



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
STORM SEWER CROSSING NORTH OF 16TH AVENUE
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
MARKHAM, ONTARIO
G.W.P. 2930-17-00**

GEOCRES NO. 30M14-504

**Latitude 43.865635°
Longitude -79.375491°**

Report

to

WSP Canada Inc.

Date: August 27, 2019
File: 15786



TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION	1
2.	PROJECT AND SITE DESCRIPTION.....	2
3.	SITE INVESTIGATION AND FIELD TESTING.....	2
4.	LABORATORY TESTING	4
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	4
5.1	Topsoil.....	5
5.2	Pavement Structure	5
5.3	Embankment Fill.....	5
5.4	Silty Clay Till with Sand and Silt Interlayers	6
5.5	Groundwater Conditions	8
6.	MISCELLANEOUS	9

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7.	GENERAL.....	11
8.	Sewer Crossing	11
8.1	Open Excavation and Groundwater Control.....	13
8.1.1	Stability of Temporary Open Excavation.....	14
8.2	Trenching	16
8.3	Groundwater Control	16
8.4	Temporary Protection System	18
8.5	Subgrade Preparation and Sewer Bedding.....	19
8.6	Sewer Backfill.....	20
8.7	Settlement	20
9.	CONSTRUCTION CONCERNS.....	21
9.1	Loss of Ground.....	21
9.2	Groundwater Control	21
9.3	Obstructions	21
9.4	Buried Utilities and Adjacent Roadway	22
9.5	Impact of excavation on the existing pavement surface	22
9.6	Existing Slopes and Temporary Excavation Slopes	22
10.	CLOSURE	22



APPENDICES

Appendix A	Record of Borehole Sheets (Present Site Investigation)
Appendix B	Laboratory Test Results (Present and Previous Site Investigation)
Appendix C	Record of Borehole Sheets (Previous Site Investigation)
Appendix D	Borehole Locations and Soil Strata Drawings
Appendix E	Selected Slope Stability Outputs
Appendix F	List of Ontario Provincial Standards and Suggested Wording for NSSP



**FOUNDATION INVESTIGATION AND DESIGN REPORT
STORM SEWER CROSSING NORTH OF 16TH AVENUE
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
MARKHAM, ONTARIO
G.W.P. 2930-17-00**

GEOCRES NO. 30M14-504

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the design and installation of a proposed sewer crossing to be located on the north side of 16th Avenue, at the Highway 404 and 16th Avenue interchange in the Regional Municipality of York, Ontario. The proposed work forms a part of the project which includes rehabilitation and widening of Highway 404 and 16th Avenue.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, provide a borehole location plan, record of boreholes, a stratigraphic profile, and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and installation of the sewer.

Thurber was retained by WSP Canada Inc. (WSP) to carry out this foundation investigation under the Ministry of Transportation Ontario (MTO) Assignment Number 2016-E-0014.

Reference has been made to information on subsurface conditions contained in a previous foundation report prepared for this site. The title of this report is:

- Foundation Investigation Report, Highway 404 16th Avenue Overpass, Replacement and Widening, Highway 404 HOV Lane Expansion and Rehabilitation, Contract 2, Markham, Ontario, Site 37-366, G.W.P. 2930-02-00, Geocres No. 30M14-487, prepared by Thurber Engineering Ltd., dated January 30, 2018. (Reference 1).

Client: WSP
File No.: 15786

Date: August 27, 2019
Page: 1 of 23

E file: H:\15000-15999\15786 Hwy 404 Widening 2016-E-0014\Reports and Memos\Contract 2\Sewer Crossing north of 16th Ave\FINAL\15786 16th Avenue - Sewer Crossing north of 16 Ave FIDR aug 19.docx



2. PROJECT AND SITE DESCRIPTION

The site is located on the north side of the Highway 404 and 16th Avenue Overpass in the Region of York.

The project involves installation of a storm sewer, which will cross under the Highway 404 southbound lanes (SBL) and northbound lanes (NBL) from east to west, and will be located approximately 50 m north of the existing 16th Avenue centreline, or in the order of 16 m north of the crest of the proposed permanent cut as part of the 16th Avenue widening.

The proposed sewer pipe is 1050 mm in diameter and approximately 84 m long.

The approximate location of the proposed sewer is shown on the key plan on the Borehole Locations and Soil Strata Drawing in Appendix D.

The land use adjacent to the site is largely commercial. Buttonville Airport is located on the southeast side of the Highway 404 overpass at 16th Avenue.

The site is located within the physiographic region known as the Peel Plain. The topography is flat to gently undulating. The soil cover in the region typically comprises silty clay glacial tills with sand and silt layers. Shale bedrock of the Georgian Bay Formation is anticipated at an approximate depth of 50 m.

3. SITE INVESTIGATION AND FIELD TESTING

The current borehole investigation and field testing program for this site was carried out on March 18 and 19, 2019, and consisted of drilling and sampling four (4) boreholes, designated as Boreholes TUN-01 to TUN-04. These four boreholes were drilled near the alignment of the proposed sewer crossing. Boreholes TUN-01 and TUN-02 were drilled near the existing Ramp E-S and the Highway 404 SBL, and terminated at 9.8 m depth (Elevations 186.4 and 186.6). Boreholes TUN-03 and TUN-04 were drilled near the Highway 404 NBL and Ramp S-E/W and terminated at 11.3 m depth (Elevations 185.0 and 184.8). The Record of Borehole sheets for the boreholes from this current investigation are included in Appendix A.



Reference has been made to Boreholes 16TH-01, 16TH-02 and 16TH-05 drilled during a previous foundation investigation (Reference 1) at the Highway 404 and 16th Avenue overpass. The Record of Borehole sheets of the boreholes from the previous investigation are included in Appendix C.

Lane closures and traffic control were implemented for drilling each borehole for the current investigation. Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

The approximate locations of the boreholes from the current and previous investigations are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D. The coordinates and elevations of the boreholes are given on this drawing and on the individual Record of Borehole Sheets in Appendices A and C. Northing and easting co-ordinates at the current borehole locations were obtained by Thurber using a GPS unit, and the corresponding ground surface elevations were provided by WSP based on the project DTM survey. The precision of the horizontal survey of the boreholes is rated at within 1 m, whereas the precision of the elevation is the same as that of the DTM survey.

The current boreholes were advanced using truck-mounted D-27 and D-90 drill rigs. Solid stem augers were used to advance the boreholes, and soil samples were obtained at selected intervals using a 50-mm diameter split spoon sampler in conjunction with the Standard Penetration Test (SPT) as per ASTM D1586. During the previous investigation, in situ vane shear testing was carried out to assess the undrained shear strength of firm cohesive deposits.

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full-time basis. The supervisor logged the boreholes, visually examined the recovered soil samples, and transported them to Thurber's laboratory for further examination and testing.

Groundwater conditions in the open boreholes were observed throughout the current drilling operations. Upon completion, the boreholes were abandoned in general accordance with Ontario Regulation 903 amended by Ontario Reg. 372 (O.Reg. 903). The details of borehole completion are summarized in Table 3.1.



Table 3.1 – Borehole Completion Details

Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth/ Elevation (m)	Completion Details
TUN-01	9.8/186.4	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.6 m, cement from 0.6 m to 0.2 m, then asphalt to surface.
TUN-02	9.8/186.6	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 0.5 m, cement from 0.5 m to 0.2 m, then asphalt to surface.
TUN-03	11.3/185.0	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 1.5 m, auger cuttings from 1.5 m to 0.2 m, then asphalt to surface.
TUN-04	11.3/184.8	None installed	Borehole backfilled with bentonite holeplug and auger cuttings to 1.5 m, auger cuttings from 1.5 m to 0.2 m, then asphalt to surface.

4. LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing of current and previous investigations are summarized on the Record of Borehole sheets in Appendices A and C, and also presented on the figures included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendices A and C for details of the encountered soil stratigraphy. A soil profile along the proposed sewer alignment is presented on the “Borehole Locations and Soil Strata” drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations.



In general, the subsurface conditions encountered in the boreholes drilled during the current and previous investigations consist of topsoil or pavement structure (asphalt over granular base) overlying embankment fill which typically consists of layers of sand and silty clay. Below the fill lies a native layer of firm to hard silty clay till with interlayers of loose to dense sand to sand and silt. Deeper boreholes drilled during the previous investigation, revealed the presence of compact to dense silty sand till/sand and silt till underlain by a lower layer of silty clay till. During the current investigation, boreholes caved to depths ranging from 5.5 m to 6.7 m, and groundwater levels were measured in the open boreholes at depths ranging from 5.1 m to 6.1 m (Elevations 190.0 to 191.1).

More detailed descriptions of the individual stratum are presented below.

5.1 Topsoil

Topsoil was encountered surficially in Boreholes 16TH-01, 16TH-02 and 16TH-05. The thickness of the topsoil was 125 mm in Boreholes 16TH-01 and 16TH-02, and 800 mm in Borehole 16TH-05.

The topsoil thickness may vary between and beyond the borehole locations, and the data is not intended for the purpose of estimating quantities.

5.2 Pavement Structure

Pavement structure consisting of approximately 150 mm to 200 mm of asphalt overlying granular (sand and gravel fill) road base was encountered in Boreholes TUN-01 to TUN-04. The thickness of the granular road fill varied from 500 mm to 575 mm.

SPT 'N' values, where measured, for the sand and gravel fill were 51 blows per 0.3 m penetration and 100 blows per 0.125 m of penetration, indicating a very dense state. Measured moisture contents of the granular road base were 3 percent and 11 percent.

5.3 Embankment Fill

Embankment fill was contacted below the pavement structure and the topsoil in Boreholes TUN-01 to TUN-04, 16TH-01, 16TH-02 and 16TH-05. The embankment fill generally consists

of layers of cohesionless and cohesive soils.

The cohesionless fill consists of brown to grey sand containing trace to some gravel and trace silt, and silty sand containing some clay, trace to some gravel and clay pockets. The cohesive fill consists of brown to grey silty clay containing trace to some sand and trace gravel. Occasional black staining, organics, decayed wood pieces and rootlets were noted in the fill material. The thickness of the embankment fill ranged from 0.5 m to 2.6 m.

In general, the depths to the base of the fill ranged from 0.6 m to 3.3 m depth (Elevations 193.0 to 194.8).

SPT 'N' values for the cohesionless fill layer typically ranged from 11 to 37 blows per 0.3 m penetration indicating a generally compact to dense state. Measured moisture contents of the cohesionless fill samples ranged from 3 percent to 28 percent.

SPT 'N' values measured in the cohesive fill ranged from 13 to 21 blows per 0.3 m penetration, indicating a stiff to very stiff consistency. Moisture contents measured in the cohesive fill ranged from 14 percent to 34 percent.

The results of grain size distribution analyses carried out on a selected sample of the cohesionless fill are presented on the Record of Borehole sheets included in Appendix A. Grain size distribution curve of the fill sample tested, is presented in Figure B1 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Silty Sand Fill (percent)
Gravel	7
Sand	43
Silt	33
Clay	17

5.4 Silty Clay Till with Sand and Silt Interlayers

A native deposit of brown to grey silty clay till containing some sand to with sand and trace gravel was contacted below the fill at depths ranging from 0.6 m to 3.3 m.



Interlayers of sand, silt, silty sand, sandy silt and, sand and silt were encountered within the silty clay till at various depths. An upper sand/sandy silt layer was contacted in Boreholes 16TH-01, 16TH-02 and 16TH-05 at depths ranging from 1.0 m to 1.4 m. A deeper layer of sands and silts was contacted in Boreholes 16TH-01, 16TH-02, 16TH-05 and TUN-01 to TUN-04, at depths ranging from 3.7 m to 5.8 m and at 7.2 m in Borehole 16TH-05. The sand and silt interlayers varied in thickness from 0.7 m to 5.0 m.

The depth to the base of the silty clay till was 23.3 m (Elevation 172.0) in Borehole 16TH-05. Boreholes 16TH-01, 16TH-02, and TUN-01 to TUN-04 were terminated within the silty clay till at depths ranging from 9.8 m to 11.3 m (Elevations 184.1 to 186.6).

SPT 'N' values for the silty clay till ranged from 5 to 64 blows per 0.3 m penetration, indicating a firm to hard consistency. Moisture contents in the cohesive glacial till ranged from 10 to 31 percent.

SPT 'N' values measured in the sand and silt interlayers typically ranged from 4 to 47 blows per 0.3 m of penetration, indicating a loose to dense state. Moisture contents in the interlayers of sands and silts varied between 8 and 28 percent.

The results of grain size distribution analyses carried out on selected samples of the silty clay till and the interbedded sands and silts are presented on the Record of Borehole sheets included in Appendices A and C. Grain size distribution curves of samples of the silty clay till and sand/silt layers are presented in Figures B2 to B4 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Silty Clay Till (percent)	Sand and Silt Interlayers (percent)
Gravel	0 to 2	0 to 5
Sand	3 to 28	3 to 76
Silt	29 to 77	16 to 93
Clay	20 to 60	3 to 7

The results of Atterberg Limits tests conducted on samples of the silty clay till of the present and previous investigations are provided on the Record of Borehole sheets in Appendices A



and C, and illustrated in Figures B5 and B6 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Liquid Limit	20 to 43
Plastic Limit	12 to 20
Plasticity Index	7 to 23

The results of the Atterberg Limits testing indicate that the silty clay till is generally of low plasticity with a group symbol of CL, and contains zones of medium plasticity with a group symbol of CI.

Glacial tills inherently contain cobbles and boulders.

5.5 Groundwater Conditions

Groundwater levels in the boreholes were observed during the drilling operations and measured upon completion of drilling. During the previous investigation, a standpipe piezometer was installed in Borehole 16TH-01 to permit monitoring of groundwater levels. Water levels measured in the installed standpipe and open boreholes are presented in Table 5.1 below.

