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Preliminary Foundation Investigation and Design Report
High Fill Embankments, Deep Cuts, Swamp Crossing and Culverts

Highway 17, Westbound Truck Climbing Lane and Realignment
Little Pic River Bridge Westerly for 4.5 km
Marathon, Ontario
G.W.P. 6132-17-00, GEOCRES No. 42D15-001

Client Name: BT Engineering
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TABLE OF CONTENTS

IN-TEXT TABLES

APPENDICES

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PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGH FILL EMBANKMENTS, DEEP CUTS, SWAMP CROSSING, AND CULVERTS
HIGHWAY 17 WESTBOUND TRUCK CLIMBING LANE AND REALIGNMENT
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G.W.P. 6132-17-00

GEOGRES No. 42D15-001

PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation for the proposed Highway 17 high fill embankments, deep cuts, swamp crossing and culverts required for widening and partial realignment of Highway 17 from west of the Little Pic River Bridge for 4.5 km westerly. The project is located west of Marathon in the Township of Walsh, within the Thunder Bay District, Ontario.

The proposed works are to accommodate a new approximately 3.4 km long westbound truck climbing lane and 1.1 km of curve flattening on Highway 17. The project will include construction of high fill embankments and deep cuts for both new alignment and widened portions of Highway 17, a portion of new high fill embankment crossing a swamp, and potential installation or replacement of several non-structural culverts.

In preparation for the field investigation, a preliminary geotechnical feasibility study was conducted to provide a generalized summary of the surficial and bedrock geology, potential foundation conditions, foundation recommendations for planning purposes and route selection, and to identify requirements for the scope of future subsurface investigations. The feasibility study was completed in December 2022. The final report was dated September 28, 2023 and is presented under a separate cover.

The purpose of this investigation was to explore the subsurface conditions along the proposed alignment of the high fill embankments, deep cuts and culverts, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the assignment as a sub-consultant to BTE, under the Ministry of Transportation Ontario (MTO), Assignment No. 6020-E-0003.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

2.1 Existing Highway and Proposed Alignment

The existing Highway 17 within the project limits is a two-lane rural highway that extends from just west of the Little Pic River Bridge, a 225 m long bridge built approximately 55 m above the river height, crossing the steep Little Pic River Valley, and ends just east of an at-grade intersection at Dead Horse Road. The existing highway is surrounded by heavily wooded areas and is intersected by two hydro corridors which run approximately east-west. A wetland and two waterbodies are located to the south of the existing highway.

In general, the proposed highway alignment is underlain by bedrock of the Canadian Shield. The bedrock topography on site is described as rugged, knobby, cliffy and jagged. Bedrock hills along the existing and proposed alignments are divided by steep gullies. The low-lying basins between the bedrock hills generally contain small swampy areas and small seasonal watercourses or drainage pathways that typically flow towards the south.

The proposed widened highway alignment follows portions of the existing highway at approximate Sta. 16+756 to 17+360, Sta. 18+240 to 18+980, and Sta. 20+860 to 21+473, and includes new alignment sections at approximate Sta. 17+360 to 18+240 and Sta. 18+960 to 20+860. The widened highway portions typically consist of existing bedrock cut areas or high rock fill embankments that span steep valleys. The new alignment portions typically pass through rugged terrain including steep bedrock hills, low-lying areas, and a swamp.

Typical photographs of the proposed alignment are included in Appendix F.

2.2 Geology

In general, the study area is underlain by bedrock of the Canadian Shield. The geology is characterized by rolling to rugged, bedrock-controlled topography consisting of Precambrian bedrock that is bare or covered by a discontinuous thin layer of drift. Fine-textured glaciolacustrine sediment and organic deposits can also be found in low-lying areas including bedrock depressions or where water has accumulated.

The bedrock is comprised of three geological formations. Bedrock Geology of Ontario Map 2542 indicates the bedrock ranges from mafic to intermediate metavolcanic rocks (basaltic and

andesitic flows, etc.) near the west limit of the project area, to metasedimentary rocks (wacke, arkose, argillite, etc.) through the middle of the site, to carbonatite-alkalic intrusive suite rocks (syenite, nepheline, etc.) at the east portion of the site.

3. SITE INVESTIGATION AND FIELD TESTING

Following selection of the preferred project alignment by BTE and MTO in 2022 (see Appendix A, Drawing 1), the preliminary foundation investigation commenced in 2023. The scope of the preliminary foundation investigation consisted of advancing drilled boreholes, dynamic cone penetration tests (DCPTs), hand auger holes, and shovel probes at selected intervals along the proposed highway alignment where high fill embankments (fills of 4.5 m height or greater), deep cuts (cuts of 4.5 m deep or deeper), a swamp crossing, and potential culverts are planned. The investigation program consisting of a total of 28 boreholes (drilled or hand excavated) was based on review of the proposed highway plan, profile and cross section drawings provided by BTE, as well as site reconnaissance visits conducted by Thurber staff. Where the proposed works involve deep cut sections to widen the existing highway into existing exposed rock cuts, no boreholes were included for the preliminary investigation.

The site investigation and field testing were carried out in three mobilizations. Mobilization 1 was completed between March 28 and 30, 2023. Mobilization 2 was completed on May 11, 2023. Mobilization 3 was completed between July 18 and July 24, 2023. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawings in Appendix A. The records of boreholes sheets are provided in Appendix B. The centreline of the proposed new alignment areas was staked and surveyed by TBT Surveyors Inc. (TBT). The borehole locations were established in the field based on measurements (stations and offset distances) from the staked centreline alignment. The horizontal coordinates and ground surface elevations at the borehole locations were established from the TBT survey data and topographic data provided by BTE. The coordinate system MTM NAD83, Zone 14 was used. Utility clearances were obtained prior to the start of drilling. The boreholes completed during this investigation, along with the investigation locations and assigned nomenclature are summarized in Table 3.1.

Table 3.1 Summary of Boreholes

Location and Assigned Nomenclature	Station	Foundation Boreholes
High Fill Area #1 (HF1)	17+515 to 17+540	Borehole: HF1-01
Deep Cut Area #1 (DC1)	17+580 to 17+960	Shovel Probe: DC1-01, DC1-02, DC1-03
High Fill Area #2 (HF2)	17+980 to 18+020	Shovel Probe: HF2-01, HF2-03 Borehole: HF2-02
Deep Cut Area #2 (DC2)	18+660 to 18+840	*
High Fill Area #3 (HF3)	19+150 to 19+180	Borehole: HF3-01
Swamp Area #1 (SW1)	19+180 to 19+430	Borehole: SW1-01, SW1-03, SW1-04, SW1-06, SW1-07 DCPT: SW1-02, SW1-05
Deep Cut Area #3 (DC3)	19+460 to 19+630	Shovel Probe: DC3-01
High Fill Area #4 (HF4)	19+640 to 19+710	Shovel Probe: HF4-01
Deep Cut Area #4 (DC4)	19+ 720 to 19+840	Shovel Probe: DC4-01
Culvert (CULV1)	19+980	Borehole: CULV1-01
Deep Cut Area #5 (DC5)	19+980 to 20+160	Hand Auger: DC5-01 Shovel Probe: DC5-02
High Fill Area #5 (HF5)	20+180 to 20+230	Hand Auger: HF5-01
Deep Cut Area #6 (DC6)	20+300 to 20+440	Shovel Probe: DC6-01, DC6-02
Deep Cut Area #7 (DC7)	20+550 to 20+720	Shovel Probe: DC7-01 Hand Auger: DC7-02
High Fill Area #6 (HF6)	20+760 to 20+860	Hand Auger: HF6-01 Borehole: HF6-02
Deep Cut Area #8 (DC8)	20+920 to 21+100	*
Deep Cut Area #9 (DC9)	21+260 to 21+360	*
Deep Cut Area #10 (DC10)	21+440 to 21+460	*

** Indicates no boreholes were completed in this section (for widening into existing rock cuts)*

The drilled boreholes and DCPTs were advanced using truck and track-mounted drill rigs with hollow stem augers and NW casing, supplied and operated by Eastern Ontario Diamond Drilling of Hawkesbury, Ontario. The hand auger boreholes and shovel probes were conducted by Thurber's technical staff. Standard Penetration Testing (SPT) was carried out in the drilled boreholes in accordance with ASTM D1586 at selected depth intervals and to obtain soil samples. NQ coring methods were used to advance boreholes HF1-01, HF2-02, CULV-1 and HF6-02 through embankment rock fill and to collect core samples of the bedrock when encountered.

The field investigation was supervised on a full-time basis by members of Thurber's technical staff who directed the drilling, sampling and in-situ testing operations, conducted the hand auger boreholes and shovel probes, logged the boreholes, and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

The rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions were observed in the open boreholes throughout the drilling operation. A standpipe piezometer was installed in a selected borehole in the swamp area for additional measurement of the groundwater level at the site. The piezometer was decommissioned in general accordance with Ontario Regulation 903 as amended at the completion of the field investigation carried out during Mobilization 1. All other boreholes were decommissioned in general accordance with Ontario Regulation 903 as amended upon completion of drilling.

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 distribution analyses (sieve and/or hydrometer), and Atterberg Limits testing where appropriate. Rock core samples were subject to Unconfined Compression Tests (UCS) and Point Load Testing. The laboratory test results are summarized on the Record of Borehole sheets included in Appendix B and the figures included in Appendices C and D.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the potential culverts, selected samples of the fill and native soil from four boreholes were collected for analytical testing. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 5.5 and are presented in Appendix E.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the subsurface conditions encountered during the foundation investigation are presented in the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawings included in Appendices A and B.

A general description of the soil stratigraphy is given below. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be

used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the deep cut areas of the site consist of a typically very thin layer of topsoil overlying Precambrian Bedrock. The boreholes drilled on Highway 17 at the high fill embankment and culvert areas contain embankment rock fill overlying peat, native deposits of sand or clayey silt to silty clay, and/or bedrock. The boreholes in the swamp crossing area contained a thick layer of peat overlying sand and possible bedrock.

5.1 Swamp Area (SW1)

Five (5) boreholes (SW1-01, SW1-03, SW1-04, SW1-06, and SW1-07) and two (2) DCPTs (SW1-02 and SW1-05) were advanced to depths ranging from 0.5 to 8.5 m (Elev. 288.2 to 270.7 m) along the proposed highway alignment between Sta. 19+180 to Sta 19+430, which contains a low-lying area characterized as a swamp. Although not observed during the borehole investigation, which was drilled during snow cover conditions, the swamp area appears to receive surface water flow from the northeast, which subsequently flows to a waterbody to the southwest. Existing topographic mapping indicates that a watercourse may cross below the existing Highway 17 to the northeast of the swamp; however, the presence of a watercourse or existing culvert was not readily apparent during the investigation. The boreholes and visual observations indicated that the portion of the swamp area within the proposed right-of-way is approximately 80 m long (extending from approximate Sta. 19+340 to 19+420), and that the swamp appears to be longer to the southwest of the proposed alignment. Boreholes SW1-01 to SW1-03 were drilled at higher ground elevations (Elev. 288.9 to 283.8 m) to the north of the low-lying swamp area. Boreholes SW1-04 to SW1-07 were drilled within the swamp at ground elevations ranging from Elev. 279.5 to 279.2 m.

The soil conditions encountered generally consist of a variable thickness of peat, overlying sand to silty sand and possible bedrock.

5.1.1 Peat

Peat was encountered at the ground surface in each of Boreholes SW1-01 to SW1-07. The peat thickness ranged from 0.2 to 0.3 m in Boreholes SW1-01 and SW1-03 (base Elev. from 288.5 to 283.6 m), and from 2.2 to 4.6 m in Boreholes SW1-04 to SW1-07 (base Elev. 277.0 to 274.7 m). The peat thickness may vary between and beyond the boreholes. The peat is described as fibrous, with some roots.

SPT ‘N’ values recorded within the peat ranged from 0 (weight of hammer) to 5 blows per 0.3 m penetration, indicating that the peat is very loose to loose. Natural moisture contents of samples of the peat ranged from 114 to 1473%.

5.1.2 Sand to Silty Sand

A native deposit ranging in composition from sand to silty sand was encountered below the peat. The sand to silty sand deposit generally contained trace silt to silty, trace clay, and trace to some gravel and became gravelly near the underlying anticipated bedrock surface. In Boreholes SW1-01 and SW1-03, the sand to silty sand deposit was 0.3 to 4.5 m thick and extended to depths from 0.6 to 4.7 m (Elev. 288.2 to 279.1 m). The DCPT at SW1-02 was terminated at a depth of 0.5 m (Elev. 284.6 m) upon refusal on inferred bedrock. In Boreholes SW1-04, SW1-06, and SW1-07, the sand to silty sand deposit was 0.4 to 3.9 m thick and extended to depths from 3.3 m to 8.5 m (Elev. 275.9 to 270.7 m). The DCPTs at SW1-05 and the base of SW1-07 were terminated at depths of 4.3 to 8.5 m (Elev. 275.1 to 207.7 m) upon refusal on inferred bedrock. All boreholes were terminated within the sand to silty sand deposit upon auger refusal on inferred bedrock, except for Borehole SW1-06, where the sand unit was penetrated at a depth of 3.3 m (Elev. 276.2 m), overlying a gravel layer.

SPT 'N' values recorded within the sand to silty sand deposit typically ranged from 16 to greater than 50 blows per 0.3 m penetration, indicating that the density ranges from compact to very dense. Lower SPT 'N' values from 0 (weight of hammer) to 5 blows per 0.3 m of penetration were recorded in Borehole SW1-07, where sand blowback inside the augers was noted, and may have contributed to the very loose to loose density of the sand to silty sand at this borehole. The SPT 'N' values of greater than 50 blows per 0.3 m of penetration at the base of Boreholes SW1-03 and SW1-04 were due to split spoon refusal on possible bedrock.

The natural moisture content of samples of the sand to silty sand ranged from 5 to 28%.

The results of grain size analyses conducted on samples of the sand to silty sand are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C3 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Silty Sand	Sand
Gravel	11 to 15	5
Sand	53 to 65	92
Silt	24	-
Clay	8	-
Silt and Clay	24	3

5.1.3 Gravel

A 0.2 m thick layer of gravel with some sand and some silt was encountered underlying the silty sand in Borehole SW1-06 at a depth of 3.3 m (Elev. 276.2 m). The base of the gravel was encountered at a depth of 3.5 m (Elev. 276.0 m) where auger refusal on possible bedrock was encountered. An SPT 'N' value of 50 blows per 0.1 m penetration was recorded in the gravel due

to split spoon refusal on possible bedrock. The measured natural moisture content of the gravel was 12%.

The results of a grain size analysis conducted on a sample of the gravel are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C5 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
	Gravel
Gravel	76
Sand	11
Silt and Clay	13

5.1.4 Inferred Bedrock

All boreholes were terminated by reaching auger or DCPT refusal at depths ranging from 0.5 to 8.5 m (Elev. 288.2 to 270.7 m) upon encountering the possible bedrock surface.

5.2 High Fill and Culvert Areas

Ten (10) boreholes (HF1-01, HF2-01 to 03, HF3-01, HF4-01, HF5-01, HF6-01 to 02, and CULV-01) were advanced along six (6) high fill embankment sections and near one existing CSP culvert along the proposed alignment. Four (4) boreholes, HF1-01, HF2-02, HF6-02 and CULV-01 were drilled through the existing Highway 17 embankment to depths ranging from 8.9 to 19.6 m (Elev. 280.1 to 250.2 m). The remaining six (6) boreholes were advanced along new alignment high fill (off-road) areas by hollow stem augers, hand augers or shovel probes to depths ranging from 0.1 to 2.1 m (Elev. 293.1 to 264.1 m).

The soil conditions encountered along the new alignment areas generally consist of a thin layer of topsoil or peat directly overlying bedrock or a thin sand layer. The boreholes drilled on the highway were advanced through asphalt and granular fill, overlying the embankment rock fill material. Below the fill materials, peat and native deposits of sand, silt and clay were encountered overlying the Precambrian bedrock.

5.2.1 Pavement Structure

A 100 to 150 mm thick layer of asphalt was encountered at the ground surface at all road boreholes (HF1-01, HF2-02, CULV-01, and HF6-02). The asphalt was underlain by gravelly sand to sand and gravel granular fill in all boreholes.

The gravelly sand to sand and gravel fill was encountered directly below the asphalt and ranged in thickness from 0.6 to 1.4 m. The base of the granular fill was encountered at depths ranging

from 0.8 to 1.5 m (Elev. 287.8 to 268.9 m). The granular material was brown and contained trace silt to silty and occasional cobbles.

SPT 'N' values recorded within the granular fill ranged 39 to 88 blows per 0.3 m penetration, indicating that the fill ranges from dense to very dense. Natural moisture contents ranged from 3 to 9%.

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

Soil Particle	Percentage (%)	
	Gravelly Sand	Sand and Gravel
Gravel	34	37 to 46
Sand	57	37 to 54
Silt and Clay	9	9 to 17

Locally, a layer of silty sand fill with trace gravel was observed below the granular material in Borehole CULV-01 from a depth of 1.4 to 2.0 m (Elev. 283.8 to 283.2 m). The SPT "N" value recorded in the dense silty sand fill was 33 blows per 0.3 m of penetration. The natural moisture content was measured as 7%.

5.2.2 Rock Fill

The granular fill was underlain by rock fill, which composed the embankment. The rock fill generally contained cobbles, boulders, some gravelly sand, and trace silt to silty. Typically, the boreholes were advanced by rock coring through this layer, but SPTs were taken between the cobbles and boulders. Boulders in the rock fill ranged in diameter from 200 to 300 mm.

The thickness of the rock fill encountered in the boreholes ranged from 3.2 to 12.1 m and extended to depths from 5.2 to 13.0 m (Elev. 280.1 to 256.8 m) below the road surface. Borehole HF2-02 was terminated at the base of the rock fill upon encountering the top of a previously unidentified wooden culvert at a depth of 9.1 m (Elev. 280.1 m).

SPT 'N' values recorded in the rock fill typically ranged from 12 to 78 blows per 0.3 m penetration. Additional SPT 'N' values of 50 blows per 0.15 m penetration were recorded throughout the rock fill, where the SPT reached refusal on possible boulders or cobbles. The results of the SPT testing generally indicated that the rock fill ranged from compact to very dense. One SPT 'N' value in Borehole HF6-02 was recorded as 7 blows per 0.3 m of penetration, indicating that occasional loose zones may exist in the rock fill between the boulders and cobbles.

Natural moisture contents typically ranged from 1 to 21% in the rock fill, and up to 37% where silty zones were encountered.

The results of grain size analyses conducted on samples of the rock fill are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C2 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	15 to 72
Sand	16 to 65
Silt and Clay	7 to 31

5.2.3 Topsoil

Topsoil was encountered at the ground surface in the off-road boreholes (HF2-01, HF4-01, HF5-01, and HF6-01). The topsoil thickness ranged from 25 mm to 150 mm at the borehole locations. The moisture content in the topsoil was measured as 146% in a sample from Borehole HF6-01. The topsoil thickness may vary between and beyond the boreholes.

5.2.4 Peat

Native peat was encountered below the embankment rock fill at depths of 5.2 and 13.0 m (Elev. 280.0 and 256.8 m) below the road surface in Boreholes CULV-01 and HF6-02, respectively. The peat was 0.7 m thick in both boreholes, and the base was encountered at depths of 5.9 and 13.7 m below the road surface (Elev. 279.3 and 256.1 m). The peat was described as fibrous, with occasional sand seams present in Borehole HF6-02.

Peat was also observed at the ground surface in Boreholes HF2-03 and HF3-01. The peat layer extended to depths of 0.3 and 0.9 m (Elev. 293.1 and 279.2 m).

The measured natural moisture content of the peat ranged from 110 to 410%, typically higher in the surficial deposits. Two SPT ‘N’ values were recorded in the peat, 7 blows per 0.3 m of penetration (loose) and 10 blows per 0.1 m of penetration, which was terminated due to refusal on possible bedrock in Borehole HF3-01.

5.2.5 Sand

A sand layer was encountered below the peat in Boreholes HF2-03 and CULV-01. The composition of the sand layer ranged from sand with some silt, trace clay and trace gravel to gravelly sand with some silt to silty and trace clay. The thickness of the sand layer ranged from 0.7 to 1.2 m, with the base encountered at depths of 2.1 and 6.6 m below the ground surface (Elev. 278.0 and 278.6 m), where it overlies possible bedrock in Borehole HF2-03 and confirmed bedrock in Borehole CULV-01.

An SPT ‘N’ value recorded in the gravelly sand layer in Borehole CULV-01 was 23 blows per 0.3 m penetration, indicating a compact density. The natural moisture content of the sand ranged from 10 to 54%.

The results of grain size analyses conducted on samples of the sand and gravelly sand are provided on the Record of Borehole sheets in Appendix B and illustrated in Figures C3 and C4 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	1 to 32
Sand	43 to 86
Silt and Clay	25
Silt	10
Clay	3

5.2.6 Clayey Silt to Silty Clay

A deposit of clayey silt to silty clay with trace sand was encountered underlying the peat deposit in Borehole HF6-02 at a depth of 13.7 m (Elev 256.1 m). The deposit was approximately 5.9 m thick, based on DCPT refusal on possible bedrock at a depth of 19.6 m (Elev. 250.2 m) below the roadway, where the borehole was terminated.

SPT ‘N’ values recorded in the clayey silt to silty clay ranged from 14 to 21 blows per 0.3 m penetration, indicating a stiff to very stiff consistency. The natural moisture content ranged from 21 to 29%.

The results of grain size analyses conducted on samples of the clayey silt to silty clay are provided on the Record of Borehole sheets in Appendix B and illustrated in Figures C6 and C7 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Clayey Silt	Silty Clay
Gravel	0	0
Sand	3	3
Silt	81	57
Clay	16	40

The results of the Atterberg Limits tests conducted on samples of the clayey silt to silty clay are provided on the Record of Borehole sheets in Appendix B and illustrated in Figures C8 and C9 of Appendix C. The results are summarized as follows:

Index Property	Percentage (%)	
	Clayey Silt	Silty Clay
Liquid Limit	21	31
Plastic Limit	18	18
Plasticity Index	3	13

The results of the Atterberg Limits testing indicate the clayey silt and silty clay have low plasticity, with group symbols of ML and CL respectively.

5.2.7 Bedrock and Inferred Bedrock

Proven and inferred bedrock was encountered underlying the overburden soils in all boreholes (except for Borehole HF2-02) in the high fill embankment areas, which was either confirmed by rock coring or inferred by drill refusal or DCPT refusal. The bedrock depth ranged from 0.03 to 2.1 m (Elev. 293.1 to 264.1 m) in the off-road boreholes and from 5.7 to 19.6 m (Elev. 278.6 to 250.2 m) in the on-road boreholes.

Bedrock was confirmed by coring 3.2 and 3.6 m in Boreholes HF1-01 and CULV-01, which were terminated at depths of 8.9 and 10.2 m (Elev. 263.3 and 275.0 m), respectively.

The bedrock encountered in Borehole HF1-01 was described as a grey meta-volcanic (mafic to intermediate in composition), which was slightly weathered. The bedrock encountered at Borehole CULV-01 was described as a grey syenite, which was fresh.

The Fracture index (FI), measured as the total number of fractures per 0.3 m of rock core length, was typically between 0 and 2 for the syenite and between 0 and 8 for the metavolcanic, with >greater than 10 in localized zones in both rock types. Total Core Recovery (TCR) values measured on recovered bedrock samples ranged from 78 to 100%, with the majority of the TCR values between 98 to 100%. Solid Core Recovery (SCR) values ranged from 56 to 100% (average of 82%). Rock Quality Designation (RQD) values varied from 0 to 95% with most values exceeding 50% indicating typically fair to excellent quality (average of 65%).

Two Uniaxial Compressive Strength (UCS) tests were completed on the rock core samples from each borehole. The results of the testing indicate that the metavolcanic UCS ranges from 106 to 112 MPa, and the Syenite UCS ranges from 109 to 172 MPa. Additional estimated rock strength values were interpreted from point load tests conducted on the rock cores. The average UCS values per core run from the point load tests ranged from 189 to greater than 245 MPa for the metavolcanic rock, and from 226 to 241 MPa for the syenite. The UCS and point load test results indicate that the bedrock is very strong. The results of the UCS tests and photographs of the rock core samples are presented in Appendix D.

5.3 Deep Cut Areas

Eleven (11) boreholes (DC1-01 to 03, DC3-01, DC4-01, DC5-01 to 02, DC6-01 to 02, and DC7-01 to 02) were advanced along six (6) deep cut sections along the proposed alignment of Highway 17. The soil conditions encountered typically consist of a layer of topsoil overlying shallow bedrock. The boreholes were all located off-road and advanced by shovel probe or hand auger.

