APPENDIX ‘A’

GEOTECHNICAL REPORT

TREK GEOTECHNICAL
Quality Engineering | Valued Relationships

Dillon Consulting Ltd.

Regional Streets Renewal Projects – 2018 Program Geotechnical Report

Prepared for:

Tina Sontag, C.E.T.
Dillon Consulting Ltd.
1558 Willson Place
Winnipeg, MB
R3T 0Y4

Project Number:
0022-061-00

Date:
November 2, 2017

TREK GEOTECHNICAL
Quality Engineering | Valued Relationships

November 2, 2017

Our File No. 0022-061-00

Tina Sontag, C.E.T.
Dillon Consulting Ltd.
1558 Willson Place
Winnipeg, MB
R3T 0Y4

RE: Regional Streets Renewal Projects – 2018 Program
Geotechnical Report

TREK Geotechnical Inc. is pleased to submit our Geotechnical Investigation Report for the above noted project located in Winnipeg, MB.

Please contact Ryan Belbas of our office if you have any questions. Thank you for the opportunity to work with you on this assignment.

Sincerely

TREK Geotechnical Inc.
Per:

Ryan Belbas, M.Sc., P.Eng.
Geotechnical Engineer
Tel: 204.975.9433 ext. 113

www.trekgeotechnical.ca
1712 St. James Street | Winnipeg, Manitoba R3H 0L3 | Tel 1.204.975.9433 | Fax 1.204.975.9435

Revision History

Revision No.	Author	Issue Date	Description
0	RB	November 2, 2017	Final Report

Authorization Signature

PROVINCE OF MANITOBA
R.E.J.
BELBAS
Member
31045
REGISTERED PROFESSIONAL ENGINEER

Nov. 2/2017

Prepared By:

Ryan Belbas, M.Sc., P.Eng.
Geotechnical Engineer

Reviewed By:

Ken Skaftfeld, M.Sc., P.Eng.
Senior Geotechnical Engineer

APEGM
Certificate of Authorization
Trek Geotechnical Inc.
No. 4877 Date: Nov2/17.

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1.0 Introduction

This report summarizes the results of the geotechnical assessment completed by TREK Geotechnical Inc. (TREK) for a new Active Transpiration (AT) pathway along the Red River in St. Norbert, MB. The terms of reference for the investigation are included in our proposal to Dillon Consulting Ltd. (Dillon) dated May 8th, 2017. The scope of work for the assessment includes the following tasks:

- Perform a site reconnaissance,
- Conduct a review of existing information,
- Assess the impact of the AT pathway on riverbank stability,
- Provide recommendations for design of the new AT pathway related to riverbank stability.

A detailed description of the geotechnical assessment is provided in the forthcoming sections.

2.0 Proposed Works

The City of Winnipeg (The City) is planning an extension to the existing Active Transportation Network to St. Norbert by connecting the existing pathway along Pembina Highway from the Perimeter Highway (PTH 1) interchange to 3514 Pembina Highway. A section of the pathway between 3270 Pembina Highway and Grandmont Boulevard will run within close proximity to a section of riverbank previously stabilized (UMA|AECOM, 2005). This segment of the pathway was investigated as part of the current scope to assess the pathway's potential impact on riverbank stability. This location, as well as the remaining length of the proposed pathway within 107 m of the regulated summer river level, is situated within the Waterway's regulated zone and construction will require a Waterways Permit. This geotechnical report provides supporting documentation for a Waterways Permit application.

The AT pathway will (typically) consist of a 3 m wide asphalt bicycle path and 1.5 m wide sidewalk. We understand that the pathway may be narrowed in areas where geometric constraints exist, for example at the U-turn loop on the northbound lane of Pembina Highway. Here, the new pathway and sidewalk will be confined to the available space between the existing curb and the retaining wall to avoid placing fill in the area of the previous slide. The pavement structure for the AT path will consist of 75 mm of asphalt over 225 mm of granular base course and the pavement structure for the sidewalk will consist of 100 mm of concrete over 225 mm of granular base course. The vertical alignment for the pathway and sidewalk will be consistent with existing grades within the City's right-of-way and will not require any net fill at the top of the bank.

3.0 Review of Background Information

3.1 Existing Reports

The following background information provided by Dillon and the City of Winnipeg was pertinent to the geotechnical assessment:

1. Report - Pembina Highway Slope Stability Study Red River Near Cloutier Drive (UMA, September 30, 1976)
2. Report - Pembina Highway at Grandmont Blvd. Riverbank Stability Assessment and Preliminary Design of Stabilization Measures (UMA|AECOM, April 21, 2005)
3. Letter - Waterways Permit No. 152/2006 Pembina Highway at Grandmont Boulevard Riverbank Stabilization Phase 2 (UMA|AECOM, June 12, 2007).
4. Slope Inclinometer cumulative displacement plots (AECOM, 2009 to 2017).

3.2 Site History

The riverbank along this section of Pembina Highway has a history of instability dating back to 1976, when a major slide occurred disturbing a buried MTS cable and City of Winnipeg watermain. In the summer of 1976, Underwood McLellan & Associates Ltd. (UMA) undertook a detailed slope stability study to assess the post-slide conditions and develop remedial alternatives to stabilize the riverbank. In early winter of 1976, remedial works consisting of re-grading the riverbank and planting grass to promote drainage was completed.

In the summer of 2004, tension cracks appeared within the riverbank and movements retrogressed farther upslope threatening the integrity of the sidewalk and roadway. As a short-term mitigation measure to protect against undermining of Pembina Highway, until permanent stabilization works could be implemented, a soldier pile retaining wall with timber lagging was installed in 2005.

Riverbank stabilization measures were constructed at the site in 2007, which included the construction of approximately 230 rock columns, placement of riprap at the bank toe, and bank re-grading. Near the end of construction in 2007, fill was placed in front of the retaining wall to restore the site grade and eliminate the 1 to 2 m vertical drop that had developed due to the pre-construction bank movements. The regrading work allowed for removal of the chain link fence along the east edge of the sidewalk.

Two SIs (SI09-10c and SI15-11) were installed by AECOM in 2009 and 2015 upslope of the rock columns, inline with the centre of the retaining wall, after construction of the rock columns was complete for long-term monitoring of the riverbank by the City. The locations of the SIs are shown on the Site Plan. Average annual rates of 18 and 5 mm of displacement have been measured in SI09-10c and SI15-11 at respective depths of about 7.5 and 6 m below ground surface. Based on the existing site information and our findings during the site reconnaissance, the displacements measured in the SIs can likely be attributed to mobilizing creep displacements of the rock columns and are not considered to be reflective of active global instability. TREK anticipates that these relatively minor movements will continue as the rock columns continue to mobilize resistance; the rate of movement is expected to decrease over time. The vertical drop at the retaining wall can likely be attributed to settlement of the fill placed in 2007, as there is no evidence of instability (e.g. bulging toe, tensions crack, slump blocks) downslope of the wall. The retaining wall is probably providing additional protection against local slip surfaces from developing within the upper bank and through Pembina Highway, although local stability is likely adequate without the presence of the wall.

3.3 Sub-surface Conditions

Eighteen test holes were drilled at the site as part of the 1976 (9 test holes) and 2005 (9 test holes) geotechnical investigations. The approximate locations of the test holes from the 2005 investigation are shown on the attached Site Plan and the locations of the 1976 test holes are shown on a separate attached figure exported from the original report. These test holes formed the basis of the geotechnical model used in the stability analysis conducted as part of our stability assessment. A brief description of the soil units encountered during drilling is provided below.

Soil Stratigraphy

The soil stratigraphy generally consists of silty lacustrine clay over silt till and bedrock. The silty clay is generally moist, highly plastic and firm becoming soft with depth. The thickness of the clay layer varies from 14 m at the top of the bank to 5 m near the river’s edge. The underlying silt till consists of a heterogenous mixture of the clay, sand, gravel, cobbles, and boulders within a predominately silt matrix. The till is generally moist to wet and loose becoming compact with depth. The bedrock consists of limestone of the Red River Formation.

