coffey geotechnics
SPECIALISTS MANAGING THE EARTH

FOUNDATION INVESTIGATION REPORT PROPOSED PASSING LANES ON HIGHWAY 11, TOWNSHIP OF ARMSTRONG, ONTARIO G.W.P. 161-98-00, GEOCRES NO. 31M-83

D.M. Wills Associates Limited

Project: TRANETOB01237AA-AB
June 07, 2010

Coffey Geotechnics Inc.
20 Meteor Drive Etobicoke Ontario M9W 1A4 Canada

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

June 07, 2010

D.M. WILLS Associates Limited
452 Charlotte Street
Peterborough, Ontario
K9J 2W3

Attention: Michael Lang, P.Eng.

Dear Sir:

RE: Foundation Investigation and Design Report, Proposed Passing Lanes on Highway 11, Township of Armstrong, Ontario, G.W.P. 161-98-00, Geocres No. 31M-83

Please find attached the results of our foundation investigation and design report relating to the above noted site.

If you have any comments or enquiries please contact the undersigned.

For and on behalf of Coffey Geotechnics Inc.

Ramon Miranda, P.Eng.
Manager, Transportation Division

Attachment A: Attachments

CONTENTS

CONTENTS

CONTENTS

FOUNDATION INVESTIGATION REPORT
PROPOSED PASSING LANES ON HIGHWAY 11
TOWNSHIP OF ARMSTRONG, ONTARIO
G.W.P. 161-98-00

1 INTRODUCTION

This project includes five proposed passing lanes along Highway 11 in the Township of Armstrong, Ontario. Coffey Geotechnics Inc. (Coffey) was retained by D.M. Wills Associate Limited (Wills) to conduct a foundation investigation for the proposed passing lanes. This report covers the foundation investigation conducted along Highway 11 at two proposed passing lanes with 5 areas, listed in Table 1.1.

Table 1.1 – Passing Lane Location

Passing Lane	Area	Location	Length (m)
Northbound Passing Lanes	1	12+475 – 12+750	275
	2	13+675 – 13+700	25
Southbound Passing Lanes	1	15+275 – 15+575	300
	2	15+850 – 16+000	150
	3	16+250 – 17+200	950

The purpose of the investigation was to obtain information about the subsurface conditions at the sites by means of boreholes, and to determine the engineering characteristics of the subsurface soils by means of field and laboratory tests.

The findings of the investigation are presented in this report.

2 SITE DESCRIPTION AND PHYSIOGRAPHY

The physiography of Englehart area is strongly controlled by the structure of the underlying Precambrian Canadian Shield, comprising the Timiskaming fault system and the fault of the Larder Lake block. The boundary between the two fault systems is followed approximately by the course of the Blanche River. Thick quaternary sediments occupy the lowlands and several of the intermediate terraces, while the uplands and tablelands tend to be more sporadically veneered with till, outwash, moronic and lacustrine sediments. Many of the sediments in Englehart area are lacustro-deltaic in character and comprise layered silt and sands, while finer lacustrine varved clays appear more typical of the tableland, south and west part of Englehart. Several major delta structures have been identified. Many of the rock hills have been washed clean by wave action during high water stages of late-glacial Lakes of Barlow and Barlow-O-jibway and the plane of highest water level has been established.

According to the Ontario Geological Survey Map P. 2700, the bedrock underlying the project site is thinly bedded, very fine to sublithgraphic grey limestone with shaly partings, bioclastic and oolitic beds in upper part and dolostone interbedded in lower part belongs to the Middle Silrurian Earlton Formation.

3 FIELD AND LABORATORY WORK

A summary of the fieldwork conducted for this project is presented in Table 3.1 through Table 3.5.

Table 3.1- Boreholes advanced for Northbound Passing Lane – Area 1

Borehole/ DCPT	Station	Offset	Elevation (m)	Depth (m)	Boring/Test Method
F1	12+475	11.2 m Rt C/L	246.2	9.4	Hollow Stem Auger
F2	12+525	6.5 m Rt C/L	248.7	10.7	Hollow Stem Auger
A1	12+542	11.9 m Rt C/L	247.0	7.8	DCPT
F3	12+565	11.7 m Rt C/L	247.5	8.5	Hollow Stem Auger
A2	12+602	11.7 m Rt C/L	248.4	9.1	DCPT
F4	12+625	6.5 m Rt C/L	250.7	10.4	Hollow Stem Auger
A3	12+650	12.2 m Rt C/L	249.0	9.0	DCPT
F5	12+675	12.4 m Rt C/L	249.7	7.4	Hollow Stem Auger
F6	12+725	8.1 m Rt C/L	252.3	7.7	Hollow Stem Auger
F7	12+785	10.6 Rt C/L	252.8	4.9	Hollow Stem Auger

Table 3.2 - Boreholes advanced for Northbound Passing Lane – Area 2

Borehole / DCPT	Station	Offset	Elevation (m)	Depth (m)	Boring/Test Method
C8	13+695	7.8 m Rt C/L	258.7	6.4	Hollow Stem Auger, DCPT
A4	13+675	13.9 m Rt C/L	258.1	5.3	DCPT
C9	13+700	24.6 m Rt C/L	256.6	7.8	Hollow Stem Auger, DCPT, Wash Boring, Rock Coring
F8	13+625	6.7 m Rt C/L	258.7	6.4	Hollow Stem Auger
F9	13+660	12.6 m Rt C/L	258.2	5.0	Hollow Stem Auger
F10	13+740	14.6 m Rt C/L	258.1	6.2	Hollow Stem Auger
F11	13+775	6.5 m Rt C/L	259.2	6.9	Hollow Stem Auger

Table 3.3 - Boreholes advanced for Southbound Passing Lane – Area 1

Borehole/ DCPT	Station	Offset	Elevation (m)	Depth (m)	Boring/Test Method
D2	15+275	9.0 m Lt C/L	261.7	11.0	Hollow Stem Auger
C6	15+331	19.5 m Lt C/L	258.4	12.3	Hollow Stem Auger, NQ Coring, Wash Boring
C6A	15+326	18.8 m Lt C/L	258.9	11.2	DCPT
D3	15+375	15.3 m Lt C/L	259.4	9.9	Hollow Stem Auger
A5	15+350	19.5 m Lt C/L	259.0	9.8	DCPT
D4	15+425	7.2 m Lt C/L	262.6	9.4	Hollow Stem Auger
D5	15+450	8.4 m Lt C/L	262.5	13.1	Hollow Stem Auger
A6	15+475	7.7 m Lt C/L	262.8	13.6	DCPT
D6	15+500	8.5 m Lt C/L	262.6	13.0	Hollow Stem Auger
D7	15+525	12.6 m Lt C/L	260.9	10.7	Hollow Stem Auger
D8	15+550	7.6 m Lt C/L	262.6	11.3	Hollow Stem Auger
A7	15+575	15.3 m Lt C/L	260.6	8.8	DCPT

Table 3.4 - Boreholes advanced for Southbound Passing Lane – Area 2

Borehole/ DCPT	Station	Offset	Elevation (m)	Depth (m)	Boring/Test Method
H1	15+850	8.0 m Lt C/L	258.8	3.7	Hollow Stem Auger
H2	15+875	7.6 m Lt C/L	258.5	4.6	Hollow Stem Auger
A8	15+887	8.0 m Lt C/L	258.3	4.6	DCPT
H3	15+900	8.0 m Lt C/L	258.1	5.7	Hollow Stem Auger
H4	15+925	7.9 m Lt C/L	257.7	5.3	Hollow Stem Auger, DCPT
H5	15+950	8.1 m Lt C/L	257.4	6.6	Hollow Stem Auger
A9	15+962	7.9 m Lt C/L	257.2	6.8	DCPT
H6	15+975	8.0 m Lt C/L	257.0	6.4	Hollow Stem Auger
H7	15+995	16.8 m Lt C/L	255.1	5.2	Hollow Stem Auger

Table 3.5 - Boreholes advanced for Southbound Passing Lane – Area 3

Borehole/ DCPT	Station	Offset	Elevation (m)	Depth (m)	Boring/Test Method
C1	16+269	16.6 m Lt C/L	252.7	6.3	Hollow Stem Auger, NQ Coring, Wash Boring
C4	16+272	8.0 m Lt C/L	254.5	5.1	Hollow Stem Auger
C4A	16+265	8.8 m Lt C/L	254.9	5.2	DCPT
H10	16+230	6.7 m Lt C/L	255.0	6.3	Hollow Stem Auger
H11	16+305	18.2 m Lt C/L	252.6	2.5	Hollow Stem Auger
A10	16+350	19.3 Lt C/L	252.6	2.6	DCPT
H12	16+353	6.5 m Lt C/L	254.5	4.0	Hollow Stem Auger
H13	16+352	17.6 m Lt C/L	252.5	2.6	Hollow Stem Auger
H14	16+400	6.5 m Lt C/L	254.4	4.2	Hollow Stem Auger
A11	16+400	19.0 Lt C/L	252.4	2.8	DCPT
H15	16+450	17.8 m Lt C/L	252.3	2.5	Hollow Stem Auger
H16	16+500	16.6 m Lt C/L	254.1	3.9	Hollow Stem Auger
A12	16+500	18.8 m Lt C/L	252.1	2.3	DCPT
H17	16+550	18.7 m Lt C/L	251.8	2.5	Hollow Stem Auger
H18	16+600	6.9 m Lt C/L	253.7	4.2	Hollow Stem Auger
A13	16+600	19.2 m Lt C/L	251.7	3.0	DCPT
H19	16+650	18.4 m Lt C/L	251.6	4.0	Hollow Stem Auger
H20	16+700	6.9 m Lt C/L	253.2	5.7	Hollow Stem Auger
A14	16+700	18.2 m Lt C/L	251.2	4.7	DCPT
H21	16+750	18.4 m Lt C/L	251.0	5.5	Hollow Stem Auger
H22	16+800	7.0 m Lt C/L	252.8	8.6	Hollow Stem Auger
A15	16+800	18.5 m Lt C/L	251.0	7.4	DCPT
H23	16+850	8.3 m Lt C/L	250.5	9.2	Hollow Stem Auger
H24	16+900	6.7 m Lt C/L	252.2	12.0	Hollow Stem Auger
A16	16+900	18.7 m Lt C/L	250.3	10.8	DCPT
H25	16+950	18.3 m Lt C/L	250.2	11.3	Hollow Stem Auger
H26	17+000	7.6 m Lt C/L	251.6	13.0	Hollow Stem Auger
A17	17+000	18.5 m Lt C/L	250.0	12.1	DCPT
H27	17+050	18.6 m Lt C/L	249.6	13.1	Hollow Stem Auger

Borehole/ DCPT	Station	Offset	Elevation (m)	Depth (m)	Boring/Test Method
H28	17+100	7.5 m Lt C/L	251.0	14.6	Hollow Stem Auger
A18	17+100	18.9 m Lt C/L	249.2	13.1	DCPT
H29	17+150	19.0 m Lt C/L	248.8	14.3	Hollow Stem Auger
H30	17+200	7.5 m Lt C/L	250.1	15.8	Hollow Stem Auger
A19	17+200	16.0 m Lt C/L	248.9	15.1	DCPT

Landcore Drilling Inc. of Chelmsford, Ontario carried out the drilling, testing and sampling work of all boreholes. Fieldwork was conducted under the direction and supervision of technical staff from Coffey. Upon completion, each borehole was backfilled with a mixture of bentonite/cement, as per MTO procedures.

The borehole locations were established in the field by Coffey engineering staff, in relation to the existing features. The locations were then tied in and the geodetic elevations of the ground at the borehole locations were determined by the client's surveyors. This survey information was provided to us.

Sampling in the boreholes was effected at frequent intervals of depth by the Standard Penetration Test method (SPT), in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51 mm O.D. split barrel (SS – split-spoon) sampler into the ground in the borehole. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil which is indicative of the compactness condition of granular (cohesionless) soils (gravels, sands and coarse silts) or the consistency of cohesive soils (clays and clayey silts).

As mentioned above, Dynamic Cone Penetration Tests (DCPT) were performed at locations presented in Tables 3.1 to 3.5. In this test, a 51 mm diameter, 60-degree apex cone, screw attached to the tip of an A-size rod, is driven into the ground, using the same driving energy as the SPT method. By recording the number of blows of the hammer to drive the cone/rod assembly into the soil every 0.3 m, a qualitative record of soil compactness condition is obtained. Although the interpretation of the test results is difficult because no samples are obtained by the DCPT and the penetration resistances are not necessarily equal to the N-values, useful information is gained by the continuity of the results and by the elimination of unbalanced hydrostatic force effects which in some cases affect the SPT results.

Water level observations in the open boreholes (or casing) were made during the drilling and at completion of each borehole.

Piezometers were installed at selected boreholes to measure the long-term (stabilized) groundwater levels.

The soil and rock core samples were transported to our geotechnical laboratory in Toronto for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations, grain size analyses and one-dimensional consolidation (oedometer) tests was performed on selected representative samples. The results of the laboratory tests are presented on the appropriate Record of Borehole Sheets.

4 SUMMARIZED SUBSURFACE CONDITIONS

4.1 Northbound Passing Lane Area 1 between Stations 12+475 and 12+750

For this passing lane widening section, seven boreholes were drilled and three DCPT were put down between Stations 12+475 and 12+750, on the right side of the existing highway. Three of the boreholes were put down from the top of the embankment, three boreholes from the bottom (i.e. from the o.g. level) while one borehole (Borehole F7) was drilled from about quarter-way up the embankment at Station 12+785. Three DCPT (A1, A2 and A3) were performed in between the boreholes.

The top of the road elevation (i.e. centerline elevation) in this stretch ranges from about 248.3 m at Station 12+475 gradually increasing to about 253.4 m at Station 12+750 (i.e. an elevation raise of 5.1 m over a horizontal distance of 275 m), representing an approximate 1.9 % average gradient.

The o.g. level elevations in this area range from about 245.3 m at Station 12+475 to about 251.5 m at Station 12+750. The existing embankment is typically 1.6 to 2.5 m high.

Details of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A1, while the borehole location plan and a stratigraphic profile are given in Drawing A1-1. The various soil strata encountered in the boreholes and their geotechnical properties are briefly described in the following paragraphs. It should be noted that the soil and groundwater conditions may vary in between and beyond the borehole locations.

4.1.1 Topsoil

Boreholes F1, F3 and F5 were drilled from the toe area of the existing embankment and encountered a 0.2 to 0.6 m thick topsoil layer at the ground surface.

4.1.2 Embankment Fill

Boreholes F2, F4, F6 were drilled from the existing road shoulder and Borehole F7 drilled from about quarter-way up the embankment encountered fill materials.

Boreholes F2, F4 and F6 encountered 0.6 m of sand with gravel or sand some gravel pavement followed by 1.5 to 2.3 m thick silty clay to clayey silt embankment fill. Borehole F7 contacted a 0.5 m thick sand embankment fill material near the toe of the embankment.

The grain-size distribution of two samples from the cohesive embankment fill material is given in Figure B1-1 in Appendix B1. These show the following grain-size distribution.

Gravel:	0 – 1 %
Sand:	18 – 30 %
Silt:	27 – 32 %
Clay:	42 – 50 %

Based on Standard Penetration test results, which yielded N-values of 4 and 5 blows/0.3 m, a relative density of the granular fill at the existing grade is described as very loose while N-values recorded in the underlying cohesive embankment fill range from 4 to 12 blows/0.3 m, indicating a firm to stiff consistency.

In Boreholes F2, F4 and F6, a 0.1 to 0.4 m thick peaty topsoil/organic soil was contacted at the bottom portion of the embankment fill (i.e. peaty topsoil/organic soils appear not to have been properly stripped prior to placing the embankment fill). It should be noted that, based on our experience at many sites, the thickness of peaty topsoil/organic soils may vary considerably between and beyond the borehole locations, especially in the low lying areas; therefore, allowances should be made for possible variations in quantities when making estimates.

4.1.3 Surficial Granular Soils

Boreholes F1 and F3 were drilled from the o.g. level near the existing embankment toe and encountered, immediately below the topsoil, a surficial soil deposit consisting of sand, sand and silty sand. N–values recorded in this granular soil type were 3 and 4 blows/0.3 m which indicate a very loose compactness condition.

4.1.4 Silty Clay

In all boreholes, underlying the embankment fill, peaty topsoil/organic soils or the surficial granular soil, a silty clay deposit was contacted at depths of 0.5 to 2.9 m (El. 245.6 to 252.3 m) and was found to extend to depths ranging from 3.3 m to 8.2 m below the ground surface or El. 238.6 to 249.5 m. This silty clay deposit contains frequent clayey silt seams. Its thickness was found to range from 1.7 to 7.0 m

In Boreholes F1 through F4, the deposit attains a more distinct varved structure, below depths of 3.8 to 6.2 m or at El. 241.4 to 244.5 m.

The grain-size distribution of four samples from the upper zones (i.e. not varved) of the deposit is given in Figure B1-2 in Appendix B1. These show the following grain-size distribution.

Gravel:	0 %
Sand:	3 – 7 %
Silt:	27 – 40 %
Clay:	56 – 66 %

The results of Atterberg Limits tests performed on four samples recovered from the deposit are given on the individual Record of Borehole Sheets and also on a plasticity chart in Figure B1-3 in Appendix B1. The following index values were obtained:

Liquid Limit:	41 – 48 %
Plastic Limit:	23 – 27 %
Plasticity Index:	15 – 21

These results are characteristic of clayey soil with intermediate plasticity.

The grain-size distribution of four samples from the lower varved zones of the deposit, encountered in Boreholes F1 through F4, is given in Figure B1-4 in Appendix B1. These show the following grain-size distribution.

Gravel:	0 %
Sand:	1 – 3 %
Silt:	32 – 35 %
Clay:	63 – 65 %

The results of Atterberg Limits tests performed on four samples recovered from the varved portion of the deposit are given on the individual Record of Borehole Sheets and also on a plasticity chart in Figure B1-5 in Appendix B1. The following index values were obtained:

Liquid Limit:	40 – 49 %
Plastic Limit:	23 – 27 %
Plasticity Index:	17 – 22

These results are characteristic of clayey soil with intermediate plasticity.

Standard Penetration tests performed in the deposit yielded N-values range from 1 to 24 blows/0.3 m. Field vane tests yielded undrained in-situ shear strengths of 65 to in excess of 100 kPa. These results indicate a very soft to very stiff but typically firm to stiff consistency.

One oedometer (one dimensional consolidation) test was performed in the laboratory on a Shelby tube sample (Sample F1/TW7) from the varved zone. The results are presented in Figure B1-6 in Appendix B1. The results show a pre-consolidation pressure higher than the existing overburden pressure which indicates that the clay deposit is probably over-consolidated. Compression index (C_c) of about 0.8 and recompression index (C_r) of about 0.1 are obtained.

The measured bulk unit weight of the TW sample is 15.0 kN/m^3.

The silty clay deposit is a relatively impervious soil type but large differences can be expected in the coefficient of permeability in the horizontal and vertical directions. While the mass permeability in the vertical direction can be expected to be practically impervious, higher permeabilities could occur in the horizontal direction in the clay silt and silt seams.

4.1.5 Clayey Silt to Silty Clay (Possible Till)

Underlying the silty clay, Boreholes F3, F4, F5, F6 and F7 encountered a heterogeneous mixture of clayey silt with sand and traces of gravel (possible till, glacial till-like texture) deposit at depths ranging from 3.3 to 7.6 m (or El. 242.1 to 249.5 m) and found to extend to depths ranging 4.3 to 9.1 m (or El. 239.0 to 248.5 m) below the ground surface. This deposit contains occasional sand layers. Boreholes F3 and F6 were terminated within this deposit at depths of 8.5 and 7.7 m or Elevations of 239.0 and 244.6 m, respectively, upon encountering refusal whereas in Boreholes F4, F5 and F7, it was found to be underlain by a relatively coarser glacial till deposit (sandy silt to silty sand till).

The grain-size distribution of six samples from the deposit is given in Figure B1-7 in Appendix B1. These show the following grain-size distribution.

Gravel:	4 – 15 %
Sand:	20 – 45 %
Silt:	25 – 36 %
Clay:	21 – 40 %

The results of Atterberg Limits tests performed on four samples recovered from the deposit are given on the individual Record of Borehole Sheets and also on the Plasticity Chart in Figure B1-8 in Appendix B1. The following index values were obtained:

Liquid Limit:	19 – 29 %
Plastic Limit:	12 – 17 %
Plasticity Index:	7 – 13

These results are characteristic of clayey soils of low plasticity.

N–values recorded in this cohesive material range from 5 to 34 blows/0.3 m which indicate a firm to hard consistency but typically stiff to very stiff.

The presence of cobbles and boulders should be anticipated in this deposit.

4.1.6 Sandy Silt to Silty Sand Till

Underlying the silty clay or the silty clay till, in Borehole F1, F2, F4, F5 and F7 encountered a sandy silt to silty sand till deposit at depths ranging 4.3 to 9.1 m (or El. 238.6 to 248.5 m) which was found to extend to depths ranging from 4.9 to 10.7 m (or El. 236.8 to 247.8 m). This glacial deposit consists of a heterogeneous mixture of sandy silt to silty sand with some gravel and clay size particles. This is a basically granular material but in some cases, where the clay content is high, this imparts the deposit some apparent cohesion. The grain size distribution of two samples from the deposit is in Figure B1-9 in Appendix B1. The curves indicate the following grain-size distribution.

Gravel:	14 - 26 %
Sand:	34 – 41 %
Silt:	18 – 27 %
Clay:	15 – 25 %

Sample F4/SS12 represents a zone with higher clay content (i.e. relatively finer) while Sample F1/SS11 represents a relatively coarser zone (i.e. higher gravel and lower clay size particle content), while typically the grain size distribution falls in between these two extremes.

N–values recorded in this soil deposit range from 4 to in excess of 100 blows/0.3 m which indicate a very loose to very dense compactness condition.

Due to their mode of deposition, the presence of cobbles and boulders should always be anticipated in the glacial till deposits.

4.1.7 Refusal Depths

Boreholes F3 and F6 were terminated in the clayey silt (possible till) deposit and Boreholes F1, F2, F4, F5 and F7 were terminated in the sandy silt to silty sand till deposit after encountering refusal on the split-spoon penetration and/or on the augers at depths of between 4.9 and 10.7 m below the existing grade. Three DCPT indicate refusal depths at 7.8 to 9.1 m below the ground surface. Refusal depths are summarized in Table 4.1.7.1.

Table 4.1.7.1 - Auger/DCPT Refusal Depths

Borehole/ DCPT	Station	offset	Ground Elevation (m)	Refusal Depth / Elevation	Remark
F1	12+475	11.2 m Rt C/L	246.2	9.4/236.8	
F2	12+525	6.5 m Rt C/L	248.7	10.7/238.0	
A1	12+542	11.9 m Rt C/L	247.0	7.8/239.2	DCPT
F3	12+565	11.7 m Rt C/L	247.5	8.5/239.0	
A2	12+602	11.7 m Rt C/L	248.4	9.1/239.3	DCPT
F4	12+625	6.5 m Rt C/L	250.7	10.4/240.3	
A3	12+650	12.2 m Rt C/L	249.0	9.0/240.0	DCPT
F5	12+675	12.4 m Rt C/L	249.7	7.4/242.3	
F6	12+725	8.1 m Rt C/L	252.3	7.7/244.6	
F7	12+785	10.6 m Rt C/L	252.8	4.9/247.9	

Many of refusals may have been caused by a boulder while some may be on the surface of the bedrock or close to it.

4.1.8 Groundwater Conditions

The groundwater conditions in the open boreholes were observed during the drilling and upon completion of each borehole, as shown on the individual Record of Borehole Sheets. The observations made in the boreholes are summarized in Table 4.1.8.1 and presented on the Record of Borehole Sheets in Appendix A1.

Table 4.1.8.1 - Groundwater Conditions

Borehole	Station	offset	Ground Elevation (m)	Depth / Elevation of the Tip of Piezometer (m)	Date	Water Level Depth / Elevation (m)
F1	12+474	11.2 m Rt C/L	246.2	-	Upon completion	3.0/243.2
F2	12+525	6.5 m Rt C/L	248.7	-	Upon completion	7.3/241.4
F3	12+565	11.7 m Rt C/L	247.5	-	Upon completion	4.0/243.5
F4	12+625	6.5 m Rt C/L	250.7	-	Upon completion	7.6/243.1
F5	12+675	12.4 m Rt C/L	249.7	-	Upon completion	6.1/243.6
F6	12+725	8.1 m Rt C/L	252.3	-	Upon completion	4.9/247.4
F7	12+785	10.6 m Rt C/L	252.8	-	Upon completion	4.1/248.7

As the observations were made upon completion of each borehole, the recorded levels are unlikely to represent the stabilized groundwater levels. Furthermore, the groundwater levels would be subject to seasonal variations and fluctuations in response to major weather events.

4.2 Northbound Passing Lane Area 2 between Stations 13+675 and 13+700

Boreholes F8, F9, F10, F1, C8 and A4 were drilled on top of the highway embankment on the right (north-east) shoulder of Highway 11. Borehole C9 was put down at about 24.6 m right of the centreline of Highway 11, away from the highway embankment. Locations of these boreholes are summarized and presented in Table 3.2.

In general the boreholes show, below some fill (primarily embankment fill) with a maximum depth of 2.6 m, the presence of a discontinuous layer of silty clay in four of the six boreholes drilled at the site. The thickness of the silty clay deposit was found to range from 0.3 to 1.6 m at the borehole locations. Underlying the fill and/or the silty clay deposit is a silty sand till deposit. All six boreholes were extended to auger refusal within the silty sand till at 4.9 to 6.9 m below the ground surface. In one borehole (Borehole C9), the borehole was extended below the refusal depth of 4.9 m (El. 251.7 m) and the refusal was found to represent the surface of the bedrock. In the remaining boreholes, the refusal depths may represent boulders or the bedrock surface.

Details of the subsurface conditions encountered in the boreholes are presented on the Records of Boreholes in Appendix A2. An interpreted stratigraphic profile is given in Drawing A2-1. The various soil strata encountered in the boreholes and their geotechnical properties are briefly described in the following paragraphs. It should be noted that the soil and groundwater conditions may vary in between and beyond the borehole locations.

4.2.1 Topsoil

Boreholes F9 and F10 which was drilled on the embankment side slope encountered 0.2 and 0.3 m of topsoil overlying the embankment fill.

4.2.2 Embankment Fill

4.2.2.1 Granular Fill

Boreholes C8, F8 and F11, advanced on the shoulder of Highway 11, encountered 0.1 to 0.5 m of granular fill overlying the embankment fill. The granular fill consists of sand and gravel with traces of silt.

Grain-size distribution of two samples recovered from this layer is as follows and shown in Figure B2-1, Appendix B2.

Gravel:	34 %
Sand:	57 %
Silt and Clay:	9 %

4.2.2.2 Embankment Earth Fill

Underlying the topsoil in Boreholes F9 and F10 and granular fill in Boreholes C8, F8 and F11, an embankment fill consisting of silty clay with silt & sand mixtures was encountered. At the borehole locations, this embankment fill is about 1.1 to 2.2 m thick and extends to depths of between 1.4 and 2.6 m below the ground surface or to Elevations 257.1 and 256.1 m. This is a basically cohesive soil with some fine grained granular zones. The presence of organic traces was noted in the embankment fill, as well as an organic layer at the bottom of Borehole F11. This probably represents the original topsoil/organic natural soil which got mixed with fill during the construction of the embankment.

Atterberg Limits test was performed on a sample from this deposit. The results are shown in Figure B2-2, and are summarized below.

Liquid Limit:	36 %
Plastic Limit:	24 %
Plasticity Index:	12

These results are characteristic of clayey soils of low plasticity.

N-values, yielded from Standard Penetration tests performed in this embankment fill, range from 5 to 10 blows/0.3 m. These results indicate that at the borehole locations the embankment fill exhibits a firm to stiff consistency. The test results also indicate that the fill did not receive a systematic compaction during its construction.

4.2.3 Earth Fill

Borehole C9 which was put down from the o.g. level, beyond the toe of the embankment, near the existing watercourse, contacted a 0.9 m thick fill layer (i.e. from the ground surface to 1.0 m below the ground surface or to El. 255.6 m). The fill at this location consists of silty clay/clayey silt with sand and traces of gravel and organics. Similar to the embankment fill, this fill is a basically cohesive material with some non-cohesive (i.e., granular) zones. An Atterberg limits test was performed on the cohesive portion of the fill and the test yielded the following index values:

Liquid Limit:	30 %
Plastic Limit:	18 %
Plasticity Index:	13

As shown on the Plasticity chart in Figure B2-3 in Appendix B2, these results indicate a clayey soil of low plasticity.

A SPT N-value of 8 blows/0.3 m was recorded in the fill deposit, indicating a firm to stiff or loose condition.

4.2.4 Silty Clay

A silty clay deposit underlies the embankment fill in Boreholes C8, F9, F10 and F1 at depths between 1.4 and 2.1 m below ground surface or Elevations between 257.1 and 256.4 m. The thickness of this cohesive material at the borehole locations ranges from 0.3 to 1.6 m and the deposit extends to El. 256.1 – 255.4 m.

Grain-size analysis was performed on one sample retrieved from this deposit in Borehole C8, shown in Figure B2-4, Appendix B2. The distribution is as follows:

Gravel:	0 %
Sand:	2 %
Silt:	32 %
Clay:	66 %

Atterberg Limits tests were performed on two samples from Boreholes C8 and F11 and summarized as follows (shown in Figure B2-5, Appendix B2).

Liquid Limit:	43 – 44 %
Plastic Limit:	26 – 28 %
Plasticity Index:	16 – 18
Natural Moisture Content:	42 – 43 %

These results indicate that the material is of intermediate plasticity and from the fact that the measured natural moisture contents are very close to the measured liquid limits indicates that the deposit can be expected to be relatively weak and compressible.

Standard Penetration tests performed in this cohesive deposit yielded N-values between 6 and 17 blows/0.3 m. As well, a field vane test yielded an undrained, in-situ shear strength of 80 kPa. These results reflect that the deposit is firm to very stiff in consistency.

4.2.5 Silty Sand Till

Underlying the earth fill in Borehole C9 and the embankment fill in Borehole F8 and the silty clay to clayey silt deposit in Boreholes C8, 9, F10 and F11 is a glacial deposit consisting of silty sand till. This deposit was contacted at depths of between 0.9 and 3.7 m below the ground surface (or El. 256.1 – 255.4 m) and extended to depths between 4.9 and 6.9 m or El. 253.2 – 251.7 m. All the boreholes, with the exception of Boreholes C9 and F8, were terminated in this deposit after encountering auger refusal. In Borehole F8, the silty sand till is underlain by a sand & gravel deposit while in Borehole C9 it extends to the surface of bedrock where it was cored.

The glacial till deposit consists of a heterogeneous mixture of silty sand with traces of gravel and clay and is described as granular (non-cohesive) soil type.

Grain-size distributions of five samples recovered from this deposit are summarized as follows and are shown in Figure B2-6, Appendix B2).

Gravel:	3 – 10 %
Sand:	46 – 56 %
Silt:	26 – 38 %
Clay:	12 – 14 %

Standard Penetration Tests performed in the deposit yielded N-values which range from 3 to in excess of 100 blows/0.3 m which indicate a very loose to very dense relative density. However, N-values are generally between 3 and 22 blows/0.3 m (i.e. typically very loose to compact).

4.2.6 Sand and Gravel Till

In Borehole F8 at a depth of 6.1 m, the silty sand till became coarse and attained a sand and gravel till texture. The borehole was terminated after penetrating the deposit for 0.3 m at a depth of 6.4 m (El. 252.3 m), due to auger refusal.

A Standard Penetration Test performed in this granular soil yielded an N-value of in excess of 100 blows/0.3 m indicating a very dense condition.

4.2.7 Bedrock

Borehole C9 was advanced beyond auger refusal at 4.9 m below the ground surface level (El. 251.7 m) using rock coring techniques. The refusal was found to be on the surface of the bedrock and the bedrock was found to consist of dolomitic limestone that is brown to grey in colour. Total Core Recovery (TCR) of the rock cores is between 88% and 89% and Rock Quality Designation (RQD) is between 45% and 64%. These results indicate the bedrock is fair in quality within the depth that was sampled.

Refusal depths in the boreholes/DCPT are summarized in Table 4.2.7.1.

Table 4.2.7.1 - Auger/DCPT Refusal Depths

Borehole/ DCPT	Station	Ground Elevation (m)	Auger/DCPT Refusal Depth/ Elevation (m)
C8	13+695	258.7	6.4 / 252.3
A4	13+675	258.1	5.3 / 252.8
C9	13+700	256.6	4.9 / 251.7 (Bedrock proven)
F8	13+625	258.7	6.4 / 252.3
F9	13+660	258.2	5.0 / 253.2
F10	13+740	258.1	6.2 / 251.9
F11	13+775	259.2	6.9 / 252.3

With the exception of Borehole C9 (where the bedrock was proven by coring), the refusal depths may represent a boulder or the surface of the bedrock.

From these observations, the inferred bedrock elevation is between El. 253 and 251.

4.2.8 Groundwater Conditions

Groundwater conditions at the site were observed during the drilling and upon completion of the boreholes. A piezometer was installed in Borehole C9 at 7.6 m below o.g. level (El. 249.0 m). The observations made in the open boreholes and in the piezometer are shown on the individual Records of Borehole Sheets and are summarized below.

Table 4.2.8.1 - Groundwater conditions

Borehole Number	Ground Surface Elevation	Depth/Elevation of the Tip of Piezometer (m)	Measured Groundwater Depth/Elevation (m)	Date Measured	Piezometer Installed?
C8	258.7	-	None Observed* (dry on completion)	October 8, 2009	No
C9	256.6	7.6 / 249.0	3.1 / 253.5	August 26, 2009 (41 days after completion)	Yes
F8	258.7	-	4.6 / 254.1* (on completion)	July 15, 2009	No
F9	258.2	-	None Observed* (dry on completion, caved-in @ 3.1m)	July 15, 2009	No
F10	258.1	-	None Observed* (dry on completion, caved-in @ 4.6m)	July 15, 2009	No
F11	259.2	-	None Observed* (dry on completion, caved-in @ 6.3m)	July 15, 2009	No

*not stabilized

It should be pointed out that groundwater levels are subject to fluctuations due to weather or seasonal changes.

4.3 Southbound Passing Lane Area 1 between Station 15+275 and 15+575

Boreholes D2 to D8 and C6 were advanced on the left side (west) of Highway 11. Table 3.3 in Section 3 presents the location of all the boreholes advanced for this passing lane location. Boreholes D4, D5, D6 and D8 were put down on the shoulder of Highway 11, at the top of the highway embankment; Borehole D2 was advanced on the slope of the highway embankment; and Boreholes D3 and D7 were put down near the toe of the highway embankment. Borehole C6 was put down away from the highway embankment.

Boreholes D4, D5, D6 and D8 drilled from the shoulder of the highway embankment encountered embankment fill varying from 1.5 to 2.3 m in thickness. Borehole D2 drilled from the slope of the highway embankment also encountered fill material to 0.8 m depth. At 2.3 and 1.5 m below grade (El. 260.3 and 261.0 m), Boreholes D4 and D5 contacted a 1.4 and 2.2 m thick layer of clayey silt below the embankment fill. Borehole D8 contacted a layer of 1.1 m thick buried topsoil below the embankment fill at 1.5 m below o.g. level or Elevation 261.1 m. Below the embankment fill in Boreholes D2 and D6, clayey silt in Boreholes D4 and D5 and surficial or buried topsoil in Boreholes C6, D3, D7 and D8, all boreholes encountered a rather thick deposit of silty sand till at between 0.2 and 3.7 m below the ground surface (El. 260.9 to 258.2 m). This silty sand till deposit ranges from 5.7 to 11.2 m in thickness. All boreholes and DCPT were terminated due to auger/DCPT refusal at between 8.8 to 13.6 m depth (El. 253.2 to 247.7 m). Rock coring technique was used to advance beyond the refusal depth at 9.3 m below ground surface (El. 249.1 m) in Borehole C6.

Details of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A3. An interpreted stratigraphic profile is given in Drawing A3-1. The various soil strata encountered in the boreholes and their geotechnical properties are briefly described in the following paragraphs. It should be noted that the soil and groundwater conditions may vary in between and beyond the borehole locations.

4.3.1 Topsoil

Boreholes C6, D3 and D7 encountered a 0.2 to 0.3 m thick layer of topsoil from the ground level. Borehole D8 contacted a layer of 1.1 m thick buried topsoil at El. 261.1 m (1.5 m from o.g. level).

4.3.2 Embankment Fill

Boreholes D4, D5, D6 and D8 were drilled from the left shoulder of Highway 11. These boreholes contacted 0.6 m of granular pavement consisting of sand with some gravel, overlying an embankment fill that extends to between 1.5 and 2.3 m depth or to El. 261.1 to 260.3 m. Two types of embankment fill were encountered in these boreholes namely, silty sand with some clay and gravel (primarily non-cohesive) and silty clay with sand and gravel (primarily cohesive). The non-cohesive embankment fill was contacted in Boreholes D4, D5 and D8, while the cohesive fill (i.e. silty clay) was contacted in Borehole D6.

Borehole D2 was advanced on the slope of the highway embankment fill and encountered a gravelly sand embankment fill with traces of silt and clay. Grain-size distribution of a sample retrieved from this soil unit is presented in Figure B3-1 (Appendix B3) which indicates the following distribution:

Gravel:	30 %
Sand:	61 %
Silt and Clay:	9 %

An N-value of 5 blows/0.3 m was obtained from Standard Penetration test conducted in this granular (i.e. non-cohesive) unit which shows that this embankment fill is loose. It also indicates that this gravelly sand embankment fill has not received a systematic compaction when it was first placed.

As mentioned before, a silty clay embankment fill was encountered in Borehole D6 from beneath the granular should pavement fill at 0.6 m to 1.4 m. This embankment fill also contains some sand and traces of gravel and organics. Grain-size distribution of a sample recovered from this unit is presented in Figure B3-2, in Appendix B3.

Gravel:	1 %
Sand:	21 %

Silt:	34 %
Clay:	44 %

Standard Penetration tests conducted in this cohesive material yielded an N-value of 10 blows/0.3 m, which indicates the fill has a stiff consistency.

As mentioned earlier, Boreholes D4 and D8 contacted a silty sand embankment fill with some gravel and clay underlying the granular shoulder pavement fill to between 1.5 and 2.3 m depth. A similar embankment fill with some gravel and clay and traces of organics was contacted in Borehole D6 from 1.4 to 1.8 m below grade. Occasional silty clay pockets were also observed within the fill in Borehole D4. Grain-size analyses were performed on three samples obtained from these basically granular (i.e. non-cohesive) fill in Boreholes D4, D6 and D8. Figure B3-3 in Appendix B3 presents the following distribution:

Gravel:	4 – 15 %
Sand:	48 – 62 %
Silt:	20 – 29 %
Clay:	11 – 18 %

Standard Penetration tests conducted in this embankment fill deposit yielded N-values of between 6 and 21 blows/0.3 m of penetration. These results indicate that this embankment fill is in a loose to compact condition.

It should also be pointed out that a 1.1 m thick buried topsoil layer was contacted in Borehole D8 underlying the embankment fill at depth of 1.5 m (El. 261.1 m).

4.3.3 Clayey Silt

A clayey silt deposit, between 1.4 and 2.2 m in thickness, was encountered under the embankment fill in Boreholes D4 and D5. This deposit contains traces of gravel and some sand, as well as some silt seams. Dilatancy was observed within this unit in Borehole D4. The deposit extends to 3.7 m depth (El. 258.9 and 258.8 m).

Grain-size distribution of two samples retrieved from the material from Borehole D5 is as follows, as presented in Figure B3-4 in Appendix B3.

Gravel:	0 – 1 %
Sand:	10 – 29 %
Silt:	39 – 41 %
Clay:	29 – 51 %

In the lower zones of Borehole D4, the deposit attains a more sandy and gravelly character (immediately above the underlying glacial till deposit). The grain-size distribution of one sample from this silty sand seam is given below (also presented in Figure B3-5 in Appendix B3).

Gravel:	19 %
Sand:	37 %
Silt:	23 %
Clay:	21 %

The results of Atterberg Limits tests conducted with two samples obtained from this clayey silt deposit is presented in Figure B3-6 in Appendix B3. The liquid limits, plastic limits and plasticity indices are as follows:

Liquid Limit:	14 – 26 %
Plastic Limit:	8 – 15 %
Plasticity Index:	6 – 11

These results are characteristic of clayey soils of low plasticity. The relatively lower Plasticity Index obtained from Sample D5/SS6 represents the influence of silt seams in the deposit.

N-values yielded from Standard Penetration tests conducted within this cohesive deposit range from 3 to 8 blows/0.3 m of penetration. Based on these results the consistency of the deposit can be described as soft to firm.

4.3.4 Silty Sand Till

Underlying the embankment fill, the buried topsoil (Borehole D8), or the clayey silt (Boreholes D4 and D5), all boreholes contacted a silty sand till deposit at depths between 0.2 and 3.7 m below the ground surface or between El. 260.9 and 258.2 m. This till deposit consists of a heterogeneous mixture of silty sand with some gravel and clay size particles. Occasional sand seams were also contacted. Dilatancy was also observed in Borehole D7 at shallow depth. All boreholes were terminated within this deposit due to auger refusal on possible bedrock between 9.3 and 13.1 m (El. 253.2 to 249.1 m). In Borehole C6, the borehole was further extended below the refusal depth and the presence of bedrock at this location was proven. In the Dynamic Cone Penetration Tests (DCPT) (i.e. C6A, A5, A6 and A7), refusal was contacted at 8.8 to 13.6 m below the ground surface or at El. 249.2 – 251.8 m.

Grain-size analyses were performed on 14 samples retrieved from this deposit and the grain-size distributions are presented in Figure B3-7 in Appendix B3 in an envelope form. The grain-size distribution is as follows:

Gravel:	5 – 16 %
Sand:	43 – 58 %
Silt:	21 – 37 %
Clay:	8 – 21 %

Due to their mode of deposition the presence of cobbles and boulders should always be anticipated in the glacial till deposits. In fact, the presence of cobbles and boulders was inferred in the boreholes while drilling. Grain-size distributions of two samples containing sand seams are presented in Figure B3-8 (Appendix B3) and give the following results:

Gravel:	9 %
Sand:	65 – 75%
Silt and Clay:	16 – 26%

Grain-size distribution of a sample containing a clayey silt interbed is presented in Figure 3-9, in Appendix B3.

Gravel:	0 %
Sand:	5 %
Sand:	53 %
Clay:	42 %

This glacial till is a basically granular (i.e. non-cohesive) deposit with very occasional cohesive clayey silt interbeds. N-values obtained from Standard Penetration tests conducted in the deposit range between 0 and 61 blows/0.3 m of penetration. This indicates that this deposit is very loose to very dense in condition, but typically very loose to compact.

4.3.5 Bedrock

Borehole C6 encountered dolomitic limestone bedrock at Elevation 249.1 m or 9.3 m below the o.g. level. All other boreholes were terminated due to auger/DCPT refusal possibly on the bedrock or on boulders. The refusal depths are summarized in Table 4.3.5.1.

Table 4.3.5.1- Auger/DCPT Refusal Depths

Borehole/ DCPT	Station	Ground Elevation (m)	Auger/DCPT Refusal Depth/Elevation (m)
D2	15+275	261.7	11.0 / 250.7
C6	15+331	258.4	9.3 / 249.1
C6A	15+326	258.9	11.2 / 247.7
D3	15+375	259.4	9.9 / 249.5
A5	15+350	259.0	9.8 / 249.2
D4	15+425	262.6	9.4 / 253.2
D5	15+450	262.5	13.1 / 249.4
A6	15+475	262.8	13.6 / 249.3
D6	15+500	262.6	13.0 / 249.6
D7	15+525	260.9	10.7 / 250.2
D8	15+550	262.6	11.3 / 251.3
A7	15+575	260.6	8.8 / 251.8

From these observations, the inferred bedrock elevation is approximately between El. 253 and 249 m. In Borehole C6, where the bedrock was proven by coring, Total Core Recovery (TCR) of the rock cores is between 87% and 100% and Rock Quality Designation (RQD) is between 57% and 97%. These results indicate the bedrock is fair in quality within the depths that it was sampled.

4.3.6 Groundwater Conditions

Groundwater conditions were observed in open boreholes while drilling and upon completion. Water levels observed in each borehole upon completion are tabulated in Table 4.3.6.1 and presented on Record of Borehole sheets in Appendix A4.

Table 4.3.6.1- Groundwater Conditions

Borehole	Ground Surface Elevation (m)	Depth/Elevation of the Tip of Piezometer (m)	Measured Groundwater Depth/Elevation (m)	Date Measured	Depth/Elevation (m) where soil changes colour from brown to grey
C6	258.4	9.2 / 249.2	1.7 / 256.7* 1.9 / 256.5	June 18, 2009 August 26, 2009	-
D2	261.7	-	7.9 / 253.8*	June 5, 2009	3.7 / 258.0
D3	259.4	-	None Observed8 (dry on completion, caved-in @ 9.8 m)	June 19, 2009	N/A
D4	262.6	-	7.0 / 255.6*	June 20, 2009	3.7 / 258.9
D5	262.5	-	9.4 / 253.1*	June 5, 2009	2.7 / 259.8
D6	262.6	-	10.4 / 252.2*	June 6, 2009	3.7 / 258.9
D7	260.9		7.9 / 253.0*	June 7, 2009	2.2 / 258.7
D8	262.6		9.5 / 253.1*	June 19, 2009	2.6 / 260.0

*not stabilized.

It should be noted that the groundwater level is subject to fluctuations both seasonally and in response to major weather events.

4.4 Southbound Passing Lane Area 2 between Station 15+275 and 15+575

Boreholes H1 through H6 were drilled from the left (west) granular shoulder, about 7.6 to 8.1 m from the centreline, of Highway 11 while Borehole H7 was advanced at 16.8 m left of the centreline of highway (from the o.g. level). In addition, Dynamic Cone Penetration tests A8 and A9 were put down from the left shoulder area. Table 3.4 in the Section 3 of this report summarized the location of boreholes drilled and Dynamic Cone Penetration tests advanced for Passing Lane 4.

In general, Boreholes H1 to H6 contacted embankment fill to depths of 1.1 to 1.5 m below the road shoulder level. Underlying the embankment fill, Boreholes H1, H2 and H6 encountered a 0.6 to 0.7 m thick layer of buried topsoil. Borehole H7 was drilled from the original ground (o.g.) level and contacted a 0.3 m thick surficial topsoil.

Underlying the embankment and/or topsoil, all boreholes, except for Borehole H1, contacted a 0.3 to 2.7 m thick silty clay deposit. Beneath the buried topsoil in Borehole H1 and the silty clay in the remaining boreholes, the site is underlain by a silty sand till deposit. The boreholes were terminated in the silty sand till at depths between 3.7 to 6.6 m due to auger refusal, possibly on bedrock or boulders.

Details of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole sheets in Appendix A4. An interpreted stratigraphic profile is given in Drawing A4-1. The various soil strata encountered in the boreholes and their geotechnical properties are briefly described in the following paragraphs. It should be noted that the soil and groundwater conditions may vary in between and beyond the borehole locations.

4.4.1 Topsoil

Borehole H7, put down away from the highway embankment, encountered 0.3 m of topsoil at o.g. level (El. 255.1 m). Boreholes H1, H2 and H6 contacted topsoil buried beneath the highway embankment fill at depths between 1.4 and 1.5 m at El. 257.3-255.6 m. This buried topsoil ranges from 0.6 to 0.7 m in thickness.

4.4.2 Embankment Fill

All the boreholes, except for Borehole H7, were drilled from the top of the existing highway embankment and encountered embankment fill to depths of 1.1 to 1.5 m below the ground surface or to El. 257.3 - 255.6 m. The upper 0.6 m of the embankment fill consists of shoulder granular pavement fill overlying a silty sand to sand embankment fill. The primarily silty sand to sand embankment fill contains some gravel and clay size particles.

Grain-size distribution of four samples, retrieved from the embankment fill is presented in Figure B4-1 in Appendix B4 and is as follows:

Gravel:	5 – 10 %
Sand:	57 – 64 %
Silt:	16 – 24 %
Clay:	10 – 14 %

The embankment fill is classified as a primarily granular (i.e. non-cohesive) soil.

Standard Penetration Tests performed within the embankment fill yielded N-values between 2 and 14 blows/0.3 m of penetration, indicating very loose to compact in relative density but primarily loose. These tests indicate that the embankment fill along this stretch did not receive a systematic compaction when it was first placed.

4.4.3 Silty Clay

A silty clay deposit was encountered under the embankment fill in Boreholes H3, H4 and H5, under buried topsoil in Boreholes H2 and H6 and topsoil in Borehole H7. It was not encountered in Borehole H1. The thickness of the deposit varies from 0.3 to 2.7 m and the deposit extends to between Elevations 256.1 and 253.0 m (2.1 and 3.8 m below ground level). The silty clay deposit contains traces of gravel and traces to some sand. The presence of organics was also noted at shallow depths. The deposit also contains frequent clayey silt to silt interbeds.

Grain-size analyses were performed on four samples recovered from this deposit, in Boreholes H3, H4, H6 and H6. The grain-size distribution is presented in Figure B4-2 in Appendix B4 and is summarized below.

Gravel:	0 – 10 %
Sand:	4 – 19 %
Silt:	31 – 39 %
Clay:	40 – 59 %

Atterberg Limits Tests were conducted on four samples retrieved from this cohesive deposit. Results of these tests are presented in Figure B4-3, in Appendix B4, as follow:

Liquid Limit:	31 – 47 %
Plastic Limit:	9 – 21 %
Plasticity Index:	16 – 26

From these results, it can be concluded that this silty clay is cohesive with low to medium plasticity.

Standard Penetration tests performed in this deposit yielded N-values between 2 and 12 blows/0.3 m. The undrained, in-situ shear strength of the material was measured in the field by means of field vane testing. The test results indicated undrained shear strength values in excess of 100 kPa. Based on these test results the consistency of the material is described as soft to very stiff.

4.4.4 Silty Sand Till

A silty sand till deposit was encountered in all boreholes at between depths 2.1 and 3.8 m (El. 256.7 and 253.0 m) underlying the buried topsoil in Borehole H1 and the silty clay deposit in the remaining boreholes. All seven boreholes terminated in this deposit due to practical auger refusal between Elevations 255.1 and 249.9 m (3.7 and 6.6 m below the ground surface), possibly on bedrock or on boulders.

The deposit is described as a granular (i.e. non-cohesive) soil type.

Grain-size distribution of six samples recovered from this deposit is as follows, as presented in Figure B4-4 in Appendix B4.

Gravel:	11 – 26 %
Sand:	40 – 53 %
Silt:	18 – 42 %
Clay:	7 – 14 %

N-values yielded from Standard Penetration Tests performed in this deposit range between 3 and in excess of 60 blows/ 0.3 m. Based on the test results, the relative density of this basal unit is described to vary widely from very loose to very dense.

4.4.5 Refusal Depths

All boreholes were terminated due to auger/DCPT refusal. The refusal depths are presented in the Table 4.4.5.1.

Table 4.4.5.1 - Auger/DCPT Refusal Depths

Borehole/ DCPT Number	Station	Ground Elevation (m)	Auger/DCPT Refusal Depth/Elevation (m)
H1	15+850	258.8	3.7 / 255.1
H2	15+875	258.5	4.6 / 253.9
A8	15+887	258.3	4.6 / 253.7
H3	15+900	258.1	5.7 / 252.4
H4	15+925	257.7	5.3 / 252.4
H5	15+950	257.4	6.6 / 250.8
A9	15+962	257.2	6.8 / 250.4
H6	15+975	257.0	6.4 / 250.6
H7	15+995	255.1	5.2 / 249.9

4.4.6 Groundwater Conditions

Groundwater conditions were observed during drilling and upon completion of the boreholes. Table 4.4.6.1 summarizes the groundwater conditions observed at the time of our investigation.

Table 4.4.6.1 - Groundwater Conditions

Borehole	Ground Elevation (m)	Water Depth/Elevation (m) upon completion	Date Measured	Depth/Elevation (m) where soil changes colour from brown to grey
H1	258.8	3.3 / 255.5 *	June 10, 2009	N/A
H2	258.5	Caved-in @4.1/254.5*	June 9, 2009	2.1 / 256.4
H3	258.1	Caved-in @4.5/253.6*	June 10, 2009	4.2 / 253.9
H4	257.7	Dry *	June 9, 2009	3.5 / 254.2
H5	257.4	Caved-in @5.8/251.6*	June 10, 2009	4.9 / 252.5
H6	257.0	Caved-in @5.8/251.2*	June 9, 2009	5.2 / 251.8
H7	255.1	4.1 / 251.0 *	June 10, 2009	2.1 / 253.0

*not stabilized

It should be noted that groundwater table is subject to fluctuations seasonally and in response to major weather events. In addition, a perched water table condition can occur due to the accumulation of surface water in the fill and topsoil materials overlying the practically impervious silty clay.

4.5 Southbound Passing Lane Area 3 between Station 16+250 and 17+200

For Passing Lane Area 5, twenty-three boreholes (including culvert foundation Boreholes, C1 and C4) were drilled and eleven DCPT were put down between Stations 16+250 and 17+200 (total 950 m long), on the left side of the highway. Twelve of the boreholes were put down from the top of the embankment (road shoulder), while eleven boreholes were put down from the bottom (i.e. from the o.g. level) of the existing embankment.

At Station 16+250 the top of road elevation is about 255.2 m, dropping to about El. 250.4 m at Station 17+200 (i.e. an elevation drop of about 4.8 m over a horizontal distance of 950 m) which represents an approximate 0.5 % average gradient.

The o.g. level elevations on the proposed widening side (left side) of the existing highway in this stretch range from about 254.6 m at Station 16+250 to about 249.1 m at Station 17+200 m. The embankment is typically 1.5 to 2.3 m high.

In general, the boreholes showed along this 950 m stretch below some embankment fill the presence of a silty clay deposit which attains a varved structure with increased depth. This silty clay is underlain by a glacial till deposit to refusal depths contacted at about 2.5 m to 15.8 m below the o.g. levels, on boulders or possibly on the surface of the bedrock.

Details of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A5, while a stratigraphic profile is given in Drawings A5-1, A5-2 and A5-3. The various soil strata encountered in the boreholes and their geotechnical properties are briefly described in the following paragraphs. It should be noted that the soil and groundwater conditions may vary in between and beyond the borehole locations.

4.5.1 Embankment Fill

All the boreholes drilled from the shoulder of the existing road embankment encountered fill materials consisting of sand some gravel, sand with gravel, silty sand to sandy silt and clayey silt to silty clay which extend to depths of 1.5 to 2.3 m below the ground surface or El. 252.8 m to 248.0 m.

A granular pavement (i.e. sand to sand some gravel) fill was contacted in all the boreholes drilled from the existing road shoulder to depths of 0.3 to 0.6 m.

The grain-size distribution of two samples from the granular pavement fill is presented in Figure B5-1. This shows 8 - 25 % gravel, 67 - 86 % sand, 6 - 8 % silt and clay size particles.

Underlying the granular pavement fill, the embankment fill generally consists of silty sand to sandy silt (i.e. basically non-cohesive material) except for Boreholes H26 and H30 as well the lower portion in Boreholes H18, H22 and H28. Boreholes H10, H14, H16 and H18 contacted trace to some organics and topsoil mixed with the embankment fill materials. Occasional cohesive zones were also found in the otherwise basically granular embankment fill.

The grain-size distribution of three samples from the embankment fill was determined and these show the following grain-size distribution, as presented in Figure B5-2 in Appendix B5.

Gravel:	4 – 9 %
Sand:	30 – 50 %
Silt:	27 – 42 %.
Clay:	2 – 14 %

The grain-size distribution of a sample from a silty clay zone (SS3 in Borehole H10) within the silty sand embankment fill is presented in Figure B5-3. This shows 0% gravel, 23% sand, 35% silt and 42% clay size particles.

The grain-size distribution of a sample from the basically cohesive embankment fill was determined on a sample and the results show the following grain-size distribution, as presented in Figure B5-4 in Appendix B5.

Gravel:	2 %
Sand:	23 %
Silt:	37 %
Clay:	38 %

Standard Penetration tests yielded N-values ranging from 3 to 15 blows/0.3 m in the basically granular embankment fill materials (non-cohesive) indicating a very loose to compact condition but typically very loose to loose. The recorded N-values in the clayey (cohesive) embankment fill materials range from 6 to 9 blows/0.3 m, which indicate a firm to stiff consistency. Based on the recorded N-values which typically range from 4 to 9 blows/0.3 m, the embankment fills in this stretch appear not to have received a systematic compaction when they were first placed.

4.5.2 Topsoil and Buried Topsoil

Boreholes drilled from the toe area of the existing embankment encountered a 0.3 to 0.6 m thick topsoil layer at the ground surface.

In the boreholes drilled from the top of the embankment (left shoulder area), the bottom part of the embankment fill appeared to be mixed with topsoil and other organic soils. As well, Boreholes H22 and H24 contacted a 0.6 to 0.7 m thick buried peaty topsoil below the existing embankment fill at 1.5 m depth. From these observations, it appears that organic soils have not been properly stripped prior to placing the embankment fills. Standard Penetration tests performed in the buried peaty topsoil in Boreholes H22 and H24 yielded N-values of between 7 and 10 blows/0.3 m, indicating a loose relative density.

It should be noted that, based on our experience at many sites, the thickness of peaty topsoil/organic soils may vary considerably between and beyond the borehole locations, especially in the low lying areas; therefore, allowances should be made for possible variations in quantities when making estimates.

4.5.3 Surficial Sandy Silt to Silty Sand

Underlying the topsoil, Borehole H27 contacted an about 1.2 m thick surficial granular soil deposit consisting of sandy silt to silty sand. This deposit was found to extend to a depth of 1.5 m or El. 248.1 m.

N-values recorded in this deposit were 9 and 10 blows/0.3 m. These results indicate a loose to compact relative density.

4.5.4 Silty Clay

All of the boreholes contacted major silty clay deposit underlying the embankment fill and topsoil at depths of 0.3 to 2.3 m below the existing grade. At the borehole locations the deposit was found to be 1.1 to 13.9 m thick and generally increases from south to north with increasing station numbers. The deposit was found to extend to depths of 1.5 m (Borehole H11) to 15.0 m (Borehole H30) below the ground surface or to El. 251.1 – 235.1 m. This massive silty clay deposit is a cohesive material. Borehole H19 was terminated within this deposit after encountering refusal to further augering while the remaining boreholes were extended into the underlying silty sand till.

The silty clay deposit contains frequent thin silt interbeds. In most of the boreholes, with depth, the deposit attains a varved structure.

The grain-size distribution of samples from the upper zone of the deposit which do not display a varved structure was determined on sixteen samples and these show the following grain-size distribution, as presented in Figure B5-5 in Appendix B5.

Gravel:	0 – 4 %
Sand:	1 – 14 %
Silt:	31 – 45 %
Clay:	44 – 68 %

Atterberg Limits tests performed in the laboratory showed the following index values:

Liquid Limit:	36 – 49%
Plasticity Limit:	20 – 30%
Plasticity Index:	15 – 19

As shown on the Plasticity Chart presented in Figure B5-6, Appendix B5, these results are characteristic of clayey soils of intermediate plasticity.

The grain-size distribution of a sample from the sandy silt zone at the bottom of the deposit in Borehole H10 is presented in Figure B5-7. This shows 13% gravel, 25% sand, 40% silt and 22% clay size particles. Atterberg Limits tests was also performed on the same sample and showed the following index values:

Liquid Limit:	23 %
Plasticity Limit:	16 %
Plasticity Index:	7

This zone in Borehole H10 probably represents a transition into underlying glacial till.

Standard Penetration tests conducted in the upper zone of the silty clay deposit which do not display a varved characteristic gave N-values ranging from 2 to 19 blows/0.3 m. The undrained in-situ shear strength of the deposit was measured in the field by means of field vane tests, using MTO type field vanes. The measured values range from 40 to in excess of 100 kPa. Based on these field test results the consistency of the soil is described as very soft to very stiff.

As mentioned before, the deposit attains a varved structure in most boreholes, with increased depth.

The grain-size distribution of eleven samples from the varved lower zones of the silty clay deposit was determined in the laboratory and the test results show the following grain-size distribution, as presented in Figure B5-8 in Appendix B5.

Gravel: 0 %

Sand: 1 – 5 %

Silt: 24 – 47 %

Clay: 50 – 75 %

Atterberg Limits tests performed in the laboratory showed the following index values:

Liquid Limit: 38 – 46 %

Plasticity Limit: 21 – 28 %

Plasticity Index: 15 – 20

As shown on the Plasticity Chart presented in Figure B5-9, Appendix B5, these results are characteristic of clayey soils of intermediate plasticity.

Standard Penetration tests conducted in the varved silty clay deposit gave N-values which range from 0 to 6 blows/0.3 m. The undrained in-situ shear strengths of the deposit were measured in the field by means of field vane tests, using MTO type field vanes. The measured values range from 30 to 75 kPa. These field tests indicate very soft to stiff consistency. It should be pointed out that the frequent clayey silt and silt interbeds may have influenced the measured in-situ undrained shear vane strengths, especially in the lower varved zones.

Two oedometer (one dimensional consolidation) tests were performed in the laboratory on 51 mm (2") and 76 mm (3") diameter Shelby tube (TW) samples. The results are presented in Figure B5-11 and B5-12 in Appendix B5. These results show a possible pre-consolidation pressure that is higher than the existing overburden pressure at a shallow depth (TW4 in Borehole H27) (i.e. P_c'-$P'_o \approx$ 40kPa) while the second sample from a greater depth (i.e. TW14 / Borehole H30) indicates little or no pre-consolidation pressure in excess of the existing overburden pressure. A compression index (C_c) of about 0.54 to 0.93 and a recompression index (C_r) of about 0.05 are obtained from the oedometer test results presented.

The measured bulk unit weight of the TW samples are 16.6 and 16.7 kN/m^3. The relatively high bulk unit weights probably reflect the influence of clayey silt and silt interbeds.

Figure C1 in Appendix C presents the measured undrained in-situ shear strengths versus elevation under and beyond the existing embankment.

In Figures C2 and C3 in Appendix C, the variation of the measured in-situ vane strength values (i.e. in-situ undrained shear strengths) versus elevation is presented, for Boreholes H27 and H28 in which the silty clay was found to be relatively thick. Also plotted in the figure is the effective overburden stress (P'_o), as well as the plot of 0.23 x P'_o with elevation. It is commonly acknowledged that with Ontario clays if the measured undrained shear strengths are in excess of 0.23 P'_o line, the deposit may be somewhat over-consolidated. Based on this criterion, the silty clay appears to exhibit some pre-consolidation near the upper zones to about El. 246.7 m and below this it only exhibits a slight over-consolidation.

4.5.5 Basal Granular Till

Underlying the silty clay deposit, all boreholes drilled at the site, except for Borehole H19, encountered a basal granular glacial deposit consisting of heterogeneous mixture of silty sand with some gravel and clay size particles. This basal glacial till was contacted at depths ranging from 1.5 m (Borehole H11) to 15.0 m (Borehole H30) below the ground surface or at Elevations 251.1 m (Borehole H11) to 235.1 m (Boreholes H29 and H30). This rather thin basal deposit was found to extend to depths ranging from 2.5 to 15.8 m or Elevations 250.5 – 234.4 m. The glacial till is a basically granular (non-cohesive) material.

The grain-size determination of nine samples from the deposit is given in Figure B5-10 in Appendix B5. These indicate the following grain-size distribution:

Gravel:	5 – 25%
Sand:	34 – 56 %
Silt:	23 – 33 %
Clay:	5 – 18 %

Due to their mode of deposition, the presence of cobbles and boulders should always be anticipated in the glacial till deposits.

N-values recorded in the deposit range widely from 1 to in excess of 100 blows/0.3 m, indicating a very loose to very dense compactness condition.

The basal glacial till deposit is water bearing and appeared to be under excess hydrostatic pressure.

4.5.6 Bedrock

Borehole C1, drilled at the culvert (C20, Station 16+268) location, encountered dolomitic limestone bedrock at a depth of 3.3 m (or El. 249.4 m) where the bedrock was proved by NQ coring. Borehole was advanced into the bedrock for 3 m and was terminated at a depth of 6.3 m or (El. 246.4 m). The total core recovery (TCR) in the cores recovered from the bedrock was measured to be 100%, and a Rock Quality Designation (RQD) of 60% was recorded. This RQD value indicates a fair rock quality in Borehole C1.

4.5.7 Refusal Depths

All the boreholes were terminated upon encountering refusal on the spoon-sampler and/or on the augers at depths of 2.5 to 15.8 m below the existing grade or El. 234.3 to 250.2 m. Some of the refusal depths are likely to be close to the bedrock surface. Ten DCPT results indicated that the refusal depth in between the boreholes were at 2.3 to 15.1 m below the ground surface. Refusal depths are summarized in Table 4.5.7.1.

4.5.7.1 - Auger/DCPT Refusal Depth

Borehole	Station	offset	Ground Elevation (m)	Refusal Depth / Elevation	Remark
C1	16+269	16.6 m Lt C/L	252.7	3.3 / 249.4	
C4	16+272	8.0 m Lt C/L	254.5	5.1 / 249.4	
C4A	16+265	8.8 m Lt C/L	254.9	5.2 / 249.7	DCPT
H10	16+230	6.7 m Lt C/L	255.0	6.3 / 248.7	
H11	16+305	18.2 m Lt C/L	252.6	2.5 / 250.1	
A10	16+350	19.3 Lt C/L	252.6	2.6 / 250.0	DCPT
H12	16+353	6.5 m Lt C/L	254.5	4.0 / 250.5	
H13	16+352	17.6 m Lt C/L	252.5	2.6 / 249.9	
H14	16+400	6.5 m Lt C/L	254.4	4.2 / 250.2	
A11	16+400	19.0 Lt C/L	252.4	2.8 / 249.6	DCPT
H15	16+450	17.8 m Lt C/L	252.3	2.5 / 249.8	
H16	16+500	16.6 m Lt C/L	254.1	3.9 / 250.2	
A12	16+500	18.8 m Lt C/L	252.1	2.3 / 249.8	DCPT
H17	16+550	18.7 m Lt C/L	251.8	2.5 / 249.3	
H18	16+600	6.9 m Lt C/L	253.7	4.2 / 249.5	
A13	16+600	19.2 m Lt C/L	251.7	3.0 / 248.7	DCPT
H19	16+650	18.4 m Lt C/L	251.6	4.0 / 247.6	
H20	16+700	6.9 m Lt C/L	253.2	5.7 / 247.5	
A14	16+700	18.2 m Lt C/L	251.2	4.7 / 246.5	DCPT
H21	16+750	18.4 m Lt C/L	251.0	5.5 / 245.5	
H22	16+800	7.0 m Lt C/L	252.8	8.6 / 244.2	
A15	16+800	18.5 m Lt C/L	251.0	7.4 / 243.6	DCPT
H23	16+850	8.3 m Lt C/L	250.5	9.2 / 241.3	
H24	16+900	6.7 m Lt C/L	252.2	12.0 / 240.2	
A16	16+900	18.7 m Lt C/L	250.3	10.8 / 239.5	DCPT
H25	16+950	18.3 m Lt C/L	250.2	11.3 / 238.9	
H26	17+000	7.6 m Lt C/L	251.6	13.0 / 238.6	
A17	17+000	18.5 m Lt C/L	250.0	12.1 / 237.9	DCPT
H27	17+050	18.6 m Lt C/L	249.6	13.1 / 236.5	
H28	17+100	7.5 m Lt C/L	251.0	14.6 / 236.4	
A18	17+100	18.9 m Lt C/L	249.2	13.1 / 236.1	DCPT
H29	17+150	19.0 m Lt C/L	248.8	14.3 / 234.5	
H30	17+200	7.5 m Lt C/L	250.1	15.8 / 234.3	
A19	17+200	16.0 m Lt C/L	248.9	15.1 / 233.8	DCPT

4.5.8 Groundwater Conditions

The groundwater conditions in the open boreholes were observed during the drilling and upon completion of each borehole, as shown on the individual Record of Borehole Sheets. The observations made in the boreholes are summarized in Table 4.5.8.1 and presented on the Record of Borehole Sheets in Appendix A5

4.5.8.1 - Groundwater Conditions

Borehole	Station	offset	Ground Elevation (m)	Depth / Elevation of the Tip of Piezometer (m)	Date	Water Level Depth / Elevation (m)
C1	16+269	16.6 m Lt C/L	252.7	3.5/249.2	one week after installation	1.1/251.6
C4	16+272	8.0 m Lt C/L	254.5	-	Upon completion	Dry (caved-in @4.4 m)
H10	16+230	6.7 m Lt C/L	255.0	-	Upon completion	Dry (caved–in @5.8 m)
H11	16+305	18.2 m Lt C/L	252.6	-	Upon completion	Dry/Open
H12	16+353	6.5 m Lt C/L	254.5	-	Upon completion	Dry (caved-in @3.2 m)
H13	16+352	17.6 m Lt C/L	252.5	-	Upon completion	Dry (caved-in @2.3 m)
H14	16+400	6.5 m Lt C/L	254.4	-	Upon completion	Dry (caved-in @3.2 m)
H15	16+450	17.8 m Lt C/L	252.3	-	Upon completion	Dry (caved-in @2.3 m)
H16	16+500	16.6 m Lt C/L	254.1	-	Upon completion	Dry (caved-in @3.2 m)
H17	16+550	18.7 m Lt C/L	251.8	-	Upon completion	Dry (caved-in @2.4 m)
H18	16+600	6.9 m Lt C/L	253.7	-	Upon completion	Dry (caved-in @3.3 m)
H19	16+650	18.4 m Lt C/L	251.6	-	Upon completion	Dry (caved-in @3.8 m)
H20	16+700	6.9 m Lt C/L	253.2	-	Upon completion	4.9/248.3
H21	16+750	18.4 m Lt C/L	251.0	-	Upon completion	Dry/Open
H22	16+800	7.0 m Lt C/L	252.8	-	Upon completion	Dry/Open
H23	16+850	18.3 m Lt C/L	250.5	-	Upon completion	Dry/Open
H24	16+900	6.7 m Lt C/L	252.2	-	Upon completion	Dry (caved-in @11.0 m)
H25	16+950	18.3 m Lt C/L	250.2	-	Upon completion	Dry/Open
H26	17+000	7.6 m Lt C/L	251.6	-	Upon completion	Dry (caved-in @7.3 m)
H27	17+050	18.6 m Lt C/L	249.6	-	Upon completion	12.6/237.0
H28	17+100	7.5 m Lt C/L	251.0	-	Upon completion	Dry (caved-in @5.9 m)
H29	17+150	19.0 m Lt C/L	248.8	-	Upon completion	Dry (caved-in @5.9 m)
H30	17+200	7.5 m Lt C/L	250.1	-	Upon completion	Dry (caved-in @9.3 m)

Except for Borehole C1, in which a piezometer was installed, the water levels recorded on completion are unlikely to represent the stabilized groundwater conditions.

It should however be pointed out that the groundwater levels would be subject to seasonal variations and fluctuations in response to major weather events.

For and on behalf of Coffey Geotechnics Inc.

Gwangha Roh, Ph.D.

Ramon Miranda, P.Eng.
Manager, Transportation Division

LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
PROVINCE OF ONTARIO

Zuhtu Ozden, P.Eng.
Senior Principal

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
PROVINCE OF ONTARIO

Appendix A1

Drawing and Record of Borehole Sheets - Passing Lane 1

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.

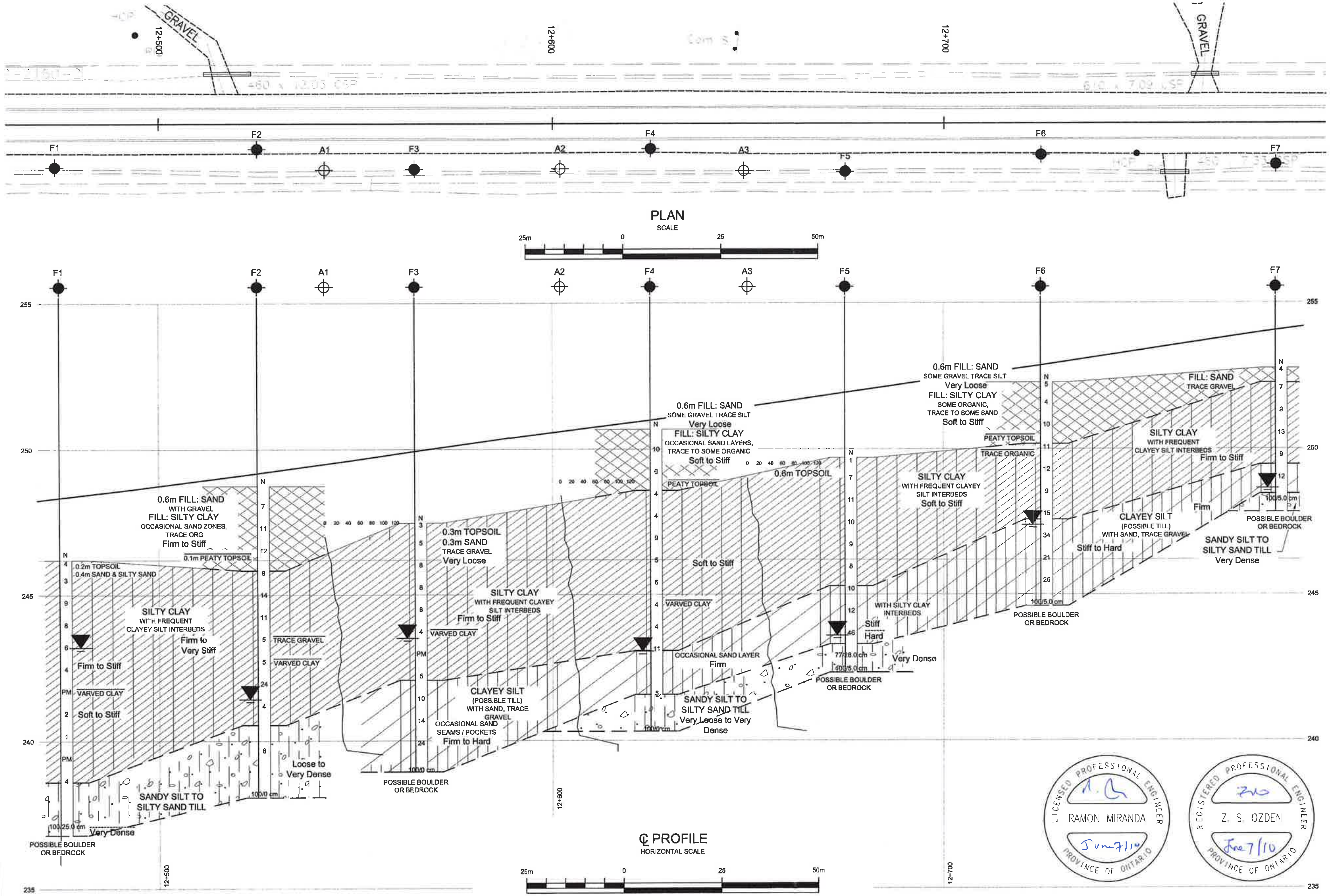
CONT No.

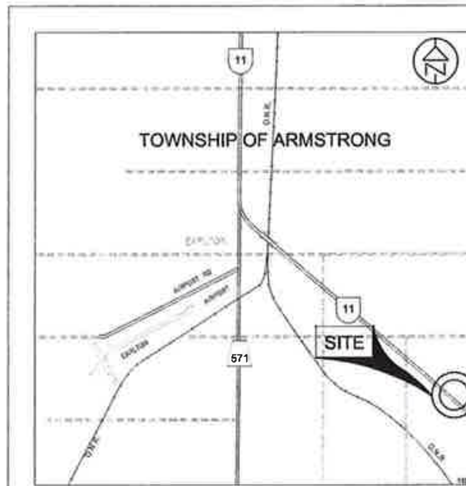
GWP: 161-98-00

HIGHWAY 11, ARMSTRONG TWP
NORTHBOUND PASSING LANE AREA 1
BOREHOLE LOCATION PLAN
& SOIL STRATA

SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH





LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & Cone
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
F1	246.2	12+475	11.2m Rt C/L
F2	248.7	12+525	6.5m Rt C/L
F3	247.5	12+565	11.7m Rt C/L
F4	250.7	12+625	6.5m Rt C/L
F5	249.7	12+675	12.4m Rt C/L
F6	252.3	12+725	8.1m Rt C/L
F7	252.8	12+785	10.6m Rt C/L
A1	247.0	12+542	11.9m Rt C/L
A2	248.4	12+602	11.7m Rt C/L
A3	249.0	12+649	12.2m Rt C/L

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

LICENSED PROFESSIONAL ENGINEER — RAMON MIRANDA — Jun 7/10 — PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER — Z. S. OZDEN — Jun 7/10 — PROVINCE OF ONTARIO

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 31M-82

TRANETOB01237AA			DIST
SUBM'D	CHECKED	DATE May 10, 2010	SITE
DRAWN PHK	CHECKED RM	APPROVED ZO	DWG A1-1

RECORD OF BOREHOLE No F1

METRIC

GWP 161-98-00	LOCATION Passing Lane #1, Sta: 12+475, 11.2 m Rt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY W.C.
DATUM Geodetic	DATE 6/2/2009 6/3/2009		CHECKED BY Z.O.

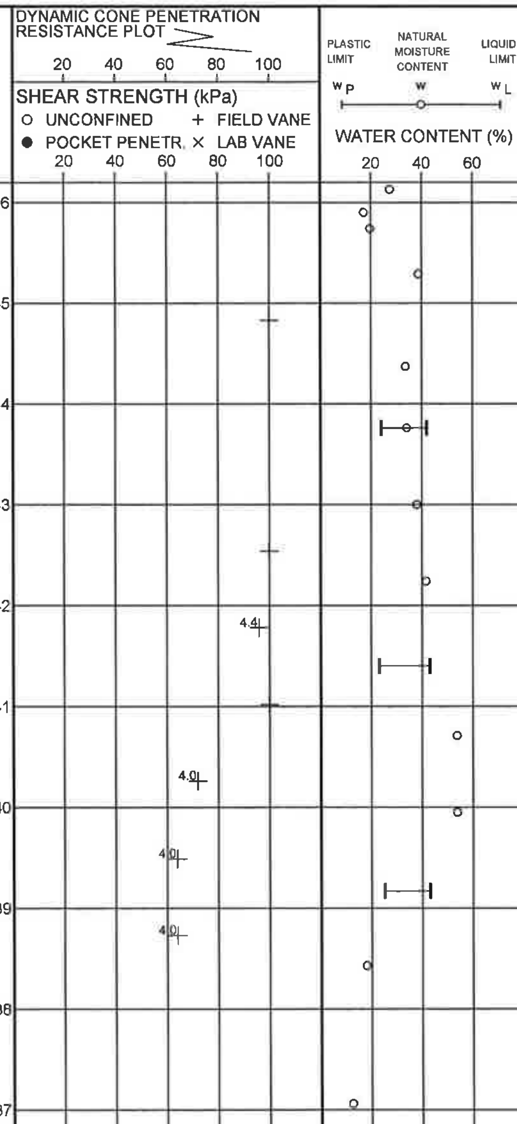
SOIL PROFILE / SAMPLES

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
246.2	GROUND SURFACE				
0.0	0.2 m **TOPSOIL** 0.4 m **SAND & SILTY SAND**	1	SS	4	
	SILTY CLAY with freq. clayey silt interbeds brown	2	SS	3	
		3	SS	9	
		4	SS	8	0 3 40 57
		5	SS	6	
	firm to stiff	6	SS	4	
	varved clay	7	TW	PM	consolidation test; 0 3 32 65
	soft to stiff	8	SS	2	
		9	SS	1	
		10	TW	PM	0 2 33 63
238.6 / 7.6	**SANDY SILT TO SILTY SAND TILL** gravelly, some clay grey, v. loose, wet	11	SS	4	26 41 18 15; auger grinding below 8.3 m
236.8	v. dense	12	SS	100/25.0 cm	
9.4	End of Borehole.				

Unit weight (sample 7): 15.0 kN/m³

Ground water: ▼* at approx. elev. 243.2

End of Borehole.
Auger refusal @ 9.4 m on possible boulder or bedrock
Water level @ 3.0 m (not stabilized)* upon completion
Hole caved-in @ 8.8 m upon completion



+³, ×³: Numbers refer to Sensitivity

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No F2

METRIC

GWP 161-98-00	LOCATION Passing Lane # 1, Sta: 12+525, 6.5 m Rt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY W.C.
DATUM Geodetic	DATE 7/14/2009		CHECKED BY Z.O.

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
248.7	GROUND SURFACE
0.0	0.6 m **FILL:** Sand with gravel, brown
	FILL: Clayey Silt occ. sand zones, tr. org brown, firm to stiff, moist
	0.1 m peaty topsoil
245.8 / 2.9	**SILTY CLAY** with freq. clayey silt interbeds brown, firm to v. stiff, moist
	tr. gravel
	varved clay
240.5 / 8.2	**SANDY SILT TO SILTY SAND TILL** tr. to some clay grey, loose to v. dense, wet
238.0 / 10.7	End of Borehole. Water level @ 7.3 m (not stabilized)* upon completion. Borehole caved-in @ 8.4 m upon completion.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	AS		
2	SS	7	1 30 27 42
3	SS	11	
4	SS	12	wet spoon below
5	SS	9	
6	SS	14	
7	SS	11	
8	SS	5	TW sampler could not push in
9	SS	5	TW sampler could not push in
10	AS	24	0 2 33 65
11	SS	4	
12	SS	8	
13	SS	100/0 cm	Sampler refusal @ 10.7 m on possible bedrock

Elevation scale: 248, 247, 246, 245, 244, 243, 242, 241, 240, 239, 238

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A1

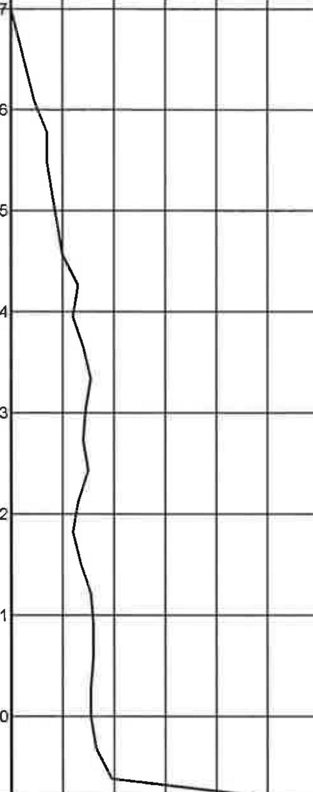
1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Embankment Fill Location #1 - (DCPT), Sta: 12+542, 11.9 m Rt C/L of Hwy 11 ORIGINATED BY G.J.

DIST ___ HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY W.C.

DATUM Geodetic DATE 6/3/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
247.0 0.0	GROUND SURFACE						247 246 245 244 243 242 241 240				
239.2 7.8	End of DCPT refusal @ 7.8 m										



+ ³, × ³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No F3

METRIC

GWP 161-98-00	LOCATION Passing Lane #1, Sta: 12+565, 11.7 m Rt C/L of Hwy 11		ORIGINATED BY G.J.
DIST ____ HWY 11	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY W.C.
DATUM Geodetic	DATE 6/3/2009		CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
247.5	GROUND SURFACE					
0.0	0.3 m **TOPSOIL**; 0.3 m **SAND**, tr. gravel, v. loose	1	SS	3		
	SILTY CLAY with freq. clayey silt interbeds, brown, firm to stiff, moist	2	SS	5		
		3	SS	8		
		4	SS	8		0 4 38 58
		5	SS	6		
	varved clay	6	SS	4	▼*	
		7	TW	PM		0 1 35 64
242.1 / 5.4	**CLAYEY SILT TO SILTY CLAY** (Possible Till) with sand, tr. gravel, occ. sand seams/pockets, grey, firm to hard, wet	8	SS	5		spoon wet below 5.4 m
		9	SS	10		5 39 30 26
		10	SS	14		
		11	SS	24		
239.0 / 8.5	End of Borehole. Auger refusal @ 8.5 m on possible boulder or bedrock. Water level @ 4.0 m (not stabilized)* upon completion. Hole caved-in @ 8.1 m upon completion	~~12~~	~~SS~~	~~100/0 cm~~		

Elevation scale: 247, 246, 245, 244, 243, 242, 241, 240, 239

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE; 20 40 60 80 100 (field vane values annotated: 4.2, 6.0)

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

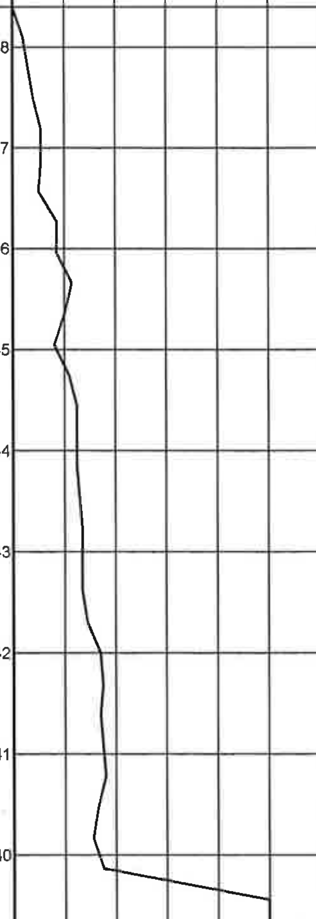
15-⊕-5 (20 above, 10 below): (%) STRAIN AT FAILURE

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No A2

METRIC

GWP 161-98-00	LOCATION Passing Lane #1 - (DCPT), Sta: 12+602, 11.7 m Rt C/L of Hwy 11	ORIGINATED BY G.J.
DIST HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic	DATE 6/3/2009	CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
248.4 0.0	GROUND SURFACE						248, 247, 246, 245, 244, 243, 242, 241, 240				
239.3 9.1	End of DCPT refusal @ 9.1 m										

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No F4

METRIC

GWP 161-98-00 LOCATION Passing Lane #1, Sta: 12+625, 6.5 m Rt C/L of Hwy 11 ORIGINATED BY G.J.
DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.
DATUM Geodetic DATE 7/15/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.7	GROUND SURFACE						
0.0	0.6 m **FILL:** Sand, some gravel tr. silt, v. loose	1	AS				
	FILL: Silty Clay occ. sand layers tr. to some organic brown, soft to stiff, moist	2	SS	10		250	0 18 32 50
	pealy topsoil	3	SS	6		249	
248.6 / 2.1	**SILTY CLAY** with freq. clayey silt interbeds brown, soft to stiff	4	SS	4		248	spoon wet
		5	SS	4			0 7 27 66 spoon wet
		6	SS	9		247	
		7	SS	5		246	
		8	SS	6		245	
	varved clay	9	SS	4		244	
		10	SS	4			
243.1 / 7.6	**CLAYEY SILT** (Possible Till) with sand, tr. gravel occ. sand layer grey, firm, wet	11	SS	11	▽*	243	15 30 25 30
						242	
241.6 / 9.1	**SANDY SILT TO SILTY SAND TILL** some clay, grey v. loose to v. dense, wet	12	SS	5		241	14 34 27 25
240.3		13	SS	100/0 cm			Sampler refusal
10.4	End of Borehole. Water level @ 7.6 m (not stabilized)* upon completion. Borehole caved-in @ 9.5 m upon completion.						@ 10.4 m

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

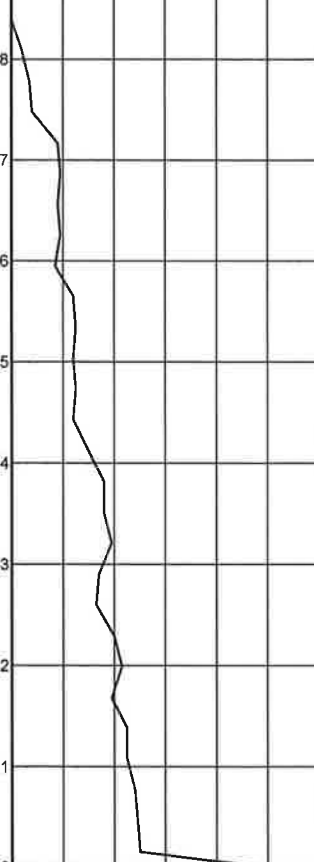
+ ³, × ³: Numbers refer to Sensitivity
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A3

METRIC

GWP 161-98-00	LOCATION Passing Lane #1 - (DCPT), Sta: 12+650, 12.2 m Rt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic	DATE 6/3/2009		CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLES – NUMBER	SAMPLES – TYPE	SAMPLES – "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
249.0 0.0	GROUND SURFACE						249				
							248				
							247				
							246				
							245				
							244				
							243				
							242				
							241				
240.0 9.0	End of DCPT refusal @ 9.0 m						240				



+ ³, × ³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No F5

METRIC

GWP 161-98-00 | LOCATION Passing Lane #1, Sta: 12+675, 12.4 m Rt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST | HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/3/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
249.7	GROUND SURFACE								
0.0	0.6 m **TOPSOIL** **SILTY CLAY** with freq. clayey silt interbeds brown, soft to stiff, moist	1	SS	1					
		2	SS	7		249			
		3	SS	11		248			
		4	SS	10		247			
		5	SS	9		246			
		6	SS	8					
245.3 4.4	**CLAYEY SILT** (Possible Till) with sand and tr. gravel with silty clay interbeds grey, stiff	7	SS	10		245			6 28 35 31
		8	SS	12		244			
	hard	9	SS	46	▼*				
243.3 6.4	**SANDY SILT TO SILTY SAND TILL** tr. to some clay grey, v. dense, wet	10	SS	77/28.0 cm		243			auger grinding @ 6.7 m and below
242.3		11	SS	100/5.0 cm					
7.4	End of Borehole. Auger refusal @ 7.4 m on possible boulderor bedrock Water level @ 6.1 m (not stabilized)* upon completion Hole caved-in @ 6.3 m upon completion								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

+³, ×³: Numbers refer to Sensitivity   15-⊕-5 (20/10) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No F6

METRIC

GWP 161-98-00 LOCATION Passing Lane #1, Sta: 12+725, 8.1 m Rt C/L of Hwy 11 ORIGINATED BY G.J.

