

**FOUNDATION INVESTIGATION AND
DESIGN REPORT - HIGHWAY 401
EXPANSION, DEEP CUTS ON PROPOSED
W-S, W-N AND N/E-S RAMPS AT COUNTY
ROAD 45 INTERCHANGE, TOWN OF
COBOURG AND TOWNSHIP OF
HAMILTON, ONTARIO
G.W.P. NO. 205-00-01 GEOCRES 30M16-52**

AECOM

TRANETOB10434AA-AN
April 25, 2012

FINAL REPORT

April 25, 2012

AECOM
5080 Commerce Boulevard
Mississauga, ON L4W 4P2

Attention: Ms. Peggy Baleka

Dear Ms. Baleka,

RE: Final Foundation Investigation and Design Reports, Highway 401 Expansion, Deep Cuts on Proposed W-S, W-N and N/E-S Ramps at County Road 45 Interchange, Town of Cobourg and Township of Hamilton, Ontario G.W.P. No. 205-00-01 GEOCRE 30M16-52

Coffey Geotechnics Inc. (Coffey) is pleased to present the Final Foundation Investigation and Design Reports relating to the above noted site.

Please call us on 416 213 1255 should you require further clarification on any aspects of the reports.

For and on behalf of Coffey Geotechnics Inc.



Ramon Miranda, P.Eng.

Principal Engineer

Distribution: Original held by Coffey Geotechnics Inc.
1 hard copy to AECOM
1 hard copy to MTO Project Manager
1 hard copy to MTO Pavements and Foundation Section

**FOUNDATION INVESTIGATION REPORT -
HIGHWAY 401 EXPANSION, DEEP CUTS
ON PROPOSED W-S, W-N AND N/E-S
RAMPS AT COUNTY ROAD 45
INTERCHANGE, TOWN OF COBOURG
AND TOWNSHIP OF HAMILTON, ONTARIO
G.W.P. NO. 205-00-01 GEOCRES 30M16-52**

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FINAL REPORT

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FOUNDATION INVESTIGATION REPORT

HIGHWAY 401 EXPANSION, DEEP CUTS ON PROPOSED W-S, W-N AND N/E-S RAMPS AT COUNTY ROAD 45 INTERCHANGE, TOWN OF COBOURG AND TOWNSHIP OF HAMILTON, ONTARIO G.W.P. NO. 205-00-01

1 INTRODUCTION

As part of the expansion (six laning) of Hwy 401 from Burnham Street, Cobourg, Ontario to approx. 2.0 km east of Nagle Road, Coffey Geotechnics Inc. (Coffey) has prepared this foundation investigation report for proposed deep cuts for new ramps to be located in southwest and southeast quadrants of Highway 401 interchange with County Road 45.

Coffey was retained by AECOM to carry out a foundation investigation for the proposed deep cut sections. The foundation investigation was generally carried out in accordance with Coffey proposal (Reference PO 9236, dated May 25, 2009) and the requirements of the RFP.

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

The findings of the investigation are presented in this report. The report provides factual information concerning subsurface conditions, in situ tests and laboratory test results, based on the foundation investigation undertaken.

Table 1.1 below presents the locations of the proposed deep cuts.

Table 1.1: Investigated Deep Cut Location

Cut Number	Ramp	Ramp Centreline Station	Length (m)	Max. Height of Cut (m)	Comments
Cut Area 1	W-S Ramp	18+230 to 18+380	150	7.9	in the vicinity of southwest quadrant of County Road 45 Interchange
Cut Area 2	W-N Ramp	18+890 to 19+040	150	5.3	in the vicinity of southeast quadrant of County Road 45 interchange
Cut Area 3	N/S-E Ramp	18+530 to 18+725	195	4.7	in the vicinity of southeast quadrant of County Road 45 interchange

2 SITE DESCRIPTION AND PHYSIOGRAPHY

2.1 Site Description

The proposed three deep cuts are located in the southwest and southeast quadrants of Highway 401 interchange with County Road 45. During our field investigation, no significant signs of slope instability were observed. Site photographs are presented in Appendix D.

The original ground level elevations along the centreline of the proposed west-south ramp, from ramp Station 18+230 to 18+380 are in the range from 97.9 to 105.6 m (i.e. an elevation rise of 7.7 m over a horizontal distance of 150 m), representing an approximately 5.1% average gradient. The existing cut is typically 3.4 to 7.5 m high and generally sloped flatter than 2.7H:1V, within the investigated stretch.

The original ground surface elevations along the centreline of the proposed west-north ramp between ramp Station 18+890 and 19+040 range from 110.7 to 107.1 m (i.e. an elevation fall of 3.6 m over a horizontal distance of 150 m), representing an approximate 2.4% average down gradient. The existing cut is typically negligible to 5.8 m high, typically with an almost flat slope, within the investigated area.

The existing ground level elevations along the centreline of the proposed north/south-east ramp between ramp Station 18+530 and 18+725 range from 106.6 to 113.8 m (i.e. an elevation rise of 7.2 m over a horizontal distance of 195 m), representing an approximate 3.7% average gradient. The existing cut is typically negligible to 5.5 m high and is generally sloped at flatter than 1.7H:1V side slopes, within the investigated section. At some locations beyond existing ROW, the existing cut slope is steeper than 1H:1V.

2.2 Physiography

According to "The Physiography of Southern Ontario" by L.J. Chapman and D.F. Putnam, 1984, the proposed cut sections are located within the physiographic region known as the Iroquois Plain. The Iroquois Plain was previously inundated by a body of water known as Lake Iroquois, the fore-runner of the present Lake Ontario. Iroquois Plain at Cobourg is about five kilometers in width and has a peculiar belted pattern. The land within the project area is generally covered by glaciolacustrine deposits overlying sandy glacial till deposits.

The bedrock underlying the project area is known to belong to the Trenton and Black River Groups (Simcoe Group), which are approximately 480 million years old, and consist of primarily limestone, with some dolostone, shale, arkose and sandstone (Bedrock Geology of Ontario, Southern Sheet, Map 2544 and Geological Highway Map Southern Ontario, Map 2441).

3 METHOD OF INVESTIGATION

3.1 Fieldwork

The fieldwork for the investigation was carried out between July and November, 2010 and comprised of drilling 10 boreholes. The locations of the boreholes are shown on Borehole Location Plan along with Soil Stratigraphic Sections on Drawing Nos. 1, 2 & 3 in Appendix C. The boreholes drilled for the foundation investigation of the proposed retaining wall adjacent to the proposed cut locations are also presented in this

report to provide more complete coverage and better understanding of the subsurface conditions at the proposed cuts. Tables 3.1 to 3.3 below present summaries of the boreholes drilled at the proposed cut sections for each of the proposed ramps.

Table 3.1: Borehole Details for Proposed West-South Ramp – Cut Area 1

Borehole No.	Station of Proposed Ramp	Offset from Proposed Ramp C/L	Existing Ground Elevation (m)	Drilled Depth (m)
R2*	18+284	11 m Right of C/L	103.5	16.8
R3*	18+324	9 m Right of C/L	105.0	18.9
F73	18+340	7 m Right of C/L	105.6	20.2
F74	18+374	3 m Left of C/L	105.7	21.8

* Boreholes drilled originally for foundation investigation for proposed retaining wall and could be utilized for Cut 1

Table 3.2: Borehole Details for Proposed West-North Ramp – Cut Area 2

Borehole No.	Station of Proposed Ramp	Offset from Proposed Ramp C/L	Existing Ground Elevation (m)	Drilled Depth (m)
F76	19+024	at C/L	107.6	6.6
F77**	19+005	13 m Left of C/L	108.0	6.6
F79	18+953	at C/L	109.1	8.1
F81	18+902	at C/L	110.7	8.1

**Borehole drilled originally for subsoil investigation for Proposed N/S-E Ramp (Cut 3) and could be utilized for Cut 2

Table 3.3: Borehole Details for Proposed North/South-East – Cut Area 3

Borehole No.	Station of Proposed Ramp	Offset from Proposed Ramp C/L	Existing Ground Elevation (m)	Drilled Depth (m)
F75	18+526	at C/L	106.6	6.6
F77	18+573	6 m Left of C/L	108.0	6.6
F78	18+596	5 m Right of C/L	108.9	6.6

Borehole No.	Station of Proposed Ramp	Offset from Proposed Ramp C/L	Existing Ground Elevation (m)	Drilled Depth (m)
F80	18+675	at C/L	111.4	11.1
F82	18+724	at C/L	110.3	8.1

The borehole drilling was carried out by two drilling subcontractors, Eastern Soil Investigation Limited and Strong Soil Search. The boreholes were advanced using either a track mounted (Bombardier) or a truck mounted drilling rig. Each borehole was advanced using solid flight or hollow stem augers to depths of 6.6 to 21.8 m below the ground surface. Standard Penetration Tests (SPTs) were carried out in the overburden at selected depth intervals, to assess the soil strength and to obtain samples for logging and testing purposes. SPTs were carried out in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer from a vertical distance of 0.76 m to drive a 51 mm outside diameter (OD) split-barrel (SS-split-spoon) sampler into the ground. 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 (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils). Where consistency permitted, the in-situ undrained shear strength of the cohesive soils was measured by means of field vane tests, using MTO type field vanes.

The soil samples were described in the field, placed in appropriate containers, labelled and transported to our Etobicoke geotechnical laboratory where the samples underwent further detailed visual examination and samples were selected for geotechnical laboratory testing.

Groundwater levels and inflows observed in the open boreholes during drilling were recorded. In each Boreholes F73, F74, F75, F77, F80 and F82, standpipe piezometer was installed to enable long term groundwater level monitoring. These should be decommissioned during the construction. The remaining boreholes were grouted upon their completion using a cement/bentonite mixture, as per MTO procedures.

The boreholes were located on site using existing site features. The borehole location coordinates and ground elevations were subsequently measured by the client's surveyors and were provided to Coffey.

A Coffey representative was present during the drilling operations to direct sampling and testing, record test results and log materials encountered.

Appendix A presents the Record of Borehole Sheets.

3.2 Laboratory Testing

Soil samples obtained during the investigation were taken to our Etobicoke laboratory, where the following tests were performed on selected soil samples:

- Natural moisture content tests;
- Grain size analyses (sieve);

- Grain size analyses (sieve and hydrometer tests);
- Atterberg Limits tests;

Appendix B presents the laboratory test results sheets. The results of natural moisture content are presented on the Record of Borehole Sheets in Appendix A.

4 SUBSURFACE CONDITIONS

The following sections present the subsurface conditions for each of the cut sections.

Drawing No. 1, 2 & 3 in Appendix C present the borehole location plan and the generalized subsurface profile at each of the proposed cuts involved for the proposed ramps. Record of Borehole sheets for each of the proposed ramp are presented in Appendix A and the corresponding laboratory test results are presented in Appendix B.

The Record of Borehole Sheets and the inferred stratigraphy indicate the subsurface conditions only at the borehole locations. Note that the material boundaries indicated on the Record of Borehole sheets are based on visual observations and should therefore be considered approximate only. These boundaries typically represent a transition from one material type to another and should not be regarded as an exact plane of geological change. It should be pointed out that the subsurface conditions may vary in between and beyond the borehole locations.

4.1 Proposed West-South Ramp - Cut Area 1 (Stations 18+320 to 18+380; Boreholes R2, R3, F73 and F74)

The proposed west-south ramp is to be located in the southwest quadrant of Hwy 401 interchange with County Road 45 and will involve deep cuts. It is noted that the site is located about 0.4 km east of the Cobourg Creek. The subsoil investigation was carried out by drilling two boreholes (F73 and F74). In addition, two Boreholes (R2 and R3), originally drilled for a proposed retaining wall (which will be covered in a separate report) that is located immediately next of the proposed cut site, have also been included to provide additional information.

As described before, the existing ground level rises at approximately 5.1% average gradient with the increasing of stations along the proposed ramp centreline and the existing cuts are typically 3.4 to 7.5 m high and sloped at 2.7H:1V or flatter within the investigated stretch.

Detailed descriptions of the subsurface conditions encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A. The inferred stratigraphy is presented on Drawing 1 in Appendix C.

The boreholes were advanced from the top or from the sloping portion of the existing slope from elevations ranging from 105.7 to 103.5 m and encountered 0.15 to 0.25 m thick topsoil at the ground surface. In general, below the topsoil, Boreholes R3, F73 and F74 encountered a 1.9 to 2.3 m thick surficial granular deposit comprised of silty sand to sand. Underlying the surficial granular deposit in Borehole R3, F73, F74 and topsoil in Borehole R2, a clayey silt deposit was encountered to depths of 14.6 to 20.0 m below the ground surface or to Elevation 88.9 – 85.7 m. This clayey silt deposit is interbedded with silty sand to

sandy silt layers/seams. The clayey silt is underlain by a glacial deposit which consists of silty sand to sandy silt till. All four boreholes were terminated within this glacial till deposit at depths of 16.8 to 21.8 m below the ground surface or at Elevations 86.7 to 83.9 m.

The following summarizes the surface conditions encountered in the boreholes.

4.1.1 Topsoil

Topsoil was encountered at the ground surface in all the boreholes and its thickness ranged from 0.15 to 0.25 m.

It should, however, be pointed out that, in our experience, the thickness of organic rich soils frequently varies in between and beyond the borehole locations.

4.1.2 Silty Sand to Sand

Below the topsoil, silty sand to sand with some gravel and traces to some rootlets/organics was encountered in all the boreholes, except in Borehole R2. This deposit was found to extend to depths ranging from 2.1 to 2.4 m below the existing ground level or to Elevation 103.6 - 102.9 m.

Grain size distribution analyses were carried out on two selected samples taken from this deposit indicate the following distribution, as shown in Figure B-1, in Appendix B.

Gravel:	0 – 12 %
Sand:	48 – 69 %
Silt and Clay:	31 – 40 %

This is basically a granular (non-cohesive) material.

Standard Penetration Tests performed in this soil yielded N-values ranging from 4 to 33 blows/0.3 m, indicating very loose to dense, but typically loose to compact relative density. It should be pointed out that the single digit values (i.e. very loose to loose) were recorded within the upper 0.6 m of the ground surface and below this zone the recorded N-values indicate a typically compact condition.

4.1.3 Clayey Silt

Underneath the surficial silty sand to sand or the topsoil (in Borehole R2), a massive clayey silt deposit underlies the site at all the borehole locations at depths ranging from 0.2 to 2.4 m (El. 103.6 to 102.9 m). This deposit extends to depths ranging from 14.6 to 20.0 m below the ground surface (El. 88.9 to 85.7 m). This deposit contains frequent fine grained granular interbeds. A relatively thick layer of these granular interbeds divides the clayey silt deposit into upper and lower zones as discussed below.

4.1.3.1 Upper Clayey Silt

The upper zone was contacted immediately below the topsoil or the surficial granular soils and extended to depths of 7.9 to 13.5 m below the ground surface or to Elevation 95.6 – 92.1 m.

It is considered practically an impervious cohesive soil but contains some fine grained granular (non-cohesive) seams/layers of relatively pervious silty sand to sandy silt.

The following are the grain size distribution of three selected samples taken from this upper zone of the clayey silt deposit, as shown in Figure B-2, in Appendix B.

Gravel:	0 %
Sand:	3 – 4 %
Silt:	61 – 65 %
Clay:	31 – 35 %

Atterberg Limits tests conducted on the three samples taken from this upper cohesive deposit indicated the following results, also shown in Figure B-3, in Appendix B.

Liquid Limit:	26 – 28 %
Plastic Limit:	15 – 16 %
Plasticity Index:	11 – 12
Natural Moisture Content:	19 – 23 %

Based on the above, this deposit is considered to have low plasticity.

The measured natural moisture contents typically range from 20 to 25%.

Standard Penetration Tests yielded SPT N-values ranging from 8 to 40 blows/0.3 m within this clayey silt deposit. A field vane test was also carried out in this cohesive deposit and recorded an undrained in-situ shear strength value in excess of 100 kPa. Based on these test results, this deposit is considered to have a stiff to hard consistency.

4.1.3.2 Lower Clayey Silt

The lower zone of clayey silt deposit was encountered at depths ranging from 10.2 to 14.1 m (El. 93.3 to 91.5 m) and extended to depths ranging from 14.6 to 20.0 m below the original ground surface (El. 88.9 to 85.7 m). Thus at the borehole locations, the thickness of this lower clayey deposit varies from 4.4 to 6.1 m. The deposit contains occasional sand, silt and clay seams.

It is considered practically an impervious cohesive soil, except for the silt and sand interbed zones.

Standard Penetration Tests yielded SPT N-values ranging from 6 to 23 blows/0.3 m within this lower clayey silt deposit. Field vane tests were also carried out in this cohesive deposit and recorded undrained in-situ shear strength values ranging from 60 to in excess of 100 kPa. Based on these test results, this deposit is considered to have a stiff to very stiff consistency.

4.1.4 Silty Sand to Sandy Silt

As mentioned before, a silty sand to sandy silt layer separates the clayey silt deposit into an upper and lower zones. The thickness of this layer was found to range from 0.6 m in Borehole F73 to 2.3 m in Borehole R2. This silty sand to sandy silt was found at depths ranging from 7.9 to 12.7 m below the ground surface (El. 95.6 to 93.0 m) and found to extend to depths ranging from 10.2 to 13.9 m (El. 93.3 to 91.8 m). The deposit is considered to be granular (non-cohesive) material.

Grain-size analyses were carried out on two representative samples from this soil. The results are presented on Record of Borehole sheets in Appendix A, and the grain size curves are shown in Figure B-4 in Appendix B. This shows the following grain-size distribution.

Gravel:	0 – 1 %
Sand:	33 – 36 %
Silt:	55 – 57 %
Clay:	8 – 10 %

Standard Penetration Tests yielded SPT N-values of 8 to in excess of 100 blows/0.3 m, indicating a loose to very dense but typically compact to dense relative density.

This deposit is considered to be wet and water bearing.

4.1.5 Silty Sand Till

Underlying the clayey silt, all the boreholes contacted a glacial till deposit consisting of a heterogeneous mixture of sand and silt with traces to some gravel and clay size particles. This till deposit was encountered at depths ranging from 14.6 to 20.0 m (El. 88.9 to 85.7 m) and was found to extend to the remaining depth of the boreholes. Occasional cobbles were also encountered within the glacial till deposit. Due to their mode of deposition, the presence of cobbles and boulders should always be anticipated in the glacial till deposits.

The silty sand till is basically a granular material but, in some cases, where the clay content is high, it exhibits some apparent cohesion. Grain size distribution of a sample from the till deposit is presented in Figure B-5 in Appendix B. The results indicate the following grain-size distribution.

Gravel:	9 %
Sand:	55 %
Silt:	27 %
Clay:	9 %

SPT N-values recorded in this glacial till ranging from 37 to in excess of 100 blows/0.3 m, indicating a dense to generally a very dense condition.

4.1.6 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 in Appendix A. The observations made in the boreholes are summarized in Table 4.1.

Table 4.1: Groundwater Level Observations – Proposed West South Ramp – Cut Area 1

Borehole No.	Depth/Elevation of the Tip of Piezometer (m)	Date of Water Level Measurement	Measured Water Level Depth/Elevation (m)	Comments
R2	-	July 21, 2010	6.1 / 97.4*	Measured upon borehole completion
R3	-	July 22, 2010	8.2 / 96.8*	Measured upon borehole completion
F73	19.8 / 85.8	July 22, 2010 July 26, 2010 Aug 19, 2010 Oct 15, 2010	15.2 / 90.6* 8.5 / 97.1 8.3 / 97.3 7.8 / 97.8	First reading measured upon borehole completion and succeeding readings measured within the piezometer installed
F74	20.1 / 85.6	July 26, 2010 Aug 19, 2010 Oct 15, 2010	6.5 / 99.2* 7.2 / 98.5 6.7 / 99.0	First reading measured upon borehole completion and succeeding readings measured within the piezometer installed

Note: * Groundwater level measured not stabilized.

As the observations in Boreholes R2 and R3 were made upon their completion (short term single observation), the recorded water levels are unlikely to represent the stabilized groundwater levels. In each of Boreholes F73 and F74, a standpipe piezometer was installed (stabilized water level recorded). In general, the groundwater table at the site at the time of our investigation was found to range from about 6 to 8 m below the original ground level or between about Elevations 99 and 97 m.

It should be pointed out that the observed groundwater levels represent the conditions at the time of our investigation and that the groundwater level would be subject to fluctuations, both seasonally and in response to major weather events. In addition, there is also a potential for the development of perched groundwater condition in the relatively more pervious surficial granular layer, underlain by the less pervious clayey silt material. The water level in the existing watercourse (i.e. Cobourg Creek) would also influence the groundwater level at the site.

4.2 Proposed West-North Ramp - Cut Area 2 (Stations 18+890 to 19+040; Boreholes F76, F79 and F81)

The proposed west-north ramp, located in the southeast quadrant of the Hwy 401 interchange with County Road 45 involves cut sections to be constructed. The subsoil investigation was carried out by drilling three boreholes (BH F76, F79 and F81). Borehole F77, which was originally drilled for the proposed north/south-east ramp, is believed to provide useful subsurface information and has been included herein.

As mentioned before, the existing ground level drops mildly at approximately 2.4% average down gradient with the increasing of stations along the proposed ramp centreline.

Detailed descriptions of the stratigraphy encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A. The borehole location plan and the inferred stratigraphy are presented on Drawing 2 in Appendix C.

The boreholes contacted a veneer of topsoil at the ground surface or a 0.5 to 0.6 m thick fill (dumped soil). All the boreholes, except F81, encountered a 0.9 to 1.3 m thick surficial granular soil consisting of sand, some silt to silty sand. The surficial sand in Boreholes F76, F77 and F79 and fill in Borehole F81 are underlain by a 2.9 to 4.9 m thick clayey silt, which in turn underlain by a glacial deposit consisting of silty sand to sandy silt till. All the boreholes were terminated within this glacial till deposit after 0.2 to 4.6 m penetration at depths of about 6.6 to 8.1 m below the ground surface or at Elevations 102.6 to 101.0 m.

The individual strata along with the groundwater conditions are briefly discussed in the following sections.

4.2.1 Topsoil

The boreholes were extended from elevations ranging from 110.7 to 107.6 m. In Boreholes F76 and F77, an about 0.15 m thick topsoil layer was encountered at ground surface. In Boreholes F79 and F81, the topsoil was found mixed with fill (dumped excavated material).

It should be pointed out that in our experience, the thickness of topsoil and other organic rich soils frequently varies in between and beyond borehole locations.

4.2.2 Fill

Boreholes F79 and F81 encountered about 0.5 to 0.6 m thick fill consisting of sand, some silt. The fill encountered at the borehole locations also contains some rootlets and trace to some topsoil.

The fill contacted can be classified as a granular (cohesionless) material.

Standard Penetration Tests performed and the recorded N-values in this fill soil were 4 blows/0.3 m, which indicates a very loose condition.

It should be pointed out that at the time of our soil investigation, we noted the presence of about 1 to 4 m high stockpiles at few locations. We drilled our boreholes little away from these manmade stockpiles (probably dumped excavated soil).

4.2.3 Sand to Silty Sand

A sand to silty sand deposit was encountered in all the boreholes except Borehole F81 below topsoil or fill, and it was found to extend to depths ranging from 1.4 to 1.5 m below the ground surface (Elevation 107.7 to 106.1 m). The thickness of this surficial deposit encountered was 1.3 m at west side (Borehole F76) and reduces to 0.9 m at east side (Borehole F79). As mentioned before, this deposit was not encountered further east in Borehole F81. This deposit contains traces to some clay size particles and rootlets/organics.

This soil can be considered as a granular (cohesionless) material.

A grain-size analysis was carried out on a representative sample from this deposit and results are presented on the Record of Borehole sheets in Appendix A, and in Figure B-6 in Appendix B.

These show the following grain-size distribution.

Gravel:	0 %
Sand:	49 %
Silt:	40 %
Clay:	11 %

Standard Penetration Tests performed in the deposit yielded N-values ranging from 9 to 30 blows/0.3 m which indicate a loose to compact relative density.

4.2.4 Clayey Silt

Below the surficial deposit of sand to silty sand in Boreholes F76, F77 and F79 and fill at Borehole F81, a clayey silt deposit was encountered at depths ranging from 0.6 to 1.5 m (El. 110.1 to 106.1 m) and was extended to depths ranging from 3.5 to 6.4 m below the ground surface (El. 107.2 to 101.2 m). The thickness of clayey deposit contacted in the boreholes ranged from 2.9 to 4.9 m. This is basically a cohesive (non-granular) soil deposit.

The measured natural moisture contents from this soil samples varying from 11% to 28%.

Standard Penetration Tests yielded SPT N-values ranging from 10 to 41 blows/0.3 m within this clayey silt deposit. Based on these test results, this deposit is considered to have a stiff to hard consistency.

In borehole F79, sandy silt seams were found within this clayey deposit, whose grain size distribution shows 2% gravel, 34% sand, 52% silt and 12% clay, as presented on the Record of Borehole sheet in Appendix A, and in Figure B-7 in Appendix B.

4.2.5 Sandy Silt to Silty Sand Till

Clayey silt is underlain by a glacial deposit consisting of sandy silt to silty sand till. The deposit consists of a heterogeneous mixture of sand and silt with traces to some gravel and clay. The boreholes contacted this glacial deposit at depths varying from 3.5 to 6.4 m depth (El. 107.2 to 101.2 m). This unit extended to the remaining depth of the exploration (i.e. 6.6 to 8.1 m or El. 102.6 to 101.0 m) where the boreholes were terminated.

Two grain-size analyses were carried out on representative samples of this soil. The results are presented on the Record of Borehole sheets in Appendix A, and the grain size curves are shown in Figure B-8 in Appendix B.

These show the following grain-size distribution.

Gravel:	7 – 9 %
Sand:	35 %
Silt:	37 – 39 %
Clay:	19 %

It should be pointed out that due to their mode of deposition, the presence of cobbles and boulders should always be anticipated in such glacial till deposits. In fact auger grinding and sampler bouncing were noted during the drilling operations, which are indicative of such occurrences.

Where the clay content is relatively high, the deposit was noted to exhibit some apparent cohesion. An Atterberg Limits test was performed on a sample from such a zone and the results are shown in Figure B-8A in Appendix B. The results indicate a slightly plastic material.

Standard Penetration Tests performed and recorded N-values in this soil deposit range from 29 to in excess of 100 blows/0.3 m, which indicate a compact to very dense compactness condition, but generally dense to very dense.

4.2.6 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 in Appendix A. The observations made in the boreholes are summarized in Table 4.2.

Table 4.2: Groundwater Level Observations – Proposed West North Ramp – Cut Area 2

Borehole No.	Depth/Elevation of the Tip of Piezometer (m)	Date of Water Level Measurement	Measured Water Level Depth/Elevation (m)	Comments
F76	-	Nov 19, 2010	1.4 / 106.2*	Measured upon borehole completion
F77	6.6 / 101.4	Sept 08, 2011	1.2 / 106.8	Measured after 296 days after the piezometer installation
F79	-	Nov 24, 2010	dry*	Dry and open upon borehole completion

Borehole No.	Depth/Elevation of the Tip of Piezometer (m)	Date of Water Level Measurement	Measured Water Level Depth/Elevation (m)	Comments
F81	-	Nov 25, 2010	dry*	Dry and open upon borehole completion

Note: * Groundwater level measured not stabilized.

As the water level observations in Boreholes F76, F79 and F81 were made upon the completion of the boreholes, the recorded levels in these boreholes are unlikely to represent the stabilized groundwater levels. Based on the change in soil colour from brown to grey and natural moisture contents, the anticipated groundwater table at the site at the time of our investigation was generally 1 to 3.5 m below the existing ground level or between about Elevations 107 and 106 m. It should also be pointed out that in Borehole F75, drilled for Cut Area 3, a mild artesian condition was recorded at about 0.7 m above the grade (See Table 4.3) or at El. 107.3 m. This borehole is located close to Cut Area 2.

It should also be pointed out that the observed groundwater levels represent the conditions at the time of our investigation and that the groundwater level would be subject to fluctuations, both seasonally and in response to major weather events. In addition to the observed groundwater conditions, a perched water condition could possibly be encountered at the site due to the accumulation of the surface water in fill and surficial granular materials, overlying the practically impervious clayey silt deposit.

4.3 Proposed North/South-East Ramp - Cut Area 3 (Stations 18+530 to 18+725; Boreholes F75, F77, F78, F80 and F82)

The proposed Cut Area 3 for the proposed north/south-east ramp is to be located in the southeast quadrant of Hwy 401 interchange with County Road 45. The subsoil conditions were explored by drilling five boreholes (BH F75, F77, F78, F80 and F82).

As described before, the existing ground level rises at approximately 3.7% average gradient with the increasing of stations along the proposed ramp centreline and the existing cut is up to 5.5 m high, within the investigated stretch. As per the cross sections provided by AECOM, the proposed profile along the centreline of proposed N/S-E Ramp involves up to about 4.5 m deep cuts.

Detailed descriptions of the materials encountered in the boreholes are presented on the Record of Borehole Sheets in Appendix A. The Borehole Location Plan and the inferred stratigraphy are presented on Drawing 3 in Appendix C.

Borehole F77 contacted a veneer of topsoil having a thickness of about 0.15 m at the ground surface. In the remaining four boreholes, the topsoil was found mixed with a 0.5 to 0.7 m thick fill (dumped soil). Underlying the surficial topsoil or fill, Boreholes F77 and F80 encountered a 1.2 to 1.4 m thick granular soil consisting of sand with some silt. These surficial deposits are underlain by a 1.2 to more than 6.0 m thick clayey silt deposit, which in turn further underlain by a glacial soil consisting of silty sand till. All the boreholes, except F75, were terminated within this glacial till deposit after 1.7 to 8.0 m penetration at

depths of about 6.6 to 11.1 m below the ground surface or at Elevations 102.3 to 100.3 m. Borehole F75 was terminated within the clayey silt deposit at depth of 6.6 m (El. 100.0 m)

The various soil strata encountered in the boreholes and their geotechnical properties are described in the following sections.

4.3.1 Topsoil

Borehole F77 encountered about 0.15 m thick topsoil layer at ground surface, while all other boreholes found topsoil mixed with fill (dumped fill material).

It should however be pointed out that in our experience, the thickness of topsoil and other organic rich soils frequently varies in between and beyond borehole locations.

4.3.2 Fill

It should be noted that at the time of our soil investigation, the presence of 1 to 4 m high fill stockpiles were noted at some locations strewn across the site. We drilled the boreholes away from these manmade stockpiles. All the Boreholes, except F77, encountered an about 0.5 to 0.7 m thick fill consisting of sand, some silt. They also contains some organics, some rootlets and trace to some topsoil, probably also includes the original topsoil.

This soil can be classified as a granular (cohesionless) material.

N-values recorded from Standard Penetration Tests performed in the fill soil were ranging from 4 to 8 blows/0.3 m, which indicate very loose to loose condition (i.e. dumped, non-compacted material).

4.3.3 Sand

A 1.2 to 1.4 m thick sand deposit was encountered in Boreholes F77 and F80 below topsoil or fill, and extended to depths of 1.4 and 1.9 m below the ground surface (Elevations 109.5 and 106.6 m). This deposit contains some silt, traces of gravel and rootlets/organics.

Basically this soil can be considered as a granular (cohesionless) material.

Standard Penetration Tests performed in the deposit yielded N-values ranging from 9 to 31 blows/0.3 m indicating a loose to dense, but in general, a compact relative density.

4.3.4 Clayey Silt

All the boreholes contacted clayey silt at depths ranging from 0.6 to 1.9 m below the ground level or at Elevations 109.7 to 106.0 m. This unit was found to extend to 3.1 m to greater than 6.6 m below the ground surface (El. 108.3 to less than 100.0 m). Borehole F75 was terminated within this deposit at a depth of 6.6 m (El. 100.0 m). The thickness of clayey silt deposit ranges from 1.2 m (Borehole F80) to more than 6.0 m (Borehole F75). The material contains traces to some sand. In Borehole F82, trace rootlets was found in this deposit, immediately below the fill.

The grain-size distribution of three samples from this layer is presented in Figure B-9 in Appendix B4. The distribution can be summarized as follows:

Gravel:	0 – 14 %
Sand:	7 – 36 %
Silt:	36 – 58 %
Clay:	14 – 36 %

Atterberg Limits tests were performed on three samples retrieved from this cohesive deposit. The results from these tests are presented in Figure B-10 in Appendix B4.

Liquid Limit:	13 – 31 %
Plastic Limit:	11 – 19 %
Plasticity Index:	2 – 12

The results presented above indicate that this clayey (cohesive) deposit possesses low plasticity.

Standard Penetration Tests performed within this deposit yielded N-values varying from 10 to 64 blows/0.3 m, indicating that consistency of this cohesive layer can be described as stiff to hard, but typically stiff to very stiff.

4.3.5 Sandy Silt to Silty Sand Till

All the boreholes (except for F75) contacted a glacial deposit underlying the clayey silt at depths ranging from 3.1 to 4.9 m (El. 108.3 and 103.1 m) and extended to the remaining depth of boreholes. Borehole F75 was terminated within the clayey silt at a depth of 6.6 m (El. 100.0 m) before contacting this deposit. The glacial till consists of a heterogeneous mixture of sand and silt with traces to some gravel and clay. Due to its mode of deposition, the presence of cobbles and boulders should always be expected within this deposit.

The silty sand till is basically a granular material but in some cases, where the clay content is high, and this deposit shows some apparent cohesion. Grain size distribution of a sample from the till deposit is presented in Figure B-11 in Appendix B. The results indicate the following grain-size distribution.

Gravel:	9 %
Sand:	35 %
Silt:	37 %
Clay:	19 %

SPT N-values recorded in this glacial till range from 30 to in excess of 100 blows/0.3 m, indicating a dense to very dense condition.

4.3.6 Groundwater Conditions

The groundwater conditions were observed during drilling and upon completion of each borehole. The groundwater conditions observed in the boreholes are presented in the individual Record of Borehole Sheets in Appendix A and are also summarized in Table 4.3.

Table 4.3: Groundwater Level Observations – Proposed North/South-East Ramp – Cut Area 3

Borehole No.	Depth/Elevation of the Tip of Piezometer (m)	Date of Water Level Measurement	Measured Water Level Depth/Elevation (m)	Comments
F75	6.6 / 100.0	Nov 24, 2010 Sept 08, 2011	0.2 / 106.4 (-) 0.7 / 107.3	Measured after 5 days Measured after 293 days (artesian)
F77	6.6 / 101.4	Sept 08, 2011	1.2 / 106.8	Measured after 296 days
F78	-	Nov 18, 2010	dry*	Dry and open upon borehole completion
F80	11.1 / 100.3	Jan 05, 2011 Sept 08, 2011	10.2 / 101.2 2.1 / 109.3	Measured after 41 days Measured after 287 days
F82	7.6 / 102.7	Jan 05, 2011 Sept 08, 2011	7.6 / 102.7 1.4 / 108.9	Measured after 41 days Measured after 287 days

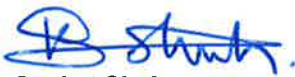
Note: * Groundwater level measured not stabilized.

It should be noted that the water level observed in Borehole F78 upon its completion is unlikely to be reliable, as it had not been stabilized. In this borehole, the estimated groundwater level based on the change of the soil colour from brown to grey is about 2.5 m below the ground surface or at about Elevation 106.5 m.

In the remaining four boreholes, the piezometers were installed and these showed that the groundwater table at the site at the time of our investigation was measured from 0.7 m above the ground surface (i.e. a slight artesian) to about 2 m below the ground surface or typically between Elevation 109 to 107 m.

It should however be noted that the groundwater levels are subject to seasonal variations and fluctuations due to major weather events. In addition to the observed groundwater conditions, a perched water condition could possibly be encountered at the site due to the accumulation of surface water in fill and surficial granular materials, overlying the practically impervious clayey silt deposit.

For and on behalf of Coffey Geotechnics Inc.




Sanket Shah

Engineer in Training




Ramon Miranda, P.Eng.

Principal Engineer


Zuhtu Ozden, P.Eng.

Senior Principal



Appendix A

Record of Borehole Sheets

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No R2

1 OF 2

METRIC

GWP G.W.P. 205-00-01 LOCATION Station 18+284, 40 m Rt C/L (9 m Rt of Prop. W-S Ramp C/L) (E 410996.5, N 4872040) DATED BY RK
 DIST HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/21/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)		
								20	40	60			80	100	10
103.5 0.0	GROUND SURFACE														
	0.2 m TOPSOIL		1	SS	9										
	tr. org damp, stiff		2	SS	21										
	moist		3	SS	31										
	CLAYEY SILT with sand seams brown, v. stiff to hard		4	SS	17										
			5	SS	17										
	sandy silt layer with clay seams brown, dense, moist		6	SS	46										
			7	SS	23										
	brown		8	SS	19										
	brownish grey		9	SS	10										
	moist														
	grey, wet														
95.6 7.9	SILTY SAND TO SANDY SILT tr. to some clay brown, v. dense, wet		10	SS	24										
			11	SS	100 / 28 cm*										
93.3 10.2	CLAYEY SILT with sand seams grey, stiff, wet		12	SS	9										
			13	SS	8										
	tr. gravel		14	SS	10										
88.9 14.6	SILTY SAND TILL														

Continued Next Page

+³, X³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

+³, ×³: Numbers refer to Sensitivity

TRANETO10434AA: Highway 401

RECORD OF BOREHOLE No R3

1 OF 2

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+323, 40 m Rt C/L (E 411031.1, N 4872511.7) ORIGINATED BY RK
 DIST HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/21/2010 7/22/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
FLEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	
105.0 0.0	GROUND SURFACE						105					
	0.2 m TOPSOIL		1	SS	7							
	tr. org., loose											
	SILTY SAND TO SAND		2	SS	33		104					12 48 (40)
	tr. silt pockets											
	brown, dense to compact, moist to wet		3	SS	14		103					
102.9 2.1												
		stiff	4	SS	13		102					0 4 61 35
		v. stiff to hard	5	SS	17		101					
	CLAYEY SILT		6	SS	16		100					
	with silt and clay layers/seams											
	varved like		7	SS	26		99					
	occ. sand seams											
	moist		8	SS	27		98					
		brown										
		brownish grey	9	SS	40		97					
		moist to wet										
			10	SS	31		96					
		grey, wet					95					
			11	SS	23		94					
		silty clay layer with										
		silt seams, wet	12	SS	25		93					
93.5 11.5	SANDY SILT TO SILTY SAND		13	SS	23		92					0 33 57 10
	trace to some clay											
	grey, compact, wet											
92.3 12.7							91					
	CLAYEY SILT		14	SS	6							
	with clay and silt seams											
	grey, firm, moist to wet											

Continued Next Page

+ 3 x 3

Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

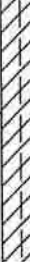

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No R3

2 OF 2

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+323, 40 m Rt C/L (E 411031.1, N 4872511.7) ORIGINATED BY RK
 DIST HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/21/2010 7/22/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL		
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)						
								20	40	60			80	100
90.0														
87.3 17.7	CLAYEY SILT with clay and silt seams grey, moist to wet		15	SS	7									
			16	SS	16									
86.1 18.9	SILTY SAND TILL trace gravel, occ. cobbles and boulders grey, v. dense, moist		17	SS	115									
	End of Borehole. Water level @ 8.2 m (not stabilized)* upon completion. Borehole caved-in @ 9.1 m upon completion.		18	SS	10 / 0 cm									

METRIC

CHECKED BY ZO

+³, ×³: Numbers refer to Sensitivity

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F73

2 OF 2

METRIC

GWP G.W P 205-00-01 LOCATION Station 18+340, 7 m Rt of C/L of Proposed W-S Ramp (E 411045.3, N 4872518.2) ORIGINATED BY RK/SK
 DIST HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/22/2010 CHECKED BY ZO

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20 40 60 80 100						20 40 60 80 100
90.6	CLAYEY SILT tr. to some sand greyish brown, stiff to v. stiff		15	SS	12									
86.9	SILTY SAND TILL tr. to some gravel grey, v. dense, wet		17	SS	23									
18.7														
85.4			18	SS100 / 20										
20.2	End of Borehole Piezometer installed @ 19.8 m Date / Measured Water Depth July 22, 2010 / 15.2 m July 26, 2010 / 8.5 m August 19, 2010 / 8.3 m October 15, 2010 / 7.8 m													

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F74

1 OF 2

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+374, 3 m Lt of C/L of Proposed W-S Ramp (E 411077 6, N 4872529.2) ORIGINATED BY SK
 DIST HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/28/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE		WATER CONTENT (%)			
105.7 0.0	GROUND SURFACE 0.25 m TOPSOIL		1	SS	4								
	SILTY SAND TO SAND tr. org. tr. clay brownish grey, v. loose to compact, moist		2	SS	28								
			3	SS	17								
103.6 2.1		sandy silt some clay	4	SS	13								
			5	SS	14								
			6	SS	14								
	CLAYEY SILT tr. to some sand occ. fine sand seams greyish brown, stiff to v. stiff		7	SS	14								
			8	SS	16								
		moist wet	9	SS	19								
			10	SS	16								
			11	SS	10								
		moist wet	12	SS	20								
			13	SS	14								
93.0 12.7	SILTY SAND TO SANDY SILT some clay grey, compact, wet		14	SS	37								
91.8 13.9	CLAYEY SILT tr. to some sand occ. fine sand seams greyish brown, stiff to v. stiff												

Continued Next Page

+ 3 x 3 Numbers refer to
Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F74

2 OF 2

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+374, 3 m Lt of C/L of Proposed W-S Ramp (E 411077.6, N 4872529.2) ORIGINATED BY SK
 DIST _____ HWY 401 BOREHOLE TYPE Hollow Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 7/26/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L				
90.7														
	CLAYEY SILT tr. to some sand occ. fine sand seams greyish brown, stiff to v. stiff		15	SS	14									
			16	SS	17									
			17	SS	21									
85.7 20.0	SILTY SAND TILL tr. to some gravel grey, dense to v. dense, wet some clay tr. clay		18	SS	37									
83.9 21.8			19	SS	98									
End of Borehole Borehole caved-in @ 20.1 m upon completion. Piezometer installed @ 20.1 m below ground level. Date / Measured Water Level July 26, 2010 / 6.5 m (on completion) August 19, 2010 / 7.2 m October 15, 2010 / 6.7 m														

+³, ×³ Numbers refer to Sensitivity

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F75

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+526, 2 m Lt C/L of Proposed N/S-E Ramp (E 411389.8, N 4872480.2) ORIGINATED BY LG
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 11/19/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)					WATER CONTENT (%)
								20	40	60			
106.6	GROUND SURFACE												
0.0	0.15 m TOPSOIL SANDY SILT some org. tr. rootlets dk. brown, loose, moist		1	SS	4								
105.9			2	SS	12								
0.7			3	SS	16								
	CLAYEY SILT trace to some sand stiff to v. stiff, moist		4	SS	23								
			5	SS	16								
			6	SS	12								
			7	SS	14								
			8	SS	14								
			9	SS	22								
100.0	End of Borehole. Water level @ 1.4 m (not stabilized)* and caved-in @ 2.4 m in borehole upon completion. Piezometer installed @ 6.6 m below ground level Date / Measured Water Level Nov 24, 2010 / 0.2 m												
6.6													

+ 3 X 3 Numbers refer to 20 15 10 Sensitivity (%) STRAIN AT FAILURE

TRANETO810434AA: Highway 401

RECORD OF BOREHOLE No F76

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 19+024, at C/L of Proposed W-N Ramp (E 411409.3, N 4872503.0) ORIGINATED BY LG
DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
DATUM Geodetic DATE 11/19/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE ● POCKET PENETR X LAB VANE						
107.6 0.0	GROUND SURFACE						20 40 60 80 100	10 20 30						
	0.15 m TOPSOIL		1	SS	14									
	SILTY SAND some clay, some org., tr. rootlets dk. brown to brown, compact, moist		2	SS	18								0 49 40 11	
106.1 1.5			3	SS	10								Spoon wet @ 1.5 m	
	CLAYEY SILT tr. to some sand grey, stiff to v. stiff, moist		4	SS	11									
			5	SS	23									
			6	SS	19									
			7	SS	16									
			8	SS	19									
101.2 6.4			9	SS	29									
101.0 6.6	SANDY SILT TILL													
	End of Borehole. Water level @ 1.4 m (not stabilized)* upon completion Borehole caved-in @ 1.5 m upon completion													

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

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F77

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+573.6 m Lt C/L of Proposed N/S-E Ramp (E 411431.5, N 4872501.3) ORIGINATED BY LG
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 11/16/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
FLEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)		WATER CONTENT (%)				
								20 40 60 80 100	20 40 60 80 100	w _p	w	w _L		
								○ UNCONFINED + FIELD VANE						
								● POCKET PENETR. X LAB VANE						
108.0	GROUND SURFACE						108							
0.0	0.15 m TOPSOIL		1	SS	9									
	SAND some silt tr. org., tr. rootlets brown, loose to compact, moist		2	SS	19		107							
106.6														
1.4		brown grey	3	SS	18		106							
	CLAYEY SILT tr. to some sand v stiff, moist		4	SS	26									
			5	SS	24		105							
			6	SS	20		104							
			7	SS	41		103							
103.1														
4.9	SANDY SILT TO SILTY SAND TILL tr. to some clay and gravel grey, dense to v. dense, moist		8	SS 50 / 10	16		102							9 35 37 19
			9	SS 50 / 15	17									Spoon bouncing @ 6.3 m
101.4														
6.6	End of Borehole. Borehole was dry (not stabilized)* and open upon completion Piezometer installed @ 6.6 m below ground level Date / Measured Water Level													

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F78

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+596, 5 m Rt C/L of Proposed N/S-E Ramp (E 411456.2, N 4872502.6) ORIGINATED BY LG
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 11/18/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
EL. E.V. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)							
							20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
							○ UNCONFINED + FIELD VANE				WATER CONTENT (%)				
							● POCKET PENETR. x LAB VANE								
							20	40	60	80	100	10	20	30	
108.9	GROUND SURFACE														
0.0	FILL: Sand, some silt some topsoil tr. rootlets, brown, loose, moist		1	SS	8										
108.2															
0.7	CLAYEY SILT tr. to some sand v. stiff, moist		2	SS	22		108								
			3	SS	35		107								
			4	SS	50		106								1 16 58 25
			5	SS	64		105								
105.5															
3.4			6	SS	50 / 15 cm		104								
	SANDY SILT TO SILTY SAND TILL tr. clay, some gravel grey, v. dense, moist														
			7	SS	60 / 15 cm		103								
			8	SS	70 / 15 cm										
			9	SS	94										
102.3															
6.6	End of Borehole. Borehole was dry (not stabilized)* and open upon completion.														

+³, X³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

TRANETO810434AA: Highway 401

RECORD OF BOREHOLE No F79

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+953, 4 m Rt C/L of Proposed W-N Ramp (E 411465.9, N 4872543.6) ORIGINATED BY LG
 DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
 DATUM Geodetic DATE 11/24/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)						
							20 40 60 80 100	20 40 60 80 100	10 20 30					
							○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE							
109.1	GROUND SURFACE													
0.0	FILL: Sand, some silt, some topsoil brownish grey, v. loose, moist		1	SS	4									
108.6														
0.5	SAND some silt brown, compact, moist		2	SS	30									
107.7														
1.4			3	SS	12									
	brown sandy silt seams grey		4	SS	41									2 34 52 12
	CLAYEY SILT tr. to some sand stiff to v. stiff, moist		5	SS	12									
			6	SS	30									
			7	SS	29									
103.6			8	SS	68									
5.5	SANDY SILT TILL some clay, tr. to some gravel grey, v. dense, moist		9	SS	56									
101.0			10	SS	51									
8.1	End of Borehole Borehole was dry (not stabilized)* and open upon completion.													

+ 3, x 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F80

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+675, at C/L of Proposed N/S-E Ramp (E 411503.4, N 4872565.7) ORIGINATED BY LG
DIST 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY WC
DATUM Geodetic DATE 11/25/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
111.4	GROUND SURFACE													
0.0	FILL: Sand, some silt, some topsoil tr. gravel		1	SS	5									
110.9														
0.5	SAND some silt, tr. gravel brown, compact to dense, moist		2	SS	17									
109.5			3	SS	31									
1.9	CLAYEY SILT some sand brown, v. stiff, moist		4	SS	40									
108.3			5	SS	50 / 10.0									Auger grinding @ 3.1 m
3.1														
	SANDY SILT TO SILTY SAND TILL tr. to some clay and gravel grey, v. dense, moist		6	SS	50 / 13.0									
			7	SS	50 / 10.0									
			8	SS	50 / 10.0									
			9	SS	50 / 15.0									Spoon bouncing @ 3.8, 4.6, 5.3 and 6.1 m
			10	SS	30									
	clayey grey, v. stiff													
			11	SS	35									
100.3			12	SS	52									
11.1	End of Borehole Borehole was dry and open upon completion Piezometer installed at 11.1 m Date / Measured Water Level Jan 05, 2011 / 10.2 m													

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

TRANETO810434AA: Highway 401

RECORD OF BOREHOLE No F81

1 OF 1

METRIC

GWP G.W.P 205-00-01 LOCATION Station 18+902, at C/L of Proposed W-N Ramp (E 411493.2, N 4872585.5) ORIGINATED BY LG
DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY SK
DATUM Geodetic DATE 11/25/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH (kPa)		WATER CONTENT (%)							
								○ UNCONFINED ● POCKET PENETR.	+ FIELD VANE × LAB VANE	W _p	W	W _L					
						20	40	60	80	100	10	20	30	GR	SA	SI	CL
110.7	GROUND SURFACE																
0.0	FILL: Sand some silt, some topsoil, some rootlets brown, v. loose, moist		1	SS	4							○					
110.1							110										
0.6			2	SS	13							○					
	CLAYEY SILT tr. to some sand brown, stiff to v. stiff, moist		3	SS	11		109					○					
			4	SS	22		108					○					
			5	SS	17							○					
107.2							107										
3.5			6	SS	30												
	SANDY SILT TO SILTY SAND TILL tr. to some clay and gravel grey, compact to v. dense, moist		7	SS	35		106					○					7 35 39 19
			8	SS	49		105					○					
			9	SS	134		104					○					
102.6			10	SS	100		103					○					
8.1	End of Borehole. Borehole was dry (not stabilized)* and open upon completion																

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

TRANETOB10434AA: Highway 401

RECORD OF BOREHOLE No F82

1 OF 1

METRIC

GWP G.W.P. 205-00-01 LOCATION Station 18+724, at C/L of Proposed N/S-E Ramp (E 411514.2, N 4872612.4) ORIGINATED BY LG
DIST HWY 401 BOREHOLE TYPE Solid Stem Auger COMPILED BY WC
DATUM Geodetic DATE 11/25/2010 CHECKED BY ZO

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p W W _L	10 20 30	GR SA SI CL		
110.3 0.0	GROUND SURFACE													
109.7 0.6	FILL: Sand some silt, some topsoil, loose		1	SS	5									
	tr. rootlets		2	SS	15									
	CLAYEY SILT tr. to some sand stiff to v. stiff, moist		3	SS	10									
	brown sandy silt seams grey		4	SS	42									14 36 36 14
106.9 3.4	SANDY SILT TO SILTY SAND TILL tr. clay and gravel grey, dense to v. dense, moist		5	SS	30									
			6	SS	83									
			7	SS	88									
			8	SS	113									
			9	SS	107									
			10	SS	31									
102.2 8.1	End of Borehole. Borehole was dry (not stabilized)* and open upon completion. Piezometer installed @ 7.6 m below ground level Date / Measured Water Level Jan 05, 2011 / 7.6 m													

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

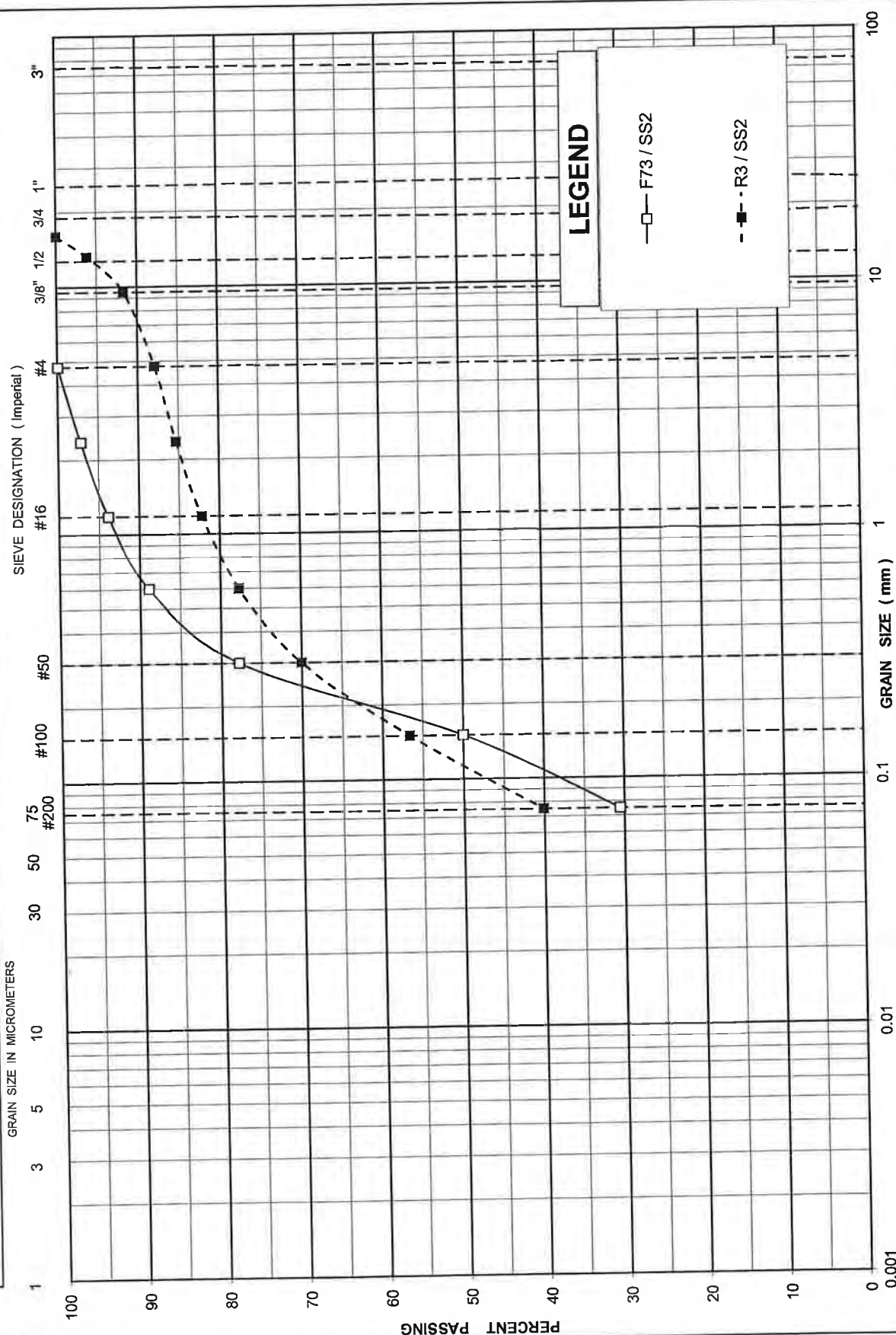


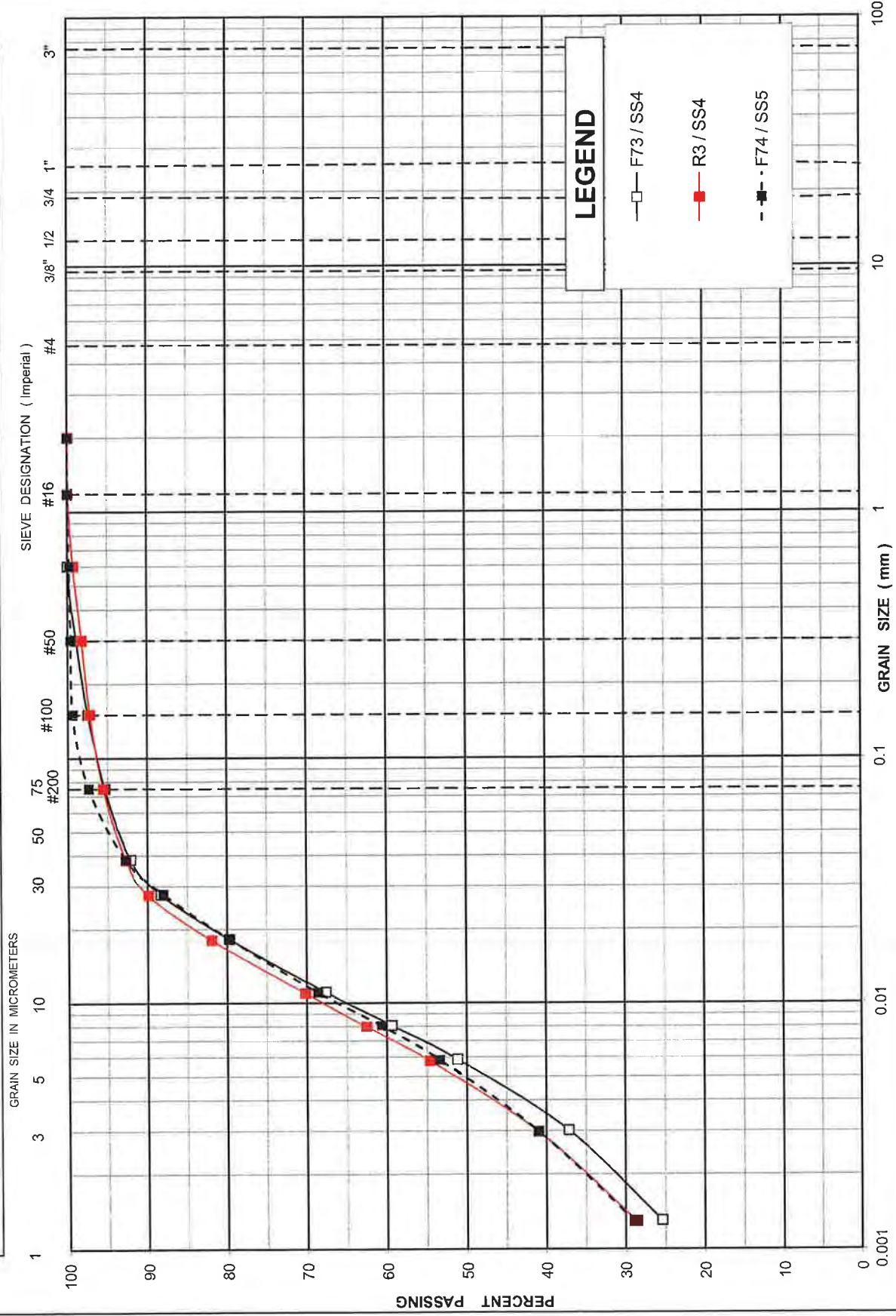
FIGURE NO.: B-1

PROJECT NO: TRANETOB10434AA

DATE: Sept, 2011

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION
CLAYEY SILT

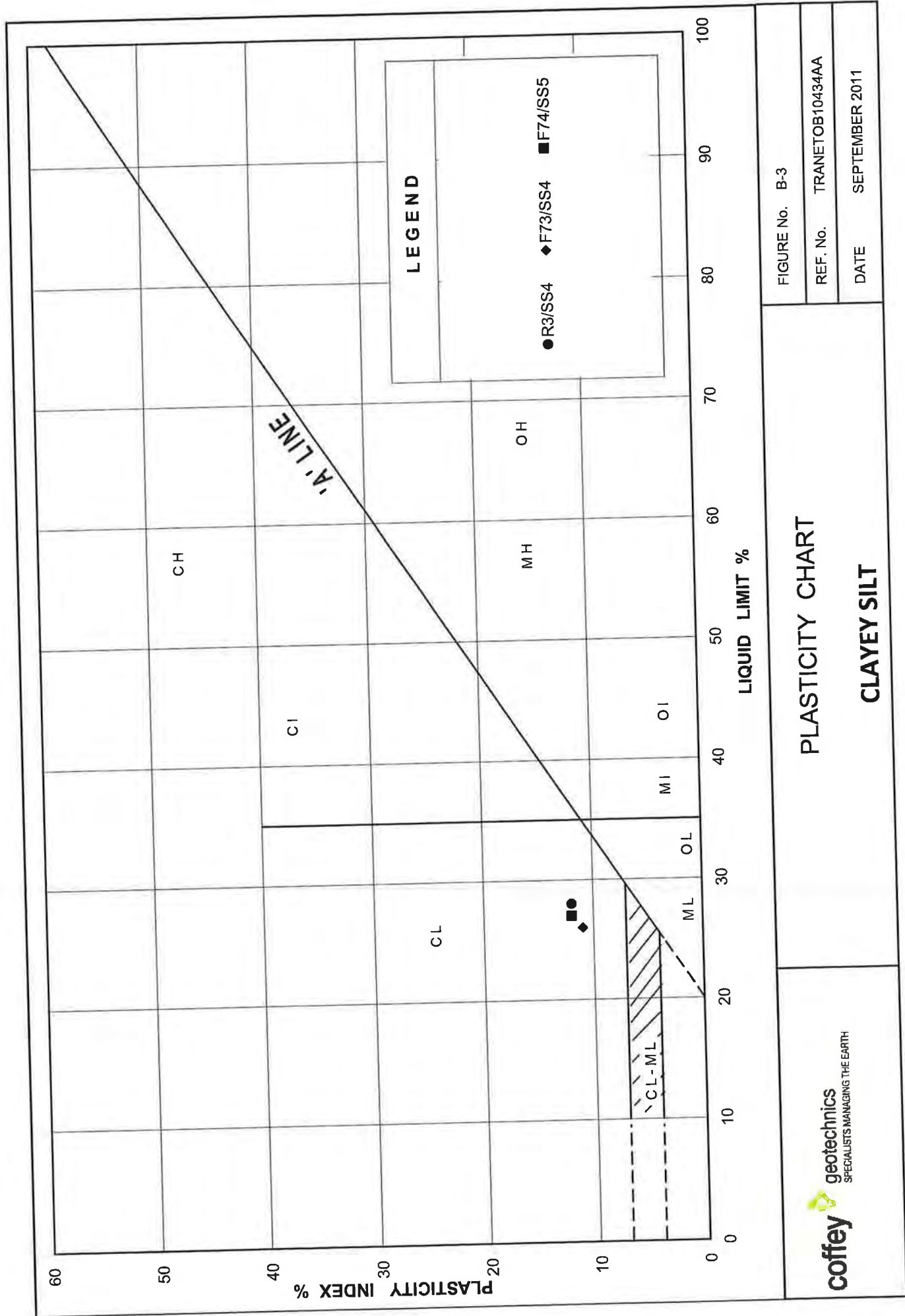


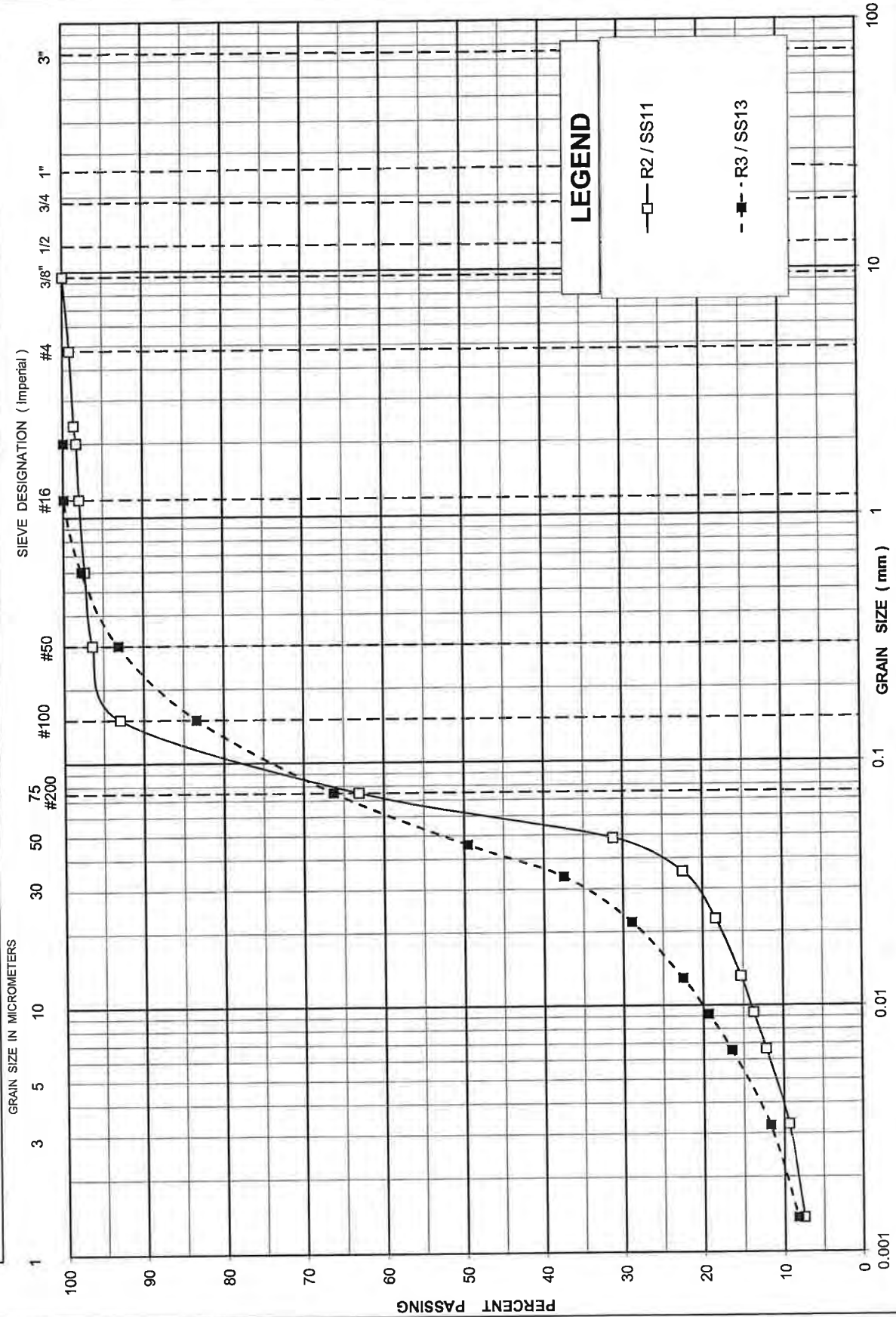
FIGURE No. B-3

REF. No. TRANETOB10434AA

DATE SEPTEMBER 2011

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT		SAND			GRAVEL		
		Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION

SILTY SAND TO SANDY SILT

FIGURE NO.: B-4

PROJECT NO: TRANETOB10434AA

DATE: Sept, 2011

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

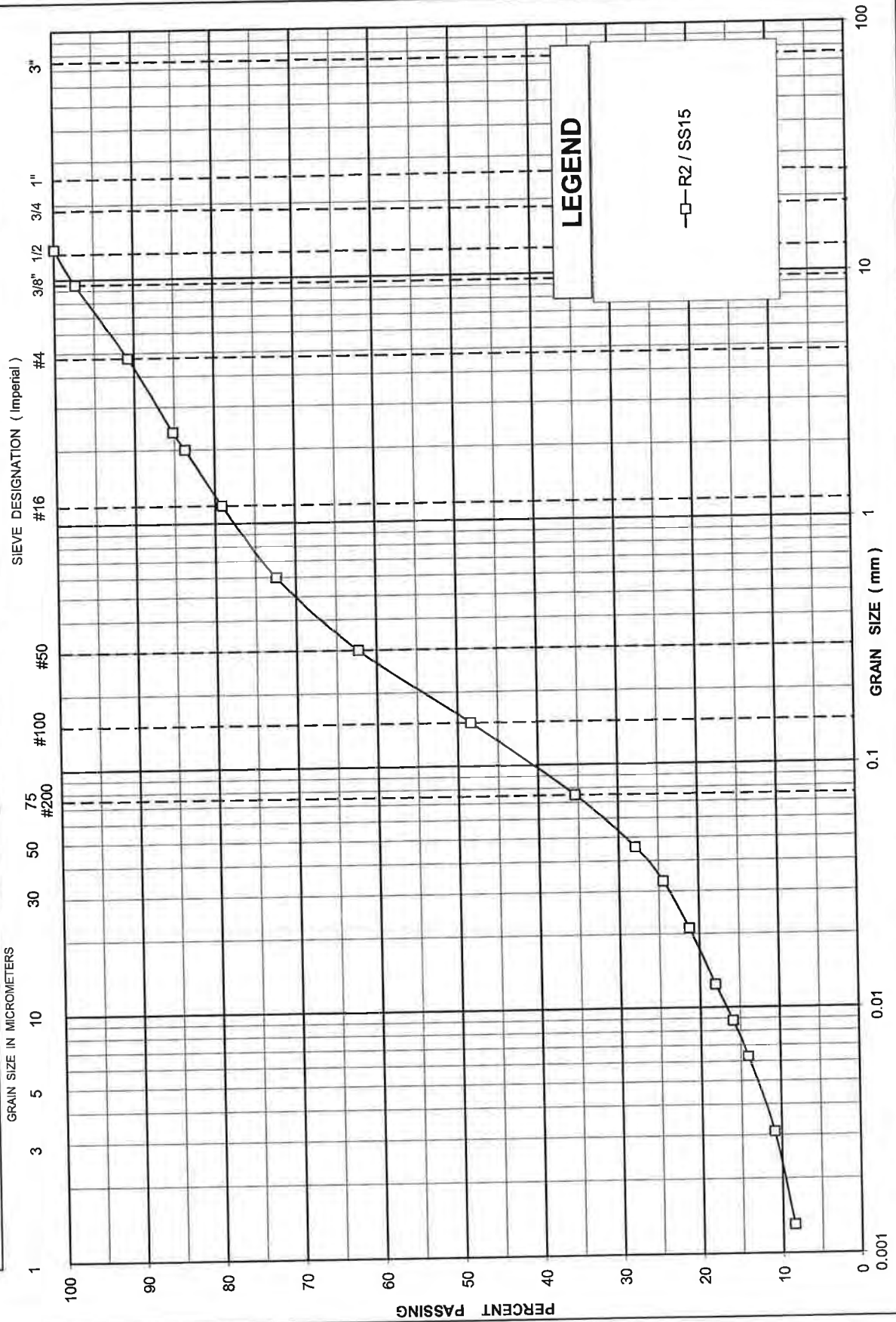


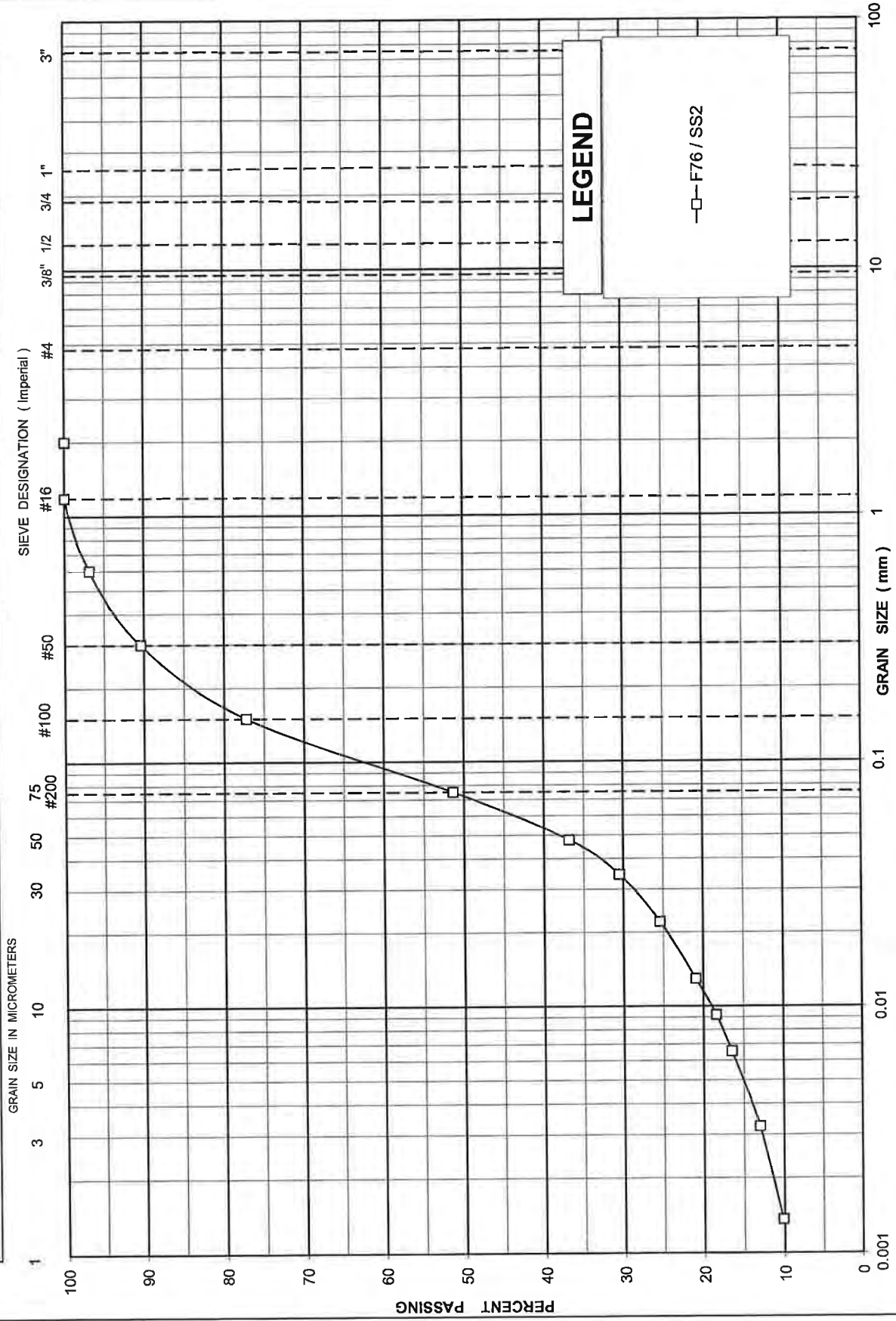
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PROJECT NO: TRANETOB10434AA

DATE: Sept, 2011

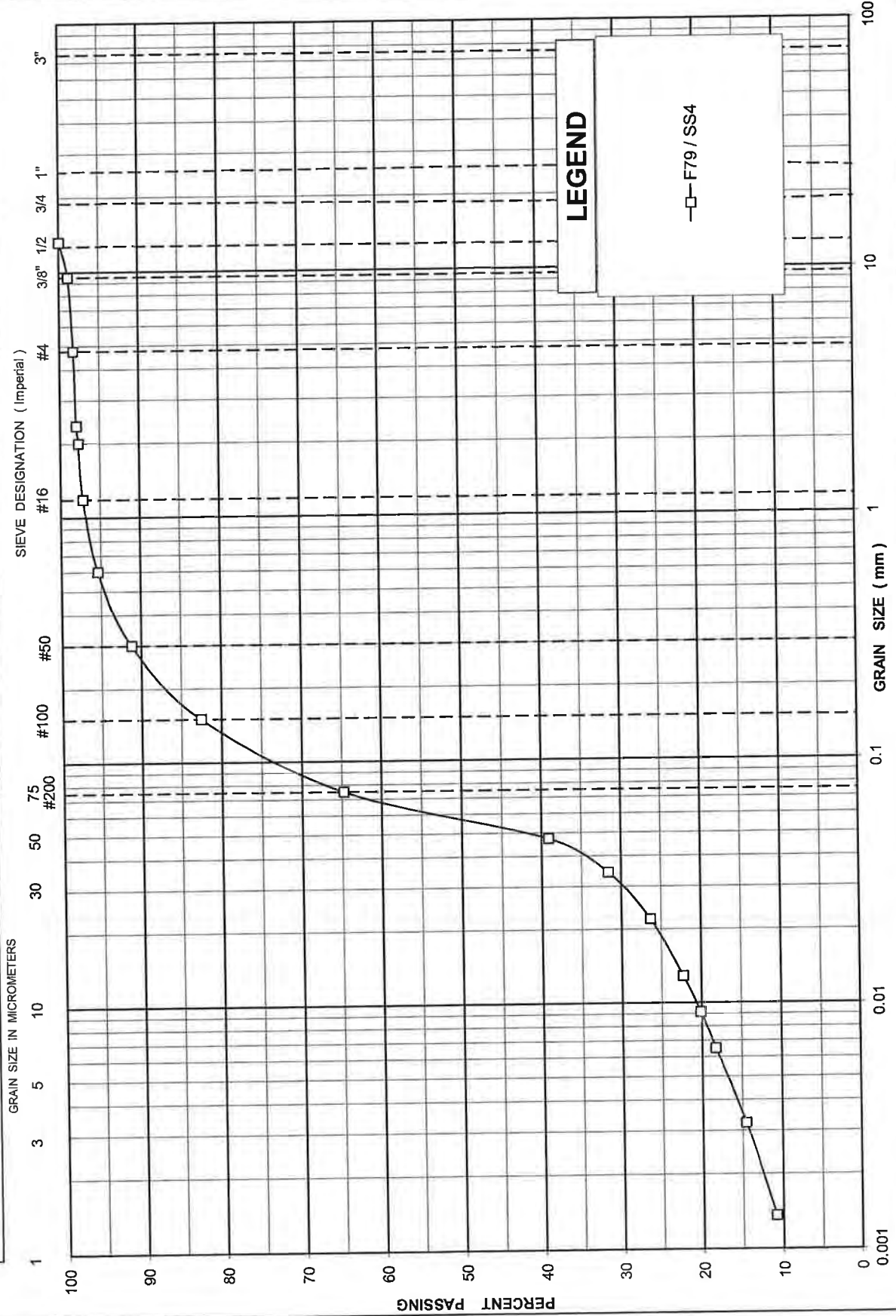
UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	

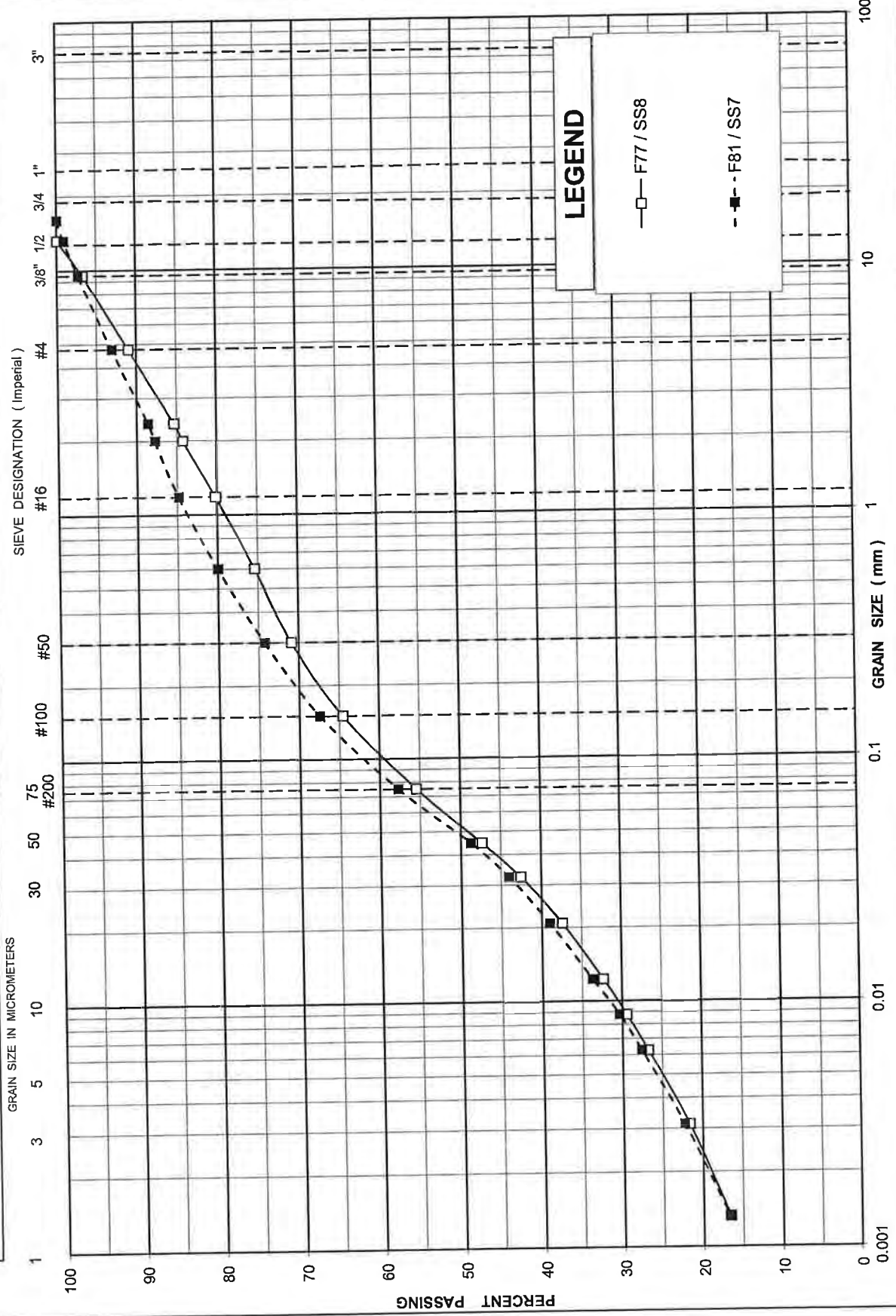
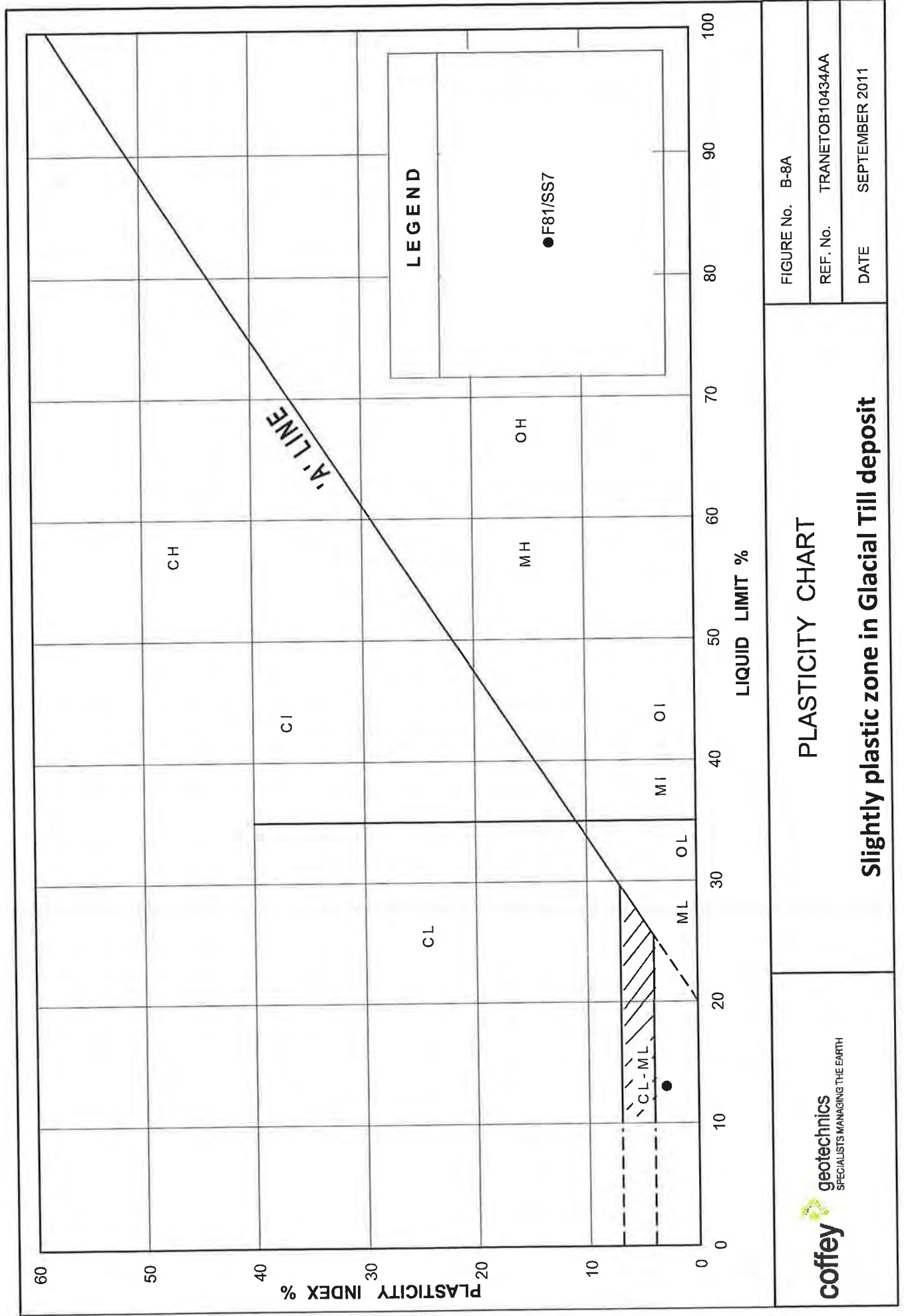
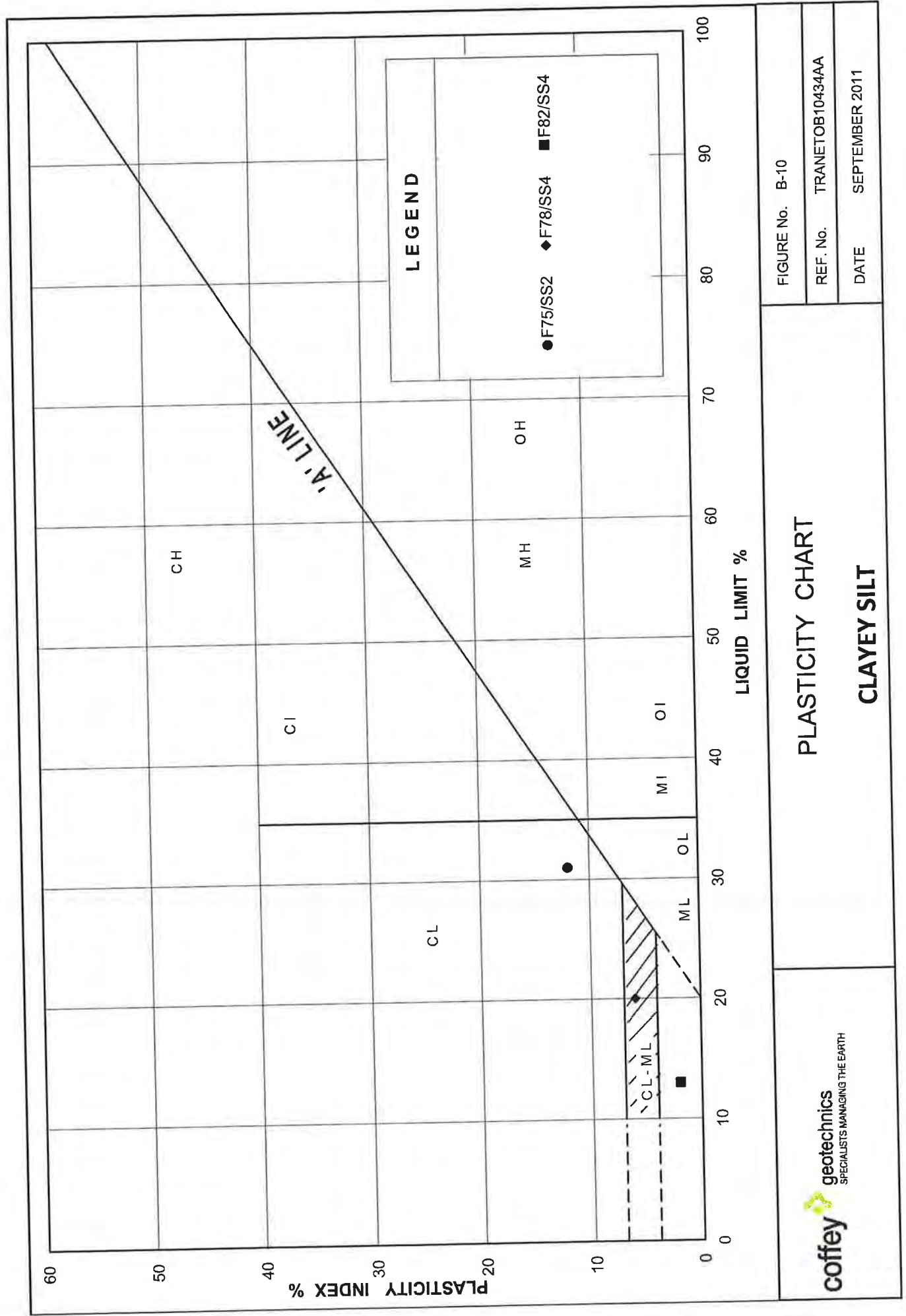


FIGURE NO.: B-8
PROJECT NO: TRANETOB10434AA
DATE: Sept, 2011



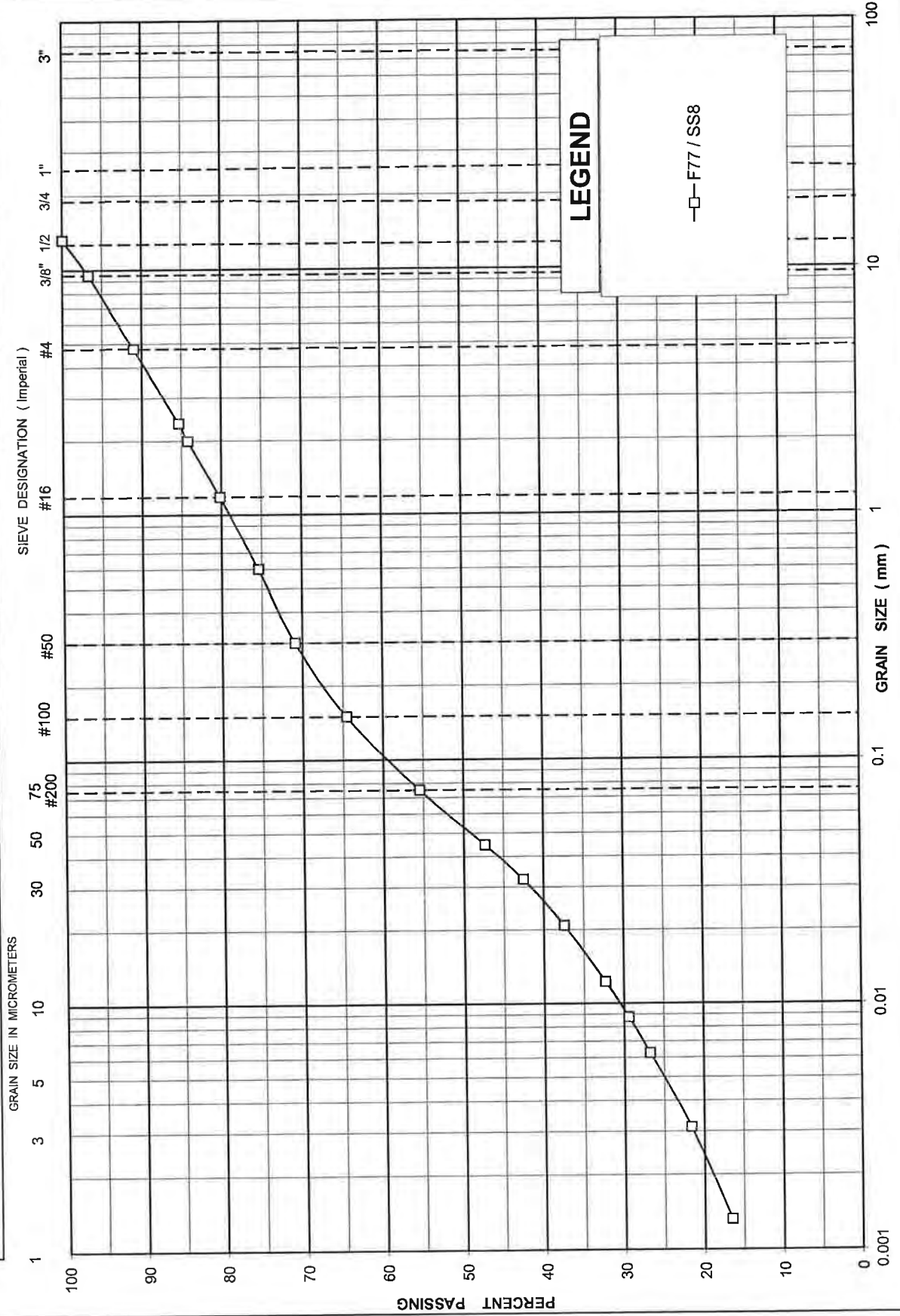
CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse





UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT			SAND			GRAVEL		
			Fine	Medium	Coarse	Fine	Coarse	



GRAIN SIZE DISTRIBUTION SANDY SILT TO SILTY SAND TILL

Appendix C

Drawings

METRIC

NOTES:

FOR DETAILED SUBSURFACE CONDITIONS
REFER TO RECORD OF BOREHOLE SHEETS.

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

CONT No.

GWP: 205-00-01

HIGHWAY 401 EXPANSION
DEEP CUT AREA 1- PROPOSED W - S RAMP
AT COUNTY RD. 45
BOREHOLE LOCATION PLAN
AND SOIL STRATA



SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



LEGEND

- Borehole
- 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	EASTING	NORTHING
R2	103.5	410996.5	4872494.8
R3	105.0	411031.1	4872511.7
F73	105.6	411045.3	4872518.2
F74	105.7	411077.6	4872528.2

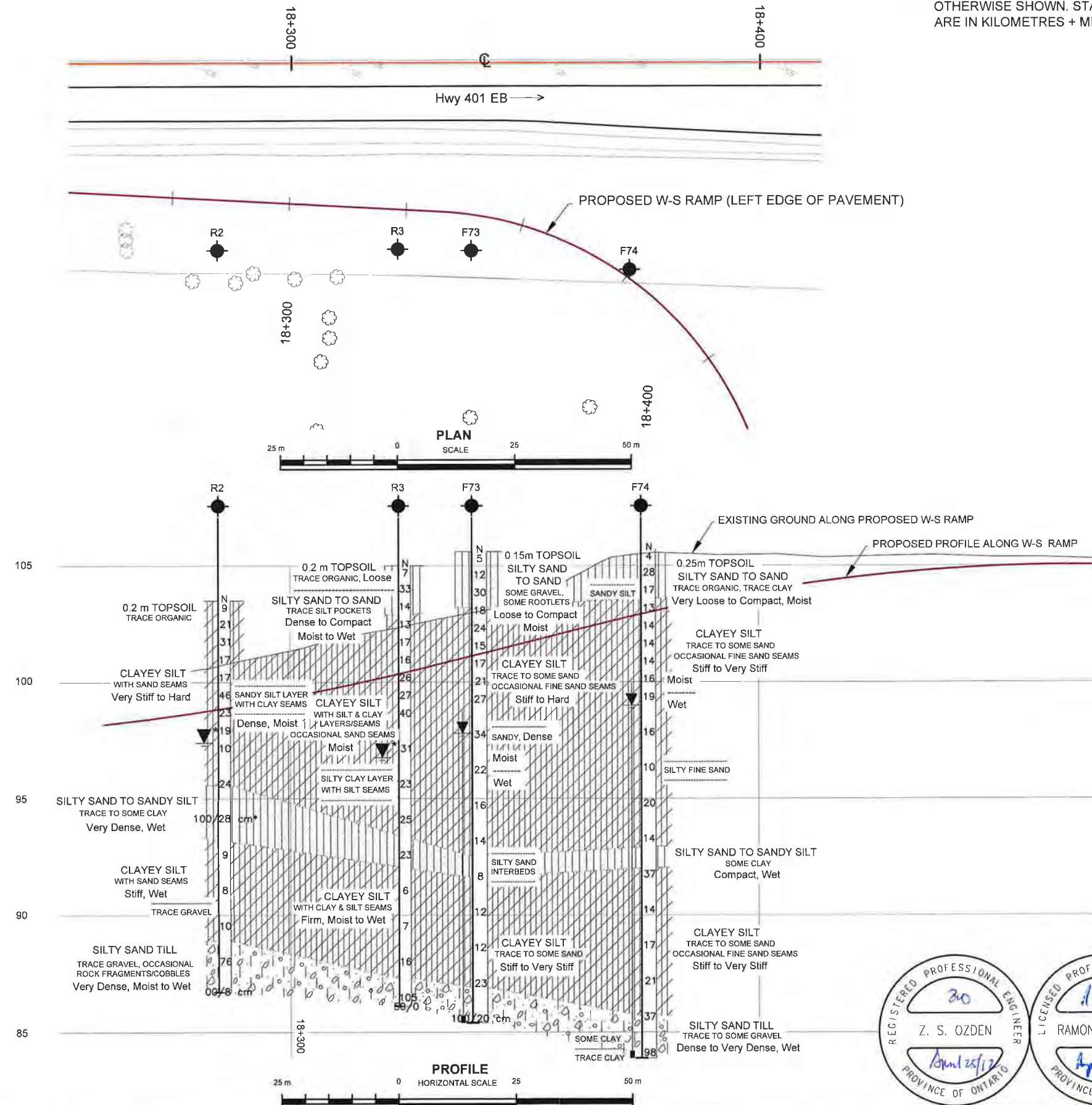
-NOTE-

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.	TRANETO10434AA	DIST	
SUBMD	CHECKED	DATE	Oct 03, 2011
DRAWN	SH	CHECKED	RM
APPROVED	ZO	DWG	1



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: 205-00-01
HIGHWAY 401 EXPANSION
DEEP CUT AREA 2- PROPOSED W - N RAMP
AT COUNTY RD. 45
BOREHOLE LOCATION PLAN
AND SOIL STRATA

SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



KEY PLAN
N.T.S.

LEGEND

- Borehole
- 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

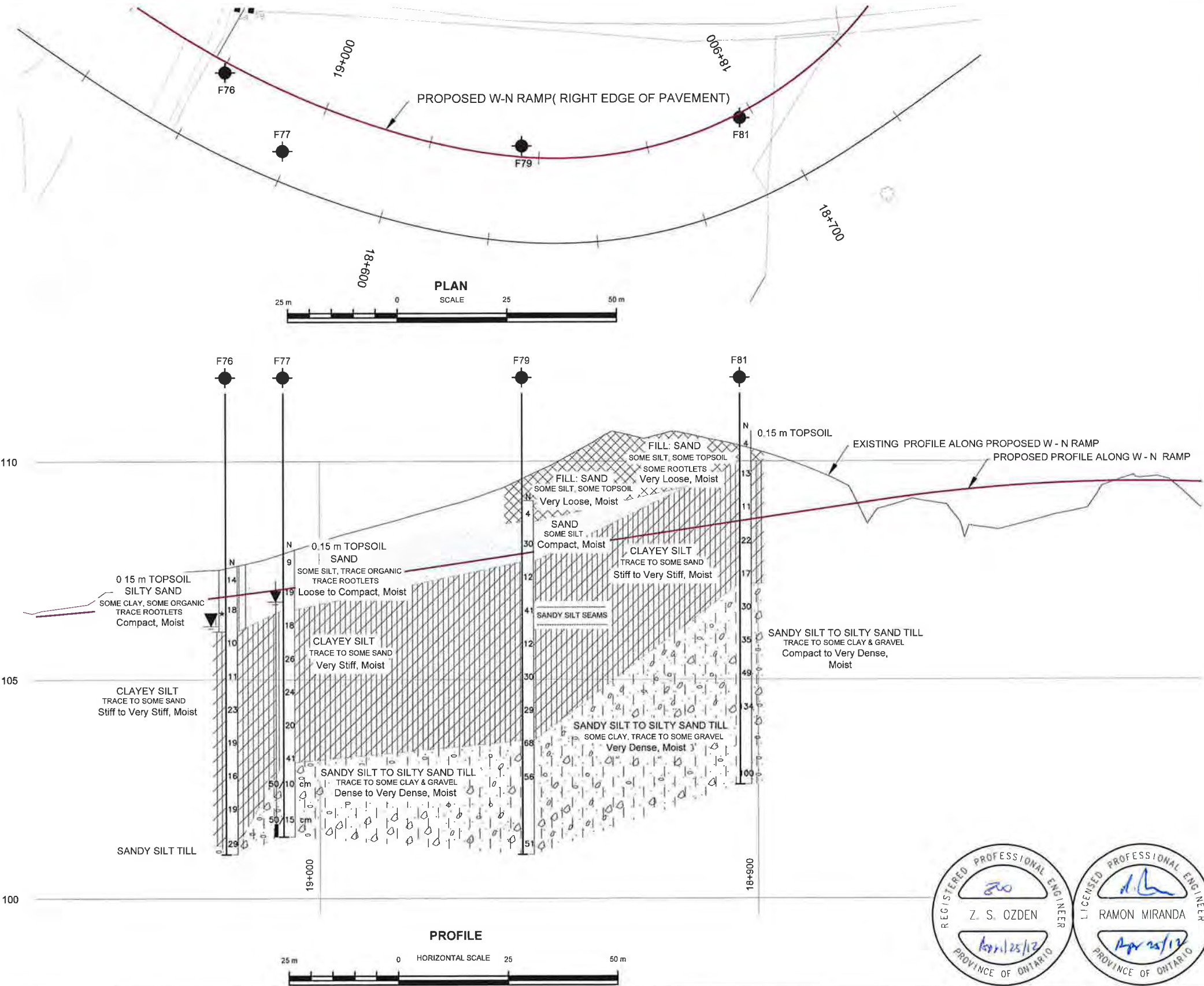
No	ELEVATION	EASTING	NORTHING
F76	107.6	411409.2	4872503.0
F77	108.0	411431.5	4872501.3
F79	109.1	411465.9	4872543.6
F81	110.7	411493.2	4872585.5

-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.	TRANET010434AA	DIST	
SUBM'D	CHECKED	DATE	Oct 03, 2011
DRAWN	SH	CHECKED	RM
APPROVED	ZO	DWG	2



REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
PROVINCE OF ONTARIO
April 25/12

LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
PROVINCE OF ONTARIO
Apr 25/12

METRIC

NOTES:
FOR DETAILED SUBSURFACE CONDITIONS
REFER TO RECORD OF BOREHOLE SHEETS.

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

CONT No.

GWP: 205-00-01

HIGHWAY 401 EXPANSION
DEEP CUT AREA 3 - PROPOSED N/S-E RAMP
AT COUNTY RD. 45
BOREHOLE LOCATION PLAN
AND SOIL STRATA



SHEET

coffey geotechnics
SPECIALISTS MANAGING THE EARTH



KEY PLAN
N.T.S.

LEGEND

- Borehole
- 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	EASTING	NORTHING
F75	106.6	411389.8	4872480.2
F77	108.0	411431.5	4872501.3
F78	108.9	411456.2	4872502.6
F80	111.4	411503.3	4872565.6
F82	110.3	411514.2	4872612.4

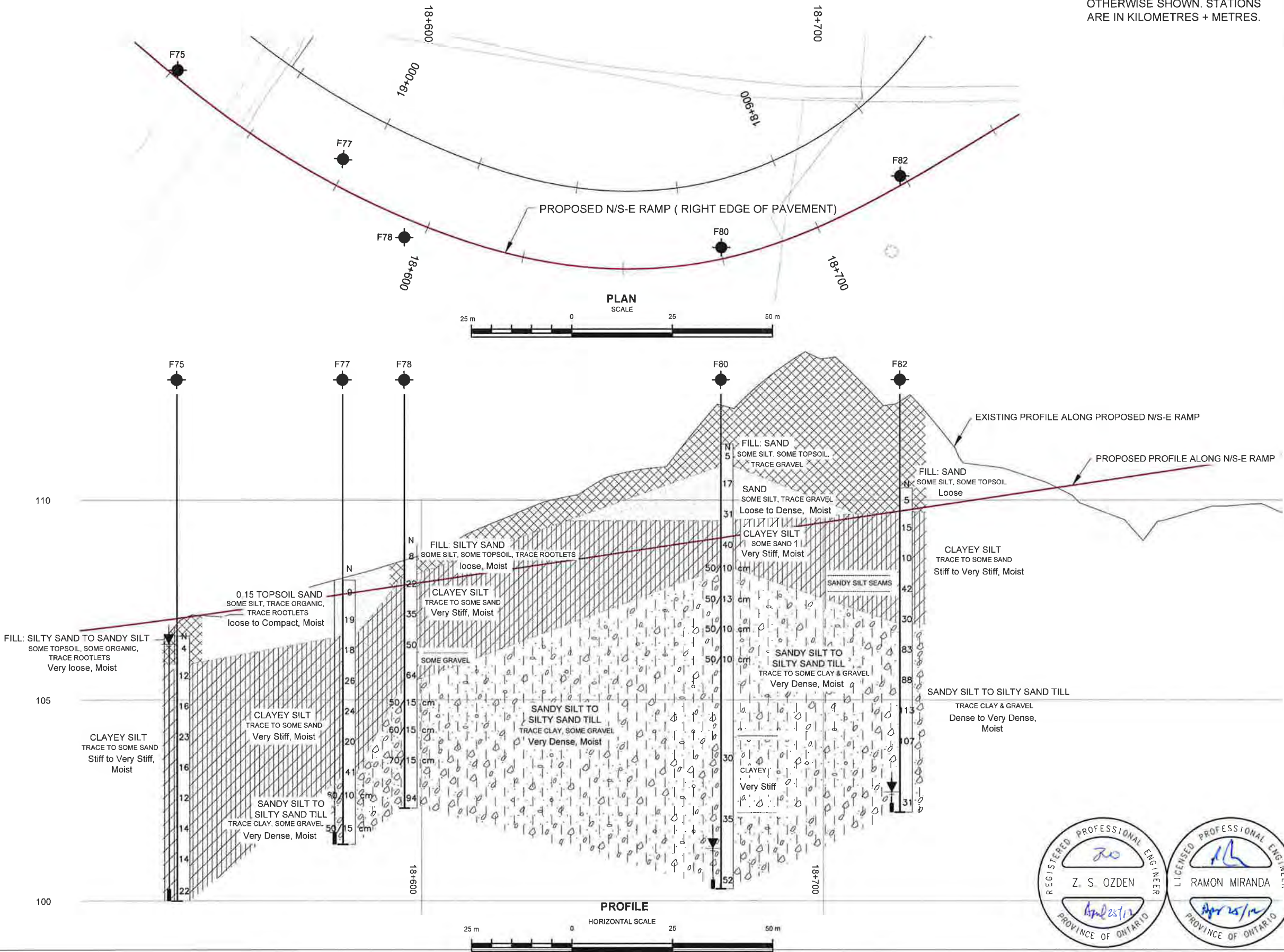
-NOTE-

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

Geoties No.	TRANET010434AA	DIST
SUBMD	CHECKED	DATE Oct 03, 2011
DRAWN	SH	CHECKED RM
APPROVED	ZO	DWG



Appendix D

Site Photographs



Proposed W-S Ramp: Looking west from county road 45 bridge (S-W Quadrant)



Proposed W-S Ramp: Looking east from road level (S-W Quadrant)



Proposed W-N and N/S-E Ramp: (S-E Quadrant): showing vegetation



Proposed W-N and N/S-E Ramp: (S-E Quadrant): showing stock piles and vegetation



Proposed N/S-E Ramp: (S-E Quadrant) Station 18+675 – Borehole F80



Proposed N/S-E Ramp (S-E Quadrant) Station 18+724 – Borehole F82

Appendix E

Explanation of Terms Used in 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 63.5 kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N-VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N-VALUE IS DENOTED THUS \bar{N} .

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 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 COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

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

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (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
\bar{u}	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	$^\circ$	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	$^\circ$	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_l	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
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
P_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
P	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ'	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
P_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
P_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(w - w_p) / I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(w_L - w) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
P'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

**FOUNDATION DESIGN REPORT -
HIGHWAY 401 EXPANSION, DEEP CUTS
ON PROPOSED W-S, W-N AND N/E-S
RAMPS AT COUNTY ROAD 45
INTERCHANGE, TOWN OF COBOURG
AND TOWNSHIP OF HAMILTON, ONTARIO
G.W.P. NO. 205-00-01 GEOCRETS 30M16-52**

AECOM

TRANETOB10434AA-AN
April 25, 2012

FINAL REPORT

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FOUNDATION DESIGN REPORT

HIGHWAY 401 EXPANSION, DEEP CUTS ON PROPOSED W-S, W-N AND N/E-S RAMPS AT COUNTY ROAD 45 INTERCHANGE, TOWN OF COBOURG AND TOWNSHIP OF HAMILTON, ONTARIO G.W.P. NO. 205-00-01

5 DISCUSSION AND RECOMMENDATIONS

5.1 General

It is planned to expand (widen) Highway 401 from its present configuration of four lanes to six lanes from Burnham Street to approximately 2.0 km east of Nagle Road, within the Town of Cobourg and Township of Hamilton, Ontario. In conjunction with this expansion, a foundation investigation was carried out for three deep excavation (cut) areas for the proposed ramps located in the southwest and southeast quadrants of the interchange of Highway 401 and County Road 45. The proposed West-South Ramp (W-S Ramp), West-North Ramp (W-N Ramp), and North/South-East Ramp (N/S-E Ramp) of the interchange will be partly constructed on deep cuts.

Table 5.1 presents the locations of the proposed deep cut areas.

Table 5.1: Deep Cut Area Locations

Cut Number	Proposed Ramps	Stations	Length (m)	Max. Height of Cut (m)	Comments
Cut Area 1	W-S Ramp	18+230 to 18+380	150	7.9	in the vicinity of southwest quadrant of County Road 45 Interchange
Cut Area 2	W-N Ramp	18+890 to 19+040	150	5.3	in the vicinity of southeast quadrant of County Road 45 interchange
Cut Area 3	N/S-E Ramp	18+530 to 18+725	195	4.7	in the vicinity of southeast quadrant of County Road 45 interchange

The cross sections of the existing and of the proposed ramps, prepared by AECOM for their 30% Submission, are presented in Appendix F. As shown, the existing side slopes of Cut Area 1 are in the range of 2.7H:1V and 6.9H:1V. The presently proposed side slopes are 3H:1V, and the heights range from 7.9 to 3.6 m (see Appendix F1). The existing side slopes of Cut Area 2 are standing at 1.7H:1V or flatter. The side slopes proposed by AECOM are 3H:1V, and the heights are between 5.3 and 2.0 m (see Appendix F2). The existing side slopes of Cut Area 3 are also standing at 1.7H:1V or flatter. The proposed

side slopes are approximately 3H:1V, and the heights are typically between 4.7 and 1.1 m (see Appendix F3).

5.2 Proposed Cut Areas

5.2.1 Cut Design Components

Numerical slope stability analyses were carried out using the proposed cross sections and various slope configurations for the new cut slopes. The cross sections provided to us by AECOM are shown in Appendix F. The existing and proposed dimensions of the selected sections are summarized in Tables F-1 to F-3, Appendix F. The cross sections show that the existing cut slopes at Cut Areas 1, 2 and 3 typically range from 2H:1V to 4H:1V and the presently proposed side slopes as presented in Appendix F are 3H:1V. Based on visual observations during our field work, the surfaces of the existing ground are heavily vegetated by shrubs and small trees for the cut areas at the SE quadrant and the surfaces of the existing slopes are covered with a few trees and grass for the cut area at the SW quadrant of the interchange. No apparent signs of instability were observed. Normally, if the existing cut slope did not exhibit any instability and erosion problems, the same slope configuration can be used for the new slope cutting, if significant slope geometry change is not anticipated by new slope cutting and provided that the subsurface conditions are relatively uniform between the existing and the new configurations. As the existing slopes are standing at the same angle or steeper than the proposed side slopes and since the ramp construction will not involve any significant grade raise, problems with instability of proposed cut slopes due to foundation soils and slope itself are not anticipated. We have however carried out slope stability analyses for completeness and for confirmatory purposes, as well as due to the fact that MTO Eastern Region has reported instability problems in the general area.

The global, internal and surficial stability of the cuts will depend on the slope geometry and also to a large degree on the properties of the existing soils and water levels. The soil parameters were estimated with the information from the subsurface investigation. The borehole findings indicate that the subsurface conditions at this site comprise of mainly some surficial fill, loose to compact silty sand to sand, stiff to very stiff clayey silt, and a basal, dense to very dense sandy silt to silty sand glacial till.

The groundwater level at the time of our investigation generally varied from about 6 to 8 m below the original ground surface. However, during major weather events, the groundwater level may rise and, as well, a perched water condition may also occur in the surficial sand fill and the underlying sand to silty sand. As well, sandy layers were noted within the clayey silt deposit. In these sandy layers, water can accumulate and if that occurs they will provide access for water flow that may daylight on the cut slope and may present surficial erosion and instability problems. The clayey silt deposit is not considered to be highly erodible. Nevertheless, erosion protection measures as well as drainage need to be provided on the new cut slopes. Recommendations regarding drainage and erosion control for the new cut slopes are presented below.

Erosion protection measures, such as benching the cut slope, are recommended for the cut areas. As per MTO normal procedures, benching is carried out at every 6 m height along the height of the slope. In this case, benching is required for Cut Area 1, as in some sections the cut slope height will be in excess of 6 m, while it will be not necessary for Cut Areas 2 and 3 as the cut slope heights will be less than 6 m. The advantage of including benches is to minimize the velocity of surface water runoff as the water's

uninterrupted travel distance on the cut face will be lessened by the bench and therefore reducing the erosion potential and any slope instability that it may cause. The bench is typically 2 m wide and the bench surface dips 3% away from the cut face. Benches within the cut slope will however result in additional excavation and possible property acquisition beyond the crest of the existing cut slope. Therefore, the construction of the recommended cut slope geometry may extend beyond the property line. Purchase of land behind the existing cut slope may be required. This matter needs to be addressed prior to construction. The slope stability analyses, presented in the following section, provide a discussion on using one bench for those sections of Cut Area 1 where the height is 6 m or greater.

We also recommend that toe drains be installed at the cut slopes to maintain the drained condition of the cut slopes. At the toe of the cuts, aside from the normally provided ditch, we recommend that subdrains, about 1.5 m deep, be constructed to intercept the ground water below the ground surface, keep the road embankment drained and reduce the adverse effects of frost action. The subdrains should be directed to a positive outlet or to a municipal sewer. At the crests of the cut slopes, the ground is gently sloping down towards the cut slopes. We recommend that where the grade at the top slope towards the crest of the slope, interceptor ditches (i.e. swales) be constructed behind the crests of the cut slopes to intercept surface water coming down the slopes and drain it sideways and away from the faces of the slopes. Depending on the design, the water intercepted by these swales may be drained down the slopes at controlled points at every 15 to 20 m or so. These drainage points will need to be properly designed to prevent any erosion.

In addition to the above drainage control, we recommend that a drainage blanket be installed on the cut slopes that are steeper than 3H:1V, since wet sand interbeds were encountered within the clayey silt deposit and due to the possibility that a perched water condition may occur due to the fact that surface water may accumulate in the surficial sandy (i.e. more pervious) deposits overlying the practically impervious clayey silt.

The recommended drainage blanket is as follows:

- A minimum 200 mm thick fine filter material against the surface of the cut slope. The fine filter material can consist of Concrete Fine Aggregates (Type FA1).
- A minimum 200 mm thick coarse filter consisting of Concrete Coarse Aggregate (Group I/20-5) placed over the fine filter material.
- A minimum 250 mm thick rip-rap layer (20 – 120 mm in nominal particle size).

These materials should be placed without causing segregation of the particles. A schematic representation of the recommended protection system is given in Figure H-1 in Appendix H.

If this is considered impractical or too expensive to implement and if small degree of risk can be accommodated by MTO, a simplified design can be considered, as follows:

- A minimum 250 mm thick Granular 'A' material against the surface of the cut slope
- A minimum 250 mm thick rip-rap layer (20-120 mm nominal size) placed over Granular 'A' blanket

The risks associated with this simplified blanket system are possible clogging of the blanket due to soil fines infiltration from the natural soil and lower permeability for the rapid discharge of the seeping

groundwater. A schematic representation of the recommended protection system is given in Figures H-3 in Appendix H.

5.2.2 Slope Stability

Slope analyses were carried out to assess the stability of the new cut slopes. The stability of the slopes 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 was adopted for both short-term (undrained) and long-term (drained) analyses. Also provided are recommendations on slope components such as erosion control and drainage. A discussion of the slope stability analyses for each excavation cut area is presented in following paragraphs. The results of the slope stability analyses are presented in Appendix G.

As mentioned before, the proposed slopes at the critical cross sections are approximately 3H:1V (the proposed slope of AECOM drawings) and other proposed slope configurations include 2.5H:1V, 2.25H:1V and 2H:1V. MTO cut slope design procedure (i.e. minimum 2m wide bench per every 6 m height) was also considered in the stability analyses. Surficial failures on the slope such as sloughing or localized erosion were not considered in our analyses, but rather only relatively deep seated failures.

The critical cross section for each cut area was selected as follows. Detailed dimensions of the slopes are summarized in Tables F-1 to F-3, Appendix F.

- Cut Area 1 - Station 18+290, the height of new cut will be 7.9 m
- Cut Area 1 - Station 18+330, the height of new cut will be 6.0 m
- Cut Area 2 - Station 18+960, the height of new cut will be 5.3 m
- Cut Area 3 - Station 18+700, the height of new cut will be 4.7 m

Based on the borehole information (Boreholes R2, R3, F73 to F82) and inferred subsurface profile, (Drawing No.'s 1 to 3), the following soil parameters were adopted in the slope stability analysis.

Table 5.2: Soil Parameters Used for Slope Stability Analyses – Cut Area 1

Soil Type	Unit Weight	Undrained Cohesion, c	Undrained Friction Angle, ϕ	Drained Cohesion, c'	Drained Friction Angle, ϕ'
	(kN/m ³)	(kPa)	(degrees)	(kPa)	(degrees)
New Pavement Fill	21.0	0	32	0	32
Silty Sand to Sand	20.0	0	30	0	30
Clayey Silt	20.0	50	0	5	28

Soil Type	Unit Weight (kN/m³)	Undrained Cohesion, c (kPa)	Undrained Friction Angle, ϕ (degrees)	Drained Cohesion, c' (kPa)	Drained Friction Angle, ϕ' (degrees)
Silty Sand to Sandy Silt	20.5	0	32	0	32

Table 5.3: Soil Parameters Used for Slope Stability Analyses – Cut Areas 2 and 3

Soil Type	Unit Weight (kN/m³)	Undrained Cohesion, c (kPa)	Undrained Friction Angle, ϕ (degrees)	Drained Cohesion, c' (kPa)	Drained Friction Angle, ϕ' (degrees)
New Pavement Fill	21.0	0	32	0	32
Fill - Sand	19.5	0	30	0	30
Sand to Silty Sand	20.0	0	31	0	31
Clayey Silt	20.0	60	0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33	0	33

The slope stability analyses for critical cross sections are shown on the figures in Appendix G. The results of the analyses are summarized in the following tables.

Table 5.4: Slope Stability Analyses Results – Cut Area 1

Station	Slope Height (m)	Side Slope (xH:1V)	Bench	Assumed Phreatic Surface	Factor of Safety (FOS)		Figure No.
					Undrained	Drained	
18+290	7.9	2	-	as measured	2.22	1.62	G1-1, G1-2
18+290	7.9	2	-	mid-height	2.01	1.13	G1-3, G1-4

Station	Slope Height (m)	Side Slope (xH:1V)	Bench	Assumed Phreatic Surface	Factor of Safety (FOS)		Figure No.
					Undrained	Drained	
18+290	7.9	2	1	as measured	2.31	1.82	G1-5, G1-6
18+290	7.9	2	1	mid-height	2.08	1.16	G1-7, G1-8
18+290	7.9	2.25	-	as measured	2.25	1.74	G1-9, G1-10
18+290	7.9	2.25	-	mid-height	2.04	1.21	G1-11, G1-12
18+290	7.9	2.25	1	as measured	2.34	1.92	G1-13, G1-14
18+290	7.9	2.25	1	mid-height	2.12	1.25	G1-15, G1-16
18+290	7.9	2.5	-	as measured	2.30	1.84	G1-17, G1-18
18+290	7.9	2.5	-	mid-height	2.09	1.30	G1-19, G1-20
18+290	7.9	2.5	1	as measured	2.39	2.02	G1-21, G1-22
18+290	7.9	2.5	1	mid-height	2.18	1.34	G1-23, G1-24
18+290	7.9	2.95 *	-	as measured	2.41	2.01	G1-25, G1-26
18+290	7.9	2.95 *	-	mid-height	2.18	1.45	G1-27, G1-28
18+330	6.0	2	-	as measured	2.51	1.66	G1-29, G1-30
18+330	6.0	2	-	mid-height	2.51	1.22	G1-31, G1-32
18+330	6.0	2.25	-	as measured	2.51	1.83	G1-33, G1-34
18+330	6.0	2.25	-	mid-height	2.51	1.28	G1-35, G1-36
18+330	6.0	2.5	-	as measured	2.54	1.95	G1-37, G1-38
18+330	6.0	2.5	-	mid-height	2.54	1.38	G1-39, G1-40
18+330	6.0	2.97 *	-	as measured	2.35	2.22	G1-41, G1-42

Station	Slope Height (m)	Side Slope (xH:1V)	Bench	Assumed Phreatic Surface	Factor of Safety (FOS)		Figure No.
					Undrained	Drained	
18+330	6.0	2.97 *	-	mid-height	2.35	1.55	G1-43, G1-44

* as proposed by AECOM

Table 5.5: Slope Stability Analyses Results – Cut Area 2

Station	Slope Height (m)	Side Slope (xH:1V)	Bench	Assumed Phreatic Surface	Factor of Safety (FOS)		Figure No.
					Undrained	Drained	
18+960	5.3	2	-	as measured	1.39	1.35	G2-1, G2-2
18+960	5.3	2	-	mid-height	1.12	1.08	G2-3, G2-4
18+960	5.3	2.25	-	as measured	1.65	1.60	G2-5, G2-6
18+960	5.3	2.25	-	mid-height	1.34	1.32	G2-7, G2-8
18+960	5.3	2.5	-	as measured	1.75	1.73	G2-9, G2-10
18+960	5.3	2.5	-	mid-height	1.17 **	1.17 **	G2-11, G2-12
18+960	5.3	2.92 *	-	as measured	1.81	1.81	G2-13, G2-14
18+960	5.3	2.92 *	-	mid-height	1.27	1.27	G2-15, G2-16
18+960	3.8	2.92 *	-	as measured	1.91	1.91	G2-17, G2-18
18+960	3.8	2.92 *	-	mid-height	1.47	1.47	G2-19, G2-20

* as proposed by AECOM

** The decrease in the factor of safety with a flatter slope (e.g. 1.34 for 2.25H:1V vs. 1.17 for 2.5H:1V) is due to the fact that the fill behind the crest of the slope causes the increase of slope height with slope flattening.

Table 5.6: Slope Stability Analyses Results – Cut Area 3

Station	Slope Height (m)	Side Slope (xH:1V)	Bench	Assumed Phreatic Surface	Factor of Safety (FOS)		Figure No.
					Undrained	Drained	
18+700	4.7	2	-	as measured	2.86	1.74	G3-1, G3-2
18+700	4.7	2	-	mid-height	2.46	1.24	G3-3, G3-4
18+700	4.7	2.25	-	as measured	2.57	1.91	G3-5, G3-6
18+700	4.7	2.25	-	mid-height	2.17	1.33	G3-7, G3-8
18+700	4.7	2.5	-	as measured	2.16	2.04	G3-9, G3-10
18+700	4.7	2.5	-	mid-height	1.78	1.45	G3-11, G3-12
18+700	4.7	2.91 *	-	as measured	1.94 **	1.93 **	G3-13, G3-14
18+700	4.7	2.91 *	-	mid-height	1.53	1.52	G3-15, G3-16

* as proposed by AECOM

** The decrease in the factor of safety with a flatter slope (e.g. 2.16 for 2.5H:1V vs. 1.94 for 2.91H:1V) is attributed to the increase of slope height with slope flattening.

The following table presents the slope options from 3H:1V to 2H:1V, the corresponding results of the analyses (i.e. calculated factors of safety), and the advantages and disadvantages for using the specified slope.

Table 5.7: Stability Analyses Summary for More Than 6 m High Slopes, Cut Area 1

Slope Option	Factor of Safety (FOS)	Comments
2H:1V no bench	2.0 - 2.2 (Undrained, G1-1, G1-3) 1.1 * – 1.6 (Drained, G1-2, G1-4)	The calculations indicate that 2H:1V cut slopes would be stable with the measured groundwater levels. However, should the groundwater table rises to slope mid-height level, the calculated factor of safety for long term stability drops to about 1.1, which is unacceptably low. This may happen if the groundwater rises due to prolonged wet weather conditions. Disadvantages <ul style="list-style-type: none"> • May be adversely affected by frost, erosion, sloughing, etc. • Deviates from MTO protocol to bench every 6 m high.
2H:1V 1 bench	2.1 – 2.3 (Undrained, G1-5, G1-7) 1.2 * - 1.8 (Drained, G1-6, G1-8)	Advantages <ul style="list-style-type: none"> • More stable. • Follows the MTO protocol – bench every 6 m high. Disadvantages <ul style="list-style-type: none"> • Less likely to be adversely affected by erosion. • More property to be acquired compared to the above option. • More excavation compared to the above option. • May exhibit instability (i.e. FOS = 1.2 in drained condition).
2.25H:1V no bench	2.0 - 2.3 (Undrained, G1-9, G1-11) 1.2 * - 1.7 (Drained, G1-10, G1-12)	Advantages <ul style="list-style-type: none"> • More stable compared to the above no bench option. • Less likely prone to erosion compared to the above no bench option with 2H:1V slope configuration. • Easier slope maintenance compared to 2H:1V option. Disadvantages <ul style="list-style-type: none"> • More property to be acquired compared to above options. • Requires the more excavation compared to above options. • Deviates from MTO protocol to bench every 6 m high. • May exhibit instability (i.e. FOS = 1.2 in drained condition).

Slope Option	Factor of Safety (FOS)	Comments
2.25H:1V 1 bench	2.1 - 2.3 (Undrained, G1-13, G1-15) 1.3 * - 1.9 (Drained, G1-14, G1-16)	<p>Advantages</p> <ul style="list-style-type: none"> • More stable compared to the 2H:1V one bench option. • Easier slope maintenance in comparison. • Follows the MTO protocol – bench every 6 m high. • Less likely to be adversely affected by frost, sloughing, etc. • Unlikely to be adversely affected by erosion. <p>Disadvantages</p> <ul style="list-style-type: none"> • More property to be acquired compared to the similar options as above. • More excavation required compared to the similar options as above.
2.5H:1V no bench	2.1 - 2.3 (Undrained, G1-17, G1-19) 1.3 * - 1.8 (Drained, G1-18, G1-20)	<p>Advantages</p> <ul style="list-style-type: none"> • More stable compared to the above no bench options. • Not likely prone to erosion compared to the above no bench options. • Easier slope maintenance compared to the above options. <p>Disadvantages</p> <ul style="list-style-type: none"> • Relatively low FOS (1.30) for drained case although somewhat improved in comparison with steeper slopes. • More property to be acquired compared to above options. • Requires the more excavation compared to above options. • Deviates from MTO protocol to bench every 6 m high.

Slope Option	Factor of Safety (FOS)	Comments
2.5H:1V 1 bench	2.2 - 2.4 (Undrained, G1-21, G1-23) 1.3 * - 2.0 (Drained, G1-22, G1-24)	<p>Advantages</p> <ul style="list-style-type: none"> • More stable compared to the above options. • Easier slope maintenance. • Follows the MTO protocol – bench every 6 m high. • Unlikely to be adversely affected by creep, frost, etc. • Slightly higher FOS (1.34) for drained case in comparison with above options. <p>Disadvantages</p> <ul style="list-style-type: none"> • More property to be acquired compared to the above options. • More excavation required compared to the above options.
~ 3H:1V no bench	2.2 - 2.4 (Undrained, G1-25, G1-27) 1.5 * - 2.0 (Drained, G1-26, G1-28)	<p>Advantages</p> <ul style="list-style-type: none"> • More stable compared to the above no bench options. • Not prone to erosion. • Easier slope maintenance. • Acceptable FOS even for the drained case. <p>Disadvantages</p> <ul style="list-style-type: none"> • Requires the most property to be acquired compared to all other options. • Requires the most excavation compared to all other options.

* Slope stability (drained case) analyses with water table at mid-height of the slopes.

The recommended option for slopes in excess of 6.0 m is 2.5H:1V slopes with full height drainage blanket. As the maximum height of slope is only 7.9 m, the slope is flatter than typical 2H:1V configuration and rip-rap is to be placed, it is our opinion that the implementation of a mid-height bench is not necessary. However, if MTO convention in this regard must be adhered to, we have no objection to the inclusion of a mid-height bench in the design.