Groundwater Conditions

Two standpipe piezometers (SP-04-05 and 06) fitted with Casagrande tips were installed at the site within the silt till layer. The locations of the piezometers are shown on the Site Plan. Based on measurements obtained between July 2004 and November 2006, groundwater levels within the till layer fluctuated between elevations of 220.4 and 227.4 m.

4.0 Current Site Conditions

4.1 Surface Features

A site reconnaissance was carried out by TREK on September 4th, 2017 to assess the general surface features and condition of the riverbank where the pathway could be affected by, or potentially worsen, the existing level of stability. The slopes of the upper and lower bank within the general area of the outside bend downstream of the retaining wall sit at approximately 5.5H:1V and 6.5H:1V respectively. Within the vicinity of the retaining wall and the south area of the site, the upper bank slope is at approximately 3.5H:1V and the lower bank is at about 6H:1V. A land drainage sewer outfall located at the south end of the site (indicated on the Site Plan) consists of a 750 mm diameter corrugated steel pipe. The slope gradient upslope of the culvert outlet is steeper than the surrounding area of the riverbank and sits at about 2.5H:1V. Downslope of the pipe, the gradient flattens out to about 12H:1V. There are no signs of any instabilities of the bank in the vicinity of the outfall.

A hand auger test hole (HA 17-01) was drilled by TREK above the outfall pipe to determine the method of installation and determine the presence of backfill soils. Sand and clay fill are present to a depth of 2.2 m below which native clay was encountered to a depth of 3 m where the hole was terminated. This stratigraphy suggests the pipe was likely installed using trenchless methods. The surficial soils may be associated with in-filling a natural drainage feature when Pembina Highway was constructed.

The top of the retaining wall is exposed along a short section of the upper bank where the soil in front of the wall has subsided by about 0.5 m (Photo attached); this is within the area where regrading was carried out following installation of the rockfill columns. The wall consists of H-Piles spaced at approximately 1.5 m and horizontal treated timber lagging. Based on available information, we believe the wall to be approximately 35 m long and 10 m deep. Although the tops of several piles are damaged and in some cases twisted, the lagging is intact and appears to be in good condition. The damage to the piles can likely be attributed to installation methods rather than slope movements. Aside from the noted subsidence, there is no visual evidence of active slope movements such as tension cracks, scarps or bulging downslope of the retaining wall or in the immediate upstream and downstream vicinity. Additionally, there was no indication of movements such as cracking or slumping of the ground behind the wall. It should be noted that vegetation on the site prevented a detailed examination. The current riverbank topography (based on a recent site survey by Dillon) is generally consistent with the final grading completed during riverbank stabilization works.

5.0 Assessment of New Pathway

5.1 Design Objectives

A design objective that commensurate with the proposed work and in consideration of the cost of riverbank stabilization is considered one whereby the AT pathway is constructed in an area where there is an acceptable level of stability (FS > 1.3) and where the construction of the pathway does not reduce the existing level of stability where riverbank stability concerns exist. In this regard, a slope stability analysis was undertaken to assess the impact of the pathway by comparing the factor of safety (FS) of the bank under existing conditions and with the new pathway in place.

5.2 Slope Stability Analysis

5.2.1 Numerical Model

The stability analysis was conducted using a limit-equilibrium slope stability model (Slope/W) from the GeoStudio 2012 software package (Geo-Slope International Ltd.). The slope stability model used the Morgenstern-Price method of slices with the half-sine, inter-slice, force function to calculate the FS. Theoretical slip surfaces were identified using a grid and radius slip method. A static piezometric line was used to represent groundwater and river water levels.

5.2.2 Riverbank Geometry and Soil Properties

Cross sections (A, B, and C) through representative areas of the bank were surveyed by Dillon for use in our stability analyses. The locations of the cross-sections are shown in plan view on the attached Site Plan and the cross-sections are shown on the slope stability outputs. Cross-section A was developed to assess the steep slope at the outfall pipe, Cross-section B was developed to assess the critical area of the pre-existing failure zone at the retaining wall, and Cross-section C represents the general grade of the north area of the site.

The soil stratigraphy was based on the available subsurface information from previous investigations and the test hole drilled by TREK. The soil units used in the model include clay fill, clay (residual and fully softened), till and bedrock, as well as the materials used for rock column and pathway construction. Residual clay properties were used above the till to represent the pre-existing failure zone in front of the retaining wall for analysis of Cross-section B. Table 1 lists the properties assigned to each soil unit which are based on published values and experience with similar soils. These values are consistent with those used by UMA|AECOM in the stability analyses conducted as part of their 2005 riverbank stability assessment and provided in their 2005 geotechnical report.

Table 1. Soil Properties used in Slope Stability Analysis

Soil Description	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (degrees)
Fully Softened Clay	17	5	17
Residual Clay	17	0	13
Clay Fill	17	1	17
Silt (Till)	21	5	35
Rock Fill and Riprap	20	0	40

5.2.3 Groundwater and River Levels

The groundwater and river levels analyzed were consistent with the levels used in the 2005 geotechnical investigation by UMA|AECOM. The river level was set at El. 221.7 m transitioning to the upper bank at El. 226.0 m (established from piezometer readings). The river bathymetry was based on a survey conducted by Bruce Harding Consulting Ltd. in 2013.

5.3 Stability Analysis Results

The factor of safety for two general cases at each cross-section was calculated to assess the impact of the new pathway on riverbank stability, including the FS under existing conditions and with the new pathway in place; the difference being a small change in grading across the width of the pathway and replacement of clay with granular fill. For Cross-section B, an additional case was analyzed where clay fill is placed in front of the wall restoring the slope up to street level using a slip surface similar to that analyzed previously by UMA|AECOM. For Cross-sections A and C, the critical slip surface was used for comparison. Table 2 summarizes the calculated FS for each case analyzed. The calculated factors of safety are shown in the figures attached in Appendix A.

Table 2. Summary of Calculated Factors of Safety

Location	Calculated Factor of Safety		
	Existing Conditions	New Pathway	New Pathway + Clay Fill
Cross-Section A	1.67	1.65	Not Applicable
Cross-Section B (downslope of retaining wall)	1.39	1.39	1.35
Cross-Section C	2.19	2.19	Not Applicable

The placement of the pathway at all cross-sections results in a negligible reduction of FS. Clay fill placement at Cross-section B, results in a 4% reduction of FS.

6.0 Conclusions and Recommendations

The existing level of stability for the proposed pathway alignment is considered acceptable, and any change in FS associated with its construction is inconsequential to bank stability. However, placement of clay fill in front of the retaining wall to the sidewalk level will result in a 4% reduction in stability in an area where previous failures have occurred (Cross-section B) and where some continued horizontal ground displacements are continuing to occur farther downslope. For these reasons, it is recommended that light weight fill, such as wood chips, be used to restore grades in front of the retaining wall, or that no fill be placed and a guard rail installed for safety reasons along the top of the wall where the subsidence has occurred. In consideration of the overall geometry of the potential slip surface, the small additional load associated with this amount of fill is not considered to be of any consequence in overall bank stability. If any additional future subsidence occurs, it may be necessary to place additional light weight fill to re-establish grades.

7.0 Closure

The geotechnical information provided in this report is in accordance with current engineering principles and practices (Standard of Practice). The findings of this report were based on information provided (field investigation and laboratory testing). Soil conditions are natural deposits that can be highly variable across a site. If sub-surface conditions are different than the conditions previously encountered on-site or those presented here, we should be notified to adjust our findings if necessary.

