Foundation Investigation and Design Report

Highway 17 Steel River Westerly for 4.3 km
Deep Cut
Township of Tuuri
Station 10+060 to Station 10+220
Station 10+060, Centreline, Lat: 48.775690, Lon: -86.895400
Station 10+220, Centreline, Lat: 48.776066, Lon: -86.893302
District Thunder Bay
Highway 17

W.P. 6328-18-00

GEOCRES No. 42D-69

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APPENDICIES

Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ontario Ministry of Transportation Northwest Region (MTO) to provide foundation investigation and design services under the Northwest Region (NWR) Geotechnical Retainer Assignment. This assignment covers the proposed re-alignment of Highway 17 from Steel River westerly for 4.3 km. This report covers a deep cut area identified between Station 10+060 to 10+220. The proposed cut ranges significantly from approximately 7 m to 24 m in depth.

The site is located approximately 0.8 km west of the Steel River along Highway 17. The site coordinates are as follows:

- Station 10+060, CL, Latitude: 48.7757, Longitude: -86.8954
- Station 10+220, CL, Latitude: 48.7761, Longitude: -86.8933

A Google Earth image illustrating the site location can be seen in Figure 1.1.

The foundation investigation was carried out to investigate subsurface conditions from Station 10+060 to 10+220 along the proposed alignment. The investigation consisted of four boreholes. All initial borehole locations were determined through consultation with MTO, while final borehole locations were adjusted to suit field conditions. This report (Part A) describes the subsurface conditions encountered during the investigation.

The MTO Foundations Section has assigned Geocres No. 42D-69 to this site.

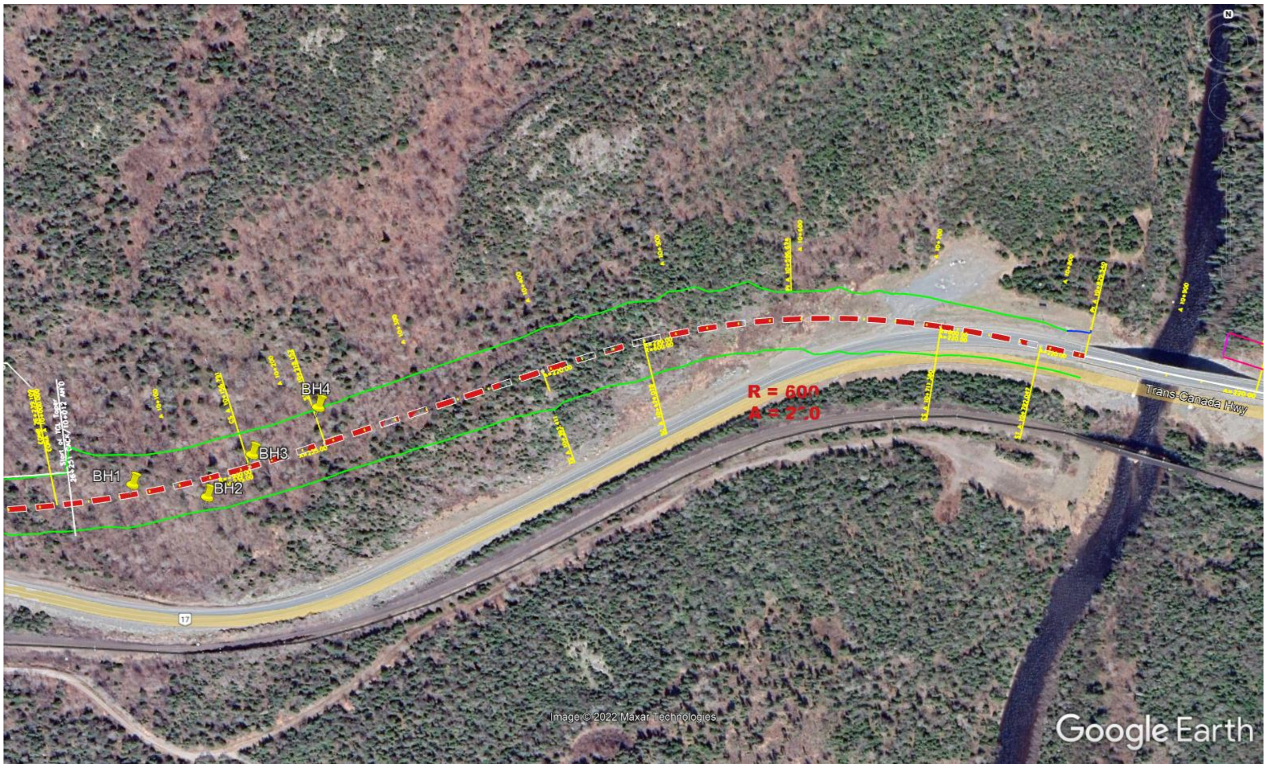


Figure 1.1: A Google Earth Image Illustrating the Site Location.

2 Site Description

The site is densely vegetated and located north of the current Highway 17 alignment. Trails were cleared to access the borehole locations with a drill rig. The general terrain is sloping upwards from west to east, until approximately Station 10+155, then undulates continuing east.

2.1 Surficial Geology

As defined by the Ontario Ministry of Natural Resources' Northern Ontario Engineering Geology Terrain Study (NOEGTS) 60, 1979, Map No. 5093 "Heron Bay", the site is in an area which borders bedrock knob terrain and outwash plain/valley terrain. The site is rugged with high local relief and is generally dry.

The site indicates the general landforms of the outwash plains with overburden ranging from 7 m to 24 m. The description of primary soils of gravel and secondary units of sand is typically confirmed from the field investigation.

3 Investigation Procedures

A geotechnical site investigation was undertaken from May 11, 2022 to May 18, 2022. The field investigation consisted of advancing a total of four boreholes. Initial borehole locations were established through consultation with MTO, while final borehole locations were adjusted to suit field conditions. Borehole locations are illustrated on the Borehole Location and Soil Strata Drawings provided in Appendix C.

All boreholes were advanced to refusal on bedrock using casing advancer. The refusal material was cored at all boreholes to confirm the presence of bedrock.

The borehole locations were identified in the field by TBTE personnel and service clearances were completed prior to mobilizing the drill rig to site. The boreholes were advanced using a drill rig mounted on an all-terrain carrier equipped with casing advancer and apparatus used to carry out Standard Penetration Testing. During the drilling operations for the boreholes, soil samples were obtained by using the techniques of the Standard Penetration Test (SPT). SPTs are typically taken at a frequency of every 0.75 m for the first 3 m of the borehole, and every 1.5 m afterwards, to the termination depth of the borehole. Sample frequency may vary due to circumstances experienced in the field.

Borehole locations and elevations are taken from the Site Plan and cross section drawings provided by the MTO. A hand-held Garmin GPS device was used in the field to locate borehole locations. A summary of the borehole location data is provided in the table below, and on the enclosed Borehole Location and Soil Strata drawings, Appendix C.

Table 3.1: Summary of Borehole Information.

Borehole Number	Co-ordinates	Surface Elevation (m)	Depth of Exploration (m)
1	Lat: 48.7758693 Lon: -86.8953997	226.8	22.4
2	Lat: 48.7756077 Lon: -86.8946108	220.4	23.7
3	Lat: 48.7759041 Lon: -86.8941066	228.2	24.3
4	Lat: 48.7762363 Lon: -86.8934117	229.8	12.6

Standpipe piezometers were installed at Boreholes 2 and 4 to depths of 18.0 m and 12.0 m, respectively.

All boreholes, have been backfilled and/or decommissioned with auger cuttings and bentonite in accordance with the Ministry of the Environment Regulation 903, as amended by Regulation 128/03 (the water well regulation under the Ontario Water Resources Act).

4 Laboratory Testing

Soil samples obtained during the field investigation were subjected to routine laboratory testing. The routine testing included moisture content and grain size analysis. Typically, 100% of the recovered soil samples are tested for natural moisture content determination, and 25% of the recovered soil samples are chosen for grain size analysis and/or Atterberg limits testing, as applicable. The following test methods/standards are followed for the above testing: LS 602, LS 701, ASTM C136, ASTM D4318, ASTM D2216. The results of this testing are shown on the borehole logs (Appendix A) and on the laboratory data reports (Appendix B).

Rock core samples were obtained at all boreholes. The rock core samples were subjected to Rock Quality Designation (RQD) determination, point-load testing, and detailed rock core logging. One point-load test is typically chosen per 1 m of recovered sample. Point-load testing follows ASTM D5731.

5 Subsurface Conditions

Details of the subsurface conditions are provided on the borehole logs in Appendix A and on the Borehole Location and Soil Strata drawings in Appendix C.

The generalized subsurface soils at this site consist of various mixtures of gravels, sands and silts with cobbles and boulders. Bedrock underlies the soils at all boreholes.

5.1 Gravel and Sands

Sand and gravel with a trace of silt and occasional to numerous cobbles and boulders was encountered at the surface of Boreholes 1, 2 and 3. Gravel with a trace to some sand and a trace of silt with numerous cobbles and boulders was encountered at the surface of Borehole 4. This stratum extends to depths ranging from 8.6 m to 10.2 m (elevation 210.3 m to 221.1 m). The results of five grain size analyses indicate the gravel and sands consist of 45-71% gravel, 27-50% sand and 2-8% silt/clay sized particles. This material is in a compact to very dense condition based on SPT N-values ranging from 11 to 94 blows per 0.3 m, with one instance of 8 blows per 0.3 m, indicating a loose condition. Instances of N-values greater than 100 blows per 0.3 m may have been influenced by the presence of cobbles and/or boulders.

5.2 Sand

Sand with a trace of silt and some to a trace of gravel was encountered below the gravel at all borehole locations. The sand ranges in thickness from 0.9 m to 6.1 m and extends to depths ranging from 9.6 m to 14.7 m (elevation 206.5 m to 220.2 m). The sand is in a compact to dense condition based on SPT N-values ranging from 11 to 35 blows per 0.3 m. The results of three grain size analyses indicate the sand consists of 5-16% gravel, 80-88% sand and 4-7% silt/clay sized particles.

5.3 Silt

Sandy silt with a trace of gravel was encountered below the sand at Boreholes 1, 2 and 3. The silt has a thickness ranging from 3.8 m to 4.5 m and extends to depths ranging from 17.8 m to 19.2 m (elevation 202.6 m to 209.0 m). The results of one grain size analysis indicate this material consists of 1% gravel, 20% sand and 79% silt/clay sized particles. The condition of this material is generally compact with SPT N-values ranging from 13 to 29 blows per 0.3 m, however one instance of loose material (N-value 7) and one instance of dense material (N-value 44) was also encountered.

5.4 Till

Till consisting of a heterogeneous mixture of sand, silt and gravel was encountered at Boreholes 1, 2 and 3. Occasional cobbles were encountered within the till. The till was encountered beneath the silt and ranges in thickness from 1.9 m to 2.0 m and extends to depths ranging from 19.7 m to 21.6 m (elevations 199.6 m to 207.1 m). The results of one grain size analysis indicate this material consists of 20% gravel, 46% sand and 34% silt/clay sized particles. The condition of this material is compact to dense with SPT N-values ranging from 21 to 49 blows per 0.3 m. Instances of N-values greater than 100 blows per 0.3 m may have been on bedrock or influenced by the presence of cobbles and/or boulders.

5.5 Refusal and Bedrock

SPT refusal (100+ blows per 0.3 m) may have been encountered on cobbles or boulders at all boreholes. Bedrock was cored and sampled at all boreholes at depths/elevations summarized below.

Table 5.1: Bedrock Depths/Elevations.

Location	Bedrock Surface	
	Depth (m)	Elevation (m)
Borehole 1	19.7	207.1
Borehole 2	20.8	199.6
Borehole 3	21.6	206.6
Borehole 4	9.6	220.2

The bedrock consisted of amphibolite and metagabbro. Further details on the bedrock can be found on the rock core logs in Appendix A.

5.5.1 Rock Quality Designation (RQD)

The RQD is a measure of the number of fractures and jointing in a rock mass. The RQD is expressed as a percentage of the ratio of summed core lengths greater than 100 mm to the total length cored. The RQD index is used to provide a classification for the rock quality according to the limits provided by the Canadian Foundation Engineering Manual (CFEM) which are shown below in Table 5.2.

Table 5.2: Classification of Rock with Respect to RQD Value.

RQD Classification	RQD Value (%)	Number of Occurrences
Very Poor Quality	< 25	0
Poor Quality	25 to 50	0
Fair Quality	50 to 75	0
Good Quality	75 to 90	3
Excellent Quality	90 to 100	5

The quality of bedrock encountered at this site varies from good to excellent. Across all bedrock samples the recovery of the cores ranged from 95-100% and the rock quality designation (RQD) ranged from 78-100%.

5.5.2 Point-Load Testing

To estimate the strength of the bedrock encountered at this site, multiple point-load tests were completed on the core samples. The point-load test results are provided below in Table 5.3.

Table 5.3: Estimated Uniaxial Compressive Strength of Bedrock Samples.

Borehole	Sample	Depth from Ground Surface (m)	Estimated Uniaxial Compressive Strength* (MPa)
1	RC #1	20.16	293
1	RC #2	21.32	203
1	RC #2	22.32	212
2	RC #1	21.18	218
2	RC #2	22.30	250
2	RC #2	23.60	266
3	RC #1	21.70	255
3	RC #2	22.87	213
3	RC #2	23.90	207
4	RC #1	10.03	190
4	RC #2	11.19	276
4	RC #2	12.30	184

* Estimated in accordance with ASTM D5731-16.

Based on the range of estimated uniaxial compressive strengths of 184 MPa to 293 MPa, the bedrock is classified as “very strong” to “extremely strong”, according to the CFEM 4th Edition.

5.6 Groundwater

The groundwater levels were read 24 hours and 48 hours after completion of drilling within the standpipe piezometers installed to depths of 18.0 m and 12.0 m at Boreholes 2 and 4, respectively. Observed groundwater levels have been provided below. Water level readings are not taken upon completion of drilling where water is introduced to the boreholes to facilitate the advancement of casing and rock coring. This supply of water will potentially elevate water levels and provide misleading information. Groundwater levels may vary from season to season and from the effects of heavy precipitation events.

Table 5.4: Observed Groundwater Levels.

Location	Surface Elevation (m)	Groundwater Level, Depth (m)
Borehole 2	220.4	7.4 (24 hrs after completion)
Borehole 4	229.8	4.9 (48 hrs after completion)

6 Miscellaneous

Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The drill equipment for this investigation was operated by TBT Engineering. The field operations were supervised by Glen Hephner. Laboratory testing was supervised by Forch Valela, C.Tech. This report was prepared and reviewed by Steven Anderson, P.Eng., and Steven Seller, P.Eng. (TBTE's designated principal contact identified for MTO Foundation Engineering projects).

Part B - FOUNDATION DESIGN RECOMMENDATIONS

7 Introduction

TBT Engineering Limited (TBTE) has been retained by the Ontario Ministry of Transportation Northwest Region (MTO) to provide foundation investigation and design services under the Northwest Region (NWR) Geotechnical Retainer Assignment. This assignment covers the proposed re-alignment of Highway 17 from Steel River westerly for 4.3 km. This report covers a deep cut area identified between Station 10+060 to 10+220. The proposed cut ranges significantly from approximately 7 m to 24 m in depth.

The foundation investigations, as described in Part A, were completed to investigate subsurface conditions at this site. Part A describes the subsurface conditions encountered during the investigation.

The generalized subsurface soils at this site consist of various mixtures of gravels, sands and silts with cobbles and boulders. Bedrock underlies the soils at all boreholes.

