THURBER ENGINEERING LTD.

PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
COUNTY ROAD 6 INTERCHANGE
STA. 23+603, HORTON TOWNSHIP
COUNTY ROAD 6 UNDERPASS - SITE NO. 29X-0408/B0
DEIL'S CREEK CULVERTS - SITE NOS. 29X-0242/C1-C3
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009

Geocres No.: 31F-230

Report to:

Ministry of Transportation Ontario

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Geocres No.: 31F-230

PART 1. FACTUAL INFORMATION

1 INTRODUCTION

Thurber Engineering Ltd. (Thurber) has been engaged by the Ministry of Transportation Ontario (MTO) to carry out Foundation Investigations to support the design of the Highway 17 Twinning Project which extends from Scheel Drive westerly to 3 km west of Bruce Street in the Renfrew area. Thurber carried out the investigation under MTO Assignment No. 4018-E-0009.

The existing Highway 17 alignment at this site will become the future Highway 17 eastbound lanes and new westbound lanes will be constructed to the north of the existing alignment. This proposed interchange includes four structures: the Highway 17 County Road 6 Underpass (Site No. 29X-0408/B0), the replacement of the existing culvert (Site No. 29X-0425/C1) under the proposed eastbound lanes of Highway 17 at Sta. 23+642, a new culvert under the proposed westbound lanes (Site No. 29X-0242/C3) around the same station and a new culvert under County Road 6 at Sta. 9+927 (Site No. 29X-0425/C2). The three culverts will convey Deil’s Creek under Highway 17 and Country Road 6.

Previous foundation investigation information from boreholes completed in 2004 for the proposed underpass was available under Geocres 31F-137 and information from boreholes completed in 2018 for the rehabilitation of the existing Deil’s Creek Culvert (Site No. 29-242/C1), 30 m east of the proposed underpass, was available under Geocres 31F-202.

This section of the report presents the factual findings obtained from historical foundation investigations available from the online Geocres Library and from the foundation investigation completed as part of the current study.

The purpose of this investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work.

2 SITE DESCRIPTION

2.1 General

The site is located on Highway 17 at the existing County Road 6 Intersection. For project purposes, Highway 17 is herein described as oriented east-west and Country Road 6, north-south. Within the project limits County Road 6 is also known as Gillan Road to the south and Lochwinnoch Road to the north of Highway 17. For clarity, County Road 6 will be used to reference the cross street.

The existing Highway 17 County Road 6 Intersection is an at-grade crossing. In the vicinity of the site, Highway 17 is an undivided highway with left and right turning lanes at County Road 6, gravel shoulders and a posted speed limit of 90 km/hr. The AADT for the section of Highway 17 near the site was reported to be 13,900 in 2016.

Near the intersection, County Road 6 is a two-lane roadway with gravel shoulders and a rural cross-section. An elevated and paved bull-nose is present at the southeast quadrant of the intersection, directing traffic flow through the eastbound on-ramp to Highway 17.

The Highway 17 road surface elevation is approximately 138.1 m at the intersection; the elevation decreases from east to west. The existing road surface of County Road 6 decreases in elevation from south to north.

Deil's Creek crosses existing Highway 17 approximately 30 m east of the intersection via a rigid frame open footing (RFO) culvert rehabilitated in 2004 (Site No. 29-242/C1). The existing RFO has a span of 3.7 m, a rise of 1.5 m and a length of 57.8 m. Flow through the culvert is from south to north. The streambed elevation is approximately 136.0 m. The asphalt surface of the highway is at approximate Elevation 138.6 m and the cover over the culvert from shoulder to the top of the culvert is approximately 0.8 m.

Twin corrugated steel pipe (CSP) culverts facilitate the flow of Deil's Creek under County Road 6 approximately 25 m north of the intersection (Site No. 29-242/C2). The twin CSP pipes have a diameter of 2.4 m and are 25.1 m long. The flow in the creek is from the south to the north under Highway 17 and east to west under County Road 6 (almost 90° bend north of Highway 17). The creek is approximately 4.5 m wide at the south side of Highway 17 and 2.0 m wide west of County Road 6. There was approximately 0.3 m of water in the creek on November 6, 2019.

The existing highway embankment side slopes near the existing Highway 17 Deil's Creek Culvert did not show any visible signs of distress at the time of the investigation. The embankment sides are sloped at approximately 2H:1V to 2.5H:1V.

Bedrock outcrops are visible on both sides of Highway 17 approximately 80 m west of the intersection and on both sides of County Road 6 approximately 60 m north of the intersection.

Photographs showing the existing conditions in the area of the site at the time of the field investigation are included in Appendix D for reference.

2.2 Site Geology

Based on published geological information in *The Physiography of Southern Ontario* by Chapman and Putnam (1984), the site lies within the physiographic region known as the Ottawa Valley Clay Plains. The Ottawa Valley Clay Plains are characterized primarily by clay plains deposited by the Champlain Sea (Leda Clay) interrupted by ridges of rock or sand.

Ontario Geological Survey Map P.3784 for Precambrian Geology for the Horton Area suggests the bedrock is comprised of dolomitic and calcitic carbonate metasedimentary bedrock including dolomite and calcite marble.

3 SITE INVESTIGATION AND FIELD TESTING

The current site investigation and field-testing program was carried out in multiple phases; August 26, 2019 to September 6, 2019, May 4, 2020 to May 6, 2020 and April 28, 2021 and April 29, 2021. The current investigation consisted of advancing 33 boreholes, both on-road and off-road. Prior to commencement of drilling, utility clearances were obtained in the vicinity of the borehole locations.

The locations and elevations of the boreholes were surveyed by Thurber with a Trimble Catalyst DA1 antenna with centimeter accuracy. The northing, easting and elevation details of the boreholes are shown on the Borehole Location and Soil Strata Drawing No. 1 in Appendix A, the individual Record of Borehole sheets in Appendix B, and in Table 3-1, Table 3-2 and Table 3-3 below. The site is located within MTM Zone 9.

Table 3-1: Borehole Summary – County Road 6 Underpass

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
19-01	South Abutment	5036548.6 (45.468799)	295187.7 (-76.622930)	138.3	12.0
19-02	South Abutment	5036545.6 (45.468771)	295182.7 (-76.622994)	138.2	9.1
19-03	Central Pier	5036592.9 (45.469198)	295200 (-76.622773)	137.7	5.1
19-04	Central Pier	5036596.5 (45.469230)	295203 (-76.622735)	137.5	5.1

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
19-05	Central Pier	5036572.8 (45.469017)	295216.3 (-76.622565)	138.1	7.6
19-06	Central Pier	5036577.9 (45.469063)	295218.7 (-76.622534)	137.9	6.3
19-07	North Abutment	5036620.1 (45.469442)	295231.3 (-76.622374)	136.6	6.4
19-08	North Abutment	5036623.5 (45.469473)	295235.0 (-76.622326)	136.7	3.1
19-09	North Abutment	5036617.0 (45.469415)	295241.4 (-76.622244)	137.1	6.0
19-10	North Abutment	5036598.3 (45.469247)	295247.8 (-76.622162)	137.4	5.0
19-12	North Abutment	5036627.7 (45.469511)	295249.2 (-76.622145)	137.0	6.8
19-13	South Approach	5036482.5 (45.468203)	295100.7 (-76.624042)	139.4	9.8
19-14	South Approach	5036513.2 (45.468479)	295132.3 (-76.623637)	139.0	13.0
19-15	South Approach	5036546.8 (45.468782)	295162.9 (-76.623246)	137.8	10.2
19-17	North Approach	5036657.4 (45.469779)	295279.2 (-76.621762)	136.1	5.4
19-19	North Approach	5036725.0 (45.470388)	295350.9 (-76.620846)	131.9	4.4
19-20	North Approach	5036754.1 (45.470650)	295382.9 (-76.620438)	130.9	6.1
19-21	North Approach	5036778.9 (45.470874)	295416.7 (-76.620005)	130.3	7.7
19-22	North Approach	5036687.4 (45.470050)	295320.2 (-76.621237)	133.9	9.1

Table 3-2: Borehole Summary – High Fill Ramps

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
19-23	E-N/S Ramp	5036648.4 (45.469699)	295359.0 (-76.620741)	132.7	5.7

19-24	E-N/S Ramp	5036611.7 (45.469369)	295387.5 (-76.620376)	132.3	2.4
19-25	E-N/S Ramp	5036567.0 (45.468967)	295390.1 (-76.620342)	134.7	0.7
19-26	S-W Ramp	5036592.5 (45.469196)	295370.7 (-76.62059)	134.0	0.9
19-27	S-W Ramp	5036633.4 (45.469564)	295353.3 (-76.620814)	133.5	2.7
19-28	S-W Ramp	5036644.6 (45.469664)	295299.0 (-76.621509)	136.0	4.7
19-30	N-E Ramp	5036535.2 (45.468677)	295125.3 (-76.623727)	137.7	9.6
19-31	N-E Ramp	5036545.0 (45.468764)	295043.8 (-76.624770)	140.9	6.7

Table 3-3: Borehole Summary – Deil's Creek Culverts

Borehole No.	Drilled Location	Northing (Latitude)	Easting (Longitude)	Ground Surface Elevation (m)	Termination Depth (m)
CV-10	Deil's Creek Culvert (C1)	5036540.7 (45.468728)	295206.0 (-76.622695)	138.6	6.6
CV-11	Deil's Creek Culvert (C3)	5036586.3 (45.469139)	295252.0 (-76.622108)	137.3	5.3
CV-12	Deil's Creek Culvert (C3)	5036571.6 (45.469006)	295242.7 (-76.622227)	136.9	6.4
CV-13	Deil's Creek Culvert (C2)	5036620.1 (45.469443)	295272.0 (-76.621853)	137.7	4.1
CV-14	Deil's Creek Culvert (C2)	5036646.0 (45.469676)	295248.6 (-76.622153)	137.8	4.8
CV-15	Deil's Creek Culvert (C2)	5036629.5 (45.469527)	295262.3 (-76.621977)	136.8	5.1

Boreholes 19-01 through 19-06, 19-09, 19-12 though 19-15, 19-17, 19-19 through 19-22, CV-10 and CV-15 were advanced with a CME 55 truck-mount drill rig equipped with hollow stem augers, NW casing and HW casing. Boreholes 19-07, 19-08, 19-10, 19-23 through 19-28, 19-30, 19-31 and CV-11 through CV-14 were advanced with a CME 45 track-mount drill rig equipped with hollow stem augers, NW casing, NW casing and NQ coring.

Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT).

Piezometers, 19 mm in diameter, were installed in Boreholes 19-01, CV-10 and CV-15. A piezometer, 25 mm in diameter, was installed in Borehole 19-23. Monitoring wells, 38 mm to 50 mm in diameter, were installed in Boreholes 19-06, 19-10, 19-30, CV-11. The installation details are illustrated on the respective Record of Borehole sheets provided in Appendix B. The piezometer in Borehole 19-23 was decommissioned on April 30, 2021. The remaining piezometers and monitoring wells will be decommissioned by Thurber, as outlined in the Hydrogeological Investigation and Design Report.

The boreholes were backfilled in accordance with MOE requirements (O.Reg 903, as amended).

The drilling and sampling operations were supervised on a full-time basis by members of Thurber's geotechnical staff. The drilling supervisors logged the boreholes and processed the recovered soil samples for transport to Thurber's Ottawa geotechnical laboratory for further examination and testing.

4 LABORATORY TESTING

Laboratory testing was selected in accordance with the current MTO Guideline for Foundation Engineering Services, Section 5. Geotechnical laboratory testing consisted of natural moisture content determination and visual identification of all retained soil samples. At least 25% of the recovered soil samples were subjected to testing for grain size distribution analysis and, where appropriate, Atterberg Limits in accordance with MTO and ASTM standards. Rock cores were logged and total core recovery (TCR), solid core recovery (SCR) and rock quality designation (RQD) were determined in the field. Point load and unconfined compression (UCS) testing was carried out on selected samples to give an indication of the bedrock strength. Chemical analysis for determination of pH, conductivity, resistivity, sulphide, sulphate and chloride was carried out on five soil samples.

The results of the geotechnical tests are summarized on the Record of Borehole sheets included in Appendix B and all laboratory results are presented on the figures included in Appendix C.

5 GENERAL DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and the Borehole Location and Soil Strata Drawing included in Appendix A. A general description of the stratigraphy based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Borehole Records takes precedence over the Soil Strata Drawing and the general description. It must be recognized that the soil, bedrock and groundwater conditions may vary between and beyond borehole locations. Soil classification is in accordance with ASTM D2487. Cohesive soils are described per current MTO protocols.

The boreholes from Geocres 31F-137 and Geocres 31F-202 have been incorporated into the following sections. The historic Borehole Location and Soil Strata Drawings and Borehole Logs can be found in Appendix A and B, respectively.

For simplicity, this site has been separated into two areas:

- Area A – north of existing Highway 17
    - Shallow bedrock (generally less than 3 m below existing ground surface).
    - In general, the boreholes encountered fill directly over marble bedrock, till over marble bedrock or some combination of fill, silty sand/sand, clayey silt and till over marble bedrock.
    - Asphalt was encountered in the on-road boreholes; topsoil was encountered in some off-road boreholes.
- Area B – south of (and including) existing Highway 17
    - Deeper bedrock (generally 3 m or more below existing ground surface).
    - In general, the boreholes encountered fill, silty sand/sand, clayey silt and till over marble bedrock.
    - Asphalt was encountered in the on-road boreholes; topsoil was encountered in some off-road boreholes.

In plan, Area B consists of all holes southwest of the proposed median as well as 19-5 and 17-1 in the median and 19-20 and 19-21 at the northeast limit. Area A covers all the boreholes in the central portion of the site.

5.1 Area A – North of Highway 17 (Shallow Bedrock)

Area A generally extends about 200 m north of the northern limit of the existing intersection and includes Boreholes 19-03, 19-04, 19-06, 19-07, 19-08, 19-09, 19-10, 19-12, 19-17, 19-19, 19-22, 19-23, 19-24, 19-25, 19-26, 19-27, 19-28, CV-11, CV-12, CV-13, CV-14, CV-15, CR6-2 and CR6-3.

5.1.1 Asphalt

Asphalt ranging in thickness from 50 mm to 125 mm was encountered in Boreholes 19-09, 19-12, 19-17, 19-19 and 19-22. All of these boreholes are located on County Road 6 north of Highway 17.

5.1.2 Sand with Silt and Gravel to Silty Sand with Gravel to Gravel with Silt and Sand (Fill)

A fill layer consisting of sand with silt and gravel to silty sand with gravel to gravel with silt and sand was encountered below the asphalt in Boreholes 19-09, 19-12, 19-17, 19-19 and 19-22, and from the ground surface in Boreholes 19-03, 19-04, 19-06, CV-15, CR6-2 and CR6-3. The thickness of the layer ranges from 0.8 m to 2.3 m with base depths ranging from 0.9 m to 2.3 m (base elevations ranging from 136.3 m to 131.0 m).

The SPT N-values ranged from 13 to 100 blows per 76 mm; indicating a compact to very dense condition.

The moisture content of the samples tested ranged from 2% to 12%. The results of grain size analyses conducted on nine samples of the fill material are summarized below and are illustrated on Figures C1 and C2 in Appendix C.

Summary of Grain Size Distribution Testing - Fill

Soil Particle	Percentage (%)
Gravel	31 – 61
Sand	27 – 57
Silt & Clay	7 – 20

5.1.3 Topsoil / Rootmat

A layer of topsoil / rootmat was encountered at the ground surface in Boreholes 19-07, 19-23, 19-24, 19-25, 19-26, 19-27 and CV-13. The topsoil was observed to range in thickness from 130 mm to 460 mm in the boreholes. Recorded moisture contents ranged from 30% to 45%. One SPT-N value of 4 was recorded indicating a loose condition. One SPT-N value of 100 blows per 75 mm was recorded directly over bedrock and is therefore not indicative of the actual density.

It should be noted that the topsoil thickness may vary between boreholes and in other areas of the site. This limited data should not be used for estimating topsoil stripping quantities.

5.1.4 Silty Sand (SM) to Sand (SP), trace gravel

A deposit consisting of silty sand to sand was encountered below the topsoil in Borehole 19-07 and from the ground surface in Boreholes CV-11 and CV-12. This deposit was described as having trace gravel and trace to with organics. The thickness of this deposit ranged from 0.3 m to 1.5 m with base depths ranging from 0.6 m to 1.5 m (base elevations ranging from 136.3 m to 135.8 m).

The SPT-N values ranged from 1 to 6; indicating a very loose to loose condition.

The moisture content of the samples tested ranges from 8% to 36%. The results of grain size analyses conducted on one sample of the deposit are summarized below and are illustrated on Figure C3 in Appendix C.

Summary of Grain Size Distribution Testing – Silty Sand to Sand

Soil Particle	Percentage (%)
Gravel	6
Sand	90
Silt & Clay	4

5.1.5 Clayey Silt (CL) with Sand to Clayey Silt (CL-ML)

A deposit of non-cohesive clayey silt with sand was encountered below the topsoil in Borehole 19-23 and below the silty sand in Borehole CV-12. The thickness of this deposit ranged from 1.1 m to 1.7 m with base depths ranging from 1.2 m to 2.3 m (base elevations ranging from 134.6 m to 131.5 m).

The SPT-N values ranged from 2 to 48; indicating a very loose to dense condition. It is noted that the till underlying this deposit in Borehole 19-23 likely influenced the SPT-N value of 48.

The moisture content of the samples tested ranged from 20% to 33%. The results of two grain size analysis tests conducted on samples of this deposit are summarized below and are illustrated on Figure C4 in Appendix C.

Summary of Grain Size Distribution Testing – Clayey Silt

Soil Particle	Percentage (%)
Gravel	0
Sand	17 – 23
Silt	54 – 61
Clay	22 – 23

The results of Atterberg Limits testing carried out on two samples of this deposit are summarized below and are illustrated on Figure C7 in Appendix C. The laboratory results indicate that the tested samples could generally be classified as clayey silt of low plasticity (CL-ML to CL), however this deposit was generally considered to exhibit non-cohesive behaviour.

Summary of Atterberg Limit Testing – Clayey Silt

Parameter	Value
Liquid Limit	20 – 26
Plastic Limit	13 – 18
Plasticity Index	7 – 8

5.1.6 Silty Sand (SM) to Silty Sand (SM) with Gravel to Silty Gravel (GM) with Sand to Gravel (GW-GM) with Silt and Sand Till

A deposit of silty sand to silty sand with gravel to silty gravel with sand to gravel with silt and sand till was encountered from the surface in Boreholes 19-08, 19-10, 19-28 and CV-14, below the fill in Borehole 19-06, below the topsoil in Boreholes 19-24 to 19-27, below the silty sand to sand in in Boreholes 19-07 and CV-11, and below the clayey silt in Boreholes 19-23 and CV-12. The thickness of this deposit ranged from 0.1 m to 2.6 m with base depths ranging from 0.1 m to 2.8 m (base elevations ranging from 136.9 m to 129.9 m). Cobbles and boulders were encountered in this deposit.

The SPT-N values ranged from 2 to 100 blows per 150 mm penetration; indicating a very loose to very dense condition. It is noted that the SPT-N values obtained in this deposit directly over the bedrock were impacted by the bedrock.

The moisture content of the samples tested ranged from 2% to 35%. The results of eight grain size analysis tests conducted on samples of this deposit are summarized below and are illustrated on Figures C5 and C6 in Appendix C.

Summary of Grain Size Distribution Testing – Till

Soil Particle	Percentage (%)	
Gravel	10 - 61	
Sand	31 - 75	
Silt	27 - 33	8 - 27
Clay	5 - 8	

5.2 Area B – South of Highway 17 (Deeper Bedrock)

Area B generally extends south of the northern limit of Highway 17 (i.e. including the intersection) as well as the portion of County Road 6 located greater than 200 m north of Highway 17 and includes Boreholes 19-01, 19-02, 19-05, 19-13, 19-14, 19-15, 19-20, 19-21, 19-30, 19-31, CV-10, 17-1, 17-2 and CR6-1.

5.2.1 Asphalt

Asphalt ranging in thickness from 50 mm to 175 mm was encountered in Boreholes 19-01, 19-02, 19-20, 19-21 and CV-10. It is noted that a 225 mm concrete layer was noted below the asphalt in 19-21. Borehole CV-10 is located on the south shoulder of Highway 17. The remaining boreholes mentioned above are on County Road 6.

5.2.2 Topsoil / Rootmat

A layer of topsoil / rootmat was encountered at the ground surface in Boreholes 17-1, 19-30 and CR6-1. The topsoil / rootmat was observed to range in thickness from 50 mm to 125 mm in the boreholes. Recorded moisture contents ranged from 5% to 71%.

It should be noted that the topsoil thickness may vary between boreholes and in other areas of the site. This limited data should not be used for estimating topsoil stripping quantities.

5.2.3 Sand with Silt and Gravel to Silty Sand, some Gravel to Gravel with Silt and Sand to Clay with Sand to Clayey Silt (Fill)

A fill layer consisting of sand with silt and gravel to silty sand, some gravel to gravel with silt and sand was encountered below the asphalt in Boreholes 19-01, 19-02, 19-20, 19-21 and CV-10, and from the ground surface in Boreholes 19-05, 19-13, 19-14, and 19-15, and below the topsoil/rootmat in Borehole CR6-1. Occasional cobbles were observed in the fill. The thickness of the layer ranges from 0.6 m to 3.0 m with base depths ranging from 0.6 m to 3.0 m (base elevations ranging from 137.8 m to 128.8 m). The SPT N-values recorded in the non-cohesive fill ranged from 7 to 59 blows per 0.3 m of penetration, indicating a loose to very dense condition.

At the boreholes put down in 2018 near the existing Deil's Creek culvert that crosses Highway 17, a fill layer consisting of clay with sand to clayey silt was encountered at the ground surface at the inlet (Borehole 17-2) and beneath a 100 mm thick rootmat at the outlet (Borehole 17-1) at the time of that investigation. The thickness of the fill at the inlet and outlet was 0.6 m and 1.4 m (base elevations of from 136.1 m to 135.6 m), respectively. The SPT N-values recorded in the clayey fill ranged from 9 to 21 blows per 0.3 m of penetration, indicating a generally stiff to very stiff consistency.

The moisture content of the fill samples tested ranged from 2% to 39%. The results of grain size analyses conducted on eight samples of this fill material are summarized below and are illustrated on Figures C8 and C9 in Appendix C.

Summary of Grain Size Distribution Testing - Fill

Soil Particle	Percentage (%)	
Gravel	0 – 56	
Sand	26 – 67	
Silt	53	4 – 74
Clay	21	

The results of Atterberg Limits testing carried out on one sample of the cohesive part of the fill are summarized below and are illustrated on Figure C16 in Appendix C. The laboratory results indicate that the material is of low plasticity (CL).

Summary of Atterberg Limit Testing – Fill

Parameter	Value
Liquid Limit	33
Plastic Limit	18
Plasticity Index	15

5.2.4 Silty Sand (SM) to Silty Sand (SM) with Gravel to Sandy Silt (ML), trace to some gravel

A deposit consisting of silty sand to sandy silt was encountered from the ground surface in Borehole 19-31, below the topsoil in Borehole 19-30 and below the fill in Boreholes 19-01, 19-02, 19-05, 19-13, 19-14 and 19-15. This deposit was described as having trace to some gravel and trace clay. The thickness of this deposit ranged from 1.5 m to more than 6.7 m with base depths ranging from 2.3 m to 6.9 m (base elevations ranging from 135.4 m to 132.1 m). Borehole 19-31 was terminated in this deposit at a depth of 6.7 m (base elevation 134.2 m).

The SPT-N values ranged from 2 to 82; indicating a very loose to very dense condition.

The moisture content of the samples tested ranges from 12% to 24%. The results of grain size analyses conducted on ten samples of the deposit are summarized below and are illustrated on Figures C10 and C11 in Appendix C.

Summary of Grain Size Distribution Testing – Silty Sand to Sandy Silt

<table>
<tr><th>Soil Particle</th><th colspan="2">Percentage (%)</th></tr>
<tr><td>Gravel</td><td colspan="2">0 – 19</td></tr>
<tr><td>Sand</td><td colspan="2">39 – 86</td></tr>
<tr><td>Silt</td><td>32 – 50</td><td rowspan="2">8 – 61</td></tr>
<tr><td>Clay</td><td>4 – 11</td></tr>
</table>

The results of Atterberg Limits testing carried out on five samples from this deposit yielded five non-plastic results.

5.2.5 Clayey Silt (CL to CL-ML) to Clayey Silt (CL) with Sand to Sandy Silt (ML) with Clay to Sandy Clayey Silt (CL-ML), trace gravel

A deposit of non-cohesive clayey silt to sandy silt to sandy clayey silt was encountered below the fill in Boreholes 19-20, 19-21, CV-10, 17-1 and CR6-1, and below the silty sand in Boreholes 19-01, 19-13, 19-14, 19-15 and 19-30. The deposit was noted to have trace gravel and occasional organic inclusions (only in Borehole CR6-1). The thickness of this deposit ranged from 0.3 m to 4.6 m with base depths ranging from 2.2 m to more than 9.8 m (base elevations ranging from 136.3 m to 127.4 m).

The SPT-N values ranged from 2 to 42; indicating a very loose to dense condition. It is noted that the till underlying this deposit in Borehole 19-20 likely influenced the SPT-N value of 100 blows per 275 mm.

Summary of Grain Size Distribution Testing – Clayey Silt to Sandy Clayey Silt

Soil Particle	Percentage (%)
Gravel	0 – 7
Sand	3 – 44
Silt	43 – 67
Clay	15 – 30

The moisture content of the samples tested ranged from 11% to 36%. The results of twelve grain size analysis tests conducted on samples of this deposit are summarized above and are illustrated on Figures C12 and C13 in Appendix C. The results of Atterberg Limits testing carried out on ten samples of this deposit are summarized below and are illustrated on Figures C18 and C19 in Appendix C. The laboratory results indicate that the tested samples could generally be classified as silt to a clayey silt of low plasticity (ML to CL), however this deposit was generally considered to exhibit non-cohesive behaviour.

Summary of Atterberg Limit Testing – Clayey Silt

Parameter	Value
Liquid Limit	16 – 28
Plastic Limit	12 – 17
Plasticity Index	4 – 12

5.2.6 Sandy Silt (ML), trace gravel to Silty Sand (SM) with Gravel to Silty Gravel with Sand to Gravel, some Sand Till

A deposit of sandy silt to silty sand with gravel to silty gravel with sand to gravel till was encountered below the fill in Borehole 17-2, below the silty sand to sandy silt in Boreholes 19-02 and 19-05, and below the clayey silt in Boreholes 19-01, 19-14, 19-15, 19-20, 19-21, 19-30, CV-10 and 17-1. The thickness of this deposit ranged from 0.3 m to 5.3 m with base depths ranging from 3.0 m to 9.6 m (base elevations ranging from 135.5 m to 125.9 m). Frequent cobbles and boulders were encountered in this deposit. Coring was required to get though this layer at some locations.

The SPT-N values ranged from 3 to 100 blows per 50 mm penetration: indicating a very loose to very dense condition. It is noted that the refusal SPT-N values obtained in this deposit directly over the bedrock were impacted by the bedrock.

The moisture content of the samples tested ranged from 6% to 18%. The results of seven grain size analysis tests conducted on samples of this deposit are summarized below and are illustrated on Figures C14 and C15 in Appendix C.

Summary of Grain Size Distribution Testing – Till

<table>
<tr><th>Soil Particle</th><th colspan="2">Percentage (%)</th></tr>
<tr><td>Gravel</td><td colspan="2">3 – 46</td></tr>
<tr><td>Sand</td><td colspan="2">35 – 58</td></tr>
<tr><td>Silt</td><td>31 – 51</td><td rowspan="2">13 – 21</td></tr>
<tr><td>Clay</td><td>7 – 12</td></tr>
</table>

5.3 Bedrock

Bedrock (cored or inferred) was encountered in all boreholes except Boreholes 19-13 and 19-31. The bedrock encountered consisted of moderately weathered to fresh, fine to large grained, marble that is predominantly white and black in colour. Bedrock logs are provided in Appendix B. Photographs of the bedrock cores are provided in Appendix C. The following table summarizes the rock core quality:

Table 5-1: Summary of Bedrock Core Quality

Summary of Rock Core Quality Parameter	Range	Average
Total Core Recovery (TCR), %	38 – 100	96
Solid Core Recovery (SCR), %	0 – 100	68
Rock Quality Designation (RQD), %	0 – 100	45
Fracture Index (fractures per 0.3m)	0 – >10	5

Based on the RQD values, the bedrock is classified as very poor to excellent quality. The RQD values did not show a clear delineation between an upper portion of lower-quality and more sound bedrock below.

Unconfined compressive strength (UCS) testing was carried out on five samples of the bedrock in Boreholes 19-01, 19-03, 19-06 and 19-09. The UCS values ranged from 35 MPa to 81 MPa with an average of 57 MPa. Based on the unconfined compressive strength testing the bedrock is classified as medium strong to strong. Point loads tests were conducted on seven bedrock samples from Boreholes CR6-1, CR6-2 and CR6-3; yielding estimated UCS values ranging from 55 MPa to 152 MPa with an average of 110 MPa. These values should be used with caution. It is noted that within the rock cores a silt seam was present in 19-01, 19-05, 19-20 and CV-10. Fractured zones and vertical and sub-vertical fractures were present in most boreholes.

A summary of the bedrock surface information is provided in Table 5-2 below.

Table 5-2: Summary of Bedrock Depth/Elevation

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)	Comments
Area A – North of Highway 17[a]			
19-03	1.4	136.3	Cored Bedrock
19-04	1.3	136.2	Cored Bedrock
19-06	2.8	135.1	Cored Bedrock
19-07	2.4	134.2	Cored Bedrock
19-08	0.1	136.6	Cored Bedrock
19-09	1.5	135.6	Cored Bedrock

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)	Comments
19-10	2.0	135.4	Cored Bedrock
19-12	1.2	135.8	Cored Bedrock
19-17	1.3	134.8	Cored Bedrock
19-19	0.9	131.0	Cored Bedrock
19-22	2.2	131.7	Cored Bedrock
19-23	2.1	130.6	Cored Bedrock
19-24	2.4	129.9	Spoon / Auger Refusal
19-25	0.7	134.0	Spoon / Auger Refusal
19-26	0.9	133.1	Spoon / Auger Refusal
19-27	2.7	130.8	Auger Refusal
19-28	0.6	135.4	Cored Bedrock
CV-11	1.9	135.4	Cored Bedrock
CV-12	2.8	134.1	Cored Bedrock
CV-13	0.2	137.5	Cored Bedrock
CV-14	0.9	136.9	Cored Bedrock
CV-15	1.5	135.3	Cored Bedrock
CR6-2	1.6	136.2	Cored Bedrock
CR6-3	1.8	134.9	Cored Bedrock
Area B – South of Highway 17[b]			
17-1	5.2	132.0	Cored Bedrock
17-2	4.2	132.5	Cored Bedrock
19-01	8.1	130.2	Cored Bedrock
19-02	9.1	129.1	Spoon / Auger Refusal
19-05	4.3	133.8	Cored Bedrock
19-13	n/a	n/a	Not Cored
19-14	9.1	129.9	Cored Bedrock
19-15	6.9	130.9	Cored Bedrock
19-20	3.0	127.9	Cored Bedrock
19-21	4.4	125.9	Cored Bedrock
19-30	9.6	128.1	DCPT Refusal
19-31	n/a	n/a	Not Cored

Borehole No.	Depth to Bedrock Surface (mbgs)	Bedrock Surface Elevation (m)	Comments
CV-10	3.1	135.5	Cored Bedrock
CR6-1	5.3	132.2	Cored Bedrock

Notes: [a] refer to Section 5.1 for description of Area A
[b] refer to Section 5.2 for description of Area B

5.4 Groundwater

Groundwater levels recorded in the piezometer and monitoring wells are presented in Table 5-3.

Table 5-3: Summary of Groundwater Levels

Borehole No. [Diameter]	Elevation (m)		Screened Material	Groundwater Level		Date of Measurement
	Ground Surface[a]	Screen Bottom		Depth (m)	Elevation (m)	
19-01 [19mm]	138.3	130.5	Clayey SILT / Silty SAND TILL	1.9	136.4	September 26, 2019
				1.4	136.9	April 21, 2020
				1.4	136.9	June 3, 2020
				1.8	136.5	September 29, 2020
				1.5	136.8	December 15, 2021
19-06 [38mm]	137.9	131.6	Bedrock	1.9	136.0	September 26, 2019
				0.5	137.4	April 21, 2020
				1.7	136.2	September 29, 2020
19-10 [50mm]	137.4	132.4	Bedrock	1.7	135.7	June 3, 2020
				1.9	135.5	September 29, 2020
				1.9	135.5	September 23, 2021
				1.5	135.9	October 3, 2021
				1.8	135.6	January 20, 2022
19-23 [25mm]	132.7	130.5	Clayey SILT / Sand TILL	0.8[b]	131.9	April 30, 2021
19-30 [50mm]	137.7	130.8	Sandy Clayey SILT	0.6	137.1	September 29, 2020
				0.2	137.5	June 3, 2020
				0.7	137.0	September 23, 2021
				0.9	136.8	October 3, 2021
				0.8	136.9	January 20, 2022

Borehole No. [Diameter]	Elevation (m)		Screened Material	Groundwater Level		Date of Measurement
	Ground Surface[a]	Screen Bottom		Depth (m)	Elevation (m)	
CV-10 [19mm]	138.6	135.5	FILL / Sandy SILT / GRAVEL TILL	2.2	136.4	September 26, 2019
				1.8	136.8	April 21, 2020
				1.8	136.8	June 3, 2020
				2.2	136.4	September 29, 2020
				1.9	136.7	September 23, 2021
				1.9	136.7	November 4, 2021
CV-11 [50mm]	137.3	132.0	Bedrock	1.3	136.0	September 29, 2020
				0.9	136.4	June 3, 2020
				1.5	135.8	September 23, 2021
				1.2	136.1	October 3, 2021
				1.0	136.3	January 20, 2022
CV-15 [19mm]	136.8	131.7	Bedrock	2.2	134.6	September 26, 2019
				2.0	134.8	April 21, 2020
				2.1	134.7	September 29, 2020
				0.5	136.3	November 24, 2021
CR6-1 [19mm]	137.5	128.4	Bedrock	1.4	136.1	October 16, 2003
				1.2	136.3	October 22, 2004
				Piezometer destroyed		December 16, 2003
CR6-2 [19mm]	137.8	133.3	Bedrock	1.7	136.1	October 16, 2003
				1.6	136.2	October 22, 2004
				1.7	136.1	December 16, 2003
				1.7	136.1	February 4, 2004
				0.4	137.4	March 11, 2004
CR6-3 [19mm]	136.6	132.4	Bedrock	1.7	134.9	October 16, 2003
				1.6	135.0	October 22, 2004
				Piezometer destroyed		December 16, 2003

Notes:
[a] ground surface elevation at the time of borehole survey
[b] final reading prior to decommissioning

On November 6, 2019, the water level in Deil's creek was reported to be at elevation 136.4 m.

These observations are considered short term and it should be noted that the creek level and groundwater level at the time of construction may be different and seasonal fluctuations of the levels are to be expected. In particular, the levels may be at a higher elevation after periods of significant and/or prolonged precipitation.

5.5 Analytical Testing

Five samples were submitted to Paracel Laboratories in Ottawa, Ontario for analysis of pH, water soluble sulphate, sulphide and chloride concentrations, resistivity and conductivity. The analysis results are summarized in Table 5-4. Copies of the test results are provided in Appendix C.

Table 5-4: Results of Chemical Analysis

Borehole	Sample (Soil Type)	Depth (m)	Chloride (μg/g)	Sulphate (μg/g)	Sulphide (%)	pH (-)	Resistivity (Ohm-cm)
19-01	SS4 (Silty Sand)	2.3 – 2.9	291	65	0.11	7.34	1,430
19-05	SS4 (Silty Sand)	2.3 – 2.9	455	109	0.10	7.57	973
19-09	SS1 (Sand Fill)	0.0 – 0.7	569	26	0.05	7.96	842
CV-10	SS2 (Sand Fill)	0.8 – 1.4	87	38	0.03	7.81	1,720
CV-15	SS2 (Sand Fill)	0.8 – 1.4	60	6	<0.02	8.21	4,990

6 MISCELLANEOUS

Borehole locations were selected by Thurber relative to existing site features. The as-drilled locations and ground surface elevation of the boreholes were surveyed by Thurber following completion of the field program. The elevation survey was carried out with reference to geodetic elevation benchmarks provided by the MTO.

Marathon Underground of Greely, Ontario supplied and operated the drilling equipment and carried out the drilling, soil sampling, in-situ testing, piezometer/monitoring well installation and borehole decommissioning. The field investigation was supervised on a full-time basis by Sean O'Bryan, Jamil Pirani and Anderson de Oliveira of Thurber. Overall supervision of the investigation program was provided by Justin Gray, P.Eng.

Routine geotechnical laboratory testing was completed by Thurber's laboratory in Ottawa, Ontario. UCS testing was completed by Thurber's laboratory in Oakville, Ontario. Analytical testing was completed by Paracel Laboratories in Ottawa.

Overall project management and direction of the field program was provided by Fred Griffiths, P.Eng. Interpretation of the factual data and preparation of this report were carried out by Deanna Pizycki, P.Eng., Matt Kennedy, P.Eng., and Fred Griffiths, P.Eng. The report was reviewed by P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 17 TWINNING, RENFREW AREA
COUNTY ROAD 6 INTERCHANGE
STA. 23+603, HORTON TOWNSHIP
COUNTY ROAD 6 UNDERPASS - SITE NO. 29X-0408/B0
DEIL'S CREEK CULVERTS - SITE NOS. 29X-0242/C1-C3
WP 4068-09-00 / ASSIGNMENT NO. 4018-E-0009

Geocres No.: 31F-230

PART 2. ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 INTRODUCTION

Part 2 of the report provides an interpretation of the factual data from Part 1 and presents geotechnical recommendations to assist the project team in designing the foundations for various structures at the Highway 17 County Road 6 Interchange in the Township of Horton, Renfrew County, Ontario.

The existing Highway 17 alignment at this site will become the future Highway 17 eastbound lanes and new westbound lanes will be constructed to the north of the existing alignment at this location. For project purposes, Highway 17 is herein described as oriented east to west and County Road 6 north to south.This interchange includes four proposed structures: the Highway 17 County Road 6 Underpass (Site No. 29X-0408/B0), the replacement of the existing culvert under Highway 17 (proposed eastbound lanes) at Sta. 23+642 (Site No. 29X-0425/C1), a new culvert under the proposed westbound lanes around the same station (Site No. 29X-0242/C3) and a new culvert under County Road 6 at Station 9+927 (Site No. 29X-0425/C2). The culverts will convey Deil's Creek under Highway 17 and Country Road 6.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and shall not be used or relied upon for any other purposes or by any other parties including design-build contractors. It should be noted that the use of and reliance on Part 1 of the Report is governed by and limited to the terms and conditions set out in the Report and a reliance letter. The Preferred Proponent remains responsible to assess the need for additional investigations and to complete that work. The Preferred Proponent must make their own interpretation based on the factual data in Part 1 of the report. The information included in Part 2 is not to be relied upon for design purposes and foundation design is the sole responsibility of the Preferred Proponent. No use shall be made of Part 2 or any part thereof. The Preferred Proponent must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

The following sections provide preliminary geotechnical recommendations for the construction of foundation elements for the proposed structures. The discussions and recommendations presented in this report are based on the information provided by the Ministry of Transportation of Ontario (MTO) and on the factual data obtained during the course of this investigation.

7.1 Proposed Structures

7.1.1 County Road 6 Underpass

Per the Preliminary General Arrangement Drawing (GA) from Parsons dated June 11, 2021 (See Appendix F), the proposed underpass structure is a two-span pre-cast concrete girder bridge that will facilitate the traffic flow of County Road 6 over Highway 17 with a skew of about 7.5 degrees. The proposed span lengths are 40 m. The proposed width of the structure is 23.2 m. Finished grade at the south and north abutments is to be 146.0 m and 145.4 m respectively. It is assumed that the underside of the abutments (or pile caps) will be approximately 6 m below finished grade or elevation 140.0 m and 139.4 m for the south and north sides respectively. The underside of the pier foundation cap will be selected based on frost cover requirements and bedrock elevations. Based on the GA for the County Road 6 underpass, dated June 11, 2021, wingwalls parallel with the centreline of County Road 6 of less than 10 m length are proposed in each quadrant.

The cross-section of Highway 17 under the structure for the proposed eastbound (existing Highway 17 embankment) and westbound consists of two 3.75 m lanes, a ramp/speed change lane varying in width, a 2.5 m shoulder towards the abutments and a 1.0 m shoulder towards the median. The center-to-center distance between the eastbound and westbound alignments is 40 m. It is noted that the proposed Highway 17 cross-section includes room for a future additional 3.75 m lane in each direction with widenings into the median. The ground surface elevation in the median ditch is expected to be approximately 136.0 m based on OPSD 200.020, a pavement structure thickness of 900 mm, and a finished grade of 138.1 m for the eastbound lanes and 137.8 m for the westbound lanes.

The cross-section of County Road 6 at the structure will include two 3.5 m lanes, tapers for the north-east and south-west ramps and a side clearance of 2.5 m each side between the travelled edge and the face of the parapet walls.

Based on the proposed County Road 6 profile relative to the existing ground surface, the fill height at the north and south abutment is 8.1 m. The maximum fill height for the NS-E Ramp is 8.3 m, E-NS Ramp is 9.0 m and the NS-W Ramp is 8.0 m. The fill height for the W-NS Ramp is expected to be less than 4.5 m and has not been evaluated in this preliminary foundation report.

Per the Preliminary Design Report, it is understood that the proposed underpass will have semi-integral abutments.

It is noted that the available preliminary GA drawings show discrepancies in the plan and profile elevations. The recommendations below will need to be re-valuated once the actual foundation elevations are determined.

7.1.2 Deil's Creek Culverts

The 2003 Stormwater Management and Drainage Report by National Capital Engineering (NCE) in support of the Preliminary Design Report for this project indicates a culvert is present beneath the existing Highway 17 (proposed eastbound lanes) at approximately Sta. 23+642. The existing culvert is described as a closed bottom box culvert (CBC) having a 4.2 m span by 1.5 m rise. This report recommended a replacement CBC with the same dimensions on the same alignment. For the new culvert under the proposed westbound lanes and the culvert under County Road 6, the report recommended new CBCs having a 4.2 m span by 1.5 m rise.

It is understood from the 2018 RFP that the proposed culverts on Highway 17 at Sta. 23+642 are 4.2 m by 1.5 m CBCs. The proposed culvert on County Road 6 is the same size.

Per the Preliminary General Arrangement Drawing from Parsons dated June 11, 2021 (See Appendix F), the proposed Deil's Creek culverts are as follows:

- The replacement culvert under the existing Highway 17 (proposed eastbound) is on the same alignment as the existing and is a new CBC with a 3.2 m span, a 1.5 m rise and a length of 57.7 m;
- The new culvert under the proposed Highway 17 westbound lanes is a CBC with a 3.5 m span, a 1.5 m rise and a length of 31.2 m;
- The new culvert under County Road 6, north of Highway 17, is a CBC with a 3.5 m span, a 1.5 m rise and a length of 47.2 m and will be on a new alignment 40 m north of the existing culvert.

It is anticipated that the replacement culvert under the existing Highway 17 embankment (proposed eastbound) will be constructed on the same alignment as the existing and have a similar invert elevation of approximately 136.0 m. It is assumed that the culvert inverts for the new westbound lanes and County Road 6 will be approximately 135.9 m and 135.8 m respectively.

It is noted that the available preliminary GA drawings do not have invert elevations. The recommendations below will need to be re-valuated once the actual foundation elevations are determined.

7.2 Applicable Codes and Design Considerations

The geotechnical assessment presented below has been prepared based on the available data regarding the proposed foundations and existing ground conditions and in accordance with the Canadian Highway Bridge Design Code (CHBDC) version CSA S6:19.

In accordance with CHBDC, the analysis and design of the structures take into consideration the importance of the structure and the consequence associated with exceeding limit states. The importance category and consequence classification are defined by the Regulatory Authority, which in this case is the Ministry of Transportation, Ontario (MTO).

It is understood that the new underpass structure and associated culverts is being designed to the “Major Route” importance category.

This project has been assigned Typical Consequence Classification, in accordance with Section 6.5.1 of the CHBDC. Accordingly, a consequence factor (Ψ) of 1.0, as per Table 6.1 of the CHBDC, has been used in assessing factored geotechnical resistances.

The degree of site and prediction model understanding for this site has been assessed to be typical understanding (Section 6.5.3 of CHBDC).

7.3 Frost Penetration Depth

The depth of frost penetration at this site is estimated to be 1.9 m (as per OPSD 3090.101); shallow foundations should be founded at or below this depth or provided with equivalent insulation unless the footings are founded on bedrock. Typically, closed bottom box culverts, foundations with mass concrete on bedrock and RSS walls are not provided with frost protection.

Please refer to the pavement design report for frost taper recommendations for the pavement.

8 SEISMIC CONSIDERATIONS

8.1 Spectral and Peak Acceleration Hazard Values

The seismic hazard data for the CHBDC is based on the fifth-generation seismic model developed by the Geological Survey of Canada (GSC). The seismic hazard for this site has been obtained from the GSC online calculator. The data includes a peak ground acceleration (PGA), peak ground velocity (PGV) and the 5% spectral response acceleration values (Sa(T)) for the *reference* ground condition (Site Class C) for a range of periods (T) and for a range of return periods including 475-year, 975-year and 2475-year events. The GSC seismic hazard calculated data sheet for this site is included in Appendix E.

The site coefficients used to determine the design spectral acceleration and displacement values are a function of the Site Class and the peak ground acceleration (PGA). The PGA at this site for a *reference* Site Class C with a 2% probability of exceedance in 50 years (2475-year event) is 0.225g. This value is to be scaled by the F(PGA) based on the site-specific Site Class.

8.2 CHBDC Seismic Site Classification

In accordance with the CHBDC, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy.

As per Table 4.8 of the CHBDC, the following seismic site classes have been applied to each structure for a 2475-year event.

Table 8-1: Seismic Site Class for a 2475-year Event

Location	Site Class	PGA_{ref}	F(PGA)	PGA
County Road 6 Underpass	E*	0.180	1.346	0.303
Deil's Creek Culverts under Highway 17	D	0.180	1.138	0.256
Deil's Creek Culvert under County Road 6	B	0.180	0.870	0.196

Note: *See Section 8.3

8.3 Seismic Liquefaction Potential

The susceptibility of the soils at the site to experience liquefaction was assessed using the SPT data following the simplified method for cohesionless soil as outlined in Boulanger and Idriss (2014)[i]. The clayey silt/sandy silt and silty sand/sand below the water table at the south abutment (and associated approach and ramps), is considered to be susceptible to liquefaction.

As per Table 4.8 in Section 4.4.3.2 of the CHBDC S6-19, sites with liquefiable soils should be considered a Site Class F and a site-specific evaluation is required. It is recommended that a more detailed liquefaction assessment be completed for this site using Seismic Cone Penetration Tests (SCPTs) and a site-specific response analysis. There are three possible outcomes upon completion of that more rigorous work:

1. liquefaction is determined to have a low risk of occurrence and does not need to be considered in design,
2. liquefaction is assessed to be an issue and the structure and embankments are designed to accommodate the forces and displacements induced by liquefaction; or
3. liquefaction is assessed to be an issue and ground improvement techniques are employed to densify the soils to minimize the liquefaction potential.

The following sections of this report have been prepared based on the assumption that the first or third scenarios will prevail and that design of the structures and embankments will not be influenced by liquefaction. It is recommended that the County Road 6 underpass structure and associated approach and ramps at the south abutment are treated as a Site Class E until the site-specific evaluation has been carried out.

8.4 Seismic Performance Category

Utilizing a PGA_{ref} value of 0.18, a Site Class of E and values of 0.10 for $S(0.2)_{ref}$ and 0.35 for $S(1.0)_{ref}$ for County Road 6, site specific values of 0.46 and 0.22 have been calculated for S(0.2) and S(1.0) respectively using Tables 4.2 and 4.4 of the CHBDC. This information has been compared to Table 4.10 for a major route bridge and it is determined that the site should be assigned to Seismic Performance Category 2 or 3 depending on the fundamental period of the bridge.

9 STRUCTURE FOUNDATION ALTERNATIVES

9.1 Foundation Alternatives

9.1.1 County Road 6 Underpass

Table 9-1 presents the key elevations for the bridge structure.

Table 9-1: Key Elevations for the Proposed County Road 6 Underpass

Foundation Element	South Abutment	Central Pier	North Abutment
Applicable Boreholes	19-01, 19-02, CR6-1	19-03, 19-04, 19-05, 19-06, CR6-2	19-07, 19-08, 19-09, 19-10, CR6-3
Prop. Top of Pavement Elevation (m)	146.0	146.0	145.4
Existing Ground Surface Elevation (m)	137.9	137.9	137.3
Prop. Base of Abutment/Footing Elevation (m)	140.0 (1)	134.1 (2)	139.4 (1)
Top of Till Elevation (m)	134.4 to 131.4	135.6 to 135.1	136.0 to 137.4
Top of Bedrock Elevation (m)	132.2 to 129.1	136.3 to 133.8	136.6 to 134.2
Water Level (m)	137.2	137.4	135.7

Notes: (1) Base of abutment/pile cap assumed to be about 6 m below finished grade, as shown on preliminary GA.
(2) Base of pier footing selected based on frost depth of 1.9 m and assumed ditch elevation of 136.0 m.

It is noted that the existing culvert conveying Deil's Creek beneath County Road 6 will need to be decommissioned prior to construction of the pier foundation.

Given the soil stratigraphy encountered, the following options have been considered from a geotechnical perspective for the support of the new bridge foundations:

- Spread Footings on Mass Concrete to Bedrock:

  At the north abutment and central pier, spread footings founded on mass concrete cast directly on bedrock is considered a feasible alternative from a geotechnical perspective. For this option, all of the overburden would be removed and mass concrete would be placed on the bedrock up to the underside of the abutment footings. Excavation depths would range from 0.1 m to 2.4 m at the north abutment and from 1.3 m to 4.3 m at the central pier. These excavations will extend below the water level by 1.5 m at the north abutment and 3.6 m at the central pier; dewatering will be required to maintain a dry excavation. The mass concrete should be placed to at least 0.5 m beyond the footing horizontally with a near vertical face down to rock. It is noted that the bedrock slopes from west to east at the central pier; excavation depths will vary to as deep as elev. 133.8 m on the east side of the pier. This option is not recommended for the south abutment given the significantly greater depth to bedrock.

- Spread Footings on an Engineered Pad over Bedrock:

  At the north abutment, spread footings constructed on an engineered pad consisting of well-compacted OPSS Granular A backfill over bedrock is considered a feasible alternative from a geotechnical perspective. For this option, all of the overburden would be removed and Granular A backfill would be compacted in lifts from the bedrock surface up to the underside of the abutment footing. Excavation depths would range from 0.1 m to 2.4 m at the north abutment and from 1.3 m to 4.3 m at the central pier. These excavations will extend below the water level by 1.5 m at the north abutment and 3.6 m at the central pier; dewatering will be required to maintain a dry excavation. It will likely be considered a cheaper option to backfill the excavation with engineered granular backfill rather than concrete even though the granular pad will need to be defined based on a 1H:1V line down and away from 0.5 m outside of the footing. This option would give lower bearing capacities than the mass concrete. This option is not recommended for the south abutment given the significantly greater depth to bedrock.

- Spread Footings on an Engineered Pad on Overburden:

  At the north abutment, spread footings constructed on an engineered pad consisting of well-compacted OPSS Granular A backfill on overburden is considered a feasible alternative from a geotechnical perspective. For this option, all unsuitable materials would be removed (see Section 10.4) and the granular pad would be constructed to the underside of the abutment footing. The granular pad will need to be defined based on a 1H:1V line down and away from 0.5 m outside of the footing. This would reduce the costs associated with excavation to bedrock and reduce the quantity of backfill materials required. However, this option would provide the lowest bearing capacities and would have the highest potential for differential settlements between structural elements.

- Steel H-Piles:

  At the south abutment, steel H-piles are considered a feasible alternative from a geotechnical perspective.

  It is noted the bedrock slopes from west to east at the south abutment with bedrock encountered as high as elevation 132.2 m in Borehole CR6-1; it should be expected that bedrock elevations could be higher at other locations. Cobbles and boulders were observed in the till layer in Borehole 19-02 at the south abutment and could influence driven pile depth.

  Given the shallow bedrock encountered at the north abutment and central pier, it is not considered feasible from a geotechnical perspective to use steel driven steel piles to support these foundation elements.

- Caissons:

  Supporting the south bridge abutment on caissons socketed into bedrock is considered a feasible foundation option. Given the variable bedrock depth and the presence of cobbles and boulders, caissons with a nominal rock socket would be appropriate. Socketed caissons generally provide a higher geotechnical resistance relative to other deep foundation options. Caisson installation equipment should be able to advance past cobbles and boulders in the till.

- Micropiles:

  Micropiles offer lower lateral capacities compared to other deep foundation options and have a higher cost. Therefore, micropiles will not be discussed further within this report.

An evaluation of the bridge foundation alternatives including the advantages, disadvantages, risk/consequences and relative cost from a foundation perspective is provided in Appendix F.

9.1.2 Deil's Creek Culverts

Selection of the culvert type must consider the proposed construction procedures, staging requirements, geotechnical resistance available in the foundation soils, depth to suitable bearing stratum and post-construction settlement criteria. It is noted that the existing Deil's Creek culvert under the current Highway 17 alignment (future eastbound) is an open bottom culvert. From a geotechnical perspective, the following culvert types were considered:

- Circular Pipes (Concrete, HDPE, Steel)

  From a foundation engineering perspective, a pipe culvert is a technically feasible alternative for all culvert locations. The size of the pipe culverts will depend on the required hydraulic capacities. Multiple smaller pipes may be required to carry the flow.

- Open-Bottom Culvert (Box, Arch)

  From a general foundation engineering perspective, the construction of an open-bottom culvert will have greater construction concerns due to the high water table and requirement for greater excavation depths to construct the culvert footings to satisfy frost depth requirements (for culverts founded on overburden). The use of an open-bottom culvert would generally require greater dewatering efforts and has the potential for larger settlement following construction when compared to other culvert options. However, it is noted that the culvert crossing County Road 6 could be founded on shallow bedrock; an open bottom culvert supported on the bedrock would be a suitable option for this location. Bedrock excavation will be required for the County Road 6 crossing. At the time of this report, the proposed invert elevation for the culvert crossing the future Highway 17 westbound lanes is unknown. Bedrock elevation is variable along the proposed alignment and it is likely that bedrock will be encountered within the excavation.

- Closed-Bottom Box Culvert

  A precast, segmental, closed-bottom, box culvert is considered a feasible option from a foundation engineering perspective at the two Highway 17 culvert locations. Precast sections, rather than cast-in-place construction, can be installed expediently with less potential for disturbance of the founding soils during installation.

A comparison of these alternatives, based on their respective advantages and disadvantages, is included in Appendix F. It is not considered to be economical or practical to support a culvert on deep foundations at this site and therefore this option is not presented in this report.

9.2 Construction Methodology

At the time of preparation of this report, a construction staging plan has not yet been developed. The foundation recommendations presented herein have been prepared based on the assumption that the County Road 6 will be closed for periods of the construction while at least one lane of traffic in each direction will be maintained on Highway 17. It is envisioned that the north abutment and median pier of the underpass as well as the new culverts crossing the proposed Highway 17 westbound lanes and County Road 6 will be constructed initially with County Road 6 closed north of the highway. It is anticipated that the Highway 17 new west bound lanes and ramp embankments north of the highway would also be constructed at this time excluding the County Road 6 fills within 20 m of the north abutment. It is anticipated that two-way traffic on existing Highway 17 would not be affected by the excavation for the pier foundation, but if needed the lanes could be reconfigured to eliminate turning movements in conjunction with briefly closing County Road 6 south of Highway 17.

Highway 17 traffic would then be flipped over to the new westbound lanes with one lane in each direction. The embankments for the ramps and County Road 6 to within 10 m of the south abutment should be constructed early in the second stage with a delay to allow any time dependent settlement to occur early. The south abutment of the underpass, the structure deck and the replacement culvert beneath the eastbound lanes would be constructed. Upon completion of the structure, the approach fills at both ends of the bridge would be placed. Pavement rehabilitation of the eastbound lanes would be carried out last and immediately prior to opening Highway 17 and County Road 6 fully.

9.3 Recommended Approach

9.3.1 County Road 6 Underpass

From a foundation perspective, the central pier and north abutment should be founded on shallow foundations on mass concrete placed on sound bedrock. The south abutment should be supported on caissons socketed into bedrock or H-Piles driven to refusal. Wingwall foundations should match those utilized to support the adjacent abutments.

9.3.2 Deil's Creek Culverts

From a foundation perspective, a closed bottom box culvert is recommended for the culverts crossing Highway 17 (existing and proposed lanes). For the culvert on County Road 6, an open-bottom culvert founded on bedrock is the recommended alternative. A closed bottom box culvert would also be feasible for the culvert on County Road 6 but will required a greater bedrock excavation depth.

It is noted that the bedrock surface is variable and may be encountered along the length of the proposed culvert under the Highway 17 future westbound lanes.

10 FOUNDATION DESIGN RECOMMENDATIONS

10.1 County Road 6 Underpass

10.1.1 North Abutment and Pier: Spread Footings on Bedrock

Spread footings on mass concrete have been considered for the north abutment and central pier. The overburden should be removed and mass concrete placed on the bedrock up to the underside of the abutment footings (see Section 10.4.1 for bedrock subgrade preparation). The area of the mass concrete should extend at least 0.5 m beyond the perimeter of the footing. The mass concrete should be the same class and strength as the footing concrete.

The recommended geotechnical resistances for a 5.0 m wide footing installed on mass concrete placed on bedrock are as follows:

- Factored Geotechnical Resistance at ULS of 3,000 kPa
- Factored Geotechnical Resistance at SLS is not applicable.

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC Table 6.1)
- Geotechnical resistance factors (as per CHBDC Table 6.2):
  - ϕ_{gu} = 0.5 (static analysis; typical degree of understanding)
  - ϕ_{gs} = 0.8 (static analysis; typical degree of understanding)

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clause 6.10.2 and Clause 6.10.5.

Resistance to lateral forces/sliding resistance between the cast-in-place concrete and the underlying bedrock should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.70. If sufficient lateral resistance is not available, rock dowels could be considered.

10.1.2 South Abutment: Caissons

Drilled in caissons socketed into sound bedrock are a feasible option to support the south abutment. The caissons should consist of temporary steel casing liners seated into bedrock. The steel liners must be continuous and form a tight seal at the bedrock surface to minimize the ingress of soils and to facilitate cleaning of the socket base. The caisson should be installed as per OPSS.PROV 903. Suggested text for an NSSP for “Construction of Caissons” is provided in Appendix I, which includes additional requirements for inspection of the caisson base.

Depth of socket shall be measured from the lower bedrock elevation for the sloping bedrock condition present at this site.

10.1.2.1 Axial Geotechnical Resistance and Founding Elevation

The axial geotechnical capacity at factored ULS for a caisson socketed a minimum of 2 caisson diameters into sound bedrock is provided in the table below. The caisson capacities include a resistance factor of 0.4 and 0.3 (ϕ_{gu}) for ULS compression and tension, respectively as per Table 6.2 of the CHBDC (static analysis – typical understanding). The SLS condition will not govern for a caisson socketed into sound bedrock.

Table 10-1 Axial Geotechnical Resistance for Caissons

Caisson Diameter (mm)	Factored ULS (Compression) (kN)	Factored ULS (Tension) (kN)	Factored SLS (Compression) (kN)
610	2,000	830	will not govern
915	4,500	1,870	will not govern
1200	7,800	3,220	will not govern

The structural resistance of the caissons must be checked by the structural designer. The required depth of socket into sound bedrock should be lengthened, if required, based on the required lateral capacity requirements (recommendations provided in Section 10.1.2.3), moment capacity and seismic analysis to satisfy the structural assessment.

Construction of caissons will require temporary steel casing to support the sidewalls through the native soils and enable machine-cleaning of the socket base. The axial bearing resistances provided are based, in part, on end bearing and the base of the socket must be thoroughly cleaned. The caisson equipment supplied by the Contractor must be capable of advancing through the existing soils and penetrate or push aside potential obstructions in the till. Coring equipment must be able to seat the casing into sloping bedrock and also penetrate into the bedrock without fracturing the sidewalls. The tension/uplift resistances provided are based on full contact of the caisson concrete with the socket sidewalls.

10.1.2.2 Downdrag

Downdrag forces (negative skin friction) acting upon the caissons supporting the south abutment are expected to develop as a result of settlement of the clayey silt deposit under the imposed loading from the newly placed fill at the south abutment (See Section 10.6.2). The unfactored downdrag load acting on a single caisson is estimated as per the following table.

Table 10-2 *Unfactored* Downdrag Load for Caissons

Caisson Diameter (mm)	*Unfactored* Static Downdrag Load (kN)
610	750
915	1,100
1200	1,450

The downdrag load should be factored in accordance with the CHBDC. In accordance with Section 6.11.4.10 of the CHBDC and Clause C6.11.4.10 of the Commentary, in the structural design of a caisson, the factored downdrag load should be added to the factored permanent loads to assess the effects of downdrag. In geotechnical analysis of downdrag, live load effects should not be considered.

The neutral plane for static downdrag calculations can be taken as the base of the clayey silt deposits.

10.1.2.3 Lateral Geotechnical Resistance and Group Effects

The lateral resistance of a caisson can be estimated using p-y curves. The p-y curves for static conditions are shown in Tables H1 through H3 (for caisson diameters of 610 mm, 910 mm and 1200mm, respectively) in Appendix I to allow for the calculation of the ultimate lateral capacity. A geotechnical resistance factor of 0.5 (ϕ_{gu}) and 0.8 (ϕ_{gs}) as per Table 6.2 of the CHBDC (static analysis – typical understanding) should be applied to the ultimate ULS and SLS values, respectively.

A minimum caisson embedment of two caisson diameter into sound bedrock should be used in design irrespective of the calculated lateral capacity.

Where the lateral spacing between an adjacent caisson embedded into the rock is less than 4 equivalent diameters, the subgrade modulus of the soil will need to be reduced based on the center-to-center spacing. The reduction factors to be used are provided in Figure C6.22, C6.23 and C6.24 of the CHBDC.

10.1.3 H-Piles

As discussed in Section 9.1.1, driven piles are not considered a feasible option at the north abutment and central pier given the shallow bedrock. At the south abutment, driven piles are considered feasible but it is noted that the bedrock surface elevation is variable. Based on the preliminary, assumed elevations provided in Table 9-1, H-piles ranging from about 8.0 to 11.0 m long (tip Elevations ranging from about 132.2 to 129.1 m) will be required at the south abutment.

10.1.3.1 Axial Geotechnical Resistance and Founding Elevation

The axial geotechnical resistances for HP310x110 piles driven to refusal on bedrock is provided in Table 10-3 and may be used in design.

Table 10-3 Axial Geotechnical Resistance for HP310x110 Piles Driven to Bedrock

Pile Size	Factored ULS (Compression) (kN)	Factored ULS (Tension) (kN)	Factored SLS (Compression) (kN)
HP310x110	2,000	200	will not govern

The pile capacities as provided include a resistance factor of 0.4 (ϕgu), 0.8 (ϕgs) and 0.3 (ϕgu) for ULS compression, SLS compression and ULS tension values, respectively, as per Table 6.2 of the CHBDC (static analysis – typical understanding).

The structural resistance of the pile must be checked by the structural engineer which may govern the design.

10.1.3.2 Downdrag

Downdrag forces (negative skin friction) acting upon the piles supporting the south abutment are expected to develop as a result of settlement of the clayey silt deposit under the imposed loading from the newly placed fill at the south abutment (See Section 10.6.2). The unfactored downdrag load acting on a single HP 310x110 pile is estimated to be 480 kN.

10.1.3.3 Lateral Geotechnical Resistance and Group Effects in Soil

Piles can be installed with a batter to resist lateral loads for a conventional or semi-integral abutment.

The lateral resistance for the soil adjacent to a vertical pile is developed on the face of the pile embedded in the foundation soils and estimated using p-y curves. The p-y curves for static conditions are shown in Table H4 in Appendix H, considering the soil parameters summarized below in Table 10-4, to allow for calculation of the *ultimate* lateral capacity of an individual pile. A geotechnical resistance factor of 0.5 (ϕ_{gu}) and 0.8 (ϕ_{gs}) as per Table 6.2 of the CHBDC (static analysis – typical understanding) should be applied to the *ultimate* ULS and SLS values, respectively.

Where lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, the lateral resistance in soil will also need to be further reduced based on the center-to-center spacing. The reduction factors to be used can be obtained from Figures C6.22, C6.33, and C6.24 of the Commentary to the CHBDC.

Table 10-4 L-Pile Analyses – Soil Stratigraphy

Soil Stratum	Bulk Unit Weight (kN/m^3)	Friction Angle (degrees)
Granular Fill (New)	22.8	40
Granular Fill (Existing)	20.0	30
Silty Sand	19.0	30
Clayey Silt	17.0	29
Glacial Till	21.0	35

10.1.3.4 Lateral Geotechnical Resistance in Bedrock

The lateral resistance in marble bedrock at this site may be calculated using ultimate lateral resistance (p_{ult}) as follows:

For $z \leq 3D$, $p_{ult} = (1+1.4\,z / D)\,\sigma_{rm}$ (kPa)

For $z > 3D$, $p_{ult} = 5.2\,\sigma_{rm}$ (kPa)

Where z = depth of socket below surface of sound bedrock (m)

D = pile or caisson diameter (m)

σ_{rm} = 3 MPa, average rock mass strength within rock socket

The ultimate lateral resistance, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult}\,L\,D$ (kN), where D is the pile diameter (m) and L is the length (m) of the pile segment or element used in the analysis. This represents the ultimate load at which the rock fails and will not support any additional load at greater displacement.

10.1.3.5 Pile Tips and Driving

It is expected the pile installation will encounter cobbles and boulders. Care must be exercised not to damage the piles while driving into layers with cobbles and boulders and to bedrock. The tips of all piles must be protected from damage when driving and should be fitted with a Titus Steel (standard H Point) or approved equivalent.

Pile driving must be carried out in accordance with OPSS.PROV 903 and Special Provision 109F57 for piles driven to refusal in the bedrock The appropriate pile driving note is “Piles to be driven to bedrock”.

10.1.4 Abutment Type

Integral abutments are not considered suitable for this site. Semi-integral abutments should be considered.

10.2 Deil's Creek Culverts

Table 10-5 presents the key elevations for the proposed culverts.

Table 10-5: Key Elevations for the Deil's Creek Culverts

Culvert Location	Existing Hwy / Proposed EBL (29X-0242/C1)	County Rd 6 (29X-0242/C2)	Proposed WBL (29X-0242/C3)
Applicable Boreholes	CV-10, 17-1, 17-2	CV-13, CV-14, CV-15	CV-11, CV-12
Prop. Top of Pavement Elevation (m)	138.6	144.7	138.1
Prop. Invert Elevation at Inlet (m)	136.1 (1)	136.0	135.9
Prop. Invert Elevation at Outlet (m)	136.0 (1)	135.9	135.8
Prop. elevation of underside of base slab of culvert (at centerline) (m)	135.8 (2)	135.7 (2)	135.6 (2)
Existing Ground Surface Elevation (m)	138.6	136.7	136.7
Top of Till Elevation (m)	136.3 to 134.1	137.8	135.8 to 134.6
Top of Bedrock Elevation (m)	135.5 to 132.0	137.5 to 135.3	135.4 to 134.1
Water Level (m)	136.8	134.8	136.4

Notes: (1) assumed same as existing culvert invert elevation
(2) based on culvert thickness in GA drawing shown in Appendix F

10.2.1 Culvert Foundation Bearing Resistances

10.2.1.1 Culvert under County Road 6

The excavation for the culvert under County Road 6 will be completed within a bedrock outcrop. For a culvert with footings cast directly on bedrock, no settlement due to the placement of embankment fill is anticipated.

The bedrock subgrade should be prepared as described in Section 10.4.2. Surface water diversion and dewatering will be required to place the bedding material and install the culvert in the dry (Section 11.3).

The recommended geotechnical resistances for a minimum 0.8 m wide footing cast on sound bedrock are as follows:

- Factored Geotechnical Resistance at ULS of 3,000 kPa
- Factored Geotechnical Resistance at SLS will not govern for footings on bedrock

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC Table 6.1)
- Geotechnical resistance factors (as per CHBDC Table 6.2):
  - ϕ_{gu} = 0.5 (static analysis; typical degree of understanding)
  - ϕ_{gs} = 0.8 (static analysis; typical degree of understanding)

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces/sliding resistance between the precast concrete and the underlying bedrock (Section 10.4) should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.7.

The bearing capacities given in this section are based on an assumed founding elevation for the culvert. If the founding elevations are different than those assumed in Table 10-5, the bearing capacities should be reassessed.

10.2.1.2 Culverts under Highway 17 (EBL and WBL)

It is assumed that the existing Highway 17 embankment (proposed eastbound lanes) following the culvert replacement will be similar to the existing dimensions. It is not anticipated that the subgrade soils within the proposed culvert footprint will be subjected to any additional loads when compared to the existing embankment footprint.

It is assumed the proposed Highway 17 westbound lanes will have a similar geometry to the existing highway geometry. The construction of the new embankment will add additional loads within and beyond the culvert footprint. Further discussion on the potential settlement of the subgrade soils due to the placement of the new westbound embankment is provided in Section 10.6.

The subgrade should be prepared as described in Section 10.4.2. Surface water diversion, creek diversion and dewatering will be required to place the bedding material and install the culvert in the dry (Section 11.3).

The recommended geotechnical resistances for a pre-cast closed-bottom, box culvert up to 4.0 m wide (exterior) with the underside of culvert base slab at or below approximate elevation 135.8 m, installed on a bedding layer as described in Section 10.4 placed on an undisturbed sandy silty clay to clayey silt are as follows:

- Factored Geotechnical Resistance at ULS of 250 kPa
- Factored Geotechnical Resistance at SLS of 170 kPa

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC Table 6.1)

- Geotechnical resistance factors (as per CHBDC Table 6.2):
    - ϕ_{gu} = 0.5 (static analysis; typical degree of understanding)
    - ϕ_{gs} = 0.8 (static analysis; typical degree of understanding)

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces/sliding resistance between the precast concrete and the underlying Granular 'A' bedding (Section 10.4) should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.45. A reduction factor of 0.8 (as per CHBDC Table 6.2) should be used to estimate the sliding resistance between the culvert and Granular A. An unfactored coefficient of friction of 0.35 can be assumed for the interface between the Granular 'A' and the clayey subgrade. A reduction factor of 0.6 (as per CHBDC Table 6.2) should be used to estimate the sliding resistance between the Granular A and the clayey subgrade.

The bearing capacities given in this section are based on an assumed founding elevation for the culvert. If the founding elevations are different than those assumed in Table 10-5, the bearing capacities should be reassessed.

It is noted that the bedrock elevation is variable under the length of the culvert crossing the proposed Highway 17 WBL (bedrock elevation ranges from 132.0 m to 135.4 m). If the culvert is determined to be partially founded on bedrock, it is recommended that the subgrade be prepared to reduce the potential for non-uniform and abrupt settlement (i.e. hard point effect) between the bedrock and soils. An NSSP alerting the Contractor to this issue and providing a recommended design approach is included in Appendix I.

10.3 Wingwalls / Retaining Walls

Based on the General Arrangement (GA) Drawing for the County Road 6 underpass dated June 11, 2021 (See Appendix F) wingwalls parallel with the centreline of County Road 6 of less than 10 m length are proposed in each quadrant.

Based on the GA Drawing for the Deil's Creek Culverts dated June 15, 2021 (See Appendix F), no retaining walls or headwalls are proposed for the culverts.

10.3.1 Concrete Wingwalls / Retaining Walls

Concrete wingwalls / retaining walls could be cantilevered off the abutment or could employ a similar foundation as those discussed above to support the abutments. The relevant foundations recommendations of Section 10.1 above apply.

Concrete wingwalls / retaining walls perched in the fill are feasible at the north abutment only. Settlements greater than 25 mm are anticipated at the south abutment due to the embankment loading (See Section 10.6.2) and, therefore, concrete wingwalls / retaining walls at that location should be cantilevered off the abutment or supported on deep foundations, as discussed in

Section 10.1. Alternatively, RSS wingwalls could be constructed at the south abutment (see Section 10.3.2). See also subgrade recommendations provided in Section 10.4.

For the north abutment, the recommended geotechnical resistances for a 2 m wide by 10 m long wingwalls / retaining wall on a minimum granular pad thickness as described in Section 10.4.3.1 over bedrock are:

- Factored Geotechnical Resistance at ULS of 750 kPa
- Factored Geotechnical Resistance at SLS of 300 kPa

For the north abutment, the recommended geotechnical resistances for a 2 m wide by 10 m long wingwall / retaining wall perched in the embankment fill over native soil at the elevations provided in Table 9-1 and on a minimum granular pad thickness as described in Section 10.4.3.1 are:

- Factored Geotechnical Resistance at ULS of 350 kPa
- Factored Geotechnical Resistance at SLS of 200 kPa

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC Table 6.1)
- Geotechnical resistance factors (as per CHBDC Table 6.2):
    - ϕ_{gu} = 0.5 (static analysis; typical degree of understanding)
    - ϕ_{gs} = 0.8 (static analysis; typical degree of understanding)

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces/sliding resistance between the precast concrete footing and the underlying Granular ‘A’ bedding should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.45. A reduction factor of 0.8 (as per CHBDC Table 6.2) should be used to estimate the sliding resistance between the concrete and Granular A. An unfactored coefficient of friction of 0.35 can be assumed for the interface between the Granular ‘A’ and the silty sand. A resistance factor of 0.8 (as per CHBDC Table 6.2) should be used to estimate the sliding resistance between the Granular A and the silty sand subgrade.

10.3.2 RSS Walls

RSS walls are considered feasible at the County Road 6 underpass; assuming they are outside of the watercourse and will not be affected by fluctuating water levels. This should be reviewed as the centreline of the north abutment is within 25 m of the County Road 6 culvert. The design of proprietary RSS walls is the responsibility of the supplier. Typically, such systems do not require full frost protection as they are able to tolerate some movement due to frost heave. The RSS system should be designed in accordance with the MTO RSS Design Guidelines. Once the location and height of the wall is established, the following recommendations should be confirmed:

Performance	H
Appearance	H
Acceptance	A

The subgrade and granular pad shall be prepared based on the recommendations provided in Section 10.4. The lateral pressure comments provided in Section 10.5 may be used in RSS design. Please also refer to Section 10.6.1 for comments on Global Stability.

For the north abutment, the recommended geotechnical resistances for a 4 m wide reinforced RSS placed on a granular pad (Section 10.4) on bedrock are:

- Factored Geotechnical Resistance at ULS of 750 kPa
- Factored Geotechnical Resistance at SLS of 300 kPa

For the south abutment, the recommended geotechnical resistances for a 4 m wide reinforced RSS placed on a granular pad (Section 10.4) on undisturbed silty sand are:

- Factored Geotechnical Resistance at ULS of 250 kPa
- Factored Geotechnical Resistance at SLS of 150 kPa

It is noted that the native soils under the wingwalls at the south approach fill will also settle significantly in response to the embankment fills, see Section 10.6.2. The SLS value above is in addition to that settlement. There will be differential settlement between an RSS wall and the south abutment. Consideration should be given to precluding the use of RSS at this location.

The factored geotechnical resistances include the following factors:

- Consequence factor (Ψ) of 1.0 (as per CHBDC Table 6.1)
- Geotechnical resistance factors (as per CHBDC Table 6.2):
  - $\phi_{gu} = 0.5$ (static analysis; typical degree of understanding)
  - $\phi_{gs} = 0.8$ (static analysis; typical degree of understanding)

The bearing resistance values are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be reduced in accordance with CHBDC Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces/sliding resistance between the precast concrete leveling pad and the underlying Granular 'A' bedding should be evaluated in accordance with the CHBDC assuming an unfactored coefficient of friction of 0.45. A reduction factor of 0.8 (as per CHBDC Table 6.2) should be used to estimate the sliding resistance between the concrete and Granular A. An unfactored coefficient of friction of 0.35 can be assumed for the interface between the Granular 'A' and the silty sand. A resistance factor of 0.8 (as per CHBDC Table 6.2) should be used to estimate the sliding resistance between the Granular A and the silty sand subgrade.

10.4 Subgrade Preparation, Granular Pads, Bedding and Backfilling

“Granular A” and “Granular B Type II” in this section refer to OPSS Granular A or Granular B Type II meeting the specifications of OPSS.PROV 1010 and SP110S06. “Granular A” is further defined as “Quarry-Source Granular A” unless specifically described as “Pit-Source Granular A”.

The existing culverts crossing Highway 17 and County Road 6 must be removed entirely (including foundations) where potential interactions are possible with new foundation elements or embankments.

10.4.1 County Road 6 Underpass

The subgrade preparation recommendations in this section are only applicable for foundation elements comprising mass concrete on bedrock. The bearing capacities in Section 10.1.1 assume sound, unfractured bedrock. Subgrade preparation is not applicable for foundation elements on deep foundations.

At the foundation locations, the top of bedrock elevation is variable; sloping bedrock will likely be encountered within the excavation footprint. Bedrock excavation and/or mass concrete should be used to provide a flat surface for the footings.

The foundation subgrade should be prepared as per OPSS.PROV 902 using mass concrete as backfill, where required. The mass concrete should be the same class and strength as the footing concrete. All shattered and loosened rock fragments should be removed from the footprint of the footing. The bedrock surface shall be cleaned with a hydrovac or air-lance prior to the placement of concrete to create a clean bedrock/concrete interface.