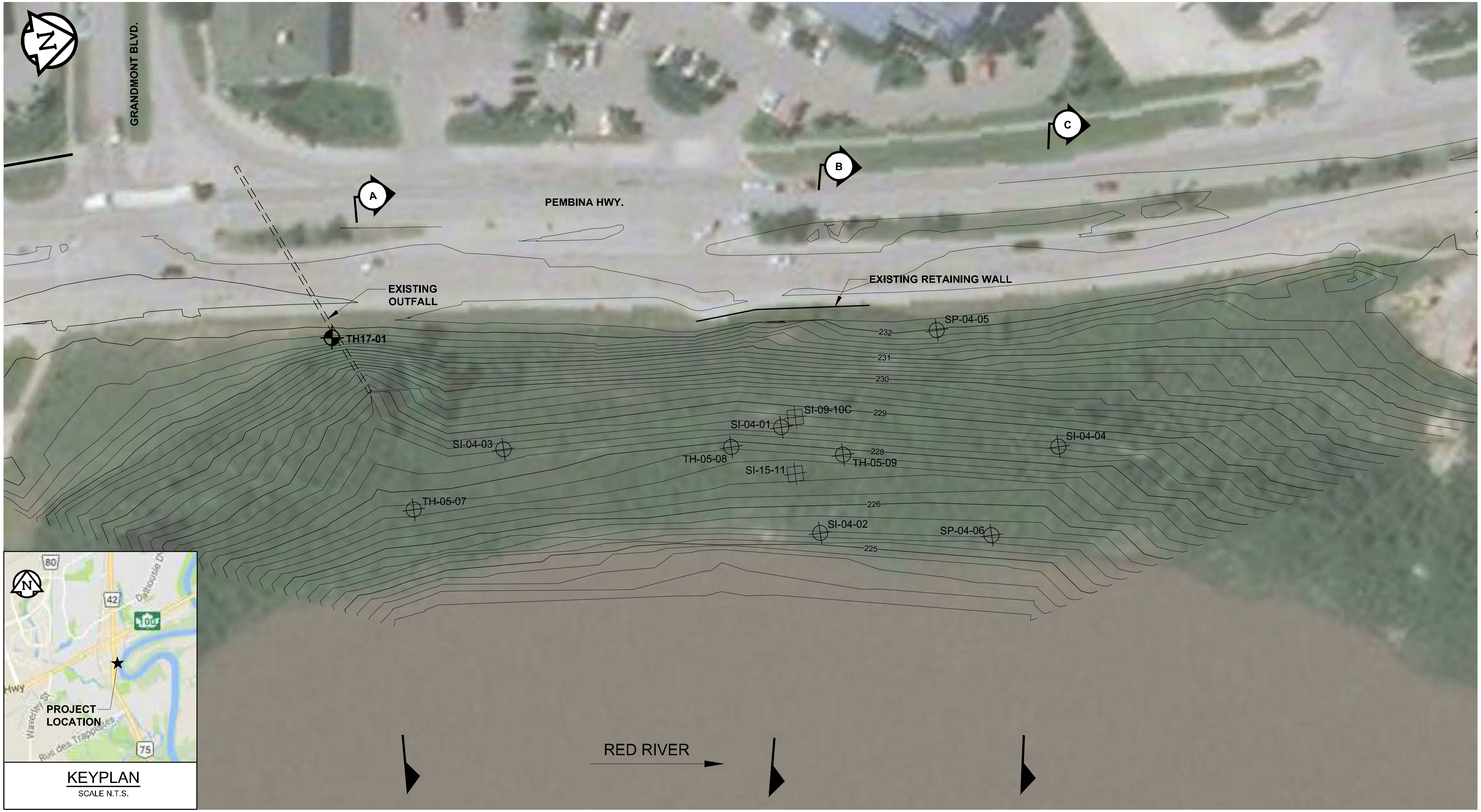
All information provided in this report is subject to our standard terms and conditions for engineering services, a copy of which is provided to each of our clients with the original scope of work or standard engineering services agreement. If these conditions are not attached, and you are not already in possession of such terms and conditions, contact our office and you will be promptly provided with a copy.

This report has been prepared by TREK Geotechnical Inc. (the Consultant) for the exclusive use of the Dillon Consulting Ltd. (the Client) and their agents for the work product presented in the report. Any findings or recommendations provided in this report are not to be used or relied upon by any third parties, except as agreed to in writing by the Client and Consultant prior to use.

Figures

TREK GEOTECHNICAL

0022 061 00
Dillon Consulting Ltd.
Regional Streets Renewal Projects - 2018 Program



0 10 20 30 m
SCALE = 1 : 750 (279 mm x 432 mm)

LEGEND:
- TEST HOLE (TREK, 2017)
- TEST HOLE (UMA / AECOM, 2004/2005)
- SLOPE INCLINOMETER (AECOM, 2009/2015)

NOTES:
1. BATHYMETRY BASED ON 2013 SURVEY BY BRUCE HARDING LTD.
2. CONTOUR INTERVALS AT 0.25m.

Figure 01
Site Plan

Z:\Projects\0022 Dillon Consulting Ltd\0022 061 00 2018 Regional Streets Pembina at Grandmont\3 Survey and Dwg\3.4 CAD\3.4.3 Working Folder, 11/2/2017 10:45:23 AM

ANSI full bleed B (11.00 x 17.00 Inches)

Photos

Subsidence of soil in front of retaining wall

Subsidence of soil in front of retaining wall

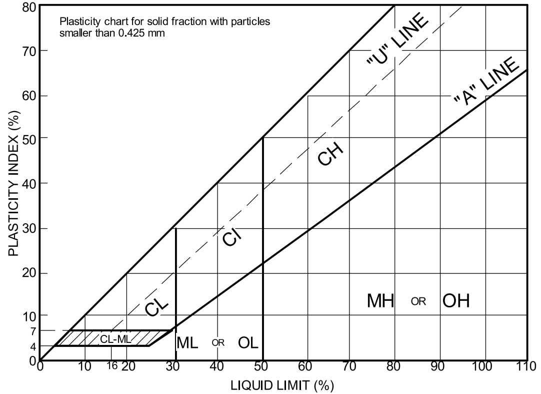
Test Hole Logs

TREK GEOTECHNICAL

EXPLANATION OF FIELD AND LABORATORY TESTING

GENERAL NOTES

1. Classifications are based on the United Soil Classification System and include consistency, moisture, and color. Field descriptions have been modified to reflect results of laboratory tests where deemed appropriate.
2. Descriptions on these test hole logs apply only at the specific test hole locations and at the time the test holes were drilled. Variability of soil and groundwater conditions may exist between test hole locations.
3. When the following classification terms are used in this report or test hole logs, the primary and secondary soil fractions may be visually estimated.

Major Divisions			USCS Classi- fication	Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-Grained soils (More than half the material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than 4.75 mm)	Clean gravel (Little or no fines)	GW	●	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain size curve, depending on percentage of fines (fraction smaller than No. 200 sieve) coarse-grained soils are classified as follows: Less than 5 percent...... GW, GP, SW, SP More than 12 percent...... GM, GC, SM, SC 6 to 12 percent...... Borderline case4s requiring dual symbols*	$C_U = \frac{D_{60}}{D_{10}}$ greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	○	Poorly-graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	○	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			GC	▨	Clayey gravels, gravel-sand-silt mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than 4.75 mm)	Clean sands (Little or no fines)	SW	⁘	Well-graded sands, gravelly sands, little or no fines		$C_U = \frac{D_{60}}{D_{10}}$ greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	░	Poorly-graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	▥	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols
			SC	▨	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-Grained soils (More than half the material is smaller than No. 200 sieve size)	Silts and Clays (Liquid limit less than 50)		ML	▥	Inorganic silts and very fine sands, rock floor, silty or clayey fine sands or clayey silts with slight plasticity	Plasticity Chart 		
			CL	▨	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays			
			OL	☰	Organic silts and organic silty clays of low plasticity			
	Silts and Clays (Liquid limit greater than 50)		MH	▥	Inorganic silts, micaceous or distomaceous fine sandy or silty soils, organic silts			
			CH	▨	Inorganic clays of high plasticity, fat clays			
			OH	≋	Organic clays of medium to high plasticity, organic silts			
	Highly Organic Soils		Pt	⁂	Peat and other highly organic soils	Von Post Classification Limit	Strong colour or odour, and often fibrous texture	

Material		Particle Size mm	Particle Size ASTM Sieve sizes
Sand	Coarse	2.00 to 4.75	#10 to #4
	Medium	0.425 to 2.00	#40 to #10
	Fine	0.075 to 0.425	#200 to #40
Silt or Clay		< 0.075	< #200

Material		Particle Size mm	Particle Size ASTM Sieve Sizes
Boulders		> 300	> 12 in.
Cobbles		75 to 300	3 in. to 12 in.
Gravel	Coarse	19 to 75	3/4 in. to 3 in.
	Fine	4.75 to 19	#4 to 3/4 in.

