



**THURBER** ENGINEERING LTD.

# **FOUNDATION INVESTIGATION AND DESIGN REPORT FREDERICK STREET UNDERPASS – MUNICIPAL UTILITIES**

**HIGHWAY 7 / 85, KITCHENER, ONTARIO**

**Assignment No. 3020-E-0016-01**

**G.W.P. 3001-22-00**

**GEOCRES NO. 40P08-301**

**Client Name:** MTO

**Date:** March 5, 2024

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**FOUNDATION INVESTIGATION REPORT  
FREDERICK STREET UNDERPASS - MUNICIPAL UTILITIES  
HIGHWAY 7 – NEW, KITCHENER TO GUELPH  
G.W.P. 3001-22-00**

**GEOCRES NO.:40P08-301**

**PART A: FACTUAL INFORMATION**

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**1. INTRODUCTION**

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Thurber Engineering (Thurber) has been retained by the Ministry of Transportation, Ontario (MTO) to undertake a geotechnical and hydrogeological investigation in support of the proposed utility replacement and relocation along Becker Street, Fife Avenue and Ann Street in the City of Kitchener, Ontario. A site location map is provided on Drawing 1 in Appendix A. This work is part of the foundation investigation for the Frederick Street Bridge Replacement.

This work is completed as per the MTO Work Order Number 1 and 4 of the Retainer Assignment 3020-E-0016 dated September 19, 2022, and July 11, 2023, respectively.

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, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

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

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**2. SITE AND PROJECT DESCRIPTION**

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Due to widening of the Highway corridor at the Frederick Street Underpass location, the existing Frederick Street Underpass will be replaced with a longer structure and the existing utilities currently located in the vicinity will be replaced or relocated.

The proposed site is in the City of Kitchener, and the utility replacement/relocation will occur along Becker Street (southerly from the north end to the Fife Avenue intersection), along Fife Avenue (easterly from Becker Street to Ann Street), and along Ann Street (northerly from Fife Avenue to

the north end). The proposed Bridge Underpass structure (MTO Structure Site No. 33X-0234/B0) and its associated retaining walls are situated approximately 350 meters south of the Highway 7/85 Victoria Street Underpass. Details pertaining to the bridge underpass structure are provided in Thurber's draft report titled Foundation Investigation and Design Report, Frederick Street Underpass, dated September 29, 2023.

Summarized details of the proposed utility replacement / relocation as taken from the 90 % design drawings prepared by GHD are provided below:

The portion of the existing sanitary forcemain along Becker Street east of Highway 7 will be abandoned. The new 500 mm dia. sanitary forcemain (HDPE DR 13.5), situated at depths ranging between 4.0 to 5.5 m, i.e. elevation 323.9 m (location of connection to the existing forcemain) to 318.5 m, will connect to the existing forcemain just south of Fife Avenue and Becker Street intersection. The new forcemain will run along Fife Avenue and continue along Ann Street connecting to the existing forcemain north of Ephraim Street and Ann Street intersection.

Selected portions of the existing sanitary sewer will be removed and replaced by 200 to 600 mm dia. The new sanitary sewer pipe section (PVC and Concrete) is to be located at an approximate depth of 3.5 to 5.5 m, i.e. elevation 322.2 to 318.5 m.

Selected sections of existing storm sewer will be replaced by 375 to 1200 mm dia. storm sewer (PVC and Concrete) to be installed at an approximate depth ranging from 3.5 to 5.5 m, i.e. elevation ranging from 321.5 m to 318.5 m.

The proposed 150 mm dia. and 200 mm dia. Watermain (PVC) will follow the same alignment as the existing watermain of the same dia. except some localized adjustments in the horizontal alignment and vertical profile.

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### **3. INVESTIGATION PROCEDURES**

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The subsurface investigation involved the completion of a total of fifteen (15) boreholes out of which twelve (12) boreholes designated as BH-01 to BH-12, were drilled between December 2022 and January 2023 (Work Order #1). Three additional boreholes designated as BH-13 to BH-15 were advanced under an additional scope of work (Work Order #4) due to a design change in the proposed utility alignment. These boreholes were advanced to an approximate depth ranging between 9.8 m and 12.8 m.

Utility clearances and Permits were obtained prior to mobilization to the site. The borehole locations were marked in the field by Thurber using a Trimble R10 survey unit. The coordinate system MTM NAD 83, Zone 10 was used for the boreholes.

The boreholes were advanced using truck or track mounted drill rig depending on the site access conditions. The drill rigs were supplied and operated by Elements GEO of Hamilton, Ontario. Hollow-stem augers were used to advance the boreholes and the soil samples were obtained using a 50 mm outer diameter split-spoon sampler driven by an automatic hammer in accordance with the Standard Penetration Test (SPT). Due to the proximity of the underground utilities, the upper 3.3 m of the Boreholes BH-13 and BH15 were daylighted by a vacuum truck. At Borehole BH-07, Dynamic Cone Penetration Testing (DCPT) was performed below the sampled depth to 11.5 m depth.

The as-drilled borehole locations were surveyed upon completion of drilling and are shown in the Borehole Location Plan included in Appendix A.

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.

Monitoring wells were installed in Boreholes BH-02, BH-05, BH-08, BH-11, BH-13, BH-14 and BH-15 to permit subsequent hydrogeological investigation and groundwater level monitoring. The monitoring wells consisted of a 50 mm Schedule 40 PVC pipe with a 3.05 m long slotted screen except at BH-02 where a 1.52 m long slotted screen was used. Where monitoring wells were not installed, the boreholes were backfilled with bentonite to the ground surface off the road or up to 0.15 m depth and then backfilled with cold patch asphalt to reinstate the pavement surface.

A summary of the borehole elevations, termination depths and elevations, and monitoring well tip are in the table below.

<b>Borehole</b>	<b>Ground Surface Elevation (m)</b>	<b>Borehole Depth (m) / Borehole Termination Elevation (m)</b>	<b>Monitoring Well Tip Depth (m) / Elevation (m)</b>
BH-1	325.6	9.8 / 315.7	-
BH-2	326.1	9.8 / 316.3	5.3 / 320.8
BH-3	326.3	9.9 / 316.4	-
BH-4	326.6	9.8 / 316.8	-
BH-5	326.9	9.8 / 317.1	8.8 / 318.1



Borehole	Ground Surface Elevation (m)	Borehole Depth (m) / Borehole Termination Elevation (m)	Monitoring Well Tip Depth (m) / Elevation (m)
BH-6	327.0	9.8 / 317.2	-
BH-7	326.8	9.8 / 317.0*	-
BH-8	325.9	9.8 / 316.1	9.1 / 316.8
BH-9	325.0	9.9 / 315.1	-
BH-10	323.8	9.9 / 313.9	-
BH-11	323.4	9.8 / 313.6	7.7 / 315.7
BH-12	323.3	9.8 / 313.5	-
BH-13	323.4	9.8 / 313.6	7.6 / 315.8
BH-14	318.9	12.8 / 306.1	6.1 / 312.8
BH-15	327.6	9.8 / 317.8	7.7 / 319.9

\* Dynamic Cone Penetration test (DCPT) was conducted to 11.5 m depth.

### 3.1 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 where appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix B and are shown on figures in Appendix C.

Testing was carried out on samples of the fill and native soils to assess the potential for sulphate attack on buried concrete structures, as well as the potential for corrosion associated with buried steel elements of the structures. The results of the analytical testing are summarized in this report and presented in Appendix D.

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## 4. SITE GEOLOGY AND SUBSURFACE CONDITIONS

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### 4.1 Regional Geology

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.

## **4.2 Subsurface Conditions**

Details of the encountered soil stratigraphy are presented on the Record of Borehole sheets included in Appendix B and interpreted stratigraphic profile is presented in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes is given in the following sections. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description for interpretation of the site conditions. Classification and descriptions of coarse-grained and fine-grained soils are made in general accordance with ASTM D2487, and MTO's Soil Classification Manual, respectively.

The boundaries between soil strata on the record of boreholes have been inferred from non-continuous sampling, observation of the progress of drilling, and the results of Standard Penetration Testing. Therefore, the boundaries represent the transitions between soil deposits rather than exact planes of geological change. Variation on the stratigraphic boundaries between and beyond boreholes will exist and is to be expected.

In general, the subsurface conditions below the pavement structure and layers of a non-homogeneous fill consist of native deposits of sand and silt overlying clayey silt to silty clay till.

It should be noted that the glacial till and granular deposits may contain boulders. Possible large obstructions can be anticipated in the fill material. Contractor should be prepared for such conditions during construction.

A detailed description of the subsurface conditions is presented in the following sections.

## **4.3 Pavement Structure**

Boreholes BH-01 to BH-13 were advanced within existing roadway sections. At Boreholes BH-01 to BH-13 locations, asphalt ranging in thickness between 40 and 175 mm was encountered at the ground surface. Asphalt was underlain by 100 to 700 mm thick layer of sand and gravel to gravelly sand fill material in all the boreholes except at Borehole BH-13 location, where approximately 200 mm thick granular base / subbase was encountered underlying asphalt.

The SPT 'N' values within the granular fill material ranged from 5 to 26 blows per 0.3 m of penetration indicating a loose to compact relative density. Natural moisture contents ranged from 3 to 20 percent.

The result of a grain size analysis test conducted on a granular fill sample (BH-10) indicated a gravel content of 28%, a sand content of 49%, and a fines content of 23%.

#### 4.4 Topsoil

At Boreholes BH-14 and BH-15, topsoil approximately 300 mm thick was encountered at the ground surface. The topsoil thickness may vary in other areas of the site.

#### 4.5 Fill

Fill material of approximate thickness ranging between 0.7 to 3.0 m and generally consisting of sand / sandy silt / silt and sand / sand and gravel to clayey silt was encountered underlying the pavement structure in all the boreholes except at Borehole BH-14. Boreholes BH-13 and BH-15 were daylighted up to an approximate depth of 3.3 m. The base of the fill was at elevation ranging from 320.1 to 325.3 m.

The SPT 'N' values ranged from 3 to 26 blows per 0.3 m of penetration in the sand and gravel to gravelly sand fill, from 2 to 18 blows in the sandy silt to silty sand fill, and from 6 to 9 blows in the clayey silt fill. The measured SPT 'N' values suggest that the sand and gravel to gravelly sand is very loose to compact, the sandy silt to silty sand fill is very loose to compact, and the clayey silt fill is firm to stiff.

Natural moisture contents ranged from 3 to 20 percent on samples of the sand and gravel to gravelly sand fill, 3 to 20 percent on samples of the sandy silt to silty sand fill, and 4 to 21 percent on samples of the clayey silt fill.