It is noted that construction will extend below groundwater elevation. Dewatering will be required to keep the base of the excavation dry. Please refer to Section 11.3 for additional comments on groundwater and surface water control.

Backfilling behind abutments shall be as per Section 10.5.

10.4.2 Deil’s Creek Culverts

This section is applicable for both closed bottom box culverts and open bottom box culverts with the exception of subgrade preparation; if open bottom culverts founded on bedrock are selected, subgrade preparation shall be as per Section 10.4.1 and no bedding layer is required.

For closed bottom box culverts, the foundation subgrade should be prepared as per OPSS.PROV 422.07.06 using Granular A material as backfill of over-excavated areas, where required. The granular shall be compacted as per OPSS.PROV 501.

In order to provide a more uniform foundation subgrade condition for the closed bottom box culvert foundations, a bedding layer and levelling course shall be provided as per OPSD 803.010 (notwithstanding culvert span) and OPSS.PROV 422. A minimum bedding thickness of 0.3 m of Granular A is recommended.

Construction equipment should not be permitted to travel on the exposed subgrade.

It is noted that construction will extend below groundwater elevation. Creek diversion and dewatering will be required to prepare the subgrade in the dry. Please refer to Section 5511.3 for additional comments on groundwater and surface water control.

Backfilling against the culvert walls shall be as per Section 10.5.

10.4.3 Wingwalls / Retaining Walls

10.4.3.1 Concrete Wingwalls / Retaining Walls

Concrete wingwalls / retaining walls cast directly on bedrock shall follow the recommendations in Section 10.4.1.

For concrete wingwalls / retaining walls founded on granular pads on silty sand, clayey soils or overlying bedrock, the foundation subgrade should be prepared as per OPSS.PROV 902 using Granular A material as backfill of over-excavated areas, where required.

The walls should be founded on a granular pad with a minimum thickness of 0.3 m consisting of Granular A material. The top of the Granular A pad must extend to 0.5 m beyond the outside edge of all sides of the footing and sloped away from the footing at 1H:1V, or flatter. The granular shall be compacted as per OPSS.PROV 501.

Construction equipment should not be permitted to travel on the exposed subgrade.

It is noted that construction may extend below groundwater elevation. Dewatering will be required to prepare the subgrade in the dry. Please refer to Section 11.3 for additional comments on groundwater and surface water control.

Backfilling against the walls shall be as per Section 10.5.

10.4.3.2 RSS Walls

RSS walls are only considered feasible at the County Road 6 Underpass at this site (Section 10.3.2).

RSS walls placed directly on bedrock shall follow the recommendations in Section 10.4.1.

For RSS walls founded on silty sand, clayey soils, or on granular pads overlying bedrock, the foundation subgrade should be prepared as per OPSS.PROV 902 using Granular A material as backfill of over-excavated areas, where required.

A minimum 1 m thick engineered fill pad constructed on the underlying undisturbed native soils should be provided below the RSS wall as well as under the reinforced retained soil. The engineered fill pads should consist of Granular A placed and compacted in accordance with OPSS.PROV 501. Engineered fill pads should be constructed with 1H:1V sides slopes with the crest of slope a minimum of 1 m from the edge of footing and reinforced retained soil on all sides.

10.5 Backfill and Lateral Earth Pressures

Structural backfill material should consist of Granular A or Granular B Type II meeting the OPSS.PROV 1010 and SP 110S06 specifications. Large scale direct shear box testing on samples of Granular A and Granular B Type II from numerous nearby aggregate sources was completed for this project. The results indicate that for design of structural backfill for this project, an internal angle of friction of 40 degrees and 42 degrees can be used for quarry-sourced Granular A and Granular B Type II, respectively, in this area provided the effective vertical pressure on the material is less than 150 kPa (Geocres Memorandum 31F-213). An Operational Constraint will be required in the contract restricting the source of Granular A to quarries. Throughout this report, the term “Granular A” is defined as “Quarry-Source Granular A” unless specifically described as “Pit-Source Granular A”.

The backfill must be in accordance with OPSS 902 and placed to the extents shown on OPSD 3101.150 for the abutment, culverts and wingwalls/retaining walls. Structural backfill should consist of Granular A or Granular B Type II placed and compacted in accordance with OPSS.PROV 501. Heavy compaction equipment used adjacent to the walls must be restricted in accordance with OPSS.PROV 501.07.02a). The design of the abutments and wingwalls / retaining walls, where required, must incorporate a subdrain as shown in OPSD 3101.150.

Lateral earth pressure parameters provided in Table 10-1 and Table 10-2 in the sections below are based on the assumptions that the wall is vertical and the backfill is fully drained so that there are no unbalanced hydrostatic pressures above the permanent groundwater level. If adequate drainage cannot be confirmed, the potential for buildup of hydrostatic pressures should be considered in design.

Where back slopes are horizontal, the corresponding coefficients provided in Table 10-1 and Table 10-2 should be used. For other backfill and wall geometries, Thurber will need to calculate the appropriate earth pressure coefficients once the final geometry is confirmed.

10.5.1 Static Lateral Earth Pressure

Lateral earth pressures acting on structures should be computed in accordance with the CHBDC. Under drained conditions the lateral earth pressure is generally given by the following expression:

$$\sigma_h \quad = \quad K * (\gamma h + q)$$

where:

σ_h = horizontal pressure on the wall at depth h (kPa)
K = earth pressure coefficient (see table below)
(K$_a$ for yielding walls, K$_o$ for non-yielding walls)
γ = unit weight of retained soil (see table below),
use submerged unit weight below groundwater level
h = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

A lateral earth pressure due to backfill compaction should be added to the calculated lateral earth pressure in accordance with Clause 6.12.3 of the CHBDC. Typical earth pressure coefficients for OPSS Granular A and OPSS Granular B Type II backfill are shown in Table 10-1.

Table 10-6: Static Earth Pressure Coefficients

Condition	**Pit Sourced OPSS Granular A** **ϕ = 35°, γ = 22.8 kN/m^3**	**Quarry Sourced OPSS Granular A** **ϕ = 40°, γ = 22.8 kN/m^3**	**Quarry Sourced OPSS Granular B Type II** **ϕ = 42°, γ = 22.8 kN/m^3**
Coefficient of at Rest Earth Pressure, K$_o$ (Restrained Wall)	0.43	0.36	0.33
Coefficient of Active Earth Pressure, K$_A$ (Unrestrained Wall)	0.27	0.22	0.20

The parameters in the table correspond to full mobilization of active and passive earth pressures and require certain relative movements between the wall and adjacent soil to produce these conditions. The movement required can be assessed from Table C6.12 of the Commentary to the CHBDC. Active earth pressures should be used for any wingwalls or unrestrained walls. For rigid structures, at-rest horizontal earth pressures would apply for design.

10.5.2 Combined Static and Seismic Lateral Earth Pressure

In accordance with Clause 6.14 of the current version of CHBDC, retaining structures should be designed using dynamic earth pressure coefficients that incorporate the effects of earthquake loading. The following recommendations are per Section C6.14 of the Commentary of the CHBDC which states that seismically induced lateral soil pressures may be calculated using the Mononobe-Okabe Method with:

- k_h = ½ * F(PGA) * PGA, for structures that allow 25 to 50 mm of movement, and
- k_h = F(PGA) * PGA, for non-yielding walls

The coefficients of horizontal earth pressure for combined static and seismic loading presented in Table 10-2 may be used. The provided earth pressure coefficients are based on Seismic Site Classes B, D and E are presented in Table 10-7, Table 10-8 and Table 10-9, respectively. Please see Section 8.2 for the respective PGA and F(PGA) values.

Table 10-7: Combined Static and Seismic Earth Pressure Coefficients – Site Class B (2,475-year)

Condition	Pit Sourced OPSS Granular A $\phi = 35^o$, $\gamma = 22.8$ kN/m^3	Quarry Sourced OPSS Granular A $\phi = 40^o$, $\gamma = 22.8$ kN/m^3	Quarry Sourced OPSS Granular B Type II $\phi = 42^o$, $\gamma = 22.8$ kN/m^3
Coefficient of Active Earth Pressure, K_{AE} (Restrained Wall)	0.39	0.33	0.30
Coefficient of Active Earth Pressure, K_{AE} (Unrestrained Wall)	0.33	0.27	0.25

Table 10-8: Combined Static and Seismic Earth Pressure Coefficients – Site Class D (2,475-year)

Condition	Pit Sourced OPSS Granular A $\phi = 35^o$, $\gamma = 22.8$ kN/m^3	Quarry Sourced OPSS Granular A $\phi = 40^o$, $\gamma = 22.8$ kN/m^3	Quarry Sourced OPSS Granular B Type II $\phi = 42^o$, $\gamma = 22.8$ kN/m^3
Coefficient of Active Earth Pressure, K_{AE} (Restrained Wall)	0.44	0.37	0.34
Coefficient of Active Earth Pressure, K_{AE} (Unrestrained Wall)	0.35	0.28	0.26

Table 10-9: Combined Static and Seismic Earth Pressure Coefficients – Site Class E (2,475-year)

Condition	Pit Sourced OPSS Granular A $\phi = 35^o$, $\gamma = 22.8$ kN/m^3	Quarry Sourced OPSS Granular A $\phi = 40^o$, $\gamma = 22.8$ kN/m^3	Quarry Sourced OPSS Granular B Type II $\phi = 42^o$, $\gamma = 22.8$ kN/m^3
Coefficient of Active Earth Pressure, K_{AE} (Restrained Wall)	0.48	0.40	0.37
Coefficient of Active Earth Pressure, K_{AE} (Unrestrained Wall)	0.36	0.30	0.28

The total pressure due to combined static and seismic loads acting at a specific depth below the top of the wall may be determined using the following equation that includes consideration of material properties and the soils profile.

$$\sigma_h = K * \gamma * d + (K_{AE} - K_A) * \gamma * (H - d)$$

where:

σ_h = lateral earth pressure at depth d (kPa)
d = depth below the top of the wall (m)
K = static earth pressure coefficient
(K_A for yielding walls, K_o for non-yielding walls)
γ = unit weight of retained soil, use submerged unit weight below groundwater level
K_{AE} = combined static and seismic earth pressure coefficient
H = total height of the wall (m)

10.6 Embankment Fill

Embankments should be constructed in accordance with OPSS.PROV 206. Marine clay must not be used as embankment fill.

10.6.1 Embankment Stability

The slope stability analyses were carried out using GeoStudio 2020 Slope/W software for limit equilibrium analysis. Input parameters for the embankment fill and foundation soils for the analysis are based on the SPT N values, observations in the field and the results of laboratory testing. The stability analyses outputs are provided in Appendix G. Each output figure shows the slope geometry, groundwater conditions, soil stratigraphy and soil strength parameters utilized in the analysis.

Table 6.2 of the CHBDC for embankment fills with a typical degree of understanding and a Ψ of 1.0 generates minimum Factors of Safety of 1.5 and 1.3 for static permanent and static temporary conditions respectively**.**

For seismic analysis, Table 6.3 in Section 6.14.4.1 of the CHBDC indicates a minimum resistance factor of 0.95 ($\varphi_{gu,\ static(temporary)} = 0.75 + 0.2$) for force-based design and 1.0 for performance-based design. Based on these values and Ψ of 1.0, a target Factor of Safety of 1.1 for this temporary condition with a typical degree of understanding is appropriate for the pseudo-static seismic analysis. However, as is stated in Section 6.14.9.1, some embankment displacement can occur where the pseudo-static Factor of Safety is less than 1.3; in this case, the bridge foundations must be designed to withstand the permanent deformations and/or slope stabilizing measures shall be incorporated into the design. Where the pseudo-static Factor of Safety is greater than 1.3, the slope is considered to be seismically stable with deformations of less than 50 mm.

Typically, where the initial 1 in 2,475-year pseudo-static analyses generates a Factor of Safety less than 1.3, a screening level deformation check should be completed where there are potential implications to the bridge foundations or embankment slopes. For this site, the simplified deformation analysis outlined in Bray and Travasarou (2007)[ii] was used. This analysis uses a semi-empirical predictive relationship with earthquake magnitude, yield acceleration and PGA to estimate permanent deformations due to earthquake loading.

In addition, Sections 6.14.2.1 and 6.14.2.3 of the CHBDC present performance criteria requirements for Major Route geotechnical systems (embankments) inside and outside the bridge interface zone, respectively. Based on Clause 6.14.2.2, the bridge interface zone at this site extends to 20 m behind the abutment (based on a fill height of 8.1 m). The performance criteria for the Major Route embankments are as follows:

- Within the bridge interface zone (bridge approaches): 100% of the travelled lanes shall be available for use following a ground motion event with a return period of at least 475 years.
- Outside the bridge interface zone (beyond bridge approaches): sites that fall within Seismic Performance Category 2 or 3 (See Section 8) shall have at least 50% of travelled lanes, but not less than one, available for use following ground motions with a return period of at least 475 years.

As per Table 4.8 of the CHBDC, the following seismic site classes have been calculated for each approach embankment for a 1 in 475-year event.

Table 10.9: Seismic Site Class for a 475-year Event

Location	Site Class	PGA_{ref}	F(PGA)	PGA
County Road 6 South Approach	E	0.06	1.81	0.14
County Road 6 North Approach	D	0.06	1.13	0.10

To assess this performance criteria for the embankments, an additional pseudo-static analysis was run considering the 1 in 475-year event. Where the critical factor of safety was above 1.1 and the slip surface did not “daylight” past the minimum allowable lane width, the slope was considered to have met the performance criteria.

10.6.1.1 Highway 17 Embankments near Deil’s Creek Culverts

It is assumed that the reinstated Highway 17 embankment (future eastbound) will have a similar height and footprint to the existing; the existing embankment height is approximately 1.4 m. If the embankment is reinstated to conventional 2H:1V slopes, the stability of the embankment should not change.

It is further assumed that the proposed Highway 17 westbound lanes will have a similar height and footprint to the reinstated Highway 17 embankment (future eastbound) and should therefore also be stable.

10.6.1.2 County Road 6 Underpass

Embankment stability has been assessed at the following locations:

- South Approach (perpendicular to CR6)
- North Approach (perpendicular to CR6)
- Underpass South Abutment (parallel to CR6)

The following additional parameters and assumptions were used in the analysis:

- The soil stratigraphy is based on the nearest boreholes.
- A midpoint fill height of 8.1 m (adjacent to north and south abutments).
- The loose alluvial/organic deposits within the existing Deil's Creek alignment and the existing culvert are removed prior to the placement of the embankment fill at the north abutment.
- Approach embankment: options for conventional 2H:1V SSM/Granular B Type I, 1.25H:1V rockfill or retaining wall.
- Mid-height 2m wide benches were used for conventional SSM/Granular B Type I slopes.
- For the cases parallel to County Road 6 (towards the highway) the existing fill was removed and replaced with GA or Rockfill in front of the abutment.
- Retaining walls: concrete retaining walls must be founded at or below the frost depth outlined in Section 7.3 on a granular pad as outlined in Section 10.4.3.1. The recommendations provided for retaining walls are based on the strength parameters of quarry-source Granular A material.
- A horizontal coefficient equal to ½ of the site adjusted PGA value was used for the initial 1-2475 year seismic analysis, as per Section 4.4.3.3, of the CHBDC and outlined in Section 8.2 above (see Tables below for horizontal coefficient used).
- A horizontal coefficient equal to ½ of the site adjusted PGA value was used for the subsequent 1-475 year seismic analysis, as per Section 4.4.3.3, of the CHBDC and outlined in Section 10.6.1 above (see Tables below for horizontal coefficient used).
- Rock fill strength has been modelled using a non-linear envelope based on vertical confining stresses. Guidance was obtained from AASHTO LRFD Bridge Design Specifications, 8th Edition (September 2017)[iii] Figure 10.4.6.2.4 1 using a Rock Fill Grade of "D" which varies the secant friction angle based on effective normal stress. An interpretation of the shear normal plot is provided in Appendix G.
- A traffic surcharge of 17 kPa has been applied as a temporary load.

The stability analyses generated the following factor of safety values for the County Road 6 approach embankment design:

Table 10-10: Slope Stability Analysis Results for County Road 6 – North Approach (perpendicular)

Condition	Case	Factor of Safety		
		2H:1V [SSM/Granular BI]	**1.25H:1V** [Rockfill]	**Retaining Wall** [Granular A*]
Permanent	Long Term	1.6 (Fig G1-1)	1.8 (Fig G2-1)	1.5 (Fig G3-1)
Temporary (traffic loading)	Short Term	1.6 (Fig G1-2)	1.8 (Fig G2-2)	1.4 (Fig G3-2)
Temporary (seismic loading)	Pseudo-Static, 2,475-yr Site Class D – 0.13g	1.2** (Fig G1-3)	1.4 (Fig G2-3)	1.2** (Fig G3-3)
	Pseudo-Static, 475-yr Site Class D – 0.05g	1.4 (Fig G1-4)	-	1.4 (Fig G3-4)

Note: * Quarry Sourced Granular A, ** Less than 1.3, Deformation analysis carried out

Table 10-11: Slope Stability Analysis Results for County Road 6 – South Approach (perpendicular)

Condition	Case	Factor of Safety		
		2H:1V [SSM/Granular BI]	**1.25H:1V** [Rockfill]	**Retaining Wall** [Granular A*]***
Permanent	Long Term	1.6 (Fig G4-1)	1.7 (Fig G5-1)	1.5 (Fig G6-1)
Temporary (traffic loading)	Short Term	1.6 (Fig G4-2)	1.7 (Fig G5-2)	1.4 (Fig G6-2)
Temporary (seismic loading)	Pseudo-Static, 2,475-yr Site Class E – 0.15g	1.1** (Fig G4-3)	1.3 (Fig G5-3)	1.2** (Fig G6-3)
	Pseudo-Static, 475-yr Site Class E – 0.07g	1.4 (Fig G4-4)	-	1.3 (Fig G6-4)

Note: * Quarry Sourced Granular A, ** Less than 1.3, Deformation analysis carried out
*** See Figure for assumptions related to material geometry; 0.5m sub-excavation backfilled with GA required

Table 10-12: Slope Stability Analysis Results for County Road 6 – South Approach (parallel)

Condition	Case	Factor of Safety	
		2H:1V*** [SSM/Granular BI]	**1.25H:1V***** [Rockfill]
Permanent	Long Term	1.5 (Fig G7-1)	1.5 (Fig G8-1)
Temporary (traffic loading)	Short Term	1.4 (Fig G7-2)	1.5 (Fig G8-2)
Temporary (seismic loading)	Pseudo-Static, 2,475-yr Site Class E – 0.15g	1.1** (Fig G7-3)	1.2** (Fig G8-3)
	Pseudo-Static, 475-yr Site Class E – 0.07g	1.3 (Fig G7-4)	1.3 (Fig G8-4)

Note: * Quarry Sourced Granular A, ** Less than 1.3, Deformation analysis carried out
*** See Figures for assumptions related to material geometry

All of the static design analyses (temporary/traffic and permanent conditions) presented above meet or exceed the target Factors of Safety. Note the Granular A geometry requirements at the south approach (parallel cases) and the retaining wall at the south approach.

For the seismic analysis, all of the analyses meet or exceed the target Factor of Safety of 1.1 for seismic design for a 1 in 2,475-year seismic event. However, only the rockfill embankments perpendicular to the road meet or exceed a Factor of Safety of 1.3 for the same event. All other analyses yielded factor of safety values below 1.3, thus, the simplified deformation analysis outlined in Bray and Travasarou (2007)[iii] was carried out. The results of the deformation analyses indicate that displacements of up to about 15 mm could be expected.

These anticipated deformations are less than the typically acceptable value of 50 mm. Nonetheless they should be evaluated to ensure they are acceptable in the structural design. If not, additional measures should be incorporated into the design to stabilize the slopes.

Additional analysis was carried out to determine if performance criteria were met for the major Route geotechnical systems inside and outside the bridge interface zone. A 1 in 475-year pseudo-static analyses was completed using the full PGA. In all instances, the projected failure surfaces indicated that the performance requirements would be met.

10.6.1.3 Highway 17 / County Road 6 High Fill Ramps

Embankment stability has been assessed at the following locations:

- N-E Ramp (perpendicular to ramp)
- E-NS Ramp (perpendicular to ramp)
- SW Ramp (perpendicular ramp)

The following additional parameters and assumptions were used in the analysis:

- The soil stratigraphy is based on the nearest boreholes.
- A maximum fill height of:
  - N-E Ramp at Sta. 23+267: 8.3 m (GS elev.137.2 m; Pavement elev. 145.5 m)
  - E-NS Ramp at Sta. 23+560: 9.0 m (GS elev. 132.5 m; Pavement elev. 141.5 m)
  - S-W Ramp at Sta. 23+845: 8.0 m (GS elev. 133.5 m; Pavement elev. 141.5 m)
- The loose alluvial/organic deposits within the existing Deil's Creek alignment are removed prior to the placement of the embankment fill.
- Options for conventional 2H:1V SSM/Granular B Type I or 1.25H:1V rockfill.
- Mid-height 2m wide benches were used for all 2H:1V SSM/Granular B Type I slopes.
- A horizontal coefficient equal to ½ of the site adjusted PGA value was used for the initial 1-2475-year seismic analysis, as per Section 4.4.3.3, of the CHBDC and outlined in Section 8.2 above (see Tables below for horizontal coefficient used).

- A horizontal coefficient equal to ½ of the site adjusted PGA value was used for the subsequent 1-475-year seismic analysis, as per Section 4.4.3.3, of the CHBDC and outlined in Section 10.6.1 above (see Tables below for horizontal coefficient used).
- Rock fill strength has been modelled using a non-linear envelope based on vertical confining stresses. Guidance was obtained from AASHTO LRFD Bridge Design Specifications, 8th Edition (September 2017)[iii] Figure 10.4.6.2.4 1 using a Rock Fill Grade of "D" which varies the secant friction angle based on effective normal stress. An interpretation of the shear normal plot is provided in Appendix G.
- A traffic surcharge of 17 kPa has been applied as a temporary load.

The stability analyses generated the following factor of safety values for the Highway 17 / Country Road 6 high fill ramp embankment design:

Table 10-13: Slope Stability Analysis Results for Highway 17 / County Road 6 – N-E Ramp

Condition	Case	Factor of Safety	
		2H:1V [SSM/Granular BI]	**1.25H:1V** [Rockfill]
Permanent	Long Term	1.6 (Fig G9-1)	1.5 (Fig G10-1)
Temporary (traffic loading)	Short Term	1.6 (Fig G9-2)	1.5 (Fig G10-2)
Temporary (seismic loading)	Pseudo-Static, 2,475-yr Site Class E – 0.15g	1.1* (Fig G9-3)	1.1* (Fig G10-3)
	Pseudo-Static, 475-yr Site Class E – 0.07g	1.3 (Fig G9-4)	1.3 (Fig G10-4)

* Less than 1.3, Deformation analysis carried out

Table 10-14: Slope Stability Analysis Results for Highway 17 / County Road 6 – E-NS & SW Ramp

Condition	Case	Factor of Safety	
		2H:1V [SSM/Granular BI]	**1.25H:1V** [Rockfill]
Permanent	Long Term	1.6 (Fig G11-1)	1.5 (Fig G12-1)
Temporary (traffic loading)	Short Term	1.6 (Fig G11-2)	1.5 (Fig G12-2)
Temporary (seismic loading)	Pseudo-Static, 2,475-yr Site Class D – 0.13g	1.1* (Fig G11-3)	1.2* (Fig G12-3)
	Pseudo-Static, 475-yr Site Class D – 0.05g	1.4 (Fig G11-4)	1.4 (Fig G12-4)

* Less than 1.3, Deformation analysis carried out

All of the static design analyses presented above meet or exceed the target Factors of Safety.

For the seismic analysis, all of the analyses meet or exceed the target Factor of Safety of 1.1 for seismic design for a 1 in 2475-year seismic event (Table 10-13 and Table 10-14). However, all pseudo static analyses yielded factor of safety values below 1.3 for a 1 in 2475-year event, thus, the simplified deformation analysis outlined in Bray and Travasarou (2007)[iii] was carried out. The results of the deformation analyses indicate that displacements of up to about 20 mm could be expected. These anticipated deformations are less than the typically acceptable value of 50 mm.

A subsequent analysis was carried out to determine if the performance criteria were met for the major Route geotechnical systems outside the bridge interface zone. A 1 in 475-year pseudo-static analyses was completed using the full PGA. In all instances, the projected failure surfaces indicated that the performance requirements would be met.

10.6.2 Embankment Settlement

Construction of the new embankments for underpass bridge and associated ramps will require placement of significant thicknesses of embankment fill. Based on the preliminary design profiles and general arrangement drawings available at the time of preparation of this report, the underpass approach embankments will range up to about 9.0 m high.

The loading imposed from the new fill will increase the effective stress in underlying soil deposits and induce elastic settlement in the granular deposits at the site. As noted previously in this report, the behaviour of the clayey silt layer was generally observed to be non-cohesive. However, in order to provide a conservative assessment of settlement for this site we have utilized consolidation parameters for the clayey silt layers encountered south of Highway 17. Settlement analyses were carried out using the software Settle3 (Version 5) by Rocscience.

In accordance with MTO's document "Embankment Settlement Criteria for Design" (March 2, 2010), the criteria adopted for embankment design at this site is as follows:

Table 10-15: Summary of MTO Settlement Criteria

Distance from Abutment	0-20 m	20-50 m	50-75 m	>75 m	Post Construction Settlement Period
Settlement Limits Non-Freeway	25 mm	50 mm	100 mm	200 mm	15 years

Representative site stratigraphy was developed based on the Record of Borehole logs with material properties based on the results of in-situ field testing and laboratory testing. The design stratigraphy considered material parameters of the clayey silt deposit based on laboratory results of similar deposits encountered elsewhere on the project and engineering judgement.

The soil parameters used in the models are summarized in Table 10-16, below.

Analyses were carried out to calculate the predicted settlement with time, considering SSM embankments with 2H:1V slopes and a unit weight of 21 kN/m^3. The modeled embankment thicknesses and resulting settlements at each location are described in the sections below. If rockfill embankments are selected, the settlement will be slightly less than those reported in the following sections. See Section 10.6.2.1 for comments on long-term settlement in rockfill embankments.

Table 10-16 Summary of Material Parameters

Soil Type	Thickness (m)	Unit Weight (kN/m^3)	Settlement Parameters				
			P_c' (kPa)	C_c	C_r	c_v (cm^2/s)	c_{vr} (cm^2/s)
Area A – North of Highway 17[a]							
Sandy Silt to Sand	0 – 2.1	18	E_s = 2 – 5 MPa				
Silty Sand (Till)	0.5 – 2.6	21	E_s = 25 – 60 MPa				
Area B – South of Highway 17[b]							
Silty Sand to Sand	1.5 – 2.2	19	E_s = 10 – 14 MPa				
Clayey Silt	3.9 – 4.6	18	200	0.15	0.015	0.005	0.015
Silty Sand (Till)	1.2 – 2.7	21	E_s = 10 – 15 MPa				

Notes: [a] refer to Section 5.1 for description of Area A
[b] refer to Section 5.2 for description of Area B

It is anticipated that all settlement of the native soils at the County Road 6 Interchange due to imposed loads is expected to occur during the period of fill placement and should be predominantly completed at end of construction.

10.6.2.1 Rockfill Embankments (General)

The following section is applicable if rockfill embankments are selected for construction.

Settlement of the rock fill, due to particle re-orientation and degradation of the interparticle contact, is expected at a decreasing rate over time. In accordance with the MTO document “Post-Construction Rock Fill Settlement and Guidelines for Estimating Rock Fill Quantity” (April 12, 2010), the estimated magnitude of this settlement for compacted rock fill placed in the dry is expected to range from 0.50 to 0.75% of the fill height within 1 year of construction (90% in the first 6 months) and a further 0.1% of the embankment height after the 1 year period.

Based on the maximum fill height of 9.0 m, this would yield a settlement of 60 mm within 6 months and an additional 20 mm after 6 months.

Should slope flattening of the rock fill embankments be used on site with surplus excavated material, slope protection and drainage measures will be required to ensure the long-term surficial stability of the embankment slopes, see Section 11.4. Slope flattening should meet the requirements of OPSD 202.010 and OPSD 202.020.

10.6.2.2 County Road 6 Underpass and Deil's Creek Culvert (County Road 6)

The following settlement is expected in the soils beneath the embankments at the County Road 6 Underpass and Deil's Creek Culvert crossing County Road 6:

- North Abutment: Max Fill Height is 8.1 m; Settlement of 40 to 50 mm (immediate)
- South Abutment: Max Fill Height is 8.1 m; Settlement of up to 90 mm
- Deil's Creek Culvert: Max Fill Hight is 8.0 m; Settlement of less than 25 mm (immediate)

Settlement at the north abutment and Deil's Creek would be elastic and occur entirely during fill placement. Settlement at the south abutment would be a combination of elastic and consolidation settlement, with greater than 65 mm occurring in the first month. Long term post construction settlement will be less than 25 mm.

If deep foundations are installed prior to the placement of the fill at the south abutment, downdrag loads will need to be considered (see Sections 10.1.2.2 and 10.1.3.2). Should the south abutment piles or caissons be driven/constructed prior to construction of the embankment, downdrag loads would be subsequently imposed on the deep foundation elements. Depending on the project schedule and sequencing of embankment and foundation construction, preloading (pre-constructing) the south embankment for a period of 2 to 3 months prior to constructing the deep foundations is recommended. It is recommended that the roadway is not paved until after this settlement has occurred.

Consideration could also be given to construction of the embankment with lightweight fill to reduce the imposed load on the compressible soil at the site and, therefore, reduce the anticipated settlement of the embankment.

Concrete wingwalls / retaining walls may not be able to accommodate the settlement described above without preloading or use of lightweight fill. Alternative options are designing an RSS wall that can accommodate the settlement or cantilevering the wingwalls / retaining walls off of the abutment.

Regardless of construction methodology, monitoring of the embankment during construction would be required to determine the actual rate and magnitude of settlement of the embankment. A suitable settlement monitoring program should be required by the Contract. The detailed requirements of the requisite settlement monitoring plan should be determined at the detailed design stage by the design-build team following completion of the structural design, foundation design requirements, and final embankment geometries.

10.6.2.3 Deil's Creek Culverts (Highway 17)

It is assumed that the reinstated Highway 17 embankment (future eastbound) will have a similar height and footprint to the existing. Further, the proposed culvert opening is greater than the existing, thus, the construction represents a net unloading. No additional settlement is expected along the existing alignment. However, settlement should be reviewed if the embankments are widened or reinstated to design grades greater than the existing grades.

The proposed Highway 17 westbound lanes will result in a fill height of about 1.4 m across the proposed culvert. This fill placement will result in approximately 40 mm of settlement in the underlying soils. It is anticipated that the settlement in the vicinity of the culvert will be elastic and will be completed during fill placement.

10.6.2.4 County Road 6 High Fill Embankment Ramps

The following settlement is expected to occur in the soils beneath the high fill ramps:

- NS-E Ramp; Max Fill Hight is 8.3 m; Settlement of 90 mm
- E-NS Ramp; Max Fill Height is 9.0 m; Settlement of 75 mm (immediate)
- NS-W Ramp; Max Fill Height is 8.0 m; Settlement of less than 25 mm (immediate)

Settlement at the E-NS Ramp and NS-W Ramp would be elastic and occur entirely during fill placement. Settlement at the NS-E Ramp would be a combination of elastic and consolidation settlement, with greater than 65 mm occurring in the first month. Long term post construction settlement will be less than 25 mm for all three ramps assessed.

It is noted that the W-NS Ramp is not considered to be a high fill, thus settlement has not been evaluated.

The settlement at the NS-E Ramp due to the embankment loads will be largely complete within the first month. It is recommended that the roadway is not paved until after this settlement has occurred. Monitoring of the embankment during construction would be required, as described in Section 10.6.2.2.

10.7 Cement Type and Corrosion Potential

Chemical analysis for determination of pH, water soluble sulphate, sulphides, chloride concentrations, resistivity and electrical conductivity was carried out on samples of the native materials. The analysis results are summarized in Section 5.5 and a copy of the test results is provided in Appendix C.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The test results provided in Section 5.5 were compared with Table 3.2 of the MTO Gravity Pipe Design Guideline and generally indicate a severe corrosive environment; note a sample of the fill in CV-15 indicated a low corrosive environment. The test results provided in Section 5.5 may be used to aid in the selection of coatings and corrosion protection systems for buried steel objects.

The concentration of soluble sulphate provides an indication of the degree of sulphate attack that is expected for concrete in contact with the soil and groundwater at the site. The sulphate results in were compared with Table 3 of Canadian Standards Association Standards A23.1-19 (CSA A23.1) and indicate a low degree of sulphate attack potential on concrete structures at this site.

The corrosive effects of road de-icing salts should also be considered.

11 CONSTRUCTION CONSIDERATIONS

11.1 Temporary Excavations

All temporary excavations must be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of OHSA, the silty sand and clayey silt soils are considered Type 3 soils. Unsupported excavations made in Type 3 soils must have side slopes no steeper than 1H:1V from the base of the excavation. **Side slopes for excavations through more than one soil type must be entirely based on the highest soil type number.**

Excavation should be carried out in accordance OPSS.PROV 902. The management and disposal of excess material shall be in accordance with OPSS.PROV 180. Excavations will extend into the underlying native soil deposits and bedrock. Selection of the equipment and methodology to excavate and prepare the founding surface is the responsibility of the Contractor. Stockpiling or surface surcharge should not be allowed on the embankment or side slopes.

Although not anticipated, at locations where there are space restrictions, the excavations could be carried out within a protection system. Further discussion on temporary protection systems (TPS) is presented in Section 11.2.

11.2 Temporary Protection Systems

Temporary Protection Systems (TPS) could be used for excavation support or groundwater control, they must be implemented in accordance with OPSS.PROV 539 and designed for Performance Level 2. The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. The protection system should be installed at a suitable distance away from the new structures to limit the disturbance to subgrade associated with removal of the protection system following completing of construction. Alternatively, the protection system near the structures could be left in place and cut off in accordance with OPSS.PROV 903 to limit the disturbance of subgrade during removal of the TPS.

Lateral earth pressure coefficients, under fully mobilized conditions, that can be used in design of the protection system installed through the embankment fill, abutment fill and culvert backfill are provided in Table 10-1. The lateral earth pressure coefficients for the underlying native soils are given below for a vertical wall and a horizontal backslope:

Existing Fill:

γ = 21.0 (kN/m^3 bulk unit weight of soil, to be adjusted below water)
K_A = 0.33
K_P = 3.0

Native clayey silt:

γ = 17.0 (kN/m^3 bulk unit weight of soil, to be adjusted below water)
K_A = 0.36
K_P = 2.8

Native sand to silty sand:

γ = 19.0 (kN/m^3 bulk unit weight of soil, to be adjusted below water)
K_A = 0.33
K_P = 3.0

Native till:

γ = 21.0 (kN/m^3 bulk unit weight of soil, to be adjusted below water)
K_A = 0.27
K_P = 3.69

The design of roadway protection is the responsibility of the Contractor. All protection systems should be designed by a licensed Professional Engineer experienced in such designs and retained by the Contractor. The design of the roadway protection system must incorporate traffic loading and surcharge loading due to construction equipment and operations.

The use of sheet piles is generally not considered feasible across the site due to potential obstructions such as cobbles and boulders in the till, variable bedrock elevation and the limited thickness of native soils that may not provide sufficient depth to achieve lateral stability. In addition, there will be high lateral earth pressures associated with the embankment (retained heights of up to 8.1 m); tie back anchors consisting of soil anchors installed within the till or rock may be required to maintain stability. The use of deadman anchor blocks or internal bracing could also be considered.

A soldier pile and lagging system is a feasible option. It may be necessary to predrill for the soldier piles. Lateral support may need to be enhanced by socketing the soldier piles into bedrock and/or by using bracing or rakers. Suggested wording for an NSSP for obstructions is included in Appendix I.

11.3 Surface and Groundwater Control

The existing Deil's Creek crosses Highway 17 east of the existing intersection and crosses County Road 6 north of existing Highway 17. The flow in the creek is from the south to the north under Highway 17 and east to west under County Road 6 (almost 90° bend north of Highway 17). Based on the GA prepared by Parson's (See Appendix F), the creek will be realigned to cross the proposed Highway 17 westbound embankment and cross County Road 6 25 m north centreline of the north abutment of the new underpass. Based on this information, the replacement of the Deil's Creek culvert beneath existing Highway 17 will be the only foundation constructed within the existing creek channel and thus the only site requiring creek diversion.

Subgrade preparation and placement and compaction of granular bedding/pads or mass concrete for culvert, footing and retaining wall construction must be carried out in the dry. Based on the groundwater elevation at the time of the investigation, it is anticipated that the site will require dewatering to lower the groundwater to below the final excavation or footing level (minimum of 0.5 m below the underside of the planned excavation base prior to each stage of excavation). Furthermore, surface runoff will tend to seep into and accumulate into the excavations.

The Contractor must control groundwater, perched groundwater and surface water flow at the site with a properly designed dewatering system to permit construction in a dry and stable excavation. The dewatering system will be required to remain operational and effective until the temporary excavations are backfilled and then should be decommissioned and removed. Creek diversion may be required for the replacement of the existing Deil's Creek Culvert crossing Highway 17.

The design of dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP No. FOUN0003 which amends OPSS 902 and SP517F01 which amends OPSS.PROV 517. Given the site conditions and anticipated works, the Designer Fill-In ***** in SP517F01 Table A should be "No"; the design Engineer and design-checking Engineer do not need a minimum of 5 years of experience in designing similar dewatering systems. A preconstruction survey is not required, thus Designer Fill-In ** in this SP should be "NA".

The water level will fluctuate and the minimum groundwater elevation for the site at the time of the excavation should be taken as the expected high-water level defined in SP517F01 and SP FOUN0003.

A sheet pile cofferdam enclosure might be difficult to install at this site (Discussion in Section 11.2). Alternative dewatering methods such as a sandbag cofferdam with sump pumps to extract water from the excavation are likely sufficient.

Further assessment of dewatering requirements and the need for a Permit to take Water (PTTW) should be carried out by specialists experienced in this field.

It is noted that a Hydrogeological Investigation and Design Report is under preparation for the Highway 17 Twinning Project. Please refer to that document for additional discussion on dewatering with respect to this assignment.

11.4 Erosion and Scour Control

The Contractor should provide silt fences and erosion control blankets as per OPSS 805 throughout the duration of construction to prevent transport of silt/sediment into the creek.

Slope protection and drainage measures will be required to ensure the long-term surficial stability of the earth and granular embankment slopes. A vegetation cover should be established on exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804. Slope vegetation should be established as soon as possible after completion of the embankment fills in order to limit surficial erosion.

Particle size analysis on samples of the existing soils indicate the following erodibility (based on Wischmeier Nomograph factor, K):

Fills	0.03 to 0.34 (Low to Moderate Erodibility)
Sandy Silt / Silty Sand	0.02 to 0.47 (Low to Moderate Erodibility)
Clayey Silt	0.38 to 0.55 (Moderate Erodibility)
Till	0.05 to 0.38 (Low to Moderate Erodibility)

Scour protection should be provided at the culvert inlet and outlet areas. Effective scour and erosion protection should be provided along the waterline, ditches and around culvert footings founded on soils. Design of the erosion protection measures at the creek must consider hydrologic and hydraulic factors and shall be carried out by specialists experienced in this field. Typically, rock protection as per OPSS.PROV 511 should be provided over all surfaces with which creek water is likely to be in contact. Treatment at the inlet and outlet of culverts shall be in accordance with OPSD 810.010.

Liaison between the Foundations Consultant, Structural Engineer and Hydraulic/Drainage Engineer will be required in design to ensure that scour protections, if required, is adequately addressed.

12 DESIGN AND CONSTRUCTION CONCERNS

The recommendations presented herein must be reassessed once the type, location and orientation of the foundation elements are established to ensure suitability given the variations in stratigraphy and bedrock elevation at the site.

The DB Contractor must review the existing factual information and determine the extent of additional field investigations and laboratory testing required to support the foundation design of the proposed structures. Of particular note at this site is the identification of potentially liquefiable soils at the abutment, approach fill and ramps on the south side of the highway; additional investigation and design is required.

The planned construction methodology includes open cut excavations for the installation of a bridge structure and three culverts. Potential construction concerns include, but are not necessarily limited to the following:

- Construction will extend below the water level in the creek. An adequate and effective surface water management and dewatering plan must be implemented to construct the foundations for all structural elements in the dry.

- The Contractor’s selection of construction equipment and methodology must include assessment of the capability of the existing soils to support the proposed construction equipment and supplies.
- Obstructions could be encountered in the existing embankment fill and may limit choice of equipment and methods used.
- The loose alluvial/organic deposits within the existing Deil’s Creek alignment shall be removed prior to the placement of the embankment fill at the north abutment.
- The bedrock elevation is variable across the site. Sloping bedrock will be encountered. A Notice to Contractor has been included in Appendix I.

The successful performance of the structure installations will depend largely upon good workmanship and quality control during construction. Observation of the excavation and backfilling operations will be required as per OPSS 902 during construction to confirm that the foundation recommendations are correctly implemented, and material specifications are met.

13 CLOSURE

Engineering analysis and preparation of this report was carried out by Deanna Pizycki, P.Eng., Matt Kennedy, P.Eng., and Dr. Fred Griffiths, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundation Projects.

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Report Prepared By:

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Sep 13, 2022
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Senior Geotechnical Engineer,
Senior Associate

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MTO Review Principal,
Senior Geotechnical Engineer

REFERENCES

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[i] Boulanger, R. W., and Idriss, I. M. (2014). CPT and SPT based liquefaction triggering procedures, Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 pp.6

[ii] Bray, J.D., and Travasarou, T. (2007). Simplified Procedure for Estimating Earthquake-Induced Deviatoric Slope Displacements

[iii] American Association of State Highways and Transportation Officials (2017). AASHTO LRFD Bridge Design Specification, Washington, D.C.

THURBER

Appendix A.

Borehole Location Plan and Stratigraphic Drawings

MINISTRY OF TRANSPORTATION, ONTARIO

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

CONT No
WP No

HIGHWAY 17 TWINNING
COUNTY ROAD 6

BOREHOLE LOCATION

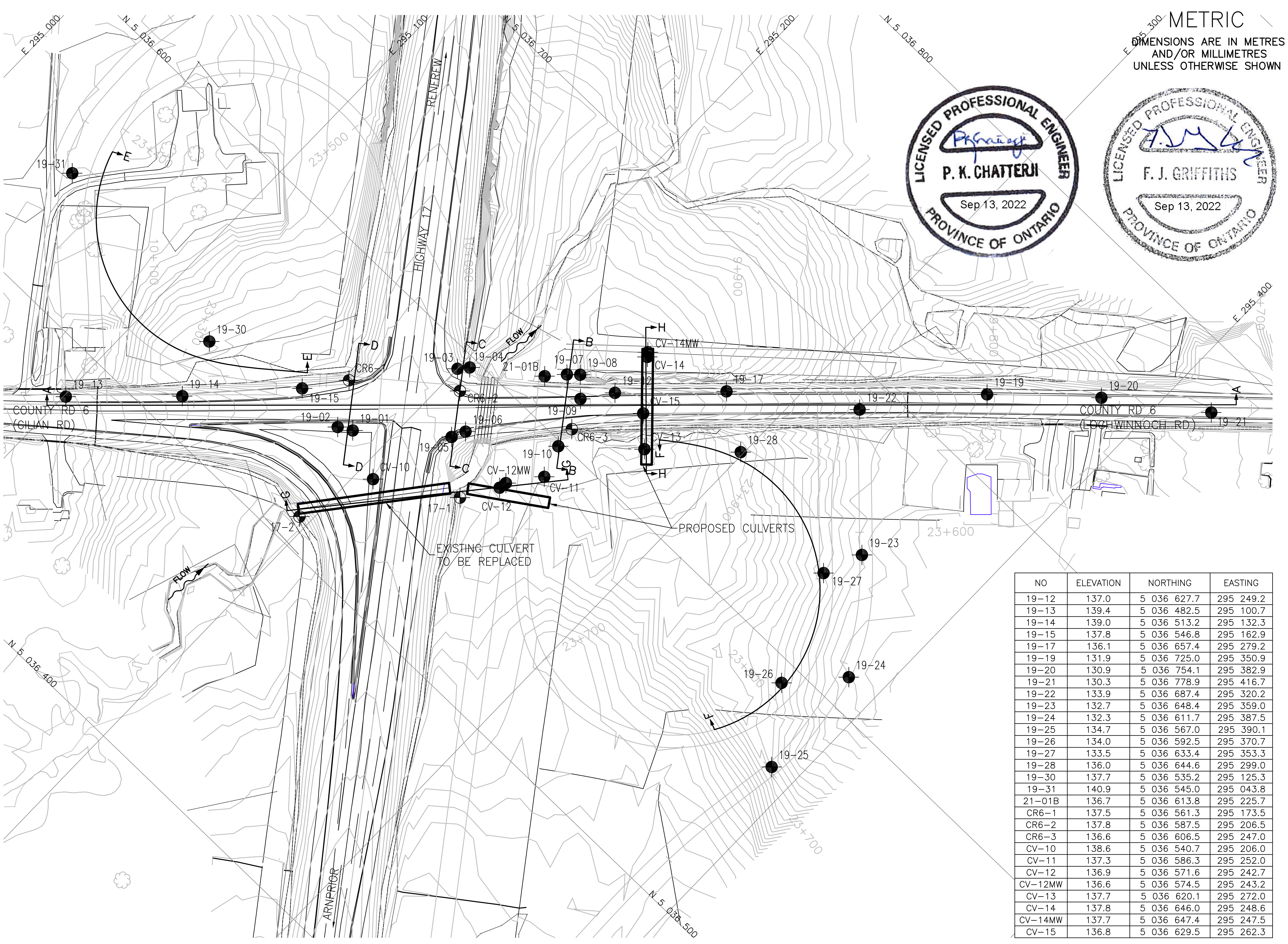
SHEET

Ontario

THURBER ENGINEERING LTD.

P. K. CHATTERJI
Sep 13, 2022

F. J. GRIFFITHS
Sep 13, 2022



PLAN OF COUNTY ROAD 6

20 0 20 40m H 1:1000

5 0 5 10m V 1:250

NO	ELEVATION	NORTHING	EASTING
19-12	137.0	5 036 627.7	295 249.2
19-13	139.4	5 036 482.5	295 100.7
19-14	139.0	5 036 513.2	295 132.3
19-15	137.8	5 036 546.8	295 162.9
19-17	136.1	5 036 657.4	295 279.2
19-19	131.9	5 036 725.0	295 350.9
19-20	130.9	5 036 754.1	295 382.9
19-21	130.3	5 036 778.9	295 416.7
19-22	133.9	5 036 687.4	295 320.2
19-23	132.7	5 036 648.4	295 359.0
19-24	132.3	5 036 611.7	295 387.5
19-25	134.7	5 036 567.0	295 390.1
19-26	134.0	5 036 592.5	295 370.7
19-27	133.5	5 036 633.4	295 353.3
19-28	136.0	5 036 644.6	295 299.0
19-30	137.7	5 036 535.2	295 125.3
19-31	140.9	5 036 545.0	295 043.8
21-01B	136.7	5 036 613.8	295 225.7
CR6-1	137.5	5 036 561.3	295 173.5
CR6-2	137.8	5 036 587.5	295 206.5
CR6-3	136.6	5 036 606.5	295 247.0
CV-10	138.6	5 036 540.7	295 206.0
CV-11	137.3	5 036 586.3	295 252.0
CV-12	136.9	5 036 571.6	295 242.7
CV-12MW	136.6	5 036 574.5	295 243.2
CV-13	137.7	5 036 620.1	295 272.0
CV-14	137.8	5 036 646.0	295 248.6
CV-14MW	137.7	5 036 647.4	295 247.5
CV-15	136.8	5 036 629.5	295 262.3

KEYPLAN

LEGEND

●	Borehole
⊕	Borehole (2003 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
∇	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-1	137.2	5 036 558.5	295 234.5
17-2	136.7	5 036 511.2	295 195.8
19-01	138.3	5 036 548.6	295 187.7
19-02	138.2	5 036 545.6	295 182.7
19-03	137.7	5 036 592.9	295 200.0
19-04	137.5	5 036 596.5	295 203.0
19-05	138.1	5 036 572.8	295 216.3
19-06	137.9	5 036 577.9	295 218.7
19-07	136.6	5 036 620.1	295 231.3
19-08	136.7	5 036 623.5	295 235.0
19-09	137.1	5 036 617.0	295 241.4
19-10	137.4	5 036 598.3	295 247.8

-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 9.

GEOCRES No. 31F-230

REVISIONS	DATE	BY	DESCRIPTION

DESIGN DP	CHK –	CODE	LOAD	DATE SEP 2022
DRAWN BH	CHK DP	SITE	STRUCT	DWG 1

FILENAME: H:\Drafting\24000\24726\TED-24726-BHPP-CR6.dwg
PLOTDATE: 2/18/2022 8:31 AM

CONT No
WP No

HIGHWAY 17 TWINNING
COUNTY ROAD 6

BOREHOLE SOIL STRATA

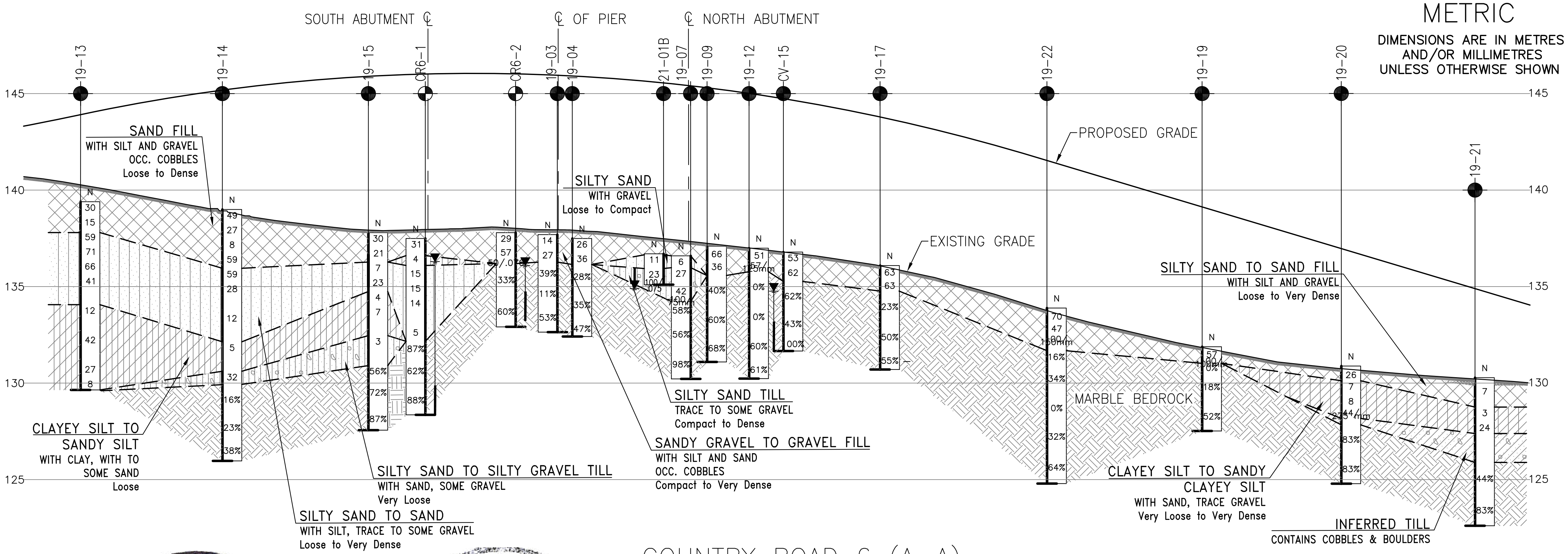
SHEET

Ontario

THURBER ENGINEERING LTD.

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN



COUNTRY ROAD 6 (A–A)

30 0 30 60m H 1:1500
5 0 5 10m V 1:250

P. K. CHATTERJI
Sep 13, 2022

F. J. GRIFFITHS
Sep 13, 2022

NO	ELEVATION	NORTHING	EASTING
19–17	136.1	5 036 657.4	295 279.2
19–19	131.9	5 036 725.0	295 350.9
19–20	130.9	5 036 754.1	295 382.9
19–21	130.3	5 036 778.9	295 416.7
19–22	133.9	5 036 687.4	295 320.2
21–01B	136.7	5 036 613.8	295 225.7
CR6–1	137.5	5 036 561.3	295 173.5
CR6–2	137.8	5 036 587.5	295 206.5
CR6–3	136.6	5 036 606.5	295 247.0
CV–15	136.8	5 036 629.5	295 262.3

KEYPLAN

LEGEND

●	Borehole
⊕	Borehole (2003 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
┃	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
19–03	137.7	5 036 592.9	295 200.0
19–04	137.5	5 036 596.5	295 203.0
19–05	138.1	5 036 572.8	295 216.3
19–06	137.9	5 036 577.9	295 218.7
19–07	136.6	5 036 620.1	295 231.3
19–08	136.7	5 036 623.5	295 235.0
19–09	137.1	5 036 617.0	295 241.4
19–10	137.4	5 036 598.3	295 247.8
19–12	137.0	5 036 627.7	295 249.2
19–13	139.4	5 036 482.5	295 100.7
19–14	139.0	5 036 513.2	295 132.3
19–15	137.8	5 036 546.8	295 162.9

-NOTES-

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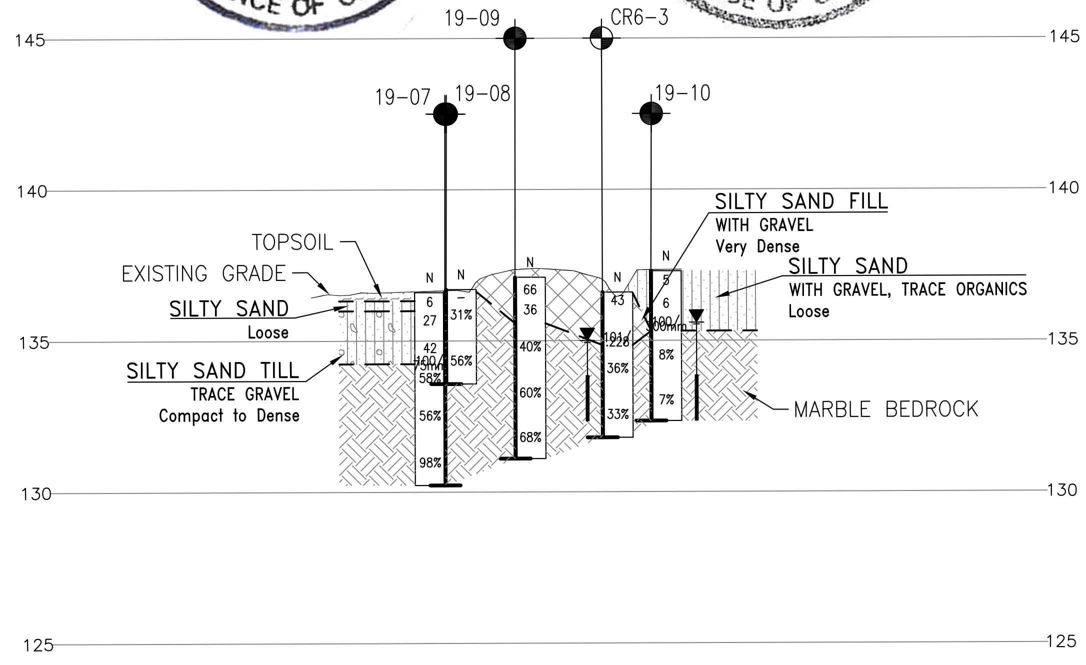
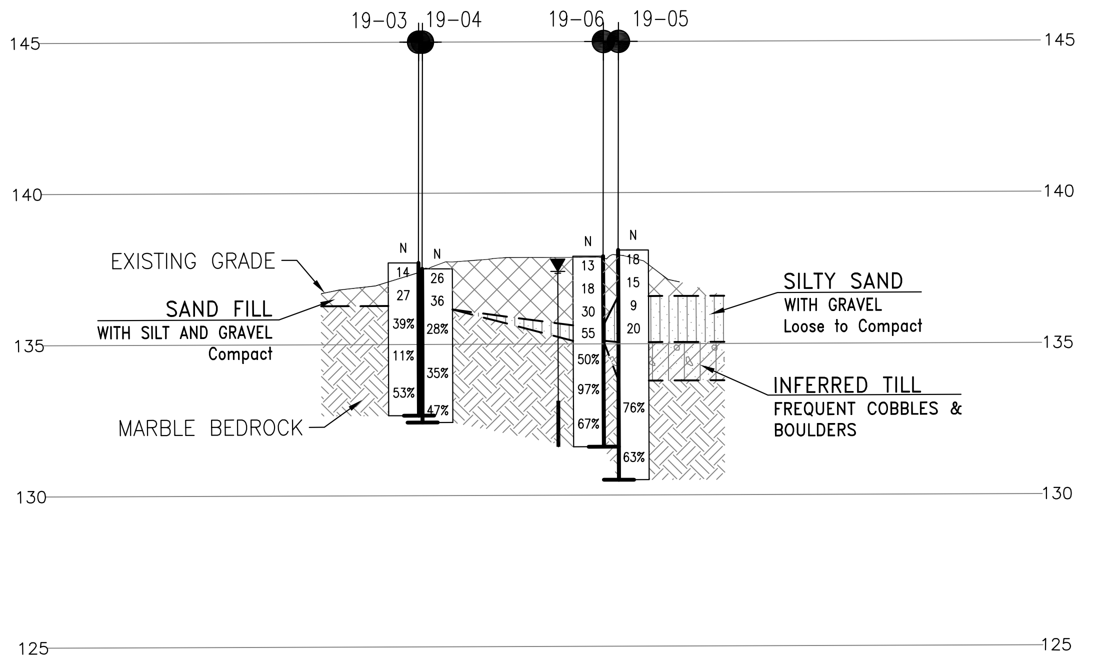
3) Coordinate system is MTM NAD 83 Zone 9.

GEOCRES No. 31F-230



NORTH ABUTMENT (B–B)

20 0 20 40m H 1:1000
5 0 5 10m V 1:250



PIER (C–C)

20 0 20 40m H 1:1000
5 0 5 10m V 1:250

REVISIONS	DATE	BY	DESCRIPTION	
DESIGN DP	CHK –	CODE	LOAD	DATE SEP 2022
DRAWN BH	CHK DP	SITE	STRUCT	DWG 2

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

CONT No
WP No

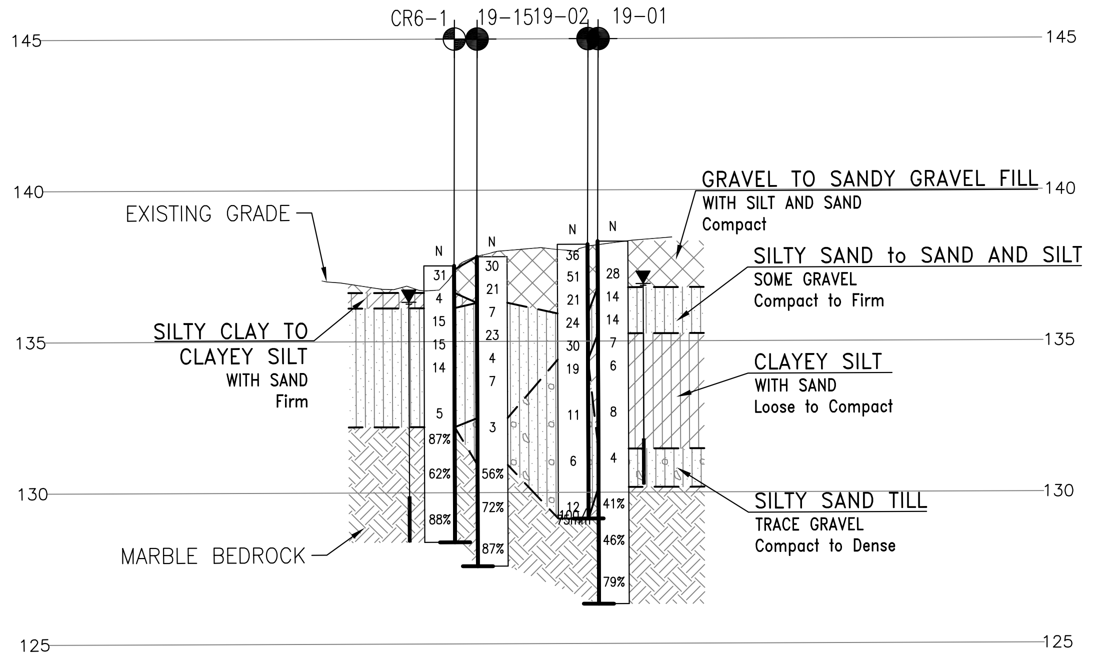
HIGHWAY 17 TWINNING
COUNTY ROAD 6

BOREHOLE SOIL STRATA

SHEET

Ontario

THURBER ENGINEERING LTD.



SOUTH ABUTMENT (D–D)

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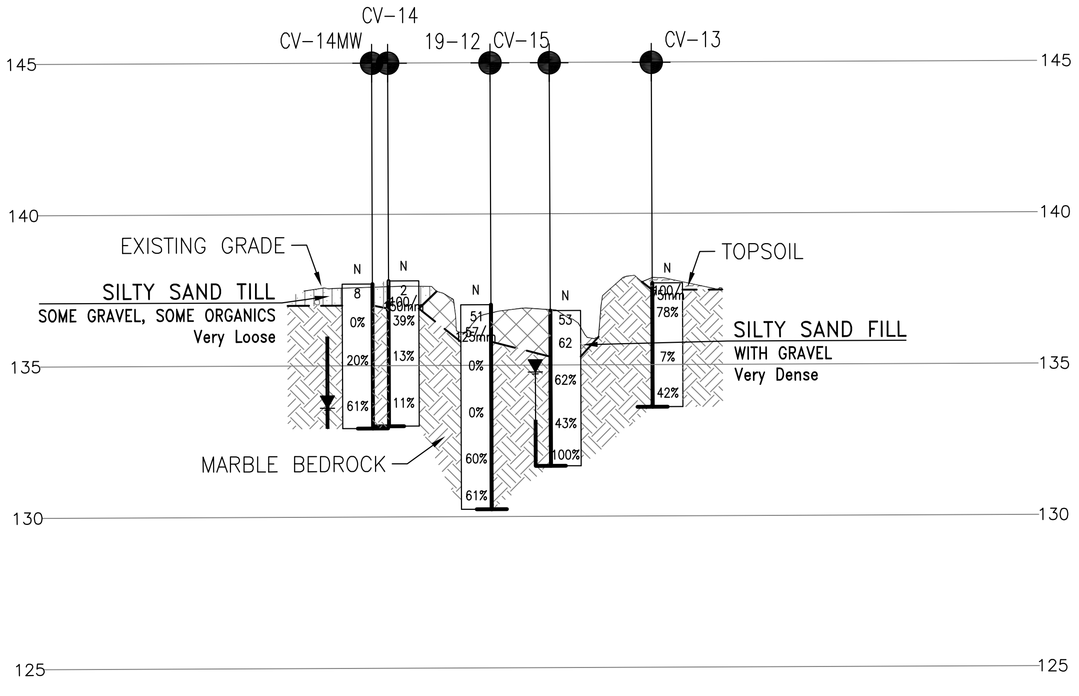


COUNTY ROAD 6 CULVERT (H–H)

20 0 20 40m H 1:1000
5 0 5 10m V 1:250

KEYPLAN

LEGEND

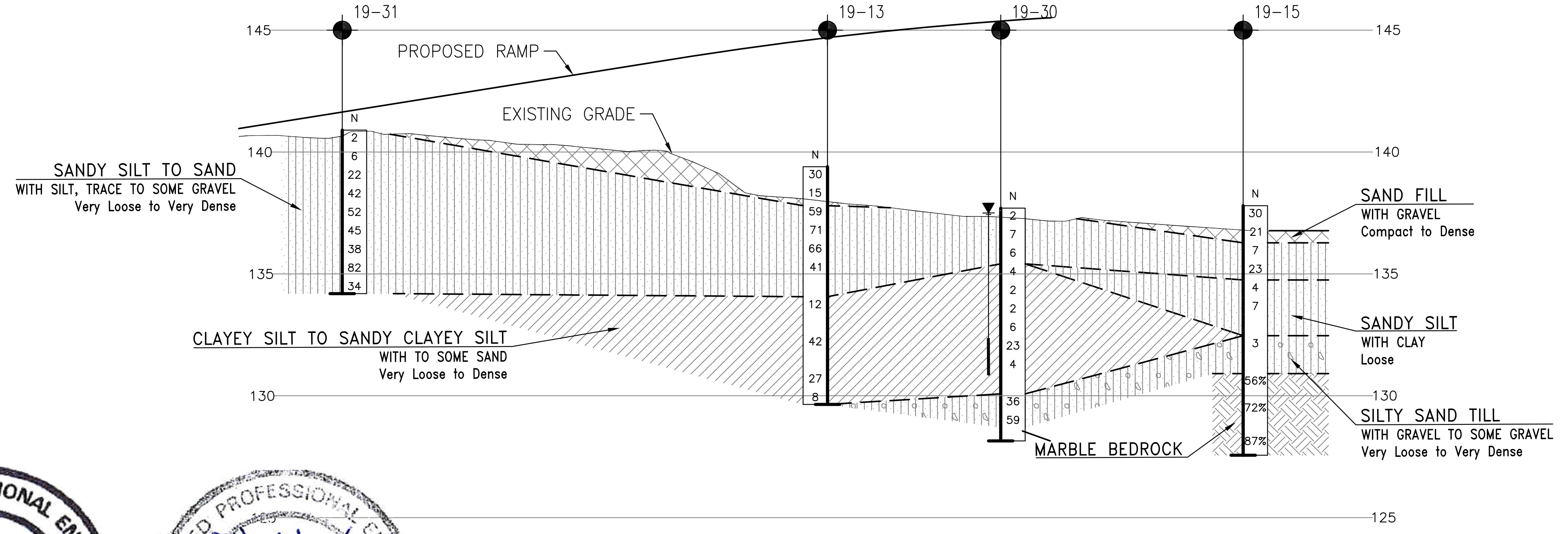
●	Borehole
⊕	Borehole (2003 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
┃	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
19–01	138.3	5 036 548.6	295 187.7
19–02	138.2	5 036 545.6	295 182.7
19–12	137.0	5 036 627.7	295 249.2
19–13	139.4	5 036 482.5	295 100.7
19–15	137.8	5 036 546.8	295 162.9
19–30	137.7	5 036 535.2	295 125.3
19–31	140.9	5 036 545.0	295 043.8
CR6–1	137.5	5 036 561.3	295 173.5
CV–13	137.7	5 036 620.1	295 272.0
CV–14	137.8	5 036 646.0	295 248.6
CV–14MW	137.7	5 036 647.4	295 247.5
CV–15	136.8	5 036 629.5	295 262.3

-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 9.

GEOCRES No. 31F-230



N–E RAMP (E–E)

20 0 20 40m H 1:1000
5 0 5 10m V 1:250

P. K. CHATTERJI
Sep 13, 2022

F. J. GRIFFITHS
Sep 13, 2022

REVISIONS			
	DATE	BY	DESCRIPTION

DESIGN DP	CHK –	CODE	LOAD	DATE SEP 2022
DRAWN BH	CHK DP	SITE	STRUCT	DWG 3

FILENAME: H:\Drafting\24000\24726\TED-24726-BHPP-CR6.dwg
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MINISTRY OF TRANSPORTATION, ONTARIO

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

CONT No
WP No

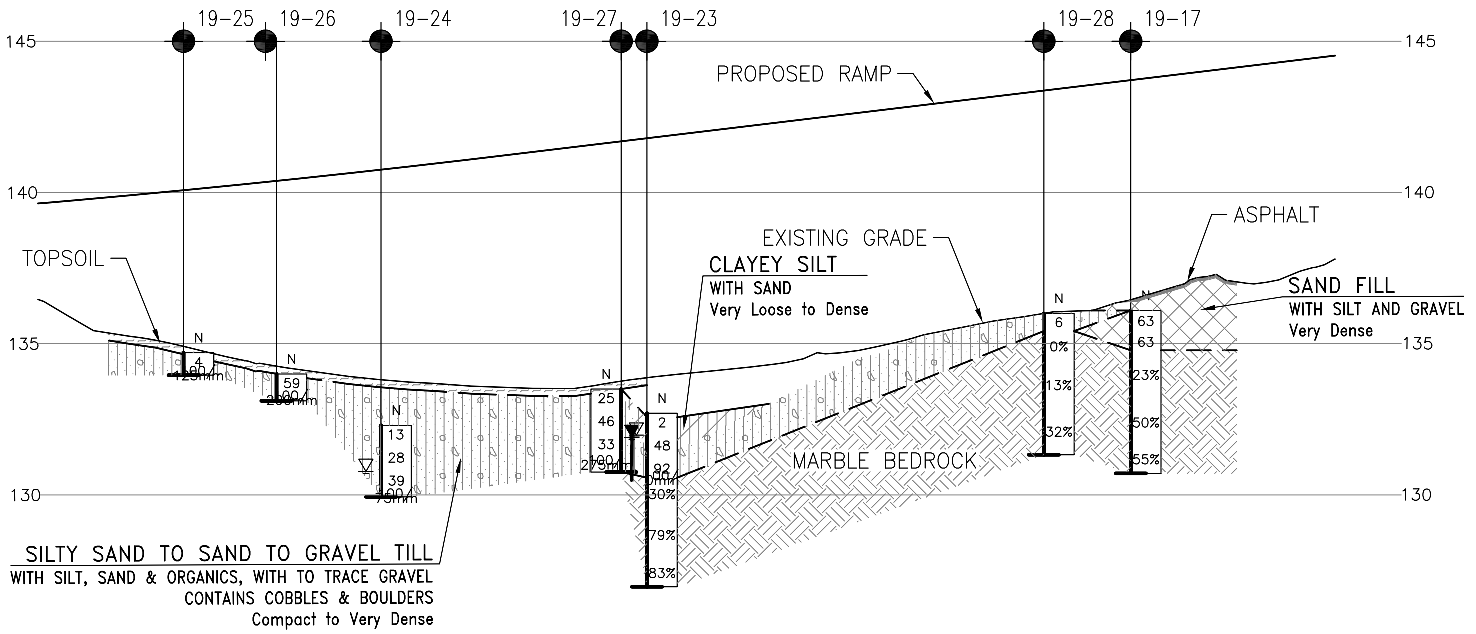
HIGHWAY 17 TWINNING
COUNTY ROAD 6

BOREHOLE SOIL STRATA

SHEET

Ontario

THURBER ENGINEERING LTD.



S-W RAMP (F-F)

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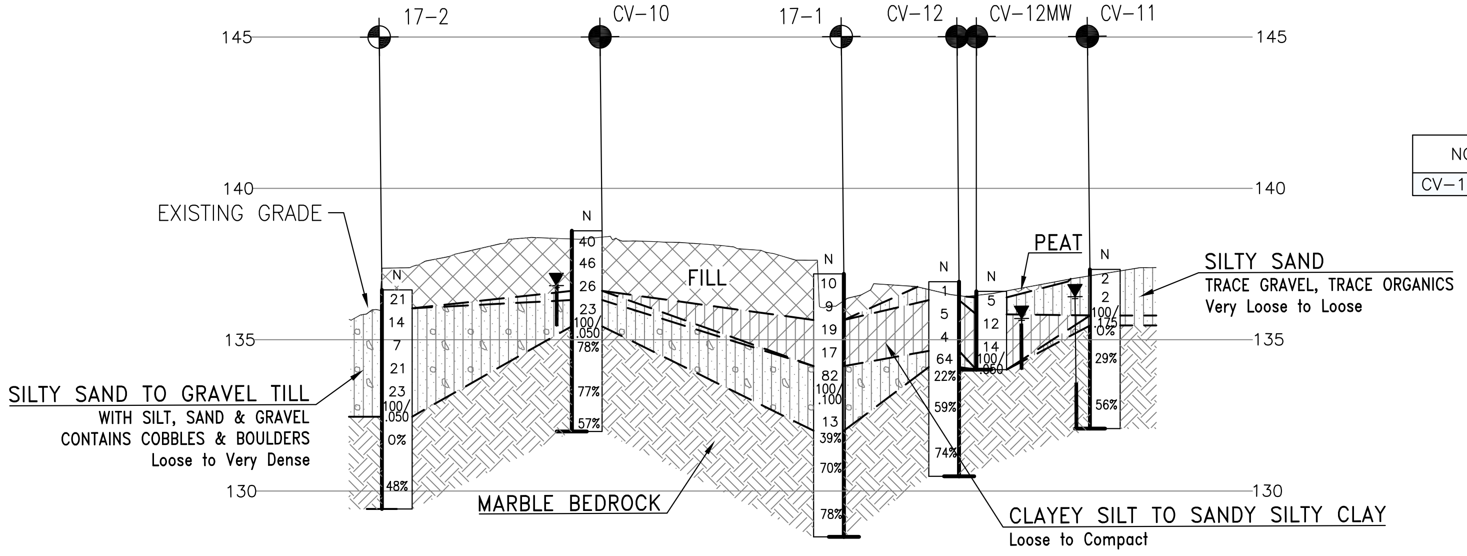
5 0 5 10m V 1:250



NO	ELEVATION	NORTHING	EASTING
CV-12MW	136.6	5 036 574.5	295 243.2

HIGHWAY 17 CULVERT (G-G)

20 0 20 40m H 1:1000
5 0 5 10m V 1:250

KEYPLAN

LEGEND

●	Borehole
⊕	Borehole (2003 Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
⊻	Water Level
▼	Head Artesian Water
┃	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
17-1	137.2	5 036 558.5	295 234.5
17-2	136.7	5 036 511.2	295 195.8
19-17	136.1	5 036 657.4	295 279.2
19-23	132.7	5 036 648.4	295 359.0
19-24	132.3	5 036 611.7	295 387.5
19-25	134.7	5 036 567.0	295 390.1
19-26	134.0	5 036 592.5	295 370.7
19-27	133.5	5 036 633.4	295 353.3
19-28	136.0	5 036 644.6	295 299.0
CV-10	138.6	5 036 540.7	295 206.0
CV-11	137.3	5 036 586.3	295 252.0
CV-12	136.9	5 036 571.6	295 242.7

-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 9.