The purpose of this section of the report (Part B) is to provide design recommendations for the permanent earth cut. These are based on the conditions encountered at the borehole locations, TBTE's interpretation of the subsurface conditions at the site and analyses of cut slope stability and settlement.

8 Subgrade Preparation

All organic soils must be stripped from the pavement structure footprint to expose an undisturbed, native, inorganic subgrade prior to fill placement. The exposed subgrade may be sensitive to disturbance so worker traffic may need to be minimized prior to fill placement.

The existing subgrade material may be subject to pumping conditions during compaction of the pavement structure material during periods of high groundwater levels or during periods of heavy precipitation. To mitigate pumping conditions, improved drainage, or a delay to compaction efforts (several hours to a few days) may be required for the first few lifts.

9 Earth Cut Stability Analyses

For the new alignment, cut back slopes will have heights of up to approximately 28 m. Along the new alignment, cut slopes may consist solely of earth cuts, or consist of earth cuts and rock cuts. Transitions to and from earth cuts and rock cuts will be required.

As per O.Reg. 213/91, Part III Excavations, Section 226, the soils encountered on site vary from Type 3 to Type 1 soil. Due to variable soil conditions between and beyond the borehole locations, and due to any changes in soil conditions, and/or groundwater conditions during construction, the contractor will need to field-determine the soil classification in order to comply with the Regulations.

9.1 Stability

Stability modeling was carried out using SLOPE/W software and limit equilibrium analysis using the Morgenstern-Price method.

The soil properties established for the permanent earth cut and foundation materials are presented below in Table 9.1. The strength properties of the native soils are based on published correlations with index tests. Typical strength properties have been selected for the various potential fill materials.

Table 9.1: Soil Properties for Stability Analyses.

Soil	Effective Shear Strength Properties		Unit Weight, γ (kN/m^3)
	Angle of Internal Friction, ϕ' (degrees)	Cohesion Intercept, c' (kPa)	
Compacted Granular B, Type I	32	0	21
Pavement Structure	32	0	21
Compact Sand and Gravel	32	0	21
Dense sand and Gravel	35	0	21
Compact Sand	31	0	21
Loose Silt	29	0	20
Compact Silt	30	0	21
Compact Till	32	0	21
Bedrock Interface Material	29	0	21

Stability analyses have been completed to assess the global stability of the proposed permanent earth cut.

Design sections were selected at Station 10+160 and Station 10+220. The earth cut slope at Station 10+160 is approximately 24 m deep, with overburden material up to 22 m deep. The cut at Station 10+220 may be up to 28 m deep, however bedrock was encountered at a much shallower depth, and thus has different slope stability requirements. Separate slope stability requirements have been provided for earth cuts of less than 10 m in depth and for earth cuts of greater than 10 m in depth. Consideration was given to the cut slopes to the right and left of the roadway, due to the local topography.

It has been assumed that any organics will be stripped and removed and that surface water drainage measures will be incorporated into the design of the cut to ensure no ponding of water occurs. Slope stability models are provided in Appendix D.

The design recommendations provided are based on the following design/construction criteria/assumptions:

- All organics will be stripped and removed to expose native inorganic soils.
- The stratigraphy of the earth cut soils continue across the design section (maintaining a thickness) following the topography/profile of the original ground shown in the cross-section drawings provided by the MTO.
- Permanent earth cuts shall have minimum factor of safety (FOS) of 1.5 for global stability.
- To improve stability and control seepage through the cut slope, the use of a graded filter consisting of 150 mm thick layer of granular sheeting covered with 53 mm clear stone is required. Thickness of the 53 mm clear stone will depend on the slope of the back cut, as outlined in tables below. The graded filter shall extend to 50% of the height of the earth cut slope.
- The graded filter materials were selected to meet filter criteria. These materials shall be constructed as per OPSS.PROV 511 Nov. 2018 and OPSS.PROV 1004 Nov. 2012.
- Surface water drainage measures will be incorporated into the design of the cut.
- As per OPSD 202.010 Nov. 2016 (read in conjunction with OPSD 201.010), a 2 m minimum mid-slope bench will be incorporated into the cut slope.
- OPSD 201.010 Nov. 2009 for Rock Grading shall be followed for rock cuts, at a minimum.
- Excavations shall be conducted in accordance with OPSS.PROV 206 Nov. 2014.
- The stability of a rock cut should be checked by an engineer who is certified to do so in MTO’s Registry, Appraisal and Qualification System (RAQS).

As illustrated by the stability models, the design slope is governed by the strength of the native sands and silts, as well as the ability of the graded filter to drain groundwater from the cut slope. The slip surface with the minimum calculated factor of safety extends through the native soils and exits the cut slope along the top of the bedrock. The results of the analyses indicate a suitable level of stability if the requirements above are adhered to.

Table 9.2: Computed Factors of Safety from Stability Analyses for Left Side Earth Cut Backslopes of Greater than 10 m Not Exceeding 22 m.

Cut Slope	Graded Filter	Factor of Safety	Appendix D Figure Number
2H:1V	4.5 m Total: 0.15 m thick Granular Sheeting covered by 3.85 m thick 53 mm Clear Stone.	1.5	D.1
2.5H:1V	2.6 m Total: 0.15 m thick Granular Sheeting covered by 2.45 m thick 53 mm Clear Stone.	1.5	D.2
3H:1V	1.6 m Total: 0.15 m thick Granular Sheeting covered by 1.15 m thick 53 mm Clear Stone.	1.5	D.3

Table 9.3 Computed Factors of Safety from Stability Analyses for Right Side Earth Cut Backslopes of Greater than 10 m Not Exceeding 16 m.

Cut Slope	Graded Filter	Factor of Safety	Appendix D Figure Number
2H:1V	2.7 m Total: 0.15 m thick Granular Sheeting covered by 2.55 m thick 53 mm Clear Stone.	1.5	D.4
2.5H:1V	1.9 m Total: 0.15 m thick Granular Sheeting covered by 1.75 m thick 53 mm Clear Stone.	1.5	D.5
3H:1V	1.3 m Total: 0.15 m thick Granular Sheeting covered by 0.85 m thick 53 mm Clear Stone.	1.5	D.6

Table 9.4: Computed Factors of Safety from Stability Analyses for Left Side Earth Cut Backslopes of Less than 10 m.

Cut Slope	Graded Filter	Factor of Safety	Appendix D Figure Number
2H:1V	1.8 m Total: 0.15 m thick Granular Sheeting covered by 1.65 m thick 53 mm Clear Stone.	1.5	D.7
2.5H:1V	1.1 m Total: 0.15 m thick Granular Sheeting covered by 0.95 m thick 53 mm Clear Stone.	1.5	D.8
3H:1V	0.75 m Total: 0.15 m thick Granular Sheeting covered by 0.6 m thick 53 mm Clear Stone.	1.5	D.9

Table 9.5: Computed Factors of Safety from Stability Analyses for Right Side Earth Cut Backslopes of Less than 10 m.

Cut Slope	Graded Filter	Factor of Safety	Appendix D Figure Number
2H:1V	1.8 m Total: 0.15 m thick Granular Sheeting covered by 1.65 m thick 53 mm Clear Stone.	1.6	D.10
2.5H:1V	1.1 m Total: 0.15 m thick Granular Sheeting covered by 0.95 m thick 53 mm Clear Stone.	1.6	D.11
3H:1V	0.75 m Total: 0.15 m thick Granular Sheeting covered by 0.6 m thick 53 mm Clear Stone.	1.6	D.12

As bedrock was encountered and exists within the cut slopes, presence of a preferential slip surface along a bedrock interface was checked. The maximum slope of the bedrock was estimated by assuming bedrock exists at the maximum depth encountered at the boreholes, and assuming it follows the topography of the original ground surface.

The stability of the cut slopes was also analyzed as if the excavation of the cut does not encounter bedrock (i.e., earth cut only). These analyses indicate an adequate Factor of Safety.

9.2 Settlement Performance

The total maximum foundation settlements due to the proposed construction are expected to be negligible.

9.3 Dewatering of Cut Slopes

Dewatering measures and design of dewatering systems is the responsibility of the contractor. The complexity of a dewatering system will be governed by the depth, staging, location of the excavation, type of work and any requirements for working in the dry. Dewatering should be completed in compliance with OPSS.PROV 517 Nov. 2016. The need for a permit to take water or the registration of the project on the MOECC's Environmental Activity and Sector Registry should be determined by the contractor.

A permanent high groundwater level within the overburden soils is not expected. If groundwater seepage through the proposed earth cut is observed at the time of construction, the groundwater level should be lowered to the base of excavation to a distance of 10 m from the toe of the excavation slope into the excavation slope. The groundwater level should be controlled until such a time that the graded filter is in place. Alternatively, construction may be delayed until the groundwater level lowers to a suitable level.

To facilitate construction of the new roadway, control of surface water and groundwater may be required. Any dewatering measures that are required should be designed by an engineer with experience in similar conditions.

10 Erosion Protection

Exposed granular fill and native soils may be subject to erosion from surface water runoff. At areas where runoff is expected or observed during construction, the granular surface shall be provided with suitable erosion protection. Embankment slopes beyond specific erosion treatment locations (e.g., Granular Sheeting or Rock Protection) should be treated as per the construction specification for temporary erosion control, OPSS.PROV 804 Apr. 2021 and/or the construction specification for vegetative cover, OPSS.PROV 803 Nov. 2020. Available organic material meeting the construction specification for topsoil, OPSS 802 Nov. 2019, should be applied to the cut slopes in accordance with OPSS 802 prior to the application of temporary erosion control and/or vegetative cover. Erosion control blankets (ECB) may be utilized in conjunction with vegetative cover operations. Bonded Fibre Matrix (BFM) application may also warrant consideration as an alternative treatment. These treatments should be applied at the discretion of the designer.

11 Frost Penetration Depth

The depth of frost penetration for this site can be estimated as approximately 2.2 m, as per OPSD 3090.100 Nov 2010.

12 Potential Construction Issues

No major construction difficulties are foreseen at this site. Issues that may require consideration include, but are not limited to:

- Should a high groundwater table be present during excavation of overburden, dewatering may be required to facilitate the construction of the graded filter, as well as blasting any bedrock. Dewatering systems should be designed in accordance with OPSS.PROV 517 Nov. 2016 and SSP 517F01 July 2017. It is recommended that any dewatering system be designed and checked by engineers with experience designing similar systems.
- There is potential for boulders greater than 1 m in diameter to be present at the surface as well as within the native soils. Removal of any boulders shall be in accordance with OPSS.PROV 201 Apr. 2019.
- Native silts and/or silty soils may be present under the pavement structure of the proposed alignment. These soils may be frost susceptible and may warrant excavation of this material prior to construction of the pavement structure. Native soils excavated from below the pavement structure should be replaced with a suitable, non-frost susceptible material in a compacted state.
- The stability of a rock cut should be checked by an engineer who is certified to do so in MTO’s Registry, Appraisal and Qualification System (RAQS).

13 Limitations

Conclusions and recommendations presented in this report are based on the information determined at a limited number of test hole locations. Subsurface and groundwater conditions between and beyond these locations may differ from those encountered. Conditions may become apparent during construction that were not detected and could not be anticipated at the time of the site investigation.

The stability of a rock cut should be checked by an engineer who is certified to do so in MTO's Registry, Appraisal and Qualification System (RAQS).

The comments given in this report on potential construction problems and possible methods of construction are intended only for the guidance of the designer.

Groundwater levels indicated are based on the information described within the report. The presence of all conditions that could affect the type and scope of the dewatering procedures which may be considered during construction cannot readily be determined from site investigation or boreholes. These conditions include local and seasonal fluctuations of the groundwater level, changes in soil conditions between borehole locations, thin and/or discontinuous layers of highly permeable soils, etc.

In no way does the information contained within this report reflect any environmental aspect of the site or soil.

14 Closure

We trust the above addresses your project requirements at this time. Should you have any questions or comments, please do not hesitate to contact us at your convenience.

Yours truly,
For TBT ENGINEERING

Steven Anderson, P.Eng.
Project Engineer

Steven Seller, P.Eng.
Senior Engineer
Principal Contact for MTO Foundations

APPENDIX A
Borehole Logs and Core Logs

TBT ENGINEERING CONSULTING GROUP

EXPLANAITION OF TERMS

N Value: The Standard Penetration Test (SPT) N value is the number of blows required to cause a standard 51mm O.D. split barrel sampler to penetrate 0.3m into undisturbed ground in a borehole when driven by a hammer with a mass of 63.5 kg, falling freely a distance of 0.76m. For penetrations of less than 0.3m N values are indicated as the number of blows for the penetration achieved. Average N value is denoted thus $\bar{N}$.

Dynamic Cone Penetration Test: Continuous penetration of a conical steel point (51mm O.D. 60˚ cone angle) driven by 475 J impact energy on 'A' size drill rods. The resistance to cone penetration is measured as the number of blows for each 0.3m advance of the conical point into the undisturbed ground.

Soils are described by their composition and consistency/condition.

Consistency: Cohesive soils are described on the basis of their undrained shear strength (c_u) as follows:

C_u (kPa)	0-12	12-25	25-50	50-100	100-200	>200
	Very Soft	Soft	Firm	Stiff	Very Stiff	Hard

Condition: Cohesionless soils are described on the basis of denseness as indicated by SPT N values as follows:

N (Blows/0.3m)	0-4	4-10	10-30	30-50	>50
	Very Loose	Loose	Compact	Dense	Very Dense

Minor Soil Components: Terminology used to represent the amount of minor components based on their percent of the sample by weight as follows:

% by weight	0-10	10-20	20-35	35-50
	Trace	Some	"ey" or "y"	And

ABBREVIATIONS AND SYMBOLS

Field Sampling, Insitu Testing, Laboratory Testing

S S	Split Spoon	T P	Thin Wall Piston
A S	Auger	O S	Osterberg
W S	Wash	R C	Rock Core
S T	Slotted Tube	P H	T W Advanced Hydraulically
B S	Block	P M	T W Advanced Manually
C S	Chunk	F S	Foil
V T	Vane Test (kPa)	P P	Pocket Penetrometer (kg/cm^2)
T W	Thin Wall Shellby Tube		

EXPLANAITION OF TERMS Cont'd.

