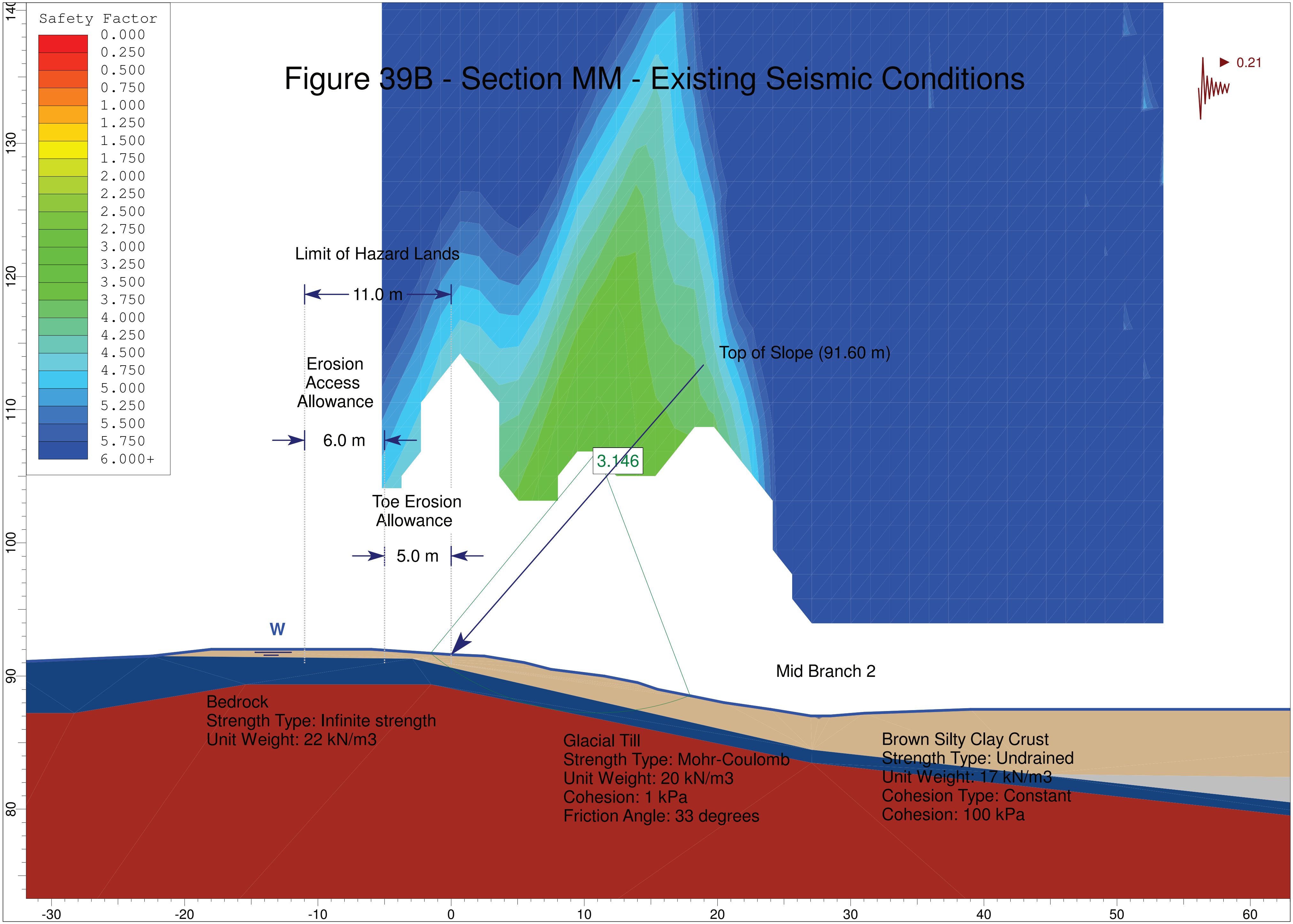


Figure 39B - Section MM - Existing Seismic Conditions

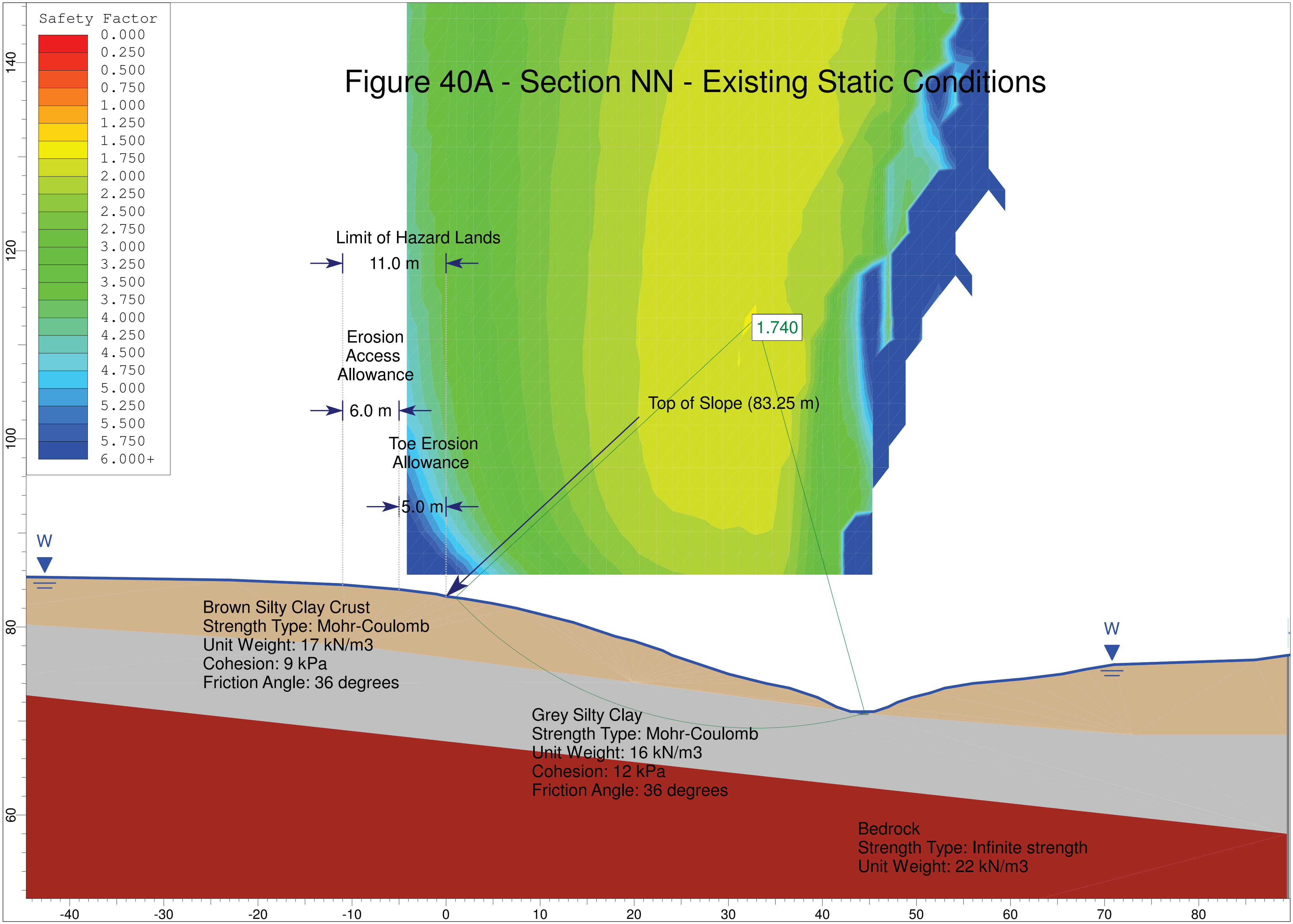


Figure 40A - Section NN - Existing Static Conditions

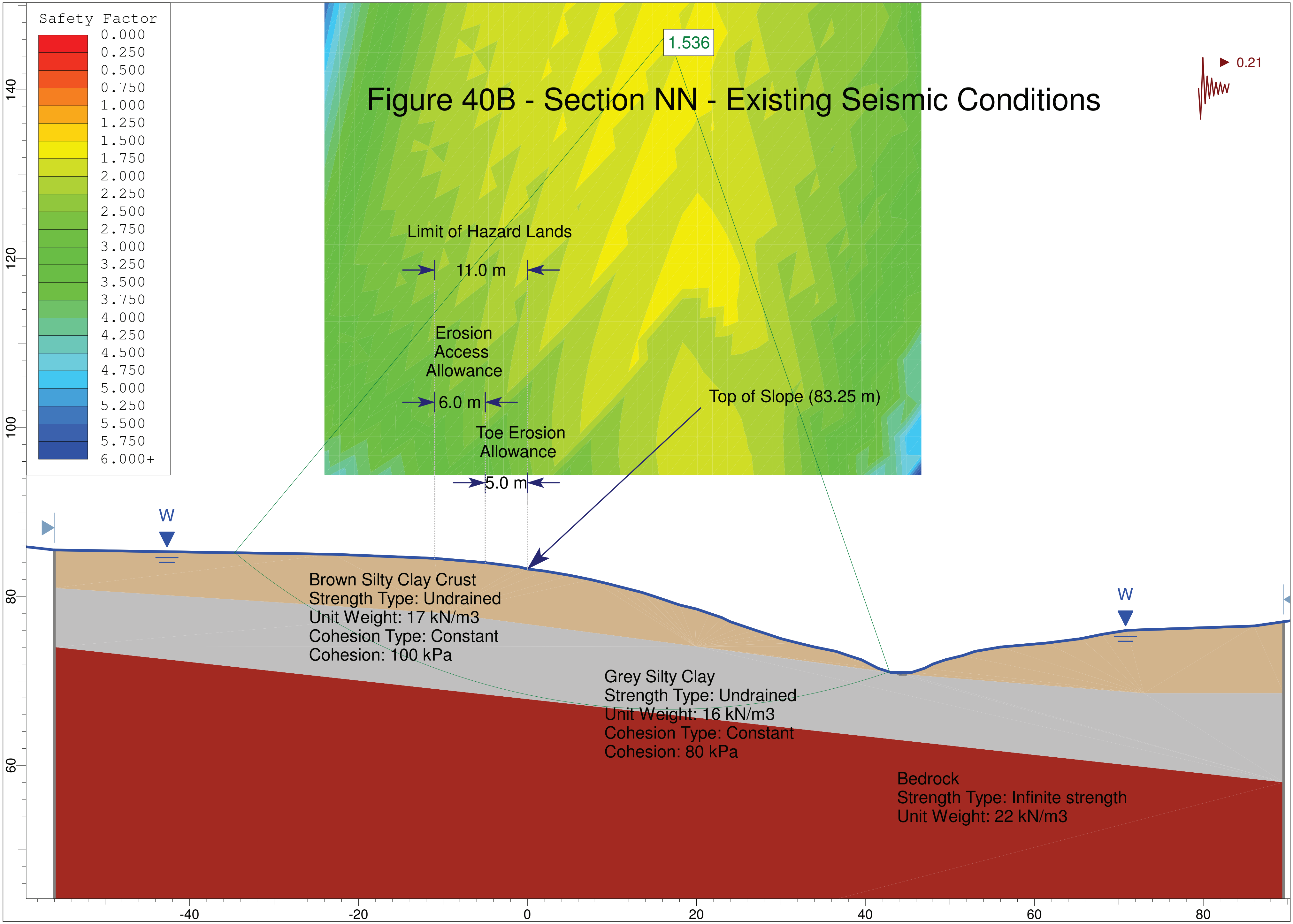


