

**FOUNDATION INVESTIGATION REPORT
LOW TO MEDIUM EMBANKMENTS
HIGHWAY 11/17 RED ROCK TO NIPIGON
FROM 4.8 KM WEST OF HWY 628 TO 1.5 KM WEST OF HWY 585
G.W.P. 647-89-00**

Geocres Number: 52A-182

VOLUME 1 / 2

Report to

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- Borehole Locations and Soil Strata Drawings

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for proposed low to medium embankments required for the Highway 11/17 four-laning project extending from 4.8 km west of Highway 628 to 1.5 km west of Highway 585 between Red Rock and Nipigon, Ontario.

The purpose of the investigation was to explore the subsurface conditions at sites where low to medium embankments have been identified to be constructed on compressible foundation soils along the proposed alignment and, based on the data obtained, to provide record of borehole sheets, borehole location plans, stratigraphic profiles, laboratory test results, and a generalized description of the subsurface conditions at each location. This information provides a model of the anticipated geotechnical conditions influencing design and construction of the embankments.

Thurber Engineering Ltd. (Thurber) carried out the investigation as a sub-consultant to MMM Group Limited (MMM) under the Ministry of Transportation Ontario (MTO) Agreement Number 6009-E-0019.

2 SITE DESCRIPTION

The current Highway 11/17 comprises a two lane undivided highway. The alignment of the proposed four lane divided highway typically follows the existing highway alignment except at Sta. 13+500 to 16+450 and Sta. 18+500 to 19+100 where the proposed alignment runs north of the existing alignment and at Sta. 11+800 to 12+700 and Sta. 16+450 to 17+300 where the proposed alignment runs south of the existing alignment.

The site topography along the roadway corridor typically comprises relatively heavily treed rolling hills separated by low-lying soft ground and occasional streams. Frequent bedrock outcrops are present along the alignment.

The site is overlain by intermittent lacustrine deposits comprising varved or massive clay and silt, silty to sandy till and bare bedrock outcrops (ref: Surficial Geological Map of the Ontario Department of Lands and Forest). Thin layers of recent organic deposits of peat occur in low lying areas. The area is underlain by Precambrian felsic igneous and metamorphic rocks, as well as sedimentary rocks of the Sibley Group (OGS Map No. 2232).

The locations and existing conditions at each embankment section investigated during the current study are summarized below:

- **Sta. 12+050 to 12+100 EBL and WBL** – Partially treed area with a few residential houses, located on the right side of the existing Highway 11/17. Embankment fill heights of up to 5.6 m are proposed.
- **Sta. 12+170 to 12+270, EBL and WBL** – Low-lying, treed area with a residential property, located on the right side of the existing Highway 11/17. Embankment fill heights up to 5.6 m are proposed.
- **Sta. 12+420 to 12+540, EBL** – Treed area located on the right side of the existing Highway 11/17. Embankment fill heights proposed up to 3.2 m.
- **Sta. 12+650 to 13+100, EBL and WBL** – Low-lying, partially treed swamp area that runs along the existing Highway 11/17. Embankment fill heights proposed up to 3.7 m.
- **Sta. 13+300 to 13+450, EBL and WBL** – Low-lying, partially treed area that crosses the existing Itzcaulde Creek culvert and an abandoned gravel road alignment. Embankment fill heights proposed up to 6.5 m.
- **Sta. 16+250 to 16+460, EBL and WBL** – Flat, partially treed area that runs along the transmission tower corridor on the left side of the existing Highway 11/17. Embankment fill heights proposed up to 3.7 m.
- **Sta. 16+830 to 16+940, EBL and WBL** – Low-lying, treed area bounded by bedrock outcrops to the south and north. Runs along the transmission tower corridor on the east side of the existing Highway 11/17. Embankment fill heights proposed up to 4.1 m.
- **Sta. 18+450 to 18+500, EBL and WBL** – Low lying, treed swamp area bounded by bedrock outcrops to the south and north. Located south of Golf Course Road, on the west side of the existing Highway 11/17. Embankment fill heights proposed up to 2.3 m.
- **Sta. 19+850 to 19+900, EBL and WBL** – Flat, sparsely treed area that runs along the existing Highway 11/17. Embankment fill heights proposed up to 4.3 m.

3 SITE INVESTIGATION AND FIELD TESTING

Thurber carried out the site investigation and field testing at each embankment location as identified in the Proposal for Additional Geotechnical Investigation, dated November 15, 2012. The site investigation was carried out during the periods of January 29 to May 9, 2013 and March 25 to May 5, 2014 and consisted of advancing 71 boreholes and 39 Dynamic Cone Penetration Tests (DCPTs). Boreholes and DCPTs were typically advanced to refusal or to a maximum depth of investigation of 15 m below the ground surface, however where deeper soft soil deposits were encountered, selected boreholes at the relevant embankment sections were extended to depths of up to 29.2 m.

The boreholes were generally positioned along the centrelines of the proposed eastbound lanes (EBL) and westbound lanes (WBL) embankments at longitudinal intervals of 50 m, with additional

boreholes and DCPTs conducted at the embankment toe locations, alternating at the midpoint between centreline boreholes.

A summary of the locations and depths of the boreholes and DCPTs carried out during this study is provided in Table A1 in Appendix A. The boreholes and DCPTs are identified by the station and offset distance from the median centerline. The approximate locations of the boreholes and DCPTs are shown on the Borehole Locations and Soil Strata Drawings included in Appendices B to J.

The investigated locations were chosen by Thurber with reference to the centerline established by MMM. The borehole locations were laid out by Thunder Bay Testing and Engineering (TBTE) personnel. The approximate ground surface elevations at the borehole locations were interpreted by MMM based on topographic data.

The advancement of the boreholes was carried out using a CME 55 drill rig in conjunction with hollow stem augers (HSA). Prior to commencement of drilling, utility clearances were obtained for all investigated locations. A member of Thurber's technical field staff supervised the drilling and sampling operations on a full time basis. The onsite supervisor logged the boreholes and processed the recovered soil samples for transport to TBTE's geotechnical laboratory in Thunder Bay, Ontario for further examination and testing.

Soil samples were obtained using a split spoon sampler in conjunction with Standard Penetration Tests (SPT). Two samples of cohesive soils were obtained using a thin-walled (Shelby) tube sampler. In situ vane shear testing was carried out to assess the undrained shear strength of the cohesive deposits. Sampling of the underlying rock was not included in the scope of this project.

Groundwater conditions in the open boreholes were observed upon completion of the drilling operations. Standpipe piezometers were installed in selected boreholes to monitor groundwater levels after drilling. Completion of the boreholes and standpipe piezometers was carried out in general accordance with the requirement of O.Reg 903 (as amended by O. Reg. 372/07). Following the final water level readings, the piezometers were decommissioned by TBTE in general accordance with MOE Regulation 903.

4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to gradation analysis (hydrometer and/or sieve) and Atterberg Limits testing, where appropriate. The results of this testing is shown on the Record of Borehole sheets and figures included in their respective appendices. Thin-walled tube samples were also used to conduct Oedometer Testing. All testing was completed in TBTE's geotechnical laboratory.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawings included in Appendices B to J. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following sections. However, the factual data presented in the borehole logs shall take precedence over these

general descriptions and interpretations of the site conditions. It must be recognized that the soil conditions may vary between and beyond the investigated borehole locations.

5.1 Highway 11/17 EBL and WBL, Sta. 12+050 to 12+100 (Appendix B)

5.1.1 General

Four boreholes and four DCPTs were advanced within Sta. 12+050 to 12+100. The site stratigraphy encountered generally consists of a surficial layer of organic soils underlain by a deposit of silt with some sand to sandy which was further underlain by silty clay. Below the above deposits was a lower deposit of silt with trace clay to clayey and trace sand.

5.1.2 Organic Soils

A layer of organics ranging from 100 to 1200 mm thick was encountered at the surface of all four boreholes. The underside elevation of the organics varied from Elev. 229.8 to 225.6 m. The organic material comprised a topsoil layer of 100 to 150 mm thick in Boreholes 12+050 29R, 12+056.5 27.5L, and 12+080 19L, as well as a sandy Peat layer at the ground surface in Borehole 12+080.9 17.8R and underlying the topsoil in Borehole 12+080 19L. the peat thickness varied from 0.7 m to 1.2 m. The thickness of the organic soils may vary between and beyond the borehole locations.

5.1.3 Silt

A 1.4 m thick layer of silt with some sand to sandy and trace clay was encountered below the surficial layer of organics in Boreholes 12+050 29R and 12+056.5 27.5L. The silt layer had a lower boundary at a depth of 1.5 m (Elev. 228.4 to 227.6 m).

SPT N-values of 6 blows per 0.3 m of penetration were recorded, indicating loose relative density. The moisture content varied from 21 to 37%.

