FOUNDATION INVESTIGATION AND DESIGN REPORTS
PROPOSED HIGHWAY 404 EXTENSION
ADVANCE STRUCTURES AT MOUNT ALBERT ROAD
TOWN OF EAST GWILLIMBURY, ONTARIO
MTO CENTRAL REGION
W.O. 04-20024
AGREEMENT NO. 2004-E-0051

Prepared For:

UMA ENGINEERING LTD.

Prepared by:

SHAHEEN & PEAKER LIMITED

Project: SPT1178
April 24, 2007

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1. INTRODUCTION

Shaheen & Peaker Limited (S&P) was retained by UMA Engineering Limited (UMA) to carry out a foundation investigation at the site of the proposed Highway 404 Extension/Mt. Albert Road advance structures. The site is part of the future extension of Highway 404 in the MTO Central Region, north of Green Lane in the Town of East Gwillimbury, Region of York, in Ontario.

The project involves the detailed design of twin bridges for the proposed Highway 404 overpass at Mt. Albert Road and associated abutments and approach embankments, as well as the proposed Mt. Albert Road cut.

In 2004, a preliminary study was conducted by URS Canada Inc. and a foundation investigation was carried out by Golder Associates Ltd. for the preliminary structural design of the project. Excerpts from the Draft Transportation Environmental Study Report, Hydrogeological Assessment and related drawings were provided in the RFP and the associated clarification documents. As a result, a detailed geotechnical investigation was recommended to confirm the subsurface conditions, foundation recommendations and the design assumptions indicated in these reports.

The Terms of Reference (TOR) for this foundation investigation are outlined in the MTO's Request for Proposal (RFP) for Assignment No. 2004-E-0051, issued on January 2005 and the associated clarification document and the subsequent S&P Proposal P07149 dated July 14, 2005.

The purpose of this follow-up investigation was to obtain supplementary subsurface information for detailed design of the proposed structures by means of boreholes and to determine the engineering characteristics of the subsurface soils by means of field and laboratory tests. The findings of this supplementary investigation for the proposed overpass structures are presented in this report.

For the purposes of this report, the plans for the two proposed Northbound (NB) and Southbound (SB) Highway 404 bridges (including the north and south abutments and approach embankments) and for the new Mt. Albert Road cut provided by UMA Engineering, and the subsoil profiles encountered at the borehole locations are presented on Drawings No. 1, 2, 3 and 4.

2. SITE DESCRIPTION AND PHYSIOGRAPHY

The study area is the site of the proposed Highway 404 Extension and Mt. Albert Road overpass. The proposed overpass structures will be located about 350 m west of the existing Mt. Albert Road & Woodbine Avenue intersection in the Town of East Gwillimbury. In general, the topography of the site is flat-lying to gently sloping towards south and east.

According to the Physiography of Southern Ontario (by Putnam & Chapman) and the Ontario Geological Survey Map P.2715, the study area is located within the Peterborough Drumlinized Till Plain, east of Lake Simcoe Lowlands, Holland Landing Marsh and Schomberg Clay Plains and north of Oak Ridges Moraine. In the western portion of the Peterborough Till Plain, the drumlinized till is typically sandy. Some of the drumlins in this area are covered with shallow silt and fine sand. Drumlins with exposed bouldery surfaces are also present near the Simcoe Lowlands immediately south and east of Lake Simcoe. Localized deposits of silt, clay and peat may also be present in the low-lying areas between drumlins.

3. REVIEW OF EXISTING GEOTECHNICAL INFORMAT ION

The Preliminary Foundation Investigation and Design Report by Golder Associates dated April 2006 obtained from GEOCRES database (31D-408) was reviewed. In addition, the associated groundwater protection plan, issued as an addendum to Final Hydrogeological Assessment Report in April 2006 by Golder Associates Ltd., was reviewed. The existing subsurface information contained in these reports has been incorporated in our investigation in accordance with the TOR. Borehole information relevant to this investigation is presented in Appendix C of this report.

The fieldwork for the preliminary investigation was carried out in May 2004 and included a total of 4 boreholes at various locations near the proposed structures. The results indicated that the subsurface conditions at the site consist of silt deposits, interlayered with glacial till which ranges from clayey silt till to sandy silt till. The groundwater level was found to be relatively high, varying between 1 m and 1.5 m below the existing ground surface.

Considering the reported borehole locations and coordinates on the logs and the associated drawings, we have included two of the earlier boreholes in particular as listed in Table 1 below because their anticipated depth and positions have satisfied the requirements of the TOR for this geotechnical investigation with respect to the location of the proposed structures. It is noted that both of these boreholes had extended at least 3 m below competent strata.

Table 1: Utilized borehole information from Golder's Report

Existing BH No.	Locations	BH Depth (m)
BH 101	Proposed NBL north abutment	10.8
BH 103	Proposed SBL south abutment	12.3

As a result of our preliminary review, we have determined that additional boreholes are needed to meet the MTO requirements in the RFP. Therefore, a supplementary geotechnical investigation program was developed and carried out as described in the following section. The number of boreholes in this program and their locations with respect to the structures satisfy or exceed the MTO protocol for detailed geotechnical investigation. Boreholes 102 and 104 of the previous (Golder Associates) investigation are also included in this report, as they provide additional information.

4. SITE INVESTIGATION

Based on our review and evaluation of the available geological information and existing information from MTO sources (e.g., GEOCRES); results of earlier investigations in RFP documents and other pertinent subsurface information (including the nature of the terrain and the performance of the existing structures and/or roads); and a preliminary site reconnaissance visit (to verify access to site and ability to drill at the precise locations); a foundation investigation was planned and carried out as follows.

4.1 INVESTIGATION PROGRAM

The fieldwork for the foundation investigation was performed during the period of August 10 through September 13, 2006. As per the TOR (agreed by MTO), the field investigation program consisted of drilling and sampling twenty-two (22) boreholes, M1 to M16, P1 to P4, and R2 and R3, at the locations shown on the plan and profile drawings (Drawings No. 1 to 4) and summarized in Table 2. The depth of boreholes varied from 6.6 to 15.6 m.

Table 2: Overview of Field Investigation Program

<table>
<tr><th colspan="2">Design Elements</th><th>Number of BHs</th><th>Max. BH Depth (m)</th><th>No. of Piezometer</th></tr>
<tr><td rowspan="3">NB and SB Highway 404 Bridges</td><td>NB Abutments</td><td>3</td><td>15.6</td><td rowspan="3">4</td></tr>
<tr><td>SB Abutments</td><td>3</td><td>15.7</td></tr>
<tr><td>Approach Embankments</td><td>4</td><td>7.8 to 8.1</td></tr>
<tr><td colspan="2">Mt. Albert Road Cut</td><td>12</td><td>3.4 to 10.4</td><td>9</td></tr>
<tr><td colspan="2">Total</td><td>22</td><td>3.4 to 15.7</td><td>13</td></tr>
</table>

4.1.1 BRIDGES, APPROACH EMBANKMENTS AND ABUTMENT WALLS

As per the TOR for deep foundations (in the RFP document), for detail design of each foundation element, two (2) boreholes were advanced to at least 15 m depth to verify the subsurface conditions to the founding elevation for the element and below. A minimum of one exploratory borehole was drilled at each bridge approach to investigate the embankment foundations and to verify assumptions regarding embankment performance. At approach embankments, boreholes were extended to a minimum of 100% of the embankment fill height or cut depth below the base of the fill or cut. Considering two earlier Golder Associates Boreholes No. 101 and 103 drilled near two abutments from previous report, the field investigation program for the two bridges consisted of six (6) new boreholes to at least 15 m depth at the location of the four proposed abutments. The borehole locations were strategically selected to provide representative subsurface information across the plan area of the proposed foundation elements. Due to the presence of overhead hydro lines and underground Bell lines, boreholes for the north abutments were moved towards north.

In addition, four (4) boreholes were drilled at the approaches within 20 m of the abutment to a depth of approximately 8 m (i.e., Boreholes P1 through P4). In addition, two (2) piezometers were installed in two of these boreholes to monitor the groundwater condition.

Six deep boreholes to a maximum of 15.7 m were drilled for the structures (as tabulated below), as part of the detailed design phase of investigation at this site, in order to confirm the continuity of the hard/very dense lower till deposit with depth. The locations of piezometer installations at or near the limits of the Right-of-Way (ROW) were selected beyond the anticipated proposed crest of the road cut to allow groundwater monitoring during construction.

Table 3: List of Boreholes at Approach Embankments and Abutment Walls

<table>
<tr><th>Location</th><th>Design Element</th><th>BH No.</th><th>Depth (m)</th><th>Piezometer</th></tr>
<tr><td rowspan="6">Highway 404 SB Bridge</td><td rowspan="2">North Abutment</td><td>M5</td><td>15.7</td><td>No</td></tr>
<tr><td>M7</td><td>15.4</td><td>No</td></tr>
<tr><td>South Abutment</td><td>M6</td><td>15.7</td><td>Yes</td></tr>
<tr><td>North Approach Embankment</td><td>P1</td><td>8.1</td><td>Yes</td></tr>
<tr><td>South Approach Embankment</td><td>P3</td><td>8.1</td><td>No</td></tr>
<tr><td rowspan="6">Highway 404 NB Bridge</td><td rowspan="2">North Abutment</td><td>M8</td><td>15.6</td><td>No</td></tr>
<tr><td>M9</td><td>15.6</td><td>Yes</td></tr>
<tr><td>South Abutment</td><td>M10</td><td>15.6</td><td>No</td></tr>
<tr><td>North Approach Embankment</td><td>P2</td><td>8.1</td><td>No</td></tr>
<tr><td>South Approach Embankment</td><td>P4</td><td>7.8</td><td>Yes</td></tr>
</table>

4.1.2 PROPOSED DEEP CUTS ALONG MT. ALBERT ROAD

Based on the preliminary profile drawings prepared by URS, the proposed cut along Mt. Albert Road ranges from about 3 to 6 m below existing grade. The TOR required drilling boreholes at a maximum of 50 m intervals along Mount Albert Road from Station 9+800 to Station 10+250. Considering the abutment boreholes at the overpass locations, a total of 12 new boreholes were drilled up to about 10 m depth, as listed in Table 4 below. This table also includes the proposed cut depths and the location of the piezometers installed in most boreholes.

Table 4: List of Boreholes along the Proposed Mt. Albert Road Cut

BH No.	Stations	Offsets	Proposed Cut Depth from Rd C/L (m)	BH Depth (m)	Piezometers
M2	9+880	Shoulder 5m Rt C/L	4	6.6	yes
M3	9+930	30 m Rt C/L	5	10.4	yes
M4	9+930	27 m Lt C/L	5	10.4	yes
M11	10+070	34 m Rt C/L	6	10.1	yes
M12	10+070	20m Lt C/L	6	10.4	yes
M13	10+110	Shoulder 5 m Lt C/L	5.5	9.4	yes
M14	10+110	33m Rt C/L	5.5	9.5	yes
M1	10+145	34 m Lt C/L	4*	9.5	yes
M15	10+189.6	Shoulder 6m Rt C/L	4	6.3	No
M16	10+215	34 m Lt C/L	3*	9.3	yes
R2	9+820	5 m Lt C/L	2	3.7	No
R3	10+260	Shoulder 5 m Lt C/L	2	3.4	No

***** Existing road cut on the Lt side of the road is currently about 2 to 3 m high.

The preliminary profile drawings prepared by URS indicate that the proposed cut at the locations of Boreholes R2 and R3 is about 2 m. Foundation investigation guidelines for cut require borehole depth to 1.5 times the depth of cut or to 3 m below existing grade. Therefore, Boreholes R2 and R3 were drilled to a minimum of 3 m depth.

4.2 INVESTIGATION PROCEDURES

All field and laboratory works were carried out in accordance to the MTO field and laboratory procedures and protocols. Prior to drilling, all underground services were cleared. Also prior to commencement of the field work, the Region of York was advised and a detailed traffic control plan was prepared and submitted to UMA. All work was carried out in full compliance with OHSA Act and regulations, MOL requirements and appropriate traffic control measures (e.g., using appropriate protocols and signage), in accordance with the Ontario Traffic Manual – Book 7.

The field investigation included soil sampling and standard penetration tests with continuous flight augers (both solid and hollow stem augers). The field investigation was followed by laboratory geotechnical testing on selected recovered samples. The results of the field investigation and laboratory testing provided the necessary factual information concerning the vertical and horizontal extent of subsurface conditions (including both soil and rock and their pertinent engineering properties). Particular attention was paid to documenting groundwater conditions during drilling and in the piezometers installed in selected boreholes. It is recognized that the anticipated groundwater level along the proposed earth cut will have significant impact on the potential cost of dewatering during construction.

All borehole locations were staked out in the field by S & P staff. Upon completion of the boreholes, the borehole coordinates and elevations were determined by J.D. Barnes on behalf of UMA and were supplied to us.

The boreholes were advanced using continuous-flight hollow or solid-stem augers powered by a drilling rig, outfitted with tools and equipment for soil sampling and testing.

A specialist drilling contractor Eastern Soil Investigation carried out the drilling, field testing and sampling work under the direction and supervision of Geotechnical Engineers from S&P.

Normal interval of SPT testing and sampling is 0.76 m from the ground surface to 5 m depth, and then this interval is increased to 1.5 m below 5 m to a depth of 15 m. In this case, however, to capture the presence of pervious sand layers or lense and to minimize the risk of basal heave, close sampling and SPT testing (i.e., at 0.76m intervals of depth) were carried generally to full borehole depths. The Standard Penetration Test method (SPT) performed in general accordance with ASTM D1586, consists of freely dropping a 63.5 kg hammer a vertical distance of 0.76 m to drive a 51mm O.D. 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).

Groundwater conditions in the boreholes were observed during and on completion of drilling in the open boreholes and in the installed piezometers. Follow-up groundwater monitoring was also conducted to measure the stabilized groundwater levels in the piezometers. Upon their completion, the open boreholes were grouted using a cement/bentonite mixture as per

MTO procedures in accordance with Ministry of the Environment Regulation 903 and its Amendments (the water well regulation under the OWRA). Grouting was effected in the boreholes containing piezometers. However, the pipes were not decommissioned so that they can be utilized to monitor groundwater levels, prior to and during construction, if required.

The soil samples were transported to our geotechnical laboratory in Toronto for further examination and classification. A laboratory testing programme, consisting of natural moisture content determinations, grain size analyses and Atterberg Limits tests, was performed on selected representative samples according to the following specifications:

- Sieve Analysis (LS-602)
- Natural Moisture Content (LS-701)
- Particle Size Analysis (LS-602/LS-702)
- Atterberg Limits (LS-703/LS-704)

The results of the laboratory tests are presented on the appropriate Record of Borehole Sheets (Appendix A) and also in Appendix B.

5. SUBSURFACE CONDITIONS

The subsurface conditions were explored at twenty-two (22) boreholes (listed in Tables 2, 3 and 4 in Section 4 above) during the current investigation. The plan locations of the boreholes along with the inferred stratigraphic sections along the proposed Highway 404 bridges and Mt. Albert cut are shown on Drawings 1 to 4. Details of subsurface conditions encountered at each borehole location for the current investigation, including the results of in-situ testing, groundwater observations and laboratory test results, are presented on the Record of Borehole Sheets in Appendix A. Detailed laboratory test results are enclosed in Appendix B. Relevant borehole information (Records of Boreholes) from previous preliminary investigation at the site (Boreholes BH 101 to BH 104) put down by others in May 2004 is also provided in Appendix C for reference purposes.

In general, the subsurface stratigraphy comprises topsoil/pavement structure underlain by a sequence of upper and lower silt and till deposits, respectively. The upper silt deposit is underlain by an upper clayey silt till/sandy silt till deposit, which is in turn underlain by a lower silt deposit. The lower silt deposit is underlain by a lower clayey silt till/sandy silt till deposit. The groundwater table was found to be between 0.6 and about 2.5 m below existing grade, but generally 1 to 1.5 m deep.

The various strata encountered in the boreholes and their geotechnical properties are briefly described in the following subsections of this report. Please note that the following summary is to assist the designers of the project with an understanding of the anticipated soil conditions across the site. Detailed geotechnical information is presented in the Record of Borehole sheets (Appendix A). It should be noted that the soil and groundwater conditions may vary in between and beyond borehole locations.

5.1 TOPSOIL

Topsoil was encountered in Boreholes M1, M3 to M12, M14, M16, and P1 to P4, ranging in thickness between about 0.1 and 0.25 m. It should be noted that the thickness of topsoil may vary in between and beyond the borehole locations.

5.2 FILL

Boreholes M2, M13, M15, R2 and R3 drilled on the shoulders of existing Mt. Albert Road encountered granular fill extending to about 0.8 m to 1.4 m depth, or El. 269.8 m in BH M2 to 264.8 m in BH R3. The fill layer in these boreholes consists of surficial sand and gravel, underlain by sand and silt in some boreholes.

The measured SPT “N” values of 17 to 38 blows per 0.3 m of penetration suggest that this granular fill layer is generally in a compact to dense state. The measured natural moisture contents in the upper sand and gravel fill ranged from 2 to 3%.

Grain size analyses were carried out on three samples of the granular pavement fill materials with the results as follows:

Table 5: Results of Grain Size Analysis for Pavement Fill

Sample	Depth (m)	Mid-El. (m)	Gravel	Sand	Silt
BH M2/SS1	0 - 0.6	270.3	26%	57%	17%
BH M13/SS1	0 - 0.6	270.1	11%	69%	20%
BH M15/SS1	0 - 0.6	267.9	42%	46%	12%

In summary, the tested samples of granular pavement fill consisted of: 11-42% Gravel, 46-69% Sand, and 12-20% Silt & Clay. The grain size distribution curves are shown in Figure B1 in Appendix B.

Figure B2 presents the results of grain size analysis from two samples of the silty sand to silt and sand fill materials underlying the pavement fill. These consist of 44-66% sand and 34-56% soil fines (i.e., silt and clay size particles), as shown in Figure B2.

Table 6: Results of Grain Size Analysis for Silty Sand to Silt & Sand Fill

Sample	Depth	Mid-El.	Gravel	Sand	Silt and Clay

	(m)	(m)			
BH M2/SS2	0.75 - 1.35	269.55	0%	66%	34%
BH R2/SS2	0.6 - 1.2	269.4	1%	44%	56%

5.3 UPPER SILT TO SANDY SILT

Below the topsoil or fill materials, a fine-grained cohesionless silt deposit with trace to some sand deposit was encountered across the site, except at the location of Borehole M4 where the silt deposit is slightly cohesive (i.e., clayey silt). At the location of Boreholes M3, M4, M14, the upper silt deposit was found to be more sandy, which is therefore classified as sandy silt. The upper silt deposit was contacted at depth ranging between 0.1 m and 1.2 m, at or below El.271.3 to 269.8 m. This deposit extended to depths of about 1.4 m to 5.3 m (El. 270 m to El.268 m).

The measured natural moisture contents generally ranged between 9 and 22%.

Grain size analyses were carried out on two samples of this deposit with the results summarized in the following table.

Table 7: Results of Grain Size Analyses for Upper Silt

Sample	Depth (m)	Mid-El. (m)	Gravel	Sand	Silt	Clay
BH M6/SS2	0.75 - 1.2	269.53	0%	4 %	86%	10%
BH M9/SS2	0.75 - 1.2	269.92	0%	1%	92%	7%

Based on these results the tested material consist of 1 to 4% sand, 86 to 92% silt and 7 to 10% clay size particles, as shown in Figure B3.

Measured N-values within this deposit ranged from 6 blows to 52 blows per 0.3 m indicating loose to very dense relative density, but generally loose to compact.

In Borehole M4, the clayey silt layer within the upper silt deposit has a stiff to hard consistency with measured N-values of 10 to 41 blows per 0.3 m.

5.4 UPPER CLAYEY SILT TILL TO SANDY SILT/SILTY SAND TILL

The upper silt layer was generally underlain by a glacial deposit of clayey silt till to sandy silt/silty sand till consisting of a heterogeneous mixture of clayey silt to silty sand, with traces of gravel and occasional cobbles and boulders. The composition of this deposit generally varied from cohesive clayey silt to slightly cohesive, but mostly granular (non-cohesive) sandy silt to silty sand till.

This glacial deposit was encountered at shallow depths from about 1 m to 2 m depth (ranging from El. 270 m to 268 m), and extended down to a maximum of 9.5 m depth in Borehole M1 (El. 260.9m, or termination of this borehole), but generally extended to elevations ranging from El. 267 m to 265 m.

A grain size analysis was carried out on a sample from the more clayey (cohesive) till and the results are presented in the following table and Figure B4 in Appendix B.

Table 8: Results of Grain Size Analyses for Upper Clayey Silt Till

Sample	Depth (m)	Mid-El. (m)	Gravel	Sand	Silt	Clay
BH M5/SS4	2.1~2.55	268.68	4%	22%	52%	22%

An Atterberg Limit test was conducted on the same sample (i.e., BH M5/ SS4 from 3.1 - 3.55m depth, or El. 267.9 - 267.45m). The measured liquid and plastic limits (LL, PL) are 16.2 % and 10.6 %, respectively, and the resultant Plasticity index (PI) for the tested sample is 5.6 %, as shown in Figure B5. The results suggest that the tested material can be classified as CL-ML.

Grain size distribution analyses were performed on samples from the basically non-cohesive (i.e., granular) zones of the deposit and the results are as follows:

Table 9: Results of Grain Size Analyses for Non-cohesive Till

Sample	Depth (m)	Mid-El. (m)	Gravel	Sand	Silt	Clay
BH M5/SS7	4.5 -4.95	266.28	0%	11%	85%	3%
BH M8/SS4	2.35 - 2.8	268.12	0%	23%	68%	9%
BH M13/SS6	3.8 - 4.1	266.2	0%	0%	95%	5%
BH M14/SS7	6.1 - 6.55	262.98	2%	44%	49%	5%

Based on these results the tested material consists of 0 to 2% Gravel, 0 to 44% sand, 49 to 95% silt and 3 to 9% clay size particles, as shown in Figure B6 in Appendix B.

The measured natural moisture contents for this deposit generally range between 7 and 24%.

The measured unit weight for this deposit generally ranges from 21.6 to 22.5 kN/m3.

Presence of occasional cobbles and boulders were inferred from high SPT N-values at variable depths within the till deposit. The results of Standard Penetration tests conducted on the cohesive (clayey silt till) zones of the deposit range from 13 to 131 blows/0.3m indicating a stiff to hard consistency. The N-values recorded in the basically granular zones of the till range from 10 to in excess of 100 blows/0.3m indicating a compact to very dense relative density.

5.5 LOWER SILT

In many of the boreholes, the upper till deposit is underlain by a fine-grained cohesionless to slightly cohesive lower silt deposit. This deposit was encountered at about 2 to 7 m depth, or about El.264 to 267 m and extended to depths ranging between about 5 to in excess of 10 m below the ground surface, or about El. 265 to below El. 261m. This deposit contained trace to some sand and trace clay in several boreholes.

Measured N-values within this deposit range from 20 to in excess of 100 blows per 0.3m indicating compact to very dense relative density. The measured natural moisture contents in this deposit generally ranged between 9 and 22%.

Grain size analyses were carried out on ten samples from this deposit with the results summarized in the following table.

Table 10: Results of Grain Size Analyses for Lower Silt

Sample	Depth (m)	Mid-El. (m)	Gravel	Sand	Silt	Clay
BH M2/SS5	3.05 - 3.65	267.25	0%	1%	80%	19%
BH M2/SS7	4.55 - 5.00	265.7	0%	2%	96%	2%
BH M4/SS6	3.80 - 4.25	267.38	0%	2%	86%	12%
BH M5/SS11	6.05 - 6.50	264.73	0%	2%	82%	16%
BH M6/SS9	6.00 - 6.45	264.28	0%	0%	94%	6%
BH M7/SS8	4.90 - 5.35	265.68	0%	0%	81%	19%
BH M8/SS7	4.60 - 5.05	265.88	0%	0%	90%	10%
BH M10/SS6	3.80 - 4.25	266.08	0%	2%	89%	10%
BH P3/SS5	3.05 - 3.50	266.85	O%	0%	95%	5%
BH P4/SS7	4.20 - 4.65	265.28	0%	1%	98%	1%

Based on these results the tested material consists of 1 to 2% sand and 80 to 98% silt and 2 to 19% clay size particles, as shown in Figure B7 in Appendix B.

The measured natural moisture contents for this deposit generally ranged between 13 and 25%.

The silt deposit was found to be wet and water bearing. In Boreholes M13, M14 and M15, this deposit was found to be relatively coarser and attained a silty sand nature. The grain-size distribution of samples from the more sandy zones is given in the following table:

Table 11: Results of Grain Size Analysis Results

Borehole	Gravel	Sand	Silt

BH M13/SS8	0	60	40
BH M14/SS8	0	65	35
BH M15/SS7	2	60	38

Based on these results the tested material consists of 0 to 2% gravel, 60 to 65% sand and 35 to 40% silt, as shown in Figure B8 in Appendix B.

The recorded N-values in this water-bearing granular soil ranges from 44 to in excess of 100 blows/0.3 m indicating a dense to generally very dense relative density.

It should be pointed out that in several of the boreholes these fine-grained granular silt to silty sand deposits were not encountered and as a result the upper and lower till deposits represent one continuous stratigraphy.

5.6 LOWER CLAYEY SILT TILL TO SANDY SILT TILL

The lower silt deposit is underlain by a lower glacial deposit of clayey silt till to sandy silt till consisting of a heterogeneous mixture of sandy silt to clayey silt, with traces of gravel, occasional cobbles and boulders. Owing to this mode of deposition, the presence of cobbles and boulders can always be expected in the glacial till deposits. The composition of this deposit generally varied from cohesive clayey silt to slightly cohesive, or mostly granular (non-cohesive) sandy silt till. Most boreholes were terminated in this lower silt till deposit upon auger/spoon refusal on possible boulders/cobbles.

This glacial deposit was encountered at depths ranging from 4 to 9 m depth (Elevations ranging from 267 m to 262 m) and extended to depths in excess of 15 m or below the termination of most boreholes. The measured SPT “N” values for this deposit varied from 15 to in excess of 100 blows/0.3 m, indicating a compact to very dense (generally very dense) relative density or hard consistency.

The measured natural moisture contents for this deposit generally ranged between 7 and 19%.

Grain size distribution analyses were conducted on selected soil samples from this stratum, giving the following grain size measurements:

Table 12: Results of Grain Size Analysis for Lower Silt Till

Sample	**Depth (m)**	**Mid-El. (m)**	**Gravel**	**Sand**	**Silt**	**Clay**
BH M4/SS9	5.9 - 6.35	265.28	1%	15%	73%	10%
BH M9/SS8	5.8 - 6.25	264.98	1%	5%	86%	8%
BH M9/SS11	7.65 -7.95	263.1	3%	36%	52%	9%

BH M12/SS8	5.33 - 5.78	264.85	1%	41%	49%	9%
BH M13/SS9	6.1- 6.25	263.93	3%	46%	45%	6%
BH M7/SS16	11.2 - 11.5	259.45	0%	38%	60%	2%

Based on the results of the grain size analysis on the tested samples, the lower sit till deposit generally consists of 0 to 3 % gravel, 2 to 46% Sand, 45 to 86% Silt and 2 to 10% Clay. The grain size curves for this material are provided in an envelope form in Figure B9.

Atterberg limit tests were conducted on three samples from this material. The results are summarized in the following table and also presented on the plasticity chart in Figure B10.

Table 13: Results of Laboratory Atterberg Limits Tests

Borehole No. / Sample	**Depth (m)**	**El. (m)**	**PL**	**LL**	**PI**	**Classification**
BHM4/ SS9	6.1 - 6.55	265.30-264.85	12.9	16.5	3.6	ML
BHM9/ SS8	5.4 - 5.85	265.50-265.05	15.0	18.3	3.3	ML
BHP4/ SS8	5.4 - 5.85	264.40-263.95	10.7	15.9	5.2	CL - ML

Based on these measured Atterberg limits, the tested material can be classified as low plasticity silt (ML) to clayey silt (CL-ML), as shown in Figure B10 in Appendix B.

5.7 GROUNDWATER CONDITIONS

Groundwater conditions were observed in the open boreholes during the drilling and upon completion of each borehole, as detailed on the Record of Borehole Sheets. However, the reported short-term water levels have not stabilized. In addition, water levels were recorded in sealed piezometers installed in most boreholes. The results of groundwater monitoring in the piezometers are presented in the Table 14 along with the reported groundwater levels from earlier investigations by others.

Table 14: Groundwater Monitoring Results in Sealed Piezometers

Borehole No	**Ground El (m)**	**Borehole Depth (m)**	**Measured Groundwater Level**			
			August/September 2006		**October 2006**	
			Depth (m)	Elev. (m)	Depth (m)	Elev. (m)
M1	270.4	9.5	8.1	262.3	0.6	269.8
M2	270.6	6.6	1.7	268.9	0.8	269.8
M3	270.8	10.4	4.0	266.8	4.1	266.7
M4	271.4	10.4	5.4	266.0	1.9	269.5

Borehole No	Ground El (m)	Borehole Depth (m)	Measured Groundwater Level			
			August/September 2006		October 2006	
			Depth (m)	Elev. (m)	Depth (m)	Elev. (m)
M13	270.1	9.4	3.3	266.5	1.1	269.1
M14	269.3	9.5	4.3	265.0	1.6	267.7
M16	270.5	9.3	8.5	262.0	3.2	267.3
P1	271.0	8.1	4.9	266.9	2.2	268.8
P4	269.7	7.8	6.5	263.2	4.9	264.8

* From earlier investigation by others in May 2004.

Based on the recorded measurements in sealed piezometers to date, the groundwater level ranges from 0.6 m (in Borehole M1) to 4.9 m in depth (in Borehole P4), or between Elevations 269.8 m (Boreholes M1 and M2) and 264.8 m (Borehole P4). However, most measured groundwater levels are between 1 and 3 m below existing grade (roughly between El. 269.5 and 268 m).

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

SHAHEEN & PEAKER LIMITED

Farbod Saadat, Ph.D., P.Eng.

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Z.S. Ozden, M.A.Sc., M.Eng., P.Eng.