Stress and Strain

u_w	kPa	Pore Water Pressure
$_u$		Pore Pressure Ratio
σ	kPa	Total Normal Stress
σ'	kPa	Effective Normal Stress
τ	kPa	Shear Stress
$\sigma_1, \sigma_2, \sigma_3$	kPa	Principal Stress
ε	%	Linear Strain
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	Principal Strains
E	MPa	Young's Modulus
G	kPa	Modulus of Shear Deformation
m	MPa	Constrained Modulus
μ		Coefficient of Friction

Mechanical Properties of Soil

m_v	kPa^{-1}	Coefficient of Volume Change
C_c		Compression Index
C_s		Swelling Index
C_a		Rate of Secondary Consolidation
c_v	m^2/s	Coefficient of Consolidation
H	m	Drainage Path
T_v		Time Factor
U	%	Degree of Consolidation
P'_o	kPa	Effective Overburden Pressure
P'_c	kPa	Preconsolidation Pressure
τ_f	kPa	Shear Strength
c'	kPa	Effective Cohesion Intercept
ϕ'	°	Effective Angle of Internal Friction
c_u	kPa	Undrained Shear Strength
s		Sensitivity

Physical Properties of Soil

ρ_s	kg/m^3	Density of Solid Particles	e	%	Void Ratio	e_{min}	%	Void Ratio in Densest State
γ_s	kN/m^3	Unit Weight of Solid Particles	n	%	Porosity	I_D		Density Index $= \frac{e_{max}-e}{e_{max}-e_{min}}$
ρ_w	kg/m^3	Density of Water	w	%	Water Content	D	mm	Grain Diameter
γ_w	kN/m^3	Unit Weight of Water	S_r	%	Degree of Saturation	D_n	mm	n Percent Diameter
ρ	kg/m^3	Density of Soil	w_L	%	Liquid Limit	C_U		Uniformity Coefficient
γ	kN/m^3	Unit Weight of Soil	w_P	%	Plastic Limit	h	m	Hydraulic Head or Potential
ρ_d	kg/m^3	Density of Dry Soil	w_S	%	Shrinkage Limit	q	$m\ ^{3}/_{5}$	Rate of Discharge
γ_d	kN/m^3	Unit Weight of Dry Soil	I_P	%	Plasticity Index $= w_L - w_P$	v	m/s	Discharge Velocity
ρ_{sat}	kg/m^3	Density of Saturated Soil	I_L		Liquidity Index $= \frac{w-w_P}{I_P}$	i		Hydraulic Gradient
γ_{sat}	kN/m^3	Unit Weight of Saturated Soil	I_C		Consistency Index $= \frac{w_L-w}{I_P}$	k	m/s	Hydraulic Conductivity
ρ'	kg/m^3	Density of Submerged Soil	e_{max}	%	Void Ratio in Loosest State	j	kN/m^3	Seepage Force
γ'	kN/m^3	Unit Weight of Submerged Soil						

RECORD OF BOREHOLE No 1

METRIC

W.P. 6328-18-00	LOCATION N:5404167.412; E:312487.306 MTM Zone:14		ORIGINATED BY GH
DIST NWR HWY 17	BOREHOLE TYPE Casing Advancer		COMPILED BY TG
DATUM Geodetic	DATE 2022.05.17 - 2022.05.18	LATITUDE 48.7758693 LONGITUDE -86.8953997	CHECKED BY SS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
226.8 / 0.0	SAND & GRAVEL - trace silt, occasional cobbles, brown, compact to dense	1	SS	11	
		2	SS	12	
		3	SS	33	47 48 (5)
		4	SS	48	
		5	SS	40	
		6	SS	100+	No Recovery.
		7	SS	100+	No Recovery.
	- - - - - - numerous cobbles & boulders	8	SS	100+	No Recovery.
216.6 / 10.2	SAND - trace gravel, trace silt, brown, very loose to compact	9	SS	30	8 86 (6)
		10	GRAB		
		11	GRAB		
212.8 / 14.0	SILT - Sandy, trace gravel, occasional cobbles, grey, loose to compact	12	SS	14	1 20 (79)
		13	SS	7	
209.0 / 17.8	TILL - SAND & SILT - some gravel, occasional cobbles, grey, dense	14	SS	49	No Recovery.
207.1 / 19.7	BEDROCK - AMPHIBOLITE See rock core logs for full detail	1	RC		RC #1 REC 97% RQD 90%
	- - - - - - METAGABBRO See rock core logs for details	2	RC		RC #2 REC 100% RQD 100%
204.4 / 22.4	End of Borehole @ 22.4 m.				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (226, 224, 222, 220, 218, 216, 214, 212, 210, 208, 206); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE PP=Pocket Penetrometer (Kg/cm²)

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 2

METRIC

W.P. 6328-18-00	LOCATION N:5404138.404; E:312545.324 MTM Zone:14		ORIGINATED BY GH
DIST NWR HWY 17	BOREHOLE TYPE Casing Advancer		COMPILED BY TG
DATUM Geodetic	DATE 2022.05.15 - 2022.05.16	LATITUDE 48.7756077 LONGITUDE -86.8946108	CHECKED BY SS

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
220.4 / 0.0	SAND & GRAVEL - trace silt, numerous cobbles & boulders, brown, compact to dense
210.3 / 10.1	SAND - trace gravel, trace silt, brown, compact to dense
206.5 / 13.9	SILT - Sandy, brown, compact to dense
202.6 / 17.8	TILL - SAND - Silty, some gravel, occasional cobbles, grey, compact to very dense
199.6 / 20.8	BEDROCK - METAGABBRO See rock core logs for details
196.7 / 23.7	End of Borehole @ 23.7 m.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
			Water level @ 7.4 m 24 hours after completion.
1	SS	15	
2	GRAB		53 44 (3)
3	SS	100+	No recovery.
4	SS	100+	No recovery.
5	SS	100+	
6	SS	100+	No recovery.
7	SS	22	
8	SS	35	5 88 (7)
9	SS	15	
10	SS	13	
11	SS	44	No recovery.
			Standpipe installed to 18.0 m.
12	SS	27	
13	SS	100+	20 46 (34)
1	RC		RC #1 REC 100% RQD 88%
2	RC		RC #2 REC 95% RQD 95%

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (220, 218, 216, 214, 212, 210, 208, 206, 204, 202, 200, 198); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE PP=Pocket Penetrometer (Kg/cm²)

RECORD OF BOREHOLE No 3

METRIC

W.P. 6328-18-00 LOCATION N:5404171.414; E:312582.335 MTM Zone:14 ORIGINATED BY GH
DIST NWR HWY 17 BOREHOLE TYPE Casing Advancer COMPILED BY TG
DATUM Geodetic DATE 2022.05.13 - 2022.05.15 LATITUDE 48.7759041 LONGITUDE -86.8941066 CHECKED BY SS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
228.2 / 0.0	SAND & GRAVEL - trace silt, occasional cobbles, brown, compact to very dense	1	SS	14	
		2	SS	20	45 50 (5)
		3	SS	25	
		4	SS	53	
		5	SS	94	55 37 (8)
		6	SS	100+	No recovery.
		7	SS	33	No recovery.
219.6 / 8.6	SAND - trace gravel, trace silt, brown, compact	8	SS	21	
		9	SS	23	
	- - - - - - occasional cobbles	10	SS	11	
		11	SS	27	
213.5 / 14.7	SILT - Sandy, trace gravel, occasional cobbles, compact	12	SS	21	
		13	SS	29	
		14	SS	17	
209.0 / 19.2	TILL - SAND & SILT - some gravel, grey, compact	15	SS	21	
206.6 / 21.6	BEDROCK - METAGABBRO See rock core logs for details	1	RC		RC #1 REC 100% RQD 78%
		2	RC		RC #2 REC 95% RQD 95%
203.9 / 24.3	End of Borehole @ 24.3 m.				

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (228–204); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL.

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE PP=Pocket Penetrometer (Kg/cm²)

RECORD OF BOREHOLE No 4

METRIC

W.P. 6328-18-00	LOCATION N:5404208.425; E:312633.35 MTM Zone:14		ORIGINATED BY GH
DIST NWR HWY 17	BOREHOLE TYPE Casing Advancer		COMPILED BY TG
DATUM Geodetic	DATE 2022.05.11 - 2022.05.12	LATITUDE 48.7762363 LONGITUDE -86.8934117	CHECKED BY SS

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
229.8 / 0.0	GRAVEL - trace to some sand, trace silt, numerous cobbles and boulders, grey, loose to very dense				Water level @ 4.9 m 48 hours after completion.
		1	SS	8	
		2	SS	100+	
		3	SS	100+	No recovery, on boulder.
		4	SS	100+	
		5	SS	52	71 27 (2)
	- - - - - - Sandy, trace silt	6	SS	22	
221.1 / 8.7	SAND - some gravel, trace silt, occasional cobbles, brown, dense	7	SS	32	16 80 (4)
220.2 / 9.6	BEDROCK - METAGABBRO See rock core logs for details	1	RC		RC #1 REC 97% RQD 95%
		2	RC		RC #2 REC 95% RQD 81%
217.2 / 12.6	End of Borehole @ 12.6 m.				Standpipe installed to 12.0 m.

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (228, 226, 224, 222, 220, 218); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE PP=Pocket Penetrometer (Kg/cm²)

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP

Project #: 20-656-6	**Site:** Steel River	**Logger:** L Cosby	**Borehole #:** BH1
Lab #: 1016 and 1017	**Client:** MTO	**Date:** 11-Aug-22	**Page #:** 1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES # OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES
From 19.70 To 21.20	1/1	97%	90%	**AMPHIBOLITE - greenish grey, foliated, greasy, veined, fine-grained, intact and broken pieces**	H-VH	U	2	F	D	C	RP	O/C	N/T	- calcite veins throughout - 20 mm vein at 21.0 m
								F	F	C	RU	O/C	N/T	
From 21.20 To 22.40	1/2	100%	100%	**METAGABBRO - greenish grey, massive, veined, fine-grained, mainly intact**	H-VH	U	2	F	D	C	RP	O/C	N/T	- calcite veins throughout
								F	F	M	RP	O	N/T	
From 22.40 To 0.00														
From 0.00 To 0.00														
From 0.00 To 0.00														

NOTES:

Strength (MPa)
VH = Very High = >200
H = High = 50-200
M = Medium = 15-50
L = Low = 4-15
VL = Very Low = 1-4

Weathering
U = Unweathered (No signs)
S = Slightly (Oxidized)
M = Moderately (Discoloured)
H = Highly (Friable)
C = Completely (Soil-like)

Type
B = Bedding joint
J = Cross Joint
F = Fault
S = Shear Plane

Orientation
F = Flat (0-20°)
D = Dipping (20-50°)
V = Near Vertical (>50°)

Spacing
VW = Very wide = >3m
W = Wide = 1-3m
M = Moderate = 0.3-1m
C = Close = 5-30cm
VC = Very close = <5cm

Roughness
RU = Rough undulating
RP = Rough planar
SU = Smooth undulating
SP = Smooth planar
LU = Slicken sided undulating
LP = Slicken sided planar

Aperture
O = Open
C = Closed
F = Filled

Filling
T = Tight, hard
O = Oxidized
SA = Slightly altered, clay free
S = Sandy, Clay free
Si = Sandy, silty, minor clay
NC = Non-softening clay
SC = Swelling, softening clay
N= No filling

*Strength shown above is estimated and not measured laboratory values

FULL ROCK CORE: Dry

FULL ROCK CORE: Wet

ROCK CORE: Detail #1

ROCK CORE: Detail #2

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP	Project #:	20-656-6	Site:	Steel River	Logger:	L Cosby	Borehole #:	BH2
	Lab #:	1003 and 1004	Client:	MTO	Date:	11-Aug-22	Page #:	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES: # OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES
From 20.80 To 22.20	1/1	100%	88%	**METAGABBRO - greenish grey, massive, veined, lightly foliated medium- to coarse-grained, mainly intact**	H-VH	U	2	F F	F D	C M	RP SU	O O	N/O N/O	- calcite veins throughout - some red staining on fracture surfaces
From 22.20 To 23.70	1/2	95%	95%	**METAGABBRO - greenish grey, massive, veined, lightly foliated medium- to coarse-grained, mainly intact**	H-VH	U	1	F	F	C	RP	O/C	N/T	- calcite veins throughout
From 23.70 To 0.00														
From 0.00 To 0.00														
From 0.00 To 0.00														

NOTES:

Strength (MPa)
VH = Very High = >200
H = High = 50-200
M = Medium = 15-50
L = Low = 4-15
VL = Very Low = 1-4

Weathering
U = Unweathered (No signs)
S = Slightly (Oxidized)
M = Moderately (Discoloured)
H = Highly (Friable)
C = Completely (Soil-like)

Type
B = Bedding joint
J = Cross Joint
F = Fault
S = Shear Plane

Orientation
F = Flat (0-20°)
D = Dipping (20-50°)
V = Near Vertical (>50°)

Spacing
VW = Very wide = >3m
W = Wide = 1-3m
M = Moderate = 0.3-1m
C = Close = 5-30cm
VC = Very close = <5cm

Roughness
RU = Rough undulating
RP = Rough planar
SU = Smooth undulating
SP = Smooth planar
LU = Slicken sided undulating
LP = Slicken sided planar

Aperture
O = Open
C = Closed
F = Filled

Filling
T = Tight, hard
O = Oxidized
SA = Slightly altered, clay free
S = Sandy, Clay free
Si = Sandy, silty, minor clay
NC = Non-softening clay
SC = Swelling, softening clay
N= No filling

*Strength shown above is estimated and not measured laboratory values

FULL ROCK CORE: Dry

FULL ROCK CORE: Wet

ROCK CORE: Detail #1

ROCK CORE: Detail #2

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP	Project #:	20-656-6	Site:	Steel River	Logger:	L Cosby	Borehole #:	BH3
	Lab #:	991 and 992	Client:	MTO	Date:	11-Aug-22	Page #:	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES # OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES
From 21.60 To 22.80	1/1	100%	78%	**METAGABBRO - greenish grey, massive, veined, fine-grained, intact and broken pieces**	H-VH	U	3	F	F	C	RP	O	N	- calcite veins throughout - slight schistocity on fractured surfaces
								F	V	C	RU	C	T	
								F	D	N/A	SP	O	SA	
From 22.80 To 24.30	1/2	95%	95%	**METAGABBRO - greenish grey, massive, veined, fine-grained, mainly intact**	H-VH	U	2	F	F	C	RP	O	N	- calcite veins throughout
								F	D	M	RP	C	T	
From 24.30 To 0.00														
From 0.00 To 0.00														
From 0.00 To 0.00														

NOTES:

Strength (MPa)	Weathering	Type	Orientation	Spacing	Roughness	Aperture	Filling
VH = Very High = >200	U = Unweathered (No signs)	B = Bedding joint	F = Flat (0-20°)	VW = Very wide = >3m	RU = Rough undulating	O = Open	T = Tight, hard
H = High = 50-200	S = Slightly (Oxidized)	J = Cross Joint	D = Dipping (20-50°)	W = Wide = 1-3m	RP = Rough planar	C = Closed	O = Oxidized
M = Medium = 15-50	M = Moderately (Discoloured)	F = Fault	V = Near Vertical (>50°)	M = Moderate = 0.3-1m	SU = Smooth undulating	F = Filled	SA = Slightly altered, clay free
L = Low = 4-15	H = Highly (Friable)	S = Shear Plane		C = Close = 5-30cm	SP = Smooth planar		S = Sandy, Clay free
VL = Very Low = 1-4	C = Completely (Soil-like)			VC = Very close = <5cm	LU = Slicken sided undulating		Si = Sandy, silty, minor clay
					LP = Slicken sided planar		NC = Non-softening clay
							SC = Swelling, softening clay
							N= No filling

*Strength shown above is estimated and not measured laboratory values

FULL ROCK CORE: Dry

FULL ROCK CORE: Wet

ROCK CORE: Detail #1

ROCK CORE: Detail #2

ROCK CORE LOG

TBT ENGINEERING CONSULTING GROUP	Project #:	20-656-6	Site:	Steel River	Logger:	L Cosby	Borehole #:	BH4
	Lab #:	976 and 977	Client:	MTO	Date:	11-Aug-22	Page #:	1 of 1

DEPTH FROM SURFACE (m)	BOX/RUN	% REC (m)	% RQD (m)	GENERAL DESCRIPTION (Rock type(s), %, colour, texture, etc.)	STRENGTH*	WEATHERING	DISCONTINUITIES # OF SETS	TYPE(S)	ORIENTATION	SPACING	ROUGHNESS	APERTURE	FILLING	OCCASIONAL FEATURES
From 9.60 To 11.10	1/1	97%	95%	**METAGABBRO - greenish grey, massive, veined, medium-grained, mainly intact**	H-VH	U	2	F	F	M	RP	O	N	- calcite veins throughout - some sulfides present
								F	D	N/A	RU	O	N	
From 11.10 To 12.60	1/2	95%	81%	**METAGABBRO - greenish grey, massive, veined, medium- to fine-grained, mainly intact**	H-VH	U	2	F	F	C	RP	O	N	- calcite veins throughout - some sulfides present
								F	V	C	RP	C	T	
From 12.60 To 0.00														
From 0.00 To 0.00														
From 0.00 To 0.00														