A grain size distribution test was carried out on a single sample of the silt. The result of the testing is presented on the Record of Borehole Sheet included in Appendix B. The grain size distribution curve for the sample is plotted on Figure B1 of Appendix B. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	25
Silt %	72
Clay %	3

5.1.4 Silty Clay

A deposit of silty clay was encountered beneath the surficial layer of organic soils in Boreholes 12+080.9 17.8R and 12+080 19L and below the silt layer in the remaining two boreholes. The thickness of this layer ranged from 3.1 to 4.6 m with a corresponding underside elevation varying between 224.1 to 222.5 m.

SPT N-values were recorded in the silty clay between 0 to 6 blows per 0.3 m of penetration, typically decreasing with depth. In situ field vane testing, conducted within the deeper part of

the layer measured undrained shear strengths ranging from 32 to 53 kPa. The SPT N-values and vane test results indicate that the silty clay is soft to stiff, typically firm. The measured sensitivity, from remolded field vane testing, ranged from 3 to 5 indicating the clay is classified as medium-sensitive to sensitive. The moisture content of the silty clay ranged from 30 to 49%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix B. The grain size distribution curves for the samples are plotted on Figure B2 and the Atterberg Limits test results are plotted on Figure B4 of Appendix B. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	41 to 46
Clay %	54 to 59
Liquid Limit %	37 to 48
Plastic Limit %	19 to 21

The results of the Atterberg Limit tests indicate that the silty clay is intermediate plasticity with group symbol of CI.

5.1.5 Lower Silt

A lower layer of silt with trace to some clay and trace sand was encountered below the above deposits in all four boreholes. Each borehole was terminated in this layer. Boreholes 12+050 29R and 12+080 19L were terminated at maximum depths of 14.3 and 11.3 m respectively (Elev. 214.8 m and 217.1 m). Boreholes 12+056.5 27.5L and 12+080.9 17.8R were terminated upon auger refusal at depths of 13.4 and 13.7 m respectively (Elev. 216.5 to 213.1 m). The four DCPTs were terminated at depths ranging from 10.4 to 15.1m (Elev. 219.0 to 211.3 m).

SPT N-values in the silt ranged from 4 to 53 blows per 0.3 m of penetration, typically increasing with depth, indicating loose to very dense relative density. The moisture contents ranged from 16 to 28%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix B. The grain size distribution curves for the samples are plotted on Figure B1 and the Atterberg Limits test results are plotted on Figure B3 of Appendix B. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 2
Silt %	73 to 91
Clay %	8 to 27

Liquid Limit %	21 to 30
Plastic Limit %	17 to 19

The results of the Atterberg Limit tests indicate that the silt is low plasticity with group symbol of ML to CL.

5.1.6 Groundwater Conditions

Standpipe piezometers were installed in two of the four boreholes to monitor the seasonal groundwater levels after completion of drilling. A summary of the recorded short term groundwater levels is provided below.

Table 5-1 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+050 29R	Mar. 01, 2013	6.4	222.7	Open borehole
12+056.5 27.5L	Mar. 01, 2013	7.3	222.6	Open borehole
12+080.9 17.8R	Feb. 28, 2013	5.5	221.3	Open borehole
	May 22, 2013	0.1	226.7	Piezometer
12+080 19L	Feb. 28, 2013	5.1	223.3	Open borehole
	May 22, 2013	0.1	228.3	Piezometer

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.2 Highway 11/17 EBL and WBL, Sta. 12+170 to 12+270 (Appendix C)

5.2.1 General

Six boreholes and seven DCPTs were advanced within Sta. 12+170 to 12+270. The site stratigraphy encountered generally consists of a surficial layer of organic soils underlain by upper and lower deposits of silty clay and a middle clayey silt layer throughout the site.

5.2.2 Organic Soils

A 125 to 150 mm thick layer of topsoil was encountered at the surface of Boreholes 12+200 19L, 12+230 19R, 12+243 30.7L, 12+250 19L, and 12+265 CL. The topsoil was underlain by a 1.2 to 1.5 m thick layer of silty organic clay in boreholes 12+243 30.7L and 12+250 19L. A 1.2 m thick layer of peat was also encountered at the ground surface in Borehole 12+180 19R. The underside elevation of the organics varied from Elev. 229.0 to 224.1 m. The thickness of the organic soils may vary between and beyond the borehole locations.

SPT N-values of 0 to 2 blows per 0.3 m of penetration were recorded in the peat and organic clay layers, indicating that the organic material is very soft to soft. The moisture content of the organic material ranged from 42 to 172%.

5.2.3 Silt

A deposit of silt with trace clay and trace sand was encountered below the topsoil layer in Borehole 12+200 19L. The silt layer was 1.0 m thick, with a lower boundary at 1.2 m deep (Elev. 228.0 m). The silt deposit was loose, based on an SPT N-value of 8 blows per 0.3 m of penetration. The moisture content of the silt was measured as 27%.

5.2.4 Upper Silty Clay

An upper silty clay layer with trace sand and occasional silt seams was encountered below the organics and silt in all of the boreholes except for 12+243 30.7L. The silty clay layer ranged in thickness from 3.2 to 5.5 m, with the lower boundary at depths from 4.0 to 6.1 m (Elev. 223.4 to 220.9 m).

SPT N-values recorded in the upper silty clay ranged from 0 to 8 blows per 0.3 m of penetration. An in situ field vane test, conducted within the deeper part of the layer measured an undrained shear strength of 50 kPa, with a measured sensitivity of 6, based on a remolded field vane test. The SPT N-values and vane test result indicate that the upper silty clay is typically soft to firm and sensitive. The moisture content of the upper silty clay ranged from 24 to 43%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the upper silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix C. The grain size distribution curves for the samples are plotted on Figure C2 and the Atterberg Limits test results are plotted on Figure C4 of Appendix C. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 3
Silt %	42 to 64
Clay %	35 to 56
Liquid Limit %	30 to 52
Plastic Limit %	17 to 22

The results of the Atterberg Limit tests indicate that the upper silty clay ranges from low to high plasticity with group symbols from CL to CH.

5.2.5 Silt

A layer of silt with some clay to clayey and trace sand was encountered below the upper silty clay in all of the boreholes, except for 12+243 30.7L, where the silt was beneath the organic clay layer. The silt layer ranged in thickness from 1.0 to 2.7 m, with the base encountered at

depths from 2.7 m to 8.5 m (Elev. 223.1 to 218.8 m). Borehole 12+200 19L was terminated within the silt upon auger refusal at a depth of 8.5 m (Elev. 220.7 m).

The cohesive silt deposit is typically soft to stiff in consistency, based on SPT N-values ranging from 2 to 14 blows per 0.3 m of penetration. The moisture content ranged from 19 to 29%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the clayey silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix C. The grain size distribution curves for the samples are plotted on Figure C1 and the Atterberg Limits test results are plotted on Figure C3 of Appendix C. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 4
Sand %	1 to 6
Silt %	71 to 88
Clay %	10 to 28
Liquid Limit %	21 to 26
Plastic Limit %	16 to 18

The results of the Atterberg Limit tests indicate that the clayey silt ranges from non-plastic to low plasticity with group symbols from ML to CL.

5.2.6 Lower Silty Clay

A lower silty clay layer with occasional silt seams was encountered below the clayey silt layer in all of the boreholes except for 12+200 19L. Boreholes 12+180 19R, 12+230 19R, 12+243 30.7L, 12+250 19L, and 12+265 CL were terminated at the base of the lower silty clay layer upon auger refusal at depths from 5.8 to 10.7 m (Elev. 220.0 to 217.5 m). The seven DCPTs were terminated upon refusal (100 blows per 0.3 m of penetration) at depths ranging from 5.9 to 12.5 m (Elev. 222.2 to 215.1 m).

SPT N-values recorded in the lower silty clay ranged from 2 to 8 blows per 0.3 m of penetration. An in situ field vane test, conducted within the lower silty clay layer measured an undrained shear strength of 50 kPa, with a measured sensitivity of 4, based on a remolded field vane test. The SPT N-values and vane test result indicate that the lower silty clay is typically soft to stiff, with medium sensitivity. The moisture content of the lower silty clay ranged from 20 to 42%.

A grain size distribution and Atterberg Limits test were carried out on a sample of the lower silty clay from Borehole 12+243 30.7L. The results of the testing are presented on the Record of Borehole Sheets included in Appendix C. The grain size distribution curve for the sample is plotted on Figure C2 and the Atterberg Limits test result is plotted on Figure C4 of Appendix C. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0
Silt %	65
Clay %	35
Liquid Limit %	31
Plastic Limit %	27

The results of the Atterberg Limit tests indicate that the tested sample of the lower silty clay has low plasticity with a group symbol of CL.

5.2.7 Groundwater conditions

Standpipe piezometers were installed in two of the six boreholes to monitor the seasonal groundwater levels after completion of drilling. A summary of the recorded short term groundwater levels is provided below.