Table 5.8: Stability Analyses Summary for Less Than 6 m High Slopes, Cut Area 1

Slope Option	Factor of Safety (FOS)	Comments
2H:1V	2.5 (Undrained, G1-29, G1-31) 1.2 * – 1.7 (Drained, G1-30, G1-32)	The calculations indicate that 2H:1V cut slopes would be stable with the groundwater levels as measured during our investigation. Should the groundwater levels rise to mid-height level of the cut, however, drained case FOS drops to 1.2. Comparing to the other options, this option requires the least property acquirement and excavation.
2.25H:1V	2.5 (Undrained, G1-33, G1-35) 1.3 * – 1.8 (Drained, G1-34, G1-36)	Advantages <ul style="list-style-type: none"> • More stable compared to the above option. • Easier slope maintenance compared to the above option. Disadvantages <ul style="list-style-type: none"> • More property to be acquired compared to the above option. • Requires more excavation compared to the above option.
2.5H:1V	2.5 (Undrained, G1-37, G1-39) 1.4 * – 2.0 (Drained, G1-38, G1-40)	Advantages <ul style="list-style-type: none"> • Theoretically more stable compared to the above options. • Easier slope maintenance compared to the above options. Disadvantages <ul style="list-style-type: none"> • More property to be acquired compared to above options. • Requires more excavation compared to above options.
2.92H:1V	2.4 (Undrained, G1-41, G1-43) 1.6 * – 2.2 (Drained, G1-42, G1-44)	Advantages <ul style="list-style-type: none"> • Theoretically more stable compared to the above options. • Easier slope maintenance. Disadvantages <ul style="list-style-type: none"> • Requires the most property to be acquired compared to all other options. • Requires the most excavation compared to all other options.

*Slope stability (drained case) analyses with water table at mid-height of the slopes.

The recommended option for Cut Area 1 for slopes less than 6.0 m in height is 2.5H:1V side slopes with a drainage blanket throughout the entire face of the cut slope.

Table 5.9: Stability Analyses Summary, Cut Area 2

Slope Option	Factor of Safety (FOS)	Comments
2H:1V	1.1 – 1.4 (Undrained, G2-1, G2-3) 1.1 * – 1.4 (Drained, G2-2, G2-4)	Slope stability analyses indicated that the FOS is 1.4 with the groundwater levels as measured during our investigation and drops to 1.1 if water table rises to mid-height slope. These values are theoretically unacceptable. Comparing to the other options, this option requires the least property acquirement and excavation.
2.25H:1V	1.3 – 1.7 (Undrained, G2-5, G2-7) 1.3 * – 1.6 (Drained, G2-6, G2-8)	Advantages <ul style="list-style-type: none"> • More stable compared to the above option (minimum FOS increases to 1.3 from 1.1). • Easier slope maintenance compared to the above option. Disadvantages <ul style="list-style-type: none"> • More property to be acquired compared to the above option. • Requires the more excavation compared to the above option.
2.5H:1V	1.2 – 1.8 (Undrained, G2-9, G2-11) 1.2 * – 1.7 (Drained, G2-10, G2-12)	Advantages <ul style="list-style-type: none"> • Theoretically more stable compared to the above options, except when the water table rises above the measured values.** • Easier slope maintenance compared to the above options. Disadvantages <ul style="list-style-type: none"> • More property to be acquired compared to above options. • Requires the more excavation compared to above options.

Slope Option	Factor of Safety (FOS)	Comments
2.92H:1V	1.3 – 1.9 (Undrained, G2-13, G2-15, G2-17, G2-19) 1.3 * – 1.9 (Drained, G2-14, G2-16, G2-18, G2-20)	Advantages <ul style="list-style-type: none"> • Theoretically more stable compared to the above options. • Easier slope maintenance. Disadvantages <ul style="list-style-type: none"> • Requires the most property to be acquired compared to all other options. • Requires the most excavation compared to all other options.

* Slope stability analyses (drained case) with water table at mid-height of the slopes.

**As mentioned before, the decrease of the FOS with slope flattening is due to the fact that the height of the cut increases with the flatter slopes.

The recommended option for Cut Area 2 is 2.5H:1V side slopes with a drainage blanket throughout the entire face of the cut slope. Alternatively, a 3H:1V side slope can be adopted, as presently proposed by AECOM, and in this instance, drainage blanket is considered unnecessary provided the top 1.5 m of the existing fill is removed from the crest (as shown in Figures G2-17 to G2-20 in Appendix G and also in a sketch form in Figure H-2 in Appendix H) from Station 18+890 to Station 18+970.

Table 5.10: Stability Analyses Summary, Cut Area 3

Slope Option	Factor of Safety (FOS)	Comments
2H:1V	2.5 – 2.9 (Undrained, G3-1, G3-3) 1.2 * – 1.7 (Drained, G3-2, G3-4)	Slope stability analyses indicated that 2H:1V cut slopes would be stable with groundwater levels as measured during our investigation. If however groundwater table were to rise to mid-height of the cut slope, the FOS for the drained condition would fall to 1.2, which is theoretically unacceptable. Comparing to the other options, this option requires the least property acquisition and excavation.

Slope Option	Factor of Safety (FOS)	Comments
2.25H:1V	2.2 – 2.6 (Undrained, G3-5, G3-7) 1.3 * – 1.9 (Drained, G3-6, G3-8)	Advantages <ul style="list-style-type: none"> • More stable compared to the above option. • Easier slope maintenance compared to the above option. Disadvantages <ul style="list-style-type: none"> • More property to be acquired compared to the above option. • Requires the more excavation compared to the above option.
2.5H:1V	1.8 – 2.2 (Undrained, G3-9, G3-11) 1.5 * – 2.0 (Drained, G3-10, G3-12)	Advantages <ul style="list-style-type: none"> • Theoretically more stable compared to the above options. • Easier slope maintenance compared to the above options. Disadvantages <ul style="list-style-type: none"> • More property to be acquired compared to above options. • Requires the more excavation compared to above options.
2.92H:1V	1.5 – 1.9 (Undrained, G3-13, G3-15) 1.5 * – 1.9 (Drained, G3-14, G3-16)	Advantages <ul style="list-style-type: none"> • Theoretically more stable compared to the above options. • Easier slope maintenance. Disadvantages <ul style="list-style-type: none"> • Requires the most property to be acquired compared to all other options. • Requires the most excavation compared to all other options.

* Slope stability analyses (drained case) with water table at mid-height of the slopes.

The recommended option for Cut Area 3 is 2.5H:1V side slopes, with a drainage blanket throughout the entire face of the cut slope. Alternatively, a 3H:1V side slope configuration can be maintained, as presently proposed by AECOM. In this case, the installation of a drainage blanket is considered unnecessary.

To accommodate the proposed highway ramps, additional land acquisition is required for the cut slopes in some sections even if 2.5H:1V slope configuration without any bench is selected. The cost of the land in this rural area along Highway 401 is relatively inexpensive as well, material excavated from flatter cuts can probably be used in other parts of this contract. It is therefore our opinion that flattening slopes beyond the normal 2H:1V side slope, along this corridor of this major highway, which is very important for the economy

of the Province, is justified for long term stability of the cut slopes. However, final decision regarding this aspect should be made by the designer based on a benefit/cost/risk analyses.

5.2.3 Conclusions

Relatively low factors of safety were obtained for long term (drained) stability conditions in our sensitivity analysis when the groundwater table was assumed to have risen to about the half height of the cut slopes. This is primarily due to the fact that the surficial soils at most borehole locations consist of non-cohesive, typically very loose to compact materials. The slope stability analysis is therefore very sensitive to the position of the groundwater table. In addition, there is a real possibility that a perched water condition may occur due to the accumulation of surface water in the relatively more pervious surficial fine grained granular (non-cohesive) soils overlying the practically impervious clayey silt deposit. For this reason, the installation of a drainage blanket is recommended to effectively remove the accumulated water before the phreatic surface reaches critical levels for stability (see Figure H-1 in Appendix H). For the relatively shallower cut heights in Cut Areas 2 and 3, consideration can be given to adopting 3H:1V side slopes without this drainage blanket. Even with these flat slopes, the calculated safety factors are still somewhat lower than desirable levels, but in our opinion, the risk of a large scale failure is low and thus if a small risk is acceptable, 3H:1V side slopes can be used for Cut Areas 2 and 3, without the use of a drainage blanket. But in the case of Cut Area 2, the top 1.5 m of the existing soils need to be removed between Stations 18+890 and 18+970, as depicted in Figure H-2 in Appendix H (also see Figures G2-17 to G2-20 in Appendix G) for the 3H:1V option.

In summary, the following are the recommended slope configurations.

Table 5.11: Recommended Cut Slope

Height of Slope	Recommended Slope	
Cut Area 1	2.5H:1V	with drainage blanket throughout the entire face of the cut slopes *
Cut Area 2	2.5H:1V	with drainage blanket throughout the entire face of the cut slopes *, or
	3H:1V	cut slopes without drainage blanket, provided that the top 1.5 m of the existing fill is removed (see Figure H-2 in Appendix H and Figures G2-17 to G2-20 in Appendix G) between Stations 18+890 and 18+970
Cut Area 3	2.5H:1V	with drainage blanket throughout the entire face of the cut slopes *, or
	3H:1V	cut slopes without drainage blanket

Note: * see Figure H-1 in appendix H.

As mentioned in the previous section of this report, to accommodate the proposed highway ramps, additional land acquisition is required for the cut slopes in some sections even if 2.5H:1V slope

configuration without any bench is selected. The cost of the land in this rural area along Highway 401 is relatively inexpensive, as well material excavated from flatter cuts can probably be used in other parts of this contract. It is therefore our opinion that flattening slopes beyond the normal 2H:1V side slope, along this corridor of this major highway, which is very important for the economy of the Province, is justified for long term stability of the cut slopes. However, final decision regarding this aspect should be made by the designer based on a benefit/cost/risk analyses.

5.2.4 Construction

The construction of the proposed cut will involve excavation onto the existing ground surface. Based on the borehole information, the excavations are anticipated to be through the topsoil, fill and typically loose to compact silty sand to sand, and stiff to very stiff clayey silt. A hydraulic excavator should be adequate for excavation in topsoil and underlying deposits.

Earth cuts should be constructed in accordance with OPSS 180, OPSS 201, OPSS 206, OPSS 501, and SP 206S03 (see Appendix I).

The excavation of the new cut slopes may extend several meters away (depending on the height of the proposed cut) behind the crest of the existing slope or the existing ground surface. As discussed above, the construction of the recommended slope geometry (i.e. inclusion of mid height bench) may extend beyond the present property line and this matter needs to be addressed prior to construction.

The groundwater readings from the piezometers installed in the boreholes indicated that at the time of our investigation, the groundwater was below the toe of the proposed cut. However, the construction of the new cut may take place below the groundwater level due to the seasonal fluctuation or after severe weather events. Dewatering such as pumping from filtered sumps may therefore need to be implemented to facilitate construction. If these measures do not appear to be effective, additional measures such as vacuum well points may be required.

We recommend that erosion protection measures, including proper drainage and rip-rap, be installed for the new cut slope as discussed in Section 5.2.1. The placement of filter materials should be carried out without causing the segregation of the coarser particles.

We also recommend that no additional loading such as stockpiles, heavy machinery or any surcharge loads be present near the crest of the slope during construction. A NSSP should be issued to alert the Contractor of this issue, as presented in Appendix J.

5.2.4.1 Suitability of Excavated Materials for Re-use

The excavated soils free from topsoil and organics can be used as general construction backfill (e.g. for flattening slopes beyond 2H:1V configurations) for the fill section of the project where they can be compacted with smooth drum or pad-foot type rollers, depending on the nature of the soil. The loose lifts should not exceed 300 mm when first placed. On site verification of the excavated fill for re-use as backfill by suitably qualified personnel during construction would be required. Most of the excavated soils are not considered to be free draining. Where free draining backfill is required, imported granular fill such as OPSS Granular B should be used. Note that the excavated soils are subject to moisture content increase

during wet weather which would make these materials too wet for adequate compaction. Stockpiles should therefore be compacted at the surface or be covered with tarpaulins to help minimize moisture uptake.

With the exception of surficial silty sand to sand deposit encountered in Boreholes R3, F73 and F74 in Cut Area 1, the percentage of particles passing sieve # 200 (i.e. particles finer than 0.075 mm) is greater than 25%. As such, most of the deposits to be excavated, except for the surficial soils mentioned above, do not qualify for use as Selected Subgrade Materials (SSM) as per OPSS 1010, and should not be used for embankment construction, unless otherwise certified as a suitable "earth borrow" by the CA.

6 CLOSURE

The "Limitations of Report" as presented in Appendix K are integral part of the report.

For and on behalf of Coffey Geotechnics Inc.



Hongliu Wang, Ph.D., P.Eng.

Geotechnical Engineer



Ramon Miranda, P.Eng.

Principal



Zuhtu Ozden, P.Eng.

Senior Principal



Appendix F

Typical Sections of the Proposed Cut Areas

Table F-1 Cut Area 1 - Stations 18+230 to 18+380, W-S Ramp

Station	Proposed Road Centreline Elevation (m)	Existing Slope Dimension *				Proposed Slope Dimension *			
		Crest Elevation (m)	Toe Elevation (m)	Slope Height (m)	Slope xH:1V	Crest Elevation (m)	Ditch Bottom Elevation (m)	Slope Height (m)	Slope xH:1V
18+290	99.0	104.8	97.5	7.3	3.77	105.4	97.5	7.9	3.0
18+330	100.7	105.0	98.2	6.8	2.88	105.1	99.1	6.0	3.0

Table F-2 Cut Area 2 - Stations 18+890 to 19+040, W-N Ramp

Station	Proposed Road Centreline Elevation (m)	Existing Slope Dimension *				Proposed Slope Dimension *			
		Crest Elevation (m)	Toe Elevation (m)	Slope Height (m)	Slope xH:1V	Crest Elevation (m)	Ditch Bottom Elevation (m)	Slope Height (m)	Slope xH:1V
18+960	107.8	112.1	109.3	2.8	9.57	111.9	106.6	5.3	3.0

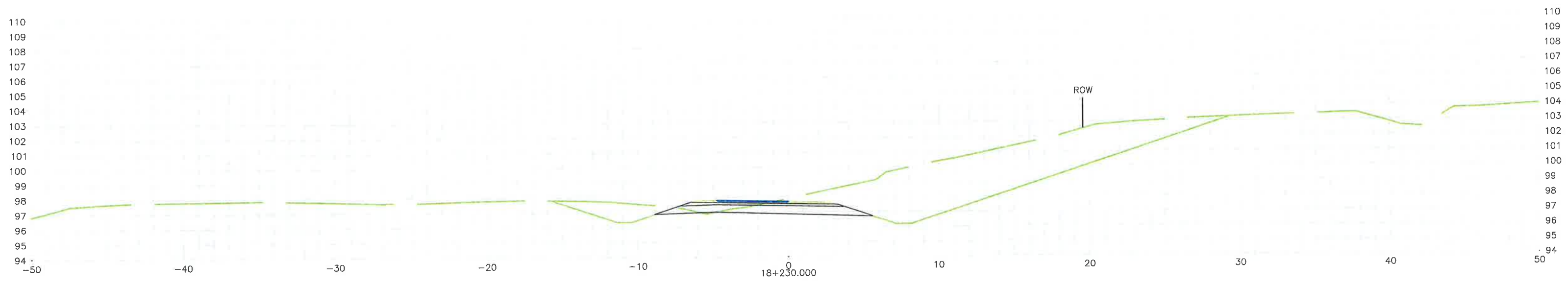
Table F-3 Cut Area 3 - Stations 18+530 to 18+725, N/S-E Ramp

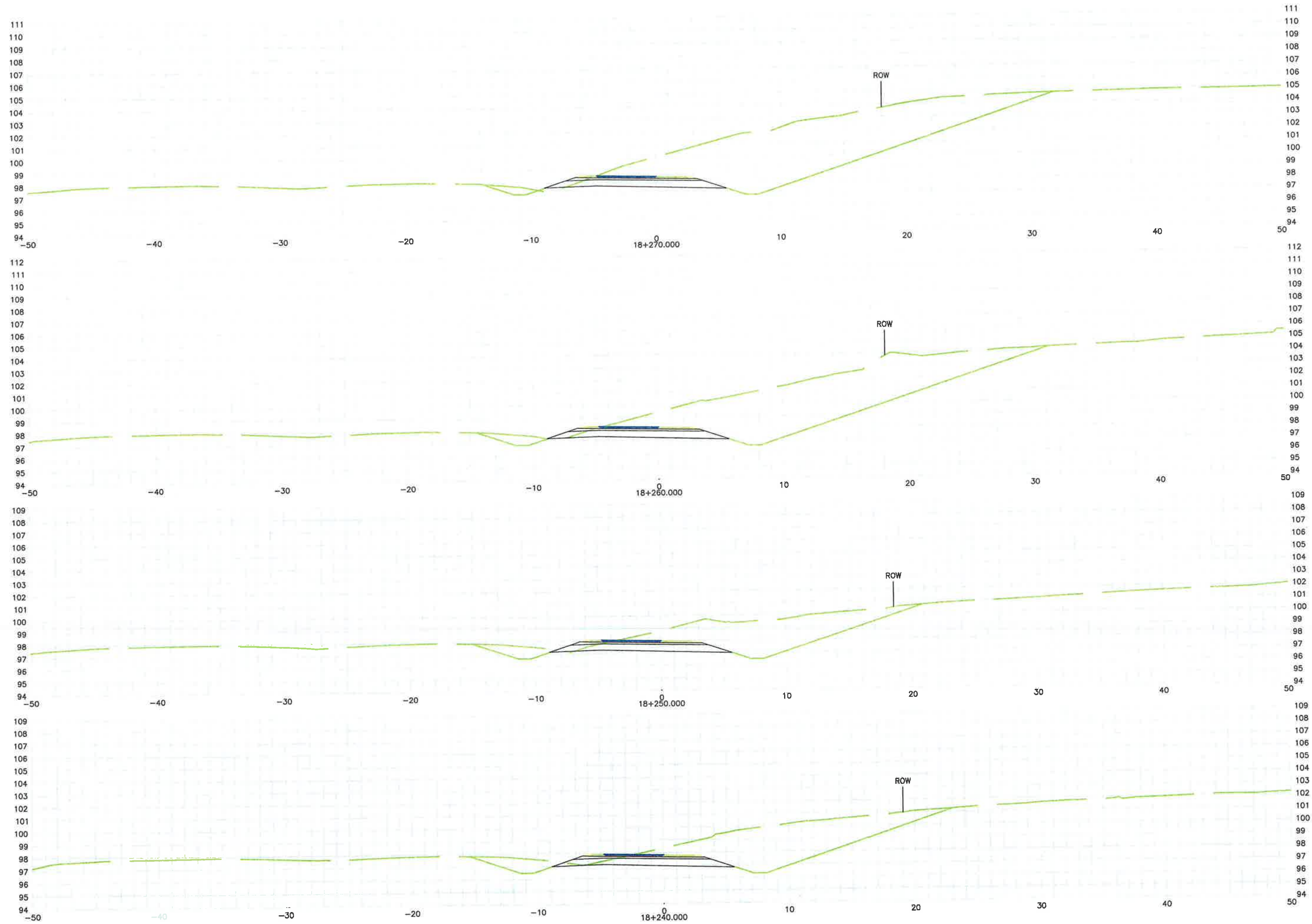
Station	Proposed Road Centreline Elevation (m)	Existing Slope Dimension *				Proposed Slope Dimension *			
		Crest Elevation (m)	Toe Elevation (m)	Slope Height (m)	Slope xH:1V	Crest Elevation (m)	Ditch Bottom Elevation (m)	Slope Height (m)	Slope xH:1V
18+700	109.5	113.8	112.0	1.8	3.06	112.6	107.9	4.7	3.0

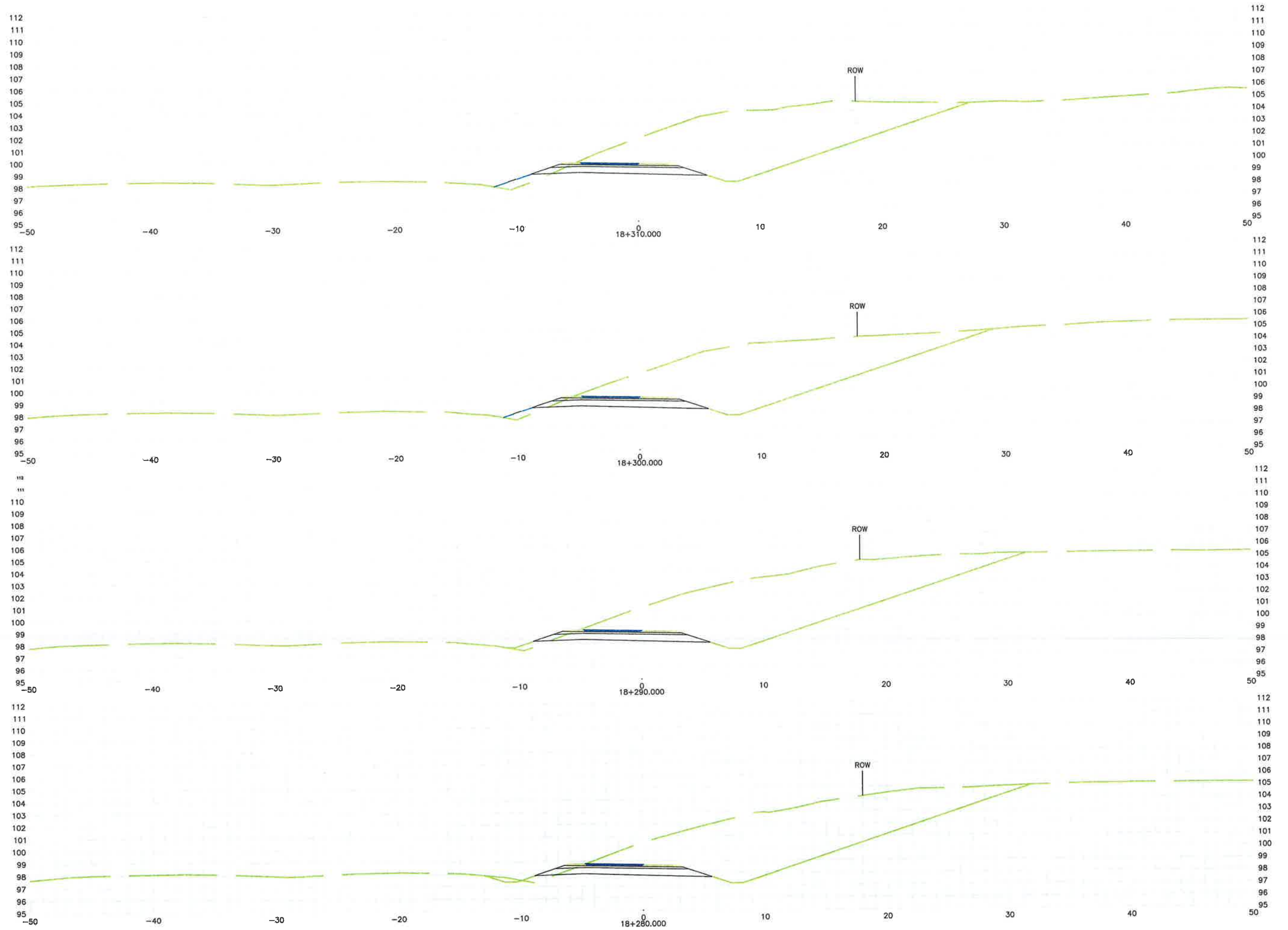
Note: * all slope dimensions based on cross section drawings provided by AECOM

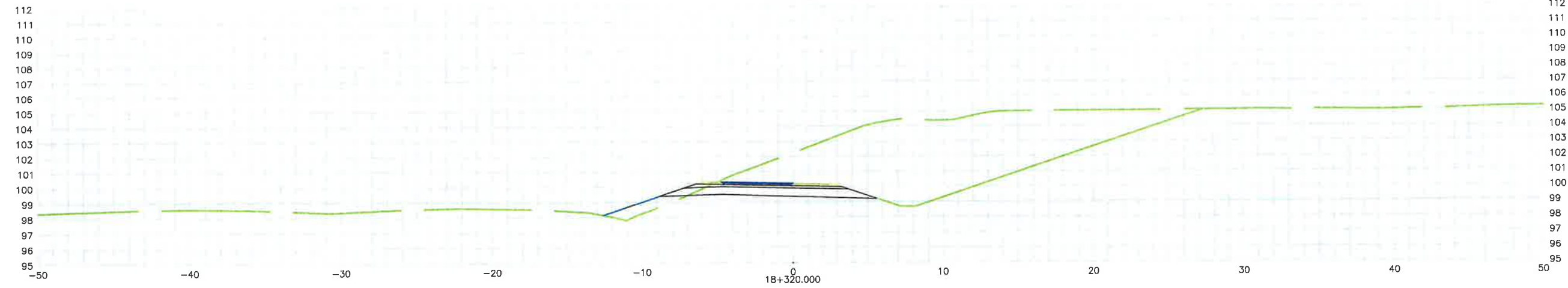
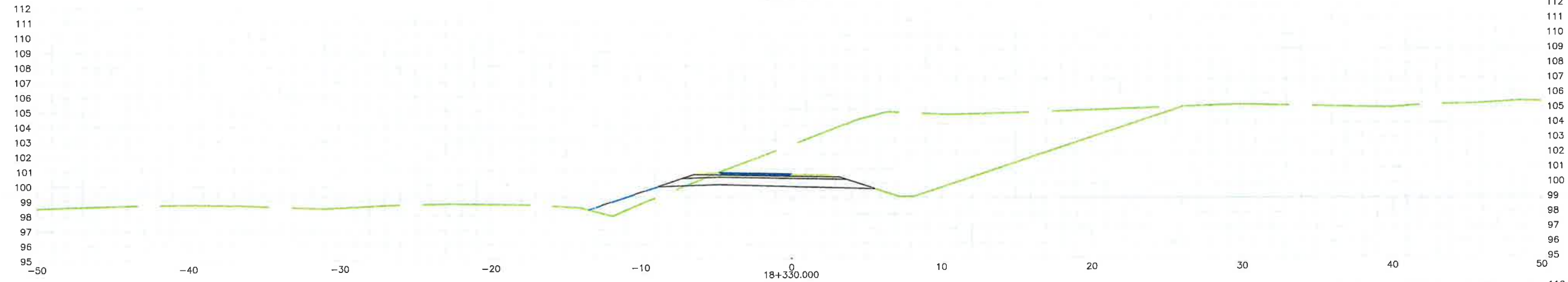
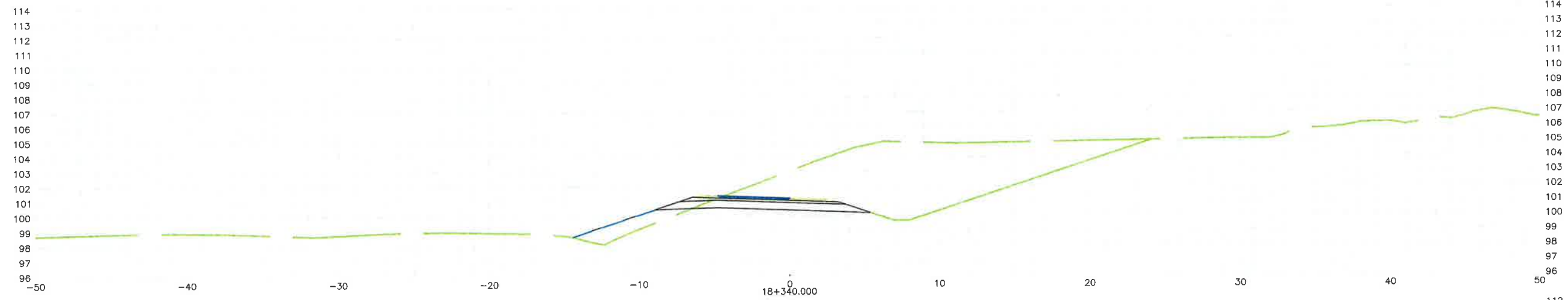
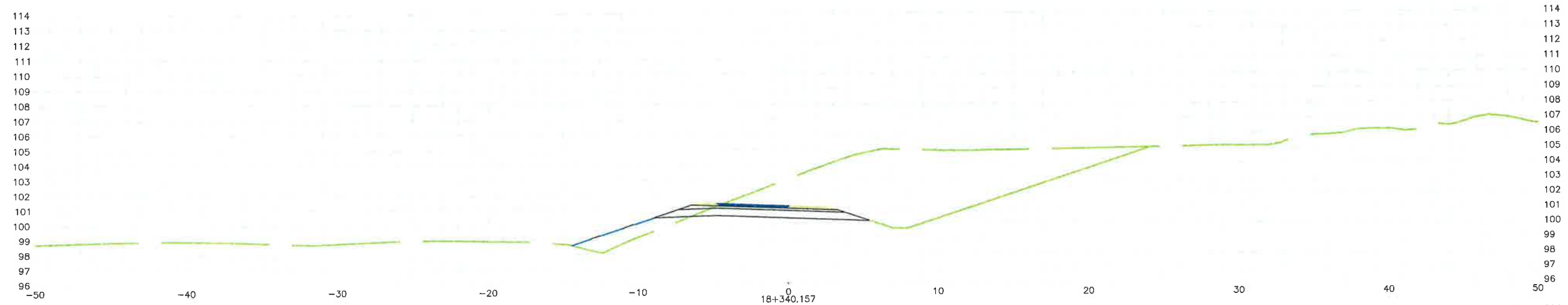
Appendix F1

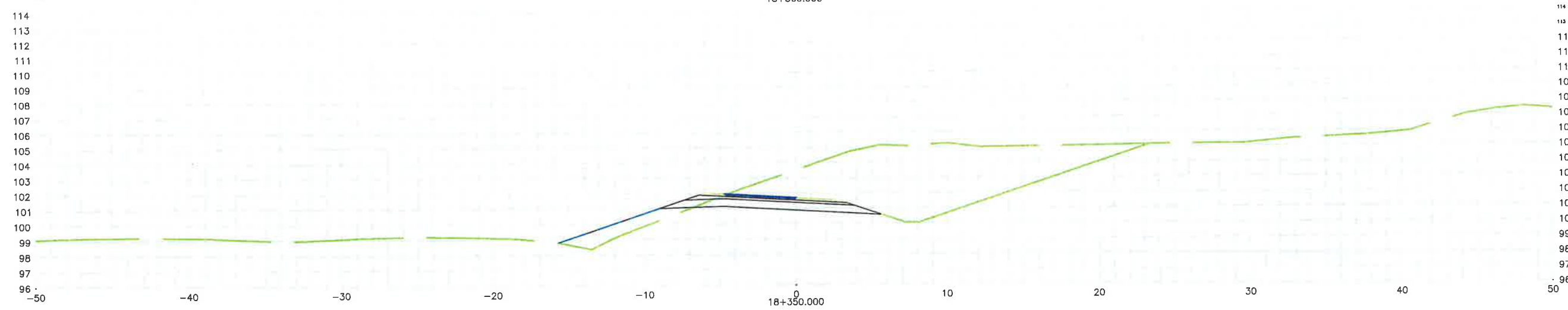
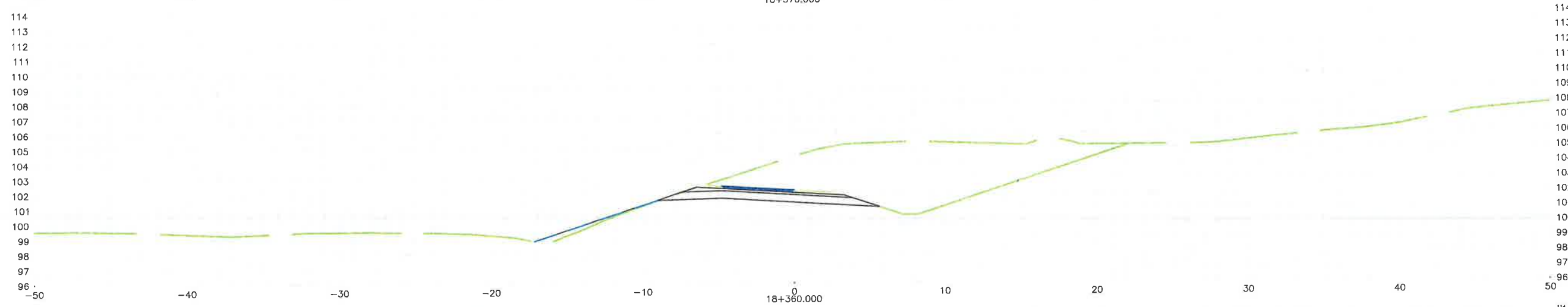
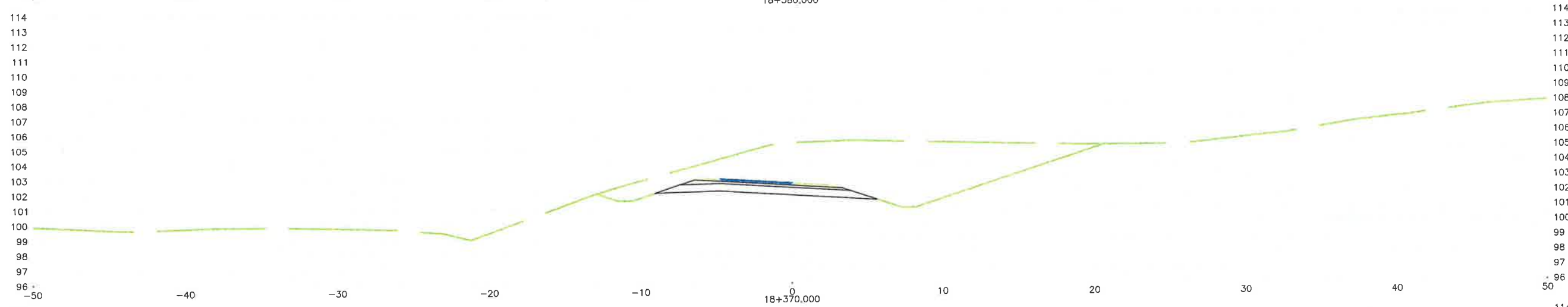
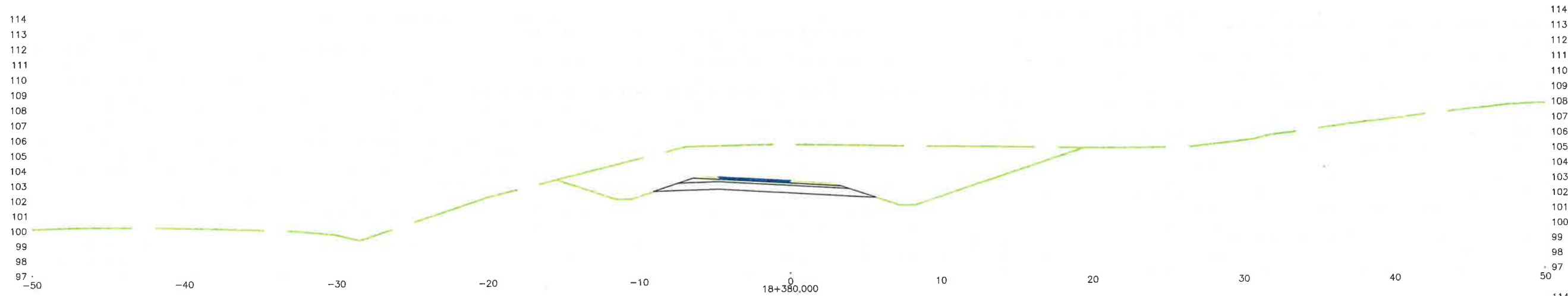
Typical Sections of Cut Area 1





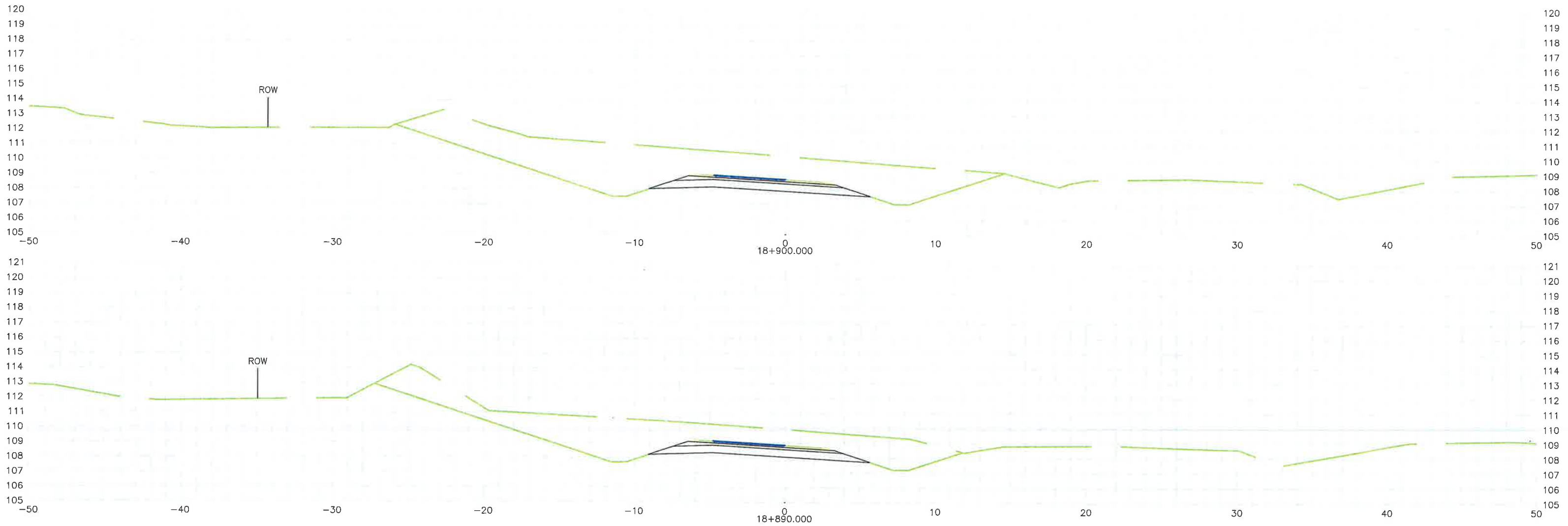


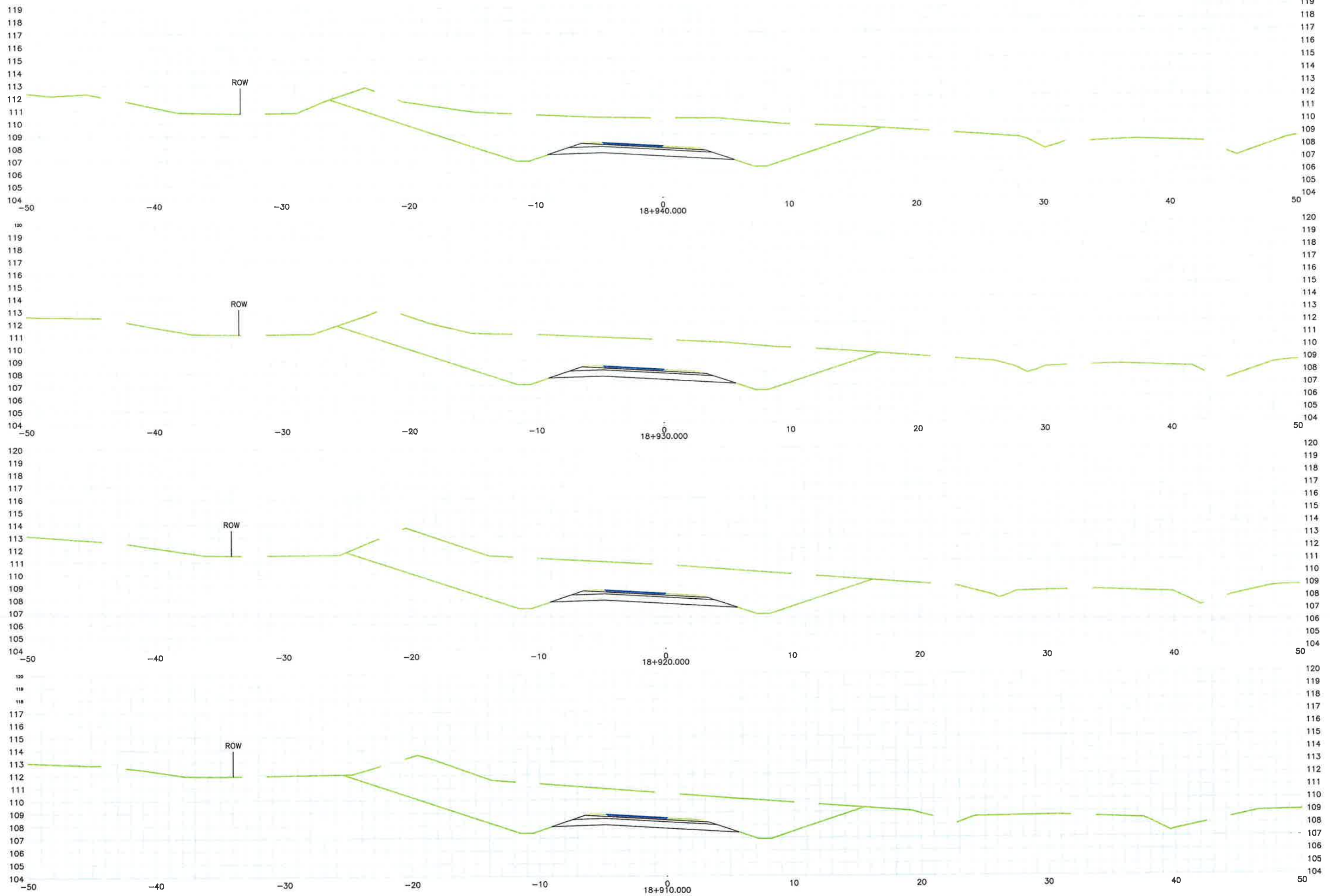


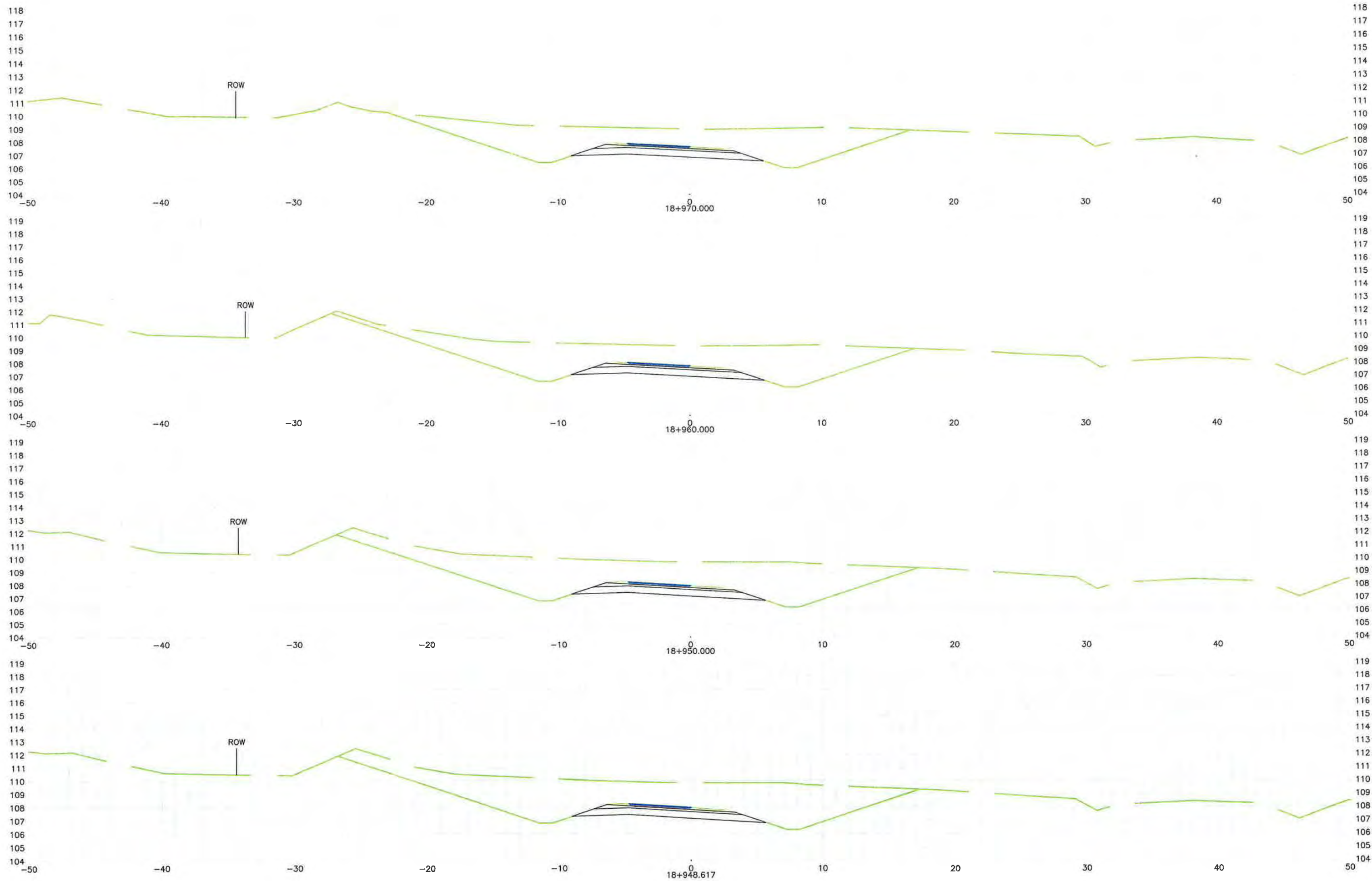


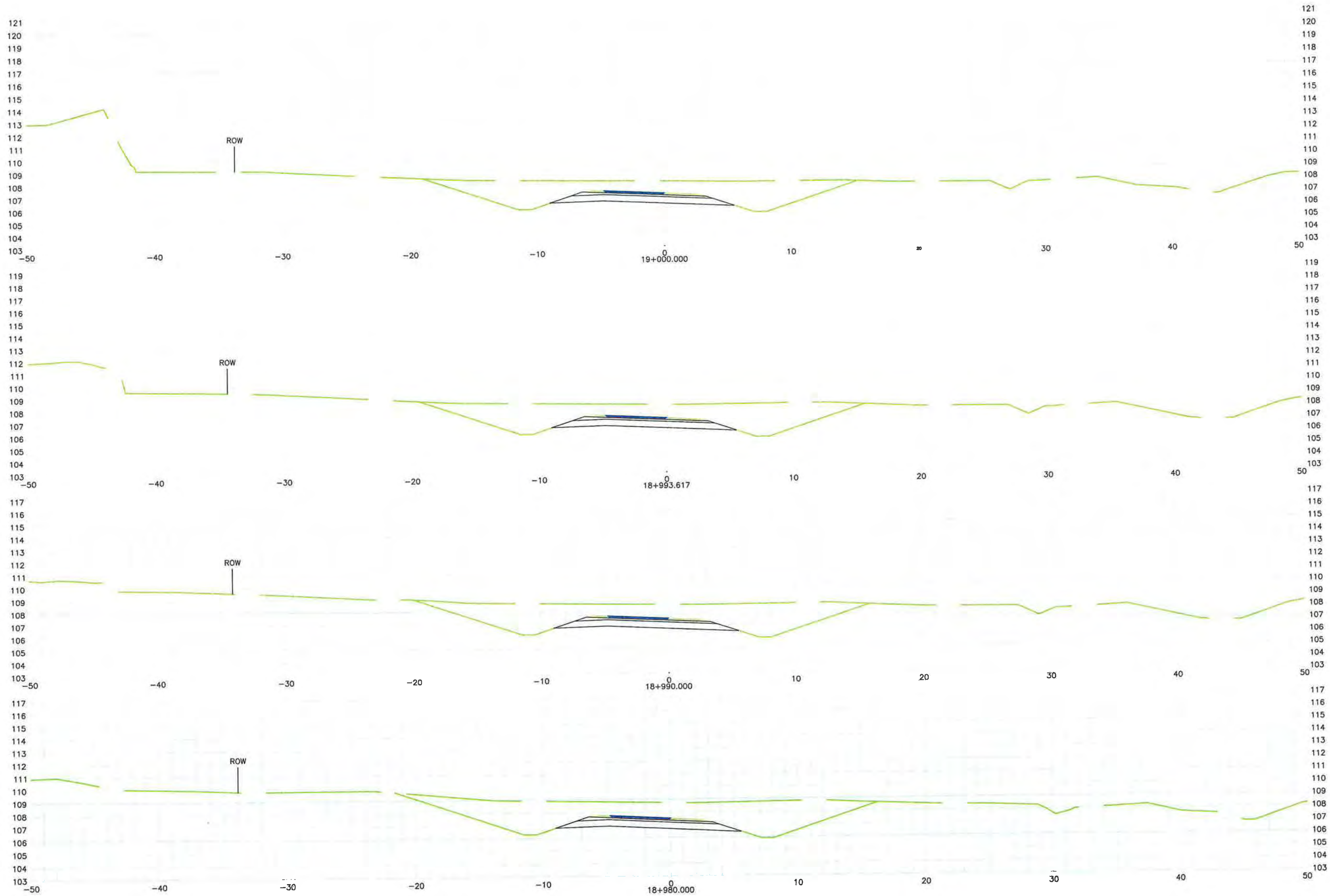
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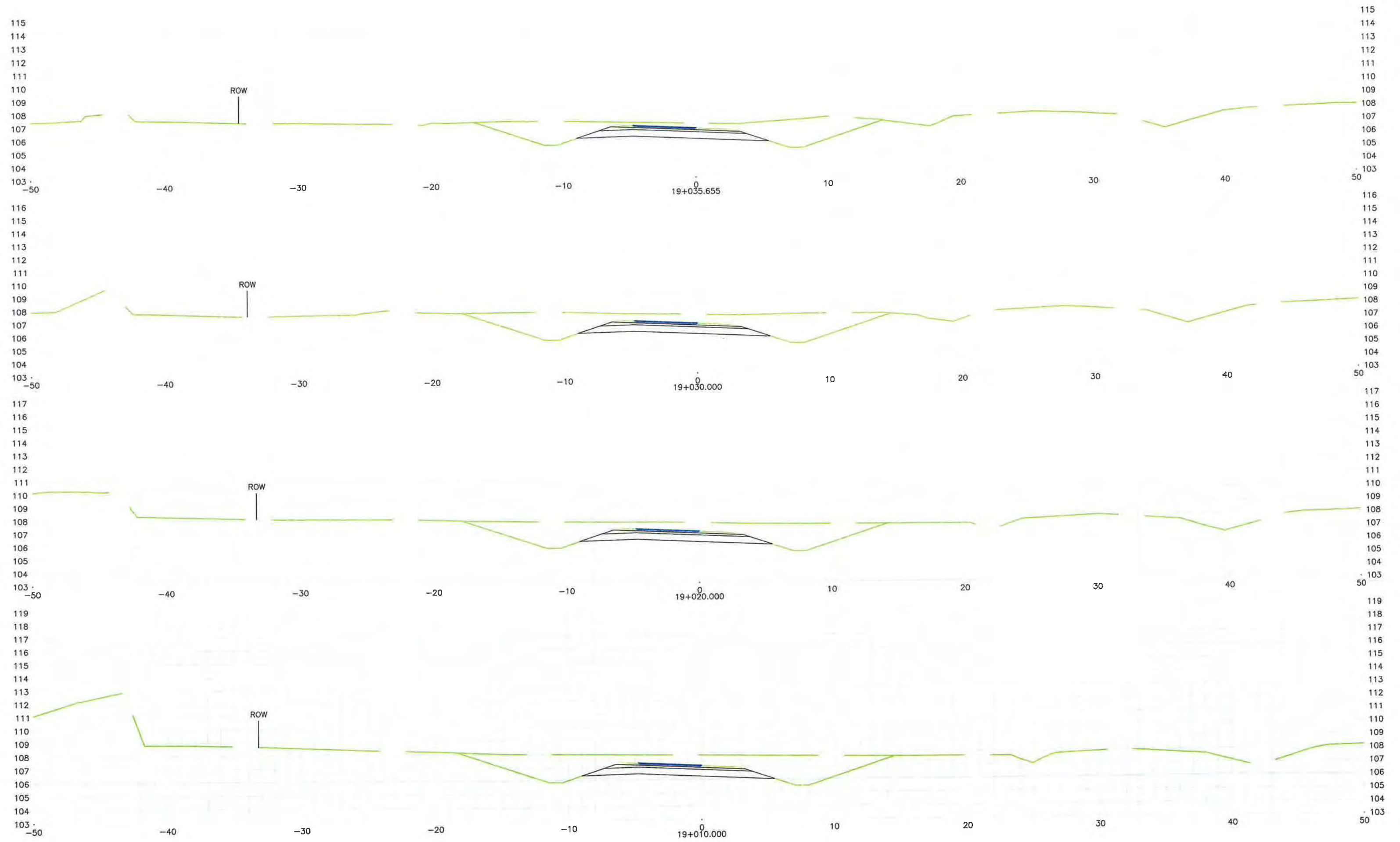
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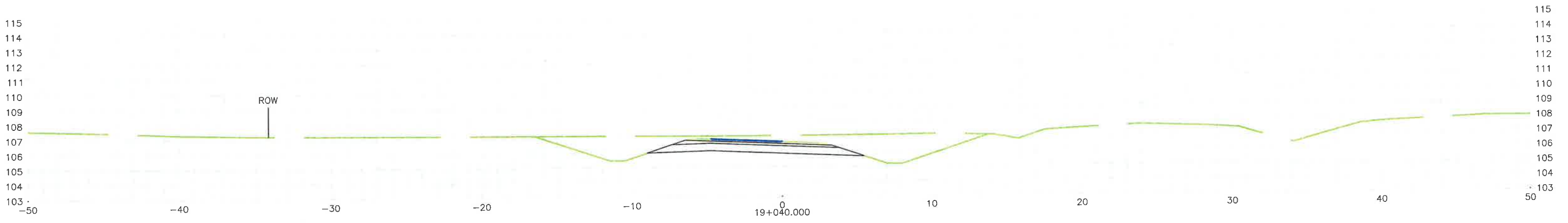






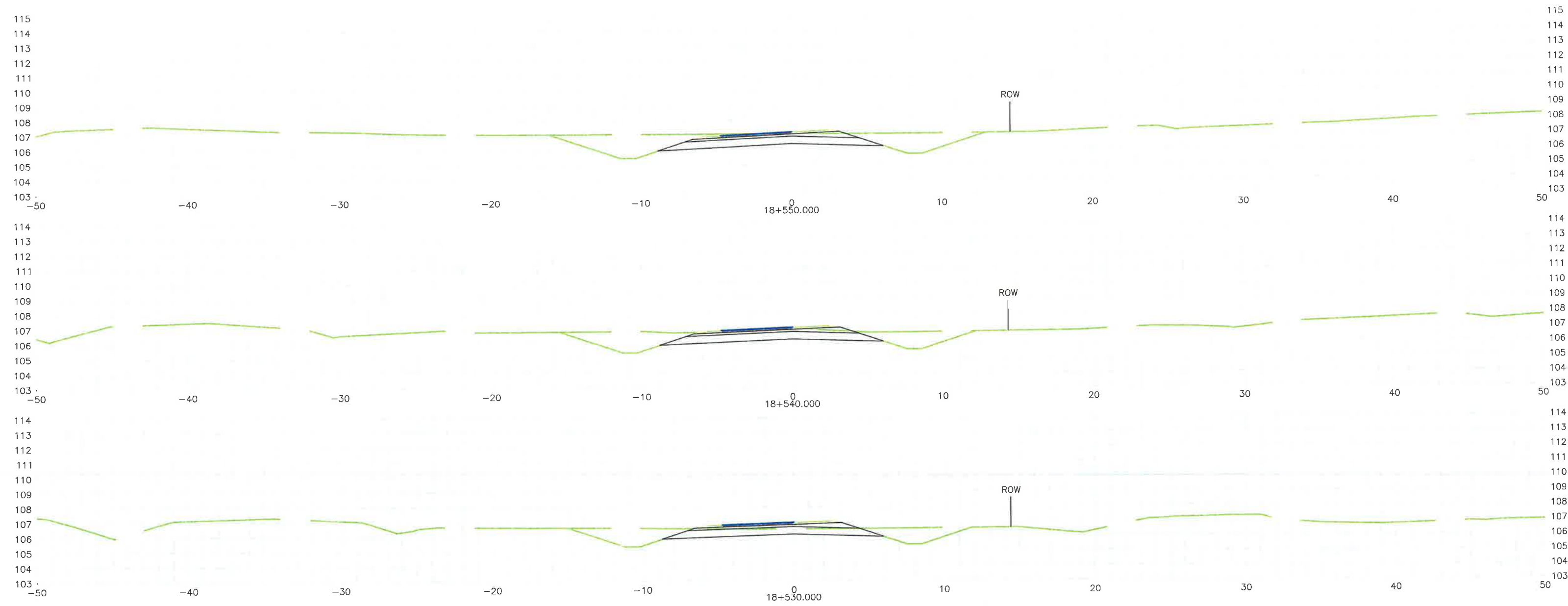


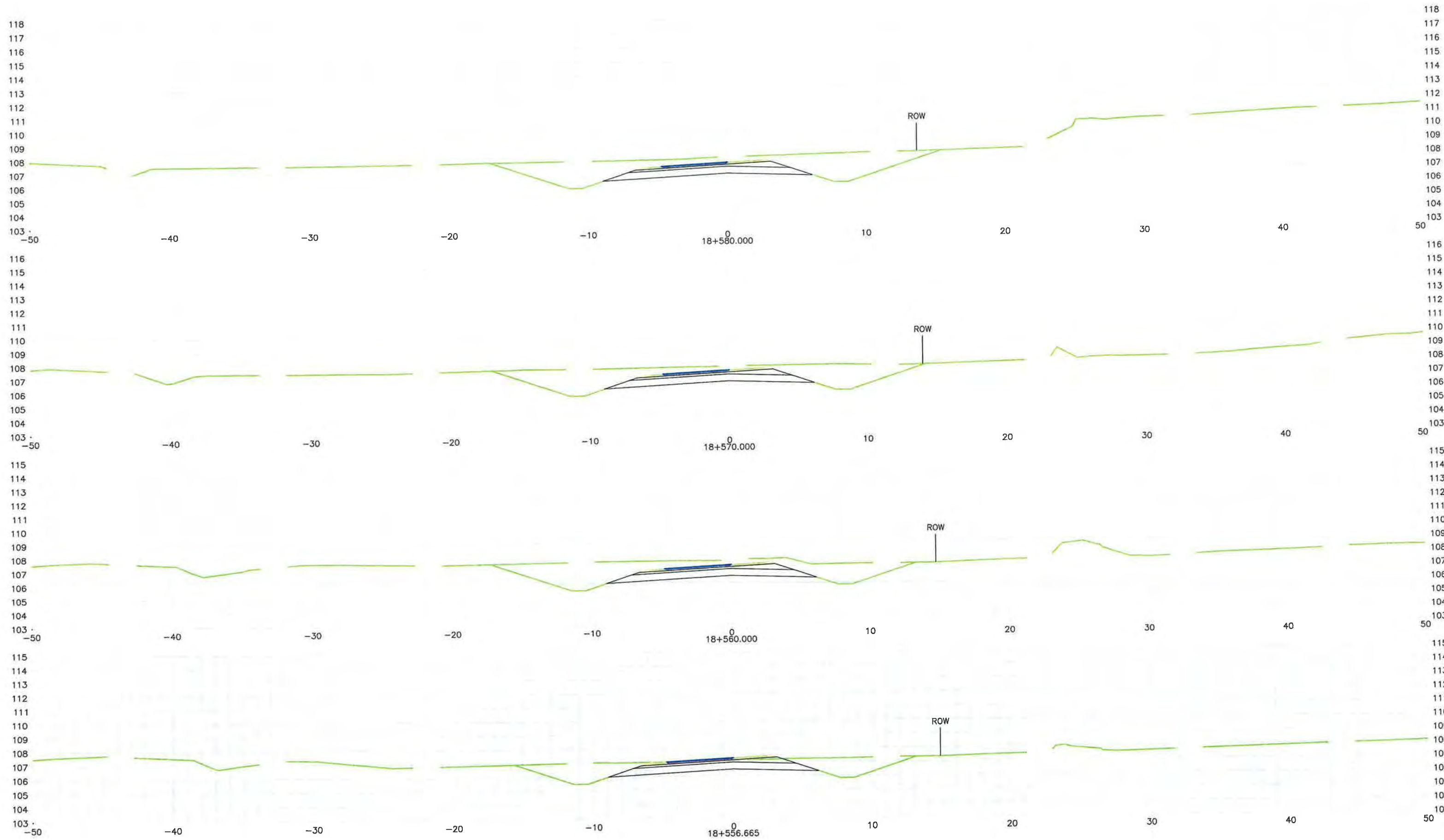


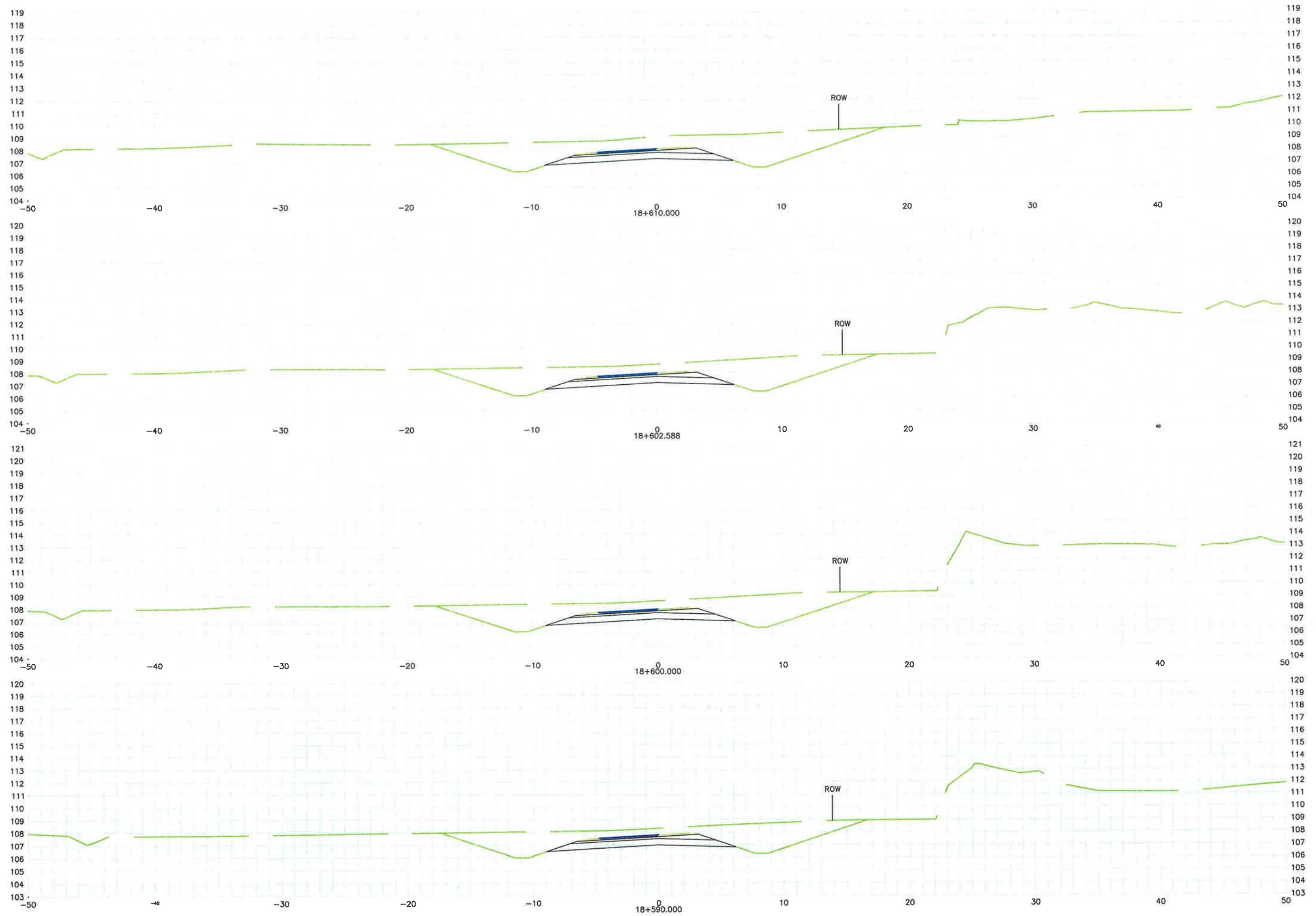


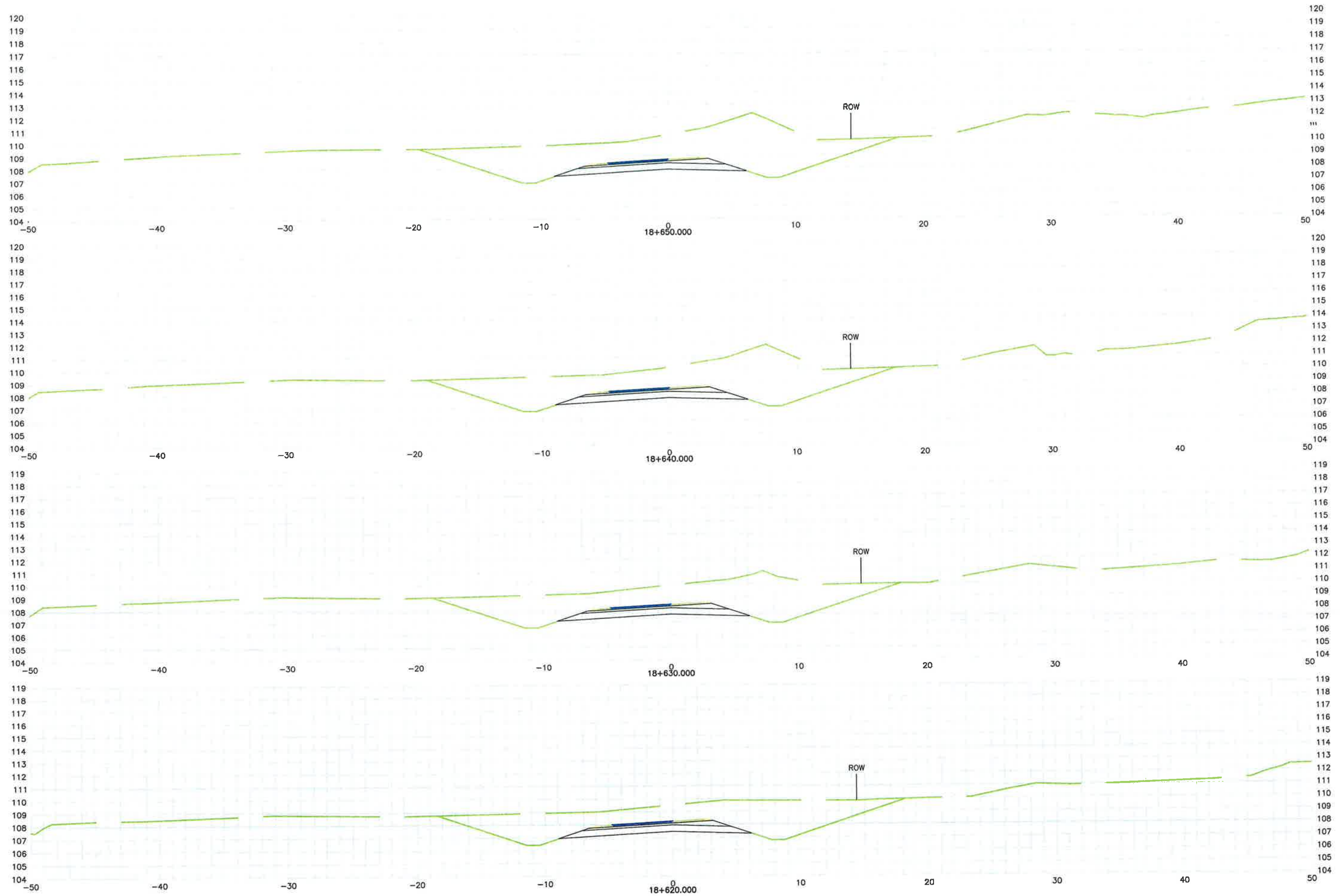
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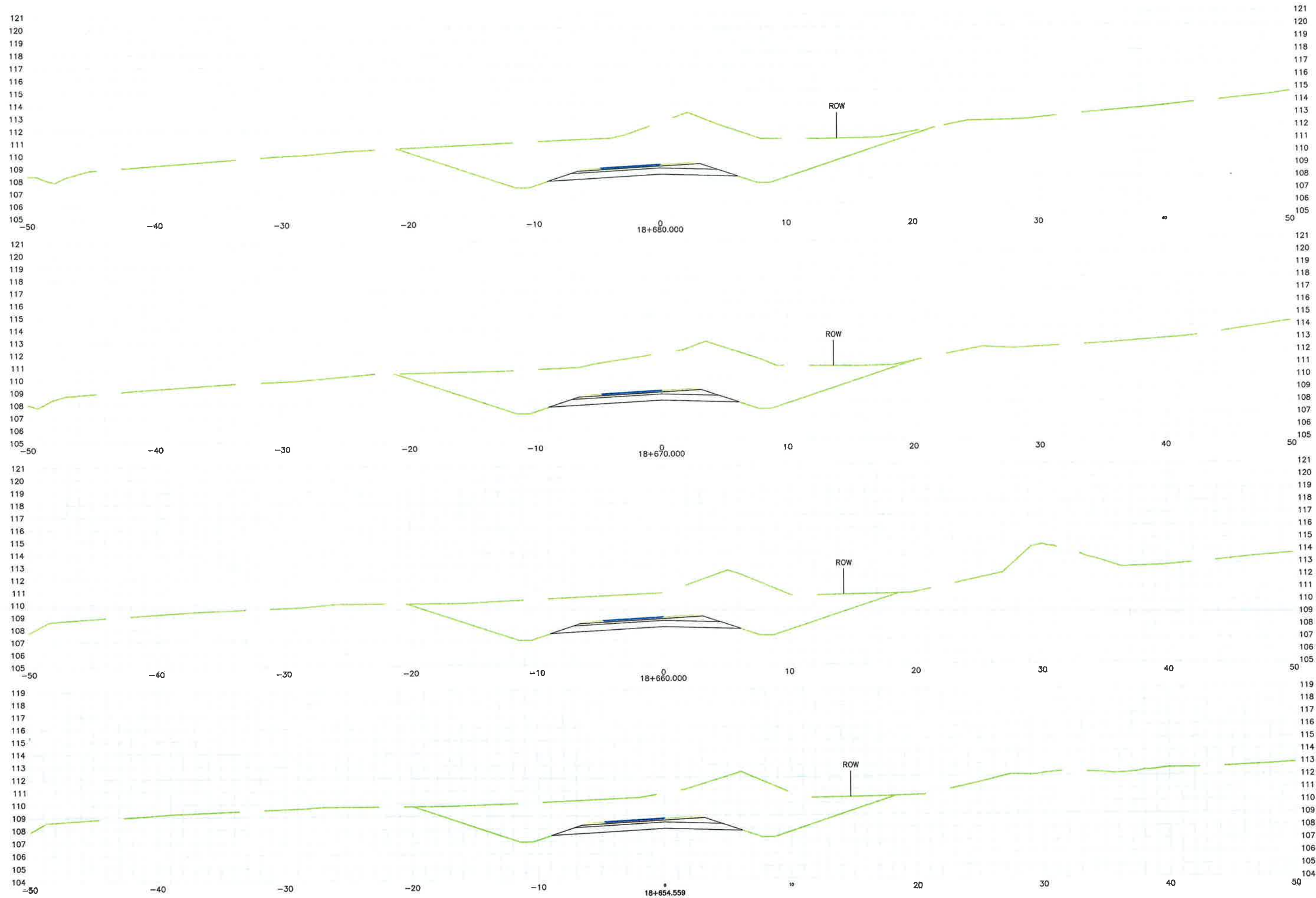
Typical Sections of Cut Area 3

