THURBER ENGINEERING LTD.

FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 7-NEW EBL AND WBL OVER THE GRAND RIVER
HIGHWAY 7- NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

GEOCRES NO. 40P08-297

Latitude 43.474417°, Longitude -80.457664°

Report

to

WSP

Date: March 15, 2024
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a detailed foundation investigation conducted at the site of the proposed structures to carry the eastbound lanes (EBL) and westbound lanes (WBL) of proposed Highway 7-New over the Grand River in the Regional Municipality of Waterloo, Ontario.

The purpose of the 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, a stratigraphic profile, cross sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions under the potential foundation footprint was developed from the data obtained in the course of the investigation.

Thurber was retained by WSP to carry out the site investigation under the Ministry of Transportation Ontario (MTO) Agreement Order Number 3014-E-0013.

Reference has been made to information on subsurface conditions contained in two previous foundation reports prepared for this site during the preliminary design phase and a previous foundations report. The title of the two reports are:

- Foundation investigation report for Grand River Bridges, EBL & WBL, Highway 7 (Wellington Street Extension), City of Kitchener, Regional Municipality of Waterloo, District #3, Stratford, W.P. 646-64-02, Site No. 33-266, Geocres Number 40P8-62, dated October 7, 1974. (Reference 1)

- Preliminary, Foundation Investigation and Design Report, Highway 7-New EBL And WBL over the Grand River, G.W.P. 408-88-00, Geocres No. 40P8-159, Report to Ministry of Transportation Ontario West Region, File: 15-64-17, dated June 1, 2009. (Reference 2).

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

2 SITE DESCRIPTION

The site for the proposed new WBL and EBL crossing lies across the valley of the Grand River on the east side of the City of Kitchener. At the site, the Highway 7-New alignment runs approximately parallel to the existing Highway 7 alignment, 750 m to the north and 1.4 km to the east of the existing Kitchener-Waterloo Expressway.

At the site location, the river channel is approximately 60.0 to 70.0 m wide and 1.5 m deep, flowing in an easterly direction. The south shoreline of the river consists of a generally level floodplain with a gentle slope towards the river channel. The floodplain is mainly vegetated with grass, shrubs and some trees. The north shoreline of the river consists of an approximately 12.0 m high cliff with an average slope of 2H:1V, though some local steepening is evident. The slope is vegetated with grass and trees. Lands within the site are generally agricultural and undeveloped. A campground and a park currently occupy the east lands and lands to the south are generally industrial.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within the physiographic region known as the Waterloo Hills, characterized by ridges of sandy till and kames or kame moraines, with outwash sands occupying the intervening hollows. The surficial soils of this region are underlain by shaley dolostone of the Salina Formation.

3 SITE INVESTIGATION AND FIELD TESTING

Previous investigations conducted in 1971 and 1974 at this site (Reference 1) consisted of drilling and sampling a total of sixteen boreholes (numbered 1 to 15 and 10a) on the east and west banks/sides of the river and through the riverbed.

A preliminary foundation investigation (Reference 2) was carried out from June 24 to 27, 2008. Seven boreholes, numbered 08-060 to 08-066, were drilled for the proposed WBL and EBL bridges. All the boreholes of the preliminary investigation were drilled on the west side of the Grand River.

A detailed geotechnical investigation was conducted at the site for the detailed design phase. During this investigation, twenty-one additional boreholes, numbered GRB16-01 to GRB16-21, were drilled between January 23, 2017 and March 2, 2018.

Details of boreholes drilled during the previous and 2017/2018 site investigations and field testing, including location and termination depths are presented in Table 3.1.

It should be noted that boreholes were planned to be drilled for Piers 5 and 6 within/adjacent to Grand River in 2018/2019. However, approval was not granted by MTO at that time.

The approximate locations of the completed boreholes are shown on the attached Borehole Locations and Soil Strata Drawings in Appendix C. The coordinates and elevations of the 2017/2018 and previous boreholes are given on the drawings and on the individual Record of Borehole Sheets in Appendices A and B, respectively.

The ground surface elevations and coordinates of the recent as-drilled boreholes were provided by WSP.

Prior to commencing the site investigation, utility clearances were obtained for all borehole locations.

During the 2017/2018 investigation, a track mounted D120 drill rig was used in conjunction with hollow-stem augers and rotary drilling to advance the boreholes. In general, soil samples were obtained at selected intervals using a 50mm diameter split spoon sampler in conjunction with the Standard Penetration Testing (SPT).

The drilling, sampling and in-situ testing operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing. Results of field drilling and sampling of the 2017/2018 and previous investigations are presented on the Record of Borehole sheets in Appendices A and B, respectively.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Thirteen standpipe piezometers were installed in selected boreholes (08-060, 08-061, 08-065, GRB16-01, GRB16-04, GRB16-05, GRB16-07, GRB16-09, GRB16-12, GRB16-14, GRB16-16, GRB16-18, GRB16-20). Each piezometer consisted of a 25 mm Schedule 40 PVC pipe with a 1.5 m or 3.0 m long slotted screen enclosed in a column of

filter sand to permit groundwater level monitoring. Piezometer installation details, groundwater level observations and water level readings are shown on the Record of Borehole sheets. Upon completion of the drilling operations, the boreholes without piezometers were abandoned in general accordance with Ontario Regulation 903. The details of standpipe piezometer installation and borehole completion are summarized in Table 3.1. It is understood that the piezometers will be monitored prior to and during construction and will be decommissioned as per O.Reg. 903.

Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
West Approach	GRB16-01	302.4	10.9/291.5	10.7/291.7	Piezometer with 3.0 m slotted screen installed with sand filter from 10.7 m to 6.4 m, bentonite holeplug and auger cuttings from 6.4 m to surface
	GRB16-02	301.4	8.2/293.2	None Installed	Borehole backfilled with bentonite holeplug to 0.3 m and auger cuttings to surface
West Abutment	08-065	300.6	11.1/289.5	10.6/290	Piezometer with 1.5 m slotted screen installed with sand filter from 10.6 m to 8.7 m, bentonite holeplug and auger cuttings from 8.7 m to surface
	08-066	303.1	10.7/292.3	None Installed	Borehole backfilled with grout to 0.6 m then auger cuttings, sand and bentonite holeplug to surface
	GRB16-03	300.5	24.0/276.5	None Installed	Borehole backfilled with grout to surface
	GRB16-05	300.8	24.4/276.5	10.9/289.9	Piezometer with 3.0 m slotted screen installed with sand filter from 10.9 m to 7.3 m, bentonite holeplug and auger cuttings from 7.3 m to surface
Pier 1	08-064	300.9	11.0/289.9	None Installed	Borehole backfilled with grout to 0.6 m then auger cuttings, sand and bentonite holeplug to surface

Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
	GRB16-04	300.1	24.3/275.8	11.0/289.1	Piezometer with 3.0 m slotted screen installed with sand filter from 11.0 m to 7.2 m, bentonite holeplug and auger cuttings from 7.2 m to surface
	GRB16-06	299.2	14.3/285.0	None Installed	Borehole backfilled with holeplug and auger cuttings to surface
	GRB16-08	299.6	12.3/287.3	None Installed	Borehole backfilled with holeplug and auger cuttings to surface
Pier 2	08-062	299.6	7.8/291.7	None Installed	Borehole backfilled with grout to 0.6 m then auger cuttings to surface
	GRB16-07	298.6	22.7/275.9	17.1/281.5	Piezometer with 3.0 m slotted screen installed with sand filter from 17.1 m to 13.4 m, bentonite holeplug and auger cuttings from 13.4 m to surface
	GRB16-09	300.1	23.3/276.8	18.7/281.4	Piezometer with 3.0 m slotted screen installed with sand filter from 18.7 m to 15.1 m, bentonite holeplug and auger cuttings from 15.1 m to surface
	GRB16-11	299.2	18.9/280.3	None Installed	Borehole backfilled with bentonite holeplug to surface
Pier 3	4	299.0	12.3/286.7	None Installed	N/A
	5	298.6	12.5/286.1	None Installed	N/A
	08-061	303.8	6.5/297.3	5.8/298.0	Piezometer with 1.5 m slotted screen installed with sand filter from 5.8 m to 3.8 m, bentonite holeplug from 3.8 m to surface
	08-063	298.9	8.0/290.9	None Installed	Borehole backfilled with grout to 0.6 m, bentonite holeplug and auger cuttings to 0.3, then auger cuttings to surface.
	GRB16-10	298.8	23.6/275.2	None	Borehole backfilled with

Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
				Installed	bentonite holeplug and auger cuttings to surface
	GRB16-12	298.6	22.5/276.1	22.5/276.1	Piezometer with 3.0 m slotted screen installed with sand filter from 22.5 m to 18.0 m, bentonite holeplug and auger cuttings from 18.0 m to surface
Pier 4	6	297.4	12.5/284.9	None Installed	N/A
	7	298.0	12.6/285.4	None Installed	N/A
	08-060	302.9	14.2/288.8	13.3/289.6	Piezometer with 1.5 m slotted screen installed with sand filter from 13.3 m to 11.4 m, bentonite holeplug from 11.4 m to surface
	GRB16-13	297.5	20.9/276.6	None Installed	Borehole backfilled with peltonite to 12.2 m then holeplug to surface
	GRB16-14	298.8	21.2/277.6	17.7/281.1	Piezometer with 3.0 m slotted screen installed with sand filter from 17.7 m to 14.1 m, bentonite holeplug and auger cuttings from 14.1 m to surface
Pier 5	1	296.2	9.4/286.8	None Installed	N/A
	2	295.4	6.2/288.3	None Installed	N/A
	8	296.2	12.5/283.7	None Installed	N/A
	9	297.2	12.0/285.2	None Installed	N/A
	10	295.4	12.5/282.9	None Installed	N/A
	10a	295.4	3.3/292.1	None Installed	N/A
	11	295.4	12.6/282.7	None Installed	N/A
	GRB16-15	297.5	19.4/278.1	None	Borehole backfilled with

Foundation Unit	Borehole	Ground Surface Elevation (m)	Borehole Depth / Base Elevation (m)	Piezometer Tip Elevation (m)	Completion Details
				Installed	bentonite holeplug and auger cuttings to surface
Pier 6	12	295.4	12.5/282.9	None Installed	N/A
	13	295.4	12.5/282.9	None Installed	N/A
	14	308.8	12.3/296.5	None Installed	N/A
	15	309.1	13.8/295.3	None Installed	N/A
East Abutment	3	309.6	18.3/291.2	None Installed	N/A
	GRB16-16	308.6	30.6/278.1	18.3/290.3	Piezometer with 3.0 m slotted screen installed with sand filter from 18.3 m to 14.6 m, bentonite holeplug and auger cuttings from 14.6 m to surface
	GRB16-17	309.1	20.1/289.0	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface
	GRB16-19	310.4	20.3/290.2	None Installed	Borehole backfilled with bentonite holeplug and auger cuttings to surface
	GRB16-21	309.3	35.4/273.9	None Installed	Borehole backfilled with grout to surface
East Approach	GRB16-18	309.8	11.0/298.9	6.1/303.7	Piezometer with 3.0 m slotted screen installed with sand filter from 6.1 m to 2.7 m, bentonite holeplug and auger cuttings from 2.7 m to surface
	GRB16-20	311.8	11.0/300.8	7.6/304.2	Piezometer with 3.0 m slotted screen installed with sand filter from 7.8 m to 4.3 m, bentonite holeplug and auger cuttings from 4.3 m to surface

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out in accordance with MTO and/or ASTM Standards, as appropriate. The results of the laboratory testing of 2017/2018 and previous investigations are summarized on the Record of Borehole sheets and figures in Appendices A and B, respectively.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, two native soil samples were collected and submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 6 and are presented in Appendix A.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets in Appendices A and B. Details of the encountered soil stratigraphy along the proposed alignment are presented in these appendices and on the Borehole Locations and Soil Strata Drawings in Appendix C. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, the site is underlain by topsoil/alluvium overlying native layers of sand and gravel, silty clay, clayey silt, and silty sand to sandy silt underlain by an extensive deposit of silty sand to sandy silt till which in turn is underlain by a lower sand and gravel layer and dolostone bedrock.

5.1 Recent Alluvium

A layer of dark brown recent alluvium mixed with disseminated organics, some silt and trace of clay, was contacted at surface in Borehole 08-060. The thickness of the alluvium was 2.4 m and the base of the alluvium was encountered at Elevation 300.5 m.

SPT ‘N’ values measured in the alluvium were 9 and 10 blows per 0.3 m of penetration, indicating a loose to compact relative density. The natural moisture contents measured on samples of the alluvium ranged from 30 percent to 39 percent.

5.2 Topsoil

Topsoil was identified at ground surface in Boreholes 08-061 to 08-066 and all 2017/2018 boreholes (i.e. GRB16-02 to GRB16-21) with the exception of GRB16-14. The topsoil thickness ranged from 0.1 m to 1.4 m.

The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.3 Clayey Silt

Native clayey silt was encountered at surface in Borehole 1 and below the topsoil in Boreholes GRB16-13 and GRB16-15. The thickness of the clayey silt layer ranged from 0.9 m to 1.5 m. The base of the layer was encountered between 0.9 m and 1.6 m depth (Elevation 296.0 and 295.3).

In Borehole 3, two layers of clayey silt with some sand and trace of gravel were encountered at 4.3 m and 7.0 m depth (Elevations 305.2 and 302.6). Thickness of these layers ranged from 1.1 m to 3.0 m.

Clayey silt was encountered at 2.3 m depth (Elevation 306.5) in Borehole 14. Thickness of the layer was 1.7 m. The depth to the base of the clayey silt is 4.0 m (Elevation 304.8).

SPT ‘N’ values measured in the clayey silt ranged from 5 blows per 0.3 m of penetration to 195 blows per 0.2 m of penetration, indicating a variable firm to hard consistency. The natural moisture contents measured on samples of the clayey silt ranged from 10 percent to 59 percent.

The results of grain size analyses testing conducted on samples of the clayey silt are provided on the Record of Borehole Sheets in Appendices A and B. The results are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	1
Silt	65
Clay	34

The results of Atterberg Limits testing conducted on samples of the clayey silt from the previous investigation are summarized below.

Liquid Limit	21 to 28
Plastic Limit	16 to 19
Plasticity Index	5 to 9

The above results indicate that the clayey silt is of low plasticity with a group symbol of CL.

5.4 Silty Sand to Sandy Silt

Native brown silty sand to sandy silt containing trace to some clay, trace gravel to gravelly, was encountered at depths ranging from 0.0 m to 7.0 m depth (Elevation 306.3 to 296.0) in Boreholes 6, 7, 15, 08-061, GRB16-01, GRB16-02, GRB16-05, GRB16-07, GRB16-09, GRB16-10, GRB16-11, GRB19-14, GRB16-15, GRB16-16, GRB16-21. The thickness of the silty sand to sandy silt layer ranged from 0.6 m to 3.4 m. The base of the silty sand to sandy silt was encountered at depths ranging from 1.4 m to 8.8 m (Elevation 304.3 to 295.0)

SPT ‘N’ values measured in the layer ranged from 3 blows per 0.3 m of penetration to 50 blows per 0.1 m of penetration, indicating a loose to very dense relative density. The natural moisture contents measured on samples of the silty sand to sandy silt ranged from 10 percent to 59 percent.

Organics were encountered within the silty sand to sandy silt layer in Boreholes GRB16-02 and GRB16-09. Occasional wood fibres were also noted within the layer in Borehole BRG16-14.

The results of grain size analyses conducted on samples of the silty sand to sandy silt are provided on the Record of Borehole Sheets in Appendices A and B and illustrated in Figures A1 and A2 in Appendix A. The results are summarized as follows:

Soil Particles	(%)
Gravel	0 to 23
Sand	21 to 70
Silt	21 to 64
Clay	4 to 15

Occasional cobbles were noted within the silty sand to sandy silt deposit. Photographs showing the cobbles are provided in Appendix G.

5.5 Upper Sand and Gravel

Native brown to grey sand and gravel containing trace to some silt, trace clay and occasional cobbles was encountered below the alluvium, topsoil, silty sand and clayey silt in all the boreholes shown in Table 5.1.

Depths and elevations where the upper sand and gravel was encountered are indicated in Table 5.1.

Table 5.1 – Depths and Elevations of Sand and Gravel

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
West abutment	EBL	08-066	0.6 to 5.5	302.5 to 297.6	4.9
		GRB16-05	1.4 to 5.9	299.5 to 294.9	4.5
	WBL	08-065	0.6 to 6.4	300.0 to 294.2	5.8
		GRB16-03	0.8 to 4.6	299.7 to 295.9	3.8
Pier 1	EBL	08-064	1.0 to 5.8	299.9 to 295.1	4.8
		GRB16-08	1.4 to 6.2	298.2 to 293.4	4.8
	WBL	GRB16-06	0.7 to 6.2	298.6 to 293.0	5.5
	EBL/ WBL	GRB16-04	0.7 to 4.1	299.4 to 296.0	3.4

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
Pier 2	WBL	08-062	0.3 to 3.7	299.3 to 295.9	3.4
		GRB16-09	2.2 to 5.5	297.9 to 294.6	3.3
		GRB16-07	2.3 to 5.3	296.3 to 293.3	3.0
	EBL	08-063	0.8 to 4.9	298.1 to 294.0	4.1
		GRB16-11	1.5 to 5.0	297.7 to 294.2	3.5
Pier 3	WBL	4	0.0 to 4.1	299.0 to 294.9	4.1
	EBL	08-061	1.5 to 5.5	302.3 to 298.3	4.0
		5	0.0 to 5.5	298.6 to 293.1	5.5
		GRB16-12	0.8 to 4.9	297.8 to 293.7	4.1
	EBL/ WBL	GRB16-10	2.2 to 4.9	296.6 to 293.9	2.7
Pier 4	WBL	08-060	2.4 to 4.9	300.5 to 298.1	2.5
		6	2.4 to 4.1	295.0 to 293.3	1.7
		GRB16-14	2.9 to 5.1	295.9 to 293.7	2.2
	EBL	7	1.5 to 4.0	296.5 to 294.0	2.5
		GRB16-13	1.6 to 3.9	295.9 to 293.6	2.3
Pier 5	EBL/ WBL	1	0.9 to 2.4	295.3 to 293.8	1.5
		2	0.8 to 1.2	294.6 to 294.1	0.4
	WBL	8	0.0 to 2.0	296.2 to 294.3	2.0
	EBL	9	0.0 to 2.9	297.2 to 294.3	2.9
		11	0.9 to 1.8	294.5 to 293.6	0.9
		GRB16-15	2.3 to 4.6	295.2 to 292.9	2.3
Pier 6	EBL	13	0.3 to 1.5	295.1 to 293.9	1.2
		15	0.0 to 3.7	309.1 to 305.5	3.7
	WBL	14	0.0 to 2.3	308.8 to 306.5	2.3
East abutment	WBL	GRB16-16	0.8 to 3.0	307.9 to 305.6	2.2
		GRB16-17	0.2 to 3.7	308.9 to 305.4	3.5
	EBL	GRB16-19	0.2 to 4.3	310.2 to 306.2	4.1

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
	EBL/ WBL	3	0.0 to 4.3 5.3 to 7.0	309.6 to 305.2 304.3 to 302.6	4.3 1.7
		GRB16-21	0.2 to 3.0	309.1 to 306.3	2.8
East Approach	EBL	GRB16-20	0.2 to 6.6	311.6 to 305.3	6.4

The SPT 'N' values measured in the upper sand and gravel layer ranged from 5 blows per 0.3 m of penetration to 100 blows per 0.05 m of penetration with the majority of the 'N' values greater than 30 blows per 0.3 m of penetration (dense to very dense). Augur grinding was noted in this layer in a number of the boreholes suggesting the presence of cobbles and/or boulders. The natural moisture content measured on samples ranged from 2% to 28%.

The results of grain size analyses conducted on samples of the upper sand and gravel are provided on the Record of Borehole Sheets in Appendices A and B and illustrated in Figures A3 to A6 in Appendix A and Figures B1 and B2 in Appendix B. The results are summarized as follows:

Soil Particles	(%)
Gravel	20 to 71
Sand	22 to 73
Silt	5 to 26
Clay	5
Silt and Clay	5 to 24

This sand and gravel layer may contain cobbles and boulders which may account for some high SPT 'N' values.

Occasional cobbles were noted within the upper sand and gravel deposit. Photographs showing the cobbles are provided in Appendix G.

5.6 Silty Clay

Native brown silty clay with organics was encountered surfically in Boreholes GRB16-01 and beneath the topsoil in GRB16-02. The silty clay ranged in thickness from 0.7 m to 1.2 m and the base of the layer was encountered between Elevation 301.7 m and 300.0.

Native brown to grey silty clay containing trace sand was encountered below the sand and gravel layer in Boreholes 08-060, GRB16-16, GRB16-17, GRB16-19 and GRB16-21 at depths ranging from 3.0 m to 5.0 m depth (Elevation 306.2 to 298.1). The thickness of the silty clay layer ranged from 2.4 m to 4.4 m and the depth to the base of the silty clay ranged from 7.0 m to 8.7 m (Elevation 301.8 to 295.6).

SPT 'N' values measured within the silty clay ranged from 2 blows per 0.3 m of penetration to 50 blows per 0.075 m of penetration, indicating a soft to hard consistency. The natural moisture contents measured on samples of the silty clay ranged from 15 percent to 42 percent.

The results of grain size analyses conducted on samples of the silty clay are provided on the Record of Borehole Sheets in Appendices A and B and illustrated in Figure A7 in Appendix A and Figure B3 in Appendix B. The results are summarized as follows:

Soil Particles	(%)
Gravel	0 to 3
Sand	0 to 19
Silt	35 to 48
Clay	32 to 65

The results of Atterberg Limits testing conducted on samples of the silty clay are shown in Figure A20 in Appendix A and Figure B7 in Appendix B. The results are also summarized below.

Liquid Limit	23 to 42
Plastic Limit	13 to 18
Plasticity Index	10 to 24

The above results indicate that the silty clay is of low to medium plasticity with a group symbol of CL to CI.

5.7 Silt

Native grey silt containing trace to some clay and trace of gravel was encountered below the silty clay in Borehole 08-060 at 7.3 m depth (Elevation 295.6). Thickness of the silt layer was 1.2 m. The depth to the base of the silt was 8.5 m (Elevation 294.4).

Native silt was also contacted below the sand and gravel layer in Borehole 6 at 4.1 m depth (Elevation 293.3). Thickness of the layer was 4.4 m. The depth to the base of the silt layer was 8.5 m (Elevation 288.9)

SPT 'N' values in the silt ranged from 58 blows per 0.3 m of penetration to 75 blows per 0.1 m of penetration, indicating a very dense relative density. The natural moisture contents measured on samples of the silt ranged from 19 percent to 22 percent.

The results of a grain size analysis conducted on a sample of the silt are presented on the Record of Borehole sheets in Appendix B and in Figure B4 Appendix B. The results are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	5
Silt	86
Clay	9

5.8 Silty Sand to Sandy Silt Till

Native brown to grey silty sand to sandy silt till containing trace to some gravel, trace to some clay and occasional cobbles was encountered in all boreholes, typically below the sand and gravel layer. All the boreholes from the previous investigations were terminated within the till at depths ranging from 3.3 m to 18.3 m (Elevations 282.7 to 297.3).

Layers of gravel were encountered within the sandy silt till in Boreholes 10 and 10a at 5.8 m and 1.1 m depth (Elevations 288.9 and 294.3).

The silty sand to sandy silt till deposit was encountered at depths ranging from 0.2 m to 10.1 m. Where penetrated, the thickness of the till ranged from 8.2 m to 23.2 m.

Depths and elevations where native silty sand to sandy silt till was encountered are provided in Table 5.2.

It should be noted that several of the boreholes in Table 5.2 were terminated in the silty sand to sandy silt till deposit.

Table 5.2 – Depths and Elevations of Silty Sand to Sandy Silt Till

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Proven Thickness (m)
West Approach	WBL	GRB16-01	4.1 to 10.9	298.2 to 291.5	6.8*
	EBL	GRB16-02	3.4 to 8.2	298.0 to 293.2	4.8*
West abutment	EBL	08-066	5.5 to 10.7	297.6 to 292.3	5.2*
		GRB16-05	5.9 to 19.3	294.9 to 281.6	13.4
	WBL	08-065	6.4 to 11.1	294.2 to 289.5	4.7*
		GRB16-03	4.6 to 20.5	295.9 to 280.0	15.9
Pier 1	EBL	08-064	5.8 to 11.0	295.1 to 289.9	5.2*
		GRB16-08	6.2 to 12.3	293.4 to 287.3	6.1*
	WBL	GRB16-06	6.2 to 14.3	293.0 to 285.0	8.1*
	EBL/WBL	GRB16-04	4.1 to 21.1	296.0 to 279.0	17
Pier 2	WBL	08-062	3.7 to 7.8	295.9 to 291.7	4.1*
		GRB16-09	5.5 to 17.6	294.6 to 282.5	12.1
	EBL	GRB16-11	5.0 to 14.6	294.2 to 284.6	9.6
		08-063	4.9 to 8.0	294.0 to 290.9	3.1*
	EBL/WBL	GRB16-07	5.3 to 17.5	293.3 to 281.1	12.2
Pier 3	WBL	4	4.1 to 12.3	294.9 to 286.7	8.2*
	EBL	08-061	5.5 to 6.5	298.3 to 297.3	1.0*
		5	5.5 to 12.5	293.1 to 286.1	7.0*
		GRB16-12	4.9 to 14.8	293.7 to 283.8	9.9
	EBL/WBL	GRB16-10	4.9 to 14.7	293.9 to 284.1	9.8
Pier 4	WBL	08-060	8.5 to 14.2	294.4 to 288.8	5.7*
		6	8.5 to 12.5	288.9 to 284.9	4.0*
		GRB16-14	5.1 to 13.3	293.7 to 285.6	8.2
	EBL	7	4.0 to 12.6	294.0 to 285.4	8.6*
		GRB16-13	3.9 to 14.1	293.6 to 283.4	10.2
Pier 5	EBL/WBL	1	2.4 to 9.4	293.8 to 286.8	7.0*

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Proven Thickness (m)
		2	1.2 to 6.2	294.1 to 289.1	5.0*
	WBL	8	2.0 to 12.5	294.3 to 283.7	10.5*
		10	1.4 to 12.5	294.0 to 282.9	11.1*
		10a	1.1 to 3.3	294.3 to 292.1	2.2*
	EBL	9	2.9 to 12.0	294.3 to 285.2	9.1*
		GRB16-15	4.6 to 17.4	292.9 to 280.1	12.8
		11	1.8 to 12.6	293.6 to 282.7	10.8*
Pier 6	WBL	12	0.2 to 12.5	295.2 to 282.9	12.3*
		14	4.0 to 12.3	304.8 to 296.5	8.3*
	EBL	13	1.5 to 12.5	293.9 to 282.9	11.0*
		15	6.4 to 13.8	302.7 to 295.4	7.4*
East Abutment	EBL/WBL	3	10.1 to 18.3	299.5 to 291.2	8.2*
		GRB16-21	7.6 to 30.9	301.7 to 278.4	23.3
	WBL	GRB16-17	7.4 to 20.1	301.7 to 289.0	12.7*
		GRB16-16	8.8 to 30.6	299.8 to 278.1	21.8*
	EBL	GRB16-19	8.7 to 20.3	301.8 to 290.2	11.6*
East Approach	WBL	GRB16-18	3.0 to 11.0	306.8 to 298.9	8.0*
	EBL	GRB16-20	6.6 to 11.0	305.3 to 300.8	4.4*

* Boreholes that were terminated in the sand and silt till

SPT ‘N’ values measured in the silty sand to sandy silt till ranged from 12 blows per 0.3 m of penetration to 150 blows per 0.05 m of penetration, indicating a compact to very dense relative density (generally dense to very dense).

The natural moisture contents measured on samples of the till ranged from 6 percent to 22 percent.

The results of grain size analyses conducted on samples of the silty sand to sandy silt till are provided on the Record of Borehole Sheets in Appendices A and B and illustrated in Figure A8 to A14 in Appendix A and Figures B5 and B6 in Appendix B. The results are summarized as follows:

Soil Particles	(%)
Gravel	0 to 47
Sand	19 to 57
Silt	19 to 63
Clay	3 to 22
Silt + Clay	28

The results of Atterberg Limits testing conducted on samples of the silty sand to sandy silt till are shown in Figure A17 to A19 in Appendix A. The results are also summarized below.

Liquid Limit	14 to 35
Plastic Limit	8 to 15
Plasticity Index	6 to 20

The above results indicate that the fines of the silty sand to sandy silt exhibit slight to low plasticity with a group symbol of CL-ML to CL.

Cobbles and boulders were encountered in the till deposit at this site and are inherently present in glacial tills.

5.9 Sand

A layer of brown sand containing trace to some gravel, trace silt and trace clay, was encountered below the silty sand to sandy silt till in Boreholes GRB16-07, GRB16-10, GRB16-11, and GRB16-12 at depths ranging from 14.6 m to 17.5 m (Elevation 284.6 to 281.1). The thickness of the sand layer ranged from 1.2 m to 1.9 m.

SPT ‘N’ values measured in the sand ranged from 26 blows per 0.3 m of penetration to 100 blows per 0.25 m of penetration, indicating a compact to very dense relative density. The natural moisture contents measured on samples of the sand ranged from 15 percent to 19 percent.

The results of grain size analyses conducted on samples of the sand are provided on the Record of Borehole Sheets and Figure A15 in Appendix A. The results are summarized as follows:

Soil Particles	(%)
Gravel	1 to 10
Sand	77 to 88
Silt + Clay	11 to 13

5.10 Lower Sand and Gravel

A lower sand and gravel layer ranging from gravelly sand to gravel, trace sand, with trace silt to silty and trace clay, was encountered below the silty sand to sandy silt till layer at depths ranging from 13.3 m to 19.3 m (Elevation 285.6 to 280.1) in Boreholes GRB16-05, GRB16-09, GRB16-10, GRB16-12, GRB16-13, GRB16-14, GRB16-15. The thickness of this layer ranged from 1.8 m to 4.7 m and the base of this layer was encountered at depths ranging from 17.4 m to 21.1 m (Elev. 280.8 to 278.1). Cobbles and boulders were noted in the sand and gravel layer.

SPT 'N' values measured in the lower sand and gravel ranged from 58 blows per 0.3 m of penetration to 100 blows per 0.025 m of penetration, indicating a very dense relative density.

The natural moisture contents measured on samples of the lower sand and gravel ranged from 7 percent to 19 percent.

The results of grain size analyses conducted on samples of the lower sand and gravel are provided on the Record of Borehole Sheets and Figure A16 in Appendix A. The results are summarized as follows:

Soil Particles	(%)
Gravel	21 to 56
Sand	35 to 56
Silt	17 to 24
Clay	6 to 9
Silt + Clay	1 to 31

5.11 Gravel and Cobbles

A layer of grey gravel and cobbles was encountered below the sand layer in Borehole GRB16-11. Several of the cobbles were cored through since auger refusal was encountered at 16.2 m (Elev. 283.0). An SPT 'N' value of 112 blows per 0.225 m of penetration was measured within the gravel and cobbles layer, indicating a very dense relative density.

5.12 Bedrock

Bedrock was encountered underlying the silty sand to sandy silt till and lower sand and gravel deposits at depths ranging from 17.4 m to 30.9 m (Elevation 280.8 to 278.4). The bedrock is described as grey dolostone with limestone interbeds. The rock is generally moderately weathered within the upper 1 m and less weathered with depth. In several of the boreholes, vugs, rubble zones, and clay seams were noted within the bedrock.

The bedrock was proven by coring to a depth of 3.0 to 4.5 m below the interpreted bedrock surface. The depths and elevations at which bedrock was encountered are summarized in Table 5.3. Photographs of the recovered rock cores are presented in Appendix A.

Table 5.3 – Bedrock Contact Depths and Elevations

Foundation Unit	Borehole	Bedrock Surface	
		Depth (m)	Elevation
West Abutment	GRB16-03	20.5	280.0
	GRB16-05	21.1	279.7
Pier 1	GRB16-04	21.1	279.0
Pier 2	GRB16-07	19.4	279.2
	GRB16-09	19.7	280.4
Pier 3	GRB16-10	20.1	278.7
	GRB16-12	19.5	279.1
Pier 4	GRB16-13	17.4	280.1
	GRB16-14	18.0	280.8
Pier 5	No Boreholes Drilled Yet	TBD(^)	TBD(^)
Pier 6	No Boreholes Drilled Yet	TBD(^)	TBD(^)
East Abutment	GRB16-21	30.9	278.4

(^) Depth / elevation of bedrock surface at Piers 5 & 6 to be confirmed following completion of additional boreholes within Grand River

The bedrock was highly fractured with the fracture index ranging from 2 to 25, with an average fracture index of 7. In general, the upper 0.3 m of the bedrock was highly fractured. Total core recovery (TCR) values ranged from 62% to 100% and solid core recovery (SCR) values ranged from 0 to 100%. The RQD of the rock cores ranged from 0 to 94% and the majority of the RQD values were less than 40% (very poor to poor quality).

To calculate the strength of the rock the rock quality designation was observed in the field and point load tests were performed by Thurber for all of the collected rock samples. Additionally, uniaxial compression tests following ASTM D7012 were performed by Golder Associates on 6 selected samples. The unconfined compressive strength (UCS) of the rock estimated from point load tests ranged from 44.7 MPa to 250.5 MPa indicating medium strong to extremely strong rock. The UCS values measured in uniaxial compressive strength tests ranged from 33.6 MPa to 115.5 MPa indicating medium strong to very strong bedrock. In general, the rock was strong to very strong. The strength characteristics of the rock are summarized in Table 5.4.

Table 5.4 – Rock Strength Characteristics

Borehole	Run #	TCR (%)	SCR (%)	RQD (%)	Point Load Test UCS (MPa)	Uniaxial Compression Test UCS (MPa)
GRB16-03	1	100	73	11	250.5	-
	2	95	75	37	82.4	70.2
	3	79	0	0	248.3	-
GRB16-04	1	62	62	30	98.6	61.3
	2	88	85	18	120.0	89.0
GRB16-05	1	100	82	0	-	-
	2	100	83	32	124.3	115.5
GRB16-07	1	100	95	0	105.8	-
	2	85	78	18	130.0	-
GRB16-09	1	90	77	35	78.1	-
	2	95	80	32	71.6	-
GRB16-10	1	67	55	30	108.0	-
	2	95	95	13	127.2	-

Borehole	Run #	TCR (%)	SCR (%)	RQD (%)	Point Load Test UCS (MPa)	Uniaxial Compression Test UCS (MPa)
	3	87	83	17	56.0	-
GRB16-12	1	100	90	40	179.6	108.8
	2	100	98	90	152.4	-
	3	100	92	71	44.7	-
GRB16-13	1	100	100	0	153.1	-
	2	100	97	0	97.3	-
	3	100	83	0	125.6	-
GRB16-14	1	98	96	29	135.9	-
	2	100	100	80	140.1	-
GRB16-21	1	100	67	7	130.6	-
	2	95	42	0	93.0	-
	3	100	71	29	158.8	-
	4	100	88	94	-	33.6

5.13 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in Boreholes 08-060, 08-061, 08-065, GRB16-01, GRB16-04, GRB16-05, GRB16-07, GRB16-09, GRB16-12, GRB16-14, GRB16-16, GRB16-18, GRB16-20 to monitor water levels after completion of drilling. The water levels measured in the piezometers and upon completion of drilling are summarized in Table 5.5.

Table 5.5 – Water Level Measurements

Foundation Unit	Borehole	Date	Water Level (m)		Comment
			Depth	Elevation	
West Approach	GRB16-01	March 2, 2018 March 21, 2018	0.8 1.2	301.6 301.2	Piezometer
West Abutment	08-065	July 4, 2008 August 20, 2008	0.5 0.7	300.1 299.9	Piezometer

Foundation Unit	Borehole	Date	Water Level (m)		Comment
			Depth	Elevation	
	08-066	June 27, 2008	1.8	301.3	Open Borehole
	GRB16-05	March 1, 2018 March 2, 2018 March 21, 2018 April 30, 2018 June 25, 2018	0.2 0.3 0.7 0.9 0.8	300.6 300.5 300.1 299.9 300.0	Piezometer
Pier 1	08-064	June 26, 2008	2.1	298.8	Open Borehole
	GRB16-04	March 1, 2018 March 2, 2018 March 21, 2018 April 30, 2018	0.7 1.6 1.1 0.8	299.4 298.5 299.0 299.3	Piezometer
	GRB16-06	December 12, 2017	2.4	296.8	Open Borehole
	GRB16-08	December 11, 2017	1.2	298.4	Open Borehole
Pier 2	08-062	June 24, 2008	2.1	297.5	Open Borehole
	08-063	June 24, 2018	2.1	296.8	Open Borehole
	GRB16-07	February 15, 2018	-1.8	300.4	Open Borehole
		February 22, 2018 March 2, 2018 March 21, 2018 April 30, 2018 June 25, 2018	-0.4 -0.1 0.0 0.0 0.2	299.0 298.7 298.6 298.6 298.4	Piezometer
	GRB16-09	February 9, 2018	-2.1	302.2	Open Borehole
		February 22, 2018 March 2, 2018 March 21, 2018 April 30, 2018 June 25, 2018	0.3 0.4 0.4 0.0 0.7	299.8 299.7 299.7 300.1 299.4	Piezometer
	GRB16-11	December 15, 2017	3.0	296.2	Open Borehole
Pier 3	4	August 7, 1974	2.0	297.0	Open Borehole

Foundation Unit	Borehole	Date	Water Level (m)		Comment
			Depth	Elevation	
	5	August 7, 1974	1.5	297.0	Open Borehole
	08-061	July 4, 2008 August 20, 2008	1.1 0.7	302.7 303.1	Piezometer
	GRB16-12	January 10, 2018 February 22, 2018 March 21, 2018 April 30, 2018 June 25, 2018	-1.2 -0.2 -0.4 -0.8 -0.2	299.8 298.8 299.0 299.4 298.8	Piezometer
Pier 4	6	August 12, 1974	1.5	295.9	Open Borehole
	7	August 15, 1974	2.1	295.9	Open Borehole
	08-060	July 4, 2008 August 20, 2008	1.5 1.2	301.4 301.7	Piezometer
	GRB16-13	January 17, 2018	-1.2	298.7	Open Borehole
	GRB16-14	March 1, 2018 March 2, 2018 March 21, 2018 April 30, 2018 June 25, 2018	-1.2 -1.2 -1.0 -1.1 -0.5	300.0 300.0 299.8 299.9 299.3	Piezometer
Pier 5	1	November 29, 1971	1.1	295.1	Open Borehole
	8	August 13, 1974	0.6	295.6	Open Borehole
	9	August 14, 1974	1.1	296.1	Open Borehole
	GRB16-15	January 31, 2018	-3.4	300.9	Open Borehole with temp. casing above ground
	River Measurement	-	-	295.7	From GA Drawing
East Abutment	3	December 1, 1971	3.2	306.5	Open Borehole
	GRB16-16	February 27, 2018	3.3	305.3	Piezometer

Foundation Unit	Borehole	Date	Water Level (m)		Comment
			Depth	Elevation	
		March 16, 2018 March 23, 2018 April 30, 2018 June 25, 2018	3.7 3.8 3.4 4.6	304.9 304.8 305.2 304.0	
	GRB16-17	January 25, 2017	4.3	304.8	Open Borehole
	GRB16-19	January 27, 2017	20.3	290	Open Borehole
	GRB16-21	February 27, 2018	2.2	307.1	Open Borehole
East Approach	GRB16-18	February 27, 2018 March 16, 2018 March 23, 2018 April 30, 2018 June 25, 2018	1.7 3.9 2.2 1.8 2.7	308.1 305.9 307.6 308.0 307.1	Piezometer
	GRB16-20	February 27, 2018 March 16, 2018 March 23, 2018 April 30, 2018 June 25, 2018	4.4 4.3 4.8 4.3 5.0	307.4 307.5 307.0 307.5 306.8	Piezometer

The groundwater levels measured in piezometers ranged from 5 m below the ground surface to 1.2 m above the ground surface (Elevations 298.4 to 308.1). In general, the groundwater level is between approximately Elevation 298 and 303 on the west side of the Grand River and between approximately Elevation 305 and 308 on the east side of the Grand River. Since no recent boreholes were drilled within the Grand River, groundwater levels in the river were not known. Artesian conditions with elevation heads ranging from 1.2 m to 3.4 m above ground surface were encountered during drilling at boreholes GRB16-07, GRB16-09, GRB16-10, GRB16-12, GRB16-13, GRB16-14 and GRB16-15. The artesian conditions were observed while drilling through the lower sand and gravel and during bedrock coring suggesting that a confined artesian aquifer is present at this site and has a static water level Elevation of approximately 300 m or higher.

The above values are short-term readings, and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

Due to the proximity of the site to the Grand River flood plain, it is anticipated that the water levels in the sand units identified at the site, may be affected by flooding of the Grand River.

6 CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the sand and silt till from Boreholes GRB16-10 and GRB16-21 were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix A.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Test Results	
		GRB16-10 SS 4 Depth 2.3 m (Upper Sand and Gravel)	GRB16-21 SS 4 Depth 2.3 m (Upper Sand and Gravel)
Sulphide	%	<0.02	<0.02
Chloride	µg/g	67	68
Sulphate	µg/g	22	11
pH	No unit	9.14	8.91
Electrical Conductivity	µS/cm	118	122
Resistivity	Ohms.cm	8470	8200
Redox Potential	mV	230	246

7 MISCELLANEOUS

Altech Drilling & Investigative Services of Elmira, Ontario supplied a D120 track-mounted drill rig and conducted the drilling, sampling and in-situ testing operations for the present investigation.

The coordinates for the boreholes were obtained with GPS equipment by Thurber, and the elevations were provided by WSP.

The drilling and sampling operations in the field for the 2017/2018 investigation, were supervised on a full-time basis by Thurber field technicians.

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

Details of the previous investigation, conducted in 2008, are presented in Reference 1.

Overall supervision of the field program for the present investigation was conducted by Dr. Nancy Berg, EIT. Interpretation of the data and preparation of the 2017/2018 report was carried out by Mr. Geoff Lay, P.Eng, and Mr. Keli Shi, P.Eng.

Mr. Jason Lee, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects, reviewed the report.

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8 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system for a new structure to carry the Highway 7-New EBL and WBL over the Grand River in the Regional Municipality of Waterloo, Ontario.

The General Arrangement (GA) drawing provided by WSP, dated February 2019, indicates that the proposed overpass is a seven-span structure supported by two abutments and six piers. The proposed lengths of the spans are shown in Table 8.0 below, resulting in a total length of 485.0 m. The width of the EBL and WBL bridges is 17.9 m.

Table 8.0 – Proposed Span Lengths

Span	EBL (m)	WBL (m)
West abutment to Pier 1	48.0	48.0
Pier 1 to Pier 2	60.0	60.0
Pier 2 to Pier 3	60.0	60.0
Pier 3 to Pier 4	60.0	60.0
Pier 4 to Pier 5	80.0	80.0
Pier 5 to Pier 6	115.0	115.0
Pier 6 to East Abutment	62.0	62.0

The Highway 7-New bridge over the Grand River will range in elevation from approximately 313.0 m at the west abutment to 310.0 m at the east abutment. Placement of new fill, up to approximately 13.5 m high at the west abutment and approximately 1 m to 2 m at the east abutment, will be required at this site to construct the west and east approaches.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-

build contractor. The contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects, which could affect the design of the project. Contractors must make their own interpretation of the information provided as it may affect equipment selection, proposed construction methods and scheduling.

The discussion and recommendations presented in this report are based on the information provided by WSP and on the factual data obtained in the course of the previous and the present investigations.

9 STRUCTURE CLASSIFICATION

In accordance with the currently applicable Canadian Highway Bridge Design Code (CHBDC) (2019) CSA S6-19, the analysis and design of structures are influenced by its importance category and consequence classification. Such designations are defined by the Regulatory Authority which, in this case, is the Ministry of Transportation of Ontario (MTO).

For the purpose of reporting, the structures have been classified as Lifeline Bridges with Typical Consequence based on CHBDC S6-19 Sections 4.4.2 and 6.5.2, respectively. Seismic analysis and design for Lifeline Seismic Performance Category 3 structures have not been carried out during preparation of this report.

Based on the above classification and Table 6.1 in Section 6.5.2 in the CHBDC (2019), a consequence factor, ψ, of 1.0 has been used for assessing ULS and SLS factored geotechnical resistances. Should the consequence classification change, the geotechnical assessment and recommendations will need to be reviewed and revised as necessary.

10 STRUCTURE FOUNDATIONS

In general, the stratigraphy identified in the investigations consisted of topsoil/alluvium overlying native layers of sand and gravel, silty clay, clayey silt, and silty sand to sandy silt underlain by an extensive deposit of silty sand to sandy silt till which in turn is underlain by a lower sand and gravel layer and dolostone bedrock.

