



THURBER ENGINEERING LTD.



**FOUNDATION INVESTIGATION AND DESIGN REPORT
STORMWATER MANAGEMENT POND
HIGHWAY 400 AND LLOYDTOWN-AURORA ROAD INTERCHANGE
HIGHWAY 400 WIDENING
TOWNSHIP OF KING, ONTARIO
G.W.P. 2085-15-00**

GEOCRES No. 31D-680

Report

to

WSP

Date: August 2, 2017
File: 12187

TABLE OF CONTENTS

PART 1: FACTUAL INFORMATION

1.	INTRODUCTION	1
2.	SITE DESCRIPTION	1
3.	INVESTIGATION PROCEDURES	2
4.	LABORATORY TESTING	3
5.	DESCRIPTION OF SUBSURFACE CONDITIONS	3
5.1	Topsoil.....	4
5.2	Surficial Clayey Silt	4
5.3	Surficial Sandy Silt.....	4
5.4	Sand and Silt Till.....	4
5.5	Sand.....	5
5.6	Sandy Silt	6
5.7	Silty Clay Till.....	6
5.8	Groundwater Conditions	7
6.	MISCELLANEOUS	8

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7.	GENERAL.....	10
8.	STORMWATER MANAGEMENT POND DESIGN	11
8.1	Pond Design Criteria.....	11
8.2	Stability Analysis Methodology	11
9.	SLOPE STABILITY ANALYSIS OF POND.....	12
9.1	General.....	12
9.2	Selected Cases for Stability Analysis	12
9.3	Pond Design and Construction	13
10.	CONSTRUCTION CONCERNS.....	14
11.	CLOSURE	15



APPENDICES

Appendix A	Record of Borehole Sheets
Appendix B	Laboratory Test Results
Appendix C	Borehole Locations and Soil Strata Drawing
Appendix D	Site Photographs
Appendix E	Selected Results of Slope Stability Analyses
Appendix F	List of SPs and OPSSs, Suggested Wording for NSSP

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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 a proposed Stormwater Management Pond (SWMP) located at the northwest quadrant of the Highway 400 and Lloydtown-Aurora Road interchange in the Township of King, Ontario. This pond is a part of the Ministry of Transportation Ontario (MTO) Highway 400 widening project that includes accommodation of the ultimate 10-lane configuration including two HOV lanes in each direction, within the current MTO right-of-way.

The purpose of this investigation was to explore the subsurface conditions in the vicinity of the proposed SWMP and, based on the data obtained, to provide a borehole locations and soil strata drawing, 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 / MMM Group (WSP / MMM) under MTO Assignment Nos. 2015-E-0008.

2. SITE DESCRIPTION

The site is located on the west side of the Highway 400 southbound lanes (SBL) and north of Lloydtown-Aurora Road in the Township of King, Ontario. The site of the proposed SWMP is situated within agricultural lands and the terrain is relatively flat.

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

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

The project area is located within the transition zone between the physiographic regions known as the South Slope and the Oak Ridges Moraine. The South Slope is comprised predominantly of the Halton Till which is an interbedded complex of clayey silt to silt till and sand. This till comprises a slightly hummocky till plain into which the surface watercourses have eroded 10 to 15 m deep gullies. The Oak Ridges Moraine is comprised of till overlying sands and gravels, sometimes with artesian conditions, in this area.

3. INVESTIGATION PROCEDURES

The field investigation for this project was carried out on May 11 and 12, 2017 and consisted of drilling and sampling three boreholes (numbered LAP-01 to LAP-03) advanced within the footprint of the proposed SWMP.

Prior to the start of drilling, the borehole locations were marked/staked in the field and utility clearances were obtained. The co-ordinates and elevations of the as-drilled boreholes were subsequently provided by WSP / MMM. The approximate locations of the boreholes are shown on Borehole Locations and Soil Strata drawings included in Appendix C. The coordinates and elevations of these boreholes are given on this drawing and on the individual Record of Borehole Sheets in Appendix A.

A track-mounted drill rig was used to drill and sample the boreholes. Solid 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 and B.

Groundwater conditions were observed in the open boreholes throughout the drilling operations. Standpipe piezometers were installed in two of the boreholes (Boreholes LAP-02 and LAP-03) to permit monitoring of the groundwater levels at the site. Each standpipe piezometer consisted of a 19 mm diameter PVC pipe, with a slotted screen sealed at selected depths within the boreholes. The borehole, in which no standpipe piezometer was installed, was backfilled in general accordance with Ontario Regulation 903 (O.Reg. 903). After the final water level readings are

taken, the piezometers will be decommissioned in general accordance with O.Reg. 903. Details of the 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)	
LAP-01	9.5 / 290.4	None installed		Borehole backfilled with bentonite holeplug and auger cuttings to surface.
LAP-02	9.5 / 291.6	9.1 / 292.0	6.0 – 9.5/ 295.1 – 291.6	Borehole backfilled with sand filter from 9.5 m to 6.0 m, bentonite holeplug from 6.0 m to 0.6 m, then bentonite holeplug and auger cuttings from 0.6 m to surface.
LAP-03	9.4 / 291.8	9.1 / 292.1	6.7 – 9.4/ 294.5 – 291.8	Borehole backfilled with sand filter from 9.4 m to 6.7 m, bentonite holeplug from 6.7 m 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 in Appendix A and are presented on the figures included in Appendix B.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

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” drawings in Appendix C. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond borehole locations. More detailed descriptions of the individual strata are presented below.

In general, the subsurface conditions encountered in the boreholes consisted of topsoil overlying surficial layers of native clayey silt and sandy silt. Sand and silt till was contacted immediately below the surficial soils. Layers of sand and sandy silt were encountered below the cohesionless till. A cohesive silty clay glacial till deposit was encountered below the sands and silts.

5.1 Topsoil

A 50 mm thick veneer of topsoil was encountered surficially in all boreholes. The thickness of the topsoil may vary between and beyond borehole locations.

5.2 Surficial Clayey Silt

A 650 mm thick layer of brown clayey silt containing some sand and occasional organics was contacted below the topsoil in Borehole LAP-01.

An SPT 'N' value measured in the clayey silt was 7 blows per 0.3 m penetration indicating a firm consistency. A moisture content of 22 percent was measured for a sample.

5.3 Surficial Sandy Silt

A surficial layer of sandy silt containing trace clay, trace gravel and occasional organics, was contacted below the topsoil in Boreholes LAP-02 and LAP-03. The thickness of this soil was 650mm.

SPT 'N' values measured in the surficial sandy silt were 8 and 10 blows per 0.3 m penetration, indicating a loose to compact state. Moisture contents measured in the surficial sandy silt were 17% and 26%.

5.4 Sand and Silt Till

A deposit of brown to grey sand and silt till containing some clay and trace gravel was contacted in the three boreholes immediately below the surficial soils. The thickness of the sand and silt till ranged from 2.2 m to 2.3 m. The depth to the base of the sand and silt till varied from 2.9 m to 3.0m (Elevations 297.0 to 298.2).

SPT 'N' values measured in the sand and silt till typically ranged from 13 to 46 blows per 0.3 m of penetration indicating a compact to dense state. One 'N' value of 51 blows measured in Borehole LAP-02 indicated a very dense zone. The moisture content in the sand and silt till varied from 9 percent to 18 percent.

The results of grain size distribution analyses carried out on selected samples of the sand and silt till are presented on the Record of Borehole sheets included in Appendix A and on Figure B1 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0 to 1
Sand	51 to 53
Silt	35 to 44
Clay	4 to 13

Glacial tills inherently contain cobbles and boulders.

5.5 Sand

A deposit of brown to grey sand containing trace to some silt and trace clay was contacted below the sand and silt till in the three boreholes. The thickness of the sand layer varied between 1.1 m in Boreholes LAP-03 and 6.1 m in Borehole LAP-02. The depths to the base of the sand were 5.2 m and 4.1 m (Elevations 294.7 and 297.1) in Boreholes LAP-01 and LAP-03, respectively; and 9.1 m (Elevation 292.0) in Borehole LAP-02.

A lower layer of sand was contacted in Borehole LAP-01 at 8.7 m depth. Borehole LAP-01 was terminated within this layer at 9.5 m depth (Elevation 290.4).

SPT 'N' values obtained in the sand layers ranged between 49 blows per 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration indicating dense to very dense conditions. An SPT 'N' value of 27 blows per 0.3 m of penetration, indicating a compact state, was measured in Borehole LAP-03 near Elevation 297.8. Measure moisture contents in the sand were between 16 percent and 20 percent.

The results of grain size distribution analyses carried out on selected samples of the sand are presented on the Record of Borehole sheets included in Appendix A and on Figure B2 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	88 to 91
Silt	7 to 10
Clay	2

5.6 Sandy Silt

A layer of brown sandy silt containing some clay was contacted below the sand, at 4.1 m depth in Borehole LAP-03. The thickness of the sandy silt was 3.1 m. The depth to the base of the sandy silt was at 7.2 m (Elevation 294.0).