Table 5-2 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+180 19R	Feb. 27, 2013	6.4	220.9	Open Borehole
12+200 19L	May 22, 2013	1.0	228.2	Piezometer
12+230 19R	May 22, 2013	0.0	224.9	Piezometer
12+243 30.7L	Feb. 25, 2013	2.1	223.7	Open Borehole
12+250 19L	Feb. 25, 2013	Dry	-	Open Borehole
12+265 CL	Feb. 25, 2013	10.1	218.0	Open Borehole

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.3 Highway 11/17 EBL, Sta. 12+420 to 12+540 (Appendix D)

5.3.1 General

Five boreholes and two DCPTs were advanced within Sta. 12+420 to 12+540. The site stratigraphy encountered generally consists of a surficial layer of organic soils underlain by a deposit of sandy to clayey silt, which was further underlain by silty clay with trace sand. Below the above deposits was a cohesionless layer ranging from gravelly sand to sand and gravel.

5.3.2 Organic Soils

A layer of organic soils ranging from 100 to 900 mm thick was encountered at the surface of all five boreholes. The underside elevation of the organic soils varied from Elev. 226.4 to 224.3 m. The thickness of the organic soils may vary between and beyond the borehole locations.

A single SPT N-value of 2 blows per 0.3 m of penetration was recorded in the organic soils in Borehole 12+505 CL. The corresponding moisture content was measured to be 167%.

5.3.3 Silt

A 0.5 to 1.0 m thick layer of silt, ranging in composition from sandy to clayey was encountered below the surficial layer of organics in four of the boreholes. The silt layer had a lower boundary at a depth of 0.7 to 1.1 m (Elev. 225.9 to 224.9 m).

SPT N-values of 13 to 25 blows per 0.3 m of penetration were recorded in the silt, indicating a compact relative density. The moisture content varied from 24 to 37%.

5.3.4 Silty Clay

A silty clay deposit with trace sand was encountered below the silt and/or organic layers. The investigated thickness of this layer, where fully penetrated, ranged from 7.2 to 12.0 m, with a lower boundary at depths between and m (Elev. 218.3 to 212.9 m). Boreholes 12+430 19R and 12+455 28R were terminated within this layer at depths from 14.3 to 14.9 m (Elev. 211.6 m). DCPT 12+455 CL was terminated at a depth of 14.9 m (Elev. 211.9 m), which likely occurred within the silty clay deposit.

SPT N-values were recorded between 0 to 13 blows per 0.3 m of penetration. In situ field vane tests conducted in the silty clay measured undrained shear strengths between 21 and 66 kPa, indicating that the layer is soft to stiff. The measured sensitivity, from remolded field vane testing, ranged from 3 to 15, indicating that the silty clay is classified as medium to extra sensitive.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix D. The grain size distribution curves for the samples are plotted on Figures D2 and D3 and the Atterberg Limits test results are plotted on Figures D4 and D5 of Appendix D. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 3
Silt %	40 to 61
Clay %	38 to 60
Liquid Limit %	32 to 51
Plastic Limit %	17 to 22

The results of the Atterberg Limit tests indicate that the silty clay is typically intermediate plasticity with group symbol of CI.

5.3.5 Gravelly Sand to Sand and Gravel

Below the silty clay deposit, a cohesionless deposit of gravelly sand ranging to sand and gravel was encountered in Boreholes 12+480 19R, 12+505 CL, and 12+520 19R. The investigated thickness of the sand layer ranged from 1.2 to 2.0 m. The three boreholes were terminated within the sand at depths ranging from 9.9 to 14.3 m (Elev. 216.3 to 211.7 m), with auger refusal occurring at the base of the deposit in Borehole 12+505 CL. DCPT 12+505 28R was terminated upon refusal (100 blows per 0.3 m of penetration) at a depth of 12.2 m (Elev. 213.6 m).

SPT N-values of 4 to 40 blows per 0.3 m of penetration were recorded in this cohesionless deposit, indicating loose to dense relative density. The measured moisture content of the sand ranged between 8 and 10%.

The results of grain size distribution analyses conducted on two samples of the sand are presented on the Record of Borehole sheets in Appendix D and are plotted on Figure D1 of Appendix D. The results of the laboratory tests are summarized as follows:

Gravel %	20 to 44
Sand %	37 to 59
Silt & Clay %	19 to 21

5.3.6 Groundwater Conditions

A standpipe piezometer was installed in Borehole 12+480 19R to monitor the seasonal groundwater level after completion of drilling. A summary of the recorded short term groundwater levels is provided below.

Table 5-3 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+480 19R	Feb. 23, 2013	12.2	213.8	Open Borehole Piezometer
	May 22, 2013	3.1	222.9	

The recorded groundwater level is considered short-term reading and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.4 Highway 11/17 EBL, Sta. 12+650 to 13+100 and Highway 11/17 WBL, Sta. 12+900 to 13+100 (Appendix E)

5.4.1 General

Twenty-one boreholes and eleven DCPTs were advanced within Sta. 12+650 to 13+100. The site stratigraphy encountered generally consists of surficial layers of organics, silt and sand, underlain by a silty clay deposit and a lower sand to sand and gravel deposit.

5.4.2 Organic Soils

A layer of organic soils was encountered at the ground surface at seventeen of the boreholes. The organics ranged in thickness from 50 to 800 mm, with underside elevations between 220.8 and 219.1 m. The thickness of the organic soils may vary between and beyond the borehole locations.

At the time of the field investigation, the organic material was generally frozen, or covered with ice (at Borehole 12+926 28R).

A layer of buried organics including peat was also encountered at depths of 0.6 to 1.2 m in Boreholes 12+750 19R, 12+776 CL, and 12+926 28R. The buried organics ranged in thickness from 200 to 1700 mm, with underside elevations between 220.2 and 218.1 m.

SPT N-values recorded in the organics varied from 0 to 72 blows per 0.3 m of penetration; however the higher N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture contents ranged from 47 to 408%.

5.4.3 Silt

A layer of silt ranging in composition from some sand to sandy and with trace to some clay was encountered below the organic soils or at the ground surface throughout the site. The thickness of the silt layer ranged from 0.2 to 3.8 m, and the underside was encountered at depths of 0.3 to 6.1 m (Elev. 219.9 to 214.8 m).

SPT N-values of 0 to 48 blows per 300 mm of penetration were recorded in the silt, indicating a very loose to dense relative density, however the higher N-values are likely related to the frozen nature of the surficial soils at the time of the investigation. The moisture content measurements ranged between 22 to 55%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix E. The grain size distribution curves for the samples are plotted on Figure E2 and the Atterberg Limits test results are plotted on Figure E8 of Appendix E. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 16
Sand %	11 to 56
Silt %	38 to 75
Clay %	4 to 19

Liquid Limit %	23 to 30
Plastic Limit %	19 to 20

The results of the Atterberg Limit tests indicate that the silt is non-plastic to low plasticity with group symbols from ML to CL.

5.4.4 Sand

A 0.5 to 1.7 m thick sand layer was encountered beneath the organics and/or silt in Boreholes 12+876 CL, 12+899 19L, 12+926 29L, and 12+950 19L. The sand contained trace to some silt and trace to some gravel. The base of the sand was encountered at depths of 0.6 to 2.3 m, with underside elevations from 220.0 to 218.6 m.

SPT N-values recorded in the sand ranged from 4 to 11 blows per 0.3 m of penetration, indicating a loose to compact relative density. The moisture content ranged from 18 to 62%.

The results of grain size distribution analyses conducted on two samples of the sand deposit are presented on the Record of Borehole sheets in Appendix E and are plotted on Figure E1 of Appendix E. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	63 to 71
Silt & Clay %	29 to 37

5.4.5 Silty Clay

A silty clay deposit with trace to some sand and occasional sand and silt seams was encountered beneath the silt, sand or organics in all of the boreholes. The thickness of this layer ranged from 1.2 to 17.7 m with the lower boundary encountered at depths from 3.5 to 21.8 m (Elev. 217.4 to 198.8 m) where fully penetrated. Boreholes 12+776 CL, 13+026 28R, 13+050 19L, and 13+076 06R were terminated upon auger refusal at the inferred base of the silty clay at depths of 5.6 to 13.0 m (Elev. 215.9 to 207.1 m). Boreholes 12+826 28R, 12+899 19L, and 12+926 29L did not reach the base of the clay layer, and were terminated at depths from 14.9 to 16.5 m (Elev. 206.0 to 203.9 m). Borehole 12+850 19R was extended beyond the termination depth at 26.8 m (Elev. 193.5 m) by conducting a DCPT at the bottom of the borehole, which encountered refusal (100 blows per 0.3 m of penetration) at a depth of 29.2 m (Elev. 191.1 m).

SPT N-values were recorded in the silty clay ranging between 0 to 7 blows per 0.3 m of penetration. In situ field vane testing measured undrained shear strengths ranging from 16 to greater than 80 kPa, indicating that the silty clay layer ranges from soft to stiff. The measured sensitivity, from remolded field vane testing, ranged from 3 to 14, indicating that the clay is classified as medium to extra sensitive.