GEOCRES No. 31F-230

P. K. CHATTERJI
Sep 13, 2022

F. J. GRIFFITHS
Sep 13, 2022

REVISIONS	DATE	BY	DESCRIPTION

DESIGN DP	CHK –	CODE	LOAD	DATE SEP 2022
DRAWN BH	CHK DP	SITE	STRUCT	DWG 4

FILENAME: H:\Drafting\24000\24726\TED-24726-BHPP-CR6.dwg
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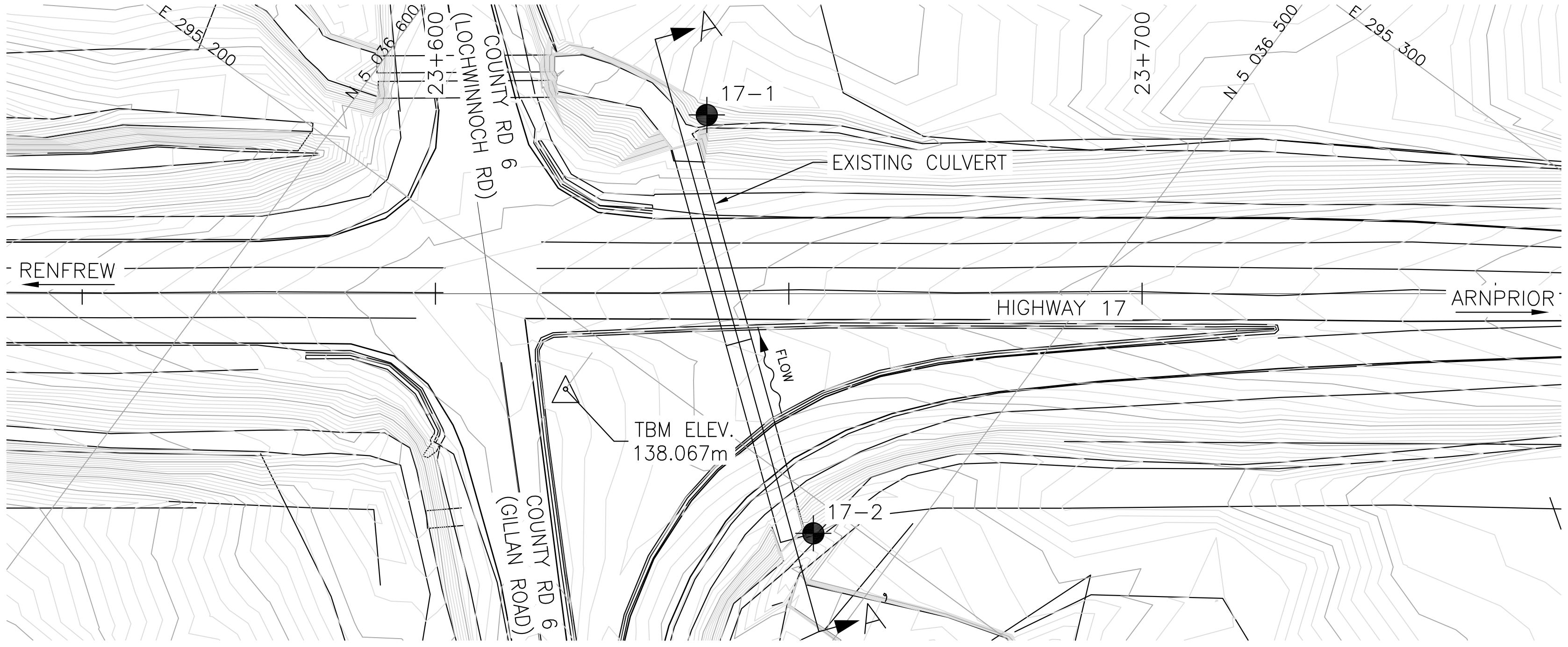
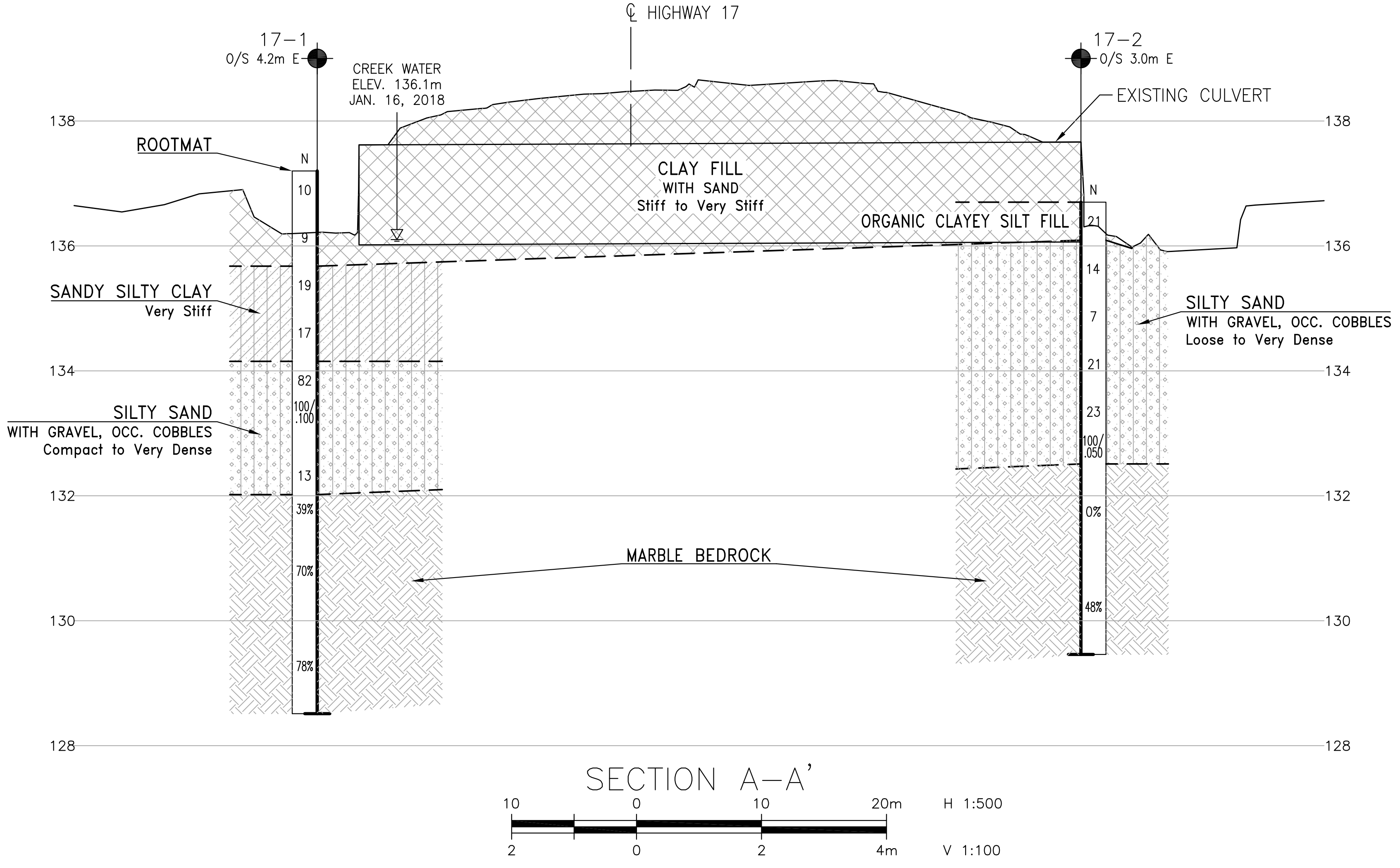
MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE 1:1000



SECTION A-A'

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

LICENSED PROFESSIONAL ENGINEER
K. T. C. POWER
100130652
2018/06/08
PROVINCE OF ONTARIO

P. K. CHATTERJI
June 8/18

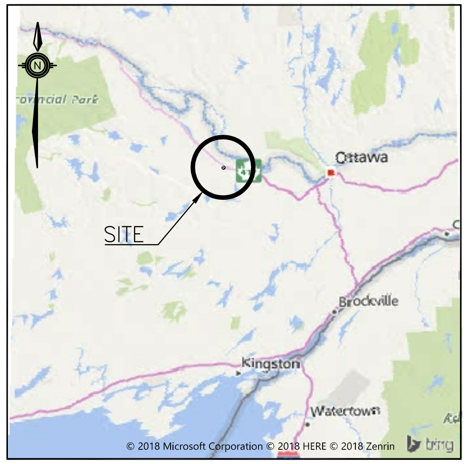
CONT No
GWP No 4076-13-00

HIGHWAY 17
DEIL'S CREEK
CULVERT REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

McINTOSH PERRY

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
17-1	137.2	5 036 558.5	295 234.5
17-2	136.7	5 036 511.2	295 195.8

-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) Boreholes are shown in MTM Zone 9 coordinates.

GEOCRES No. 31F-202

REVISIONS

DATE	BY	DESCRIPTION

DESIGN KP	CHK –	CODE	LOAD	DATE JUN 2018	
DRAWN MFA	CHK KP	SITE	STRUCT	DWG 1	

FILENAME: H:\Drafting\20000\20479\TED-20479-BHPP-DC.dwg
PLOTDATE: 6/5/2018 4:42 PM

HWY.17
GWP NO. 647-92-00

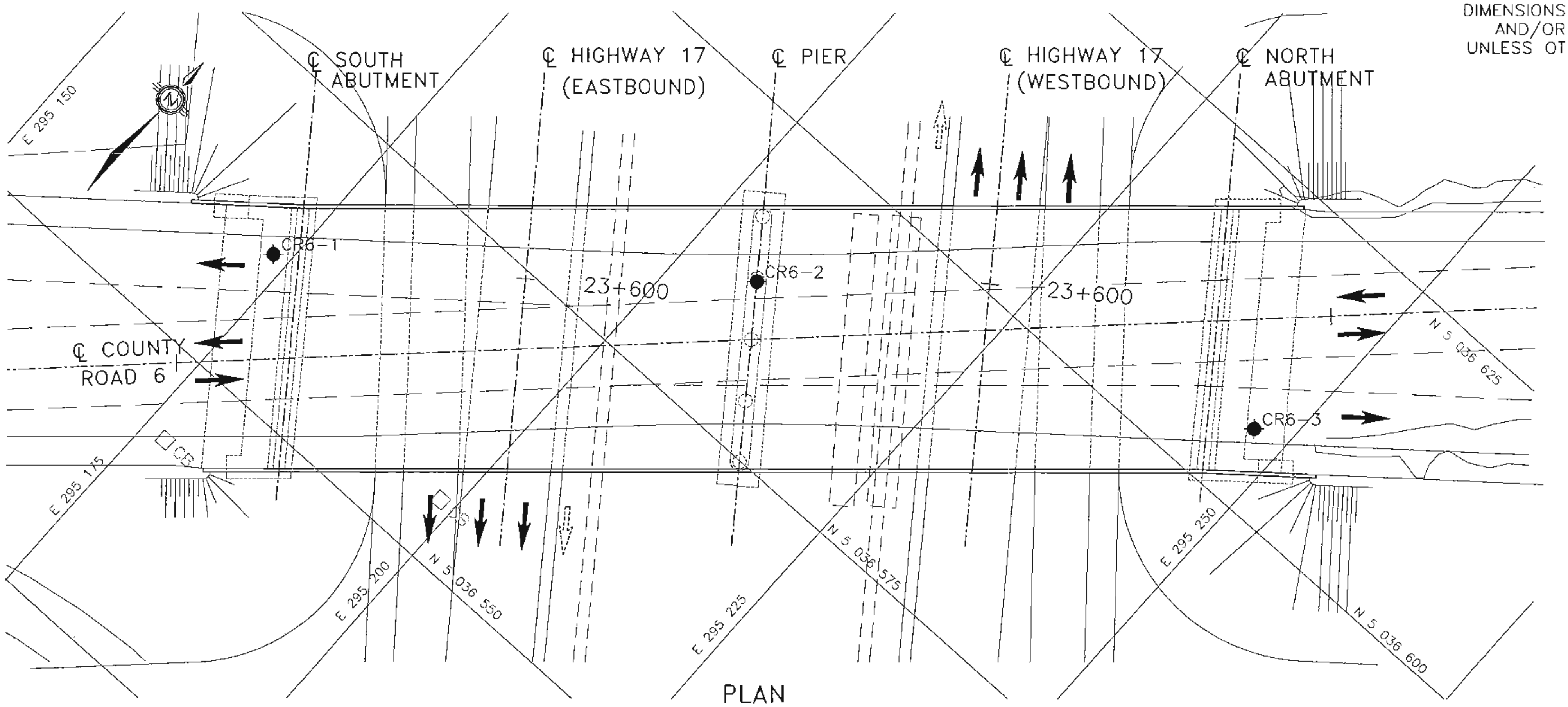
HIGHWAY 17 TWINNING
COUNTY ROAD 6 UNDERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

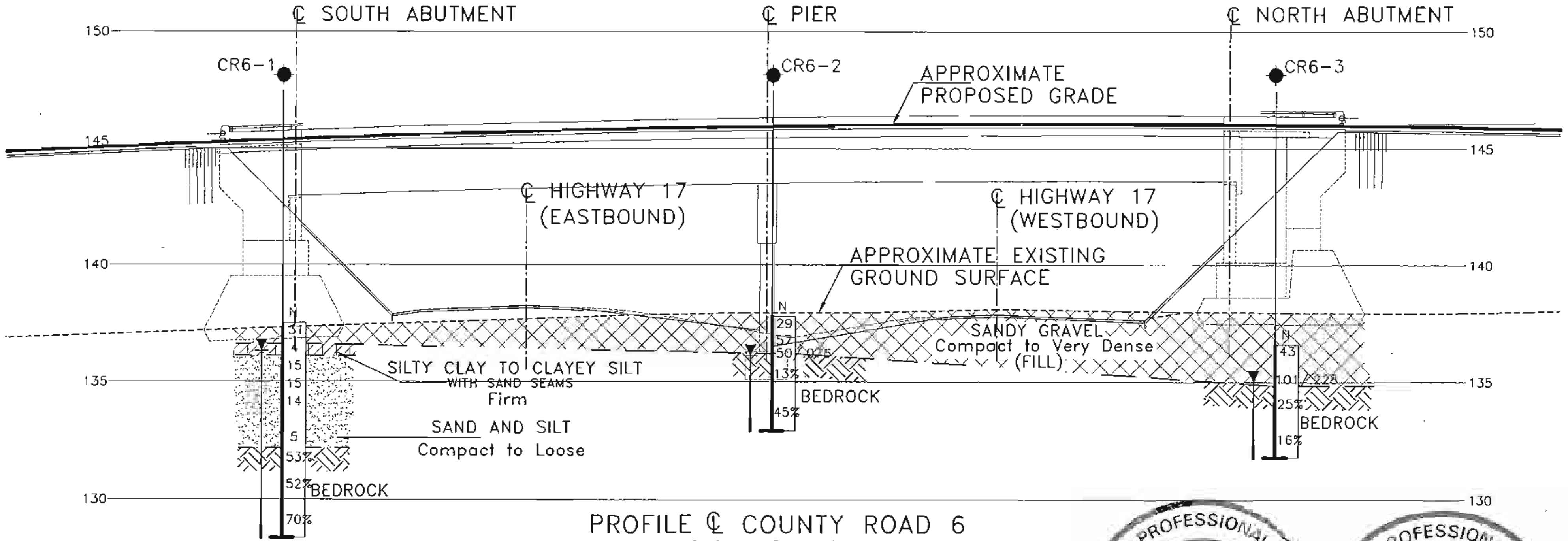
TSH
engineers
architects
planners

THURBER ENGINEERING LTD.

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

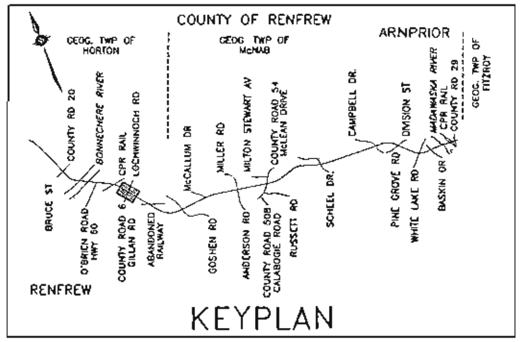


PLAN



PROFILE ℄ COUNTY ROAD 6

2 0 5 10m HOR
1 0 2.5 5m VERT



KEYPLAN

	LEGEND
●	Bore Hole
⊕	Dynamic Cone Penetration Test (cone)
◈	Bore Hole & Cone
N	Blows/ 0.3m (Std Pen Test, 475 J/blow)
CONE	Blows/ 0.3m (60° Cone, 475 J/blow)
PH	Pressure, Hydraulic
▼	WL at Time of Investigation
⊼	Head Artesian Water
│	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CR6-1	137.5	5 036 561.3	295 173.5
CR6-2	137.8	5 036 587.5	295 206.5
CR6-3	136.6	5 036 606.5	295 247.0

— NOTE —

The boundaries between soil strata have been established only at Bore Hole locations . Between Bore Holes the boundaries are assumed from geological evidence .

S. PANG
May 28/04

P. K. CHATTERJI
May 28/04

REVISIONS		
MAY. 04	SP	ISSUED AS DRAFT FOR REVIEW
DATE	BY	DESCRIPTION

DESIGN SP	CHK PKC	CHBDC 2000	LOAD	DATE MAY.2004
DRAWN SS	CHK SP	SITE 29-408	STRUCT	DWG.

Appendix B.

Record of Borehole Sheets

THURBER

SYMBOLS, ABBREVIATIONS AND TERMS USED ON TEST HOLE RECORDS

TERMINOLOGY DESCRIBING COMMON SOIL GENESIS

Topsoil	mixture of soil and humus capable of supporting vegetative growth
Peat	mixture of fragments of decayed organic matter
Till	unstratified glacial deposit which may include particles ranging in sizes from clay to boulder
Fill	material below the surface identified as placed by humans (excluding buried services)

TERMINOLOGY DESCRIBING SOIL STRUCTURE:

Desiccated	having visible signs of weathering by oxidization of clay materials, shrinkage cracks, etc.
Fissured	having cracks, and hence a blocky structure
Varved	composed of alternating layers of silt and clay
Stratified	composed of alternating successions of different soil types, e.g. silt and sand
Layer	> 75 mm in thickness
Seam	2 mm to 75 mm in thickness
Parting	< 2 mm in thickness

RECOVERY:

For soil samples, the recovery is recorded as the length of the soil sample recovered.

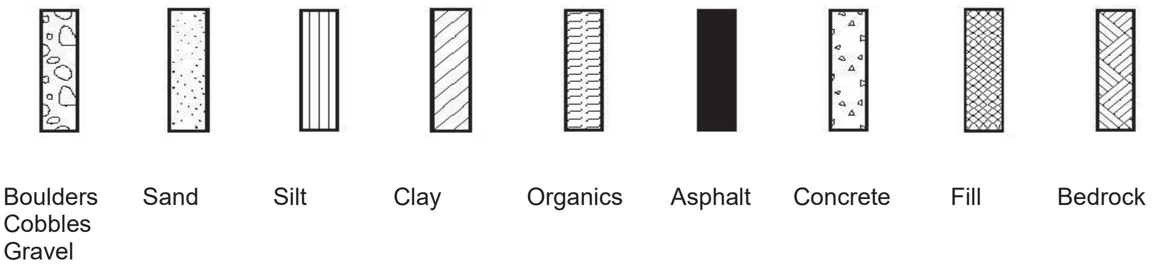
N-VALUE:

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 63.5 kg hammer falling 0.76 m, required to drive a 50 mm O.D. split spoon sampler 0.3 m into undisturbed soil. For samples where insufficient penetration was achieved and N-value cannot be presented, the number of blows are reported over the sampler penetration in millimetres (e.g. 50/75).

DYNAMIC CONE PENETRATION TEST (DCPT):

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to an “A” size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone 0.3 m into the soil. The DCPT is used as a probe to assess soil variability.

STRATA PLOT:
Strata plots symbolize the soil and bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



TEXTURING CLASSIFICATION OF SOILS

Classification	Particle Size
Boulders	Greater than 200 mm
Cobbles	75 – 200 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75 mm
Silt	0.002 – 0.075 mm
Clay	Less than 0.002 mm

TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

Descriptive Term	Undrained Shear Strength (kPa)
Very Soft	12 or less
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

NOTE: Clay sensitivity is defined as the ratio of the undisturbed strength over the remolded strength.

SAMPLE TYPES

SS	Split spoon samples
ST	Shelby tube or thin wall tube
DP	Direct push sample
PS	Piston sample
BS	Bulk sample
WS	Wash sample
HQ, NQ, BQ etc.	Rock core sample obtained with the use of standard size diamond coring equipment

TERMS DESCRIBING CONSISTENCY (COHESIONLESS SOILS ONLY)

Descriptive Term	SPT “N” Value
Very Loose	Less than 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	Greater than 50

MODIFIED UNIFIED SOIL CLASSIFICATION

Major Divisions		Group Symbol	Typical Description
COARSE GRAINED SOIL	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	SILT AND CLAY SOILS $W_L < 35\%$	ML	Inorganic silts, 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.
		OL	Organic silts and organic silty-clays of low plasticity.
	SILT AND CLAY SOILS $35\% < W_L < 50\%$	MI	Inorganic compressible fine sandy silt with clay of medium plasticity, clayey silts.
		CI	Inorganic clays of medium plasticity, silty clays.
		OI	Organic silty clays of medium plasticity.
	SILT AND CLAY SOILS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy of silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other organic soils.

Note - W_L= Liquid Limit

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION

Fresh (FR)	No visible signs of weathering.
Fresh Jointed (FJ)	Weathering limited to surface of major discontinuities.
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock materials.
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 structures are preserved.

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 0.1 m in length or larger, as a percentage of total core length
Unconfined Compressive Strength: (UCS)	Axial stress required to break the specimen.
Fracture Index: (FI)	Frequency of natural fractures per 0.3 m of core run.

DISCONTINUITY SPACING

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

STRENGTH CLASSIFICATION

Rock Strength	**Approximate Uniaxial Compressive Strength (MPa)**
Extremely Strong	Greater than 250
Very Strong	100 – 250
Strong	50 – 100
Medium Strong	25 – 50
Weak	5 – 25
Very Weak	1 – 5
Extremely Weak	0.25 – 1

Ministry of Transportation
Ontario

THURBER

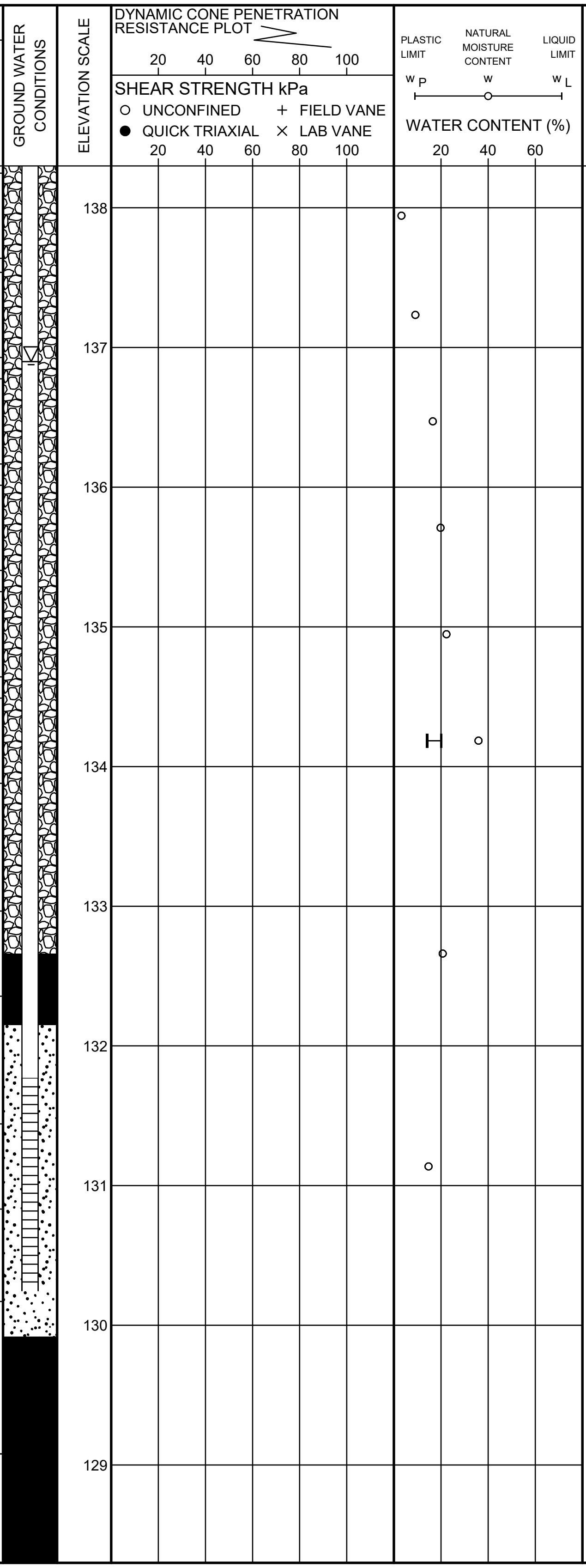
RECORD OF BOREHOLE No 19-01

1 OF 2

METRIC

WP# 4068-09-00
LOCATION Lat: 45.468799°, Long: -76.62293° Country Road 6 MTM Zone 9: N 5 036 548.6 E 295 187.7
ORIGINATED BY SOB
HWY 17
BOREHOLE TYPE CME 55 Truckmount, HSA, NW Casing, NQ Coring
COMPILED BY MW
DATUM Geodetic
DATE 2019.09.04 - 2019.09.04
CHECKED BY FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.3	Pavement Surface					
0.0 0.1	**ASPHALT (50mm)**					
	GRAVEL with silt and sand Compact Brown Dry **(FILL)**	1	GS			49 46 5 (SI+CL)
		2	SS	28		
136.8 1.5	**Silty SAND (SM)**, some gravel Compact Brownish Grey Moist	3	SS	14		11 70 19 (SI+CL)
		4	SS	14		
135.3 3.0	**Clayey SILT (CL-ML)**, with sand Loose to Compact Grey	5	SS	7		
		6	SS	6		0 23 62 15
	- silty sand seam at 5.5 m	7	SS	8		
131.4 6.9	**Silty SAND (SM)**, some gravel Very Loose Grey Wet **(TILL)**	8	SS	4		12 42 39 7 -non-plastic
130.2 8.1	**MARBLE BEDROCK** Slightly Weathered Large Grain Smooth Strong White and Black	1	RUN		FI 8 4 8	RUN #1 TCR=100% SCR=100% RQD=41%
		2	RUN		1 >10 4	RUN #2 TCR=100% SCR=69% RQD=46%



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 19-01

2 OF 2

METRIC

WP# 4068-09-00	LOCATION Lat: 45.468799°, Long: -76.62293° Country Road 6 MTM Zone 9: N 5 036 548.6 E 295 187.7	ORIGINATED BY SOB
HWY 17	BOREHOLE TYPE CME 55 Truckmount, HSA, NW Casing, NQ Coring	COMPILED BY MW
DATUM Geodetic	DATE 2019.09.04 - 2019.09.04	CHECKED BY FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"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
	Continued From Previous Page										
	MARBLE BEDROCK Slightly Weathered Large Grain Smooth Strong White and Black Silt seam at 10.4 m to 10.5						128			>10	
			3	RUN			127			2 1 4 2 4	RUN #3 TCR=65% SCR=93% RQD=79% UCS=64.4MPa UCS=81.1MPa
126.3 12.0	End of Borehole Piezometer consists of 19 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen WATER LEVEL READING:										

DATE	DEPTH (m)	ELEV. (m)
2019.09.26	1.9	136.4
2020.04.21	1.4	136.9
2020.06.03	1.4	136.9
2020.09.29	1.8	136.5
2021.12.15	1.5	136.8

+³, ×³: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

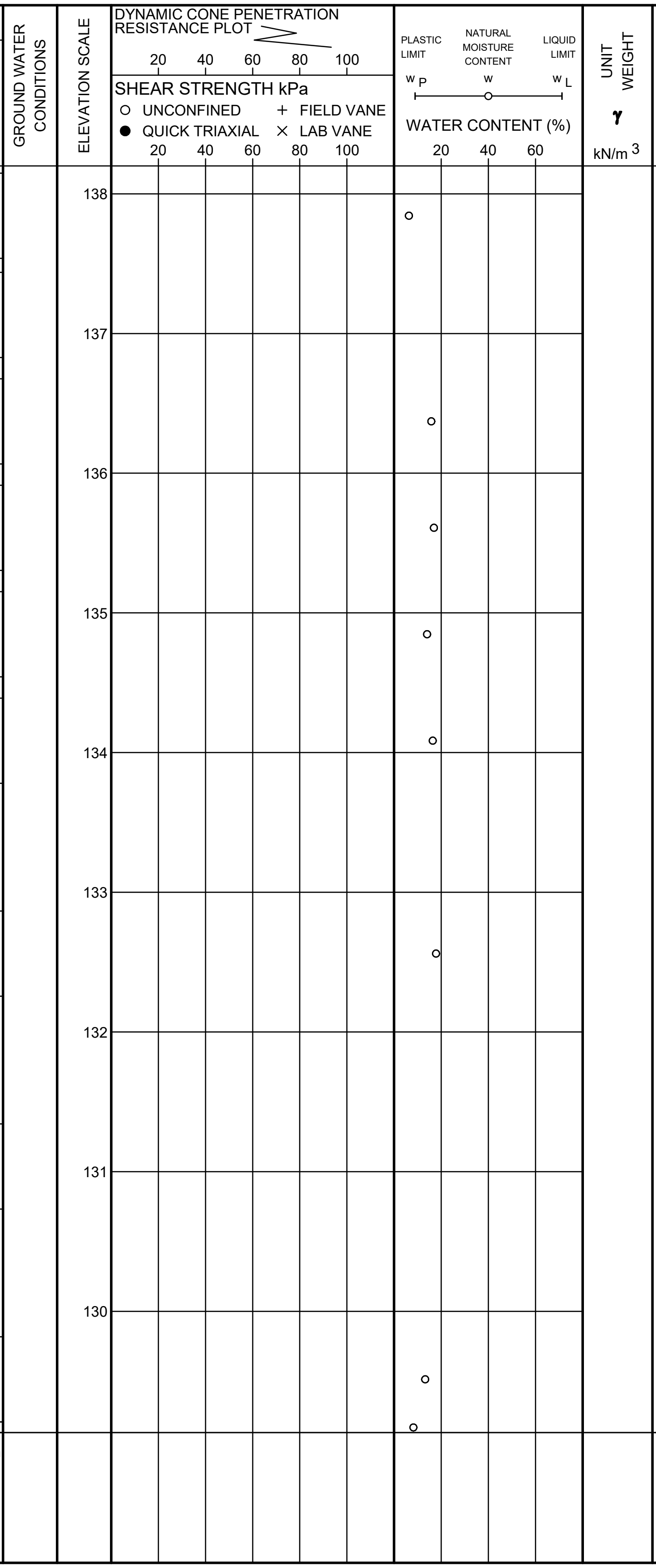
THURBER

RECORD OF BOREHOLE No 19-02

1 OF 1 **METRIC**

WP# 4068-09-00	LOCATION	Lat: 45.468771°, Long: -76.622994° Country Road 6 MTM Zone 9: N 5 036 545.6 E 295 182.7	ORIGINATED BY SOB
HWY 17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing	COMPILED BY MW
DATUM Geodetic	DATE	2019.09.04 - 2019.09.04	CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.2	Ground Surface				
0.0	**ASPHALT (50mm)**				
0.1	Silty SAND, some gravel Dense to Compact Brown **(FILL)**	1	SS	36	
		2	SS	51	
		3	SS	21	16 67 17 (SI+CL)
135.9 2.3	**Silty SAND (SM)** Compact Grey	4	SS	24	0 53 40 7 -non-plastic
		5	SS	30	
134.4 3.8	**Sandy SILT (ML)**, trace gravel, occasional boulders/cobbles Compact Grey **(TILL)** -200mm boulder between 4.4m and 5.3m	6	SS	19	3 35 51 11 -non-plastic
		7	SS	11	
		8	SS	6	
		9	SS	12	
		10	SS	100/ 75mm	
129.1 9.1	End of Borehole Spoon refusal and difficult casing advancement on inferred bedrock.				



+3, ×3: Numbers refer to Sensitivity

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

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-03

1 OF 1

METRIC

WP# 4068-09-00
LOCATION Lat: 45.469198°, Long: -76.622773° Country Road 6 MTM Zone 9: N 5 036 592.9 E 295 200.0
ORIGINATED BY SOB
HWY 17
BOREHOLE TYPE CME 55 Truckmount, NW Casing, NQ Coring
COMPILED BY MW
DATUM Geodetic
DATE 2019.08.30 - 2019.08.30
CHECKED BY FG

SOIL PROFILE			SAMPLES								REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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	GR	SA	SI	CL
137.7	**Ground Surface**													
0.0	SAND with silt and gravel Compact Brown **(FILL)**	⊠	1	SS	14				○		41	52	7 (SI+CL)	
		⊠					137							
		⊠	2	SS	27				○					
136.3 1.4	**MARBLE BEDROCK** Slightly Weathered Large Grain Medium Strong Pinkish Grey - Fractures from 1.7 m to 1.8 m - Fractures from 2.0 m to 2.2 m	▨	1	RUN			136			FI 4 6 >10	RUN #1 TCR=100% SCR=67% RQD=39%			
		▨	2	RUN			135			5 4 5 6	RUN #2 TCR=100% SCR=97% RQD=11%			
		▨	3	RUN			134 133			3 2 4 4 8	RUN #3 TCR=100% SCR=90% RQD=53% UCS=34.5MPa			
132.6 5.1	End of Borehole													

+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-04

1 OF 1

METRIC

WP# 4068-09-00	LOCATION	Lat: 45.46923°, Long: -76.622735° Country Road 6 MTM Zone 9: N 5 036 596.5 E 295 203.0	ORIGINATED BY SOB
HWY 17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY MW
DATUM Geodetic	DATE	2019.08.30 - 2019.08.30	CHECKED BY FG

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/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
137.5	Ground Surface							
0.0	GRAVEL with silt and sand Compact to Dense Brown **(FILL)**		1	SS	26	137		
			2	SS	36		FI	56 36 8 (SI+CL)
136.2 1.3	**MARBLE BEDROCK** Slightly Weathered Large Grain Pinkish Grey - Highly fractured from 1.4 m to 2.1 m		1	RUN		136	>10 4 4	RUN #1 TCR=100% SCR=64% RQD=28%
			2	RUN		135 134	6 5 8 3 5 4	RUN #2 TCR=100% SCR=65% RQD=35%
			3	RUN		133	2 3 3	RUN #3 TCR=100% SCR=72% RQD=47%
132.4 5.1	End of Borehole							

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

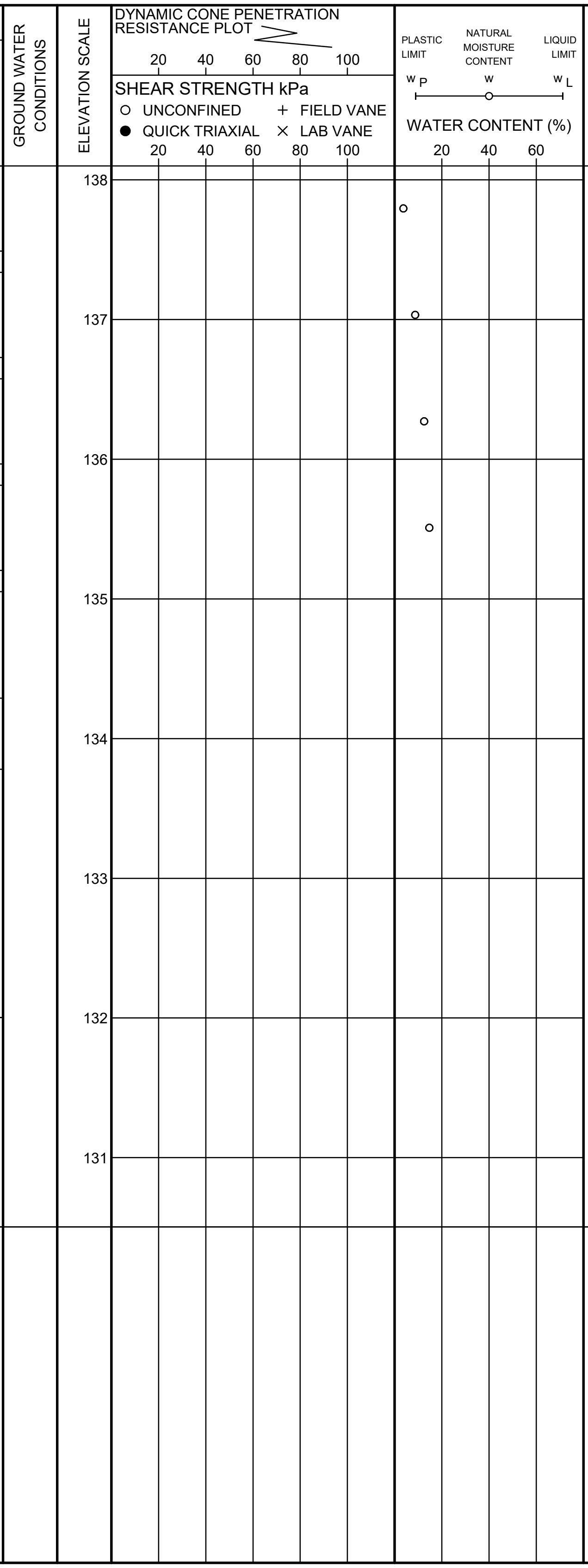
RECORD OF BOREHOLE No 19-05

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469017°, Long: -76.622565° Country Road 6 MTM Zone 9: N 5 036 572.8 E 295 216.3	ORIGINATED BY	SOB
HWY	17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2019.08.30 - 2019.08.30	CHECKED BY	FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.1	**Ground Surface**					
0.0	SAND with silt and gravel Compact Brown **(FILL)**	1	SS	18		
		2	SS	15		33 60 7 (SI+CL)
136.6 1.5	**Silty SAND (SM)** with gravel Loose to Compact Grey	3	SS	9		19 64 17 (SI+CL)
		4	SS	20		
135.1 3.0	Frequent Boulders and Cobbles **(Inferred TILL)**	5	NQ			
133.8 4.3	**MARBLE BEDROCK** Fresh Small Grain Smooth White	1	RUN		FI 3 0 3 1 1 2	RUN #1 TCR=100% SCR=91% RQD=76%
	- Vertical fractures from 6.2 m to 6.5 m - Silt seam from 7.3 m to 7.5 m	2	RUN		4 2 1 3 2	RUN #2 TCR=100% SCR=64% RQD=63%
130.5 7.6	End of Borehole					



+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

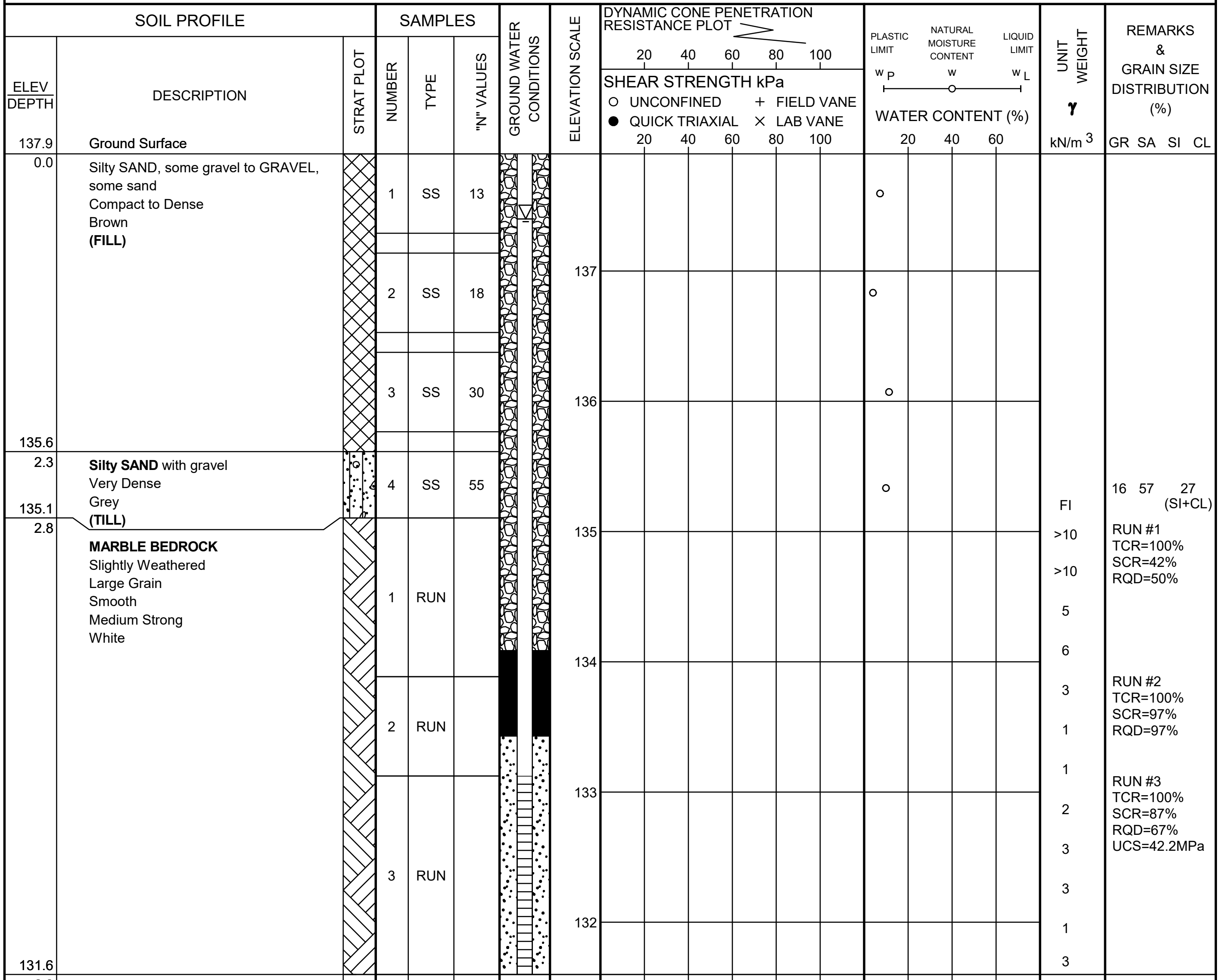
THURBER

RECORD OF BOREHOLE No 19-06

1 OF 1

METRIC

WP# 4068-09-00
LOCATION Lat: 45.469063°, Long: -76.622534° Country Road 6 MTM Zone 9: N 5 036 577.9 E 295 218.7
ORIGINATED BY SOB
HWY 17
BOREHOLE TYPE CME 55 Truckmount, HW Casing, HQ Coring
COMPILED BY MW
DATUM Geodetic
DATE 2019.09.04 - 2019.09.04
CHECKED BY FG



ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.9	Ground Surface					
0.0	Silty SAND, some gravel to GRAVEL, some sand Compact to Dense Brown **(FILL)**	1	SS	13		
		2	SS	18		
		3	SS	30		
135.6 2.3	**Silty SAND** with gravel Very Dense Grey **(TILL)**	4	SS	55	FI	16 57 27 (SI+CL)
135.1 2.8	**MARBLE BEDROCK** Slightly Weathered Large Grain Smooth Medium Strong White	1	RUN		>10 >10 5 6	RUN #1 TCR=100% SCR=42% RQD=50%
		2	RUN		3 1	RUN #2 TCR=100% SCR=97% RQD=97%
		3	RUN		1 2 3 3 1 3	RUN #3 TCR=100% SCR=87% RQD=67% UCS=42.2MPa
131.6 6.3	End of Borehole					

Monitoring well consists of 38 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2019.09.26	1.9	135.9
2020.04.21	0.5	137.3
2020.09.29	1.7	136.1

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-07

1 OF 1

METRIC

WP# 4068-09-00
LOCATION Lat: 45.469442°, Long: -76.622374° Country Road 6 MTM Zone 9: N 5 036 620.1 E 295 231.3
ORIGINATED BY JP
HWY 17
BOREHOLE TYPE CME 45 Trackmount, NW Casing, NQ Coring
COMPILED BY MW
DATUM Geodetic
DATE 2020.05.05 - 2020.05.05
CHECKED BY FG

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

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
136.6	Ground Surface							
0.0 136.3	**TOPSOIL (270 mm)**							
0.3 136.0	**Silty SAND** Loose Grey-Brown	1	SS	6				
0.6	**Silty SAND (SM)**, trace gravel Compact to Dense Grey **(TILL)**	2	SS	27		136		10 52 33 5 -non-plastic
		3	SS	42		135		
134.2		4	SS	100/ 75mm			FI	
2.4	**MARBLE BEDROCK** Fresh Jointed Large Grain Rough Grey	1	RUN			134	5 2 3	RUN #1 TCR=100% SCR=92% RQD=58%
		2	RUN			133	6 2 2 1	RUN #2 TCR=100% SCR=89% RQD=56%
		3	RUN			132 131	5 2 2 2 2 1	RUN #3 TCR=100% SCR=100% RQD=98%
130.2 6.4	End of Borehole							

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

+ ³, × ³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 19-08

1 OF 1 **METRIC**

WP# 4068-09-00	LOCATION	Lat: 45.469473°, Long: -76.622326° Country Road 6 MTM Zone 9: N 5 036 623.5 E 295 235.0	ORIGINATED BY JP
HWY 17	BOREHOLE TYPE	CME 45 Trackmount, NQ Coring	COMPILED BY MW
DATUM Geodetic	DATE	2020.05.05 - 2020.05.05	CHECKED BY FG

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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
136.7	Ground Surface										
0.0 0.1	**Silty SAND**, trace gravel Brown **(TILL)**		1	GS	-					FI	
	MARBLE BEDROCK Slightly Weathered to Fresh Jointed Large Grain Rough Grey to Grey-Pink		1	RUN			136			8 6 7 3 3	RUN #1 TCR=100% SCR=64% RQD=31%
133.6			2	RUN			135 134			2 2 3 4 3	RUN #2 TCR=100% SCR=95% RQD=56%
3.1	End of Borehole										

+ 3, × 3 : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

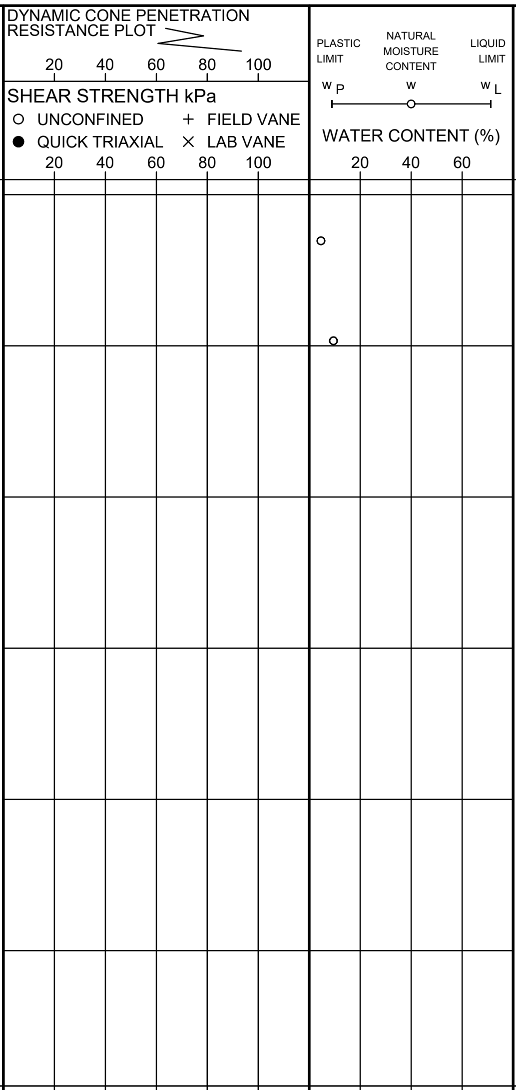
RECORD OF BOREHOLE No 19-09

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469415°, Long: -76.622244° Country Road 6 MTM Zone 9: N 5 036 617.0 E 295 241.4
ORIGINATED BY	SOB	HWY	17
BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2019.08.26 - 2019.08.26
CHECKED BY	FG		

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.1	**Pavement Surface**						
0.0	**ASPHALT (100mm)**				137		
0.1	Silty SAND with gravel Very Dense Brown **(FILL)**	1	SS	66			
		2	SS	36	136		31 49 20 (SI+CL)
135.6 1.5	**MARBLE BEDROCK** Slightly Weathered Small Grain Strong Grey to Grey-Pink - Very fractured from 1.5 m to 1.9 m - Very fractured from 2.5 m to 2.8 m - Very fractured from 3.0 m to 3.7 m	1	RUN		135	FI >10 >10 1 >10 3	RUN #1 TCR=100% SCR=55% RQD=40%
		2	RUN		134 133	6 6 4 4 2	RUN #2 TCR=100% SCR=80% RQD=60%
131.1		3	RUN		132	2 2 2 2 1	RUN #3 TCR=100% SCR=82% RQD=68% UCS=62.2MPa
6.0	End of Borehole						



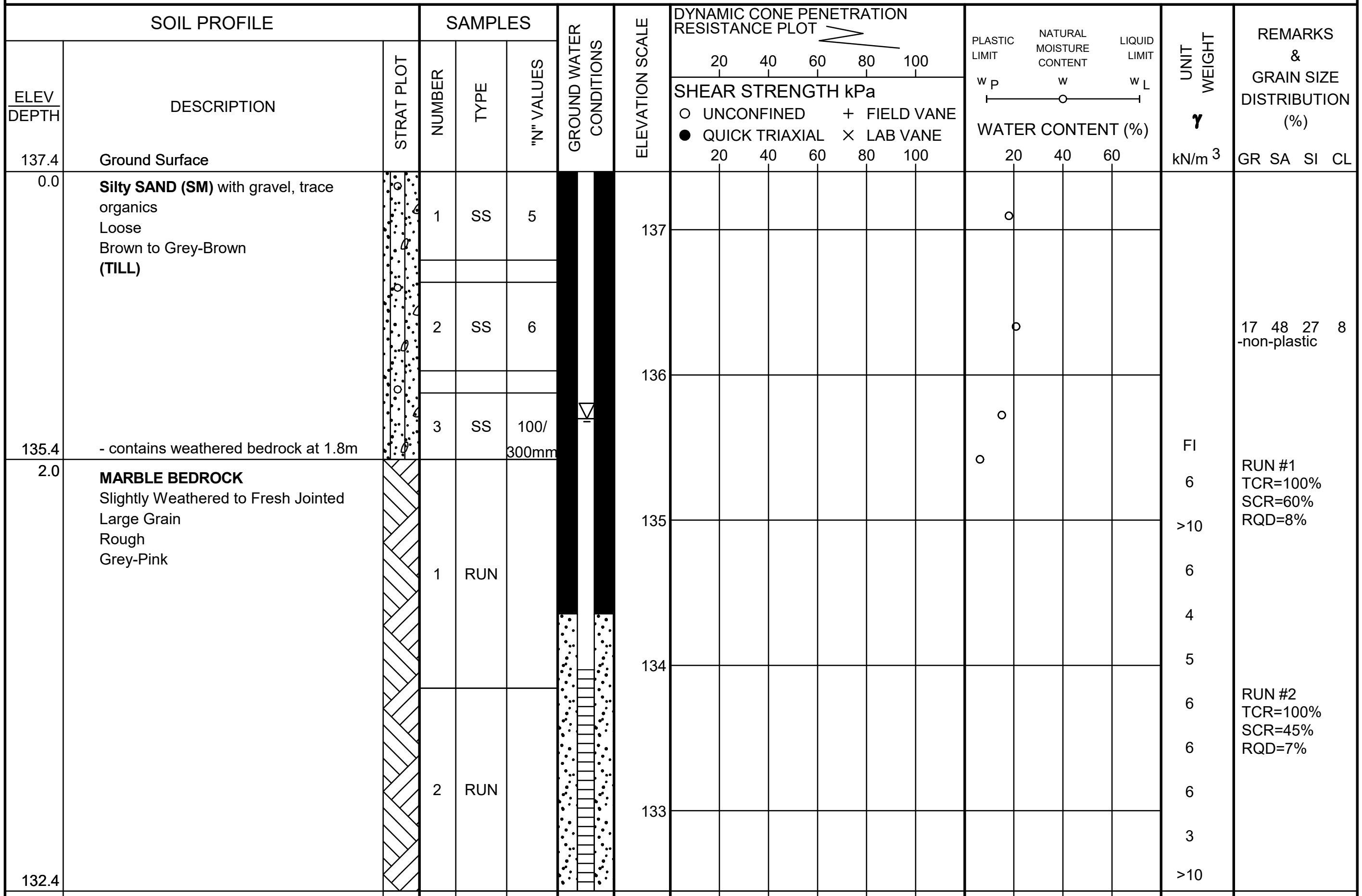
+ 3, × 3 : Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 19-10

1 OF 1 **METRIC**

WP# 4068-09-00	LOCATION Lat: 45.469247°, Long: -76.622162° Country Road 6 MTM Zone 9: N 5 036 598.3 E 295 247.8	ORIGINATED BY JP
HWY 17	BOREHOLE TYPE CME 45 Trackmount, HW Casing, HQ Coring	COMPILED BY MW
DATUM Geodetic	DATE 2020.05.04 - 2020.05.04	CHECKED BY FG



ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.4	Ground Surface					
0.0	**Silty SAND (SM)** with gravel, trace organics Loose Brown to Grey-Brown **(TILL)**	1	SS	5		
		2	SS	6		17 48 27 8 -non-plastic
		3	SS	100/ 300mm		
135.4	- contains weathered bedrock at 1.8m				FI	
2.0	**MARBLE BEDROCK** Slightly Weathered to Fresh Jointed Large Grain Rough Grey-Pink	1	RUN		6 >10 6 4 5	RUN #1 TCR=100% SCR=60% RQD=8%
		2	RUN		6 6 6 3 >10	RUN #2 TCR=100% SCR=45% RQD=7%
132.4 5.0	End of Borehole					

Monitoring well installation consists of 50mm diameter Schedule 40 PVC pipe
with a 1.5-m slotted screen
WATER LEVEL READING:

DATE	DEPTH (m)	ELEV. (m)
2020.06.03	1.7	135.7
2020.09.29	1.9	135.5
2021.09.23	1.9	135.5
2021.10.03	1.5	135.9
2022.01.22	1.8	135.6

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-12

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469511°, Long: -76.622145° Country Road 6 MTM Zone 9: N 5 036 627.7 E 295 249.2	ORIGINATED BY	SOB
HWY	17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2019.08.26 - 2019.08.26	CHECKED BY	FG

SOIL PROFILE			SAMPLES					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
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
137.0	Pavement Surface										
0.0 0.1	**ASPHALT (75mm)**										
	Silty SAND with gravel Very Dense Brown to Grey **(FILL)** - contains weathered bedrock at 0.8 m		1	SS	51				○		32 55 13 (SI+CL)
			2	SS	100/ 125mm		136		○		
135.8 1.2	**MARBLE BEDROCK** Slightly Weathered Large Grain Rough Strong White		1	RUN			135			FI >10 >10 >10 >10 >10	RUN #1 TCR=77% SCR=10% RQD=0%
			2	RUN			134 133			>10 >10 >10 >10 5	RUN #2 TCR=100% SCR=28% RQD=0%
			3	RUN			132			2 3 1 4 2	RUN #3 TCR=100% SCR=97% RQD=60%
			4	RUN			131			>10 >10 2	RUN #4 TCR=100% SCR=78% RQD=61%
130.2 6.8	End of Borehole										

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

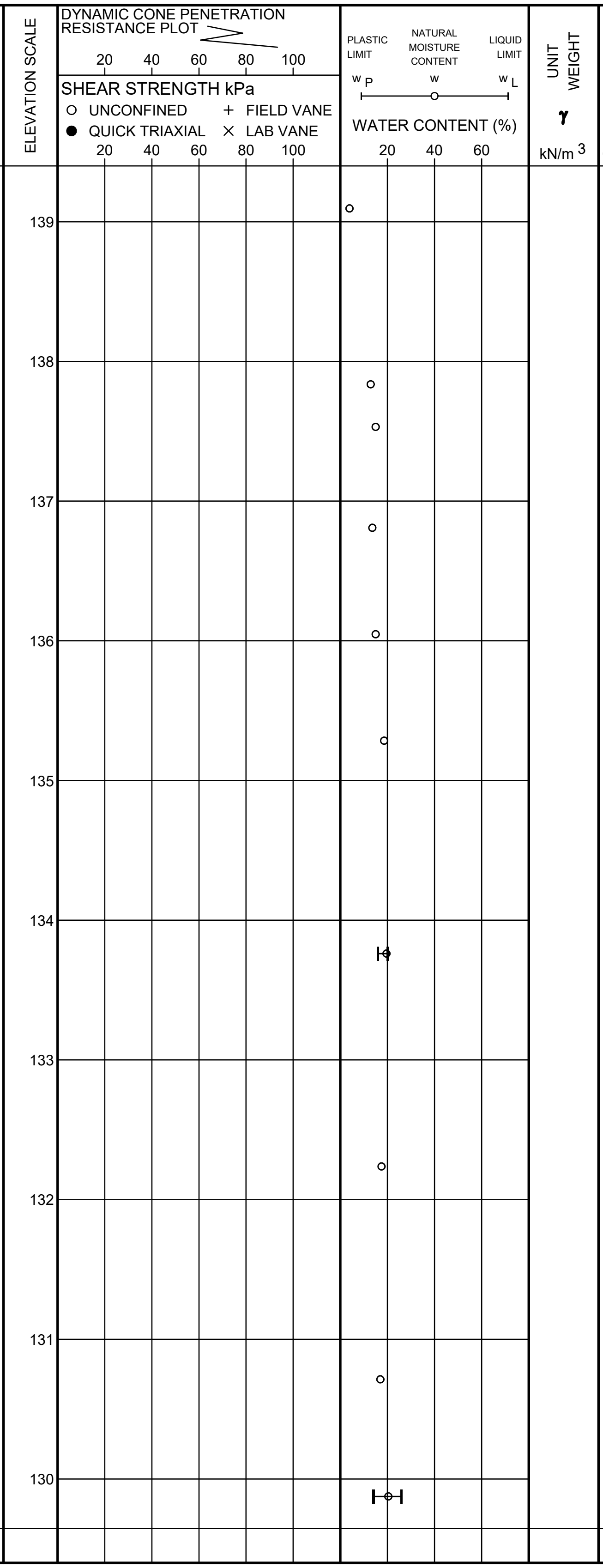
RECORD OF BOREHOLE No 19-13

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.468203°, Long: -76.624042° Country Road 6 MTM Zone 9: N 5 036 482.5 E 295 100.7	ORIGINATED BY	SOB
HWY	17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing	COMPILED BY	MW
DATUM	Geodetic	DATE	2019.09.06 - 2019.09.06	CHECKED BY	FG

ELEV DEPTH	SOIL PROFILE: DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
139.4	Ground Surface									
0.0	SAND with gravel, occasional cobbles Compact Brown with red and black gravel **(FILL)**		1	SS	30					
			2	SS	15					
137.8 1.6	**Silty SAND (SM)** to **SAND (SP-SM)** with silt, trace gravel Dense to Very Dense Grey to Brown		3	SS	59					
			4	SS	71		3	71	26 (SI+CL)	
			5	SS	66					
			6	SS	41		6	86	8 (SI+CL)	
134.1 5.3	**Clayey SILT (CL-ML)** with sand to **Clayey SILT (CL)**, some sand Loose to Dense Brown		7	SS	12		0	28	56	16
	- higher silt content from 6.9 m to 9.0 m		8	SS	42					
			9	SS	27					
	- becoming grey		10	SS	8		0	12	58	30
129.6 9.8	End of Borehole									



+ 3, × 3: Numbers refer to Sensitivity

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

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-14

1 OF 2

METRIC

WP#	4068-09-00	ORIGINATED BY	SOB
LOCATION	Lat: 45.468479°, Long: -76.623637° Country Road 6 MTM Zone 9: N 5 036 513.2 E 295 132.3	COMPILED BY	MW
HWY	17	CHECKED BY	FG
BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring		
DATUM	Geodetic		
DATE	2019.09.05 - 2019.09.05		

SOIL PROFILE		SAMPLES			REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL	
139.0	Ground Surface								
0.0	SAND with silt and gravel Loose to Dense Brown **(FILL)** - very low recovery below 0.8 m	1	SS	49	32	57	11		(SI+CL)
		2	SS	27					
		3	SS	8					
		4	SS	59					
136.0 3.0	**Silty SAND (SM)** Compact to Very Dense Brown	5	SS	59	0	64	32	4	-non-plastic
		6	SS	28					
		7	SS	12					
132.1 6.9	**CLAYEY SILT (CL)** Loose Brown	8	SS	5	0	3	67	30	
130.6 8.4	**Silty GRAVEL** with sand Dense Brown **(TILL)**	9	SS	32	46	41	13		(SI+CL)
129.9 9.1	**MARBLE BEDROCK** Slightly Weathered Highly Fractured Large Grain Grey	1	RUN						RUN #1 TCR=61% SCR=16% RQD=16%

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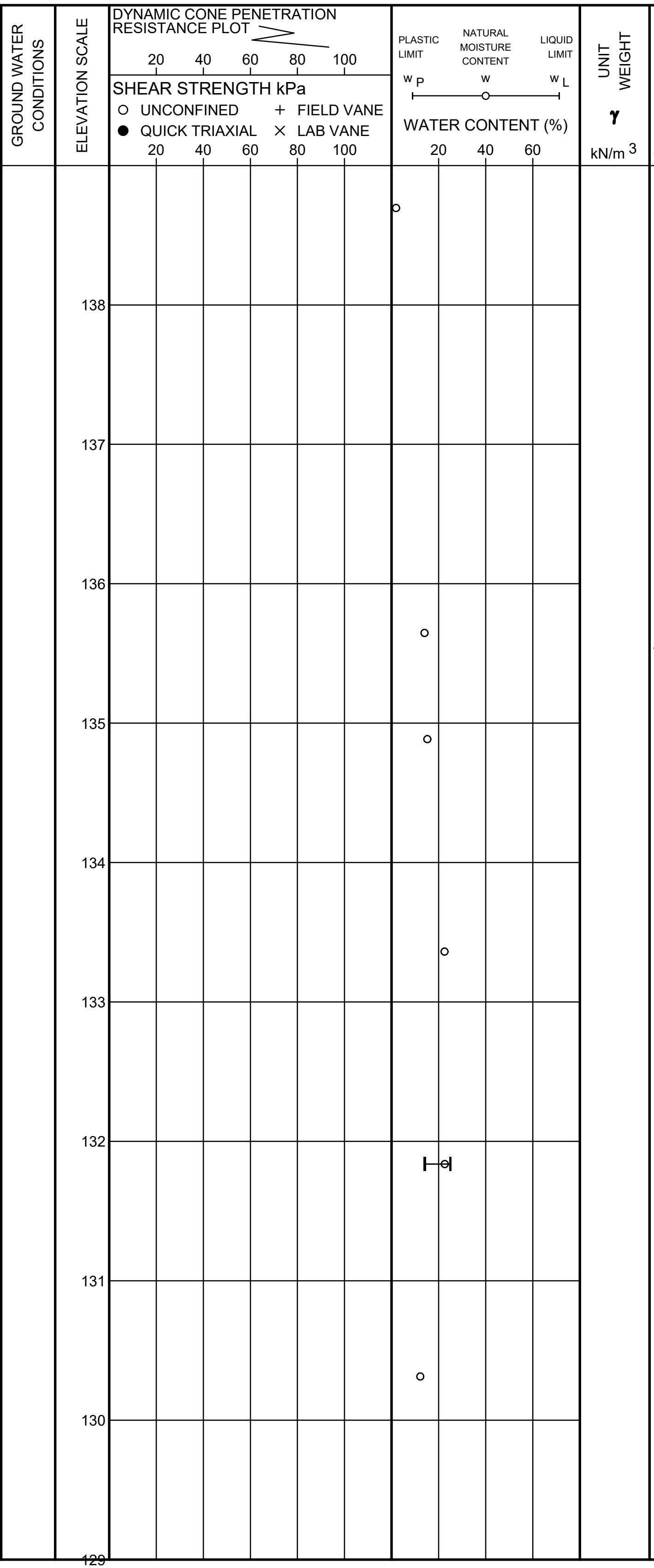


+3, ×3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-14

2 OF 2

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.468479°, Long: -76.623637° Country Road 6 MTM Zone 9: N 5 036 513.2 E 295 132.3	ORIGINATED BY	SOB
HWY	17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2019.09.05 - 2019.09.05	CHECKED BY	FG

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

ELEV DEPTH	SOIL PROFILE: DESCRIPTION (Continued From Previous Page)	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m 3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	MARBLE BEDROCK Slightly Weathered Highly Fractured Large Grain Grey								
			2	RUN			128		RUN #2 TCR=85% SCR=23% RQD=23%
			3	RUN			127		RUN #3 TCR=100% SCR=62% RQD=38%
126.0 13.0	End of Borehole						126		

+ 3, × 3: Numbers refer to Sensitivity

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

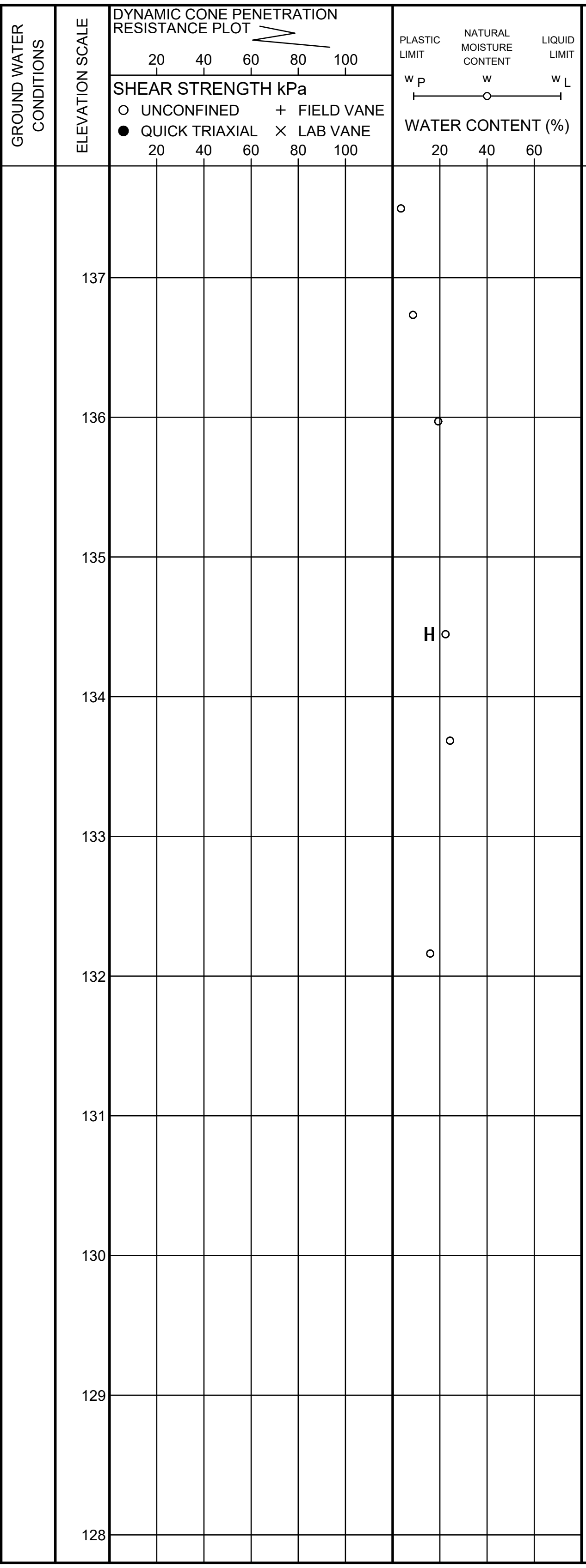
RECORD OF BOREHOLE No 19-15

1 OF 2 **METRIC**

WP#	4068-09-00	LOCATION	Lat: 45.468782°, Long: -76.623246° Country Road 6 MTM Zone 9: N 5 036 546.8 E 295 162.9
HWY	17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring
DATUM	Geodetic	DATE	2019.09.05 - 2019.09.05

ORIGINATED BY SOB
COMPILED BY MW
CHECKED BY FG

ELEV DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³ / FI	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.8	Ground Surface					
0.0	SAND with gravel Compact to Dense Brown **(FILL)**	1	SS	30		
		2	SS	21		
136.3 1.5	**Silty SAND**, some gravel Loose Brown	3	SS	7		
		4	SS	23		
134.8 3.0	**Sandy SILT (ML)** with clay Loose Grey	5	SS	4		0 32 51 17
		6	SS	7		
132.5 5.3	**Silty SAND (SM)**, some gravel Very Loose Grey **(TILL)**	7	SS	3		14 48 31 7 -non-plastic
		8	SS	100/ 75mm	FI	
130.9 6.9	**MARBLE BEDROCK** Slightly Weathered Large Grain Smooth White-Yellow	1	RUN		>10 0	RUN #1 TCR=100% SCR=72% RQD=56%
		2	RUN		1 1 1 4 3	RUN #2 TCR=100% SCR=95% RQD=72%
	- 50 mm silt seam at 9.7 m	3	RUN		2 1 3	RUN #3 TCR=100% SCR=93% RQD=87%



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-15

2 OF 2

METRIC

WP# 4068-09-00	LOCATION Lat: 45.468782°, Long: -76.623246° Country Road 6 MTM Zone 9: N 5 036 546.8 E 295 162.9		ORIGINATED BY SOB
HWY 17	BOREHOLE TYPE CME 55 Truckmount, NW Casing, NQ Coring		COMPILED BY MW
DATUM Geodetic	DATE 2019.09.05 - 2019.09.05		CHECKED BY FG

SOIL PROFILE			SAMPLES											
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"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
127.6	**MARBLE BEDROCK**	▨								2				
10.2	End of Borehole													

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

20
15 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

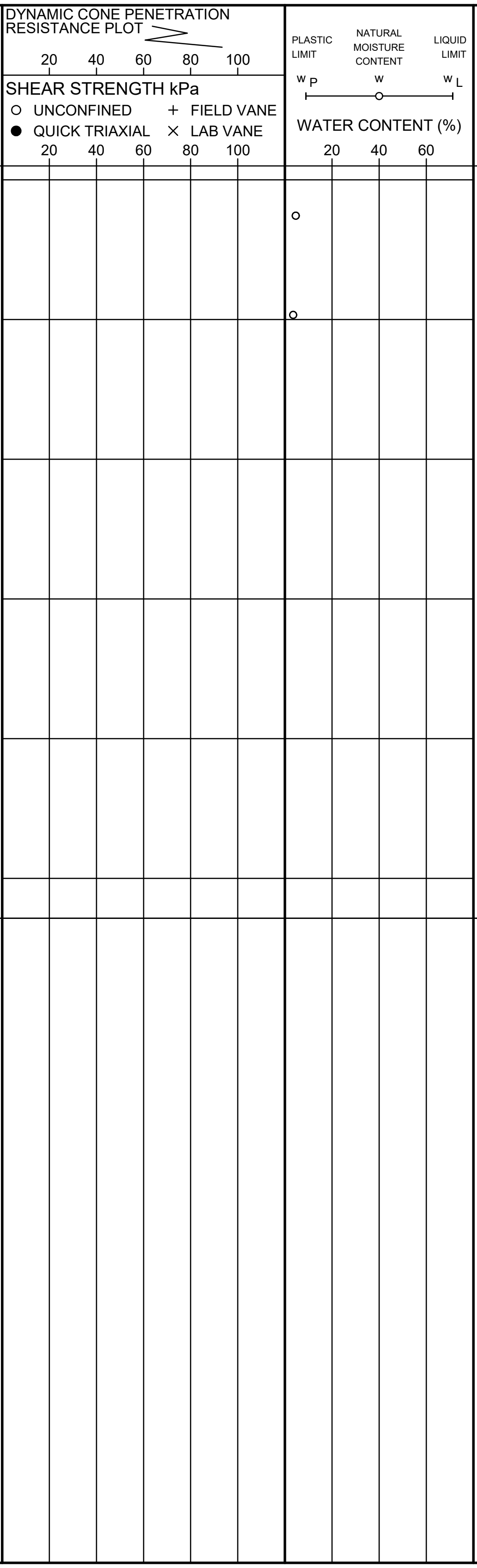
RECORD OF BOREHOLE No 19-17

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469779°, Long: -76.621762° Country Road 6 MTM Zone 9: N 5 036 657.4 E 295 279.2	ORIGINATED BY	SOB
HWY	17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2019.08.27 - 2019.08.27	CHECKED BY	FG

SOIL PROFILE		SAMPLES						REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
136.1	Pavement Surface										
0.0 0.1	**ASPHALT (50mm)**					136					
	SAND with silt and gravel Very Dense Brown **(FILL)** - contains weathered bedrock	1	SS	63				36	53	11 (SI+CL)	
		2	SS	63		135					
134.8 1.3	**MARBLE BEDROCK** Slightly Weathered Large Grain Grey	1	RUN			134	FI >10 >10 >10 >10 1	RUN #1 TCR=86% SCR=41% RQD=23%			
		2	RUN			133 132	3 >10 3 3 >10	RUN #2 TCR=100% SCR=75% RQD=50%			
		3	RUN			131	>10 1 3	RUN #3 TCR=100% SCR=67% RQD=55%			
130.7 5.4	End of Borehole										



+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 19-19

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.470388°, Long: -76.620846° Country Road 6 MTM Zone 9: N 5 036 725.0 E 295 350.9	ORIGINATED BY	SOB
HWY	17	BOREHOLE TYPE	CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2019.08.28 - 2019.08.28	CHECKED BY	FG

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

SOIL PROFILE ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
131.9	Pavement Surface							
0.0	**ASPHALT (100mm)**							
0.1	SAND with silt and gravel Very Dense Brown **(FILL)**	1	SS	57				32 57 11 (SI+CL)
131.0 0.9	- contains weathered bedrock	2	SS	100/ 100mm		131	FI	
	MARBLE BEDROCK Slightly Weathered Small Grain Grey-Yellow	1	RUN				>10 >10 7	RUN #1 TCR=100% SCR=50% RQD=0% RUN #2 TCR=100% SCR=60% RQD=18%
		2	RUN			130	>10 >10 4 2	
		3	RUN			129 128	3 4 3 5 1 2	RUN #3 TCR=100% SCR=60% RQD=52%
127.5 4.4	End of Borehole							

+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

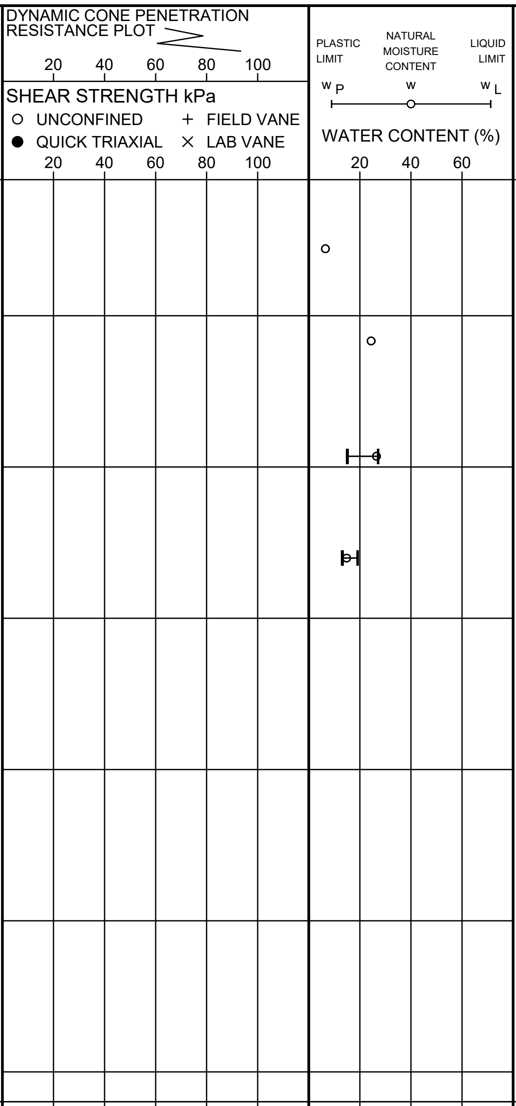
THURBER

RECORD OF BOREHOLE No 19-20

1 OF 1 **METRIC**

WP# 4068-09-00	LOCATION Lat: 45.47065°, Long: -76.620438° Country Road 6 MTM Zone 9: N 5 036 754.1 E 295 382.9	ORIGINATED BY SOB
HWY 17	BOREHOLE TYPE CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY MW
DATUM Geodetic	DATE 2019.08.28 - 2019.08.28	CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
130.9	Pavement Surface						
0.0	**ASPHALT (150mm)**						
0.2	SAND, some gravel Compact Brown **(FILL)**	1	SS	26			
130.1 0.8	**Clayey SILT (CL)** with sand to **Sandy Clayey SILT (CL-ML)**, trace gravel Loose to Very Dense Brown	2	SS	7	130		
		3	SS	8	129		0 18 59 23
		4	SS	100/ 275 mm			8 41 39 12
128.2 2.7	**(inferred TILL)**				128		
127.9 3.0	**MARBLE BEDROCK** Slightly Weathered Large Grain Rough Grey-White - 50 mm silt seam at 3.6 m	1	RUN		127	FI >10 2 2 0 2	RUN #1 TCR=97% SCR=55% RQD=83%
		2	RUN		126 125	1 0 3 2 1	RUN #2 TCR=100% SCR=93% RQD=83%
124.8 6.1	End of Borehole						



+³, ×³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

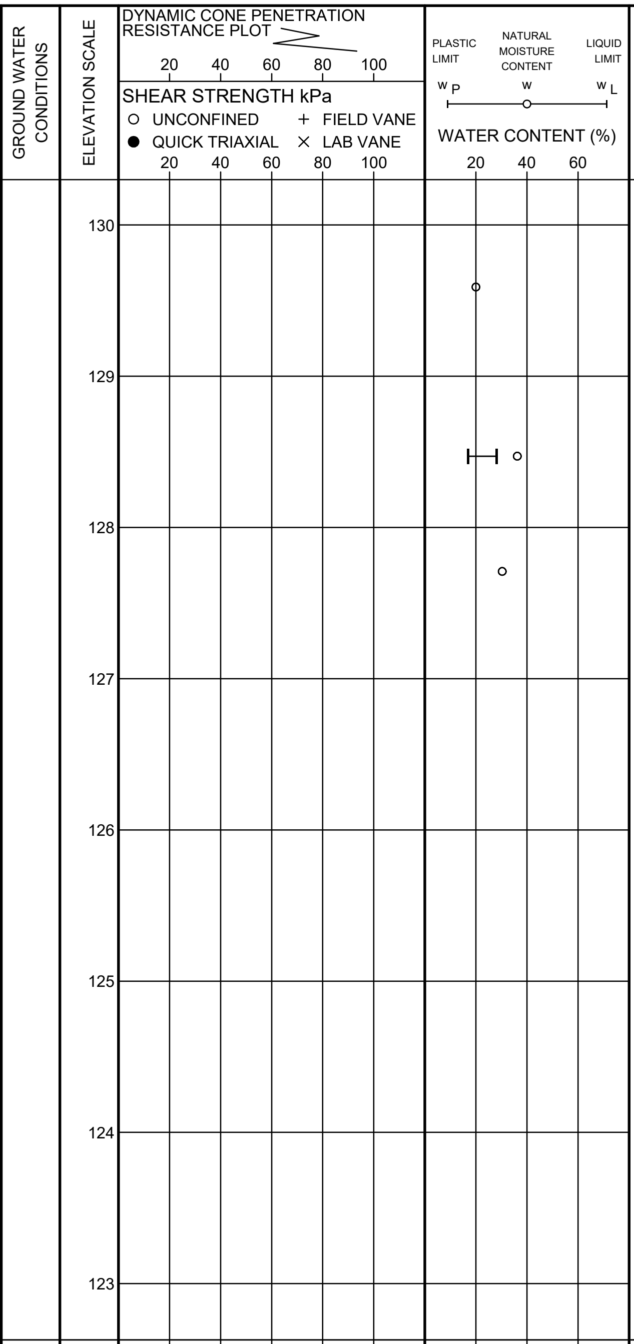
RECORD OF BOREHOLE No 19-21

1 OF 1

METRIC

WP# 4068-09-00
HWY 17
DATUM Geodetic
LOCATION Lat: 45.470874°, Long: -76.620005°
Country Road 6 MTM Zone 9: N 5 036 778.9 E 295 416.7
BOREHOLE TYPE CME 55 Truckmount, NW Casing, NQ Coring
DATE 2019.08.28 - 2019.08.28
ORIGINATED BY SOB
COMPILED BY MW
CHECKED BY FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
130.3	Pavement Surface					
0.0	**ASPHALT (175mm)**					
0.2	**CONCRETE (225mm)**					
129.9 0.4	Silty SAND Loose Brown **(FILL)**	1	SS	7		1 66 33 (SI+CL)
128.8 1.5	**Clayey SILT (CL)** with sand, trace gravel Very Loose to Compact Brown	2	SS	3		7 18 55 20
		3	SS	24		
127.4 2.9	Frequent Cobbles and Boulders **(Inferred TILL)**	4	NQ			
125.9 4.4	**MARBLE BEDROCK** Slightly Weathered Large Grain Grey - Very fractured from 4.4 m to 5.2 m	1	RUN		FI >10 >10 >10 0 1 1	RUN #1 TCR=82% SCR=53% RQD=44%
		2	RUN		2 2 3 1 3	RUN #2 TCR=100% SCR=94% RQD=83%
122.6 7.7	End of Borehole					



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

20 15 5 10 (%) STRAIN AT FAILURE

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-22

1 OF 1

METRIC

WP# 4068-09-00	LOCATION Lat: 45.47005°, Long: -76.621237° Country Road 6 MTM Zone 9: N 5 036 687.4 E 295 320.2	ORIGINATED BY SOB
HWY 17	BOREHOLE TYPE CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY MW
DATUM Geodetic	DATE 2019.08.27 - 2019.08.27	CHECKED BY FG

SOIL PROFILE

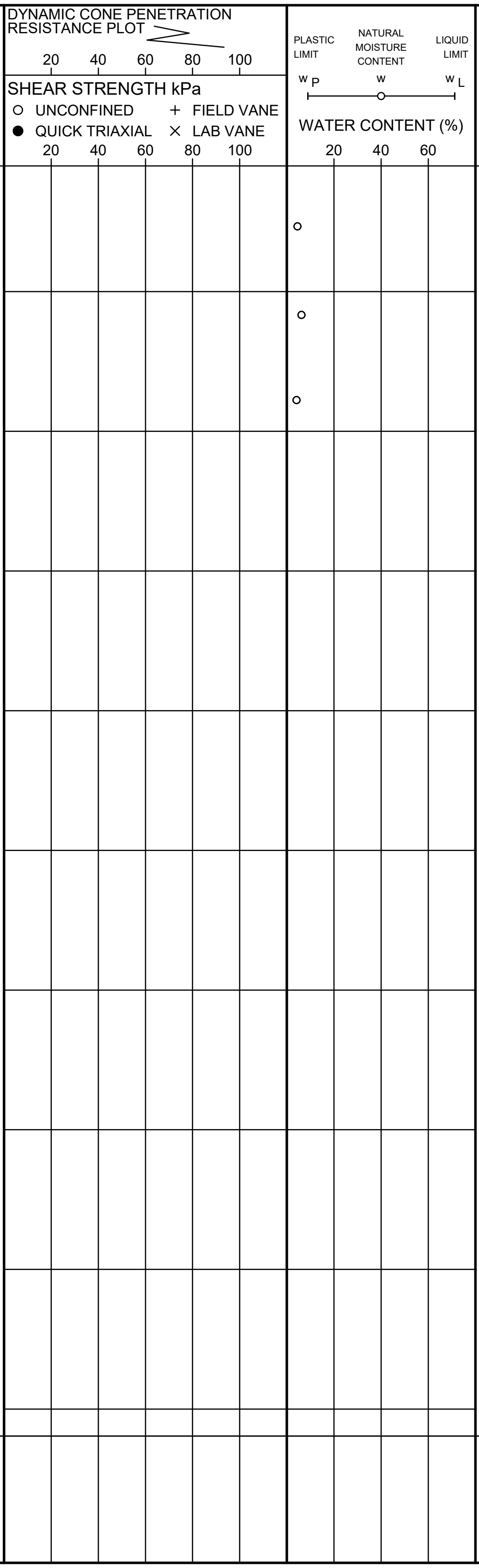
ELEV / DEPTH	DESCRIPTION	STRAT PLOT
133.9	Pavement Surface	
0.0	**ASPHALT (125mm)**	■
0.1	SAND with silt and gravel Dense to Very Dense Brown **(FILL)** - contains weathered bedrock	☒
131.7 / 2.2	**MARBLE BEDROCK** Slightly Weathered Large Grain Grey	▨
124.8 / 9.1	End of Borehole	

SAMPLES

NUMBER	TYPE	"N" VALUES
1	SS	70
2	SS	47
3	SS	100/ 150mm
1	RUN	
2	RUN	
3	RUN	
4	RUN	
5	RUN	

GROUND WATER CONDITIONS

ELEVATION SCALE: 133, 132, 131, 130, 129, 128, 127, 126, 125



UNIT WEIGHT γ kN/m 3

FI: >10, >10, >10, >10, 1, >10, 4, >10, >10, >10, >10, >10, >10, >10, 8, >10, >10, 2, 4, 1, 5

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR	SA	SI	CL
41	50	9 (SI+CL)	

RUN #1
TCR=100%
SCR=28%
RQD=16%

RUN #2
TCR=91%
SCR=42%
RQD=34%

RUN #3
TCR=38%
SCR=22%
RQD=0%

RUN #4
TCR=100%
SCR=55%
RQD=32%

RUN #5
TCR=88%
SCR=76%
RQD=64%

+ 3, × 3: Numbers refer to Sensitivity

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

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

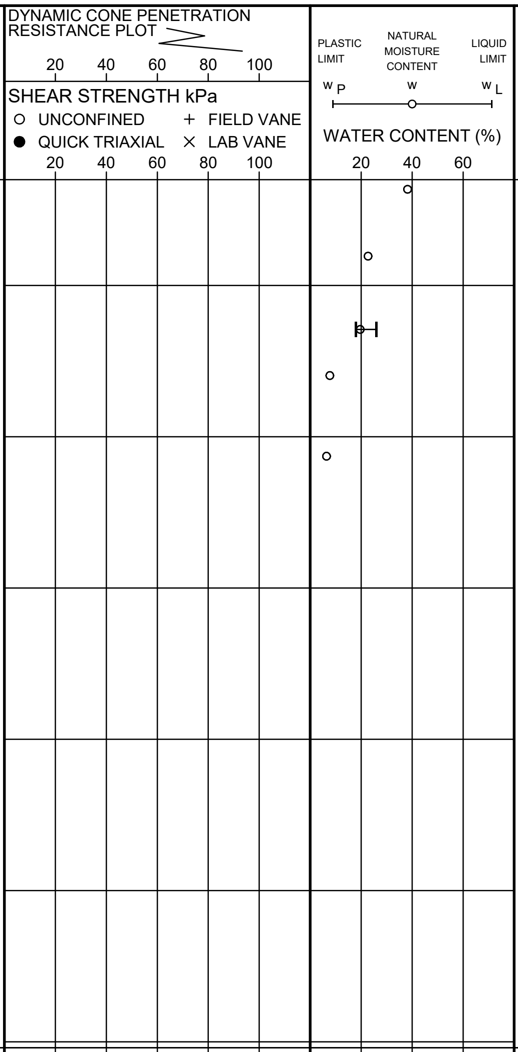
RECORD OF BOREHOLE No 19-23

1 OF 1

METRIC

WP# 4068-09-00
LOCATION Lat: 45.469699°, Long: -76.620741° Country Road 6 MTM Zone 9: N 5 036 648.4 E 295 359.0
ORIGINATED BY AO
HWY 17
BOREHOLE TYPE CME 45 Trackmount, HSA, NQ Coring
COMPILED BY AO
DATUM Geodetic
DATE 2021.04.28 - 2021.04.28
CHECKED BY FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
132.7	Ground Surface						
0.0	**TOP SOIL (130 mm)**						
0.1	**Clayey SILT (CL)**, with sand Very Loose to Dense Grey-brown	1	SS	2			
					132		
131.5		2	SS	48			0 17 61 22
1.2	**SAND** with silt and gravel Grey-brown Very dense **(TILL)** - contains cobbles and boulders				131		
130.6		3	SS	92		FI	35 54 11 (SI+CL)
		~~4~~	~~SS~~	~~100/~~ 0mm			
2.1	**MARBLE BEDROCK** Moderately Weathered to Fresh Jointed Medium Grain Grey-white to Yellowish-Grey	1	RUN		130	5 5 >10	RUN #1 TCR=100% SCR=28% RQD=30%
		2	RUN		129 128	2 1 2 2 6 2	RUN #2 TCR=100% SCR=83% RQD=79%
127.0		3	RUN		127	2 3 1	RUN #3 TCR=97% SCR=83% RQD=83%
5.7	End of Borehole Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2021.04.30 0.8 131.9						



+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

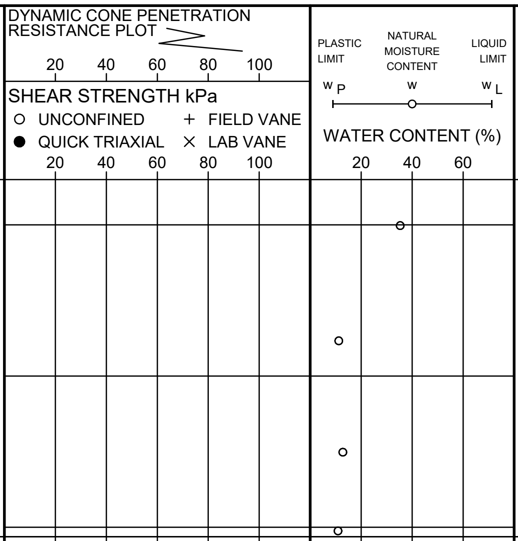
THURBER

RECORD OF BOREHOLE No 19-24

1 OF 1 **METRIC**

WP# 4068-09-00
LOCATION Lat: 45.469369°, Long: -76.620376°
Country Road 6 MTM Zone 9: N 5 036 611.7 E 295 387.5
ORIGINATED BY AO
HWY 17
BOREHOLE TYPE CME 45 Trackmount, HSA
COMPILED BY AO
DATUM Geodetic
DATE 2021.04.29 - 2021.04.29
CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m 3	GR	SA	SI	CL
132.3	Ground Surface										
0.0	**TOP SOIL (250 mm)**										
0.2	**Silty GRAVEL (GM)** with sand Contains clayey silt seams Yellowish-white Compact to dense **(TILL)** - contains weathered bedrock	1	SS	13		132					
		2	SS	28		131					
					▼						
		3	SS	39				44	42	14 (SI+CL)	
129.9		4	SS	100/ 75mm		130					
2.4	End of borehole Auger and spoon refusal on inferred bedrock.										