* Borderline classifications used for soils possessing characteristics of two groups are designated by combinations of groups symbols. For example; GW-GC, well-graded gravel-sand mixture with clay binder.

Other Symbol Types

■	Asphalt	▧	Bedrock (undifferentiated)	○	Cobbles
░	Concrete	▦	Limestone Bedrock	■	Boulders and Cobbles
▩	Fill	☰	Cemented Shale	▥	Silt Till
		▤	Non-Cemented Shale	▨	Clay Till

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EXPLANATION OF FIELD AND LABORATORY TESTING

LEGEND OF ABBREVIATIONS AND SYMBOLS

LL - Liquid Limit (%)
PL - Plastic Limit (%)
PI - Plasticity Index (%)
MC - Moisture Content (%)
SPT - Standard Penetration Test
RQD - Rock Quality Designation
Qu - Unconfined Compression
Su - Undrained Shear Strength
VW - Vibrating Wire Piezometer
SI - Slope Inclinometer

▽ Water Level at Time of Drilling

▼ Water Level at End of Drilling

⧨ Water Level After Drilling as Indicated on Test Hole Logs

FRACTION OF SECONDARY SOIL CONSTITUENTS ARE BASED ON THE FOLLOWING TERMINOLOGY

TERM	EXAMPLES	PERCENTAGE
and	and CLAY	35 to 50 percent
"y" or "ey"	clayey, silty	20 to 35 percent
some	some silt	10 to 20 percent
trace	trace gravel	1 to 10 percent

TERMS DESCRIBING CONSISTENCY OR COMPACTION CONDITION

The Standard Penetration Test blow count (N) of a non-cohesive soil can be related to compactness condition as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	> 50

The Standard Penetration Test blow count (N) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	SPT (N) (Blows/300 mm)
Very soft	< 2
Soft	2 to 4
Firm	4 to 8
Stiff	8 to 15
Very stiff	15 to 30
Hard	> 30

The undrained shear strength (Su) of a cohesive soil can be related to its consistency as follows:

Descriptive Terms	Undrained Shear Strength (kPa)
Very soft	< 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	> 200

Test Hole HA17-01

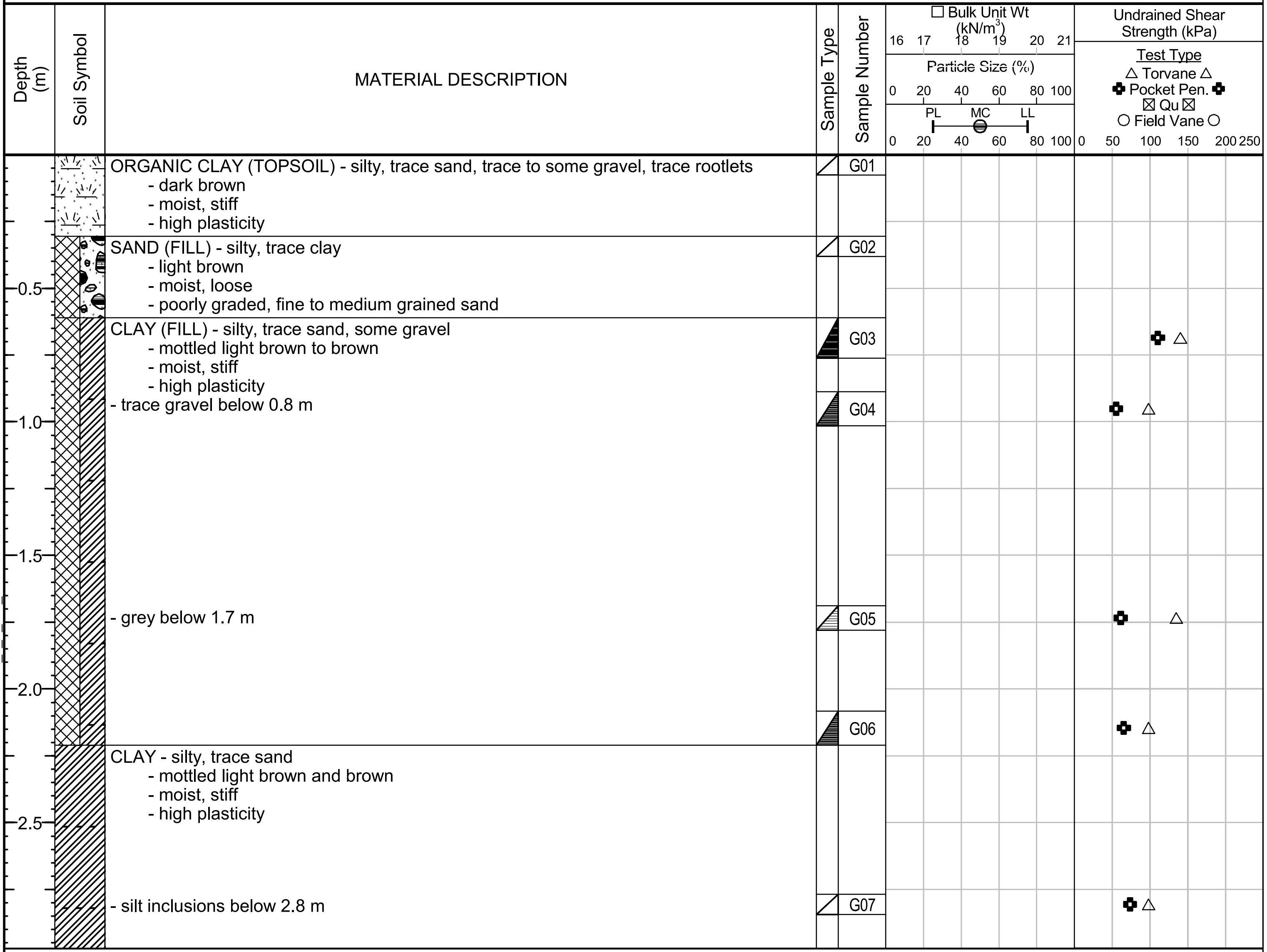
1 of 1

Sub-Surface Log

Client: Dillon Consulting Ltd.
Project Number: 0022-061-00
Project Name: Regional Streets Renewal Projects - 2018 Program
Location: UTM N-5514903, E-632745
Contractor: TREK Geotechnical Inc.
Ground Elevation: Existing Ground
Method: 50 mm Hand Auger
Date Drilled: 28 September 2017

Sample Type: ◿ Grab (G) ▮ Shelby Tube (T) ☒ Split Spoon (SS) ☒ Split Barrel (SB) ▮ Core (C)

Particle Size Legend: ▦ Fines ▨ Clay ▥ Silt ⁘ Sand Gravel Cobbles Boulders



ORGANIC CLAY (TOPSOIL) - silty, trace sand, trace to some gravel, trace rootlets
- dark brown
- moist, stiff
- high plasticity

SAND (FILL) - silty, trace clay
- light brown
- moist, loose
- poorly graded, fine to medium grained sand

CLAY (FILL) - silty, trace sand, some gravel
- mottled light brown to brown
- moist, stiff
- high plasticity
- trace gravel below 0.8 m
- grey below 1.7 m

CLAY - silty, trace sand
- mottled light brown and brown
- moist, stiff
- high plasticity
- silt inclusions below 2.8 m

END OF TEST HOLE AT 3 m IN CLAY
Notes:
1) Hand auger refusal at 3 m depth.
2) No seepage or sloughing observed.
3) Test hole open to 3 m after drilling.
4) Test hole backfilled with auger cuttings to surface.