The groundwater levels measured in piezometers ranged from 5 m below the ground surface to 1.2 m above the ground surface (Elevations 308.1 to 298.4). Artesian conditions

with elevation heads ranging from 1.2 m to 3.4 m above ground surface were encountered during drilling at boreholes GRB16-07, GRB16-09, GRB16-10, GRB16-12, GRB16-13, GRB16-14 and GRB16-15. No boreholes have been completed to date at the proposed Piers 5 and 6 (both EBL and WBL structures) within/adjacent to the Grand River to confirm the presence and extent of the lower sand and gravel layer or confirm the artesian conditions (i.e. in the confined aquifer). It is recommended that additional boreholes be completed at these four pier locations prior to construction to confirm the subsurface conditions and groundwater regime.

In the preparation of the geotechnical design recommendations, consideration was given to the following foundation types:

1. Spread footings bearing on native soil
2. Spread footings on engineered fill
3. Steel H-piles driven into the very dense glacial till or to bedrock
4. Augered caissons (drilled shafts) socketed into bedrock with steel casings

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix D.

10.1 Spread Footing on Native Soil

Spread footings bearing on native soil generally are a cost-effective form of construction and are feasible for the foundation elements away from the Grand River provided that the base of the footings located within the floodplain is founded below the scour depth. This foundation option is not feasible for the piers within the Grand River. The temporary excavations for the footings within the floodplain will extend 5 m to 7 m through the upper silty sand to sandy silt and sand and gravel deposits and below the measured water level.

The following risks should be highlighted with respect to footing construction:

- Excavation in the cohesionless soils below the water table without a dewatering system is expected to result in “flowing sand” and is not recommended. Dewatering measures and cofferdams will be required to maintain a dry excavation base and

construct the footings in the dry. The design of the cofferdam/dewatering system is the responsibility of the Contractor.

- Excavation into the silty sand to sandy silt, upper sand and gravel, and silty sand to sandy silt till deposits will likely encounter cobbles and boulders. The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating such obstructions.

- Footings located within the floodplain will be susceptible to scour and must be founded at an elevation that a river hydrologist determines will protect them against undermining by scour.

Spread footings must bear on native undisturbed dense to very dense sand and gravel or dense to very dense silty sand to sandy silt till. Provided a minimum footing width of 3 m is maintained and the front edge of the footing is set back a minimum horizontal distance of twice the footing width behind the forward slope, footings founded on the above recommended strata, must be designed in accordance with the elevations and bearing resistances given in Table 10.1. Footings should be founded at or below these elevations, subject to minimum requirements for frost and scour protection.

Table 10.1 – Bearing Resistances for Spread Footings

Foundation Element for WBL/EBL	Borehole	Highest Founding Elevation (m)	Anticipated Founding Strata	Factored ULS_f (kPa)	Factored SLS (up to 25 mm settlement) (kPa)
West Abutment	08-065 08-066 GRB16-03 GRB16-05	299.5	Dense to V. Dense Sand and Gravel	600	400
Pier 1	08-064 GRB16-04 GRB16-06 GRB16-08	295.0	Dense to V. Dense Sandy Silt to Silty Sand Till / Dense to V. Dense Sand and Gravel	600	400

Foundation Element for WBL/EBL	Borehole	Highest Founding Elevation (m)	Anticipated Founding Strata	Factored ULS_f (kPa)	Factored SLS (up to 25 mm settlement) (kPa)
Pier 2	08-062 08-063 GRB16-07 GRB16-09 GRB16-11	296.0	V. Dense Sandy Silt Till / Dense to V. Dense Sand and Gravel	600	400
Pier 3	5 08-061 GRB16-10 GRB16-12	296.0	V. Dense Sandy Silt Till / Dense to V. Dense Sand and Gravel	600	400
Pier 4	7 08-060 GRB16-13 GRB16-14	293.5	Dense to V. Dense Silty Sand to Sandy Silt Till	600	400
Pier 5	9 10/10a 11 GRB16-15	293.0	Dense to V. Dense Silty Sand to Sandy Silt Till	600	400
Pier 6	12 13 15 (no recent Boreholes)	293.0	Dense to V. Dense Silty Sand to Sandy Silt Till	600	400
East Abutment	GRB16-16 GRB16-17 GRB16-19 GRB16-21	307.0	Dense to V. Dense Sand and Gravel	600(*)	400(*)

*based on minimum footing setback distance of 3 m from the crest of the valley slope

The above recommended factored ULS/SLS bearing resistances assume that adequate scour and erosion protection will be provided at each foundation element.

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.5 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The bearing resistances in Table 10.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2019) Clauses 6.10.2 to 6.10.5.

The geotechnical SLS values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 25 mm across the width of the structure or between foundation elements.

The sliding resistance of cast-in-place concrete founded on the native dense to very dense soils should be designed using an ultimate unfactored coefficient of base friction of 0.45. A resistance factor of 0.6 should be used when checking lateral stability of the footings in sliding mode.

The founding elevations presented in Table 10.1 are expected to extend below the groundwater level. Local groundwater control and prior dewatering, as discussed in Section 15, will be required to construct the footing in the dry and to prevent disturbance of the footing base.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed subgrade surface conforms to the design requirements and has been adequately prepared to receive concrete. Once approved, the subgrade should be protected by a working mat with a minimum thickness of 100 mm and consisting of mass concrete of the same strength and class as that of the footing. Where subexcavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using the same mass concrete.

Footings must be founded at an elevation that a river hydrologist determines will protect them against undermining by scour. During the detail design stage, it is essential that there be discussions between structural engineer, the foundation consultant, a river hydrologist and a geomorphologist to determine appropriate founding elevations.

10.2 Spread Footing on Engineered Fill

Spread footings supported on Granular “A” engineered fill pads are not considered feasible because this foundation type carries a high risk of erosion/scour due to high water level and flood potential within the Grand River floodplain. As a result, this option has not been developed further.

10.3 Driven Steel H-Piles

From a foundation engineering perspective, it is feasible to support the structure on steel H-piles driven into the very dense sandy silt to silty sand till or to bedrock. However, it is recommended that the following risks be addressed prior to selecting this foundation option.

Cobbles and boulders were randomly encountered within the silty sand to sandy silt, upper sand and gravel, and silty sand to sandy silt till deposits. Cobbles and boulders inherently occur in glacial tills and shall be assumed to be present at this site.

The cobbles and boulders may interfere with H-pile installation. The Contractor shall be prepared to remove, dislodge or otherwise penetrate these obstructions to advance the piles to the specified tip elevation/resistance while meeting the specified deflection tolerances. The Contractor shall have appropriate equipment available on site at the time of the pile installation for this purpose.

H-piles driven to bedrock will likely depressurize the artesian layers (i.e. lower sand and gravel deposit) and potentially cause long-term loss of lateral pile support due to continuous upward seepage along pile shafts.

10.3.1 Axial Resistance

The axial resistances of HP 310 X 110 and HP 360 x 132 steel piles, driven into the very dense till and to bedrock were assessed based on the subsurface conditions encountered at the abutment and pier locations. The estimated Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS), as well as the recommended pile tip elevations are summarized in Tables 10.2 and Table 10.3.

Table 10.2 – Estimated Axial Resistance and Pile Tip Elevation for H-Piles with tip in Silty Sand to Sandy Silt Till

Foundation Unit	Borehole	Approx. Underside Pile Cap Elevation (m)	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Pile Section HP 310 X 110		Pile Section HP 360 X 132	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
West Abutment	08-065 08-066 GRB16-03 GRB16-05	306 (WBL) 305.8 (EBL)	289	17 (WBL) 17.2 (EBL)	850(*)	700(*)	1,100(*)	900(*)
Pier 1	08-064 GRB16-04 GRB16-06 GRB16-08	299 (**)	287	12(**)	750	650	950	800
Pier 2	08-062 08-063 GRB16-07 GRB16-09 GRB16-11	299 (**)	287	12(**)	750	650	950	800
Pier 3	5 08-061 GRB16-10 GRB16-12	298.5 (**)	287	11.5(**)	750	650	950	800
Pier 4	7 08-060 GRB16-13	297.5 (**)	287	10.5(**)	750	650	950	800

Foundation Unit	Borehole	Approx. Underside Pile Cap Elevation (m)	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Pile Section HP 310 X 110		Pile Section HP 360 X 132	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
	GRB16-14							
Pier 5	9 10/10a 11 GRB16-15	291.6(^)	TBD(^)	TBD(^)	TBD(^)	TBD(^)	TBD(^)	TBD(^)
Pier 6	12 13 15 (no recent Boreholes)	294.1(^)	TBD(^)	TBD(^)	TBD(^)	TBD(^)	TBD(^)	TBD(^)
East Abutment	GRB16-16 GRB16-17 GRB16-19 GRB16-21	302.2 (WBL) 301.7 (EBL)	290	12.2 (WBL) 11.7 (EBL)	850	700	1,100	900

(*) Shaft friction along pile length within approach fills has been neglected in computing pile capacities

(**) Pile cap elevation has not been provided for Piers 1 to 4, the length provided in table is from the original ground surface to the pile tip elevation

(^) Recommendations for Piers 5 & 6 to be provided following completion of additional boreholes within Grand River

Table 10.3 – Estimated Axial Resistance and Pile Tip Elevation for H-Piles driven to Bedrock

Foundation Unit	Borehole	Approx. Underside Pile Cap Elevation (m)	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Plie Section HP 310 X 110		Pile Section HP 360 X 132	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
West Abutment	08-065 08-066 GRB16-03 GRB16-05	306 (WBL) 305.8 (EBL)	280	26 (WBL) 26.2 (EBL)	2,000	Does not govern	2,400	Does not govern

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Foundation Unit	Borehole	Approx. Underside Pile Cap Elevation (m)	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Plie Section HP 310 X 110		Pile Section HP 360 X 132	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
Pier 1	08-064 GRB16-04 GRB16-06 GRB16-08	299 (*)	279	20 (*)	2,000	Does not govern	2,400	Does not govern
Pier 2	08-062 08-063 GRB16-07 GRB16-09 GRB16-11	299 (*)	279	20 (*)	2,000	Does not govern	2,400	Does not govern
Pier 3	5 08-061 GRB16-10 GRB16-12	298.5 (*)	279	19.5 (*)	2,000	Does not govern	2,400	Does not govern
Pier 4	7 08-060 GRB16-13 GRB16-14	297.5 (*)	280	17.5 (*)	2,000	Does not govern	2,400	Does not govern
Pier 5(^)	9 10/10a 11 GRB16-15	291.6(^)	TBD(^)	TBD(^)	2,000(^)	Does not govern(^)	2,400(^)	Does not govern(^)
Pier 6(^)	12 13 15 (no recent Boreholes)	294.1(^)	TBD(^)	TBD(^)	2,000(^)	Does not govern(^)	2,400(^)	Does not govern(^)
East Abutment	GRB16-16 GRB16-17 GRB16-19	302.2 (WBL) 301.7 (EBL)	278.5	23.7 (WBL) 23.2 (EBL)	2,000	Does not govern	2,400	Does not govern

Foundation Unit	Borehole	Approx. Underside Pile Cap Elevation (m)	Approx. Pile Tip Elevation (m)	Minimum Pile Length Assumed (m)	Plie Section HP 310 X 110		Pile Section HP 360 X 132	
					Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
	GRB16-21							

(*) Pile cap elevation has not been provided for Piers 1 to 4, the length provided in table is from the original ground surface to the pile tip elevation

(^) Recommendations for Piers 5 & 6 to be provided/confirmed following completion of additional boreholes within Grand River

The values of the Factored Geotechnical Resistance at ULS were assessed assuming a Consequence Factor equal to 1 (Typical), and a Resistance Factor equal to 0.4 (Typical degree of understanding of the subsurface conditions), as per CHBDC 2019. The SLS values correspond to a maximum pile settlement of 25 mm. The Factored Geotechnical Resistance at SLS was assessed assuming a factor of 0.8 for typical degree of understanding of the subsurface conditions.

The structural resistance of the pile must be checked by the structural designer.

10.3.2 Downdrag

Downdrag on the piles is not an issue at this site.

10.3.3 Lateral Resistance

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction (ks) and the ultimate lateral resistance (Pult) as follows:

Silty Clay (cohesive soils)

$k_s = 67\ C_u / B$ (kN/m^3)
$p_{ult} = 9\ C_u$ (kPa) at and below a depth of 3B reduced to zero at ground surface

where p_{ult} = ultimate lateral resistance mobilized by a pile, kPa
C_u = undrained shear strength of cohesive soils, kPa
γ = unit weight of soil, kN/m^3

B = width of pile, m

Silty Sand to Sandy Silt Till (cohesionless soils)

k_s = $n_h \cdot z / B$ (kN/m^3)
p_{ult} = $3 \cdot \gamma' \cdot z \cdot K_p$ (kPa)

where z = depth of embedment of pile, m
B = pile width, m
n_h = coefficient related to soil density, kN/m^3 , Table 10.4
γ' = Buoyant unit weight of soil, kN/m^3, Table 10.4
K_p = passive earth pressure coefficient, Table 10.4

The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressure obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, K, for analysis may be obtained by the expression, K = ks x dz x B (kN/m), where ks is the coefficient of horizontal subgrade reaction (kN/m3), B is the pile width (m), dz is the length (m) of the pile segment used in the analysis. The ultimate lateral resistance on any one segment of pile, Pult, may be obtained from the expression, Pult = pult x dz x B. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

Parameters for lateral pile resistance are provided in Table 10.4.

Table 10.4 –Recommended Geotechnical Parameters for Lateral Resistance Design

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
West Abutment	08-065 08-066 GRB16-03 GRB16-05	300.0-299.5	-	11*	3.2	3,600	Compact Silty Sand
		299.5-295.0	-	12*	3.6	6,800	Compact to Very Dense Sand and Gravel
		295.0-281.5	-	10*	4.2	10,900	Dense to Very Dense Silty Sand to Sandy

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
							Silt Till
		281.5-280.0	-	10*	4.3	12,500	Very Dense Gravelly Sand
Pier 1	08-064 GRB16-04 GRB16-06 GRB16-08	299.0-294.0	-	12*	3.5	5,600	Compact to Dense Sandy Gravel
		294.0-285.0	-	10*	4.2	10,900	Very Dense Silty Sand to Sandy Silt Till
Pier 2	08-062 08-063 GRB16-07 GRB16-09 GRB16-11	298.0-296.0	-	9*	2.8	1,300	Loose Silty Sand
		296.0-294.0	-	12*	3.6	6,800	Compact to Dense Sandy Gravel
		294.0-281.0	-	10*	4.2	10,900	Dense to Very Dense Silty Sand to Sandy Silt Till
		281.0-280.0	-	10*	4.3	12,500	Very Dense Sand/Gravel
Pier 3	4 5 08-061 GRB16-10 GRB16-12	298.5-296.5	-	9*	3.0	2,000	Compact Silty Sand
		296.5-294.0	-	12*	3.6	6,800	Dense to Very Dense Sand and Gravel
		294.0-284.0	-	10*	3.8	8,000	Dense to Very Dense Silty Sand to Sandy Silt Till
		284.0-282.5	-	10*	4.3	12,500	Very Dense Sand

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
		282.5-280.0	-	10*	4.3	12,500	Very Dense Silty Sand and Gravel
Pier 4	6 7 08-060 GRB16-13 GRB16-14	298.0-296.0	-	9*	2.8	1,300	Loose Sandy Silt
		296.0-293.5	-	12*	3.2	3,600	Compact to Dense Sand and Gravel
		293.5-284.0		10*	4.2	10,900	Very Dense Silty Sand to Sandy Silt Till
		284.0-280	-	10*	4.2	10,900	Very Dense Gravelly Sand
Pier 5(^)	1, 2 8, 9 10, 10a 11 GRB16-15	297.5-296.0	-	9*	2.8	1,300	Loose Silt
		296.0-295.0	-	10*	3.0	2,000	Loose Silty Sand
		295.0-293.0	-	9*	3.3	4,500	Compact Sandy Gravel
		293.0-280.0	-	10*	4.3	12,500	Dense to Very Dense Silty Sand to Sandy Silt Till
		280.0-278.0	-	10*	4.3	12,500	Very Dense Gravelly Sand
Pier 6(^)	12, 13 14, 15	308.5-306.5	-	11*	3.2	3,600	Compact to Very Dense Sand and Gravel
		306.5-304.5	225	11*	-	-	Very Stiff Clayey Silt

Location	Reference Boreholes	Approx. Elevation (m)	Undrained Shear Strength C_u (kPa)	Unit Weight γ (kN/m^3)	K_p	n_h (kN/m^3)	Soil Conditions
		304.5-283	-	10*	4.3	12,500	Very Dense Silty Sand to Sandy Silt Till
East Abutment	3 GRB16-16 GRB16-17 GRB16-19 GRB16-21	308.5-305.5	-	12*	3.6	6,800	Compact to Very Dense Sand and Gravel
		305.5-301.5	125	11*	-		Stiff Silty Clay
		301.5-300.0	-	12*	3.5	5,600	Dense Sandy Silt
		300.0-278.0	-	10*	4.3	12,500	Very Dense Silty Sand to Sandy Silt Till

* Buoyant unit weight below water table

(^) Recommendations for Piers 5 & 6 to be provided/confirmed following completion of additional boreholes within Grand River

The group efficiency factors can be calculated based on side-by-side and line-by-line factors shown in Figures C6.22, C6.23 and C6.24 of the CHBDC (2019), S6:19 (Commentary).

10.3.4 Pile Installation

All piles shall be installed in accordance with OPSS 903 and SP 109F57.

Pile driving to refusal in dense till must be controlled in accordance with Standard Provision SS103-11 (Hiley Formula) and an ultimate pile resistance must be specified by the designer. The Hiley formula does not need to be used until the pile tip is within 2 m of the design tip elevation. The appropriate pile driving note to be shown on the contract drawing is “Piles to be driven in accordance with Standard SS103-11 using an ultimate geotechnical resistance of R kN per pile” where “R” must have a minimum value of twice the factored design load at ULS. It is recommended that Pile Driving Analysis (PDA) testing be conducted in conjunction with the Hiley tests at this site, to establish set criteria, ensure the integrity of the pile and verify pile ultimate geotechnical resistance.

Due to the presence of cobbles and boulders within the overburden soils at this site, it is anticipated that the piles may encounter refusal above the bedrock surface or be damaged during driving due to these obstructions. Consequently, pile tip protection is recommended for driven H-piles to prevent pile damage during installation. The tips of all driven H-piles must be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point) or an approved equivalent.

H-piles driven to bedrock will likely depressurize the artesian layers (i.e. lower sand and gravel deposit) and potentially cause long-term loss of lateral pile support due to continuous upward seepage along pile shafts. Pre-augering is also not recommended for driven piles at this site given the potential for depressurization of the artesian layer.

The Contract Documents must contain a NSSP alerting the Bidders to the presence of cobbles and boulders in the overburden soils and the use of PDA Testing. Suggested texts for the NSSP's are included in Appendix F. The NSSP should contain a requirement to terminate driving before the pile is damaged by overdriving.

10.4 Augured Caissons (Drilled Shafts) with Steel Casings

Augured caissons socketed into sound bedrock may be used to support the piers. The use of caissons may also be considered for support of the abutments, either founded in the very dense till or socketed into sound bedrock.

Caissons extended into the very dense till would require use of a casing to maintain stability of the caisson sidewalls as well as techniques such as drilling slurry to prevent disturbance of the caisson base.

Caissons socketed into bedrock will require penetrating though the lower sand and gravel deposit prior to reaching bedrock and therefore will depressurize the artesian layers. The short-term and long-term impact of aquifer depressurization must be assessed by a qualified hydrogeologist prior to selecting this foundation option.

10.4.1 Axial Resistance

Table 10.5 presents the factored axial geotechnical resistances calculated for 0.76 m and 1.5 m diameter caissons. The SLS condition will not govern the caisson design founded in

the sound bedrock. The recommended factored ULS resistance values assume that the caisson is in full contact with the rock at the base of the socket. At the abutments, caissons may alternatively be founded in the dense to very dense till deposit. The factored SLS resistances for 15 mm of settlement are also provided.

Table 10.5 – Estimated Axial Resistance and Pile Tip Elevation for Caissons

Foundation Unit	Borehole	Underside of Caisson Elev. (m)	Top of Bedrock Elev./ Sound Bedrock Elev. (m)	Approx. Caisson Base Elev. (m)	Founding Strata	Min. Caisson Length Assumed (m)	0.76 m Diameter		1.5 m Diameter	
							Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
West Abutment	08-065 08-066 GRB16-03 GRB16-05	306 (WBL) 305.8 (EBL)	280 / 279	289	Very Dense Silty Sand to Sandy Silt Till	17	2,200	1,800	-	-
				2 m Socket into Sound Bedrock	Dolostone Bedrock	28	4,000	-	10,000	-
				3.5 m Socket into Sound Bedrock	Dolostone Bedrock	29.5	-	-	13,500	-
Pier 1	08-064 GRB16-04 GRB16-06 GRB16-08	299(*)	279 / 278	2 m Socket into Sound Bedrock	Dolostone Bedrock	22(*)	-	-	10,000	-
				3.5 m Socket into Sound Bedrock	Dolostone Bedrock	23.5(*)	-	-	13,500	-
Pier 2	08-062 08-063 GRB16-07 GRB16-09 GRB16-11	299(*)	279 / 278	2 m Socket into Sound Bedrock	Dolostone Bedrock	22(*)	-	-	10,000	-
				3.5 m Socket into	Dolostone Bedrock	23.5(*)	-	-	13,500	-

Foundation Unit	Borehole	Underside of Caisson Elev. (m)	Top of Bedrock Elev./ Sound Bedrock Elev. (m)	Approx. Caisson Base Elev. (m)	Founding Strata	Min. Caisson Length Assumed (m)	0.76 m Diameter		1.5 m Diameter	
							Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
				Sound Bedrock						
Pier 3	5 08-061 GRB16-10 GRB16-12	298.5(*)	279 / 278	2 m Socket into Sound Bedrock	Dolostone Bedrock	21.5(*)	-	-	10,000	-
				3.5 m Socket into Sound Bedrock	Dolostone Bedrock	23(*)	-	-	13,500	-
Pier 4	7 08-060 GRB16-13 GRB16-14	297.5(*)	280 / 279	2 m Socket into Sound Bedrock	Dolostone Bedrock	19.5(*)	-	-	10,000	-
				3.5 m Socket into Sound Bedrock	Dolostone Bedrock	21(*)	-	-	13,500	-
Pier 5	9 10/10a 11 GRB16-15	291.6(^)	TBD(^)	2 m Socket into Sound Bedrock	Dolostone Bedrock	TBD(^)	-	-	TBD(^)	-
				3.5 m Socket into Sound Bedrock	Dolostone Bedrock	TBD(^)	-	-	TBD(^)	-
Pier 6	12 13 15 (no recent boreholes)	294.1(^)	TBD(^)	2.5 m Socket into Sound Bedrock	Dolostone Bedrock	TBD(^)	-	-	TBD(^)	-
				3.5 m Socket into Sound Bedrock	Dolostone Bedrock	TBD(^)	-	-	TBD(^)	-

Foundation Unit	Borehole	Underside of Caisson Elev. (m)	Top of Bedrock Elev./ Sound Bedrock Elev. (m)	Approx. Caisson Base Elev. (m)	Founding Strata	Min. Caisson Length Assumed (m)	0.76 m Diameter		1.5 m Diameter	
							Factored ULS (kN)	Factored SLS (kN)	Factored ULS (kN)	Factored SLS (kN)
East Abutment	GRB16-16 GRB16-17 GRB16-19 GRB16-21	302.2 (WBL) 301.7 (EBL)	278 / 277	290	Very Dense Silty Sand to Sandy Silt Till	12.2	2,200	1,800	-	-
				2 m Socket into Sound Bedrock	Dolostone Bedrock	25.7	4,000	-	10,000	-
				3.5 m Socket into Sound Bedrock	Dolostone Bedrock	27.2	-	-	13,500	-

(*)Pile cap elevation has not been given for Piers 1 to 4, the length provided in table is from the original ground surface to the pile tip elevation

(^) Recommendations for Piers 5 & 6 to be provided/confirmed following completion of additional boreholes within Grand River

The selection of a suitable socket depth will be governed by axial loads, lateral load and maximum shear and moment demand on each caisson. The structural designer must check the structural capacities of the caissons against the geotechnical resistances.

10.4.2 Lateral Resistance in Soil

The geotechnical lateral resistance of a pile may be calculated using the coefficient of horizontal subgrade reaction (k_s) and the ultimate lateral resistance (P_{ult}) as follows:

<u>Silty Clay (cohesive soils)</u>

$k_s = 67\ C_u / B$ (kN/m^3)

$p_{ult} = 9\ C_u$ (kPa) at and below a depth of 3B reduced to zero at ground surface

where p_{ult} = ultimate lateral resistance mobilized by a pile, kPa

C_u = undrained shear strength of cohesive soils, kPa

γ = unit weight of soil, kN/m^3

B = width of pile, m

Sand and Silt Till (cohesionless soils)

k_s = $n_h \cdot z / B$ (kN/m^3)
p_{ult} = $3 \cdot \gamma' \cdot z \cdot K_p$ (kPa)

where z = depth of embedment of pile, m
B = pile width, m
nh = coefficient related to soil density, kN/m3 , Table 10.4
γ' = Buoyant unit weight of soil, kN/m3, Table 10.4
Kp = passive earth pressure coefficient, Table 10.4

The above equations and parameters provided in Table 10.4 may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressure obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, Ks, for analysis may be obtained by the expression, Ks = ks L D (kN/m), where ks is the coefficient of horizontal subgrade reaction (kN/m3), D is the caisson diameter (m) and L is the length (m) of the caisson segment or element used in the analysis. The ultimate lateral resistance, Pult, can be obtained from the expression, Pult = pult L D. This represents the ultimate load at which the supporting soil fails and will not support any additional load at greater displacements. The coefficient of horizontal subgrade reaction and ultimate lateral resistance should be reduced based on the caisson/pile spacing to account for group effect. The group efficiency factors provided in CHBDC (2019) Commentary Section C6.11.3.4 may be used for a caisson/pile group oriented perpendicular or parallel to the direction of loading.

The ultimate lateral resistance of the caisson/pile group may be estimated to be the smaller of the following two:

1. Ultimate lateral resistance of an equivalent block. The lateral resistance of the block may be estimated as the passive earth pressure (Kp γ'z in kPa) acting over an equivalent wall area that equals to the dimension of the caisson/pile group in plan perpendicular to the loading direction multiplied by a depth of six caisson/pile diameter (6D). The depth should extend from the base of the caisson/pile cap or ground surface (riverbed), whichever is lower. The lateral soil resistance within the frost depth (1.4 m in Kitchener) should be neglected for the piers located on land.

2. Sum of the ultimate lateral resistances of individual caissons/piles in the group reduced by group efficiency factors as per CHBDC (2019) Commentary Section C6.11.3.4.

10.4.3 Lateral Resistance in Rock Socket

The lateral resistance of the socket in the dolostone bedrock at this site may be calculated using ultimate lateral resistance (pult) as follows:

For $z \leq 3D$, $p_{ult} = (1+1.4 * z / D) * s_{rm}$ (MPa)
For $z > 3D$, $p_{ult} = 5.2 * s_{rm}$ (MPa)

Where: z = depth of socket below bedrock surface (m)
D = caisson diameter (m)
s_{rm} = rock mass strength, recommend 4 MPa

The ultimate lateral resistance, Pult, may be obtained from the expression, Pult = pult L D (kN), where D is the caisson diameter (m) and L is the length (m) of the caisson 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. A resistance factor of 0.5 should be applied to the calculated ultimate lateral resistance based on CHBDC (2019).

The spring constant of the socket in the dolostone bedrock can be calculated using coefficient of subgrade reaction (kh) as follows:

$$K_h=0.065\ E_M / (B\ (1- n_r\ ^2)) * [E_M\ B^4 / E_s\ I_s]^{1/12}\ \ (MN/m^3)$$

Where: B = caisson diameter (m)
E_M = rock mass modulus, recommend 1,200 MPa
n_r = 0.2, Poisson's ratio of dolostone bedrock
E_s = elastic modulus of caisson concrete (MPa)
I_s = moment of inertia of a caisson in bending (m^4)

The spring constant, Kh, for analysis may be obtained by the expression, Kh = kh L D (kN/m), where D is the caisson diameter (m) and L is the length (m) of the caisson segment or element used in the analysis.

10.4.4 Caisson Installation

Drilled caissons must be installed in accordance with OPSS 903 where applicable.

Based on the borehole data, caisson excavation will extend through the upper silty sand to sandy silt, sand and gravel, silty sand to sandy silt till, and lower sand and sand and gravel layers, and into dolostone bedrock. The silty sand to sandy silt, upper sand and gravel, and silty sand to sandy silt till deposits were noted to contain cobbles and boulders. Augering and socketing operations may be difficult and significantly impacted by these conditions. The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating such obstructions.

Caisson installation equipment with rock drilling/coring capabilities must be capable of penetrating hard layers within the medium strong to very strong dolostone bedrock. The strength and hardness of this rock must be taken into account when selecting equipment to advance the caisson into rock. Equipment supplied to construct the rock socket must be capable of excavating the bedrock to the specified socket dimensions without disturbing or fracturing the bedrock forming the sidewalls and base of the socket. Blasting to facilitate the removal of bedrock is not permitted.

Permanent casings will be required to maintain stability of the caisson sidewalls in the cohesionless overburden soils and upper portion of the bedrock. Techniques such as drilling slurry will be necessary to prevent disturbance of the caisson base.

High volumes of seepage due to the observed artesian conditions in the lower sand and gravel deposit and the upper fractured portion of the rock 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.

After each rock socket is drilled, cleaned and approved, structural concrete must be placed within 6 hours to prevent softening of the dolostone exposed on the base and sidewalls of the excavation.

10.5 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for the design of conventional, semi-integral or integral abutments.

For integral abutments, the flexibility of the upper portion of the pile may be provided by a single corrugated steel pipe (CSP) system. Reference should be made to the integral abutment manual for details of this system. Piles should be driven first before pouring in loose uniform sand.

10.6 Frost Cover

The design depth of frost penetration for this site is 1.4 m as per OPSD 3090.101. All footing bases and undersides of pile caps/abutment stems must be provided with at least 1.4 m of soil cover.

10.7 Recommended Foundation

From a geotechnical perspective, and based on 2017/2018 information, the recommended foundation at the piers as well as both abutments is shown in Table 10.6.

Table 10.6 – Recommended Foundation

Foundation Element WBL/EBL	Foundation Type
West Abutment	Driven H-Pile into very dense till
Pier 1	Spread Footing
Pier 2	Spread Footing
Pier 3	Spread Footing
Pier 4	Spread Footing
Pier 5	Caissons socketed into sound bedrock (To be confirmed following completion of additional boreholes within Grand River)
Pier 6	Caissons socketed into sound bedrock (To be confirmed following completion of additional boreholes within Grand River)
East Abutment	Caissons founded in very dense till

11 LATERAL EARTH PRESSURES

Earth pressures acting on the abutments may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC 2019 but are generally given by the expression:

$$p_h = K(\gamma h + q)$$

where: p_h = horizontal pressure on the wall at depth h (kPa)

K = earth pressure coefficient (see Table 11.1)

γ = unit weight of retained soil (see Table 11.1)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa).

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added. Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with OPSS.PROV 501.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 11.1.

Table 11.1 – Earth Pressure Coefficients

Wall Condition	Earth Pressure Coefficient (K)			
	OPSS Granular A or OPSS Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48
At rest (Restrained Wall)	0.43	0.62	0.47	0.70
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-

Note: Submerged unit weight should be used below the groundwater level.

If some movement of the wall is allowed (unrestrained system), active horizontal earth pressure may be used in the geotechnical design of the structure. For rigid walls, at-rest horizontal earth pressures should be used.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

The factors in Table 11.1 are “ultimate” values and require certain movements for the respective conditions to be mobilized. The values to be used in the design can be estimated from Figure C6.27 in the Commentary to the CHBDC 2019.

The impact of seismic induced forces on the abutments should be assessed in accordance with Section C6.14.7.2 of the Commentary to the CHBDC.

It is recommended that perforated sub-drains and/or weep holes be installed, where applicable, to provide positive drainage of the granular backfill behind the abutment walls. Reference may be made to OPSD 3102.100 where appropriate.

12 APPROACH EMBANKMENTS AND PERMANENT CUTS

Based on the GA drawing dated February 2019, new fill up to 13.5 m in height will be placed for the west approach embankments and 1 to 2 m of fill will be placed for the east approach embankments of the proposed Grand River Bridges. Permanent cuts up to 10 m will be required into the existing east riverbank to permit construction of Piers 6. Slope inclinations not steeper than 2 horizontal to 1 vertical (2H:1V) may be used for embankments up to 13.5 m in height provided the embankments are constructed with clean earth fill which does not contain medium or high plastic clay. All embankment fills must be constructed with adequate quality control in accordance with OPSS.PROV 206 and OPSS.PROV 501 requirements.

Mid-height berms comprising 2 m wide benches should be incorporated along the length of embankments at greater than 8 m in height. The benches should extend for the length through which the embankment height exceeds 8 m and have a 2% positive grade to shed run-off water.

Where new fill is placed against an existing embankment slope or on a sloping ground surface steeper than 3H:1V, the existing slope should be benched in accordance with OPSD208.010.

It is also recommended that all permanent and temporary slope surfaces be vegetated and seeded in accordance with current MTO practice with reference to OPSS.PROV 804. Surface runoff and precipitation must be prevented from flowing perpendicularly down any slope surface. Erosion protection measures will have to be taken as necessary to maintain slope stability.

Prior to fill placement, the subgrade must be adequately prepared to receive the new fill. All vegetation, topsoil, organics, soft/loosened or wet soils should be sub-excavated.

Permanent cut slopes may be formed at inclinations not steeper than 2H:1V. Flatter slopes may be required in areas of seepage. Excavation for cut slope construction should be carried out in accordance with OPSS.PROV.206.

Mid-height berms comprising 2 m wide benches should be incorporated along the length of earth cuts with depths at or exceeding 6 m. The benches should maintain a 2% slope to shed surface run-off.

Temporary drainage of the cuts should be provided to maintain a relatively dry, stable excavation. Positive drainage of the road base (e.g. access road) and permanent cuts must be provided.

It is recommended that the deep cut between the east abutment and Pier 6 be regularly inspected by geotechnical personnel during construction. Should signs of sloughing, seepage, cracking and or movements on the excavated slope are observed remedial action such as slope flattening, construction of buttress or gravel sheeting should be immediately implemented.

12.1 Slope Stability

Global stability analyses were carried out to assess the global stability of the critical high fill section at the west approach embankment and the deep cut behind the east abutment The stability analyses were performed using the commercially available software Slope/W, developed by GEO-SLOPE International Ltd.

The results of the stability analyses are presented in Appendix E. Factors of Safety equal to or greater than 1.3, 1.5 and 1.1 were computed for the short-term, long-term and seismic conditions, respectively. The results of the analysis indicate that approach embankments up to 13.5 m high should be stable with side slopes inclined to 2H:1V and temporary cuts up to 10 m deep should be stable at 2H:1V inclination. The analysis is based on the assumption that the approach embankments will be constructed using granular material, select subgrade material and/or clean earth fill.

12.2 Settlement

A 0.8 m thick surficial layer of topsoil and very soft silty clay was encountered in the boreholes advanced in the west approach areas. It is recommended that all topsoil and soft materials be stripped within the embankment footprint prior to fill placement. It is estimated that at the west approach embankments, settlements of 20 mm to 25 mm will occur in the foundation soils under the loading imposed by the approximately 13.5 m approach fill. This settlement will be immediate and essentially complete when construction of the fill is completed. Due to the low fill height proposed in the east approach areas, foundation settlement is expected to be negligible.

Embankment settlement due to fill compression is estimated to 0.5% of the fill height. Approximately 50% of the total fill compression (or 0.25% of the fill height) will occur during construction and the remaining 50% or approximately 30 to 35 mm at this site will occur after construction in the west approach area.

No long-term settlement issues are anticipated for approach embankments built at this site.

13 TEMPORARY EXCAVATION

All excavations at this site must be carried out in accordance with the Occupational Health and Safety Act (OHSA). The excavation and backfilling for foundations must be carried out in accordance with OPSS.PROV 902.

Excavation for foundation construction will extend through loose to very dense silty sand to sandy silt, loose to very dense upper sand and gravel, and into the dense to very dense silty sand to sandy silt till deposit.

For the purposes of the OHSA, the fills and native soils above the water table may be classed as Type 3; and the soils below the groundwater level may be classed as Type 4.

Use of a hydraulic excavator should be suitable for excavation in the overburden soils. The selection of the method of excavating soils is the responsibility of the Contractor and must be based on their equipment, experience and interpretation of the site conditions. Provision must be made for handling the potential cobbles and boulders in the silty sand to sandy silt, upper sand and gravel, and silty sand to sandy silt till deposits. The Contractor's excavation

equipment must be able to dislodge and remove these obstructions. Laboured excavation should be anticipated in the hard/dense to very dense soils.

Excavations should regularly be inspected for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

14 BACKFILL TO ABUTMENTS

For backfilling immediately behind the new abutment wall, it is recommended that the new fill be Granular A, Granular B Type II or Granular B Type I materials meeting the gradation and relevant requirements stipulated in OPSS.PROV 1010. Beyond this zone, clean earth fill may be used. The earth fill should not contain medium or high plastic clays or deleterious materials and organics.

The backfill should be in accordance with OPSS.PROV 206 requirements and OPSD 3101.150. Compaction equipment to be used adjacent to abutments/retaining structures must be restricted in accordance to OPSS.PROV 501.

The design of the abutment must incorporate a subdrain as shown in OPSD 3102.100.

15 GROUNDWATER AND SURFACE WATER CONTROL

The observed groundwater levels ranged from 5 m below the ground surface to 3.4 m above the ground surface (Elevations 298.4 to 308.1). In general, the groundwater level is between approximately Elevation 298 and 303 on the west side of the Grand River and between approximately Elevation 305 and 308 on the east side of the Grand River. Due to the fact that no recent boreholes were drilled at Piers 5 and 6 within the Grand River, the groundwater conditions in this area are not known. Artesian conditions with elevation heads ranging from 1.2 m to 3.4 m above ground surface were encountered during drilling in seven boreholes advanced in the flood plain west of Grand River. The artesian conditions were observed while drilling through the lower sand and gravel and during bedrock coring suggesting that a confined artesian aquifer is present at this site and has a static water level Elevation of approximately 301 m.

The groundwater level will vary and may be higher at the time of construction and seasonal fluctuations of the groundwater level are to be expected. Additionally, water levels may be significantly affected during high water level in Grand River.

Excavation for footing or pile cap construction within the floodplain will require cofferdam installation and dewatering. The design of an effective cofferdam and dewatering system is the responsibility of the Contractor. The dewatering equipment may need to handle significant flow volumes in view of the permeable nature of the cohesionless deposits at the site. High volume sumps installed within the excavation in conjunction with interlocking steel sheet piling cutoff around the foundation excavation may provide a suitable system. However, high volume sumps and pumps may not be adequate and a more robust dewatering system may be required. The groundwater control measures must be implemented prior to commencing excavation below the water level.

Installation of sheet pile cofferdams may be problematic due to the frequency of cobbles and/or boulders, as well as the locally very dense conditions. The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating such obstructions. Predrilling may be required for the sheet pile cofferdams to loosen the soils and push obstructions aside from the pile alignment. Suggested wording for an NSSP to alert the Contractor to these conditions is provided in Appendix F.

The dewatering system must be effective to lower the groundwater table at a minimum of 0.5 m below the final subgrade level to avoid basal heave and base boiling. Any accumulation of water from the base of the excavation should be removed prior to placing concrete. Placement of concrete must be done in the dry. Unwatering must remain operational and effective until the footings are constructed and backfilled.

The foundation options being considered for the Grand River Bridges also include caisson foundations socketed into bedrock. Artesian head in the lower sand and gravel layer and in the bedrock underlying this layer must be depressurized before start of caisson construction. Installation of caisson foundations bearing on the bedrock would provide high axial resistance but would have potential for internal erosion of fine-grained material along the sides and at the base of the caisson liner under the artesian conditions. Permanent dewatering of the area could potentially alleviate this concern, but it may impact adjacent well users and surface water features depending on the aquifer properties. The short-term

and long-term impact of aquifer depressurization must be assessed by a qualified hydrogeologist prior to selecting this foundation option.

Dewatering of all excavations should be carried out in accordance with OPSS. PROV 517, SP 517F01 Amendment to OPSS 517, November 2016 (issued July 2017), NSP FOUN0003 and OPSS. PROV 902. A dewatering engineer with a minimum of 10 years experience in designing dewatering systems shall be retained by the Contractor for design of an effective dewatering system.

A Ministry of Environment (MOE) Permit to Take Water (PTTW) or requesting with Environmental Activity and Sector Registry (EASR), depending on the groundwater pumping volume, will be required prior to construction and must be anticipated by the Contractor.

Water discharged from unwatering operations or displaced during concrete placement may not be suitable for direct discharge to the existing water channel. The contract documents must alert the contractor to this fact and include an item for treatment of the water to the satisfaction of MOE, Ministry of Natural Resources (MNR), Department of Fisheries and Oceans (DFO) or other agencies having jurisdiction, prior to discharge to the channel.

16 SCOUR AND EROSION PROTECTION

Erosion protection must be provided to prevent scour and undermining of the footings and pile caps. The depth of scour must be determined by a river/creek hydraulics specialist and the depth of pile embedment to achieve fixity must be measured from the predicted scour level.

Suitable erosion protection (e.g. rip-rap) must also be provided along the toe of any slopes that may be in contact with the high river flow. Above this level, a vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

Erosion and scour protection measures for footings and slopes should be designed by a qualified and experienced hydrological professional.

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17 SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the averaged soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of the site consists of layers of loose to very dense silty sand to sandy silt, firm to stiff clayey silt, and loose to very dense sand and gravel, overlying very dense silty sand to sandy silt till and dolostone bedrock. This would correspond to a Seismic Site Class C in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak seismic hazard values based on the 6th generation seismic hazard maps published by the GSC are provided in Appendix H. The recommended soil-structure interaction springs for shallow surface foundations of Piers 1 to 4 of the proposed bridge produced based on the simplified methods outlined in Section C6.14.5 of the Commentary on CHBDC have been provided in Appendix H. The soil springs have been developed using a lower bound shear wave velocity for a Site Class C (i.e., 360 m/s) and based on the assumption that the pier foundations will have a width of about 11 m and a length of about 13.5 m with be at least 1 m of Rip-Rap be placed above the footings. For design of deep foundations under seismic loading, the static lateral modulus of subgrade reactions should be reduced by about 10% (using a p-multiplier of 0.9).

In accordance with Clause 6.14.7 of the CHBDC 2019, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 17.1 may be used:

Table 17.1 – Earth Pressure Coefficients for Earthquake Loading (2% in 50 Years)

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II ϕ = 35°, γ = 22.8 kN/m^3	**OPSS Granular B Type I ϕ = 32°, γ = 21.2 kN/m^3**
Active (K_{AE})*	0.31	0.35
Passive (K_{PE})	3.5	3.1
At Rest (K_{OE})**	0.57	0.61

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

Based on the subsurface conditions, liquefaction is not considered to be a concern at this site.

18 CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soils during the 2017/2018 investigation indicates the following conditions at the locations tested:

- The potential for sulphate attack on concrete foundations from the surrounding native soils is considered to be negligible due to the low concentration of sulphate and chloride in the samples tested. The selection of class of concrete should consider the effects of the road de-icing salts.

- The potential for soil corrosion on metal is considered to be mild.

- Appropriate protection measures commensurate with the above are recommended if metal structural elements are used. The effects of road de-icing salts should be also considered.

19 CONSTRUCTION CONCERNS

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

1. H-Pile/Caisson Installation

   Cobbles and boulders were encountered within the overburden soils at this site. The cobbles and boulders may interfere with H-pile/caisson installation. The Contractor shall be prepared to remove, dislodge or otherwise penetrate these obstructions to advance the piles to the specified tip elevation/resistance while meeting the specified deflection tolerances. The Contractor shall have appropriate equipment available on site at the time of the H-pile/caisson installation for this purpose.

2. Excavation and Groundwater Control for Footing Construction

   Hydraulic equipment is expected to be capable of excavating to the required depths at this site. The equipment must be capable of penetrating, handling and/or removing cobbles and boulders present within the overburden soils.

   Cofferdam installation in conjunction with dewatering will be required for footing excavation or pile cap construction within the floodplain to permit construction in the dry.

The dewatering equipment may need to handle significant flow volumes in view of the permeable nature of the cohesionless deposits. It is envisaged that high volume sumps and pumps may not be adequate and a more robust dewatering system may be required. Cofferdam installation may be problematic due to the frequency of cobbles and/or boulders, as well as the locally very dense conditions.

The design of an effective cofferdam and dewatering system is the responsibility of the Contractor. The Contractor's dewatering plan must be in place prior to commencing excavation.