+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-25

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.468967°, Long: -76.620342° Country Road 6 MTM Zone 9: N 5 036 567.0 E 295 390.1	ORIGINATED BY	AO
HWY	17	BOREHOLE TYPE	CME 45 Trackmount, HSA	COMPILED BY	AO
DATUM	Geodetic	DATE	2021.04.29 - 2021.04.29	CHECKED BY	FG

SOIL PROFILE			SAMPLES								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"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
134.7	Ground Surface										
0.0	**TOP SOIL (460 mm)**		1	SS	4						
134.2 0.5	**Silty GRAVEL (GM)** with sand Contains clayey silty sand seams Yellowish-white **(TILL)**		2	SS	100/ 125mm		134				
134.0 0.7	End of borehole Auger and spoon refusal on inferred bedrock.										

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

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

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

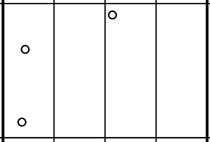
RECORD OF BOREHOLE No 19-26

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469196°, Long: -76.62059° Country Road 6 MTM Zone 9: N 5 036 592.5 E 295 370.7	ORIGINATED BY	AO
HWY	17	BOREHOLE TYPE	CME 45 Trackmount, HSA	COMPILED BY	AO
DATUM	Geodetic	DATE	2021.04.29 - 2021.04.29	CHECKED BY	FG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES						
134.0	Ground Surface									
0.0	**TOP SOIL (150 mm)**									
0.2	**SAND (SW)** with gravel Yellowish-white Very dense **(TILL)**	1	SS	59						
133.1 0.9	- contains weathered bedrock	2	SS	100/ 200mm						
	End of borehole Auger and spoon refusal on inferred bedrock.									



+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-27

1 OF 1

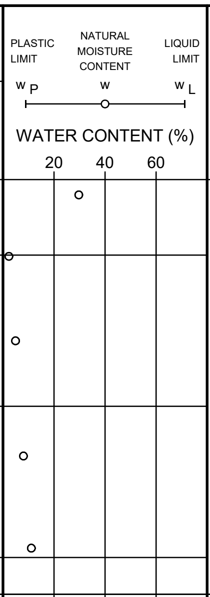
METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469564°, Long: -76.620814° Country Road 6 MTM Zone 9: N 5 036 633.4 E 295 353.3	ORIGINATED BY	AO
HWY	17	BOREHOLE TYPE	CME 45 Trackmount, HSA	COMPILED BY	AO
DATUM	Geodetic	DATE	2021.04.29 - 2021.04.29	CHECKED BY	FG

SOIL PROFILE		SAMPLES							
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
133.5	Ground Surface								
0.0	**TOP SOIL (150 mm)**								
0.1	**GRAVEL (GW-GM)** with silt and sand Yellowish-white Dense to very dense **(TILL)** - contains weathered bedrock	1	SS	25					
						133			
		2	SS	46				61 31 8 (SI+CL)	
					▼	132			
		3	SS	33					
		4	SS	100/ 275mm					
						131			
130.8 2.7	End of borehole Auge refusal on inferred bedrock.								

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



+ 3, × 3: Numbers refer to Sensitivity

20
15 5
10
(%) STRAIN AT FAILURE

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-28

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469664°, Long: -76.621509° Country Road 6 MTM Zone 9: N 5 036 644.6 E 295 299.0	ORIGINATED BY	JP
HWY	17	BOREHOLE TYPE	CME 45 Trackmount, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2020.05.05 - 2020.05.05	CHECKED BY	FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
136.0	Ground Surface							
0.0 135.4	**Silty SAND** with organics, trace gravel Loose Brown	1	SS	6				
0.6	**(TILL)**						FI	
	MARBLE BEDROCK Moderately Weathered to Fresh Jointed Large Grain Rough Grey-Pink - brown stain in fracture from 0.6 m to 1.7m - Vertical fracture from 1.0 m to 1.7 m - Vertical fracture from 1.7 m to 2.1 m	1	RUN			135	>10 >10 7	RUN #1 TCR=90% SCR=13% RQD=0%
		2	RUN			134 133	4 5 4 5 4	RUN #2 TCR=100% SCR=70% RQD=13%
131.3	- Weathered section from 3.8 m to 4 m	3	RUN			132	4 2 4 >10 5 6	RUN #3 TCR=100% SCR=87% RQD=32%
4.7	End of Borehole							

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

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-30

1 OF 2

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.468677°, Long: -76.623727° Country Road 6 MTM Zone 9: N 5 036 535.2 E 295 125.3	ORIGINATED BY	JP
HWY	17	BOREHOLE TYPE	CME 45 Trackmount, HSA	COMPILED BY	MW
DATUM	Geodetic	DATE	2020.05.06 - 2020.05.06	CHECKED BY	FG

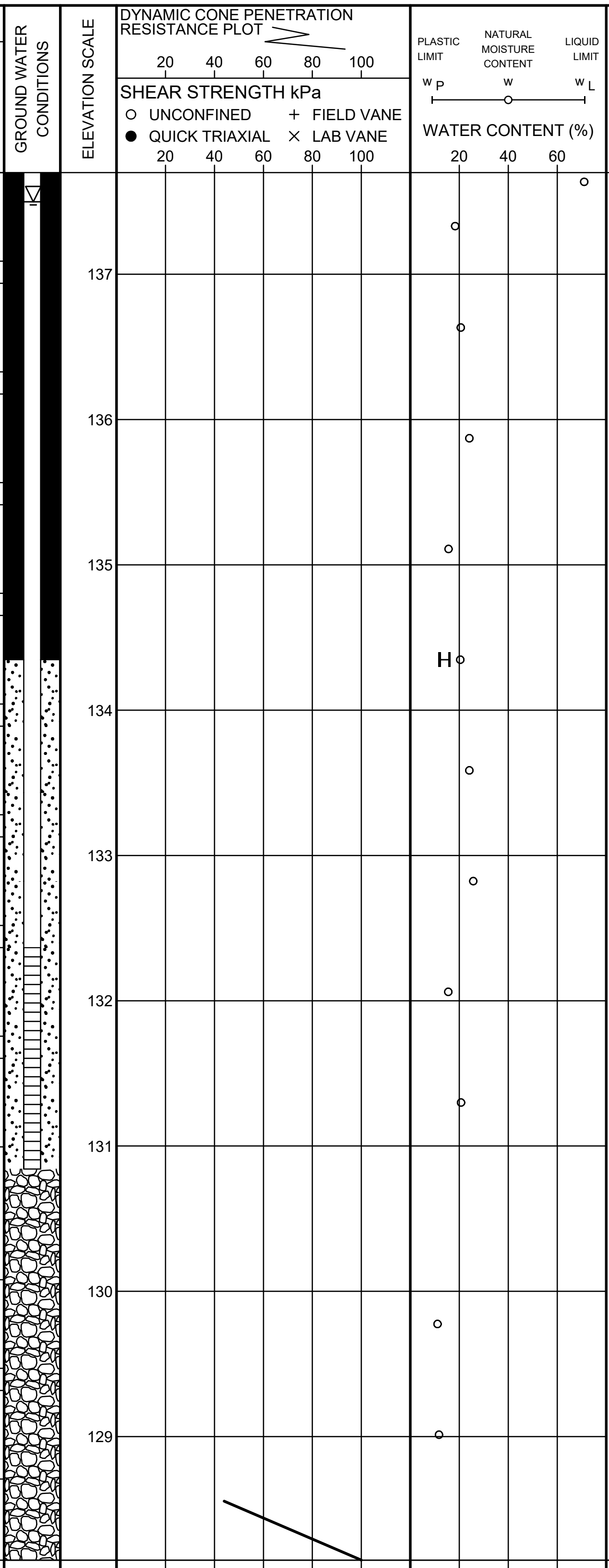
SOIL PROFILE

ELEV DEPTH	DESCRIPTION
137.7	Ground Surface
0.0	**TOPSOIL (125mm)**
0.1	**Silty SAND (SM)**, trace gravel Very Loose to Loose Brown to Grey
135.4 2.3	**Sandy CLAYEY SILT (CL-ML)** Very Loose to Compact Grey to Grey-Brown
130.8 6.9	**Silty SAND (SM)** with gravel Dense to Very Dense Grey-Brown **(TILL)** -augers grinding from 6.9 m
128.7 9.0	DCPT from 29'6"
128.1 9.6	End of Borehole DCPT refusal on inferred bedrock.

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
1	SS	2				
2	SS	7				
3	SS	6	0	76	24 (SI+CL)	
4	SS	4				
5	SS	2	1	34	46	19
6	SS	2				
7	SS	6				
8	SS	23				
9	SS	4				
10	SS	36	38	43	19 (SI+CL)	
11	SS	59				

UNIT WEIGHT γ kN/m³



Continued Next Page

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-30

2 OF 2

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.468677°, Long: -76.623727° Country Road 6 MTM Zone 9: N 5 036 535.2 E 295 125.3	ORIGINATED BY	JP
HWY	17	BOREHOLE TYPE	CME 45 Trackmount, HSA	COMPILED BY	MW
DATUM	Geodetic	DATE	2020.05.06 - 2020.05.06	CHECKED BY	FG

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Monitoring well installation consists of 50mm diameter Schedule 40 PVC pipe with a 1.5-m slotted screen WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2020.09.29 0.6 137.1 2020.06.03 0.2 137.5 2021.09.23 0.7 137.0 2021.10.03 0.9 136.8 2022.01.20 0.8 136.9										

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

$\overset{20}{15\text{-}\oplus\text{-}5}_{10}$ (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 19-31

1 OF 1

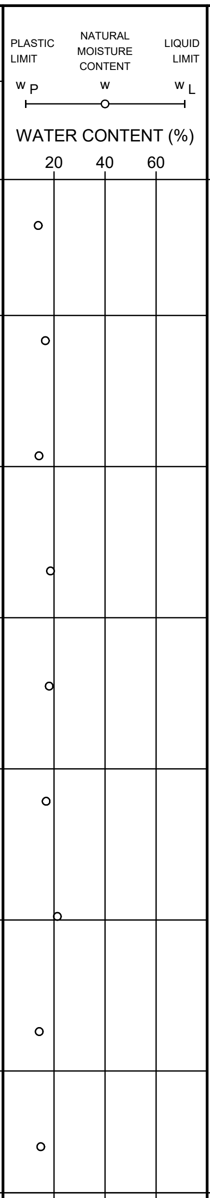
METRIC

WP# 4068-09-00	LOCATION Lat: 45.468764°, Long: -76.62477° Country Road 6 MTM Zone 9: N 5 036 545.0 E 295 043.8	ORIGINATED BY JP
HWY 17	BOREHOLE TYPE CME 45 Trackmount, HSA	COMPILED BY MW
DATUM Geodetic	DATE 2020.05.05 - 2020.05.05	CHECKED BY FG

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
140.9	Ground Surface						
0.0	**Sandy SILT (ML)** Very Loose to Very Dense Brown Moist to Wet	1	SS	2			
		2	SS	6		140	1 39 49 11 -non-plastic
		3	SS	22		139	
		4	SS	42		138	
		5	SS	52			
		6	SS	45		137	
		7	SS	38		136	0 39 50 11 -non-plastic
135.7 5.2	**Silty SAND (SM)** Very Dense Brown Wet	8	SS	82		135	
		9	SS	34			1 56 34 9 -non-plastic
134.2 6.7	End of Borehole						

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



UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-10

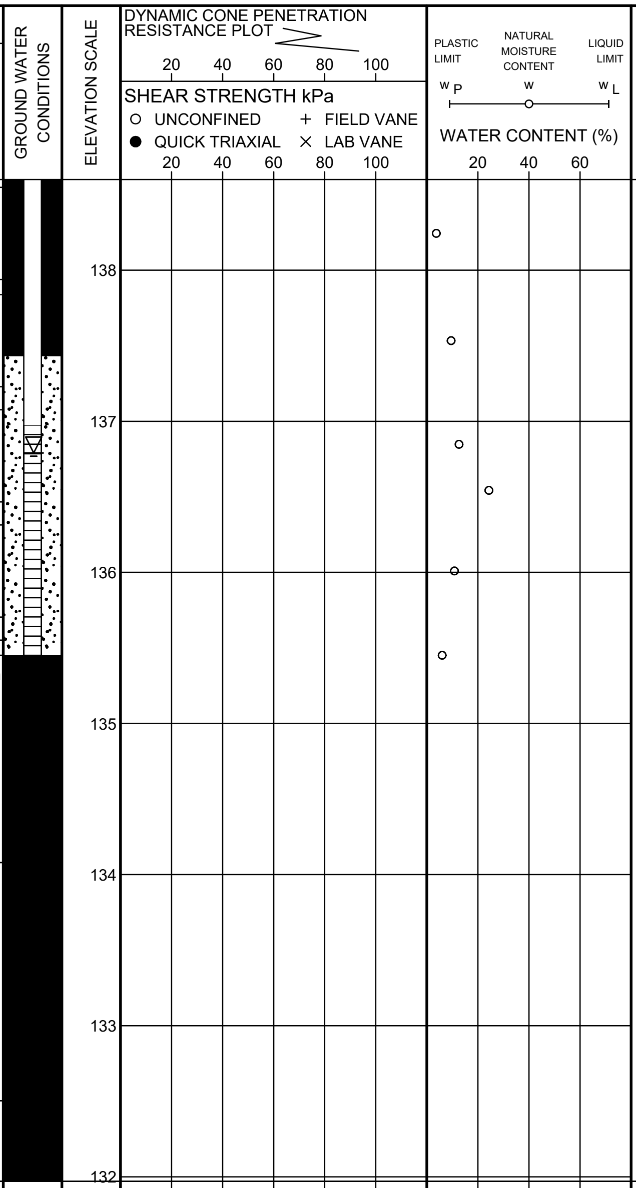
1 OF 1 **METRIC**

WP# 4068-09-00	LOCATION Lat: 45.468728°, Long: -76.622695° Country Road 6 (Culvert) MTM Zone 9: N 5 036 540.7 E 295 206.0	ORIGINATED BY SOB
HWY 17	BOREHOLE TYPE CME 55 Truckmount, NW Casing, NQ Coring	COMPILED BY MW
DATUM Geodetic	DATE 2019.08.27 - 2019.08.27	CHECKED BY FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
138.6	Ground Surface					
0.0 0.1	**ASPHALT (50mm)**					
	SAND with gravel to GRAVEL with silt and sand Compact to Dense Brown **(FILL)**	1	SS	40		36 60 4 (SI+CL)
		2	SS	46		
		3	SS	26		56 38 6 (SI+CL)
136.6 2.0	**Sandy SILT** with clay Compact Grey					
136.3 2.3	**GRAVEL**, some sand Compact Brown **(TILL)**	4	SS	23		
		5	SS	100/ 50mm	FI	
135.5 3.1	**MARBLE BEDROCK** Slightly Weathered Large Grain Smooth White - 75 mm silt seam at 3.9 m	1	RUN		1 2 2 2	RUN #1 TCR=94% SCR=76% RQD=78%
		2	RUN		1 3 2 2 2	RUN #2 TCR=100% SCR=95% RQD=77%
		3	RUN		2 4	RUN #3 TCR=100% SCR=86% RQD=57%
132.0 6.6	End of Borehole Piezometer consists of 19 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen					

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2019.09.29	2.2	136.4
2020.04.21	1.8	136.8
2020.06.03	1.8	136.8
2020.09.29	2.2	136.4
2021.09.23	1.9	136.7
2021.11.04	1.9	136.7



+ 3, × 3: Numbers refer to Sensitivity

20
15 ⊕ 5
10
(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-11

1 OF 1

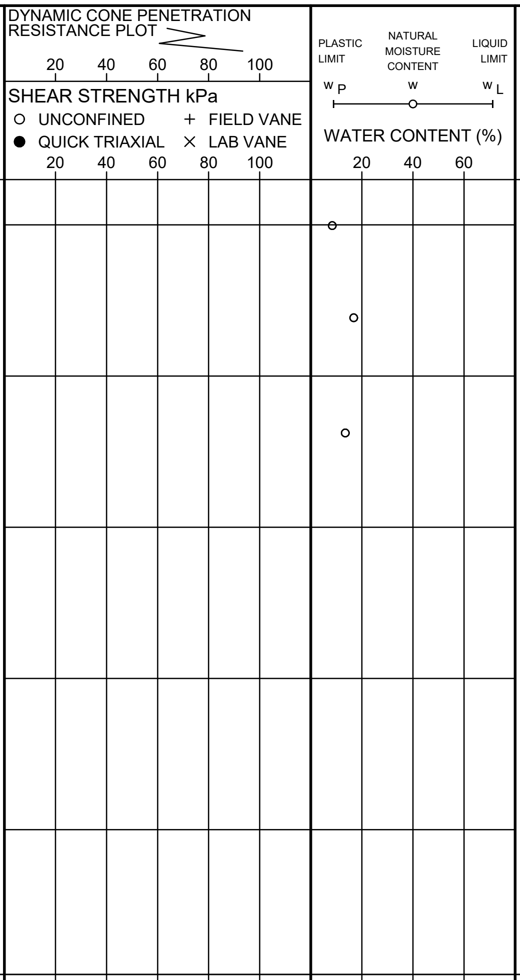
METRIC

WP# 4068-09-00
LOCATION Lat: 45.469139°, Long: -76.622108°
Country Road 6 (Culvert) MTM Zone 9: N 5 036 586.3 E 295 252.0
ORIGINATED BY JP
HWY 17
BOREHOLE TYPE CME 45 Trackmount, HW Casing, HQ Coring
COMPILED BY MW
DATUM Geodetic
DATE 2020.05.04 - 2020.05.04
CHECKED BY FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION
137.3	Ground Surface
0.0	**SAND (SP)** to **Silty SAND**, trace gravel, trace organics Very Loose Brown
135.8 1.5	**GRAVEL** with silt and sand Very Dense Grey-Brown **(TILL)**
135.4 1.9	**MARBLE BEDROCK** Moderately Weathered to Fresh Jointed Large Grain Rough Grey-Pink
132.0 5.3	End of Borehole

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	2	6 90 4 (SI+CL)
2	SS	2	
3	SS	100/175mm	
1	RUN		RUN #1 TCR=100% SCR=23% RQD=0%
2	RUN		RUN #2 TCR=100% SCR=75% RQD=29%
3	RUN		RUN #3 TCR=100% SCR=92% RQD=56%

UNIT WEIGHT γ kN/m³ column: FI
>10
>10
2
3
>10
3
4
3
3
1
2



Monitoring well consists of 50 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen
WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2020.09.29	1.3	136.0
2020.06.03	0.9	136.4
2021.09.23	1.5	135.8
2021.10.03	1.2	136.1
2022.01.22	1.0	136.3

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

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

Ministry of Transportation
Ontario

THURBER

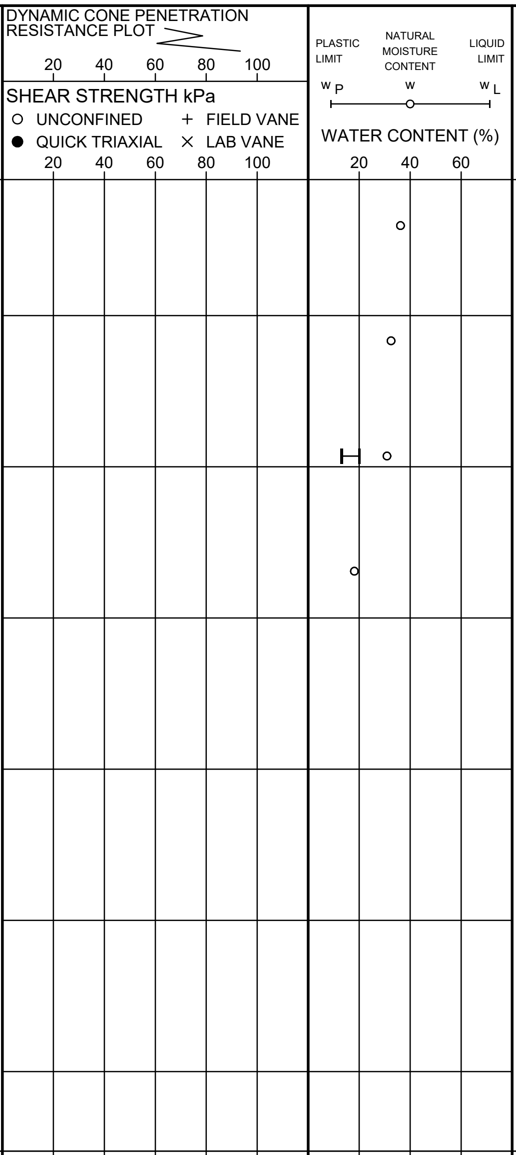
RECORD OF BOREHOLE No CV-12

1 OF 1

METRIC

WP#	4068-09-00	LOCATION	Lat: 45.469006°, Long: -76.622227° Country Road 6 (Culvert) MTM Zone 9: N 5 036 571.6 E 295 242.7	ORIGINATED BY	JP
HWY	17	BOREHOLE TYPE	CME 45 Trackmount, NW Casing, NQ Coring	COMPILED BY	MW
DATUM	Geodetic	DATE	2020.05.04 - 2020.05.04	CHECKED BY	FG

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
136.9	Ground Surface						
0.0	**Silty SAND**, trace to with organics Very Loose to Loose Brown to Grey-Brown	1	SS	1			
136.3 0.6	**Clayey SILT (CL-ML)** Loose Grey Brown	2	SS	5	136		
		3	SS	4	135		0 23 54 23
134.6 2.3	**GRAVEL** with silt and sand Very Dense Grey **(TILL)**	4	SS	64		FI	54 35 11 (SI+CL)
134.1 2.8	**MARBLE BEDROCK** Moderately Weathered to Fresh Jointed Large Grain Rough Grey - Highly Fractured from 2.8 m to 3.4 m	1	RUN		134	>10 >10	RUN #1 TCR=100% SCR=22% RQD=22%
		2	RUN		133	1 5 1 3 3	RUN #2 TCR=100% SCR=90% RQD=59%
		3	RUN		132 131	2 1 2 4 3	RUN #3 TCR=100% SCR=89% RQD=74%
130.5 6.4	End of Borehole						



+³, ×³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-13

1 OF 1

METRIC

WP# 4068-09-00	LOCATION Lat: 45.469443°, Long: -76.621853° Country Road 6 (Culvert) MTM Zone 9: N 5 036 620.1 E 295 272.0	ORIGINATED BY JP
HWY 17	BOREHOLE TYPE CME 45 Trackmount, NW Casing, NQ Coring	COMPILED BY MW
DATUM Geodetic	DATE 2020.05.04 - 2020.05.04	CHECKED BY FG

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

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.7	Ground Surface								
0.0	**TOPSOIL (220mm)**		1	SS	100/ 75mm			FI	
0.2	**MARBLE BEDROCK** Slightly Weathered to Fresh Jointed Coarse-Medium Grain Grey-White to Grey-Pink		1	RUN			137	1 0 1 1 5	RUN #1 TCR=90% SCR=81% RQD=78%
			2	RUN			136 135	4 2 4 4	RUN #2 TCR=100% SCR=17% RQD=7%
133.6			3	RUN			134	1 5 6 1	RUN #3 TCR=100% SCR=89% RQD=42%
4.1	End of Borehole								

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

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

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

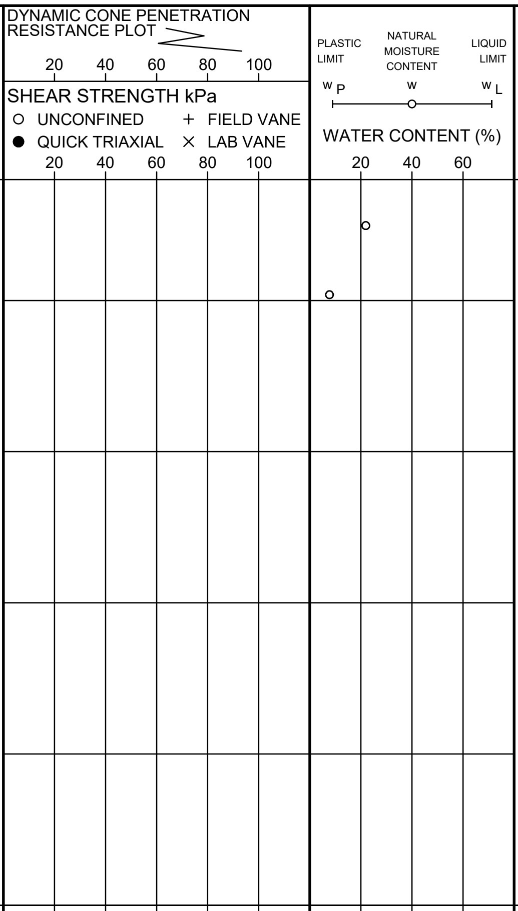
THURBER

RECORD OF BOREHOLE No CV-14

1 OF 1 **METRIC**

WP# 4068-09-00
LOCATION Lat: 45.469676°, Long: -76.622153° Country Road 6 (Culvert) MTM Zone 9: N 5 036 646.0 E 295 248.6
ORIGINATED BY JP
HWY 17
BOREHOLE TYPE CME 45 Trackmount, NQ Coring
COMPILED BY MW
DATUM Geodetic
DATE 2020.05.05 - 2020.05.05
CHECKED BY FG

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.8	Ground Surface							
0.0	**Silty SAND (SM)**, some gravel, some organics Very Loose Brown **(TILL)**	1	SS	2				
		2	SS	100/ 150mm		137	FI	11 75 14 (SI+CL)
136.9 0.9	**MARBLE BEDROCK** Fresh to Fresh Jointed Large Grain Rough Grey	1	RUN				3 2 3	RUN #1 TCR=80% SCR=68% RQD=39%
		2	RUN			136 135	4 5 4 4 5	RUN #2 TCR=100% SCR=97% RQD=13%
133.0		3	RUN			134	3 2 2 4 1	RUN #3 TCR=100% SCR=97% RQD=11%
4.8	End of Borehole					133		



+ ³, × ³: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

DOUBLE LINE 24726 CR6.GPJ 2012TEMPLATE(MTO).GDT 22-8-24

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CV-15

1 OF 1 **METRIC**

WP# 4068-09-00
LOCATION Lat: 45.469527°, Long: -76.621977° Country Road 6 (Culvert) MTM Zone 9: N 5 036 629.5 E 295 262.3
ORIGINATED BY SOB
HWY 17
BOREHOLE TYPE CME 55 Truckmount, NW Casing, NQ Coring
COMPILED BY MW
DATUM Geodetic
DATE 2019.09.05 - 2019.09.05
CHECKED BY FG

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES						
136.8	Ground Surface									
0.0	Silty SAND with gravel Very Dense Brown to White-brown **(FILL)**	1	SS	53				○		34 53 13 (SI+CL)
		2	SS	62		136		○		
135.3 1.5	**MARBE BEDROCK** Slightly Weathered Large Grain Smooth Grey	1	RUN		∇	135 134			FI 6 4 1 3 3	RUN #1 TCR=100% SCR=87% RQD=62%
	-Very fractured from 3.0 m to 3.8 m	2	RUN			133			>10 >10 7 4 2	RUN #2 TCR=100% SCR=57% RQD=43%
131.7		3	RUN			132			1 2 2	RUN #3 TCR=100% SCR=90% RQD=100%
5.1	End of Borehole									

Monitoring well consists of 19 mm diameter Schedule 40 PVC pipe with a 1.5 m slotted screen

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2019.09.26	2.2	134.6
2020.04.21	2.0	134.8
2020.09.29	2.1	134.7
2021.11.24	0.5	136.5

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

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

Ministry of Transportation
Ontario

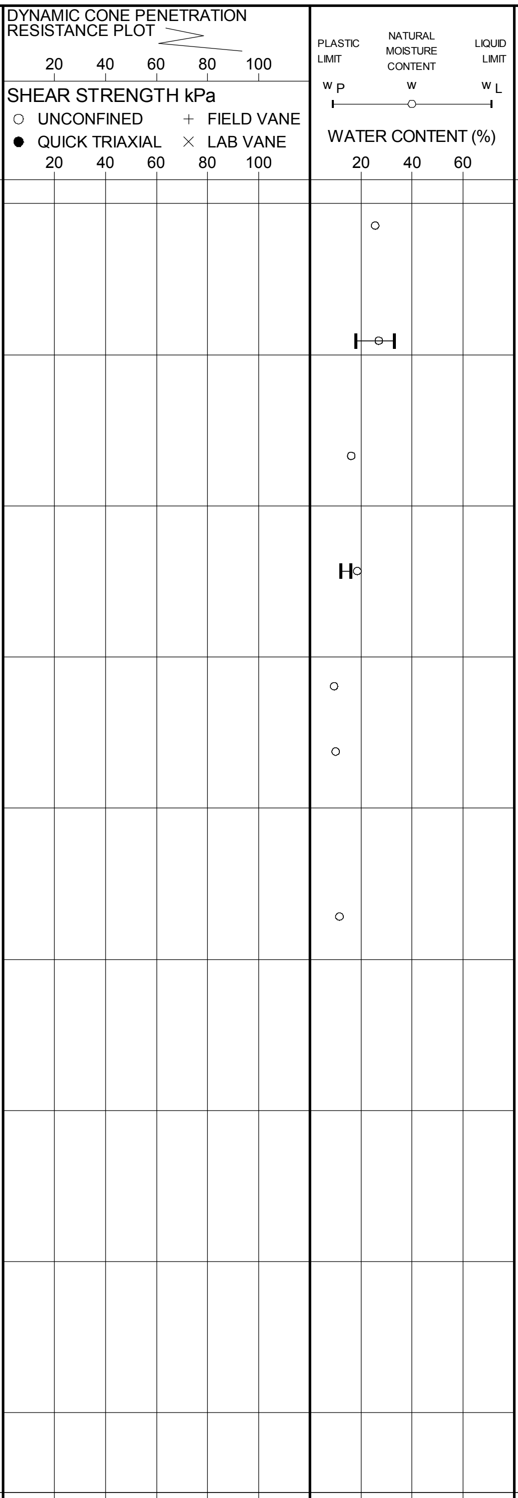
THURBER

RECORD OF BOREHOLE No 17-1

1 OF 1 **METRIC**

GWP# 4076-13-00	LOCATION Site 29-242/C1 Deil's Creek Culvert, MTM Zone 9: N 5 036 558.5 E 295 234.5		ORIGINATED BY NW
HWY 17	BOREHOLE TYPE NW Casing / NQ Coring		COMPILED BY CM
DATUM Geodetic	DATE 2018.01.16 - 2018.01.17		CHECKED BY KP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.2						
0.0 0.1	**50 mm ROOTMAT**				137	
	Clay with sand Stiff to very stiff Brown **FILL**	1	SS	10		
		2	SS	9	136	0 26 53 21
135.6 1.5	**SANDY SILTY CLAY (CL-ML)** Very stiff Brown to grey	3	SS	19	135	
		4	SS	17		1 38 43 18
134.1 3.0	**SILTY SAND (SM) with gravel** - occasional cobbles Compact to very dense Grey	5	SS	82	134	32 47 21 (SI+CL)
	- 180 mm Cobble at 3.9 m	6	SS	100/ 100mm	133	
		7	SS	13		
132.0 5.2	**MARBLE BEDROCK** Slightly weathered Poor to good quality Medium grained White	1	RUN		132	RUN #1 TCR=100% SCR=100% RQD=39%
		2	RUN		131	RUN #2 TCR=100% SCR=72% RQD=70%
		3	RUN		130 129	RUN #3 TCR=100% SCR=100% RQD=78%
128.5 8.7	End of Borehole					



UNIT WEIGHT γ kN/m³

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

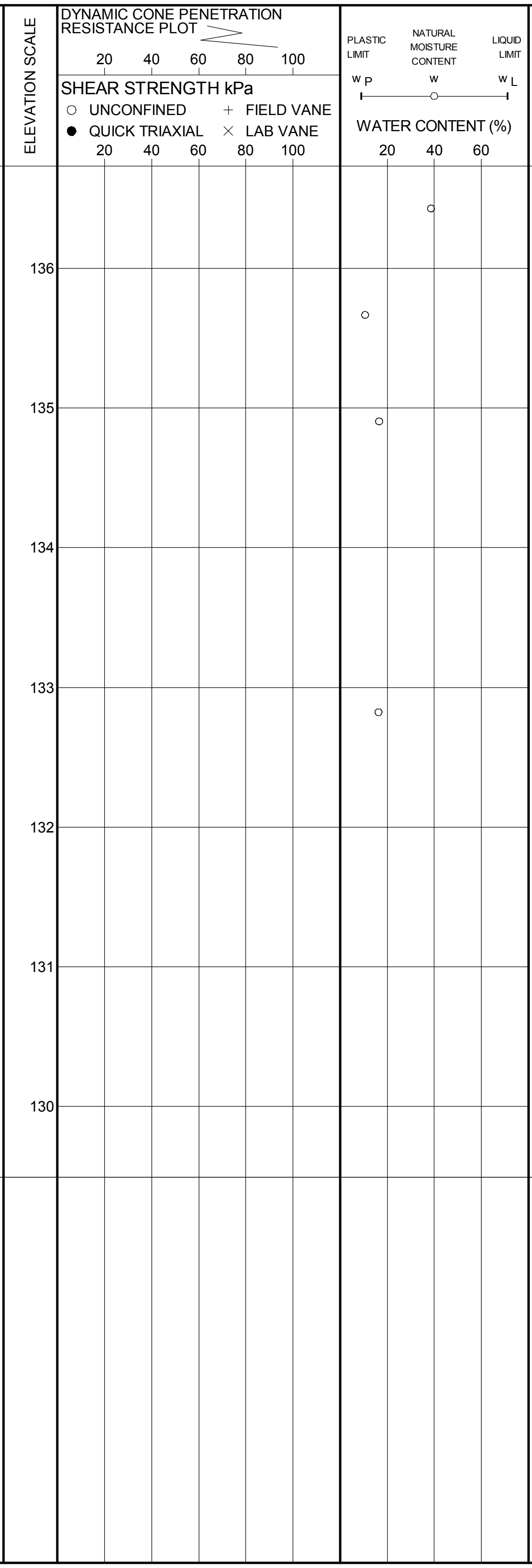
RECORD OF BOREHOLE No 17-2

1 OF 1

METRIC

GWP# 4076-13-00
LOCATION Site 29-242/C1 Deil's Creek Culvert, MTM Zone 9: N 5 036 511.2 E 295 195.8
ORIGINATED BY NW
HWY 17
BOREHOLE TYPE NW Casing / NQ Coring
COMPILED BY CM
DATUM Geodetic
DATE 2018.01.17 - 2018.01.17
CHECKED BY KP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
136.7 0.0	Organic clayey silt - frozen Brown **FILL**	1	SS	21			
136.1 0.6	**SILTY SAND (SM) with gravel** Loose to very dense Brown to grey	2	SS	14			
		3	SS	7			29 58 13 (SI+CL)
		4	SS	21			
		5	SS	23			
	- 175 mm Cobble at 4.0 m	6	SS	100/ 50mm			
132.5 4.2	**MARBLE BEDROCK** Slightly weathered Poor to good quality Medium grained White	1	RUN				RUN #1 TCR=97% SCR=0% RQD=0% *vertical fracture throughout Run#1
		2	RUN				RUN #2 TCR=70% SCR=67% RQD=48%
129.5 7.2	End of Borehole						



+ ³, × ³: Numbers refer to Sensitivity

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

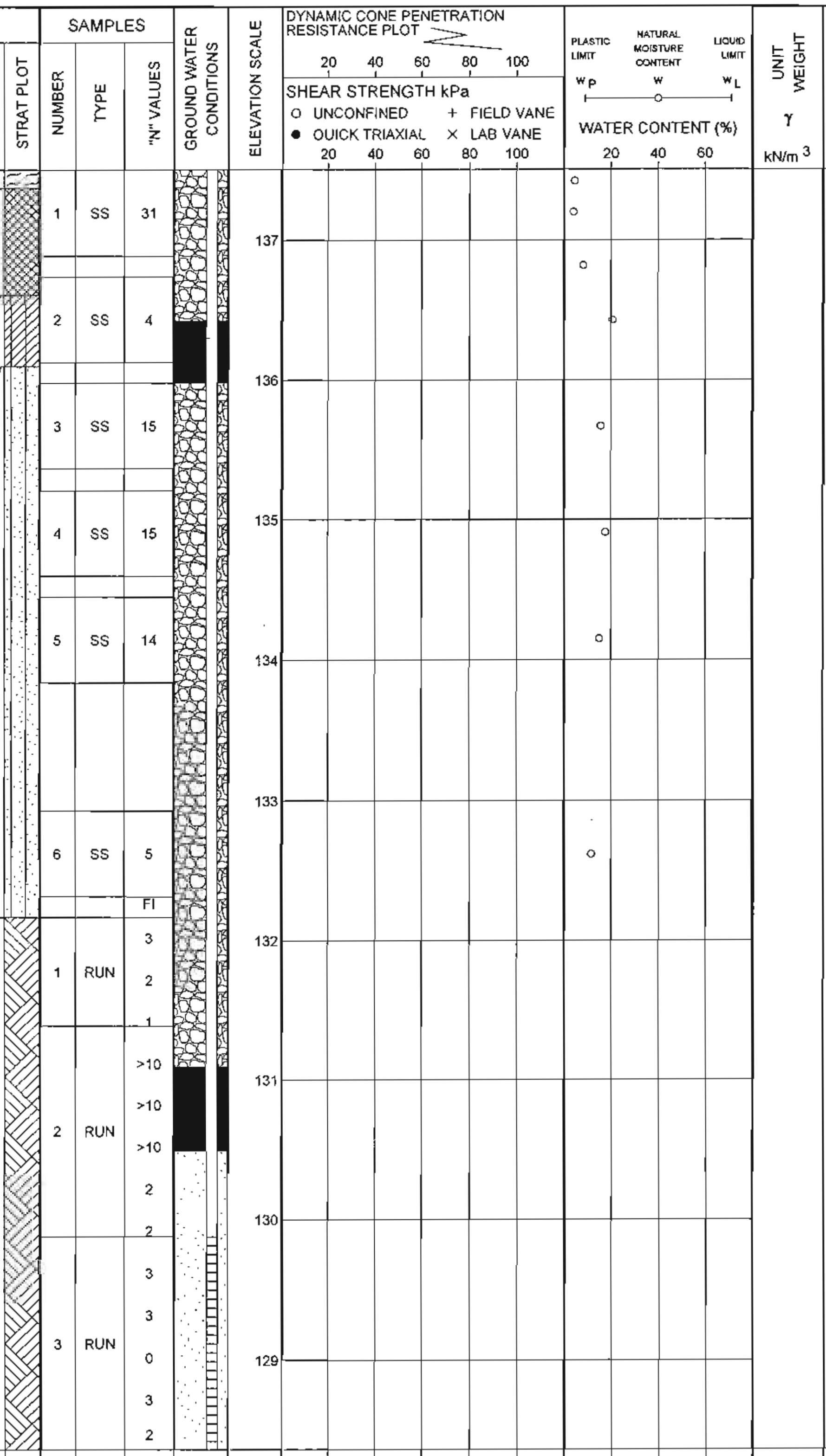
RECORD OF BOREHOLE No CR6-1

1 OF 2

METRIC

G.W.P.	647-92-00	LOCATION	N 5 036 561.3 E 295 173.5 (County Road 6)	ORIGINATED BY	JL
HWY	HWY 17	BOREHOLE TYPE	Hollow Stem Augers, NO Coring	COMPILED BY	SS
DATUM	Geodetic	DATE	14.10.03 - 14.10.03	CHECKED BY	SKP

ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.5					
130.0	**TOPSOIL** (125mm)				
0.1	Sandy **GRAVEL**, occasional organic inclusions Compact Brown Moist (FILL)	1	SS	31	
136.6 0.9	Silty **CLAY** to clayey **SILT**, with sand seams, occasional organic inclusions Firm Grey Moist	2	SS	4	0 21 61 18
136.1 1.4	**SAND and SILT** Compact Grey Moist to Wet (SP)	3	SS	15	
		4	SS	15	
	occasional clay lumps seams and partings	5	SS	14	0 44 56 (SI+CL)
	Loose	6	SS	5	
	Auger refusal at 5.33m.			FI	
132.2 5.3	**CRYSTALLINE LIMESTONE** (BEDROCK) Slightly weathered, very thinly bedded, grey and partially light brown with white and dark grey, horizontal and subvertical banding, strong to very strong, horizontal and subvertical banding Subvertical joints from 6.02m to 6.1m, 6.32m to 6.45m, 6.55m to 6.6m, 6.78m to 6.83m, 6.68m to 6.96m, 7.24m to 7.26m, 8.08m to 8.13m, 8.59m to 8.66m Vertical joint from 6.1m to 6.32m	1	RUN	3 2 1	RUN 1# TCR=100%, SCR=87%, RQD=53%, UCS=152MPa RUN 2# TCR=100%, SCR=62%, RQD=52%, UCS=132MPa
		2	RUN	>10 >10 >10 2 2	
		3	RUN	3 3 0 3 2	RUN 3# TCR=98%, SCR=88%, RQD=70%, UCS=141MPa
128.4 9.1	END OF BOREHOLE AT 9.14m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.				



Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20
15-⊕-5 (%) STRAIN AT FAILURE
10

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CR6-1

2 OF 2

METRIC

G.W.P. 647-92-00	LOCATION N 5 036 561.3 E 295 173.5 (County Road 6)	ORIGINATED BY JL
HWY HWY 17	BOREHOLE TYPE Hollow Stem Augers, NQ Coring	COMPILED BY SS
DATUM Geodetic	DATE 14.10.03 - 14.10.03	CHECKED BY SKP

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/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	WATER LEVEL READINGS: DATE ELEVATION (m) 16/10/2003 136.1 22/10/2003 136.3 16/12/2003 destroyed										

+ ³, × ³: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No CR6-2

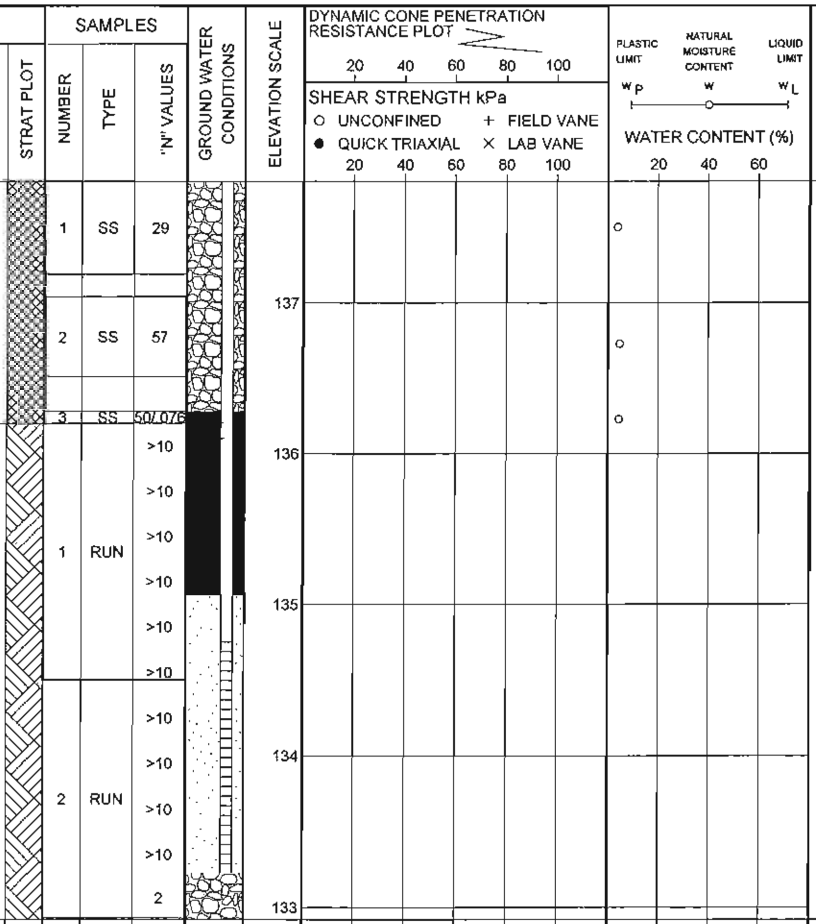
1 OF 1

METRIC

G.W.P. 647-92-00	LOCATION N 5 036 567.5 E 295 206.5 (County Road 6)	ORIGINATED BY JL
HWY HWY 17	BOREHOLE TYPE Hollow Stem Augers, NO Coring	COMPILED BY SS
DATUM Geodetic	DATE 14.10.03 - 14.10.03	CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	SAMPLES NUMBER	SAMPLES TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
137.8					
0.0	Sandy **GRAVEL**, occasional cobbles Compact to Very Dense Brown Moist (FILL)	1	SS	29	
		2	SS	57	
136.2	SAMPLER REFUSAL AT 1.6m.	3	SS	50/.076	
1.6	**CRYSTALLINE LIMESTONE (BEDROCK)** Slightly to moderately weathered, very thinly to thinly bedded, grey, brown and occasional red with dark grey and white horizontal and subvertical banding, moderately strong to very strong Subvertical joints from 1.98m to 2.08m, 2.24m to 2.26m, 2.31m to 2.72m, 2.79m to 2.92m, 2.97m to 3.02m, 3.25m to 3.3m, 3.4m to 3.45m Vertical joints from 1.65m to 1.78m, 2.41m to 2.57m, 2.92m to 2.97m, 3.12m to 3.2m, 3.75m to 3.64m, 4.22m to 4.32m Multiple fractures from 3.91m to 4.22m, 4.32m to 4.37m	1	RUN	>10 >10 >10 >10 >10 >10	RUN 1# TCR=100%, SCR=33%, RQD=13%, UCS=87MPa
		2	RUN	>10 >10 >10 >10 2	RUN 2# TCR=100%, SCR=60%, RQD=45%, UCS=147MPa
132.9 / 4.9	END OF BOREHOLE AT 4.88m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS:			FI	

DATE	ELEVATION (m)
16/10/2003	136.1
22/10/2003	136.2
16/12/2003	136.1
04/02/2004	136.1
11/03/2004	137.4



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

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

RECORD OF BOREHOLE No CR6-3

1 OF 1

METRIC

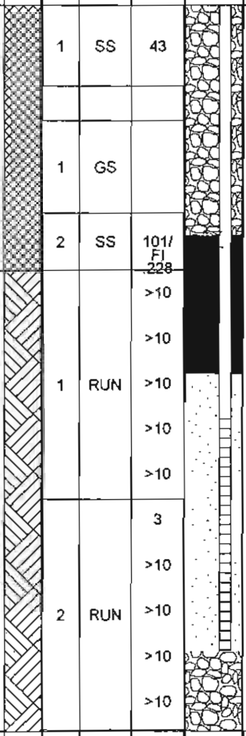
G.W.P.	647-92-00	LOCATION	N 5 036 606.5 E 295 247.0 (County Road 6)	ORIGINATED BY	JL
HWY	HWY 17	BOREHOLE TYPE	Hollow Stem Augers, NQ Coring	COMPILED BY	SS
DATUM	Geodetic	DATE	14.10.03 - 14.10.03	CHECKED BY	SKP

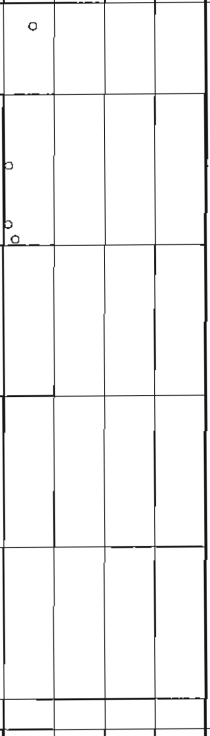
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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/m³





ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
136.6 0.0	Sandy **GRAVEL**, trace silt, frequent cobbles Dense Brown Moist (FILL)	1	SS	43		
					136	
		1	GS			
		2	SS	101/ FI .228	135	61 27 12 (SI+CL)
134.9	SAMPLER REFUSAL AT 1.75m.					
1.8	**CRYSTALLINE LIMESTONE (BEDROCK)** Slightly to moderately weathered, very thinly to thinly bedded, light grey and light brown with white and black horizontal and subvertical banding, moderately strong to strong Subvertical joints from 2.41m to 2.49m, 3.35m to 3.43m, 3.86m, 4.06m to 4.27m Vertical joints from 2.11m to 2.21m, 2.49m to 2.57m, 2.74m to 2.97m, 3.0m to 3.12m, 3.28m to 3.43m, 3.53m to 3.58m, 4.24m to 4.75m Multiple fracture from 1.75m to 1.98m	1	RUN	>10 >10 >10 >10 >10	134	RUN 1# TCR=100%, SCR=36%, RQD=25%, UCS=60MPa
		2	RUN	3 >10 >10 >10 >10	133 132	RUN 2# TCR=100%, SCR=33%, RQD=16%, UCS=55MPa
131.8 4.8	END OF BOREHOLE AT 4.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.					

WATER LEVEL READINGS:

DATE	ELEVATION (m)
16/10/2003	134.9
22/10/2003	135.0
16/12/2003	destroyed

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

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

Appendix C.

Laboratory Testing

Appendix C.1

Particle Size Analysis Figures

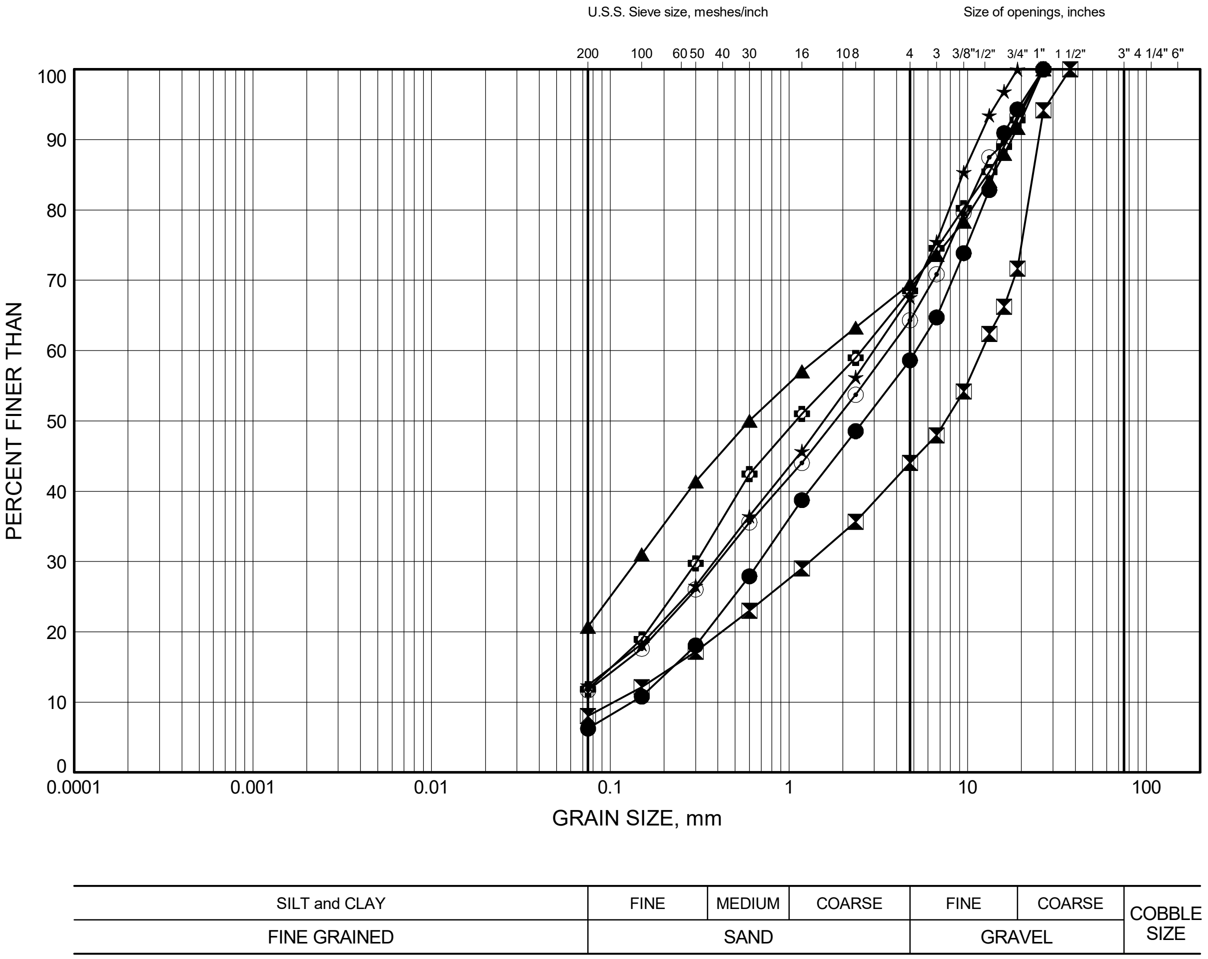
Atterberg Limit Test Results

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C1

Sand with Silt and Gravel to Silty Sand with Gravel to Gravel with Silt and Sand (Fill)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-03	0.3	137.4
⧗	19-04	1.1	136.4
▲	19-09	1.1	136.0
★	19-12	0.4	136.6
⊙	19-17	0.4	135.7
✿	19-19	0.4	131.5

GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 7/9/21

Date September 2021

WP# 4068-09-00

THURBER

Prep'd DP

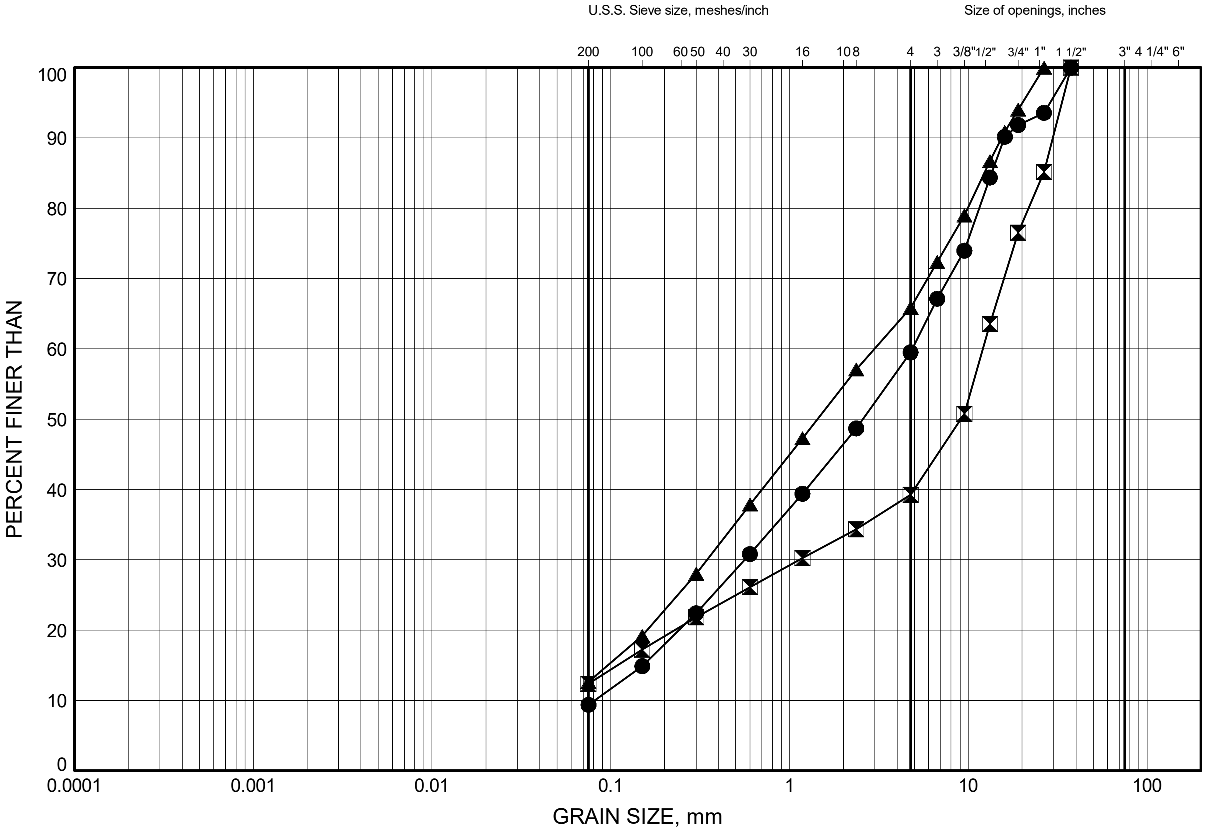
Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C2

Sand with Silt and Gravel to Silty Sand with Gravel to Gravel with Silt and Sand (Fill)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-22	0.4	133.5
⧗	CR6-3	1.5	135.1
▲	CV-15	0.3	136.5

Date September 2021

WP# 4068-09-00

THURBER

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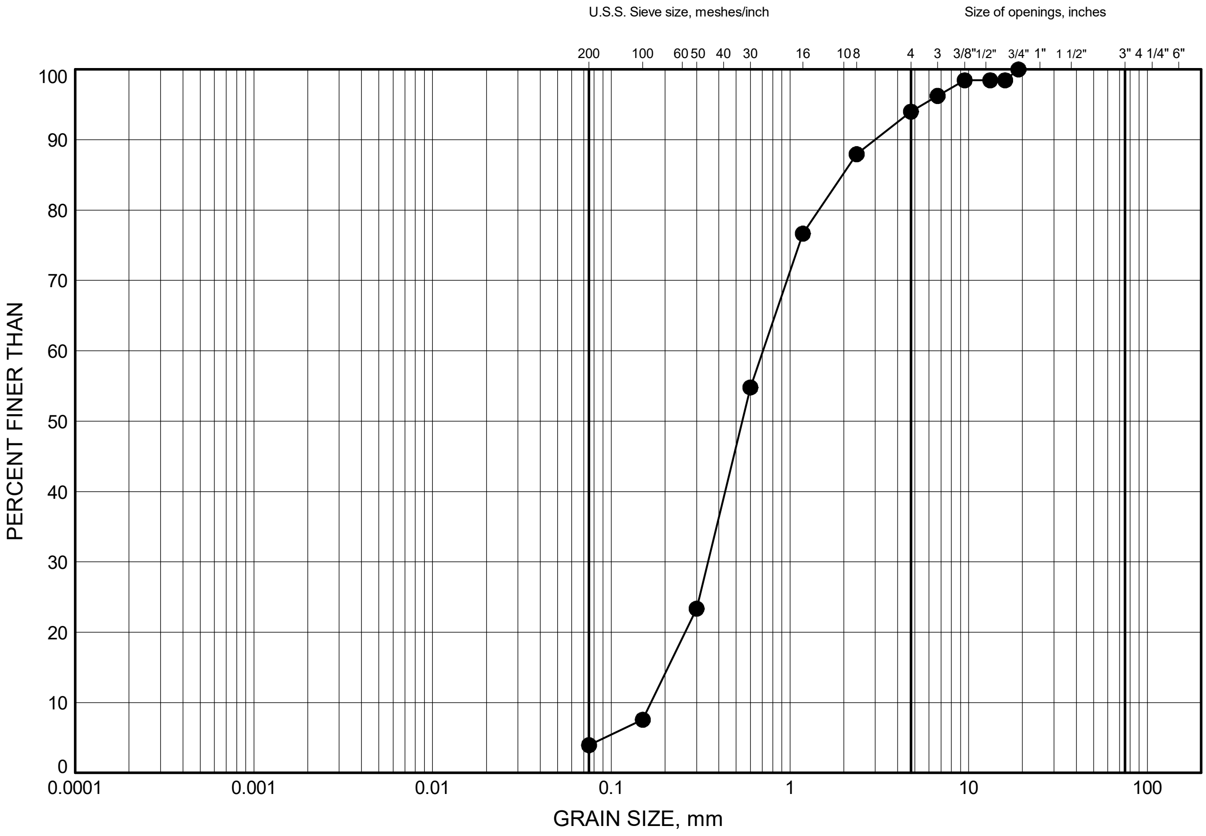
Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C3

Silty Sand (SM) to Sand (SP), trace gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-11	0.3	137.0

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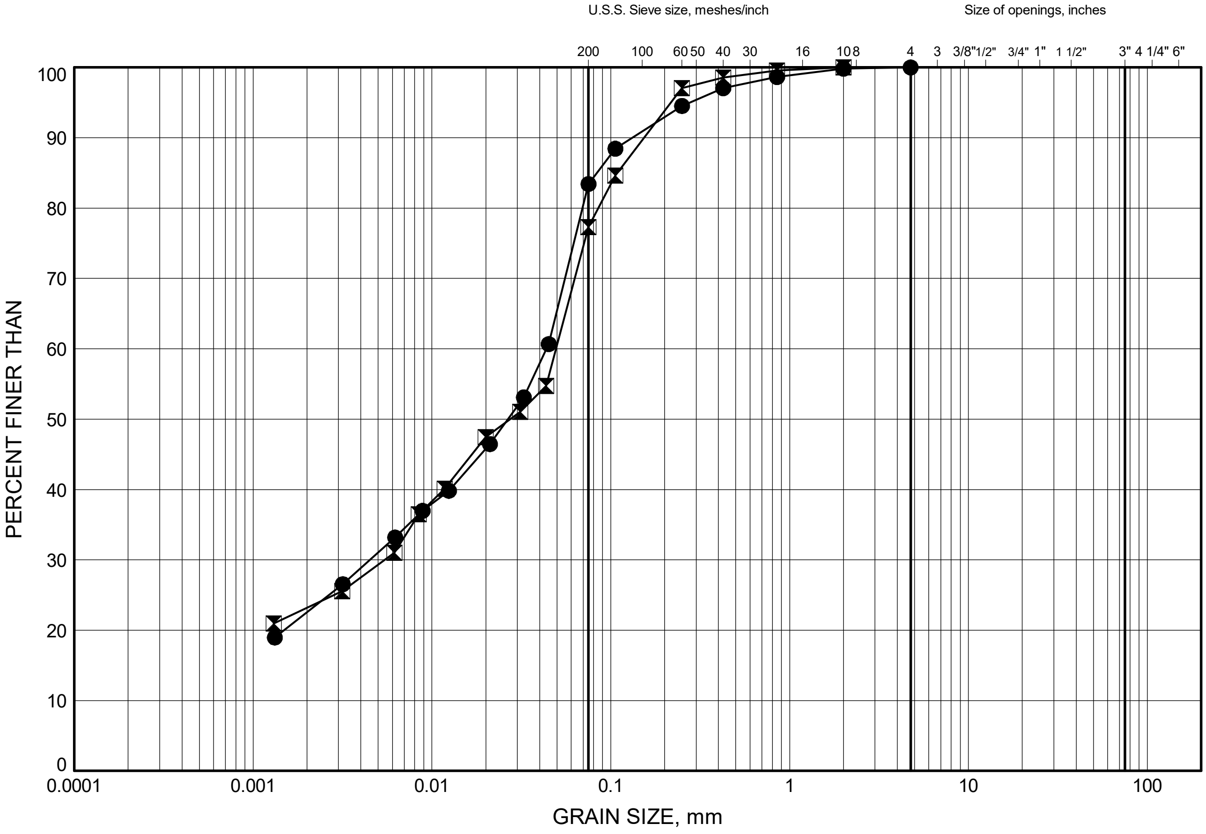
GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 7/9/21

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C4

Clayey Silt (CL) with Sand to Clayey Silt (CL-ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-23	0.9	131.8
⧗	CV-12	1.8	135.1

GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 7/9/21

Date September 2021

WP# 4068-09-00

THURBER

Prep'd DP

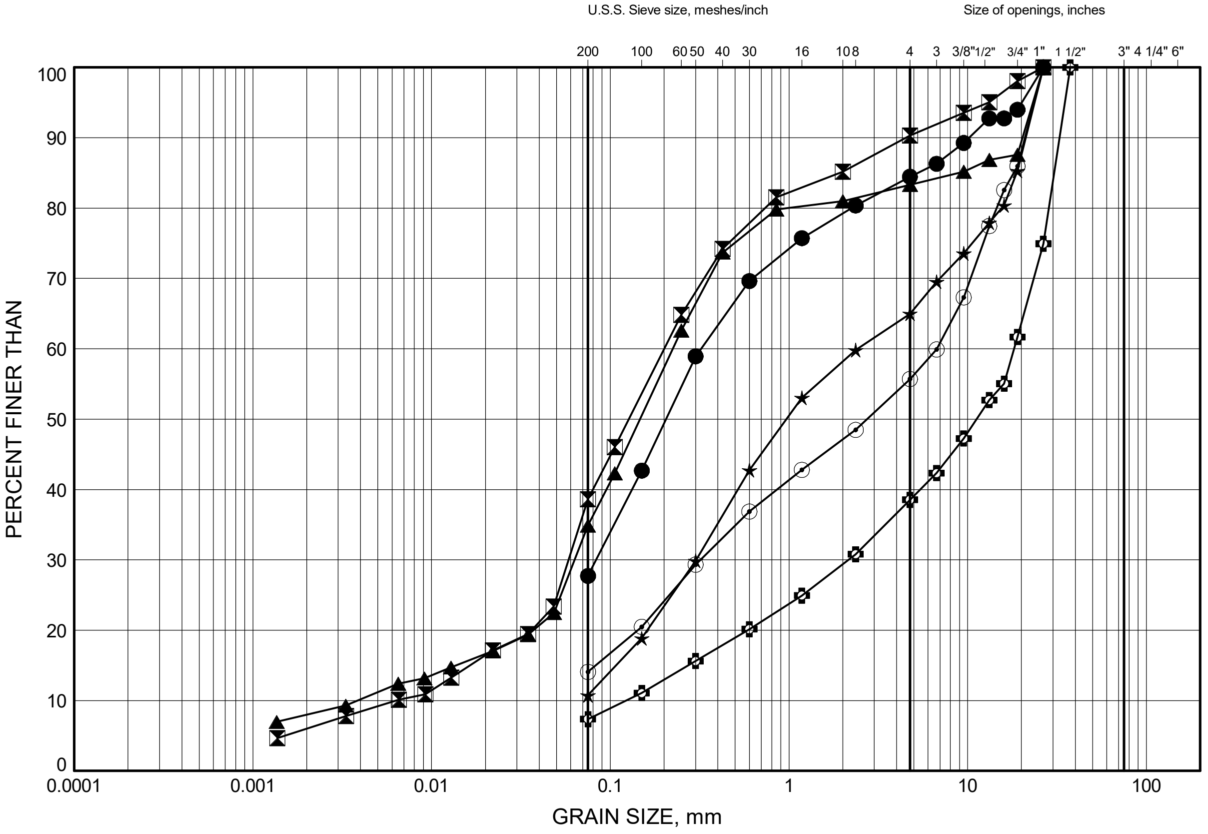
Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C5

Silty Sand (SM) to Gravel (GW-GM) with Silt and Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-06	2.6	135.3
⧗	19-07	0.9	135.7
▲	19-10	1.1	136.3
★	19-23	1.8	130.9
⊙	19-24	1.8	130.5
✿	19-27	1.1	132.4