DIST ___ HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/4/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.3	GROUND SURFACE						
0.0	0.6 m **FILL:** Sand, some gravel tr. silt, v. loose	1	SS	5		252	
	FILL: Silty Clay some organic, tr to some sand brown, soft to stiff, moist	2	SS	4		251	
	black, peaty topsoil	3	SS	10			
250.2 / 2.1	tr. organic; **SILTY CLAY** with freq. clayey silt interbeds brown, stiff, moist	4	SS	11		250	
		5	SS	12		249	
248.5 / 3.8	**CLAYEY SILT** (Possible Till) with sand and tr. gravel grey, stiff to hard	6	SS	9		248	
	moist	7	SS	15	▼*		4 20 36 40
	wet	8	SS	34		247	
		9	SS	21		246	auger grinding @ 6.1 m
		10	SS	26		245	wet spoon 4 45 30 21
244.6 / 7.7		11	SS	100/5.0 cm			

End of Borehole.
Auger refusal @ 7.7 m on possible boulder or bedrock
Water level @ 4.9 m (not stabilized)* upon completion
Hole caved-in @ 7.3 m upon completion

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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 15-⊕-5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No F7

METRIC

GWP 161-98-00 | LOCATION Passing Lane #1, Sta: 12+765, 10.6 m Rt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ___ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/4/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
252.6	GROUND SURFACE									
0.0	**FILL:** Sand, tr. gravel	1	SS	4						
252.3 / 0.5	**SILTY CLAY** with freq. clayey silt interbeds greyish brown, firm to stiff, moist	2	SS	7		252				
		3	SS	9		251	0	4	40	56
		4	SS	13		250				
249.5 / 3.3	**CLAYEY SILT TO SILTY CLAY** (Possible Till) with sand, tr. gravel grey, firm, wet	5	SS	9		249				
		6	SS	12	▼*		6	27	30	37
248.5 / 4.3	**SANDY SILT TO SILTY SAND TILL** tr. to some clay brown, v. dense, wet	7	SS	100/5.0 cm		248				
247.9 / 4.9	End of Borehole. Auger refusal @ 4.9 m on possible boulder Hole open & water level @ 4.1 m (not stabilized)* upon completion									

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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 (%)

+³, ×³: Numbers refer to Sensitivity   15-⊕-5 (20, 10) (%) STRAIN AT FAILURE

Appendix A2

Drawings and Record of Borehole Sheets - Passing Lane 2

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

NOTES:

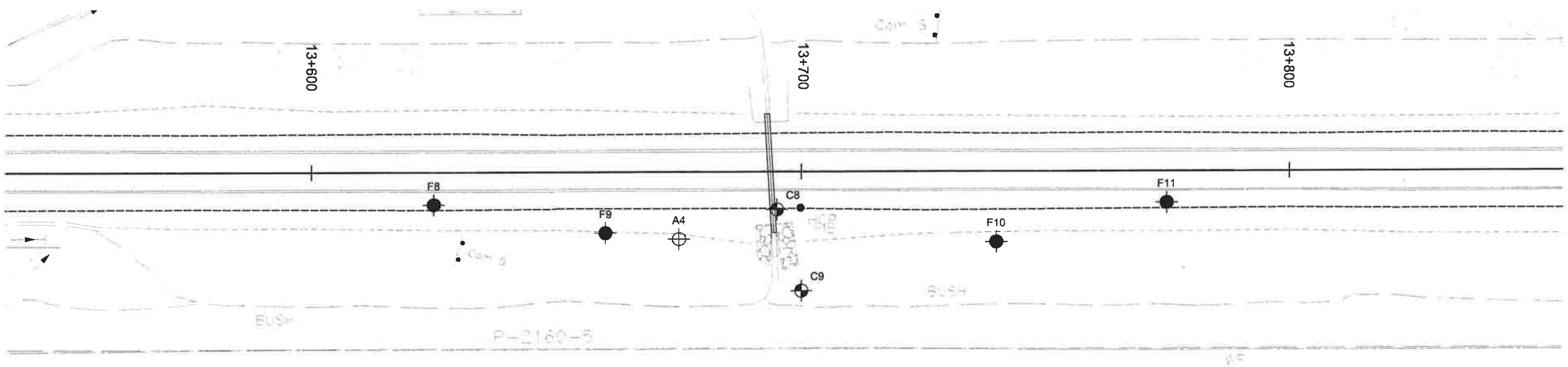
FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.
GWP: 161-98-00

HIGHWAY 11, ARMSTRONG TWP
NORTHBOUND PASSING LANE AREA 2
BOREHOLE LOCATION PLAN
& SOIL STRATA

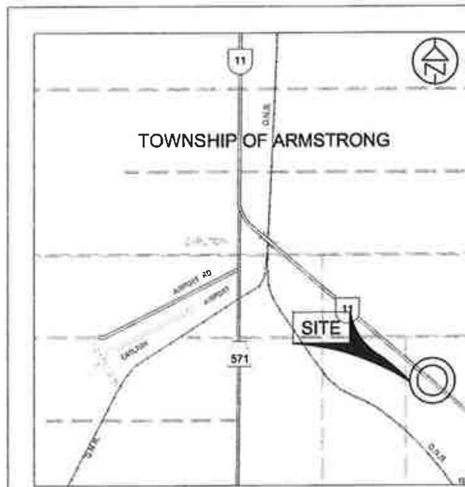
SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

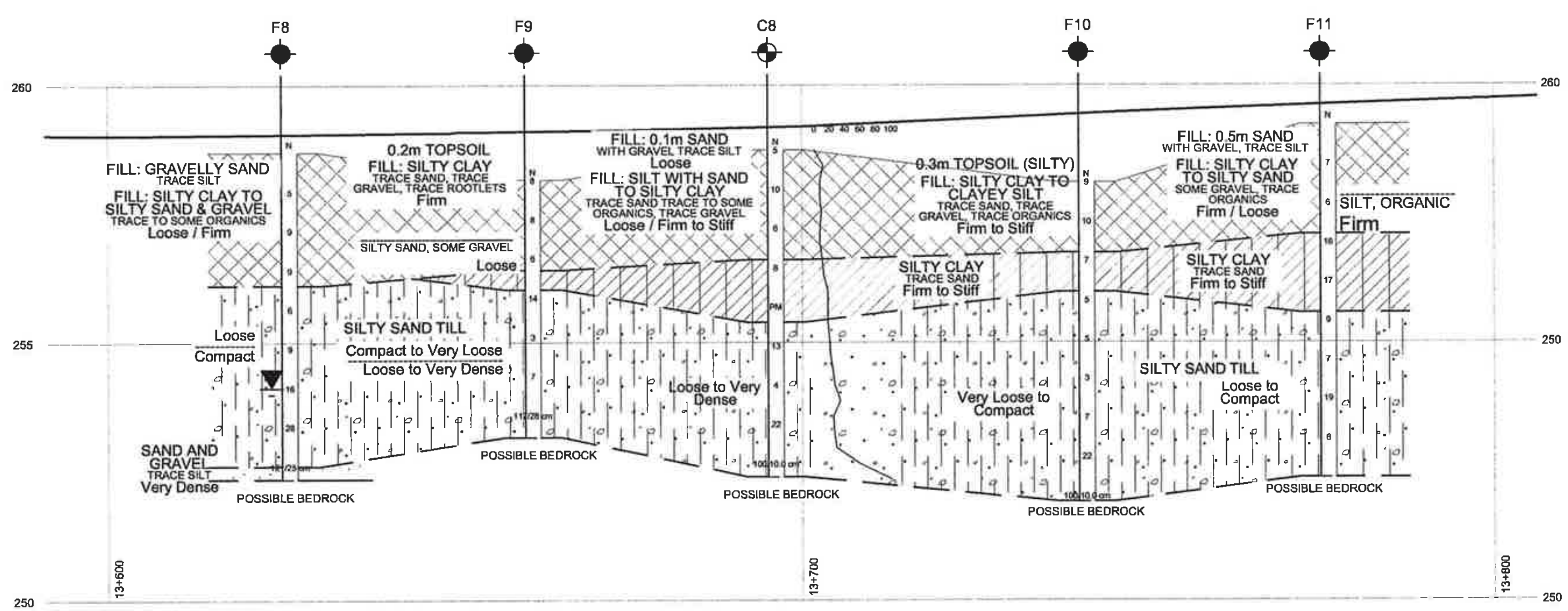


PLAN
SCALE

25m 0 25 50m



KEY PLAN
N.T.S.



℄ PROFILE
HORIZONTAL SCALE

25m 0 25 50m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & Cone
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
C8	258.7	13+695	7.8m Rt C/L
C9	256.6	13+700	24.6m Rt C/L
F8	258.7	13+625	6.7m Rt C/L
F9	258.2	13+660	12.6m Rt C/L
F10	258.1	13+740	14.6m Rt C/L
F11	259.2	13+775	6.5m Rt C/L
A4	258.1	13+675	13.9m Rt C/L

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

Geocres No 31M-82

	TRANETOB01237AA		DIST
SUBM'D	CHECKED	DATE May 10, 2010	SITE
DRAWN PHK	CHECKED RM	APPROVED ZO	DWG A2-1

RECORD OF BOREHOLE No C8

METRIC

GWP 161-98-00		LOCATION Culvert # 16 / Passing Lane #2, Sta:13+695, 7.8 m Rt C/L of Hwy 11	ORIGINATED BY Z.I.
DIST	HWY 11	BOREHOLE TYPE Hollow Stem Auger, DCPT	COMPILED BY S.K.
DATUM Geodetic		DATE 8/10/2009	CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.7	GROUND SURFACE					
0.0	**FILL:** 0.1 m thick sand with gravel trace silt, loose, brown, moist	1	SS	5		
	FILL: mixture silt with sand to silty clay trace sand trace to some organics, trace gravel greyish brown & dark brown loose / firm to stiff, moist	2	SS	10	258	
		3	SS	6	257	
256.6 / 2.1	**SILTY CLAY** trace sand, brown to grey firm to stiff, moist	4	SS	8	256	0 2 32 66
		5	TW	PM		
255.4 / 3.4	**SILTY SAND TILL** some clay, trace gravel brownish grey, loose to v. dense, moist	6	SS	13	255	7 55 26 12
	grey, wet to moist @ 4.3 m	7	SS	4	254	
		8	SS	22	253	
252.3 / 6.4		9	SS	100/10.0 cm		

End of Borehole.
Auger refusal @ 6.4 m on possible bedrock
Hole dry (not stabilized) and open upon completion
Dynamic Cone Penetration Test (DCPT) performed adjacent to the borehole from ground to 6.4 m

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

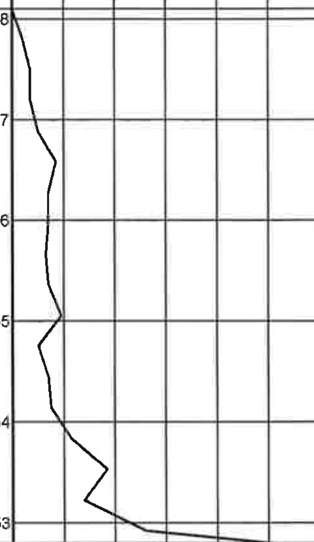
20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A4

METRIC

GWP 161-98-00	LOCATION Culvert # 16 / Passing Lane # 2, Sta:13+675, 13.9 m Rt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY S.K.
DATUM Geodetic	DATE 7/15/2009		CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
258.1	GROUND SURFACE										
0.0							258				
							257				
							256				
							255				
							254				
252.8							253				
5.3	End of DCPT @ 5.3 m on poss. bedrock										



$+^3, \times^3$: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No C9

METRIC

GWP 161-98-00	LOCATION Culvert # 16 / Passing Lane #2, Sta: 13+700, 24.6 m Rt C/L of Hwy 11	ORIGINATED BY G.J./Z.I.
DIST HWY 11	BOREHOLE TYPE Hollow Stem Auger, NQ Coring, Wash Boring, DCPT	COMPILED BY S.K.
DATUM Geodetic	DATE 7/16/2009 8/11/2009	CHECKED BY Z.O.

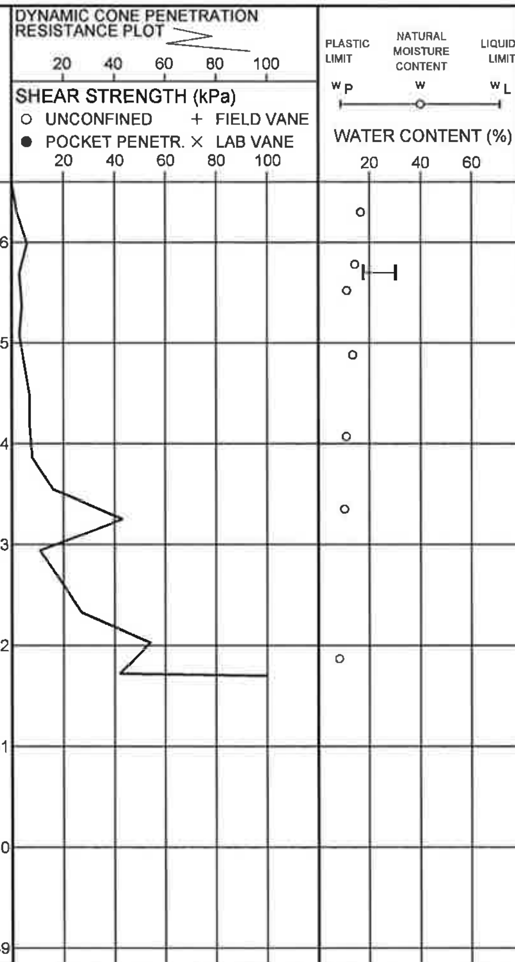
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
256.6	GROUND SURFACE
0.0	**FILL:** silty clay & sand, trace gravel, trace organics, dark brown to light brown, loose / firm, moist
255.7 0.9	**SILTY SAND TILL** trace to some gravel, trace to some clay, wet; v. loose; loose; light brown; grey; v. dense; cobbles and boulders
251.7 4.9	**DOLOMITIC LIMESTONE** brown to grey, fair to poor quality, weathering along joints
248.8 7.8	End of Borehole @ 7.8 m

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	8
2	SS	3
3	SS	7
4	SS	5
5	SS	4
6	SS	50/2.5 c
7	SS	122/15 c
8	RC	TCR=89% ; RQD=64%
9	RC	TCR=68% ; RQD=45%

Elevation scale: 256, 255, 254, 253, 252, 251, 250, 249



UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Sample	GR	SA	SI	CL
3	10	53	25	12

- auger grinding (sample 6)
- Hole advanced by NQ Coring @ 4.88 m

End of Borehole @ 7.8 m
Dynamic Cone Penetration Test (DCPT) performed adjacent to the borehole from ground to 4.9 m
Piezometer installed to 7.6 m
Piezometer water level records :

Aug 11, 2009	2.1 m
Aug 23, 2009	3.1 m
Aug 26, 2009	3.1 m

$+^3$, $\times^3$: Numbers refer to Sensitivity

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No F8

METRIC

GWP 161-98-00 LOCATION Culvert # 16 / Passing Lane # 2, Sta: 13+625, 6.7 m Rt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY S.K.

DATUM Geodetic DATE 7/15/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.7 / 0.0	GROUND SURFACE					
258.3 / 0.4	**FILL:** Gravelly Sand trace silt	1	AS			34 57 (9)
	FILL: Silty Clay to Silty Sand & Gravel trace to some organics greyish brown to black, loose / firm, moist	2	SS	5		
		3	SS	9		
256.1 / 2.6	**SILTY SAND TILL** some clay, trace gravel moist to wet	4	SS	9		
	light brown, loose	5	SS	6		
	grey, compact	6	SS	9		
		7	SS	16	Water level (not stabilized)	
		8	SS	28		
252.6 / 6.1	**SAND AND GRAVEL** trace silt light red brown, v. dense, wet	9	SS	121/25 cm		spoon wet
252.3 / 6.4	End of Borehole. Auger refusal @ 6.4 m on possible bedrock Water level @ 4.6 m (not stabilized) and caved-in @ 5.5 m upon completion.					

Elevation scale: 258, 257, 256, 255, 254, 253

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

15-⊕-5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No F9

METRIC

GWP 161-98-00 | LOCATION Culvert # 16 / Truck Climbing Lane # 2, Sta: 13+660, 12.6 m Rt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ____ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY S.K.

DATUM Geodetic | DATE 7/15/2009 | CHECKED BY Z.O.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.2	GROUND SURFACE						
0.0	**0.2 m TOPSOIL** **FILL:** Silty Clay, trace sand, trace gravel, trace rootlets, grey to brown, firm, moist	1	SS	8		258	
		2	SS	8		257	
	silty sand, some gravel, light brown, loose, wet	3	SS	6			
256.4 / 1.8	**SILTY CLAY** trace sand, grey / brown, firm, moist					256	
256.1 / 2.1	**SILTY SAND TILL** some clay, trace to some gravel, wet to moist	4	SS	14			
	light brown, compact to v. loose	5	SS	3		255	6 54 26 14
	grey, loose to v. dense	6	SS	7		254	
253.2 / 5.0		7	SS	117/28 cm			

End of Borehole.
Auger refusal @ 5.0 m on possible boulder
Hole dry (not stabilized) and caved-in @ 3.1 m upon completion.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No F10

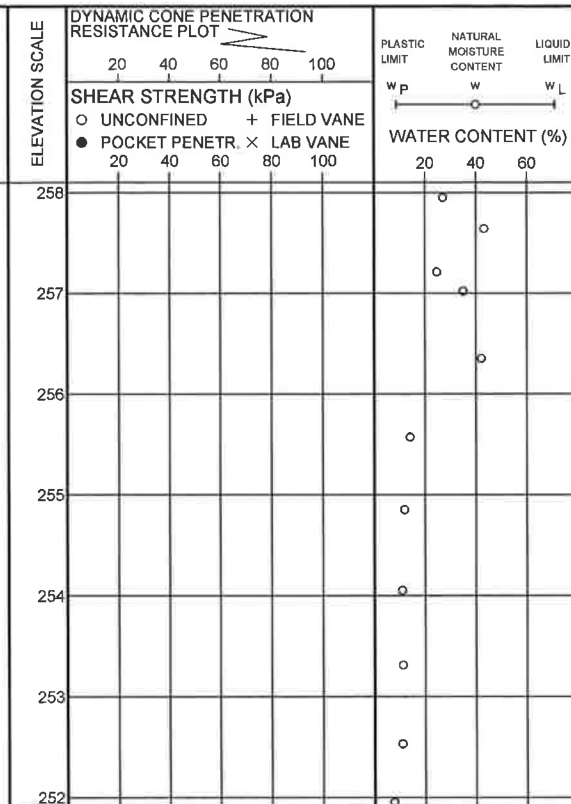
METRIC

GWP 161-98-00 LOCATION Culvert # 16 / Passing Lane # 2, Sta: 13+740, 14.6 m Rt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY S.K.

DATUM Geodetic DATE 7/15/2009 CHECKED BY Z.O.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.1	GROUND SURFACE				
0.0	0.3 m **TOPSOIL (SILTY)** **FILL:** silty clay to clayey silt trace sand, trace gravel trace organics grey to dark brown, firm to stiff, moist	1	SS	9	
		2	SS	10	
256.7 / 1.4	**SILTY CLAY** trace sand greyish brown, firm, moist	3	SS	7	
256.0 / 2.1	**SILTY SAND TILL** trace to some clay, trace to some gravel v. loose to compact, wet to moist	4	SS	5	
	light brown	5	SS	5	
	grey	6	SS	3	spoon wet
		7	SS	7	
		8	SS	22	
251.9 / 6.2		9	SS	100/10.0 cm	
	End of Borehole. Auger refusal @ 6.2 m on possible bedrock Hole dry (not stabilized) and caved-in @ 4.6 m upon completion.				



+ 3, × 3: Numbers refer to Sensitivity

15-5 / 20 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No F11

METRIC

GWP 161-98-00 LOCATION Culvert # 16 / Passing Lane # 2, Sta: 13+775, 6.5 m Rt C/L of Hwy 11 ORIGINATED BY G.J.

DIST ___ HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY S.K.

DATUM Geodetic DATE 7/15/2009 CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.2	GROUND SURFACE						
0.0	**FILL:** (0.5 m) sand with gravel trace silt, brown, moist	1	AS			259	34 57 (9)
	FILL: mixture silty clay to silty sand some gravel, trace organics grey to brown firm / loose, moist	2	SS	7		258	
257.1	1.7 to 1.8 m silt, organic, black, firm, moist	3	SS	6			
2.1	**SILTY CLAY** trace sand grey to brown firm to stiff, moist	4	SS	16		257	
255.5		5	SS	17		256	
3.7	**SILTY SAND TILL** some clay, trace gravel loose to compact, wet	6	SS	9		255	
	light brown	7	SS	7			3 56 29 12
	grey	8	SS	19		254	
		9	SS	6		253	3 46 38 13
252.3		10	AS				
6.9	End of Borehole. Split-Barrel sample attempted @ 6.9 m - 100/0 cm Auger refusal @ 6.9 m on possible bedrock Hole dry (not stabilized) and caved-in @ 6.3 m upon completion.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Appendix A3

Drawings and Record of Borehole Sheets - Passing Lane 3

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.

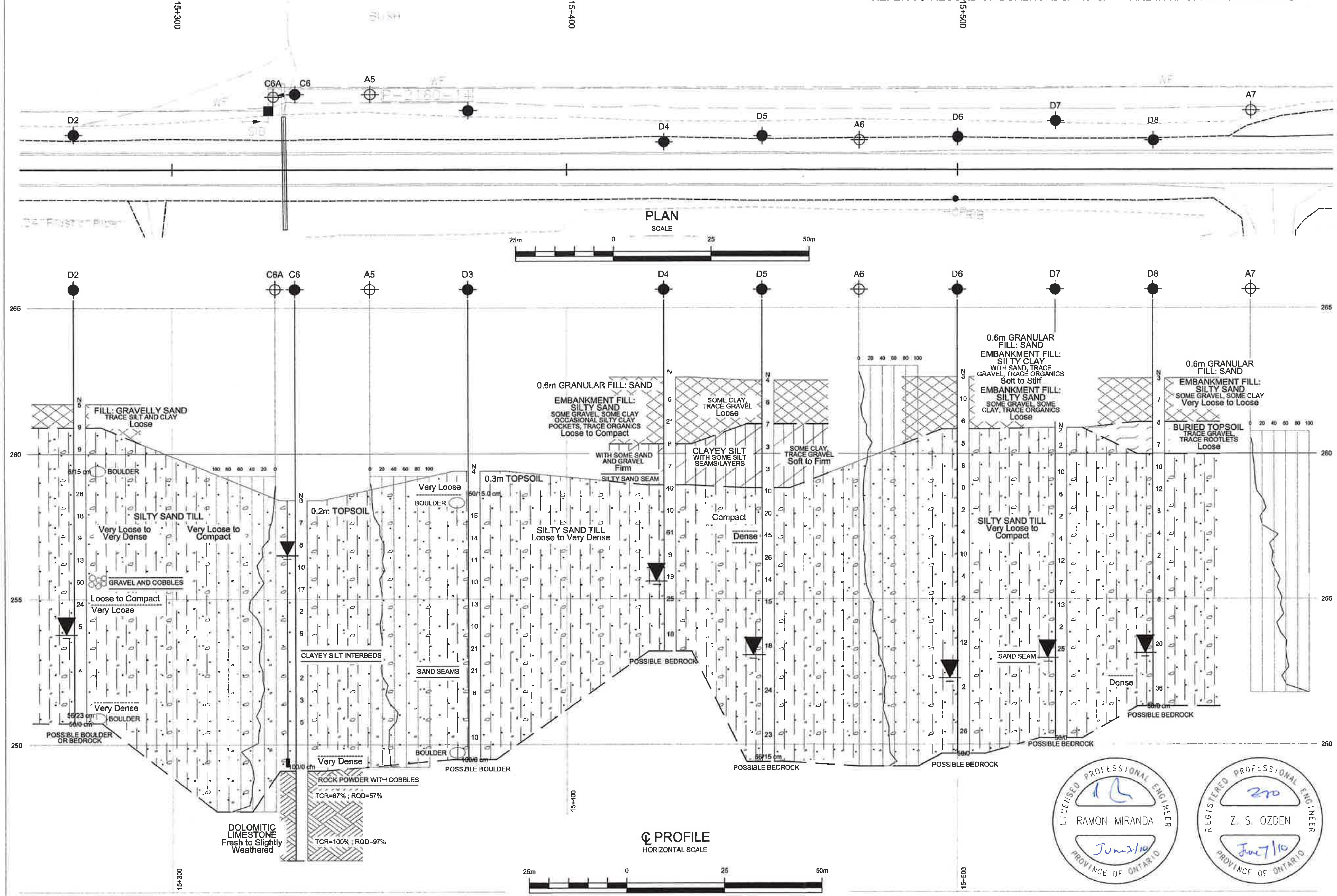
CONT No.

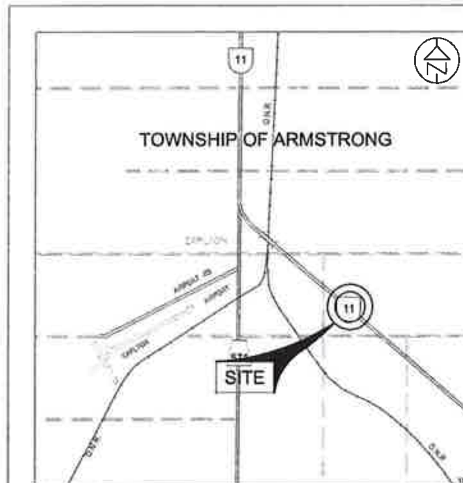
GWP: 161-98-00

HIGHWAY 11, ARMSTRONG
SOUTHBOUND PASSING LANE AREA 1
BOREHOLE LOCATION PLAN
& SOIL STRATA

SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH





KEY PLAN
N.T.S.

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & Cone
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
C6	258.4	15+331	19.5m Lt C/L
C6A	258.9	15+326	18.8m Lt C/L
D2	261.7	15+275	9.0m Lt C/L
D3	259.4	15+375	15.3m Lt C/L
D4	262.6	15+425	7.2m Lt C/L
D5	262.5	15+450	8.4m Lt C/L
D6	262.6	15+500	8.5m Lt C/L
D7	260.9	15+525	12.6m Lt C/L
D8	262.6	15+550	7.6m Lt C/L
A5	259.0	15+350	19.5m Lt C/L
A6	262.8	15+475	7.7m Lt C/L
A7	260.6	15+575	15.3m Lt C/L

-NOTE-

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS DATE	BY	DESCRIPTION

Geocres No 31M-82

TRANETOB01237AA			DIST
SUBM'D	CHECKED	DATE May 10, 2010	SITE
DRAWN PHK	CHECKED RM	APPROVED ZO	DWG A3-1

RECORD OF BOREHOLE No D2

1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Culvert # 19 & Passing Lane # 3, Sta: 15+275, 9.0 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY S.K.

DATUM Geodetic DATE 6/5/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
261.7	GROUND SURFACE							
0.0	**FILL :** Gravelly Sand, tr. silt and clay, brown, loose, moist	1	SS	5			o	30 61 (9)
260.9 / 0.8	**SILTY SAND TILL** some gravel, tr. to some clay, brown	2	SS	9		261	o	
		3	SS	9		260	o	
	boulder	4	SS	6/15 cm			o	refusal on boulder, no recovery
		5	SS	28		259	o	
	brown, moist / grey, wet	6	SS	18		258	o	7 43 35 15
		7	SS	9		257	o	
		8	SS	13		256	o	
	gravel and cobbles	9	SS	60			o	less recovery, auger grinding
	loose to compact	10	SS	24		255	o	auger grinding
	v. loose	11	SS	5	▼*	254	o	
		12	SS	4		253, 252	o	
	v. dense	13	SS	56/23 cm		251	o	no recovery
250.7 / 11.0	End of Borehole.	14	SS	50/0 cm				no recovery

End of Borehole.
Auger refusal @ 11.0 m on possible boulder or bedrock.
Water level @ 7.9 m (not stabilized)* upon completion.
Hole caved-in @ 10.4 m upon completion.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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; 15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C6

METRIC

GWP 161-98-00 LOCATION Culvert # 19 / Passing Lane # 3 , Sta: 15+331, 19.5 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger, NQ Coring , Wash Boring COMPILED BY S.K.

DATUM Geodetic DATE 6/18/2009 CHECKED BY Z.O.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.4	GROUND SURFACE				
0.0	0.2 m **TOPSOIL**; moist	1	SS	0	
	wet; **SILTY SAND TILL** some gravel, trace to some clay brown, v. loose to compact	2	SS	7	
		3	SS	8	
		4	SS	10	8 51 27 14
		5	SS	17	
	clayey silt interbed	6	SS	2	0 5 53 42
		7	SS	6	
		8	SS	2	8 52 28 12
		9	SS	2	
		10	SS	3	
		11	SS	5	6 57 (37)
	v. dense	12	SS	100/0 c	
249.1 / 9.3	rock powder with cobbles; **DOLOMITIC LIME STONE** brown, fresh to slightly weathered	13	RC	TCR=87, RQD=57%	hole advanced by NQ Coring
		14	RC	TCR=100, RQD=97%	
246.1 / 12.3	End of Borehole @ 12.3 m				

End of Borehole @ 12.3 m
Hole dry (not stabilized) and open upon completion.
Piezometer installed to 12.3 m
Water level records in Piezometer :
June 18, 2009 1.3 m
July 21, 2009 1.7 m
July 24, 2009 1.7 m
Aug 23, 2009 1.9 m
Aug 26, 2009 1.9 m

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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; ELEVATION SCALE 258–247.

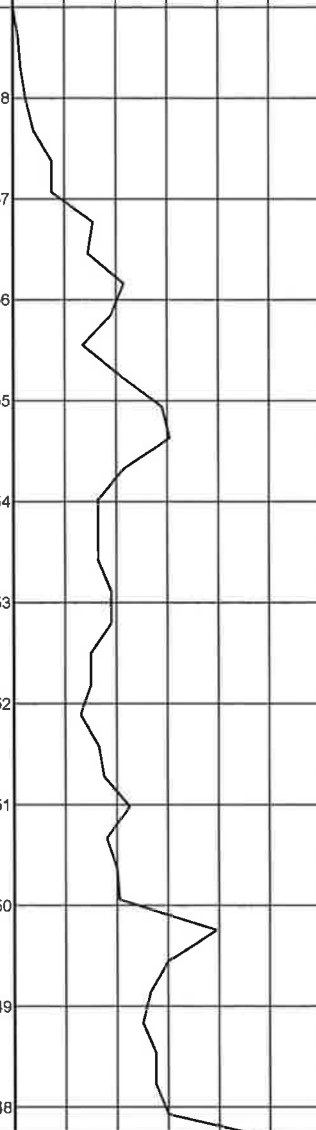
+3, ×3: Numbers refer to Sensitivity; 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C6A

METRIC

GWP 161-98-00	LOCATION Culvert # 19 / Passing Lane # 3, Sta: 15+326, 18.8 m Lt C/L of Hwy 11		ORIGINATED BY Z.I.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY S.K.
DATUM Geodetic	DATE 8/11/2009		CHECKED BY Z.O.

SOIL PROFILE		SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
258.9 / 0.0	GROUND SURFACE						258, 257, 256, 255, 254, 253, 252, 251, 250, 249, 248				
247.7 / 11.2	End of DCPT @ 11.2 m on possible bedrock										



$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D3

METRIC

GWP 161-98-00 | LOCATION Culvert # 19 & Passing Lane # 3, Sta: 15+375, 15.3 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST | HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY S.K.

DATUM Geodetic | DATE 6/19/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
259.4	GROUND SURFACE							
0.0	0.3 m **TOPSOIL**	1	SS	4	259	o	14	
	SILTY SAND TILL tr. to some clay grey, moist, loose to v. dense (v. loose; boulder)	2	SS	50/15.0 cm		o		N-value high due to boulder
		3	SS	15	258	o		
		4	SS	14	257	o		
		5	SS	11	256	o		
		6	SS	10		o		3 43 33 21
		7	SS	13	255	o		
		8	SS	10	254	o		
		9	SS	21	253	o		
	sand seams	10	SS	21		o		9 65 (26)
		11	SS	6	252	o		
		12	SS	10	251, 250	o		
249.5 / 9.9		13	SS	100/0 cm				no recovery

End of Borehole.
Auger refusal @ 9.9 m on possible boulder or bedrock.
Hole dry (not stabilized) and caved-in @ 9.8 m upon completion.

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L.

+ 3, × 3: Numbers refer to Sensitivity

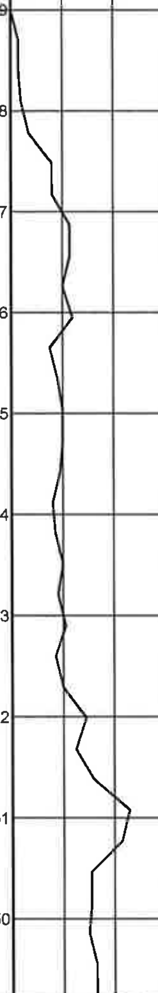
15 ⊕ 5 (20/10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A5

METRIC

GWP 161-98-00	LOCATION Passing Lane # 3, Sta: 15+350, 19.5 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic	DATE 6/19/2009		CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100) / SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
259.0 0.0	GROUND SURFACE						259				
							258				
							257				
							256				
							255				
							254				
							253				
							252				
							251				
							250				
249.2 9.8	End of DCPT refusal @ 9.8 m										



+ ³, × ³: Numbers refer to Sensitivity

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No D4

METRIC

GWP 161-98-00 | LOCATION Passing Lane # 3, Sta: 15+425, 7.2 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ____ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/20/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.6	GROUND SURFACE						
0.0	0.6 m **GRANULAR FILL**:Sand	1	AS			262	
	EMBANKMENT FILL:Silty Sand some gravel, some clay occ. silty clay pockets, tr. organic brown, loose to compact, moist to wet	2	SS	6			4 49 29 18
		3	SS	21		261	
260.3 / 2.3	dilatant **CLAYEY SILT** with some silt seams/lenses some sand and gravel brown, firm, wet	4	SS	8		260	
		5	SS	7			19 37 23 21
258.9 / 3.7	silty sand seam **SILTY SAND TILL** tr. to some clay grey, loose to v. dense, wet	6	SS	40		259	spoon wet @ 4.0 m
		7	SS	10		258	14 57 21 8
		8	SS	61		257	
		9	SS	9		256	
		10	SS	18	▼*		
		11	SS	25		255	auger grinding from 7.9 to 8.8 m
						254	
253.2		12	SS	18			
9.4	End of Borehole. Auger refusal @ 9.4 m on possible boulder or bedrock. Water level @ 7.0 m (not stabilized)* upon completion. Hole caved-in @ 7.9 m upon completion.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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/m^3

+ 3, × 3: Numbers refer to Sensitivity

15-○-5 (20/10) (%) STRAIN AT FAILURE

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No D5

METRIC

GWP 161-98-00	LOCATION Passing Lane #3, Sta: 15+450, 8.4 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY W.C.
DATUM Geodetic	DATE 6/5/2009		CHECKED BY Z.O.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
262.5	GROUND SURFACE
0.0	0.6 m **GRANULAR FILL**:Sand **EMBANKMENT FILL**:Silty Sand some clay, tr. gravel, brown loose, moist to wet
261.0 / 1.5	**CLAYEY SILT** with some silt seams/lenses some clay, tr. gravel, soft to firm, wet; brown / grey
258.8 / 3.7	**SILTY SAND TILL** tr. to some clay grey, compact, wet; dense
249.4 / 13.1	End of Borehole. Auger refusal @ 13.1 m on possible boulder or bedrock. Water level @ 9.4 m (not stabilized)* upon completion. Hole caved-in @ 11.6 m upon completion.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	4	
2	SS	6	
3	SS	7	0 10 39 51
4	SS	3	
5	SS	3	1 29 41 29
6	SS	10	6 47 33 14
7	SS	20	
8	SS	45	spoon wet @ 5.3 m
9	SS	26	
10	SS	14	
11	SS	15	auger grinding from 7.6 to 10.7 m
12	SS	18	16 54 22 8
13	SS	24	
14	SS	23	
15	SS	56/15 cm	

GROUND WATER CONDITIONS: water level symbol (*) at approx. elev. 253.1 (sample 12)

ELEVATION SCALE: 262, 261, 260, 259, 258, 257, 256, 255, 254, 253, 252, 251, 250

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

$+^3, \times^3$: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A6

METRIC

GWP 161-98-00	LOCATION Passing Lane #3 - (DCPT), Sta: 15+475, 7.7 m Lt C/L of Hwy 11	ORIGINATED BY G.J.
DIST HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic	DATE 6/19/2009	CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
262.8 / 0.0	GROUND SURFACE						262, 261, 260, 259, 258, 257, 256, 255, 254, 253, 252, 251, 250				
249.2 / 13.6	End of DCPT refusal @ 13.6 m										

$+^3$, $\times^3$: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D6

1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Passing Lane #3, Sta: 15+500, 8.5 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/6/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
262.6	GROUND SURFACE								
0.0	0.6 m **GRANULAR FILL**: Sand; **EMBANKMENT FILL**: Silty Clay with sand, tr. gravel, tr. organic, brown soft to stiff, moist to wet	1	SS	3					
		2	SS	10		1	21	34	44
261.2 / 1.4	**EMBANKMENT FILL**: Silty Sand some gravel, some clay, tr. organics loose, brown, wet								
260.8 / 1.8	**SILTY SAND TILL** tr. to some clay v. loose to compact, wet; brown / grey	3	SS	6		15	48	24	13
		4	SS	5					
		5	SS	8					
		6	SS	0		5	57	27	11
		7	SS	2					
		8	SS	4					
		9	SS	10					
		10	SS	4					
		11	SS	2					
		12	SS	12					
					▼* (approx. 252.2)				
		13	SS	2		9	57	23	11
		14	SS	26					
249.6 / 13.0	End of Borehole. Auger refusal @ 13.0 m on possible boulder or bedrock. Water level @ 10.4 m (not stabilized)* upon completion. Hole caved-in @ 11.6 m upon completion.	~~15~~	~~SS~~	~~50/0~~					

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (262–250); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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   15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D7

METRIC

GWP 161-98-00 LOCATION Passing Lane #3, Sta: 15+525, 12.6 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/7/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
260.9	GROUND SURFACE								
0.0	0.3 m **TOPSOIL**	1	SS	2			~13		
	dilatant	2	SS	2		260	~14		3 56 29 12
		3	SS	10		259	~8		
	brown / grey	4	SS	6		258	~9		
	SILTY SAND TILL tr. to some clay v. loose to compact, wet	5	SS	2			~10		
		6	SS	4		257	~10		
		7	SS	12		256	~9		
		8	SS	7		255	~11		spoon wet @ 5.3 m; 5 58 26 11
		9	SS	13			~12		
		10	SS	2		254	~10		
	sand seam	11	SS	25	▼*	253	~12		9 75 7 9
						252			
		12	SS	7		251	~10		
250.2 10.7		13	SS	50/0					

Unit weight at top: 103

End of Borehole.
Auger refusal @ 10.7 m on possible boulder or bedrock.
Water level @ 7.9 m (not stabilized)* upon completion.
Hole caved-in @ 8.8 m upon completion.

+ ³, × ³ : Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No D8

METRIC

GWP 161-98-00 — LOCATION Passing Lane #3, Sta: 15+550, 7.6 m Lt C/L of Hwy 11 — ORIGINATED BY G.J.

DIST — HWY 11 — BOREHOLE TYPE Hollow Stem Auger — COMPILED BY W.C.

DATUM Geodetic — DATE 6/7/2009 — CHECKED BY Z.O.

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
262.6	GROUND SURFACE					
0.0	0.6 m **GRANULAR FILL: Sand** **EMBANKMENT FILL:** Silty Sand some gravel, some clay brown, v. loose to loose, moist to wet	1	SS	3		
		2	SS	7		7 62 20 11
261.1 / 1.5	**BURIED TOPSOIL** tr. gravel, tr. rootlets black, loose, moist	3	SS	8		
		4	SS	7		
260.0 / 2.6	**SILTY SAND TILL** tr. to some clay grey, v. loose to compact, wet	5	SS	10		11 54 22 13
		6	SS	12		
		7	SS	8		
		8	SS	4		
		9	SS	2		
		10	SS	4		
		11	SS	8		
		12	SS	20	▼*	8 53 23 16
	dense	13	SS	36		
251.3 / 11.3		14	SS	50/0 cm		

End of Borehole.
Auger refusal @ 11.3 m on possible boulder or bedrock.
Water level @ 9.5 m (not stabilized)* upon completion.
Hole caved-in @ 10.5 m upon completion.

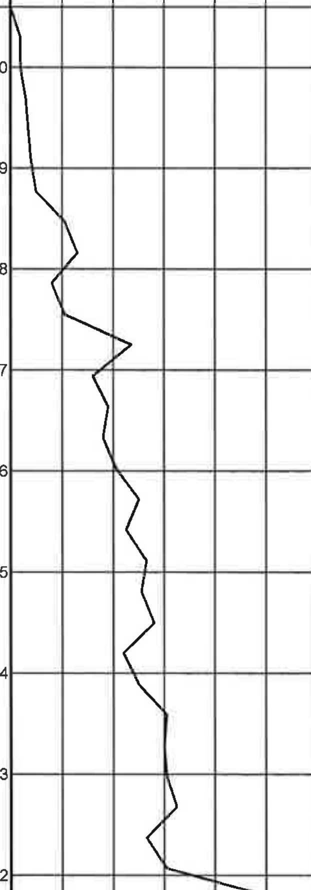
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
ELEVATION SCALE: 262, 261, 260, 259, 258, 257, 256, 255, 254, 253, 252

+³, ×³: Numbers refer to Sensitivity — 15 ⊕ 5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A7

1 OF 1 **METRIC**

GWP 161-98-00	LOCATION Passing Lane #3 - (DCPT), Sta: 15+575, 15.3 m Lt C/L of Hwy 11	ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic		DATE 6/7/2009	CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
260.6	GROUND SURFACE										
0.0							260, 259, 258, 257, 256, 255, 254, 253, 252				
251.8 8.8	End of DCPT refusal @ 8.8 m										

$+^{3}, \times^{3}$: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Appendix A4

Drawings and Record of Borehole Sheets - Passing Lane 4

CONT No.
GWP: 161-98-00

HIGHWAY 11, ARMSTRONG
SOUTHBOUND PASSING LANE AREA 2
BOREHOLE LOCATION PLAN
& SOIL STRATA

SHEET

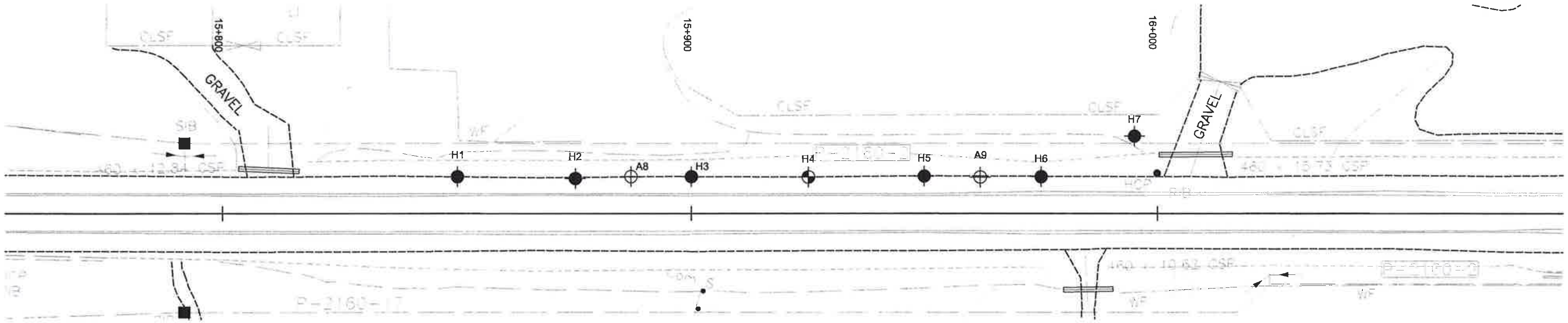
coffey geotechnics
SPECIALISTS MANAGING THE EARTH

METRIC

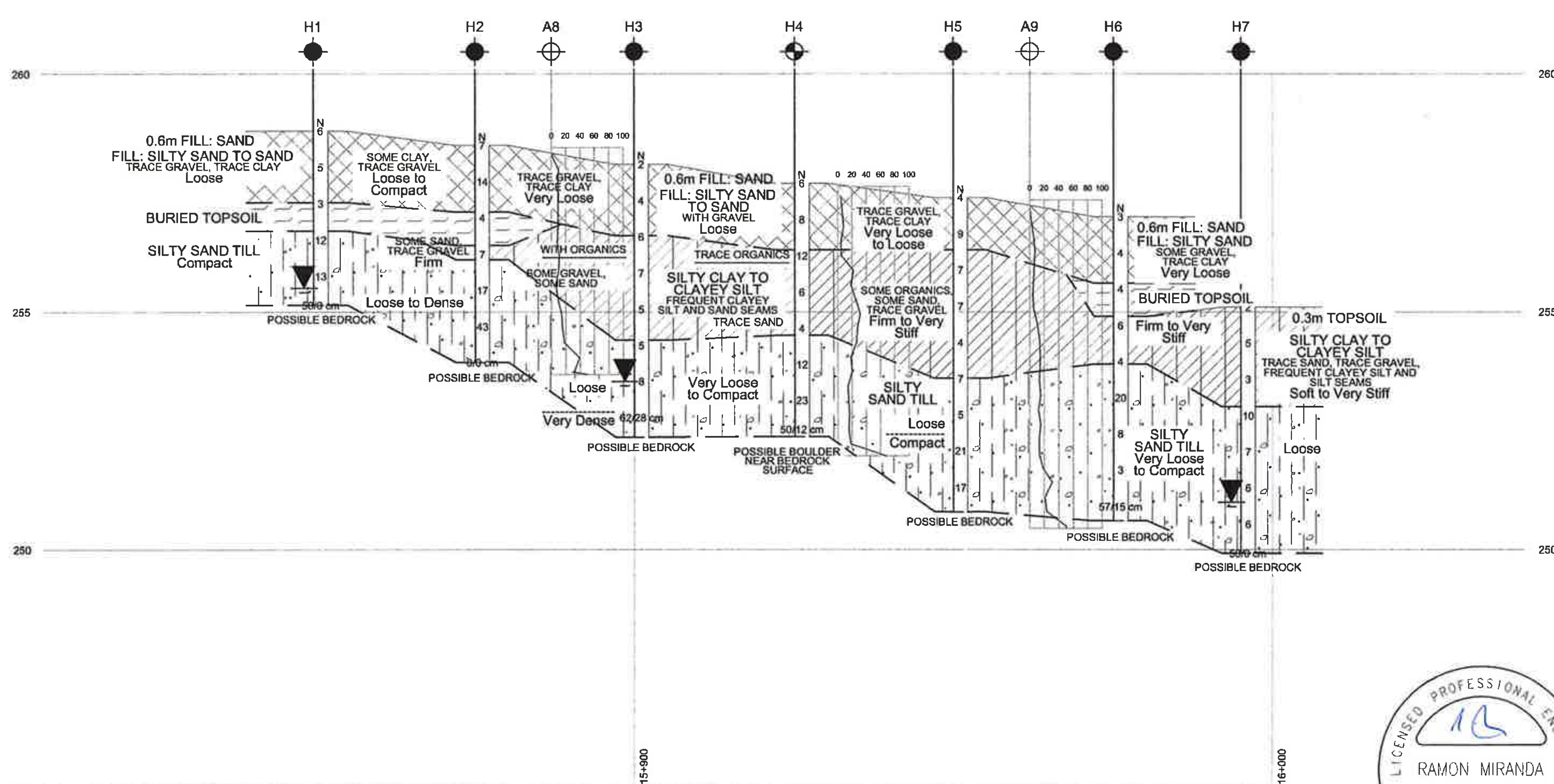
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

NOTES:

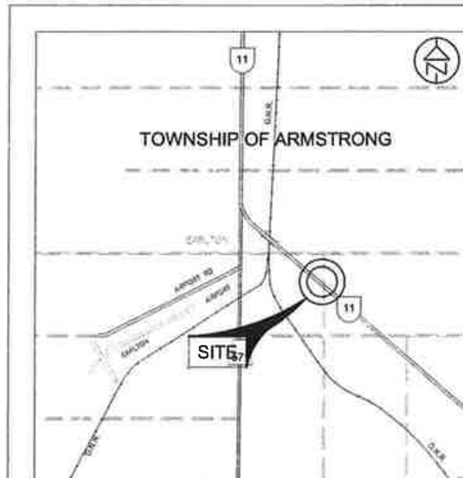
FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.



PLAN
SCALE
25m 0 25 50m



℄ PROFILE
HORIZONTAL SCALE
25m 0 25 50m



KEY PLAN
N.T.S.

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & Cone
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
H1	258.8	15+850	8.0m Lt C/L
H2	258.5	15+875	7.6m Lt C/L
H3	258.1	15+900	8.0m Lt C/L
H4	257.7	15+925	7.9m Lt C/L
H5	257.4	15+950	8.1m Lt C/L
H6	257.0	15+975	8.0m Lt C/L
H7	255.1	15+995	16.8m Lt C/L
A8	258.3	15+887	8.0m Lt C/L
A9	257.2	15+962	7.9m Lt C/L

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
June 7/10
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
June 7/10
PROVINCE OF ONTARIO

REVISIONS

DATE	BY	DESCRIPTION

Geocres No 31M-82

TRANETOB01237AA			DIST
SUBM'D	CHECKED	DATE May 10, 2010	SITE
DRAWN PHK	CHECKED RM	APPROVED ZO	DWG A4-1

RECORD OF BOREHOLE No H1

METRIC

GWP 161-98-00 LOCATION Passing Lane #4, Sta: 15+850, 8.0 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/10/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
258.8	GROUND SURFACE								
0.0	0.6 m **FILL:** Sand **FILL:** Silty Sand to Sand tr. gravel, tr. clay brown, loose, wet	1	SS	6					
		2	SS	5		10	64	16	10
257.3 1.5	**BURIED TOPSOIL**	3	SS	3					
256.7 2.1	**SILTY SAND TILL** some gravel, some clay brown, compact, wet	4	SS	12					
		5	SS	13	▼*	14	53	21	12
255.1 3.7	End of Borehole. Auger refusal @ 3.7 m on possible bedrock. Water level @ 3.3 m (not stabilized)* upon completion. Borehole caved-in @ 3.5 m upon completion.	6	SS	50/0 cm					

Chart columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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 (%). Elevation scale: 258, 257, 256.

+³, ×³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No H2

METRIC

GWP 161-98-00 LOCATION Passing Lane #4, Sta: 15+875, 7.6 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/9/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.5	GROUND SURFACE						
0.0	0.6 m **FILL:** Sand	1	SS	7		258	
	FILL: Silty Sand some clay, tr. gravel brown, loose to compact, wet	2	SS	14			5 58 23 14
257.1 / 1.4	**BURIED TOPSOIL**	3	SS	4		257	
256.4 / 2.1	**SILTY CLAY** some sand, tr. gravel, grey, firm						
256.1 / 2.4	**SILTY SAND TILL** some gravel, some clay grey, loose to dense, wet	4	SS	7		256	
		5	SS	17		255	
	gravelly	6	SS	43			26 42 18 14 auger grinding from 3.8 to 4.3 m
253.9 / 4.6	End of Borehole. Auger refusal @ 4.6 m on possible bedrock. Borehole dry (not stabilized)* and caved-in @ 4.0 m upon completion.	7	SS	0/0 cm		254	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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: 107

$+^3, \times^3$: Numbers refer to Sensitivity

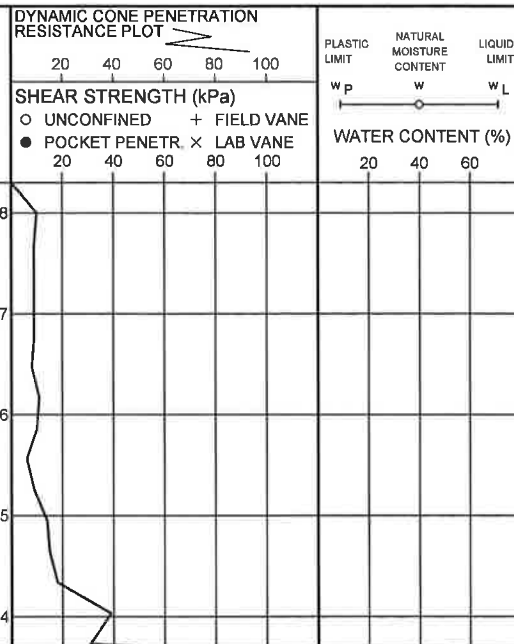
20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A8

METRIC

GWP 161-98-00	LOCATION Passing Lane #4 - (DCPT), Sta: 15+887, 8.0 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic	DATE 6/10/2009		CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
258.3	GROUND SURFACE							
0.0							258	
							257	
							256	
							255	
							254	
253.7 4.6	End of DCPT refusal @ 4.6 m							



$+^3, \times^3$: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H3

1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Passing Lane #4, Sta: 15+900, 8.0 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/10/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
258.1	GROUND SURFACE								
0.0	0.6 m **FILL:** Sand; **FILL:** Silty Sand to Sand, tr. gravel, tr. clay, brown, v. loose, wet	1	SS	2					
		2	SS	4		9	57	24	10
256.6 / 1.5	**SILTY CLAY** some sand and gravel, freq. clayey silt and silt seams, brown, firm to v. stiff; with organics	3	SS	6					
		4	SS	7					
		5	SS	5		10	19	31	40
254.4 / 3.7	**SILTY SAND TILL** some gravel, some clay, loose, wet; brown	6	SS	5					
	grey	7	SS	8	▽*	12	52	23	13
252.4 / 5.7	v. dense	8	SS	62/28 cm					

End of Borehole.
Auger refusal @ 5.7 m on possible bedrock.
Borehole dry (not stabilized)* upon completion.
Borehole caved-in @ 4.6 m upon completion.

Column headings also include: STRAT PLOT; ELEVATION SCALE (258–253); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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 (%).

+ [3], × [3]: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H4

METRIC

GWP 161-98-00 | LOCATION Passing Lane #4, Sta: 15+925, 7.9 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST | HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/9/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
257.7	GROUND SURFACE										
0.0	0.6 m **FILL:** Sand; **FILL:** Silty Sand to Sand with gravel, brown, loose, wet	1	SS	6							
		2	SS	8		257					
256.3 / 1.4	**SILTY CLAY** tr. sand, freq. clayey silt and silt seams brown to grey, firm to v. stiff (tr. organics)	3	SS	12		256					
		4	SS	6		255		0	4	39	57
254.5 / 3.2	**SILTY SAND TILL** with gravel, tr. clay v. loose to compact, wet (brown / grey)	5	SS	4							
		6	SS	12		254					
		7	SS	23		253					
252.4 / 5.3	End of Borehole.	8	SS	50/12 cm							
252.0 / 5.7	Auger refusal @ 5.3 m due to possible boulder near bedrock surface. DCPT performed adjacent to borehole from ground to 5.7 m. Borehole dry (not stabilized)* upon completion. Borehole caved-in @ 5.2 m upon completion.										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity

15-⊕-5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H5

METRIC

GWP 161-98-00 LOCATION Passing Lane #4, Sta: 15+950, 8.1 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/10/2009 CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.4	GROUND SURFACE						
0.0	0.6 m **FILL:** Sand **FILL:** Silty Sand to Sand tr. gravel, tr. clay brown, v. loose to loose, wet	1	SS	4		257	
256.3		2	SS	9			5 61 24 10
1.1	**SILTY CLAY** some organics, some sand, tr. gravel freq. clayey silt and silt seams firm to v. stiff, brown	3	SS	7		256	
		4	SS	7		255	
		5	SS	4		254	0 17 39 44
253.6							
3.8	**SILTY SAND TILL** some gravel, tr. clay, wet	6	SS	7		253	
	brown, loose	7	SS	5			
	grey, compact	8	SS	21		252	20 50 22 8
		9	SS	17		251	
250.8							
6.6	End of Borehole. Auger refusal @ 6.6 m on possible bedrock. Borehole dry (not stabilized)* upon completion. Borehole caved-in @ 5.8 m upon completion.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

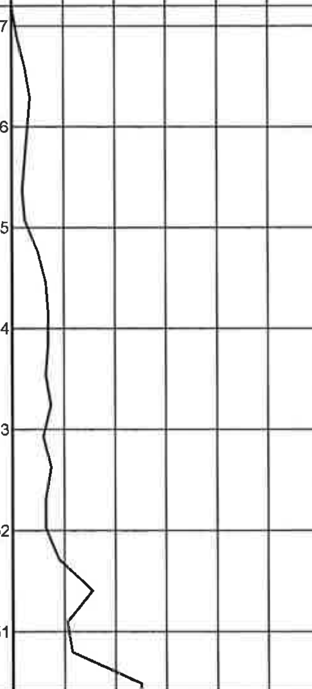
RECORD OF BOREHOLE No A9

METRIC

GWP 161-98-00 LOCATION Passing Lane #4 - (DCPT), Sta: 15+962, 7.9 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY W.C.

DATUM Geodetic DATE 6/10/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
257.2	GROUND SURFACE										
0.0							257 256 255 254 253 252 251				
250.4 6.8	End of DCPT refusal @ 6.8 m										

$+^3, \times^3$: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H6

METRIC

GWP 161-98-00 | LOCATION Passing Lane #4, Sta: 15+975, 8.0 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ___ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/9/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
257.0	GROUND SURFACE					
0.0	0.6 m **FILL:** Sand **FILL:** Silty Sand to Sand some gravel, tr. clay, v. loose, wet	1	SS	3		
		2	SS	4		
255.6 / 1.4	**BURIED TOPSOIL**	3	SS	4		
254.9 / 2.1	**SILTY CLAY** tr. gravel, tr. sand freq. clayey silt and silt seams brown, firm to v. stiff	4	SS	6		0 4 37 59
253.9 / 3.1	**SILTY SAND TILL** some gravel, tr. clay v. loose to compact, wet	5	SS	4		
		6	SS	20		
	brown	7	SS	8		
	grey	8	SS	3	▽	11 40 42 7
250.6		9	SS	57/15 cm		
6.4	End of Borehole. Auger refusal @ 6.4 m on possible bedrock. Borehole dry (not stabilized)* upon completion Borehole caved-in @ 5.8 m upon completion.					

Chart columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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. Elevation scale 257–251.

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H7

METRIC

GWP 161-98-00 | LOCATION Passing Lane #4, Sta: 15+995, 16.8 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ___ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/10/2009 | CHECKED BY Z.O.

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
255.1	GROUND SURFACE					255	
0.0	0.3 m **TOPSOIL** **SILTY CLAY** tr. sand and gravel freq. clayey silt and silt seams brown, soft to v. stiff	1	SS	2			
		2	SS	5		254	
		3	SS	3			
253.0 2.1	**SILTY SAND TILL** some gravel, tr. clay grey, loose, wet	4	SS	10		253	
		5	SS	7		252	
		6	SS	6	▼*	251	13 53 24 10
		7	SS	6			
249.9 5.2	End of Borehole. Auger refusal @ 5.2 m on possible bedrock. Water level @ 4.1 m (not stabilized)* upon completion. Borehole caved-in @ 4.6 m upon completion.	8	SS	50/0 cm		250	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

Appendix A5

Drawings and Record of Borehole Sheets - Passing Lane 5

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.

METRIC

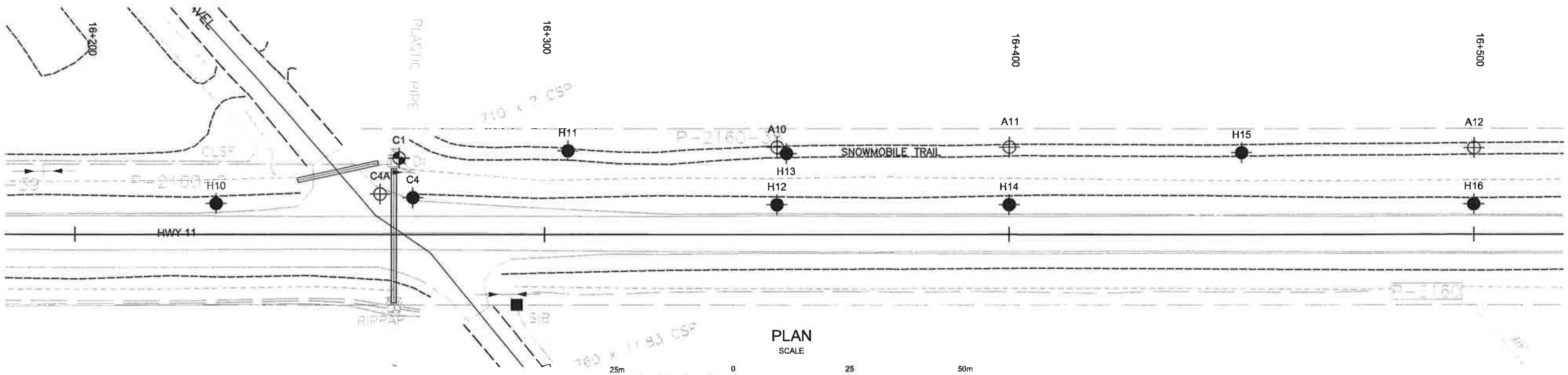
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

CONT No.
GWP: 161-98-00

HIGHWAY 11, ARMSTRONG
SOUTHBOUND PASSING LANE AREA 3
BOREHOLE LOCATION PLAN
& SOIL STRATA 1 OF 3

SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

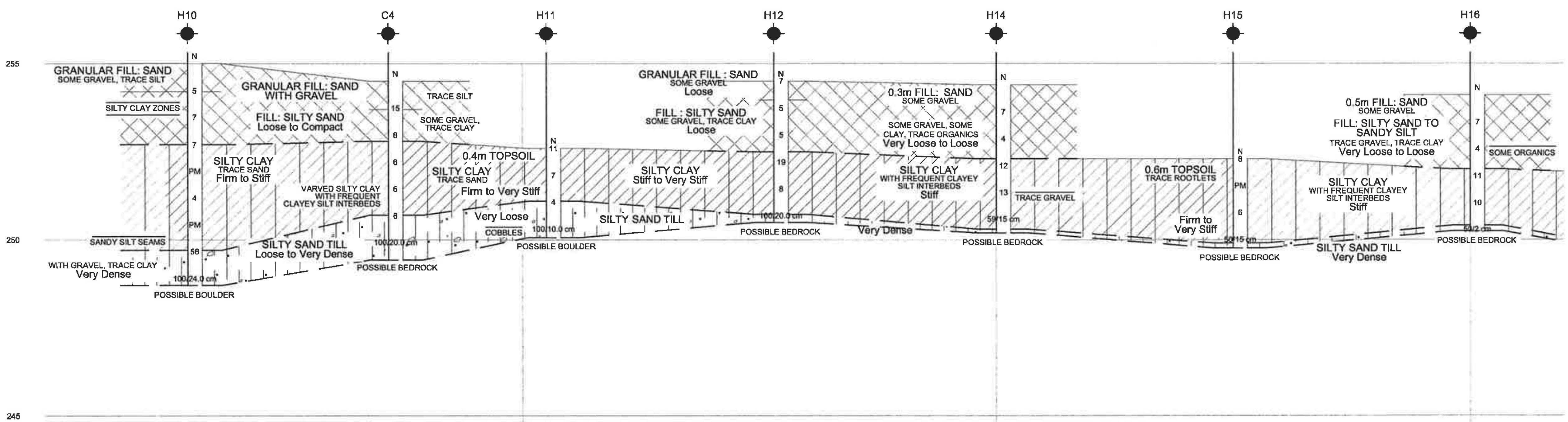


PLAN

SCALE

25m 0 25 50m

KEY PLAN
N.T.S.



℄ PROFILE

HORIZONTAL SCALE

25m 0 25 50m

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & Cone
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
H10	255.0	16+230	6.7m Lt C/L
H11	252.6	16+305	18.2m Lt C/L
H12	254.5	16+350	6.5m Lt C/L
H13	252.5	16+352	17.6m Lt C/L
H14	254.4	16+400	6.5m Lt C/L
H15	252.3	16+450	17.8m Lt C/L
H16	254.1	16+500	6.6m Lt C/L
A10	252.6	16+350	19.3m Lt C/L
A11	252.4	16+400	19.0m Lt C/L
A12	252.1	16+500	18.8m Lt C/L
C1	252.7	16+269	16.6m Lt C/L
C4	254.5	16+272	8.0m Lt C/L
C4A	254.9	16+265	8.8m Lt C/L

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 31M-82

TRANETOB01237AA			DIST
SUBM'D	CHECKED	DATE May 10, 2010	SITE
DRAWN PHK	CHECKED RM	APPROVED ZO	DWG A5-1

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

NOTES:

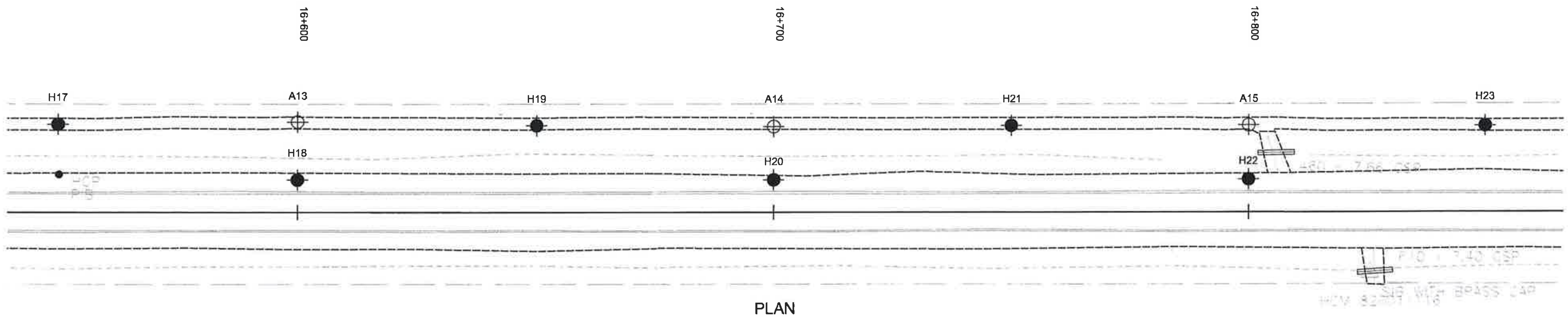
FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.

CONT No.
GWP: 161-98-00

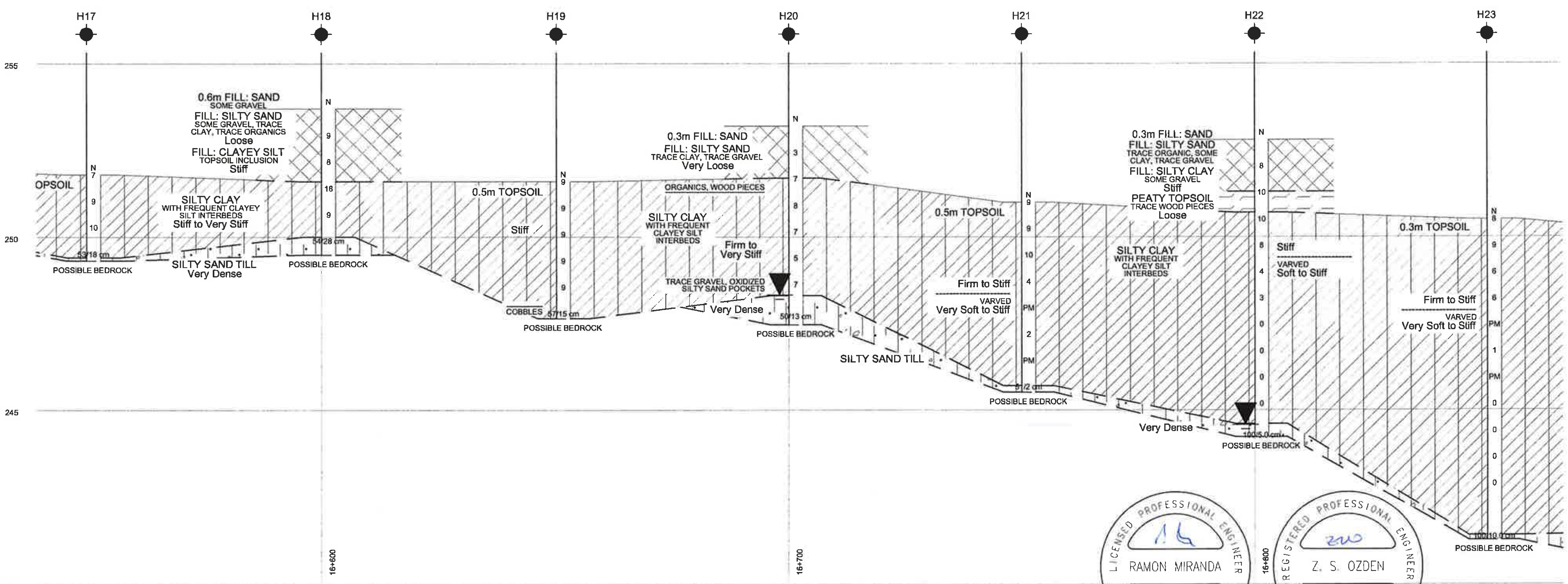
SHEET

HIGHWAY 11, ARMSTRONG
SOUTHBOUND PASSING LANE AREA 3
BOREHOLE LOCATION PLAN
& SOIL STRATA 2 OF 3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



PLAN
SCALE
25m 0 25 50m



LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
Jun 7/10
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
June 7/10
PROVINCE OF ONTARIO

℄ PROFILE
HORIZONTAL SCALE
25m 0 25 50m

KEY PLAN
N.T.S.

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & Cone
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
Hi7	251.8	16+550	18 7m Lt C/L
H18	253 7	16+600	6 9m Lt C/L
H19	251 6	16+650	18 4m Lt C/L
H20	253 2	16+700	6 9m Lt C/L
H21	251 0	16+750	18.4m Lt C/L
H22	252 8	16+800	7 0m Lt C/L
H23	250 5	16+850	18 3m Lt C/L
A13	251 7	16+700	18 2m Lt C/L
A14	251.2	16+800	18 5m Lt C/L

-NOTE-

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 31M-82

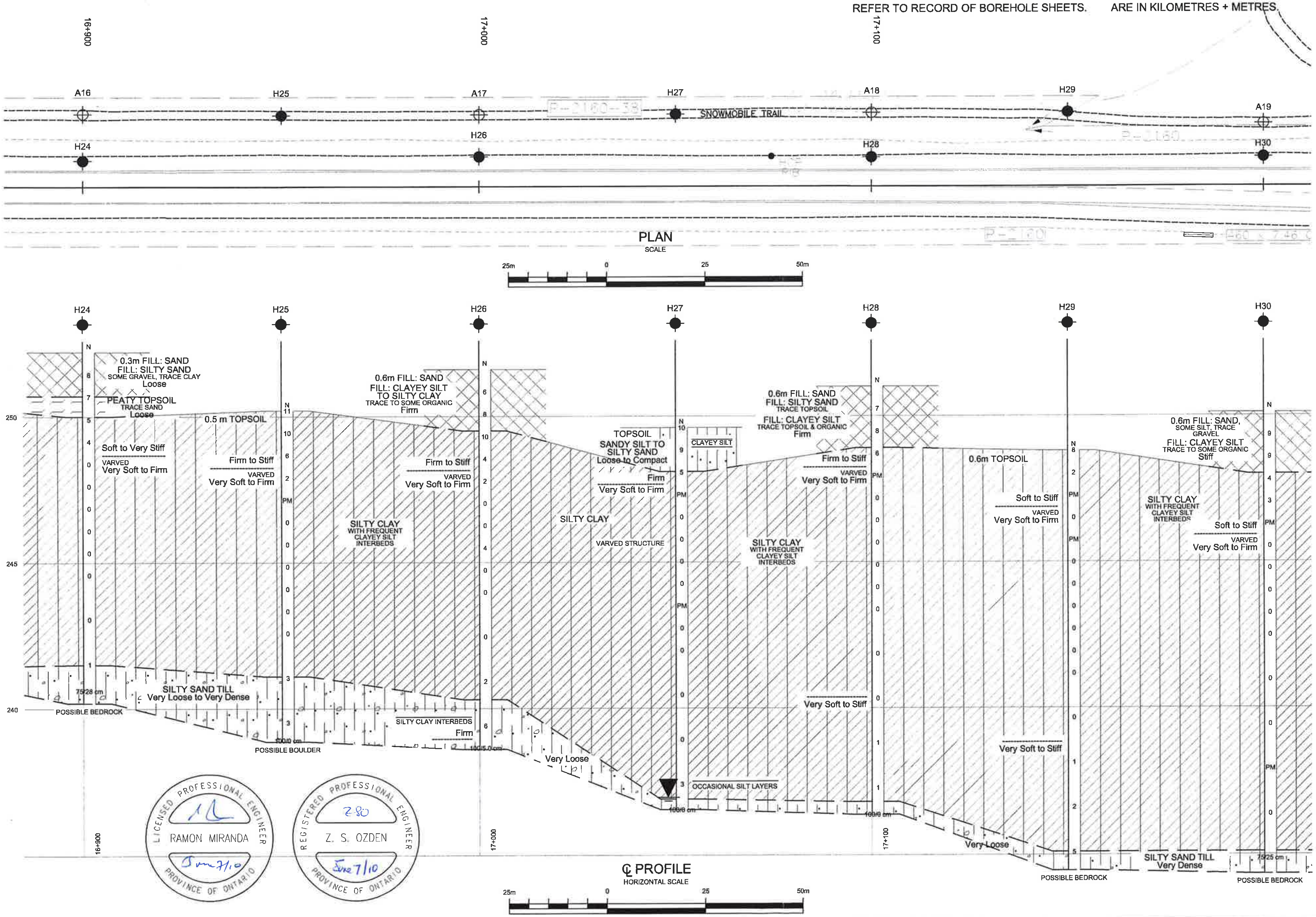
TRANETOB01237AA			DIST
SUBM'D	CHECKED	DATE May 10, 2010	SITE
DRAWN PHK	CHECKED RM	APPROVED ZO	DWG A5-2

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS REFER TO RECORD OF BOREHOLE SHEETS.



CONT No.

GWP: 161-98-00

HIGHWAY 11, ARMSTRONG
SOUTHBOUND PASSING LANE AREA 3
BOREHOLE LOCATION PLAN
& SOIL STRATA 3 OF 3

SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

KEY PLAN
N.T.S.

LEGEND

- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole & Cone
- N — Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer

No.	ELEVATION	STATION	OFFSET
H24	252.2	16+900	6.7m Lt C/L
H25	250.2	16+950	18.3m Lt C/L
H26	251.6	17+000	7.6m Lt C/L
H27	249.6	17+050	18.6m Lt C/L
H28	251.0	17+100	7.5m Lt C/L
H29	248.8	17+150	19.0m Lt C/L
H30	250.1	17+200	7.5m Lt C/L
A16	250.3	16+900	18.7m Lt C/L
A17	250.0	17+000	18.5m Lt C/L
A18	249.2	17+100	18.9m Lt C/L

-NOTE-

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

NOTE: This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

Geocres No 31M-82

	TRANETOB01237AA		DIST
SUBM'D	CHECKED	DATE May 10, 2010	SITE
DRAWN PHK	CHECKED RM	APPROVED ZO	DWG A5-3

RECORD OF BOREHOLE No C1

1 OF 1 **METRIC**

GWP 161-98-00	LOCATION Culvert # 20 / Passing Lane #5, Sta: 16+269, 16.6 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Hollow Stem Auger, NQ Coring, Wash Boring, DCPT	COMPILED BY S.K.
DATUM Geodetic	DATE 6/16/2009		CHECKED BY Z.O.

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.7 / 0.0	GROUND SURFACE				
	0.3 m **TOPSOIL** (tr. gravel)	1	SS	7	
	SILTY CLAY trace sand brown, wet, firm to v. stiff	2	SS	6	0 1 38 61
		3	SS	5	
250.5 / 2.2	**SILTY SAND TILL** some clay, some gravel grey, loose to v. dense (moist / damp)	4	SS	8	13 49 27 11
249.4 / 3.3		5	SS	100/23.0 cm	Hole advanced by NQ Coring
	DOLOMITIC LIMESTONE fresh to slightly weathered (light grey / brown)	6	RC	TCR=100% RQD=60%	
246.4 / 6.3					

Chart column headings: GROUND WATER CONDITIONS; ELEVATION SCALE (252, 251, 250, 249, 248, 247); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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.

End of Borehole @ 6.3 m
Borehole dry (not stabilized) and open upon completion
Dynamic Cone Penetration Test (DCPT) performed adjacent to the borehole from ground up to 3.3 m
Piezometer installed to 3.5 m
Piezometer water level records :

June 25, 2009	1.2 m
July 21, 2009	1.1 m
July 24, 2009	1.2 m
Aug 23, 2009	1.3 m
Aug 26, 2009	1.3 m

$+^3, \times^3$: Numbers refer to Sensitivity   15-20-5-10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No C4

1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Culvert # 20 / Passing Lane #5, Sta: 16+272, 8.0 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY S.K.

DATUM Geodetic DATE 6/25/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.5	GROUND SURFACE				
253.9 / 0.0–0.6	**GRANULAR FILL :** Sand With Gravel trace silt, brown, moist	1	AS		25 67 (8)
252.8 / 0.6–1.7	**FILL :** Silty Sand some gravel, trace clay brown, moist loose to compact	2	SS	15	
		3	SS	8	
251.8 / 1.7–2.7	**SILTY CLAY** trace sand wet, firm	4	SS	6	
250.7 / 2.7–3.8	**SILTY CLAY** varved silty clay with freq. clayey silt interbeds grey, firm, wet	5	SS	6	0 2 35 63
249.4 / 3.8–5.1	**SILTY SAND TILL** some clay, trace gravel grey, moist, loose to v. dense	6	SS	6	9 41 33 17
		7	SS	100/20.0 cm	5 56 25 14
5.1	End of Borehole Auger refusal @ 5.1 m on probable bedrock Borehole dry (not stabilized) upon completion Hole caved-in @ 4.4 m upon completion				

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (254, 253, 252, 251, 250); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No C4A

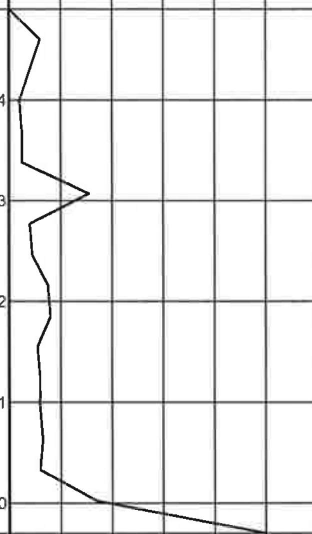
METRIC

GWP 161-98-00 | LOCATION Culvert # 20 / Passing Lane #5, Sta: 16+265, 8.8 m Lt C/L of Hwy 11 | ORIGINATED BY Z.I.

DIST ____ HWY 11 | BOREHOLE TYPE Dynamic Cone Penetration Test | COMPILED BY S.K.

DATUM Geodetic | DATE 8/12/2009 | CHECKED BY Z.O.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
254.9	GROUND SURFACE										
0.0							254				
							253				
							252				
							251				
							250				
249.7 / 5.2	End of DCPT @ 5.2 m on possible bedrock										



$+^{3}, \times^{3}$: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H10

1 OF 1 **METRIC**

GWP 161-98-00	LOCATION Culvert # 20 & Passing Lane # 5, Sta: 16+230, 6.7 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST ___ HWY 11	BOREHOLE TYPE Hollow Stem Auger		COMPILED BY S.K.
DATUM Geodetic	DATE 6/20/2009		CHECKED BY Z.O.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (kPa)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
255.0	GROUND SURFACE				255			
0.0 / 254.4	**GRANULAR FILL:** Sand, some gravel trace silt brown, moist	1	AS					
0.6	**FILL:** Silty Sand greyish brown, loose	2	SS	5	254			
	dark grey silty clay zones	3	SS	7				0 23 35 42
252.7	wet				253			
2.3	**SILTY CLAY** greyish brown, firm to stiff	4	SS	7		2.9 (field vane)		0 1 35 64
		5	TW	PM	252	3.8 (field vane)		
		6	SS	4	251	3.3		
249.7	sandy silt seams	7	TW	PM	250			13 25 40 22
5.3	**SILTY SAND TILL** with gravel, trace clay grey, moist, v. dense	8	SS	56	249			21 50 24 5
248.7		9	SS	100/24.0 cm				
6.3	End of Borehole Auger refusal @ 6.3 m on possible boulder Borehole dry (not stabilized) upon completion Hole caved-in @ 5.8 m upon completion							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H11

1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Culvert # 20 & Passing Lane # 5, Sta: 16+305, 18.2 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/20/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
252.6	GROUND SURFACE				
0.0	0.4 m **TOPSOIL** **SILTY CLAY** greyish brown, firm to v. stiff	1	SS	11	252
		2	SS	7	
251.1 1.5	**SILTY SAND TILL** some gravel, trace to some clay brown, v. loose, moist to wet	3	SS	4	251
250.1 2.5	cobbles	4	SS	100/10.0 cm	
	End of Borehole Auger refusal @ 2.5 m on possible bedrock Confirmatory refusal @ 2.6 m at Sta. 16+310 Hole dry (not stabilized) and open upon completion				

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

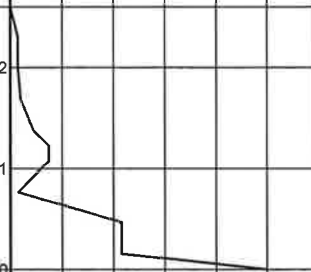
15-20-5-10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A10

METRIC

GWP 161-98-00	LOCATION Embankment Fill Location # 5, Sta: 16+350, 19.3 m Lt C/L o f Hwy 11	ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic	DATE 8/12/2009	CHECKED BY Z.O.

SOIL PROFILE: ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
252.6	GROUND SURFACE										
0.0							252				
							251				
250.0 / 2.6	End of DCPT. Refusal @ 2.6 m.						250				



+ ³ , × ³ : Numbers refer to Sensitivity

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H12

METRIC

GWP 161-98-00 LOCATION Culvert # 20 & Passing Lane # 5, Sta: 16+353, 6.5 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST ____ HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/25/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.5	GROUND SURFACE										
0.0	**GRANULAR FILL :** SAND, SOME GRAVEL brown, moist, loose		1	SS	7						8 86 (6)
254.1 / 0.4	**FILL :** SILTY SAND some gravel, trace clay brown, moist, loose		2	SS	5		254				
			3	SS	5		253				Hole advanced by moving 3.0 m north as refusal @ 1.5 m
252.5 / 2.0	**SILTY CLAY** greyish brown, stiff to v. stiff		4	SS	19		252				
			5	SS	8		251				0 5 45 50
250.7 / 3.8	**SILTY SAND TILL** some gravel		6	SS	100/20.0 cm						
250.5 / 4.0	End of Borehole Borehole moved 3.0 m north due to shallow refusal Auger refusal @ 4.0 m on possible bedrock Borehole dry (not stabilized) upon completion Hole caved-in @ 3.2 m upon completion										

Shear strength legend: O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE

Water content: PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

$+^3, \times^3$: Numbers refer to Sensitivity   15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H13

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+352, 17.6 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/20/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.5	GROUND SURFACE					
0.0 / 251.9 0.6	0.6 m **TOPSOIL**	1	SS	6	252	
	SILTY CLAY with freq. clayey silt interbeds brown, firm to v. stiff	2	SS	7	251	
250.4 2.1	tr. gravel	3	SS	7		4 14 38 44
249.9 2.6	**SILTY SAND TILL** tr. gravel, brown v. dense, damp to moist	4	SS	63/25 cm	250	

End of Borehole
DCPT performed adjacent to borehole from ground to 2.4 m.
Auger refusal @ 2.6 m on possible boulder
Hole dry (not stabilized) upon completion
Hole caved-in @ 2.3 m upon completion

Dynamic Cone Penetration Resistance Plot (20, 40, 60, 80, 100); Shear Strength (kPa): ○ Unconfined, + Field Vane, ● Pocket Penetr., × Lab Vane (20, 40, 60, 80, 100); Water Content (%) (20, 40, 60): w_P, w, w_L; Unit Weight γ kN/m³.