3. Excavation and Groundwater Control for Caisson Construction

Groundwater levels observed in the lower sand and gravel layer and dolostone bedrock underling the silty sand to sandy silt till deposit indicated artesian conditions with water levels as high as 3.4 m above existing ground surface. Permanent casings will be required to maintain stability of the caisson sidewalls in the cohesionless overburden soils and upper portion of the bedrock. Techniques such as drilling slurry will be necessary to prevent disturbance of the caisson base.

High volumes of seepage due to the observed artesian conditions in the lower sand and gravel deposit and the upper fractured portion of the rock should be anticipated into caisson excavations. The aquifer will need to be depressurized to prevent erosion and disturbance of the soil during the installation of the caissons. The ground water flowing from the lower aquifer will need to be contained and treated before it can enter the Grand River.

Caisson installation equipment with rock drilling/coring capabilities must be capable of penetrating hard layers within the dolostone bedrock.

4. Confirmation of Subsurface Conditions

As of the date of this report, no boreholes have been completed within Grand River at the proposed Pier 5 and 6 locations. Additional boreholes should be completed within the River prior to construction to confirm the subsurface conditions and the groundwater regime at these locations.

20 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Geoff Lay and Mr. Keli Shi.

The report was reviewed by Mr. Jason Lee, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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

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

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

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

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

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

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Appendix A
Record of Borehole Sheets, Laboratory Test Results for Present Site Investigation and Analytical Laboratory Test Results

Ministry of Transportation
Ontario

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RECORD OF BOREHOLE No GRB16-01 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 260.5 E 227 261.4 ORIGINATED BY AHF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.02.28 - 2018.03.01 LATITUDE 43.473242 LONGITUDE -80.458397 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
302.4	GROUND SURFACE										
0.0	Silty **CLAY**, with organics, trace sand and rootlets Soft Brown Moist		1	SS	2		302				
301.7											
0.7	**SAND** and **SILT**, some clay, trace gravel Compact Brown Moist		2	SS	16	▽	301				
			3	SS	11						6 42 40 12
	Pieces of cobbles		4	SS	14		300				
			5	SS	16		299				
298.2											
4.1	Silty **SAND**, some gravel and clay Dense to Very Dense Grey Moist (TILL)		6	SS	37		298				13 48 27 12
			7	SS	53		297				
			8	SS	100/.200		296				
			9	SS	100/.150		295				
							294				
							293				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-01 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 260.5 E 227 261.4 ORIGINATED BY AHF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.02.28 - 2018.03.01 LATITUDE 43.473242 LONGITUDE -80.458397 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Sandy **SILT**, trace gravel and clay Dense to Very Dense Grey Moist (TILL)						292				
291.5			10	SS	100/				o		
10.9	END OF BOREHOLE AT 10.9m. Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.				.075						

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

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.02	0.8	301.6
2018.03.21	1.2	301.2

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-02 1 OF 1 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 274.6 E 227 299.1 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.02.28 - 2018.02.28 LATITUDE 43.473373 LONGITUDE -80.457933 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
301.4	GROUND SURFACE										
0.0	**TOPSOIL:** (200mm)										
0.2	Silty **CLAY**, with organics, trace rootlets Very Soft to Very Stiff Brown Moist		1	SS	0		301		○		
			2	SS	17				○		
300.0							300				
1.4	Silty **SAND**, some gravel, trace clay Compact to Loose Brown Wet		3	SS	19				○		
	Some organics, trace rootlets Loose to Compact		4	SS	5		299		○		
298.0			5	SS	15		298		○		15 57 21 7
3.4	**SAND** and **SILT**, some clay, trace gravel Compact to Very Dense Brown Moist (TILL)								○		
			6	SS	36		297		○		
							296				
			7	SS	28		295		○		
							294				
293.2			8	SS	64				○		5 37 38 20
8.2	END OF BOREHOLE AT 8.2m. GROUNDWATER WAS ENCOUNTERED AT A DEPTH OF ABOUT 1.4m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED BENTONITE HOLEPLUG TO 0.3m AND CUTTINGS TO SURFACE.										

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-03 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 304.2 E 227 263.6 ORIGINATED BY AHF/SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.03.01 - 2018.03.02 LATITUDE 43.473636 LONGITUDE -80.458376 CHECKED BY RPR

ELEV / DEPTH	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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.5	GROUND SURFACE										
0.0	**TOPSOIL**, trace sand and gravel, trace rootlets Compact Brown Moist		1	SS	5		300		○		
299.7											
0.8	Sandy **GRAVEL**, trace silt, trace clay, occasional cobbles Dense to Compact Brown Moist		2	SS	32				○		60 30 10 (SI+CL)
			3	SS	34		299		○		
	Compact Wet		4	SS	28		298		○		
			5	SS	31		297		○		50 43 7 (SI+CL)
295.9							296				
4.6	Silty **SAND**, some clay, trace gravel, occasional cobbles Very Dense Brown (TILL)		6	SS	89				○		
							295				
	Becoming grey		7	SS	62		294		○		
			8	SS	63		293		○		
							292				
			9	SS	100/275		291		○		

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-03 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 304.2 E 227 263.6 ORIGINATED BY AHF/SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.03.01 - 2018.03.02 LATITUDE 43.473636 LONGITUDE -80.458376 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (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
	Continued From Previous Page										
	Silty **SAND**, some clay, trace gravel, occasional cobbles Very Dense Grey (TILL)						290				
			10	SS	100				o		9 46 28 17
							289				
			11	SS	100/.150				o		
							288				
			12	SS	54		287		o		
							286				
			13	SS	79		285		o		
284.2											
16.3	**SAND** and **SILT**, some clay, trace gravel, occasional cobbles Very Dense Grey Wet (TILL)						284				
			14	SS	80				o		
							283				
	(CL-ML)		15	SS	76		282		⊣		7 40 36 17
							281				
			16	SS	100/				o		

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-03 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 304.2 E 227 263.6 ORIGINATED BY AHF/SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.03.01 - 2018.03.02 LATITUDE 43.473636 LONGITUDE -80.458376 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	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
	Continued From Previous Page								
280.0	**SAND** and **SILT**, some clay, trace gravel, occasional cobbles Very Dense Grey Wet (TILL)		17	SS	100/ .075		280	FI	
20.5	**DOLOSTONE,** with limestone interbeds, grey: (Salina Formation) Vertical joint at 20.7m, 20.9m, 21.0m, 21.2m, 21.3m, 21.4m, 21.5m		1	RUN	.075			1 3 5	RUN #1 TCR=100% SCR=73% RQD=11% UCS=250.5MPa (PLT)
	Vertical joint at 21.7m, 21.8m, 22.0m, 22.2m, 22.5m, 22.7m, 22.9m, 23.0m, 23.1m Saturated clay seam (175mm) at 22.0m		2	RUN			279 278	1 3 2 1 2	RUN #2 TCR=95% SCR=75% RQD=35% UCS=70.2MPa UCS=82.4MPa (PLT)
276.5	Erosion (150mm) at 23.6m and (100mm) at 23.8m Vertical joint at 23.4m, 23.5m, 23.6m, 23.7m, 23.8m		3	RUN			277	4 3 4	RUN #3 TCR=79% SCR=66% RQD=21% UCS=248.3MPa (PLT)
24.0	END OF BOREHOLE AT 24.0m. ADDITIONAL WATER WAS USED FOR CORING. THEREFORE, GROUNDWATER LEVEL WAS NOT MEASURED. BOREHOLE BACKFILLED WITH 6 BAGS OF GROUT.								

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-04 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 351.6 E 227 300.6 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.24 - 2018.02.28 LATITUDE 43.474066 LONGITUDE -80.457925 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.1	GROUND SURFACE										
0.0	**TOPSOIL**, trace rootlets Loose Dark Brown Moist		1	SS	4		300				
299.4											
0.7	Sandy **GRAVEL**, some organics, trace rootlets, trace silt, trace clay Compact Dark Brown Moist		2	SS	18		299				Wet Spoon
	Brown		3	SS	23		298				
			4	SS	17						58 31 11 (SI+CL)
	Auger grinding from 3.1m to 4.6m		5	SS	26		297				
296.0											
4.1	**SAND** and **SILT**, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)		6	SS	30		296				
			7	SS	50		295				
			8	SS	100		294				7 40 37 16
			9	SS	90		293				
							292				
							291				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-04 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 351.6 E 227 300.6 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.24 - 2018.02.28 LATITUDE 43.474066 LONGITUDE -80.457925 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace to some gravel Very Dense Brown Moist (TILL)						290				
			10	SS	87		289		o		
							288				
	(CL-ML)		11	SS	55				o H		6 42 40 12
							287				
			12	SS	79		286		o		
							285				
	Occasional cobbles		13	SS	73				o		
							284				
			14	SS	63		283		o		
							282				
			15	SS	79				o		15 38 32 15
							281				
			16	SS	100/						No recovery

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-04 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 351.6 E 227 300.6 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.24 - 2018.02.28 LATITUDE 43.474066 LONGITUDE -80.457925 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (UNCONFINED, QUICK TRIAXIAL, FIELD VANE, LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Possible artesian conditions encountered. 1.5m of casing added above ground level to manage artesian condition				.060		280				
279.0							279				
21.1	**DOLOSTONE,** with limestone interbeds, moderately weathered, thinly bedded, grey: (Salina Formation)										
	Artesian condition at 21.3m		1	RUN						FI	RUN #1
	Vugs at 21.3m						278			4	TCR=62%
										4	SCR=62%
										6	RQD=30%
										9	UCS=61.3MPa
										5	UCS=98.6MPa
	Vertical joint (75mm) at 21.9m										(PLT Average)
	Sub-angular joint (75mm) at 22.0m		2	RUN			277			2	RUN #2
	Vertical joint at 22.3m									7	TCR=88%
										6	SCR=85%
	Vugs at 23.6m, 24.0m										RQD=18%
275.8							276				UCS=89MPa
24.3	END OF BOREHOLE AT 24.3m. Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										UCS=120MPa (PLT Average)

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.01	0.7	299.4
2018.03.02	1.6	298.5
2018.03.21	1.1	299.0
2018.04.30	0.8	299.3

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

(%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-05 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 326.1 E 227 319.3 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.16 - 2018.02.23 LATITUDE 43.473839 LONGITUDE -80.457691 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.8	GROUND SURFACE										
0.0 / 300.2	**TOPSOIL**, trace rootlets Compact Dark Brown Wet		1	SS	12				○		
0.6 / 299.4	Silty **SAND**, trace gravel, occasional cobbles Compact Brown Wet		2	SS	17	▼	300		○		
1.4	**SAND** and **GRAVEL**, trace silt, occasional cobbles Very Dense to Dense Brown Wet		3	SS	60		299		○		52 39 9 (SI+CL)
	Auger grinding from 2.1m to 2.4m		4	SS	61		298		○		
			5	SS	42		297		○		
	Auger grinding from 4.6m to 5.2m		6	SS	42		296		○		38 54 8 (SI+CL)
294.9	Auger grinding from 5.8m to 6.1m						295				
5.9	**SAND** and **SILT**, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)		7	SS	36		294		○		
			8	SS	50		293		○		
			9	SS	100/225		292		○		
							291				

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-05 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 326.1 E 227 319.3 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.16 - 2018.02.23 LATITUDE 43.473839 LONGITUDE -80.457691 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)										
			10	SS	64		290		○		
							289				
			11	SS	94		288				
							287				
			12	SS	54				○		8 40 39 13
							286				
	Possible artesian conditions encountered at 15.2m. 1.5m of casing added above ground level to manage artesian condition		13	SS	47				○		
							285				
			14	SS	46		284		○		
							283				
			15	SS	38				○		
281.5							282				
19.3	Gravelly **SAND**, some silt, trace clay Very Dense Brown Moist										
			16	SS	100/		281		○		26 45 29

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 GRB16-05 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 326.1 E 227 319.3 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.16 - 2018.02.23 LATITUDE 43.473839 LONGITUDE -80.457691 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	Gravelly **SAND**, some silt, trace clay Very Dense Brown Moist				.275		280			FI	(SI+CL)
279.6											
21.2	**DOLOSTONE**, with limestone interbeds, moderately weathered, thinly bedded, grey: (Salina Formation) Vertical joint at 21.3m		1	RUN			279			6 11 8 14	RUN #1 TCR=100% SCR=88% RQD=0%
	Vertical joint at 21.8m, 22.6m and (25mm) at 22.9m									13	
	Vugs at (150mm) 23.2m		2	RUN			278 277			12 9 9 3	RUN #2 TCR=100% SCR=83% RQD=32% UCS=115.5MPa UCS=124.3MPa (PLT Average)
276.4	Vertical joint (25mm) at 24.4m									8	
24.4	END OF BOREHOLE AT 24.4m. Piezometer installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.01	0.3	300.5
2018.03.02	0.3	300.5
2018.03.21	0.8	300.0
2018.04.30	0.9	299.9
2018.06.25	0.8	300.0

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-06 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 345.5 E 227 275.8 ORIGINATED BY CAR

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.12 - 2017.12.13 LATITUDE 43.474008 LONGITUDE -80.458231 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (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
299.2	GROUND SURFACE										
0.0	**TOPSOIL**, trace sand, trace gravel Loose Dark Brown Moist		1	SS	8		299				
298.6											
0.7	**SAND** and **GRAVEL**, trace silt, trace clay, occasional cobbles Compact to Very Dense Brown Moist		2	SS	21		298				
			3	SS	36						58 33 9 (SI+CL)
	Auger grinding at 2.3m Wet		4	SS	87	▽	297				
			5	SS	42		296				
			6	SS	37		295				
			7	SS	42						28 59 13 (SI+CL)
293.0							294				
6.2	Silty **SAND**, some to trace gravel, trace clay Compact Brown Wet (TILL)		8	SS	22		293				
			9	SS	29		292				
							291				
			10	SS	12		290				10 57 24 9

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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-06 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 345.5 E 227 275.8 ORIGINATED BY CAR

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.12 - 2017.12.13 LATITUDE 43.474008 LONGITUDE -80.458231 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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
	Continued From Previous Page											
289.0												
10.2	**SAND** and **SILT**, trace to some clay, trace to some gravel Very Dense Grey Wet (TILL)		11	SS	80		289			○		
							288					
	Brown		12	SS	72		287			○		3 38 44 15
							286					
285.0			13	SS	73		285			○		
14.3	END OF BOREHOLE AT 14.3m. BOREHOLE OPEN TO 3.7m AND WATER LEVEL AT 2.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.											

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-07 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 403.2 E 227 312.8 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.12 - 2018.02.15 LATITUDE 43.474532 LONGITUDE -80.457781 CHECKED BY RPR

ELEV / DEPTH	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
298.6	GROUND SURFACE										
0.0 / 298.1 / 0.5	**TOPSOIL**, trace rootlets Very Loose Dark Brown Moist		1	SS	3	▽	298		○		
	Silty **SAND**, some clay Loose Brown Moist		2	SS	5				○		0 67 21 12
296.3			3	SS	4		297		○		
2.3	Sandy **GRAVEL**, trace silt, trace clay Compact to Dense Brown Auger grinding at 2.7m		4	SS	28		296		○		
	Auger grinding at 3.7m		5	SS	44		295		○		Wet Spoon
293.3			6	SS	26		294		○		
5.3	Silty **SAND** to Sandy **SILT**, trace gravel to gravelly, trace clay to clayey Dense to Very Dense Brown Wet (TILL)		7	SS	38		293		○		24 50 20 6
			8	SS	66		292		○		
			9	SS	34		291		○		11 34 36 19
							290		○		
							289				

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 GRB16-07 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 403.2 E 227 312.8 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.12 - 2018.02.15 LATITUDE 43.474532 LONGITUDE -80.457781 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (UNCONFINED, FIELD VANE, QUICK TRIAXIAL, LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Silty **SAND** to Sandy **SILT**, trace gravel to gravelly, trace clay to clayey Very Dense to Dense Brown Wet (TILL)						288				
			10	SS	88				o		
							287				
	Auger grinding at 11.6m										
			11	SS	53		286		⊢●⊣		5 20 53 22
	(CL)										
							285				
			12	SS	55				o		
							284				
			13	SS	30		283		o		
281.1							282				
			14	SS	75				o		
17.5	**SAND**, some gravel, trace silt, trace clay, occasional shale fragments Very Dense Brown Wet						281				
			15	SS	100/ .250				o		10 77 13 (SI+CL)
	Artesian conditions encountered. 1.5m of casing added above ground level to manage artesian condition Auger refusal at 19.4m, switched to coring						280				
278.9											
19.7	**DOLOSTONE,** with limestone interbeds, moderately weathered,						279			FI	RUN #1
	Continued Next Page										

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-07 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 403.2 E 227 312.8 ORIGINATED BY MB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.12 - 2018.02.15 LATITUDE 43.474532 LONGITUDE -80.457781 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (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
	Continued From Previous Page										
	thinly laminated, grey: (Salina Formation)		1	RUN						11	TCR=100% SCR=95% RQD=0% UCS=105.8MPa (PLT Average)
	Vugs at 19.8m									17	
	Rubble zone at 20.1m						278				
	Vertical joint at 19.9m, 20.3m, 20.5m									11	
										12	
										108	RUN #2 TCR=85% SCR=78% RQD=18% UCS=130MPa (PLT Average)
							277				
	Rubble zone at 21.7m, 22.4m		2	RUN						9	
	Vertical joint at 22.3m									8	
	Vugs at 22.2m, 22.3m, 22.5m									9	
	Clay void at 22.5m										
275.9							276			6	
22.7	END OF BOREHOLE AT 23.0m. WATER LEVEL 1.8m ABOVE GROUND SURFACE UPON COMPLETION. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.1m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.02.22	-0.4	299.0
Artesian Condition		
2018.03.02	-0.1	298.7
Artesian Condition		
2018.03.21	0.0	298.6
2018.04.30	0.0	298.6
2018.06.25	0.2	298.4

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-08 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 369.3 E 227 329.9 ORIGINATED BY CAR

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.11 - 2017.12.12 LATITUDE 43.474229 LONGITUDE -80.457566 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED (O), 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
299.6	GROUND SURFACE										
0.0	**TOPSOIL**, some sand, some silt Soft Brown Moist		1	SS	3		299				
298.2			2	SS	5	▽					
1.4	Sandy **GRAVEL** to Gravelly **SAND**, trace silt, trace clay, occasional cobbles Compact to Dense Brown Wet		3	SS	29		298				
	Auger grinding at 2.3m		4	SS	44		297				56 33 11 (SI+CL)
			5	SS	19		296				
	Auger grinding at 3.8m		6	SS	34						20 73 7 (SI+CL)
			7	SS	20		295				
293.4							294				
6.2	**SAND** and **SILT**, trace gravel, some clay to clayey, occasional cobbles/boulders Dense to Very Dense Grey Moist (TILL)		8	SS	100/225		293				
			9	SS	35		292				
							291				
	(CL)		10	SS	75		290				7 37 38 18
	Auger grinding at 9.8m										

Continued Next Page

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

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

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THURBER

RECORD OF BOREHOLE No GRB16-08 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 369.3 E 227 329.9 ORIGINATED BY CAR

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.11 - 2017.12.12 LATITUDE 43.474229 LONGITUDE -80.457566 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page									
	SAND and **SILT**, trace gravel, trace to some clay, occasional cobbles/boulders Dense to Very Dense Grey Moist (TILL)		11	SS	100/ .125		289 288			
287.3			12	SS	100/				○	
12.3	END OF BOREHOLE AT 12.4m. BOREHOLE OPEN TO 13.0m AND WATER LEVEL AT 1.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.				.150					

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-09 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 409.0 E 227 291.0 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.02.01 - 2018.02.09 LATITUDE 43.474582 LONGITUDE -80.458052 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.1	GROUND SURFACE										
0.0	**TOPSOIL**, trace rootlets, wood fibre Loose Dark Brown Frozen		1	SS	3		300				
299.5											
0.6	Silty **SAND**, trace gravel, trace clay Loose Brown Wet		2	SS	3	▼	299				
	Organic layer		3	SS	5		298				
297.9											
2.2	**SAND** and **GRAVEL**, trace silt, trace clay, occasional cobbles Dense Brown Wet		4	SS	38		297				43 39 18 (SI+CL)
	Auger grinding from 2.4m to 2.7m		5	SS	44		296				
	Auger grinding from 3.0m to 4.6m		6	SS	38		295				
294.6											
5.5	**SAND** and **SILT**, some clay, trace to some gravel Dense to Very Dense Brown Wet (TILL)		7	SS	35		294				
			8	SS	38		293				4 44 39 13
			9	SS	62		292				
							291				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-09 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 409.0 E 227 291.0 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.02.01 - 2018.02.09 LATITUDE 43.474582 LONGITUDE -80.458052 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace to some gravel Dense to Very Dense Brown Wet (TILL)						290				
			10	SS	43		289		○		
			11	SS	100/.125		288		○		
			12	SS	60		287		○		
			13	SS	55		286		○		14 43 31 12
			14	SS	100/.275		285		○		
282.5	Auger grinding at 17.4m						284		○		
17.6	**GRAVEL**, some sand, trace silt, occuring shale fragments Very Dense Brown Wet		15	SS	100		283				
	Artesian conditions encountered. 1.5m of casing added above ground level to manage artesian condition						282		○		
	Auger refusal at 20.2m, switched to coring		16	SS	100/		281				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-09 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 409.0 E 227 291.0 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2018.02.01 - 2018.02.09 LATITUDE 43.474582 LONGITUDE -80.458052 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
279.9					.025		280				
20.2	**DOLOSTONE,** with limestone interbeds, moderately weathered, thinly laminated, grey: (Salina Formation) Artesian conditions encountered Rubble zone at 21.0m, 21.1m Vertical joint at 21.2m		1	RUN			279				RUN #1 TCR=90% SCR=77% RQD=35% UCS=78.1MPa (PLT Average)
	Rubble zone at 22.1m, 22.3m and 22.6m Vertical joint at 22.7m Vugs at 22.8m		2	RUN			278				RUN #2 TCR=95% SCR=80% RQD=32% UCS=71.6MPa (PLT Average)
276.8							277				
23.3	END OF BOREHOLE AT 23.4m. WATER LEVEL 2.1m ABOVE GROUND SURFACE UPON COMPLETION. Well installation consists of 50mm diameter Schedule 40 PVC pipe with a 3.1m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.02.22	0.3	299.8
2018.03.02	0.4	299.7
2018.03.21	0.4	299.7
2018.04.30	Surface	-
2018.06.25	0.7	299.4

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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-10 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 488.4 E 227 332.9 ORIGINATED BY JZ/SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2017.12.17 - 2017.12.20 LATITUDE 43.475301 LONGITUDE -80.457546 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.8	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)										
0.2	Silty **SAND**, trace clay, trace gravel Compact to Very Dense Brown Wet		1	SS	6						
			2	SS	12		298				6 58 28 8
			3	SS	51		297				
296.6	Auger grinding at 2.1m										
2.2	**SAND** and **GRAVEL**, trace silt, trace clay, occasional cobbles Dense Brown Wet		4	SS	47		296				
	Auger grinding from 2.4m to 2.9m Severe auger grinding caused drill rig to stall from 3.0m to 3.7m		5	SS	43		295				48 43 9 (SI+CL)
293.9			6	SS	56		294				
4.9	**SAND** and **SILT**, trace gravel, trace clay, occasional cobbles and boulders Dense to Very Dense Brown Wet (TILL)						293				
	Low SPT "N" likely due to hydraulic disturbance with sand blowback Auger grinding at 6.7m		7	SS	11		292				6 33 52 9
	Auger grinding at 8.7m		8	SS	44		291				
			9	SS	80		290				
	Auger grinding at 9.9m						289				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-10 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 488.4 E 227 332.9 ORIGINATED BY JZ/SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2017.12.17 - 2017.12.20 LATITUDE 43.475301 LONGITUDE -80.457546 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, trace gravel, some clay to clayey, occasional cobbles and boulders Compact to Very Dense Brown Wet (TILL) (CL)						288				
			10	SS	44				○		4 33 44 19
							287				
			11	SS	28				○		
							286				
			12	SS	62		285		○		
284.1											
14.7	**SAND**, coarse grained, trace silt, saturated Very Dense Grey Wet Auger grinding from 14.7m to 15.2m		13	SS	100/ 250		284		○		
282.9							283				
15.9	Silty **SAND** and **GRAVEL**, trace to some clay, occasional cobbles Very Dense Brown Wet		14	SS	100/ .225		282		○		
							281				
			15	SS	100/ .225				○		34 35 31 (SI+CL)
	Heavy grinding from 19.5m to 20.1m						280				
			16	SS	100/		279				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-10 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 488.4 E 227 332.9 ORIGINATED BY JZ/SB

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2017.12.17 - 2017.12.20 LATITUDE 43.475301 LONGITUDE -80.457546 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (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
278.7	Continued From Previous Page				.200					FI	
20.1	**DOLOSTONE,** with limestone interbeds, grey: (Salina Formation)		1	RUN						3	RUN #1 TCR=67% SCR=55% RQD=30% UCS=108MPa (PLT Average)
	Horizontal joint at 20.3m, 20.4m and 20.6m						278			1	
	Vertical joint at 21.2m		2	RUN						3	RUN #2 TCR=95% SCR=95% RQD=13% UCS=127.2MPa (PLT Average)
	Horizontal joint at 21.0m, 21.2m, 21.3m, 21.4m, 21.5m, 21.6m, 21.9m, 22.0m and 22.4m						277			5	
	Sub-vertical joint (50mm) at 23.3m. Vertical joint at 22.9m, (75mm) at 23.1m and (50mm) at 23.3m.									2	
	Horizontal joint at 22.7m, 22.8m, 22.9m, 23.1m, 23.2m, 23.3m and 23.4m		3	RUN			276			3	
	Artesian conditions encountered during 3rd core run, resulting in									1	
275.2	borehole needing to be terminated									2	RUN #3 TCR=87% SCR=83% RQD=17% UCS=56MPa (PLT Average)
23.6	END OF BOREHOLE AT 23.6m. ARTESIAN CONDITIONS ENCOUNTERED UPON COMPLETION OF DRILLING. THEREFORE, GROUNDWATER LEVEL WAS NOT MEASURED. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND AUGER CUTTINGS TO SURFACE.									5	
										7	
										2	

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-11 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 423.4 E 227 347.5 ORIGINATED BY CAR

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.13 - 2017.12.15 LATITUDE 43.474717 LONGITUDE -80.457356 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED (O), QUICK TRIAXIAL (●), FIELD VANE (+), 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
299.2	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)										
0.2	Silty **SAND**, trace clay, trace gravel, occasional cobbles Loose Brown Moist to Wet		1	SS	4		299				
			2	SS	4		298				
297.7											
1.5	**SAND** and **GRAVEL**, trace silt, trace clay Dense to Very Dense Brown Wet		3	SS	32		297				
			4	SS	47						
	Heavy grinding on boulders/cobbles at 2.1m Borehole moved 1.0m southeast and continued to advance		5	SS	85	▽	296				57 32 11 (SI+CL)
			6	SS	33		295				
294.2			7	SS	79						
5.0	**SAND** and **SILT**, some clay, trace to some gravel, occasional cobbles Dense to Very Dense Brown Moist (TILL) (CL-ML)		8	SS	50		294				11 40 36 13
			9	SS	100/.275		293				
			10	SS	106/.225		292				
							291				
			11	SS	81		290				9 36 39 16

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-11 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 423.4 E 227 347.5 ORIGINATED BY CAR

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.13 - 2017.12.15 LATITUDE 43.474717 LONGITUDE -80.457356 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace gravel, occasional cobbles Dense to Very Dense Brown Moist (TILL)						289				
			12	SS	37		288		○		
			13	SS	100/ 250		287		○		
	Occasional sand seams between 12.2m and 12.8m						286				
			14	SS	106/ .225		285		○		
284.6											
14.6	**SAND**, trace gravel, trace silt, Compact Brown Wet Lower SPT "N" blow counts likely due to hydraulic disturbance		15	SS	26		284		○		1 88 11 (SI+CL)
283.2	Heavy grinding at 16.2m										
16.0	**GRAVEL** and **COBBLES** Very Dense Grey Wet		~~16~~	~~SS~~	~~100/ .025~~		283				No recovery
	Cored through multiple boulders (size up to 250mm)						282				
			17	SS	112/ .225		281				No recovery
280.3	Possible boulder at 18.4m										
18.9	END OF BOREHOLE AT 18.9m AUGER REFUSAL ON POSSIBLE BOULDER. BOREHOLE CAVED TO 7.6m AND WATER LEVEL AT 3.0m UPON COMPLETION. BOREHOLE BACKFILLED WITH										

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-11 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 423.4 E 227 347.5 ORIGINATED BY CAR

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MP

DATUM Geodetic DATE 2017.12.13 - 2017.12.15 LATITUDE 43.474717 LONGITUDE -80.457356 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	BENTONITE HOLEPLUG TO SURFACE.										

○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

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

(%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No GRB16-12 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 488.4 E 227 354.6 ORIGINATED BY JZ/ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.01.02 - 2018.01.09 LATITUDE 43.475303 LONGITUDE -80.457278 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.6	GROUND SURFACE										
0.0	**TOPSOIL** Dark Brown Moist		1	SS	21						
297.8	Boulders from 0.5m to 0.8m						298				
0.8	**SAND** and **GRAVEL**, trace to some silt, trace clay Compact to Very Dense Brown Wet		2	SS	18						
	Auger grinding at 1.5m		3	SS	14		297				
	Possible cobbles and boulders		4	SS	40		296				62 28 10 (SI+CL)
	Auger grinding at 3.0m		5	SS	100/.150						
	Possible cobbles and boulders		6	SS	100/.250		295				
293.7			7	SS	52		294				
4.9	**SAND** and **SILT**, some clay, trace gravel Very Dense Brown to Grey Moist (TILL)						293				
	Auger grinding at 5.5m		8	SS	100/.175		292				
	Auger grinding at 7.2m		9	SS	60		291				5 36 44 15
	Possible cobbles and boulders						290				
	Auger grinding at 8.9m		10	SS	79		289				

Continued Next Page

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

15 20 10 5 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-12 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 488.4 E 227 354.6 ORIGINATED BY JZ/ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.01.02 - 2018.01.09 LATITUDE 43.475303 LONGITUDE -80.457278 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
	SAND and **SILT**, some clay, trace gravel Very Dense Brown to Grey Wet (TILL)		11	SS	100/.225		288		○		
			12	SS	64		287		○		
			13	SS	67		286		○		11 39 36 14
283.8	(CL-ML)						285				
14.8	**SAND**, some silt, trace clay, occasional cobbles Very Dense Grey Wet		14	SS	100		284		○		
282.3			15	SS	100/250		283				
16.3	Gravelly **SAND**, some silt, trace clay, occasional cobbles Very Dense Grey Wet Boulders at 17.7m		16	SS	100/.200		282		○		21 56 17 6
280.1							281				
18.5	**GRAVEL**, trace sand, occasional shale fragments Very Dense Grey Wet Auger refusal at 19.4m						280				
279.1										FI	
19.5	**DOLOSTONE,** with limestone interbeds, moderately weathered, thinly bedded, horizontal laminated,		1	RUN			279			5	RUN #1 TCR=100% SCR=90% RQD=40%

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-12 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 488.4 E 227 354.6 ORIGINATED BY JZ/ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.01.02 - 2018.01.09 LATITUDE 43.475303 LONGITUDE -80.457278 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page									
	grey: (Salina Formation) Limestone interbed at 19.5m and 19.8m Clay seam at 20.0m									8
										>10
			2	RUN			278			5
	Limestone interbeds at 20.1m, 20.4m, 20.6m, 20.9m, 21.0m and 21.4m Vertical fracture at 20.2m and 21.2m Sub-vertical fracture at 21.2m and 21.9m									6 8 6
			3	RUN			277			>10
276.1	Artesian conditions encountered, resulting in borehole needing to be terminated									8 4
22.5	END OF BOREHOLE AT 22.5m Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.1m slotted screen.									

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.01.10	-1.2	299.8
Artesian Condition		
2018.02.22	-0.2	298.8
Artesian Condition		
2018.03.21	-0.4	299.0
Artesian Condition		
2018.04.30	-0.8	299.4
2018.06.25	-0.2	298.8

REMARKS & GRAIN SIZE DISTRIBUTION (%)

UCS=108.8MPa
UCS=179.6MPa
(PLT Average)
RUN #2
TCR=100%
SCR=98%
RQD=90%

UCS=152.4MPa
(PLT Average)

RUN #3
TCR=100%
SCR=92%
RQD=71%

UCS=44.7MPa
(PLT Average)

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

(%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No GRB16-13 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 548.0 E 227 356.1 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.01.10 - 2018.01.17 LATITUDE 43.475840 LONGITUDE -80.457267 CHECKED BY RPR

ELEV / DEPTH	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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
297.5	GROUND SURFACE										
0.0	**TOPSOIL:** (100mm)										
0.1	Clayey **SILT**, trace sand, trace organics Firm Brown Moist		1	SS	8		297		○		
	Trace rootlets Auger grinding from 1.4m to 2.3m		2	SS	5				○		
295.9							296				
1.6	**SAND** and **GRAVEL**, trace silt Compact to Loose Brown to Dark Grey Moist to Wet		3	SS	20				○		
			4	SS	6		295		○		
	Occasional cobbles		5	SS	24		294		○		55 35 10 (SI+CL)
293.6											
3.9	**SAND** and **SILT**, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)		6	SS	38				○		
			7	SS	80		293		○		
	(CL-ML)		8	SS	76		292		○		8 43 37 12
			9	SS	56		291		○		
			10	SS	85		290		○		
							289				
							288				

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

15 20 10 5 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No GRB16-13 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 548.0 E 227 356.1 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.01.10 - 2018.01.17 LATITUDE 43.475840 LONGITUDE -80.457267 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace gravel Very Dense Brown Moist (TILL)						287				
			11	SS	66				○		12 41 36 11
							286				
			12	SS	79		285		○		
283.4			13	SS	100/.250		284		○		
14.1	Sandy **GRAVEL**, some silt Very Dense Brown Wet Auger grinding from 14.0m to 15.2m						283				
			14	SS	100/.175		282		○		
281.5											
16.0	Gravelly Silty **SAND**, trace clay, occasional shale fragments Very Dense Grey Wet						281				
			15	SS	58				○		23 44 24 9
280.1	Auger refusal at 17.4m										
17.4	**DOLOSTONE,** with limestone interbeds, moderately weathered, thinly bedded, grey, medium strong: (Salina Formation) Limestone interbed at 17.4m, 17.6m, 17.8m, 17.9m, 18.0m, 18.1m and 18.2m Vertical fracture (25mm) at 17.7m Horizontal fracture at 17.7m, 17.8m, 17.9m and 18.0m Sub-vertical fractures at 18.2m, 19.1m and 19.4m Limestone interbeds at 18.2m, 18.7m, 19.1m, to 19.2m, 19.3m, 19.4m and 19.5m Artesian conditions encountered Vertical fractures at 19.8m, 20.1m ,		1	RUN			280				RUN #1 TCR=100% SCR=100% RQD=0% UCS=153.1MPa (PLT Average)
			2	RUN			279			FI 8 5 7 6 5	RUN #2 TCR=100% SCR=97% RQD=0% UCS=97.3MPa (PLT Average)
							278			>20	RUN #3 TCR=100%

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

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THURBER

RECORD OF BOREHOLE No GRB16-13 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 548.0 E 227 356.1 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.01.10 - 2018.01.17 LATITUDE 43.475840 LONGITUDE -80.457267 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	20.6m and 20.9m Soft zones at 19.9m, 20.2m, 20.4m , 20.5m and 20.7m Limestone interbeds at 20.1m, 20.2m, 20.5m, 20.7m and 20.8m		3	RUN			277			7 7 10	SCR=83% RQD=0% UCS=125.6MPa (PLT Average)
276.6											
20.9	END OF BOREHOLE AT 20.9m. ARTESIAN CONDITION: WATER LEVEL APPROXIMATELY 1.2m ABOVE GROUND SURFACE UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE TO 12.2m, THEN HOLEPLUG TO SURFACE.										

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

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

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THURBER

RECORD OF BOREHOLE No GRB16-14 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 547.6 E 227 335.4 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advances COMPILED BY MP

DATUM Geodetic DATE 2018.01.18 - 2018.01.18 LATITUDE 43.475834 LONGITUDE -80.457523 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
298.8	GROUND SURFACE										
0.0	Sandy **SILT**, some clay, trace rootlets Loose Dark Brown Frozen		1	SS	7						
			2	SS	7		298				0 21 64 15
			3	SS	4		297				
295.9	Occasional wood fibre, occasional sand seams		4	SS	4		296				
2.9	Sandy **GRAVEL**, trace silt, trace clay Compact to Dense Brown Wet		5	SS	25		295				58 27 15 (SI+CL)
	Auger grinding from 3.8m to 4.2m										
293.7			6	SS	31		294				
5.1	**SAND** and **SILT**, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)		7	SS	86		293				
							292				
	(CL-ML)		8	SS	48		291				6 42 39 13
			9	SS	51		290				
							289				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-14 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 547.6 E 227 335.4 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advances COMPILED BY MP

DATUM Geodetic DATE 2018.01.18 - 2018.01.18 LATITUDE 43.475834 LONGITUDE -80.457523 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: UNCONFINED, FIELD VANE, QUICK TRIAXIAL, LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace gravel Very Dense Brown Moist (TILL)		10	SS	79		288		o		
							287				
	Occasional cobbles		11	SS	100/ .175				o		
285.5							286				
13.3	**SAND** and **GRAVEL**, trace silt Very Dense Grey Wet		12	SS	71		285		o		56 43 1 (SI+CL)
	Auger grinding from 13.7m to 14.6m Switched to casing advance						284				
	Casing grinding from 15.2m to 16.8m Possible cobbles and boulders		13	SS	100/ .075				o		
							283				
	Artesian conditions encountered. 1.5m of casing added above ground level to manage artesian condition		14	SS	100/ .025		282				
	Cobbles and gravel						281			FI	RUN #1 TCR=100% SCR=0% RQD=0%
280.6										>25	
18.2	**DOLOSTONE,** with limestone interbeds, thinly bedded, highly weathered, grey: (Salina Formation)		1	RUN						8	RUN #2 TCR=98% SCR=96% RQD=29% UCS=135.9MPa (PLT Average)
	Sub-vertical fracture at 19.1m		2	RUN			280			5	
	Limestone interbeds at 18.9m, 19.0m, 19.1m, 19.2m, 19.4m and 19.6m									6	
										5	
							279			8	

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-14 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 547.6 E 227 335.4 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advances COMPILED BY MP

DATUM Geodetic DATE 2018.01.18 - 2018.01.18 LATITUDE 43.475834 LONGITUDE -80.457523 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (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
	Continued From Previous Page										
	Limestone interbeds at 19.7m, 19.8m, 20.0m, 22.2m, 22.4m, 20.8m Vertical fracture at 19.4m and 19.8m Sub-vertical fracture at 20.7m and 20.9m		3	RUN			278			4 3 4 >10	RUN #3 TCR=100% SCR=100% RQD=80% UCS=140.1MPa (PLT Average)
277.6 21.2	END OF BOREHOLE AT 21.2m Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.1m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.03.01	-1.2	300.0
Artesian Condition		
2018.03.02	-1.2	300.0
Artesian Condition		
2018.03.21	-1.0	299.8
Artesian Condition		
2018.04.30	-1.1	299.9
2018.06.25	-0.5	299.3

SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-15 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 595.8 E 227 396.7 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advances COMPILED BY MP

DATUM Geodetic DATE 2018.01.29 - 2018.01.31 LATITUDE 43.476274 LONGITUDE -80.456772 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
297.5	GROUND SURFACE										
0.0	**TOPSOIL:** (175mm)										
0.2	Silty **CLAY**, some sand, trace organics, trace roots Firm Dark Brown Wet		1	SS	5		297		○		
			2	SS	8				○		
296.0							296				
1.5	Silty **SAND**, trace gravel, trace clay Loose Brown Wet		3	SS	7				○		2 70 22 6
295.2							295				
2.3	Sandy **GRAVEL**, occasional cobbles Compact Brown Wet to Saturated		4	SS	16				○		
	Auger grinding from 2.4m to 4.1m.		5	SS	19		294		○		
292.9							293				
4.6	**SAND** and **SILT**, some clay, trace gravel Dense to Very Dense Brown Moist (TILL)		6	SS	100/.275				○		7 46 34 13
			7	SS	100/.250		292		○		
			8	SS	48		291		○		
			9	SS	100/.225		290		○		
							289		○		
							288				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-15 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 595.8 E 227 396.7 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advances COMPILED BY MP

DATUM Geodetic DATE 2018.01.29 - 2018.01.31 LATITUDE 43.476274 LONGITUDE -80.456772 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace gravel Very Dense to Dense Brown Moist (TILL)						287				
			10	SS	93				○		
							286				
			11	SS	46		285		○		
							284				
			12	SS	36				○		7 40 39 14
282.7							283				
14.8	Silty **SAND**, some gravel, trace clay Very Dense to Dense Brown Moist (TILL)										
			13	SS	63		282		○		
							281				
			14	SS	42				○		16 49 29 6
280.1							280				
17.4	Gravelly **SAND**, occasional shale fragments Very Dense Brown Wet										
			15	SS	100/.025		279		○		
	Artesian conditions encountered resulting in borehole needing to be terminated										
278.1											
19.4	END OF BOREHOLE AT 19.4m AT PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND										

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-15 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 595.8 E 227 396.7 ORIGINATED BY ES

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/Casing Advances COMPILED BY MP

DATUM Geodetic DATE 2018.01.29 - 2018.01.31 LATITUDE 43.476274 LONGITUDE -80.456772 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	CUTTINGS TO SURFACE. WATER LEVEL APPROXIMATELY 3.4m ABOVE GROUND SURFACE UPON COMPLETION.										

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

15 20 10 5 (%) STRAIN AT FAILURE

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Ontario

THURBER

RECORD OF BOREHOLE No GRB16-16 1 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 738.1 E 227 411.4 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.23 - 2017.01.24 LATITUDE 43.477556 LONGITUDE -80.456611 CHECKED BY RPR

ELEV / DEPTH	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/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
308.6	GROUND SURFACE										
0.0	**TOPSOIL:** (175mm)										
0.2	**SAND** and **GRAVEL** Compact to Very Dense Brown Moist		1	SS	19		308		○		
			2	SS	49				○		
	Auger grinding from 1.5m to 2.3m		3	SS	98		307		○		
	Wet		4	SS	30		306		○		
305.6											
3.0	Silty **CLAY**, trace sand Very Stiff to Stiff Brown Wet		5	SS	24	▽	305		○		
	Grey (CL)		6	SS	16	▼	304		⊖		0 0 44 56
			7	SS	8		303		○		
301.6							302				
7.0	Sandy **SILT**, some clay Dense Brown to Grey Wet		8	SS	37		301		○		0 32 56 12
299.8							300				
8.8	**SAND** and **SILT**, some gravel, some clay Very Dense Grey Wet (TILL)		9	SS	89		299		○		

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-16 2 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 738.1 E 227 411.4 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.23 - 2017.01.24 LATITUDE 43.477556 LONGITUDE -80.456611 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some gravel, some clay Very Dense Grey Wet (TILL)										
			10	SS	96		298		○		
							297		○		
			11	SS	51/.150		296				
			12	SS	117		295		○		
			13	SS	121		294		○		10 34 45 11
			14	SS	112		293				
							292		○		
			15	SS	108		291				
							290		○		
							289				

Continued Next Page

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-16 3 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 738.1 E 227 411.4 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.23 - 2017.01.24 LATITUDE 43.477556 LONGITUDE -80.456611 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, trace to some gravel, some clay Very Dense Grey Wet (TILL)		16	SS	103		288		○		
			17	SS	113		287		○		14 45 29 12
			18	SS	102		286		○		
			19	SS	104		285		○		
			20	SS	113		284		○		
			21	SS	109		283		○		
			22	SS	100/.150		282		○		
	(CL-ML)						281		H		4 38 41 17
							280				
							279				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-16 4 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 738.1 E 227 411.4 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.23 - 2017.01.24 LATITUDE 43.477556 LONGITUDE -80.456611 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
278.1	**SAND** and **SILT**, some clay, trace gravel Very Dense Grey		23	SS	100/						
30.6	Wet (TILL)				.075						
	END OF BOREHOLE AT 30.6m. BOREHOLE OPEN TO 30.6m AND WATER LEVEL AT 3.1m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.02.27	3.3	305.4
2017.03.16	3.7	305.0
2018.03.23	3.8	304.9
2018.04.30	3.4	305.3
2018.06.25	4.6	304.1

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

(%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-17 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 757.5 E 227 427.8 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.25 - 2017.01.25 LATITUDE 43.477732 LONGITUDE -80.456410 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
309.1	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)						309				
0.2	**SAND** and **GRAVEL**, trace silt, trace clay Compact to Very Dense Brown Moist		1	SS	12				○		
			2	SS	12		308		○		
			3	SS	13				○		
			4	SS	77		307		○		58 33 9 (SI+CL)
			5	SS	100/.050		306				
305.4											
3.7	Silty **CLAY**, trace sand Stiff to Very Stiff Grey Wet					▽	305				
			6	SS	14				○		
							304				
	Very Stiff		7	SS	22		303		○		
301.7							302				
7.4	**SAND** and **SILT**, some clay, trace gravel Very Dense Grey Wet (TILL)		8	SS	50/.150				○		
							301				
			9	SS	92		300		○		2 34 47 17

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 GRB16-17 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 757.5 E 227 427.8 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.25 - 2017.01.25 LATITUDE 43.477732 LONGITUDE -80.456410 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace gravel Very Dense Grey Wet (TILL)		10	SS	100/.150		299		○		
							298				
							297				
			11	SS	127				○		
							296				
	(CL)		12	SS	107		295		○		2 40 39 19
			13	SS	100/.075		294		○		
							293				
			14	SS	110		292		○		
							291				
	(CL)		15	SS	102				○		7 40 35 18
							290				

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-17 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 757.5 E 227 427.8 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.25 - 2017.01.25 LATITUDE 43.477732 LONGITUDE -80.456410 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
289.0	Continued From Previous Page		16	SS	114		289				
20.1	END OF BOREHOLE AT 20.1m. BOREHOLE OPEN TO 20.1m AND WATER LEVEL AT 4.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.										