Table 5.1- Groundwater Level Measurements

Location	Borehole	Date	Groundwater Level		Comments
			Depth (m)	Elevation (m)	
Sewer Crossing (north of 16 th Avenue)	TUN-01	March 18, 2019	5.1	191.1	Borehole caved to 6.2 m
	TUN-02	March 19, 2019	6.1	190.3	Borehole caved to 6.7 m
	TUN-03	March 18, 2019	6.1	190.2	Borehole caved to 6.4 m
	TUN-04	March 19, 2019	6.1*	190.0	Borehole caved to 5.5 m
North Approach	16TH-01	June 4, 2018	4.6	190.9	Open borehole Piezometer Piezometer
		August 22, 2018	5.7	189.8	
		November 23, 2018	4.8	190.7	
	16TH-02	June 1, 2018	6.1	189.3	Open borehole

* Water level observed before borehole caving in.



The values shown in Table 5.1 are short-term readings, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after periods of significant or prolonged precipitation.

6. MISCELLANEOUS

Thurber staked and/or marked the borehole locations in the field and obtained utility clearances prior to drilling. Thurber obtained the northing and easting coordinates at this site, and WSP provided the ground surface elevations.

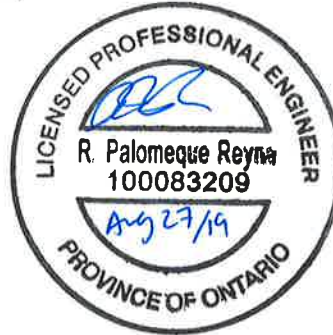
Walker Drilling of Utopia, Ontario and DBW Drilling Limited of Ajax, Ontario, supplied and operated truck-mounted drill rigs to carry out the drilling, sampling and in-situ testing operations for the boreholes.

The drilling and sampling operations in the field were supervised on a full-time basis by Mr. Kevin Kweon and Mr. Bryan Lui of Thurber. Geotechnical laboratory testing was carried out by Thurber in its MTO-approved laboratory. Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Ms. Rocío Palomeque Reyna, P.Eng. The report was reviewed by Dr. Sydney Pang, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



THURBER ENGINEERING LTD.



Rocio Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact

Client: WSP
File No.: 15786

E file: H:\15000-15999\15786 Hwy 404 Widening 2016-E-0014\Reports and Memos\Contract 2\Sewer Crossing north of 16th Ave\FINAL\15786 16th Avenue - Sewer Crossing north of 16 Ave FIDR aug 19.docx

Date: August 27, 2019
Page: 10 of 23



**FOUNDATION INVESTIGATION AND DESIGN REPORT
STORM SEWER CROSSING NORTH OF 16TH AVENUE
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
MARKHAM, ONTARIO
G.W.P. 2930-17-00**

GEOCRES NO. 30M14-504

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides recommendations for installation of a proposed storm sewer crossing to be located on the north side of 16th Avenue near the Highway 404 and 16th Avenue interchange in the Regional Municipality of York, Ontario.

This foundation investigation and design report, with the interpretation and recommendations, is intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction contractor. The contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the information provided as it may affect equipment selection, proposed construction methods and scheduling.

The discussion and recommendations presented in this report are based on information provided by WSP to Thurber, and on the factual data obtained during the course of this investigation, and a previous investigation (Reference 1).

8. SEWER CROSSING

A proposed storm sewer crossing will be located at approximately 50 m north of the existing 16th Avenue centreline or in the order of 16 m north of the crest of the proposed permanent



earth cut as part of the 16th Avenue widening. Inside widening (into the median) of the existing Highway 404 SBL and NBL is also proposed at this site.

The new storm sewer crossing may consist of concrete, PVC/PP or HDPE pipes. Some physical dimensions of the proposed sewer pipes are presented in Table 8.1, as provided by WSP.

Table 8.1- Details of Storm sewer crossing

From (inlet #)	To (outlet #)	Approx. Length (m) (invert to invert)	Slope (%)	Pipe Diameter (mm)	Inverts (m)	
					Upstream	Down- stream
264	263	46.0	1.0	1050	191.771	191.314
263	262	2.5	1.0	1050	191.314	191.289
262	211 (west side)	35.7	1.0	1050	191.289	190.933

The overall length of the pipe between the inlet and outlet is in the order of 84.2 m.

No grade raise of Highway 404 is planned at the location of the storm sewer crossing. The finished grade of the highway will be at approximate Elevation 196.3. Therefore, based on invert levels, excavation in the order of 4.5 m to 5.2 m, from east to west, will be required to install the storm sewer pipe.

It is understood that installation of the storm sewer crossing is planned to be carried out in temporary open excavation with inclined side slopes. This work will be carried out in stages in co-ordination with the highway lane closures planned for the main cuts associated with the 16th Avenue widening.

Foundation design aspects for the sewer crossing include subgrade conditions and preparation, settlement of founding soils, lateral earth pressures, roadway protection system design, groundwater control, staged construction, and restoration of the roadway embankment.

It is recommended that sewer pipe installation, excavating, backfilling and compacting be carried out in accordance with OPSS.PROV 401, OPSS.PROV 902, OPSS.PROV 410,



OPSS.PROV 492 and OPSD 802.030, OPSD 802.031, OPSD 802.032 as appropriate. Care must be exercised when compacting the fill immediately above the crown of the pipe in order not to damage the pipe. Reference should also be made to OPSS.PROV 501 and OPSS.PROV 1010.

8.1 Open Excavation and Groundwater Control

The subsurface conditions along the storm sewer crossing alignment generally consists of pavement structure (asphalt over granular base) overlying layers of stiff to very stiff silty clay fill and compact sand and silt fill, which are underlain by stiff to hard silty clay till with interbedded layers of compact to dense sands and silts. The groundwater levels observed in the open boreholes during the investigation and measured in the piezometers ranged between 5 m to 6 m depth below ground surface, or at Elevations 191 to 190 m.

Excavation for storm sewer installation will extend to depths of 4.5 m to 5.2 m through the embankment fill and native stiff to hard silty clay till into the compact sands and silts. It is anticipated that water-bearing sands and silts will be exposed at or above the pipe subgrade. Where water seepage and sloughing of these soils is a concern, dewatering and/or depressurization will be required in conjunction with various forms of earth support. Temporary protection (shoring) and partial groundwater cutoff such as interlocking sheetpiles may be considered.

All excavations should conform to the requirements of the latest edition of the Ontario Occupational Health & Safety Act (OHSA), its regulations and other applicable local regulations. For the purposes of the OHSA, the fill and native soils above the water table are classified as Type 3. Cohesionless soils below the water table are classified as Type 4.

Inclined slopes of temporarily unsupported cuts conforming with the requirements of the OHSA may be formed, but should not be steeper than 1H : 1V above the groundwater level. Flatter slopes may be required at locations where water seepage or sloughing occurs during excavation.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should regularly be inspected for evidence of instability if they have been left open for



extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

Cobbles or boulders should be expected in the glacial tills. Excavation of these obstructions and hard zones within the till is anticipated to be laboured and difficult. The contractor's excavating equipment must be capable of dislodging, handling and removing the obstructions, and penetrating the hard zones to reach the desired depths.

Drainage will be required to remove water originating from storm runoff and seepage from the sides of the excavation and cohesionless soils. Temporary drainage of the excavation should be provided to maintain a relatively dry, stable excavation. Further comments are provided in Section 8.3.

The sewer design should take into account any protective measures that may be required for any existing buried utilities that may exist in the vicinity of the work areas. This may require discussions with relevant owners of these facilities and design of temporary protection and support of the particular utility.

Where excavation for pipe installation is located in close proximity to existing buried utilities and where temporary protection is otherwise required, consideration may be given to using temporary protection such as interlocking sheetpile walls or soldier pile and lagging walls. Design of a temporary protection system is the responsibility of the contractor. Recommendations for temporary protection (shoring) are presented in Section 8.4 of this report.

8.1.1 Stability of Temporary Open Excavation

Analyses of global stability was carried out for open excavations through embankment fills overlying stiff to very stiff silty clay till, which is underlain by typically compact sands and silts,.

The computed factors of safety are as shown in Table 8.2. Graphical outputs of these analyses are included in Appendix E.

Table 8.2 Computed Factors of Safety

Condition	Factor of Safety	Figure (Appendix E)
Excavation height 4.6 m – East Side – Short Term Conditions		
Pavement and Fill (1H : 1V – upper) (1H : 1V – lower)	0.98	E1
Pavement and Fill (1.5H : 1V – upper) (1H : 1V – lower)	1.31	E2
Overall (1H : 1V)	1.76	E3
Overall (1.5H : 1V – upper) (1H : 1V – lower)	1.82	E4
Excavation height 5.4 m – West Side – Short Term Conditions		
Pavement and Fill (1H : 1V – upper) (1H : 1V – lower)	0.99	E5
Pavement and Fill (1.5H : 1V – upper) (1H : 1V – lower)	1.29	E6
Overall (1H : 1V)	1.45	E7
Overall (1.5H : 1V – upper) (1H : 1V – lower)	1.52	E8

As per typical MTO requirements, a Factor of Safety (F.S.) of 1.3 is acceptable for short term and total stress (undrained) conditions. For the upper slope of pavement over embankment fill, an F.S. of 1.3 can be achieved with a slope inclination of 1.5H : 1V (Figures E2 and E6). However, Figures E1 and E5 indicate that surficial sloughing would occur as the F.S. is in the order of 1.0. For the overall slope of 1H : 1V or flatter, Figures E3, E4, E7 and E8 show that global stability in the short term can be achieved.

Since these open cuts are expected to be carried out in relatively short sections and opened for limited time for pipe installation prior to backfilling, the slope configurations discussed above are considered acceptable as long as all OHSA requirements are met. It is recommended that the upper slopes with exposed cohesionless fills be covered with tarpaulin, or equivalent, for protection against adverse effects due to water seepage, surface runoff and precipitation.



8.2 Trenching

As an alternative to open excavation, the sewer crossing may be installed by trenching. In general, vertically sided excavations may be carried out within temporary protection (shoring) systems. For deeper excavations where water seepage is a concern and adjacent ground movement is to be minimized, steel interlocking sheetpiles may be considered for adjacent ground support and partial groundwater cutoff.

Trench boxes (multi-layered if necessary) are typically used in shallow cuts, but are not suitable for limiting ground water ingress and adjacent ground movement at this site. Ground movement adjacent to vertically sided trenches must be subjected to the criterion associated with Performance Level 2 as per Clause 539.04.01.01 in OPSS.PROV 539 (also see Section 8.4 Temporary Protection System).

Trenching, backfilling and compacting must be carried out as per OPSS.PROV 401 and OPSS.PROV 501 requirements.

Further details for groundwater control, subgrade preparation, sewer bedding, sewer backfill are presented in the subsequent sections of this report.

8.3 Groundwater Control

The groundwater levels were at depths ranging between 5 m and 6 m (Elevations 191 m to 190 m) in Boreholes TUN-01 to TUN-04, which were slightly above the proposed pipe invert level.

Along the westerly portion of the pipe alignment under Highway 404 SBL and Ramp E-S, layers of water-bearing silt, sandy silt and sand were observed in Boreholes TUN-01 and TUN-02 between approximate Elevations 192.3 m and 187.7 m. The proposed pipe invert levels are, therefore, located within the wet silt/sand layers.

The contractor should be alerted that it is their responsibility to carry out groundwater control during excavation. Water seepage should be expected from the sands and silts that are likely to be exposed at and above the base of the excavation, and also from water-bearing seams/layers within the silty clay till, and perched water within the existing surficial fill at



shallow depths. Sump pumping will be required at all times in conjunction with other means of dewatering such as vacuum well points or sheetpile cutoff walls, where required, to maintain reasonably dry excavations. Surface runoff and precipitation should be diverted away from all excavations where practicable.

In zones where excavation extends through surficial fill, and cohesionless sands and silts, sloughing of the excavation sidewalls should be expected, especially in cases where the groundwater level is above the pipe invert level. Should sloughing or caving occur at depths below the water table or at any other location, the contractor must immediately modify the excavating and shoring methods, and construction sequence in order to prevent further sloughing from occurring, and full support must be provided. At these locations, localized effective dewatering, e.g. well points or sheetpile cutoff, may need to be used. It is always a good practice to excavate from areas of low invert elevations to areas of higher elevation (i.e. uphill) so that the previously placed sewer backfill may act as a drain to the subsequent sections of the excavation.

Dewatering and unwatering should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), and SP No. FOUN0003. A design engineer will be required for the dewatering system implemented at this site. Suggesting wording for an NSSP in this regard is included in Appendix F.

The majority of the sewer installation works will be carried out in sloped open cuts. Temporary protection systems may be required locally or in association with a groundwater control system. It is recommended that a temporary protection system, where used, be removed prior to completing construction of the sewer. Consideration may be given to using vibratory equipment for installation and removal of a temporary protection system provided that the newly installed sewer and any surrounding utilities will not be adversely affected.

Decisions regarding temporary protection (shoring) methods and sequencing should be made by the contractor. Any required temporary protection system must be designed by a licensed Professional Engineer experienced in such designs. Any dewatering system must be designed by specialists experienced in such designs.

8.4 Temporary Protection System

Temporary protection (shoring) may be required for installation of the storm sewer crossing. An item titled "Protection System" as per OPSS.PROV 539 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.01.01 be used.

The design of temporary protection is the responsibility of the Contractor. However, interlocking steel sheetpile walls may be considered as temporary shoring at this site. It is anticipated that the protection system will extend predominantly through the existing silty clay/sand embankment fill into the underlying stiff to hard silty clay till with interbedded layers of compact sands and silts, to develop the required toe resistance. Installation of temporary protection should consider that the existing embankment fill may contain obstructions.

A temporary shoring wall may be designed using the parameters given below:

Soil Bulk Unit Weight	γ	=	20 kN/m ³
Soil Submerged Unit Weight (below gwl)	γ_w	=	10 kN/m ³
Coefficient of Active Pressure	K_a	=	0.33 (embankment fills)
		=	0.33 (native sand and silts)
		=	0.31 (native silty clay till)
Coefficient of Passive Pressure	K_p	=	3.0 (embankment fills)
		=	3.0 (native sands and silts)
		=	3.2 (native silty clay till)

It is recommended that lateral earth pressures acting on the wall be computed in accordance with the CHBDC 2014. The surcharge should include soil loadings above the retained soil and other loadings adjacent to the wall. Full groundwater pressure will have to be taken into account for a sheetpile wall design. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the temporary protection system.