SPT 'N' values measured in the sandy silt were 64 and 93 blows per 0.3 m penetration, indicating a very dense condition. Measure moisture contents in the sandy silt were 17 percent and 19 percent.

The results of grain size distribution analyses carried out a sample of the sandy silt are presented on the Record of Borehole sheets included in Appendix A and on Figure B3 of Appendix B. The results of the grain size distribution analyses are summarized below:

Soil Particle	Percentage (%)
Gravel	0
Sand	23
Silt	65
Clay	12

5.7 Silty Clay Till

Grey silty clay till with sand was encountered below the soils described above at depths ranging from 5.2 m to 9.1 m. The thickness of the silty clay till was 3.5 m in Borehole LAP-01. The depth to the base of the silty clay till was at 8.7 m (Elevation 291.2) in Borehole LAP-01. Boreholes LAP-02 and LAP-03 were terminated within the silty clay till at 9.5m and 9.4 m depths (Elevations 291.6 and 291.8), respectively.

SPT 'N' values obtained in the silty clay till typically ranged from 96 blows for 0.3 m penetration to greater than 100 blows for less than 0.3 m of penetration indicating a hard consistency. An SPT 'N' value of 25 blows per 0.3 m of penetration, indicating a very stiff consistency, was measured in Borehole LAP-03 near Elevation 293.3. Moisture contents of the silty clay till ranged from 11 percent to 16 percent.

The results of grain size analyses conducted on a silty clay till sample are presented on the Record of Borehole sheets in Appendix A, and are illustrated in Figure B4 of Appendix B. The laboratory test results are summarized in the following table.

Soil Particle	Percentage (%)
Gravel	0
Sand	33
Silt	43
Clay	24

The results of Atterberg Limits tests conducted on a sample of the silty clay till are provided on the Record of Borehole sheets in Appendix A and illustrated in Figure B5 of Appendix B. The results are summarized as follows:

Index Property	Percentage (%)
Plasticity Index	11
Liquid Limit	24

The results of the Atterberg Limits testing indicate that this till is of low plasticity with a group symbol CL.

Glacial tills inherently contain cobbles and boulders.

5.8 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 Boreholes LAP-02 and LAP-03 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 5-1. Measured Groundwater Levels

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
LAP-01	May 11, 2017	2.3	297.6	Open borehole
LAP-02	May 12, 2017	3.7	297.4	Open borehole Piezometer
	May 19, 2017	2.0	299.1	
	June 23, 2017	1.4	299.7	
LAP-03	May 11, 2017	3.4	297.8	Open borehole Piezometer
	May 19, 2017	2.4	298.8	
	June 23, 2017	2.2	299.0	

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 / MMM provided the northing and easting coordinates and ground surface elevations.

DBW Drilling Ltd. of Ajax, 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 Mr. Abdul Nasri 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 Ms. R. Palomeque Reyna, P. Eng. and Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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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 a Stormwater Management Pond (SWMP) to be located at the northwest quadrant of the Highway 400 and Lloydtown-Aurora Road interchange in the Township of King, 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.

The general arrangement drawing of the proposed pond, plans, and profiles related to the slopes adjacent to the pond have been provided by WSP / MMM. Based on this information, the essential features of the new pond are summarized as follows:

- The proposed pond is currently designed to have two permanent pond facilities (Cells 1 and 2) and a sediment forebay, each one of them separated by berms.
- The base of Cells 1 and 2 will be at Elevation 298.0 m, some 1.8 m to 2.8 m depths below the existing ground surface. The base of the sediment forebay will be at Elevation 297.5, approximately 3.2 m to 3.5 m depths below existing ground surface. The highest design water level in the Cells 1 and 2 ranges between Elevations 299.6 and 299.0.

- The pond is irregularly shaped with an overall longitudinal dimension of approximately 115m (north–south), and a transverse dimension of about 60 m.
- The current design uses a 5H : 1V finished slope along the perimeter of the pond. The berms separating the permanent ponds and the sediment forebay will have 3H : 1V side slopes.
- Along the east side, the edge of the pond will be at or greater than 10 m from the toe of the proposed realigned Ramp N-EW embankment.

It is understood that the SWMP will function as a wet pond, i.e. a water level is to be continually maintained.

The discussions and recommendations presented in this report are based on project information provided by WSP / MMM 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 and their implication to water retention. A liner would be required at the base and sideslopes of the pond which coincides with relatively permeable soils such as sands and silts.

Based on information provided by WSP / MMM, the design crest elevation along the outer perimeter of the pond ranges between approximate Elevations 300.4 and 300.8 m. The design base of the pond is irregularly shaped and the deepest portions are designed to be at approximate Elevations 298.0 m and 297.5 m, for the proposed Cells 1 and 2 (permanent pond) and sediment forebay, respectively. The maximum depth of cut of the pond would be up to the order of 3.5 m.

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, past experience of slope and embankment performance and site specific conditions, a criterion of a minimum Factor of Safety (F.S.) of 1.3 against global slope instability has been used in this report.

9. SLOPE STABILITY ANALYSIS OF POND

9.1 General

The borehole results indicate that the subsurface condition at the SWMP location typically consists of surficial loose to compact sandy silt or firm clayey silt, overlying compact to dense sand and silt till, and dense to very dense sand to sandy silt. The site is underlain by very stiff to hard silty clay till at depth. The groundwater levels were measured at approximate Elevation 299.

The proposed SWMP design will involve excavations through the surficial sand silt to clayey silt into the sand and silt till. The sand deposit underlying the till may be exposed at some locations.

9.2 Selected Cases for Stability Analysis

Representative cross-sections of the pond side slopes have 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.

Selected 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 F.S.'s 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
Sediment forebay Slope 5H:1V	Drained	> 2	-
	Rapid Drawdown	2.0	E1
	Seismic	1.4	E2
Berm Slope 3H:1V	Drained	> 3	-
	Rapid Drawdown	2.9	E3
	Seismic	2.1	E4
Pond adjacent to new Ramp N-W	Drained	3.0	E5
	Seismic	2.2	E6

Figures E1 to E6 in Appendix E present selected stability analysis results of representative rapid drawdown cases. The soil properties assumed in the analyses are shown on these figures.

Results of the above analyses indicate that adequate factors of safety will be maintained for global stability of the pond slopes.

9.3 Pond Design and Construction

Based on the above and from a foundation/geotechnical engineering perspective, the design of the SWMP slopes as currently considered by WSP / MMM should satisfy global stability requirements.

Construction of the new pond will require excavation through the loose to compact sandy silt or firm clayey silt, into the compact to dense sand and silt till, and dense to very dense sand to sandy silt. The groundwater level at this site is up to 1 m to 2 m above the proposed base of the pond. Dewatering will be required during construction to minimize the risk of excavation basal instability primarily due to water seepage and to maintain a reasonably dry work area. The dewatering should be supplemented by pumping from filtered sumps within the excavation. The dewatering requirement at this site is categorized as typical given the size of the work area and the water head under consideration. Reference should be made to OPSS.PROV 517 for dewatering system design. Any dewatering systems that may be required is the responsibility of the Contractor, who should retain a dewatering specialist/consultant to undertake the design and implementation. Suggested wordings of an NSSP on groundwater control during construction is included in Appendix F.

The silts and silty sands that will be exposed on the pond sideslopes have a high erodibility rating. Gravel sheeting (MTO Construction Manual – e.g. 0.3 to 0.6 m thick Granular B placed evenly over slope surface) or other measures will be required on the sideslopes at locations where persistent water seepage from the exposed sands and silts could result in gullyng and instability.

The current design information also indicates that the existing Ramp N-EW will be realigned to accommodate the easterly perimeter of the pond.

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

It is anticipated that the sand and silt till will be exposed across the pond sideslopes and the underlying sand will be exposed at some locations within the pond base. These sands and silts have relatively high hydraulic conductivities and, will be causes of leakage. For design purposes, the following hydraulic conductivities may be assumed:

- Sand (10^{-2} to 10^{-3} cm/s)
- Sand and Silt Till (10^{-4} to 10^{-6} cm/s)

It is understood that the SWMP is designed to be a wet pond. Therefore, a head of water will need to be maintained in the pond at all times. The sands and silts at the pond base and the sideslopes are unsuitable for water retention. It is therefore recommended that a compacted clay liner or a geosynthetic clay liner be placed on the anticipated wet surface inside the pond. A typical compacted clay liner should be approximately 0.5 m in thickness. The design of the liner should take into consideration the potential buoyant effects at the base and lower sideslopes of the pond.

The excavated sands and silts have relatively high hydraulic conductivities and may be too wet for adequate compaction. Should consideration be given to reusing on site as general fill, these sands and silts may be dried where practicable prior to placement and compaction.

All new earth fill, where required, should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. Vegetation cover should be established on all exposed slopes to protect against surficial erosion in accordance with OPSS.PROV 804.

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.