Date September 2021

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THURBER

Prep'd DP

Chkd. FG

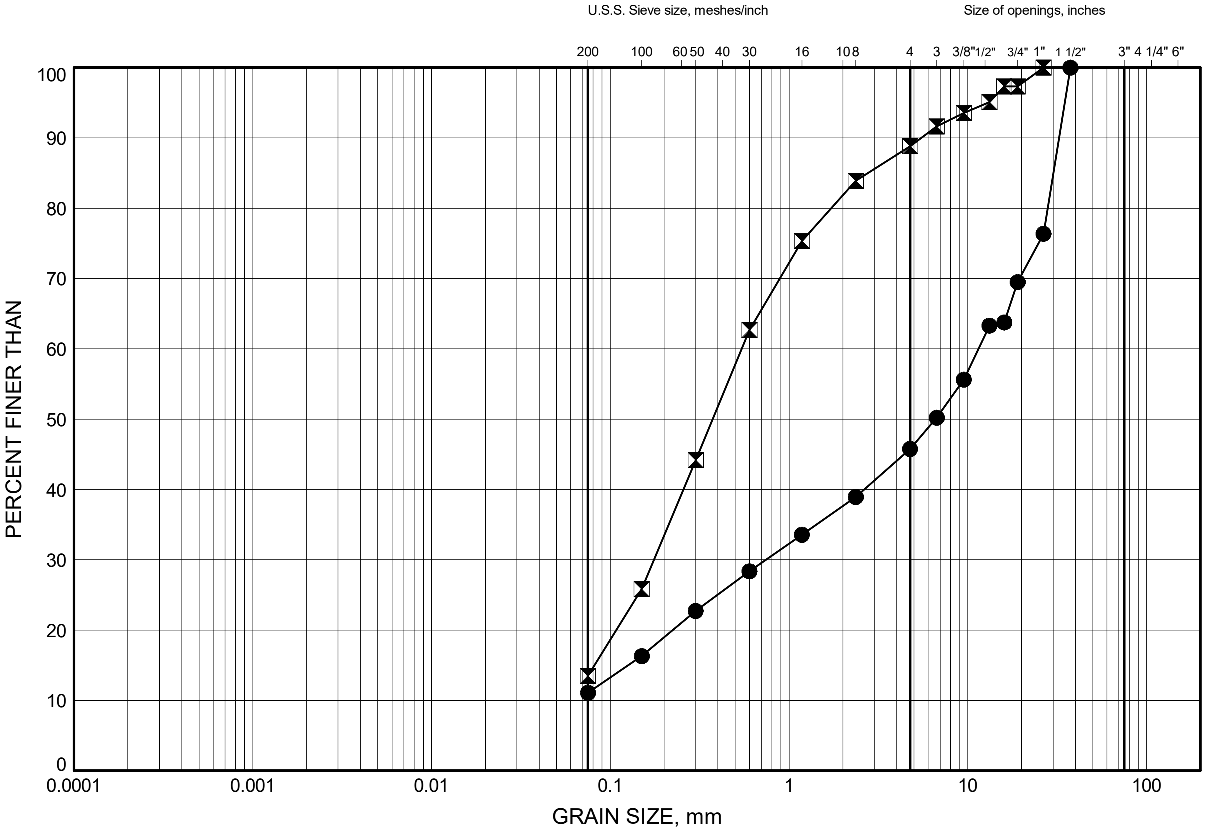
GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 7/9/21

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C6

Silty Sand (SM) to Gravel (GW-GM) with Silt and Sand Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-12	2.6	134.3
⧗	CV-14	0.8	137.0

Date September 2021

WP# 4068-09-00

THURBER

Prep'd DP

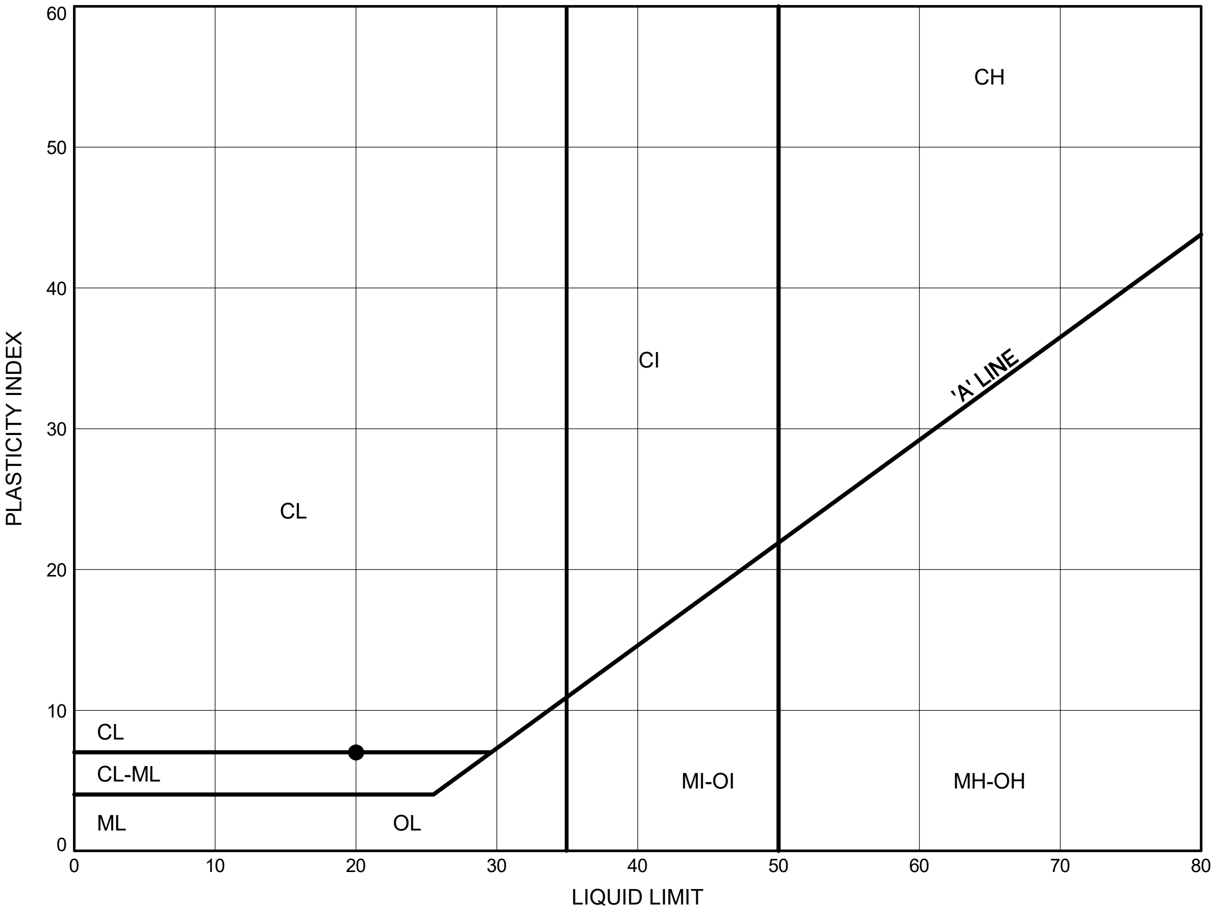
Chkd. FG

Highway 17 Twinning

ATTERBERG LIMITS TEST RESULTS

FIGURE C7

Clayey Silt (CL) with Sand to Clayey Silt (CL-ML)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-12	1.8	135.1

THURBALT 24726 CR6.GPJ 7/9/21

Date September 2021

WP# 4068-09-00

THURBER

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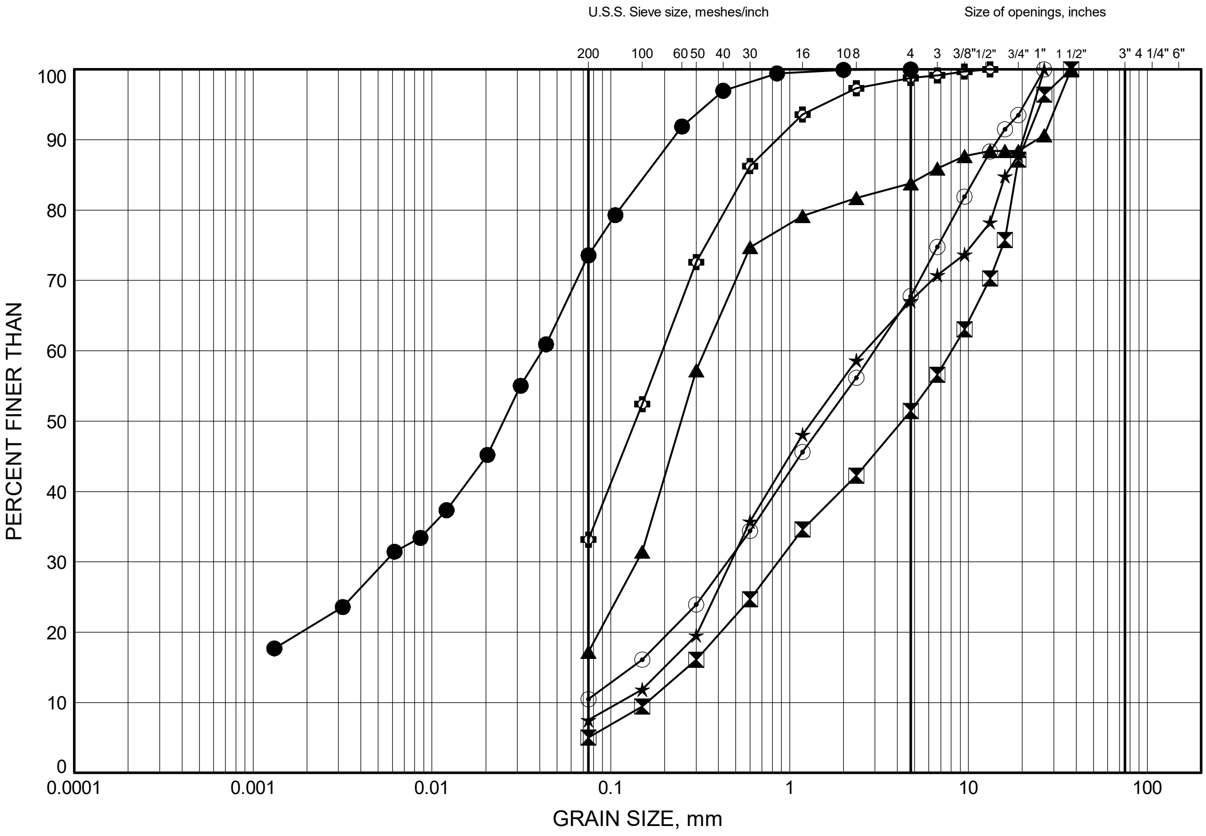
Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C8

Sand w Silt & Gravel to Silty Sand to Gravel w Silt & Sand to Clay w Sand to Clayey Silt (Fill)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	1.1	136.1
⧗	19-01	0.4	137.9
▲	19-02	1.8	136.4
★	19-05	1.1	137.0
⊙	19-14	0.3	138.7
✪	19-21	0.7	129.6

Date September 2021

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Prep'd DP

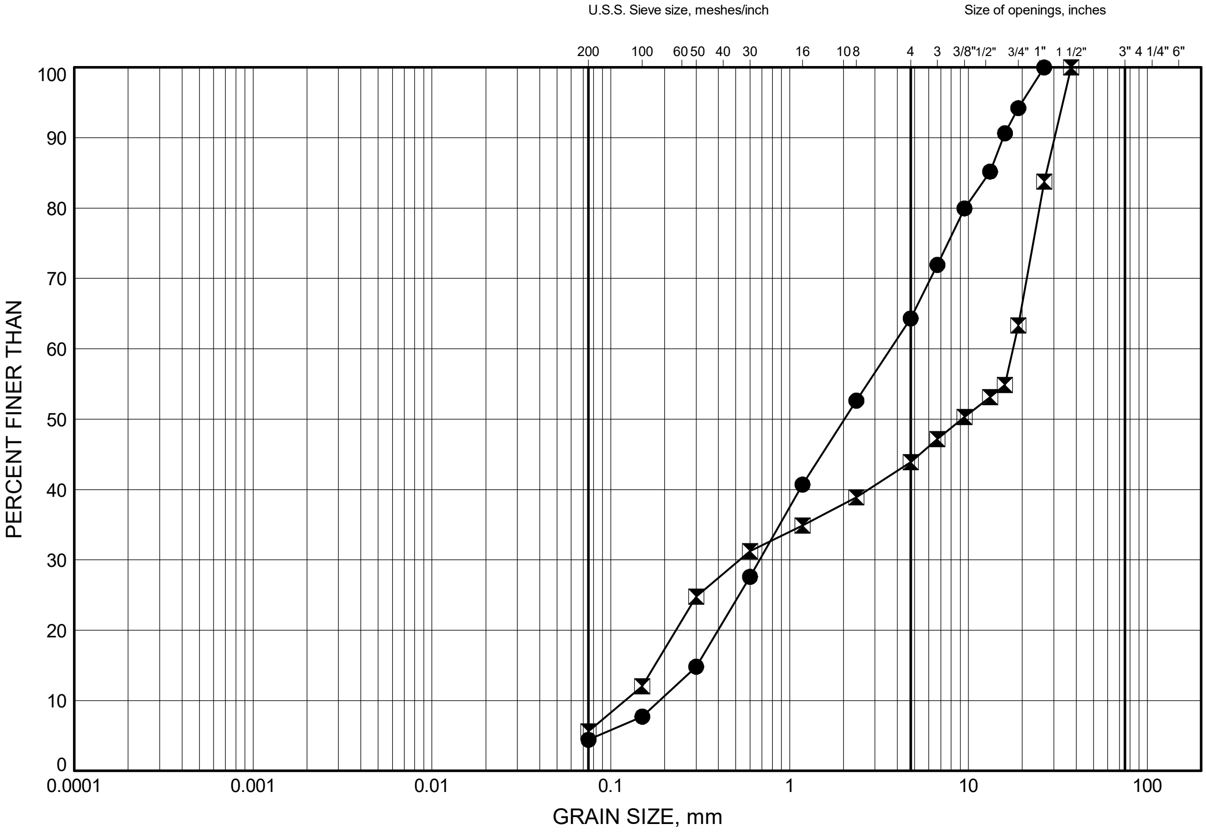
Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C9

Sand w Silt & Gravel to Silty Sand to Gravel w Silt & Sand to Clay w Sand to Clayey Silt (Fill)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CV-10	0.4	138.2
⧗	CV-10	1.8	136.8

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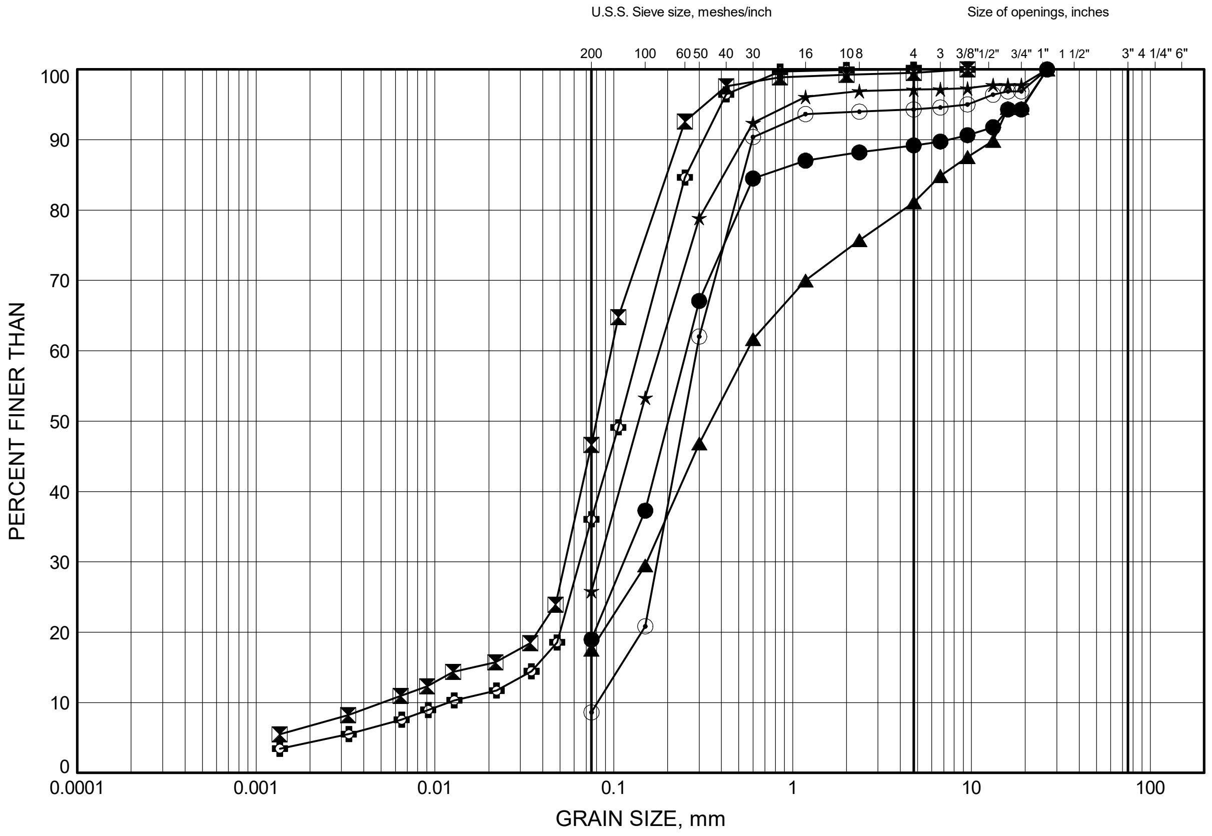
GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 7/9/21

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C10

Silty Sand (SM) to Silty Sand (SM) with Gravel to Sandy Silt (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-01	1.8	136.5
⧗	19-02	2.6	135.6
▲	19-05	1.8	136.3
★	19-13	2.6	136.8
⊙	19-13	4.1	135.3
✤	19-14	3.4	135.6

Date September 2021

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THURBER

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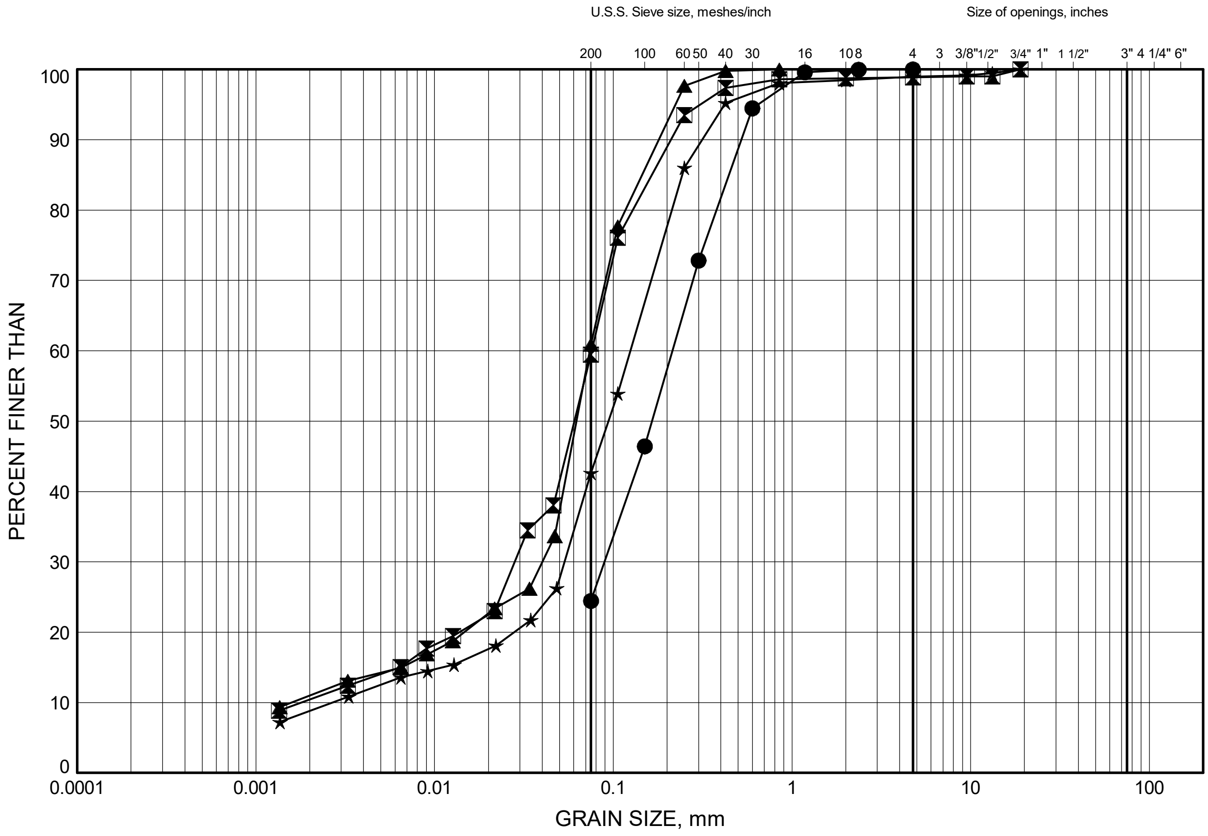
GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 7/9/21

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C11

Silty Sand (SM) to Silty Sand (SM) with Gravel to Sandy Silt (ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-30	1.8	135.9
⧗	19-31	1.1	139.8
▲	19-31	4.9	136.0
★	19-31	6.4	134.5

Date September 2021

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THURBER

Prep'd DP

Chkd. FG

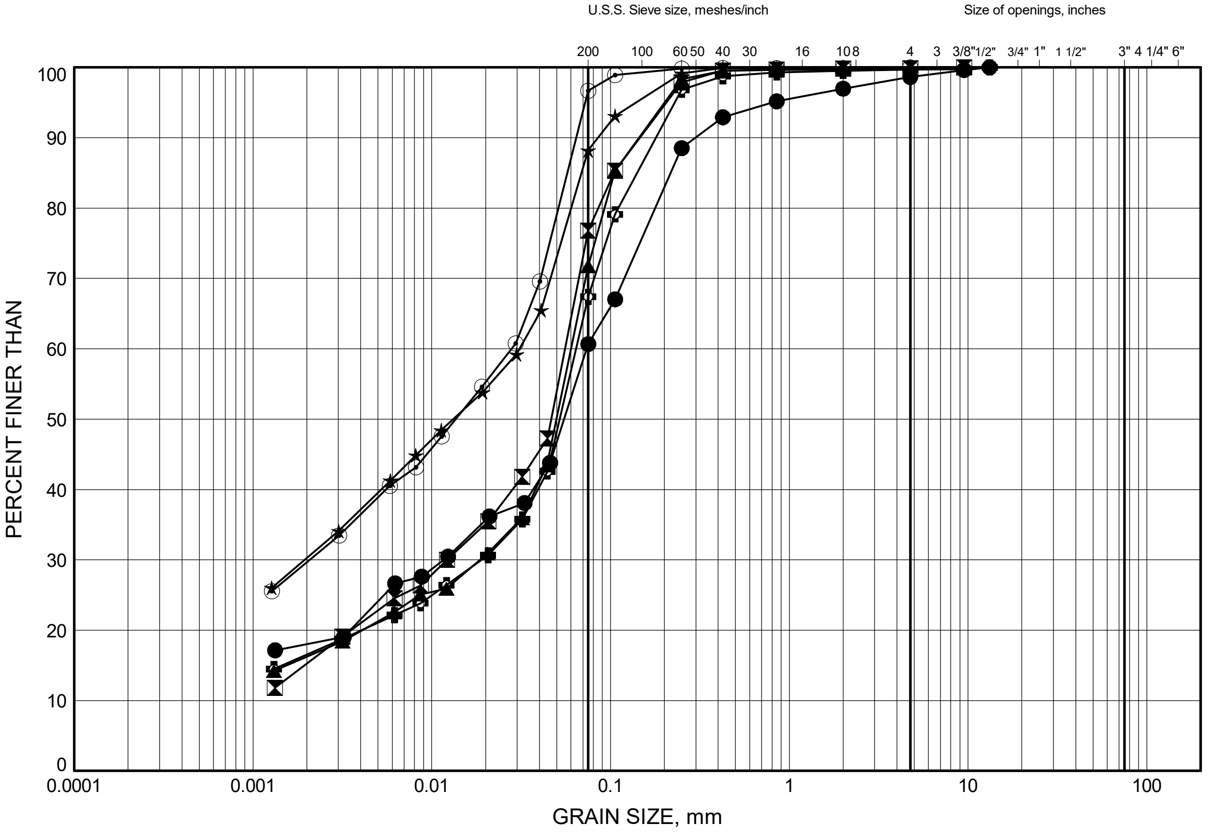
GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 24/9/21

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C12

Clayey Silt (CL to CL-ML) to Clayey Silt (CL) with Sand to Silt (ML) with Clay to Sandy Clayey Silt (CL-ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	2.6	134.6
⧗	19-01	4.1	134.2
▲	19-13	5.6	133.8
★	19-13	9.5	129.9
⊙	19-14	7.2	131.8
✤	19-15	3.4	134.4

GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 24/9/21

Date September 2021

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THURBER

Prep'd DP

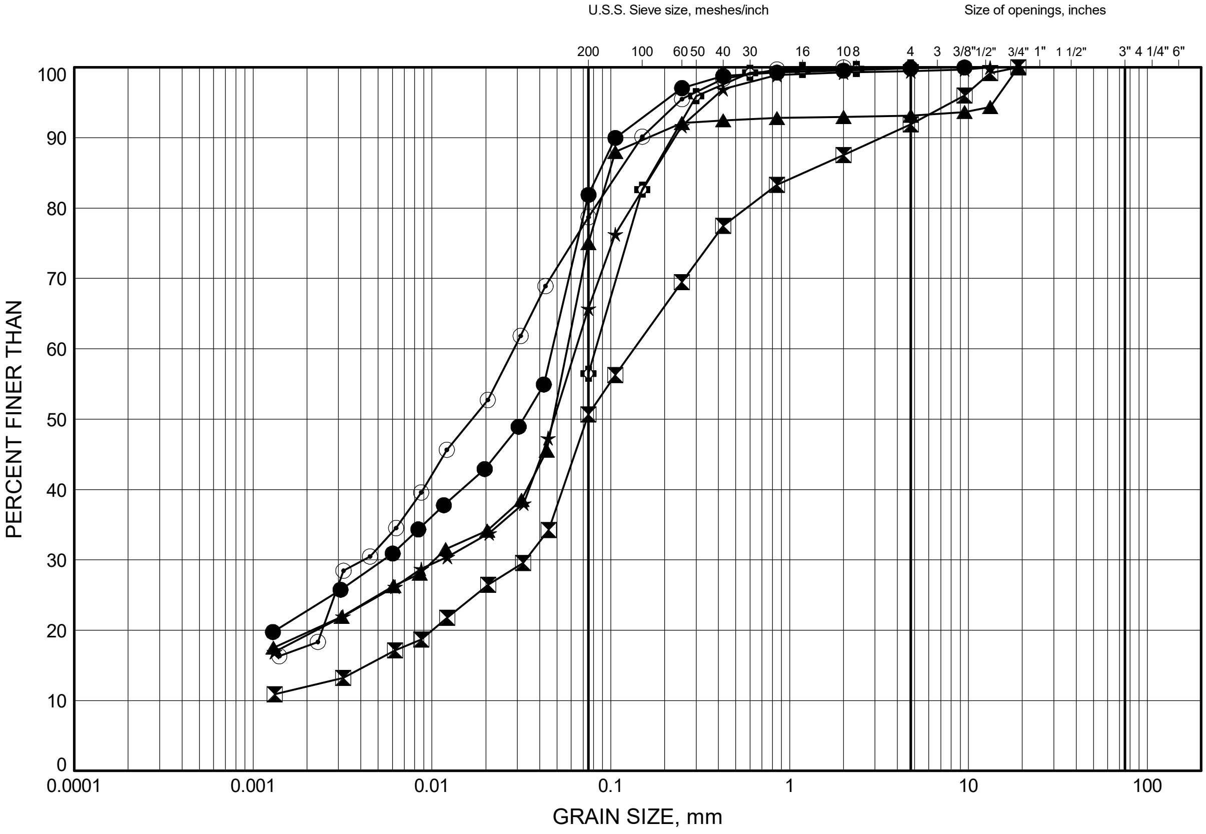
Chkd. FG

Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C13

Clayey Silt (CL to CL-ML) to Clayey Silt (CL) with Sand to Silt (ML) with Clay to Sandy Clayey Silt (CL-ML)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-20	1.8	129.1
⧗	19-20	2.5	128.4
▲	19-21	1.8	128.5
★	19-30	3.4	134.3
⊙	CR6-1	1.1	136.4
✢	CR6-1	3.4	134.1

GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 24/9/21

Date September 2021

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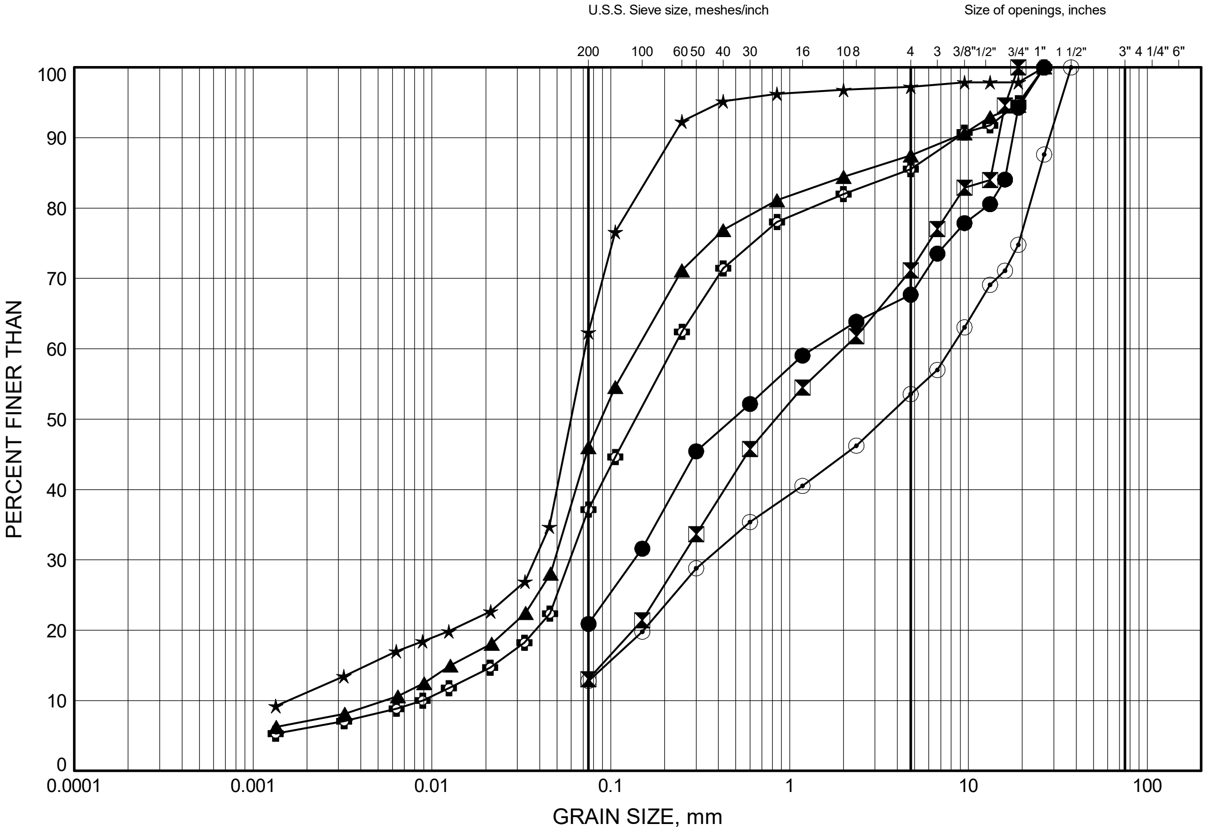
Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C14

Sandy Silt (ML) to Silty Sand (SM) with Gravel to Silty Gravel with Sand to Gravel (Till)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	3.4	133.8
⧗	17-2	1.8	134.9
▲	19-01	7.2	131.1
★	19-02	4.1	134.1
⊙	19-14	8.7	130.3
✿	19-15	5.6	132.2

GRAIN SIZE DISTRIBUTION - THURBER 24726 CR6.GPJ 7/9/21

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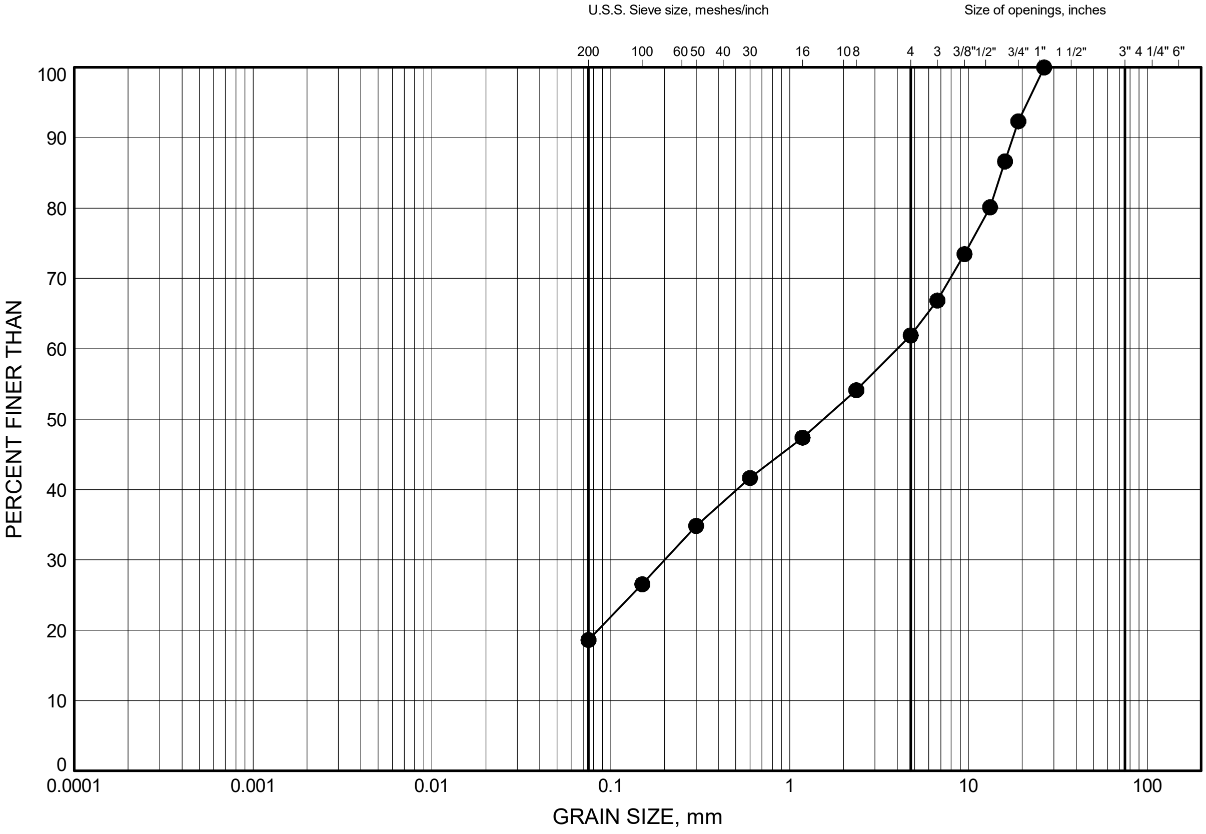
Highway 17 Twinning

GRAIN SIZE DISTRIBUTION

FIGURE C15

Sandy Silt (ML) to Silty Sand (SM) with Gravel to Silty Gravel with Sand to Gravel (Till)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-30	7.9	129.8

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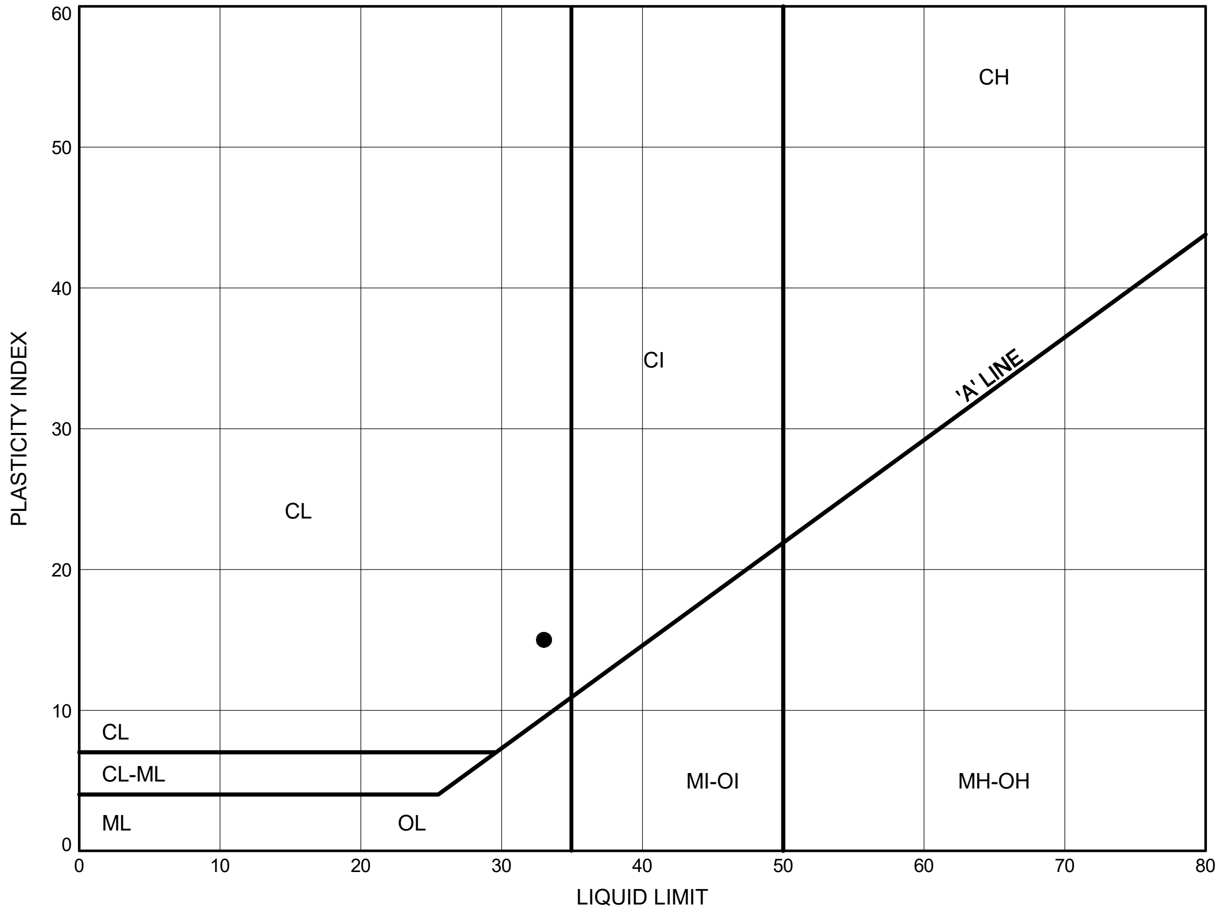
Highway 17 Twinning

ATTERBERG LIMITS TEST RESULTS

FIGURE C16

Sand w Silt & Gravel to Silty Sand to Gravel w Silt & Sand to Clay w Sand to Clayey Silt (Fill)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	1.1	136.1

THURBALT 24726 CR6.GPJ 7/9/21

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THURBER

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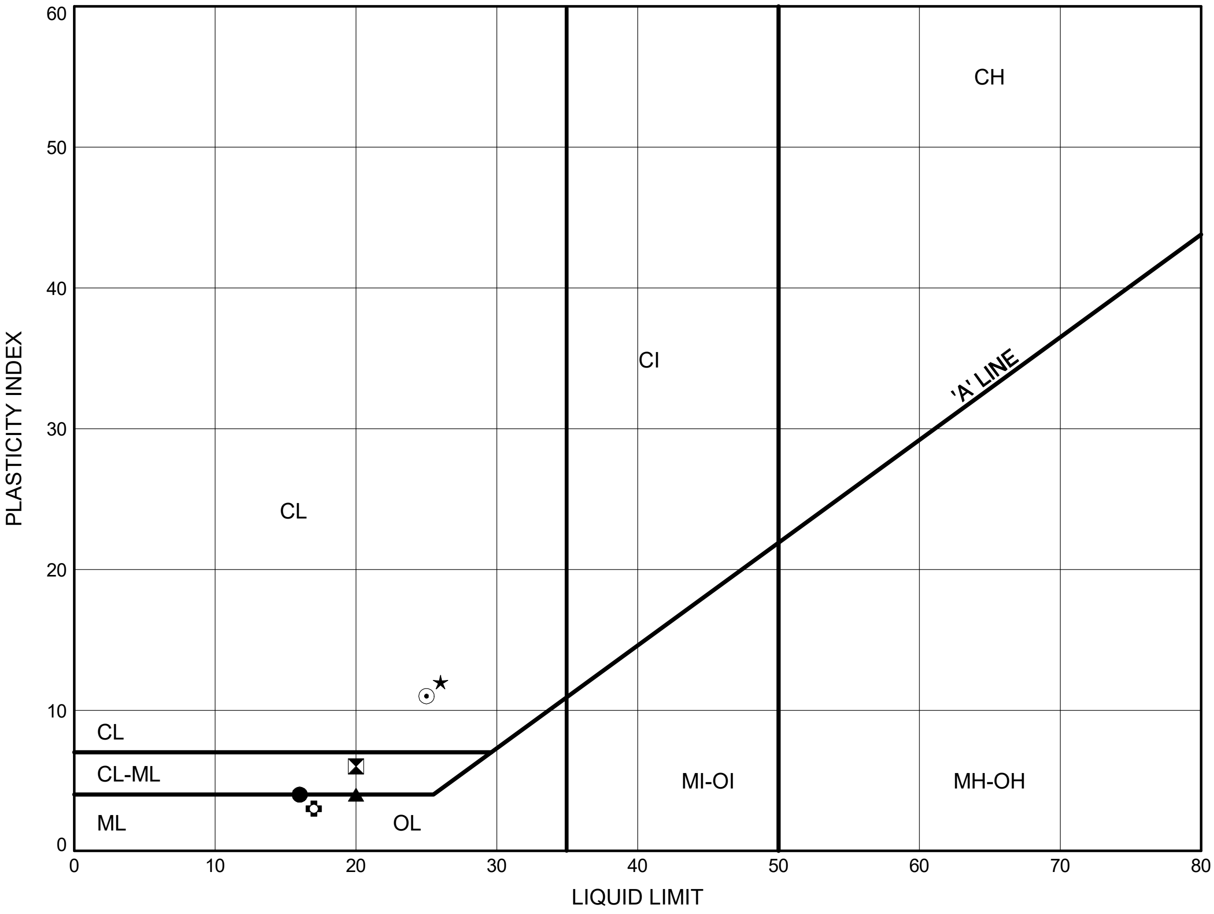
Highway 17 Twinning

ATTERBERG LIMITS TEST RESULTS

FIGURE C17

Clayey Silt (CL to CL-ML) to Clayey Silt (CL) with Sand to Silt (ML) with Clay to Sandy Clayey Silt (CL-ML)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	17-1	2.6	134.6
⧗	19-01	4.1	134.2
▲	19-13	5.6	133.8
★	19-13	9.5	129.9
⊙	19-14	7.2	131.8
✿	19-15	3.4	134.4

Date September 2021

WP# 4068-09-00

Prep'd DP

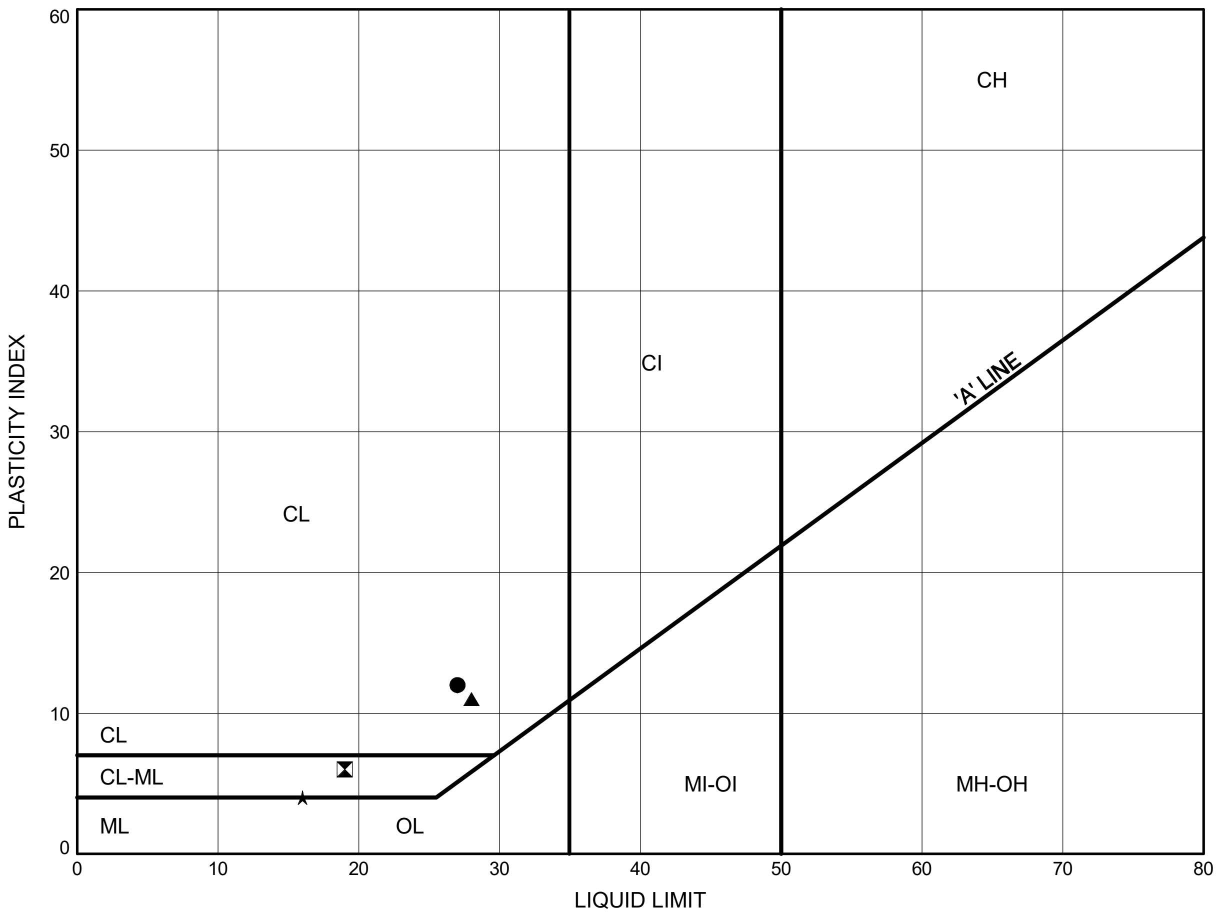
Chkd. FG

Highway 17 Twinning

ATTERBERG LIMITS TEST RESULTS

FIGURE C18

Clayey Silt (CL to CL-ML) to Clayey Silt (CL) with Sand to Silt (ML) with Clay to Sandy Clayey Silt (CL-ML)



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	19-20	1.8	129.1
⧗	19-20	2.5	128.4
▲	19-21	1.8	128.5
★	19-30	3.4	134.3

THURBALT 24726 CR6.GPJ 24/9/21

Date September 2021

WP# 4068-09-00

Prep'd DP

Chkd. FG

THURBER

Appendix C.2

Analytical Testing Results

Certificate of Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Client PO:
Project: 24726
Custody: 40227

Report Date: 20-Sep-2019
Order Date: 16-Sep-2019

Order #: 1938128

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1938128-01	CR6 19-01, SS4 (7'6-9'6)
1938128-02	CR6 19-05, SS4 (7'6-9'6)
1938128-03	CR6 19-09, SS1 (0'4"-2'4")

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	18-Sep-19	18-Sep-19
Conductivity	MOE E3138 - probe @25 °C, water ext	19-Sep-19	20-Sep-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Sep-19	19-Sep-19
Resistivity	EPA 120.1 - probe, water extraction	19-Sep-19	20-Sep-19
Solids, %	Gravimetric, calculation	17-Sep-19	17-Sep-19

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 20-Sep-2019

Order Date: 16-Sep-2019

Project Description: 24726

Client ID:	CR6 19-01, SS4 (7'6-9'6)	CR6 19-05, SS4 (7'6-9'6)	CR6 19-09, SS1 (0'4"-2'4")	-
Sample Date:	04-Sep-19 09:00	30-Aug-19 09:00	26-Aug-19 09:00	-
Sample ID:	1938128-01	1938128-02	1938128-03	-
MDL/Units	Soil	Soil	Soil	-

Physical Characteristics

% Solids	0.1 % by Wt.	85.1	85.2	94.7	-

General Inorganics

Conductivity	5 uS/cm	698	1030	1190	-
pH	0.05 pH Units	7.34	7.57	7.96	-
Resistivity	0.10 Ohm.m	14.3	9.73	8.42	-

Anions

Chloride	5 ug/g dry	291	455	569	-
Sulphate	5 ug/g dry	65	109	26	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 20-Sep-2019
Order Date: 16-Sep-2019
Project Description: 24726

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	21.0	5	ug/g dry	21.5			2.6	20	
Sulphate	ND	5	ug/g dry	ND			0.0	20	
General Inorganics									
Conductivity	97.4	5	uS/cm	101			3.2	5	
pH	7.39	0.05	pH Units	7.50			1.5	2.3	
Physical Characteristics									
% Solids	90.4	0.1	% by Wt.	90.3			0.1	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	114	5	ug/g	21.5	92.9	82-118			
Sulphate	108	5	ug/g	ND	108	80-120			

Qualifier Notes:

Login Qualifiers :

Received at temperature > 25C

Applies to samples: CR6 19-01, SS4 (7'6-9'6), CR6 19-05, SS4 (7'6-9'6), CR6 19-09, SS1 (0'4''-2'4'')

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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Subcontracted Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No **1938128**
Client Project(s): **24726**
Client PO:
Reference: **Standing Offer**
CoC Number: **40227**

Order Date: 16-Sep-19
Report Date: 23-Sep-19

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor’s report is attached

Paracel ID	**Client ID**	**Analysis**
1938128-01	CR6 19-01, SS4 (7'6-9'6)	Sulphide, solid
1938128-02	CR6 19-05, SS4 (7'6-9'6)	Sulphide, solid
1938128-03	CR6 19-09, SS1 (0'4"-2'4")	Sulphide, solid

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

23-September-2019

Paracel Laboratories
Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

Date Rec. : 18 September 2019
LR Report: **CA13702-SEP19**
Reference: Project#: 1938128

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		20-Sep-19
2: Analysis Start Time		12:49
3: Analysis Completed Date		20-Sep-19
4: Analysis Completed Time		14:35
5: QC - Blank		< 0.02
6: QC - STD % Recovery		113%
7: QC - DUP % RPD		3%
8: RL		0.02
9: CR6 19-01, SS4 (7'6-9'6)	04-Sep-19	0.11
10: CR6 19-05, SS4 (7'6-9'6)	30-Aug-19	0.10
11: CR6 19-06, SS1 (0'4"-2'4")	26-Aug-19	0.05

RL - SGS Reporting Limit

Kimberley Didsbury
Project Specialist,
Environment, Health & Safety

OnLine LIMS

0001900502

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Certificate of Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Client PO:
Project: 24726
Custody:

Report Date: 24-Sep-2019
Order Date: 18-Sep-2019

Order #: 1938293

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1938293-01	CV10, SS2 (2'6"-4'6")

Approved By:

Dale Robertson, BSc
Laboratory Director

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

Project Description: 24726

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	23-Sep-19	23-Sep-19
Conductivity	MOE E3138 - probe @25 °C, water ext	24-Sep-19	24-Sep-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Sep-19	19-Sep-19
Resistivity	EPA 120.1 - probe, water extraction	24-Sep-19	24-Sep-19
Solids, %	Gravimetric, calculation	18-Sep-19	18-Sep-19

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 24-Sep-2019
Order Date: 18-Sep-2019
Project Description: 24726

	Client ID:	CV10, SS2 (2'6"-4'6")	-	-	-
	Sample Date:	05-Sep-19 09:00	-	-	-
	Sample ID:	1938293-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	90.3	-	-	-
General Inorganics					
Conductivity	5 uS/cm	581	-	-	-
pH	0.05 pH Units	7.81	-	-	-
Resistivity	0.10 Ohm.m	17.2	-	-	-
Anions					
Chloride	5 ug/g dry	87	-	-	-
Sulphate	5 ug/g dry	38	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	275	5	ug/g dry	277			0.9	20	
Sulphate	34.2	5	ug/g dry	34.6			1.3	20	
General Inorganics									
pH	7.39	0.05	pH Units	7.50			1.5	2.3	
Resistivity	18.2	0.10	Ohm.m	17.2			5.6	20	
Physical Characteristics									
% Solids	77.6	0.1	% by Wt.	79.2			2.1	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	372	5	ug/g	277	94.1	82-118			
Sulphate	142	5	ug/g	34.6	108	80-120			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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Subcontracted Analysis

Thurber Engineering Ltd.
2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No **1938293**
Client Project(s): **24726**
Client PO:
Reference: **Standing Offer**
CoC Number:

Order Date: 18-Sep-19
Report Date: 23-Sep-19

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor’s report is attached

Paracel ID	**Client ID**	**Analysis**
1938293-01	CV10, SS2 (2'6"-4'6")	Sulphide, solid

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

23-September-2019

Paracel Laboratories
Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

Date Rec. : 19 September 2019
LR Report: **CA13706-SEP19**
Reference: Project#: 1938293

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	**Sample Date & Time**	**Sulphide %**
1: Analysis Start Date		20-Sep-19
2: Analysis Start Time		12:49
3: Analysis Completed Date		20-Sep-19
4: Analysis Completed Time		14:35
5: QC - Blank		< 0.02
6: QC - STD % Recovery		113%
7: QC - DUP % RPD		3%
8: RL		0.02
9: CV10. SS2 (2'6"-4'6")	05-Sep-19	0.03

`RL - SGS Reporting Limit`

Kimberley Didsbury,
Project Specialist,
Environment, Health & Safety

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Certificate of Analysis

Thurber Engineering Ltd.

2460 Lancaster Rd, Suite 104
Ottawa, ON K1B4S5
Attn: Chris Murray

Client PO:
Project: 24726
Custody: 49914

Report Date: 24-Sep-2019
Order Date: 18-Sep-2019

Order #: 1938296

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1938296-01	CV15, SS2 (2'6"-4'6")

Approved By:

Dale Robertson, BSc
Laboratory Director

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 24-Sep-2019
Order Date: 18-Sep-2019
Project Description: 24726

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	23-Sep-19	24-Sep-19
Conductivity	MOE E3138 - probe @25 °C, water ext	24-Sep-19	24-Sep-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	19-Sep-19	19-Sep-19
Resistivity	EPA 120.1 - probe, water extraction	24-Sep-19	24-Sep-19
Solids, %	Gravimetric, calculation	18-Sep-19	18-Sep-19

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 24-Sep-2019
Order Date: 18-Sep-2019
Project Description: 24726

	Client ID:	CV15, SS2 (2'6"-4'6")	-	-	-
	Sample Date:	27-Aug-19 09:00	-	-	-
	Sample ID:	1938296-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	95.3	-	-	-
General Inorganics					
Conductivity	5 uS/cm	201	-	-	-
pH	0.05 pH Units	8.21	-	-	-
Resistivity	0.10 Ohm.m	49.9	-	-	-
Anions					
Chloride	5 ug/g dry	60	-	-	-
Sulphate	5 ug/g dry	6	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Certificate of Analysis

Client: Thurber Engineering Ltd.

Client PO:

Report Date: 24-Sep-2019

Order Date: 18-Sep-2019

Project Description: 24726

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	275	5	ug/g dry	277			0.9	20	
Sulphate	34.2	5	ug/g dry	34.6			1.3	20	
General Inorganics									
pH	7.39	0.05	pH Units	7.50			1.5	2.3	
Resistivity	18.2	0.10	Ohm.m	17.2			5.6	20	
Physical Characteristics									
% Solids	77.6	0.1	% by Wt.	79.2			2.1	25	

Certificate of Analysis
Client: Thurber Engineering Ltd.
Client PO:

Report Date: 24-Sep-2019
Order Date: 18-Sep-2019
Project Description: 24726

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	372	5	ug/g	277	94.1	82-118			
Sulphate	142	5	ug/g	34.6	108	80-120			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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Thurber Engineering Ltd.
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Ottawa, ON K1B4S5
Attn: Chris Murray

Tel: (613) 247-2121
Fax: (613) 247-2185

Paracel Report No **1938296**
Client Project(s): **24726**
Client PO:
Reference: **Standing Offer**
CoC Number: **49914**

Order Date: 18-Sep-19
Report Date: 23-Sep-19

Sample(s) from this project were subcontracted for the listed parameters. A copy of the subcontractor’s report is attached

Paracel ID	**Client ID**	**Analysis**
1938296-01	CV15, SS2 (2'6"-4'6")	Sulphide, solid

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

23-September-2019

Paracel Laboratories
Attn : Dale Robertson

300-2319 St.Laurent Blvd.
Ottawa, ON
K1G 4K6, Canada

Phone: 613-731-9577
Fax:613-731-9064

Date Rec. : 19 September 2019
LR Report: **CA13705-SEP19**
Reference: Project#: 1938296

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Sample ID	Sample Date & Time	Sulphide %
1: Analysis Start Date		20-Sep-19
2: Analysis Start Time		12:49
3: Analysis Completed Date		20-Sep-19
4: Analysis Completed Time		14:35
5: QC - Blank		< 0.02
6: QC - STD % Recovery		113%
7: QC - DUP % RPD		3%
8: RL		0.02
9: CV15, SS2 (2'6"-4'6")	27-Aug-19	< 0.02

`RL - SGS Reporting Limit`

Kimberley Didsbury,
Project Specialist,
Environment, Health & Safety

THURBER

Appendix C.3

Rock Core Photos and UCS Results

Borehole CR6 19-01

Run 1 to 3 (of 3)

Elevation 130.2 m to 126.3 m

Run 1 Start
elev. 130.2m

Run 1 End
elev. 129.1 m

Run 2 Start
elev. 129.1 m

Run 2 End
elev. 127.8 m

Run 3 Start
elev. 127.8 m

End of BH
elev. 126.3 m

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Foundation Investigation
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Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-03

Run 1 to 3 (of 3)

Elevation 136.3 m to 132.6 m

Run 1 Start
elev. 136.3 m

Run 2 Start
elev. 135.1m

Run 3 Start
elev. 134.3 m

Run 1 End
elev. 135.1m

Run 2 End
elev. 134.3 m

End of BH
elev. 132.6 m

THURBER ENGINEERING LTD.

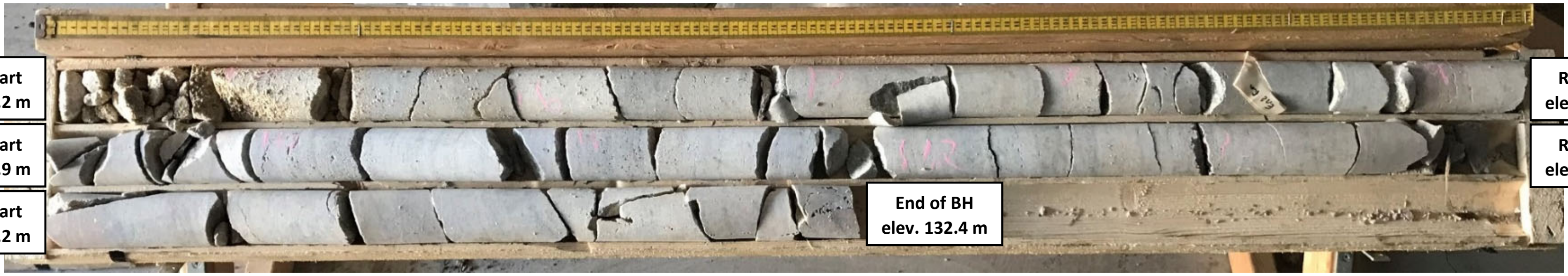
Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-04

Run 1 to 3 (of 3)

Elevation 136.2 m to 132.4m



Run 1 Start
elev. 136.2 m

Run 1 End
elev. 134.9 m

Run 2 Start
elev. 134.9 m

Run 2 End
elev. 133.2 m

Run 3 Start
elev. 133.2 m

End of BH
elev. 132.4 m

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Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-05

Run 1 to 2 (of 2)

Elevation 133.8 m to 138.1 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-06

Run 1 to 3 (of 3)

Elevation 135.1 m to 131.6 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-07

Run 1 to 3 (of 3)

Elevation 134.2 m to 130.2 m

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Foundation Investigation
County Road 6 Interchange
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W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-08

Run 1 to 2 (of 2)

Elevation 136.6 m to 133.6 m

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Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-09

Run 1 to 3 (of 3)

Elevation 135.6 m to 131.1 m

Run 1 Start
elev. 135.6 m

Run 2 Start
elev. 134.1 m

Run 3 Start
elev. 132.5 m

Run 1 End
elev. 134.1 m

Run 2 End
elev. 132.5 m

End of BH
elev. 131.1m

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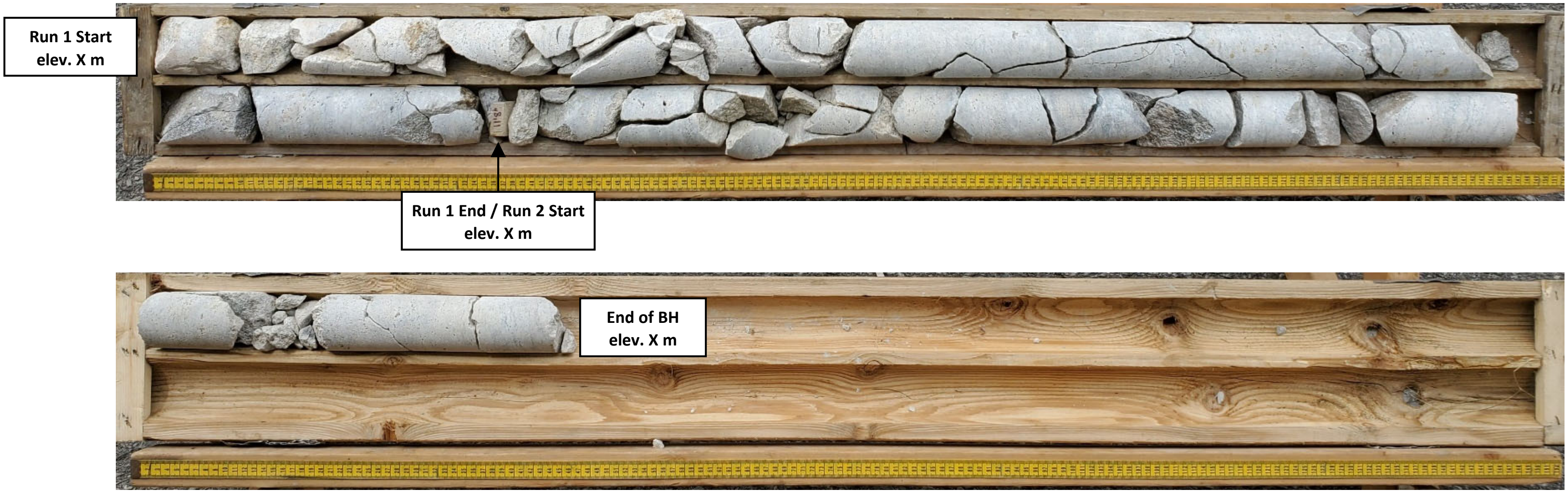
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-10

Run 1 to 3 (of 3)

Elevation X m to X m



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Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-12

Run 1 to 4 (of 4)

Elevation 135.8 m to 130.2 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-14

Run 1 to 3 (of 3)

Elevation 129.9 m to 126.0 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-15

Run 1 to 3 (of 3)

Elevation 130.9 m to 127.6 m

Run 1 End / Run 2 Start
elev. 130.3 m

Run 1 Start
elev. 130.9 m

Run 2 End
elev. 128.7 m

Run 3 Start
elev. 128.7 m

End of BH
elev. 127.6 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-17

Run 1 to 3 (of 3)

Elevation 134.8 m to 130.7m

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Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-19

Run 1 to 3 (of 3)

Elevation 131.0 m to 127.5 m

Run 1 Start
elev. 131.0 m

Run 1 End
elev. 130.6 m

Run 2 Start
elev.130.6 m

Run 2 End
elev. 129.1 m

Run 3 Start
elev. 129.1 m

End of BH
elev. 127.5 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-20

Run 1 to 2 (of 2)

Elevation 127.9 m to 124.8 m

Run 1 Start
elev. 127.9 m

Run 2 Start
elev. 126.3 m

Run 1 End
elev. 126.3 m

End of BH
elev. 124.8 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-21

Run 1 to 2 (of 2)

Elevation 125.9 m to 122.6 m

Run 1 Start
elev. 125.9 m

Run 1 End
elev. 124.2 m

Run 2 Start
elev. 124.2 m

End of BH
elev. 122.6 m

THURBER ENGINEERING LTD.

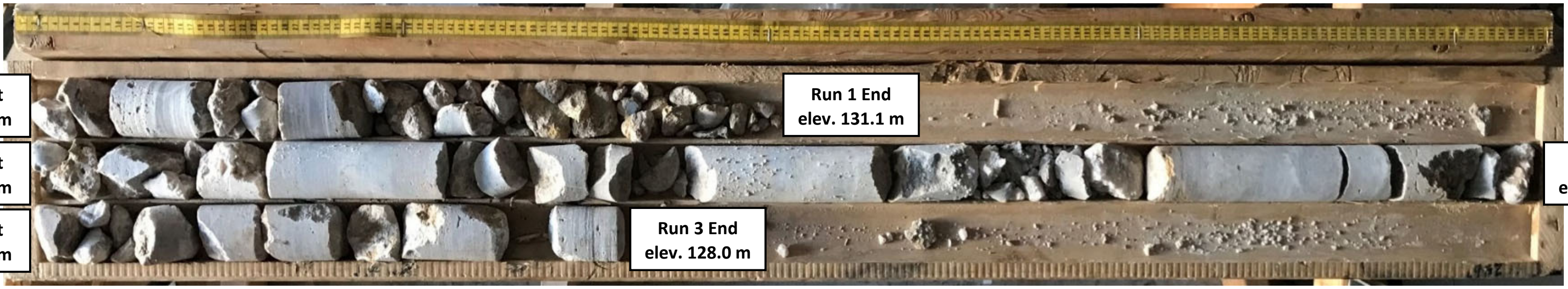
Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-22

Run 1 to 5 (of 5)

Elevation 131.7 m to 124.8 m



Run 1 Start
elev. 131.7 m

Run 1 End
elev. 131.1 m

Run 2 Start
elev. 131.1 m

Run 2 End
elev. 129.4 m

Run 3 Start
elev. 129.4 m

Run 3 End
elev. 128.0 m

Run 4 Start
elev. 128.0 m

Run 4 End
elev. 126.5 m

Run 5 Start
elev. 126.5 m

End of BH
elev. 124.8 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-23

Run 1 to 3 (of 3)

Elevation 130.6 m to 127.0 m

Run 1 Start
elev. 130.6 m

Run 1 End
elev. 129.5 m

Run 2 Start
elev. 129.5 m

Run 2 End
elev. 127.9 m

Run 3 Start
elev. 127.9 m

End of BH
elev. 127.0 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 19-28

Run 1 to 3 (of 3)

Elevation 135.4 m to 131.2 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 CV-10

Run 1 to 3 (of 3)

Elevation 135.5 m to 132.0 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 CV-11

Run 1 to 3 (of 3)

Elevation 135.4 m to 132.0 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 CV-12

Run 1 to 3 (of 3)

Elevation 134.1 m to 130.5 m

Run 1 Start
elev. 134.1 m

Run 1 End / Run 2 Start
elev. 133.5 m

End of BH
elev. 130.5 m

Run 2 End / Run 3 Start
elev. 132.0 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 CV-13

Run 1 to 3 (of 3)

Elevation 137.5 m to 133.6 m

Run 1 Start
elev. 137.5 m

Run 2 Start
elev.136.0 m

Run 3 Start
elev. 134.5 m

Run 1 End
elev. 136.0 m

Run 2 End
elev. 134.5 m

End of BH
elev. 133.6 m

THURBER ENGINEERING LTD.

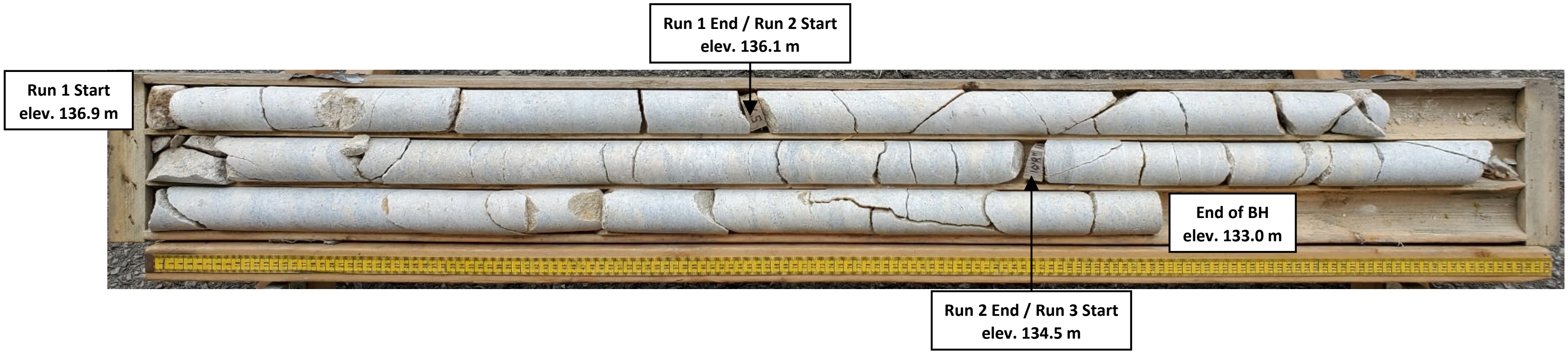
Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 CV-14

Run 1 to 3 (of 3)

Elevation 136.9 m to 133.0 m



THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole CR6 CV-15

Run 1 to 3 (of 3)

Elevation 135.3 m to 131.7 m

Run 1 Start
elev. 135.3 m

Run 1 End
elev. 133.8 m

Run 2 Start
elev. 133.8 m

Run 2 End
elev. 132.4 m

Run 3 Start
elev. 132.4 m

Run 3 End
elev. 131.7 m

THURBER ENGINEERING LTD.

Foundation Investigation
County Road 6 Interchange
Renfrew County, Ontario

W.P. 4068-09-00
Project No.: 24726

Borehole 17-1

Box 1 (of 2)

Elevation 132.0 m to 129.6 m

Run 1 Start
elev. 132.0 m

Run 1 End
elev. 131.6 m

Run 2 Start
elev. 131.6 m

Run 2 End
elev. 130.0 m

Run 3 Start
elev. 130.0 m

End of Box 1
elev. 129.6 m

THURBER ENGINEERING LTD.

Foundation Investigation
Site 29-242/C1 Deil's Creek Culvert
Highway 17
Renfrew County, Ontario

G.W.P. No.: 4076-13-00

Project No.: 20479

Borehole 17-1

Box 2 (of 2)

Elevation 129.6 m to 128.5 m

Start of Box 2
elev. 129.6 m

Run 3 End
elev. 128.5 m

THURBER ENGINEERING LTD.

Foundation Investigation
Site 29-242/C1 Deil's Creek Culvert
Highway 17
Renfrew County, Ontario

G.W.P. No.: 4076-13-00

Project No.: 20479

Borehole 17-2

Box 1 (of 1)

Elevation 132.6 m to 129.5 m

Start Run 1
elev. 132.5 m

Run 1 End
elev. 131.0 m

Run 2 Start
elev. 131.0 m

Run 2 End
elev. 129.5 m

THURBER ENGINEERING LTD.

Foundation Investigation
Site 29-242/C1 Deil's Creek Culvert
Highway 17
Renfrew County, Ontario

G.W.P. No.: 4076-13-00

Project No.: 20479

THURBER ENGINEERING LTD.

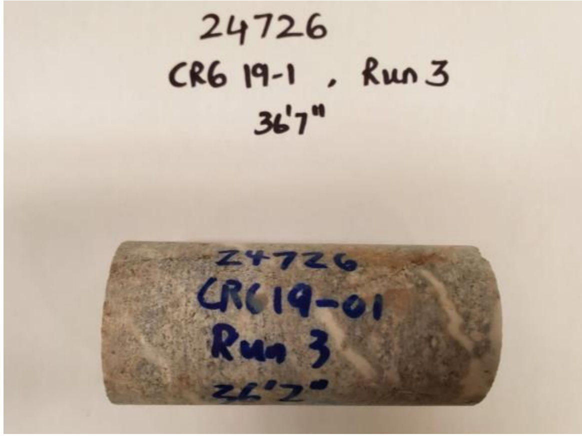
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	CR6 19-01	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 3		
SAMPLE DEPTH:	11.2m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.7	Weight (g):	484.9
Avg. Diameter (cm):	4.8	Wet Density (kg/m^3):	2,763
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,763
Cross Sectional Area (cm^2):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm^3):	175.53		

ORIGINAL SPECIMEN



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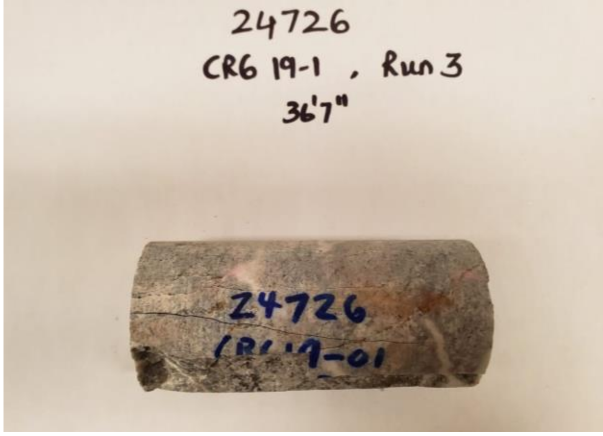


AVG. RATE OF STRAIN TO FAILURE:	1.5%	/ min
MAXIMUM COMPRESSIVE LOAD:	116.5	kN
UNCONFINED COMPRESSIVE STRENGTH:	64.4	MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

24726 - CR6 19-01 UCS Run 3, 36'7

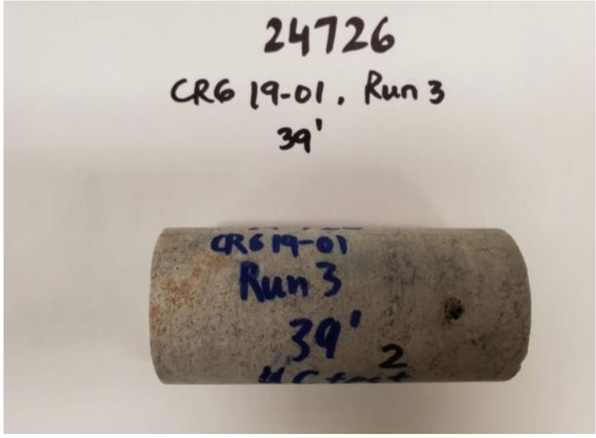
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	CR6 19-01	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 3		
SAMPLE DEPTH:	11.9m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.8	Weight (g):	474.9
Avg. Diameter (cm):	4.8	Wet Density (kg/m^3):	2,678
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,678
Cross Sectional Area (cm^2):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm^3):	177.34		

ORIGINAL SPECIMEN



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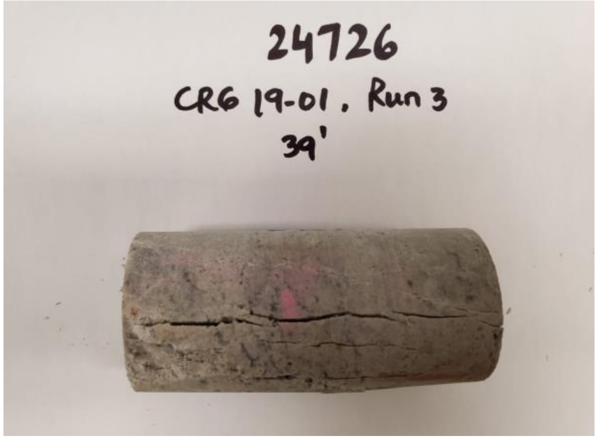


AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	146.8 kN
UNCONFINED COMPRESSIVE STRENGTH:	81.1 MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

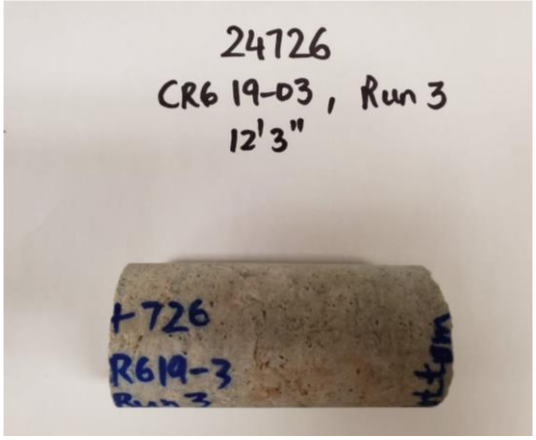
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

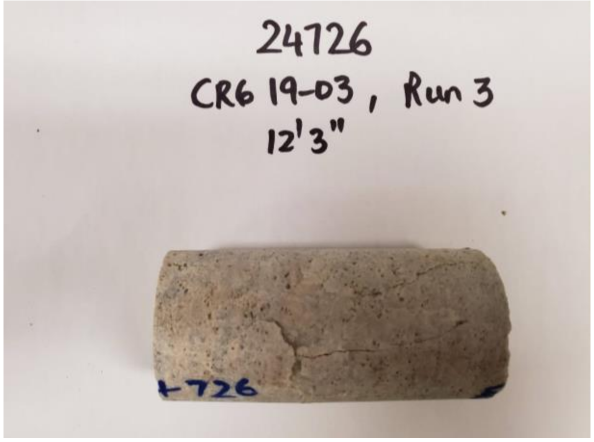
CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	CR6 19-03	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 3		
SAMPLE DEPTH:	3.7m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.7	Weight (g):	461.1
Avg. Diameter (cm):	4.8	Wet Density (kg/m^3):	2,627
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,627
Cross Sectional Area (cm^2):	18.10	Moisture Content* (%):	N/A
Sample Volume (cm^3):	175.53		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	62.4 kN
UNCONFINED COMPRESSIVE STRENGTH:	34.5 MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

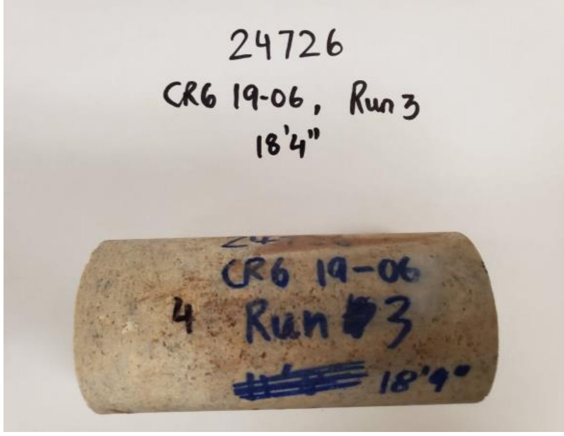
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	Thurber Engineering (Ottawa)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	CR6 19-06	TEST DATE:	12-Dec-19
SAMPLE No.:	HQ RUN 3		
SAMPLE DEPTH:	5.6m		
DESCRIPTION:	Marble		

Avg. Height (cm):	12.6	Weight (g):	1057.6
Avg. Diameter (cm):	6.3	Wet Density (kg/m^3):	2,693
H. to Dia. Ratio**:	2:1	Dry Density (kg/m^3):	2,693
Cross Sectional Area (cm^2):	31.17	Moisture Content* (%):	N/A
Sample Volume (cm^3):	392.77		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN

AVG. RATE OF STRAIN TO FAILURE:	1.2% / min
MAXIMUM COMPRESSIVE LOAD:	131.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	42.2 MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

THURBER ENGINEERING LTD.