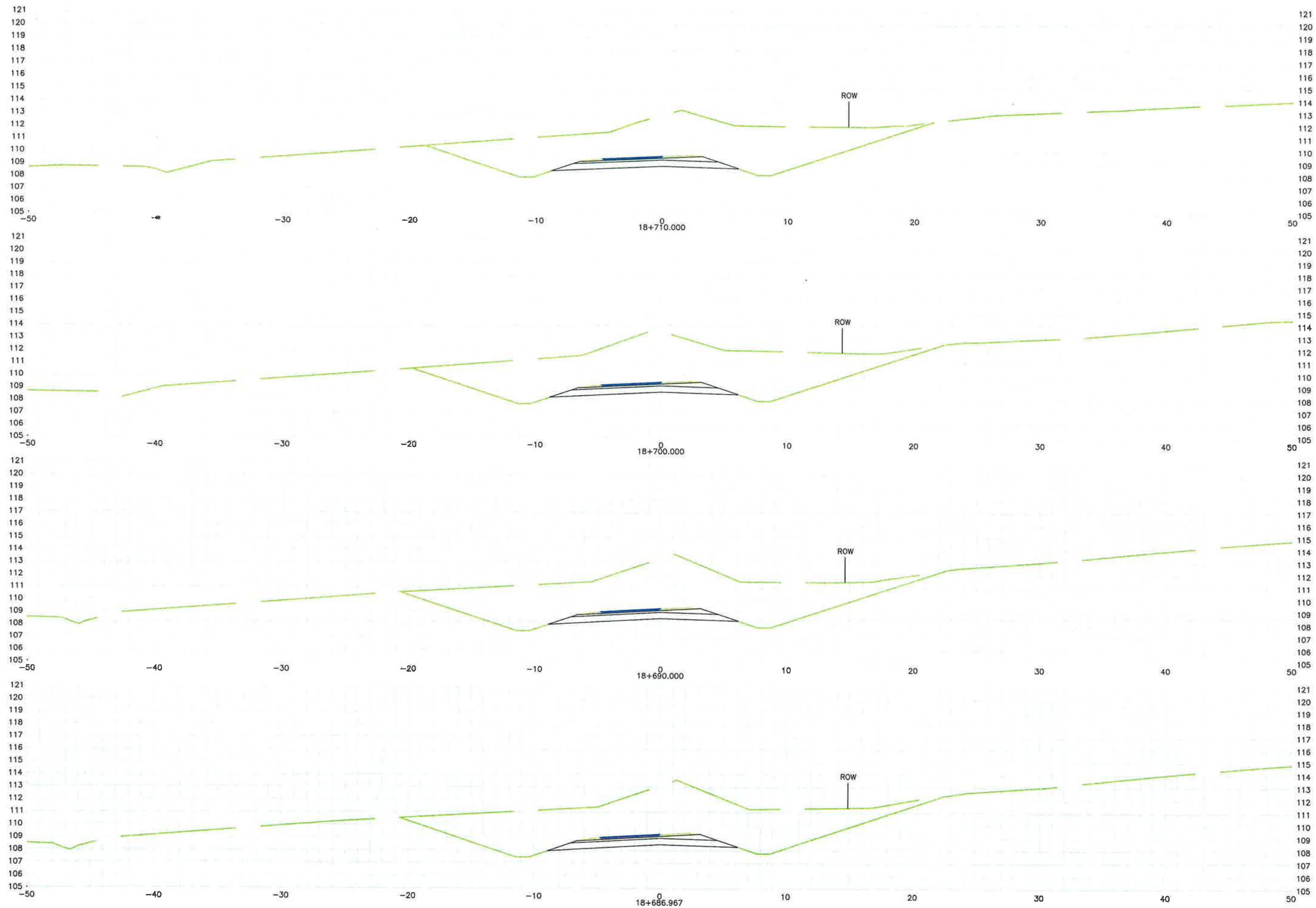


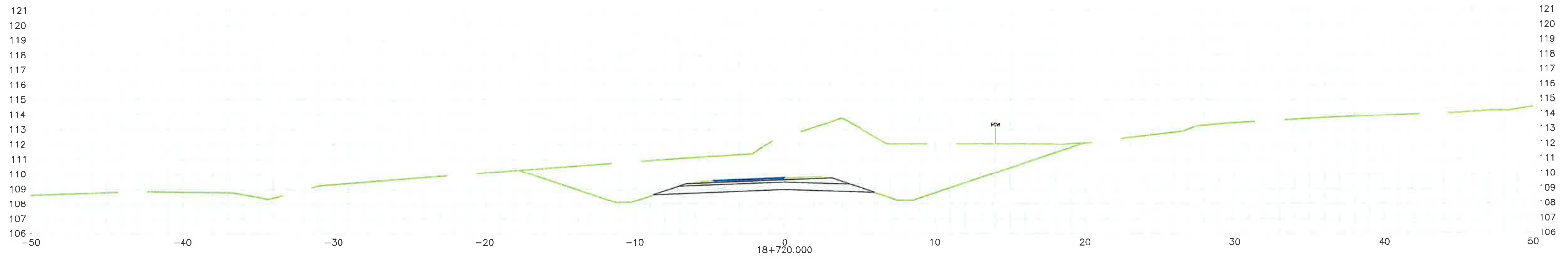






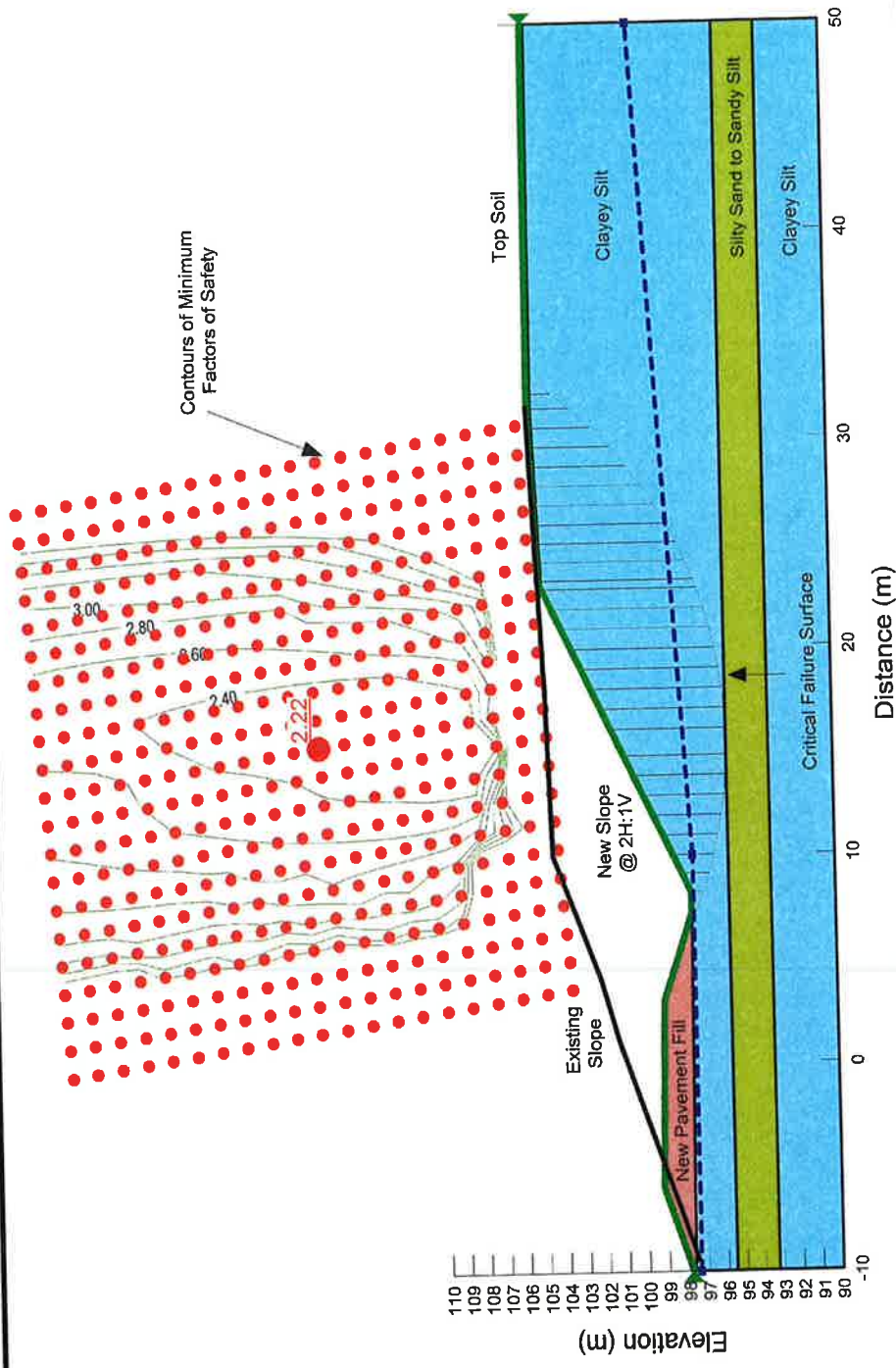






Appendix G

Results of Slope Stability Analyses

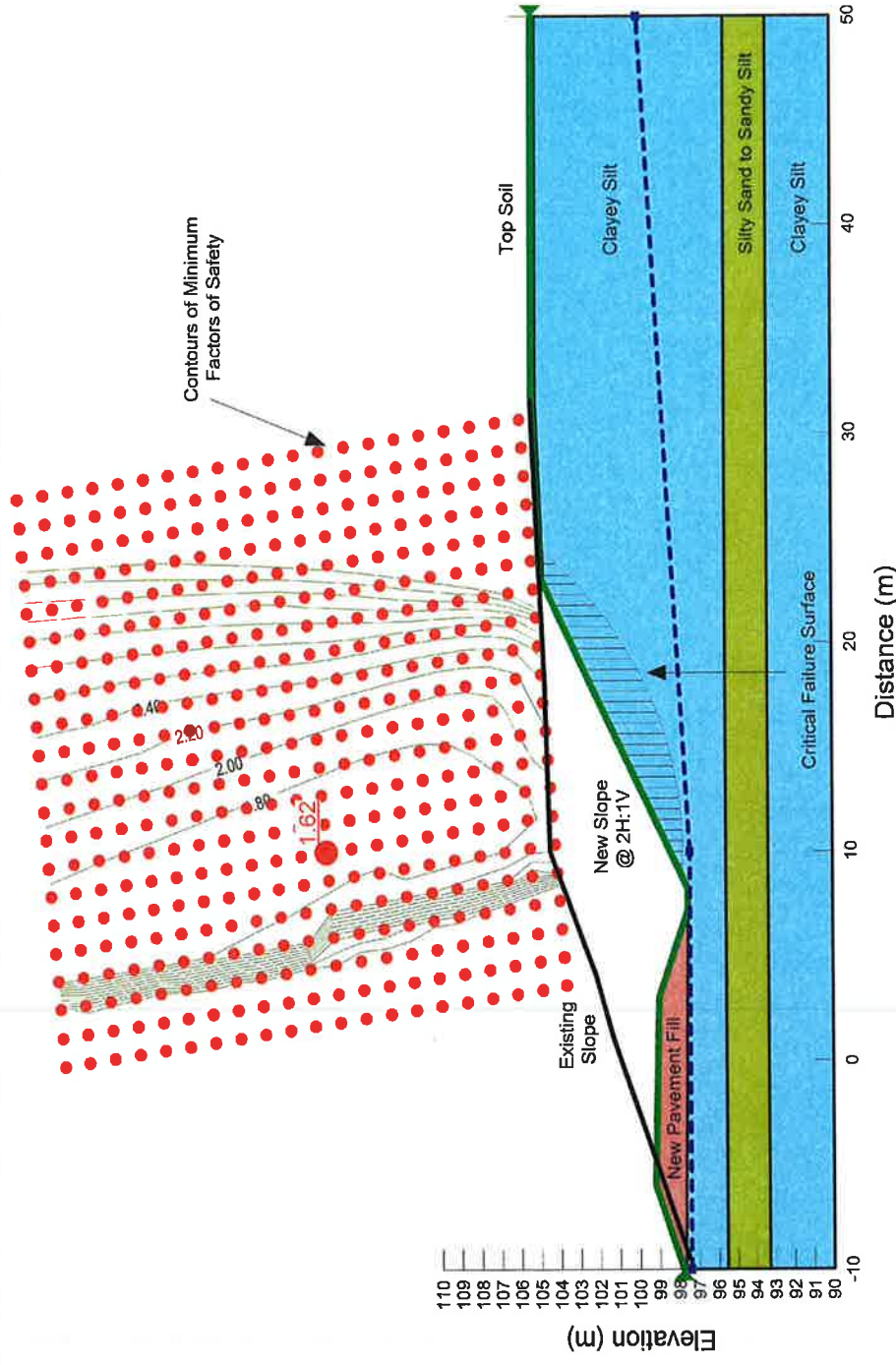


Section : Sta. 18+330
 Slope : 2H:1V
 Condition : Undrained
 Measured water table
 No bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

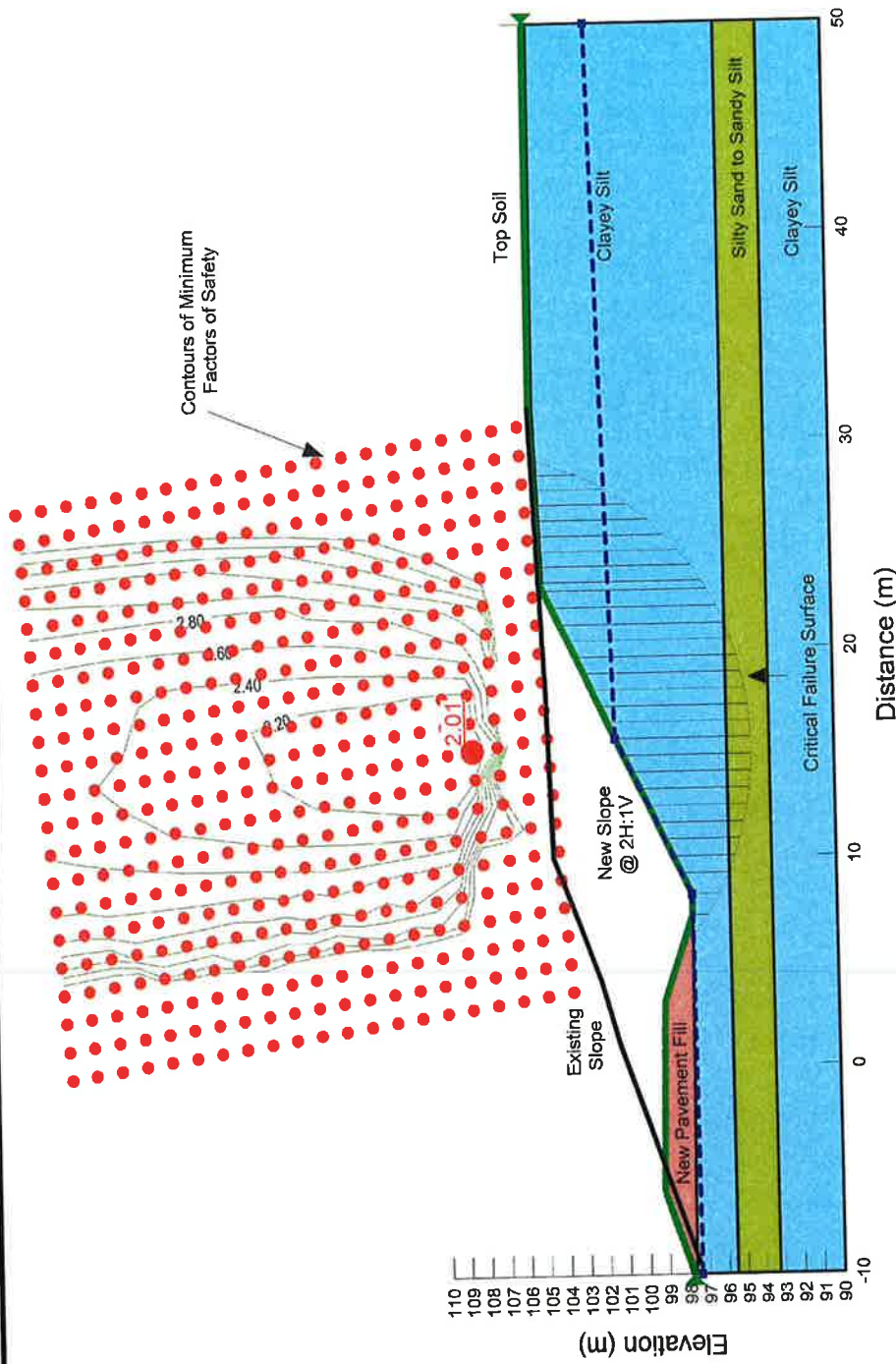
STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330
 Slope : 2H:1V
 Condition : Drained
 Measured water table
 No bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32



Section : Sta. 18+330

Slope : 2H:1V

Condition : Undrained

Mid-height water table

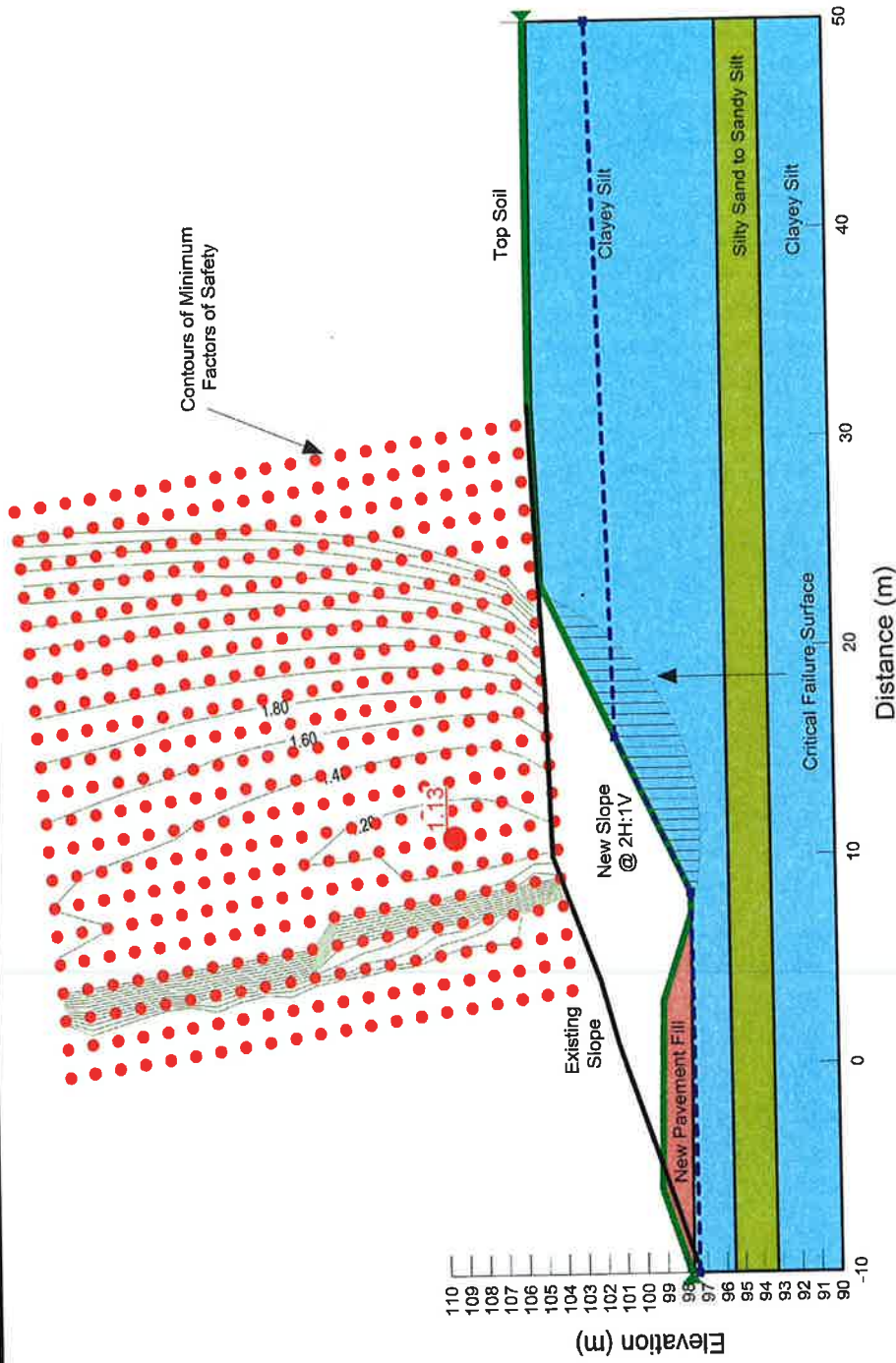
No bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2H:1V

Condition : Drained

Mid-height water table

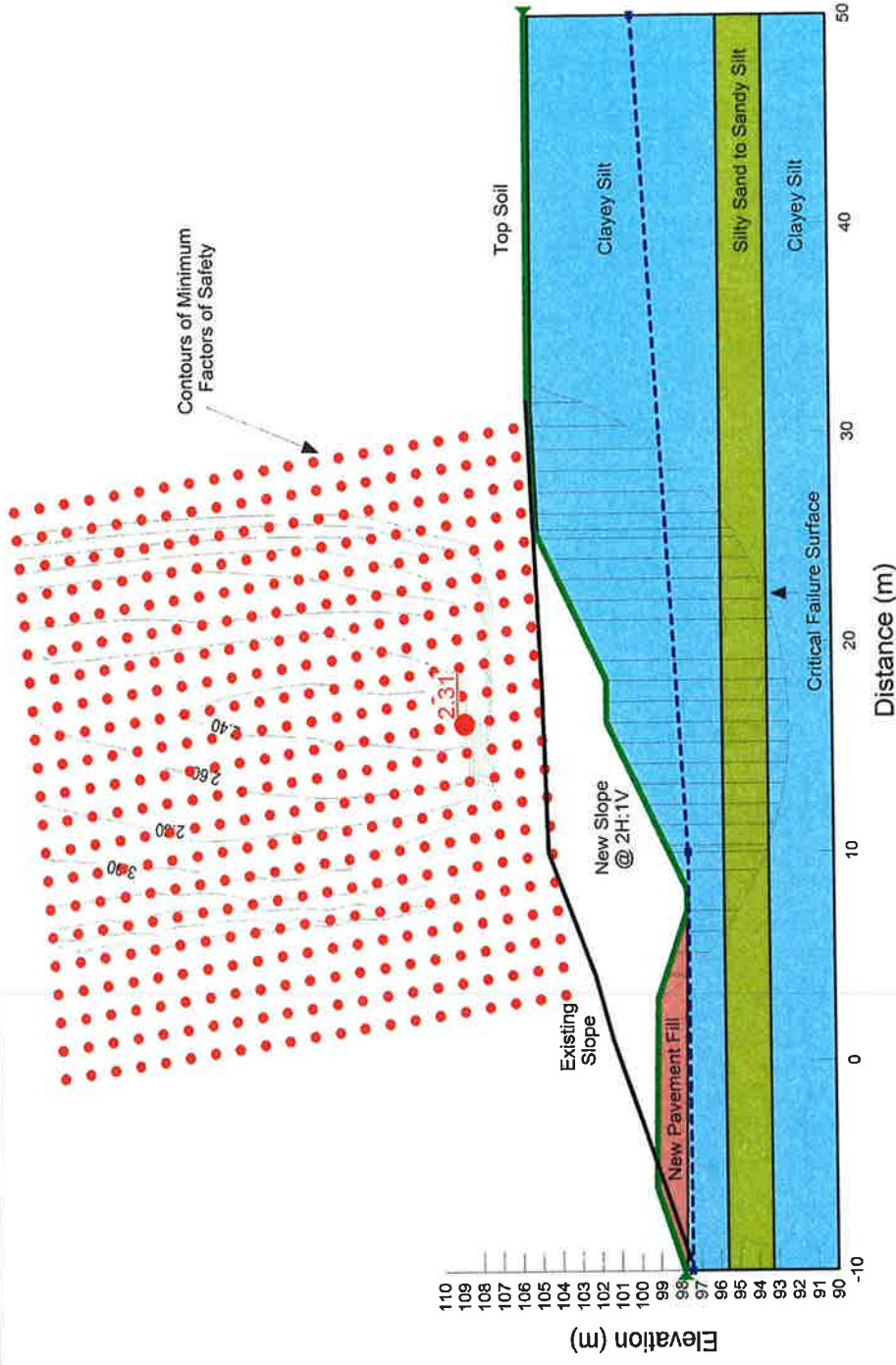
No bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2H:1V

Condition : Undrained

Measured water table
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32



SPECIALISTS MANAGING THE EARTH

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

PROJECT:

TRANETOB10434AA-AN

DATE: Jan-2012

FIGURE G1-5

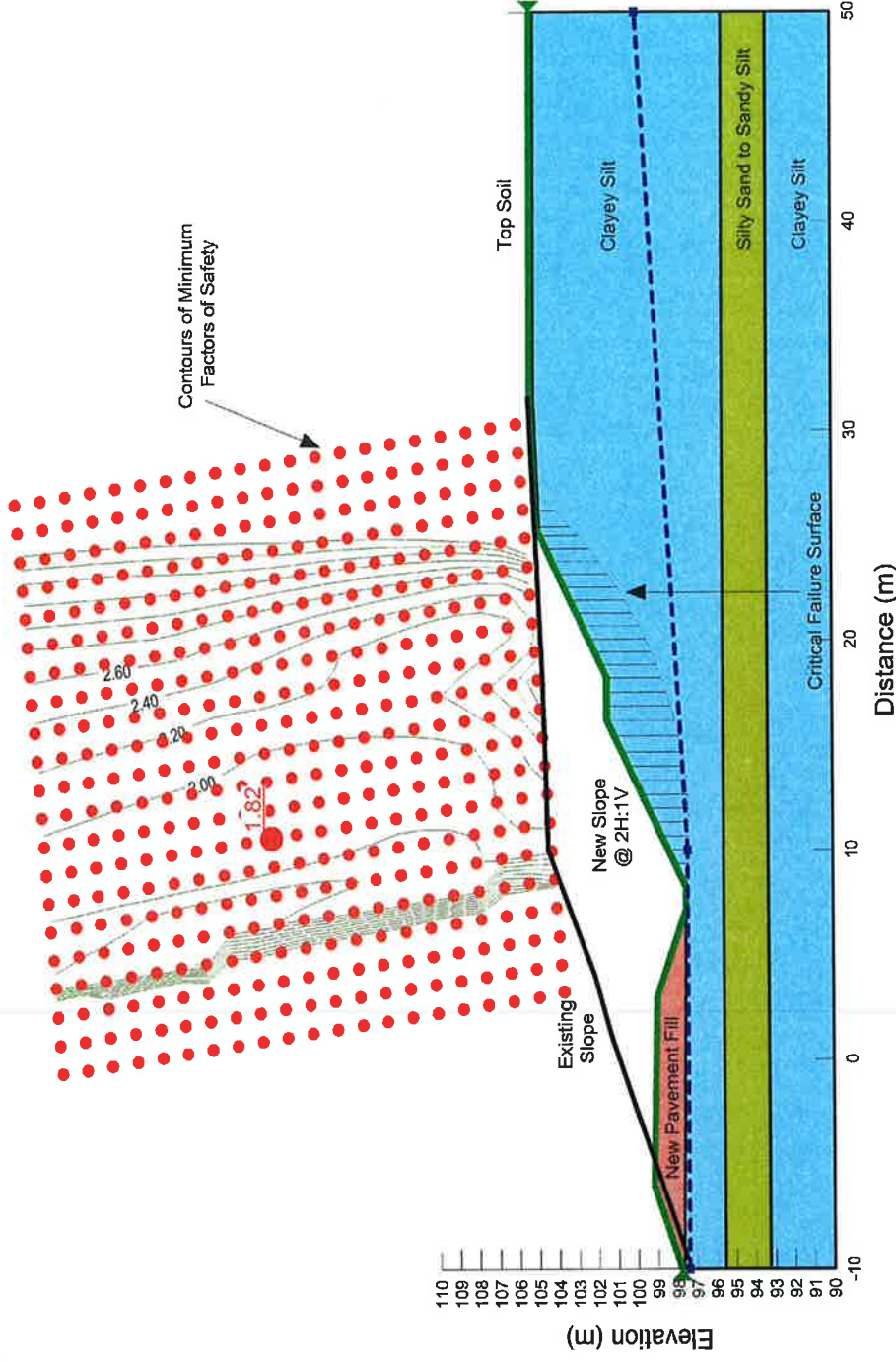
DESIGN:

HW

REVIEW:

ZO

Highway 401 Expansion



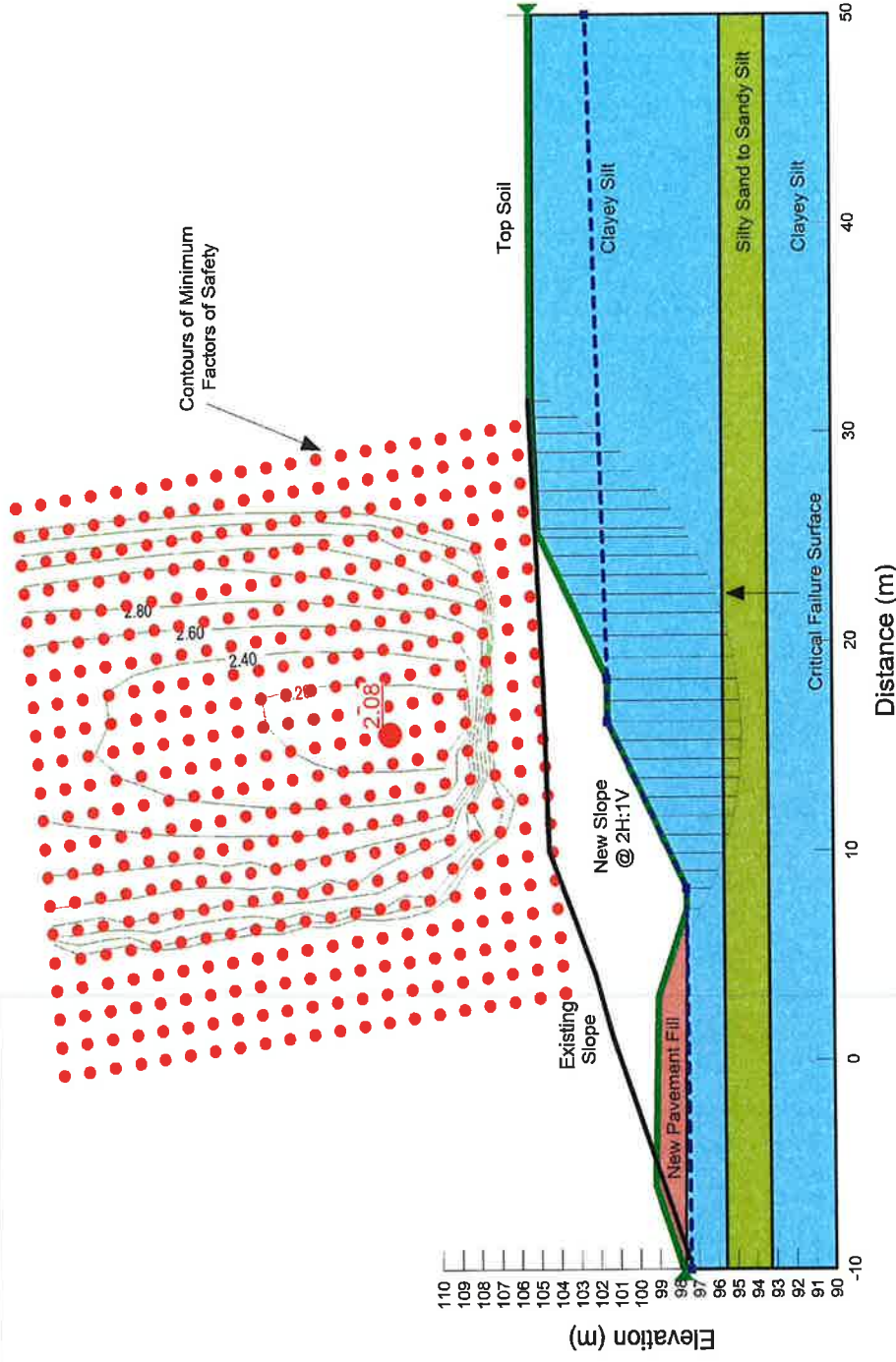
Section : Sta. 18+330

Slope : 2H:1V

Condition : Drained
Measured water table
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32



Section : Sta. 18+330

Slope : 2H:1V

Condition : Undrained

Mid-height water table
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32



SPECIALISTS MANAGING THE EARTH

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

PROJECT:

TRANETOB10434AA-AN

DATE:

Jan-2012

DESIGN:

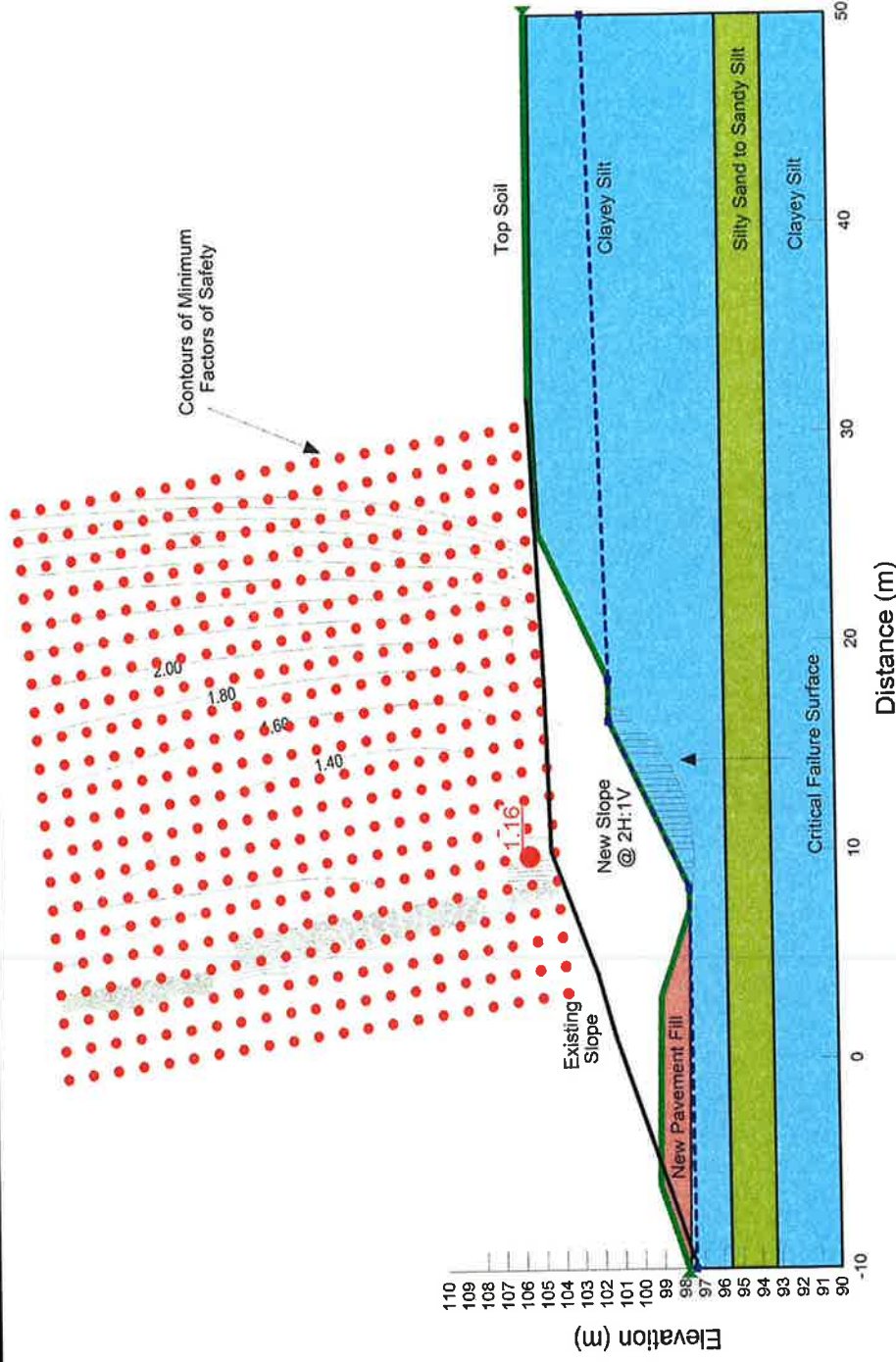
HW

REVIEW:

ZO

Highway 401 Expansion

FIGURE G1-7

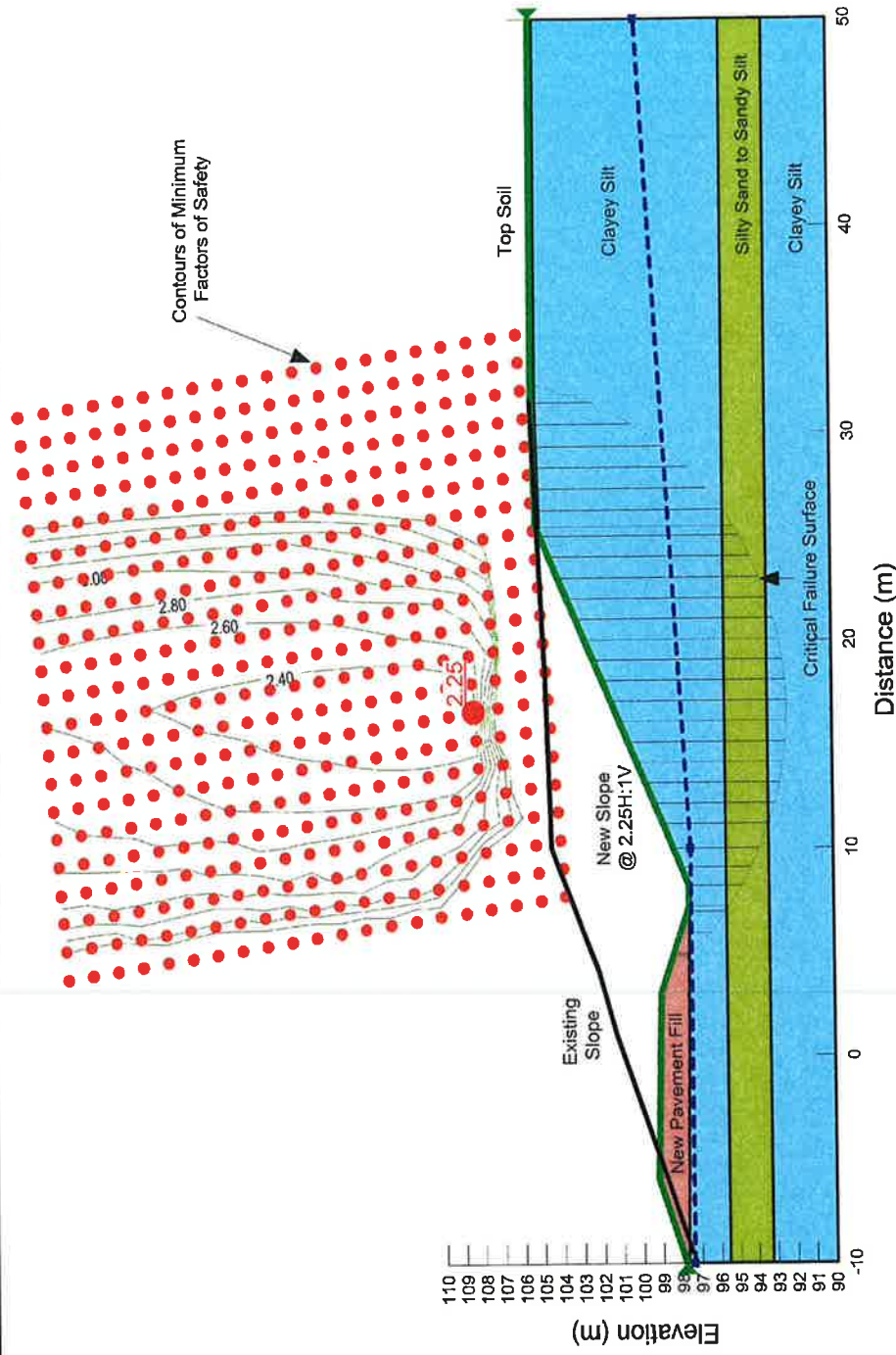


Section : Sta. 18+330
 Slope : 2H:1V
 Condition : Drained
 Mid-height water table
 1 bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2.25H:1V

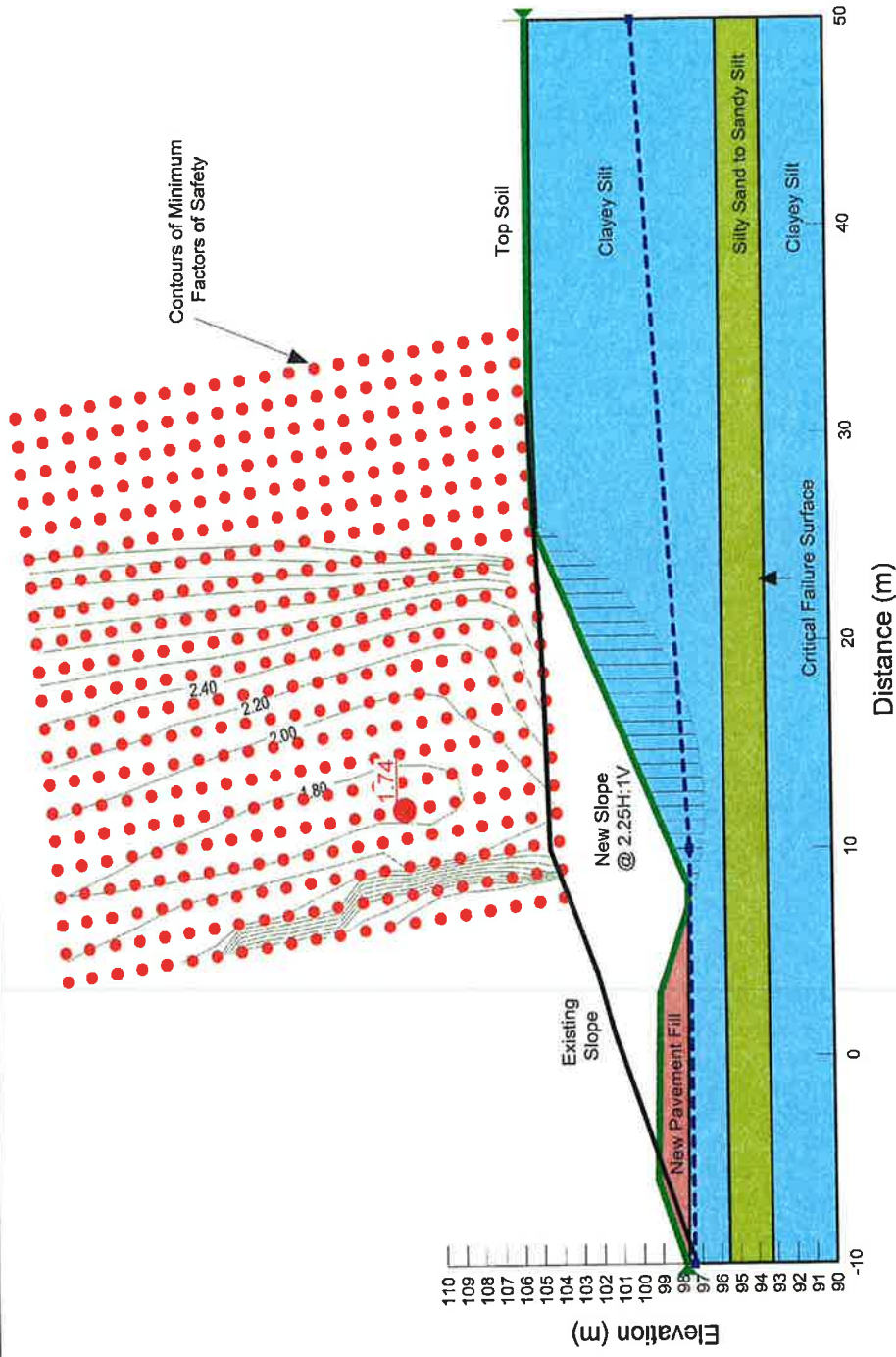
Condition : Undrained

Measured water table

No bench

Method : Morgenstern - Price

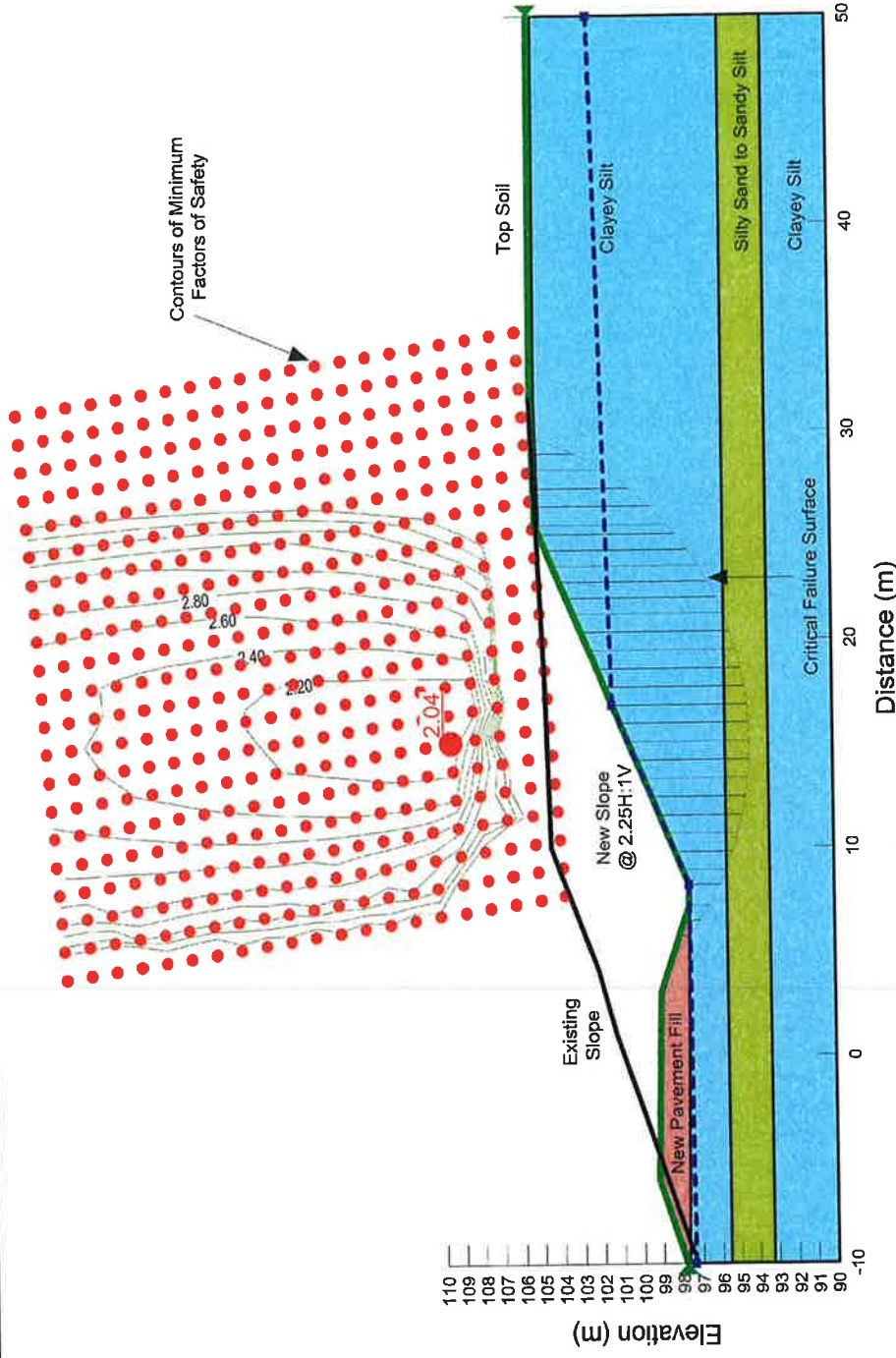
Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32



Section : Sta. 18+330
 Slope : 2.25H:1V
 Condition : Drained
 Measured water table
 No bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS
 Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2.25H:1V

Condition : Undrained

Mid-height water table

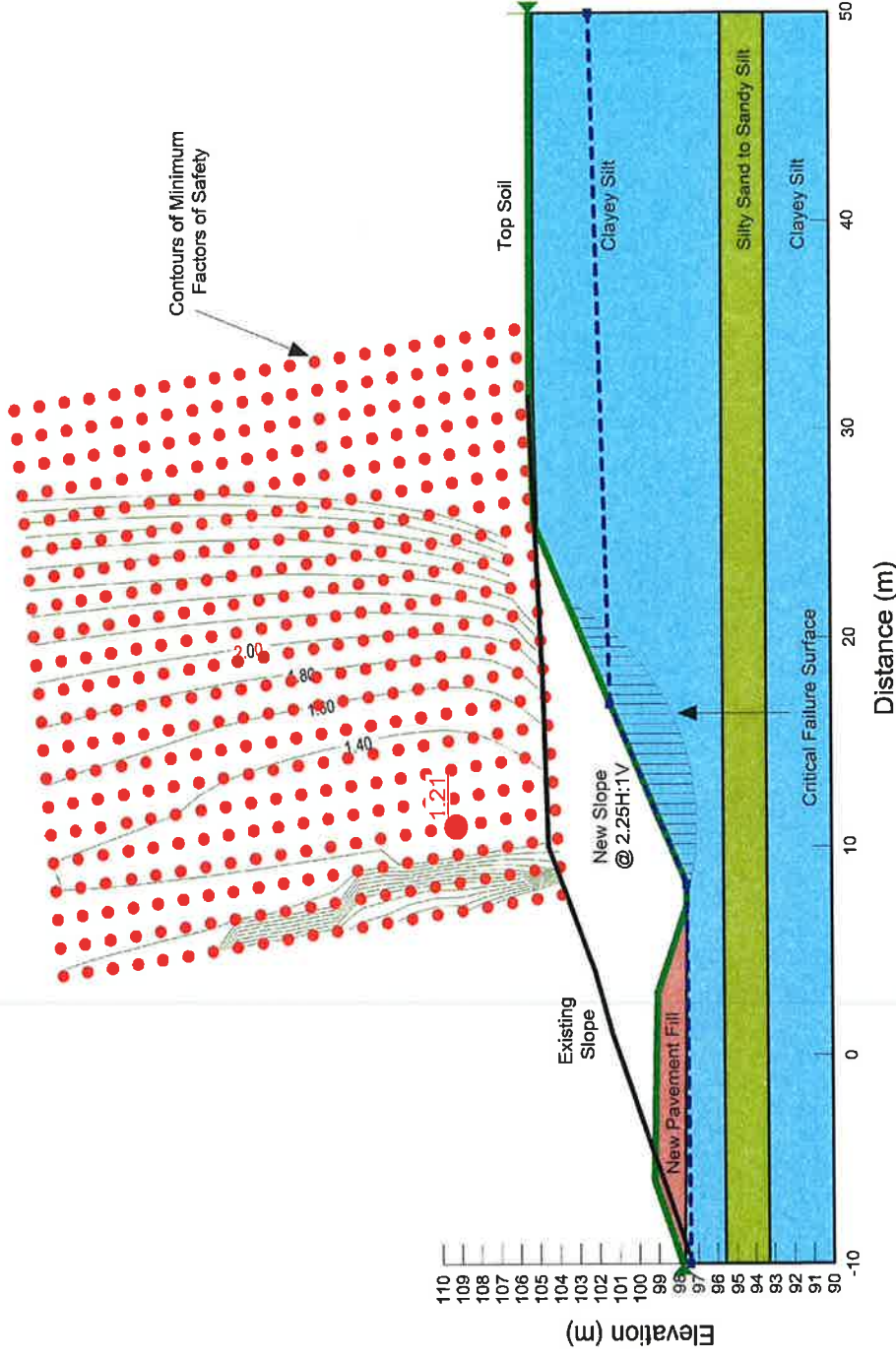
No bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2.25H:1V

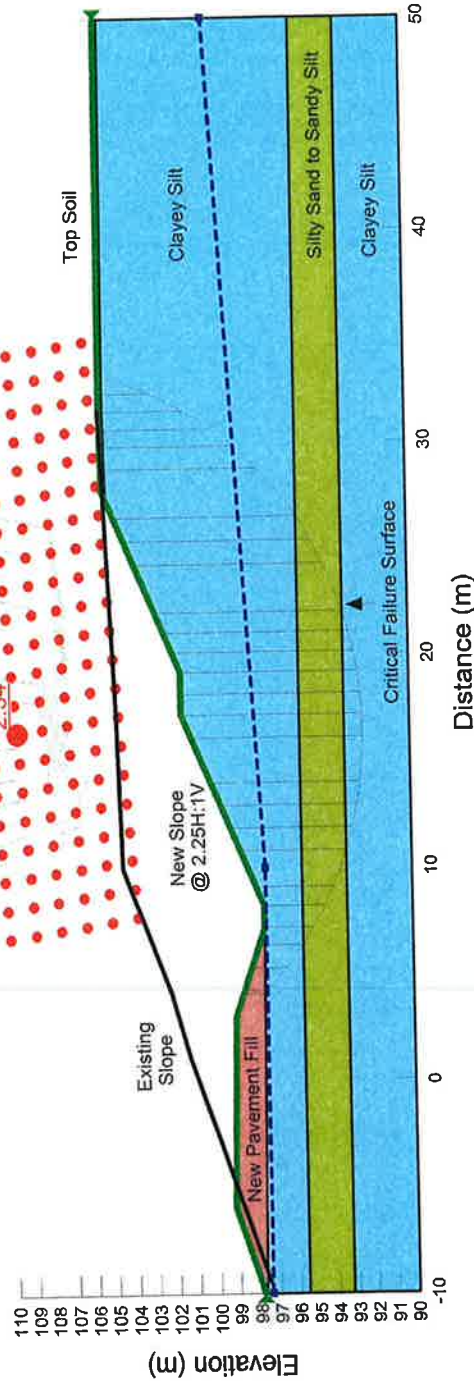
Condition : Drained

Mid-height water table

No bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32



Section : Sta. 18+330

Slope : 2.25H:1V

Condition : Undrained

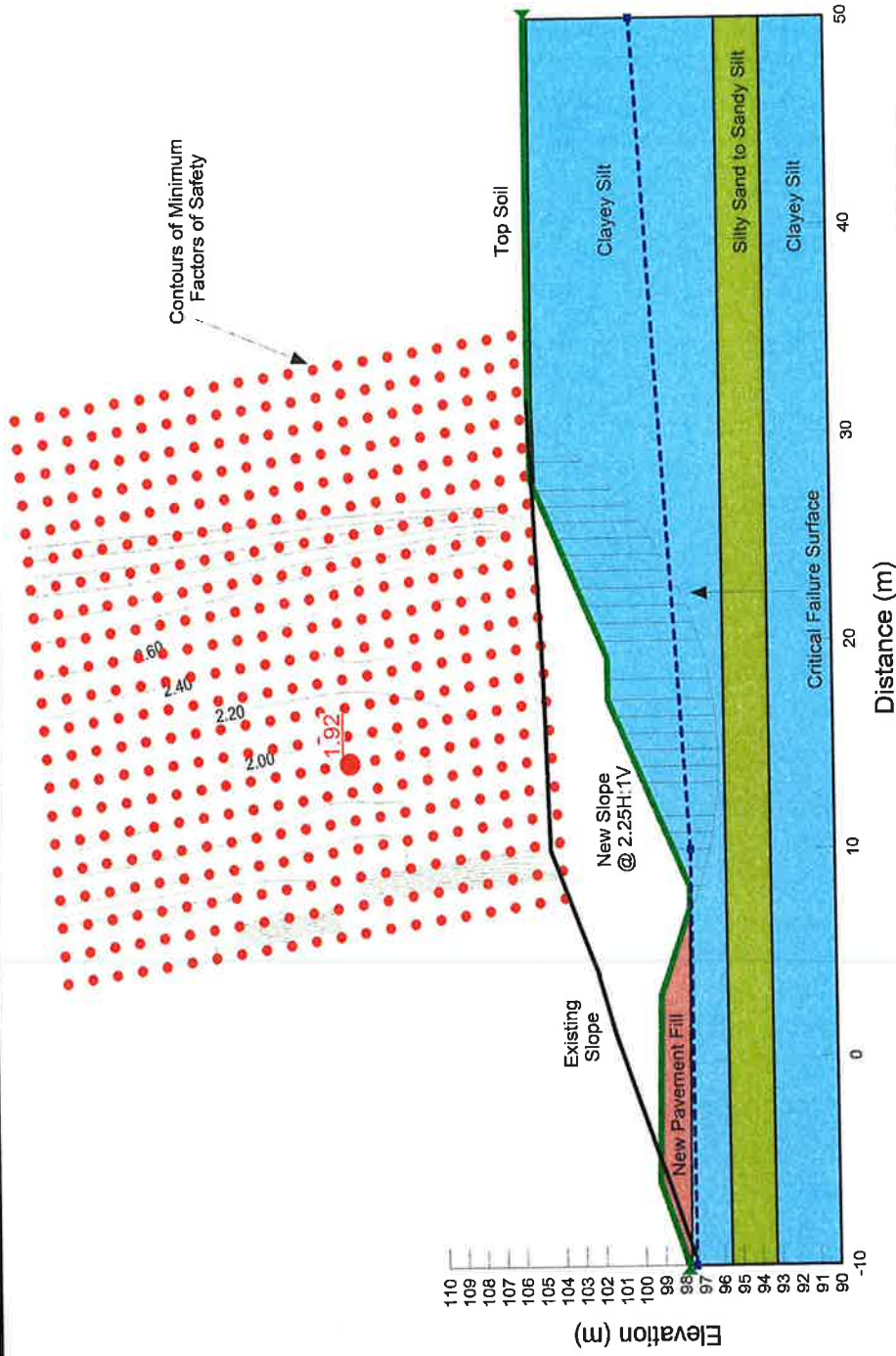
Measured water table
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

