



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
STORMWATER MANAGEMENT PONDS
HIGHWAY 404 HOV LANE EXPANSION AND REHABILITATION
CONTRACT 2
FROM STOUFFVILLE ROAD TO MAJOR MACKENZIE DRIVE
YORK REGION, ONTARIO
G.W.P. 2930-17-00**

GEOCRES No. 30M14-490

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Report

to

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for three (3) proposed Stormwater Management Ponds (SWMP) located within the section of the Highway 404 corridor between Major MacKenzie Drive East and Stouffville Road covered by Contract 2, in the Towns of Richmond Hill and Whitchurch-Stouffville, York Region, Ontario. These ponds are a part of the Ministry of Transportation Ontario (MTO) Highway 404 HOV lane expansion and rehabilitation project from Highway 407 ETR to Stouffville Road.

The purpose of this investigation was to explore the subsurface conditions in the area of the proposed SWMPs and, based on the data obtained, to provide borehole locations and soil strata drawings, records of boreholes, laboratory test results and a written description of the subsurface conditions.

Thurber carried out this investigation as a sub-consultant to WSP under MTO Assignment Nos. 2016-E-0014.

2. SITE DESCRIPTION

The project area is located within the physiographic region known as the Peel Plain. The general topography of this region consists of level to gently rolling terrain, sloping gradually southward towards Lake Ontario. The Peel Plain is characterized by a surficial till sheet which generally consists of silty clay to clayey silt, with occasional sand to silt zones. The till is known to contain shallow, localized deposits of loose sand and silt and/or soft clay, often concentrated within valleys and near streams.



2.1 Stormwater Management Pond C2-1

Stormwater Management Pond C2-1 is located on the west side of the Highway 404 southbound lanes (SBL), approximately 900 m north of Highway 7, and north of Beaver Creek. The area where the SWMPC2-1 will be located is relatively flat and vegetated with grass and shrubs.

The approximate footprint of the proposed SWMP1 covered in this report is shown on the Borehole Locations and Soil Strata drawing in Appendix A.

Appendix A also presents selected photographs of the observed site conditions for reference.

2.2 Stormwater Management Pond C2-2

Stormwater Management Pond C2-2 is located on the west side of the Highway 404 SBL, north of 16th Avenue, and east of the Highway 404 interchange Ramp N-E/W. The area where the SWMPC2-2 will be located is currently empty and vegetated with grass. The terrain is relatively flat with the exception of a shallow ditch for Highway 404 which runs parallel to the highway and along the east side of the proposed SWMPC2-2.

The approximate footprint of the proposed SWMPC2-2 covered in this report is shown on the Borehole Locations and Soil Strata drawing in Appendix B.

Appendix B also presents selected photographs of the observed site conditions for reference.

2.3 Stormwater Management Pond C2-3

Stormwater Management Pond C2-3 is located on the west side of the Highway 404 southbound SBL, approximately 800 m south of Major Mackenzie Drive, and north of Rouge River. The area where the SWMPC2-3 will be located is relatively flat and vegetated with grass and shrubs and a few deciduous trees.

The approximate footprint of the proposed SWMPC2-3 covered in this report is shown on the Borehole Locations and Soil Strata drawing in Appendix C. Appendix C also presents selected photographs of the observed site conditions for reference.

3. INVESTIGATIVE PROCEDURES

The field investigation for this project was carried out between September 13 and October 21, 2018 and consisted of drilling and sampling the following boreholes:



- Boreholes numbered C2-1A to C2-1D were advanced within and adjacent to the footprint of the proposed SWMPC2-1;
- Boreholes numbered C2-2A to C2-2D were advanced within and adjacent to the footprint of the proposed SWMPC2-2;
- Boreholes numbered C2-3A to C2-3D were advanced within and adjacent to the footprint of the proposed SWMPC2-3.

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The approximate locations of the boreholes are shown on Borehole Locations and Soil Strata drawings included in Appendices A through C. The coordinates and elevations of these boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendices A through 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.

A track-mounted drill rig was used to drill and sample the boreholes. Solid and hollow stem augers were used to advance the boreholes until the target depth was reached. In general, soil samples were obtained at selected depth intervals using a 50 mm diameter split spoon sampler in conjunction with the Standard Penetration Testing (SPT).

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing. Results of field drilling and sampling are presented on the Record of Borehole sheets in Appendices A through C.

Groundwater conditions were observed in the open boreholes throughout the drilling operations. The boreholes were backfilled in general accordance with Ontario Regulation 903 (O.Reg. 903). Standpipe piezometers were installed in selected boreholes to allow monitoring of groundwater levels. The completion details of boreholes with piezometer installations are summarized as follows:



Borehole Number	Piezometer Installations			Completion Details
	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Sand Filter Depth / Elevation (m)	
SWM-C2-1C	9.8 / 179.5	8.5 / 180.8	4.9 – 9.5 / 184.4 – 179.8	Borehole backfilled with sand filter from 9.5 m to 4.9 m, then bentonite holeplug and cuttings to surface.
SWM-C2-2C	9.8 / 187.8	9.1 / 188.5	5.5 – 9.1 / 192.1 – 188.5	Borehole backfilled with sand filter from 9.1 m to 5.5 m, then bentonite holeplug and cuttings to 0.2 m, then concrete to surface.
SWM-C2-3C	7.8 / 196.4	7.6 / 196.6	4.0 – 7.8 / 200.2 – 196.4	Borehole backfilled with sand filter from 7.8 m to 4.0 m, then bentonite holeplug and cuttings from 4.0 m to 0.2 m then concrete 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 are summarized on the Record of Borehole sheets and are presented on the figures included in Appendices A through C.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

An overall description of the stratigraphy is given for each SWMP location in the following sections. 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.

5.1 Stormwater Management Pond C2-1

Reference is made to the Record of Borehole sheets in Appendix A for details of the encountered soil stratigraphy. A soil profile parallel to the long axis (generally north-south) of the pond is presented on the “Borehole Locations and Soil Strata” drawing in Appendix A. More detailed descriptions of the individual strata are presented below.



In general, the subsurface conditions encountered in Boreholes SWM-C2-1A to SWM-C2-1D at the SWMPC2-1 location consist of stiff to hard silty clay fill overlying stiff to very stiff silty clay till which is in turn underlain by compact silty sand to sand. The silty sand to sand is underlain by a deposit of stiff to hard clayey silt till which overlies sands and silts at some locations. Descriptions of the individual strata are presented below.

5.1.1 Topsoil

Topsoil was encountered in all four boreholes advanced at Pond C2-1. The topsoil thickness was measured as 75 mm. The topsoil thickness may vary in other areas of the site as this limited data is not sufficient to estimate topsoil quantity.

5.1.2 Silty Clay Fill

Fill consisting of silty clay, with sand to trace sand, trace to some gravel, trace rootlets and occasional cobbles, was encountered beneath the topsoil in all but Borehole SWM C2-1D. The fill was approximately 1.9 m to 2.5 m thick and the base of the fill was encountered at depths ranging between 2.0 m and 2.6 m (Elev. 187.6 m and 186.8 m).

SPT 'N' values measured in the fill typically ranged from 9 to 31 blows per 0.3 m penetration indicating a stiff to hard consistency. 'N' values of greater than 100 blows for less than 0.3 m penetration measured in Borehole SWM C2-1C indicates the potential presence of cobbles and boulders. The measured moisture contents in the silty clay fill ranged from 6 percent to 26 percent.

5.1.3 Silty Clay Till

Silty clay till, some sand to with sand, trace gravel and rootlets, was encountered beneath the silty clay fill in all but Borehole SWM C2-1D, where it was encountered beneath the topsoil. The thickness of the till ranged from 1.7 m to 2.7 m and the surface of the till was encountered at depths ranging between 0.1 m and 2.6 m. The base of the till was encountered at depths ranging between 2.2 m and 4.9 m (Elev. 185.9 m and 184.9 m). Glacial tills inherently contain cobbles and boulders.

SPT 'N' values measured in this till ranged from 8 to 18 blows for 0.3 m penetration indicating a stiff to very stiff consistency. Measured moisture contents in this till ranged from 12 percent to 30 percent.



The results of grain size analyses conducted on samples of the silty clay till are provided on the Record of Borehole sheet in Appendix A and illustrated in Figure A1 of Appendix A. The results are summarized as follows:

Soil Particle	Percentage
Gravel	1 to 3
Sand	15 to 22
Silt	27 to 33
Clay	44 to 55

The results of Atterberg Limits tests carried out on samples of the silty clay till are shown on Figures A5 in Appendix A and summarized below:

Soil Property	Percentage (%)
Liquid Limit	29 to 36
Plasticity Index	13 to 19

The results of the Atterberg Limit tests indicate that the till has low to intermediate plasticity (CL-CI).

5.1.4 Silty Sand to Sand

Silty sand to sand, some silt, trace clay and gravel, was encountered beneath the silty clay till in all four boreholes. The thickness of the silty sand to sand layer ranged from 1.5 m to 2.7 m and the surface of the layer was encountered at depths ranging between 2.2 m and 4.9 m. The base of this layer was encountered at 4.9 m to 6.5 m depths (Elev. 182.8 m to 183.4 m).

SPT 'N' values measured in the silty sand to sand ranged from 11 to 19 blows per 0.3 m penetration, indicating a compact condition. The measured moisture contents in ranged from 19 percent to 24 percent.

The results of grain size analyses conducted on samples of the silty sand to sand are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure A2 of Appendix A. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0 to 2
Sand	72 to 90
Silt	7 to 22
Clay	3 to 4
Silty + Clay	10



5.1.5 Clayey Silt Till

Clayey silt till, with sand, trace gravel, was encountered beneath the silty sand to sand layer in all four boreholes. Where fully penetrated in Boreholes C2-1B, C2-1C and C2-1D, the thickness of the till ranged from 1.5 m to 2.7 m and the surface of the till was encountered at depths ranging between 4.9 m and 6.5 m. Borehole C2-1A was terminated within this till at 8.2 m depth (Elev. 181.6 m). Glacial tills inherently contain cobbles and boulders.

SPT 'N' values measured in this cohesive till ranged from 9 to 56 blows per 0.3 m penetration, indicating a stiff to hard consistency. The measured moisture contents in the till ranged from 9 percent to 19 percent.

The results of grain size analyses conducted on samples of the clayey silt till are provided on the Record of Borehole sheet in Appendix A and illustrated in Figure A3 of Appendix A. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	23 to 49
Silt	33 to 59
Clay	18 to 26

The results of an Atterberg Limits test carried out on a sample of the clayey silt till are shown on Figure A6 in Appendix A and summarized below:

Soil Property	Percentage (%)
Liquid Limit	18
Plasticity Index	6

The results of the Atterberg Limit tests indicate that the till has slight plasticity (CL-ML).

5.1.6 Lower Silty Sand to Sand

A lower silty sand to sand, trace to some silt, trace clay and gravel, was encountered beneath the clayey silt in all but Borehole SWM C2-1A. The surface of this deposit was encountered at depths ranging between 7.6 m and 9.1 m. Boreholes SWM C2-1C and C2-1D were terminated within this deposit at 9.8 m to 8.2 m (Elev. 179.5 m to 179.9 m).



SPT 'N' values measured in this lower silty sand to sand ranged from 15 to 31 blows per 0.3 m penetration indicating a compact to dense condition. The measured moisture contents ranged from 17 percent to 20 percent.

The results of a grain size analysis conducted on a sample of the silty sand to sand are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure A4 of Appendix A. The results are summarized as follows:

Soil Particle	Percentage
Gravel	3
Sand	90
Silt + Clay	7

5.1.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The groundwater levels measured upon completion of drilling and in the boreholes are summarized below:

Table 5-1. Measured Groundwater Levels

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
SWM-C2-1A	September 19, 2018	4.2	185.6	Open Borehole
SWM-C2-1B	September 25, 2018	4.3	185.1	Open Borehole
SWM-C2-1C	November 22, 2018	2.8	186.5	Piezometer
SWM-C2-1D	September 19, 2018	4.0	184.1	Open Borehole

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

5.2 Stormwater Management Pond C2-2

Reference is made to the Record of Borehole sheets in Appendix B for details of the encountered soil stratigraphy. A soil profile parallel to the long axis (generally north-south) of the pond is



presented on the “Borehole Locations and Soil Strata” drawing in Appendix B. More detailed descriptions of the individual strata are presented below.

In general, the subsurface conditions encountered in Boreholes SWM-C2-2A to SWM-C2-2D at the SWMPC2-2 location consist of surficial loose to compact sandy silt till overlying stiff to hard silty clay till, which is in turn underlain by compact silty sand to sandy silt. A lower deposit of clayey silt to silty clay till was encountered in some boreholes. Descriptions of the individual strata are presented below.

5.2.1 Topsoil

Topsoil was encountered in all four boreholes advanced at Pond C2-2. The topsoil thickness ranged from 75 mm to 200 mm. The topsoil thickness may vary in other areas of the site as this limited data is not sufficient to estimate topsoil quantity.

5.2.2 Sandy Silt Till

Sandy silt till, trace to some clay, and trace gravel, was encountered beneath the topsoil in all but Borehole SWM C2-2B. The till was approximately 1.2 m to 1.6 m thick and the base of the deposit was encountered at depths ranging between 1.4 m and 1.8 m (Elev. 197.1 m and 195.8 m). Glacial tills inherently contain cobbles and boulders.

SPT ‘N’ values measured in the silt till ranged from 8 to 18 blows per 0.3 m penetration indicating a loose to compact condition. The measured moisture contents in the till ranged from 10 percent to 20 percent.

5.2.3 Silty Clay Till

Silty clay till, some sand to with sand, and trace gravel, was encountered beneath the sandy silt till in all but Borehole SWM C2-2B, where it was encountered just below the topsoil. The thickness of the silty clay till ranged from 3.2 m to 4.9 m and the surface of the till was encountered at depths ranging between 0.2 m and 1.8 m. The base of the till was encountered at depths ranging between 4.6 m and 5.6 m (Elev. 194.3 m and 191.7 m). Glacial tills inherently contain cobbles and boulders.

SPT ‘N’ values measured in this till ranged from 9 to 39 blows for 0.3 m penetration indicating a stiff to hard consistency. Measured moisture contents in this till ranged from 10 percent to 28 percent.



The results of grain size analyses conducted on samples of the silty clay till are provided on the Record of Borehole sheet in Appendix B and illustrated in Figure B1 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0 to 2
Sand	12 to 42
Silt	25 to 69
Clay	18 to 55

The results of Atterberg Limits tests carried out on samples of the silty clay till are shown on Figures B4 in Appendix B and summarized below:

Soil Property	Percentage (%)
Liquid Limit	21 to 41
Plasticity Index	8 to 22

The results of the Atterberg Limit tests indicate that the till has low to intermediate plasticity (CL-CI).

5.2.4 Silty Sand to Sandy Silt

Silty sand to sandy silt, containing trace clay and trace gravel, was encountered beneath the silty clay till layer in all boreholes. Where fully penetrated in Boreholes SWM C2-2B, C2-2C and C2-2D, these sands and silts were approximately 1.0 m to 2.5 m thick. The surface of the layer was encountered at depths ranging between 4.6 m and 5.6 m. Borehole SWM C2-2A was terminated in this layer.

SPT 'N' values measured in the silty sand to sandy silt ranged from 10 to 18 blows per 0.3 m penetration indicating a compact condition. The measured moisture contents in ranged from 18 percent to 21 percent.

The results of grain size analyses conducted on samples of the silty sand to sandy silt are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure B2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0 to 1
Sand	24 to 70
Silt	24 to 68
Clay	3 to 8



5.2.5 Lower Clayey Silt to Silty Clay Till

A lower clayey silt to silty clay till, containing trace to some sand, and trace gravel, was encountered beneath the sands and silts in all but Borehole SWM C2-2A. The surface of this till layer was encountered at depths ranging between 6.3 m and 7.5 m and the boreholes were terminated in this till at depths ranging between 7.6 m and 9.8 m (Elev. 191.2 m and 187.8 m). Glacial tills inherently contain cobbles and boulders.

SPT 'N' values measured in the lower clayey silt to silty clay till ranged from 13 to 19 blows per 0.3 m penetration indicating a stiff to very stiff consistency. The measured moisture contents in the till ranged from 14 percent to 22 percent.

The results of grain size analysis conducted on a sample of the silty clay till are provided on the Record of Borehole sheet in Appendix B and illustrated in Figure B3 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	24
Silt	34
Clay	42

The results of an Atterberg Limits test carried out on a sample of the silty clay till are shown on Figures B5 in Appendix B and summarized below:

Soil Property	Percentage (%)
Liquid Limit	25
Plasticity Index	12

5.2.6 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. A standpipe piezometer was installed in Borehole SWM-C2-2C to monitor the groundwater level at the site. The groundwater levels measured upon completion of drilling and in the standpipe piezometers are summarized below:



Table 5-2. Measured Groundwater Levels

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
SWM-C2-2A	September 14, 2018	4.9	193.6	Open borehole
SWM-C2-2B	September 17, 2018	5.5	193.9	Open borehole
SWM-C2-2C	September 13, 2018	5.6	192.0	Piezometer
	September 17, 2018	4.7	192.9	
	November 22, 2018	3.3	194.4	
SWM-C2-2D	September 17, 2018	2.3	195.0	Open borehole

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

5.3 Stormwater Management Pond C2-3

Reference is made to the Record of Borehole sheets in Appendix C for details of the encountered soil stratigraphy. A soil profile parallel to the long axis (generally north-south) of the pond is presented on the "Borehole Locations and Soil Strata" drawings in Appendix C. More detailed descriptions of the individual strata are presented below.

In general, the subsurface conditions encountered in Boreholes SWM-C2-3A to SWM-C2-3D near the SWMPC2-3 location consisted of a pavement structure and silty clay to silty sand fill overlying a typically stiff to very stiff silty clay deposit, which is in turn underlain by dense to very dense sands and silts. Silty clay till underlies the site. Descriptions of the individual strata are presented below.

5.3.1 Asphalt

All four boreholes were drilled through the paved shoulder of Highway 404 and three of the boreholes encountered a surface layer of asphalt that ranged in thickness from 50 mm to 200mm.

5.3.2 Sand and Gravel Fill

Sand and gravel fill (pavement granular), trace silt and trace clay, was encountered at ground surface in Borehole SWM C2-3A and beneath the asphalt in Boreholes SWM C2-3B to C2-3D. The sand and gravel fill was approximately 0.4 m to 0.7 m thick and extended to depths of approximately 0.6 m to 0.8 m (Elevations 203.2 m to 204.0 m).



SPT 'N' values measured in the sand and gravel ranged from 19 to 23 blows for 0.3 m penetration indicating a compact condition. Measured moisture contents in the sand and gravel ranged from 5 percent to 6 percent.

5.3.3 Silty Clay Fill

Silty clay fill, containing trace to some sand trace gravel, and trace organics, was encountered in Boreholes SWM C2-3A, C2-3C, and C2-3D at depths of approximately 0.6 m to 0.8 m. The silty clay fill was approximately 0.6 m to 1.5 m thick and extended to depths of 1.4 m to 2.2 m (Elevations 201.7 m to 203.2 m).

SPT 'N' values measured in the silty clay fill ranged from 7 to 12 blows for 0.3 penetration indicating a firm to stiff consistency. The measured moisture contents in the silty clay fill ranged from 13 percent to 20 percent.

5.3.4 Silty Sand Fill

Silty sand fill with organics was encountered in Borehole SWM C2-3B at a depth of approximately 0.6 m. This fill was approximately 1.7 m thick and extended to a depth of 2.3 m (Elevation 202.2m).

SPT 'N' values measured in the silty sand ranged from 9 to 13 blows for 0.3 m penetration, indicating a loose to compact condition. Measured moisture contents in the silty sand ranged from 13 to 18 percent.

5.3.5 Silty Clay

Silty clay, containing trace to some sand and trace gravel, was encountered in all boreholes at depths of between 1.4 m to 2.3 m. The silty clay layer was approximately 1.9 m to 2.7 m thick and extended to depth of between 4.1 m to 4.6 m (Elevations 199.8 m to 200.5 m).

SPT 'N' values measured within the silty clay layer ranged from 5 to 25 blows for 0.3 m penetration, indicating a firm to very stiff condition. Measured moisture contents within silty clay varied between 18 to 25 percent.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C1 of Appendix B. The results are summarized as follows:



Soil Particle	Percentage
Gravel	0 to 1
Sand	3 to 17
Silt	33 to 39
Clay	43 to 64

The results of an Atterberg Limits test carried out on a samples of the silty clay are shown on Figures C4 in Appendix C and summarized below:

Soil Property	Percentage (%)
Liquid Limit	30 to 42
Plasticity Index	15 to 22

The results of the Atterberg Limits indicate the layer to be of low to medium plasticity with group symbols CL to CI.

5.3.6 Sand and Silt

A layer of sand and silt, containing trace gravel was encountered in Borehole SWM C2-3C below the silty clay at a depth of approximately 4.1 m. The sand and silt was approximately 1.5 m thick and extended to a depth of 5.6 m (Elevation 198.6 m).

A SPT 'N' value measured within the sand and silt layer was 37 blows for 0.3 m penetration, indicating a dense condition. The measured moisture content in the sand and silt was 12 percent.

5.3.7 Silty Clay Till

Silty clay till, with sand to trace sand and trace gravel, was encountered in all four boreholes at depths of between 4.1 m and 5.6 m. Where fully penetrated in Borehole SWM C2-3D, the silty clay till was approximately 3.1 m thick and extended to a depth of 7.2 m (Elevation 196.7 m). Boreholes SWM C2-3A, SWM C2-3B and SWM C2-3C were terminated in the silty clay till at depths of between 7.8 m to 8.2 m (Elevations 196.4 m to 196.5 m).

SPT 'N' values within the silty clay till ranged from 9 blows for 0.3 m penetration to greater than 100 blows for less than 0.3 m penetration indicating a stiff to hard consistency. The high 'N' values indicates the potential presence of cobbles and boulders. Measured moisture contents within silty clay varied between 10 to 25 percent.



The results of grain size analyses conducted on samples of the silty clay till are provided on the Record of Borehole sheet in Appendix C and illustrated in Figure C2 of Appendix B. The results are summarized as follows:

Soil Particle	Percentage
Gravel	1 to 2
Sand	7 to 32
Silt	35 to 72
Clay	20 to 31

The results of Atterberg Limits test carried out on a sample of the silty clay till are shown on Figure C5 in Appendix B and summarized below:

Soil Property	Percentage (%)
Liquid Limit	17
Plasticity Index	7

The results of the Atterberg Limits indicate this cohesive till to be of slight to low plasticity with group symbols CL-ML to CL.

5.3.1 Sand

Sand, containing trace silt and trace clay, was encountered in Borehole SWM C2-3D at a depth of approximately 7.2 m. Borehole SWM C2-3D was terminated within the sand layer at a depth of 9.5 m (Elevation 194.4 m).

SPT 'N' values measured within the sand were greater than 100 blows for less than 0.3 m penetration indicating a very dense condition and potential presence of cobbles and boulders. Measured moisture contents in the sand ranged from 4 to 6 percent.