The results of a grain size analysis tests conducted on samples of the fill are provided on the Record of Borehole Sheets in Appendix B and illustrated in Figure 1 to 3 in Appendix C. The results are summarized as follows:

<b>Soil Particles</b>	<b>Sand and Gravel to Gravelly Sand Fill (%)</b>	<b>Sand to Sandy Silt to Silty Sand Fill (%)</b>	<b>Clayey Silt Fill (%)</b>
Gravel	21 to 28	1 to 3	0 to 5
Sand	49 to 69	46 to 90	25 to 26
Silt	10	7 to 42	50 to 57
Clay	0	2 to 9	13 to 24
Silt + Clay	23	-	-

#### 4.6 Clayey Silt to Silty Clay Till

Native clayey silt to silty clay till were encountered in all the boreholes except BH-13 and BH-15. The native cohesive till deposits were encountered underlying the fill material in Boreholes BH-04, BH-06, BH-07, and BH-12 and underlying the native cohesionless soil deposits in Boreholes BH-01, BH-08, BH-09 and BH-11. In Boreholes BH-02, BH-03, BH-04, BH-10, and BH-11, these cohesive soil deposits were found to be interbedded within the native sand deposits. Boreholes BH-01, BH-02, BH-03, BH-04, BH-08, BH-09, BH-10, BH-12 and BH-14 were terminated within these cohesive soil deposits.

It should be noted that the glacial till deposits inherently contain cobbles and boulders.

The SPT 'N' values encountered within these native cohesive soil deposits ranged between 10 to more than 50 blows per 300 mm penetration, indicating these deposits to be stiff to hard. The measured moisture contents generally ranged from 10 to 22 percent.

The results of grain size analysis testing conducted on samples of the till deposit are provided on the Record of Borehole Sheets in Appendix B and included on Figure 8 in Appendix C. The results are summarized as follows:

<b>Soil Particles</b>	<b>(%)</b>
Gravel	0 to 5
Sand	0 to 44
Silt	35 to 65
Clay	16 to 53
Silt + Clay	72

The results of Atterberg Limits testing conducted on samples of the clayey silt till are included on Figure 9 in Appendix C and summarized below.

<b>Atterberg Limits</b>	<b>(%)</b>
Liquid Limit	16 to 43
Plastic Limit	11 to 18
Plasticity Index	5 to 25

The above results indicate that the clayey silt to silty clay till deposit is of low to medium plasticity with a group symbol ranging from CL-ML to CL and CI.

#### **4.7 Silt and Sand**

In Boreholes BH-04, BH-06 and BH-07, native deposits consisting of silt and sand to sandy silt were encountered underlying the shallow clayey silt till deposits. These layers of cohesionless soil deposits were 0.6 to 1.3 m thick and extended to the approximate depths of 2.9 to 4.1 m (elevation 324.2 to 322.5 m).

SPT 'N' values encountered within these soil deposits ranged between 13 to 21 blows per 300 mm penetration, indicating these deposits to be compact. The measured moisture contents generally ranged from 16 to 19 percent.

The results of grain size analysis testing conducted on samples of the silt and sand deposit are provided on the Record of Borehole Sheets in Appendix B and included on Figures 4 in Appendix C. The results are summarized as follows:

Soil Particles	(%)
Gravel	0 to 3
Sand	24 to 44
Silt	49 to 67
Clay	4 to 9

#### **4.8 Sand**

In all the boreholes, native sand to silty sand deposits were encountered underlying the fill material except at Borehole BH-14 where these soil deposits were encountered underlying the topsoil. These cohesionless soil deposits were generally 2.7 to 8.1 m thick and extended to the approximate depths of 3.0 to 10.1 m (elevation 320.5 to 313.6 m). In Boreholes BH-02, BH-03, BH-04, BH-05, BH-10 and BH-11, native cohesive soil deposits, generally 0.2 to 2.9 m thick were also found within the native cohesionless soil deposits. Boreholes BH-03, BH-05, BH-06, BH-07, BH-11, BH-13 and BH-15 were terminated within the sand deposits.

SPT 'N' values encountered within these native cohesionless soil deposits ranged between 8 to more than 50 blows per 300 mm penetration of split spoon sampler indicating these deposits to be loose to very dense. In Boreholes BH-03, BH-05 and BH-13, SPT 'N' values in the range of 1 to 2 blows per 300 mm penetration were also noted indicating these soil deposits to be in very loose condition. The measured moisture contents generally ranged from 8 to 30 percent.

The results of grain size analysis testing conducted on samples of the sand deposit are provided on the Record of Borehole Sheets in Appendix B and included on Figures 5 to 7 in Appendix C. The results are summarized as follows:

Soil Particles	(%)
Gravel	0 to 12
Sand	72 to 97
Silt	8 to 15
Clay	0 to 5
Silt + Clay	3 to 10

#### 4.9 Groundwater Conditions

Details of the water level observed in the boreholes upon completion of drilling and in monitoring wells are presented on the record of boreholes and summarized below.

Borehole	Date of Measurement	Groundwater Level (m)		Screened Unit	Borehole Cave-in Depth (m) after completion
		Depth	Elevation		
BH-01	-	-	-	-	9.1
BH-02	March 1, 2023	4.6	321.5	Sand	-
BH-03	-	-	-	-	6.7
BH-04	-	-	-	-	5.2
BH-05	February 1, 2023	5.5	321.4	Sand, Clayey Silt	-
	March 1, 2023	5.5	321.4		-
BH-06	-	-	-	-	5.5
BH-07	-	-	-	-	5.8
BH-08	February 1, 2023	5.3	320.6	Sand	-
	March 1, 2023	5.3	320.6		-
BH-09	-	-	-	-	4.6
BH-10	-	-	-	-	5.0
BH-11	March 8, 2023	3.9	319.5	Sand, Clayey Silt	-
BH-12	-	-	-	-	4.6
BH-13	November 9, 2023	4.4	318.9	Sand	-
	November 27, 2023	4.4	318.9		-
BH-14	November 9, 2023	0.7	318.2	Sand, Silty Clay	-
	November 27, 2023	1.0	317.9		-
BH-15	November 9, 2023	5.9	321.7	Sandy Silt, Sand	-
	November 27, 2023	5.9	321.7		-

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.

Perched water may be present in the fill material, old trench/infrastructure backfill, granular pavement base and/or more previous sand pockets within the native silty/clayey soils.

#### 4.10 Single Well Response Test Results – Hydraulic Conductivity

The SWRT results were analyzed using the Hvorslev method. The SWRT analysis plots are included in Appendix C. The hydraulic conductivity values calculated from the in-situ SWRTs are summarized in the following table:

Monitoring Well	Screen Interval (m BGS)	Screened Unit	Hydraulic Conductivity (m/s)
BH-02	4.5 – 7.6	Sand	$8.8 \times 10^{-5}$
BH-05	4.5 – 7.6	Sand, Clayey Silt	$4.5 \times 10^{-5}$
BH-08	4.5 – 7.6	Sand	$1.8 \times 10^{-4}$
BH-11	4.5 – 7.6	Sand, Clayey Silt	$7.8 \times 10^{-6}$
BH-13	4.5 – 7.6	Sand	$7.3 \times 10^{-5}$
BH-14	3.0 – 6.1	Sand, Silty Clay	$7.6 \times 10^{-5}$ *
BH-15	4.5 – 7.6	Sand, Sandy Silt	$1.7 \times 10^{-4}$

\*The hydraulic conductivity at BH-14 was estimated based on the grain size analysis using the Hazen method.

## 5. ANALYTICAL LABORATORY TESTING

A total of fifteen selected samples (i.e. one sample per BH) were submitted for analytical testing for corrosivity analysis and sulphide content. The analytical test results for the soil are presented in Appendix D and are summarized below.

Borehole	BH-01	BH-02	BH-03	BH-04	BH-05
Sample	SS1	SS5	SS5	SS4	SS4
Depth (m)	0 – 0.6	3.0 – 3.6	3.0 – 3.6	2.3 – 2.9	2.3 – 2.9
Sulphide (Na <sub>2</sub> CO <sub>3</sub> ) %	<0.04	<0.04	<0.04	<0.04	<0.04
Chloride (µg/g)	350	58	31	83	56
Sulphate (µg/g)	28	5	3.4	4.3	8.8
pH	8.99	9.05	9.20	8.55	9.16
Conductivity (µS/cm)	915	217	142	245	300
Resistivity (Ohm-cm)	1090	4610	7040	4080	3330
Redox Potential (mV)	276	303	242	317	231



Borehole	BH-06	BH-07	BH-08	BH-09	BH-10
Sample	SS6	SS6	SS5	SS3	SS5
Depth (m)	4.6 – 5.2	4.6 – 5.2	3.0 – 3.6	1.5 – 2.1	3.0 – 3.6
Sulphide (Na <sub>2</sub> CO <sub>3</sub> ) %	<0.04	<0.04	<0.04	<0.04	<0.04
Chloride (µg/g)	40	22	14	160	82
Sulphate (µg/g)	4.2	3.4	2.8	12.0	5.4
pH	9.30	9.28	9.32	8.86	9.42
Conductivity (µS/cm)	188	120	113	439	251
Resistivity (Ohm-cm)	5320	8330	8850	2280	3980
Redox Potential (mV)	243	371	252	306	329
Borehole	BH-11	BH-12	BH-13	BH-14	BH-15
Sample	SS3	SS6	SS1	SS4	GS2
Depth (m)	1.5 – 2.1	4.6 – 5.2	3.8 – 4.4	2.3 – 2.9	1.5 – 2.1
Sulphide (Na <sub>2</sub> CO <sub>3</sub> ) %	<0.04	<0.04	<0.01	<0.01	<0.01
Chloride (µg/g)	97	43	54	96	14
Sulphate (µg/g)	10	5.6	7.8	7.9	7.0
pH	9.13	8.91	9.15	9.04	8.48
Conductivity (µS/cm)	446	175	261	380	111
Resistivity (Ohm-cm)	2240	5710	3830	2630	9010
Redox Potential (mV)	280	309	232	238	267

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## 6. MISCELLANEOUS

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Elements Geo of Hamilton, Ontario supplied a truck and track mounted drill rig and conducted the drilling, sampling and in-situ testing operations for the present investigation.

The coordinates and elevations for the boreholes were obtained by Thurber using a Trimble R10.

The drilling and sampling operations in the field for the current 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.



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Overall supervision of the field program, interpretation of the data, and preparation of the report was conducted by Mr. Puneet Verma, P.Eng. and Mr. Justin Rumney, P.Geo. The report was reviewed by Mr. Keli Shi, P.Eng., and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations projects.

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**GEOCRES NO.:40P08-301**

**PART B: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

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**7. GENERAL**

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**7.1 General**

This section of the report presents interpretations of the factual geotechnical data and provides geotechnical recommendations for design and installation of the proposed underground utilities including watermain, sanitary sewer, storm sewer and sanitary forcemain. The discussions and recommendations presented herein are based on our understanding of the project and our interpretation of the factual data obtained from the subsurface investigations.

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

Details of the proposed utility replacement / relocation based on the 90% design drawings provided to Thurber by GHD are summarized below.

Sanitary Forcemain Replacement / Relocation

The portion of the existing sanitary forcemain along Becker Street and north of Fife Avenue, east of Highway 7 will be abandoned. The new sanitary forcemain will connect the existing forcemain just south of Fife Avenue and Becker Street intersection (approximate station 2+980). The new forcemain will run along Fife Avenue and continue along Ann Street connecting to the existing forcemain north of Ephraim Street and Ann Street intersection (approximate station 1+370). The

proposed forcemain (HDPE DR 13.5) will be 500 mm diameter and will be situated at depths ranging between 4.0 and 5.5 m below street level. The invert elevation is expected to be approximately 323.9 m (location of connection to the existing forcemain) to 318.5 m.