+³, ×³: Numbers refer to Sensitivity   15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H14 — 1 OF 1 — METRIC

GWP 161-98-00 | LOCATION Passing Lane #5, Sta: 16+400, 6.5 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ____ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/25/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.4	GROUND SURFACE						
0.0	0.3 m **FILL:** Sand, some gravel	1	AS			254	
	FILL: Silty Sand some gravel, some clay, tr. organics brown, v. loose to loose moist to wet	2	SS	7			
		3	SS	4		253	
252.3 2.1	**SILTY CLAY** with freq. clayey silt interbeds brown, stiff	4	SS	12		252	0 4 44 52
	tr. gravel	5	SS	13		251	
		6	SS	59/15 cm			
250.3 4.1	**SILTY SAND TILL** tr. clay, some gravel brown, v. dense, wet						
250.2 4.2	End of Borehole Auger refusal @ 4.2 m on possible bedrock Hole dry (not stabilized) upon completion Hole caved-in @ 3.2 m upon completion						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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

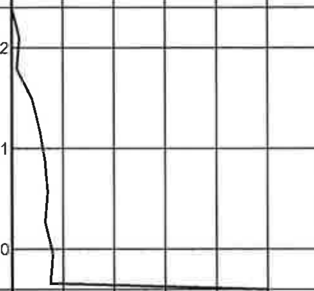
$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A11

METRIC

GWP 161-98-00	LOCATION Embankment Fill Location #5, Sta: 16+400, 19.0 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic		DATE 8/12/2009	CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
252.4	GROUND SURFACE										
0.0							252 / 251 / 250				
249.6 2.8	End of DCPT. Refusal @ 2.8 on possible bedrock.										

$+^3, \times^3$: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H15

METRIC

GWP 161-98-00	LOCATION Passing Lane #5, Sta: 16+450, 17.8 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY W.C.
DATUM Geodetic	DATE 6/21/2009		CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.3	GROUND SURFACE					
0.0	0.6 m **TOPSOIL** tr. rootlets	1	SS	8	252	
	SILTY CLAY with freq. clayey silt interbeds brown, firm to v. stiff	2	TW	PM		0 2 33 65
					251	
		3	SS	6		
249.9 / 2.4	**SAND & GRAVEL TILL** brown, v. dense, moist	4	SS	50/15 cm	250	
249.8 / 2.5	End of Borehole Auger refusal @ 2.5 m on possible bedrock Hole dry (not stabilized) upon completion Hole caved-in @ 2.3 m upon completion					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H16

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+500, 16.6 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST ____ HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/24/2009 CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.1	GROUND SURFACE				254	
0.0	0.5 m **FILL:** Sand, some gravel	1	AS			
	FILL: Silty Sand to Sandy Silt tr. gravel, tr. clay brown, v. loose to loose, moist	2	SS	7	253	4 30 42 2
	some organics	3	SS	4		
252.0 / 2.1	**SILTY CLAY** with freq. clayey silt interbeds brown, stiff	4	SS	11	252	
		5	SS	10	251	
250.4 / 3.7	**SILTY SAND TILL** tr. gravel, brown v. dense, moist	6	SS	50/2 cm		
250.2 / 3.9	End of Borehole					

End of Borehole
Auger refusal @ 3.9 m on possible bedrock
Hole dry (not stabilized) upon completion
Hole caved-in @ 3.2 m upon completion

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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; GROUND WATER CONDITIONS; STRAT PLOT.

$+^3, \times^3$: Numbers refer to Sensitivity   15-20-5-10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No A12

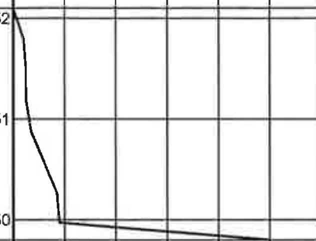
METRIC

GWP 161-98-00 | LOCATION Embankment Fill Location # 5, Sta: 16+500, 18.8 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ______ HWY 11 | BOREHOLE TYPE Dynamic Cone Penetration Test | COMPILED BY W.C.

DATUM Geodetic | DATE 8/12/2009 | CHECKED BY Z.O.

SOIL PROFILE			SAMPLES					DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
252.1	GROUND SURFACE										
0.0							252				
							251				
249.8							250				
2.3	End of DCPT. Refusal @ 2.3 m on possible bedrock.										



+³, ×³: Numbers refer to Sensitivity

15-⊕-5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H17

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+550, 18.7 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/21/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
251.8	GROUND SURFACE									
0.0	0.5 m **TOPSOIL**	1	SS	7		~27				
	SILTY CLAY with freq. clayey silt interbeds brown, stiff					~32				
					251					
		2	SS	9		~38 (Wp ~27, WL ~44)	0	3	37	60
		3	SS	10		~45				
					250					
249.4 / 2.4	**SANDY SILT TILL** with gravel brown, v. dense, wet	4	SS	53/18 cm		~30				
249.3 / 2.5	End of Borehole									

End of Borehole
Auger refusal @ 2.5 m on possible bedrock
Hole dry (not stabilized) upon completion
Hole caved-in @ 2.4 m upon completion

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H18

METRIC

GWP 161-98-00 | LOCATION Passing Lane #5, Sta: 16+600, 6.9 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ___ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/24/2009 | CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
253.7	GROUND SURFACE						
0.0	0.6 m **FILL:** Sand, some gravel	1	AS				
	FILL: Silty Sand some gravel, tr. clay, tr. organics brown, loose, moist	2	SS	9		253	
252.5 / 1.2	**FILL:** Clayey Silt topsoil inclusion, brown/grey mixture stiff, moist	3	SS	8		252	
251.6 / 2.1	**SILTY CLAY** with freq. clayey silt interbeds brown, stiff to v. stiff	4	SS	18		251	0 3 36 61
		5	SS	9			
250.0 / 3.7	**SILTY SAND TILL** tr. gravel, tr. clay brown, v. dense, wet	6	SS	54/28 cm		250	10 48 30 12
249.5 / 4.2	End of Borehole Auger refusal @ 4.2 m on possible bedrock Hole dry (not stabilized) upon completion Hole caved-in @ 3.3 m upon completion						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A13

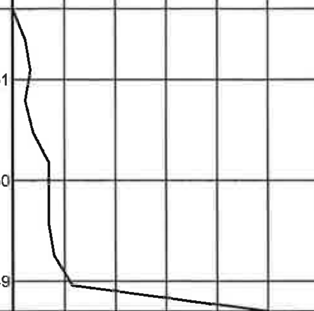
METRIC

GWP 161-98-00 LOCATION Embankment Fill Location # 5, Sta: 16+600, 19.2 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY W.C.

DATUM Geodetic DATE 8/13/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
251.7	GROUND SURFACE										
0.0							251				
							250				
							249				
248.7 / 3.0	End of DCPT. Refusal @ 3.0 m on possible bedrock.										



$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H19

METRIC

GWP 161-98-00 | LOCATION Passing Lane #5, Sta: 16+650, 18.4 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ____ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/21/2009 | CHECKED BY Z.O.

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.6	GROUND SURFACE						
0.0	0.5 m **TOPSOIL**	1	SS	9			
	SILTY CLAY with freq. clayey silt interbeds brown, stiff	2	SS	9		251	
		3	SS	9		250	0 2 35 63
		4	SS	9		249	
		5	SS	9		248	
247.6 / 4.0	cobbles	6	SS	57/15 cm			

End of Borehole
Auger refusal @ 4.0 m on possible bedrock
Hole dry (not stabilized) upon completion
Hole caved-in @ 3.8 m upon completion

Chart columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H20

1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+700, 6.9 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/24/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
253.2	GROUND SURFACE						
0.0	0.3 m **FILL:** Sand	1	AS			253	
	FILL: Silty Sand tr. clay, tr. gravel brown, v. loose, moist to wet	2	SS	3		252	9 50 27 14
251.7 1.5	**SILTY CLAY** with freq. clayey silt interbeds brown, firm to v. stiff; organics, wood pieces	3	SS	7		251	
		4	SS	8		250	
		5	SS	7			0 1 31 68
	moist / wet	6	SS	5		249	
	tr. gravel, oxidized silty sand pockets	7	SS	7	▼*		
248.3 4.9	**SILTY SAND TILL** tr. to some clay, some gravel brown, loose to v. dense, wet	8	SS	50/13 cm		248	
247.5 5.7	End of Borehole Auger refusal @ 5.7 m on possible bedrock Water level @ 4.9 m (not stabilized)* upon completion Hole caved-in @ 5.5 m upon completion						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

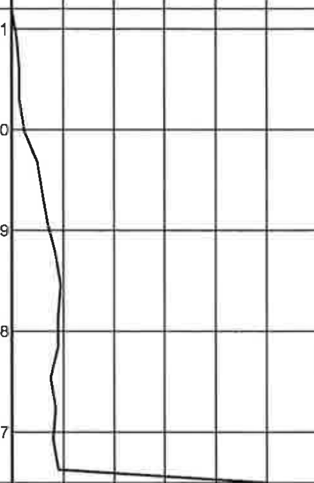
+³, ×³: Numbers refer to Sensitivity; 20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A14

METRIC

GWP 161-98-00	LOCATION Embankment Fill Location # 5, Sta: 16+700, 18.2 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic		DATE 8/13/2009	CHECKED BY Z.O.

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
251.2	GROUND SURFACE										
0.0							251				
							250				
							249				
							248				
							247				
246.5 / 4.7	End of DCPT. Refusal @ 4.7 on possible bedrock.										



$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H21

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+750, 18.4 m Lt C/L of Hwy 11 ORIGINATED BY G.J.
DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.
DATUM Geodetic DATE 6/21/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (kPa)	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.0	GROUND SURFACE				251			
0.0	0.5 m **TOPSOIL**	1	SS	9				
	SILTY CLAY with freq. clayey silt interbeds	2	SS	9	250			
		3	SS	10	249			
	brown, firm to stiff	4	SS	4	248	3.5		
	varved, grey v. soft to stiff	5	TW	PM				0 3 47 50
		6	SS	2	247	4.8		
		7	TW	PM	246	5.2		
245.7 / 5.3	**SILTY SAND TILL** some clay, tr. to some gravel brown, wet	8	SS	51/2 cm				
245.5 / 5.5	End of Borehole Auger refusal @ 5.5 m on probable bedrock Hole dry (not stabilized)* and open upon completion							

+ 3, × 3: Numbers refer to Sensitivity

15 ⊕ 5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H22

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+800, 7.0 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/24/2009 CHECKED BY Z.O.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.8	GROUND SURFACE					
0.0	0.3 m **FILL:** Sand **FILL:** Silty Sand tr. organic, some clay, tr. gravel	1	AS			
252.2 / 0.6	**FILL:** Silty Clay some gravel, brown stiff, moist	2	SS	8		
251.3 / 1.5	**PEATY TOPSOIL** tr. wood pieces, black loose, moist	3	SS	10		
250.7 / 2.1	**SILTY CLAY** with freq. clayey silt interbeds	4	SS	10		0 4 41 55
	brown, stiff	5	SS	8		
	varved, grey soft to stiff	6	SS	4		
		7	SS	3		
		8	SS	0		0 2 28 70
		9	SS	0		
		10	SS	0		
		11	SS	0	▼*	
244.6 / 8.2	**SILTY SAND TILL** some gravel, tr. clay brown, v. dense, wet	12	SS	100/5.0 cm		
244.2 / 8.6	End of Borehole Auger refusal @ 8.6 m on possible boulder Hole open and water level @ 8.2 m (not stabilized)* upon completion					

ELEVATION SCALE: 252, 251, 250, 249, 248, 247, 246, 245

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE: 20 40 60 80 100

Field vane sensitivity values plotted: 4.8, 4.8, 5.3, 4.4

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%): 20 40 60 (143)

UNIT WEIGHT γ kN/m³

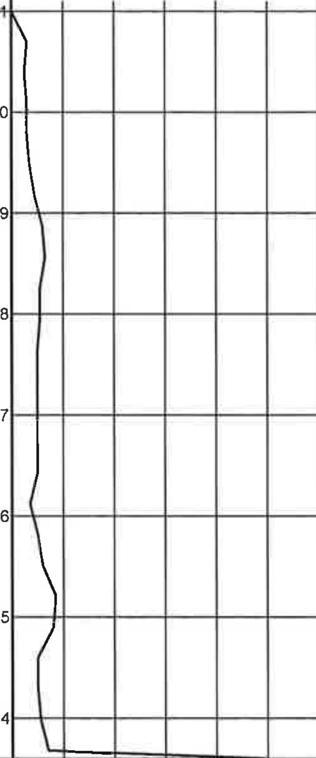
+³, ×³: Numbers refer to Sensitivity   20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A15

METRIC

GWP 161-98-00	LOCATION Passing Lane # 5, Sta: 16+800, 18.5 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Dynamic Cone Penetration Test	COMPILED BY W.C.
DATUM Geodetic	DATE 8/13/2009		CHECKED BY Z.O.

SOIL PROFILE			SAMPLES									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
251.0 0.0	GROUND SURFACE						251				
							250				
							249				
							248				
							247				
							246				
							245				
							244				
243.6 7.4	End of DCPT. Refusal @ 7.4 m on possible bedrock.										



$+^3$, $\times^3$: Numbers refer to Sensitivity

15 -⊕- 5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H23

1 OF 1 **METRIC**

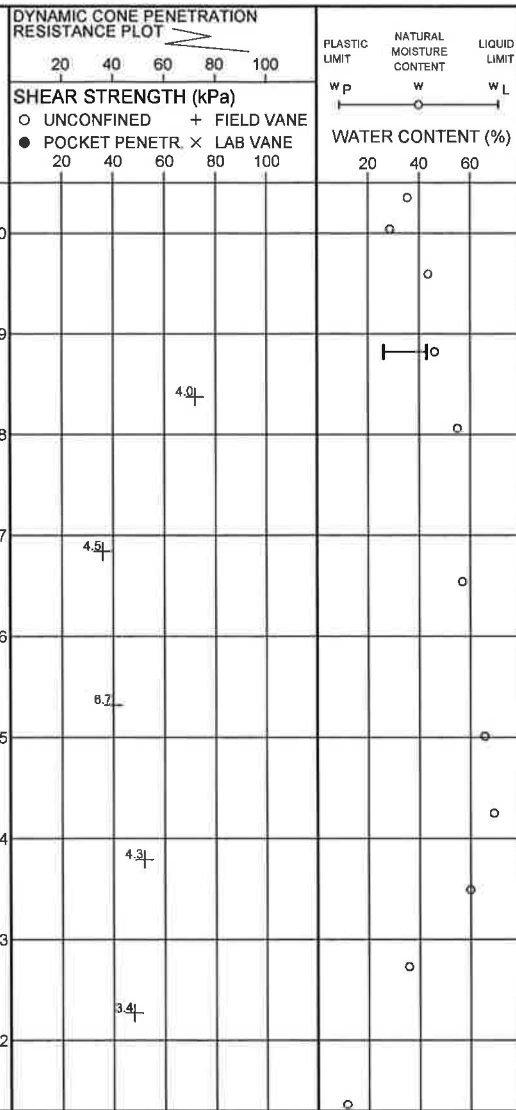
GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+850, 18.3 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/21/2009 CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.5	GROUND SURFACE					
0.0	0.3 m **TOPSOIL**	1	SS	8		
	SILTY CLAY with freq. clayey silt interbeds				250	
		2	SS	9		
					249	
		3	SS	6		0 3 40 57
	brown firm to stiff	4	SS	6	248	
	varved, grey v. soft to stiff	5	TW	PM		
					247	
		6	SS	1		
					246	
		7	TW	PM		
		8	SS	0	245	
		9	SS	0		
					244	
		10	SS	0		
					243	
		11	SS	0		
					242	
241.4 / 9.1		12	SS	100/10.0 cm		
241.3 / 9.2	**SILTY SAND TILL** some gravel, tr. clay grey, v. dense, moist					

End of Borehole
Auger refusal @ 9.2 m on probable boulder
Hole dry (not stabilized)* and open upon completion



UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H24

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+900, 6.7 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/24/2009 CHECKED BY Z.O.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
252.2 / 0.0	GROUND SURFACE; 0.3 m **FILL:** Sand; **FILL:** Silty Sand some gravel, tr. clay brown, loose	1	AS		
		2	SS	8	
250.7 / 1.5	**PEATY TOPSOIL** tr. sand, black loose, moist	3	SS	7	
250.0 / 2.2	**SILTY CLAY** varved silty clay with freq. clayey silt interbeds; brown soft to v. stiff	4	SS	5	0 4 36 60
		5	SS	4	
	varved, grey v. soft to firm	6	SS	0	
		7	SS	0	
		8	SS	0	
		9	SS	0	
		10	SS	0	0 2 34 64
		11	SS	0	
		12	SS	0	
241.5 / 10.7	**SILTY SAND TILL** tr. to some gravel & clay brown, v. loose to v. dense wet to moist	13	SS	1	8 49 29 14
		14	SS	75/28 cm	
240.2 / 12.0	End of Borehole; Auger refusal @ 12.0 m on possible boulder; Hole dry (not stabilized)* upon completion; Hole caved-in @ 11.0 m on completion				

ELEVATION SCALE: 252, 251, 250, 249, 248, 247, 246, 245, 244, 243, 242, 241

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE: 20 40 60 80 100

Field vane sensitivity values plotted: 5.3, 4.5, 5.3, 4.5; >> (off scale) at approx. 249.3 and 248.5

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

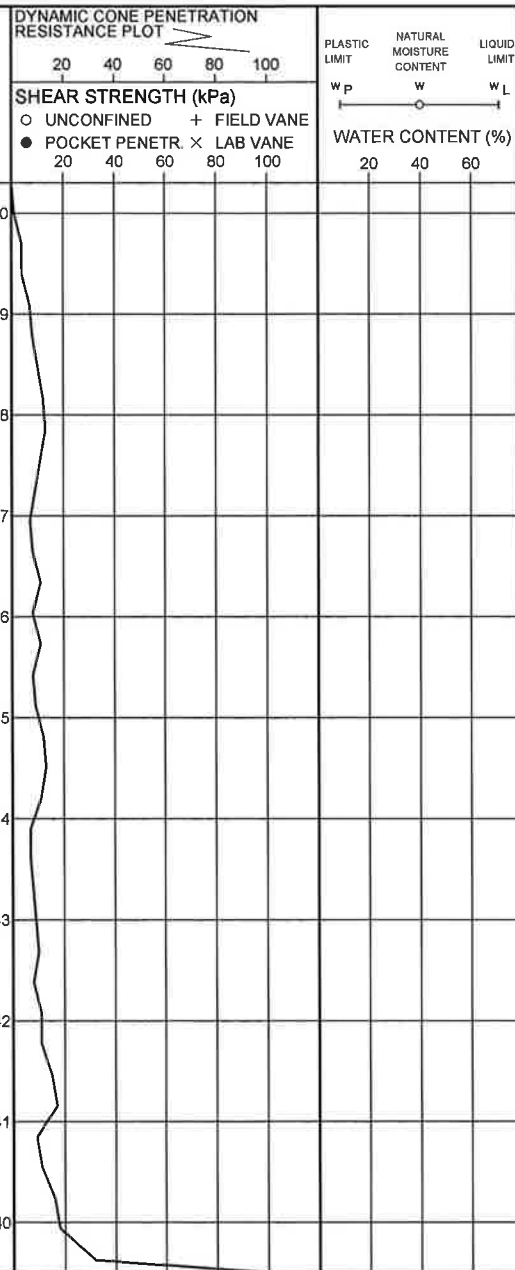
15-⊕-5 (20 / 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A16

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+900, 18.7 m Lt C/L of Hwy 11 ORIGINATED BY G.J.
DIST HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY W.C.
DATUM Geodetic DATE 8/13/2009 CHECKED BY Z.O.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.3 / 0.0	GROUND SURFACE						250, 249, 248, 247, 246, 245, 244, 243, 242, 241, 240		
239.5 / 10.8	End of DCPT. Refusal @ 10.8 m on possible bedrock.								



$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

Foundation Design

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No H25

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 16+950, 18.3 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/21/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	SHEAR STRENGTH (kPa)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.2	GROUND SURFACE						
0.0	0.5 m **TOPSOIL**				250		
	SILTY CLAY with freq. clayey silt interbeds; brown, firm to stiff	1	SS	11			
		2	SS	10	249		
		3	SS	6		4.5	
	varved, grey, v. soft to firm	4	SS	2	248		
		5	TW	PM	247	6.0	0 2 38 60
		6	SS	0	246		
		7	SS	0	245	8.0	
		8	SS	0			
		9	SS	0	244	8.0	
		10	SS	0	243		
		11	SS	0	242	4.5	
241.1 / 9.1	**SILTY SAND TILL** some clay, tr. to some gravel brown, v. loose, wet	12	SS	3	241		10 43 29 18
		13	SS	3	240		
238.9 / 11.3	End of Borehole Auger refusal @ 11.3 m on possible boulder Hole dry (not stabilized)* and open upon completion	~~14~~	~~SS~~	~~100/0 cm~~	239		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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

15-⊕-5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H26

1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 17+000, 7.6 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/23/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR SA SI CL
251.6	GROUND SURFACE				
0.0	0.6 m **FILL:** Sand brown, moist	1	AS		
	FILL: Clayey Silt to Silty Clay tr. to some organic brown, firm, moist	2	SS	6	2 23 37 38
		3	SS	8	
249.5 / 2.1	**SILTY CLAY** with freq. clayey silt interbeds; brown, firm to stiff	4	SS	10	0 4 42 54
		5	SS	4	
	varved, grey, v. soft to firm	6	SS	2	
		7	SS	0	
		8	SS	0	
		9	SS	4	0 2 39 59
		10	SS	0	
		11	SS	0	
		12	SS	0	
		13	SS	2	
240.4 / 11.2	**SILTY SAND TILL** tr. to some clay, tr. to some gravel, brown, v. loose to loose, moist to wet				25 34 26 15
	silty clay interbeds, firm (0.3 m)	14	SS	6	
238.6 / 13.0		15	SS	100/5.0 cm	

Field vane shear strength (sensitivity): 3.6, 4.5, 5.3, 4.7, 4.0, 5.2

End of Borehole
Auger refusal @ 13.0 m
Hole dry (not stabilized)* upon completion
Hole caved-in @ 7.3 m upon completion

+ [3], × [3]: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A17

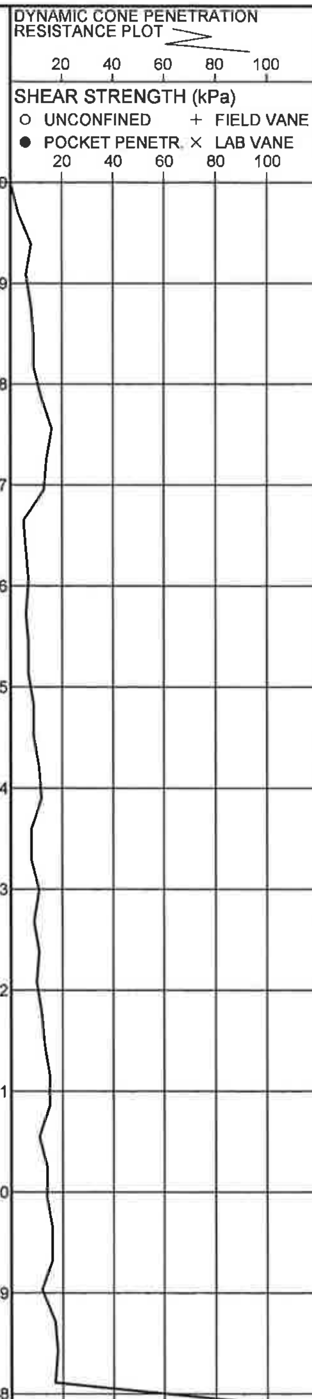
METRIC

GWP 161-98-00 LOCATION Passing Lane # 5, Sta: 17+000, 18.5 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY W.C.

DATUM Geodetic DATE 8/13/2009 CHECKED BY Z.O.

ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT, WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
250.0 / 0.0	GROUND SURFACE						250				
							249				
							248				
							247				
							246				
							245				
							244				
							243				
							242				
							241				
							240				
							239				
237.9 / 12.1	End of DCPT. Refusal @ 12.1 m on possible bedrock.						238				



$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No H27

1 OF 1

METRIC

GWP 161-98-00 | LOCATION Passing Lane #5, Sta: 17+050, 18.6 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST | HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/22/2009 | CHECKED BY Z.O.

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
249.6	GROUND SURFACE
0.0	0.6 m **TOPSOIL**; clayey silt, 0.2 m thick; **SANDY SILT TO SILTY SAND** brown, loose to compact, moist
248.1 / 1.5	**SILTY CLAY** varved structure, grey; firm; v. soft to firm; occ. silt layers
236.9 / 12.7	**SILTY SAND TILL** some gravel, some clay brown, v. loose, wet
236.5 / 13.1	End of Borehole

End of Borehole
Auger refusal @ 13.1 m
Water level @ 12.6 m (not stabilized)* upon completion
Hole caved-in @ 12.9 m upon completion

SAMPLES

NUMBER	TYPE	"N" VALUES	Remarks & Grain Size Distribution (%) GR SA SI CL	Unit Weight γ (kN/m³)
1	SS	10		
2	SS	9		
3	SS	5		
4	TW	PM	0 3 40 57 consolidation test	16.7
5	SS	0		
6	SS	0		
7	SS	0		
8	SS	0		
9	TW	PM	0 2 42 56	
10	SS	0		
11	SS	0		
12	SS	0		
13	SS	0		
14	SS	3		
15	AS	100/0 cm		

Field vane sensitivity values plotted: 4.0, 4.5, 4.5, 5.3, 4.5, 3.1, 4.7, 5.6

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100
PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60

ELEVATION SCALE: 249, 248, 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237

+ ³, × ³: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

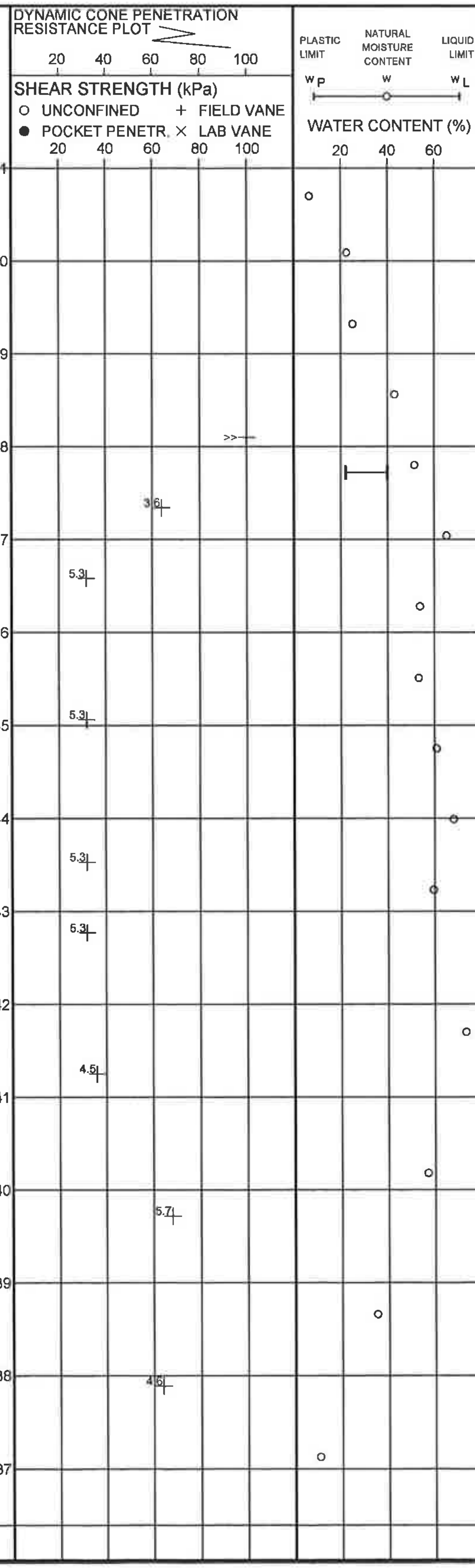
TRANETOB01237AA: HWY 11

RECORD OF BOREHOLE No H28

METRIC

GWP 161-98-00	LOCATION Passing Lane #5, Sta: 17+100, 7.5 m Lt C/L of Hwy 11	ORIGINATED BY G.J.
DIST HWY 11	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY W.C.
DATUM Geodetic	DATE 6/23/2009	CHECKED BY Z.O.

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
251.0 / 0.0	GROUND SURFACE				
	0.6 m **FILL:** Sand	1	AS		
	FILL: Silty Sand, tr. topsoil, greyish brown, loose, moist	2	SS	7	
249.8 / 1.2	**FILL:** Clayey Silt, tr. topsoil & organic, greyish brown, firm	3	SS	8	
248.9 / 2.1	**SILTY CLAY** with freq. clayey silt interbeds; brown, firm to v. stiff	4	SS	6	
	varved, grey, v. soft to firm	5	TW	PM	0 5 44 51
		6	SS	0	
		7	SS	0	
		8	SS	0	
		9	SS	0	
		10	SS	0	
		11	SS	0	
		12	SS	0	
	v. soft to stiff	13	SS	0	
		14	SS	1	
		15	SS	1	
236.8 / 14.2	**SILTY SAND TILL** some gravel, some clay, brown, v. loose, wet	16	SS	100/0 cm	
236.4 / 14.6					



UNIT WEIGHT γ kN/m³

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H28

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 17+100, 7.5 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/23/2009 CHECKED BY Z.O.

SOIL PROFILE		SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
236.0	End of Borehole Auger refusal @ 14.6 m Hole dry (not stabilized) & caved-in @ 5.9 m upon completion										

$+^3, \times^3$: Numbers refer to Sensitivity

20 / 15 -⊕- 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A18

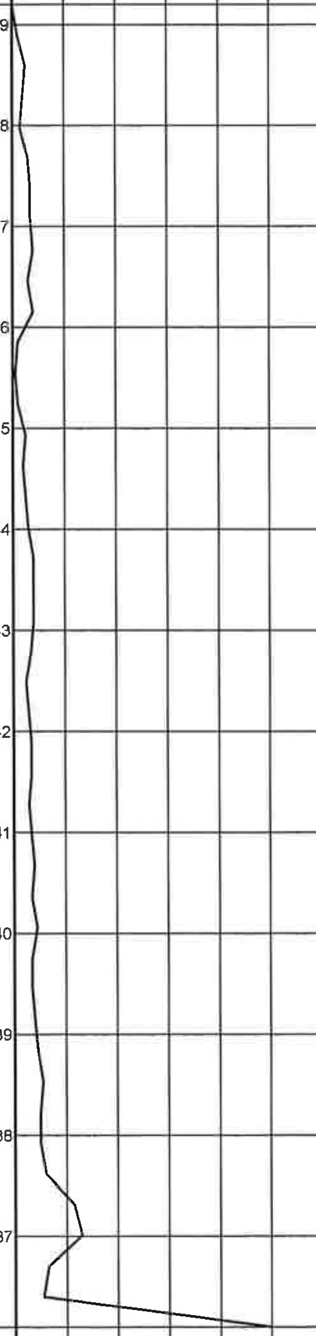
1 OF 1 **METRIC**

GWP 161-98-00 LOCATION Passing Lane # 5, Sta: 17+100, 18.9 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST ____ HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY W.C.

DATUM Geodetic DATE 8/13/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × 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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
249.2	GROUND SURFACE										
0.0							249, 248, 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237				
236.1 13.1	End of DCPT. Refusal @ 13.1 m on possible bedrock.										



$+^3, \times^3$: Numbers refer to Sensitivity

15 -⊕- 5 (20 above, 10 below) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H29

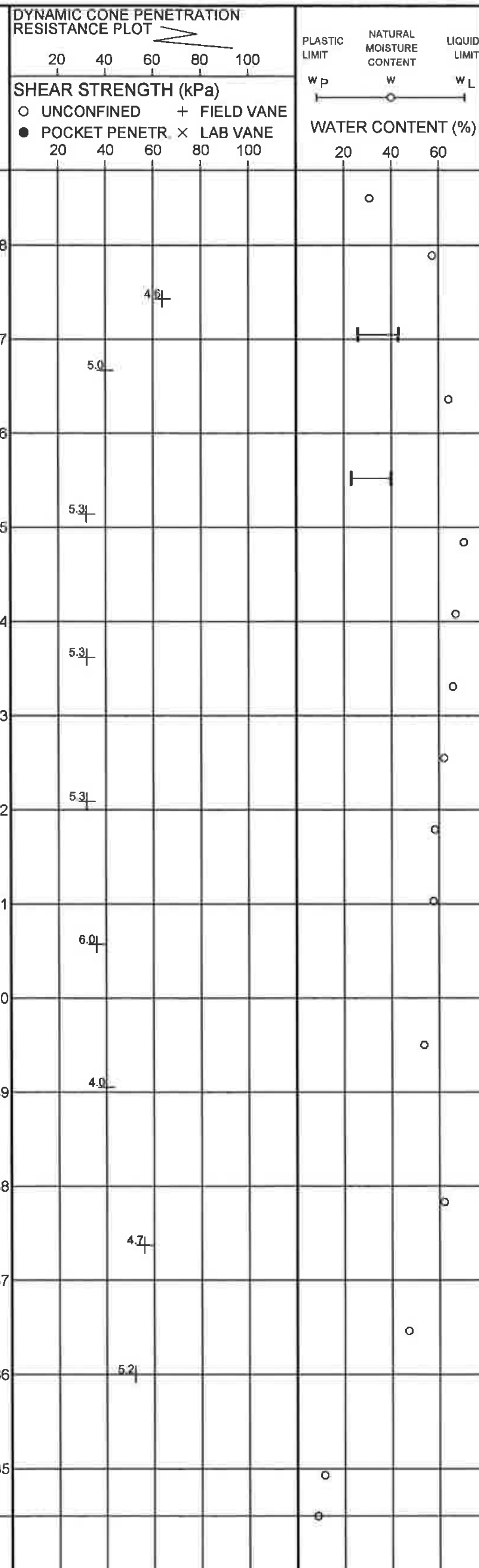
METRIC

GWP 161-98-00 | LOCATION Passing Lane #5, Sta: 17+150, 19.0 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST ____ HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/21/2009 6/22/2009 | CHECKED BY Z.O.

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
248.8	GROUND SURFACE				
0.0	0.6 m **TOPSOIL**	1	SS	8	
		2	SS	2	
	greyish brown soft to stiff	3	TW	PM	0 5 35 60
	varved, grey v. soft to firm	4	SS	0	
		5	TW	PM	0 2 36 62
	SILTY CLAY with freq. clayey silt interbeds	6	SS	0	
		7	SS	0	
		8	SS	0	
		9	SS	0	
		10	SS	0	
		11	SS	0	
		12	SS	0	
	v. soft to stiff	13	SS	1	
		14	SS	2	
235.1 / 13.7	**SILTY SAND TILL** tr. clay, some gravel brown, v. loose, wet	15	SS	5	auger grinding below 13.7 m
234.5 / 14.3	End of Borehole. Auger refusal @ 14.3 m on probable bedrock. Hole dry (not stabilized) & caved-in @ 5.9 m				12 51 23 11



Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity   20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H29

METRIC

GWP 161-98-00 | LOCATION Passing Lane #5, Sta: 17+150, 19.0 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST | HWY 11 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY W.C.

DATUM Geodetic | DATE 6/21/2009 6/22/2009 | CHECKED BY Z.O.

SOIL PROFILE		SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
233.8	upon completion										

+³, ×³: Numbers refer to Sensitivity

20 / 15-⊕-5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H30

METRIC

GWP 161-98-00	LOCATION Passing Lane #5, Sta: 17+200, 7.5 m Lt C/L of Hwy 11		ORIGINATED BY G.J.
DIST	HWY 11	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY W.C.
DATUM Geodetic	DATE 6/22/2009 6/23/2009		CHECKED BY Z.O.

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
250.1	GROUND SURFACE
0.0	0.6 m **FILL:** Sand, some silt, tr. gravel
	FILL: Clayey Silt tr. to some organic greyish brown to brown stiff, moist
248.0 / 2.1	**SILTY CLAY** with freq. clayey silt interbeds — greyish brown, soft to firm; varved, grey, v. soft to firm
235.1	

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	UNIT WEIGHT γ kN/m³
1	AS			
2	SS	9		
3	SS	9		
4	SS	4		
5	SS	3		
6	TW	PM	0 1 33 66	
7	SS	0		
8	SS	0		
9	SS	0		
10	SS	0		
11	SS	0		
12	SS	0		
13	SS	0		
14	TW	PM	0 1 24 75 Consolidation Test	16.6
15	SS	0		

Field vane sensitivity values (top to bottom): 3.1, 5.3, 5.3, 5.3, 4.5, 5.3, 4.4, 3.4, 4.7

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE: 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%): 20 40 60

ELEVATION SCALE: 250, 249, 248, 247, 246, 245, 244, 243, 242, 241, 240, 239, 238, 237, 236

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No H30

METRIC

GWP 161-98-00 LOCATION Passing Lane #5, Sta: 17+200, 7.5 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Hollow Stem Auger COMPILED BY W.C.

DATUM Geodetic DATE 6/22/2009 6/23/2009 CHECKED BY Z.O.

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH (kPa)	WATER CONTENT (%)	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
235.1 15.0	**SILTY SAND TILL** tr. clay, some gravel, broken rock pieces brown, v. dense, wet		16	SS	75/25 cm		235		o		
234.3 15.8	End of Borehole Auger refusal @ 15.8 m on possible bedrock Hole dry (not stabilized) & caved-in @ 9.3 m upon completion										

Legend: ○ UNCONFINED; + FIELD VANE; ● POCKET PENETR.; × LAB VANE. Plastic limit w_P, Natural moisture content w, Liquid limit w_L.

$+^3$, $\times^3$: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A19

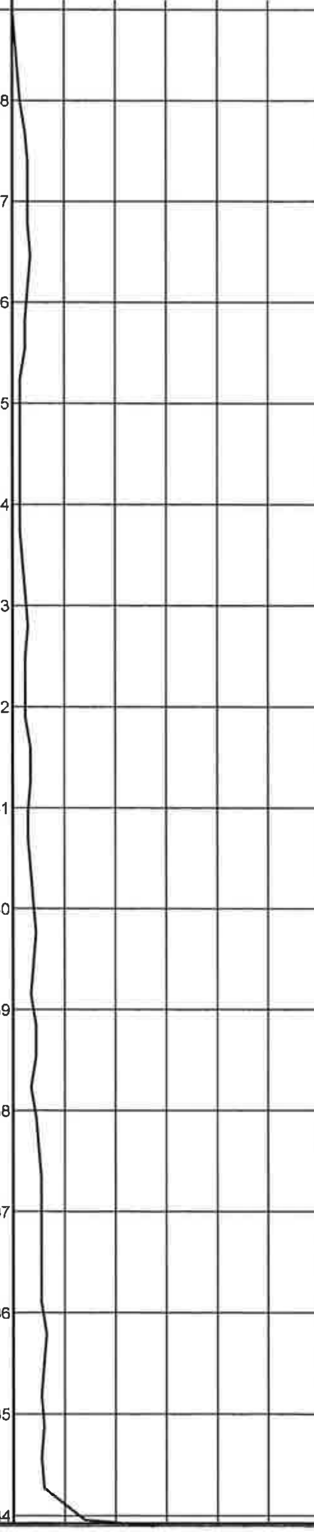
METRIC

GWP 161-98-00 LOCATION Passing Lane # 5, Sta: 17+200, 16.0 m Lt C/L of Hwy 11 ORIGINATED BY G.J.

DIST HWY 11 BOREHOLE TYPE Dynamic Cone Penetration Test COMPILED BY W.C.

DATUM Geodetic DATE 8/13/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE, ● POCKET PENETR., × 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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
248.9 0.0	GROUND SURFACE										
							248				
							247				
							246				
							245				
							244				
							243				
							242				
							241				
							240				
							239				
							238				
							237				
							236				
							235				
							234				



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No A19

METRIC

GWP 161-98-00 | LOCATION Passing Lane # 5, Sta: 17+200, 16.0 m Lt C/L of Hwy 11 | ORIGINATED BY G.J.

DIST | HWY 11 | BOREHOLE TYPE Dynamic Cone Penetration Test | COMPILED BY W.C.

DATUM Geodetic | DATE 8/13/2009 | CHECKED BY Z.O.

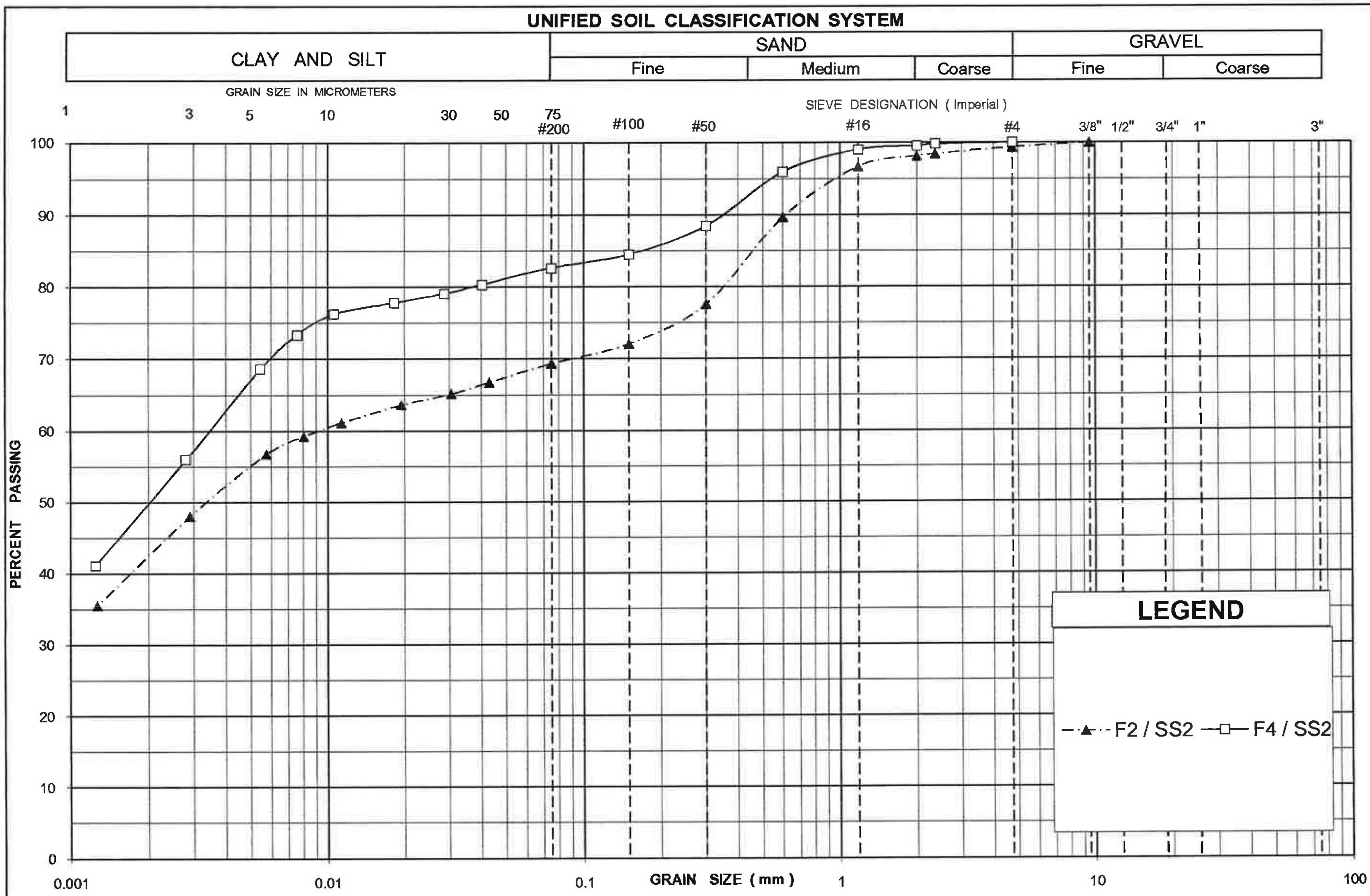
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
233.9											
233.8											
15.1	End of DCPT. Refusal @ 15.1 m on possible bedrock.										
							233				

+ ³, × ³: Numbers refer to Sensitivity

15-5 / 20 / 10: (%) STRAIN AT FAILURE

Appendix B1

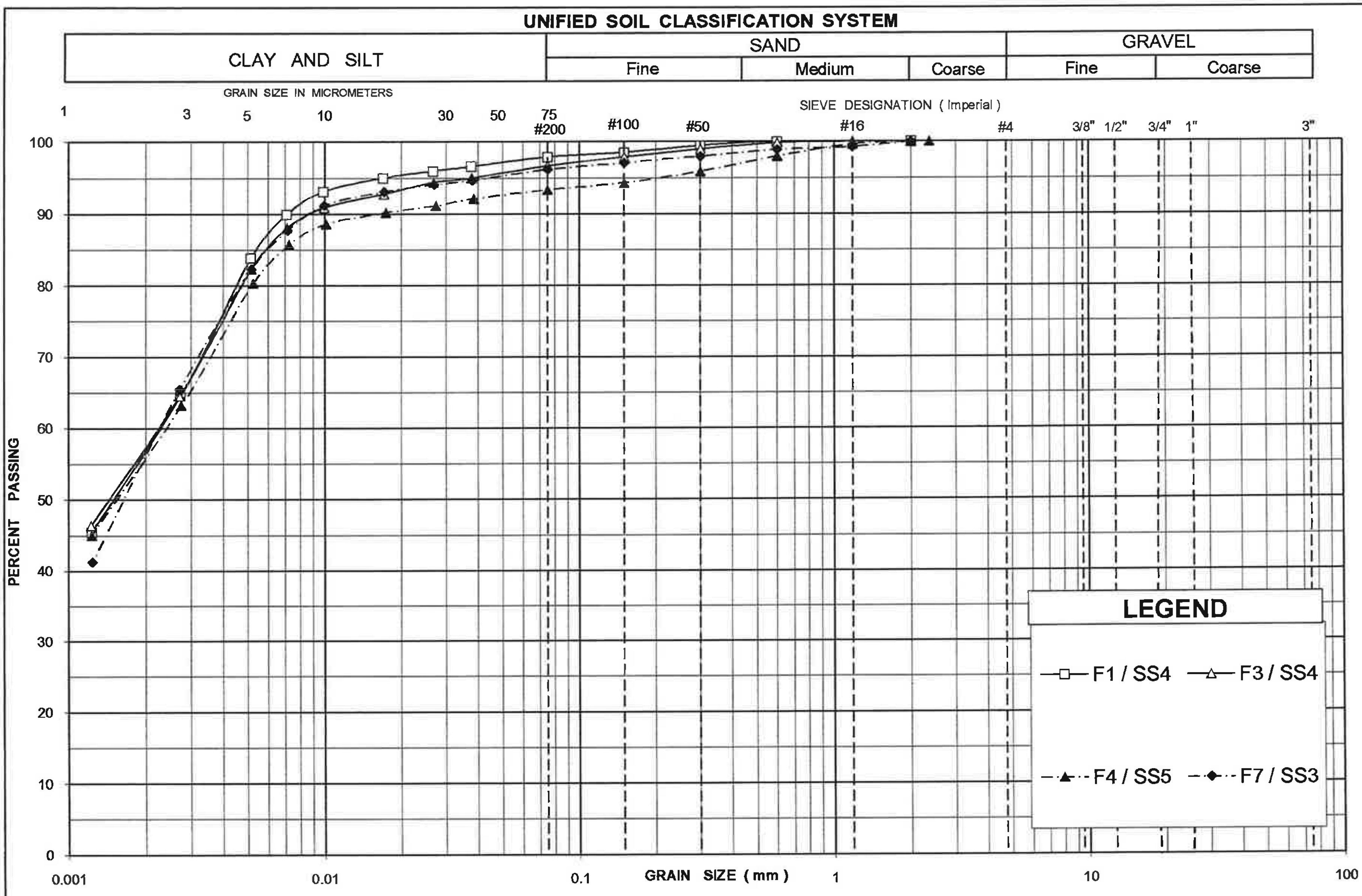
Laboratory Test Results - Passing Lane 1



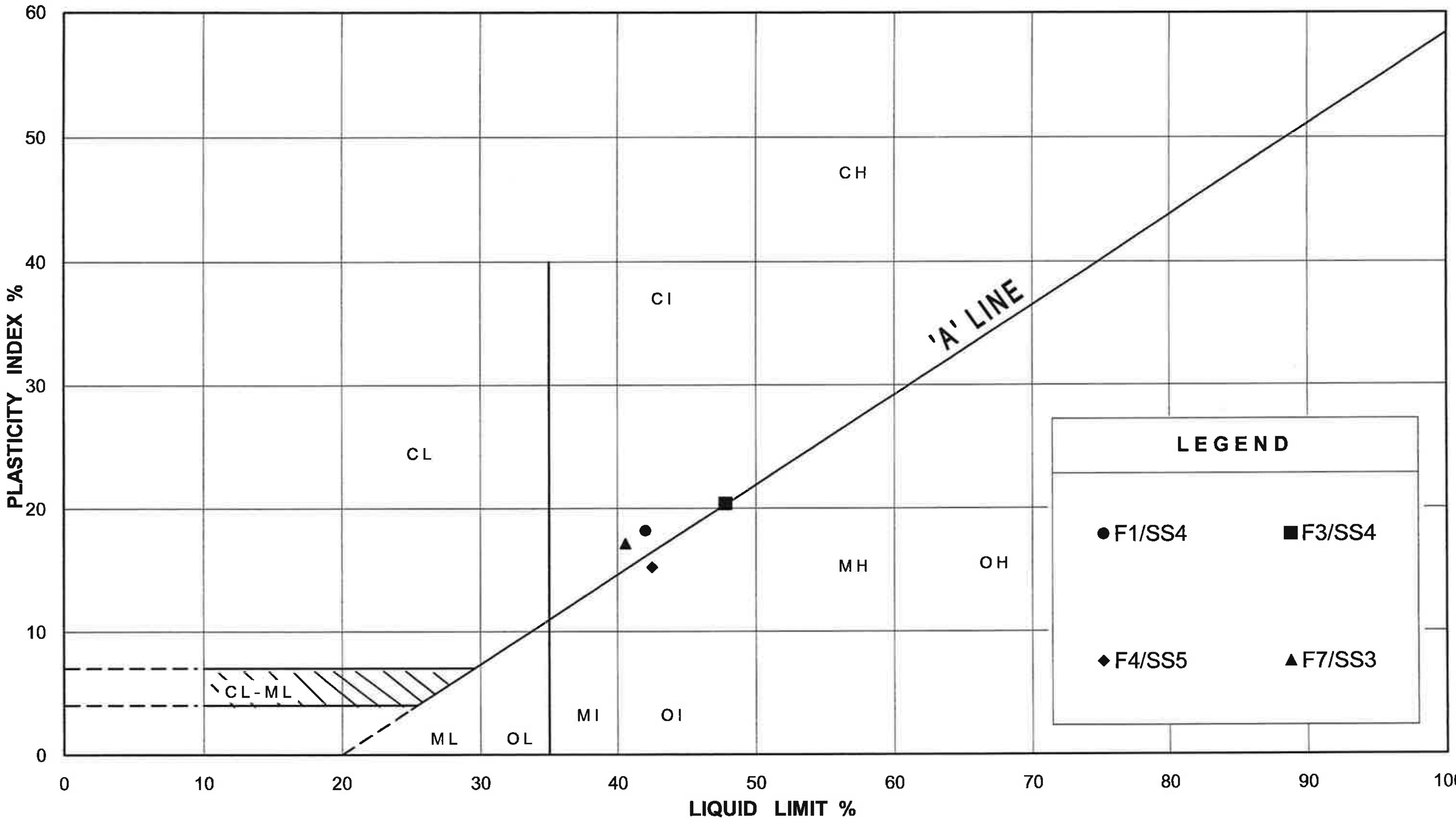
coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
EMBANKMENT FILL: Silty Clay, some sand

FIGURE NO.: B1-1
PROJECT NO: TRANETOB01237AA
DATE: Nov, 2009



coffey geotechnics SPECIALISTS MANAGING THE EARTH	GRAIN SIZE DISTRIBUTION SILTY CLAY	FIGURE NO.: B1-2 PROJECT NO: TRANETOB01237AA DATE: Nov, 2009

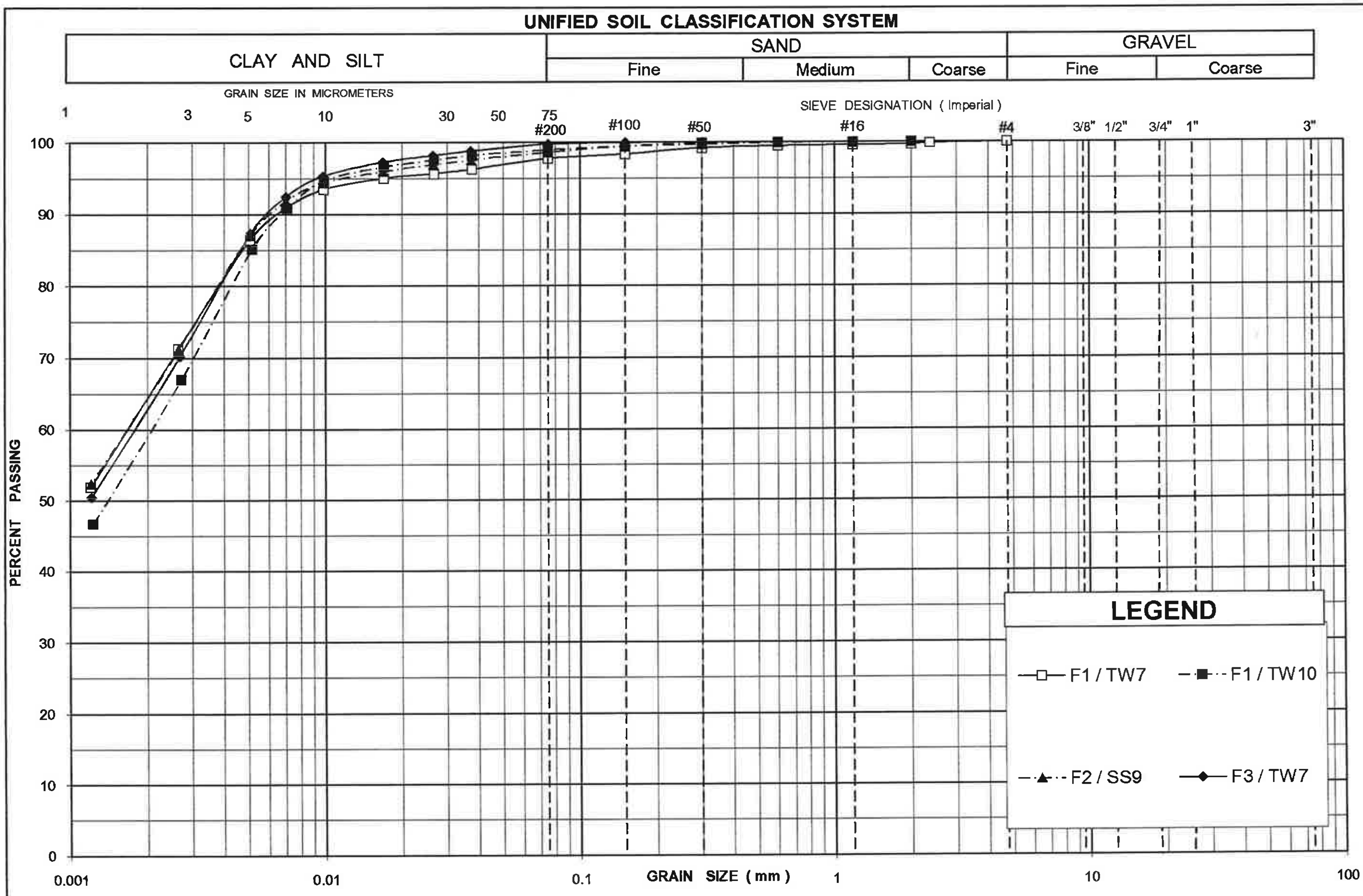


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

SILTY CLAY

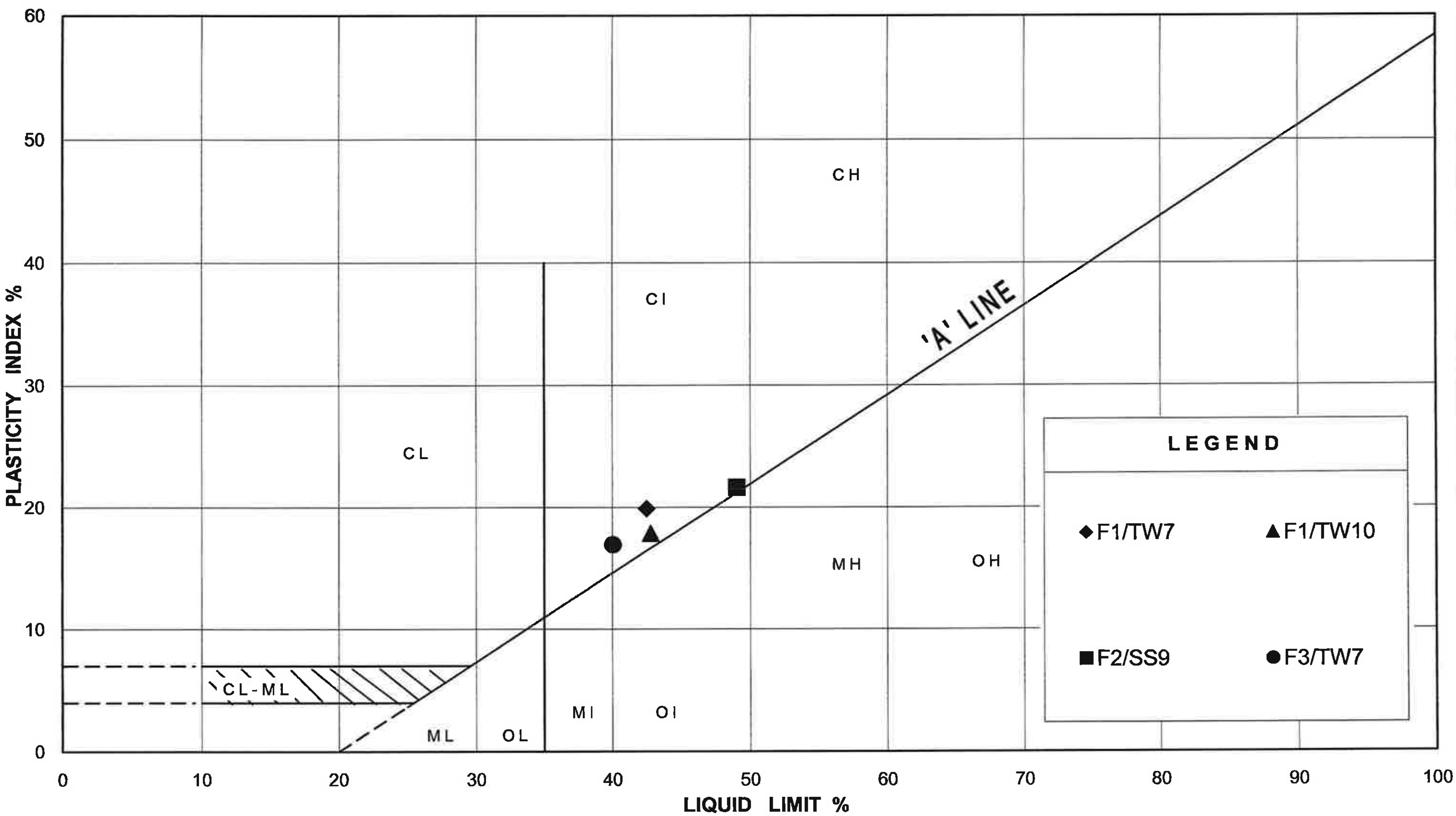
FIGURE No.	B1-3
REF. No.	TRANETOB01237AA
DATE	OCTOBER, 2009



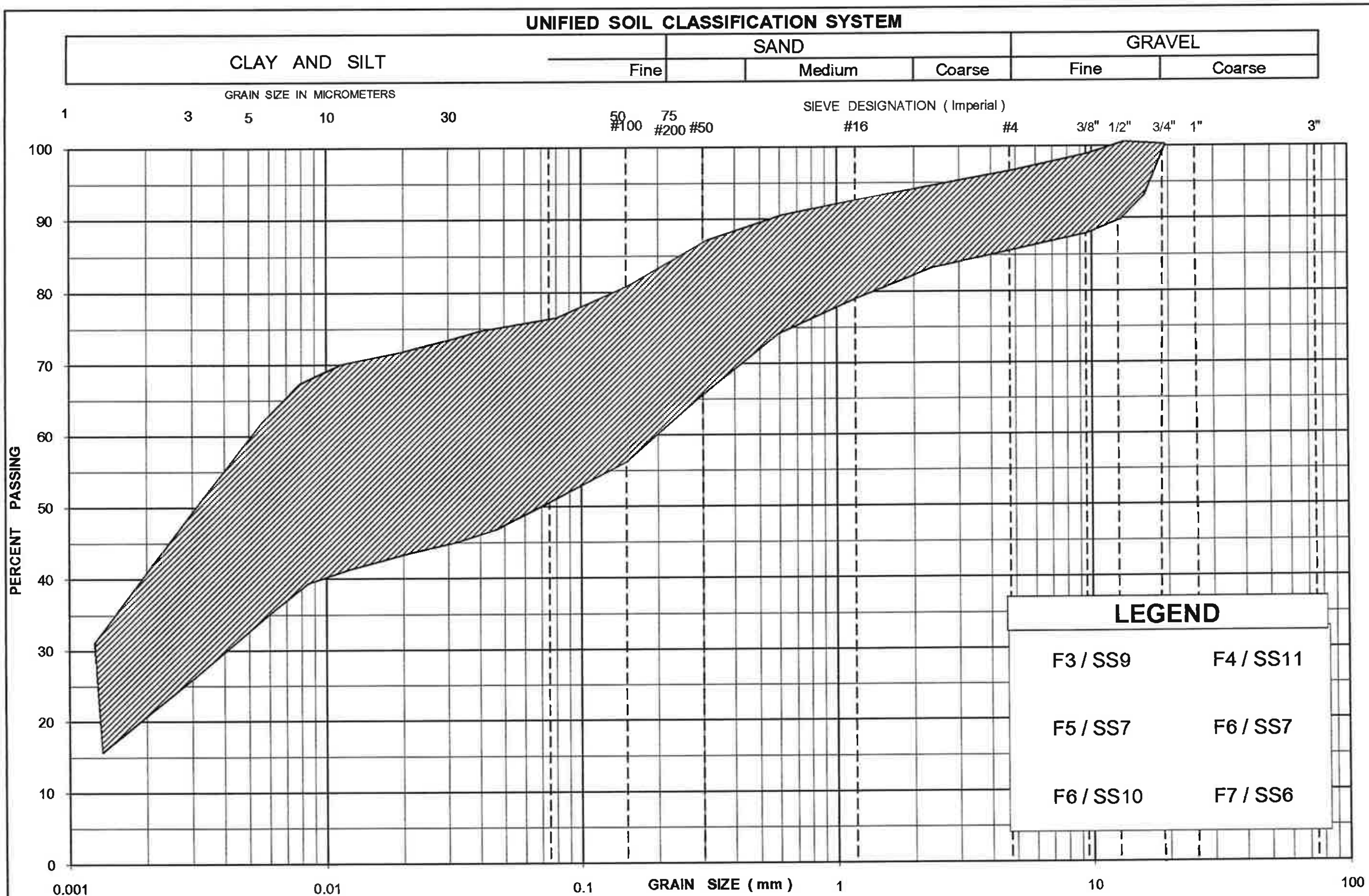
coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
VARVED SILTY CLAY, trace sand

FIGURE NO.:	B1-4
PROJECT NO:	TRANETOB01237AA
DATE:	Nov, 2009



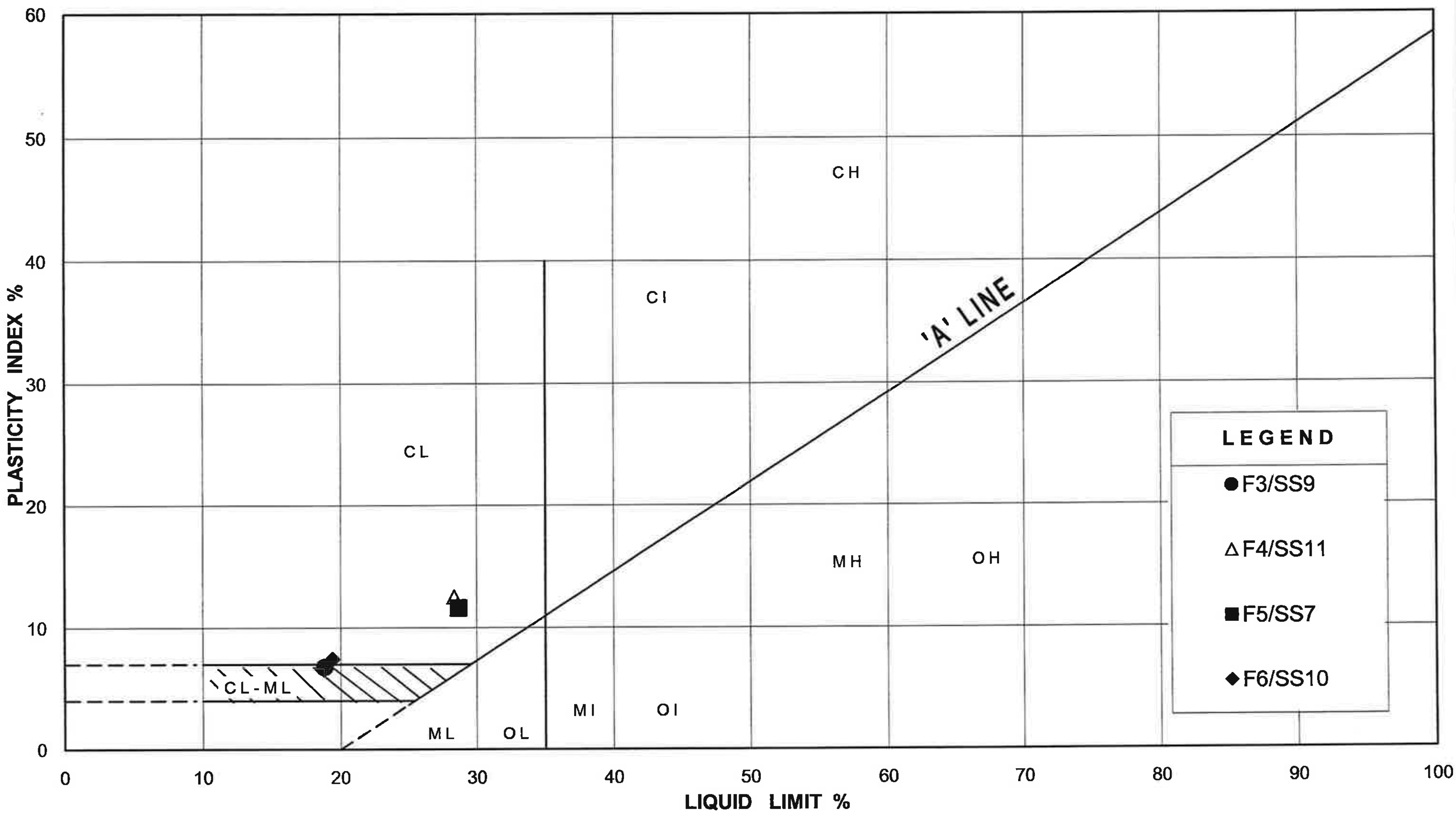
coffey geotechnics SPECIALISTS MANAGING THE EARTH	PLASTICITY CHART	FIGURE No.	B1-5
	SILTY CLAY TO CLAY	REF. No.	TRANETOB01237AA
		DATE	OCTOBER, 2009



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
CLAYEY SILT, with sand and trace gravel (Possible Till)

FIGURE NO.: B1-7
PROJECT NO: TRANETOB01237AA
DATE: Nov, 2009

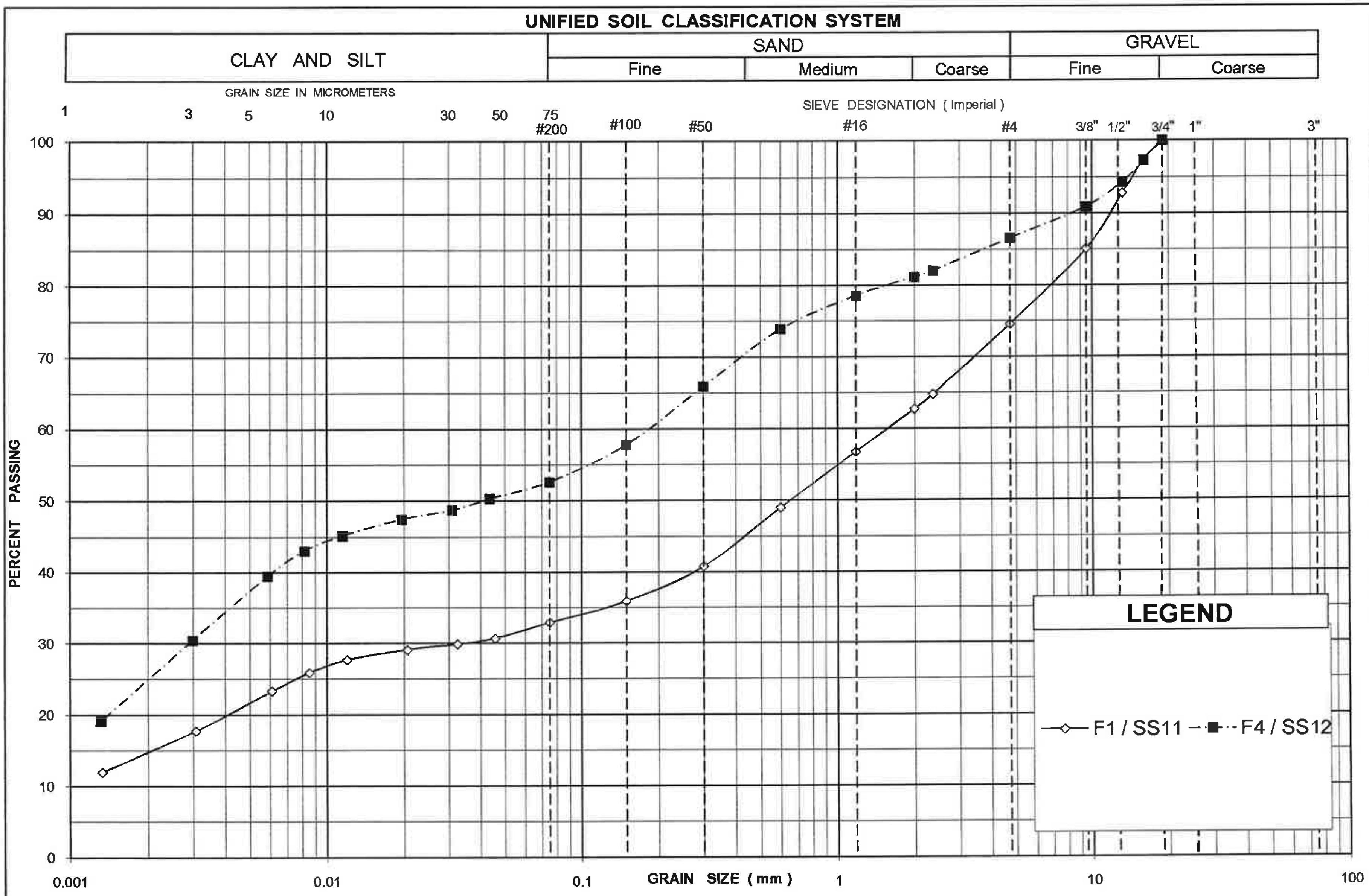


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

CLAYEY SILT, with sand and trave gravel (Possible Till)

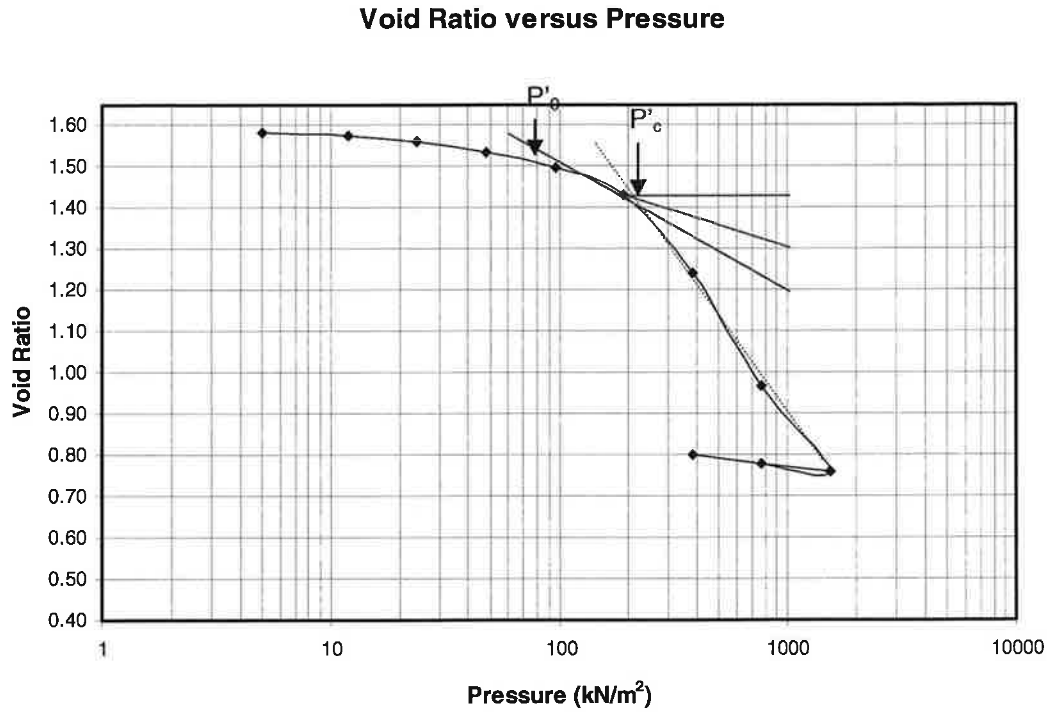
FIGURE No.	B1-8
REF. No.	TRANETOB01237AA
DATE	OCTOBER, 2009



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
SANDY SILT TO SILTY SAND TILL

FIGURE NO.:	B1-9
PROJECT NO:	TRANETOB01237AA
DATE:	Nov, 2009



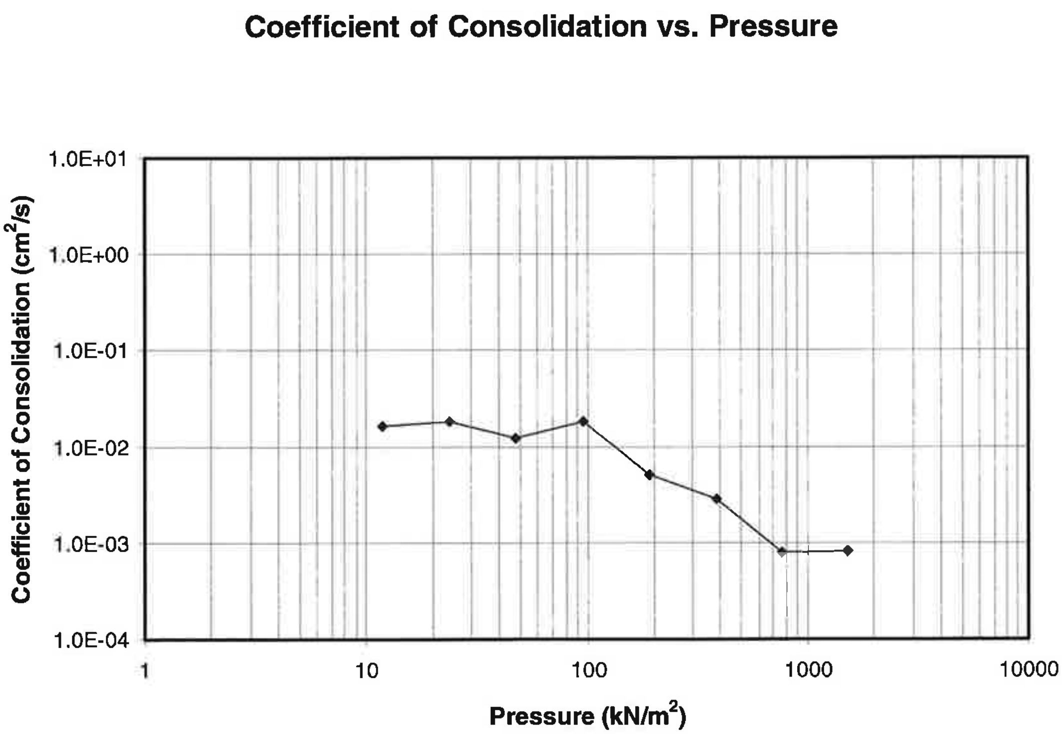
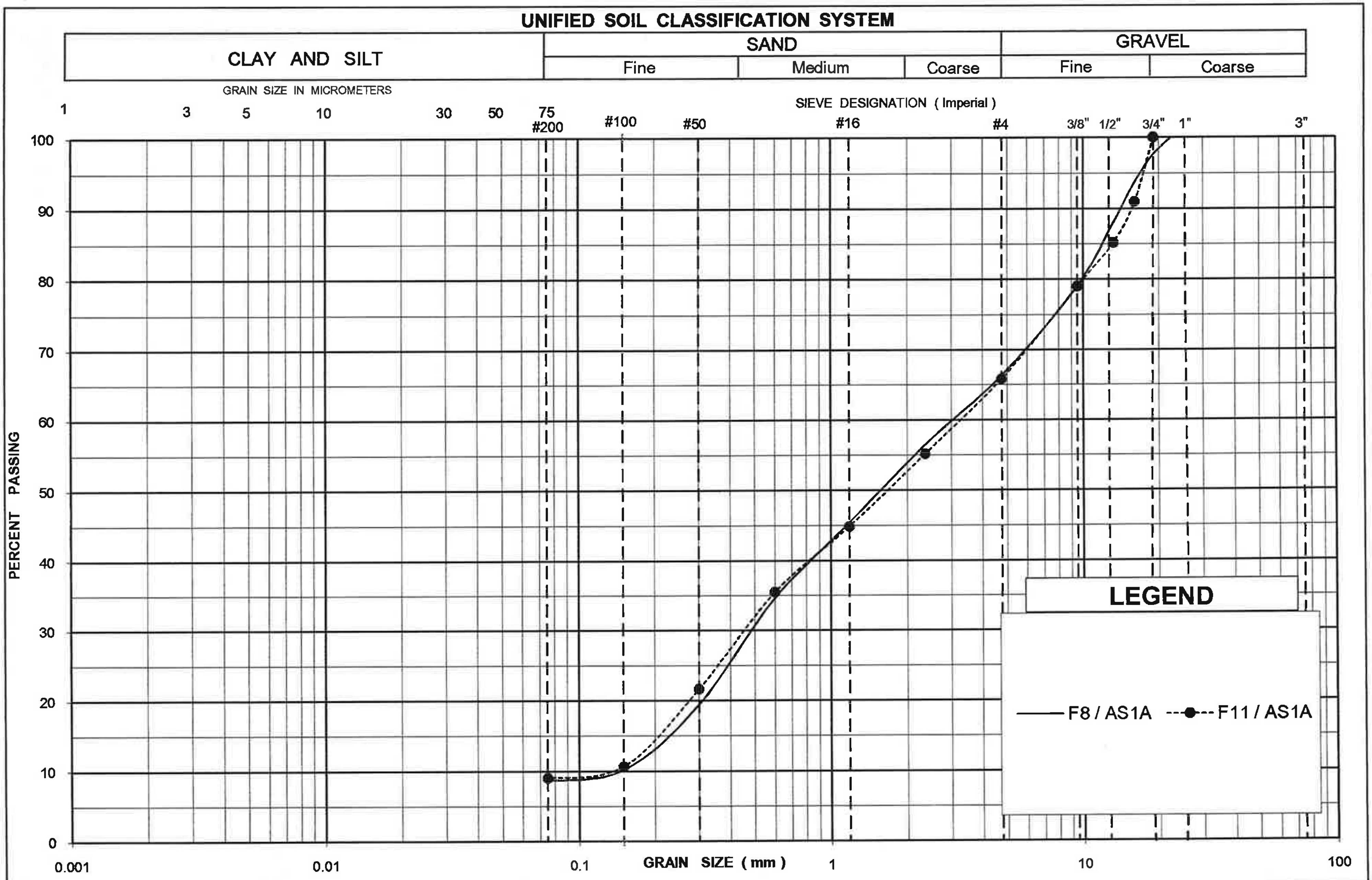