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

15 20 10 5 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-18 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 781.4 E 227 457.9 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.26 - 2017.01.26 LATITUDE 43.477951 LONGITUDE -80.456042 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
309.8	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)										
0.2	**SAND** and **GRAVEL**, trace silt Compact Black Moist		1	SS	10				○		
			2	SS	15		309		○		
			3	SS	10	▼	308		○		
			4	SS	10				○		
306.8							307				
3.0	Silty **CLAY**, sandy, trace gravel Hard Brown Moist (TILL)		5	SS	35				○		
							306				
	Grey Wet		6	SS	50/.150				○		
							305				
							304				
	(CL)		7	SS	86				⊢○⊣		2 27 45 26
							303				
			8	SS	89		302		○		
301.1											
8.7	**SAND** and **SILT**, some clay, trace gravel Very Dense Grey Wet (TILL)		9	SS	100		301		○		
							300				

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-18 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 781.4 E 227 457.9 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.26 - 2017.01.26 LATITUDE 43.477951 LONGITUDE -80.456042 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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
	Continued From Previous Page										
298.9	**SAND** and **SILT**, some clay, trace gravel Very Dense Grey Wet (TILL) (CL-ML)		10	SS	112		299				4 46 35 15
11.0	END OF BOREHOLE AT 11.0m. BOREHOLE OPEN TO 11.0m AND WATER LEVEL AT 4.0m UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.02.27	1.7	308.1
2017.03.16	3.9	305.9
2018.03.23	2.2	307.6
2018.04.30	1.8	308.0
2018.06.25	2.7	307.2

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

(%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-19 1 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 769.3 E 227 493.2 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.26 - 2017.01.27 LATITUDE 43.477846 LONGITUDE -80.455604 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
310.4	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)										
0.2	**SAND** and **GRAVEL**, trace silt, trace clay Compact to Very Dense Brown Moist		1	SS	15		310				
			2	SS	13		309				
	Auger grinding from 1.5m to 3.0m		3	SS	79		308				
			4	SS	81		307				
			5	SS	81						54 36 10 (SI+CL)
306.2							306				
4.3	Silty **CLAY** Very Stiff to Hard Grey Moist		6	SS	27		305				
	(CL)		7	SS	50/.150		304				0 0 35 65 slow augering
			8	SS	50/.075		303				
301.8							302				
8.7	**SAND** and **SILT**, some clay, trace to some gravel Very Dense Grey Moist (TILL)		9	SS	100/.075		301				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-19 2 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 769.3 E 227 493.2 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.26 - 2017.01.27 LATITUDE 43.477846 LONGITUDE -80.455604 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × 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										
	SAND and **SILT**, some clay, trace to some gravel Very Dense Grey Moist (TILL)		10	SS	125		300		○		12 35 34 19
			11	SS	100/.200		299				
	Cobble at 13.4m (100mm) No recovery		~~12~~	~~SS~~	~~100/~~.025		298		○		
	Trace gravel Wet		13	SS	114		297				slow augering
							296		○		
	(CL-ML)		14	SS	132		295		⊖		2 45 37 16
			15	SS	130		294				
							293		○		
							292				
							291				

Continued Next Page

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

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-19 3 OF 3 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 769.3 E 227 493.2 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.26 - 2017.01.27 LATITUDE 43.477846 LONGITUDE -80.455604 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
290.2	**SAND** and **SILT**, some clay, trace to some gravel (TILL)		16	SS	102	▽			o		
20.3	END OF BOREHOLE AT 20.3m. BOREHOLE OPEN TO 20.3m AND WATER LEVEL AT 20.3m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE AND AUGER CUTTINGS TO SURFACE.										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE (20 40 60 80 100)

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

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

15 20 10 5 (%) STRAIN AT FAILURE

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THURBER

RECORD OF BOREHOLE No GRB16-20 1 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 808.1 E 227 517.8 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.27 - 2017.01.27 LATITUDE 43.478197 LONGITUDE -80.455305 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
311.8	GROUND SURFACE										
0.0	**TOPSOIL:** (175mm)										
0.2	**SAND** and **GRAVEL**, trace to some silt, trace clay Loose to Very Dense Brown		1	SS	5						
			2	SS	18		311				
			3	SS	79		310				
			4	SS	90		309				
			5	SS	50/.175						
			6	SS	79		307				46 42 12 (SI+CL)
305.3			7	SS	26		306				
6.6	Silty **SAND**, some clay to clayey, trace to some gravel Compact to Very Dense Grey Moist (TILL) (CL)		8	SS	28		304				10 41 29 20
	Hard		9	SS	72		303				
							302				

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

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THURBER

RECORD OF BOREHOLE No GRB16-20 2 OF 2 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 808.1 E 227 517.8 ORIGINATED BY GA

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA

DATUM Geodetic DATE 2017.01.27 - 2017.01.27 LATITUDE 43.478197 LONGITUDE -80.455305 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (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
	Continued From Previous Page										
300.8	Silty **SAND**, some clay to clayey, trace to some gravel Very Dense Grey Moist (TILL)		10	SS	92		301				
11.0	END OF BOREHOLE AT 11.0m. BOREHOLE OPEN TO 11.0m AND DRY UPON COMPLETION. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.										

WATER LEVEL READINGS

DATE	DEPTH(m)	ELEV.(m)
2018.02.27	4.4	307.5
2017.03.16	4.3	307.5
2018.03.23	4.8	307.0
2018.04.30	4.3	307.5
2018.06.25	5.0	306.8

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-21 1 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 758.3 E 227 459.2 ORIGINATED BY AHF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.26 - 2018.02.27 LATITUDE 43.477743 LONGITUDE -80.456022 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
309.3	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)										
0.2	Sandy **GRAVEL**, trace silt, occasional cobbles Compact to Very Dense Brown Moist		1	SS	22		309				
			2	SS	50/100						
	Very Dense						308				
			3	SS	50/100						63 28 9 (SI+CL)
	Auger grinding at 2.0m					▽	307				
306.3			4	SS	31						
3.0	Silty **SAND**, some clay, some gravel Dense to Very Dense Grey Moist		5	SS	70		306				14 41 31 14
	Auger grinding at 3.4m		6	SS	36		305				
304.3			7	SS	50/100						
5.0	Silty **CLAY**, some sand, trace gravel Hard Grey Moist (TILL) (CL)		8	SS	50/100		304				3 19 46 32
			9	SS	35/075		303				
301.7							302				
7.6	Silty **SAND**, some clay, trace gravel Very Dense Grey Moist (TILL)		10	SS	98		301				
			11	SS	100/.100		300				7 47 30 16
299.3											

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-21 2 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 758.3 E 227 459.2 ORIGINATED BY AHF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.26 - 2018.02.27 LATITUDE 43.477743 LONGITUDE -80.456022 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page							20 40 60 80 100	20 40 60		
10.0	**SAND** and **SILT**, some clay, trace gravel Very Dense Grey Moist (TILL)		12	SS	100/.125		299		○		
			13	SS	100/.125		298				
			14	SS	100/.125		297		○		
			15	SS	100/.100		296				
			16	SS	100/.125		295		○		
			17	SS	100/.075		294				0 44 36 20
			18	SS	100/		293		○		
							292				
							291		○		
							290				

Continued Next Page

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

15 20 10 5 (%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-21 3 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 758.3 E 227 459.2 ORIGINATED BY AHF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.26 - 2018.02.27 LATITUDE 43.477743 LONGITUDE -80.456022 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay, trace gravel Very Dense Grey Moist (TILL)				.050		289		○		
							288				
							287				
			19	SS	58/ .050		286		○		
							285				
							284				
			20	SS	92		283		○		
							282				
							281				
	(CL)		21	SS	82		280		⊖		4 33 44 19

Continued Next Page

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

(%) STRAIN AT FAILURE

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Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No GRB16-21 4 OF 4 METRIC

GWP# 408-88-00 LOCATION Grand River Bridge, MTM NAD 83 Zone 10: N 4 815 758.3 E 227 459.2 ORIGINATED BY AHF

DIST HWY 7 BOREHOLE TYPE Hollow Stem Augers/HQ Coring COMPILED BY MP

DATUM Geodetic DATE 2018.02.26 - 2018.02.27 LATITUDE 43.477743 LONGITUDE -80.456022 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SAND and **SILT**, some clay to clayey, trace gravel Very Dense Grey Moist (TILL)						279				
278.4											
30.9	**DOLOSTONE,** with limestone interbeds, highly weathered: (Salina Formation)						278			FI	RUN #1 TCR=100% SCR=60% RQD=7% UCS=130.6MPa (PLT Average)
	Horizontal fracture at 30.9m, 31.0m, 31.1m, 31.2m, 31.3m, 31.4m, 31.5m, 31.6, 31.7, 31.8, 31.9m, 32.0m, 32.1m, 32.2m		1	RUN						8 6 7 9	
	Vertical fracture at 31.3m						277			11	RUN #2 TCR=95% SCR=42% RQD=0% UCS=93MPa (PLT Average)
	Horizontal fracture at 32.4, 32.5, 32.6, 32.7, 32.8m, 32.9, 33.0m, 33.1m, 33.2m, 33.3m, 33.4m, 33.5m, 33.6m, 33.7m, 33.8m		2	RUN			276			>20 >20 7	
	Sub-vertical fracture at 32.5m, 33.5m									3	RUN #3 TCR=100% SCR=71% RQD=29% UCS=158.8MPa (PLT Average)
	Horizontal fracture at 33.9m, 34.0m, 34.1m, 34.2m, 34.3m, 34.4m, 34.5m, 34.6m		3	RUN			275			4 6 >20	
	Sub-horizontal fracture at 35.2m		4	RUN						1	RUN #4 TCR=100% SCR=88% RQD=94%
273.9							274				
35.4	END OF BOREHOLE AT 35.4m. WATER LEVEL AT 2.21m. BOREHOLE BACKFILLED WITH GROUT TO SURFACE.										UCS=33.6MPa

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

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

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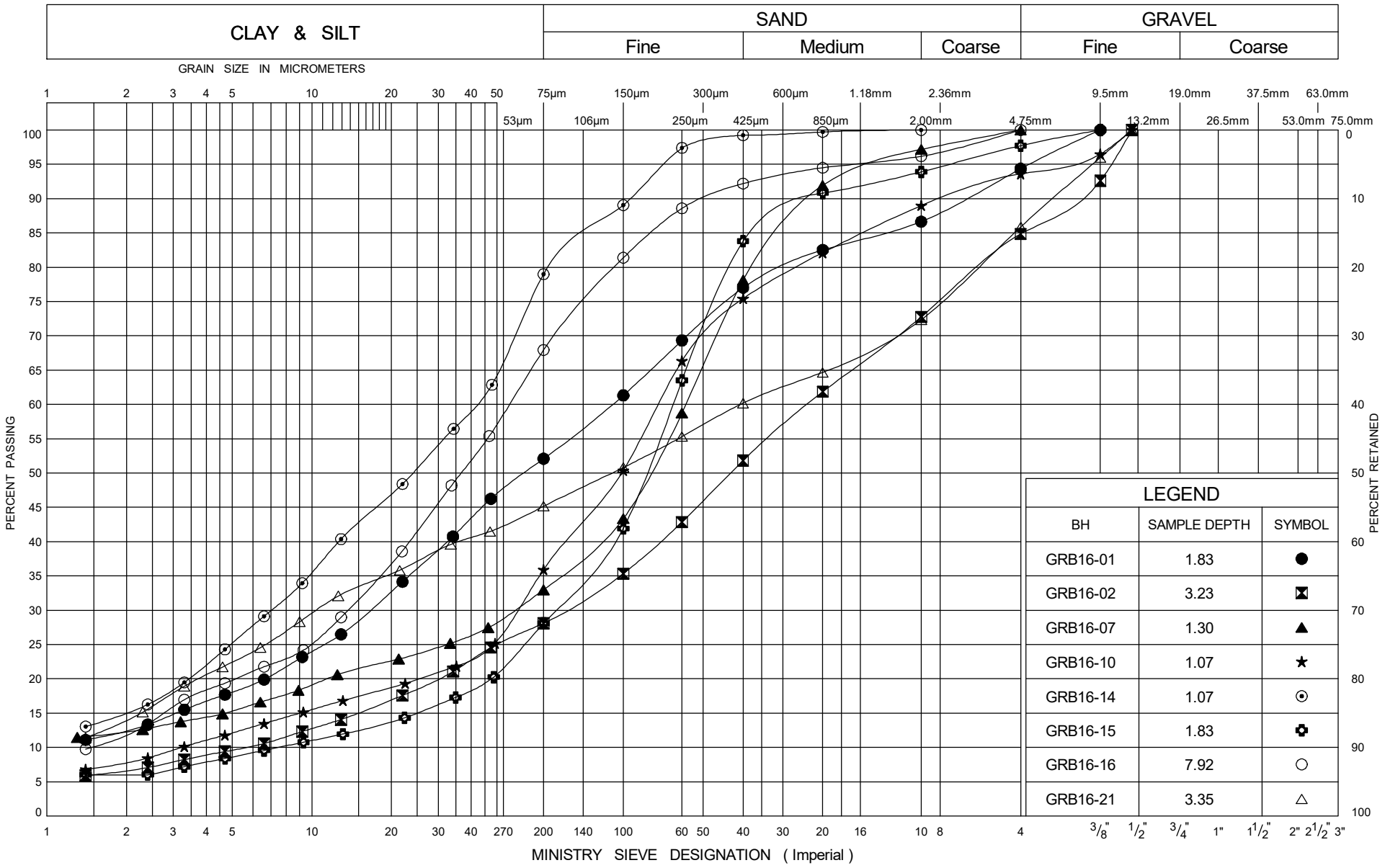

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GRAIN SIZE DISTRIBUTION

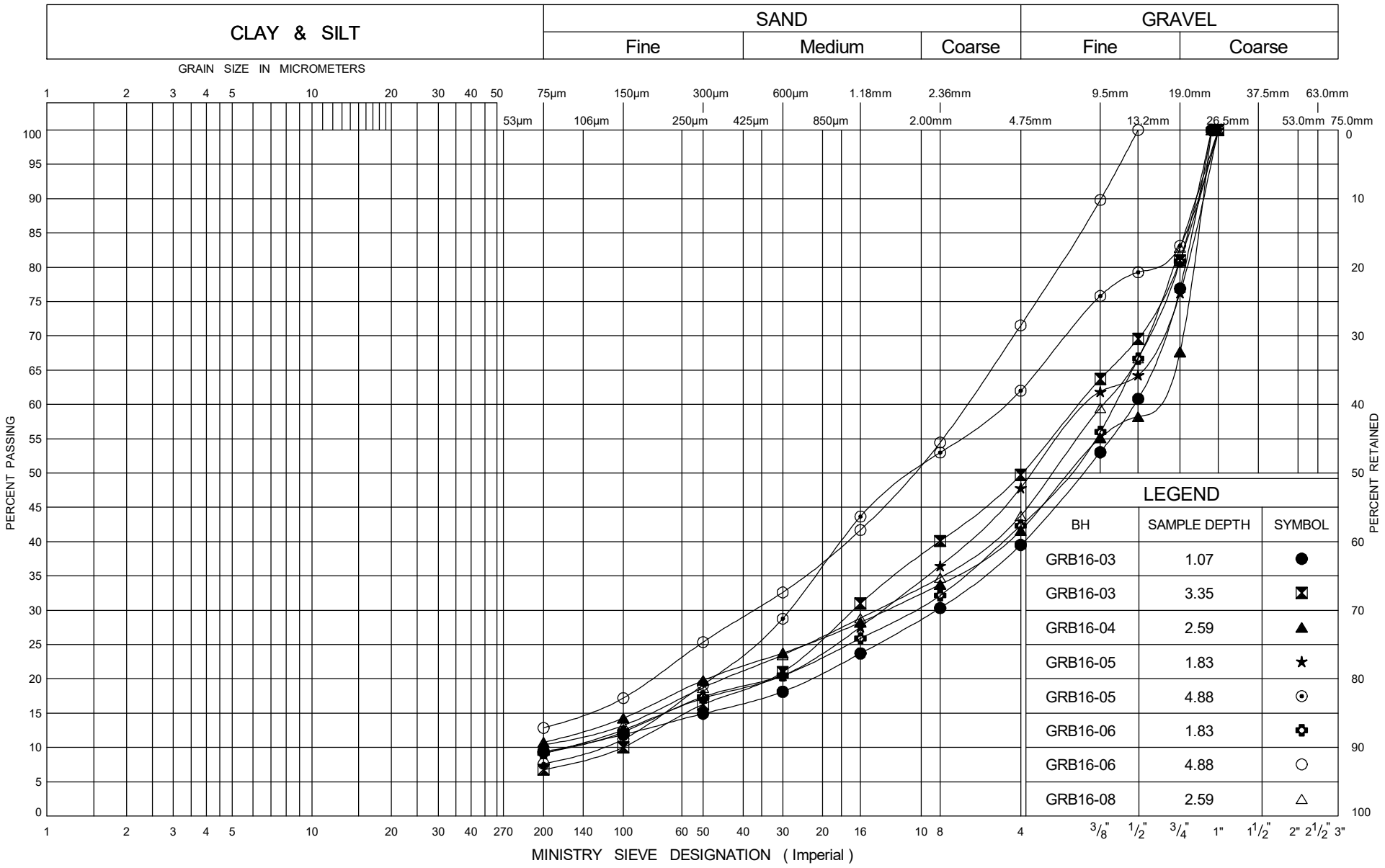
Silty SAND to Sandy SILT

FIG No A1

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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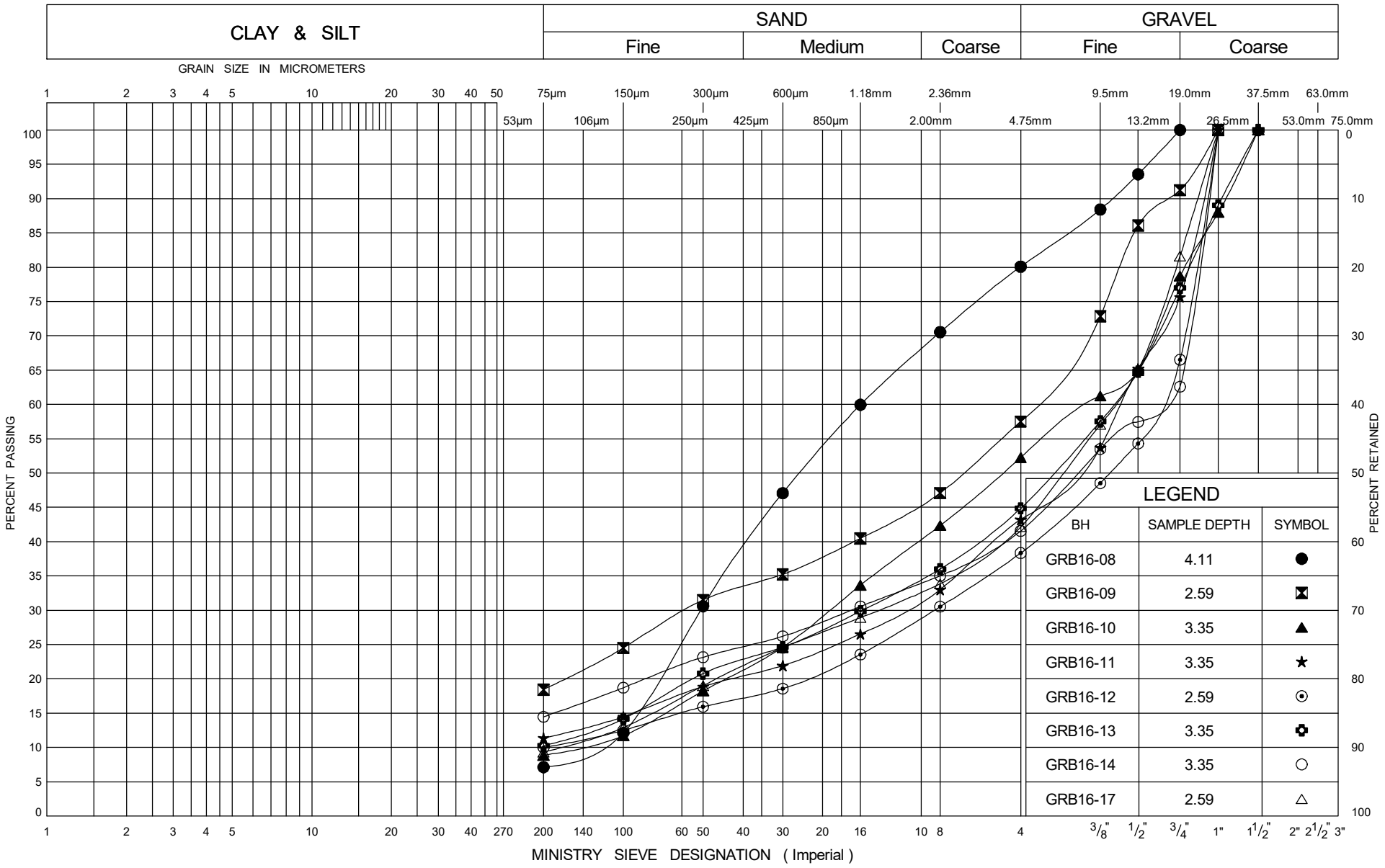
GRAIN SIZE DISTRIBUTION

UPPER SAND and GRAVEL

FIG No A2

GWP# 408-88-00

Grand River Bridge



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GRAIN SIZE DISTRIBUTION

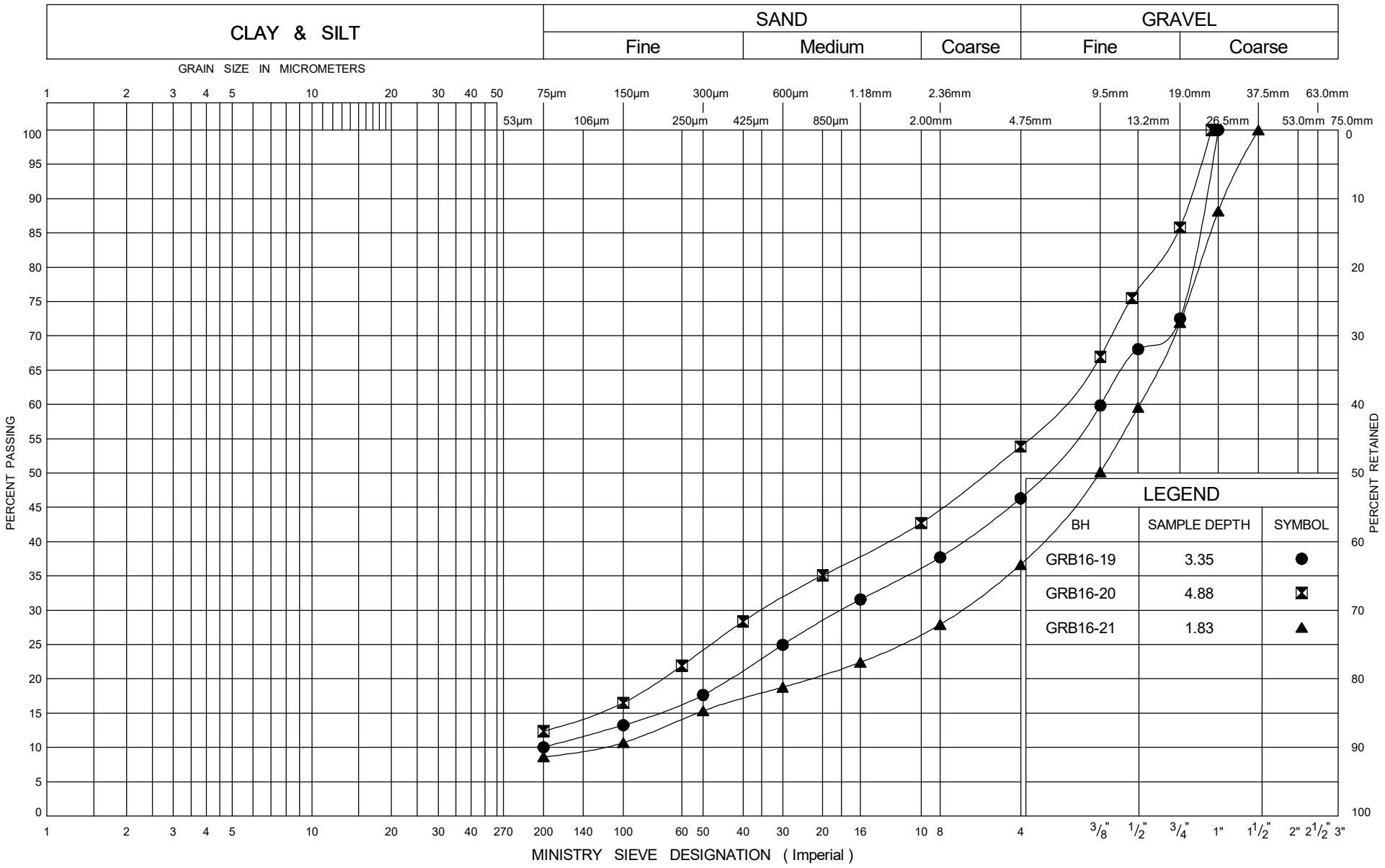
UPPER SAND and GRAVEL

FIG No A3

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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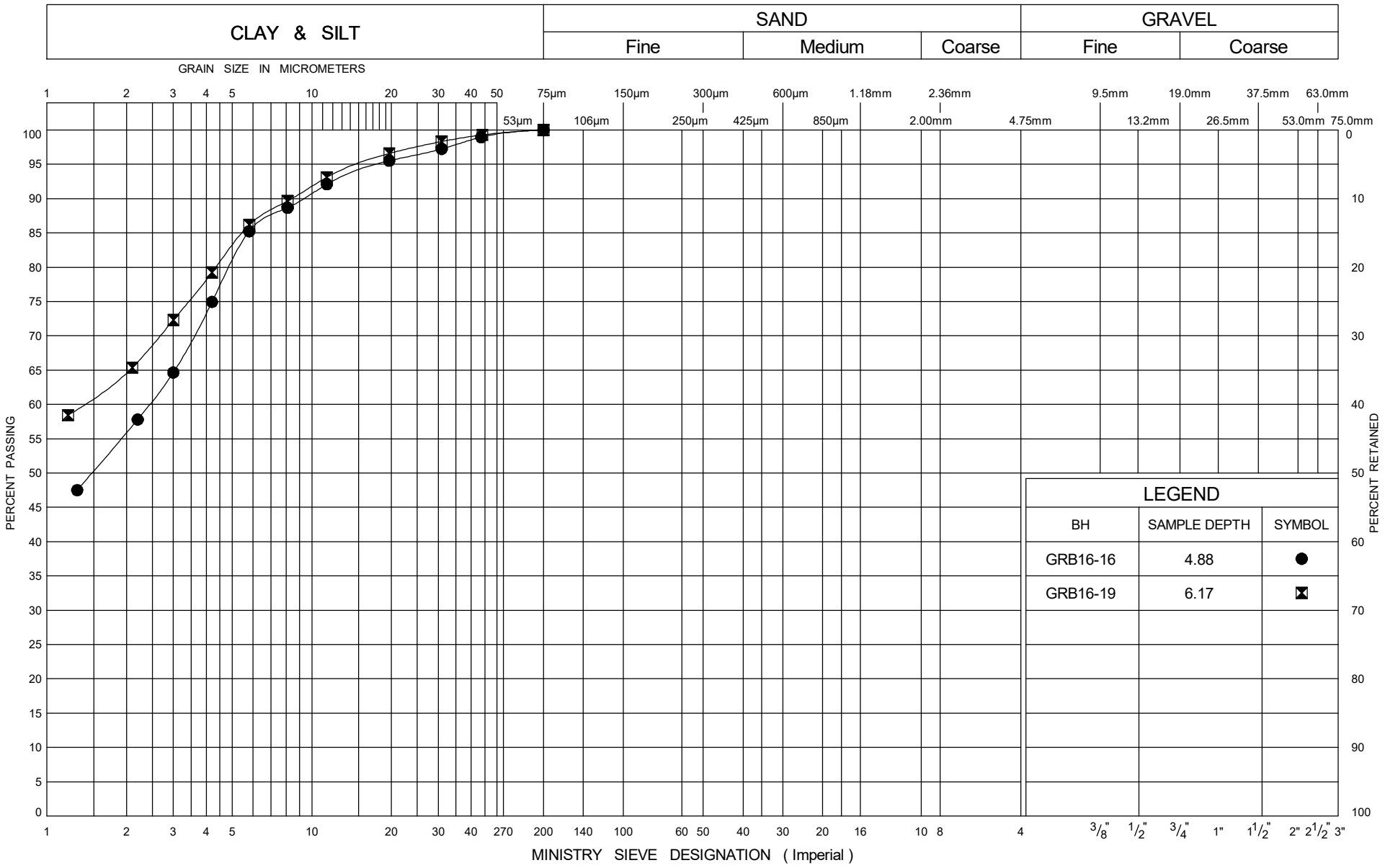
GRAIN SIZE DISTRIBUTION

UPPER SAND and GRAVEL

FIG No A4

GWP# 408-88-00

Grand River Bridge



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GRAIN SIZE DISTRIBUTION

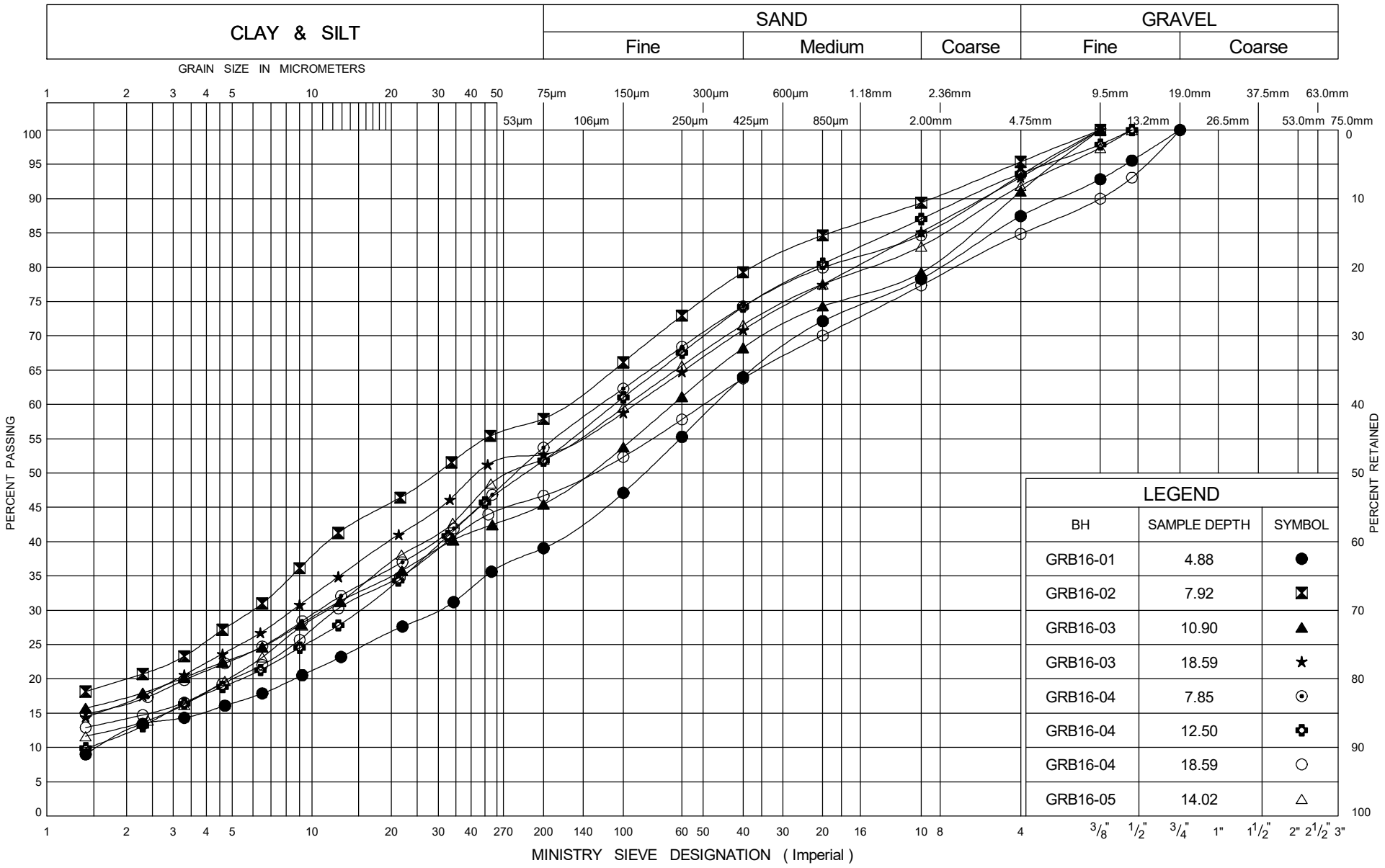
Silty CLAY

FIG No A5

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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GRAIN SIZE DISTRIBUTION

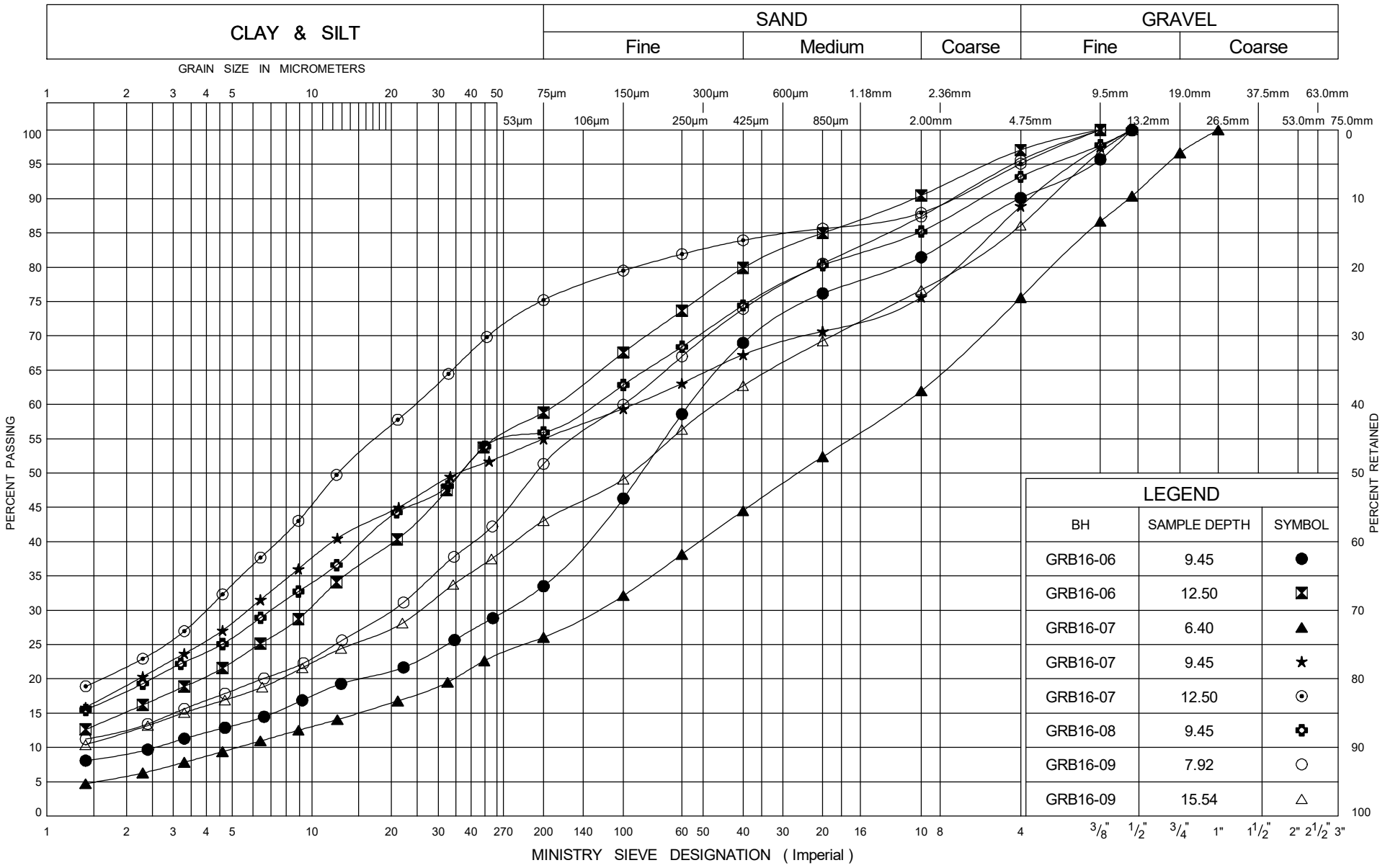
Silty SAND to Sandy SILT TILL

FIG No A6

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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GRAIN SIZE DISTRIBUTION

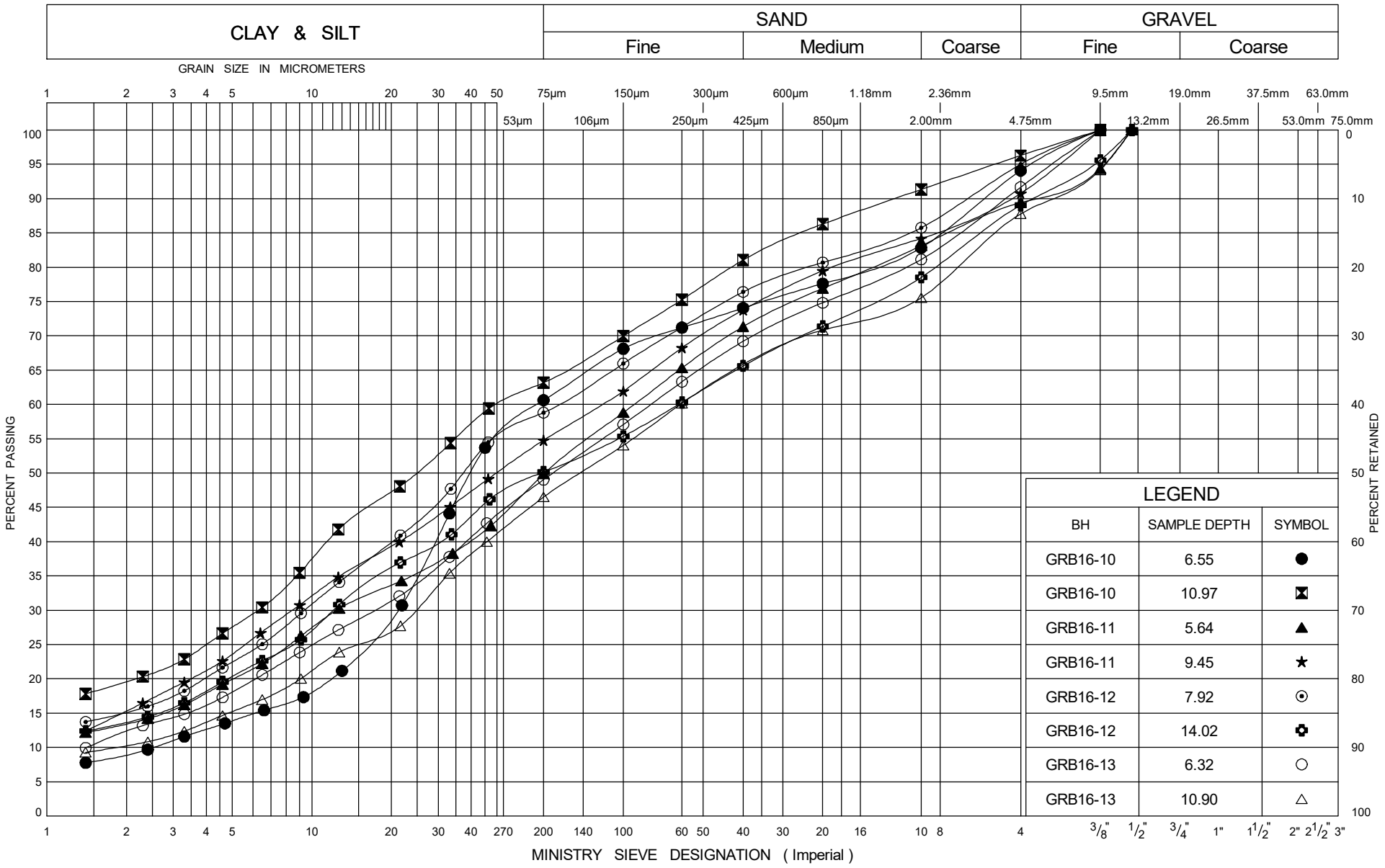
Silty SAND to Sandy SILT TILL

FIG No A7

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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GRAIN SIZE DISTRIBUTION

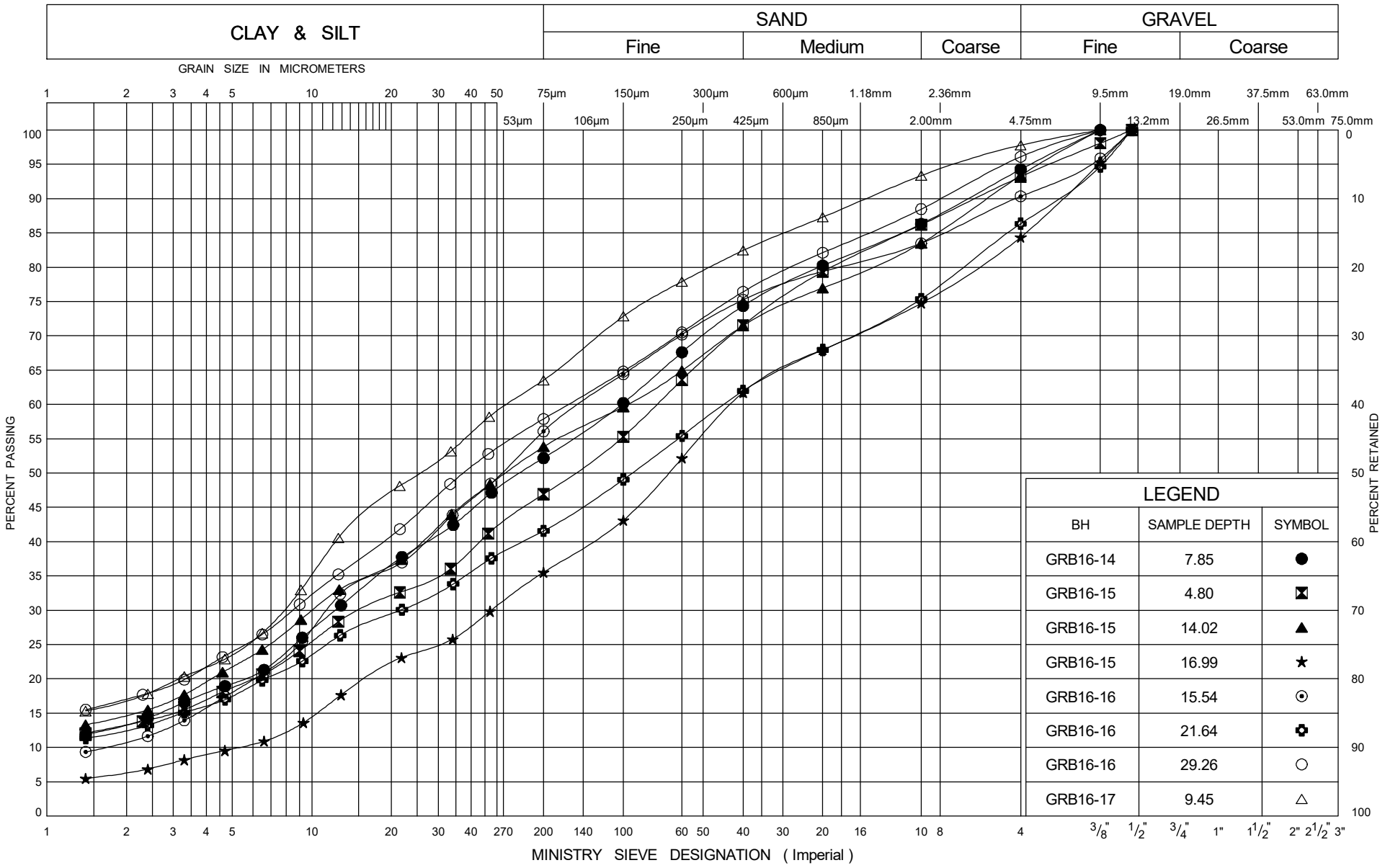
Silty SAND to Sandy SILT TILL

FIG No A8

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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GRAIN SIZE DISTRIBUTION