No boreholes were advanced at deep cut sections DC2, DC8, DC9 or DC10, where visual observation confirmed the presence of exposed bedrock where Highway 17 is proposed to be widened into existing rock cut areas.

5.3.1 Topsoil

Topsoil was encountered at the ground surface in all deep cut boreholes except for Boreholes DC1-02 and DC1-03 where bedrock was exposed. Where encountered, the topsoil thickness ranged from 25 to 325 mm at the borehole locations. The topsoil was underlain by possible bedrock at all locations. The natural moisture content of two samples of the topsoil ranged from 17 to 43%. The topsoil thickness may vary between and beyond the boreholes.

5.3.2 Bedrock

All boreholes were terminated by reaching hand auger or shovel probe refusal upon possible bedrock at depths ranging from 0 m (exposed bedrock at ground surface) to 0.3 m (Elev. 303.8 to 272.0 m).

5.4 Groundwater Conditions

A standpipe piezometer was installed in Borehole SW1-04 to measure the groundwater level in the swamp area. Groundwater conditions were also observed in the open boreholes throughout the drilling operation. The measured groundwater levels are summarized in Table 5.1 below.

Table 5.1 Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
SW1-04	March 29, 2023	3.0	276.2	Standpipe Piezometer
	March 29, 2023	1.3	277.9	
	March 30, 2023	- 0.6	279.8	
SW1-07	March 30, 2023	0.5	278.7	Open Borehole

Slight artesian pressure was noted in Borehole SW1-04, resulting in a standpipe piezometer water level measurement that was slightly above the ground surface.

Additional unstabilized water level readings ranging from 1.4 to 3.2 m below the ground surface were measured in Boreholes SW1-03 and SW1-06 following completion of drilling. Due to the short-term nature of the water level measurements, they may not reflect the stabilized water level in the swamp area, which was generally observed to be near the ground surface or near the top of the peat.

Representative groundwater readings could not be practically recorded at the drilled boreholes through the Highway 17 embankment due to the introduction of water for advancing the drilling by wash boring and rock coring techniques. The groundwater level is anticipated to lie near the base of the highway embankment or near the top of the peat where encountered in the high fill and culvert areas. No groundwater was observed where thin topsoil overlying shallow bedrock was encountered at the hand auger or shovel probe boreholes in high fill and deep cut areas.

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

5.5 Corrosivity and Sulphate Test Results

Two (2) samples of the native soils and two (2) samples of the granular fill soils were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are summarized in Table 5.2 below and the laboratory certificates of analysis are presented in Appendix E.

Table 5.2 Corrosivity Test Results

Parameter	Units	HF6-02 SS15 (55'-57')	HF2-02 SS1 (4"-2'4")	CULV-01 SS1 (6"-2'6")	SW1-07A SS7A (20'-21'8")
		Native Silty Clay, 16.8 – 17.4 m	Gravelly Sand Fill, 0.1 – 0.7 m	Gravelly Sand Fill, 0.2 – 0.8 m	Native Sand, 6.1 – 6.6 m
Redox Potential	mV	147	195	282	220
Resistivity	Ohms.cm	3150	1930	1690	3560
Chloride	µg/g	94	130	140	21
Sulphate	µg/g	42	21	35	64
Sulphide	%	< 0.04	< 0.04	< 0.04	< 0.04
Conductivity	µS/cm	317	519	591	281
pH	-	8.60	9.31	9.17	8.46

6. CLOSURE

The field investigation was supervised on a full-time basis by Mr. Ian Ross, E.I.T., Mr. Jakob Flood, and Ms. Rachel Bourassa, E.I.T. of Thurber. Overall supervision of the field program was provided by Ms. Rachel Bourassa, E.I.T.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical testing was carried out by SGS Canada Inc.

Interpretation of the field data and report preparation was carried out by Ms. Rachel Bourassa, E.I.T., and Mr. Mark Farrant, 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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Date: December 6, 2023
File: 29771

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Principal, Designated MTO Contact

PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGH FILL EMBANKMENTS, DEEP CUTS, SWAMP CROSSING, AND CULVERTS
HIGHWAY 17 WESTBOUND TRUCK CLIMBING LANE AND REALIGNMENT
LITTLE PIC RIVER BRIDGE WESTERLY FOR 4.5 KM
MARATHON, ONTARIO
G.W.P. 6132-17-00

GEOGRES No. 42D15-001

PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7. GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides foundation recommendations for the preliminary design and construction of the proposed Highway 17 high fill embankments, deep cuts, swamp crossing, and culverts within the project limits.

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

The new westbound truck climbing lane, curve flattening and realignment of Highway 17 from west of the Little Pic River bridge will include construction of high fill embankments and deep cuts for both new alignment and widened portions of Highway 17, construction of a new high fill embankment crossing a swamp, and potential installation or replacement of several non-structural culverts.

The proposed highway alignment includes widening the existing highway at approximate Sta. 16+756 to 17+360, Sta. 18+240 to 18+980, and Sta. 20+860 to 21+473, which includes widening through existing bedrock cut areas and widening high rock-fill embankments that span steep valleys. The proposed route also includes new alignment areas at approximate Sta. 17+360

to 18+240 and Sta. 18+960 to 20+860, which typically pass through rugged terrain including steep bedrock slopes, low-lying areas, and an approximately 80 m long swamp.

Cut sections with maximum cut depths in excess of 4.5 m along the proposed highway alignment are summarized in Table 7.1 below. Fill sections with maximum fill height in excess of 4.5 m along the proposed highway alignment, including the swamp crossing, are summarized in Table 7.2.

Table 7.1: Summary of Deep Cut Sections

Section	Station		Approx. Length (m)	Approx. Max Cut Depth (m)	Anticipated Foundation Soils
	From	To			
Deep Cut Area #1 (DC1)	17+580	17+960	80	26	Topsoil over shallow bedrock along new alignment
Deep Cut Area #2 (DC2)	18+660	18+840	180	11	Shallow bedrock along existing highway
Deep Cut Area #3 (DC3)	19+460	19+630	170	12	Topsoil over shallow bedrock along new alignment
Deep Cut Area #4 (DC4)	19+720	19+840	120	11	Topsoil over shallow bedrock along new alignment
Deep Cut Area #5 (DC5)	19+980	20+160	180	19	Topsoil over shallow bedrock along new alignment
Deep Cut Area #6 (DC6)	20+300	20+440	140	12.5	Topsoil over shallow bedrock along new alignment
Deep Cut Area #7 (DC7)	20+550	20+720	170	20	Topsoil over shallow bedrock along new alignment
Deep Cut Area #8 (DC8)	20+920	21+100	180	12	Shallow bedrock along existing highway
Deep Cut Area #9 (DC9)	21+260	21+360	100	10	Shallow bedrock along existing highway

Section	Station		Approx. Length (m)	Approx. Max Cut Depth (m)	Anticipated Foundation Soils
	From	To			
Deep Cut Area #10 (DC10)	21+440	21+460	20	6	Shallow bedrock along existing highway

Table 7.2: Summary of High Fill Sections

Section	Station		Approx. Length (m)	Approx. Max. Fill Height (m)	Anticipated Foundation Soils
	From	To			
High Fill Area #1 (HF1)	17+515	17+540	25	7.5	Surficial organics (topsoil & peat) & sand overlying possible shallow bedrock
High Fill Area #2 (HF2)	17+980	18+020	40	8	Topsoil, peat & sand overlying shallow bedrock
High Fill Area #3 (HF3)	19+150	19+180	30	6	Peat overlying shallow bedrock
Swamp Area #1 (SW1)	19+180	19+430	250	13	Variable thickness of peat overlying sand and bedrock
High Fill Area #4 (HF4)	19+640	19+710	70	2*	Topsoil over shallow bedrock
High Fill Area #5 (HF5)	20+180	20+230	50	12	Topsoil over shallow bedrock
High Fill Area #6 (HF6)	20+760	20+860	100	10	Existing rock fill, peat, & clayey silt to silty clay overlying bedrock

** Fill height reduced to less than 4.5 m after the field investigation was completed*

The locations of existing culverts and drainage pathways observed during Thurber's field investigations that may require new or replacement culverts are summarized in Table 7.3. The complete list of existing drainage crossings and the proposed culvert configurations are included

in the Preliminary Drainage and Hydrology Report, dated October 2023 by Sanchez Engineering Inc. (Sanchez). The Sanchez report identifies additional drainage crossings including an existing culvert (1350 mm CSP) at approximate Sta. 16+980, located beyond the limit of the foundation borehole investigation.

Table 7.3: Summary of Potential Non-Structural Culverts

Location	Approx. Chainage	Approx. Maximum Soil Cover above Culvert (m)	Approx. Invert Elevation (m)	Anticipated Foundation Soils Based on Nearest Boreholes
Potential Replacement of Existing Timber Culvert at Transition from Existing Highway 17 to Realignment at High Fill HF2*	17+980	8	280	Topsoil, peat & sand overlying shallow bedrock
Potential Replacement of Existing 800 mm Diameter CSP Culvert at Transition from Existing Highway 17 to Realignment near Deep Cut DC5*	19+980	2	284	Existing rock fill, peat & sand overlying shallow bedrock
Potential New Culvert at Widening of Existing Highway 17 at High Fill HF6*	20+820	9	260	Existing rock fill, peat, & clayey silt to silty clay overlying bedrock

** Refer to Preliminary Drainage and Hydrology Report, dated October 2023 by Sanchez Engineering Inc. for proposed approach and culvert configurations.*

The foundation stability and time dependent settlements, their impacts on the construction schedule and the long-term performance of the proposed embankments have been analyzed for selected high fill sections in critical areas, including the swamp crossing, and are discussed in the following sections of this report. The construction of the deep cut sections is also discussed, as well as preliminary recommendations for construction of non-structural culverts.

The discussion and recommendations presented in this report are based on the information provided by BT Engineering (BTE) and the factual geotechnical data obtained during the investigation by Thurber Engineering Ltd. (Thurber).

Thurber carried out the investigation as a sub-consultant to BTE, under the Ministry of Transportation Ontario (MTO) Agreement Number 6020-E-0003.

8. DESIGN METHODOLOGY

8.1 General

The subsurface conditions at the high fill, deep cut, swamp crossing and culvert locations were investigated to assess the stability of the proposed embankment fill and cut slopes, potential settlement issues under the embankments as well as anticipated construction concerns. Analyses were carried out based on soil profiles and soil design parameters, selected for critical embankment sections.

Geotechnical factors to be addressed for design of the embankments, deep cuts and culverts on this project include:

- The thickness, extent and engineering properties of the foundation soils, with consideration to the extent and thickness of peat, topsoil, organic deposits, compressible and/or excessively soft/loose soils.
- The depth to bedrock or refusal materials.
- Embankment material type (rock fill, granular fill or earth fill).
- Embankment geometry including height, side slope inclination and requirements for stabilizing berms.
- Construction and post-construction settlement of embankments.
- Cut slope geometry including slope angle and requirement for benches.
- Temporary and long-term drainage requirement and erosion control for cut slopes.
- Bedding and backfill requirements for non-structural culverts.
- Construction procedures.

For the purpose of preparing preliminary foundation design recommendations, a number of assumptions have been made that are consistent with MTO's standard highway design practices:

- All peat, topsoil, organic deposits, and other deleterious material will be stripped prior to constructing embankments (OPSS.PROV 206), including the approximately 2 to 5 m thick peat encountered at Swamp SW1.
- Where new fill is placed against an existing earth or granular embankment slope or on a sloping ground surface steeper than 3H:1V, the existing slope will be benched as per OPSD 208.010.

- It is assumed that all high fill embankments on this project (i.e. 4.5 m or greater in height) will be constructed using rock fill.
- Embankments will be constructed with side slopes not steeper than 1.25H:1V for rock fill and 2H:1V for granular and earth fill.
- Earth fill embankment slopes at or greater than 8 m high will be provided with a 2 m wide mid-height bench.
- Rock fill embankment slopes at or greater than 10 m high will be provided with a 2 m wide mid-height bench.
- A transition treatment will be provided between adjoining rock fill and granular fill embankment materials (OPSD 205.040).
- Rock cuts with depths of 10 m or greater will be constructed with side slopes not steeper than 0.25H:1V (OPSD 209.020) and all earth cuts will not be steeper than 2H:1V, unless otherwise stated.
- Earth cuts with depths of 6 m or greater will be provided with a 2 m wide mid-height bench.
- A transition will be provided between rock cuts and earth cuts (OPSD 205.050), rock cuts and granular fills (OPSD 205.030) and rock cuts and rock fills (OPSD 205.020).
- Permanent drainage and erosion protection will be provided for all earth cuts and granular embankment slopes.
- All culverts to replace or lengthen existing culverts along the widened highway or to construct new culverts in new alignment areas will be non-structural culverts, such as corrugated steel pipes (CSPs), structural plate CSPs (SPCSPs), or other options. Although not anticipated, if any structural culverts are required, they should be investigated further during the detailed design phase.
- Replacement culverts under the existing highway will be constructed along similar alignments, with a similar or slightly larger opening sizes and similar or slightly lower invert elevations as the existing culverts (refer to the Preliminary Drainage and Hydrology Report, dated October 2023 by Sanchez Engineering Inc. for details).
- Where the rock fill embankment has sufficient capacity for drainage flow (including at Sta. 20+820), the Sanchez report recommends that drainage be allowed to continue through the embankment without requiring the installation of new culverts.

8.2 Engineering Analyses

Subsurface models were prepared for stability and settlement analyses of the critical embankment locations based on a compilation and analysis of all borehole logs and available field and laboratory testing data. As the deep cut sections will be mainly in bedrock, no analysis was conducted at this stage. Engineering parameters were selected based on the results of the field and laboratory testing, and correlations with index testing results.

8.2.1 Stability Analysis

Slope stability analysis was performed to assess the global stability of the high fills at the new and widened embankment critical sections along the proposed highway alignment (i.e. where the fill height exceeds 4.5 m and the foundation does not consist of shallow bedrock). The stability analysis was performed using the commercially available software Slope/W, developed by GEO-SLOPE International Ltd.

Total stress analysis (undrained), effective stress analysis (drained), and seismic analyses were performed using the Morgenstern-Price method. As the existing highway appears to be mainly constructed of rock fill within the project limits, it is anticipated that the new embankments will be designed using rock fill at 1.25H:1V side slopes.

The analyses under seismic loading were performed using a pseudo-static slope stability analysis. As a conservative estimate for the purposes of preliminary design, all examined sections were analysed using a horizontal seismic coefficient based on an assumed CHBDC 2019 Site Class E. Therefore, a horizontal seismic coefficient, k_h, of 0.036g (one-half of the corresponding site peak ground acceleration in accordance with Section 4.6.7 of CHBDC 2019) was used for the seismic stability analysis. The site peak ground acceleration was calculated through the Natural Resource Canada's 2020 National Building Code Seismic Hazard Calculation tool.

The results of stability analysis are presented in Appendix G and summarized in Table 8.1 below.

In light of the presence of shallow bedrock anticipated at high fill areas HF1, HF3, HF4 and HF5, foundation stability is not expected to be a concern. Consequently, stability analyses were not completed for these locations.

The analyses summarized in Table 8.1 and shown in Appendix G assume that all peat and organic soils below the new or widening embankment footprint have been sub-excavated and backfilled with rock fill prior to placement of new embankment fill, as described in Section 9.2.

Table 8.1: Summary of Stability Analysis

Section	Station	Approx. Fill Height	Loading Condition	Side	Factor of Safety	Figure No.
High Fill #2 (HF2)	17+980	Up to 8 m	Long-Term	North	1.54	G1
			Seismic	North	1.46	G2
Swamp Area #1 (SW1)	19+400	Up to 12 m	Long-Term with mid-height bench	South	1.79	G3
			Long-Term with no bench	North	1.38	G4
			Seismic with mid-height bench	South	1.61	G5
			Seismic with no bench	North	1.29	G6
		Up to 10 m	Long-Term with no bench	North	1.71	G7
			Seismic with no bench	North	1.52	G8
High Fill #6 (HF6)	20+820 to 840	Up to 10 m	Short-Term	North	1.69	G9
			Long-Term	North	1.54	G10
			Seismic	North	1.52	G11

The computed Factors of Safety (FOS) against slope instability were greater than the minimum FOS required by MTO for typical degree of understanding of 1.3 and 1.5 for static analysis of temporary (short-term) and permanent (long-term) slopes, respectively. The computed FOS for pseudo-static seismic analysis were greater than the minimum FOS required by CHBDC 2019 of 1.1 for typical degree of understanding.

Based on the results of the slope stability analyses, new and widened rock fill embankments up to 10 m in height may be constructed with side slopes inclined not steeper than 1.25H:1V. Rock fill embankments equal to or greater than 10 m in height should include a 2 m wide mid-height bench.

8.2.2 Settlement Analysis

8.2.2.1 Foundation Settlement

Settlement analyses were carried out to estimate the magnitude of settlement of the foundation

soils occurring during construction and post-construction (long-term) under the weight of the new embankment fill materials. The settlement analysis was performed using the commercially available software Settle3 developed by Rocscience Inc.

Cohesive foundation soils are present at only one of the sites investigated, High Fill HF6, which consists of an approximately 6 m thick layer of stiff to very stiff clayey silt to silty clay, encountered below embankment rock fill and a 0.7 m thick layer of buried peat. The placement of up to 10 m of new fill on the slopes of the widened embankment will induce settlement of the clay and peat below the embankment.

The foundation soils at the other critical sections, after stripping of the peat and organic soils, are considered cohesionless, and therefore long-term consolidation of the foundation soils is not an issue.

In accordance with the MTO document titled “Embankment Settlement Criteria for Design” dated July 2, 2010, one of the criteria adopted for new embankment design is to limit the maximum permissible post-construction settlement within 20 years following paving to 100 mm for compressible soils and 50 mm for non-compressible soils. For widened embankments, the maximum permissible post-construction settlement is limited to 50 mm.

The results of the settlement analyses of the foundation soils at the critical embankment sections are summarized in Table 8.2. Except at High Fill HF6, the majority of the foundation settlements are expected to occur as embankment construction takes place. However, due to anticipated total foundation settlements in the peat and clay ranging from 75 to 150 mm, a preloading period of approximately 2 to 4 months will be required at High Fill HF6 to mitigate the foundation settlement prior to road paving in order to meet MTO’s Embankment Settlement Criteria.

The estimated magnitudes and rates of settlement are considered approximate and may vary along and across the highway alignment subject to the thickness of compressible layers at a particular location, variations in the consolidation characteristics of the cohesive deposits with depth and location, layer boundary conditions, variations in the relative density of cohesionless soils, the presence of organics or silt/sand/clay partings within the various strata, the depth to bedrock, the height of embankment, and degree of compaction achieved in the fill. In particular, additional investigation of the peat and clay at High Fill HF6 should be carried out during the detailed design phase to further assess the extent of foundation settlement at this location.

8.2.2.2 Embankment Compression

An assessment of the self-weight compression of the embankment fill materials was also completed. Settlement of the road grade on rock fill, due to particle re-orientation and degradation of the interparticle contacts, is expected to continue at a decreasing rate with time. In accordance

with the MTO document “MTO Guideline for Rock Fill Settlement Rock Fill Quantity Estimates” (September 14, 2010), the magnitude of this settlement in compacted rock fill over a non-compressible subgrade is expected to be approximately 0.75% of the embankment height for 5 to 10 m high fills and 1.0% of the height for greater than 10 m high fills. This occurs within 1 year of embankment construction (90% in the first 6 months) over the short-term, and settlement of a further 0.1% of the embankment height occurs after the 1-year period over the long-term life of the embankment. For dumped rock fill (placed under the water level), these settlement values would be approximately doubled.

For rock fill over a compressible subgrade (i.e. High Fill HF6), the post-construction embankment settlement includes both the fill compression and foundation settlement of the compressible soils.

The estimated settlements due to fill compression of the rock fill at the critical embankment sections are included in Table 8.2.

Table 8.2: Estimated Settlements

Section	Station	Approx. Fill Height	Rock Fill Embankment		
			Foundation Settlement (mm)	Fill Compression (mm)	
				First 6 months (*)	After 6 months
High Fill #2 (HF2), New Embankment	17+980	Up to 8 m	< 25	60	< 10
Swamp Area #1 (SW1), New Embankment	19+400	Up to 12 m	< 50	120	< 15
High Fill #6 (HF6), Widened Embankment, Compressible Subgrade	20+820 to 840	Up to 10 m	75 to 150	75	10

Notes: (*) time starts after fill has been placed up to the designed pavement elevation

To mitigate the effects of the settlement due to embankment compression, it is recommended that the new and widened embankments be constructed several months (approximately 3 to 6) in advance of pavement construction. This will also allow for a preloading period for the majority of the foundation soil settlement to take place at High Fill HF6.

The embankment and platform width design should allow for the anticipated foundation and embankment compression settlements and allow for placement of additional fill to the grade level at the end of the preloading period prior to paving.

9. DESIGN AND CONSTRUCTION CONSIDERATIONS

9.1 Cut Sections

All deep cut sections within the project limits are anticipated to involve cuts in bedrock. Preliminary hand auger and shovel probe investigations in the new alignment areas indicate that the subsurface conditions in the deep cut areas consist of a thin layer of topsoil overlying shallow bedrock within 0.4 m depth. In the widened embankment areas, deep cuts will be made into existing highway rock cuts. Based on the cross section drawings provided by BTE, it is anticipated that the base of the highway in the deep cut sections will be founded within the bedrock at depths of up to approximately 26 m below the existing ground surface.

Excavations for cut slope construction should be in accordance with OPSS.PROV 206.

Rock cuts should be designed in accordance with OPSD 209.020 and the Northwestern Region Rock Cut Design Guidelines. The guidelines provide recommendations for back-slopes, benching, clear zone width and ditching. Rock cuts at or greater than 10 m in height shall be constructed at no steeper than 0.25H:1V.

Rock excavation utilizing blasting should be carried out in accordance with OPSS.PROV 120, including blast design by a qualified engineer specialized in this area, use of explosives by a competent blasting contractor, monitoring by a blast monitoring consultant, preparation of a pre-blast survey, and notification of any nearby utility authorities. As the bedrock within the project limits does not consist of shale, excavated bedrock may be reused as rock fill subject to the requirements of OPSS.PROV 206.

Where rock is exposed, rock mapping should be carried out prior to blast design to determine pertinent conditions such as trends/dips of joints and fractures in the rock mass. After blasting, the rock cuts should be examined by a rock slope specialist to identify any areas of unstable rock requiring removal or stabilization.

Temporary drainage of the cuts should be provided to maintain a relatively dry, stable excavation. Permanent drainage of the cuts must also be provided. Roadside ditches are expected to provide an adequate level of surface drainage in most areas.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the earth cut slopes overlying the bedrock. Slope vegetation should be established as soon as possible to protect against surficial erosion in general accordance with OPSS.PROV 804.

9.2 New and Widened Fill Embankments and Swamp Crossings

New and widened high fill embankments are anticipated to be constructed with rock fill.

Embankment construction should be carried out in accordance with OPSS.PROV 206. Rock size should be controlled in accordance with OPSS.PROV 206.

Topsoil and/or organic deposits encountered within the new embankment footprints should be stripped and grubbed in accordance with OPSS.PROV 201 and OPSS.PROV 206. Organic deposits should be sub-excavated as per OPSD 203.010. Surface drainage and sump pumps are considered appropriate for dewatering where required.

Rock fill placed above the water table should be constructed in a controlled manner (not end dumped) including blading, dozing and chinking of the rock to minimize voids and bridging. Rock fill must be compacted as per OPSS.PROV 206. Rock fill used to backfill sub-excavated areas below the water table may be placed by end dumping.

At the pavement subgrade level or where granular fill is to be placed over rock fill, the rock fill subgrade must be blinded with spall material and rock fill chinking should be in accordance with OPSS.PROV 206. All granular fill must be compacted as per OPSS.PROV 501.

Mid-height berms comprising 2 m wide benches should be incorporated along the length of embankments with heights at or exceeding 10 m in rock fill. Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, the existing earth or granular fill slope must be benched in accordance with OPSD 208.010.

Construction of new embankments over swamps should be carried out in accordance with OPSS.PROV 209, with specific reference to OPSD 203.010. The OPSD shows a variable temporary slope at the edge of the excavation. An initial assumption of this slope could be approximately 1H:1V; however, some areas may be flatter due to the weak nature of the peat.