Figure B1-6 Borehole F1 TW7

Appendix B2

Laboratory Test Results - Passing Lane 2



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

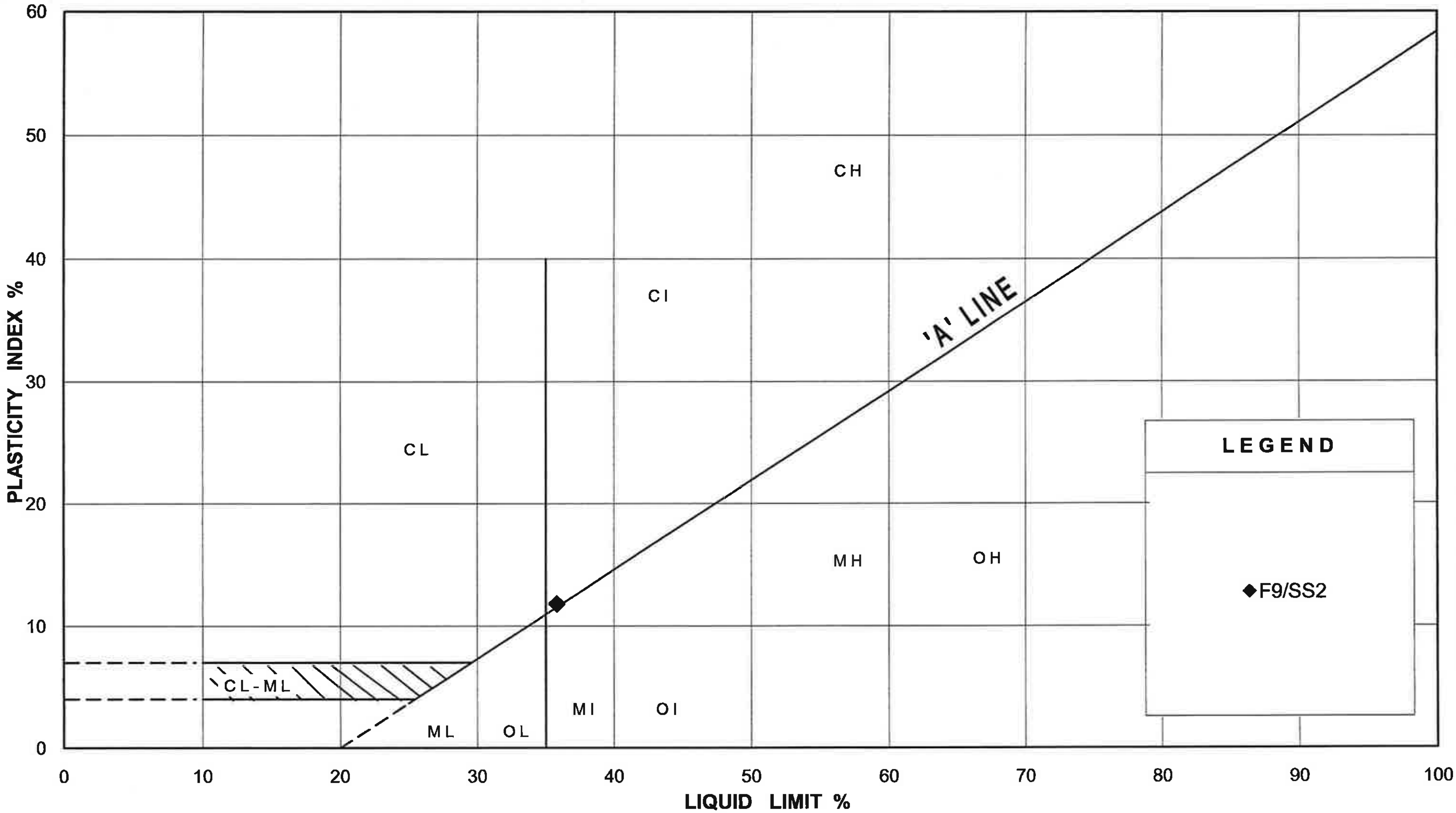
GRAIN SIZE DISTRIBUTION

GRANULAR FILL: Gravelly Sand, trace silt and clay

FIGURE NO.: B2-1

PROJECT NO: TRANETOB01237AA

DATE: NOV, 2009

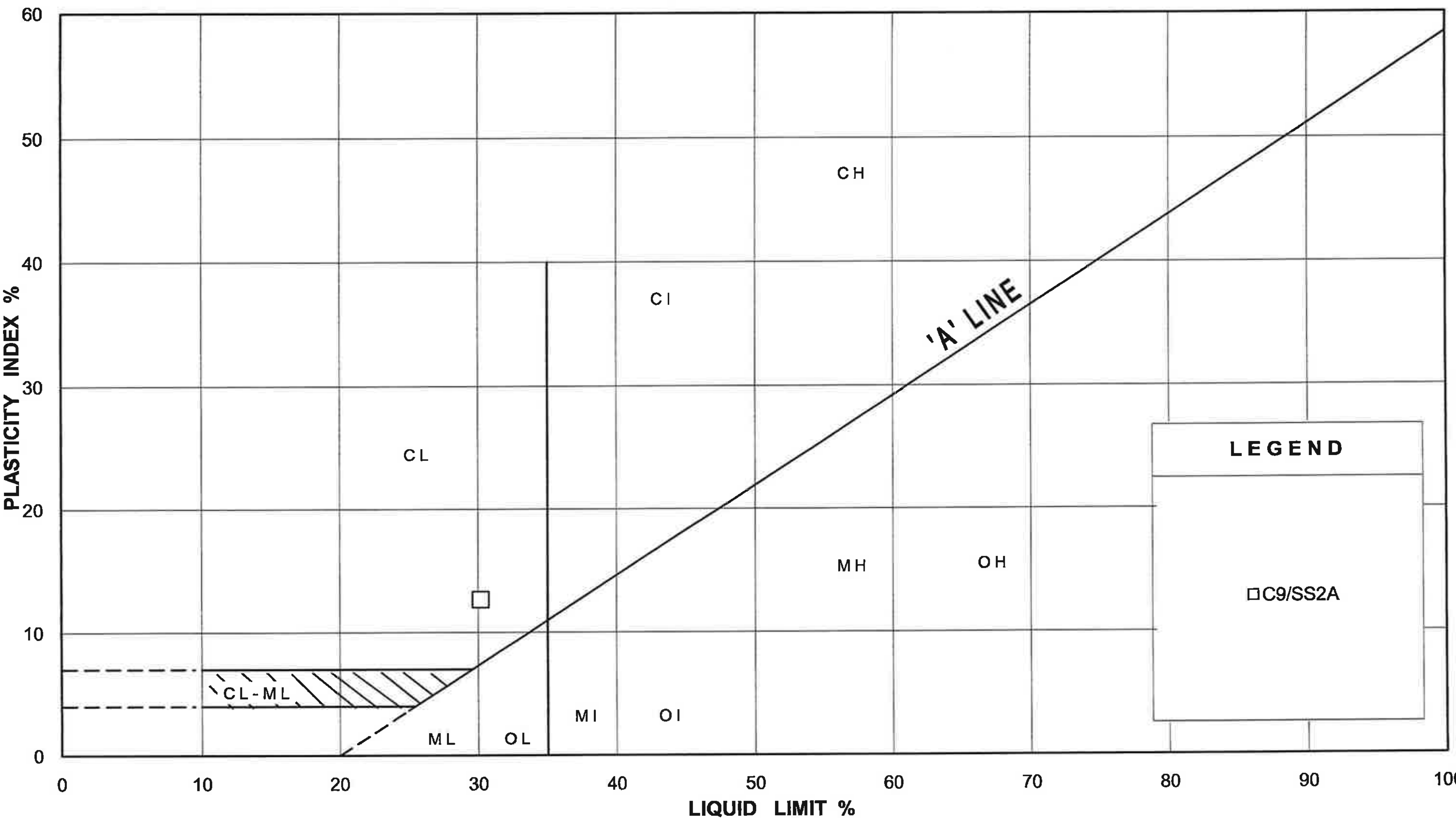


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

EMBANKMENT FILL: Silty Clay

FIGURE No.	B2-2
REF. No.	TRANETOB01237AA
DATE	NOV, 2009

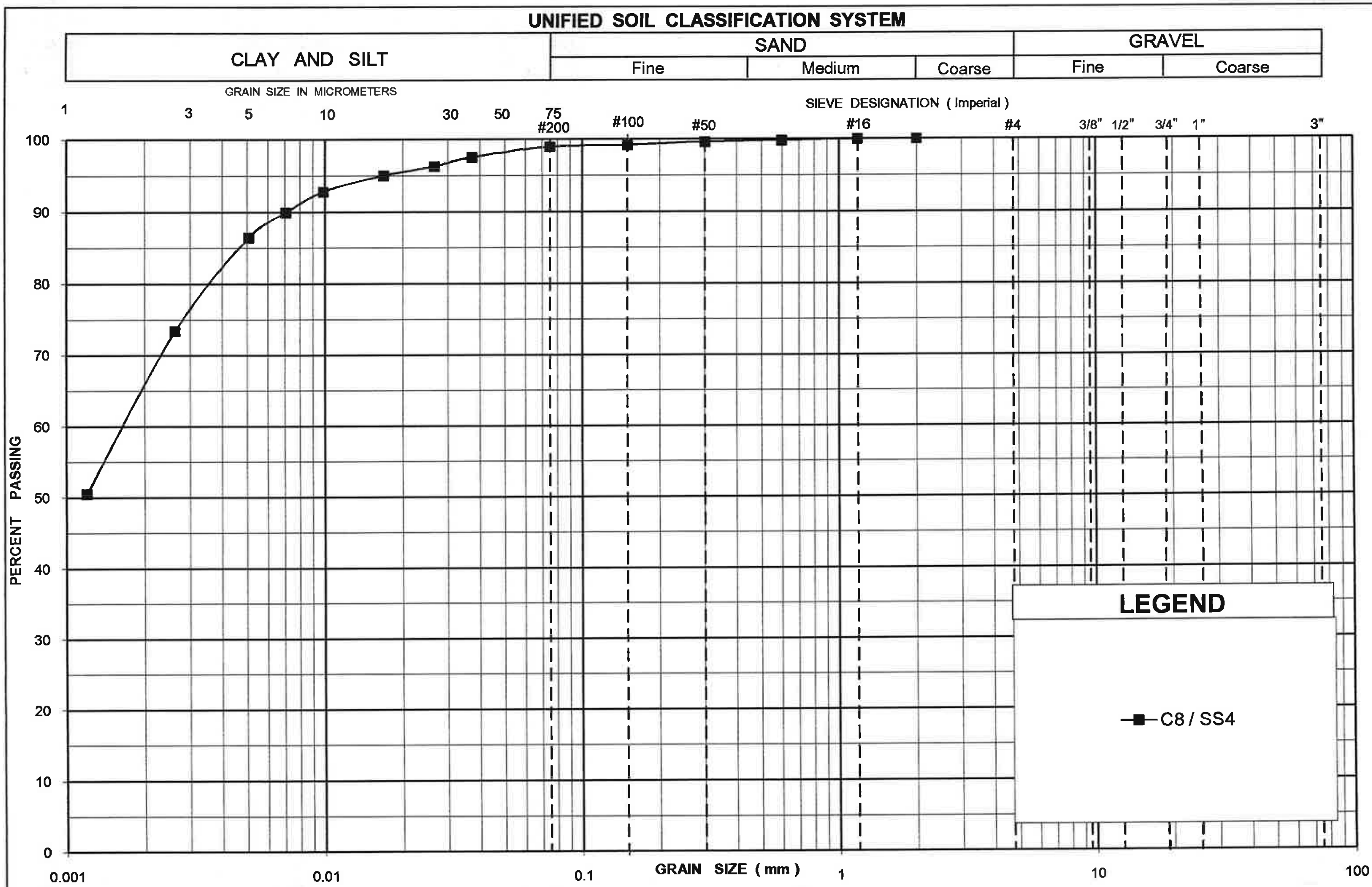


coffey geotechnics SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

EARTH FILL: Clayey Silt

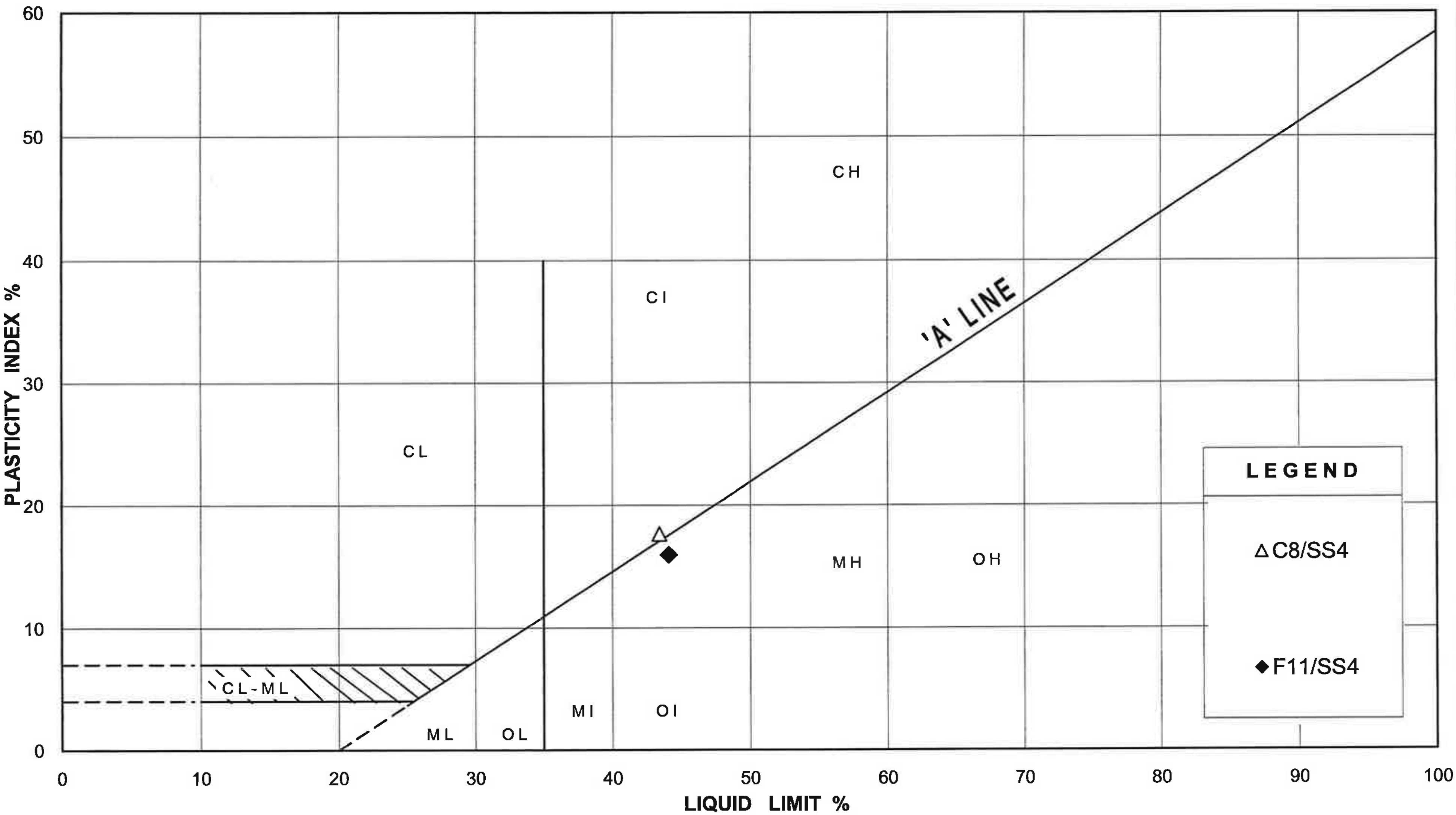
FIGURE No.	B2-3
REF. No.	TRANETOB01237AA
DATE	NOV, 2009



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIGURE NO.:	B2-4
PROJECT NO:	TRANETOB01237AA
DATE:	NOV, 2009

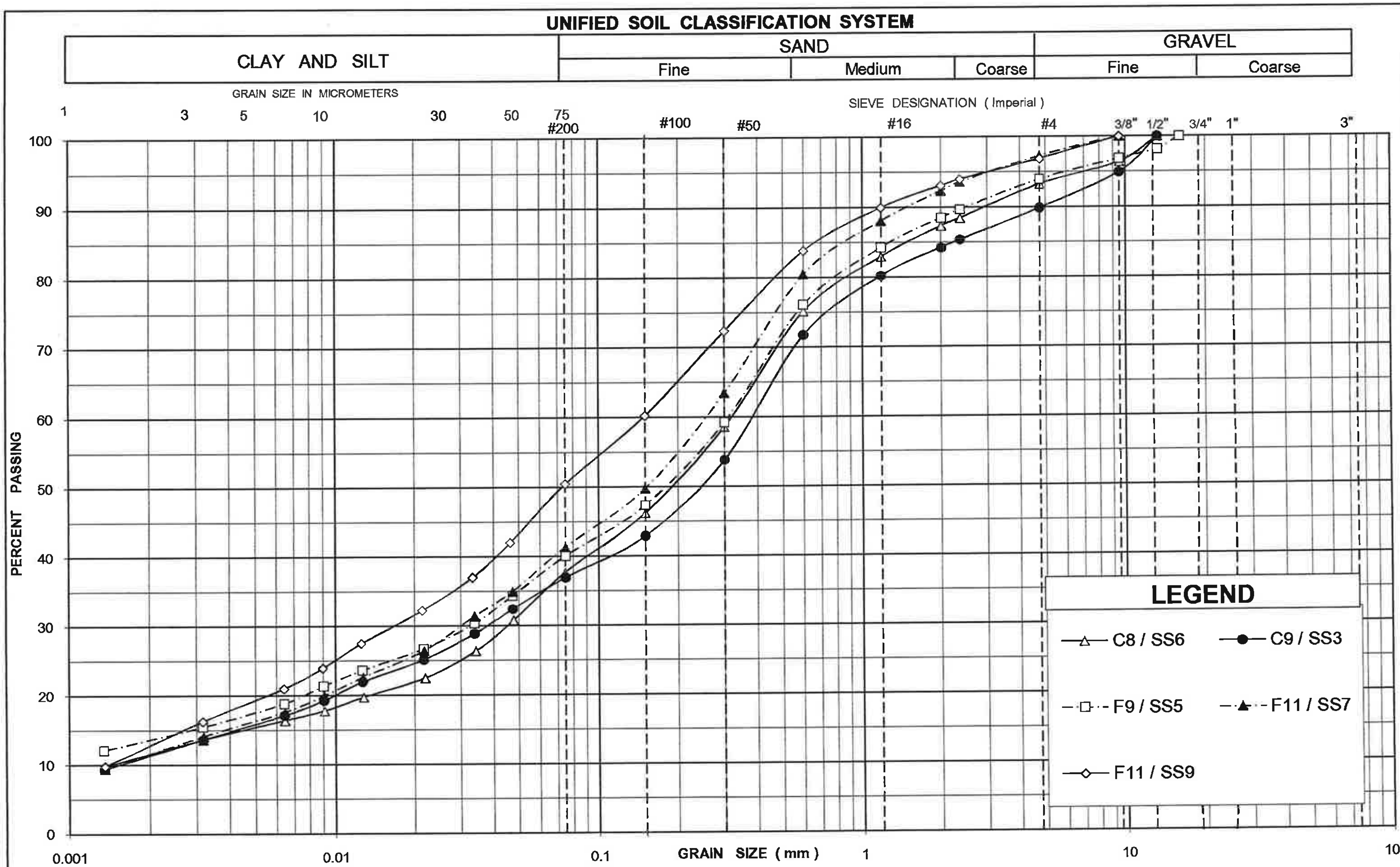


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

SILTY CLAY

FIGURE No.	B2-5
REF. No.	TRANETOB01237AA
DATE	NOV, 2009



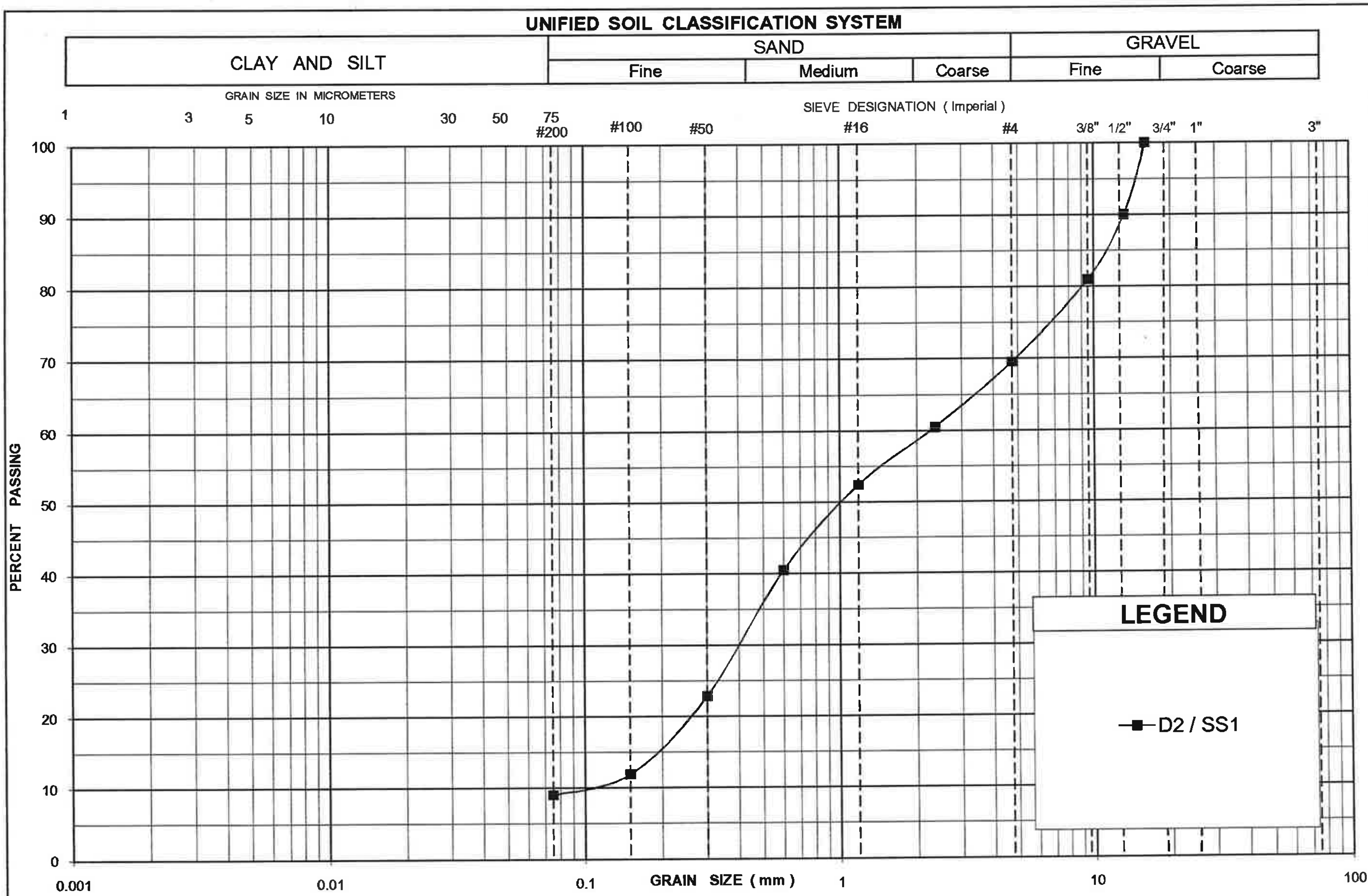
coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
SILTY SAND TILL

FIGURE NO.: B2-6
PROJECT NO: TRANETOB01237AA
DATE: NOV, 2009

Appendix B3

Laboratory Test Results - Passing Lane 3

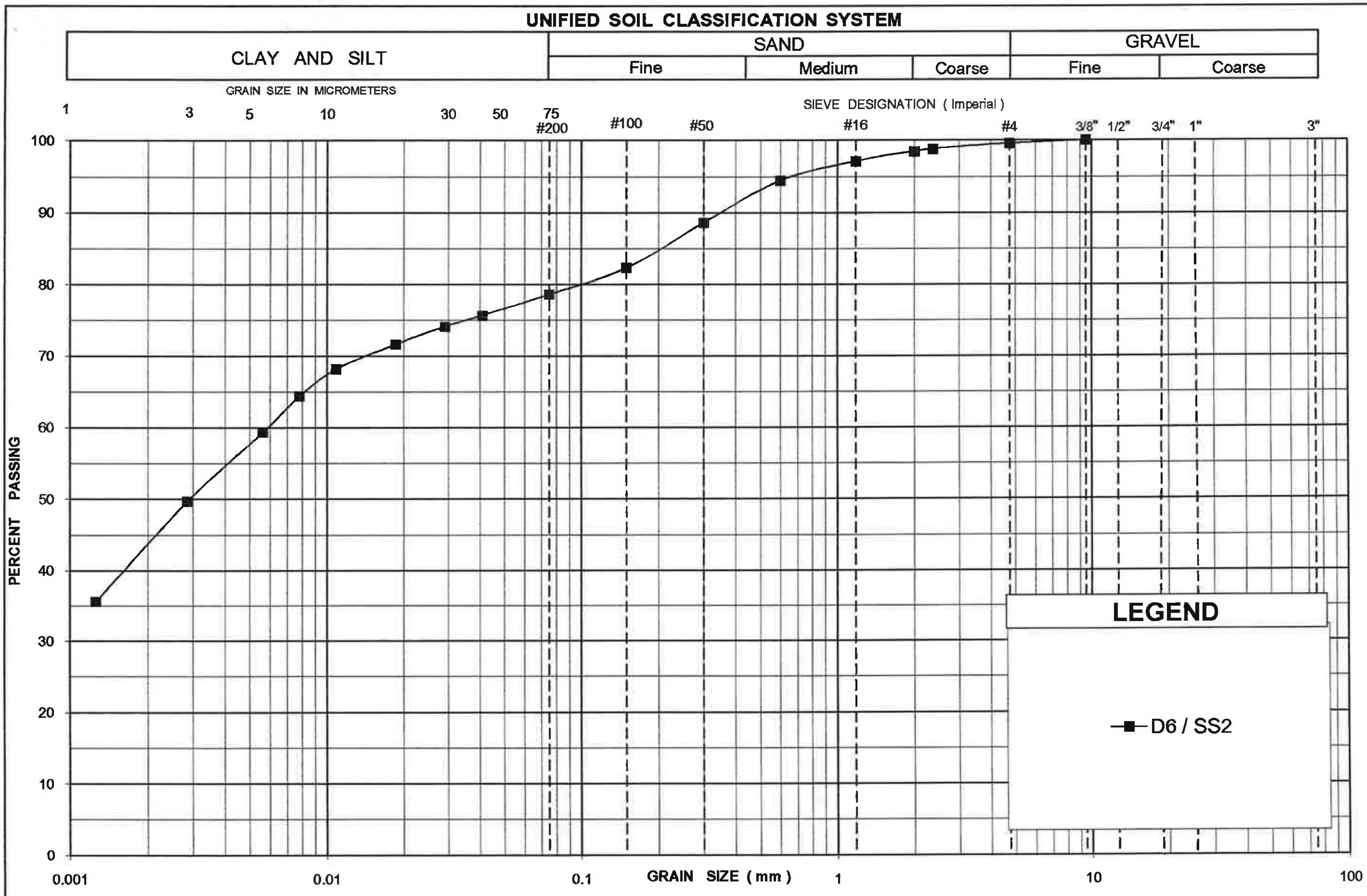


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

FILL: Gravelly Sand, trace silt and clay

FIGURE NO.:	B3-1
PROJECT NO:	TRANETOB01237AA
DATE:	October 20, 2009

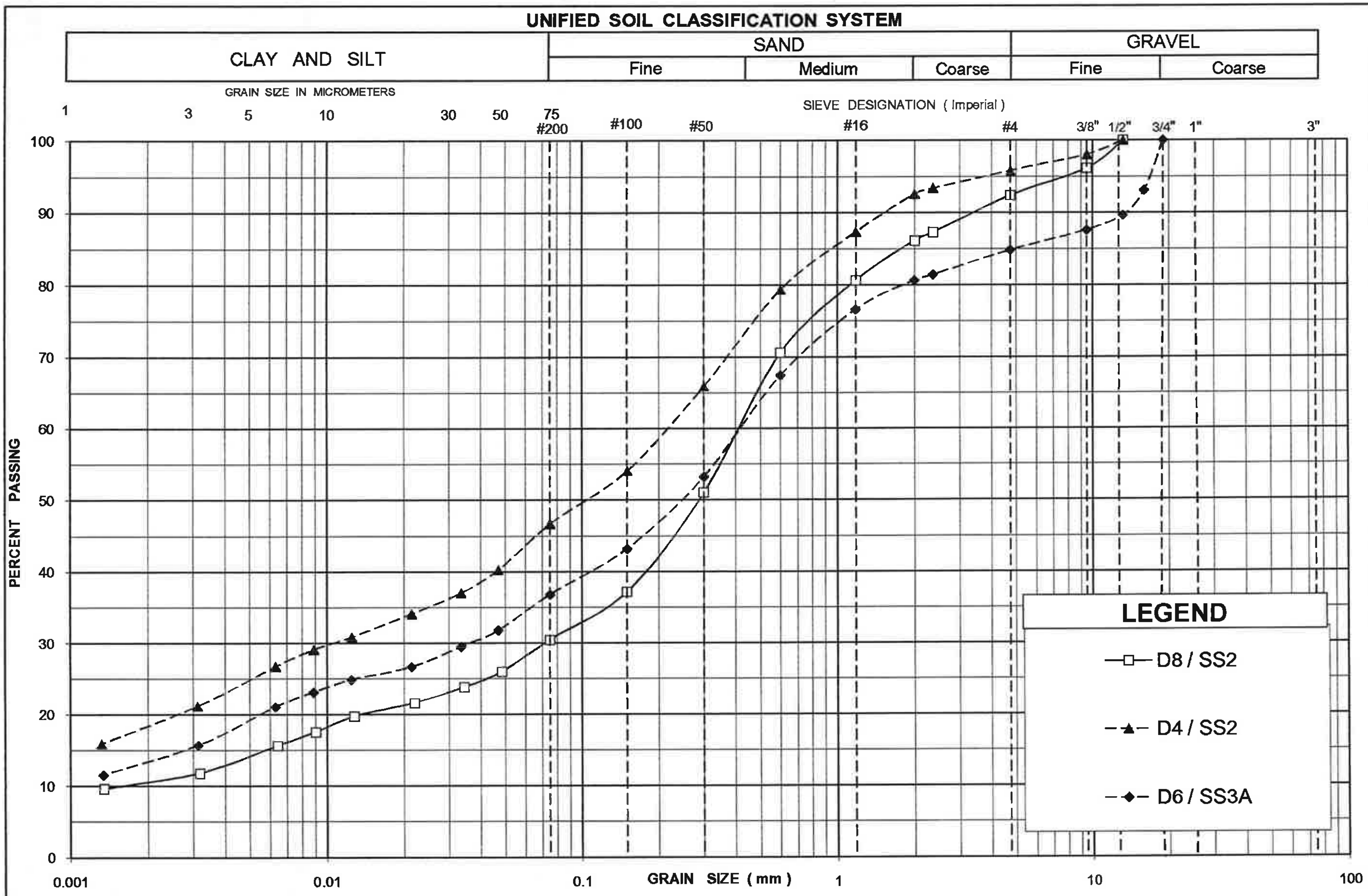


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

FILL: Silty Clay With Sand

FIGURE NO.:	B3-2
PROJECT NO:	TRANETOB01237AA
DATE:	November, 2009

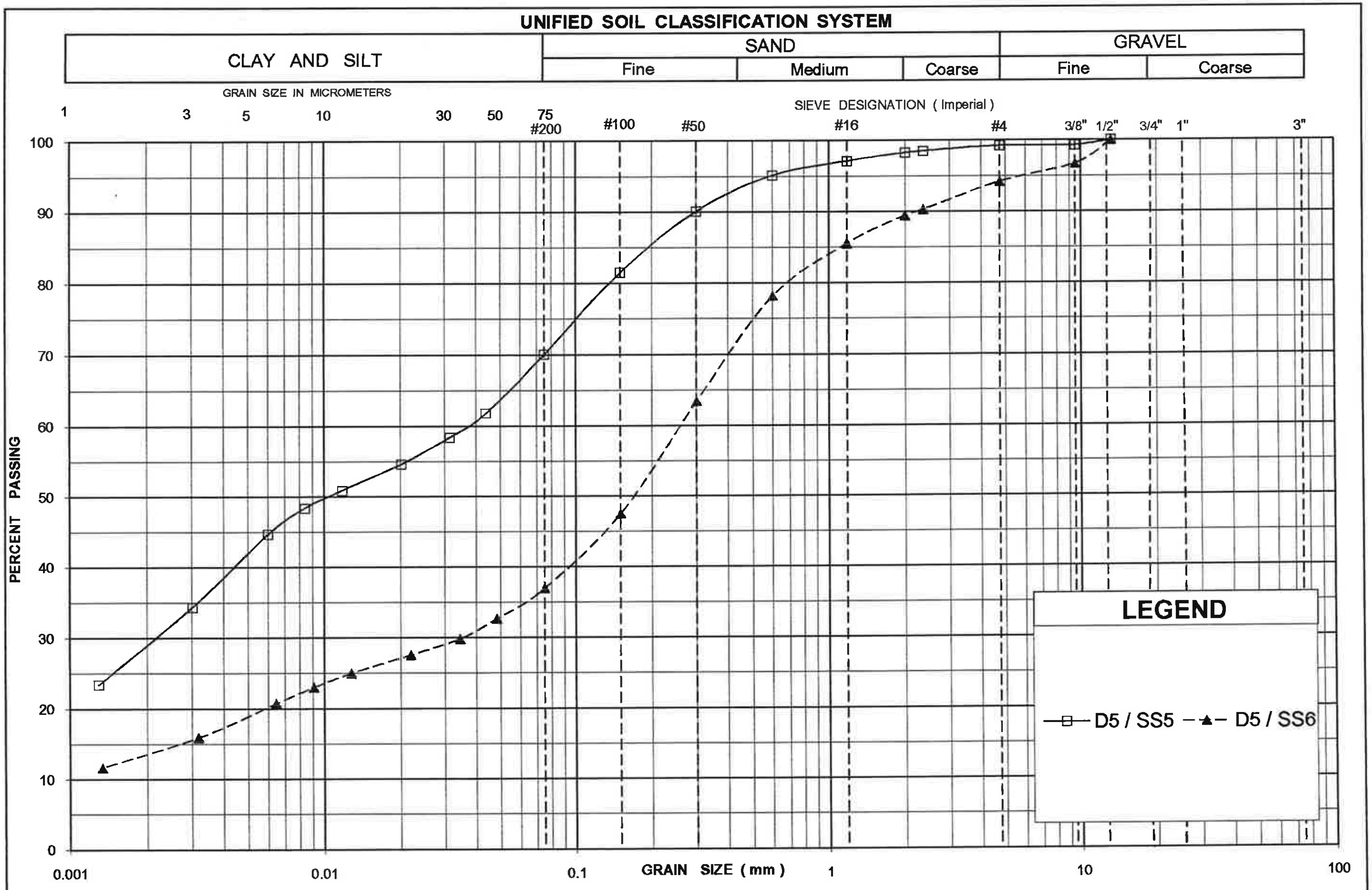


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

FILL: Silty Sand, Trace Clay, Trace Gravel

FIGURE NO.:	B3-3
PROJECT NO:	TRANETOB01237AA
DATE:	November, 2009



coffey geotechnics SPECIALISTS MANAGING THE EARTH

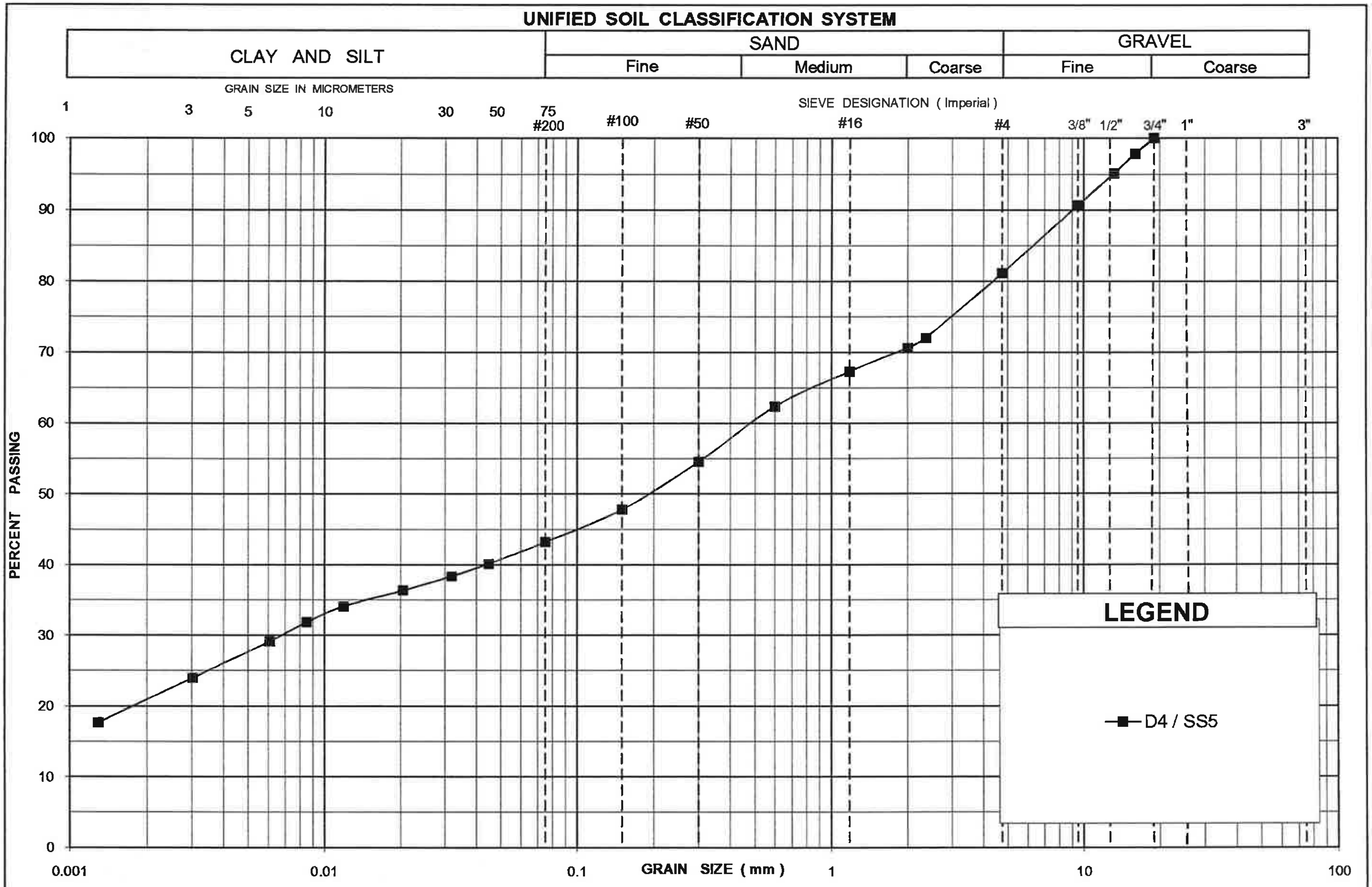
GRAIN SIZE DISTRIBUTION

CLAYEY SILT TO SILT, some sand, trace gravel

FIGURE NO.: B3-4

PROJECT NO: TRANETOB01237AA

DATE: November, 2009

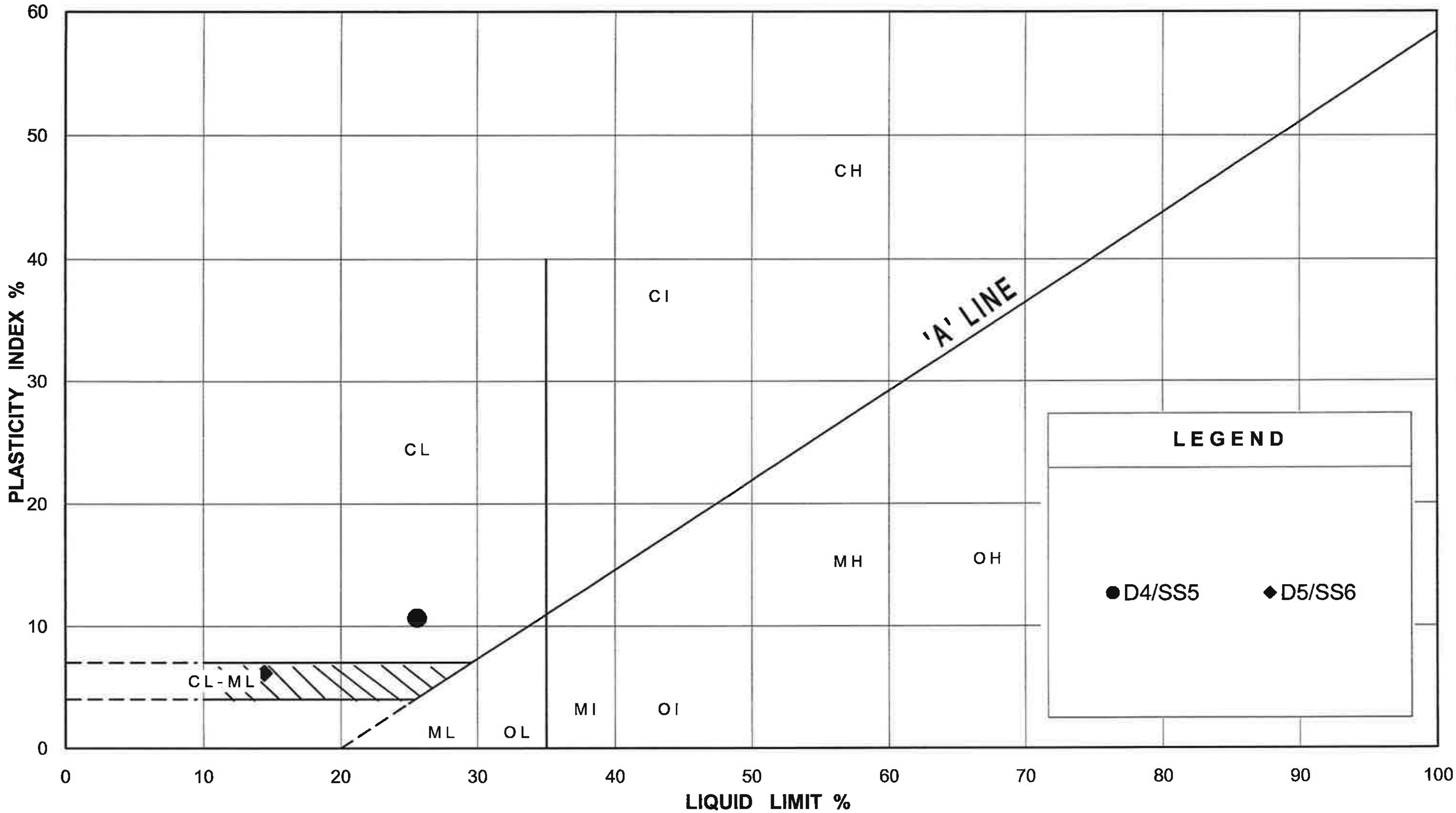


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

Silty Sand Seam within CLAYEY SILT TO SILT

FIGURE NO.:	B3-5
PROJECT NO:	TRANETOB01237AA
DATE:	October, 2009

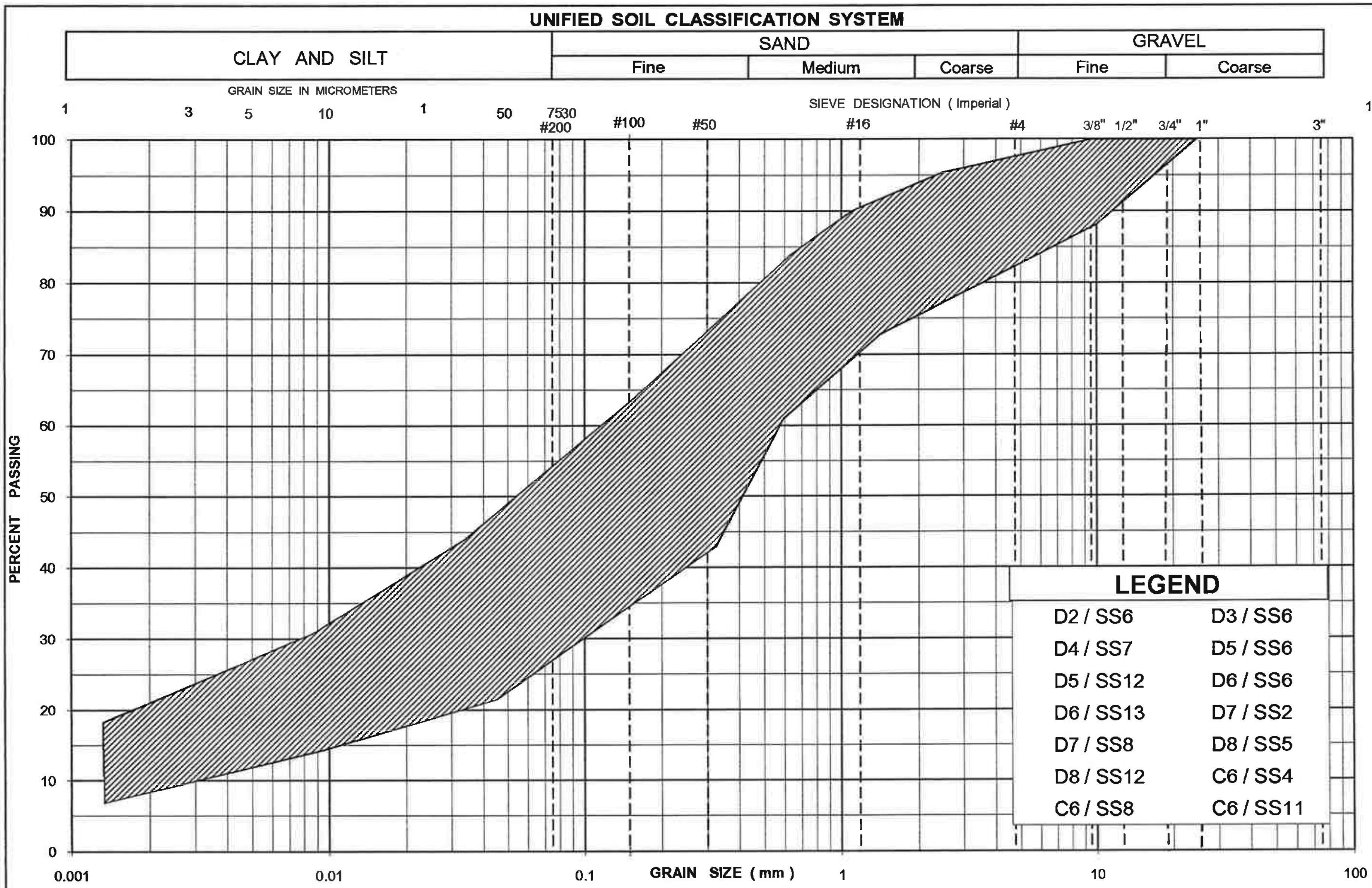


coffey geotechnics SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

CLAYEY SILT TO SILT

FIGURE No.	B3-6
REF. No.	TRANETOB01237AA
DATE	OCTOBER, 2009

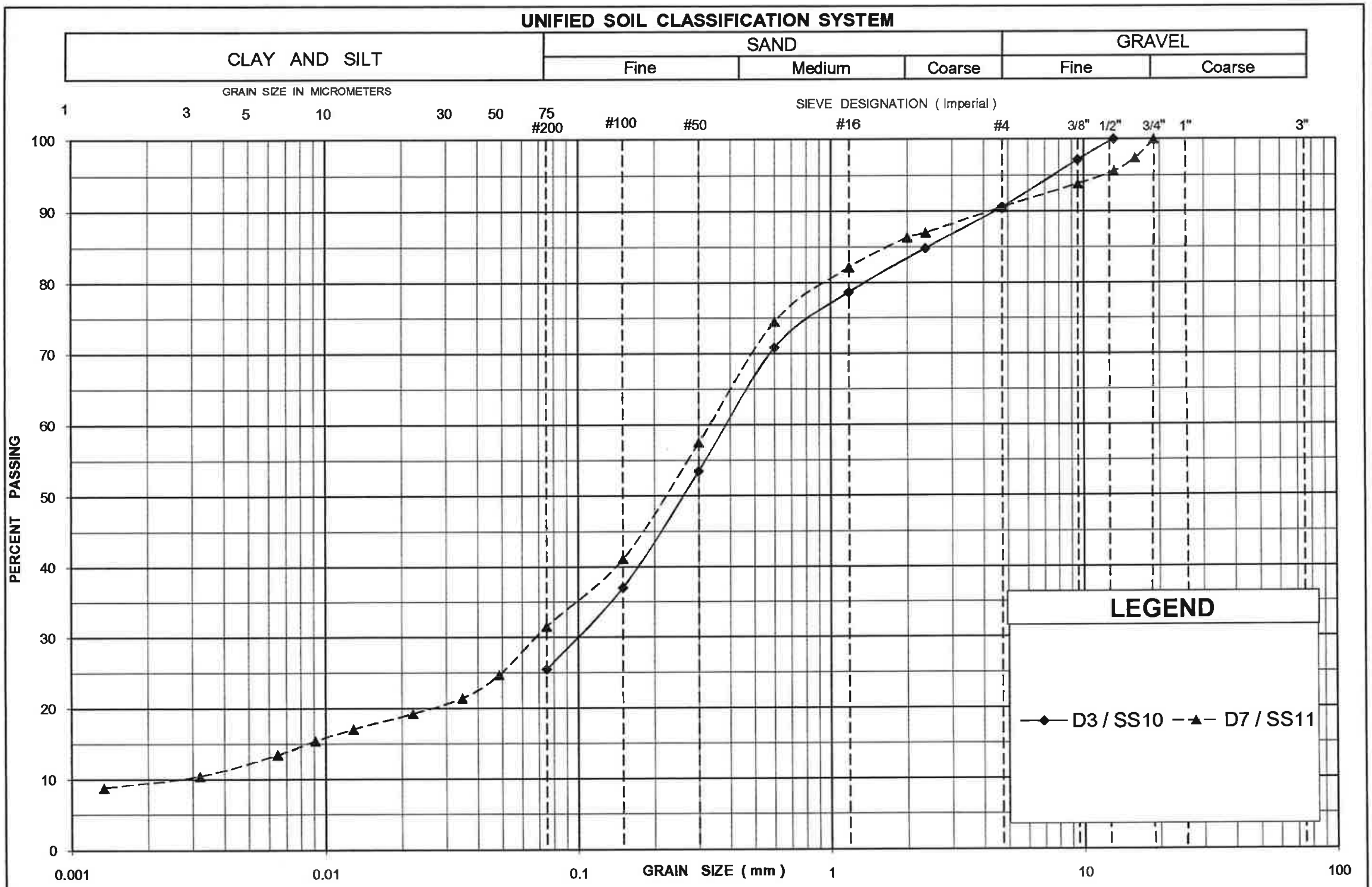


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

SILTY SAND TILL, some clay, trace gravel

FIGURE NO.:	B3-7
PROJECT NO:	TRANETOB01237AA
DATE:	October 20, 2009

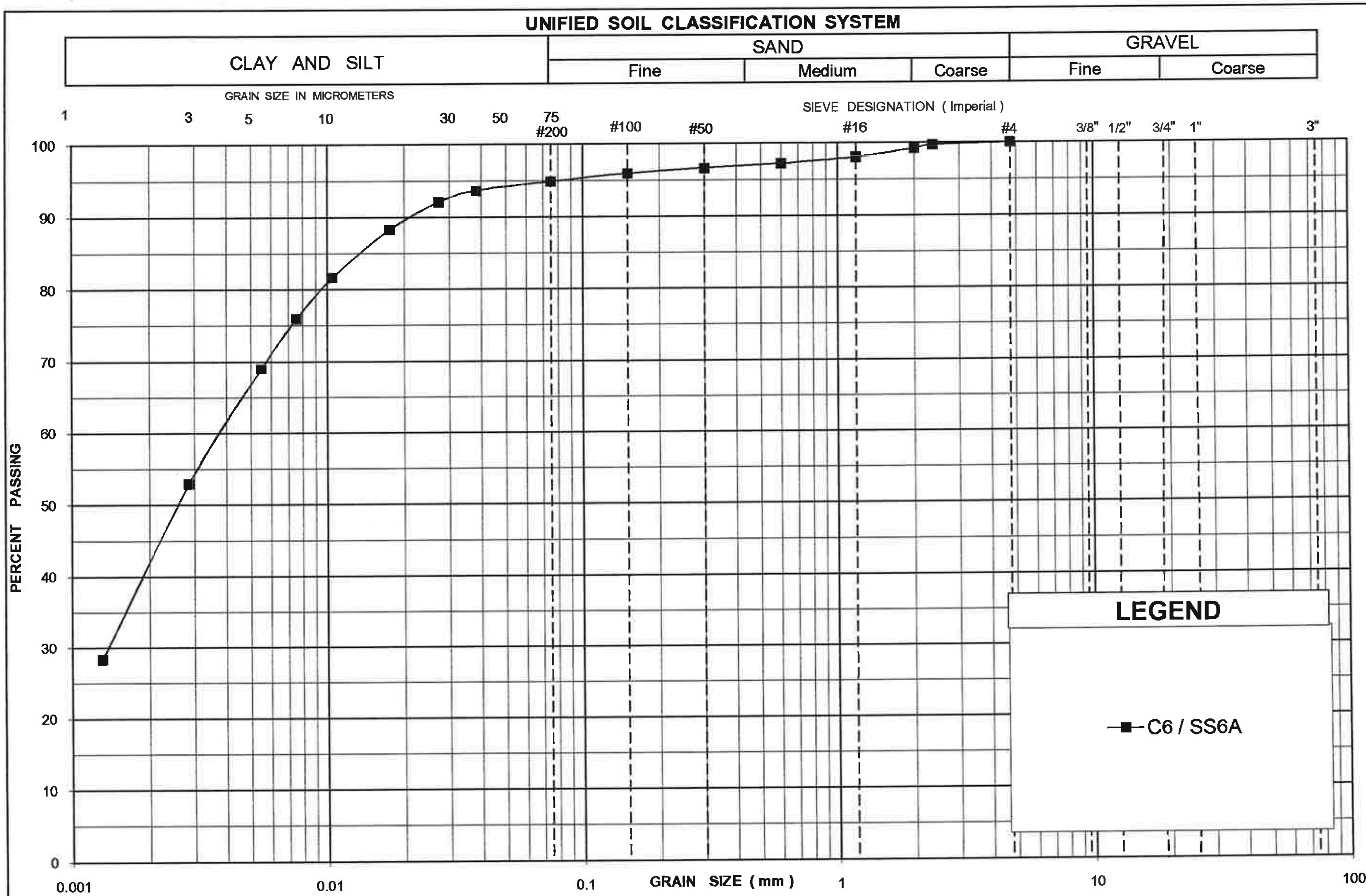


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

Sand Seam within SILTY SAND TILL

FIGURE NO.:	B3-8
PROJECT NO:	TRANETOB01237AA
DATE:	October 20, 2009



coffey geotechnics SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

Clayey Silt Interbed within SILTY SAND TILL

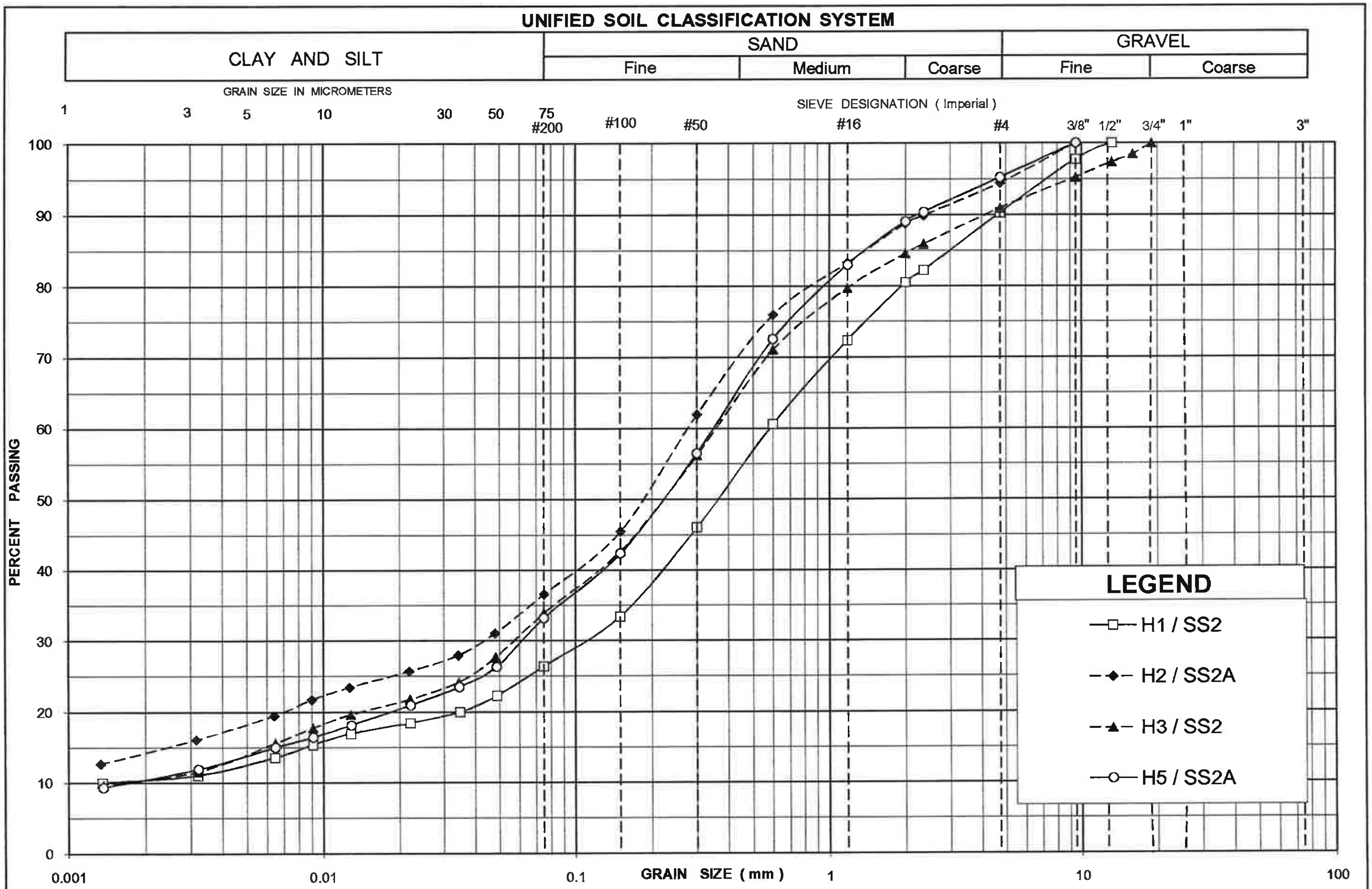
FIGURE NO.: B3-9

PROJECT NO: TRANETOB01237AA

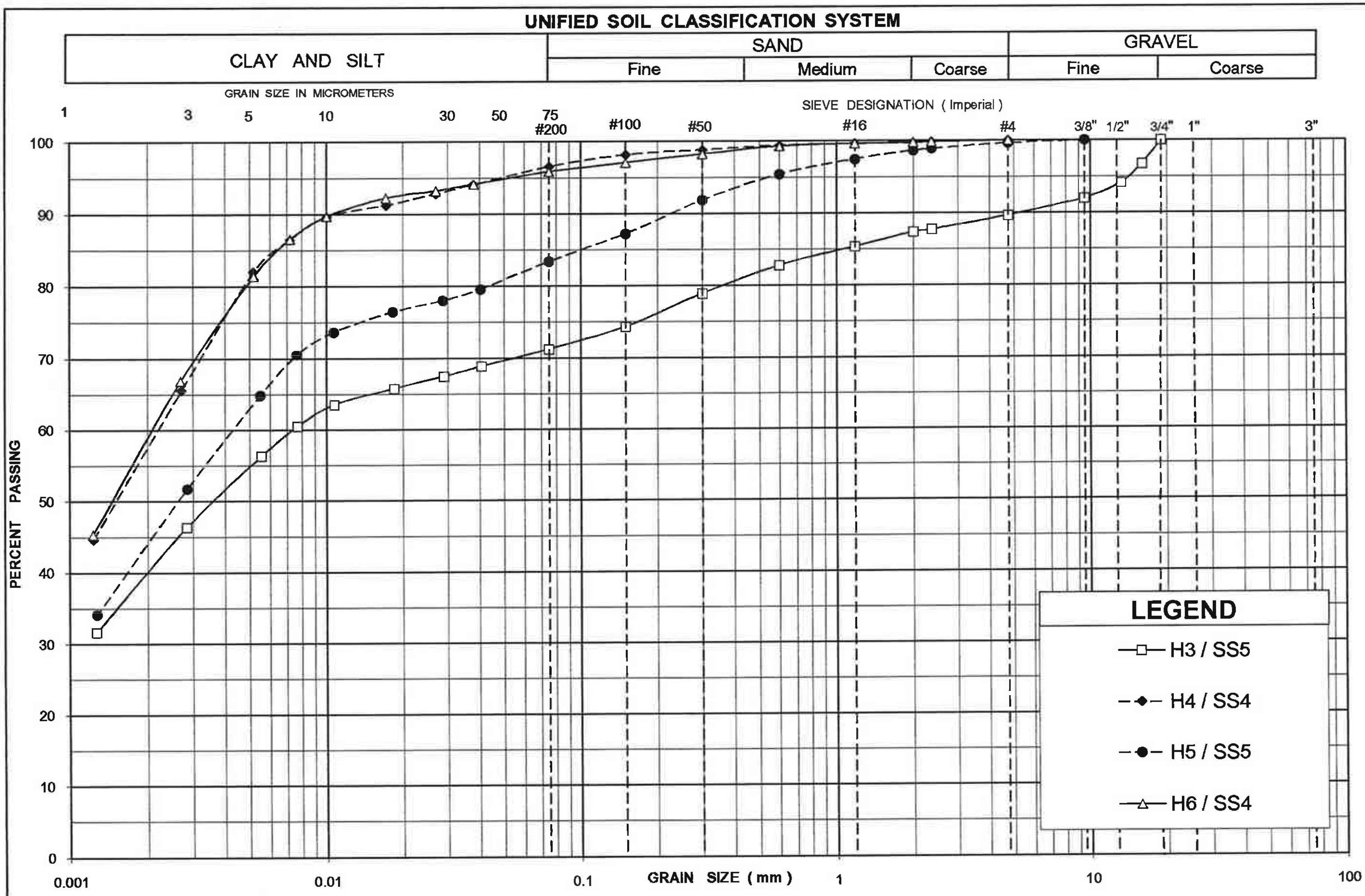
DATE: October 19 , 2009

Appendix B4

Laboratory Test Results - Passing Lane 4



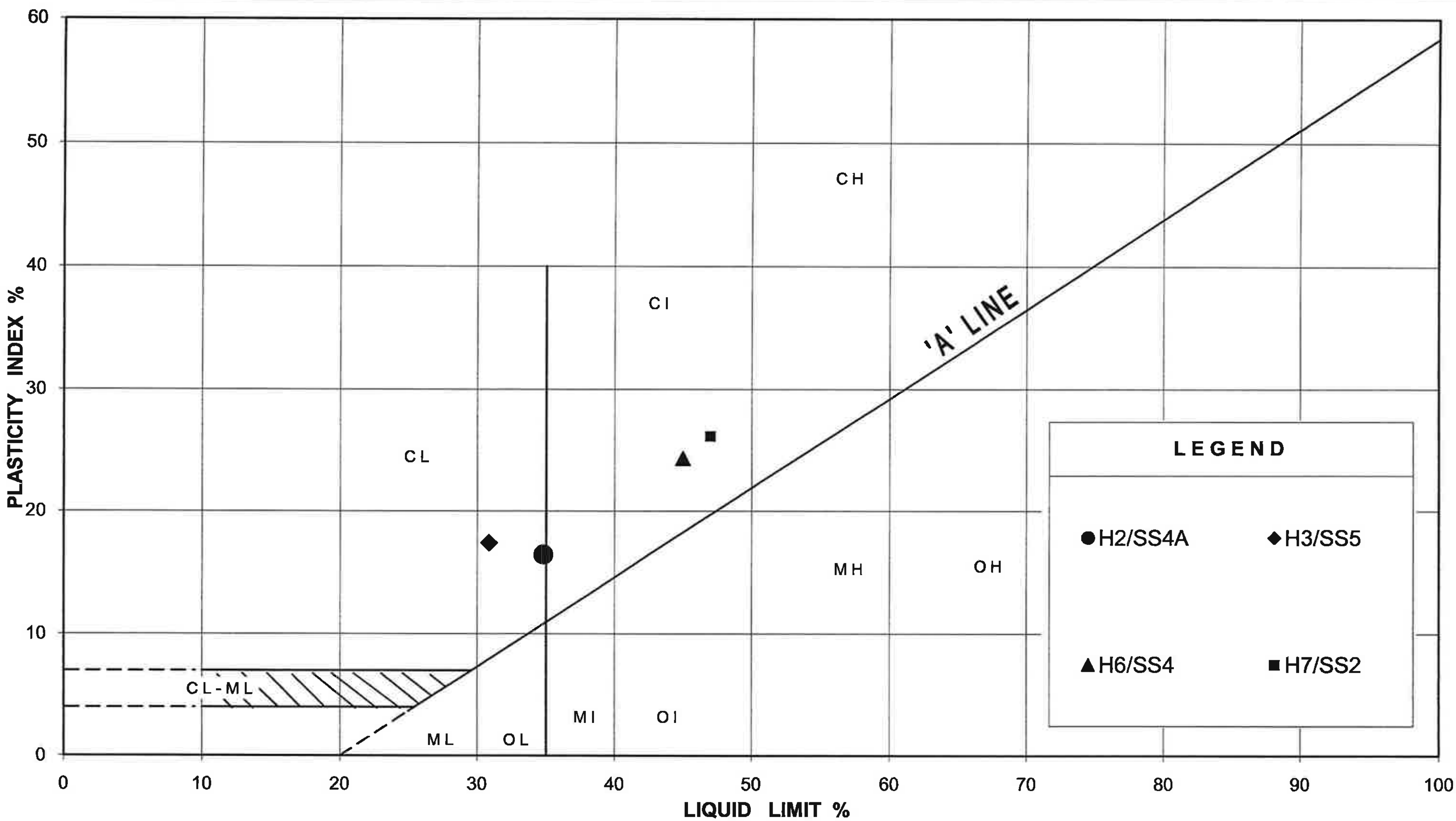
coffey geotechnics SPECIALISTS MANAGING THE EARTH	GRAIN SIZE DISTRIBUTION EMBANKMENT FILL: Silty Sand to Sand, trace gravel and clay	FIGURE NO.: B4-1 PROJECT NO: TRANETOB01237AA DATE: OCT, 2009



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIGURE NO.:	B4-2
PROJECT NO:	TRANETOB01237AA
DATE:	OCT, 2009

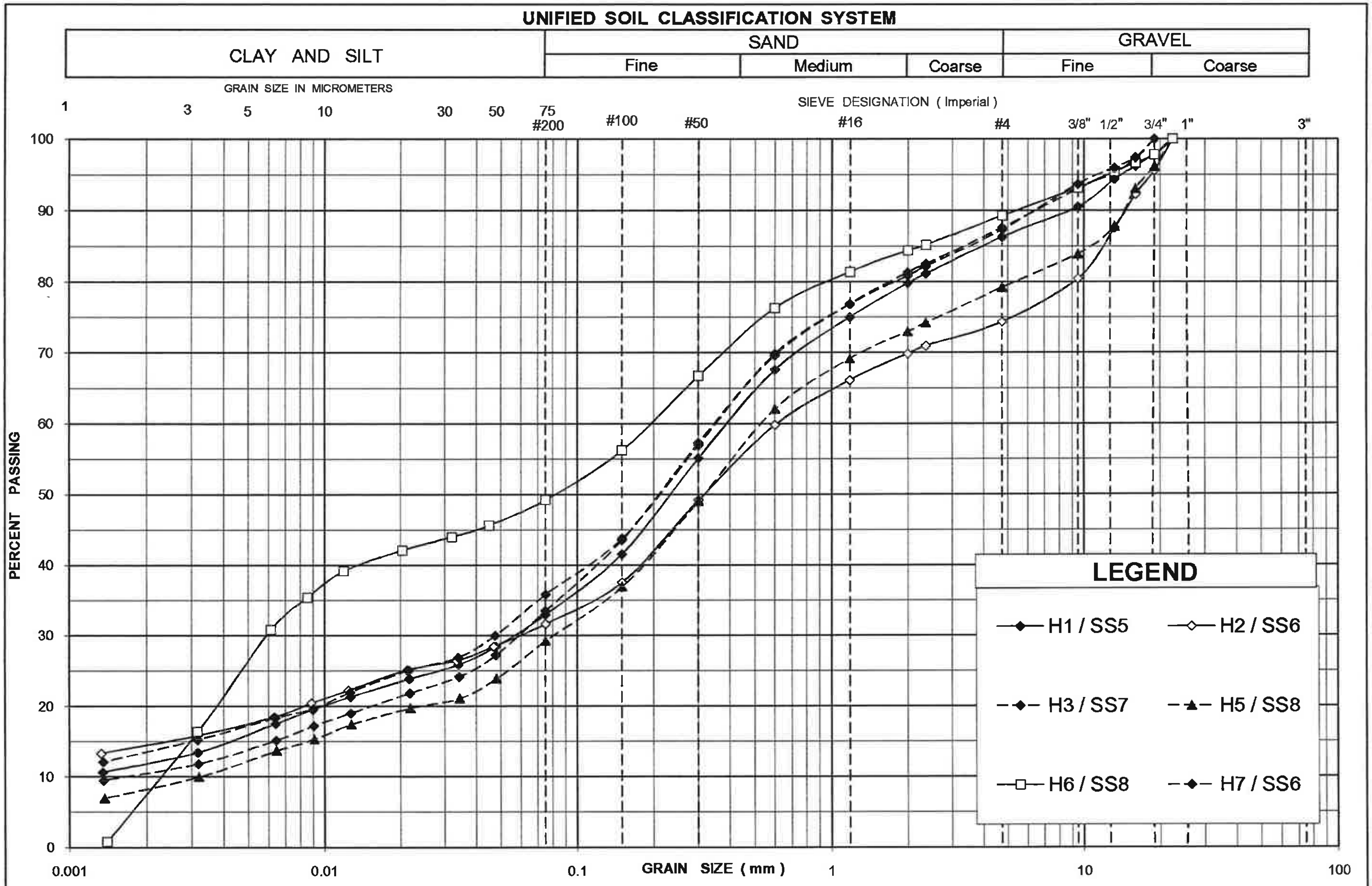


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

SILTY CLAY with clayey silt & occasional silt seams

FIGURE No.	B4-3
REF. No.	TRANETOB01237AA
DATE	OCTOBER, 2009



coffey geotechnics SPECIALISTS MANAGING THE EARTH

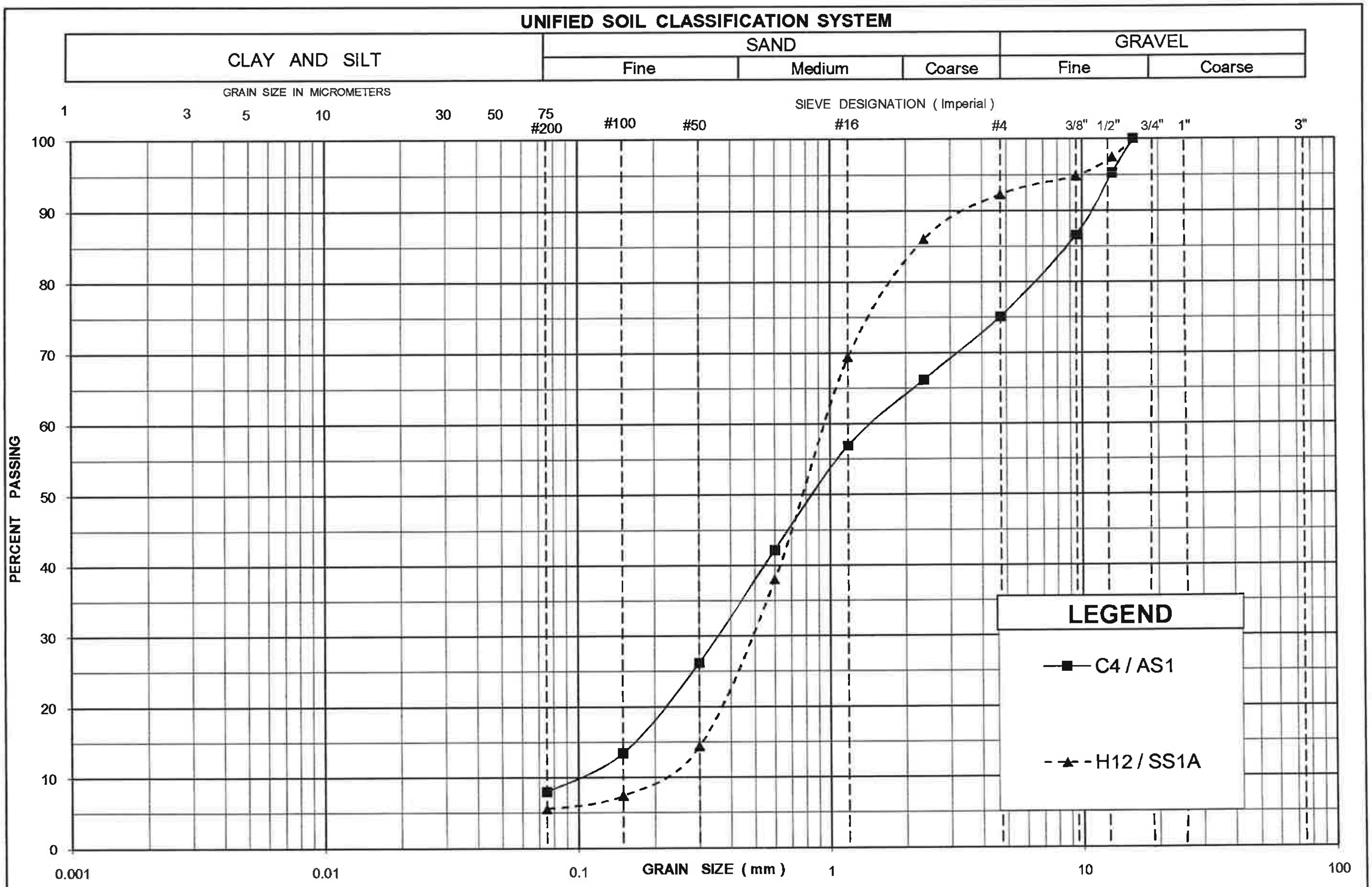
GRAIN SIZE DISTRIBUTION

SILTY SAND TILL, trace to some gravel and clay

FIGURE NO.:	B4-4
PROJECT NO:	TRANETOB01237AA
DATE:	OCT, 2009

Appendix B5

Laboratory Test Results - Passing Lane 5

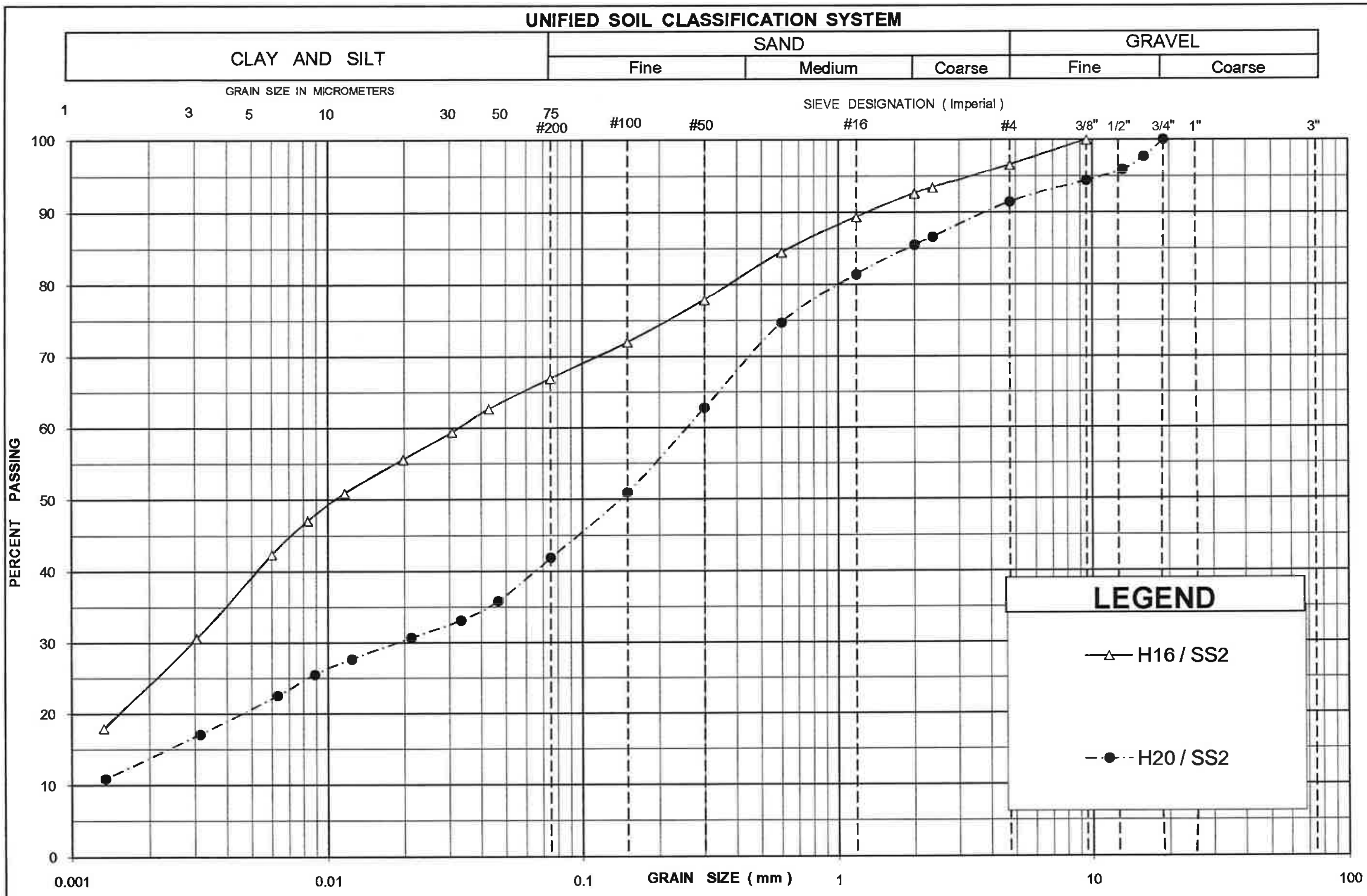


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

PAVEMENT GRANULAR FILL: Gravelly Sand, trace silt

FIGURE NO.:	B5-1
PROJECT NO:	TRANETOB01237AA
DATE:	SEPT, 2009

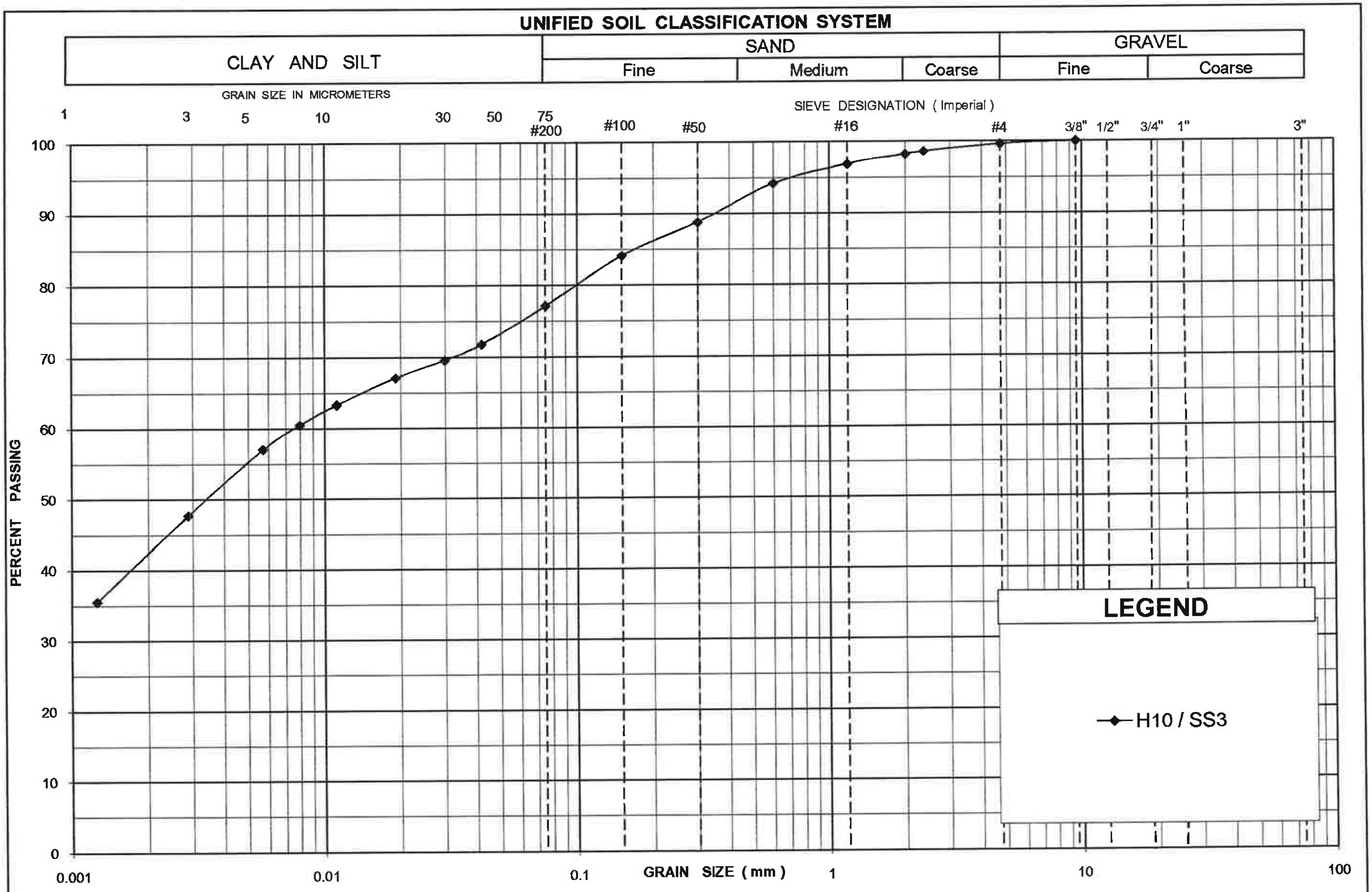


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

EMBANKMENT FILL: Silty Sand to Sandy Silt, traces to some clay, trace gravel

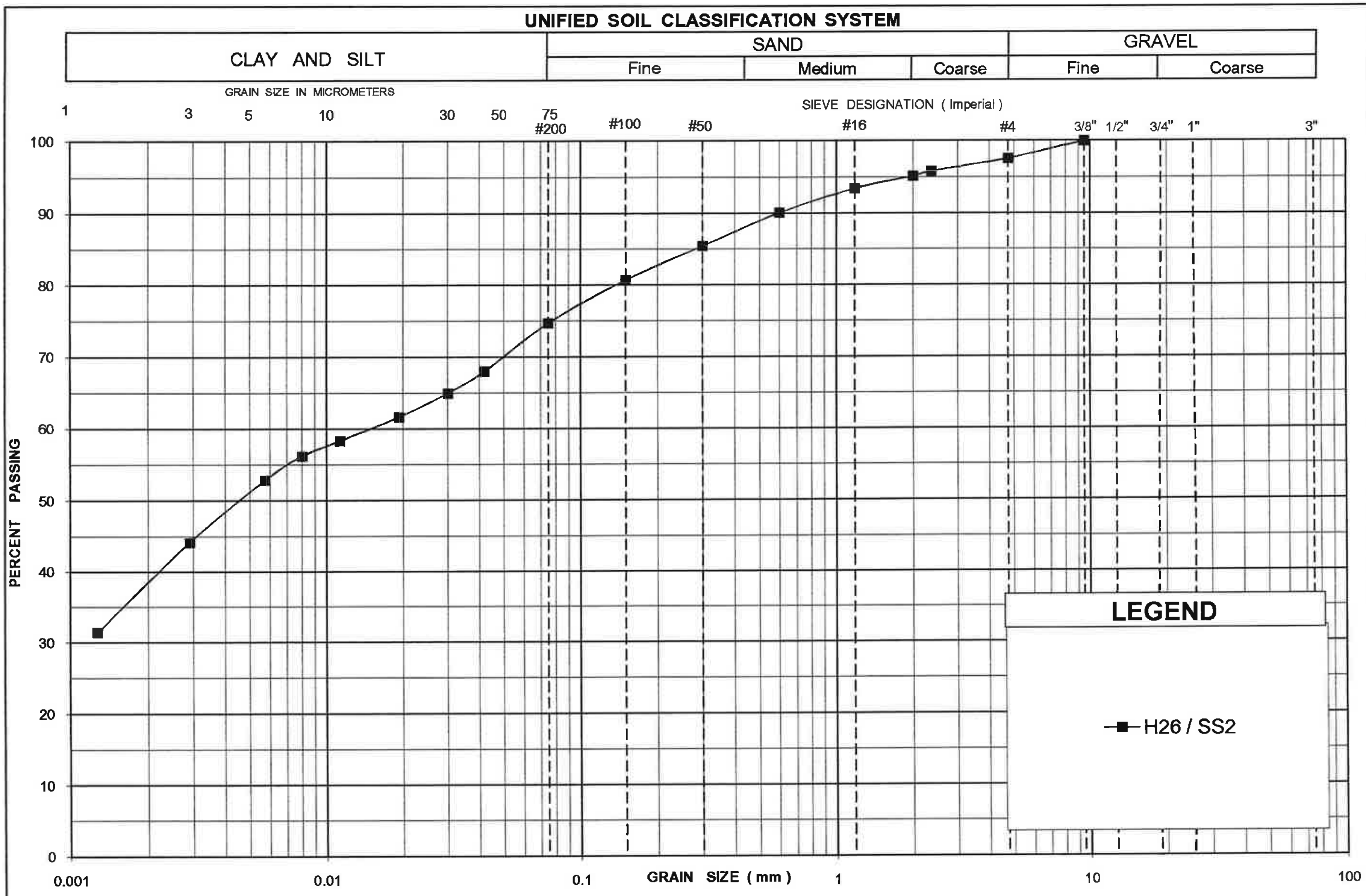
FIGURE NO.:	B5-2
PROJECT NO:	TRANETOB01237AA
DATE:	SEPT, 2009



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
EMBANKMENT FILL: Silty Clay Zone, some sand

FIGURE NO.:	B5-3
PROJECT NO:	TRANETOB01237AA
DATE:	SEPT, 2009

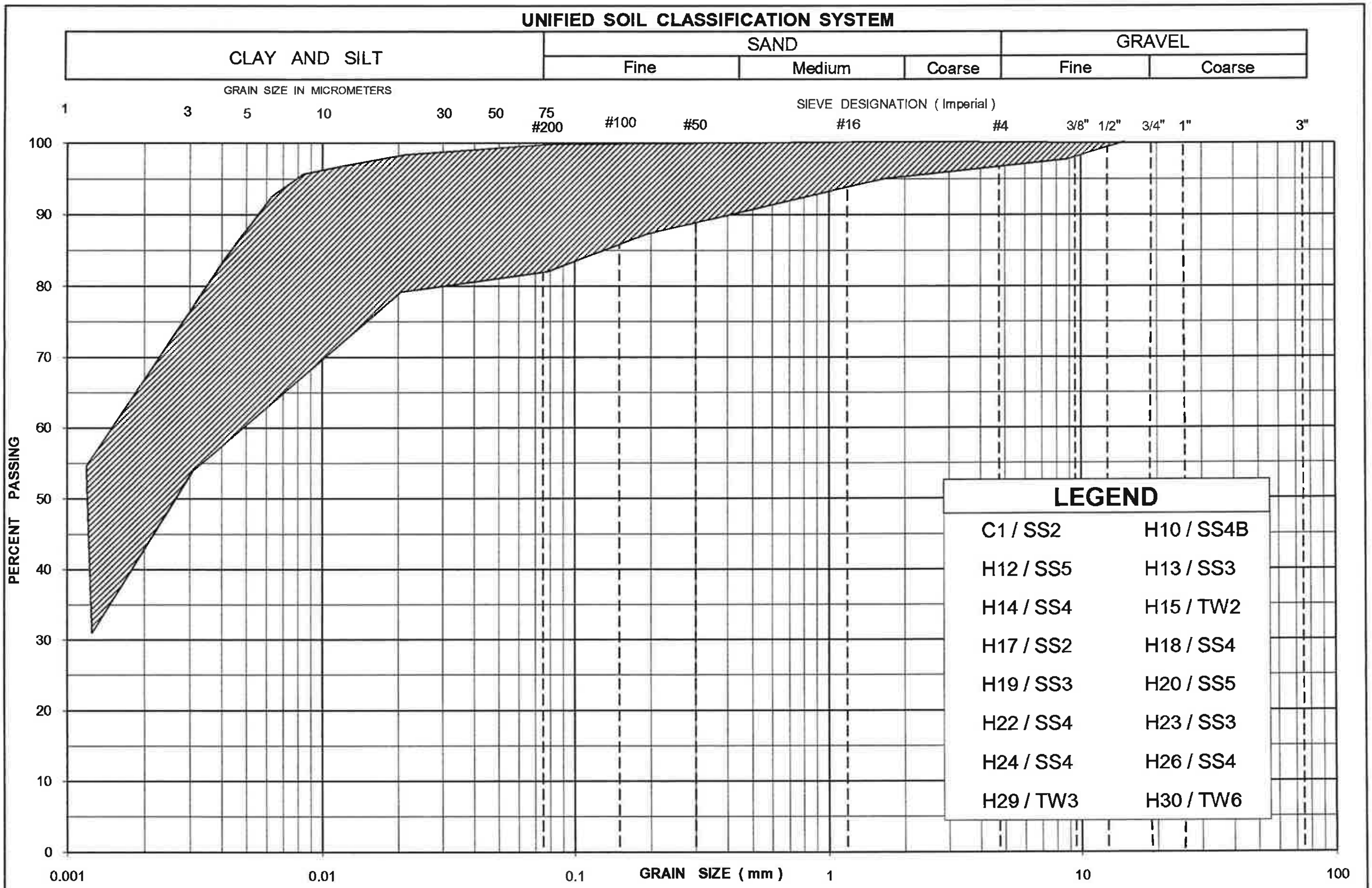


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

EMBANKMKENT FILL: Silty Clay to Clayey Silt, some sand

FIGURE NO.:	B5-4
PROJECT NO:	TRANETOB01237AA
DATE:	Nov, 2009



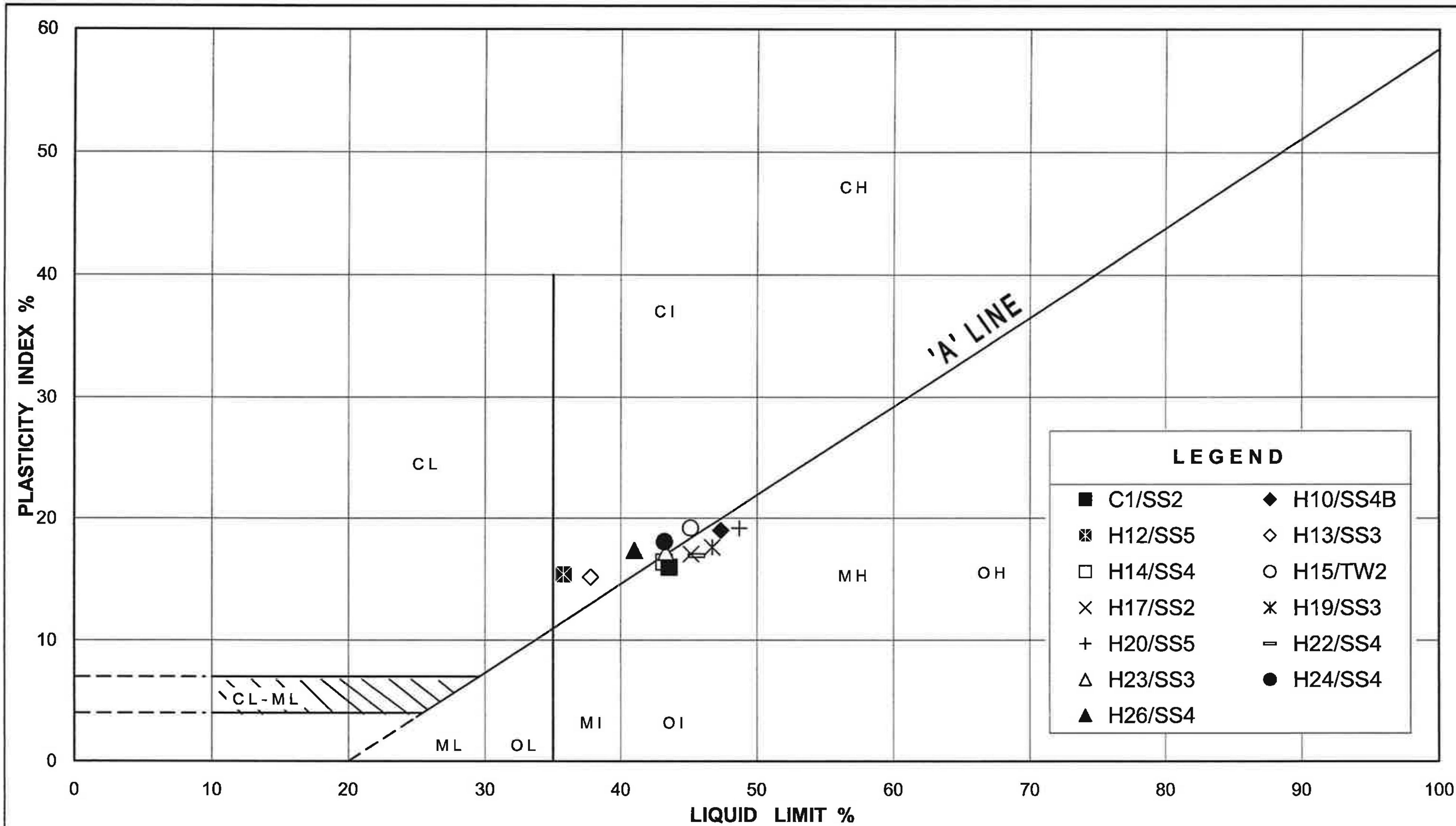
coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
SILTY CLAY