LICENSED PROFESSIONAL ENGINEER
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Drawings

METRIC

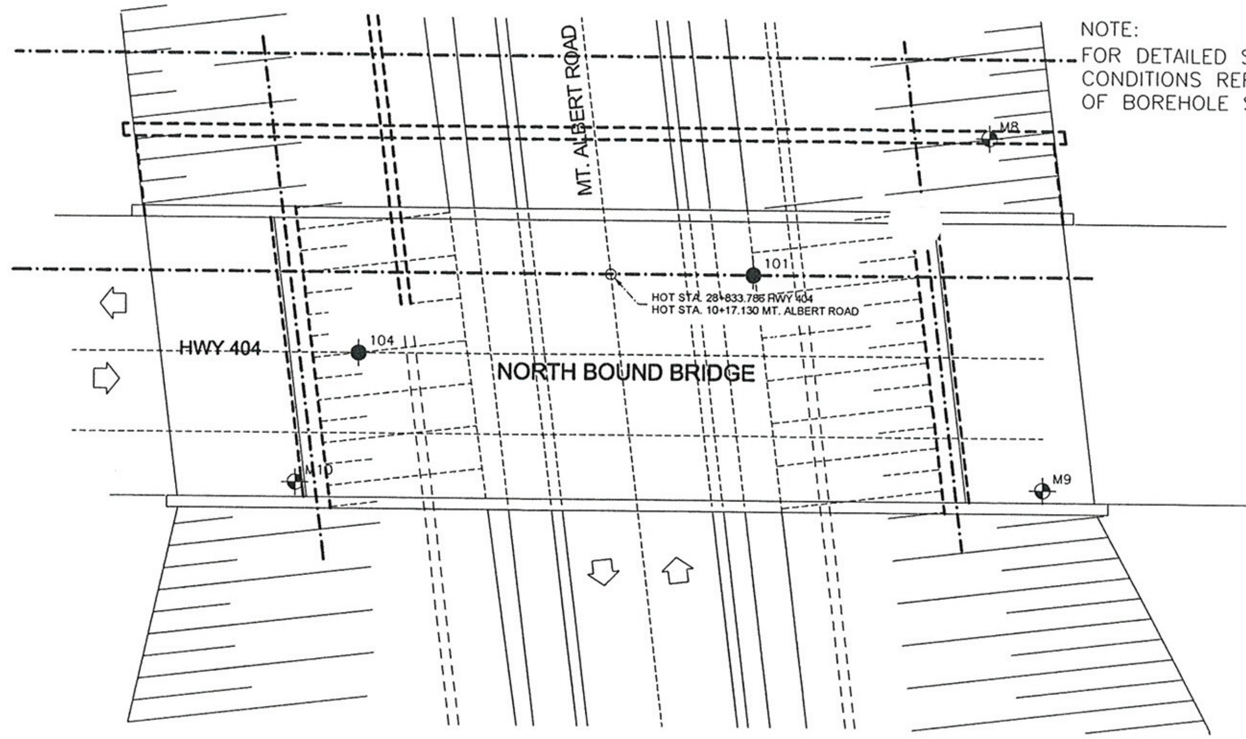
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

CONT No.
WO 04-20024

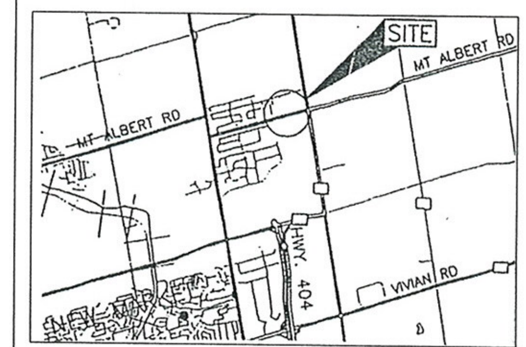
HWY 404 OVERPASS AT MT. ALBERT RD.
MT. ALBERT RD. (NORTH SIDE)
BOREHOLE LOCATIONS & SOIL STRATA

SHAHEEN & PEAKER LIMITED

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



PLAN



KEY PLAN
N.T.S

LEGEND

- Existing Borehole
- S&P Borehole
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation Aug./Sept., 2006
- Water Level in Piezometer
- Piezometer

No.	ELEV.	CO-ORDINATES NORTH	EAST
BH P4	269.7	4 885 175.0	311 145.5
BH M10	270.1	4 885 197.0	311 146.1
BH 104	270.4	4 885 199.0	311 139.0
BH 101	271.1	4 885 216.0	311 133.0
BH M8	270.7	4 885 226.1	311 124.3
BH M9	270.9	4 885 231.5	311 140.0
BH P2	271.1	4 885 243.3	311 130.9

=NOTE=
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the Boundaries are assumed from geological evidence.

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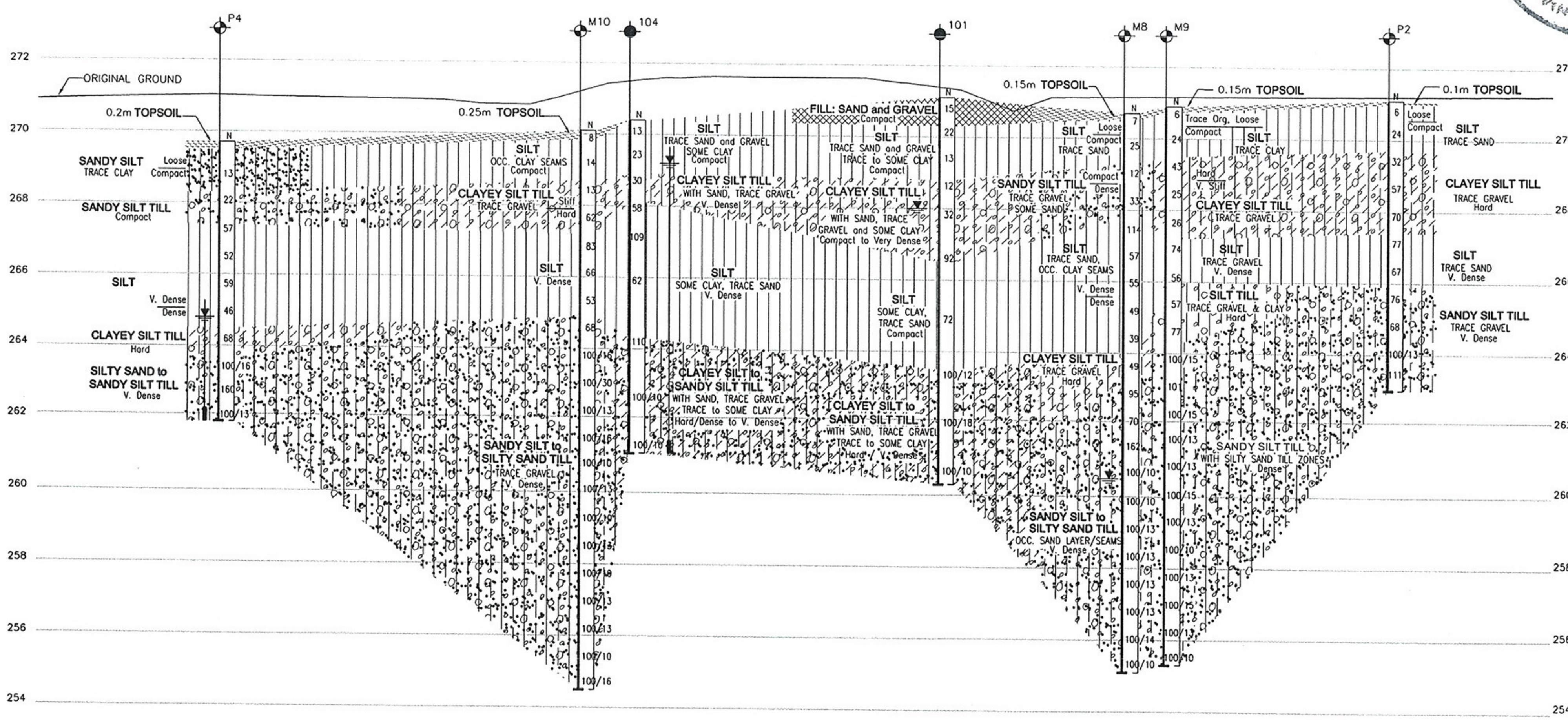


INFERRED SOIL PROFILE ALONG C/L OF HIGHWAY 404 NORTH BOUND

REV.	DATE	BY	DESCRIPTION

Geocres No.

HWY No. 404			DIST
SUBM'D ZO	CHECKED RM	DATE March,2007	SITE
DRAWN HL	CHECKED FS	APPROVED	DWG 1

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

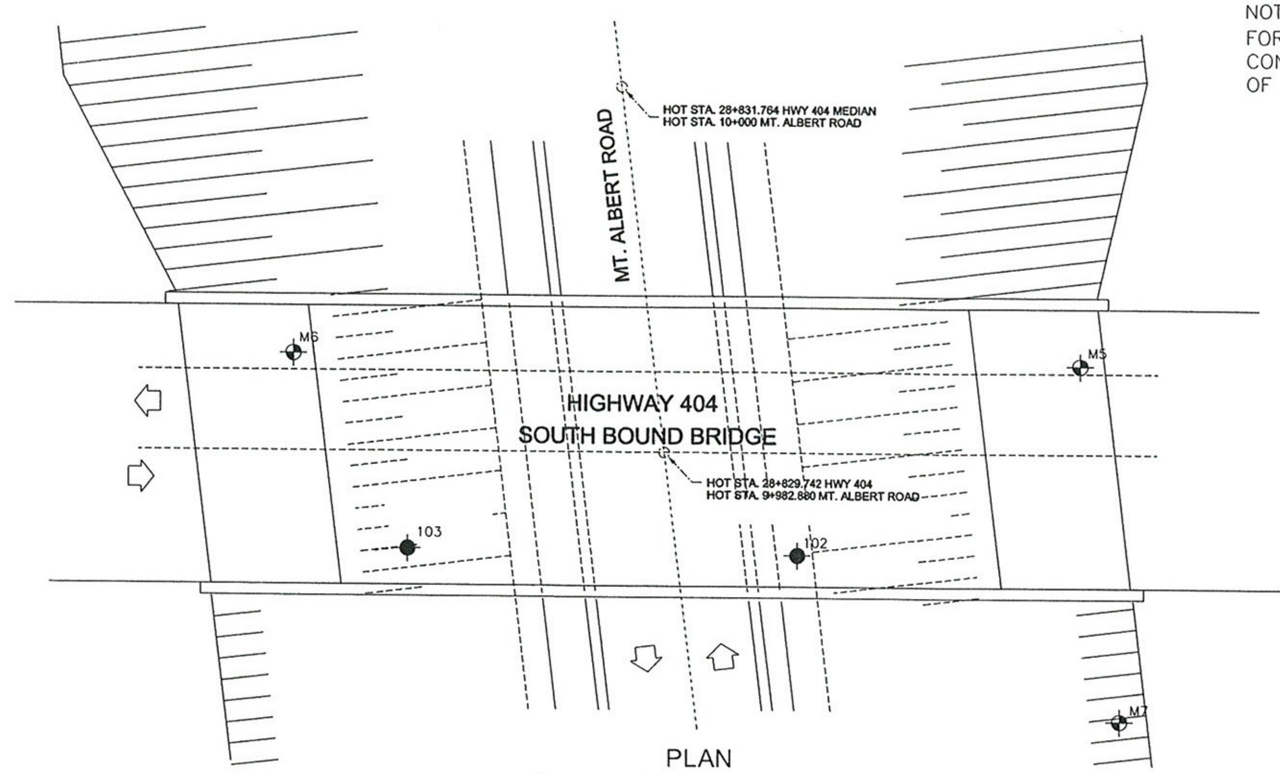
METRIC

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

CONT No.
WO 04-20024

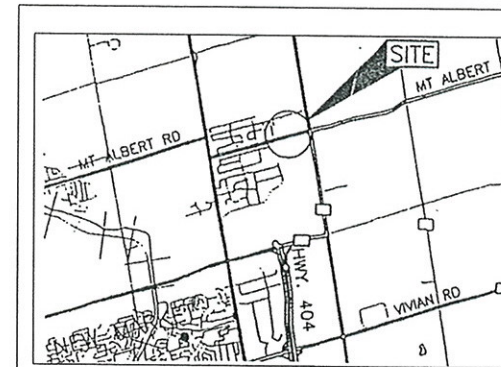
HWY 404 OVERPASS AT MT. ALBERT RD.
MT. ALBERT RD. (NORTH SIDE)
BOREHOLE LOCATIONS & SOIL STRATA

SHAHEEN & PEAKER LIMITED



PLAN

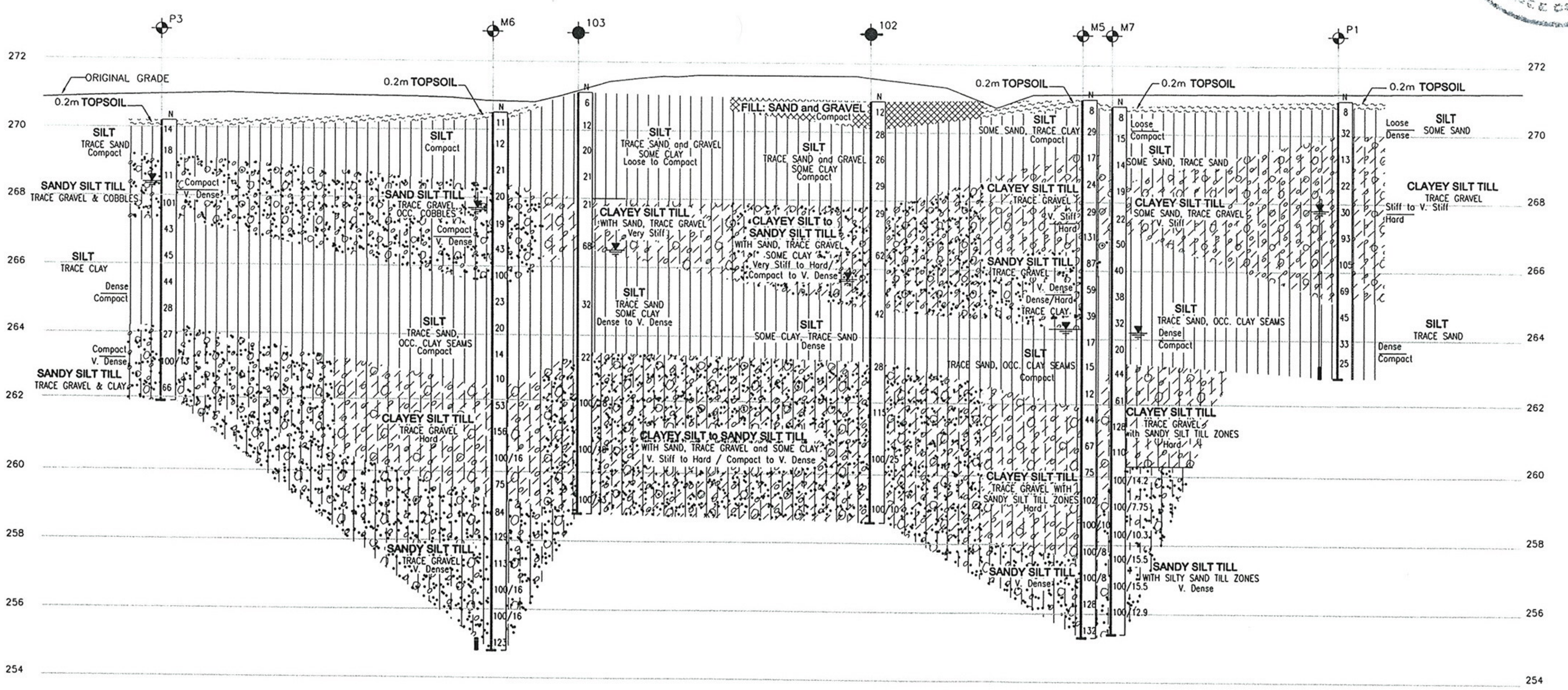
5m 0 5m 10m
SCALES



KEY PLAN
N.T.S

LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
Apr 24/07
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
Apr. 24/07
PROVINCE OF ONTARIO



INFERRED SOIL PROFILE ALONG C/L OF HIGHWAY 404 SOUTH BOUND

5m 0 5m 10m HOR
VERT
SCALES

LEGEND

- Existing Borehole
- S&P Borehole
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation Aug./Sept., 2006
- Water Level in Piezometer
- Piezometer

No.	ELEV.	CO-ORDINATES NORTH	CO-ORDINATES EAST
BH P3	270.2	4 885 162.2	311 106.3
BH M6	270.5	4 885 181.2	311 096.0
BH 103	270.9	4 885 188.0	311 104.0
BH 102	271.1	4 885 206.0	311 101.0
BH M5	271.0	4 885 217.5	311 089.9
BH M7	270.8	4 885 222.2	311 105.9
BH P1	271.0	4 885 234.8	311 095.6

=NOTE=
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REV.	DATE	BY	DESCRIPTION

Geocres No.

HWY No. 404			DIST
SUBM'D ZO	CHECKED RM	DATE March,2007	SITE
DRAWN HL	CHECKED FS	APPROVED	DWG 2

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

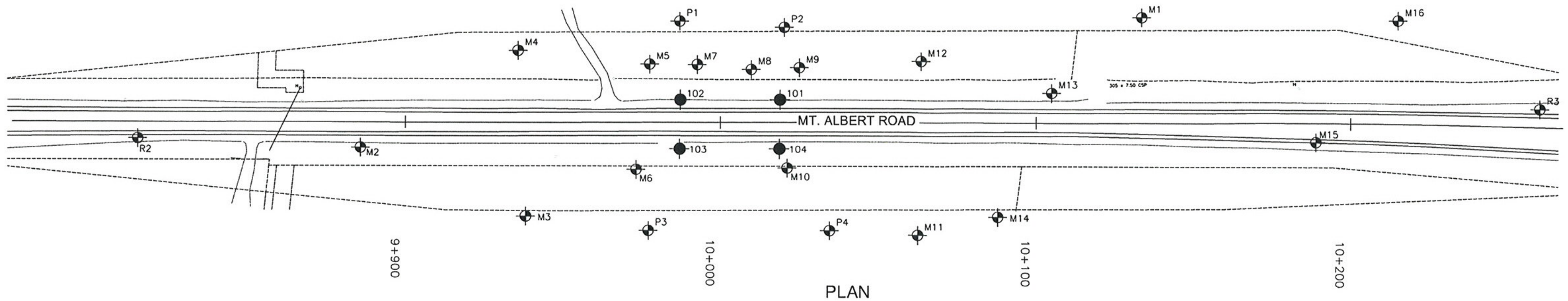
METRIC

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

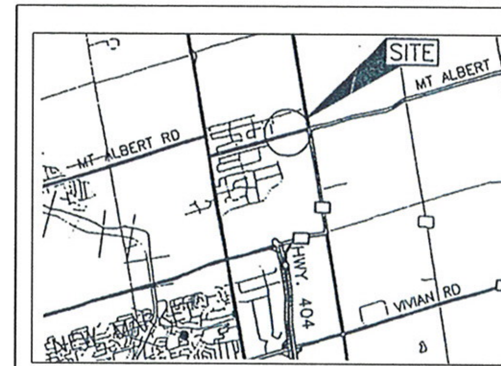
CONT No.
WO 04-20024

HWY 404 OVERPASS AT MT. ALBERT RD.
MT. ALBERT RD. (NORTH SIDE)
BOREHOLE LOCATIONS & SOIL STRATA

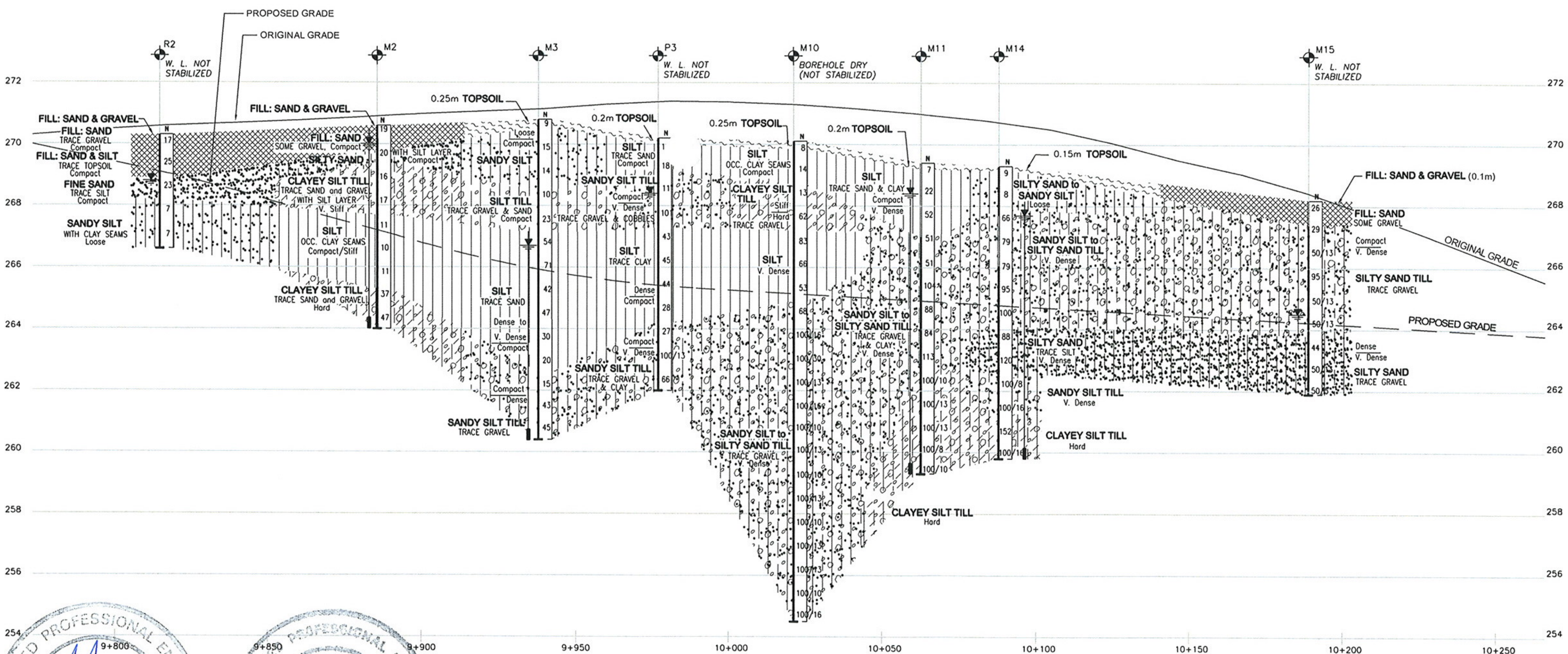
SHAHEEN & PEAKER LIMITED



PLAN



KEY PLAN
N.T.S



INFERRED SOIL PROFILE ALONG C/L OF MT. ALBERT RD. (SOUTH SIDE)

10m 0 10 20m HOR
1m 0 1 2m VERT
SCALES

LEGEND

- Existing Borehole
- S&P Borehole
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation Aug./Sept., 2006
- Water Level in Piezometer
- Piezometer

No.	ELEV.	CO-ORDINATES NORTH	CO-ORDINATES EAST
BH R2	270.3	4 885 140.8	310 927.8
BH M2	270.6	4 885 136.3	311 001.9
BH M3	270.8	4 885 154.4	311 064.2
BH P3	270.2	4 885 162.2	311 106.3
BH M10	270.1	4 885 197.0	311 146.1
BH M11	269.4	4 885 191.5	311 195.1
BH M14	269.3	4 885 202.3	311 220.8
BH M15	268.2	4 885 271.3	311 303.5

NOTE
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REV.	DATE	BY	DESCRIPTION

Geocres No.

HWY No. 404			DIST
SUBM'D ZO	CHECKED RM	DATE March,2007	SITE
DRAWN HL	CHECKED FS	APPROVED	DWG 3

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

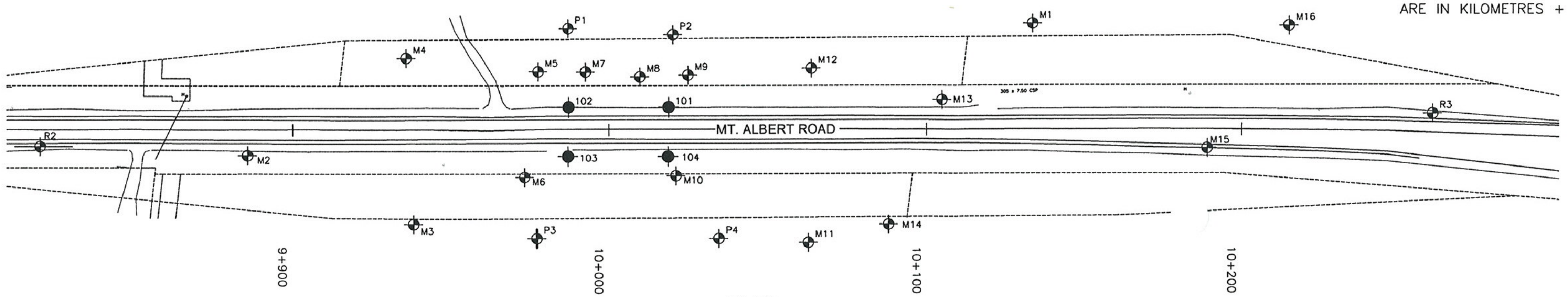
METRIC

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

CONT No.
WO 04-20024

HWY 404 OVERPASS AT MT. ALBERT RD.
MT. ALBERT RD. (NORTH SIDE)
BOREHOLE LOCATIONS & SOIL STRATA

SHAHEEN & PEAKER LIMITED



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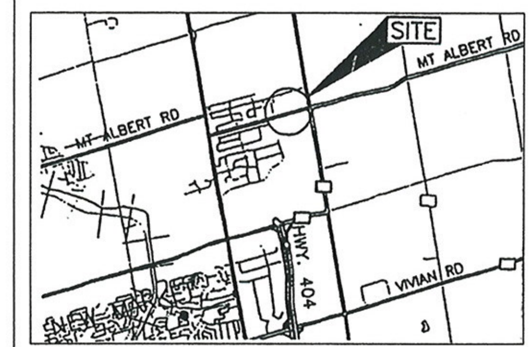
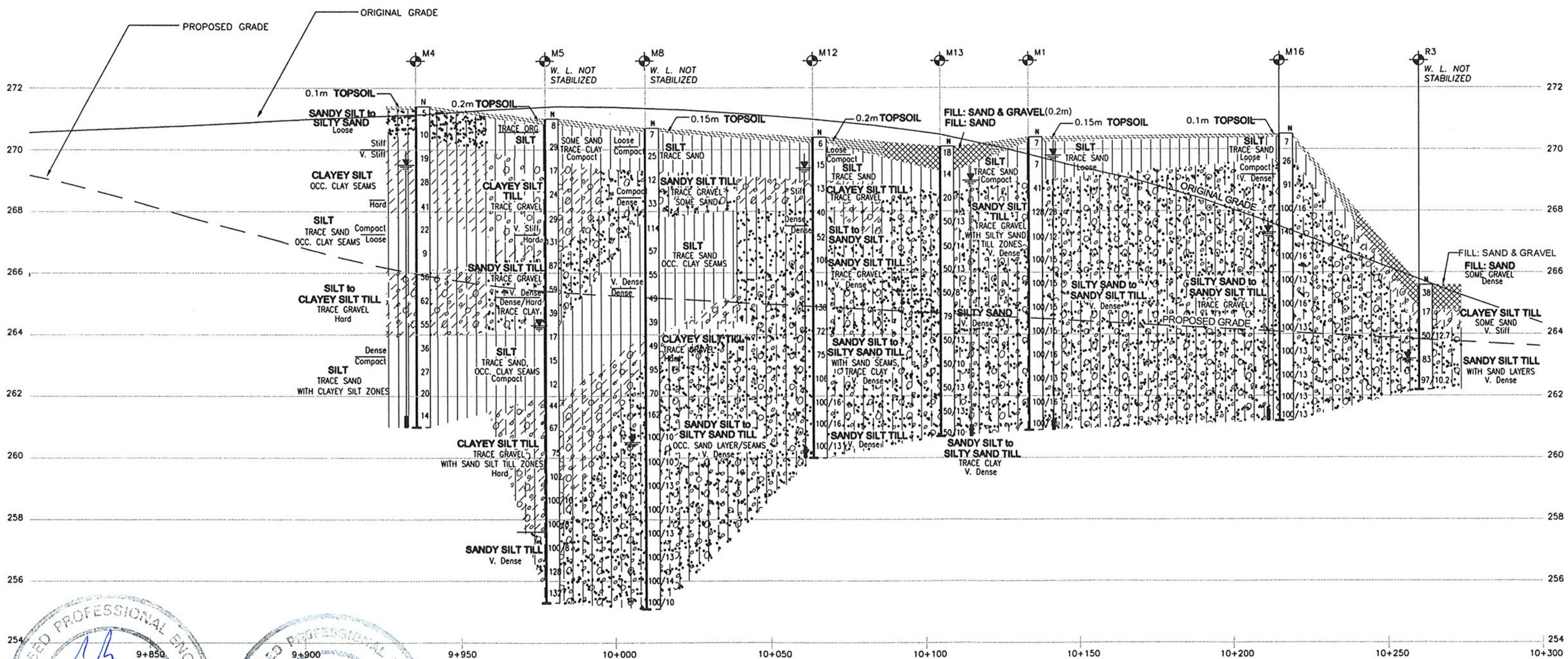


KEY PLAN
N.T.S



INFERRED SOIL PROFILE ALONG C/L OF MT. ALBERT RD. (NORTH SIDE)

LICENSED PROFESSIONAL ENGINEER
RAMON MIRANDA
PROVINCE OF ONTARIO

REGISTERED PROFESSIONAL ENGINEER
Z. S. OZDEN
PROVINCE OF ONTARIO

LEGEND

- Existing Borehole
- S&P Borehole
- N Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation Aug./Sept., 2006
- Water Level in Piezometer
- Piezometer

No.	ELEV.	CO-ORDINATES NORTH	CO-ORDINATES EAST
BH M4	271.4	4 885 208.6	311 044.5
BH M5	271.0	4 885 217.5	311 089.9
BH M8	270.7	4 885 226.1	311 124.3
BH M12	270.4	4 885 246.0	311 179.6
BH M13	270.1	4 885 244.2	311 227.2
BH M1	270.4	4 885 283.1	311 247.6
BH M16	270.5	4 885 301.5	311 308.1
BH R3	265.6	4 885 285.9	311 364.3

NOTE

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REV.	DATE	BY	DESCRIPTION

Geocres No.

HWY No. 404			DIST
SUBM'D ZO	CHECKED RM	DATE March,2007	SITE
DRAWN HL	CHECKED FS	APPROVED	DWG 4

Appendix A

Record of Borehole Sheets (Present Investigation)

Ministry of Transportation
Ontario

SPT1178

RECORD OF BOREHOLE No M1

METRIC

GWP	04-20024	LOCATION	Mt Albert Rd, Sta. 10+145 34m Lt C/L, Coords:N 4 885 283.1; E 311 247.6
DIST		HWY 404	
BOREHOLE TYPE	Solid Stem Auger		
DATUM	Geodetic	DATE	9/13/2006
ORIGINATED BY	NE	COMPILED BY	HL
CHECKED BY	RM		

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
270.4	Ground Surface				
0.0	0.15m **TOPSOIL** **SILT** trace sand brown, damp, loose	1	SS	7	270
		2	SS	7	
269.0 / 1.4	**SILTY SAND to SANDY SILT TILL** damp very dense; dense, brown / --------- / grey	3	SS	41	269
		4	SS	128/28	268
		5	SS	100/12	267
		6	SS	100/15	266
	damp / ------------------ / damp to moist	7	SS	100/15	
		8	SS	100/15	265
		9	SS	100/15	264
	---------------- / moist to wet	10	SS	100/16	
		11	SS	100/13	263
		12	SS	100/16	262
260.9 / 9.5		13	SS	100/15	261

End of borehole. Water level at 8.1m upon completion in open hole.

Water level in piezometer:
Sept 13, 2006 --- 8.1m (El. 262.3m)
Oct 3, 2006--------0.9m (El. 269.5m)
Oct 16, 2006------0.6m (El. 269.8m)

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No M10

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+025 15m Rt C/L, Coords: N 4 885 197.0; E 311 146.1 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 9/5/2006 | CHECKED BY RM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.1	Ground Surface					
0.0	0.25m **TOPSOIL** **SILT** occ. clay seams brown, moist to wet compact	1	SS	8	270	
		2	SS	14	269	
268.7 1.4	**CLAYEY SILT TILL** trace gravel brown, damp to moist stiff ------ hard	3	SS	13	268	
		4	SS	62		
267.2 2.9	**SILT** grey, moist to wet v. dense	5	SS	83	267	
		6	SS	66	266	0 2 89 9
		7	SS	53	265	
264.9 5.2	**SANDY SILT to SILTY SAND TILL** trace gravel grey, damp to moist v. dense	8	SS	68		
		9	SS	100/16	264	
		10	SS	160/30	263	
		11	SS	100/13	262	
		12	SS	100/16		
		13	SS	100/10	261	
		14	SS	100/13	260	
		15	SS	100/10	259	
		16	SS	100/13	258	
		17	SS	100/10		
		18	SS	100/13	257	
		19	SS	100/13	256	
		20	SS	100/10		

Column headings also printed: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³.

Continued Next Page

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

RECORD OF BOREHOLE No M10

METRIC

GWP 04-20024	LOCATION Mt Albert Rd, Sta. 10+025 15m Rt C/L, Coords: N 4 885 197.0; E 311 146.1	ORIGINATED BY NH
DIST HWY 404	BOREHOLE TYPE Solid Stem Auger	COMPILED BY HL
DATUM Geodetic	DATE 9/5/2006	CHECKED BY RM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SANDY SILT to SILTY SAND TILL trace gravel grey, damp to moist, v. dense						255				
254.5			21	SS	100/16				○ (approx. 9)		
15.6	End of borehole. Borehole dry(not stabilized) and open to 13.7m upon completion.										