Figure 40B - Section NN - Existing Seismic Conditions

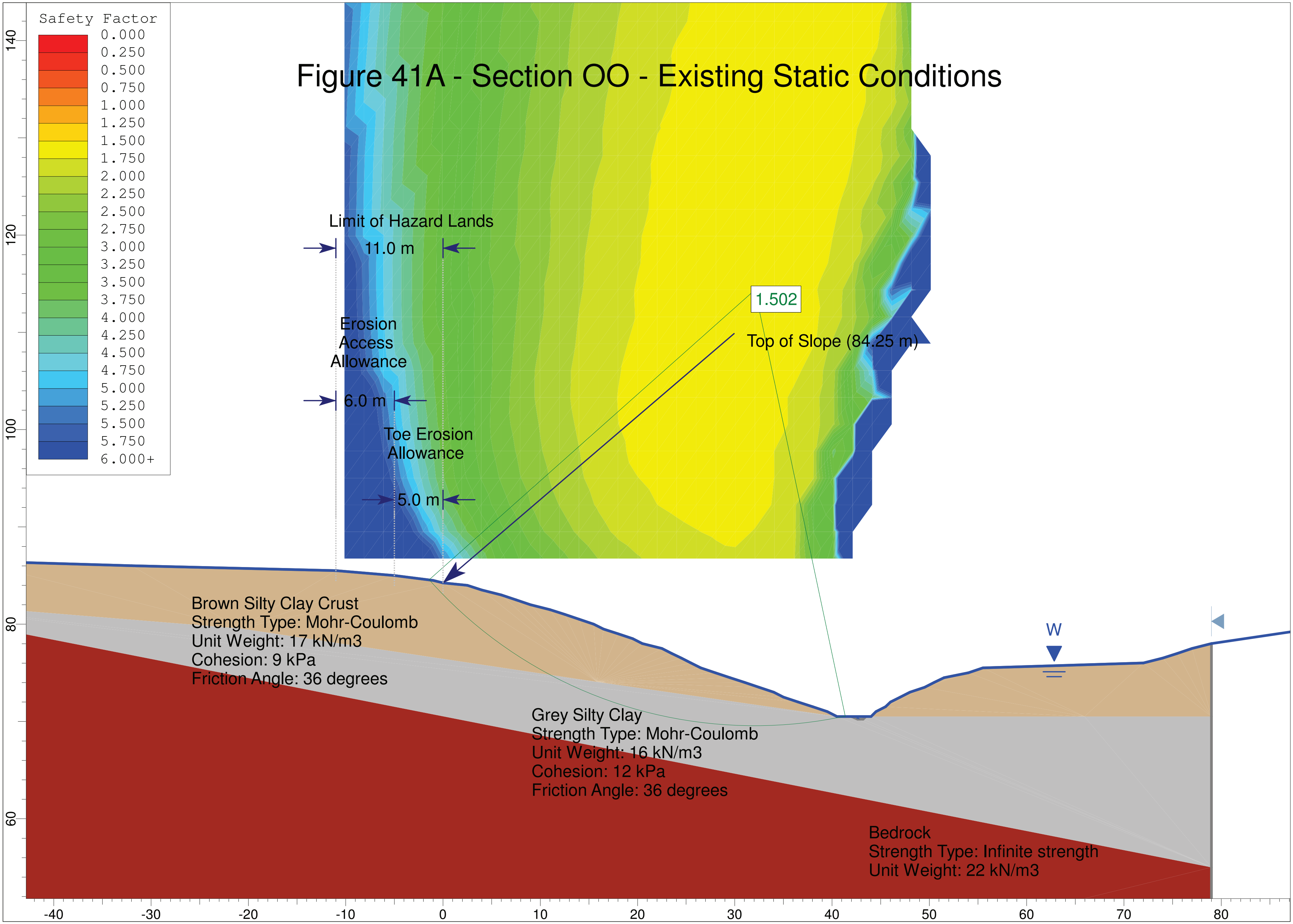


Figure 41A - Section OO - Existing Static Conditions

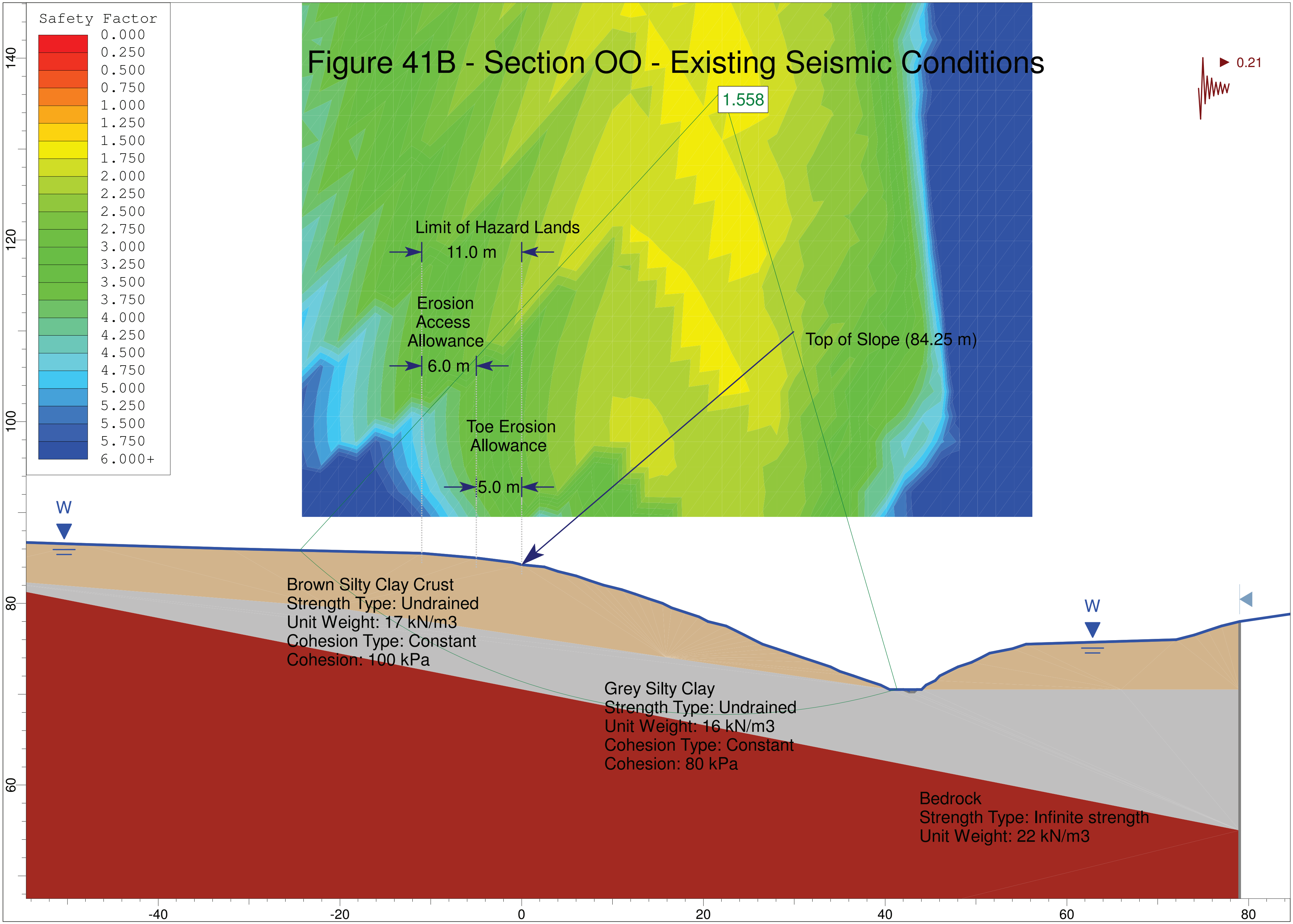


Figure 41B - Section OO - Existing Seismic Conditions

Photographs from Site Visit

Photo 1A: Photo taken on April 18, 2012 from the north bank of the valley corridor wall along the South Tributary looking east (upstream) near Section I.

