



**Foundation Investigation and Design Report
Highway 11/17, Embankment Widening for New
Eastbound Passing Lane
East of Kakabeka Falls
Station 14+110 to Station 14+240
Township of Paipoonge**

GWP 544-00-00

Geocres No.: 52A-141

**Prepared for
Ministry of Transportation, Northwestern Region**

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Part A - FOUNDATION INVESTIGATION REPORT

1 Introduction

TBT Engineering (TBTE) has been retained by the Ministry of Transportation (MTO) to provide foundation investigation and design services for a proposed embankment widening (4.5 m) to facilitate an eastbound passing lane east of Kakabeka Falls along the Highway 11/17. The foundation investigation was carried out to investigate subsurface conditions between Sta. 14+110 and Sta. 14+240 Paipoonge Township (east of the intersection with Highway 588), where the embankment crosses an existing valley.

This investigation consisted of a number of boreholes drilled in the vicinity of the proposed new widening, laboratory testing and geotechnical analysis of the data. This report (Part A) describes the subsurface conditions encountered during the investigation.

The foundation section has assigned GEOCRES No. 52A-141 to this site.

2 Site Description

The foundation investigation was carried out to investigate subsurface conditions between Sta. 14+110 and Sta. 14+240 Paipoonge Twp. (starting approximately 200 m east of the intersection with Highway 588). The highway embankment is approximately 13 m in height and crosses a relatively narrow natural valley.

The site is located approximately 30 km west of Thunder Bay. At this location, the highway runs in an east west direction.



Standing on the culvert looking West



Standing on the Culvert looking East

2.1 Surficial Geology

The project area is mapped (Ontario Geological Survey Report GR164, Burwasser, 1977) as underlain by deposits associated with the Kaministiquia glacial spillway. The shallow sands and silts (and organics) encountered were likely deposited as part of an extensive delta upland, where melt waters and sediment of the spillway entered a post-Minong level of a glacial lake in the Superior basin. Further down in the sequence, silts and massive or varved clays represent deeper water, offshore environment on more distal parts of the delta where the spillway entered glacial Lake Minong (highest level of glacial lake in the Superior Basin) approximately 9300 years ago.

3 Investigation Procedures

A geotechnical site investigation was undertaken between June 15 and 17, 2009 which included 4 boreholes. The borehole locations are illustrated on the Borehole Location Plan and Strata Drawings, Appendix C. Subsequent to this investigation a number of hand auger (Pedo) holes were drilled to delineate organic deposits identified in the initial field work.

Borehole 1 was advanced with a 75 mm diameter PVC casing using wash boring techniques through the water at the end of the existing culvert. Split spoon sampling and testing was carried out by hand using a 70 lb hammer. SPT “N” values were estimated by dividing the number of blows / 0.3 m obtained with the 70 lb hammer by a factor of 2.

Boreholes 2 to 4 were carried out using a CME 750 drill rig equipped for geotechnical testing and sampling. Hollow stem auger methods were utilized. Soil samples were obtained at the boreholes using a split spoon sampler as a part of the Standard Penetration Testing (SPT). The SPT involves driving a thick walled sampler into the soils under a standardized energy (63.5 kg, falling 760 mm). The number of blows required to drive the sampler 0.3 m is known as the SPT blow count (N).

Borehole locations were measured in the field and ground surface elevations surveyed. Boreholes were referenced to the centre line grade at Station 14+200. The centre line elevation at this station was interpreted as 258.77 m based on survey data obtained from B&C plans 297-11&17-4 survey dated September 2002.

In addition to the boreholes, 11 pedo holes were carried out to better define the limits and extent of shallow peat / organics. Pedo holes 1 to 8 were advanced along the east bound right-of-way. Pedo holes 9 to 11 were advanced along the south toe of slope.

A summary of the borehole and pedo hole location data is provided on the enclosed Borehole Location Plan and Strata Drawings, Appendix C.

The borehole characteristics are summarized in Table 1.

Table 1: Drill Summary

Location	Surface Elevation (metres)	Bottom of Borehole (metres)		Ground Water at Completion (metres)		Base of Peat/Organics (metres)	
		Elevation	Depth	Elevation	Depth	Elevation	Depth
BH 1	246.4	242.1	4.3	Water at surface		-	-
BH 2	246.4	237.0	9.4	244.2	4.2	245.1	1.3
BH 3	246.3	232.3	14.0	238.9	7.4	245.0	1.3
BH 4 (through embankment)	258.4	242.9	15.5	Dry		-	-
P1	246.4	243.5	2.9	Water at surface		-	-
P2	246.4	244.2	2.2	Water at surface		244.7	1.7
P3	246.5	244.4	2.1	246.3	0.2	244.5	2.0
P4	246.9	245.3	1.6	246.6	0.3	245.6	1.3
P5	246.4	244.6	1.8	Water at surface		244.7	1.7
P6	247.3	246.3	1.0	Dry		246.3	1.0
P7	249.0	246.5	2.5	247.0	2.0	-	-
P8	248.2	246.6	1.6	Dry		-	-
P9	246.6	245.5	1.1	246.4	0.2	245.9	0.8
P10	247.1	245.0	2.1	246.4	0.7	-	-
P11	246.8	244.5	2.3	246.3	0.5	244.8	2.0

The boreholes were backfilled at the completion of the investigations using a bentonite backfill mixture to ensure the environmental integrity of the site and in compliance with Ontario Regulation 903.

Soil samples were transported to TBT Engineering's laboratory in Thunder Bay for testing. Routine testing included moisture content, Atterberg limits and grain size analysis. The results of this testing are shown on the Borehole Logs (Appendix A) and on the laboratory data reports (Appendix B).

4 Sub-Surface Conditions

Details of the subsurface conditions are provided on the borehole logs (Appendix A) and on the Soil Strata Drawings (Appendix C).

As observed at Borehole 4, the embankment was found to consist of asphalt hot mix underlain by 15 m of granular fills (varying from sands to sandy silt). Along the right (south) side toe of the embankment, peat was encountered below shallow fills and extended to depths of up to 2.0 m. At the culvert outlet, the creek bed was found to consist of silty sand. Below the embankment fills and the peat, the native foundation soils were found to consist of upper strata of sands and silts underlain by a thick clay stratum with occasional silt substratum.

4.1 Asphalt

A 75 mm thick layer of asphalt hot mix was encountered at the surface of Borehole 4.

4.2 Fill

As indicated at Borehole 4, the existing embankment consists of up to 15 m of granular fill which consists of variable zones of sand and gravel, sand and silty sand. Grain size analyses carried out on selected samples indicates the embankment fills can consist of 0-1 % gravel, 71-90 % sand, and 9-29 % silt and clay sized particles. The fill within the embankment is generally in a compact to dense condition with SPT (N) values of 21 to 31 blows/0.3 m. One loose zone, with an SPT "N" value of 4 blows/0.3 m, was identified at a depth of 7.6 m.

Fill encountered at/adjacent to the south embankment toe can consist of sand to sandy silt with trace to some organic. This fill was encountered in Boreholes 1, 2 and 3 and within all the probeholes, with the exception of Probeholes 7, and 8. The fill ranged in thickness around the culvert location from 1.3 to 2.1 m and extended to elevations ranging from 243.5 and 245.0 m (Borehole 1, Probeholes 1, 10 and 11). Fill, away from the culvert ranged in thickness from 0.2 to 0.9 m and extended to elevations ranging from 245.1 and 246.7 m.

4.3 Peat

Peat with trace to some silt and sand was encountered below the above noted fills at and to the right of the right side toe generally between stations 14+152 and 14+217. The peat extends to

depths of up to 2.0 m with a base elevation of 244.5 m. Deeper zones may exist between and/or outside of the test hole locations. The natural moisture contents of the peat varied from 62 to 229% (dry weight basis). Peat was not encountered below the culvert.

4.4 Sands and Silts

Below the embankment fill and organic layer along the south side toe, interbedded layers of sand, silty sand and silt were encountered. The sands and silts generally vary from 0.3 to 3.3 m in thickness and extend to elevations of 241.7 to 243.5 m at the boreholes. Zones with trace to some organics were noted throughout this stratum. The sands silts are in a loose to compact condition with SPT “N” values of 5 to 25 blows / 0.3 m.

4.5 Clay

Silty clay was encountered below the sands and silts at Boreholes 1 to 3. The top of the clay layer was encountered between elevations of 241.7 m to 243.5 m. The clay stratum was not encountered at Borehole 4 as this borehole was terminated at an elevation of 243.0 m. The clay stratum has a stiff to hard consistency as indicated by SPT “N” values of 9 to 57 blows / 0.3 m and a field vane test in excess of 100 kPa. An undrained direct shear test was carried out on sample from Borehole 3 at a depth of 9.1 m. The results of this test indicate an undrained shear strength of 68 kPa. A set of drained direct shear tests were also carried out on this sample and indicate a lower bound effective angle of internal friction of 27° with an effective cohesion intercept of 0 kPa. Atterberg limit testing indicates the clay is of low to medium plasticity with the natural moisture contents generally between the liquid and plastic limits.

Two discontinuous silt layers were noted within the clay stratum. One at Borehole 2 which exists between depths of 4.6 and 5.2 m (el 241.9 to 241.2), and one at the bottom of Borehole 3 which was encountered at a depth of 13.1 m and extended to borehole terminations (14.0 m). These silt layers are in a dense to very dense condition as indicated by SPT “N” values of 36 to 76 blow/0.3 m.

4.6 Ground Water

The ground water levels observed during the field drilling investigation have been provided in Table 1. The observed ground water levels varied from dry to water at surface. Groundwater level readings taken upon completion of the boreholes would not have had time to stabilize. It should be noted that at the time of this investigation, ponded water had flooded a large area along the south side of the embankment due to the presence of a beaver dam. The ponded water level was measured at elevation 246.4 m. Observed ground water levels at the boreholes below an elevation of 246.4 m are not considered to be representative of the actual ground water level at the time of this investigation. The actual ground water level is expected to at or above elevation 246.4 m.

Ground water levels will vary from season to season and from the effects of heavy precipitation events.

5 Miscellaneous

Laboratory testing was carried out at the TBT Engineering laboratory in Thunder Bay. The field operations were supervised by Herman Finke. Laboratory testing was supervised by T. Fummerton C.E.T. This report was prepared by G. Maki, P.Eng, and reviewed by W. Hurley, P.Eng.

Part B - FOUNDATION DESIGN RECOMMENDATIONS

6 Introduction

TBT Engineering (TBTE) has been retained by the Ministry of Transportation (MTO) to provide foundation investigation and design services for a proposed embankment widening (4.5 m) to facilitate an eastbound passing lane east of Kakabeka Falls along the Highway 11/17. The foundation investigation was carried out to investigate subsurface conditions between Sta. 14+110 and Sta. 14+240, Paipoonge Township (just east of the intersection with Highway 588), where the embankment crosses an existing valley.

An existing rigid frame box centreline culvert, 1.83x1.83x73 m in size is located at the bottom of the valley.

The existing south side embankment slope is constructed at a grade of 1.8H:1V and is approximately 13 m high.

The foundation investigation as described in Part A, was carried out to investigate subsurface conditions at this site. This investigation consisted of one borehole located through the existing embankment, two boreholes located along the south side toe of the embankment and one borehole located south of the existing culvert. In addition, 11 pedo holes were carried out to investigate the depth and extent of a shallow layer of buried peat/organics.

The native foundation soils at this site consist of peat/organics underlain with interbedded layers of sands and silts overlying stiff to hard clays.

The native sands, silts and clay foundation soils are not expected to lead to any significant foundation stability and/or settlement performance issues. However, relatively shallow deposits of very loose fills overlying peat/organics were encountered below the proposed widening. These materials must be removed. Given the close proximity to the property limits, the excavation required to remove these materials below the proposed widening could result in the construction limits extending to or beyond the property limit. Several options were reviewed to minimize the risk of construction extending beyond the property limit.

The purpose of this section of the report (Part B) is to document the options investigated, review the geotechnical analyses undertaken, and to provide specific foundation recommendations for the recommended option. These are based on the conditions encountered at the test hole locations, TBTE's interpretation of the subsurface conditions at the site and the available highway design criteria.

7 Review of Foundation Options

A review of various foundation options was completed for this project. As the foundation soils were generally found to be competent (with the exception of the peat layer), the use of light weight fills, preloading and/or wick drains to improve stability and/or settlement performance were not deemed necessary. The existing peat below the proposed construction is to be removed. Various options to facilitate the proposed construction while reducing the risk of construction extending beyond the existing right-of-way were considered. The options considered are as follows:

Option 1:

Subexcavation of the existing loose fills and peat followed by construction with granular fills at a slope of 2H:1V. Option 1A considers the slope without a bench while Option 1B includes a 2 m wide mid slope bench.

Option 2:

Subexcavation of the existing loose fills and peat followed by construction with rock fill and granular fill. Rock fill is utilized below elevation 249.7 m (1.25H:1V slope). Granular fill is utilized above elevation 249.7 m (2H:1V slope). Option 2A considers the slope without a bench while Option 2B includes a 2 m wide mid slope bench.

Option 3:

Subexcavation of the existing loose fills and peat followed by construction with rock fill to underside of pavement structure. Rock fill to be graded at a slope of 1.25H:1 below a 2.0 m wide bench at elevation 250.25 m. Rock fill to be graded at a slope of 1.8H:1 above the bench.

Option 4:

Construction utilizing an upper retained soil system or bin wall to avoid construction beyond the existing embankment toe. This option leaves the existing slope below the retained soil system as is. A rock fill berm can be provided at the base of the embankment to provide a mid slope bench. Option 4A considers the use of a RSS wall while Option 4B considers a bin wall.

8 Geotechnical Analyses

8.1 Geotechnical Model

Stability analyses were carried out on a design section developed at Station 14+200 where the embankment is at its highest. Analyses were carried out to assess the stability for the options being considered. Stability analyses were carried out using Slope/W software and limit equilibrium analyses using the Morgenstern-Price method. Traffic loading was modeled with a uniformly distributed load of 20 kPa.

The soil parameters used for the analyses are shown in Table 2.