The designer of the temporary protection system should check whether the depth of embedment is sufficient to provide base fixity.



All temporary protection systems should be designed by a Professional Engineer experienced in such designs.

8.5 Subgrade Preparation and Sewer Bedding

Available information indicates that the proposed pipe invert levels vary across the site between Elevations 191.7 m and 190.3 m, from east to west. At these levels, the founding soils generally consist of stiff to very stiff silty clay till (under Highway 404 NBL) transitioning into water-bearing, compact sands and silts (under Highway 404 SBL).

Performance of the storm sewer and the highway above it will depend on the adequate preparation of the subgrade. After the excavation reaches the design subgrade elevation, the exposed surface should be inspected to confirm that the subgrade is suitable and uniformly competent. Any fill, loose/soft soils or debris within the sewer alignment should be sub-excavated and replaced with well compacted granular fill.

Prior to placement of the pipe bedding, the base of the excavation must be dewatered and in a reasonably dry condition. Where loose and wet materials are exposed at subgrade level, sub-excavation of these disturbed materials will be required. Backfill to replace the over-excavation should consist of OPSS Granular A placed in 150 mm thick loose lifts and compacted to a minimum 98 % of its Standard Proctor Maximum Dry Density (SPMDD). If a reasonably dry excavation base cannot be maintained, the Granular A backfill may be substituted with 19 mm clear stones as specified in OPSS.PROV 1004.05.02. The clear stones should be continuously wrapped in non-woven, Class II (heavy duty) geotextile filter cloth with an apparent opening size of 0.212mm, such as a Terrafix 360R.

It is critical that the pipe be supported on uniform competent subgrade and well compacted bedding in order to minimize the potential of differential settlement. At locations where less competent subgrade is encountered, the bedding thickness may be locally increased.

It is recommended that pipe bedding and cover should be in accordance with current MTO practice. The bedding materials should meet the gradation requirements for OPSS Granular A materials, and should be placed in loose lifts not thicker than 150 mm and be compacted to 100% of its Standard Proctor Maximum Dry Density (SPMDD) within 2 percent of its optimum moisture content (OMC). Placement and compaction of granular bedding and granular fill



should be in accordance with OPSS.PROV 902 and OPSS.PROV 501 requirements. The bedding thickness depends on the pipe diameter D, typically equal to $0.15D$, but should be a minimum 150 mm and should extend to at least 300 mm above the crown of the pipe to provide a granular surround. Care must be exercised when compacting the fill immediately above the crown of the pipe in order not to damage the pipe. Reference should be made to OPSD 802.030, 802.031 and 802.032, where applicable.

The bedding material should be placed as soon as practicable following inspection and approval of the final subgrade, as protection from disturbance during construction.

Construction equipment should not be allowed to travel on the prepared subgrade.

8.6 Sewer Backfill

The contract drawings indicated that Granular A will be used as backfill materials for the excavation except for the key-in areas with 16th Avenue where Granular B Type I may be used. The backfill materials must meet OPSS.PROV 1010 requirements and should be placed in loose lifts not exceeding 200 mm and be compacted to at least 98 percent of its SPMDD within ± 2 percent of its OMC.

Backfilling and compacting must be carried out as per OPSS.PROV 902 and OPSS.PROV 501 requirements. Trenching, backfilling and compacting must be carried out as per OPSS.PROV 401.

Excess excavated materials may be disposed of off site or reused as general fill for landscaping purposes elsewhere within the project.

8.7 Settlement

Grade raise of Highway 404 is not planned at this site. However, additional embankment fill in the order of 1 m thick may be required for the inside/median widening of Highway 404.

The native subgrade soils include the stiff to very stiff cohesive till and compact sands/silts along the storm sewer alignment will undergo settlement as the backfill and the grade raising



fill is placed. Any settlement should be immediate in nature and should be essentially completed by the end of construction.

9. CONSTRUCTION CONCERNS

Potential construction concerns that have been identified for this project include the following:

9.1 Loss of Ground

Excavation/Trenching for storm sewer installation will result in some adjacent ground movements depending on the soil and groundwater conditions. The Contractor must recognize that construction sequencing including the implementation of temporary protection (shoring) and groundwater control will be critical to limiting ground movements to within tolerable limits.

9.2 Groundwater Control

Groundwater control will be required for installation of the storm sewer crossing. Sump pumping in addition to other means of localized dewatering such as vacuum well points may be required in water-bearing sands and silts. Partial groundwater cut-off using interlocking sheetpile walls may be required. Surface runoff and precipitation should be diverted away from excavations at all times.

9.3 Pipe Subgrade Preparation and Trench Backfilling

The performance of the reinstated Highway 404 will depend, in part, on the subgrade preparation and trench backfilling. These tasks must be completed to the specified standards in the Contract.

9.4 Obstructions

Glacial tills inherently contain cobbles and boulders, and the existing highway fill may contain similar and other obstructions. The Contractor's equipment and methodology must be selected to handle such obstructions and successfully remove them without jeopardizing the highway.



9.5 Buried Utilities and Adjacent Roadway

The potential presence of underground utilities at the site should be confirmed prior to construction. The Contractor must accurately establish, in three dimensions, the locations of all buried utilities crossing or closely paralleling the storm sewer alignment. Any discrepancy from the Contract Drawings must be reported to the Contract Administrator.

Protection and/or relocation of utilities may be required. Underground utilities should not be undermined or damaged during storm sewer pipe installation.

9.6 Impact of excavation on the existing pavement surface

Daily visual inspection of the highway pavement surface must be carried out in the vicinity of the construction works. If cracks form in the pavement or settlement is observed to occur, these matters must immediately be brought to the attention of the CA for determining if further action is required.

9.7 Existing Slopes and Temporary Excavation Slopes

The temporary cut slopes should be inspected for surficial disturbance. Any issues should be adequately addressed for the duration of construction.

10. CLOSURE

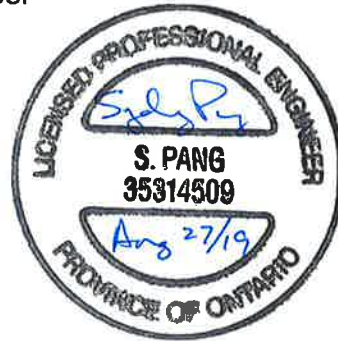
Engineering analysis and preparation of the foundation design report was conducted by Ms. Rocío Palomeque Reyna, P.Eng and Dr. Sydney Pang, P.Eng. Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects, reviewed the report.



THURBER ENGINEERING LTD.



Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer



Sydney Pang, P.Eng.
Associate, Senior Foundations Engineer



P.K. Chatterji, P.Eng.
Review Principal, Designated MTO Contact



Appendix A

Record of Borehole Sheets (Present Site Investigation)

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer


4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


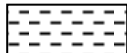



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS W _L < 50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. (W _L < 30%).
		CI	Inorganic clays of medium plasticity, silty clays. (30% < W _L < 50%).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS W _L > 50%	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen				
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.				

RECORD OF BOREHOLE No TUN-01

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 407.9 E 314 779.3 ORIGINATED BY KK
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.18 - 2019.03.18 LATITUDE 43.865575 LONGITUDE -79.375847 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
196.2	GROUND SURFACE												
0.0	ASPHALT: (175mm)												
0.2	SAND and GRAVEL, trace silt Very Dense Brown Moist (FILL)		1	SS	51		196						
195.5													
0.7	Silty SAND, some clay, trace gravel, occasional black staining, occasional clay pockets		2	SS	15		195						7 43 33 17
194.8	Compact Dark Grey Moist (FILL)		3	SS	21								
1.4													
193.8	Silty CLAY, some sand, trace gravel, trace silt, occasional decayed wood pieces and rootlets Very Stiff Grey Moist (FILL)		4	SS	15		194						
2.4													
192.3	Silty CLAY, some sand, trace gravel, oxidized stains Stiff to Very Stiff Brown Moist (TILL)		5	SS	17		193						0 11 29 60
3.9	SILT, trace gravel, trace clay Compact Grey Wet		6	SS	20		192						
			7	SS	13								0 3 93 4
							191						
190.6													
5.6	Silty CLAY, with sand, trace gravel Stiff to Very Stiff Grey Moist (TILL)		8	SS	15		190						
							189						
			9	SS	26		188						
							187						
	Hard		10	SS	64								
186.4													
9.8	END OF BOREHOLE AT 9.8m.												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TUN-01

2 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 407.9 E 314 779.3 ORIGINATED BY KK
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.18 - 2019.03.18 LATITUDE 43.865575 LONGITUDE -79.375847 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page BOREHOLE CAVED TO 6.2m AND WATER LEVEL AT 5.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.6m, CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.																

RECORD OF BOREHOLE No TUN-02

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 416.0 E 314 795.6 ORIGINATED BY KK
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.19 - 2019.03.19 LATITUDE 43.865648 LONGITUDE -79.375644 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	W _P W W _L	WATER CONTENT (%)						
196.4	GROUND SURFACE															
0.0	ASPHALT: (200mm)															
0.2	SAND and GRAVEL, trace silt Very Dense Brown		1	SS	100/											
195.7	Moist (FILL)				0.125											
0.7	Silty SAND, some clay, trace gravel, clay pockets Compact Brown to Grey Moist (FILL) Layer of silty clay fill at 1.2m (200mm) Decayed wood pieces at 1.5m		2	SS	15											
			3	SS	25											
194.0																
2.4	Silty CLAY, some sand, trace gravel, oxidized stains Very Stiff to Hard Brown Moist (TILL)		4	SS	16										0 14 51 35	
			5	SS	31											
			6	SS	25											
191.9																
4.5	Sandy SILT, trace gravel, trace clay Compact Grey Wet		7	SS	27											
			8	SS	26										0 34 63 3	
	Some clay		9	SS	13											
187.7																
8.7	Silty CLAY, with sand, trace gravel Hard Grey Moist (TILL)															
			10	SS	53											
186.6																
9.8	END OF BOREHOLE AT 9.8m.															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No TUN-02

2 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 416.0 E 314 795.6 ORIGINATED BY KK
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.19 - 2019.03.19 LATITUDE 43.865648 LONGITUDE -79.375644 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page BOREHOLE CAVED TO 6.7m AND WATER LEVEL AT 6.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 0.5m, CEMENT TO 0.2m, THEN ASPHALT TO SURFACE.																

ONTMT452 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 3/28/19

RECORD OF BOREHOLE No TUN-03

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 417.0 E 314 819.0 ORIGINATED BY BL
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.18 - 2019.03.18 LATITUDE 43.865656 LONGITUDE -79.375353 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
196.3	GROUND SURFACE												
0.0	ASPHALT: (175mm)												
0.2	SAND and GRAVEL, trace silt Compact Brown		1	GS		196							
195.6	Moist (FILL)												
0.7	Silty CLAY, some sand, trace gravel Very Stiff Grey		1	SS	20	195							
194.9	Moist (FILL)												
1.4	Silty SAND, trace gravel, trace clay, clay pockets Compact Grey		2	SS	20	194							
194.1	Moist (FILL)												
2.2	Silty CLAY, trace sand, trace gravel, occasional decayed wood pieces Stiff Grey		3	SS	13	194							
193.0	Moist (FILL)												
3.3	Silty CLAY, some sand, trace gravel Very Stiff Grey		4	SS	11	193							
	Moist (FILL)												
	Silty CLAY, some sand, trace gravel Very Stiff Grey		5	SS	23	192							
	Moist (TILL)												
			6	SS	22	191							
190.7						191							
5.6	SAND, some silt, trace gravel, trace clay Loose to Compact Grey Wet to Moist		7	SS	5	190							
						189							
188.4			8	SS	15	188							
7.9	Silty CLAY, with sand, trace gravel Stiff to Very Stiff Grey Moist (TILL)					187							
			9	SS	26								

Continued Next Page

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

RECORD OF BOREHOLE No TUN-03

2 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 417.0 E 314 819.0 ORIGINATED BY BL
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.18 - 2019.03.18 LATITUDE 43.865656 LONGITUDE -79.375353 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
185.0	Continued From Previous Page Silty CLAY , with sand, trace gravel Hard Grey Moist (TILL)		10	SS	62		186										
11.3	END OF BOREHOLE AT 11.3m. BOREHOLE CAVED TO 6.4m AND WATER LEVEL AT 6.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 1.5m, AUGER CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.																

RECORD OF BOREHOLE No TUN-04

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 428.9 E 314 838.5 ORIGINATED BY BL
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.19 - 2019.03.19 LATITUDE 43.865763 LONGITUDE -79.375110 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100		20 40 60			
196.1	GROUND SURFACE												
0.0	ASPHALT: (150mm)												
0.2	SAND and GRAVEL, trace silt Brown Moist (FILL)		1	GS									
195.4													
0.7	Silty SAND, some gravel, trace clay, clay pockets Compact Brown to Grey Moist (FILL)		1	SS	24								
			2	SS	28								
	Occasional decayed wood pieces		3	SS	20								
193.1													
3.0	Silty CLAY, trace to some sand, trace gravel Stiff to Very Stiff Grey Moist (TILL)		4	SS	10								
			5	SS	20								
			6	SS	15								
190.5													
5.6	SAND and SILT, trace gravel, trace clay Compact Grey Moist to Wet		7	SS	16								
			8	SS	14								
187.4													
8.7	Silty CLAY, with sand, trace gravel Very Stiff Grey Moist (TILL)		9	SS	23								

Continued Next Page


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

RECORD OF BOREHOLE No TUN-04

2 OF 2

METRIC

GWP# 2930-17-00 LOCATION N 4 858 428.9 E 314 838.5 ORIGINATED BY BL
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2019.03.19 - 2019.03.19 LATITUDE 43.865763 LONGITUDE -79.375110 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page																
184.8	Silty CLAY , with sand, trace gravel Very Stiff Grey Moist (TILL)		10	SS	28		186										
185																	
11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 6.1m BEFORE BOREHOLE CAVING TO 5.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO 1.5m, AUGER CUTTINGS TO 0.2m, THEN ASPHALT TO SURFACE.																