It is standard practice on MTO projects to sub-excavate all peat deposits not exceeding 6 m in depth from within the footprint of the embankment and backfill the resulting excavation with rock or granular fill. Where firm mineral soils are encountered at depths of less than 6 m, peat removal is an economical and efficient method of improving stability during construction and minimizing the potential for large post-construction settlements. Consideration should be given to managing excavated peat and swamp material within the right-of-way as much as possible. Slope flattening may be considered as per OPSS.PROV 209 and OPSD 203.010, provided that the swamp material does not affect drainage through the rock fill embankments, or embankment performance from a slope stability or settlement perspective. If the use of swamp material for slope flattening is proposed where compressible foundation soils are present, additional assessment should be conducted during the detailed design phase.

Within the Swamp Area SW1 addressed in this report, the depth of peat and organic soils is less than 5 m where investigated. Similarly, peat may also be encountered at the base of other new

and widened embankment sections. It is therefore recommended that all peat and organic soils be sub-excavated from within the proposed fill footprint in these locations. The peat sub-excavation should also be extended beyond the toe of the embankments as per OPSD 203.010. The foundation area should be backfilled with rock fill as described above.

9.3 Culverts

9.3.1 Culvert Excavation, Bedding, Backfill and Groundwater Control

The excavations for culvert installations will extend through existing granular fill and embankment rock fill (where located within the existing highway), as well as topsoil, peat and organics, underlain by native sand or clayey silt to silty clay. Localized excavation of bedrock is also anticipated where bedrock exists at or above the culvert subgrade level.

For any culverts that will be founded partially on bedrock, it is recommended that the subgrade and bedding be prepared to reduce the potential for non-uniform and abrupt settlement (i.e. hard point effect) between the bedrock and soils. In that regard, it is recommended that a transition zone (wedge) should be constructed to allow for additional bedding thickness where the subgrade will consist of soil.

Culvert subgrade preparation, placement and compaction of the bedding layer must be done in the dry. All excavations for culvert construction must be carried out in accordance with the *Occupational Health and Safety Act* (OHSA). For the purposes of the OHSA, the granular fills and rock fill, as well as native sands that are above the water table are classified as Type 3 soils. Below the water table (i.e., if the groundwater flow is not controlled), peat and other alluvial deposits, as well as native sands, silts and clays should be treated as Type 4 soils. As the excavations will extend below the groundwater table, surface water control and effective lowering of the groundwater level will be required to maintain dry excavations for subgrade and bedding preparation.

The equipment used to excavate the bedrock must be capable of penetrating the very strong bedrock that exists at this site. The selection of the excavation equipment and the means and method of excavation is the responsibility of the Contractor.

Excavation, bedding, backfilling, and compaction for culverts must be carried out in accordance with OPSS.PROV 401, OPSS.PROV 421, OPSD 802.010, OPSD 802.013, and OPSD 802.014, as appropriate. Dewatering must be carried out in accordance with OPSS.PROV 517. The design of any dewatering systems is the responsibility of the Contractor.

Any fill, peat, topsoil, organic deposits, loose streambed deposits or deleterious soils at the subgrade level should be sub-excavated to reach competent native subgrade soils or bedrock

and replaced with well compacted granular fill to the design subgrade level.

In order to provide a uniformly competent foundation subgrade condition, the culvert should be placed on a minimum 300 mm thick layer of bedding material meeting OPSS.PROV 1010 Granular A or B Type II requirements, compacted to 98% of Standard Proctor Maximum Dry Density (SPMDD) as per OPSS.PROV 501. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction. A separation layer consisting of a non-woven geotextile should be placed between the subgrade soils and the bedding material. The geotextile should meet the specifications for the OPSS Class II (OPSS.PROV 1860) and have a fabric opening size (FOS) not greater than 212 µm.

Culvert backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS.PROV 1010. All fills should be placed in regular lifts and be compacted in accordance with OPSS.PROV 501. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides of the culvert at all times. Heavy compaction equipment should not be used adjacent to the walls and on the roof of the culvert.

9.3.2 Settlement

New or replacement culverts in high embankment areas should be designed to accommodate the foundation settlements expected due to the overlying high fill embankments, described in Section 8.2.2, including culverts near High Fills HF2 and HF6, if proposed.

At the existing CSP culvert at Sta. 19+980 near Deep Cut DC5, after stripping of any peat and organic soils, based on Borehole CULV-01, the foundation soils at the subgrade level for a replacement culvert will likely consist of compact native sand or bedrock, and therefore long-term consolidation of the foundation soils due to the relatively low overlying embankment fill is not an issue.

9.3.3 Scour and Erosion Protection

Erosion protection should be provided at the culvert inlets and outlets. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field in accordance with OPSD 810.010, OPSS.PROV 511 and OPSS.PROV 1004.

Typically, rock protection should be provided over all surfaces with which water flow is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.

9.4 Corrosion and Sulphate Attack Potential

The results of the corrosivity and sulphate analytical tests conducted on the soil samples collected in the boreholes near potential culvert locations and within the swamp crossing indicate the following conditions at the locations tested:

- The potential for corrosion or sulphate attack on concrete from surrounding gravelly sand fill, native silty clay or native sand is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested.
- The potential for soil corrosion on metal is considered to be moderate to severe due to the low resistivity of the samples tested.
- Appropriate corrosion protection measures are recommended for metal elements such as CSP or SPCSP culverts. The effect of road de-icing salt should be considered when selecting the corrosion protection measures.

10. CONSTRUCTION CONCERNS

During construction, qualified geotechnical staff should be retained to observe activities related to embankment construction and advise the Contract Administrator on construction concerns or issues related to embankment and cut slope stability or settlement.

Potential construction concerns include, but are not necessarily limited to:

- The thickness and presence of organic deposits were investigated at the borehole locations only. Organic deposits may extend to greater depths or be encountered at other locations between boreholes.
- Geotechnical confirmation is required that all peat, topsoil and organic deposits within the proposed embankment footprint are stripped and replaced with approved backfill.
- Bedrock elevations may vary between and beyond the borehole locations. The cut slope geometry may require modification during construction based on the conditions encountered during excavation.
- In areas with culvert construction, care must be exercised during excavation to avoid disturbing the founding subgrade. When the excavation reaches the required elevation, the subgrade should be inspected and approved by qualified geotechnical personnel.
- Culvert excavations may extend below the groundwater level in close proximity to the watercourses. There may be challenges dewatering the excavations and maintaining a

dry excavation base. The Contractor must be prepared to employ suitable dewatering techniques to effectively lower the groundwater table below the base of the excavations until the culverts are installed and backfilled.

11. DETAILED DESIGN CONSIDERATIONS

Additional investigation is recommended to be carried out during the detailed design phase of the project. The latest MTO Guideline for Foundation Engineering Services should be followed for conducting additional investigations for detailed design of high fill embankments, deep cut sections, swamp crossings and other foundation aspects identified. Although not an exhaustive list, additional boreholes, soil sampling and testing of foundation soils is recommended at high fill areas to assess the thickness and extent of peat and compressible soils likely to be encountered. Additional geotechnical laboratory testing should be conducted on compressible soils, particularly at High Fill HF6, to allow for more detailed assessment of the extent of foundation settlement at these locations.

Additional boreholes are also recommended to identify the soil, bedrock and groundwater conditions at the locations of any structural culverts if required for the highway widening and realignment, as well as any locations where culvert installation or construction staging may require cofferdams or temporary roadway protection systems.

12. CLOSURE

Engineering analysis and preparation of the foundation design report were carried out by Mr. Mark Farrant, P.Eng., Mr. Mohamed Hosney, P.Eng., and Mr. Jason Lee, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Mark Farrant, P.Eng.
Associate, Senior Geotechnical Engineer

THURBER ENGINEERING LTD.

Jason Lee, P.Eng.
Partner, Senior Geotechnical Engineer

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

Date: December 6, 2023
File: 29771

THURBER

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. THURBER IS NOT RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF REPORT

The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming part of the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT THURBER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS THURBER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belong to Thurber. Any use which a third party makes of the Report, is the sole responsibility of such third party. Thurber accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Thurber's express written permission.

5. INTERPRETATION OF THE REPORT

a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.

c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.

d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

7. INDEPENDENT JUDGEMENTS OF CLIENT

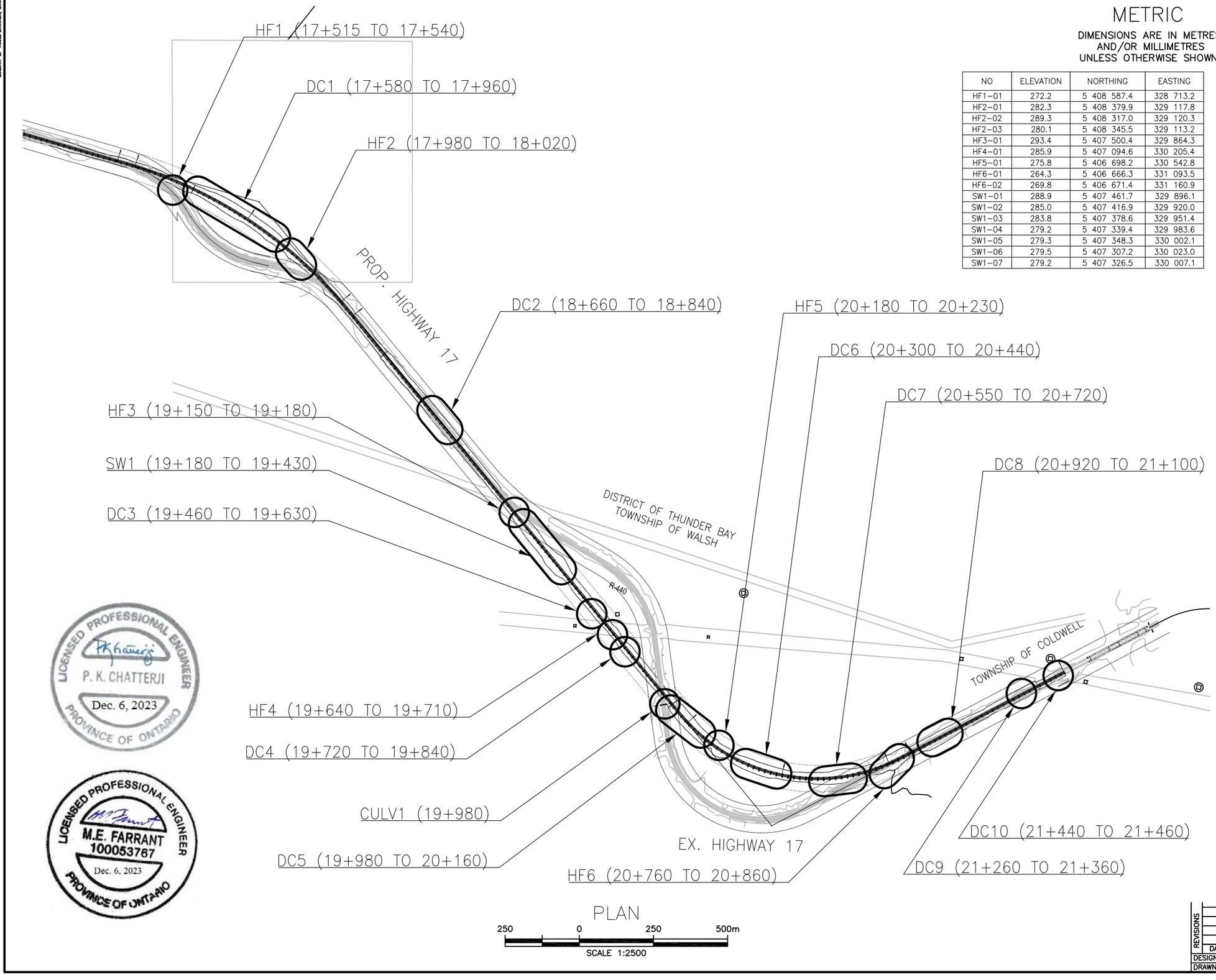
The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or decisions of the Client, or others who may come into possession of the Report, or any part thereof, which may be based on information contained in the Report. This restriction of liability includes but is not limited to decisions made to develop, purchase or sell land.

THURBER ENGINEERING LTD.

APPENDIX A

Borehole Locations and Soil Strata Drawings

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

250 0 250 500m

SCALE 1:2500

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

NO	ELEVATION	NORTHING	EASTING
HF1-01	272.2	5 408 587.4	328 713.2
HF2-01	282.3	5 408 379.9	329 117.8
HF2-02	289.3	5 408 317.0	329 120.3
HF2-03	280.1	5 408 345.5	329 113.2
HF3-01	293.4	5 407 500.4	329 864.3
HF4-01	285.9	5 407 094.6	330 205.4
HF5-01	275.8	5 406 698.2	330 542.8
HF6-01	264.3	5 406 666.3	331 093.5
HF6-02	269.8	5 406 671.4	331 160.9
SW1-01	288.9	5 407 461.7	329 896.1
SW1-02	285.0	5 407 416.9	329 920.0
SW1-03	283.8	5 407 378.6	329 951.4
SW1-04	279.2	5 407 339.4	329 983.6
SW1-05	279.3	5 407 348.3	330 002.1
SW1-06	279.5	5 407 307.2	330 023.0
SW1-07	279.2	5 407 326.5	330 007.1

CONT No
GWP No.6132-17-00

SHEET

HIGHWAY 17
WESTBOUND TRUCK CLIMBING LANE AND REALIGNMENT
SITE PLAN

BT ENGINEERING

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KEYPLAN

LEGEND

●	Borehole
⊕	Borehole and Cone
⊕	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CULV-01	285.2	5 406 854.8	330 371.7
DC1-01	272.3	5 408 583.1	328 798.3
DC1-02	303.8	5 408 519.2	328 944.4
DC1-03	301.2	5 408 419.1	329 051.8
DC3-01	296.9	5 407 177.6	330 148.8
DC4-01	293.9	5 407 043.1	330 252.9
DC5-01	298.2	5 406 853.1	330 415.5
DC5-02	301.7	5 406 748.8	330 485.9
DC6-01	295.0	5 406 653.4	330 644.6
DC6-02	293.0	5 406 618.5	330 748.7
DC7-01	293.8	5 406 612.9	330 907.1
DC7-02	291.5	5 406 623.6	330 999.8

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42D15-001

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LICENSED PROFESSIONAL ENGINEER
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MINISTRY OF TRANSPORTATION, ONTARIO

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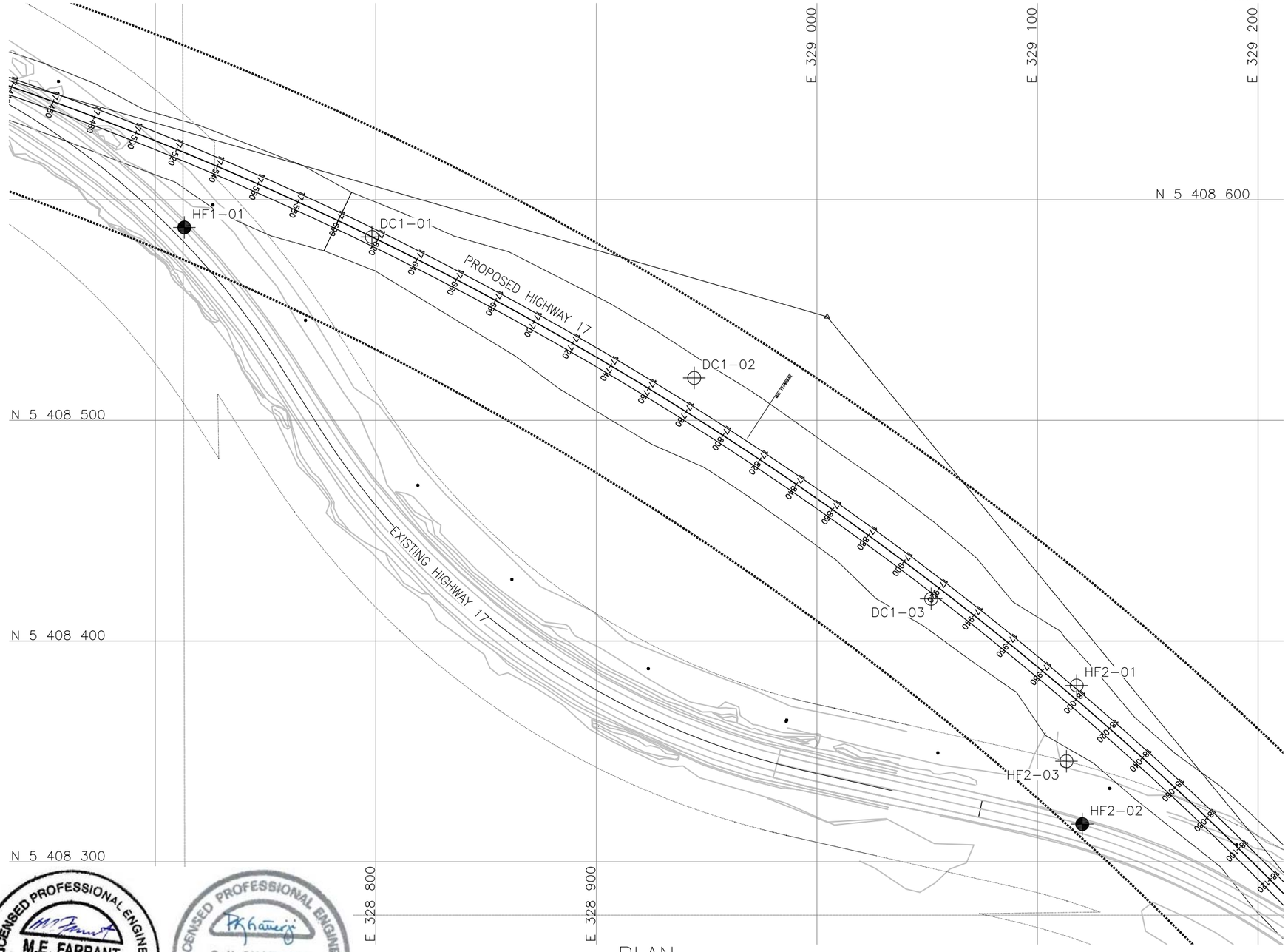

CONT No
GWP No.6132-17-00

SHEET

HIGHFILL AREAS
1 AND 2, DEEP CUT
AREA 1
BOREHOLE LOCATIONS

BT ENGINEERING

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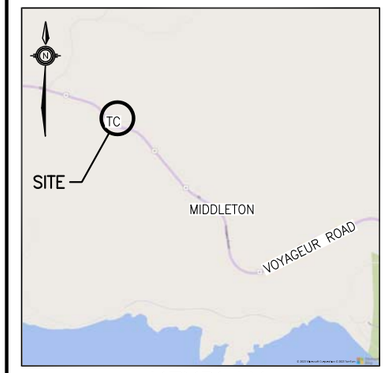

KEYPLAN

LEGEND

●	Borehole
⊕	Borehole and Cone
⊕	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
▮	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
DC1-01	272.3	5 408 583.1	328 798.3
DC1-02	303.8	5 408 519.2	328 944.4
DC1-03	301.2	5 408 419.1	329 051.8
HF1-01	272.2	5 408 587.4	328 713.2
HF2-01	282.3	5 408 379.9	329 117.8
HF2-02	289.3	5 408 317.0	329 120.3
HF2-03	280.1	5 408 345.5	329 113.2

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GEOCRES No. 42D15-001

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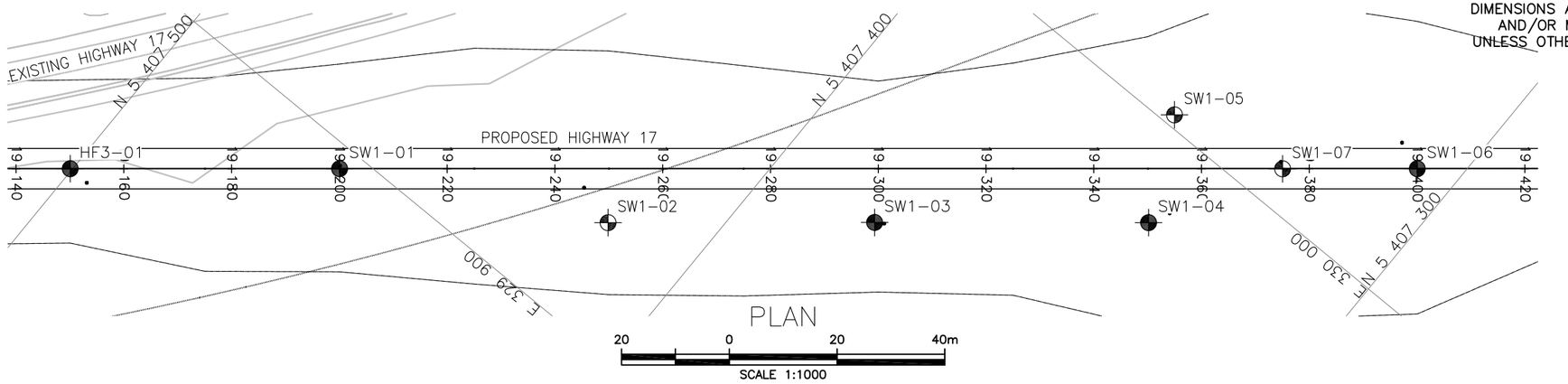
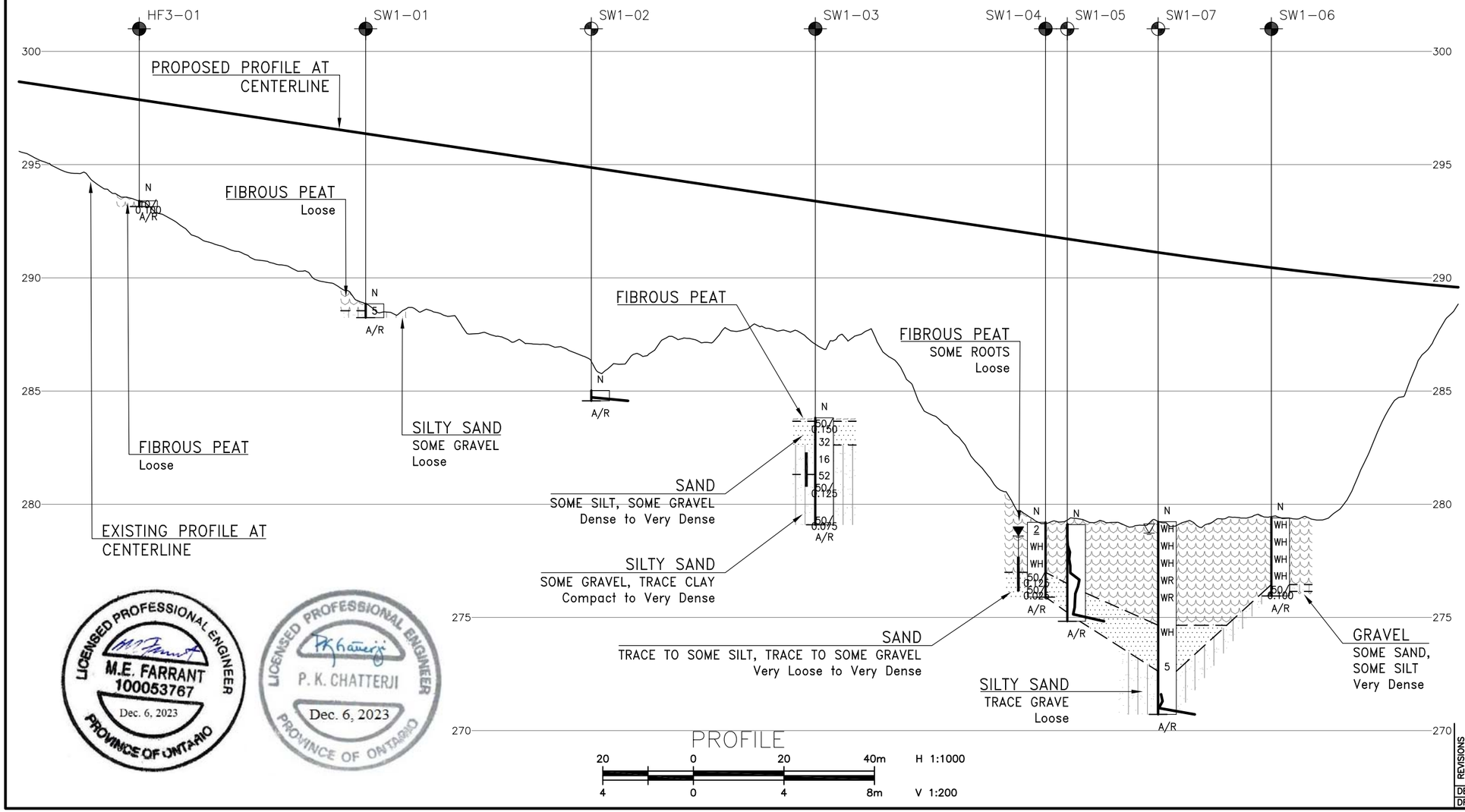