The result of a grain size analysis conducted on a sample of the sand is provided on the Record of Borehole sheet in Appendix B and illustrated in Figure C3 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage
Gravel	0
Sand	90
Silt and Clay	10



5.3.2 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. Standpipe piezometers were installed in Borehole SWM C2-3C to monitor the groundwater level at the site. The groundwater levels measured upon completion of drilling and in the standpipe piezometer are summarized below:

Table 5-3. Measured Groundwater Levels

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
SWM-C2-3A	October 1, 2018	8.0	196.6	Open borehole
SWM-C2-3B	October 1, 2018	5.9	198.6	Open borehole
SWM-C2-3C	November 22, 2018	7.5	196.7	Piezometer
SWM-C2-3D	October 21, 2018	Dry	-	Open borehole

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels 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. WSP provided the northing and easting coordinates and ground surface elevations.

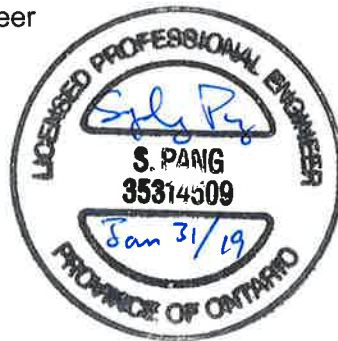
Walker Drilling Ltd. of Utopia, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the field investigation. The field investigation was supervised on a full-time basis by Ms. Jacqueline Pigeon, Mr. Amir Fereidouni, and Mr. Kevin Kweon, of Thurber. Overall supervision of the field program was provided by Mr. Stephane Loranger, CET.

Routine laboratory testing was carried out at Thurber's geotechnical laboratory. Overall project management was provided by Dr. Sydney Pang, P.Eng. Interpretation of the field data and preparation of this report was completed by Mr. Geoff Lay, P.Eng. and Mr. Cory Zanatta, P. Eng. The report was reviewed by Messrs. Sydney Pang, P.Eng. and P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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Client: WSP
File No.: 15786
E file: H:\15000-15999\15786 Hwy 404 Widening 2016-E-0014\Reports and Memos\SWMP\Contract 2\15786 FIDR Hwy 404

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**FOUNDATION INVESTIGATION AND DESIGN REPORT
STORMWATER MANAGEMENT PONDS
HIGHWAY 404 HOV EXPANSION AND REHABILITATION
CONTRACT 2
FROM STOUFFVILLE ROAD TO MAJOR MACKENZIE DRIVE
YORK REGION, ONTARIO
G.W.P. 2930-17-00**

GEOCRES No. 30M14-490

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This section of the report presents an interpretation of the geotechnical data in the factual report and provides foundation recommendations for the design and construction of the Stormwater Management Ponds located within the Contract 2 portion of the Highway 404 corridor between Major Mackenzie Drive East and Stouffville Road, in the Town of Richmond Hill and the Town of Whitchurch-Stouffville, York Region, Ontario.

This foundation investigation and design report with the interpretation and recommendations are 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 contractor 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 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.

It is noted that several boreholes were located well outside of the current pond footprints. The reason is that the borehole patterns had been established and the investigation completed based on previous information provided by WSP which showed pond footprints that were much longer than the current footprints. Given the relatively consistent subsurface conditions at these pond sites, we consider that the factual information from all the boreholes valid for pond design and construction.



The design drawings of the proposed ponds, plans, and profiles related to the slopes adjacent to the ponds have been provided by WSP. Based on this information, the essential features of the new ponds are summarized as follows:

STORMWATER MANAGEMENT POND C2-1 (between approximate Sta. 15+000 and 15+200)

- The base of pond will be at Elevation 186.21 m, approximately 1 m to 3 m below the existing ground surface. The highest design (100-year) water level in Pond 1 is Elevation 187.04 m.
- The pond is generally oval shaped with an overall longitudinal dimension of approximately 100 m (north–south), and a transverse dimension of about 20 m.
- The current design typically uses a 2H : 1V finished slope above a design pond water level along the perimeter of the pond, and 3H : 1V and 4H : 1V slopes below pond water level.
- A concrete outlet structure wall is proposed at the south end of the pond to be founded at approximate Elevation 184.2 m.

STORMWATER MANAGEMENT POND C2-2 (between approximate Sta. 16+350 and 16+450)

- The base of pond will be at Elevation 194.48 m, approximately 1 m to 3 m below the existing ground surface. The highest design water level in Pond 2 is Elevation 195.28 m.
- The pond is generally trapezoidally shaped with an overall longitudinal dimension of approximately 90 m (north–south), and a width of about 25 m at the widest point (south end of the pond).
- The current design typically uses a 3H : 1V finished slope above a design pond water level along the perimeter of the pond, and from 2H : 1V to 4H : 1V slopes below pond water level.
- A concrete outlet structure wall is proposed at the south end of the pond to be founded at approximate Elevation 192.5 m.

STORMWATER MANAGEMENT POND C2-3 (between approximate Sta. 17+350 and 17+450)

- The base of pond will be at Elevation 201.57 m, approximately 1.5 m below the existing ground surface. The highest design water level in Pond 3 is Elevation 202.07 m.



- The pond is generally rectangularly shaped with an overall longitudinal dimension of approximately 80 m (north–south), and a transverse dimension of about 15 m.
- The current design typically uses 2H : 1V and 4H : 1V finished slopes along the perimeter of the pond.
- A concrete outlet structure wall is proposed at the south end of the pond to be founded at approximate Elevation 199.5 m.

The discussions and recommendations presented in this report are based on project information provided by WSP and on the factual data obtained during the course of this investigation.

8. STORMWATER MANAGEMENT POND DESIGN

8.1 Pond Design Criteria

Major foundation/geotechnical aspects of the pond design that are addressed herein include the following:

- Assessment of the stability of the proposed pond sideslopes including the effects of rapid drawdown;
- Estimation of the hydraulic conductivities of the soils in the pond area. It is understood that all three ponds are to function as dry ponds.

8.2 Stability Analysis Methodology

For the purpose of slope stability analyses, the commercially available slope stability program GEO-SLOPE employing the Morgenstern-Price method of slices for limit equilibrium was used.

For global stability and based on consideration of the risks involved, a criterion of a minimum Factor of Safety (F.S.) of 1.3 against global slope instability has been used for the pond slopes in this report.

9. SLOPE STABILITY ANALYSIS OF PONDS

9.1 General

The borehole results indicate that the subsurface conditions at the pond locations generally consist of fill materials overlying stiff to hard clayey silt to silty clay till which is underlain by, or



interlayered with, compact sands and silts. The sands and silts are underlain by a lower deposit of stiff to hard clayey silt to silty clay till. The proposed pond designs will involve excavations through the fill materials into the clayey silt to silty clay till deposit, and possibly locally into the underlying sands and silts.

9.2 Selected Cases for Stability Analysis

A representative cross-section of the pond side slopes at each site has been selected for stability analyses. Soil parameters used for these analyses have been selected primarily based on correlations with SPT 'N' values, measured water contents and plasticity indices.

Critical sections of the pond slopes have been analysed for rapid drawdown cases, which refer to a low probability event where the water level in the pond drops abruptly (in a matter of hours) resulting in horizontal seepage gradients at the exposed slopes.

The Factors of Safety obtained from stability analysis of the selected cases as outlined above are summarized in Table 9.1 below.

Table 9.1 Selected Stability Analysis Results

Location	Type of Analysis	Factor of Safety	Figure
Pond 1 West Slope Slope 2H : 1V to 3H : 1V	Drained	1.7	A1
	Undrained	> 2	A2
	Rapid Drawdown	1.5	A3
	Seismic	1.5	A4
Pond 2 West Slope Slope 3H : 1V and 2H : 1V	Drained	1.7	B1
	Undrained	> 2	B2
	Rapid Drawdown	1.3	B3
	Seismic	1.5	B4
Pond 3 East Slope Slope 2H : 1V to 4H : 1V	Drained	> 2	C1
	Undrained	> 2	C2
	Rapid Drawdown	1.6	C3
	Seismic	1.7	C4

The figures contained in Appendices A through C present selected stability analysis results of representative drained, rapid drawdown and seismic cases. The soil properties assumed in the analyses are shown on these figures.



Results of the above analyses indicate that adequate Factors of Safety of 1.3 can be maintained for global stability of the design pond slope configurations.

9.3 Pond Design and Construction

Based on the above and from a foundation/geotechnical engineering perspective, the design of the pond slopes as shown on the drawings provided by WSP should satisfy global stability requirements.

9.3.1 General

Pond excavation, grading and compaction should be carried out with reference to the requirements of OPSS.PROV 206 and OPSS.PROV 501. All excavations should be carried out in accordance with the Ontario Occupational Health and Safety Act (OHSA). For the purpose of OHSA, the following soil classification should be followed.

- Silty Clay Fill (Type 3)
- Sandy Silt Till (Type 3)
- Silty Clay (Type 3)
- Clayey Silt to Silty Clay Till (Type 3)
- Sands and Silts (above water table) (Type 3)
- Sands and Silts (below water table) (Type 4)

Glacial tills inherently contain cobbles and boulders and, as such, the contractor should be equipped to handle and/or remove such obstructions during excavation for the ponds.

All new earth fill, where required, should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. High plastic clay must not be used as new fill. Vegetation cover should be established on all exposed slopes to protect against surficial erosion in accordance with OPSS.PROV 804.

Erosion protection should be provided for selected surfaces of the sideslopes of the pond as required. Design of the erosion protection measures must consider hydrologic and hydraulic concerns. Typically, rip-rap should be provided in areas of high velocity or concentrated water flow. Other surfaces may be treated with vegetation, hydroseeding and/or erosion control blanket as required. Reference should be made to OPSS.PROV 804 for erosion protection requirements.



Outlet Structures

After the foundation excavation reaches the design subgrade level, the exposed surface should be inspected to confirm that the subgrade is suitable and uniformly competent. Any topsoil/organics, disturbed soils, loose/soft deposits and deleterious materials within the structure footprint must be removed and replaced with suitable granular material compacted as per OPSS.PROV 501. The work should be carried out in accordance with OPSS PROV 902 and construction should be carried out in the dry.

A minimum 300 mm thick layer of bedding material conforming to OPSS.PROV 1010 Granular A or Granular B Type II requirements should be provided under the base of the outlet structures, headwalls and pipes as per OPSD 803.010 and OPSS.PROV 401. The bedding material should be placed on the prepared subgrade as soon as practicable following its inspection and approval. Given the size of the inlet and outlet structure excavation and the time required for construction, appropriate measures should be taken to minimize the subgrade disturbance from construction traffic and weather elements.

Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

9.3.2 Stormwater Management Pond C2-1 (Pond 1)

Excavations for Pond 1 will penetrate through the stiff to hard silty clay fill into the stiff to very stiff silty clay till deposit and may locally reach the underlying silty sand to sand layer. The excavations are expected to reach the groundwater table. Based on the relatively low permeability of the cohesive silty clay till and the fact that the excavations are expected not to extend significantly below the groundwater table, groundwater control measures such as perimeter ditches and pumping from filtered sumps should be sufficient to remove ponded water primarily from surface run-offs and perched water. However, some groundwater inflow into the excavations should be expected through the more permeable sand and silt interlayers and where the silty sand to sand deposit is exposed at some locations. Additional sump pumping may be required if the flow from sand and silt seams or the underlying silty sand to sand layer becomes a problem.

For the excavation and the outlet structure including the wall, reference should be made to OPSS.PROV 517 and NSSP FOUN0003 for dewatering system design where required. The structure installations should be carried out in the dry.



It is anticipated that the silty clay till will be exposed predominantly across the pond sideslopes and at the pond base. Where locally exposed, the silty sand to sand has relatively high hydraulic conductivity and will be causes of leakage. For design purposes, the following hydraulic conductivities may be assumed:

- Silty Sand to Sand (10^{-3} to 10^{-4} cm/s)
- Silty Clay Till ($< 10^{-6}$ cm/s)

It is not anticipated that the exposure of the stiff to very stiff silty clay till would result in basal instability of the pond excavation.

A concrete outlet structure wall is to be founded at approximate Elevation 184.2 m at the south side of Pond 1. Based on available borehole information, this wall will be supported on the compact silty sand to sand subgrade. It is understood that a 300 mm thick compacted Granular A pad will be placed on the subgrade prior to construction of the wall footing. For a 2.55 m wide footing as shown on the WSP drawing titled "Pond 1 Details", it is recommended that a factored geotechnical resistance at ULS of 225 kPa and a geotechnical resistance at SLS of 150 kPa be used for foundation design. The footing and granular pad should be constructed in the dry.

Resistance to lateral forces/sliding between concrete inlet and outlet structures and the underlying bedding material should be evaluated assuming an unfactored ultimate coefficient of friction of 0.45. As per the CHBDC 2014, a resistance factor of 0.8 should be applied to the above value.

9.3.3 Stormwater Management Pond C2-2 (Pond 2)

Excavations for Pond 2 will penetrate through the compact sandy silt till into the stiff to hard silty clay till deposit. The excavations may locally penetrate into the underlying silty sand to sandy silt layer. The excavations are expected to reach the groundwater table. Based on the relatively low permeability of the cohesive silty clay till and the fact that the excavations are expected not to extend significantly below the groundwater table, groundwater control measures such as perimeter ditches and pumping from filtered sumps should be sufficient to remove ponded water from surface run-offs and perched water. However, some groundwater inflow into the excavations should be expected through the more permeable sand and silt interlayers and where the underlying silty sand to sandy silt might be exposed at some locations. Additional sump pumping may be required if the flow from the sand and silt seams or the underlying silty sand to sandy silt layer becomes a problem.



For the excavation and the outlet structure including the wall, reference should be made to OPSS.PROV 517 and NSSP FOUN0003 for dewatering system design where required. The structure installations should be carried out in the dry.

It is anticipated that the clayey silt to silty clay till will be exposed predominantly across the pond sideslopes and at the pond base. Where locally exposed, the silty sand to sandy silt has relatively high hydraulic conductivity and will be causes of leakage. For design purposes, the following hydraulic conductivities may be assumed:

- Silty Sand to Sandy Silt (10^{-4} to 10^{-5} cm/s)
- Clayey Silt to Silty Clay Till ($< 10^{-5}$ cm/s)

It is not anticipated that the exposure of the predominantly stiff to hard clayey silt to silty clay till and locally the compact silty sand to sandy silt would result in basal instability of the pond excavation.

A concrete outlet structure wall is to be founded at approximate Elevation 192.5 m at the south end of Pond 2. Based on available borehole information, the proposed wall footing may straddle the stiff to very stiff clayey silt to silty clay till and the compact silty sand to sandy silt. It is understood that a 300 mm thick compacted Granular A pad will be placed on the subgrade prior to construction of the wall footing. For a 2.55 m wide footing as shown on the WSP drawing titled "Pond 2 Sections", it is recommended that a factored geotechnical resistance at ULS of 225 kPa and a geotechnical resistance at SLS of 150 kPa be used for foundation design. The footing and granular pad should be constructed in the dry.

Resistance to lateral forces/sliding between concrete inlet and outlet structures and the underlying bedding material should be evaluated assuming an unfactored ultimate coefficient of friction of 0.4. As per the CHBDC 2014, a resistance factor of 0.8 should be applied to the above value.

9.3.4 Stormwater Management Pond C2-3 (Pond 3)

Excavations for Pond 3 will penetrate through the firm to stiff silty clay fill into the typically stiff to very stiff silty clay deposit. The excavations are expected to remain above the groundwater table. Based on the relatively low permeability of the cohesive silty clay and the fact that the excavations are expected to remain above the groundwater table, groundwater control measures such as perimeter ditches and pumping from filtered sumps should be sufficient to remove any accumulation of surface water from run-offs and perched water.



For the excavation and the outlet structure including the wall, reference should be made to OPSS.PROV 517 and NSSP FOUN0003 for dewatering system design where required. The structure installations should be carried out in the dry.

It is anticipated that the silty clay will be exposed across the pond sideslopes and at the pond base with localized sands and silts. The silty clay generally has low hydraulic conductivity. For design purposes, the following hydraulic conductivity for these soils may be assumed:

- Silty Clay ($< 10^{-6}$ cm/s)
- Sands and Silts (10^{-4} to 10^{-5} cm/s)

It is not anticipated that the exposure of the stiff to very stiff silty clay would result in basal instability of the pond excavation.

A concrete outlet structure wall is to be founded at approximate Elevation 199.5 m at the south side of Pond 3. Based on available borehole information, this wall will be supported on the stiff to very stiff silty clay till with pockets of dense sands and silts. It is understood that a 300 mm thick compacted Granular A pad will be placed on the subgrade prior to construction of the wall footing. For a 2.55 m wide footing as shown on the WSP drawing titled "Pond 3 Details", it is recommended that a factored geotechnical resistance at ULS of 225 kPa and a geotechnical resistance at SLS of 150 kPa be used for foundation design. The footing and granular pad should be constructed in the dry.

Resistance to lateral forces/sliding between concrete inlet and outlet structures and the underlying bedding material should be evaluated assuming an unfactored ultimate coefficient of friction of 0.4. As per the CHBDC 2014, a resistance factor of 0.8 should be applied to the above value.

10. CONSTRUCTION CONCERNS

During construction, the Contract Administrator (CA) should employ experienced geotechnical staff to observe construction activities related to foundation construction. Potential construction concerns include, but are not necessarily limited to, the following:

- Where water-bearing sands and silts are exposed at the pond base and on the sideslopes; dewatering, gravel sheeting or other treatment measures will be required to address any slope sloughing and surficial instabilities caused by seepage.
- Dewatering and other forms of groundwater control such as sump pumping are essential measures for maintaining reasonably dry excavations during construction, and minimizing risks of basal and sideslope instability.



- The pond base and sideslopes should be inspected periodically, or as required, to confirm stability.

11. CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Mr. Geoff Lay, P.Eng. and Cory Zanatta, P.Eng. The report was reviewed by Messrs. Sydney Pang, P.Eng. and P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.



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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


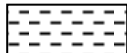



C_{pen} Shear Strength Determination by Pocket Penetrometer

- (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.				



Appendix A

SWMPC2-1 - Record of Borehole Sheets

SWMPC2-1 - Laboratory Test Results

SWMPC2-1 - Borehole Locations and Soil Strata Drawing

SWMPC2-1 - Site Photographs

SWMPC2-1 - Selected Results of Slope Stability Analyses

RECORD OF BOREHOLE No SWM C2-1A 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 857 404.0 E 314 940.7 ORIGINATED BY JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.09.19 - 2018.09.19 LATITUDE 43.856537 LONGITUDE -79.373857 CHECKED BY RD

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							WATER CONTENT (%)
								20 40 60 80 100							
189.8	GROUND SURFACE														
0.0 0.1	TOPSOIL: (75mm)														
	Silty CLAY , trace gravel and sand Stiff to Very Stiff Brown Moist (FILL)		1	SS	12		189								
			2	SS	21										
			3	SS	19		188								
187.6															
2.2	Silty CLAY , with sand, trace gravel, trace rootlets Stiff Brown Moist (TILL)		4	SS	11		187							1 22 33 44	
	Trace orange oxidized stains		5	SS	14										
							186								
184.9			6	SS	18		185							2 72 22 4	
4.9	Silty SAND , trace clay, trace gravel Compact Grey Wet						184								
183.4			7	SS	11		183								
6.4	Silty CLAY , with sand, trace gravel Stiff to Very Stiff Grey Moist (TILL)														
			8	SS	20		182								
181.6															
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE CAVED TO 4.3m AND WATER LEVEL AT 4.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE PELLETS AND AUGER CUTTINGS TO SURFACE.														

ONTMT452 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 2/11/19



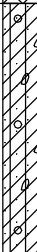



+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SWM C2-1B 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 857 361.9 E 314 945.0 ORIGINATED BY JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.09.25 - 2018.09.25 LATITUDE 43.856158 LONGITUDE -79.373806 CHECKED BY RD

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									
189.4	GROUND SURFACE																
0.0 0.1	TOPSOIL: (75mm) Silty CLAY , with sand, some gravel Stiff to Hard Brown Moist (FILL)		1	SS	9		189										
			2	SS	15		188										
			3	SS	31												
186.8			4	SS	10			187									
2.6	Silty CLAY , some sand, trace gravel Stiff Brown Moist (TILL)		5	SS	8			186									
185.1							185										
4.3	SAND , trace silt, trace clay Compact Grey Wet		6	SS	11		184										
183.3																	
6.1	Clayey SILT , with sand, trace gravel Hard Grey Moist (TILL)		7	SS	32		183										
181.8							182										
7.6 181.5 7.9 181.2	SAND , some silt, trace gravel Compact Grey Wet		8	SS	15												
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE CAVED TO 4.3m AND WATER LEVEL AT 4.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE PELLETS AND AUGER CUTTINGS TO SURFACE.																