Logged By: Nuno Mendonca
Reviewed By:
Project Engineer: Ryan Belbas

Appendix A

Slope Stability Analysis Results

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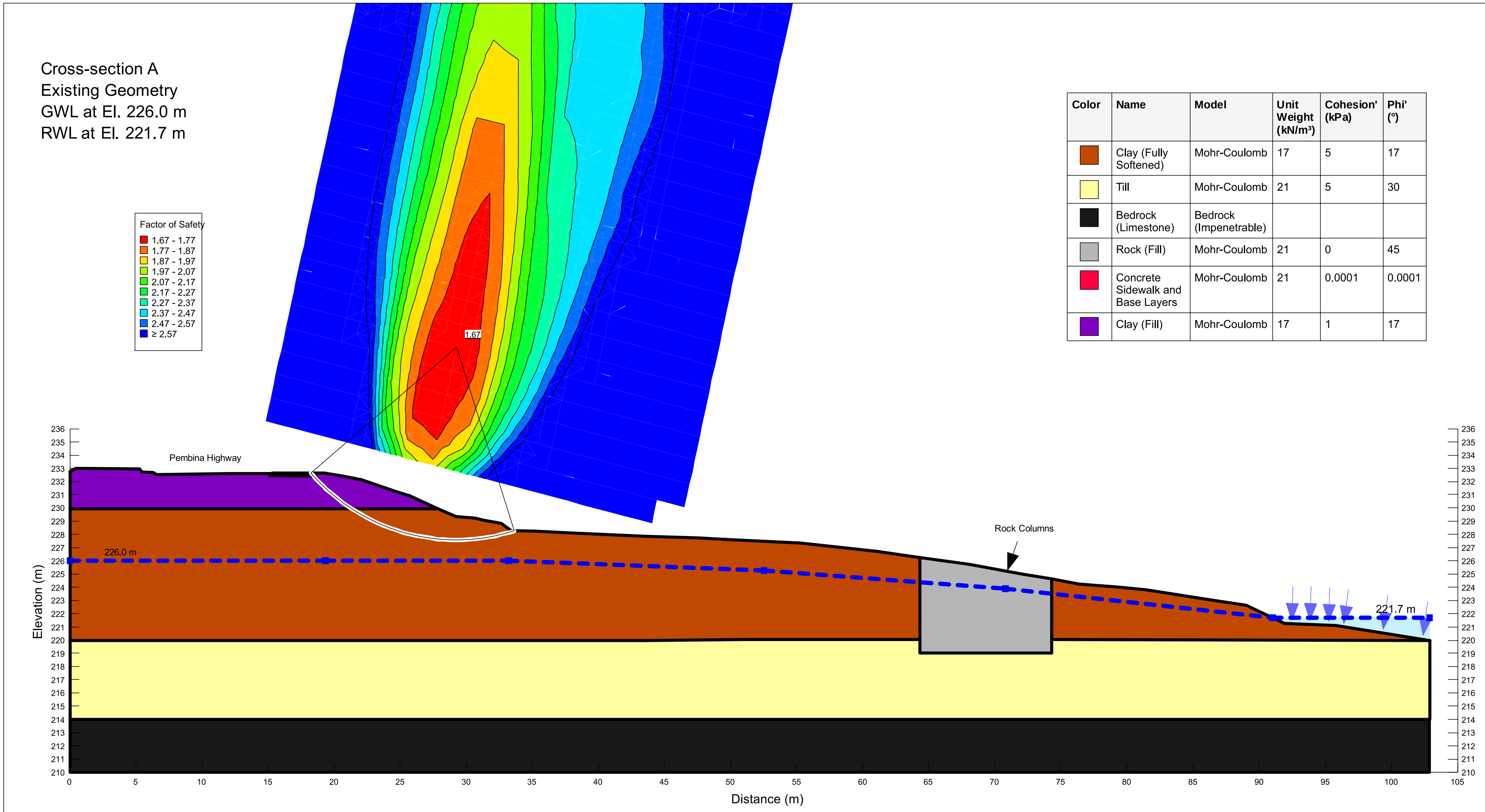
Dillon Consulting Ltd.
Regional Streets Renewal Projects 2018 Program

Cross-section A
Existing Geometry
GWL at El. 226.0 m
RWL at El. 221.7 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟫	Clay (Fully Softened)	Mohr-Coulomb	17	5	17
🟨	Till	Mohr-Coulomb	21	5	30
⬛	Bedrock (Limestone)	Bedrock (Impenetrable)			
⬜	Rock (Fill)	Mohr-Coulomb	21	0	45
🟥	Concrete Sidewalk and Base Layers	Mohr-Coulomb	21	0.0001	0.0001
🟪	Clay (Fill)	Mohr-Coulomb	17	1	17



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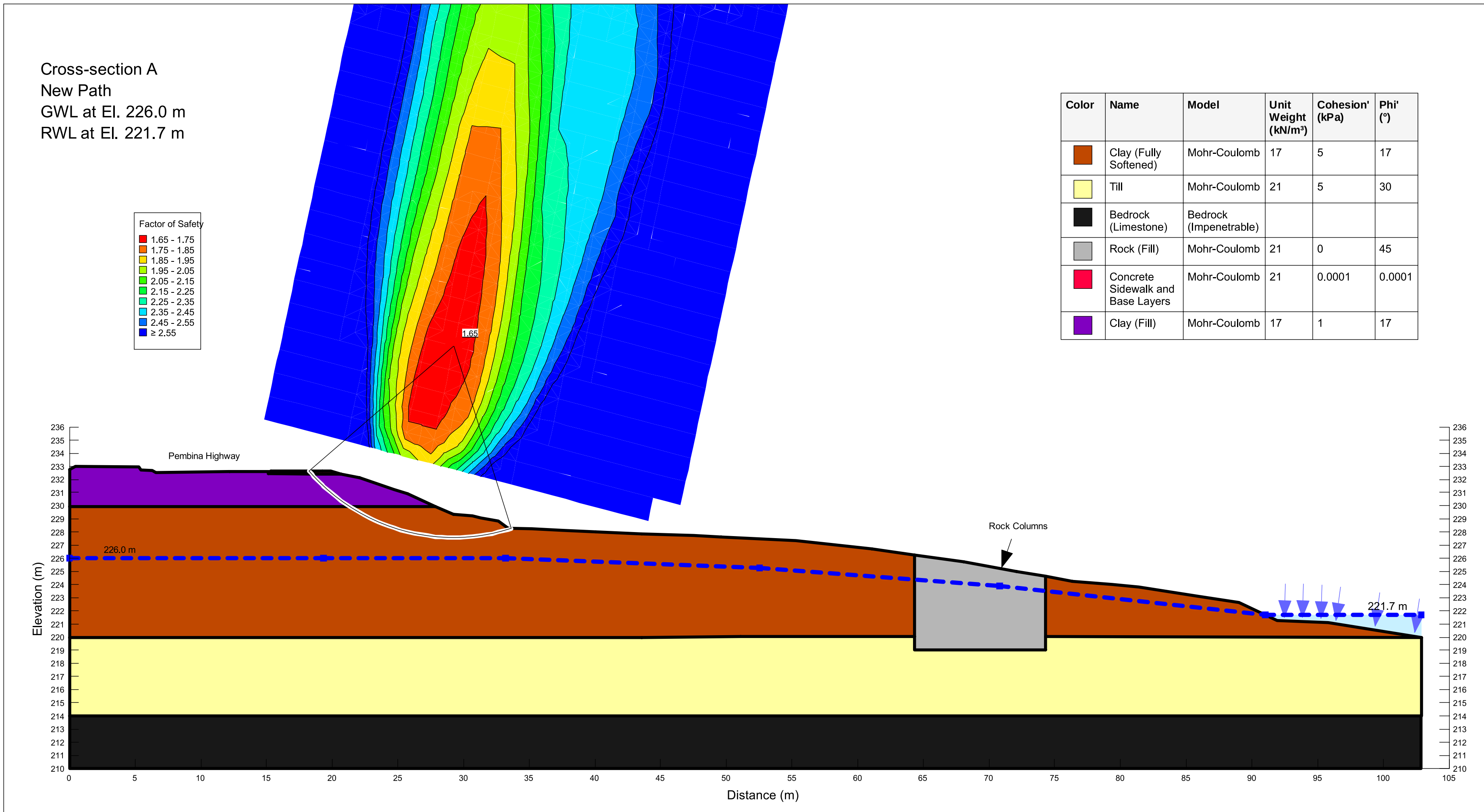
Dillon Consulting Ltd.
Regional Streets Renewal Projects 2018 Program