Table 2: Stability Analyses Soil Properties

Soil	Effective Shear Strength Properties		Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m ³)
	Effective Angle of Internal Friction, ϕ' (degrees)	Effective Cohesion Intercept, C' (kPa)		
Existing Granular Fills within Embankment	35	0	N/A	21
Existing Fills Outside of Embankment	29	0	N/A	20
Peat	28	0	N/A	12
Sands and Silts	30	0	N/A	20
Sands and Silts Outside of Existing Embankment	29	0	N/A	20
Clay	27	0	68	17
New Granular "B" Above Water	35	0	N/A	21
New Granular "B" Below Water	32	0	N/A	21
New Rock Fill	45	0	N/A	19

The minimum design factor of safety for all options was 1.3. The results of the various stability analyses have been included in Appendix E.

Settlement analysis due to consolidation of the foundation soils was also carried out for the proposed widening. This analysis was carried out utilizing finite element modeling software (Sigma/W by Geoslope Inc.). Soil parameters used in these analyses have estimated based on Canadian Bridge Code Commentary, Section C6.6.3.6 correlations with soil type and the average condition/consistency. The parameters used have been provided in Table 3.

Table 3: Settlement Analyses - Foundation Soil Properties

Foundation Soil	Effective Young's Modulus E' (MPa)	Poisson's ratio
Sands and Silts	10	0.3
Clay	10	0.3

8.2 Results of Geotechnical Analyses

Slope stability analyses were used to assess the four construction options as defined in Section 7. In addition, a back analysis of the existing conditions was carried out to validate the stability model being used. The various options were reviewed and a preferred option selected based on the results of the stability analyses, economic considerations and physical layout of the project area.

The results of the analyses have been summarized in Table 4.

Table 4: Results of Stability Analyses of Slope Movement Remediation Options

Case / Alternative	Calculated Factor of Safety (FoS)		Disadvantages / Requirements	Advantages	Estimated Construction Clearance to Property Limit	Culvert Extension Required	Estimated Cost
	Final Configuration, Undrained Shear Strengths for Clays	Final Configuration, Effective Shear Strength Parameters					
Back Analyses (existing conditions)	1.35	1.35					
Option 1A Construction utilizing granular fills (2:1V) without bench.	1.33	1.39	To facilitate the proposed widening at the required 2H:1V grade (required for stability), excavation of the existing loose fills and peat will extend beyond the existing property limit. The toe of fill placement will also extend beyond the property limit. Subexcavation to elevation 244.5 m (or deeper) may be required. Rapid excavation and backfilling with rock fill in short sections will be required to excavate peat.	Suitable level of stability. Two lanes of traffic maintained during construction. No rock fill required.	-1.7 m (beyond R.O.W.)	Y	\$180,220 + Cost of Additional Property
Option 1B Construction utilizing granular fills (2:1V) with 2 m mid-slope bench.	> 1.33	> 1.39	Same as Option 1A, but will require additional fills and will extend further beyond the existing property limit.	Suitable level of stability. Incorporates mid-slope bench. Two lanes of traffic maintained during construction. No rock fill required.	-3.6 m (beyond R.O.W.)	Y	\$225,910 + Cost of Additional Property
Option 2A Rock fill and granular fill construction. Rock fill at 1.25H:1V below el. 249.7 m. Granular fill at 2H:1V above elevation 249.7 m. No mid-slope bench.	1.32	1.31	To reduce the risk of excavation beyond the property limit, a near vertical excavation back slope will be required adjacent to the property line. Rapid excavation and backfilling with rock fill in short sections will be required to excavate peat.	Suitable level of stability. Construction within property limits likely. Two lanes of traffic maintained during construction. Limited amount of rock fill required. No culvert required.	1.3 m (within R.O.W.)	N	\$159,720
Option 2B Rock fill and granular fill construction. Rock fill at 1.25H:1V below el. 249.7 m. Granular fill at 2H:1V above elevation 249.7 m. A 2 m bench at el. 249.7 m.	> 1.32	> 1.31	Similar to Option 2A, but construction will extend beyond the property limit to facilitate the 2 m mid-slope bench.	Suitable level of stability. Incorporates mid-slope bench. Two lanes of traffic maintained during construction. Limited amount of rock fill required.	-0.5 m (beyond R.O.W.)	Y	\$205,560 + Cost of Additional Property
Option 3 Full rock fill construction at 1.25H:1V below a 2.0 m wide bench at el. 250.25 m. Rock fill above the bench at 1.8H:1V.	1.37	1.34	This option requires the largest volume of rock fill. Rapid excavation with near vertical slopes and backfilling with rock fill in short sections will be required to excavate peat.	Suitable level of stability. Incorporates mid-slope bench. Construction within property limits likely. Two lanes of traffic maintained during construction. Impacts on the existing culvert are minimized. No culvert extension required.	1.3 m (within R.O.W.)	N	\$177,604
Option 4 – RSS Wall Construction utilizing an upper retained soil system to facilitate the proposed widening. Construction of a bench at elevation 250.25 m utilizing rock fill.	> 1.33	> 1.31	A costly retained soils system (RSS) would be required. Excavation of the existing east bound lane would be required to accommodate construction of the RSS resulting in single lane traffic during construction. The west bound lane may have to be partially lowered during construction to accommodate traffic along the westbound lane and/or a roadway protection system may be incorporated.	Suitable level of stability. Incorporates mid-slope bench. Construction within property limits likely. Impacts on the existing culvert are minimized. No culvert extension required. Limited amount of rock fill required.	1.3 m (within R.O.W.)	N	\$459,520 + traffic control and detour
Option 4 – Bin Wall Construction utilizing an upper bin wall system to facilitate the proposed widening. Construction of a bench at elevation 250.25 m utilizing rock fill.	> 1.33	> 1.31	A costly bin wall system would be required. Excavation of the existing east bound lane would be required to accommodate construction of the RSS resulting in single lane traffic during construction. The west bound lane may have to be partially lowered during construction to accommodate traffic along the westbound lane and/or a roadway protection system may be incorporated.	Suitable level of stability. Incorporates mid-slope bench. Construction within property limits likely. Impacts on the existing culvert are minimized. No culvert extension required. Limited amount of rock fill required.	1.3 m (within R.O.W.)	N	\$413,520 + traffic control and detour

Based on the above review, Option 3 is recommended. This is the lowest cost option which includes the required mid slope bench.

Settlements due to consolidation of the foundation soils have been estimated to be in the order of 25 mm.

Where rock fill is used “Punching” of the embankment fill into the subgrade during placement is expected to be minimal.

Within the rock fill additional settlement should be expected due to time dependent compressions within the rock fill itself. Settlements between 0.3 and 1 % of the thickness of the rock fill should be anticipated. Approximately half of these settlements are anticipated during the first year after placement. The remaining settlements will occur over a period of years

9 Culvert Extension

If required, the existing box culvert may be extended as a part of the proposed embankment widening. Total and differential settlements along the extension have been estimated to be in the order of 25 mm provided all existing loose fill and peat are removed from below the proposed culvert extension. Excavations at the site (outside of rockfill areas) should be backfilled with Granular B, Type II or III, which are also suitable as a bedding material.

10 Construction Recommendations

Construction of the widening shall be carried out in accordance with SP 206S03 July 2007, November 2000. Sections illustrating the recommended widening (Option 3) have been provided in Appendix F. The proposed construction shall be carried out as follows:

- Sub-excavation of existing loose fills and peat between stations 14+152 and 14+217 and replacement with rock fill to existing grade.
- Rock fill placement above excavated elevations

10.1 Phase 1 – Sub-excavation of Loose Fills and Peat and Replacement with Rock Fill

The existing loose fill and peat are to be excavated between stations 14+152 and 14+217. This will require a temporary cut to be excavated along the right side toe of the existing highway embankment. This excavation is to be carried out in accordance with OPSD 203.030M, Embankments Over Swamp Existing Slopes Maintained - Modified, as provided in Appendix D. No excavation is required below the culvert.

At the present time, a beaver dam has lead to the accumulation of ponded water near and within the area of construction. Lowering of the ponded water through pumping and/or careful removal of the beaver dam may be considered to improve constructability.

The temporary excavation and backfilling operations to the existing grade are to be carried out in accordance with OPSS 209, March 1998, Method A, with excavation and backfilling carried out simultaneously.

10.2 Phase 2 – Rock Fill Placement

The embankment widening is to be extended to the underside of pavement structure utilizing rock fill. Any topsoil remaining below the proposed footprint must be removed prior to fill placement. The side slopes of the rock fill are to be constructed to 1.25H:1V below elevation 250.25 m and at 1.8H:V above elevation 250.25 m. At elevation 250.25 m, a 2.0 m wide bench is to be constructed. The existing slope shall be benched in accordance with OPSD 208.010.

11 Constructability Issues

Excavation of the loose fills and peat between the existing right side toe and the right side property limit will require near vertical cut slopes near the existing property limit. The recommended construction methodology, OPSS 209, March 1998, Method A, is to be utilized. Should excessive deformation occur during construction, excavation timing and methodology may need to be adjusted. Disposal of about 500 m³ of wet peat and fill needs to be considered.

12 Limitations

Conclusions and recommendations presented in this report are based on the information determined at the 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 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 dewatering procedures which may be considered cannot readily be determined from boreholes. These include local and seasonal fluctuations of the groundwater level, changes in soil conditions between test locations, thin and/or discontinuous layers of highly permeable soils, etc.

The information contained within this report in no way reflects any environmental aspect of the site or soil.

13 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



Gordon Maki, P.Eng
Manager of Geotechnical Engineering



Wayne Hurley, P.Eng.
Vice President of Engineering

APPENDIX A

Borehole Logs

EXPLANATION OF TERMS USED IN REPORT

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 63.5kg, 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 OR DENSENESS.

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

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

R Q D (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S SPLIT SPOON	T P THINWALL PISTON
W S WASH SAMPLE	O S OSTERBERG SAMPLE
S T SLOTTED TUBE SAMPLE	R C ROCK CORE
B S BLOCK SAMPLE	P H T W ADVANCED HYDRAULICALLY
C S CHUNK SAMPLE	P M T W ADVANCED MANUALLY
T W THINWALL OPEN	F S FOIL SAMPLE

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_a	1	RATE OF SECONDARY CONSOLIDATION
C_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
C_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_f	1	SENSITIVITY = $\frac{C_u}{\tau_r}$

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	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 STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{\min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
ρ_w	kg/m^3	DENSITY OF WATER	w	1, %	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	1	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/s	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	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{\max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^2	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

TBT Engineering Consulting Group			RECORD OF Borehole No 1			1 OF 1		METRIC					
W.P. 544-00-00			PROJECT Embankment Widening			SITE NO. _____		ORIGINATED BY HF					
DIST 61 HWY 11/17			LOCATION Sta 14+191 o/s 35.5 m Rt			TBTE JOB# 09-068		COMPILED BY DS					
DATE 2009 June 16			BOREHOLE TYPE Hollow Stem Auger			DATUM Geodetic		CHECKED BY GM					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
246.4 0.0	WATER												Water level @ 0.4 m on completion.
245.3 1.1	FILL - SAND - Silty, some organics, grey, very loose												
	----- - trace gravel		1	SS									
243.8 2.6	SILT - Sandy, some gravel, grey, loose		2	SS	3								
243.5 2.9	CLAY - Silty, grey/brown, stiff		3	SS	9								
242.5 3.9	End of Borehole @ 3.9 m.		4	SS	13								

\times^3, \star^3 : Numbers refer to Sensitivity
 NP Non Plastic
 \bigcirc 3% STRAIN AT FAILURE

ON_MOT_BH-10 09-068.GPJ ON_MOT.GDT 10/1/12

TBT Engineering Consulting Group			RECORD OF Borehole No 2		1 OF 1		METRIC	
W.P. 544-00-00			PROJECT Embankment Widening		SITE NO. _____		ORIGINATED BY HF	
DIST 61 HWY 11/17			LOCATION Sta 14+172 o/s 34.6 m Rt		TBTE JOB# 09-068		COMPILED BY DS	
DATE 2009 June 15			BOREHOLE TYPE Hollow Stem Auger		DATUM Geodetic		CHECKED BY GM	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			
246.4 0.1	TOPSOIL - 75 mm		1	AS				
245.8 0.6	FILL - SILT - Sandy, trace organics, grey		2	SS	2			
245.1 1.3	PEAT - some silt, black, very loose		3	SS	5			
243.5 2.9	SILT - some organics, trace sand, brown, loose to compact		4	SS	17			
241.9 4.5	CLAY - Silty, silt layers, grey/brown, very stiff		5	SS	15			
241.2 5.2	SILT - trace clay, grey, dense		6	SS	21			
237.0 9.4	CLAY - Silty, layered, grey/brown, hard		7	SS	36			
	- very stiff		8	SS	31			
	- grey/black		9	SS	46			
	End of Borehole @ 9.4 m.		10	SS	17			
			11	SS	16			

DYNAMIC CONE PENETRATION RESISTANCE PLOT		SHEAR STRENGTH kPa		WATER CONTENT (%)		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEVATION SCALE		UNCONFINED ○ SPT (N)	FIELD VANE ✕ FIELD VANE ★ LAB VANE	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W		
246							Water level @ 4.2 m on completion.
245							
244							
243							
242							
241							
240							
239							
238							
237							

ON_MOT_BH-10 09-068.GPJ ON_MOT.GDT 10/1/12

TBT Engineering Consulting Group			RECORD OF Borehole No 3		1 OF 2 METRIC					
W.P. 544-00-00			PROJECT Embankment Widening		SITE NO. _____					
DIST 61 HWY 11/17			LOCATION Sta 14+201 o/s 34.2 m Rt		TBTE JOB# 09-068					
DATE 2009 June 15			BOREHOLE TYPE Hollow Stem Auger		DATUM Geodetic					
					ORIGINATED BY HF					
					COMPILED BY DS					
					CHECKED BY GM					
SOIL PROFILE			SAMPLES		GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT SHEAR STRENGTH kPa ○ UNCONFINED ✕ FIELD VANE ■ SPT (N) ★ LAB VANE	PLASTIC LIMIT W _p NATURAL MOISTURE CONTENT W LIQUID LIMIT W _L WATER CONTENT (%)	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE						
246.3										
246.0	TOPSOIL - 100 mm		1	AS						Water level @ 7.4 m on completion.
245.6	FILL - SILT - Sandy, trace organics, brown		2	SS	2				228.6	
245.0	PEAT - some silt, black, very loose		3	SS						
245.0	SILT - some organics, trace sand, brown		4	TW						
	----- - some organics, trace sand, grey		5	TW						
	----- - trace gravel		6	TW						
242.4	SAND - some clay lumps, trace silt, trace gravel		7	TW						
241.7	CLAY - Silty, grey/brown, very stiff		8	SS	29					
			9	SS	21					
			10	SS	9					
	----- - layered, grey/brown, stiff		11	TW						