PLAN

20 0 20 40m

SCALE 1:1000



PROFILE

20 0 20 40m H 1:1000

4 0 4 8m V 1:200

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CONT No
GWP No.6132-17-00

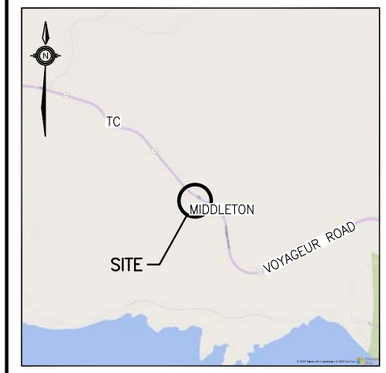
HIGH FILL AREA 3
SWAMP AREA 1

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

BT ENGINEERING

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
HF3-01	293.4	5 407 500.4	329 864.3
SW1-01	288.9	5 407 461.7	329 896.1
SW1-02	285.0	5 407 416.9	329 920.0
SW1-03	283.8	5 407 378.6	329 951.4
SW1-04	279.2	5 407 339.4	329 983.6
SW1-05	279.3	5 407 348.3	330 002.1
SW1-06	279.5	5 407 307.2	330 023.0
SW1-07	279.2	5 407 326.5	330 007.1

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METRIC

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PLAN

25 0 25 50m

SCALE 1:1250

CONT No

GWP No.6132-17-00

HIGH FILL AREA 4
DEEP CUT AREAS 3 AND 4

BOREHOLE LOCATIONS

SHEET

BT ENGINEERING

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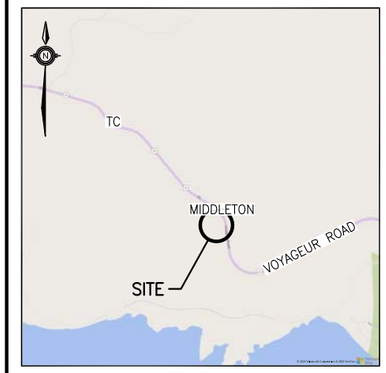

KEYPLAN

	LEGEND
⊕	Borehole
⊕	Borehole and Cone
⊕	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
▮	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
DC3-01	296.9	5 407 177.6	330 148.8
DC4-01	293.9	5 407 043.1	330 252.9
HF4-01	285.9	5 407 094.6	330 205.4

-NOTES-

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GEOCRES No. 42D15-001

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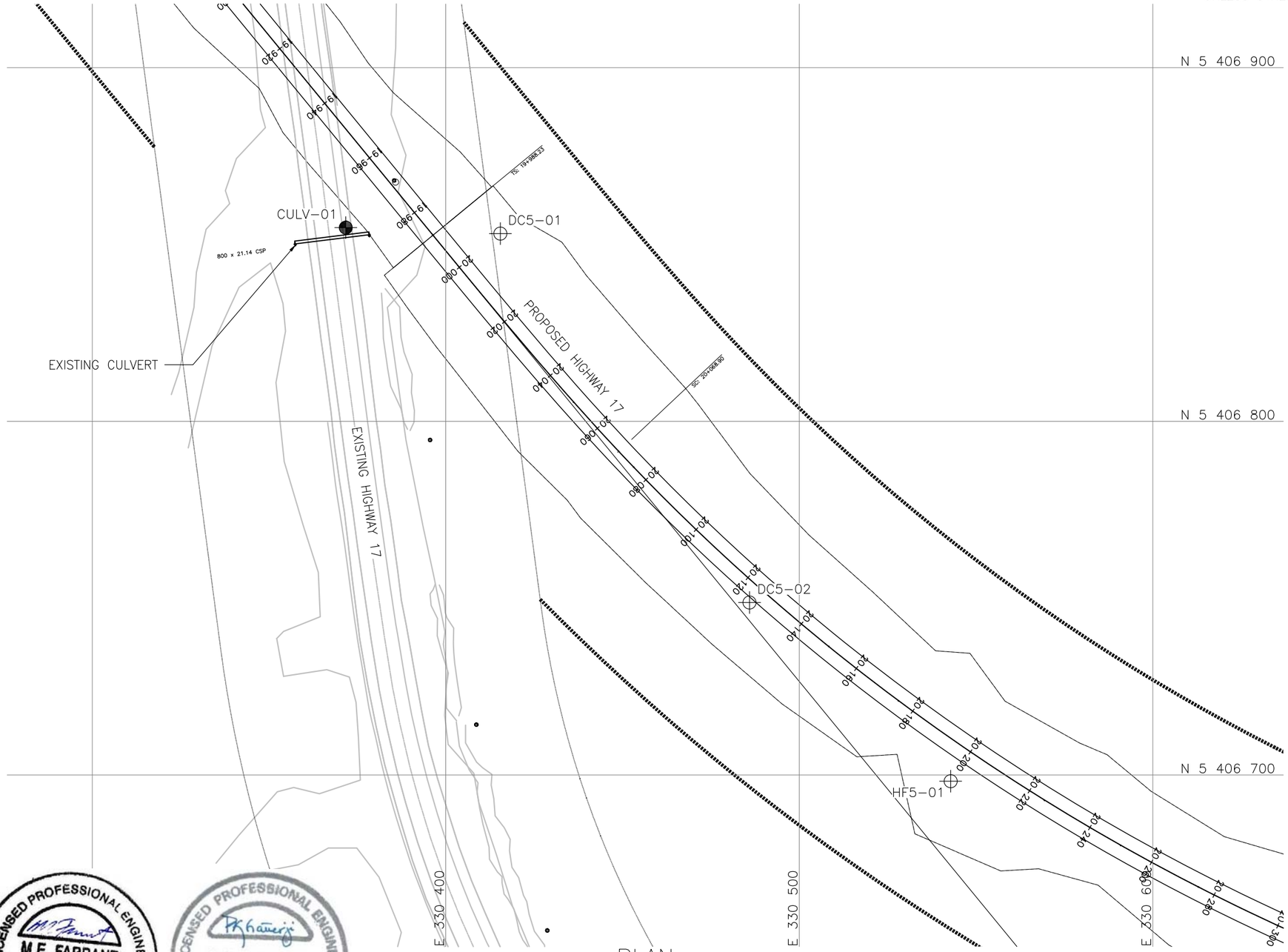

PLAN

25 0 25 50m

SCALE 1:1250

CONT No

GWP No.6132-17-00

SHEET

CULVERT 1
DEEP CUT AREA 5
HIGH FILL AREA 5
BOREHOLE LOCATIONS

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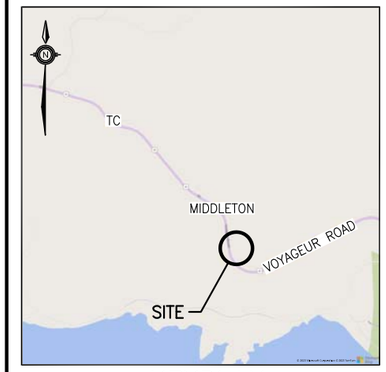

KEYPLAN

	LEGEND
⊕	Borehole
⊕	Borehole and Cone
⊕	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CULV-01	285.2	5 406 854.8	330 371.7
DC5-01	298.2	5 406 853.1	330 415.5
DC5-02	301.7	5 406 748.8	330 485.9
HF5-01	275.8	5 406 698.2	330 542.8

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GEOCRES No. 42D15-001

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PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

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DATE DEC 2023
DWG 5

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MINISTRY OF TRANSPORTATION, ONTARIO

METRIC

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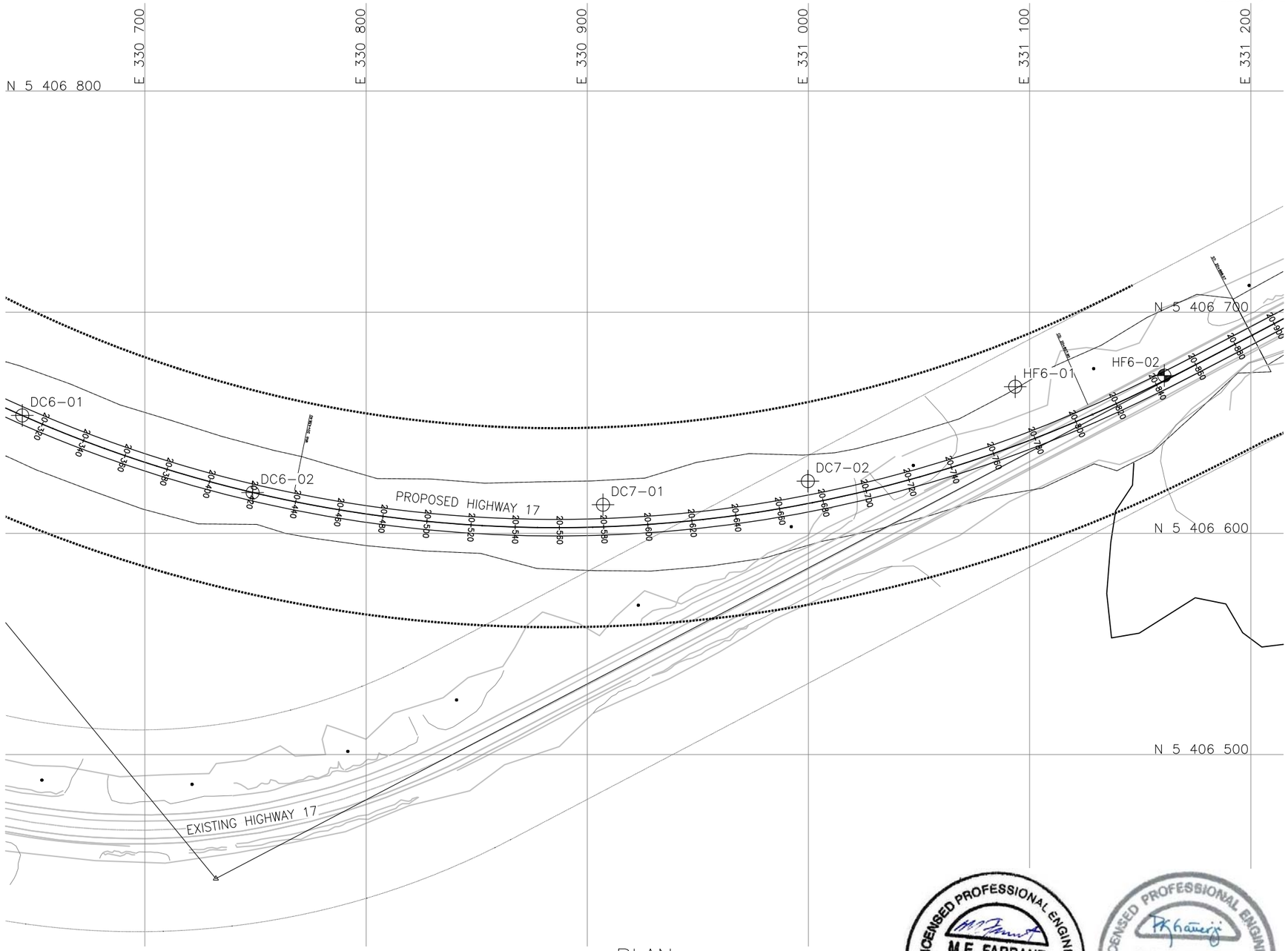

PLAN

40 0 40 80m

SCALE 1:2000

CONT No

GWP No.6132-17-00

DEEP CUT AREAS 6 AND 7
HIGH FILL AREA 6

BOREHOLE LOCATIONS

SHEET

BT ENGINEERING

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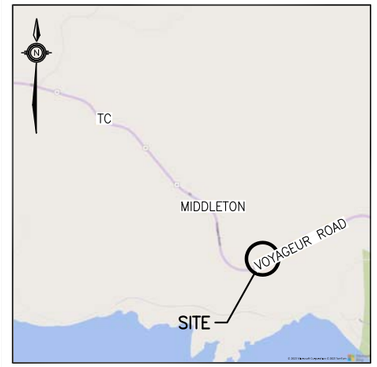

KEYPLAN

	LEGEND
⊕	Borehole
⊕	Borehole and Cone
⊕	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
▽	Water Level Upon Completion of Drilling
▼	Water Level in Monitoring Well/Piezometer
▮	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
DC6-01	295.0	5 406 653.4	330 644.6
DC6-02	293.0	5 406 618.5	330 748.7
DC7-01	293.8	5 406 612.9	330 907.1
DC7-02	291.5	5 406 623.6	330 999.8
HF6-01	264.3	5 406 666.3	331 093.5
HF6-02	269.8	5 406 671.4	331 160.9

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
3) Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42D15-001

LICENSED PROFESSIONAL ENGINEER
M.E. FARRANT
100053767
Dec. 6, 2023
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Dec. 6, 2023
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	RB	CHK	RB	CODE	LOAD	DATE	DEC 2023
DRAWN	MC	CHK	MEF	SITE	STRUCT	DWG	6

FILENAME: H:\Drafting\29000\29771\TED-29771-BHPP.dwg
PLOTDATE: 12/6/2023 4:19 PM

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APPENDIX B

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

C_{pen} Shear Strength Determination by Pocket Penetrometer

(1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.

(2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

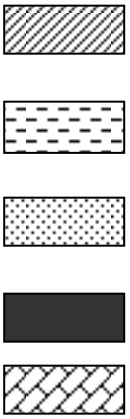
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels,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

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

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

SYMBOLS



CLAYSTONE

SILTSTONE

SANDSTONE

COAL

Bedrock (general)

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

TERMS

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.

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
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

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RECORD OF BOREHOLE No CULV-01 1 OF 2 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+970 O/S 18R N 5 406 854.8 E 330 371.7 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2023.07.18 - 2023.07.18 LATITUDE 48.799559 LONGITUDE -86.651885 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
285.2	GROUND SURFACE										
0.0	**ASPHALT:**(150mm)										
0.2	Gravelly **SAND**, trace silt, occasional cobbles Very Dense to Dense Brown Moist (FILL)		1	SS	68		285		○		
			2	SS	39				○		
283.8							284				
1.4	Silty **SAND**, trace gravel Dense Brown		3	SS	33				○		
283.2	Moist										
2.0	(FILL)						283				
	ROCKFILL, with cobbles and boulders (approx. 200 to 300mm diameter), some gravelly sand, trace silt to silty Dense to Compact Brown Moist to Wet (FILL)		4	SS	31				○		28 65 7 (SI+CL)
	Cored through blasted rockfill from 2.0m to 2.6m		5	SS	27		282		○		
	Cored through blasted rockfill from 4.0m to 4.6m		6	SS	29		281		○		15 54 31 (SI+CL)
280.0							280		○ 149		
5.2	**PEAT**, fibrous Loose Dark Brown Wet		7	SS	7				○ 204		
279.3							279		○		32 43 25 (SI+CL)
5.9	Gravelly **SAND**, some silt to silty, trace clay Compact Grey		8	SS	23					FI	
278.6	Moist										
6.6	**BEDROCK (SYENITE),** grey, fresh, very strong		1	RUN			278			2	RUN #1 TCR=100% SCR=100% RQD=92% UCS=241MPa (Point Load) UCS=109.4MPa
										2	
										0	
	Rubble zone from 7.5 to 7.6m and 8.5 to 8.6m									>10	
	Sub-vertical fractures from 7.6 to 7.8m and 8.4 to 8.5m		2	RUN						1	RUN #2 TCR=98% SCR=60% RQD=57% UCS=226MPa
							277			0	
										>10	
										0	
										0	RUN #3 TCR=98% SCR=98% RQD=95% UCS=236MPa (Point Load) UCS=171.9MPa
							276			0	
			3	RUN						1	
										1	

Continued Next Page

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

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

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RECORD OF BOREHOLE No CULV-01 2 OF 2 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+970 O/S 18R N 5 406 854.8 E 330 371.7 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2023.07.18 - 2023.07.18 LATITUDE 48.799559 LONGITUDE -86.651885 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
275.0	Continued From Previous Page						275				
10.2	END OF BOREHOLE AT 10.2m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.2m, GRAVEL TO 0.1m, THEN COLD PATCH TO SURFACE.										

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

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

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RECORD OF BOREHOLE No DC1-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 17+617 CL N 5 408 583.1 E 328 798.3 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.815165 LONGITUDE -86.673202 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
272.3	GROUND SURFACE										
0.0 272.0	**TOPSOIL:** (300mm)						272				
0.3	SHOVEL PROBE TERMINATED ON POTENTIAL BEDROCK AT 0.3m.										

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

15 10 20 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No DC1-02 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 17+775 O/S 15L N 5 408 519.2 E 328 944.4 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.814585 LONGITUDE -86.671217 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
303.8	GROUND SURFACE										
0.0	SHOVEL PROBE TERMINATED AT SURFACE UPON REFUSAL ON POSSIBLE BEDROCK.										

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

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

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RECORD OF BOREHOLE No DC1-03 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 17+920 O/S 6R N 5 408 419.1 E 329 051.8 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.813680 LONGITUDE -86.669760 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100 O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	w_P w w_L 20 40 60	γ kN/m^3	GR SA SI CL
301.2 GROUND SURFACE											
0.0	SHOVEL PROBE TERMINATED AT SURFACE UPON REFUSAL ON POSSIBLE BEDROCK.										

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

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

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RECORD OF BOREHOLE No DC3-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+580 O/S 15L N 5 407 177.6 E 330 148.8 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.802472 LONGITUDE -86.654899 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
296.9	GROUND SURFACE										
0.0 / 0.0	**TOPSOIL:** (25mm)										
	SHOVEL PROBE TERMINATED AT 0.0m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No DC4-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+750 O/S 10L N 5 407 043.1 E 330 252.9 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.801258 LONGITUDE -86.653490 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
293.9	GROUND SURFACE										
0.0 293.6	**TOPSOIL:** (325mm)										
0.3	SHOVEL PROBE TERMINATED AT 0.3m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

15 20 10 5 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No DC5-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+000 O/S 15L N 5 406 853.1 E 330 415.5 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY AN

DATUM Geodetic DATE 2023.07.20 - 2023.07.20 LATITUDE 48.799542 LONGITUDE -86.651289 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
298.2	GROUND SURFACE										
0.0	**TOPSOIL:** (75mm)								o		
0.1	HAND AUGER TERMINATED AT 0.1m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No DC5-02 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+125 O/S 5R N 5 406 748.8 E 330 485.9 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.798602 LONGITUDE -86.650337 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
301.7	GROUND SURFACE										
0.0	**TOPSOIL:** (100mm)										
0.1	SHOVEL PROBE TERMINATED AT 0.1m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

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

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RECORD OF BOREHOLE No DC6-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+310 CL N 5 406 653.4 E 330 644.6 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.797737 LONGITUDE -86.648182 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED, FIELD VANE, QUICK TRIAXIAL, LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
295.0	GROUND SURFACE										
0.0 / 0.0	**TOPSOIL:** (50mm)										
	SHOVEL PROBE TERMINATED AT 0.0m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No DC6-02 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+420 CL N 5 406 618.5 E 330 748.7 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.797419 LONGITUDE -86.646767 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
293.0	GROUND SURFACE										
0.0	**TOPSOIL:** (125mm)										
0.1	SHOVEL PROBE TERMINATED AT 0.1m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

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

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Ontario

THURBER

RECORD OF BOREHOLE No DC7-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+580 O/S 10L N 5 406 612.9 E 330 907.1 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.797362 LONGITUDE -86.644612 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
293.8	GROUND SURFACE										
0.0	**TOPSOIL:** (225mm)										
0.2	SHOVEL PROBE TERMINATED AT 0.2m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No DC7-02 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+675 O/S 10L N 5 406 623.6 E 330 999.8 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY AN

DATUM Geodetic DATE 2023.07.20 - 2023.07.20 LATITUDE 48.797454 LONGITUDE -86.643349 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
291.5	GROUND SURFACE										
0.0 / 0.1	**TOPSOIL:** (75mm)										
	HARD AUGER TERMINATED AT 0.1m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

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

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THURBER

RECORD OF BOREHOLE No HF1-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 17+540 O/S 31R N 5 408 587.4 E 328 713.2 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2023.07.21 - 2023.07.22 LATITUDE 48.815207 LONGITUDE -86.674361 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.2	GROUND SURFACE										
0.0	**ASPHALT:** (150mm)										
0.2	**SAND** and **GRAVEL**, trace silt Very Dense Brown Moist		1	SS	88		272		o		37 54 9 (SI+CL)
271.4											
0.8	(FILL)										
	ROCKFILL, with cobbles and boulders (approx. 200 to 300mm diameter), trace sand Very Dense Brown Moist (FILL)		2	SS	51		271				
	Coring from 0.8m to 5.7m										
	No recovery		3	SS	50/ 0.150		270				
	No recovery		4	SS	50/ 0.150		269				
	No recovery		5	SS	50/ 0.150		268				
266.5							267				RUN #1 TCR=100% SCR=91% RQD=69% UCS=201MPa (Point Load) UCS=112.2MPa
5.7	**BEDROCK (METAVOLCANIC),** slightly weathered, grey, very strong		1	RUN						FI	
	Sub-vertical to vertical fractures from 6.0 to 6.2m, 6.4 to 6.5m, 6.6 to 6.7m, 6.8 to 6.9m, 7.0 to 7.1m, 8.7 to 8.8m and 8.9 to 9.0m		2	RUN			266			3	RUN #2 TCR=78% SCR=56% RQD=0% UCS=188MPa
			3	RUN						4	
	Highly fractured at 6.5m		4	RUN			265			>10	RUN #3 TCR=100% SCR=73% RQD=73% UCS=189MPa
263.3			5	RUN			264			5 8 4 2 1 5 3 0	RUN #4 TCR=100% SCR=92% RQD=47% UCS=>245MPa (Point Load) UCS=105.6MPa RUN #5 TCR=88% SCR=88% RQD=88%
8.9	END OF BOREHOLE AT 8.9m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.2m, GRAVEL TO 0.1m, THEN COLD PATCH TO SURFACE.										UCS=182MPa

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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No HF2-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 17+996 O/S 5L N 5 408 379.3 E 329 117.8 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.813320 LONGITUDE -86.668864 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.3	GROUND SURFACE										
0.0	**TOPSOIL:** (75mm)										
0.1	SHOVEL PROBE TERMINATED AT 0.1m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

$\frac{20}{15-10-5}$ (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No HF2-02 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 18+040 O/S 40R N 5 408 317.0 E 329 120.3 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN

DATUM Geodetic DATE 2023.07.19 - 2023.07.20 LATITUDE 48.812759 LONGITUDE -86.668833 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.3	GROUND SURFACE										
0.0	**ASPHALT:** (100mm)										
0.1	Gravelly **SAND**, trace silt Very Dense Light Brown Moist (FILL)		1	SS	82		289		○		34 57 9 (SI+CL)
288.5											
0.8	**SAND** and **GRAVEL**, trace silt, some cobbles Dense Black to Reddish Brown Moist (FILL)		2	SS	50		288		○		
287.8											
1.5	**ROCKFILL**, with cobbles and boulders (approx. 200 to 300mm diameter), trace to some sand, trace silt Very Dense to Dense Brown and Grey Moist (FILL) No recovery Coring from 2.9m to 3.8m		3	SS	57				○		
			4	SS	-		287				
			5	SS	53						
							286				
			6	SS	78				○		72 16 12 (SI+CL)
	Coring from 4.2m to 4.8m						285				
			7	SS	43				○		
	Coring from 5.4m to 7.9m						284				
			8	SS	50		283				
							282				
	No recovery		9	SS	50						
	No recovery		10	SS	50		281				
	End of borehole at 9.1m upon encountering top of wooden culvert at 8.5m. Borehole continued by hand auger at toe of embankment beside culvert (refer to HF2-03)										
280.1											
9.2	END OF BOREHOLE AT 9.2m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.2m, GRAVEL TO 0.1m, THEN COLD PATCH TO SURFACE.										

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

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

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RECORD OF BOREHOLE No HF2-03 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 18+015 O/S 24R N 5 408 345.5 E 329 113.2 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY AN

DATUM Geodetic DATE 2023.07.20 - 2023.07.20 LATITUDE 48.813016 LONGITUDE -86.668929 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100) ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
280.1	GROUND SURFACE										
0.0	**PEAT** Dark Brown Wet		1	GS			280				
279.2											
0.9	**SAND**, some silt, trace clay, trace gravel, some organics Brown Wet		2	GS			279				
278.0	Hand auger terminated at 2.1 m on possible bedrock or boulders.		3	GS							1 86 10 3
2.1	END OF BOREHOLE AT 2.1m.										