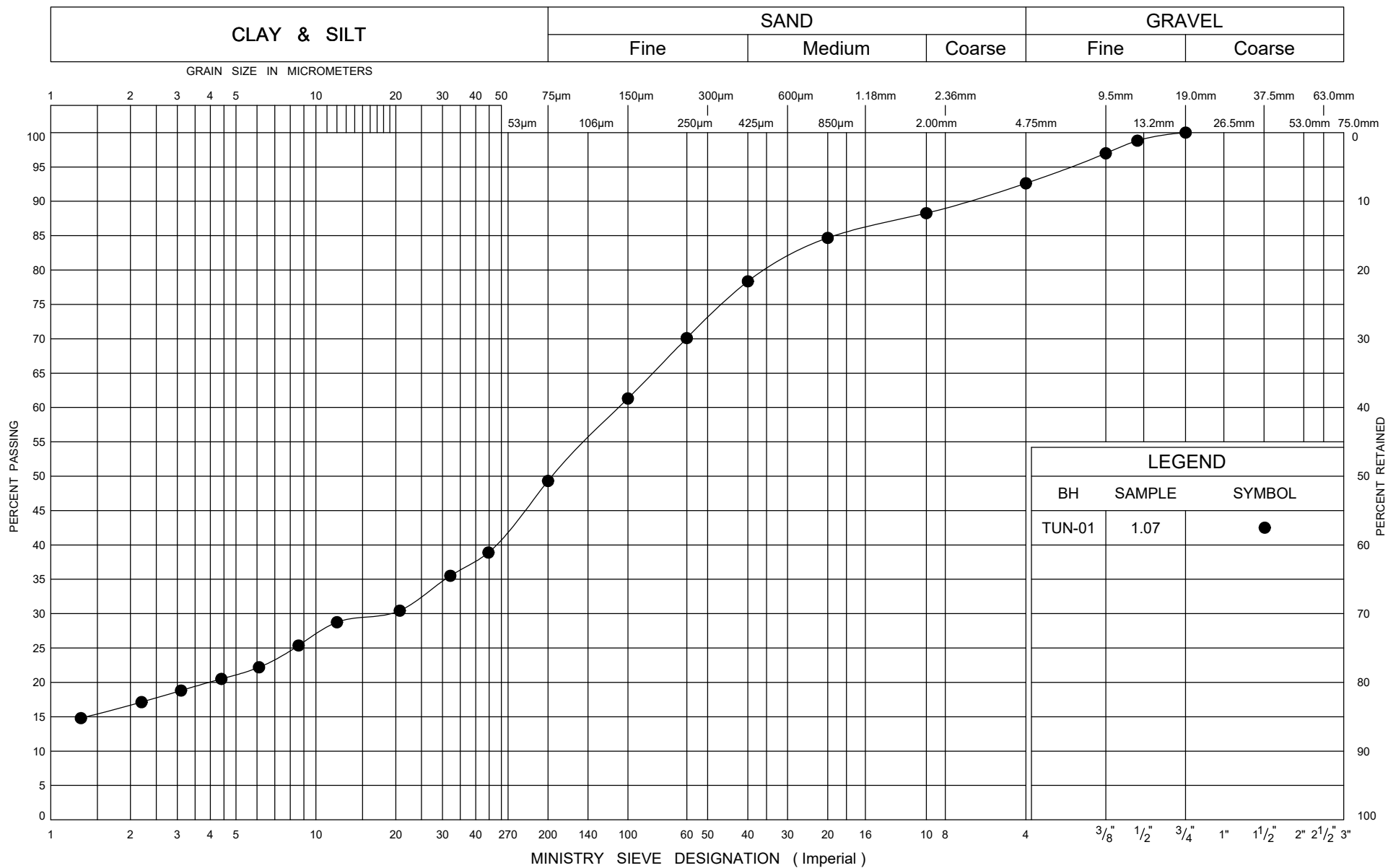
+³, ×³: Numbers refer to
Sensitivity

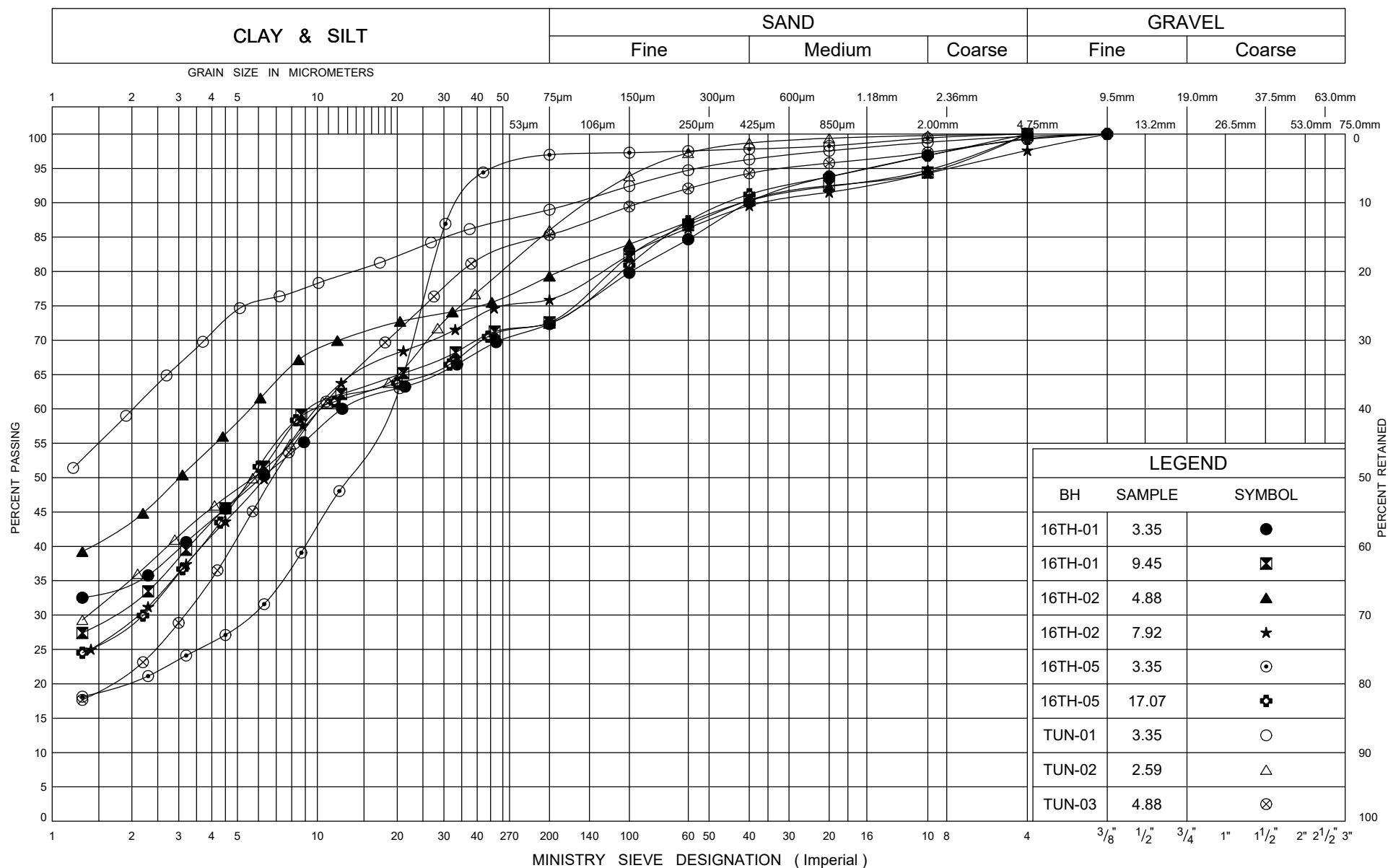
20
15
10
5
0
5
10
15
20
(%) STRAIN AT FAILURE



Appendix B

Geotechnical Laboratory Test Results (Present and Previous Site Investigation)