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

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

RECORD OF BOREHOLE No M11

METRIC

GWP 04-20024 LOCATION Mt Albert Rd, Sta.10+070 34m Lt C/L, Coords: N 4 885 191.5; E 311 195.1 ORIGINATED BY NH

DIST HWY 404 BOREHOLE TYPE Solid Stem Auger COMPILED BY HL

DATUM Geodetic DATE 9/5/2006 CHECKED BY RM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
269.4	Ground Surface				
0.0	0.2m **TOPSOIL** **SILT** trace sand & clay, brown, moist compact ------------ v. dense	1	SS	7	269
		2	SS	22	268
		3	SS	52	
267.0 2.4	**SANDY SILT to SILTY SAND TILL** trace gravel and clay, damp to moist, v. dense brown --------- grey	4	SS	51	267
		5	SS	51	266
		6	SS	104	265
		7	SS	88	
		8	SS	84	264
		9	SS	113	263
262.7 6.7	**CLAYEY SILT TILL** grey, damp to moist, hard	10	SS	100/10	262
		11	SS	100/13	261
		12	SS	100/13	
		13	SS	100/8	260
259.3 10.1	End of borehole. Water level at 4.3m upon completion. Piezometer installed to depth of 10.1m. Water level in piezometer: Sept. 5, 2006 - 4.3m (El. 265.1m) Sept. 6, 2006 - 4.2m (El. 265.2m) Sept. 7, 2006 - 4.4m (El. 265.0m) Oct. 16, 2006 - 1.0m (El. 268.4m)	14	SS	100/10	

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No M12

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+070 20m Lt C/L, Coords: N 4 885 246.0; E 311 179.6 | ORIGINATED BY NE
DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL
DATUM Geodetic | DATE 9/11/2006 | CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
270.4	Ground Surface									
0.0	0.2m **TOPSOIL** **SILT** trace sand, brown, damp to moist loose	1	SS	6	270					
	compact	2	SS	15						
269.0 / 1.4	**CLAYEY SILT TILL** trace gravel brown, moist, stiff	3	SS	13	269					
268.3 / 2.1	**SILT to SANDY SILT** brown, moist dense	4	SS	40	268					
	v. dense	5	SS	52	267					
266.8 / 3.6	**SANDY SILT TILL** trace gravel brown, damp, v. dense	6	SS	106	266					
		7	SS	114						
265.3 / 5.1	**SILTY SAND to SANDY SILT TILL** with sand seams,trace clay grey, moist to wet, very dense	8	SS	138	265		1	41	49	9
		9	SS	72	264					
	with silty sand layers	10	SS	75	263					
		11	SS	106						
		12	SS	100/16	262					
		13	SS	100/16	261					
260.9 / 9.5	**SANDY SILT TILL** grey, moist, v. dense	14	SS	100/13						
260.0 / 10.4	End of borehole.									

Borehole dry and open to 10.4m upon completion. Piezometer installed to depth of 10.4m.

Water level in piezometer:
Sept 13, 2006 ---4.3m (El. 266.1m)
Oct 3, 2006-------1.2m (El. 269.2m)
Oct 16, 2006-------1.0m (El. 269.4m)

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%).

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

RECORD OF BOREHOLE No M13

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+110 5m Lt C/L, Coords:N 4 885 244.2; E 311 227.2 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 8/10/2006 | CHECKED BY RM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m3	GR	SA	SI	CL
270.1	Ground Surface								
0.0 / 269.3	**FILL: SAND and GRAVEL(150mm)** **FILL:SAND** some gravel moist, compact	1	SS	18		20	69	11	0
0.8 / 268.7	**SILT** trace sand brown, moist, compact	2	SS	14					
1.4	**SANDY SILT TILL** trace gravel with silty sand till zones brown, damp to moist, very dense	3	SS	20					
		4	SS	50/13					
		5	SS	50/14					
		6	SS	50/13	21.6	7	34	51	8
264.9		7	SS	50/8					
5.2 / 264.1	**SILTY SAND** brown, wet, very dense	8	SS	79		0	60	40	0
6.0	brown --------- grey **SANDY SILT to SILTY SAND TILL** trace clay moist to wet, very dense	9	SS	50/13		3	46	45	6
		10	SS	50/10					
		11	SS	50/13					
		12	SS	50/13					
260.7		13	SS	50/10					
9.4	End of borehole. Water level at 5.2m upon completion. Piezometer installed to depth of 9.4m.								

Water level in piezometer:
Aug 11/ 06-----3.3m(El. 266.5m)
Sept 1/06-------3.6m(El.266.2m)
Sept 5/06-------3.7m(El.266.1m)
Oct 16/06-------1.1m(El.269.1m)

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (270–261); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No M14

METRIC

GWP 04-20024 LOCATION Mt Albert Rd, Sta. 10+100 33m Rt C/L, Coords: N 4 885 202.3; E 311 220.8 ORIGINATED BY NH

DIST HWY 404 BOREHOLE TYPE Solid Stem Auger COMPILED BY HL

DATUM Geodetic DATE 9/6/2006 CHECKED BY RM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
269.3	Ground Surface					
0.0	**0.15m TOPSOIL** **SILTY SAND to SANDY SILT** rusty brown, damp, loose	1	SS	9	269	
		2	SS	8		
267.9 / 1.4	**SANDY SILT to SILTY SAND TILL** brown, damp, very dense	3	SS	66	268	
		4	SS	79	267	
		5	SS	79	266	
		6	SS	95	265	
	------------------ moist to wet	7	SS	100		2 44 49 5
264.1 / 5.2	**SILTY SAND** with trace silt brown, wet, very dense	8	SS	88	264	0 65 35 0
		9	SS	120	263	
262.6 / 6.7	**SANDY SILT TILL** grey, damp, very dense	10	SS	100/8	262	
		11	SS	100/16		
261.1 / 8.2	**CLAYEY SILT TILL** grey, damp, hard	12	SS	152	261	
		13	SS	100/16	260	
259.8 / 9.5	End of borehole. Water level at 4.4m upon completion. Piezometer installed to depth of 9.5m. Water level in piezometer: Sept 7/06----- 4.3m(El. 265.0m) Oct 3/06-------2.3m(El.267.0m) Oct 16/06-------1.6m(El.267.7m)					

Natural moisture content (%) plotted (approx.): 1: 5; 2: 12; 3: 9; 4: 9; 5: 9; 6: 6; 7: 17; 8: 8; 9: 8; 10: 9; 11: 11.

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; STRAT PLOT; GROUND WATER CONDITIONS.

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

RECORD OF BOREHOLE No M15

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+189 6m Rt C/L, Coords:N 4 885 271.3; E 311 303.5 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 8/10/2006 | CHECKED BY RM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
268.2	Ground Surface								
0.0	**FILL: SAND and GRAVEL(0.1m)** **FILL:SAND** some gravel damp to moist	1	SS	26	268	42	46	12	0
267.4 0.8	**SILTY SAND TILL** trace gravel,brown; compact --------- very dense; damp to moist ------- moist to wet; with sandy silt till zones occasional sand layers	2	SS	29	267				
		3	SS	50/13					
		4	SS	95	266				
		5	SS	50/13	265				
		6	SS	50/13	264				
263.8 4.4	**SILTY SAND** trace gravel brown, wet; dense -------- v. dense	7	SS	44	263	2	60	38	0
		8	SS	50/13					
261.9		9	SS	50/5	262				
6.3	End of borehole. Water level at 3.7m(not stabilized) upon completion. cave at 4.3m								

Ground water level symbol shown at approx. elev. 264.6.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No M16

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+215 34m Lt C/L, Coords: N 4 885 301.5; E 311 308.1 | ORIGINATED BY NE

DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 9/13/2006 | CHECKED BY RM

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
270.5	Ground Surface
0.0	**0.1m TOPSOIL** **SILT**, trace sand, brown, damp, loose
269.7 / 0.8	**SILTY SAND to SANDY SILT TILL**, trace gravel, very dense, damp; compact (upper); brown / grey
261.2 / 9.3	End of borehole. Water level at 8.5m upon completion in open hole. Pizometer installed to depth of 9.3m.

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m3
1	SS	7	
2	SS	26	22.4
3	SS	91	
4	SS	100/16	
5	SS	140	
6	SS	100/16	
7	SS	100/13	
8	SS	100/16	
9	SS	100/13	
10	SS	100/13	
11	SS	100/13	
12	SS	100/13	
13	SS	100/13	

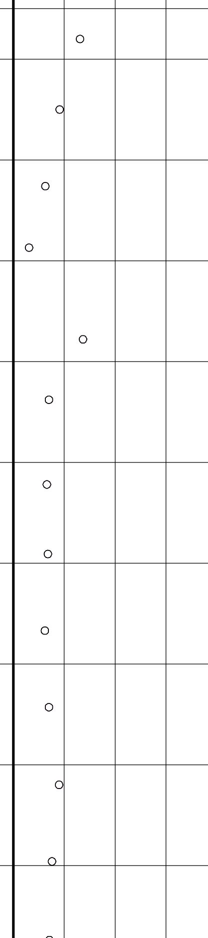
ELEVATION SCALE: 270, 269, 268, 267, 266, 265, 264, 263, 262

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

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

WATER CONTENT (%) 10 20 30



REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Water level in piezometer:
Sept 13/06------ 8.5m(El. 262.0m)
Oct 3/06----------4.0m(El. 266.5m)
Oct 16/06----------3.2m(El. 267.3m)

+3, ×3: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No M2

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 9+880 5m Rt C/L, Coords: N: 4 885 136.3; E 311 001.9 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 8/10/2006 | CHECKED BY RM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.6	Ground Surface					
270.5 / 0.1	**FILL: SAND AND GRAVEL** brown, moist					
	FILL: SAND, some gravel brown, moist, compact	1	SS	19	270	26 57 17 0
269.8 / 0.8	**SILTY SAND** (Poss FILL) with silt layer brown, moist, compact	2	SS	20		0 66 34 0
269.4 / 1.2	**CLAYEY SILT TILL** trace sand & gravel with silt layer brown, moist to wet v. stiff	3	SS	16	269	
		4	SS	17	268	
267.7 / 2.9	**SILT** occ. clay seams grey, wet compact/ stiff (brown --------- grey)	5	SS	11	267	0 1 80 19
		6	SS	10	266	
		7	SS	11		0 2 96 2
265.3 / 5.3	**CLAYEY SILT TILL** trace sand & gravel grey, moist, hard	8	SS	37	265	
		9	SS	47		
264.0 / 6.6	End of borehole.				264	

Water level at 3.4m upon completion.

Water level in piezometer:
Sept. 1, 2006 - 1.7m (El. 268.9m)
Sept. 5, 2006 - 1.7m (El. 268.9m)
Oct.16, 2006 - 0.8m (El. 269.8m)

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; STRAT PLOT; GROUND WATER CONDITIONS.

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

RECORD OF BOREHOLE No M3

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 9+930 30m Rt C/L, Coords: N 4 885 154.4; E 311 064.2 | ORIGINATED BY NH

DIST ___ HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 8/31/2006 | CHECKED BY RM

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
270.8	Ground Surface				
0.0	0.25m **TOPSOIL**; **SANDY SILT** brown, moist; loose ---------- compact	1	SS	9	
		2	SS	15	270
		3	SS	14	269
268.5 / 2.3	**SILT TILL** trace gravel and sand, brown, moist to wet, compact	4	SS	10	268
		5	SS	23	
267.1 / 3.7	**SILT** trace sand, wet; brown -------- grey; dense to very dense ------------ compact	6	SS	54	267
		7	SS	71	266
		8	SS	42	265
		9	SS	47	264
		10	SS	30	
		11	SS	20	263
262.6 / 8.2	**SANDY SILT TILL** trace gravel, grey, moist to wet; compact ------------ dense	12	SS	15	262
		13	SS	43	261
		14	SS	45	
260.4 / 10.4	End of borehole. Borehole dry and hole open to 7.6m upon completion. Piezometer installed to depth of 7.6m.				

Water level in piezometer:
Sept. 1, 2006 - 4.0m (El. 266.8m)
Sept. 5, 2006 - 4.0m (El. 266.8m)
Sept. 7, 2006 - 4.1m (El. 266.7m)

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity   (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No M4

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 9+930 27m Lt C/L, Coords: N 4 885 208.6; E 311 044.5 | ORIGINATED BY NH

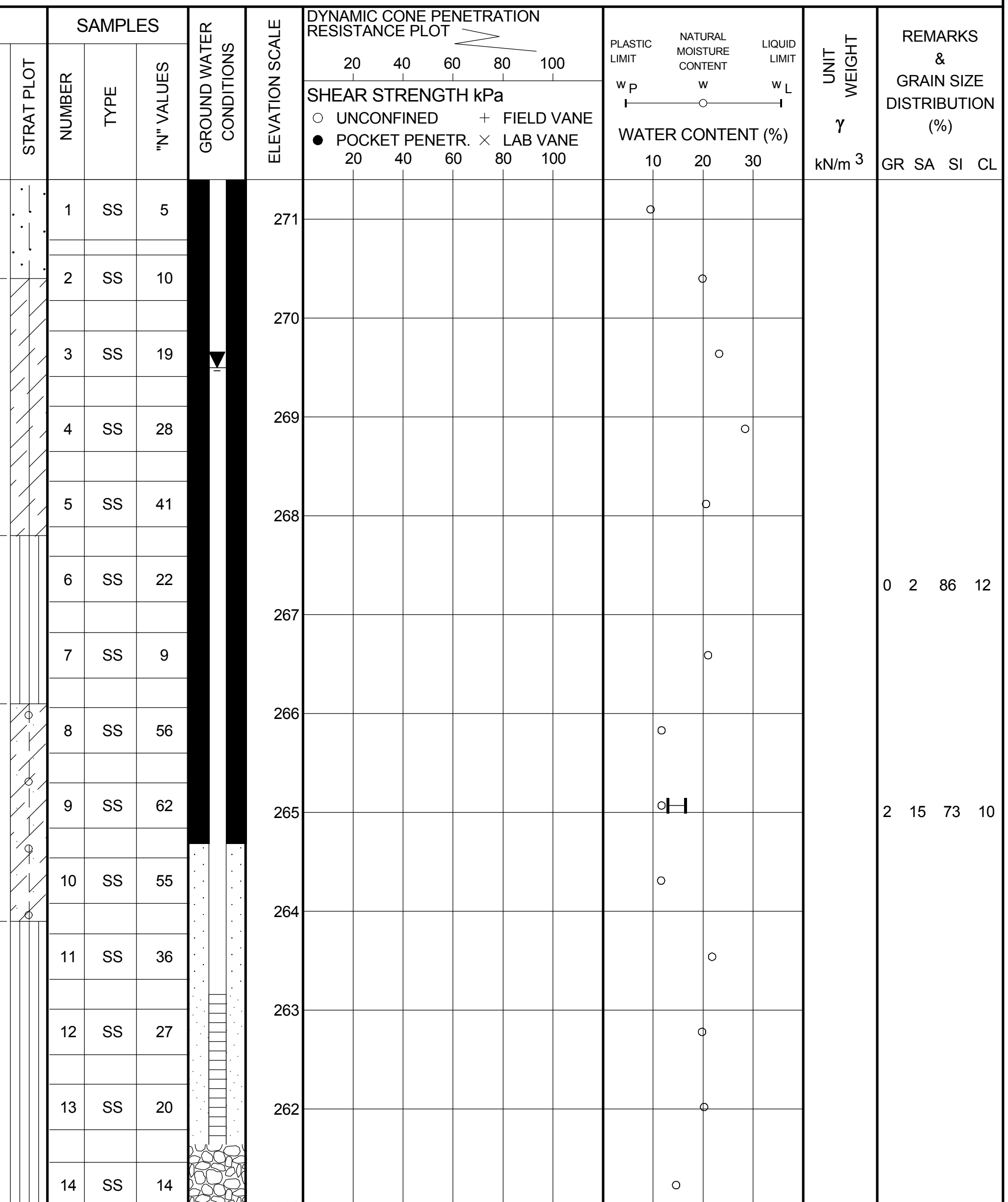
DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 9/6/2006 | CHECKED BY RM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
271.4	Ground Surface				
0.0	0.1m **TOPSOIL**				
	SANDY SILT to SILTY SAND moist, damp, loose	1	SS	5	
270.4		2	SS	10	
1.0	**CLAYEY SILT** occasional clay seams brown, moist; stiff / v. stiff	3	SS	19	
		4	SS	28	
	hard	5	SS	41	
267.8					
3.6	**SILT** trace sand, occ. clay seams, wet; compact, brown	6	SS	22	0 2 86 12
	grey, loose, trace gravel	7	SS	9	
266.1					
5.3	**SILT to CLAYEY SILT TILL** trace gravel grey, moist, hard	8	SS	56	
		9	SS	62	2 15 73 10
		10	SS	55	
263.9					
7.5	**SILT** trace sand grey, wet; dense	11	SS	36	
	compact	12	SS	27	
		13	SS	20	
261.0	with clayey silt zones	14	SS	14	
10.4	End of borehole. Waterlevel at 8.1m upon completion. Piezometer installed to depth of 9.8m.				

End of borehole. Waterlevel at 8.1m upon completion. Piezometer installed to depth of 9.8m.

Water level in piezometer:
Sept. 7, 2006 - 5.4m (El. 266.0m)
Oct. 3, 2006----2.3m (El. 269.1m)
Oct. 16, 2006----1.9m (El. 269.5m)



+ 3, × 3 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No M5

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 9+970 20m Lt C/L, Coords: N 4 885 217.5; E 311 089.9 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 9/7/2006 | CHECKED BY RM

Soil Profile

ELEV DEPTH	DESCRIPTION
271.0	Ground Surface
0.0	0.2m **TOPSOIL** trace org. / **SILT** some sand, trace clay brown, moist to wet, compact
269.5 / 1.5	**CLAYEY SILT TILL** trace gravel damp to moist, v. stiff; brown / grey hard
266.6 / 4.4	**SANDY SILT TILL** trace gravel grey, moist; v. dense / dense/ hard; trace clay
264.3 / 6.7	**SILT** trace sand, occasional clay seams grey, wet, compact
262.0 / 9.0	**CLAYEY SILT TILL** trace gravel, with sandy silt till zones grey, moist, hard
257.6 / 13.4	**SANDY SILT TILL** grey, moist v. dense

Samples

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	SS	8					
2	SS	29					
3	SS	17					
4	SS	24		4	22	52	22
5	SS	29					
6	SS	131					
7	SS	87	22.4	0	11	85	4
8	SS	59					
9	SS	39					
10	SS	17					
11	SS	15		0	2	82	16
12	SS	12					
13	SS	44					
14	SS	67					
15	SS	75					
16	SS	102					
17	SS	100/10					
18	SS	100/8					
19	SS	100/8					
20	SS	128					

Elevation scale: 271 – 256

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

RECORD OF BOREHOLE No M5

METRIC

GWP 04-20024 LOCATION Mt Albert Rd, Sta. 9+970 20m Lt C/L, Coords: N 4 885 217.5; E 311 089.9 ORIGINATED BY NH

DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger COMPILED BY HL

DATUM Geodetic DATE 9/7/2006 CHECKED BY RM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SANDY SILT TILL grey, moist, v. dense						256				
255.3			21	SS	132				○ (approx. 8)		
15.7	End of borehole. Water level at 6.7m (not stabilized) upon completion.										

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No M6

METRIC

GWP 04-20024 LOCATION Mt Albert Rd, Sta. 9+970 15m Rt C/L, Coords: N 4 885 181.2; E 311 096.0 ORIGINATED BY NH

DIST HWY 404 BOREHOLE TYPE Hollow Stem Auger COMPILED BY HL

DATUM Geodetic DATE 8/31/2006 CHECKED BY RM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.5	Ground Surface					
0.0	0.2m **TOPSOIL**	1	SS	11		
	SILT brown, compact moist ---------- moist to wet	2	SS	12		0 4 86 10
		3	SS	21		
268.4 / 2.1	**SANDY SILT TILL** trace gravel grey, moist; brown ---; compact --- dense; occ. cobbles	4	SS	20	Water level ▼	
		5	SS	19		
		6	SS	43		
		7	SS	100		
265.5 / 5.0	**SILT** trace sand, occ. clay seams grey, wet compact	8	SS	23		
		9	SS	20		0 0 94 6
		10	SS	14		
		11	SS	10		
262.5 / 8.0	**CLAYEY SILT TILL** trace gravel grey, damp, hard	12	SS	53		
		13	SS	156		
		14	SS	100/16		
259.2 / 11.3	**SANDY SILT TILL** trace gravel grey, moist v. dense	15	SS	84		
		16	SS	129		
		17	SS	113		
		18	SS	100/16		
		19	SS	100/16		

Elevation scale: 270, 269, 268, 267, 266, 265, 264, 263, 262, 261, 260, 259, 258, 257, 256

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

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Continued Next Page

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

RECORD OF BOREHOLE No M6

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 9+970 15m Rt C/L, Coords: N 4 885 181.2; E 311 096.0 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 8/31/2006 | CHECKED BY RM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L / WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
254.8	**SANDY SILT TILL** trace gravel, grey, moist, v. dense		20	SS	123		255		○		
15.7	End of borehole. Water level at 15.0m upon completion. Piezometer installed to depth of 15.7m. Water level in piezometer: Sept. 1, 2006 - 14.9m (El. 255.6m) Sept. 5, 2006 - 5.7m (El. 264.8m) Sept. 6, 2006 - 5.7m (El. 264.8m) Sept. 7, 2006 - 5.7m (El. 264.8m) Sept. 13, 2006 - 5.8m (El. 264.7m) Oct. 16, 2006 - 2.8m (El. 267.7m)										

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

SPT1178

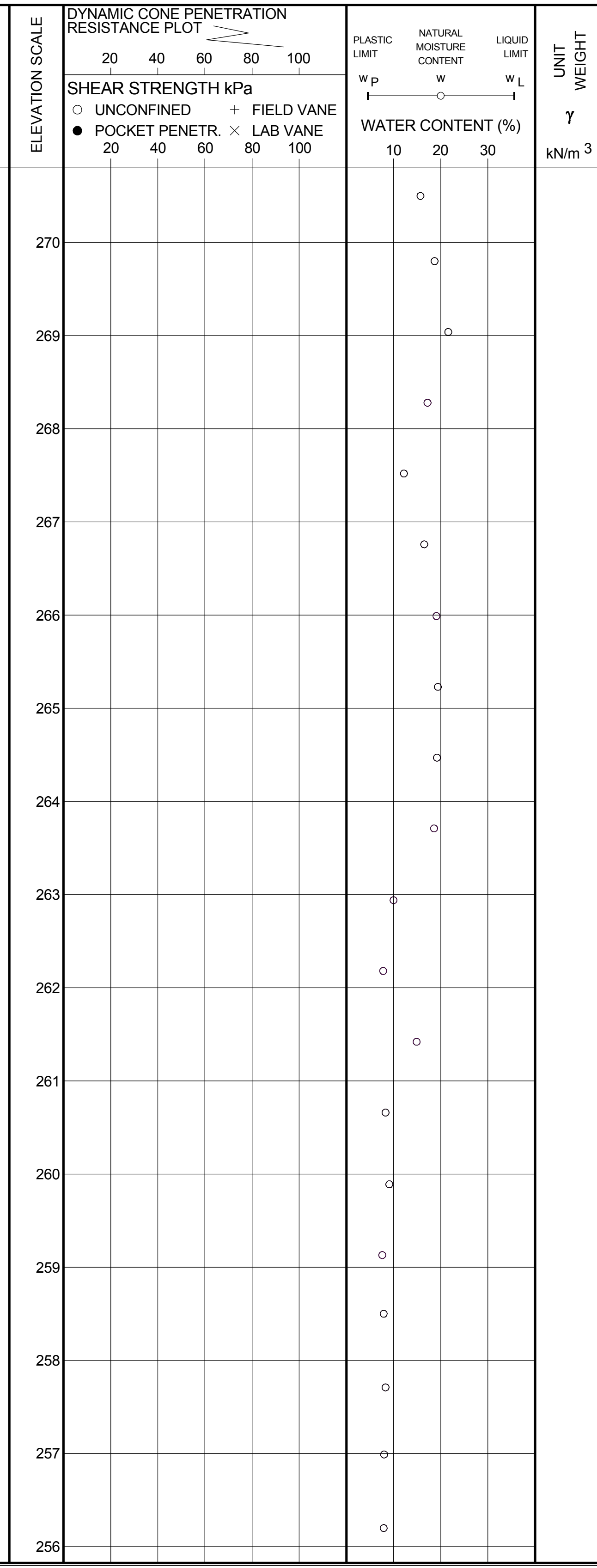
Foundation Design

RECORD OF BOREHOLE No M7

METRIC

GWP 04-20024		LOCATION Mt Albert Rd, Sta. 9+980 19m Lt C/L, Coords: N 4 885 222.2; E 311 105.9	ORIGINATED BY NH
DIST	HWY 404	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY HL
DATUM Geodetic		DATE 9/8/2006	CHECKED BY RM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.8	Ground Surface					
0.0	0.2m **TOPSOIL**					
	SILT trace sand brown, moist to wet; loose	1	SS	8		
	compact	2	SS	15		
		3	SS	14		
268.6 / 2.2	**CLAYEY SILT TILL** some sand, trace gravel moist, v. stiff; brown	4	SS	19		
	grey	5	SS	22		
267.1 / 3.7	**SILT** trace sand, occ. clay seams grey, moist to wet dense	6	SS	50		
		7	SS	40		
		8	SS	38		0 0 81 19
		9	SS	32	▼	
	compact	10	SS	20		
263.3 / 7.5	**CLAYEY SILT TILL** trace gravel grey, moist hard	11	SS	44		
		12	SS	61		
		13	SS	128		
	with sandy silt till zones	14	SS	110		
260.3 / 10.5	**SANDY SILT TILL** with silty sand till zones grey, moist, v. dense	15	SS	100/0.142		
		16	SS	100/0.103		0 38 60 2
		17	SS	100/0.0775		
		18	SS	100/0.103		
		19	SS	100/0.155		
		20	SS	100/0.155		



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

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

RECORD OF BOREHOLE No M7

METRIC

GWP 04-20024	LOCATION Mt Albert Rd, Sta. 9+980 19m Lt C/L, Coords: N 4 885 222.2; E 311 105.9	ORIGINATED BY NH
DIST	HWY 404	BOREHOLE TYPE Hollow Stem Auger	COMPILED BY HL
DATUM Geodetic	DATE 9/8/2006	CHECKED BY RM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P – NATURAL MOISTURE CONTENT w – LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SANDY SILT TILL grey, moist, v.dense		21	SS	100/0.129				○ (approx. 10)		
255.4 15.4	End of borehole. Water level at 6.6m upon completion, cave at 6.7m						255				

+ ³, × ³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No M8

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+010 15m Lt C/L, Coords: N 4 885 226.1; E 311 124.3 | ORIGINATED BY NE
DIST | HWY 404 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY HL
DATUM Geodetic | DATE 9/11/2006 | CHECKED BY RM

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
270.7	Ground Surface											
0.0	0.15m **TOPSOIL**; **SILT** trace sand brown, moist; loose / compact	1	SS	7		270						
		2	SS	25								
269.3 1.4	**SANDY SILT TILL** trace gravel, some sand brown, moist; compact / dense	3	SS	12		269						
		4	SS	33		268		22.5	0	23	68	9
267.8 2.9	**SILT** trace sand, occ. clay seams grey; brown / grey; v. dense, moist / dense, moist to wet	5	SS	114		267						
		6	SS	57								
		7	SS	55		266			0	0	90	10
		8	SS	49		265						
		9	SS	39		264						
264.0 6.7	**CLAYEY SILT TILL** trace gravel grey, moist, hard	10	SS	49								
263.2 7.5	**SANDY SILT to SILTY SAND TILL** occ. sand layer/ seams grey, damp to moist, v. dense	11	SS	95		263						
		12	SS	70		262						
		13	SS	162		261						
		14	SS	100/10	▼							
		15	SS	100/10		260						
		16	SS	100/13		259						
		17	SS	100/13		258						
	moist to wet	18	SS	100/13		257						
	damp to moist	19	SS	100/13								
		20	SS	100/14		256						

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

RECORD OF BOREHOLE No M8

METRIC

GWP	04-20024	LOCATION	Mt Albert Rd, Sta. 10+010 15m Lt C/L, Coords: N 4 885 226.1; E 311 124.3
DIST		HWY 404	ORIGINATED BY NE
BOREHOLE TYPE	Hollow Stem Auger		COMPILED BY HL
DATUM	Geodetic	DATE 9/11/2006	CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
255.1	**SANDY SILT TILL** grey, damp, v. dense		21	SS	100/10				○ (approx. 8)		
15.6	End of borehole. Water level at 10.2m(not stabilized) upon completion, cone at 10.7m						255				

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

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

RECORD OF BOREHOLE No M9

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+025 16m Lt C/L, Coords: N 4 885 231.5; E 311 140.0 | ORIGINATED BY NE

DIST ___ HWY 404 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 9/12/2006 | CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.9	Ground Surface						
0.0	0.15m **TOPSOIL** trace org, loose	1	SS	6			
	---- compact **SILT** trace clay brown, damp	2	SS	24	270		0 1 92 7
269.5 / 1.4	**CLAYEY SILT TILL** trace gravel brown, moist hard	3	SS	43	269		
	---- v. stiff	4	SS	25	268		
		5	SS	26			
267.2 / 3.7	**SILT** trace gravel moist to wet, very dense brown	6	SS	74	267		
	---- grey	7	SS	56	266		
266.0 / 4.9	**SILT TILL** trace gravel and clay grey, hard moist	8	SS	57	265		1 5 86 8
	---- damp	9	SS	77			
264.3 / 6.6	**SANDY SILT TILL** with silty sand till zones grey, v. dense	10	SS	100/15	264		
	damp ---- moist	11	SS	101	263		3 36 52 9
		12	SS	100/15	262		
		13	SS	100/13			
		14	SS	100/13	261		
	---- damp	15	SS	100/15	260		
		16	SS	100/13	259		
		17	SS	100/10			
	---- damp to moist	18	SS	100/13	258		
		19	SS	100/15	257		
		20	SS	100/13	256		

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

SPT1178

RECORD OF BOREHOLE No M9

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+025 16m Lt C/L, Coords: N 4 885 231.5; E 311 140.0 | ORIGINATED BY NE

DIST | HWY 404 | BOREHOLE TYPE Hollow Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 9/12/2006 | CHECKED BY RM

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SANDY SILT TILL grey, damp, v. dense										
255.3			21	SS	100/10				○		
15.6	End of borehole. Borehole dry and open to 15.6m upon completion. Pizometer installed to depth of 15.6m. Water level in piezometer: Sept.13, 2006 - 5.7m (El. 265.2m) Oct. 03, 2006---2.6m (El. 268.3m) Oct. 16, 2006---2.4m (El. 268.5m)						255				

+3, ×3: Numbers refer to Sensitivity

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

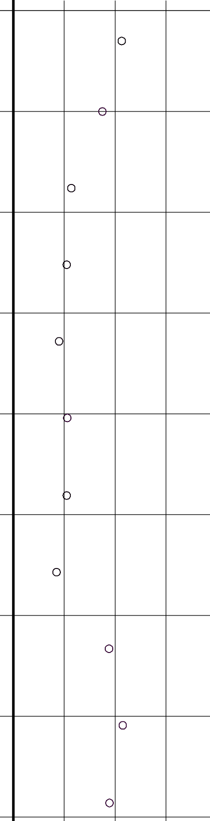
RECORD OF BOREHOLE No P1

1 OF 1 **METRIC**

GWP 04-20024	LOCATION Mt Albert Rd, Sta. 9+980 34m Lt C/L, Coords: N 4 885 234.8; E 311 095.6		ORIGINATED BY NH
DIST	HWY 404	BOREHOLE TYPE Solid Stem Auger	COMPILED BY HL
DATUM Geodetic	DATE 9/7/2006		CHECKED BY RM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE
271.0	Ground Surface				271
0.0	0.2m TOPSOIL **SILT** some sand, brown, damp loose ------- dense	1	SS	8	
270.0 / 1.0		2	SS	32	270
	CLAYEY SILT TILL trace gravel moist damp to moist stiff to v. stiff	3	SS	13	269
		4	SS	22	
	brown -------------- grey, hard	5	SS	30	268
		6	SS	93	267
		7	SS	105	266
		8	SS	69	
265.1 / 5.9	**SILT** trace sand occasional clay seams grey, wet	9	SS	45	265
	dense --------- compact	10	SS	33	264
		11	SS	25	
262.9 / 8.1	End of borehole. Water level at 6.4m upon completion. Piezometer installed to depth of 8.1m. Water level in piezometer: Sept 13/06------ 4.9m(El. 266.9m) Oct 3/06----------2.6m(El. 268.4m) Oct 16/06----------2.2m(El. 268.8m)				263

Columns: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● POCKET PENETR., × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L – WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL



+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No P2

METRIC

GWP 04-20024	LOCATION Mt Albert Rd, Sta. 10+015 34m Lt C/L, Coords: N 4 885 243.3; E 311 130.9		ORIGINATED BY NE
DIST	HWY 404	BOREHOLE TYPE Solid Stem Auger	COMPILED BY HL
DATUM Geodetic		DATE 9/8/2006	CHECKED BY RM

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
271.1	Ground Surface							
0.0	0.1m TOPSOIL **SILT** trace sand,brown, damp loose ---------- compact	1	SS	6				
		2	SS	24				
269.7 / 1.4	**CLAYEY SILT TILL** trace gravel brown, moist, hard	3	SS	32				
		4	SS	57				
		5	SS	70				
267.4 / 3.7	**SILT** trace sand grey, wet, very dense	6	SS	77				
		7	SS	67				
265.9 / 5.2	**SANDY SILT TILL** trace gravel with occasional sandy silt layers moist to wet, v. dense	8	SS	76				
		9	SS	68				
		10	SS	100/13				
		11	SS	111				
263.0 / 8.1	End of borehole. Borehole dry (not stabilized)and open to 7.9m upon completion.							