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

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

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THURBER

RECORD OF BOREHOLE No HF3-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+150 CL N 5 407 500.4 E 329 864.3 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN

DATUM Geodetic DATE 2023.03.28 - 2023.03.28 LATITUDE 48.805386 LONGITUDE -86.658753 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
293.4	GROUND SURFACE										
0.0 / 293.1	**PEAT**, fibrous Loose Black Wet Auger refusal at 0.25m		1	SS	10/ 0.100					362	
0.3	END OF BOREHOLE AT 0.3m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.										

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

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

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RECORD OF BOREHOLE No HF4-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+679 O/S 6L N 5 407 094.6 E 330 205.4 ORIGINATED BY RB

DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN

DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.801723 LONGITUDE -86.654134 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
285.9	GROUND SURFACE										
0.0 / 0.0	**TOPSOIL:** (25mm)										
	SHOVEL PROBE TERMINATED AT 0.0m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

15 20 10 5 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No HF5-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+200 O/S 10R N 5 406 698.2 E 330 542.8 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY AN

DATUM Geodetic DATE 2023.07.24 - 2023.07.24 LATITUDE 48.798144 LONGITUDE -86.649565 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
275.8	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)										
0.2	HAND AUGER TERMINATED AT 0.2m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No HF6-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+780 O/S 25L N 5 406 666.3 E 331 093.5 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY AN

DATUM Geodetic DATE 2023.07.23 - 2023.07.23 LATITUDE 48.797834 LONGITUDE -86.642071 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
264.3	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)									140	
0.2	HARD AUGER TERMINATED AT 0.2m UPON REFUSAL ON POSSIBLE BEDROCK.										

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

$\frac{20}{15-5}$ (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No HF6-02 1 OF 3 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+845 O/S 2L N 5 406 671.4 E 331 160.9 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test (DCPT) COMPILED BY AN

DATUM Geodetic DATE 2023.07.22 - 2023.07.24 LATITUDE 48.797877 LONGITUDE -86.641153 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
269.8	GROUND SURFACE										
0.0	**ASPHALT**: (125mm)										
0.1	**SAND** and **GRAVEL**, silty to some silt, occasional cobbles Very Dense Brown Moist (FILL)		1	SS	51		269	○			
268.9 0.9	**ROCKFILL,** with cobbles and boulders (approx. 200 to 300mm diameter), some sand, trace silt, occasional pockets of sand and gravel Compact to Very Dense Brown and Grey Moist (FILL) Cored from 2.0m to 3.1m		2	SS	86			○			46 37 17 (SI+CL)
			3	SS	32		268				
			4	SS	12		267	○			
	Cored from 3.2m to 4.6m		5	SS	50/ 0.150			○			
			6	SS	50/ 0.150		266				
							265				
	Cored from 6.1 to 7.0m						264				
							263				
			7	SS	23		262	○			
	Cored from 8.2m to 9.5m										
			8	SS	26		261				
			9	SS	50/ 0.0						
			10	SS	14		260				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No HF6-02 2 OF 3 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+845 O/S 2L N 5 406 671.4 E 331 160.9 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test (DCPT) COMPILED BY AN

DATUM Geodetic DATE 2023.07.22 - 2023.07.24 LATITUDE 48.797877 LONGITUDE -86.641153 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Cored from 10.3m to 12.2m		11	SS	7		259				
			12	SS	50/ 0.150		258				
256.8							257				
13.0	**PEAT** Brown Wet		1	GS					110		
256.1	Sand seam from 13.7m to 13.8m						256				
13.7	Clayey **SILT**, trace sand Very Stiff Grey Wet (ML)		13	SS	21						0 3 81 16
255.0							255				
14.8	Silty **CLAY**, trace sand Very Stiff to Stiff Grey Wet (CL)		14	SS	19						
			15	SS	17		254				0 3 57 40
			16	SS	14		253				
250.2	End of sampling at 19.5m. Dynamic cone penetration test from 19.5						252				
19.6	END OF BOREHOLE AT 19.6m UPON DCPT REFUSAL.						251				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

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

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Ontario

THURBER

RECORD OF BOREHOLE No HF6-02 3 OF 3 METRIC

GWP# 6132-17-00 LOCATION Sta. 20+845 O/S 2L N 5 406 671.4 E 331 160.9 ORIGINATED BY JF

DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test (DCPT) COMPILED BY AN

DATUM Geodetic DATE 2023.07.22 - 2023.07.24 LATITUDE 48.797877 LONGITUDE -86.641153 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	BOREHOLE BACKFILLED WITH SAND AND GRAVEL TO 0.2m, THEN ASPHALT PATCH TO SURFACE.										

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

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

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THURBER

RECORD OF BOREHOLE No SW1-01 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+200 CL N 5 407 461.7 E 329 896.1 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN

DATUM Geodetic DATE 2023.03.28 - 2023.03.28 LATITUDE 48.805037 LONGITUDE -86.658322 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
288.9	GROUND SURFACE										
0.0 288.5	**PEAT**, fibrous Loose Black Wet		1	SS	5				77%		
0.3 288.2											
0.6	Silty **SAND**, some gravel Loose Grey Wet										
	END OF BOREHOLE AT 0.61m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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THURBER

RECORD OF BOREHOLE No SW1-02 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+250 O/S 10R N 5 407 416.9 E 329 920.0 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT) COMPILED BY AN

DATUM Geodetic DATE 2023.03.28 - 2023.03.28 LATITUDE 48.804633 LONGITUDE -86.657999 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
285.0	GROUND SURFACE										
0.0 284.6	DCPT from surface										
0.5	DCPT REFUSAL AT 0.5m UPON POSSIBLE BEDROCK.										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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RECORD OF BOREHOLE No SW1-03 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+300 O/S 10R N 5 407 378.6 E 329 951.4 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN

DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.804287 LONGITUDE -86.657574 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
283.8	GROUND SURFACE										
0.0	**PEAT**, fibrous										
0.2	(150mm)		1	SS	50/ 0.150						
	SAND, some silt, some gravel Dense to Very Dense Reddish Brown Moist						283				
282.6			2	SS	32						
1.2	Silty **SAND**, some gravel, trace clay Compact to Very Dense Reddish Brown Moist		3	SS	16		282				11 65 24 (SI+CL)
			4	SS	52						
							281				
			5	SS	50/ 0.125						15 53 24 8
							280				
	Becoming gravelly, with occasional cobbles from 3.1 to 4.6,										
279.1	Auger refusal at 4.7m		6	SS	50/						
4.7	END OF BOREHOLE AT 4.7m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.				0.075						

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

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

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RECORD OF BOREHOLE No SW1-04 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+350 O/S 10R N 5 407 339.4 E 329 983.6 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN

DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.803933 LONGITUDE -86.657138 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.2	GROUND SURFACE										
0.0	**PEAT**, fibrous, some roots Very Loose Dark Brown Wet		1	SS	2	▼	279		548		
			2	SS	WH		278		861		
			3	SS	WH				466		
277.0							277				
2.2	**SAND**, some gravel to gravelly, some silt Very Dense Grey Wet		4	SS	50/0.125						
275.9	Auger refusal at 3.3m		5	SS	50/0.025		276				
3.3	END OF BOREHOLE AT 3.3m ON AUGER REFUSAL ON POSSIBLE BEDROCK. Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2023.03.29	3.0	276.2
2023.03.29	1.3	277.9
2023.03.30	-0.6	279.8

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No SW1-05 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+355 O/S 10L N 5 407 348.3 E 330 002.1 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT) COMPILED BY AN

DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.804013 LONGITUDE -86.656886 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
279.3	GROUND SURFACE										
0.0	DCPT from surface						279				
							278				
							277				
							276				
275.1											
4.3	END OF BOREHOLE AT 4.3m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE. DCPT TERMINATED AT 4.23m DUE TO POSSIBLE BEDROCK.										

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

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

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RECORD OF BOREHOLE No SW1-06 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+400 CL N 5 407 307.2 E 330 023.0 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN

DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.803642 LONGITUDE -86.656604 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.5	GROUND SURFACE										
0.0	**PEAT**, fibrous Very Loose Black Wet		1	SS	WH		279				
			2	SS	WH		278		784		
			3	SS	WH				603		
			4	SS	WH		277		302		
276.5											
2.9 276.2	Silty **SAND**, trace gravel Loose Dark Grey Wet		5	SS	50/ 0.100						76 11 13 (SI+CL)
3.3 276.0											
3.5	**GRAVEL**, some sand, some silt Very Dense Grey Wet Auger refusal at 3.5m										
	END OF BOREHOLE AT 3.5m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.										

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No SW1-07 1 OF 1 METRIC

GWP# 6132-17-00 LOCATION Sta. 19+375 CL N 5 407 326.5 E 330 007.1 ORIGINATED BY IR

DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger/Dynamic Cone Penetration Test (DCPT) COMPILED BY AN

DATUM Geodetic DATE 2023.03.30 - 2023.03.30 LATITUDE 48.803816 LONGITUDE -86.656819 CHECKED BY RB

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
279.2	GROUND SURFACE										
0.0	**PEAT**, fibrous Very Loose Black Wet		1	SS	WH	▽	279		147		
			2	SS	WH		278		649		
			3	SS	WH		277		622		
			4	SS	WR		276		512		
			5	SS	WR		275		351		
274.7											
4.6	**SAND**, trace gravel, trace silt Very Loose to Loose Grey Wet		6	SS	WH		274				5 92 3 (SI+CL)
			7	SS	5		273				
272.6											
6.6	Silty **SAND**, trace gravel Loose Grey Wet End of augering at 7.6m due to sand blowback inside augers. DCPT advanced from 7.6m						272				
270.7							271				
8.5	END OF BOREHOLE AT 8.5m UPON DCPT REFUSAL ON POSSIBLE BEDROCK. WATER LEVEL AT OPEN BOREHOLE AT 0.5m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.										

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

$\frac{20}{15}\oplus\frac{5}{10}$ (%) STRAIN AT FAILURE

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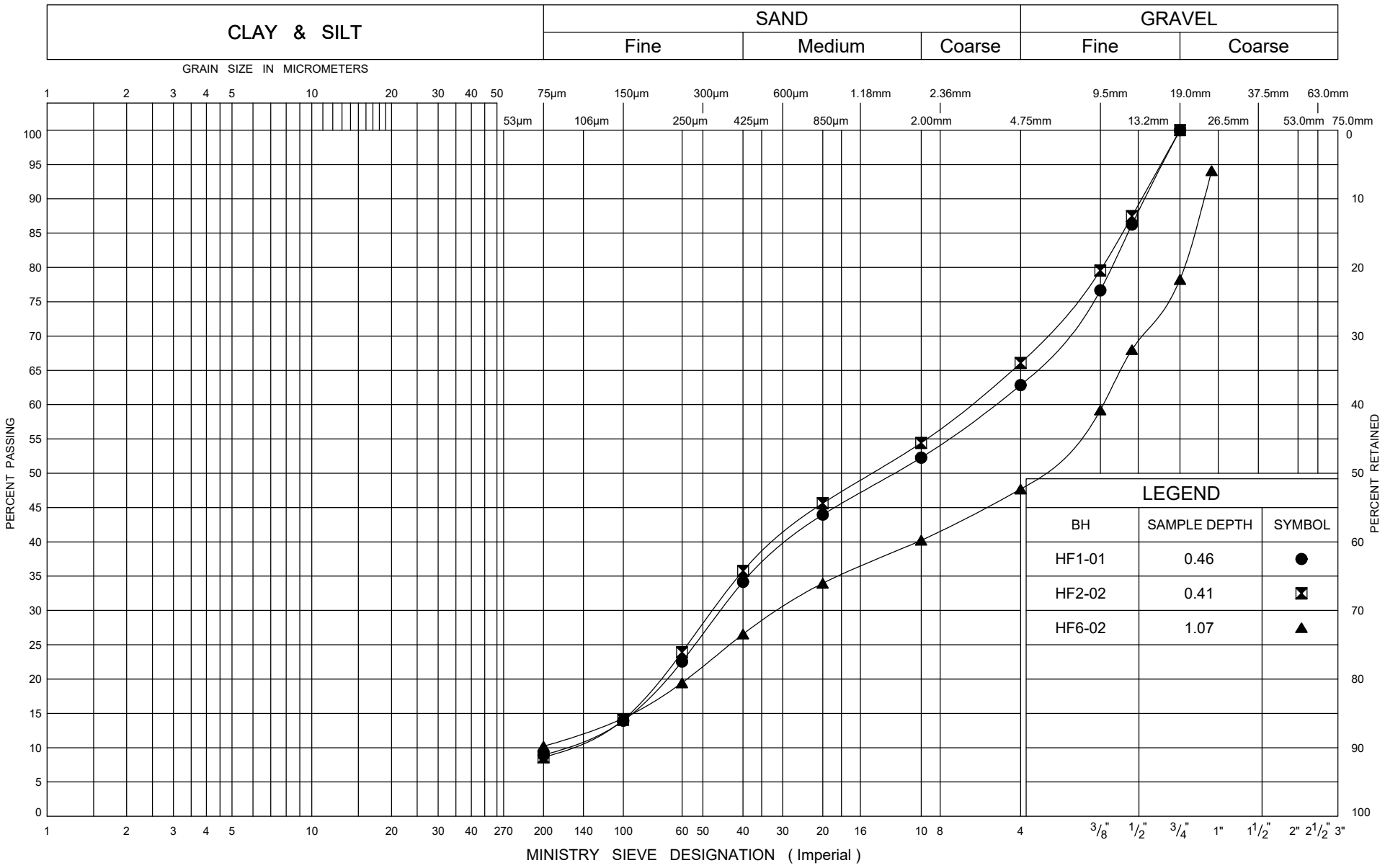
APPENDIX C

Soil Laboratory Test Results



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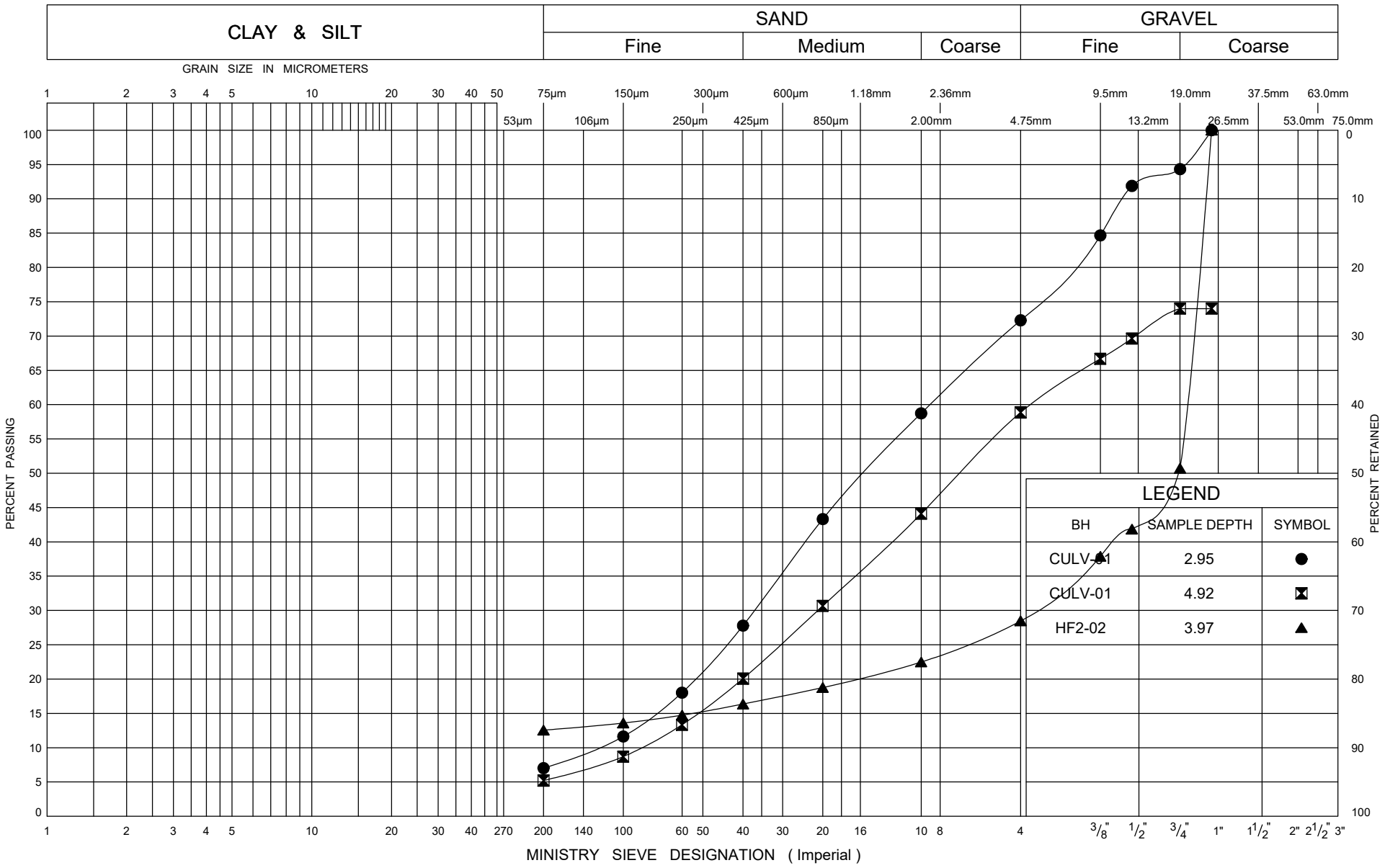
GRAIN SIZE DISTRIBUTION

Gravelly SAND to SAND and GRAVEL FILL

FIG No C1

GWP# 6132-17-00

ONTARIO MOT GRAIN SIZE 3 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23



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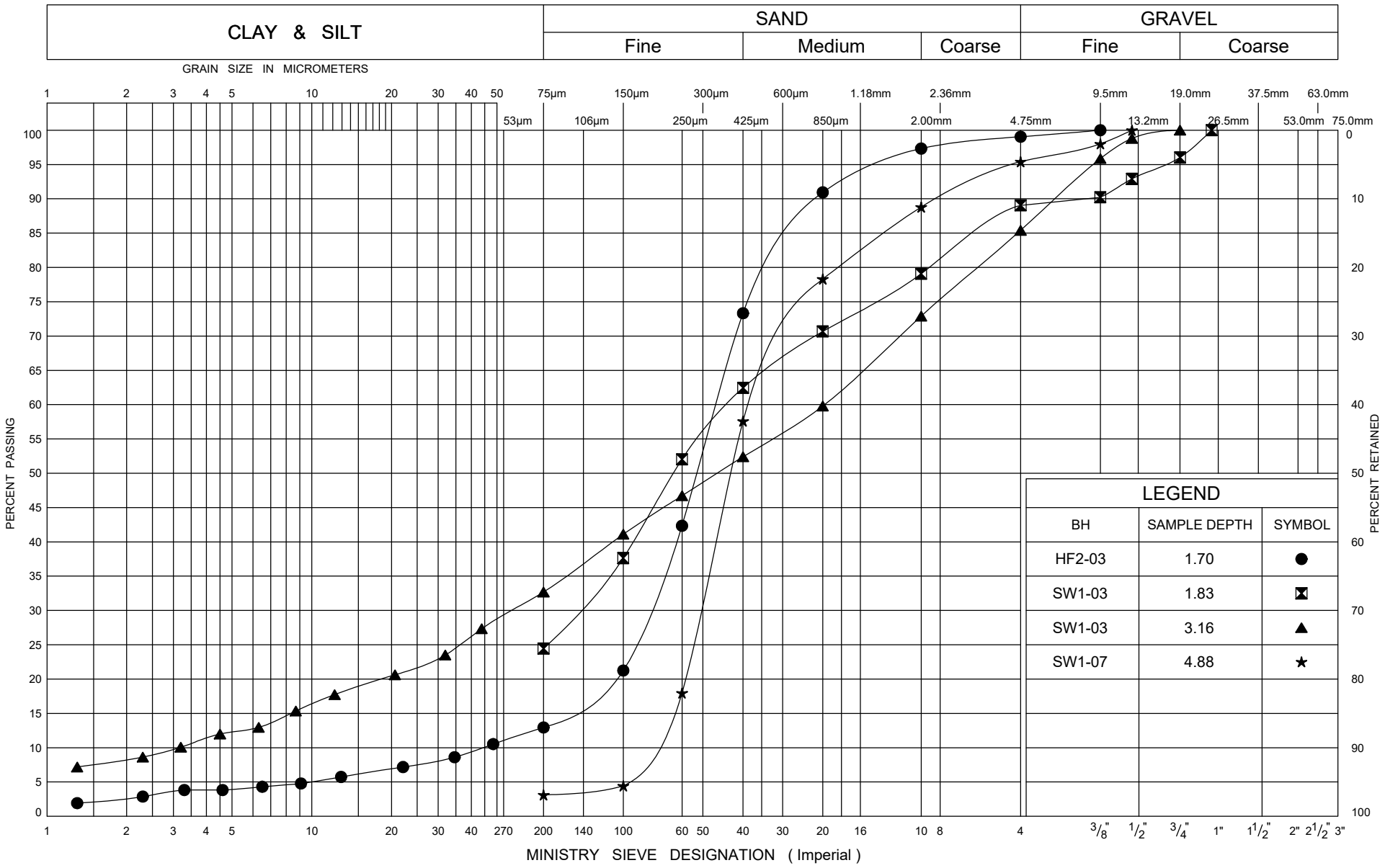
GRAIN SIZE DISTRIBUTION

Rock FILL

FIG No C2

GWP# 6132-17-00

ONTARIO MOT GRAIN SIZE 3 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23



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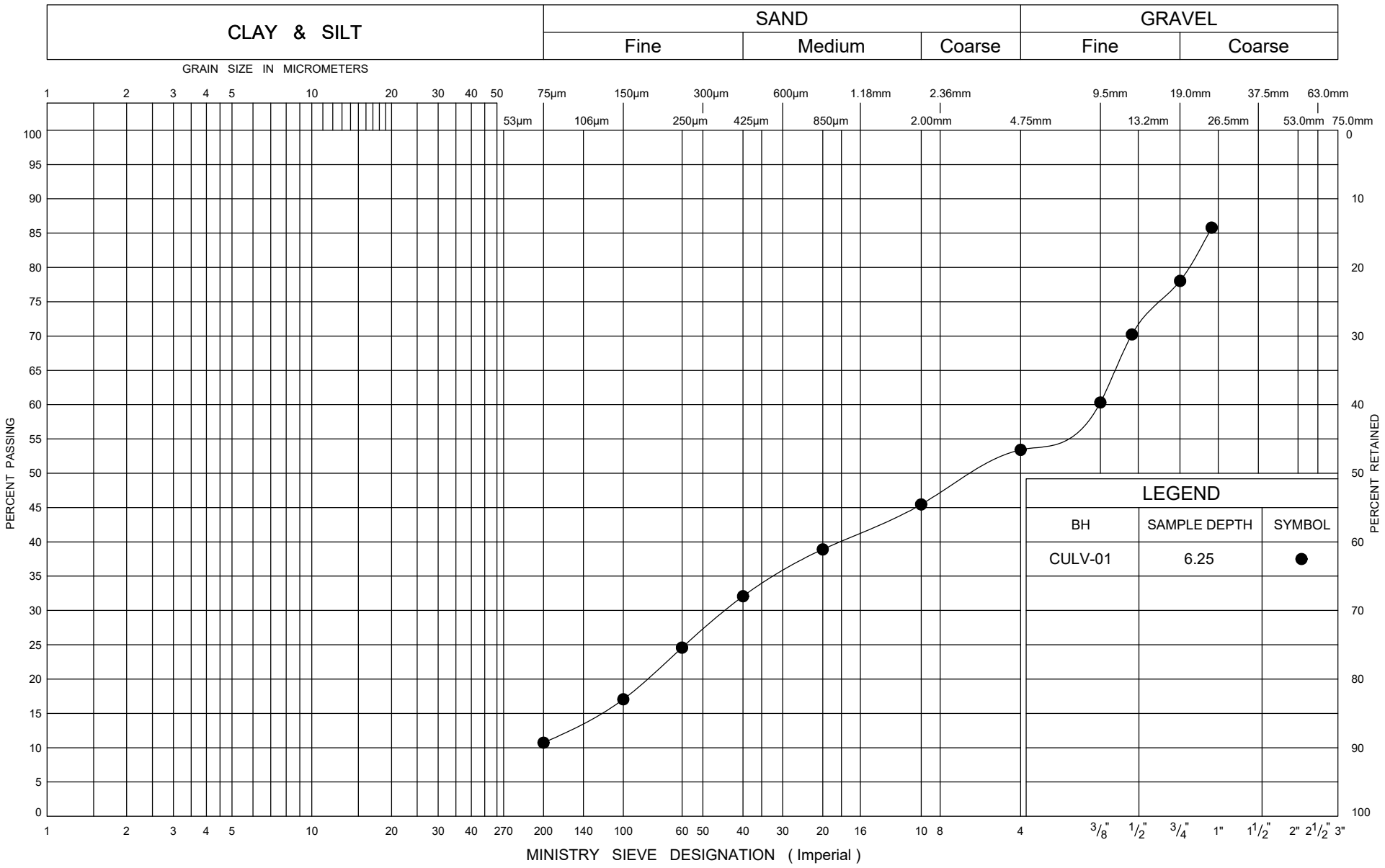
GRAIN SIZE DISTRIBUTION