#### Sanitary Sewer Replacement / Relocation

The portion of the existing 250 mm diameter sanitary sewer along Becker Street from Fife Avenue and Becker Street intersection to approximate station 3+102, will be removed and replaced by 200 mm dia. Sanitary sewer pipe section (PVC). The proposed sanitary sewer section will be situated at an approximate depth ranging between 3.5 and 4.4 m below street level. The invert elevation is expected to be approximately 322.5 m to 322.3 m.

The existing portion of 200 to 250 mm diameter sanitary sewer along Fife Avenue from Becker Street and Fife Avenue intersection to approximate station 4+120 will be replaced by 300 mm dia. Sanitary sewer (PVC). The proposed sanitary sewer section will be situated at an approximate depth ranging between 4.3 and 5.5 m below street level. The invert elevation is expected to be approximately 322.2 m to 321.5 m.

The existing portion of 375 to 600 mm sanitary sewer along Ann Street will be replaced by 300 to 600 mm diameter sanitary sewer (PVC and Concrete). The proposed sanitary sewer section will be situated at an approximate depth ranging between 3.5 and 5.5 m below street level. The invert elevation is expected to be approximately 321.5 m to 318.5 m.

#### Storm Sewer Replacement / Relocation

The existing portion of storm sewer along Becker Street up to station 3+120, along Fife Avenue from Becker Street to Ann Street, along Ann Street from Fife Avenue to station 1+270 will be replaced by 375 to 1200 mm diameter storm sewer (PVC and Concrete). The proposed storm sewer sections will be situated at an approximate depth ranging between 3.5 and 5.5 m below street level. The invert elevation is expected to be approximately 323 m to 316.5 m.

#### Watermain Replacement / Relocation

The proposed 150 mm diameter watermain (PVC) will follow the same alignment as the existing watermain of the same diameter except some localized adjustments in the horizontal alignment and vertical profile.

All utility installation shall be as per OPSS 410, OPSS 412 and OPSS 441 respectively.

## **7.2 Excavation**

It is understood that all proposed utilities will be installed in open cut excavation. Excavation should be carried out in accordance with Occupational Health and Safety Act (OHSA), OPSS.MUNI 401, and OPSS.MUNI 402. Use of support systems (Trench Boxes) shall conform to OPSS 404.

For the purposes of the OHSA, the existing fills and native soils within the proposed depth of excavation may be classified as Type 3 and Type 4 above and below the water table, respectively. The clayey silt to silty clay deposit may be classified as Type 3.

Excavation for utility installations will extend to approximately 6 m below the street level through existing fill, native sand to sand and silt, and locally clayey silt till with the groundwater table close to the base of excavation. Where very loose to loose fill or soft native material are encountered during excavation, the contractor must construct the temporary cut slopes to stable inclinations to ensure worker safety and avoid impacting existing adjacent structures and utilities.

An open cut excavation for installation of multiple utilities in a trench up to 6 m deep in sands with water table above the trench base will not be stable at temporary excavation slope of 1H:1V. Based on the soil conditions encountered along the proposed utility alignment, a preliminary global stability analysis was carried out to determine the inclination of stable temporary cut slope with the groundwater table lowered to a minimum 0.5 m below the base of excavation. The analysis indicates that all temporary cut slopes shall not be steeper than 2H:1V.

Suggested text for an N SSP on temporary excavation slope is included in Appendix E.

## **7.3 Temporary Protection Systems**

Where space restrictions do not allow open cut excavation, a shored excavation should be used to install proposed multiple utilities. The shoring must be designed by an experienced shoring design engineer retained by the contractor.

Conventional trench box system such as steel single wall or double wall trench shield would likely not be effective in supporting the excavation in the foundation sand at this site. Therefore, consideration should be given to the use of a slide rail trench box shoring system to support excavation at all times during construction.

Alternatively, appropriately designed interlocked sheet piles driven to an adequate depth into the underlying till may be required. The shoring may need to be horizontally braced to minimize lateral deflection of the shoring system.

It is contractor's responsibility to maintain stable excavations. Temporary protection systems shall be designed in accordance with OPSS.MUNI 539 and the design should be carried out by a licensed Professional Engineer experienced in shoring design. The temporary protection systems shall be designed for Performance Level 2 or better.

The recommended lateral earth pressure parameters for use in the design of temporary protection systems are provided in the following table. The lateral earth pressure coefficients are provided for horizontal ground surface behind the temporary protection system. Where the retained ground is sloping, the lateral earth pressure coefficients must be adjusted to account for the retained sloping ground.

<b>Stratigraphic Unit</b>	<b>Angle of Internal Friction (degree)</b>	<b>Unit Weight (kN/m<sup>3</sup>)</b>	<b>Active Earth Pressure (Ka)</b>	<b>At-Rest Earth Pressure (Ko)</b>	<b>Passive Earth Pressure (Kp)</b>
Existing Fill	30	20	0.33	0.50	3.0
Native Sand and Silt	31	20 / 10 (*)	0.32	0.48	3.1
Native Clayey Silt Till	30	20 / 10 (*)	0.33	0.50	3.0

(\*) Submerged unit weight.

#### **7.4 Dewatering and Surface Water Control**

Based on the water levels measured in the monitoring wells, the proposed excavation will be likely above the groundwater table on Becker St. and extend to or slightly below the groundwater table on Fife Ave. and Ann St. south of Frederick St. The proposed excavation will extend approximately 1.0 m below the groundwater table on Ann St. north of Frederick St. Construction dewatering will be required where excavation extends below the groundwater table or perched water is encountered.

Excavation in saturated sand at or below groundwater table will be unstable and may result in flowing sand condition. Dewatering must be carried out prior to any excavation into saturated sand.

It is possible that the groundwater level can rise above the proposed excavation level at some locations during the wet seasons. As such, provisions must be included in the contract for

providing effective groundwater control during utility installation. The groundwater should be lowered to and maintained at a minimum of 0.5 m below the excavation base during construction. The design of dewatering systems is the responsibility of the Contractor, who must retain a specialist in this field to undertake the design. The systems must remain operational until pipe construction is completed, and excavation is backfilled to above groundwater table. Suggested text for an NSSP on construction dewatering is included in Appendix E.

Where excavation extends below the groundwater table, considerations may be given to use of watertight sheet pile enclosure installed into the cohesive deposit underlying the sand and silt to cut off groundwater seepage in conjunction with well points and sump-and-pump inside the excavation.

Surface runoff should be diverted away from excavations at all times.

## **7.5 Dewatering Assessment**

The estimated discharge rates for the sections of the utility alignment that will be located below the ground water level, ranged between 321,000 and 933,000 L/day.

For the purpose of determining a budgeted peak flow rate for dewatering, it is assumed that trenches will be open in sections ranging from 30 m to 50 m (length) by 2.4 m (width). The following assumptions / approach were followed to estimate the budgeted peak water taking rate:

- Lowering groundwater to 1 m below the underside of the proposed utility alignment (this assumes 500 mm thick bedding material and additional 500 mm below the base of the bedding material) to facilitate a dry, stable work area.
- A base groundwater extraction flow rate was estimated, and a factor of safety of three (3) was applied to this flow rate to provide an allowance for removal of water from storage and variation in hydraulic conductivity.

For the dewatering estimate of the bypass alignment, the following assumptions as provided by GHD were used:

- The dimension of the excavation would be 15 m by 10 m.
- The depth of the excavation would be 6 m from ground surface.
- Ground surface elevation was indicated to be 321.16 m as listed on the GHD's markup drawing number TB-01, drawing titled Concept Temporary – Bypass alignment 1 of 2. Therefore, the inferred base of excavation will be at approximate elevation 317.16 m.

- Boreholes BH 13 and 14 were both considered in interpreting ground water level and subsurface soil conditions. The groundwater level was assumed to be 318.9 m and the excavation will be primarily within the sand deposits. The base of excavation at this proposed bypass location will extend to 2.7 m below the groundwater level (including lowering of groundwater to 1 m below the bottom of excavation).
- A factor of safety of three (3) was applied to calculate dewatering volume.

Using these assumptions, the dewatering estimate for the bypass alignment was estimated to be 1,271,000 L/day. As the rates for the street alignments and for the bypass alignment are greater than 400,000 L/day, our recommendation is that a Category 3 PTTW will be required.

Based on the Phasing Plan (drawing no. PH-01, dated Feb 01, 2024) provided by GHD, a breakdown of the dewatering volume estimate for each phase is provided in the table below. The total dewatering volume estimate for each phase includes a precipitation event of 50 mm in one day.

Description	Phase 1A	Phase 1B	Phase 2	Phase 3	Phase 4
Estimated Short Term Dewatering Rate (without safety factor or precipitation) (L/day)	421,000	311,000	235,000	185,000	107,000
From Precipitation Event of 50 mm in one day (L/day)	8,000	6,000	4,000	4,000	4,000
With a Factor of Safety 3 (excluding precipitation) for permit (L/day)	1,263,000	933,000	705,000	555,000	321,000
With a Factor of Safety 3 (including precipitation) for designs and budgeting (L/day)	1,271,000	939,000	709,000	559,000	325,000
Radius of Influence from sides of excavation (m)	110	125	64	44	8

## 7.6 Bedding

Prior to placement of the pipe bedding, the base of the trench excavation must be properly dewatered and dry, and free of disturbed or loose soil. Any identified disturbed/wet spots or areas must be sub-excavated and replaced with compacted granular material. It is critical that the pipe be supported on well compacted bedding overlying a competent and uniform subgrade in order to minimize the potential for differential settlement.

All bedding material shall meet the requirements as specified in the Region of Waterloo and area municipalities Design Guidelines and Supplemental Specifications for Services (DGSSMS), and OPSS 401 and compacted to 100% Standard Proctor Maximum Dry Density (SPMDD). As a minimum the bedding material shall consist of Granular A or Granular B Type II conforming to OPSS 1010. It is recommended that utility installation, trenching, backfilling and compaction be carried out in accordance with City of Kitchener Standard Specifications (CKSS) 401 standards. Other aspects of the works should be carried out in accordance with applicable City of Kitchener standards. Reference should also be made to OPSS 407, OPSS 410, OPSD 802.010 and OPSD 802.031, OPSD 802.032 as appropriate. Care must be exercised when compacting the fill immediately above the crown of the pipe in order not to damage the pipe.

## **7.7 Trench Backfill and Reusability of Excavated Material**

The existing fill materials are heterogenous and vary in composition from clayey silt to sand/silt to sand. Based on the silt fractions, the clayey silt and sand/silt fill are generally frost susceptible and should not be used as trench backfill within the frost depth or at locations where frost action may cause an issue. The existing sand/gravel to sand fill with trace fines may be reused with proper moisture conditioning and compaction.

The native sand typically contains less than 10% fines and may be reused as trench backfill. Reuse of native sand excavated from below the groundwater table will require control of moisture conditions to achieve optimum water content for compaction.

The on-site material selected for backfilling should be free of topsoil, organic material or other deleterious material. Trench backfill materials should be placed in a maximum 300 mm thick loose lifts and be uniformly compacted in accordance with OPSS.MUNI 501.