NOTES:

Strength (MPa)	Weathering	Type	Orientation	Spacing	Roughness	Aperture	Filling
VH = Very High = >200	U = Unweathered (No signs)	B = Bedding joint	F = Flat (0-20°)	VW = Very wide = >3m	RU = Rough undulating	O = Open	T = Tight, hard
H = High = 50-200	S = Slightly (Oxidized)	J = Cross Joint	D = Dipping (20-50°)	W = Wide = 1-3m	RP = Rough planar	C = Closed	O = Oxidized
M = Medium = 15-50	M = Moderately (Discoloured)	F = Fault	V = Near Vertical (>50°)	M = Moderate = 0.3-1m	SU = Smooth undulating	F = Filled	SA = Slightly altered, clay free
L = Low = 4-15	H = Highly (Friable)	S = Shear Plane		C = Close = 5-30cm	SP = Smooth planar		S = Sandy, Clay free
VL = Very Low = 1-4	C = Completely (Soil-like)			VC = Very close = <5cm	LU = Slicken sided undulating		Si = Sandy, silty, minor clay
					LP = Slicken sided planar		NC = Non-softening clay
							SC = Swelling, softening clay
							N= No filling

*Strength shown above is estimated and not measured laboratory values

FULL ROCK CORE: Dry

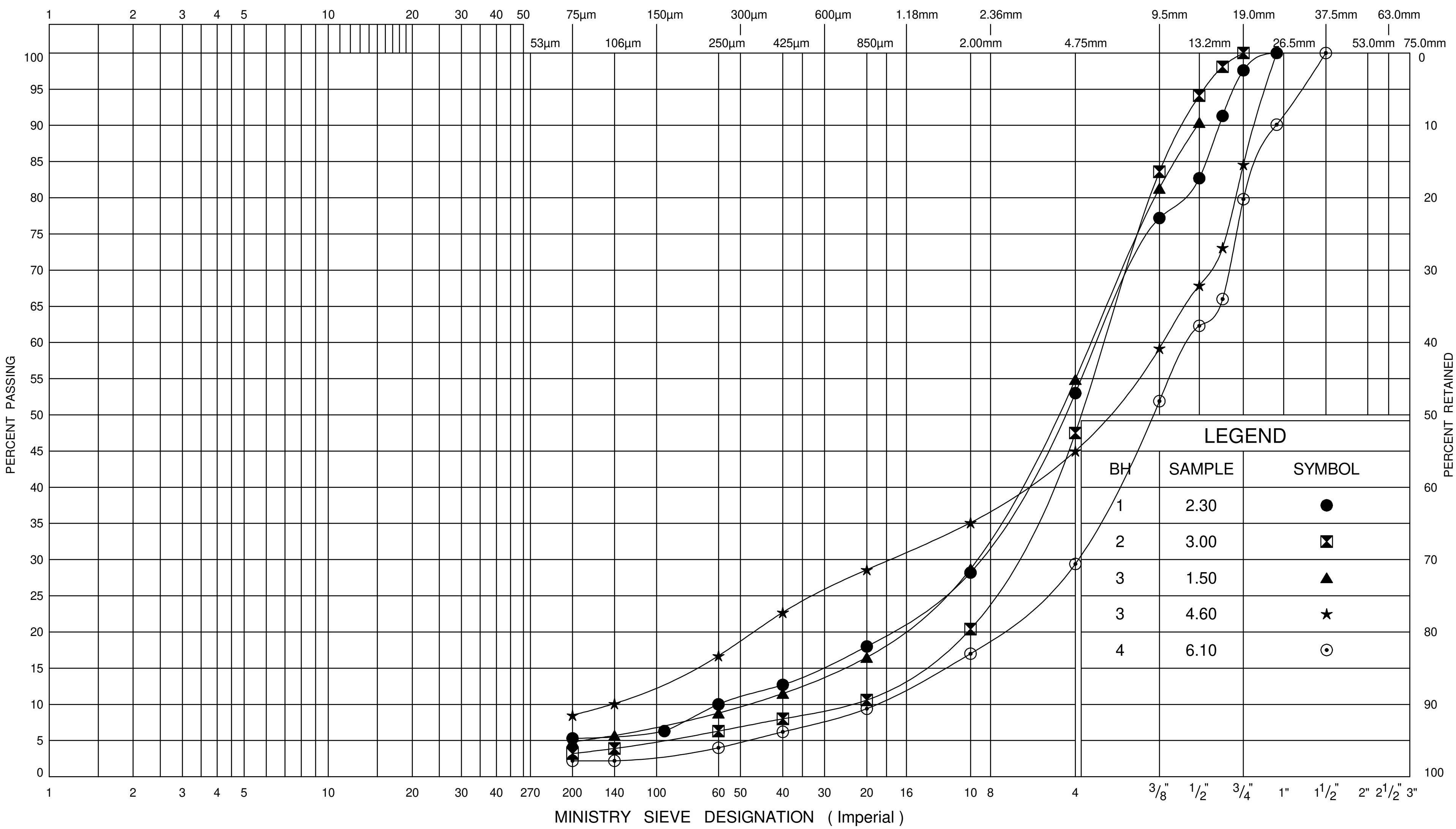
FULL ROCK CORE: Wet

ROCK CORE: Detail #1

ROCK CORE: Detail #2

APPENDIX B
Laboratory Test Data

UNIFIED SOIL CLASSIFICATION SYSTEM



LEGEND

BH	SAMPLE	SYMBOL
1	2.30	●
2	3.00	⧗ (boxed)
3	1.50	▲
3	4.60	★
4	6.10	⊙

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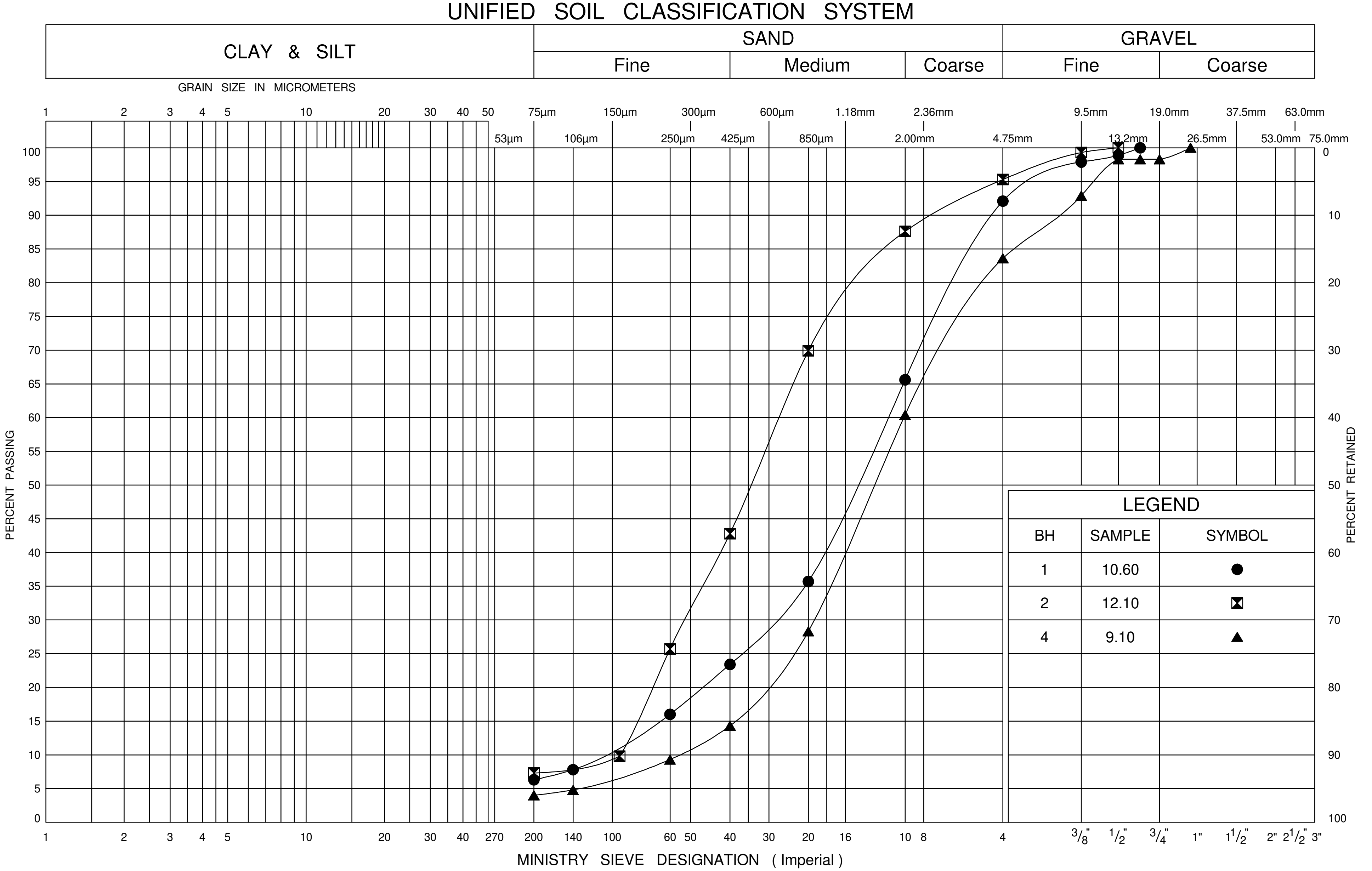
GRAIN SIZE DISTRIBUTION
SAND & GRAVEL / GRAVEL

FIG No 1

W P 6328-18-00

Steele River Hwy 17

78 12 M



BH	SAMPLE	SYMBOL
1	10.60	●
2	12.10	⊠
4	9.10	▲

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Ontario

GRAIN SIZE DISTRIBUTION
SAND

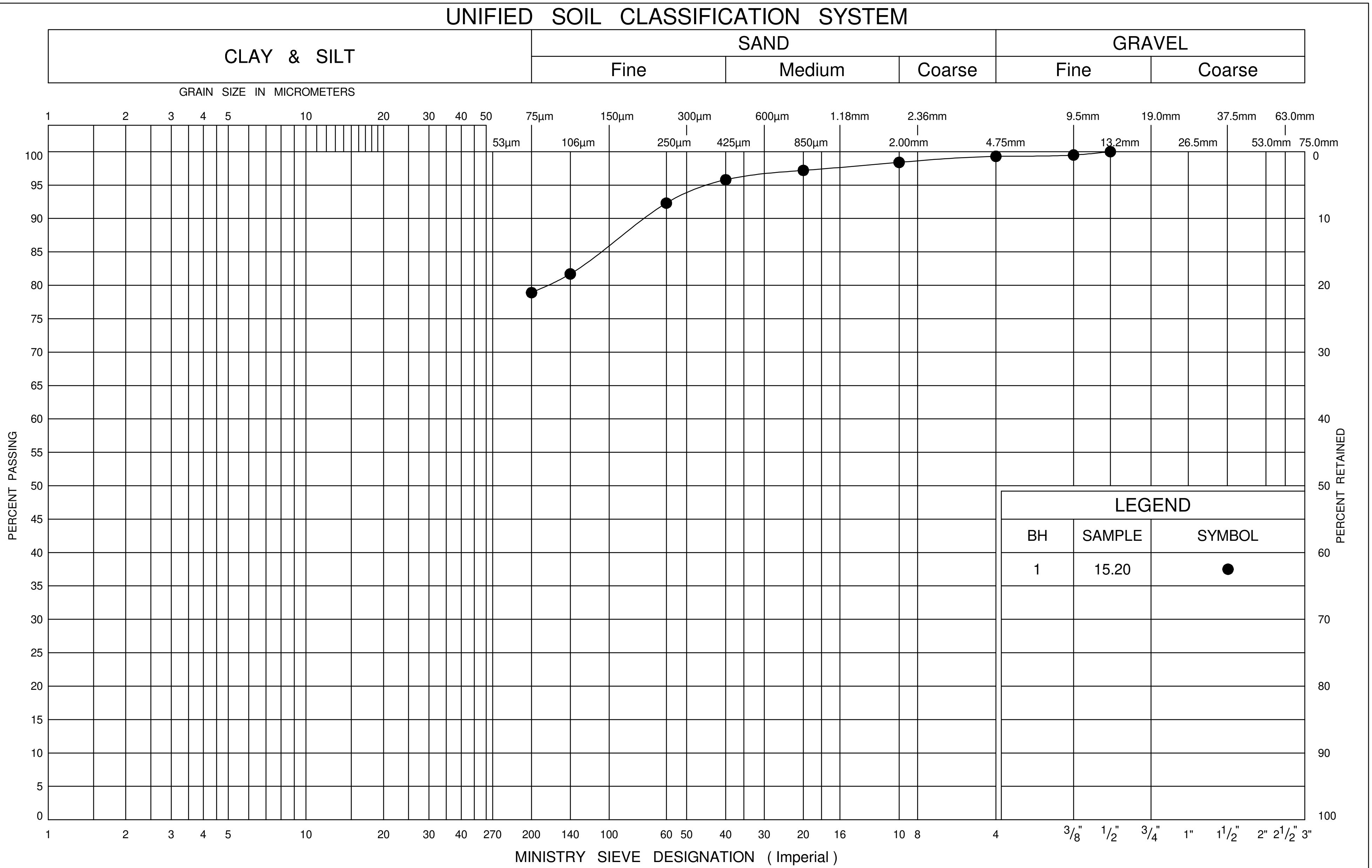
FIG No 2

W P 6328-18-00

Steele River Hwy 17

ONTARIO MOT GRAIN SIZE 20-656-6 MTO STEEL RIVER.GPJ ONTARIO MOT.GDT 8-26-22

78 12 M



ONTARIO MOT GRAIN SIZE 20-656-6 MTO STEEL RIVER.GPJ ONTARIO MOT.GDT 8-26-22

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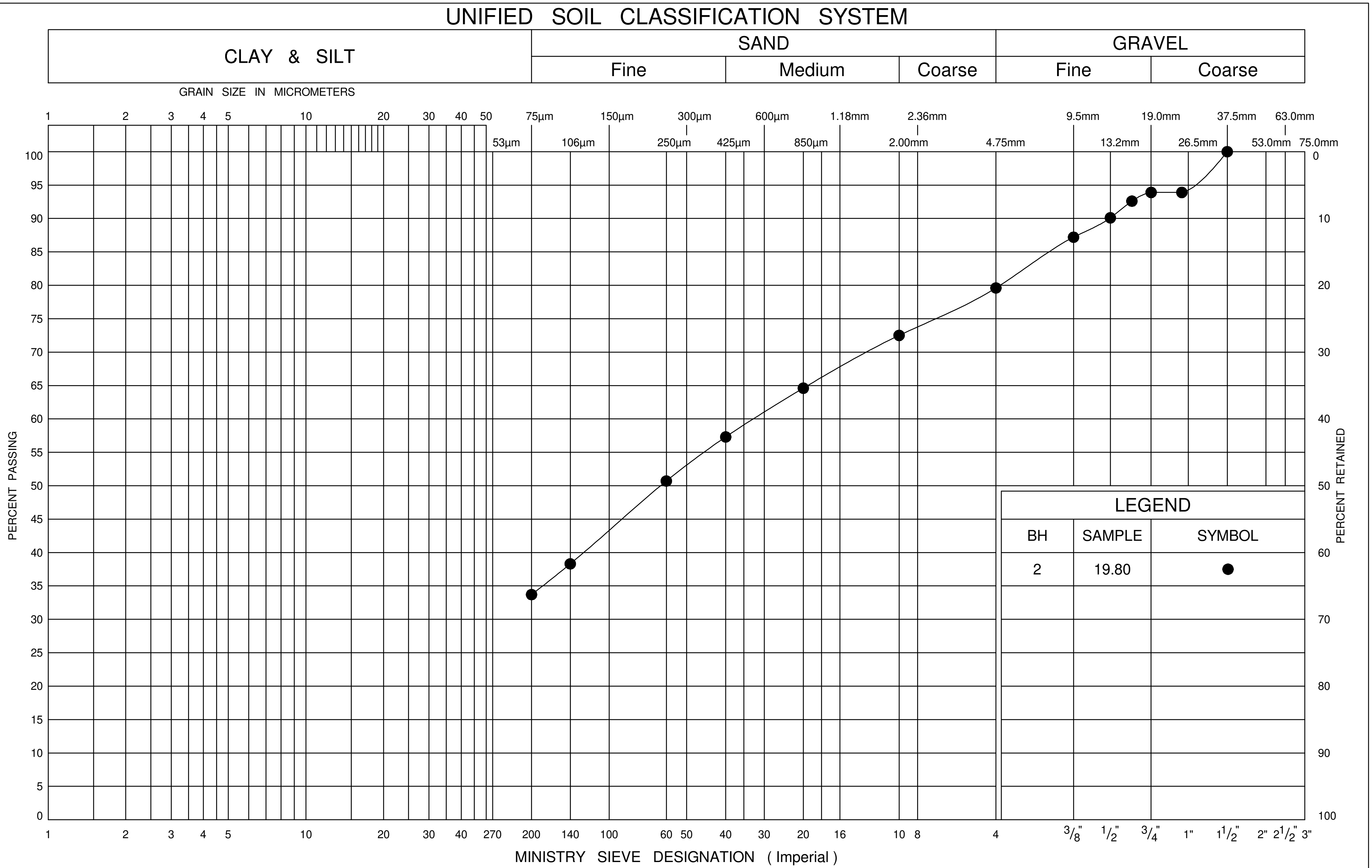
GRAIN SIZE DISTRIBUTION
SILT - Sandy