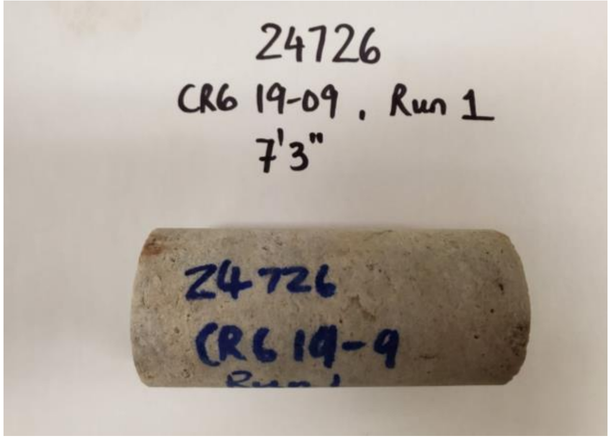
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

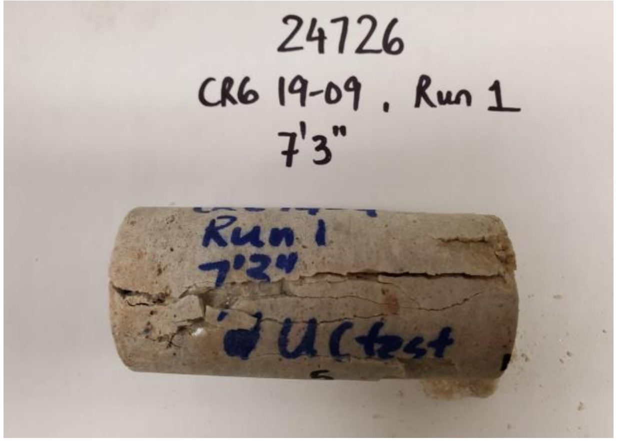
CLIENT:	Thurber Engineering (Ottawa Office)	FILE NUMBER:	24726
PROJECT NAME:	Highway 17 Twinning - Renfrew	REPORT DATE:	24-Mar-20
BOREHOLE No.:	CR6 19-09	TEST DATE:	12-Dec-19
SAMPLE No.:	NQ RUN 1		
SAMPLE DEPTH:	2.2m		
DESCRIPTION:	Marble		

Avg. Height (cm):	9.8	Weight (g):	481.7
Avg. Diameter (cm):	4.7	Wet Density (kg/m^3):	2,833
H. to Dia. Ratio**:	2.1:1	Dry Density (kg/m^3):	2,833
Cross Sectional Area (cm^2):	17.35	Moisture Content* (%):	N/A
Sample Volume (cm^3):	170.02		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	107.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	62.2 MPa

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

TEST DONE BY: BS
REVIEWED BY: WM

24726 - CR6 19-09 UCS Run 1, 7'3

Appendix D.

Site Photographs

Photo 1. Highway 17 Country Road 6 at-grade crossing looking west (2020/04/22)
Elevated asphalt bull-nose under light pole to south.

Photo 2. County Road 6 looking south (2020/04/22)
Elevated asphalt bull-nose under light pole to south.

Photo 3. Culvert crossing County Road 6 north of Highway 17 looking west (2020/04/22)
Looking at culvert inlets.

Photo 4. Culvert crossing County Road 6 north of Highway 17 looking east towards box culvert crossing Highway 17 (2020/04/22)
Looking at box culvert outlet and twin CSP inlet.

Photo 5. Looking north along County Road 6 (2020/04/22)
Inlet of twin CSPs evident to east. Bedrock outcrops visible to north.

Appendix E.

GSC Seismic Hazard Calculation

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 45.469N 76.623W **User File Reference:** Highway 17 Twinning - County Road 6 2021-08-30 18:15 UT

Requested by: Thurber Engineering Ltd.

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.353	0.181	0.104	0.031
Sa (0.1)	0.419	0.226	0.137	0.045
Sa (0.2)	0.351	0.197	0.123	0.043
Sa (0.3)	0.267	0.154	0.098	0.035
Sa (0.5)	0.191	0.112	0.072	0.026
Sa (1.0)	0.098	0.059	0.038	0.013
Sa (2.0)	0.047	0.028	0.018	0.005
Sa (5.0)	0.013	0.007	0.004	0.001
Sa (10.0)	0.005	0.003	0.002	0.001
PGA (g)	0.225	0.124	0.075	0.025
PGV (m/s)	0.160	0.090	0.055	0.018

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

THURBER

Appendix F.

Foundation Comparison
Preliminary General Arrangement Drawings

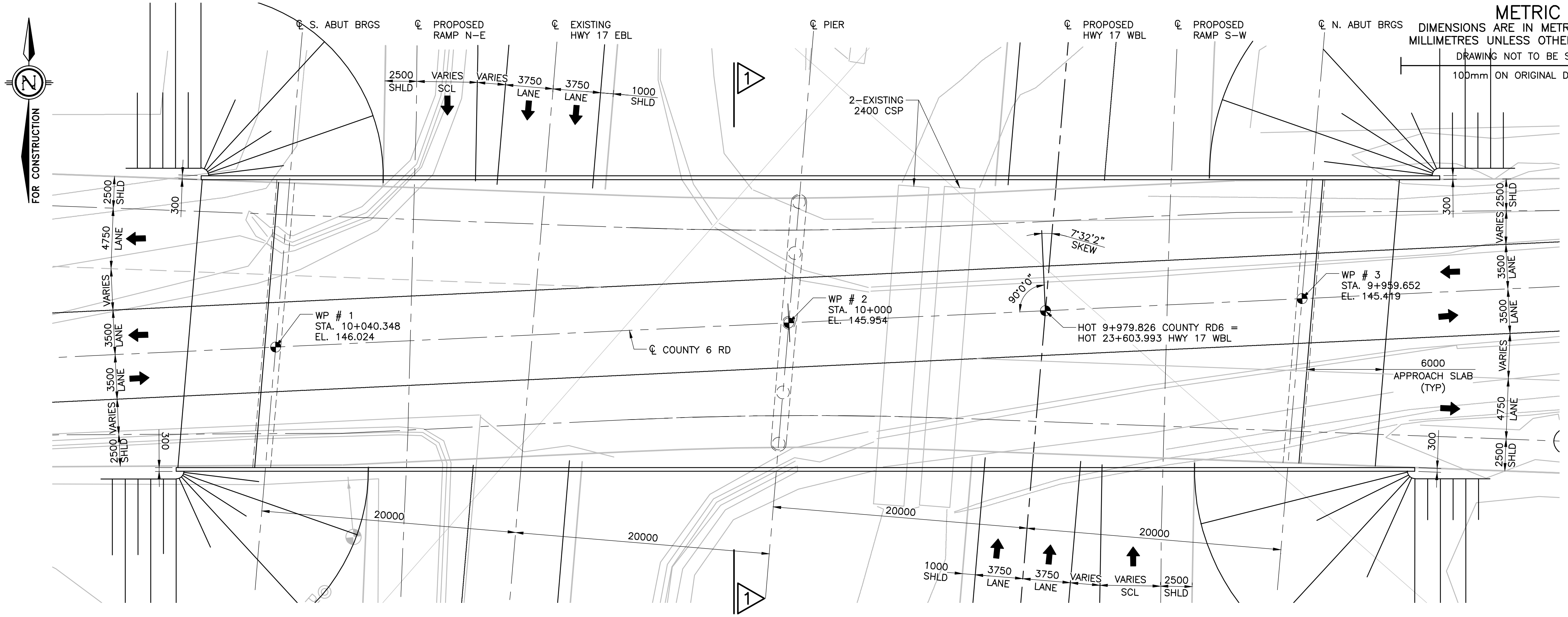
COMPARISON OF CULVERT ALTERNATIVES

	Pipe Culverts	Open-Bottom Box Culvert	Closed- Bottom Box Culvert
Advantages	• Relatively expedient installation if precast units are used. • Smaller magnitude of settlement than open footing culvert due to lower bearing stress on subgrade.	• Relatively expedient installation if precast units are used. • Possibility to maintain work zone outside of existing waterway. • Limits excavation depth (bedrock only).	• Relatively expedient installation if precast units are used. • Smaller magnitude of settlement than open footing culvert due to lower bearing stress on subgrade.
Disadvantages	• Requires a temporary by-pass to maintain waterflow. • Several parallel pipes required to provide hydraulic opening equivalent to box culvert. • Increases excavation depth for bedding layer (bedrock only).	• May require protection system for construction of foundations. • Deepest excavation, increases quantities and dewatering concerns (overburden only). • Lower geotechnical resistances (overburden only). • Potential for post construction settlement (overburden only).	• Requires a temporary by-pass to maintain waterflow. • Increases excavation depth for culvert base and bedding layer (bedrock only).
Risks/ Consequences	• Potential for damage due to settlement.	• Increased risk of basal instability of footing excavation due to depth of excavation below water table (overburden only). • Potential for damage due to settlement (overburden only).	• Potential for damage due to settlement (overburden only).
Relative Cost	Low to Moderate	Moderate	Moderate
Recommendation	**Feasible**	**Recommended** (for foundations on bedrock)	**Recommended** (for foundations on overburden)

COMPARISON OF BRIDGE FOUNDATION ALTERNATIVES

	Spread Footings			Deep Foundations	
	Engineered Granular A Pad on Overburden	**Engineered Granular A Pad on Bedrock**	**Mass Concrete on Bedrock**	**Steel Pile**	**Caissons**
Advantages	• Requires less specialized construction equipment.	• Requires less specialized construction equipment. • Higher geotechnical capacity than spread footings on Granular A pad on overburden.	• Requires less specialized construction equipment. • Higher geotechnical capacity than spread footings on Granular A pad on either bedrock or overburden.	• Higher geotechnical capacity than spread footings. • Construction could continue in winter weather conditions. • Likely requires less concrete than spread footings or caissons. • Less dewatering efforts. • Shorter construction period. • Could allow for integral abutment.	• Higher geotechnical capacity than piled and spread footing foundations. • Construction could continue in winter weather conditions.
Disadvantages	• Lowest geotechnical capacities. • Requires deeper excavations to construct granular pads. • Less effective resistance to uplift or overturning. • Granular pad to be protected from erosion/scour. • Differential settlement due to underlying soils.	• Lower geotechnical capacity than spread footings on Granular A pad on bedrock. • Requires deeper excavation than spread footings on Granular A pad on overburden. • Lower geotechnical capacity than spread footings on Granular A pad (on bedrock only).	• Requires deeper excavation than spread footings on Granular A pad on overburden. • High cost due to large quality of concrete.	• Higher unit costs than spread footings • Requires specialized construction equipment • Lower geotechnical resistance than caissons • If integral abutment is selected, bedrock coring will be required to achieve sufficient pile length	• Higher unit costs than spread footings. • Requires specialized installation measures such as equipment, liners and drilling mud will be required. • Difficulty in cleaning and inspecting the base. • May be difficult to dewater.
Risks/ Consequences	• Large excavations • Requires dewatering an excavation beside the creek	• Large excavations • Requires dewatering an excavation beside the creek	• Large excavations • Requires dewatering an excavation beside the creek	• Shallow, variable, sloping bedrock • Risk of encountering obstructions	• Risk of encountering obstructions • Encountering artesian conditions in the till
Relative Cost	Moderate		Low to Moderate	Moderate to High	Moderate to High
Recommendation	**Feasible** (not recommended)	**Feasible** (not recommended)	**Recommended** (north abutment and pier)	**Feasible** (south abutment)	**Recommended** (south abutment and pier)

MINISTRY OF TRANSPORTATION, ONTARIO ANSI-D 2017-08



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DIMENSIONS ARE IN METRES AND/OR
MILLIMETRES UNLESS OTHERWISE SHOWN
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

PARSONS

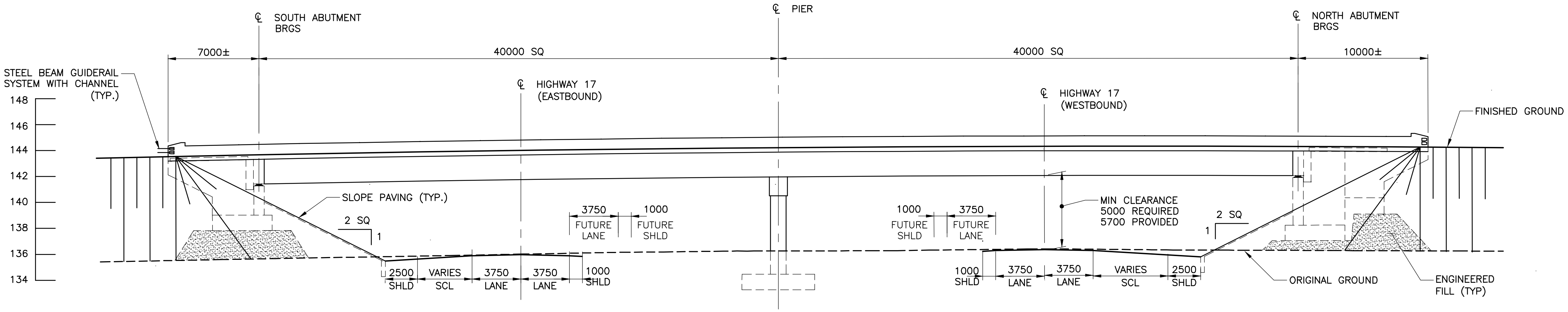
CONT No –
WP –

HWY 17 TWINNING
COUNTY ROAD 6 UNDERPASS

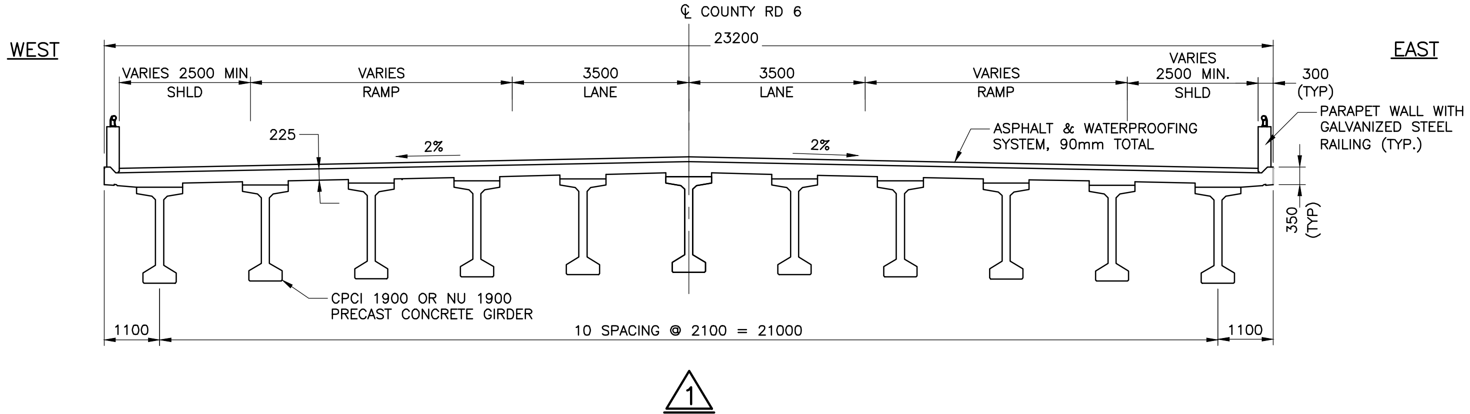
GENERAL ARRANGEMENT

SHEET
–

PLAN
1:200



ELEVATION
1:200



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MODIFIED: 2021-06-11 12:19

REVISIONS NO	DATE	BY	DESCRIPTION

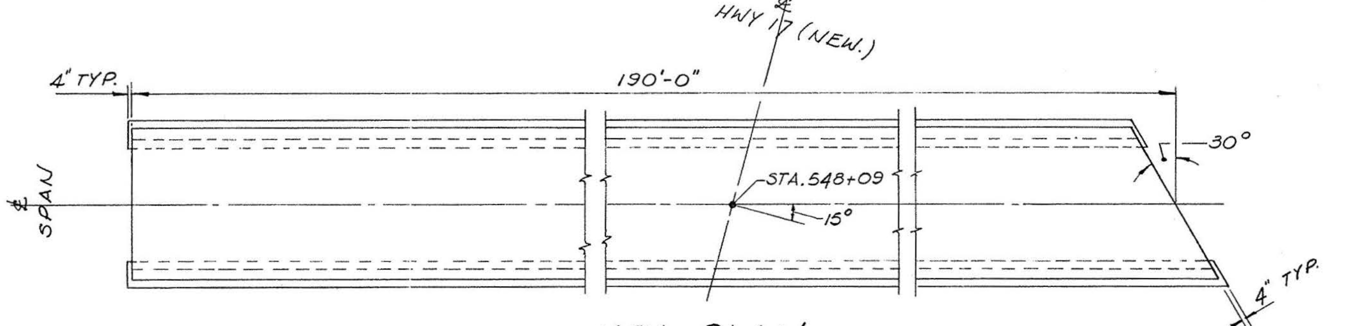
DESIGN AL	CHK	CODE CAN/CSA S6-14	LOAD CL-625-ONT	DATE
DRAWN FP	CHK AL	SITE 29x-0408/B1		DWG

DOCUMENT CODE:

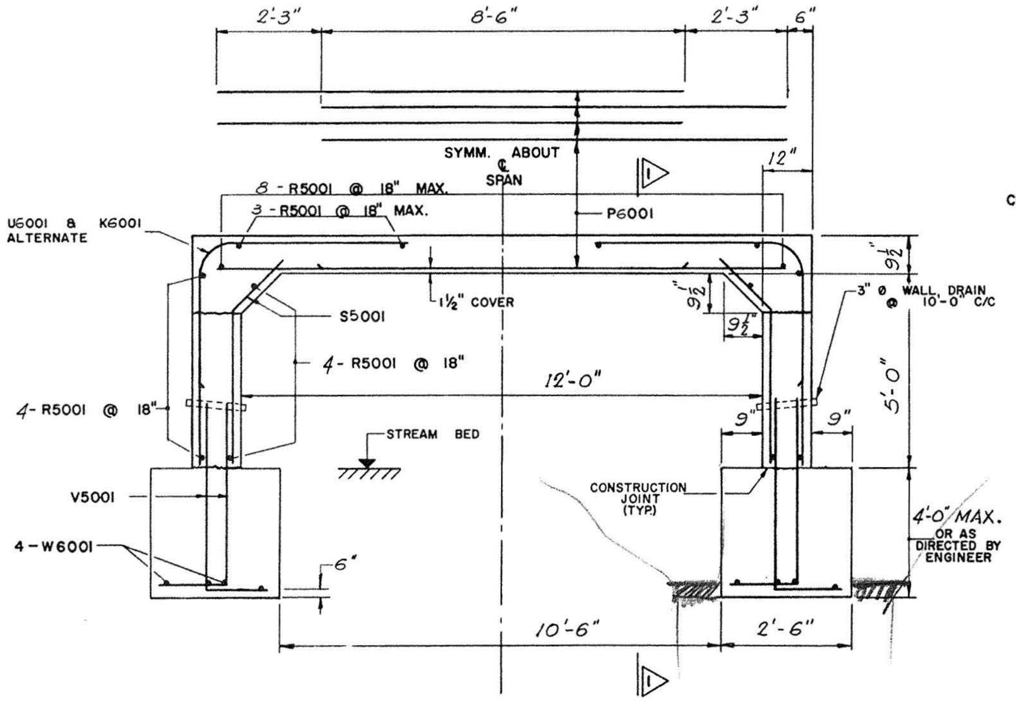
CONT. No. 73-186
W. P. No. 5-67-01

CULVERT STATION 548+09

SHEET 65

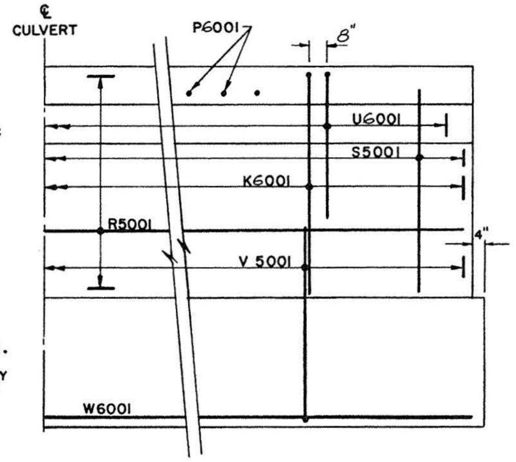


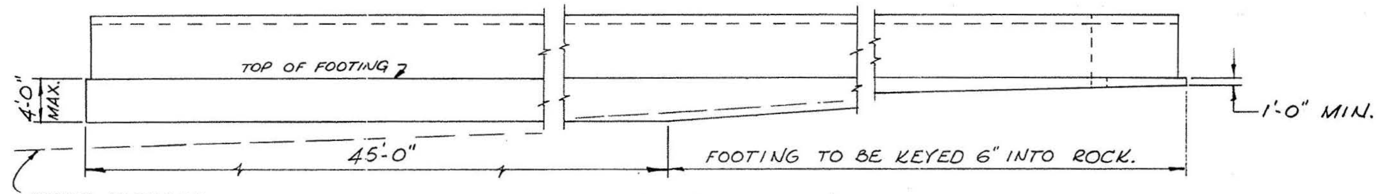
KEY PLAN



TYPICAL CULVERT SECTION

MAX. FILL 1'-6"





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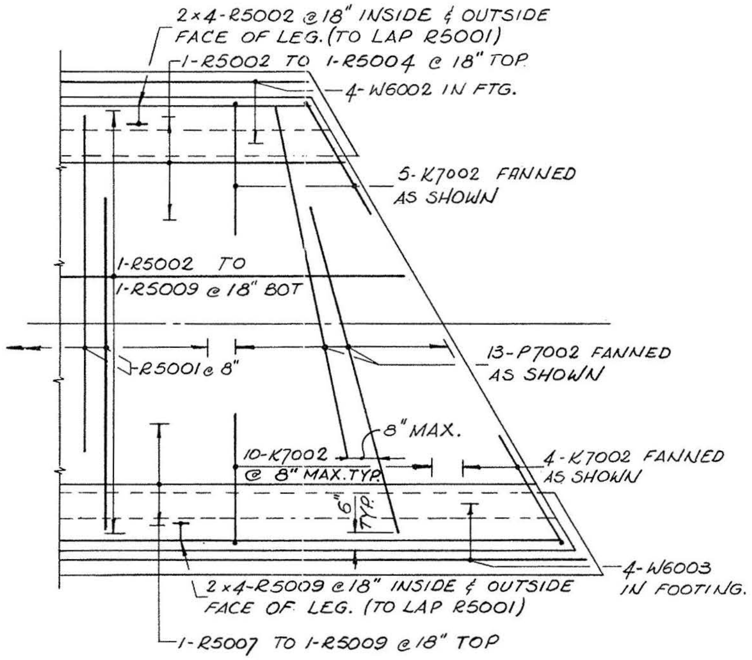


PART PLAN
AT S. END OF CULVERT

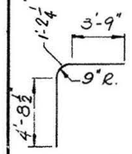
GENERAL NOTES

- CLASS OF CONCRETE 3000 PSI.
- CLEAR COVER TO REINFORCING STEEL 3" EXCEPT AS NOTED.
- ALL EXPOSED CORNERS TO BE CHAMFERED ¾".
- NO CONCRETE SHALL BE PLACED FOR ANY FOOTING, UNTIL THE DEPTH OF THE EXCAVATION AND CHARACTER OF THE FOUNDATION MATERIAL HAVE BEEN APPROVED BY THE ENGINEER.
- FILL SHALL BE PLACED AT BOTH SIDES OF CULVERT SIMULTANEOUSLY.
- CULVERT AND WINGWALLS SHALL BE BUILT IN ACCORDANCE WITH M.T.C. FORM 9.
- REINFORCING STEEL SHALL BE HARD GRADE.
- STEEL FOR THIS CULVERT (INCLUDING WINGWALLS WHERE APPLICABLE) SHALL BE BUNDLED SEPARATELY AND MARKED WITH STATION NUMBER.
- WALL DRAINS SHALL BE BITUMINIZED FIBRE PIPE. VERTICAL LOCATION OF WALL DRAINS SHALL BE DETERMINED IN FIELD BY THE ENGINEER.
- I.F. DENOTES INSIDE FACE.
- O.F. DENOTES OUTSIDE FACE.
- E.F. DENOTES EACH FACE.
- FOR GRANULAR BACKFILL REQUIREMENTS SEE DD809 A, B & C.

REINFORCING STEEL SCHEDULE FOR CULVERT

MARK	Nº	SPAC.	LENGTH	DETAIL	REMARKS
P6001	276	8"	10'-9"	STRAIGHT	IN BOTTOM OF SLAB STAGGERED
K6001	276	16"	9'-3¼"	1'-2¼" 3'-3½" K 3'-6" U R=9" 4'-9½" 3'-3¾"	IN SLAB AND LEG U6001 ALTERNATE WITH K600
U6001	276	16"	7'-11¾"		
S5001	286	16"	5'-10½"	4'-2½" 45° 1'-8"	INSIDE FACE OF LEG
R5001	240	18"	22'-6"	STRAIGHT 30 LINES. 8 PER LINE	DISTRIBUTION STEEL (MIN. LAP 1'-6")
V5001	572	16"	6'-9"	1'-3" 5'-6"	FOOTING DOWELS
W6001	64	—	22'-9"	STRAIGHT 8 LINES. 8 PER LINE	LONGITUDINAL IN FOOTING (LAP 2'-0")
P7002	13	—	12'-0"	STR.	BOT. OF SLAB. STAGGERED
K7002	19	8"	9'-7¾"	SEE DETAIL	IN SLAB & LEG.
R5002	10	18"	22'-6"	STR.	DISTRIBUTION STEEL
R5003	2	18"	23'-7	STR.	
R5004	2	18"	24'-8"	STR.	
R5005	1	18"	25'-9"	STR.	

R5006	1	18"	26'-10"	STR	DISTRIBUTION STEEL
R5007	2	18"	27'-11"	STR	
R5008	2	18"	29'-0"	STR.	
R5009	10	18"	30'-0"	STR.	
W6002	4	—	22'-0"	STR.	LONGITUDINAL IN FOOTING.
W6003	4	—	30'-0"	STR.	



K7002

CULVERT & WINGWALL QUANTITIES	CULVERT	WINGWALLS
WT. OF REINF. STEEL	13.52 TONS	TONS
VOLUME OF CONCRETE	253.55 CU. YDS.	CU. YDS.

DRAWING NOT TO SCALE

SS 114-1

B.S. - H.J.D.

PARSONS

CONT No –
WP –

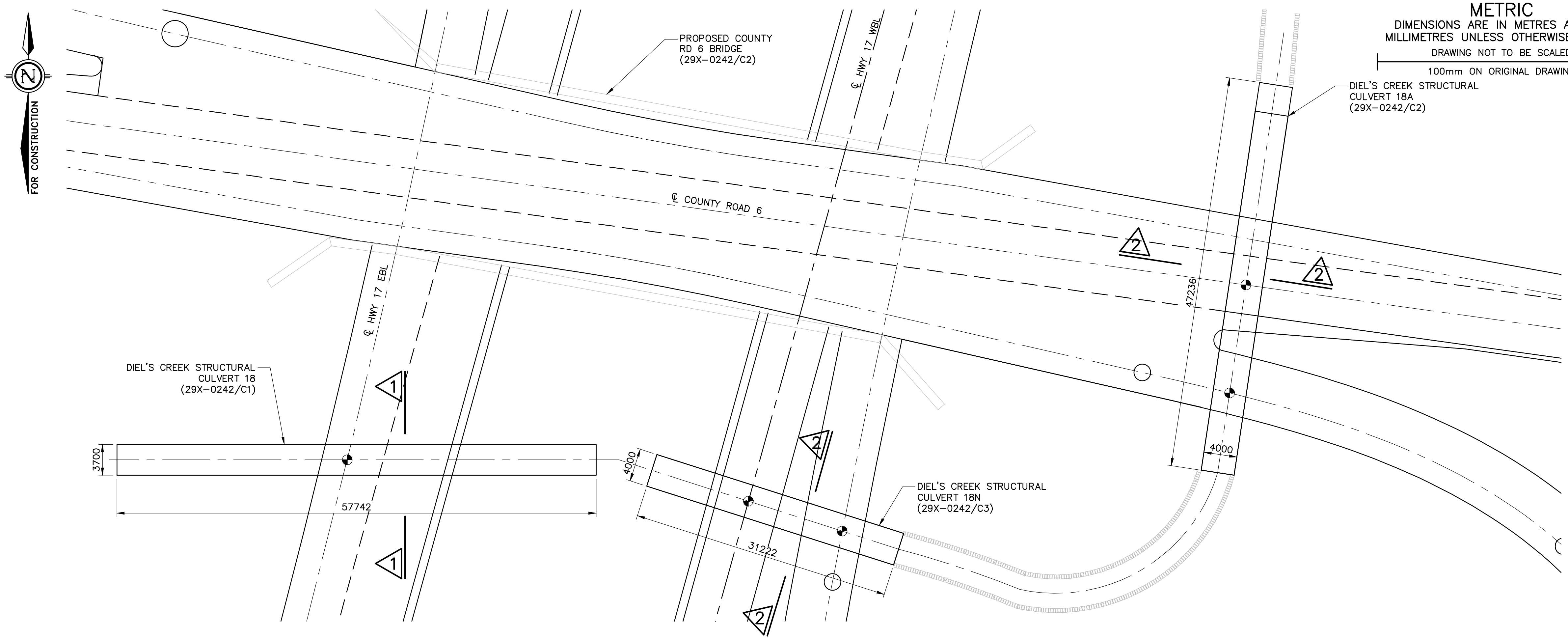
HWY 17 TWINNING
DEIL'S CREEK CULVERTS

GENERAL ARRANGEMENT

SHEET
–

METRIC
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN
DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

FOR CONSTRUCTION



PLAN
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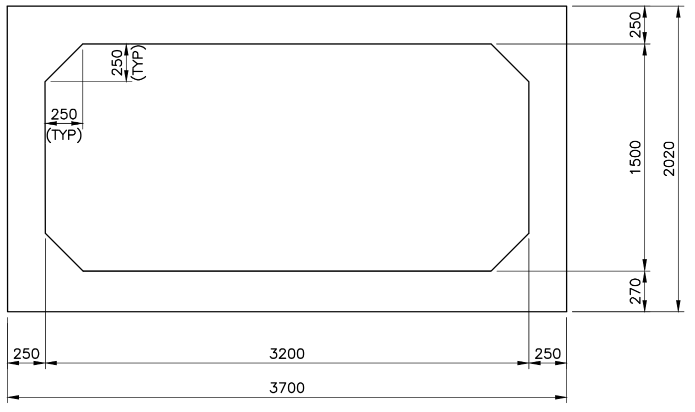

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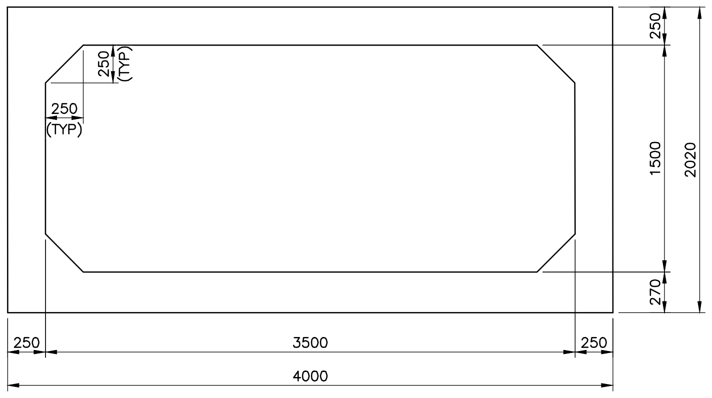

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REVISIONS NO	DATE	BY	DESCRIPTION

DESIGN AL	CHK	CODE CAN/CSA S6-14	LOAD CL-625-ONT	DATE
DRAWN FP	CHK AL	SITE 29x-0242/C1/C2/C3		DWG

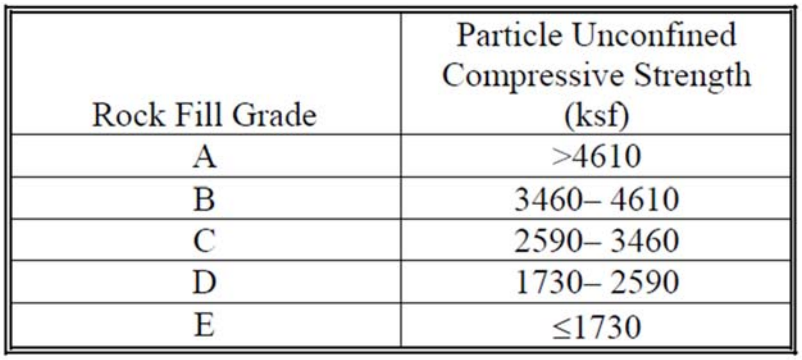
DOCUMENT CODE:

MINISTRY OF TRANSPORTATION, ONTARIO ANSI-D 2017-08

FILE NAME: J:\TOR\477796 WO#24-P-3 Hwy 17 Twinning\5 General\8 Structural\1-CAD\Deils Creek_ 3 Culvers_GA.dwg
MODIFIED: 2021-06-15 17:51

Appendix G.

Slope Stability Analysis Figures



Rock Fill Grade	Particle Unconfined Compressive Strength (ksf)
A	>4610
B	3460– 4610
C	2590– 3460
D	1730– 2590
E	≤1730

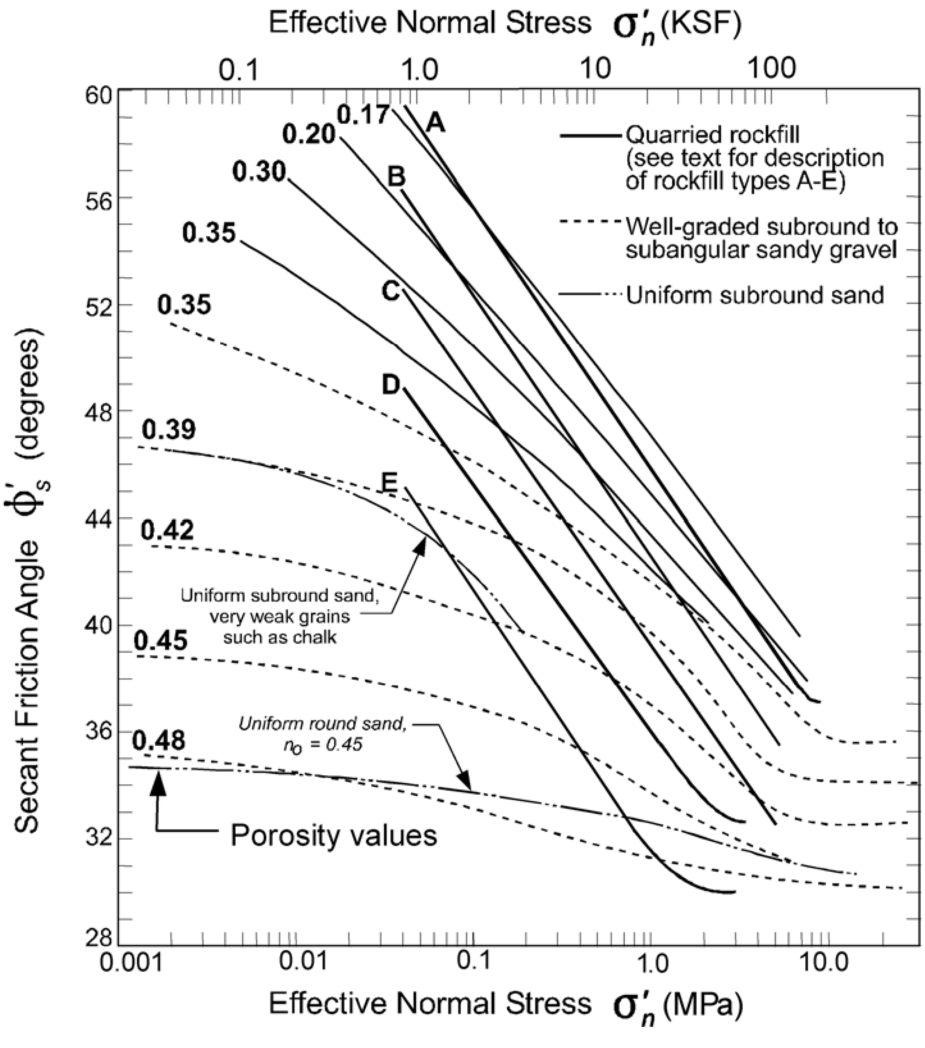


Figure 10.4.6.2.4-1—Estimation of Drained Friction Angle of Gravels and Rock Fills (modified after Terzaghi, Peck, and Mesri, 1996)

[copied from Page 10-18 of the AASHTO LRFD Bridge Design Specification[1]]

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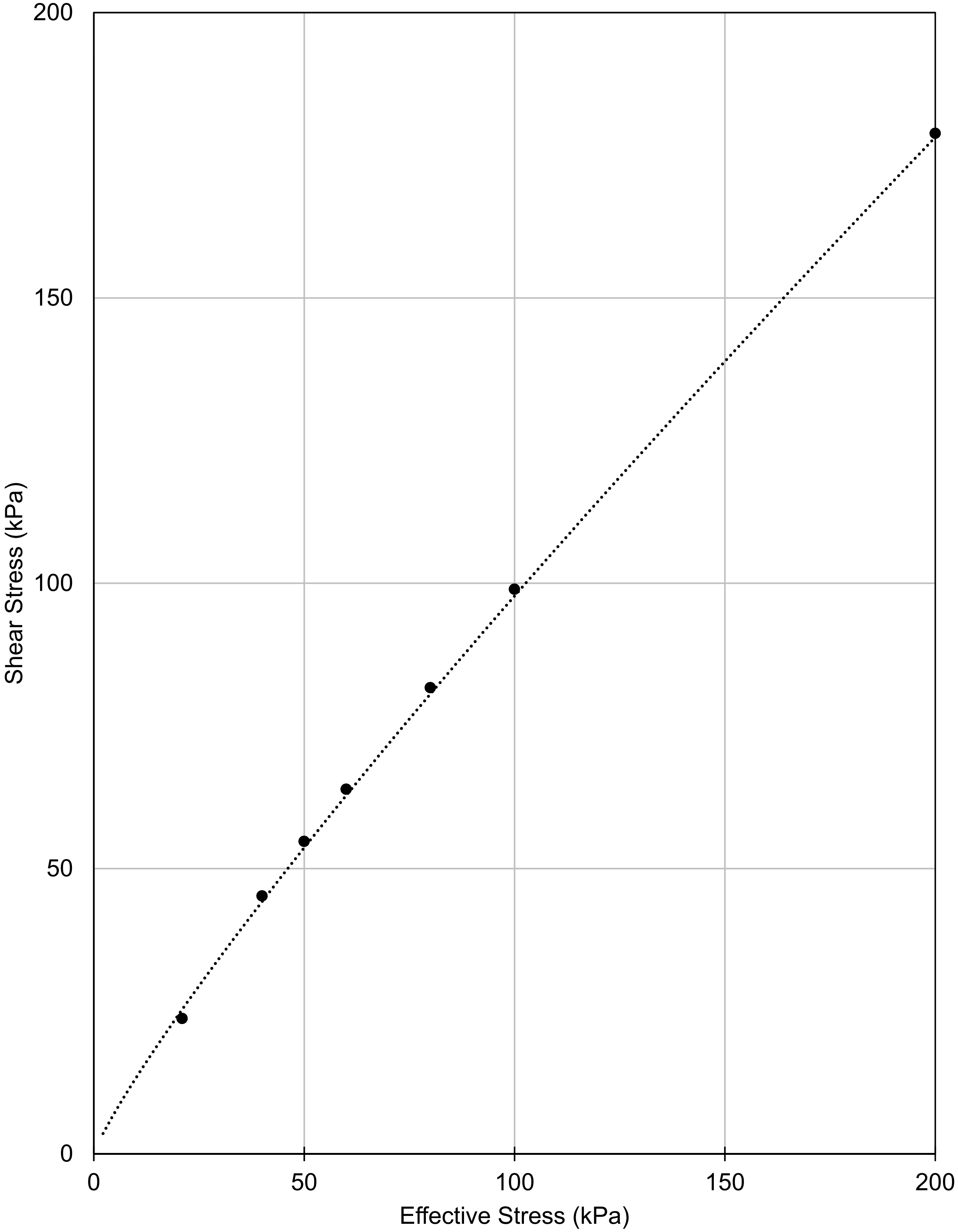
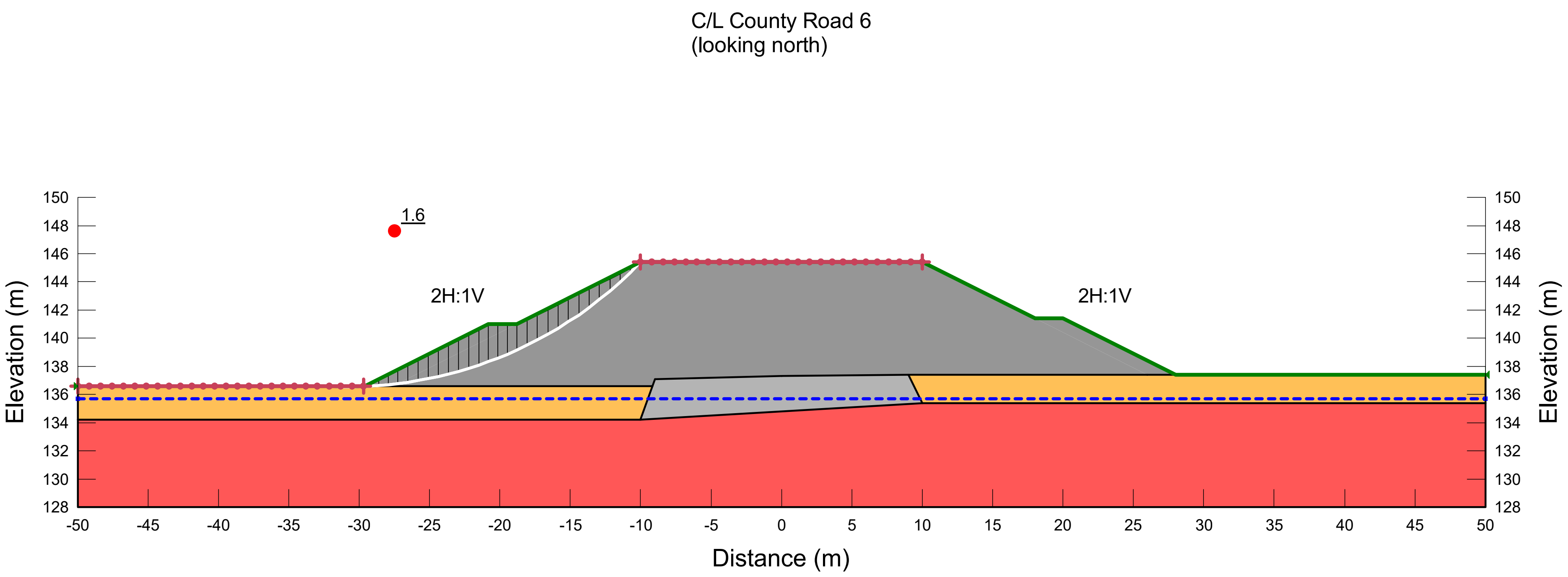
[1] American Association of State Highways and Transportation Officials (2017). AASHTO LRFD Bridge Design Specification, Washington, D.C.,

Interpreted AASHTO Figure 10.4.6.2.4-1
Rockfill Grade D



Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. Bl	Mohr-Coulomb	21	0	32
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



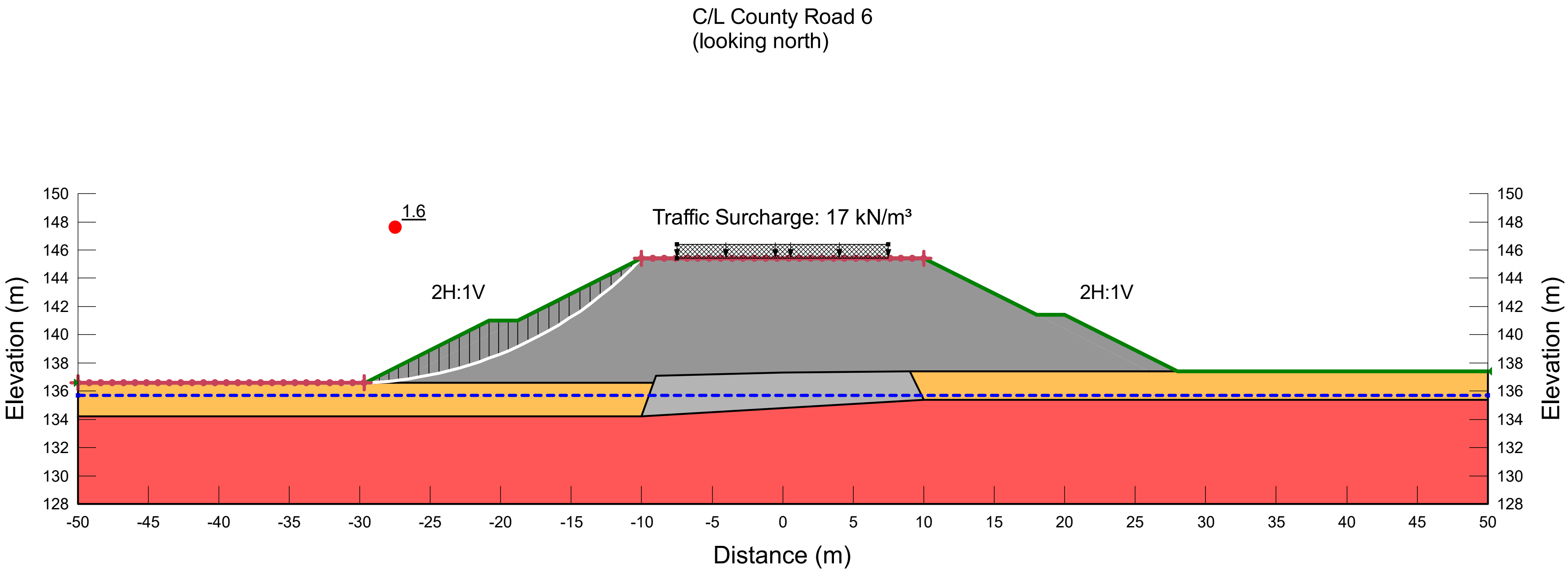
Project	Additional Details
County Road 6	Name: G01. North Approach (2H:1V) Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (-10, 145.4) m, Exit: (-32.136, 136.6) m Center: (-30.721727, 165.28351) m, Radius: 28.718357 m

Analysis		
G1.1 Long Term - Static		
Seismic Coefficient	**Last Run**	**Scale**
H: 0g, V: 0g	2022/08/09, 05:22:54 PM	1:450

THURBER

Figure G1-1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



Project	County Road 6
Analysis	G1.2 Temporary - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/09, 05:22:50 PM
Scale	1:450

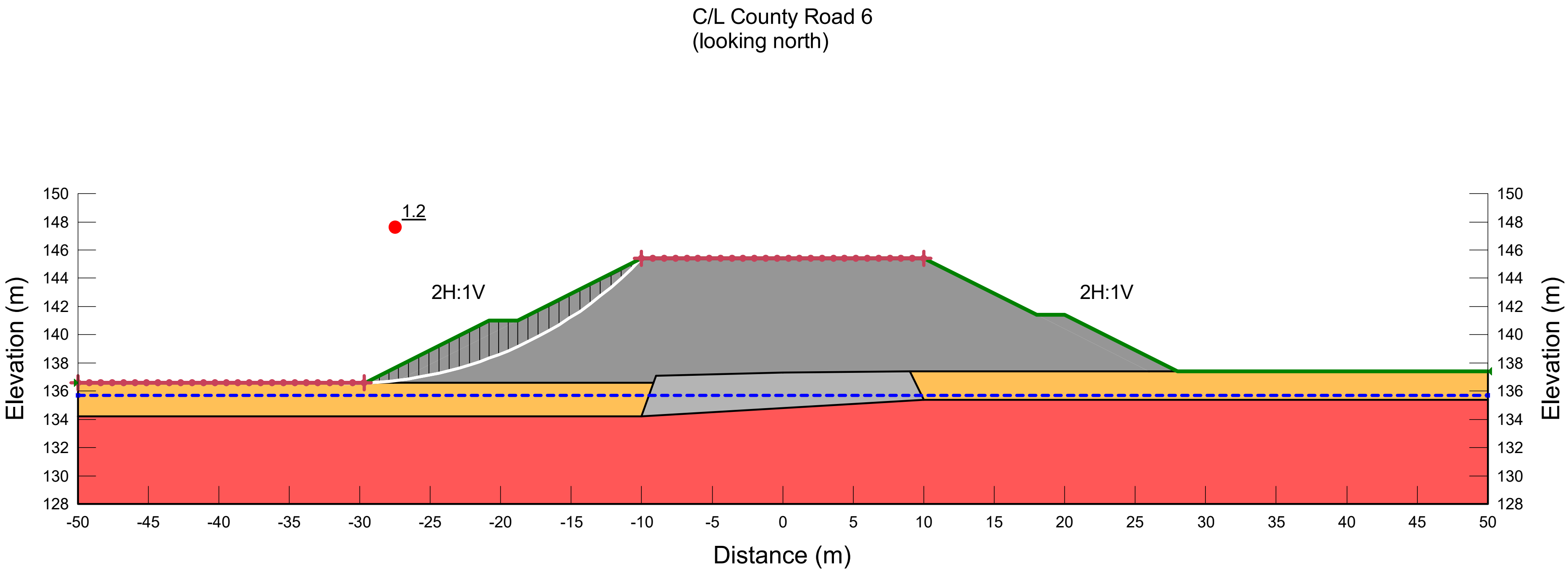
THURBER

Additional Details

Name: G01. North Approach (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-10, 145.4) m, Exit: (-32.136, 136.6) m
Center: (-30.721727, 165.28351) m, Radius: 28.718357 m

Figure G1-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project	County Road 6
Analysis	G1.3 Temporary - Seismic - 2475yr
Seismic Coefficient	H: 0.13g, V: 0g
Last Run	2022/08/09, 05:22:58 PM
Scale	1:450

Additional Details

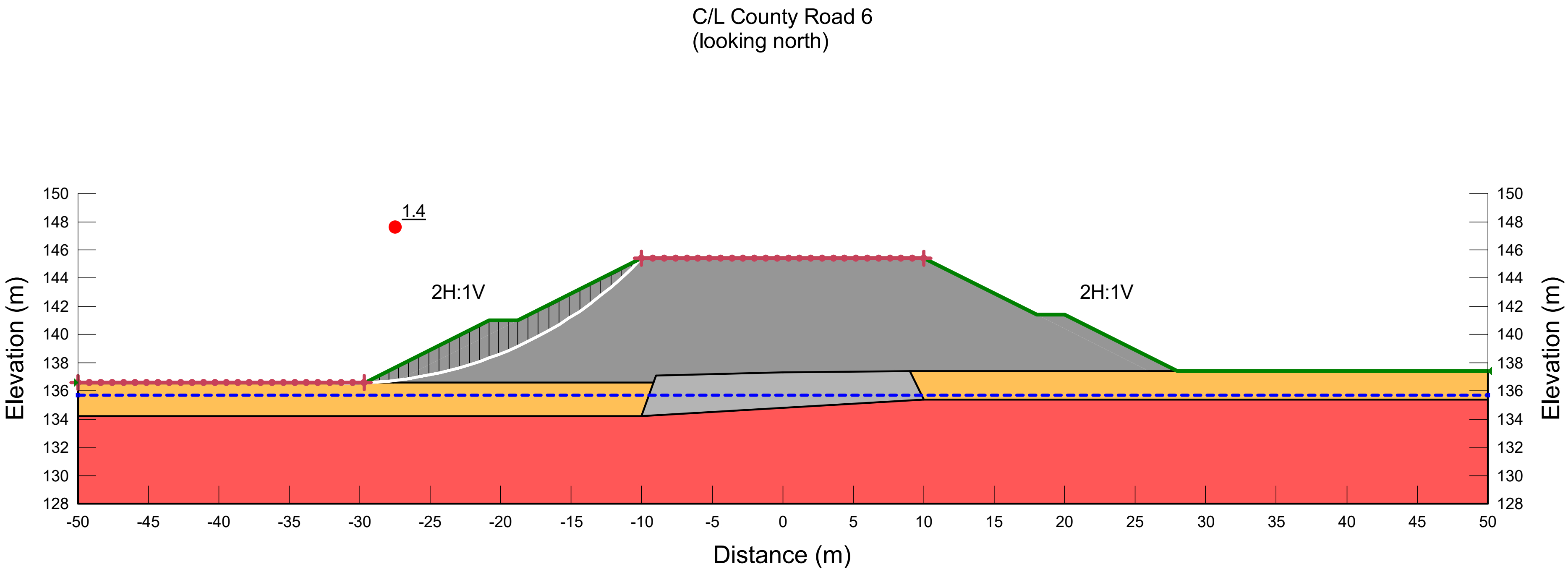
Name: G01. North Approach (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-10, 145.4) m, Exit: (-32.136, 136.6) m
Center: (-30.721727, 165.28351) m, Radius: 28.718357 m

Figure G1-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
▒	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G1.4 Temporary - Seismic - 475yr

Seismic Coefficient
H: 0.05g, V: 0g

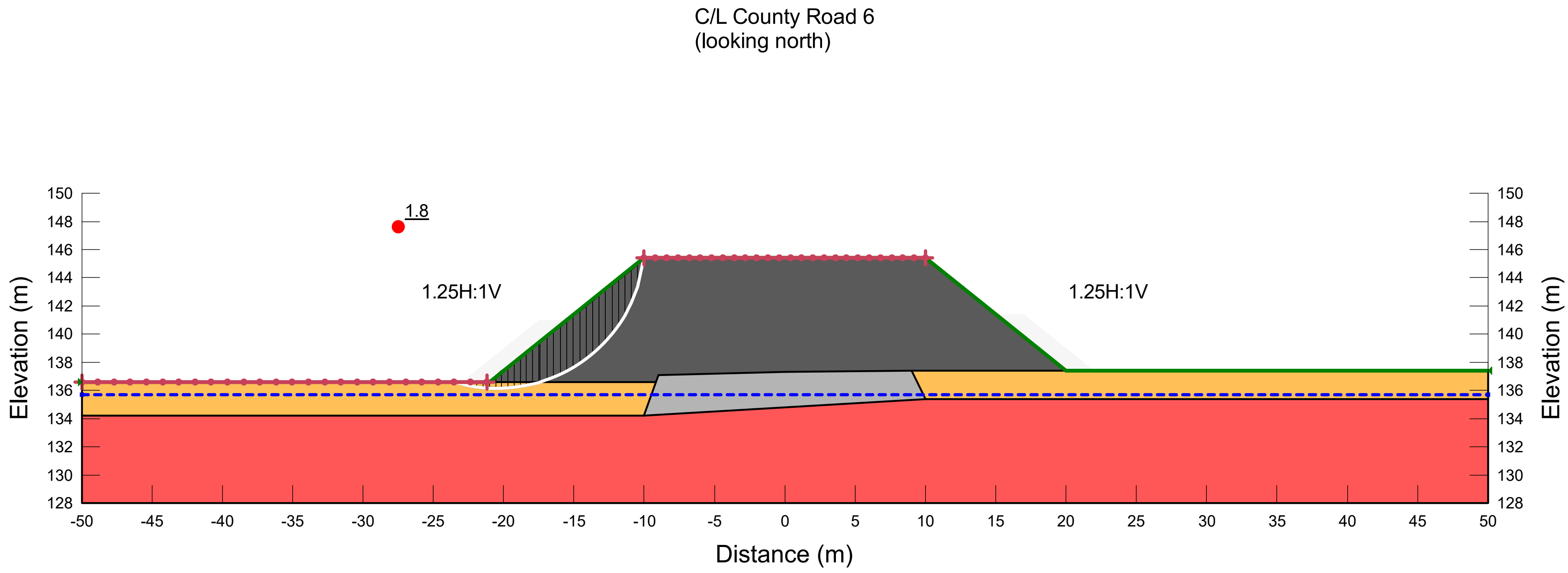
Last Run
2022/08/10, 07:51:22 AM

Scale
1:450

Additional Details
Name: G01. North Approach (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-10, 145.4) m, Exit: (-32.136, 136.6) m
Center: (-30.721727, 165.28351) m, Radius: 28.718357 m

Figure G1-4

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project
County Road 6

Analysis
G2.1 Long Term - Static

Seismic Coefficient
H: 0g, V: 0g

Last Run
2022/08/09, 05:23:04 PM

Scale
1:450

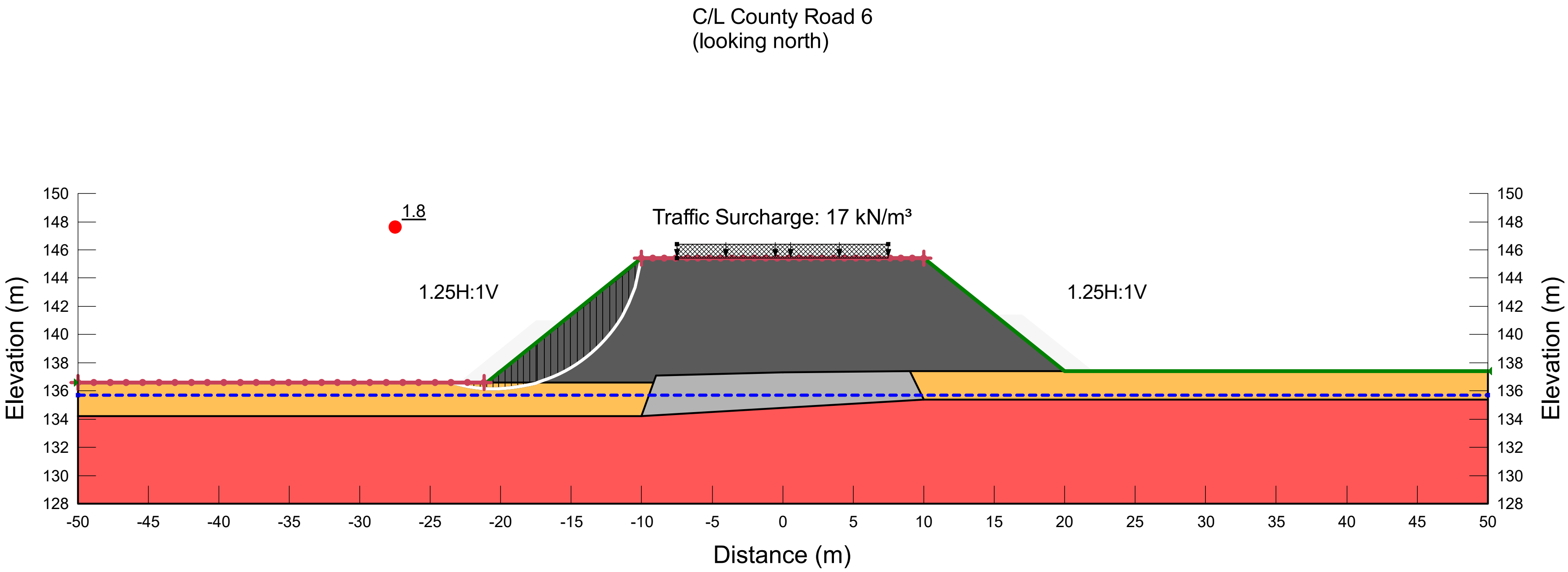
Additional Details
Name: G02. North Approach (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-10, 145.4) m, Exit: (-23.504, 136.6) m
Center: (-20.447071, 146.67025) m, Radius: 10.524012 m

Figure G2-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

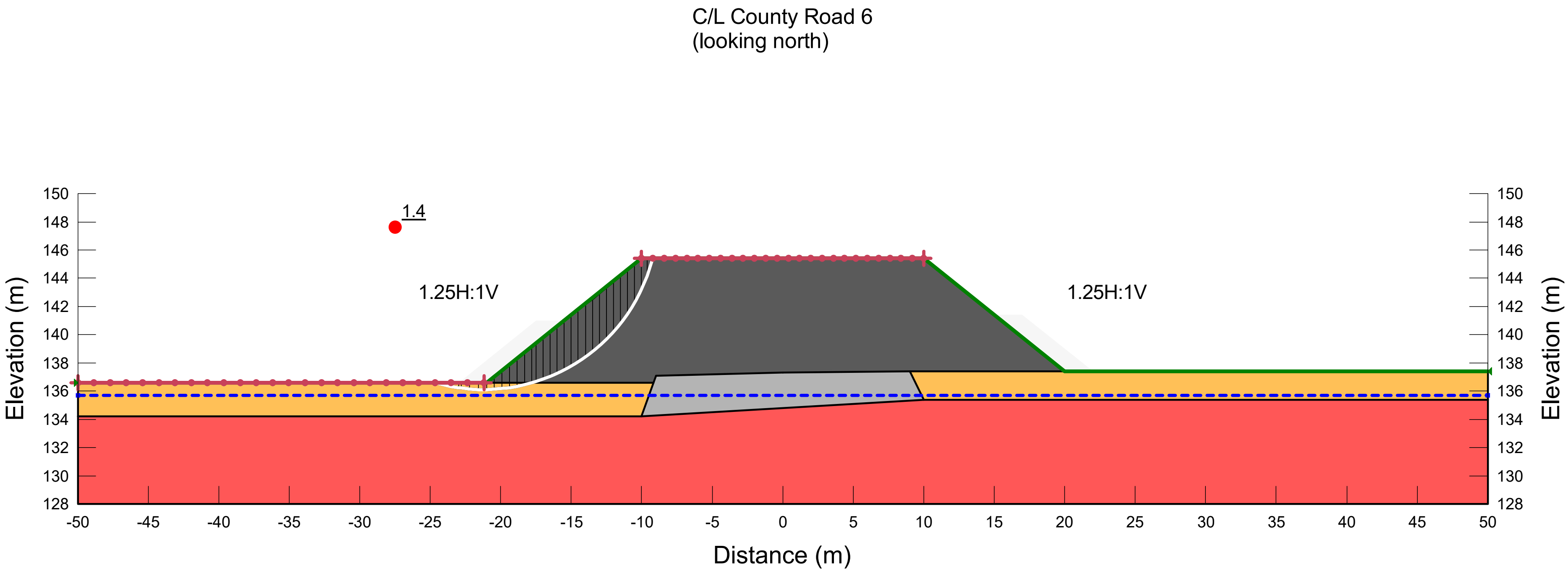
Project County Road 6		
Analysis G2.2 Temporary - Static		
Seismic Coefficient H: 0g, V: 0g	Last Run 2022/08/09, 05:23:02 PM	Scale 1:450

Additional Details

Name: G02. North Approach (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-10, 145.4) m, Exit: (-23.504, 136.6) m
Center: (-20.447071, 146.67025) m, Radius: 10.524012 m

Figure G2-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project
County Road 6

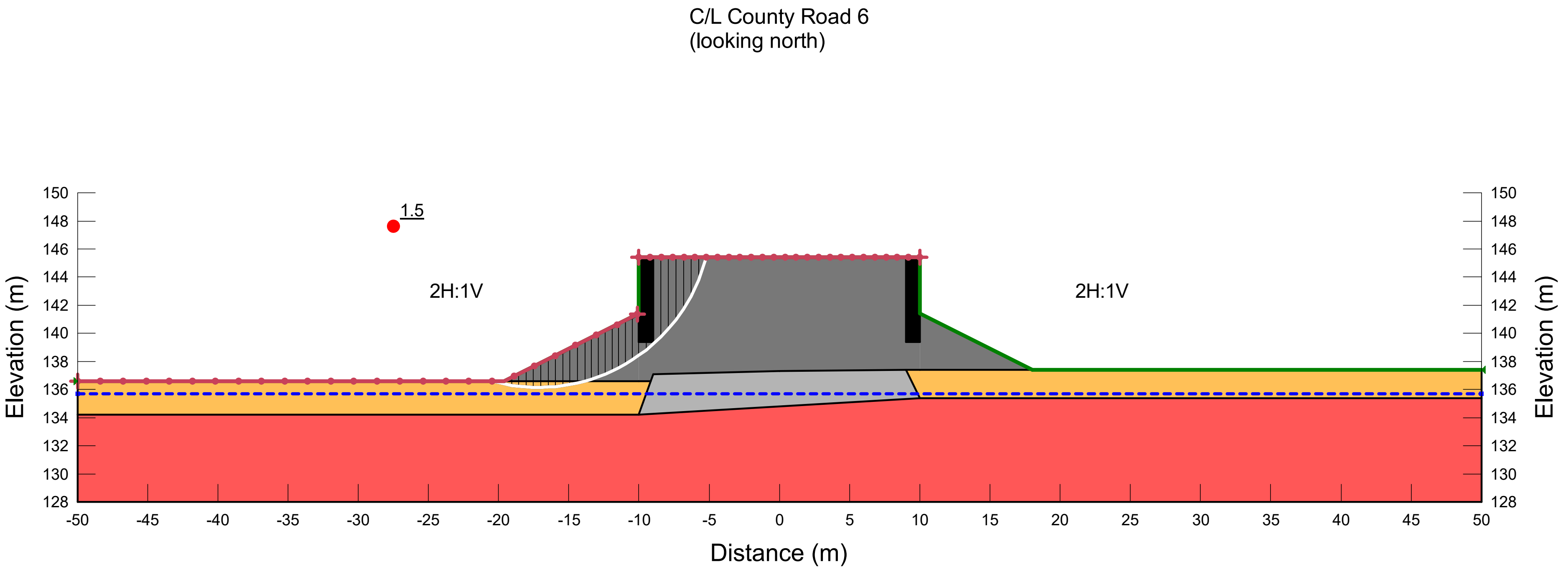
Analysis
G2.3 Temporary - Seismic - 2475yr

Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	2022/08/09, 05:23:08 PM	1:450

Additional Details
Name: G02. North Approach (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-9.2, 145.4) m, Exit: (-24.656, 136.6) m
Center: (-21.220283, 148.53881) m, Radius: 12.423338 m

Figure G2-3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE N Abut.	High Strength	24		
▒	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project	Additional Details
County Road 6	Name: G03. North Approach (Retaining Wall) Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (-5.2, 145.4) m, Exit: (-20.464648, 136.6) m Center: (-17.162756, 148.51165) m, Radius: 12.360821 m

Analysis
G3.1 Long Term - Static

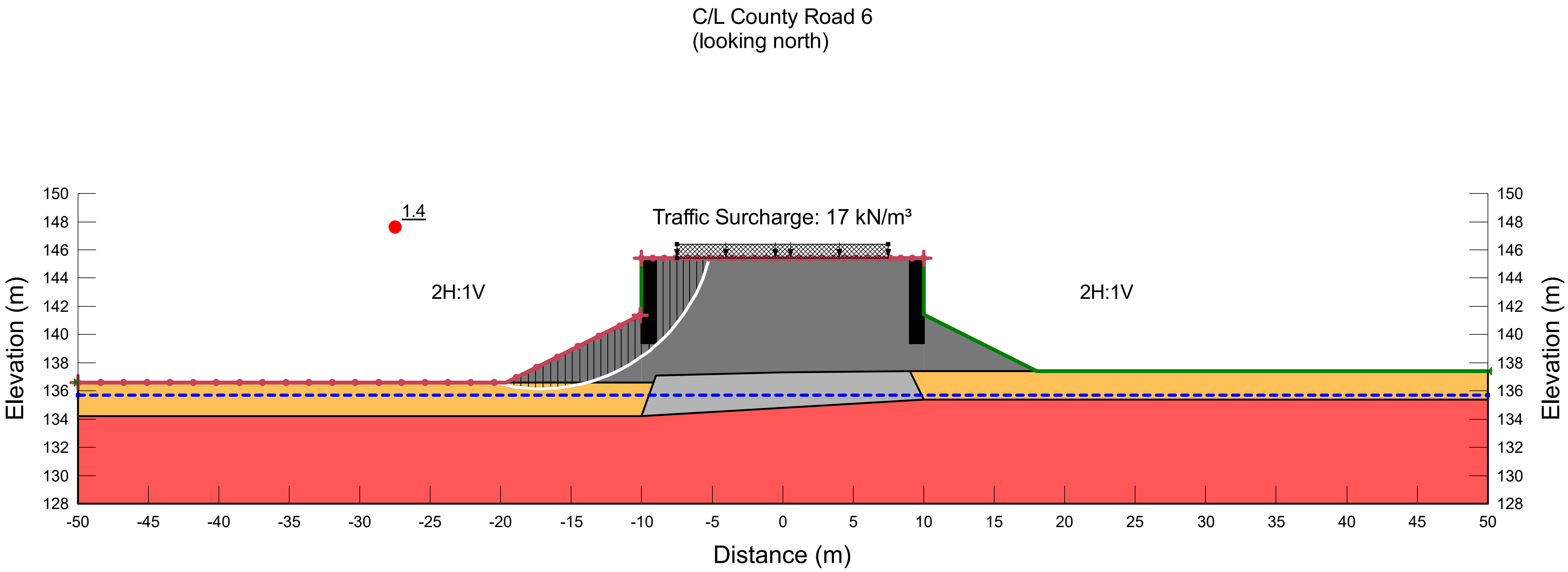
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/08/09, 05:23:12 PM	1:450

Figure G3-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE N Abut.	High Strength	24		
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
◼	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project	County Road 6
Analysis	G3.2 Temporary - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/09, 05:23:10 PM
Scale	1:450

Additional Details

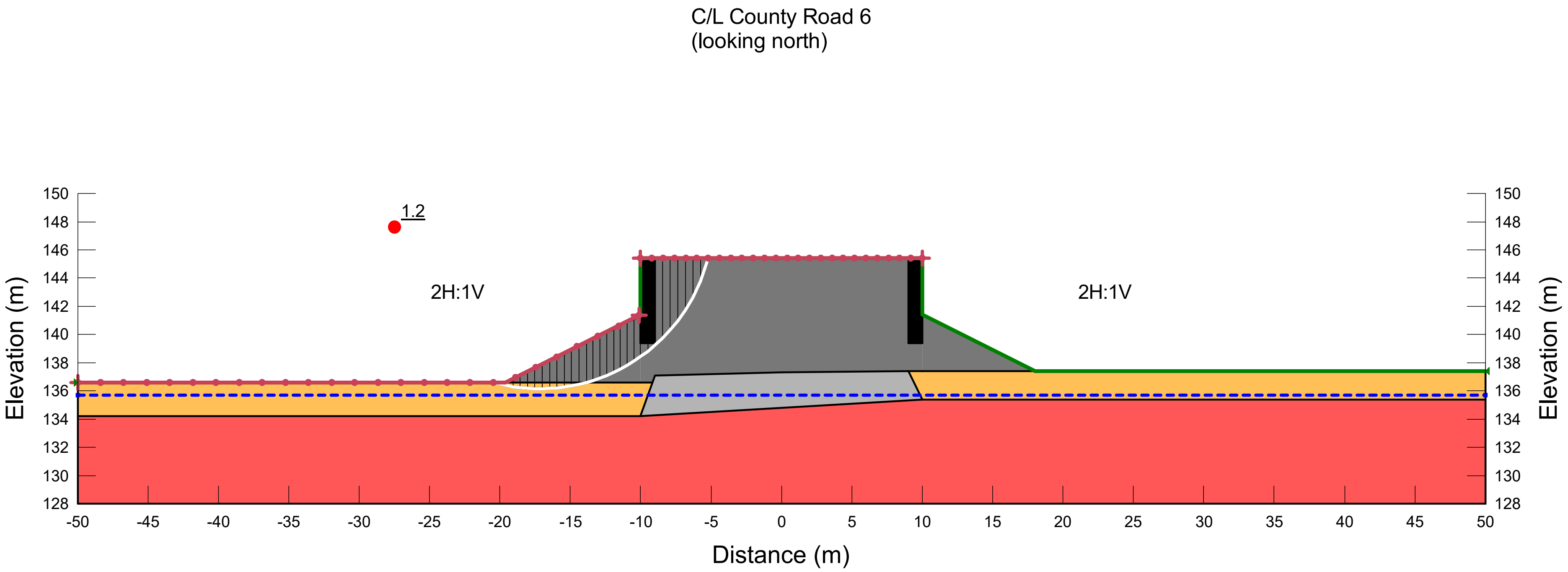
Name: G03. North Approach (Retaining Wall)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-5.2, 145.4) m, Exit: (-20.464648, 136.6) m
Center: (-17.162756, 148.51165) m, Radius: 12.360821 m

Figure G3-2

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE N Abut.	High Strength	24		
▒	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G3.3 Temporary - Seismic - 2475yr

Seismic Coefficient
H: 0.13g, V: 0g

Last Run
2022/08/09, 05:23:16 PM

Scale
1:450

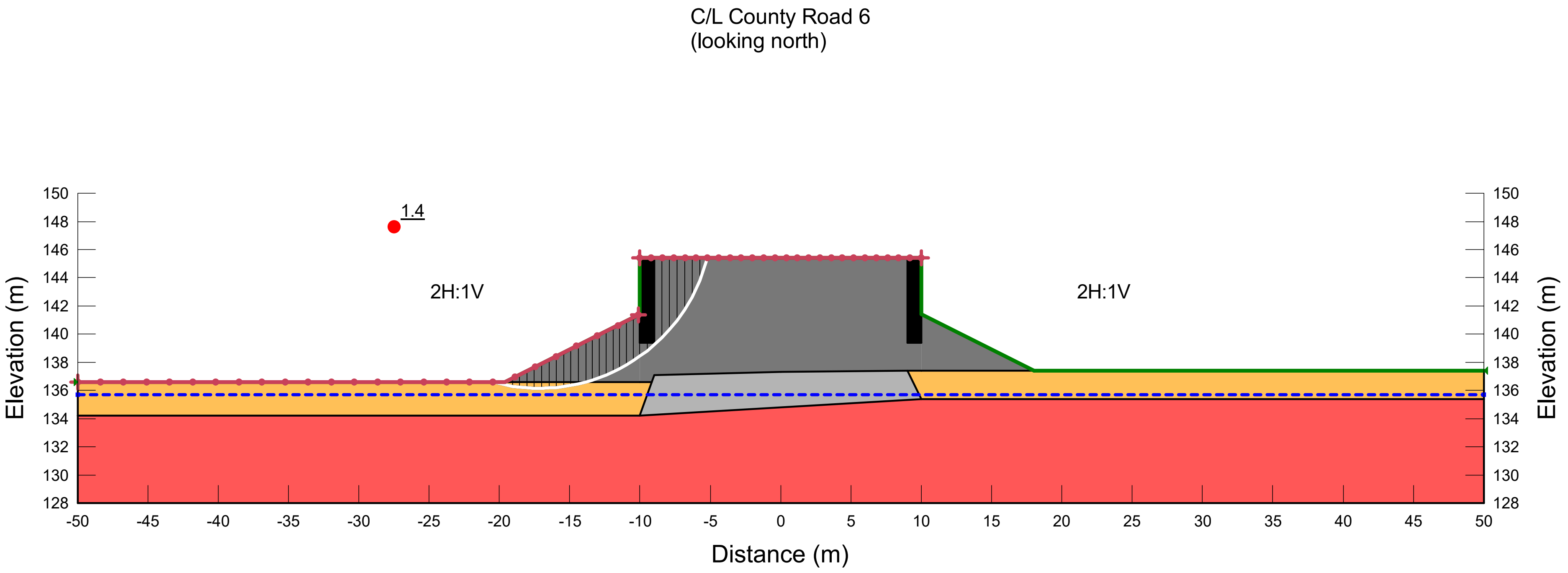
Additional Details
Name: G03. North Approach (Retaining Wall)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-5.2, 145.4) m, Exit: (-20.464648, 136.6) m
Center: (-17.162756, 148.51165) m, Radius: 12.360821 m

Figure G3-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE N Abut.	High Strength	24		
░	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			