- Surficial sandy silt and clayey silt (Type 4)
- Sand and Silt Till (Type 3)
- Sand to Sandy Silt (below water table) (Type 4)

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.

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:

- The water-bearing sands and silts will be exposed at the pond base and on the sideslopes; therefore, 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 surficial slope instability.
- The pond base and sideslopes should be inspected periodically, or as required, to confirm stability.

Suggested wordings on an NSSP on construction inspection is included in Appendix F.

11. CLOSURE

Engineering analysis and preparation of this foundation design report was carried out by Ms. R. Palomeque Reyna, P. Eng., and Dr. Sydney Pang, P.Eng. The report was reviewed by Dr. P. K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

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

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


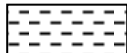



 Water Level
 Shear Strength Determination by Pocket Penetrometer

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

UNIFIED SOILS CLASSIFICATION

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

EXPLANATION OF ROCK LOGGING TERMS

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

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

<u>TERMS</u>	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
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.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No LAP-01

1 OF 2

METRIC

GWP# 2085-13-00 LOCATION SWM Pond North of Lloydtown-Aurora Rd. N 4 873 687.8 E 297 692.6 ORIGINATED BY SB
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.11 - 2017.05.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							WATER CONTENT (%) w _p w w _L PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			
299.9	GROUND SURFACE							20	40	60	80	100						
0.0	TOPSOIL: (50mm) Clayey SILT , some sand, occasional organics Firm Brown Moist		1	SS	7									○				
299.2							299							○				1 51 35 13
0.7	SAND and SILT , some clay, trace gravel Compact to Dense Brown to Grey Moist (TILL) Wet		2	SS	29									○				
							298							○				
			3	SS	33													
			4	SS	38									○				
297.0							297											
2.9	SAND , trace silt, trace clay Very Dense Brown to Grey Wet		5	SS	72									○				0 91 7 2
							296											
			6	SS	100/ 0.150		295							○				
294.7																		
5.2	Silty CLAY , with sand Hard Grey Moist (TILL)		7	SS	100/ 0.225		294							○				
							293											
			8	SS	96		292							○				0 33 43 24
291.2																		
8.7	SAND , trace silt Very Dense Brown Wet		9	SS	100/ 0.250		291							○				
290.4																		
9.5	END OF BOREHOLE AT 9.5m. WATER LEVEL AT 2.3m UPON COMPLETION																	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

METRIC

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

[illegible]

ONTMT4S MTO-12187.GPJ 2017TEMPLATE(MTO).GDT 17/7/12

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No LAP-02

1 OF 2

METRIC

GWP# 2085-13-00 LOCATION SWM Pond North of Lloydtown-Aurora Rd. N 4 873 636.7 E 297 699.7 ORIGINATED BY SB
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.12 - 2017.05.12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								20 40 60 80 100						
301.1	GROUND SURFACE													
0.0	TOPSOIL: (50mm)						301							
300.4	Sandy SILT , trace clay, trace gravel, occasional organics		1	SS	8									
0.7	Loose Brown Moist													
	SAND and SILT , some clay Compact to Very Dense		2	SS	17		300							
	Brown Moist (TILL)													
	Grey		3	SS	51		299							0 53 36 11
			4	SS	46									
298.1														
3.0	SAND , trace to some silt, trace clay Very Dense		5	SS	64		298							
	Brown Wet													
297.0							297							
4.1			6	SS	49		296							0 88 10 2
	Dense													
295.5														
5.6			7	SS	52/ 0.150		295							
	Very Dense													
							294							
			8	SS	61/ 0.125		293							
	Brown to Grey													
292.0														
9.1	Silty CLAY , with sand		9	SS	100/ 0.200		292							
291.6	Hard													
9.5	Grey Moist (TILL)													

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No LAP-02

2 OF 2

METRIC

GWP# 2085-13-00 LOCATION SWM Pond North of Lloydtown-Aurora Rd. N 4 873 636.7 E 297 699.7 ORIGINATED BY SB
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.12 - 2017.05.12 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	END OF BOREHOLE AT 9.5m. WATER LEVEL AT 3.7m UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.05.19 2.0 299.1 2017.06.23 1.4 299.7																

RECORD OF BOREHOLE No LAP-03

1 OF 2

METRIC

GWP# 2085-13-00 LOCATION SWM Pond North of Lloydtown-Aurora Rd. N 4 873 705.8 E 297 752.0 ORIGINATED BY SB
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.11 - 2017.05.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w _P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								<div><div></div><div>20406080100</div></div>									
								<div>○ UNCONFINED + FIELD VANE</div>									
								<div>● QUICK TRIAXIAL × LAB VANE</div>									
								20406080100				204060				kN/m ³	
								WATER CONTENT (%)									
301.2	GROUND SURFACE																
0.0	TOPSOIL: (50mm)																
	Sandy SILT , trace clay, occasional organics Compact		1	SS	10		301										
300.5	Brown Moist																
0.7	SAND and SILT , trace clay Compact to Dense Brown Moist (TILL)		2	SS	13		300										
			3	SS	20		299										
	Wet																
			4	SS	36		298										
298.2																	
3.0	SAND , trace to some silt. trace clay Compact Brown Wet		5	SS	27		297										
297.1																	
4.1	Sandy SILT , some clay Very Dense Brown Wet		6	SS	64		296										
			7	SS	93		295										
294.0																	
7.2	Silty CLAY , with sand Very Stiff to Hard Grey Moist (TILL)		8	SS	25		294										
			9	SS	100/		292										
291.8																	
9.4	END OF BOREHOLE AT 9.4m. WATER LEVEL AT 3.4m UPON COMPLETION. Piezometer installation consists of				0.125												

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No LAP-03

2 OF 2

METRIC

GWP# 2085-13-00 LOCATION SWM Pond North of Lloydtown-Aurora Rd. N 4 873 705.8 E 297 752.0 ORIGINATED BY SB
 HWY 400 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2017.05.11 - 2017.05.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page							20	40	60	80	100					
	19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.																
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2017.05.19 2.4 298.8 2017.06.23 2.2 299.0																



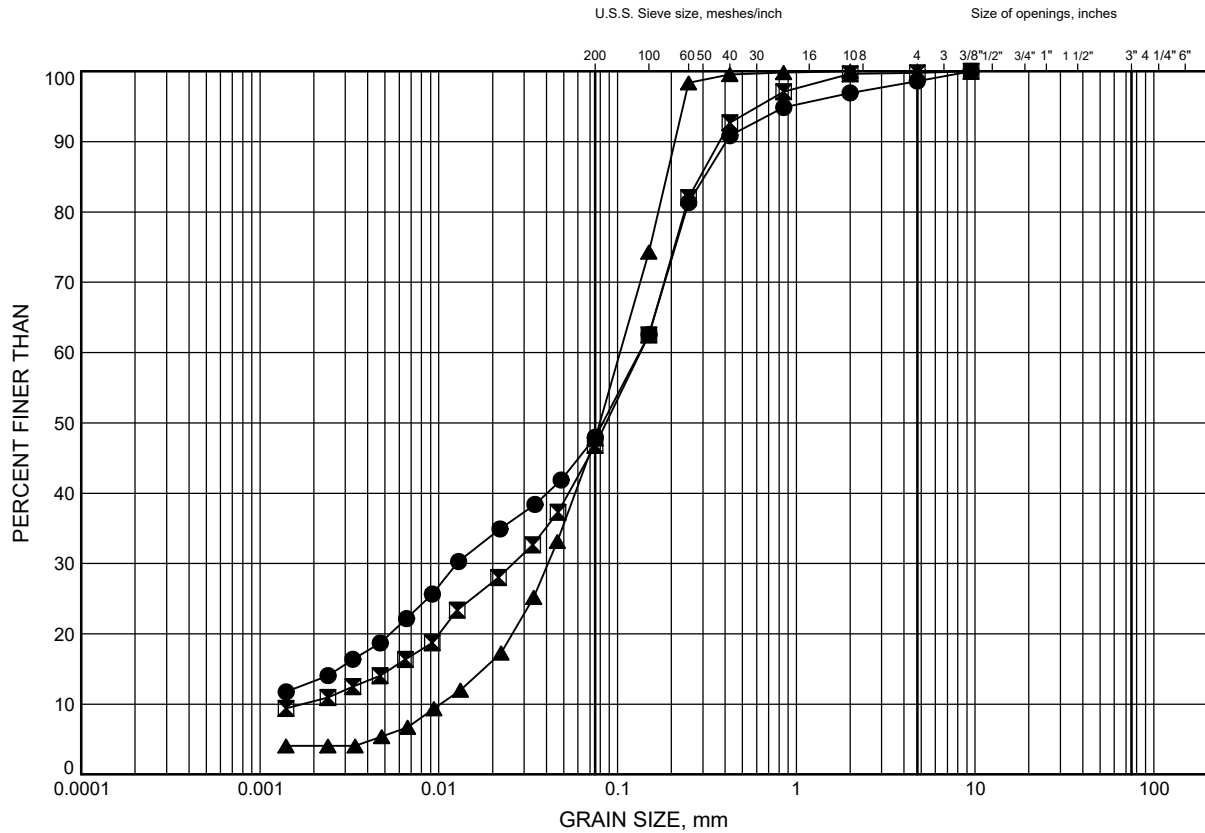
Appendix B

Laboratory Test Results

SWM Pond North of Lloydtown-Aurora Rd. GRAIN SIZE DISTRIBUTION

FIGURE B1

SAND and SILT TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	LAP-01	1.1	298.8
⊠	LAP-02	1.8	299.3
▲	LAP-03	2.6	298.6