FIGURE NO.: B5-5

PROJECT NO: TRANETOB01237AA

DATE: OCT, 2009

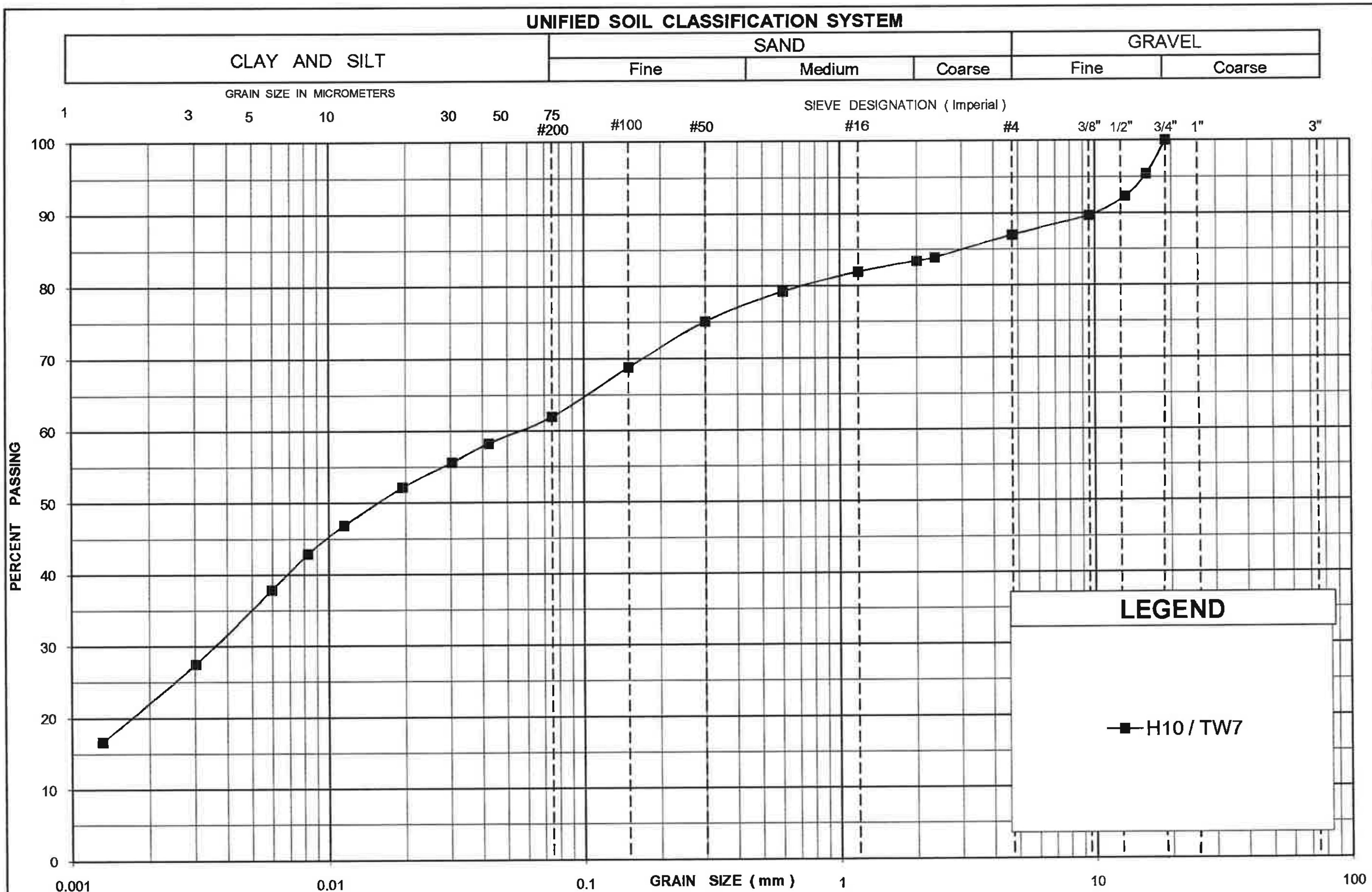


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

SILTY CLAY

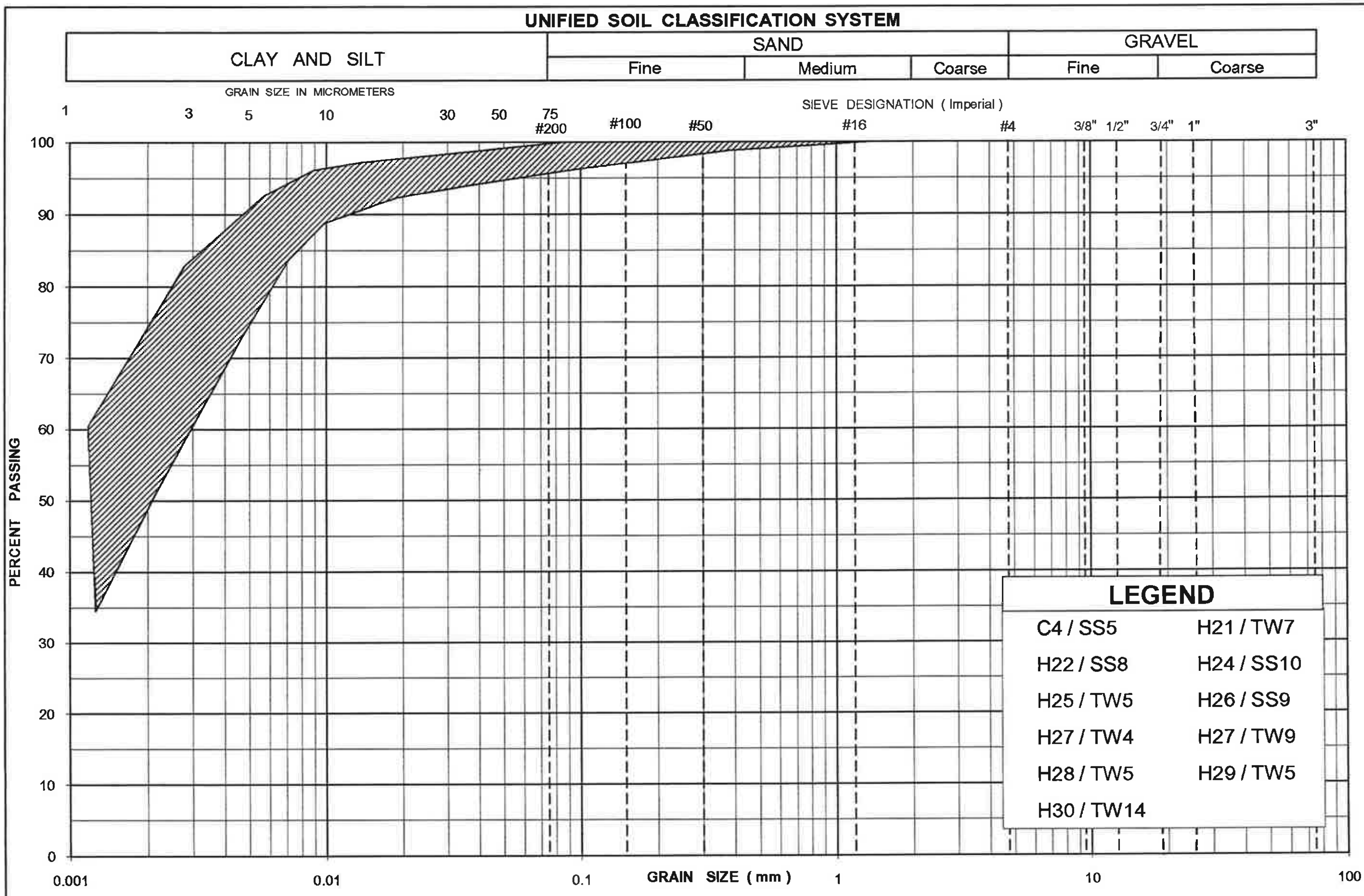
FIGURE No.	B5-6
REF. No.	TRANETOB01237AA
DATE	OCTOBER, 2009



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
Sandy Silt Zone within SILTY CLAY

FIGURE NO.:	B5-7
PROJECT NO:	TRANETOB01237AA
DATE:	SEPT, 2009

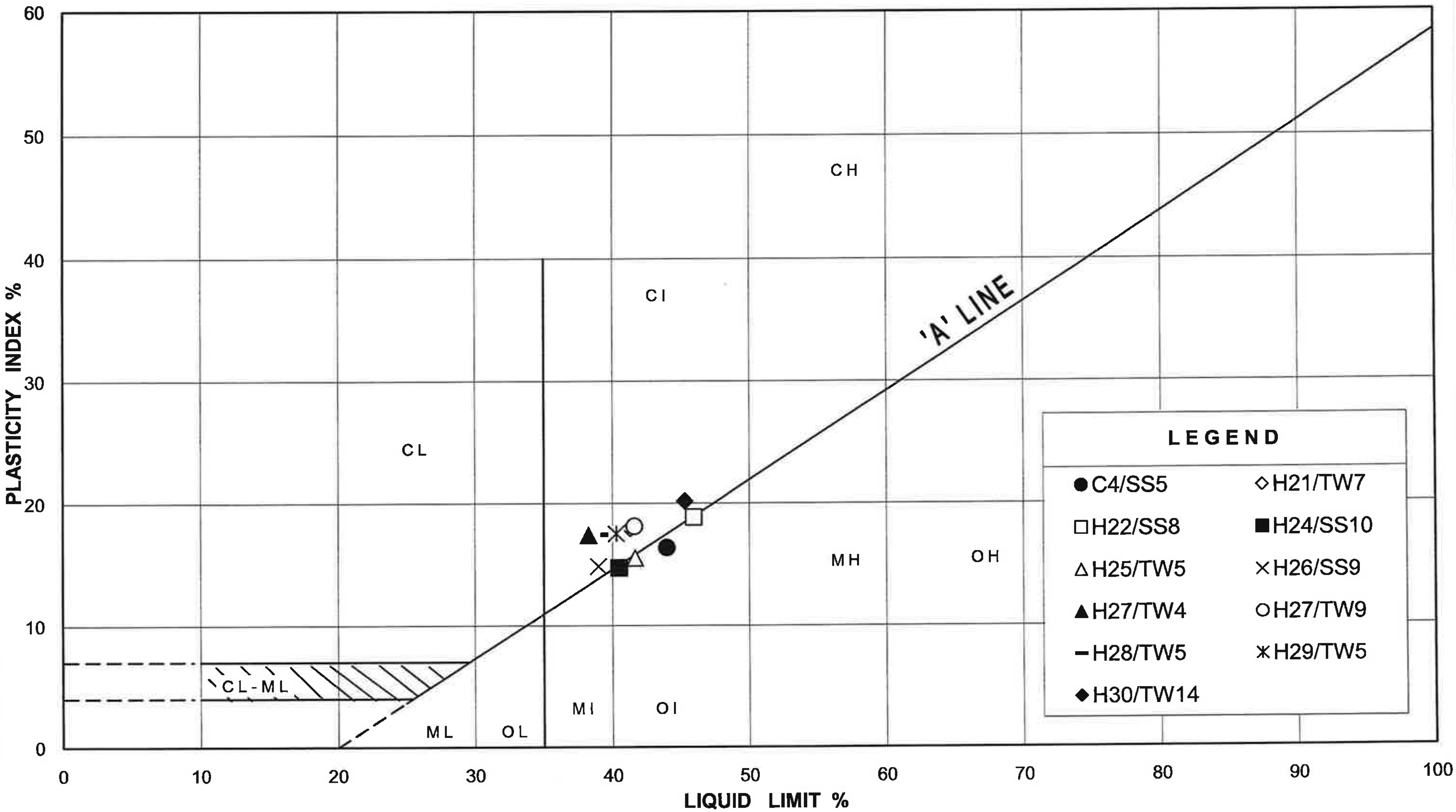


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION

SILTY CLAY (varved)

FIGURE NO.:	B5-8
PROJECT NO:	TRANETOB01237AA
DATE:	SEPT, 2009

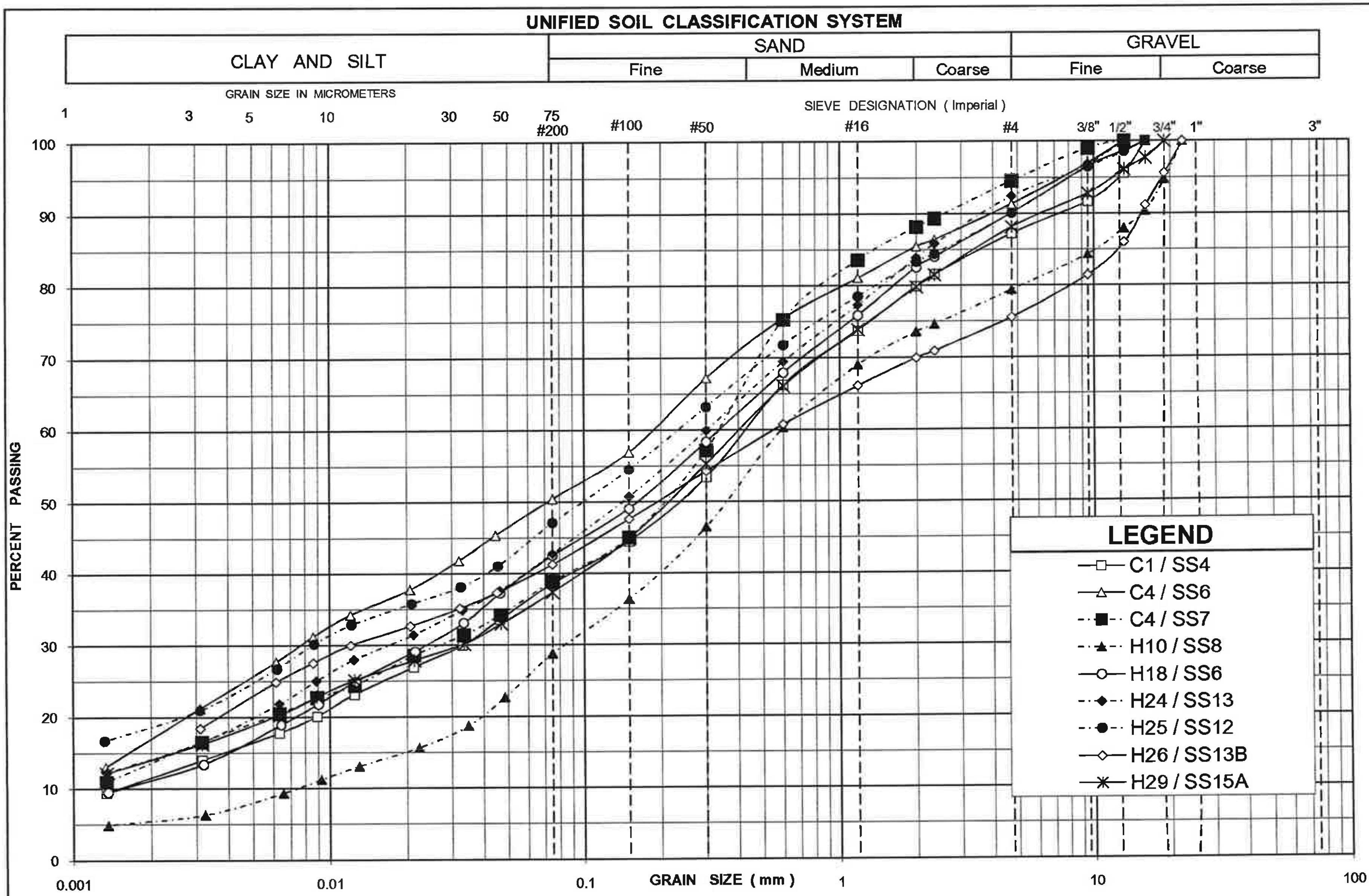


coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PLASTICITY CHART

SILTY CLAY (varved)

FIGURE No.	B5-9
REF. No.	TRANETOB01237AA
DATE	NOVEMBER, 2009



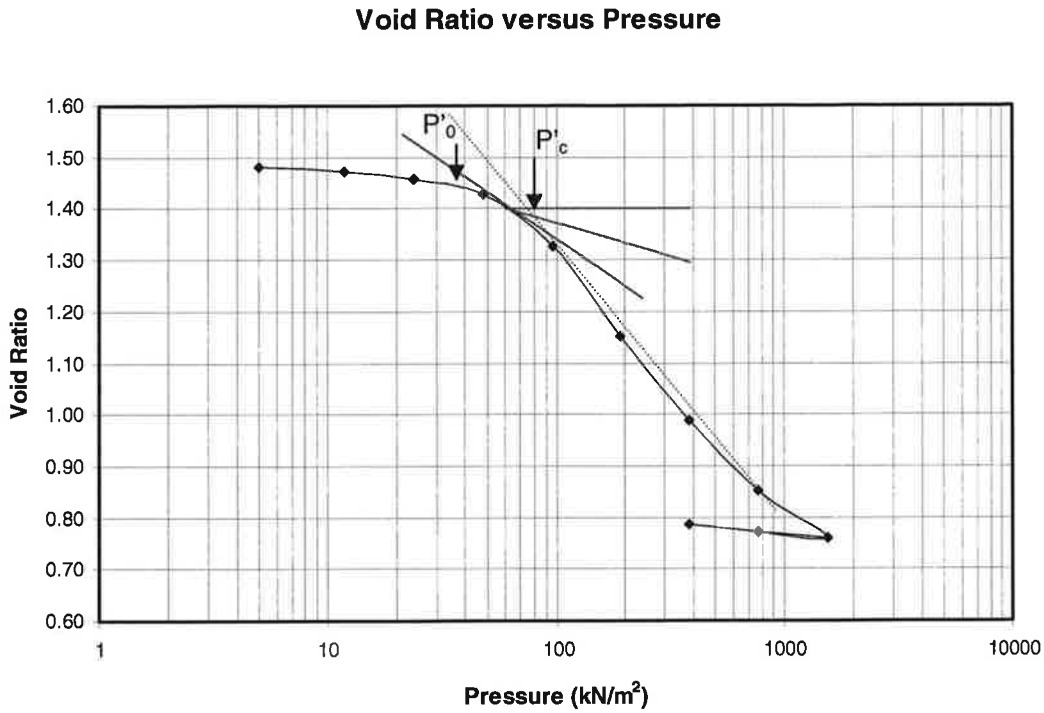
coffey geotechnics
SPECIALISTS MANAGING THE EARTH

GRAIN SIZE DISTRIBUTION
SILTY SAND TILL

FIGURE NO.: B5-10

PROJECT NO: TRANETOB01237AA

DATE: SEPT, 2009



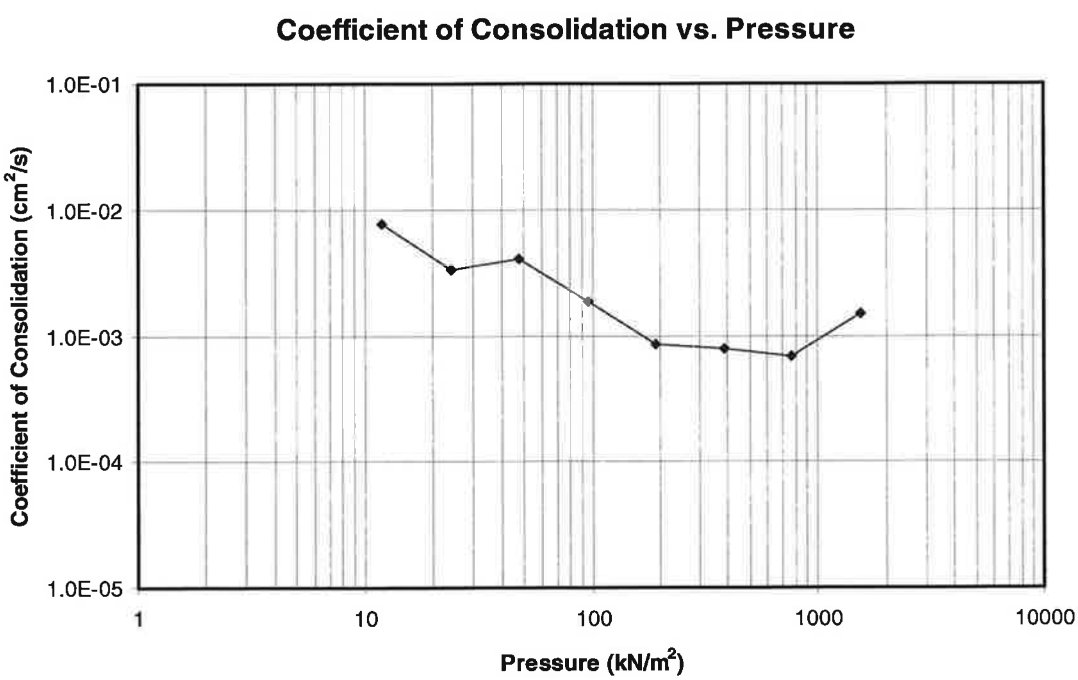
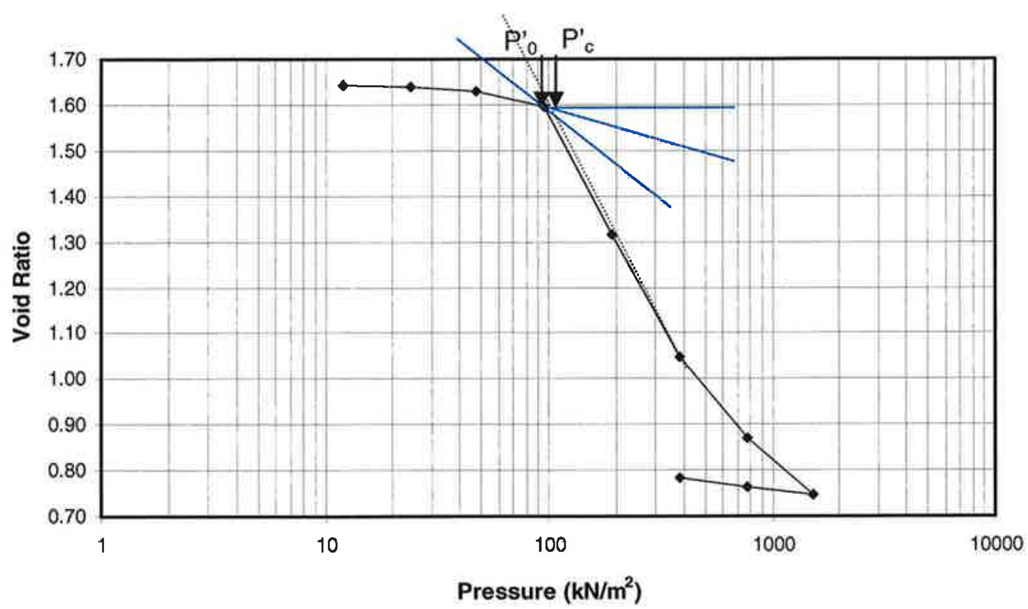


Figure B5-11 Borehole H27 TW4

Void Ratio versus Pressure



Coefficient of Consolidation vs. Pressure

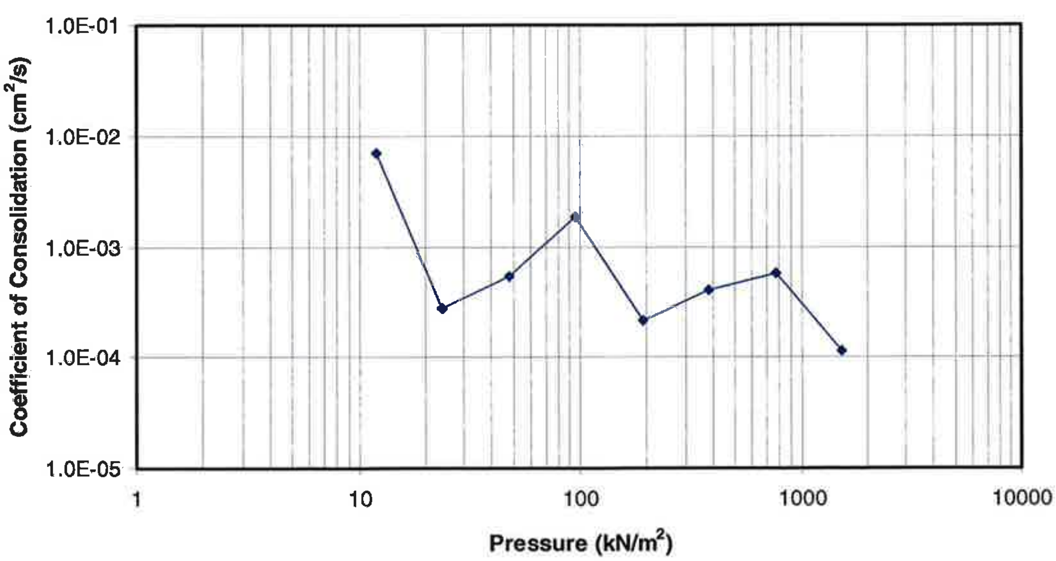


Figure B5-12 Borehole H30 TW14

Appendix C

Undrained Shear Strength

Figure C1. Undrained Shear Strength (kPa) VS Elevation (m)

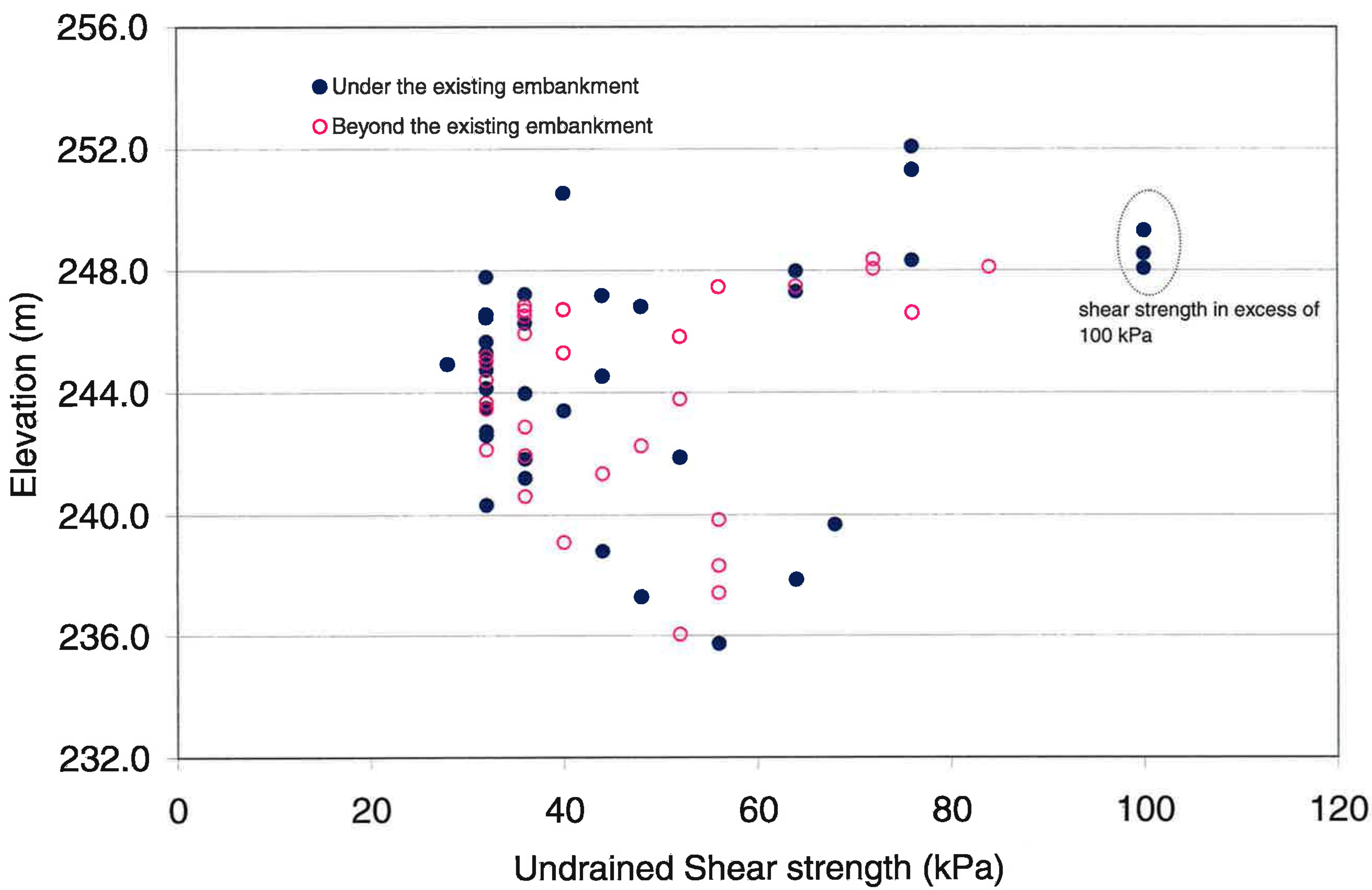


Figure C2. Undrained shear strength distribution
(Borehole H27 at Station 17+050, beyond the existing embankment)

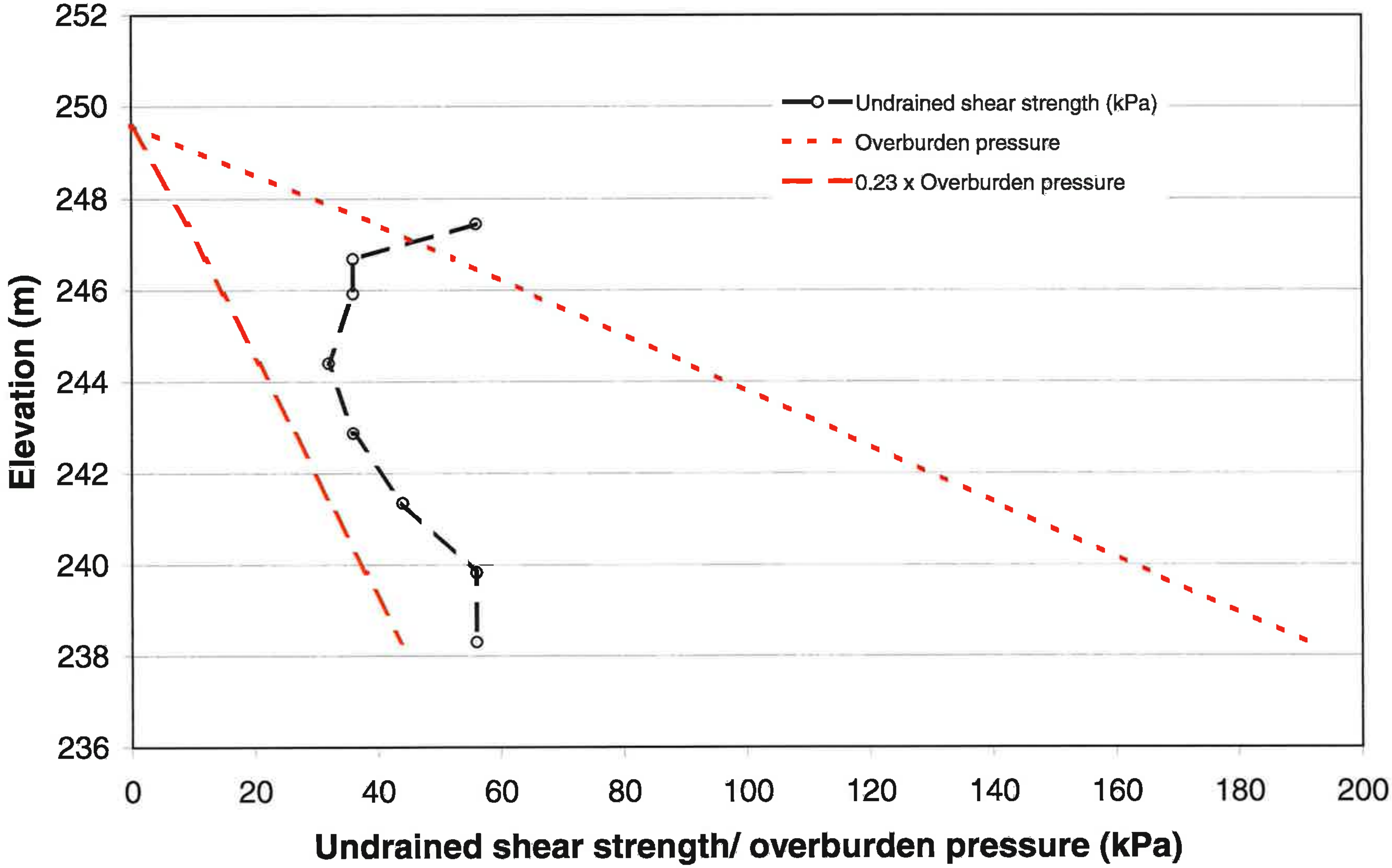
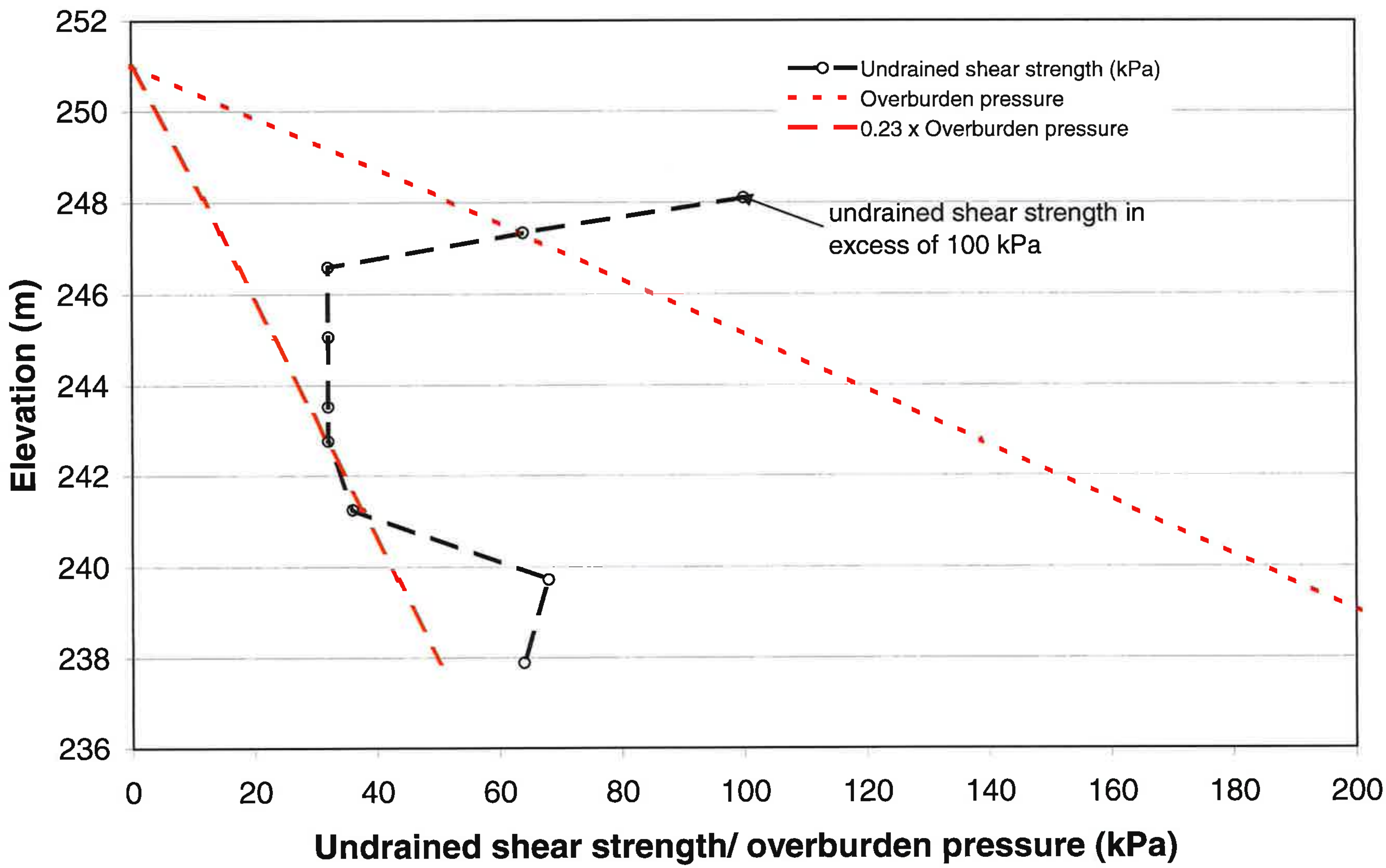


Figure C3. Undrained shear strength distribution
(Borehole H28 at Station 17+100, under the existing embankment)



Appendix D

Site Photogprahs

Figure D1 – Pavement cracks at Passing Lane 1, Station 13+000

Figure D2 -Longitudinal cracks at Passing Lane 3, about Station 15+300

Figure D3 - Pavement cracks at Passing Lane 4, about Station 16+000

Figure D5 - Longitudinal cracking at Passing Lane 5, about Station 17+065

Appendix E

Rock Core Photographs

Figure E1 – Rock Core Sample (RC9) from Borehole C9 at Passing Lane 2

Figure E2 – Rock Core Sample (RC13) from Borehole C6 at Passing Lane 3

Appendix F

Explanation of Terms Used in the Report

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 $\overline{N}$.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J 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 COMPOSION AND STRUCUTRAL 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 (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINT AND BEDDING:

SPACING	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

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

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
$\sigma_l, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL 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'	$-^o$	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	$-^o$	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1,%	VOID RATIO	e_{min}	1,%	VOID RATIO IN DENSEST STATE
i_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1,%	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
P_w	kg/m^3	DENSITY OF WATER	w	1,%	WATER CONTENT	D	mm	GRAIN DIAMETER
i_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
P	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
i	kN/m^3	UNIT WEIGHT OF SOIL	w_P	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
P_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
i_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_P	%	PLASTICITY INDEX = $(W_L - W_L)$	v	m/s	DISCHARGE VELOCITY
P_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_P) / I_P$	i	1	HYDAULIC GRADIENT
i_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_C	1	CONSISTENCY INDEX = $(W_L - W) / 1_P$	k	m/s	HYDRAULIC CONDUCTIVITY
P'	kg/m^3	DENSITY OF SUBMERED SOIL	e_{max}	1,%	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
i'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

FOUNDATION DESIGN REPORT PROPOSED PASSING LANES ON HIGHWAY 11, TOWNSHIP OF ARMSTRONG, ONTARIO G.W.P. 161-98-00, GEOCRES 31M-83

D.M. Wills Associates Limited

Project: TRANETOB01237AA-AB
June 07, 2010

Coffey Geotechnics Inc.
20 Meteor Drive Etobicoke Ontario M9W 1A4 Canada

CONTENTS

Appendices

FOUNDATION DESIGN REPORT
PROPOSED PASSING LANES ON HIGHWAY 11
TOWNSHIP OF ARMSTRONG, ONTARIO
G.W.P. 161-98-00

5 DISCUSSION AND RECOMMENDATIONS

As a part of rehabilitation and resurfacing of Highway 11, the widening of the existing embankment for two passing lanes (southbound and northbound) with 5 areas is proposed, as listed in Table 5.1.

Table 5.1 Proposed Embankment Widening

Passing Lane	Area	Location	Length (m)
Northbound Passing Lanes	1	12+475 – 12+750	275
	2	13+675 – 13+700	25
Southbound Passing Lanes	1	15+275 – 15+575	300
	2	15+850 – 16+000	150
	3	16+250 – 17+200	950

The cross-sections provided to us by D.M. Wills Associates Limited (Wills) indicate that typically 6 m widening (about 3.5 m wide new passing lane with about 2.5 m wide new road shoulder) is proposed without any grade raise, as shown in Appendix G. In general, the new passing lane will be accommodated on the existing shoulder by levelling it. The actual widening of the embankment itself will typically be about 2.5 m. The proposed side slopes for the widening sections are typically 3H:1V which are generally flatter than the existing embankment side slopes.

5.1 Embankment Stability

As the existing slopes are standing at the same angle or generally steeper than the proposed 3H:1V side slopes without any significant signs of instability, and since the road will only be widened without any significant grade raise, problems with instability due to foundation and slope itself are not anticipated. We have however carried out slope stability analyses for completeness and for confirmatory purposes.

Slope stability analysis was carried out using the proposed embankment cross-sections (as given in Appendix G) provided to us by Wills. The stability of the proposed embankments was analysed by the limit equilibrium approach. The analyses were carried out using the commercial two-dimensional slope stability computer program Slope/W and the Morgenstern-Price method of analysis was adopted for both short-term (undrained) and long-term (drained) analyses.

Proper pavement design requires that in order to provide positive drainage of the sub-base materials , the thickness of the granular soils in the widened section match that of the existing granular soils along Highway 11. As such, it is expected that the existing road shoulder will be sub-excavated to a suitable depth to match the existing. At the time of the preparation of the foundation design report, exact details were not as yet available as part of the geotechnical pavement design. We were however given to understand that the depth of the granular thickness below the final ground surface will probably range from 0.9 to 1.5 m but will typically be about one metre.

For the stability analyses, we have therefore assumed that the existing road shoulder under the proposed widening portions will be sub-excavated to a depth about one metre below the existing grade and replaced with new granular pavement fill material (see slope stability analyses results in Appendix H).

The soil profiles used for slope stability analyses were based on the boreholes drilled along the existing highway. The soil parameters adopted on the analysis are given in the following sections.

5.1.1 Embankment Stability - Station 12+475 - 12+750

The following soil parameters were used for slope stability analyses.

Table 5.1.1.1 Soil Parameters for Stability Analyses

Soil Type	Unit Weight (kN/m^3)	Shear Strength Parameters			
		Undrained		Drained	
		Shear Strength (kPa)	Angle of internal friction (deg)	Cohesion (kPa)	Effective angle of internal friction (deg)
New embankment pavement fill: granular soils	21.0	0	33	0	33
Existing embankment fill: basically granular soils (i.e. sand, silty sand, sandy silt)	20.0	0	30	0	30
Existing embankment fill: basically cohesive soils (i.e. clayey silt to silty clay)	17.5	80	0	3	22
Surficial granular soils: silty sand to sandy silt	19.0	0	30	0	30
Silty clay (brown)	17.5	60	0	3	20
Silty clay (varved, grey)	16.5	30	0	2	18
Clayey silt to silty clay (possible till)	18.0	80	0	5	22
Sandy silt to silty sand till	20.5	0	32	0	32

Typical analyse result (after widening) are given in Appendix H1. The results indicate factors of safety of between 1.8 and 1.9. In summary, based on the borehole data and the results of our analyses, it is our opinion that the proposed embankment widening for the new passing lanes, constructed at 3H:1V side slopes, will not cause stability problems. In any event, the analyses are somewhat academic since the existing slopes (which are stable) are somewhat steeper than the proposed.

As was discussed before in Section 5.1 and will further be discussed in Section 5.3, the fill used for the widening should consist of granular materials to a depth and type matching the existing granular base and sub-base courses under the highway. SSM could be utilized underlying the granular fill. The fill will be placed and compacted as per MTO standards.

5.1.2 Embankment Stability - Station 13+675 – 13+700

The following table summarizes the soil parameters utilized for our slope stability analyses.

Table 5.1.2.1 Soil Parameters for Stability Analyses

Soil Type	Unit Weight (kN/m^3)	Shear Strength Parameters			
		Undrained		Drained	
		Shear Strength (kPa)	Angle of internal friction (deg)	Cohesion (kPa)	Effective angle of internal friction (deg)
New embankment pavement fill: granular soils	21.0	0	33	0	33
Embankment fill: granular soils	20.0	0	30	0	30
Embankment fill: clayey silt to silty clay	17.5	80	0	3	22
Silty clay	17.5	50	0	3	20
Silty sand till	20.5	0	32	0	32

Typical analyses results (after widening) are presented in Appendix H2. A factor of safety of 1.9 was obtained. Therefore, based on the borehole data and the results of analyses, the proposed 3H:1V side slopes are considered safe. This result is not unexpected since the proposed slopes (i.e. 3H:1V) are flatter than the existing side slopes which are steeper than the proposed 3H:1V side slopes.

As was discussed before in section 5.1 and will further be discussed in section 5.3, the fill used for the widening should consist of granular materials to a depth and type matching the existing granular base and sub-base courses under the highway. SSM could be utilized underlying the granular fill. The fill will be placed and compacted as per MTO standards.

5.1.3 Embankment Stability - Station 15+275 – 15+575

The following soil parameters were used for slope stability analyses.

Table 5.1.3.1 Soil Parameters for Stability Analyses

Soil Type	Unit Weight (kN/m^3)	Shear Strength Parameters			
		Undrained		Drained	
		Shear Strength (kPa)	Angle of internal friction (deg)	Cohesion (kPa)	Effective angle of internal friction (deg)
New embankment pavement fill: granular soils	21.0	0	33	0	33
Embankment fill: granular soils	20.0	0	30	0	30
Embankment fill: clayey silt to silty clay	17.5	80	0	3	22
Clayey silt to silt	17.5	40	0	3	20
Silty sand till	20.5	0	32	0	32

Typical analyses result (after widening) are given in Appendix H3. The results indicate factors of safety of about 2.0. In summary, based on the borehole data and the results of our analyses, it is our opinion that the proposed embankment widening for the new passing lanes, constructed at 3H:1V side slopes, will not cause stability problems. In any event the analyses are somewhat academic since the existing slopes (which are stable) are somewhat steeper than the proposed.

As was discussed before in Section 5.1 and will further be discussed in Section 5.3, the fill used for the widening should consist of granular materials to a depth and type matching the existing granular base and sub-base courses under the highway. SSM could be utilized underlying the granular fill. The fill will be placed and compacted as per MTO standards.

5.1.4 Embankment Stability - Station 15+850 – 16+000

The following table summerizes the soil parameters utilized for our slope stability analyses.

Table 5.1.4.1 Soil Parameters for Stability Analyses

Soil Type	Unit Weight (kN/m^3)	Shear Strength Parameters			
		Undrained		Drained	
		Shear Strength (kPa)	Angle of internal friction (deg)	Cohesion (kPa)	Effective angle of internal friction (deg)
New embankment pavement fill: granular soils	21.0	0	33	0	33
Embankment fill: granular soils	20.0	0	30	-	-
Silty clay	16.5	40	0	3	20
Silty sand till	20.5	0	32	0	32

Typical analyses results (after widening) are presented in Appendix H4. The results indicate factors of safety about 1.9. In summary, based on the borehole data and the results of our analyses, it is our opinion that the proposed embankment widening for the new passing lanes, constructed at 3H:1V side slopes, will not cause stability problems. In any case, the analyses are somewhat academic since the existing slopes (which are stable) are somewhat steeper than the proposed.

As was discussed before in Section 5.1 and will further be discussed in Section 5.3, the fill used for the widening should consist of granular materials to a depth and type matching the existing granular base and sub-base courses under the highway. SSM could be utilized underlying the granular fill. The fill will be placed and compacted as per MTO standards.

5.1.5 Embankment Stability - Station 16+250 – 17+200

The following table summerizes the soil parameters utilized for our slope stability analyses.

Table 5.1.5.1 Soil Parameters for Stability Analyses

Soil Type	Unit Weight (kN/m^3)	Shear Strength Parameters			
		Undrained		Drained	
		Shear Strength (kPa)	Angle of internal friction (deg)	Cohesion (kPa)	Effective angle of internal friction (deg)
New embankment pavement fill: granular soils	21.0	0	33	0	33
Embankment fill: granular soils	20.0	0	30	0	30
Embankment fill: clayey silt to silty clay	17.5	80	0	3	22
Silty clay	16.5	40	0	3	20
Silty clay (varved, grey)	16.5	30	0	2	18
Basal granular till	20.5	0	32	0	32

Typical analyses results (after widening) are presented in Appendix H5. The results indicate factors of safety about 1.9. In summary, based on the borehole data and the results of our analyses, it is our opinion that the proposed embankment widening for the new passing lanes, constructed at 3H:1V side slopes, will not cause stability problems. In any event the analyses are somewhat redundant as the existing slopes (which are stable) are somewhat steeper than the proposed.

As was discussed before in Section 5.1 and will further be discussed in Section 5.3, the fill used for the widening should consist of granular materials to a depth and type matching the existing granular base and sub-base courses under the highway. SSM could be utilized underlying the granular fill. The fill will be placed and compacted as per MTO standards.

5.2 Settlement of the New Embankment

Based on the borehole data, laboratory test results and the proposed widening configurations, as shown in Appendices A, B and G, the estimated settlements induced by the proposed widening are summarized in Table 5.2.1

Table 5.2.1 Settlement Estimation

Stations	Embankment fills settlement (mm, due to their own weight)	Immediate settlement (mm)	Consolidation settlement(mm) / Expected time (t_{90}, years) of 90% total settlement	Maximum fill height (m)	Silty Clay layer thickness (m)	Total settlement (mm)
Northbound Passing Lane Area 1 (Station12+475 – 12+750)						
12+475 to12+675	15	5	65 / 2.0	1.5*	7.6	85
12+675 to 12+750	10	5	25 / 1.0	1.0*	6.0	40
Northbound Passing Lane Area 2 (Station 13+675 – 13+700)						
13+675 to 13+700	15	10	5/0.5	1.3*	1.2**	30
Culvert @ Sta. 13+694	15	10	15/0.5	1.5*	1.3**	40
Southbound Passing Lane Area 1 (station 15+275 – 15+575)						
15+275 to 15+300	15	10	-	1.2*	10.0***	25

Stations	Embankment fills settlement (mm, due to their own weight)	Immediate settlement (mm)	Consolidation settlement(mm) / Expected time (t_{90}, years) of 90% total settlement	Maximum fill height (m)	Silty Clay layer thickness (m)	Total settlement (mm)
15+300 to 15+400	20	40	-	2.0*	9.5***	60
15+400 to 15+475	20	15	20 / 0.5	1.5*	2.2	55
15+475 to 15+550	15	30	-	1.4*	9.0***	40
Southbound Passing Lane Area 2 (Station 15+850 – 16+000)						
15+850 to 15+875	10	15	-	1.2*	0.3****	35
15+875 to 16+000	10	10	30 / 1.0	1.7*	3.7	50
Southbound Passing Lane Area 3 (Station 16+250 – 17+200)						
16+250 to 16+625	10	10	15 / 2.0	1.2*	3.0	35
16+625 to 16+800	10	15	5.5 / 3.0	1.3*	9.1	80
16+800 to 17+050	10	10	120 / 4.5	1.0*	11.2	140
17+050 to 17+100	5	10	55 / 4.5	0.8*	12.1	70*****
17+100 to 17+150	5	5	20 / 4.5	0.4*	13.7	30*****
17+150 to 17+200	Virtually No widening is proposed					

Note: These settlements are for the least favorable conditions along each stretch.

* at or beyond rounding

** underlain by very loose to compact silty sand till

*** weak silty sand till with some clay content

**** buried topsoil encountered in addition to silty clay and/or weak till

***** very narrow widening

This assumes that the organic or otherwise unsuitable soils under the widened section of the embankment will be properly stripped, as per MTO convention.

It is anticipated that the magnitude of the settlement along the widened section of the highway in the proposed northbound Passing Lane area 2 and southbound Passing Lane area 1 and 2 would be mainly of immediate settlement which would be completed relatively faster than consolidation settlement due to the nature of granular founding soils at those areas. It is our opinion that the thin clay layers in northbound Passing Lane area 2 and southbound Passing Lane area 1 and 2 will not cause significant consolidation settlements. However, due to the presence of thick silty clay in the proposed northbound Passing Lane area 1 and southbound Passing Lane area 3, higher magnitudes of settlements at the widening portions are expected with relatively longer time frame. The time frame of consolidation settlement (i.e. t_{90}, 90% of total consolidation settlement) which depends on the consolidation coefficient (C_v) and drainage path length (thickness of clay deposit and drainage condition at the top and the bottom of the deposit), is also mentioned in above table. It should also noted that the varved clay encountered at the site may settle faster than that we expected due to the frequent interbeded more pervious (clayey silt, silt and silty sand) soils. Details of the treatment option for north bound Passing Lane area 1 and southbound Passing Lane area 3 will be further discussed in sections 5.2.1 through 5.2.5.

As shown in Table 5.2.1, the anticipated total settlements in the northbound Passing Lane area 2 and the southbound Passing Lane 1 and 2 range between 25 and 60 mm. These settlements have three components.

a) Settlement of the new embankment fill under its own weight

The settlement of the new embankment fill under its own weight can be expected to occur. If the embankment is constructed to MTO standards, the magnitude of the settlements under embankments' own weight can be expected to be about 10 to 20 mm as shown in Table 5.2.1. The time rate will depend on the material used for construction. However, if select subgrade materials (SSM) or granular soils are used, about half of this settlement should be completed within one month and the remaining half substantially completed within the next three months.

b) Immediate settlement

This component is the foundation settlement (i.e. 10 to 40 mm) of the typically granular foundation soils under the stresses imposed by the widening. Since the soil is basically granular, the time rate of settlement is relatively rapid and the settlements can be expected to be substantially completed within two to six months. This also induces the settlement of the existing embankment fill under the weight of the new fills placed for the widening over it.

c) Consolidation settlement

The consolidation settlement would take place in the clayey (cohesive) soils and as explained before it would depend on the thickness of the clayey soils and the magnitude of the stresses imposed. This is a time dependent settlement which may take many years to complete depending on the thickness and the permeability of the clayey soils.

In northbound Passing Lane area 2 and southbound Passing Lane 1 and 2 the thickness of the clayey soils underlying the site is relatively minor. As well, the magnitude of this component varies between zero and 20 mm. Due to the relatively thin occurrence these settlements can be expected to be substantially completed within five months.

In conclusion, it is our opinion that in northbound Passing Lane area 2 and southbound Passing Lane 1 and 2, the anticipated settlements would be reduced to acceptable levels after a preload period of five months. We therefore recommend that a minimum period of five months be provided before these areas are paved. The anticipated settlement after a preload period of five months is less than 50 mm. The anticipated settlements of relatively higher magnitude (i.e. in excess of 30 mm and approaching 50 mm) are expected to occur beyond the paved portion of the road (i.e. settlements will be highest near the rounding and along the side slopes gradually decreasing towards the paved portion of the road). This is because the grade raise is much less in the paved portions (see proposed cross section presented in Appendix G). In addition, the increase in the loads and hence the settlements are gradual, rather than abrupt. In other words with the proposed widening scheme, abrupt differential settlements which may cause major cracking affecting the performance of a flexible pavement, are not anticipated.

Settlements of the magnitude quoted would in our opinion therefore be acceptable, after the preload period. In areas where original topsoil/organic soils have been left in place, additional settlements may occur as discussed below.

Buried topsoil/organic soil was found in various boreholes drilled from the shoulder of Highway 11, as follows.

Table 5.2.2 Buried topsoil/organic soils –Northbound Passing Lane Area 2 and Southbound Passing Lane area 1 and 2

Passing Lane No.	Borehole No.	Station	Depth/Elevation of topsoil (m)	Thickness of topsoil (m)
Northbound Passing Lane Area 2	F11	13+775	1.7/257.5	0.4
Southbound Passing Lane Area 1	D8	15+530	1.5/261.1	1.1
Southbound Passing Lane Area 2	H1	15+850	1.5/257.3	0.6
Southbound Passing Lane Area 2	H2	15+875	1.4/257.1	0.7
Southbound Passing Lane Area 2	H6	15+975	1.4/255.6	0.7

In addition, at some borehole locations, the bottom of the embankment fill was found to be mixed with topsoil/organic sols, perhaps due to construction operations. From these findings it appears that original topsoil/organic soils were not properly stripped when the highway was first built. Organic soils tend to undergo secondary consolidation thus giving rise to long term settlements. Such settlements can cause differential settlements which could lead to cracking and/or distortions of the highway pavement, especially if the thickness are uneven, which appear to be the case here.

Consideration can be given to removing the original topsoil and organic mixed fill from beneath the road. The lateral and longitudinal extent of these unsuitable soil are however unknown. A complete removal of the existing embankment to effect the removal of the underlying unsuitable soils will likely require shoring to maintain the traffic during construction and will thus be rather costly. In view of this and if some future maintenance would be acceptable, the organic soils can be left in place. Another alternative would be to remove such soils in the areas known from the present investigation (e.g. Station 15+550, 15+850-15+878 and 15+975) and/or in areas where frost heave remediation is required.

5.2.1 Treatment Plan for Northbound Passing Lane Area 1 (Station 12+475 to 12+750)

Total settlements between 40 and 85 mm are expected in this proposed passing lane section, depending on the geometry of the proposed widening and subsurface conditions.

For the estimation of consolidation settlements, we utilized the following parameters, based on our consolidation tests.

e_o = 1.5 (brown silty clay) and 1.6 (grey varved silty clay)

C_c = 0.6 (brown silty clay) and 0.8 (grey varved silty clay)

C_r = 0.1(brown silty clay and over-consolidated grey varved silty clay) and 0.15 (grey varved silty clay)

C_v (cm^2/sec) = 0.002 (for both brown and grey varved silty clay)

At the most practical approach to reduce settlements, consideration should be given to a surcharge of about 0.6 m for a period of at least eight months for the proposed widening section between Stations 12+475 and 12+750. Alternatively, an about 1.0 m surcharge with a six months period for the proposed widening section between Stations 12+475 and 12+750 can be used to accelerate the consolidation settlement. A 1.0 m high surcharge in place for an uninterrupted period of six months is the preferred option. The remaining settlement after removing the surcharge will be less than 40 mm along the shoulder of the widened highway and less than 60 mm along the side slopes. In our opinion, settlements of this magnitude should not result in significant cracking or deformations for a flexible pavement.

Alternative treatment options such as light weight fill or surcharge with wick drains can be considered for this section but because the remaining settlements after the surcharge period will be within a tolerable settlement magnitude, we do not consider the significantly extra cost to implement these alternatives is warranted. We will however be please to give details of these options, if required.

As was mentioned before in section 5.2 of the report, the presence of topsoil/organic soils was noted underlying the existing embankment throughout much of this project. In the Passing Lane #1 area (between Stations 12+475 and 12+750), the presence of a 0.1 to 0.5 m thick layer of peaty topsoil was recorded in all the three boreholes drilled from the top of the embankment. Possible settlements due to the presence of organic soils were not fully accounted for in our settlement analyses. While consideration can be given to a complete removal of this material, as was discussed before this will be very costly. This cost in out opinion is not warranted, especially since surcharging can be expected to partially mitigate the possible problems due to the presence of this layer.

5.2.2 Treatment Plan for Southbound Passing Lane Area 3 (Station 16+250 to 17+200)

Total settlements up to 140 mm can be expected in this proposed Passing Lane area depending on the geometry of proposed widening and the subsurface conditions. In general the anticipated settlements are less than 30 mm between Stations 16+250 and 16+625, gradually increasing to about 140 mm between the Station 16+800 and Station 17+050, decreasing beyond Station 17+050.

For the estimation of consolidation settlements, we utilized the following parameters, based on our consolidation tests.

e_o = 1.5 (brown silty clay) and 1.6 (grey varved silty clay)

C_c = 0.55 (brown silty clay) and 0.9 (grey varved silty clay)

C_r = 0.05 (brown silty clay and over-consolidated grey varved silty clay) and 0.10 (grey varved silty clay)

C_v (cm^2/sec) = 0.002 (for both brown and grey varved silty clay)

Similar to Passing Lane 1, surcharging is considered the most expedient way of dealing with the anticipated settlements in this nearly 1 km long section. The following procedures are recommended.

- Preload from Station 16+250 to 16+625.
- Start surcharging at Station 16+625 and gradually increase the height of surcharge from zero at Station 16+625 to 1.0 m at Station 16+725.
- Retain the surcharge height at 1.0m from Station 16+725 to Station 17+100.
- Gradually reduce the height of surcharge from 1.0 m at Station 17+100 to zero at Station 17+150.

The recommended preload/surcharge time is six months.

A somewhat less surcharge height can be applied by increasing the surcharge period. This however we understand is impractical (i.e. a surcharge period in excess of six months).

Similar problems due to topsoil/organics soils will likely occur here as original topsoil/organic materials do not appear to have been stripped. As a complete removal will be rather cost ineffective, leaving topsoil/organic soils in place with possible periodic maintenance would be a more practical solution. For the sake of completeness however boreholes in which excessive topsoil was encountered are given below.

Table 5.2.2.1 Buried topsoil/organic soils –Southbound Passing Lane Area 3

Passing Lane No.	Borehole No.	Station	Depth/Elevation of topsoil (m)	Thickness of topsoil (m)
Southbound Passing Lane Area 3	H10	16+230	1.0/254.0	0.4
Southbound Passing Lane Area 3	H16	16+500	1.8/252.3	0.3
Southbound Passing Lane Area 3	H20	16+700	1.5/251.7	0.1
Southbound Passing Lane Area 3	H22	16+800	251.3/1.5	0.6
Southbound Passing Lane Area 3	H24	16+900	250.7/1.5	0.7

5.2.3 Details of Surcharging Option

Typically surcharge application schemes are given in Appendix I. Two options are presented, namely sloping ground and the use of concrete jersey barriers to retain the surcharge, with the latter being the preferred choice. This is because it provides a slightly more complete surcharge in the future paved area, as well as for ease of maintenance during the surcharge period. It is also our understanding that from a maintenance, traffic safety and cost standpoint, sloping ground is the preferred choice.

Surcharging can be applied during any continuous six month period, including winter months. However, the stockpiling of more than 0.6 m of snow on top of the surcharge should be avoided, due to slope stability concerns.

Monitoring of the settlements can be considered. This would entail the installation of settlement plates and rods in areas to be surcharged. As maximum settlements along any one cross-section can be expected to occur at or beyond the rounding, the monitors should be placed as close to the edge of the embankment shoulder as practicable. We tentatively recommend two such installations along northbound Passing Lane area 1 as follow;

Station 15+525

Station 15+625

And four such installations along southbound Passing Lane area 3, as follow;

Station 16+800

Station 16+900

Station 16+925

Station 16+950

An NSSP should be included in the contract documents specifying the monitoring program during the surcharging period. We will be pleased to provide details of settlement plate installation, if required.

5.2.4 Wick Drain with Surcharge Option

As the residual settlements with the surcharge option may necessitate some progressive maintenance, surcharging with wick drains may be considered to reduce the magnitude of the residual settlements. This would speed up the rate of consolidation of the silty clay. While this approach ensures no future maintenance due to the future settlement issues, this is a costly method and in our opinion it is cost ineffective for the return on the initial capital outlay. In addition it is impractical for this project due to lack of space on the shoulder, timing etc. For these reasons it is not recommended. If, however, you wish to further look into the feasibility of this option, we will be pleased to do so.

5.2.5 Light Weight Fill Option

If the anticipated embankment settlement is not considered acceptable, another approach would be use light weight fill with or without surcharging. The use of expanded polystyrene (EPS) or slag can be considered. For the preliminary design purposes, the unit weight of EPS can be assumed to be 1 kN/m^3 and a unit weight of 11.5 kN/m^3 can be used for the light weight expanded slag.

Light weight fill option is provided for the completeness of the report, however, it is not recommended for this project due to the high cost.

The following design criteria need to be considered for EPS option.

- The recommended thickness of the pavement fill over the EPS is 1.3 m with a concrete cover over the EPS and 1.4 m without a concrete cover. At present, MTO design requirements include a 125 mm thick concrete slab over the EPS, but this is under review since there have been reported cases of cracking of the concrete especially where post construction settlements occur. The design and construction of the EPS should be in accordance with MTO Special Provision entitled "Expanded Polystrene Embankment."
- The possible highest groundwater level (i.e. 1:100 years) should be considered to design EPS to prevent an uplift condition.
- Depending on the design, an earth cover of 1.0 m should be provided over the EPS on the side slopes to prevent a possible uplift, as well as to avoid damage due to ultra-violet light exposure.
- The soil underlying the EPS should be well compacted and the top 0.15 m of the soil should consist of sand with no gravel to prevent damage to the EPS.
- The site to receive the EPS should be properly stripped as per MTO standards, the exposed subgrade should be compacted from the surface using a suitable compactor. The granular levelling pad for EPS will need to be compacted to at least 95% of its Standard Proctor Maximum Dry Density (SPMDD) to the underside of the proposed EPS elevation. The underside of EPS should be always levelled and this can be achieved by stepping if EPS will be placed in sloping ground.

These and some other details of EPS approach would be further looked into if an EPS option is to be adopted.

5.3 Construction Considerations

The boreholes show the presence of peaty topsoil at the ground surface and under the existing embankment and also other organic soils. All the organic and otherwise unsuitable soils encountered during the widening process will need to be removed and replaced with suitable soils, as per established MTO practice. The treatment of organic soil under the existing embankment was discussed in Section 5.2. As depending on the time of construction, the excavation and backfilling may partially (especially near the culvert locations) take place below the groundwater level, it is recommended a suitable granular material be used for backfilling below the original grade levels and to at least about 0.3 m above the o.g. if groundwater table is encountered near the original grade.

Based on the findings of our investigation, a 0.6 m of stripping depth can be used for preliminary estimating purposes for all the embankment widening sections. It should however be pointed out that the thickness of unsuitable soils frequently varies in between and beyond borehole locations and may be thicker in depressed areas.

The face of the existing slope should be properly prepared for the widening, including benching as per MTO procedures in accordance with OPSD 208.010, as shown in Appendix L.

Backfilling will need to be carried out in relatively short sections to prevent instability of the existing embankments as well as the nearly vertical faces of the individual benches. The process of excavation and backfilling of each sufficiently narrow section (e.g. 10 to 15 m wide sections) should be carried out concurrently. After stripping, the exposed subgrade should be inspected and approved by an experienced geotechnical engineer appointed by the QEV. Any organics or otherwise unsuitable soils on the face of the embankment should be removed as much as practicably possible but the topsoil/organic soils or otherwise unsuitable materials should be fully removed from the bottom of the proposed wideing, as per MTO procedures. At the bottom, the first lift of the backfill may be thicker than usual backfill thickness of 0.3 m (e.g. possibly up to 0.6 m thick), depending on the site and groundwater conditions at the time of construction. As well, some dewatering consisting of gravity drainage by means of ditches and pumping from filtered sumps may be required to facilitate the construction. If relatively deep excavations are required (i.e. thick topsoil/organic soils are encountered) at the bottom of excavation, then the stripping and backfilling may need to be carried out in narrow sections (e.g. 3 to 4 m wide) and backfilled immediately to prevent embankment instability. All of these works should be carried out under the direction and supervision of the QVE. We recommend that an NSSP be issued for this purpose.

It is unlikely to encounter rock fill along these two Passing Lanes with 5 areas, however, if rock fill is exposed during the embankment widening, the rock fill should be properly chinked prior to placement of any fill on top. Also, adjacent to any exposed rock fill, a minimum 0.5 m of Granular ‘B’ Type II (OPSS 1010) should be placed on the side prior to the placement of the earth fill for the widening. This Granular ‘B’ Type II (OPSS 1010) will act as a filter between the coarse rock fill and the finer grained earth fill, which will reduce the amount of soil loss into the voids in the rock fill.

The fill used for the widening should consist of Granular 'B' type I (OPSS 1010) placed full width, matching the existing granular sub-base course under the highway. SSM could be utilized below this. These fills should be placed and compacted as per MTO standards. The fill should be placed in suitably thin lifts (e.g. 0.3 m when loose) and each lift should be compacted to not less than 95% of the material's Standard Proctor Maximum Dry Density (SPMDD) for SSM and 100% for the granular base and sub-base materials. In as much as possible, within the upper 2.3 m (frost depth) the fill should match the existing for the purpose of minimizing differential frost heave.

Proper erosion control measures should be implemented on the face of the newly constructed slopes, both during the construction and permanently. This can be achieved by prompt seed and cover (OPSS 572) or sodding (OPSS 571). Fill used for surcharging will also need to be properly protected from erosion during the surcharging.

If staged construction is to be implemented and excavations are required, it should be ensured at all times that the existing embankment will be stable. Access ramps to the embankments' toe should be in place in order to ensure that the excavations parallel with the centre line will progress with no increase of load on the crest of the embankments and that the embankments' toe will be loaded and protected.

6 CLOSURE

The Limitations of Report, as quoted in Appendix M, are an integral part of this report.

For and on behalf of Coffey Geotechnics Inc.

Gwangha Roh, Ph.D.

Ramon Miranda, P.Eng.
Manager, Transportation Division

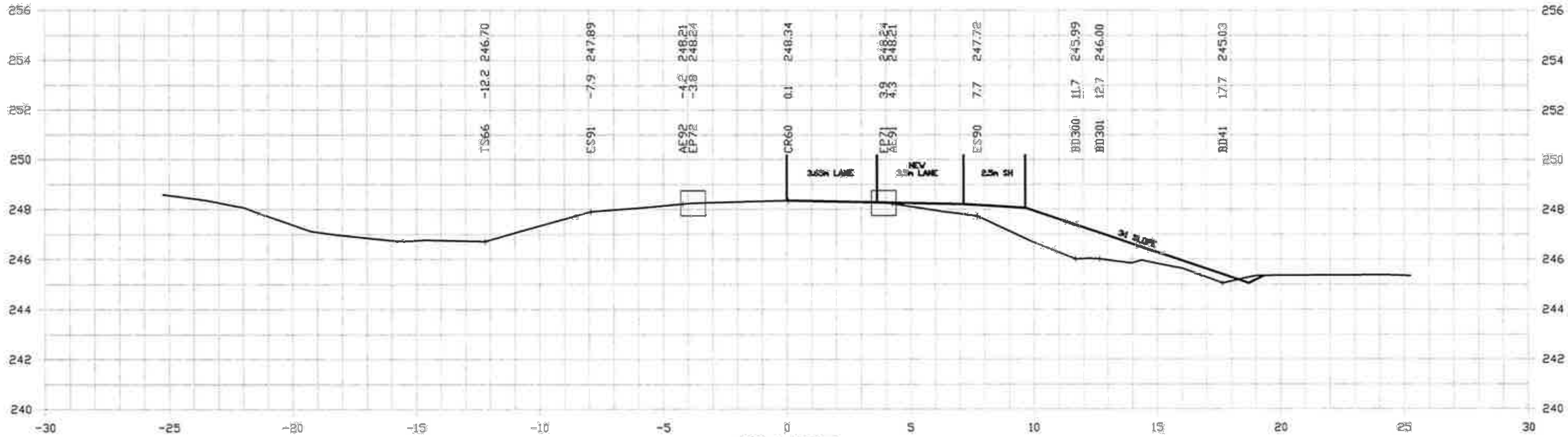
LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
PROVINCE OF ONTARIO

Zuhtu Ozden, P.Eng.
Senior Principal

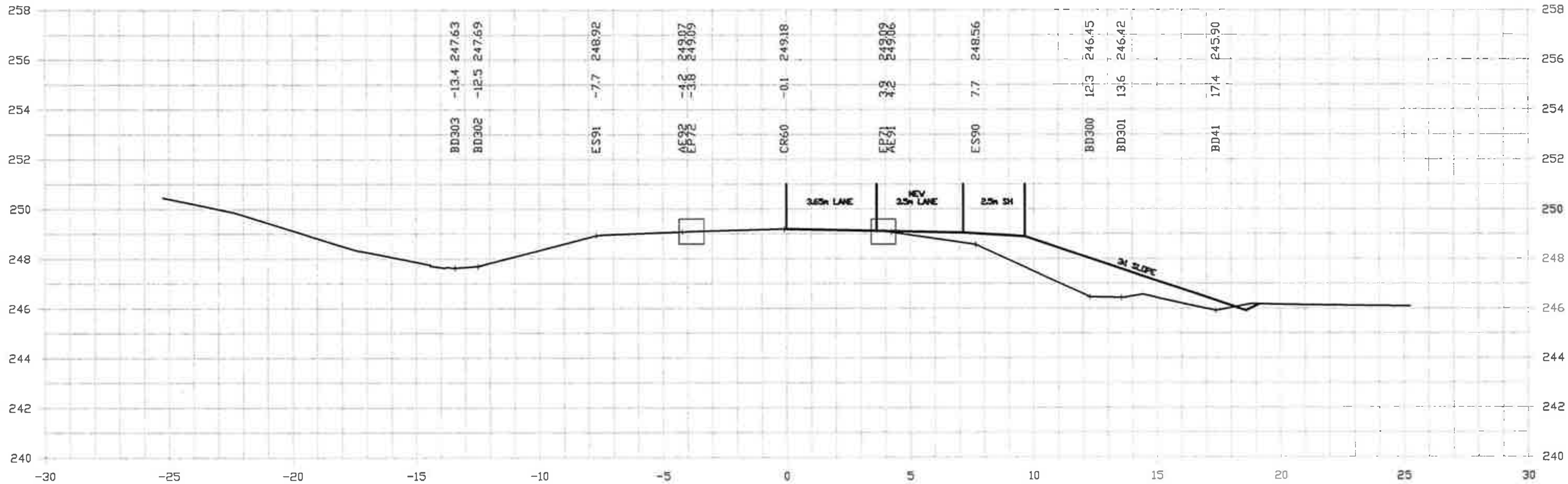
REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
PROVINCE OF ONTARIO

Appendix G

Proposed Widening Embankment Cross-sections

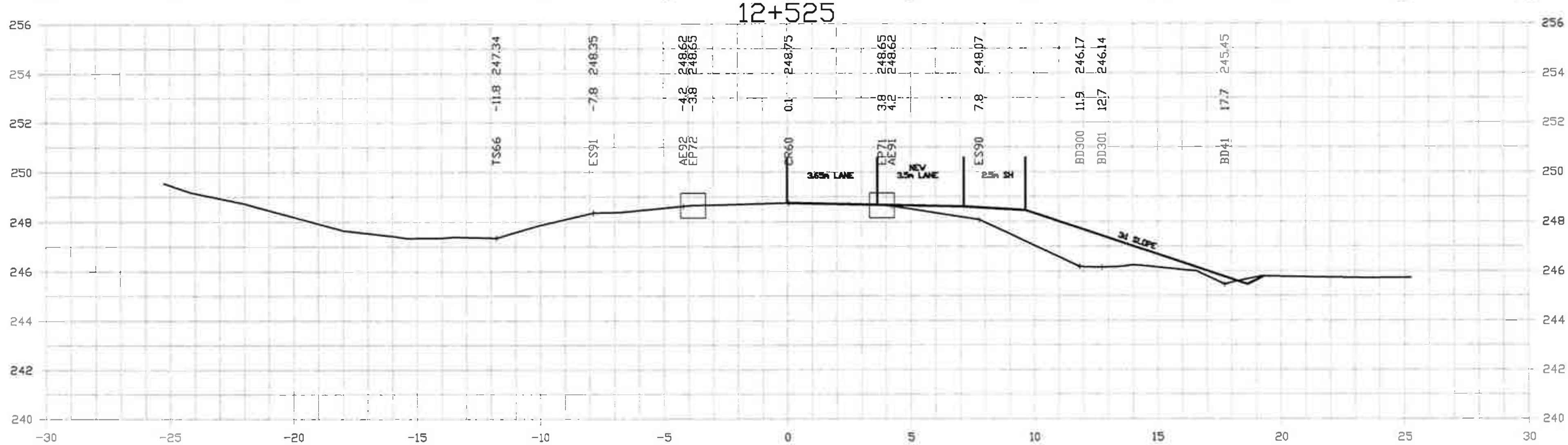

TS66 -12.2 246.70
ES91 -7.9 247.89
AE92 -4.2 248.21
EP72 -3.8 248.24
CR60 0.1 248.34
EP71 3.9 248.24
AE91 4.3 248.21
ES90 7.7 247.72
BD300 11.7 245.99
BD301 12.7 246.00
BD41 17.7 245.03
3.65m LANE
NEW
3.5m LANE
2.5m SH
256
254
252
250
248
246
244
242
240
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30

12+475



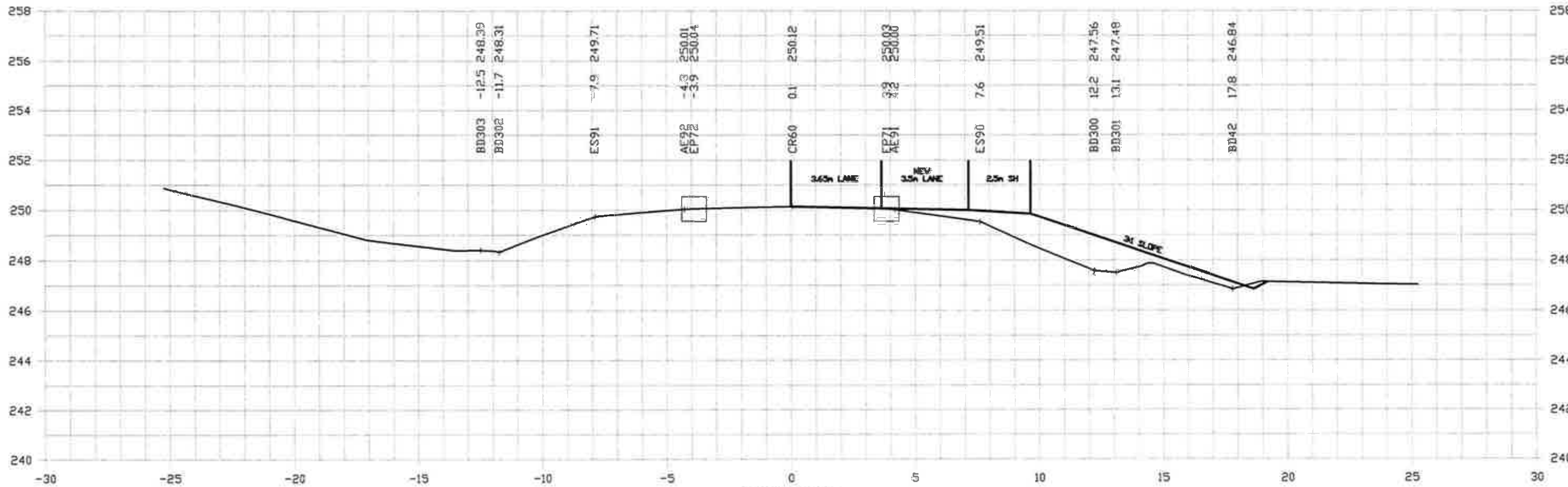
BD303 -13.4 247.63
BD302 -12.5 247.69
ES91 -7.7 248.92
AE92 -4.2 249.07
EP72 -3.8 249.09
CR60 -0.1 249.18
EP71 3.9 249.09
AE91 4.2 249.06
ES90 7.7 248.56
BD300 12.3 246.45
BD301 13.6 246.42
BD41 17.4 245.90
3.65m LANE
NEV 3.5m LANE
2.5m SH
3:1 SLOPE

12+525

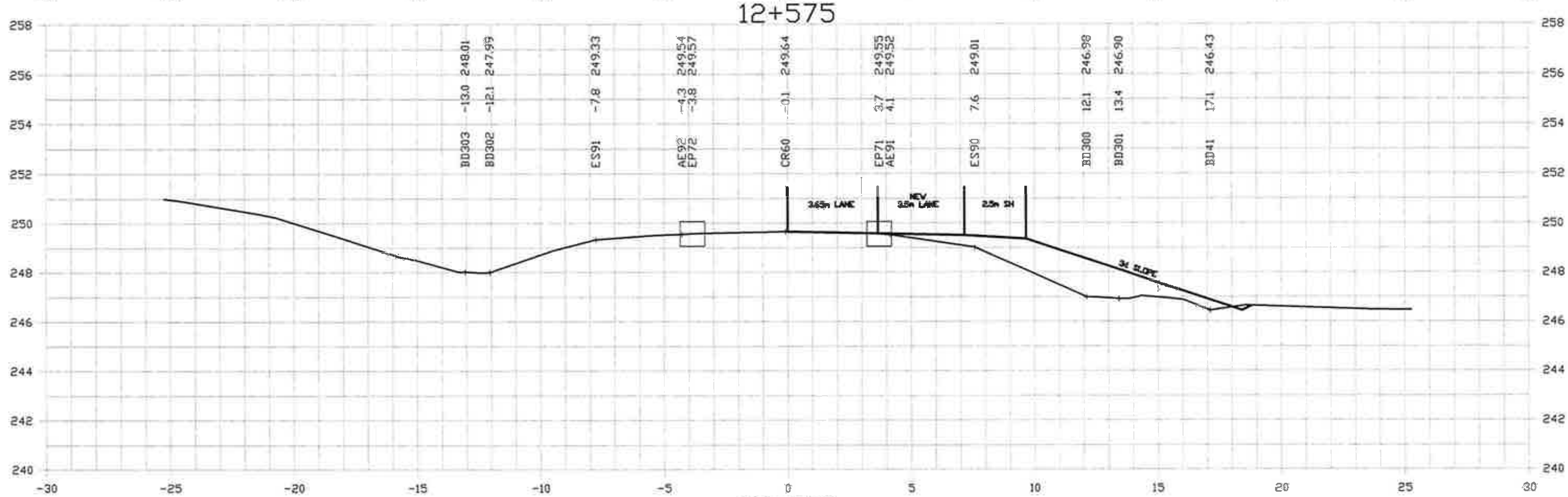


TS66 -11.8 247.34
ES91 -7.8 248.35
AE92 -4.2 248.62
EP72 -3.8 248.65
CR60 0.1 248.75
EP71 3.8 248.65
AE91 4.2 248.62
ES90 7.8 248.07
BD300 11.9 246.17
BD301 12.7 246.14
BD41 17.7 245.45
3.65m LANE
NEV 3.5m LANE
2.5m SH
3:1 SLOPE

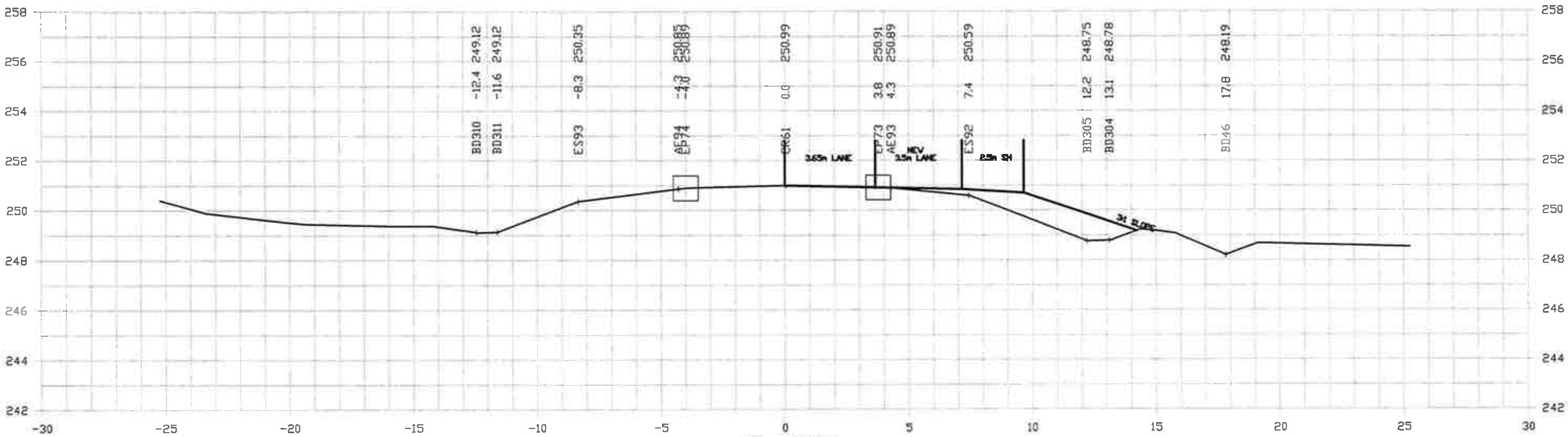
12+500


BD303 -12.5 248.39
BD302 -11.7 248.31
ES91 -7.9 249.71
AE92 -4.3 250.01
EP72 -3.9 250.04
CR60 0.1 250.12
EP71 3.9 250.03
AE91 4.2 250.00
ES90 7.6 249.51
BD300 12.2 247.56
BD301 13.1 247.48
BD42 17.8 246.84
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