The measured moisture content of samples of the silty clay deposit ranged from 22 to 62%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix E. The grain size distribution curves for the samples are plotted on Figures E3

to E7 and the Atterberg Limits test results are plotted on Figures E9 to E13 of Appendix E. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 1
Sand %	0 to 8
Silt %	30 to 80
Clay %	20 to 70
Liquid Limit %	26 to 55
Plastic Limit %	17 to 23

The results of the Atterberg Limit tests indicate that the silty clay is typically intermediate plasticity with group symbol of CI, but ranges from low to high plasticity with group symbols from CL to CH.

The results of Oedometer (one-dimensional consolidation) testing conducted on a sample of the silty clay are included in Appendix E and summarized in Table 5-4 below.

Table 5-4 – Consolidation Test Parameters

Borehole	Sample Depth (m)	Soil Type	w _o (%)	γ (kN/m ³)	e _o	p _o ' (kPa)	p _c ' (kPa)	OCR	C _c	C _r
12+926 28R	11.0	CH	39.7	17.5	1.22	110	125	1.14	0.28	.02

5.4.6 Sandy Silt

A 0.8 to 1.2 m thick layer of sandy silt with trace gravel and trace clay was encountered below the silty clay deposit in Boreholes 12+750 19R and 12+976 1R. Borehole 12+750 19R was terminated upon auger refusal at the base of the sandy silt layer at 4.3 m depth (Elev. 216.6 m), and the underside of the sandy silt layer was encountered at 12.2 m depth (Elev. 208.3 m) in Borehole 12+976 1R.

5.4.7 Sand to Sand and Gravel

A deposit of sand to sand and gravel ranging from trace silt to silty was encountered below the silty clay and sandy silt deposits in Boreholes 12+876 CL, 12+900 19R, 12+926 28R, 12+950 19L, 12+950 19R, 12+976 1R, 13+000 19L, 13+000 19R, 13+026 29L, 13+049 18R, and 13+100 4.9R. The sand deposit was 0.3 to 3.0 m thick and the boreholes were terminated upon auger refusal at the base of the deposit at depths ranging from 9.6 to 24.8 m (Elev. 210.3 to 195.8 m). The DCPTs were terminated upon refusal (100 blows per 0.3 m of penetration) at depths ranging from 2.8 to 24.7 m (Elev. 218.9 to 196.2 m).

SPT N-values recorded within the sand deposit ranged from 14 blows per 0.3 m of penetration to 100 blows per 0.1 m of penetration, indicating a compact to very dense relative density. The moisture content of the deposit ranged from 6 to 10%.

The results of grain size distribution analyses conducted on select samples of the sand deposit are presented on the Record of Borehole sheets in Appendix E and are plotted on Figure E1 of Appendix E. The results of the laboratory tests are summarized as follows:

Gravel %	22 to 43
Sand%	30 to 42
Silt & Clay%	25 to 36

5.4.8 Groundwater Conditions

Standpipe piezometers were installed in three of the twenty-one boreholes to monitor the seasonal groundwater levels after completion of drilling. A summary of the recorded short term groundwater levels is provided below.

Table 5-5 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
12+800 19R	Feb. 14, 2013	0.8	219.8	Piezometer
	May 22, 2013	0.2	220.4	Piezometer
12+950 19L	Feb. 14, 2013	1.4	219.1	Piezometer
	May 22, 2013	0.0	220.5	Piezometer
13+049 18R	Feb. 14, 2013	3.5	216.2	Piezometer
	May 22, 2013	0.3	219.4	Piezometer

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.5 Highway 11/17 EBL and WBL, Sta. 13+300 to 13+450 (Appendix F)

5.5.1 General

Seventeen boreholes and five DCPTs were advanced within Sta. 13+300 to 13+450. Four of the boreholes (SB-01 to SB-04) were drilled for foundation investigations for replacement of the Itzcaulde Creek culvert, which is located within this embankment area. The site stratigraphy encountered generally consists of existing embankment fill, peat and organics, overlying a thick layer of silty clay, underlain by deposits of silt and sand, and bedrock.

5.5.2 Sand Fill

Sand fill was encountered in the boreholes drilled on both the former and the existing Highway 11/17 embankments.

In Boreholes 13+318 01L, 13+342 07R, and 13+380 07R, drilled on the shoulder of the existing highway, the fill consisted of a layer of granular material underlain by silty sand to sand with some silt and trace of gravel. The sand fill in these boreholes extended to depths of 5.1 to 7.1 m (Elev. 214.0 to 211.6 m), and was interrupted in Boreholes 13+342 07R and 13+380 07R by a 0.6 m to 1.3 m thick layer of clay fill at 3.0 to 5.7 m depth.

In boreholes drilled through the former highway embankment, sand fill was encountered below a surficial organic layer (Boreholes SB-01 and SB-02), below silty clay fill at 1.7 m depth (Borehole 13+321 17.4L), and at the ground surface (Boreholes SB-04, 13+350 19L, 13+368.4 24.6L, 13+400 19L, and 13+424.6 5.7L). The sand fill varied from gravelly to silty, with localized sandy silt fill containing some clay in Borehole 13+368.4 24.6L. The thickness of the sand fill ranged from 0.5 to 2.9 m, with a lower boundary at depths of 0.5 to 3.6 m (Elev. 215.9 to 211.6 m).

In general, SPT N-values recorded in the sand fill varied widely from 0 to 33 blows for 0.3 m penetration, indicating a very loose to dense relative density. Higher N-values of 89 blows for 0.3 m to 50 blows for 0.05 m of penetration were obtained in the upper frozen material. Moisture contents of 4% to 30% were measured, reflecting the presence of silty/ clayey zones or organic inclusions in samples of the sand fill.

Four samples of the sand fill were subjected to laboratory grain size analysis testing. A sample of sandy silt fill also exhibited sufficient plasticity for Atterberg Limits testing. The results of the testing are presented on the Record of Borehole Sheets included in Appendix F, and are summarized below. The grain size distribution curves for the samples are plotted on Figure F1 and the Atterberg Limits test results are plotted on Figure F9 of Appendix F.

Gravel %	0 to 29
Sand %	27 to 74
Silt and Clay %	21 to 70
Liquid Limit %	27
Plastic Limit %	18

The results of the Atterberg Limits test indicate that a localized sample of the sandy silt fill in Borehole 13+368.9 24.6L was low plastic with a group symbol of CL.

5.5.3 Silty Clay (Fill and Possible Fill)

Silty clay identified as fill or possible fill was encountered below the sand fill at depths of 1.2 to 1.8 m (Elev. 213.6 to 213.9 m) in Boreholes SB-01, SB-04 and 13+350 19L drilled from the former embankment level, and at depths of 3.0 to 5.7 m (Elev. 215.4 to 213.0 m) in Boreholes 13+318 01L, 13+342 07R and 13+380 07R drilled on the existing highway embankment. The clay (fill) contained some sand, organic seams, wood fibres/fragments, roots/rootlets and peat layers. Of note are a 0.7 m thick layer of silty sand with peat encountered in Borehole 13+350 19L, a 0.8 to 1.5 m thick sand layer in Boreholes 13+342

07R and 13+380 07R, and a 0.3 m thick layer of peat in Borehole 13+380 07R. The colour of the silty clay (fill) was generally brown to dark brown.

The thickness of the silty clay (fill) including the intermixed peat and sand layers ranged from 2.4 to 5.7 m, with a lower boundary at depths of 4.6 to 9.8 m (Elev. 211.6 to 208.9 m).

Silty clay fill was also encountered below a thin organic layer and above the sand fill in Borehole 13+321 17.4L drilled on the former highway alignment. The clay fill was 1.5 m thick with a lower boundary at 1.7 m depth (Elev. 213.8 m) in this borehole.

SPT N-values recorded in the silty clay (fill) ranged from 0 to 28 blows for 0.3 m penetration, indicating a very soft to very stiff consistency. An N-value of 21 blows for 0.3 m was recorded in frozen material in Borehole 13+321 17.4L. An undrained shear strength of 52 kPa was measured by in situ vane testing in Borehole SB-01. Moisture contents ranged from about 23% to 53% in the silty clay fill.

The results of grain size distribution analyses conducted on four samples of the silty clay fill are presented on the Record of Borehole sheets in Appendix F and on the grain size distribution curves plotted on Figure F2 of Appendix F. The results of Atterberg Limits testing conducted on the samples are presented on the Record of Borehole sheets and plotted on Figure F10 of Appendix F. The results are summarized below.

Gravel %	0 to 9
Sand %	11 to 19
Silt %	43 to 61
Clay %	25 to 38
Liquid Limit %	34 to 36
Plastic Limit	17 to 23

5.5.4 Organic Soils

A thin layer of topsoil or organic soils was encountered at the surface in Boreholes SB-01, SB-02, 13+300 19L, 13+300 19R, 13+321 17.4L, 13+340 19R, and 13+405.9 23.5R. The topsoil/organic layer was 50 to 200 mm thick at these locations. The thickness of the topsoil/organic soils may vary between and beyond the borehole locations.

A 100 mm thick layer of buried organic soil was also encountered beneath the fill in Borehole 13+321 17.4L at a depth of 3.6 m (Elev. 211.9 m).