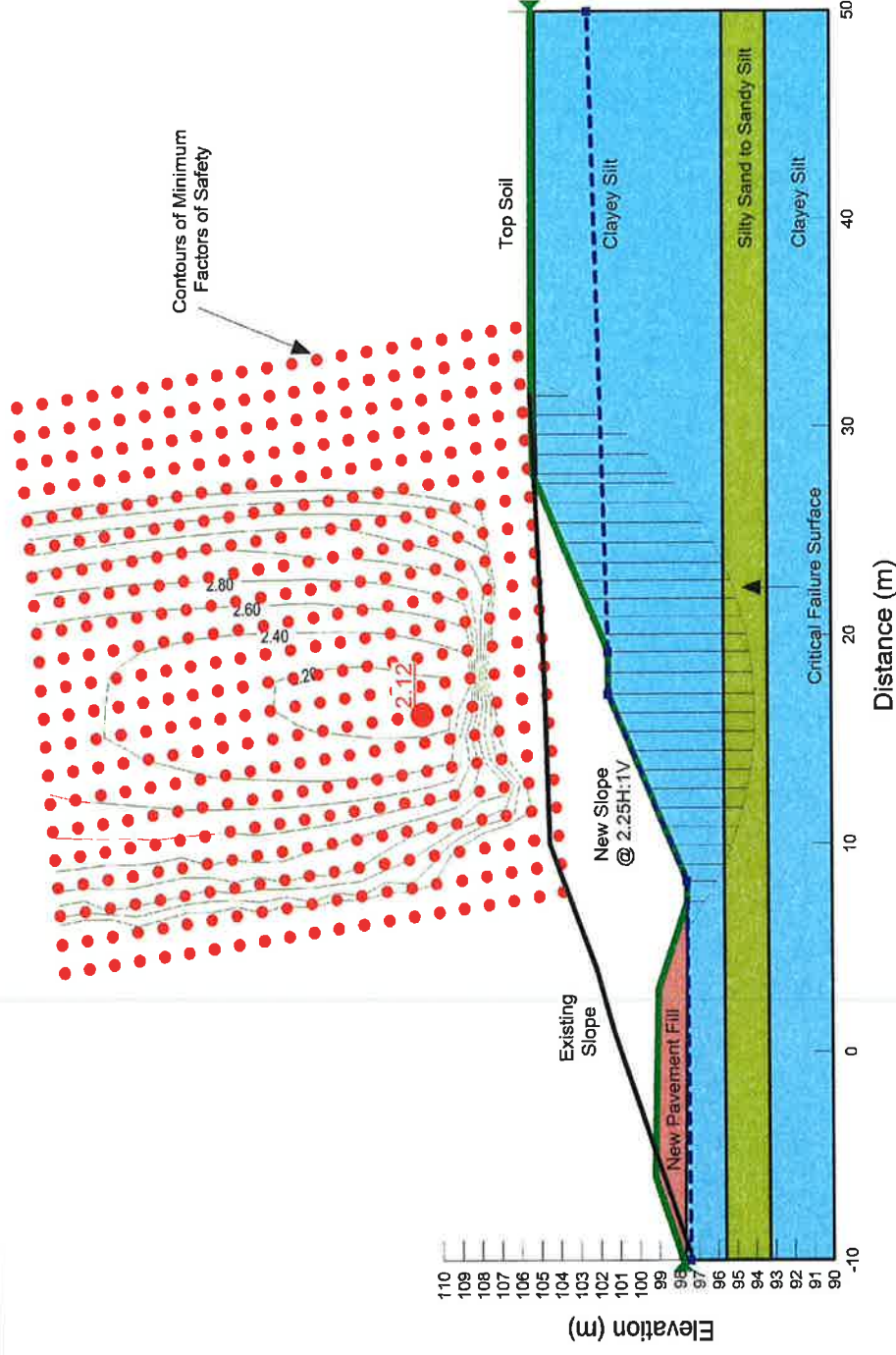


Section : Sta. 18+330
 Slope : 2.25H:1V
 Condition : Drained
 Measured water table
 1 bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

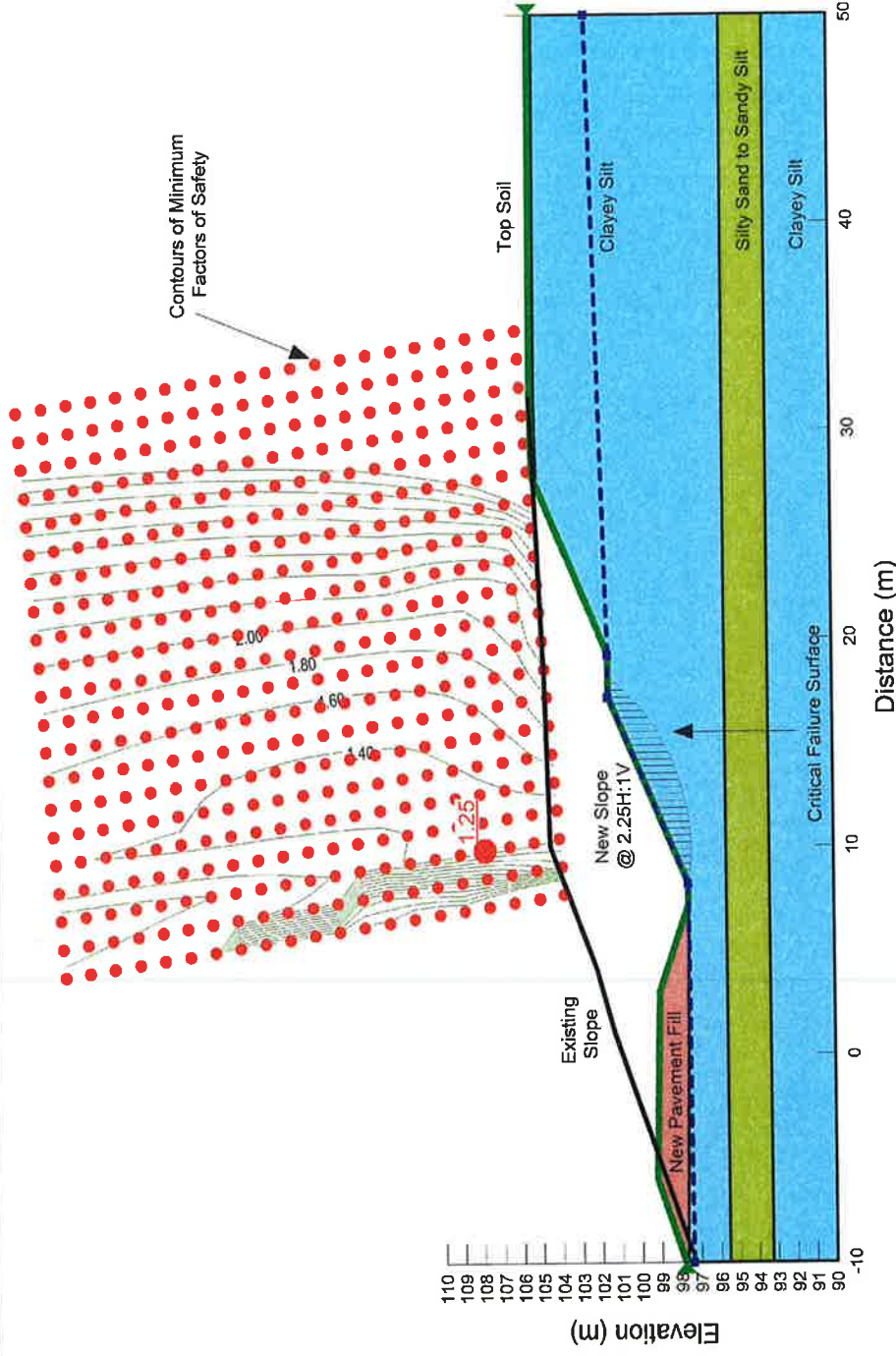
Slope : 2.25H:1V

Condition : Undrained

Mid-height water table
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

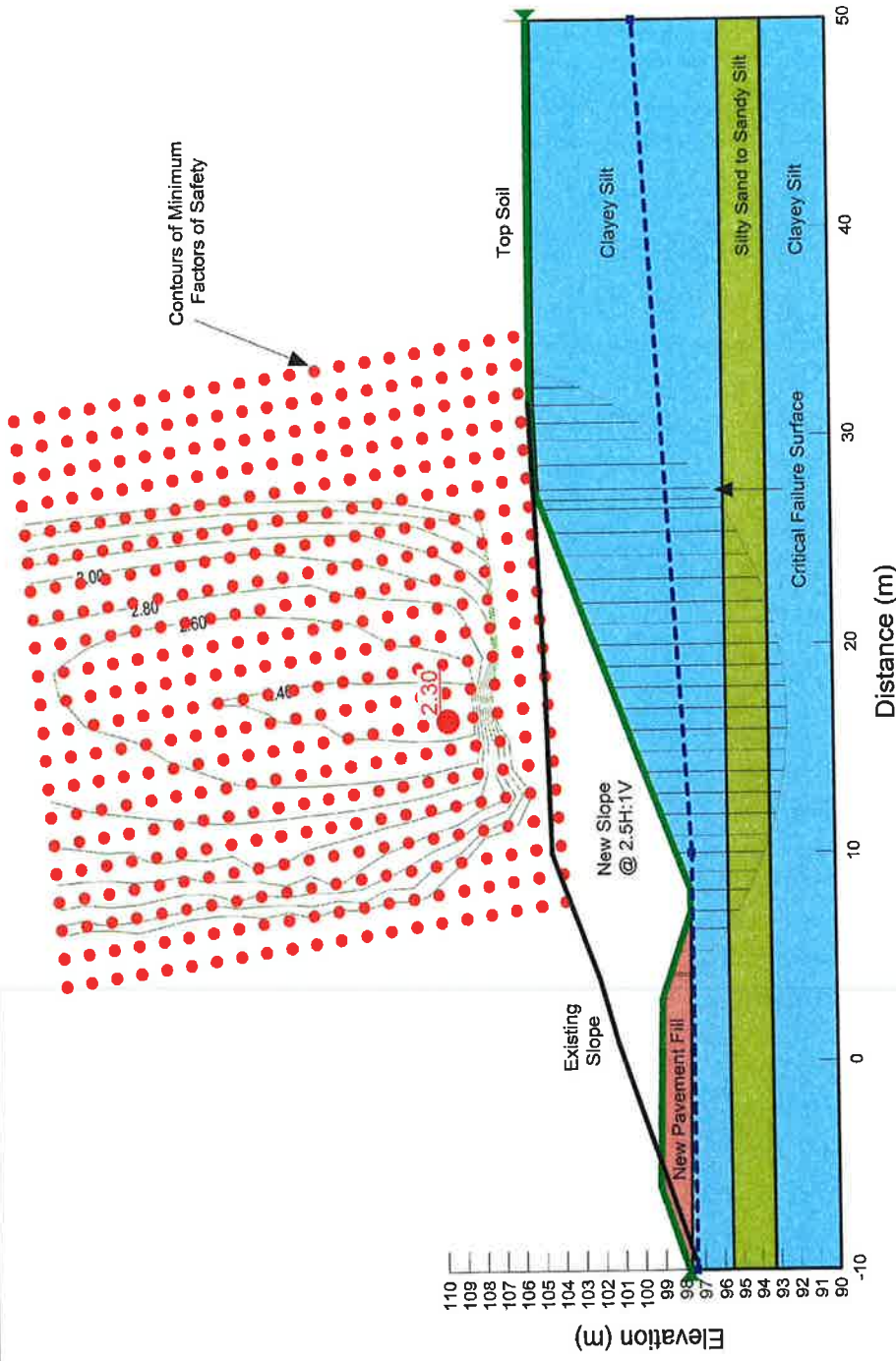


Section : Sta. 18+330
 Slope : 2.25H:1V
 Condition : Drained
 Mid-height water table
 1 bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

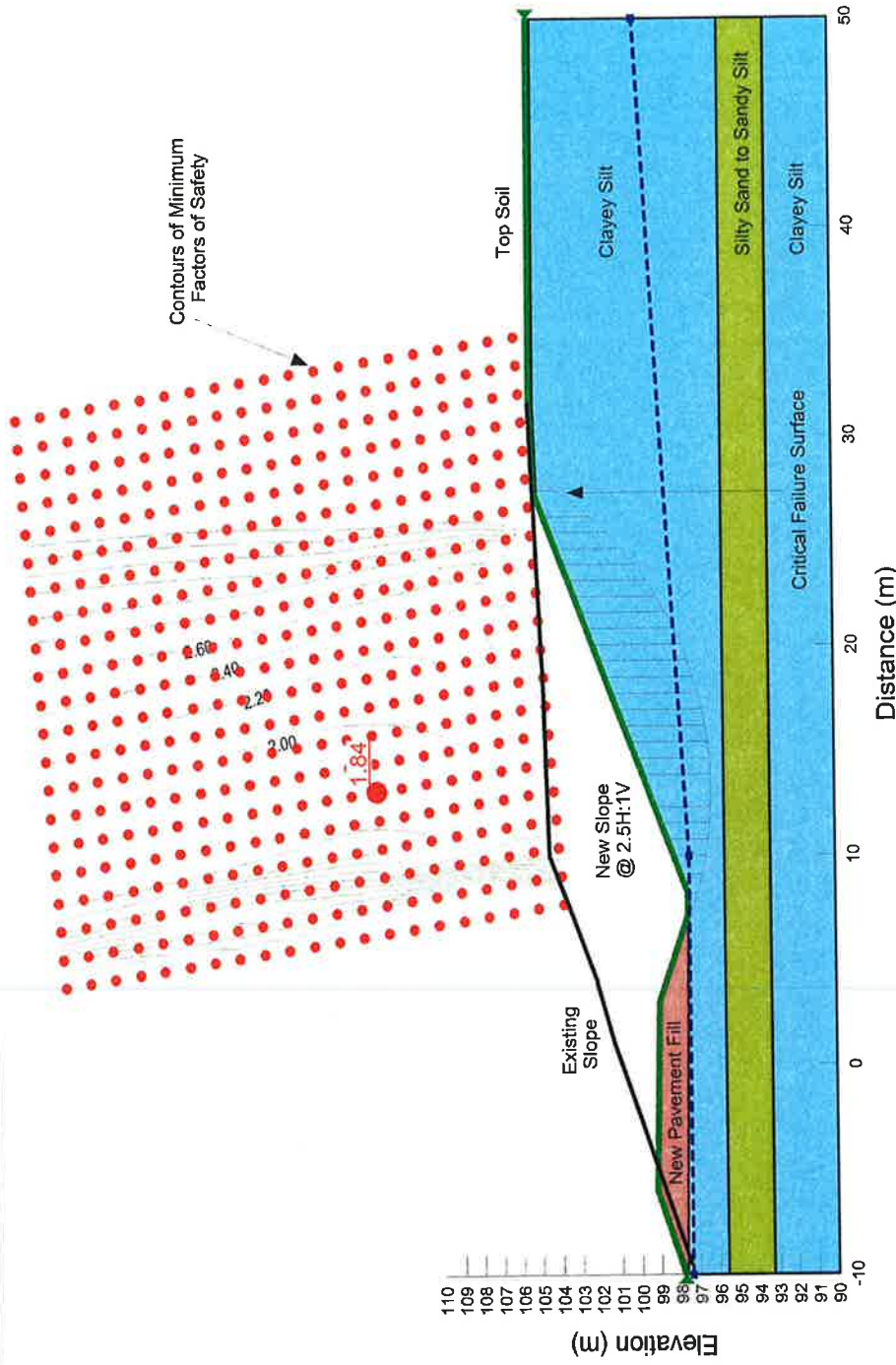


Section : Sta. 18+330
 Slope : 2.5H:1V
 Condition : Undrained
 Measured water table
 No bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2.5H:1V

Condition : Drained

Measured water table

No bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32



SPECIALISTS MANAGING THE EARTH

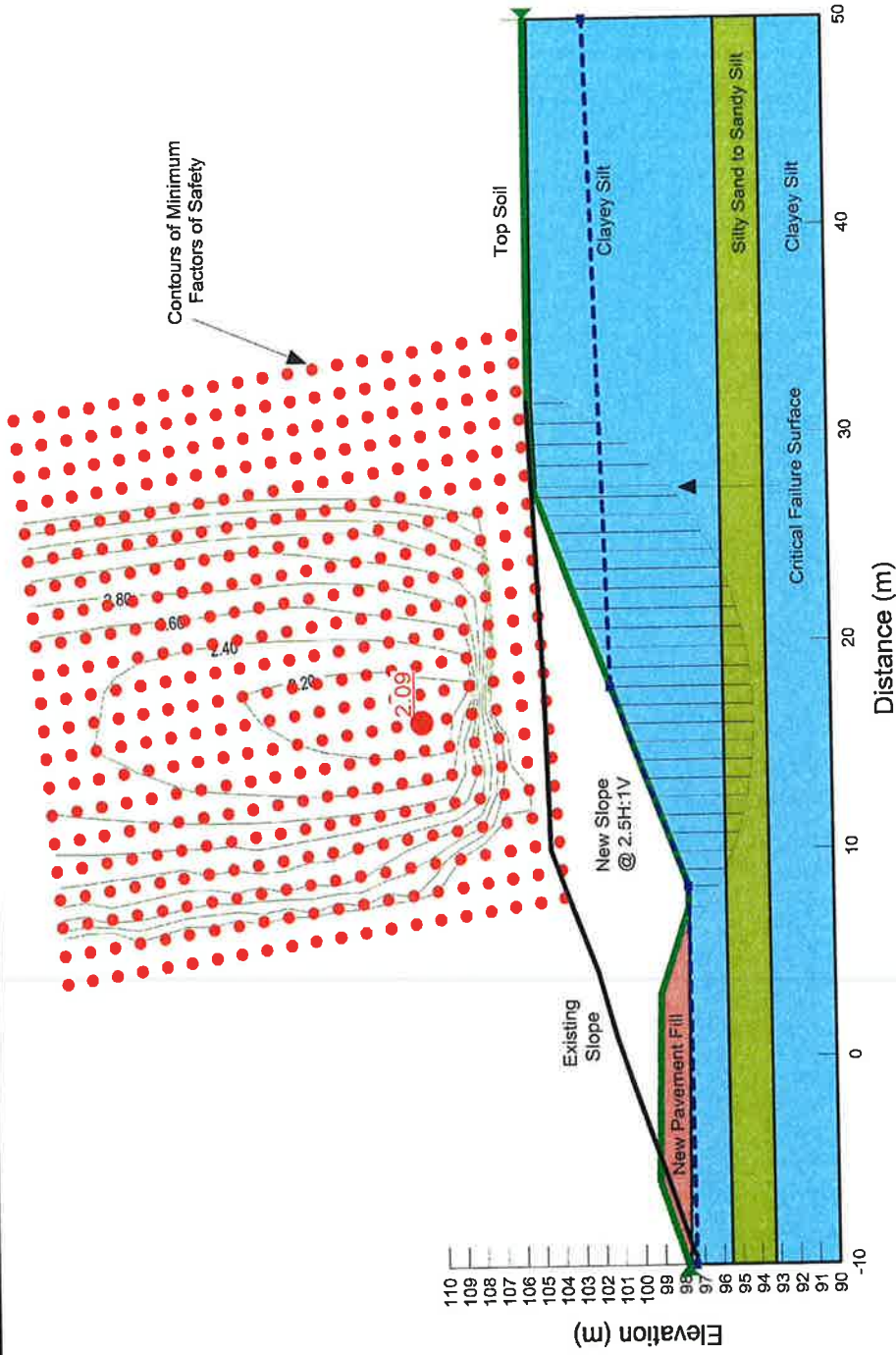
STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO

Highway 401 Expansion

FIGURE G1-18



Section : Sta. 18+330

Slope : 2.5H:1V

Condition : Undrained

Mid-height water table

No bench

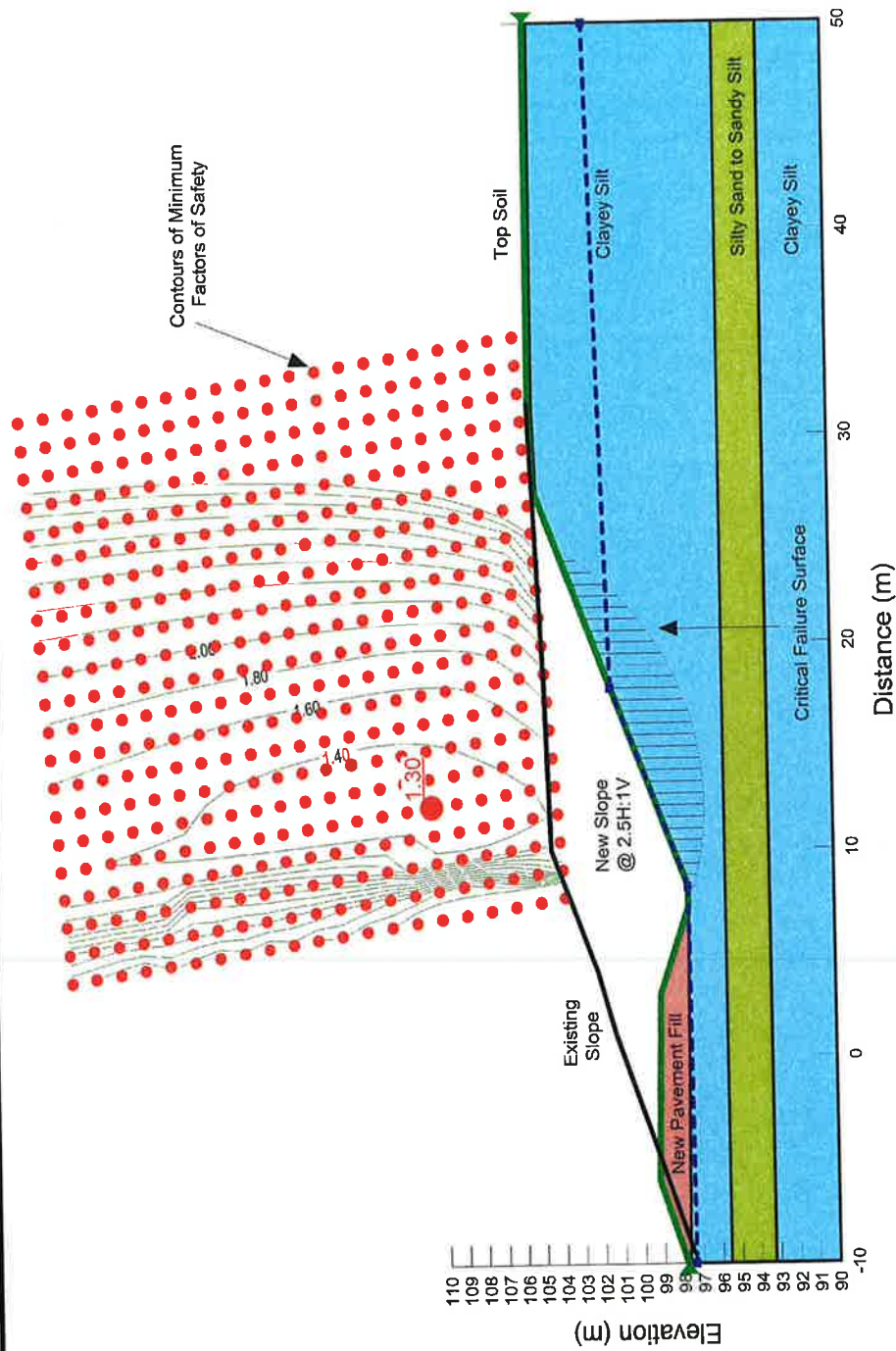
Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO

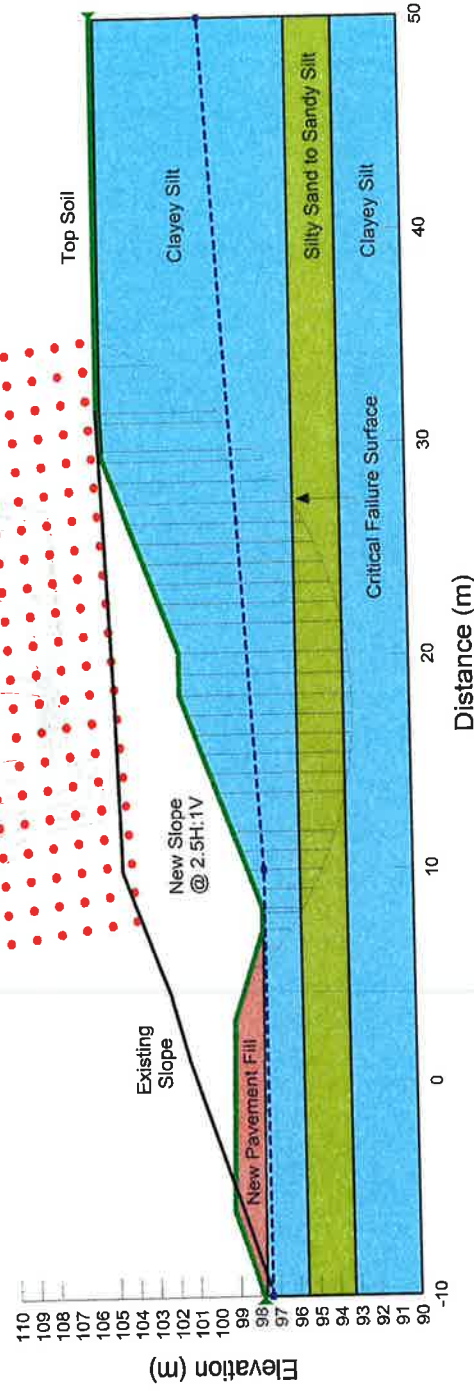


Section : Sta. 18+330
 Slope : 2.5H:1V
 Condition : Drained
 Mid-height water table
 No bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2.5H:1V

Condition : Undrained

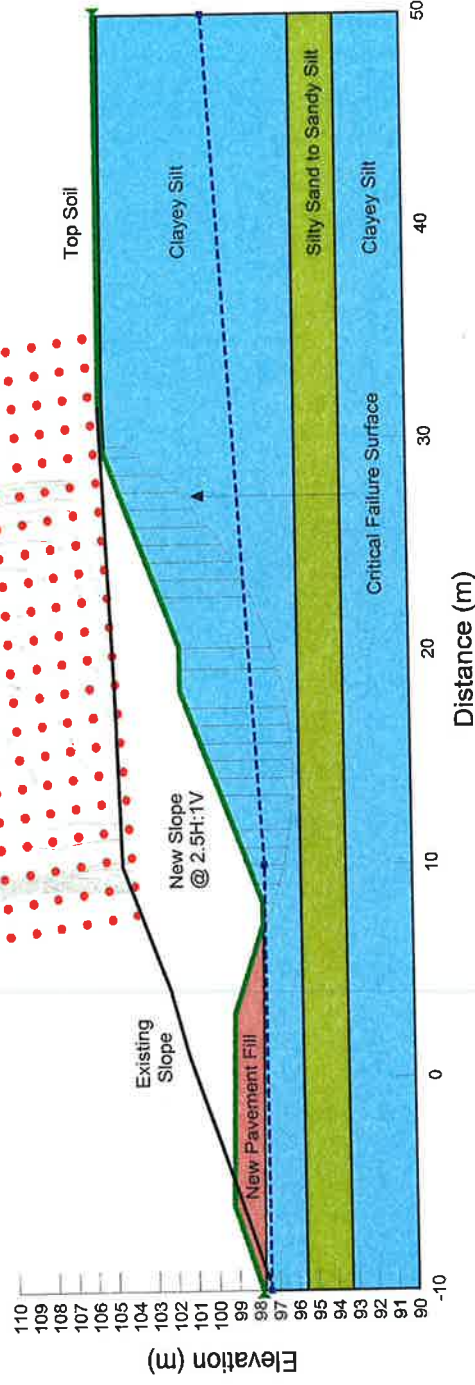
Measured water table
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2.5H:1V

Condition : Drained

Measured water table

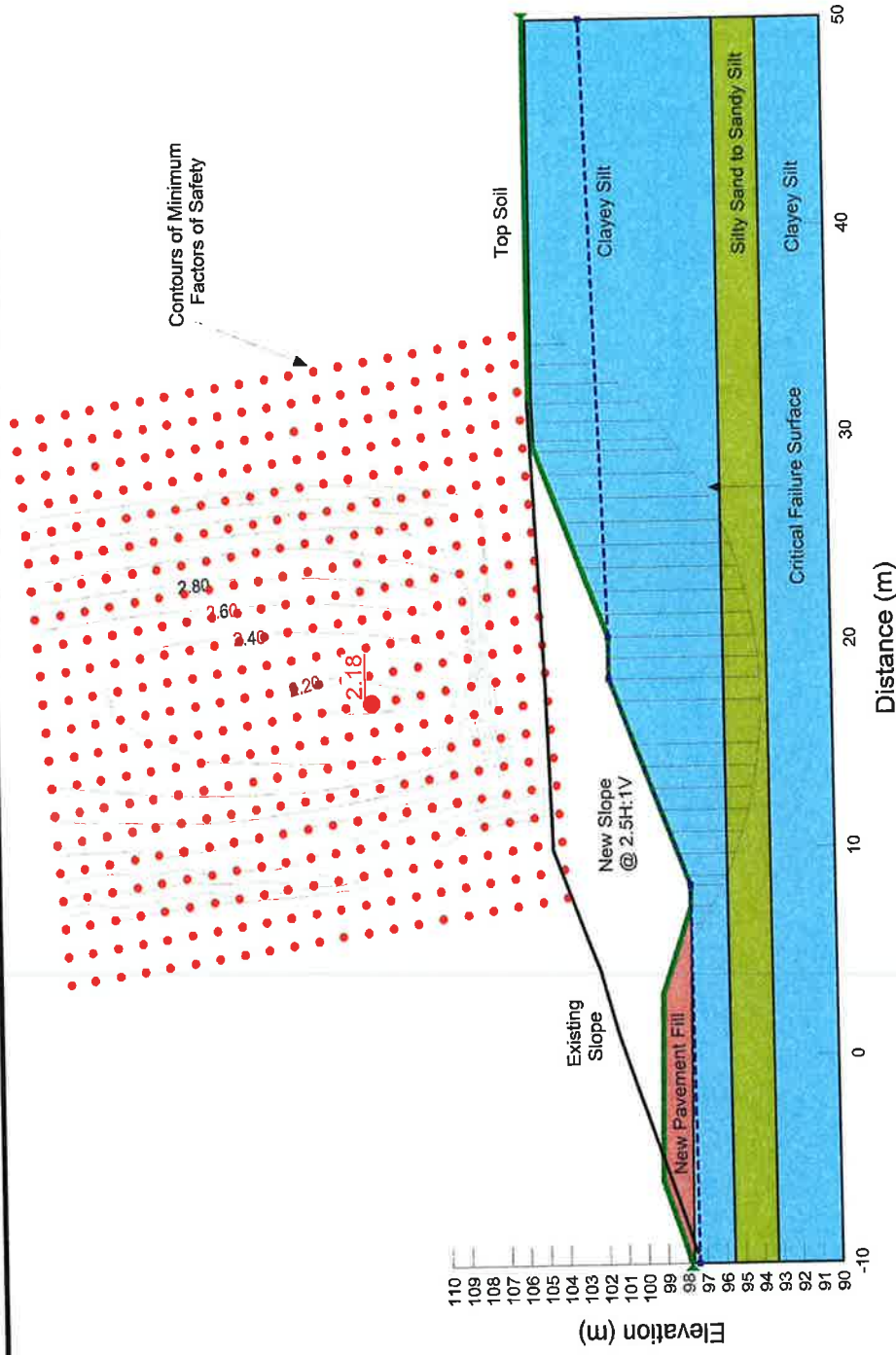
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m^3)	c (kPa)	ϕ ($^\circ$)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 2.5H:1V

Condition : Undrained

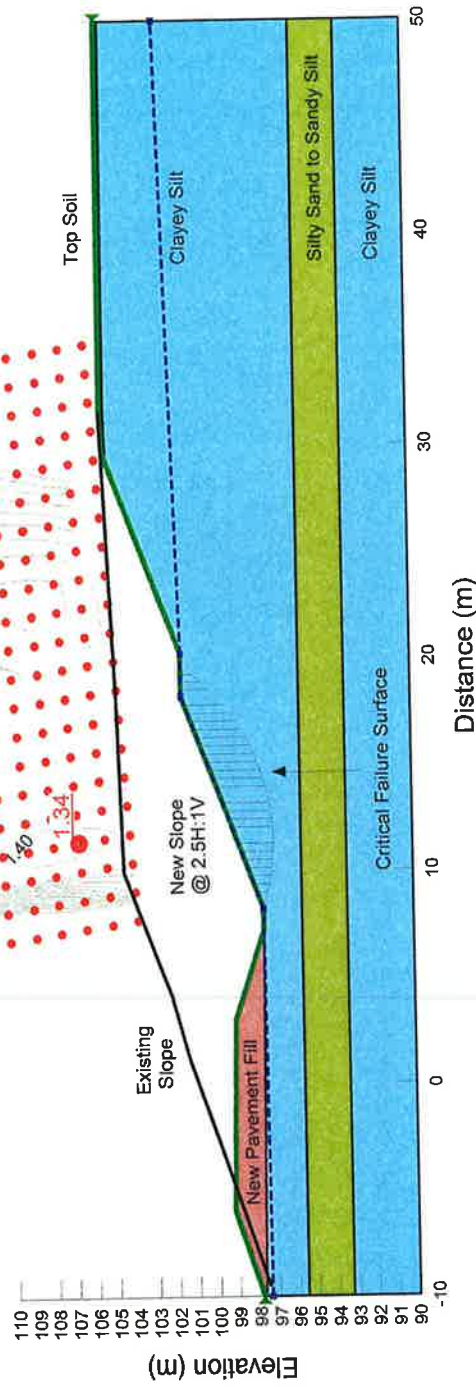
Mid-height water table
1 bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

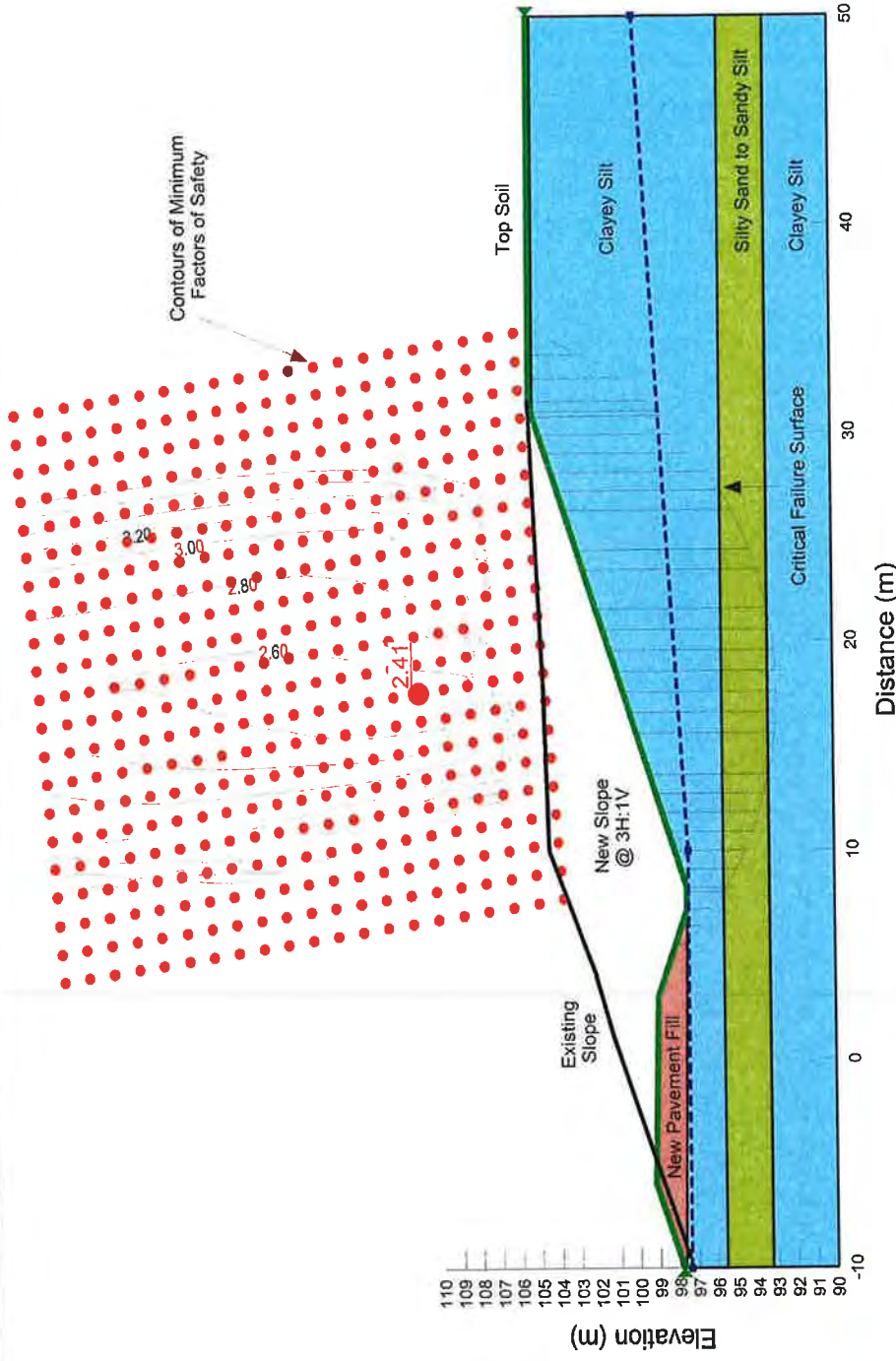


Section : Sta. 18+330
 Slope : 2.5H:1V
 Condition : Drained
 Mid-height water table
 1 bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

Slope : 3H:1V

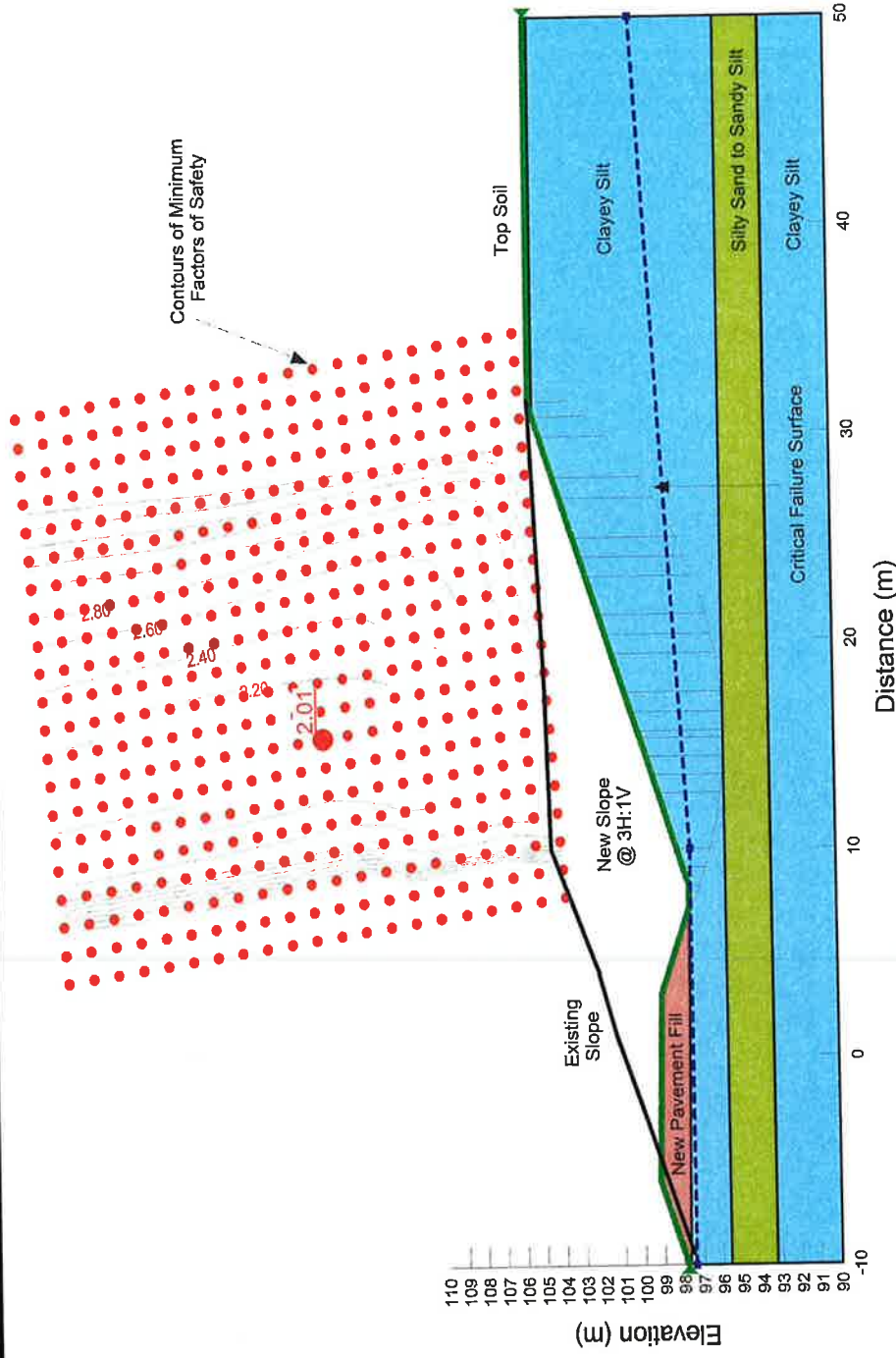
Condition : Undrained

Measured water table

No bench

Method : Morgenstern - Price

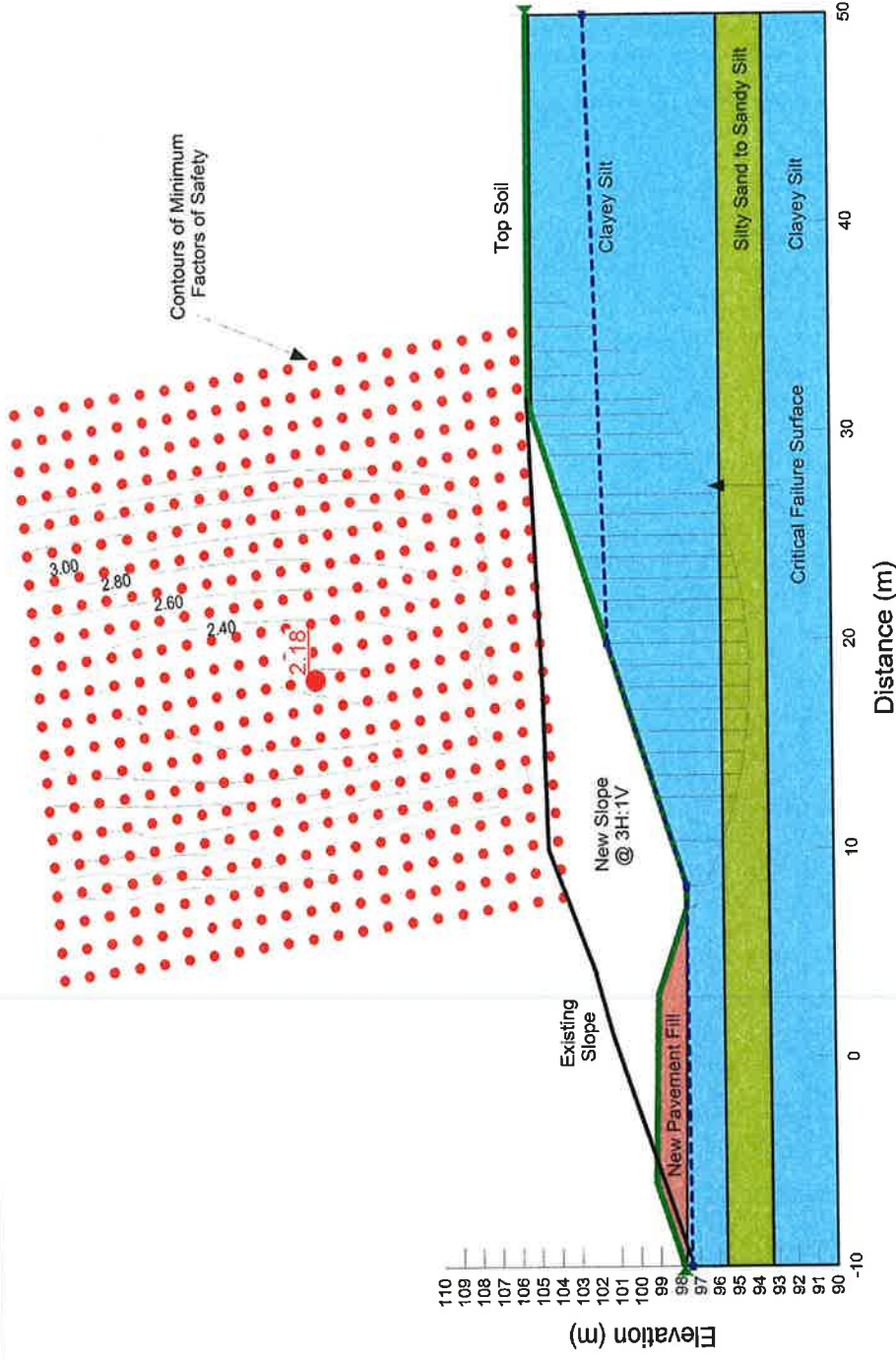
Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32



Section : Sta. 18+330
 Slope : 3H:1V
 Condition : Drained
 Measured water table
 No bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 1



Section : Sta. 18+330

Slope : 3H:1V

Condition : Undrained

Mid-height water table

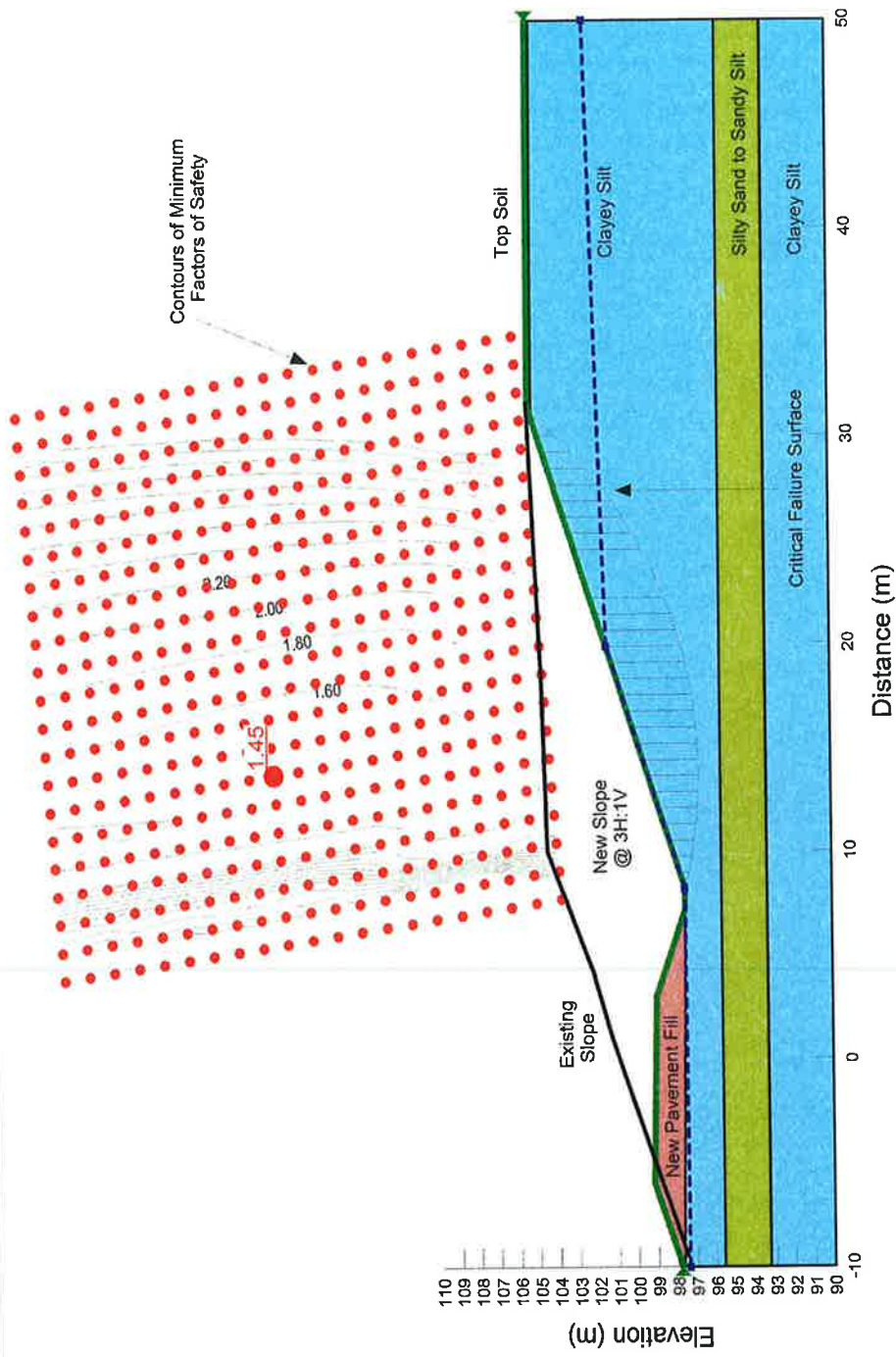
No bench

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

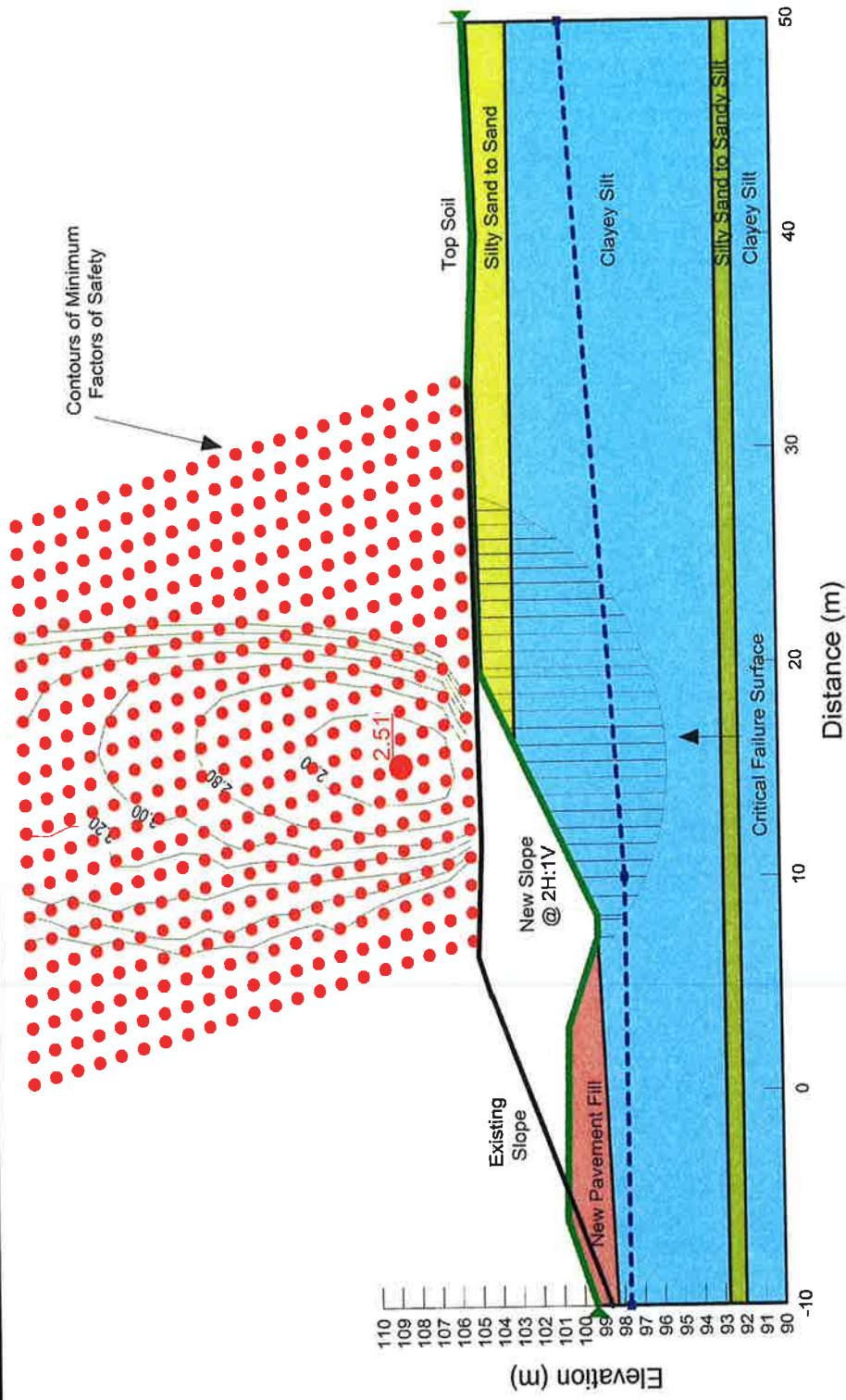


Section : Sta. 18+330
 Slope : 3H:1V
 Condition : Drained
 Mid-height water table
 No bench
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 1

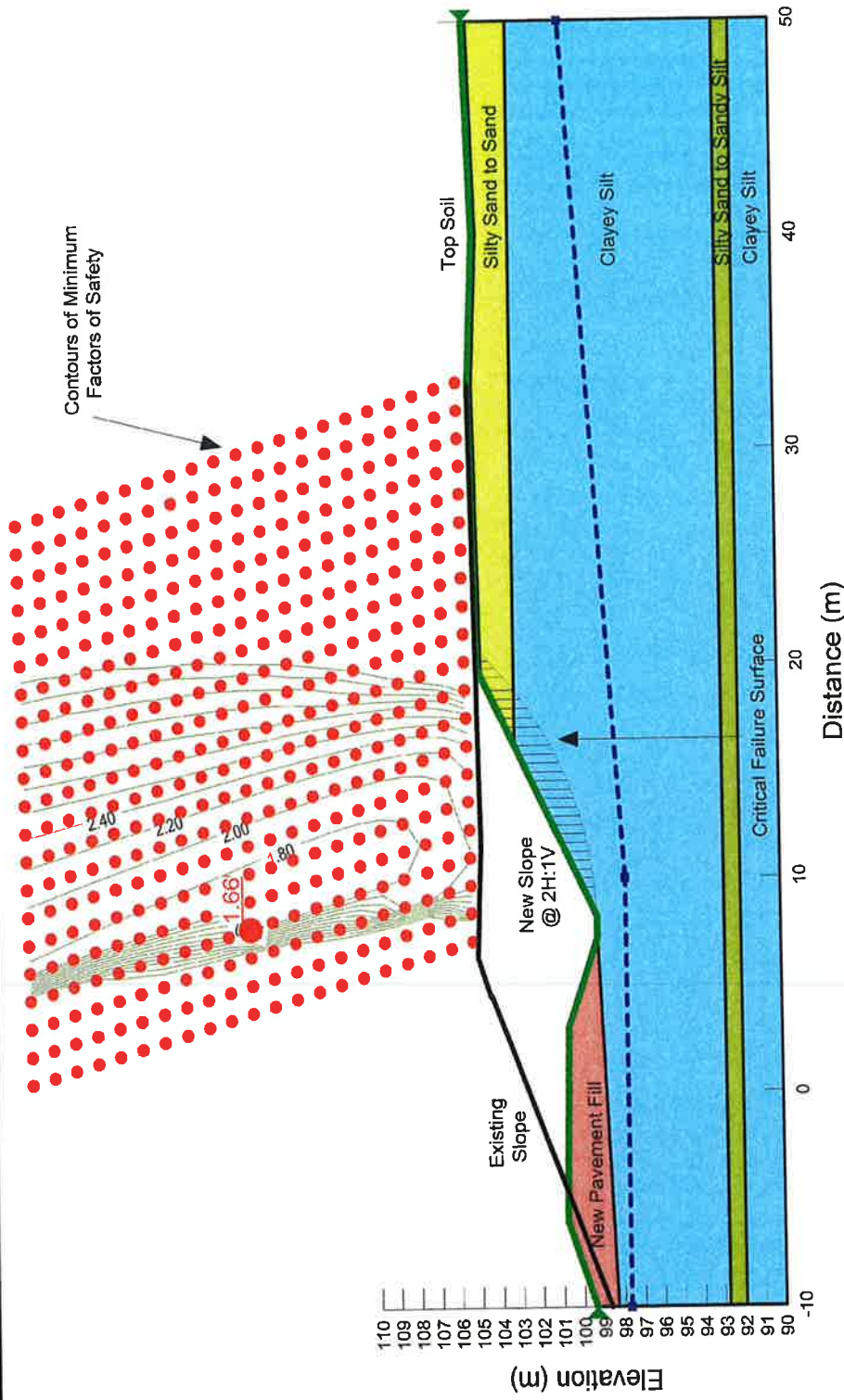
PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO



Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

Section : Sta. 18+330
 Slope : 2H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 1

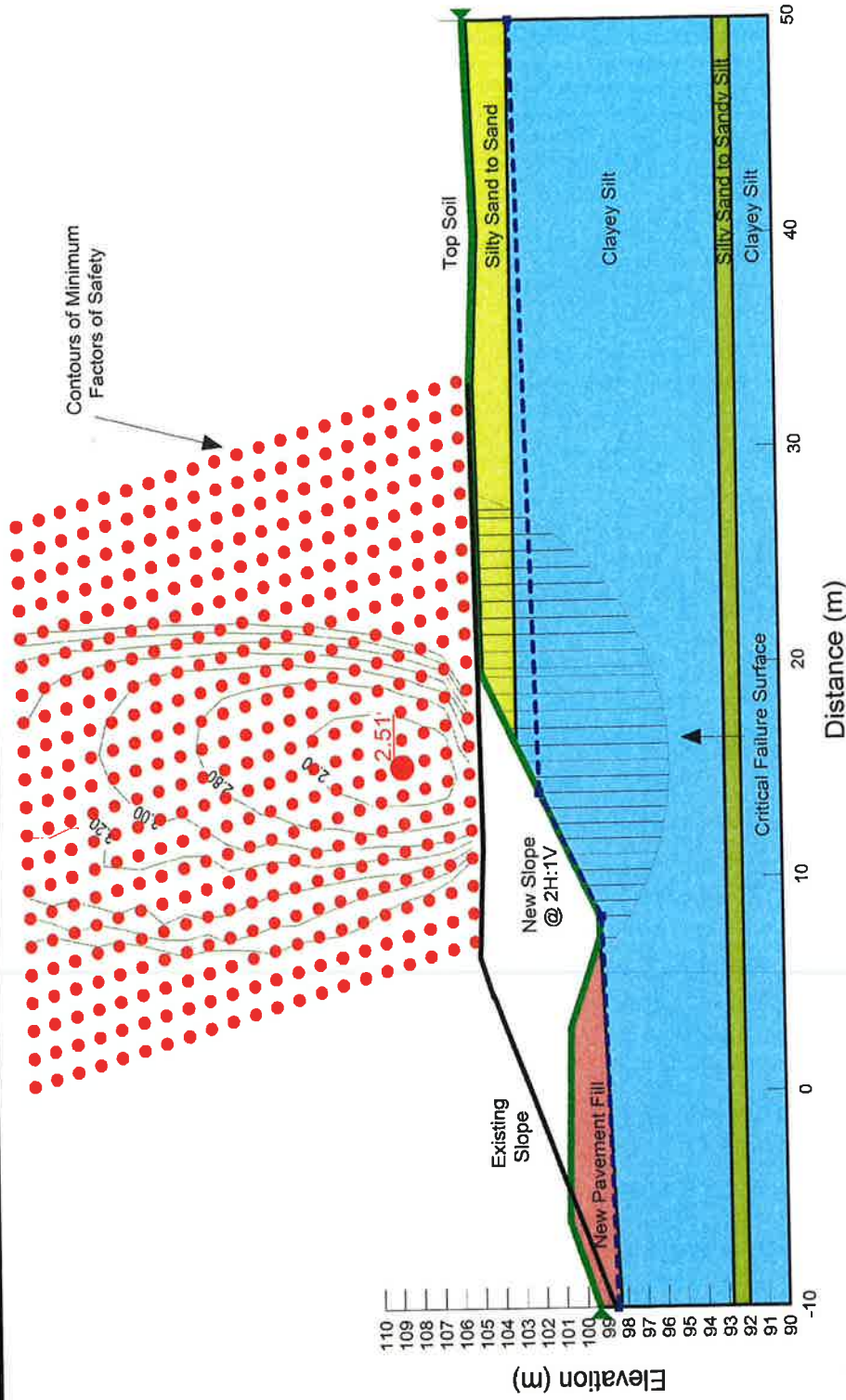


Section : Sta. 18+330
 Slope : 2H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

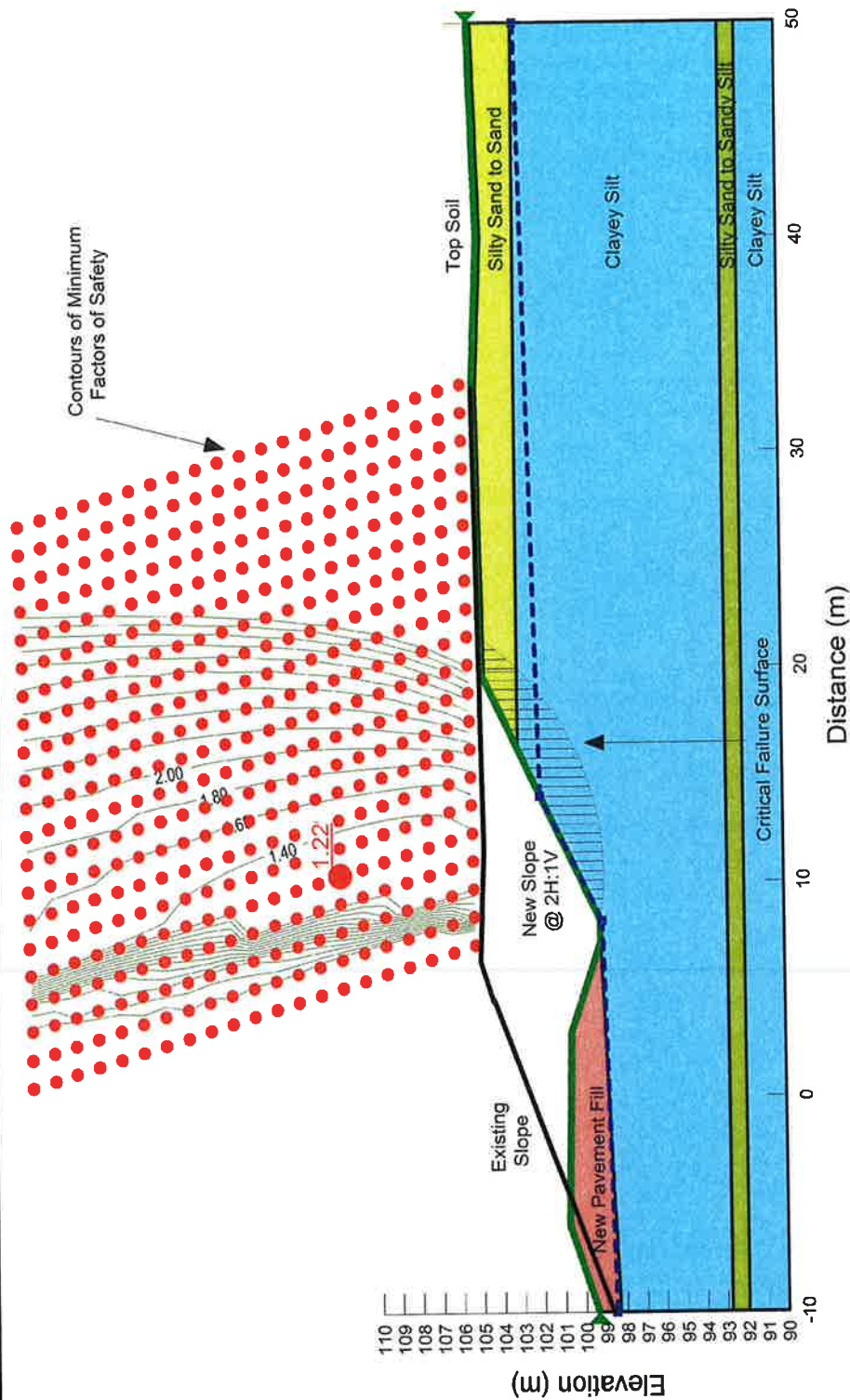


Section : Sta. 18+330
 Slope : 2H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