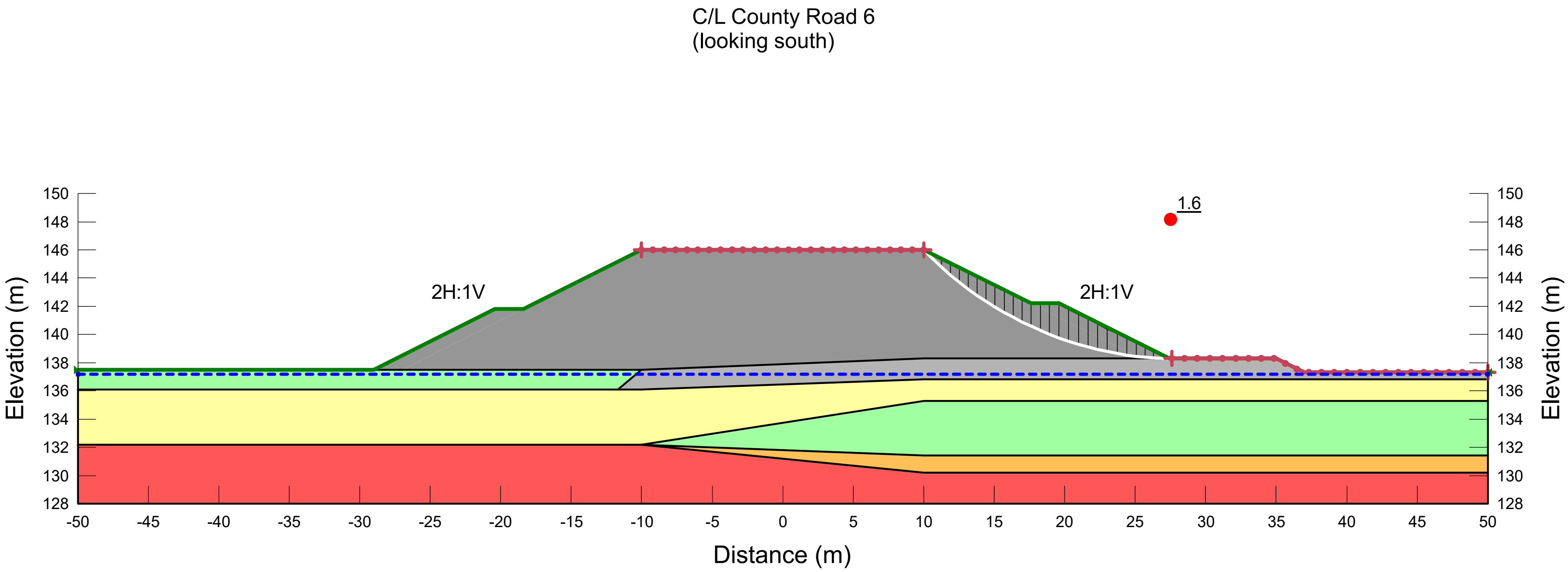


THURBER	Project County Road 6	Additional Details Name: G03. North Approach (Retaining Wall) Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (-5.2, 145.4) m, Exit: (-20.464648, 136.6) m Center: (-17.162756, 148.51165) m, Radius: 12.360821 m
	Analysis G3.4 Temporary - Seismic - 475yr	
	Seismic Coefficient: H: 0.05g, V: 0g Last Run: 2022/08/10, 07:51:28 AM Scale: 1:450	**Figure G3-4**

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



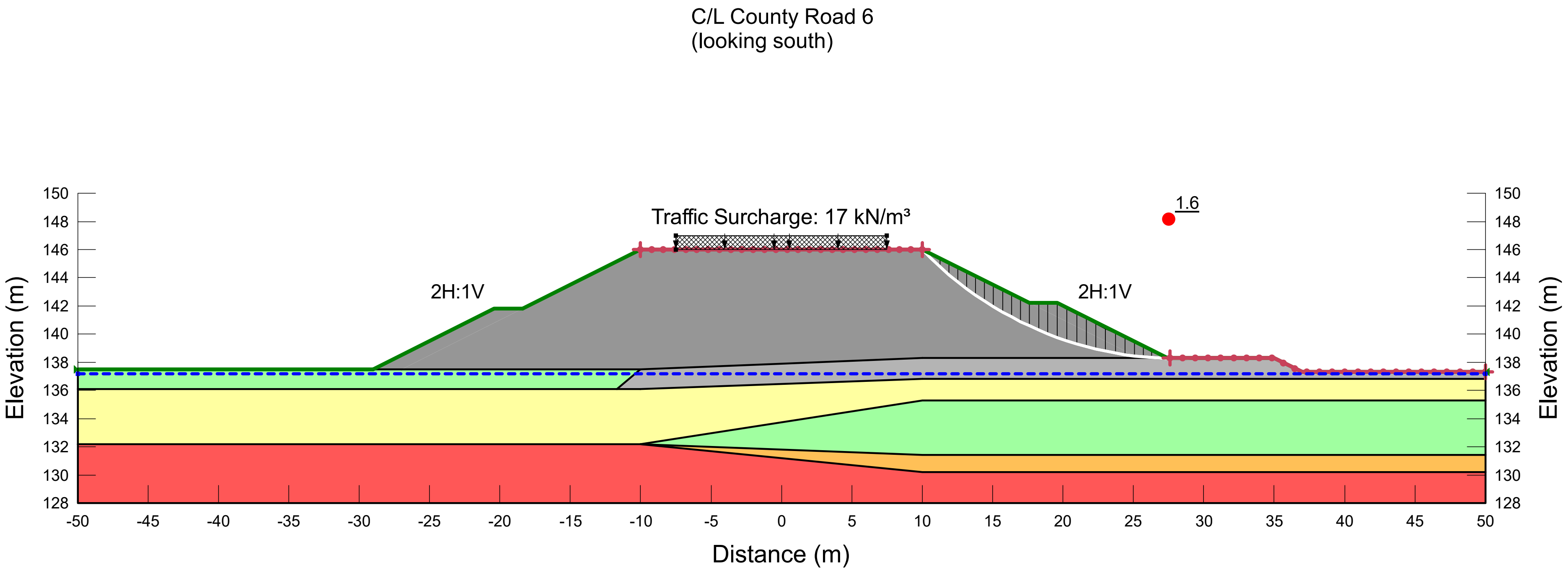
Project	County Road 6
Analysis	G4.1 Long Term - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/09, 05:23:26 PM
Scale	1:450

Additional Details
Name: G04. South Approach (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 146) m, Exit: (29.410885, 138.3) m
Center: (28.145056, 163.42537) m, Radius: 25.157238 m

Figure G4-1

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



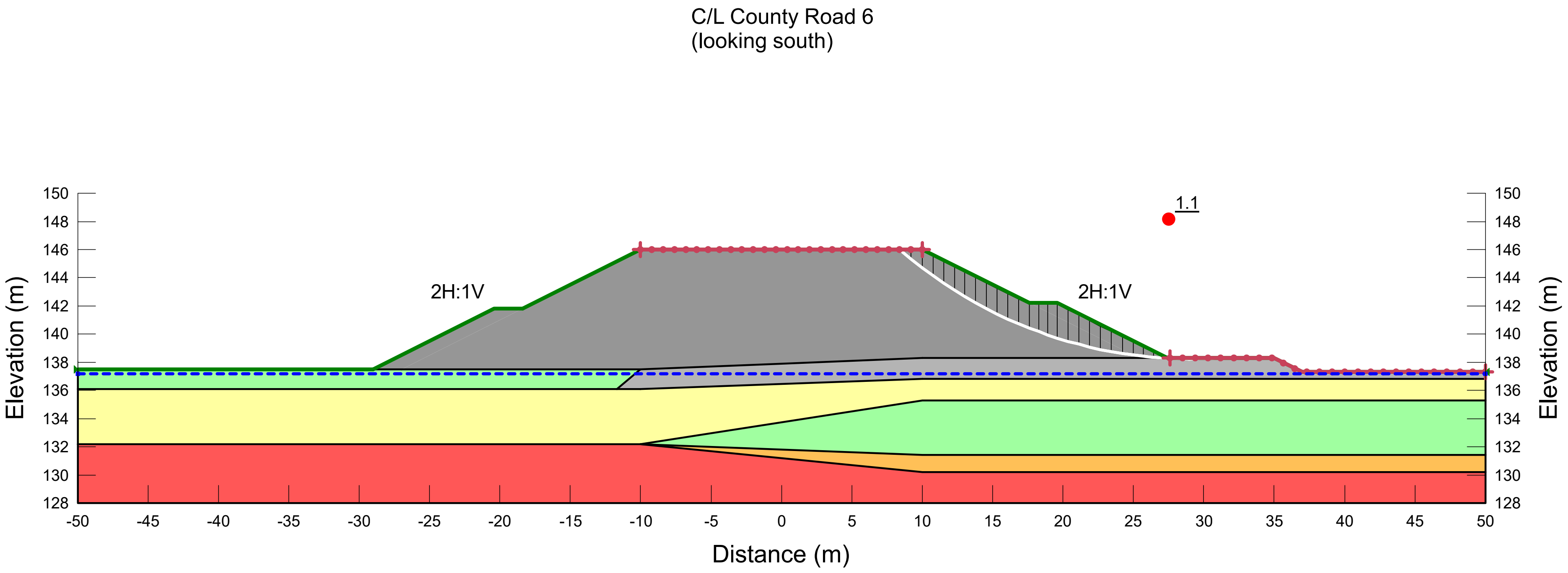
Project	Additional Details
County Road 6	Name: G04. South Approach (2H:1V) Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (10, 146) m, Exit: (29.410885, 138.3) m Center: (28.145056, 163.42537) m, Radius: 25.157238 m

Analysis		
G4.2 Temporary - Static		
Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/08/09, 05:23:20 PM	1:450

THURBER

Figure G4-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G4.3 Temporary - Seismic - 2475yr

Seismic Coefficient
H: 0.15g, V: 0g

Last Run
2022/08/09, 05:23:30 PM

Scale
1:450

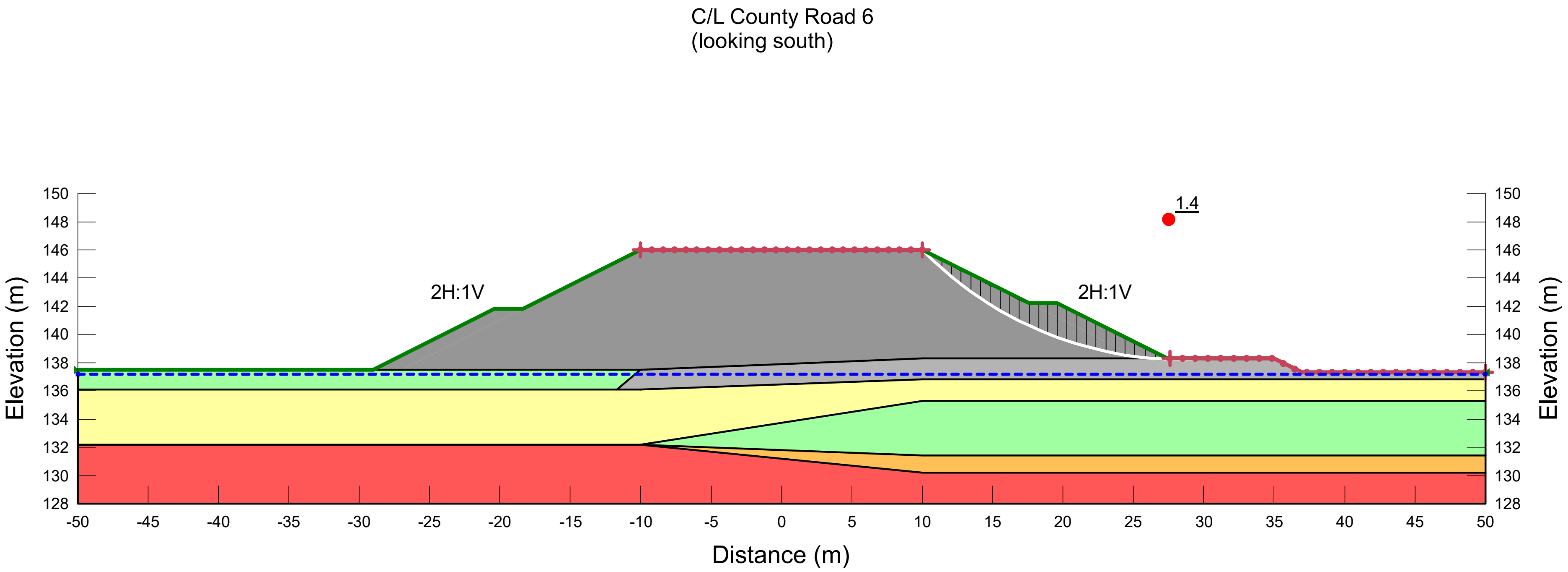
Additional Details
Name: G04. South Approach (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (8.4, 146) m, Exit: (31.221771, 138.3) m
Center: (29.180273, 169.91961) m, Radius: 31.685449 m

Figure G4-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



Project	County Road 6
Analysis	G4.4 Temporary - Seismic - 475yr
Seismic Coefficient	H: 0.07g, V: 0g
Last Run	2022/08/10, 07:51:26 AM
Scale	1:450

Additional Details

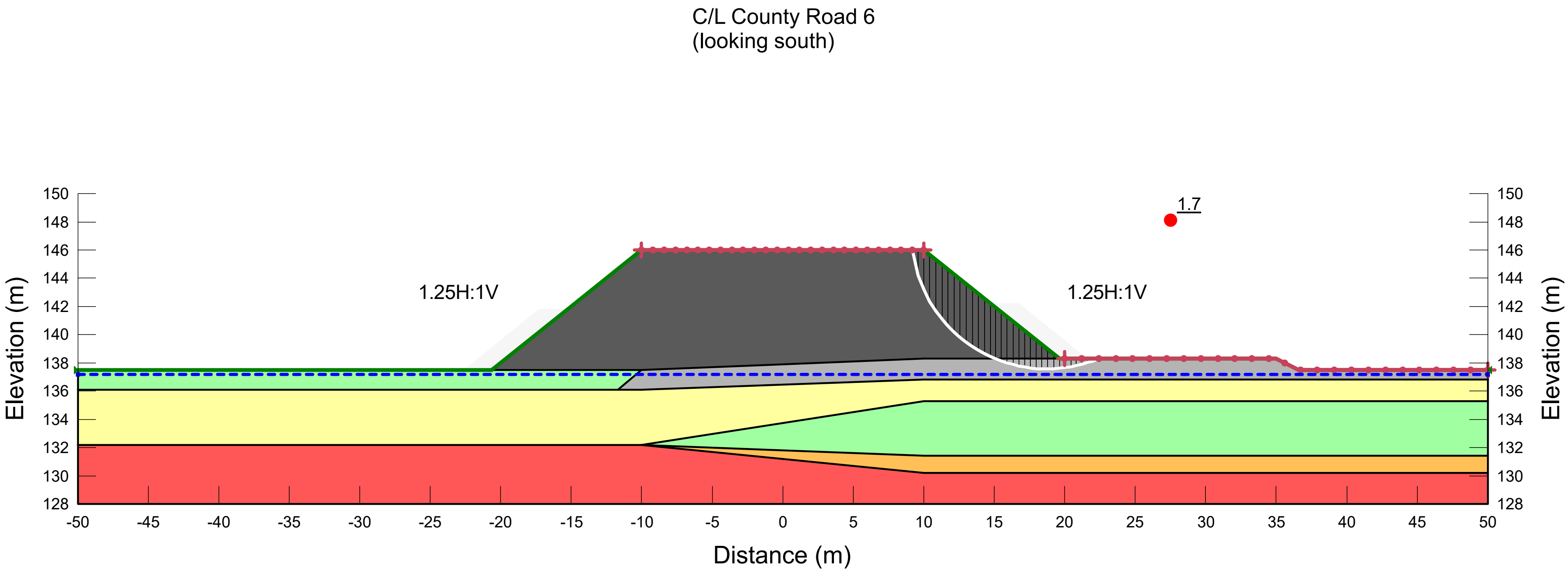
Name: G04. South Approach (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 146) m, Exit: (30.316328, 138.3) m
Center: (28.446018, 164.01737) m, Radius: 25.785292 m

Figure G4-4

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project
County Road 6

Analysis
G5.1 Long Term - Static

Seismic Coefficient
H: 0g, V: 0g

Last Run
2022/08/09, 05:23:40 PM

Scale
1:450

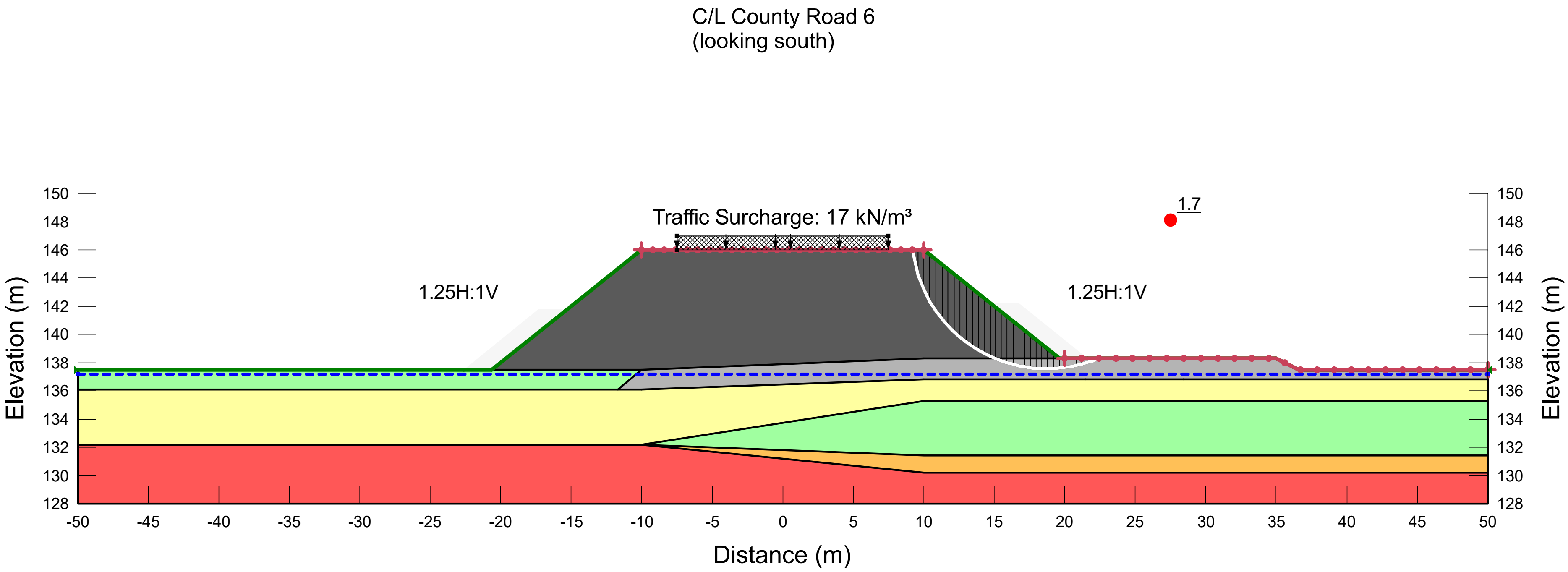
Additional Details
Name: G05. South Approach (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (9.2, 146) m, Exit: (22.415108, 138.3) m
Center: (18.75098, 147.20165) m, Radius: 9.6262755 m

Figure G5-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER	Project County Road 6		
	Analysis G5.2 Temporary - Static		
	Seismic Coefficient H: 0g, V: 0g	Last Run 2022/08/09, 05:23:34 PM	Scale 1:450

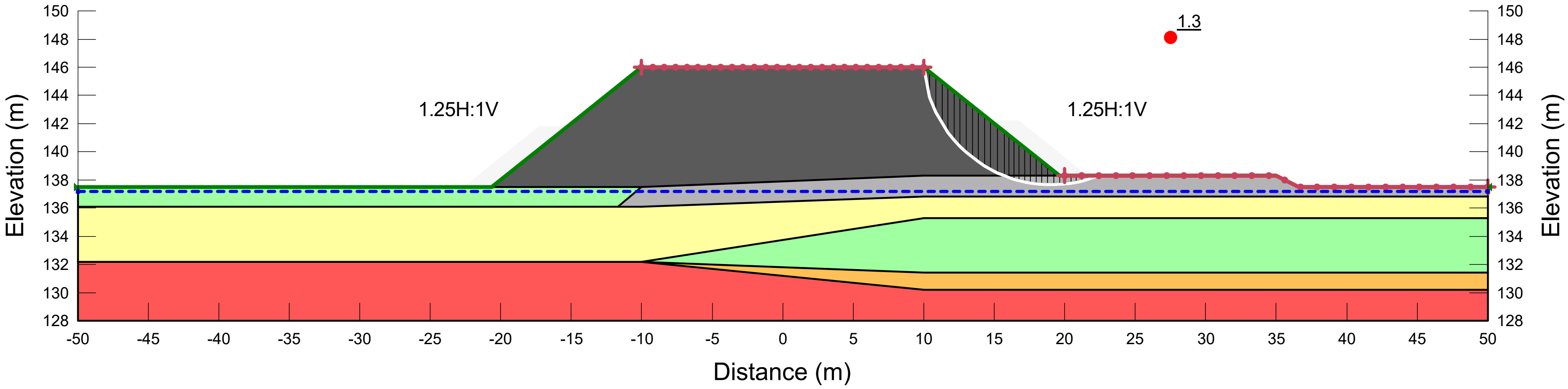
Additional Details

Name: G05. South Approach (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (9.2, 146) m, Exit: (22.415108, 138.3) m
Center: (18.75098, 147.20165) m, Radius: 9.6262755 m

Figure G5-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				

C/L County Road 6
(looking south)



THURBER

Project
County Road 6

Analysis
G5.3 Temporary - Seismic - 2475yr

Seismic Coefficient	Last Run	Scale
H: 0.15g, V: 0g	2022/08/09, 05:23:44 PM	1:450

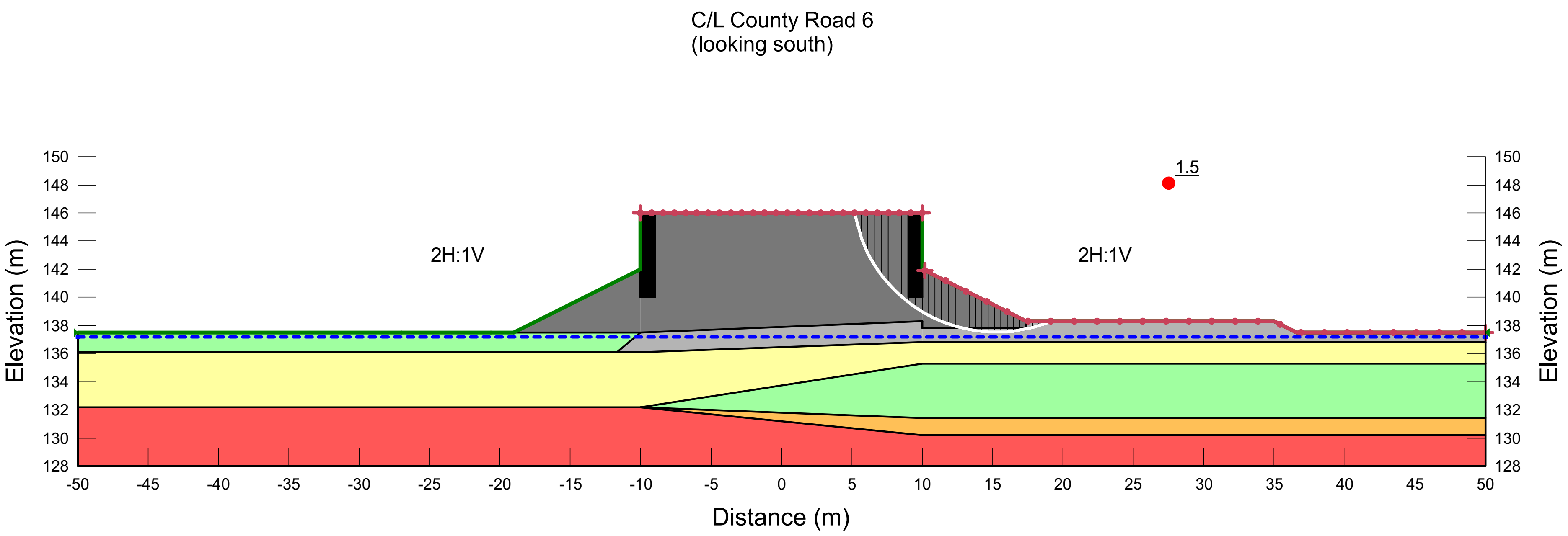
Additional Details
Name: G05. South Approach (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 146) m, Exit: (22.415108, 138.3) m
Center: (19.06025, 146.74955) m, Radius: 9.0912023 m

Figure G5-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1		
▒	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G6.1 Long Term - Static

Seismic Coefficient
H: 0g, V: 0g

Last Run
2022/08/09, 05:23:50 PM

Scale
1:450

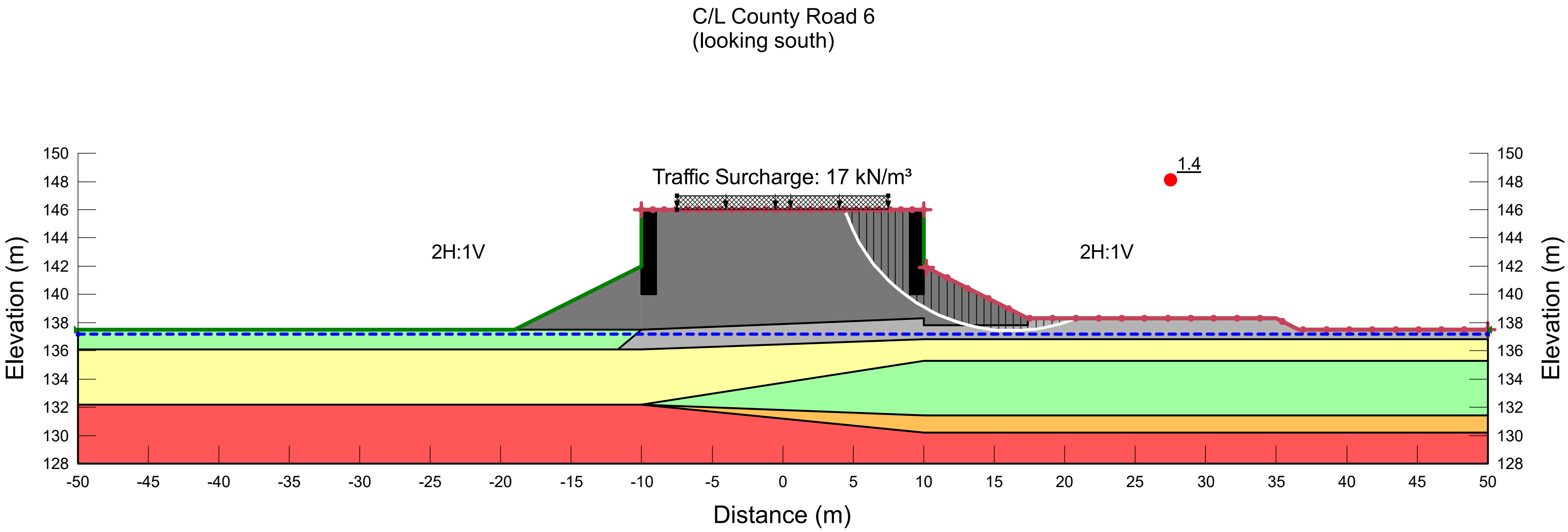
Additional Details
Name: G06. South Approach (Retaining Wall)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (5.2, 146) m, Exit: (19.151443, 138.3) m
Center: (15.251068, 147.72215) m, Radius: 10.197537 m

Figure G6-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1		
▒	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project	County Road 6
Analysis	G6.2 Temporary - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/09, 05:23:46 PM
Scale	1:450

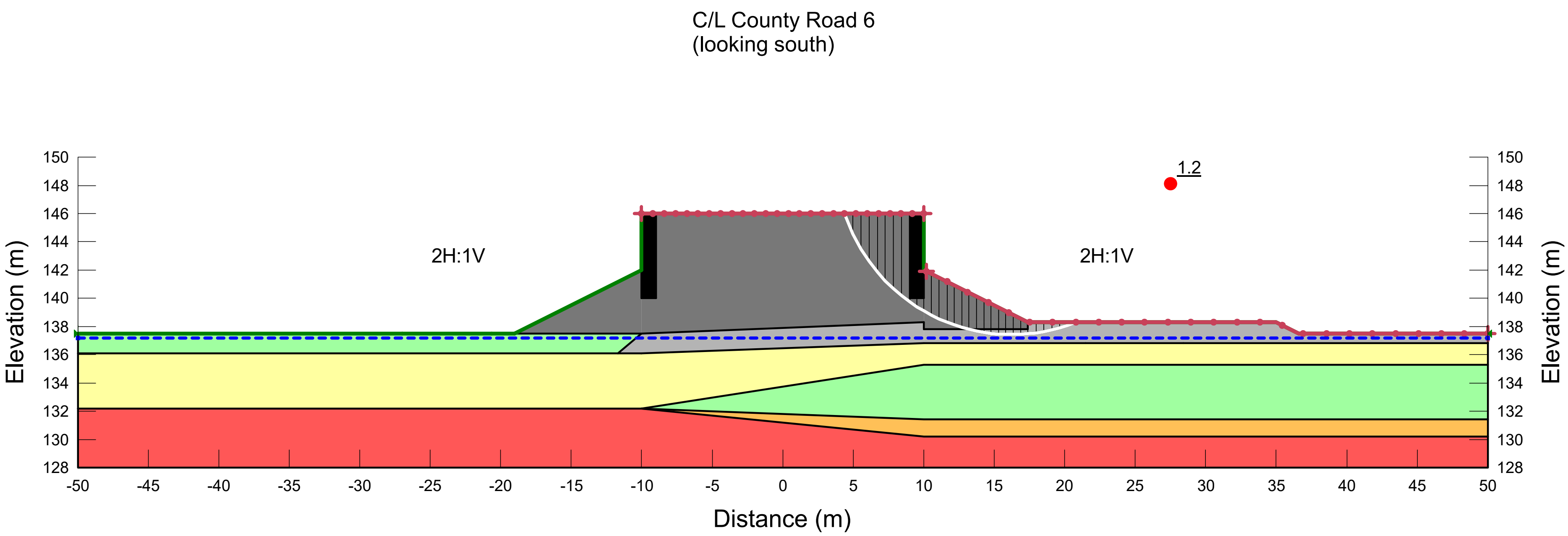
Additional Details
Name: G06. South Approach (Retaining Wall)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (4.4, 146) m, Exit: (20.784991, 138.3) m
Center: (16.219558, 149.8681) m, Radius: 12.436405 m

Figure G6-2

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1		
▒	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



Project	County Road 6
Analysis	G6.3 Temporary - Seismic - 2475yr
Seismic Coefficient	H: 0.15g, V: 0g
Last Run	2022/08/09, 05:23:52 PM
Scale	1:450

Additional Details

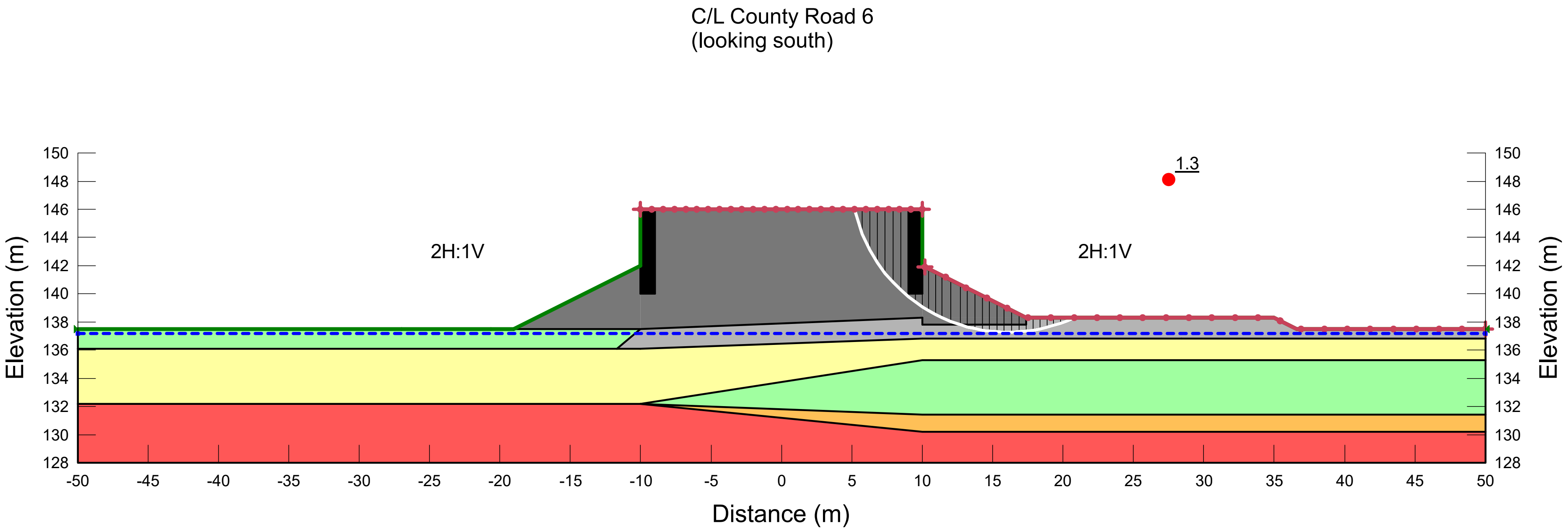
Name: G06. South Approach (Retaining Wall)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (4.4, 146) m, Exit: (20.784991, 138.3) m
Center: (16.219558, 149.8681) m, Radius: 12.436405 m

Figure G6-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1		
▒	00: FILL: Existing	Mohr-Coulomb	20	0	30
▓	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



Project
County Road 6

Analysis
G6.4 Temporary - Seismic - 475yr

Seismic Coefficient
H: 0.07g, V: 0g

Last Run
2022/08/10, 07:51:32 AM

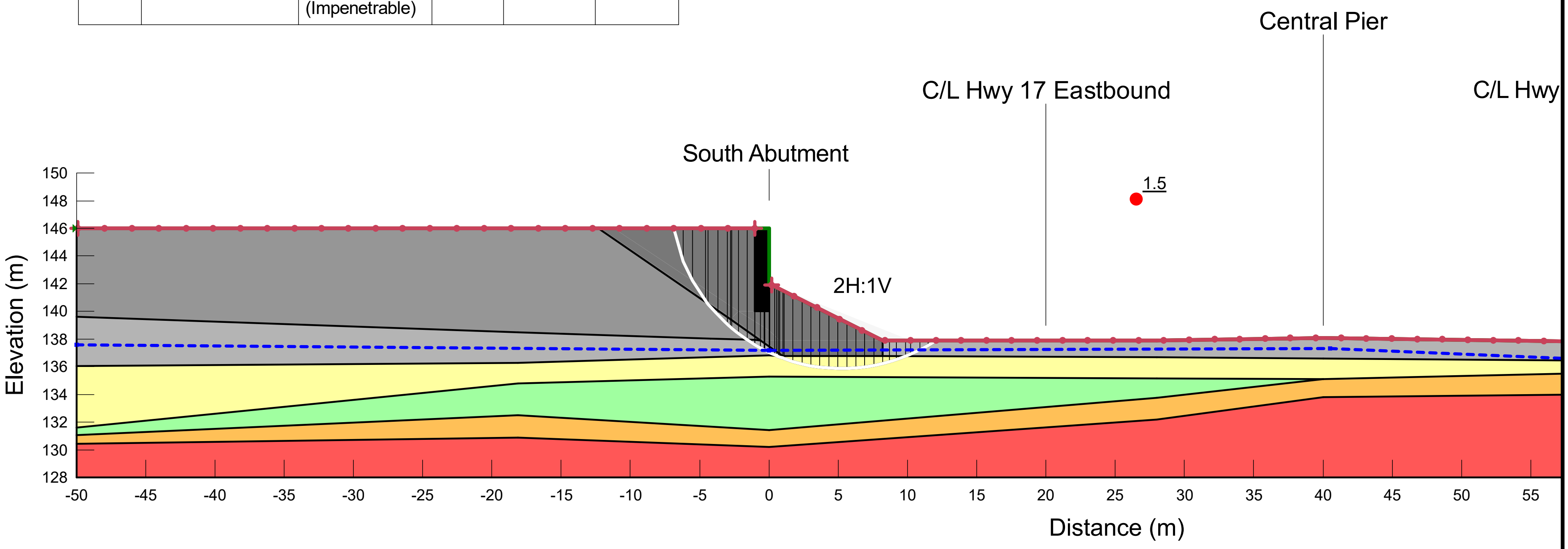
Scale
1:450

Additional Details
Name: G06. South Approach (Retaining Wall)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (5.2, 146) m, Exit: (20.784991, 138.3) m
Center: (16.095177, 148.4299) m, Radius: 11.162854 m

Figure G6-4

THURBER

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1		
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
◼	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
▩	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G7.1 Long Term - Static

Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/08/22, 03:06:04 PM	1:450

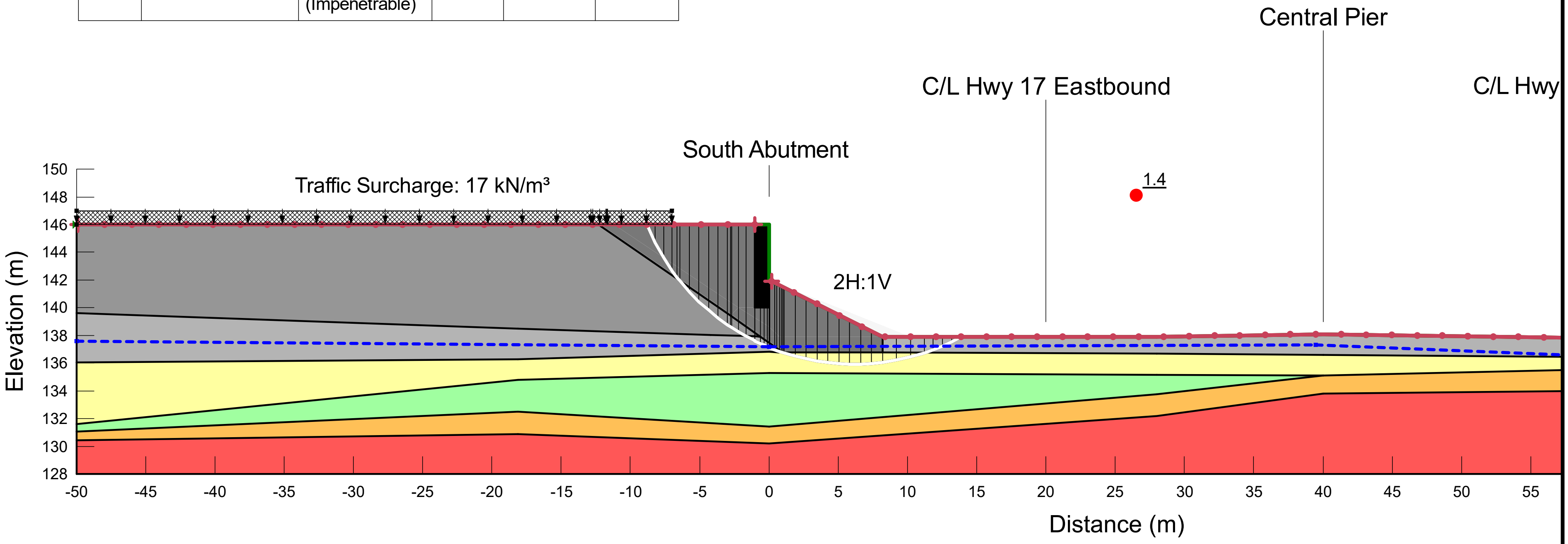
Additional Details
Name: G07. South Approach (Parallel - GBI)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-6.8676004, 146) m, Exit: (12.053116, 137.9) m
Center: (5.2705, 148.20491) m, Radius: 12.336739 m

Figure G7-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1		
▨	00: FILL: Existing	Mohr-Coulomb	20	0	30
▨	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
▨	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



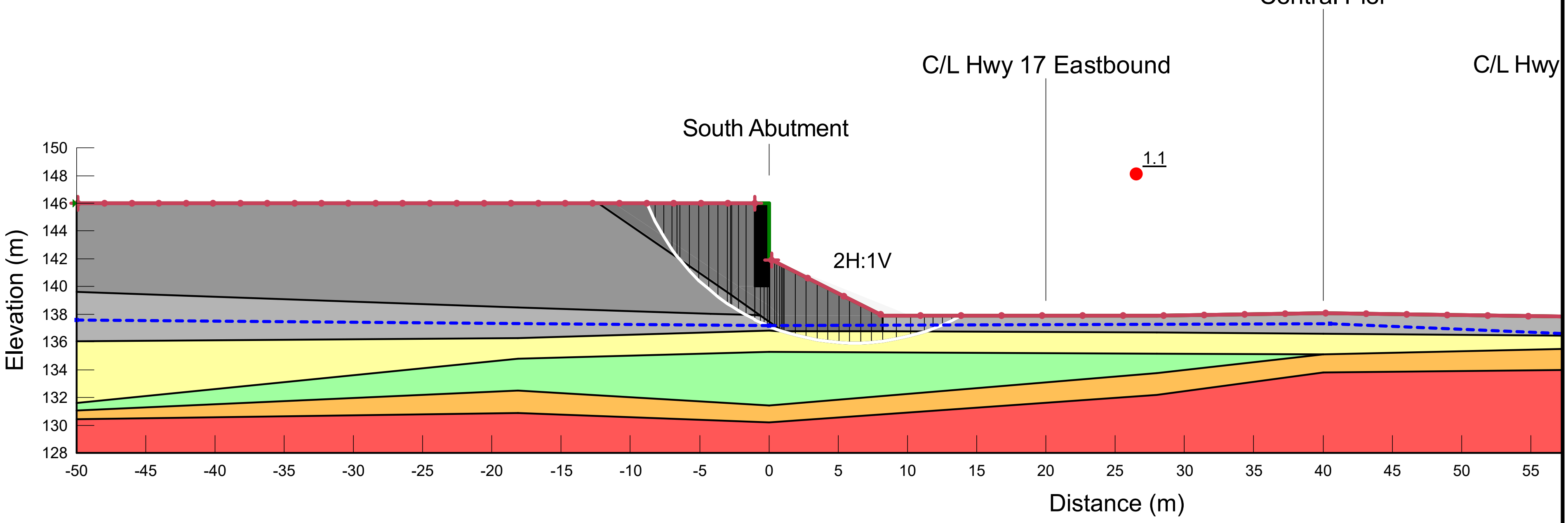
Project	County Road 6
Analysis	G7.2 Temporary - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/22, 02:57:48 PM
Scale	1:450

Additional Details

Name: G07. South Approach (Parallel - GBI)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-8.824, 146) m, Exit: (13.881908, 137.9) m
Center: (6.145862, 152.08891) m, Radius: 16.160805 m

Figure G7-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1		
▩	00: FILL: Existing	Mohr-Coulomb	20	0	30
▩	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
▩	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G7.3 Temporary - Seismic - 2475yr

Seismic Coefficient	Last Run	Scale
H: 0.15g, V: 0g	2022/08/22, 03:06:12 PM	1:450

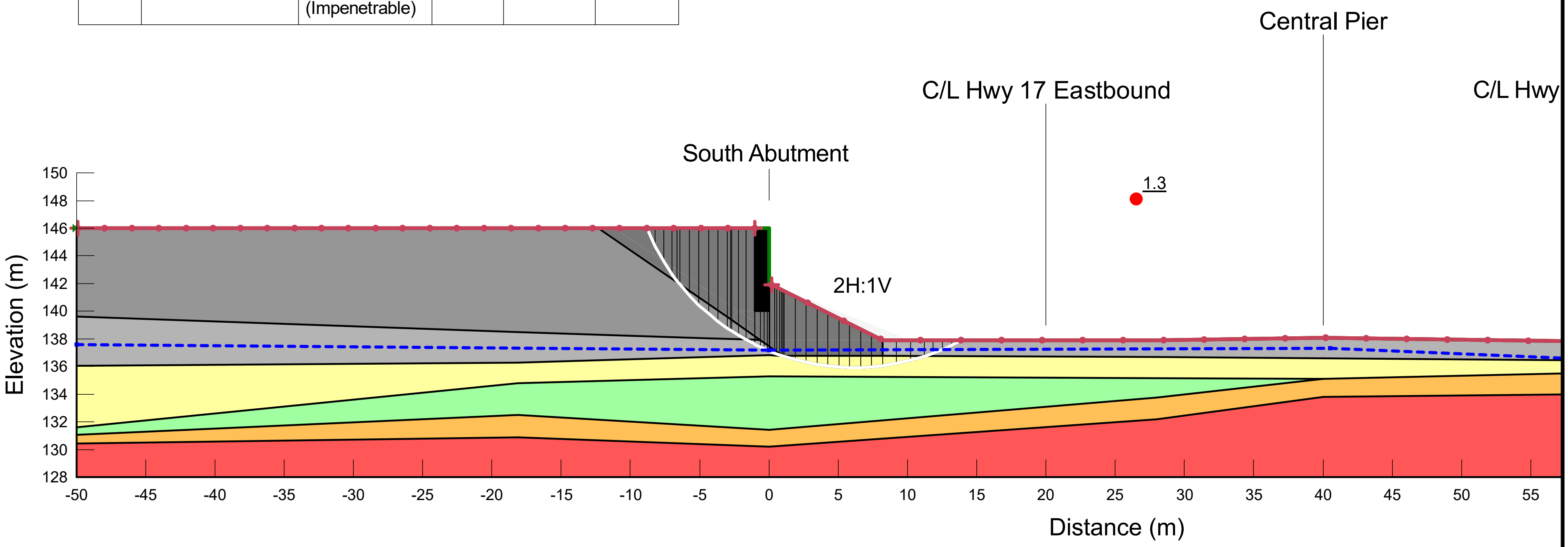
Additional Details
Name: G07. South Approach (Parallel - GBI)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-8.824, 146) m, Exit: (13.881972, 137.9) m
Center: (6.145889, 152.08893) m, Radius: 16.160835 m

Figure G7-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	00: CONCRETE S Abut.	High Strength	1		
▨	00: FILL: Existing	Mohr-Coulomb	20	0	30
▨	00: FILL: Gran. A	Mohr-Coulomb	22.8	0	40
▨	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G7.4 Temporary - Seismic - 475yr

Seismic Coefficient
H: 0.07g, V: 0g

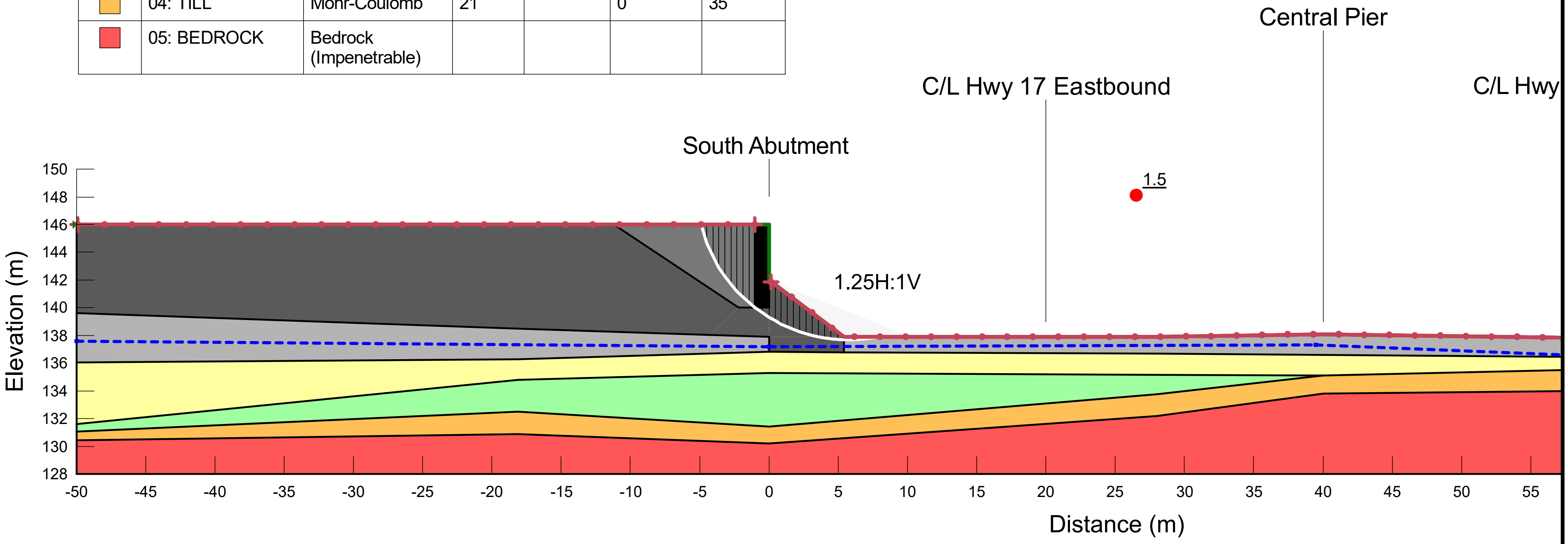
Last Run
2022/08/22, 03:06:30 PM

Scale
1:450

Additional Details
Name: G07. South Approach (Parallel - GBI)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-8.824, 146) m, Exit: (13.881972, 137.9) m
Center: (6.145889, 152.08893) m, Radius: 16.160835 m

Figure G7-4

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1			
■	00: FILL: Existing	Mohr-Coulomb	20		0	30
■	00: FILL: Gran. A	Mohr-Coulomb	22.8		0	40
■	01: FILL: Rock Fill	Mohr-Coulomb	20		0	42
■	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project	County Road 6
Analysis	G8.1 Long Term - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/10, 08:08:28 AM
Scale	1:450

Additional Details

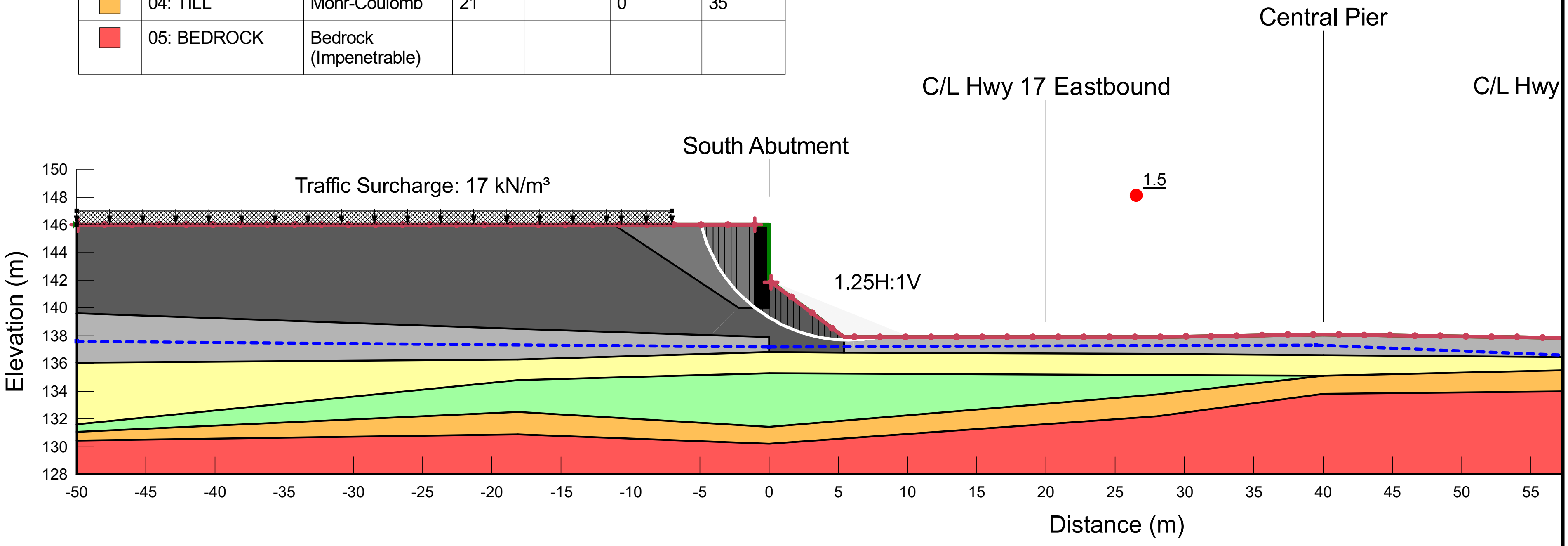
Name: G08. South Approach (Parallel -Rockfill)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-4.9117336, 146) m, Exit: (8.0267246, 137.9) m
Center: (5.7884064, 148.70821) m, Radius: 11.037544 m

Figure G8-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1			
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	00: FILL: Gran. A	Mohr-Coulomb	22.8		0	40
⬛	01: FILL: Rock Fill	Mohr-Coulomb	20		0	42
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project
County Road 6

Analysis
G8.2 Temporary - Static

Seismic Coefficient
H: 0g, V: 0g

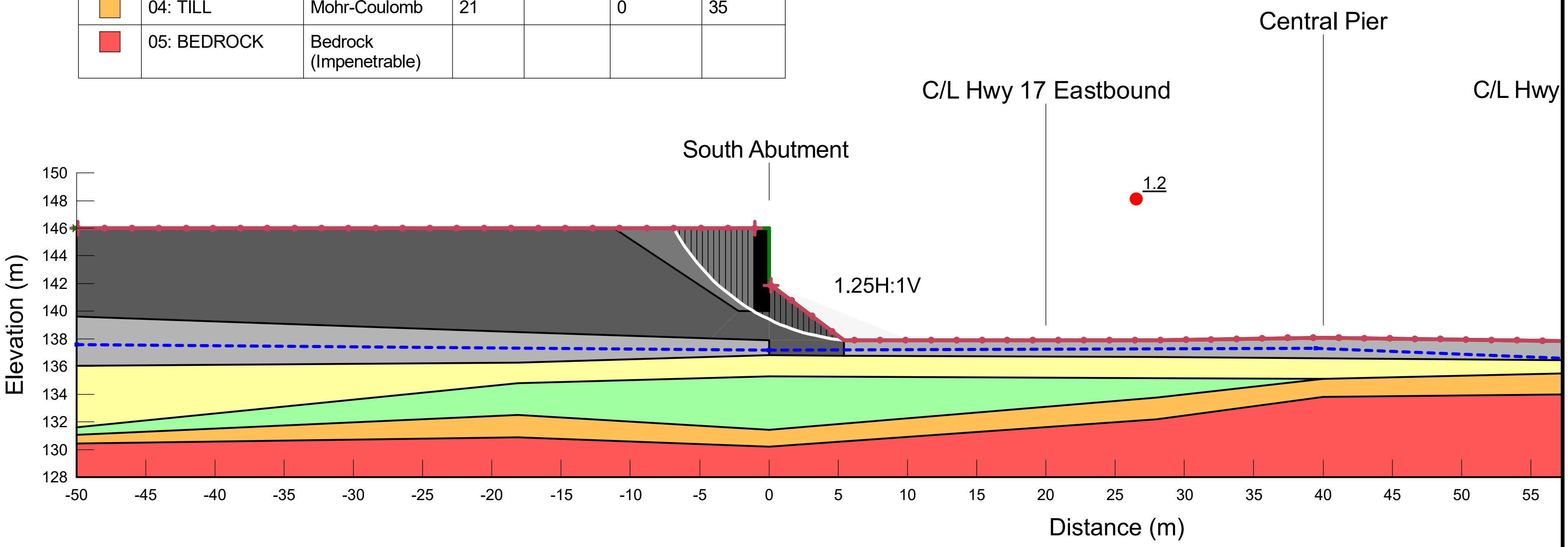
Last Run
2022/08/10, 08:08:20 AM

Scale
1:450

Additional Details
Name: G08. South Approach (Parallel -Rockfill)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-4.912, 146) m, Exit: (8.0277116, 137.9) m
Center: (5.7884656, 148.70838) m, Radius: 11.037902 m

Figure G8-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1			
▨	00: FILL: Existing	Mohr-Coulomb	20		0	30
▨	00: FILL: Gran. A	Mohr-Coulomb	22.8		0	40
▨	01: FILL: Rock Fill	Mohr-Coulomb	20		0	42
▨	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project
County Road 6

Analysis
G8.3 Temporary - Seismic - 2475yr

Seismic Coefficient
H: 0.15g, V: 0g

Last Run
2022/08/10, 08:08:36 AM

Scale
1:450

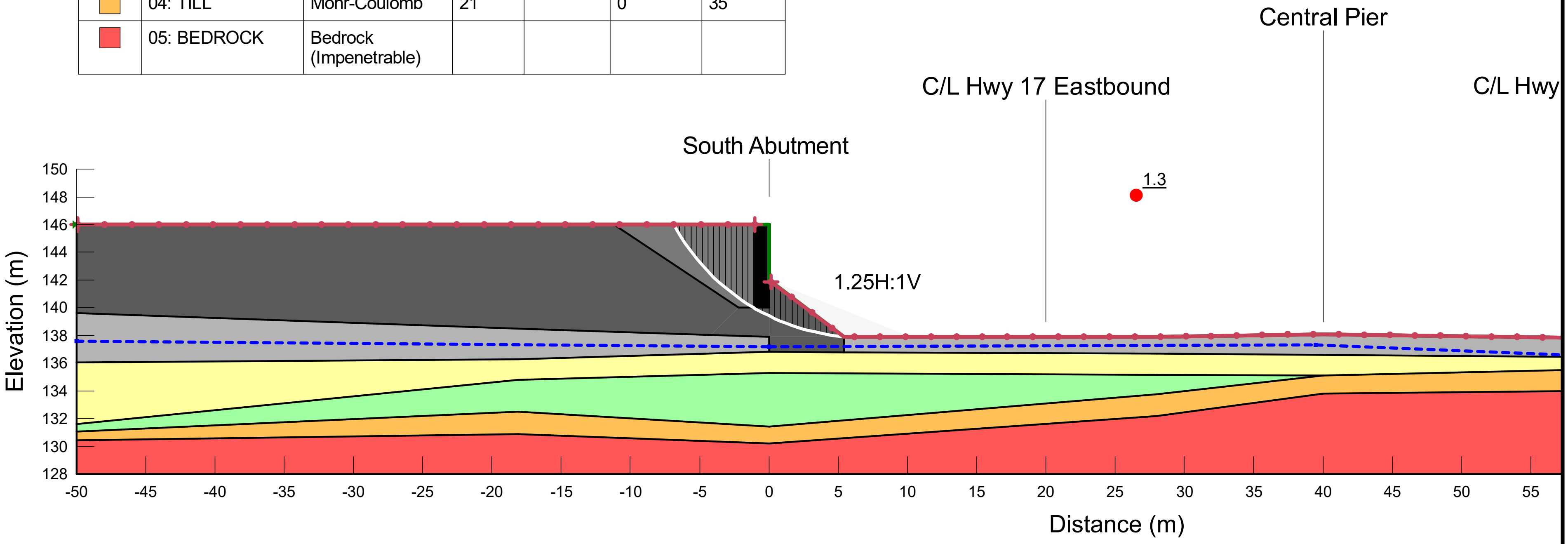
Additional Details
Name: G08. South Approach (Parallel -Rockfill)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-6.868, 146) m, Exit: (5.4096376, 137.91208) m
Center: (6.7906347, 153.37128) m, Radius: 15.520762 m

Figure G8-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: CONCRETE S Abut.	High Strength	1			
▨	00: FILL: Existing	Mohr-Coulomb	20		0	30
▩	00: FILL: Gran. A	Mohr-Coulomb	22.8		0	40
■	01: FILL: Rock Fill	Mohr-Coulomb	20		0	42
■	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project
County Road 6

Analysis
G8.4 Temporary - Seismic - 475yr

Seismic Coefficient
H: 0.07g, V: 0g

Last Run
2022/08/10, 08:08:44 AM

Scale
1:450

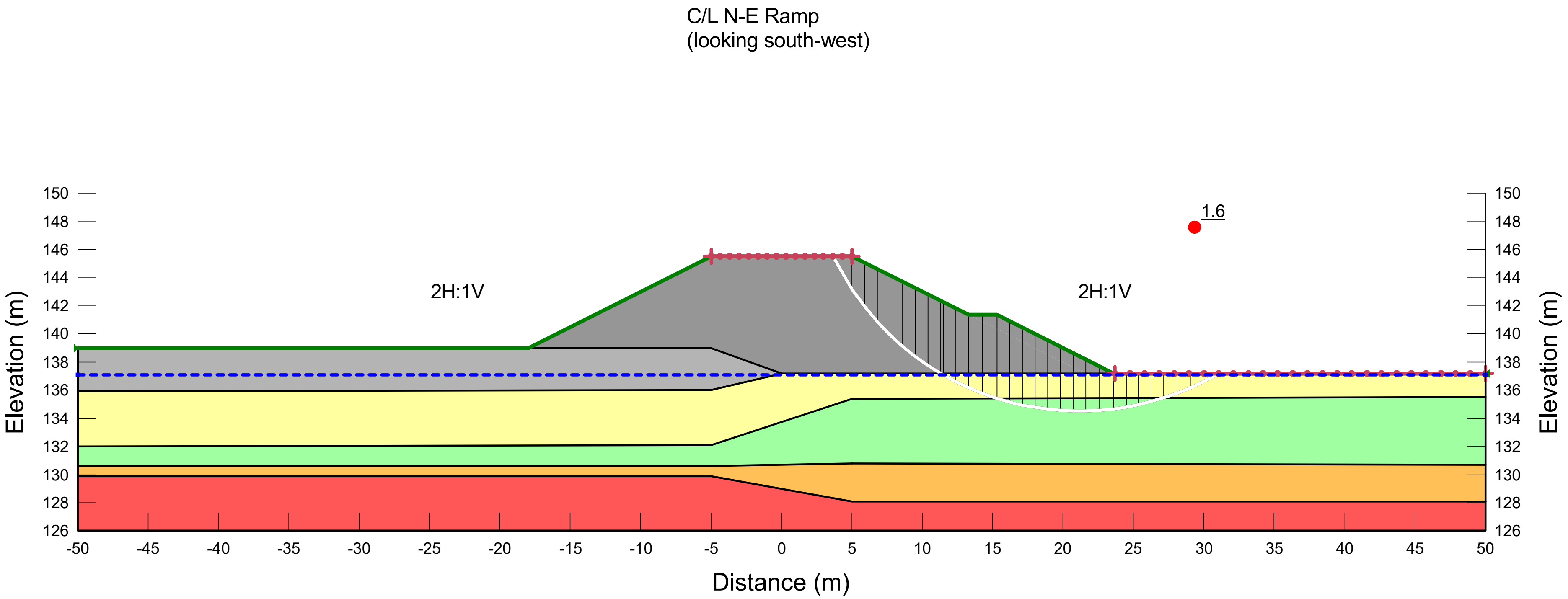
Additional Details
Name: G08. South Approach (Parallel -Rockfill)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (-6.868, 146) m, Exit: (5.4096376, 137.91208) m
Center: (6.7906347, 153.37128) m, Radius: 15.520762 m

Figure G8-4

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



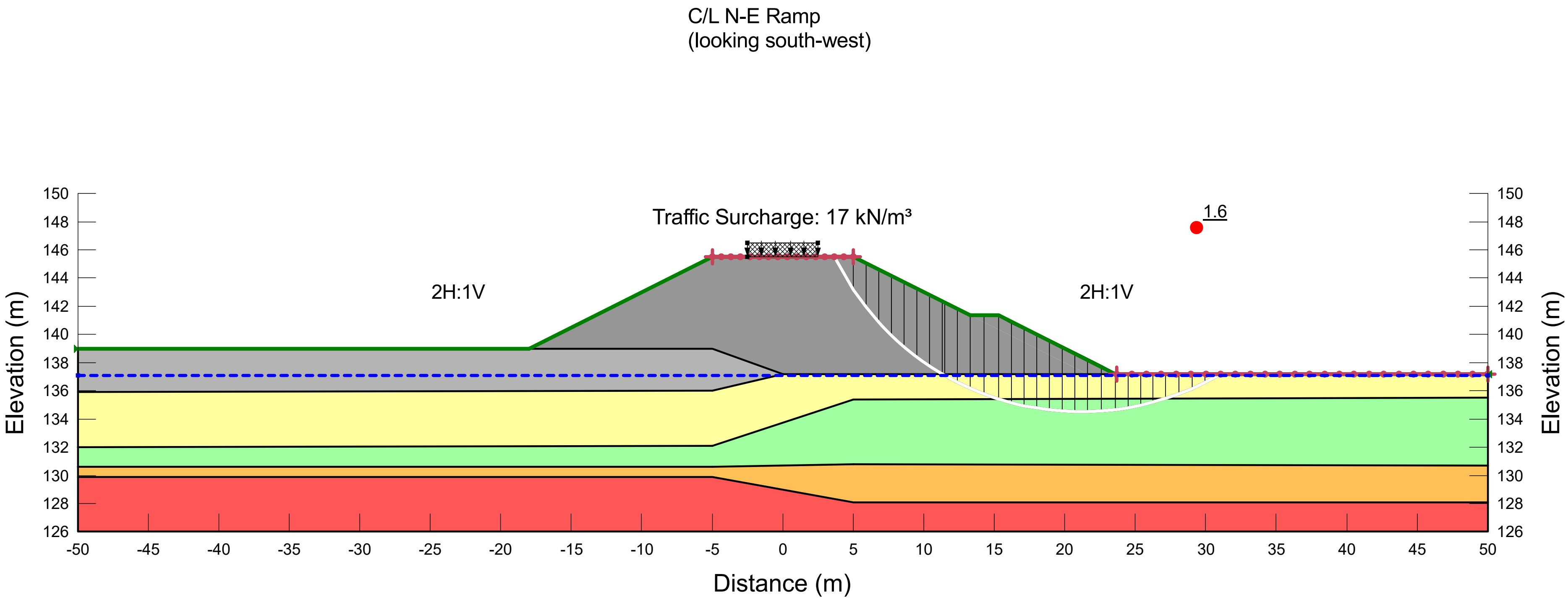
Project	County Road 6
Analysis	G9.1 Long Term - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/09, 05:24:52 PM
Scale	1:450

Additional Details

Name: G09. N-E Ramp (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (3.6666667, 145.5) m, Exit: (31.064, 137.2) m
Center: (21.197276, 153.9988) m, Radius: 19.482089 m

Figure G9-1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
◼	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G9.2 Temporary - Static

Seismic Coefficient
H: 0g, V: 0g

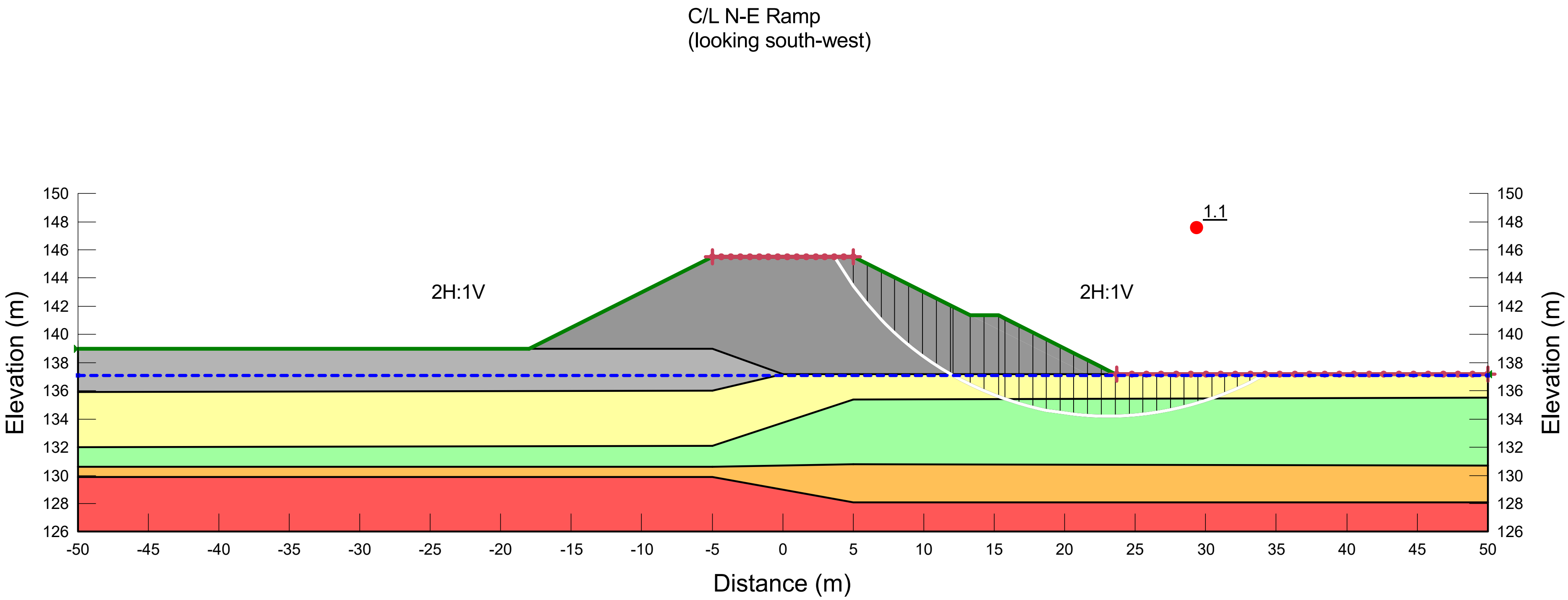
Last Run
2022/08/09, 05:24:50 PM

Scale
1:450

Additional Details
Name: G09. N-E Ramp (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (3.6666667, 145.5) m, Exit: (31.064, 137.2) m
Center: (21.197276, 153.9988) m, Radius: 19.482089 m

Figure G9-2

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project	Additional Details
County Road 6	Name: G09. N-E Ramp (2H:1V) Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (3.6666667, 145.5) m, Exit: (34.22, 137.2) m Center: (23.058294, 156.49768) m, Radius: 22.293143 m

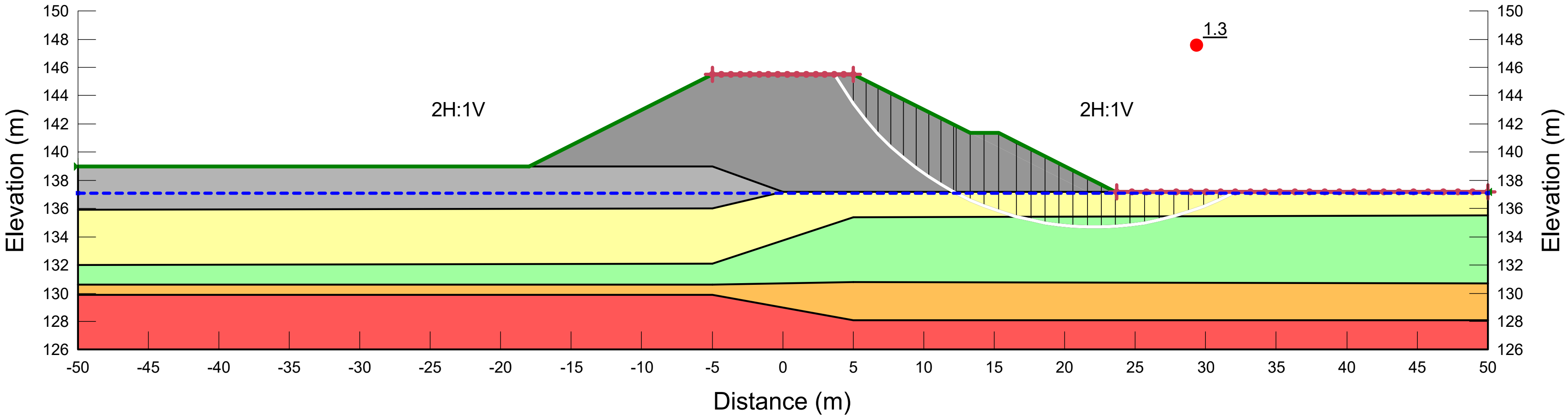
Analysis
G9.3 Temporary - Seismic - 2475-yr

Seismic Coefficient	Last Run	Scale
H: 0.15g, V: 0g	2022/08/09, 05:24:56 PM	1:450

Figure G9-3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20	0	30
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19	0	30
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			

C/L N-E Ramp
(looking south-west)



THURBER

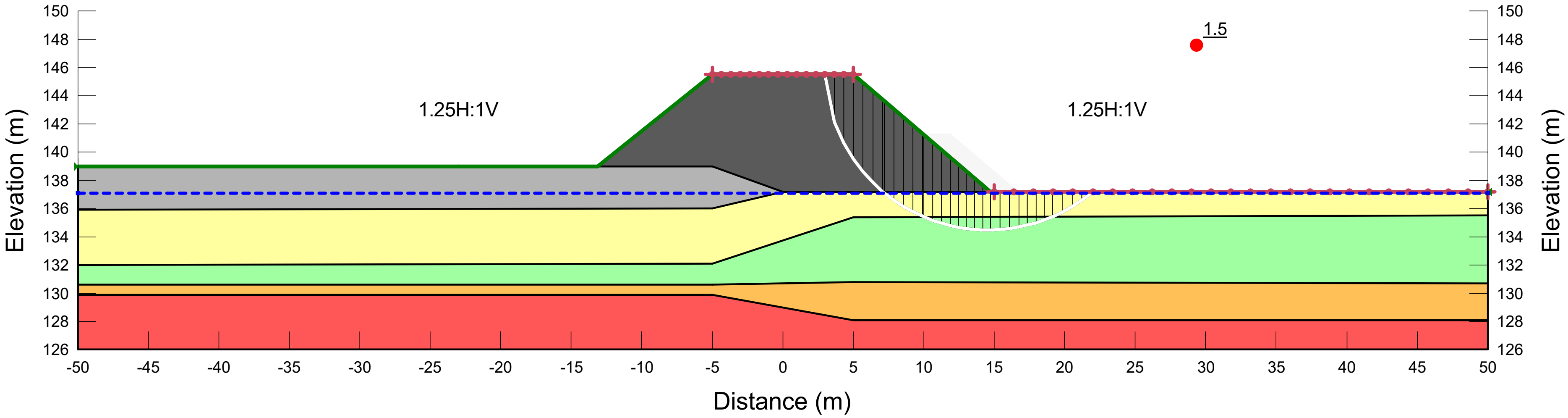
Project	Additional Details
County Road 6	Name: G09. N-E Ramp (2H:1V) Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (3.6666667, 145.5) m, Exit: (32.116, 137.2) m Center: (22.120085, 155.8446) m, Radius: 21.155126 m

Analysis		
G9.4 Temporary - Seismic - 475yr		
Seismic Coefficient	Last Run	Scale
H: 0.07g, V: 0g	2022/08/10, 07:51:50 AM	1:450

Figure G9-4

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				

C/L N-E Ramp
(looking south-west)



Project	County Road 6
Analysis	G10.1 Long Term - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/09, 05:25:00 PM
Scale	1:450

THURBER

Additional Details

Name: G10. N-E Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (3, 145.5) m, Exit: (22, 137.2) m
Center: (14.547674, 146.03745) m, Radius: 11.560174 m

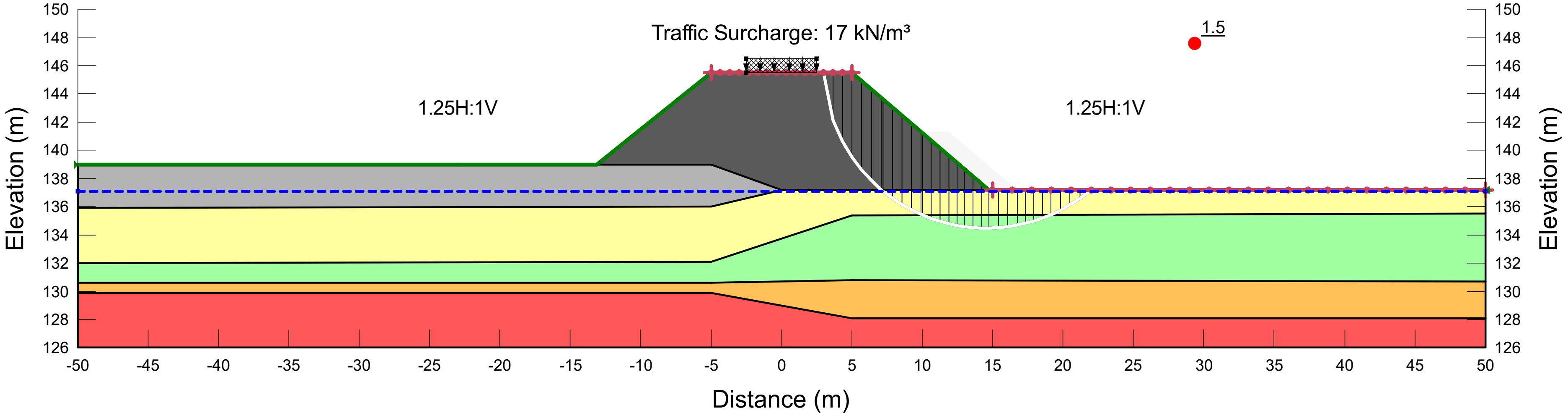
Figure G10-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				

C/L N-E Ramp
(looking south-west)



THURBER

Project
County Road 6

Analysis
G10.2 Temporary - Static

Seismic Coefficient	Last Run	Scale
H: 0g, V: 0g	2022/08/09, 05:24:58 PM	1:450

Additional Details
Name: G10. N-E Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (3, 145.5) m, Exit: (21.997952, 137.2) m
Center: (14.546849, 146.0374) m, Radius: 11.559348 m