Photo 1B: Photo taken on July 19, 2023 from the north bank of the valley corridor wall along the South Tributary looking east (upstream) near Section I.

Photographs from Site Visit

Photo 2A: Photo taken on April 18, 2012 from the centre of the watercourse along the South Tributary looking west (downstream) near Section H.

Photo 2B: Photo taken on July 19, 2023 from the centre of the watercourse along the South Tributary looking west (downstream) near Section H.

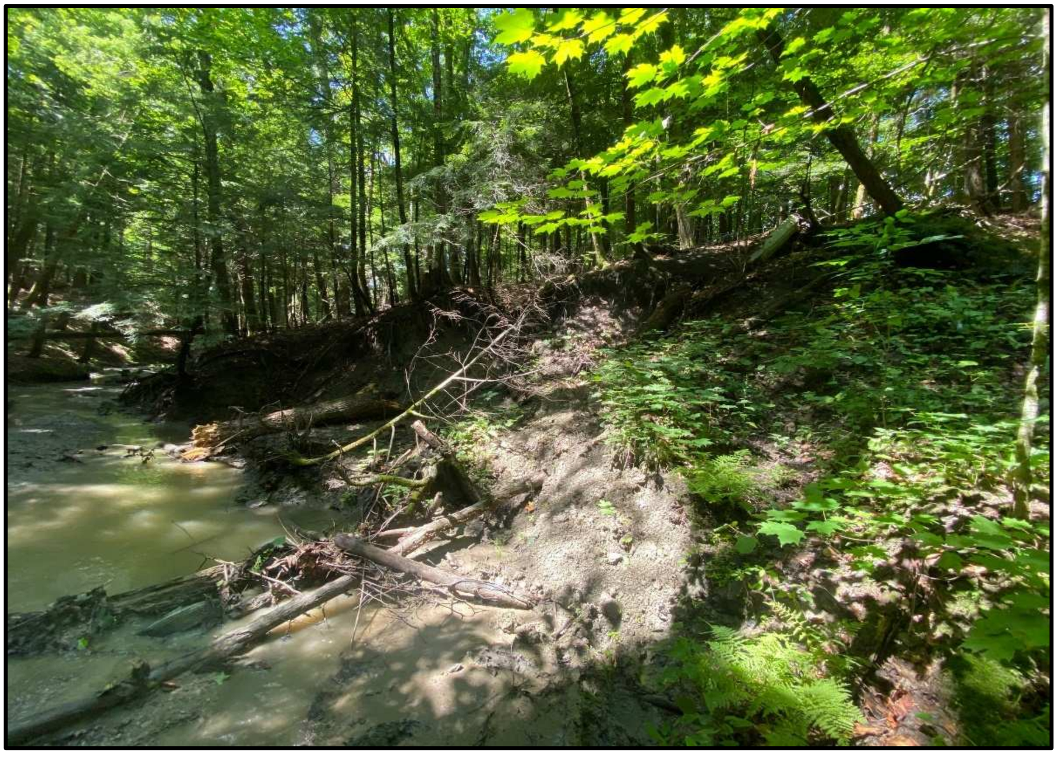


Photo 3: Photo taken on April 18, 2012 from the north bank of the valley corridor wall along the South Tributary looking west (downstream) at Section G.

Photo 4: Photo taken on April 18, 2012 from the south bank of the South Tributary looking west (downstream) near Section F.

Photographs from Site Visit

Photo 5: Photo taken on April 18, 2012 of the east bank of the valley corridor along Mid-Branch 1, north of Section J.

Photo 6A: Photo taken on April 18, 2012 along the watercourse along Mid-Branch 1 looking east (upstream) near Section N.

Photo 6B: Photo taken on July 19, 2023 along the watercourse along Mid-Branch 1 looking east (upstream) near Section N.

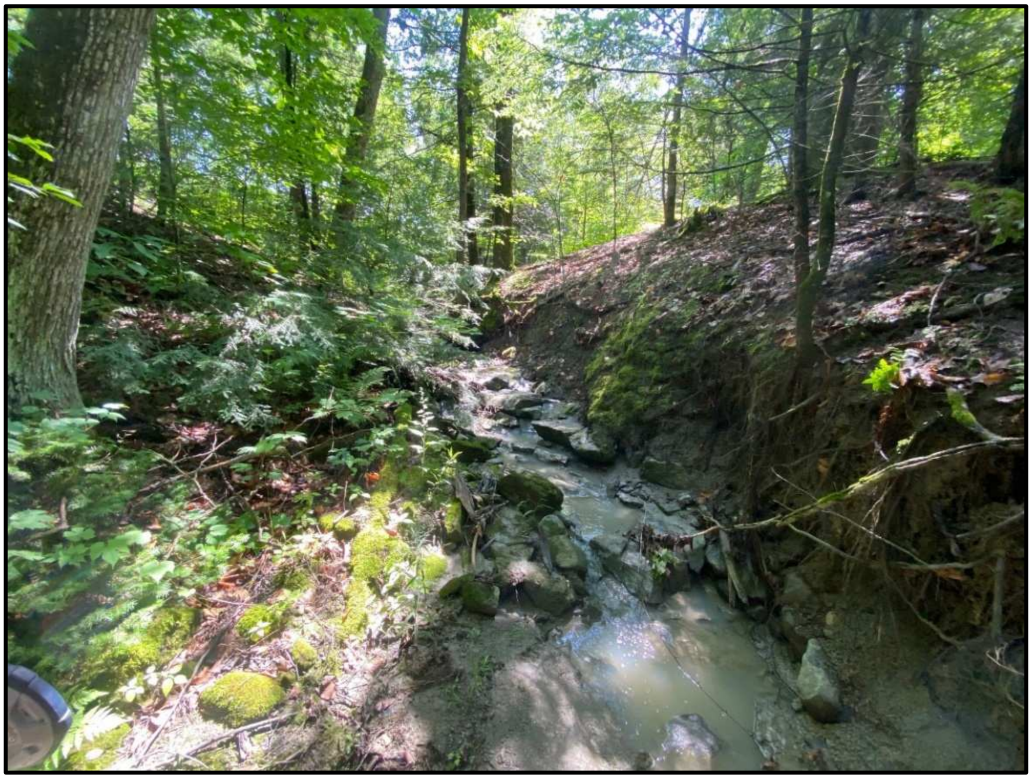


Photo 7A: Photo taken on April 18, 2012 of the drainage ravine near Section K.