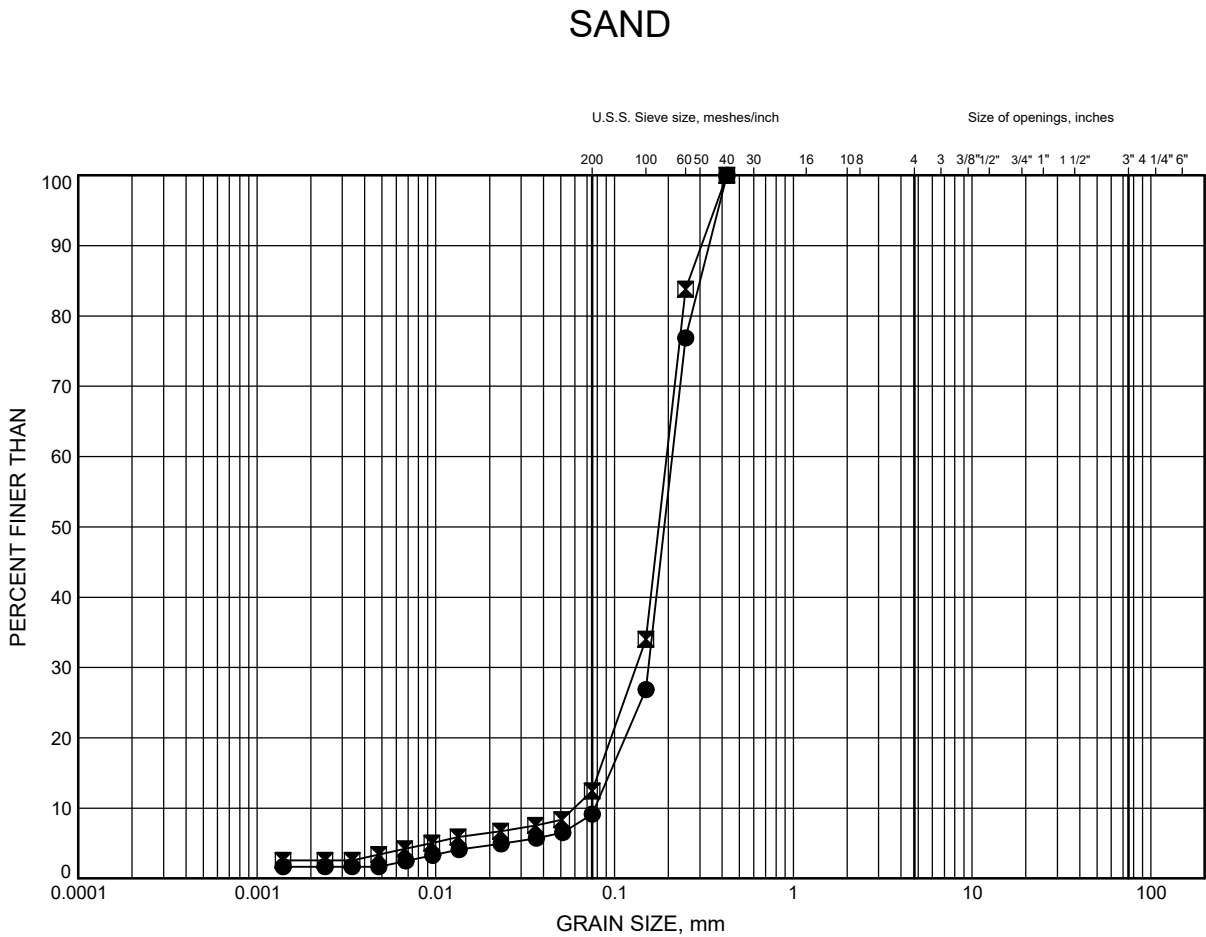
Date July 2017
GWP# 2085-13-00



Prep'd AN
Chkd. RPR

SWM Pond North of Lloydtown-Aurora Rd.
GRAIN SIZE DISTRIBUTION

FIGURE B2



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	LAP-01	3.4	296.5
⊠	LAP-02	4.9	296.2

Date July 2017
GWP# 2085-13-00

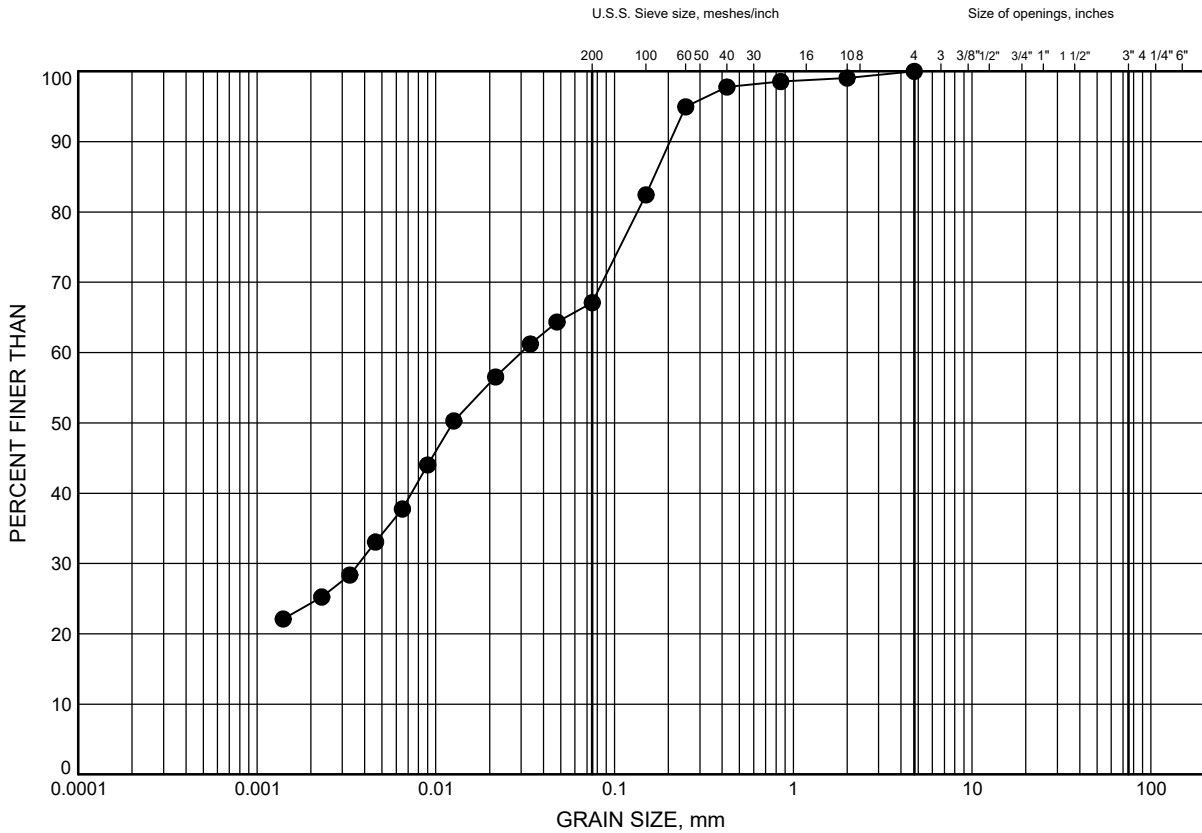


Prep'd AN
Chkd. RPR

SWM Pond North of Lloydtown-Aurora Rd.
GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty CLAY, with SAND TILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	LAP-01	7.9	292.0