A layer of organic clay with peat was encountered at the ground surface in Boreholes SB-03 and 13+375 30R drilled to the east of the existing highway embankment, and below the embankment fill in Boreholes SB-04, 13+318 01L, and 13+424.6 5.7L. The organic layer was 3.0 m thick in Borehole 13+375 30R and 0.5 to 1.5 m thick in the remaining boreholes. The lower boundary was at Elev. 215.4 to 208.7 m.

SPT N-values recorded in the organic clay ranged from 0 to 4 blows for 0.3 m penetration, locally 16 blows in Borehole 13+318 01L. Moisture contents ranged from 45 to 77%.

A further 0.9 m of sandy clayey silt with organics was encountered below the organic clay in Borehole SB-04. An N-value of 4 blows for 0.3 m and a moisture content of 53% were obtained in this layer. The lower boundary was at 7.0 m depth (Elev. 207.8). The results of a grain size distribution analysis conducted on this layer are presented on Figure F3 of Appendix F, and are summarized below.

Gravel %	0
Sand %	34
Silt %	43
Clay %	23

5.5.5 Silty Clay

A silty clay deposit with trace sand and trace gravel was encountered below the fill and/or organic layers. Occasional roots, rootlets, and wood pieces were observed near the upper boundary of the silty clay layer. The investigated thickness of this layer, where fully penetrated, ranged from 5.7 to 14.6 m with an underside elevation ranging between 203.0 to 199.2 m. Boreholes 13+318 01L, 13+342 07R, 13+375 30R, 13+380 07R, 13+400 19L and 13+405.9 23.5R were terminated within this layer at depths ranging from 10.7 to 14.6 m (underside Elev. 205.8 to 198.4 m).

SPT N-values were recorded between 0 to 11 blows per 300 mm of penetration, typically decreasing with depth and increasing just above the base of the layer. In situ field vane testing measured undrained shear strengths in the order of 19 to 84 kPa, indicating the clay layer is soft to stiff. The measured sensitivity, from remolded field vane testing, ranged from 2 to 5, indicating the clay is classified as low sensitivity to sensitive.

The moisture content of samples of the silty clay typically ranged from 23 to 57%. A value of 91% was measured near the upper boundary of the silty clay layer in Borehole 13+340 19R.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix F. The grain size distribution curves for the samples are plotted on Figures F4 to F7 and the Atterberg Limits test results are plotted on Figures F11 to F15 of Appendix F. The results of the laboratory tests are summarized as follows:

Gravel %	0 to 0
Sand %	0 to 23
Silt %	25 to 67
Clay %	29 to 75
Liquid Limit %	28 to 57
Plastic Limit %	16 to 22

The results of the Atterberg Limit tests indicate that the silty clay is typically of intermediate plasticity (CI), varying from low to high plasticity (CL to CH).

5.5.6 Sand and Silt to Gravelly Sand

A cohesionless deposit varying in gradation from sand and silt to gravelly sand was encountered below the silty clay layer in Boreholes SB-01, SB-02, SB-03, SB-04, 13+300 19L, 13+300 19R, 13+321 17.4L, 13+340 19R, 13+350 19L, 13+638.4 24.6L and 13+424.6 5.7L. Boreholes SB-01, SB-02, SB-03, SB-04, 13+300 19L, 13+321 17.4L and 13+424.6 5.7L were terminated upon encountering bedrock or refusal below the cohesionless material at depths of 13.7 to 20.2 m (Elev. 196.7 to 202.3 m), indicating a thickness of 0.3 to 4.5 m. Boreholes 13+300 19R, 13+340 19R, 13+350 19L and 13+368.4 24.6L were terminated in the buried cohesionless layer at 13.7 to 14.3 m depth (Elev. 200.5 to 202.2 m).

SPT N-values recorded within the cohesionless deposit ranged from 0 blows for 0.3 m penetration to 100 blows for 0.075 m penetration, indicating a widely variable relative density of very loose to very dense. An SPT N-value of 100 blows with no penetration was recorded on a probable cobble above the bedrock in Borehole SB-03. Moisture contents ranged from 5% to 40%.

Three samples of silty sand were selected for laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix F and the grain size distribution curve is plotted on Figure F8, Appendix F.

Gravel %	10 to 20
Sand %	52 to 54
Silt and Clay %	29 to 36

5.5.7 Bedrock and Probable Bedrock

Bedrock or refusal on probable bedrock was encountered below the cohesionless sand layer in Boreholes SB-01, SB-02, SB-03, SB-04, 13+300 19L, 13+321 17.4L and 13+424.6 5.7L, as well as in DCPT 13+324 27L. The depths and elevations of bedrock and probable bedrock are summarized in Table 5-6.

Table 5-6 – Depth to Bedrock and Refusal on Probable Bedrock

Borehole / DCPT	Bedrock or Probable Bedrock	
	Depth (m)	Elevation (m)
SB-01	17.4	198.3
SB-02	14.5*	198.5
SB-03	15.4*	197.4
SB-04	14.0*	200.8
13+321 17.4L	14.1	201.4
13+324 27L	15.2	200.2
13+424.6 5.7L	20.2	196.7

** Proven by coring*

A 3.0 to 3.3 m length of rock core was recovered from Boreholes SB-02, SB-03 and SB-04. The bedrock recovered in the core samples was described as grey gneiss. Total core recovery was 100% in all runs. RQD values of 67 to 100% were recorded, typically 90% to 100%, indicating excellent rock quality. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 5.

Average unconfined compressive strengths (UCS) of 54 to 356 MPa were assessed from the results of point load tests conducted on the rock core samples, indicating a strong to extremely strong intact rock strength. The UCS results are included on the borehole logs in Appendix F (as average per run).

5.5.8 Groundwater Conditions

Standpipe piezometers were installed in three of the seventeen boreholes to monitor the seasonal groundwater levels after completion of drilling. A summary of the recorded short term groundwater levels is provided below.

Table 5-7 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
13+300 19L	Feb. 12, 2013	3.8	212.1	Open Borehole
13+300 19R	Feb. 14, 2013	4.3	212.2	Open Borehole
13+318 01L	Mar. 25, 2014	7.7	211.4	Open Borehole
13+340 19R	Feb. 20, 2013	11.9	202.3	Open Borehole
	May 22, 2013	1.3	212.9	Piezometer
13+342 07R	Mar. 25, 2014	7.7	211.0	Open Borehole
13+350 19L	Feb. 9, 2013	5.2	209.9	Open Borehole
13+368.4 24.6L	Feb 8, 2013	5.0	210.2	Open Borehole
13+375 30R	Feb. 23, 2013	3.9	208.2	Open Borehole
13+380 07R	Mar. 25, 2014	Dry	-	Open Borehole
13+400 19L	Feb. 14, 2013	1.3	214.5	Piezometer
	May 22, 2013	0.1	215.7	Piezometer
13+405.9 23.5R	Feb. 13, 2013	Dry	-	Open Borehole
SB-01	May 7, 2013	4.8	210.9	Open Borehole
SB-02	May 9, 2013	4.9	208.1	Piezometer

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.6 Highway 11/17 EBL, Sta. 16+250 to 16+460 (Appendix G)

5.6.1 General

Seven boreholes and three DCPTs were advanced within Sta. 16+250 to 16+460. The site stratigraphy encountered generally consist of a surficial layer of organics underlain by a deposit of silty clay with trace sand which was further underlain by a deposit of sand ranging to sand and gravel.

5.6.2 Organic Soils

A layer of organic soils ranging from 125 to 1600 mm thick was encountered at the surface of all seven boreholes. The organic material ranged in composition from topsoil to peat and contained roots, rootlets and occasional wood fibres. At the time of the field investigation, the organic material was generally frozen, or covered with ice (at Borehole 16+435 CL). The underside elevation of the organics varied from Elev. 231.2 to 234.8 m. The thickness of the organic soils may vary between and beyond the borehole locations.

SPT N-values recorded in the organic soils varied between 8 to 13 blows per 0.3 m of penetration; however the N-values likely reflect the frozen nature of the soil at the time of investigation. The moisture contents ranged from 35 to 354%.

5.6.3 Silty Clay

A silty clay deposit with trace sand and trace silt seams was encountered beneath the surficial layer of organics in all seven boreholes. The thickness of this layer ranged from 4.5 to 11.7 m, with the lower boundary encountered at depths from 6.1 to 11.9 m (Elev. 227.1 to 223.1 m). Boreholes 16+260 19R, 16+302 1R and 16+435 CL were terminated in the silty clay upon encountering split spoon or auger refusal on probable bedrock. DCPT 16+300 29R was also terminated in the silty clay deposit at a depth of 4.6 m (Elev. 226.6 m) upon refusal (100 blows per 0.3 m of penetration).