Photo 7B: Photo taken on July 19, 2023 of the drainage ravine near Section K.

Photo 8A: Photo taken on September 10, 2020 of the north slope face, looking northwest.

Photo 8B: Photo taken on July 19, 2023 of the north slope face, looking northwest.

Photo 9A: Photo taken on September 10, 2020 of the north slope face, looking northwest.

Photo 9B: Photo taken on July 19, 2023 of the north slope face, looking northwest.

Photo 10A: Photo taken on September 10, 2020 of the north slope face, looking north.

Photo 10B: Photo taken on July 19, 2023 of the north slope face, looking north.

Photographs from Site Visit

Photo 11A: Photo taken on September 10, 2020 of the south slope face looking southeast near Section O

Photo 11B: Photo taken on July 14, 2023 of the south slope face, looking southeast near Section O

Photographs from Site Visit

Photo 12A: Photo taken on September 10, 2020 of the north slope face, looking northwest.

Photo 12B: Photo taken on July 19, 2023 of the north slope face, looking northwest.

Photo 13A: Photo taken on September 10, 2020 of the north slope face, looking east (upstream) near Section H.

Photo 13B: Photo taken on July 19, 2023 of the north slope face, looking east (upstream) near Section H.

Photo 14A: Photo taken on September 10, 2020 of the north slope face, looking northwest near Section CC.

Photo 14B: Photo taken on July 19, 2023 of the north slope face, looking northeast near Section CC.

Photo 15A: Photo taken on September 10, 2020 of the north slope face, looking northwest near sections G and II

Photo 15B: Photo taken on July 19, 2023 of the north slope face, looking northwest near sections G and II

Photo 16A: Photo taken on September 10, 2020 of the south slope face near section HH.

Photo 16B: Photo taken on July 19, 2023 of the south slope face near section HH.

Photo 17A: Photo taken on September 10, 2020 along the watercourse, looking east (upstream).

Photo 17B: Photo taken on July 19, 2023 along the watercourse, looking east (upstream).

Photo 18A: Photo taken on September 10, 2020 of the north slope face, looking north at section GG.

Photo 18B: Photo taken on July 19, 2023 of the north slope face, looking north at section GG.

Photo 19A: Photo taken on September 10, 2020 along the watercourse, looking east (upstream).

Photo 19B: Photo taken on July 19, 2023 along the watercourse, looking east (upstream).

Photo 20A: Photo taken on September 10, 2020 along the watercourse along Mid-Branch 1 looking east (upstream) near Section OO.

Photo 20B: Photo taken on July 19, 2023 along the watercourse along Mid-Branch 1 looking east (upstream) near Section OO.

Photo 21A: Photo taken on September 10, 2020 along the watercourse along Mid-Branch 1 looking east (upstream) near Section N.

Photo 21B: Photo taken on July 19, 2023 along the watercourse along Mid-Branch 1 looking east (upstream) near Section N.

Photo 22A: Photo taken on September 10, 2020 along the watercourse along Mid-Branch 1 looking north.

Photo 22B: Photo taken on July 19, 2023 along the watercourse along Mid-Branch 1 looking north.

Photo 23: Photo taken on July 19, 2023 of the north slope face, looking west (downstream) near Section H.

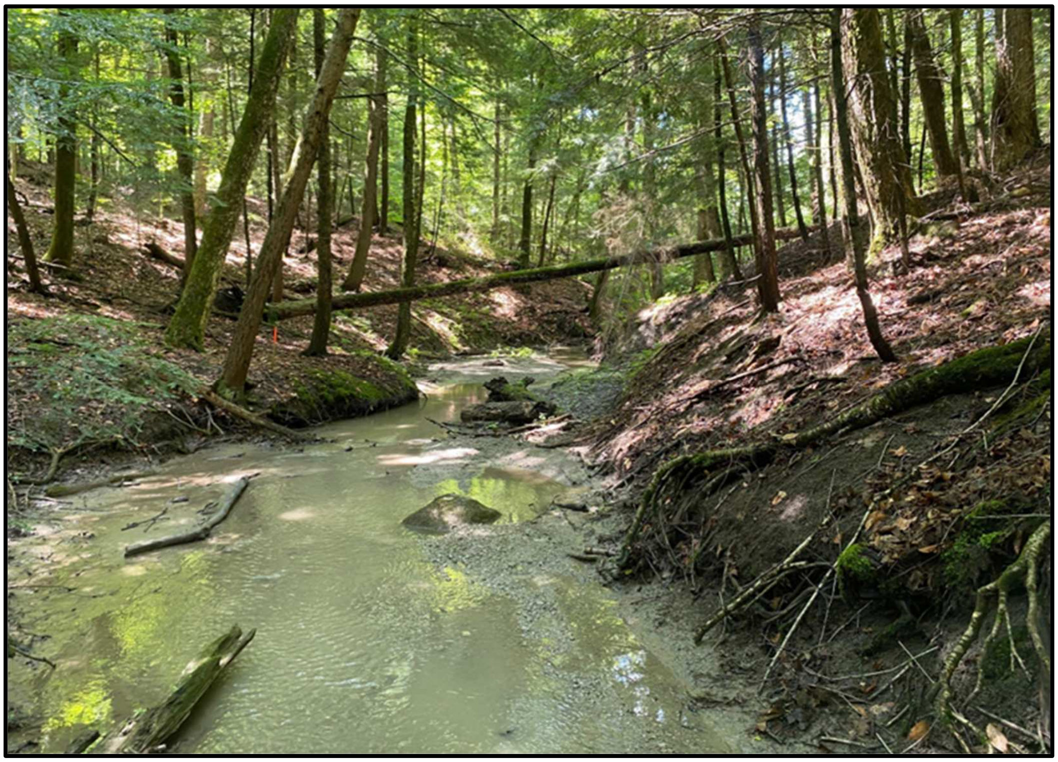
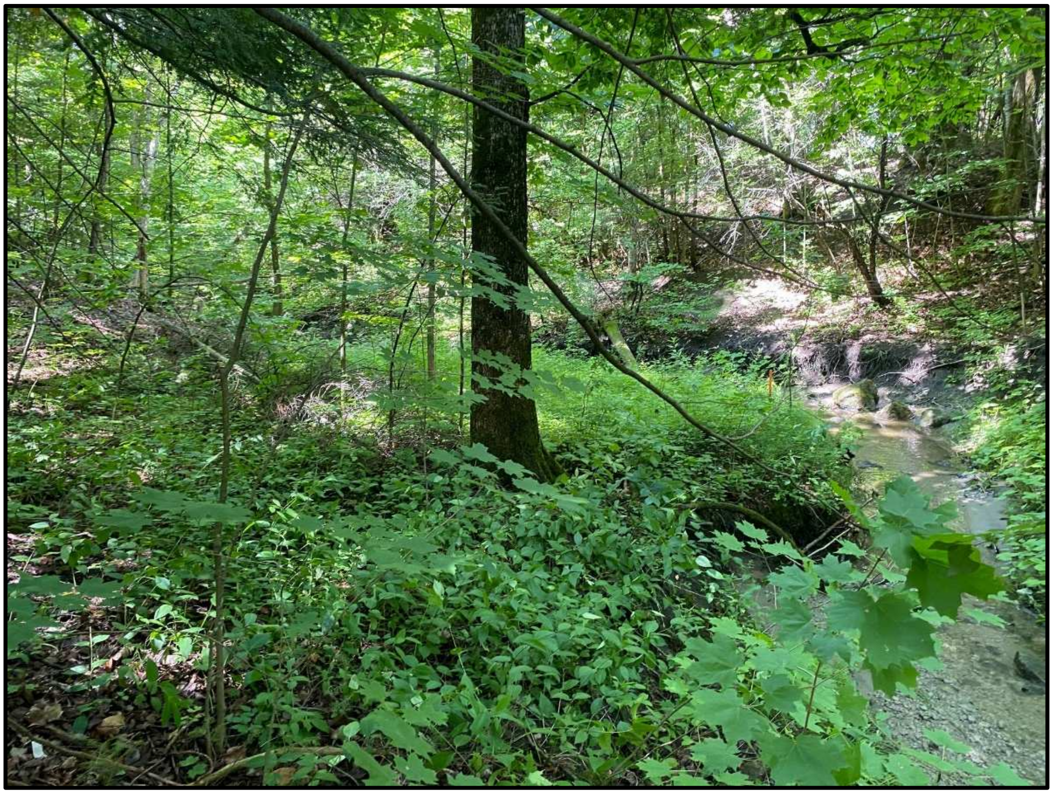