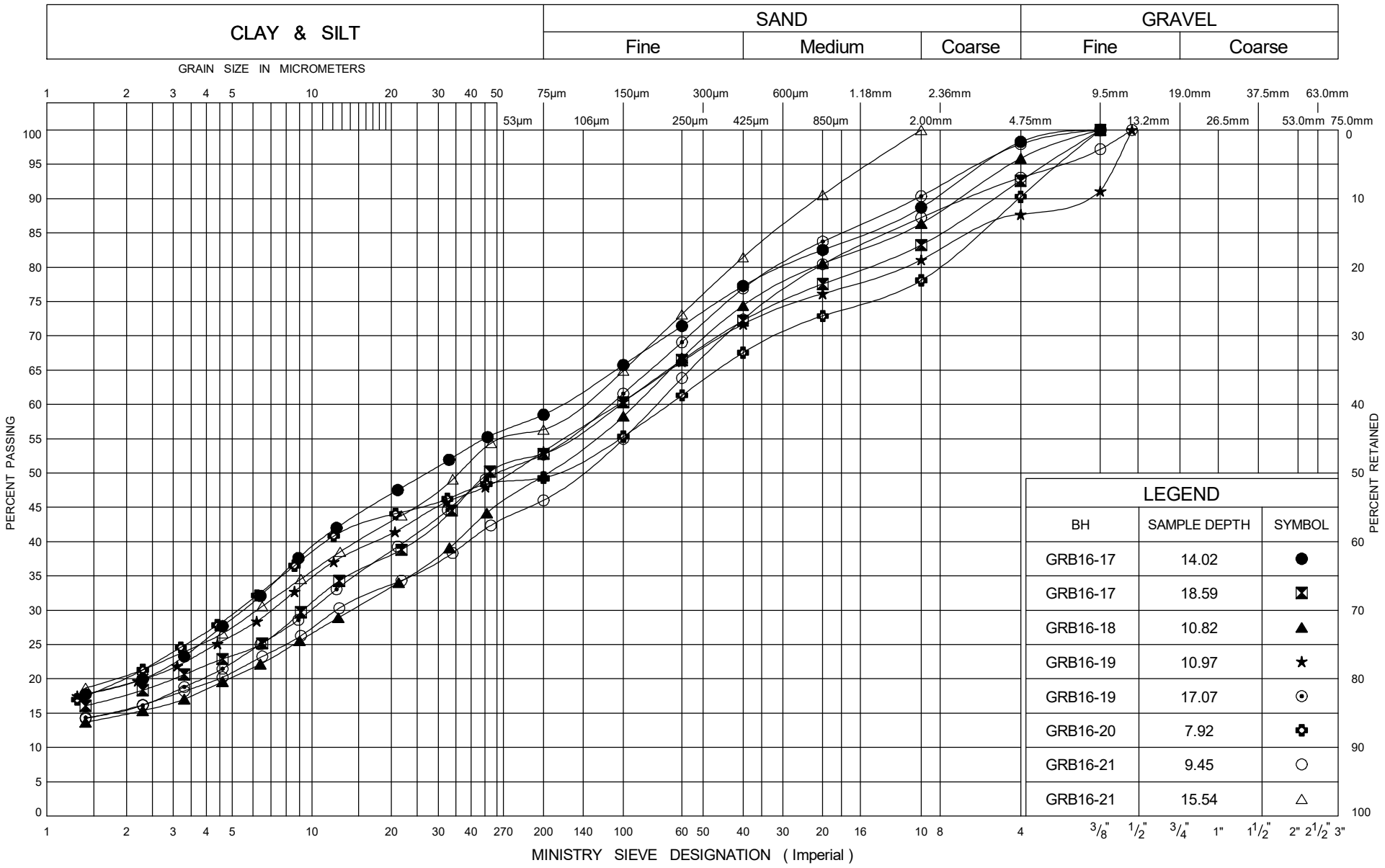
Silty SAND to Sandy SILT TILL

FIG No A9

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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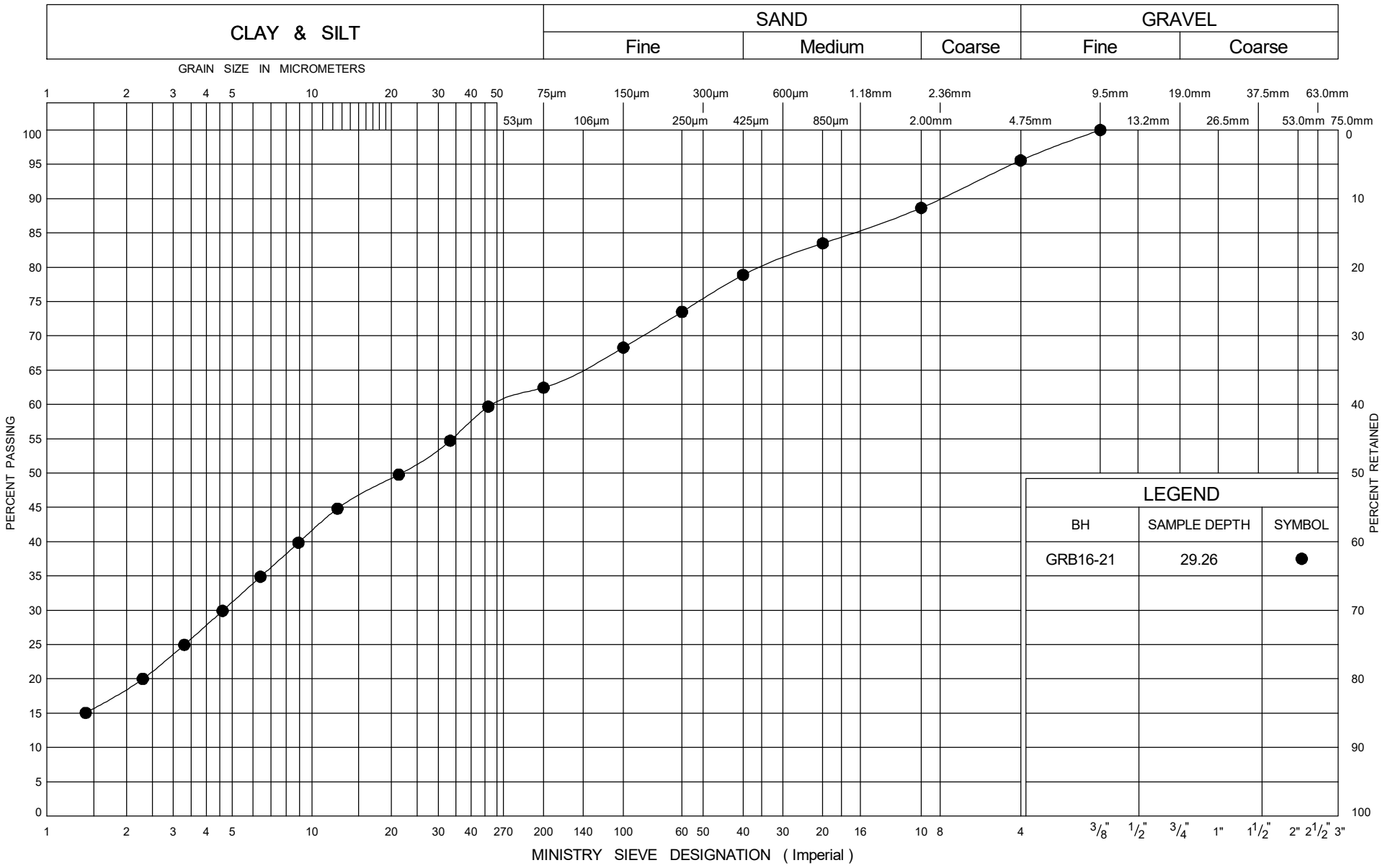
GRAIN SIZE DISTRIBUTION

Silty SAND to Sandy SILT TILL

FIG No A10

GWP# 408-88-00

Grand River Bridge



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GRAIN SIZE DISTRIBUTION

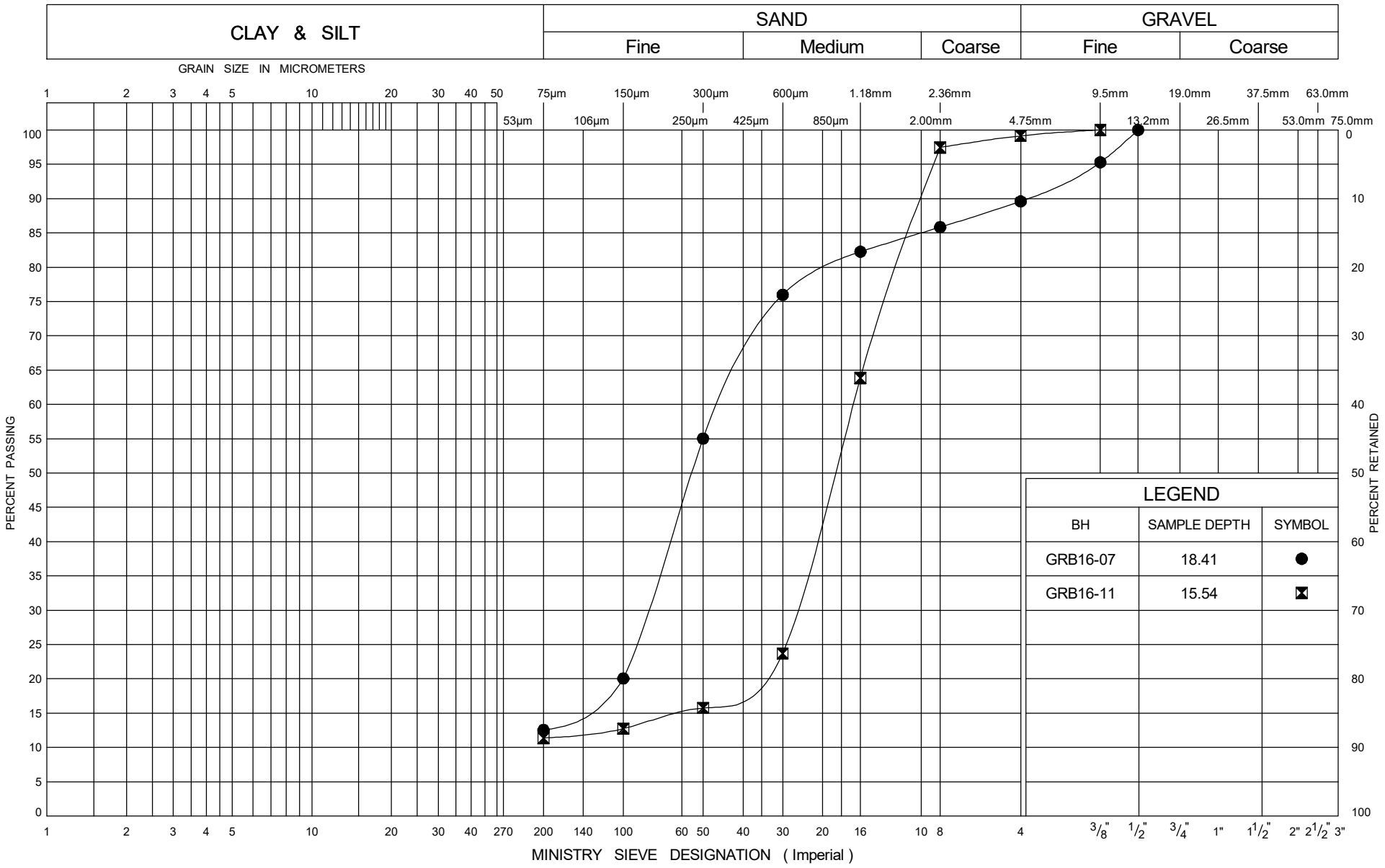
Silty SAND to Sandy SILT TILL

FIG No A11

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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GRAIN SIZE DISTRIBUTION

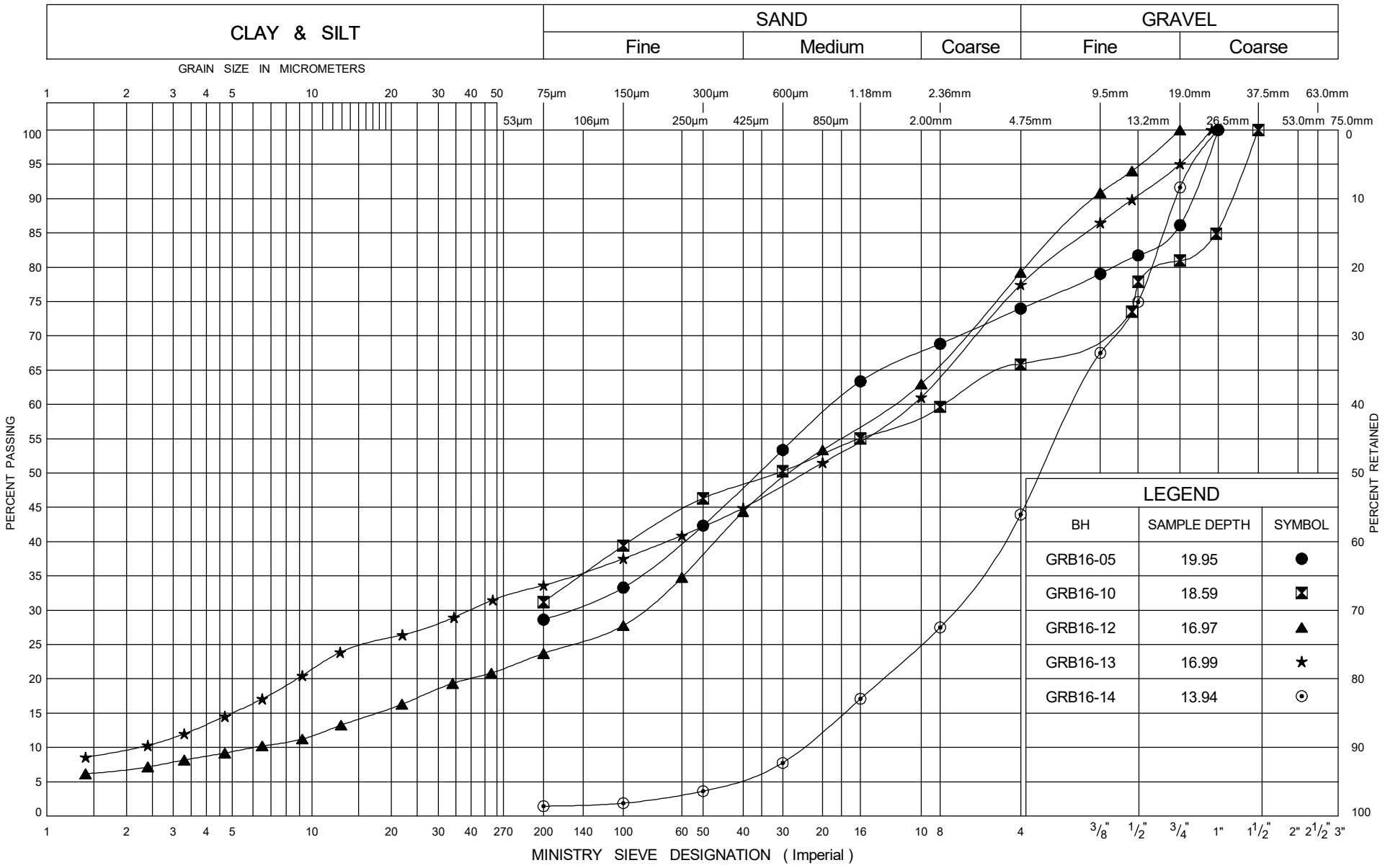
SAND

FIG No A12

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24



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GRAIN SIZE DISTRIBUTION

LOWER SAND and GRAVEL

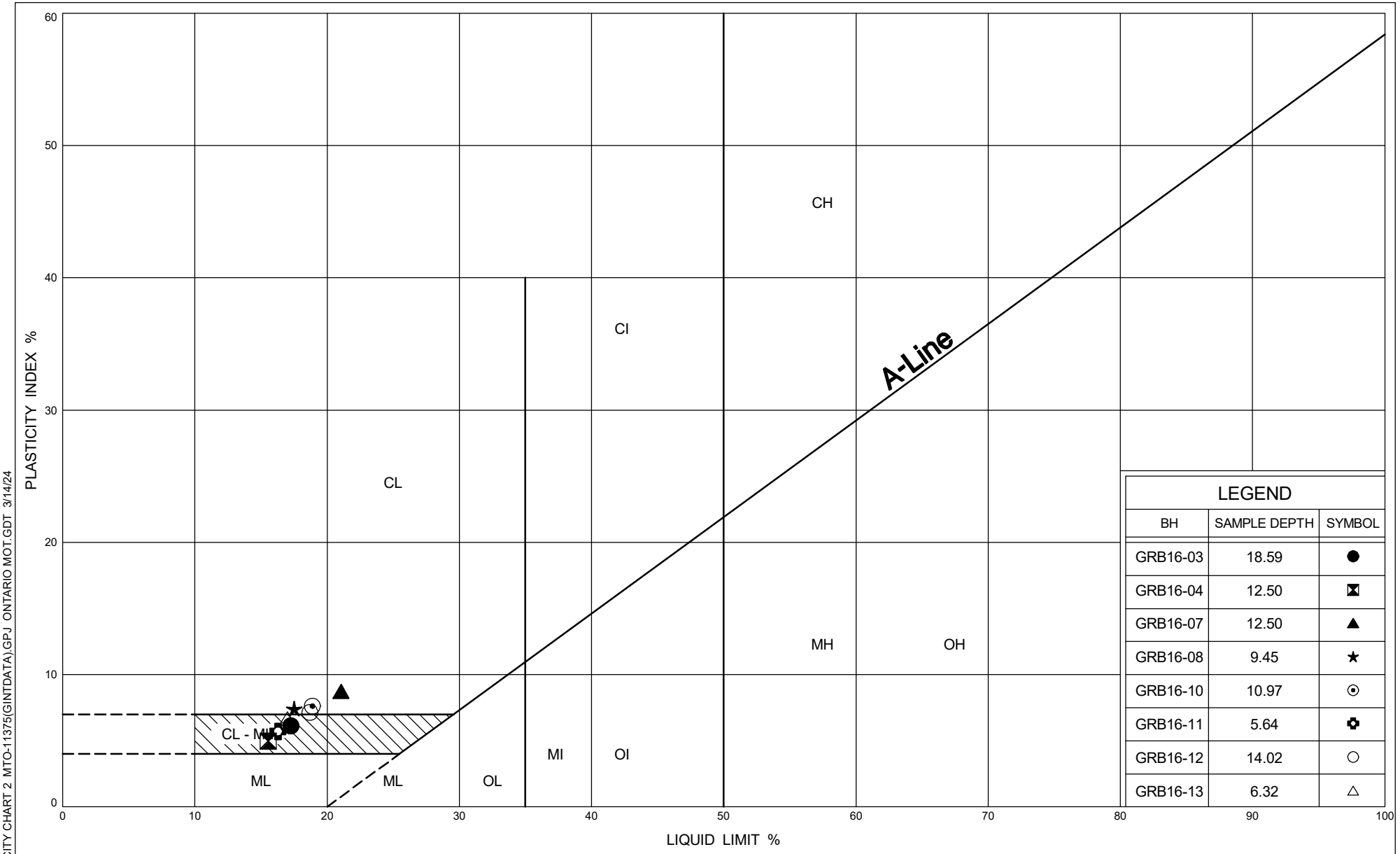
FIG No A13

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT GRAIN SIZE 3 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24

Oct 75, FF - S - 21



Ministry of Transportation
Ontario

PLASTICITY CHART

Silty SAND to Sandy SILT TILL

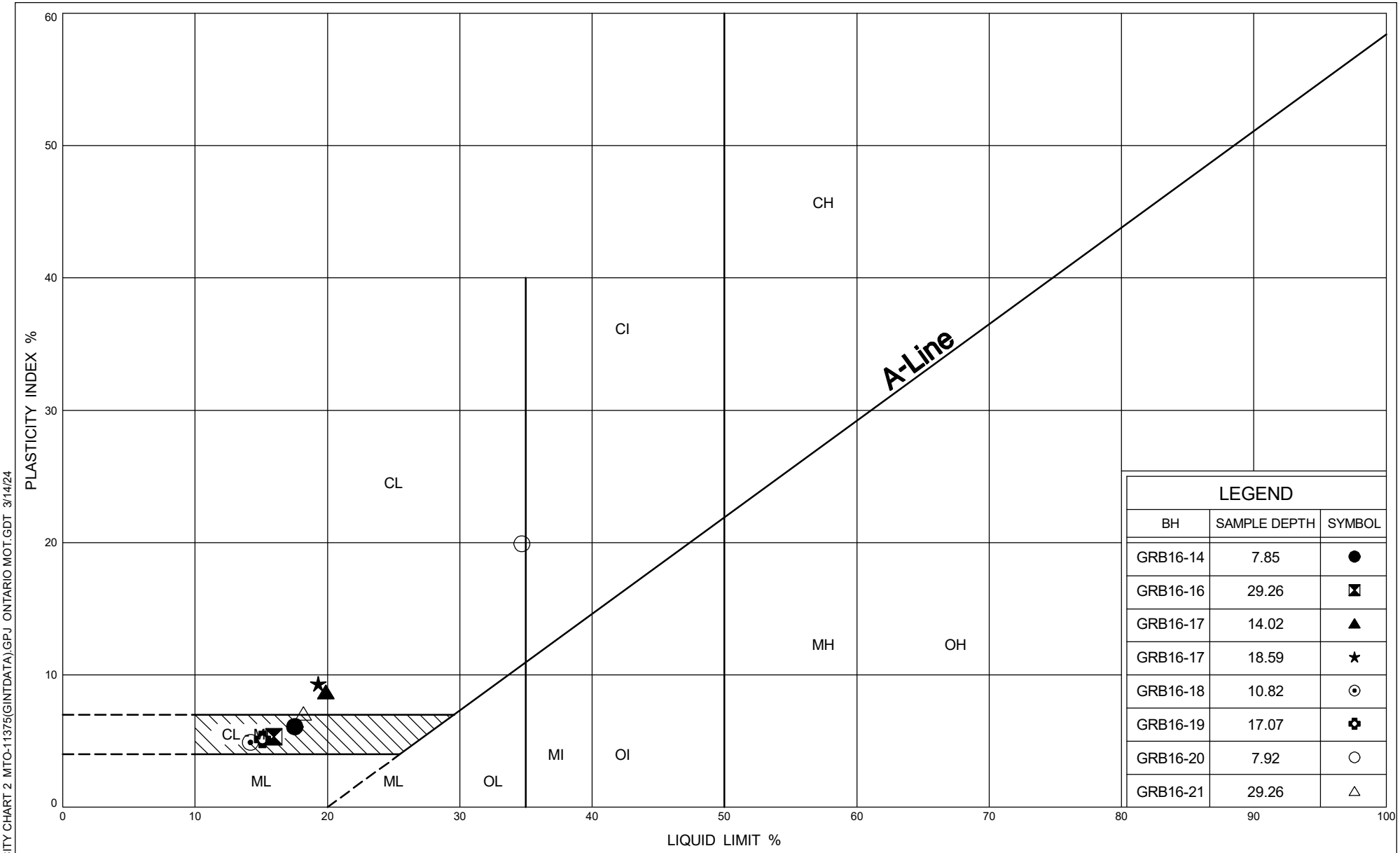
FIG No A14

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT PLASTICITY CHART 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE DEPTH	SYMBOL
GRB16-14	7.85	●
GRB16-16	29.26	⊠
GRB16-17	14.02	▲
GRB16-17	18.59	★
GRB16-18	10.82	⊙
GRB16-19	17.07	✿
GRB16-20	7.92	○
GRB16-21	29.26	△

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty SAND to Sandy SILT TILL

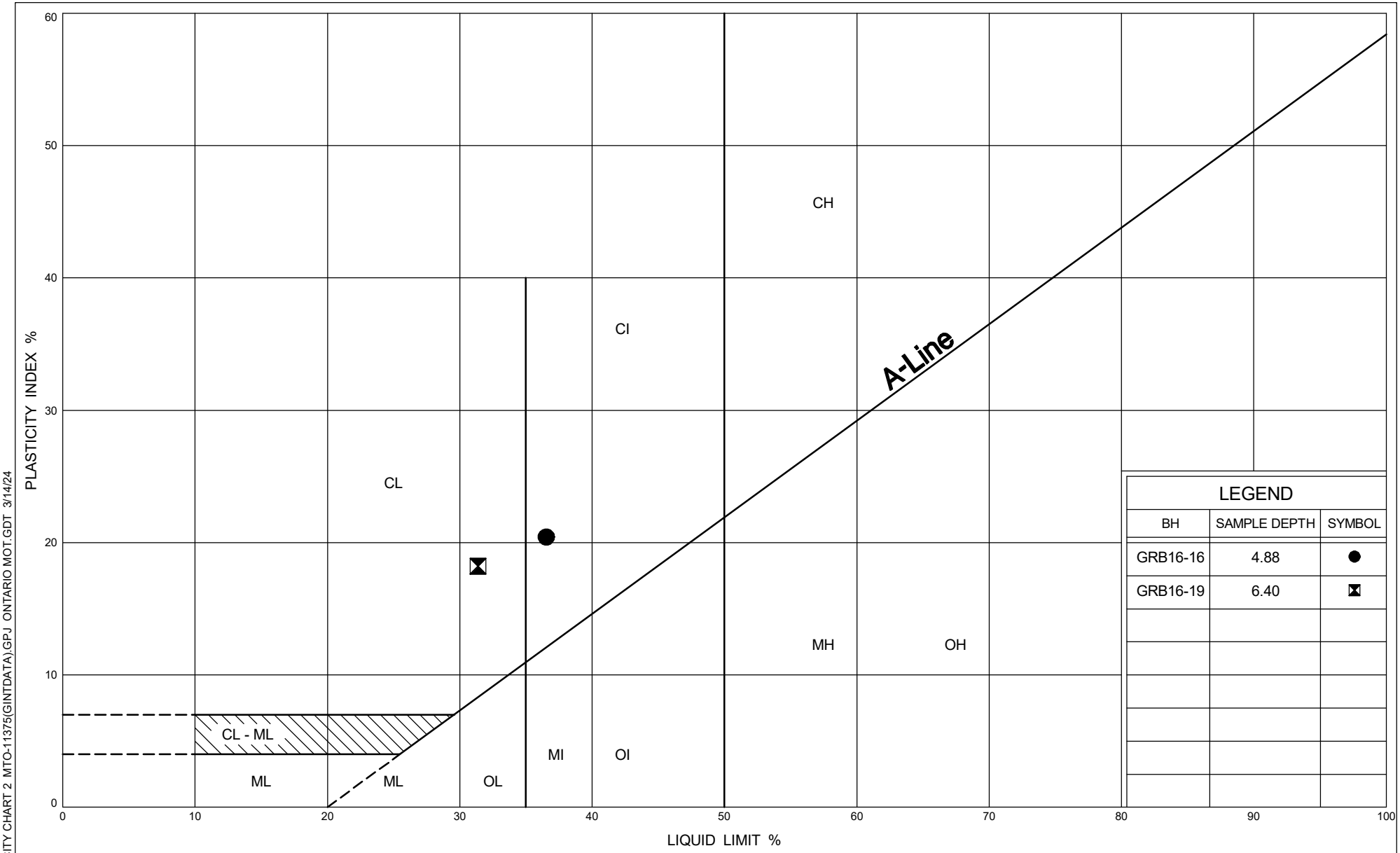
FIG No A15

GWP# 408-88-00

Grand River Bridge

ONTARIO MOT PLASTICITY CHART 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24

Oct 75, FF - S - 21



ONTARIO MOT PLASTICITY CHART 2 MTO-11375(GINTDATA).GPJ ONTARIO MOT.GDT 3/14/24

Ministry of Transportation
Ontario

PLASTICITY CHART

Silty CLAY

FIG No A16

GWP# 408-88-00

Grand River Bridge

March 16, 2018

Project No. 1897138(1000)

Nancy Berg Ph.D./Geotechnical Engineer
Thurber Engineering Ltd.
103, 2010 Winston Park Drive
Oakville, ON L6H 5R7

GEOTECHNICAL LABORATORY TESTING

Dear Mrs. Berg

This letter reports the results of laboratory testing carried out on the sample received at our office in Mississauga. The results of the tests are summarized in the attached tables and figures.

The testing services reported herein have been performed in accordance with the indicated recognized standard, unless noted otherwise. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability.

We trust that the results are sufficient for your current requirements. If you have any questions, please do not hesitate to call us.

Regards

GOLDER ASSOCIATES LTD.

Marijana Manojlovic
Laboratory Manager

MM/lh

Golder Associates Ltd.
2900 Argentia Road, Unit 15, Mississauga, Ontario, Canada L5N 7X9
Tel: +1 (905) 567 4444 Fax: +1 (905) 567 6561 www.golder.com
Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

GOLDER

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

ASTM D7012

SAMPLE IDENTIFICATION

PROJECT NUMBER	1897138	SAMPLE NUMBER	Run 1
PROJECT NAME	ThurberEng/Lab Testing/Miss	SAMPLE DEPTH, m	19.51-19.72
BOREHOLE NUMBER	GRB16-12	DATE:	02/23/2018

TEST CONDITIONS

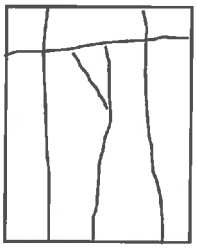
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.25

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	14.26	WATER CONTENT, (specimen) %	0.26
SAMPLE DIAMETER, cm	6.33	UNIT WEIGHT, kN/m^3	26.97
SAMPLE AREA, cm^2	31.49	DRY UNIT WT., kN/m^3	26.90
SAMPLE VOLUME, cm^3	448.98	SPECIFIC GRAVITY	-
WET WEIGHT, g	1235.20	VOID RATIO	-
DRY WEIGHT, g	1232.00		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	108.8

REMARKS:

Checked By: LY

Golder Associates

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE

BEFORE COMPRESSION

AFTER COMPRESSION

Date Feb. 23, 2018
Project 11375

Golder Associates

Drawn Frank
Chkd.

GOLDER

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

ASTM D7012

SAMPLE IDENTIFICATION

PROJECT NUMBER	1897138	SAMPLE NUMBER	Run 3
PROJECT NAME	ThurberEng/Lab Testing/Miss	SAMPLE DEPTH, m	23.65-23.83
BOREHOLE NUMBER	GRB16-05	DATE:	03/06/2018

TEST CONDITIONS

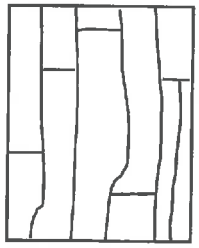
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.32

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	14.70	WATER CONTENT, (specimen) %	0.40
SAMPLE DIAMETER, cm	6.34	UNIT WEIGHT, kN/m^3	27.32
SAMPLE AREA, cm^2	31.57	DRY UNIT WT., kN/m^3	27.21
SAMPLE VOLUME, cm^3	464.07	SPECIFIC GRAVITY	-
WET WEIGHT, g	1293.26	VOID RATIO	-
DRY WEIGHT, g	1288.11		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	115.5

REMARKS:

Checked By: MJ

Golder Associates

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE

BEFORE COMPRESSION

AFTER COMPRESSION

Date Mar. 9, 2018
Project 1897138

Golder Associates

Drawn Frank
Chkd. LM

GOLDER

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

ASTM D7012

SAMPLE IDENTIFICATION

PROJECT NUMBER	1897138	SAMPLE NUMBER	Run 2
PROJECT NAME	ThurberEng/Lab Testing/Miss	SAMPLE DEPTH, m	21.56-21.72
BOREHOLE NUMBER	GRB16-04	DATE:	03/06/2018

TEST CONDITIONS

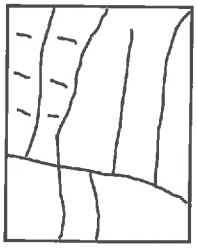
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.13

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.52	WATER CONTENT, (specimen) %	0.20
SAMPLE DIAMETER, cm	6.34	UNIT WEIGHT, kN/m^3	26.51
SAMPLE AREA, cm^2	31.57	DRY UNIT WT., kN/m^3	26.46
SAMPLE VOLUME, cm^3	426.82	SPECIFIC GRAVITY	-
WET WEIGHT, g	1154.38	VOID RATIO	-
DRY WEIGHT, g	1152.08		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	61.3

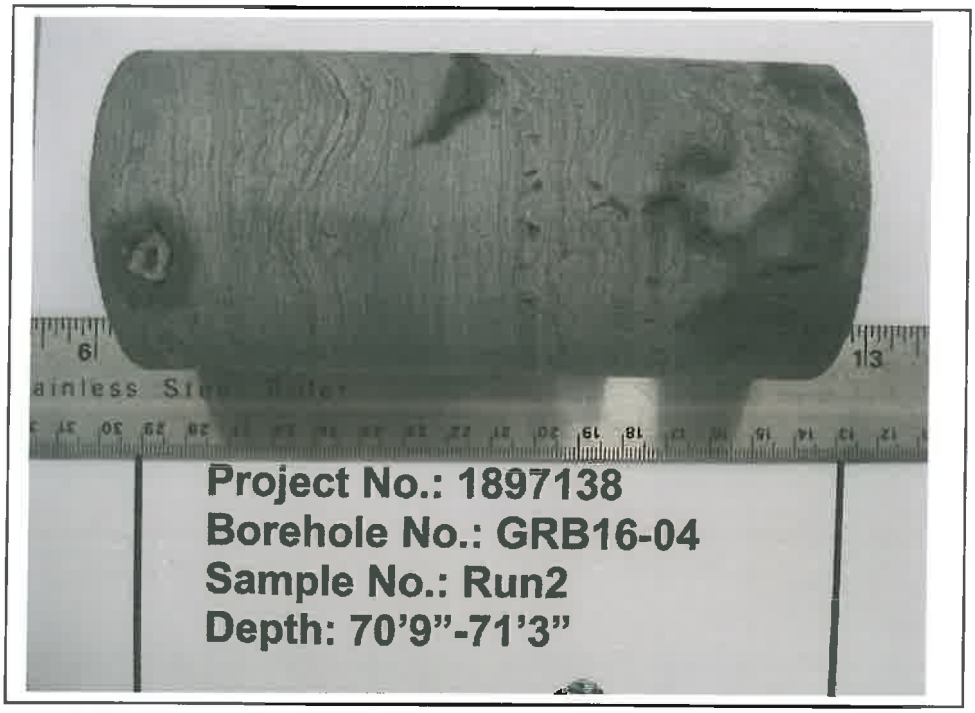
REMARKS:

Checked By: LM

Golder Associates

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE



BEFORE COMPRESSION

AFTER COMPRESSION

Date Mar. 9, 2018
Project 1897138

Golder Associates

Drawn Frank
Chkd. VM

GOLDER

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

ASTM D7012

SAMPLE IDENTIFICATION

PROJECT NUMBER	1897138	SAMPLE NUMBER	Run 3
PROJECT NAME	ThurberEng/Lab Testing/Miss	SAMPLE DEPTH, m	23.39-23.57
BOREHOLE NUMBER	GRB16-04	DATE:	03/06/2018

TEST CONDITIONS

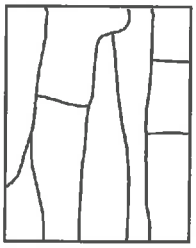
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.28

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	14.41	WATER CONTENT, (specimen) %	0.30
SAMPLE DIAMETER, cm	6.33	UNIT WEIGHT, kN/m^3	27.40
SAMPLE AREA, cm^2	31.47	DRY UNIT WT., kN/m^3	27.31
SAMPLE VOLUME, cm^3	453.48	SPECIFIC GRAVITY	-
WET WEIGHT, g	1267.37	VOID RATIO	-
DRY WEIGHT, g	1263.58		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	89.0

REMARKS:

Checked By: MJ

Golder Associates

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE

BEFORE COMPRESSION

AFTER COMPRESSION

Date Mar. 9, 2018
Project 1897138

Golder Associates

Drawn Frank
Chkd. MJ

GOLDER

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

ASTM D7012

SAMPLE IDENTIFICATION

PROJECT NUMBER	1897138	SAMPLE NUMBER	Run 2
PROJECT NAME	ThurberEng/Lab Testing/Miss	SAMPLE DEPTH, m	22.25-22.50
BOREHOLE NUMBER	GRB16-03	DATE:	03/06/2018

TEST CONDITIONS

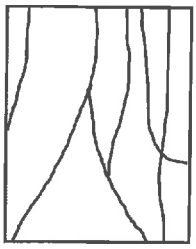
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.30

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.98	WATER CONTENT, (specimen) %	0.20
SAMPLE DIAMETER, cm	6.09	UNIT WEIGHT, kN/m^3	27.11
SAMPLE AREA, cm^2	29.13	DRY UNIT WT., kN/m^3	27.06
SAMPLE VOLUME, cm^3	407.22	SPECIFIC GRAVITY	-
WET WEIGHT, g	1126.32	VOID RATIO	-
DRY WEIGHT, g	1124.07		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	70.2

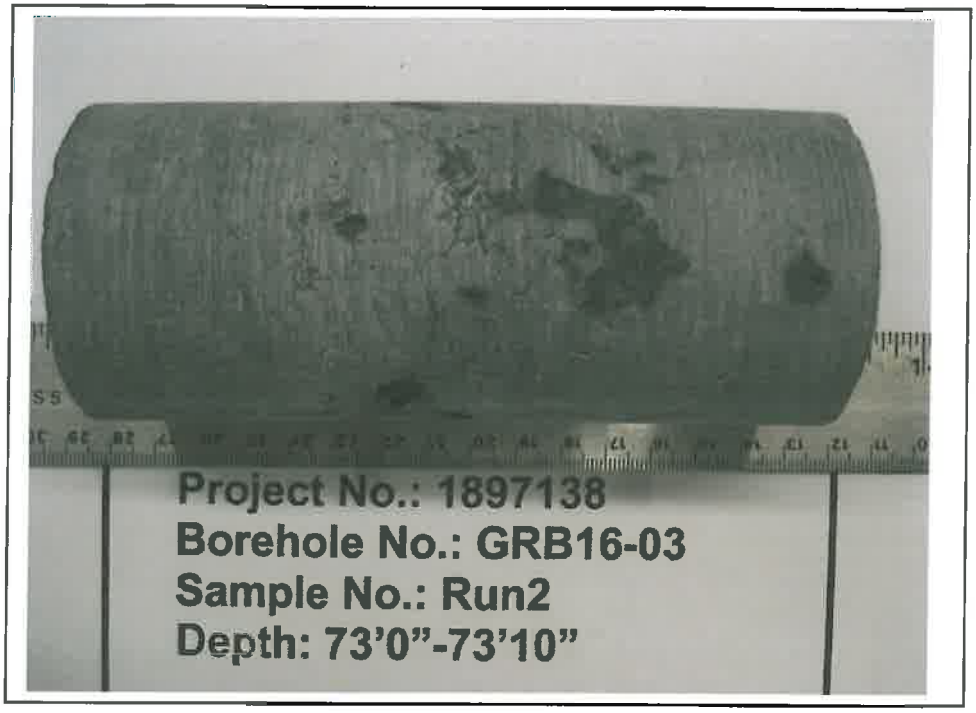
REMARKS:

Checked By: LM

Golder Associates

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE



BEFORE COMPRESSION

AFTER COMPRESSION

Date Mar. 9, 2018
Project 1897138

Golder Associates

Drawn Frank
Chkd. MM

GOLDER

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS

ASTM D7012

SAMPLE IDENTIFICATION

PROJECT NUMBER	1897138	SAMPLE NUMBER	Run 4
PROJECT NAME	ThurberEng/Lab Testing/Miss	SAMPLE DEPTH, m	34.95-35.15
BOREHOLE NUMBER	GRB16-21	DATE:	03/06/2018

TEST CONDITIONS

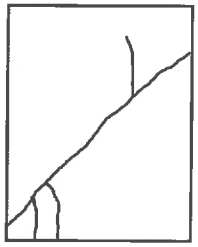
MACHINE SPEED, mm/min	N/A	TYPE OF SPECIMEN	Rock Core
DURATION OF TEST,min	>2 <15	L/D	2.18

SPECIMEN INFORMATION

SAMPLE HEIGHT, cm	13.28	WATER CONTENT, (specimen) %	0.30
SAMPLE DIAMETER, cm	6.09	UNIT WEIGHT, kN/m^3	26.95
SAMPLE AREA, cm^2	29.13	DRY UNIT WT., kN/m^3	26.87
SAMPLE VOLUME, cm^3	386.83	SPECIFIC GRAVITY	-
WET WEIGHT, g	1063.42	VOID RATIO	-
DRY WEIGHT, g	1060.24		

VISUAL INSPECTION

FAILURE SKETCH



TEST RESULTS

STRAIN AT FAILURE, %	N/A	COMPRESSIVE STRENGTH, MPa	33.6

REMARKS:

Checked By: LM

Golder Associates

UNCONFINED COMPRESSION TEST (UC) OF INTACT ROCK CORE SPECIMENS
ASTM D7012

FIGURE

BEFORE COMPRESSION

AFTER COMPRESSION

Date Mar. 9, 2018
Project 1897138

Golder Associates

Drawn Frank
Chkd.

BOREHOLE: **16-03**
CORE RUN #1: 67' 3" – 71' 0"
CORE RUN #2: 71' 0" – 76' 3"
CORE RUN #3: 76' 3" – 78' 8"

BOREHOLE: **16-04**
CORE RUN #1: 69' 4" – 69' 9"
CORE RUN #2: 69' 9" – 74' 9"
CORE RUN #3: 74' 9" – 79' 9"

THURBER ENGINEERING LTD.

HIGHWAY 7-NEW EBL AND WBL OVER THE GRAND RIVER
REGIONAL MUNICIPALITY OF WATERLOO
CITY OF KITCHENER, ONTARIO

BOREHOLE: **16-05**
CORE RUN #1: 69' 6" – 70' 2"
CORE RUN #2: 70' 2" – 75' 2"
CORE RUN #3: 75' 2" – 80' 2"

BOREHOLE: **16-07**
CORE RUN #1: 64' 7" – 65' 4"
CORE RUN #2: 65' 4" – 70' 4"
CORE RUN #3: 70' 4" – 75' 4"

THURBER ENGINEERING LTD.

HIGHWAY 7-NEW EBL AND WBL OVER THE GRAND RIVER
REGIONAL MUNICIPALITY OF WATERLOO
CITY OF KITCHENER, ONTARIO

BOREHOLE: **16-09**
CORE RUN #1: 66' 4" – 66' 9"
CORE RUN #2: 66' 9" – 71' 9"
CORE RUN #3: 71' 9" – 76' 9"

BOREHOLE: **16-10**
CORE RUN #1: 66' 0" – 68' 9"
CORE RUN #2: 68' 9" – 73' 9"
CORE RUN #3: 73' 9" – 77' 7"

THURBER ENGINEERING LTD.

HIGHWAY 7-NEW EBL AND WBL OVER THE GRAND RIVER
REGIONAL MUNICIPALITY OF WATERLOO
CITY OF KITCHENER, ONTARIO

BOREHOLE:	**16-12**
CORE RUN #1:	63' 10" – 65' 6"
CORE RUN #2:	65' 6" – 70' 6"
CORE RUN #3:	70' 6" – 73' 8"

BOREHOLE:	**16-13**
CORE RUN #1:	57' 1" – 59' 8"
CORE RUN #2:	59' 8" – 64' 8"
CORE RUN #3:	64' 8" – 68' 8"

THURBER ENGINEERING LTD.

HIGHWAY 7-NEW EBL AND WBL OVER THE GRAND RIVER
REGIONAL MUNICIPALITY OF WATERLOO
CITY OF KITCHENER, ONTARIO

BOREHOLE:	**16-14**
CORE RUN #1:	59' 2" – 60' 6"
CORE RUN #2:	60' 6" – 64' 6"
CORE RUN #3:	64' 6" – 69' 6"

BOREHOLE:	**16-21**
CORE RUN #1:	101' 5" – 106' 0"
CORE RUN #2:	106' 0" – 111' 0"
CORE RUN #3:	111' 0" – 114' 8"
CORE RUN #4:	114' 8" – 116' 0"

THURBER ENGINEERING LTD.