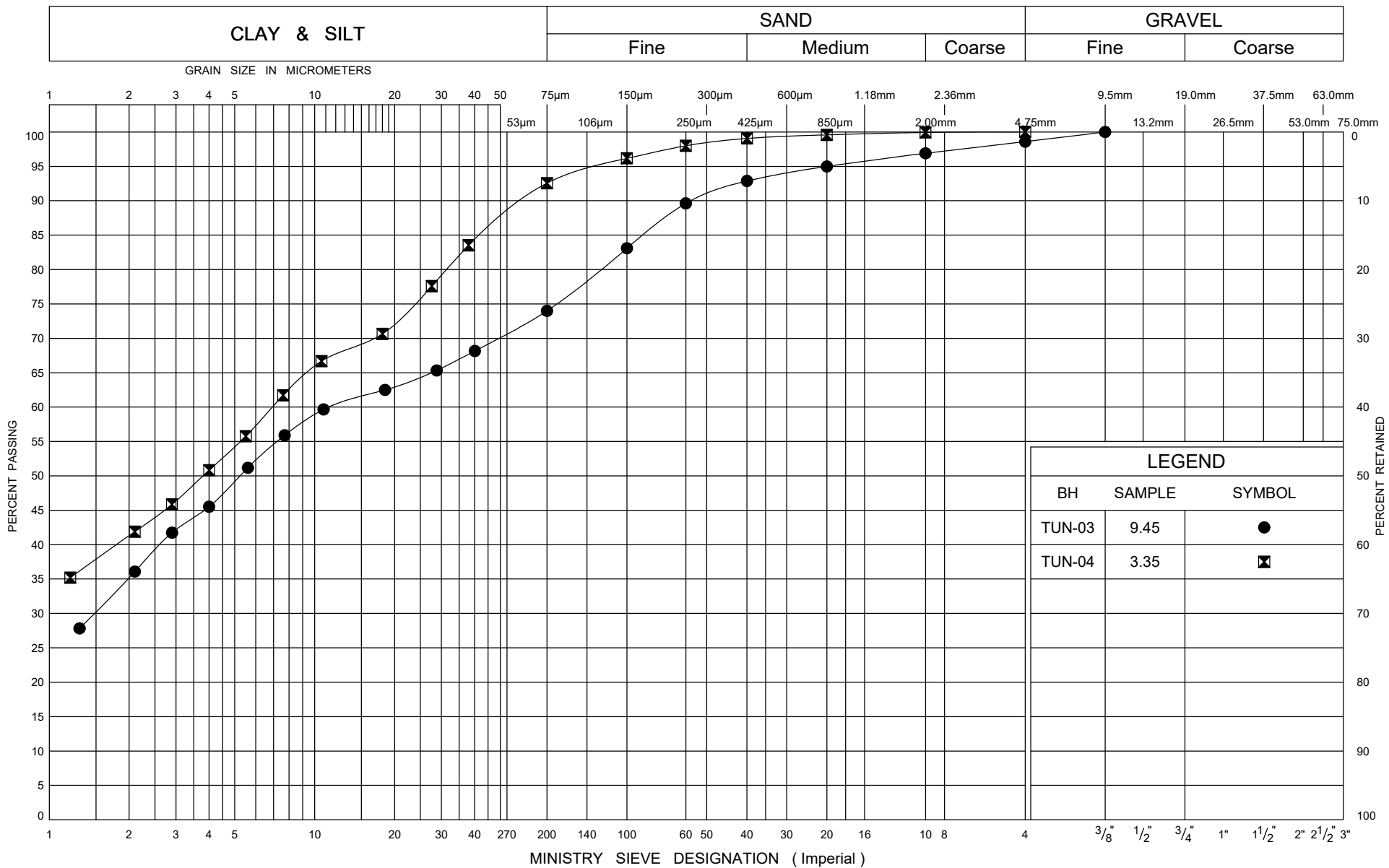
Ministry of
Transportation

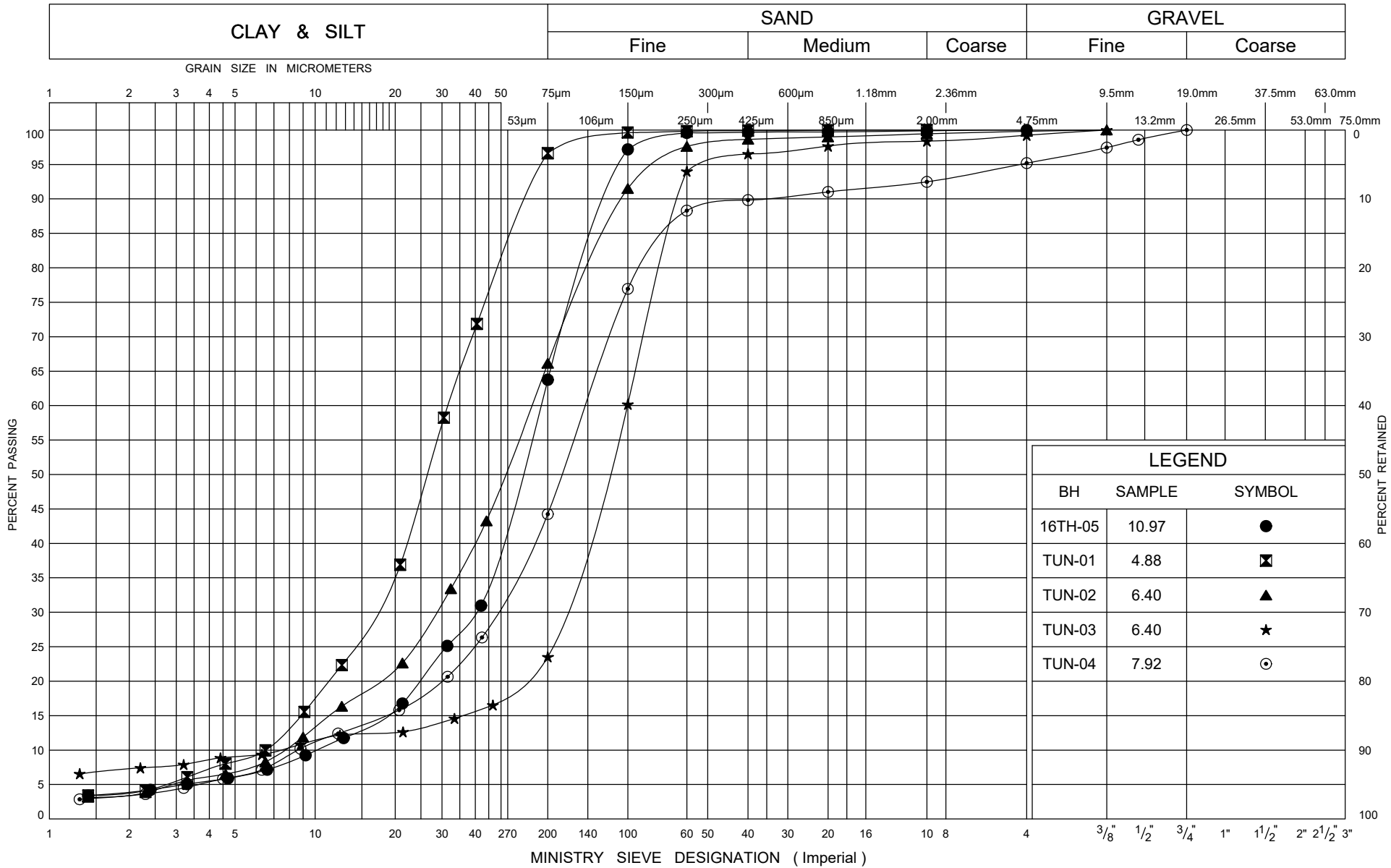
GRAIN SIZE DISTRIBUTION

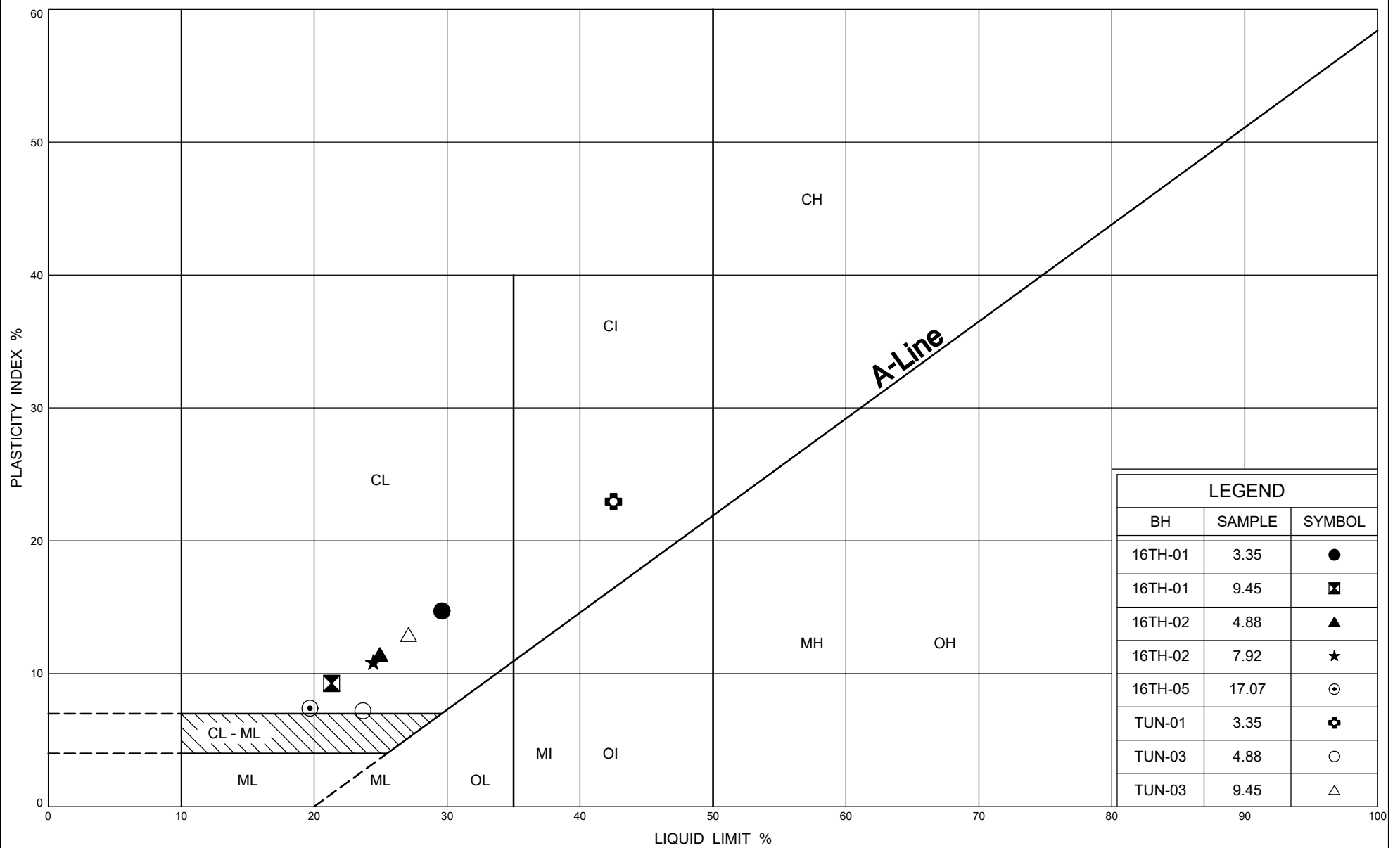
Silty CLAY TILL

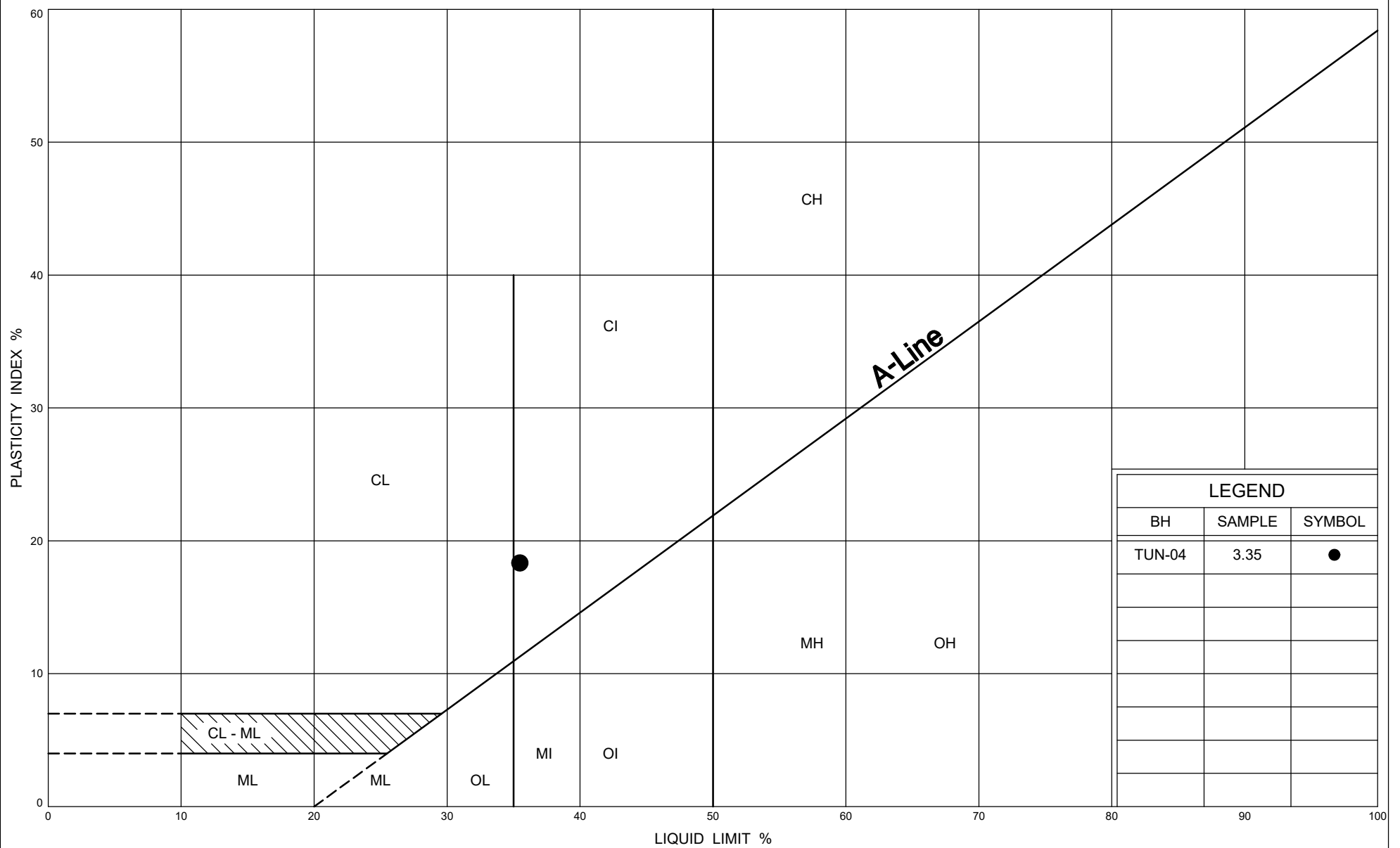
FIG No B2

W P 2930-17-00









LEGEND		
BH	SAMPLE	SYMBOL
TUN-04	3.35	●

ONTARIO MOT PLASTICITY CHART MTO-15786.GPJ ONTARIO MOT.GDT 3/26/19



Appendix C

Record of Borehole Sheets (Previous Site Investigation)

RECORD OF BOREHOLE No 16TH-01

1 OF 2

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 407.9 E 314 803.6 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.01 - 2018.06.04 LATITUDE 43.865575 LONGITUDE -79.375544 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
195.5	GROUND SURFACE							20	40	60	80	100		
0.0	TOPSOIL: (125mm)													
0.1	SAND, trace silt, trace gravel Compact Brown Moist (FILL)		1	SS	19		195							
194.7														
0.8	Silty CLAY, with sand, trace gravel Very Stiff Brown Moist (TILL)		2	SS	18		194							
193.9														
1.6	SAND, some silt Compact Brown Moist		3	SS	14		193							
193.2														
2.3	Silty CLAY, with sand, trace gravel Stiff to Very Stiff Brown to Grey Moist (TILL)		4	SS	10		192							
191.8			5	SS	17		191							
3.7	SAND, some silt, occasional cobbles Compact Grey Wet						190							
			6	SS	11		189							
189.4							188							
6.1	Silty CLAY, with sand, trace gravel Stiff Grey Wet (TILL)		7	SS	12		187							
							186							
186.7			8	SS	15		185							
8.8	SAND, some silt Grey Wet						184							
186.3							183							
9.2	Hard		9	SS	59		182							

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-01 2 OF 2 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 407.9 E 314 803.6 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.01 - 2018.06.04 LATITUDE 43.865575 LONGITUDE -79.375544 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%) W _p W W _L				
184.2	Silty CLAY , with sand, trace gravel Hard Grey Wet (TILL)		10	SS	50		185										
11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 4.6m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.08.22 5.7 189.8 2018.11.23 4.8 190.7																

METRIC


[illegible]

+³, ×³: Numbers refer to Sensitivity

ONTMT4S2 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 3/28/19

RECORD OF BOREHOLE No 16TH-02 2 OF 2 METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 407.4 E 314 812.8 ORIGINATED BY SB
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2018.06.01 - 2018.06.01 LATITUDE 43.865570 LONGITUDE -79.375430 CHECKED BY RPR

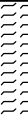


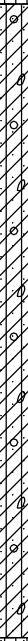

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
184.1	Continued From Previous Page Silty CLAY , with sand, trace gravel Very Stiff Grey Moist (TILL)		10	SS	25		185										
11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 6.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.																

RECORD OF BOREHOLE No 16TH-05

1 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 416.6 E 314 847.4 ORIGINATED BY BL/JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.08.29 - 2018.09.04 LATITUDE 43.865652 LONGITUDE -79.375000 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
195.3	GROUND SURFACE							20 40 60 80 100						
0.0	TOPSOIL , rootlets, grass Dark Brown Moist (800mm)		1	GS			195							
194.5														
0.8	SAND , trace gravel Dense Brown Moist (FILL)		1	SS	37		194							
193.9														
1.4	Sandy SILT , trace gravel, trace clay Compact Brown Moist		2	SS	29		193							
			3	SS	19		192							
192.3														
3.0	Silty CLAY , trace sand, trace gravel Stiff to Firm Grey Moist (TILL)		4	SS	9		191							
			5	SS	7		190							
			6	SS	5		189							
188.1														
7.2	SAND and SILT , trace to some clay, trace gravel Compact to Dense Grey Moist		7	SS	26		188							
							187							
			8	SS	32		186							

Augers grinding
at 9.9m

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-05

2 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 416.6 E 314 847.4 ORIGINATED BY BL/JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.08.29 - 2018.09.04 LATITUDE 43.865652 LONGITUDE -79.375000 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100						
	SAND and SILT , trace to some clay, trace gravel Dense Grey Moist		9	SS	47		185							0 36 60 4
							184							
183.1							183							1 27 44 28
12.2	Silty CLAY , with sand, trace to some gravel Stiff Grey Moist (TILL)		10	SS	14		182							
							181							
							180							
							179							
							178							
							177							
							176							
	Hard to Very Stiff		13	SS	47									
									</					

Continued Next Page

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

RECORD OF BOREHOLE No 16TH-05

3 OF 4

METRIC

GWP# 2930-17-00 LOCATION 16th Ave. Overpass, MTM NAD 83 Zone10: N 4 858 416.6 E 314 847.4 ORIGINATED BY BL/JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers/Tricone COMPILED BY AN
 DATUM Geodetic DATE 2018.08.29 - 2018.09.04 LATITUDE 43.865652 LONGITUDE -79.375000 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page							20 40 60 80 100						
								○ UNCONFINED + FIELD VANE						
								● QUICK TRIAXIAL × LAB VANE						
								20 40 60 80 100						
								PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT						
								W _P W W _L						
								WATER CONTENT (%)						
								20 40 60						
								</						