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✕³, ★³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE
NP Non Plastic

ON_MOT_BH-10 09-068.GPJ ON_MOT.GDT 10/1/12

TBT Engineering Consulting Group			RECORD OF Borehole No 3			2 OF 2		METRIC											
W.P. 544-00-00			PROJECT Embankment Widening			SITE NO. _____		ORIGINATED BY HF											
DIST 61 HWY 11/17			LOCATION Sta 14+201 o/s 34.2 m Rt			TBTE JOB# 09-068		COMPILED BY DS											
DATE 2009 June 15			BOREHOLE TYPE Hollow Stem Auger			DATUM Geodetic		CHECKED BY GM											
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT		SHEAR STRENGTH kPa		WATER CONTENT (%)		UNIT WEIGHT		REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		ELEVATION SCALE	20 40 60 80 100	20 40 60 80 100	W _p	W	W _L	UNCONFINED	FIELD VANE	SPT (N)	LAB VANE	20 40 60	γ	GR SA SI CL
	----- - hard		12	SS	32		236												
							235												
			13	SS	57		234												
233.2																			
13.1	SILT - trace clay. grey, very dense						233												
232.3			14	SS	76														
14.0	End of Borehole @ 14.0 m.																		

x³, ★³: Numbers refer to Sensitivity
 NP Non Plastic
 ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 09-068.GPJ ON_MOT.GDT 10/1/12



TBT Engineering Consulting Group

RECORD OF Borehole No 4

1 OF 2

METRIC

W.P. **544-00-00** PROJECT **Embankment Widening** SITE NO. _____ ORIGINATED BY **HF**
 DIST **61** HWY **11/17** LOCATION **Sta 14+186 o/s 4.8 m Rt** TBTE JOB# **09-068** COMPILED BY **DS**
 DATE **2009 June 17** BOREHOLE TYPE **Hollow Stem Auger** DATUM **Geodetic** CHECKED BY **GM**

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								○ UNCONFINED	✕ FIELD VANE						
258.4							■ SPT (N)	★ LAB VANE	WATER CONTENT (%)						
258.0	ASPHALT - 75 mm														
258.0	FILL - SAND & GRAVEL - brown														

	- SAND - some silt, brown, dense		1	AS											0 84 (16)

	- Silty		2	SS	39										

	- Silty		3	SS	35										

	- compact		4	SS	34										

	- dense		5	SS	31										

	- compact		6	SS	29										

	- dense		7	SS	35										

	- compact		8	SS	21										

	- trace silt, trace gravel, loose		9	SS	4										1 90 (9)

	- compact		10	SS	25										

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✕³, ★³: Numbers refer to Sensitivity
 NP Non Plastic
 ○ 3% STRAIN AT FAILURE

ON_MOT_BH-10 09-068.GPJ ON_MOT.GDT 10/1/12

TBT Engineering Consulting Group			RECORD OF Borehole No 4			2 OF 2		METRIC	
W.P. 544-00-00			PROJECT Embankment Widening			SITE NO. _____		ORIGINATED BY HF	
DIST 61 HWY 11/17			LOCATION Sta 14+186 o/s 4.8 m Rt			TBTE JOB# 09-068		COMPILED BY DS	
DATE 2009 June 17			BOREHOLE TYPE Hollow Stem Auger			DATUM Geodetic		CHECKED BY GM	
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS		ELEVATION SCALE	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				
248.4	- occasional cobbles		11	SS	26				
247.4	- Silty, clay lumps, brown, compact								
246.4	- SAND - Silty, trace gravel, brown, compact		12	SS	13				
245.4	- trace organics, grey								
244.4	- some silt, some organics		13	SS	16				
243.4	SILT - grey, compact		14	SS	25				
242.9	End of Borehole @ 15.5 m.								

DYNAMIC CONE PENETRATION RESISTANCE PLOT

SHEAR STRENGTH kPa

○ UNCONFINED ✕ FIELD VANE ✱ LAB VANE

■ SPT (N)



WATER CONTENT (%)

PLASTIC LIMIT (W_p) NATURAL MOISTURE CONTENT (W) LIQUID LIMIT (W_L)

UNIT WEIGHT (γ) kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

TBT Engineering Consulting Group			RECORD OF Pedo Hole No P1				1 OF 1		METRIC					
W.P. 544-00-00			PROJECT Embankment Widening				SITE NO. _____		ORIGINATED BY BS					
DIST 61 HWY 11/17			LOCATION Sta 14+191 o/s 36.5 m Rt				TBTE JOB# 09-068		COMPILED BY TB					
DATE 2009 July 31			BOREHOLE TYPE Pedo				DATUM Geodetic		CHECKED BY GM					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
246.4 0.0	WATER													
244.8 1.6	FILL - SAND - Silty, some organics, grey													
243.5 2.9	End of Borehole @ 2.9 m. On Cobbles.		1	BS										

ON_MOT_PEDO 09-068.GPJ ON_MOT.GDT 10/1/12

TBT Engineering Consulting Group			RECORD OF Pedo Hole No P2				1 OF 1		METRIC					
W.P. 544-00-00			PROJECT Embankment Widening				SITE NO. _____		ORIGINATED BY BS					
DIST 61 HWY 11/17			LOCATION Sta 14+180 o/s 37.9 m Rt				TBTE JOB# 09-068		COMPILED BY TB					
DATE 2009 July 31			BOREHOLE TYPE Pedo				DATUM Geodetic		CHECKED BY GM					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
246.4 0.0	WATER													
245.9 0.5	FILL - SAND - Silty, grey													
245.4 1.0	PEAT - some sand, some silt, black		1	BS										
244.7 1.7	SAND - grey													
244.2 2.2	- Silty													
	End of Borehole @ 2.2 m.													

✕³, ★³: Numbers refer to Sensitivity
 NP Non Plastic
 ○^{3%} STRAIN AT FAILURE

TBT Engineering Consulting Group				RECORD OF Pedo Hole No P4				1 OF 1		METRIC				
W.P. 544-00-00		PROJECT Embankment Widening				SITE NO. _____		ORIGINATED BY BS						
DIST 61 HWY 11/17		LOCATION Sta 14+161 o/s 36.5 m Rt				TBTE JOB# 09-068		COMPILED BY TB						
DATE 2009 July 31		BOREHOLE TYPE Pedo				DATUM Geodetic		CHECKED BY GM						
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> W_p W W_L </div> <div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div>							
246.9	TOPSOIL - 250 mm, brown													Wet @ 0.25 m.
246.7	FILL - SAND - brown													
246.4	PEAT - black													
245.6	SAND - some silt, trace clay, grey													
245.3	End of Borehole @ 1.6 m.													

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TBT Engineering Consulting Group				RECORD OF Pedo Hole No P5				1 OF 1		METRIC						
W.P. 544-00-00		PROJECT Embankment Widening				SITE NO. _____		ORIGINATED BY BS								
DIST 61 HWY 11/17		LOCATION Sta 14+200 o/s 36.1 m Rt				TBTE JOB# 09-068		COMPILED BY TB								
DATE 2009 July 31		BOREHOLE TYPE Pedo				DATUM Geodetic		CHECKED BY GM								
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> UNCONFINED FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> SPT (N) LAB VANE </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div> <div style="display: flex; justify-content: space-between;"> PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT </div> <div style="display: flex; justify-content: space-between;"> 20 40 60 </div> <div style="display: flex; justify-content: space-between;"> WATER CONTENT (%) </div>				
246.4 0.0	WATER															
246.0 0.4	FILL - SAND - some organics, trace gravel, grey															
245.1 1.3	----- - Silty, some clay PEAT - some sand, some silt, grey															
244.7 1.8	SAND - trace silt, trace organics End of Borehole @ 1.8 m. Sloughing.															

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TBT Engineering Consulting Group		RECORD OF Pedo Hole No P6										1 OF 1		METRIC			
W.P. 544-00-00		PROJECT Embankment Widening										SITE NO. _____		ORIGINATED BY BS			
DIST 61		HWY 11/17		LOCATION Sta 14+209 o/s 37.0 m Rt										TBTE JOB# 09-068		COMPILED BY TB	
DATE 2009 July 31		BOREHOLE TYPE Pedo										DATUM Geodetic		CHECKED BY GM			
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
247.3								20	40	60	80	100					
247.0	TOPSOIL - 180 mm, brown						247										
0.2	FILL - SAND - brown																
246.7																	
0.6	PEAT - brown																
246.3																	
1.0	End of Borehole @ 1.0 m. On Boulder, Possible Cobble.																

ON_MOT_PEDO 09-068.GPJ ON_MOT.GDT 10/1/12

✕³, ★³: Numbers refer to Sensitivity
 NP Non Plastic
 ○^{3%} STRAIN AT FAILURE

TBT Engineering Consulting Group		RECORD OF Pedo Hole No P8										1 OF 1		METRIC			
W.P. 544-00-00		PROJECT Embankment Widening					SITE NO. _____					ORIGINATED BY BS					
DIST 61 HWY 11/17		LOCATION Sta 14+152 o/s 36.9 m Rt					TBTE JOB# 09-068					COMPILED BY TB					
DATE 2009 July 31		BOREHOLE TYPE Pedo					DATUM Geodetic					CHECKED BY GM					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div>										
248.2	TOPSOIL - 200 mm																
248.0	SAND - some silt, trace gravel, brown																
0.2	- Clayey																
246.6	End of Borehole @ 1.6 m.																
1.6																	

TBT Engineering Consulting Group		RECORD OF Pedo Hole No P9										1 OF 1		METRIC			
W.P. 544-00-00		PROJECT Embankment Widening					SITE NO. _____			ORIGINATED BY BS							
DIST 61 HWY 11/17		LOCATION Sta 14+172 o/s 30.2 m Rt					TBTE JOB# 09-068			COMPILED BY TB							
DATE 2009 July 31		BOREHOLE TYPE Pedo					DATUM Geodetic			CHECKED BY GM							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED ✕ FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ■ SPT (N) ★ LAB VANE </div>					<div style="display: flex; justify-content: space-between;"> 20 40 60 20 40 60 </div>					
246.6																	
246.0	TOPSOIL - 150 mm																
246.2	FILL - SAND - trace silt, occasional cobbles, brown																
245.9	PEAT - black																
245.5	SAND - Silty, grey																
245.5	End of Borehole @ 1.1 m.																

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TBT Engineering Consulting Group		RECORD OF Pedo Hole No P10				1 OF 1		METRIC								
W.P. 544-00-00		PROJECT Embankment Widening				SITE NO. _____		ORIGINATED BY BS								
DIST 61 HWY 11/17		LOCATION Sta 14+186 o/s 28.7 m Rt				TBTE JOB# 09-068		COMPILED BY TB								
DATE 2009 July 31		BOREHOLE TYPE Pedo				DATUM Geodetic		CHECKED BY GM								
SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa								
							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div> <div style="display: flex; justify-content: space-between;"> ○ UNCONFINED ✕ FIELD VANE </div> <div style="display: flex; justify-content: space-between;"> ■ SPT (N) ★ LAB VANE </div>					<div style="display: flex; justify-content: space-between;"> W_p W W_L </div> <div style="display: flex; justify-content: space-between;"> PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT </div>				
247.1																
0.0	FILL - SAND - brown					247							Wet @ 0.7 m.			
	----- - trace silt, grey					246										
245.0						245										
2.1	End of Borehole @ 2.1 m. On Cobbles.															

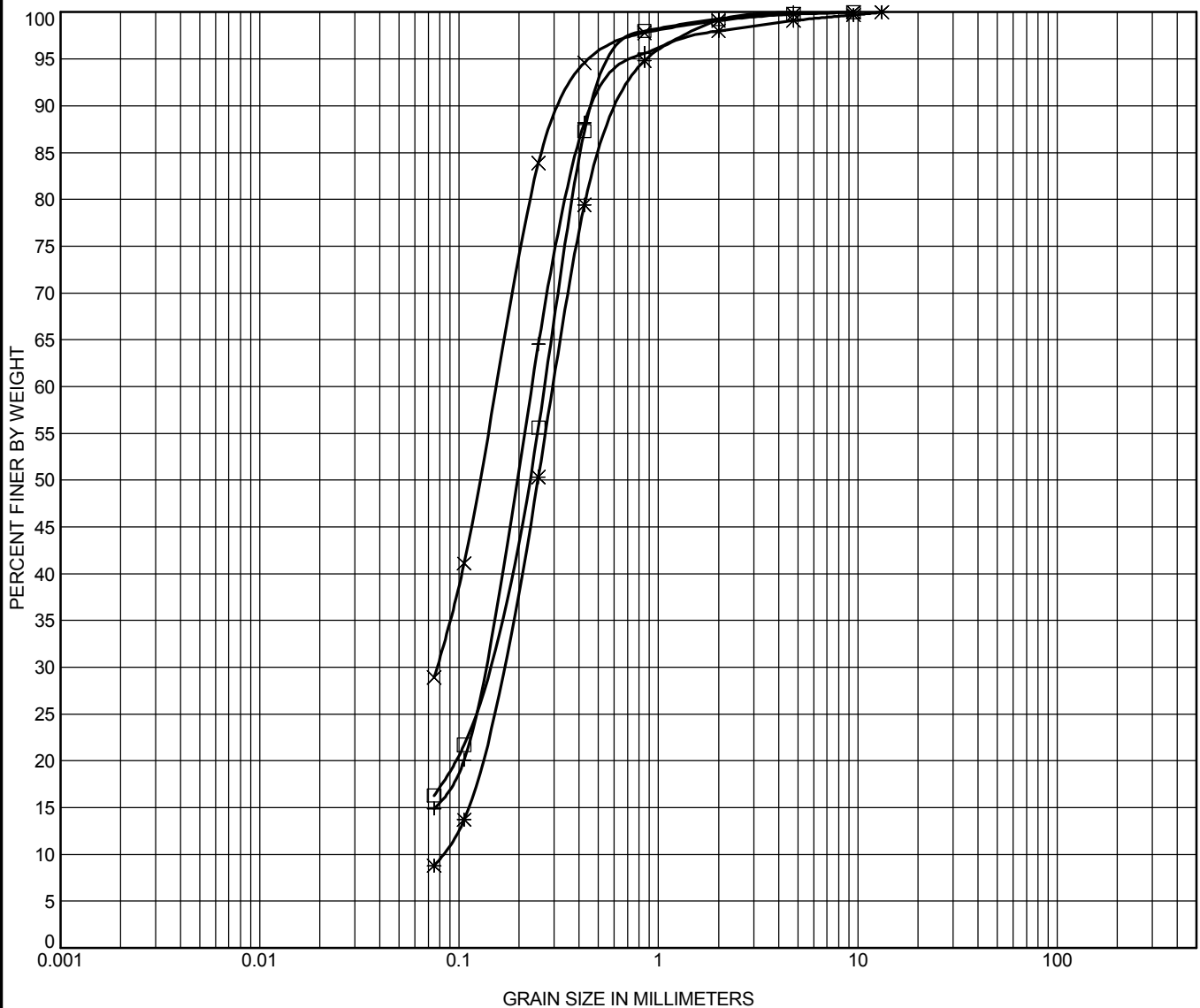
ON_MOT_PEDO 09-068.GPJ ON_MOT.GDT 10/1/12

TBT Engineering Consulting Group			RECORD OF Pedo Hole No P11				1 OF 1		METRIC					
W.P. 544-00-00			PROJECT Embankment Widening				SITE NO. _____		ORIGINATED BY BS					
DIST 61 HWY 11/17			LOCATION Sta 14+197 o/s 29.3 m Rt				TBTE JOB# 09-068		COMPILED BY TB					
DATE 2009 July 31			BOREHOLE TYPE Pedo				DATUM Geodetic		CHECKED BY GM					
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
246.8							<div style="display: flex; justify-content: space-between;"> 20 40 60 80 100 20 40 60 80 100 </div>							
0.0	FILL - SAND - trace gravel, brown					▼								Wet @ 0.5 m.
	----- - Silty, grey													
245.2	PEAT - black		1	BS										
244.8	SILT - Sandy, trace clay, grey													
244.5	End of Borehole @ 2.3 m.													