HIGHWAY 7-NEW EBL AND WBL OVER THE GRAND RIVER
REGIONAL MUNICIPALITY OF WATERLOO
CITY OF KITCHENER, ONTARIO

FINAL REPORT

CA14400-MAR18 R

11375

Prepared for

Thurber Engineering Ltd.

FINAL REPORT

CA14400-MAR18 R

First Page

CLIENT DETAILS		LABORATORY DETAILS	
Client	Thurber Engineering Ltd.	Project Specialist	Deanna Edwards, B.Sc, C.Chem
		Laboratory	SGS Canada Inc.
Address	103, 2010 Winston Park Drive Oakville, ON L6H 5R7.	Address	185 Concession St., Lakefield ON, K0L 2H0
Contact	Rocío Reyna	Telephone	705-652-2000
Telephone	905-829-8666 x 263	Facsimile	705-652-6365
Facsimile		Email	deanna.edwards@sgs.com
Email	rreyna@thurber.ca	SGS Reference	CA14400-MAR18
Project	11375	Received	03/19/2018
Order Number		Approved	03/23/2018
Samples	Soil (12)	Report Number	CA14400-MAR18 R
		Date Reported	03/23/2018

COMMENTS

Temperature of Sample upon Receipt: 2 degrees C
Cooling Agent Present: Yes
Custody Seal Present: No

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

SIGNATORIES

Deanna Edwards, B.Sc, C.Chem

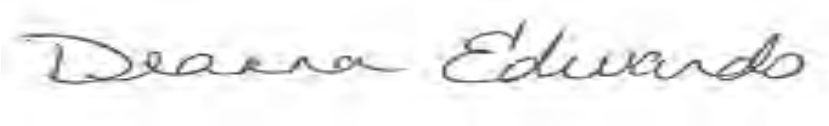


TABLE OF CONTENTS

Client: Thurber Engineering Ltd.
Project: 11375
Project Manager: Rocío Reyna
Samplers: Kamil Feszak

PACKAGE: **- Corrosivity Index** (SOIL)

Sample Number			5	6	7	8	9	10	11	12
Sample Name			BS16-04 SS4	GH16-04 SS8	RC16-02 SS3	CR04 SS3	EB 16-03 SS5	SP16-04 SS7	CV16-01 SS3	GRB16-10 SS4
Sample Matrix			Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date			21/03/2018							
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
Corrosivity Index										
Corrosivity Index	none	1	4.0	3.0	4.0	4.0	3.0	5.5	4.0	4.0
Soil Redox Potential	mV	-	343	324	305	294	332	271	228	230
Sulphide	%	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.06	< 0.02	< 0.02
pH	no unit	0.05	9.08	8.73	8.47	8.63	8.60	8.49	8.78	9.14
Resistivity (calculated)	ohms.cm	-9999	3860	3390	4630	3950	6100	2800	7520	8470

PACKAGE: **- Corrosivity Index** (SOIL)

Sample Number			13	14	15	16
Sample Name			HC16-05 SS3	TR04-SS5	SH16-04 SS4	GRB16-21 SS4
Sample Matrix			Soil	Soil	Soil	Soil
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**
Corrosivity Index						
Corrosivity Index	none	1	4.0	4.0	3.0	4.0
Soil Redox Potential	mV	-	314	250	265	246
Sulphide	%	0.02	< 0.02	< 0.02	< 0.02	< 0.02
pH	no unit	0.05	9.06	8.98	9.11	8.91
Resistivity (calculated)	ohms.cm	-9999	7810	10100	6940	8200

FINAL REPORT

CA14400-MAR18 R

Client: Thurber Engineering Ltd.
Project: 11375
Project Manager: Rocío Reyna
Samplers: Kamil Feszak

PACKAGE: **- General Chemistry** (SOIL)

Sample Number			5	6	7	8	9	10	11	12
Sample Name			BS16-04 SS4	GH16-04 SS8	RC16-02 SS3	CR04 SS3	EB 16-03 SS5	SP16-04 SS7	CV16-01 SS3	GRB16-10 SS4
Sample Matrix			Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date			21/03/2018							
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
General Chemistry										
Conductivity	uS/cm	2	259	295	216	253	164	357	133	118

PACKAGE: **- General Chemistry** (SOIL)

Sample Number		13	14	15	16	
Sample Name		HC16-05 SS3	TR04-SS5	SH16-04 SS4	GRB16-21 SS4	
Sample Matrix		Soil	Soil	Soil	Soil	
Parameter	**Units**	**Result**	**Result**	**Result**	**Result**	
General Chemistry						
Conductivity	uS/cm	128	99	144	122	

PACKAGE: **- Metals and Inorganics** (SOIL)

Sample Number			5	6	7	8	9	10	11	12
Sample Name			BS16-04 SS4	GH16-04 SS8	RC16-02 SS3	CR04 SS3	EB 16-03 SS5	SP16-04 SS7	CV16-01 SS3	GRB16-10 SS4
Sample Matrix			Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date			21/03/2018							
Parameter	**Units**	**RL**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
Metals and Inorganics										
Sulphate	µg/g	0.4	140	92	11	69	6.5	356	68	22

PACKAGE: **- Metals and Inorganics** (SOIL)

Sample Number		13	14	15	16	
Sample Name		HC16-05 SS3	TR04-SS5	SH16-04 SS4	GRB16-21 SS4	
Sample Matrix		Soil	Soil	Soil	Soil	
Parameter	**Units**	**Result**	**Result**	**Result**	**Result**	
Metals and Inorganics						
Sulphate	µg/g	22	2.4	15	11	

Client: Thurber Engineering Ltd.
Project: 11375
Project Manager: Rocío Reyna
Samplers: Kamil Feszak

PACKAGE: **- Other (ORP)** (SOIL)

			Sample Number	5	6	7	8	9	10	11	12
			Sample Name	BS16-04 SS4	GH16-04 SS8	RC16-02 SS3	CR04 SS3	EB 16-03 SS5	SP16-04 SS7	CV16-01 SS3	GRB16-10 SS4
			Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			Sample Date	21/03/2018							
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
Other (ORP)											
Chloride	µg/g	0.4		34	50	12	71	4.8	7.6	13	67

PACKAGE: **- Other (ORP)** (SOIL)

			Sample Number	13	14	15	16
			Sample Name	HC16-05 SS3	TR04-SS5	SH16-04 SS4	GRB16-21 SS4
			Sample Matrix	Soil	Soil	Soil	Soil
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**
Other (ORP)							
Chloride	µg/g	0.4		71	22	94	68

PACKAGE: **- PHCs** (SOIL)

			Sample Number	5	6	7	8	9	10	11	12
			Sample Name	BS16-04 SS4	GH16-04 SS8	RC16-02 SS3	CR04 SS3	EB 16-03 SS5	SP16-04 SS7	CV16-01 SS3	GRB16-10 SS4
			Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			Sample Date	21/03/2018							
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
PHCs											
Moisture Content	%	0.1		14.5	0.2	12.8	8.6	1.2	19.9	5.5	8.7

PACKAGE: **- PHCs** (SOIL)

			Sample Number	13	14	15	16
			Sample Name	HC16-05 SS3	TR04-SS5	SH16-04 SS4	GRB16-21 SS4
			Sample Matrix	Soil	Soil	Soil	Soil
Parameter	**Units**	**RL**		**Result**	**Result**	**Result**	**Result**
PHCs							
Moisture Content	%	0.1		12.4	7.1	2.7	10.8

QC SUMMARY

Anions by IC

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0288-MAR18	µg/g	0.4	<0.4	2	20	100	80	120	101	75	125
Sulphate	DIO0288-MAR18	µg/g	0.4	<0.4	15	20	98	80	120	96	75	125

Carbon/Sulphur

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0025-MAR18	%	0.02	<0.02	ND	20	111	80	120			

Conductivity

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0284-MAR18	uS/cm	2	< 2	1	10	99	90	110	NA		

QC SUMMARY

pH

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0284-MAR18	no unit	0.05	NA	1		101			NA		

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

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

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

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

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

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

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

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

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

LEGEND

FOOTNOTES

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

Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

-- End of Analytical Report --

SGS

Request for Laboratory Services and CHAIN OF CUSTODY

No: Page 1 of 2

SGS Environmental Services - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Toll Free: 877-747-7658 Fax: 705-652-6365
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361 Web: www.ca.sgs.com

Laboratory Information Section - Lab use only

Received By: ENCK ADSIT
Received Date (mm/dd/yyyy): 03/19/18 (mm\dd\yy)
Received Time: 11:00 AM
Received By (signature):
Custody Seal Present: ☐ NO
Custody Seal Intact: ☑
Cooling Agent Present: ☑ ICE
Temperature Upon Receipt (°C): 7.0, 7.1, 7.2
LAB LIMS #:

REPORT INFORMATION

Company: Thurber Eng.
Contact: Rocio Palomeque Reyna
Address: 103-2010 Winston Park Dr.
Oakville, ON
Phone: 905-829-8666 x 260
Fax:
Email: rreynae@thurber.ca

INVOICE INFORMATION

☑ (same as Report Information)
Company:
Contact:
Address:
Phone:
Email:

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 11375
Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☑ Regular TAT (5-7days) TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 3pm or on weekends : TAT begins the next business day

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

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: Rush Confirmation ID:

REGULATIONS

Regulation 153 (2011): ☐ Table 1 ☐ Table 2 ☐ Table 3 ☐ Table ____ ☐ Res/Park ☐ Ind/Com ☐ Agri/Other Soil Texture: ☐ Coarse ☐ Medium ☐ Fine

Other Regulations: ☐ Reg 347/558 (3 Day min TAT) ☐ PWQO ☐ MMER ☐ CCME ☐ Other: ☐ MISA

Sewer By-Law: ☐ Sanitary ☐ Storm Municipality:

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

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Cr(VI) by IC/Colorimetric	COMMENTS: Field Filtered (F) Preserved (P)
1	TR-04 -SS5	← June/2017		1	Soil	✓	
2	SH16-04 SS4	← July/2017		1	Soil	✓	
3	GRB16-2 SS4	← Feb/2017		1	Soil	✓	
4							
5							
6							
7							
8							
9							
10							

Observations/Comments/Special Instructions

Sampled By (NAME): KAMIL FESZAK	**Signature:**	Date: 03/19/18 (mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME): Sarah Hashimi	**Signature:**	Date: __/__/__ (mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.0
Date of Issue: 01 June, 2014

SGS

Request for Laboratory Services and CHAIN OF CUSTODY

SGS Environmental Services - Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Toll Free: 877-747-7658 Fax: 705-652-6365
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361 Web: www.ca.sgs.com

No: CA 14400-MAR.18
Page 2 of 2

Laboratory Information Section - Lab use only

Received By: Erick-Rose
Received Date (mm/dd/yyyy): 03/19/2018 (mm\dd\yy)
Received Time: 11:00 am
Received By (signature):
Custody Seal Present: ☑ NO
Custody Seal Intact: ☑
Cooling Agent Present: ☑ ICE
Temperature Upon Receipt (°C): 7.0, 7.1, 7.2
LAB LIMS #:
5x3

REPORT INFORMATION

Company: Thurber Eng.
Contact: Rocio Palomeque Reyna
Address: 103-2010 Winston Park Drive
Oakville, ON L6H 5R7
Phone: 905-829-8666
Fax:
Email: rreyna@thurber.ca

INVOICE INFORMATION

☒ (same as Report Information)
Company:
Contact:
Address:
Phone:
Email:

PROJECT INFORMATION

Quotation #:
P.O. #:
Project #: 11375
Site Location/ID:

TURNAROUND TIME (TAT) REQUIRED

☐ Regular TAT (5-7days) TAT's are quoted in business days (exclude statutory holidays & weekends). Samples received after 3pm or on weekends : TAT begins the next business day

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

PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION

Specify Due Date: Rush Confirmation ID:

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

REGULATIONS

Regulation 153 (2011):
☐ Table 1 ☐ Res/Park Soil Texture:
☐ Table 2 ☐ Ind/Com ☐ Coarse
☐ Table 3 ☐ Agri/Other ☐ Medium
☐ Table ____ ☐ Fine

Other Regulations:
☐ Reg 347/558 (3 Day min TAT)
☐ PWQO ☐ MMER
☐ CCME ☐ Other:
☐ MISA

Sewer By-Law:
☐ Sanitary
☐ Storm
Municipality:

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

ANALYSIS REQUESTED

	SAMPLE IDENTIFICATION	DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX	Conformity	COMMENTS: Field Filtered (F) Preserved (P)
1	BS16-04 SS4	March 21, 2017		1	Soil	✓	
2	GH16-04 SS8	Oct /2017		1		✓	
3	RC16-02 SS3	Mar /2017		1		✓	
4	LR04 SS3	Dec/2016		1		✓	
5	EB16-03 SS5	Oct/2016		1		✓	
6	[redacted]						
7	SP16-04 SS9	May/2017		1		✓	
8	CV16-01 SS3	June/2017		1		✓	
9	GRB16-10 SS4	Dec /2017		1		✓	
10	HC16-05 SS3	Aug/2017		1		✓	

Observations/Comments/Special Instructions

Sampled By (NAME):	KAMIL FESZAK	**Signature:**	Date: 03/19/18 (mm/dd/yy)	Pink Copy - Client
Relinquished by (NAME):	Sarah Hashimi	**Signature:**	Date: __/__/__ (mm/dd/yy)	Yellow & White Copy - SGS

Revision #: 1.0
Date of Issue: 01 June, 2014

SGS

SAMPLE INTEGRITY REPORT

Project Number: 11375

ONTARIO REGULATION 153/04

SGS Sample ID CA14400-MAR18

Date / Time Sampled See CofC

Client Sample ID See CofC

	ALL
Sample Submission General Sample Integrity Violations	
Temperature >10 C upon receipt if not sampled same day	☐
No evidence of cooling trend initiated if sampled same day	☐
Chain of Custody not submitted	☐
Chain of Custody incomplete	☐
Chain of Custody not signed / dated	☐
Chain of Custody not a current version	☐
Bottles / Samples listed on CoC but not received	☐
Bottles / Samples received but not listed on the CoC	☐
Sample container received empty	☐

Sample Specific Sample Integrity Violations							
Sample received past hold time	☐	☐	☐	☐	☐	☐	☐
Incorrect preservation (including no preservation where required)	☐	☐	☐	☐	☐	☐	☐
Headspace present in VOC vial (aqueous)	☐	☐	☐	☐	☐	☐	☐
Sample(s) received frozen	☐	☐	☐	☐	☐	☐	☐
Bottle(s) broken or damaged in transport	☐	☐	☐	☐	☐	☐	☐
Discrepancy between sample label and chain of custody	☐	☐	☐	☐	☐	☐	☐
Analysis requirements absent / unclear	☐	☐	☐	☐	☐	☐	☐
Missing or incorrect sample label(s)	☐	☐	☐	☐	☐	☐	☐
Inappropriate sample container used	☐	☐	☐	☐	☐	☐	☐
Insufficient number of bottles received	☐	☐	☐	☐	☐	☐	☐
Limited sample volume	☐	☐	☐	☐	☐	☐	☐
Insufficient sample volume	☐	☐	☐	☐	☐	☐	☐
Sample contains multiple phases	☐	☐	☐	☐	☐	☐	☐
Sediment Log							
Groundwater samples contain visible sediment / particulate	☐	☐	☐	☐	☐	☐	☐
Groundwater contains greater than 1cm of sediment / particulate matter in bottle	☐	☐	☐	☐	☐	☐	☐

Additional Comments/Remarks:

No issues upon receipt ☑ Initials: KH

THURBER

Appendix B
Record of Borehole Sheets and Laboratory Test Results for Previous Site Investigation

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-060 1 OF 2 METRIC

G.W P 408-88-00 | LOCATION N 4 815 513.62 E 227 303.57 | ORIGINATED BY WB
HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY EA
DATUM Geodetic | DATE 2008.06.25 - 2008.06.25 | CHECKED BY RPR

ELEV / DEPTH	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 (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, X LAB VANE) (40 80 120 160 200)	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
302.9 / 0.0	**RECENT ALLUVIUM**, some silt, trace clay, mixed with disseminated organics Stiff Dark Brown Damp		1	AS			305				
			1	SS	9		302				
			2	SS	10		301				
300.5 / 2.4	**SAND and GRAVEL**, trace to some silt, trace clay, occasional cobbles Compact to Dense Brown Wet		3	SS	16		300				
			4	SS	30		299				42 43 15 (SI+CL)
	Auger grinding at 3.7m						298				
298.1 / 4.9	**Silty CLAY**, trace sand Very Stiff to Hard Brown to Grey		5	SS	24		297				
			6	SS	33		296				0 2 48 50
295.6 / 7.3	**SILT**, trace sand, trace clay Very Dense Grey Moist		7	SS	78		295				0 5 87 9
294.4 / 8.5	**Sandy SILT**, trace to some clay, trace gravel Very Dense Grey Moist (TILL)		8	SS	77		294				

Continued Next Page

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-060 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 513.62 E 227 303.57 ORIGINATED BY WB
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY EA
DATUM Geodetic DATE 2008.06.25 - 2008.06.25 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40 80 120 160 200)	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
	Continued From Previous Page										
	Sandy SILT, trace to some clay, trace gravel Very Dense Grey Moist (TILL)						293				
			9	SS	100/.275		292		O		3 37 50 10
	occasional cobbles		10	SS	100/.275		291		O		
							290				
288.8			11	SS	100		289		O		
14.2	END OF BOREHOLE AT 14.2m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. Water table at 2.1m WATER LEVEL READINGS: DATE DEPTH (m) ELEV (m) 2008.07.04 1.5 301.4 2008.08.20 1.2 301.7										

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-061 1 OF 1 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 500.79 E 227 356.47 ORIGINATED BY WB
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.06.25 - 2008.06.26 CHECKED BY RPR

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 (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, X LAB VANE) (40 80 120 160 200)	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
0.0 / 303.8	**TOPSOIL**, trace clay, occasional organics Brown Damp		1	AS							
0.9 / 302.9	Silty **SAND**, trace clay, trace gravel Loose Brown Damp		1	SS	7		303				
1.5 / 302.3	**SAND and GRAVEL** Compact to Very Dense Brown to Grey Moist		2	SS	18		302				
	Wet		3	SS	71		301				46 39 15 (SI+CL)
	Auger grinding at 3.0m		4	SS	100/ 275		300				
5.5 / 298.3	Sandy **SILT**, some clay, occasional cobbles Very dense Grey Damp (TILL)		5	SS	100/ .200		299				
6.5 / 297.3	END OF BOREHOLE AT 6.5m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1 52m slotted screen.		6	SS	100/ 250		298				1 42 46 11

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2008.07 04	1.1	302.7
2008.08 20	0 7	303 1

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-062 1 OF 1 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 419.58 E 227 281.40 ORIGINATED BY WB
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.06.24 - 2008.06.24 CHECKED BY RPR

ELEV / DEPTH	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 (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) (40 80 120 160 200)	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
299.6											
0.0 / 299.3	**TOPSOIL:** (300mm), occasional organics Brown Damp		1	AS	15				o		
0.3	**SAND and GRAVEL,** trace to some silt, trace clay Compact to Dense Brown Damp		1	SS	38		299		o		
	occasional cobbles		2	SS	42	▽	298		o		
	Very Dense		3	SS	100/225		297		o		44 39 17 (SI+CL)
295.9			4	SS	100/.275				o		
3.7	**Sandy SILT,** some gravel, trace clay Very Dense Brown to Gray Moist (TILL)		5	SS	100		296				
	Slow augering.		6	SS	100/.225		295		o		27 45 28 (SI+CL)
291.7			7	SS	100/.225		294		o		7 40 43 10
7.8	END OF BOREHOLE AT 7.8m. WATER OBSERVED AT 2.1m DURING DRILLING. BOREHOLE BACKFILLED WITH GROUT TO 0.6m, THEN AUGER CUTTINGS TO SURFACE.						293 292				

ONTMT4S 6417R.GPJ 3/4/09

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

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-063 1 OF 1 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 457.16 E 227 352.22 ORIGINATED BY WB

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA

DATUM Geodetic DATE 2008.06.24 - 2008.06.24 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (40 80 120 160 200)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH 298.9	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
0.0 / 298.1	TOPSOIL, some organics, trace clay Brown Moist		1	AS					o		
0.8	SAND and GRAVEL, trace clay, occasional cobbles Compact to Dense Brown Moist		1	SS	35		298		o		
			2	SS	40	▽	297		o		
			3	SS	14				o		50 39 11 (SI+CL)
	Auger grinding at 3.0m. Very Dense		4	SS	100/ .050		296		o		
294.0			5	SS	100/ 300		295		o		
4.9	Sandy SILT, some clay Very Dense Brown to Grey Damp (TILL) slow augering at 5.8m.		6	SS	100/ 225		294		o		2 45 41 12
290.9			7	SS	100/ 200		293		o		
8.0	END OF BOREHOLE AT 8.0m, WATER OBSERVED AT 2.1m DURING DRILLING. BOREHOLE BACKFILLED WITH GROUT TO 0.6m, HOLEPLUG AND AUGER CUTTINGS TO 0.3m, THEN AUGER CUTTINGS TO SURFACE.						292				
							291				

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-064 1 OF 2 METRIC

G.W.P. 406-88-00 LOCATION N 4 815 360.98 E 227 325.43 ORIGINATED BY WB
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.06.26 - 2008.06.26 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
300.9 0.0	TOPSOIL, trace clay, occasional organics, Brown, Moist		1	AS							
299.9			1	SS	17		300				
1.0	SAND and GRAVEL, trace clay, trace silt, occasional cobbles, Loose, Brown, Damp		2	SS	10	▽	299				
	Very Dense		3	SS	100/ 225						
			4	SS	91		298				51 39 10 (SI+CL)
	Auger grinding at 4.6m.		5	SS	100/ 200		297				
295.1 5.8	Sandy SILT, trace to some clay, trace gravel, Very Dense, Grey, Damp, (TILL), Slow augering at 5.8m		6	SS	100/ 275		296				
			7	SS	100/ 150		295				7 53 32 8
	occasional cobbles		8	SS	100/ 125		294				
							293				
							292				
							291				

ONTMT4S 6417R.GPJ 3/4/09

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 15 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No 08-064 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 360.98 E 227 325.43 ORIGINATED BY WB
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.06.26 - 2008.06.26 CHECKED BY RPR

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 40 80 120 160 200	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
289.9	Sandy SILT, trace to some clay, trace gravel Very Dense Grey Damp (TILL)		9	SS	100/ .175		290		○		
11.0	END OF BOREHOLE AT 11.0m. WATER OBSERVED AT 2.1m DURING DRILLING. BOREHOLE BACKFILLED WITH GROUT TO 0.6m, THEN AUGER CUTTINGS, SAND AND HOLEPLUG TO SURFACE.										

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-065 1 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 318.04 E 227 257.28 ORIGINATED BY WB

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA

DATUM Geodetic DATE 2008.06.27 - 2008.06.27 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 80 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 40 80 120 160 200	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
300.6											
0.0	**TOPSOIL**, some clay Brown Damp		1	AS							
300.0											
0.8	**SAND and GRAVEL**, trace to some silt, trace clay Very Dense Brown Damp		1	SS	100/.150		300				
	occasional cobbles		2	SS	100/.175		299				
			3	SS	100/.200		298				
	Auger grinding at 3.0m. occasional cobbles		4	SS	100/.200		297				38 50 13 (SI+CL)
			5	SS	100		296				
294.2							295				
6.4	**Sandy SILT**, trace to some clay, trace gravel Very Dense Grey Moist (TILL)		6	SS	89		294				3 41 45 12
			7	SS	100/.175		293				
							292				
			8	SS	100/.150		291				1 39 46 14

Continued Next Page

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

THUNDER

RECORD OF BOREHOLE No 08-065 2 OF 2 METRIC

G.W.P. 405-88-00 LOCATION N 4 815 318.04 E 227 257.28 ORIGINATED BY WB

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA

DATUM Geodetic DATE 2008.06.27 - 2008.08.27 CHECKED BY RPR

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 40 80 120 160 200	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
289.5	Sandy SILT, trace to some clay, trace gravel Very Dense Grey Moist (TILL)		9	SS	100/ 275		290		o		
11.1	END OF BOREHOLE AT 11.1m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.07.04 0.5 300.1 2008.08.20 0.7 299.9										

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-066 1 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 308.83 E 227 314.29 ORIGINATED BY WB
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.06.26 - 2008.06.27 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES 'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, X LAB VANE) (40 60 120 160 200)	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
303.1							303				
0.0	TOPSOIL, trace clay, occasional organics Brown Damp		1	AS							
302.5							302				
0.6	SAND and GRAVEL, trace silt, trace clay, occasional cobbles Dense to Very Dense Brown Damp to Wet		1	SS	32						
			2	SS	100	▽	301				
			3	SS	100/.175						
			4	SS	100/.150		300				
			5	SS	100/.125		299				44 50 6 (SI+CL)
297.6							298				
5.5	Sandy SILT, trace to some clay, some gravel, occasional cobbles Very Dense Grey Moist (TILL)		6	SS	100/.075		297				
			7	SS	100/.150		296				
			8	SS	100/.125		295				
							294				11 37 39 13

Continued Next Page

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

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

ONTMT4S 6417R.GPJ 3/4/09

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-066 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 815 308.83 E 227 314.29 ORIGINATED BY WB
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA
DATUM Geodetic DATE 2008.06.26 - 2008.06.27 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40 80 120 160 200)	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
	Continued From Previous Page										
	Sandy SILT, trace to some clay, some gravel, occasional cobbles Very Dense Grey Moist						293				
292.3	(TILL)		9	SS	100/ .075						
10.7	END OF BOREHOLE AT 10.7m. WATER LEVEL AT 1.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH GROUT TO 0.6m, THEN AUGER CUTTINGS, SAND AND HOLEPLUG TO SURFACE.										

+ 3 . × 3 : Numbers refer to Sensitivity

20
15 ⊕ 5
10 (%) STRAIN AT FAILURE

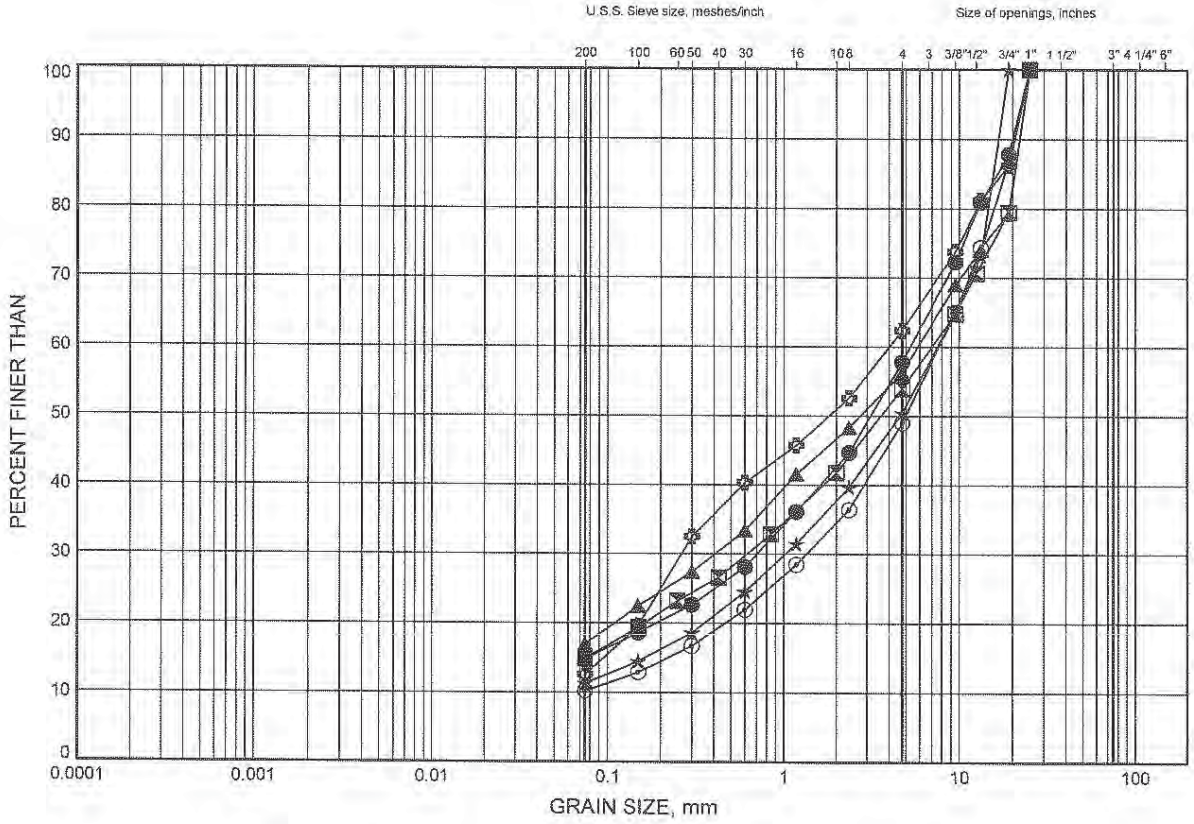
ONTMT4S 6417R.GPJ 3/4/09

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-060	3.35	299.58
⧓	08-061	2.59	301.20
▲	08-062	2.59	297.01
☆	08-063	2.59	296.29
⊙	08-064	3.35	297.55
✿	08-065	3.15	297.50

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

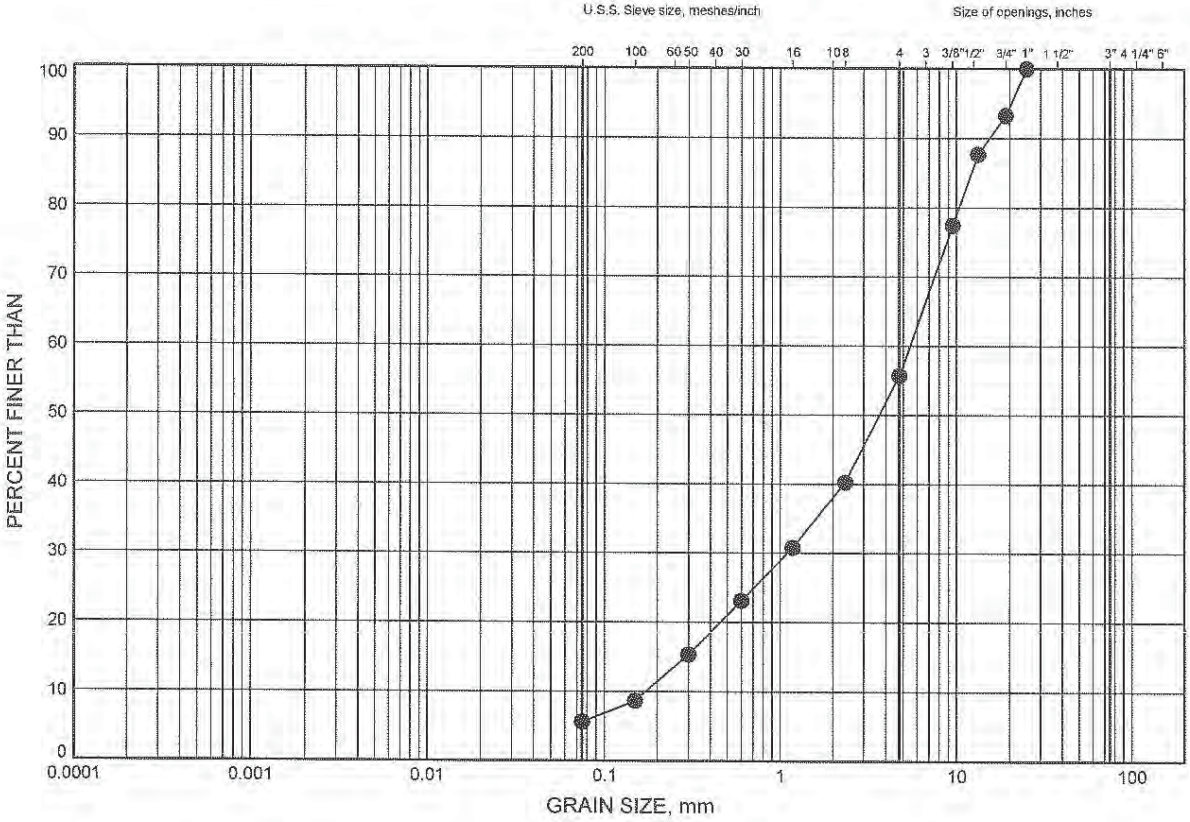
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/11/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B2

Sand and Gravel



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-066	4.72	298.34

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

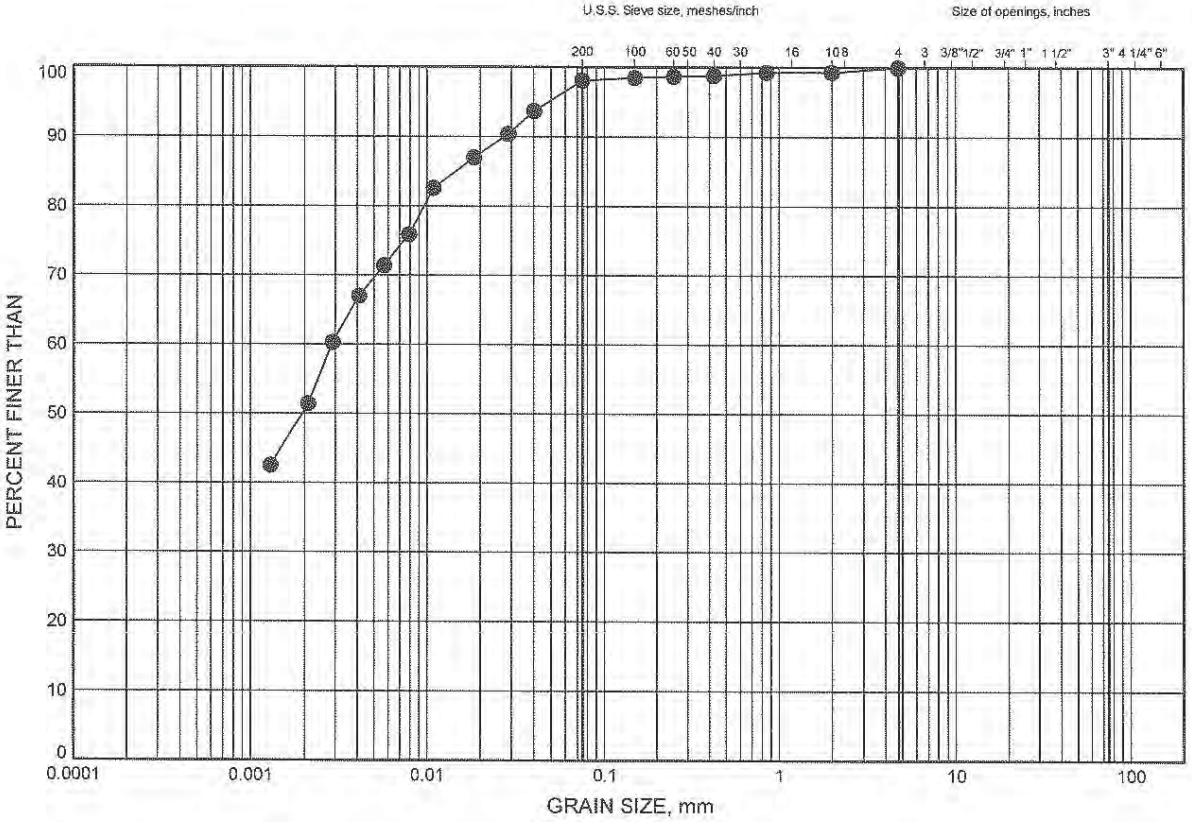
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/11/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty Clay



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-060	6.40	296.53

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

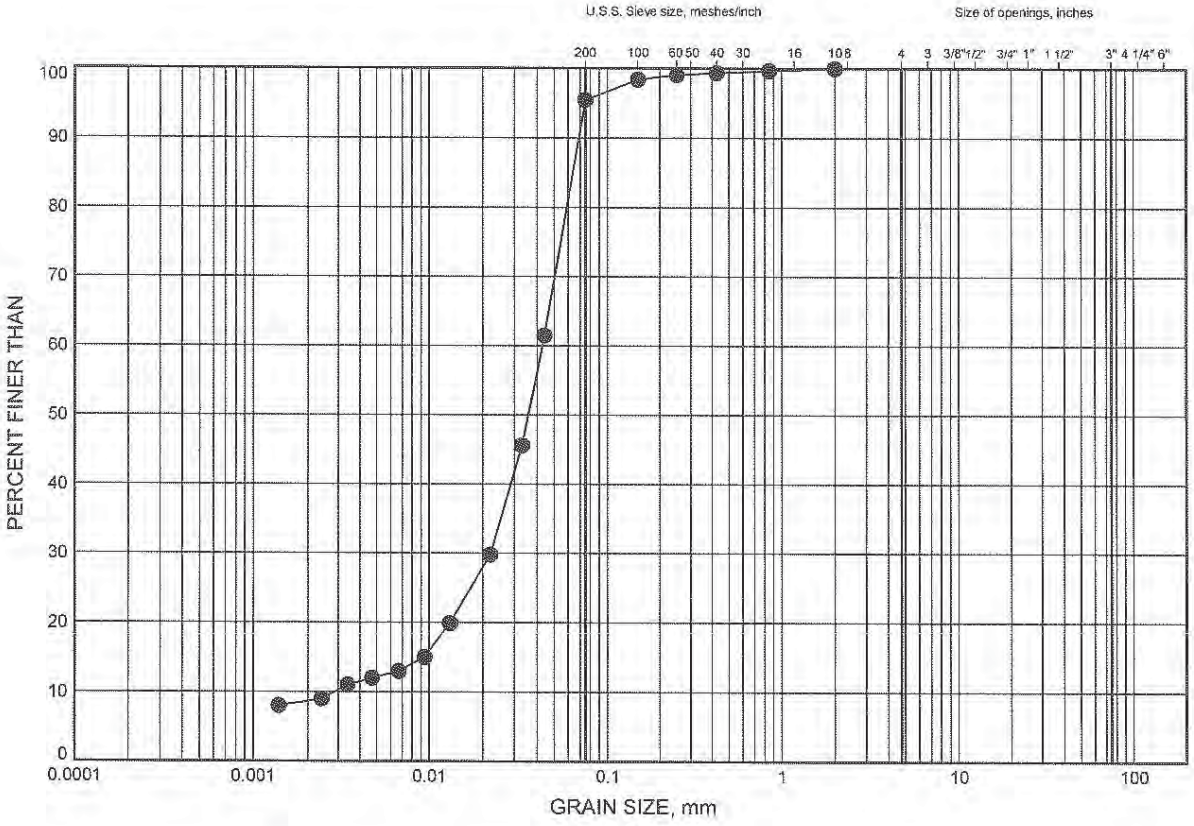
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/11/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Silt



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-060	7.92	295.01

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

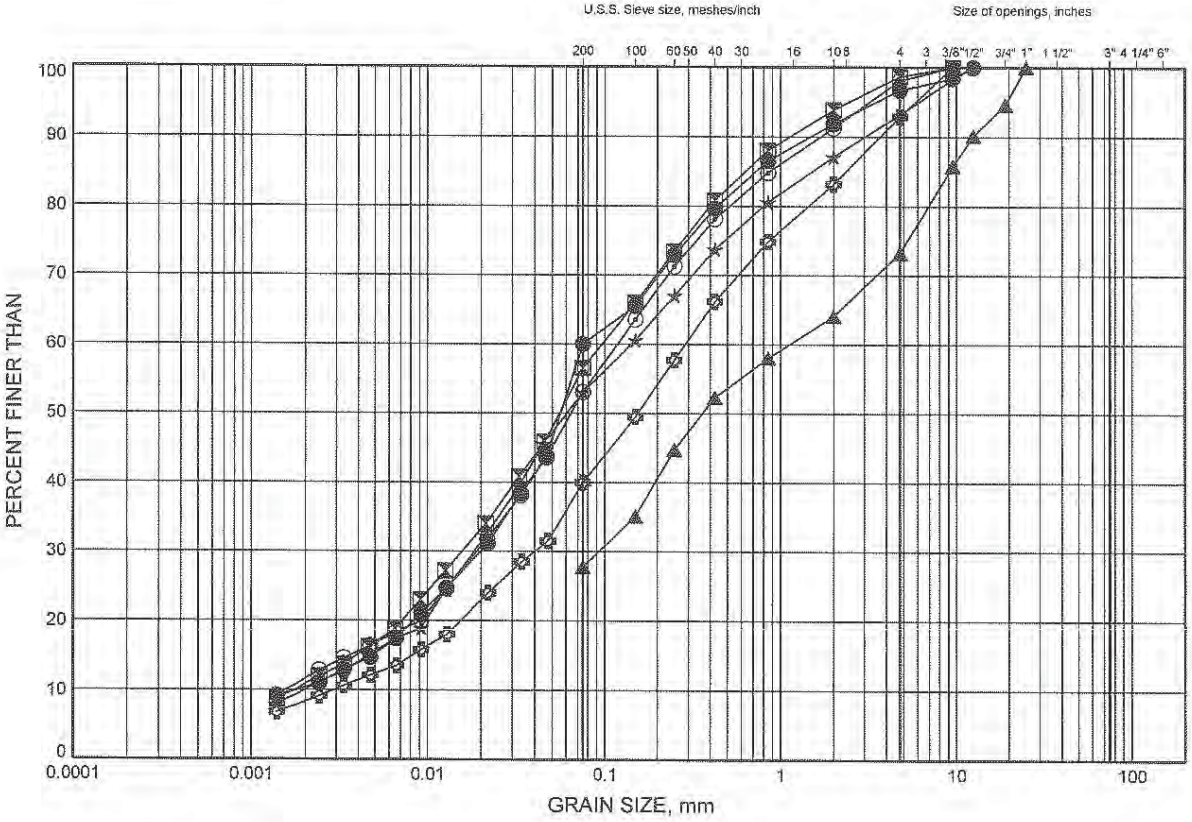
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/11/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B5

Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-060	10.91	292.02
⊠	08-061	6.30	297.49
▲	08-062	4.79	294.81
☆	08-062	6.32	293.27
⊙	08-063	6.28	292.60
✿	08-064	7.92	292.97

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

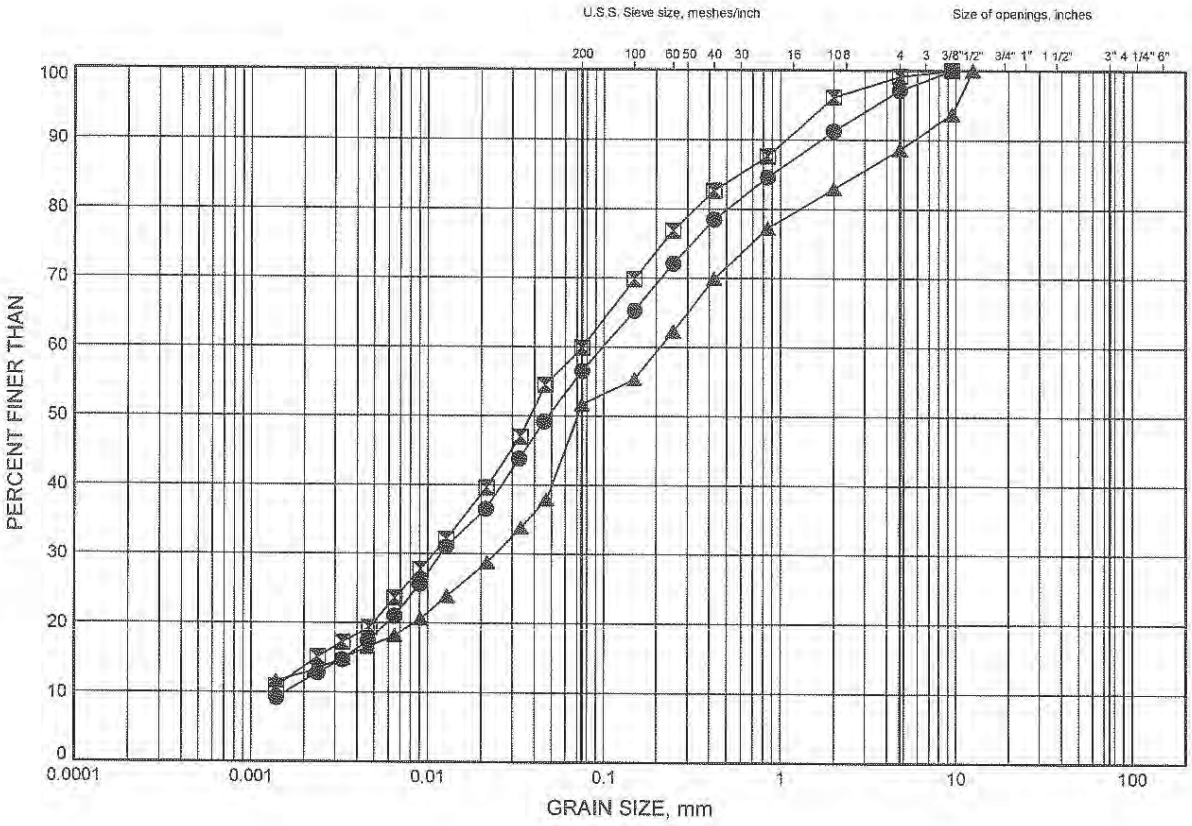
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/11/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B6

Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-065	6.55	294.10
⊠	08-065	9.30	291.35
▲	08-066	9.28	293.78

W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

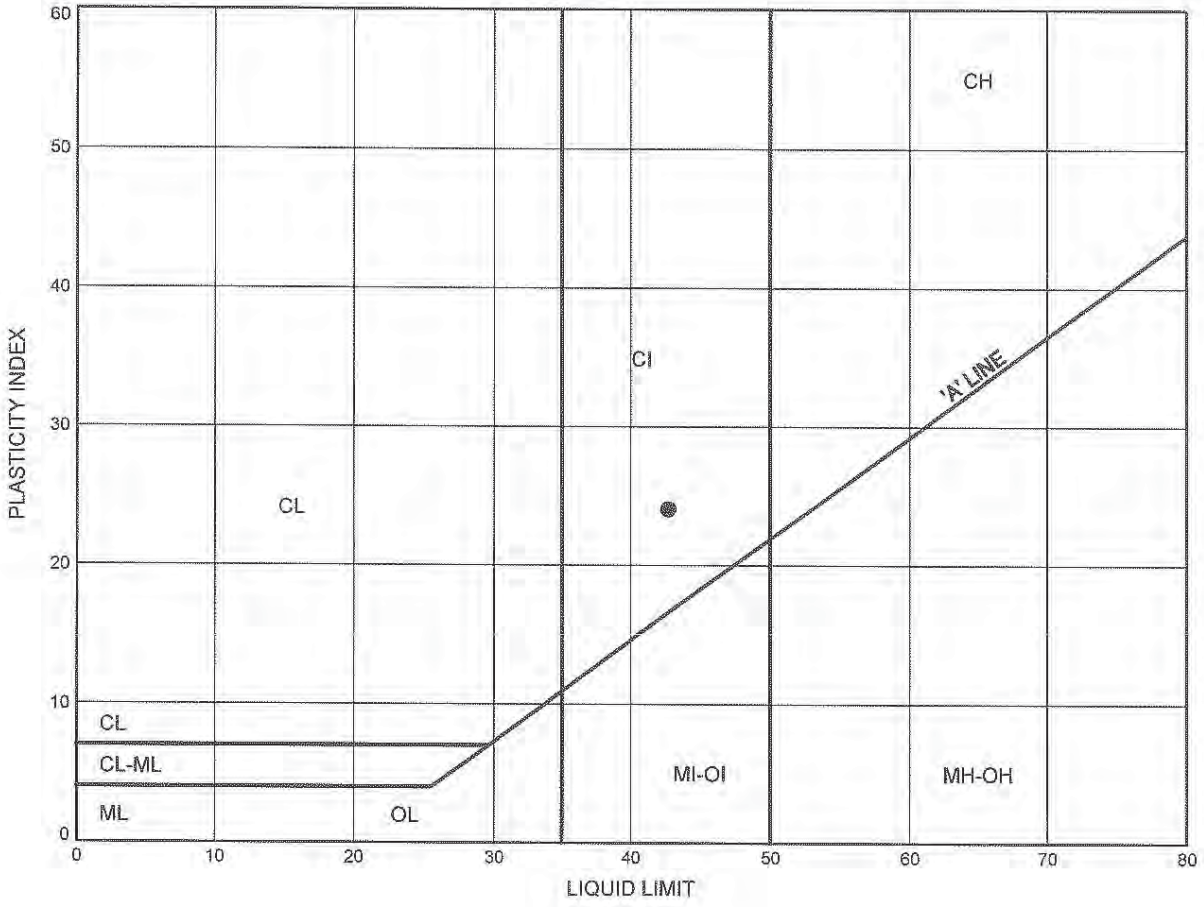
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/11/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Silty Clay



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-060	6.40	296.53

Date September 2008

Project 408-88-00

THURBER

Prep'd MFA

Chkd. RPR

THURBALT 6417R.GPJ 9/11/08

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE No 1

FOUNDATIONS OFFICE (Ref. W.O.71-11130 BH#1)

JOB _____ LOCATION Co-ords. 15,798,433 N; 745,888 E. ORIGINATED BY CK

W.P. 646-64-02 BORING DATE November 29, 1971 COMPILED BY PP

DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger; Cone CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT (20 40 60 80 100) / SHEAR STRENGTH P.S.F. (o UNCONFINED, • QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 1000 2000)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w (w_P w w_L) / WATER CONTENT % (20 40 60)	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
971.8	Ground Level									
0.0 / 968.8	Clayey silt to silt		1A	TW	PH	970			121.5	▼ 968.3
3.0 / 963.8	Sand and gravel Very Dense		1	SS	59					
8.0	Sandy silt with some clay and gravel. (Glacial Till) Very Dense		2	SS	126/8"	960				
			3	SS	137/10"					12 37 41 10
			4	SS	190/10"					
			5	SS	147/6"	950				
			6	SS	195/9"					7 38 44 11
941.0			7	SS	100/4"	940				
30.8	End of Borehole									

OFFICE REPORT ON EXPLORATION

15 10 20 5 % STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE Nº 2

FOUNDATIONS OFFICE (Ref. W.O.71-11130 BH.#2)

JOB _____ LOCATION Co-ords. 15,798,620 N; 745,964 E. ORIGINATED BY PP

W.P. 646-64-02 BORING DATE December 3, 1971 COMPILED BY PP

DATUM Geodetic BOREHOLE TYPE Washbore - NX Casing; Cone CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (20 40 60 80 100) SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w (w_P — w — w_L) WATER CONTENT % (20 40 60)	BULK DENSITY γ P.C.F.	REMARKS
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT					
969.0	Water Level									
966.4	Ground Level									
965.0	Sand and Gravel		1	SS	52					
4.0	Sandy silt with some clay & gravel, (Glacial Till) Very Dense		2	SS	132/6"	960		○		GR.SA.SI.CL 9 40 41 10
			3	SS	125/4"			○		
			4	SS	110/4"	950		○		
946.0			5	SS	120/6"			○		
20.4	End of Borehole					940				

OFFICE REPORT ON EXPLORATION

20
15 ◇ S % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH

RECORD OF BOREHOLE Nº 3

FOUNDATIONS OFFICE (Ref. W.O.71-11130 BH.#3)

JOB _____ LOCATION Co-ords. 15,798,966 N; 746,156 E. ORIGINATED BY CK

W.P 646-64-02 BORING DATE November 30 & December 1, 1971 COMPILED BY FP

DATUM Geodetic BOREHOLE TYPE Cont. Flight Auger; Cone CHECKED BY CP

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT (20 40 60 80 100) SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w (w_P — w — w_L) WATER CONTENT % (20 40 60)	BULK DENSITY γ P.C.F.	REMARKS
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV SCALE				GR.SA.SI.CL
1015.7	Ground Level									
0.0	Sand and gravel with silt & trace of clay.		1	SS	38	1010		○		33 36 26 5
			2	SS	151/11"			○		
	Dense to Very Dense		3	SS	73			○		▼1005.5
1001.3										
14.0	Clayey silt with some sand & trace of gravel		4	SS	18	1000			○	
998.2	Very Stiff									
17.5	Sand & gravel with traces of silt & clay		5	SS	377/6"			○		52 38 (10)
992.7	Very Dense									
23.0	Clayey silt to silt with sand & trace of gravel.		6	SS	195/8"	990		○ H		
			7	SS	350/3"			○		
982.7	Hard									
33.0	Sandy silt with some clay and gravel. (Glacial Till)		8	SS	100/6"	980		○ H		
			9	SS	100/2"			○		
	Very Dense		10	SS	150/4"	970		○ H		
			11	SS	100/3"			○		
			12	SS	125/3"	960		○ H		
955.5			13	SS	100/3"			○		9 39 41 11
60.2	End of Borehole					950				

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 4

JOB ____ LOCATION Co-ords. 15,798,042 N; 745,738 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 7, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE ELEV./DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT / SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w — WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
981.1	Ground Level									
0.0	Sand and gravel, trace of silt & clay Dense to Very Dense		1	SS	67	980		○		30 46 (24)
			2	SS	33			○		▼ 974.4
			3	SS	50/1"	970				
967.6			4	SS	119			○		
13.5	Sandy silt, trace of gravel & clay. (Glacial Till) Very Dense		5	SS	105			○		20 18 55 7
			6	SS	66	960		○		0 27 63 10
			7	SS	142			○		
			8	SS	61/6"	950		○		12 36 43 9
			9	SS	104					
940.6			10	SS	121			⊠		0 43 49 8
40.5	End of Borehole									

20
15 ◇ S % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 5

JOB _____ LOCATION Co-ords. 15,798,158 N; 745,870 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 7, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE ELEV./DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
979.5	Ground Level									
0.0	Sand and gravel trace of silt & clay. Compact to Dense		1	SS	41			○		▼974.5 50 35 (15)
			2	SS	17	970				
	Very Dense		3	SS	100/7"					
			4	SS	150			○		53 26 (11)
961.5			5	SS	100/5"	960				
18.0	Sandy silt, trace of gravel & clay (Glacial Till)		6	SS	155			○H		15 41 35 9
			7	SS	84			○H		7 34 48 11
	Very Dense		8	SS	119	950				
			9	SS	135					
938.6			10	SS	100/6"	940		○		10 40 43 7
40.9	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 6

JOB _____ LOCATION Co-ords. 15,798,212 N; 745,773 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 12, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE ELEV./DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT / SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w — WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
975.8	Ground Level									
0.0	Sandy silt to silty sand, trace of clay & gravel.		1	SS	18	970		○		11 43 40 6 ▽ 970.9
967.8	Compact to Very Dense		2	SS	75/6"			○		12 49 35 4
8.0	Sand & gravel, trace of silt & clay		3	SS	52			○		52 39 (9)
962.3	Dense to Very Dense		4	SS	42					
13.5	Silt, traces of clay		5	SS	58	960		○		0 0 93 7
	Very Dense		6	SS	75/4"					
947.8			7	SS	68/6"	950		○		0 0 92 8
28.0	Sandy silt, trace of gravel and clay (Glacial Till)		8	SS	57/5"			⊖		10 37 43 10
			9	SS	83/6"	940				
934.8	Very Dense		10	SS	65/5"			⊖		6 34 50 10
41.0	End of Borehole									

OFFICE REPORT ON EXPLORATION

20
15 ⊹ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 7

JOB _____ LOCATION Co-ords. 15,798,275 N; 745,893 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 15, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W	BULK DENSITY	REMARKS
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F. o UNCONFINED • QUICK TRIAXIAL + FIELD VANE × LAB VANE	WATER CONTENT % 20 40 60	γ P.C.F.	GR SA SI CL
977.7	Ground Level									
0.0	Sandy silt to silty sand									
972.7	Loose		1	SS	3			o		0 51 45 4
5.0	Sand & gravel, traces of silt & clay.		2	SS	12	970				▼ 970.9
	Compact to Dense		3	SS	37			o		71 22 (7)
964.7			4	SS	56			o—I		41 47 (12)
13.0			5	SS	66					
	Sandy silt, some gravel; trace of clay		6	SS	82/6"	960				
	(Glacial Till)		7	SS	100/5"	950		o		18 39 37 6
	Very Dense		8	SS	131					
			9	SS	100/5"	940				
936.2			10	SS	138			o—I		12 46 34 8
41.5	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 8

JOB ____ LOCATION Co-ords. 15,798,380 N; 745,814 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 13, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	LIQUID LIMIT W_L / PLASTIC LIMIT W_P / WATER CONTENT W — WATER CONTENT % (20 40 60)	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
971.9	Ground Level									
0.0	Sand and Gravel, trace of silt and clay.		1	SS	36	970		○		▽ 969.8 47 41 (12)
965.4	Dense		2	SS	102			○		25 36 31 8
6.5	Sandy silt, trace of clay and gravel		3	SS	129	960		○		
			4	SS	100/5"					
	(Glacial Till)		5	SS	90/5"			○		6 38 47 9
			6	SS	71/6"	950				
	Very Dense		7	SS	74					
			8	SS	75	940		○		12 32 50 6
			9	SS	86/6"					
930.9			10	SS	85/4"			○		13 25 50 12
41.0	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 9

JOB _____ LOCATION Co-ords. 15,798,455 N; 745,957 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 14, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY

SOIL PROFILE ELEV./DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT; SHEAR STRENGTH P.S.F. o UNCONFINED • QUICK TRIAXIAL + FIELD VANE × LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
975.0	Ground Level									
0.0	Sand & gravel, trace of silt & clay. Loose to Compact		1	SS	14	970		o		▼ 971.3
			2	SS	6			o		45 48 (7)
965.5			3	SS	7574"			o⊣		19 38 34 9
9.5	Sandy silt, trace of gravel and clay.		4	SS	100/5"			o⊣		13 40 38 9
			5	SS	100/6"	960				
	(Glacial Till)		6	SS	100/5"					
			7	SS	100/5"	950		o		7 46 40 7
	Very Dense		8	SS	100/3"					
			9	SS	100/4"	940		o⊣		8 31 52 9
935.6			10	SS	150/2"					
39.4	End of Borehole									

OFFICE REPORT ON EXPLORATION

20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 10

JOB _____ LOCATION Co-ords. 15,798,538 N; 745,878 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 13, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Washboring - NX & BX Casing CHECKED BY

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w		BULK DENSITY	
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE		WATER CONTENT % 20 40 60		γ P.C.F.	REMARKS GR.SA.SI.CL
969.1	Water Level											
0.0 / 964.6	Ground Level											
4.5	Sandy silt, trace of clay and gravel. (Glacial Till) gravel Very Dense		1	SS	135/3"	960			○			6 43 42 9
			2	SS	100/5"							
			3	SS	63/1"	950						
			4	SS	100				○			47 21 28 4
			5	SS	100/5"							
			6	SS	100/3"	940						
			7	SS	125/1"							
928.1			8	SS	90/6"	930						
41.0	End of Borehole											

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 10A

JOB _____ LOCATION Co-ords. 15,798,582 N; 745,895 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 19, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Washboring-NX Casing CHECKED BY OK

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT _____ SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT ——w_L PLASTIC LIMIT ——w_P WATER CONTENT——w w_P w w_L WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL.
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE				
969.1	Water Level									
0.0 / 965.6	Ground Level									
3.5	Sandy silt, gravel, trace of clay & gravel. (Glacial Till) Very Dense		1	SS	47			○		41 36 19 4
958.4			2	SS	100/3"	960		○		6 43 40 11
10.7	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 11

JOB _____ LOCATION Co-ords. 15,798,618 N; 746,028 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 14, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Washboring - NX & BX Casing CHECKED BY

SOIL PROFILE ELEV./DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ■ QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W (W_P — W — W_L) WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR.SA.SI.CL
969.1	Water Level									
0.0										
966.1	Ground Level									
3.0	Sand and gravel.		1	SS	29			○		64 31 (5)
963.1	Compact		2	SS	75/5"	960		○		20 39 35 6
6.0	Sandy silt, traces of clay & gravel (Glacial Till) Very Dense		3	SS	81/4"					
			4	SS	100/6"	950		○		
			5	SS	110			○		7 38 47 8
			6	SS	93	940				
			7	SS	75/3"			○		8 39 44 9
			8	SS	112			○		
927.6			9	SS	123	930		○		9 29 51 11
41.5	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 12

JOB ____ LOCATION Co-ords. 15,798,742 N; 745,968 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 19, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Washboring-NX & BX Casing CHECKED BY

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT ____ SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT W_L PLASTIC LIMIT W_P WATER CONTENT W (W_P — W — W_L) WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE				
969.1	Water Level									GR.SA.SI.CL
0.5	Sandy silt, trace of clay and gravel (Glacial Till) Very Dense		1	SS	113	960		○		15 19 56 10
			2	SS	100/3"					
			3	SS	100/6"	950				
			4	SS	100/3"					
			5	SS	120/6"			○		6 41 45 8
			6	SS	100/4"	940				
			7	SS	150					
			8	SS	100/3"	930				
928.1			9	SS	118/6"			○		19 25 46 10
41.0	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 13

JOB _____ LOCATION Co-ords. 15,798,785 N; 746,108 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 15, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Washboring - NX & BX Casing CHECKED BY _____

SOIL PROFILE ELEV./DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR SA SI. CL
969.1	Water Level									
968.1	Ground Level									
1.0 / 964.1	Sand & gravel, trace of silt & clay Very Dense		1	SS	39			○		58 35 (7)
5.0	Sandy silt, trace of clay and gravel (Glacial Till) Very Dense		2	SS	100/5"	960				5 41 46 8
			3	SS	100/5"					
			4	SS	100/5"	950				12 42 36 10
			5	SS	90/5"					
			6	SS	100/5"	940				12 43 39 6
			7	SS	100/4"					
			8	SS	100/5"	930				
928.2			9	SS	100/4"					5 39 47 9
40.9	End of Borehole									

OFFICE REPORT ON SOIL EXPLORATION

20
15 ◇ 5 % STRAIN AT FAILURE
10

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS - ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE No 14

JOB _____ LOCATION Co-ords. 15,798,892 N; 746,068 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 20, 1974 COMPILED BY PJS

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES			ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT ———	LIQUID LIMIT ——— W_L PLASTIC LIMIT ——— W_P WATER CONTENT ——— W	BULK DENSITY γ P.C.F.	REMARKS
ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT % 20 40 60		GR. SA. SI. CL
1013.0	Ground Level									
0.0	Sand & gravel, trace of silt and clay.		1	SS	14	1010				W.L. not established
1005.5	Compact to Very Dense		2	SS	57					50 37 (13)
7.5	Clayey silt sand to silt.		3	SS	48					0 40 52 8
1000.0	Very Stiff		4	SS	63	1000				0 1 65 34
13.0	Sandy silt, some gravel, trace of clay. (Glacial Till) Very Dense		5	SS	100/5"					18 49 30 3
			6	SS	100/6"					
			7	SS	100/3"	990				
			8	SS	100/4"					8 45 38 9
			9	SS	100/5"	980				
			10	SS	100/3"					
972.7			11	SS	100/1"					8 41 38 13
40.3	End of Borehole									

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

RECORD OF BOREHOLE Nº 15

JOB _____ LOCATION Co-ords. 15,798,930 N; 746,188 E. ORIGINATED BY PJS

W.P. 646-64-02 BORING DATE August 19, 1974 COMPILED BY PJS.

DATUM Geodetic BOREHOLE TYPE Hollow Stem Auger CHECKED BY _____

SOIL PROFILE			SAMPLES				DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT _____ SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	LIQUID LIMIT ——W_L PLASTIC LIMIT ——W_P WATER CONTENT——W W_P W W_L WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE				
1014.2	Ground Level									
0.0	Sand & gravel, trace of silt and clay.		1	SS	39	1010		○		W.L. not established
	Dense to Very Dense		2	SS	66/6"			○		50 41 (9)
			3	SS	89/6"					
1002.2			4	SS	50			○		61 33 (6)
12.0	Silty sand with gravel, trace of clay		5	SS	72	1000		○		23 48 25 4
993.2	Very Dense		6	SS	56					
			7	SS	87/5"					
21.0	Sandy silt, trace of gravel and clay		8	SS	90/6"	990		○—		15 25 43 17
	(Glacial Till)		9	SS	100/6"					
	Very Dense		10	SS	100/4"	980				
			11	SS	100/5"			○ ——		9 42 39 10
969.0			12	SS	100/0"	970				
45.2	End of Borehole									

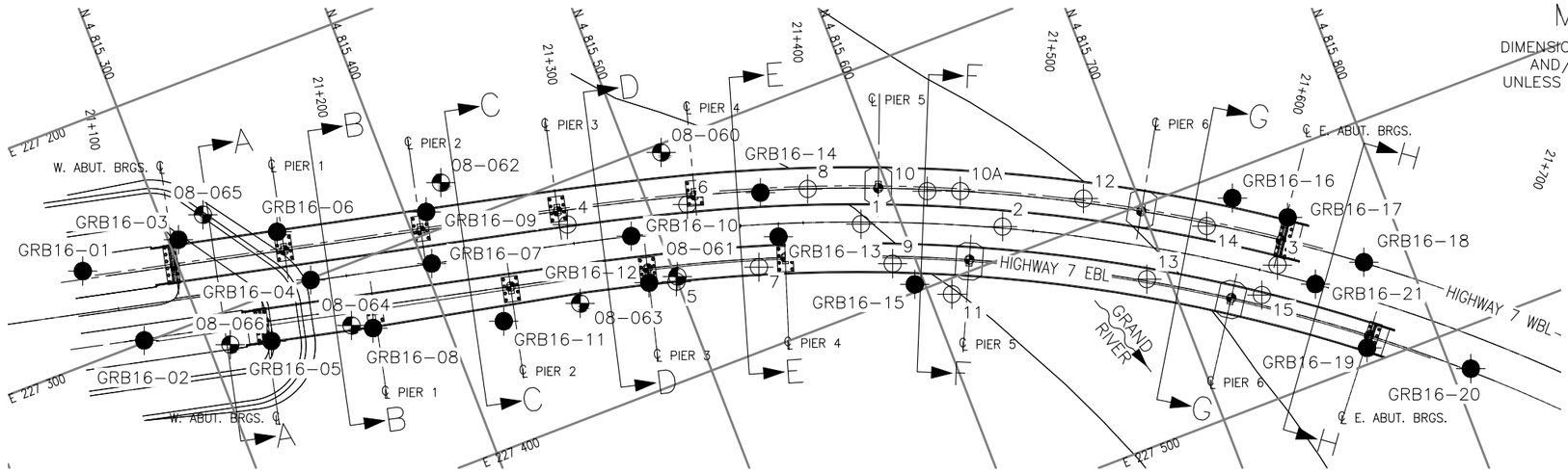
15 20 10 ◇ 5 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

THURBER

Appendix C
Borehole Locations and Soil Strata Drawings

MINISTRY OF TRANSPORTATION, ONTARIO
PR-D-707 88-05



PLAN

50 0 50 100m

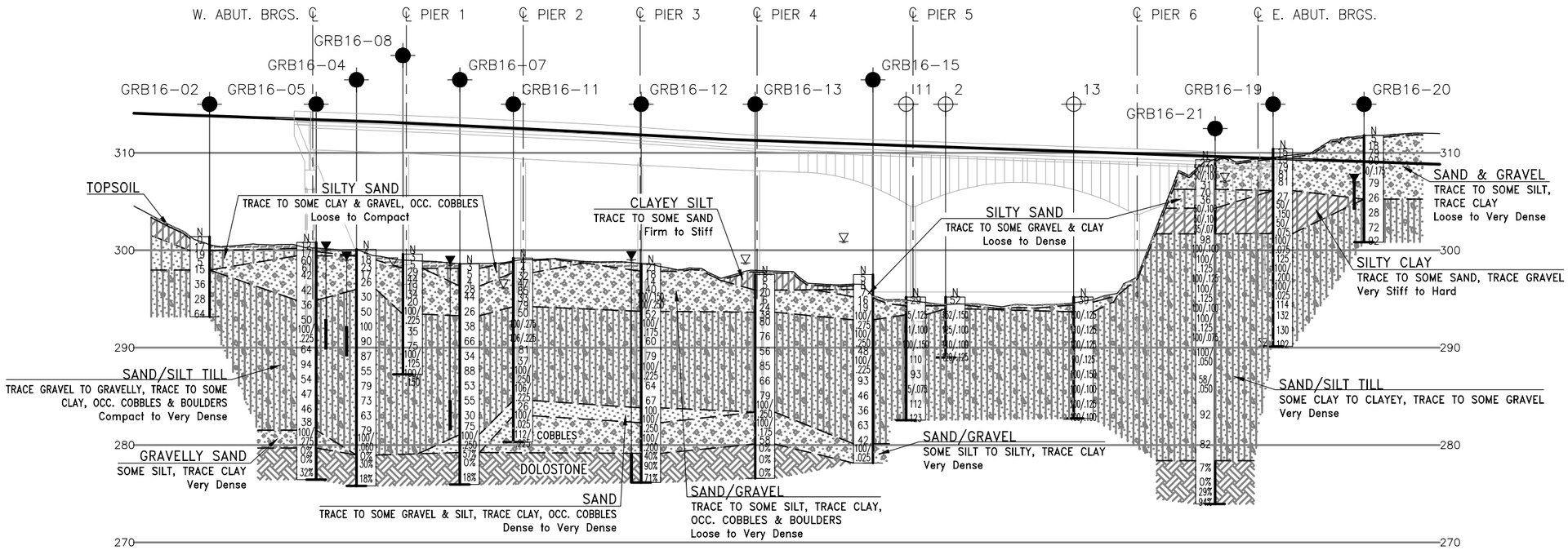
SCALE 1:2500

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

NO	ELEVATION	NORTHING	EASTING
1	296.2	4 815 583.4	227 363.9
2	295.4	4 815 640.4	227 387.0
5	298.6	4 815 499.6	227 358.4
7	298.0	4 815 535.3	227 365.4
9	297.2	4 815 590.1	227 384.9
11	295.4	4 815 609.3	227 406.6
13	295.4	4 815 690.7	227 430.9
15	309.1	4 815 734.9	227 455.3

NOTE: ELEVATION, NORTHING & EASITING FOR REMAINING BOREHOLES CAN BE FOUND IN THE TITLE BLOCK.



PROFILE ALONG PROPOSED HIGHWAY 7 EBL

50 0 50 100m H 1:2500

10 0 10 20m V 1:500

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

J.P.K. LEE 100086735 03/14/2024 PROVINCE OF ONTARIO — LICENSED PROFESSIONAL ENGINEER

P.K. CHATTERJI 03/14/2024 PROVINCE OF ONTARIO — LICENSED PROFESSIONAL ENGINEER

CONT. No.
WP No. 3060-16-03

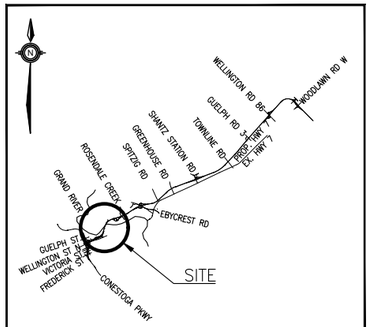
HIGHWAY 7 EBL
GRAND RIVER BRIDGE

SHEET

METRIC

wsp

THURBER ENGINEERING LTD.



Latitude: 43.475949° Longitude: −80.457291°

KEYPLAN

LEGEND

● / ⊕	Borehole by Thurber (Current / 2008)
⊕	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
▽	Water Level In Open Borehole
▼	Water Level In Piezometer
	Piezometer
90%	Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING
GRB16-02	301.4	4 815 274.6	227 299.1
GRB16-04	300.1	4 815 351.6	227 300.6
GRB16-05	300.8	4 815 326.1	227 319.3
GRB16-07	298.6	4 815 403.2	227 312.8
GRB16-08	299.6	4 815 369.3	227 329.9
GRB16-10	298.8	4 815 488.4	227 332.9
GRB16-11	299.2	4 815 423.4	227 347.5
GRB16-12	298.6	4 815 488.4	227 354.6
GRB16-13	297.5	4 815 548.0	227 356.1
GRB16-15	297.5	4 815 595.8	227 396.7
GRB16-19	310.4	4 815 769.3	227 493.2
GRB16-20	311.8	4 815 808.1	227 517.8

-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 10.

GEOCRES No. 40P08-297

REVISIONS	DATE	BY	DESCRIPTION

DESIGN	NB	CHK	PKC	CODE CHBDC 2014	LOAD CL-625-ONT	DATE MAR/24	
DRAWN	MFA	CHK	NB	SITE	STRUCT	SCHEME	DWG 1

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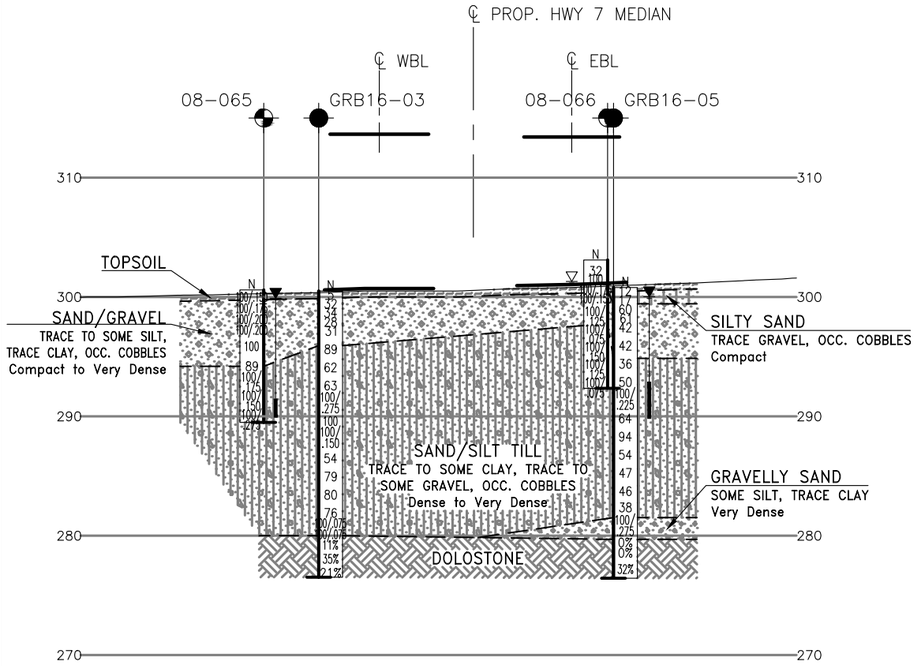
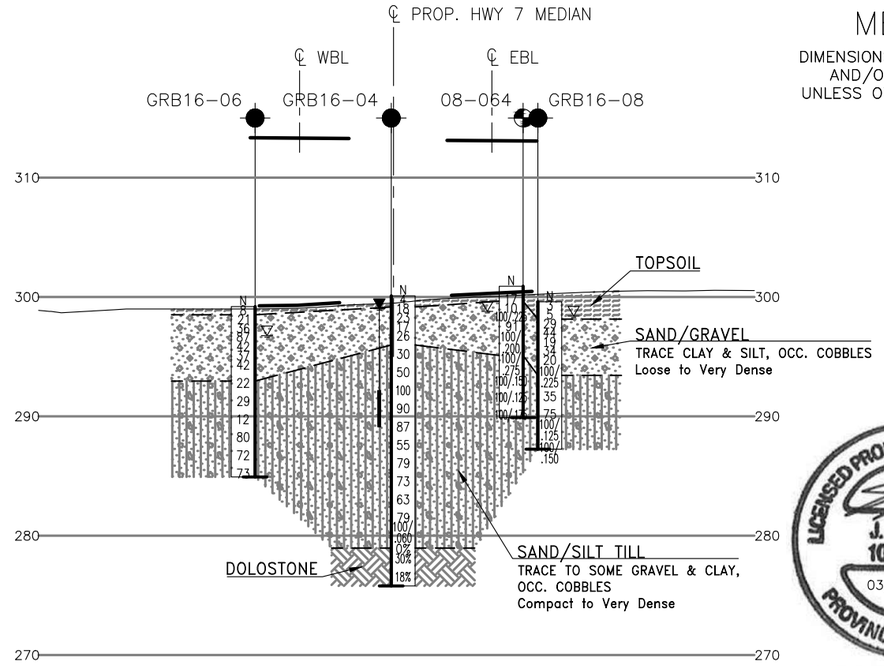
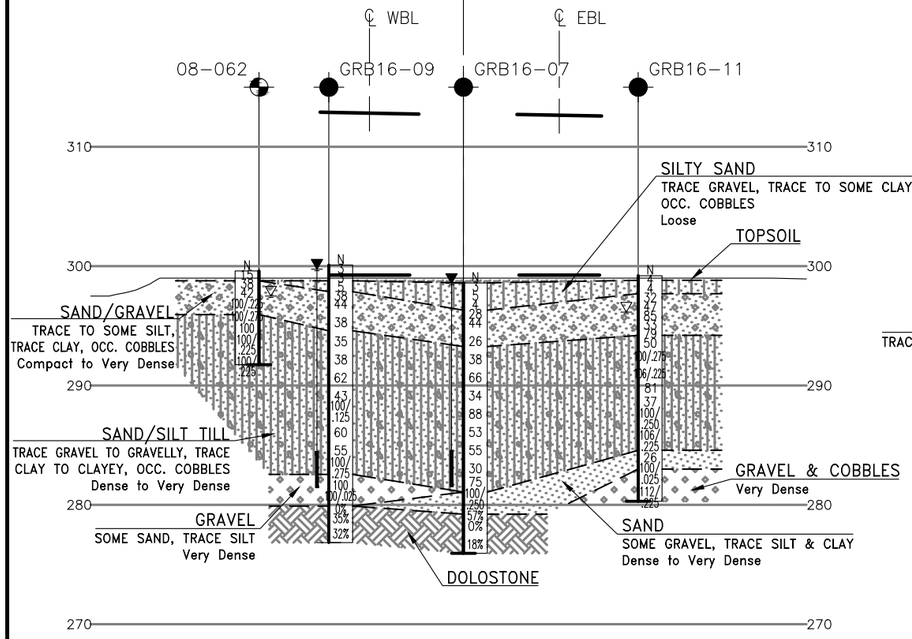
PLOTDATE: 3/14/2024 4:15 PM



SECTION A–A (WEST ABUTMENTS – WBL & EBL)



SECTION B–B (PIER 1 – WBL & EBL)



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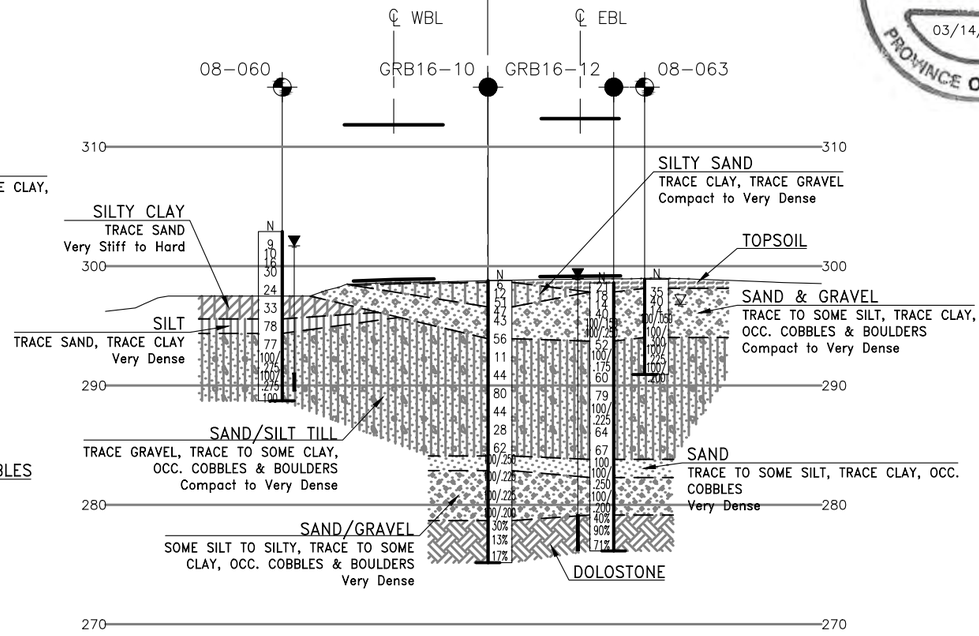

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DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT. No.
WP No. 3060-16-03

HIGHWAY 7 EBL AND WBL
GRAND RIVER BRIDGE

SHEET

METRIC

wsp

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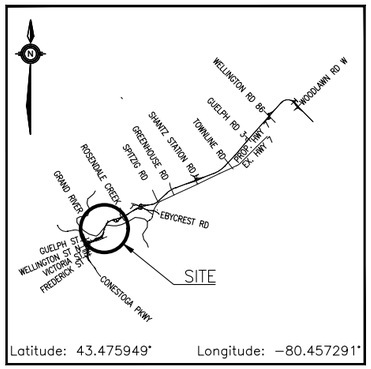

Latitude: 43.475949° Longitude: -80.457291°

KEYPLAN

LICENSED PROFESSIONAL ENGINEER
J.P.K. LEE
100086735
03/14/2024
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P.K. CHATTERJI
03/14/2024
PROVINCE OF ONTARIO

LEGEND

●/⊕	Borehole by Thurber (Current / 2008)
⊕	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
▽	Water Level In Open Borehole
▼	Water Level In Piezometer
	Piezometer
90%	Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING

-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 10.

GEOCRES No. 40P08-297

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	NB	CHK	PKC	CODE	CHBDC 2014	LOAD	CL-625-ONT DATE MAR/24
DRAWN	MFA	CHK	NB	SITE		STRUCT	SCHEME DWG 2

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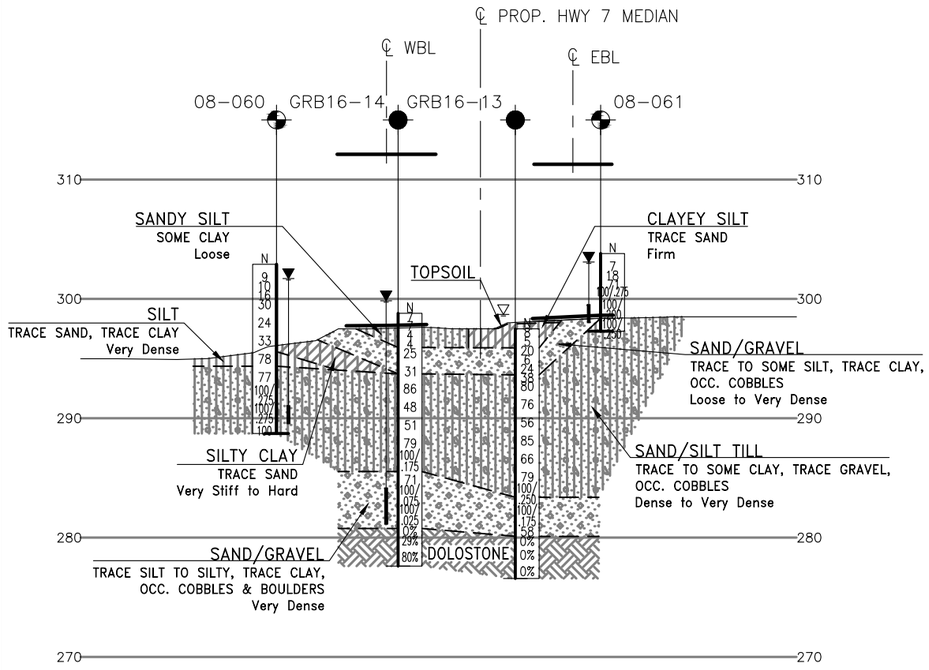
MINISTRY OF TRANSPORTATION, ONTARIO PR-D-707 88-05



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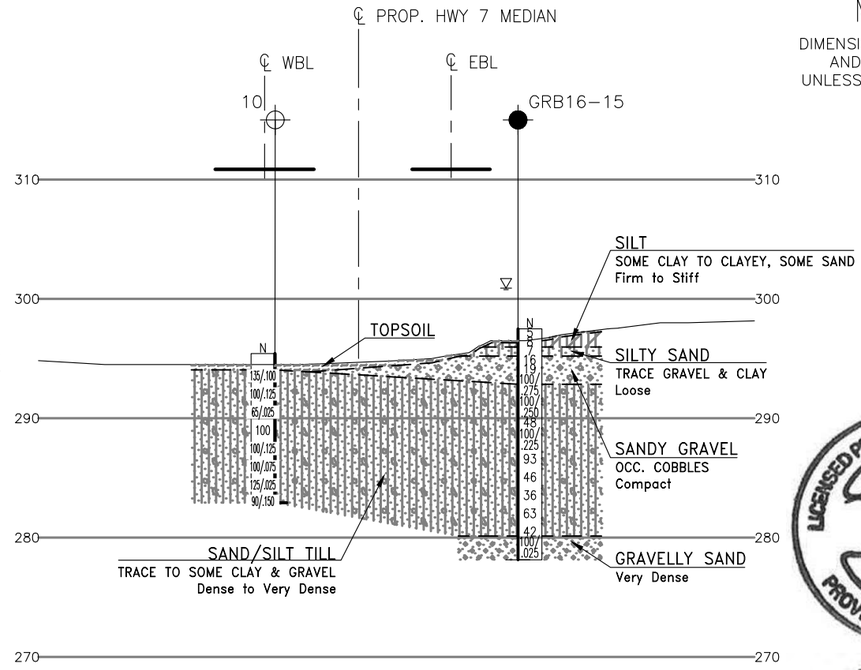

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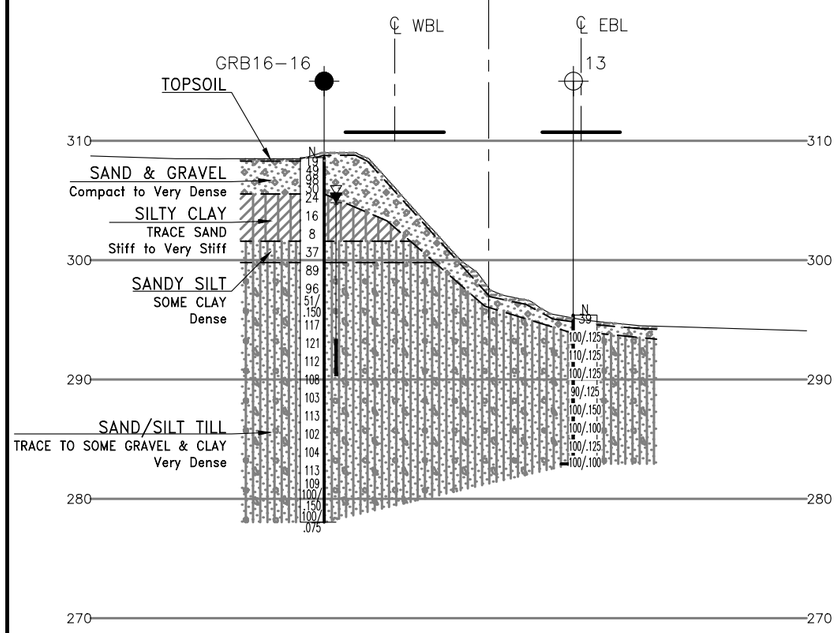

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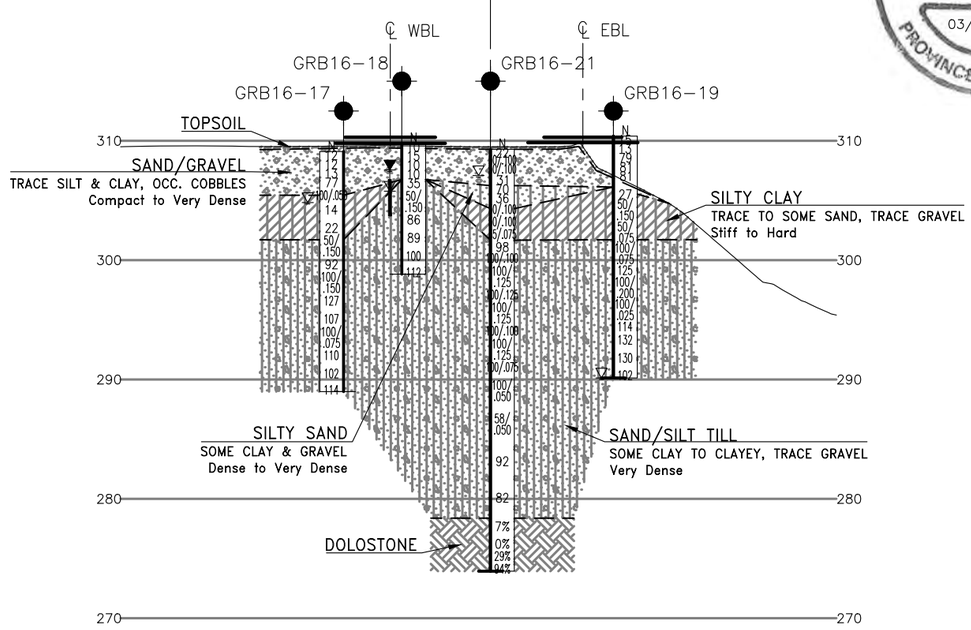

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DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

METRIC

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT. No.
WP No. 3060-16-03

HIGHWAY 7 EBL AND WBL
GRAND RIVER BRIDGE

SHEET

METRIC

wsp

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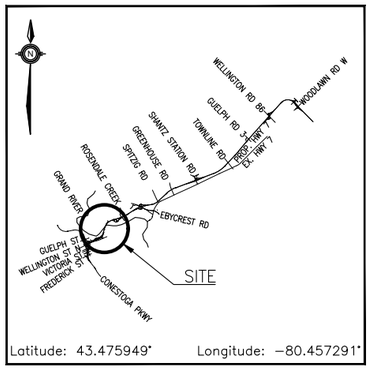
PROVINCE OF ONTARIO



Latitude: 43.475949° Longitude: -80.457291°

KEYPLAN

LEGEND

● / ⊕	Borehole by Thurber (Current / 2008)
⊕	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
▽	Water Level In Open Borehole
▼	Water Level In Piezometer
	Piezometer
90%	Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING

-NOTES-

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GEOCRES No. 40P08-297

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	NB	CHK	PKC	CODE CHBDC 2014	LOAD CL-625-ONT	DATE	MAR/24
DRAWN	MFA	CHK	NB	SITE	STRUCT	SCHEME	DWG 3

MINISTRY OF TRANSPORTATION, ONTARIO
PR-D-707 88-05

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT. No.
WP No. 3060-16-03

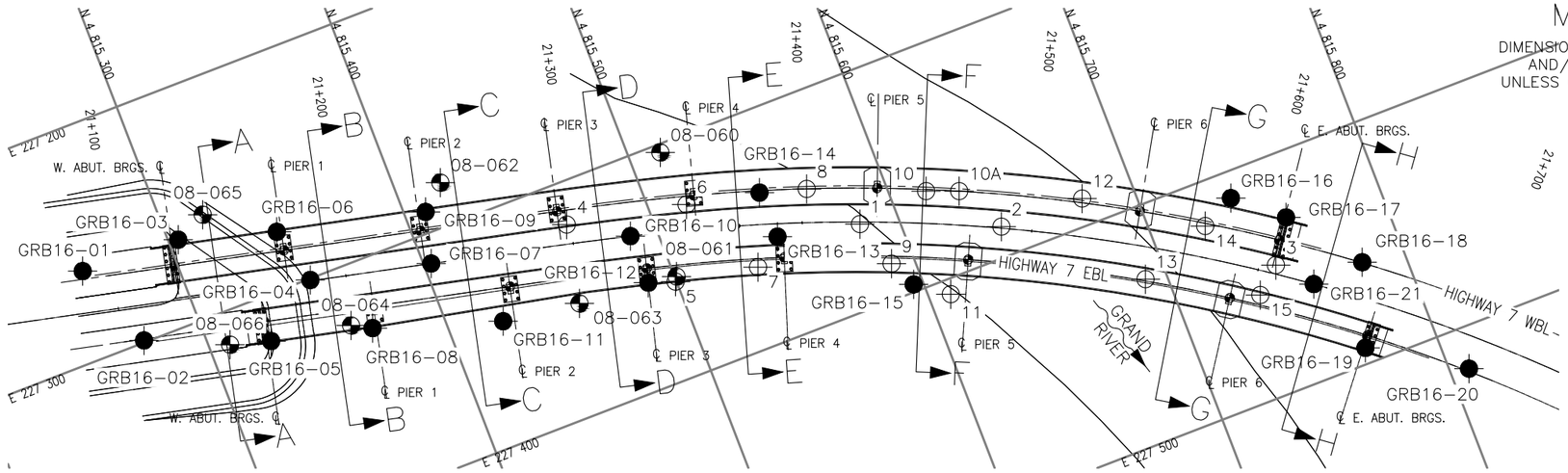
HIGHWAY 7 WBL
GRAND RIVER BRIDGE

SHEET

METRIC

WSP

THURBER ENGINEERING LTD.