It is recommended that the trench be backfilled with Granular B Type I or Type II or native sand with less than 10% fines in the areas where the proposed utility alignment will be located below existing and new roadway. The backfill should be compacted to 98% of SPMDD and within  $\pm 2\%$  of optimum moisture content. Elsewhere, the backfill should be compacted to 95% SPMDD and within  $\pm 2\%$  of optimum moisture content. Where compaction is not practical in local areas, use of Unshrinkable Fill may be considered.

When backfilling trenches with excavated materials, best efforts must be made to provide uniform subgrade conditions and support strength for the overlying pavement structure.

Normal post-construction settlement of the compacted granular material equivalent to about 0.5 to 1% of the backfill height is anticipated to occur within about six months following the completion of the backfilling operations.

After providing a suitable thickness of cover (a minimum 300 mm thick or as determined by the utility designer) above the pipes, any backfill before reaching the bedding elevation of the overlying pipes shall also be compacted to 100% of SPMDD to minimize any post construction settlement of the overlying pipes.

Risks associated with the reuse of the excavated soils include the following:

- Soil conditions, including moisture contents, will vary between and beyond the borehole locations.
- Improper handling of soil during excavation, storage and placement will adversely impact the moisture content.
- Carrying out excavation and placement activities during wet weather will adversely impact the moisture content.
- Use of frozen earth fill will result in poor compaction and high potential for long term settlements.

We recommend that excavation and placement of soils for reuse be supervised on a full-time basis by qualified geotechnical personnel to mitigate some of the risks outlined above. Further laboratory testing of the excavated soils is also recommended during construction to confirm the moisture contents and determine the Standard Proctor Maximum Dry Density and optimum moisture content.

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## **8. FROST PROTECTION**

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As per OPSD 3090.101 (*Frost Penetration Depths for Southern Ontario*), a minimum 1.4 m of soil cover for frost protection should be provided at this site. A thicker frost cover may be required for the watermain as per applicable City of Kitchener Standards.

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## **9. CORROSION POTENTIAL**

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The sulphate content analysis for the representative samples resulted in a sulphate concentration of 2.8 µg/g (0.00028%) to 28 µg/g (0.0028%). The result was compared with the Canadian

Standards Association (CSA) Standards A23.1 for sulphate attack potential on concrete structures, which indicates the site soils possess a “negligible” risk for sulphate attack on concrete material.

If concrete is placed in contact with imported fill, that fill should be tested for water-soluble sulphate ion content and the above recommendations re-evaluated.

Application of the American Water Works Association (AWWA) ten-point soil evaluation criteria to the results of the testing indicated a rating of 6 to 16. A score of 10 or greater indicates that soil is corrosive to ductile-iron pipe and protection is needed. Thus, based on the results obtained from selected representative samples tested from BH-02 to BH-15, the soil is considered to be mildly to moderately corrosive to ductile iron pipe. Therefore, this tested soil should be considered corrosive to ductile iron pipe.

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

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## **10. IMPACT ON ADJACENT STRUCTURES AND UTILITIES**

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The impact of these deep trench excavations and associated dewatering on the adjacent structures, houses and utilities along the proposed realignment/relocation route must be assessed. For structures and utilities within the zone of influence of the deep trenches, a preconstruction and postconstruction condition survey should be carried out.

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## **11. CONSTRUCTION CONCERNS**

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During construction, a qualified geotechnical personal should be retained to observe activities related to the utility replacement or relocation and advise the Contract Administrator on construction concerns related to the overall geotechnical performance and instability of slopes.

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

- Although not encountered within the drilled boreholes, glacial deposits inherently contain cobbles and boulders which may affect utility installation. Moreover, such obstructions can also be encountered within the exiting fill material. Therefore, Contractor shall be prepared to remove, drill through and / or penetrate these obstructions as required.
- Based on the site conditions, the excavation will mainly take place within the high permeable sand deposits. Therefore, the Contractor must design and implement an

effective dewatering system prior to proceeding with trench excavation in order to maintain a dry excavation.

- Temporary slopes must be stable throughout construction. Therefore, all excavations should be suitably sloped and / or braced in accordance with the OHSA.



THURBER ENGINEERING LTD.

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## 12. CLOSURE

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Engineering analysis and preparation of this report was carried out by Mr. Puneet Verma, M.Eng., P.Eng. and Mr. Alireza Hejazi, Ph.D., P.Eng. The report was reviewed by Mr. Keli Shi, M.Eng., P.Eng., a Senior Geotechnical Engineer, and Dr. P.K. Chatterji, Ph.D., P.Eng., a Designated Principal Contact for MTO Foundations Projects at Thurber.

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## STATEMENT OF LIMITATIONS AND CONDITIONS

### 1. STANDARD OF CARE

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

### 2. COMPLETE REPORT

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

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### 3. BASIS OF REPORT

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### 4. USE OF THE REPORT

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### 5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

### 6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

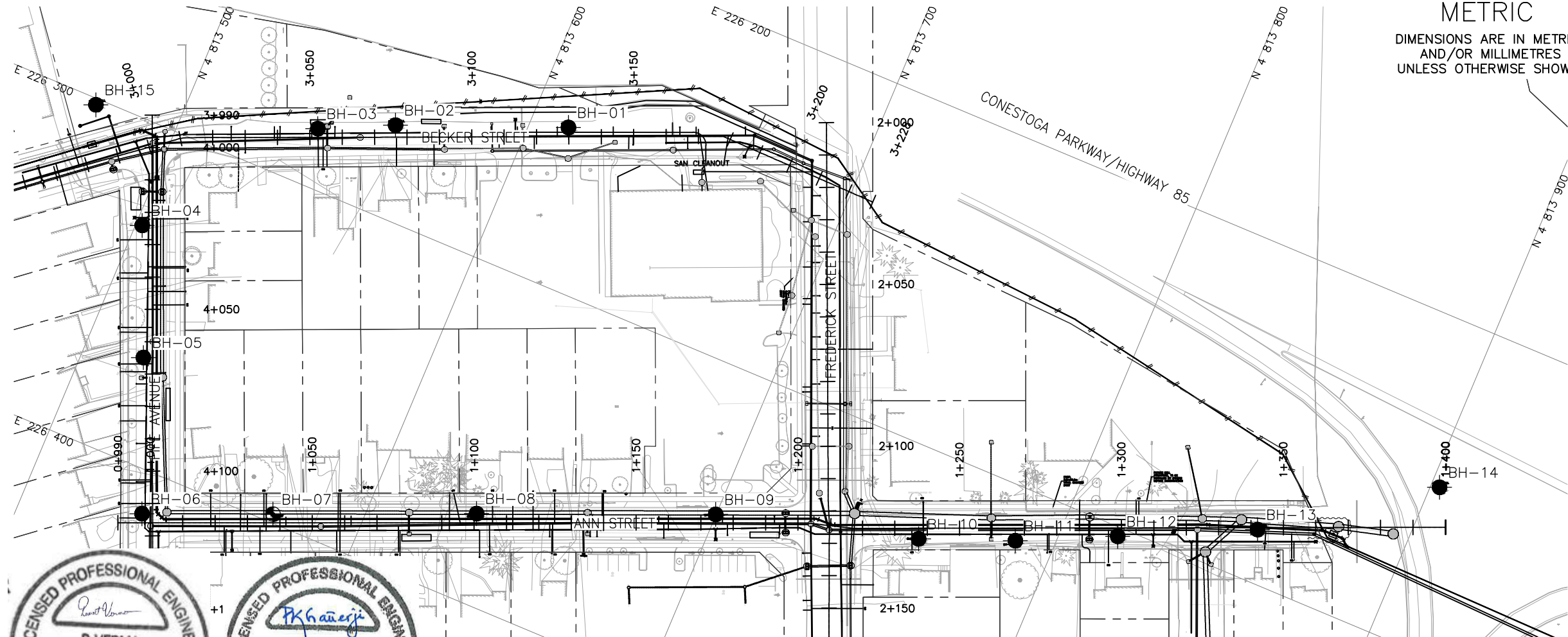
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape,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

### 7. INDEPENDENT JUDGEMENTS OF CLIENT

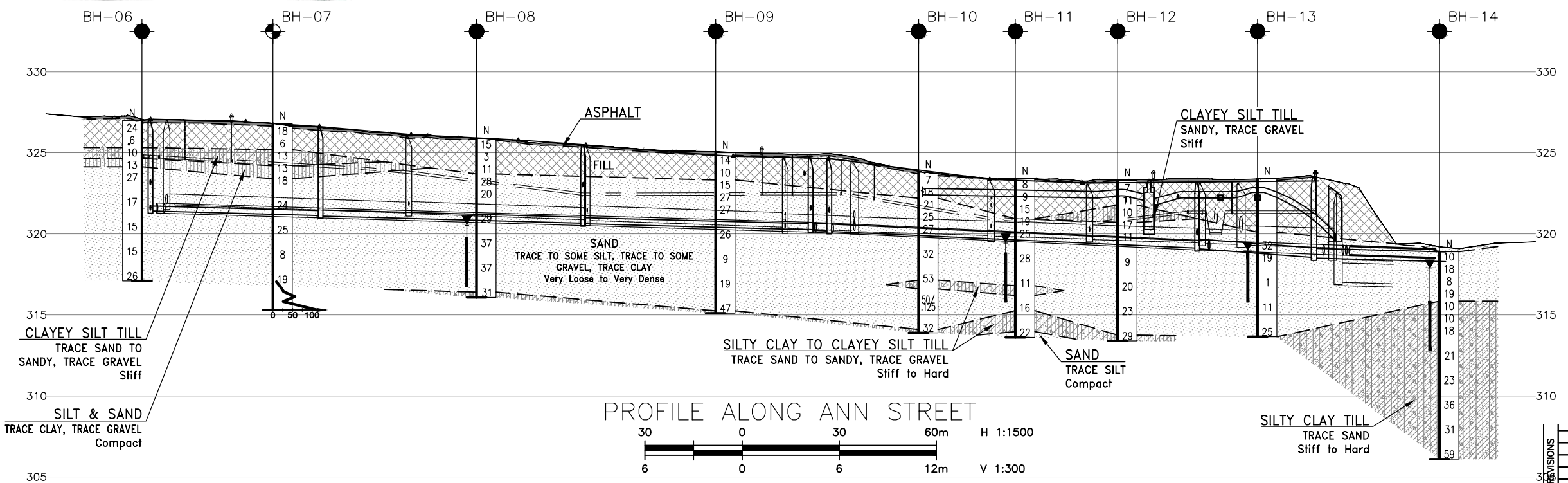
The information, interpretations and conclusions in the Report are based on Thurber's interpretation of conditions revealed through limited investigation conducted within a defined scope of services. Thurber does not accept responsibility for independent conclusions, interpretations, interpolations and/or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

## **APPENDIX A**

Borehole Locations and Soil Strata Drawings



NO	ELEVATION	NORTHING	EASTING
BH-13	323.4	4 813 855.9	226 284.1
BH-14	318.9	4 813 902.7	226 250.3
BH-15	327.6	4 813 474.4	226 301.9