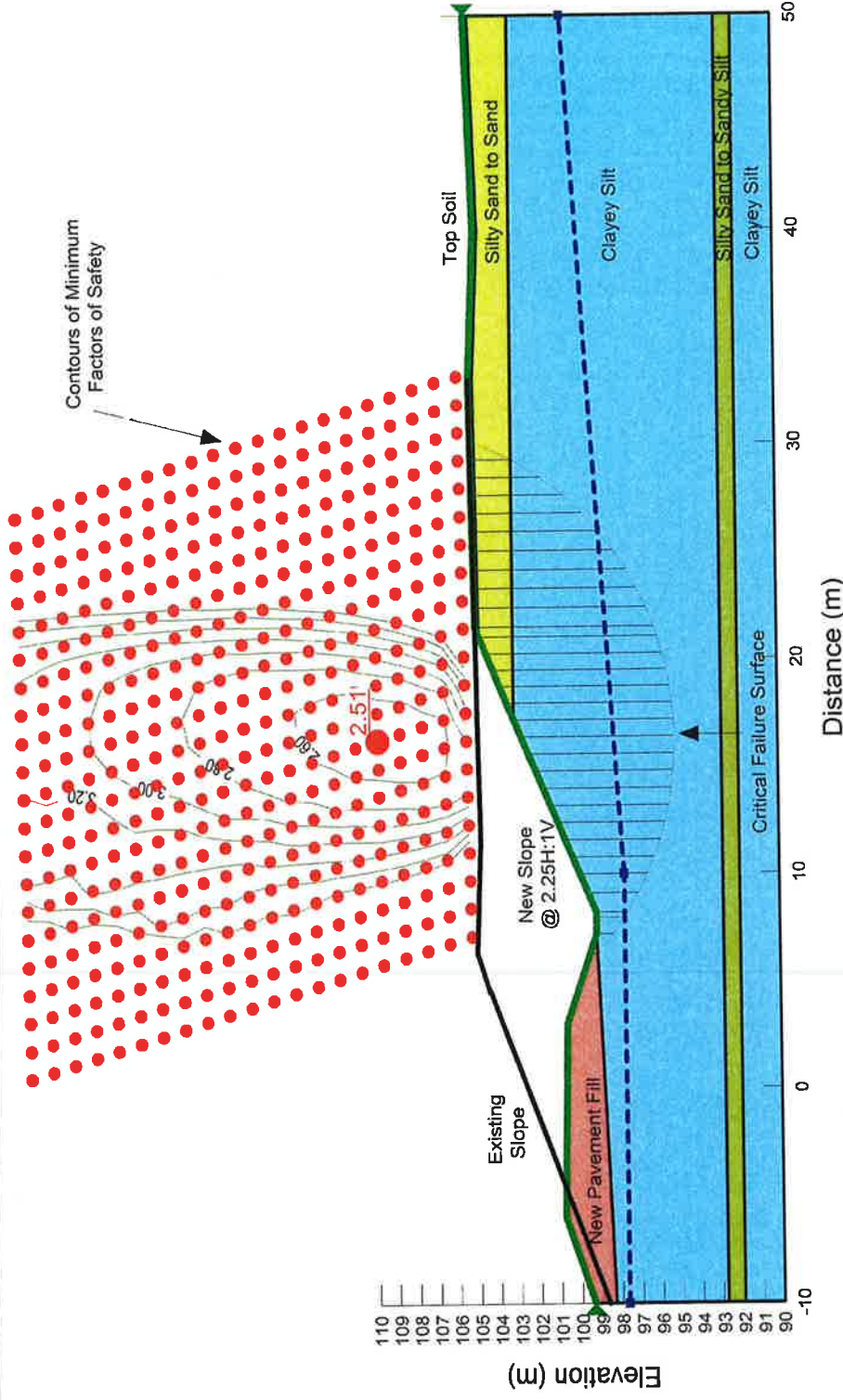
Excavation Cut Area 1



Section : Sta. 18+330
 Slope : 2H:1V
 Condition : Drained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

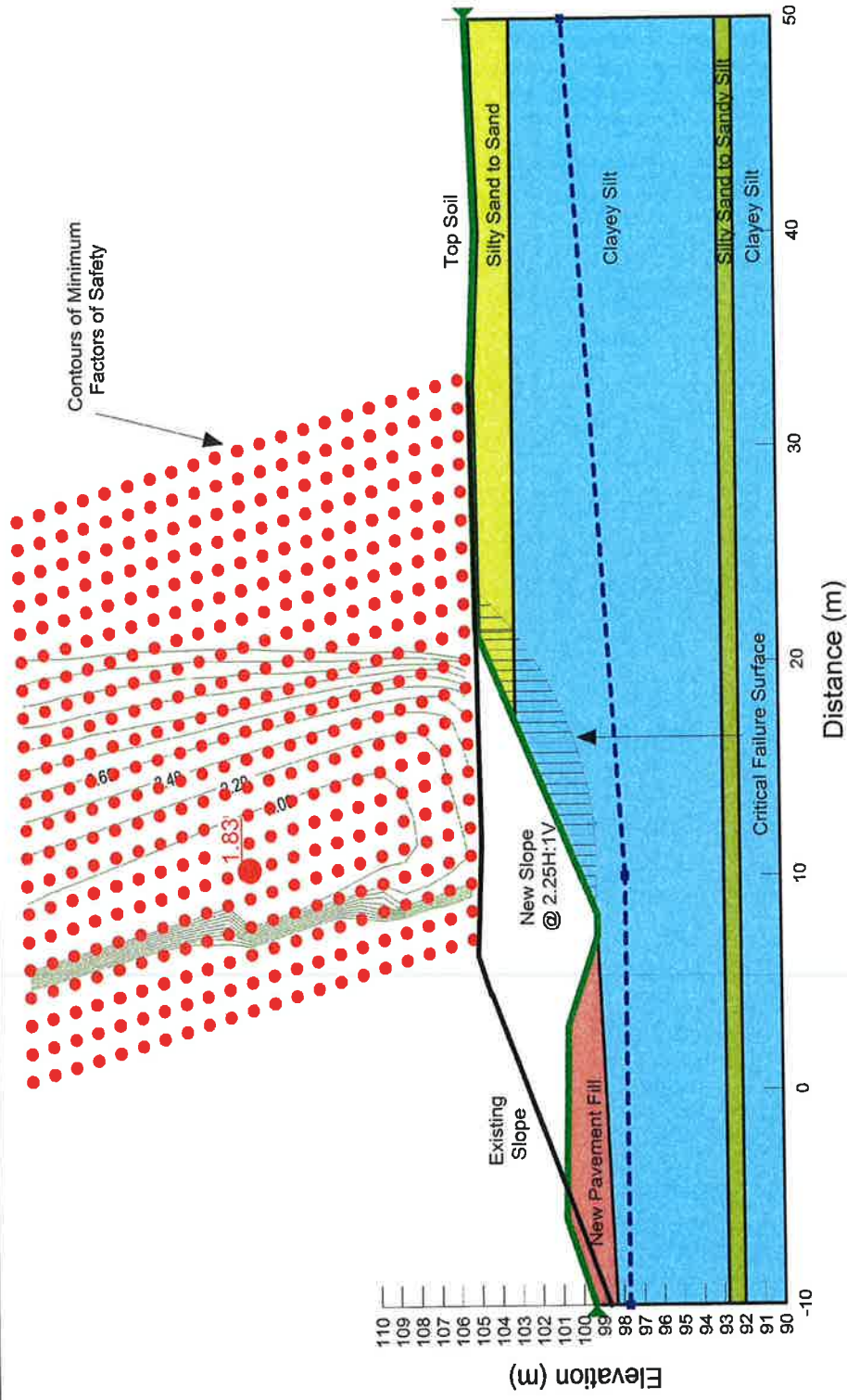
STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 1



Section : Sta. 18+330
 Slope : 2.25H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 1

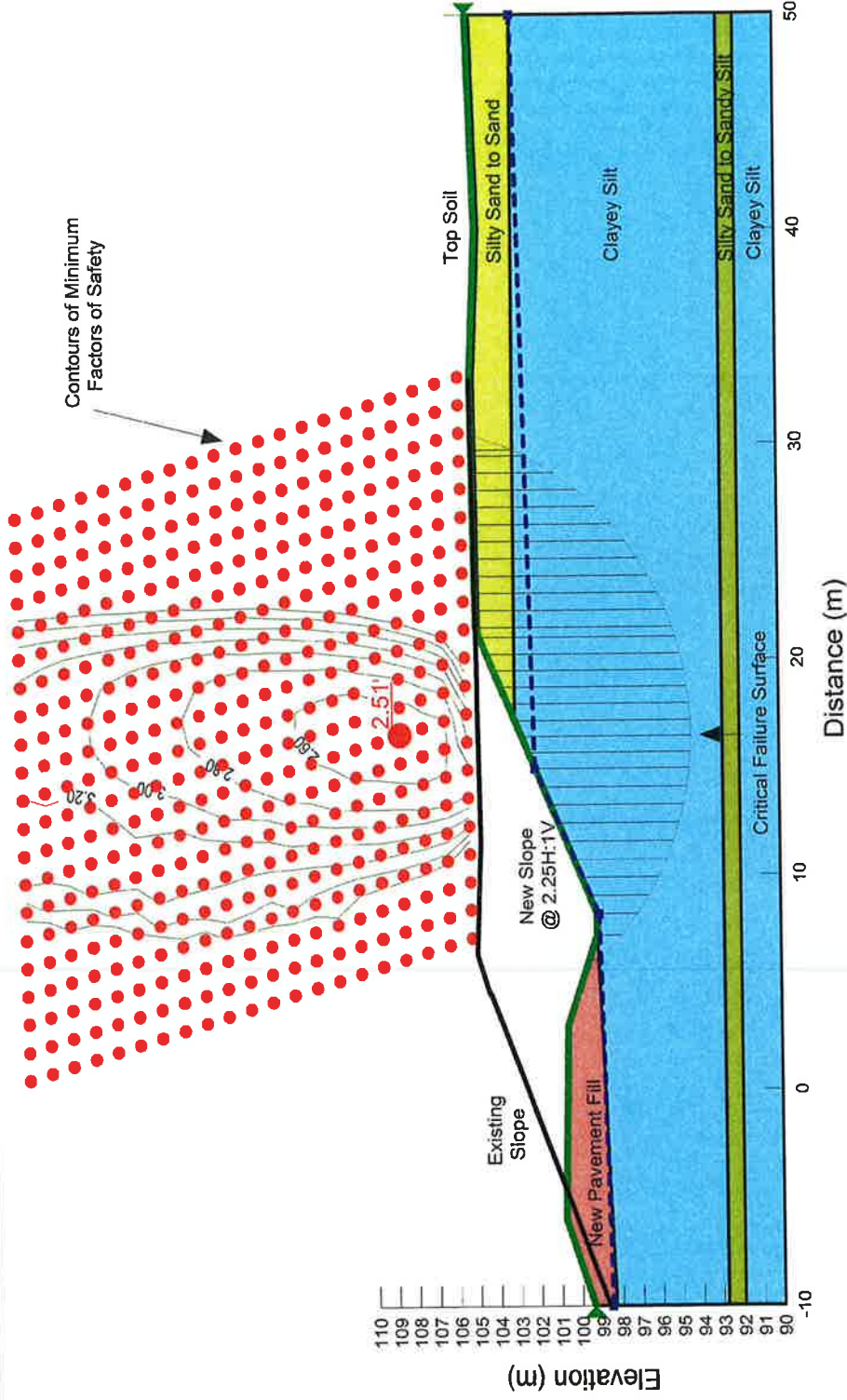


Section : Sta. 18+330
 Slope : 2.25H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS
 Excavation Cut Area 1

PROJECT:	TRANETOB1043AAA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO

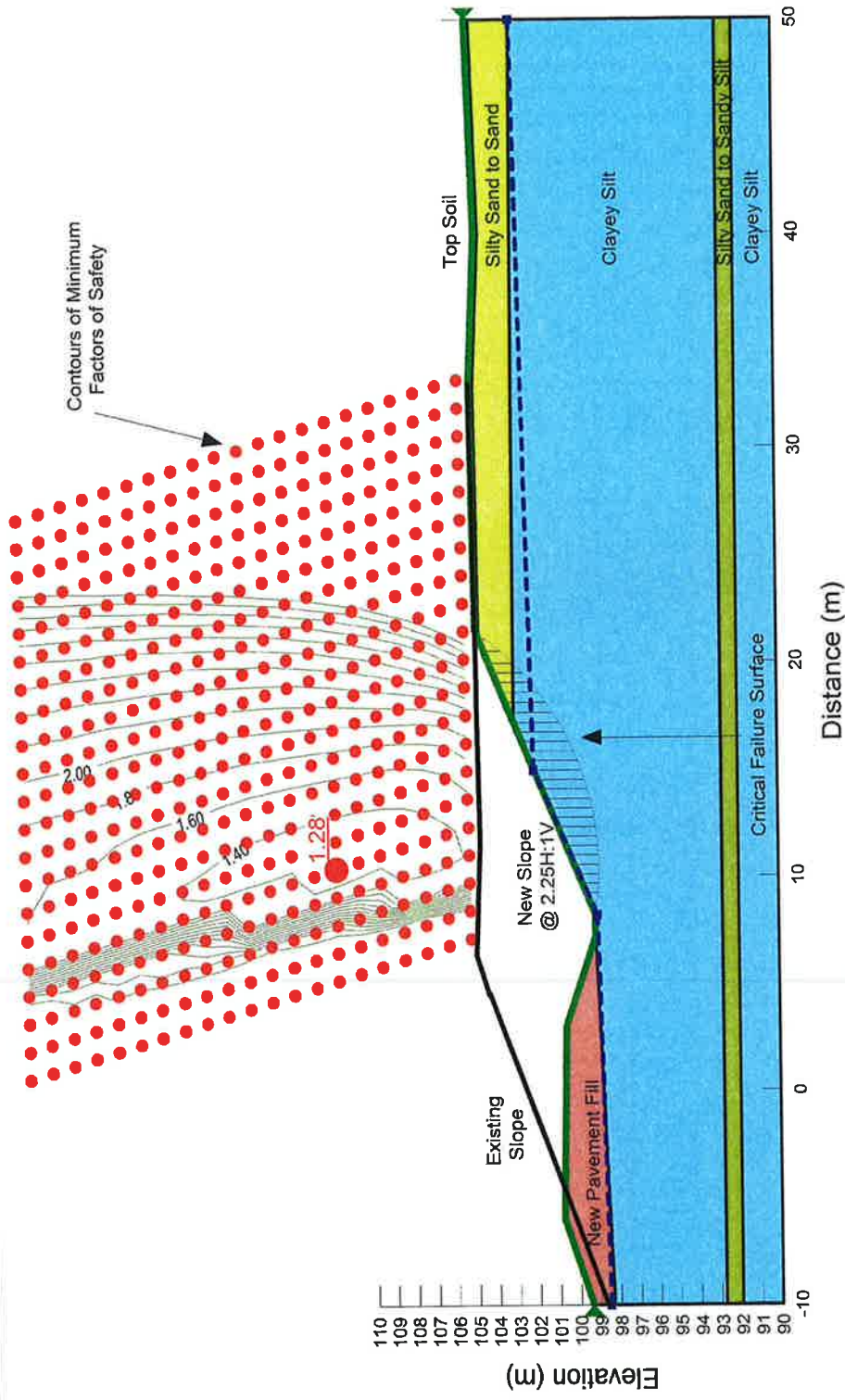


Section : Sta. 18+330
 Slope : 2.25H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

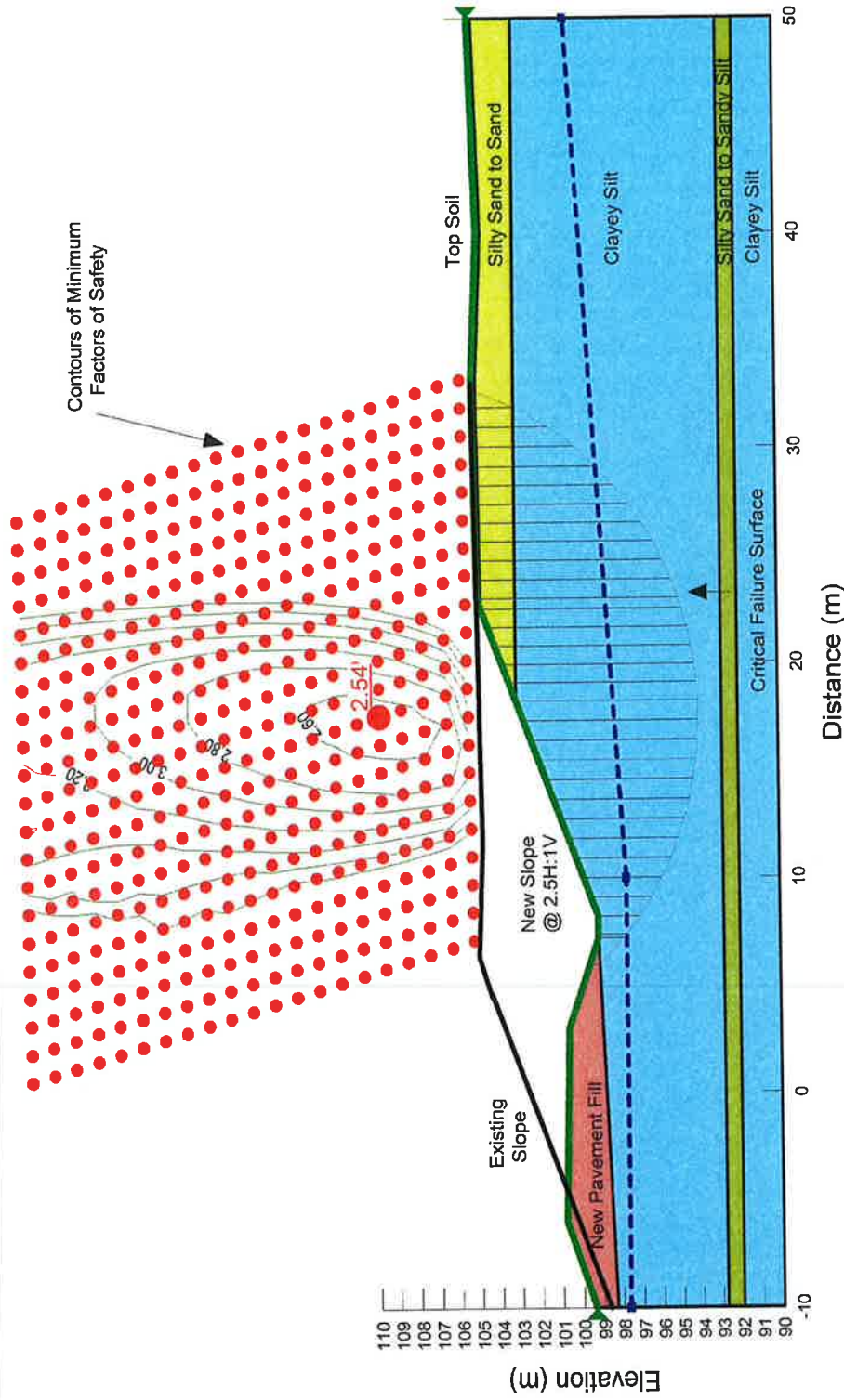
Slope : 2.25H:1V

Condition : Drained

Mid-height water table

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

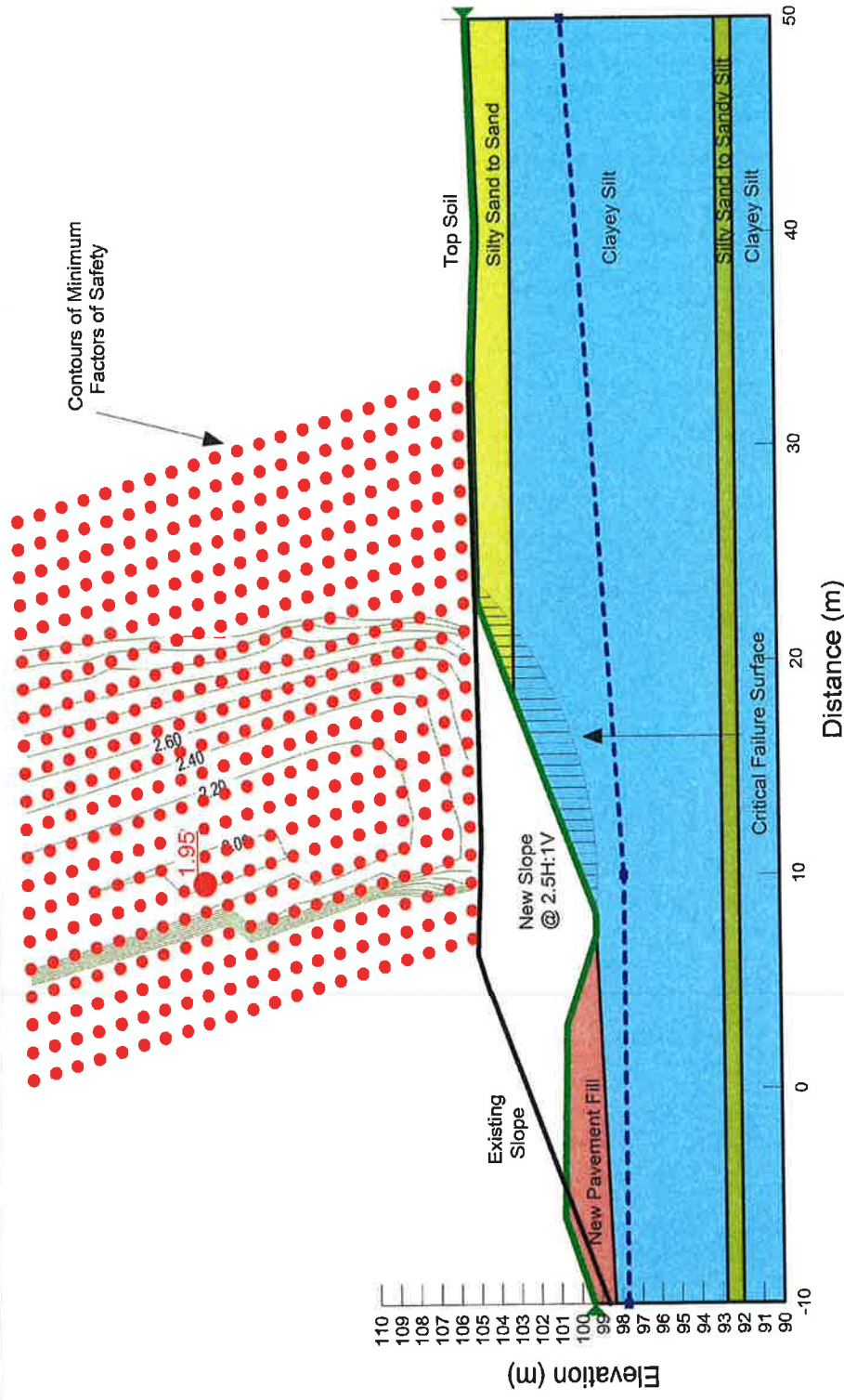


Section : Sta. 18+330
 Slope : 2.5H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

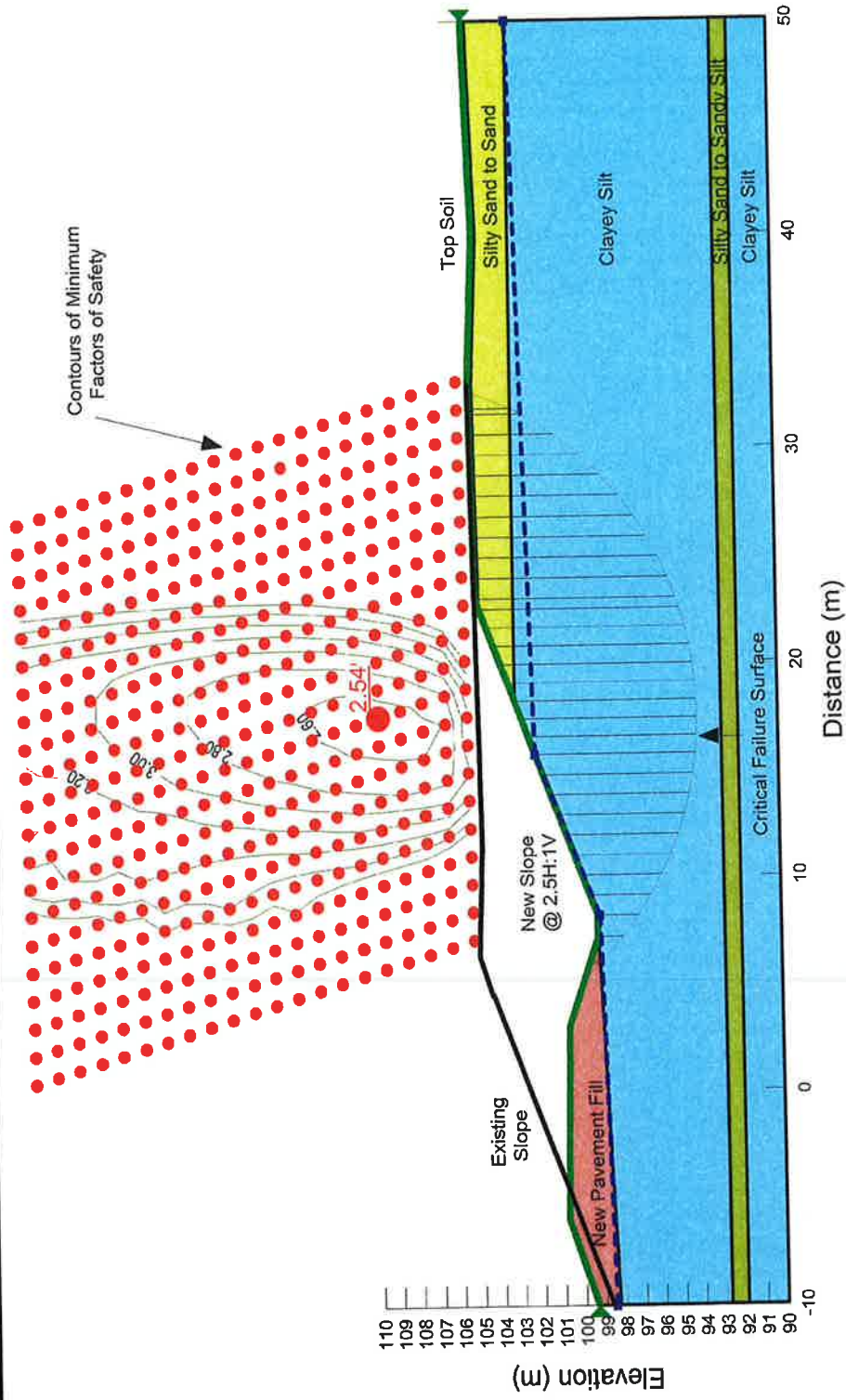
Excavation Cut Area 1



Section : Sta. 18+330
 Slope : 2.5H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 1

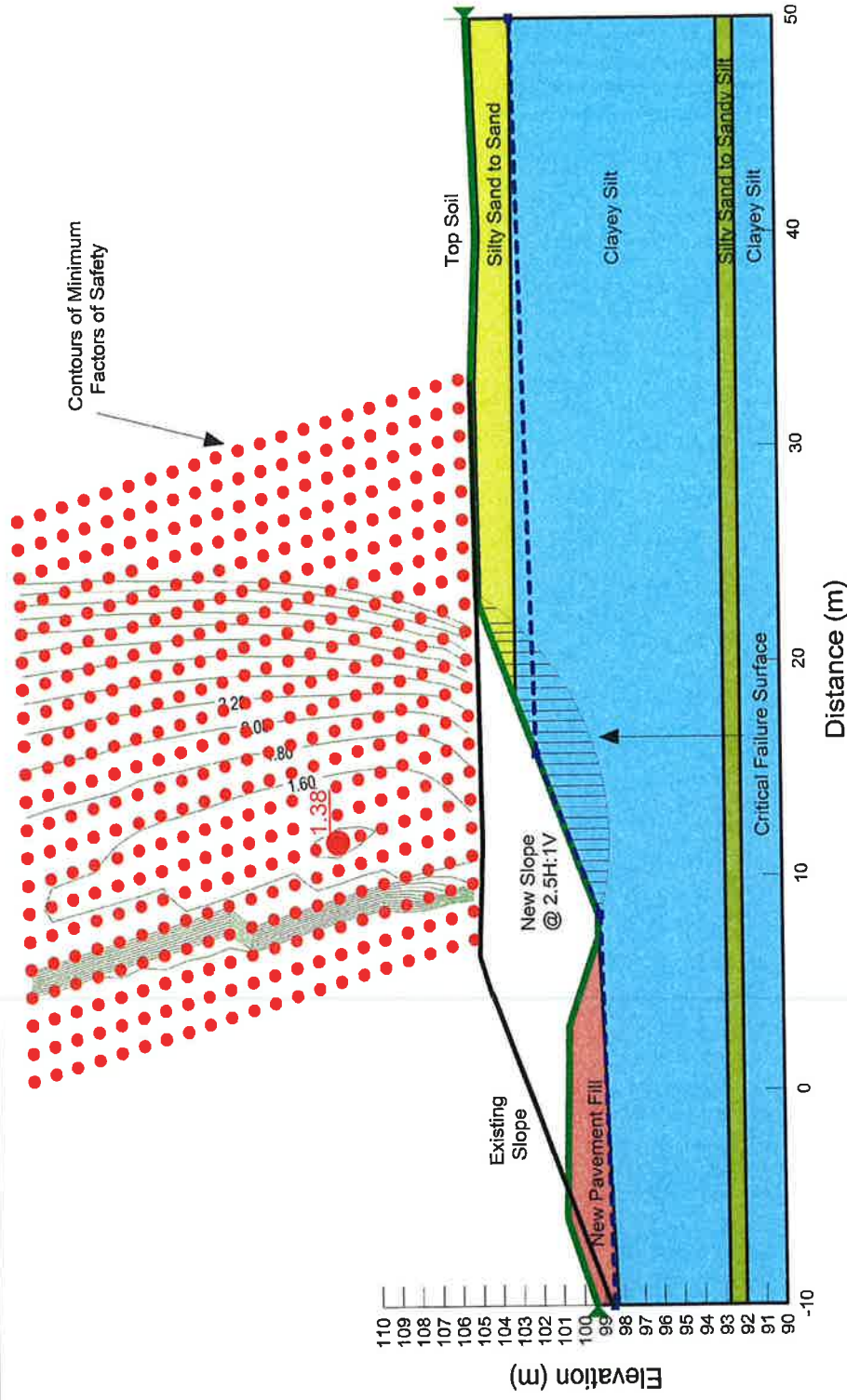


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

Section : Sta. 18+330
 Slope : 2.5H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1



Section : Sta. 18+330

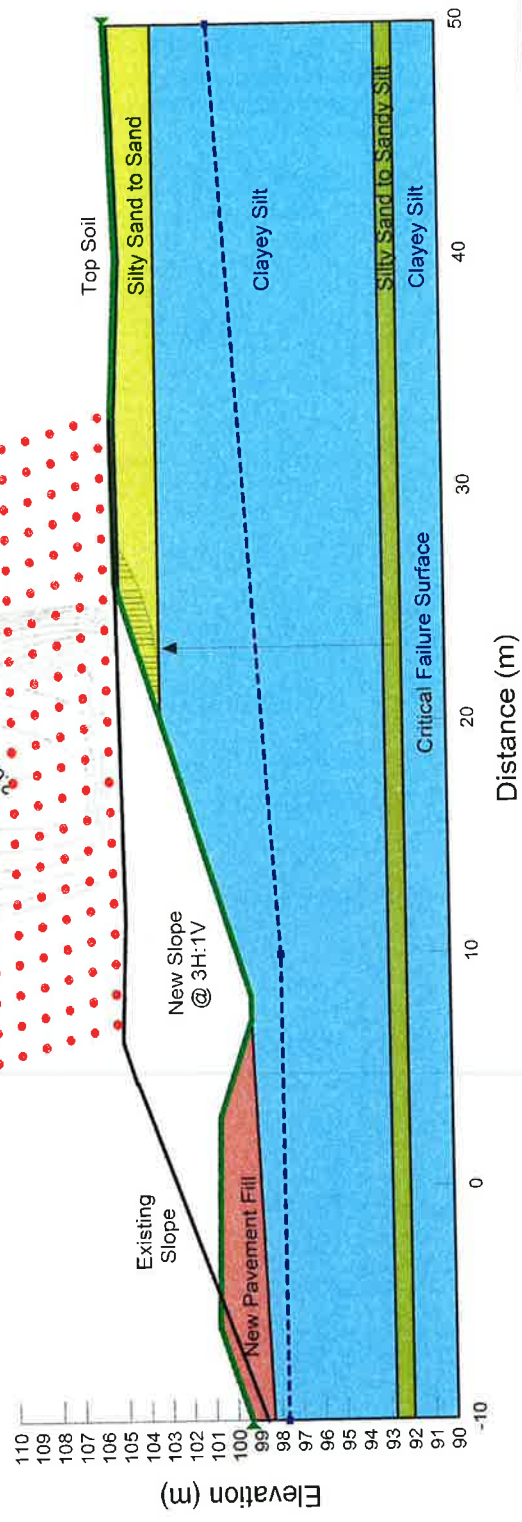
Slope : 2.5H:1V

Condition : Drained

Mid-height water table

Method : Morgenstern - Price

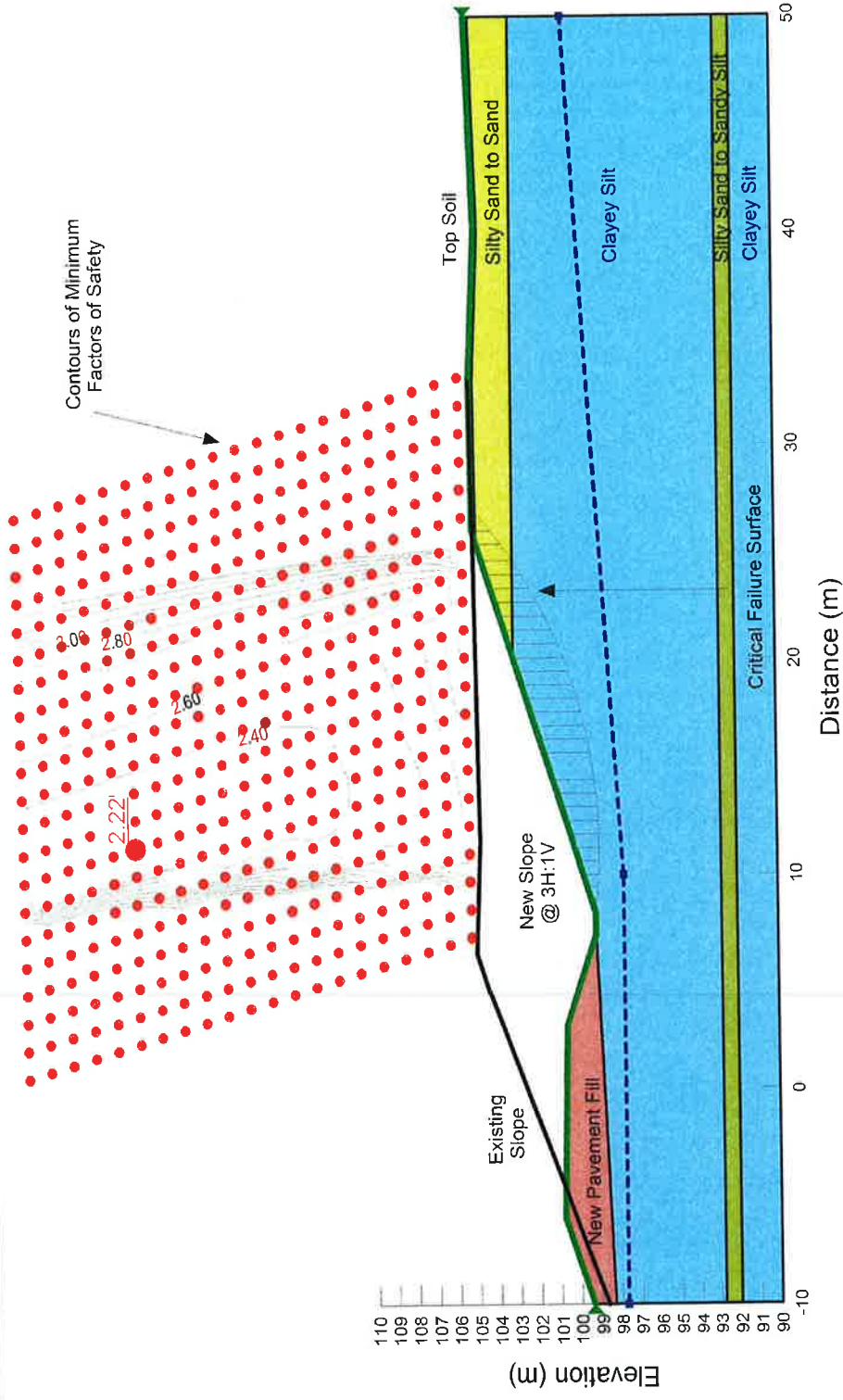
Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32



Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

Section : Sta. 18+330
 Slope : 3H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 1



Section : Sta. 18+330
 Slope : 3H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

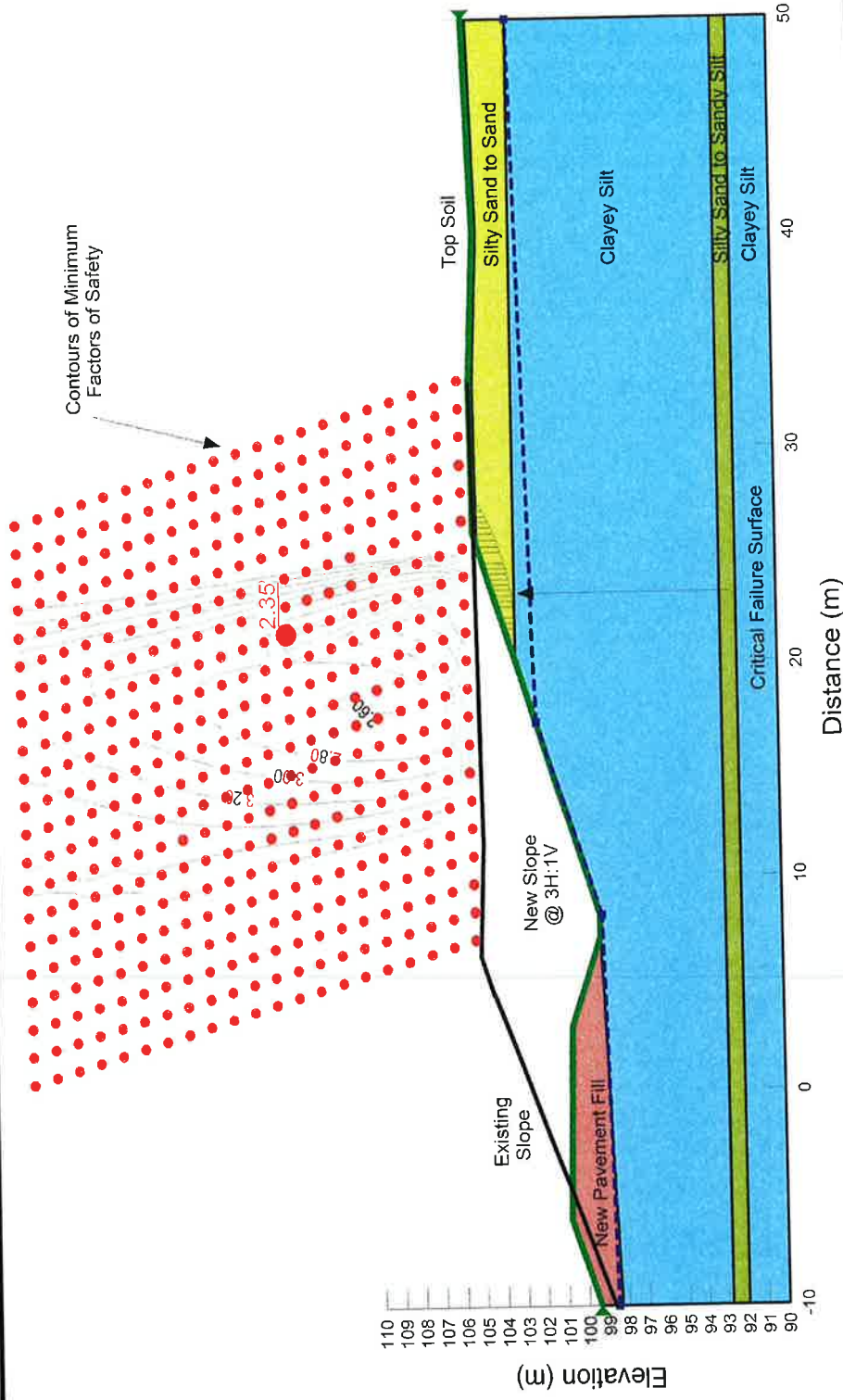
Excavation Cut Area 1

coffey geotechnics
 SPECIALISTS MANAGING THE EARTH

Highway 401 Expansion

FIGURE G1-42

PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO

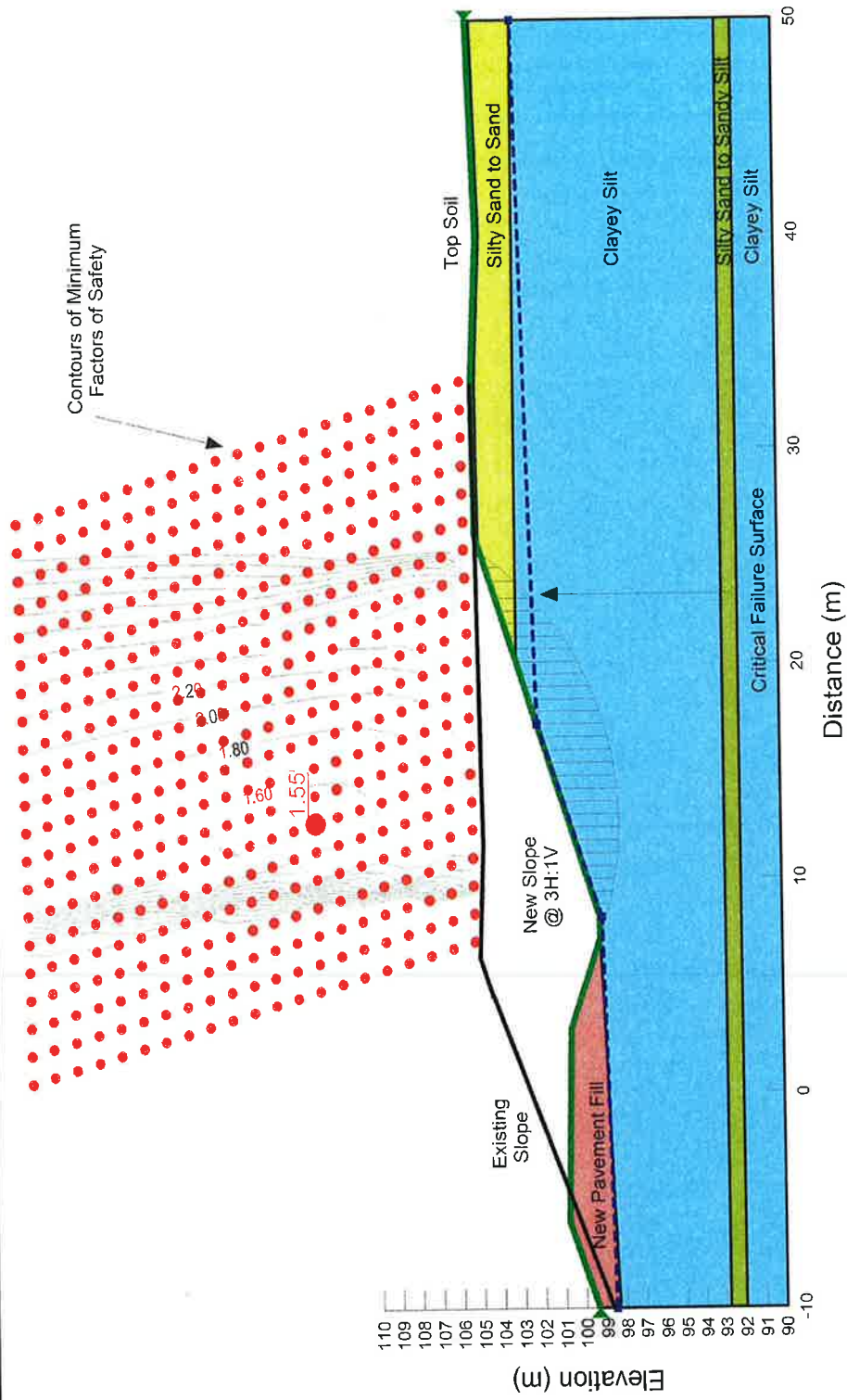


Section : Sta. 18+330
 Slope : 3H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	50	0
Silty Sand to Sandy Silt	20.5	0	32

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 1

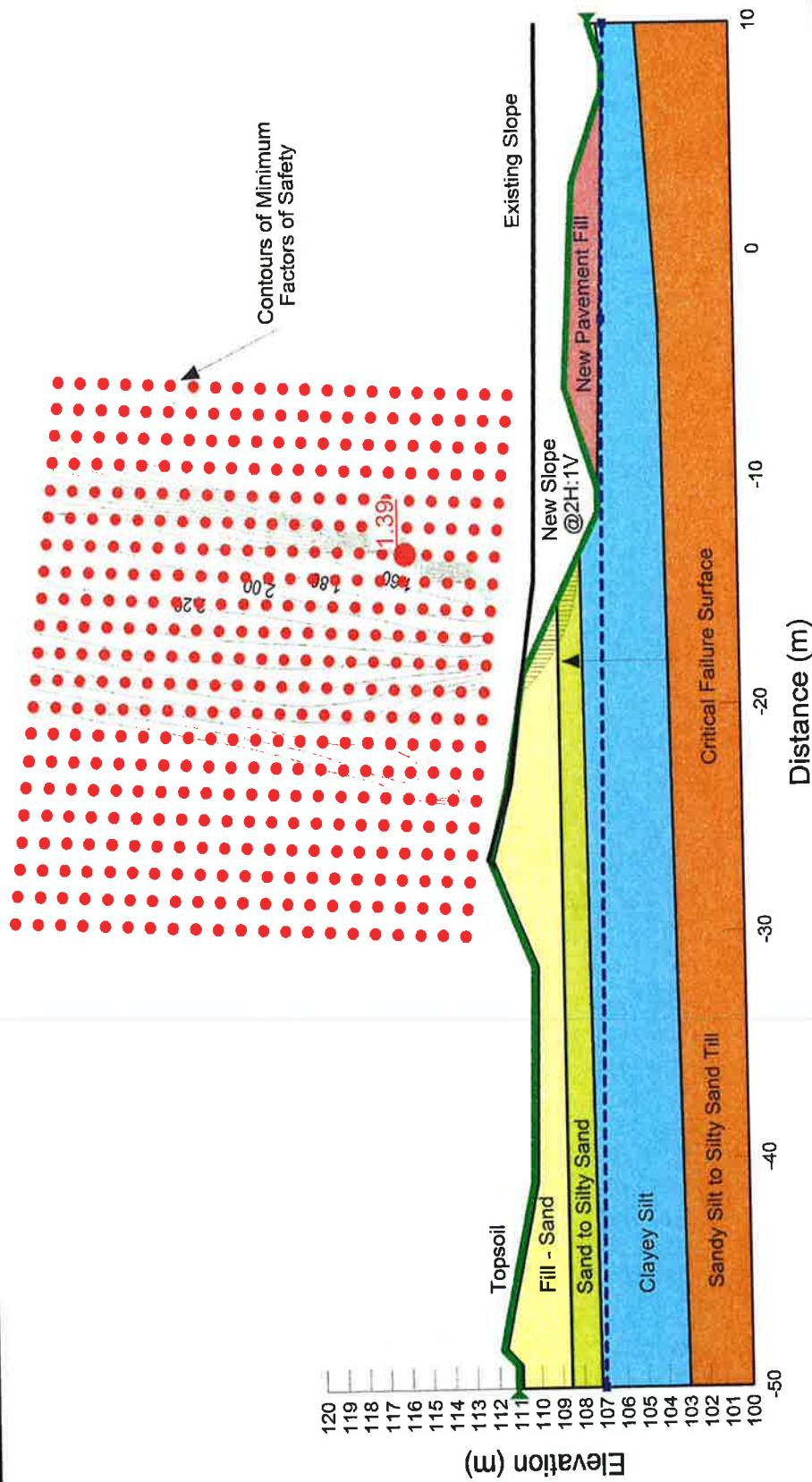


Stratum	γ (kN/m^3)	c (kPa)	ϕ ($^\circ$)
New Pavement Fill	21.0	0	32
Silty Sand to Sand	20.0	0	30
Clayey Silt	20.0	5	28
Silty Sand to Sandy Silt	20.5	0	32

Section : Sta. 18+330
 Slope : 3H:1V
 Condition : Drained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS
 Excavation Cut Area 1

PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO

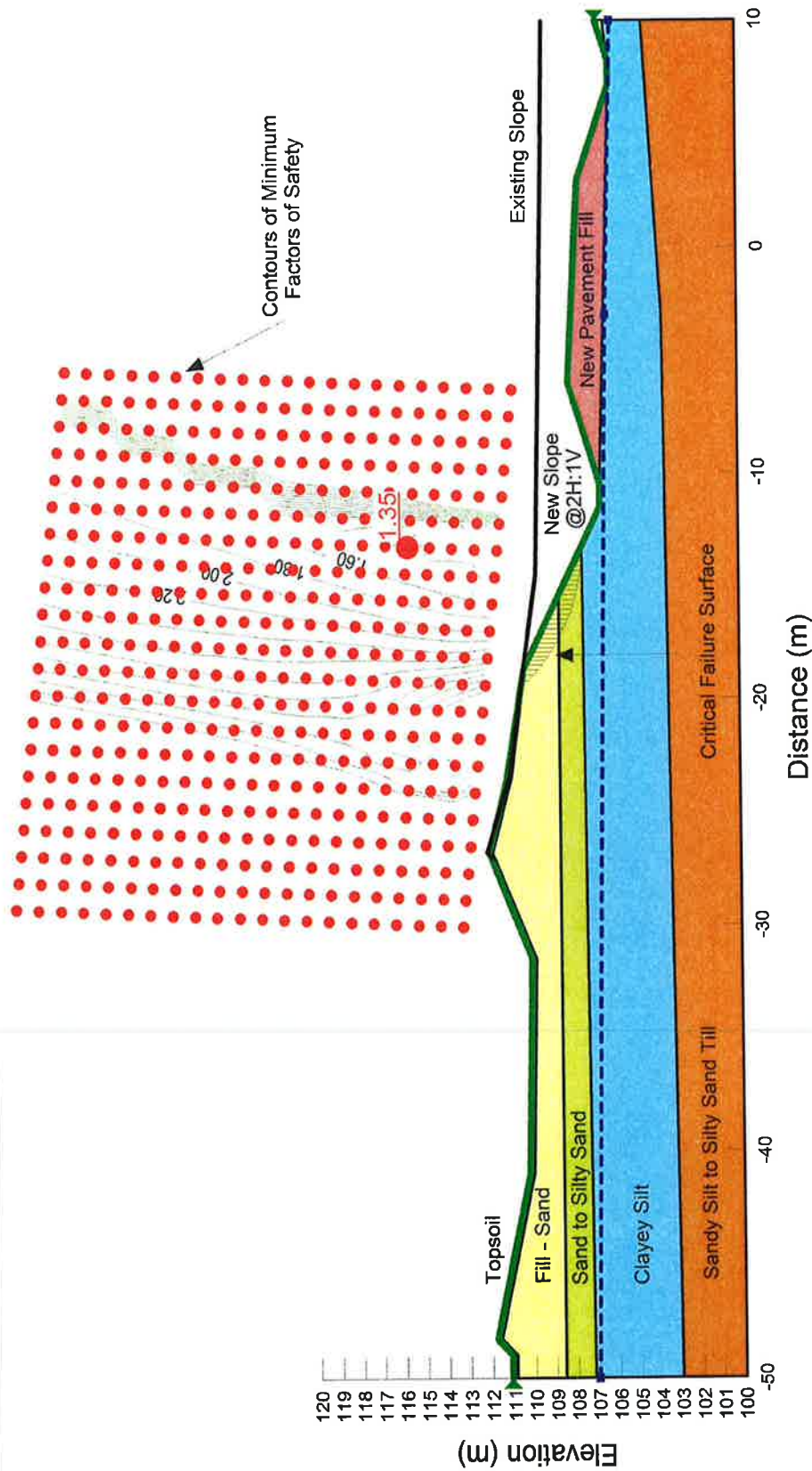


Section : Sta. 18+960
 Slope : 2H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

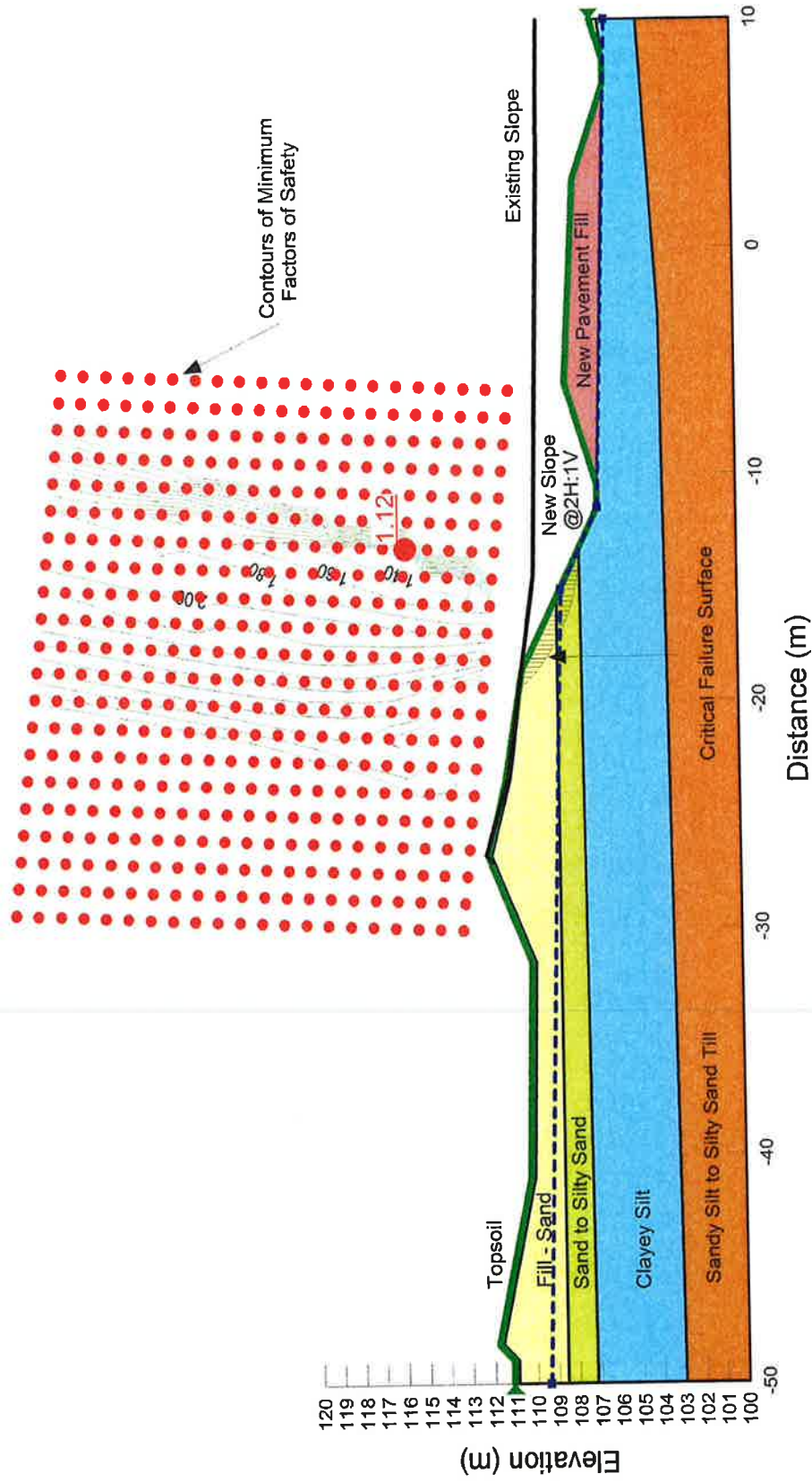
Excavation Cut Area 2



Section : Sta. 18+960
 Slope : 2H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 2

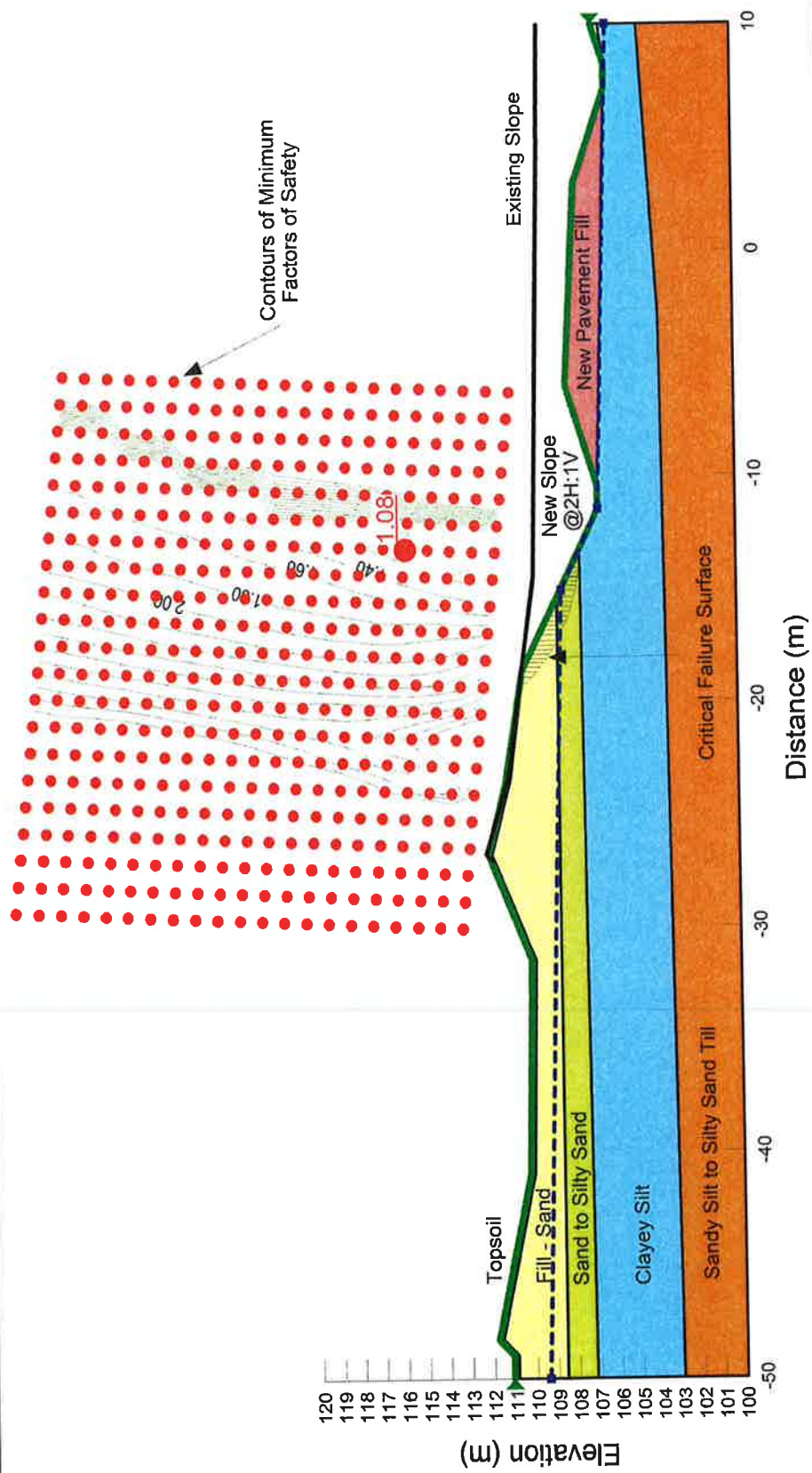


Section : Sta. 18+960
 Slope : 2H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 2

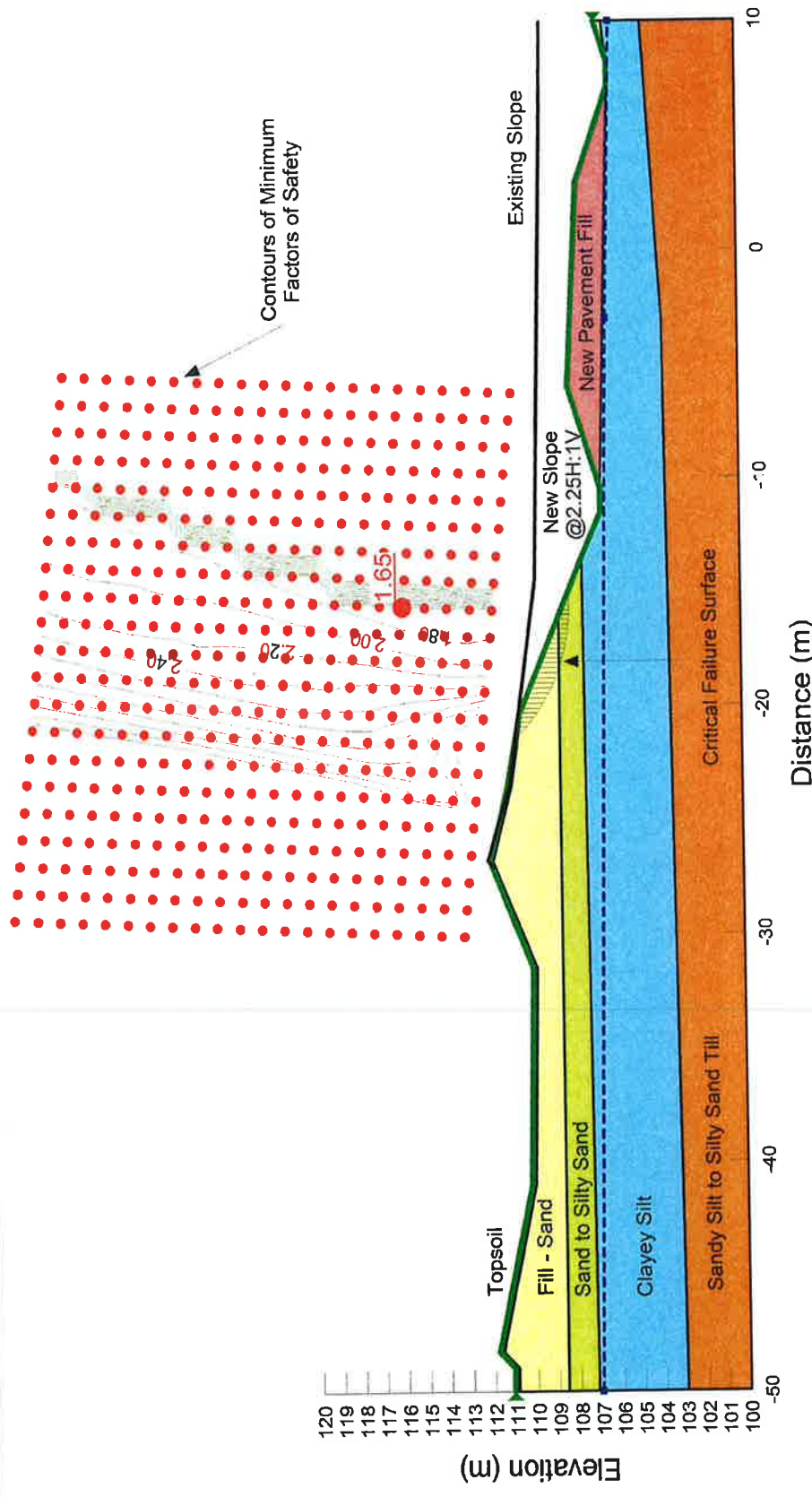


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+960
 Slope : 2H:1V
 Condition : Drained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 2