FIG No 3	
W P	6328-18-00
Steele River Hwy 17	

78 12 M



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GRAIN SIZE DISTRIBUTION
TILL - SAND

FIG No 4

W P 6328-18-00

Steele River Hwy 17

ONTARIO MOT GRAIN SIZE 20-656-6 MTO STEEL RIVER.GPJ ONTARIO MOT.GDT 9-9-22

APPENDIX C
Borehole Location and Soil Strata Drawings

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

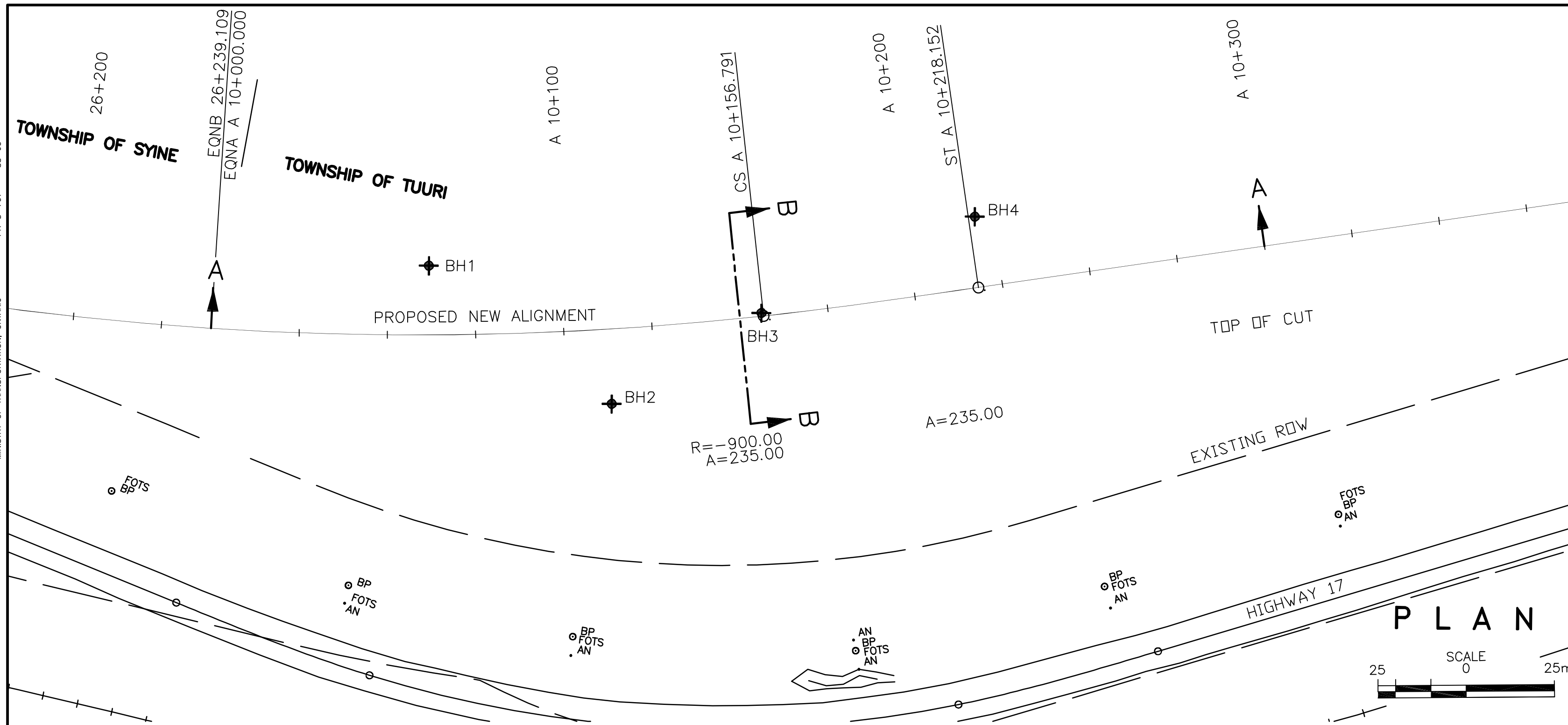
GEOCRES	No. .
CONT	No. 2022–xxxx
GWP	No. 6328–18–00

DEEP CUT
STEEL RIVER HIGHWAY 17
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

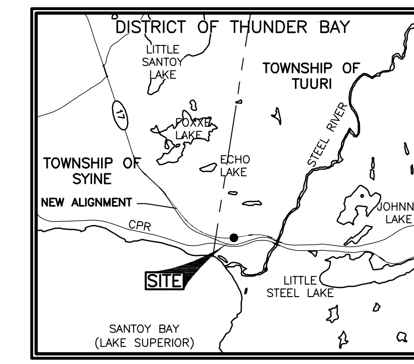
Ontario — Ministry of Transportation, Northwestern Region, Geotechnical Section

TBT ENGINEERING CONSULTING GROUP

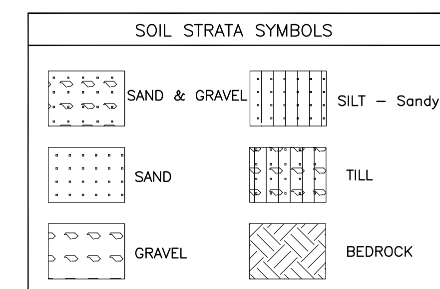


LEGEND

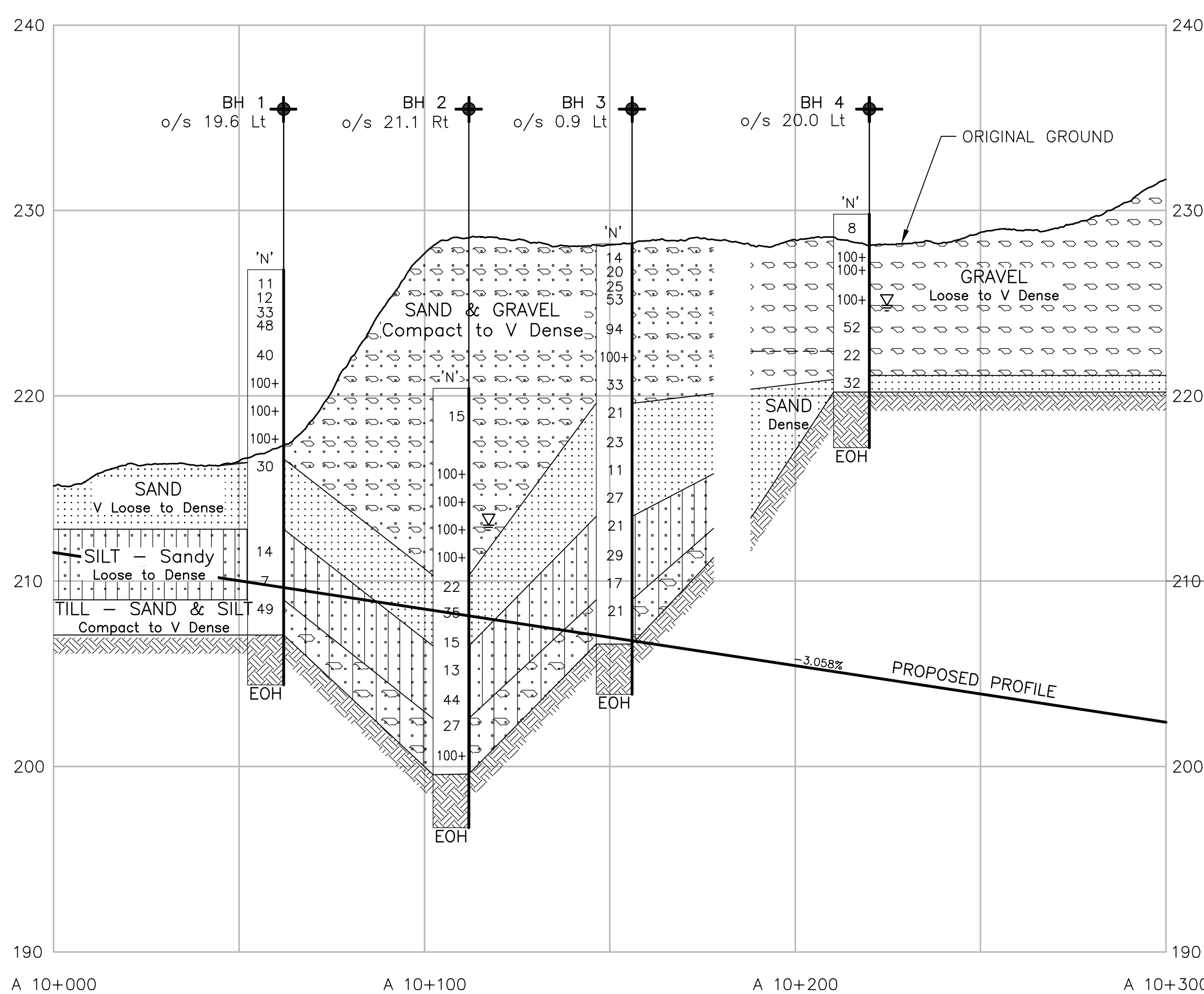
Symbol	Description
✚	Borehole
'N'	Std Pen Test (Blows/0.3m)
∇	Water Level on completion
EOH	End of Borehole
o B&H	Bell & Hydro Poles
o B	Bell Pole
• AN	Anchor
FOTS	Fibre Optic Transmission System



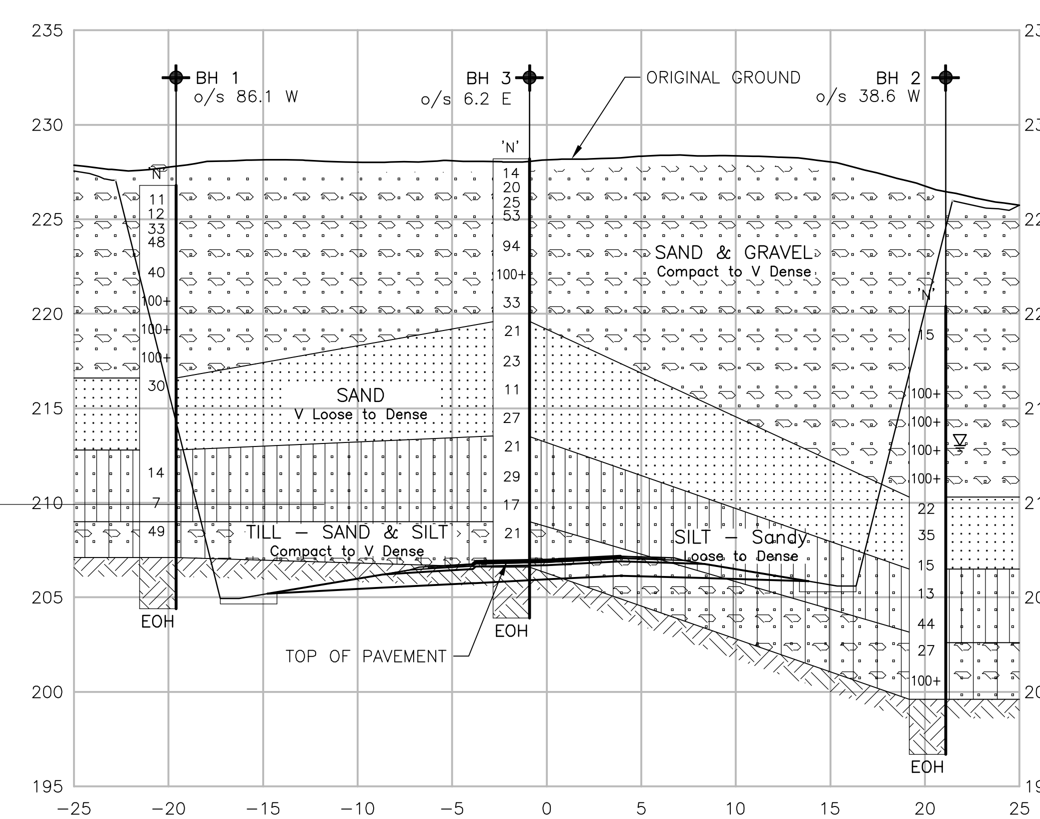
KEY PLAN
2.0 km 0 2.0 km



No	ELEVATION	CO-ORDINATES (MTM) NORTH	EAST
BH 1	226.8	14 5 404 167	312 487
BH 2	220.4	14 5 404 138	312 545
BH 3	228.2	14 5 404 171	312 582
BH 4	229.8	14 5 404 208	312 633



SECTION A – A
SCALE
HOR 25 0 25m
VERT 5 0 5m



SECTION B – B
SCALE
10 0 10m

S.W.S. SELLER 100043505 — LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

S. M. J. ANDERSON 100505351 — LICENSED PROFESSIONAL ENGINEER — PROVINCE OF ONTARIO

–NOTE–
The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

REFERENCE DRAWINGS SUPPLIED BY MTO.