Cross-section A
New Path
GWL at El. 226.0 m
RWL at El. 221.7 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
🟫	Clay (Fully Softened)	Mohr-Coulomb	17	5	17
🟨	Till	Mohr-Coulomb	21	5	30
⬛	Bedrock (Limestone)	Bedrock (Impenetrable)			
⬜	Rock (Fill)	Mohr-Coulomb	21	0	45
🟥	Concrete Sidewalk and Base Layers	Mohr-Coulomb	21	0.0001	0.0001
🟪	Clay (Fill)	Mohr-Coulomb	17	1	17



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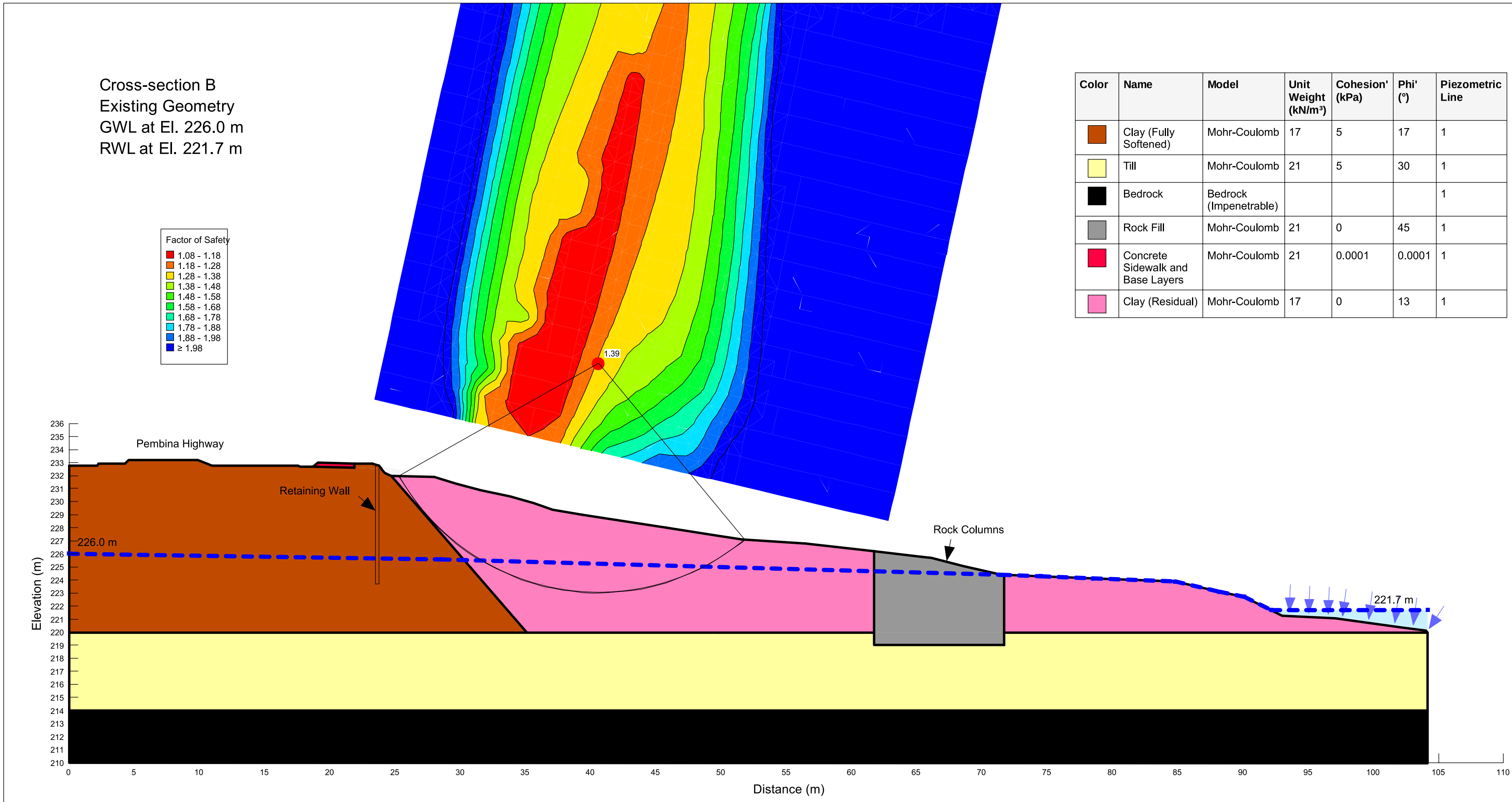
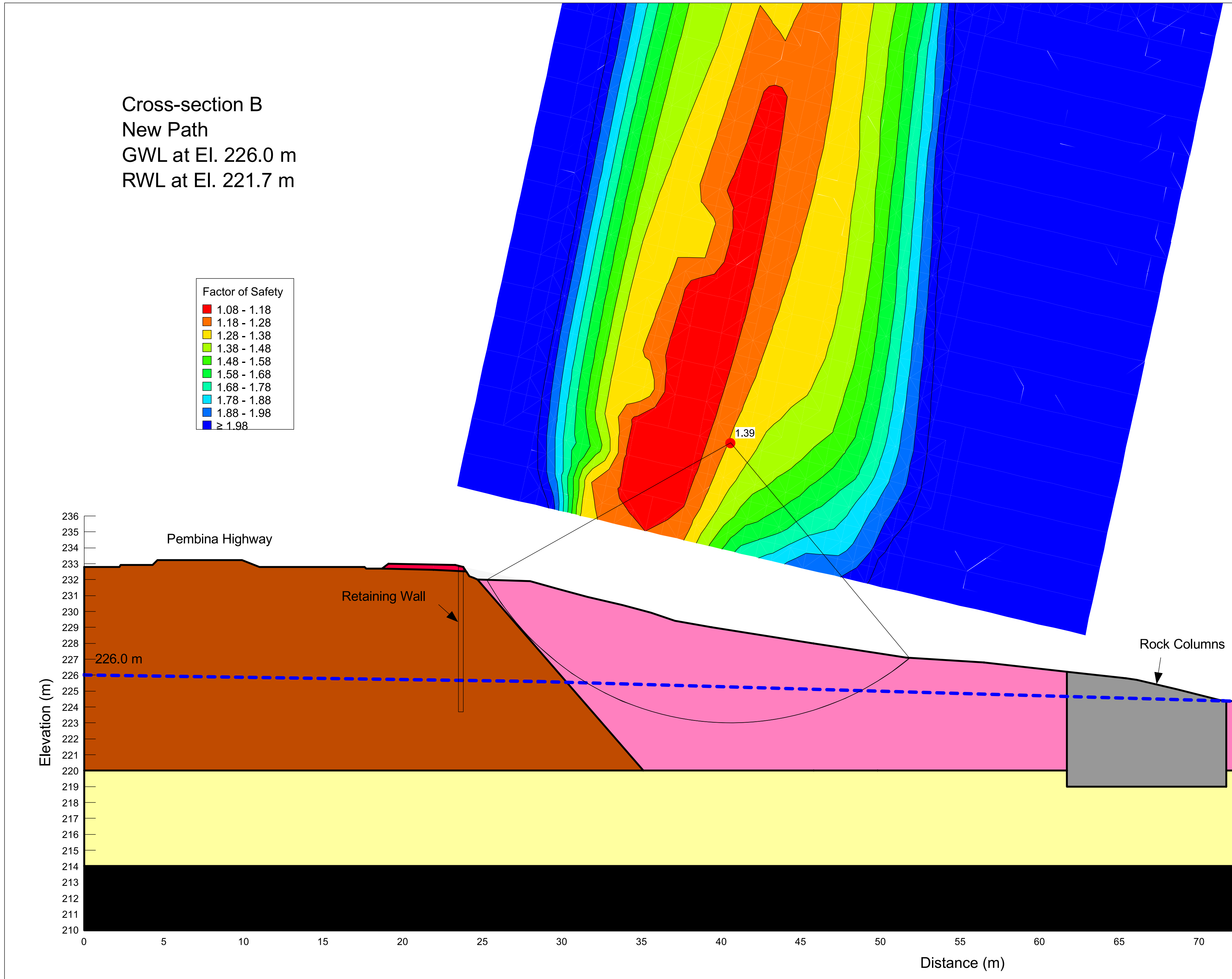
Cross-section B
Existing Geometry
GWL at El. 226.0 m
RWL at El. 221.7 m