Photo 24: Photo taken on July 19, 2023 of the north slope face, looking west (downstream) near Section CC.

Photo 25: Photo taken on July 19, 2023 of the north slope face, looking east (upstream) near Section CC.

Photo 26: Photo taken on July 19, 2023 of the north slope face, looking west (downstream) near Section F.



LEGEND:

◓	BOREHOLE LOCATION (PREVIOUS INVESTIGATION)
⊕	PROBEHOLE LOCATION (CURRENT INVESTIGATION)
●	BOREHOLE LOCATION BY OTHERS (EXP)
97.47	GROUND SURFACE ELEVATION(m)
(94.78)	PRACTICAL REFUSAL TO AUGERING ELEV.(m)
[83.46]	BEDROCK SURFACE ELEVATION(m)
94.00	BEDROCK CONTOUR (m)

TOPOGRAPHIC MAPPING FOR CITY OF OTTAWA (2005)

NOTE:

THE BEDROCK CONTOURS ARE BASED ON PROBE HOLES COMPLETED AT AN APPROXIMATE SPACING OF 100m CENTRE TO CENTRE. BEDROCK MAY VARY IN DEPTH IN SOME AREAS. THE MAJORITY OF THE PROBE HOLES WERE TERMINATED AT A DEPTH OF 6.5m(DEEPER THAN ALL THE PROPOSED SERVICES). BEDROCK DEEPER THAN 6.5m MAY RANGE FROM 7 TO 12m IN DEPTH. RANDOM PROBE HOLES WERE ADVANCED TO REFUSALS WHERE BEDROCK WAS NOT ENCOUNTERED WITHIN THE UPPER 6.5m BELOW EXISTING GRADE.

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NO.	REVISIONS	DATE	INITIAL
2	AS PER REVISED CONCEPTUAL PLAN	07/09/2023	DP
1	UPDATED TO INCLUDE BOREHOLES BY OTHERS (EXP)	05/21/2021	FA

TAGGART INVESTMENTS

GEOTECHNICAL INVESTIGATION - PROPOSED RESIDENTIAL DEVLELOPMENT
CARDINAL CREEK VILLAGE SOUTH
OTTAWA, ONTARIO

Title:

BEDROCK CONTOUR PLAN

Stamp:

Scale: 1:3000
Drawn by: RCG
Checked by: FA
Approved by: FA
Date: 03/2020
Report No.: PG5201-1
Drawing No.: PG5201-1
Revision No.: 2

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LEGEND:

⊞	TEST PIT LOCATION (CURRENT INVESTIGATION)
◒	BOREHOLE LOCATION (PREVIOUS INVESTIGATION)
⊕	PROBEHOLE LOCATION (CURRENT INVESTIGATION)
■	TEST PIT LOCATION (PREVIOUS INVESTIGATION)
97.47	GROUND SURFACE ELEVATION(m)
(94.78)	PRACTICAL REFUSAL TO AUGERING ELEV.(m)
[83.46]	BEDROCK SURFACE ELEVATION(m)
TOPOGRAPHIC MAPPING FOR CITY OF OTTAWA (2005)	
F F	SLOPE CROSS-SECTION FOR SLOPE STABILITY ANALYSIS
5	PHOTOGRAPH TAKEN DURING SITE VISIT - APRIL 18, 2012
20	PHOTOGRAPH TAKEN DURING SITE VISIT - SEPT. 10, 2020
24	PHOTOGRAPH TAKEN DURING SITE VISIT - JULY 25, 2023
━	URBAN GROWTH BOUNDARY
━	TOP OF SLOPE
━	6m EROSION ACCESS ALLOWANCE
━	TOE EROSION ALLOWANCE / LIMIT OF HAZARD LANDS
━	STABLE SLOPE ALLOWANCE
━	APPROX. 100 YEAR WATER LEVEL (JFSA, MARCH 2013)
━	APPROX. NHWM (2 YR WATER LEVEL) (JFSA, MARCH 2013)
╍	30m SETBACK FROM NHWM (DSEL, MARCH 2013)
╍	MEANDER BELT WIDTH (PARISH, MARCH 2013 - CARDINAL CREEK BASED ON VALUES FROM GEOMORPHIC SOLUTIONS, 2007)
╍	POTENTIAL TOP OF SLOPE IF INFILL IS COMPLETED
╍	POTENTIAL 6m EROSION ACCESS ALLOWANCE IF INFILL IS COMPLETED
╍	POTENTIAL TOE EROSION ALLOWANCE / LIMIT OF HAZARD LANDS IF INFILL IS COMPLETED
╍	POTENTIAL STABLE SLOPE ALLOWANCE IF INFILL IS COMPLETED