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS		
11/03/22	SS	ISSUED FOR FINAL
09/09/22	SS	ISSUED FOR DRAFT
		DESCRIPTION

DESIGN	CHK	CODE .	LOAD XX-XXX-XXX	DATE 08/25/22	
DRAWN TG	CHK SS	SITE .		DWG	1

APPENDIX D
Slope Stability Models

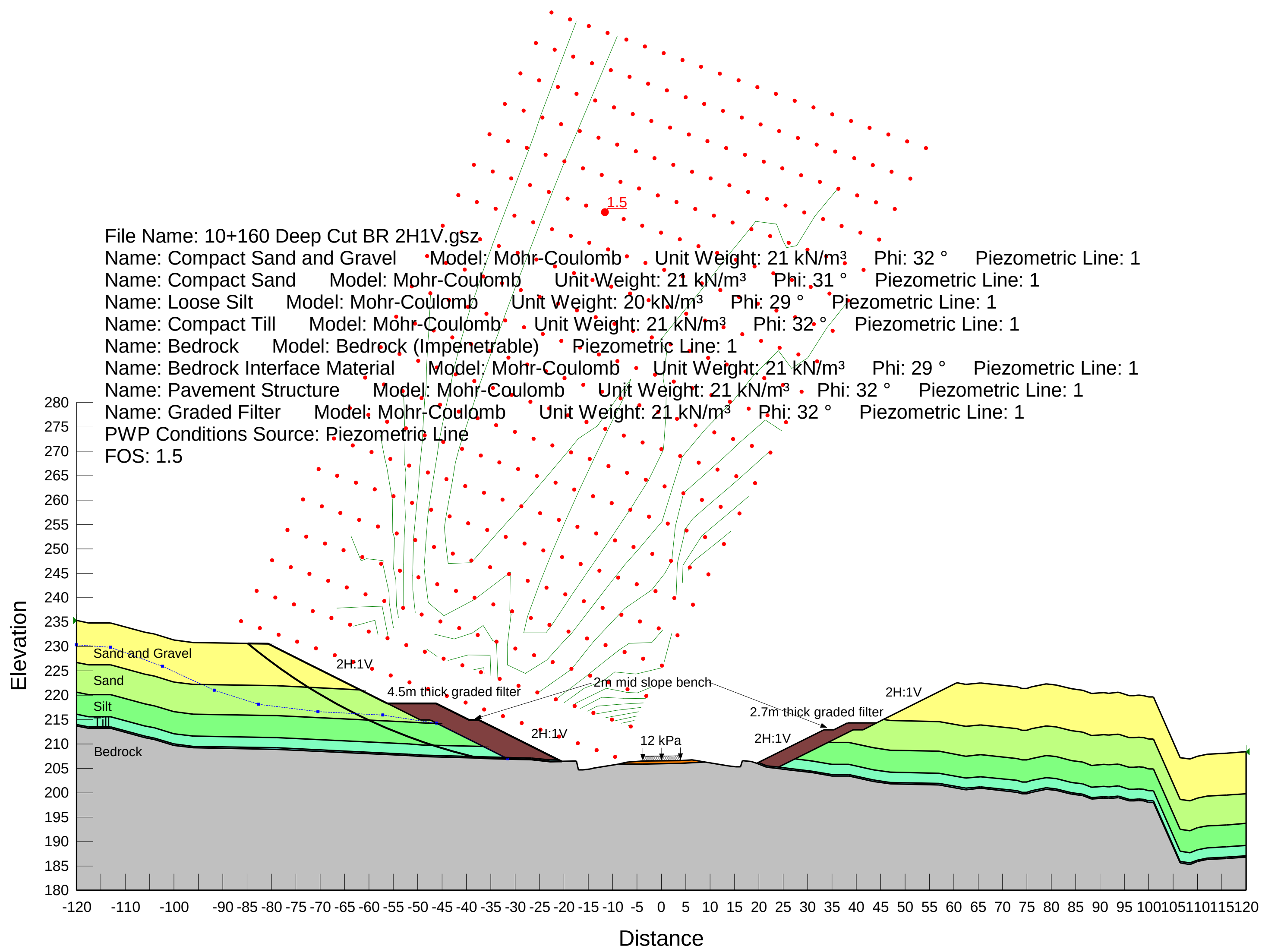


Figure D.1: Left Earth Cut Slope at 2H:1V with 4.5 m Thick Graded Filter for Earth Cuts Greater than 10 m.

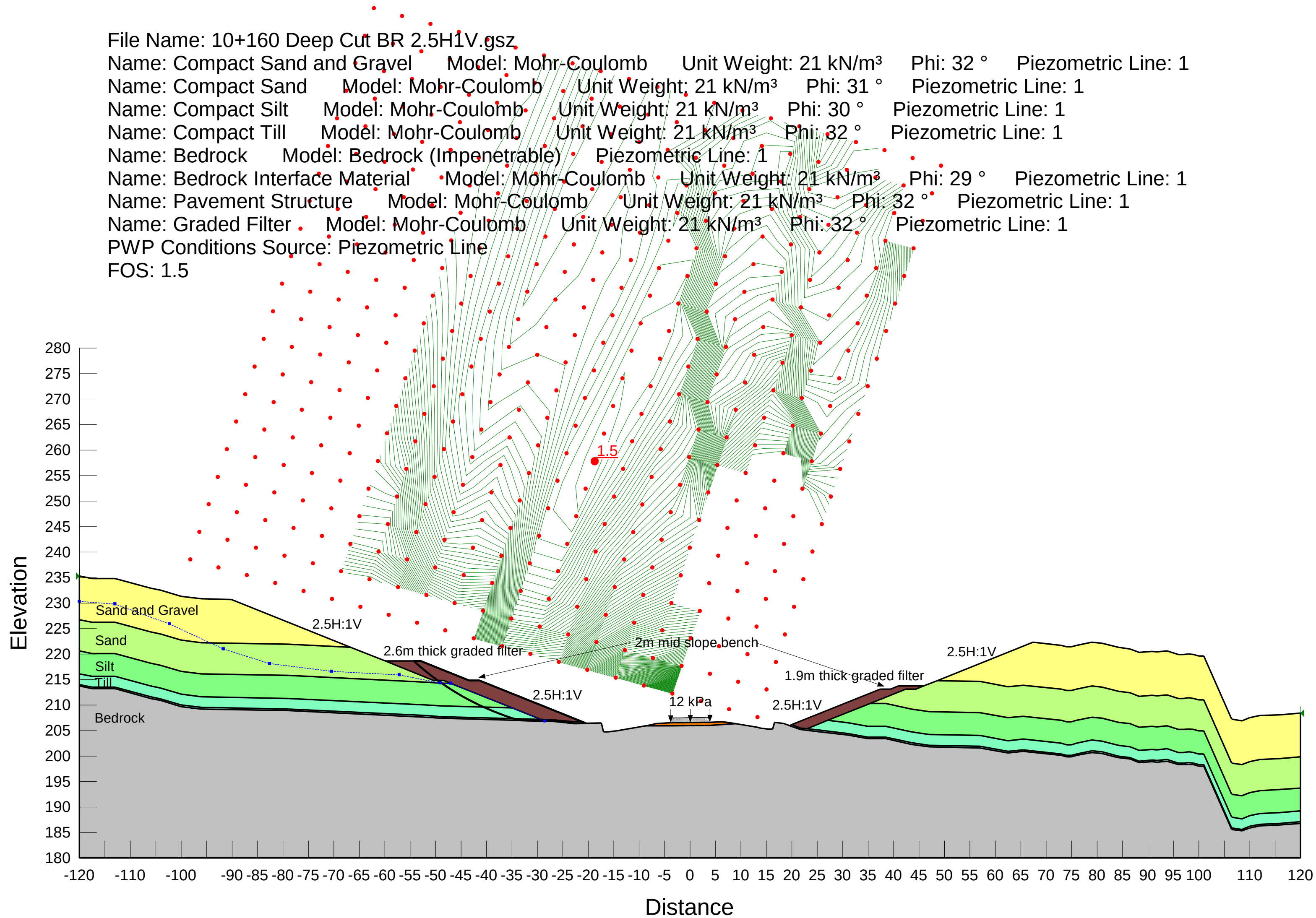


Figure D.2: Left Earth Cut Slope at 2.5H:1V with 2.6 m Thick Graded Filter for Earth Cuts Greater than 10 m.

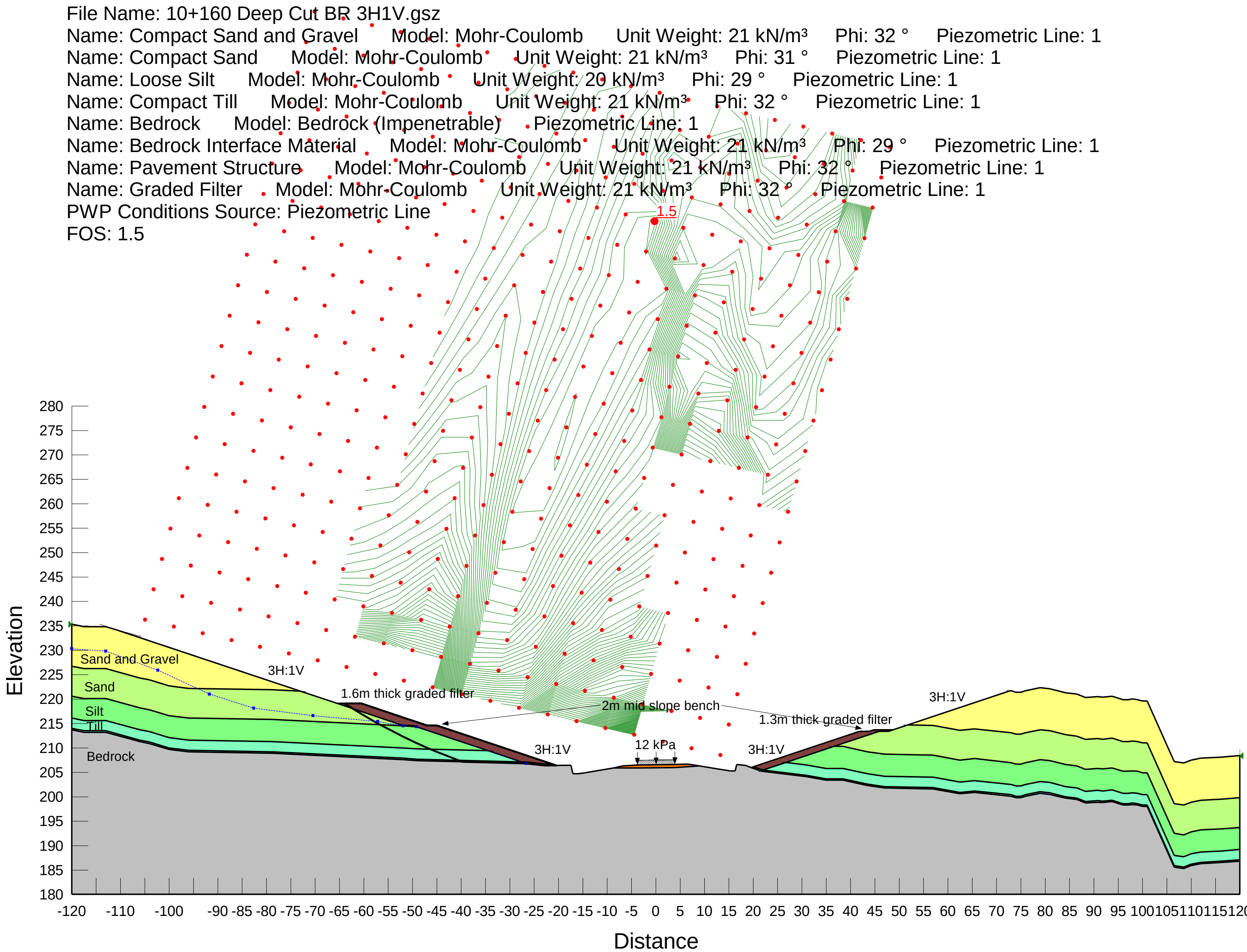


Figure D.3: Left Earth Cut Slope at 3H:1V with 1.6 m Thick Graded Filter for Earth Cuts Greater than 10 m.

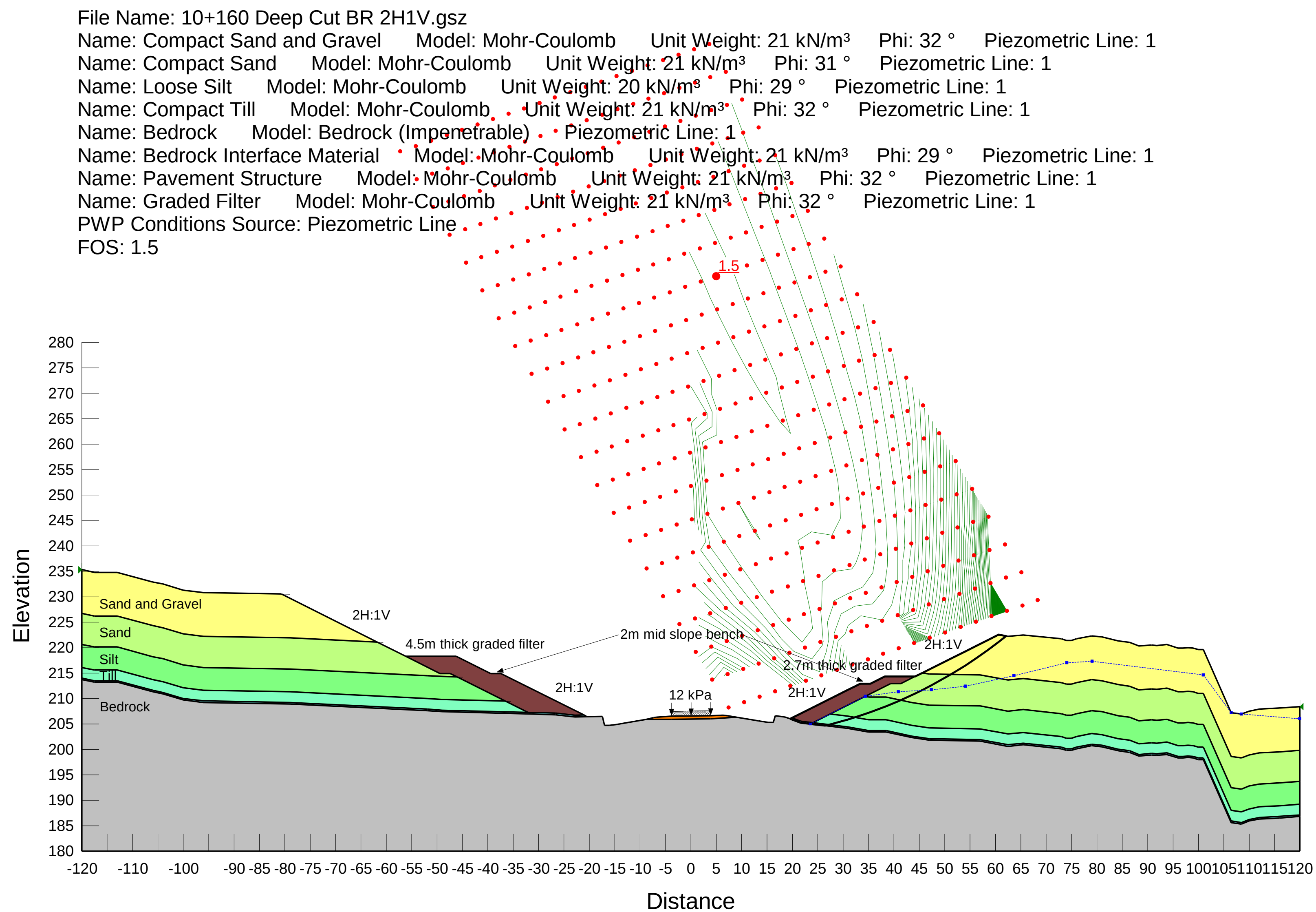


Figure D.4: Right Earth Cut Slope at 2H:1V with 2.7 m Thick Graded Filter for Earth Cuts Greater than 10 m.