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟫	Clay (Fully Softened)	Mohr-Coulomb	17	5	17	1
🟨	Till	Mohr-Coulomb	21	5	30	1
⬛	Bedrock	Bedrock (Impenetrable)				1
▨	Rock Fill	Mohr-Coulomb	21	0	45	1
🟥	Concrete Sidewalk and Base Layers	Mohr-Coulomb	21	0.0001	0.0001	1
🟪	Clay (Residual)	Mohr-Coulomb	17	0	13	1

Cross-section B
New Path
GWL at El. 226.0 m
RWL at El. 221.7 m

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟫	Clay (Fully Softened)	Mohr-Coulomb	17	5	17	1
🟨	Till	Mohr-Coulomb	21	5	30	1
⬛	Bedrock	Bedrock (Impenetrable)				1
▨	Rock Fill	Mohr-Coulomb	21	0	45	1
🟥	Concrete Sidewalk and Base Layers	Mohr-Coulomb	21	0.0001	0.0001	1
🟪	Clay (Residual)	Mohr-Coulomb	17	0	13	1



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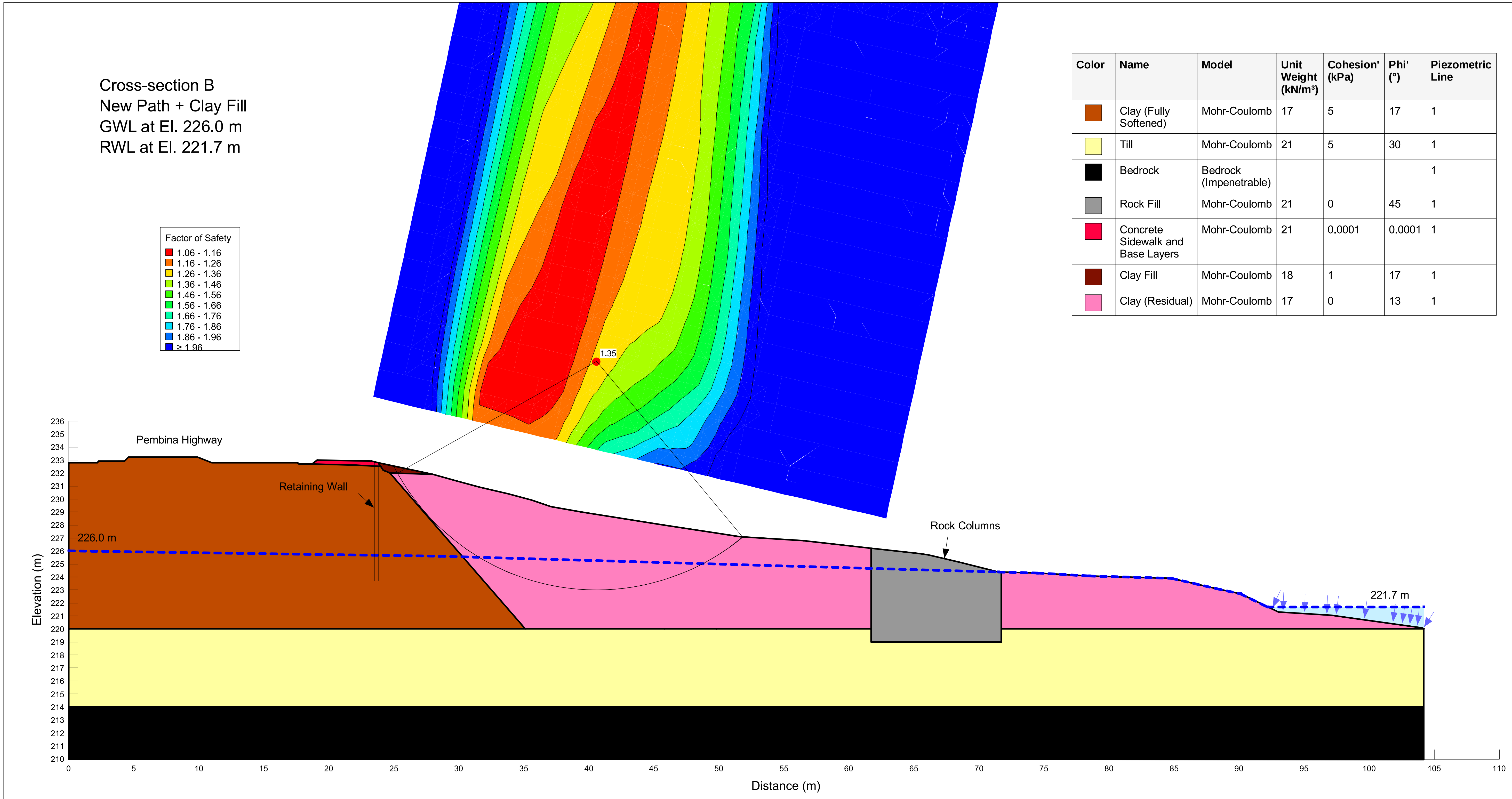
Cross-section B
New Path + Clay Fill
GWL at El. 226.0 m
RWL at El. 221.7 m



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟫	Clay (Fully Softened)	Mohr-Coulomb	17	5	17	1
🟨	Till	Mohr-Coulomb	21	5	30	1
⬛	Bedrock	Bedrock (Impenetrable)				1
⬜	Rock Fill	Mohr-Coulomb	21	0	45	1
🟥	Concrete Sidewalk and Base Layers	Mohr-Coulomb	21	0.0001	0.0001	1
🟫	Clay Fill	Mohr-Coulomb	18	1	17	1
🟪	Clay (Residual)	Mohr-Coulomb	17	0	13	1

Tabloid (279mm x 432mm)

FILE NAME: 0022 065 00- M001-Section B-Long Term - Recreating UMA Model.gsz SAVED: 24/10/2017 9:21:18 AM

SCALE: 1:300 (279mm x 432mm)