PATERSON GROUP

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NO.	REVISIONS	DD/MM/YYYY	INITIAL
5	UPDATED TO LATEST CONCEPTUAL PLAN	17/10/2024	FC
4	AS PER REVISED CONCEPTUAL PLAN	07/09/2023	FA
3	UPDATED POTENTIAL INFILL WORK AREAS	31/03/2021	FA
2	TEST PITS TP 1-21 TO TP 20-21 ADDED	05/03/2021	OM
1	NEW PHOTO LOCATION ADDED TO PLAN	14/09/2020	KP

TAGGART INVESTMENTS

GEOTECHNICAL INVESTIGATION - PROPOSED RESIDENTIAL DEVELOPMENT
CARDINAL CREEK VILLAGE SOUTH
OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Stamp:

Scale: 1:3000
Drawn by: RCG
Checked by: FA
Approved by: FA
Date: 08/2020

Report No.: PG5201-1
Drawing No.: PG5201-2
Revision No.: 5

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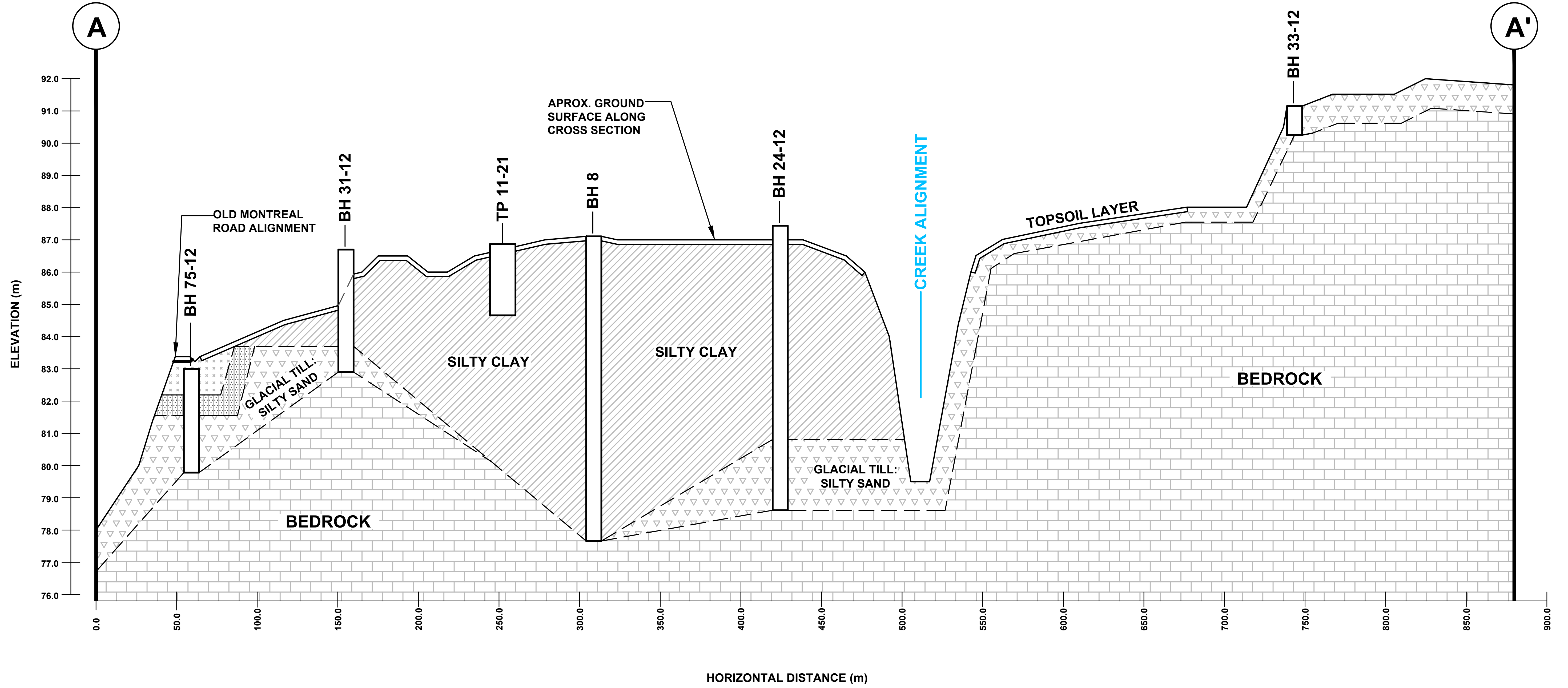

patersongroup
consulting engineers

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Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL

TAGGART INVESTMENTS
GEOTECHNICAL INVESTIGATION - PROPOSED RESIDENTIAL DEVELOPMENT
CARDINAL CREEK VILLAGE SOUTH
OTTAWA, ONTARIO

Title:

CROSS SECTION A-A'

Scale: 1:2500 H
Date: 08/2021
Drawn by: RCG
Report No.: PG5201
Checked by: FC
Approved by: DJG
PG5201-FIG.A
Revision No.:

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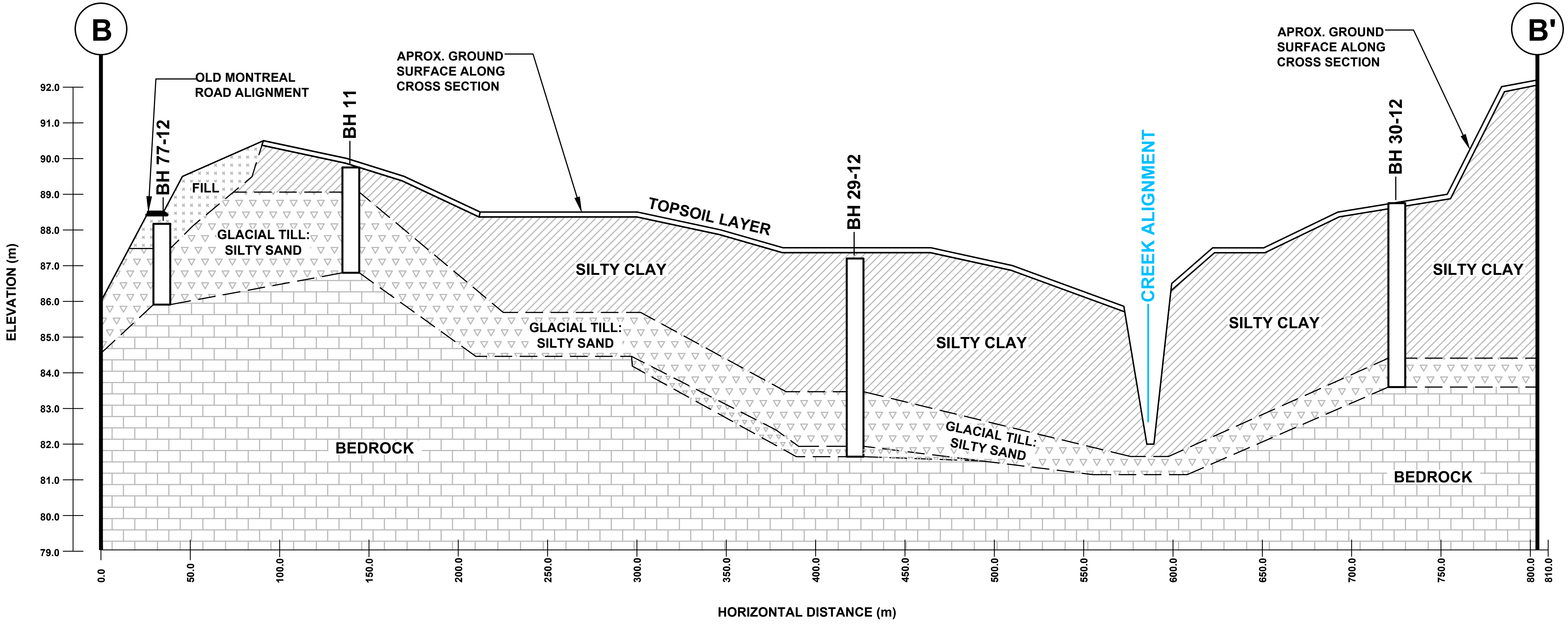

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NO.	REVISIONS	DATE	INITIAL

TAGGART INVESTMENTS

GEOTECHNICAL INVESTIGATION - PROPOSED RESIDENTIAL DEVELOPMENT
CARDINAL CREEK VILLAGE SOUTH

OTTAWA, ONTARIO

Title:

CROSS SECTION B-B'

Scale: 1:2500 H
Date: 08/2021
Drawn by: RCG
Report No.: PG5201
Checked by: FC
PG5201-FIG.B
Approved by: DJG
Revision No.:

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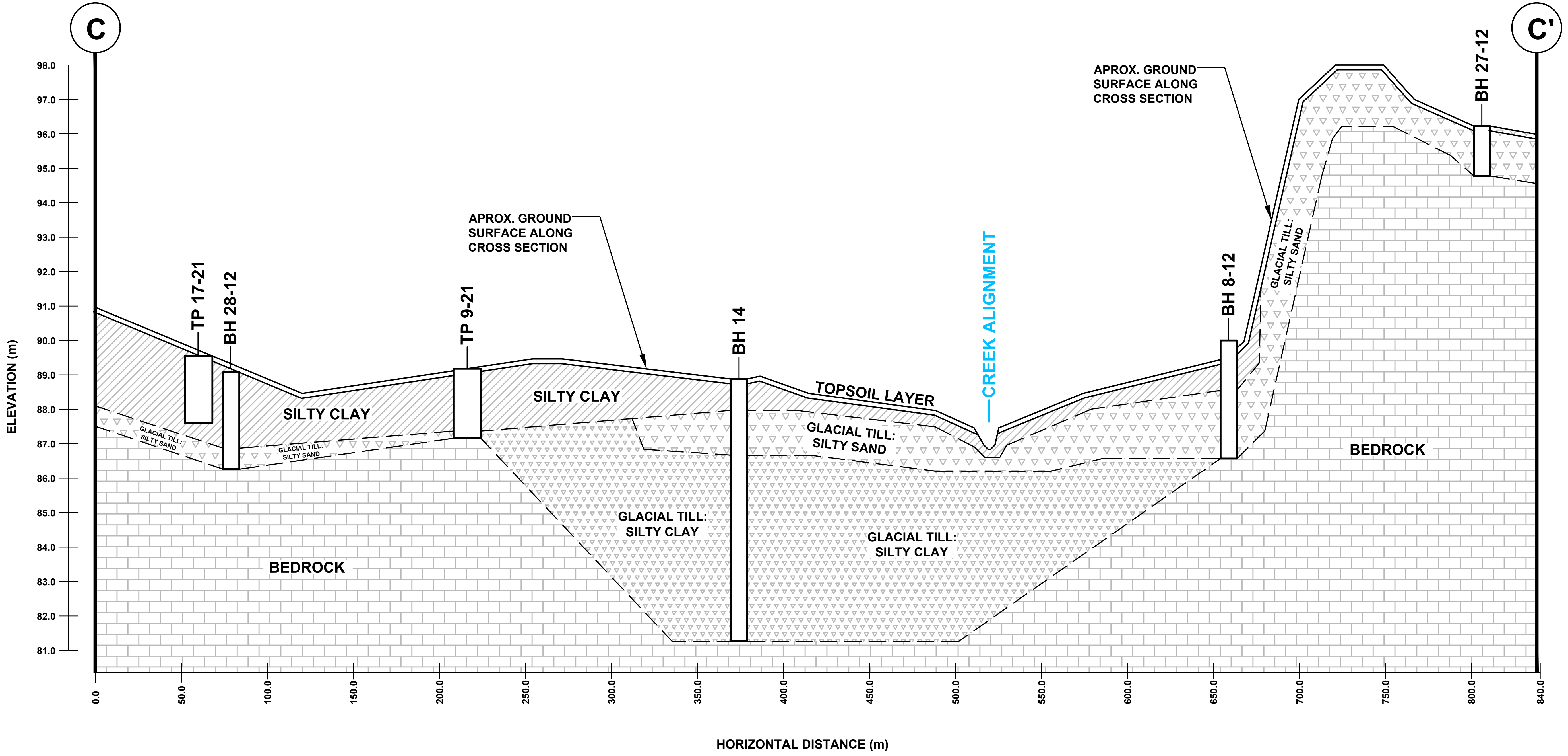

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Ottawa, Ontario K2E 7J5
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NO.	REVISIONS	DATE	INITIAL

TAGGART INVESTMENTS
GEOTECHNICAL INVESTIGATION - PROPOSED RESIDENTIAL DEVELOPMENT
CARDINAL CREEK VILLAGE SOUTH
OTTAWA, ONTARIO

Title:
CROSS SECTION C-C'

Scale: 1:2500 H
Date: 08/2021
Drawn by: RCG
Report No.: PG5201
Checked by: FC
Approved by: DJG

PG5201-FIG.C

Revision No.:

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