Date July 2017
 GWP# 2085-13-00

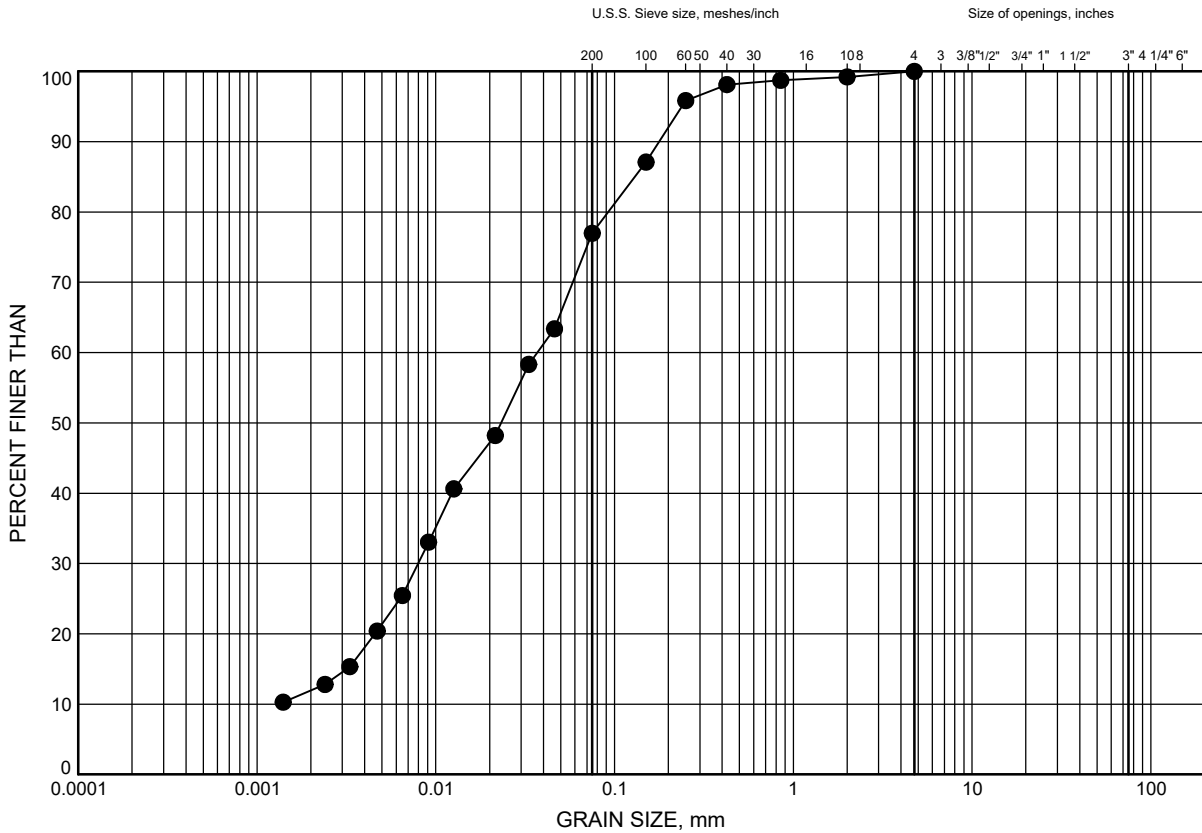


Prep'd AN
 Chkd. RPR

SWM Pond North of Lloydtown-Aurora Rd.
GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	LAP-03	6.4	294.8

Date July 2017
GWP# 2085-13-00

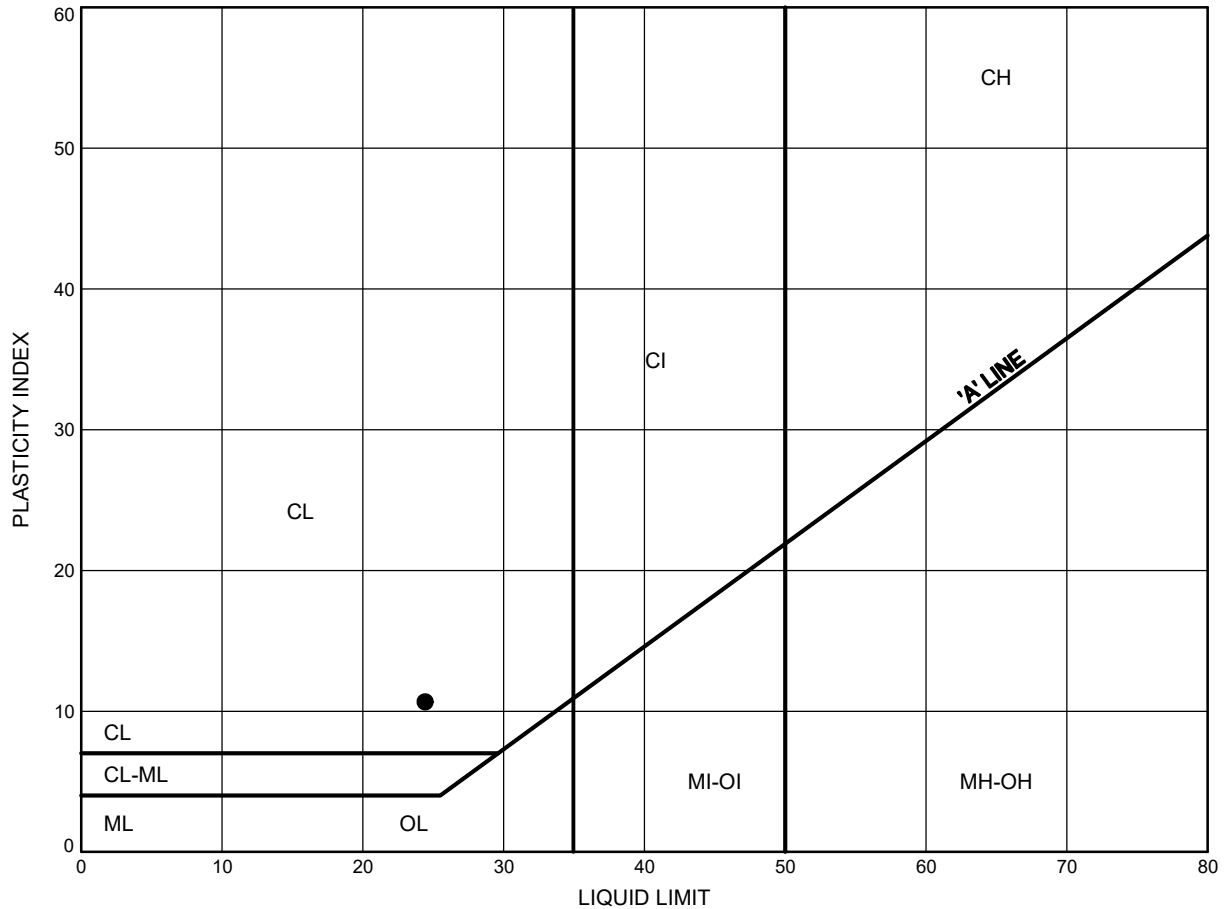


Prep'd AN
Chkd. RPR

SWM Pond North of Lloydtown-Aurora Rd.
ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty CLAY, with SAND TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	LAP-01	7.9	292.0