SPT N-values were recorded between 0 to 10 blows per 0.3 m of penetration, typically decreasing with depth and increasing just above the base of the layer. In situ field vane testing measured undrained shear strengths ranging from 16 to 90 kPa, indicating that the silty clay layer is soft to stiff. The measured sensitivity, from remolded field vane testing, ranged from 2 to 11, typically less than 5, indicating the clay is classified as low sensitivity to sensitive.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix G. The grain size distribution curves for the samples are plotted on Figures G2 and G3 and the Atterberg Limits test results are plotted on Figures G4 and G5 of Appendix G. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 2
Silt %	39 to 58
Clay %	41 to 60
Liquid Limit %	36 to 54
Plastic Limit %	19 to 22

The results of the Atterberg Limit tests indicate that the silty clay is typically intermediate plasticity with group symbol of CI.

5.6.4 Sand to Sand and Gravel

Below the silty clay deposit, a layer of sand was encountered in Boreholes 16+335.2 21.2R, 16+370 29R, 16+405 19R, and 16+460 19L. The sand layer ranged in composition from sand with some silt and trace gravel, to sand and gravel with some silt. The investigated thickness ranged from 0.7 to 1.4 m. All four boreholes were terminated within this deposit upon auger refusal on probable bedrock at depths from 6.8 to 13.3 m (Elev. 221.8 to 226.3 m). DCPTs 16+370 CL and 16+460 29L were also terminated upon refusal (100 blows per 0.3 m of penetration) on inferred bedrock at depths of 7.4 and 10.0 m (Elev. 226.3 to 224.2 m).

SPT N-values were recorded in the sand deposit between 4 and 44 blows per 0.3 m of penetration indicating loose to dense consistency. The measured moisture contents of the sand ranged between 9 to 15%.

The result of grain size distribution analyses conducted on two samples of the sand to sand and gravel deposit are presented on the corresponding Record of Borehole sheets in Appendix G and are plotted on Figure G1 of Appendix G. The results of the laboratory tests are summarized as follows:

Gravel %	27 to 40
Sand %	38 to 46
Silt & Clay %	22 to 27

5.6.5 Groundwater Conditions

Standpipe piezometers were installed in two of the seven boreholes to monitor the seasonal groundwater levels after completion of drilling. A summary of the recorded short term groundwater levels is provided below.

Table 5-8 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
16+335.2 21.2R	Feb. 14, 2013	-	-	Piezometer ⁽¹⁾
16+435 CL	Feb. 05, 2013	1.0	232.0	Open borehole
16+460 19L	Feb. 14, 2013	2.1	232.9	Piezometer
	May 22, 2013	0.4	234.6	Piezometer

Note: (1) Piezometer destroyed before reading could be taken

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.7 Highway 11/17 EBL and WBL, Sta. 16+830 to 16+940 (Appendix H)

5.7.1 General

Six boreholes and two DCPTs were advanced within Sta. 16+830 to 16+940. The site stratigraphy encountered generally consist of a surficial layer of organics underlain by a deposit of silty clay with trace sand and trace silt seams, which was further underlain by sand with trace to some gravel and trace silt.

5.7.2 Organic Soils

A thin layer of organic soils consisting of 150 to 275 mm of topsoil was encountered at the surface of all six boreholes. The thickness of the organic soils may vary between and beyond the borehole locations.

5.7.3 Silty Clay

A silty clay deposit with trace sand and trace silt seams was encountered beneath the surficial layer of topsoil in all six boreholes. The thickness of this layer ranged from 6.4 to 10.1 m with the lower boundary encountered at depths from 6.6 to 10.3 m (Elev. 237.3 to 232.1 m). Borehole 16+902.2 16.7R was terminated upon auger refusal at the inferred base of the silty clay at a depth of 8.2 m (Elev. 237.1 m).

SPT N-values were recorded between 0 to 11 blows per 0.3 m of penetration, typically decreasing with depth and increasing just above the base of the layer. In situ field vane testing measured undrained shear strengths ranging from 8 to 56 kPa, indicating that the silty clay layer is very soft to stiff. The measured sensitivity, from remolded field vane testing, ranged from 2 to 6, indicating that the clay is classified as low sensitivity to sensitive.

The moisture content of the silty clay deposit ranged from 18 to 63%.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silty clay. The results of the testing are presented on the Record of Borehole Sheets included in Appendix H. The grain size distribution curves for the samples are plotted on Figures H2 and H3 and the Atterberg Limits test results are plotted on Figures H4 and H5 of Appendix H. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	0 to 5
Silt %	32 to 59
Clay %	40 to 68
Liquid Limit %	35 to 56
Plastic Limit %	18 to 23

The results of the Atterberg Limit tests indicate that the silty clay is typically intermediate plasticity with group symbol of CI. One of the tested samples, obtained with a Shelby Tube, exhibited high plasticity with a group symbol of CH.

The results of Oedometer (one-dimensional consolidation) testing conducted on a sample of the silty clay are included in Appendix H and summarized in 5-8.

Table 5-9 – Consolidation Test Parameters

Borehole	Sample Depth (m)	Soil Type	w _o (%)	γ (kN/m ³)	e _o	p _o ' (kPa)	p _c ' (kPa)	OCR	C _c	C _r
16+850 19R	7.9	CH	53.4	16.6	1.53	80	147	1.9	0.40	0.03

5.7.4 Sand

Below the silty clay deposit, a layer of sand with trace to some gravel and trace silt was encountered in five of the boreholes. The investigated thickness ranged from 0.4 to 3.6 m. All five boreholes were terminated within this deposit upon auger refusal on probable bedrock at depths from 8.0 to 12.4 m (Elev. 236.9 to 229.8 m). The DCPTs were also terminated upon refusal (100 blows per 0.3 m of penetration) at depths of 7.8 to 14.9 m (Elev. 237.0 to 228.4 m).

SPT N-values were recorded at 7 blows per 0.3 m of penetration to 100 blows per 0.125 m of penetration indicating loose to very dense consistency. The measured moisture contents of the sand ranged between 7 to 16%.

The result of a grain size distribution analysis conducted on a single sample of sand is presented on the corresponding Record of Borehole sheet and is plotted on Figure H1 of Appendix H. The results of the laboratory tests are summarized as follows:

Gravel %	3
Sand %	89
Silt & Clay %	8

5.7.5 Groundwater Conditions

Standpipe piezometers were installed in two of the six boreholes to monitor the seasonal groundwater levels after completion of drilling. A summary of the recorded short term groundwater levels is provided below.

Table 5-10 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
16+850 19R	Feb. 10, 2013	0.7	241.5	Piezometer
	Feb. 14, 2013	0.5	241.7	Piezometer
	May 22, 2013	-1.3 ⁽¹⁾	243.5	Piezometer
16+863.3 23.9L	Feb. 02, 2013	3.2	240.5	Open borehole
16+875 29R	Feb. 01, 2013	3.5	241.0	Open borehole
16+896.5 28.2L	Feb. 03, 2013	2.6	240.7	Open borehole
16+902.2 16.7R	Jan. 31, 2013	4.6	240.8	Open borehole
16+910 19L	Feb. 10, 2013	1.5	243.4	Piezometer
	Feb. 14, 2013	1.3	243.6	Piezometer
	May 22, 2013	-1.0 ⁽¹⁾	245.9	Piezometer

Note: (1) Negative value indicates water level recorded above ground surface (artesian)

The recorded groundwater levels are considered short-term readings and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.8 Highway 11/17 EBL and WBL, Sta. 18+450 to 18+500 (Appendix I)

5.8.1 General

Two boreholes and three DCPTs were advanced within Sta. 18+450 to 18+500. The site stratigraphy encountered generally consists of a surficial deposit of peat underlain by a localized deposit of sand with some silt, all which was further underlain by clayey silt followed by a lower sand layer with trace silt and trace gravel.

5.8.2 Peat

A deposit of peat was encountered at the surface in both boreholes with a thickness of 3.0 to 3.1 m. The lower boundary of the peat deposit varied from Elev. 264.7 to 263.5 m. The thickness of the peat may vary between and beyond the borehole locations.

SPT N-values recorded in the peat were between 0 to 3 blows per 0.3 m of penetration, indicating a very soft to soft consistency. The moisture contents of ranged from 282 to 444%.

5.8.3 Upper Sand

A localized layer of sand with some silt and trace gravel was encountered directly below the peat deposit within Borehole 18+464.4 12.4R. The thickness of the sand layer was 1.4 m with an underside depth of 4.4 m (Elev. 263.2 m).

A single SPT N-value of 5 blows per 0.3 m of penetration was recorded indicating a loose relative density. A corresponding moisture content of 14% was measured.

5.8.4 Clayey Silt

Below the peat and upper sand layers, a layer of clayey silt with trace sand was encountered in both boreholes. The clayey silt layer was encountered at a depth of 3.1 to 4.4 m and was 4.3 to 4.8 m thick. The underside of the clayey silt was encountered at depths of 7.9 to 8.7 m (Elev. 259.0 to 258.7 m).

SPT N-values of 2 to 14 blows per 0.3 m of penetration were recorded in the clayey silt. In situ field vane testing in Borehole 18+475 19L measured undrained shear strengths ranging from 12 to 45 kPa, indicating that the clayey silt deposit is soft to firm. The measured sensitivity, from remolded field vane testing, ranged from 8 to 12, indicating that the clayey silt is classified as sensitive to extra-sensitive.