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

RECORD OF BOREHOLE No SWM C2-1C 1 OF 2 METRIC

GWP# 2930-17-00 LOCATION N 4 857 314.9 E 314 942.1 ORIGINATED BY JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.09.24 - 2018.09.24 LATITUDE 43.855735 LONGITUDE -79.373842 CHECKED BY RD

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
189.3	GROUND SURFACE							20 40 60 80 100	20 40 60 80 100					
0.0	TOPSOIL: (75mm)													
0.1	Silty CLAY , with sand, some gravel, some cobbles and boulders Stiff to Very Stiff Brown Moist (FILL)		1	SS	10		189							
			2	SS	50/	0.075								
			3	SS	100/	0.075	188							
187.3	Silty CLAY , some sand, trace gravel Stiff Brown Moist (TILL)		4	SS	14		187							
			5	SS	12		186							3 15 27 55
185.0	Silty SAND , trace clay, trace gravel Compact Grey Wet		6	SS	16		185							
							184							
182.8	Clayey SILT , with sand, trace gravel Very Stiff Grey Moist (TILL)		7	SS	17		183							
6.5			8	SS	22		182							0 49 33 18
180.2	SAND , trace gravel, trace silt and clay Compact Brown Wet		9	SS	16		180							3 90 7 (SI+CL)
9.1														
179.5														
9.8	END OF BOREHOLE AT 9.8m													

Continued Next Page

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

2 OF 2

GWP#	2930-17-00	LOCATION	N 4 857 314.9 E 314 942.1			ORIGINATED BY	JNP
HWY	404	BOREHOLE TYPE	Hollow Stem Augers			COMPILED BY	MP
DATUM	Geodetic	DATE	2018.09.24 - 2018.09.24	LATITUDE	43.855735	LONGITUDE	-79.373842
		CHECKED BY	RD				

[illegible]

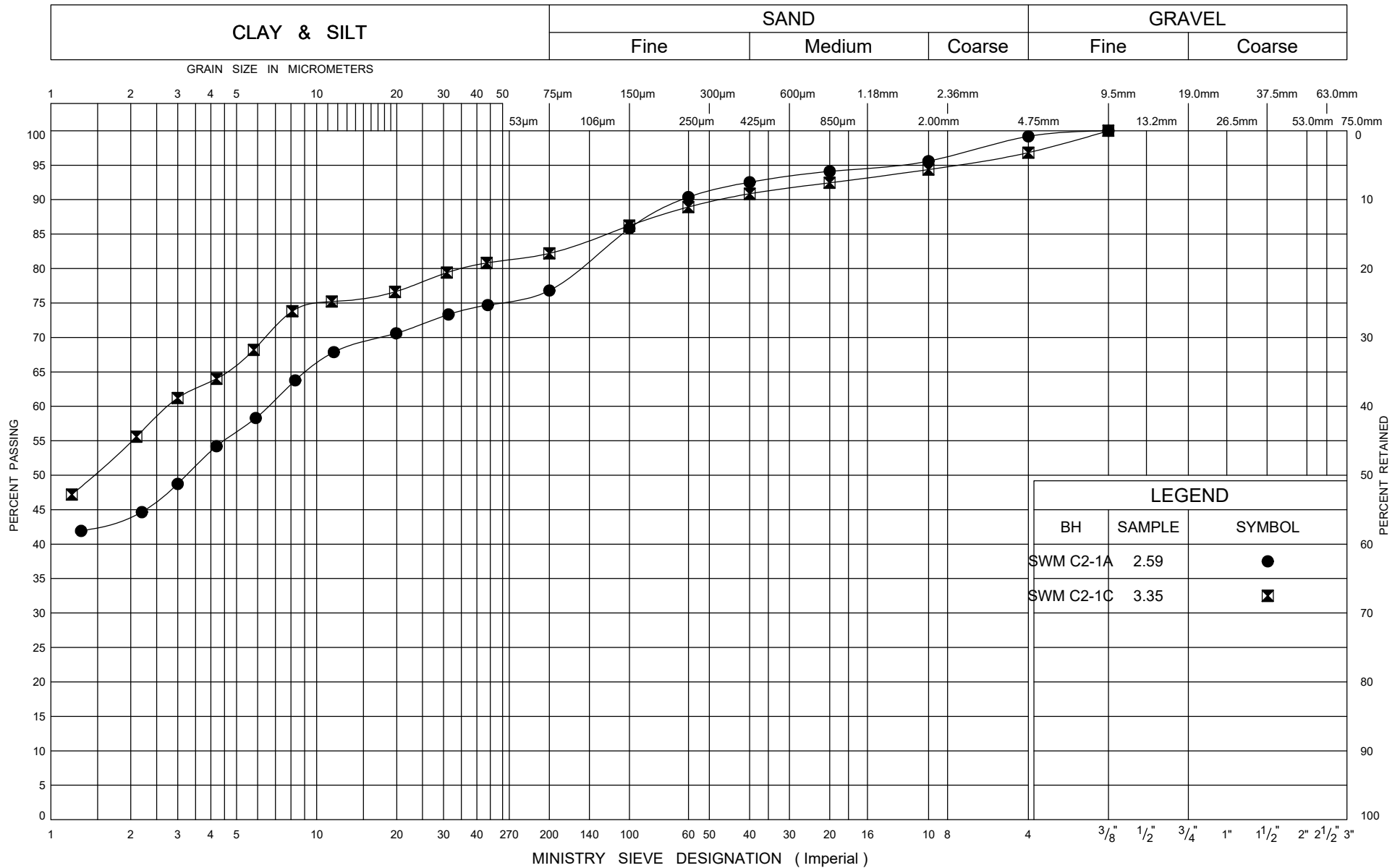
RECORD OF BOREHOLE No SWM C2-1D 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 857 241.5 E 314 961.8 ORIGINATED BY JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.09.19 - 2018.09.19 LATITUDE 43.855074 LONGITUDE -79.373599 CHECKED BY RD

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
188.1	GROUND SURFACE												
0.0 0.1	TOPSOIL: (75mm)						188						
	Silty CLAY , with sand, trace gravel, trace rootlets Very Stiff Brown Moist (TILL)		1	SS	16								
			2	SS	17		187						
			3	SS	16								
185.9							186						
2.2	Silty SAND to SAND , some silt Compact Brown Wet		4	SS	19								
			5	SS	13		185						0 90 10 (SI+CL)
							184						
183.2			6	SS	9								
4.9	Clayey SILT , with sand, trace gravel Stiff to Hard Grey Wet (TILL)						183						0 23 59 18
	Trace cobbles		7	SS	56		182						
							181						
180.5			8	SS	31								
7.6	Silty SAND , trace clay, trace gravel, trace cobbles Dense Grey Wet						180						
179.9													
8.2	END OF BOREHOLE AT 8.2m. WATER LEVEL AT 4.0m BEFORE BOREHOLE CAVING TO 3.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE PELLETS AND AUGER CUTTINGS TO SURFACE.												