ON_MOT_PEDO 09-068.GPJ ON_MOT.GDT 10/1/12

APPENDIX B

Laboratory Test Data



SILT OR CLAY	SAND			GRAVEL		COBBLES
	fine	medium	coarse	fine	coarse	

Remarks:
SAND

Test Hole	Depth	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
□ 4	0.75	9.5	0.269	0.131		0.2	83.5	16.3	
* 4	7.60	13.2	0.298	0.155	0.082	0.9	90.3	8.8	
× 4	10.70	9.5	0.155	0.077		0.2	70.9	28.9	
+ 4	13.70	4.75	0.229	0.128		0.0	85.1	14.9	



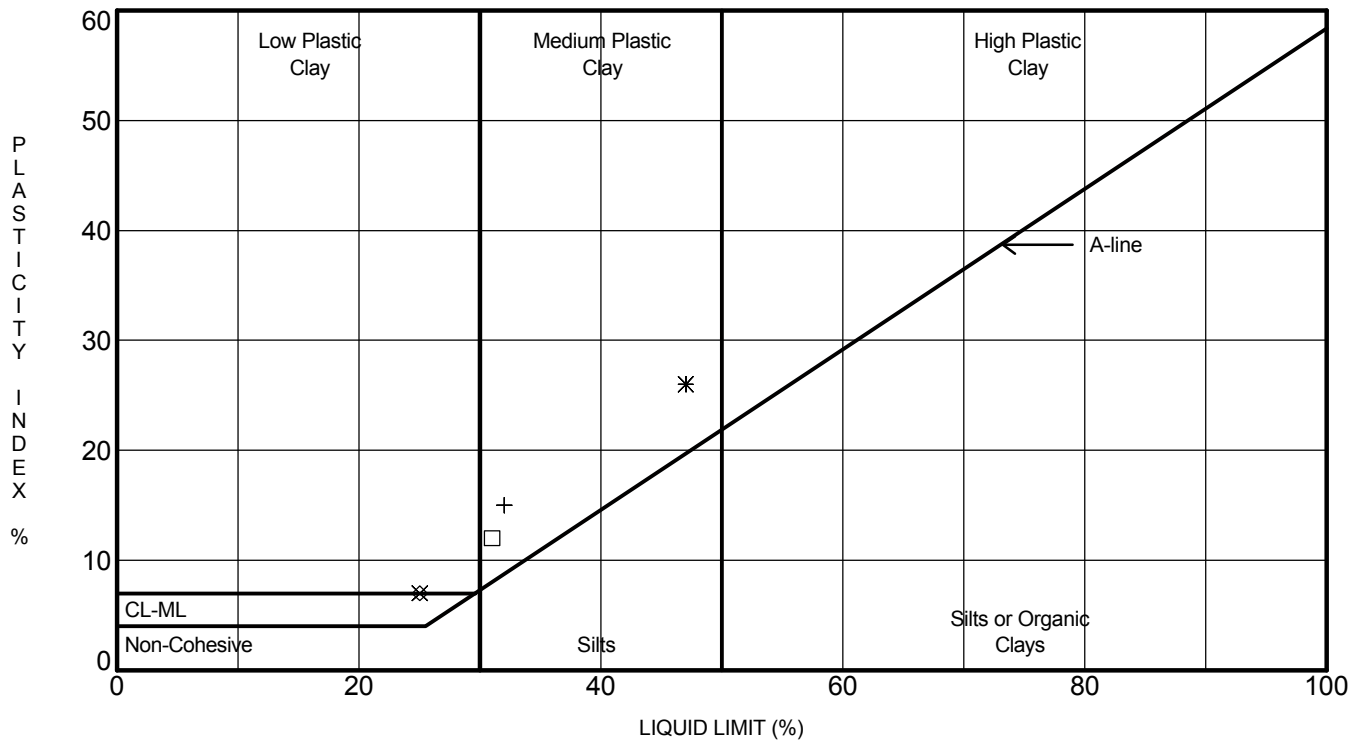
TBT Engineering Ltd.
Suite 200, 101 Syndicate Ave. N.
Thunder Bay, Ontario P7C 3V4
PH: 807-624-5160
FX: 807-264-5161
Email: tbte@tbte.ca
Web: www.tbte.ca

GRAIN SIZE DISTRIBUTION

Project: Embankment Widening

W P: 544-00-00

DIST: 61 HWY: 11/17



	Borehole No.	Sample No.	Depth (m)	LL %	PL %	PI %	M/C %	
□	2		3.00	31	19	12	27	
✱	2		7.60	47	21	26	32	
×	3		5.30	25	18	7	21	
+	3		6.10	32	17	15	22	
◇	3		12.20	25	18	7	17	



TBT Engineering Ltd.
 Suite 200, 101 Syndicate Ave. N.
 Thunder Bay, Ontario P7C 3V4
 Telephone: 807-624-5160
 Fax: 807-264-5161

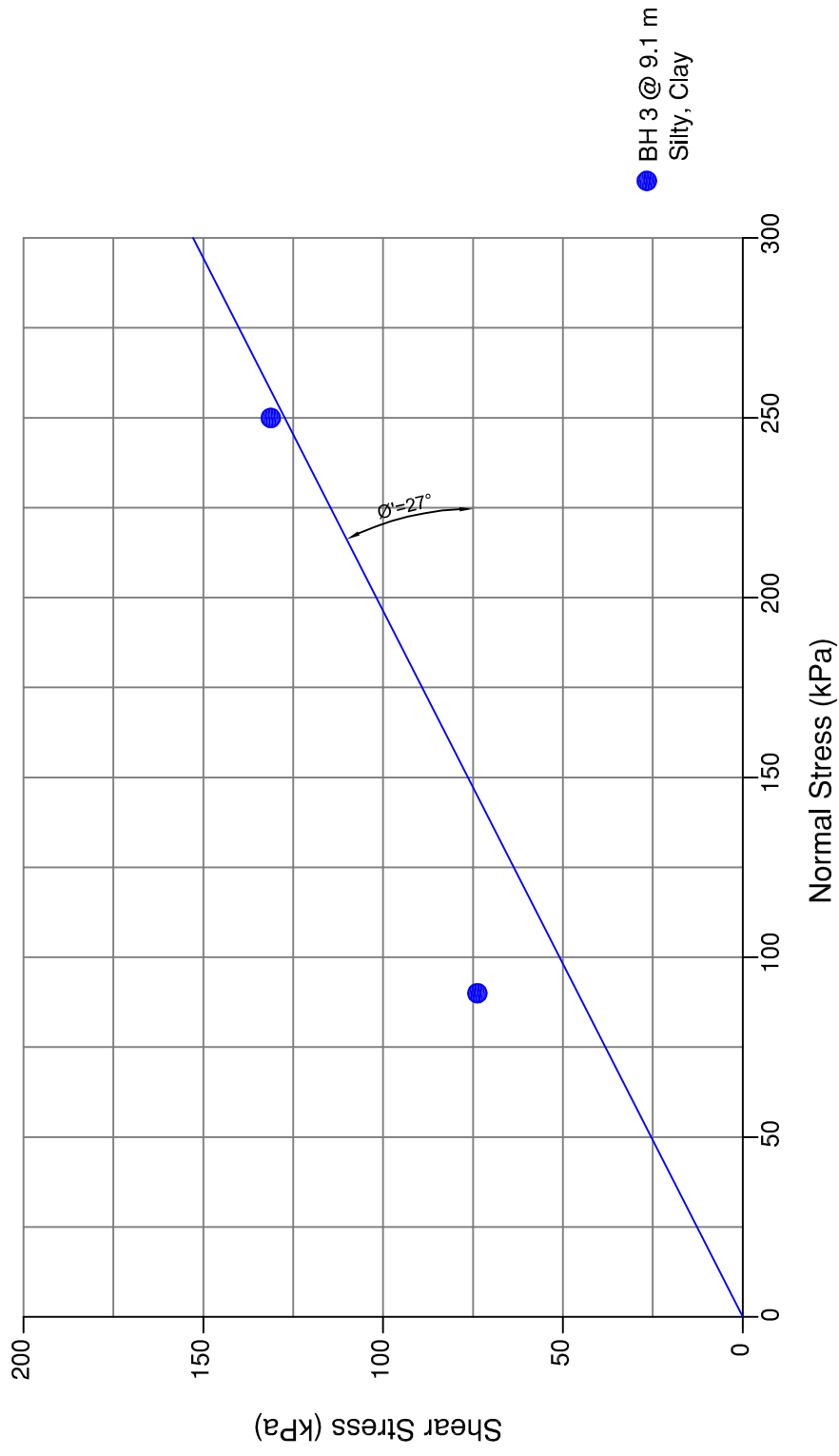
ATTERBERG LIMIT RESULTS

W P: 544-00-00

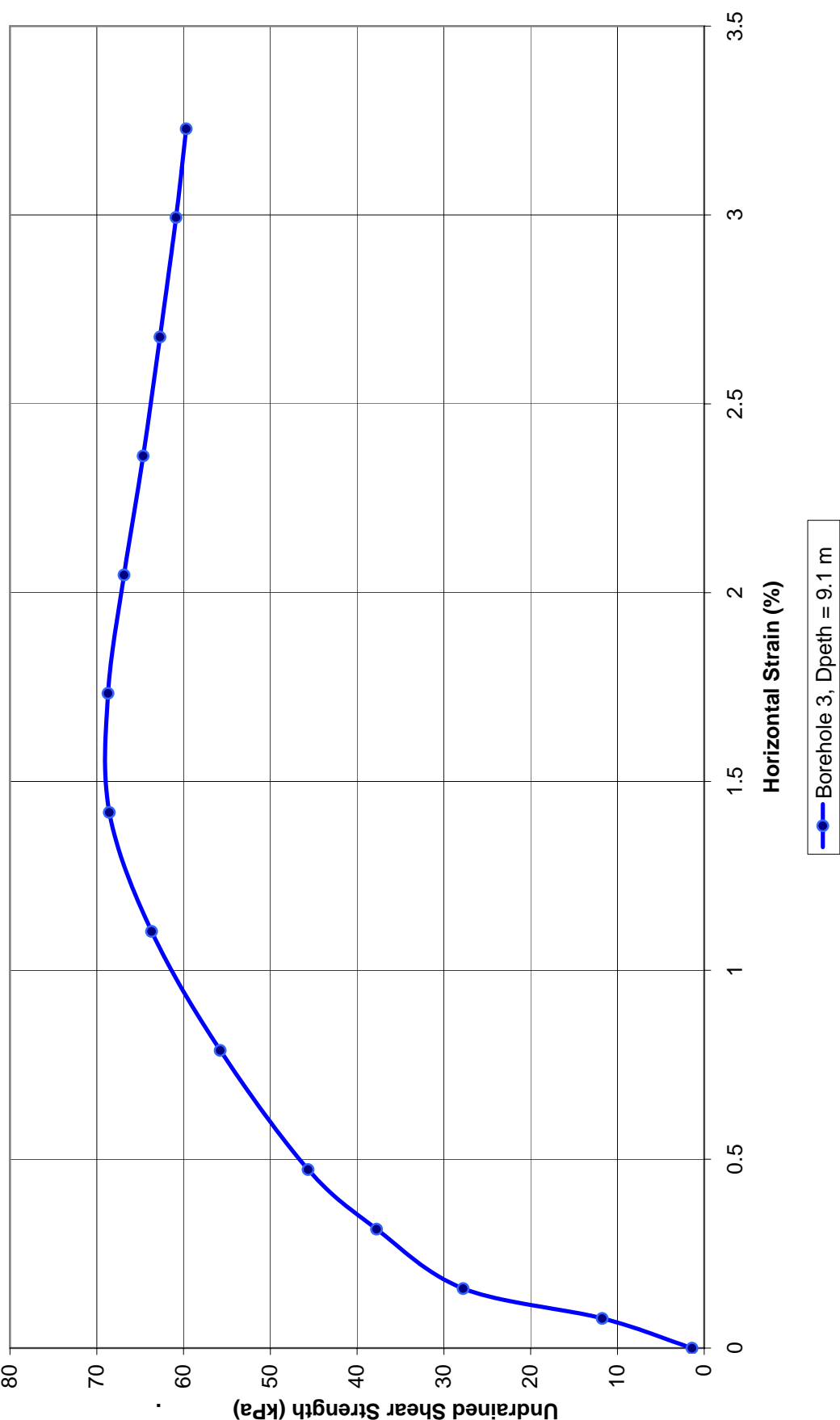
District: 61

Highway: 11/17

CONSOLIDATED/DRAINED DIRECT SHEAR TESTING



Undrained Direct Shear Testing - Clay
Consolidated to Effective Overburden Pressure