Elevation scale: 271, 270, 269, 268, 267, 266, 265, 264, 263

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No P3

METRIC

GWP 04-20024 LOCATION Mt Albert Rd, Sta. 9+975 35m Rt C/L, Coords: N 4 885 162.2; E 311 106.3 ORIGINATED BY NH

DIST HWY 404 BOREHOLE TYPE Solid Stem Auger COMPILED BY HL

DATUM Geodetic DATE 8/31/2006 CHECKED BY RM

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.2	Ground Surface						
0.0	0.2m TOPSOIL **SILT** trace sand brown, moist, compact	1	SS	14			
		2	SS	18			
269.2 / 1.0	**SANDY SILT TILL** trace gravel & cobbles brown, moist to wet compact ----------- v. dense	3	SS	11	▼		
		4	SS	101			
267.3 / 2.9	**SILT** trace clay grey, moist to wet dense --------- compact	5	SS	43			0 0 95 5
		6	SS	45			
		7	SS	44		50	
		8	SS	28		48	
264.2 / 6.0	**SANDY SILT TILL** trace gravel & clay grey, moist to wet compact ----------- very dense	9	SS	27			
		10	SS	100/13			
		11	SS	66			
262.1 / 8.1	End of borehole. Water level at 1.8m (not stabilized) upon completion.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Elevation scale: 270, 269, 268, 267, 266, 265, 264, 263

+ ³, × ³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No P4

METRIC

GWP 04-20024 LOCATION Mt Albert Rd, Sta. 10+015 35m Rt C/L, Coords: N 4 885 175.0; E 311 144.5 ORIGINATED BY NH

DIST HWY 404 BOREHOLE TYPE Solid Stem Auger COMPILED BY HL

DATUM Geodetic DATE 9/1/2006 CHECKED BY RM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
269.7	Ground Surface					
0.0	0.2m TOPSOIL **SANDY SILT** loose -------- compact, trace clay, brown, moist	1	SS	7	269	
		2	SS	13		
268.3 / 1.4	**SANDY SILT TILL** brown, moist, compact	3	SS	22	268	
267.4 / 2.3	**SILT** very dense, damp to moist, brown ---------- grey	4	SS	57	267	
		5	SS	52	266	
	moist to wet --------- dense	6	SS	59		
		7	SS	46	265	0 1 98 1
264.5 / 5.2	**CLAYEY SILT TILL** grey, damp to moist, hard	8	SS	68	264	
263.8 / 5.9	**SILTY SAND to SANDY SILT TILL** grey, very dense, damp -------- wet ---------- damp	9	SS	100/16	263	
		10	SS	160		
261.9 / 7.8		11	SS	100/13	262	

End of borehole. Water level at 7.02m upon completion. Piezometer installed to depth of 7.78m.

Water level in piezometer :
Sept 1/06-----6.5m (El. 263.2m)
Sept 5/06-----4.9m (El. 264.8m)
Sept 6/06-----4.9m (El. 264.8m)
Sept 7/06-----4.9m (El. 264.8m)
Oct 16/06, piezometer was plugged.

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m3.

+3, ×3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No R2

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 9+820 6m Rt C/L, Coords: N 4 885 140.8; E 310 927.8 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 8/10/2006 | CHECKED BY RM

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.3	Ground Surface						
0.0	**FILL:SAND and GRAVEL** **FILL:SAND, trace GRAVEL** moist, compact	1	SS	17		270	Gravel Shoulder
269.7 / 0.6	**FILL: SAND and SILT** trace topsoil brown, moist, compact	2	SS	25			1 43 47 9
268.9 / 1.4	**FINE SAND, TRACE SILT** brown, moist to wet, compact (possible fill)	3	SS	23	▼	269	
268.2 / 2.1	**SANDY SILT** with clay seams brown to grey, wet, loose	4	SS	7		268	
		5	SS	7		267	Sample not Recoverd
266.6 / 3.7	End of borehole Water level at 1.5m (not stabilized) at completion, in open hole						

Chart column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

RECORD OF BOREHOLE No R3

METRIC

GWP 04-20024 | LOCATION Mt Albert Rd, Sta. 10+260 5m Lt C/L, Coords: N 4 885 285.9; E 311 364.3 | ORIGINATED BY NH

DIST | HWY 404 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY HL

DATUM Geodetic | DATE 8/10/2006 | CHECKED BY RM

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
265.6	Ground Surface						
0.0	**FILL: SAND and GRAVEL** **FILL:SAND. some GRAVEL** moist, dense	1	SS	38		265	Gravel Shoulder
264.8 0.8	**CLAYEY SILT TILL** some sand brown, moist, very stiff	2	SS	17			
264.2 1.4	**SANDY SILT TILL** with sand layers brown, damp to moist, very dense	3	SS	50/12.7		264	
		4	SS	83	▼	263	
262.2		5	SS	97/10.2			
3.4	End of borehole Water level at 2.4m(not stabilized) at completion, in open hole						

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100

Shear Strength kPa: ○ UNCONFINED + FIELD VANE ● POCKET PENETR. × LAB VANE — 20 40 60 80 100

Plastic Limit w_P — Natural Moisture Content w — Liquid Limit w_L; Water Content (%) 10 20 30

Unit Weight γ kN/m³

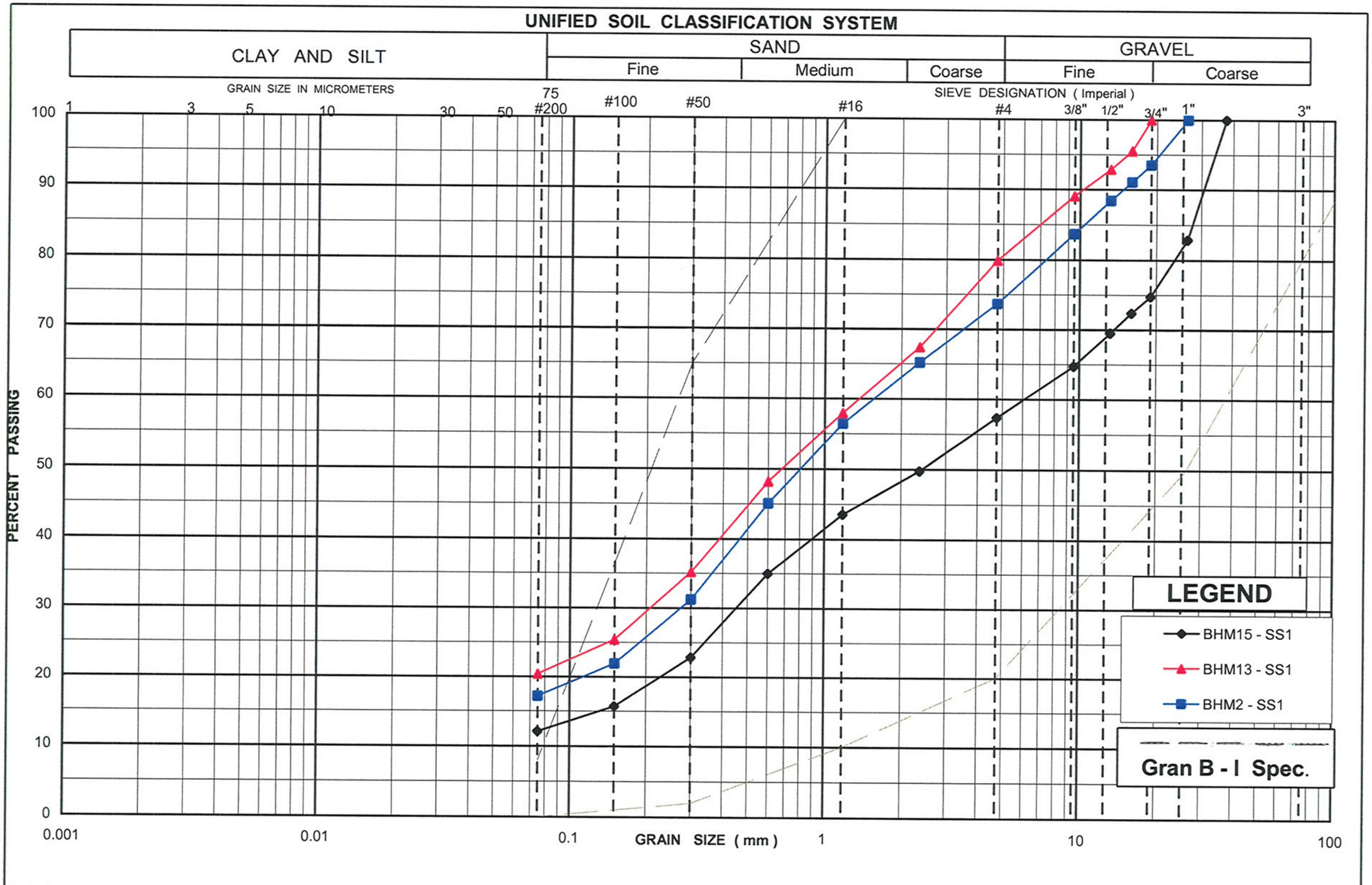
GR SA SI CL

+ 3, × 3 : Numbers refer to Sensitivity

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

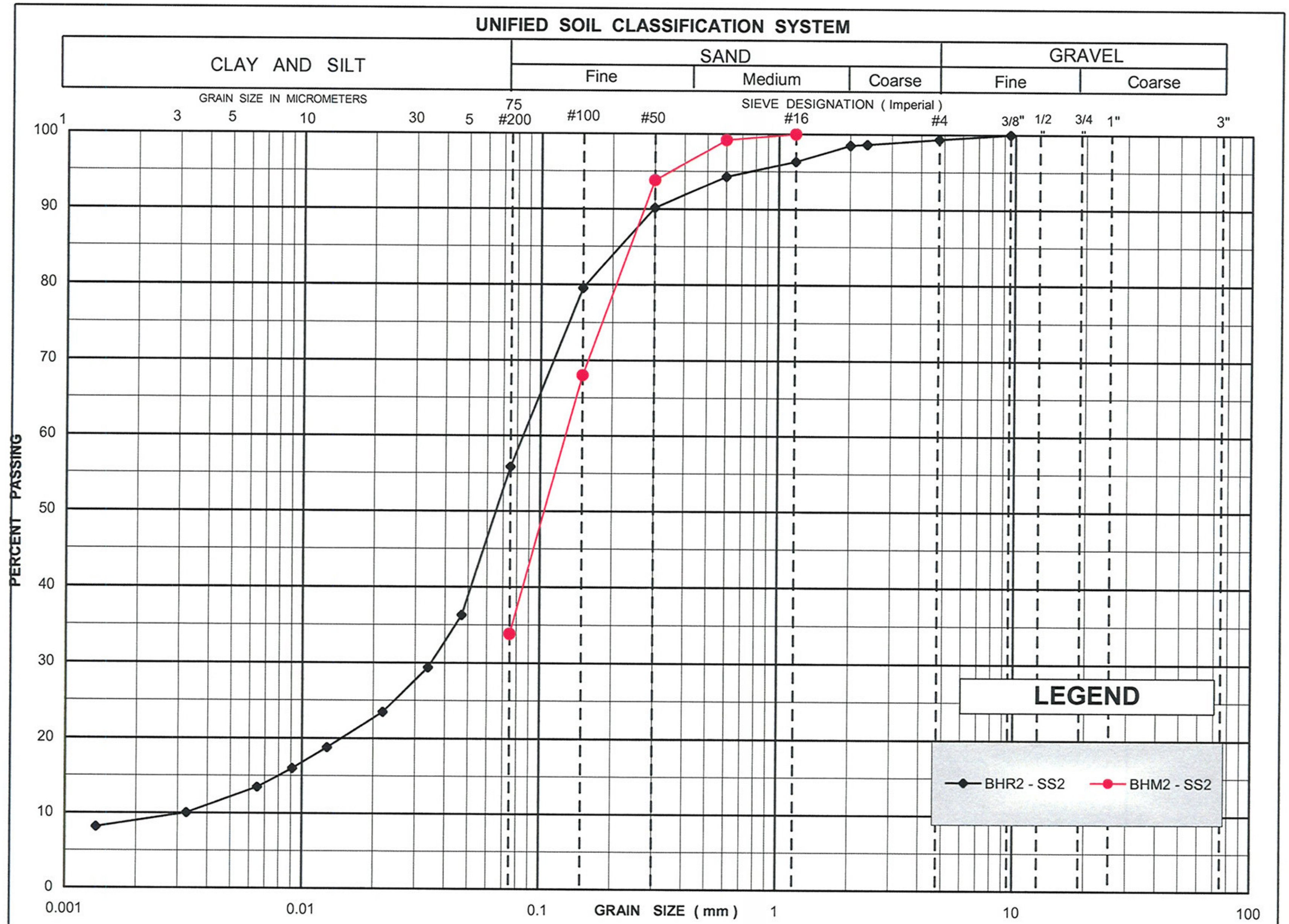
Appendix B

Laboratory Results



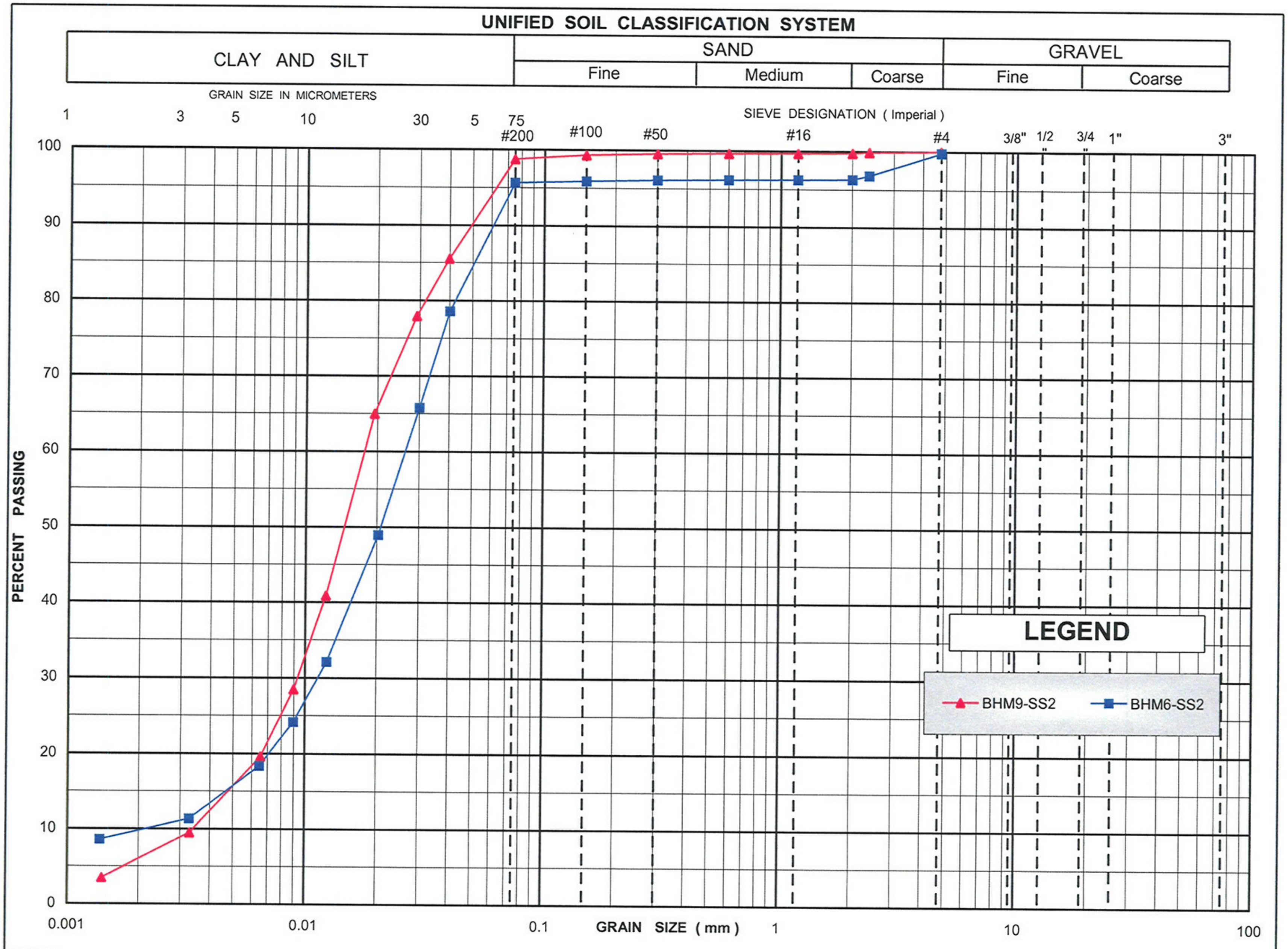
SHAHEEN & PEAKER LIMITED	GRAIN SIZE DISTRIBUTION Sand and gravel (Pavement Fill)	Figure: B1 PROJECT No: SPT - 1178 Date: October 24. 2006

FIGURE B1 - GRAIN SIZE DISTRIBUTION CURVES FOR SAMPLES BH M2-SS1, BH M13-SS1, AND BH M15-SS1



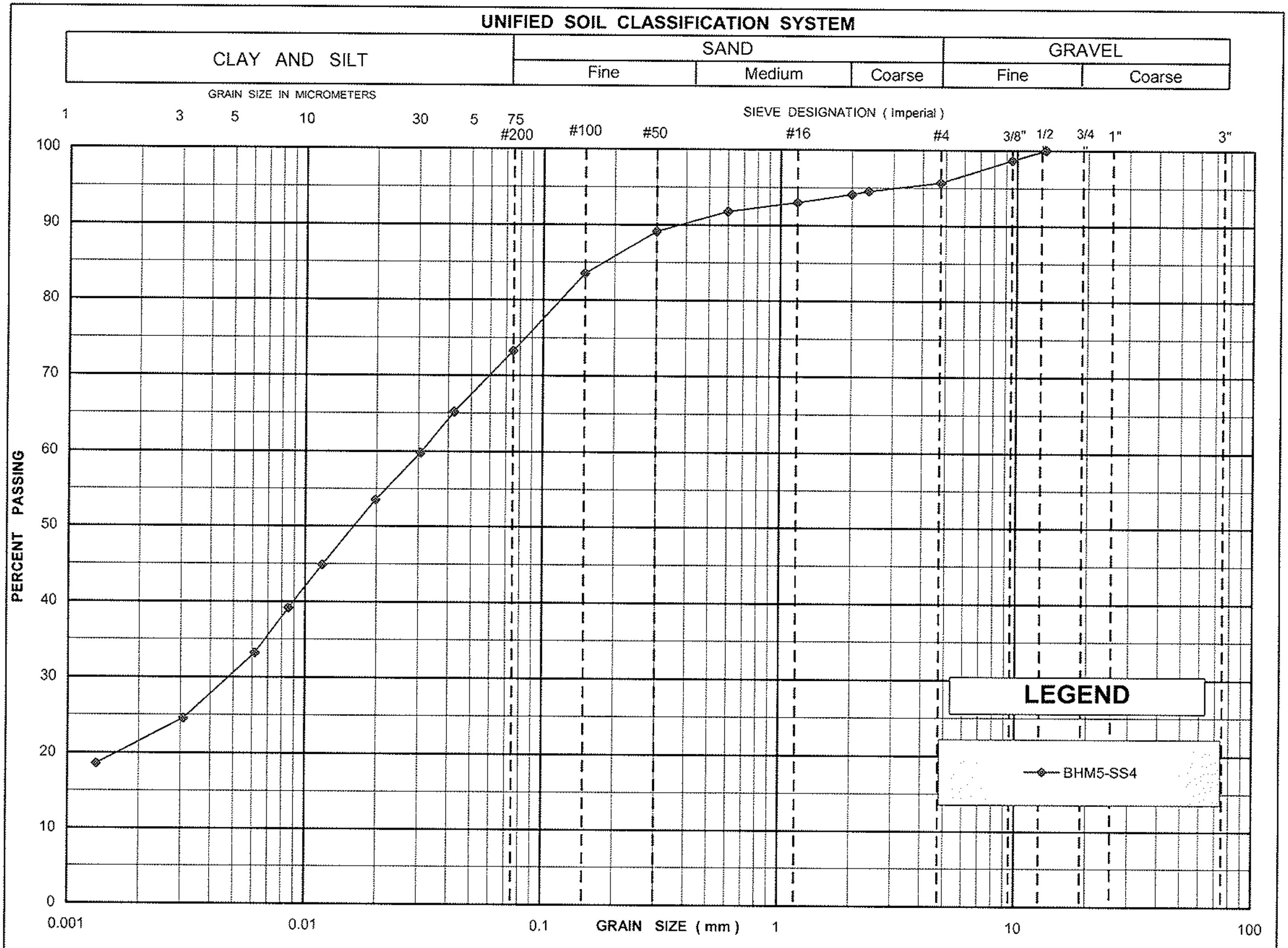
SHAHEEN & PEAKER LIMITED	GRAIN SIZE DISTRIBUTION Sand and silt, trace clay (Fill)	Figure: B2 PROJECT No: SPT - 1178 Date: October 16, 2006

FIGURE B2 - GRAIN SIZE DISTRIBUTION CURVES FOR SAMPLES BH R2-SS2 AND BH M2-SS2



SHAHEEN & PEAKER LIMITED	GRAIN SIZE DISTRIBUTION Silt to Clayey Silt, trace sand	Figure: B3 PROJECT No: SPT - 1178 Date: October 16, 2006

FIGURE B3 - GRAIN SIZE DISTRIBUTION CURVES FOR SAMPLES BH M6-SS2 AND BH M9-SS2



SHAHEEN & PEAKER LIMITED

GRAIN SIZE DISTRIBUTION

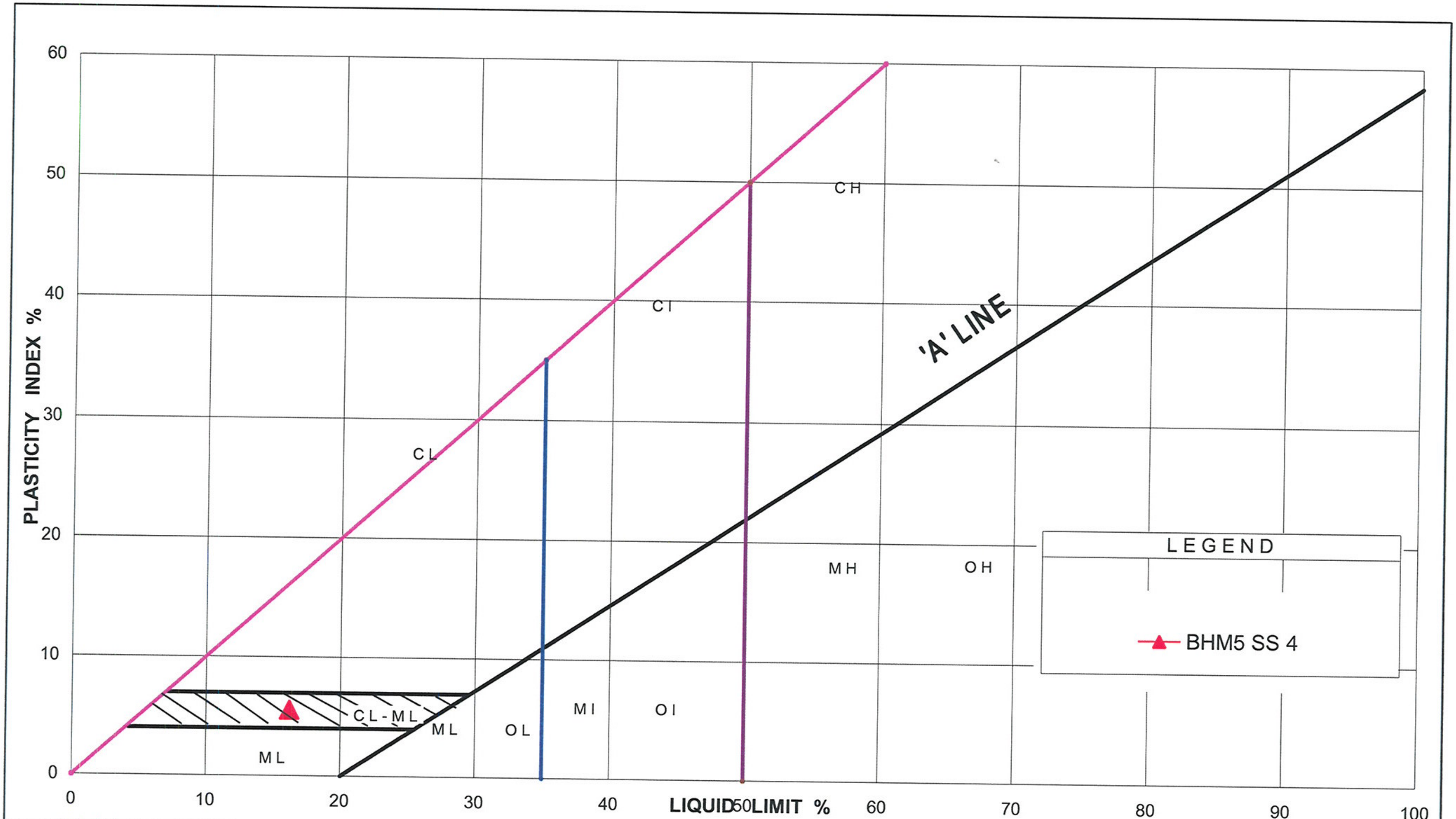
Clayey Silt Till

Figure: B4

PROJECT No: SPT - 1178

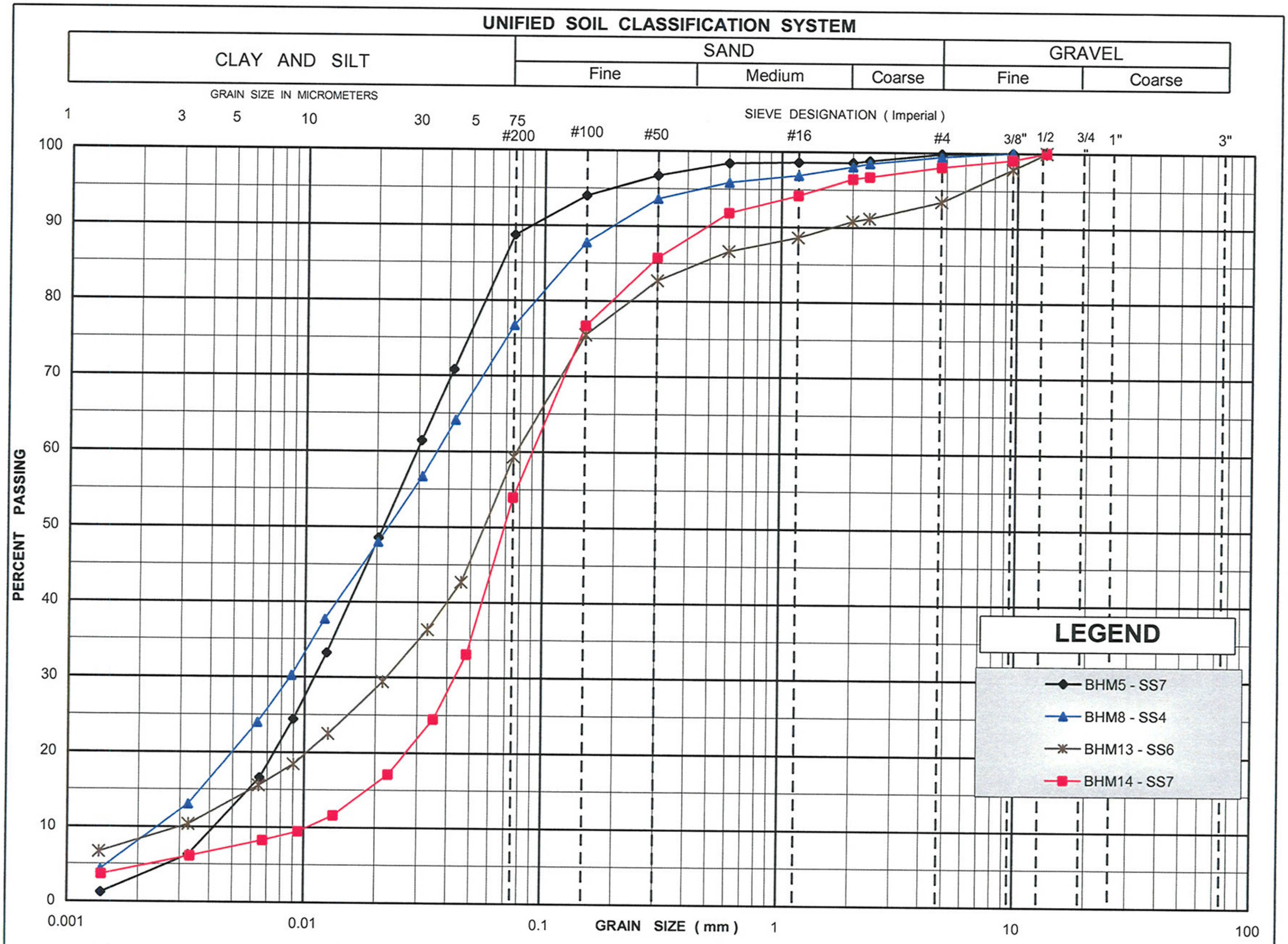
Date: October 16, 2006

FIGURE B4 - GRAIN SIZE DISTRIBUTION CURVES FOR SAMPLE BH M5 - SS4



SHAHEEN & PEAKER LIMITED	PLASTICITY CHART	Figure: B5
		Project No: SPT 1178
		Date: October16, 2006

FIGURE B 5 - ATTERBERG LIMITS TEST RESULTS FOR SAMPLE BH M5 / SS4



SHAHEEN & PEAKER LIMITED	GRAIN SIZE DISTRIBUTION Sandy Silt Till	Figure: B6 PROJECT No: SPT - 1178 Date: October 16, 2006