SAND to Silty SAND

FIG No C3

GWP# 6132-17-00

ONTARIO MOT GRAIN SIZE 3 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23



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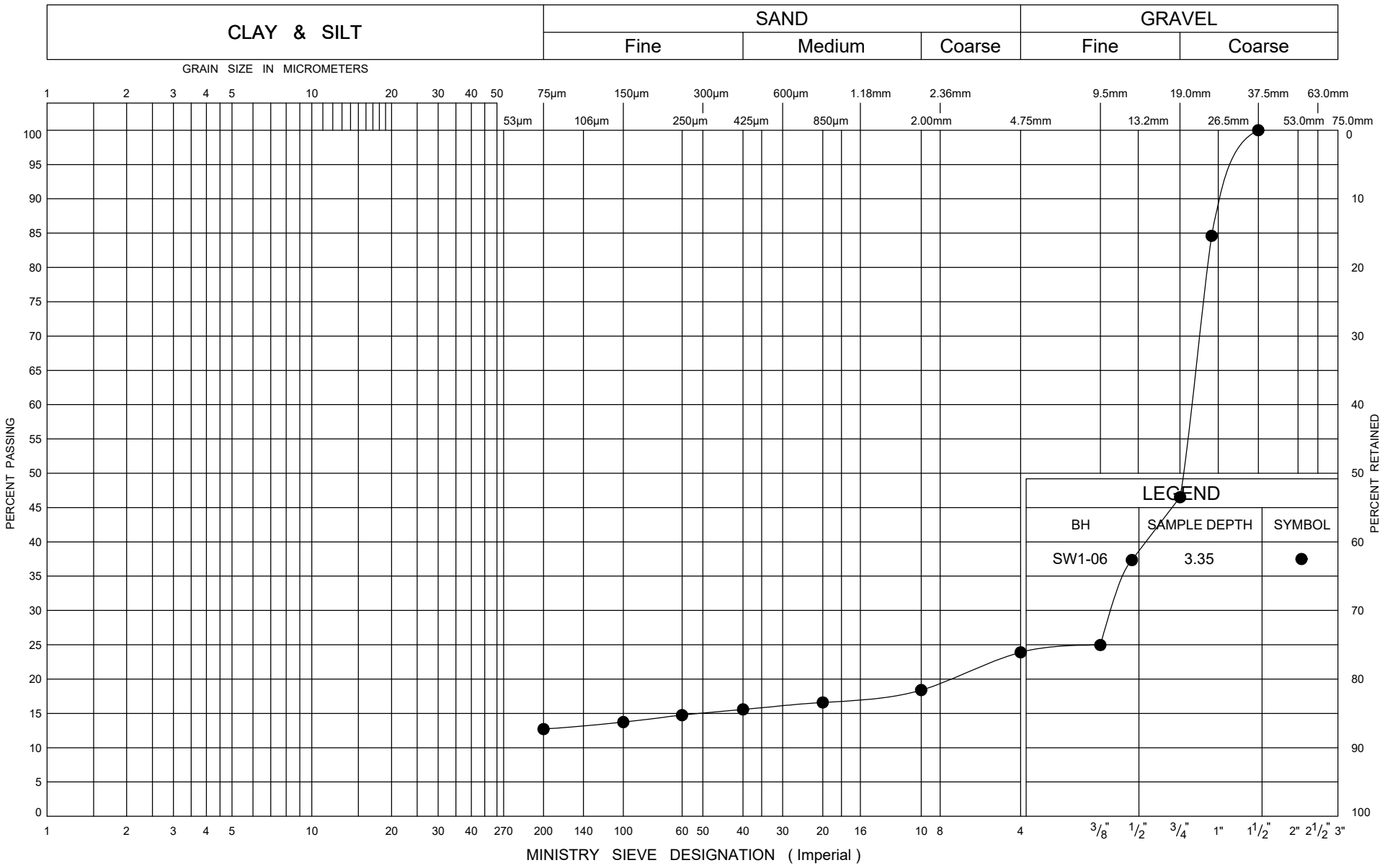
GRAIN SIZE DISTRIBUTION

Gravelly SAND

FIG No C4

GWP# 6132-17-00

ONTARIO MOT GRAIN SIZE 3 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23



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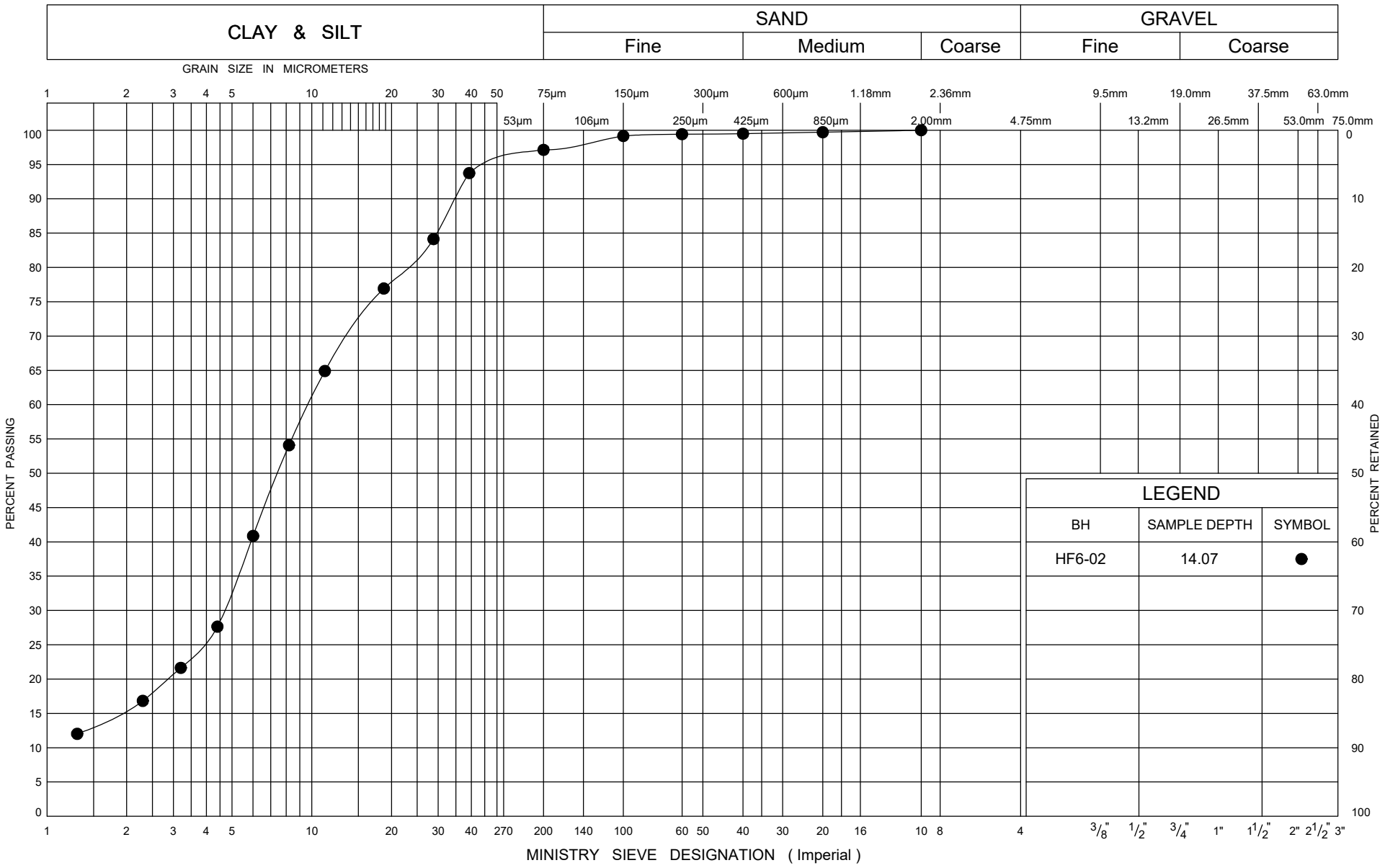
GRAIN SIZE DISTRIBUTION

GRAVEL

FIG No C5

GWP# 6132-17-00

ONTARIO MOT GRAIN SIZE 3 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23



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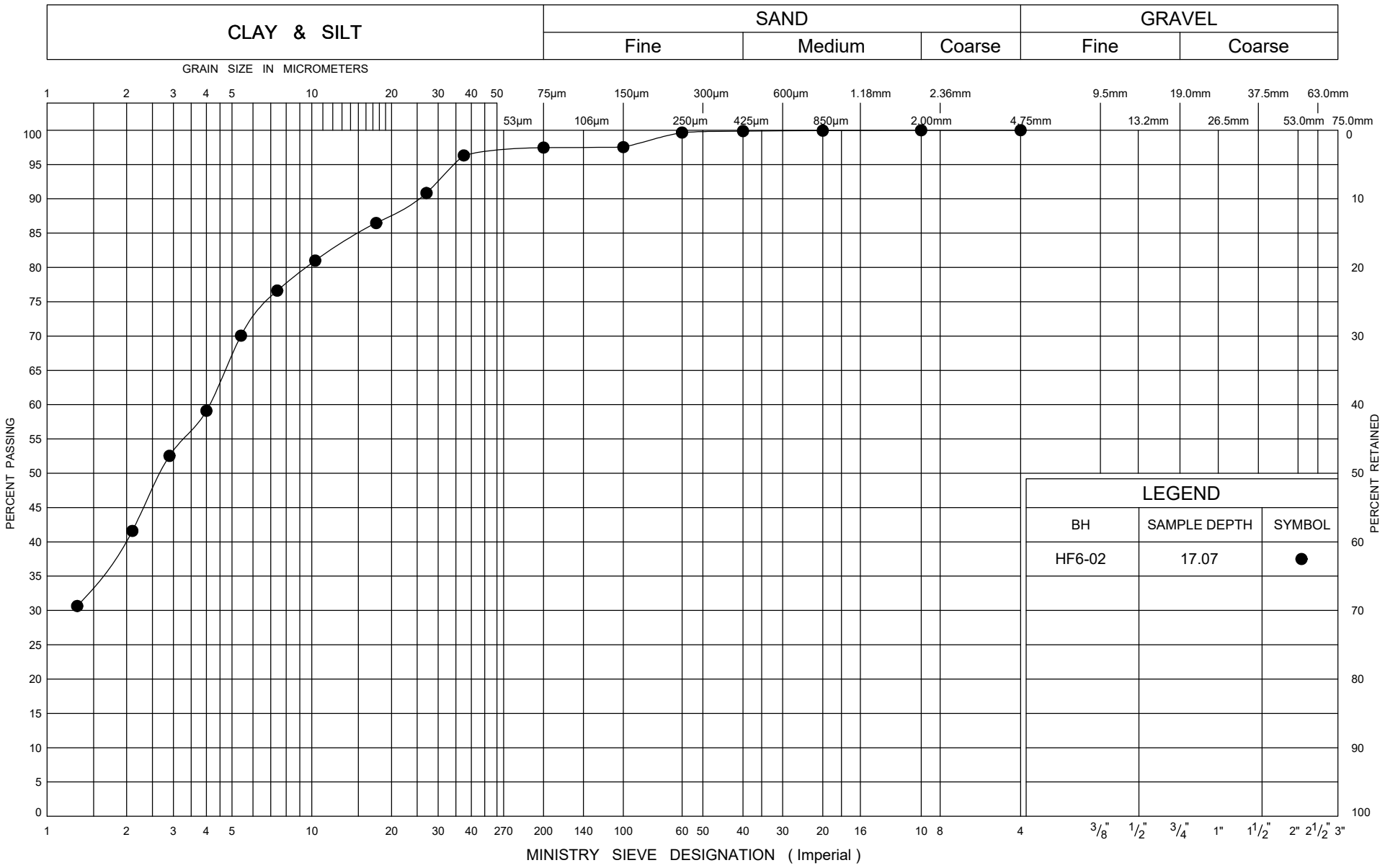
GRAIN SIZE DISTRIBUTION

Clayey SILT

FIG No C6

GWP# 6132-17-00

ONTARIO MOT GRAIN SIZE 3 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23



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GRAIN SIZE DISTRIBUTION

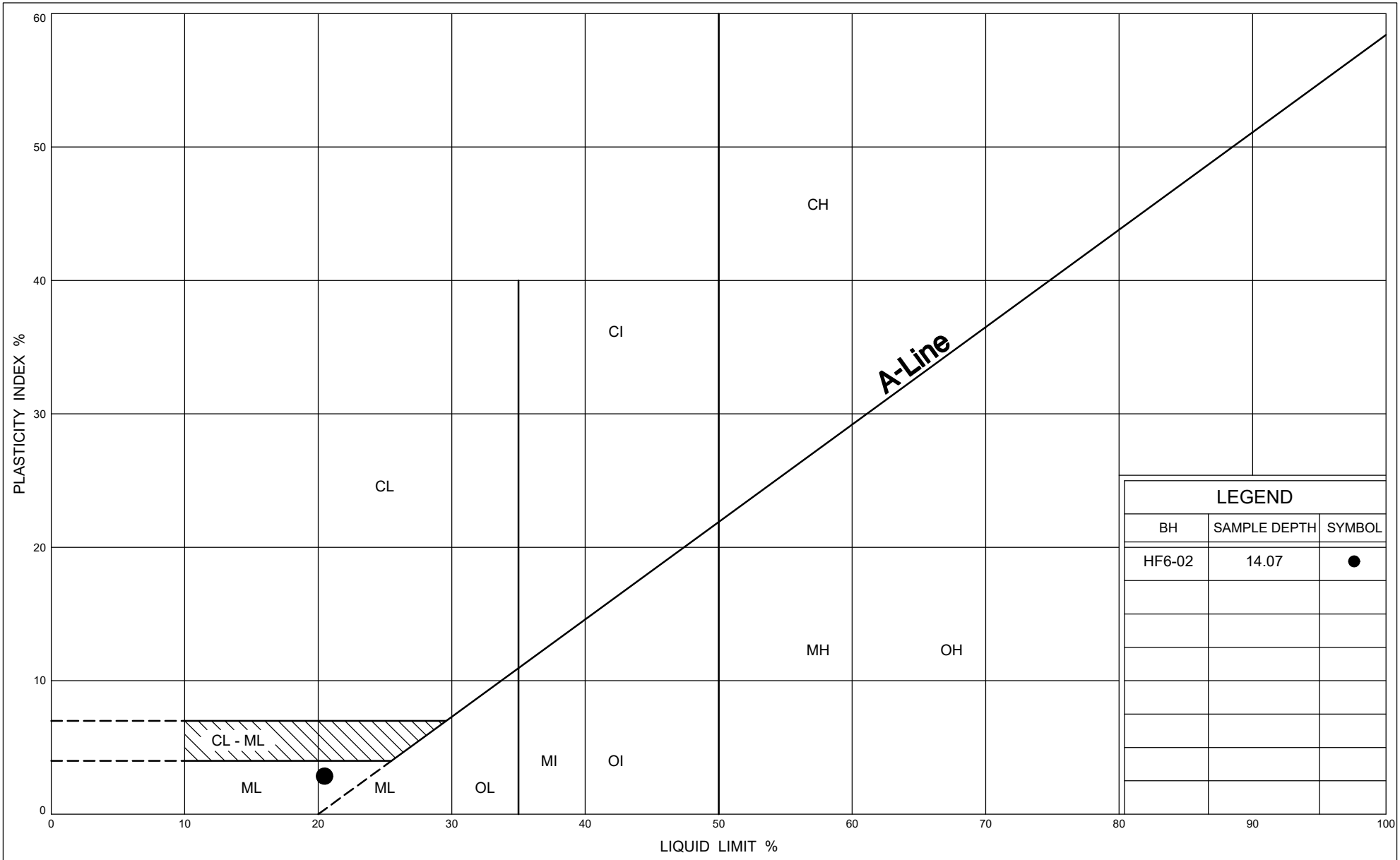
Silty CLAY

FIG No C7

GWP# 6132-17-00

ONTARIO MOT GRAIN SIZE 3 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART 2 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23

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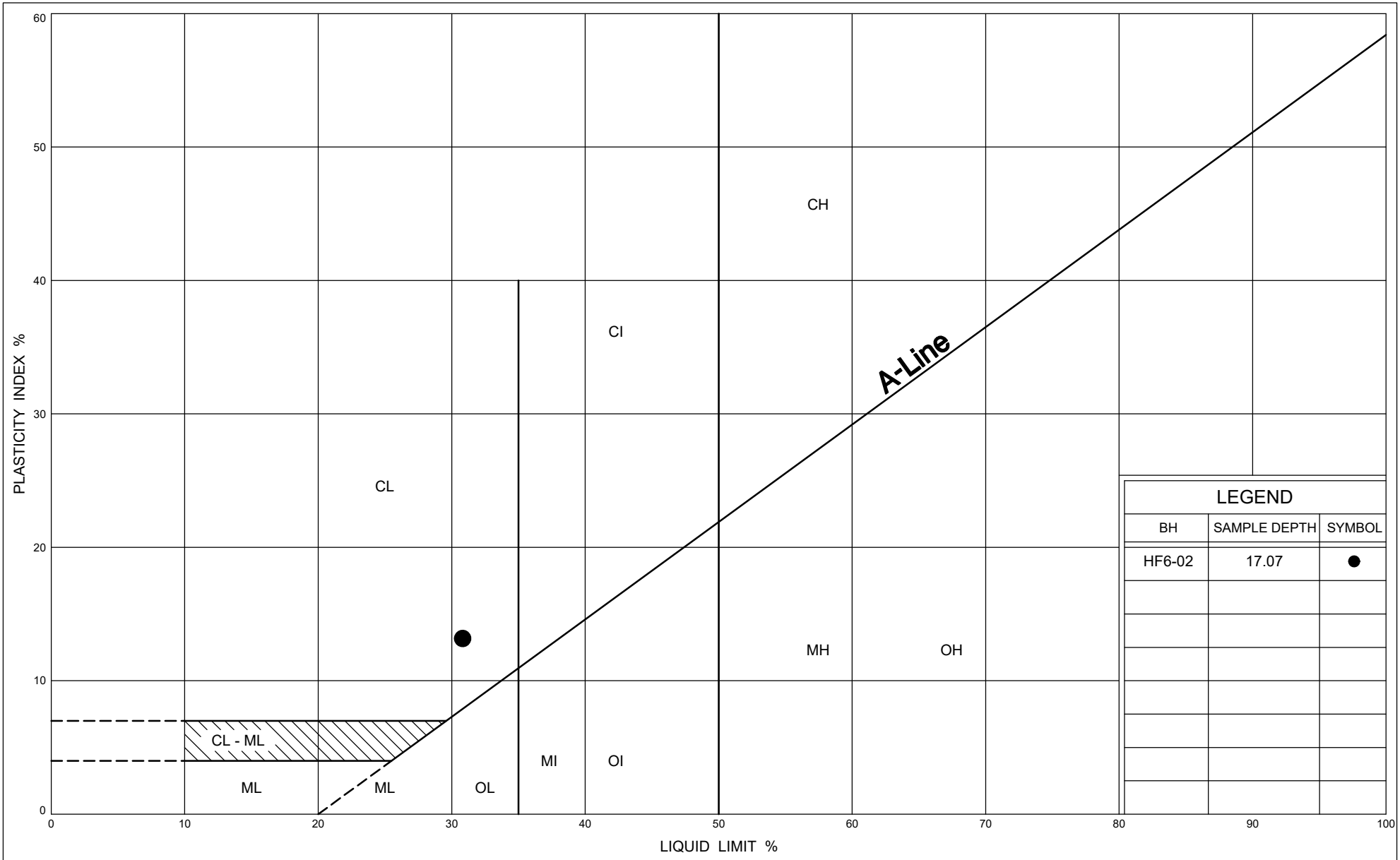
PLASTICITY CHART

Clayey SILT

FIG No C8

GWP# 6132-17-00

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART 2 MTO-29771.GPJ ONTARIO MOT.GDT 10/5/23

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PLASTICITY CHART

Silty CLAY

FIG No C9

GWP# 6132-17-00

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APPENDIX D

Bedrock Laboratory Test Results and Rock Core Photographs

THURBER ENGINEERING LTD.

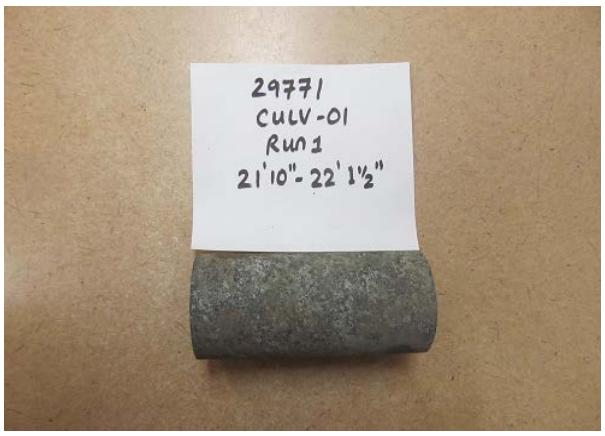
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

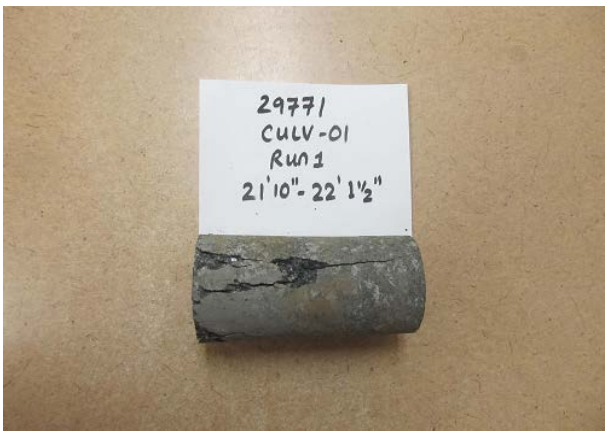
CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	CULV-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	6.65-6.74 m		
DESCRIPTION:	Syenite		

Avg. Height (cm):	9.8	Weight (g):	557.1
Avg. Diameter (cm):	4.8	Wet Density (kg/m^3):	3,208
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m^3):	2,550
Cross Sectional Area (cm^2):	17.72	Moisture Content (%):	N/A
Sample Volume (cm^3):	173.66		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	193.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	109.4 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

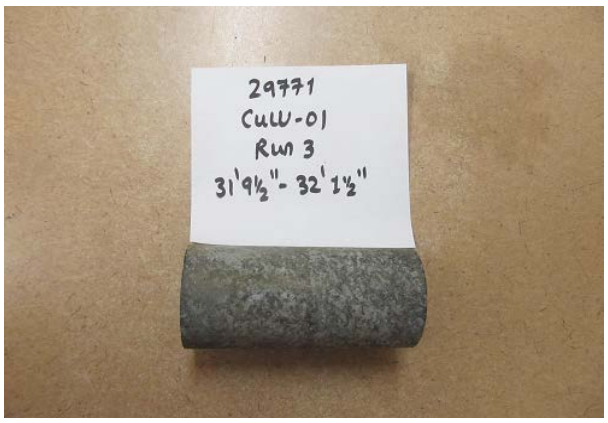
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

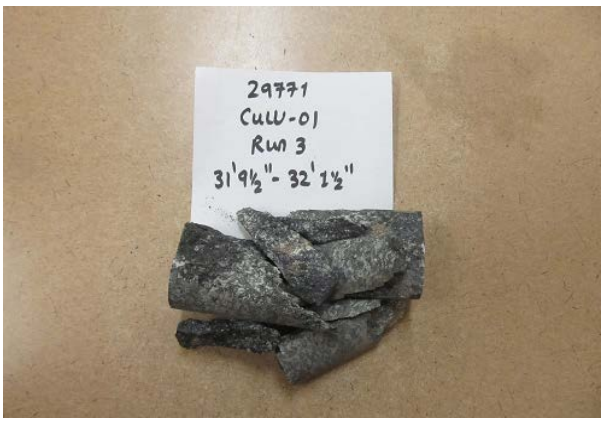
CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	CULV-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 3		
SAMPLE DEPTH:	9.69-9.79 m		
DESCRIPTION:	Syenite		