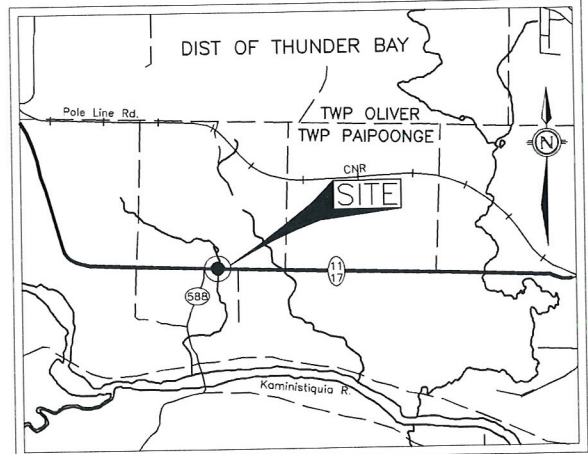
APPENDIX C
Borehole Locations and Soil Strata Drawing

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

CONT No xxxxxx
GWP No 544-00-00
GEOCRES No 52A-141

VIBERT TO KAKABEKA EMBANKMENT WIDENING
TOWNSHIP OF OLIVER-PAIPOONGE
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



KEY PLAN

1.0 km 0 1.0 km

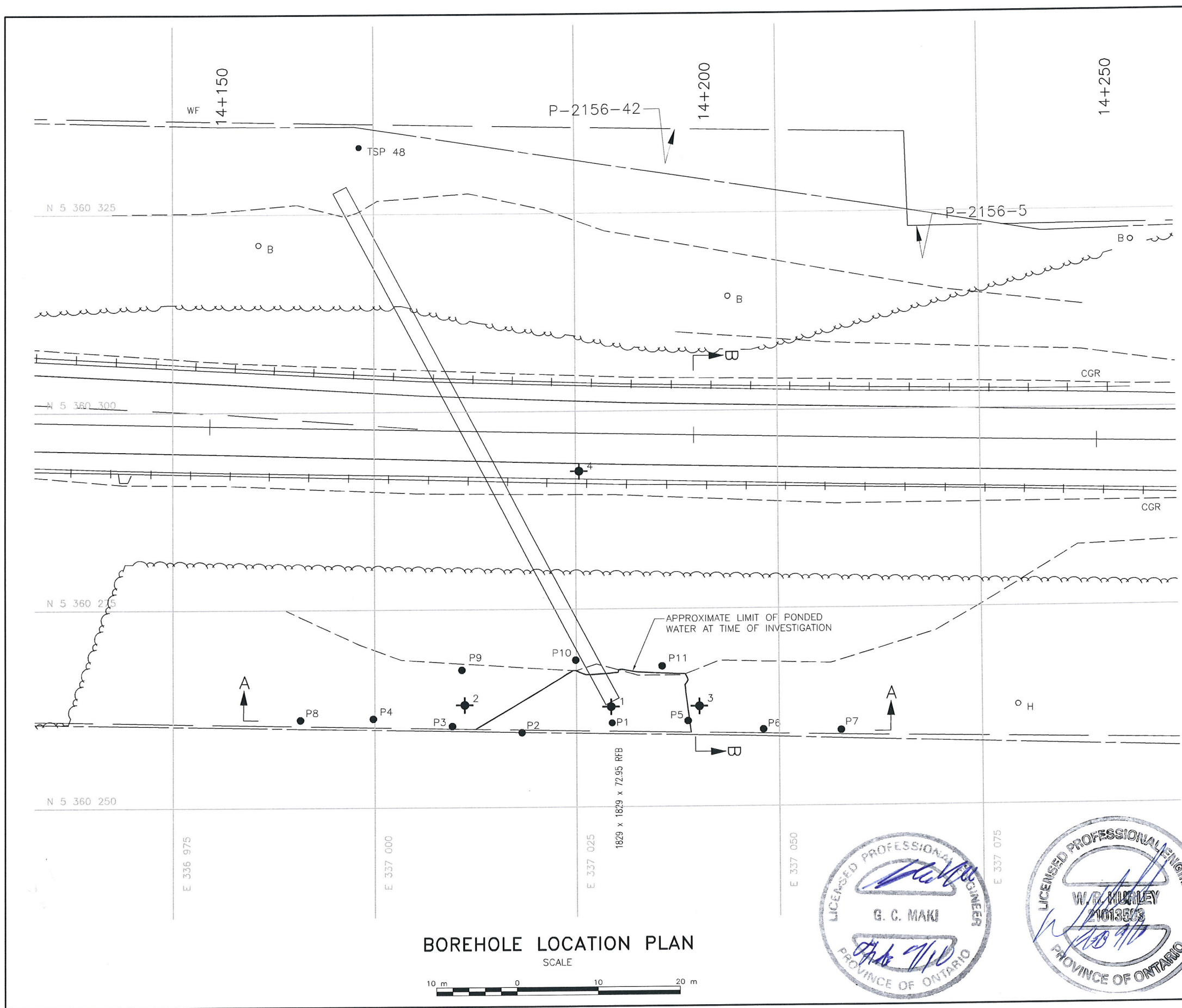
SCALE 1:50,000

—NOTE—

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

LEGEND				
	Borehole			
	Pedo Hole			
	'N' Std Pen Test (Blows/0.3m)			
	WL at time of investigation			
No	ELEVATION	CO-ORDINATES		
		NORTH	EAST	
1	246.0	15 5 360 262	337 029	
2	246.6	15 5 360 263	337 011	
3	246.6	15 5 360 263	337 040	
4	258.5	15 5 360 293	337 025	
P1	246.0	15 5 360 262	337 029	
P2	246.0	15 5 360 259	337 018	
P3	246.5	15 5 360 260	337 010	
P4	246.7	15 5 360 261	337 000	
P5	246.0	15 5 360 259	337 036	
P6	247.3	15 5 360 260	337 048	
P7	248.9	15 5 360 260	337 058	
P8	248.0	15 5 360 261	336 991	
P9	246.5	15 5 360 267	337 011	
P10	246.6	15 5 360 269	337 025	
P11	246.6	15 5 360 268	337 036	

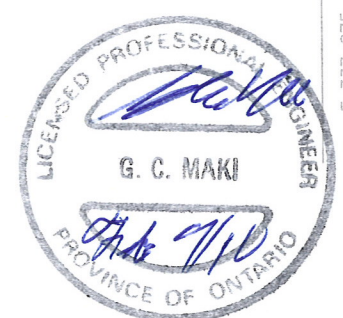
REVISIONS																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
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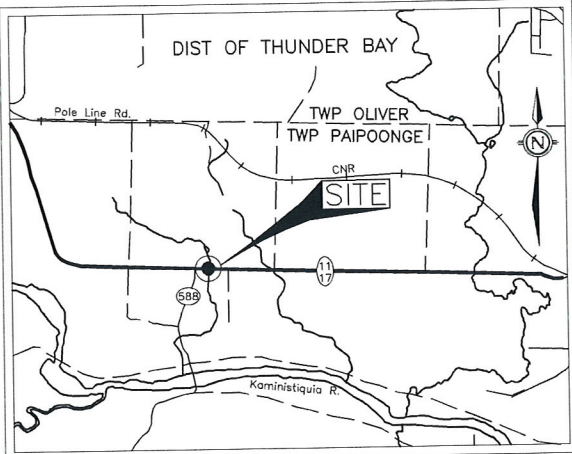


BOREHOLE LOCATION PLAN

SCALE

10 m 0 10 20 m







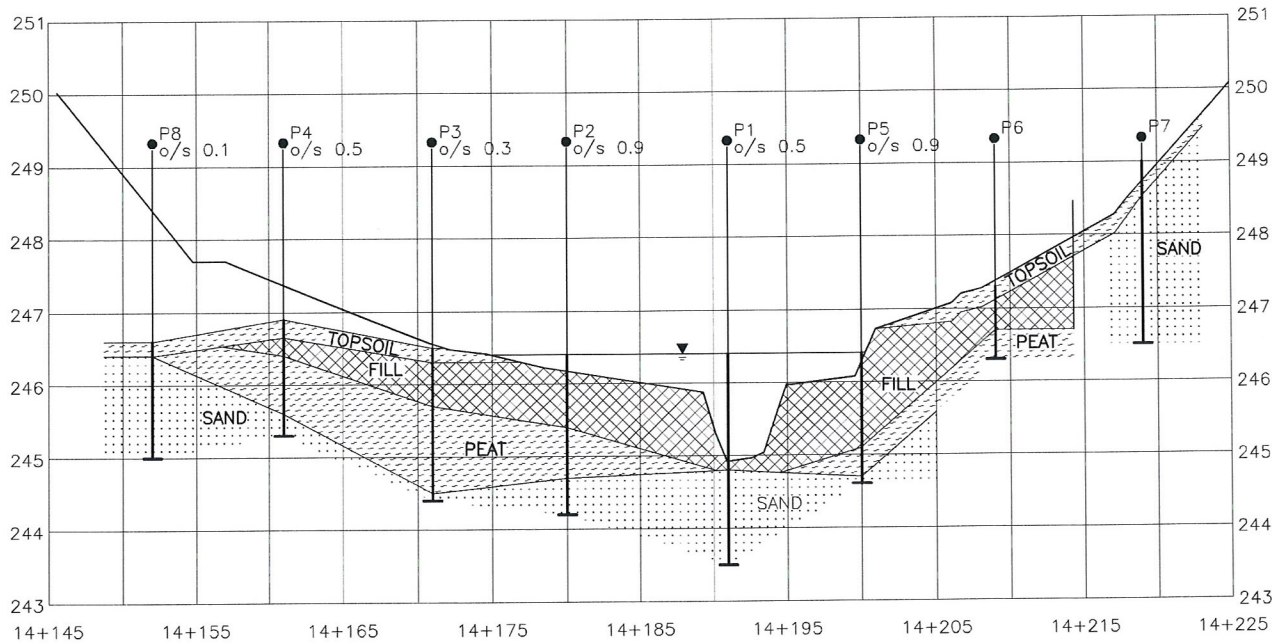


KEY PLAN

1.0 km 0 1.0 km
SCALE 1:50,000

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

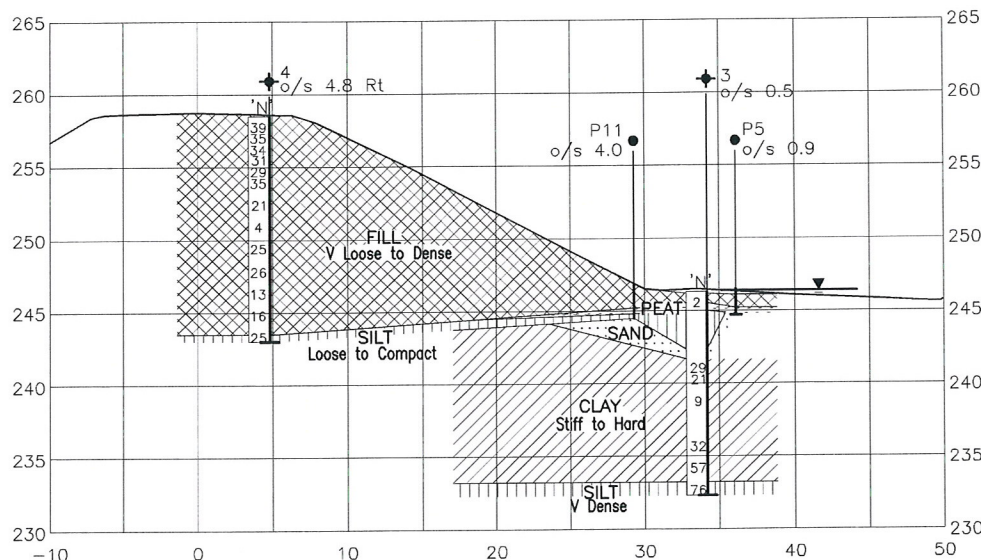
LEGEND			
	Borehole		
	Pedo Hole		
	Std Pen Test (Blows/0.3m)		
	WL at time of investigation		
No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
1	246.0	15 5 360 262	337 029
2	246.6	15 5 360 263	337 011
3	246.6	15 5 360 263	337 040
4	258.5	15 5 360 293	337 025
P1	246.0	15 5 360 262	337 029
P2	246.0	15 5 360 259	337 018
P3	246.5	15 5 360 260	337 010
P4	246.7	15 5 360 261	337 000
P5	246.0	15 5 360 259	337 036
P6	247.3	15 5 360 260	337 048
P7	248.9	15 5 360 260	337 058
P8	248.0	15 5 360 261	336 991
P9	246.5	15 5 360 267	337 011
P10	246.6	15 5 360 269	337 025
P11	246.6	15 5 360 268	337 036



NOTE: VERTICAL SCALE EXAGGERATED.

PROFILE A-A






HOR. 5m 0 10m
VERT. 2.5m 0 2m
SCALE



SECTION B-B STA. 14+200

SCALE
5m 0 10m

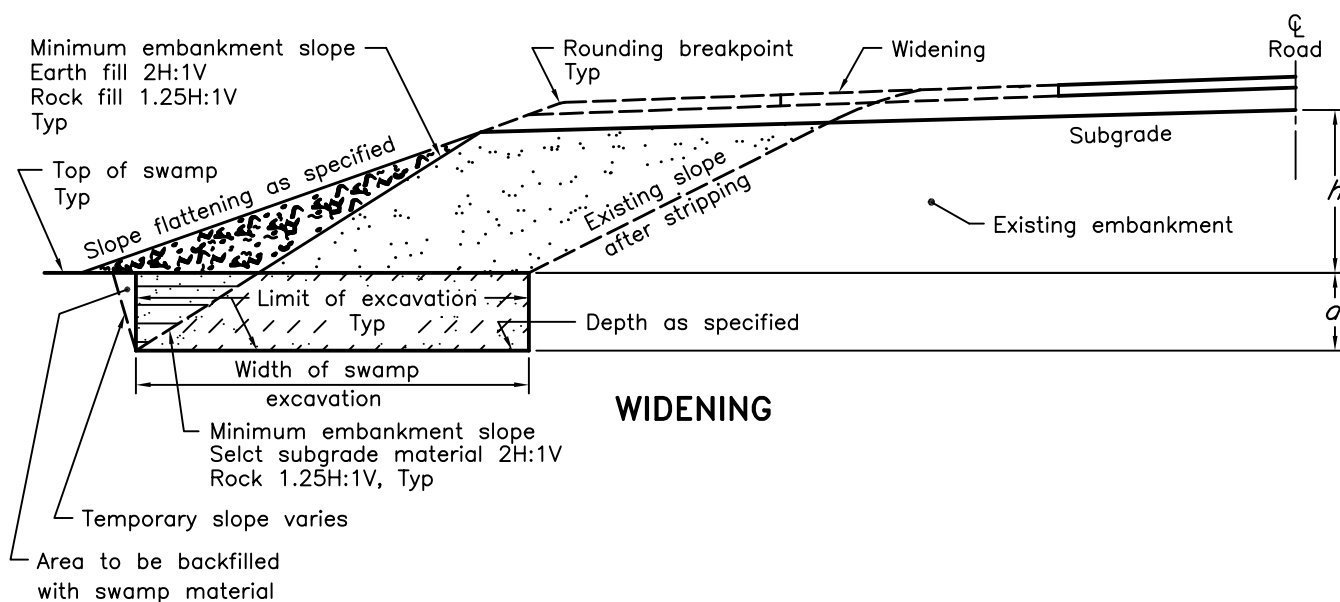


SOIL STRATA SYMBOLS			
	PEAT or TOPSOIL		FILL
	SAND		SILT
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APPENDIX D

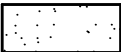


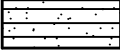
Modified OPSD



NOTES:

- A For this OPSD, h must be $\leq 13\text{m}$ and d must be $\leq 3.0\text{m}$.
- B Topsoil shall be stripped from existing slopes.
- C Height of fill is the vertical difference between top of subgrade and top of swamp elevation measured at new road centreline.
- D Widening of existing earth embankments shall be benched according to OPSD-208.010.
- E All dimensions are in millimetres unless otherwise shown.