FIGURE B6 - GRAIN SIZE DISTRIBUTION CURVES FOR SAMPLES BHM5-SS7,BHM8-SS4,BHM13-SS6 AND BHM14-SS7

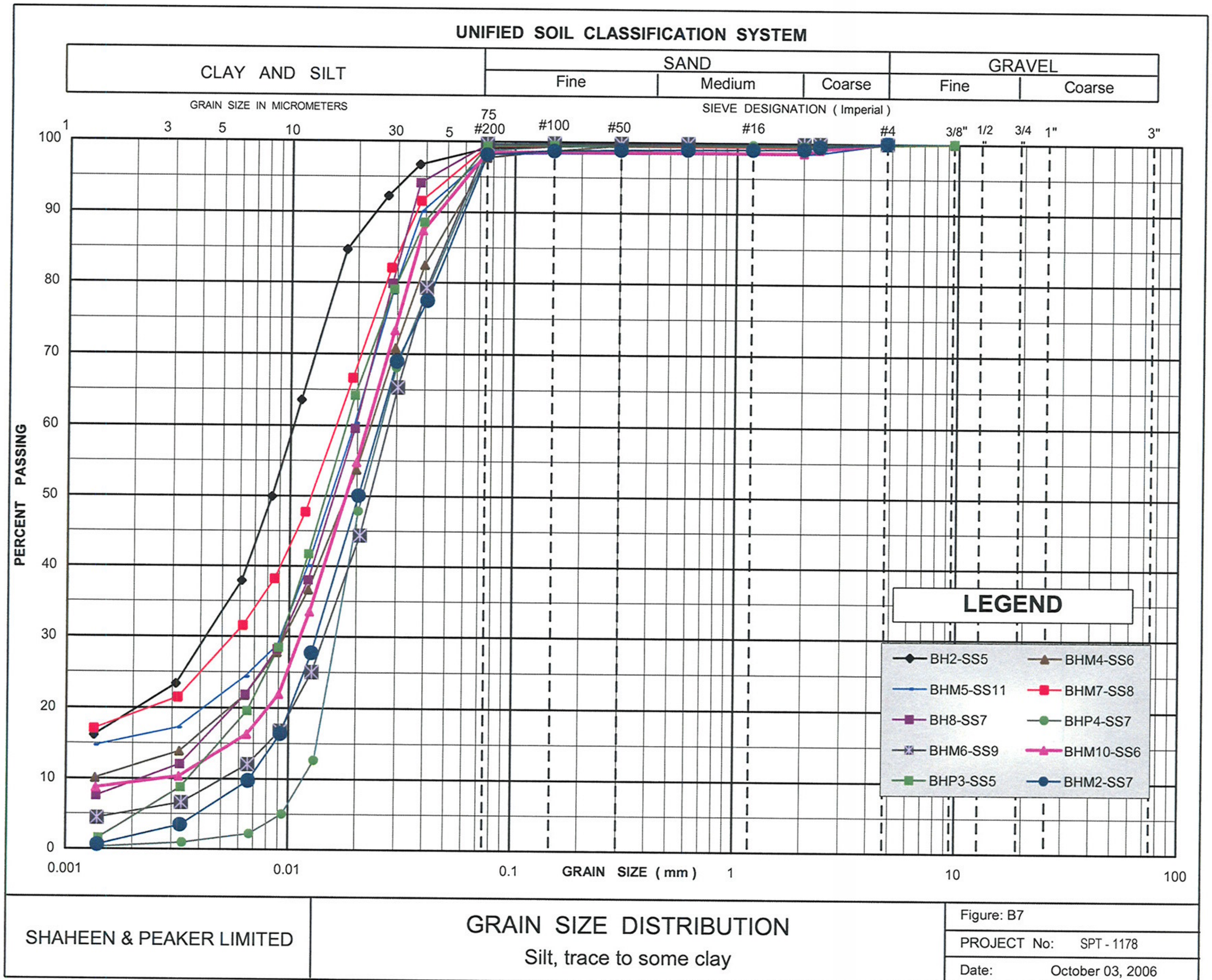
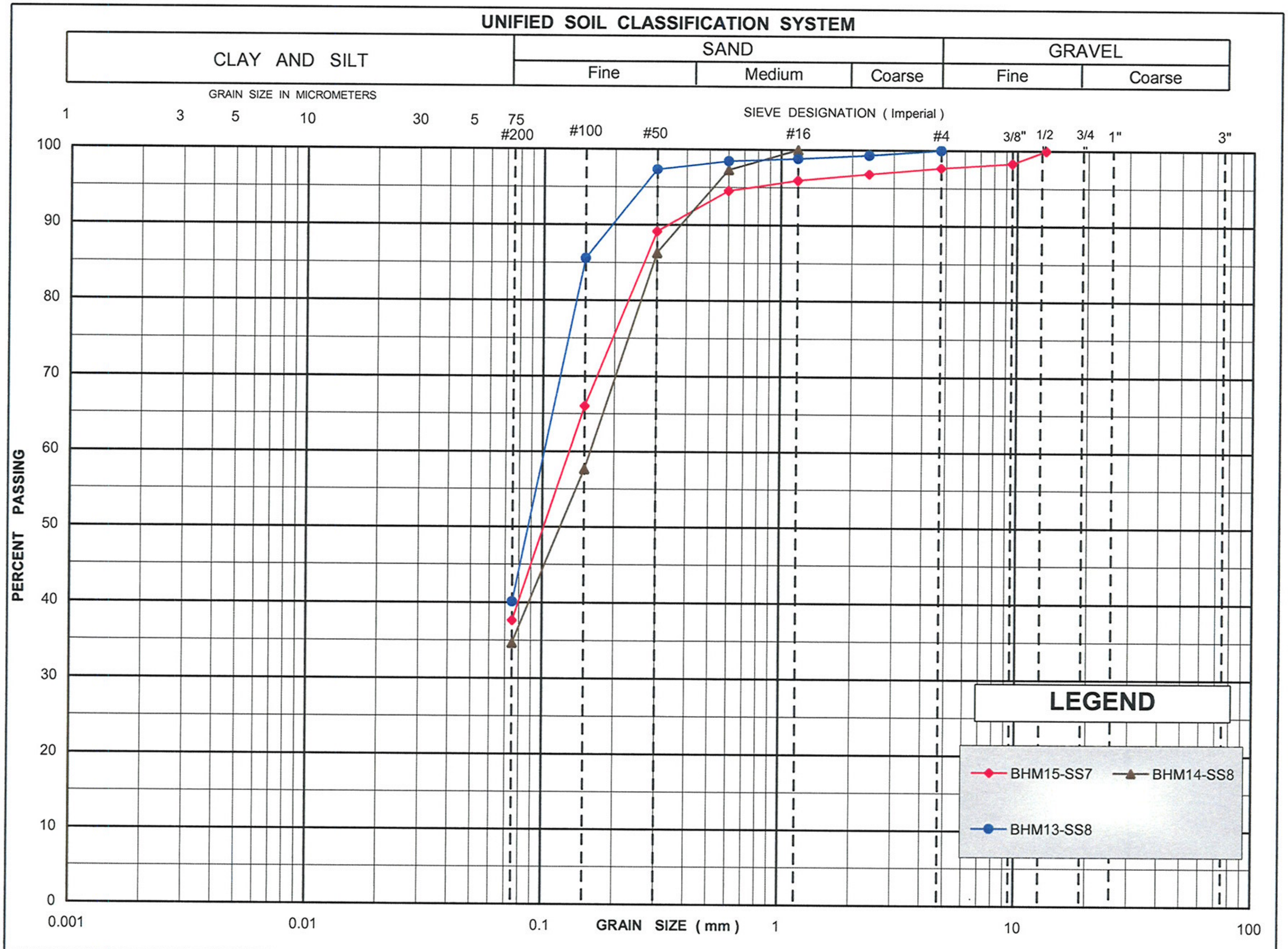
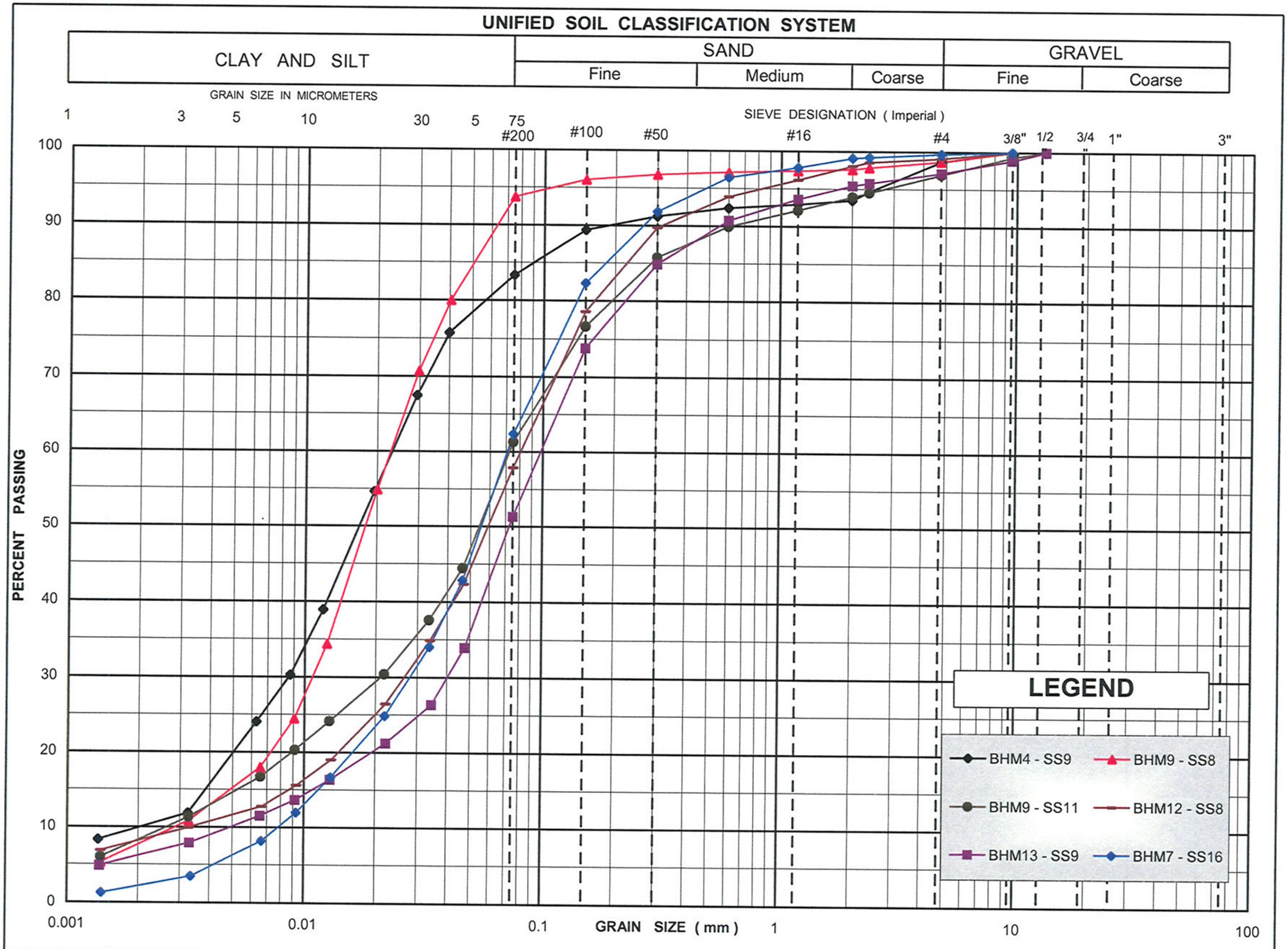


FIGURE B7 - GRAIN SIZE DISTRIBUTION CURVES FOR TESTED SAMPLES OF LOWER SILT DEPOSIT



SHAHEEN & PEAKER LIMITED	GRAIN SIZE DISTRIBUTION Silty Sand, trace gravel	Figure: B8 PROJECT No: SPT - 1178 Date: October 24, 2006

FIGURE B8 - GRAIN SIZE DISTRIBUTION CURVES FOR SAMPLES BH M13-SS8, BH M14-SS8 AND BH M15-SS7



SHAHEEN & PEAKER LIMITED	GRAIN SIZE DISTRIBUTION Silt, some sand, trace clay	Figure: B9 PROJECT No: SPT - 1178 Date: October 16, 2006

FIGURE B9 - GRAIN SIZE DISTRIBUTION CURVES FOR SAMPLES BH M4-SS9,M9-SS8,M9-SS11,M12-SS8,M13-SS9 & M7-SS1

Appendix C

Record of Borehole Sheets for BH101 to BH104 from Previous Preliminary Investigation by Others – Geocres No. 31D-408

Golder Associates

Foundation Design

RECORD OF BOREHOLE No 101

1 OF 1 **METRIC**

PROJECT 04-1111-016
W.P.
LOCATION N 4885216.0 ;E 311133.0
DIST Central HWY 404
BOREHOLE TYPE 108 mm Diameter Solid Stem Augers
DATUM Geodetic
DATE May 25, 2004
ORIGINATED BY PKS
COMPILED BY NK
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	WATER CONTENT (%)	GR	SA	SI	CL
271.1	GROUND SURFACE									
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	15						
270.3 / 0.8	Silt, trace sand and gravel, trace to some clay Compact Brown Moist to wet	2	SS	22						
		3	SS	13		~20	8	2	82	8
268.8 / 2.3	Clayey Silt with sand, trace gravel (TILL) Stiff to hard Brown Moist to wet	4	SS	12	∇ (Elev. 268.0)					
		5	SS	32		~9				
266.5 / 4.6	Silt, some clay, trace sand Very dense Grey Wet	6	SS	92						
		7	SS	72		~13	0	2	86	12
263.5 / 7.6	Clayey Silt with sand, trace gravel to Sandy Silt, trace to some clay, trace gravel (TILL) Hard/Very dense Grey Moist to wet	8	SS	100/.15						
		9	SS	100/.18		~5				
260.3 / 10.8	End of Borehole	10	SS	100/.10						

Note:

Water level in open borehole at 3.1m depth (Elev. 268.0m) on completion of drilling

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X REMOULDED (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10, 20, 30; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL; ELEVATION SCALE 271 – 261.

+ 3, X 3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

MISS_MTO_04111016AAGRD.GPJ ON_MOT.GDT 6/9/04

RECORD OF BOREHOLE No 102

METRIC

PROJECT 04-1111-016

W.P.

LOCATION N 4885206.0 ;E 311101.0

ORIGINATED BY PKS

DIST Central HWY 404

BOREHOLE TYPE 108 mm Diameter Solid Stem Augers

COMPILED BY NK

DATUM Geodetic

DATE May 25, 2004

CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
271.1	GROUND SURFACE					271		
0.0	Sand and gravel (FILL) Compact Brown Moist	1	SS	12				
270.3 0.8	Silt, trace sand and gravel, trace to some clay Compact Brown Moist to wet	2	SS	28		270		
		3	SS	26		269		
		4	SS	29			o	1 7 81 11
268.1 3.1	Clayey Silt with sand to Sandy Silt, trace clay, trace gravel (TILL) Very stiff to hard/Compact to very dense Grey Wet	5	SS	29		268		
						267		
		6	SS	62	∇	266	H	
265.0 6.1	Silt, some clay, trace sand Dense Grey Wet	7	SS	42		265		
						264		
263.5 7.6	Clayey Silt with sand, trace gravel to Sandy Silt, trace to some clay, trace gravel (TILL) Very stiff to hard/Compact to very dense Grey Wet	8	SS	26		263	o	
		9	SS	115		262		
						261		
		10	SS	100/.25		260	H	
258.8 12.3	End of Borehole	11	SS	100/.10		259		

Note:

Water level in open borehole at 5.2m depth (Elev. 265.9m) on completion of drilling

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × REMOULDED (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; UNIT WEIGHT γ kN/m³

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No 103

METRIC

PROJECT 04-1111-016
W.P.
LOCATION N 4885188.0 ;E 311104.0
DIST Central HWY 404
BOREHOLE TYPE 108 mm Diameter Solid Stem Augers
DATUM Geodetic
DATE May 25, 2004
ORIGINATED BY PKS
COMPILED BY NK
CHECKED BY LCC

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.9	GROUND SURFACE					
0.0	Silt, trace sand and gravel, trace to some clay Loose to compact Brown, becoming grey at 2.7 m depth Wet	1	SS	6		
		2	SS	12		
		3	SS	20		
		4	SS	21		
267.9 3.1	Clayey Silt with sand, trace gravel (TILL) Very stiff Grey Wet	5	SS	21		3 29 55 13
266.3 4.6	Silt, some clay, trace sand Dense to very dense Grey Wet	6	SS	68	∇	
		7	SS	32		
263.3 7.6	Clayey Silt with sand, trace gravel to Sandy Silt, trace to some clay, trace gravel (TILL) Very stiff to hard/Compact to very dense Grey Wet	8	SS	22		
		9	SS	100/.18		
		10	SS	100/.18		
258.6 12.3	End of Borehole	11	SS	100/.13		

Elevation scale: 270, 269, 268, 267, 266, 265, 264, 263, 262, 261, 260, 259

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%): 10 20 30

UNIT WEIGHT γ kN/m³

Note:

Water level in open borehole at 4.6m depth (Elev. 266.3m) on completion of drilling

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

Golder Associates

Foundation Design

RECORD OF BOREHOLE No 104

METRIC

PROJECT 04-1111-016
W.P.
DIST Central HWY 404
DATUM Geodetic

LOCATION N 4885199.0 ;E 311189.0
BOREHOLE TYPE 108 mm Diameter Solid Stem Augers
DATE May 25, 2004

ORIGINATED BY PKS
COMPILED BY NK
CHECKED BY LCC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
270.4	GROUND SURFACE					
0.0	Silt, trace sand and gravel, trace to some clay Compact Brown Moist to wet	1	SS	13	270	
		2	SS	23		
268.9 / 1.5	Clayey Silt with sand, trace gravel (TILL) Hard Brown Moist to wet	3	SS	80	269	
268.1 / 2.3	Silt, some clay, trace sand Very dense Brown to grey Wet	4	SS	58	268	
		5	SS	109	267	
		6	SS	62	266	0 1 87 12
264.3 / 6.1	Clayey Silt with sand to some sand, trace gravel to Sandy Silt, trace to some clay, trace gravel (TILL) Hard/Dense to very dense Grey Moist	7	SS	110	264	4 32 52 12
		8	SS	[illegible]	283	
		9	SS	[illegible]	262	
261.1 / 9.3	End of Borehole					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × REMOULDED — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ kN/m³

Notes;

1. Water level in open borehole at 3.1m depth (Elev. 267.3m) on completion of drilling

2. Water level in piezometer at 1.2m depth (Elev. 269.2m) on June 9, 2004.

$+^3, \times^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

Appendix D

Site Photographs

Photograph 1 – 10+250 North Side looking east

Photograph 2 – 10+250. south side looking east

Photograph 3 – 10+250 South Side looking west

Photograph 4 –10+250 North Side looking west

Photograph 5 – 10+050 South Side looking west

Photograph 6 – 10+050 North Side looking west

Photograph 7 – 10+000 Looking North

.

Photograph 8 – 10+000 looking south

Photograph 9 - 9+950 South Side looking west

Photograph 10 – 9+950 North Side looking west

Photograph 11 –9+850 South Side looking west

Photograph 12 –9+850 North Side looking west


Photograph 13 –9+750 South Side looking west


Photograph 14 –9+750 North Side looking west

Photograph 15 –Mt. Albert at east end of site at Woodbine Avenue

Photograph 16 –Mt. Albert at west end of site

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

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

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

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

ROCKS ARE DESCRIBED BY THEIR COMPOSION AND STRUCUTRAL FEATURES AND/OR STRENGTH.

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

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

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

JOINT AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
σ_l, σ_2, σ_3	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
ε_1, ε_2, ε_3	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICALL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	$-^o$	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	$-^o$	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

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

FOUNDATION DESIGN REPORT
PROPOSED HIGHWAY 404 EXTENSION
ADVANCE STRUCTURES AT MOUNT ALBERT ROAD
TOWN OF EAST GWILLIMBURY, ONTARIO
MTO CENTRAL REGION
W.O. 04-20024
AGREEMENT NO. 2004-E-0051

Prepared For:

UMA ENGINEERING LTD.

Prepared by:

SHAHEEN & PEAKER LIMITED

Project: SPT1178
April 24, 2007

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FOUNDATION DESIGN REPORT
PROPOSED HIGHWAY 404 EXTENSION
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6. DISCUSSION AND RECOMMENDATIONS

The proposed Highway 404 Overpass structures over Mt. Albert Road will be single-span twin bridges to accommodate the future 4-lane (initial two-lane) Mt. Albert Road. With the present design, each overpass structure will have a single span of 30 m length and integral abutments. Initially, the bridges will be built to accommodate four-lanes of Highway 404 but may be widened to six-lanes in the future. The existing Mt. Albert Road will be cut (lowered) by up to about 6 m below the existing grade, such that the finished Mt. Albert Road grade will be at about Elevation 265.5 m. The proposed Highway 404 grade will be at about Elevation 272.8 m. The existing ground surface at the bridge site varies from about Elevation 270.0 to 271.4 m. The height of the abutment walls will, therefore, be approximately 7 m. (See Drawings F-1 and F-2 in Appendix F.)

Below the topsoil or pavement structure, the site is generally underlain by an upper silt deposit, followed by an upper clayey silt till/sandy silt till, which is, in turn, underlain by a lower silt deposit. The lower silt deposit is underlain by a lower clayey silt till/sandy silt till.

Groundwater levels at the time of our investigation were found at depths ranging between 0.6 and 4.9 m below the ground surface or at El. 269.8 to 264.8 m. However, most measured groundwater levels are between 1 and 3 m depth (roughly between El. 269.5 and 268.0 m). It should be noted that the measured groundwater levels are subject to seasonal variations and in response to major weather events.

Based on the subsurface soil and groundwater conditions encountered during the geotechnical investigation, recommendations are provided with regard to the design and construction of the proposed works. The soil conditions may vary between and beyond the borehole locations, and accordingly geotechnical inspection during construction is important to assess any variation of subsurface conditions and to provide recommendations in a timely manner such that impacts of the variations can be mitigated.

It must be noted that a number of underground utilities may be present near the project site. Prior to any foundation installation, the locations of all underground utilities must be carefully located and protected or relocated, if necessary, to avoid damaging the utilities during foundation and earthwork construction. Furthermore, construction operations may encounter trench backfill and other subsurface conditions not identified by the boreholes.

6.1 FOUNDATION DESIGN ALTERNATIVES

6.1.1 GENERAL

This section starts with the general discussion of the feasibility of potential foundation support systems for the proposed twin bridges. Table 6.1.1.1 presents the merits and disadvantages of various foundation alternatives such as spread footings, augered caissons and driven piles. The upper loose to compact silt/sandy silt is not generally considered suitable to support any significant foundation. Considering that the proposed grade for the new bridges will be raised by up to about 2.8 m above the original ground surface, the construction of the new approach embankments and placement of the abutment fills is expected to impose additional stresses on in-situ soils, which could potentially lead to some settlements. It should also be noted that the existing Mt. Albert Road in the area of the proposed underpass will be cut by about 6 m below the existing grade to about El. 265.5 m. Assuming a minimum soil cover of 1.5 m for frost protection, the possible founding level for normal spread footing foundations for the twin bridges is at around El. 264± m (i.e. 265.5 m – 1.5 m).

Table 6.1.1.1 - Summary of Foundation Alternatives

Foundation Option	Comments	Recommendations
Conventional spread footings founded on dense lower silt deposit at about 1.5 m depth below the proposed Mt. Albert Road grade, at about El. 264±m	Moderate to good bearing resistance but potential for excessive differential settlements. Effective dewatering which would be required during construction could be difficult to implement. In addition, there may be potential for "basal heave" in case of rise in groundwater level prior to application of adequate dead load on the base of the footing.	Conventional spread footings founded on compact to dense lower silt deposit are not recommended, because of concerns about the reliability and effectiveness of the necessary dewatering and potential for loss of fines as well as potential for differential settlements. Not Recommended.
Extended spread footings on hard/very dense lower till at appropriate depths below the lower silt deposit	Good bearing resistance and limited settlement can be expected for footings founded on the lower competent glacial till deposits. Additional excavation would be required beyond the proposed Mt. Albert Road cut, which is expected to be difficult. Potential for extensive and difficult dewatering.	Extended spread footings founded on dewatered competent lower till can be considered. However, this will require footing bases at variable elevations and will present construction difficulties, as well as extensive dewatering. In addition, this approach will not be suitable for integral abutments. Not Recommended.
Spread footings on Engineered Fill (i.e., compacted Granular 'A' pad)	Moderate bearing capacity and moderate potential settlement could be expected for footings founded on compacted Granular 'A' pad resting on the upper till after the removal of the upper silt deposit. This option is likely to	Spread footings on Granular 'A' pad can be considered subject to practicability of staged construction and economics. However, this option is not considered an economically feasible option for the

Foundation Option	Comments	Recommendations
	require dewatering and may be impractical considering the proposed cut slopes for the future four-lane Mount Albert Road.	presently proposed scheme and is not recommended.
Footings on Expanded Base (Franki-type) concrete piles	Not a good approach with the prevailing subsurface conditions.	Not recommended.
Drilled and cast-in-place concrete piles (caisson foundations)	Not a good choice due to high water table and the presence of water-bearing upper and lower silt deposits as well as the presence of wet sand seams in the lower glacial till.	Drilled caissons founded on competent lower till can be considered, provided that the bases of the caissons can be effectively dewatered and it can be proven to be cost effective. However, this type of foundation is not suitable for the integral abutment type bridge proposed.
Auger press concrete piles	May not provide adequate lateral support and are costly.	Not recommended due to concerns about potential cost and reliability.
Driven concrete piles	Considered uneconomical as well as being high displacement piles.	Not recommended based on cost and reliability.
Timber piles	Short piles will not provide adequate axial resistance.	Not recommended based on reliability.
Steel H-piles	Low displacement steel H-piles represent the best foundation option for support of the proposed structures at moderate depths with integral abutments.	Considered best choice based on reliability and suitability.
Steel tube piles	Steel tube piles may be considered as an alternative to steel H-piles. However, tube piles are high displacement piles and are less suitable for this project. As well, the presence of obstructions such very dense layers with boulders and cobbles in glacial till, if encountered, could result in significant problems.	Considered less reliable and less suitable than low displacement steel H-piles. As well, this option is not suitable for integral abutments. Further evaluation and discussions with specialized contractors would be required to assess the feasibility of construction of this type of pile successfully driven through glacial till, if such a system needs to be considered.

6.1.2 CONVENTIONAL/EXTENDED SPREAD FOOTINGS ON NATIVE SOIL

To about El. 265 to 262 m, the soil deposits have variable relative density/consistency, as evidenced by variable N-values recorded in the boreholes. For example, in Borehole M6, the N-values recorded in the sandy silt till between El. 266.5 and 265.5 m are 43 and 100 blows/0.3 m, while in the underlying silt between El. 265.5 m and 262.5 m, the recorded N-values are 23, 20, 14 and 10 blows/0.3 m. These low N-values may be partially due to inevitable disturbance while drilling in the wet, water-bearing silt deposit; nevertheless, considering potential differential settlements due to variable soil conditions, as well as the N-values, it is considered unwise to support the bridges in this variable zone. For this reason, spread footings will need to be extended below the wet silt and into the underlying more reliable clayey silt to sandy silt till deposits. In addition, with this option, it is necessary to dewater the water-bearing silt and also the wet sand layers in the lower till deposit in advance of the foundation excavations in order to maintain sufficiently dry conditions and basal stability of the bearing soils during construction. Considering the high water table at the site, dewatering the site by up to 7 m can be expected to be difficult and costly. As well, due to variable foundation depths, significant engineering control would be required during the construction. For these reasons, the use of spread footings for this project is not recommended. As well, spread footing foundations may not be a feasible option for integral abutments. However, the following information is provided for the sake of completeness.

For spread footing foundations, the footings for the bridge structures should be founded on the lower glacial till consisting of clayey silt till or sandy silt to silty sand till (i.e. below the lower silt deposit) at or below the levels recommended in Table 6.1.2.1.

Table 6.1.2.1 – Extended Spread Footings

Borehole No.	Recommended Highest Footing Level Below Existing Grade (m)	Recommended Highest Foundation Elevation (m)	Factored Geotechnical Bearing Resistance at ULS (kPa)	Bearing Resistance at SLS (kPa)
Highway 404 NB				
M10	5.4	264.7	800	500
104*	6.1	264.3	800	500
101*	7.6	263.5	800	500
M8	7.2	263.5	800	500
M9	5.9	265.0	800	500
Highway 404 SB				
M6	8.5	262.0	800	500
103*	8.8	262.1	800	500
102*	8.7	262.4	800	500
M5	9.4	261.6	800	500
M7	8.0	262.8	800	500

*Boreholes by others.

Under inclined loading conditions, the bearing resistance at U.L.S. will need to be reduced in accordance with the Canadian Highway Bridge Design Code (C.H.B.D.C.).

If necessary, the footings may be stepped to accommodate variations in the profiles of the proposed road cut and suitable soil founding levels. To provide a level base, the lower portions of the excavations can be filled with weak concrete. The design of stepped footings should be in accordance with the requirements of the CHBDC. Allowance will need to be made to place a 100 mm thick concrete mud mat (i.e. skim coat) in all footing excavations.

Resistance to lateral forces/sliding resistance between the concrete footings and undisturbed dense to very dense/hard lower silt till may be calculated using an ultimate friction angle of 28 degrees.

6.1.3 SPREAD FOOTING ON COMPACTED GRANULAR PAD FOUNDATION OPTION

With the prevailing soil conditions and the proposed bridge configurations, the use of spread footings on compacted granular pad is not a suitable option, especially since it will increase the span of the bridges considerably. However, the following information is provided for the sake of completeness.

For spread footing foundations on a minimum 2 m thick compacted Granular 'A' pad, as per normal MTO convention, our recommendations are presented in Table 6.1.3.1 below.

Table 6.1.3.1
Spread Footings on Compacted Granular 'A' Pad

BH No.	Recommended Highest Possible Founding Level for Granular 'A' Pad Below Existing Grade (m)	Recommended Highest Possible Foundation Elevation (m) (i.e. bottom of Granular 'A' pad)	Factored Geotechnical Bearing Resistance at ULS (kPa)	Bearing Resistance at SLS (kPa)
Hwy 404 NB				
M10	2.4	267.7	800	350
104*	1.7	268.7	800	350
101*	3.0	268.1	800	350
M8	2.3	268.4	800	350
M9	1.7	269.2	800	350
Hwy 404 SB				
M6	3.7	266.8	800	350
103*	3.2	267.7	800	350
102*	3.1	268.0	800	350
M5	2.6	268.4	800	350
M7	3.2	267.6	800	350

* Boreholes by others.

This option may also require some dewatering during construction. Further consultations are recommended, if this option is to be considered.

6.1.4 CAST-IN-PLACE CONCRETE CAISSON FOUNDATION

It should be noted that the bottom of the proposed excavation for Mt. Albert Road cut is expected to be between Elevation 265.0 and 265.5 m, or about 6 m below existing grades. The bottom of the excavation for the bridges will generally be in the native wet silt deposit and about 1.5 to 2.5 m above the hard/very dense lower till deposit. For a minimum 5 m long caisson length below the pile cap (assuming El. 267 m for the pile cap – see Drawing F-1 and F-2 in Appendix F), the bottom elevations are expected to be at or below about El. 262 ±m.

For caisson foundation alternative (i.e. drilled and cast-in-place concrete piles) founded on hard clayey silt till, or very dense sandy silt till, the recommended foundation depth/elevations (minimum 5 m length below pile cap) and bearing resistances are presented in Table 6.1.4.1 below.

Table 6.1.4.1
Caisson Foundations

BH No.	Recommended Minimum Caisson Length Below Pile Cap* (m)	Recommended Highest Caisson Base Elevation (m)	Factored Geotechnical Bearing Resistance at ULS (kPa)	Bearing Resistance at SLS (kPa)
Hwy 404 NB				
M10	5	262.3	3000	1800
104**	5	262.5	3000	1800
101**	5	262.0	3000	1800
M8	5	261.0	3000	1800
M9	5	262.6	3000	1800
Hwy 404 SB				
M6	7	260.0	3000	1800
103**	5	260.3	3000	1800
102**	5	260.5	3000	1800
M5	5	259.0	3000	1800
M7	5	261.2	3000	1800

* Caisson cap assumed to be at Elevation 267± m
** Boreholes by Others

The potential presence of pervious sand layers within the upper zones of the lower till or within the overlying silt deposit could have implications for basal heave. Transient or steady state groundwater flow could potentially lead to disturbance of the base of the caisson, or basal heave, if significant upward groundwater gradients are encountered, or if the underlying soils are not adequately dewatered prior to the installation of the caissons. This could create some problems during the installation of the caissons, e.g., if the bottom of the caisson falls within a water-bearing wet sand seam, or relatively coarser silty sand till, potential groundwater flow may lead to basal instability and potential loss of bearing capacity. Furthermore, the installation of the caissons through the water-bearing silt deposit would be difficult unless the water-bearing, relatively more pervious soils were dewatered ahead of the installation of the caissons. For these reasons, the use of caisson foundations is not a good choice, since, as well, integral abutments are proposed.

6.1.5 STEEL H-PILES

The geotechnical conditions at this site are considered suitable for the use of driven steel H-piles to support the proposed Highway 404 bridge overpasses at Mt. Albert Road. The borehole data show that with the prevailing subsurface conditions the use of a low displacement pile, such as a steel H-pile with a heavy section (e.g. HP 310 x 110), would be better suited than other pile types (e.g. steel tube piles, steel H-piles with lighter sections or precast concrete piles).