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

CONT No  
WP No 408-88-00

HIGHWAY 85/FREDERICK ST  
MUNICIPAL STREETS  
UTILITY RELOCATIONS  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



KEYPLAN

LEGEND

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

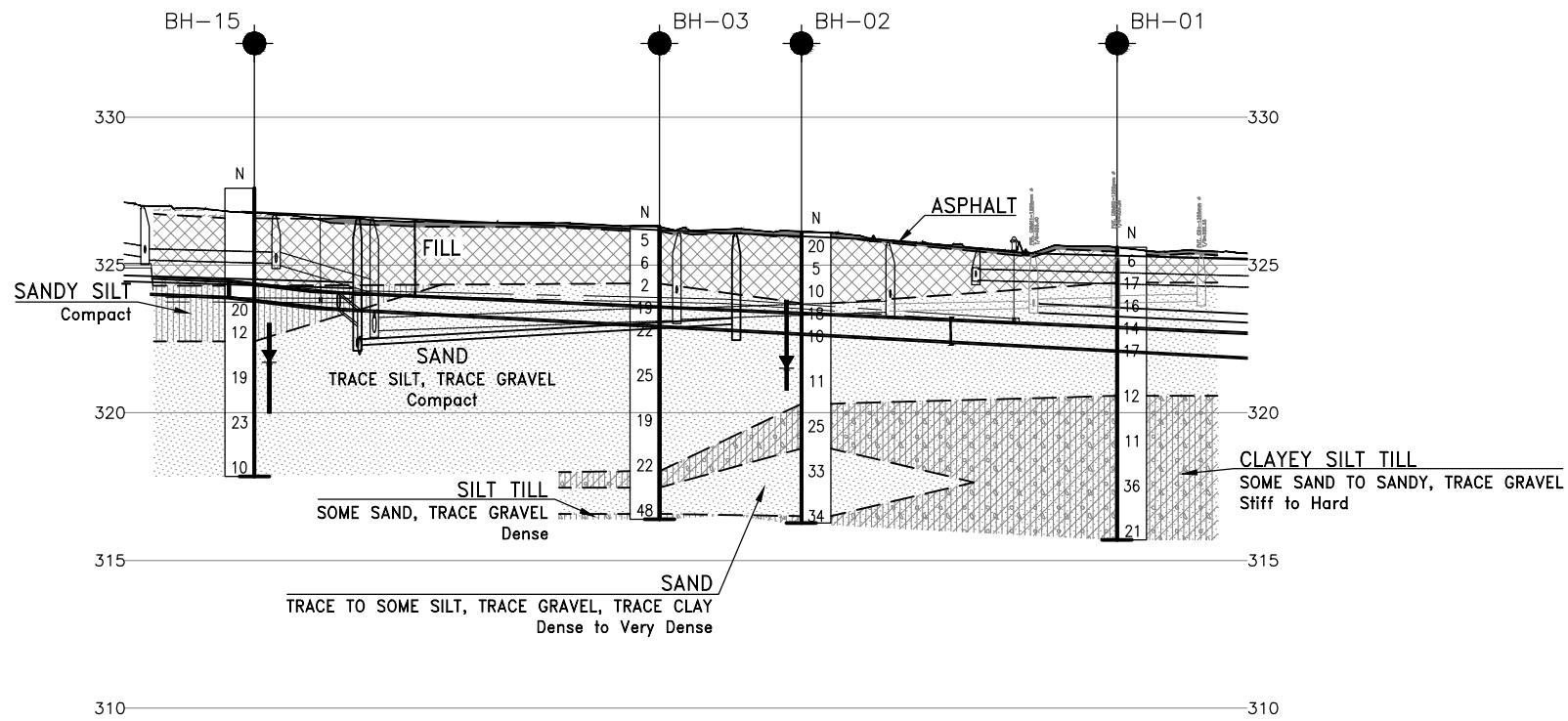
NO	ELEVATION	NORTHING	EASTING
BH-01	325.6	4 813 611.6	226 251.9
BH-02	326.1	4 813 562.1	226 271.9
BH-03	326.3	4 813 540.4	226 282.2
BH-04	326.6	4 813 502.0	226 330.7
BH-05	326.9	4 813 518.1	226 368.2
BH-06	327.0	4 813 536.4	226 412.9
BH-07	326.8	4 813 573.7	226 397.4
BH-08	325.9	4 813 631.6	226 372.8
BH-09	325.0	4 813 699.8	226 344.5
BH-10	323.8	4 813 760.5	226 327.3
BH-11	323.4	4 813 788.3	226 316.2
BH-12	323.3	4 813 816.9	226 302.8

-NOTES-

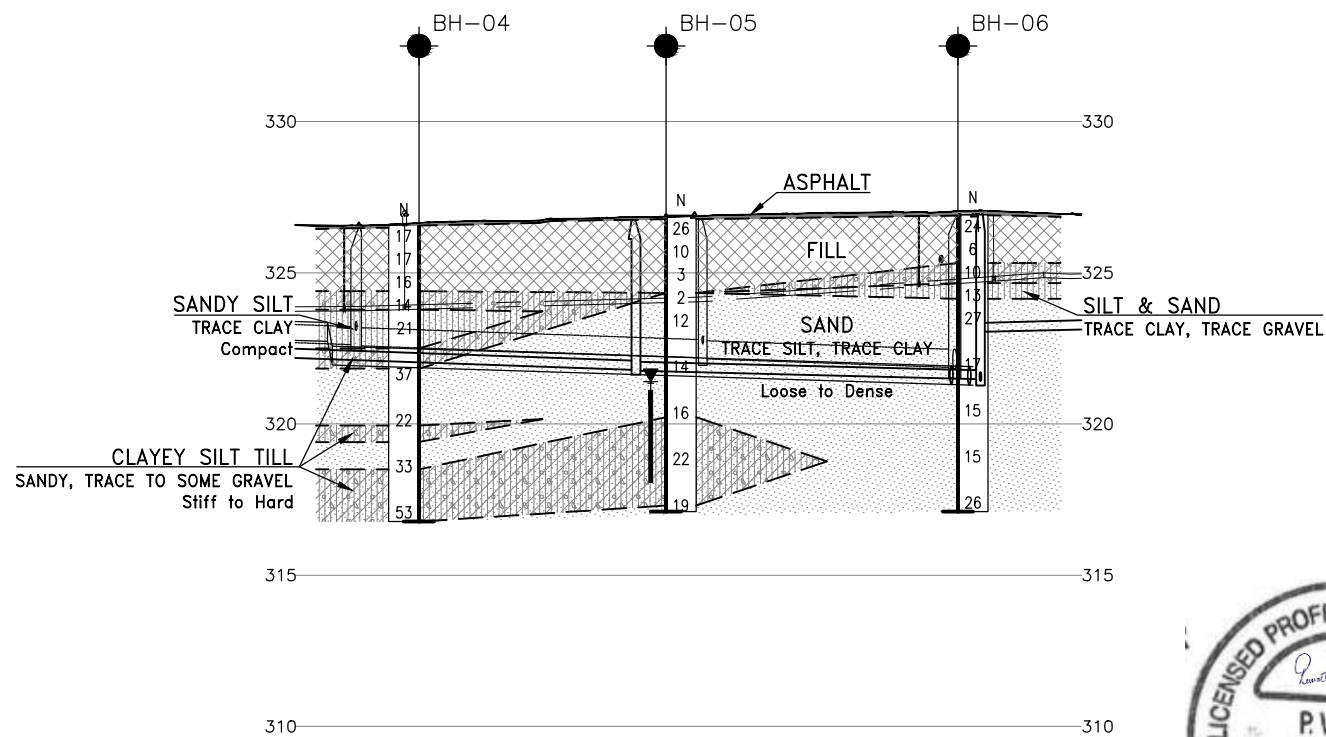
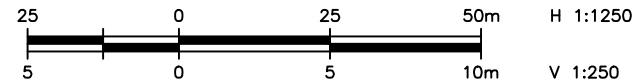
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 10.

GEOCRES No. 40P08-301

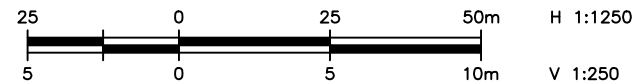
REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GL	CHK -	CODE
DRAWN	MFA	CHK GL	SITE
LOAD	DATE	MAR 2024	
STRUCT	DWG	1	



# PROFILE ALONG BECKER STREET



# PROFILE ALONG FIFE AVENUE



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

CONT No  
WP No 408-88-00






HIGHWAY 85/FREDERICK ST  
MUNICIPAL STREETS  
UTILITY RELOCATIONS  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



## KEYPLAN

## LEGEND

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

NO	ELEVATION	NORTHING	EASTING
BH-01	325.6	4 813 611.6	226 251.9
BH-02	326.1	4 813 562.1	226 271.9
BH-03	326.3	4 813 540.4	226 282.2
BH-04	326.6	4 813 502.0	226 330.7
BH-05	326.9	4 813 518.1	226 368.2
BH-06	327.0	4 813 536.4	226 412.9
BH-15	327.6	4 813 474.4	226 301.9

-NOTES-

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Coordinate system is MTM NAD 83 Zone 10.

**GEOCRES No. 40P08-301**

[illegible]

## **APPENDIX B**

### Record of Borehole Sheets

## SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

### 1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

### 3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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



### 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

### 5. LEGEND FOR RECORDS OF BOREHOLES

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

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

 Water Level  
 Shear Strength Determination by Pocket Penetrometer

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

# UNIFIED SOILS CLASSIFICATION

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

## METRIC

[illegible]

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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

## METRIC

[illegible]

# RECORD OF BOREHOLE No BH-02

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 562.1 E 226 271.9 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2022.12.20 - 2022.12.20 LATITUDE 43.457853 LONGITUDE -80.470381 CHECKED BY GRL

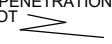
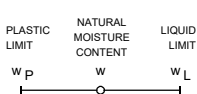
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
326.1	GROUND SURFACE													
0.0	ASPHALT(175 mm)						326							
0.2	Gravelly <b>SAND</b> Compact Brown Moist (FILL)		1	SS	20									
325.2														
0.9	Sandy <b>SILT</b> , trace clay, trace gravel Loose Brown Moist (FILL)		2	SS	5		325							
324.5														
1.6	<b>SAND</b> , trace silt Compact Dark Brown Moist (FILL)		3	SS	10		324							
323.7														
2.4	<b>SAND</b> , trace gravel, trace fines Compact Brown Moist		4	SS	18		323							
			5	SS	10									
							322							
	Wet													
			6	SS	11		321							7 90 3 (SI+CL)
320.3														
5.8	Clayey <b>SILT</b> , sandy, trace gravel Very Stiff Grey Wet (TILL)		7	SS	25		320							4 26 54 16
318.8							319							
7.3	Silty <b>SAND</b> Dense Light Brown Wet		8	SS	33		318							0 83 15 2
							317							
316.5			9	SS	34									
9.6														
316.3	Clayey <b>SILT</b> , sandy, trace gravel Hard													
9.8														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

## METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT</div> <div>SHEAR STRENGTH kPa</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> <div>WATER CONTENT (%)</div> <div>UNIT WEIGHT γ</div> <div>REMARKS &amp; GRAIN SIZE DISTRIBUTION (%)</div>					
	Continued From Previous Page				
	<div>Grey Moist (TILL)</div> <div>END OF BOREHOLE AT 9.8 m. INSTALLATION OF PIEZOMETER CONSISTS OF 50 mm DIAMETER SCHEDULE 40 PVC PIPE WITH A 1.52 m SLOTTED SCREEN.</div> <div>WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.03.01 4.6 321.5</div>				

# RECORD OF BOREHOLE No BH-03

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 540.4 E 226 282.2 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2022.12.16 - 2022.12.16 LATITUDE 43.457659 LONGITUDE -80.470251 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
326.3	GROUND SURFACE													
0.0	ASPHALT(175 mm)													
0.2	SAND and GRAVEL Brown Moist (FILL)		1	SS	5									3 46 42 9
325.8														
0.4	SILT and Sand, trace gravel Loose Brown Moist (FILL)		2	SS	6									
324.3	SAND, trace gravel, trace non-plastic fines Compact Brown Moist		3	SS	2									2 91 7 (SI+CL)
1.9			4	SS	19									
			5	SS	22									
			6	SS	25									
			7	SS	19									
			8	SS	22									
318.0	Clayey SILT, some sand, trace gravel Very Stiff Grey Wet (TILL)													1 96 3 (SI+CL)
8.3														
317.4	SAND, trace gravel, trace silt Very Dense Brown Wet		9	SS	48									
8.8														
316.6	Clayey SILT, some sand, trace													
318.4														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-03

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 540.4 E 226 282.2 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2022.12.16 - 2022.12.16 LATITUDE 43.457659 LONGITUDE -80.470251 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
9.9	Continued From Previous Page  gravel Dense Grey Moist (TILL)  END OF BOREHOLE AT 9.9 m. BOREHOLE CAVED TO 6.7 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.15 m, THEN ASPHALT TO SURFACE.																