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE



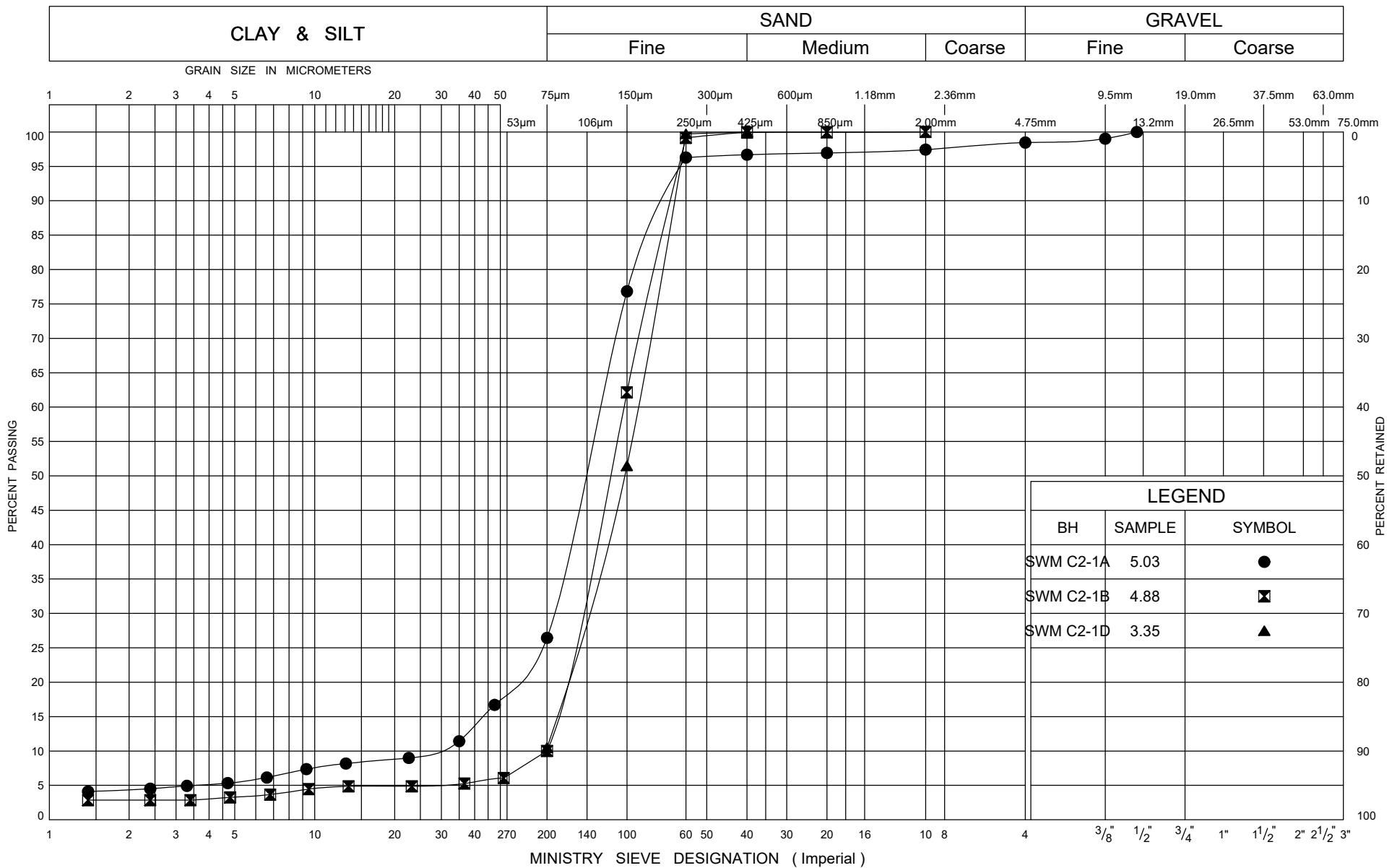
Ministry of
Transportation

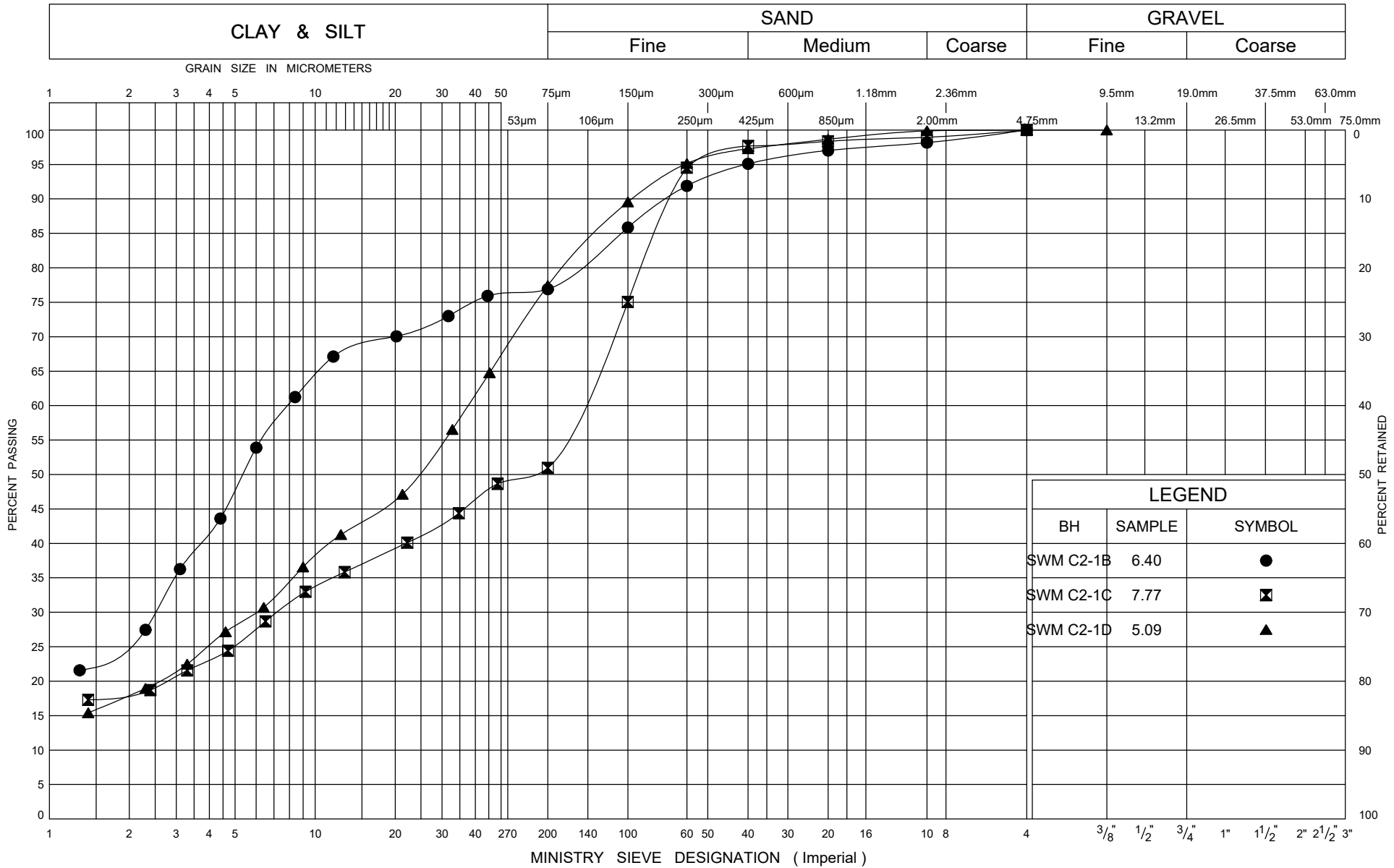
GRAIN SIZE DISTRIBUTION

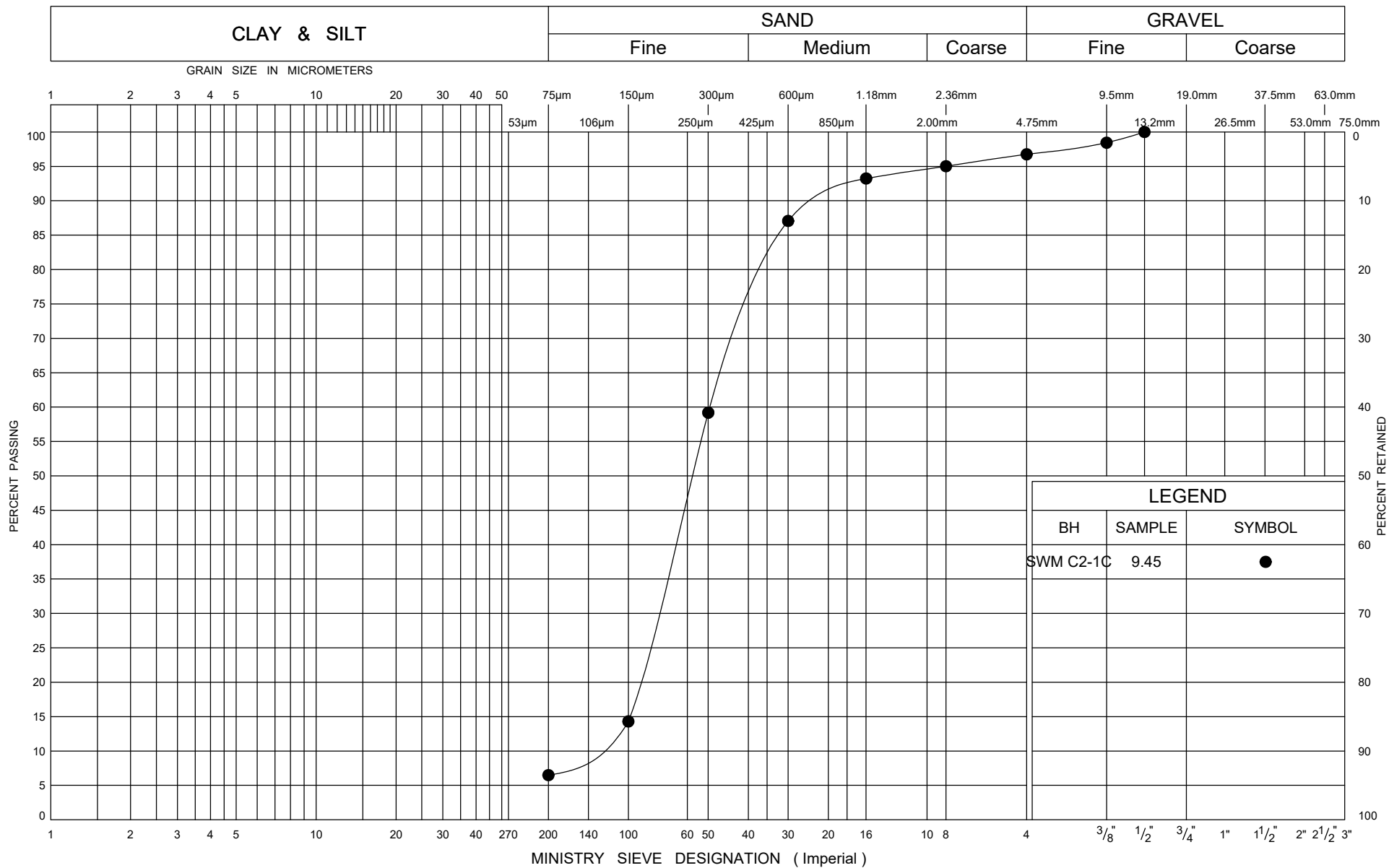
Silty CLAY TILL

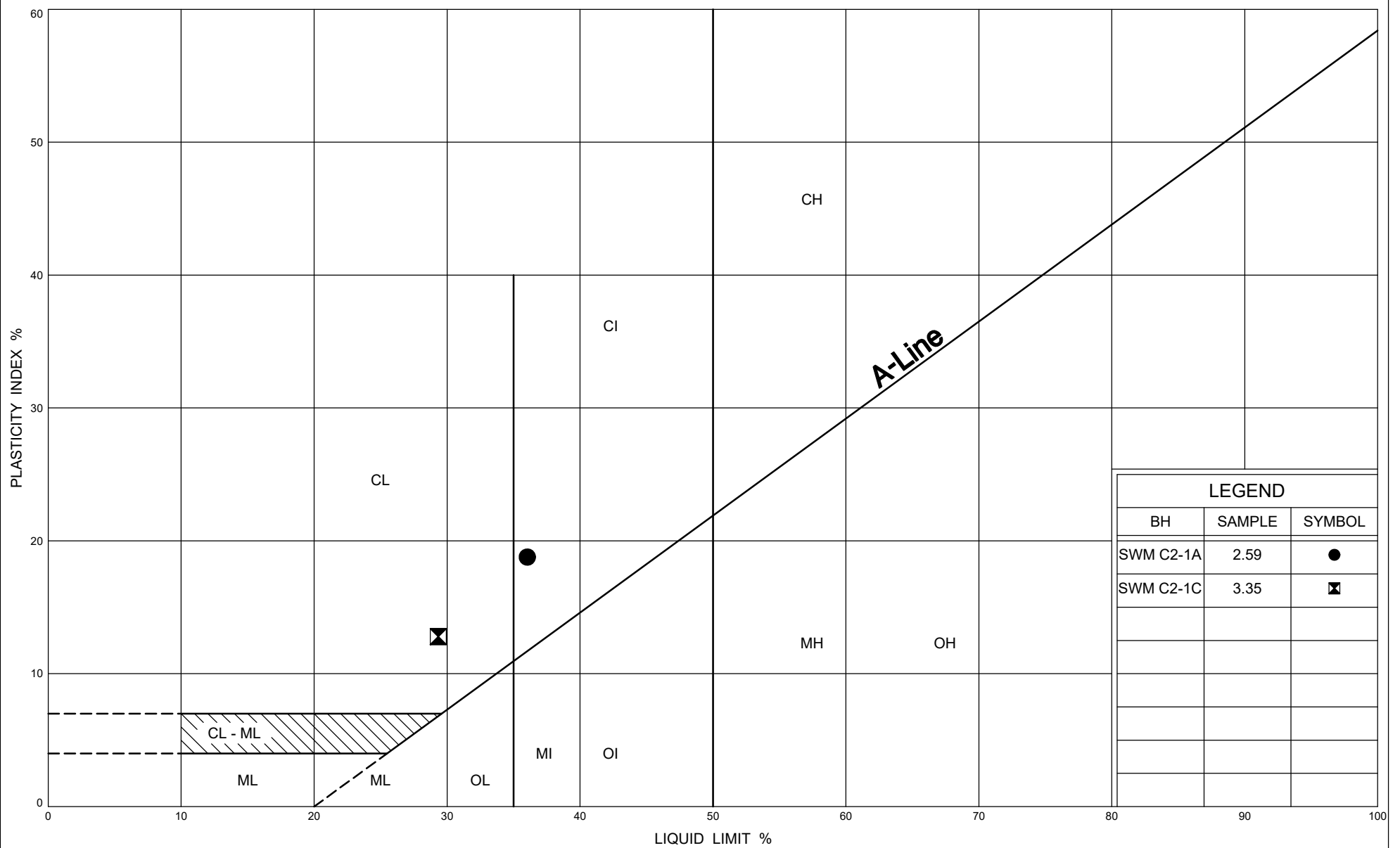
FIG No A1

G W P 2930-17-00









PLASTICITY CHART Silty CLAY TILL

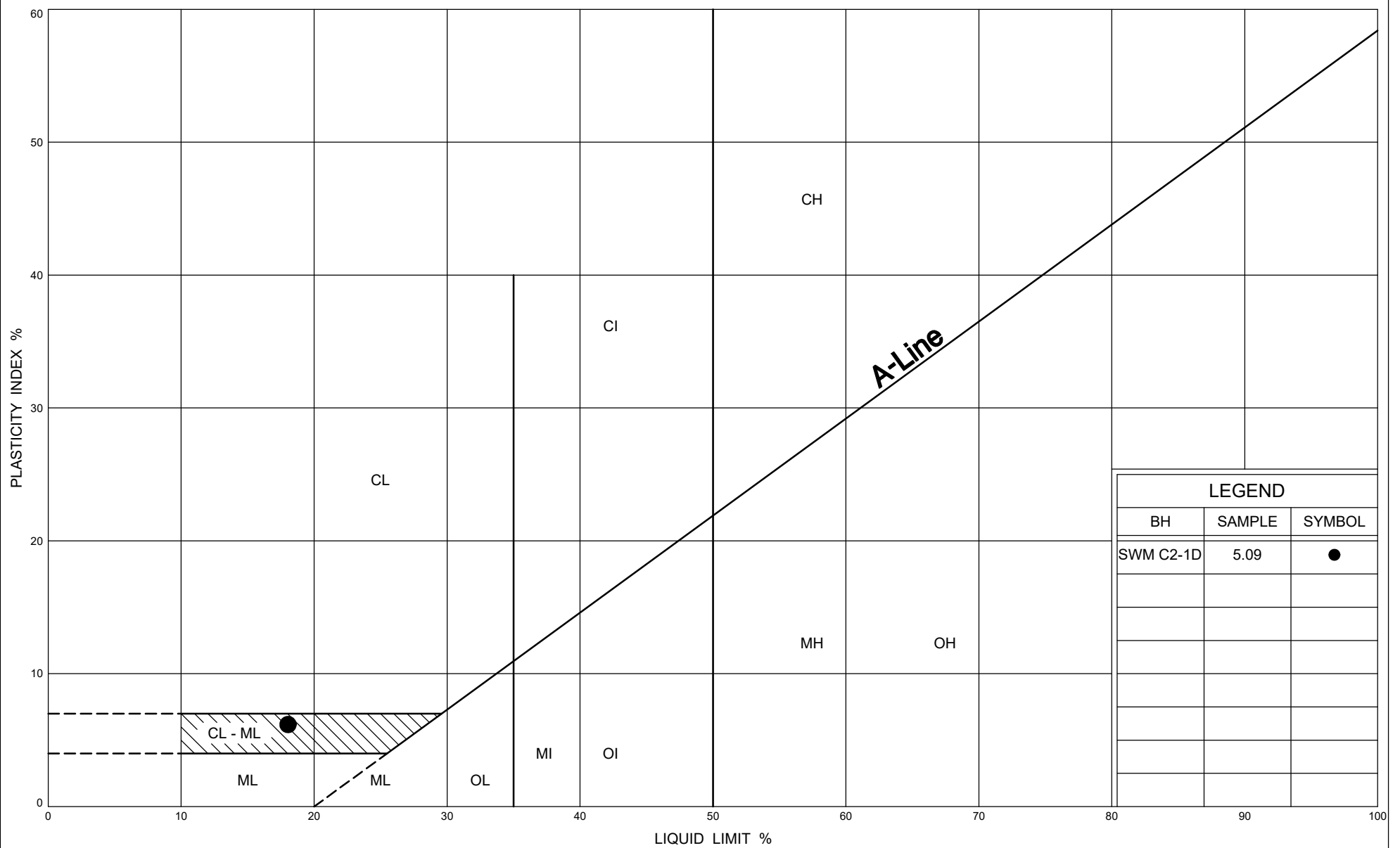
FIG No A5

G W P 2930-17-00



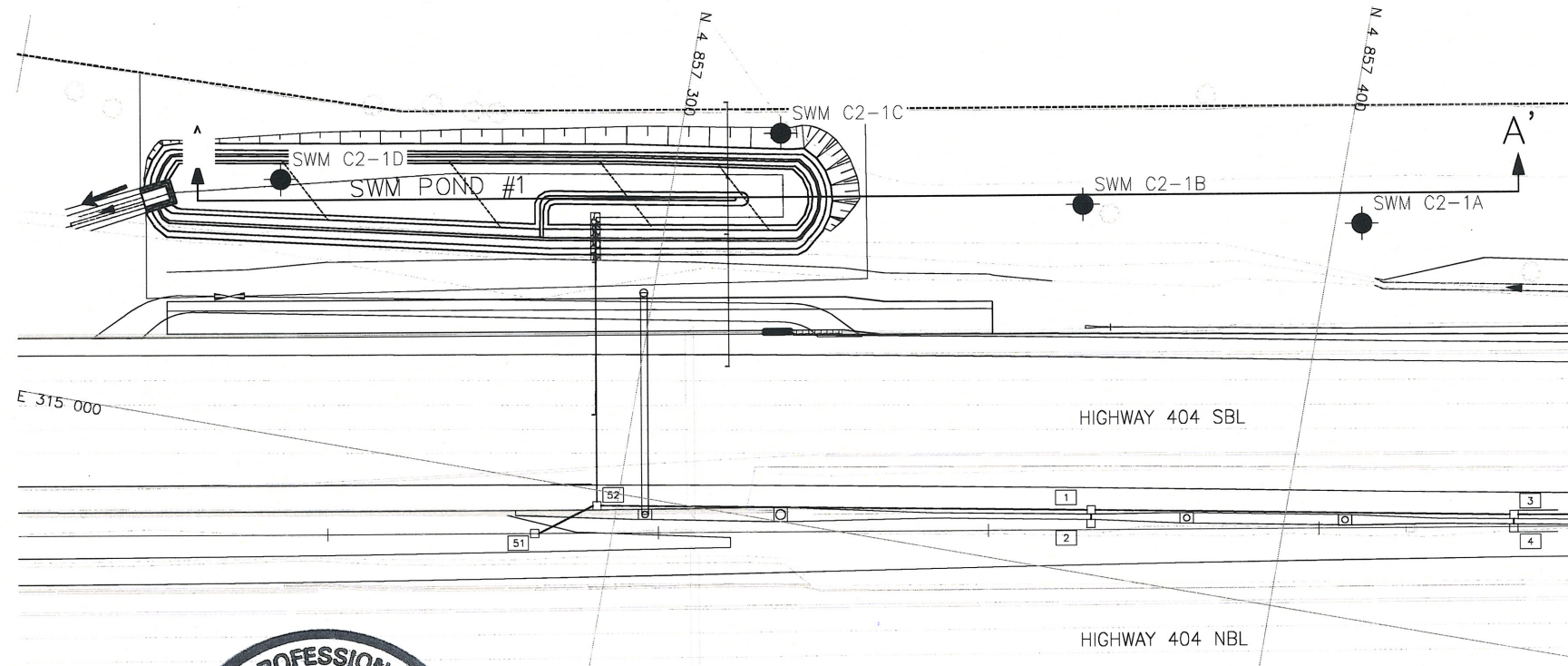
Ministry of
Transportation

Ontario

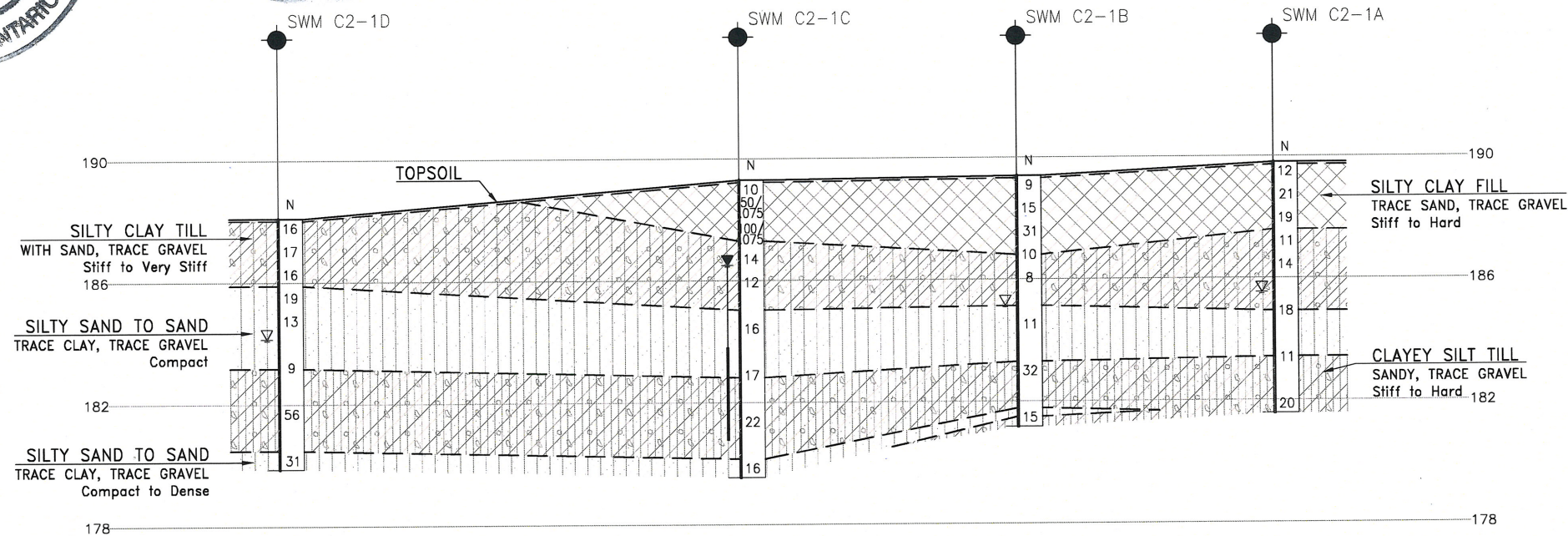
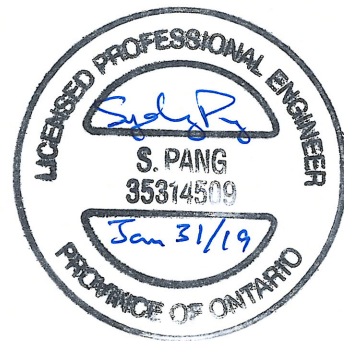


LEGEND		
BH	SAMPLE	SYMBOL
SWM C2-1D	5.09	●

ONTARIO MOT PLASTICITY CHART MTO-15786.GPJ ONTARIO MOT.GDT 12/13/18



PLAN
SCALE 1:1000



SECTION A-A'

SCALE 1:1000
SCALE 1:200

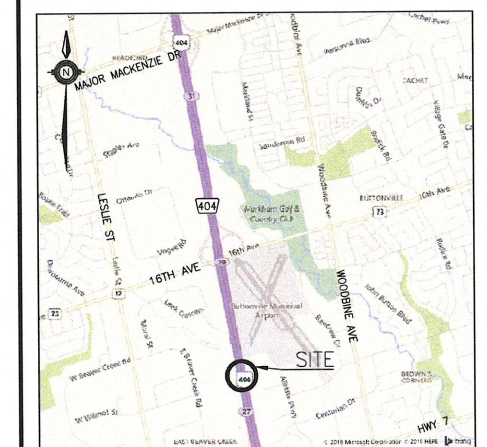
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 2930-17-00

HIGHWAY 404 WIDENING
STORM WATER MANAGEMENT
SWM POND 1
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole
⊙	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⊥	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SWM C2-1A	189.8	4 857 404.0	314 940.7
SWM C2-1B	189.4	4 857 361.9	314 945.0
SWM C2-1C	189.3	4 857 314.9	314 942.1
SWM C2-1D	188.1	4 857 241.5	314 961.8

-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. 30M14-490

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



Photo 1. – Looking northwest from Highway 404 southbound lanes towards area of proposed SWMPC2-1



Photo 2. – Looking southeast from Highway 404 southbound lanes towards area of proposed SWMPC2-1

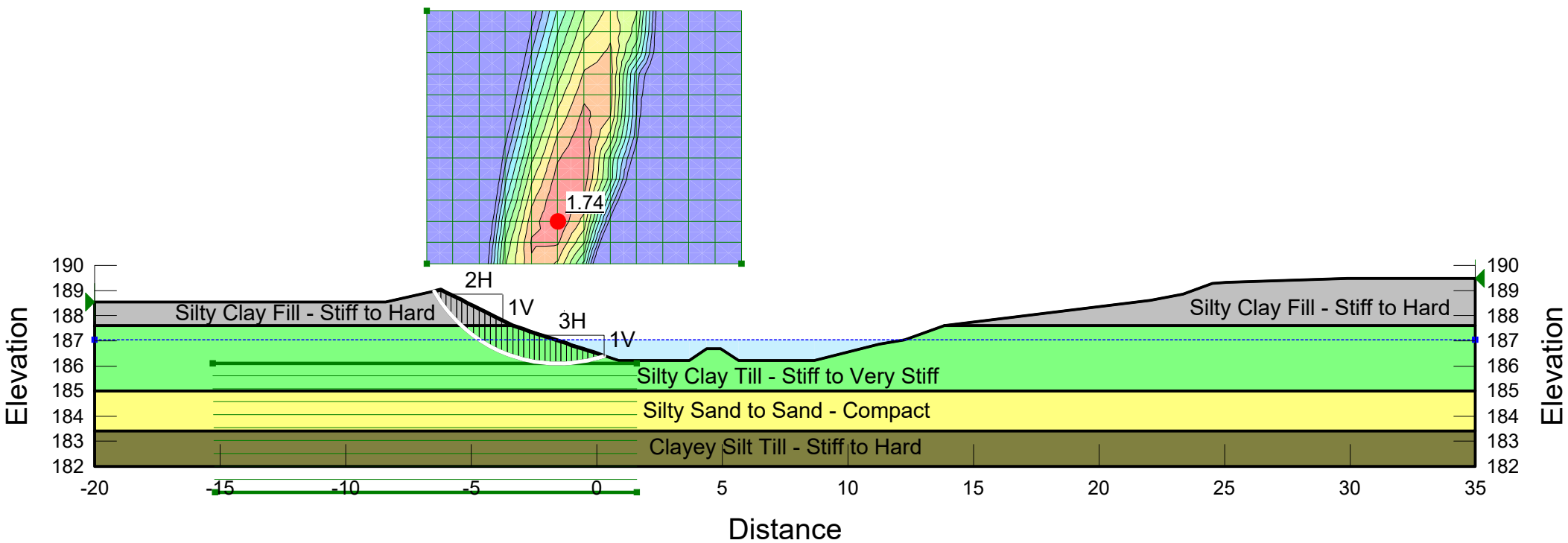
STATIC STABILITY ANALYSIS - POND 1 DRAINED CONDITION

FIGURE A1

File Name: Pond 1 - B-B - Drained.gsz
Created By: Cory Zanatta
Date: 2018-12-13

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5 m
Seismic: 0

Silty Clay Fill - Stiff to Hard	20 kN/m ³	0 kPa	30 °
Silty Clay Till - Stiff to Very Stiff	20 kN/m ³	2 kPa	29 °
Silty Sand to Sand - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt Till - Stiff to Hard	21 kN/m ³	2 kPa	30 °



STATIC STABILITY ANALYSIS - POND 1 UNDRAINED CONDITION

FIGURE A2

File Name: Pond 1 - B-B - Undrained.gsz

Created By: Cory Zanatta

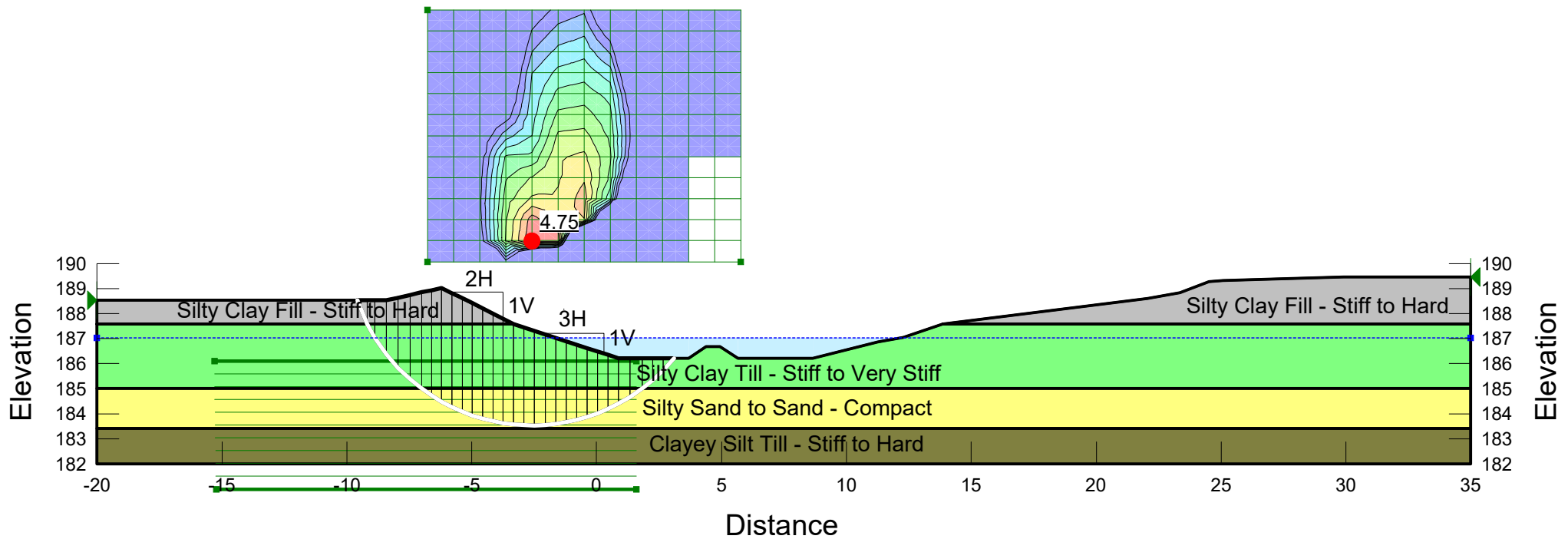
Date: 2018-12-18

Method: Morgenstern-Price

Minimum Slip Surface Depth: 0.5 m

Seismic: 0

Silty Clay Fill - Stiff to Hard	20 kN/m ³	50 kPa	0 °
Silty Clay Till - Stiff to Very Stiff	20 kN/m ³	50 kPa	0 °
Silty Sand to Sand - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt Till - Stiff to Hard	21 kN/m ³	100 kPa	0 °



STATIC STABILITY ANALYSIS - POND 1

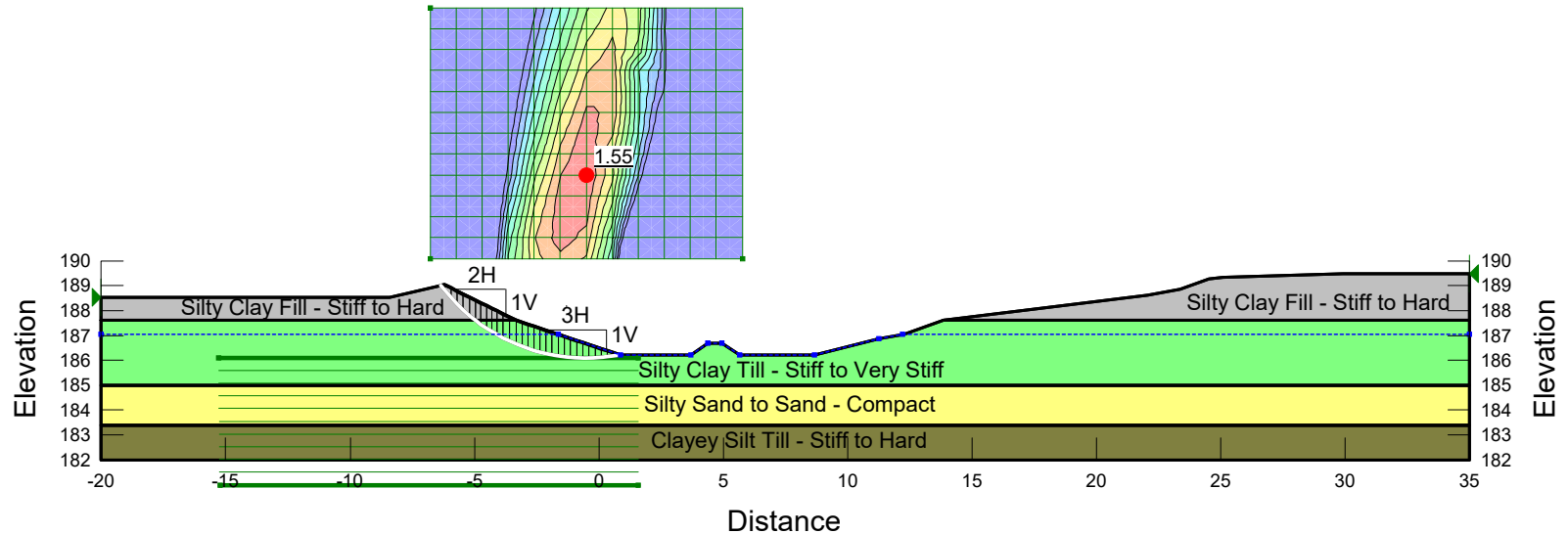
RAPID DRAWDOWN CONDITION

FIGURE A3

File Name: Pond 1 - B-B - Rapid Drawdown.gsz
Created By: Cory Zanatta
Date: 2018-12-18

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5 m
Seismic: 0

Silty Clay Fill - Stiff to Hard	20 kN/m ³	0 kPa	30 °
Silty Clay Till - Stiff to Very Stiff	20 kN/m ³	2 kPa	29 °
Silty Sand to Sand - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt Till - Stiff to Hard	21 kN/m ³	2 kPa	30 °



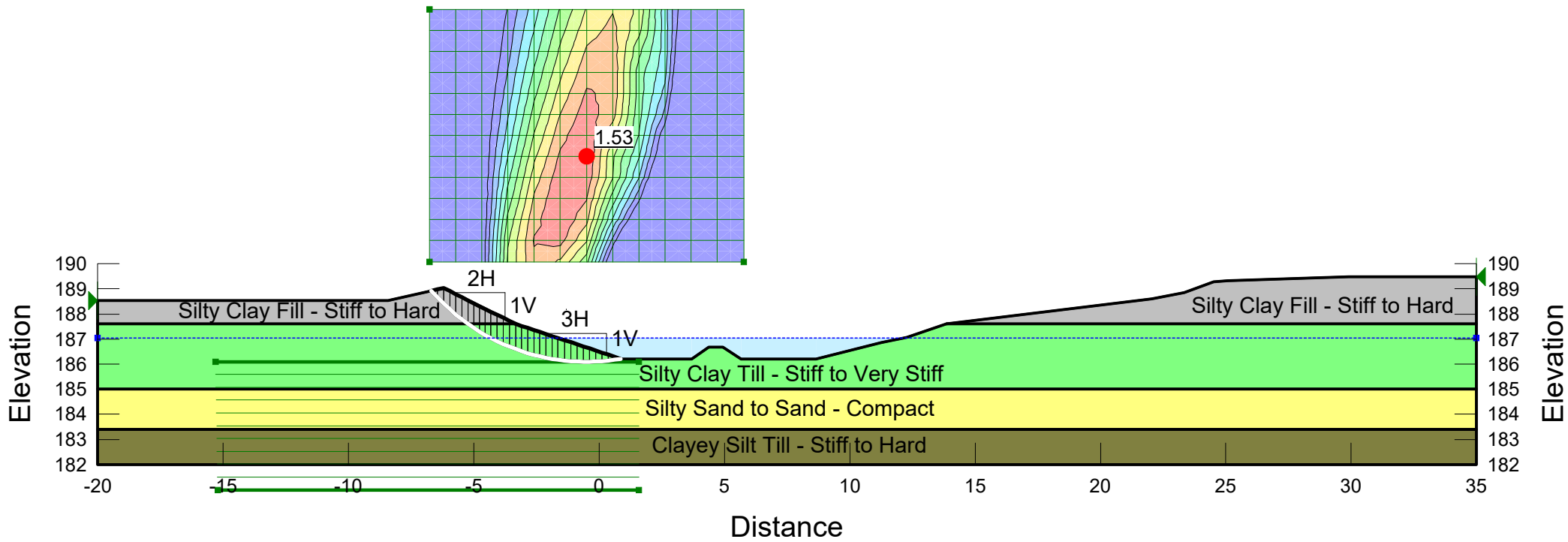
STATIC STABILITY ANALYSIS - POND 1 SEISMIC CONDITION

FIGURE A4

File Name: Pond 1 - B-B - Seismic.gsz
Created By: Cory Zanatta
Date: 2018-12-18

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5
Horz Seismic Coef.: 0.045

Silty Clay Fill - Stiff to Hard	20 kN/m ³	0 kPa	30 °
Silty Clay Till - Stiff to Very Stiff	20 kN/m ³	2 kPa	29 °
Silty Sand to Sand - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt Till - Stiff to Hard	21 kN/m ³	2 kPa	30 °





Appendix B

SWMPC2-2 - Record of Borehole Sheets

SWMPC2-2 - Laboratory Test Results

SWMPC2-2 - Borehole Locations and Soil Strata Drawing

SWMPC2-2 - Site Photographs

SWMPC2-2 - Selected Results of Slope Stability Analyses

RECORD OF BOREHOLE No SWM C2-2A 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 578.2 E 314 725.0 ORIGINATED BY JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.09.13 - 2018.09.14 LATITUDE 43.867109 LONGITUDE -79.376519 CHECKED BY RD

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								
198.5	GROUND SURFACE							20	40	60	80	100				
0.0	TOPSOIL: (200mm)							20	40	60	80	100				
0.2	Sandy SILT , some clay, trace gravel Compact Brown Moist (TILL)		1	SS	11		198									
			2	SS	12											
197.1																
1.4	Silty CLAY , some sand Stiff to Very Stiff Brown Moist (TILL)		3	SS	13											
			4	SS	19											
			5	SS	20											
193.9						∇	194									
4.6	Sandy SILT , trace clay Compact Brown Wet		6	SS	14											0 19 33 48
			7	SS	18											0 24 68 8
							192									
							191									
190.3			8	SS	10											
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE CAVED TO 4.9m AND WATER LEVEL AT 4.9m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE PELLETS AND AUGER CUTTINGS TO SURFACE.															

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RECORD OF BOREHOLE No SWM C2-2B 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 515.2 E 314 727.3 ORIGINATED BY JNP
HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.09.17 - 2018.09.17 LATITUDE 43.866542 LONGITUDE -79.376492 CHECKED BY RD

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												
199.4	GROUND SURFACE																			
0.0	TOPSOIL: (175mm)																			
0.2	Silty CLAY , with sand, trace rootlets Stiff to Very stiff Brown Moist (TILL)		1	SS	11		199													
			2	SS	9															
			3	SS	16															
			4	SS	23															
			5	SS	23															
			6	SS	15															
194.3																				
5.1	Silty SAND , trace clay, trace gravel Compact Brown Moist							194												
193.1																				
6.3	Clayey SILT , some sand, trace gravel Very Stiff Brown Moist (TILL)		7	SS	15				193											
			8	SS	18				192											
191.2																				
8.2	END OF BOREHOLE AT 8.2m. BOREHOLE CAVED TO 5.5m AND WATER LEVEL AT 5.5m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE PELLETS AND AUGER CUTTINGS TO SURFACE.																			