Steel H-piles (310x110) driven to appropriate depth within the lower glacial till deposit can be used to support the abutments. The estimated pile tip elevations are presented in Table 6.1.5.1 below. Considering the short pile lengths, the recommended ULS and SLS axial geotechnical pile resistances are 1500 kN/pile and 1000 kN/pile, respectively. In anticipation of the expected heavy driving conditions and minimum pile penetration depth requirements (i.e. minimum 5 m pile length in undisturbed soil, as discussed later on in this section of the report), the recommended ULS and SLS values were kept somewhat below MTO's standard values of 1700 kN/pile and 1200 kN/pile for ULS and SLS, respectively, for very dense/hard till soils. However, as discussed later, with the present design scheme (Drawings F-1 and F-2 in Appendix F) even somewhat lower resistances may need to be considered, depending on the design requirements. This is because it is necessary for the piles to penetrate the undisturbed competent soil by at least 5 m and this minimum length requirement may create some design/construction problems. This aspect should be further looked into when the design details are known.

Table 6.1.5.1
Estimated Tip Elevations for Steel H-Piles Foundations

Borehole No.	**Existing Ground Elevation at BH Location (m)**	**Estimated Pile length Below Pile Top* (m)**	**Estimated Pile Tip Elevation (m)**
Hwy 404 NBL			
M10	270.1	5**	262**
104**	270.4	5**	262**
101**	271.1	6**	261**
M8	270.7	7**	260**
M9	270.9	5**	262**
Hwy 404 SBL			
M6	270.5	10	257

Borehole No.	Existing Ground Elevation at BH Location (m)	Estimated Pile length Below Pile Top* (m)	Estimated Pile Tip Elevation (m)
103**	270.9	8	259
102**	271.1	8	259
M5	271.0	9	258
M7	270.8	8	259

* Pile top assumed to be at Elevation 267 ± m
** As will be discussed later in this section, pile tips may have to be extended to El. 259 m or lower to allow for the required flex zone for integral abutments.

The pile tip elevations provided in Table 6.1.5.1 are for estimating purposes only. Due to potentially variable soil conditions, the actual pile tip elevation may vary. The contract should allow for some variations in pile length and this aspect should be taken into consideration when ordering the piles. The piles should be driven into the competent lower glacial till deposit using a suitably heavy hammer capable of delivering a rated energy of between 60 and 70 kilojoules/blow. The possibility of piles encountering potential cobbles and boulders in the till should be anticipated. In view of this, as well as the very dense/hard nature of the till and minimum penetration requirements of the piles (as will be discussed later on in the section of the report) tips and tops of the piles should be stiffened to minimize damage to the piles in anticipation of heavy driving conditions. Care must be taken to avoid overdriving and damaging the pile tip (i.e., the structural capacity of the piles should not be exceeded).

The actual pile tip elevations and the driving of the piles in the field should be controlled by dynamic analysis, or a recognized pile driving formula such as the Hiley Formula. Normally, in accordance with MTO practice, the estimated ultimate resistance of the piles by the Hiley Formula can be calculated by multiplying the recommended axial resistance at U.L.S. by a factor of 2 (i.e., 1500 x 2), giving an ultimate geotechnical resistance of 3000 kN.

In accordance with the above criterion, we recommend that the piles be driven to about 2 m above the estimated pile tip elevations, and driving should then be monitored and controlled by employing the Hiley Dynamic Pile Driving Formula in accordance with MTO Standard SS103-11, using an ultimate geotechnical resistance of 3000 kN per pile, subject to the approval of the QVE. In addition to meeting this criterion, the piles will need to be driven to not less than 5 m into the undisturbed competent soil.

If the piles encounter refusal before sufficiently penetrating into the lower competent sandy silt till deposit underlying the lower silt deposit, then pile capacities may need to be revisited and alternative measures sought. Therefore, pile driving records should be kept and if refusal is met above the recommended bearing zone, a geotechnical engineer should review the driving records to assess the axial resistance. As well, the Structural Engineer should be consulted for minimum pile length requirements. It is also possible that the piles may be driven some distance below the estimated pile tip elevations to achieve the desired capacity.

All pile driving should be carried out in accordance with SP903S01. Re-striking should be done as per SP903S01. After each pile is installed, an elevation should be taken of the pile top or on a suitable mark on the side of the pile. This elevation should be checked periodically to confirm that the pile has not heaved as a result of the driving of adjacent piles. Piles that are heaved must be redriven to the required resistance as required by the engineer. At least 10% of the piles (but not less than two piles) driven at each support element should be re-tapped not less than 24 hours after the driving of the pile, as per SP903S01, to check that relaxation has not occurred. If it has, then all the piles should be re-tapped.

In addition, it may be necessary to stagger the driving of the piles, if heaving is observed. The piles should normally be driven upon completion of surcharging, if required. The use of light-weight (e.g. HP 310 x 79) piles is not recommended due to the energy required to extend the piles to relatively deep tip elevations (i.e. piles may be damaged). We also recommend that the potential need for pile load test(s) be allowed for in the contract documents.

The recommended minimum embedded pile length is 5 m, in order to provide adequate uplift resistance, as well as to provide adequate axial and lateral geotechnical resistance. As was mentioned, this may create some design/construction difficulties, especially in the case of integral abutments. As will be discussed later on in this section, in accordance with MTO requirements, piles for integral abutments require a 3.0 m long flex zone. The required minimum embedment zone starts below the bottom of this flex zone. For example, if the top elevation for the pile (i.e. top of flex zone) will be El. 267 m (see Drawings F-1 and F-2 in Appendix F) then the bottom of the flex zone will be at El. 264 m (i.e. 267 m – 3 m = El. 264 m). The piles in this instance will need to be driven to not less than 5 m below El. 264 m, or to El. 259 m (i.e. 264 m – 5 m = El. 259 m) or below. Based on the borehole results (i.e. competent tills to drive through, as well as the presence of possible cobbles and/or boulders), to extend the piles to this elevation may be difficult, especially at the NBL Bridge location. For example, reference to Table 6.1.5.1 shows that anticipated pile refusal elevations at Boreholes M10, 104 and M9 are 262 m. This means the piles need to be driven at least 3 m below this elevation to maintain a minimum 5 m penetration depth to El. 259 m. This may be difficult to achieve without causing damage to the piles and consideration may be given to a heavier pile section or less stringent penetration requirements, especially at the NBL bridge location. Allowance may, therefore, be made to resort to pre-augering, if necessary, or to reduce the axial resistance and uplift capacity of the piles, if these elevations could not be reached. Any decision regarding pre-augering should be made in consultation with the QVE and the Structural Engineer, since pre-augering will lead to a loss in lateral resistances and also possibly in axial resistances. Consideration should also be given to provide an NSSP to alert the contractor of the possible presence of cobbles and boulders and possible heavy driving requirements through the very dense/hard strata, as well as possible pre-augering.

As will be discussed later on this report, it would be desirable/necessary to raise the grade of the bridges by 1 to 2 m, in order to provide adequate drainage for the proposed Mt. Albert Road pavement structure and if this is done, 5 m penetration of the piles below the bottom of the flex zone will be much easier to achieve. This is the recommended solution.

Eccentric loading on piles and the required pile spacing should be considered as per the latest Canadian and Ontario Highway Bridge Design Codes and the Canadian Foundation Engineering Manual. Reference may be made to Section C6-8.7.1 of the Canadian Highway Bridge Design Code (2000), CHBDC, for assessing lateral pile resistance.

In cohesionless soils, the lateral resistance of the piles may be calculated using values for the coefficient of horizontal subgrade reaction k_s which can be estimated as follows:

$$k_s = n_h z / d \qquad (MN/m^3)$$

where n_h = coefficient related to soil density
z = depth below abutment base (m)
d = pile width (m)

n_h = 1,500 kN/m^3 for loose to compact upper silt to sandy silt
= 4,400 kN/m^3 for compact to dense upper till
= 11,000 kN/m^3 for dense to very dense lower silt or sandy silt to silty sand till.

Applicable soil parameters are detailed in Appendix G.

Where the soil is primarily cohesive, k_s is estimated based on the undrained shear strength of the soil as follows:

$$k_s = 67\, C_u / d \qquad (MN/m^3)$$

where C_u = undrained shear strength of the cohesive soil deposit.

Soil parameters are provided in Appendix G.

For preliminary estimating purposes, the recommended horizontal resistances for HP310x110 steel H-piles are as follows (assuming minimum 5 m penetration into the undisturbed, hard/very dense soil):

Factored Horizontal Resistance at U.L.S. = 120 kN/pile
Horizontal Resistance at S.L.S. = 50 kN/pile

If integral abutments are not constructed then the lateral resistance of the piles can be supplemented, if desired, by the horizontal components of battered piles. For practical installation purposes, we recommend that the batter be limited to no more than 1H:5V, as in practice greater batter is difficult to install, especially considering the anticipated hard driving conditions.

The minimum spacing between piles should be in accordance with Clause 6.8.9.2 of the CAN/CSA-S6-00, Canadian Highway Bridge Design Code.

Design frost protection depth for the general area of this site is 1.5 m. Therefore, a permanent earth cover of at least 1.5 m or its thermal equivalent of artificial insulation is required for frost protection of foundations, including any pile caps. In case of rip-rap (rock fill), only one-half of the rock fill thickness should be assumed to be effective in providing frost protection.

Oversize materials (e.g. greater than 75 mm nominal diameter) should not be used in backfill or embankment fills through which piles would be driven.

In accordance with MTO requirements (MTO Structural Office Standard), piles for integral abutments require a 3 m long flex zone. The flex zone consists of an annular space in between two concentric corrugated steel pipes (CSP's). One of the CSP's surrounds the H-pile (i.e. has a diameter of about 600 mm surrounding the pile, while the second CSP has a somewhat larger diameter; typically 800 mm for a 310 mm H-pile). In accordance with current MTO practice, this space between the CSP's can be left void. After the pile is driven, the space between the H-pile and the inner CSP is filled with sand. The sand for filling the hole should meet the gradation requirements as presented in MTO's integral abutment design standard.

Alternatively, in accordance with MTO structural office requirements (Report SO-96-01), the flex zone can be provided by augering a 600 mm diameter hole 3000 mm deep and filling with uniform sand. A special provision should be included in the contract specifying the gradation of the sand as follows:

Table 6.1.5.2

Sieve Size	**Percentage Passing**
2 mm	100 %
600 µm	80-100 %
425 µm	40-80 %
250 µm	4-25 %
150 µm	0-6 %

A problem that may arise is upward water and/or silt migration along the driven piles. As was mentioned before, high groundwater conditions were encountered in most boreholes, emanating from the upper and lower silt deposits and possibly also in the sand and silt interlayers in the glacial till deposits. It is likely that the clayey silt till, where present, will seal the piles and prevent water and soil particles from migrating upwards along the pile. However, the placement of the CSP's to provide a flex zone will increase the chances of such an occurrence. It is, therefore, recommended that conditions at the site be carefully observed to detect such occurrence during and several weeks after the driving of the piles. In addition, an NSSP be provided in this contract to deal with this eventuality should this happen. This could consist of standard MTO inverted filter at the base of the piles, as shown in Appendix J.

6.1.6 CLOSED-END STEEL TUBE PILES

Tube piles will provide lower resistances in comparison with H-piles as they will not drive as deep, but it is possible that the lower resistances may be somewhat compensated by the relatively shorter pile lengths and material costs. Steel tube piles have the advantage that they can be inspected (after driving and prior to pouring the concrete) for possible damage that may have incurred while driving. They should have sufficient wall thickness and base plate thickness to minimize potential damage caused by the expected hard driving conditions. The end plates should not be wider than the base area of the piles (i.e. should not project beyond the circumference of the pile) so that adhesion/friction is not adversely affected. Tube piles will need to be filled with concrete after their installation and inspection for possible damage.

Steel tube piles of 300 mm nominal diameter (e.g. 324 mm x 12.5 mm) driven at least 2 m into the hard/very dense lower glacial silt till deposit underlying the lower silt can be expected to provide a Factored Axial Resistance at U.L.S. of 1000 kN/pile and an Axial Resistance at S.L.S. equal to 700 kN/pile (at about 1 to 2 m above the elevations given in Table 6.1.5.1 of this report).

The piles will need to be driven using a suitably heavy hammer capable of delivering a rated energy of at least 55 kilojoules/blow but not more than 70 kilojoules/blow. The driving of the piles in the field should be controlled by a recognized pile driving formula, such as the Hiley Formula. The estimated ultimate resistance of the piles based on the Hiley Formula can be calculated by multiplying the recommended axial resistance at U.L.S. by a factor of 2.0. With this criterion, the estimated ultimate resistance required would be 1000 x 2.0 = 2000 kN/pile.

The piles should be driven to about 2 m above the design elevation and driving should then be monitored and controlled by employing Hiley Dynamic Pile Driving Formula in accordance with MTO Standard SS103-11. The driving of the piles should be conducted in accordance with SP903S01. As was mentioned for steel H-piles re-striking and staggering should be allowed for, if necessary.

Pile lengths may be different than the estimated values and, therefore, this aspect will need to be considered in the contract documents and when ordering piles. If some piles can not reach the required pile tip elevations and pile load test(s) may need to be conducted.

The minimum pile spacing should be in accordance with CHBDC and with due consideration of the pile lengths.

Suggested soil parameters for the calculation of the lateral resistance/deflection of the piles were given in the previous section of this report. If battered piles are required to sustain horizontal loads, then the batter should be limited to 1H:5V in view of the lengths of the piles as was discussed earlier.

Steel tube piles are less likely to reach the required depths in comparison with steel H-piles and are therefore considered to be a less desirable choice. As well, they are not suitable for use with integral abutments and as such their use is not recommended (i.e. low displacement of steel H-piles are a better option for this project).

6.2 LATERAL EARTH PRESSURES FOR ABUTMENTS AND WING WALLS

Design of abutment walls and wing walls should be carried out in accordance with the latest CHBDC using conventional cantilevered type gravity walls or retained soil systems supported on shallow or deep foundations. In either case, the design of the abutment walls should include checking for resistance against sliding, overturning and global stability.

Backfill behind abutments should consist of non-frost susceptible, select free-draining granular materials meeting the specifications of OPSS Granular A, Granular B Type II (with less than 5 % fines content passing #200 sieve), or Granular B Type I (modified) (Special Provision No. 110F13), in accordance with the Ontario Ministry of Transportation Standards and the requirements of OPSD 3101.150. The backfill should be placed and compacted in accordance with OPSS 501.

Free-draining backfill materials (i.e. Granular 'A' or Granular 'B') and the provision of longitudinal sub-drains (drain pipes) and weep holes, etc., should prevent hydrostatic pressure build-up. An effective permanent drainage design for the new Mt. Albert Road cut is also required, especially adjacent to the new bridges.

For design purposes, the following parameters (unfactored) can be used, assuming an essentially level ground surface behind and in front of the wall.

Compacted Granular 'A' and Granular 'B' Type II

Angle of Internal Friction, ϕ = 35° (unfactored)
Unit Weight = 22 kN/m^3
Coefficient of Lateral Earth Pressure:
K_a = 0.27 K_b = 0.35
K_o = 0.43 K* = 0.45

Compacted Granular 'B' Type I

Angle of Internal Friction, ϕ = 32° (unfactored)
Unit Weight = 21 kN/m^3

Coefficient of Lateral Earth Pressure:

K_a = 0.31 K_b = 0.41

K_o = 0.47 K* = 0.57

Where K_b is the 'intermediate' earth pressure coefficient for a partially restrained structure.

K* is the earth pressure coefficient for a soil loading a fully-restrained structure, including compaction surcharge effects.

These values are based on the assumption that the backfill behind the retaining structure is free-draining and adequate drainage is provided along the proposed road cut and behind the abutments. As well, it is assumed that the ground behind the retaining structure is level.

For sloping ground, the following unfactored parameters are recommended for design.

Table 6.1.6.1
Earth Pressure Coefficient (K)

Conditions Behind Wall	OPSS Granular A ϕ = 35° ; γ = 22 kN/m^3		OPSS Granular B, Type II ϕ = 35° ; γ = 22 kN/m^3		OPSS Granular B, Type I ϕ = 32° ; γ = 21 kN/m^3	
	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall
Active Coefficient,	0.27	0.40	0.27	0.40	0.31	0.54

Conditions Behind Wall	OPSS Granular A $\phi = 35°$; $\gamma = 22$ kN/m^3		OPSS Granular B, Type II $\phi = 35°$; $\gamma = 22$ kN/m^3		OPSS Granular B, Type I $\phi = 32°$; $\gamma = 21$ kN/m^3	
	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall	Horizontal Ground Behind Wall	Ground Sloping at 2H : 1V Behind Wall
K_a						
At-Rest Coefficient, K_0	0.43	0.62	0.43	0.62	0.47	0.76

The earth pressure coefficient adopted will depend on whether the retaining structure is restrained or movements can be allowed such that the active state of earth pressure can develop. If the abutment is restrained and does not allow lateral yielding, then at rest pressures should be used in accordance with C.H.B.D.C.

The earth pressure coefficients in the table above do not include potential compaction effects that must be included in the design. The effect of compaction should also be taken into account in the selection of the appropriate earth pressure coefficients in accordance with Section 6.9 of C.H.B.D.C. Heavy compaction equipment should not be used adjacent to the new abutment walls. Vibratory equipment for use behind abutments and retaining walls should be restricted in size as per current MTO practice.

For unrestrained wing walls (if any), the intermediate earth pressure coefficient K_b may be adopted. In the determination of degree of wall displacement or rotation to mobilize the fully active earth pressure state, Section C6.9 of the C.H.B.D.C. Commentary can be consulted. We understand, however, that the present design of the bridge structures does not incorporate any wing walls.

Wall backfill should be placed in maximum 200 mm loose lifts and compacted to 95% of the material's SPMDD. Considering the prevailing high static ground water table along the new alignment of Mt. Albert Road, imported granular materials are recommended in the low-lying areas of the proposed cut. To avoid imposing excessive lateral stresses, care should be taken not to over-compact adjacent to the walls. As such, manual compaction equipment should be used. In order to achieve the desired density, the backfill material should have a moisture content within 2% of the Optimum Moisture Content (OMC).

6.3 RETAINED SOIL SYSTEM (RSS) WALLS/SLOPES

With the present design, the use of RSS walls/slopes is not contemplated for this project. However, if further grade raise is required (e.g. for improved drainage, etc), depending on the availability of space (i.e., whether adequate land is available along the proposed Mt. Albert Road cut), the design of the new abutment walls and cut slopes (including consideration of their global stability) may possibly involve utilization of Retained Soil Systems (RSS) walls/slopes.

In general conditions would be suitable for this purpose, however, if an RSS wall system is contemplated for this project, further consultations are recommended. Design for stability of an RSS wall should be carried out by the proprietary designer/supplier.

6.4 APPROACH EMBANKMENTS

Based on the information provided to us by UMA, the existing ground surface at the bridge crossings varies from about Elevation 270.0 (on the south side) to 271.4 m (on the north side) and the proposed Highway 404 grade will be at about Elevation 272.8 m. The grades at the proposed approach embankment locations will therefore be raised by up to about 1.4 m high on the north side and up to 2.8 m high on the south side of the bridges.

Based on the borehole data, no foundation failures are anticipated for approach embankments up to 2.8 m high with side slopes of 2H:1V or flatter, provided that all organic or otherwise unsuitable materials will be removed as per MTO standards prior to placing the embankment fills.

All organic and other unsuitable soils should be removed within an envelope area given by an imaginary slope not steeper than 1H:1V from the toe of the proposed embankment. Based on the available borehole data, for preliminary estimating purposes, the average thickness of unsuitable soils to be stripped may be assumed to be 0.25 m. However, the thickness of topsoil or otherwise organic soils can be variable under the footprint of the proposed embankments. After stripping, the exposed subgrade should be inspected, approved and properly compacted (i.e. proof rolled) from the surface, using a suitably heavy compactor. The existing site conditions (i.e. high groundwater table and fine-grained granular soils) could influence the choice of compaction equipment. The groundwater table should be lowered to at least 1 m below the subgrade level, before any proof rolling and application of significant compaction efforts.

Assuming properly compacted, acceptable inorganic earth fill materials are utilized, 2 Horizontal in 1 Vertical (2H:1V) side slopes can normally be used for the construction of the approach fills. However, given the existing topography and the geometry of the proposed Mt. Albert Road cut, flatter slopes are generally expected, except for the areas of proposed cut, which will be discussed later. Proper erosion control measures should be implemented by prompt seed and cover (OPSS 572) or sodding (OPSS 571).

It should be pointed out that most of the subsoils on this site (i.e. silt to sandy/clayey silt) are highly erodible and frost susceptible materials. These aspects should be considered in the design. Therefore, materials used for the construction of the embankment fills should consist of approved, acceptable earth fill. If Granular 'B' (Type I) is readily available, this material is recommended especially near or below the groundwater level as well as within the upper zones of the embankment fill (i.e. within the frost zones). Oversize materials (having a nominal diameter in excess of 75 mm) should not be used in embankment fills through which piles may be driven. Fill used for construction of the embankments should be in accordance with OPSS 212 and fill placement should meet or exceed the requirements of OPSS 501 and OPSS 206. In general, the fills should be placed in lifts not exceeding 300 mm before compaction and each lift should be uniformly compacted to at least 95% of the material's Standard Proctor Maximum Dry Density.

The settlement of embankment fills under their own weight, prepared as described above, should not exceed 25 mm for embankment heights of up to about 3 m. The time-rate of settlement will depend on the materials used. For example, granular soils will settle more rapidly than finer soils and most of the anticipated settlements will be substantially completed during construction. In addition to settlement under self-weight, some foundation settlements can be expected under the weight of the approach fills to be placed. With the present design, on the north side the approach embankments will be up to about 1.4 m high on the north side and up to 2.8 m high on the south side. The estimated total settlements under up to about 1.4 and 2.8 m of embankment fill is expected to range from about 15 mm to 30 mm maximum, depending on the height of the fill and the thickness of cohesive tills below the embankment. These figures include settlements during the construction period (i.e. fill placement to full height). Important aspects of the anticipated settlements are the timing and rate of settlements. A significant portion of the anticipated elastic settlement of the fine-grained granular soils (upper loose to compact silt at relatively shallow depth, and lower silt and sandy silt till) are expected to take place during construction. However, some additional consolidation settlement of the upper and lower clayey silt till deposits can be expected to take place over time (the following 15 years).

Assuming that, as part of the proposed Mt. Albert Road cut, the groundwater level will be lowered by several meters permanently (using an effective enhanced drainage system), the anticipated long-term settlement due to groundwater lowering is expected to be less than 25 mm. The actual magnitude of total and differential settlements will depend on the depth and thickness of clayey silt tills and their variations under the proposed approach embankments.

The above quoted settlements are considered to be acceptable and will normally not require surcharging. However, a period of least one month of preloading is recommended prior to paving of the road.

6.5 DESIGN CHANGE RECOMMENDATIONS

Based on our discussions with UMA and preliminary design drawings provided to us (see Drawings F-1 and F-2 in Appendix F), the finished bridge elevations (i.e. Highway 404 elevation) will be about 272.5 m, that is about 1 m above the top of the existing Mt. Albert Road and typically about 2 m above the existing ground surface elevations adjacent to the existing road.

The proposed finished grade for Mt. Albert Road is at about El. 265.5 m. Therefore, an approximately 6 m grade lowering is required. Assuming a 1.0 m to 1.2 m pavement thickness for the proposed Mt. Albert Road, the excavation depth during construction may exceed 7 m below present grades.

The twin bridges which will carry Highway 404 over Mt. Albert Road will be built to carry four lanes of Highway 404, with a provision to widen them to six lanes in the future. The length of the single-span bridges (30 m long) will be sufficient for a four-lane Mt. Albert Road but initially a two-lane rural type roadway is proposed, as shown in Drawings F-1 and F-2.

As will be discussed later, the safe permanent cut slopes at the bridges site, were determined to be 2.75H:1V (assuming measures to permanently lower the groundwater are implemented). Preliminary design concept, which was provided to us for the proposed bridges and for the proposed Mt Albert Road beneath the proposed bridges, incorporates a thick blanket of Granular 'A' material which will enable 2H:1V side slopes to be used provided that a 150 mm diameter perforated subdrain is maintained at about El. 266.6 m, as shown in Drawings F-1 and F-2. For future widening of Mt. Albert Road at the structures, we understand that the Granular 'A' materials will be removed and the widened roadway will be changed to urban (i.e. curb and gutter design) section. This is considered feasible. However, beyond the bridges the natural slopes will need to be sloped at 2.75 H:1V before placing the granular soils. As well, a filter zone should be provided between the natural soils and the Granular 'A' materials.

The borehole results show that the permanent cuts and construction at the bridge location and along Mt. Albert Road will be carried typically through an upper silt layer, underlain generally by an upper clayey to sandy silt till deposit and will extend into a lower silt deposit. The groundwater table at the site appears to be about 1.5 m below the existing ground surface. This means that excavations will be carried through wet and generally dilatant soils (which can easily be disturbed and turn liverish and lose their load carrying capability in the presence of water). To stabilize the soil, construction dewatering and permanent drainage will be required. Since the excavations will extend typically 5 to 6 m below the groundwater table, both permanent and construction dewatering will require careful planning for construction stability and for future performance of the Mt. Albert Road (this is because unless Mt. Albert Road is properly designed and drained, frost damage will likely occur due to the presence of frost susceptible, water bearing silt deposit).

In order to alleviate this condition, we recommend the following measures:

a) Provide a storm drain beneath Mt. Albert Road

b) Raise the grade of the road.

Storm drain should be deep enough beneath the road structure to provide effective permanent drainage across the site, including for the permanent slopes beyond the bridge location.

It should also be pointed out that based on the grain-size distribution curves presented, the silt deposits encountered in the boreholes are generally at the low (fine) limit of dewaterability by the use of well points and thus difficulties may be experienced during construction dewatering of the site.

Raising the road grade will provide less severe dewatering conditions both during the construction and for permanent side slopes (i.e. less penetration below the groundwater table). It will also reduce the amount of water that will be taken away during construction and permanently and increase the longevity of Mt. Albert Road.

6.6 SLOPE STABILITY

As shown on Drawings 3 and 4, the existing grades along Mt. Albert Road will be lowered by up to about 6 m. As well, in some areas up to about 2 m fill will be placed, but the combination of cut and fill will not exceed 7 m. Preliminary design incorporates 2.5H:1V side slopes for up to 6 m cuts.

We carried out slope stability analyses to determine safe side slopes along Mt. Albert Road. In order to carry out the analyses, based on the results of our field investigation and laboratory testing along the proposed Mt. Albert Road cut and our experience with local soils in this general area including typical soil parameters reported in the literature, appropriate shear strength parameters were assigned to the subsoil layers, as listed in Table 6.6.1 below. For example, based on the laboratory test results and the consistency of the soils encountered at Boreholes M2, M4, M9 and M12 drilled along the proposed cut slopes for Mt. Albert Road, an effective friction angle (ϕ') of 27 or 28 degrees and an intercept cohesion (c') of 2 kPa were selected for the stiff to very stiff upper silt to clayey silt or upper cohesive till deposits (classified as ML, or CL-ML in Section 5 of the investigation report). For compact to dense Granular 'B', a typical effective friction angle (ϕ) of 32 degrees was assumed with an intercept cohesion (c') of zero. It should be noted that the selected soil parameters are average values, but are generally conservative. The specific soil parameters used in each slope stability analysis run are recorded on Figures H-1 through H-7 in Appendix H.

Table 6.6.1
Typical Soil Parameters Used in Slope Stability Analyses

Soil Type	Bulk Unit Weight kN/m^3	Total Shear Strength Parameters(Short-term)		Effective Shear Strength Parameters (Long-Term)	
		Undrained Shear Strength C (kPa)	Angle of Internal Friction (ϕ) Degrees	Cohesion Intercept C (kPa)	Angle of Internal Friction (ϕ) Degrees
Riprap	20	0	43	0	43
Granular 'A' and granular filter materials placed against slope face	20-21	0	31-34	0	31-34
Compacted Granular 'B'	21	0	32	0	32
Loose to compact sandy silt fill	18.5	0	29	0	29
Fill to be used for embankments	20.5	0	30	0	30
Stiff to very stiff upper silt to clayey silt	20	100	0	2	27
Loose to compact upper sandy silt/silt	18-19	0	28-29	0	28-29
Stiff to very stiff upper clayey silt/silt till	20	100	0	2	28
Upper silt to sandy silt till	20	0	31	0	31
Lower hard clayey silt till	21	200	0	3	30
Compact to very dense lower silt	20	0	31	0	31
Very dense lower sandy silt till	22	0	34	0	34

Selected sections of the proposed roadway cut slopes (provided to us by UMA) were analyzed by the limit equilibrium approach. The analyses were carried out using the commercial two-dimensional slope stability computer program Slope/W program and the simplified Bishop method of analysis for both short-term (undrained) and long-term (drained) analyses calculations. The program calculated a factor of safety based on the limit equilibrium of forces and moments, assuming circular slip surfaces. The factor of safety is defined as the ratio of available shear strength to the shear strength that must be mobilized to maintain a condition of limiting equilibrium. Long-term stability of the slopes was examined using effective shear strength parameters, which tends to be more critical than the short-term condition. In this analysis, the pore pressure distribution along the slip surface was based on presumed groundwater levels as shown in the figures. The required minimum safety factors against failure were assumed to be 1.3, as per MTO procedures.

We understand that initially Mt. Albert Road will be of rural design (i.e. side ditches rather than curb and gutter). This was taken into consideration in our analysis. We recommend the placement of a 200 mm thick filter layer of concrete sand (i.e. concrete fine aggregates) on the natural cut slope surface, overlain by 200 mm thick layer of concrete coarse aggregates, which is, in turn, overlain by 300 mm thick riprap layer and this was assumed to be the case in our analysis. In addition, in our analysis we assumed that the groundwater level at the crest of the slope will be maintained below 1.5 m. This can be achieved by the provision of french drain about 2 to 3 m beyond the crest of the slope. Typical results of the stability analysis are presented in Appendix H. As shown, the calculated safety factors are in excess of 1.3 required by MTO.

Based on the above, the following side slope configuration is recommended.

Height of Slope	Slope No Steeper Than
4.0 – 7.0 m	2.75H:1V
2.0 – 3.9 m	2.5H:1V
less than 2.0 m	2.0H:1V

As was mentioned before, these recommendations are based on the following:

- Installation of a 1.8 m deep French drain type drainage with a 100 mm diameter filtered, perforated drain pipe at the bottom of the drain (see Figure I-1 in Appendix I). The drain is located about 2 to 3 m from the crest of the cut slope and its purpose is to ensure that the water table will be maintained below 1.5 m of the top of the slope. The water collected in the drain pipe must be effectively removed.

- 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 Aggregates (Group I/20-5) placed over the fine filter material.

- A minimum 300 mm thick riprap layer over the coarse filter layer.

A schematic representation of the slope protection scheme recommended is given in Figure I-1 (Appendix I).

The materials must be placed in a manner to avoid segregation on the sloping surface.

Normal MTO practice with cut slopes is to use a 300 mm thick Granular 'A' material over the cut slope overlain by riprap. In this instance, however, based on the grain-size distribution curves, Granular 'A' materials do not provide a suitable filter material and do not meet MTO's requirements for filtering over the natural silt soils. The MTO filtering requirement in our opinion is important for this project since wet silts may percolate into the Granular 'A' and possibly through, causing a nearly impervious blanket, as well as possibly leading to a loss of silts from subgrade soils.

It should be pointed out the recommended double filter system does not provide a totally ideal filtering medium. However, for the sake of economy we selected readily available commercial granular materials which can be obtained in a cost-effective manner. Otherwise, for ideal filter media, materials will require special orders which will meet strict grain-size distribution requirements and this will be expensive. If, however, MTO has concerns with the selected materials and will not assume a small risk factor, we will be pleased to provide necessary specifications for specially manufactured filter materials.

A filter material is also required in the immediate vicinity of the bridges between the natural cut slopes and the proposed Granular 'A' fill.

6.7 CONSTRUCTION

As shown on Drawings 3 and 4, the existing Mt. Albert Road profile will be lowered by about 6 m between about Stations 9+950 and 10+100 (proposed centerline of the bridges at Station 10+000), gradually decreasing to about 2 m at about Station 9+820 on the west side and 10+260 m on the east side.

The high groundwater conditions, which prevail at the site, along with wet, dilatant silts and silt till soils, can be expected to pose construction challenges.