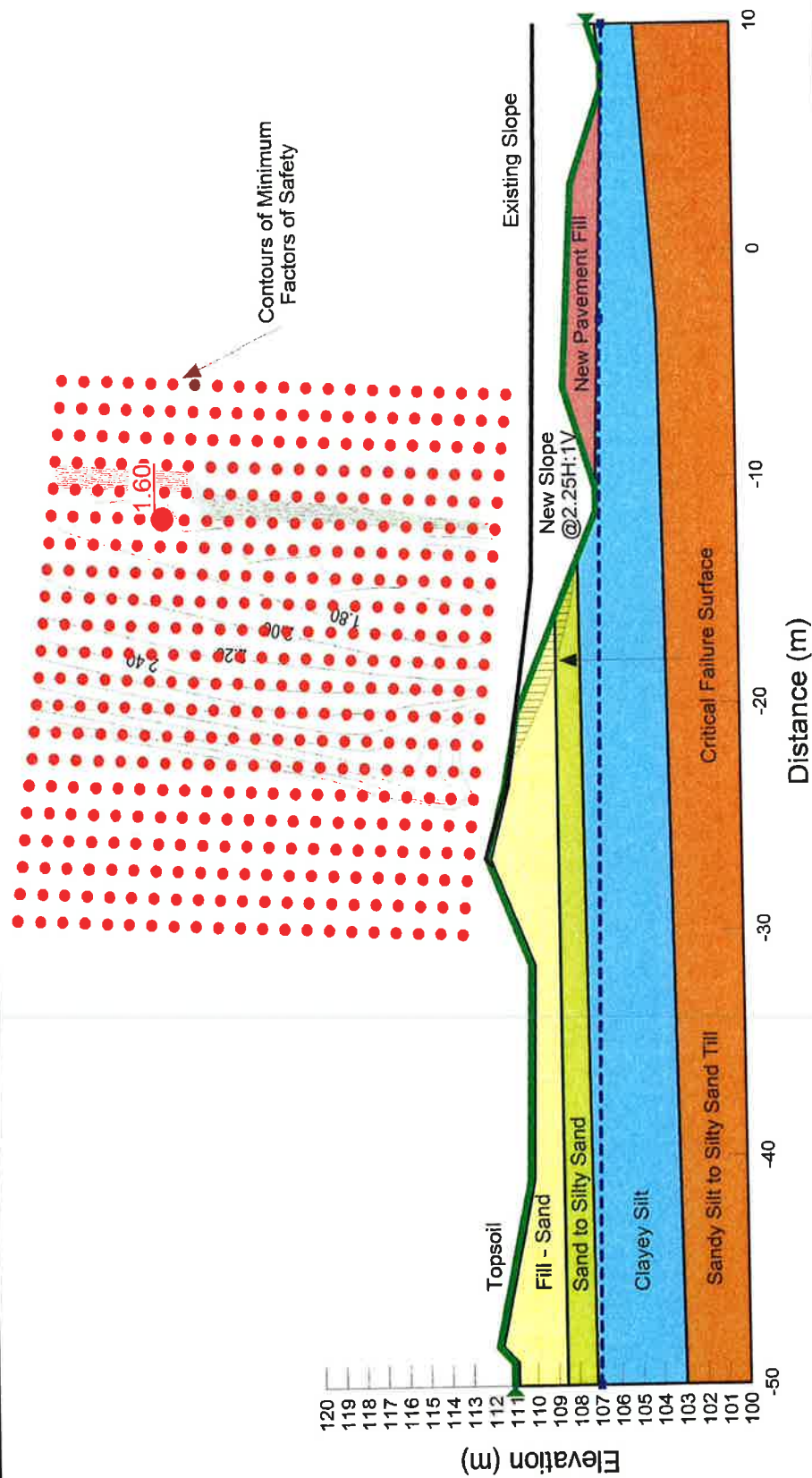


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+960
 Slope : 2.25H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 2

PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO

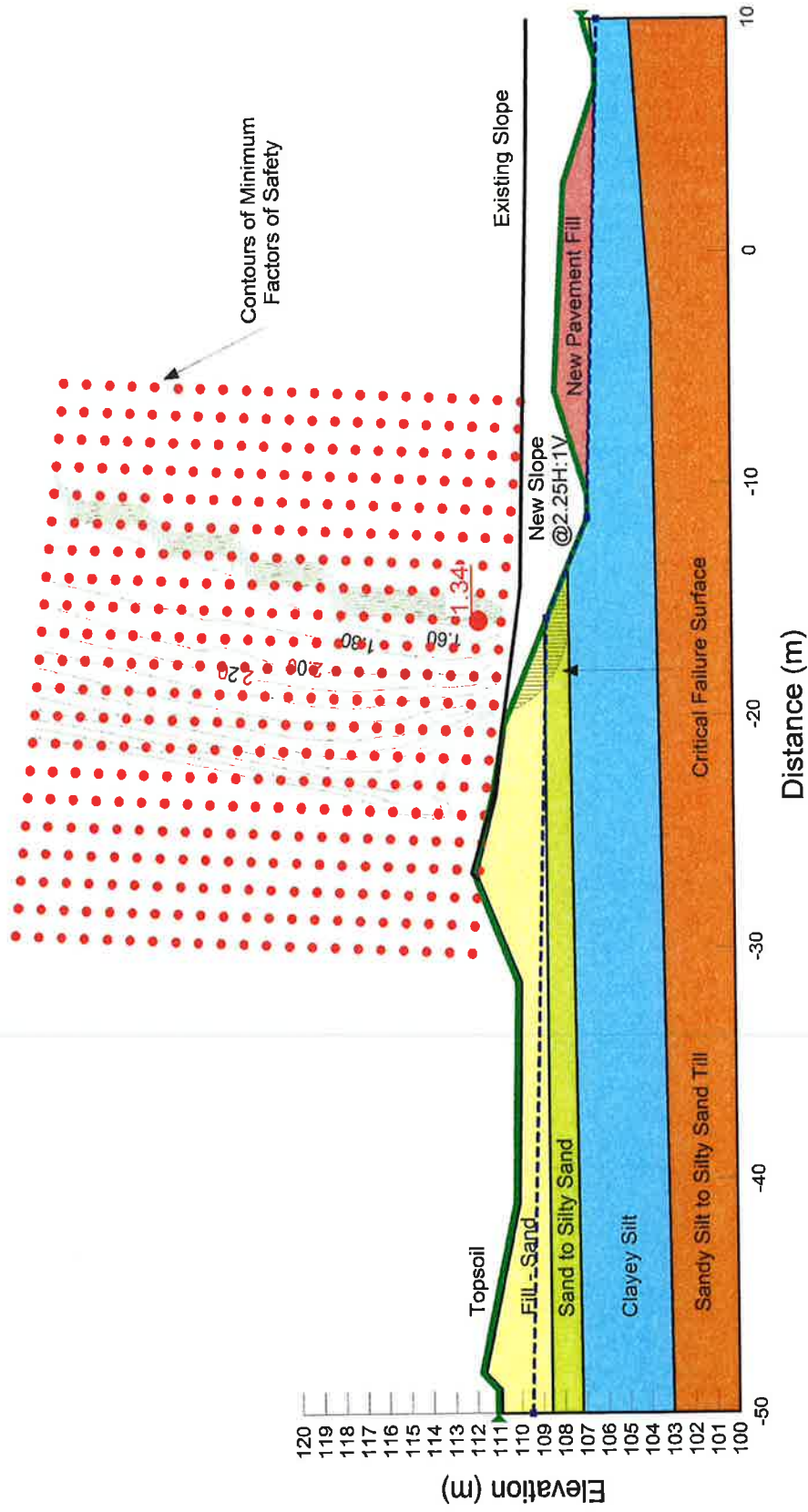


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+960
 Slope : 2.25H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 2

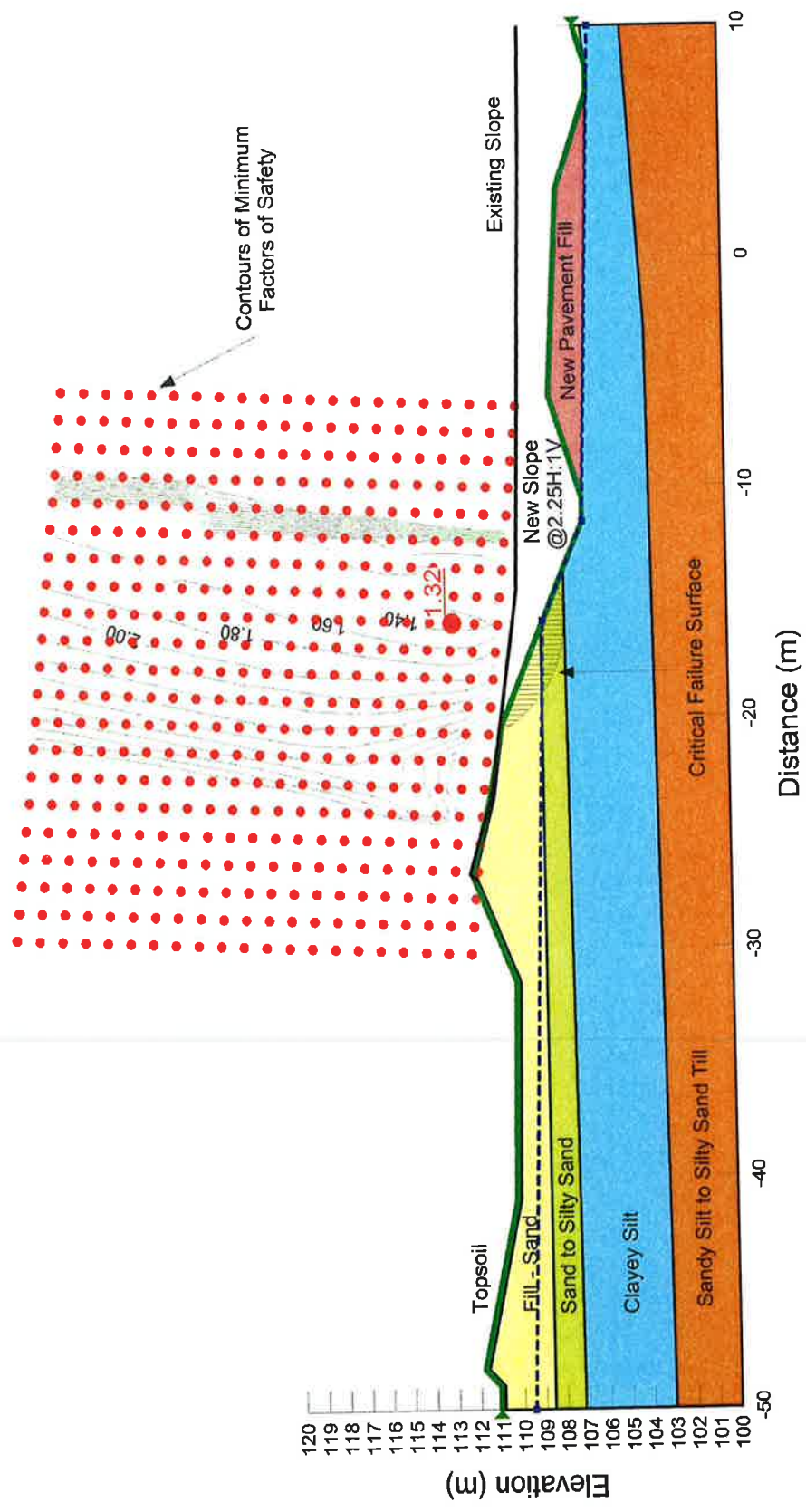


Section : Sta. 18+960
 Slope : 2.25H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

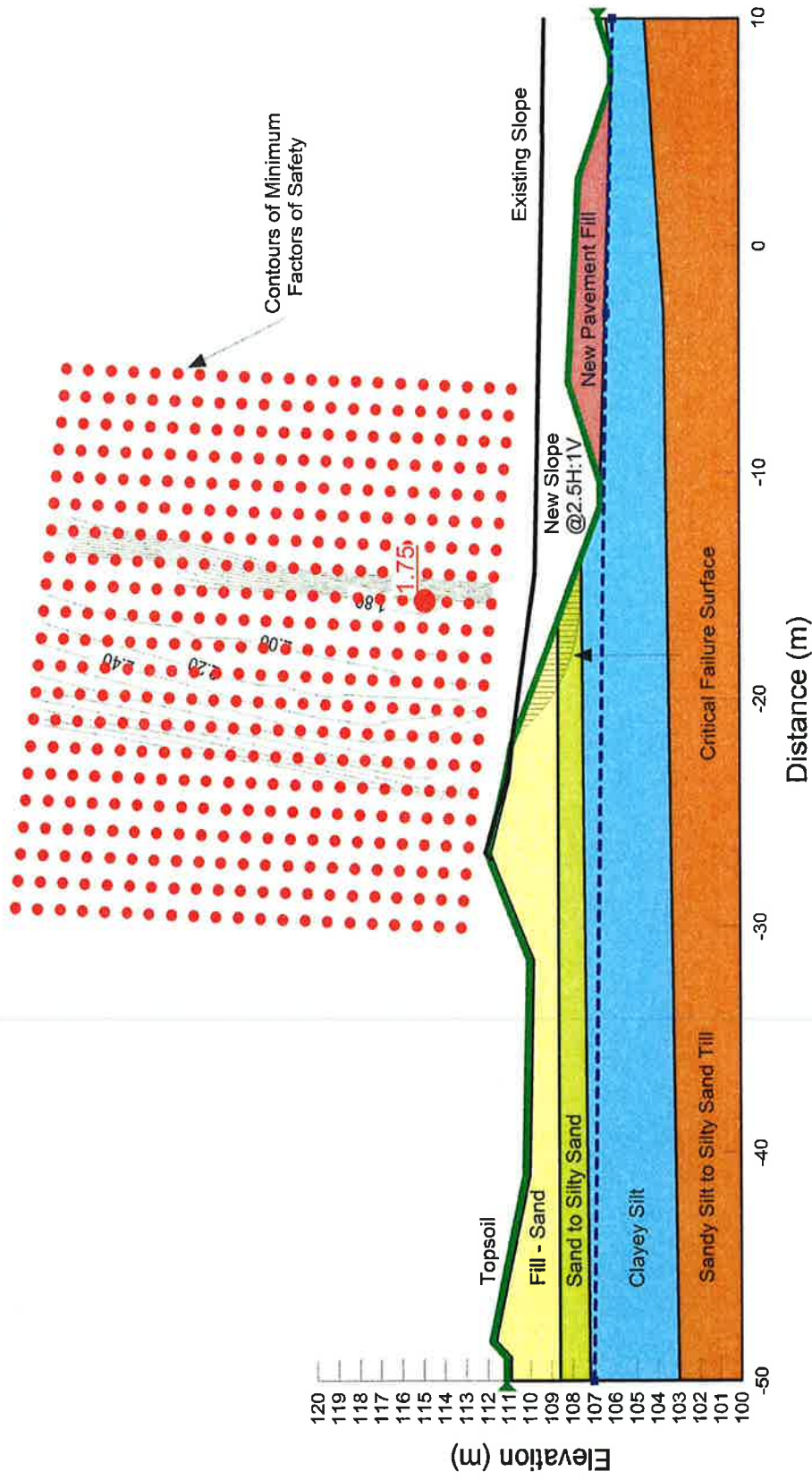
Excavation Cut Area 2



Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

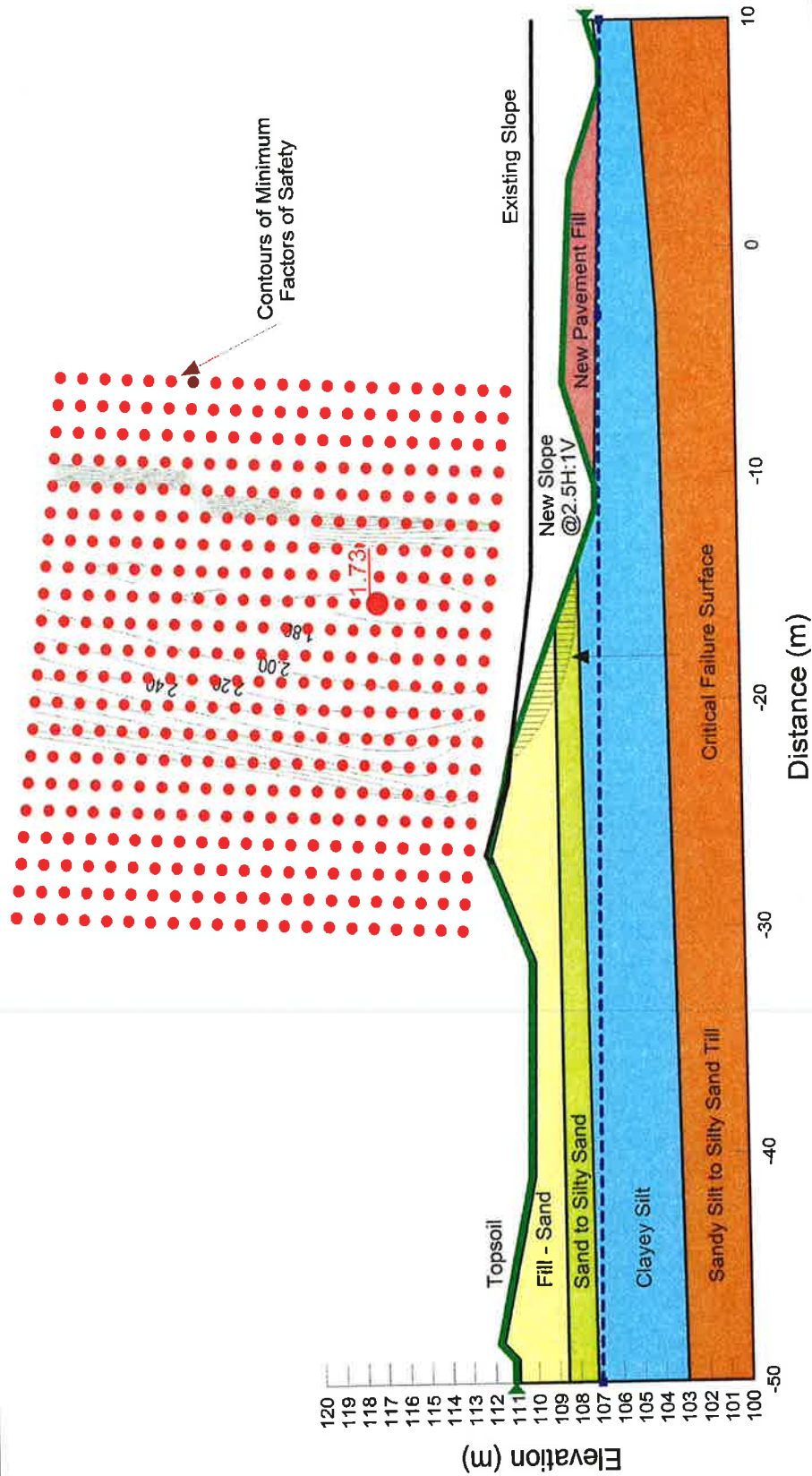
Section : Sta. 18+960
 Slope : 2.25H:1V
 Condition : Drained
 Method : Mid-height water table
 Morganstern - Price

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 2



Section : Sta. 18+960
 Slope : 2.5H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

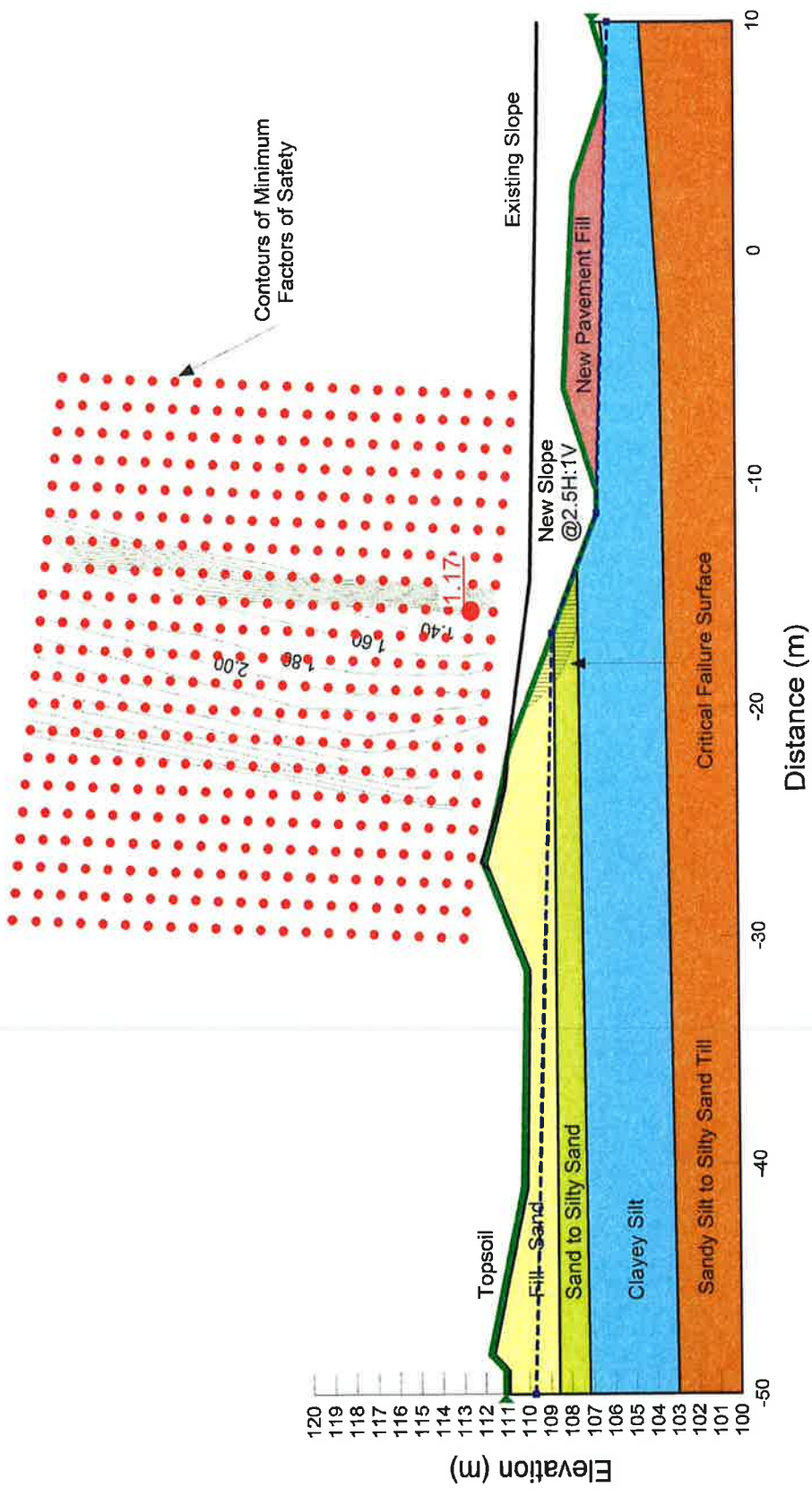


Section : Sta. 18+960
 Slope : 2.5H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

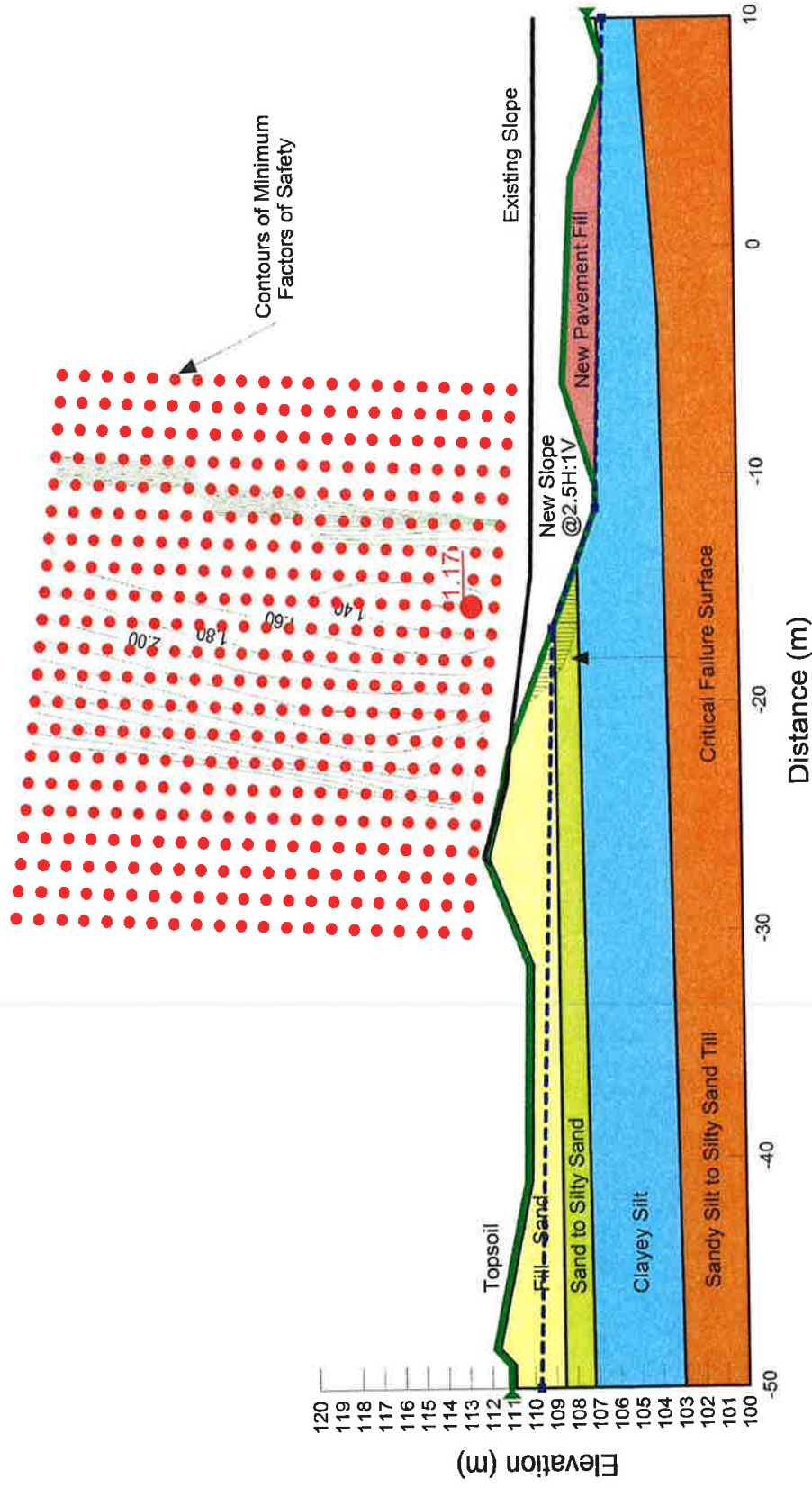
Excavation Cut Area 2



Section : Sta. 18+960
 Slope : 2.5H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 2

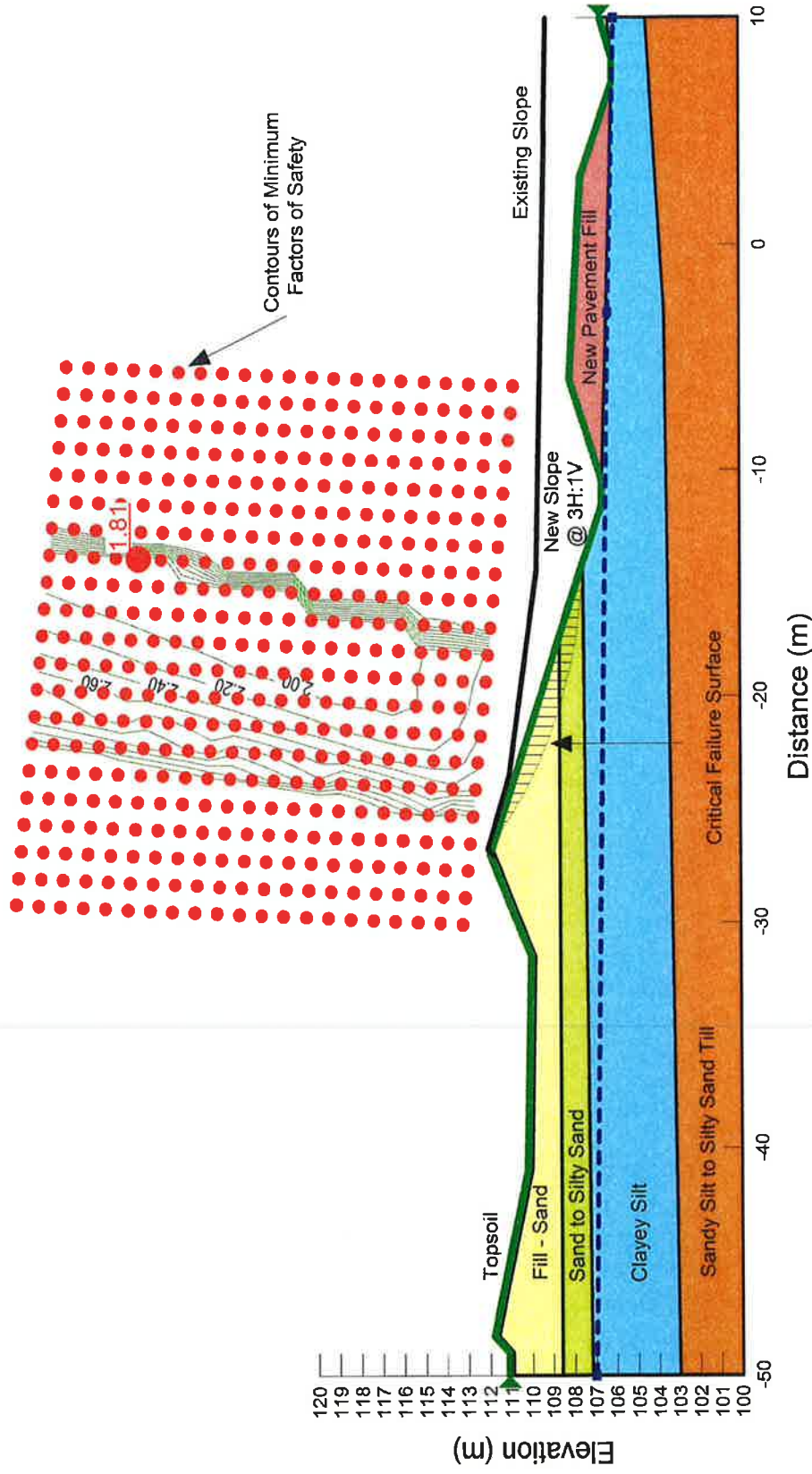


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+960
 Slope : 2.5H:1V
 Condition : Drained
 Mid-height water table
 Method : Morgenstern - Price

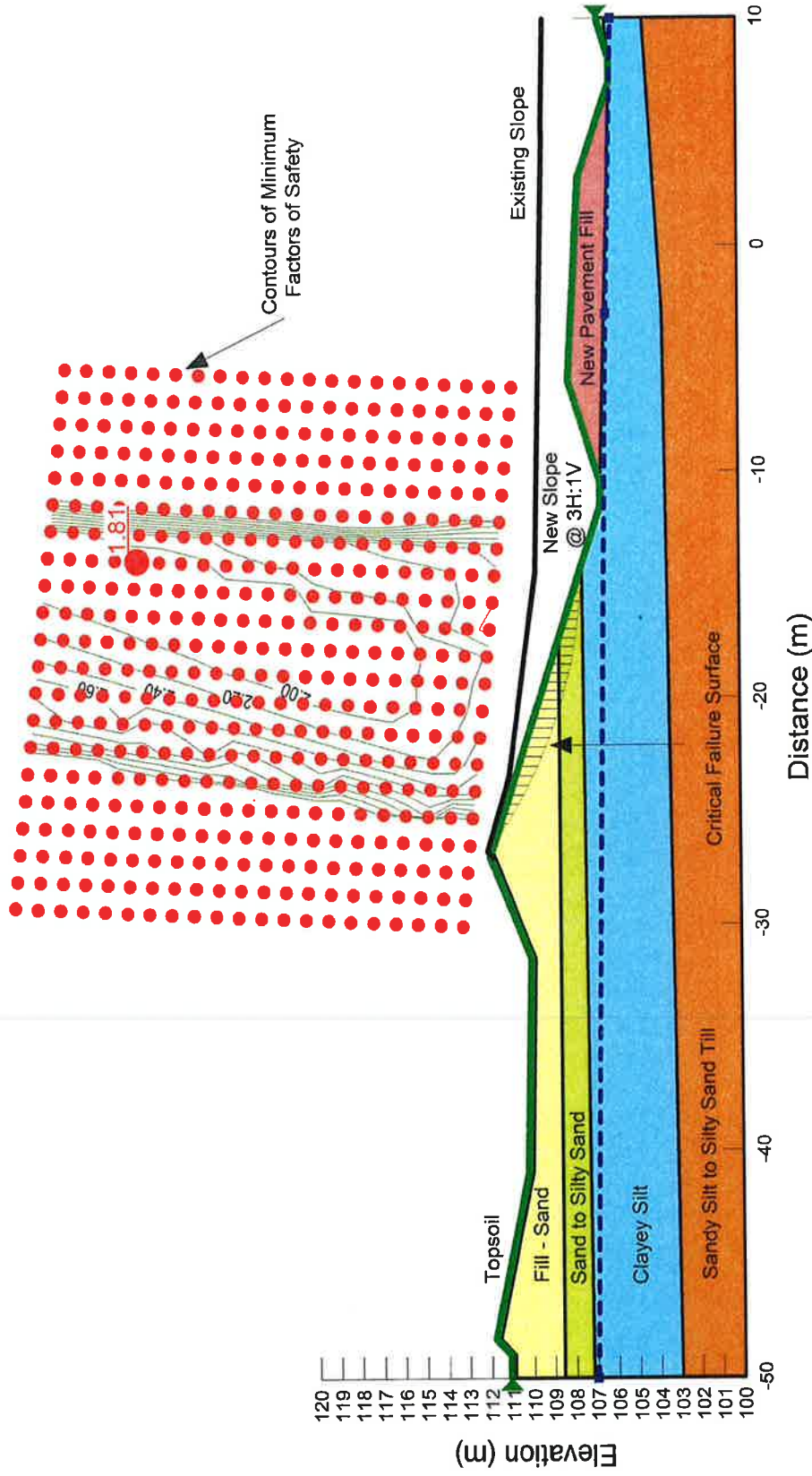
STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 2



Section : Sta. 18+960
 Slope : 3H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

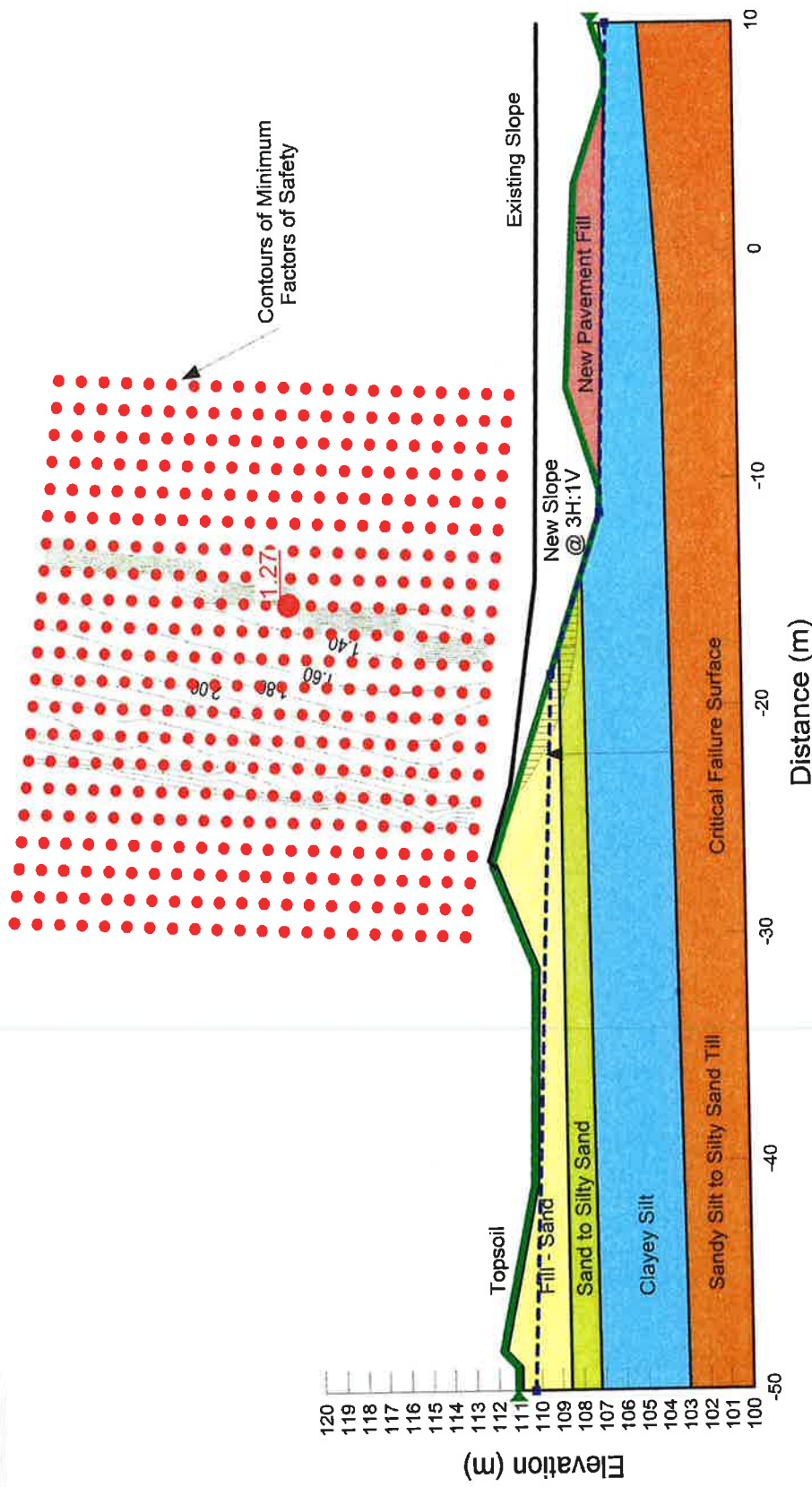
Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33



Section : Sta. 18+960
 Slope : 3H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 2

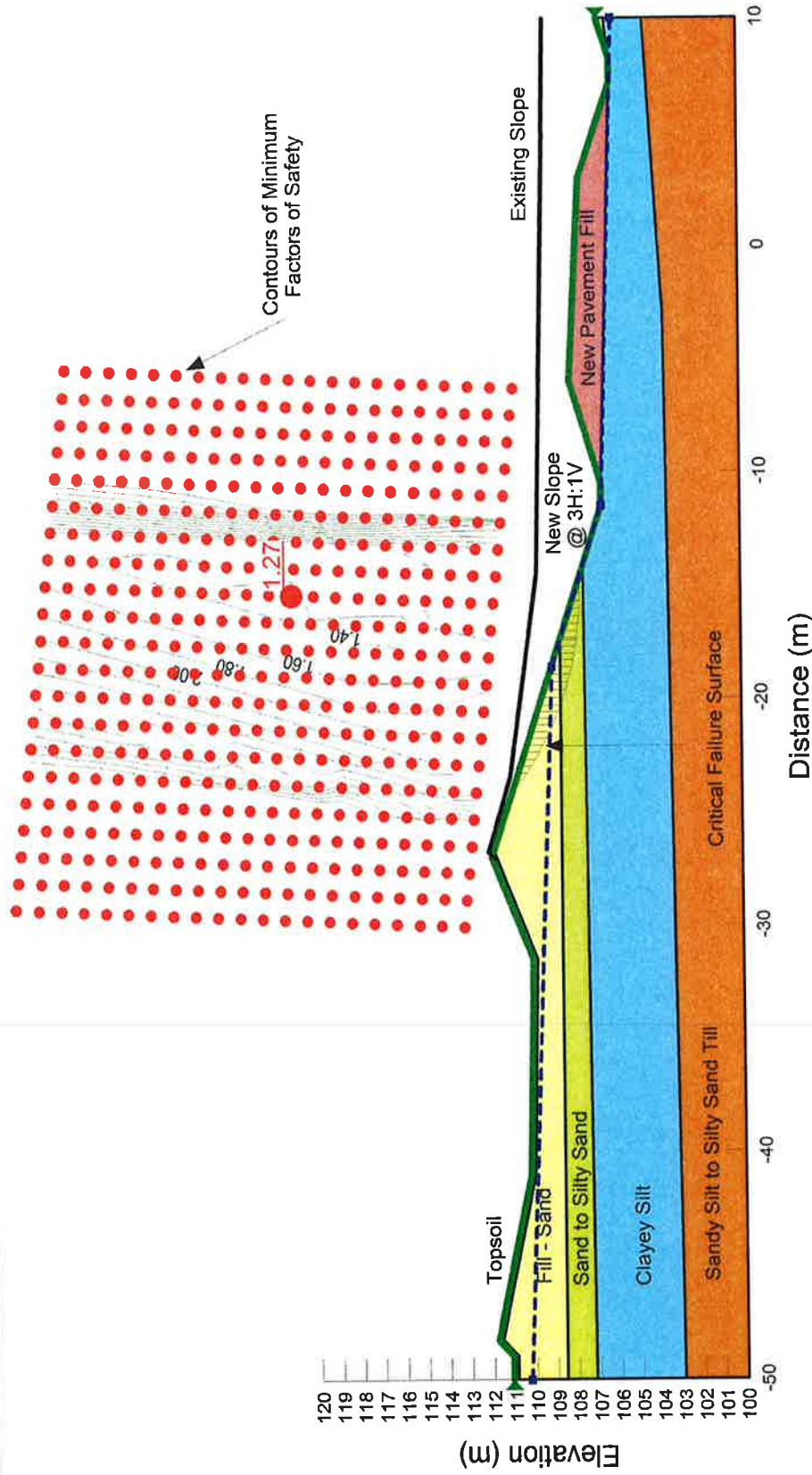


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+960
 Slope : 3H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS

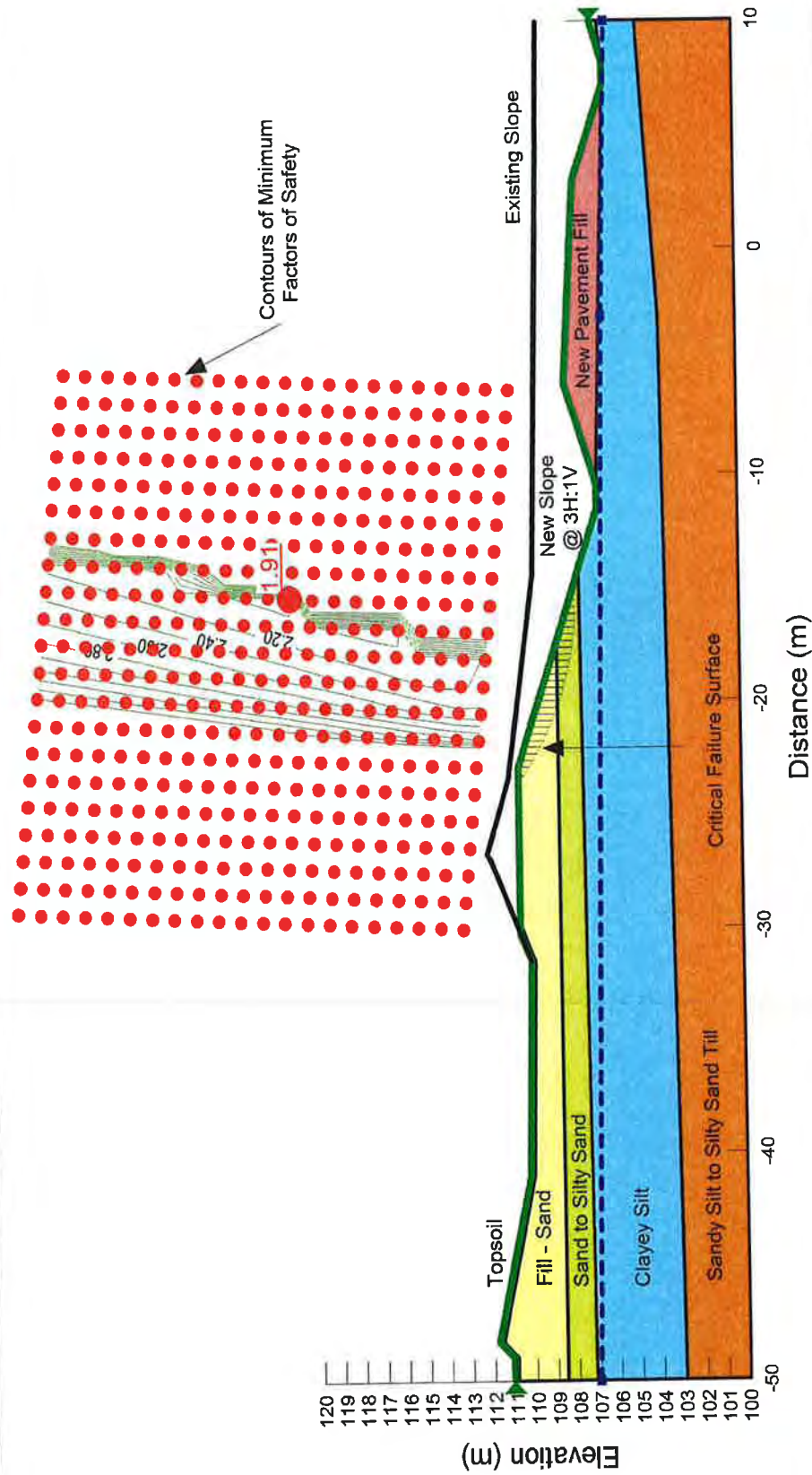
Excavation Cut Area 2



Section	Sta. 18+960				
Slope	3H:1V				
Condition	Drained				
	Mid-height water table				
Method	Morgenstern - Price				
Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)		
New Pavement Fill	21.0	0	32		
Fill - Sand	19.5	0	30		
Sand to Silty Sand	20.0	0	31		
Clayey Silt	20.0	5	28		
Sandy Silt to Silty Sand Till	21.5	0	33		

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 2



Section : Sta. 18+960

Slope : 3H:1V

Condition : Undrained

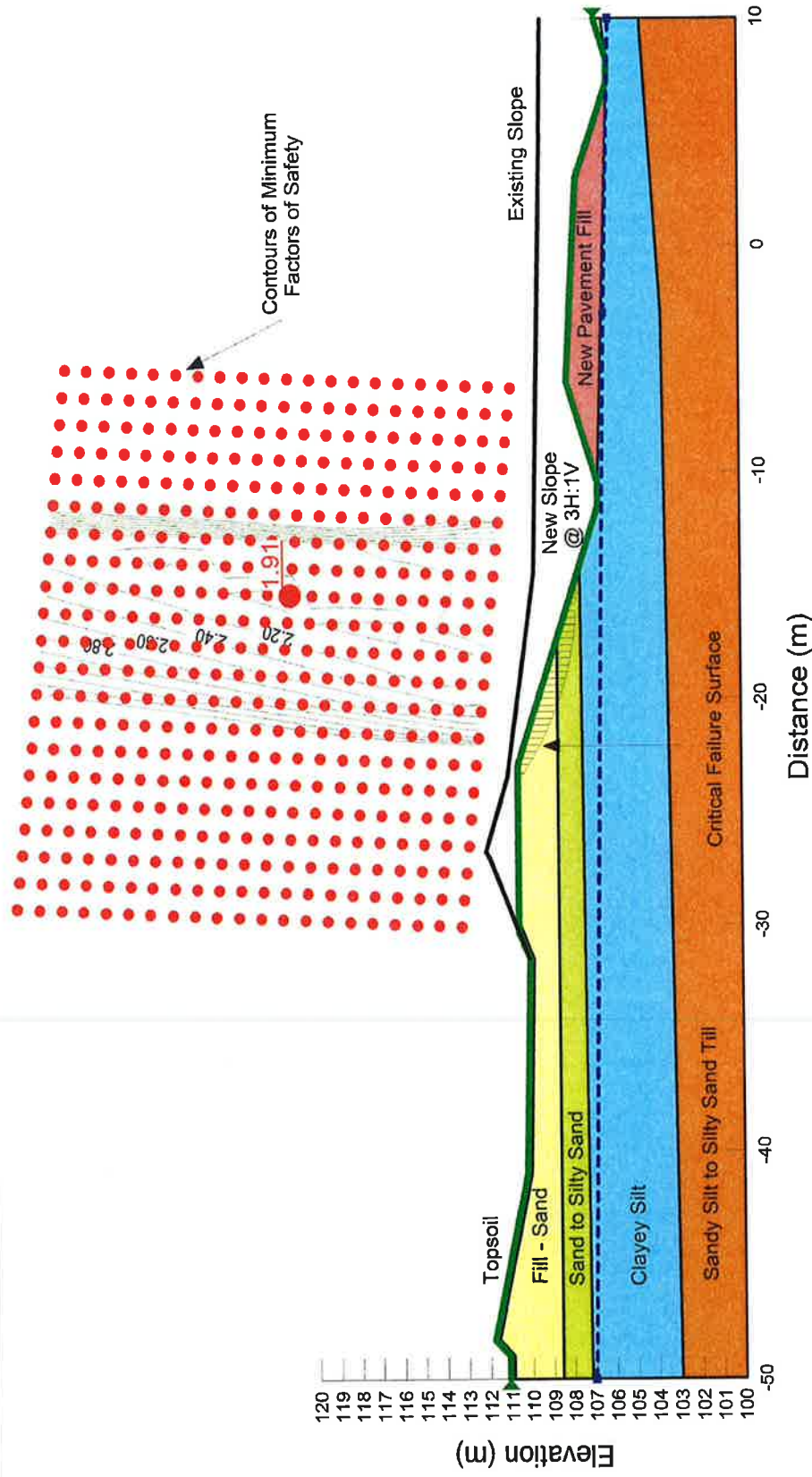
Measured water table
1.5 m surficial stripping

Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

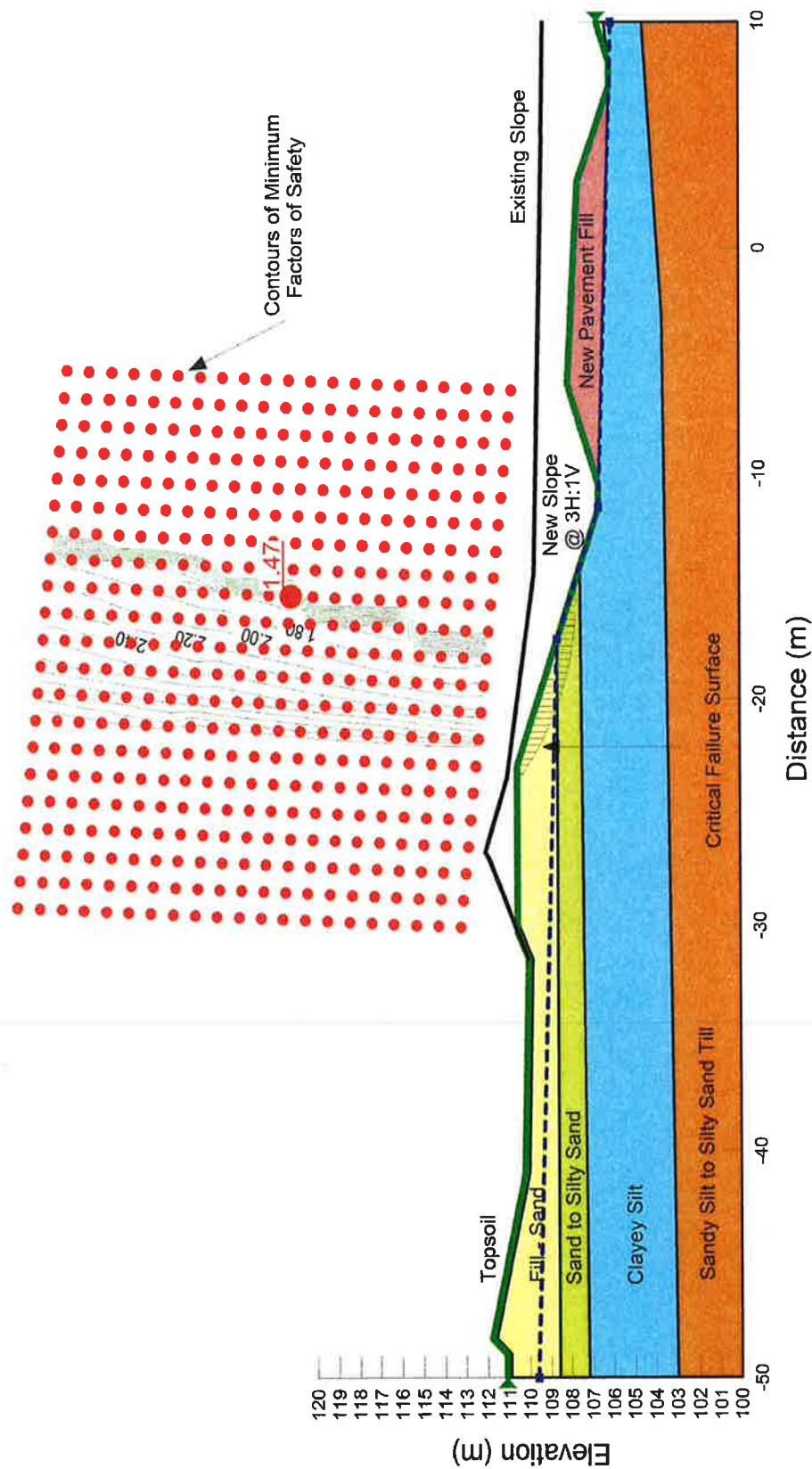
Excavation Cut Area 2



Section	Sta. 18+960	Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
Slope	3H:1V	New Pavement Fill	21.0	0	32
Condition	Drained	Fill - Sand	19.5	0	30
	Measured water table	Sand to Silty Sand	20.0	0	31
	1.5 m surficial stripping	Clayey Silt	20.0	5	28
Method	Morgenstern - Price	Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

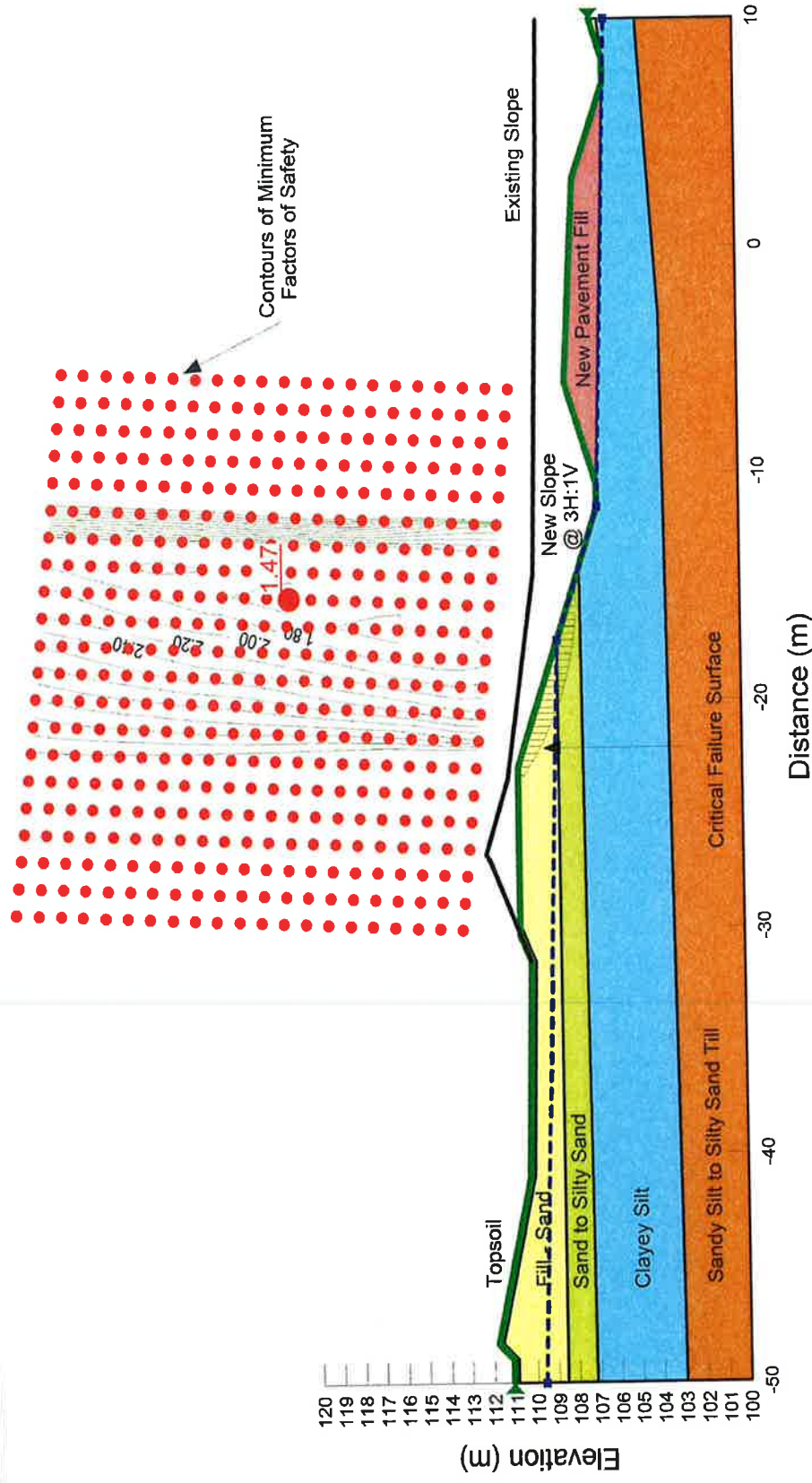
Excavation Cut Area 2



Section	Sta. 18+960	Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
Slope	3H:1V	New Pavement Fill	21.0	0	32
Condition	Undrained	Fill - Sand	19.5	0	30
	Mid-height water table	Sand to Silty Sand	20.0	0	31
	1.5 m surficial stripping	Clayey Silt	20.0	60	0
Method	Morgenstern - Price	Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 2

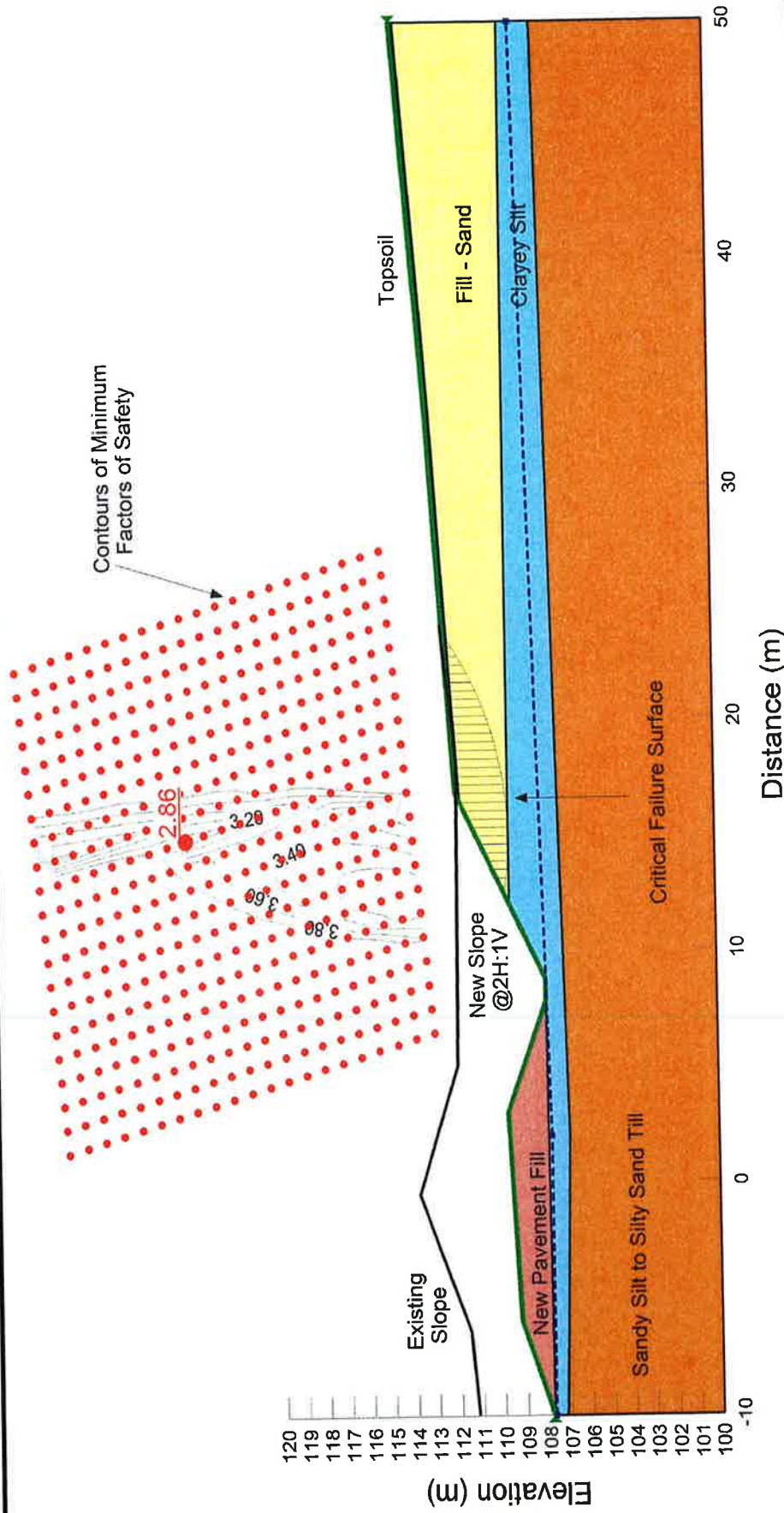


Section : Sta. 18+960
 Slope : 3H:1V
 Condition : Drained
 Mid-height water table
 1.5 m surficial stripping
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Sand to Silty Sand	20.0	0	31
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 2

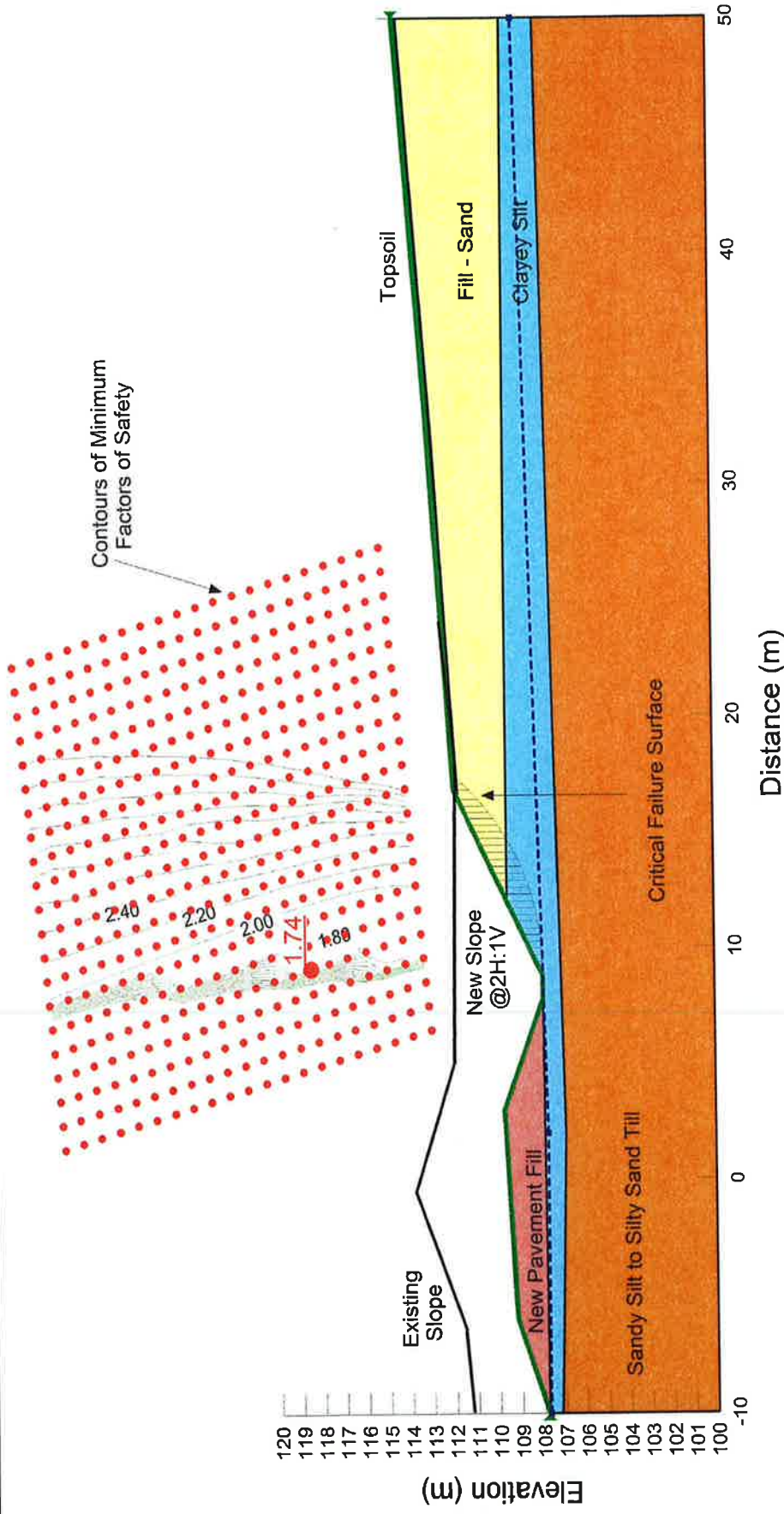


Section : Sta. 18+700
 Slope : 2H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 3