Date July 2017
 GWP# 2085-13-00

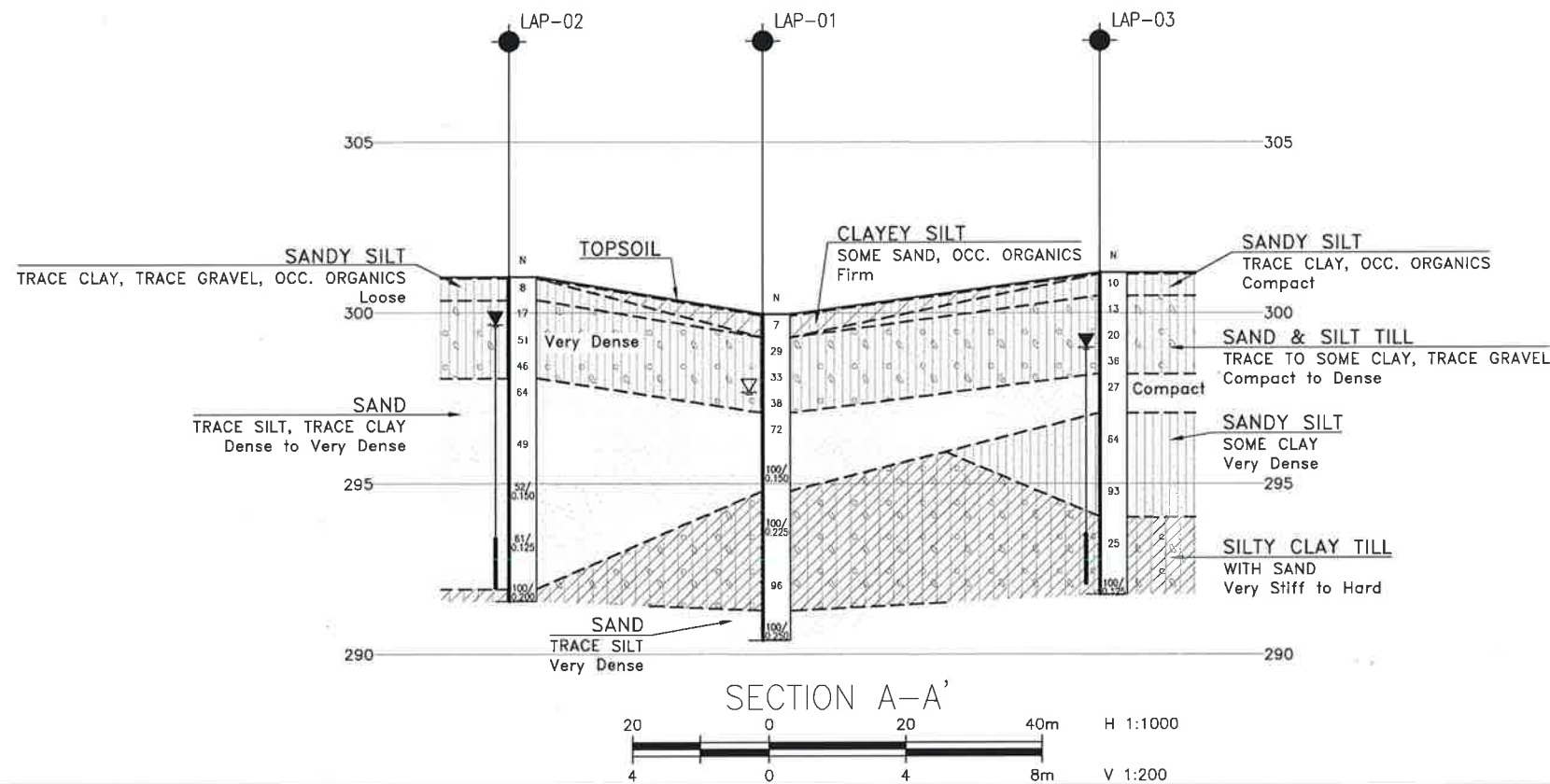
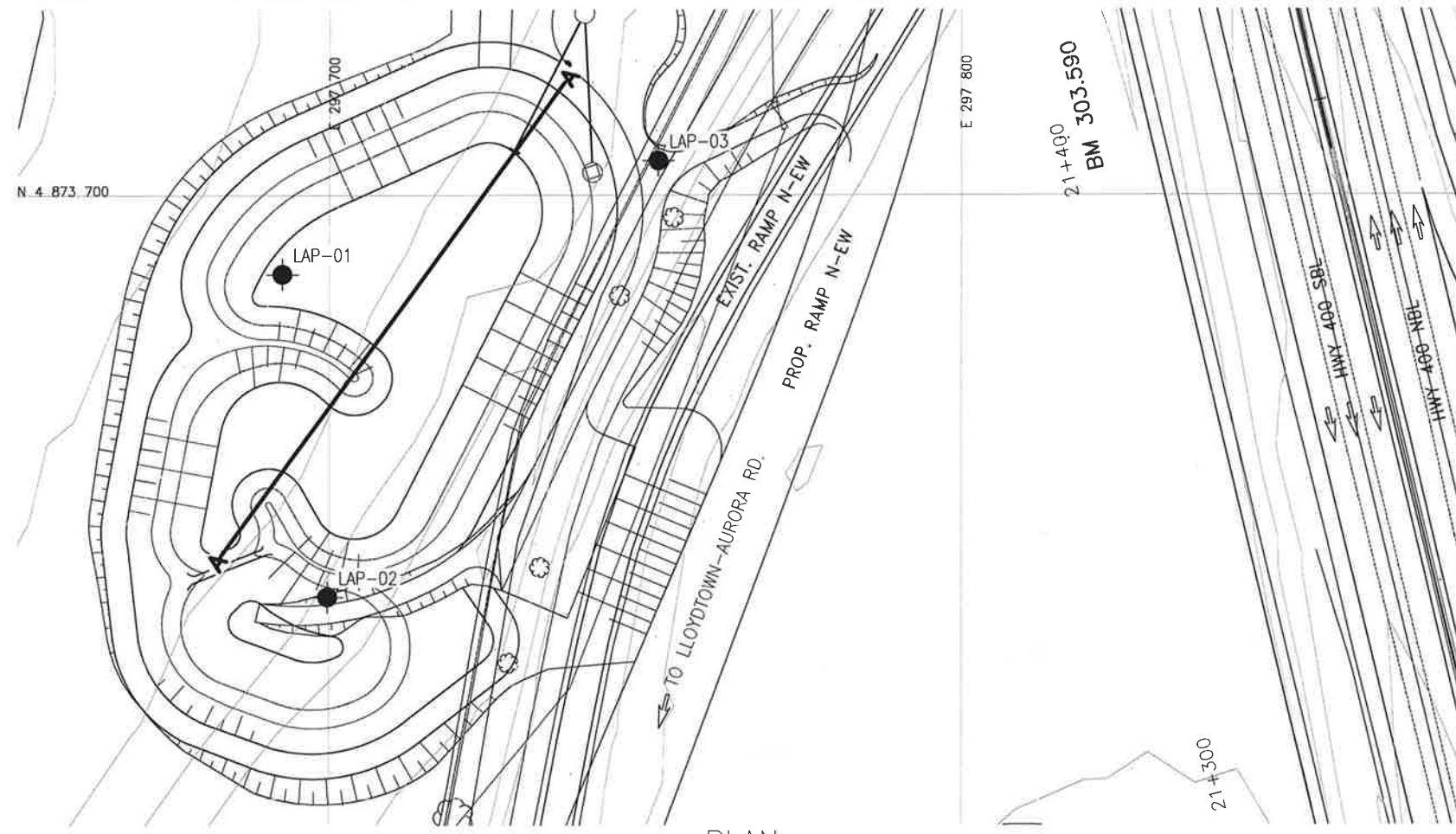


Prep'd AN
 Chkd. RPR



Appendix C

Borehole Locations and Soil Strata Drawing



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

CONT No
GWP No 2085-13-00

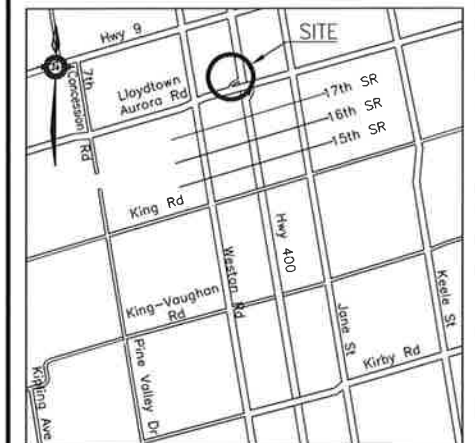


SHEET

HIGHWAY 400
SWM POND NORTH OF
LLOYDTOWN-AURORA ROAD
BOREHOLE LOCATIONS AND SOIL STRATA



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
LAP-01	299.9	4 873 687.8	297 692.6
LAP-02	301.1	4 873 636.7	297 699.7
LAP-03	301.2	4 873 705.8	297 752.0

-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.

GEOCRES No. 31D-680



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RPR	CHK SKP	CODE
DRAWN	AN	CHK RPR	SITE
			LOAD
			DATE
			JUL 2017
			STRUCT
			DWG 1



Appendix D

Site Photographs



Photo 1. – North end of the proposed SWMP footprint



Photo 2. – Middle section of the proposed SWMP footprint



Photo 3. – South end of the proposed SWMP footprint

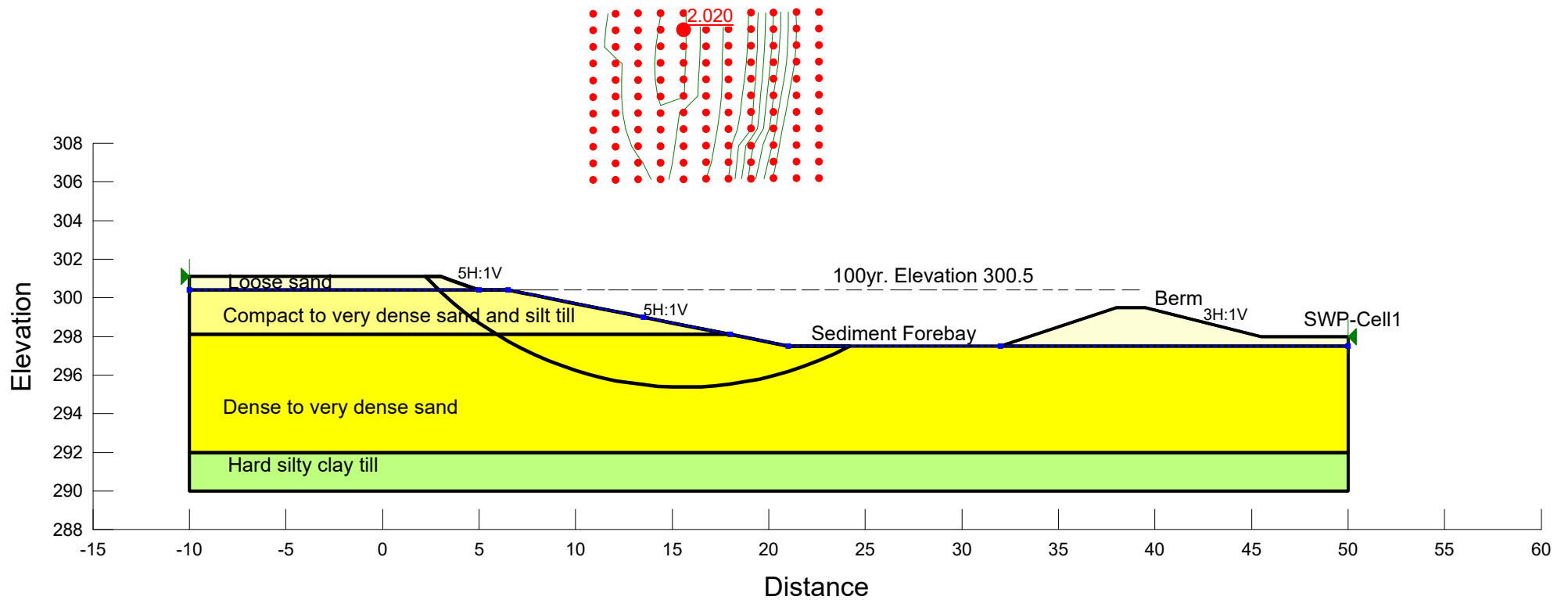


Appendix E

Selected Results of Slope Stability Analyses

Project Number: 12187
 Highway 400 Widening
 Stormwater Management Pond - Sediment Bay and SWMP Cell 1
 Rapid Drawdown Stability - Saturated Pond Slopes