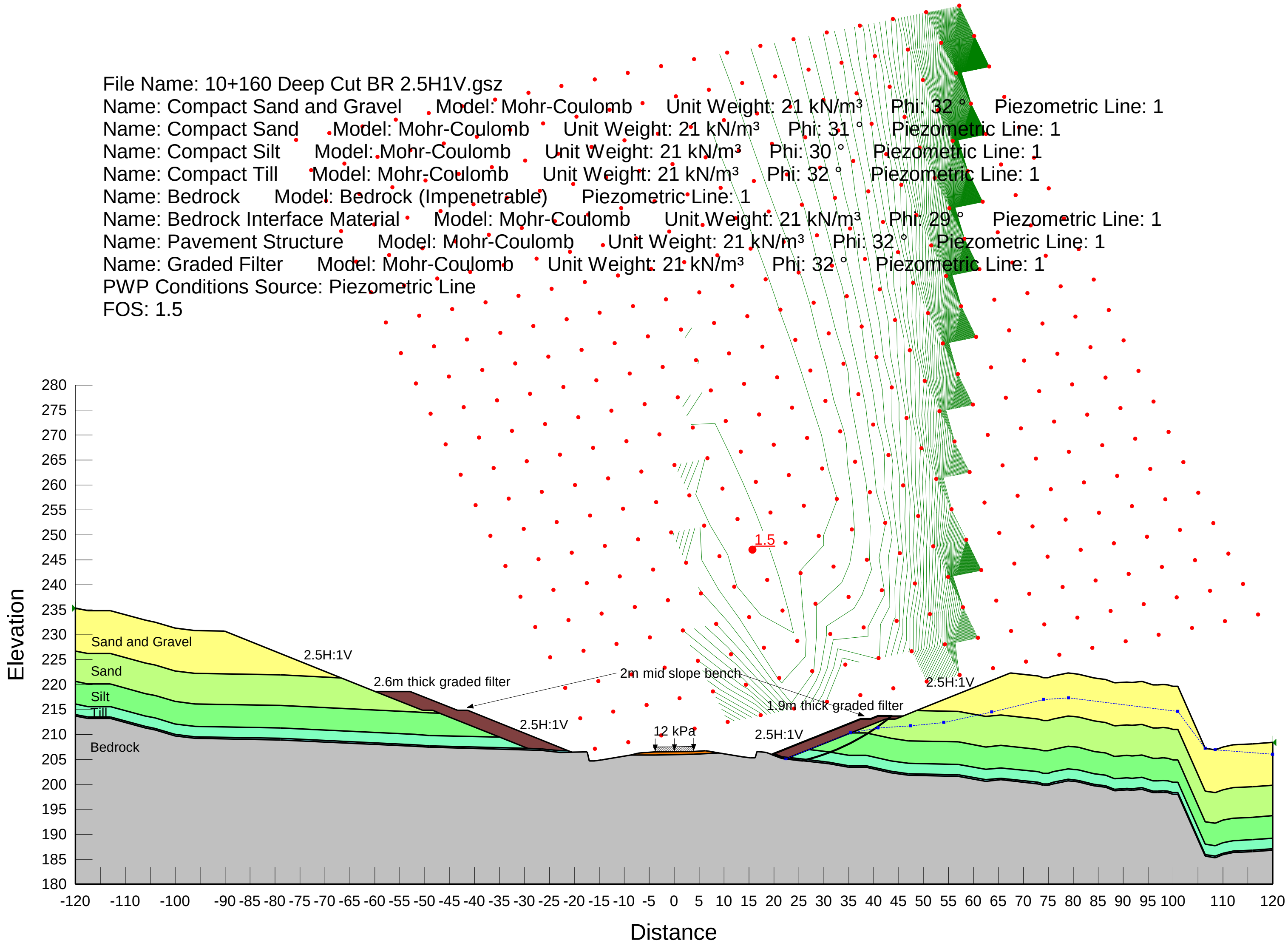


Figure D.5: Right Earth Cut Slope at 2.5H:1V with 1.9 m Thick Graded Filter for Earth Cuts Greater than 10 m.

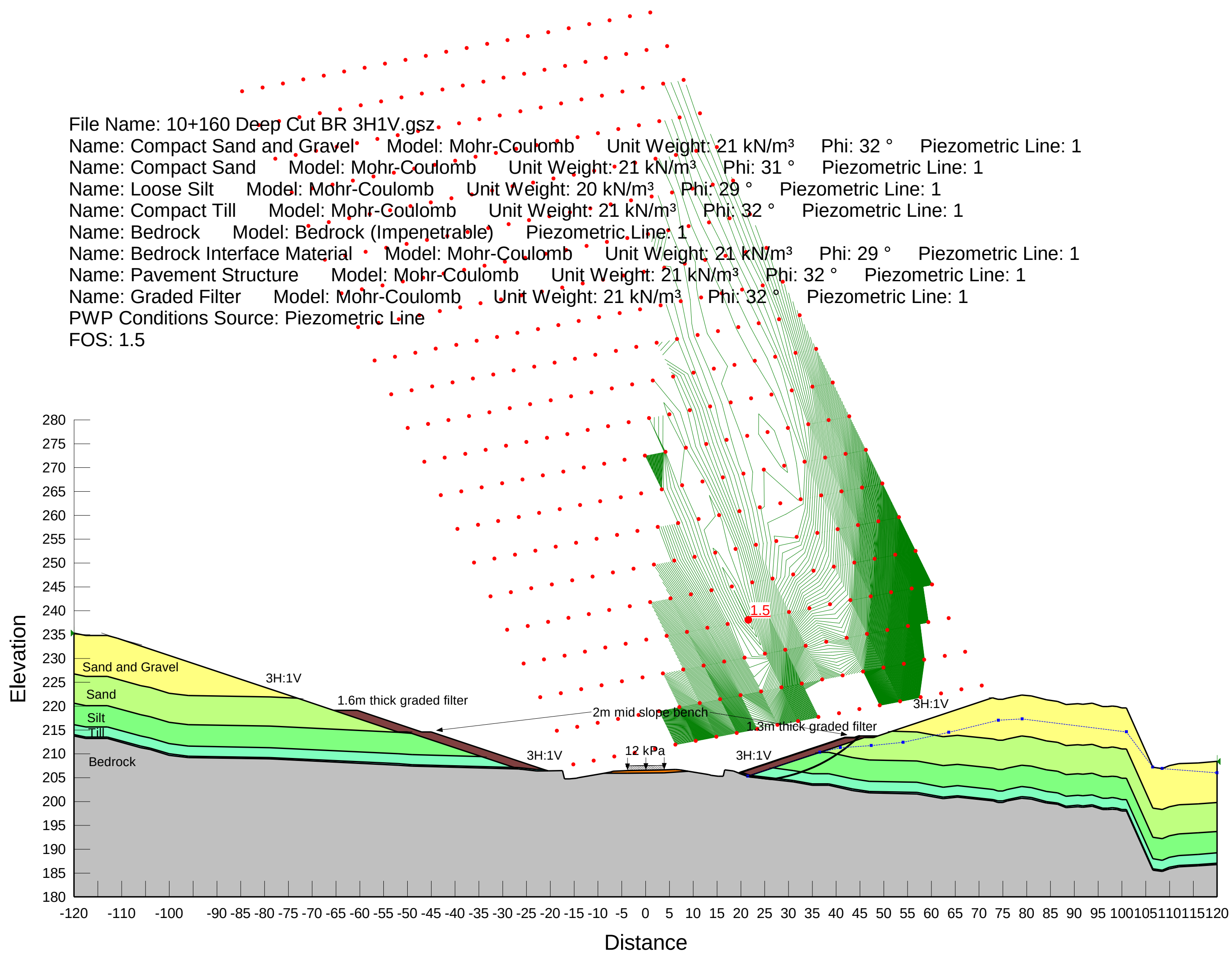


Figure D.6: Right Earth Cut Slope at 3H:1V with 1.3 m Thick Graded Filter for Earth Cuts Greater than 10 m.

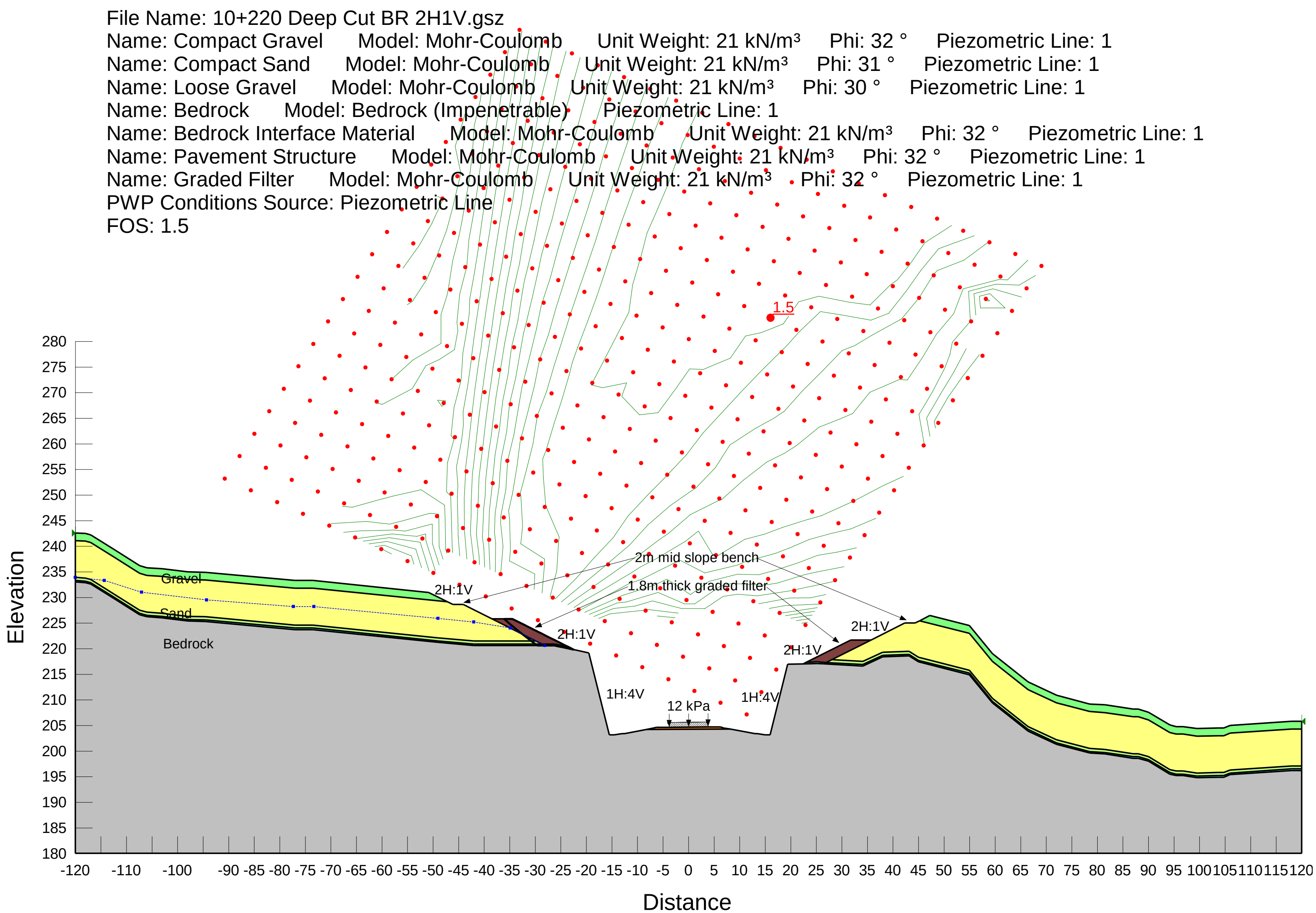


Figure D.7: Left Earth Cut Slope at 2H:1V with 1.8 m Thick Graded Filter for Earth Cuts Less than 10 m.

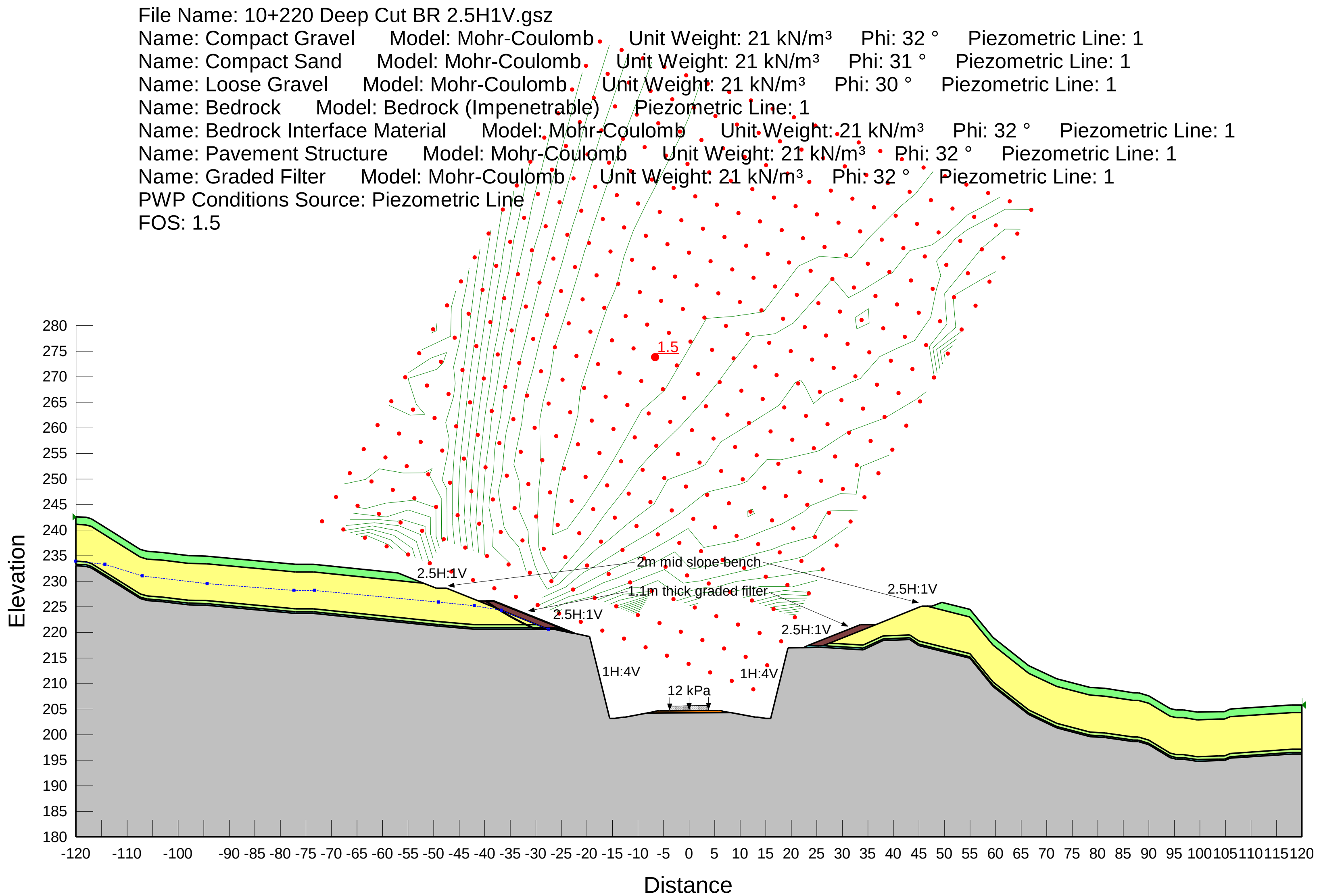


Figure D.8: Left Earth Cut Slope at 2.5H:1V with 1.1 m Thick Graded Filter for Earth Cuts Less than 10 m.