Avg. Height (cm):	9.8	Weight (g):	548.1
Avg. Diameter (cm):	4.8	Wet Density (kg/m^3):	3,156
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m^3):	2,550
Cross Sectional Area (cm^2):	17.72	Moisture Content (%):	N/A
Sample Volume (cm^3):	173.66		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	304.7 kN
UNCONFINED COMPRESSIVE STRENGTH:	171.9 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

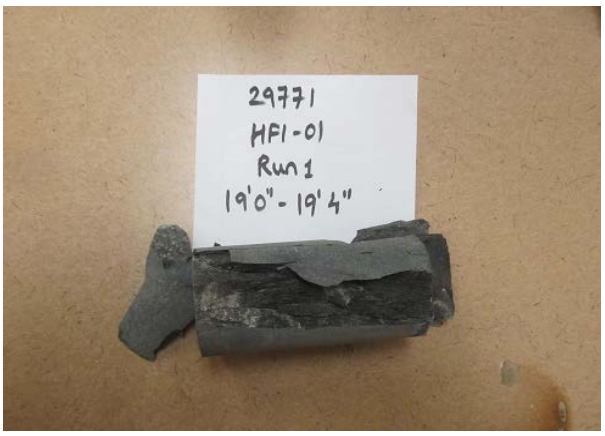
ASTM D7012-14

CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	HF1-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	5.79-5.89 m		
DESCRIPTION:	Metavolcanic		

Avg. Height (cm):	9.8	Weight (g):	477.9
Avg. Diameter (cm):	4.8	Wet Density (kg/m^3):	2,749
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m^3):	2,550
Cross Sectional Area (cm^2):	17.80	Moisture Content (%):	N/A
Sample Volume (cm^3):	173.86		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	199.6 kN
UNCONFINED COMPRESSIVE STRENGTH:	112.2 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	HF1-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 4		
SAMPLE DEPTH:	7.52-7.62 m		
DESCRIPTION:	Metavolcanic		

Avg. Height (cm):	10.0	Weight (g):	482.6
Avg. Diameter (cm):	4.8	Wet Density (kg/m^3):	2,720
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m^3):	2,550
Cross Sectional Area (cm^2):	17.80	Moisture Content (%):	N/A
Sample Volume (cm^3):	177.42		

ORIGINAL SPECIMEN

FRACTURED SPECIMEN

AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	187.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	105.6 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	29771	**Date Drilled:**	18-Jul-23
Client:	BTE	**Date Tested:**	20-Sep-23
Project Name:	Highway 17, Little Pic River Westerly	**Tester:**	AK
Core Size:	NQ **BH No :** CULV - 01	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	6.9	D	24.8	47.5	109.0	10.2	245.0	Syenite	Very Strong
2	1	7.2	D	24.1	47.5	101.0	9.9	237.7	Syenite	Very Strong
3	2	7.5	D	21.5	47.5	93.0	8.8	212.1	Syenite	Very Strong
4	2	7.8	D	19.8	47.5	112.2	8.2	195.7	Syenite	Very Strong
5	2	8.3	D	25.0	47.5	94.0	10.3	246.6	Syenite	Very Strong
6	2	8.4	D	23.2	47.5	105.2	9.6	229.2	Syenite	Very Strong
7	2	8.7	D	24.9	47.5	109.6	10.2	245.4	Syenite	Very Strong
8	3	9.0	D	22.8	47.5	100.6	9.4	225.1	Syenite	Very Strong
9	3	9.3	D	25.0	47.5	100.7	10.3	246.6	Syenite	Very Strong
10										
11						**RUN #1 AVERAGE:**		241.4		Very Strong
12						**RUN #2 AVERAGE:**		225.8		Very Strong
13						**RUN #3 AVERAGE:**		235.8		Very Strong
14										
15						Note: Tests 5 and 9 did not break				
16										
17										
18										
19										
20										

THURBER ENGINEERING LTD.

POINT LOAD TEST SHEET

ASTM D5731-08

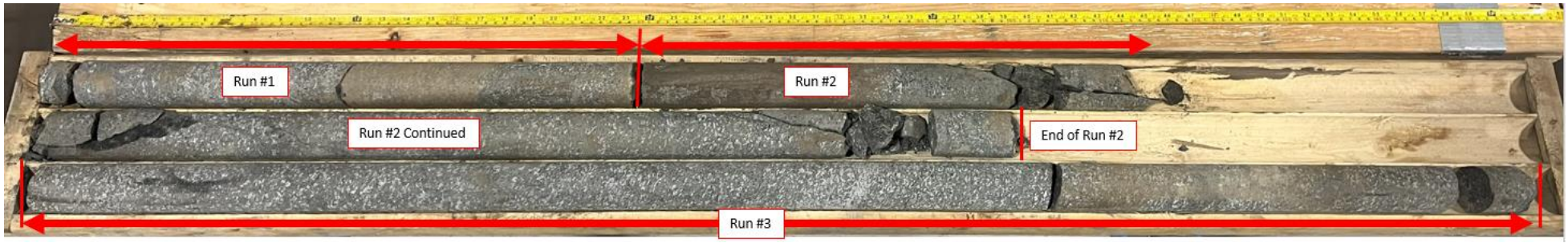
Job No:	29771	**Date Drilled:**	22-Jul-23
Client:	BTE	**Date Tested:**	20-Sep-23
Project Name:	Highway 17, Little Pic River Westerly	**Tester:**	AK
Core Size:	NQ **BH No :** HF1-01	**Reviewed by:**	MEF

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	6.2	D	20.4	47.6	91.5	8.4	200.6	Metavolcanic	Very Strong
2	2	6.3	D	19.1	47.6	84.4	7.8	188.0	Metavolcanic	Very Strong
3	3	6.7	D	20.2	47.6	93.9	8.3	198.8	Metavolcanic	Very Strong
4	3	6.9	D	18.2	47.6	89.1	7.5	179.2	Metavolcanic	Very Strong
5	4	7.5	D	25.0	47.6	110.6	10.2	245.5	Metavolcanic	Very Strong
6	4	7.8	D	25.0	47.6	93.6	10.2	245.5	Metavolcanic	Very Strong
7	5	8.7	D	18.5	47.6	94.1	7.6	181.7	Metavolcanic	Very Strong
9										
8						**RUN #3 AVERAGE:**		**189.0**		Very Strong
10						**RUN #4 AVERAGE:**		**>245**		Very Strong
11										
12						Note: Tests 5 and 6 did not break				
13										
14										
15										
16										
17										
18										
19										
20										

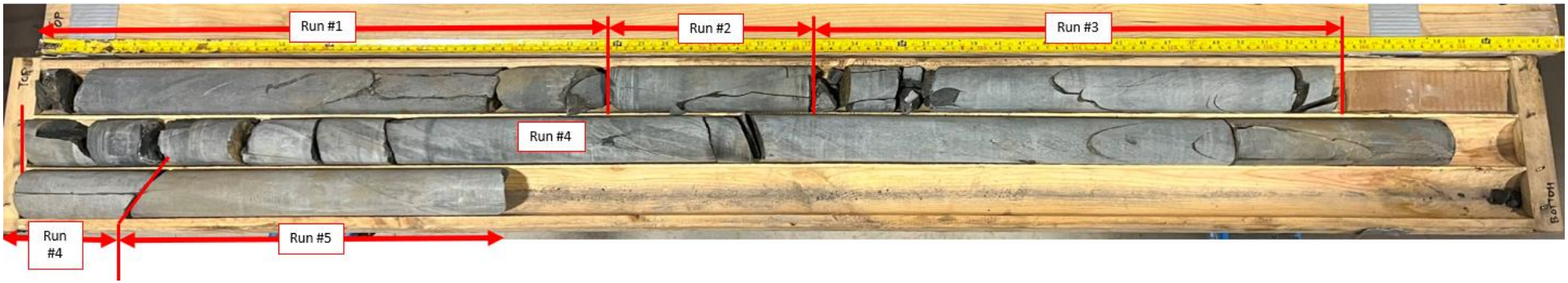
THURBER ENGINEERING LTD.

Photographs of Rock Core

Borehole CULV-01– Runs 1, 2, and 3 – 6.6 to 10.2 m (Elev. 275.0 to 278.6 m)



Borehole HF1-01 – Runs 1, 2, and 3 – 5.7 to 8.9 m (Elev. 263.3 to 266.5 m)



THURBER ENGINEERING LTD.

APPENDIX E

Analytical Laboratory Test Results

FINAL REPORT

CA40254-AUG23 R1

29771, Little Pic River

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

CA40254-AUG23 R1

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Maarit Wolfe, Hon.B.Sc
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7. Canada	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Rachel Bourassa	Telephone	705-652-2000
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	Maarit.Wolfe@sgs.com
Email	rbourassa@thurber.ca	SGS Reference	CA40254-AUG23
Project	29771, Little Pic River	Received	08/24/2023
Order Number		Approved	08/31/2023
Samples	Soil (4)	Report Number	CA40254-AUG23 R1
		Date Reported	08/31/2023

COMMENTS

Temperature of Sample upon Receipt: 8 degrees C
Cooling Agent Present: Yes
Custody Seal Present: Yes

Chain of Custody Number: n/a

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Maarit Wolfe, Hon.B.Sc

TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project: 29771, Little Pic River
Project Manager: Rachel Bourassa
Samplers: NA

MATRIX: SOIL

			Sample Number	5	6	7	8
			Sample Name	HF6-02 SS15 (55'-57')	HF2-02 SS1 (4"-2'4")	CUIV-01 SS1 (6"-2'6")	SW1-07 SS7A (20'-21'8")
			Sample Matrix	Soil	Soil	Soil	Soil
			Sample Date	19/07/2023	24/07/2023	18/07/2023	30/03/2023
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**
Corrosivity Index							
Corrosivity Index	none	1		4	9	12	1
Soil Redox Potential	mV	no		147	195	282	220
Sulphide (Na2CO3)	%	0.04		< 0.04	< 0.04	< 0.04	< 0.04
pH	pH Units	0.05		8.60	9.31	9.17	8.46
Resistivity (calculated)	ohms.cm	-9999		3150	1930	1690	3560
General Chemistry							
Conductivity	uS/cm	2		317	519	591	281
Metals and Inorganics							
Moisture Content	%	0.1		20.2	3.4	7.8	18.7
Sulphate	µg/g	0.4		42	21	35	64
Other (ORP)							
Chloride	µg/g	0.4		94	130	140	21

QC SUMMARY

Anions by IC

Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-[ENV]IC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0656-AUG23	µg/g	0.4	<0.4	2	35	102	80	120	104	75	125
Sulphate	DIO0656-AUG23	µg/g	0.4	<0.4	5	35	97	80	120	97	75	125

Carbon/Sulphur

Method: ASTM E1915-07A | Internal ref.: ME-CA-[ENV]ARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0111-AUG23	%	0.04	< 0.04	ND	20	83	80	120			

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-[ENV]EWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0547-AUG23	uS/cm	2	3	1	20	100	90	110	NA		

QC SUMMARY

pH

Method: SM 4500 I Internal ref.: ME-CA-[ENV]EWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0520-AUG23	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS	Insufficient sample for analysis.
RL	Reporting Limit.
↑	Reporting limit raised.
↓	Reporting limit lowered.
NA	The sample was not analysed for this analyte
ND	Non Detect

Results relate only to the sample tested.
Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.
"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.
Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

This report supersedes all previous versions.

-- End of Analytical Report --

Request for Laboratory Services and CHAIN OF CUSTODY

SGS Environment, Health & Safety - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Fax: 705-652-6365 Web: www.sgs.com/environment
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361

No: Page _____ of _____

Laboratory Information Section - Lab use only

Received By: ED
Received Date: 8/24/23 (mm/dd/yy)
Received Time: 13:30 (hr : min)
Received By (signature):
Custody Seal Present: Yes ☑ No ☐
Custody Seal Intact: Yes ☑ No ☐
Cooling Agent Present: Yes ☑ No ☐ Type: ICE
Temperature Upon Receipt (°C): 8.3
LAB LIMS #: CA40254-Aug 23

REPORT INFORMATION	INVOICE INFORMATION
Company: Thurber Engineering	☑ (same as Report Information)
Contact: Rachel Bourassa	Company:
Address: 2010 Winston Park Dr	Contact:
Oakville ON L6H 5R7	Address:
Phone: (416)523-1015	
Fax:	Phone:
Email: rbourassa@thurber.ca	Email:

Quotation #: P.O. #:
Project #: 29771 Site Location/ID: Little Pic River

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days) TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 6pm or on weekends: TAT begins next business day

RUSH TAT (Additional Charges May Apply): ☐1 Day ☐2 Days ☐3 Days ☐4 Days

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date:

*NOTE: DRINKING (POTABLE) WATER SAMPLES FOR HUMAN CONSUMPTION MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

REGULATIONS

☐ O.Reg 153/04 ☐ O.Reg 406/19
☐ Table 1 ☐ Res/Park Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium/Fine
☐ Table _____
Soil Volume ☐ <350m3 ☐ >350m3

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA _____
☐ ODWS Not Reportable *See note

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX
1	HF6-02 SS15(55'-57')	July 19, 2023	-	1	Soil
2	HF2-02 SS1 (4"-2'4")	July 24, 2023	-	1	Soil
3	CUIV-01 SS1 (6"-2'6")	July 18, 2023	-	1	Soil
4	SW1-07 SS7A (20'-21'8")	Mar 30, 2023	-	1	Soil
5					
6					
7					
8					
9					
10					
11					
12					

	Field Filtered (Y/N)	Metals & Inorganics (incl CrVI, CN, Hg pH, (B(HWS), EC, SAR–soil) (Cl, Na–water)	Full Metals Suite (ICP metals plus B(HWS-soil only) Hg, CrVI	ICP Metals only Sb,As,Ba,Be,B,Cd,Cr,Co,Cu,Pb,Mo,Ni,	PAHs only	SVOCs all incl PAHs, ABNs, CPs	PCB ☐ Total ☐ Aroclor	F1-F4 + BTEX	F1-F4 only no BTEX	VOCs all incl BTEX	BTEX only	Pesticides Organochlorine or specify other	Other (please specify): Corrosivity				Appendix 2: 406/19 Leachate Screening Levels Table :	Sewer Use: Specify pkg:	Water Characterization Pkg General ☐ Extended ☐	TCLP: Specify TCLP tests ☐M&I ☐VOC ☐PCB ☐B(a)P ☐ABN ☐Ignit.
1													✓						
2													✓						
3													✓						
4													✓						

COMMENTS:

Observations/Comments/Special Instructions
Corrosivity Includes PH, Sulphates, Chlorides, resistivity and electrical Conductivity

Sampled By (NAME): Signature: Date: _____/_____/_____ (mm/dd/yy)
Relinquished by (NAME): Rachel Bourassa Signature: Rachel Bourassa Date: 08/24/2023 (mm/dd/yy)

Pink Copy - Client
Yellow & White Copy - SGS

Revision #: 1.4
Date of Issue: 22 May. 2020

Note: Submission of samples to SGS is acknowledgement that you have been provided direction on sample collection/handling and transportation of samples. {2} Submission of samples to SGS is considered authorization for completion of work. Signatures may appear on this form or be retained on file in the contract, or in an alternative format (e.g. shipping documents). {3} Results may be sent by email to an unlimited number of addresses for no additional cost. Fax is available upon request. This document is issued by the Company under its General Conditions of Service accessible at http://www.sgs.com/terms_and_conditions.htm. (Printed copies are available upon request.) Attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein.

THURBER ENGINEERING LTD.

APPENDIX F

Site Photographs

THURBER ENGINEERING LTD.

PHOTOS

Photo 1: West end of proposed highway alignment looking southeast towards HF1, Photo Taken May 11, 2023

Photo 2: HF1 Section, looking south at existing highway embankment, Photo Taken May 11, 2023

PHOTOS

Photo 3: Rock outcropping in DC1 Section looking east at Station 17+725, Photo taken May 11, 2023

Photo 4: Rock Cliff leading from DC1 to HF2 Section. Photo of centerline looking southwest, Photo taken May 11, 2023

PHOTOS

Photo 5: HF2 Section. Photo of centerline looking southwest, Photo taken May 11, 2023

Photo 6: Near DC2 Section looking northwest towards HF2, Photo taken September 29, 2023

PHOTOS

Photo 7: DC2 Section. Photo of existing highway alignment looking southwest, Photo taken November 10, 2023

Photo 8: Looking northwest at Swamp area SW1, Photo taken September 29, 2023

Photo 9: Approaching DC3 Rock slope in the Hydro Corridor looking northwest down alignment centerline, Photo taken May 11, 2023

Photo 10: Approaching DC4 Rock slope from the north, looking southwest towards alignment, Photo taken May 11, 2023

Photo 11: Approaching CULV-01 from the north. Looking south towards alignment, Photo taken September 29, 2023

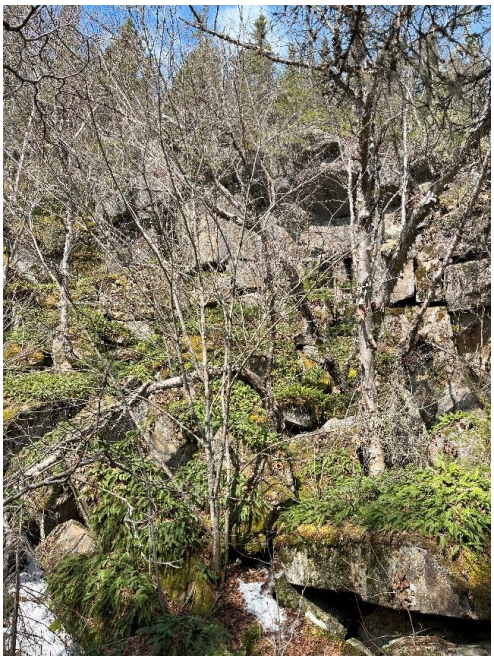


Photo 12: HF5 Section looking west at cliff boundary of the section along alignment,

Photo taken May 11, 2023

Photo 13: DC5 Section looking southeast along alignment, Photo taken May 11, 2023

Photo 14: DC6 Section looking east along alignment, Photo taken May 11, 2023

Photo 15: Looking at DC7 from the east side along alignment, Photo taken May 11, 2023

Photo 16: Looking at HF6 from the west side along alignment, Photo taken May 11, 2023

Photo 17: Image of DC8, taken from the south side along existing highway, looking east towards Little Pic River. Photo taken November 12, 2020

Photo 18: Looking north at DC10 from the south side of the existing highway, Photo taken November 12, 2020

THURBER ENGINEERING LTD.

APPENDIX G

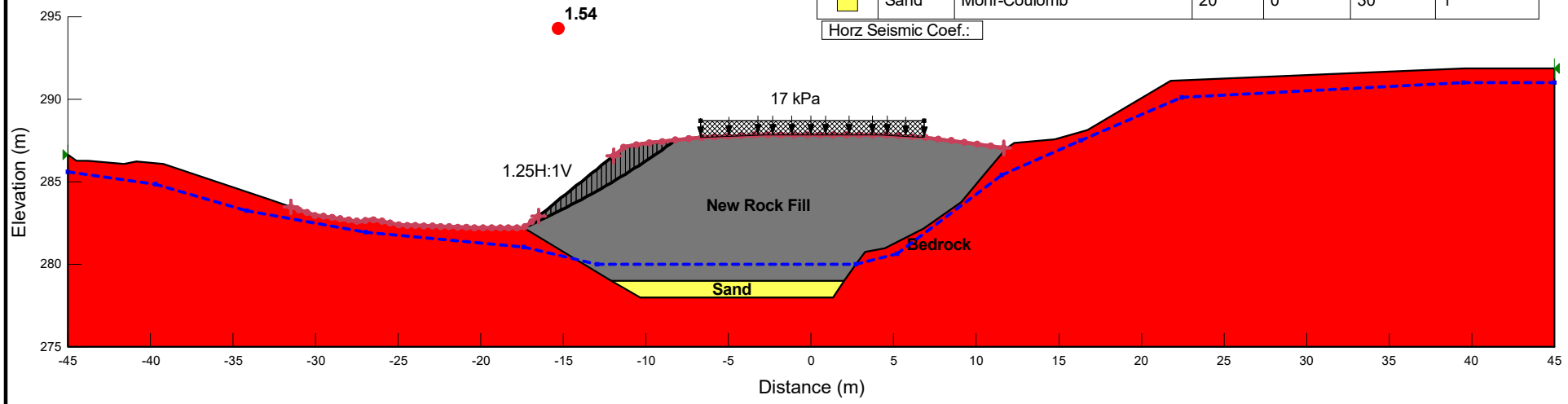
Slope Stability Analysis Figures

FIGURE G1

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	New Rock Fill	Mohr-Coulomb	19	0	42	1
	Sand	Mohr-Coulomb	20	0	30	1

Horz Seismic Coef.:



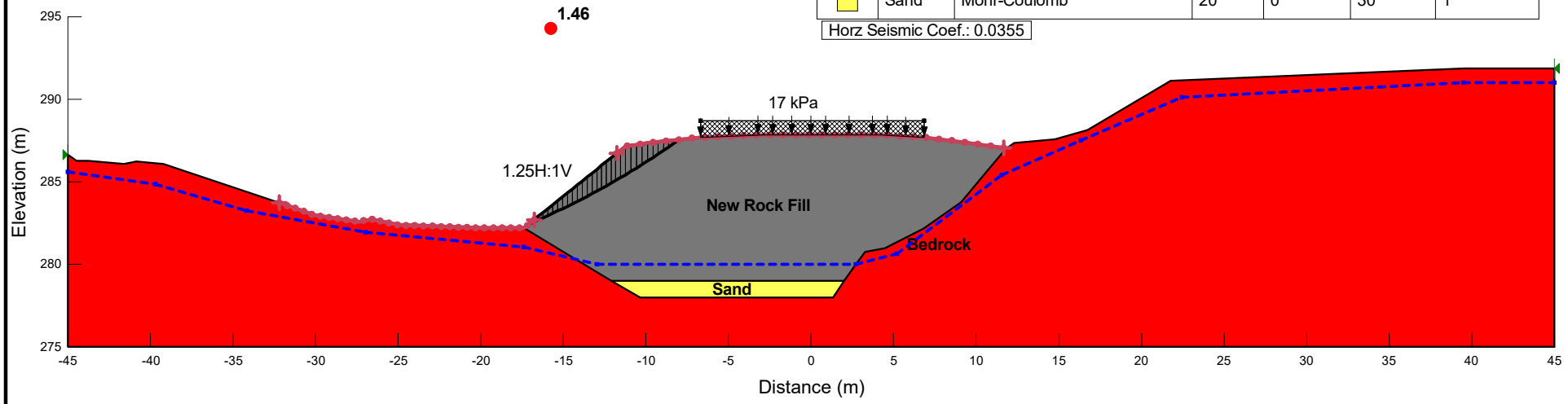
Highway 17, Little Pic River Bridge Westerly for 4.5 km
HF02 - Station No. 17+980
10/18/2023

THURBER

FIGURE G2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Piezometric Surface
	Bedrock	Bedrock (Impenetrable)				1
	New Rock Fill	Mohr-Coulomb	19	0	42	1
	Sand	Mohr-Coulomb	20	0	30	1