The moisture content measurements ranged between 13 to 31% for the clayey silt.

Grain size distribution and Atterberg Limits testing were carried out on select samples of the silt. The results of the testing are presented on the Record of Borehole Sheets included in Appendix I. The grain size distribution curves for the samples are plotted on Figure I2 and the Atterberg Limits test results are plotted on Figure I3 of Appendix I. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	2 to 8
Silt %	66 to 78
Clay %	20 to 26
Liquid Limit %	24 to 26
Plastic Limit %	17 to 21

The results of the Atterberg Limit tests indicate that the clayey silt is generally non-plastic to low plasticity with group symbols of CL - ML.

5.8.5 Lower Sand

Below the clayey silt deposit, in both boreholes, a lower layer of sand with trace gravel and trace silt was encountered. The lower sand deposit was 1.3 to 1.8 m thick, and both boreholes were terminated within the sand upon auger refusal on probable bedrock at depths of 9.2 to 10.5 m (Elev. 257.4 to 257.2 m). The termination depth of the DCPTs ranged from 9.7 to 12.9 m (258.1 to 254.1 m).

An SPT N-value was measured at 9 blows per 0.3 m of penetration. Moisture content was measured at 13%.

The result of a grain size distribution analysis conducted on a single sample of sand is presented on the corresponding Record of Borehole sheet in Appendix I and is plotted on Figure I1 of Appendix I. The results of the laboratory tests are summarized as follows:

Gravel %	15
Sand %	71
Silt & Clay %	14

5.8.6 Groundwater Conditions

A standpipe piezometer was installed in Borehole 18+475 19L to monitor the seasonal groundwater level after completion of drilling and a summary of the recorded short term groundwater level is provided below.

Table 5-11 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
18+475 19L	Feb. 10, 2013	0.1	266.5	Piezometer
	Feb. 14, 2013	N/A (Frozen)	N/A (Frozen)	Piezometer
	May 22, 2013	0.0	266.6	Piezometer

The recorded groundwater level is considered short-term reading and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

5.9 Highway 11/17 EBL and WBL, Sta. 19+850 to 19+900 (Appendix J)

5.9.1 General

Three boreholes and two DCPTs were advanced within Sta. 19+850 to 19+900. The site stratigraphy encountered typically consists of a thin, surficial layer of organics overlying a deposit of sand with trace silt and trace gravel to gravelly. Within the sand layer is a localized layer of silt with trace clay and trace sand.

5.9.2 Organic Soils

A 150 to 160 mm thick layer of organic soils was encountered at the surface of all three boreholes. The thickness of the organic soils may vary between and beyond the borehole locations.

5.9.3 Sand

A deposit of sand with trace silt and trace gravel was encountered directly below the organic soils in all three boreholes. The thickness of the sand layer was between 4.5 and 5.4 m in Boreholes 19+875 19L and 19+875 19R, which were terminated upon auger refusal on probable bedrock at depths of 4.7 to 5.6 m (Elev. 270.9 to 270.5 m). Borehole 19+885 19R was terminated within this sand layer at a depth of 3.0 m (Elev. 271.9 m). The DCPTs were terminated upon refusal (100 blows per 0.3 m of penetration) at depths of 2.2 to 3.0 m (Elev. 273.4 to 272.3 m) within the sand layer.

SPT N-values of 7 blows per 0.3 m of penetration to 100 blows per 0.125 m of penetration were recorded, indicating a loose to very dense relative density. The recorded moisture content of the retained samples of sand ranged from 4 to 28%.

The result of a grain size distribution analysis conducted on a single sample of sand is presented on the corresponding Record of Borehole sheet in Appendix J and is plotted on Figure J1 of Appendix J. The results of the laboratory tests are summarized as follows:

Gravel %	3
Sand %	93
Silt & Clay %	4

5.9.4 Silt

A localized 0.8 m thick layer of silt with trace clay and trace sand was encountered within the sand layer in Borehole 19+975 19R. The silt layer was encountered between depths of 2.2 and 3.0 m, with an underside elevation of 272.2 m.

A SPT N-value of 52 blows per 0.3 m of penetration was recorded, indicating a very dense relative density. A moisture content of 18% was recorded.

The result of a grain size distribution analysis conducted on a single sample of silt is presented on the corresponding Record of Borehole sheet in Appendix J and is plotted on Figure J2 of Appendix J. The results of the laboratory tests are summarized as follows:

Gravel %	0
Sand %	9
Silt %	83
Clay %	8

5.9.5 Groundwater Conditions

A short-term water level measurement was recorded in the open borehole at 19+875 19R following completion of drilling. The recorded short-term groundwater level is provided below.

Table 5-12 Water Level Observations

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
19+875 19R	Jan. 30, 2013	1.1	274.1	Open borehole

The recorded groundwater level is considered a short-term reading and seasonal fluctuations of the groundwater level are to be expected, particularly after spring snowmelt as well as periods of prolonged and/or significant precipitation.

6 MISCELLANEOUS

Thunder Bay Testing and Engineering (TBTE) of Thunder Bay, Ontario supplied and operated the drilling and sampling equipment for the field program. Full time supervision of the field activities was carried out by Ms. Eckie Siu, Mr. George Azzopardi and Mr. Stephane Loranger of Thurber.

Supervision of the field program was performed by Mr. Mark Farrant and interpretation of the field data and preparation of the report was performed by Mr. Mark Farrant and Mr. Jason Lee. 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

Tables

Table A1-1 to A1-3	Borehole Summary
Table A2	Piezometer Installation Details

Low to Medium Embankments
Highway 11/17 - Red Rock to Nipigon

Table A1-1
Borehole Summary

Appendix	Borehole / DCPT (*) / BH+DCPT (**)	Description	Depth of Investigation (m)	Depth of Peat, Topsoil and Organics Deposit (m)
B	Highway 11/17 EBL and WBL, Sta. 12+050 to 12+100			
	12+050 29R	Right toe of EBL	14.3	0.1 to 1.2
	12+060 CL*	DCPT, Right toe of WBL	10.4	
	12+080.9 17.8R	CL of EBL	13.7	
	12+090 29R*	DCPT, Right toe of EBL	15.1	
	12+090 CL*	DCPT, Right toe of WBL	12.8	
	12+056.5 27.5L	Left toe of WBL	13.4	0.1 to 0.9
	12+080 19L	CL of WBL	11.3	
	12+090 29L*	DCPT, Left toe of WBL	11.6	
C	Highway 11/17 EBL and WBL, Sta. 12+170 to 12+270			
	12+170 29R*	DCPT, Right toe of EBL	12.3	0.1 to 1.2
	12+170 CL*	DCPT, Left toe of EBL	10.4	
	12+180 19R	CL of EBL	10.1	
	12+210 29R*	DCPT, Right toe of EBL	12.5	
	12+210 CL*	DCPT, Right toe of WBL	12.5	
	12+230 19R	CL of EBL	9.1	
	12+250 29R*	DCPT, Right toe of EBL	8.8	
	12+265 CL	Right toe of WBL	10.7	0.2
	12+190 29L*	DCPT, Left toe of WBL	5.9	
	12+200 19L	CL of WBL	8.5	
	12+243 30.7L	Left toe of WBL	5.8	
	12+250 19L	CL of WBL	7.0	
12+265 29L*	DCPT, Left toe of WBL	10.1		
D	Highway 11/17 EBL, Sta. 12+420 to 12+540			
	12+430 19R	CL of EBL	14.9	0.1 to 0.9
	12+455 28R	Right toe of EBL	14.3	
	12+455 CL*	DCPT, Left toe of EBL	14.9	
	12+480 19R	CL of EBL	14.3	
	12+505 28R*	DCPT, Right toe of EBL	12.2	
	12+505 CL	Left toe of EBL	11.6	
	12+520 19R	CL of EBL	9.9	
E	Highway 11/17 EBL and WBL, Sta. 12+650 to 13+100			
	12+750 19R	CL of EBL	4.3	0.1 to 1.7
	12+750 CL*	DCPT, Left toe of EBL	2.8	
	12+776 27R*	DCPT, Right toe of EBL	5.6	
	12+800 19R	CL of EBL	9.5	
	12+826 28R	Right toe of EBL	16.5	
	12+826 CL*	DCPT, Left toe of EBL	24.7	
	12+850 19R	CL of EBL	29.2	
	12+876 28R*	DCPT, Right toe of EBL	17.6	
	12+876 CL	Left toe of EBL	24.8	
	12+900 19R	CL of EBL	12.9	
	12+926 28R	Right toe of EBL	15.1	
	12+926 CL*	DCPT, Left toe of EBL	15.6	
	12+950 19R	CL of EBL	14.7	