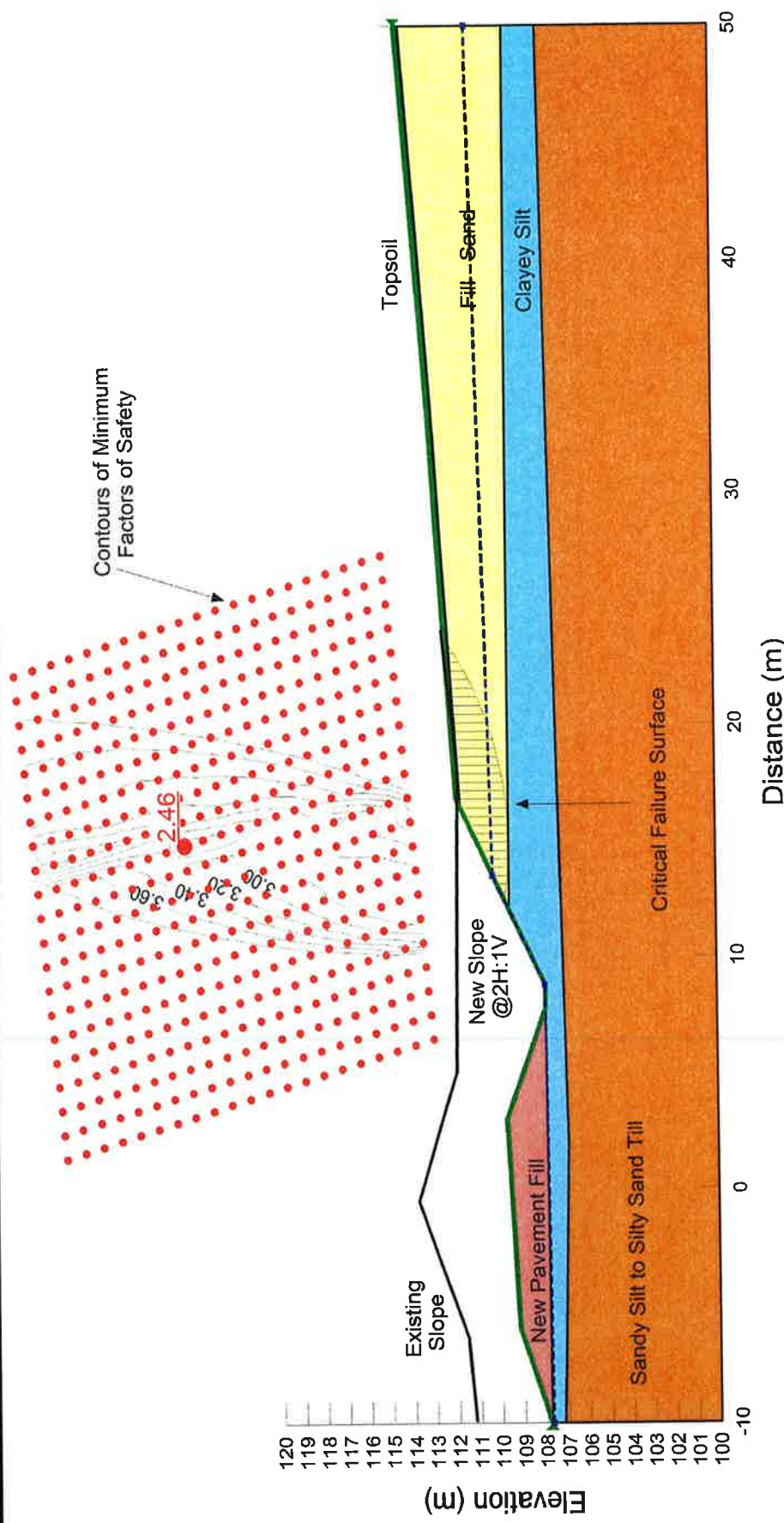


Section : Sta. 18+700
 Slope : 2H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 3

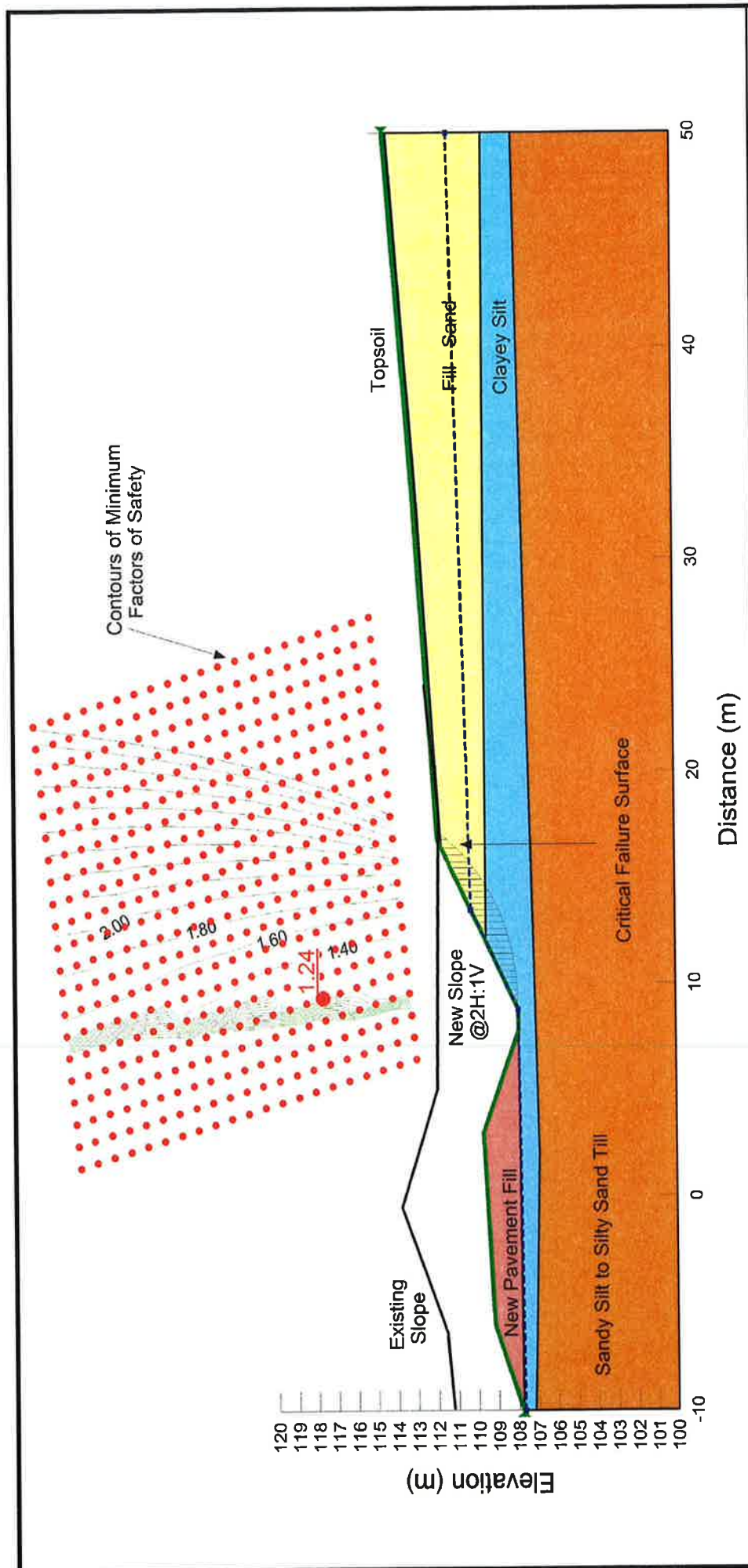


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+700
 Slope : 2H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 3





Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

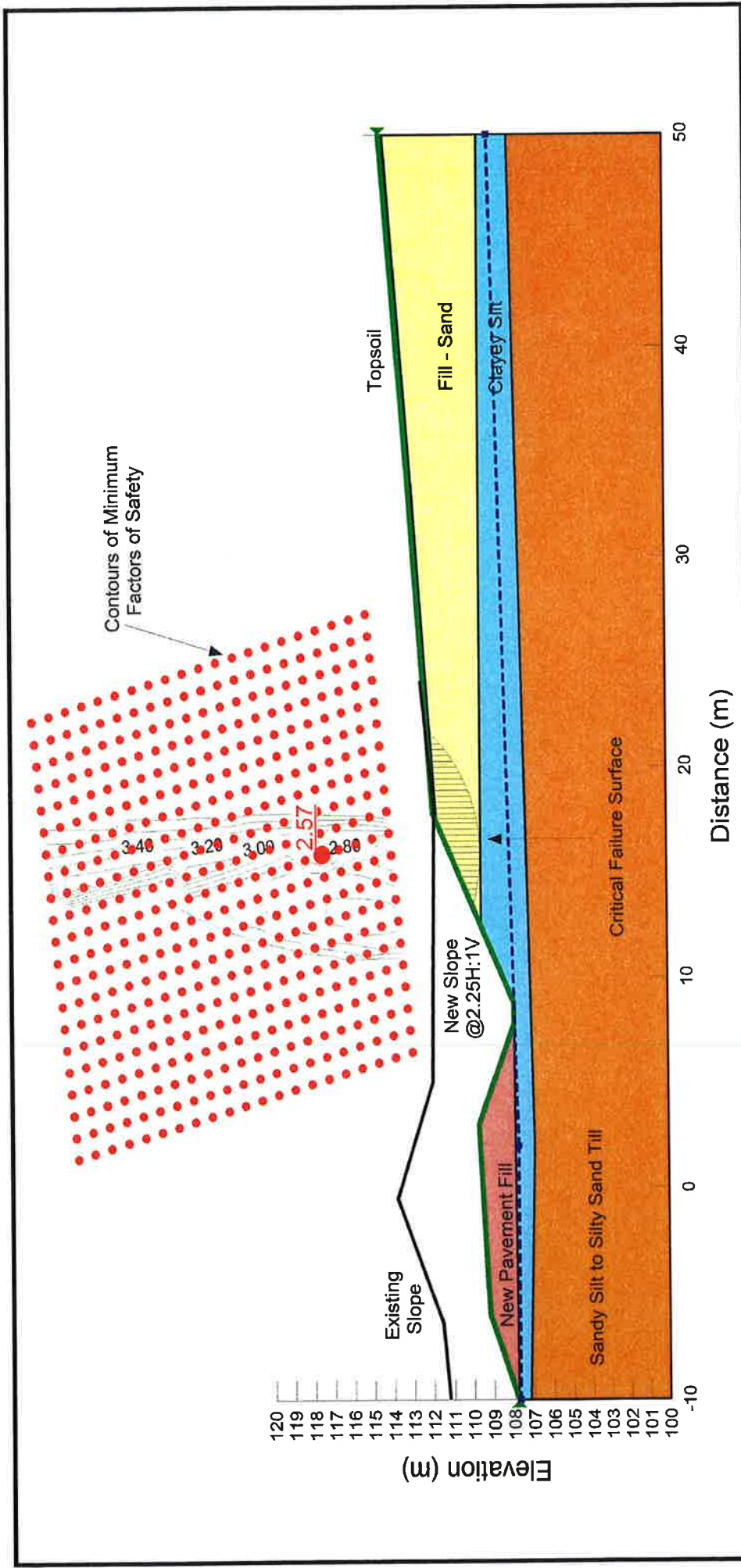
Section : Sta. 18+700
 Slope : 2H:1V
 Condition : Drained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 3



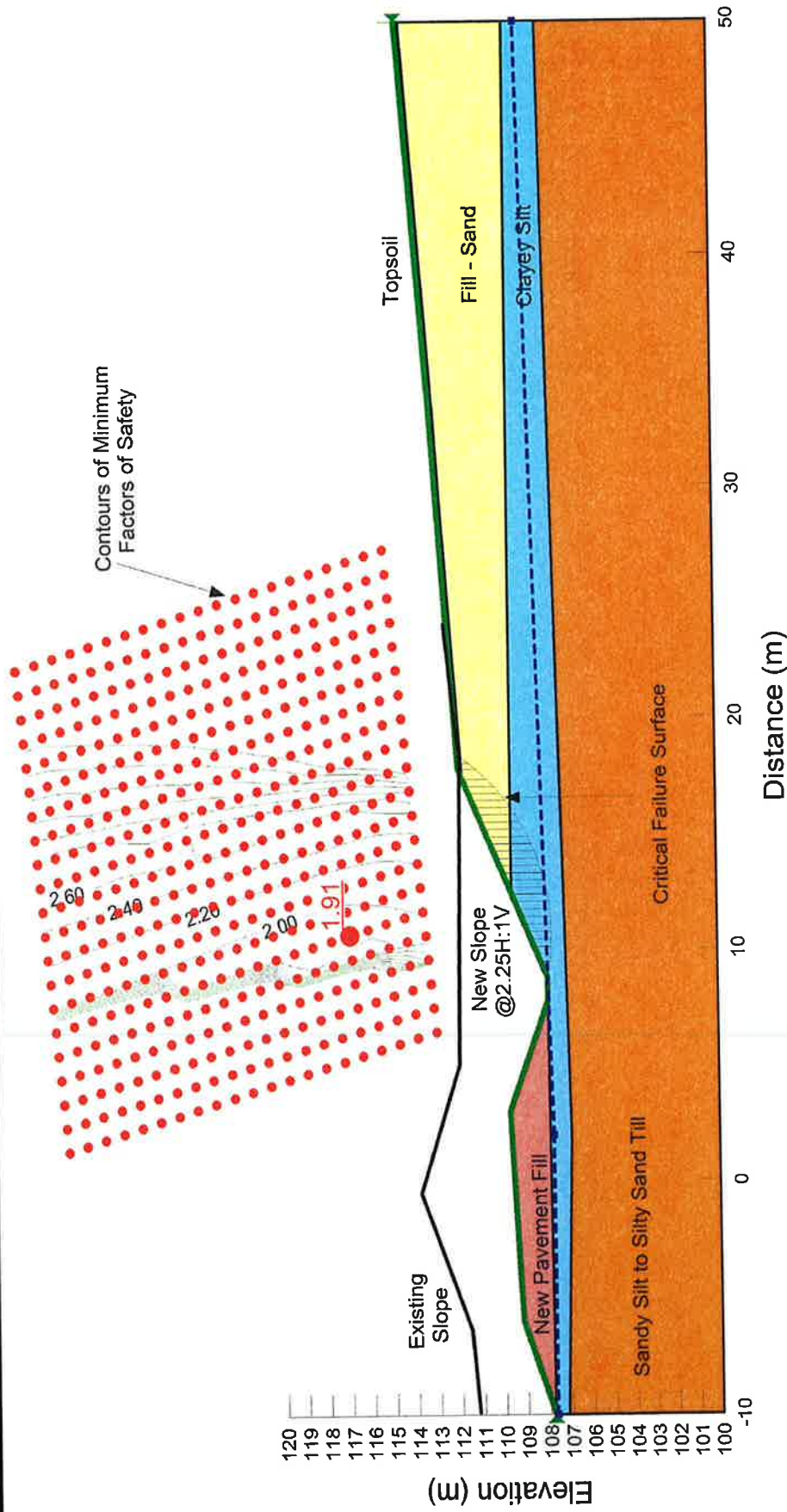
PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO
Highway 401 Expansion			FIGURE G3-4



Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+700
 Slope : 2.25H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

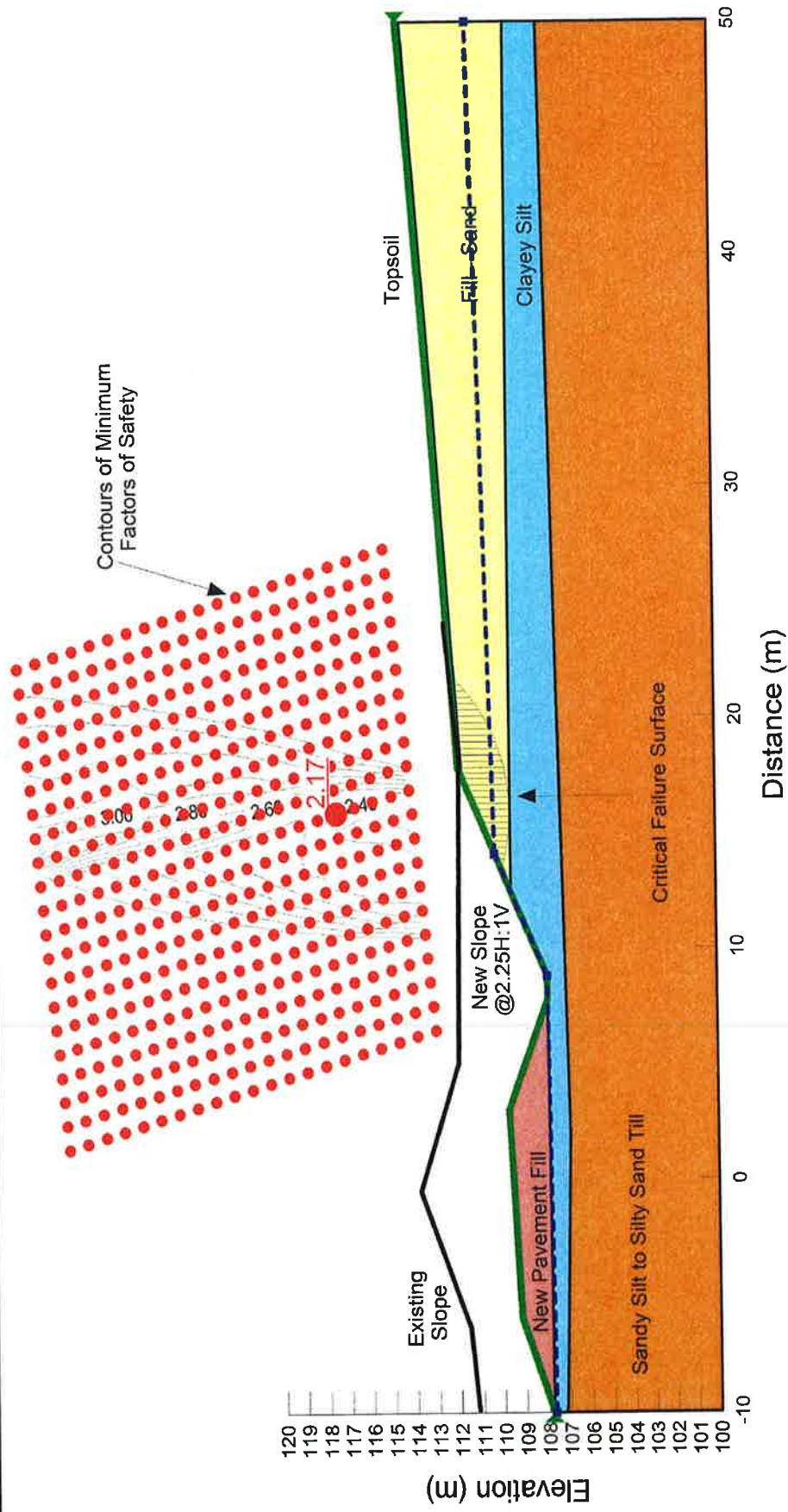
STATIC SLOPE STABILITY ANALYSIS
 Excavation Cut Area 3



Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+700
 Slope : 2.25H:1V
 Condition : Drained
 Measured water table
 Method : Morgenstern - Price

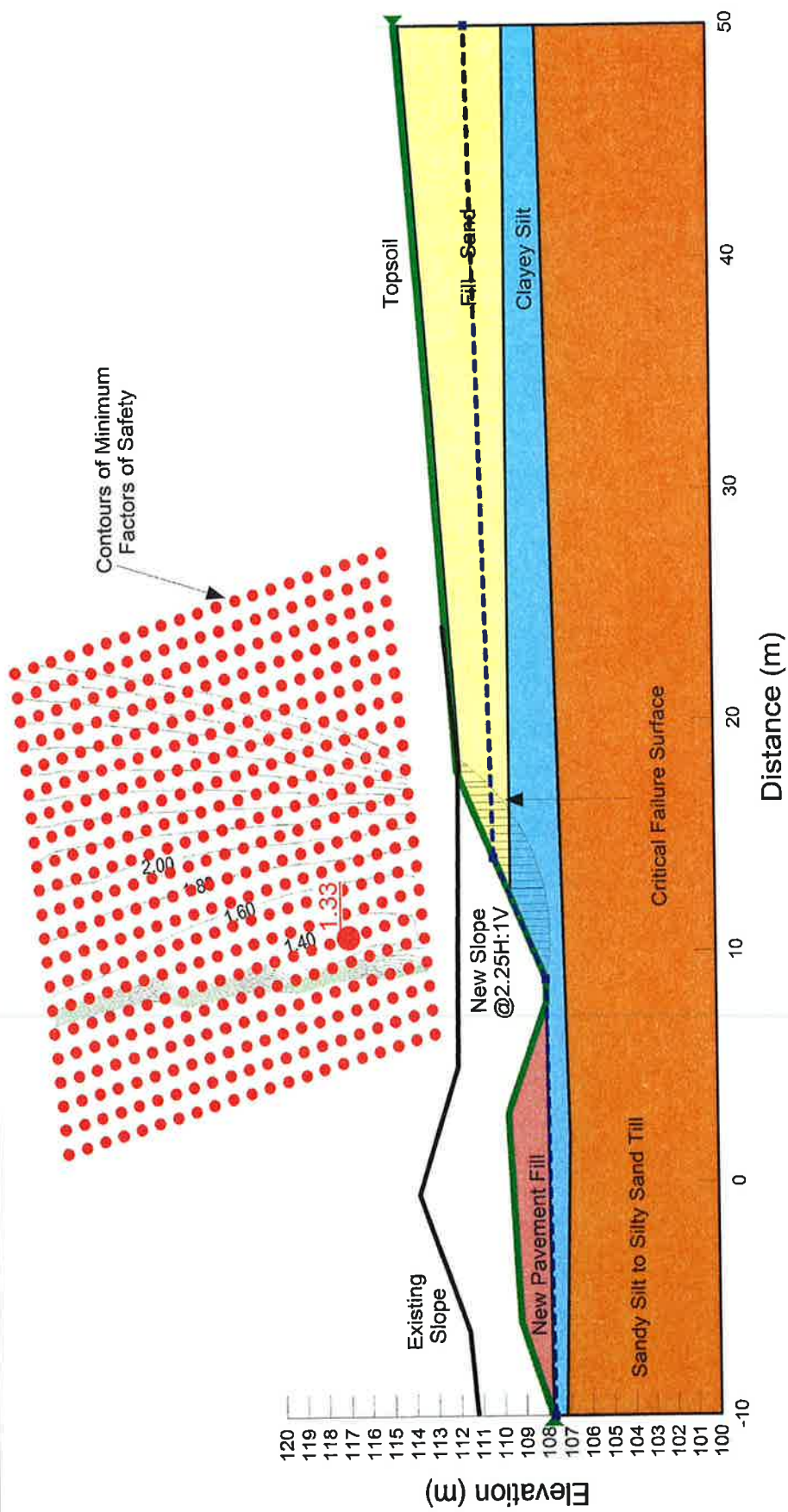
STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 3



Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+700
 Slope : 2.25H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 3

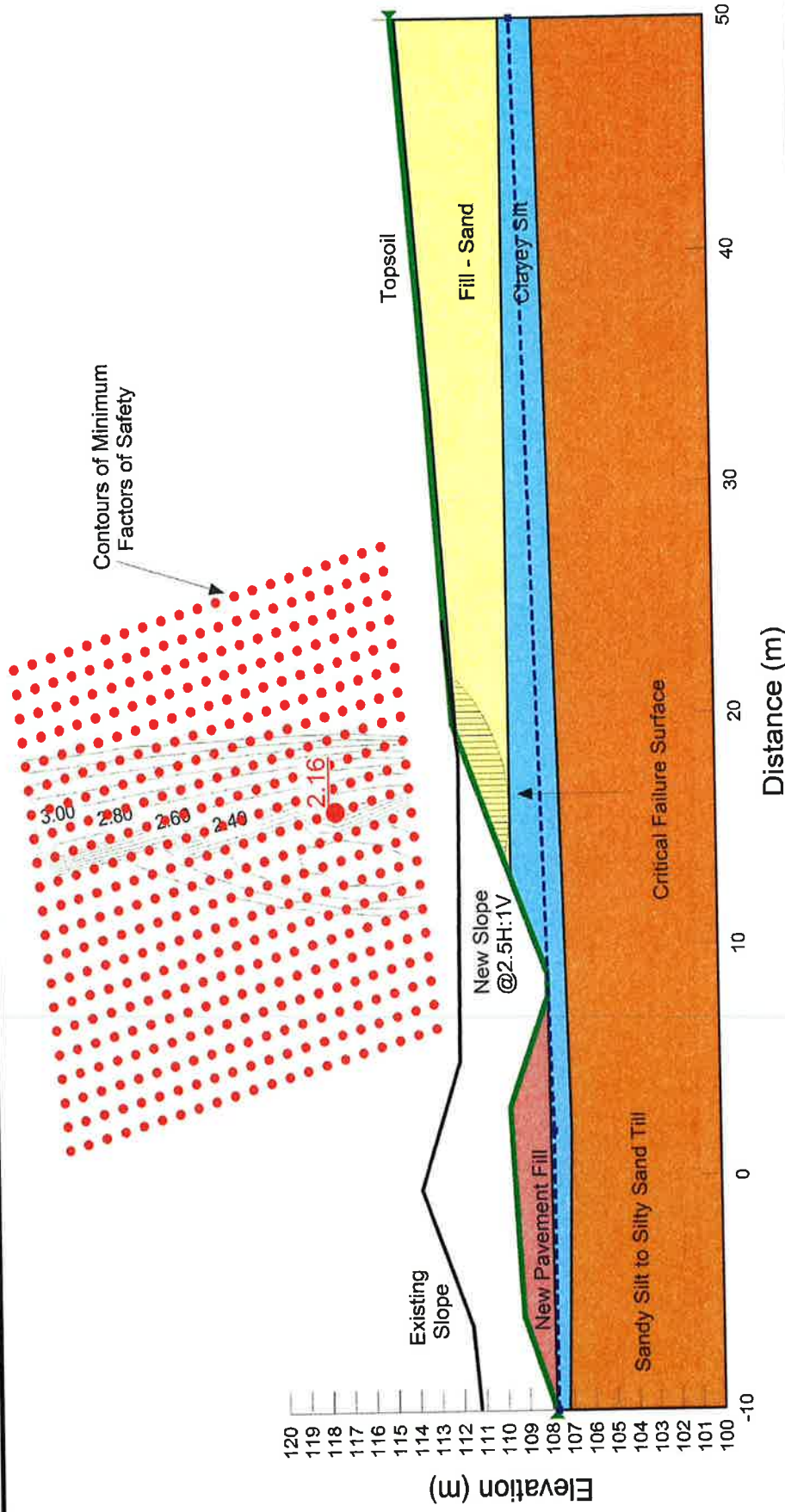


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+700
 Slope : 2.25H:1V
 Condition : Drained
 Mid-height water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS Excavation Cut Area 3

PROJECT:	TRANETOB10434AA-AN	DATE:	Jan-2012
DESIGN:	HW	REVIEW:	ZO

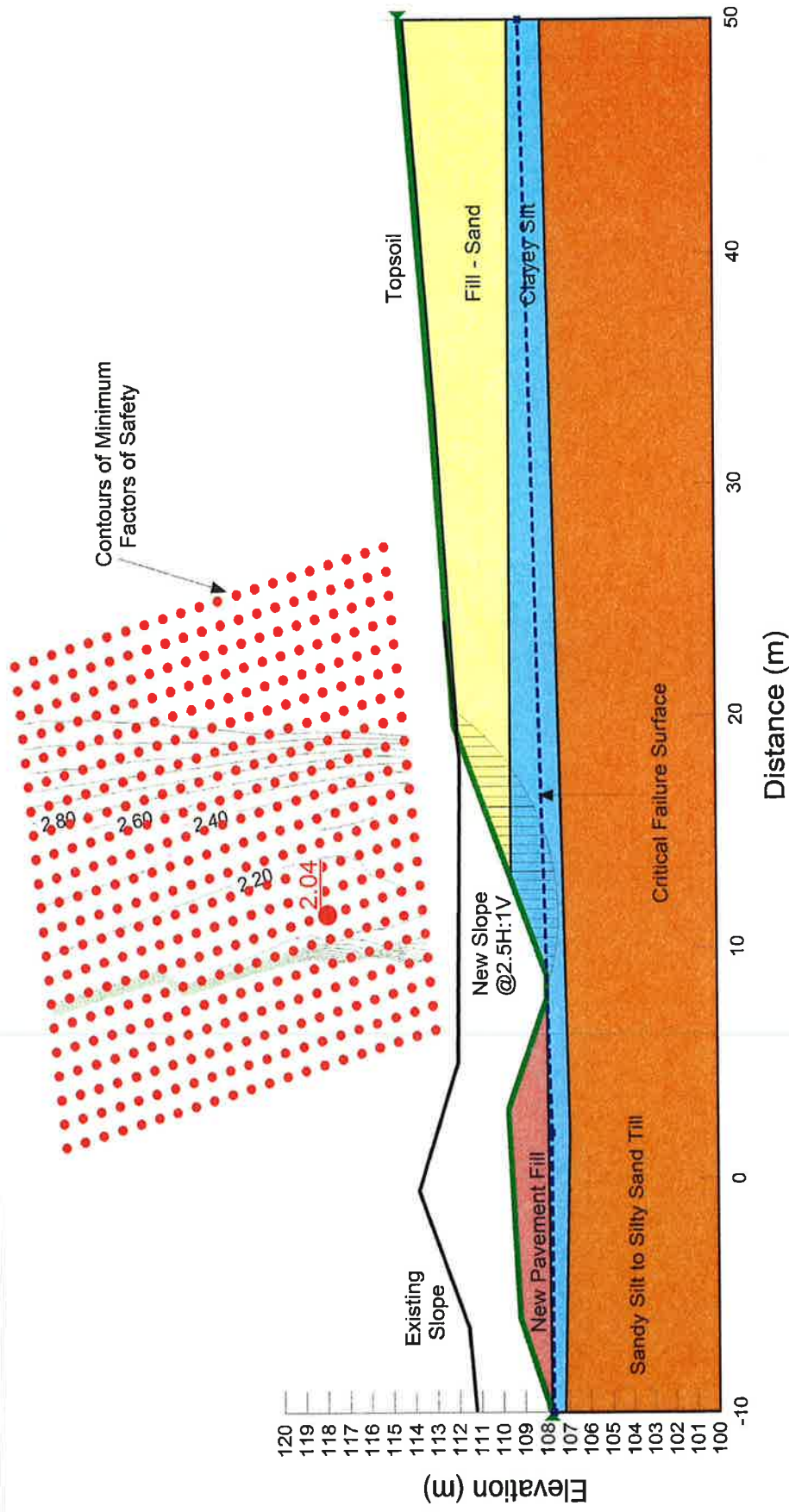


Section : Sta. 18+700
 Slope : 2.5H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

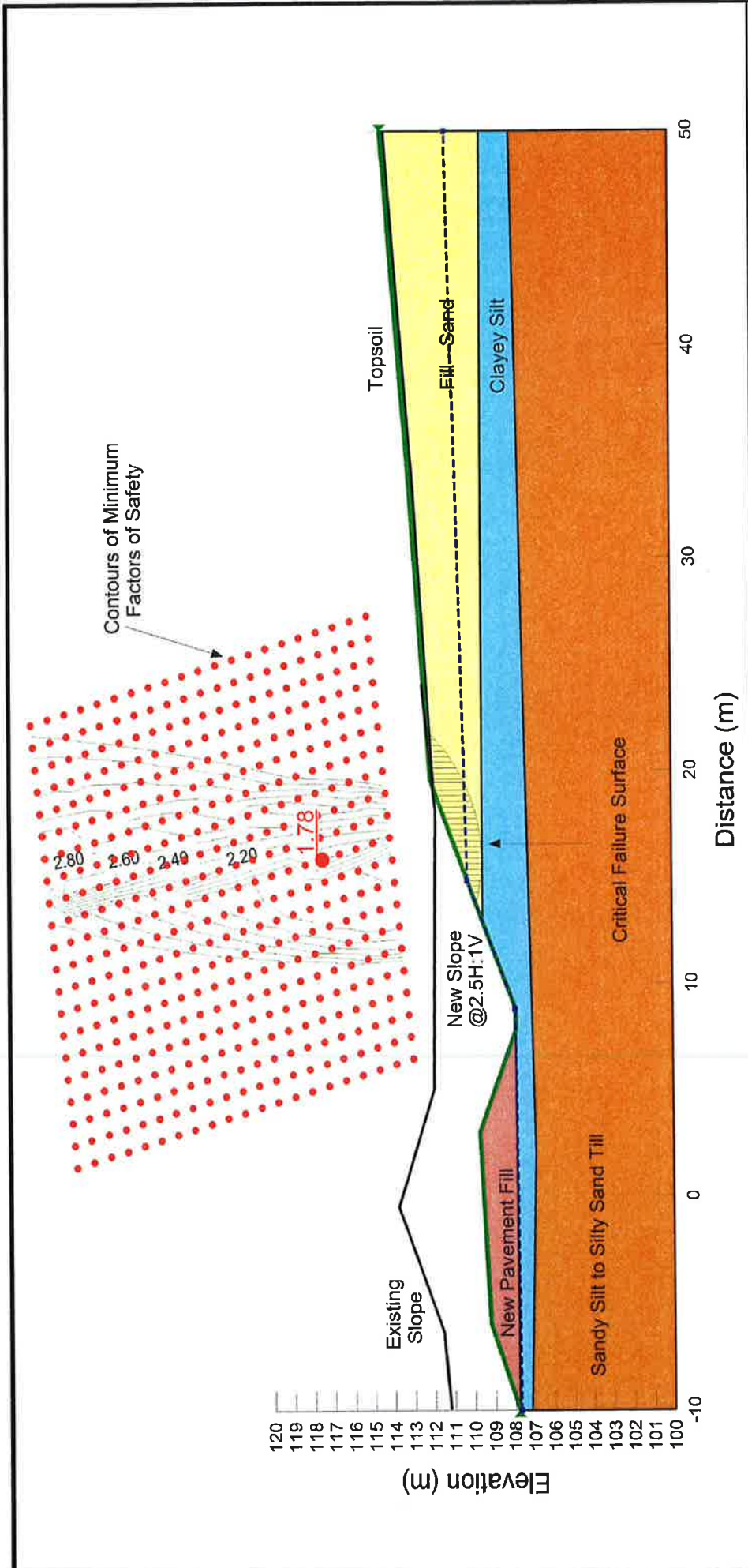
Excavation Cut Area 3



Section	Sta. 18+700	Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
Slope	2.5H:1V	New Pavement Fill	21.0	0	32
Condition	Drained	Fill - Sand	19.5	0	30
Method	Morgenstern - Price	Clayey Silt	20.0	5	28
		Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 3

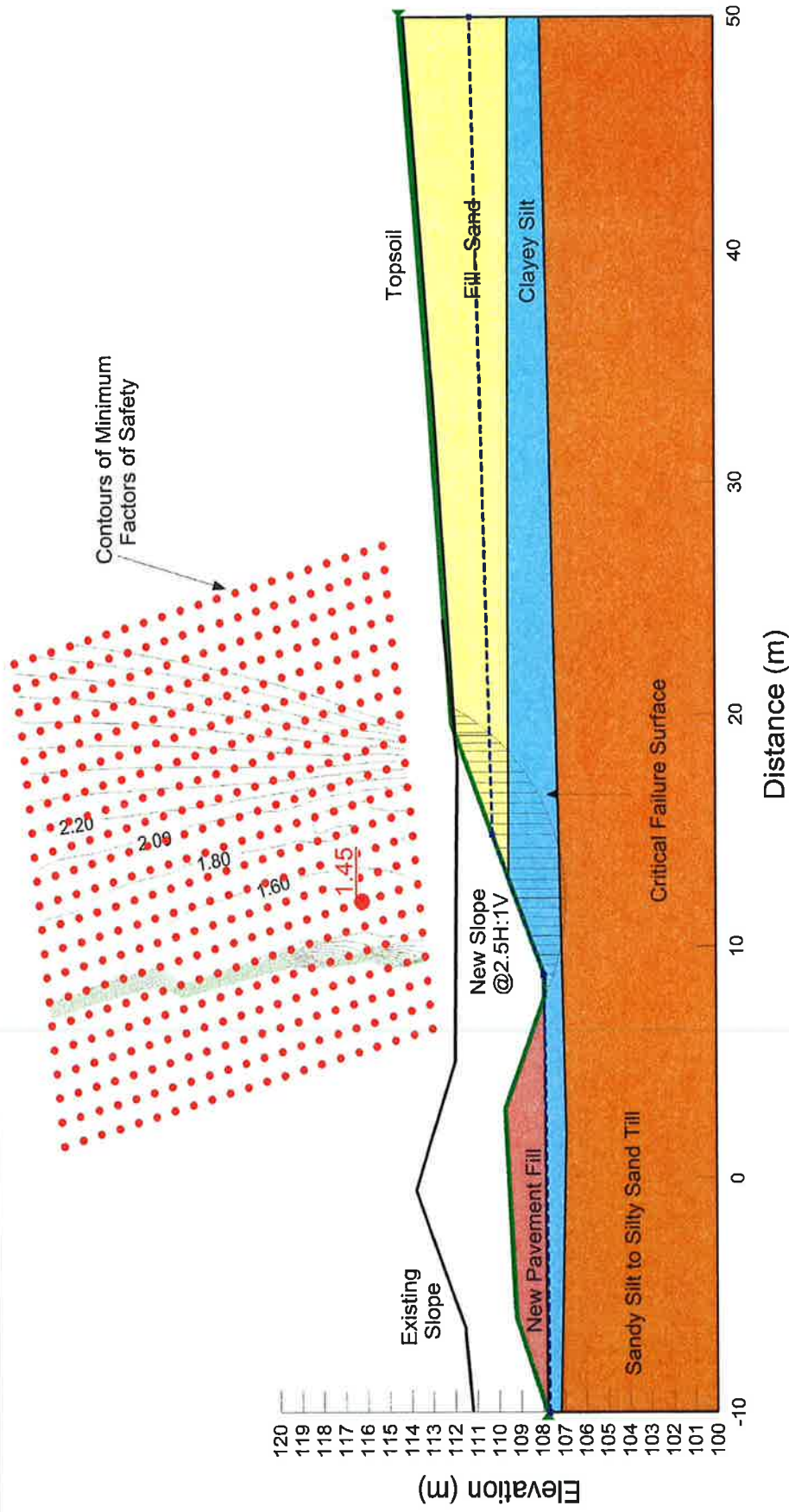


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

Section : Sta. 18+700
 Slope : 2.5H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

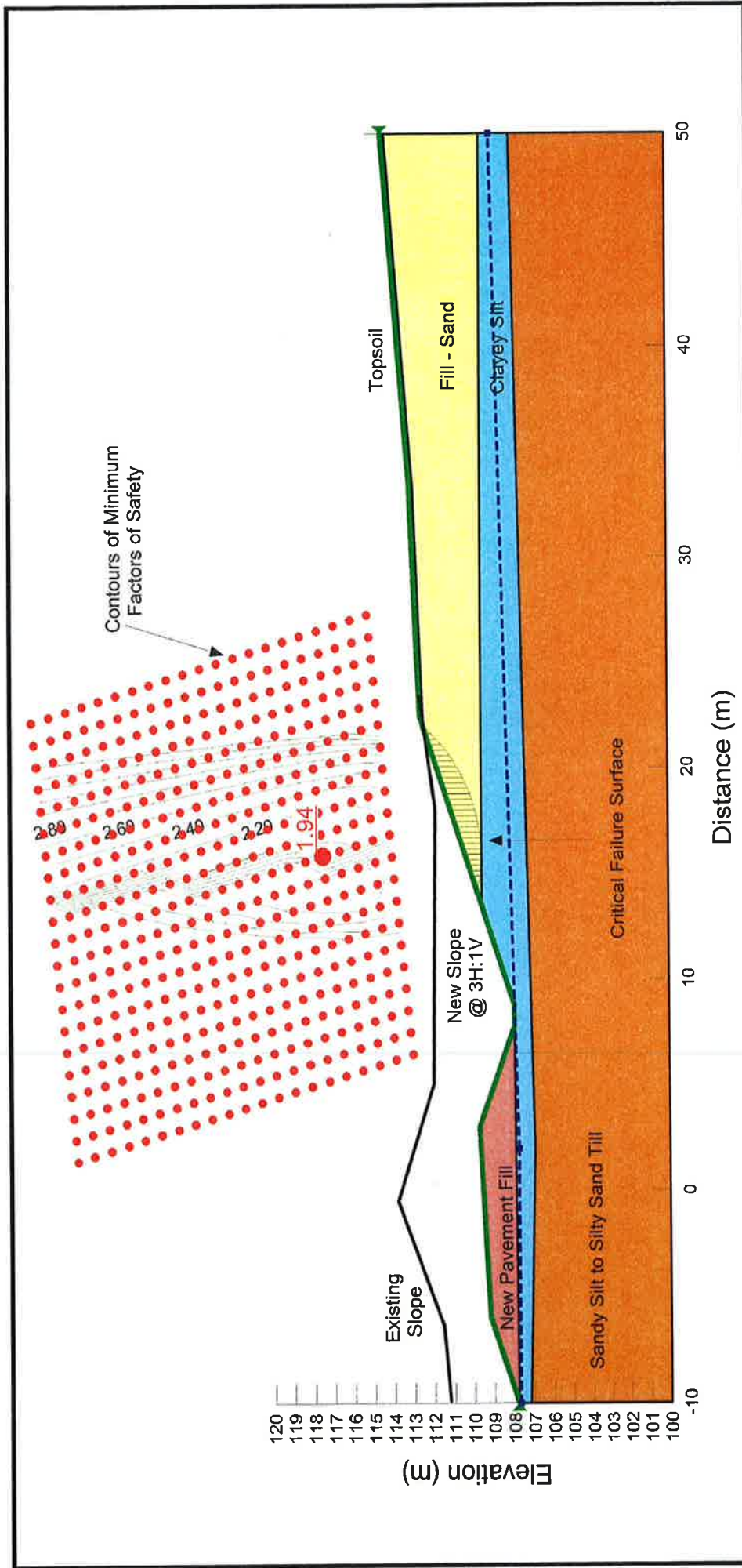
STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 3



Section : Sta. 18+700
 Slope : 2.5H:1V
 Condition : Drained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	5	28
Sandy Silt to Silty Sand Till	21.5	0	33

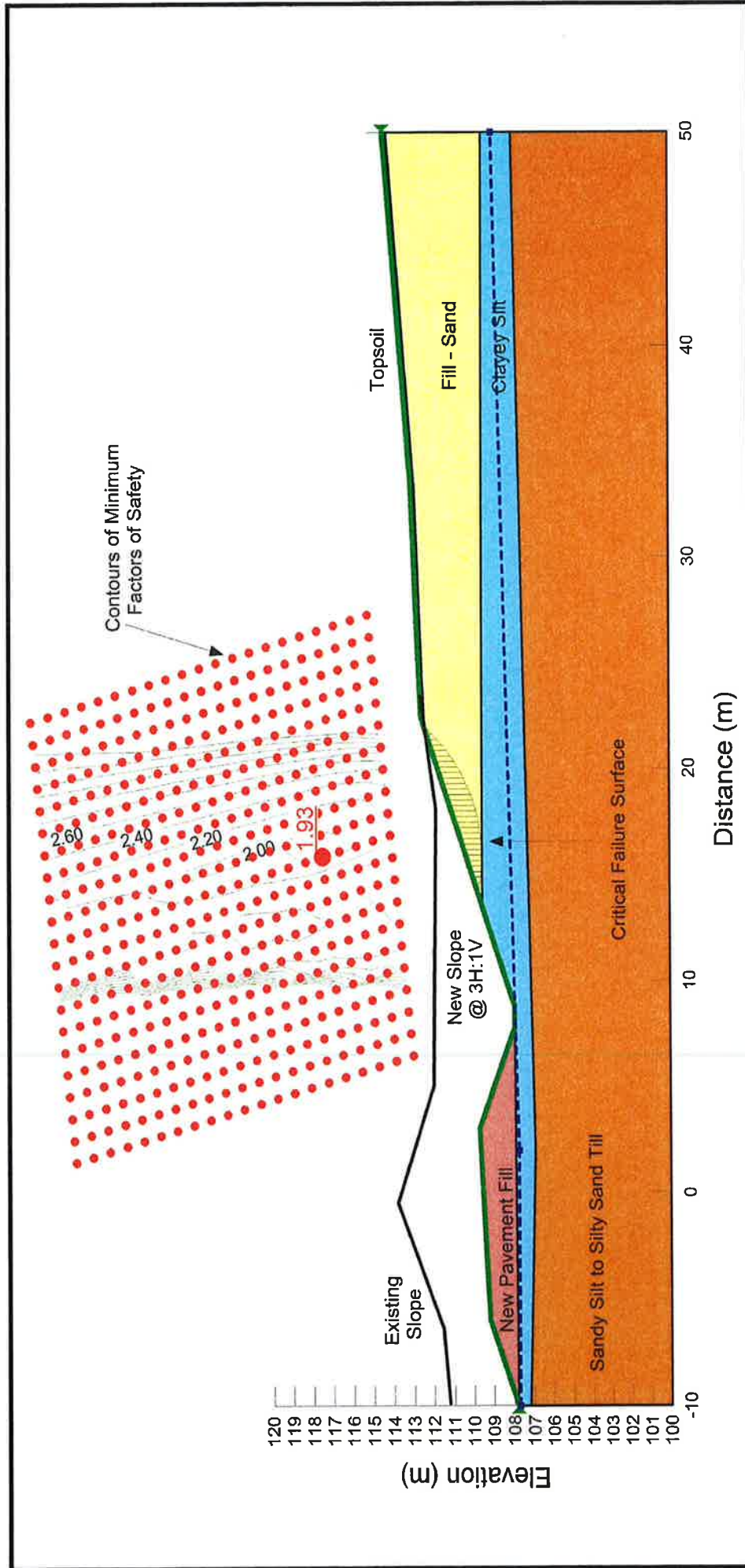


Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

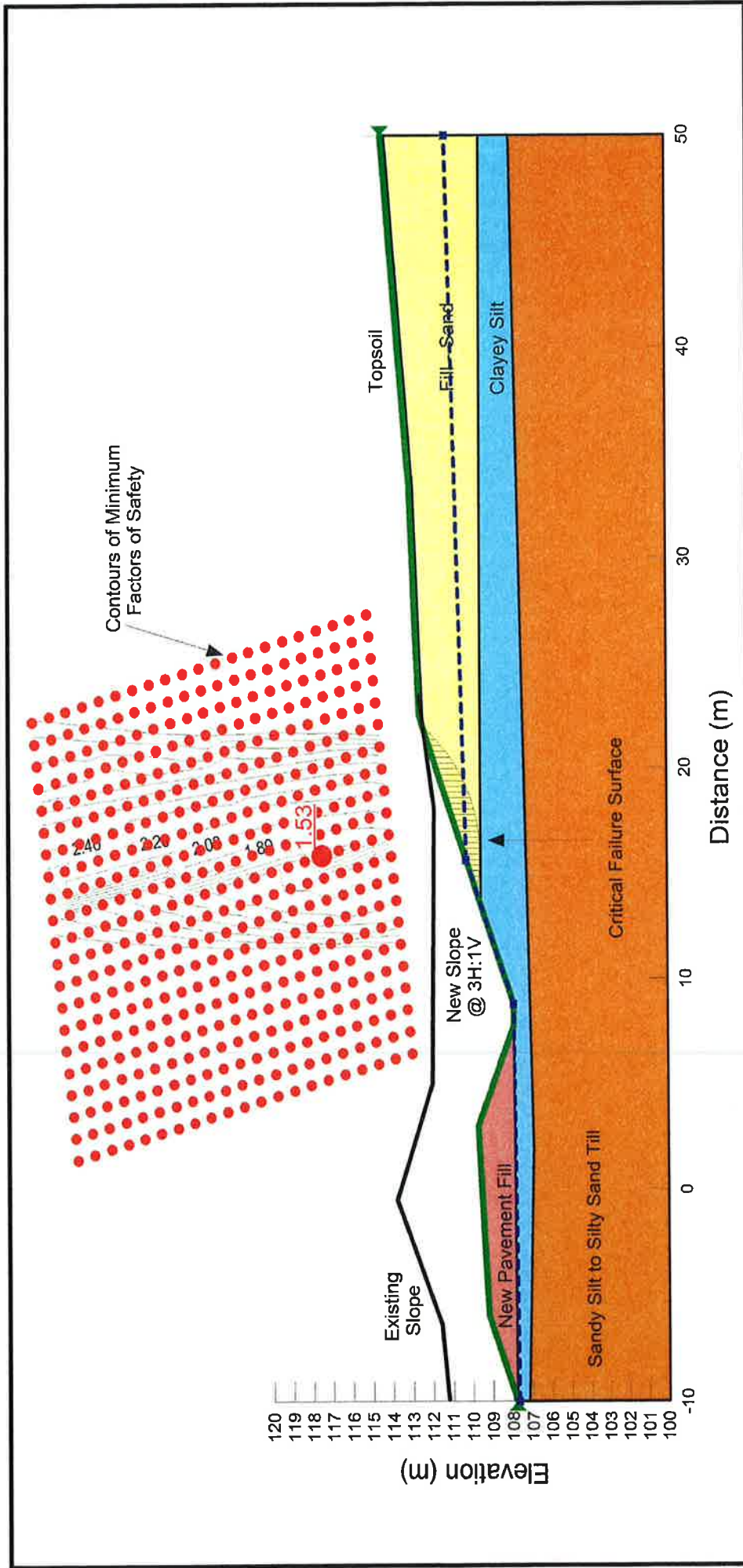
Section : Sta. 18+700
 Slope : 3H:1V
 Condition : Undrained
 Measured water table
 Method : Morgenstern - Price

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 3



Section : Sta. 18+700	Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
Slope : 3H:1V	New Pavement Fill	21.0	0	32
Condition : Drained	Fill - Sand	19.5	0	30
Measured water table	Clayey Silt	20.0	5	28
Method : Morgenstern - Price	Sandy Silt to Silty Sand Till	21.5	0	33

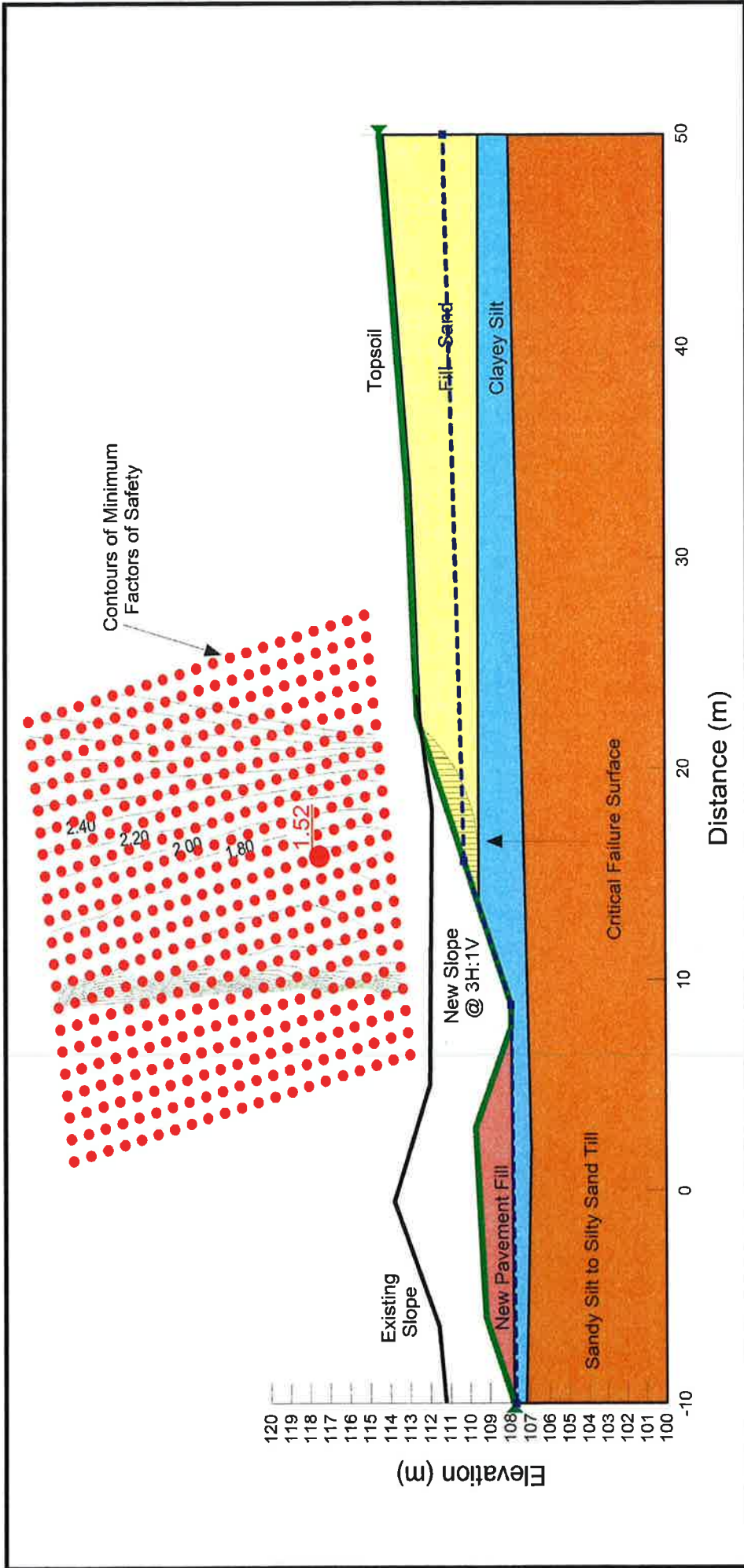


Section : Sta. 18+700
 Slope : 3H:1V
 Condition : Undrained
 Mid-height water table
 Method : Morgenstern - Price

Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
New Pavement Fill	21.0	0	32
Fill - Sand	19.5	0	30
Clayey Silt	20.0	60	0
Sandy Silt to Silty Sand Till	21.5	0	33

STATIC SLOPE STABILITY ANALYSIS

Excavation Cut Area 3



Section : Sta. 18+700 Slope : 3H:1V Condition : Drained Mid-height water table Method : Morgenstern - Price	Stratum	γ (kN/m ³)	c (kPa)	ϕ (°)
	New Pavement Fill	21.0	0	32
	Fill - Sand	19.5	0	30
	Clayey Silt	20.0	5	28
	Sandy Silt to Silty Sand Till	21.5	0	33



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

PROJECT: TRANETOB10434AA-AN
 DESIGN: HW

DATE: Jan-2012
 REVIEW: ZO

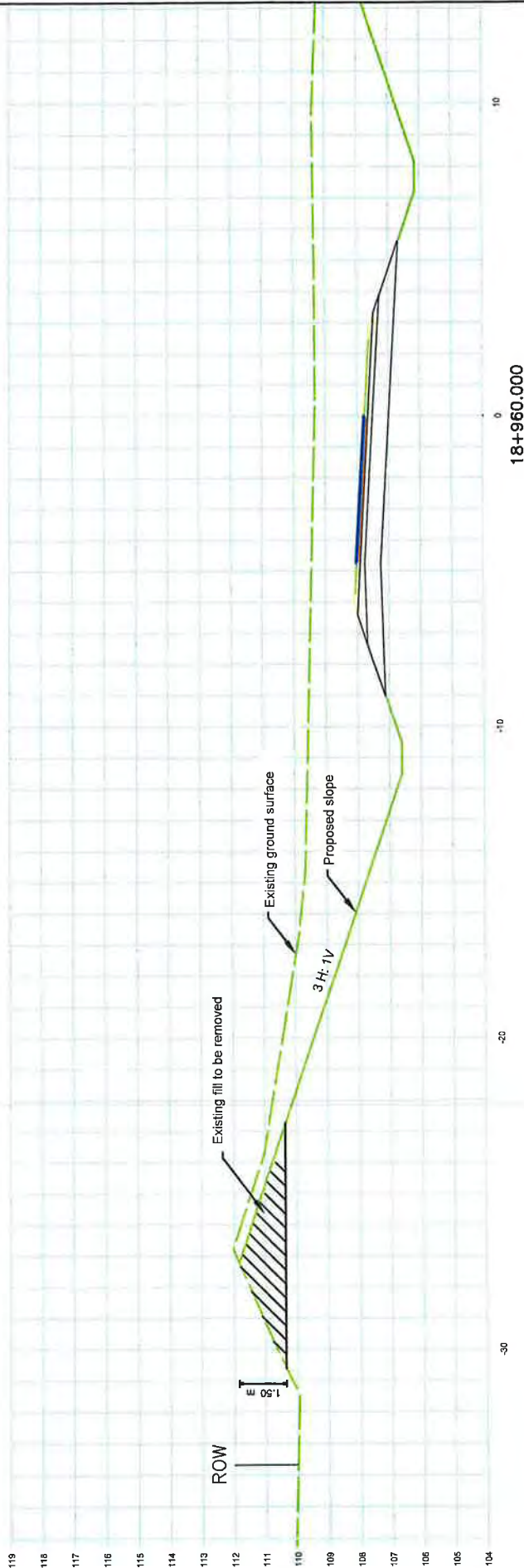
STATIC SLOPE STABILITY ANALYSIS
 Excavation Cut Area 3

Highway 401 Expansion

Appendix H

**Recommended Slope Protection Measures for the Excavation Cut Areas and A
Sketch of the Stripping of Top 1.5 m of the Existing Fill in Cut Area 2**

Stripping top 1.5 m of the existing fill for cut area 2 (from station 18+890 to station 18+970)



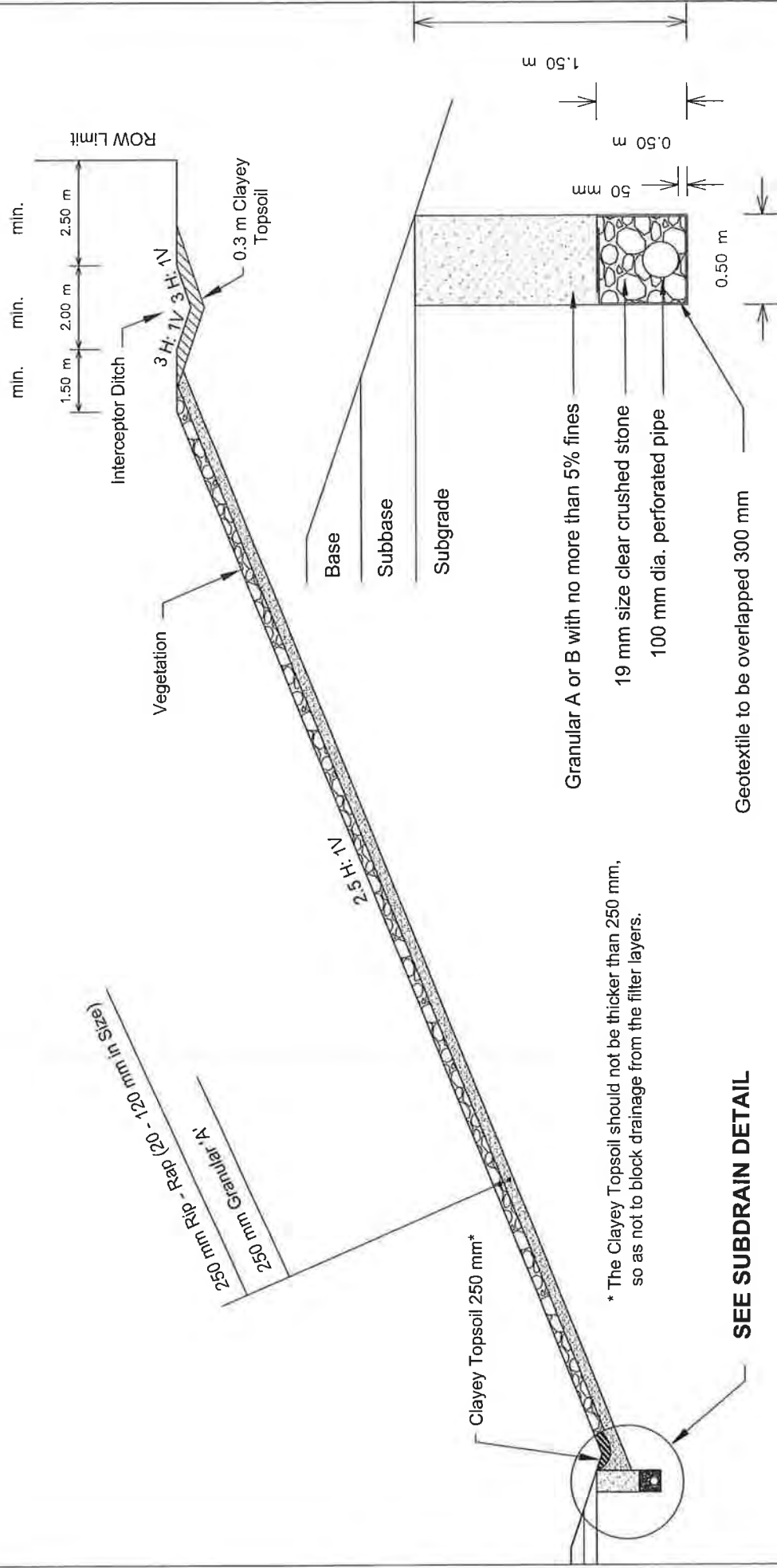
Note:

This drawing should be read in conjunction with the accompanying report.

drawn	SH	client: AECOM	
approved	HW	project: HIGHWAY 401 EXPANSION	
date	Oct. 2011	DEEP CUTS ON PROPOSED W-S, W-N & N/S-E RAMPS AT COUNTY RD. 45	
scale	Not to scale	title: A SKETCH OF THE STRIPPING OF TOP 1.5 m OF THE EXISTING FILL IN CUT AREA 2	
original size	Letter	project no: TRANETO10434AA	figure no: H-2



RECOMMENDED SLOPE FOR PROTECTION MEASURES FOR CUT AREAS



SUBDRAIN DETAIL

Note:

This drawing should be read in conjunction with the accompanying report.

client:

AECOM

project:

**HIGHWAY 401 EXPANSION
DEEP CUTS ON PROPOSED W-S, W-N & N/S-E RAMPS AT COUNTY RD. 45**

title:	RECOMMENDED SLOPE PROTECTION MEASURES FOR CILT AREAS
--------	--

project no:

TRANETOB10434AA

FIGURE no:

H-3

drawn	SH
approved	HW
date	Apr. 2012
scale	Not to scale
original size	Letter

Appendix I

List of SP and OPSSs

List of SP and OPSSs referenced in the report

SP 206S03 Grading, Earth and Rock Excavation, Excavation for Pavement Widening

OPSS 180 Management of Excess Material

OPSS 201 Clearing, Close Cut Clearing, Grubbing, and Removal of Surface and Piled Boulders

OPSS 206 Grading

OPSS 501 Compacting

Appendix J

Suggested Nssp

Suggested Text for NSSP on “Slope Stability during Construction”

To maintain the stability of cut slope during construction, additional loading such as stockpile, heavy machinery or any surcharge loads should not be present within a horizontal distance from the crest of the slope equal to the vertical height of the cut, during construction.

Appendix K

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.