12+575

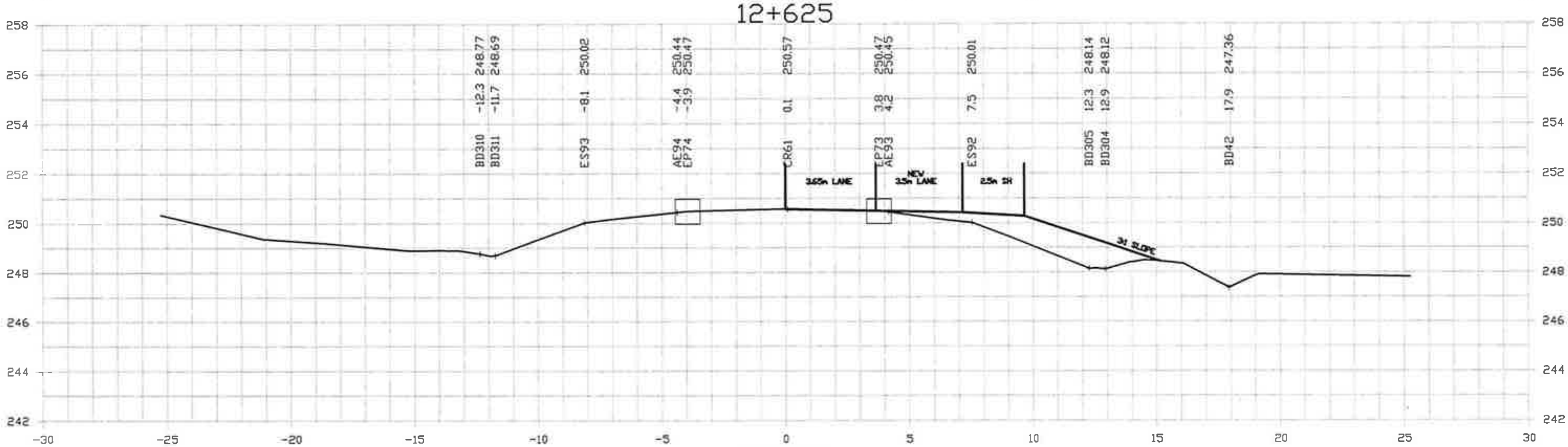

BD303 -13.0 248.01
BD302 -12.1 247.99
ES91 -7.8 249.33
AE92 -4.3 249.54
EP72 -3.8 249.57
CR60 -0.1 249.64
EP71 3.7 249.55
AE91 4.1 249.52
ES90 7.6 249.01
BD300 12.1 246.98
BD301 13.4 246.90
BD41 17.1 246.43
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

12+550



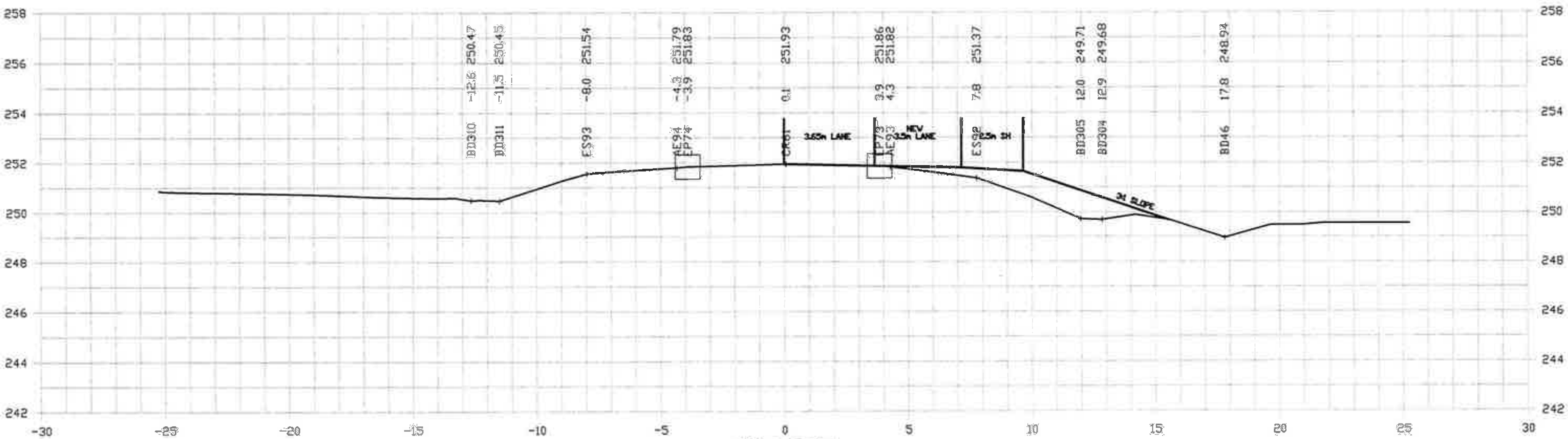
BD310 BD311 ES93 AE94 EP74 CR61 EP73 AE93 ES92 BD305 BD304 BD46
-12.4 -11.6 -8.3 -4.3 -4.0 0.0 3.8 4.3 7.4 12.2 13.1 17.8
249.12 249.12 250.35 250.85 250.89 250.99 250.91 250.89 250.59 248.75 248.78 248.19
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

12+625

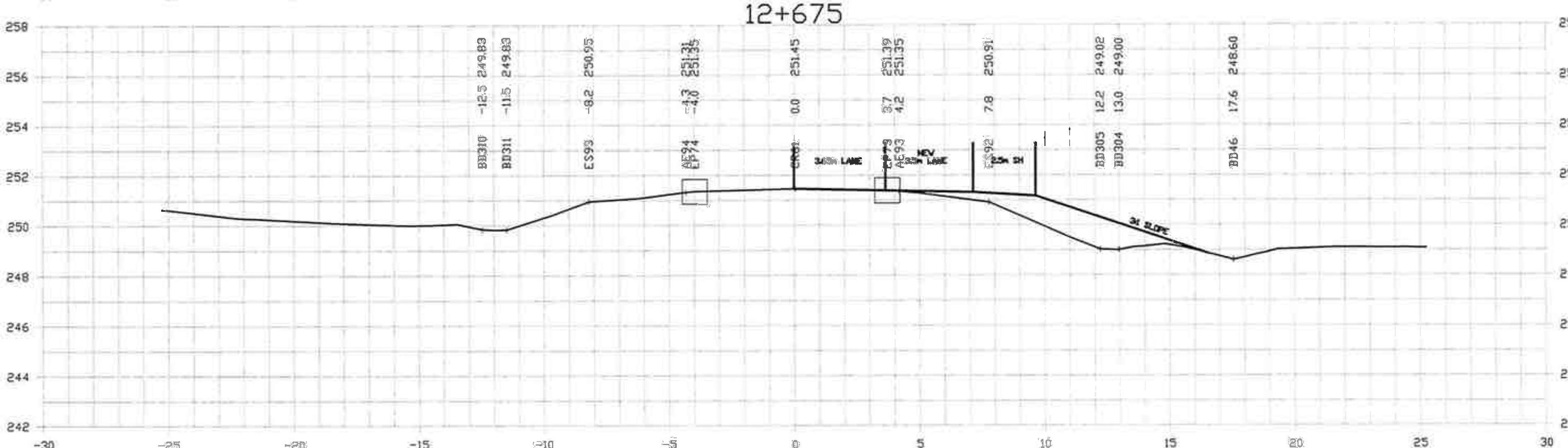


BD310 BD311 ES93 AE94 EP74 CR61 EP73 AE93 ES92 BD305 BD304 BD42
-12.3 -11.7 -8.1 -4.4 -3.9 0.1 3.8 4.2 7.5 12.3 12.9 17.9
248.77 248.69 250.02 250.44 250.47 250.57 250.47 250.45 250.01 248.14 248.12 247.36
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

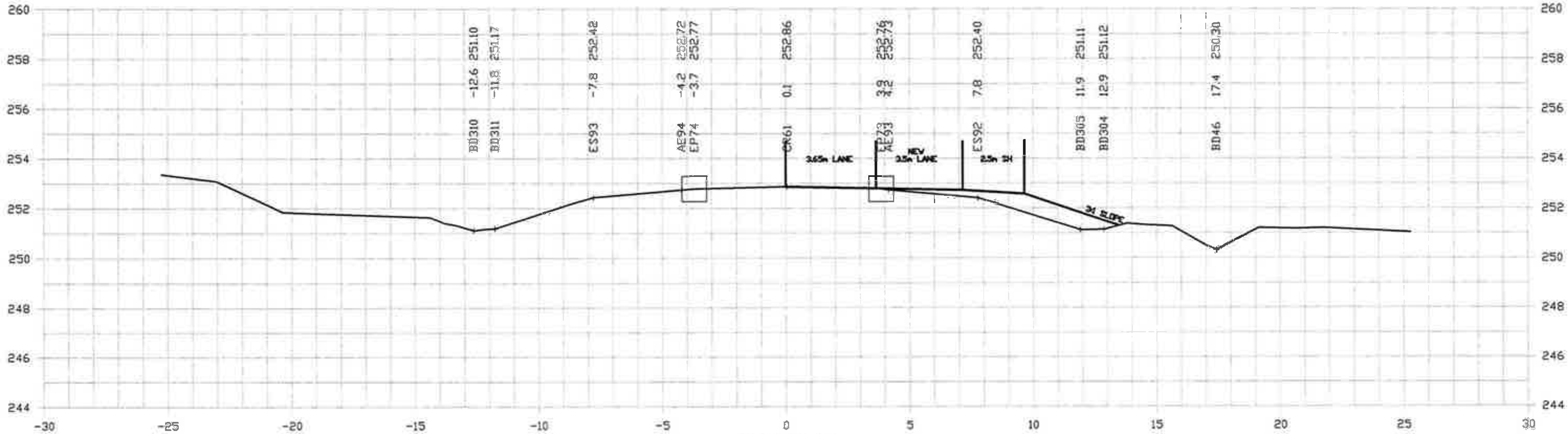
12+600


BD310 -12.6 250.47
BD311 -11.5 250.45
ES93 -8.0 251.54
AE94 EP74 -4.3 -3.9 251.79 251.83
CR61 0.1 251.93
EP73 AE93 3.9 4.3 251.86 251.82
ES92 7.8 251.37
BD305 12.0 249.71
BD304 12.9 249.68
BD46 17.8 248.94
3.65m LANE
NEV
3.5m LANE
2.5m SH
3:1 SLOPE

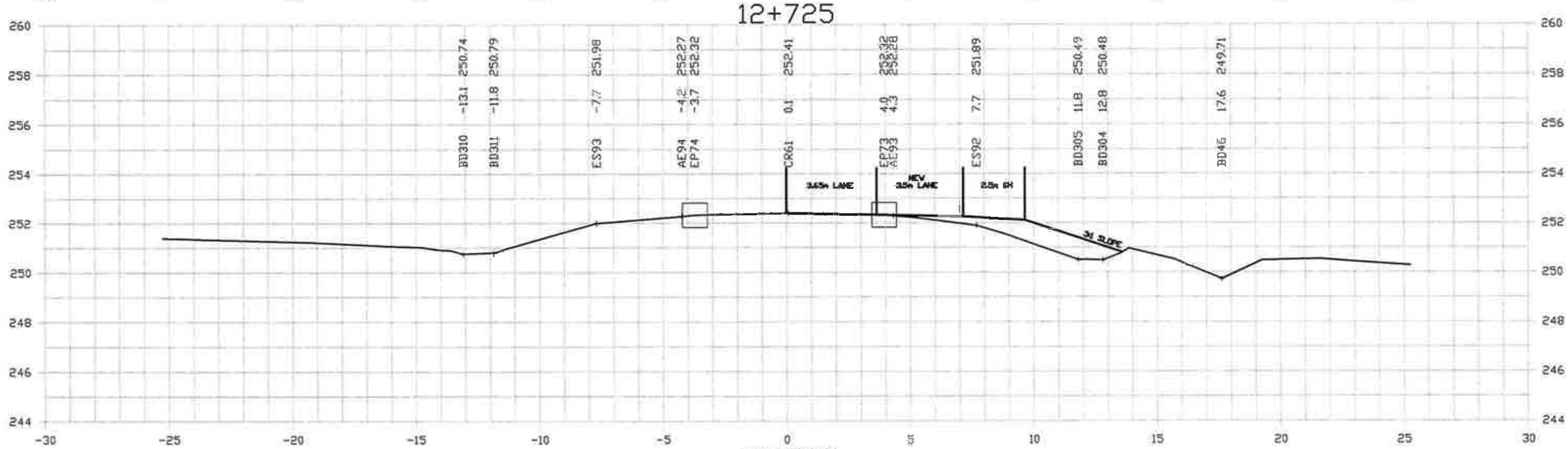
12+675


BD310 -12.5 249.83
BD311 -11.5 249.83
ES93 -8.2 250.95
AE94 EP74 -4.3 -4.0 251.31 251.35
0.0 251.45
EP73 AE93 3.7 4.2 251.39 251.35
ES92 7.8 250.91
BD305 12.2 249.02
BD304 13.0 249.00
BD46 17.6 248.60
3.65m LANE
NEV
3.5m LANE
2.5m SH
3:1 SLOPE

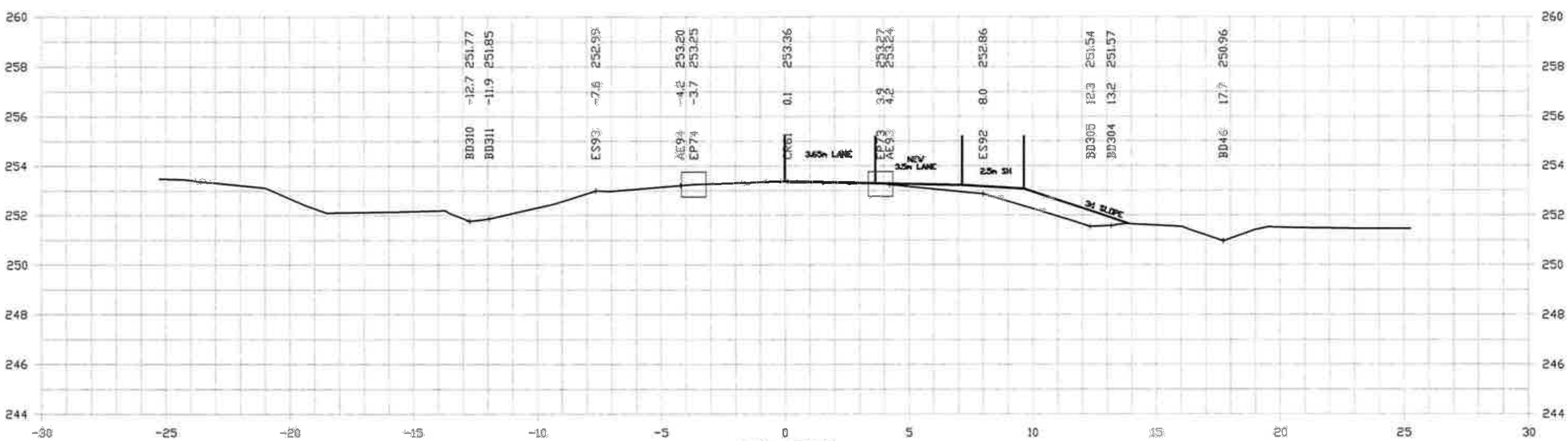
12+650


BD310 -12.6 251.10
BD311 -11.8 251.17
ES93 -7.8 252.42
AE94 -4.2 252.72
EP74 -3.7 252.77
CR61 0.1 252.86
EP73 3.9 252.76
AE93 4.2 252.73
ES92 7.8 252.40
BD305 11.9 251.11
BD304 12.9 251.12
BD46 17.4 250.30
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

12+725

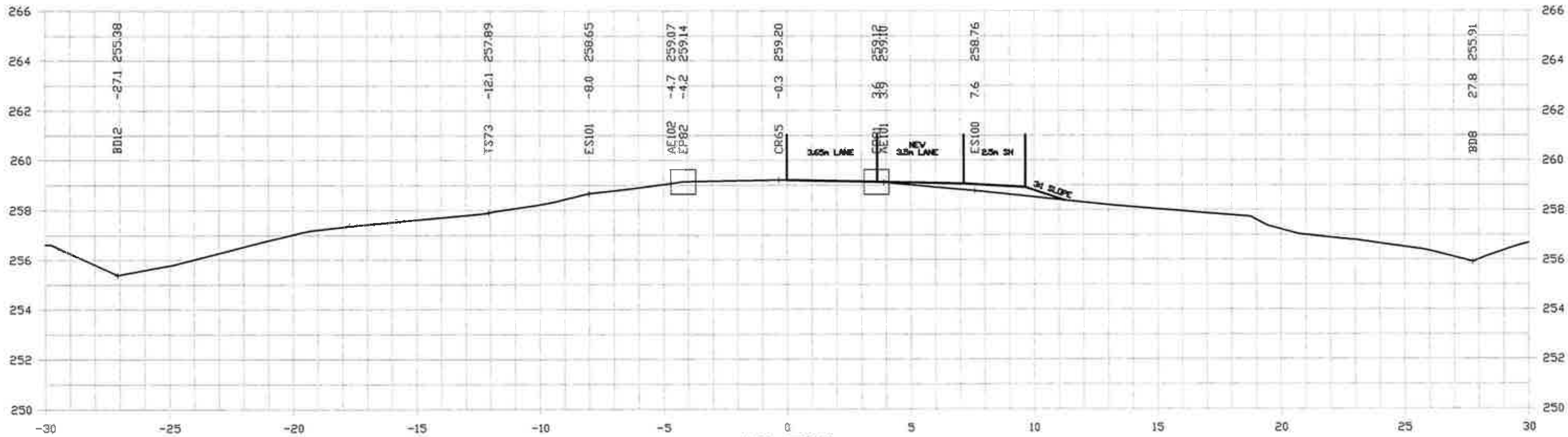

BD310 -13.1 250.74
BD311 -11.8 250.79
ES93 -7.7 251.98
AE94 -4.2 252.27
EP74 -3.7 252.32
CR61 0.1 252.41
EP73 4.0 252.32
AE93 4.3 252.28
ES92 7.7 251.89
BD305 11.8 250.49
BD304 12.8 250.48
BD46 17.6 249.71
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

12+700



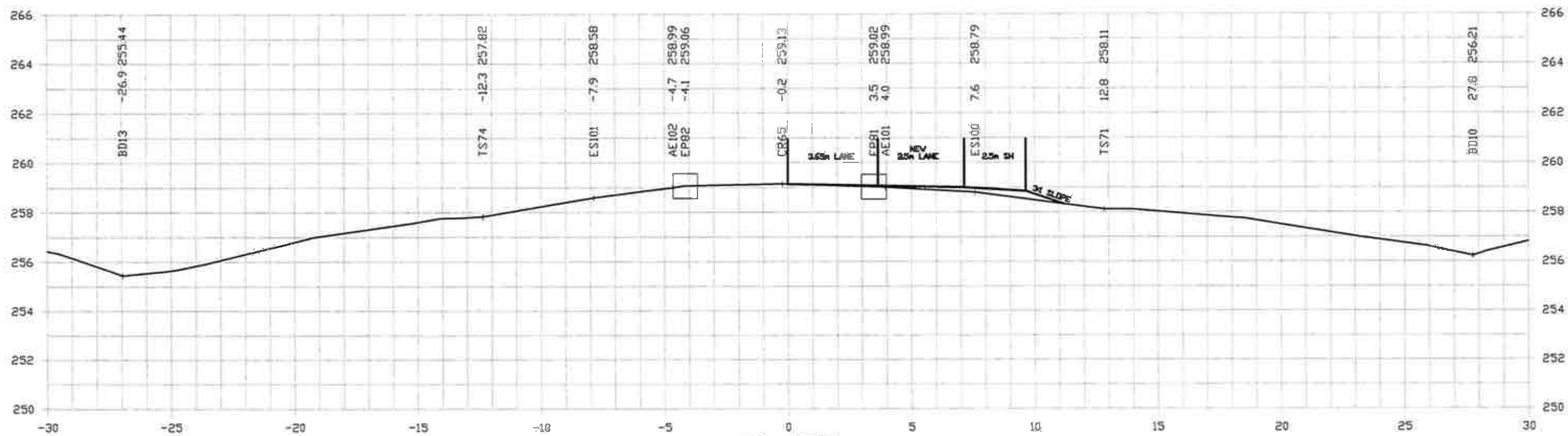
BD310 -12.7 251.77
BD311 -11.9 251.85
ES93 -7.6 252.99
AE94 -4.2 253.20
EP74 -3.7 253.25
CR61 0.1 253.36
EP73 3.9 253.27
AE93 4.2 253.24
ES92 8.0 252.86
BD305 12.3 251.54
BD304 13.2 251.57
BD46 17.7 250.96
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE
260
258
256
254
252
250
248
246
244
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30

12+750



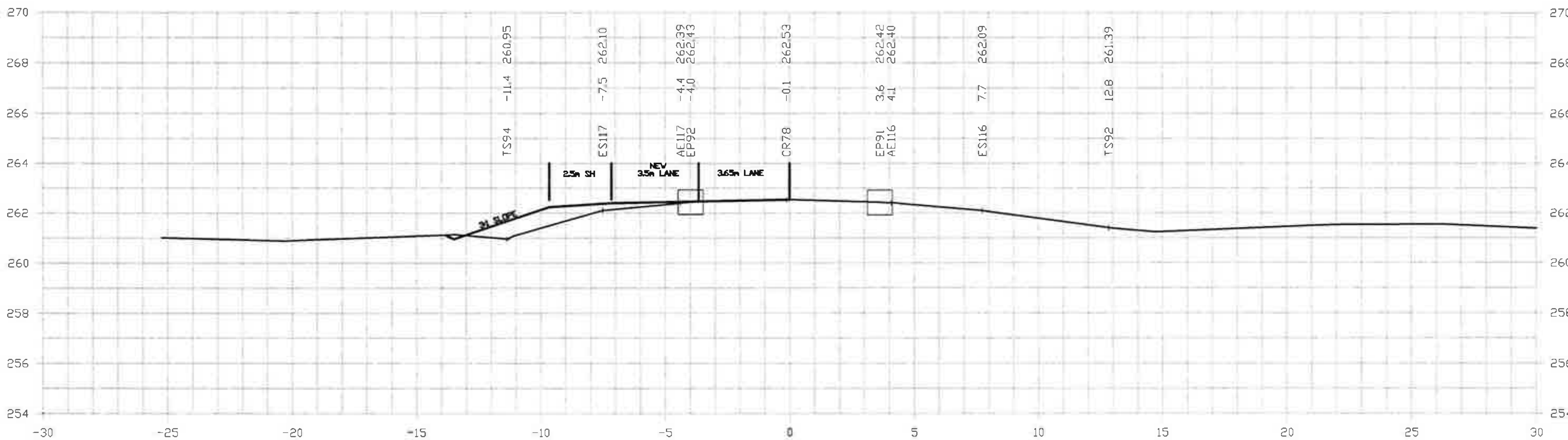
BD12 -27.1 255.38
TS73 -12.1 257.89
ES101 -8.0 258.65
AE102 EP82 -4.7 -4.2 259.07 259.14
CR65 -0.3 259.20
EP81 AE101 3.6 3.9 259.12 259.10
ES100 7.6 258.76
BD8 27.8 255.91
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

13+700

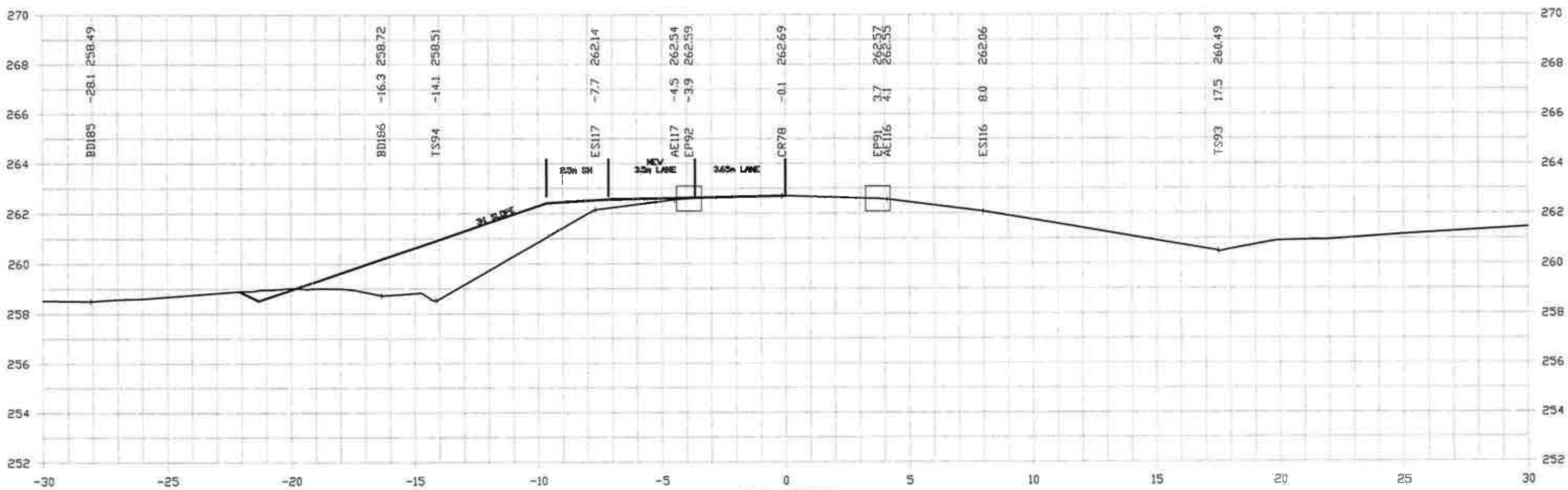


BD13 -26.9 255.44
TS74 -12.3 257.82
ES101 -7.9 258.58
AE102 EP82 -4.7 -4.1 258.99 259.06
CR65 -0.2 259.13
EP81 AE101 3.5 4.0 259.02 258.99
ES100 7.6 258.79
TS71 12.8 258.11
BD10 27.8 256.21
3.65m LANE
NEW 3.5m LANE
2.5m SH
3:1 SLOPE

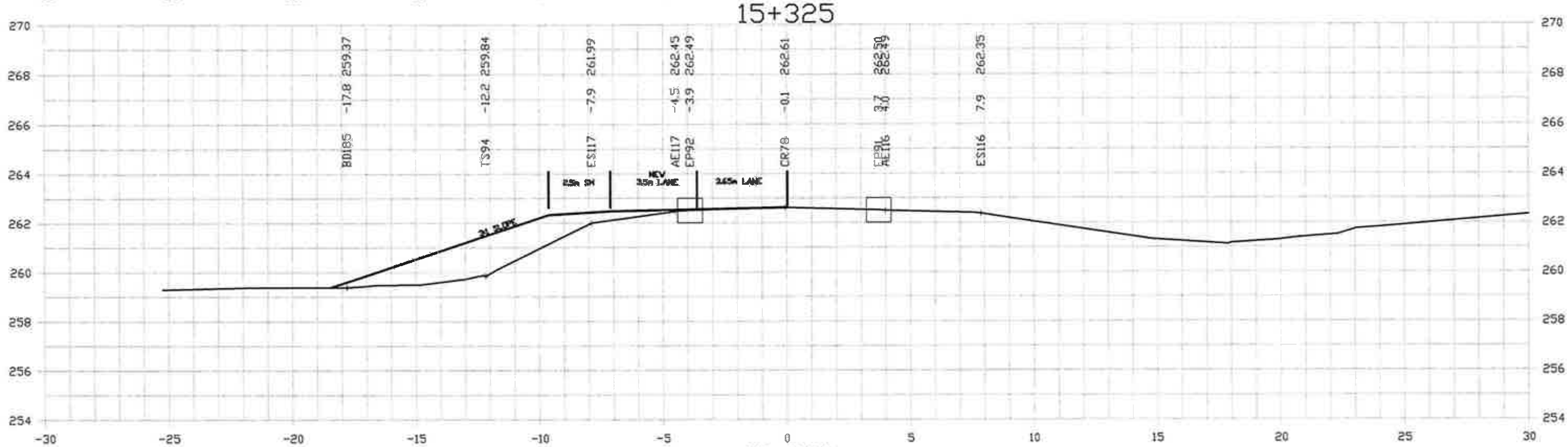
13+675


TS94 -11.4 260.95
ES117 -7.5 262.10
AE117 -4.4 262.39
EP92 -4.0 262.43
CR78 -0.1 262.53
EP91 3.6 262.42
AE116 4.1 262.40
ES116 7.7 262.09
TS92 12.8 261.39
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

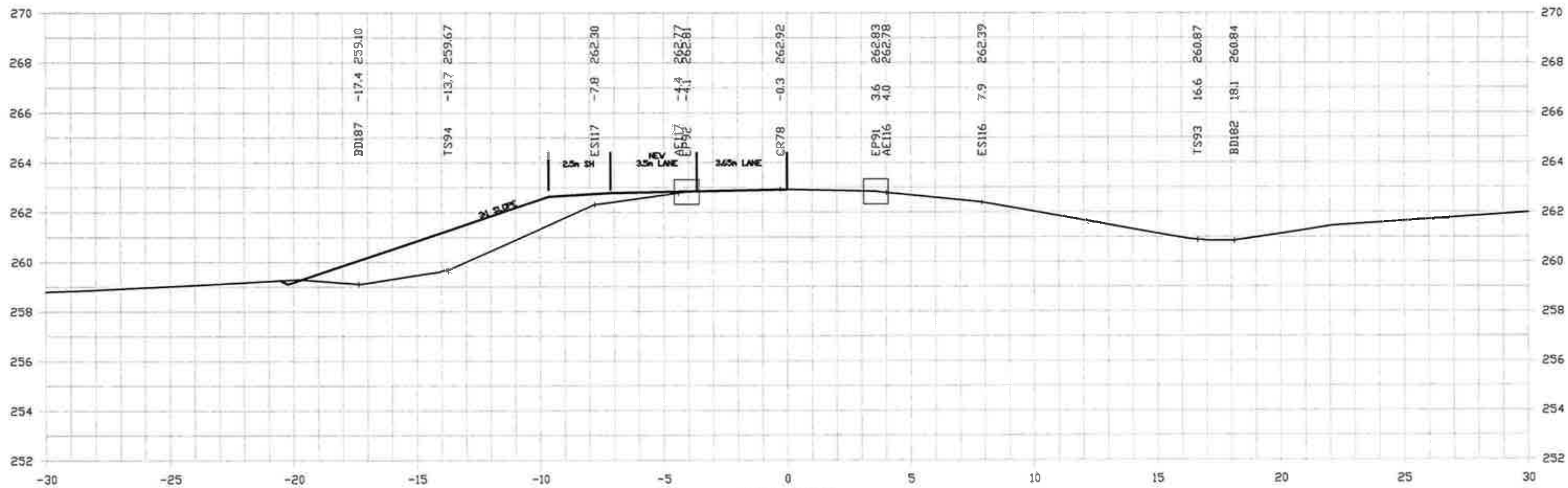
15+275


BD185 -28.1 258.49
BD186 -16.3 258.72
TS94 -14.1 258.51
ES117 -7.7 262.14
AE117 -4.5 262.54
EP92 -3.9 262.59
CR78 -0.1 262.69
EP91 3.7 262.57
AE116 4.1 262.55
ES116 8.0 262.06
TS93 17.5 260.49
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

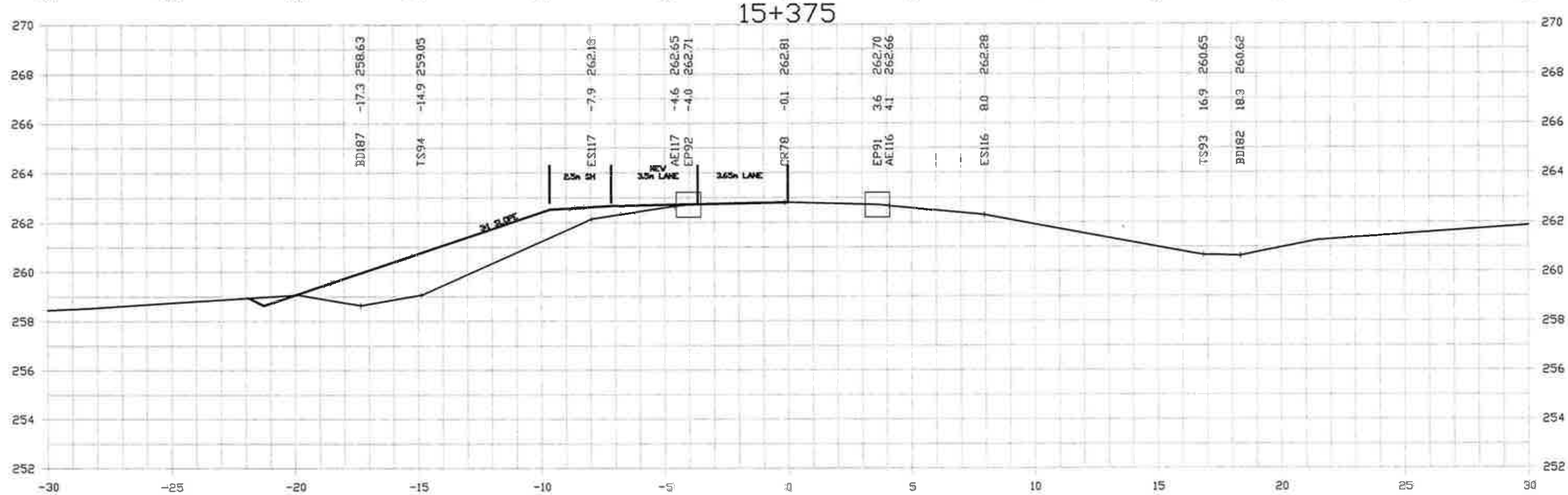
15+325


BD185 -17.8 259.37
TS94 -12.2 259.84
ES117 -7.9 261.99
AE117 -4.5 262.45
EP92 -3.9 262.49
CR78 -0.1 262.61
EP91 3.7 262.50
AE116 4.0 262.49
ES116 7.9 262.35
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

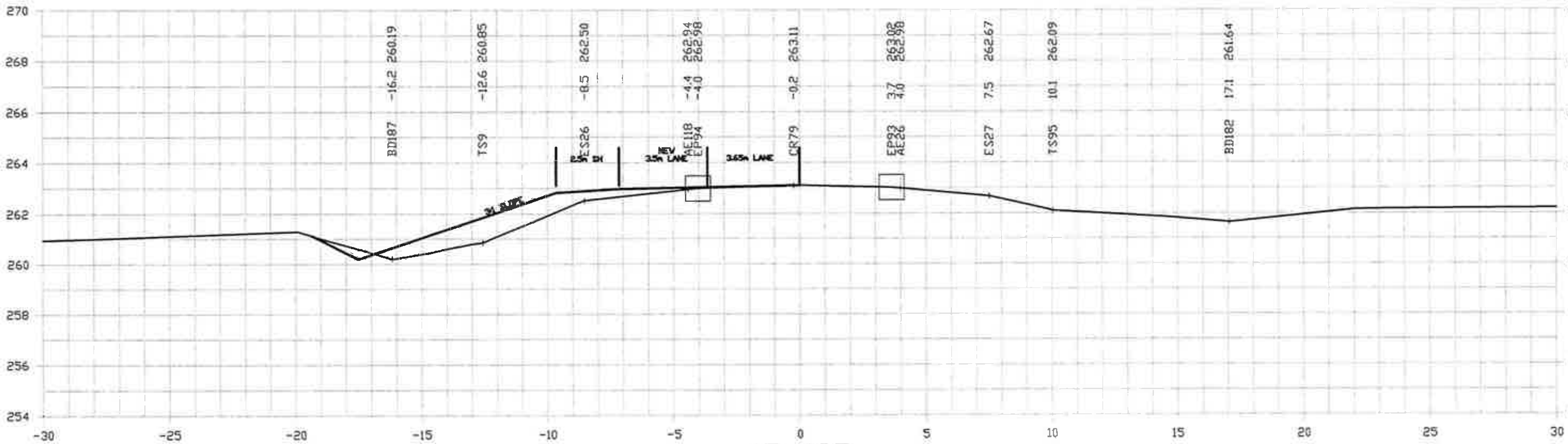
15+300


BD187 -17.4 259.10
TS94 -13.7 259.67
ES117 -7.8 262.30
AE117 EP92 -4.4 -4.1 262.77 262.81
CR78 -0.3 262.92
EP91 AE116 3.6 4.0 262.83 262.78
ES116 7.9 262.39
TS93 16.6 260.87
BD182 18.1 260.84
2.5m SH
NEV 3.5m LANE
3.65m LANE
2:1 SLOPE

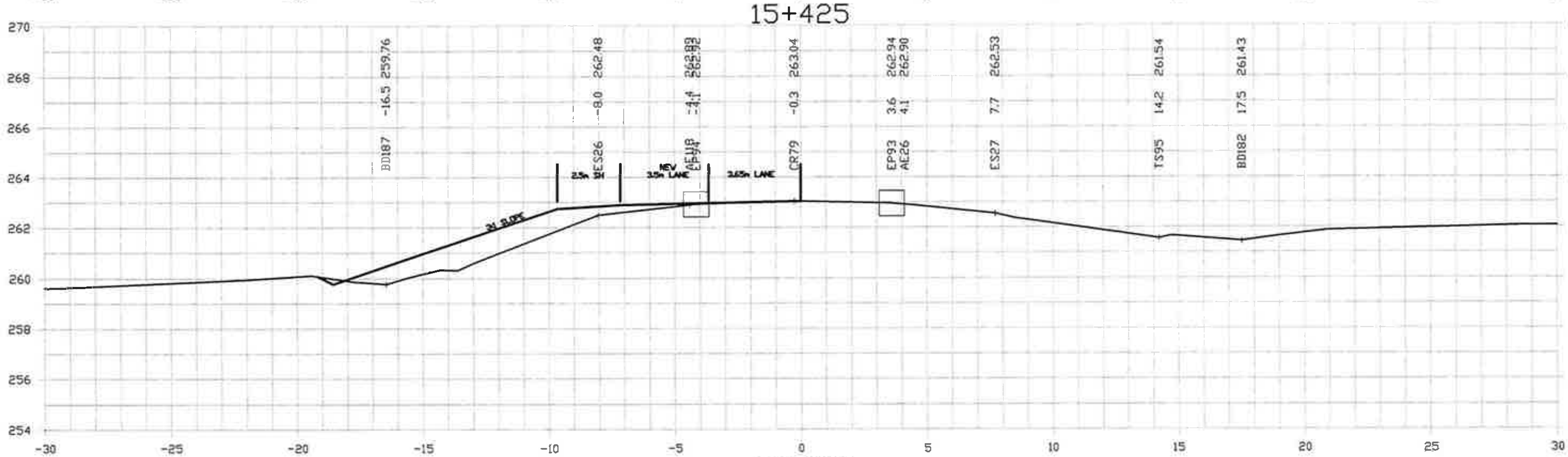
15+375


BD187 -17.3 258.63
TS94 -14.9 259.05
ES117 -7.9 262.18
AE117 EP92 -4.6 -4.0 262.65 262.71
CR78 -0.1 262.81
EP91 AE116 3.6 4.1 262.70 262.66
ES116 8.0 262.28
TS93 16.9 260.65
BD182 18.3 260.62
2.5m SH
NEV 3.5m LANE
3.65m LANE
2:1 SLOPE

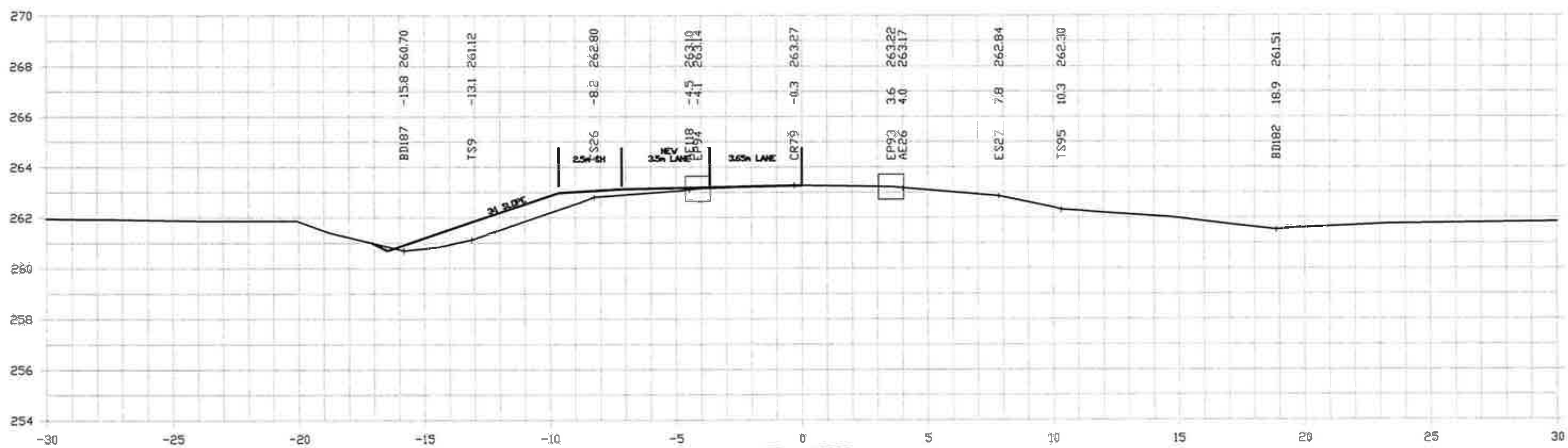
15+350


BD187 -16.2 260.19
TS9 -12.6 260.85
ES26 -8.5 262.50
AE118 EP94 -4.4 -4.0 262.94 262.98
CR79 -0.2 263.11
EP93 AE26 3.7 4.0 263.02 262.98
ES27 7.5 262.67
TS95 10.1 262.09
BD182 17.1 261.64
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

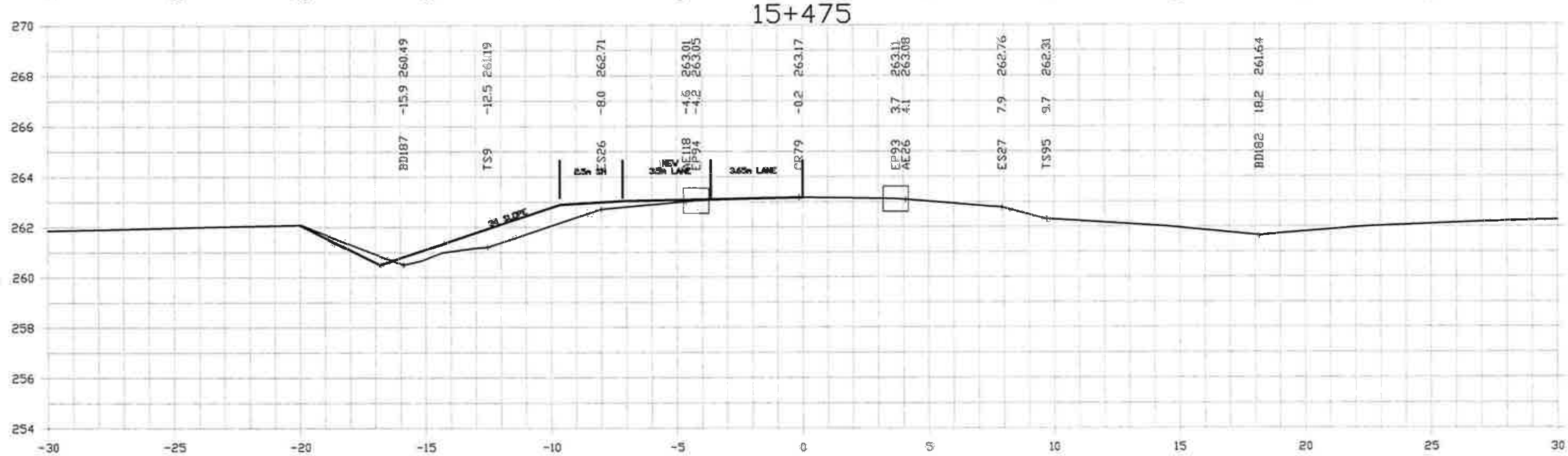
15+425


BD187 -16.5 259.76
ES26 -8.0 262.48
AE118 EP94 -4.4 -4.1 262.89 262.92
CR79 -0.3 263.04
EP93 AE26 3.6 4.1 262.94 262.90
ES27 7.7 262.53
TS95 14.2 261.54
BD182 17.5 261.43
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

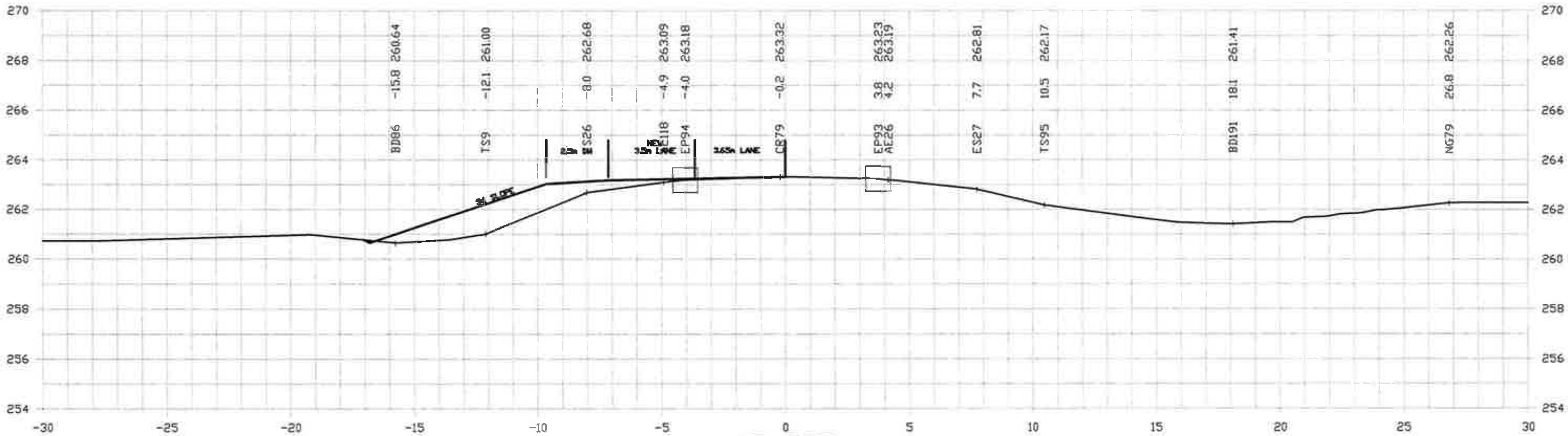
15+400


BD187 -15.8 260.70
TS9 -13.1 261.12
S26 -8.2 262.80
EF118 EP94 -4.5 -4.1 263.10 263.14
CR79 -0.3 263.27
EP93 AE26 3.6 4.0 263.22 263.17
ES27 7.8 262.84
TS95 10.3 262.30
BD182 18.9 261.51
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

15+475

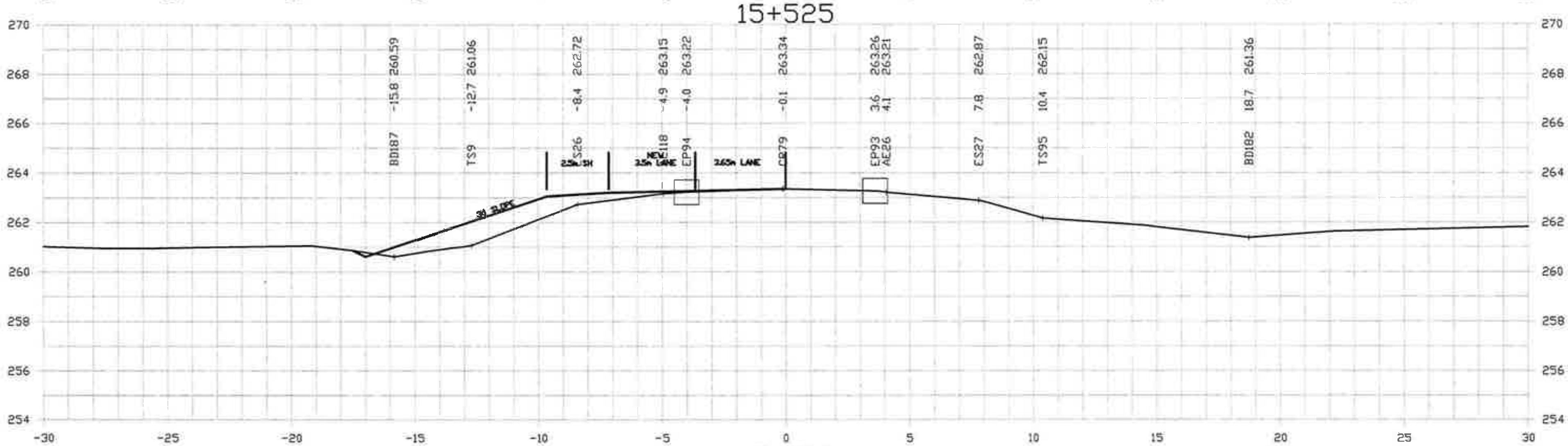

BD187 -15.9 260.49
TS9 -12.5 261.19
S26 -8.0 262.71
EF118 EP94 -4.6 -4.2 263.01 263.05
CR79 -0.2 263.17
EP93 AE26 3.7 4.1 263.11 263.08
ES27 7.9 262.76
TS95 9.7 262.31
BD182 18.2 261.64
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

15+450



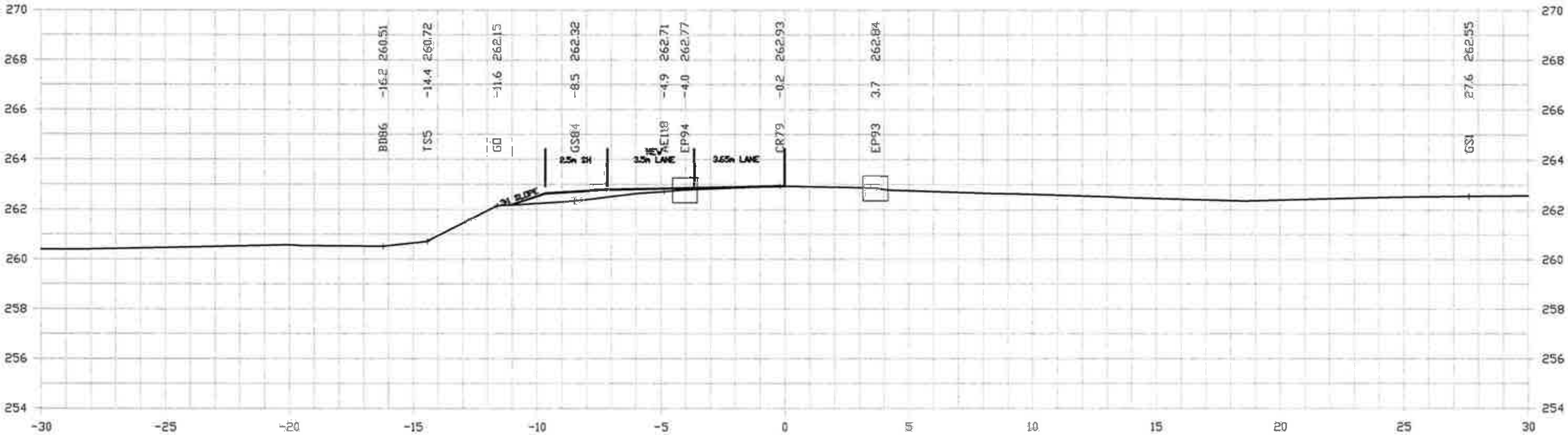
-15.8 260.64 BD86
-12.1 261.00 TS9
-8.0 262.68 S26
-4.9 263.09 E118
-4.0 263.18 EP94
-0.2 263.32 CR79
3.8 263.23 EP93
4.2 263.19 AE26
7.7 262.81 ES27
10.5 262.17 TS95
18.1 261.41 BD191
26.8 262.26 NG79
2.5m SH
NEW 3.5m LANE
3.65m LANE

15+525

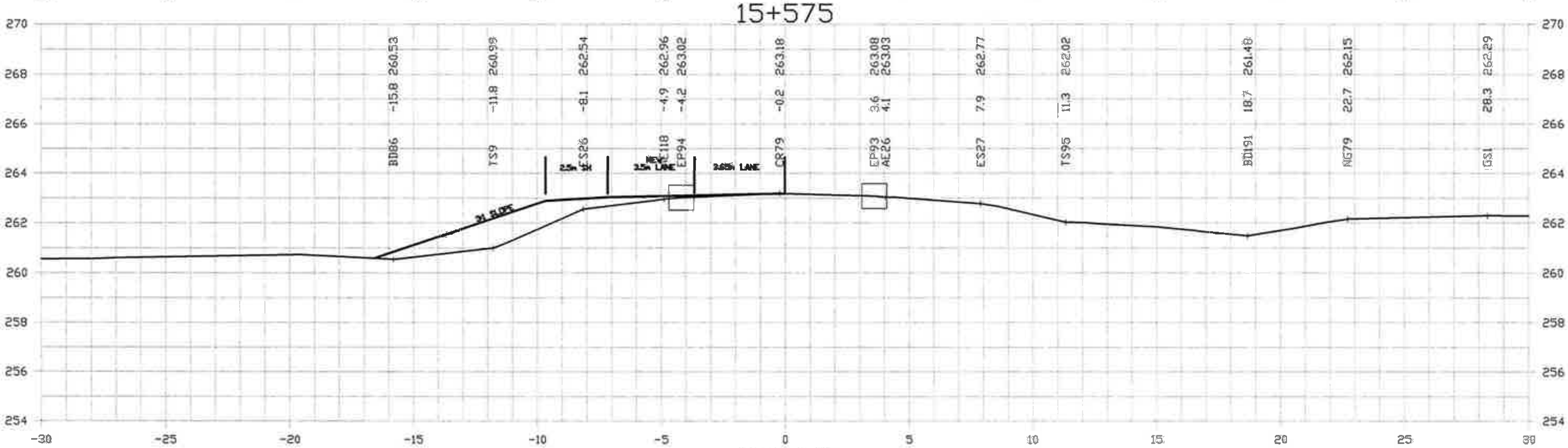


-15.8 260.59 BD187
-12.7 261.06 TS9
-8.4 262.72 S26
-4.9 263.15 E118
-4.0 263.22 EP94
-0.1 263.34 CR79
3.6 263.26 EP93
4.1 263.21 AE26
7.8 262.87 ES27
10.4 262.15 TS95
18.7 261.36 BD182
2.5m SH
NEW 3.5m LANE
3.65m LANE

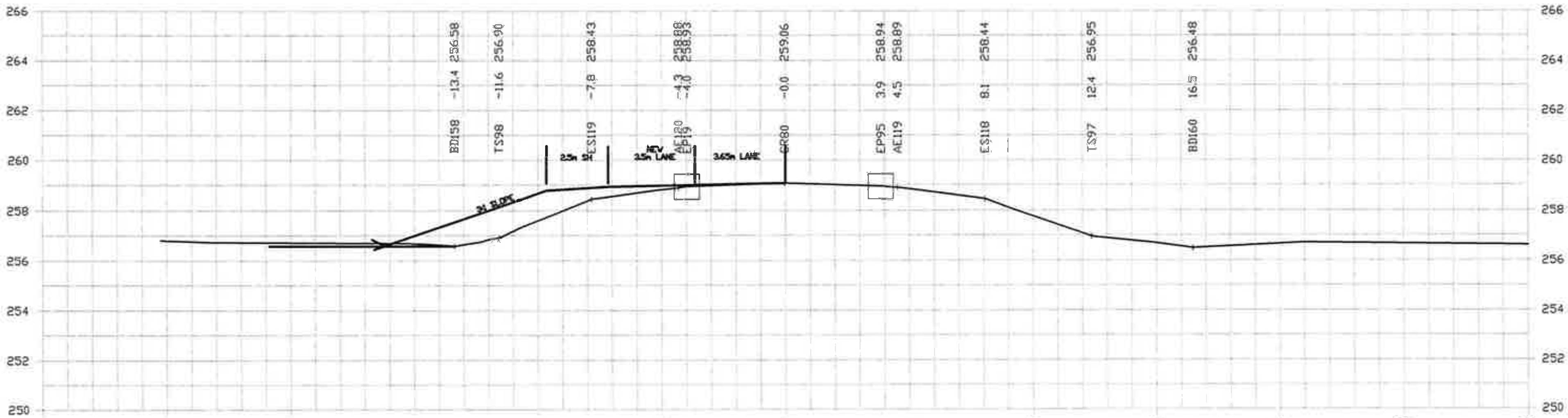
15+500


270
268
266
264
262
260
258
256
254
BD86 -16.2 260.51
TS5 -14.4 260.72
GD -11.6 262.15
GS84 -8.5 262.32
AE118 -4.9 262.71
EP94 -4.0 262.77
CR79 -0.2 262.93
EP93 3.7 262.84
GS1 27.6 262.55
2.5m SH
NEW
3.5m LANE
3.65m LANE
3:1 SLOPE
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30

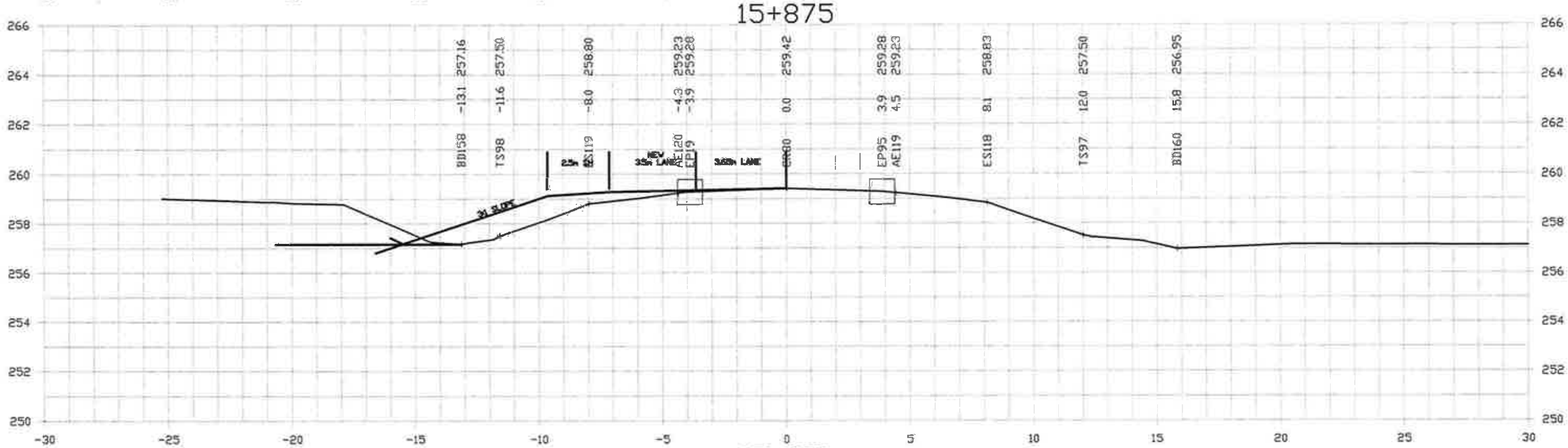
15+575


270
268
266
264
262
260
258
256
254
BD86 -15.8 260.53
TS9 -11.8 260.99
GS26 -8.1 262.54
AE118 -4.9 262.96
EP94 -4.2 263.02
CR79 -0.2 263.18
EP93 3.6 263.08
AE26 4.1 263.03
ES27 7.9 262.77
TS95 11.3 262.02
BD191 18.7 261.48
NG79 22.7 262.15
GS1 28.3 262.29
2.5m SH
NEW
3.5m LANE
3.65m LANE
3:1 SLOPE
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30

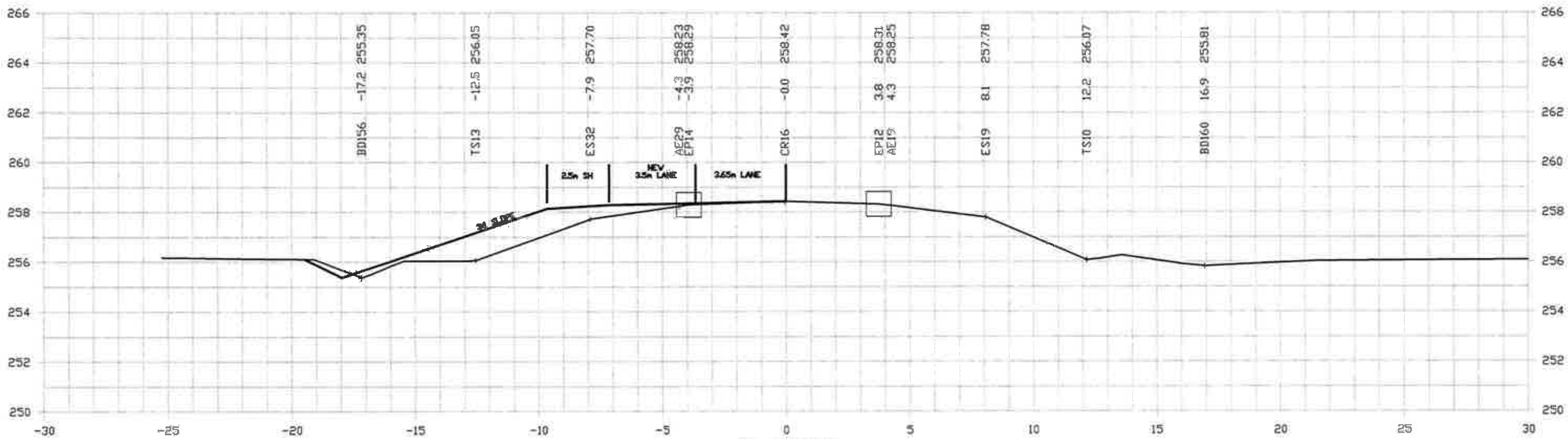
15+550


BD158 -13.4 256.58
TS98 -11.6 256.90
ES119 -7.8 258.43
AE120 -4.3 258.88
EP19 -4.0 258.93
CR80 -0.0 259.06
EP95 3.9 258.94
AE119 4.5 258.89
ES118 8.1 258.44
TS97 12.4 256.95
BD160 16.5 256.48
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

15+875

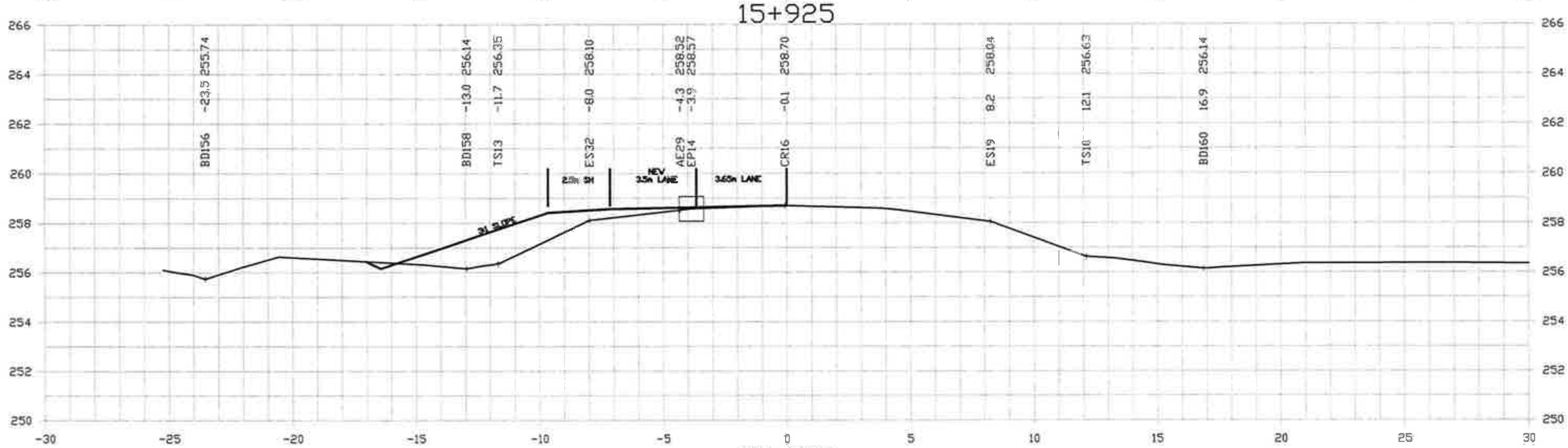

BD158 -13.1 257.16
TS98 -11.6 257.50
ES119 -8.0 258.80
AE120 -4.3 259.23
EP19 -3.9 259.28
CR80 0.0 259.42
EP95 3.9 259.28
AE119 4.5 259.23
ES118 8.1 258.83
TS97 12.0 257.50
BD160 15.8 256.95
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

15+850



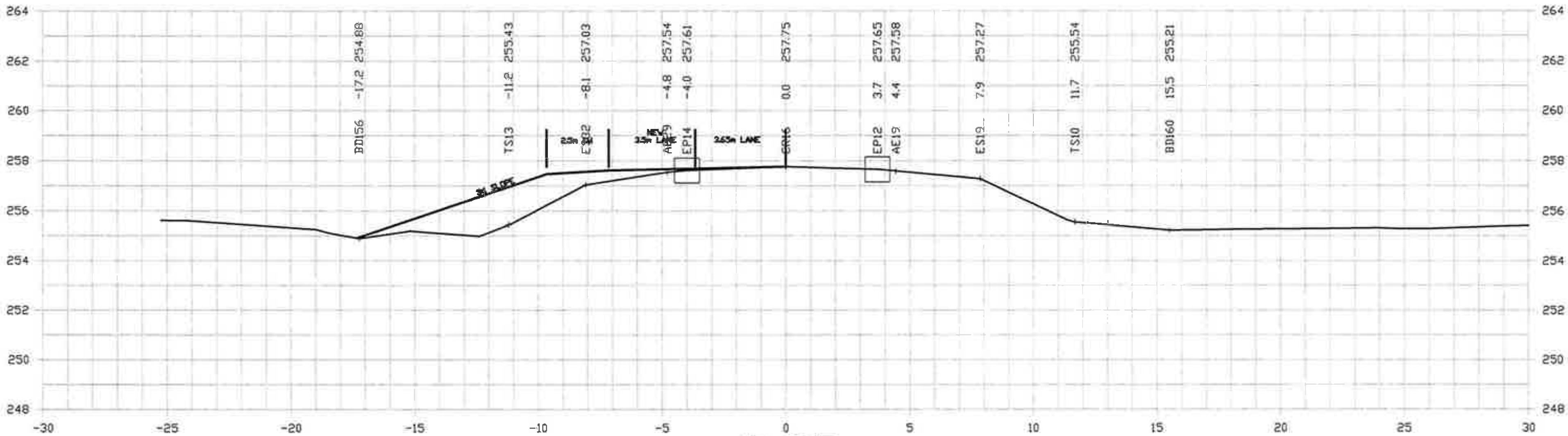
BD156 -17.2 255.35
TS13 -12.5 256.05
ES32 -7.9 257.70
AE29 -4.3 258.23
EP14 -3.9 258.29
CR16 -0.0 258.42
EP12 3.8 258.31
AE19 4.3 258.25
ES19 8.1 257.78
TS10 12.2 256.07
BD160 16.9 255.81
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

15+925

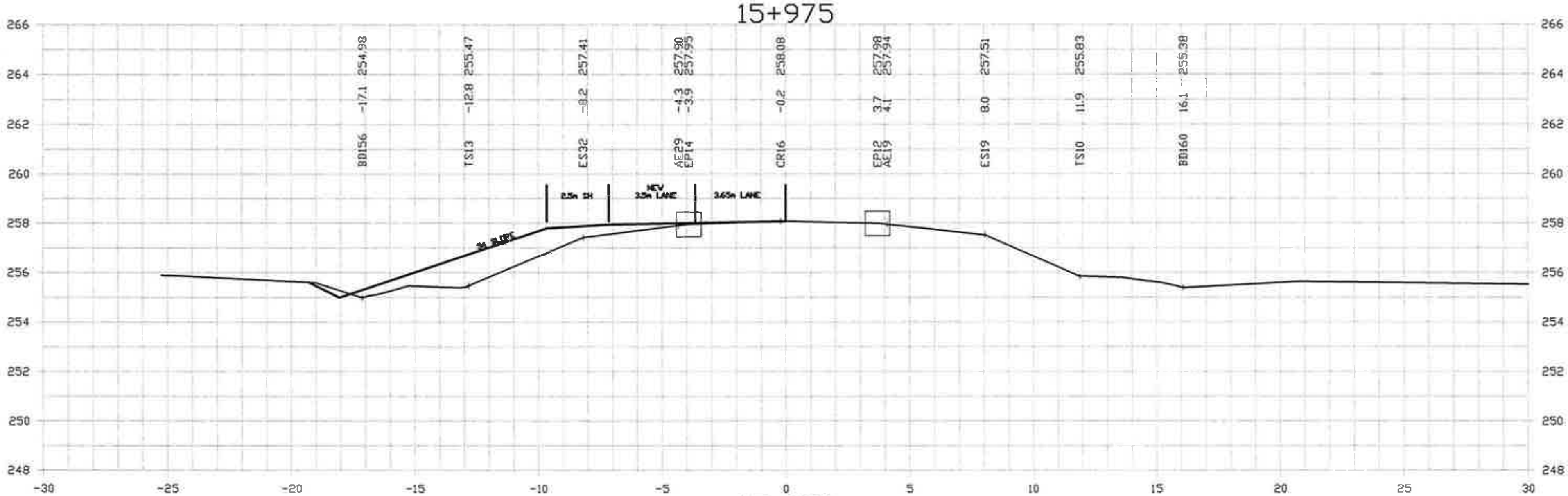


BD156 -23.5 255.74
BD158 -13.0 256.14
TS13 -11.7 256.35
ES32 -8.0 258.10
AE29 -4.3 258.52
EP14 -3.9 258.57
CR16 -0.1 258.70
ES19 8.2 258.04
TS10 12.1 256.63
BD160 16.9 256.14
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

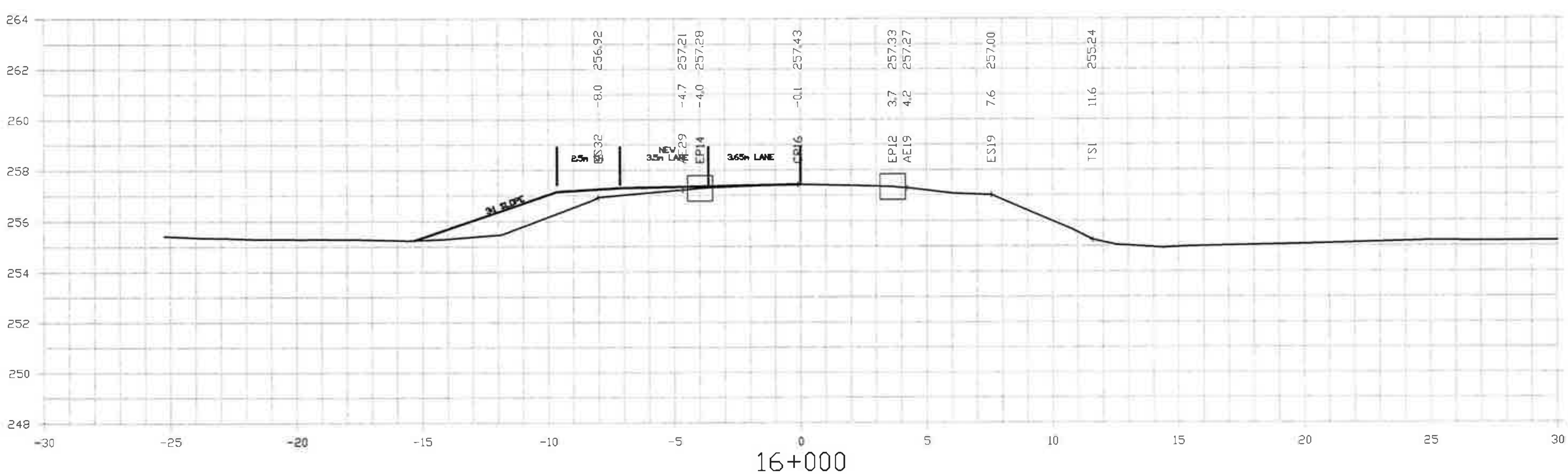
15+900


BD156 -17.2 254.88
TS13 -11.2 255.43
ES32 -8.1 257.03
AE29 -4.8 257.54
EP14 -4.0 257.61
CR16 0.0 257.75
EP12 3.7 257.65
AE19 4.4 257.58
ES19 7.9 257.27
TS10 11.7 255.54
BD160 15.5 255.21
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

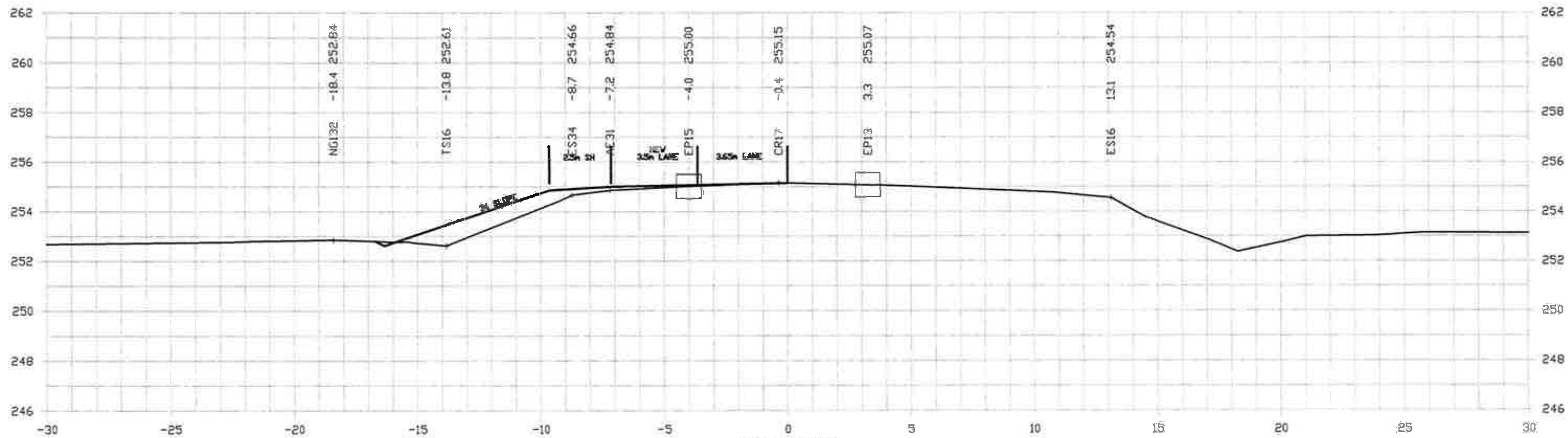
15+975


BD156 -17.1 254.98
TS13 -12.8 255.47
ES32 -8.2 257.41
AE29 -4.3 257.90
EP14 -3.9 257.95
CR16 -0.2 258.08
EP12 3.7 257.98
AE19 4.1 257.94
ES19 8.0 257.51
TS10 11.9 255.83
BD160 16.1 255.38
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

15+950

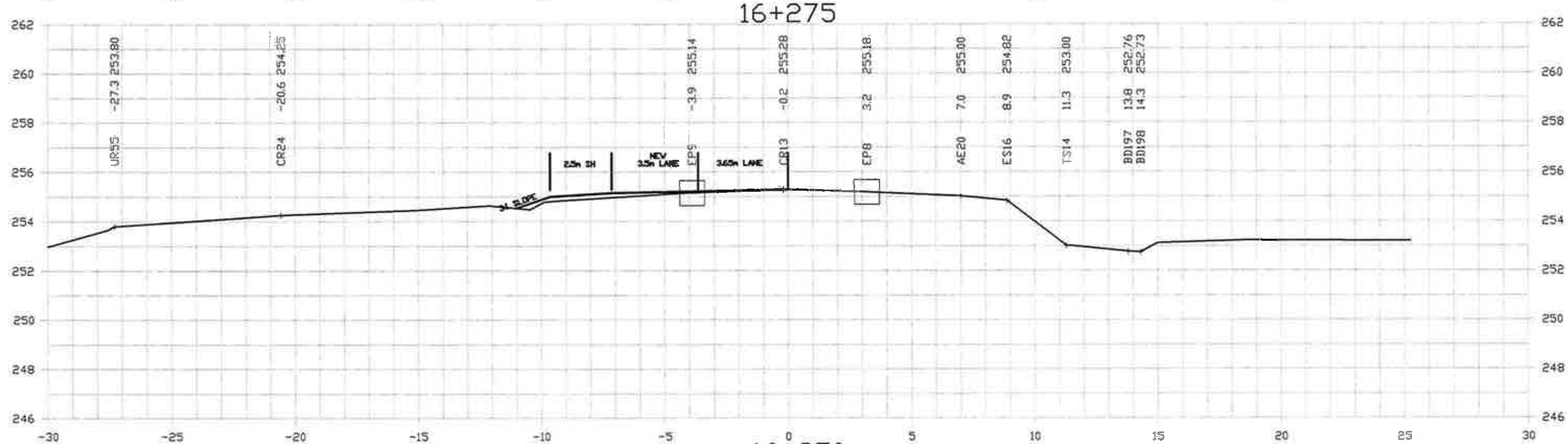


-8.0 256.92
-4.7 257.21
-4.0 257.28
-0.1 257.43
3.7 257.33
4.2 257.27
7.6 257.00
11.6 255.24
2.5m
NEW 3.5m LANE
EP14
3.65m LANE
EP12
AE19
ES19
TS1
3:1 SLOPE
16+000



NG132 -18.4 252.84
TS16 -13.8 252.61
ES34 -8.7 254.66
AE31 -7.2 254.84
EP15 -4.0 255.00
CR17 -0.4 255.15
EP13 3.3 255.07
ES16 13.1 254.54
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

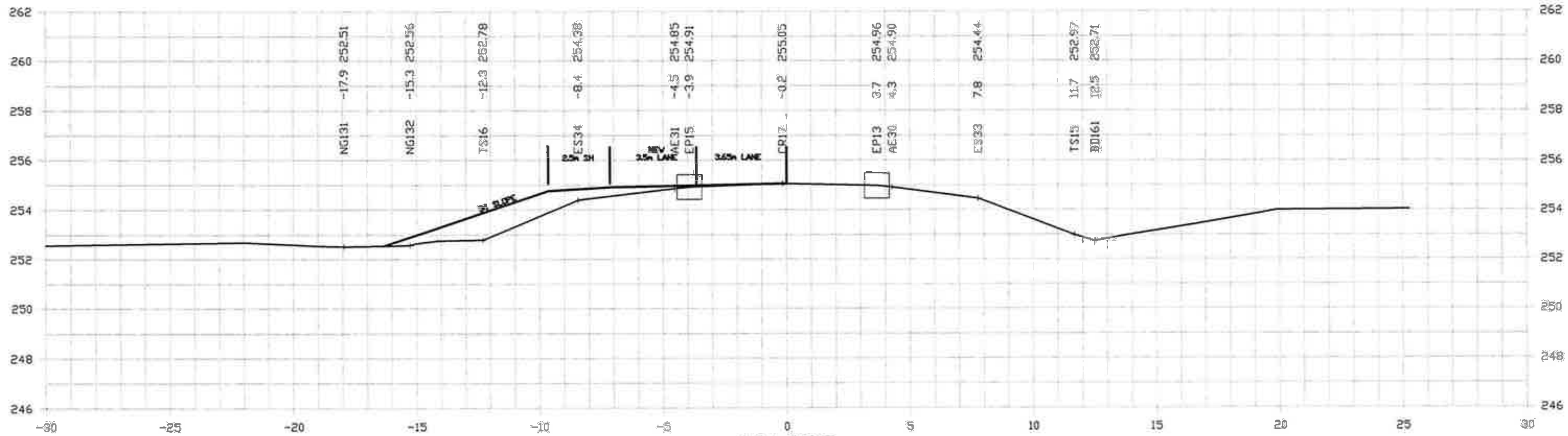
16+275



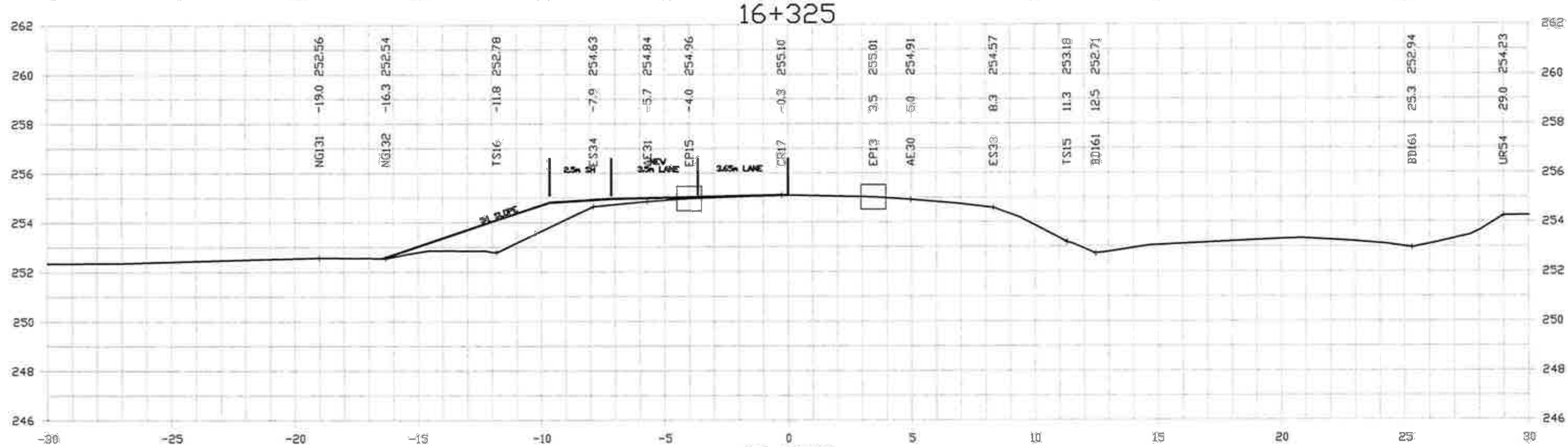
UR55 -27.3 253.80
CR24 -20.6 254.25
EP9 -3.9 255.14
CR13 -0.2 255.28
EP8 3.2 255.18
AE20 7.0 255.00
ES16 8.9 254.82
TS14 11.3 253.00
BD197 13.8 252.76
BD198 14.3 252.73
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