Augers grinding at 24.4m

8 45 34 13

Continued Next Page

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

METRIC

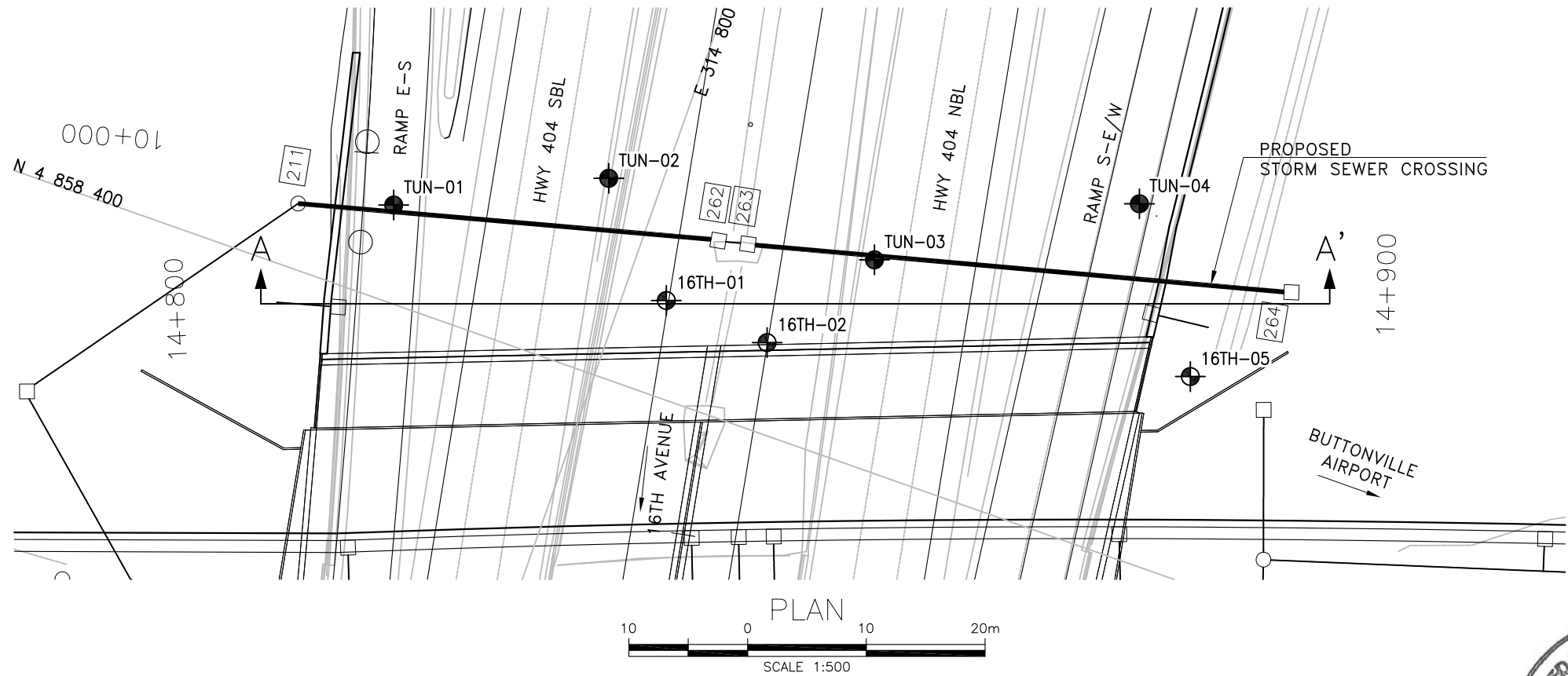
[illegible]

+³, ×³: Numbers refer to Sensitivity



Appendix D

Borehole Locations and Soil Strata Drawings



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

CONT No
GWP No 2930-17-00

HIGHWAY 404 WIDENING
STORM SEWER CROSSING
NORTH OF 16TH AVENUE
BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

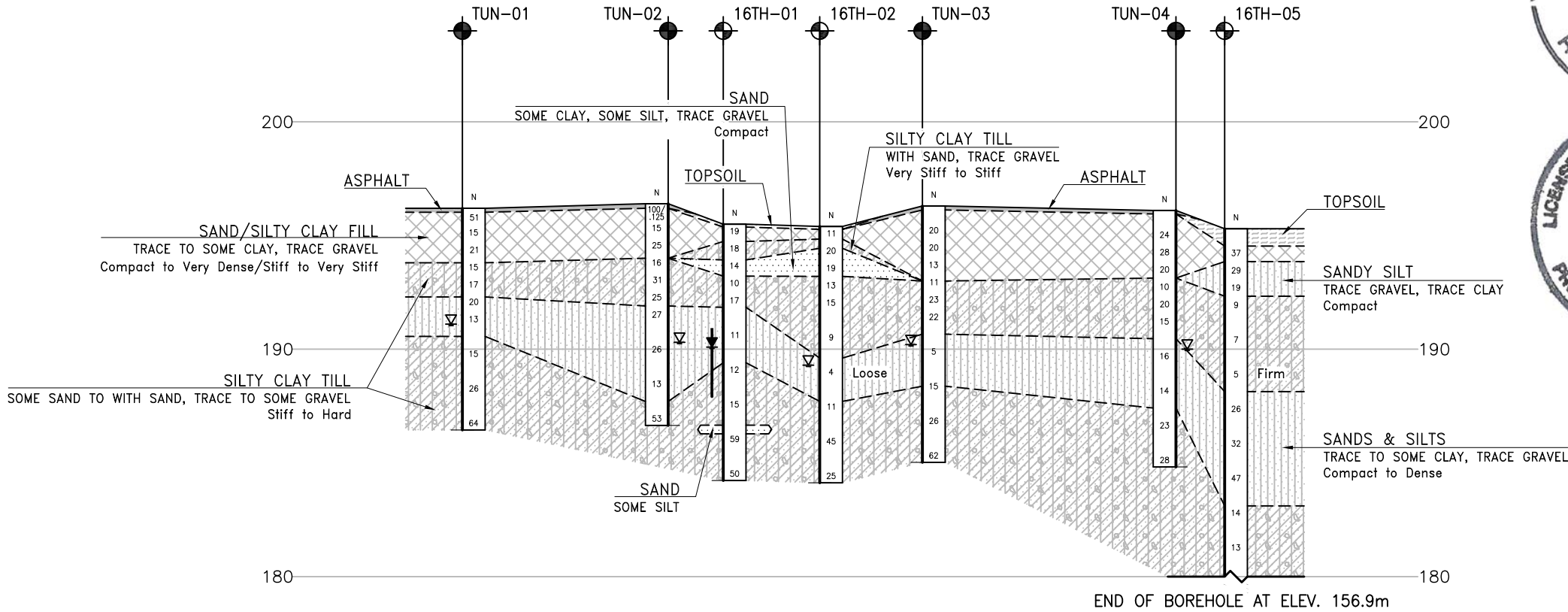
- Borehole (Current Investigation)
- Borehole (Previous Investigations)
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60° Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level (Open Borehole)
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16TH-01	195.5	4 858 407.9	314 803.6
16TH-02	195.4	4 858 407.4	314 812.8
16TH-05	195.3	4 858 416.6	314 847.4
TUN-01	196.2	4 858 407.9	314 779.3
TUN-02	196.4	4 858 416.0	314 795.6
TUN-03	196.3	4 858 417.0	314 819.0
TUN-04	196.1	4 858 428.9	314 838.5

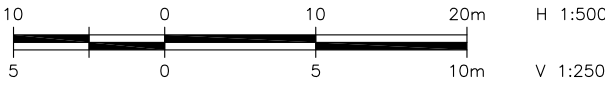
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 30M14-504



SECTION ALONG A-A'



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK	SKP
DRAWN	AN	CHK	RPR
CODE	LOAD	SITE	STRUCT
DATE	AUG 2019	DWG	1



Appendix E

Selected Slope Stability Outputs

Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
East Side (below Hwy 404 NBL)
Temporary excavation, Height 4.6 m
Undrained Analysis - Upper Slope
Slope 1H :1V

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1

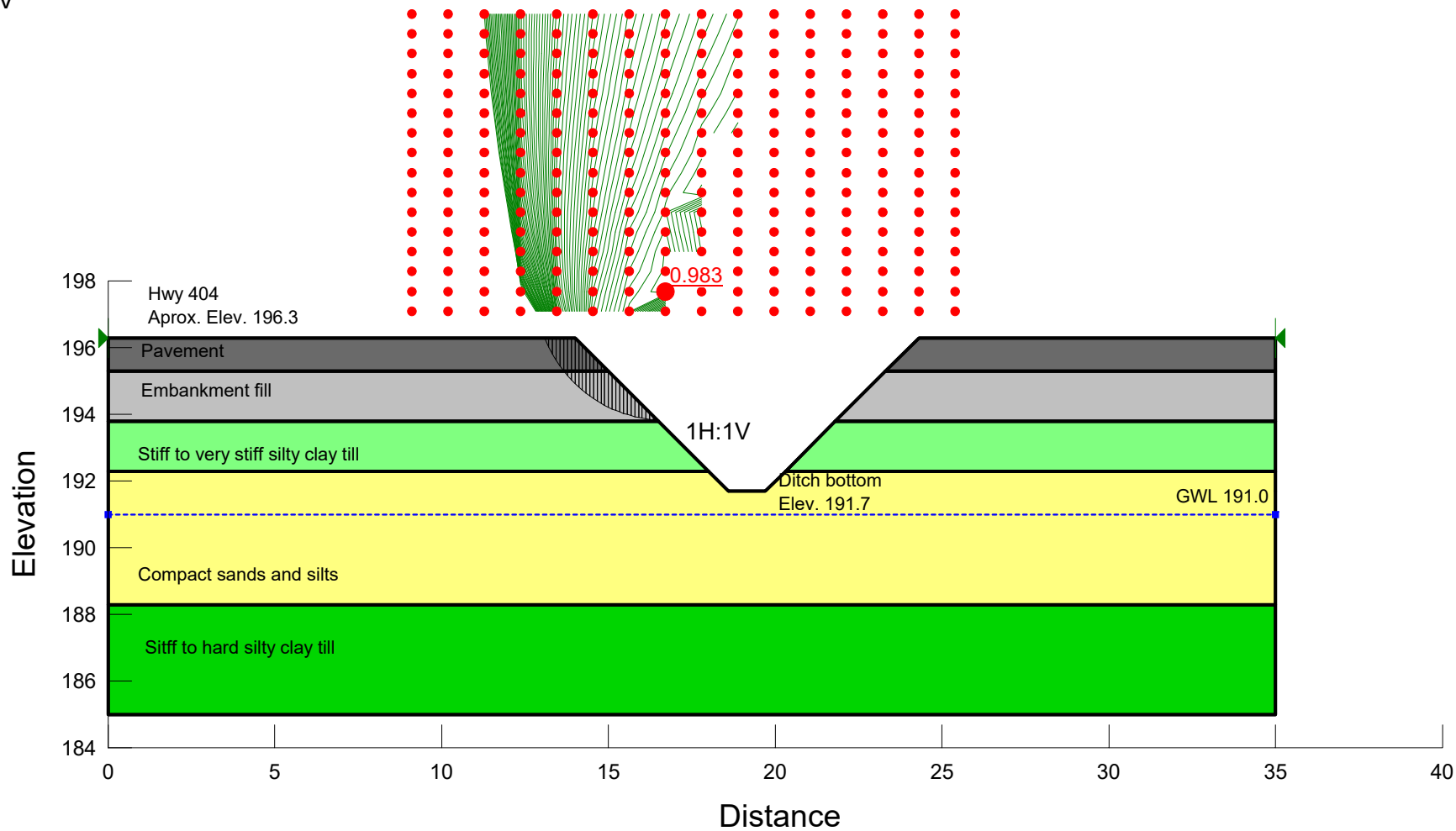
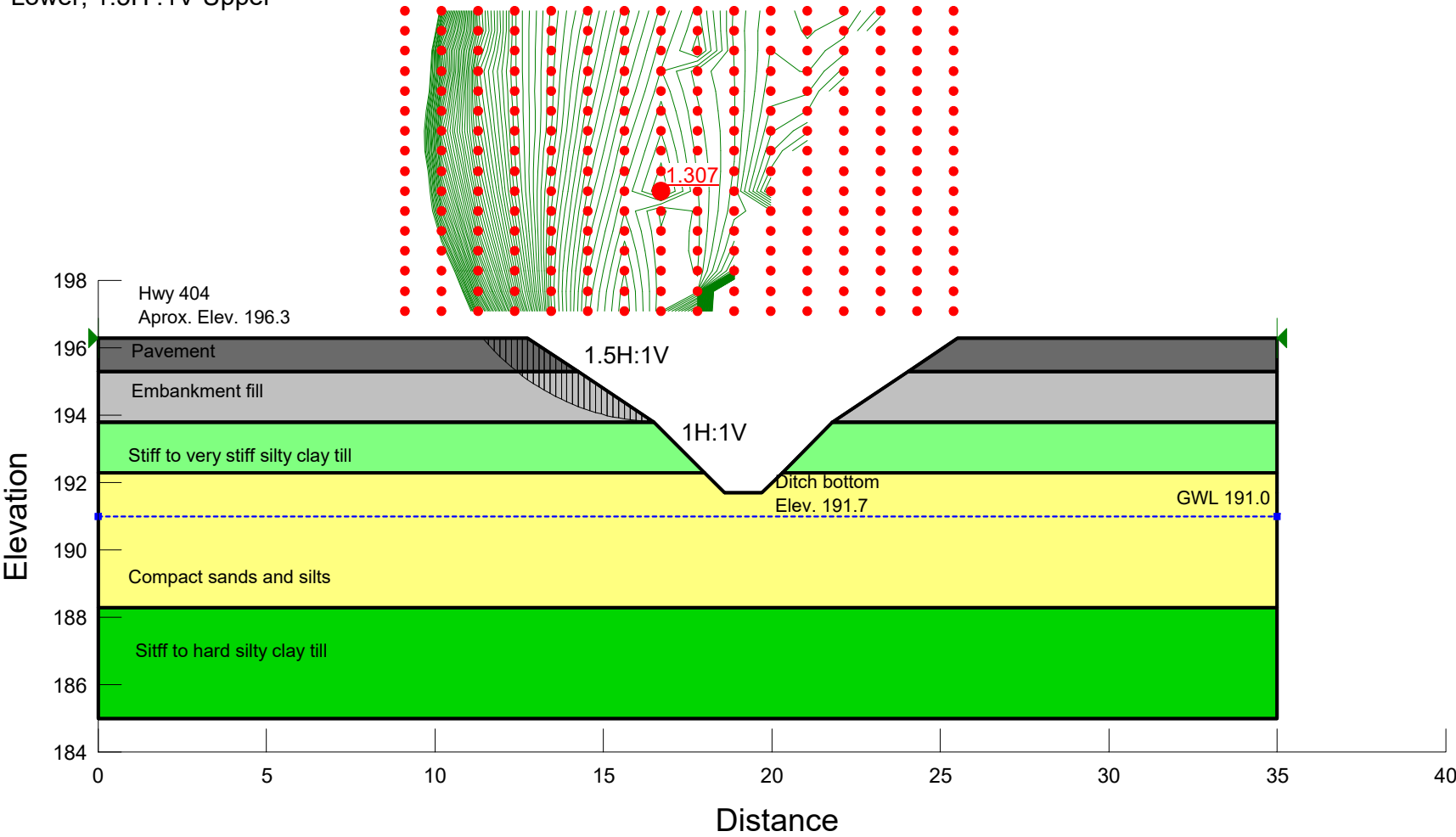