LEGEND:

- h - Height of fill
- d - Depth of sub-excavation
-  Embankment materials as specified
-  Excavated swamp material
-  Excavate and backfill as specified
-  Excavate and backfill with swamp material

ONTARIO PROVINCIAL STANDARD DRAWING

Nov 2005

Rev 2

EMBANKMENTS OVER SWAMP

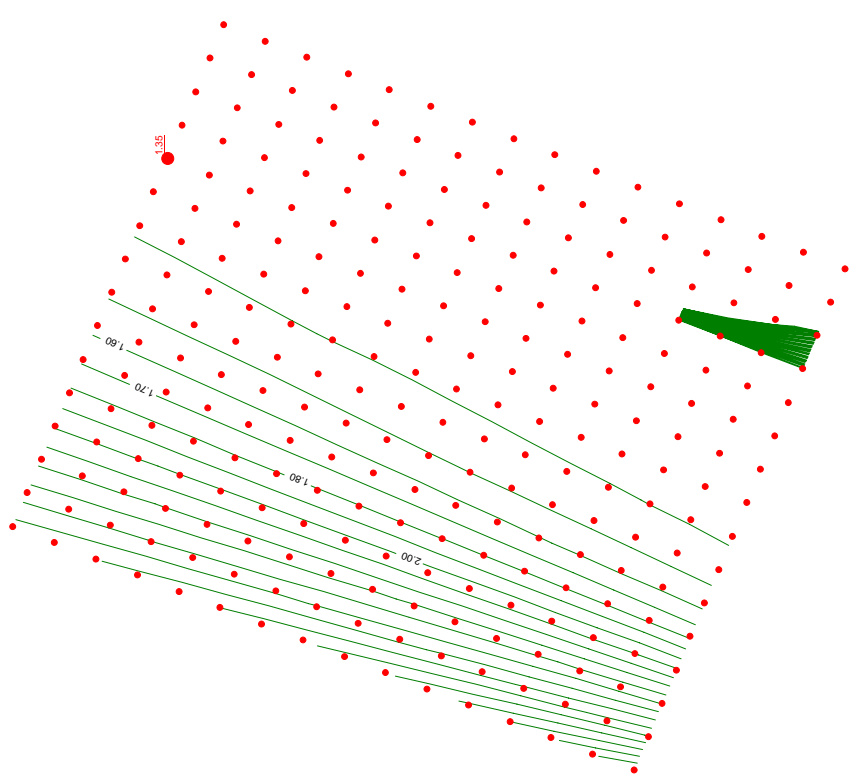
EXISTING SLOPES MAINTAINED



OPSD - 203.030M

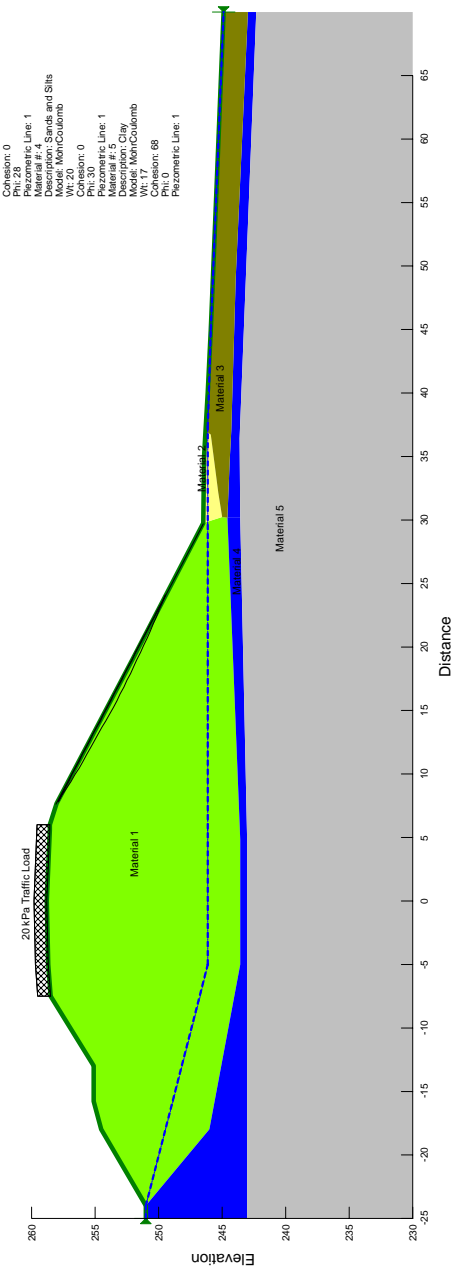
APPENDIX E

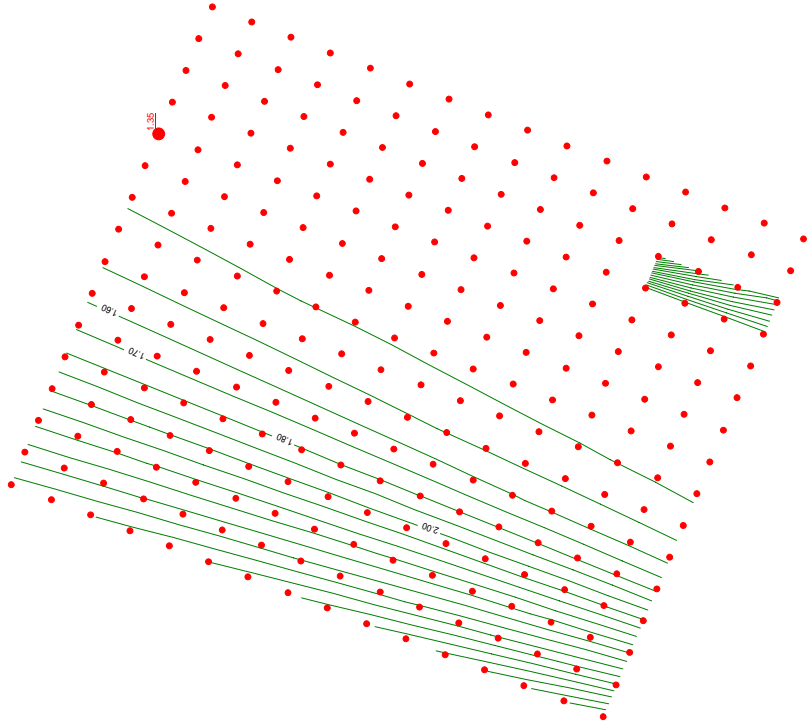
Slope Stability Analyses



Title: Station 14+200
Comments: Base case, drained
Method: Morgenstern-Price
Wedge: Optimum
Failure Line
Factor of Safety: 1.35

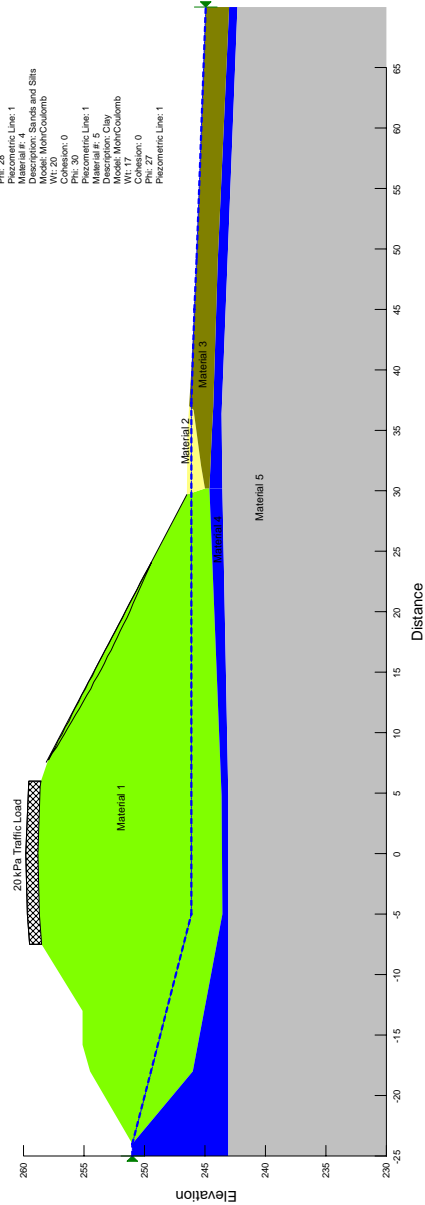
- Material # 1: Description: Existing Granular Fill within Embankment
Moist Mohr-Coulomb
Wt: 21
Cohesion: 0
Phi: 35
Piezometric Line: 1
- Material # 2: Description: Existing Silt Fills Outside of Embankment
Moist Mohr-Coulomb
Wt: 20
Cohesion: 0
Phi: 29
Piezometric Line: 1
- Material # 3: Description: Past / Organics
Moist Mohr-Coulomb
Wt: 18
Cohesion: 0
Phi: 28
Piezometric Line: 1
- Material # 4: Description: Sands and Silts
Moist Mohr-Coulomb
Wt: 20
Cohesion: 0
Phi: 35
Piezometric Line: 1
- Material # 5: Description: Underlying Soil
Moist Mohr-Coulomb
Wt: 17
Cohesion: 68
Phi: 0
Piezometric Line: 1