16+250

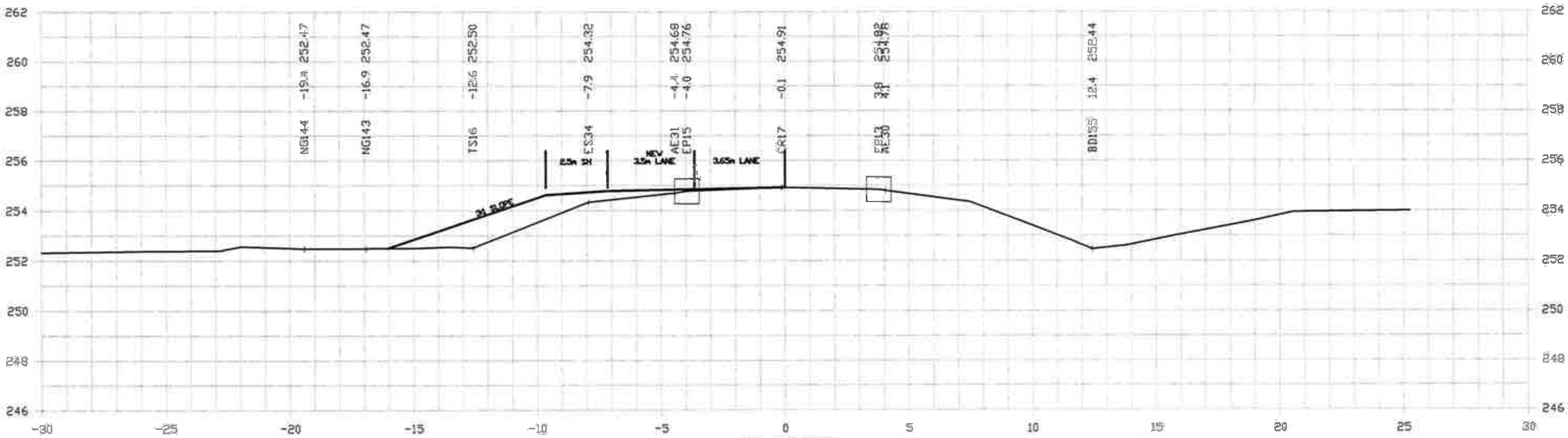
16+350



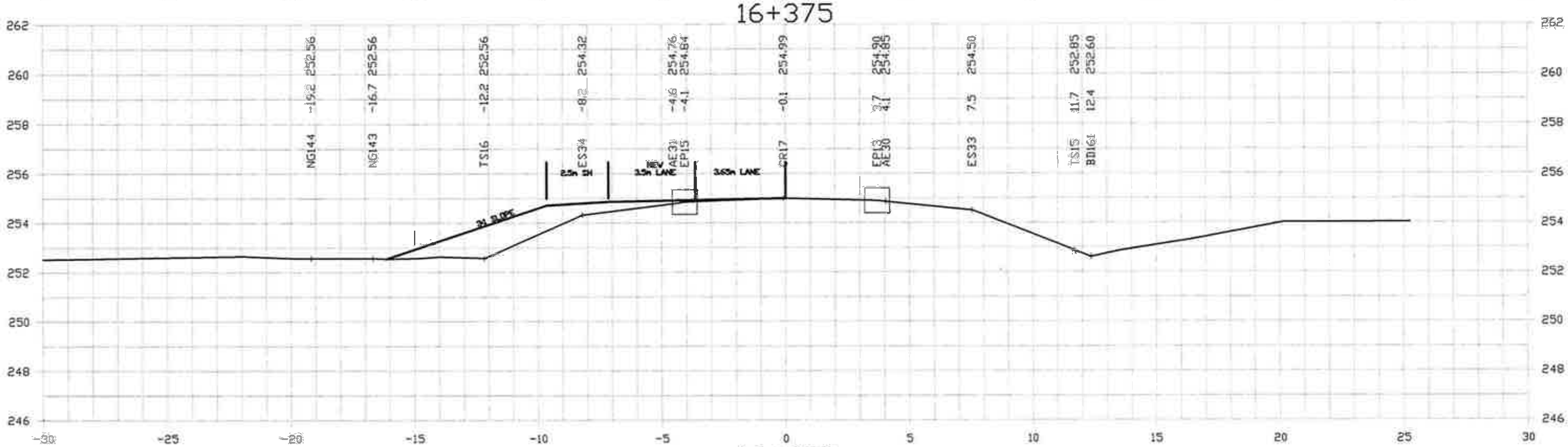
16+325



16+300

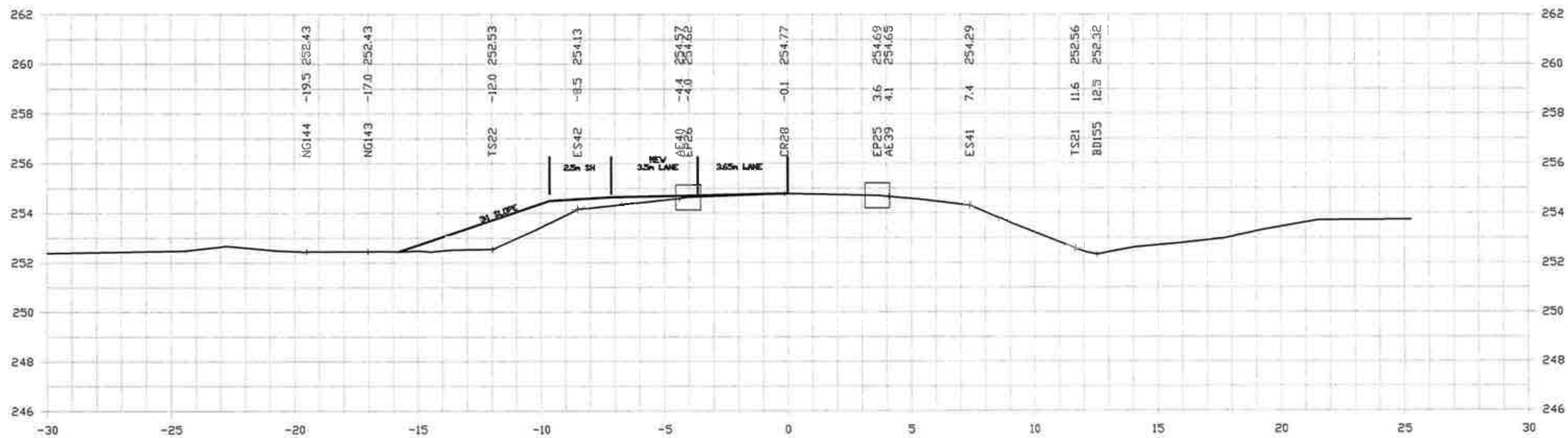


16+375

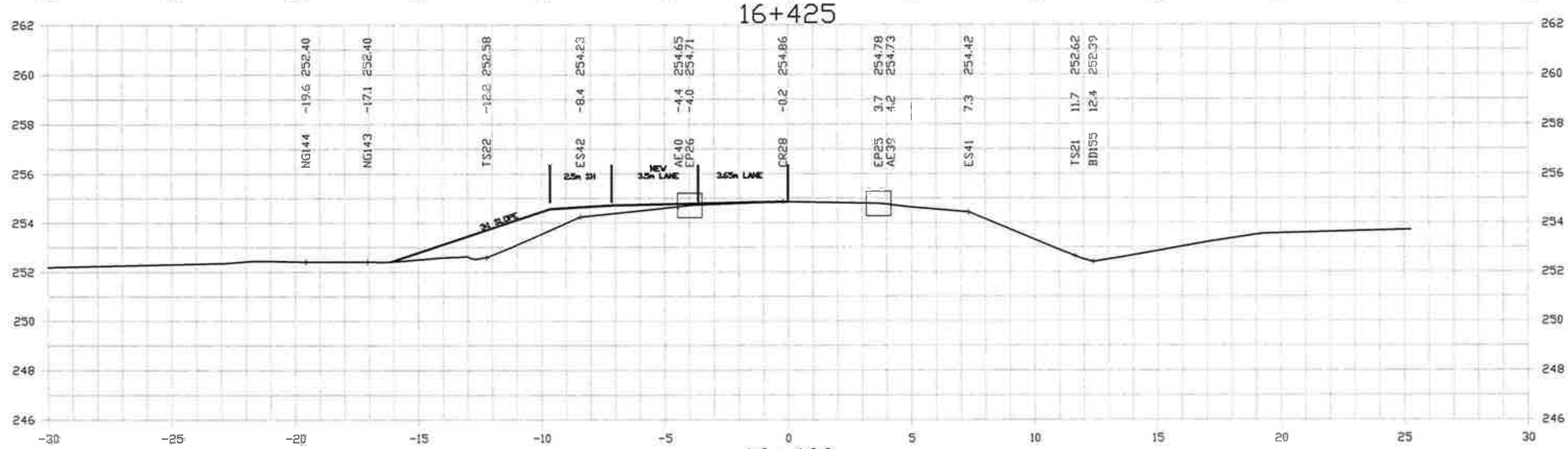


16+350

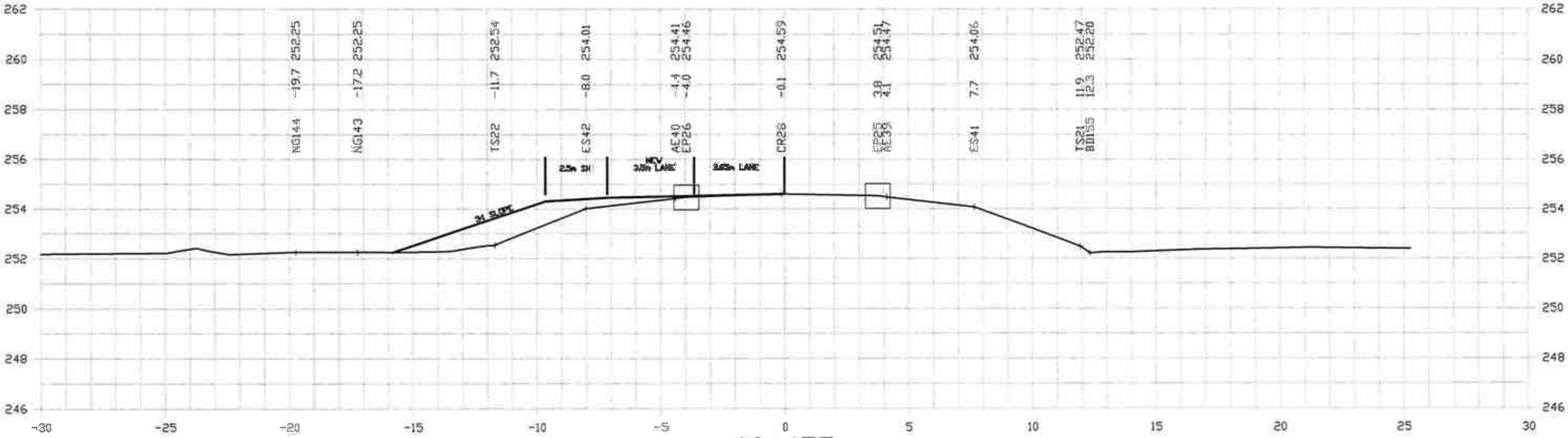
16+450



16+425

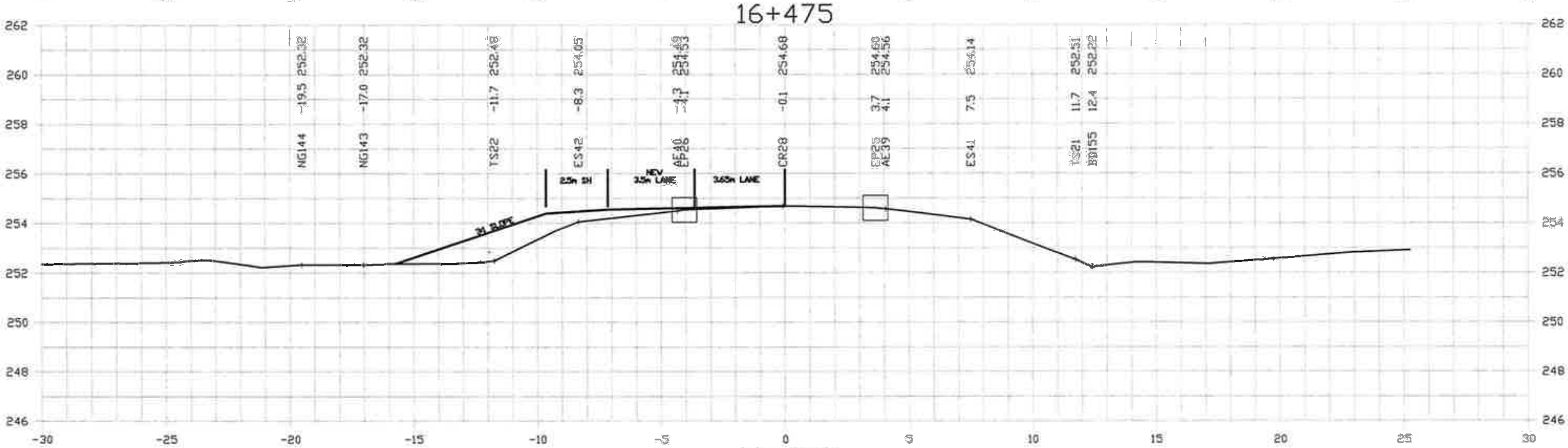


16+400



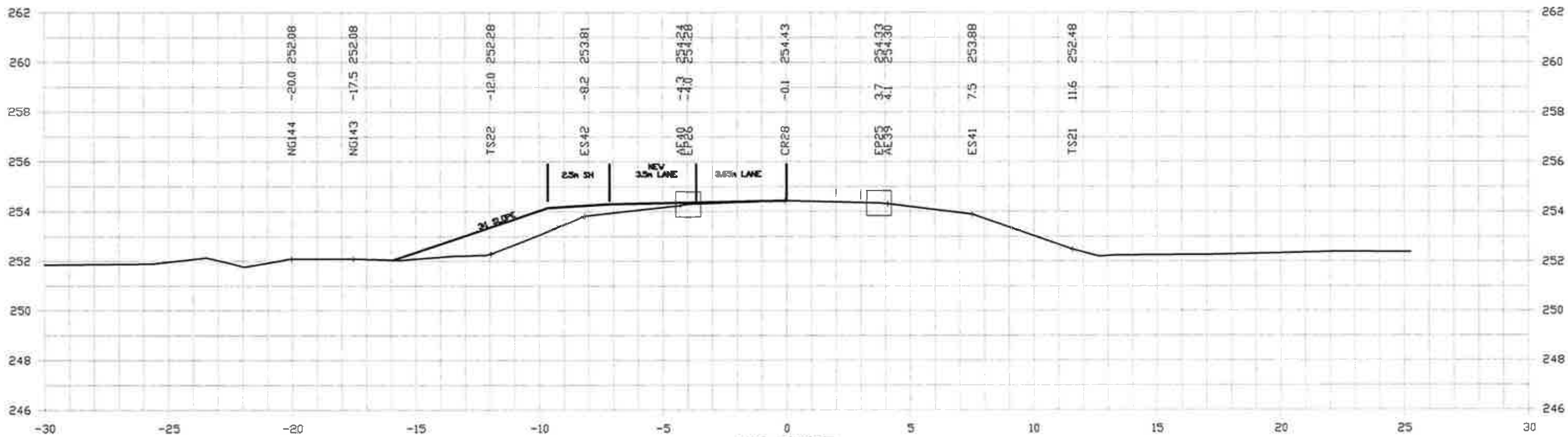
NG144 -19.7 252.25
NG143 -17.2 252.25
TS22 -11.7 252.54
ES42 -8.0 254.01
AE40 EP26 -4.4 -4.0 254.41 254.46
CR26 -0.1 254.59
EP25 AE39 3.8 4.1 254.51 254.47
ES41 7.7 254.06
TS21 BD155 11.9 12.3 252.47 252.20
2.5m SH
NEW 3.5m LANE
3.65m LANE

16+475

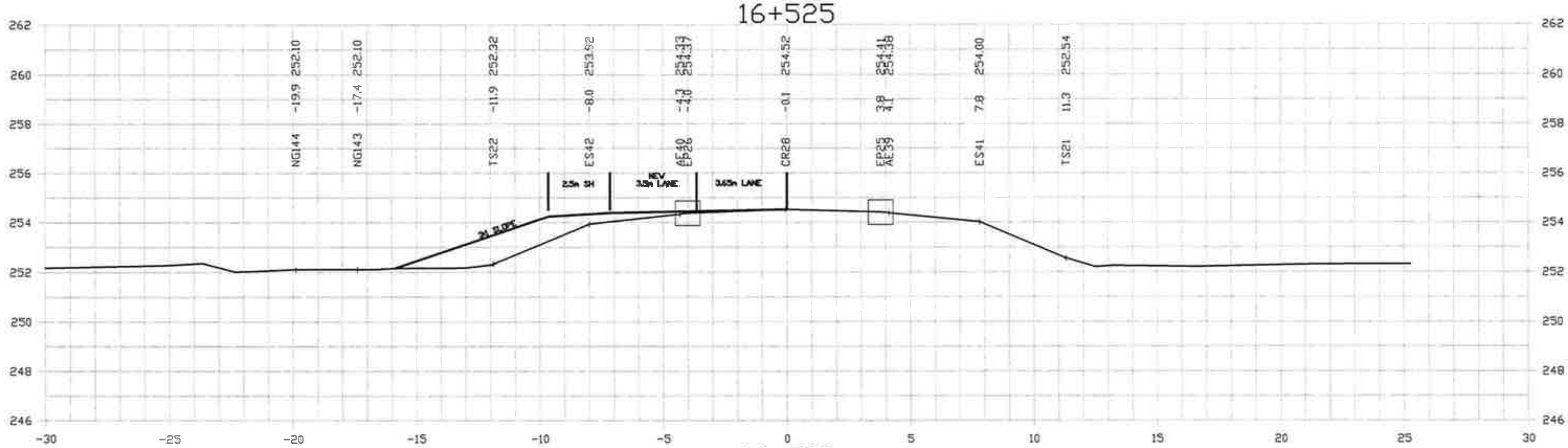


NG144 -19.5 252.32
NG143 -17.0 252.32
TS22 -11.7 252.48
ES42 -8.3 254.05
AE40 EP26 -4.3 -4.1 254.49 254.53
CR28 -0.1 254.68
EP25 AE39 3.7 4.1 254.60 254.56
ES41 7.5 254.14
TS21 BD155 11.7 12.4 252.51 252.22
2.5m SH
NEW 3.5m LANE
3.65m LANE

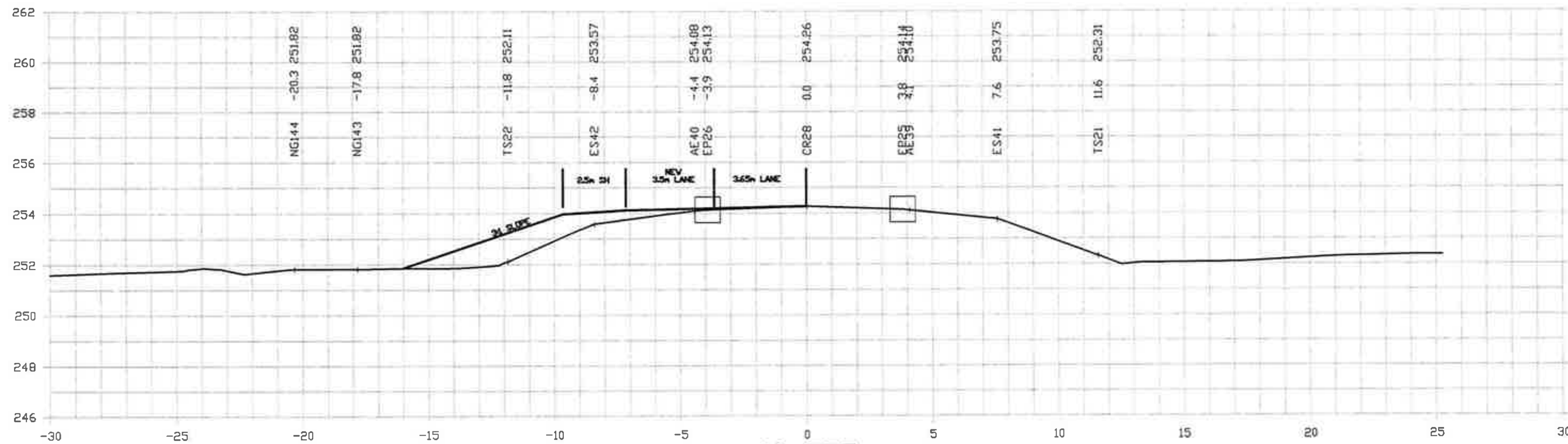
16+450


NG144 -20.0 252.08
NG143 -17.5 252.08
TS22 -12.0 252.28
ES42 -8.2 253.81
AE40 EP26 -4.3 -4.0 254.24 254.28
CR28 -0.1 254.43
EP25 AE39 3.7 4.1 254.33 254.30
ES41 7.5 253.88
TS21 11.6 252.48
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

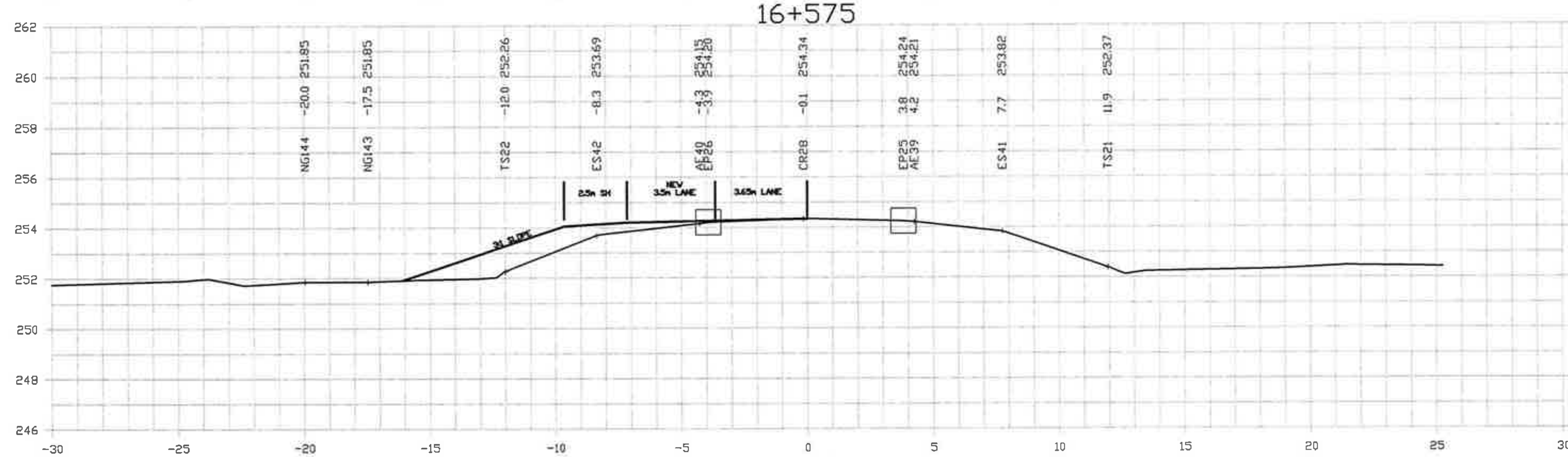
16+525


NG144 -19.9 252.10
NG143 -17.4 252.10
TS22 -11.9 252.32
ES42 -8.0 253.92
AE40 EP26 -4.3 -4.0 254.33 254.37
CR28 -0.1 254.52
EP25 AE39 3.8 4.1 254.41 254.38
ES41 7.8 254.00
TS21 11.3 252.54
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

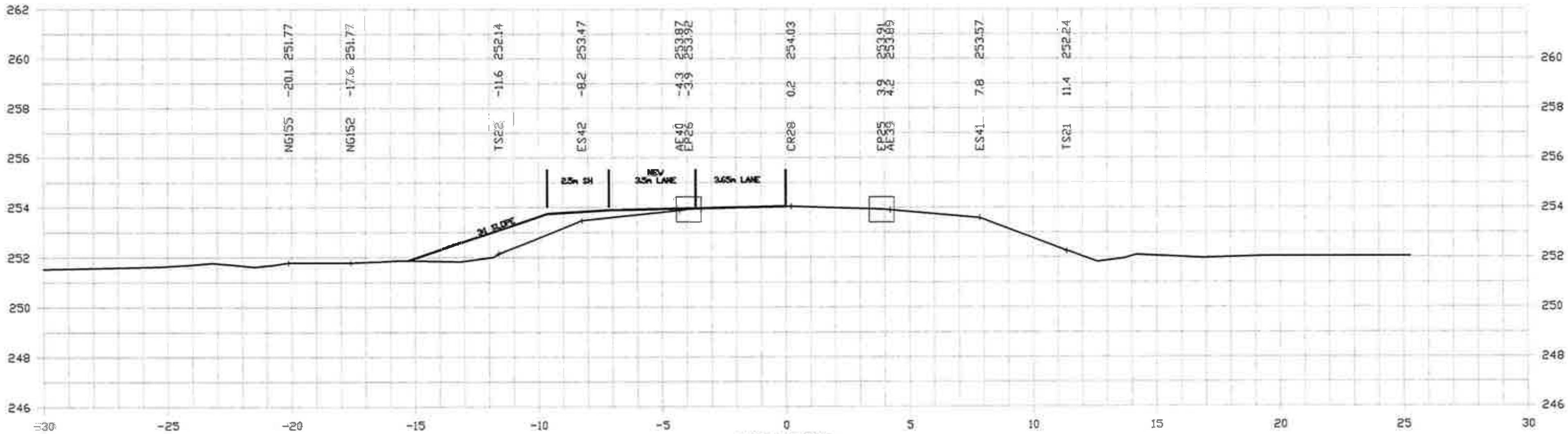
16+500


NG144 -20.3 251.82
NG143 -17.8 251.82
TS22 -11.8 252.11
ES42 -8.4 253.57
AE40 EP26 -4.4 -3.9 254.08 254.13
CR28 0.0 254.26
EP25 AE39 3.8 4.1 254.14 254.10
ES41 7.6 253.75
TS21 11.6 252.31
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

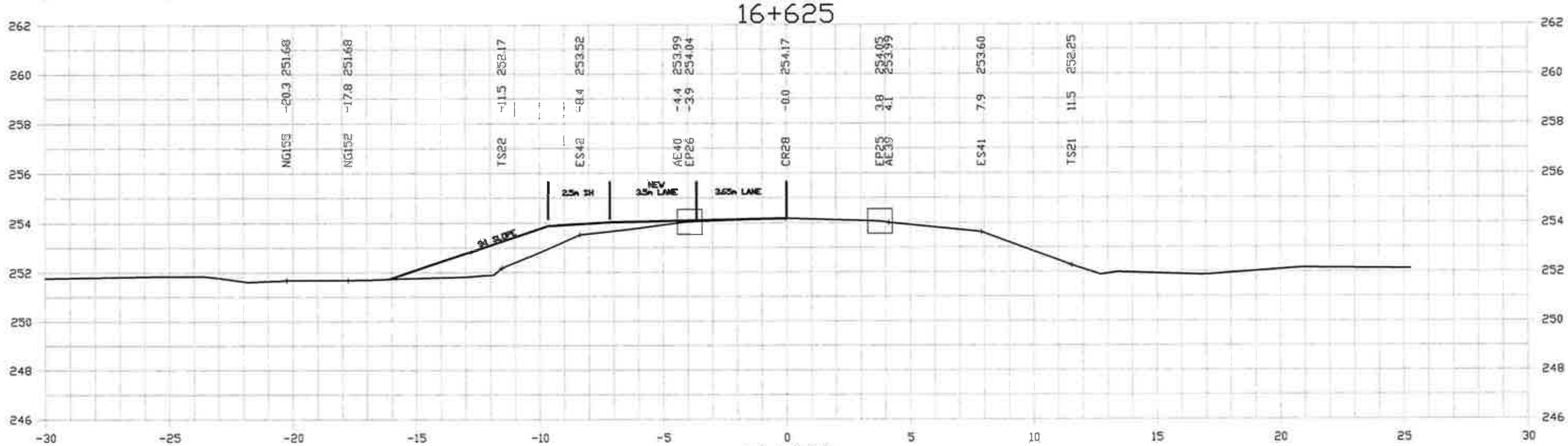
16+575


NG144 -20.0 251.85
NG143 -17.5 251.85
TS22 -12.0 252.26
ES42 -8.3 253.69
AE40 EP26 -4.3 -3.9 254.15 254.20
CR28 -0.1 254.34
EP25 AE39 3.8 4.2 254.24 254.21
ES41 7.7 253.82
TS21 11.9 252.37
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE

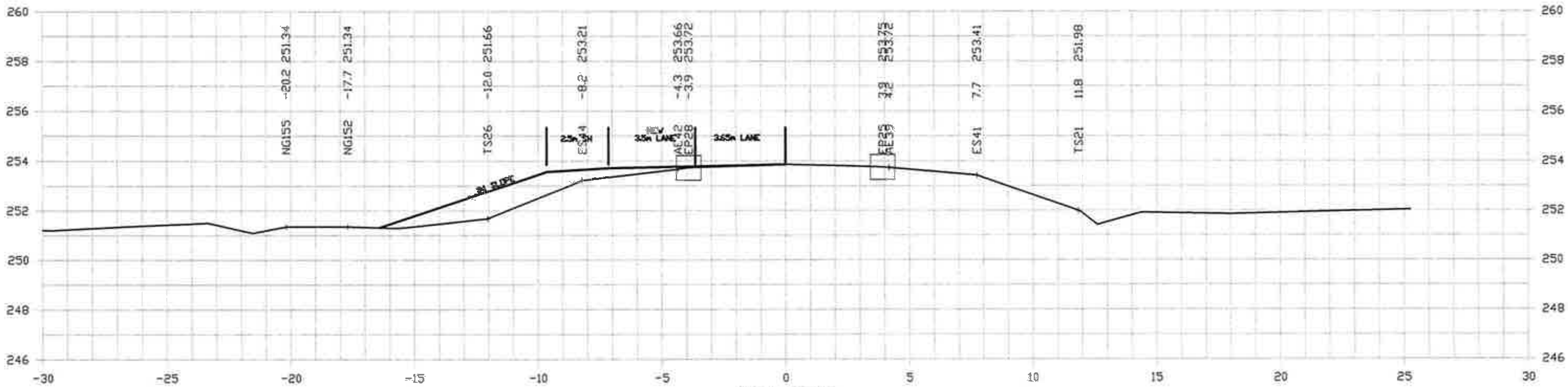
16+550


NG155 -20.1 251.77
NG152 -17.6 251.77
TS22 -11.6 252.14
ES42 -8.2 253.47
AE40 EP26 -4.3 -3.9 253.87 253.92
CR28 0.2 254.03
EP25 AE39 3.9 4.2 253.91 253.89
ES41 7.8 253.57
TS21 11.4 252.24
2.5m SH
NEW 3.5m LANE
3.65m LANE

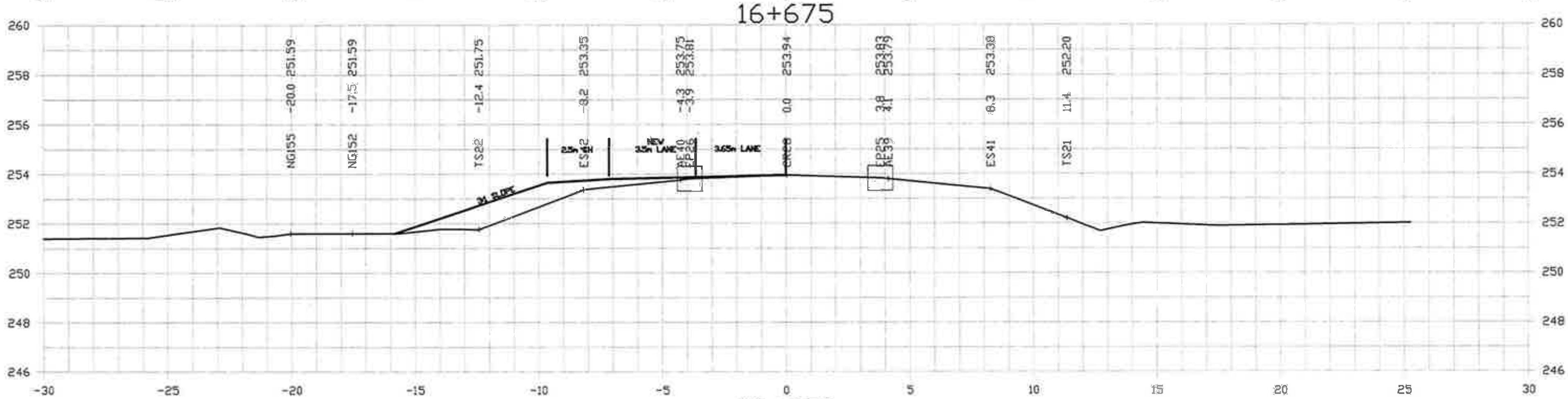
16+625


NG153 -20.3 251.68
NG152 -17.8 251.68
TS22 -11.5 252.17
ES42 -8.4 253.52
AE40 EP26 -4.4 -3.9 253.99 254.04
CR28 -0.0 254.17
EP25 AE39 3.8 4.1 254.05 253.99
ES41 7.9 253.60
TS21 11.5 252.25
2.5m SH
NEW 3.5m LANE
3.65m LANE

16+600



16+675

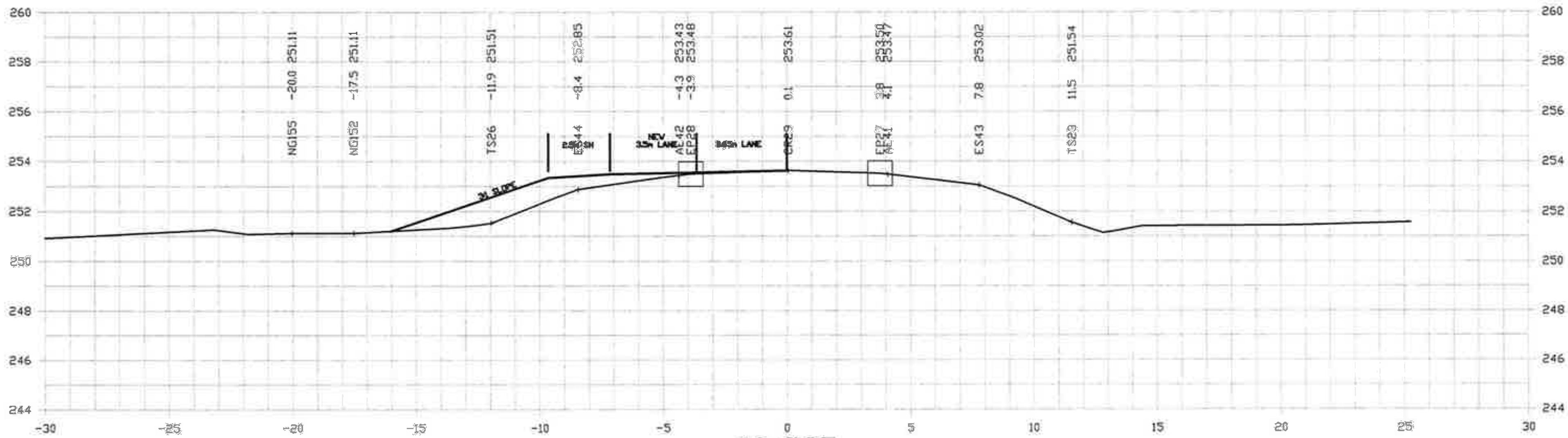


16+650

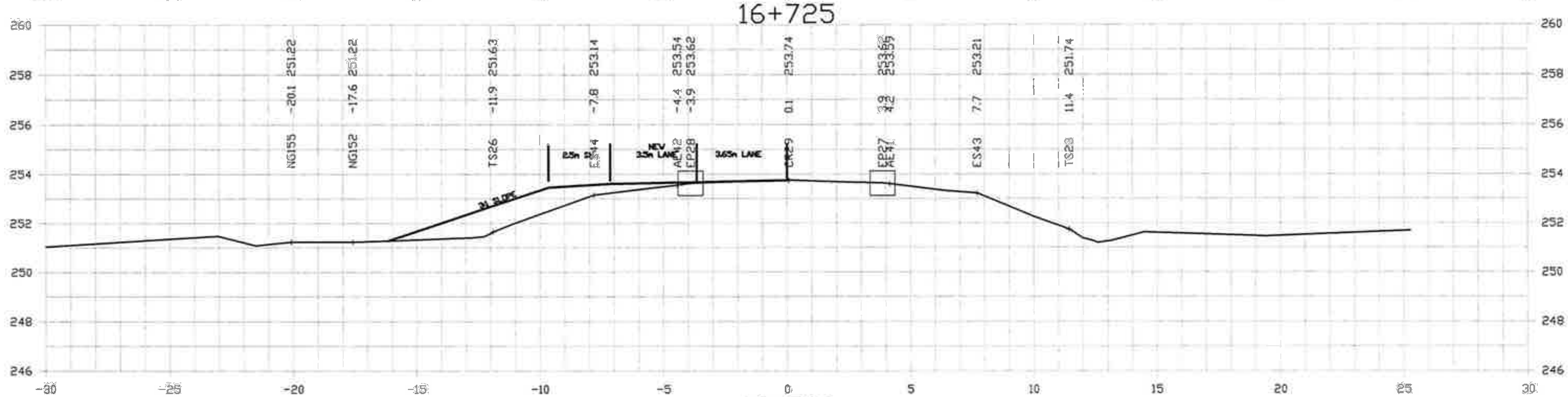
262

262

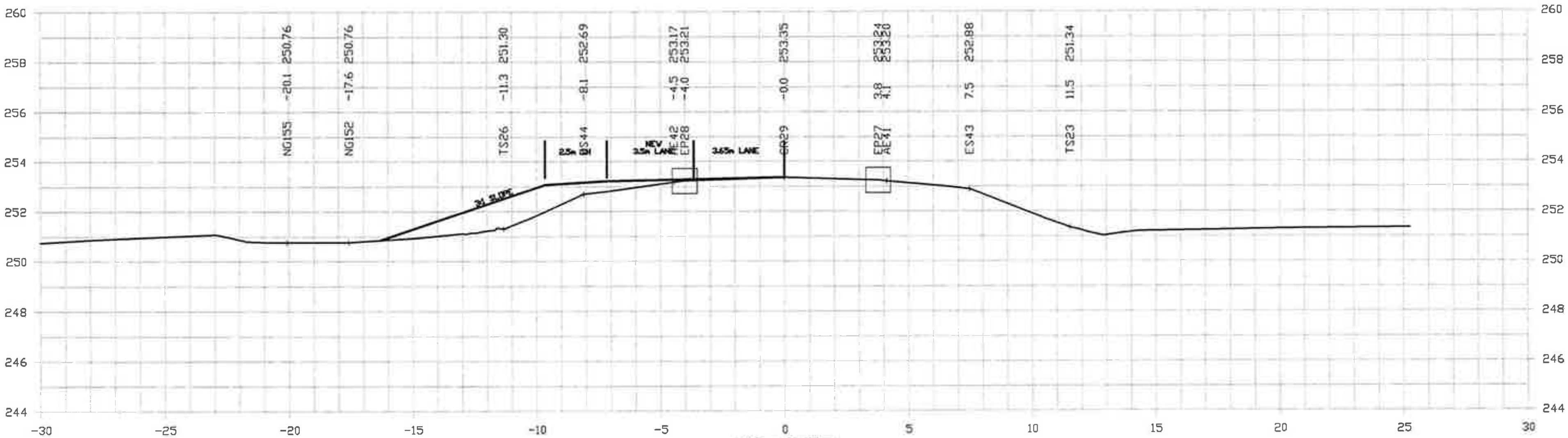
16+750



16+725

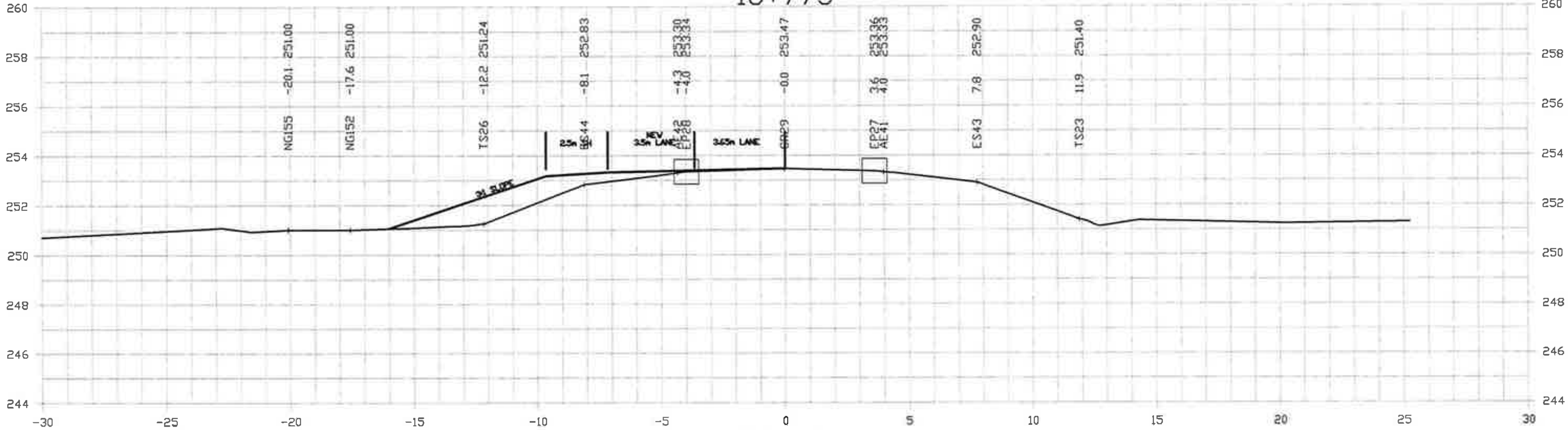


16+700



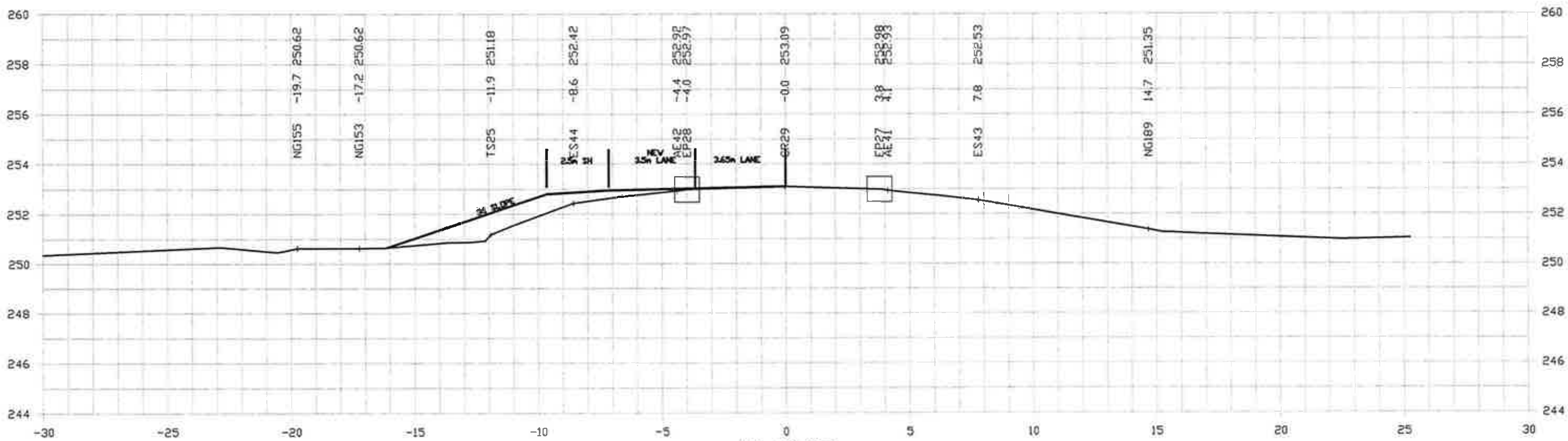
NG155 -20.1 250.76
NG152 -17.6 250.76
TS26 -11.3 251.30
ES44 -8.1 252.69
AE42 EP28 -4.5 -4.0 253.17 253.21
CR29 -0.0 253.35
EP27 AE41 3.8 4.1 253.24 253.20
ES43 7.5 252.88
TS23 11.5 251.34
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

16+775

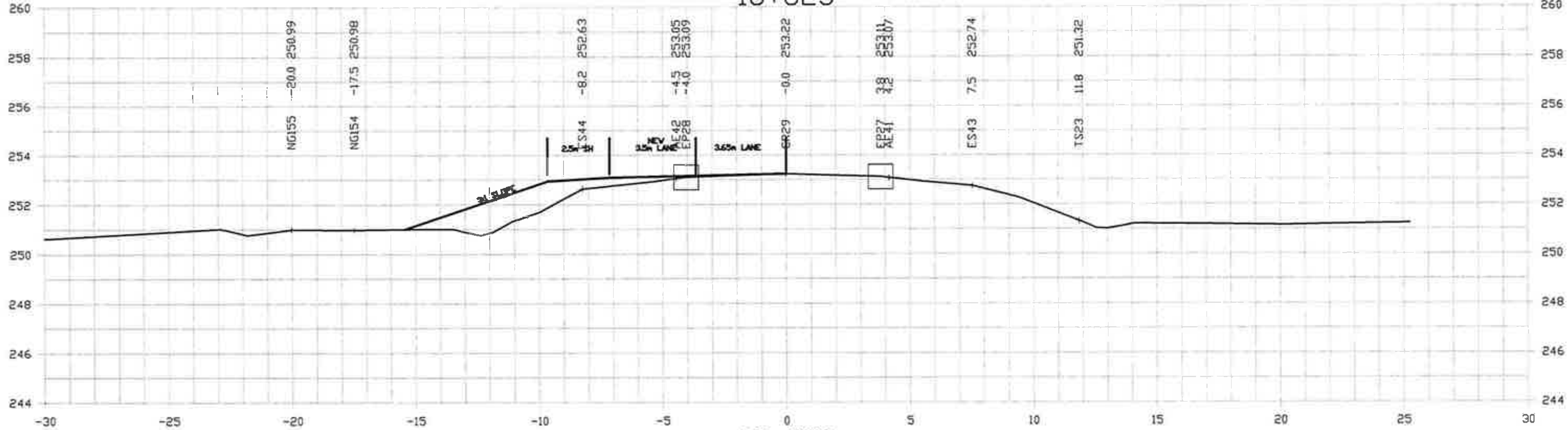


NG155 -20.1 251.00
NG152 -17.6 251.00
TS26 -12.2 251.24
ES44 -8.1 252.83
AE42 EP28 -4.3 -4.0 253.30 253.34
CR29 -0.0 253.47
EP27 AE41 3.6 4.0 253.36 253.33
ES43 7.8 252.90
TS23 11.9 251.40
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

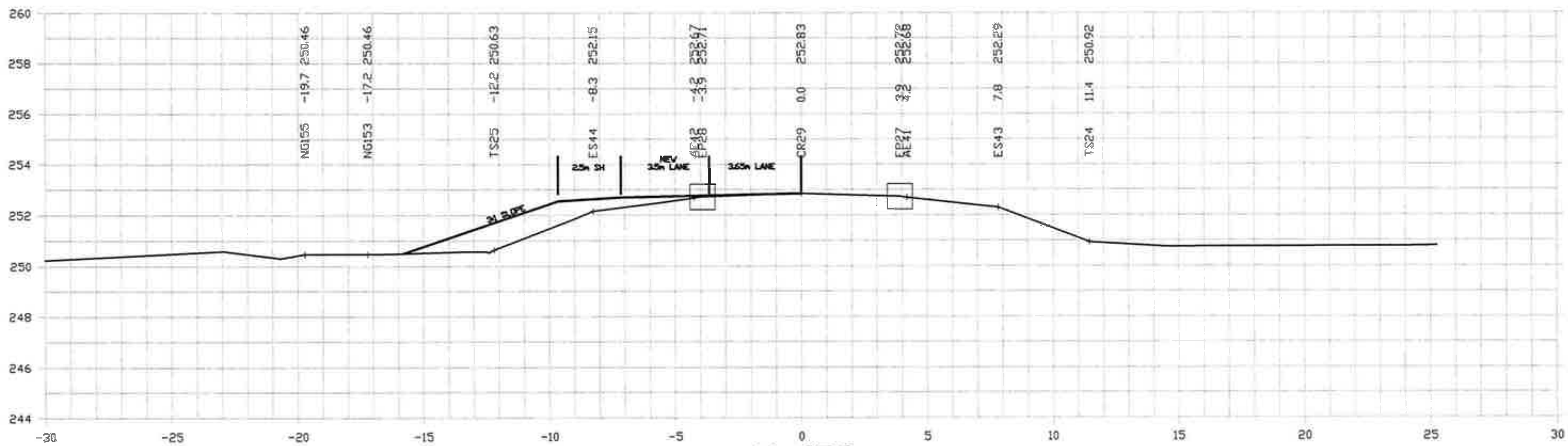
16+750


NG155 -19.7 250.62
NG153 -17.2 250.62
TS25 -11.9 251.18
ES44 -8.6 252.42
AE42 EP28 -4.4 -4.0 252.92 252.97
CR29 -0.0 253.09
EP27 AE41 3.8 4.1 252.98 252.93
ES43 7.8 252.53
NG189 14.7 251.35
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

16+825

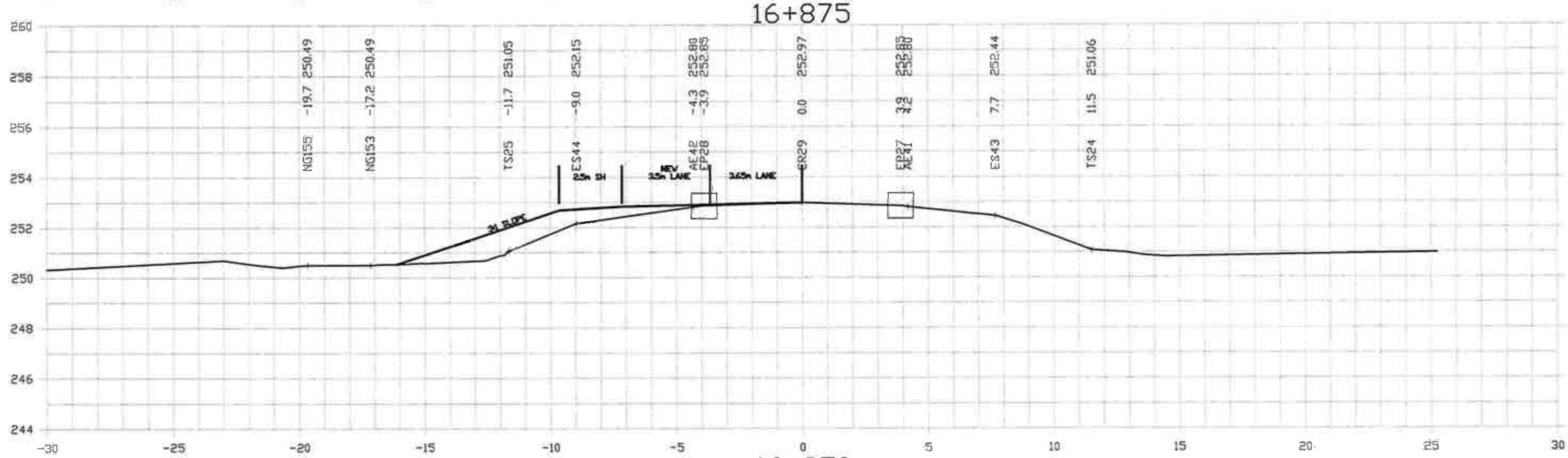

NG155 -20.0 250.99
NG154 -17.5 250.98
ES44 -8.2 252.63
AE42 EP28 -4.5 -4.0 253.05 253.09
CR29 -0.0 253.22
EP27 AE41 3.8 4.2 253.11 253.07
ES43 7.5 252.74
TS23 11.8 251.32
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

16+800



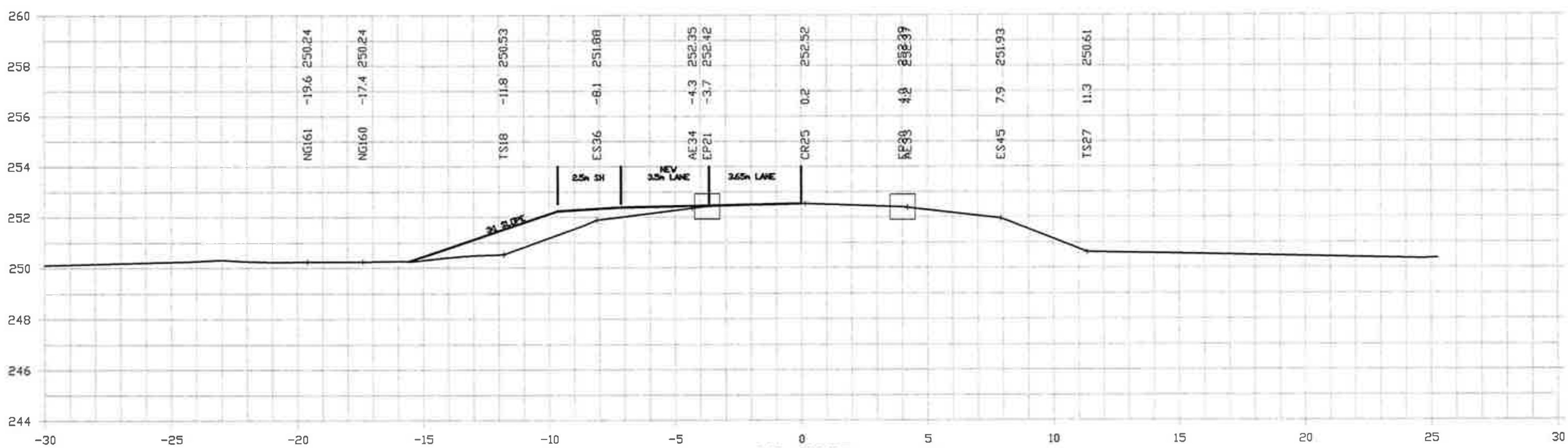
NG155 -19.7 250.46
NG153 -17.2 250.46
TS25 -12.2 250.63
ES44 -8.3 252.15
AE42 EP28 -4.3 -3.9 252.67 252.71
CR29 0.0 252.83
EP27 AE41 3.9 4.2 252.72 252.68
ES43 7.8 252.29
TS24 11.4 250.92
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

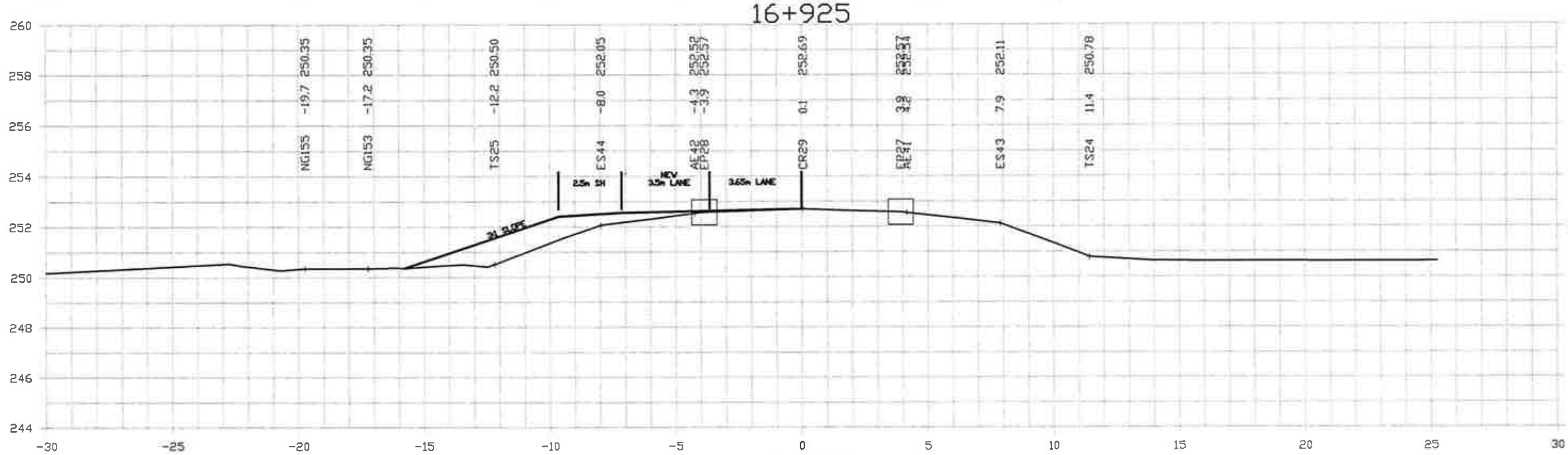
16+875

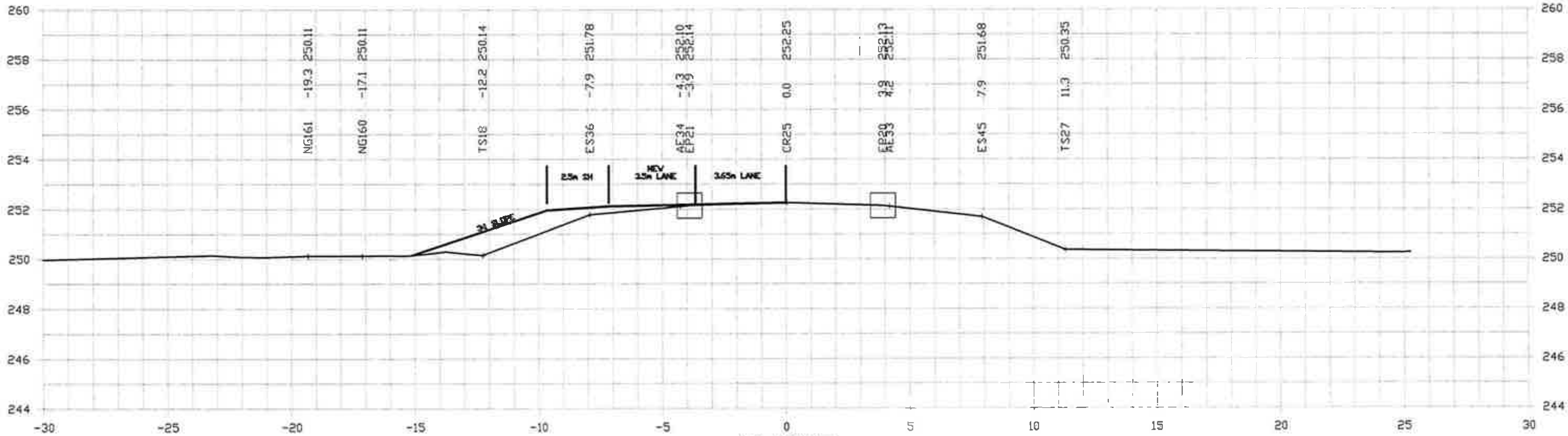


NG155 -19.7 250.49
NG153 -17.2 250.49
TS25 -11.7 251.05
ES44 -9.0 252.15
AE42 EP28 -4.3 -3.9 252.80 252.85
CR29 0.0 252.97
EP27 AE41 3.9 4.2 252.85 252.80
ES43 7.7 252.44
TS24 11.5 251.06
2.5m SH
NEV 3.5m LANE
3.65m LANE
3:1 SLOPE

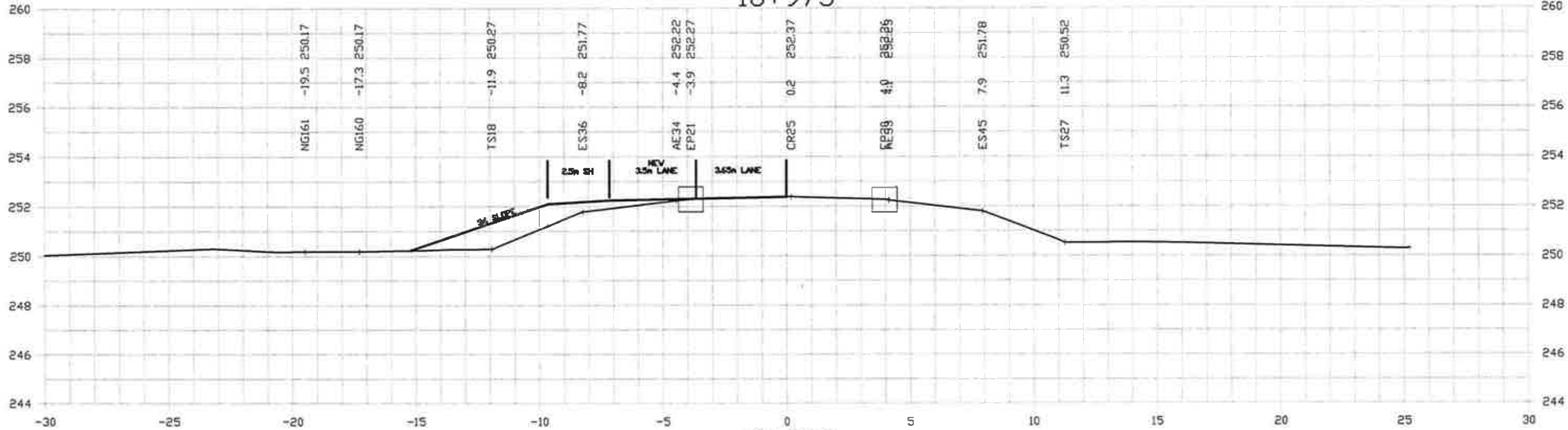
16+850


NG161 -19.6 250.24
NG160 -17.4 250.24
TS18 -11.8 250.53
ES36 -8.1 251.88
AE34 -4.3 252.35
EP21 -3.7 252.42
CR25 0.2 252.52
ES45 7.9 251.93
TS27 11.3 250.61
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE
16+925


NG155 -19.7 250.35
NG153 -17.2 250.35
TS25 -12.2 250.50
ES44 -8.0 252.05
AE42 -4.3 252.52
EP28 -3.9 252.57
CR29 0.1 252.69
ES43 7.9 252.11
TS24 11.4 250.78
2.5m SH
NEW 3.5m LANE
3.65m LANE
3:1 SLOPE
16+900

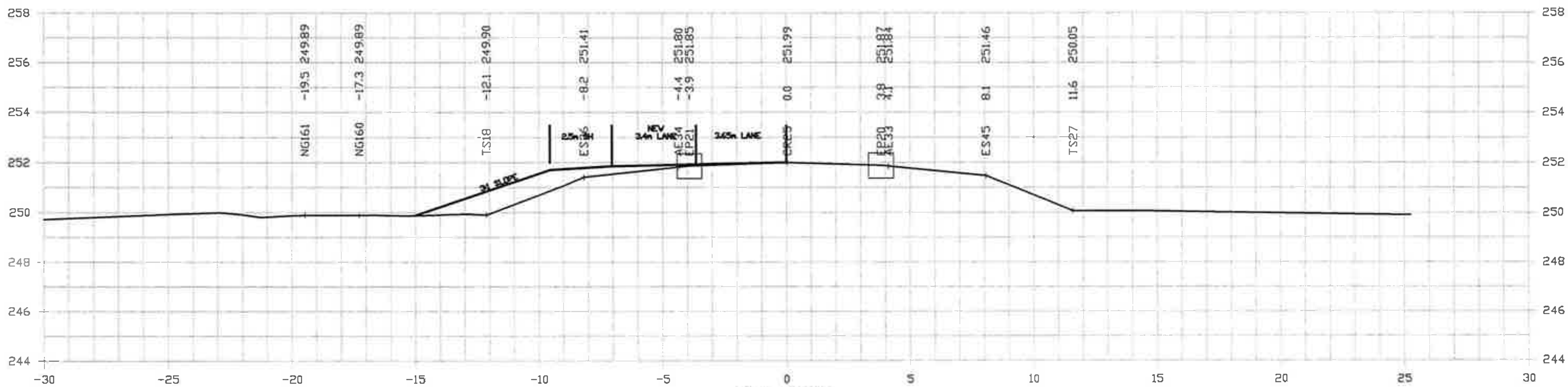

NG161 -19.3 250.11
NG160 -17.1 250.11
TS18 -12.2 250.14
ES36 -7.9 251.78
AE34 EP21 -4.3 -3.9 252.10 252.14
CR25 0.0 252.25
ES45 7.9 251.68
TS27 11.3 250.35
2.5m SH
NEV 3.5m LANE
3.65m LANE

16+975

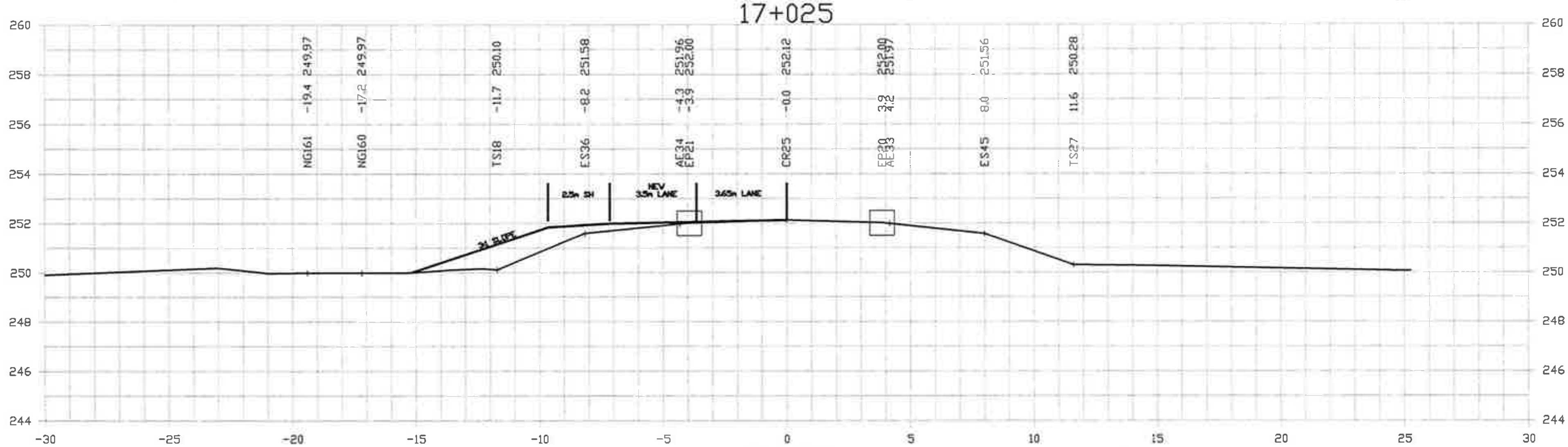

NG161 -19.5 250.17
NG160 -17.3 250.17
TS18 -11.9 250.27
ES36 -8.2 251.77
AE34 EP21 -4.4 -3.9 252.22 252.27
CR25 0.2 252.37
ES45 7.9 251.78
TS27 11.3 250.52
2.5m SH
NEV 3.5m LANE
3.65m LANE

16+950

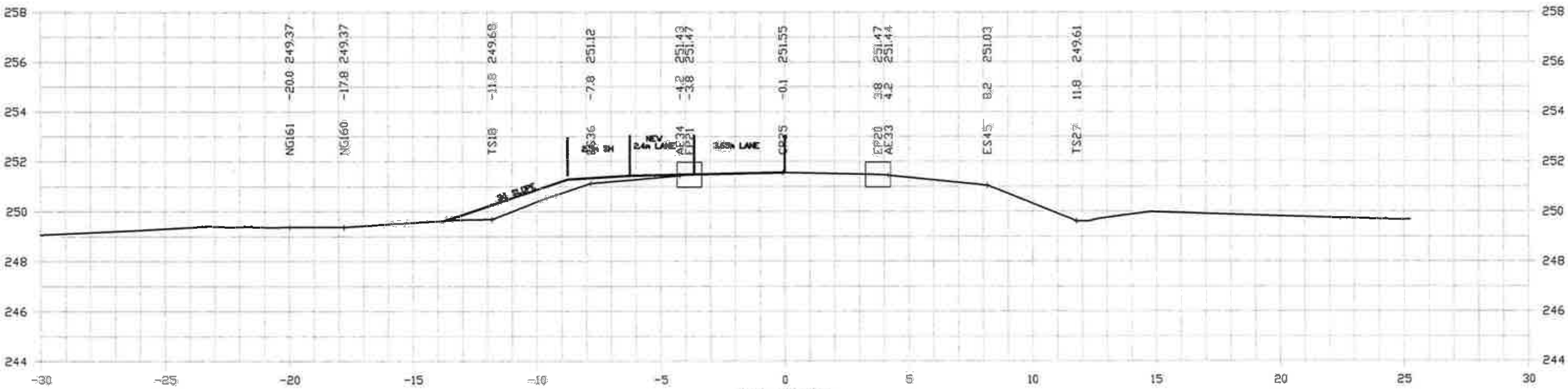
17+050



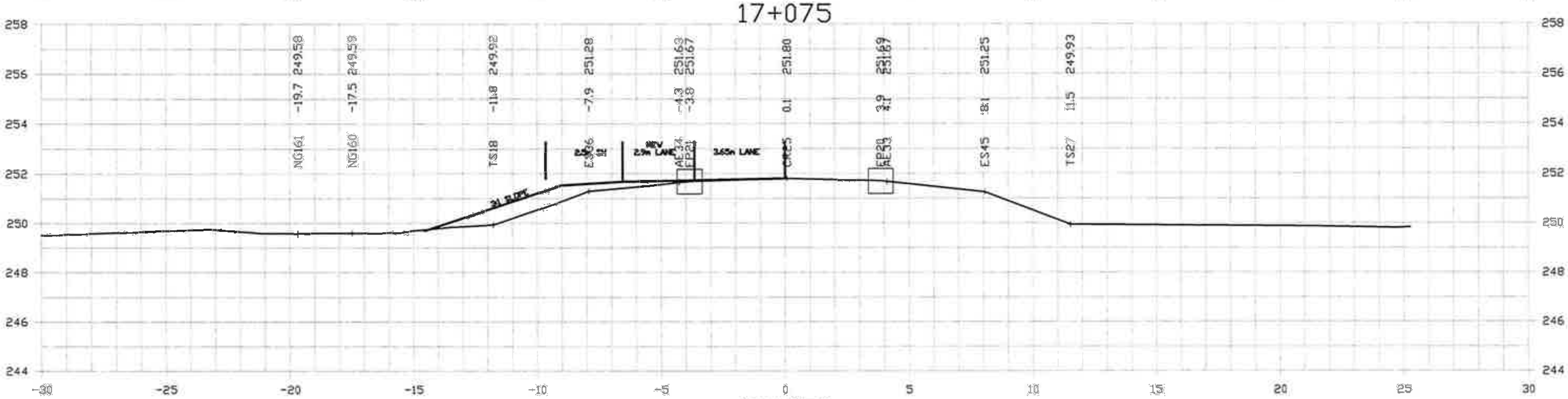
17+025



17+000

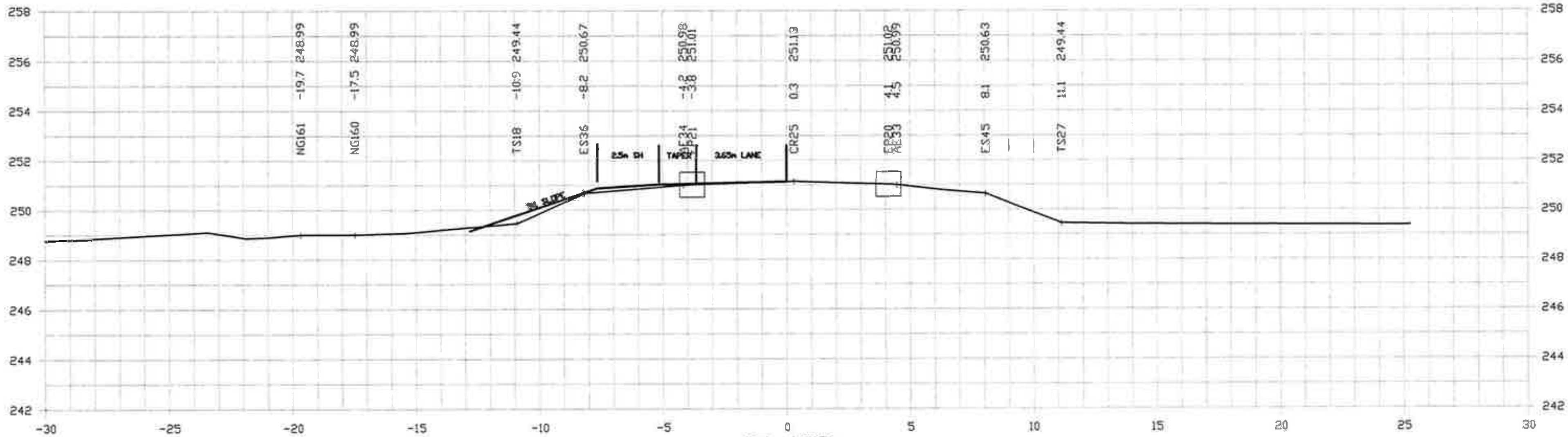

NG161 -20.0 249.37
NG160 -17.8 249.37
TS18 -11.8 249.68
ES36 -7.8 251.12
AE34 EP21 -4.2 -3.8 251.43 251.47
CR25 -0.1 251.55
EP20 AE33 3.8 4.2 251.47 251.44
ES45 8.2 251.03
TS27 11.8 249.61
3:1 SLOPE
NEV 2.4m LANE
3.65m LANE

17+075

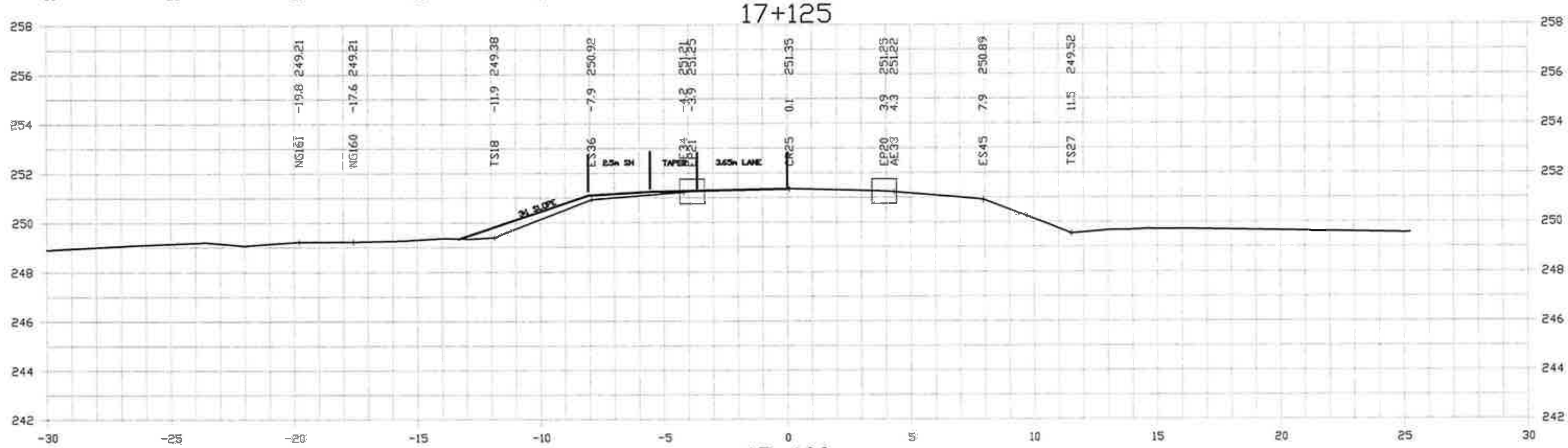

NG161 -19.7 249.58
NG160 -17.5 249.59
TS18 -11.8 249.92
ES36 -7.9 251.28
AE34 EP21 -4.3 -3.8 251.63 251.67
CR25 0.1 251.80
EP20 AE33 3.9 4.1 251.69 251.67
ES45 8.1 251.25
TS27 11.5 249.93
3:1 SLOPE
NEV 2.9m LANE
3.65m LANE

17+050

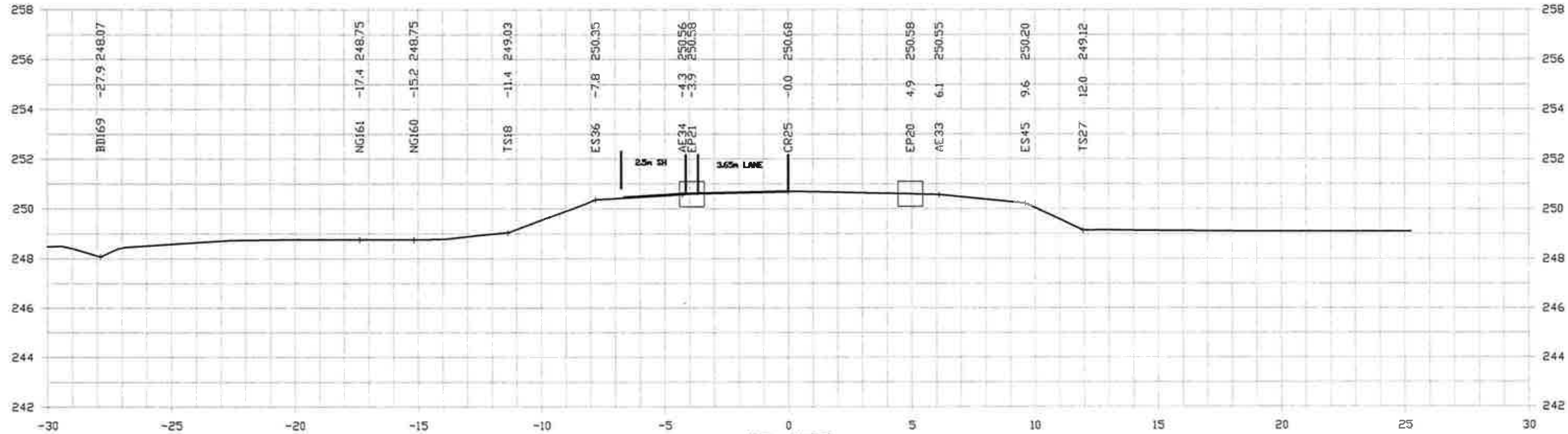
17+150



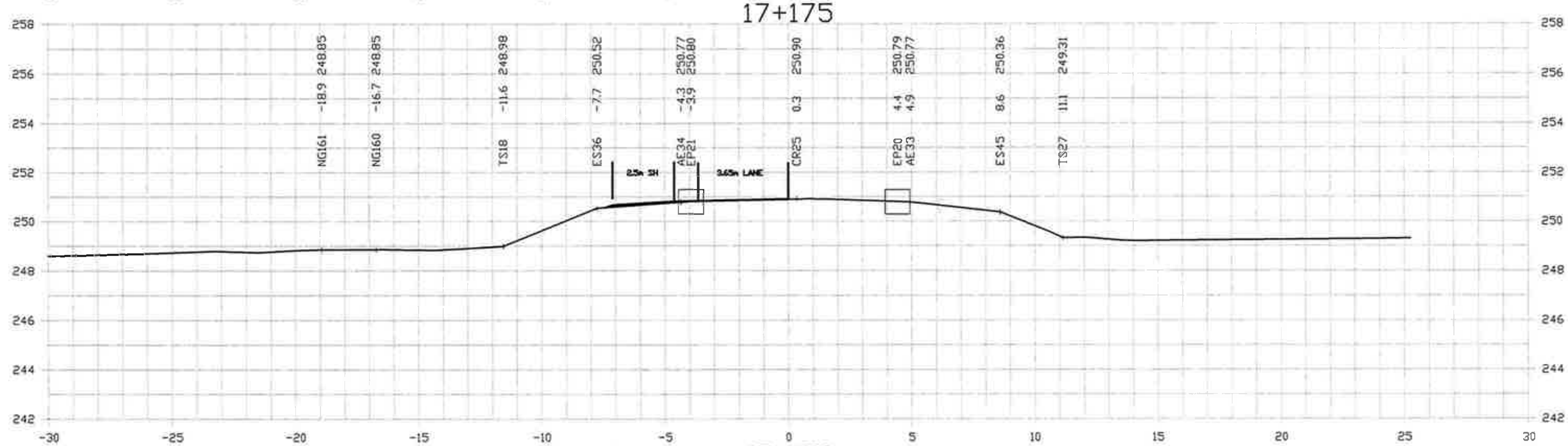
17+125



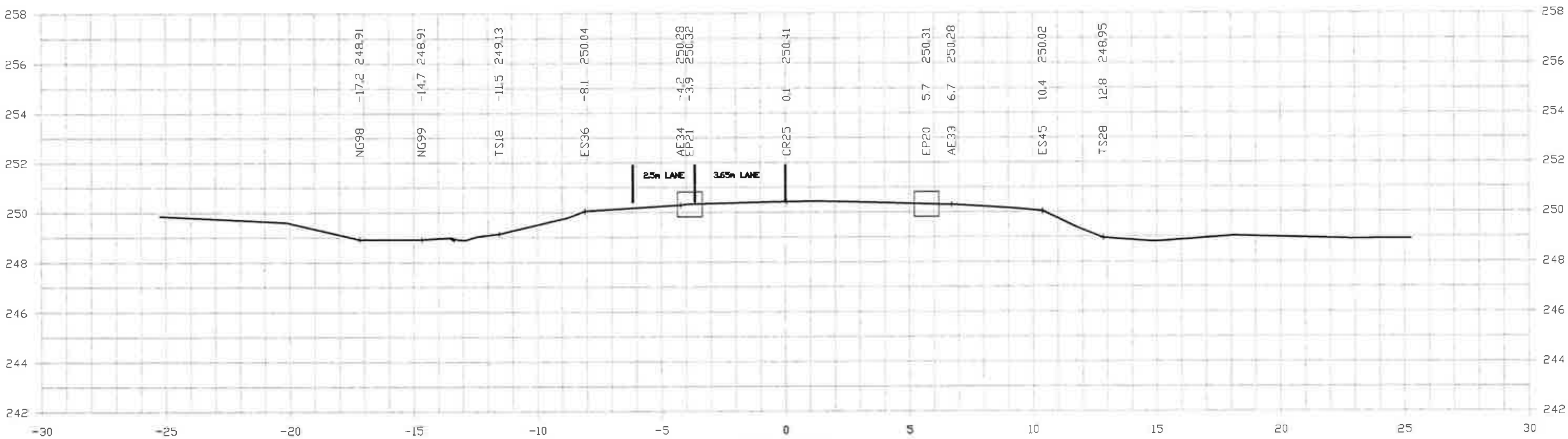
17+100


BDI69 -27.9 248.07
NG161 -17.4 248.75
NG160 -15.2 248.75
TS18 -11.4 249.03
ES36 -7.8 250.35
AE34 -4.3 250.56
EP21 -3.9 250.58
CR25 -0.0 250.68
EP20 4.9 250.58
AE33 6.1 250.55
ES45 9.6 250.20
TS27 12.0 249.12
2.5m SH
3.65m LANE

17+175


NG161 -18.9 248.85
NG160 -16.7 248.85
TS18 -11.6 248.98
ES36 -7.7 250.52
AE34 -4.3 250.77
EP21 -3.9 250.80
CR25 0.3 250.90
EP20 4.4 250.79
AE33 4.9 250.77
ES45 8.6 250.36
TS27 11.1 249.31
2.5m SH
3.65m LANE

17+150



NG98 -17.2 248.91
NG99 -14.7 248.91
TS18 -11.5 249.13
ES36 -8.1 250.04
AE34 -4.2 250.28
EP21 -3.9 250.32
CR25 0.1 250.41
EP20 5.7 250.31
AE33 6.7 250.28
ES45 10.4 250.02
TS28 12.8 248.95
2.5m LANE
3.65m LANE

17+200

Appendix H

Slope Stability Analyses Results

Appendix H1

Slope Stability Analyses Results - Station 12+475 - 12+750

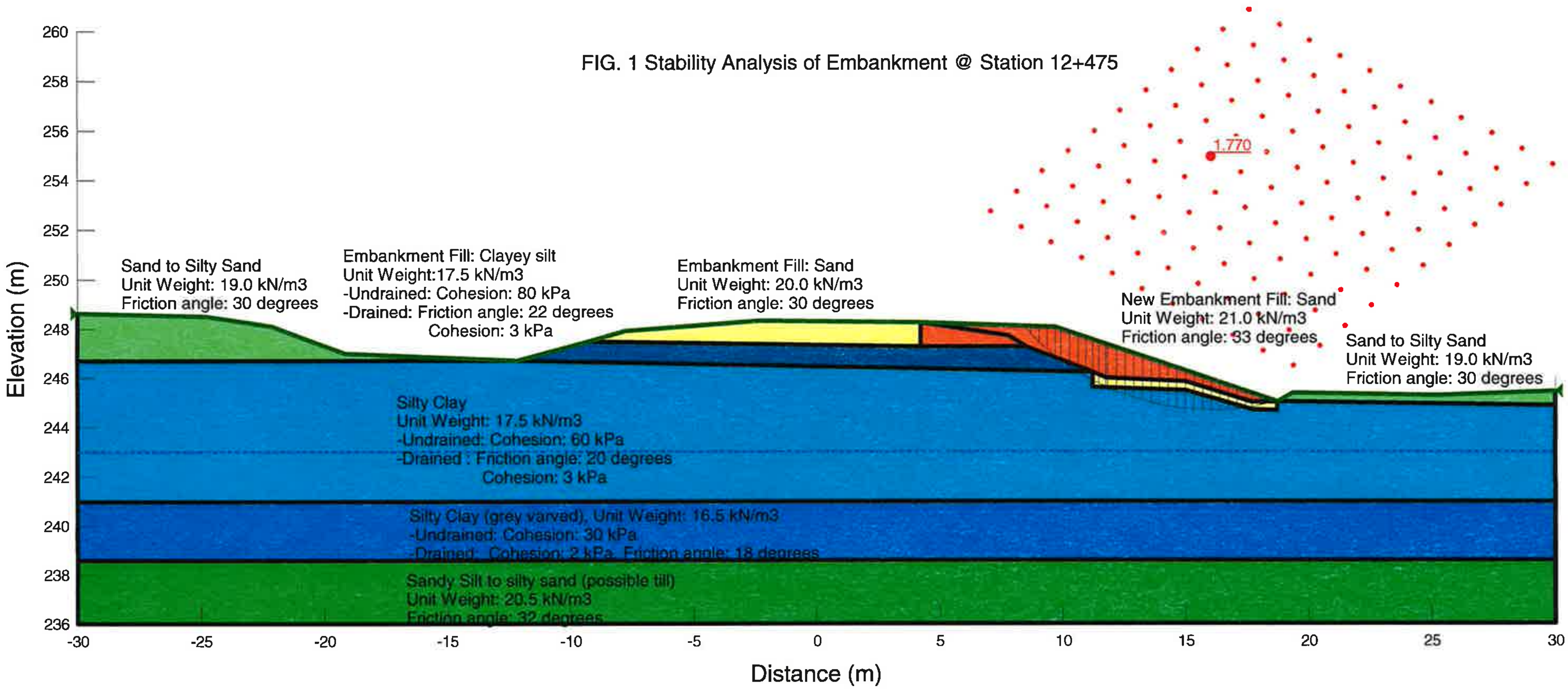


FIG. 1 Stability Analysis of Embankment @ Station 12+475

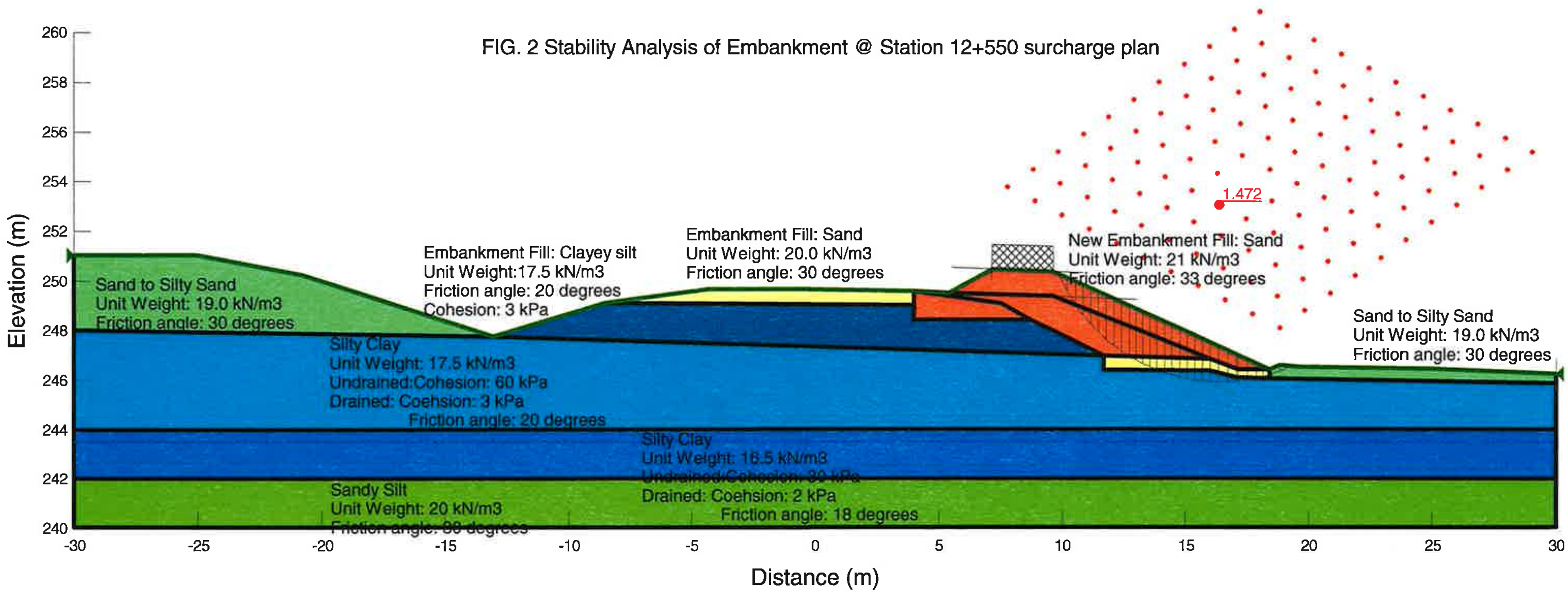
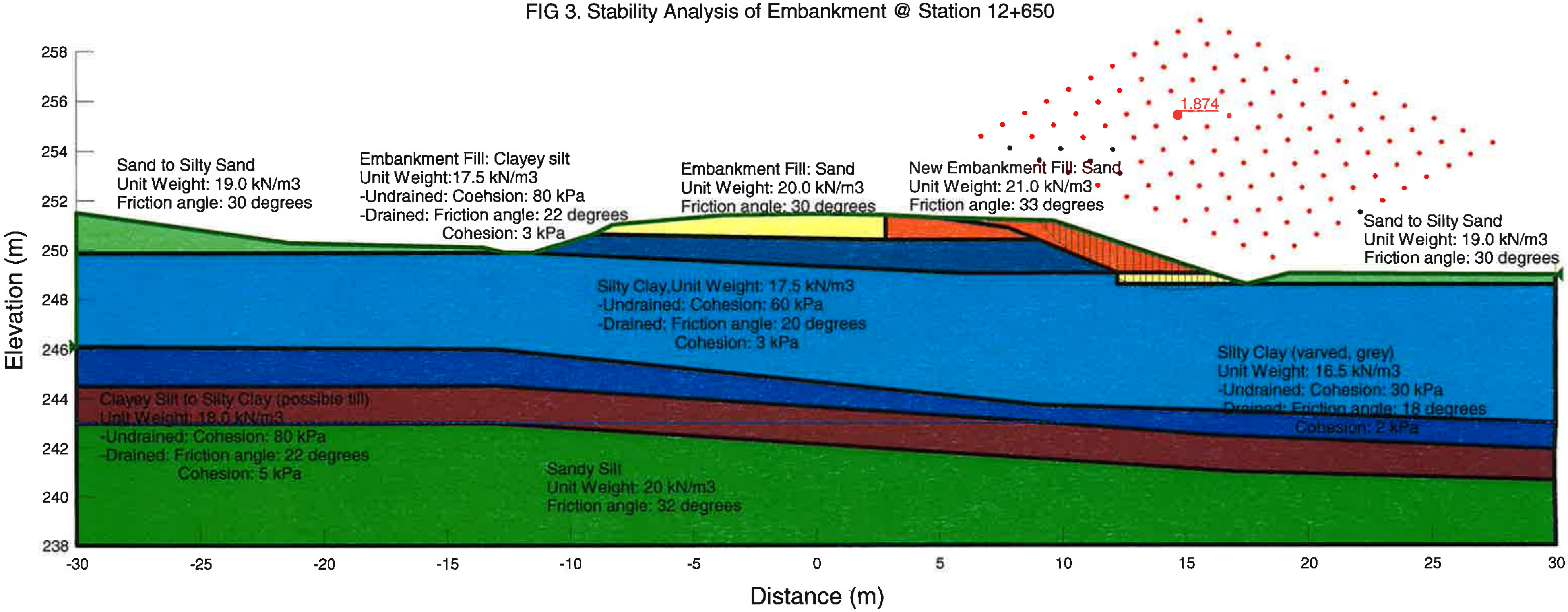