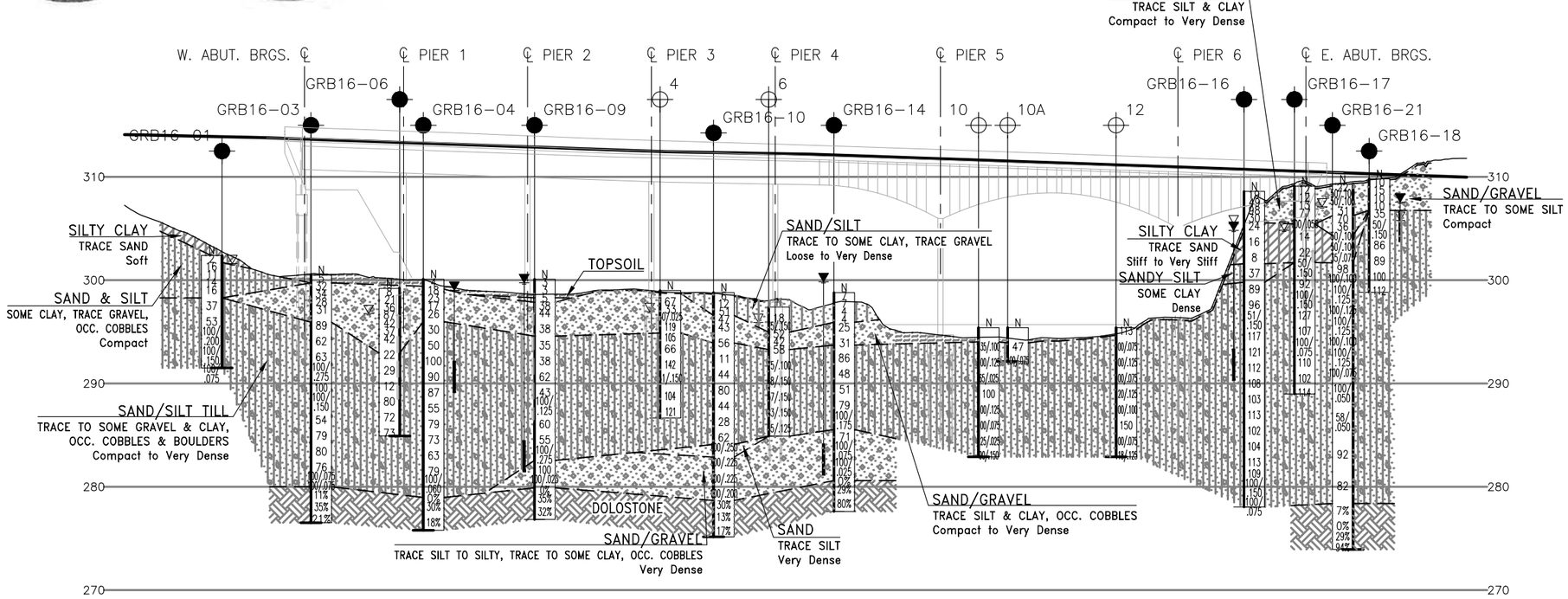
PLAN

50 0 50 100m

SCALE 1:2500

NO	ELEVATION	NORTHING	EASTING
3	309.6	4 815 745.9	227 445.6
4	299.0	4 815 464.3	227 318.2
6	297.4	4 815 516.1	227 328.8
8	296.2	4 815 567.3	227 341.3
10	295.4	4 815 615.4	227 360.8
10A	295.4	4 815 628.9	227 366.0
12	295.4	4 815 677.6	227 388.3
14	308.8	4 815 723.3	227 418.7

NOTE: ELEVATION, NORTHING & EASITING FOR REMAINING BOREHOLES CAN BE FOUND IN THE TITLE BLOCK.



PROFILE ALONG PROPOSED HIGHWAY 7 WBL

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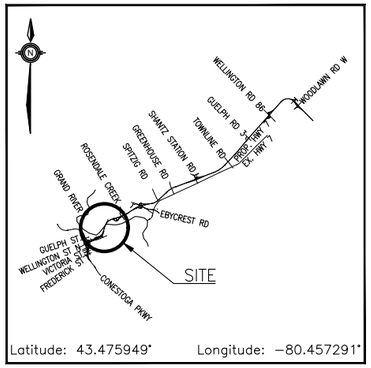
10 0 10 20m V 1:500

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING



KEYPLAN

LEGEND

● / ⊕	Borehole by Thurber (Current / 2008)
⊕	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
▽	Water Level In Open Borehole
▼	Water Level In Piezometer
	Piezometer
90%	Rock Quality Designation (RQD)

NO	ELEVATION	NORTHING	EASTING
GRB16-01	302.4	4 815 260.5	227 261.4
GRB16-03	300.5	4 815 304.2	227 263.6
GRB16-04	300.1	4 815 351.6	227 300.6
GRB16-06	299.2	4 815 345.5	227 275.8
GRB16-07	298.6	4 815 403.2	227 312.8
GRB16-09	300.1	4 815 409.0	227 291.0
GRB16-10	298.8	4 815 488.4	227 332.9
GRB16-14	298.8	4 815 547.6	227 335.4
GRB16-16	308.6	4 815 738.1	227 411.4
GRB16-17	309.1	4 815 757.5	227 427.8
GRB16-18	309.8	4 815 781.4	227 457.9
GRB16-21	309.3	4 815 758.3	227 459.2
08-060	302.9	4 815 513.6	227 303.6
08-062	299.6	4 815 419.6	227 281.4
08-065	300.6	4 815 318.0	227 257.3

-NOTES-

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3) Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 40P08-297

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P.K. CHATTERJI
03/14/2024
PROVINCE OF ONTARIO

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	NB	CHK	PKC	CODE	CHBDC 2014	LOAD	CL-625-ONT
DRAWN	MFA	CHK	NB	SITE		STRUCT	SCHEME

DATE MAR/24
DWG 4

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Appendix D
Foundation Comparison

Foundation Comparison and Recommendations

Foundation Element	Foundation Type	Advantages	Disadvantages	Remarks
West Abutment	▪ Spread Footing	▪ Ease of construction. ▪ Bearing resistance available at shallow depths. ▪ Excavation will not extend into artesian aquifer. ▪ Possible use of mass concrete to establish footing base.	▪ Requires construction dewatering including cofferdam. ▪ High approach fill will induce footing settlement. ▪ Footing base may be deeper depending on scour depth. ▪ Excavation may encounter cobbles/boulders.	Not Recommended
	▪ Driven H-Pile	▪ Minimum excavation and dewatering required. ▪ Bearing resistance available driven into till. ▪ Local contractors and piling experience available.	▪ May encounter cobbles/boulders during driving. ▪ Piles may need to be driven deeper in till to achieve capacity. ▪ Potential for upward seepage flow along pile shaft and loss of fines over time if driven into artesian layer.	**Recommended**
	▪ Caisson	▪ Higher unit bearing resistance than footing and H-piles and therefore less number of foundation elements. ▪ Installation can handle cobbles/boulders.	▪ May temporarily depressurize artesian aquifer. ▪ Requires temporary liner and pressure head control inside caisson during installation. ▪ Requires tremie method to concrete caissons. ▪ Requires good base cleaning to achieve capacity.	Feasible
Pier 1, 2, 3 & 4	▪ Spread Footing	▪ Ease of construction. ▪ Bearing resistance available at shallow depths. ▪ Excavation will not extend into artesian aquifer. ▪ Possible use of mass concrete to establish footing base.	▪ Requires construction dewatering including cofferdam. ▪ Requires scour and erosion protection around footings. ▪ Footing base may be deeper depending on scour depth. ▪ Excavation may encounter cobbles/boulders.	**Recommended**

Foundation Element	Foundation Type	Advantages	Disadvantages	Remarks
	▪ Driven H-Pile	▪ Minimum excavation and dewatering required. ▪ High bearing resistance available if driven to bedrock. ▪ Local contractors and piling experience available.	▪ May encounter cobbles/boulders during driving. ▪ Low bearing resistance if founded above artesian layers. ▪ Piles may need to be driven deeper in till to achieve capacity. ▪ Potential for upward seepage flow along pile shaft and loss of fines over time if driven into artesian layer.	Feasible
	▪ Caisson	▪ Higher unit bearing resistance than footing and H-piles and therefore less number of foundation elements. ▪ Installation can handle cobbles/boulders.	▪ May temporarily depressurize artesian aquifer. ▪ Requires temporary liner and pressure head control inside caisson during installation. ▪ Requires tremie method to concrete caissons. ▪ Requires good base cleaning to achieve capacity.	Feasible
Pier 5 & 6 (Note: Recommendations to be provided/confirmed following completion of additional boreholes within Grand River)	▪ Spread Footing	▪ Ease of construction. ▪ Excavation will not extend into artesian aquifer. ▪ Possible use of mass concrete to establish footing base.	▪ Requires construction dewatering including cofferdam. ▪ In-water cofferdam stability must be designed for. ▪ Requires robust scour and erosion protection in river. ▪ Footing base may be deeper depending on scour depth. ▪ Excavation may encounter cobbles/boulders.	Not Recommended

Foundation Element	Foundation Type	Advantages	Disadvantages	Remarks
	▪ Driven H-Pile	▪ Minimum excavation and dewatering required. ▪ High bearing resistance available if driven to refusal in till or on bedrock. ▪ Local contractors and piling experience available.	▪ May encounter cobbles/boulders during driving. ▪ Low bearing resistance if founded above artesian layers. ▪ Piles may need to be driven deeper in till to achieve capacity. ▪ Potential for upward seepage flow along pile shaft and loss of fines over time if driven into artesian layer.	Feasible
	▪ Caisson	▪ Higher unit bearing resistance than footing and H-piles and therefore less number of foundation elements. ▪ Installation can handle cobbles/boulders well. ▪ Caissons can be extended up to the underside of deck to avoid excavation for foundation cap in the riverbed.	▪ May temporarily depressurize artesian aquifer. ▪ Requires temporary liner and pressure head control inside caisson during installation. ▪ Requires tremie method to concrete caissons. ▪ Requires good base cleaning to achieve capacity.	**Recommended** (Larger diameter caissons may be required.)
East Abutment	▪ Spread Footing	▪ Ease of construction. ▪ Bearing resistance available at shallow depths. ▪ Excavation will not extend into artesian aquifer.	▪ Bearing resistance may be reduced if placed close to river valley slope. ▪ Erosion of valley slope may pose potential stability issue. ▪ Excavation may encounter cobbles/boulders.	Not Recommended
	▪ Driven H-Pile	▪ Minimum excavation and dewatering required. ▪ High bearing resistance available driven to refusal in till. ▪ Local contractors and piling experience available.	▪ May encounter cobbles/boulders during driving. ▪ Potential for upward seepage flow along pile shaft and loss of fines over time if driven into artesian layer.	Feasible

Foundation Element	Foundation Type	Advantages	Disadvantages	Remarks
	▪ Caisson	▪ Higher unit bearing resistance than footing and H-piles and therefore less number of foundation elements. ▪ Installation can handle cobbles/boulders.	▪ May temporarily depressurize artesian aquifer. ▪ Requires temporary liner and pressure head control inside caisson during installation. ▪ Requires tremie method to concrete caissons. ▪ Requires good base cleaning to achieve capacity.	**Recommended**

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Appendix E
Slope Stability Output

FIGURE E1

Project Number: 11375
Highway 7 - New
Grand River
Embankment height 13.5 m
West Approach Side Slope
Drained Analysis

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	New Embankment Fill	Mohr-Coulomb	21	0	32
	Silty Clay - Soft to V. Stiff	Mohr-Coulomb	19	0	30
	Silty Sand - Compact	Mohr-Coulomb	20	0	30
	Silty Sand to Sandy Silt Till - Compact to V. Dense	Mohr-Coulomb	21	0	33

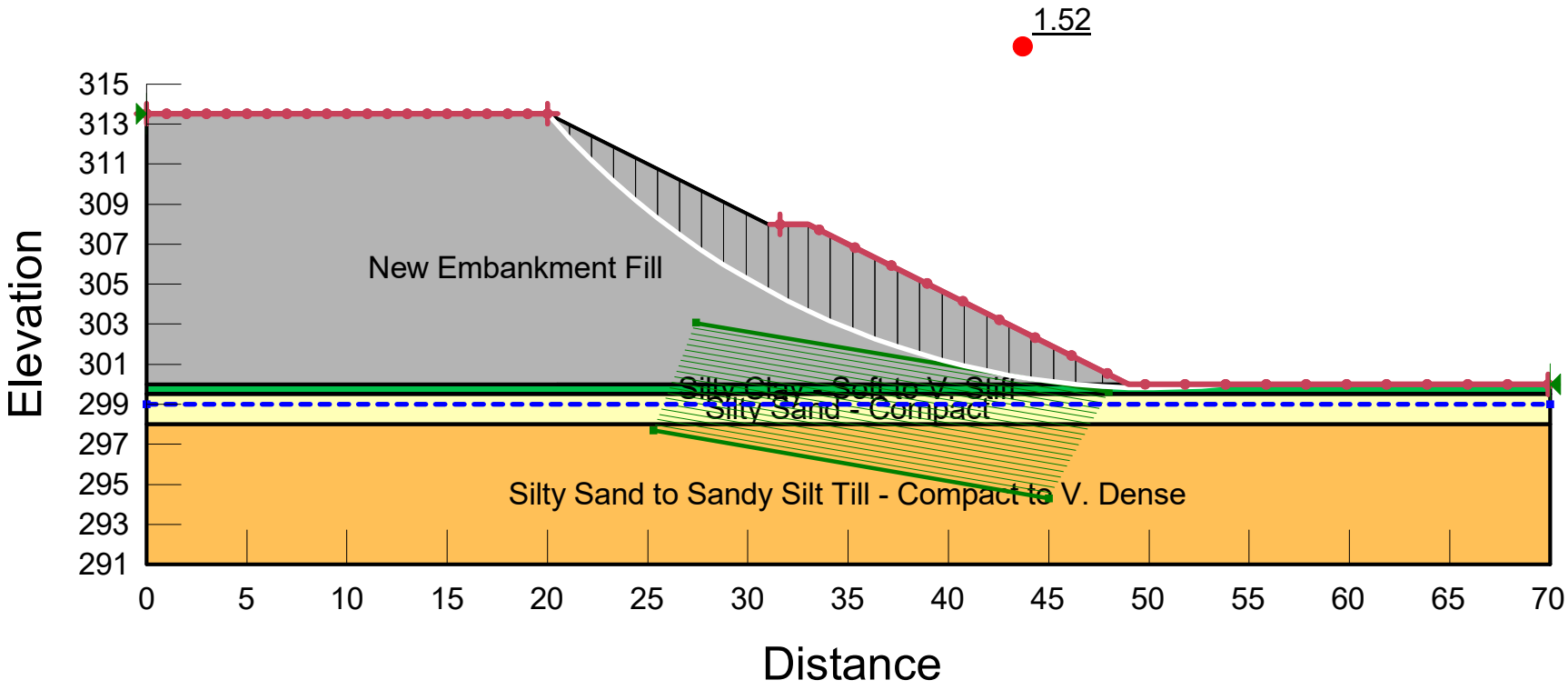

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FIGURE E2

Project Number: 11375
Highway 7 - New
Grand River
Embankment height 13.5m
West Approach Side Slope
Seismic Analysis
kh=0.0375g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	New Embankment Fill	Mohr-Coulomb	21	0	32
	Silty Clay - Soft to V. Stiff	Mohr-Coulomb	19	0	30
	Silty Sand - Compact	Mohr-Coulomb	20	0	30
	Silty Sand to Sandy Silt Till - Compact to V. Dense	Mohr-Coulomb	21	0	33

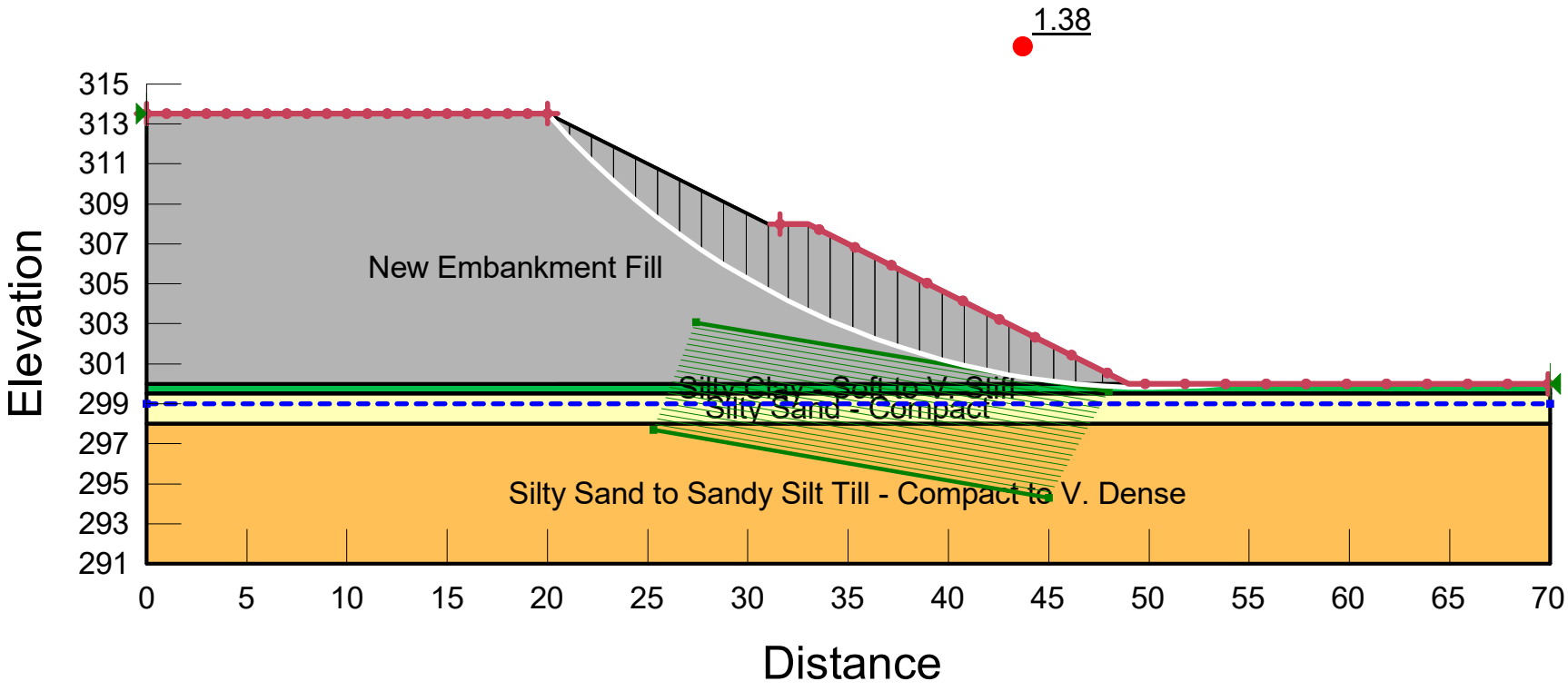

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FIGURE E3

Project Number: 11375
Highway 7 - New
Grand River
Cut depth 10m
Undrained Analysis

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Sand and Gravel - Compact	Mohr-Coulomb	21	0	32
	Sand and Gravel - V. Dense	Mohr-Coulomb	22	0	34
	Silty Clay - Stiff to V. Stiff	Mohr-Coulomb	19	85	0
	Silty Sand to Sandy Silt Till - Compact to V. Dense	Mohr-Coulomb	21	0	33

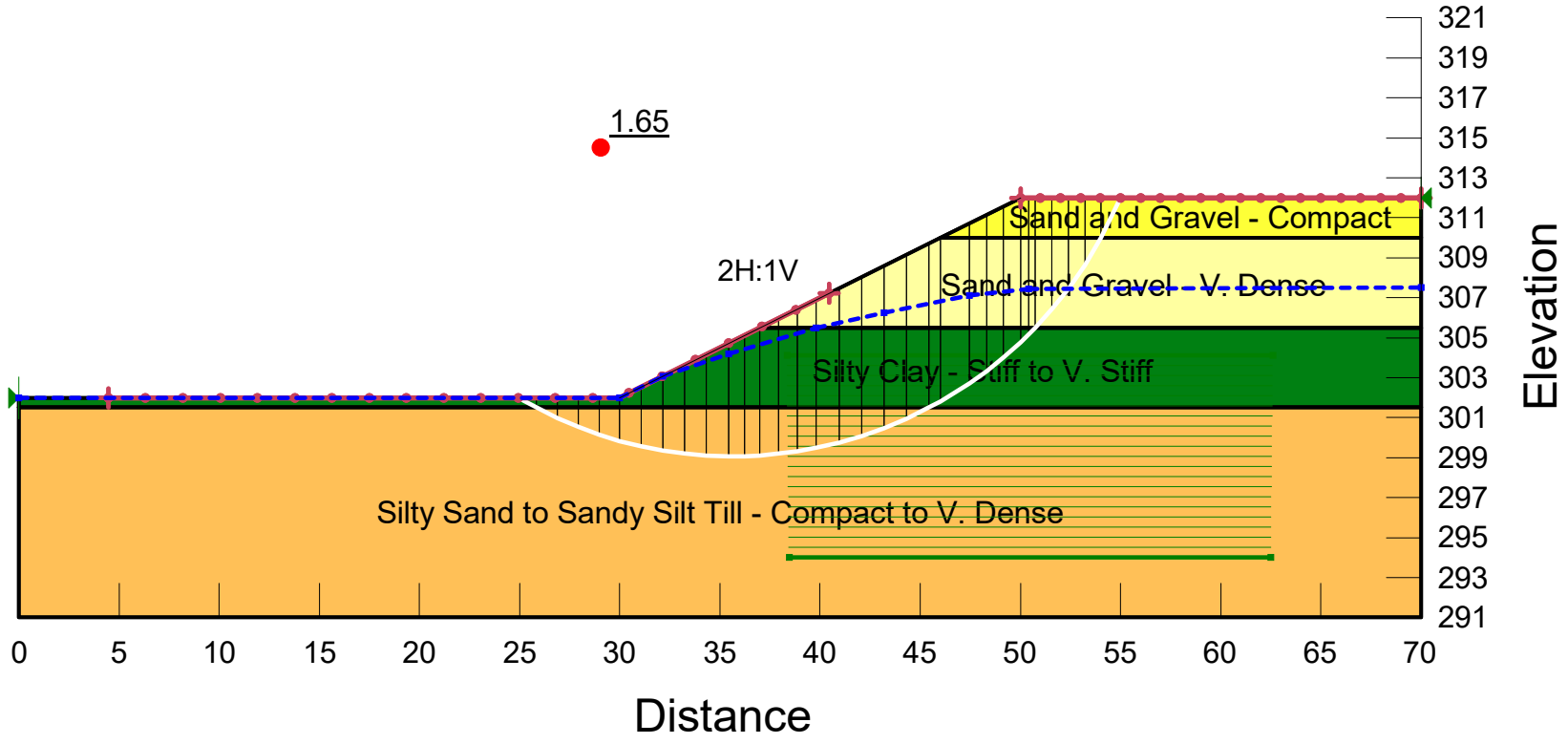

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FIGURE E4

Project Number: 11375
Highway 7 - New
Grand River
Cut depth 10m
Undrained Analysis

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Sand and Gravel - Compact	Mohr-Coulomb	21	0	32
	Sand and Gravel - V. Dense	Mohr-Coulomb	22	0	34
	Silty Clay - Stiff to V. Stiff	Mohr-Coulomb	19	5	32
	Silty Sand to Sandy Silt Till - Compact to V. Dense	Mohr-Coulomb	21	0	33

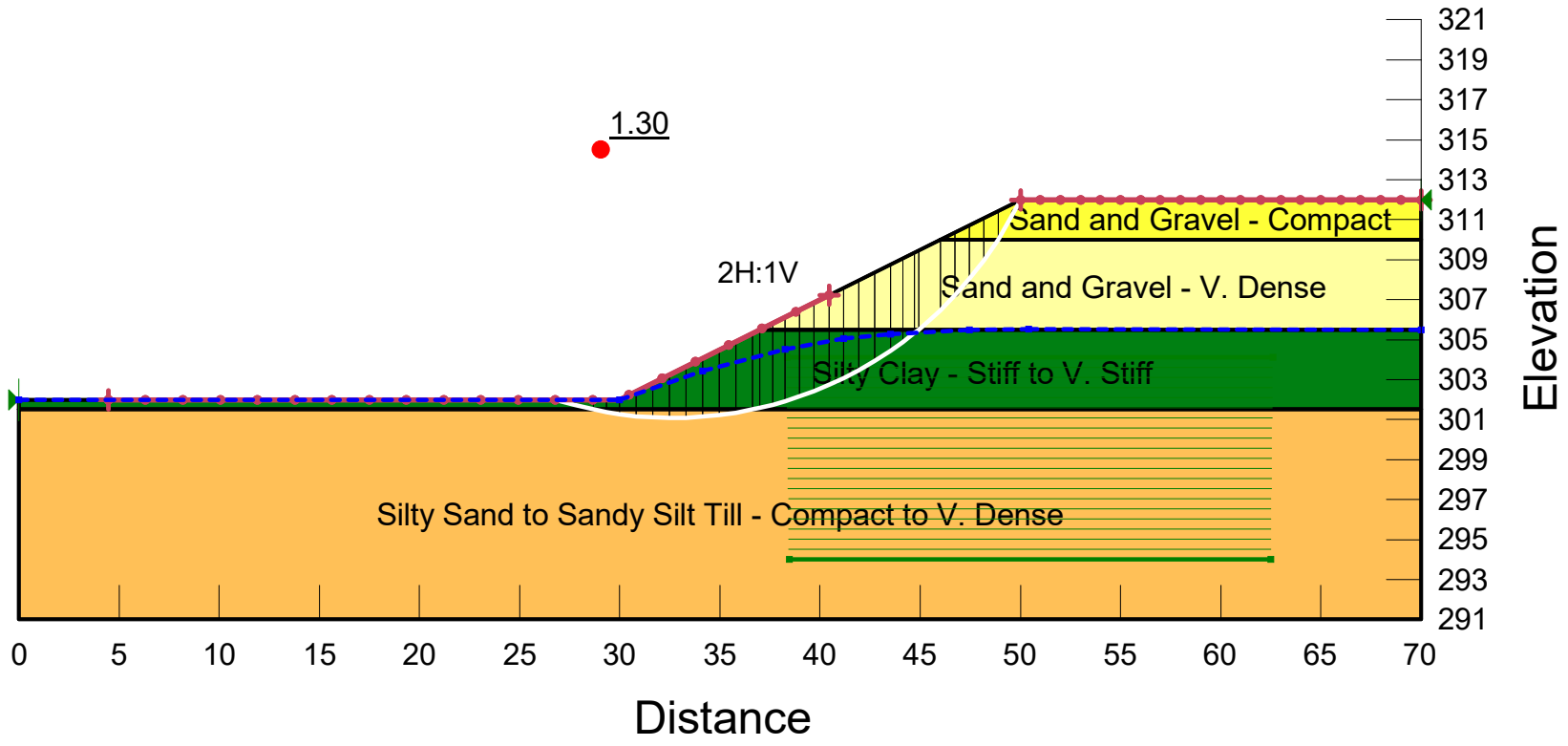

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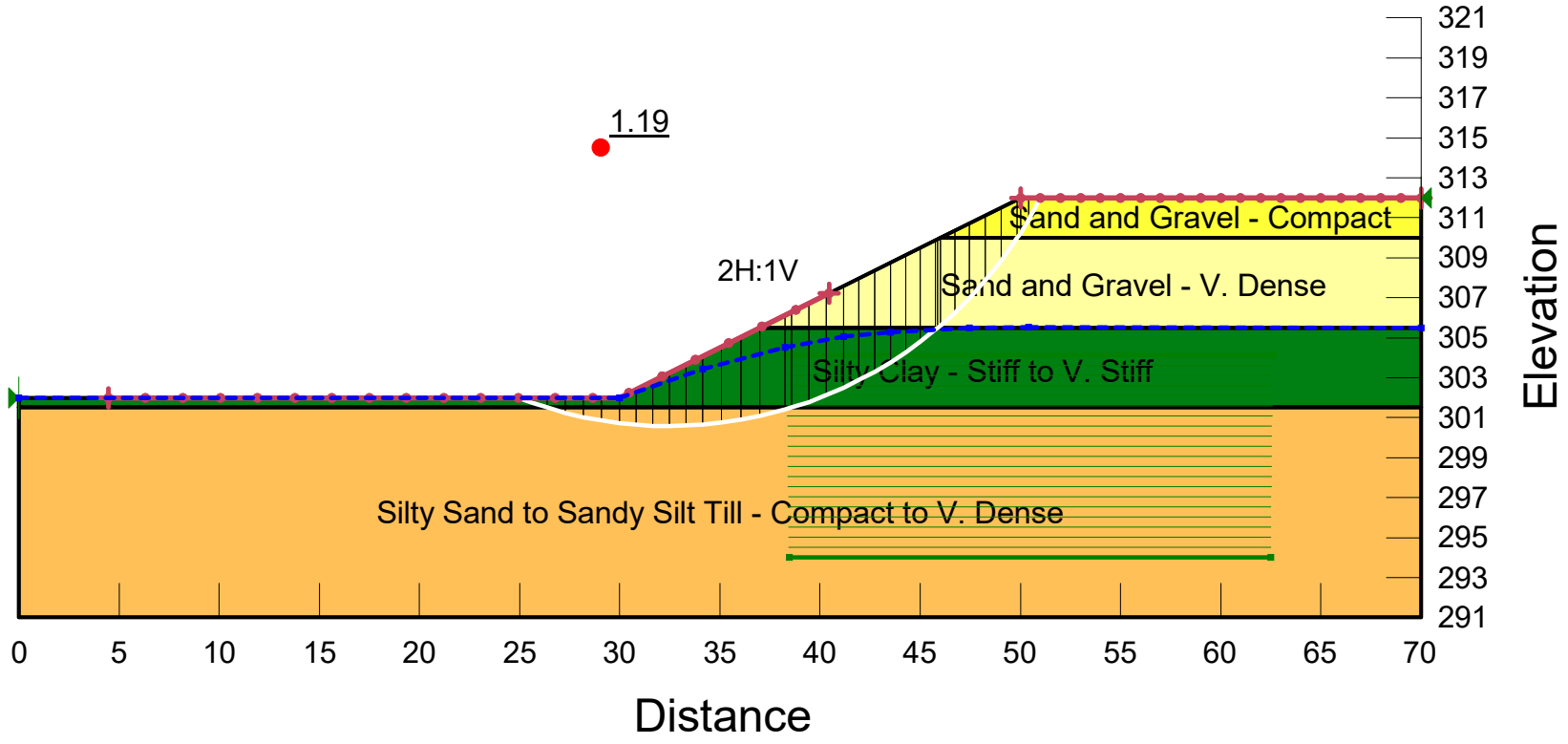
FIGURE E**5**

Project Number: 11375
Highway 7 - New
Grand River
Cut depth 10m
Seismic Analysis kh=0.0375g

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)
	Sand and Gravel - Compact	Mohr-Coulomb	21	0	32
	Sand and Gravel - V. Dense	Mohr-Coulomb	22	0	34
	Silty Clay - Stiff to V. Stiff	Mohr-Coulomb	19	5	32
	Silty Sand to Sandy Silt Till - Compact to V. Dense	Mohr-Coulomb	21	0	33



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Appendix F
List of OPSS Documents and NSSP Wording

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

- OPSS.PROV 206
- OPSS.PROV 501
- OPSS.PROV 517
- OPSS.PROV 804
- OPSS.PROV 902
- OPSS.PROV 903
- OPSS.PROV 1010
- OPSD 202.010
- OPSD 208.010
- OPSD 3090.101
- OPSD 3101.150
- SP 109F57
- SP 109S12
- SP 517F01
- SP FOUN0003

2. Suggested Text for NSSP on Pile Driving

The glacial till at this site contains cobbles and boulders. These cobbles and boulders may impede the driving of piles and at some locations the piles may not be able to penetrate the obstructions and reach the design depth of installation and refusal may be encountered at varying depths.

The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the H-piles to the design depth.

The H-piles shall be provided with pile tip protectors (e.g. Titus steel - Standard H-point) to minimize tip damage.

If the piles meet refusal at a depth less than the anticipated depth, the Contractor must terminate driving before the pile is damaged due to over-driving. The Contractor must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution.

3. Suggested Text for NSSP on High-Strain Dynamic Testing

High-strain dynamic testing using pile driving analyzer (PDA) shall be conducted as per NSSP – "HIGH-STRAIN DYNAMIC TESTING, DEEP FOUNDATIONS" to assess ultimate pile capacity and establish set criteria. The dynamic testing shall not be carried out until the piles are within 2 m of the design tip elevation.

The location, sequencing and scheduling of the individual pile testing shall be proposed by the Contractor based on the purpose of the testing, and shall be submitted to the Contract Administrator for approval.

High-strain dynamic testing shall be carried out at the end of initial driving on a minimum of five (5) piles in each pile group, one at each corner of the pile group and one near the centre.

Additional high strain dynamic testing (i.e. restrike testing) shall be carried out during the retapping of piles, as specified in the Retapping Tests on Piles clause. Restrike testing shall be performed on a minimum of 10% of piles in each pile group, rounded up, but no fewer than 2 piles; or as specified in the Contract Documents. Restrike testing shall be carried out no sooner than 24 hours after installation of the individual pile or at a time specified in the Contract Documents. If the hammer needs to be warmed up prior to performing a restrike, it shall not be warmed up by striking the intended test pile.

4. Suggested Text for NSSP on "Construction of Caissons – 1500 mm"

Caisson installation shall be in accordance with OPSS.PROV 903, SP 109F57 (April 2018) and the following:

Installation of 1500 mm diameter caissons at this site will require excavation through cohesionless silt, sand and gravel below the groundwater table and construction of sockets in the underlying bedrock. The Contractor is advised of the following:

- The cohesionless soil above the bedrock is susceptible to disturbance under conditions of unbalanced hydrostatic head and artesian head. Appropriate measures must be employed (e.g. use of temporary steel liners with the top extended above the artesian head and the base sealed in bedrock) 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.

- Caisson installation may encounter cobbles, boulders and/or large rock fragments in the soils overlying the bedrock. The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating such obstructions.

- Caisson installation equipment with rock drilling/coring capabilities must capable of penetrating hard layers within the medium strong to very strong dolostone rock with shale interbeds. The strength and hardness of this rock must be taken into account when selecting equipment to advance the caisson into rock. Equipment supplied to construct the rock socket must be capable of excavating the bedrock to the specified socket dimensions without disturbing or fracturing the bedrock forming the sidewalls and base of the socket. Blasting to facilitate the removal of bedrock is not permitted.

The Contractor shall submit caisson installation procedure and methodology to the Contract Administrator for review and comments a minimum 14 days prior to commencement of caisson construction.

5. Suggested Text for NSSP on "Construction of Caissons – 760 mm"

Caisson installation shall be in accordance with OPSS.PROV 903, SP 109F57 (April 2018) and the following.

Installation of 760 mm diameter caissons at this site will require excavation through cohesionless soils below the groundwater table. The Contractor is advised of the following:

- The cohesionless soil above the bedrock is susceptible to disturbance under conditions of unbalanced hydrostatic head and artesian head. Appropriate measures must be employed (e.g. use of temporary steel liners with the top extended above the artesian head) to maintain sidewall stability in the caisson excavation. Selection of the methods and equipment employed to achieve this is the responsibility of the Contractor.

- Caisson installation may encounter cobbles, boulders and/or large rock fragments in the soils. The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating such obstructions.

The Contractor shall submit caisson installation procedure and methodology to the Contract Administrator for review and comments a minimum 14 days prior to commencement of caisson construction.

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6. Suggested Text for NSSP on Dewatering

Several of the piers are located within the Grand River and its flood plain. Dewatering will be required to construct the pier foundations in the dry. The design of an effective dewatering system is the responsibility of the contractor. The dewatering system must be effective to lower the groundwater table at a minimum of 0.5 m below the final subgrade level to avoid basal heave and base boiling. The dewatering system is to be designed in accordance with SP FOUN0003, OPSS.PROV.517 and SP517F01. A dewatering engineer with a minimum of 5 years experience in designing dewatering systems shall be retained by the contractor for design of an effective dewatering system.

Design of the cofferdam shall account for the following:

- Cofferdam installation may encounter cobbles, boulders and/or large rock fragments in the soils overlying the bedrock. The installation methods and equipment must be capable of dislodging, removing or otherwise penetrating such obstructions.

- The cohesionless soil above the bedrock is susceptible to disturbance under conditions of unbalanced hydrostatic head and artesian head.

7. Suggested Text for NSSP on “Footing Excavation”

Cobbles and boulders are present within the upper silty sand to sandy silt, sand and gravel, silty sand to sandy silt till deposits at this site. The presence of these cobbles and boulders will make footing excavation through these deposits difficult. Excavation through these materials may first be tried using bulk excavation techniques.

8. Suggested Text for NSSP on “Installation of Steel Sheet Piles”

Cobbles and boulders were noted within the upper silty sand to sandy silt, sand and gravel, and glacial till deposits at this site. These conditions may impede the driving of sheet piles and at some locations the sheet piles may not be able to penetrate the cobbles and boulders and reach the design depth of installation.

The Contractor shall use appropriate equipment to remove, drill through and/or penetrate these obstructions and extend the piles to the design depth.

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Appendix G
Site Photographs

Photograph 1 – View of boulder near GRB16-09

Photograph 2 – View of cobbles and boulders in archaeological pit south of GRB16-13

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Appendix H
Ground Motion Parameters and Seismic Modulus of Subgrade Reactions

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Table H.1 – Ground Motion Parameters Site Class C (NBC 2020)

Seismic Hazard Value	Sa(0.05) [g]	Sa(0.1) [g]	Sa(0.2) [g]	Sa(0.3) [g]	Sa(0.5) [g]	Sa(1.0) [g]	Sa(2.0) [g]	Sa(5.0) [g]	Sa(10.0) [g]	PGA [g]	PGV [m/s]
2% Probability in 50 Years	0.224	0.242	0.215	0.191	0.144	0.0806	0.0386	0.0102	0.00355	0.105	0.224
5% Probability in 50 Years	0.117	0.133	0.125	0.113	0.0856	0.0469	0.0218	0.00542	0.00191	0.0598	0.117
10% Probability in 50 Years	0.066	0.0798	0.0785	0.0711	0.0542	0.0291	0.0131	0.00302	0.00107	0.0367	0.066

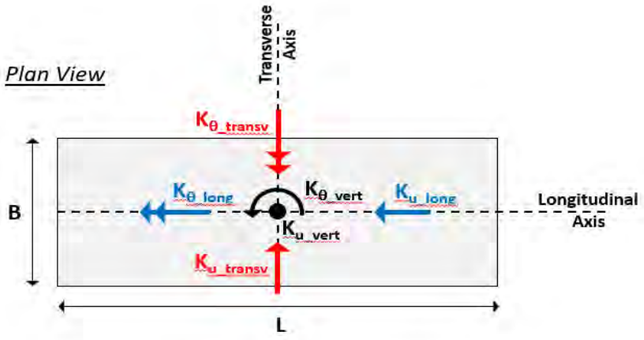
LUMPED SOIL SPRINGS FOR SHALLOW FOOTINGS

Local Axes: Forces

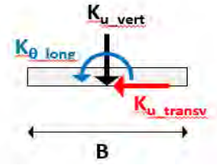
Vert: vertical
Long: longitudinal
Transv: transverse

u: translational component
θ: rotational component

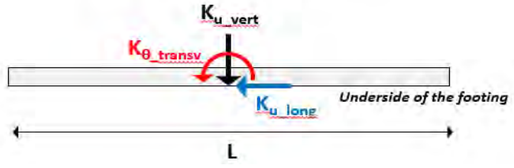
Plan View



Transverse Cross Section



Longitudinal Cross Section

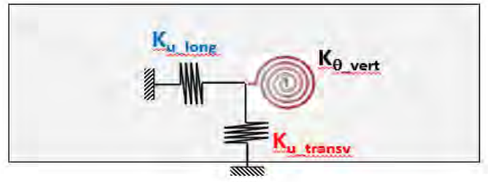


Local Axes: Springs

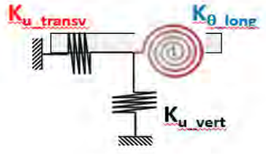
Vert: vertical
Long: longitudinal
Transv: transverse

u: translational component
θ: rotational component

Plan View



Transverse Cross Section



Longitudinal Cross Section

LUMPED SOIL SPRINGS FOR SHALLOW FOOTINGS

LOWER Estimate: V_s = 360 m/s, G/G_{max} = 0.20

e_B/B		Translation K_u (MN/m)			Rotation K_θ (MN*m/rad)		
		vert	transv	long	vert	long	transv
≤ 0.17	No uplift	2,525	2,954	2,859	181,853		
0.17 to 0.30	Uplift	2,156	2,634	2,446	130,674	see table	
0.30 to 0.40	Uplift	1,904	2,400	2,124	111,441		

UPPER Estimate: V_s = 360 m/s, G/G_{max} = 0.50

e_B/B		Translation K_u (MN/m)			Rotation K_θ (MN*m/rad)		
		vert	transv	long	vert	long	transv
≤ 0.17	No uplift	6,312	7,386	7,148	454,631		
0.17 to 0.30	Uplift	5,391	6,586	6,116	326,684	see table	
0.30 to 0.40	Uplift	4,759	6,001	5,310	278,603		

e_B/B		LOWER Estimate K_θ (MN*m/rad)		UPPER Estimate K_θ (MN*m/rad)	
		long	transv	long	transv
0	No Uplift	98,629	142,806	246,573	357,014
0.05	"	82,338	132,788	205,844	331,971
0.10	"	67,701	122,716	169,252	306,790
0.17	"	50,644	109,016	126,611	272,539
0.25	Uplift	33,049	90,981	82,624	227,451
0.30	"	24,350	79,305	60,875	198,263
0.35	"	16,944	66,570	42,359	166,426
0.40	"	10,724	52,115	26,811	130,287