ONTMT452 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 2/11/19

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

RECORD OF BOREHOLE No SWM C2-2C 1 OF 2 METRIC

GWP# 2930-17-00 LOCATION N 4 858 538.0 E 314 733.3 ORIGINATED BY JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.09.13 - 2018.09.13 LATITUDE 43.866747 LONGITUDE -79.376417 CHECKED BY RD

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 (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
197.6	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (175mm)							20	40	60	80	100					
0.2	Sandy SILT , some clay, trace gravel Compact Brown Moist (TILL)		1	SS	12		197							○			
			2	SS	12									○			
195.8			3	SS	11		196							○			
1.8	Silty CLAY , some sand, trace gravel, occasional oxide stains Stiff to Very Stiff Brown Moist (TILL)		4	SS	21		195							○			2 19 31 48
			5	SS	15		194							○			
			6	SS	15		193							○			
192.6														○			
5.0	SAND and SILT , trace clay Compact Grey Wet		7	SS	16		192							○			0 51 46 3
							191							○			
190.1							190							○			0 24 34 42
7.5	Silty CLAY , with sand, trace gravel Stiff to Very Stiff Grey Moist (TILL)		8	SS	13		189							○			
			9	SS	19		188							○			
187.8																	
9.8	END OF BOREHOLE AT 9.8m.																

Continued Next Page

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

RECORD OF BOREHOLE No SWM C2-2C 2 OF 2 METRIC

GWP# 2930-17-00 LOCATION N 4 858 538.0 E 314 733.3 ORIGINATED BY JNP
 HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.09.13 - 2018.09.13 LATITUDE 43.866747 LONGITUDE -79.376417 CHECKED BY RD

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 WATER LEVEL AT 5.6m UPON COMPLETION. Well installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.09.13 5.6 192.0 2018.09.17 4.7 192.9 2018.11.22 3.2 194.4																

ONTMT452 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 2/1/19

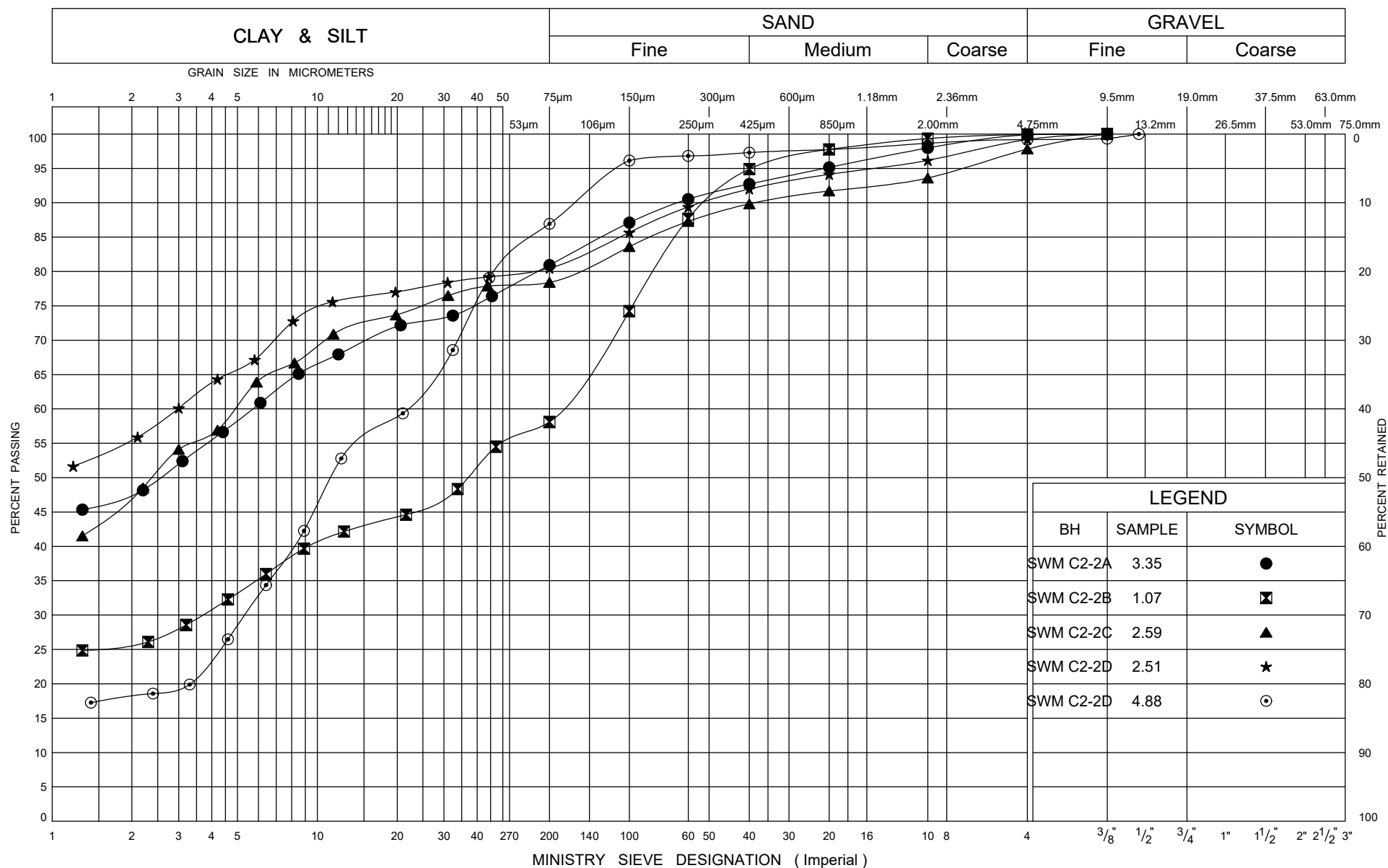
RECORD OF BOREHOLE No SWM C2-2D 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 858 526.1 E 314 729.0 ORIGINATED BY JNP
HWY 404 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP
DATUM Geodetic DATE 2018.09.17 - 2018.09.17 LATITUDE 43.866640 LONGITUDE -79.376470 CHECKED BY RD

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												
197.3	GROUND SURFACE							20	40	60	80	100								
0.0 0.1	TOPSOIL: (75mm)							20	40	60	80	100								
	Sandy SILT , some clay, trace gravel Loose to Compact Brown Moist (TILL)		1	SS	8		197													
			2	SS	18		196													
195.8																				
1.5	Silty CLAY , some sand, trace gravel Stiff to Hard Brown Moist (TILL)		3	SS	11		195													
			4	SS	20															1 19 25 55
			5	SS	39		194													
193.2																				
4.1	Clayey SILT		6	SS	22		193													1 12 69 18
							192													
191.7																				
5.6	Silty SAND , trace clay, trace gravel Compact Grey Moist		7	SS	13		191													
190.7																				
6.6	Clayey SILT , some sand, trace gravel Stiff Grey Moist (TILL)						190													
189.7																				
7.6	END OF BOREHOLE AT 7.6m. BOREHOLE CAVED TO 6.3m AND WATER LEVEL AT 2.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE PELLETS AND AUGER CUTTINGS TO SURFACE.																			