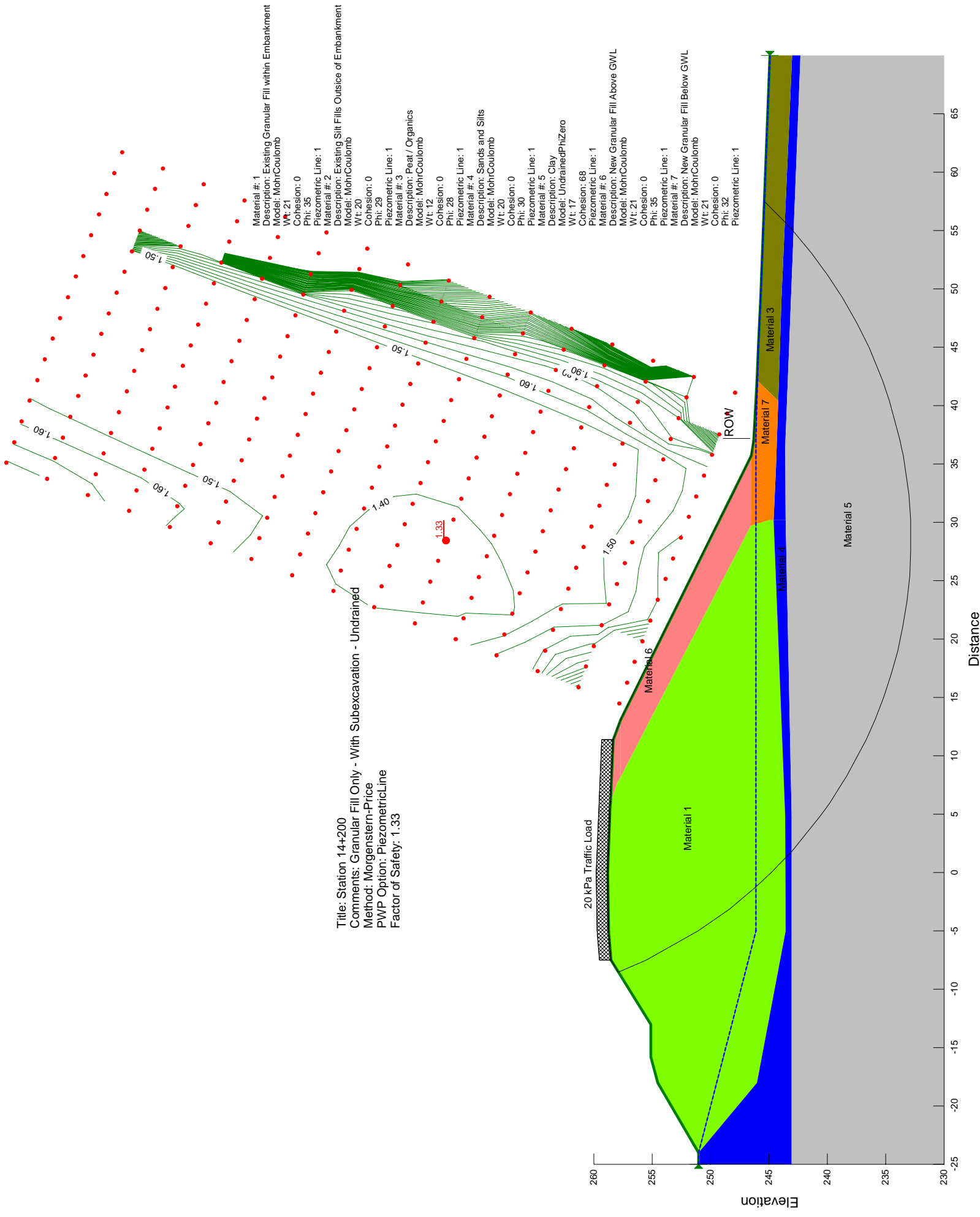


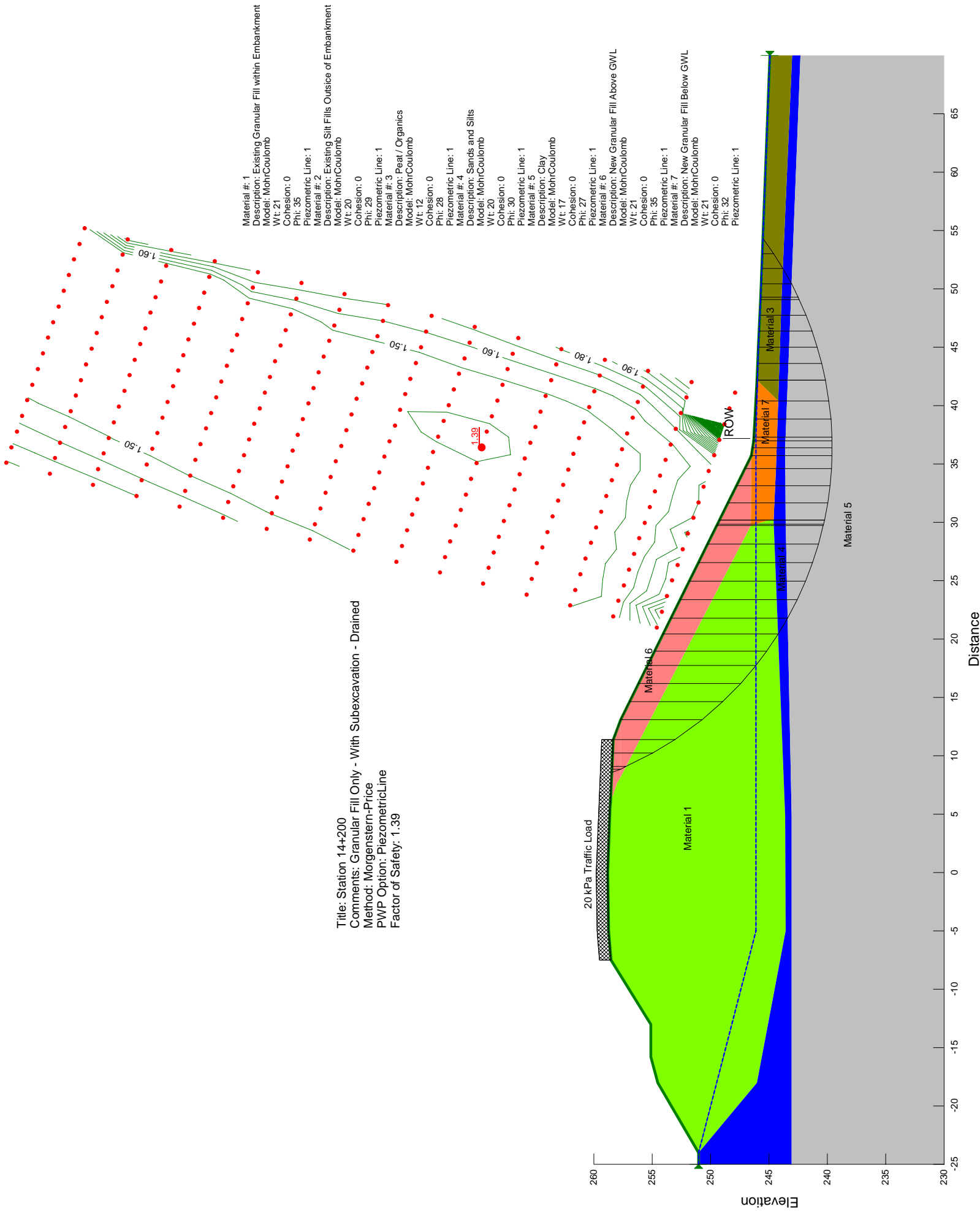


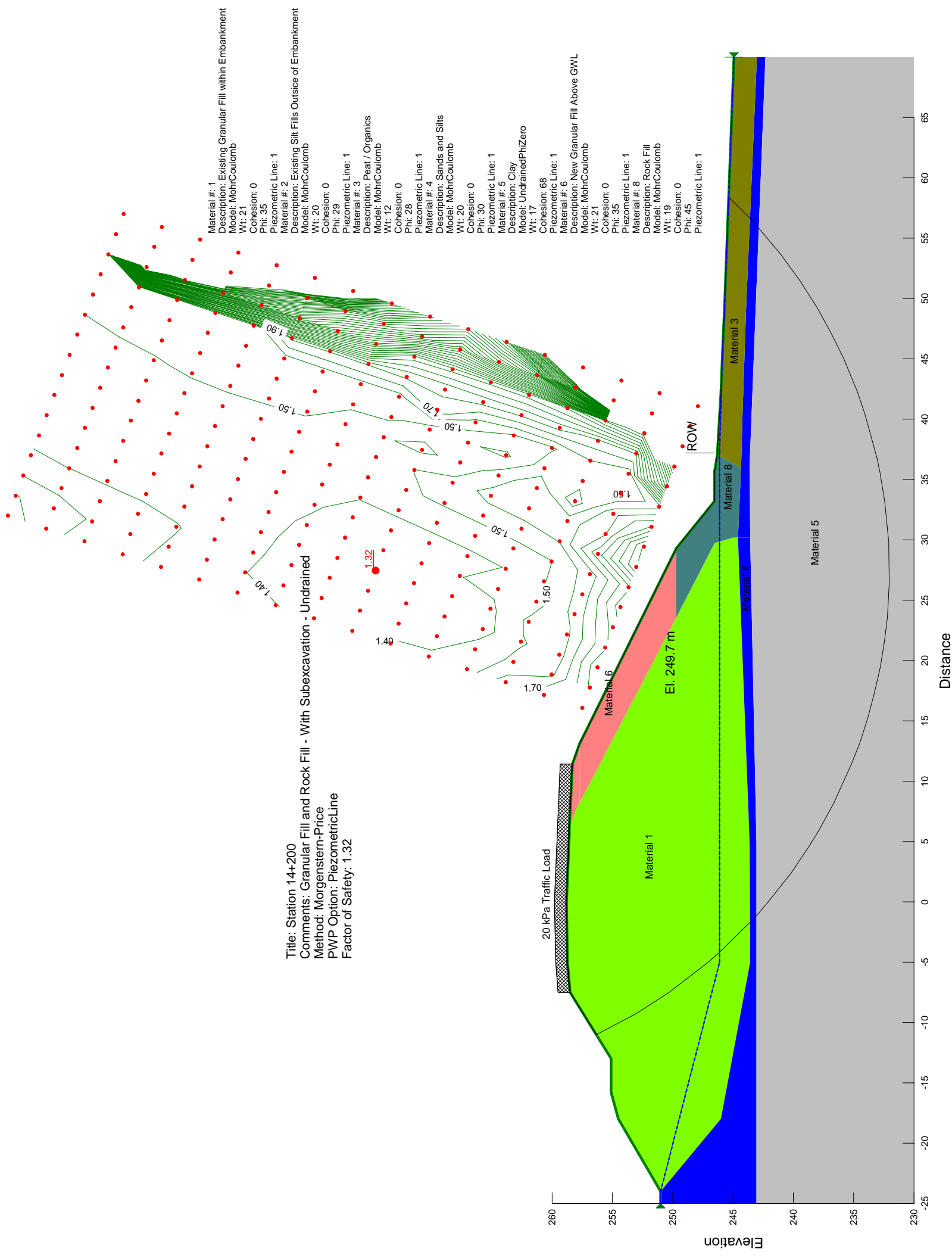
Title: Station 14+200
Comments: Base case, drained
Method: Morgenstern-Price
PWP Option: PiezometricLine
Factor of Safety: 1.35

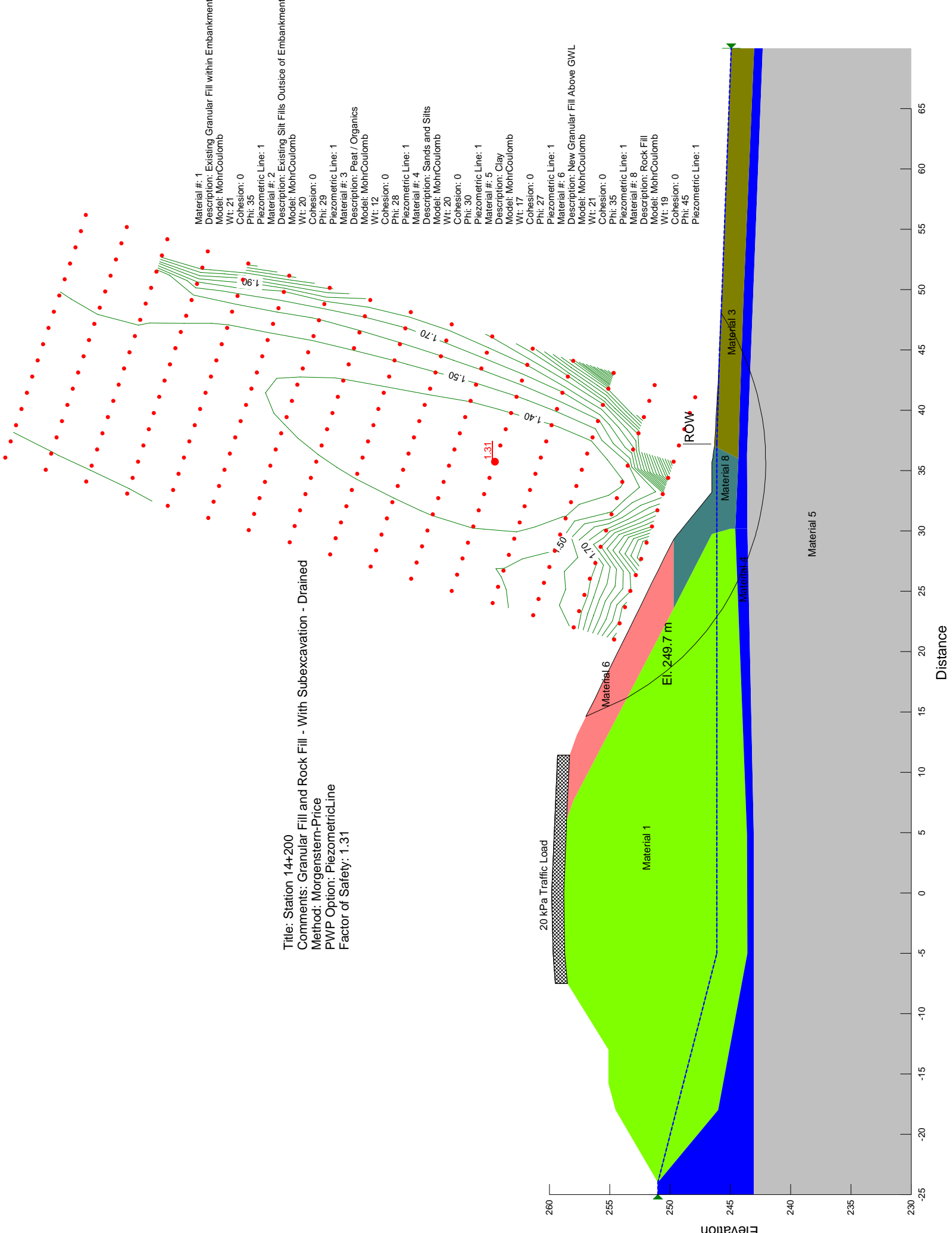
- Material # 1: Existing Granular Fill within Embankment
Model: MohrCoulomb
Wt: 21
Cohesion: 0
Phi: 35
Piezometric Line: 1
- Material # 2: Existing Silt Fills Outside of Embankment
Model: MohrCoulomb
Wt: 30
Cohesion: 0
Phi: 29
- Material # 3: Peat/Organics
Model: MohrCoulomb
Wt: 12
Cohesion: 0
Phi: 28
- Material # 4: Sand and Silts
Model: MohrCoulomb
Wt: 20
Cohesion: 0
Phi: 30
- Material # 5: Clay
Model: MohrCoulomb
Wt: 17
Cohesion: 0
Phi: 27
- Piezometric Line: 1