# RECORD OF BOREHOLE No BH-04

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 502.0 E 226 330.7 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.11 - 2023.01.11 LATITUDE 43.457318 LONGITUDE -80.469646 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20    40    60    80    100	W <sub>P</sub> W      W <sub>L</sub>	WATER CONTENT (%)						
326.6	GROUND SURFACE															
0.0 0.1	ASPHALT (75 mm)															
325.9	Gravelly SAND, silty Compact Brown Moist (FILL)		1	SS	17		326									
0.7	Sandy SILT, trace to some clay, trace gravel Compact Brown Moist (FILL)		2	SS	17		325									
324.4			3	SS	16											
2.2	Clayey SILT, sandy, some gravel Stiff Brown Moist (TILL)		4	SS	14		324									
323.8																
2.8	Sandy SILT Compact Brown Wet		5	SS	21		323								0    24    67    9	
322.5																
4.1	Clayey SILT, sandy, some gravel Hard Brown Wet (TILL)						322									
321.9			6	SS	37											
4.8	SAND, trace silt Dense Brown Wet						321									
320.0			7	SS	22		320									
6.7	Clayey SILT, sandy Very Stiff Grey Wet (TILL)															
319.4																
7.2	SAND, trace silt Dense Brown Wet						319									
318.6			8	SS	33											
8.0	Clayey SILT, with sand, trace gravel Hard Grey Wet (TILL)						318									
316.8			9	SS	53		317								5    44    35    16	
9.8	END OF BOREHOLE AT 9.8 m.															

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

## METRIC

SOIL PROFILE					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES	GROUND WATER CONDITIONS	ELEVATION SCALE
			NUMBER	TYPE	"N" VALUES
Continued From Previous Page					
	BOREHOLE CAVED TO 5.2 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.15 m, THEN ASPHALT TO SURFACE.				

# RECORD OF BOREHOLE No BH-05

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 518.1 E 226 368.2 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.16 - 2023.01.16 LATITUDE 43.457467 LONGITUDE -80.469184 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
326.9	GROUND SURFACE												
0.0	ASPHALT(125 mm)												
326.6	SAND and GRAVEL												
0.3	Brown Moist (FILL)		1	SS	26								
	Gravelly SAND, some silt Loose to Compact Brown Moist (FILL)		2	SS	10								21 69 10 0
			3	SS	3								
324.3													
2.6	SAND, some non-plastic fines Loose to Compact Light Brown Moist		4	SS	2								
			5	SS	12								
			6	SS	14								0 88 9 3
		</											

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-05

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 518.1 E 226 368.2 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.16 - 2023.01.16 LATITUDE 43.457467 LONGITUDE -80.469184 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	Brown Wet																
	END OF BOREHOLE AT 9.8 m. INSTALLATION OF PIEZOMETER CONSISTS OF 50 mm DIAMETER SCHEDULE 40 PVC PIPE WITH A 3.05 m SLOTTED SCREEN.																
	WATER LEVEL READINGS																
	DATE DEPTH(m) ELEV.(m)																
	2023.02.01 5.5 321.4																
	2023.03.01 5.5 321.4																

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

**METRIC**

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

[illegible]

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

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# RECORD OF BOREHOLE No BH-07

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 573.7 E 226 397.4 ORIGINATED BY HC  
 DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger/DCPT COMPILED BY JW  
 DATUM Geodetic DATE 2022.12.22 - 2022.12.22 LATITUDE 43.457970 LONGITUDE -80.468832 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)		
	Continued From Previous Page							20 40 60 80 100						
315.3							316	20 40 60 80 100						
11.5	END OF DCPT AT 11.5 m UPON REFUSAL. BOREHOLE CAVED TO 5.8 m UPON COMPLETION OF DRILLING AND REMOVAL OF AUGERS. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2 m, THEN ASPHALT TO SURFACE.													

# RECORD OF BOREHOLE No BH-08

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 631.6 E 226 372.8 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.09 - 2023.01.09 LATITUDE 43.458489 LONGITUDE -80.469144 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
325.9	GROUND SURFACE							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>						
0.0	ASPHALT (75 mm)							<div><div>204060</div><div>WATER CONTENT (%)</div><div>W P W W L</div></div>						
0.1														
0.2	SAND and GRAVEL Compact Brown Moist (FILL)		1	SS	15		325							
	Silty SAND, trace gravel Compact to Loose Brown Moist (FILL)		2	SS	3								3 68 24 5	
			3	SS	11		324							
323.7														
2.2	SAND, trace silt Compact to Dense Brown Moist		4	SS	28		323						0 91 8 1	
			5	SS	20									
							322							
			6	SS	29		321							
							320							
			7	SS	37		319							
							318							
			8	SS	37		317							
316.5														
9.4	Silty CLAY, Sandy, trace gravel		9	SS	31								0 90 10 (SI+CL)	
316.1	Hard Grey													
9.8	Moist													

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-08

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 631.6 E 226 372.8 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.09 - 2023.01.09 LATITUDE 43.458489 LONGITUDE -80.469144 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20	40	60	80	100					
								○ UNCONFINED	+	FIELD VANE							
								● QUICK TRIAXIAL	×	LAB VANE							
								20	40	60	80	100					
	Continued From Previous Page (TILL)																
	END OF BOREHOLE AT 9.8 m. PIEZOMETER INSTALLATION CONSISTS OF 50 mm DIAMETER SCHEDULE 40 PVC PIPE WITH 3.05 m SLOTTED SCREEN.																
	WATER LEVEL READINGS																
	DATE DEPTH(m) ELEV.(m)																
	2023.02.01 5.3 320.6																
	2023.03.01 5.3 320.6																

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

## METRIC

[illegible]

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

## METRIC

[illegible]

# RECORD OF BOREHOLE No BH-11

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 788.3 E 226 316.2 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.12 - 2023.01.12 LATITUDE 43.459893 LONGITUDE -80.469866 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE		
323.4	GROUND SURFACE												
0.0	ASPHALT(40 mm)												
322.6	Silty <b>SAND</b> , trace gravel, containing pockets of silty clay Loose Brown Moist (FILL)		1	SS	8								
0.7	Brown Moist (FILL)		2	SS	9								5 25 57 13
321.6	Clayey <b>SILT</b> , sandy, trace gravel Stiff Brown Moist (FILL)		3	SS	15								
1.8	Silty <b>SAND</b> , trace gravel Compact Light Brown Moist (FILL)		4	SS	19								
321.2	Light Brown Moist (FILL)		5	SS	25								
2.2	Clayey <b>SILT</b> , sandy, trace gravel Very Stiff Light Brown Moist (FILL)												
320.9	<b>SAND</b> , trace gravel, trace non-plastic fines Compact Brown Moist												
2.5	Wet		6	SS	28								
316.8	Clayey <b>SILT</b> , sandy, trace gravel Stiff Grey Moist (TILL)		7	SS	11								3 25 72 (SI+CL)
6.6	<b>SAND</b> , trace silt Compact Brown Wet		8	SS	16								
316.2	Silty <b>CLAY</b> , sandy, trace gravel Very Stiff Grey Moist (TILL)												
7.2													
315.2													
8.1													
313.9	<b>SAND</b> , trace silt Compact Brown Wet		9	SS	22								
9.4													
313.6													
9.8													

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-11

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 788.3 E 226 316.2 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.12 - 2023.01.12 LATITUDE 43.459893 LONGITUDE -80.469866 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	END OF BOREHOLE AT 9.8 m. PIEZOMETER INSTALLATION CONSISTS OF 50 mm DIAMETER SCHEDULE 40 PVC PIPE WITH 3.05 m SLOTTED SCREEN.																
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.03.08 3.9 319.5																

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

RECORD OF BOREHOLE No BH-12

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 816.9 E 226 302.8 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.01.12 - 2023.01.12 LATITUDE 43.460149 LONGITUDE -80.470036 CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	Moist (TILL)																
	END OF BOREHOLE AT 9.8 m. BOREHOLE CAVED TO 4.6 m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.2 m, THEN ASPHALT TO SURFACE.																

# RECORD OF BOREHOLE No BH-13

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 855.9 E 226 284.1 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hydrovac/ Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.11.06 - 2023.11.06 LATITUDE 43.460498 LONGITUDE -80.470273 CHECKED BY PV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
323.4	GROUND SURFACE							20	40	60	80	100						
0.0	ASPHALT:(150 mm)		1	GS				20	40	60	80	100						
0.2	GRANULAR BASE/ SUBBASE(200 mm)		2	GS				20	40	60	80	100						
0.4	SAND, trace to some silt Brown to Light Brown Wet (FILL)							20	40	60	80	100						
			3	GS				20	40	60	80	100						
								20	40	60	80	100						
								20	40	60	80	100						
320.1	Borehole was daylighted up to 3.3 m.							20	40	60	80	100						
3.3	SAND, trace to some silt Compact to Dense Brown to Light Brown Wet							20	40	60	80	100						
			1	SS	32			20	40	60	80	100						
								20	40	60	80	100						
			2	SS	19			20	40	60	80	100						
								20	40	60	80	100						
	Very Loose		3	SS	1			20	40	60	80	100						
								20	40	60	80	100						
	Compact		4	SS	11			20	40	60	80	100						
								20	40	60	80	100						
	Occasional pockets of clayey silt Greyish Brown		5	SS	25			20	40	60	80	100						
313.6								20	40	60	80	100						
9.8	END OF BOREHOLE AT 9.8 m.							20	40	60	80	100						

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-13

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 855.9 E 226 284.1 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hydrovac/ Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.11.06 - 2023.11.06 LATITUDE 43.460498 LONGITUDE -80.470273 CHECKED BY PV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
	Continued From Previous Page  INSTALLATION OF PIEZOMETER CONSISTS OF 50 mm DIAMETER SCHEDULE 40 PVC PIPE WITH A 3.0 m SLOTTED SCREEN.  WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.11.09 4.4 318.9 2023.11.27 4.4 319.0																