Low to Medium Embankments
Highway 11/17 - Red Rock to Nipigon

Table A1-2
Borehole Summary

Appendix	Borehole / DCPT (*) / BH+DCPT (**)	Description	Depth of Investigation (m)	Depth of Peat, Topsoil and Organics Deposit (m)
E	Highway 11/17 EBL and WBL, Sta. 12+650 to 13+100			
	12+976 28R*	DCPT, Right toe of EBL	12.7	0.1 to 1.7
	12+976 1R	Left toe of EBL	13.2	
	13+000 19R	CL of EBL	9.6	
	13+026 05R*	DCPT, Right toe of WBL	9.9	
	13+026 28R	Right toe of EBL	9.0	
	13+049 18R	CL of EBL	9.9	
	13+076 06R	Right toe of WBL	8.5	
	13+076 27R*	DCPT, Right toe of EBL	7.5	
	13+100 4.9R	CL of EBL	10.6	
	12+776 CL	Left toe of EBL	5.6	
	12+899 19L	CL of WBL	14.9	0.0 to 0.1
	12+926 29L	Left toe of WBL	14.9	
	12+950 19L	CL of WBL	14.0	
	12+976 29L*	DCPT, Left toe of WBL	13.8	
	13+000 19L	CL of WBL	10.4	
	13+026 29L	Left toe of WBL	14.1	
	13+050 19L	CL of WBL	13.0	
	13+077 28L*	DCPT, Left toe of WBL	15.2	
	13+100 19L*	DCPT, CL of WBL	13.0	
F	Highway 11/17 EBL and WBL, Sta. 13+300 to 13+450			
	13+300 19R	CL of EBL	14.3	0.0 to 0.3
	13+325 30R*	DCPT, Right toe of EBL	14.9	
	13+340 19R	CL of EBL	13.7	
	13+342 07R	Left toe of EBL	13.3	
	13+375 30R	Right toe of EBL	13.7	
	13+380 07R	Left toe of EBL	13.3	
	13+405.9 23.5R	CL of EBL	14.8	
	13+425 30R*	DCPT, Right toe of EBL	14.9	
	13+300 19L	CL of WBL	13.7	0.0 to 0.3
	13+318 01L	Right toe of WBL	13.3	
	13+321 17.4L	CL of WBL	14.1	
	13+324 27L*	DCPT, Left toe of WBL	15.2	
	13+350 19L	CL of WBL	14.3	
	13+368.4 24.6L	Left toe of WBL	14.3	
	13+379.1 11.2L*	DCPT, Right toe of WBL	15.2	
	13+400 19L	CL of WBL	14.8	
	13+425 30L*	DCPT, Left toe of WBL	19.8	
	13+424.6 5.7L	Right toe of WBL	20.2	
	SB-04	CL of WBL	17.2	0.0 to 0.1
	SB-03	Right toe of EBL	18.4	
	SB-01	CL of WBL	17.4	
	SB-02	Left toe of WBL	17.8	

Low to Medium Embankments
Highway 11/17 - Red Rock to Nipigon

Table A1-3
Borehole Summary

Appendix	Borehole / DCPT (*) / BH+DCPT (**)	Description	Depth of Investigation (m)	Depth of Peat, Topsoil and Organics Deposit (m)
G	Highway 11/17 EBL and WBL, Sta. 16+250 to 16+460			
	16+260 19R	CL of EBL	7.8	0.2 to 1.6
	16+300 29R*	DCPT, Right toe of EBL	4.6	
	16+302 1R	Left toe of EBL	9.2	
	16+335.2 21.2R	CL of EBL	6.8	
	16+370 29R	Right toe of EBL	6.9	
	16+370 CL*	DCPT, Left toe of EBL	7.4	
	16+405 19R	CL of EBL	7.5	
	16+435 CL	Left toe of EBL	7.4	
	16+460 19L	CL of WBL	13.3	0.2
	16+460 29L*	DCPT, Left toe of WBL	10.0	
H	Highway 11/17 EBL and WBL, Sta. 16+830 to 16+940			
	16+850 19R	CL of EBL	12.4	0.2 to 0.3
	16+875 29R	Right toe of EBL	11.7	
	16+875 CL*	DCPT, Left toe of EBL	14.9	
	16+902.2 16.7R	CL of EBL	8.2	
	16+850 29L*	DCPT, Left toe of WBL	7.8	0.2
	16+863.3 23.9L	CL of WBL	10.2	
	16+896.5 28.2L	Left toe of WBL	11.2	
	16+910 19L	CL of WBL	8.0	
I	Highway 11/17 EBL and WBL, Sta. 18+450 to 18+500			
	18+463.5 14R*	DCPT, Right toe of EBL	9.7	3.0
	18+464.4 12.4R	CL of EBL	10.5	
	18+475 CL*	DCPT, Right toe of WBL	12.9	
	18+475 19L	CL of WBL	9.2	3.1
	18+475 29L*	DCPT, Left toe of WBL	11.1	
J	Highway 11/17 WBL, Sta. 19+850 to 19+900			
	19+875 19R	CL of EBL	4.7	0.0 to 0.2
	19+875 29R*	DCPT, Right toe of EBL	2.2	
	19+885 19R	CL of EBL	3.0	
	19+874.3 8.3L*	DCPT, Right toe of WBL	3.0	0.2
	19+875 19L	CL of WBL	5.6	

Low to Medium Embankments
Highway 11/17 - Red Rock to Nipigon

Table A2
Piezometer Installation Details

Borehole	Piezometer Tip Depth (m)	Installation Details
12+080.9 17.8R	12.2	Piezometer with 1.5 m slotted screen installed, sand filter from 13.7 to 10.4 m, bentonite seal from 10.4 to 9.1 m, cuttings from 9.1 to 1.5 m, bentonite from 1.5 m to ground surface.
12+080 19L	9.5	Piezometer with 1.5 m slotted screen installed, sand filter from 11.3 to 7.6 m, bentonite seal from 7.6 to 6.1 m, cuttings from 6.1 to 1.5 m, bentonite from 1.5 m to ground surface.
12+200 19L	7.6	Piezometer with 1.5 m slotted screen installed, sand filter from 8.5 to 5.8 m, bentonite seal from 5.8 to 4.9 m, cuttings from 4.9 to 1.5 m, bentonite from 1.5 m to ground surface.
12+230 19R	9.1	Piezometer with 1.5 m slotted screen installed, sand filter from 9.1 to 7.3 m, bentonite seal from 7.3 to 6.4 m, cuttings from 6.4 to 1.5 m, bentonite from 1.5 m to ground surface.
12+480 19R	13.7	Piezometer with 1.5 m slotted screen installed, sand filter from 14.3 to 11.9 m, cuttings from 11.9 to 1.2 m, bentonite from 1.2 m to ground surface.
12+800 19R	9.5	Piezometer with 1.5 m slotted screen installed, sand filter from 9.5 to 7.3 m, bentonite seal from 7.3 to 6.1 m, cuttings to 6.1 to 1.8 m, bentonite from 1.8 m to ground surface.
12+950 19L	13.7	Piezometer with 1.5 m slotted screen installed, sand filter from 14.0 to 11.0 m, bentonite seal from 11.0 to 8.2 m, cuttings from 8.2 to 1.2 m, bentonite from 1.2 m to ground surface.
13+049 18R	9.9	Piezometer with 1.5 m slotted screen installed, sand filter from 9.9 to 7.6 m, bentonite seal from 7.6 m to ground surface.
13+340 19R	13.1	Piezometer with 1.5 m slotted screen installed, sand filter from 13.7 to 11.3 m, cuttings from 11.3 to 1.2 m, bentonite from 1.2 m to ground surface.
SB-02	17.7	Piezometer 3.0 m slotted screen installed, sand filter from 17.7 m to 13.3 m, bentonite seal from 13.3 m to 1.5 m, cuttings from 1.5 m to ground surface.
13+400 19L	14.3	Piezometer with 1.5 m slotted screen installed, sand filter from 14.3 to 11.7 m, bentonite seal from 11.7 to 2.3 m, cuttings from 2.3 m to ground surface.
16+335.2 21.2R	6.1	Piezometer with 1.5 m slotted screen installed, sand filter from 6.8 to 4.1 m, bentonite seal from 4.1 to 1.1 m, cuttings from 1.1 m to ground surface.
16+460 19L	13.3	Piezometer with 1.5 m slotted screen installed, sand filter from 13.3 to 10.7 m, bentonite seal from 10.7 to 1.1 m, cuttings from 1.1 m to ground surface.
16+850 19R	12.3	Piezometer with 1.5 m slotted screen installed, sand filter from 12.4 to 9.7 m, bentonite seal from 9.7 to 1.9 m, cuttings from 1.9 m to ground surface.
16+910 19L	8.0	Piezometer with 1.5 m slotted screen installed, sand filter from 8.0 to 5.6 m, bentonite seal from 5.6 to 1.9 m, cuttings from 1.9 m to ground surface.
18+475 19L	9.1	Piezometer with 1.5 m slotted screen installed, sand filter from 9.2 to 6.9 m, bentonite seal from 6.9 to 1.4 m, cuttings from 1.4 m to ground surface.