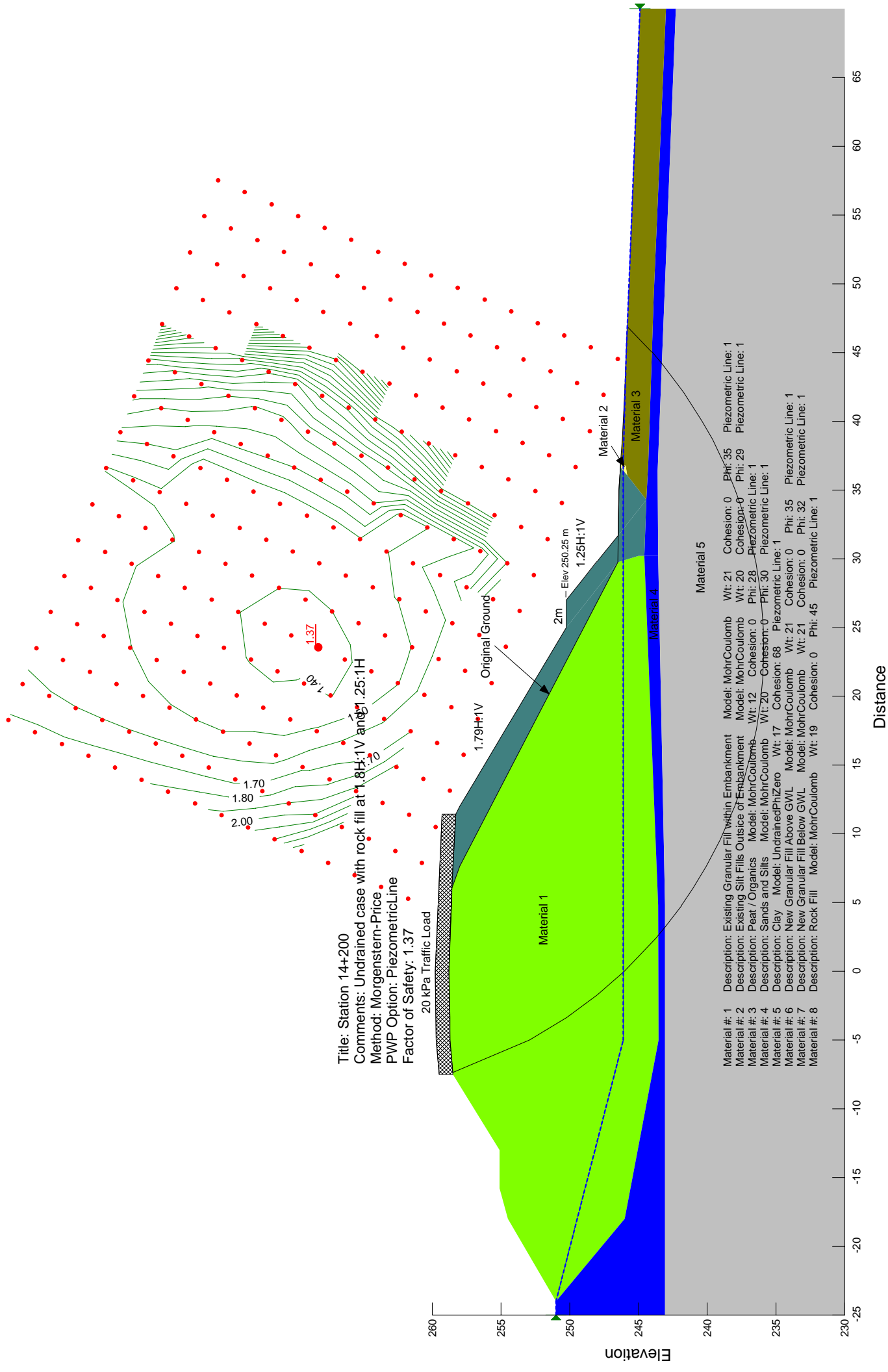




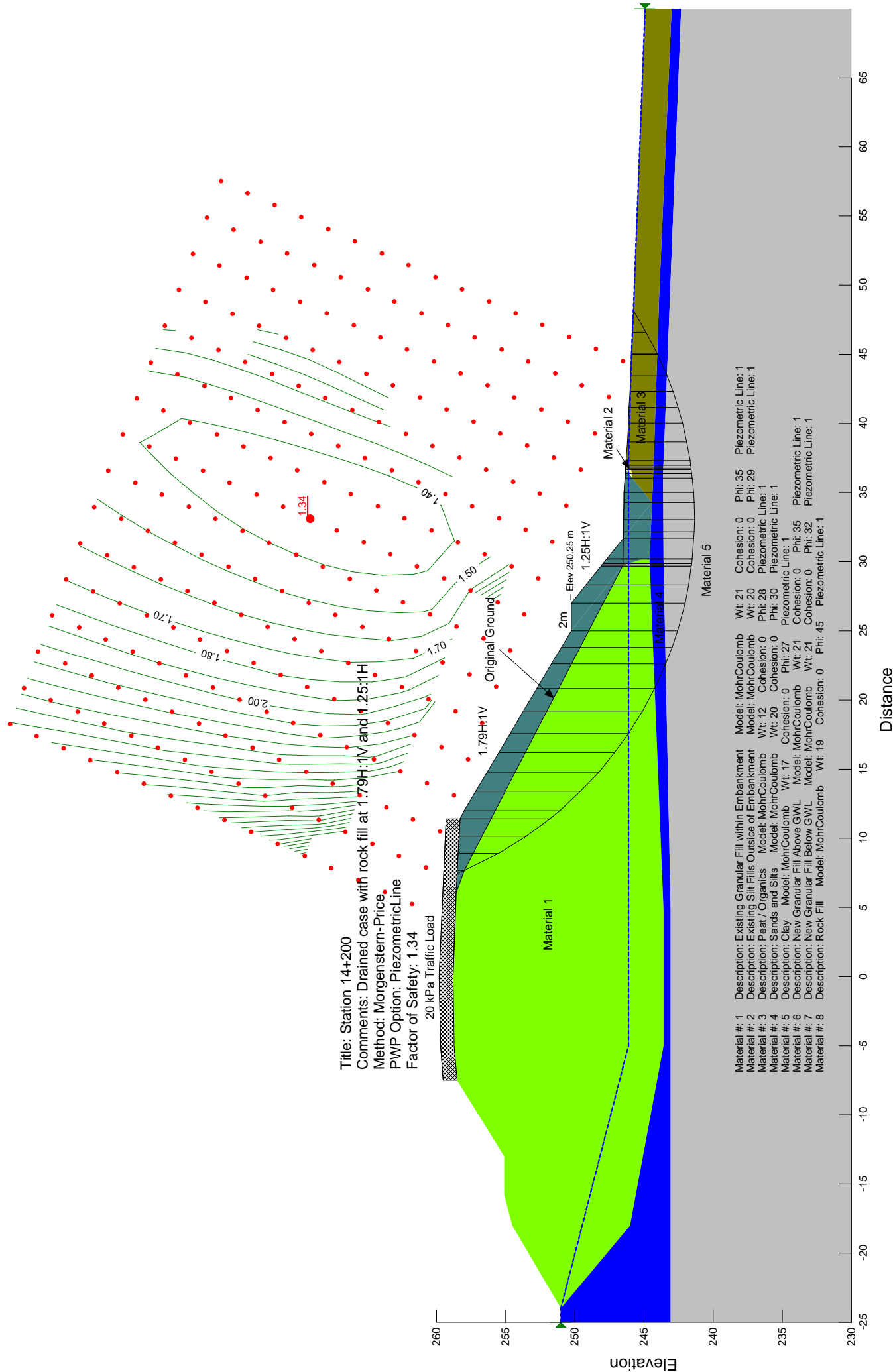


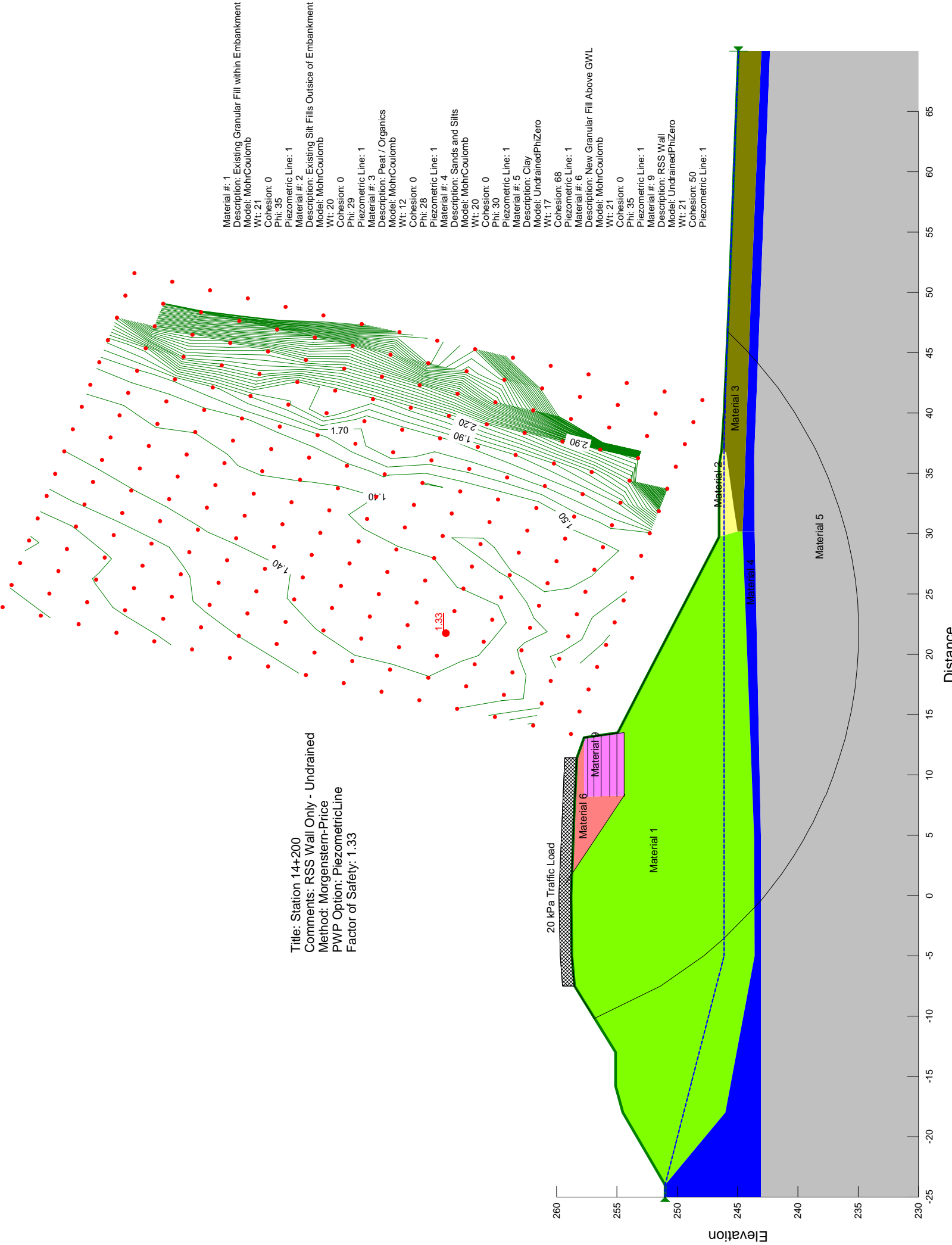


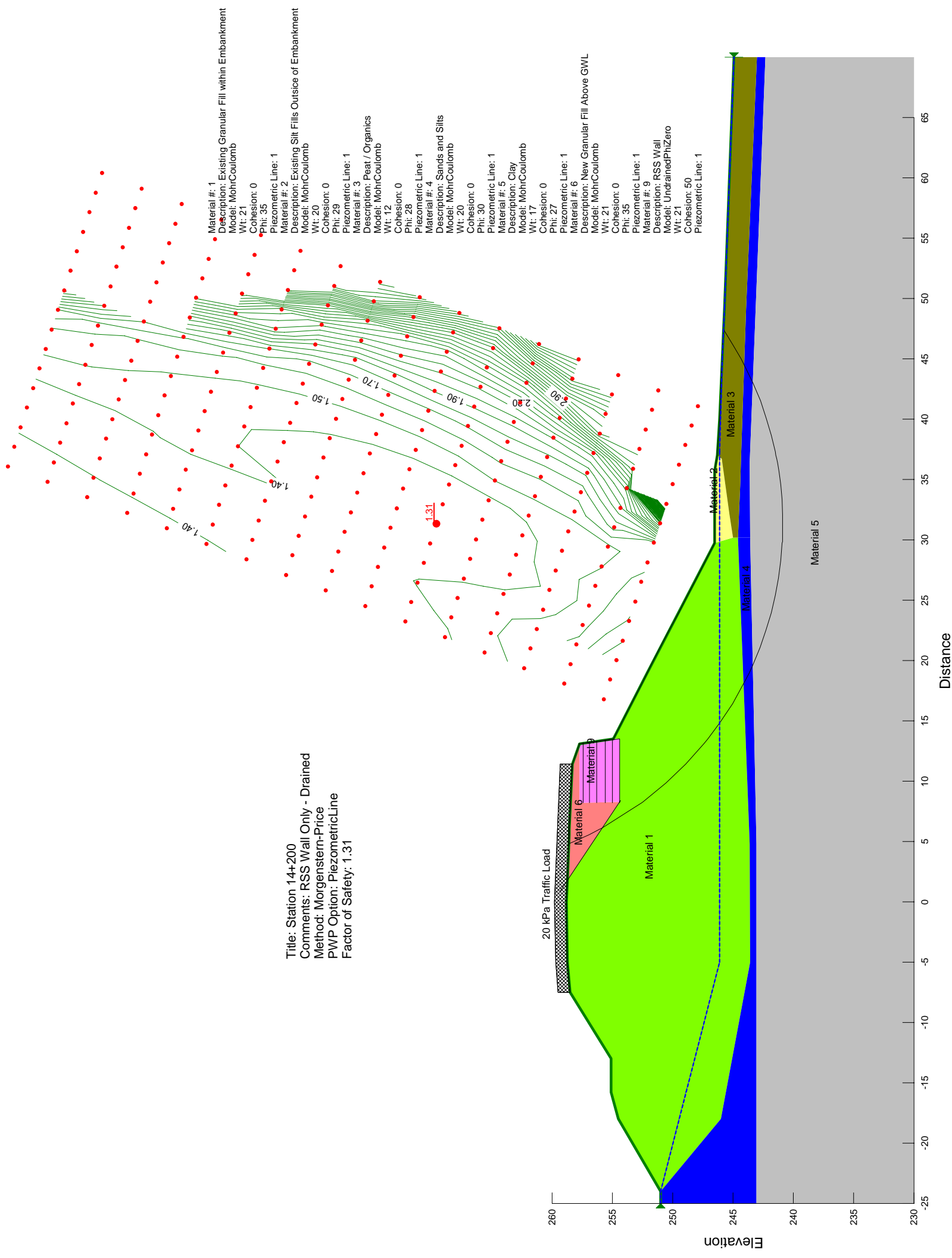




Material #:	1	Description:	Existing Granular Fill within Embankment	Model:	MohrCoulomb	Wt:	21	Cohesion:	0	Phi:	35	Piezometric Line:	1
Material #:	2	Description:	Existing Silt Fills Outside of Embankment	Model:	MohrCoulomb	Wt:	20	Cohesion:	0	Phi:	29	Piezometric Line:	1
Material #:	3	Description:	Peat / Organics	Model:	MohrCoulomb	Wt:	12	Cohesion:	0	Phi:	28	Piezometric Line:	1
Material #:	4	Description:	Sands and Silts	Model:	MohrCoulomb	Wt:	20	Cohesion:	0	Phi:	30	Piezometric Line:	1
Material #:	5	Description:	Clay	Model:	UndrainedPhiZero	Wt:	17	Cohesion:	68	Phi:	30	Piezometric Line:	1
Material #:	6	Description:	New Granular Fill Above GWL	Model:	MohrCoulomb	Wt:	21	Cohesion:	0	Phi:	35	Piezometric Line:	1
Material #:	7	Description:	New Granular Fill Below GWL	Model:	MohrCoulomb	Wt:	21	Cohesion:	0	Phi:	32	Piezometric Line:	1
Material #:	8	Description:	Rock Fill	Model:	MohrCoulomb	Wt:	19	Cohesion:	0	Phi:	45	Piezometric Line:	1







APPENDIX F

Conceptual Sketches of Recommended Embankment Widening