The silt deposits and, to a certain extent, the silt tills can be expected to exhibit dilatancy in the presence of water. In other words, unless properly stabilized by dewatering, they can be expected to dilate, a condition which can be recognized by the liverish, jelly-like appearance of the soil. Such dilated soils will have little load carrying capability and stability, including construction equipment support. In addition, dilated soils will re-settle upon the application of any structural loads, thus leading to undesirable settlements of foundations (if any) supported on such soils. Unless proper dewatering is implemented, the silt deposits may be unstable, which would create sloughing on the sides of the cut slopes and unstable conditions at the bases of excavations. Dewatering may consist of vacuum well points, eductors, as well as gravity drainage and pumping from filtered sumps.

As was mentioned before in this report, the silty deposits encountered at the site are considered to be at the fine limits of dewaterability by well points (even with the application of vacuum, based on grain-size distribution curves of soil samples tested and our experience with similar soils). In addition, in some cases, where the silt is underlain by clayey soils this may interfere with the successful operation of the well points. Furthermore, while in theory well points can lift (i.e. be effective in lowering) 6 m of water, in practice, due to inevitable system losses, they are usually effective in lowering the water level no more than about 5.5 m. This means that in many cases the header pipes may need to be placed at levels below the existing grades or a two-level system may need to be employed. Both operations will lead to increased dewatering costs. The use of eductors is considered an even more costly solution.

Under the circumstances, consideration may be given to gravity drainage, side ditches and pumping from strategically placed, properly filtered sumps. However, such a system may need to be supplemented by well-points to stabilize the silts if and where required. In such cases for gravity drainage to be effective, it is good construction practice to start the excavation from the low side of the site to enable the water to be discharged. To aid the stability of the side slopes, during the construction, consideration may be given to installing the permanent 'french drains' before the start of the excavation to aid in draining the upper zones of the surficial (upper) silt deposit. The installation of additional temporary drains may be considered within the zone to be excavated to help to pre-dewater the site to a certain extent prior to excavation. To be effective, however, these will need to be installed sufficiently ahead of excavation. It is also suggested that the recommended permanent slope protection layers (i.e. concrete sand, concrete coarse aggregates and riprap, shown in Figure I-1 in Appendix I) be established as soon as possible after excavation of the side slopes along Mt. Albert Road to their final configuration in order to prevent excessive sloughing and loss of silt particles. As was discussed before, the filter materials must be placed without causing the segregation of the coarser particles.

Normally, it is the contractor's responsibility to come up with a viable dewatering scheme, especially in cases such as the present case. It may, however, be prudent to prepare an NSSP to forewarn the contractor for possible impending difficult dewatering conditions due to high water table and potentially unstable soils, unless properly dewatered. A Permit to Take Water (PTTW) from the Ministry of Environment (MOE) may be required for dewatering during construction.

All excavations should be carried out in accordance with the Occupational Health and Safety Act of the Province, Ontario Reg 213/91.

The silt deposits and the upper tills can be classified as Type 3 soils above the water table and Type 4 soil below the water table. The lower tills can be classified as Type 2 soils above the water table and Type 3 or 4 soil below the water table (depending on the clay content).

6.8 FROST PROTECTION

Design frost protection depth for the general area is 1.5 m. Therefore, a permanent soil cover of 1.5 m or its thermal equivalent of artificial insulation is required for frost protection of foundations, including any pile caps. In case of riprap (rock fill) only one-half of the rock thickness should be assumed to be effective in providing frost protection.

7. CLOSURE

The Limitations of Report, as quoted in Appendix K, are an integral part of this report.

SHAHEEN & PEAKER LIMITED

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ZO:tr/idrive

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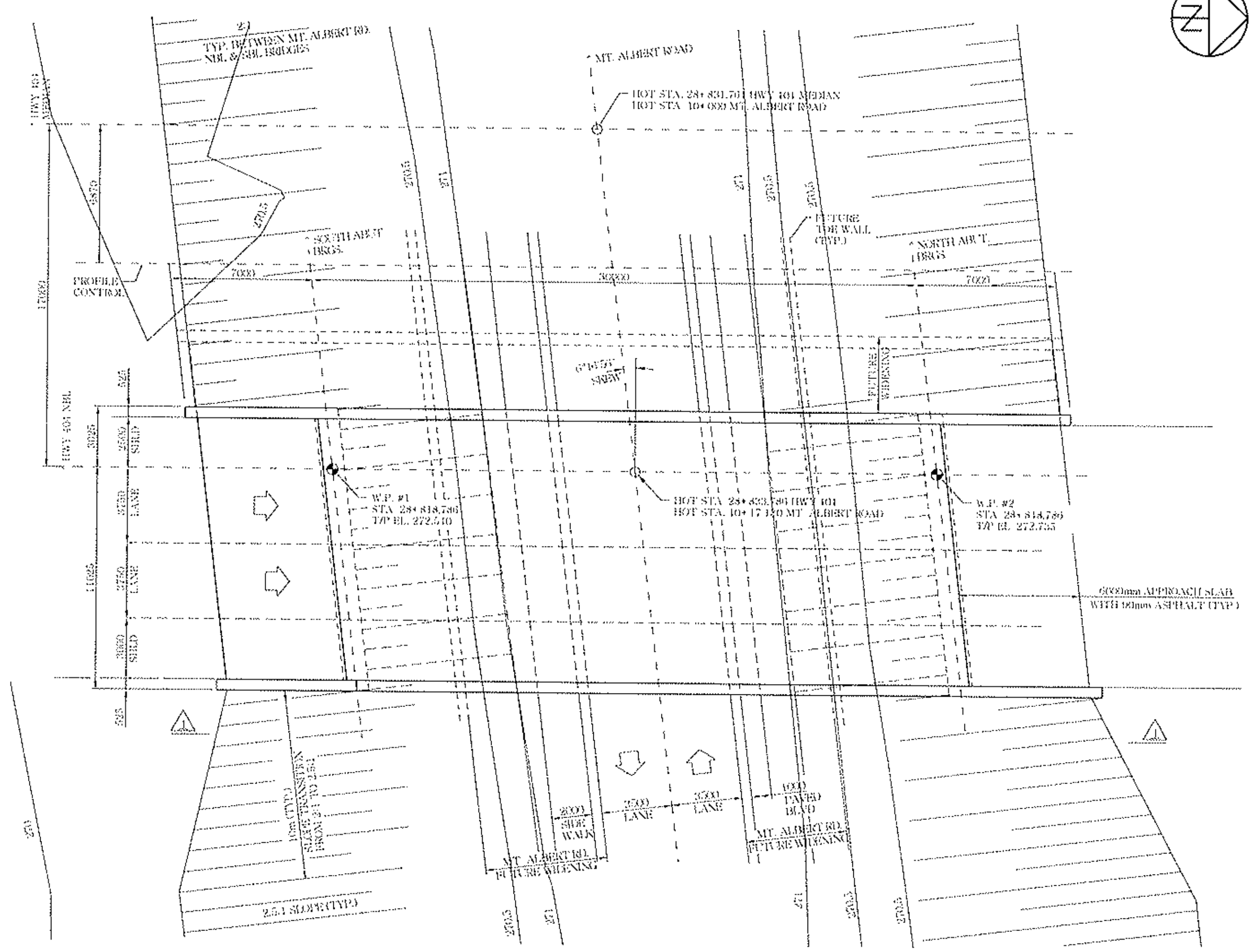
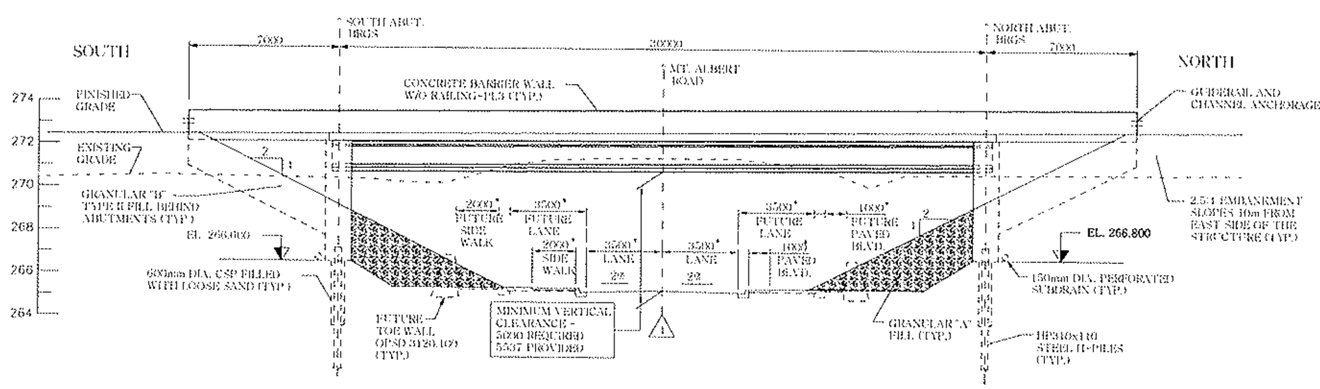
Appendix F

Presently Proposed Scheme for the Bridges

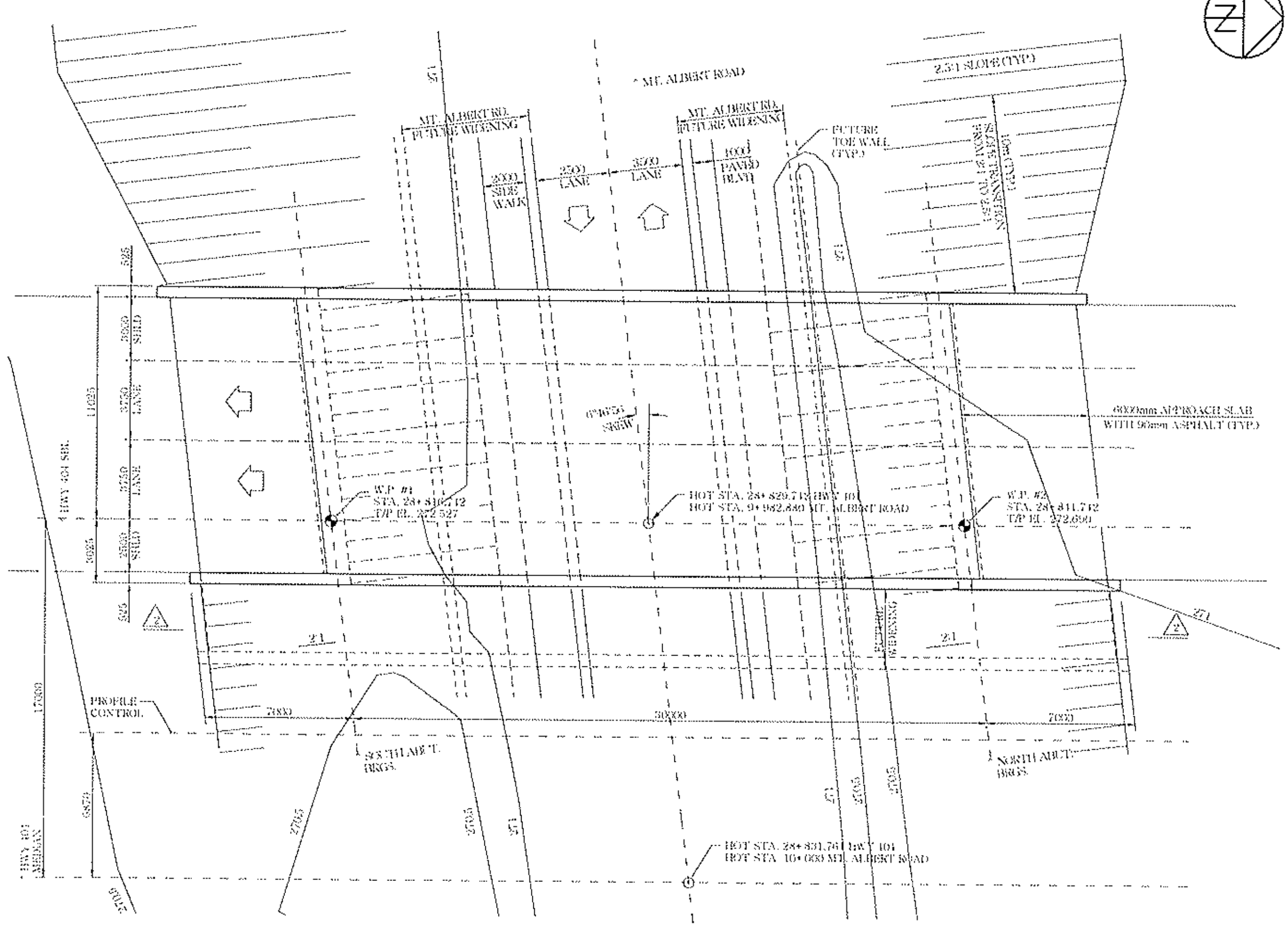


PLAN

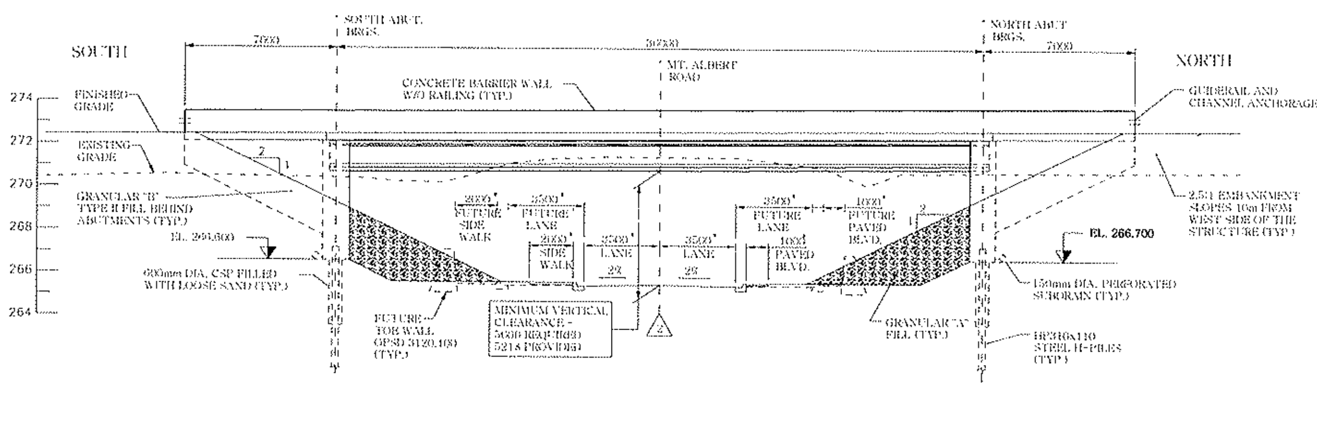


NOTE: DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES + METRES.

HWY 404 OVERPASS AT MT. ALBERT RD. PROPOSED NORTHBOUND BRIDGE			DIST
SUBM'D ZO	CHECKED RM	DATE Jan,2007	SITE
DRAWN XB	CHECKED FS	APPROVED	DWG F-1



PLAN



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

HWY 404 OVERPASS AT MT. ALBERT RD. PROPOSED SOUTHBOUND BRIDGE			DIST
SUBM'D ZO	CHECKED RM	DATE JAN,2007	SITE
DRAWN XB	CHECKED FS	APPROVED	DWG F-2

Appendix G

Detailed Soil Parameters for the Calculation of Lateral Geotechnical Pile Resistances

Table G-1
Recommended Soil Parameters

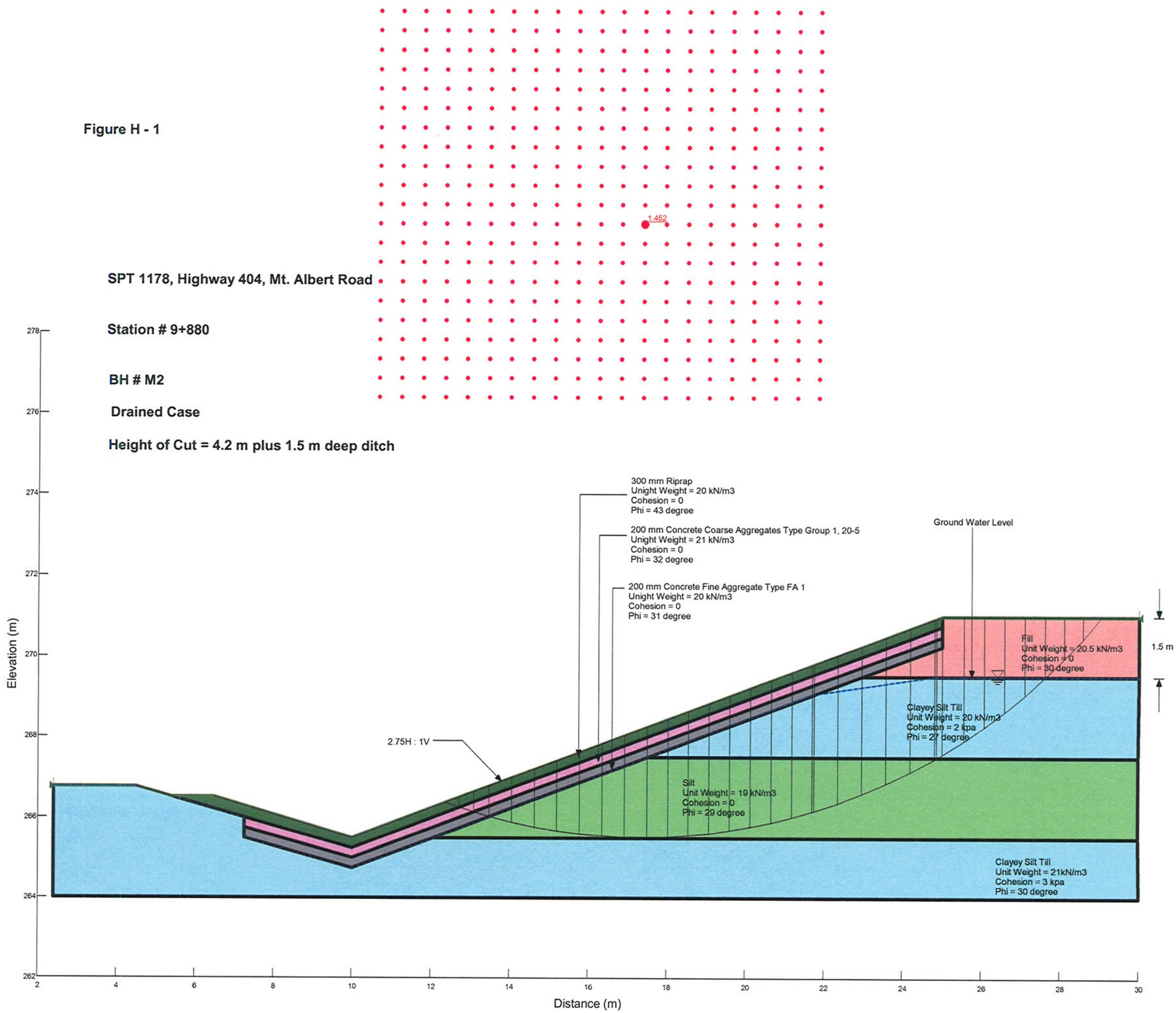
Area Reference/ Borehole No.	Applicable Elevation (m)	Soil Type	Bulk Unit Weight (kN/m^3)	Angle of Internal Friction (ϕ)	Re-commended n_h value (MN/m^3)	Re-commended Undrained Shear Strength (kPa)
SBL-North Abutment/ BH102	271.1-270.3	Fill (sand & gravel)	20	31	4.0	-
	270.3-268.1	Silt	19	29	3.0	-
	268.1-265.0	Clayey silt till	20	-	-	150
	265.0-263.5	Silt	20	31	8.0	-
	263.5-258.8	Clayey silt till	21	-	-	200
BH M5	270.8-269.5	Silt	19	29	3.0	-
	269.5-266.6	Clayey silt till	20	-	-	120
	266.6-264.3	Sandy silt till	22	33	11.0	-
	264.3-262.0	Silt	19	30	4.4	-
	262.0-257.6	Clayey silt till	21	-	-	240
	257.6-255.3	Sandy silt till	22	34	11.0	-
BH M7	270.6-268.6	Silt	18.5	29	2.0	-
	268.6-267.1	Clayey silt till	20	-	-	100
	267.1-263.3	Silt	20	31	8.0	-
	263.3-260.3	Clayey silt till	21	-	-	200
	260.3-255.4	Sandy silt till	22	34	11.0	-
SBL-South Abutment/ BH M6	270.3-268.4	Silt	19	29	3.0	-
	268.4-267.0	Sandy silt till	20	30	4.4	-
	267.0-265.5	Sandy silt till	21	33	11.0	-
	265.5-262.5	Silt	19.5	30	4.4	-
	262.5-259.2	Clayey silt till	21	-	-	200
	259.2-254.8	Sandy silt till	22	34	11.0	-
BH 103	270.9-267.9	Silt	18.5	29	3.0	
	267.9-266.3	Clayey silt till	20	-	-	100
	266.3-263.3	Silt	20	31	8.0	-
	263.3-262.0	Clayey silt till	20	-	-	100
	262.0-258.6	Clayey silt till	21	-	-	240
NBL-North Abutment/ BH M8	270.5-269.3	Silt	18.5	28	2.0	-
	269.3-267.8	Sandy silt till	20	20	4.4	-
	267.8-264.0	Silt	20	31	9.0	-
	264.0-263.2	Clayey silt till	21	-	-	150
	263.2-255.1	Sandy silt till	22	34	11.0	-
BH M9	270.7-270.0	Silt	18	28	1.0	-
	270.0-269.5	Silt	19	29	4.0	-
	269.5-267.2	Clayey silt till	21	-	-	150
	267.2-266.0	Silt	20	30	11.0	-
	266.0-264.3	Silt till	21	-	-	200
	264.3-255.3	Sandy silt till	22	34	11.0	-
BH 101	271.1-270.3	Fill (sand & gravel)	20	31	4.0	-
	270.3-268.8	Silt	19	29	3.0	-
	268.8-266.5	Clayey silt till	20	-	-	100
	266.5-263.5	Silt	20	31	11.0	-
	263.5-260.3	Clayey silt till	21	-	-	240
NBL-South Abutment/ BH M10	269.8-268.7	Silt	18	28	2.0	-
	268.7-268.0	Clayey silt till	19	-	-	80
	268.0-267.2	Clayey silt till	21	-	-	200
	267.2-264.9	Silt	20	31	11.0	-
	264.9-254.5	Sandy silt till	22	34	11.0	-

Area Reference/ Borehole No.	Applicable Elevation (m)	Soil Type	Bulk Unit Weight (kN/m^3)	Angle of Internal Friction (ϕ)	Re-commended n_h value (MN/m^3)	Re-commended Undrained Shear Strength (kPa)
BH 104	270.4-268.9	Silt	19	29	3.0	-
	268.9-268.1	Clayey silt till	21	-	-	150
	268.1-264.3	Silt	20	31	11.0	-
	264.3-261.1	Clayey silt till	21	-	-	240

Appendix H

Typical Slope Stability Analyses Results

Figure H - 1



1.452
SPT 1178, Highway 404, Mt. Albert Road
Station # 9+880
BH # M2
Drained Case
Height of Cut = 4.2 m plus 1.5 m deep ditch
300 mm Riprap
Unight Weight = 20 kN/m3
Cohesion = 0
Phi = 43 degree
200 mm Concrete Coarse Aggregates Type Group 1, 20-5
Unight Weight = 21 kN/m3
Cohesion = 0
Phi = 32 degree
200 mm Concrete Fine Aggregate Type FA 1
Unight Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
Ground Water Level
1.5 m
Fill
Unit Weight = 20.5 kN/m3
Cohesion = 0
Phi = 30 degree
Clayey Silt Till
Unit Weight = 20 kN/m3
Cohesion = 2 kpa
Phi = 27 degree
2.75H : 1V
Silt
Unit Weight = 19 kN/m3
Cohesion = 0
Phi = 29 degree
Clayey Silt Till
Unit Weight = 21kN/m3
Cohesion = 3 kpa
Phi = 30 degree
Elevation (m)
278
276
274
272
270
268
266
264
262
Distance (m)
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30

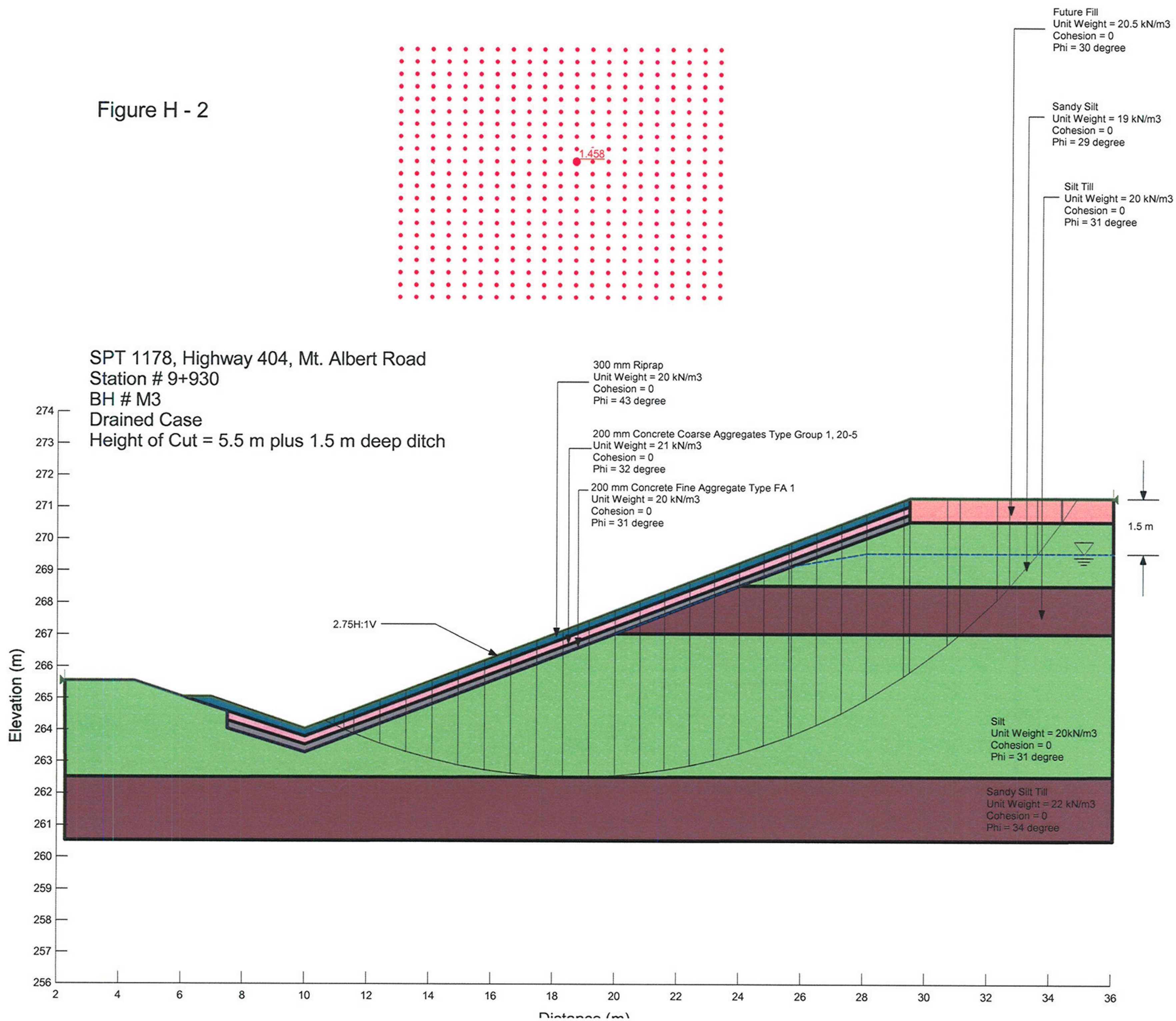


Figure H - 2
1.458
SPT 1178, Highway 404, Mt. Albert Road
Station # 9+930
BH # M3
Drained Case
Height of Cut = 5.5 m plus 1.5 m deep ditch
Future Fill
Unit Weight = 20.5 kN/m3
Cohesion = 0
Phi = 30 degree
Sandy Silt
Unit Weight = 19 kN/m3
Cohesion = 0
Phi = 29 degree
Silt Till
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
300 mm Riprap
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 43 degree
200 mm Concrete Coarse Aggregates Type Group 1, 20-5
Unit Weight = 21 kN/m3
Cohesion = 0
Phi = 32 degree
200 mm Concrete Fine Aggregate Type FA 1
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
1.5 m
2.75H:1V
Silt
Unit Weight = 20kN/m3
Cohesion = 0
Phi = 31 degree
Sandy Silt Till
Unit Weight = 22 kN/m3
Cohesion = 0
Phi = 34 degree
Elevation (m)
274
273
272
271
270
269
268
267
266
265
264
263
262
261
260
259
258
257
256
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
Distance (m)