Name: Silty Clay Till	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1
Name: Sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1
Name: Sand and Silt Till	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Loose sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 28 °	Phi-B: 0 °	Piezometric Line: 1
Name: Berm (sand)	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1

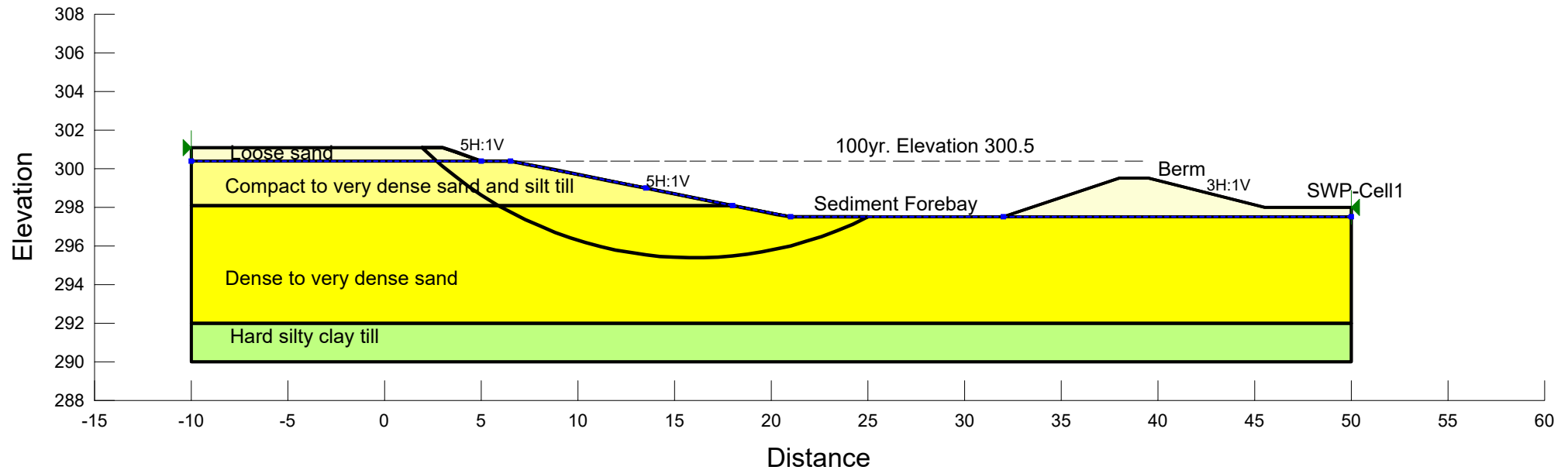
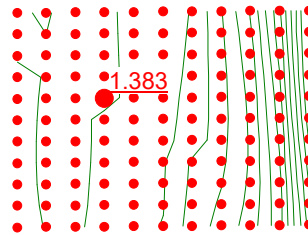


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 Date: 2017-06-16 ,Time: 3:18:04 PM

Figure E1

Project Number: 12187
 Highway 400 Widening
 Stormwater Management Pond - Sediment Bay and SWMP Cell 1
 Rapid Drawdown Stability - Saturated Pond Slopes
 Seismic Analysis
 Peak ground acceleration (PGA)=0.082 g

Name: Silty Clay Till	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1
Name: Sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1
Name: Sand and Silt Till	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Loose sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 28 °	Phi-B: 0 °	Piezometric Line: 1
Name: Berm (sand)	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1

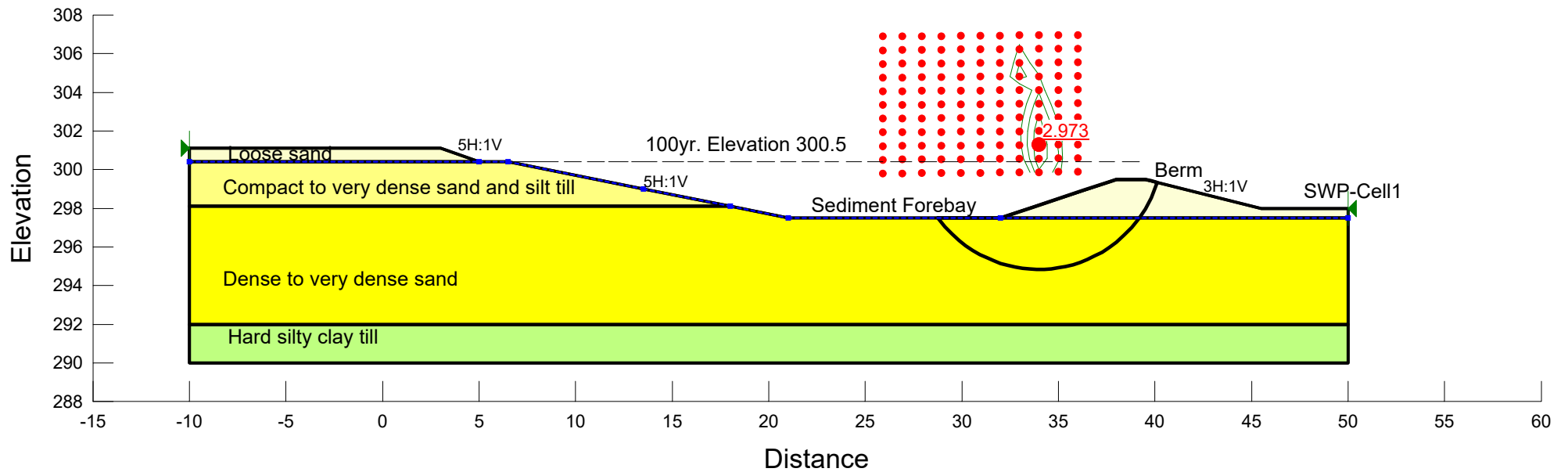


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Figure EG

Project Number: 12187
 Highway 400 Widening
 Stormwater Management Pond - Sediment Bay and SWMP Cell 1
 Rapid Drawdown Stability - Saturated Pond Slopes

Name: Silty Clay Till Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Sand and Silt Till Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Loose sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 28 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Berm (sand) Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1