FIG. 2 Stability Analysis of Embankment @ Station 12+550 surcharge plan

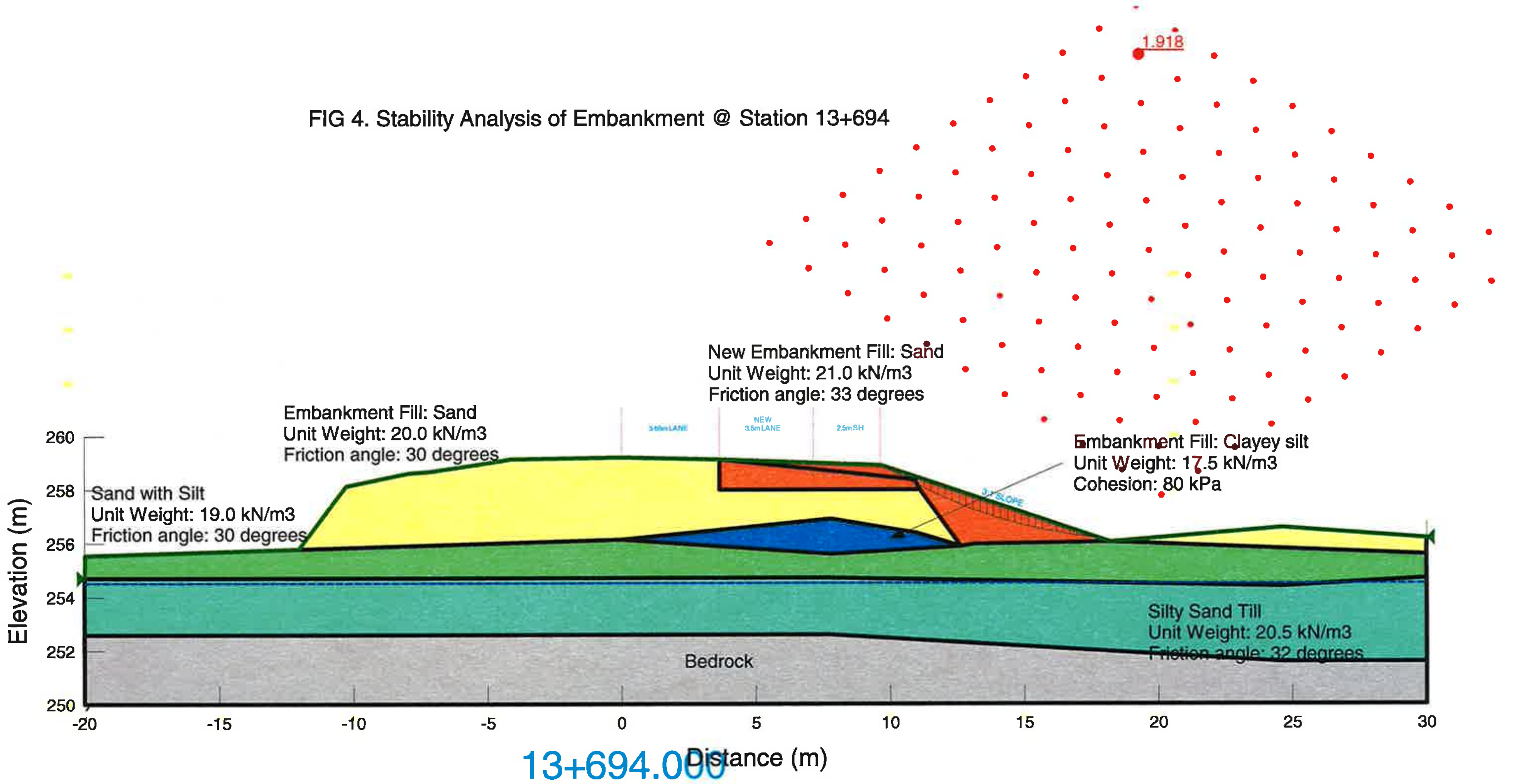
FIG 3. Stability Analysis of Embankment @ Station 12+650



Appendix H2

Slope Stability Analyses Results - Station 13+675 – 13+700

FIG 4. Stability Analysis of Embankment @ Station 13+694



Appendix H3

Slope Stability Analyses Results - Station 15+275 – 15+575

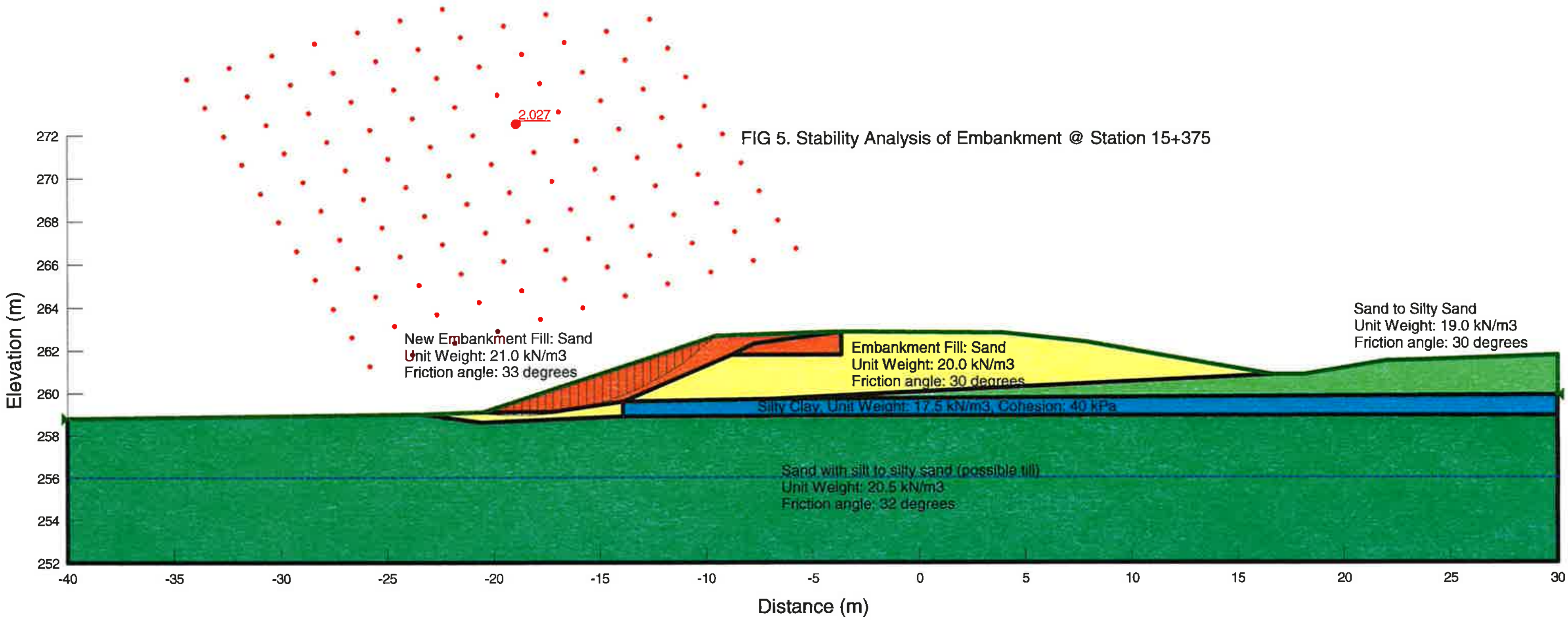


FIG 5. Stability Analysis of Embankment @ Station 15+375

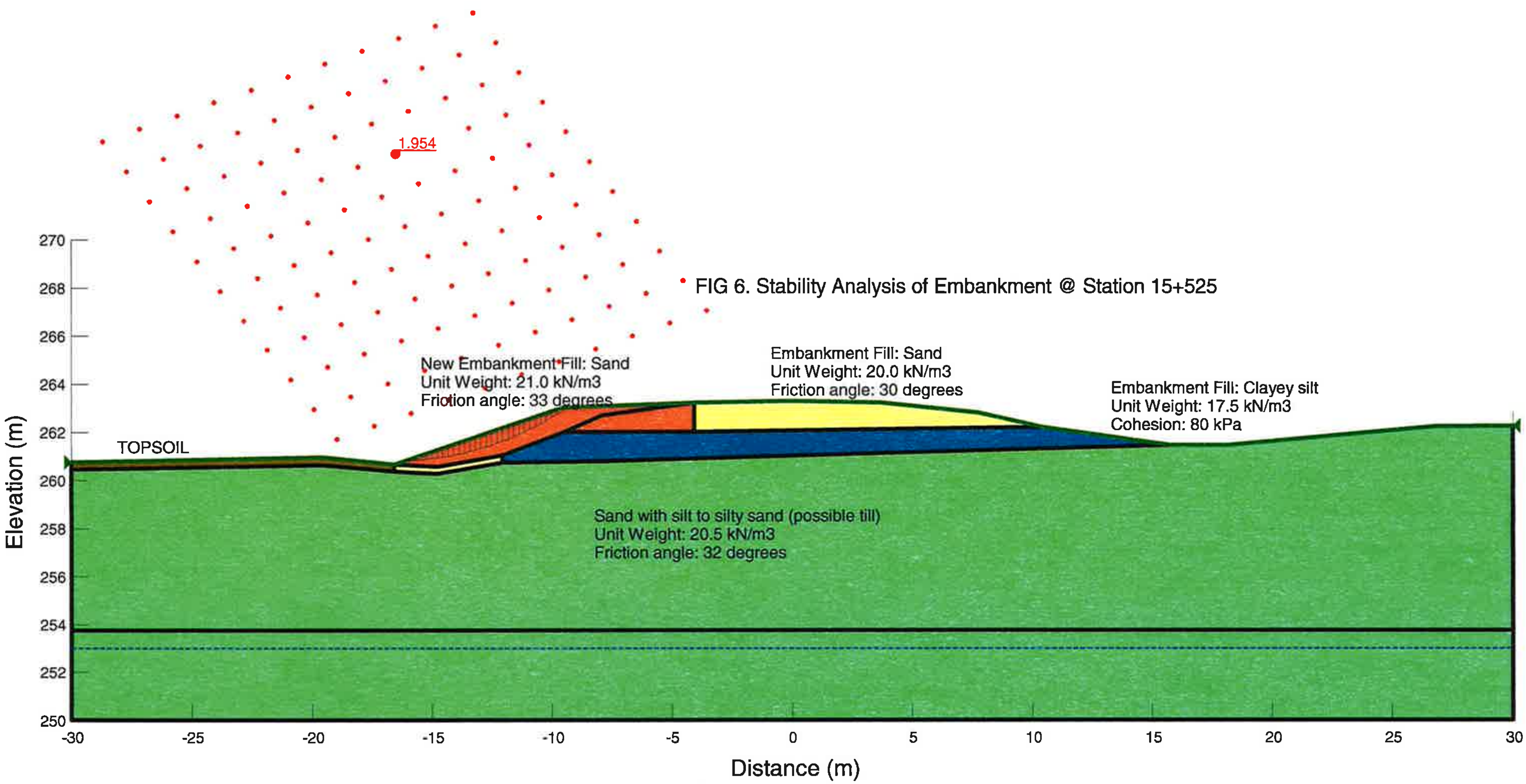
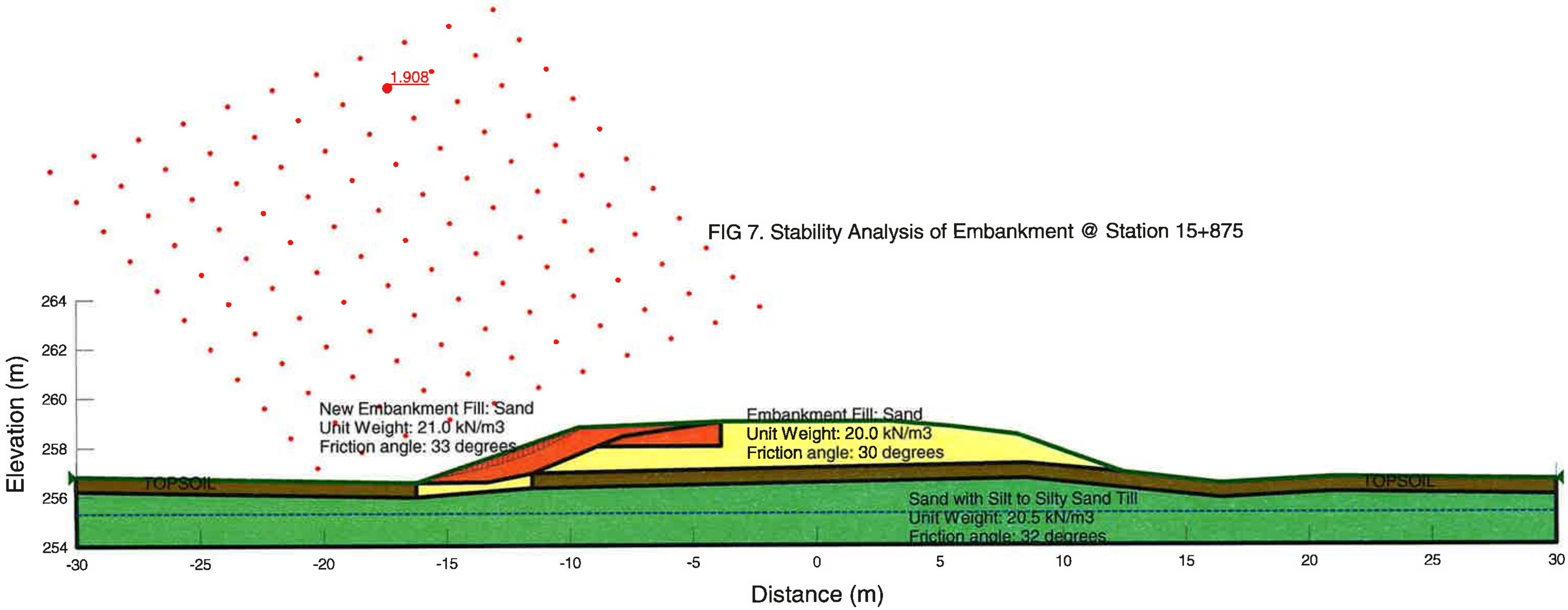

1.954
FIG 6. Stability Analysis of Embankment @ Station 15+525
New Embankment Fill: Sand
Unit Weight: 21.0 kN/m3
Friction angle: 33 degrees
Embankment Fill: Sand
Unit Weight: 20.0 kN/m3
Friction angle: 30 degrees
Embankment Fill: Clayey silt
Unit Weight: 17.5 kN/m3
Cohesion: 80 kPa
TOPSOIL
Sand with silt to silty sand (possible till)
Unit Weight: 20.5 kN/m3
Friction angle: 32 degrees
Elevation (m)
270
268
266
264
262
260
258
256
254
252
250
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
Distance (m)

FIG 7. Stability Analysis of Embankment @ Station 15+875



Appendix H4

Slope Stability Analyses Results - Station 15+850 – 16+000

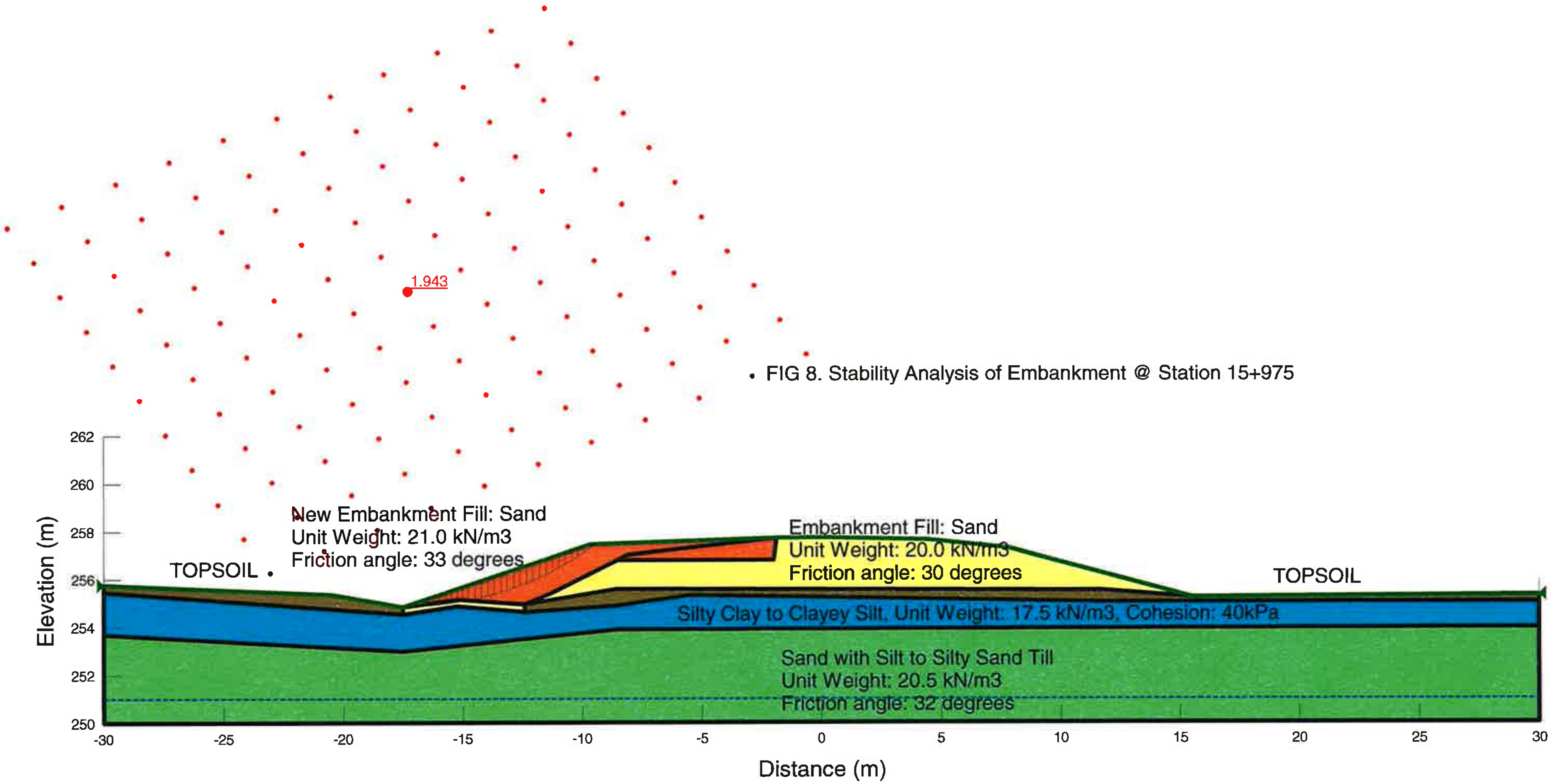


FIG 8. Stability Analysis of Embankment @ Station 15+975

Appendix H5

Slope Stability Analyses Results - Station 16+250 – 17+200

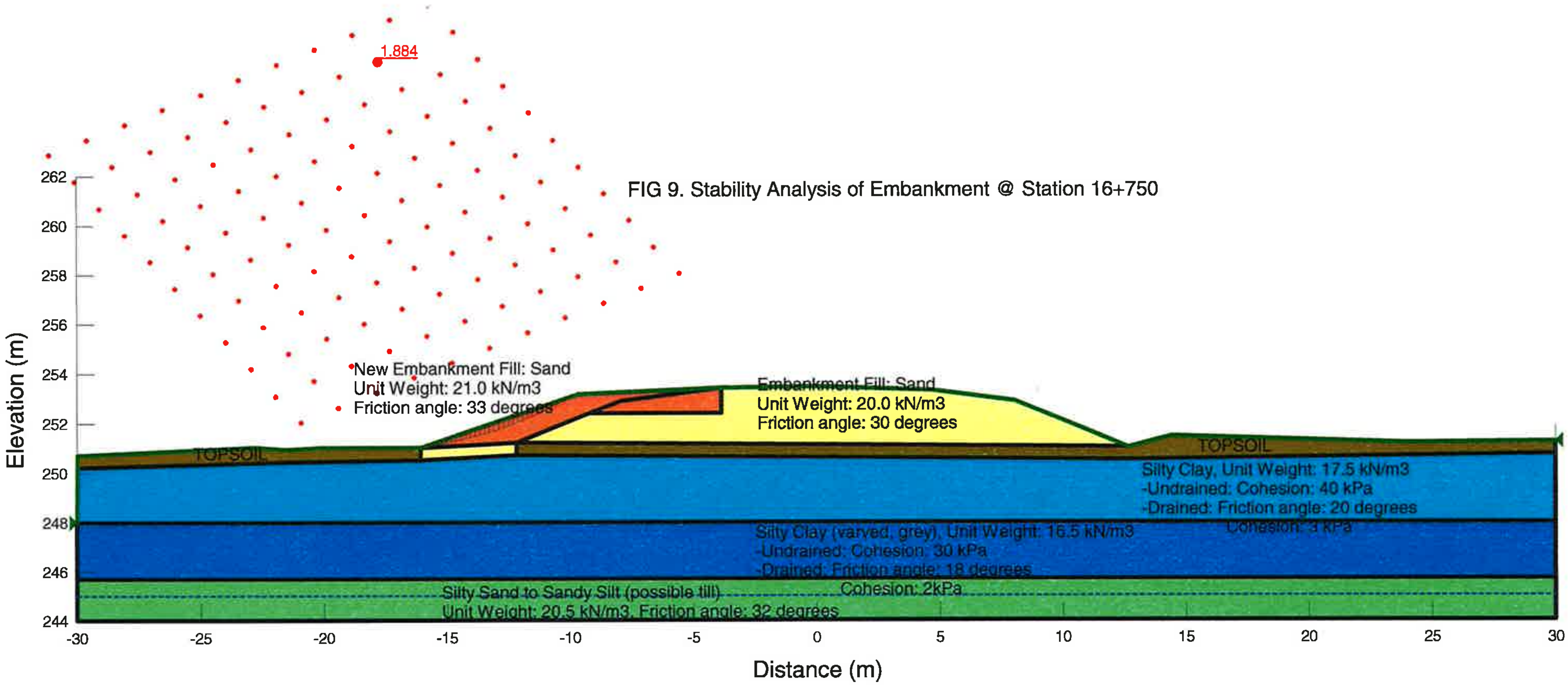
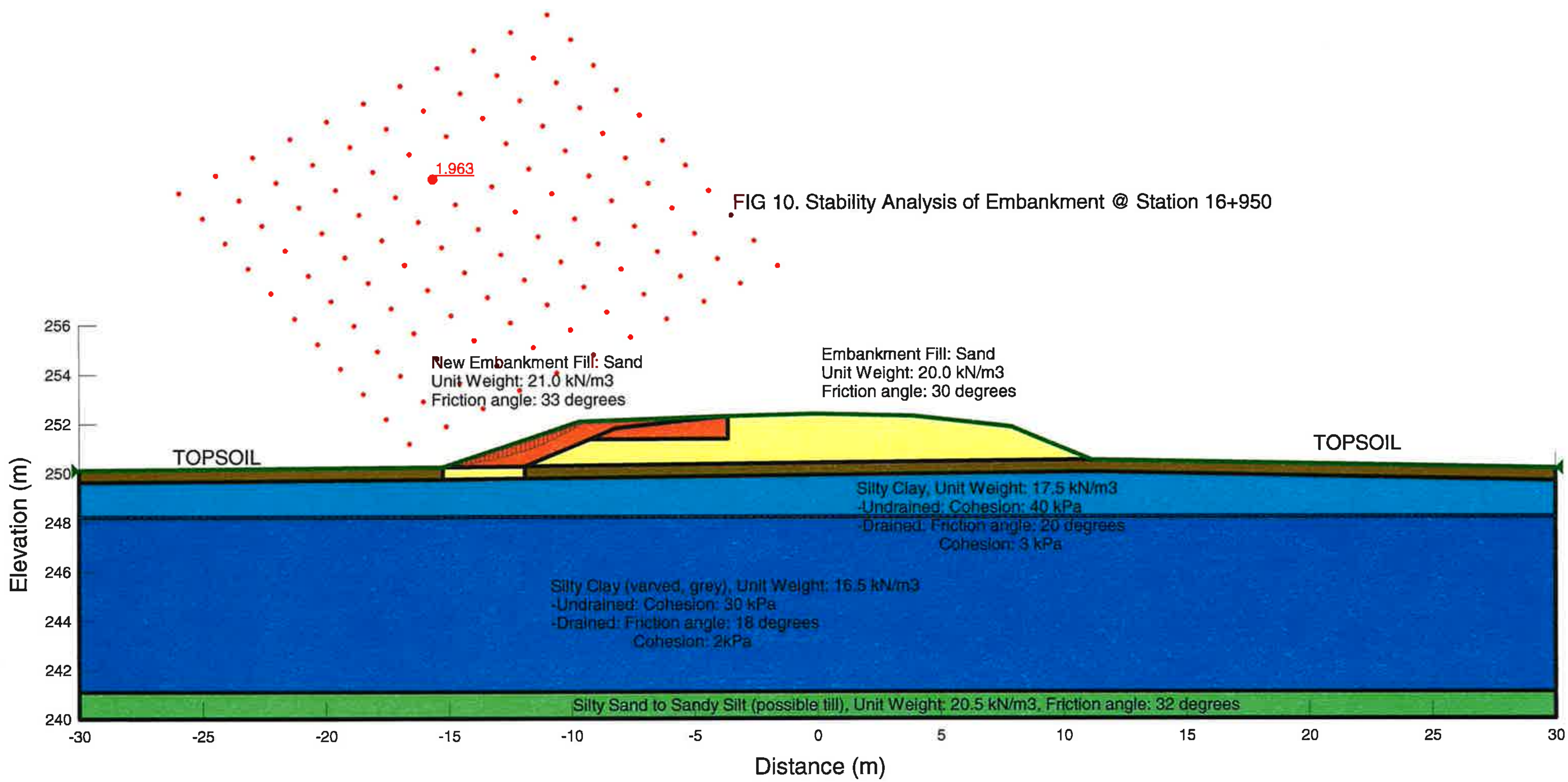


FIG 9. Stability Analysis of Embankment @ Station 16+750



1.963
FIG 10. Stability Analysis of Embankment @ Station 16+950
New Embankment Fill: Sand
Unit Weight: 21.0 kN/m3
Friction angle: 33 degrees
Embankment Fill: Sand
Unit Weight: 20.0 kN/m3
Friction angle: 30 degrees
TOPSOIL
TOPSOIL
Silty Clay, Unit Weight: 17.5 kN/m3
-Undrained: Cohesion: 40 kPa
-Drained: Friction angle: 20 degrees
Cohesion: 3 kPa
Silty Clay (varved, grey), Unit Weight: 16.5 kN/m3
-Undrained: Cohesion: 30 kPa
-Drained: Friction angle: 18 degrees
Cohesion: 2kPa
Silty Sand to Sandy Silt (possible till), Unit Weight: 20.5 kN/m3, Friction angle: 32 degrees
Elevation (m)
256
254
252
250
248
246
244
242
240
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
Distance (m)

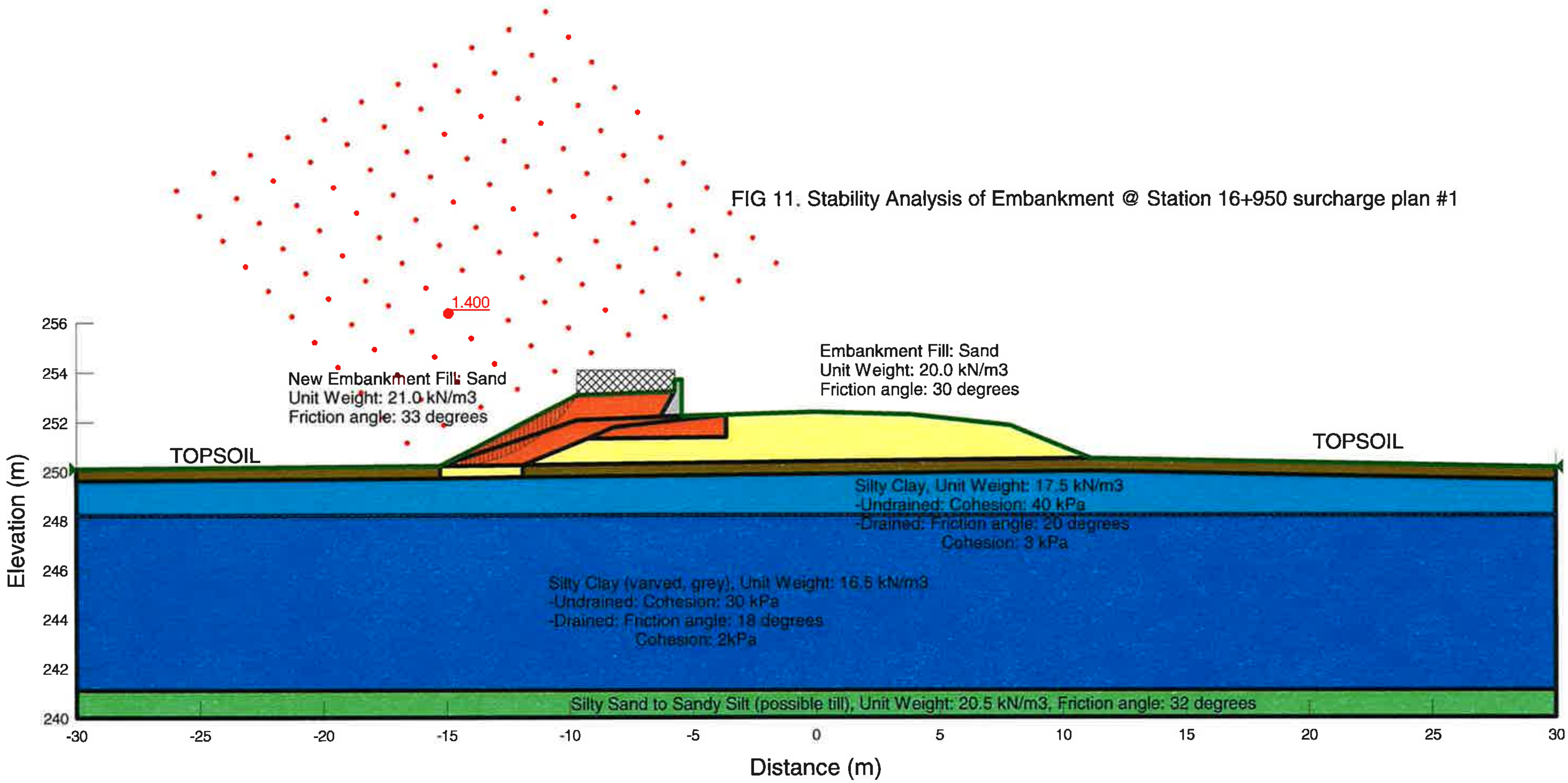


FIG 11. Stability Analysis of Embankment @ Station 16+950 surcharge plan #1

FIG 12. Stability Analysis of Embankment @ Station 16+950 surcharge plan #2

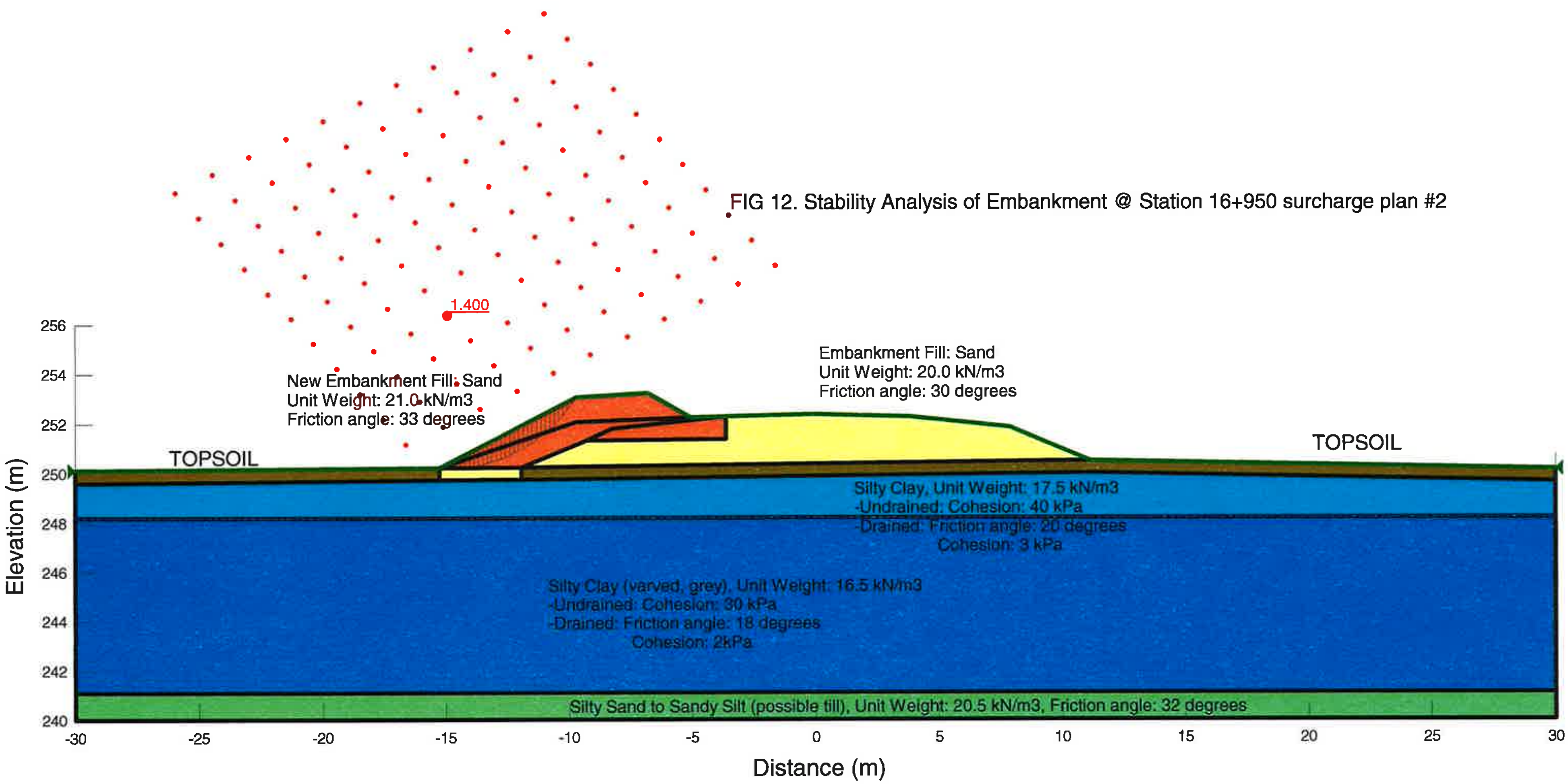
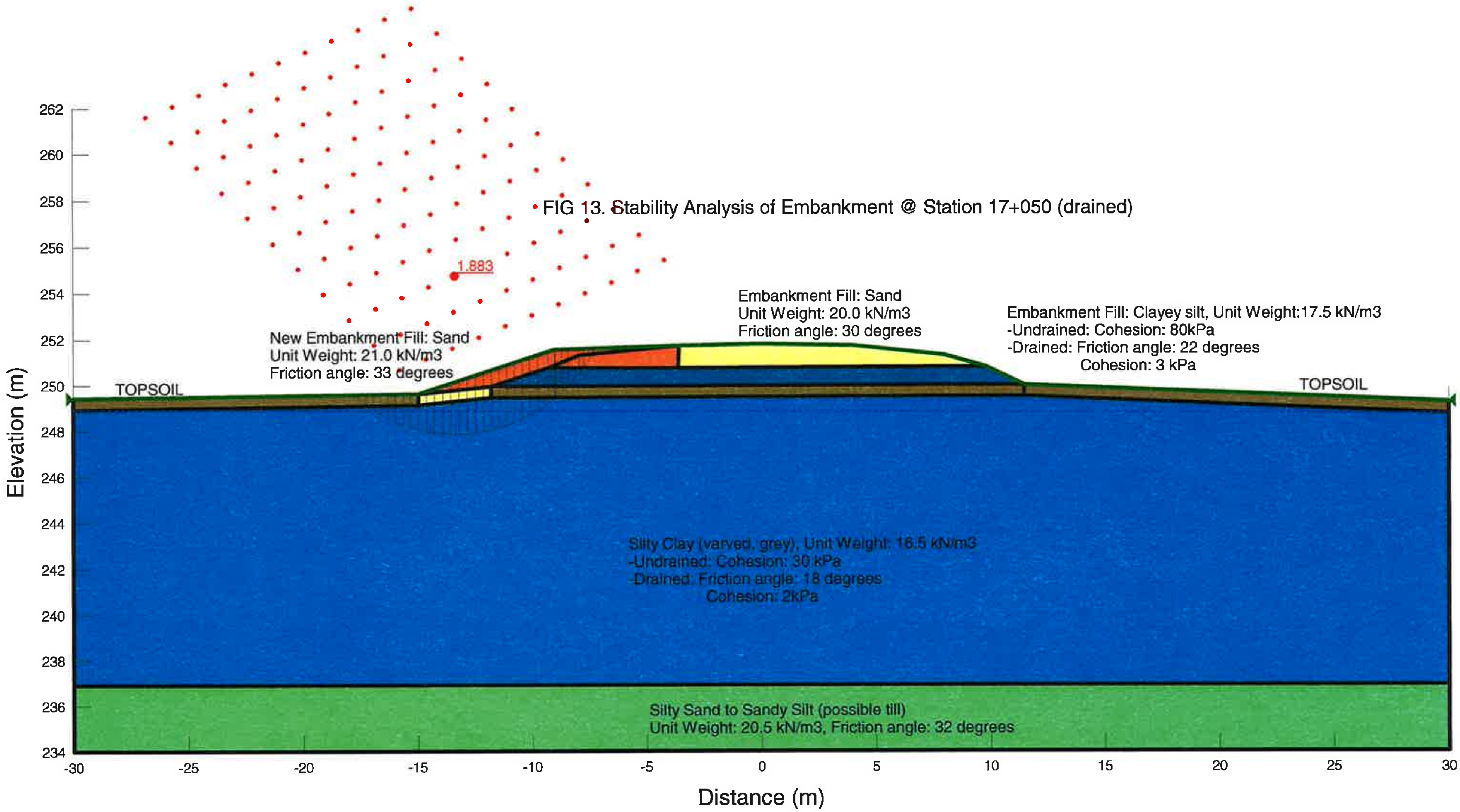


FIG 13. Stability Analysis of Embankment @ Station 17+050 (drained)



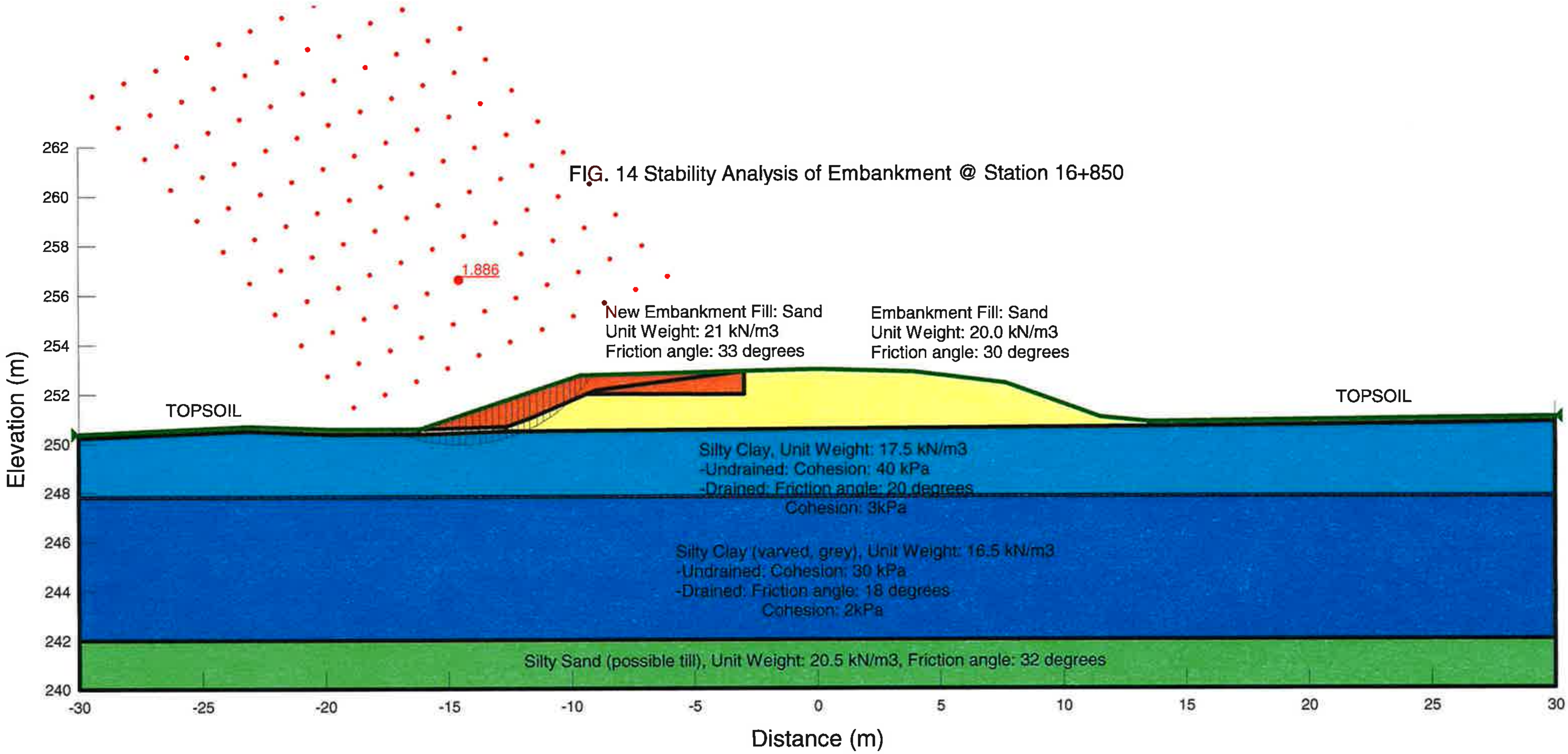
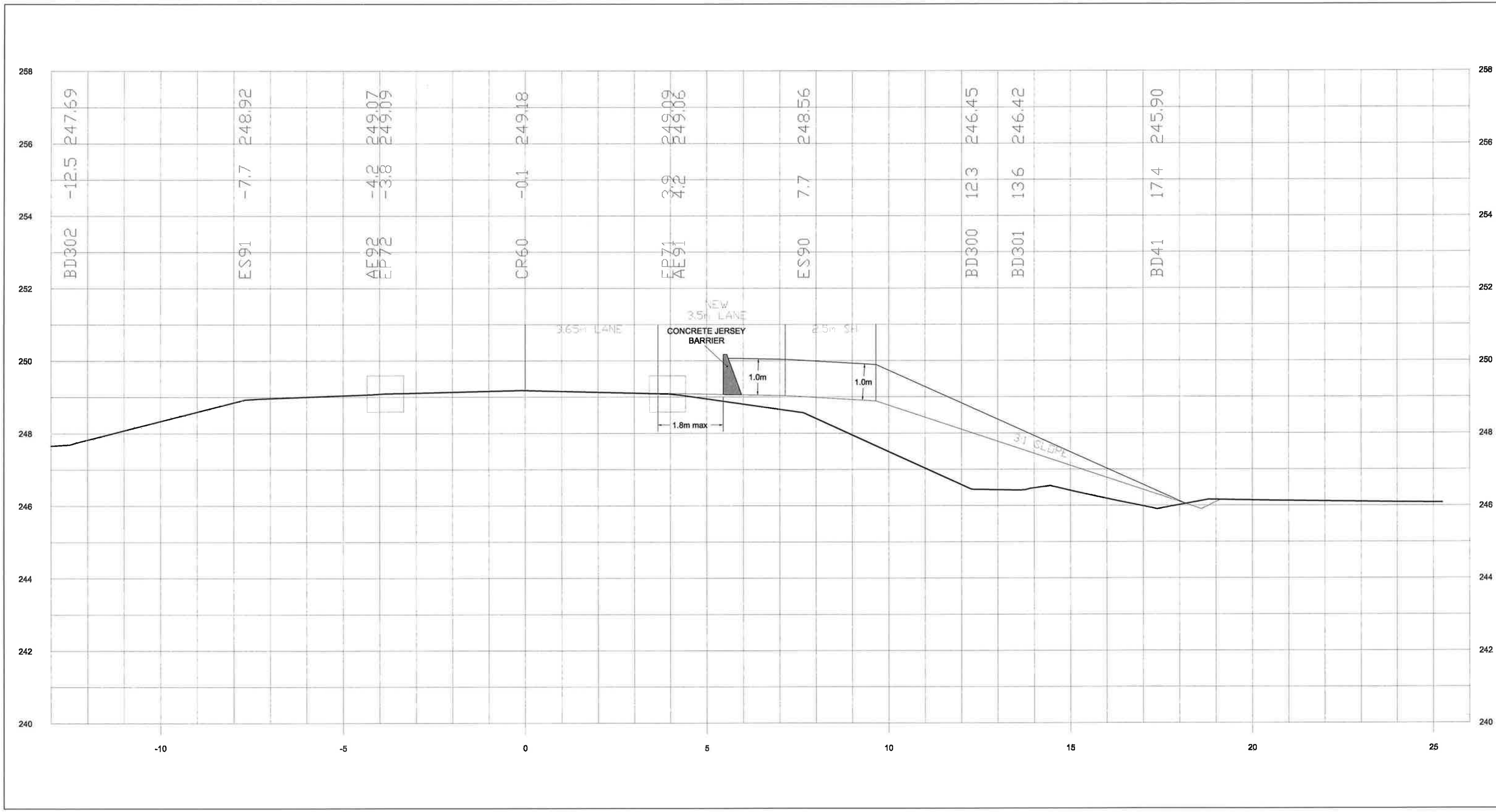


FIG. 14 Stability Analysis of Embankment @ Station 16+850

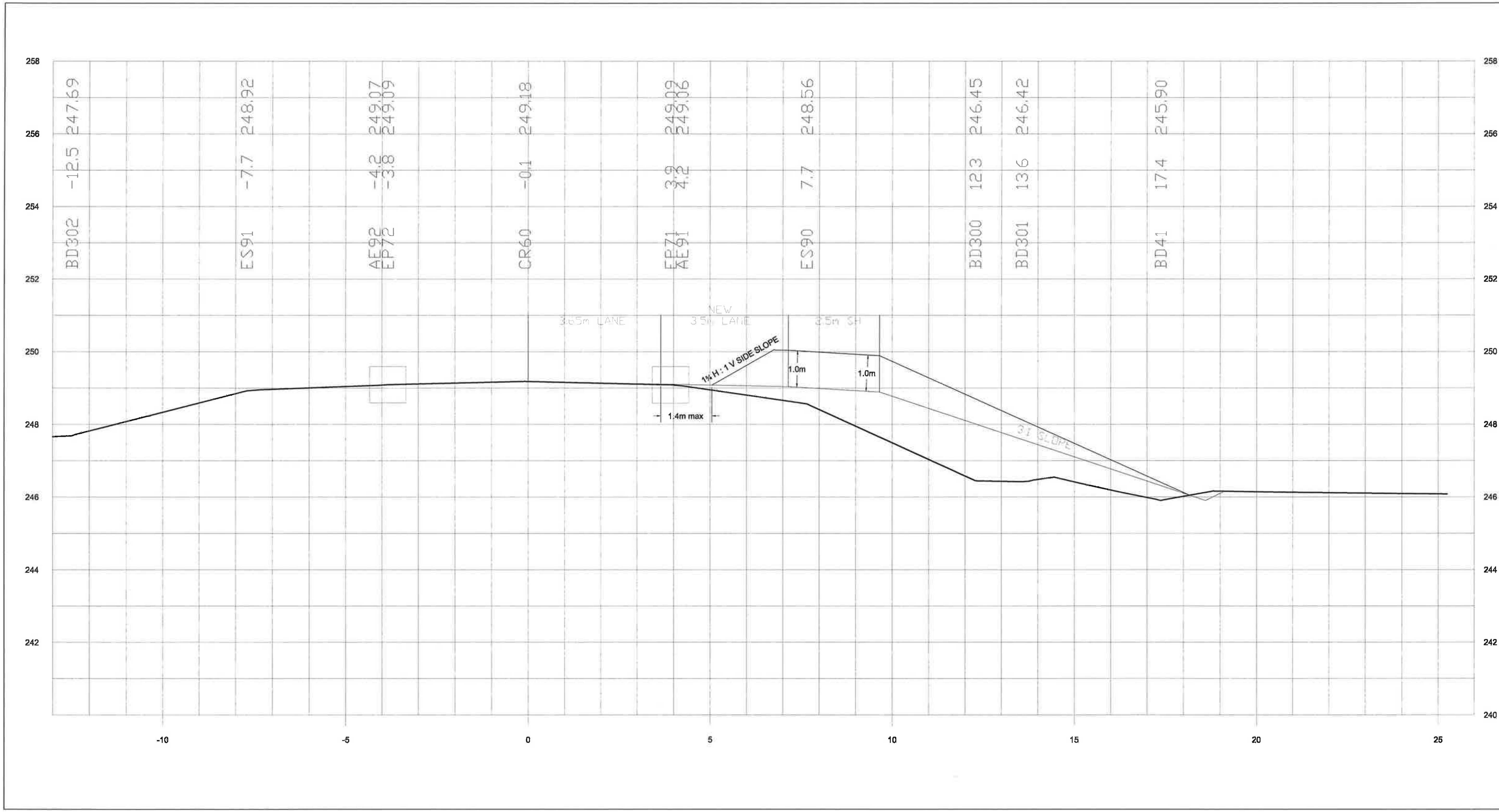
Appendix I

Surcharge Application Schemes



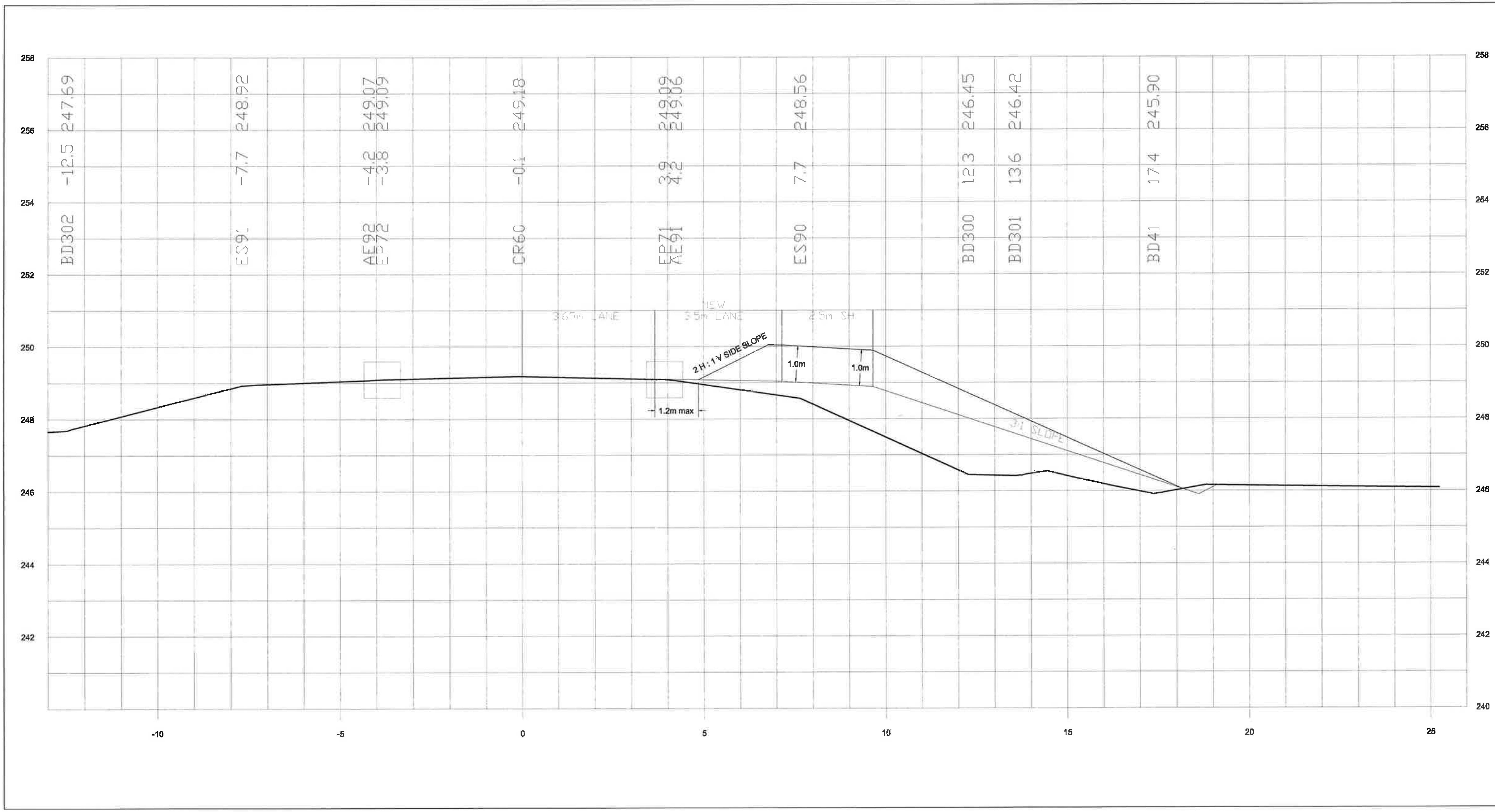
12+525

Figure I-1



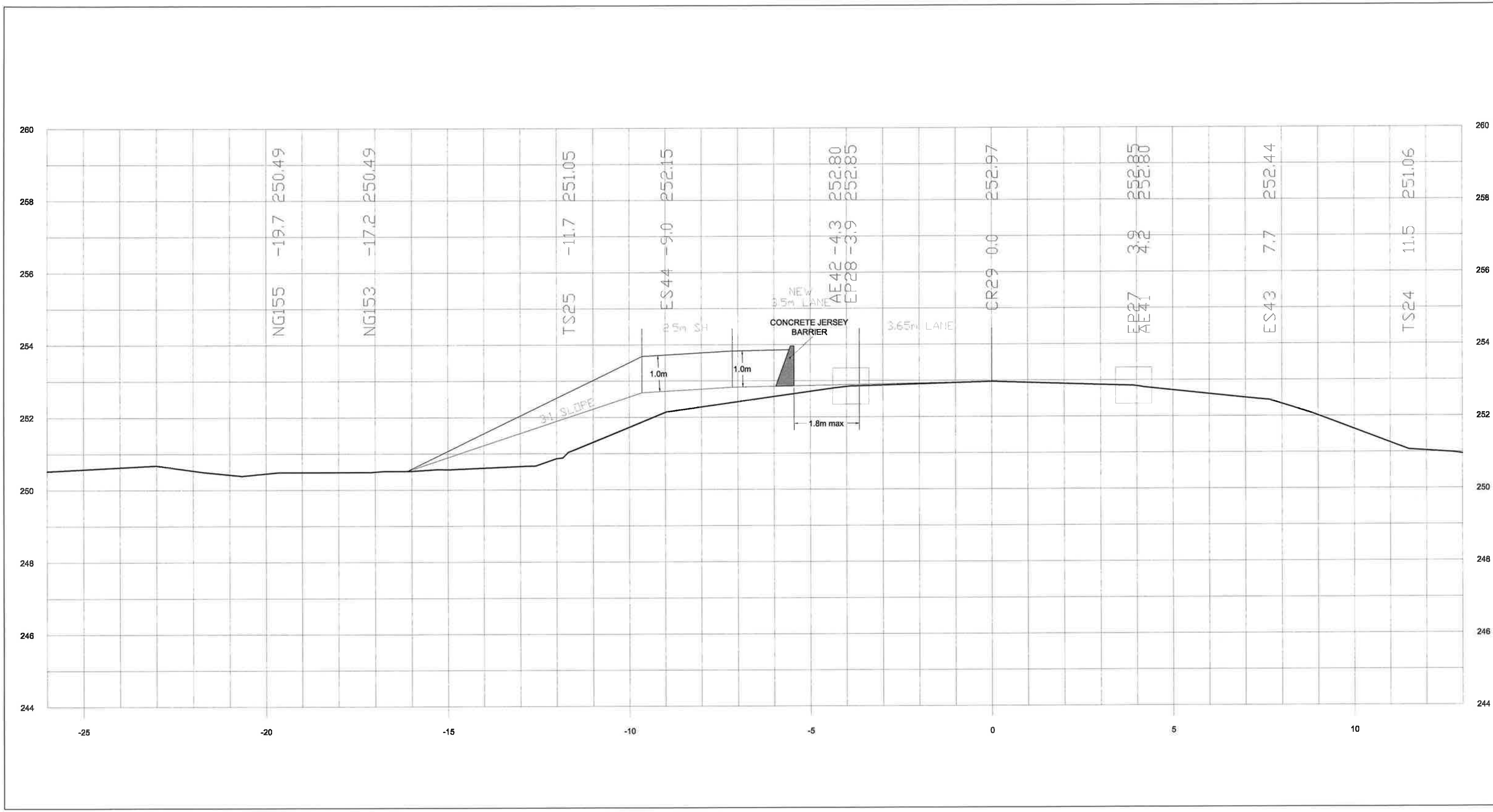
12+525

Figure I-2



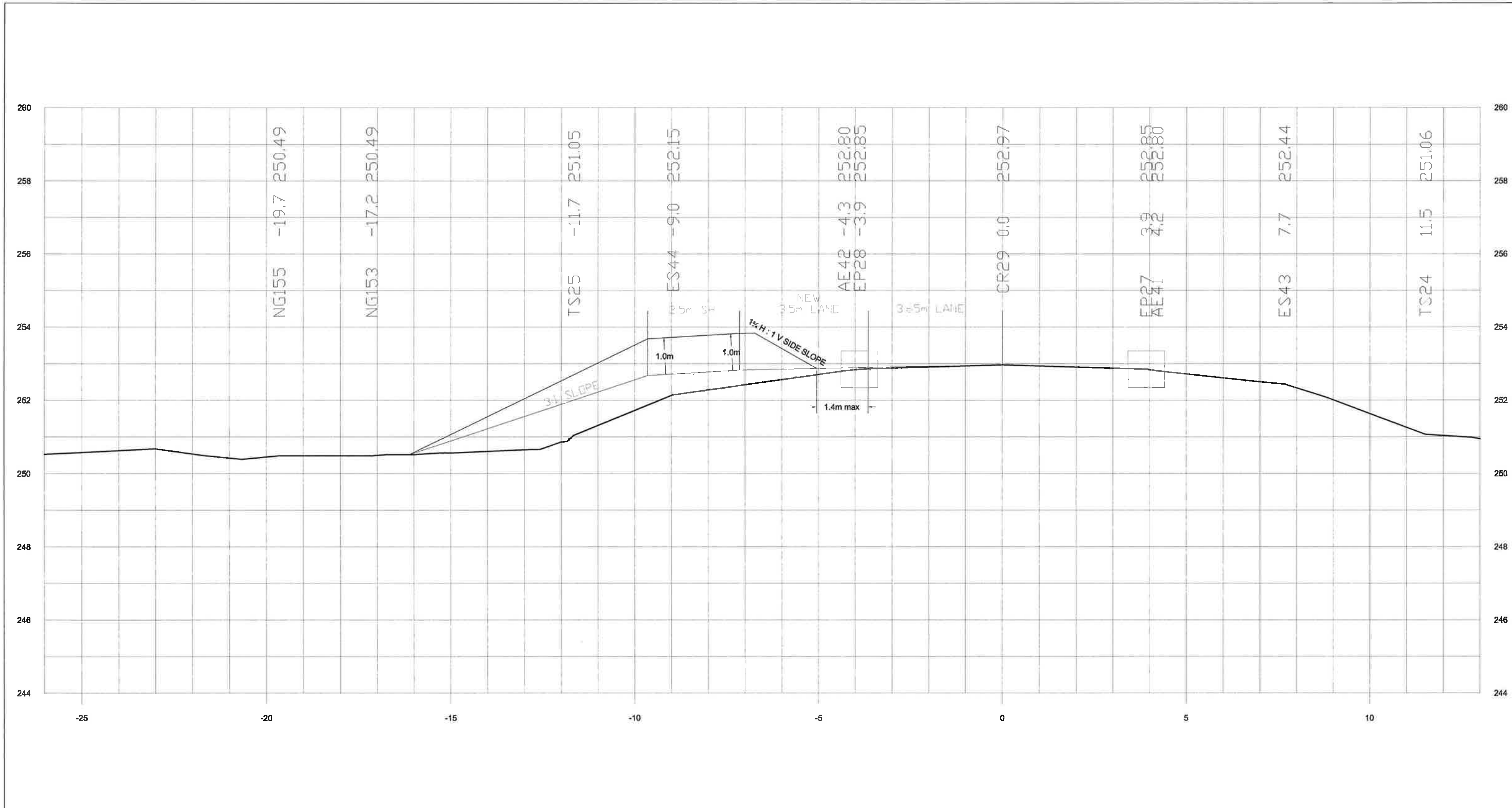
12+525

Figure I-3



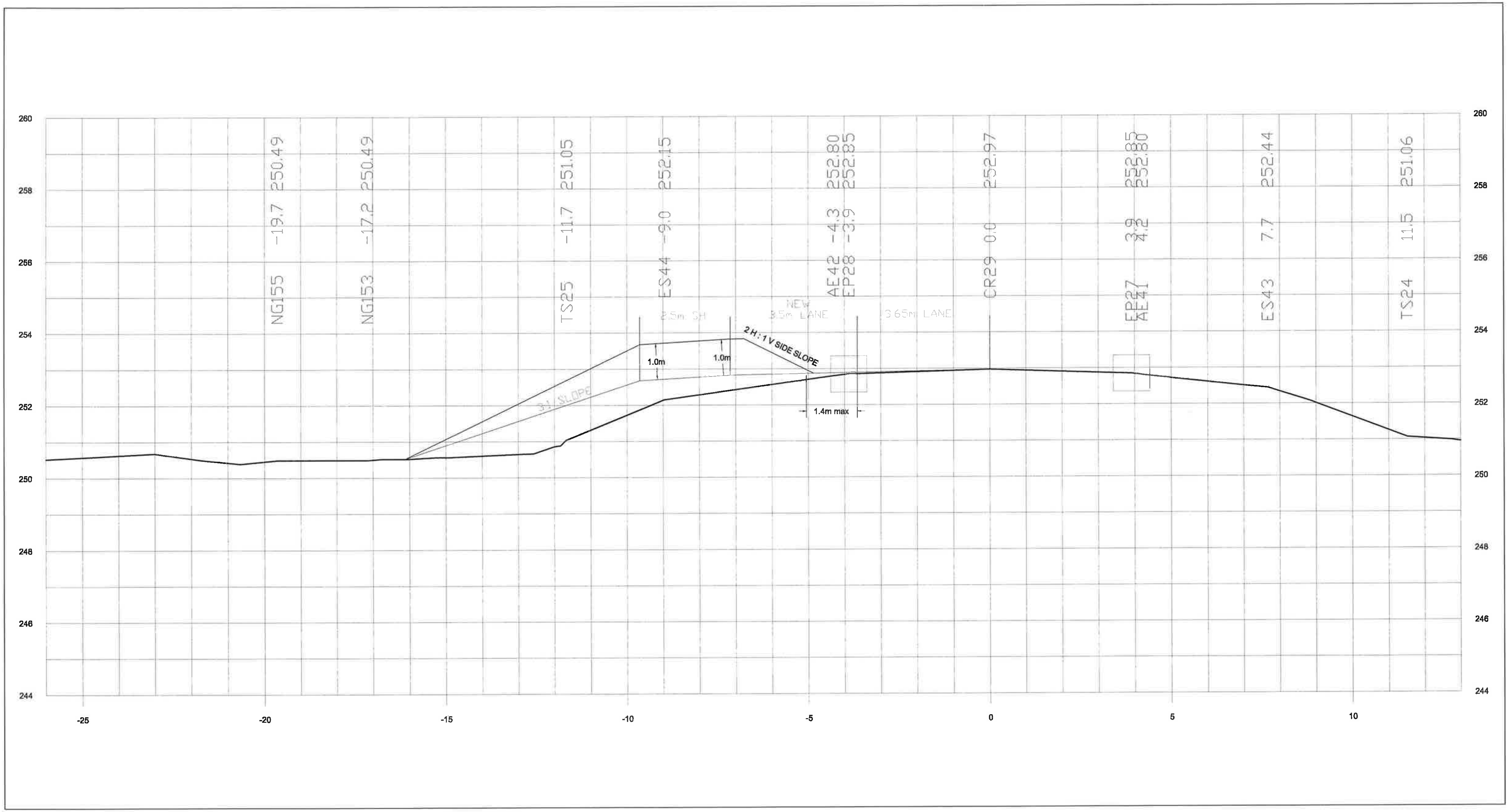
16+850

Figure I-4



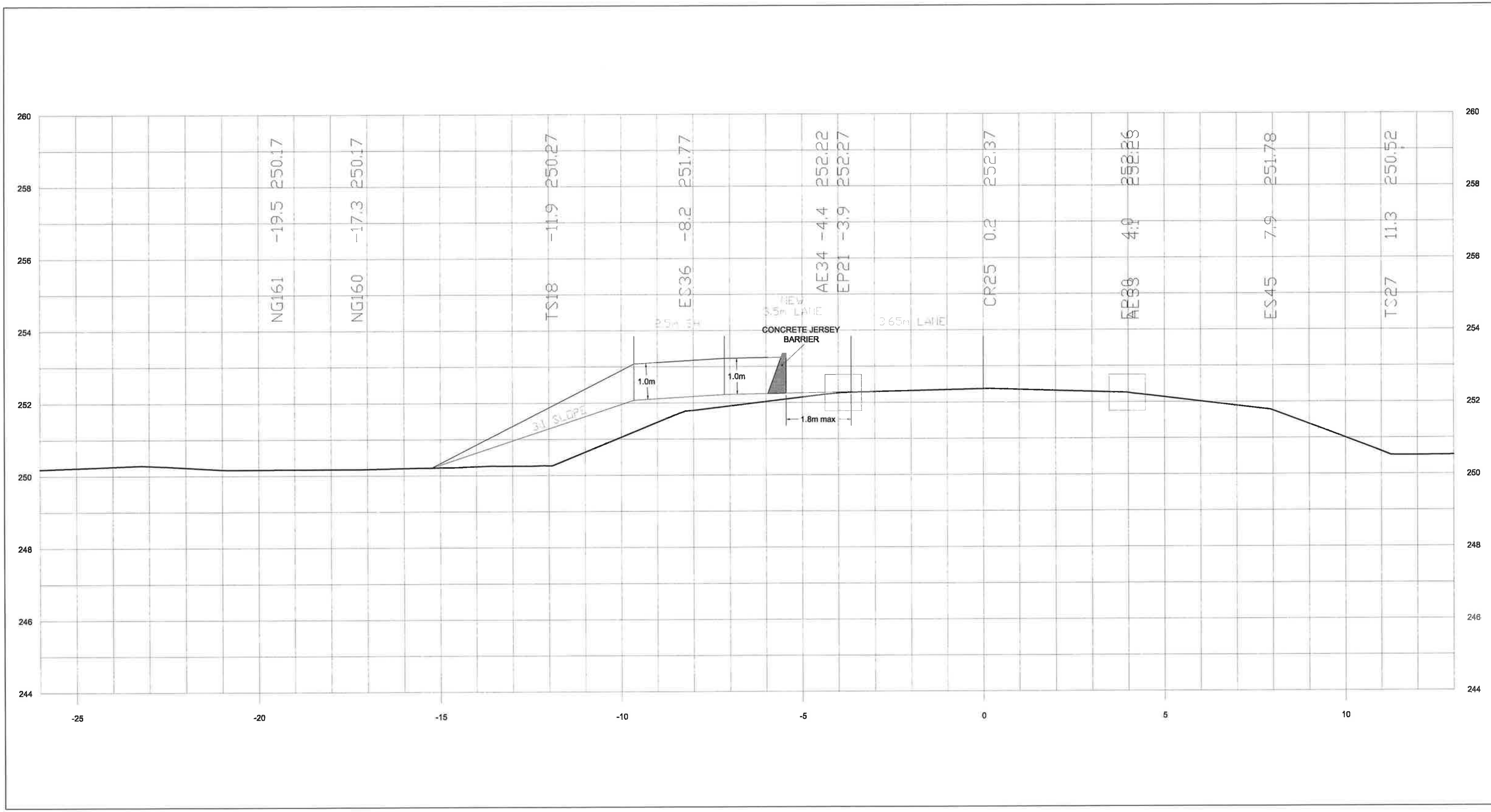
16+850

Figure I-5



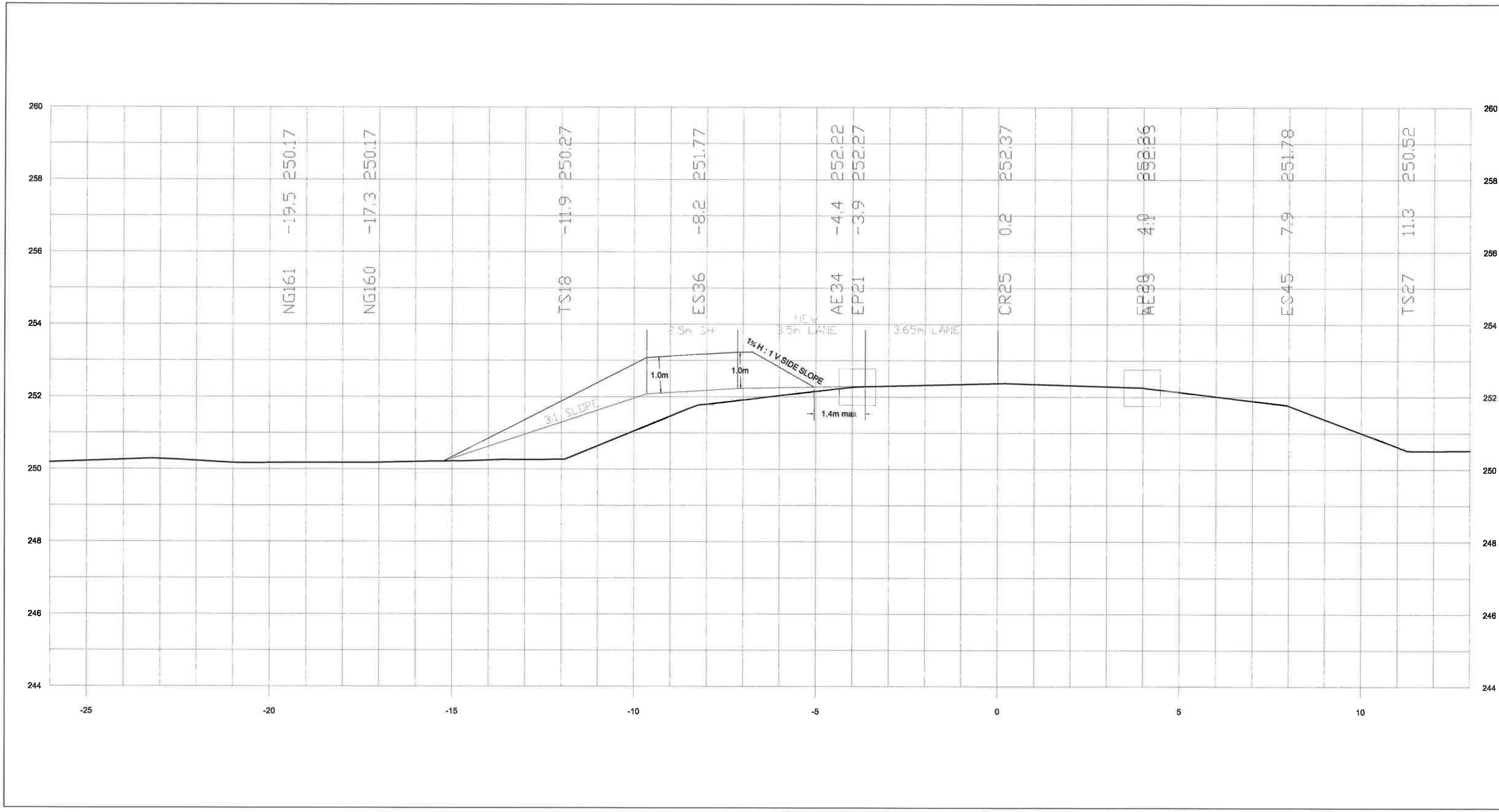
16+850

Figure I-6



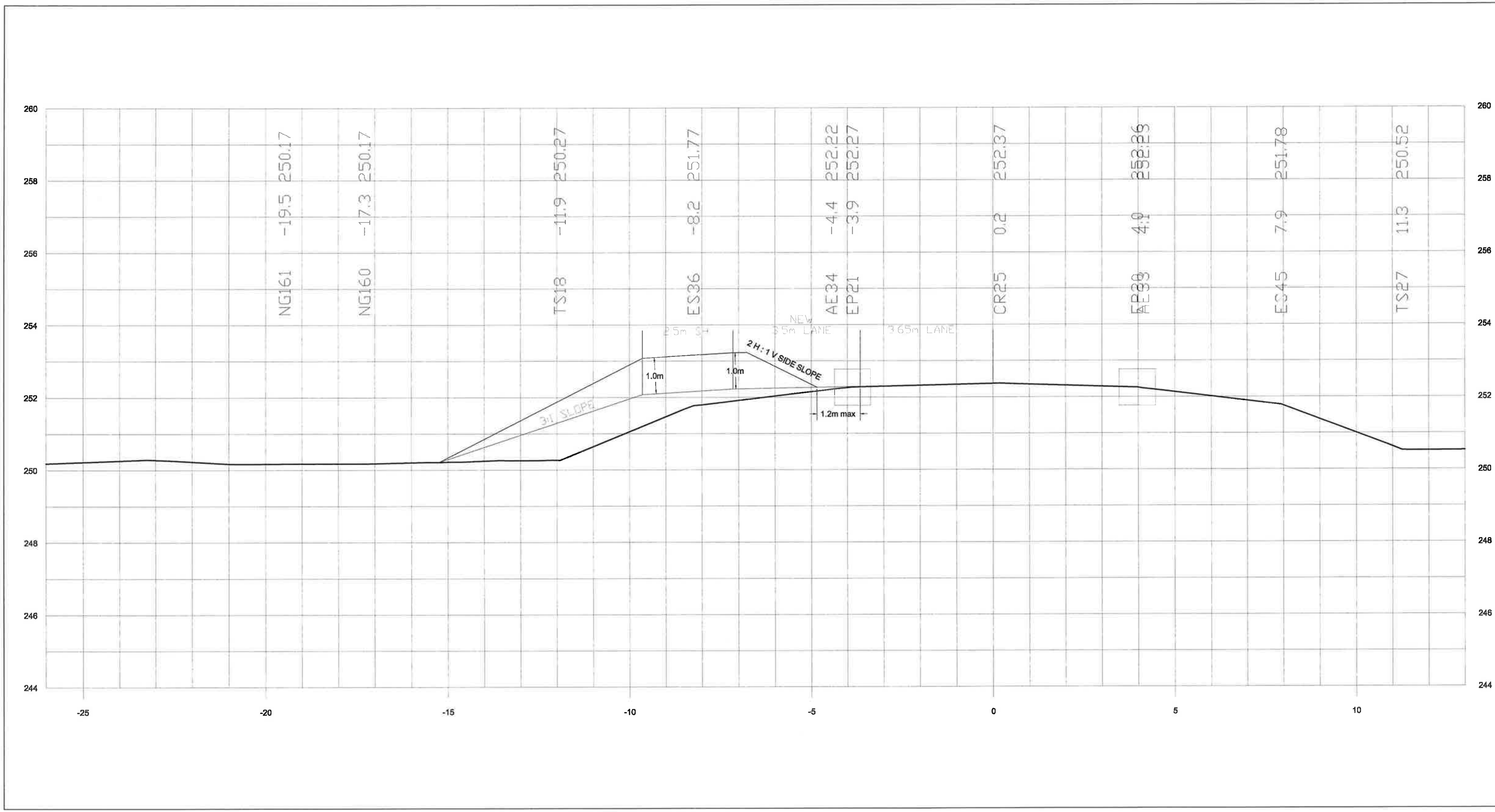
16+950

Figure I-7



16+950

Figure I-8



16+950

Figure I-9

Appendix J

Settlement Estimation

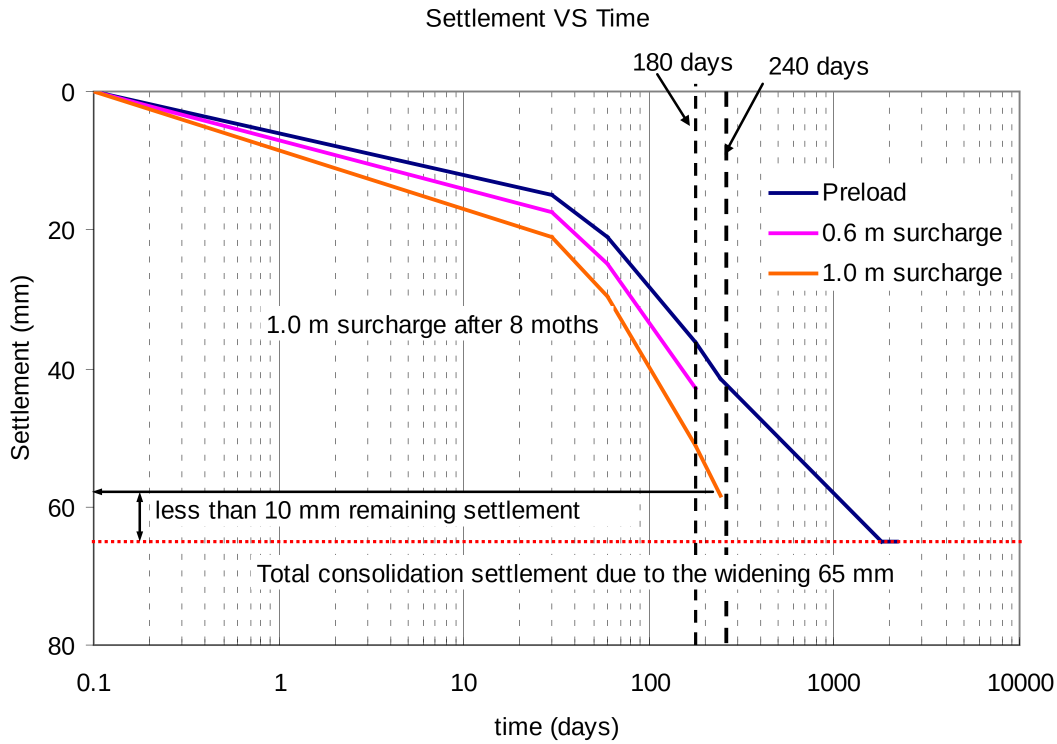


Figure J-1 Settlement estimation at Northbound Passing Lane Area 1

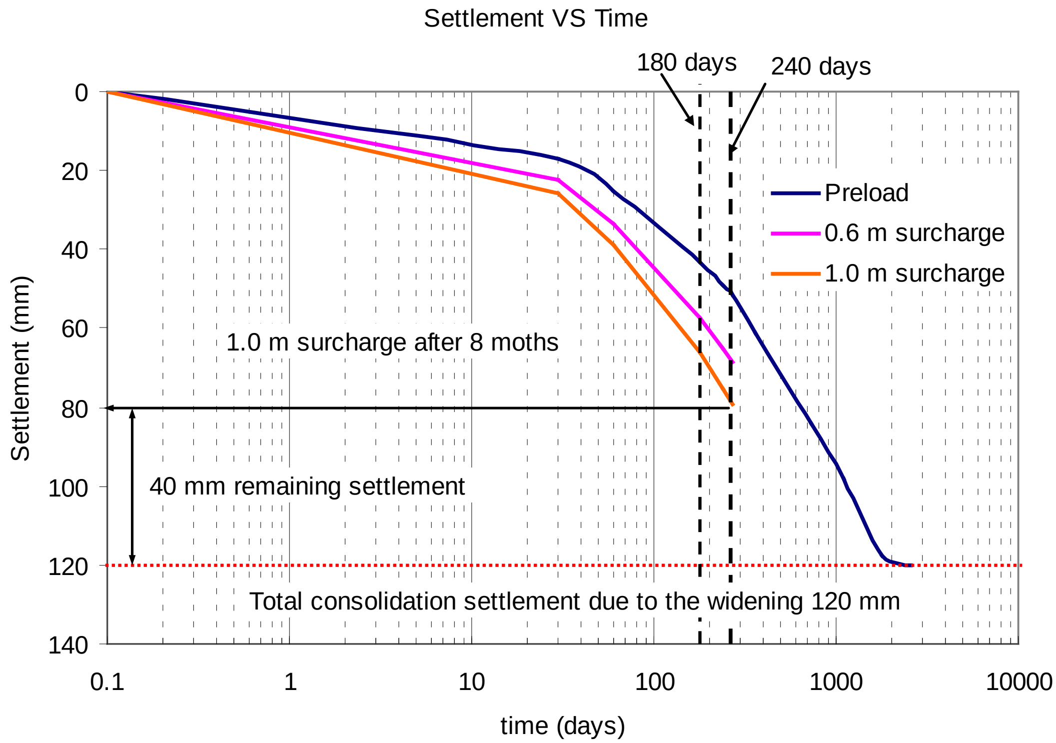


Figure J-2 Settlement estimation at Southbound Passing Lane Area 3

Appendix K

Summary of Options for Reducing Settlements

Summary of options for reducing settlements

Option	Advantages	Disadvantages	Remarks	Preferred option
Preload	-Low cost -Practical if preload can be maintained during off-season	-Longer time is required to reduce the remaining settlement amount -Large amount of remaining settlement after preloading is expected (i.e. northbound Passing Lane section 1 and southbound Passing Lane 3) -Periodic maintenance is required if remaining settlement is large	-Due to the remaining settlement amount, preloading is not recommended for northbound Passing Lane Section 2 and southbound Passing Lane section 3	-Preferred option for northbound Passing Lane Section 1 and south bound Passing Lane Sections 1 and 2
Surcharge	-Higher cost than preloading but considerably lower cost than light weight fill and wick drain options. -Practical if surcharge is maintained during off-season (e.g. winter month) -Lower remaining settlement amount than preload -Shorter period than preloading is required.	-High surcharge can not be applicable at this site due to the traffic safety and snow removal issue -Periodic maintenance may be required if remaining settlement is large	-	-Preferred option for northbound Passing Lane Section 2 and southbound Passing Lane Section 3
Surcharge with Wick Drain	-Will accelerate the consolidation settlement process	-High cost	-Uneconomical	-Not recommended based on cost
Light Weight Fill (EPS)	-Will reduce the total settlement amount	-High cost	-Uneconomical	-Not recommended based on cost

Appendix L

Ontario Standard Specifications

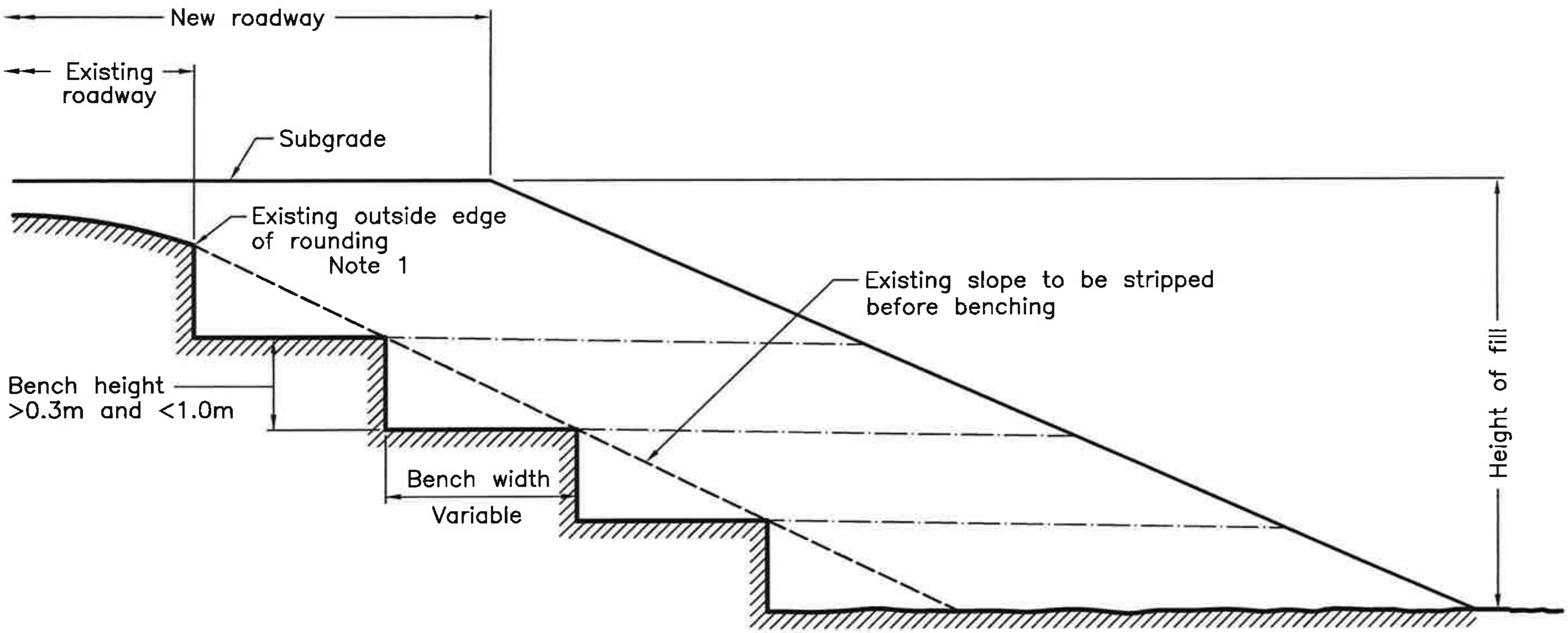
List of Standard Specifications

OPSD

- 208.010 Benching on Earth Slope

OPSS

- 571 Construction Specification for Sodding
- 572 Construction Specification for Seed and Cover



NOTES:

1 When the subgrade is below the existing outside edge of rounding, benching shall be carried out below the point where the subgrade intersects the existing slope.

A Benching is not required on existing slopes flatter than 3H:1V.

B Benches are to be excavated one level at a time and the compacted fill brought up before the next benching level is excavated.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2003	Rev 1
BENCHING OF EARTH SLOPES	**OPSD – 208.010**	

Appendix M

Limitations of Report

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to Coffey Geotechnics Inc. (Coffey) at the time of preparation. Unless otherwise agreed in writing by Coffey, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Coffey accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.