ONTMT452 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 2/11/19

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



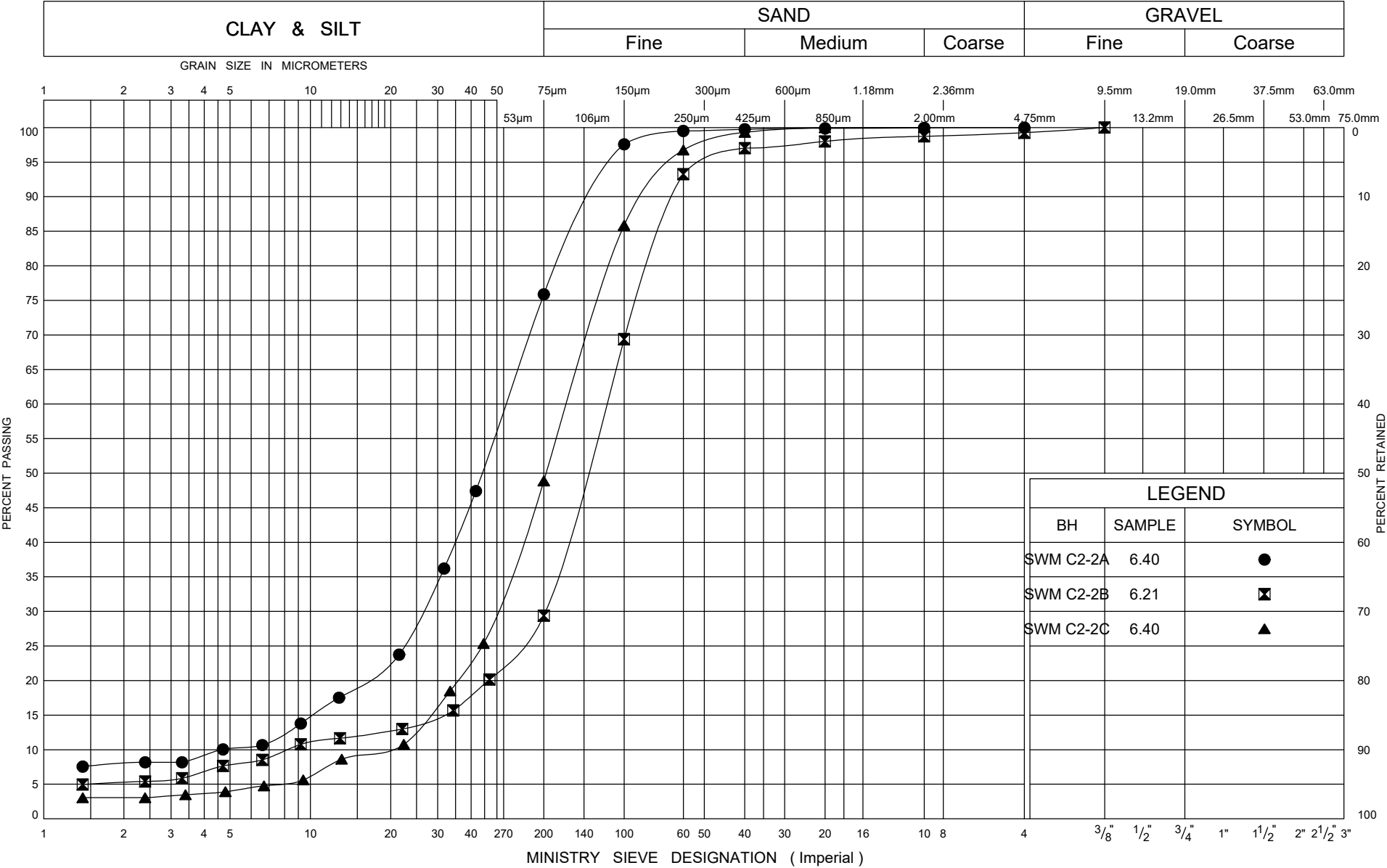
Ministry of
Transportation

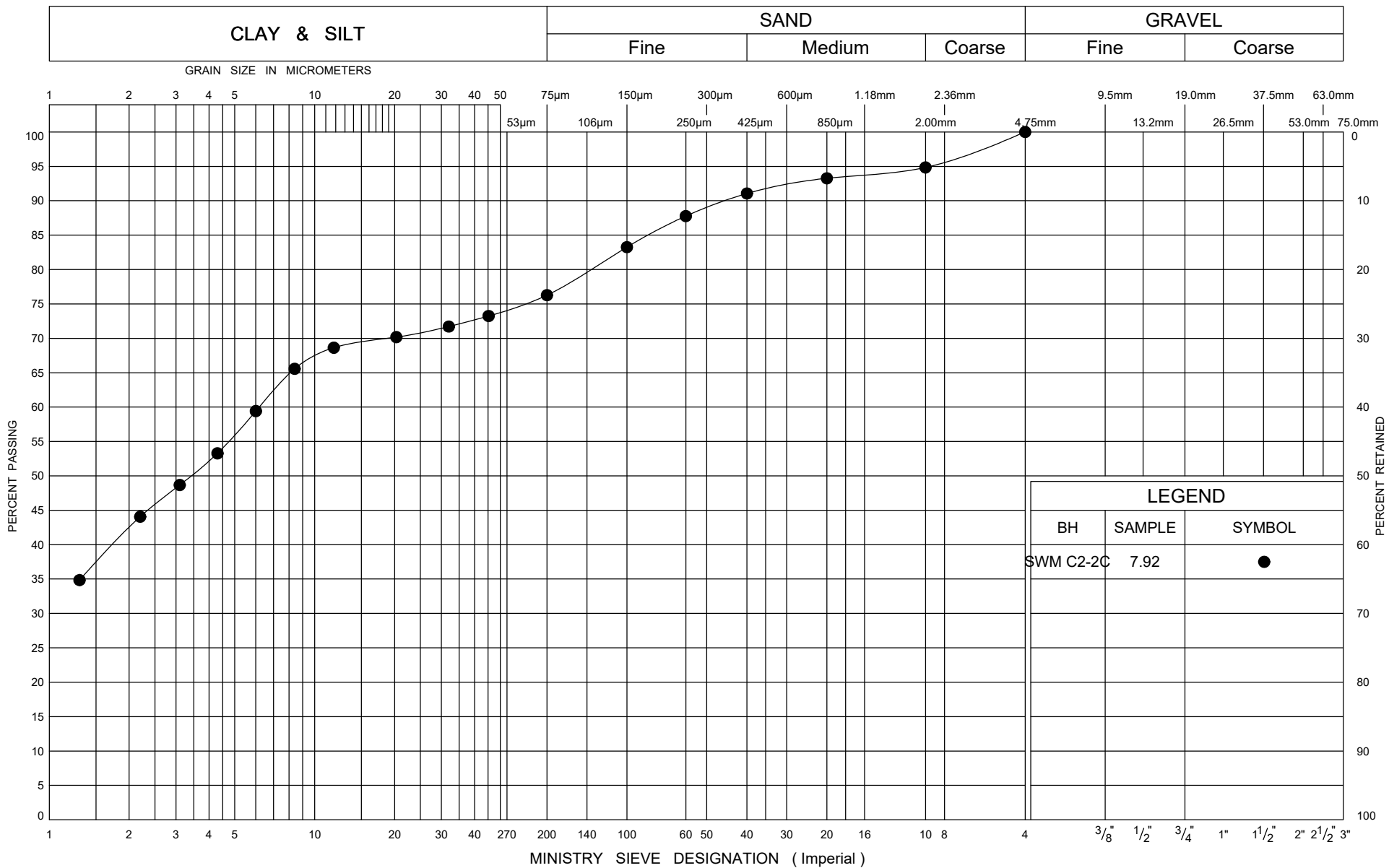
GRAIN SIZE DISTRIBUTION

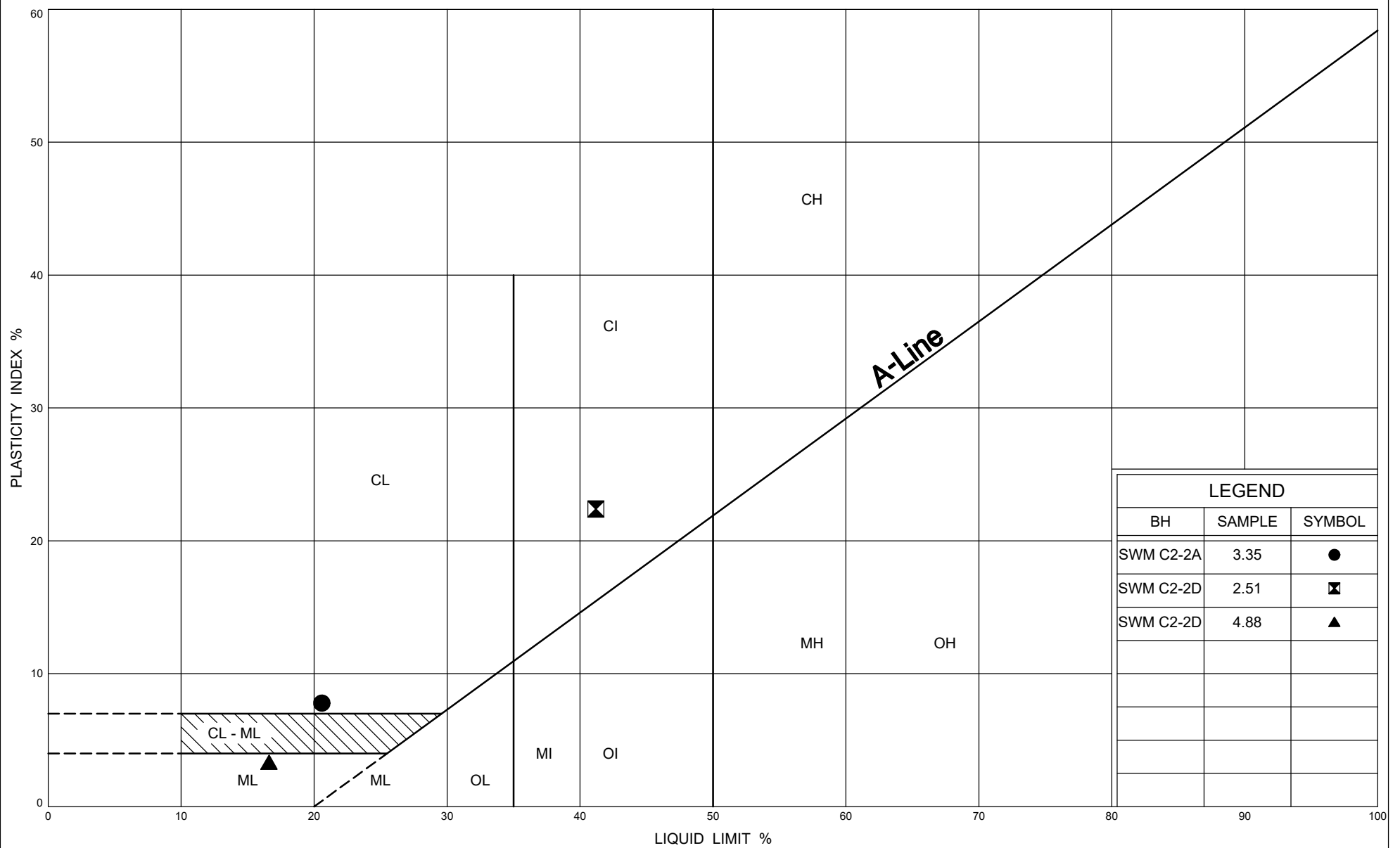
Clayey SILT to Silty CLAY TILL

FIG No B1

G W P 2930-17-00







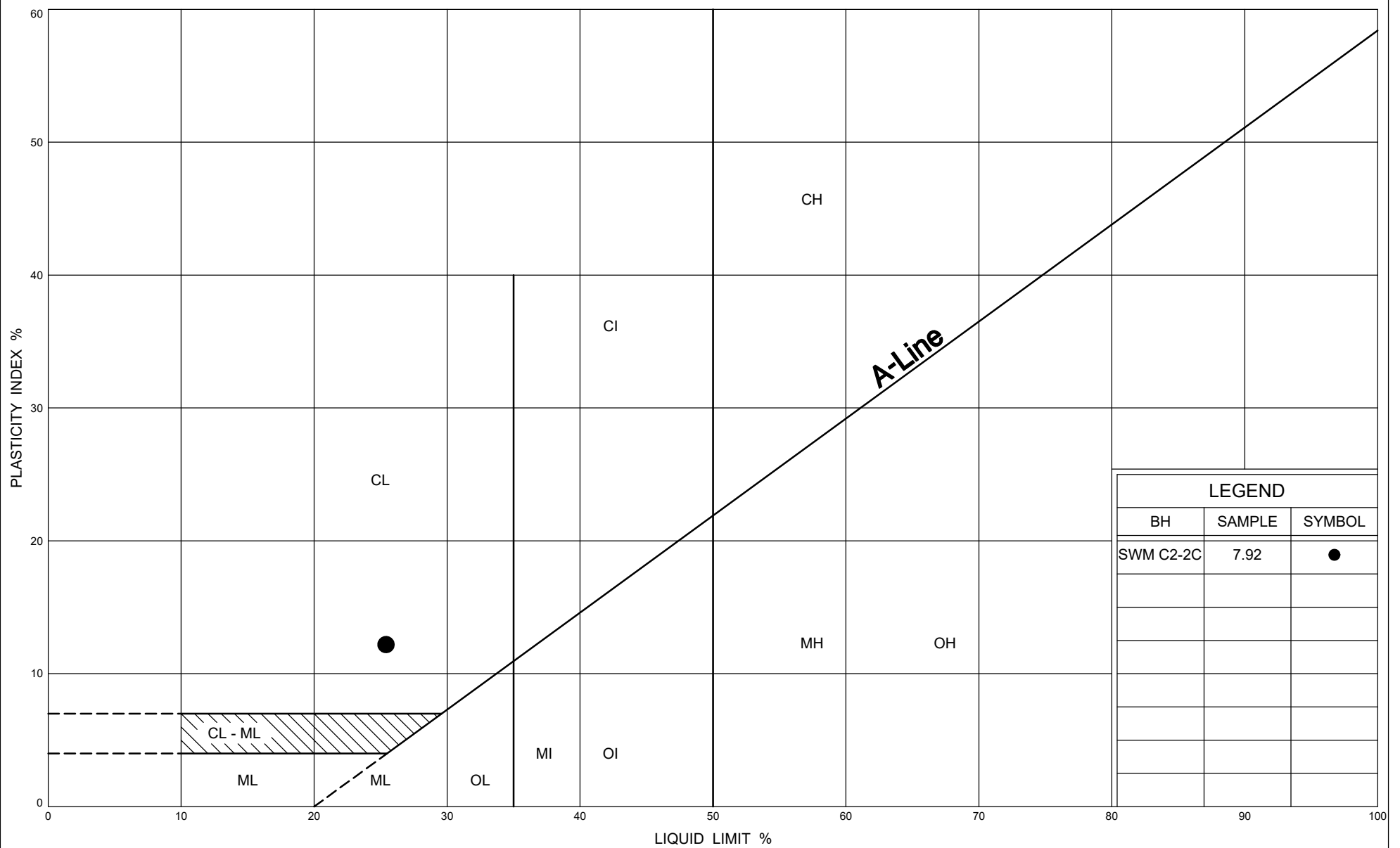
Ministry of
Transportation

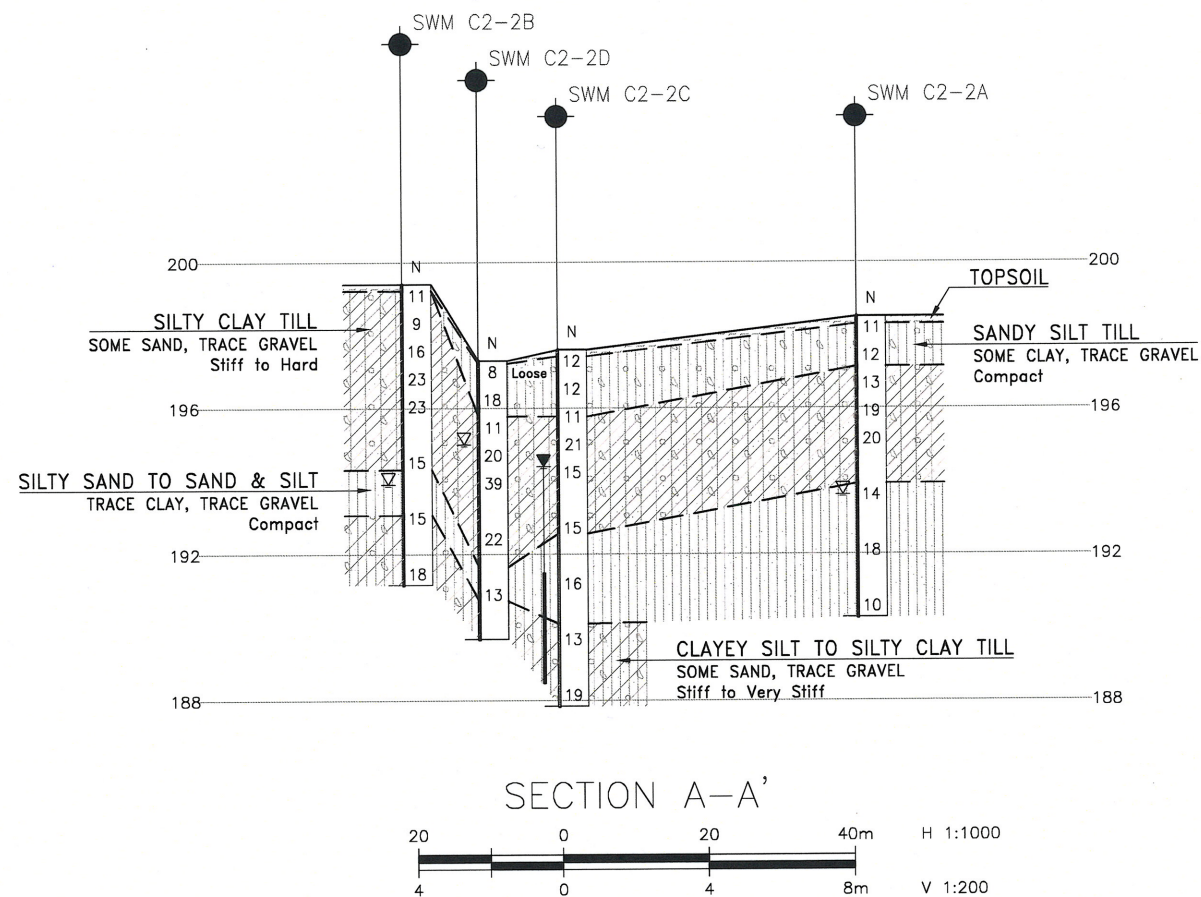
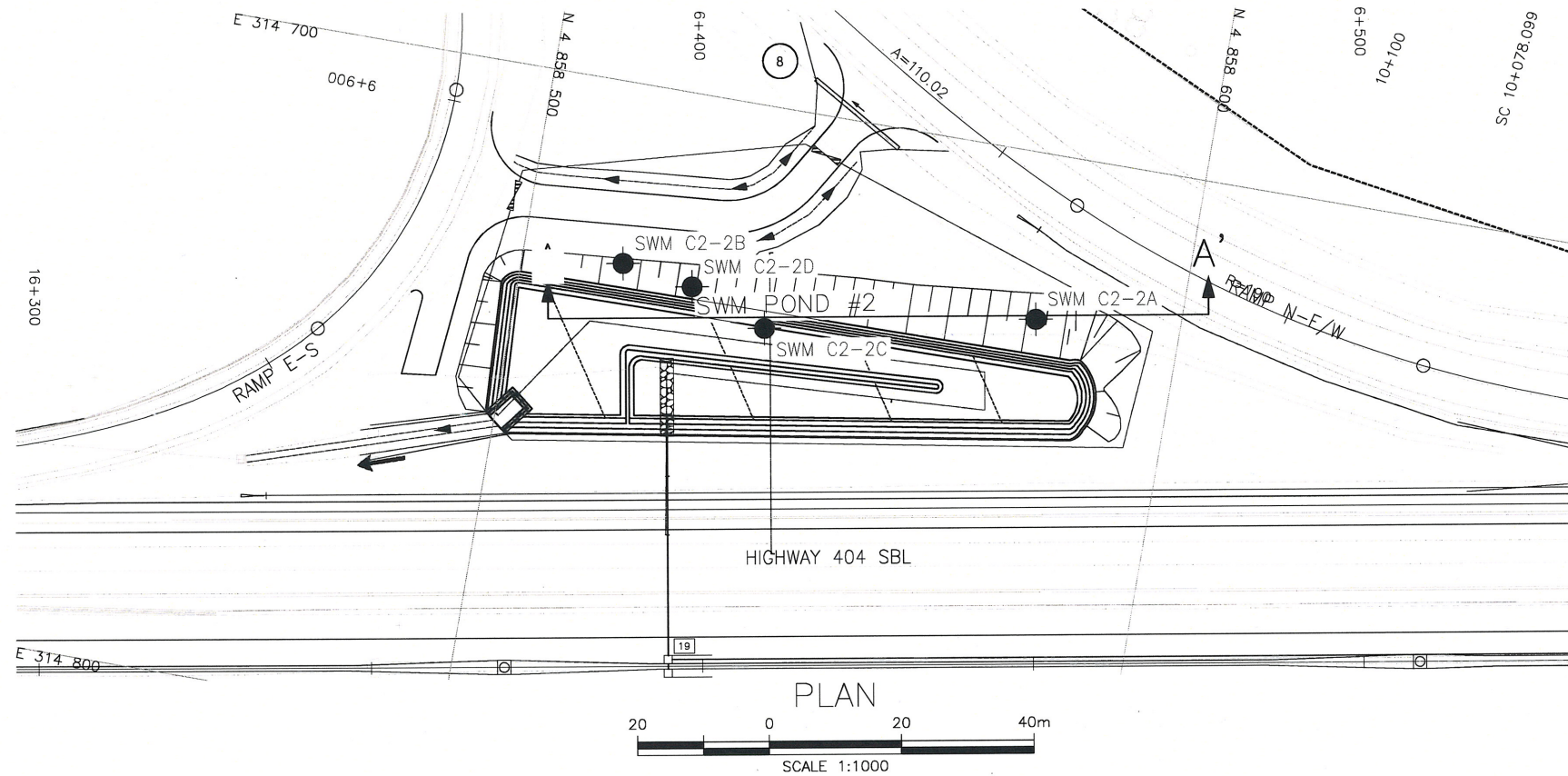
PLASTICITY CHART

Clayey SILT to Silty CLAY TILL

FIG No B4

G W P 2930-17-00





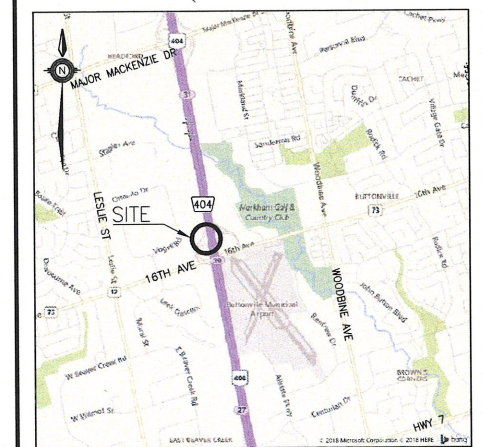
METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 2930-17-00

HIGHWAY 404 WIDENING
STORM WATER MANAGEMENT
SWM POND 2
BOREHOLE LOCATIONS AND SOIL STRATA



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⬇	Head Artesian Water
⬇	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SWM C2-2A	198.5	4 858 578.2	314 725.0
SWM C2-2B	199.4	4 858 515.2	314 727.3
SWM C2-2C	197.6	4 858 538.0	314 733.3
SWM C2-2D	197.3	4 858 526.1	314 729.0

-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. 30M14-490

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GRL	CHK SKP	CODE
DRAWN	AN	CHK GRL	SITE
			STRUCT
			DWG 1

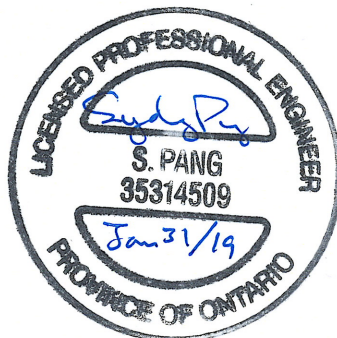




Photo 1. – Looking south from Highway 404 off-ramp towards area of proposed SWMPC2-2



Photo 2. – Looking north from Highway 404 on-ramp towards area of proposed SWMPC2-2



Photo 3. – Looking west from Highway 404 southbound lanes towards area of proposed SWMPC2-2

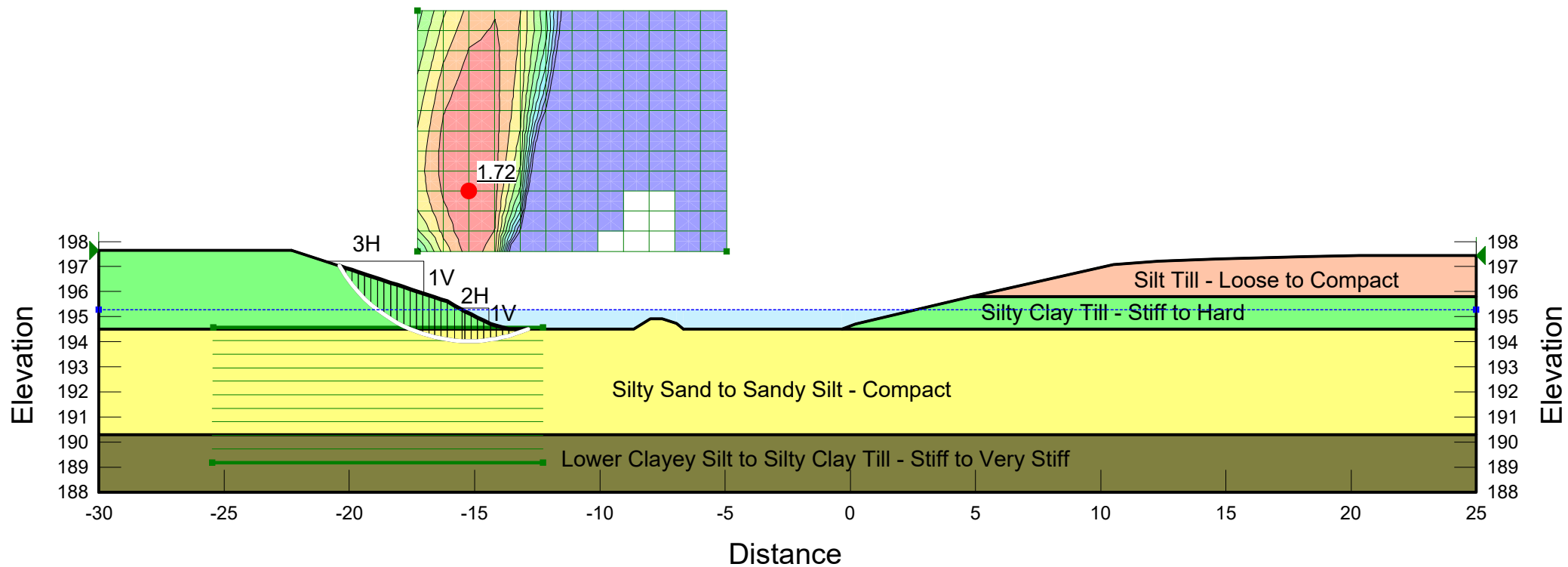
STATIC STABILITY ANALYSIS - POND 2 DRAINED CONDITION

FIGURE B1

File Name: Pond 2- B-B - Drained.gsz
Created By: Cory Zanatta
Date: 2018-12-19

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5
Horz Seismic Coef.: 0

Sandy Silt Till - Loose to Compact	19 kN/m ³	0 kPa	29 °
Silty Clay Till - Stiff to Hard	20 kN/m ³	2 kPa	29 °
Silty Sand to Sandy Silt - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt to Silty Clay Till - Stiff to Very Stiff	21 kN/m ³	2 kPa	30 °



STATIC STABILITY ANALYSIS - POND 2 UNDRAINED CONDITION

FIGURE B2

File Name: Pond 2- B-B - Undrained.gsz

Created By: Cory Zanatta

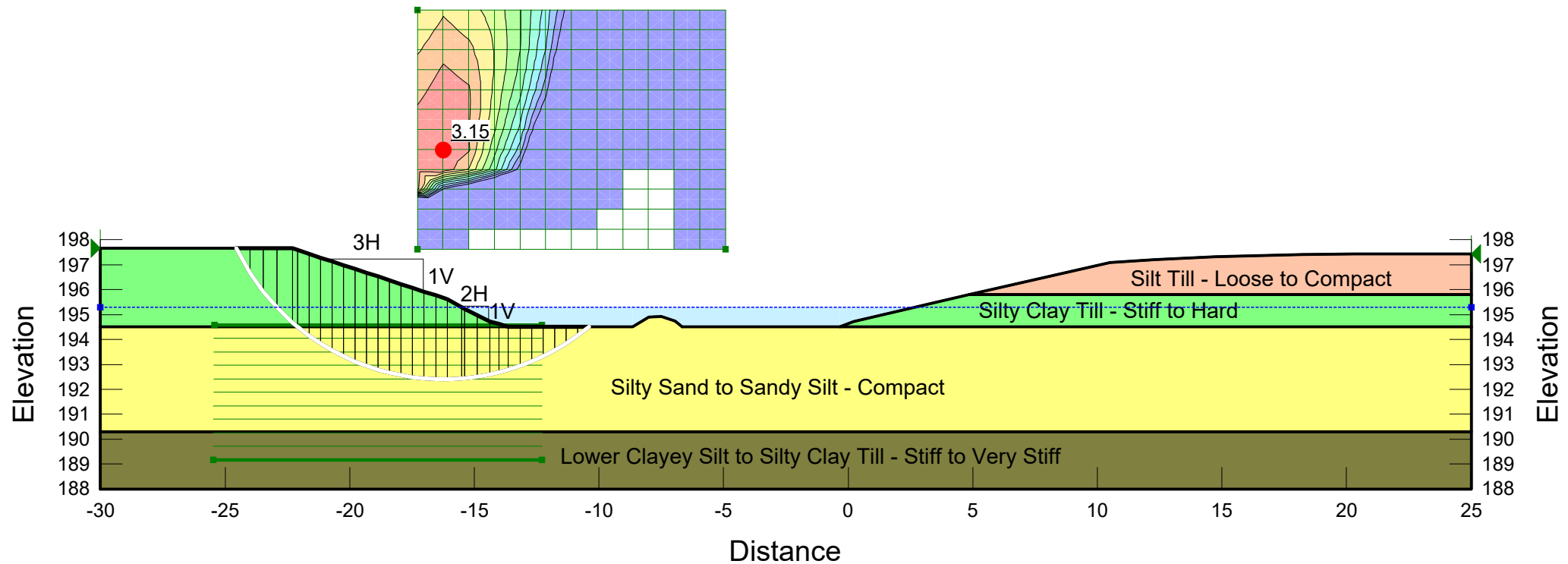
Date: 2018-12-19

Method: Morgenstern-Price

Minimum Slip Surface Depth: 0.5

Horz Seismic Coef.: 0

Sandy Silt Till - Loose to Compact	19 kN/m ³	0 kPa	29 °
Silty Clay Till - Stiff to Hard	20 kN/m ³	50 kPa	0 °
Silty Sand to Sandy Silt - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt to Silty Clay Till - Stiff to Very Stiff	21 kN/m ³	100 kPa	0 °



STATIC STABILITY ANALYSIS - POND 2

RAPID DRAWDOWN CONDITION

FIGURE B3

File Name: Pond 2 - B-B - Rapid Drawdown.gsz

Created By: Cory Zanatta

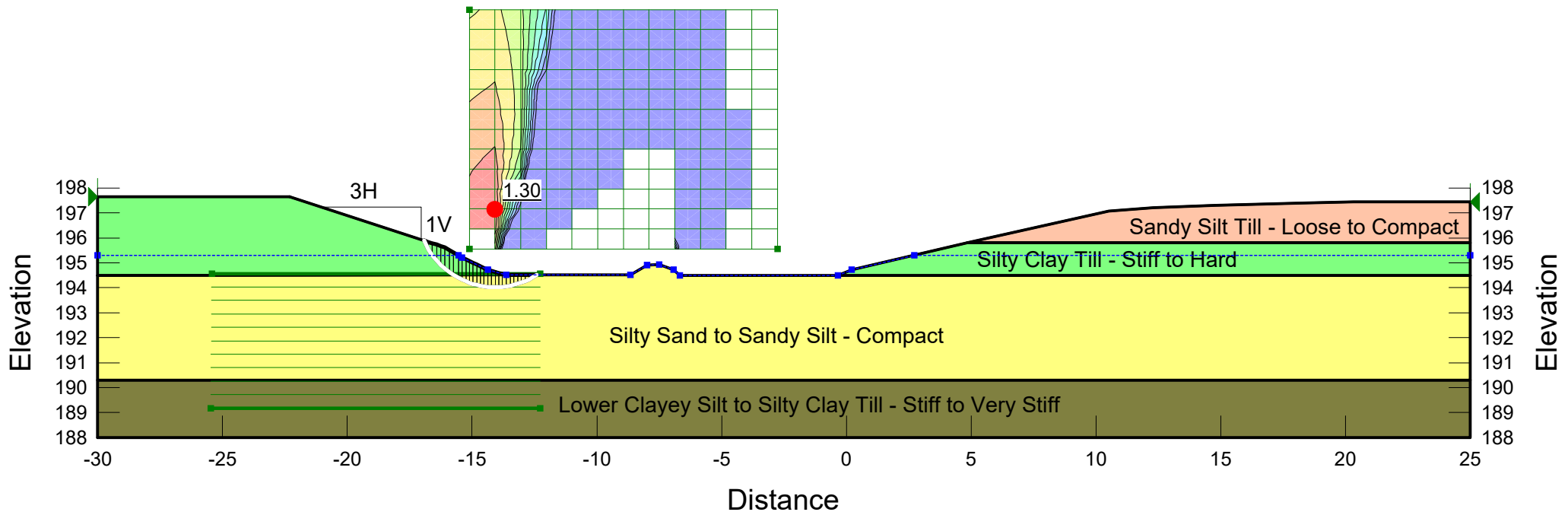
Date: 2018-12-18

Method: Morgenstern-Price

Minimum Slip Surface Depth: 0.5 m

Seismic: 0

Sandy Silt Till - Loose to Compact	19 kN/m ³	0 kPa	29 °
Silty Clay Till - Stiff to Hard	20 kN/m ³	2 kPa	29 °
Silty Sand to Sandy Silt - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt to Silty Clay Till - Stiff to Very Stiff	21 kN/m ³	2 kPa	30 °



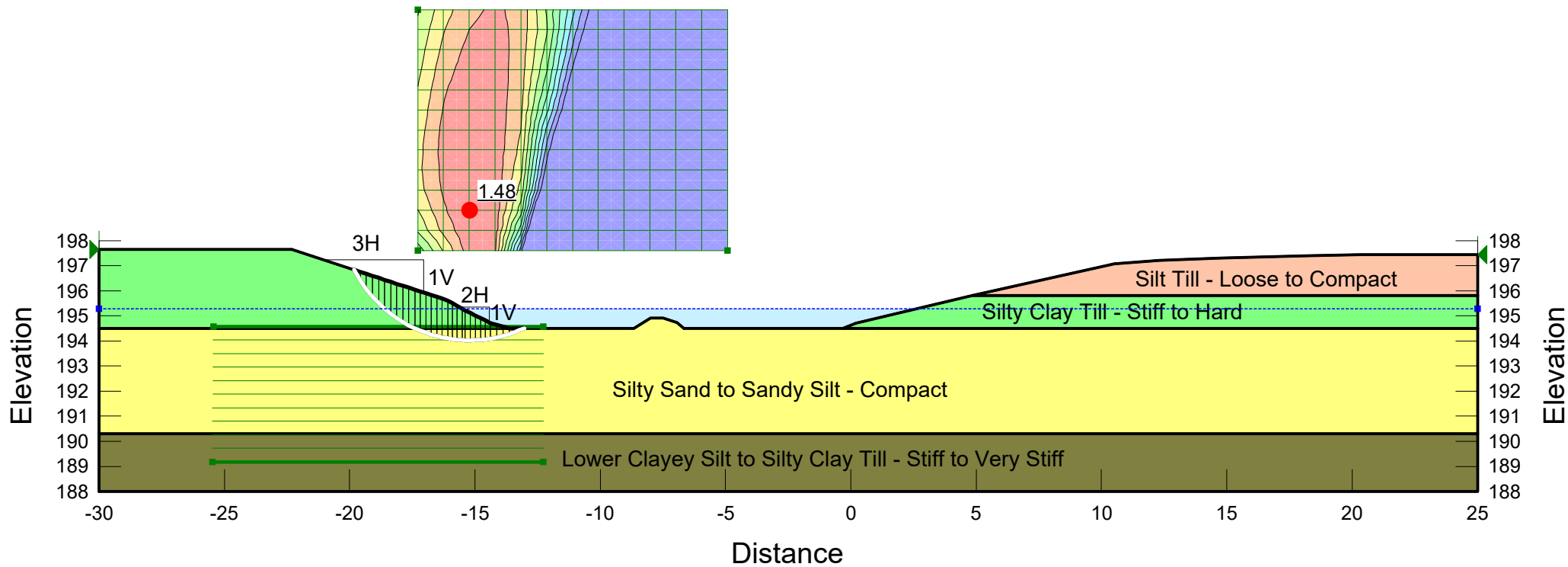
STATIC STABILITY ANALYSIS - POND 2 **SEISMIC CONDITION**

FIGURE B4

File Name: Pond 2 - B-B - Seismic.gsz
 Created By: Cory Zanatta
 Date: 2018-12-20

Method: Morgenstern-Price
 Minimum Slip Surface Depth: 0.5
 Horz Seismic Coef.: 0.045

Sandy Silt Till - Loose to Compact	19 kN/m ³	0 kPa	29 °
Silty Clay Till - Stiff to Hard	20 kN/m ³	2 kPa	29 °
Silty Sand to Sandy Silt - Compact	20 kN/m ³	0 kPa	30 °
Clayey Silt to Silty Clay Till - Stiff to Very Stiff	21 kN/m ³	2 kPa	30 °





Appendix C

SWMPC2-3 - Record of Borehole Sheets

SWMPC2-3 - Laboratory Test Results

SWMPC2-3 - Borehole Locations and Soil Strata Drawing

SWMPC2-3 - Site Photographs

SWMPC2-3 - Selected Results of Slope Stability Analyses

RECORD OF BOREHOLE No SWM C2-3A 1 OF 1 METRIC

GWP# 2930-17-00 LOCATION N 4 859 632.5 E 314 559.1 ORIGINATED BY AF
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.10.01 - 2018.10.01 LATITUDE 43.876600 LONGITUDE -79.378564 CHECKED BY RD

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					
204.6	GROUND SURFACE												
0.0	SAND and GRAVEL , trace silt, trace clay Brown (FILL)												
204.0													
0.6	Silty CLAY , some sand, trace gravel, trace organics Firm Brown Moist (FILL)		1	SS	7								
203.2													
1.4	Sandy SILT , trace gravel Dense Brown Wet		2	SS	36								
202.4													
2.2	Silty CLAY , some sand, trace gravel Very Stiff Brown Moist		3	SS	19								
			4	SS	21								
200.5													
4.1	Silty CLAY , with sand, trace gravel Stiff to Hard Grey Moist to Wet (TILL)		5	SS	9								
			6	SS	18								
			7	SS	56								
196.4													
8.2	END OF BOREHOLE AT 8.2m. WATER LEVEL AT 8.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.												