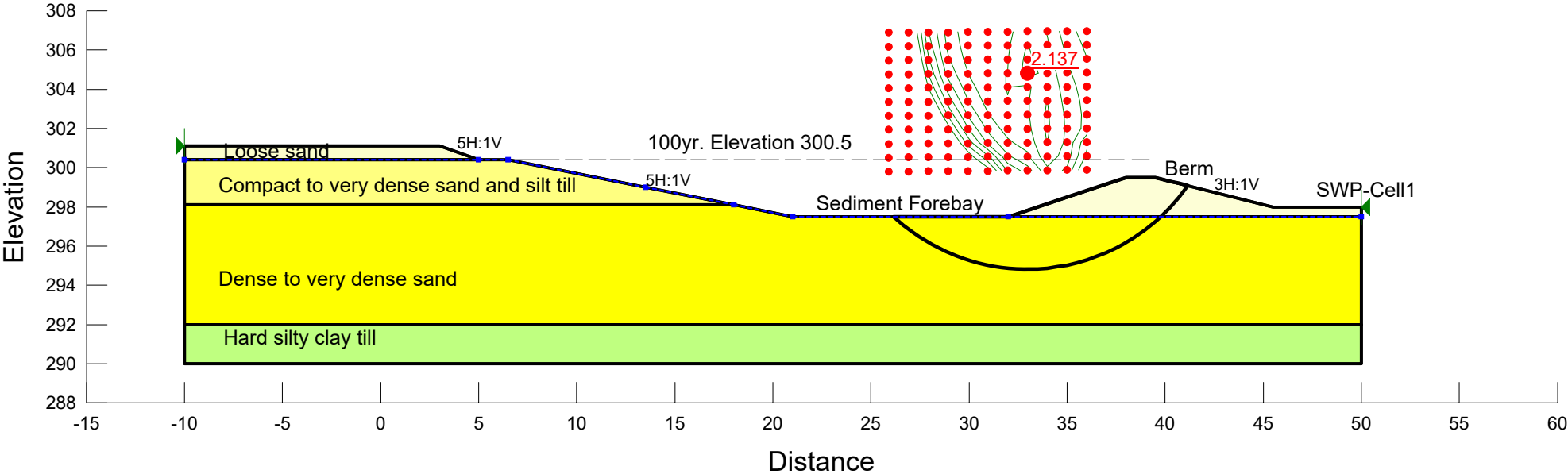


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Figure E3

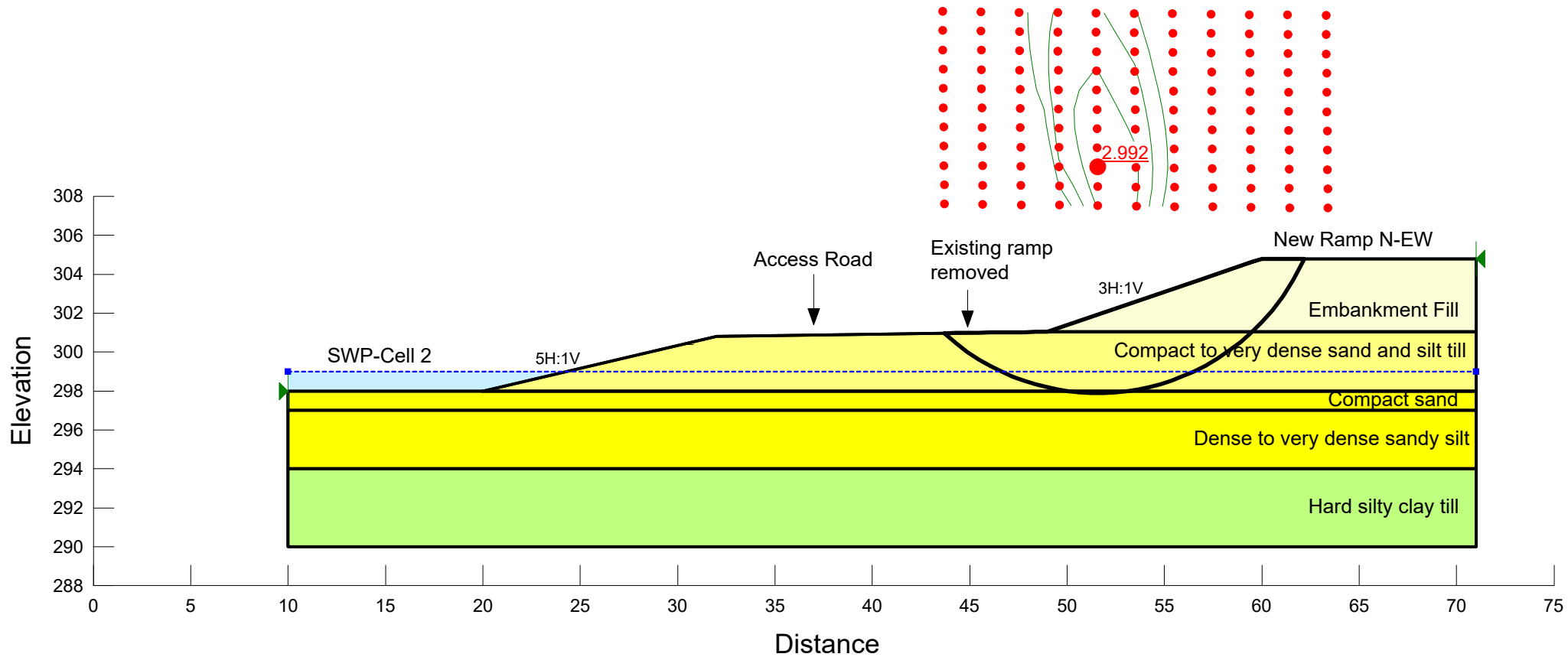
Project Number: 12187
 Highway 400 Widening
 Stormwater Management Pond - Sediment Bay and SWMP Cell 1
 Rapid Drawdown Stability - Saturated Pond Slopes
 Seismic Analysis
 Peak ground acceleration (PGA)=0.082 g

Name: Silty Clay Till	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1
Name: Sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 32 °	Phi-B: 0 °	Piezometric Line: 1
Name: Sand and Silt Till	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1
Name: Loose sand	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 28 °	Phi-B: 0 °	Piezometric Line: 1
Name: Berm (sand)	Unit Weight: 20 kN/m³	Cohesion: 0 kPa	Phi: 30 °	Phi-B: 0 °	Piezometric Line: 1



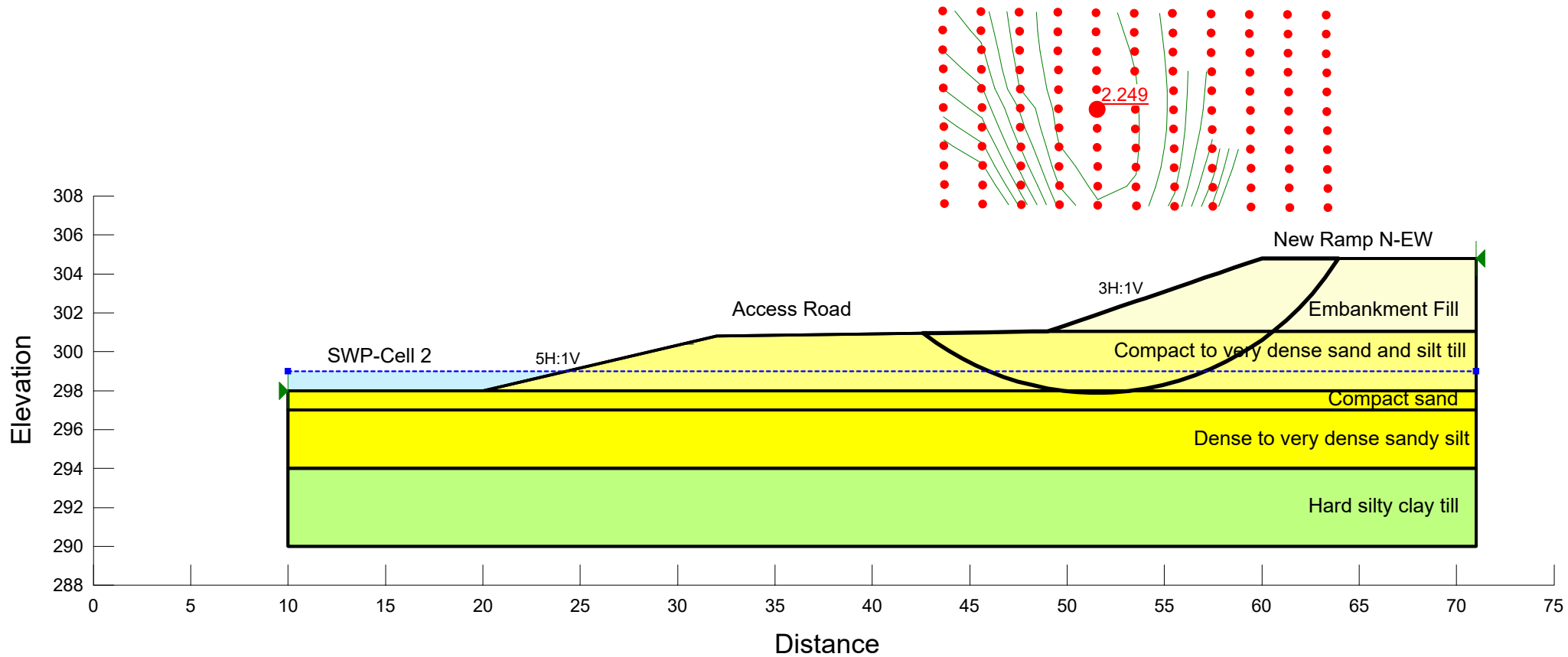
Project Number: 12187
 Highway 400 Widening
 Stormwater Management Pond - New Ramp N-EW
 Drained Analysis

Name: Silty Clay Till Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Sand and Silt Till Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Granular Fill Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1



Project Number: 12187
 Highway 400 Widening
 Stormwater Management Pond - New Ramp N-EW
 Drained Analysis
 Seismic Analysis
 Peak ground acceleration (PGA)=0.082 g

Name: Silty Clay Till Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Sand Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 32 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Sand and Silt Till Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1
 Name: Granular Fill Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Phi-B: 0 ° Piezometric Line: 1





Appendix F

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

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 surficial sandy silt or clayey silt into the sand and silt till, and the underlying sand to sandy silt. The groundwater level at this site is up to 2 m above the proposed base of the pond. 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 for dewatering system design. 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 buffer zone between the highway (Ramp N-EW) embankment toe and the edge of the pond remains in place 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.