Horz Seismic Coef.: 0.0355



Highway 17, Little Pic River Bridge Westerly for 4.5 km

HF02 - Station No. 17+980

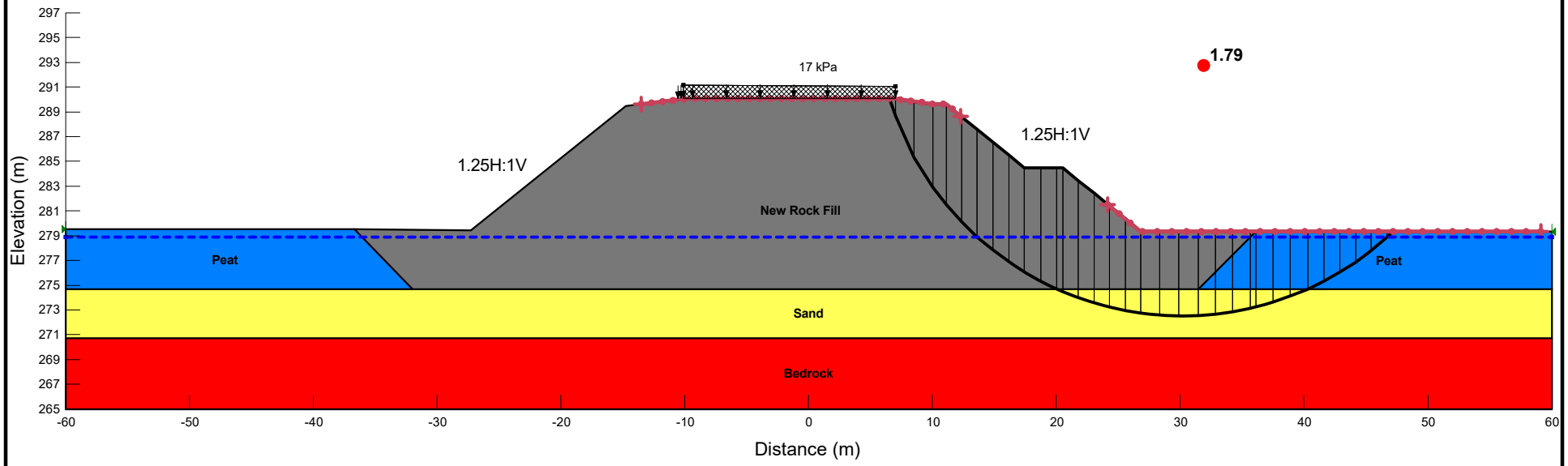
10/18/2023

FIGURE G3

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Sand	Mohr-Coulomb	20	0	30

Horz Seismic Coef.:



Highway 17, Little Pic River Bridge Westerly for 4.5 km

SW1 - Station No. 19+400

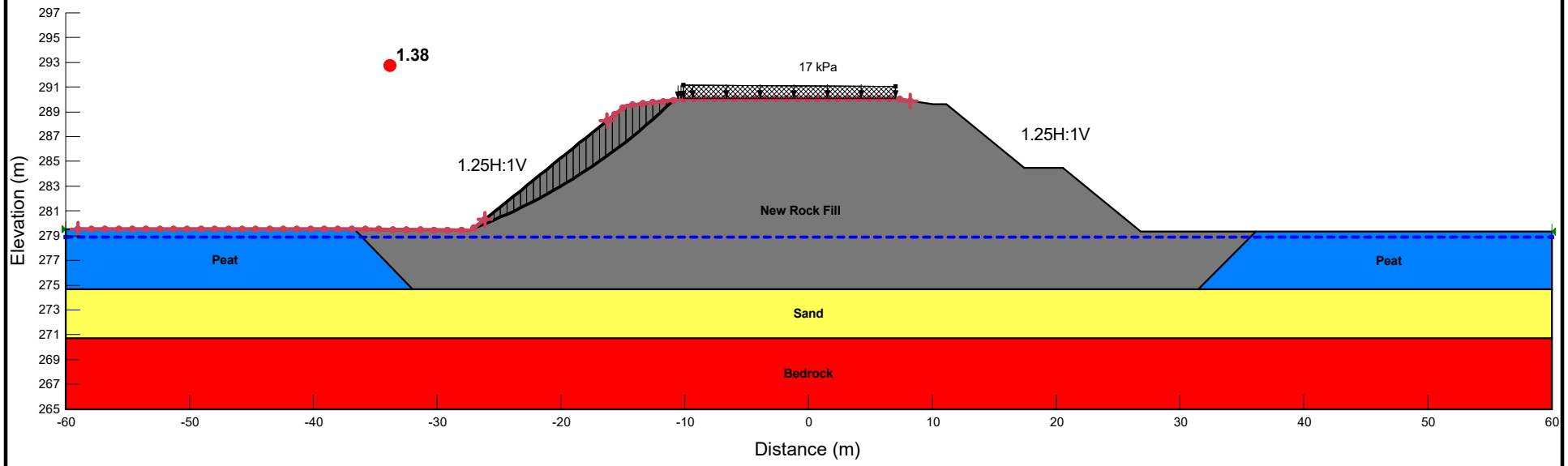
10/18/2023

FIGURE G4

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Sand	Mohr-Coulomb	20	0	30

Horz Seismic Coef.:



Highway 17, Little Pic River Bridge Westerly for 4.5 km

SW1 - Station No. 19+400

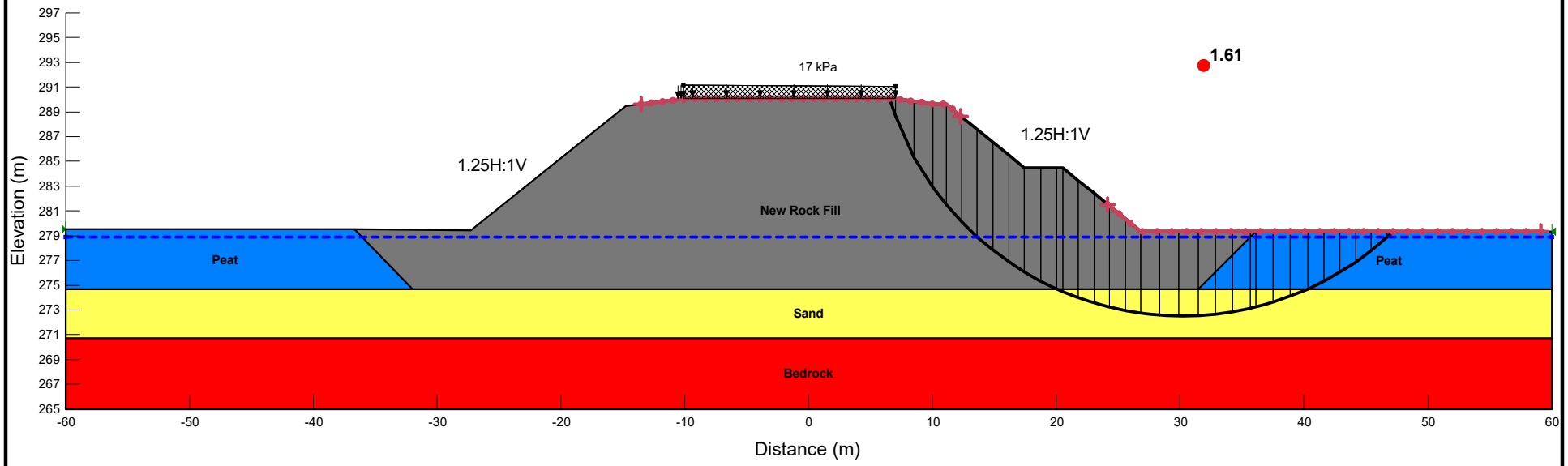
10/18/2023

FIGURE G5

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Sand	Mohr-Coulomb	20	0	30

Horz Seismic Coef.: 0.0355



Highway 17, Little Pic River Bridge Westerly for 4.5 km

SW1 - Station No. 19+400

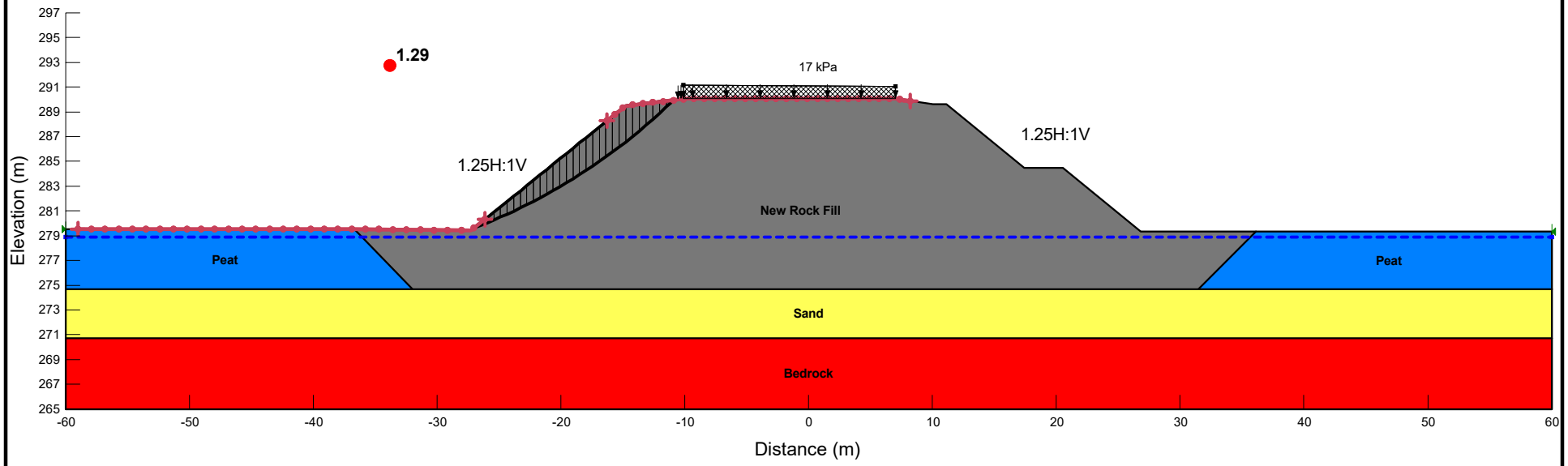
10/18/2023

FIGURE G6

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Sand	Mohr-Coulomb	20	0	30

Horz Seismic Coef.: 0.0355



Highway 17, Little Pic River Bridge Westerly for 4.5 km

SW1 - Station No. 19+400

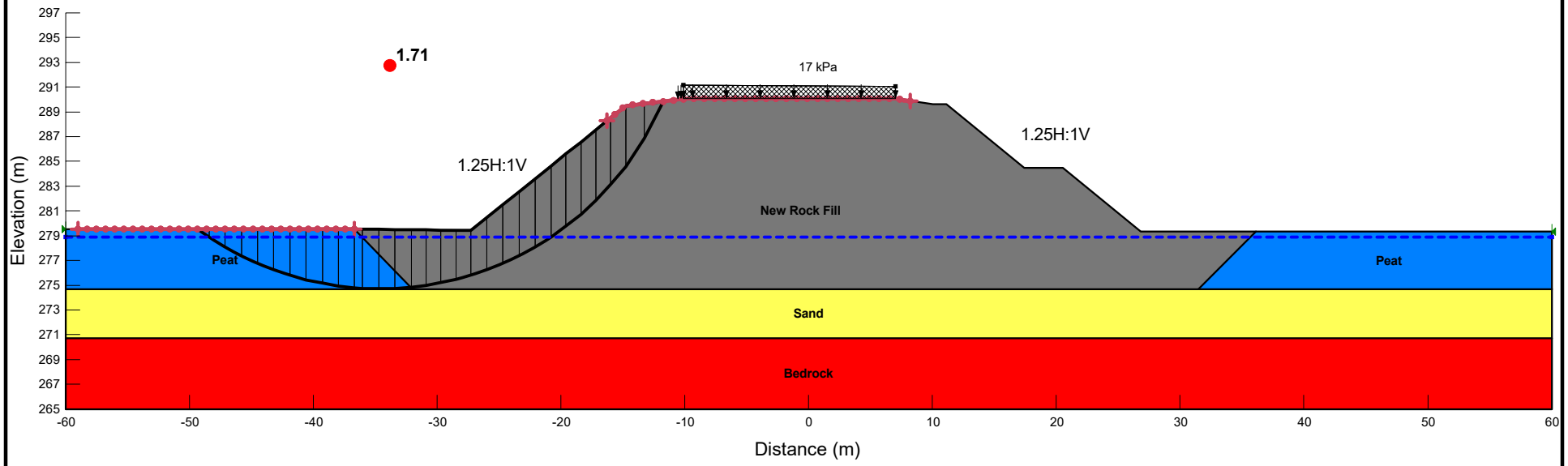
10/18/2023

FIGURE G7

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Sand	Mohr-Coulomb	20	0	30

Horz Seismic Coef.:



Highway 17, Little Pic River Bridge Westerly for 4.5 km

SW1 - Station No. 19+400

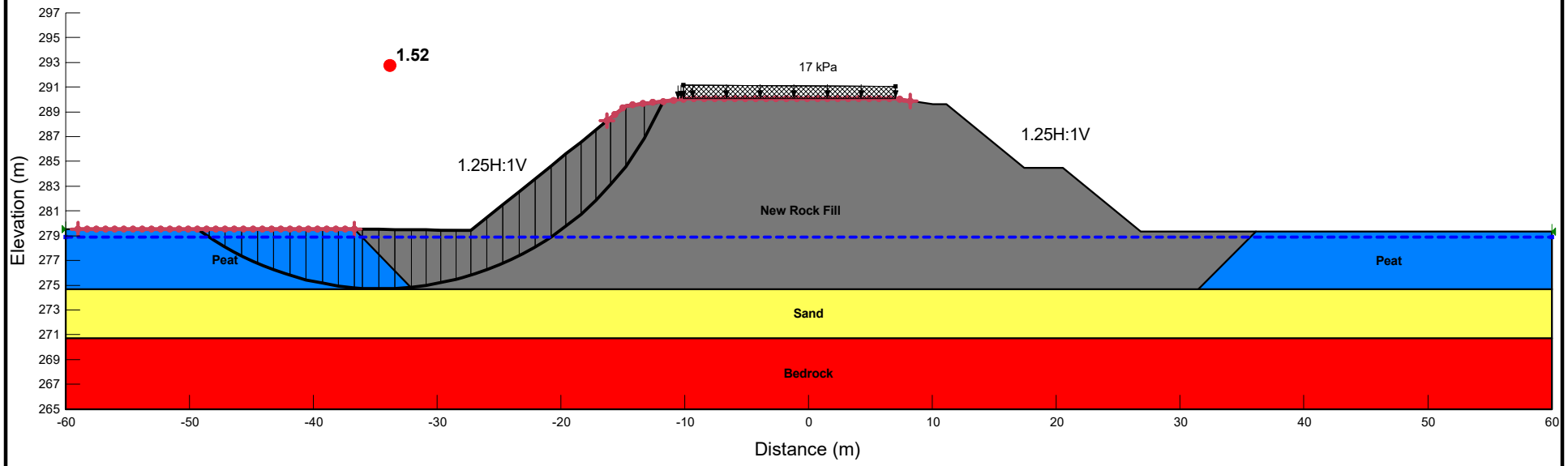
10/18/2023

FIGURE G8

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Sand	Mohr-Coulomb	20	0	30

Horz Seismic Coef.: 0.0355



Highway 17, Little Pic River Bridge Westerly for 4.5 km

SW1 - Station No. 19+400

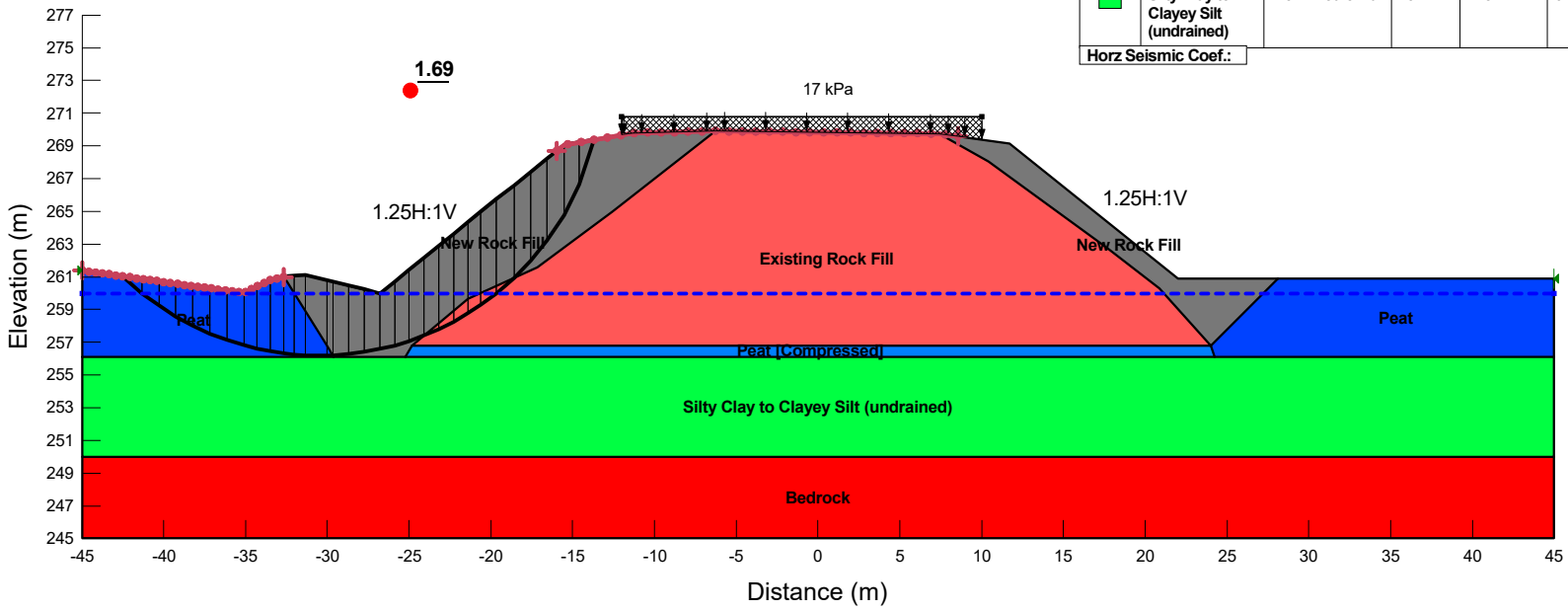
10/18/2023

FIGURE G9

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	Existing Rock Fill	Mohr-Coulomb	19	0	42
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Peat [Compressed]	Mohr-Coulomb	13	0	20
	Silty Clay to Clayey Silt (undrained)	Mohr-Coulomb	19	125	0

Horz Seismic Coef.:



Highway 17, Little Pic River Bridge Westerly for 4.5 km

HF06 - Station No. 20+820 to 20+840

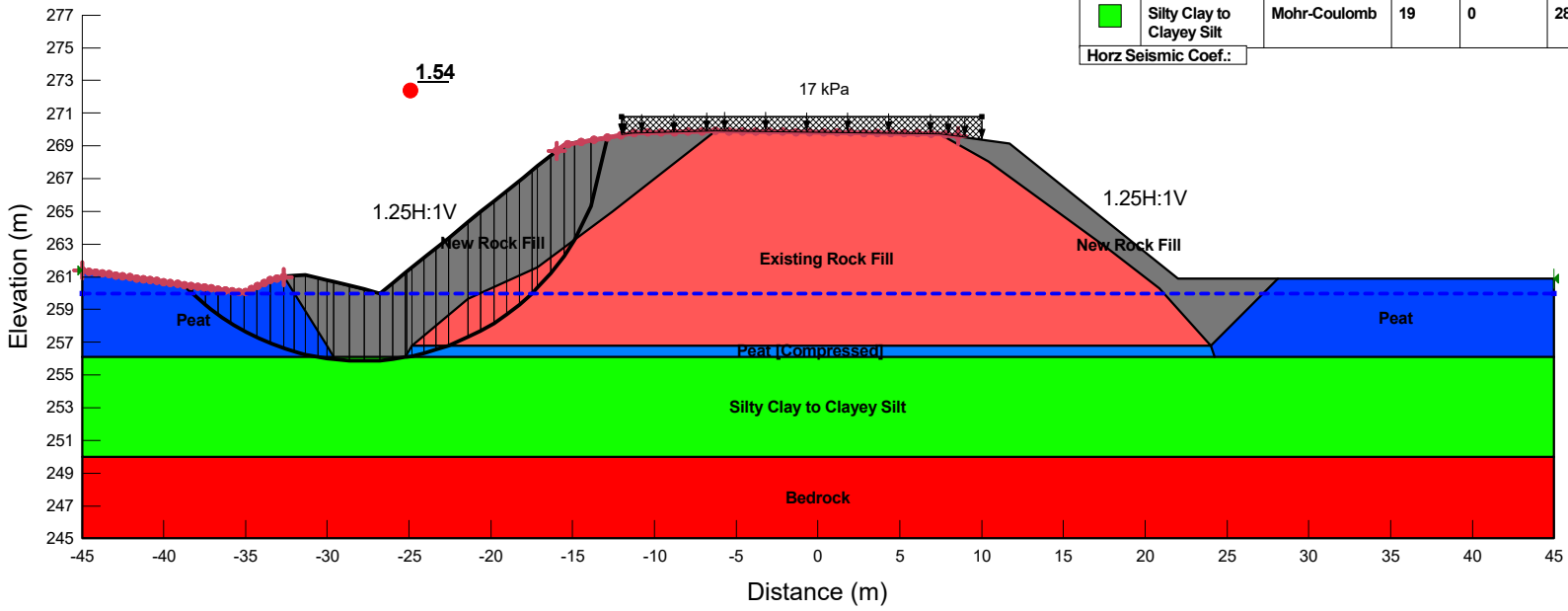
10/18/2023

FIGURE G10

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	Existing Rock Fill	Mohr-Coulomb	19	0	42
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Peat [Compressed]	Mohr-Coulomb	13	0	20
	Silty Clay to Clayey Silt	Mohr-Coulomb	19	0	28

Horz Seismic Coef.:



Highway 17, Little Pic River Bridge Westerly for 4.5 km

HF06 - Station No. 20+820 to 20+840

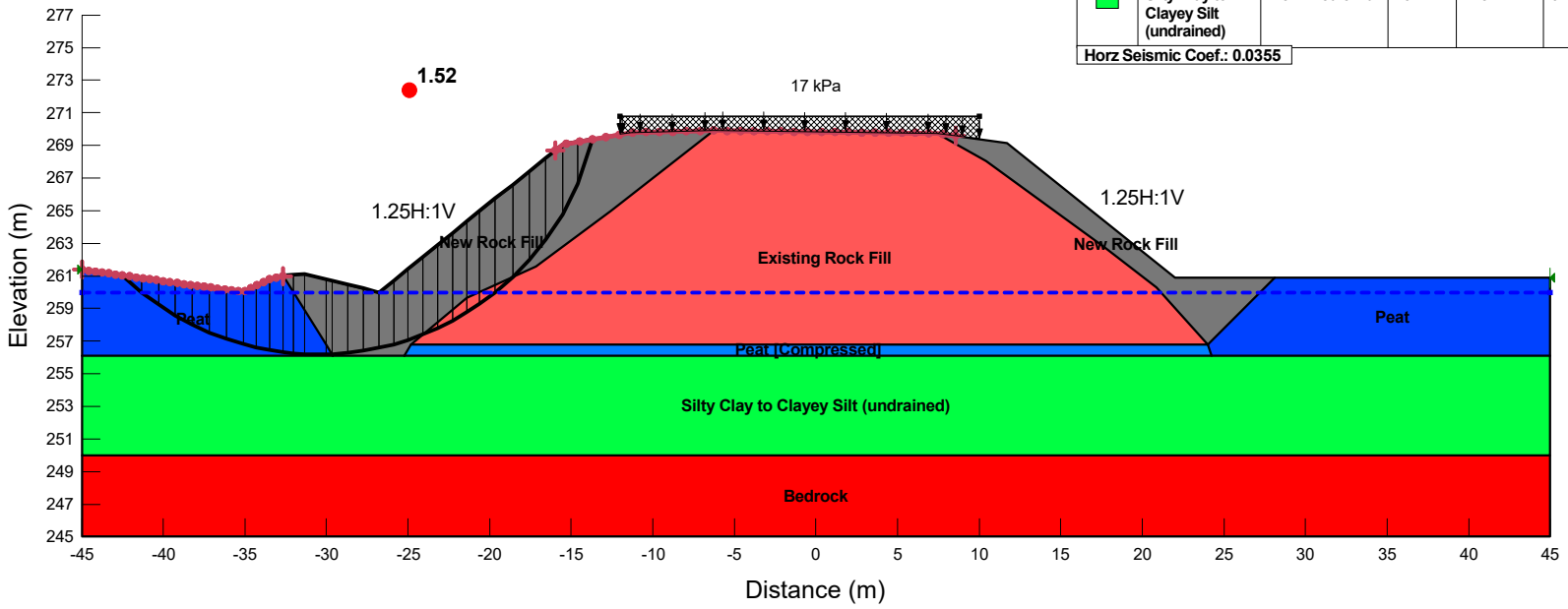
10/18/2023

THURBER

FIGURE G11

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Bedrock	Bedrock (Impenetrable)			
	Existing Rock Fill	Mohr-Coulomb	19	0	42
	New Rock Fill	Mohr-Coulomb	19	0	42
	Peat	Mohr-Coulomb	12	0	20
	Peat [Compressed]	Mohr-Coulomb	13	0	20
	Silty Clay to Clayey Silt (undrained)	Mohr-Coulomb	19	125	0

Horz Seismic Coef.: 0.0355



Highway 17, Little Pic River Bridge Westerly for 4.5 km

HF06 - Station No. 20+820 to 20+840

10/18/2023