# RECORD OF BOREHOLE No BH-14

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 902.7 E 226 250.3 ORIGINATED BY HC  
 DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
 DATUM Geodetic DATE 2023.11.04 - 2023.11.04 LATITUDE 43.460916 LONGITUDE -80.470697 CHECKED BY PV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						PLASTIC LIMIT w <sub>p</sub> NATURAL MOISTURE CONTENT w      LIQUID LIMIT w <sub>L</sub>					
318.9	GROUND SURFACE							20	40	60	80	100							
0.0	TOPSOIL: (300 mm)																		
318.6	SAND, trace silt, trace organics Loose to Compact Brown Wet		1	SS	10														
0.3																			
			2	SS	18														
			3	SS	8														
			4	SS	19														
315.8																			
3.0	Silty <b>CLAY</b> , trace sand Stiff to Very Stiff Grey Moist (TILL)  300 mm thick layer of sand and trace silt was encountered		5	SS	10														
			6	SS	10														
			7	SS	18														
			8	SS	21														
			9	SS	23														
			10	SS	36														
	Hard																		

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH-14

2 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 902.7 E 226 250.3 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hollow-Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.11.04 - 2023.11.04 LATITUDE 43.460916 LONGITUDE -80.470697 CHECKED BY PV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT								UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
								20 40 60 80 100												
Continued From Previous Page							<div><div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></div><div></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# RECORD OF BOREHOLE No BH-15

1 OF 2

METRIC

W.P. 408-88-00 LOCATION N 4 813 474.4 E 226 301.9 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hydrovac/ Hollow Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.11.06 - 2023.11.07 LATITUDE 43.457066 LONGITUDE -80.469998 CHECKED BY PV

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									
327.6	GROUND SURFACE							20	40	60	80	100					
0.0	TOPSOIL: (300 mm)		1	GS													
327.3																	
0.3	Silty <b>SAND</b> Brown Wet (FILL)																
			2	GS													
324.3	Borehole daylighted up to 3.3 m.																
3.3	Sandy <b>SILT</b> Compact Brown Wet		1	SS	20												1 34 62 3
			2	SS	12												
322.4																	
5.2	<b>SAND</b> , trace silt Compact Brown Wet																
			3	SS	19												
			4	SS	23												1 89 10 0
			5	SS	10												
317.8																	
9.8	END OF BOREHOLE AT 9.7 m.																

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No BH-15

2 OF 2

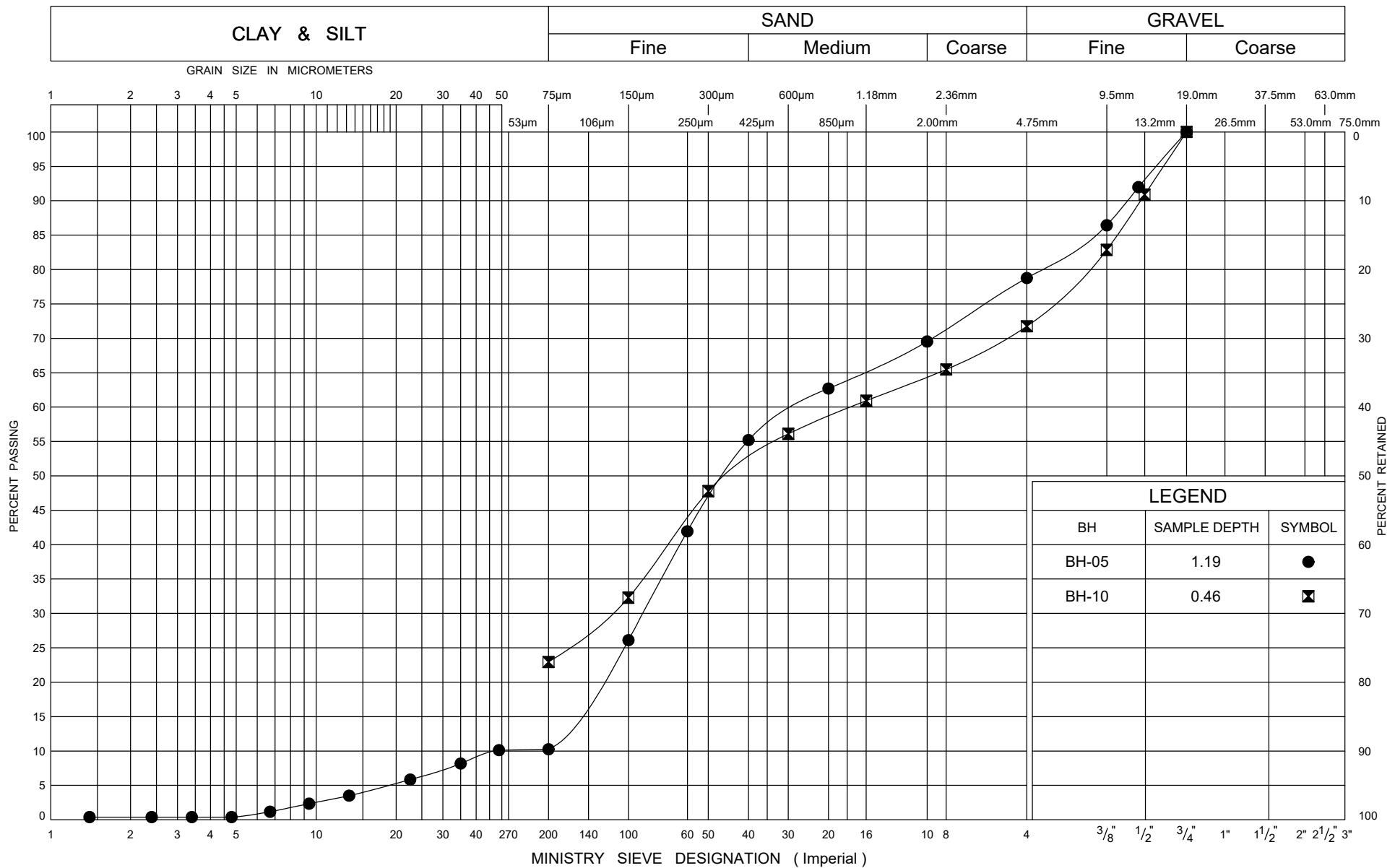
METRIC

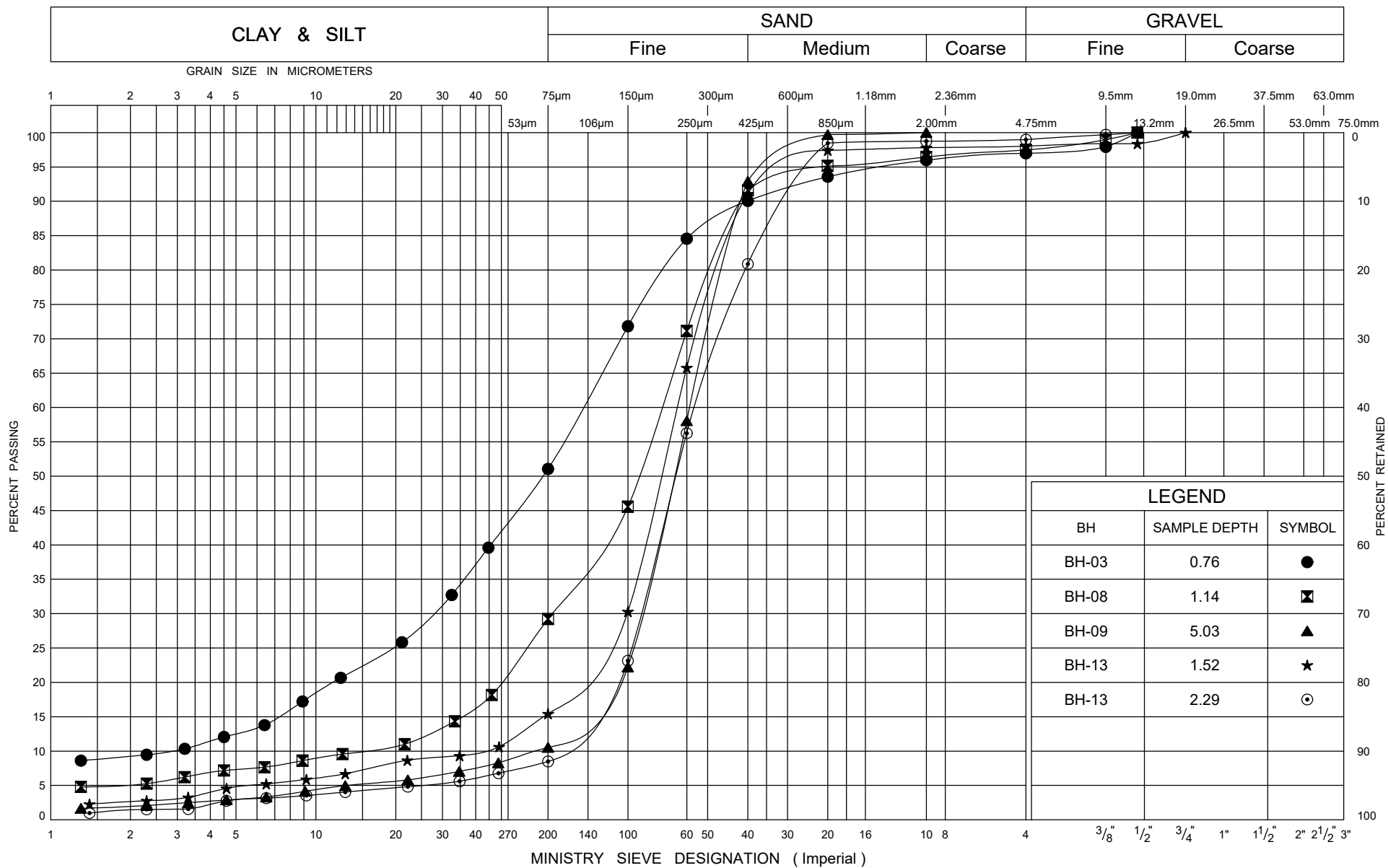
W.P. 408-88-00 LOCATION N 4 813 474.4 E 226 301.9 ORIGINATED BY HC  
DIST HWY 7/85 BOREHOLE TYPE Hydrovac/ Hollow Stem Auger COMPILED BY JW  
DATUM Geodetic DATE 2023.11.06 - 2023.11.07 LATITUDE 43.457066 LONGITUDE -80.469998 CHECKED BY PV