ONTMT452 MTO-15786.GPJ 2017TEMPLATE(MTO).GDT 2/1/19

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

1 OF 1

ORIGINATED BY AF

HWY	404	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	MP
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DATUM	Geodetic	DATE	2018.10.01 - 2018.10.01	LATITUDE	43.876203	LONGITUDE	-79.378451	CHECKED BY	RD
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+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No SWM C2-3C

1 OF 1

METRIC

GWP# 2930-17-00 LOCATION N 4 859 521.0 E 314 581.1 ORIGINATED BY KK
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.10.21 - 2018.10.21 LATITUDE 43.875597 LONGITUDE -79.378293 CHECKED BY RD

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						
204.2	GROUND SURFACE							20	40	60	80	100		
0.0	ASPHALT (150mm)							20	40	60	80	100		
0.2	SAND and GRAVEL, trace silt, trace gravel Compact Brown Moist (FILL)		1	SS	23		204							
203.4														
0.8			2	SS	12		203							
202.8	Silty CLAY, trace sand, trace gravel, occasional organics and rootlets Stiff Brown Moist (FILL)													
1.4			3	SS	5		202							
	Silty CLAY, trace sand Firm to Very Stiff Brown Moist													
			4	SS	20		202							
			5	SS	18		201							
200.1														
4.1	SAND and SILT, trace gravel Dense Brown Moist		6	SS	37		200							
198.6							199							
5.6	Silty CLAY, with sand, trace gravel Hard Grey Moist (TILL)		7	SS	42		198							
							197							
196.4			8	SS	100/									
7.8	END OF BOREHOLE AT 7.8m. BOREHOLE OPEN AND DRY UPON COMPLETION. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.1m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2018.11.22 7.5 196.7				0.075									

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

RECORD OF BOREHOLE No SWM C2-3D 1 OF 2 METRIC

GWP# 2930-17-00 LOCATION N 4 859 472.9 E 314 590.2 ORIGINATED BY KK
 HWY 404 BOREHOLE TYPE Solid Stem Augers COMPILED BY MP
 DATUM Geodetic DATE 2018.10.21 - 2018.10.21 LATITUDE 43.875163 LONGITUDE -79.378180 CHECKED BY RD

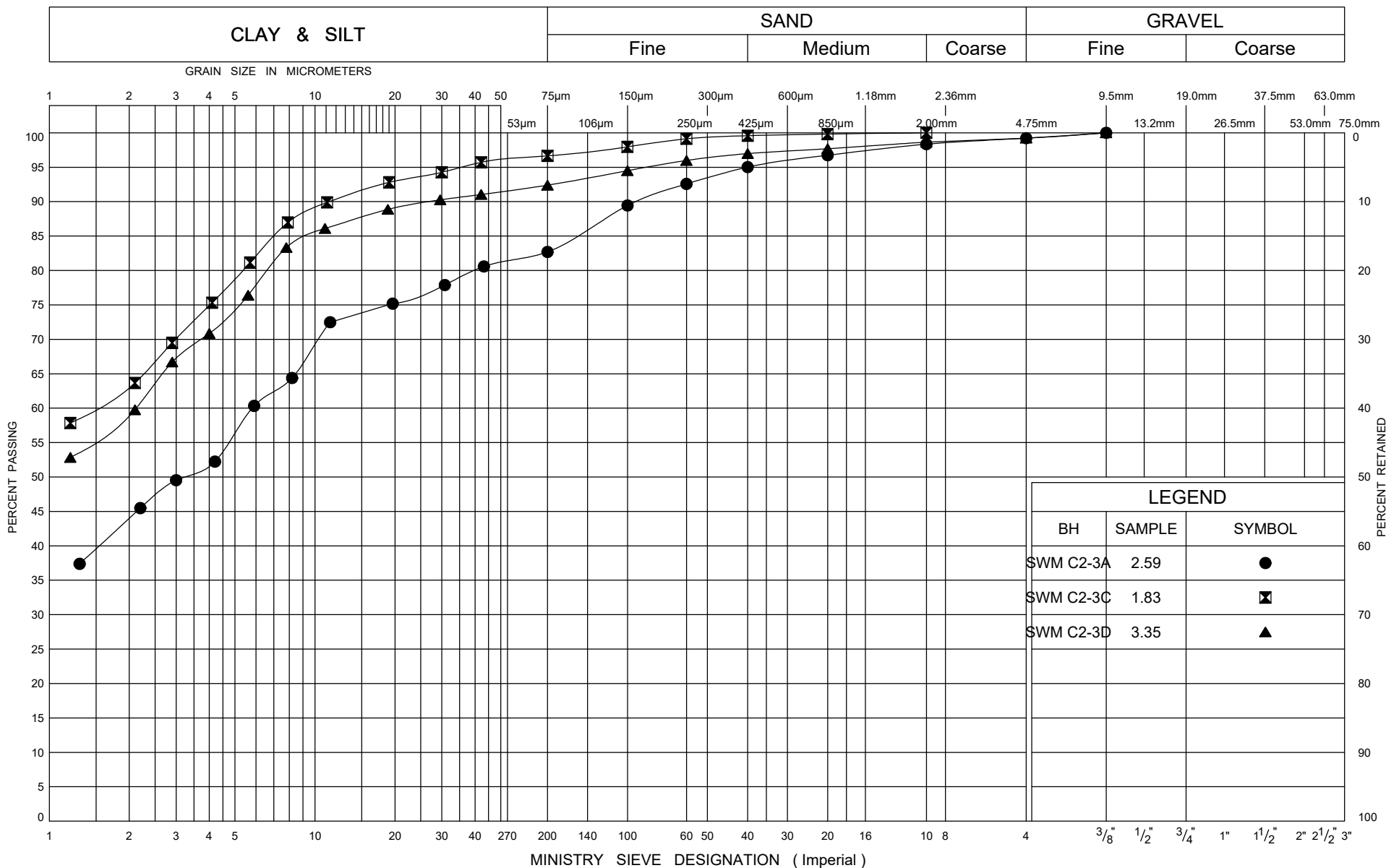
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
203.9	GROUND SURFACE							20	40	60	80	100				
0.0	ASPHALT (50mm)															
203.2	SAND and GRAVEL, trace silt, trace clay Compact Brown Moist (FILL)		1	SS	19											
0.7	Silty CLAY, some sand, trace gravel Stiff Brown Moist (FILL)		2	SS	11											
			3	SS	10											
201.7																
2.2	Silty CLAY, trace sand, trace gravel Stiff to Very Stiff Brown Moist		4	SS	12											
			5	SS	25											
199.8																
4.1	Silty CLAY, with sand, trace gravel Compact to Dense Brown Moist (TILL)		6	SS	11											