Figure H - 3

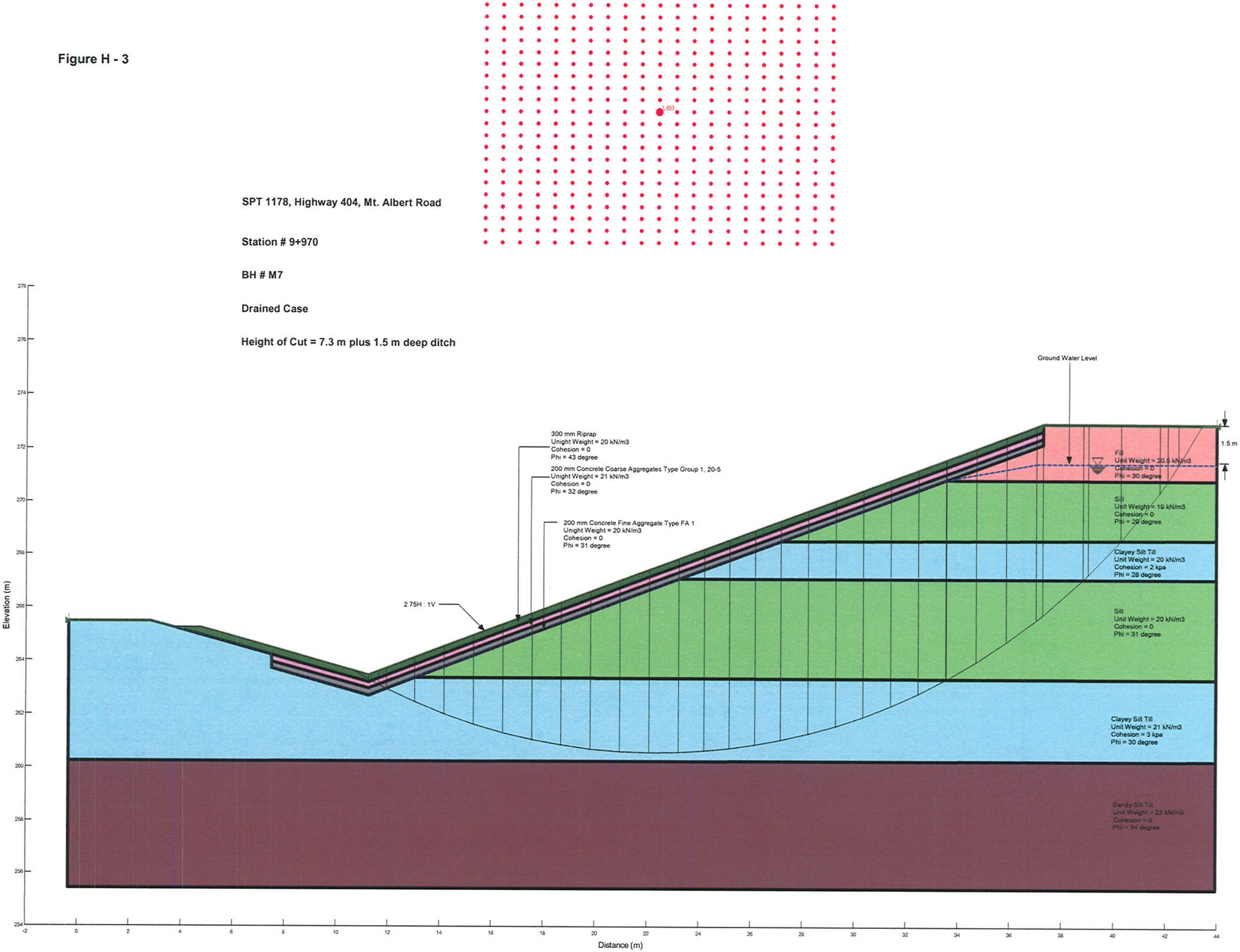
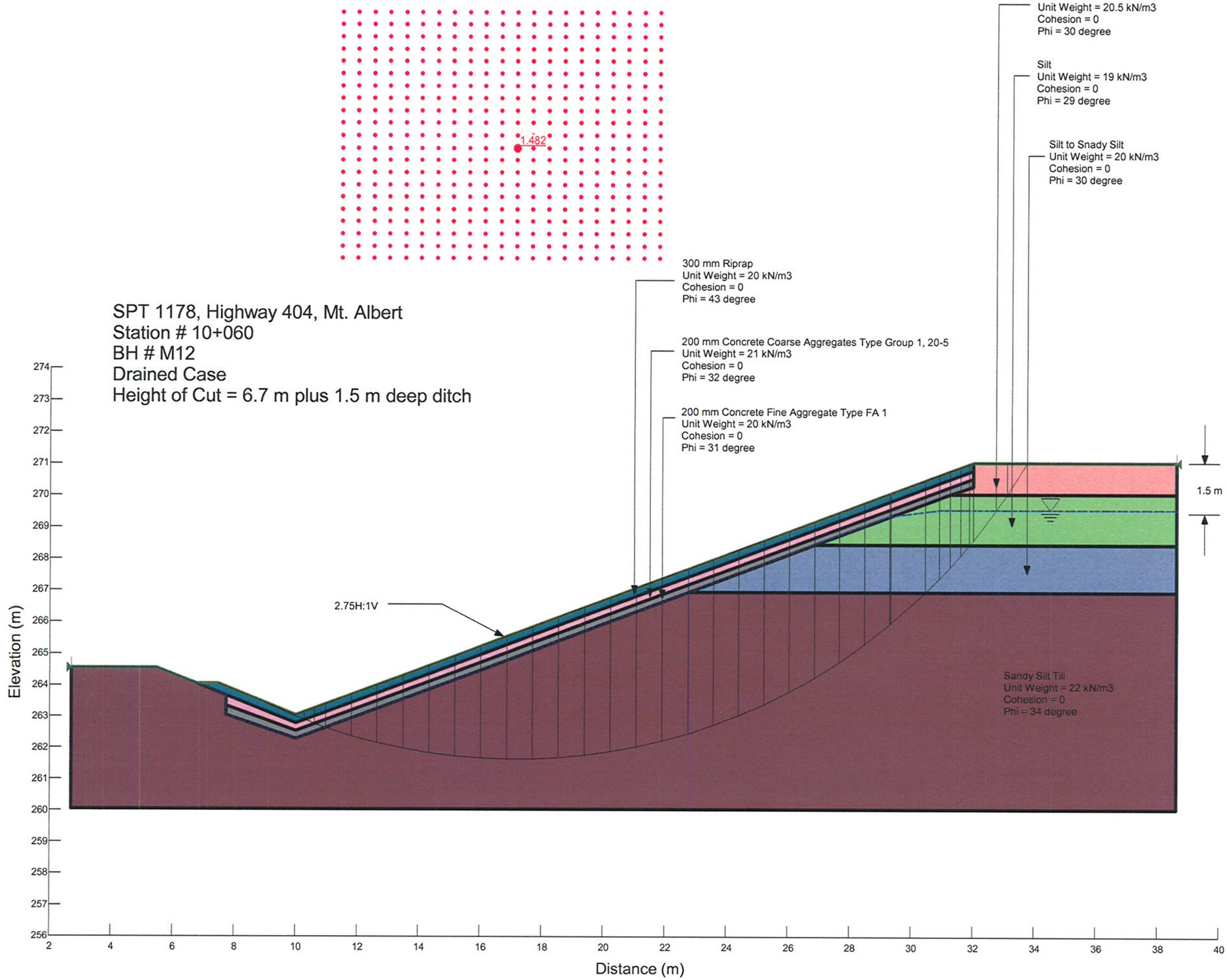

1.453
SPT 1178, Highway 404, Mt. Albert Road
Station # 9+970
BH # M7
Drained Case
Height of Cut = 7.3 m plus 1.5 m deep ditch
Ground Water Level
1.5 m
300 mm Riprap
Unight Weight = 20 kN/m3
Cohesion = 0
Phi = 43 degree
200 mm Concrete Coarse Aggregates Type Group 1, 20-5
Unight Weight = 21 kN/m3
Cohesion = 0
Phi = 32 degree
200 mm Concrete Fine Aggregate Type FA 1
Unight Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
2.75H : 1V
Fill
Unit Weight = 20.5 kN/m3
Cohesion = 0
Phi = 30 degree
Silt
Unit Weight = 19 kN/m3
Cohesion = 0
Phi = 29 degree
Clayey Silt Till
Unit Weight = 20 kN/m3
Cohesion = 2 kpa
Phi = 28 degree
Silt
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
Clayey Silt Till
Unit Weight = 21 kN/m3
Cohesion = 3 kpa
Phi = 30 degree
Sandy Silt Till
Unit Weight = 22 kN/m3
Cohesion = 0
Phi = 34 degree
Elevation (m)
Distance (m)

Figure H - 4



1.482
SPT 1178, Highway 404, Mt. Albert
Station # 10+060
BH # M12
Drained Case
Height of Cut = 6.7 m plus 1.5 m deep ditch
Future Fill
Unit Weight = 20.5 kN/m3
Cohesion = 0
Phi = 30 degree
Silt
Unit Weight = 19 kN/m3
Cohesion = 0
Phi = 29 degree
Silt to Snady Silt
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 30 degree
300 mm Riprap
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 43 degree
200 mm Concrete Coarse Aggregates Type Group 1, 20-5
Unit Weight = 21 kN/m3
Cohesion = 0
Phi = 32 degree
200 mm Concrete Fine Aggregate Type FA 1
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
1.5 m
2.75H:1V
Sandy Silt Till
Unit Weight = 22 kN/m3
Cohesion = 0
Phi = 34 degree
Elevation (m)
274
273
272
271
270
269
268
267
266
265
264
263
262
261
260
259
258
257
256
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
Distance (m)

Figure H - 5

SPT 1178, Highway 404, Mt. Albert Road

Station # 10+215

BH # M16

Drained Case

Height of Cut = 6.5 m plus 1.5 m deep ditch

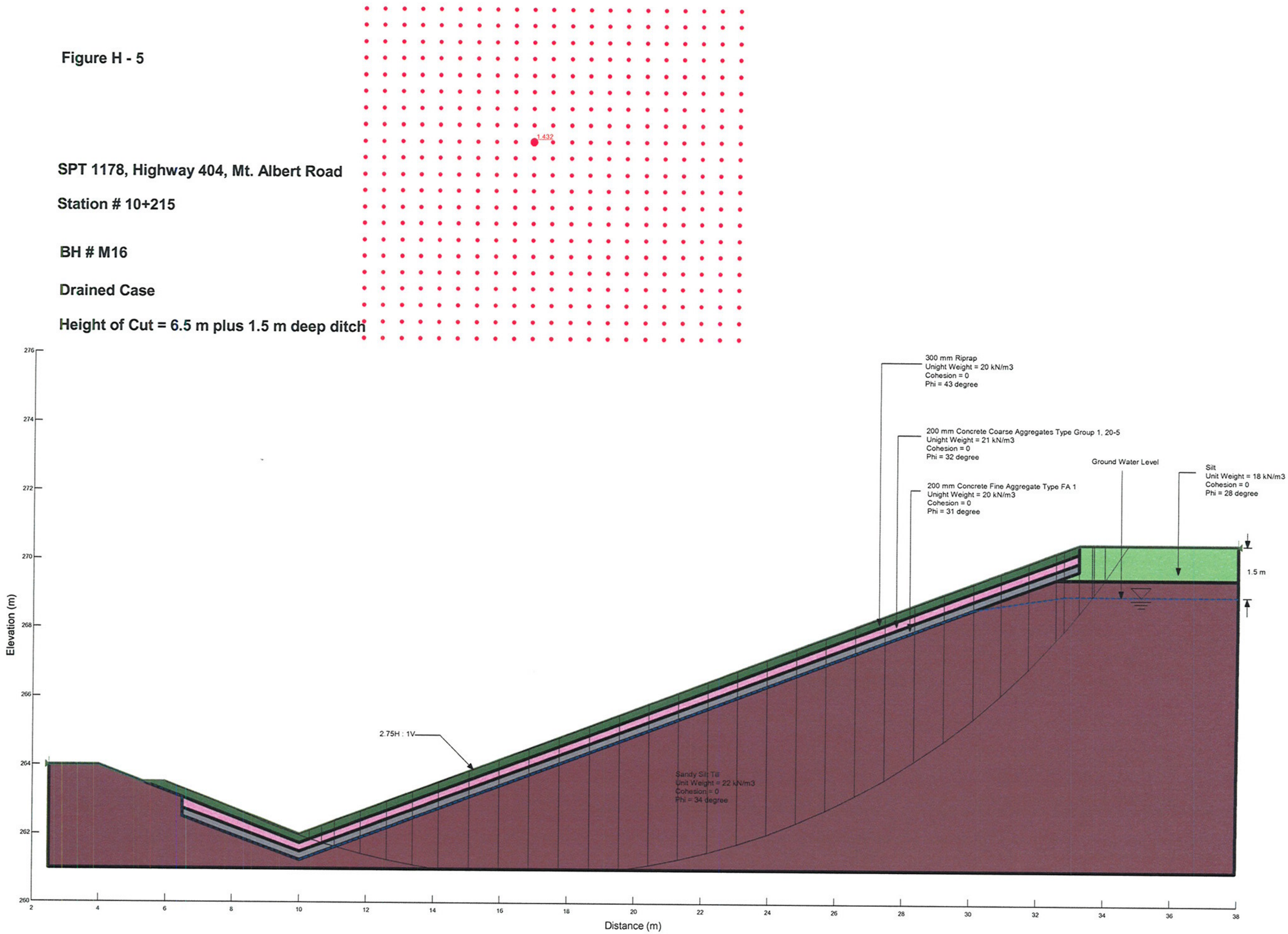
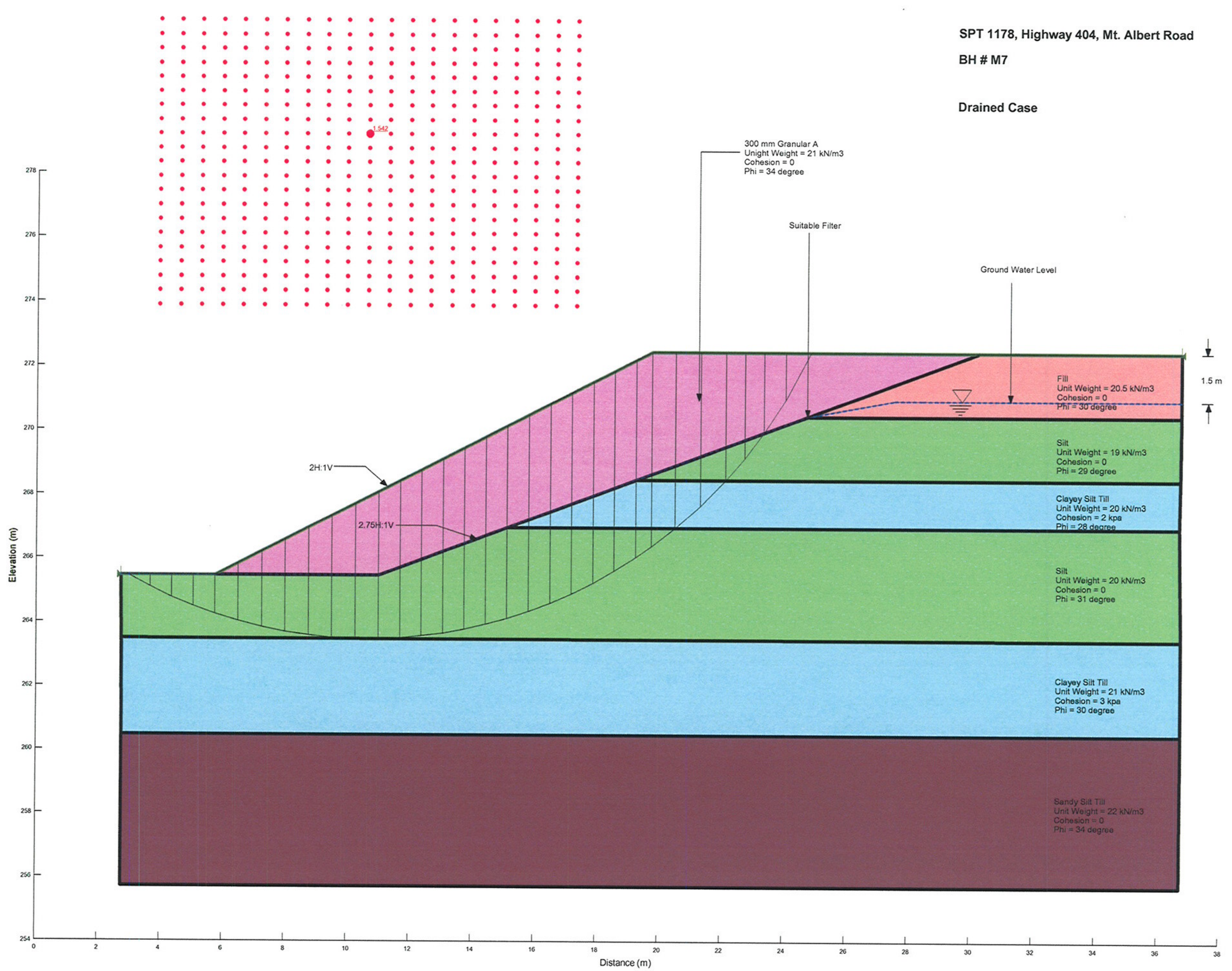


Figure H - 6



SPT 1178, Highway 404, Mt. Albert Road
BH # M7
Drained Case
1.542
300 mm Granular A
Unight Weight = 21 kN/m3
Cohesion = 0
Phi = 34 degree
Suitable Filter
Ground Water Level
1.5 m
Fill
Unit Weight = 20.5 kN/m3
Cohesion = 0
Phi = 30 degree
Silt
Unit Weight = 19 kN/m3
Cohesion = 0
Phi = 29 degree
Clayey Silt Till
Unit Weight = 20 kN/m3
Cohesion = 2 kpa
Phi = 28 degree
2H:1V
2.75H:1V
Silt
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
Clayey Silt Till
Unit Weight = 21 kN/m3
Cohesion = 3 kpa
Phi = 30 degree
Sandy Silt Till
Unit Weight = 22 kN/m3
Cohesion = 0
Phi = 34 degree
Elevation (m)
Distance (m)
278
276
274
272
270
268
266
264
262
260
258
256
254
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38

Figure H - 7

SPT 1178, Highway 404, Mt. Albert Road

Station # 9+880

BH # M2

Undrained Case

Height of Cut = 4.2 m plus 1.5 m deep ditch

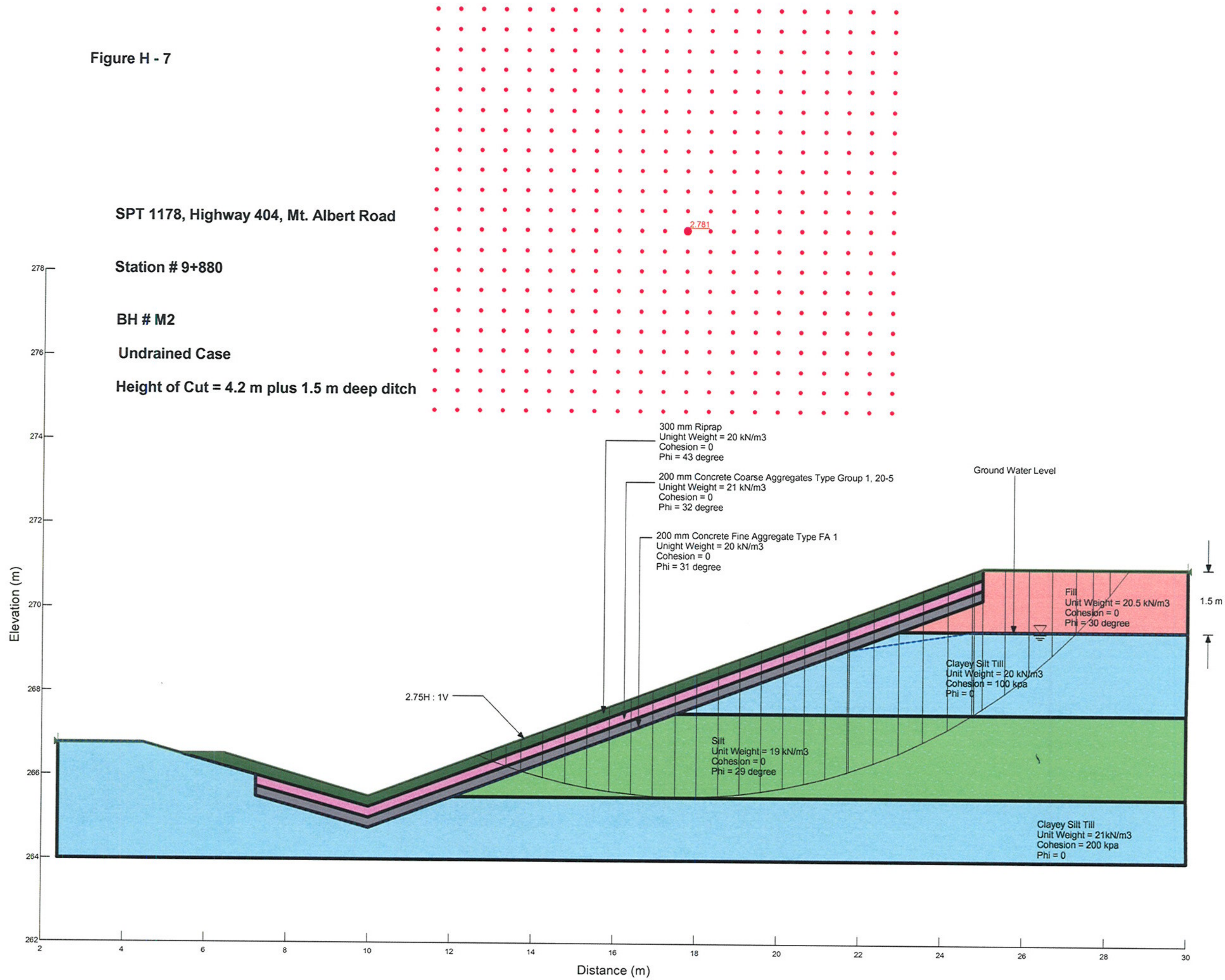
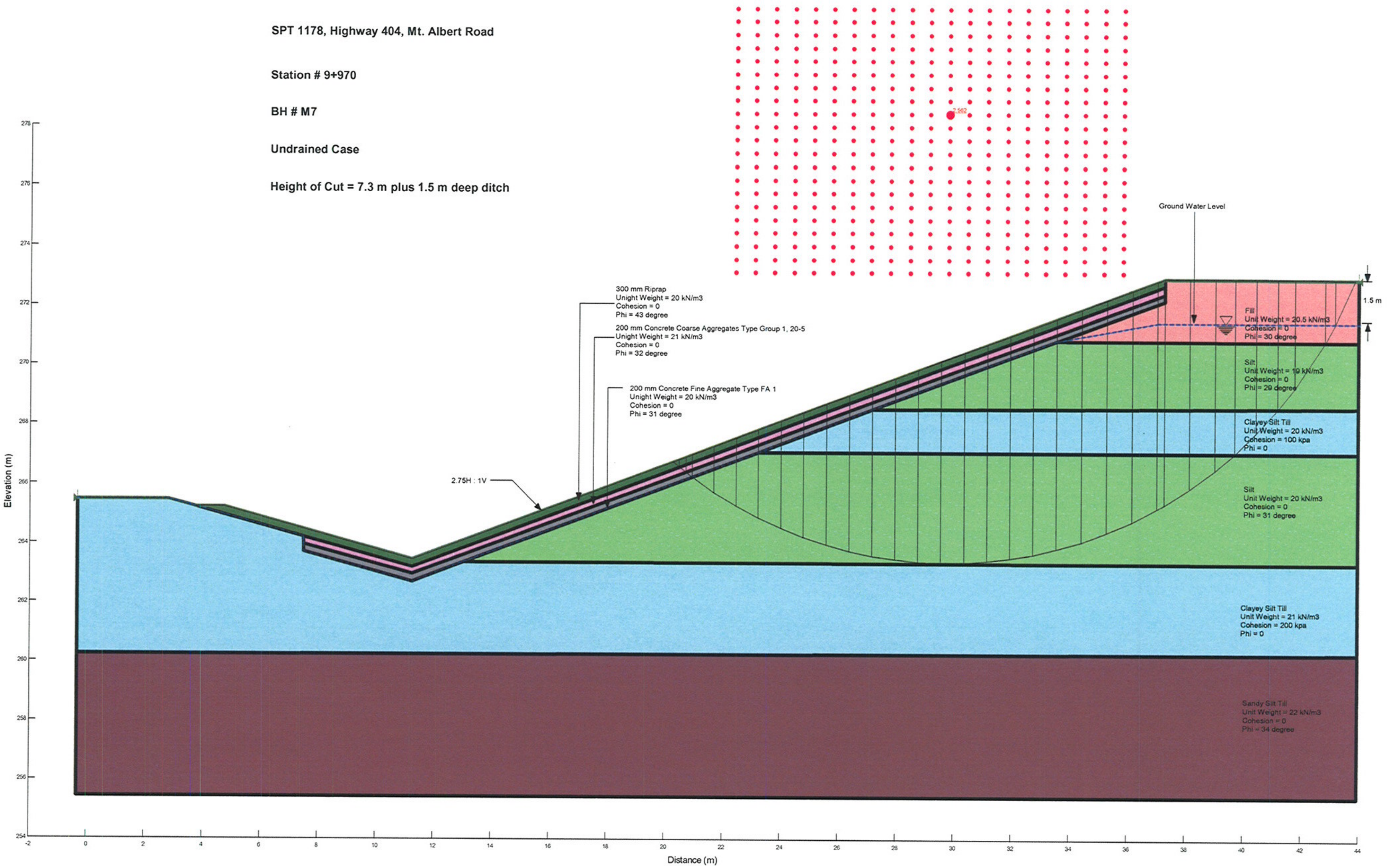
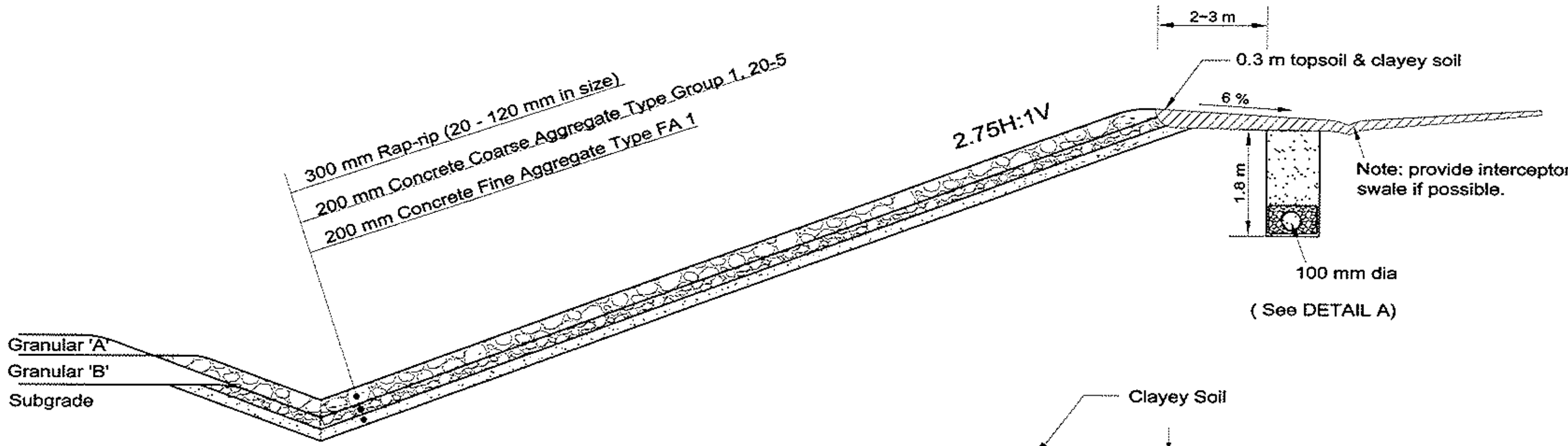


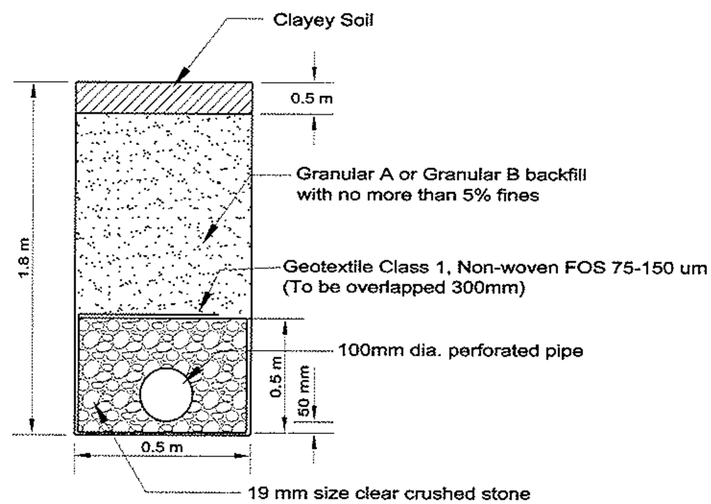
Figure H - 8


SPT 1178, Highway 404, Mt. Albert Road
Station # 9+970
BH # M7
Undrained Case
Height of Cut = 7.3 m plus 1.5 m deep ditch
Ground Water Level
1.5 m
300 mm Riprap
Unight Weight = 20 kN/m3
Cohesion = 0
Phi = 43 degree
200 mm Concrete Coarse Aggregates Type Group 1, 20-5
Unight Weight = 21 kN/m3
Cohesion = 0
Phi = 32 degree
200 mm Concrete Fine Aggregate Type FA 1
Unight Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
2.75H : 1V
Fill
Unit Weight = 20.5 kN/m3
Cohesion = 0
Phi = 30 degree
Silt
Unit Weight = 19 kN/m3
Cohesion = 0
Phi = 29 degree
Clayey Silt Till
Unit Weight = 20 kN/m3
Cohesion = 100 kpa
Phi = 0
Silt
Unit Weight = 20 kN/m3
Cohesion = 0
Phi = 31 degree
Clayey Silt Till
Unit Weight = 21 kN/m3
Cohesion = 200 kpa
Phi = 0
Sandy Silt Till
Unit Weight = 22 kN/m3
Cohesion = 0
Phi = 34 degree
Elevation (m)
Distance (m)

Appendix I

Recommended Permanent Slope Protection Measures





DETAIL A

RECOMMENDED PERMANENT SLOPE PROTECTION MEASURES

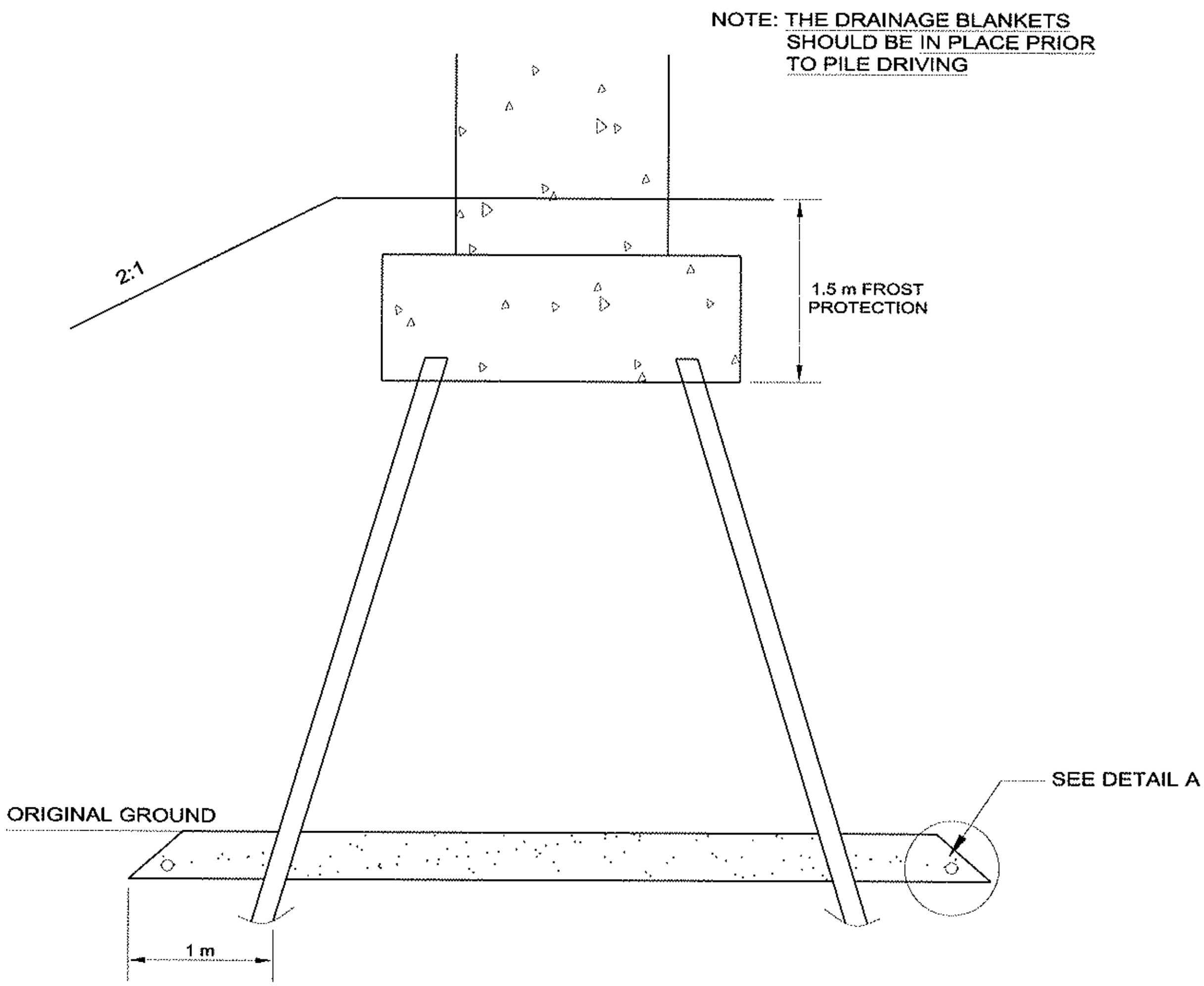
(N. T. S.)

SPT 1178

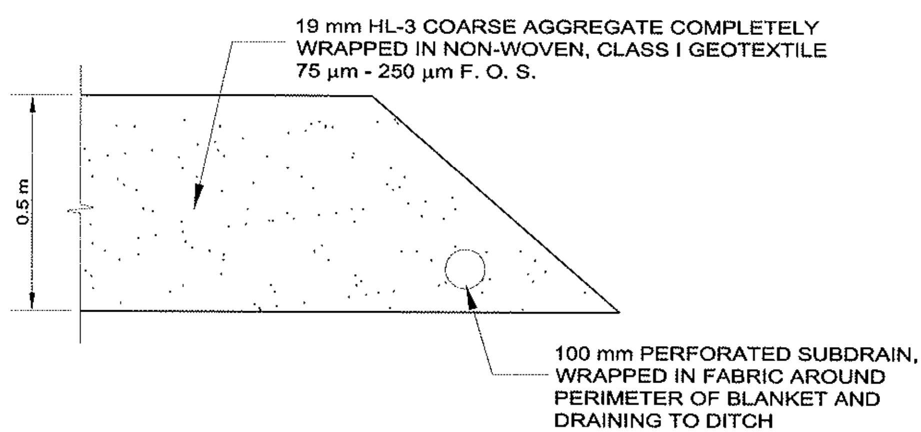
FIGURE I-1

Appendix J

Typical MTO Inverted Filter



ABUTMENT SECTION (TYP)



DETAIL A

Typical MTO Inverted Filter

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 Shaheen & Peaker Limited at the time of preparation. Unless otherwise agreed in writing by Shaheen & Peaker Limited, 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. Shaheen & Peaker Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.