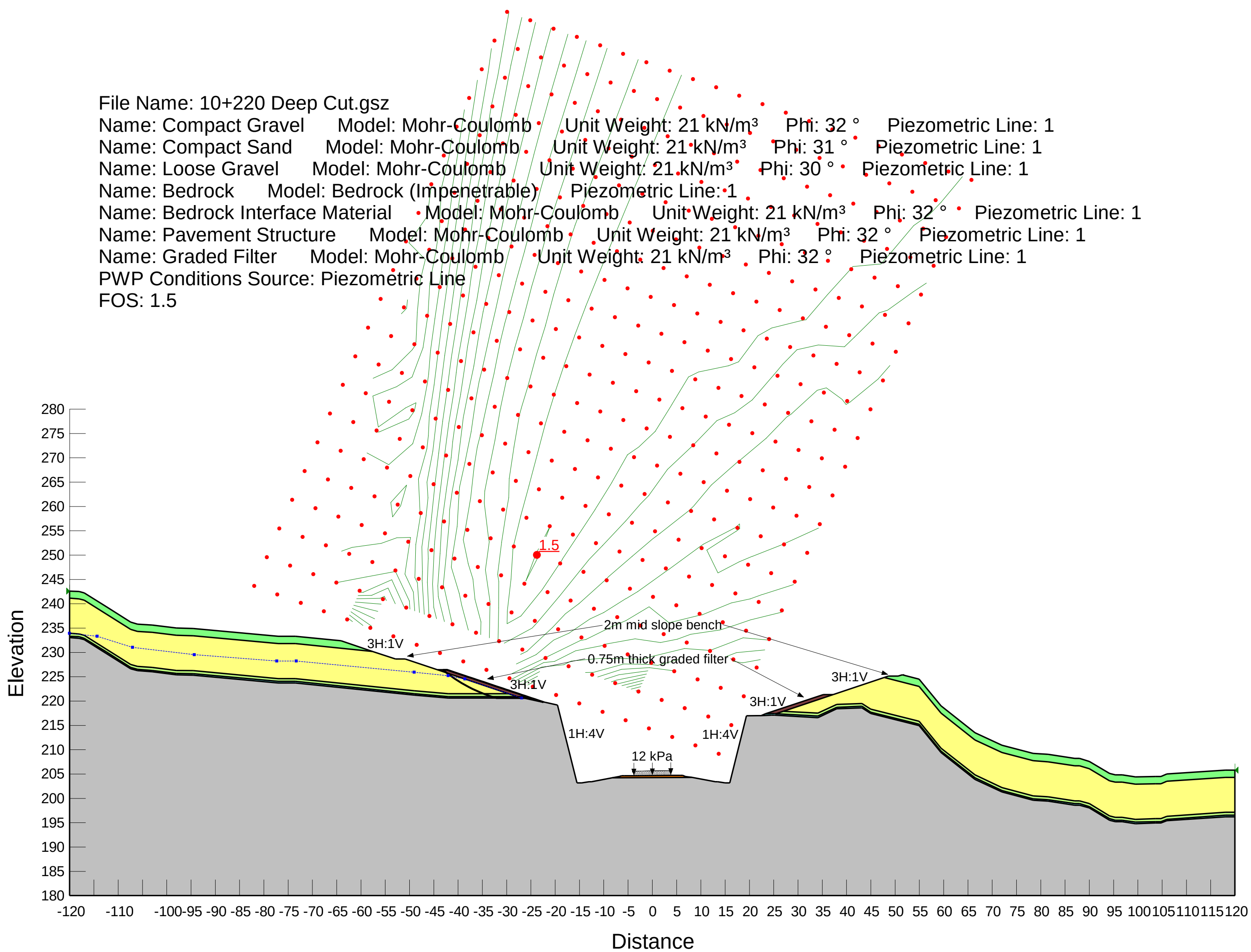


Figure D.9: Left Earth Cut Slope at 3H:1V with 0.75 m Thick Graded Filter for Earth Cuts Less than 10 m.

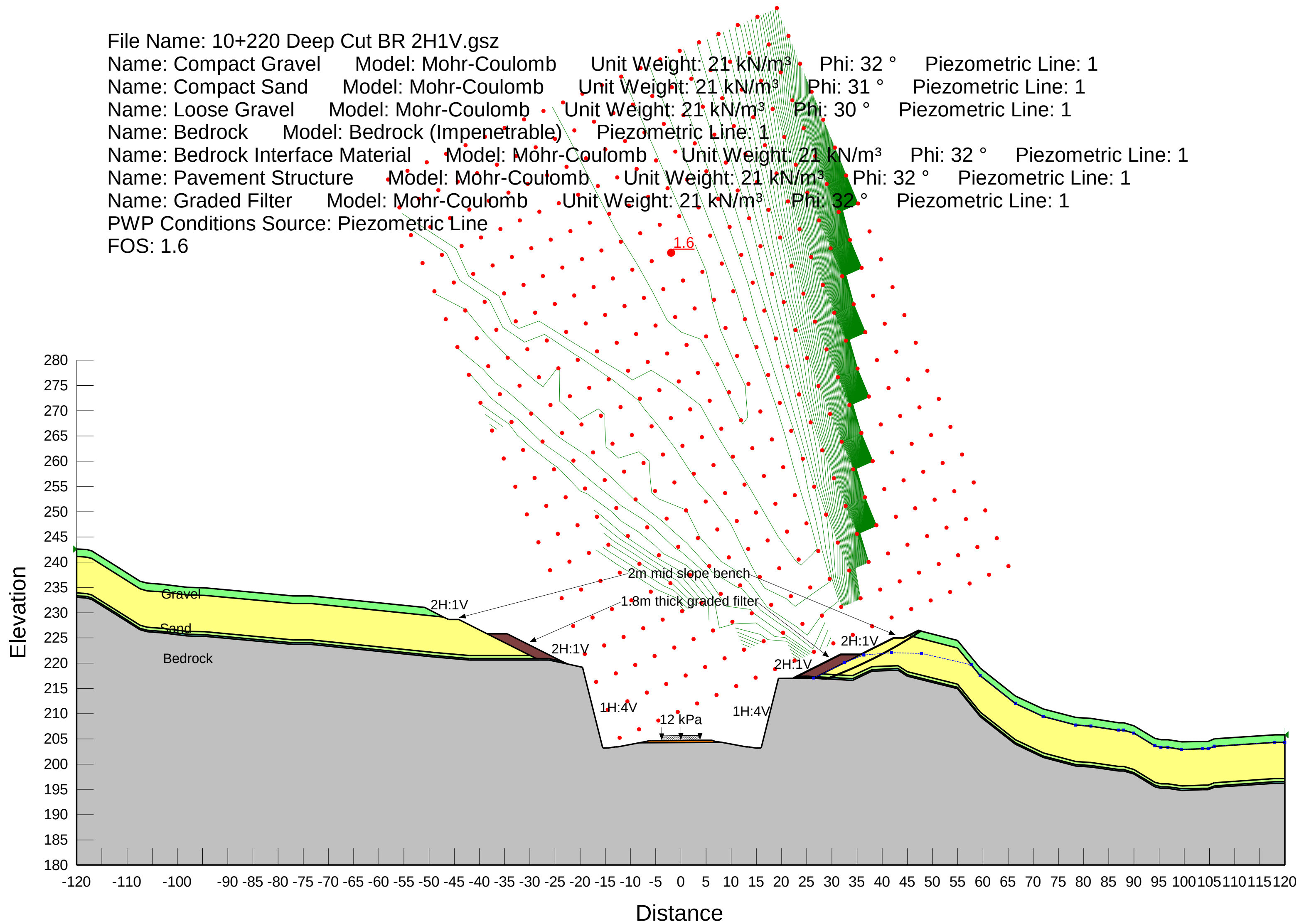


Figure D.10: Right Earth Cut Slope at 2H:1V with 1.8 m Thick Graded Filter for Earth Cuts Less than 10 m.

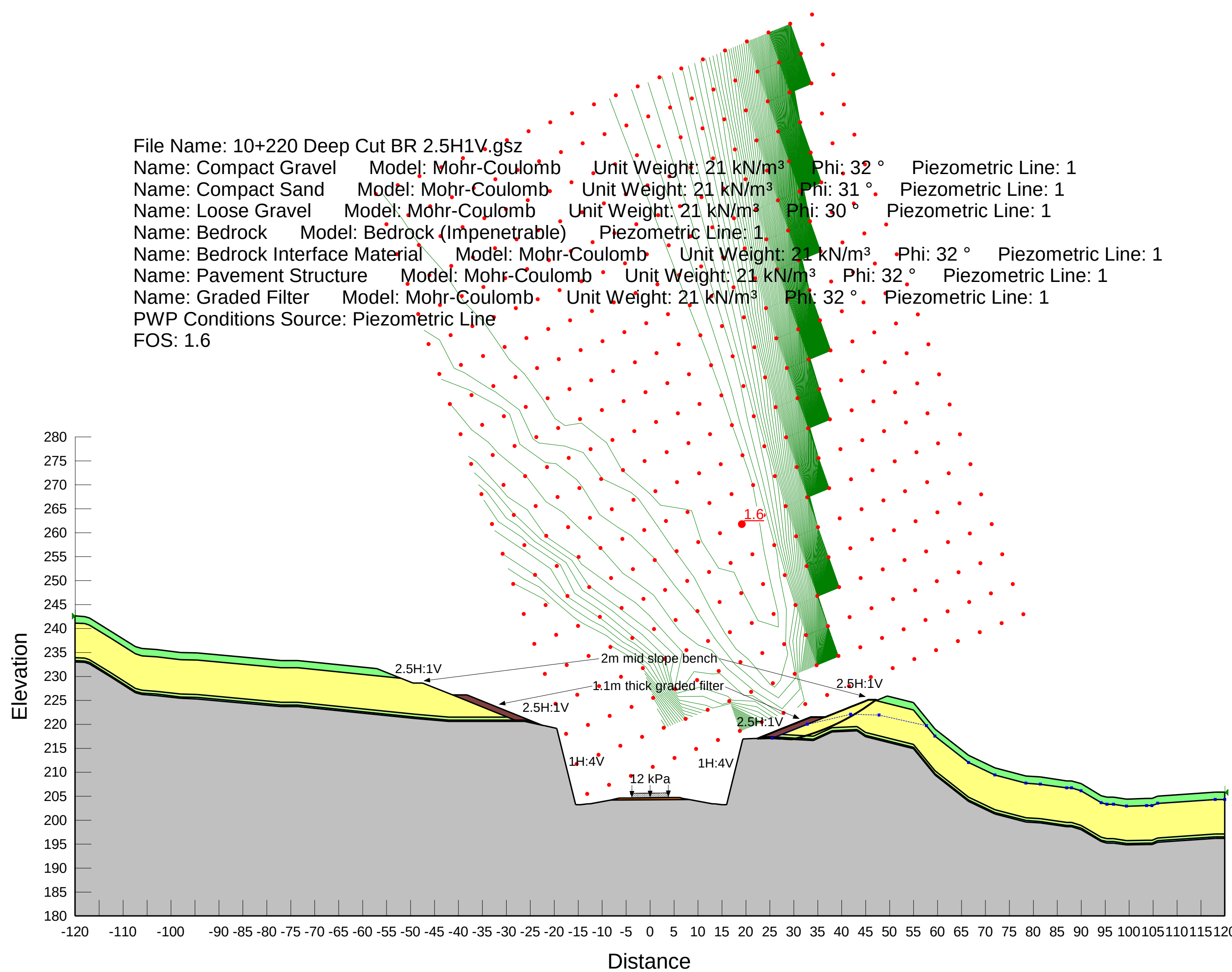


Figure D.11: Right Earth Cut Slope at 2.5H:1V with 1.1 m Thick Graded Filter for Earth Cuts Less than 10 m.

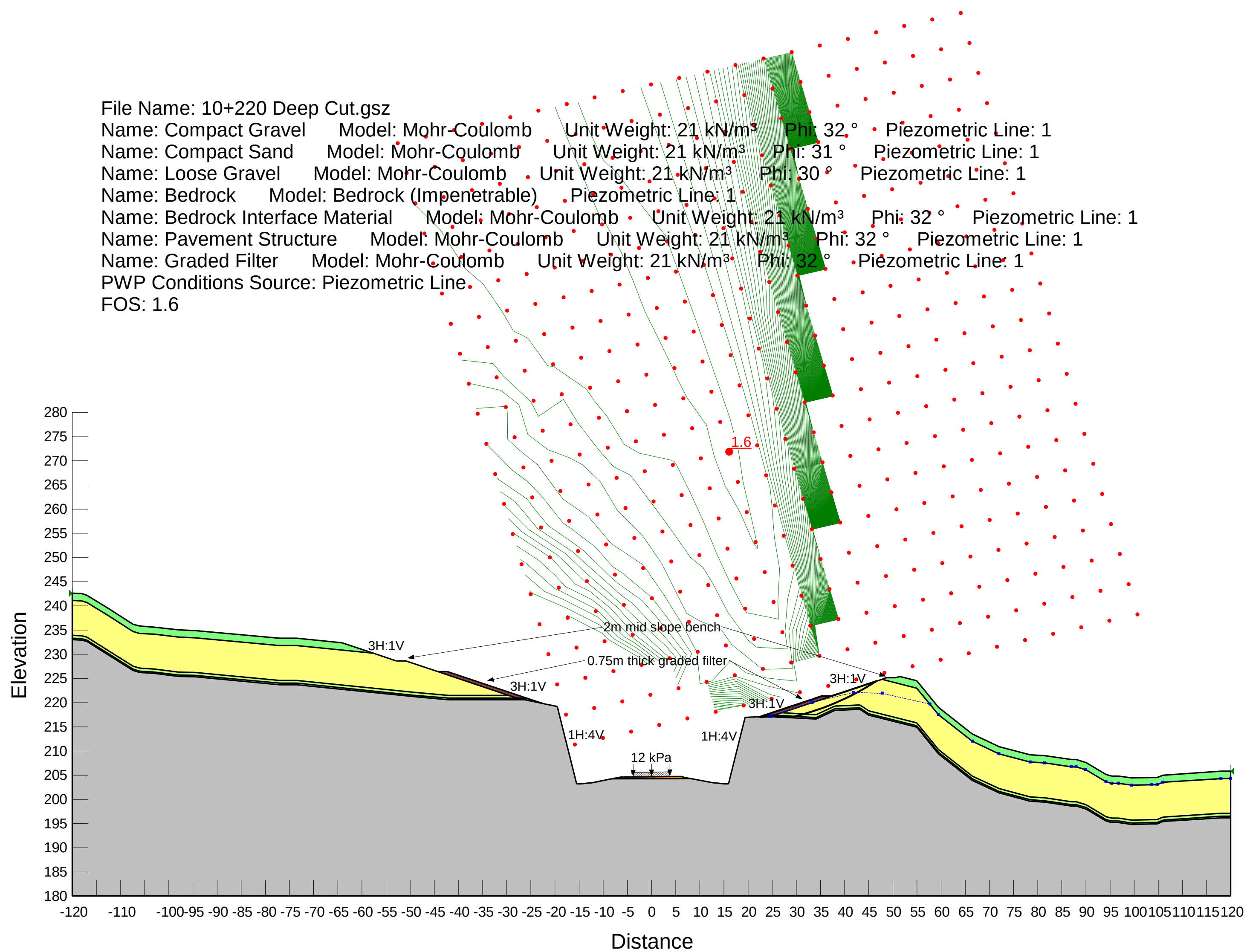


Figure D.12: Right Earth Cut Slope at 3H:1V with 0.75 m Thick Graded Filter for Earth Cuts Less than 10 m.