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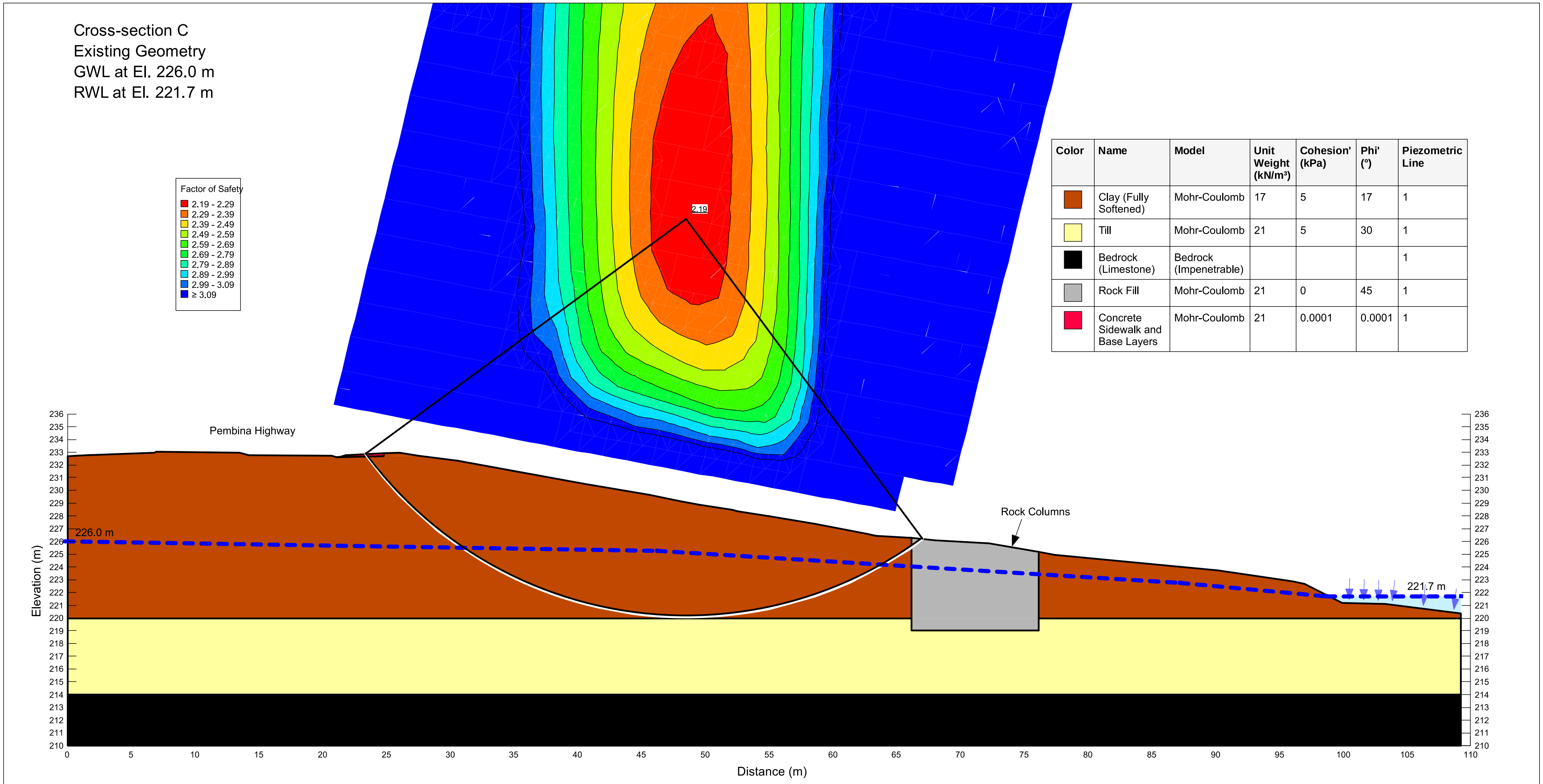
Cross-section C
Existing Geometry
GWL at El. 226.0 m
RWL at El. 221.7 m



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟫	Clay (Fully Softened)	Mohr-Coulomb	17	5	17	1
🟨	Till	Mohr-Coulomb	21	5	30	1
⬛	Bedrock (Limestone)	Bedrock (Impenetrable)				1
⬜	Rock Fill	Mohr-Coulomb	21	0	45	1
🟥	Concrete Sidewalk and Base Layers	Mohr-Coulomb	21	0.0001	0.0001	1

Tabloid (279mm x 432mm)

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FILE NAME: 0022 061 00-M001-Section C-Long Term.gsz

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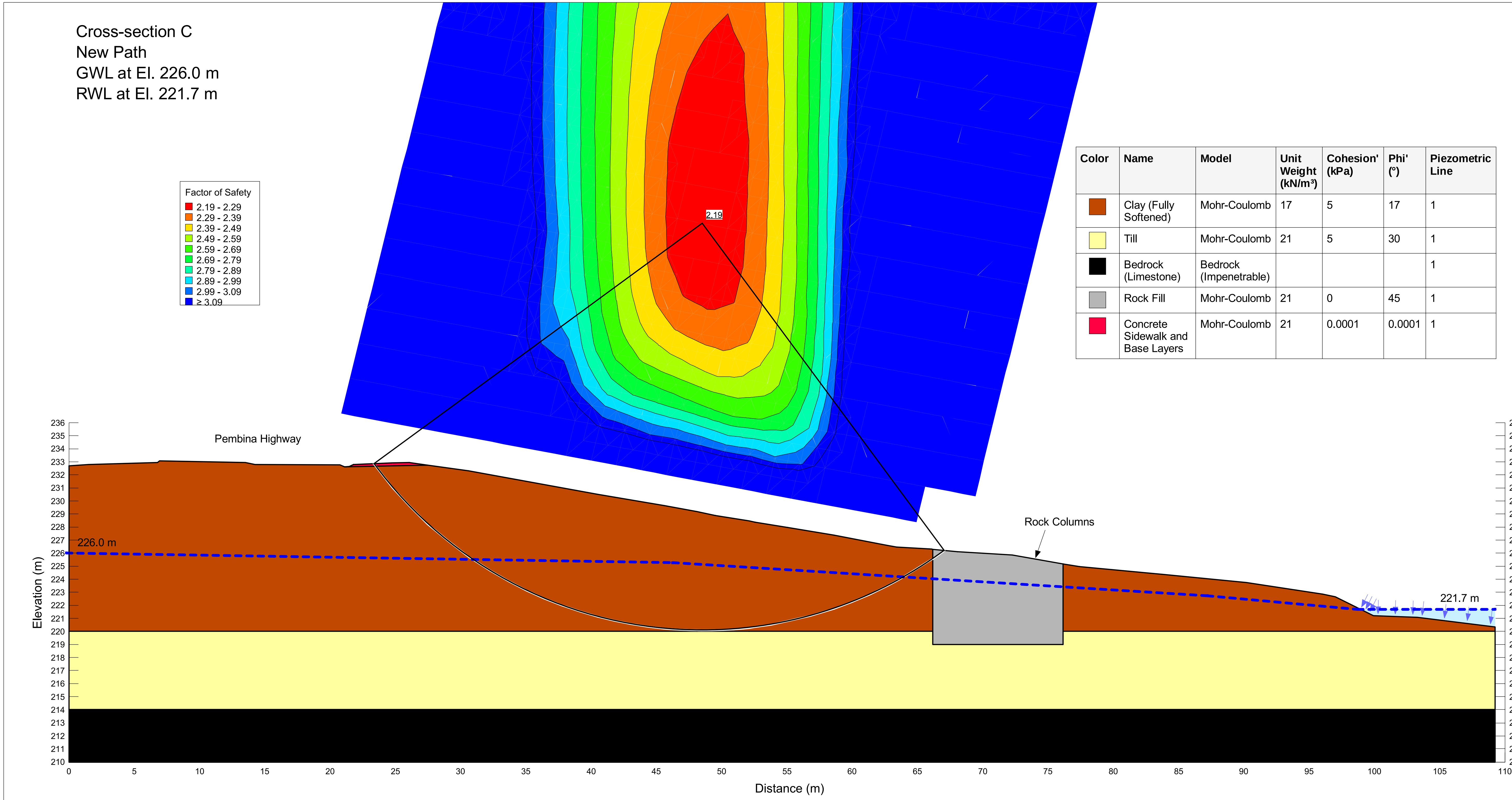
Cross-section C
New Path
GWL at El. 226.0 m
RWL at El. 221.7 m



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Piezometric Line
🟫	Clay (Fully Softened)	Mohr-Coulomb	17	5	17	1
🟨	Till	Mohr-Coulomb	21	5	30	1
⬛	Bedrock (Limestone)	Bedrock (Impenetrable)				1
⬜	Rock Fill	Mohr-Coulomb	21	0	45	1
🟥	Concrete Sidewalk and Base Layers	Mohr-Coulomb	21	0.0001	0.0001	1

Tabloid (279mm x 432mm)

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FILE NAME: 0022 061 00-M001-Section C-Long Term.gsz

SCALE: 1:300 (279mm x 432mm)