Figure E1

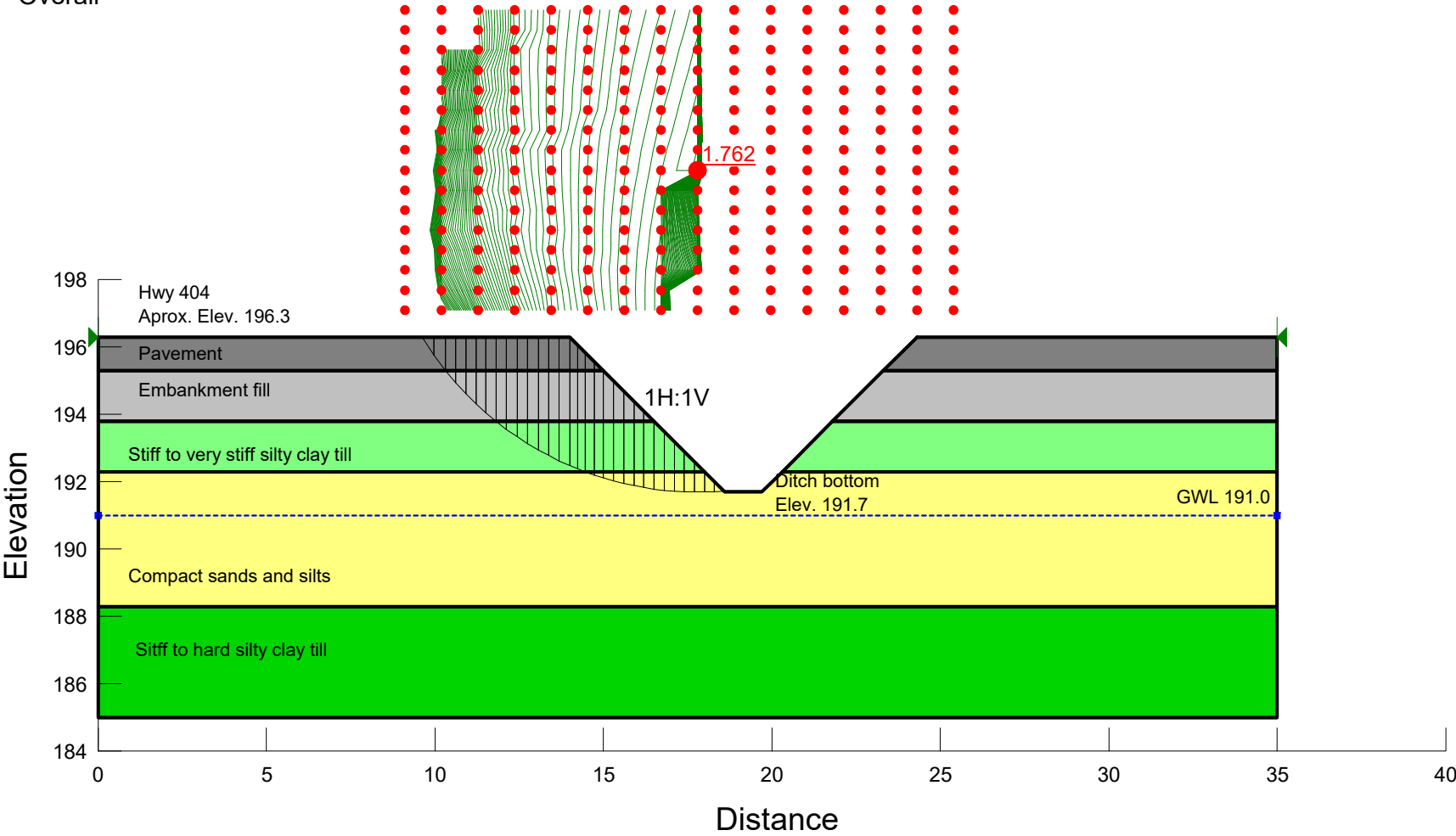
Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
East Side (below Hwy 404 NBL)
Temporary excavation, Height 4.6 m
Undrained Analysis - Upper Slope
Slope 1H :1V Lower; 1.5H :1V Upper

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1



Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
East Side (below Hwy 404 NBL)
Temporary excavation, Height 4.6 m
Undrained Analysis- Overall slope
Slope 1H :1V Overall

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1



Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
East Side (below Hwy 404 NBL)
Temporary excavation, Height 4.6 m
Undrained Analysis - Overall
Slope 1H :1V Lower; 1.5H :1V Upper

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1

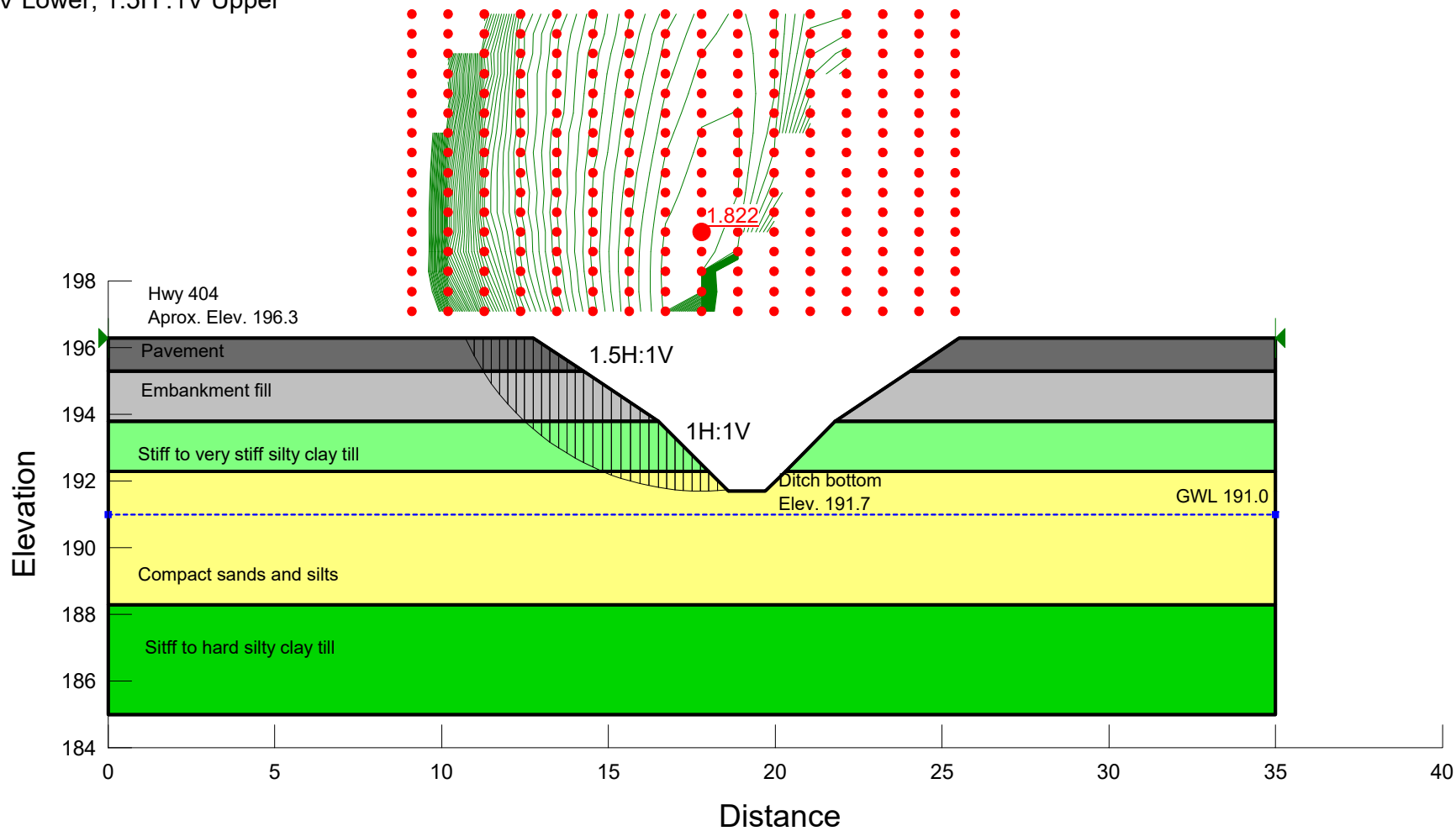


Figure E4

Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
West Side (below Hwy 404 SBL)
Temporary excavation, Height 5.4 m
Undrained Analysis- Upper Slope
Slope 1H :1V

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1

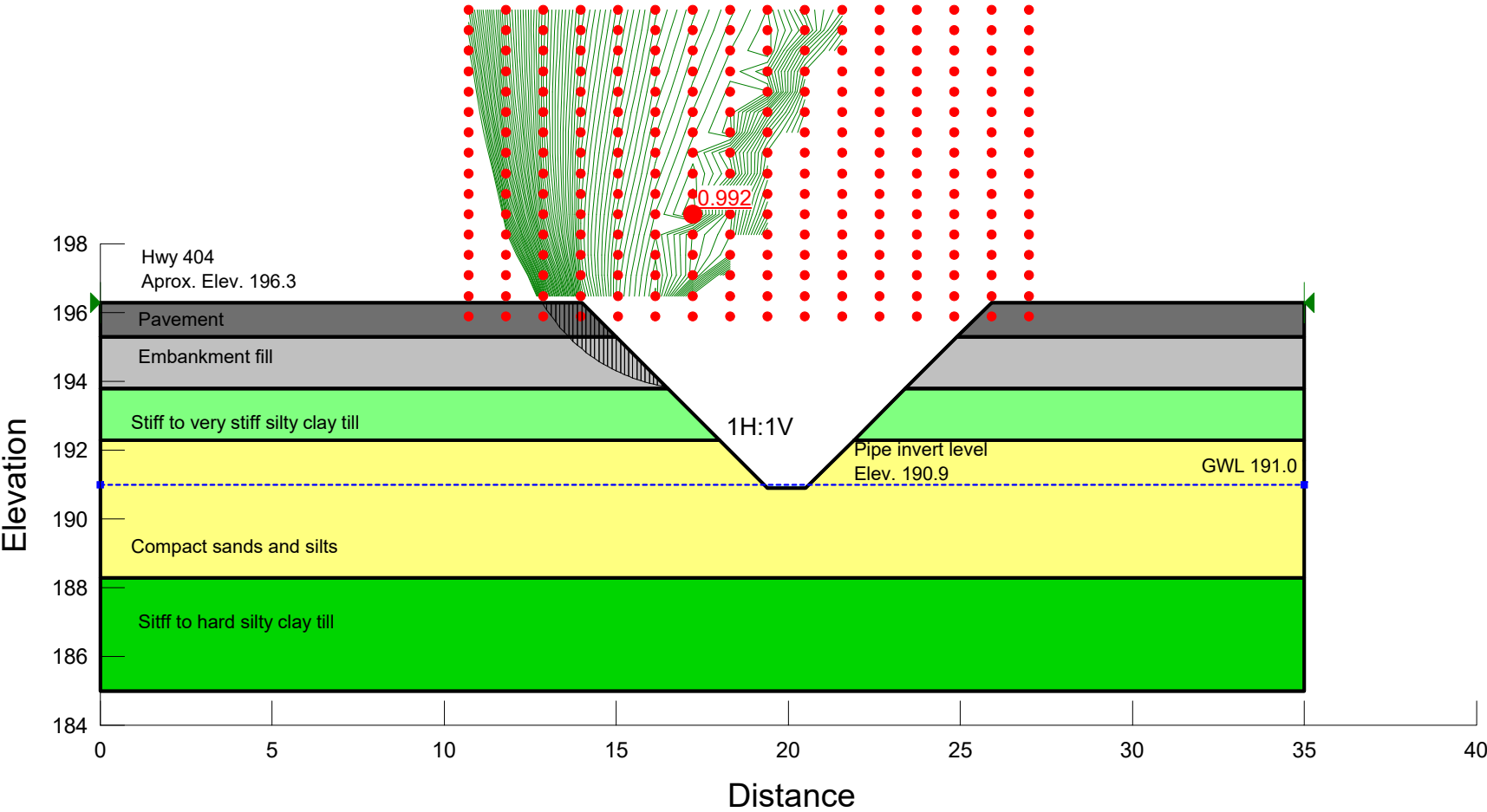


Figure E5

Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
West Side (below Hwy 404 SBL)
Temporary excavation, Height 5.4 m
Undrained Analysis- Upper Slope
Slope 1H :1V Lower; 1.5H : 1V Upper