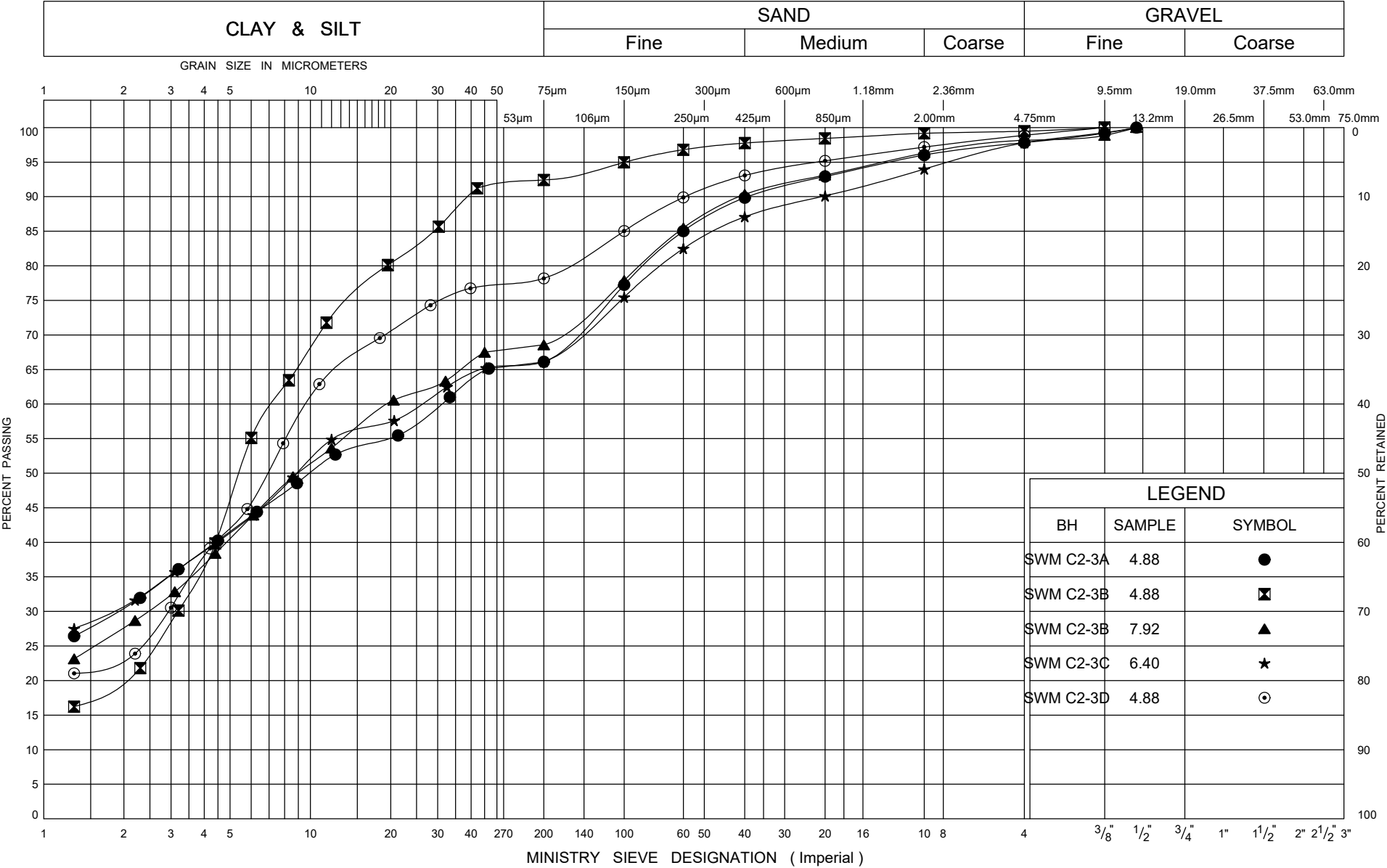
Continued Next Page

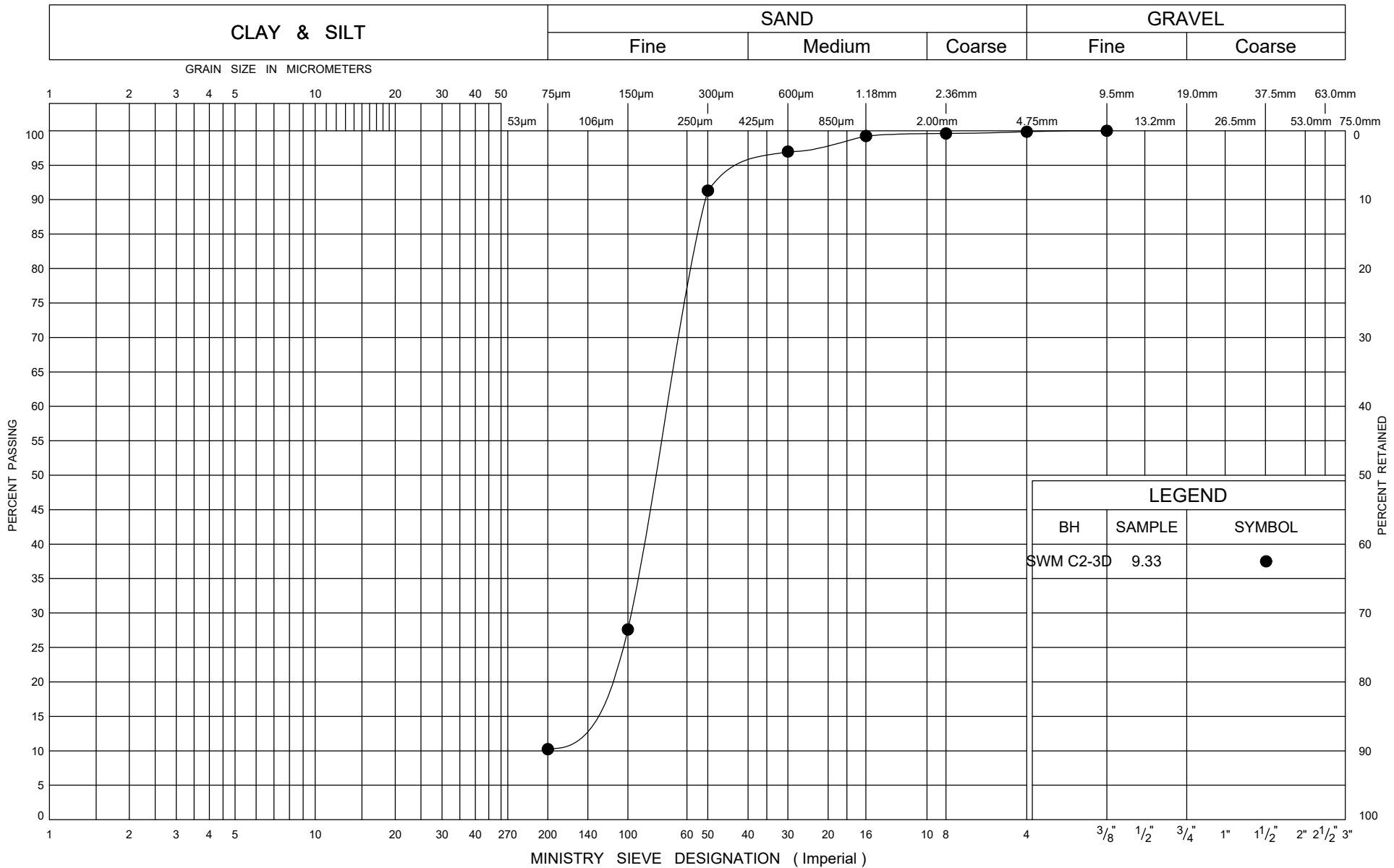
+³, ×³: Numbers refer to
Sensitivity

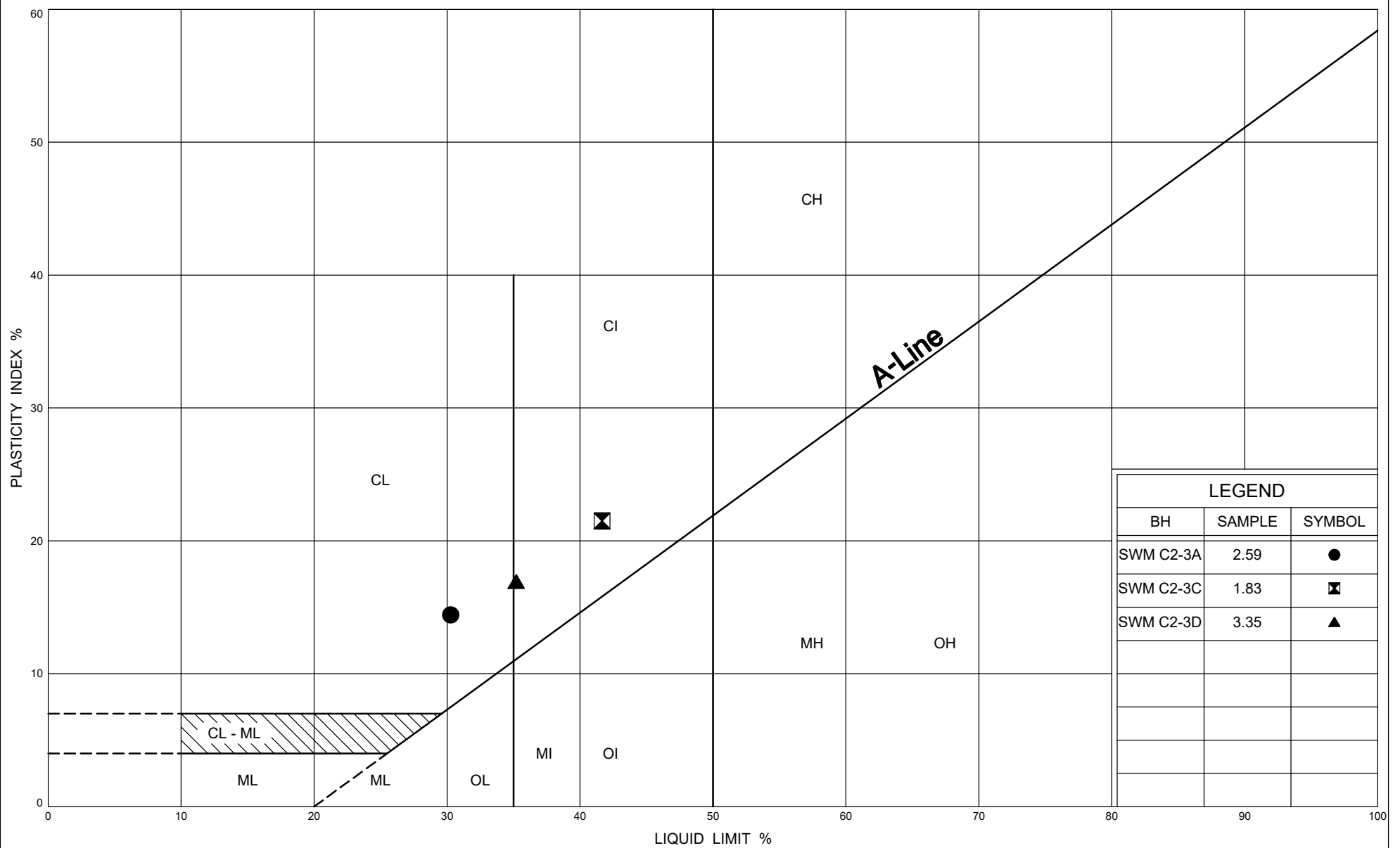
20
15
10

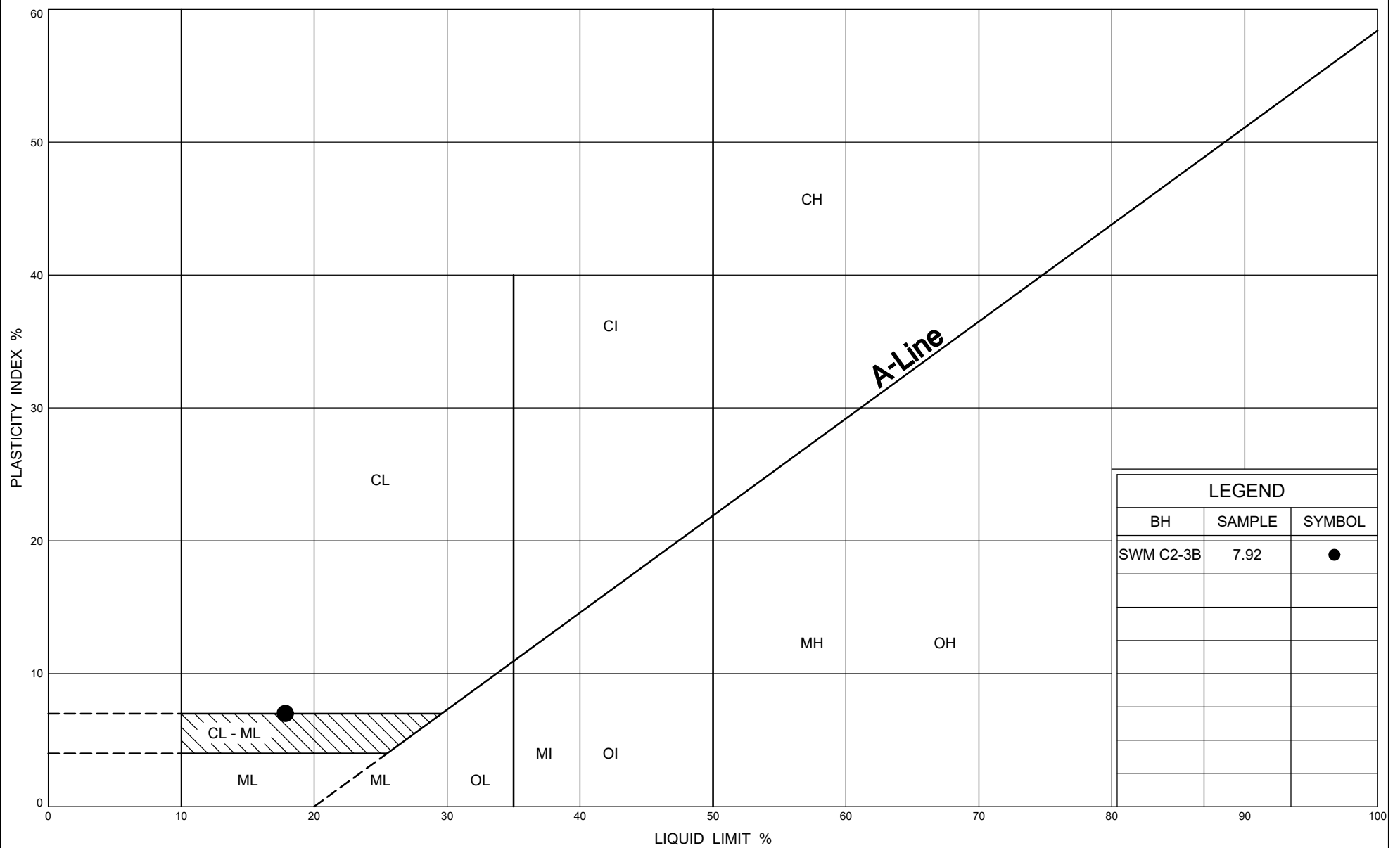
(%) STRAIN AT FAILURE

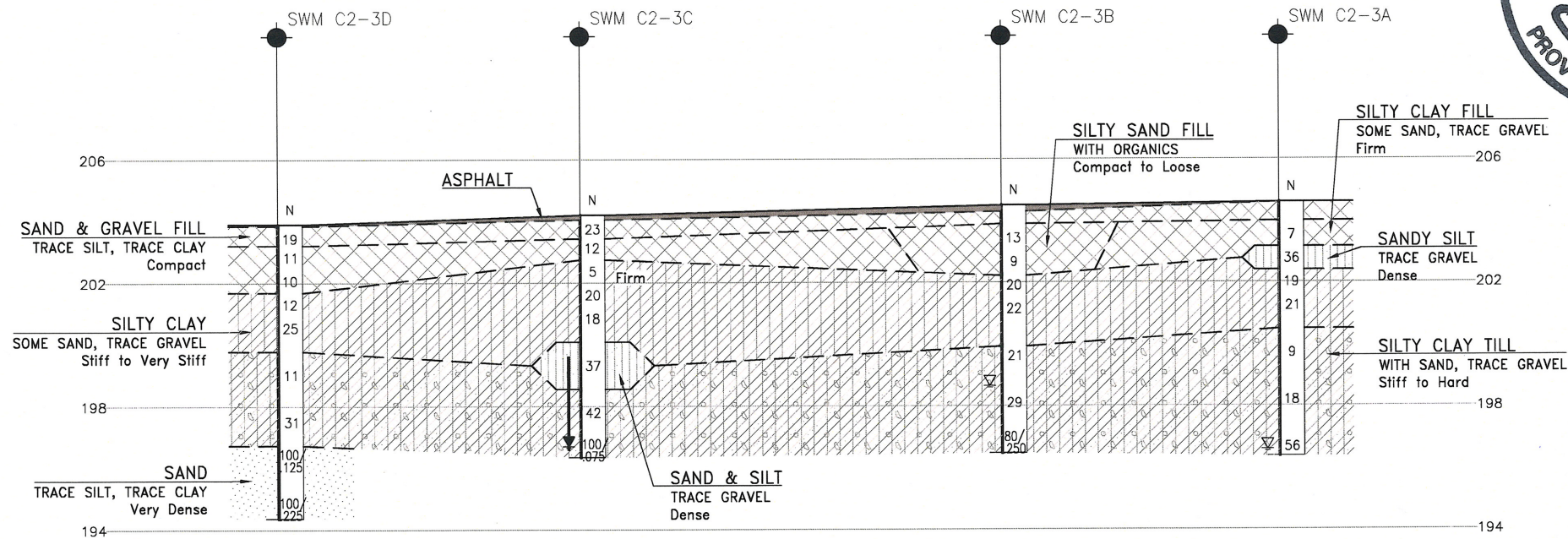
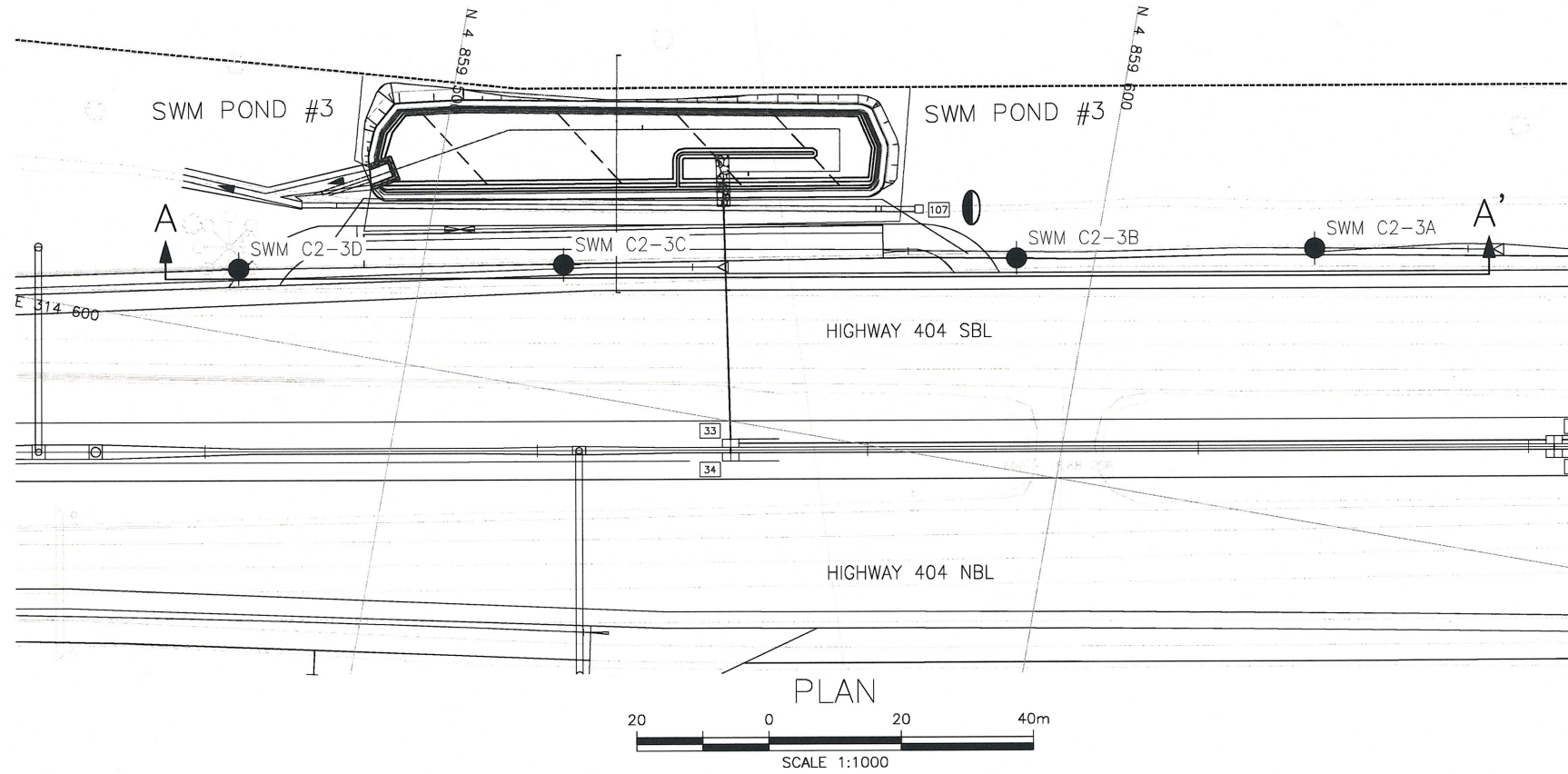












METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



CONT No
GWP No 2930-17-00
HIGHWAY 404 WIDENING
STORM WATER MANAGEMENT
SWM POND 3
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



LEGEND

●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
⌵	Head Artesian Water
⌵	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
SWM C2-3A	204.6	4 859 632.5	314 559.1
SWM C2-3B	204.5	4 859 588.3	314 568.3
SWM C2-3C	204.2	4 859 521.0	314 581.1
SWM C2-3D	203.9	4 859 472.9	314 590.2

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. 30M14-490

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GRL	CHK	SKP
DRAWN	AN	CHK	GRL
LOAD	CODE	DATE	FEB 2019
STRUCT	DWG	1	



Photo 1. – Looking northwest from the Highway 404 southbound lanes towards area of the proposed SWMPC2-3



Photo 2. – Looking southwest from Highway 404 southbound lanes towards the area of the proposed SWMPC2-3

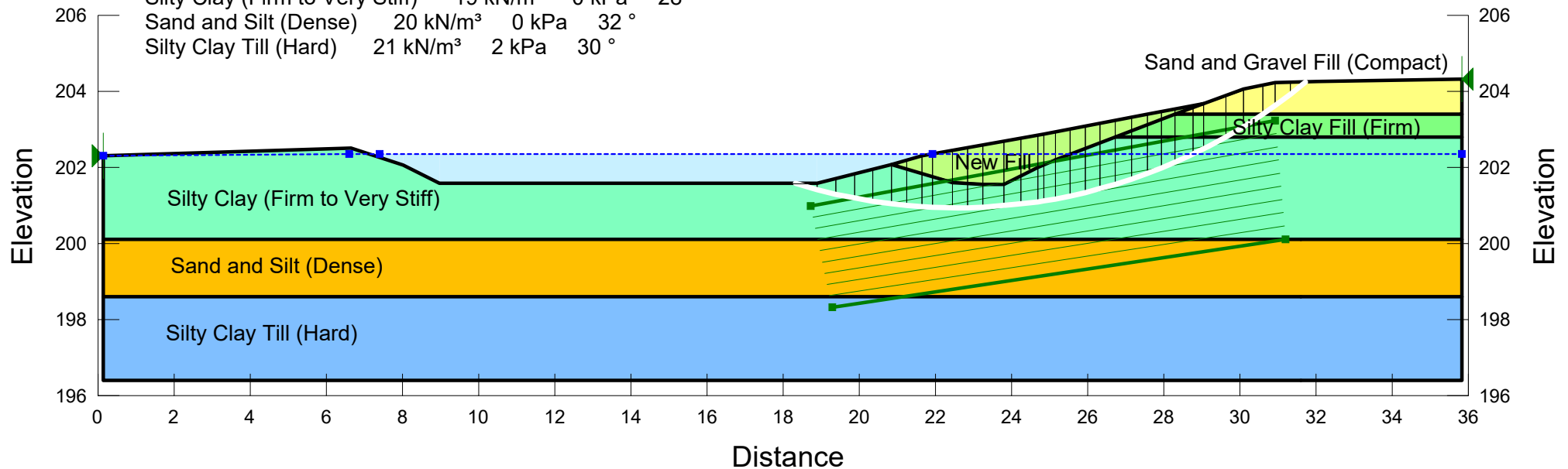
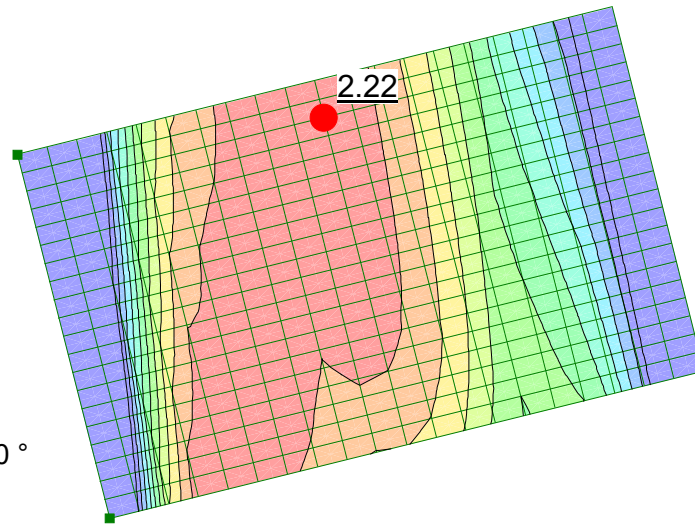
STATIC STABILITY ANALYSIS - POND 3 DRAINED CONDITION

FIGURE C1

File Name: Pond 3 Cross Section BB.gsz
Created By: Cory Zanatta
Date: 2018-12-18

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5 m
Horz Seismic Coef.:

Sand and Gravel Fill (Compact)	20 kN/m ³	0 kPa	30 °
New Fill	20 kN/m ³	0 kPa	30 °
Silty Clay Fill (Firm)	19 kN/m ³	0 kPa	27 °
Silty Clay (Firm to Very Stiff)	19 kN/m ³	0 kPa	28 °
Sand and Silt (Dense)	20 kN/m ³	0 kPa	32 °
Silty Clay Till (Hard)	21 kN/m ³	2 kPa	30 °



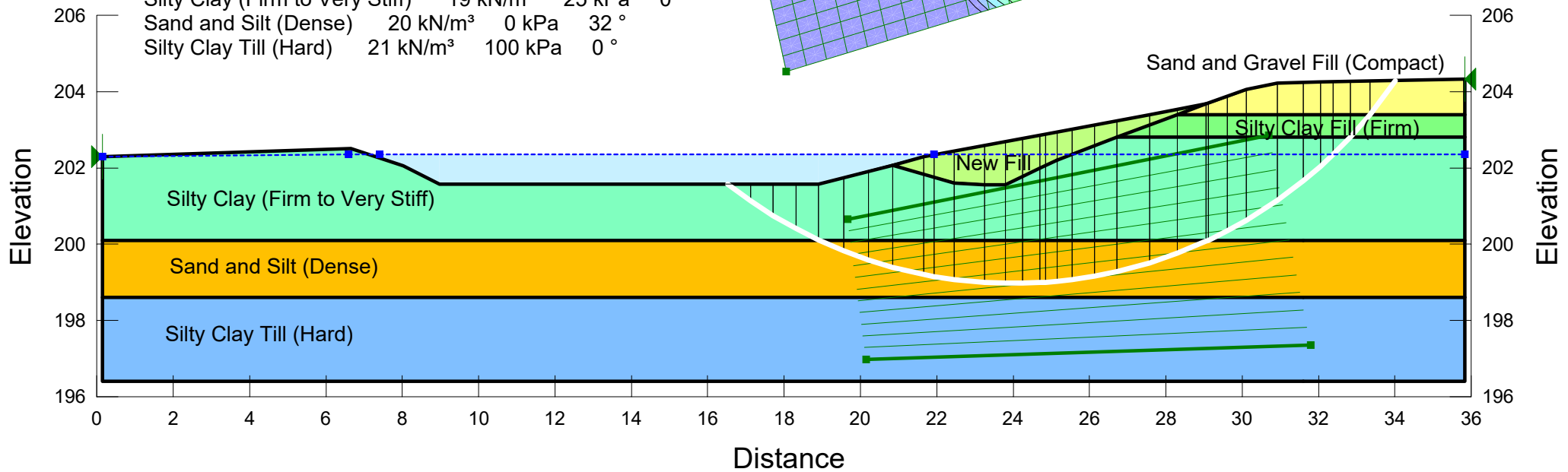
STATIC STABILITY ANALYSIS - POND 3 UNDRAINED CONDITION

FIGURE C2

File Name: Pond 3 Cross Section BB Undrained.gsz
Created By: Cory Zanatta
Date: 2018-12-20

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5 m
Horz Seismic Coef.:

Sand and Gravel Fill (Compact)	20 kN/m ³	0 kPa	30 °
New Fill	20 kN/m ³	0 kPa	30 °
Silty Clay Fill (Firm)	19 kN/m ³	25 kPa	0 °
Silty Clay (Firm to Very Stiff)	19 kN/m ³	25 kPa	0 °
Sand and Silt (Dense)	20 kN/m ³	0 kPa	32 °
Silty Clay Till (Hard)	21 kN/m ³	100 kPa	0 °



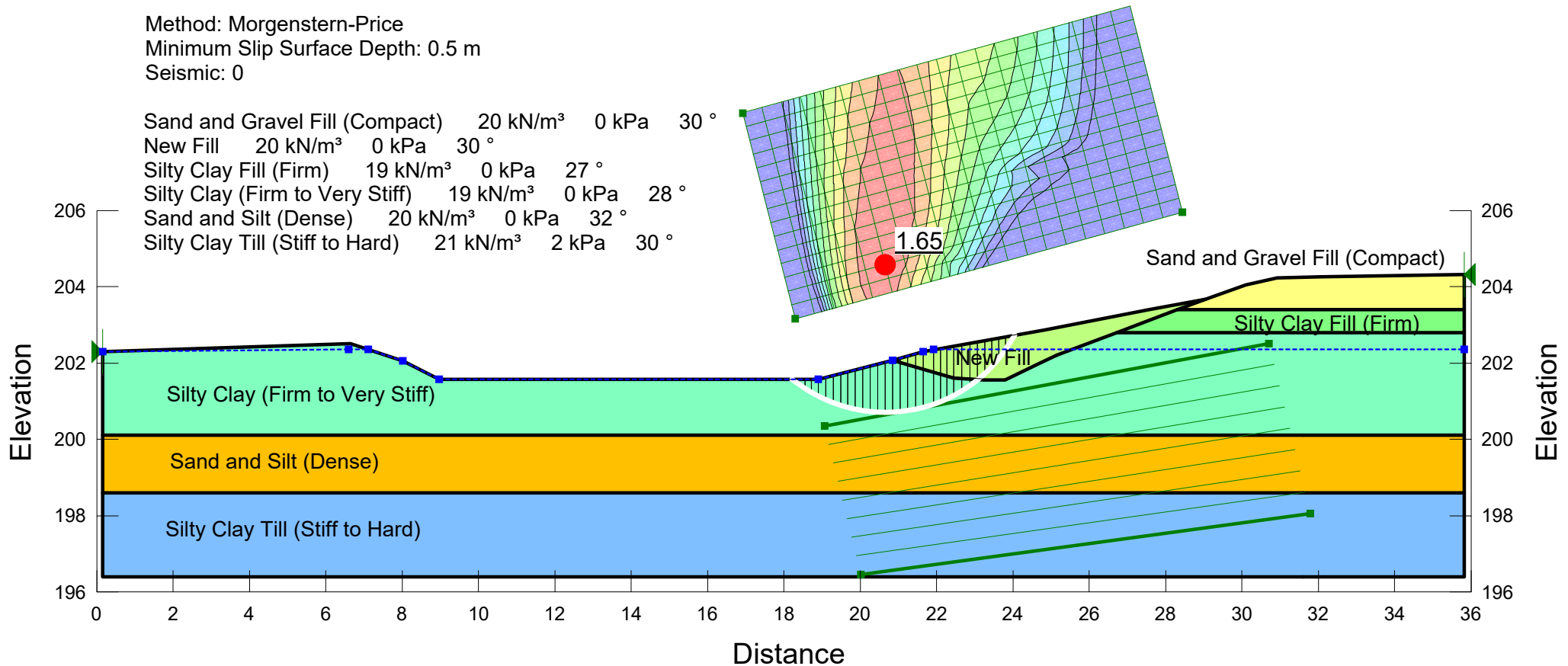
STATIC STABILITY ANALYSIS - POND 3 RAPID DRAWDOWN CONDITION

FIGURE C3

File Name: Pond 3 Cross Section BB - Rapid Drawdown.gsz
Created By: Cory Zanatta
Date: 2018-12-18

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5 m
Seismic: 0

Sand and Gravel Fill (Compact)	20 kN/m ³	0 kPa	30 °
New Fill	20 kN/m ³	0 kPa	30 °
Silty Clay Fill (Firm)	19 kN/m ³	0 kPa	27 °
Silty Clay (Firm to Very Stiff)	19 kN/m ³	0 kPa	28 °
Sand and Silt (Dense)	20 kN/m ³	0 kPa	32 °
Silty Clay Till (Stiff to Hard)	21 kN/m ³	2 kPa	30 °



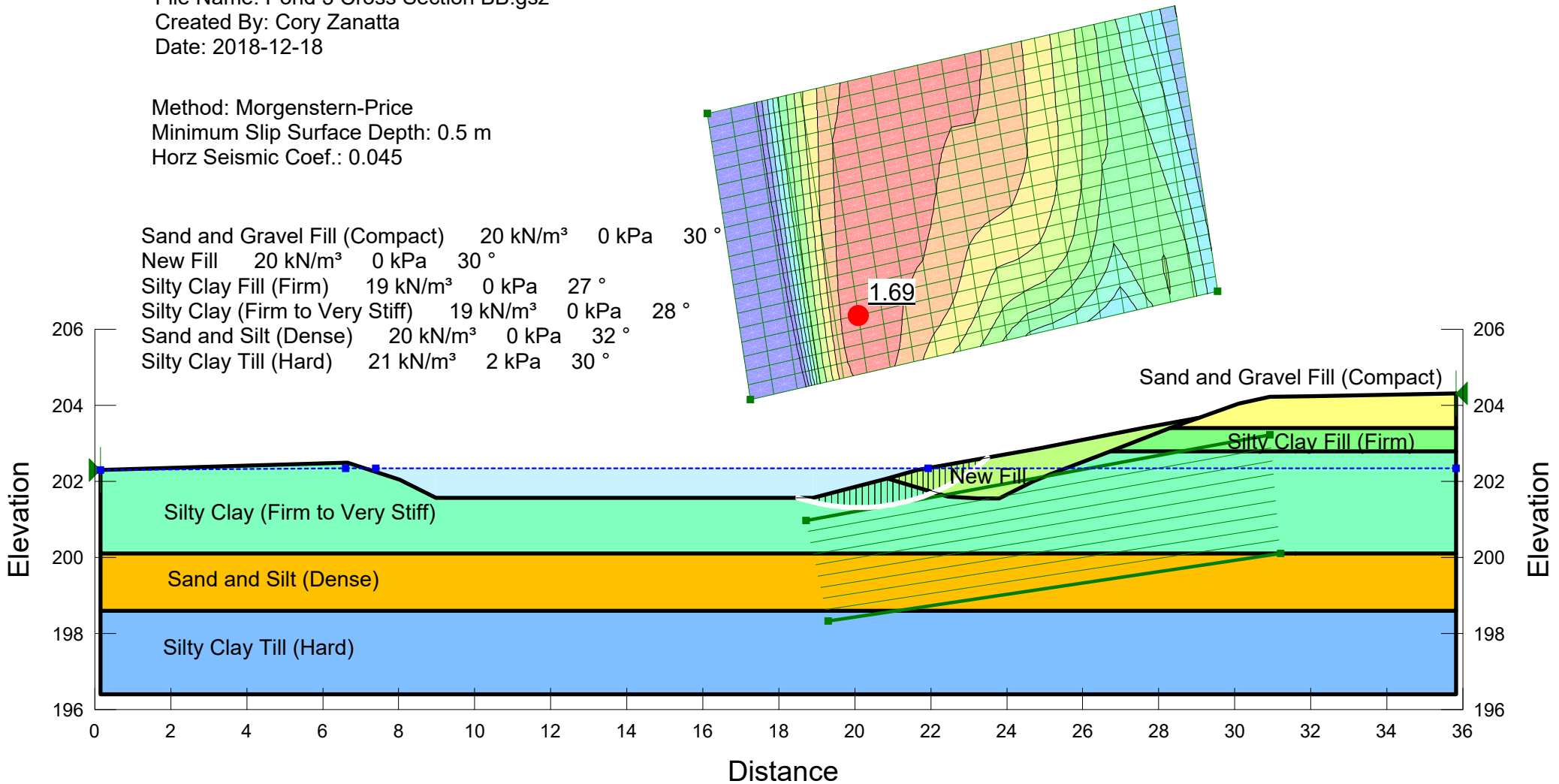
STATIC STABILITY ANALYSIS - POND 3 SEISMIC CONDITION

FIGURE C4

File Name: Pond 3 Cross Section BB.gsz
Created By: Cory Zanatta
Date: 2018-12-18

Method: Morgenstern-Price
Minimum Slip Surface Depth: 0.5 m
Horz Seismic Coef.: 0.045

Sand and Gravel Fill (Compact)	20 kN/m ³	0 kPa	30 °
New Fill	20 kN/m ³	0 kPa	30 °
Silty Clay Fill (Firm)	19 kN/m ³	0 kPa	27 °
Silty Clay (Firm to Very Stiff)	19 kN/m ³	0 kPa	28 °
Sand and Silt (Dense)	20 kN/m ³	0 kPa	32 °
Silty Clay Till (Hard)	21 kN/m ³	2 kPa	30 °





Appendix D
List of SPs and OPSSs, Suggested Wording for NSSP



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

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 517
- OPSS.PROV 804
- OPSS.PROV 902 and NSSP FOUN0003

2. Suggested Text for NSSP on “Groundwater Control During Construction”

It is important to note that construction of the new pond will require excavation through clayey silt till, clayey sand and silt till, and gravelly sand. The groundwater level varies between different sites but is up to 4 m above the proposed base of the pond at some locations. Effective dewatering systems shall be implemented during construction to minimize the risk of basal and surficial slope instability due to water seepage, and to maintain a reasonably dry work area. Reference shall be made to OPSS.PROV 517 and NSSP FOUN0003 for dewatering system design where required. Granular sheeting or other measures will be required at the locations where persistent water seepage from the exposed sands and silts could result in surficial and basal instability. The dewatering should be supplemented by pumping from filtered sumps within the excavation.

The Contractor shall be responsible to retain a dewatering specialist/consultant for designing, installing and operating any dewatering / groundwater control systems that may be required as outlined above.

3. Suggested Text for NSSP on “Construction Inspection”

Construction inspection shall carry out tasks that include, but are not limited to, the following:

- 1) Inspect periodically, or as required, during construction to confirm that the adjacent highway embankments remain stable at all times.
- 2) Inspect periodically, or as required, to confirm stability of the pond excavation base and sideslopes throughout construction.

All findings shall be reported at least on a daily basis, or as necessary, to the Contract Administrator (CA) before leaving the site.