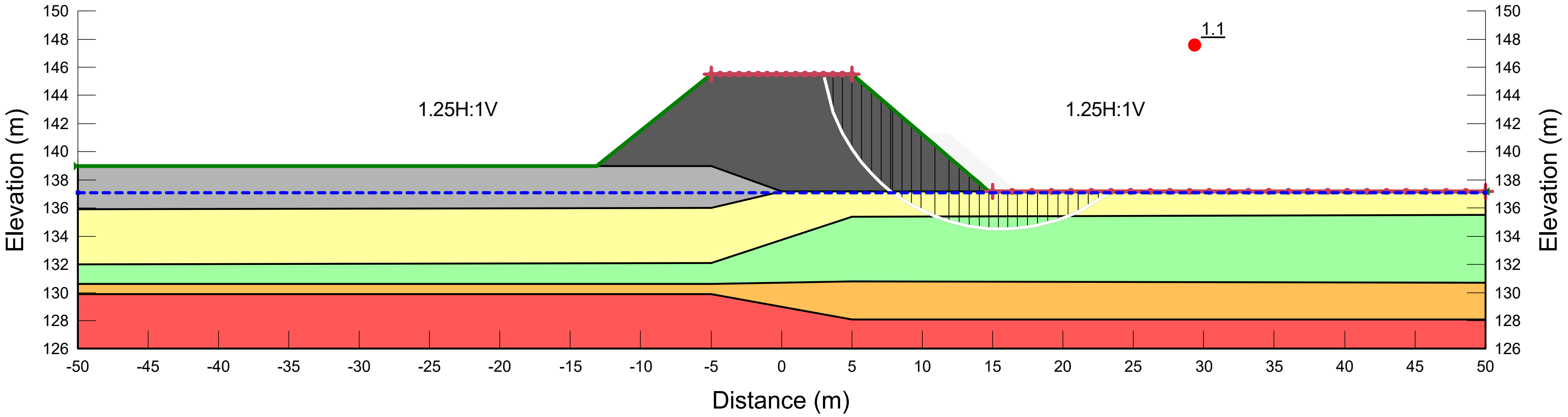
Figure G10-2

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				

C/L N-E Ramp
(looking south-west)



Project	County Road 6
Analysis	G10.3 Temporary - Seismic - 2475yr
Seismic Coefficient	H: 0.15g, V: 0g
Last Run	2022/08/09, 05:25:04 PM
Scale	1:450

THURBER

Additional Details

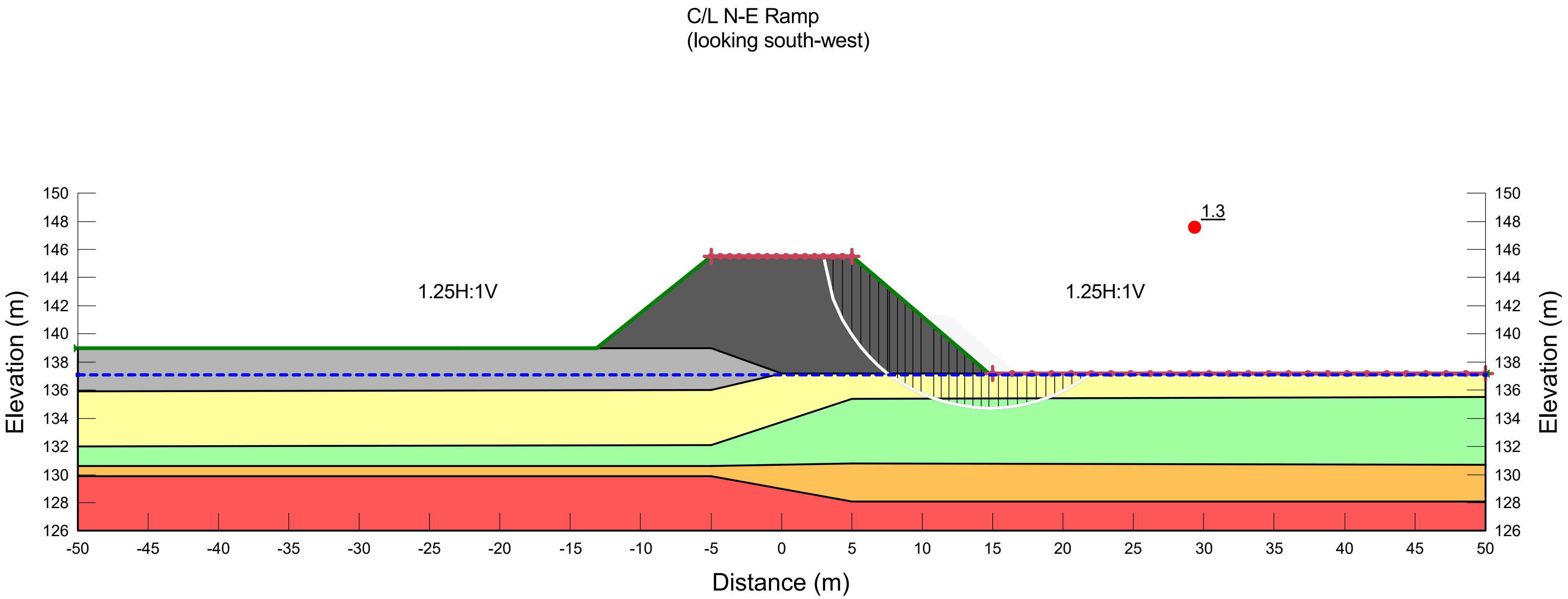
Name: G10. N-E Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (3, 145.5) m, Exit: (23.4, 137.2) m
Center: (15.586024, 147.21444) m, Radius: 12.702257 m

Figure G10-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Strength Function	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬜	00: FILL: Existing	Mohr-Coulomb	20		0	30
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20	AASHTO [D]		
🟩	02: Clayey SILT	Mohr-Coulomb	17		0	28
🟨	03: Silty SAND to SAND (ESA)	Mohr-Coulomb	19		0	30
🟧	04: TILL	Mohr-Coulomb	21		0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)				



Project	County Road 6
Analysis	G10.4 Temporary - Seismic - 475yr
Seismic Coefficient	H: 0.07g, V: 0g
Last Run	2022/08/10, 07:51:52 AM
Scale	1:450

Additional Details
Name: G10. N-E Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (3, 145.5) m, Exit: (22, 137.2) m
Center: (14.774741, 146.55724) m, Radius: 11.82211 m

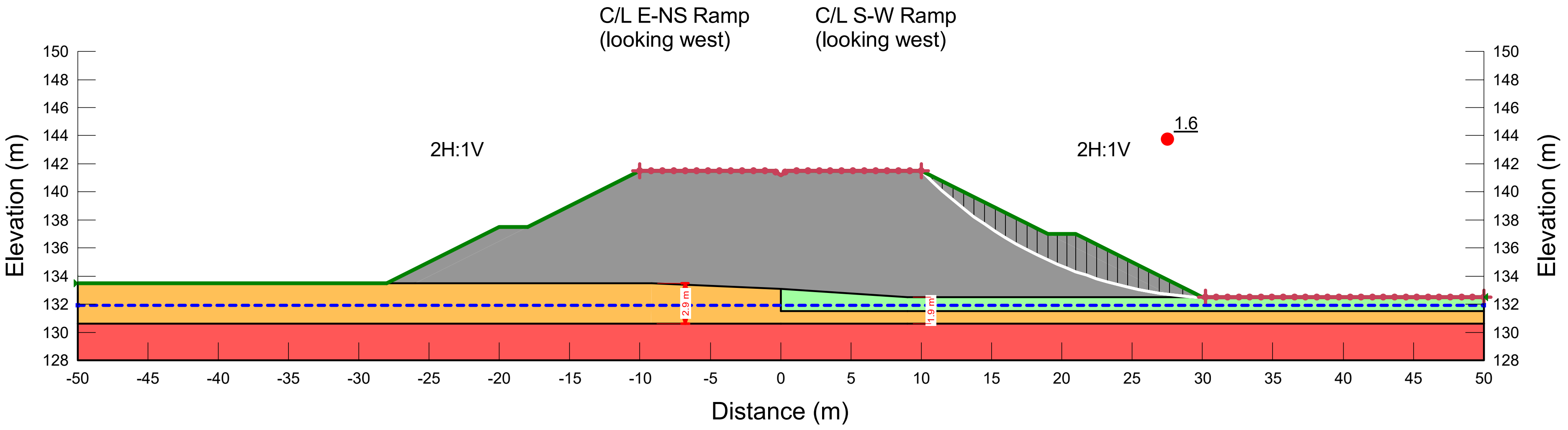
Figure G10-4

THURBER

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



Project	Additional Details
County Road 6	Name: G11. E-NS & SW Ramp (2H:1V) Method: Morgenstern-Price, Half-Sine Minimum Slip Surface Depth: 1.52 m Entry: (10, 141.5) m, Exit: (33.368, 132.5) m Center: (31.432491, 162.31142) m, Radius: 29.874181 m

Analysis		
G11.1 Long Term - Static		
Seismic Coefficient	**Last Run**	**Scale**
H: 0g, V: 0g	2022/08/09, 05:25:12 PM	1:450

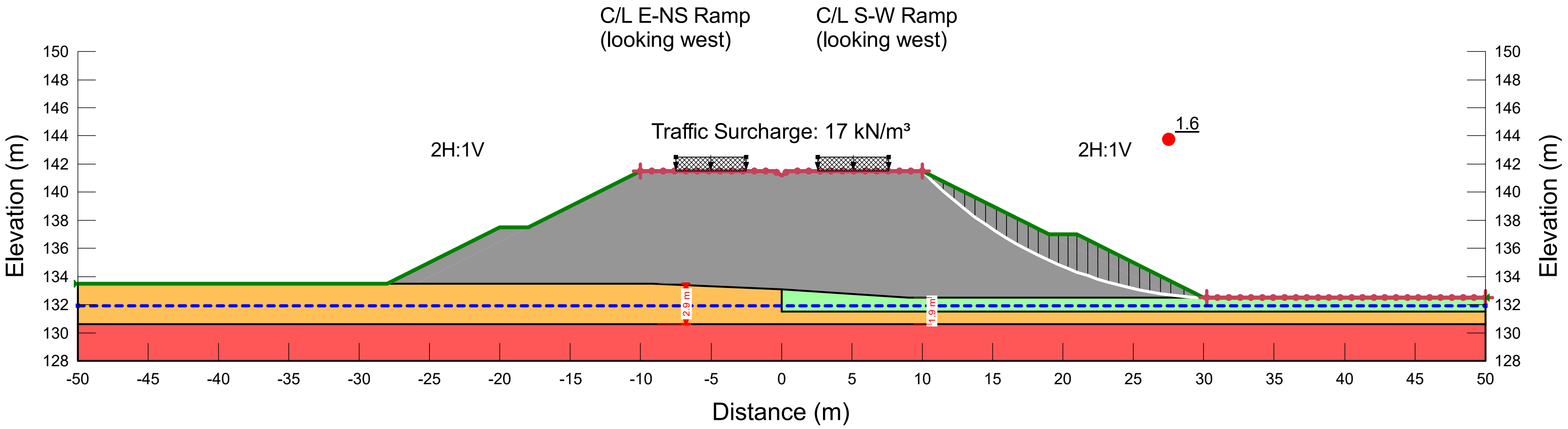
THURBER

Figure G11-1

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
⬛	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

Analysis
G11.2 Temporary - Static

Seismic Coefficient
H: 0g, V: 0g

Last Run
2022/08/09, 05:25:08 PM

Scale
1:450

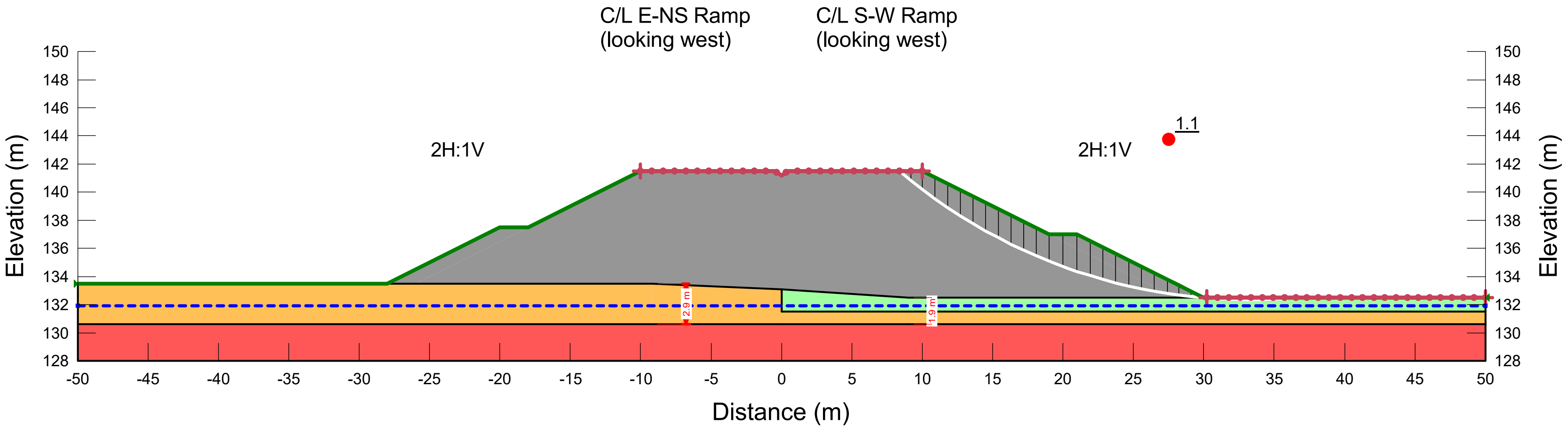
Additional Details
Name: G11. E-NS & SW Ramp (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 141.5) m, Exit: (33.368, 132.5) m
Center: (31.432491, 162.31142) m, Radius: 29.874181 m

Figure G11-2

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
◼	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project County Road 6		
Analysis G11.3 Temporary - Seismic - 2475yr		
Seismic Coefficient H: 0.13g, V: 0g	Last Run 2022/08/09, 05:25:16 PM	Scale 1:450

Additional Details

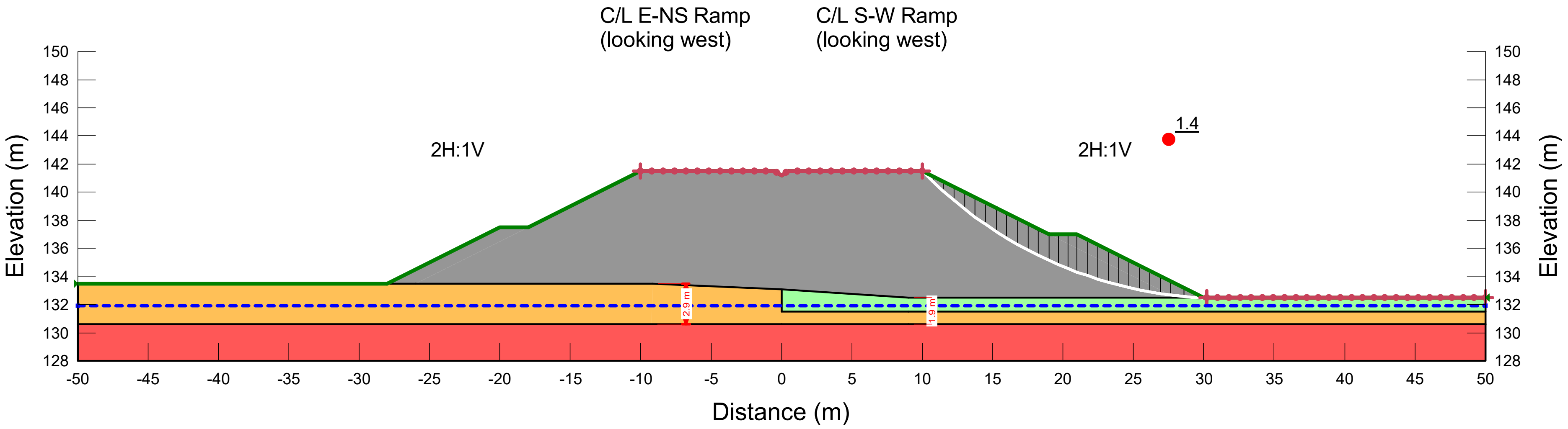
Name: G11. E-NS & SW Ramp (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (8.3867048, 141.5) m, Exit: (36.536, 132.5) m
Center: (33.215329, 170.63521) m, Radius: 38.279509 m

Figure G11-3

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
■	00: FILL: Gran. BI	Mohr-Coulomb	21	0	32
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28
🟧	04: TILL	Mohr-Coulomb	21	0	35
🟥	05: BEDROCK	Bedrock (Impenetrable)			



THURBER

Project
County Road 6

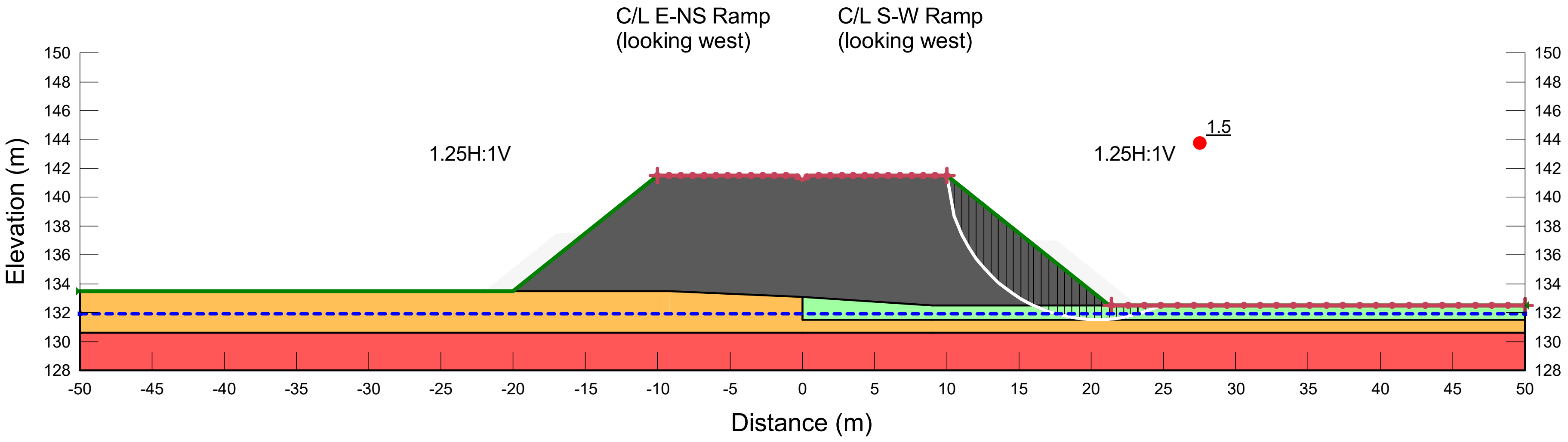
Analysis
G11.4 Temporary - Seismic - 475yr

Seismic Coefficient	Last Run	Scale
H: 0.05g, V: 0g	2022/08/10, 07:51:56 AM	1:450

Additional Details
Name: G11. E-NS & SW Ramp (2H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 141.5) m, Exit: (33.368, 132.5) m
Center: (31.432491, 162.31142) m, Radius: 29.874181 m

Figure G11-4

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20			AASHTO [D]
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28	
🟧	04: TILL	Mohr-Coulomb	21	0	35	
🟥	05: BEDROCK	Bedrock (Impenetrable)				



THURBER

Project
County Road 6

Analysis
G12.1 Long Term - Static

Seismic Coefficient
H: 0g, V: 0g

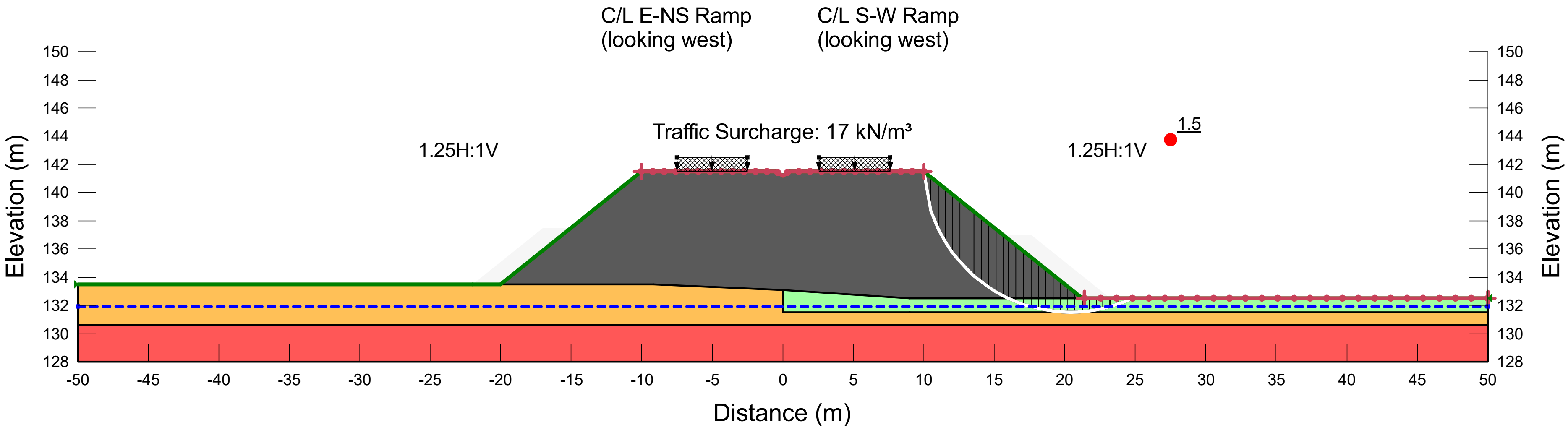
Last Run
2022/08/09, 05:25:24 PM

Scale
1:450

Additional Details
Name: G12. E-NS & SW Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 141.5) m, Exit: (24.832, 132.5) m
Center: (20.420284, 141.95106) m, Radius: 10.430042 m

Figure G12-1

Color	Name	Slope Stability Material Model	Unit Weight (kN/m^3)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20			AASHTO [D]
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28	
🟧	04: TILL	Mohr-Coulomb	21	0	35	
🟥	05: BEDROCK	Bedrock (Impenetrable)				



Project	County Road 6
Analysis	G12.2 Temporary - Static
Seismic Coefficient	H: 0g, V: 0g
Last Run	2022/08/09, 05:25:20 PM
Scale	1:450

Additional Details

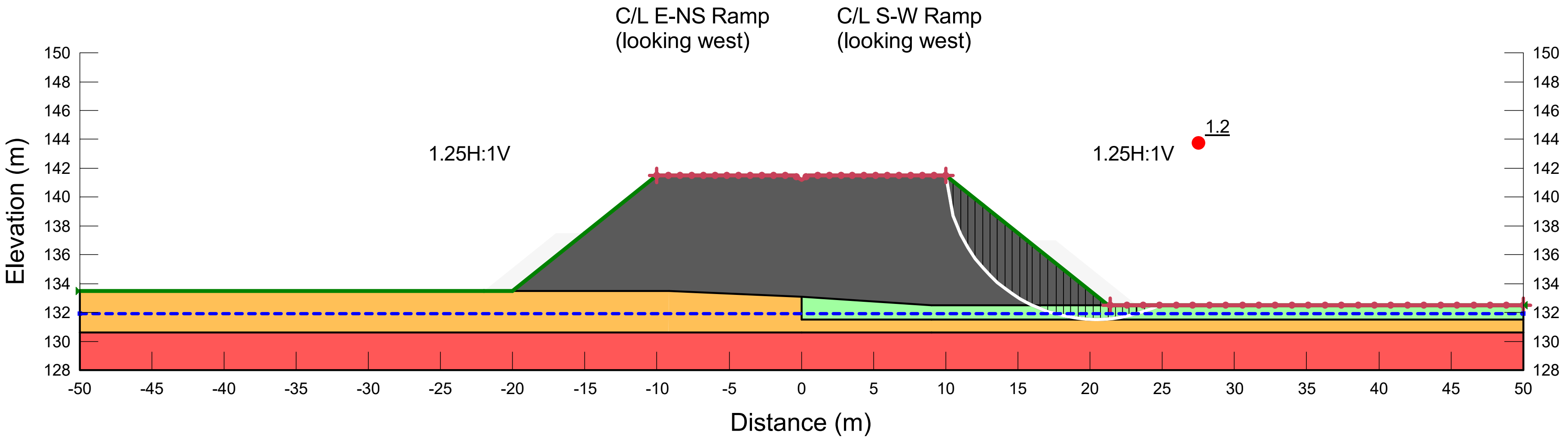
Name: G12. E-NS & SW Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 141.5) m, Exit: (24.832, 132.5) m
Center: (20.420284, 141.95106) m, Radius: 10.430042 m

Figure G12-2

H:\Projects\20001 to 30000\24726 - Hwy 17 Arnprior to Haley Station\PART 1B\Foundations\County Road 6\Analysis\Slope Stability\CR6_004.gsz

Tool Version: 11.3.1.23726

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20			AASHTO [D]
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28	
🟧	04: TILL	Mohr-Coulomb	21	0	35	
🟥	05: BEDROCK	Bedrock (Impenetrable)				



Project
County Road 6

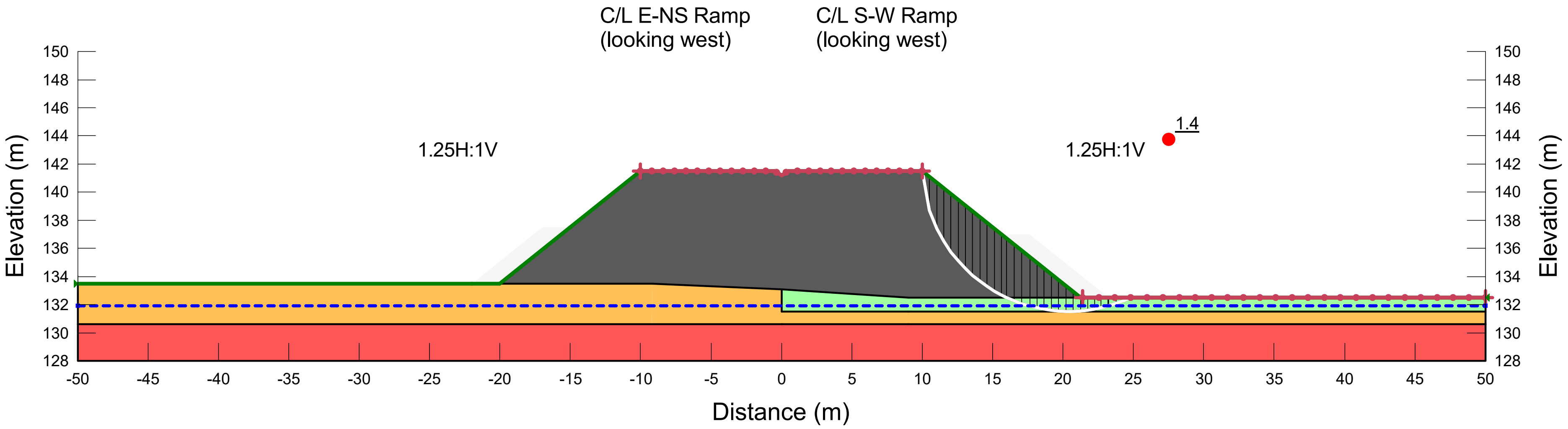
Analysis
G12.3 Temporary - Seismic - 2475yr

Seismic Coefficient	Last Run	Scale
H: 0.13g, V: 0g	2022/08/09, 05:25:28 PM	1:450

Additional Details
Name: G12. E-NS & SW Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 141.5) m, Exit: (24.832, 132.5) m
Center: (20.420284, 141.95106) m, Radius: 10.430042 m

Figure G12-3

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Strength Function
⬛	01: FILL: Rock Fill AASHTO [D]	Shear/Normal Fn.	20			AASHTO [D]
🟩	02: Clayey SILT	Mohr-Coulomb	17	0	28	
🟧	04: TILL	Mohr-Coulomb	21	0	35	
🟥	05: BEDROCK	Bedrock (Impenetrable)				



Project
County Road 6

Analysis
G12.4 Temporary - Seismic - 475yr

Seismic Coefficient
H: 0.05g, V: 0g

Last Run
2022/08/10, 07:52:00 AM

Scale
1:450

Additional Details
Name: G12. E-NS & SW Ramp (1.25H:1V)
Method: Morgenstern-Price, Half-Sine
Minimum Slip Surface Depth: 1.52 m
Entry: (10, 141.5) m, Exit: (24.832, 132.5) m
Center: (20.420284, 141.95106) m, Radius: 10.430042 m

Figure G12-4

Appendix H.

LPILE Outputs

SOIL P-Y CURVES
Highway 17 Twinning - County Road 6
South Abutment - 610mm Caisson

Figure H1

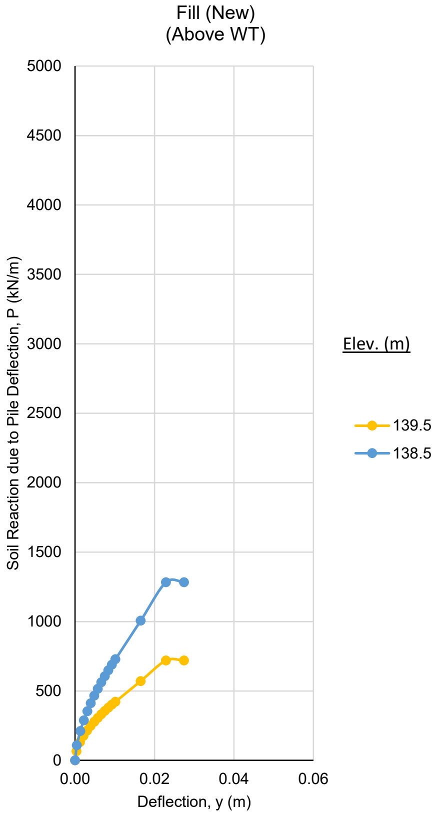
Soil Type	**Fill (New)**		**Fill (New)**		**Fill (Existing)**		**Silty Sand**		**Silty Sand**		**Clayey Silt**		**Clayey Silt**		**Clayey Silt**		**Clayey Silt**		**Till**	
Depth* (m)	**0.5**		**1.5**		**2.5**		**3.5**		**4.5**		**5.5**		**6.5**		**7.5**		**8.5**		**9.5**	
Elev* (m)	**139.5**		**138.5**		**137.5**		**136.5**		**135.5**		**134.5**		**133.5**		**132.5**		**131.5**		**130.5**	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0
	0.00038	66.0	0.00044	108.1	0.00181	105.5	0.00252	129.8	0.00230	140.0	0.00266	131.8	0.00247	138.9	0.00232	145.9	0.00220	152.9	0.00997	2664.1
	0.00127	130.7	0.00132	211.0	0.00362	211.1	0.00503	259.6	0.00459	279.9	0.00531	263.7	0.00494	277.7	0.00464	291.7	0.00440	305.8	0.00999	2667.0
	0.00216	176.3	0.00221	288.0	0.00543	316.6	0.00755	389.4	0.00689	419.9	0.00797	395.5	0.00741	416.6	0.00696	437.6	0.00660	458.7	0.01000	2670.0
	0.00305	214.2	0.00309	353.4	0.00725	422.1	0.01007	519.3	0.00918	559.8	0.01063	527.3	0.00987	555.4	0.00928	583.5	0.00880	611.6	0.01002	2672.9
	0.00394	247.4	0.00398	411.8	0.00906	527.7	0.01259	649.1	0.01148	699.8	0.01328	659.1	0.01234	694.3	0.01160	729.4	0.01100	764.5	0.01004	2675.8
	0.00483	277.5	0.00486	465.3	0.01087	633.2	0.01510	778.9	0.01378	839.7	0.01594	791.0	0.01481	833.1	0.01392	875.2	0.01320	917.4	0.01006	2678.7
	0.00572	305.3	0.00575	515.0	0.01268	738.7	0.01762	908.7	0.01607	979.7	0.01859	922.8	0.01728	972.0	0.01624	1021.1	0.01540	1070.3	0.01008	2681.7
	0.00661	331.2	0.00663	561.8	0.01449	844.2	0.02014	1038.5	0.01837	1119.6	0.02125	1054.6	0.01975	1110.8	0.01856	1167.0	0.01760	1223.1	0.01009	2684.6
	0.00750	355.6	0.00751	606.3	0.01630	949.8	0.02265	1168.3	0.02067	1259.6	0.02391	1186.5	0.02222	1249.7	0.02088	1312.8	0.01980	1376.0	0.01011	2687.5
	0.00839	378.8	0.00840	648.7	0.01811	1055.3	0.02517	1298.1	0.02296	1399.5	0.02656	1318.3	0.02469	1388.5	0.02320	1458.7	0.02201	1528.9	0.01013	2690.4
	0.00928	400.9	0.00928	689.4	0.01993	1160.8	0.02769	1427.9	0.02526	1539.5	0.02922	1450.1	0.02715	1527.4	0.02553	1604.6	0.02421	1681.8	0.01015	2693.3
	0.01017	422.2	0.01017	728.6	0.02174	1266.4	0.03020	1557.8	0.02755	1679.4	0.03188	1581.9	0.02962	1666.2	0.02785	1750.5	0.02641	1834.7	0.01017	2696.2
	0.01652	570.8	0.01652	1005.5	0.02355	1371.9	0.03272	1687.6	0.02985	1819.4	0.03453	1713.8	0.03209	1805.1	0.03017	1896.3	0.02861	1987.6	0.01652	3720.8
	0.02288	719.3	0.02288	1282.4	0.02536	1477.4	0.03524	1817.4	0.03215	1959.4	0.03719	1845.6	0.03456	1943.9	0.03249	2042.2	0.03081	2140.5	0.02288	4745.4
	0.02745	719.3	0.02745	1282.4	0.03043	1477.4	0.04229	1817.4	0.03858	1959.4	0.04463	1845.6	0.04147	1943.9	0.03898	2042.2	0.03697	2140.5	0.02745	4745.4
	0.03203	719.3	0.03203	1282.4	0.03550	1477.4	0.04933	1817.4	0.04500	1959.4	0.05206	1845.6	0.04839	1943.9	0.04548	2042.2	0.04313	2140.5	0.03203	4745.4

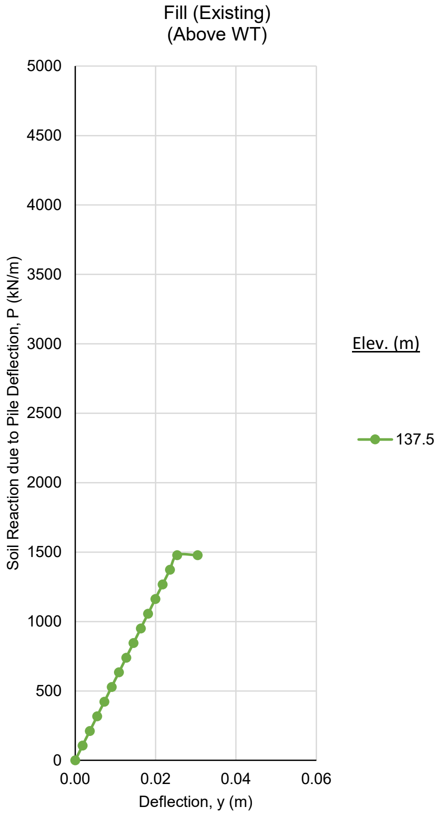
* Depth is measured below the proposed/assumed base of abutment (elevation 140.0 m)

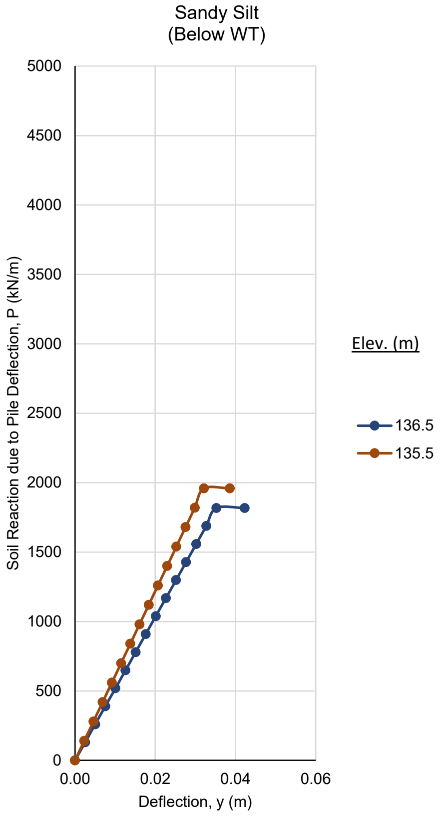
** The values P(kN/m) represent soil reaction per metre of pile length; The values y(m) represent soil/pile deflection

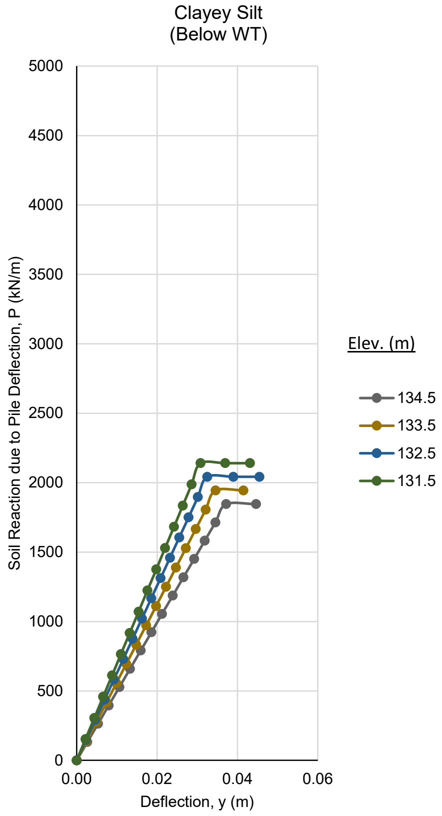
The following
1. The analysis was completed for a vertical pile (i.e. no inclination) and flat ground
2. The effects of construction disturbance or dredging is not considered. not included, the static p-y curves may be used under seismic loading.
3. Not applicable for bedrock.

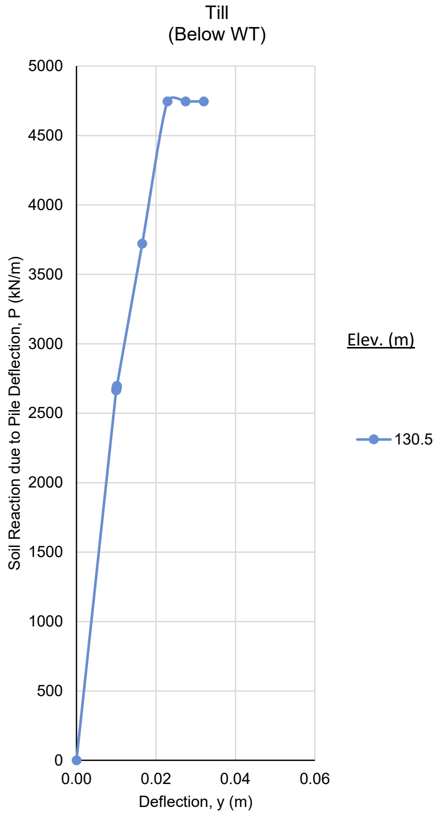
NOTES:
1. The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (Øgu and Øgs) provided in Table 6.2 of the CHBDC (S6-19)
2. If lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.11.3(r), C.6.11.3(s) and C6.11.3(t) of the CHBDC (S6-19)











Date: 2022/08/22
Project No.: 24726
Prepared By: DJP
Checked By: MJK/FG

SOIL P-Y CURVES
Highway 17 Twinning - County Road 6
South Abutment - 910mm Caisson

Figure H2

Soil Type	Fill (New)		Fill (New)		Fill (Existing)		Silty Sand		Silty Sand		Clayey Silt		Clayey Silt		Clayey Silt		Clayey Silt		Till	
Depth* (m)	0.5		1.5		2.5		3.5		4.5		5.5		6.5		7.5		8.5		9.5	
Elev* (m)	139.5		138.5		137.5		136.5		135.5		134.5		133.5		132.5		131.5		130.5	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0
	0.00182	318.5	0.00073	179.3	0.01737	1012.1	0.00301	155.1	0.00296	180.4	0.00398	197.7	0.00370	208.3	0.00348	218.8	0.00330	229.3	0.00871	2328.8
	0.00304	384.3	0.00205	307.3	0.01868	1062.7	0.00601	310.2	0.00592	360.8	0.00797	395.5	0.00741	416.6	0.00696	437.6	0.00660	458.7	0.00931	2424.1
	0.00426	434.7	0.00337	398.4	0.01998	1111.3	0.00902	465.3	0.00888	541.2	0.01195	593.2	0.01111	624.8	0.01044	656.4	0.00990	688.0	0.00990	2517.0
	0.00548	476.6	0.00469	473.4	0.02128	1159.9	0.01203	620.4	0.01184	721.6	0.01594	791.0	0.01481	833.1	0.01392	875.2	0.01320	917.4	0.01050	2607.8
	0.00670	512.9	0.00601	538.8	0.02258	1208.4	0.01504	775.5	0.01480	902.0	0.01992	988.7	0.01851	1041.4	0.01740	1094.0	0.01650	1146.7	0.01109	2696.6
	0.00792	545.2	0.00733	597.7	0.02389	1257.0	0.01804	930.6	0.01776	1082.5	0.02391	1186.5	0.02222	1249.7	0.02088	1312.8	0.01980	1376.0	0.01168	2783.6
	0.00914	574.5	0.00865	651.7	0.02519	1305.6	0.02105	1085.7	0.02072	1262.9	0.02789	1384.2	0.02592	1457.9	0.02436	1531.7	0.02311	1605.4	0.01228	2868.8
	0.01037	601.4	0.00997	701.8	0.02649	1354.2	0.02406	1240.8	0.02368	1443.3	0.03188	1581.9	0.02962	1666.2	0.02785	1750.5	0.02641	1834.7	0.01287	2952.4
	0.01159	626.4	0.01129	748.9	0.02780	1402.7	0.02707	1395.9	0.02664	1623.7	0.03586	1779.7	0.03333	1874.5	0.03133	1969.3	0.02971	2064.1	0.01347	3034.6
	0.01281	649.7	0.01261	793.4	0.02910	1451.3	0.03007	1551.0	0.02960	1804.1	0.03984	1977.4	0.03703	2082.8	0.03481	2188.1	0.03301	2293.4	0.01406	3115.3
	0.01403	671.7	0.01393	835.7	0.03040	1499.9	0.03308	1706.1	0.03256	1984.5	0.04383	2175.2	0.04073	2291.0	0.03829	2406.9	0.03631	2522.7	0.01466	3194.7
	0.01525	692.5	0.01525	876.2	0.03171	1548.5	0.03609	1861.2	0.03552	2164.9	0.04781	2372.9	0.04444	2499.3	0.04177	2625.7	0.03961	2752.1	0.01525	3272.8
	0.02478	850.5	0.02478	1162.2	0.03301	1597.0	0.03910	2016.3	0.03848	2345.3	0.05180	2570.7	0.04814	2707.6	0.04525	2844.5	0.04291	2981.4	0.02478	4516.5
	0.03431	1008.6	0.03431	1448.1	0.03431	1645.6	0.04210	2171.4	0.04144	2525.7	0.05578	2768.4	0.05184	2915.9	0.04873	3063.3	0.04621	3210.8	0.03431	5760.1
	0.04118	1008.6	0.04118	1448.1	0.04118	1645.6	0.05052	2171.4	0.04973	2525.7	0.06694	2768.4	0.06221	2915.9	0.05848	3063.3	0.05545	3210.8	0.04118	5760.1
	0.04804	1008.6	0.04804	1448.1	0.04804	1645.6	0.05894	2171.4	0.05801	2525.7	0.07809	2768.4	0.07258	2915.9	0.06822	3063.3	0.06470	3210.8	0.04804	5760.1

* Depth is measured below the proposed/assumed base of abutment (elevation 140.0 m)

** The values P(kN/m) represent soil reaction per metre of pile length; The values y(m) represent soil/pile deflection

The followinç

1. The analysis was completed for a vertical pile (i.e. no inclination) and flat ground
2. The effects of construction disturbance or dredging is not considered. not included, the static p-y curves may be used under seismic loading.
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NOTES:

1. The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (Øgu and Øgs) provided in Table 6.2 of the CHBDC (S6-19)
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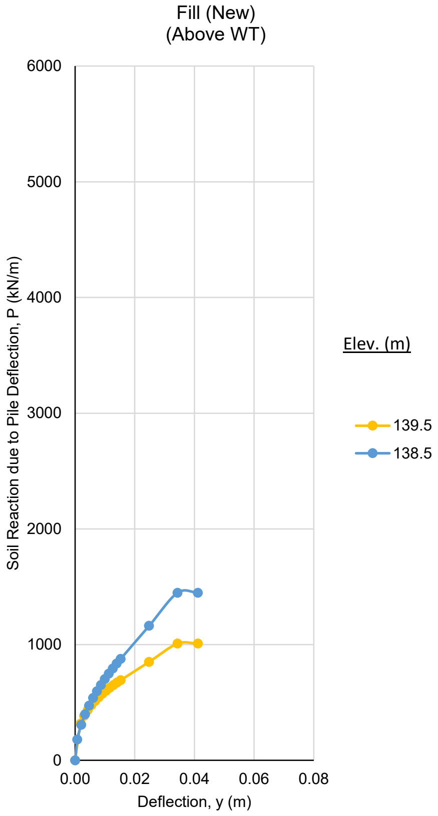
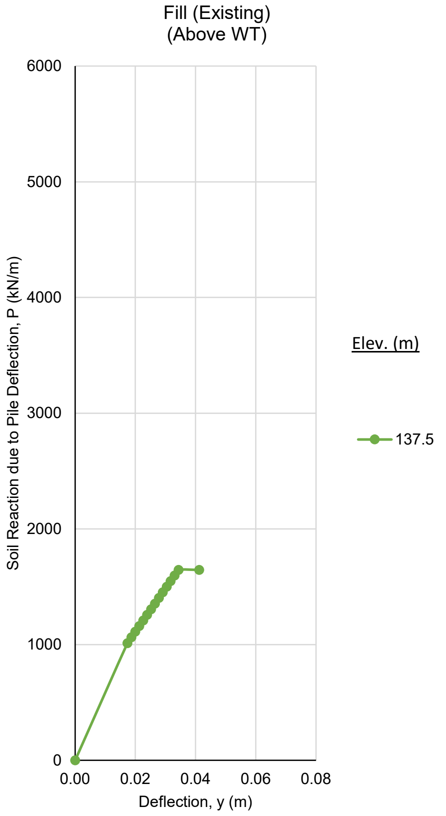
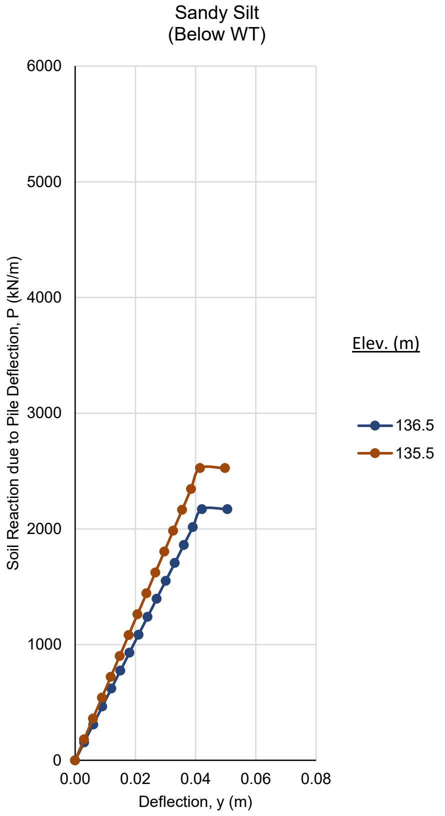
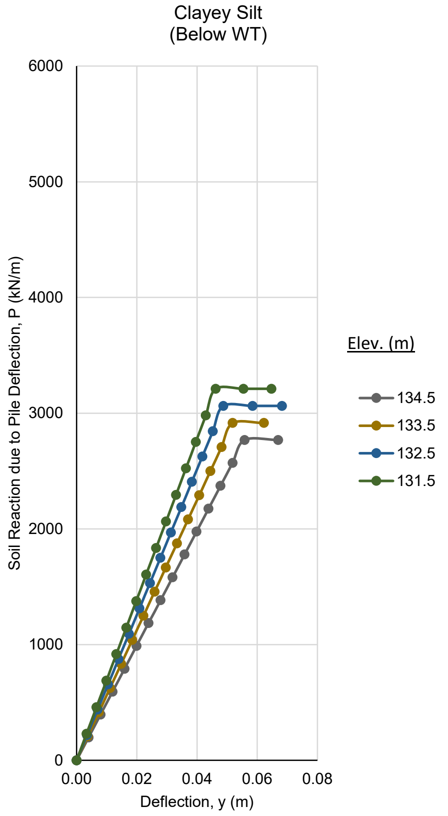
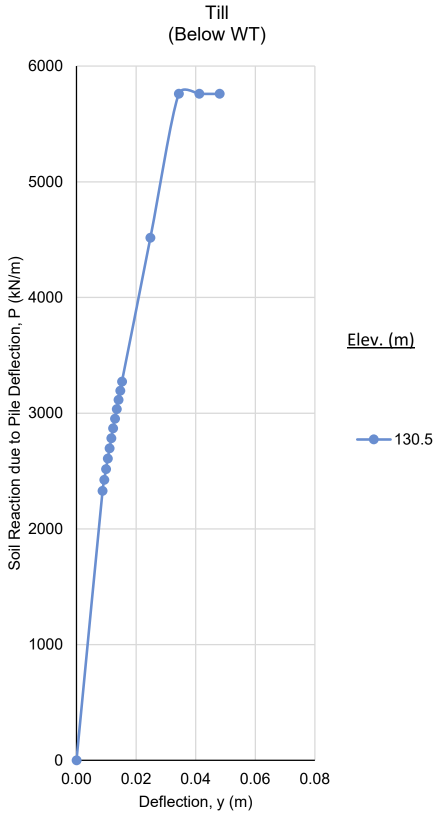










Date:	2022/08/22	**Prepared By:**	DJP
Project No.:	24726	**Checked By:**	MJK/FG

SOIL P-Y CURVES
Highway 17 Twinning - County Road 6
South Abutment - 1200mm Caisson

Figure H3

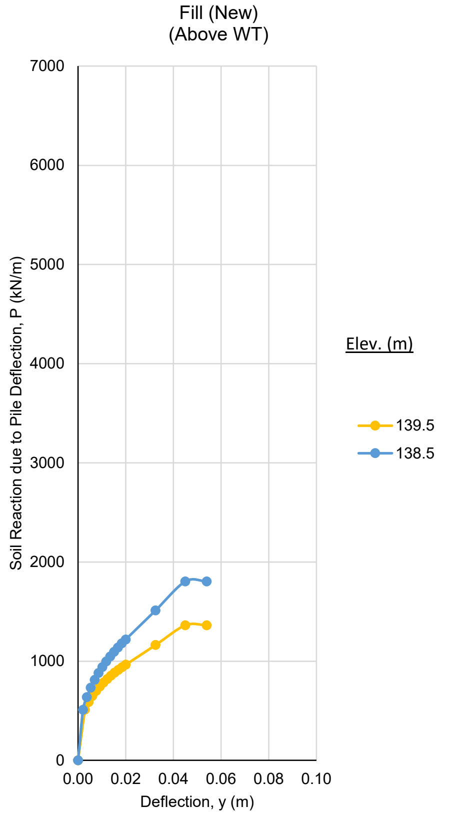
Soil Type	**Fill (New)**		**Fill (New)**		**Fill (Existing)**		**Silty Sand**		**Silty Sand**		**Clayey Silt**		**Clayey Silt**		**Clayey Silt**		**Clayey Silt**		**Till**	
Depth* (m)	**0.5**		**1.5**		**2.5**		**3.5**		**4.5**		**5.5**		**6.5**		**7.5**		**8.5**		**9.5**	
Elev* (m)	**139.5**		**138.5**		**137.5**		**136.5**		**135.5**		**134.5**		**133.5**		**132.5**		**131.5**		**130.5**	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0
	0.00291	510.4	0.00208	509.9	0.01527	889.7	0.04089	2108.9	0.03818	2327.3	0.00470	233.2	0.00460	258.7	0.00455	286.0	0.00433	300.8	0.00779	2082.7
	0.00447	587.7	0.00371	637.0	0.01570	904.9	0.04121	2125.2	0.03871	2359.2	0.00940	466.4	0.00920	517.3	0.00910	572.0	0.00866	601.5	0.00890	2258.3
	0.00602	648.6	0.00534	732.8	0.01613	919.9	0.04152	2141.5	0.03923	2391.2	0.01410	699.6	0.01380	776.0	0.01365	858.0	0.01299	902.3	0.01001	2425.5
	0.00757	699.6	0.00697	811.8	0.01656	934.7	0.04184	2157.8	0.03976	2423.2	0.01880	932.9	0.01840	1034.7	0.01820	1144.1	0.01732	1203.1	0.01112	2585.6
	0.00913	744.0	0.00860	880.2	0.01699	949.4	0.04215	2174.1	0.04028	2455.1	0.02350	1166.1	0.02299	1293.3	0.02275	1430.1	0.02164	1503.9	0.01223	2739.5
	0.01068	783.6	0.01022	940.9	0.01742	963.9	0.04247	2190.4	0.04080	2487.1	0.02820	1399.3	0.02759	1552.0	0.02730	1716.1	0.02597	1804.6	0.01334	2888.0
	0.01223	819.5	0.01185	996.0	0.01785	978.3	0.04279	2206.7	0.04133	2519.1	0.03289	1632.5	0.03219	1810.7	0.03185	2002.1	0.03030	2105.4	0.01445	3031.8
	0.01379	852.5	0.01348	1046.5	0.01828	992.5	0.04310	2223.0	0.04185	2551.0	0.03759	1865.7	0.03679	2069.3	0.03640	2288.1	0.03463	2406.2	0.01556	3171.3
	0.01534	883.1	0.01511	1093.5	0.01871	1006.7	0.04342	2239.3	0.04238	2583.0	0.04229	2098.9	0.04139	2328.0	0.04095	2574.1	0.03896	2707.0	0.01667	3306.9
	0.01689	911.6	0.01674	1137.4	0.01914	1020.7	0.04374	2255.6	0.04290	2615.0	0.04699	2332.2	0.04599	2586.7	0.04550	2860.1	0.04329	3007.7	0.01778	3439.1
	0.01845	938.5	0.01837	1178.7	0.01957	1034.5	0.04405	2271.9	0.04343	2646.9	0.05169	2565.4	0.05059	2845.3	0.05005	3146.2	0.04762	3308.5	0.01889	3568.0
	0.02000	963.8	0.02000	1217.9	0.02000	1048.3	0.04437	2288.2	0.04395	2678.9	0.05639	2798.6	0.05519	3104.0	0.05460	3432.2	0.05195	3609.3	0.02000	3694.1
	0.03250	1162.6	0.03250	1510.6	0.03250	1446.6	0.04468	2304.5	0.04448	2710.8	0.06109	3031.8	0.05978	3362.7	0.05915	3718.2	0.05628	3910.1	0.03250	5097.8
	0.04500	1361.4	0.04500	1803.4	0.04500	1845.0	0.04500	2320.8	0.04500	2742.8	0.06579	3265.0	0.06438	3621.3	0.06370	4004.2	0.06060	4210.8	0.04500	6501.5
	0.05400	1361.4	0.05400	1803.4	0.05400	1845.0	0.05400	2402.9	0.05400	2764.5	0.07895	3265.0	0.07726	3621.3	0.07644	4004.2	0.07273	4210.8	0.05400	6501.5
	0.06300	1361.4	0.06300	1803.4	0.06300	1845.0	0.06300	2402.9	0.06300	2764.5	0.09210	3265.0	0.09014	3621.3	0.08918	4004.2	0.08485	4210.8	0.06300	6501.5

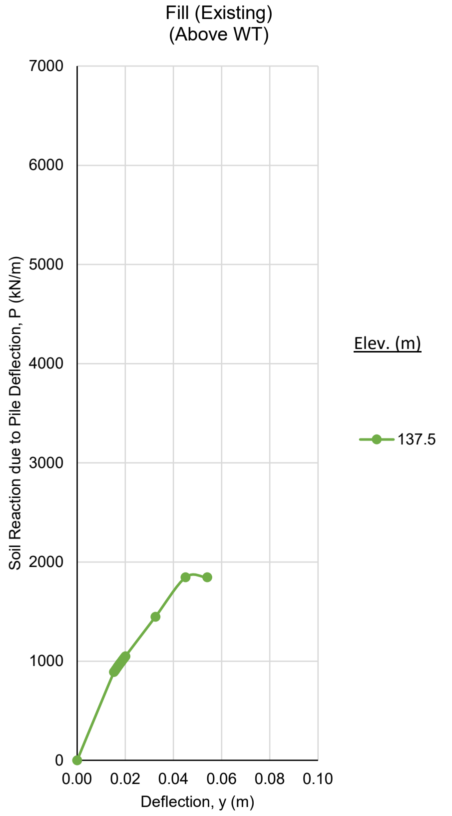
* Depth is measured below the proposed/assumed base of abutment (elevation 140.0 m)

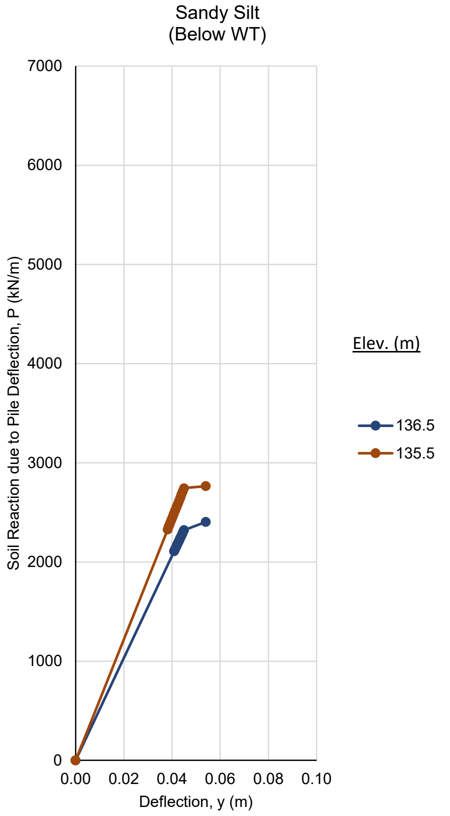
** The values P(kN/m) represent soil reaction per metre of pile length; The values y(m) represent soil/pile deflection

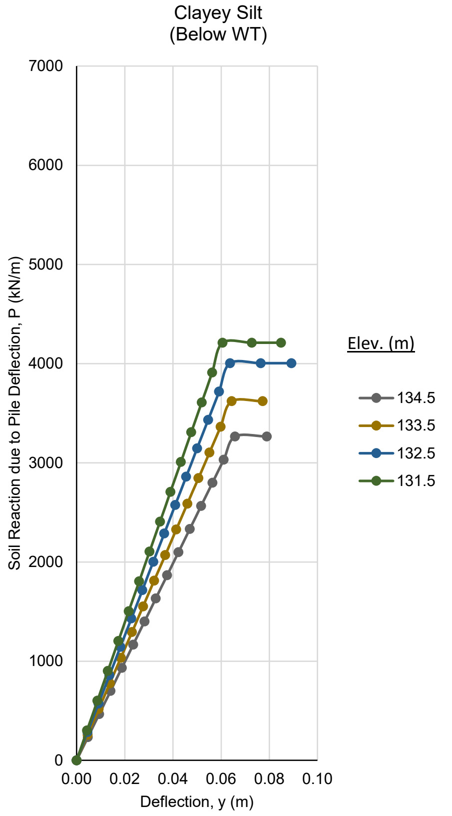
The following
1. The analysis was completed for a vertical pile (i.e. no inclination) and flat ground
2. The effects of construction disturbance or dredging is not considered. not included, the static p-y curves may be used under seismic loading.
3. Not applicable for bedrock.

NOTES:
1. The p-y data provided is unfactored. Lateral resistance or deflection calculated based on these parameters should be factored using the geotechnical resistance factors (Øgu and Øgs) provided in Table 6.2 of the CHBDC (S6-19)
2. If lateral spacing between an adjacent pile or another structural element is less than four equivalent pile diameters, suitable reduction factors based on center to center spacing should be applied based on Figures C6.11.3(r), C.6.11.3(s) and C6.11.3(t) of the CHBDC (S6-19)


Fill (New)
(Above WT)


Fill (Existing)
(Above WT)


Sandy Silt
(Below WT)


Clayey Silt
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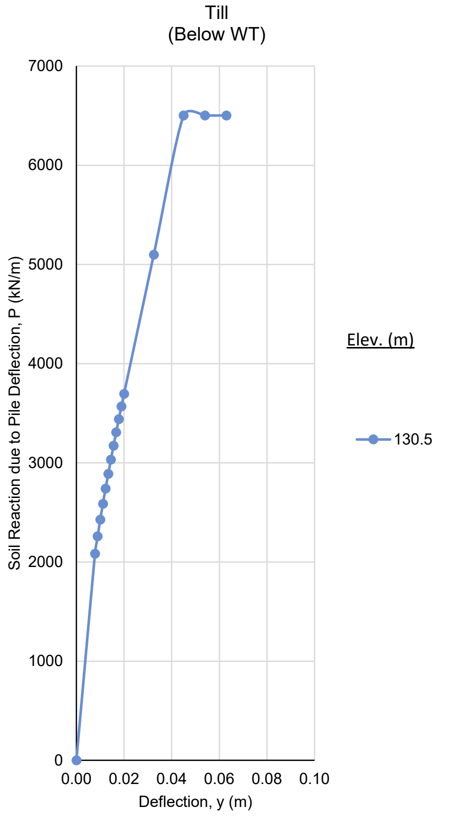
Till
(Below WT)

Date: 2022/08/22
Project No.: 24726
Prepared By: DJP
Checked By: MJK/FG

SOIL P-Y CURVES
Highway 17 Twinning - County Road 6
South Abutment - 310x110 Pile

Figure H4

	If integral abutment, disregard top 3m in CSP																			
Soil Type	**Fill (New)**		**Fill (New)**		**Fill (Existing)**		**Silty Sand**		**Silty Sand**		**Clayey Silt**		**Clayey Silt**		**Clayey Silt**		**Clayey Silt**		**Till**	
Depth* (m)	**0.5**		**1.5**		**2.5**		**3.5**		**4.5**		**5.5**		**6.5**		**7.5**		**8.5**		**9.5**	
Elev* (m)	**139.5**		**138.5**		**137.5**		**136.5**		**135.5**		**134.5**		**133.5**		**132.5**		**131.5**		**130.5**	
P-y Curves**	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)	y (m)	P (kN/m)
Static	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0	0.00000	0.0
	0.00050	88.3	0.00105	256.8	0.00094	54.8	0.00128	66.0	0.00117	71.1	0.00135	67.0	0.00125	70.6	0.00118	74.1	0.00112	77.7	0.00516	1378.1
	0.00093	128.0	0.00142	309.3	0.00188	109.5	0.00256	131.9	0.00233	142.2	0.00270	134.0	0.00251	141.1	0.00236	148.3	0.00224	155.4	0.00516	1378.2
	0.00135	160.9	0.00180	356.5	0.00282	164.3	0.00384	197.9	0.00350	213.4	0.00405	201.0	0.00376	211.7	0.00354	222.4	0.00335	233.1	0.00516	1378.4
	0.00178	189.9	0.00217	400.0	0.00376	219.1	0.00512	263.9	0.00467	284.5	0.00540	268.0	0.00502	282.3	0.00472	296.5	0.00447	310.8	0.00516	1378.5
	0.00220	216.3	0.00254	440.7	0.00470	273.8	0.00640	329.9	0.00583	355.6	0.00675	335.0	0.00627	352.8	0.00590	370.7	0.00559	388.5	0.00516	1378.7
	0.00262	240.7	0.00292	479.1	0.00564	328.6	0.00767	395.8	0.00700	426.7	0.00810	402.0	0.00753	423.4	0.00708	444.8	0.00671	466.2	0.00516	1378.8
	0.00305	263.7	0.00329	515.5	0.00658	383.4	0.00895	461.8	0.00817	497.9	0.00945	469.0	0.00878	493.9	0.00825	518.9	0.00783	543.9	0.00516	1379.0
	0.00347	285.4	0.00367	550.4	0.00752	438.1	0.01023	527.8	0.00934	569.0	0.01080	536.0	0.01004	564.5	0.00943	593.1	0.00895	621.6	0.00516	1379.2
	0.00389	306.1	0.00404	583.9	0.00846	492.9	0.01151	593.7	0.01050	640.1	0.01215	603.0	0.01129	635.1	0.01061	667.2	0.01006	699.3	0.00516	1379.3
	0.00432	326.0	0.00442	616.2	0.00940	547.7	0.01279	659.7	0.01167	711.2	0.01350	669.9	0.01255	705.6	0.01179	741.3	0.01118	777.0	0.00516	1379.5
	0.00474	345.1	0.00479	647.5	0.01034	602.5	0.01407	725.7	0.01284	782.4	0.01485	736.9	0.01380	776.2	0.01297	815.4	0.01230	854.7	0.00517	1379.6
	0.00517	363.5	0.00517	677.8	0.01128	657.2	0.01535	791.7	0.01400	853.5	0.01620	803.9	0.01505	846.8	0.01415	889.6	0.01342	932.4	0.00517	1379.8
	0.00840	501.6	0.00840	935.4	0.01222	712.0	0.01663	857.6	0.01517	924.6	0.01755	870.9	0.01631	917.3	0.01533	963.7	0.01454	1010.1	0.00840	1904.1
	0.01163	639.8	0.01163	1193.0	0.01316	766.8	0.01791	923.6	0.01634	995.7	0.01890	937.9	0.01756	987.9	0.01651	1037.8	0.01566	1087.8	0.01163	2428.4
	0.01395	639.8	0.01395	1193.0	0.01579	766.8	0.02149	923.6	0.01960	995.7	0.02268	937.9	0.02108	987.9	0.01981	1037.8	0.01879	1087.8	0.01395	2428.4
	0.01628	639.8	0.01628	1193.0	0.01843	766.8	0.02507	923.6	0.02287	995.7	0.02646	937.9	0.02459	987.9	0.02311	1037.8	0.02192	1087.8	0.01628	2428.4

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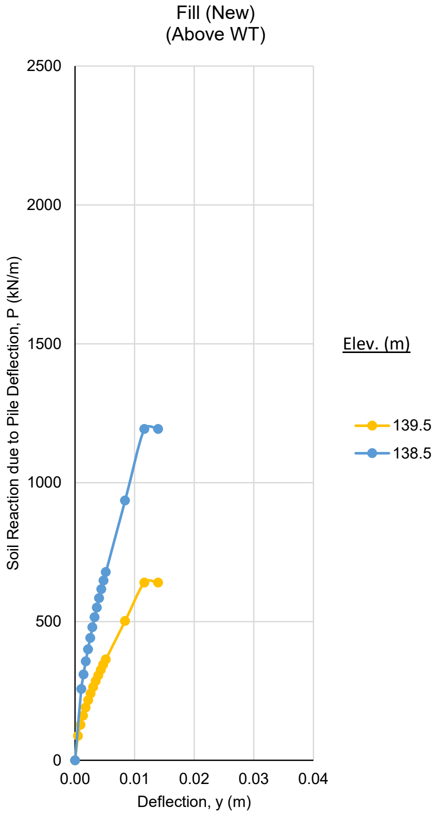

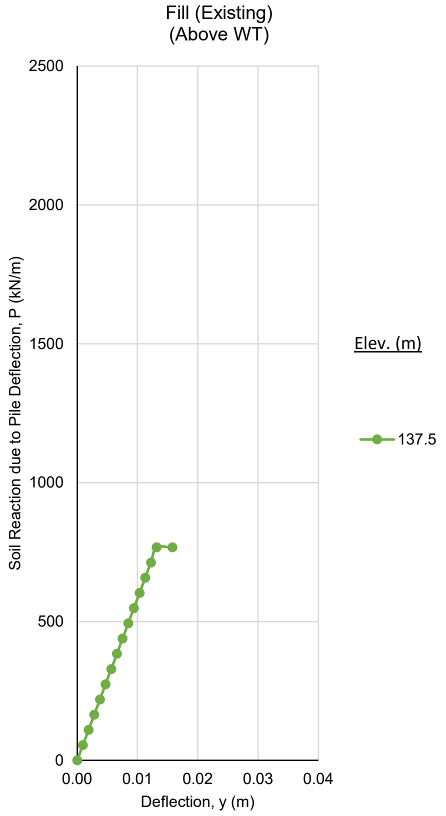

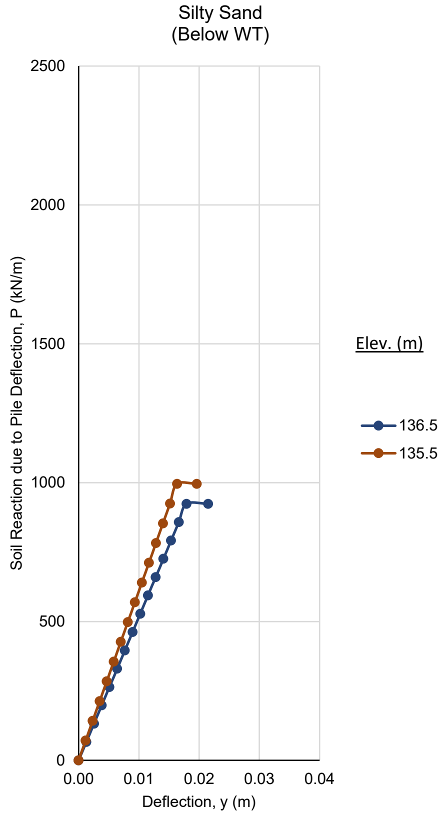

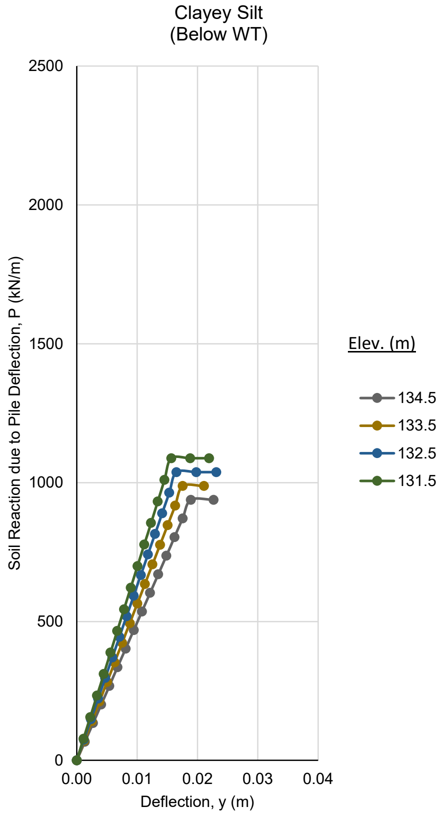

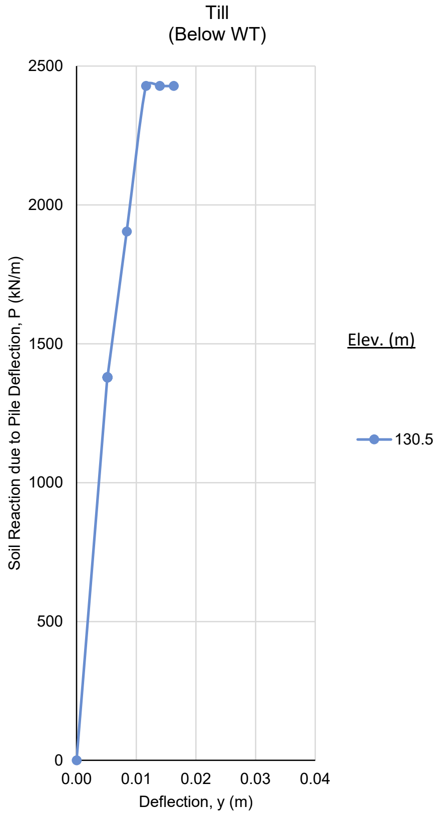

Date: 2022/08/22
Project No.: 24726
Prepared By: DJP
Checked By: MJK/FG

THURBER

Appendix I.

List of Referenced Specifications
Non-Standard Special Provisions

1. The following Special Provisions and OPSS Documents are referenced in this report:

OPSS.PROV 180	General Specification for the Management of Excess Materials
OPSS.PROV 422	Precast Reinforced Concrete Box Culverts and Box Sewers in Open Cut
OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 511	Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting
OPSS.PROV 517	Construction Specification for Dewatering
OPSS.PROV 539	Construction Specification for Temporary Protection Systems
OPSS.PROV 804	Construction Specification for Seed and Cover
OPSS.PROV 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS.PROV 902	Construction Specification for Excavating and Backfilling Structures
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 1010	Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material
OPSS.PROV 1860	Material Specification for Geotextiles
OPSD 200.020	Earth/Shale Grading Divided Rural
OPSD 202.010	Slope Flattening Using Surplus Excavated Material on Earth or Rock Embankment
OPSD 202.020	Drainage Gap for Slope Flattening on Rock or Granular Embankment
OPSD 208.010	Benching of Earth Slopes
OPSD 803.010	Backfill and Cover for Concrete Culverts with Spans Less than or Equal to 3.0M
OPSD 810.010	General Rip-Rap Layout for Sewer and Culvert Outlets
OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSD 3101.150	Walls Abutment, Backfill Minimum Granular Requirement
SP FOUN0003	Amendment to OPSS 902 – Dewatering Structure Excavations

SP 517F01	Amendment to OPSS 517 - Construction Specification for Dewatering
SP110S06	Amendment to OPSS 1010 - Material Specification for Aggregates Base, Subbase, Select Subgrade, and Backfill Material

2. Suggested wording for NSSPs

"Structural Backfill"

Structural backfill for the culvert and retaining walls shall consist of OPSS Granular B Type II or Quarry Sourced OPSS Granular A material.

"Notice to Contractor: Obstructions"

The Contractor is hereby notified that the existing embankments within the project limits have been constructed with rock fill. Considerations of these potential obstructions must be made in the selection of appropriate equipment and procedures for excavations, installations of cofferdams and temporary protection systems.

"Notice to Contractor: Sloping Bedrock"

The contractor is hereby notified that marble bedrock with variable elevation was encountered at the site. Rock excavation may be required at some locations. Mass concrete may be required to create level surfaces for foundation elements. Bedrock is classified as medium strong to strong and poor to excelled quality. Contractors equipment must be suitable for excavating bedrock.

"Construction of Caissons"

Caisson installation shall be in accordance with OPSS.PROV 903. The Contractor shall be further advised of the following:

- The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating cobbles or boulders in the native soils.
- Caissons and piles will extend through cohesionless soils below the groundwater level. Measures must be employed to maintain sidewall stability in the caisson excavation and prevent collapse/washing of cohesionless soils into the rock socket. selection of the methods and equipment employed to achieve this is the responsibility of the contractor.
- The bedrock consists of marble. The strength of the bedrock (unconfined compressive strengths of 35 to 81 MPa), and the degree of weathering vary significantly' The strength, hardness and degree of weathering of the bedrock must be taken into account when selecting equipment to advance the socket into rock' Equipment supplied to advance the pile into rock must be capable of penetrating the

bedrock without disturbing or fracturing the bedrock adjacent to the caisson. Blasting to facilitate the removal of bedrock is not permitted.

- High volumes of seepage should be anticipated into caisson excavations socketed into bedrock' and measures such as heavy duty pumping to maintain a dry excavation and enable concrete placement in a dewatered condition may not be practical. It is anticipated that placement of concrete using tremie methods will be required.
- Suggested wording to replace Clause 903.07.03.03 “Inspection of the Excavation” in OPSS.PROV 903:

  The Contractor shall use appropriate means such as a cleanout bucket, air lift, hydraulic pump, or other devices approved by Engineer to clean the bottom of the excavation of all shafts. A clean-out bucket alone is not sufficient for final clean-out. The cleaning methods, inspection method, and any additional measures required to satisfy the acceptance criteria must be selected by the contractor to ensure direct contact between the concrete and undisturbed bedrock at the socket base. It is the Contractor’s responsibility to apply means necessary (such as air lift pump or hydraulic pump, etc.) to clean the socket base and sidewalls.

  The bottom of the excavated shaft shall be inspected using a Shaft Inspection Device (SID), Shaft Quantitative Inspection Device (SQUID), down-hole camera, and/or an approved alternate to verify socket cleanliness and thickness of base sediment at the time of concreting. A minimum of 50 percent of the base of each shaft shall have less than 15 mm of sediment at the time of concrete placement. The maximum depth of sediment or any debris at any place on the base of the shaft shall not exceed 40mm at the time of concrete placement.

  A shaft inspection field report shall be submitted to the Engineer for acceptance prior to proceeding with construction. Concrete placement shall commence no later than 6 hours after acceptance of the excavation.

  The term “Engineer” should be reviewed and adjusted as necessary to be consistent with the Contract.

“Subgrade Preparation”

The Contractor is advised that the new culvert crossing the proposed Highway 17 WBL may be partially on bedrock. Blasting of bedrock is not permitted at this site. Contractor shall be further advised of the following:

- The Contractor shall prepare the subgrade to reduce the potential for non-uniform and abrupt settlement between the bedrock and the soils. The Contractor shall construct a transition zone between these variable founding materials at this site as shown elsewhere in the Contract.
- The Contractor shall sub-excavate the bedrock to a depth of 0.5 m below the base of the culvert. Subsequently, the Contractor shall construct the transition zone below

the north half of the culvert between the bedrock and the bedding layer. The transition zone excavation shall extend horizontally along the culvert alignment from the north end of the culvert towards the south to the boundary between bedrock and native soils, then upward at an 11H:1V slope to the base of bedding elevation. The transition zone shall be backfilled with Granular A or B Type II and compacted to 98% SPMDD. The work shall be carried out in the dry.

- The Contractor shall place a Class II, non-woven geotextile (e.g. Terrafix 360R or approved equivalent) in accordance with OPSS 1860 on the surface of the bedrock and native soils and wrap the geotextile around the sides of the transition zone and granular bedding to prevent migration of fines into the granular bedding. The geotextile layer shall be placed as soon as practicable after the founding level is reached and following inspection and approval of the subgrade by a qualified geotechnical engineer.
- A minimum 300 mm thick layer of bedding material consisting of Granular A or Granular B Type II should be provided under the base of the culvert in accordance with OPSD 803.010. The prepared surface to support the culvert should have a 75 mm minimum thickness top levelling course consisting of uncompacted Granular A as per OPSS 422. The bedding material shall be placed on the prepared subgrade as soon as practicable following its inspection and approval. Construction equipment shall not travel on the bedding or the prepared subgrade.