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1

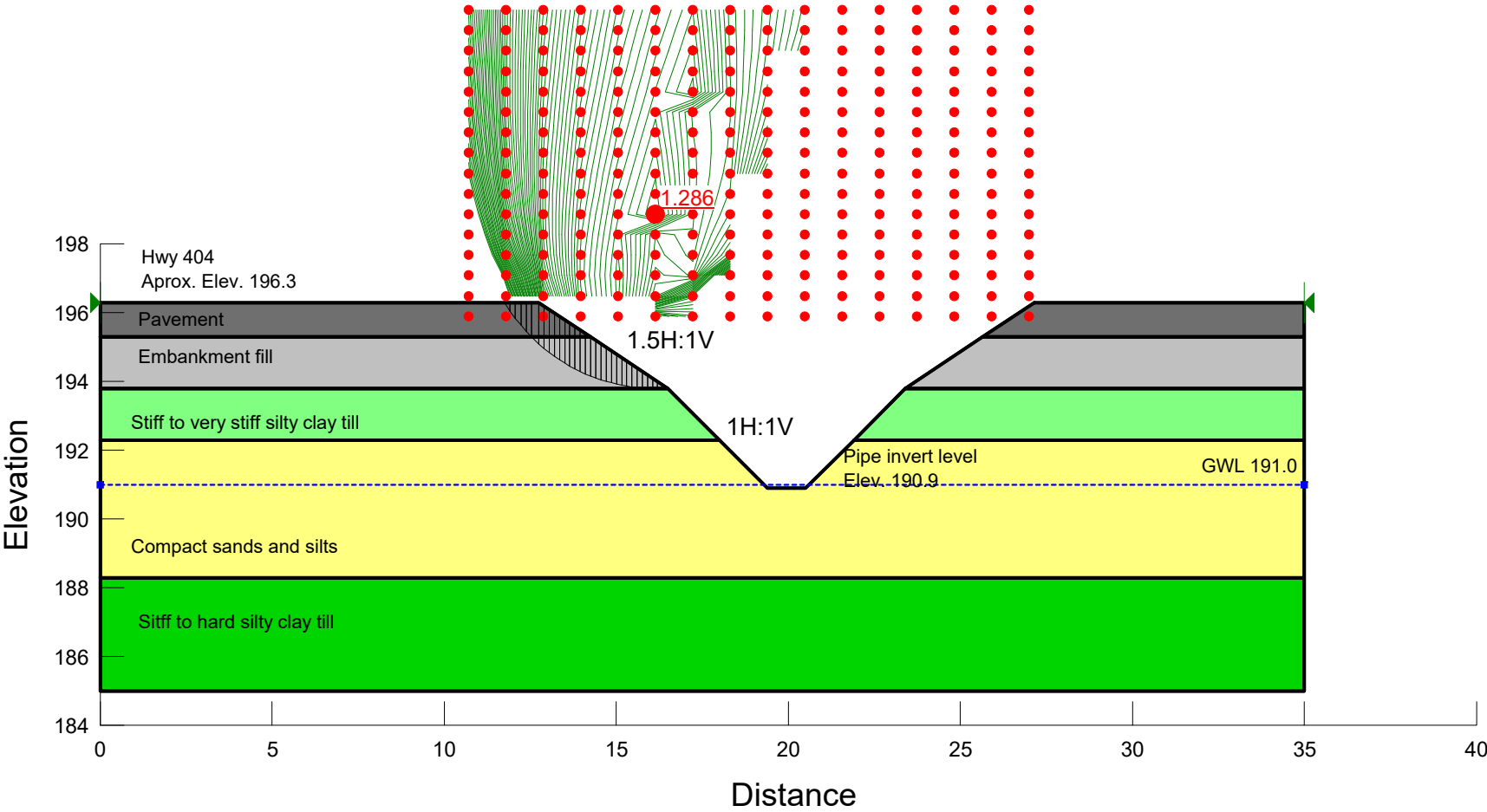
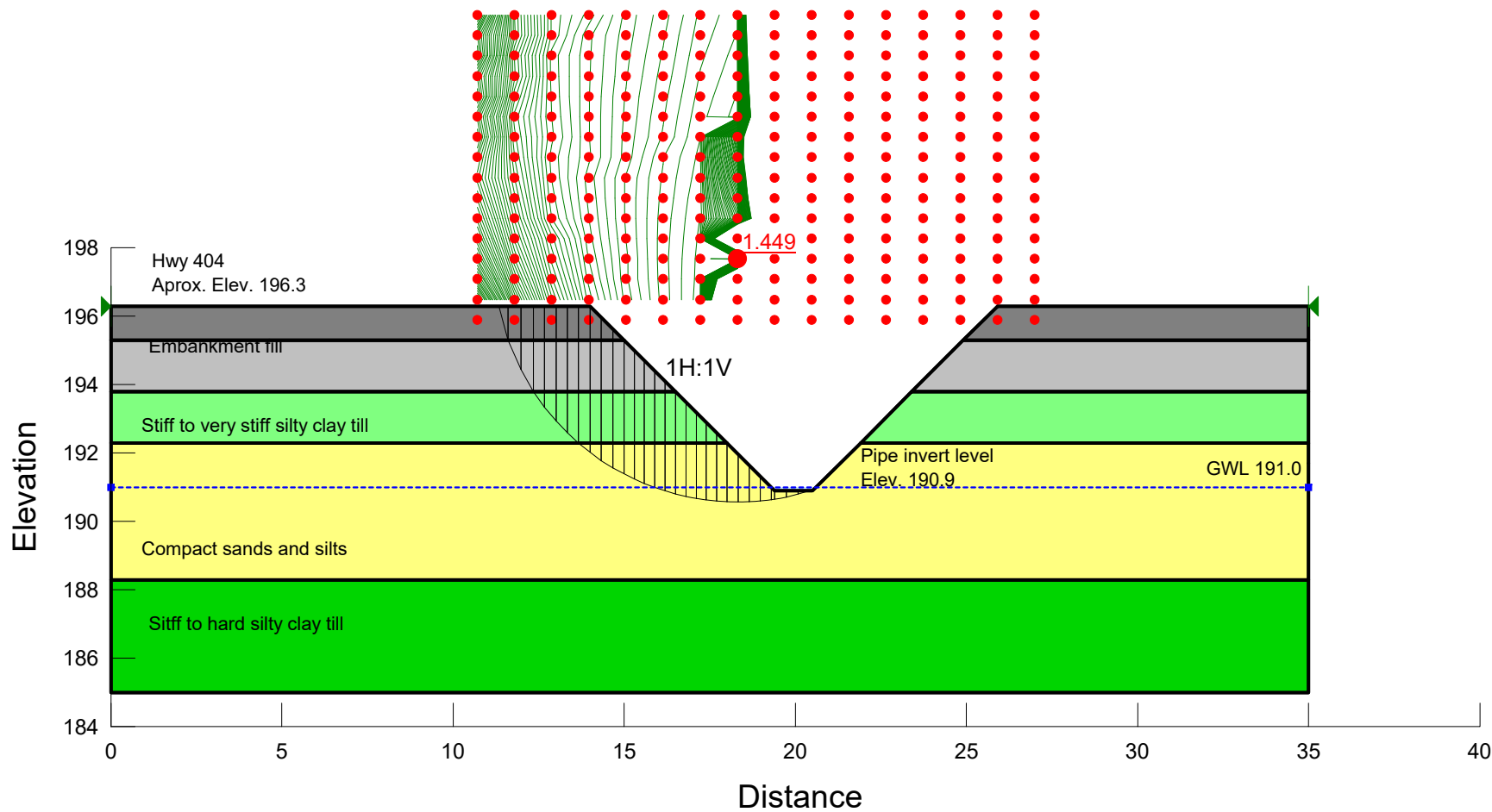


Figure E6

Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
West Side (below Hwy 404 SBL)
Temporary excavation, Height 5.4 m
Undrained Analysis - Overall Slope
Slope 1H :1V Overall

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1



Project Number: 15786
Highway 404 Widening
Storm sewer crossing
North of 16th Avenue,
West Side (below Hwy 404 SBL)
Temporary excavation, Height 5.4 m
Undrained Analysis- Overall
Slope 1H :1V Lower; 1.5H : 1V Upper

Name: Embankment fill Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
Name: Compact sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to very stiff silty clay till Unit Weight: 19 kN/m³ Cohesion: 50 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Stiff to hard silty clay till Unit Weight: 20 kN/m³ Cohesion: 150 kPa Phi: 0 ° Phi-B: 0 ° Piezometric Line: 1
Name: Pavement Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 35 ° Phi-B: 0 ° Piezometric Line: 1

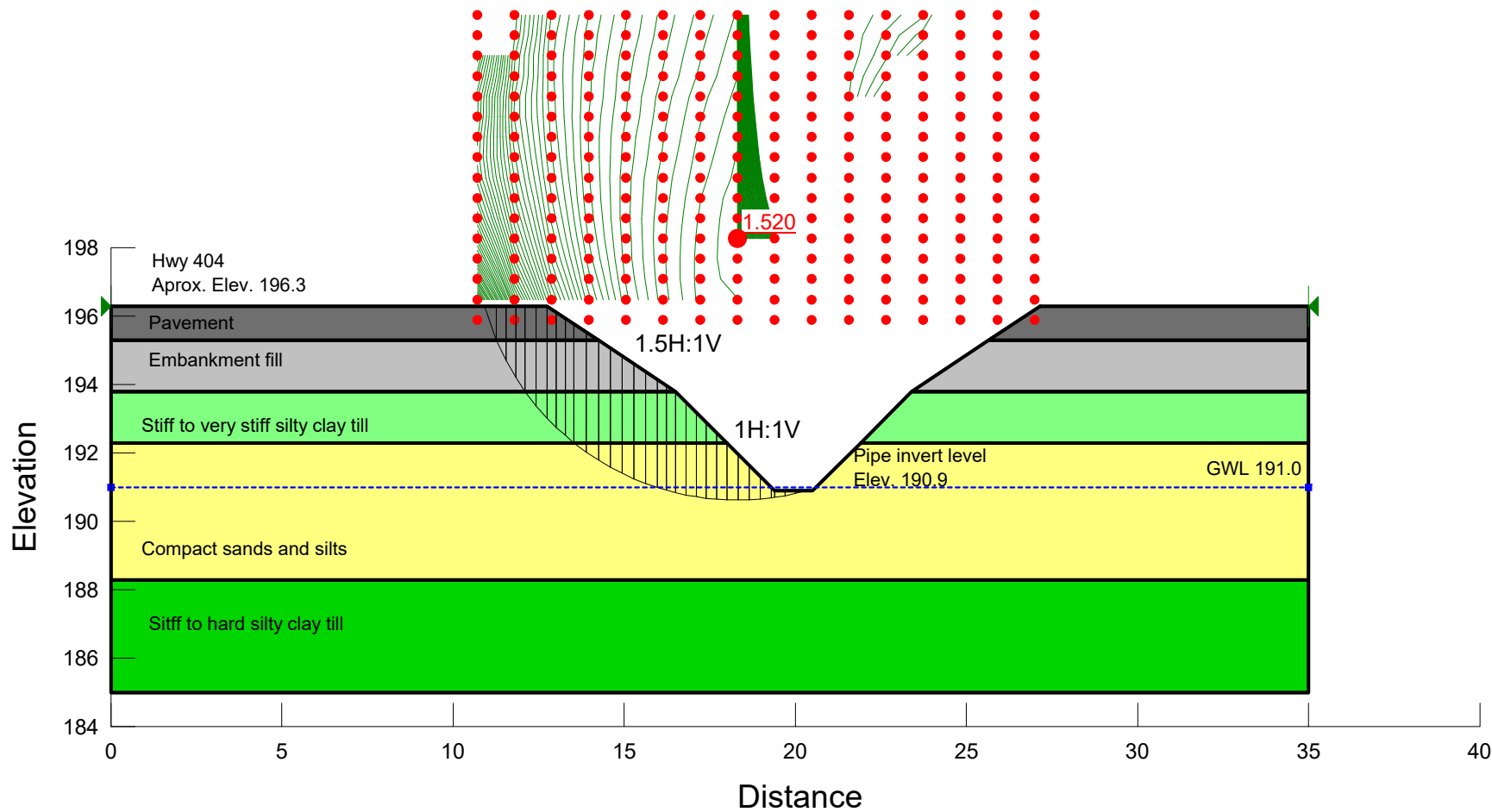


Figure E8



Appendix F

List of Ontario Provincial Standards and Suggested Wording for NSSP



1. List of Special Provisions and OPSS Documents Referenced in this Report

- OPSS.PROV 902
- OPSS.PROV 401
- OPSS.PROV 410
- OPSS 492
- OPSS.PROV 501
- OPSS.PROV 539
- OPSS.PROV 1010
- OPSS.PROV 517
- SP 517F01
- OPSS 804
- OPSD 802.030
- OPSD 802.031
- OPSD 802.032
- OPSS.PROV 1004.05.02

2. Suggested Text for NSSP on Open-Cut Excavation.

The Contractor's attention is drawn to the following:

- The fill materials and glacial till deposits may contain cobbles and boulders. The Contractor must be equipped to dislodge, remove and otherwise hand such obstructions during excavation.

3. Suggested Text for NSSP on Water Control

It is anticipated that groundwater, surface runoff and precipitation will accumulate within the open cut excavation for pipe crossing installation. Effective dewatering shall be designed and implemented by the Contractor to allow the pipe construction work to proceed in the dry, especially at the westerly alignment of the pipe within the zone of Highway 404 SBL and Ramp E-S.



Excavation into the wet cohesionless soils below the water level will encounter sloughing of the excavation sidewalls, caving and subgrade softening. The contractor must implement effective dewatering measures during construction and prior to excavating below the water level. Sump pumping will be required to supplement any dewatering measures in order to maintain reasonably dry excavations during construction.

The design of the groundwater control system is the responsibility of the contractor. However, systems that might be considered are:

- Vacuum well-points installed adjacent to the proposed excavation.
- Interlocking steel sheet piling installed as a partial cut-off with sumps and pumps inside the enclosure.

The dewatering system must be effective to maintain the water level at a minimum depth of 0.5 m below the final pipe subgrade level throughout construction. The dewatering system must remain operational and effective until the pipe is installed and backfilled.

Dewatering and unwatering should be carried out in accordance with OPSS.PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), and SP No. FOUN0003. A design engineer will be required for the dewatering system to be implemented at this site.

4. Suggested Text for NSSP on Ground Movement Adjacent to Excavation

Excavation for storm sewer shall not adversely affect the adjacent highway operation. Regardless of whether open cutting, trench box or other types of ground support is used, ground movement adjacent to excavations must not exceed the limit provided in Performance Level 2 as per Clause 539.04.01.01 in OPSS.PROV 539.