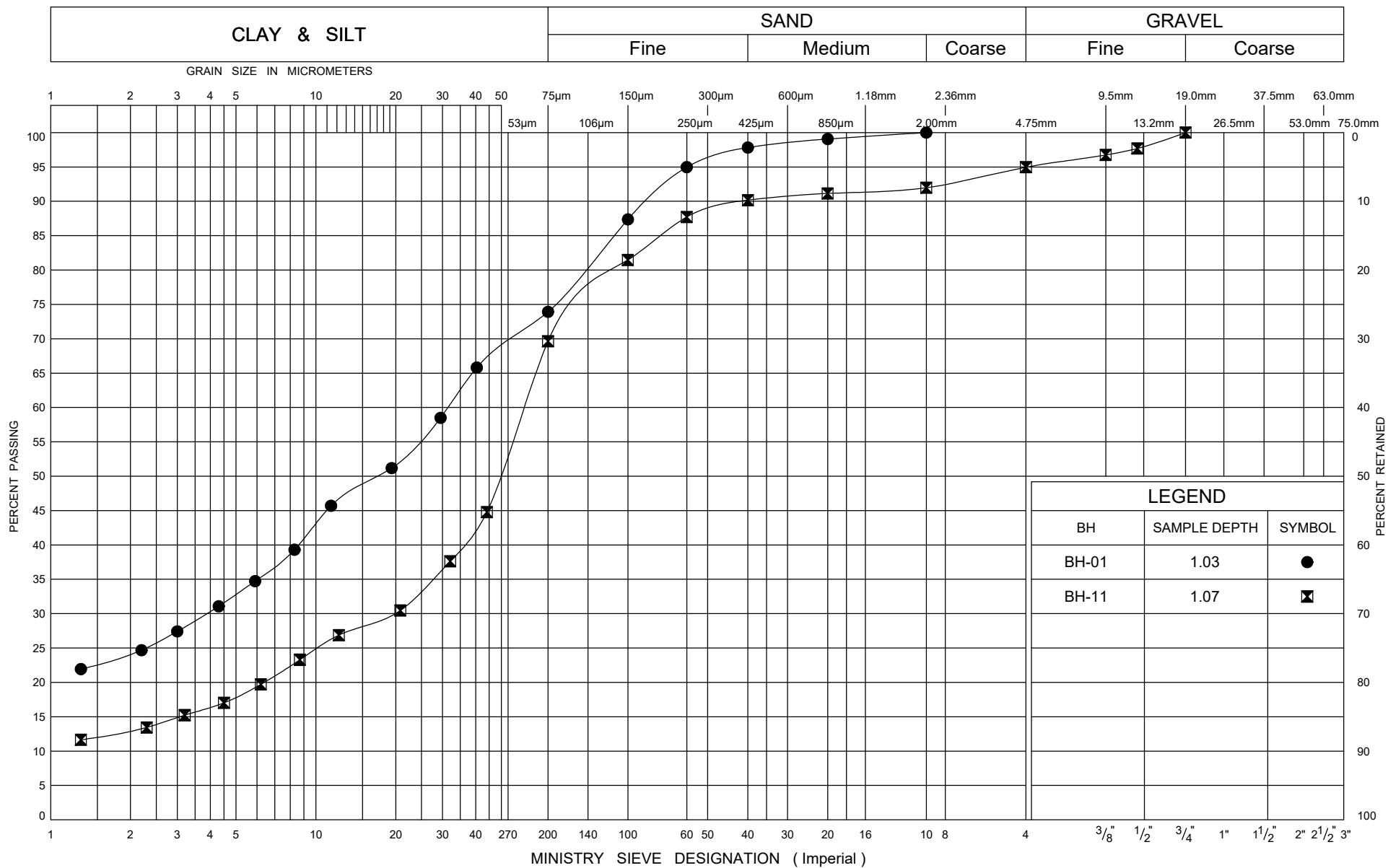
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	BOREHOLE CAVED TO 7.6 m UPON COMPLETION. INSTALLATION OF PIEZOMETER CONSISTS OS 50 mm DIAMETER SCHEDULE 40 PVC PIPE WITH A 3.0 m SLOTTED SCREEN.																
	WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.11.09 5.9 321.7 2023.11.27 5.9 321.7																

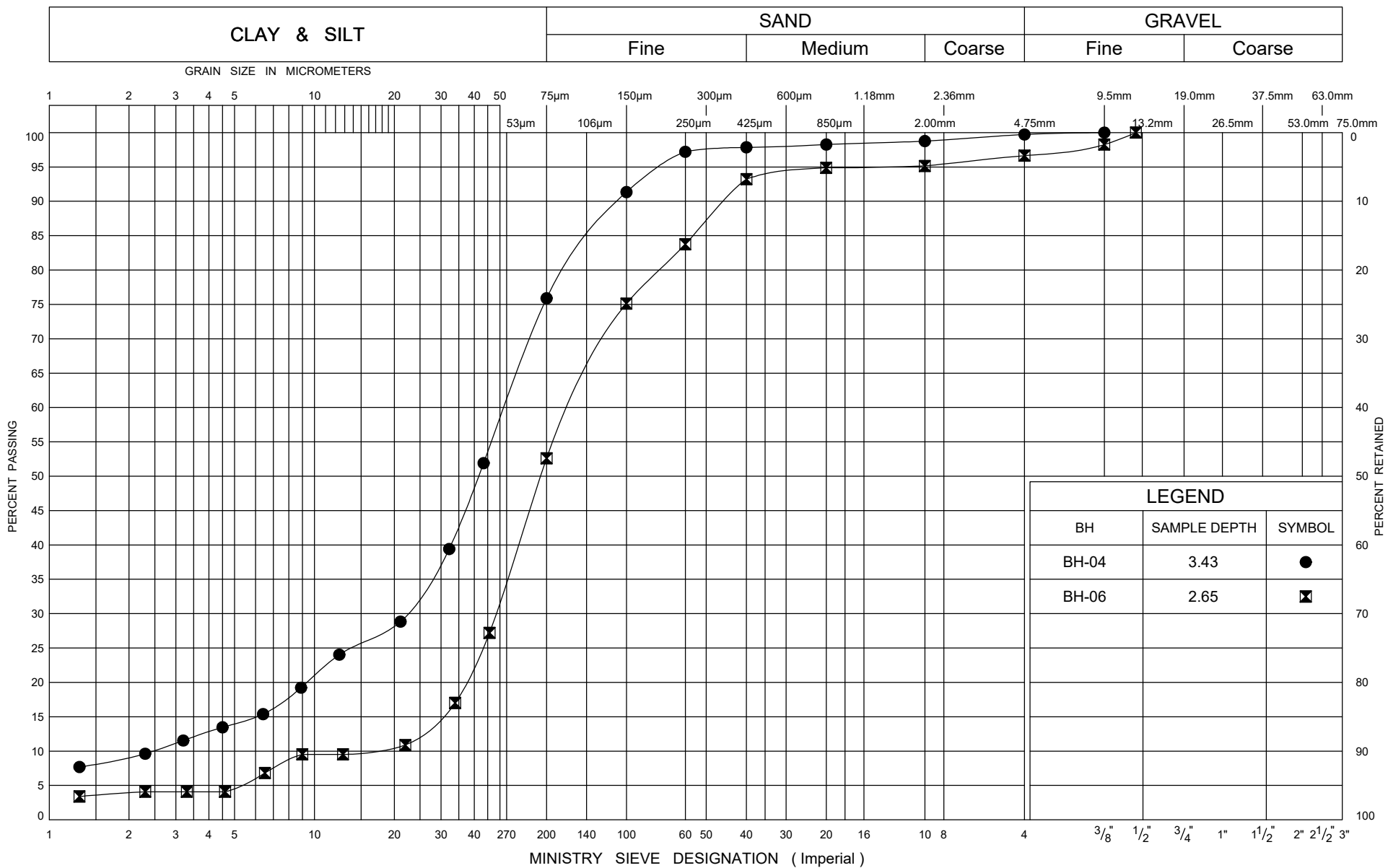
## **APPENDIX C**

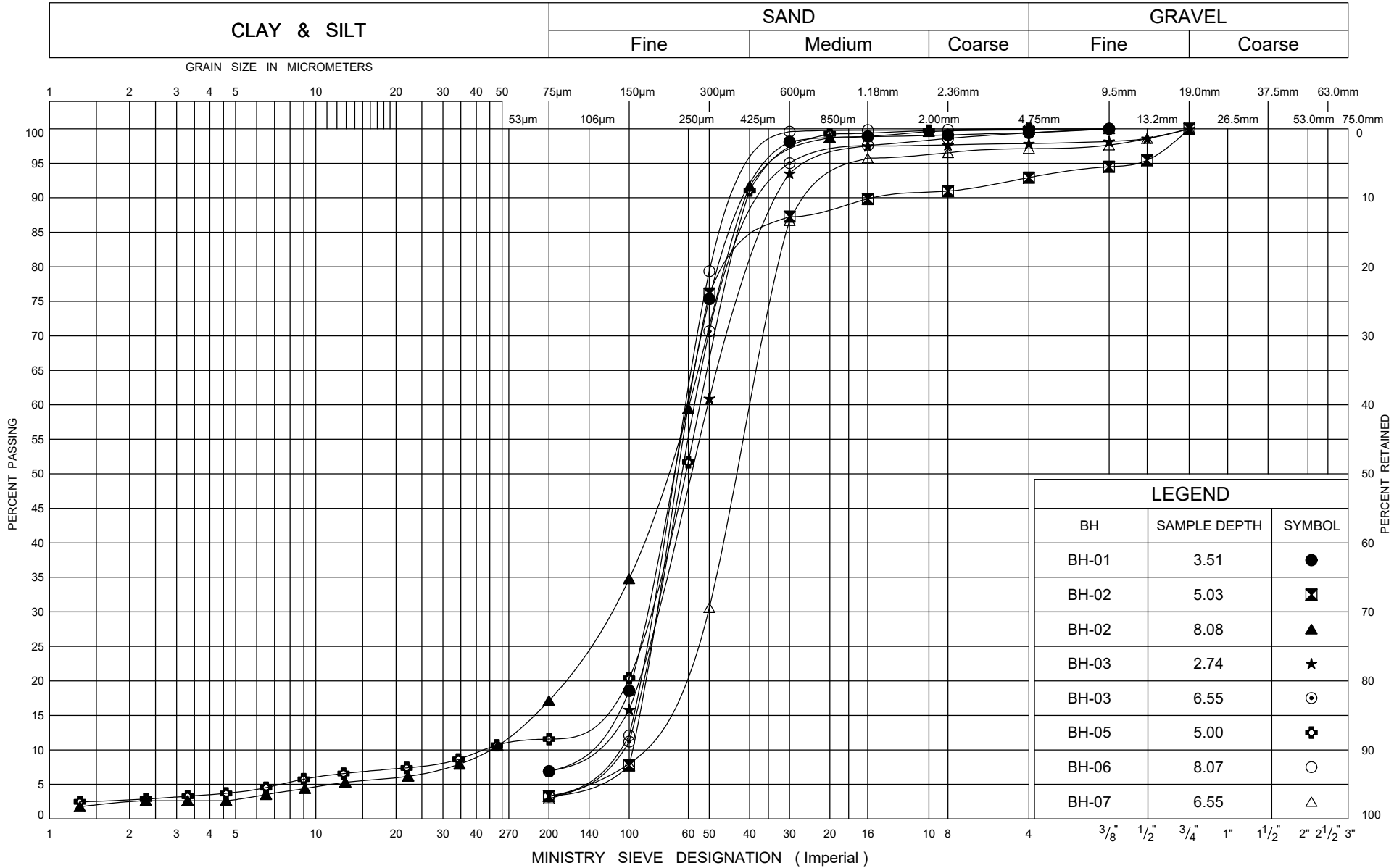
Geotechnical Laboratory Test Results  
&  
Single Well Response Test (SWRT) Analysis Plots

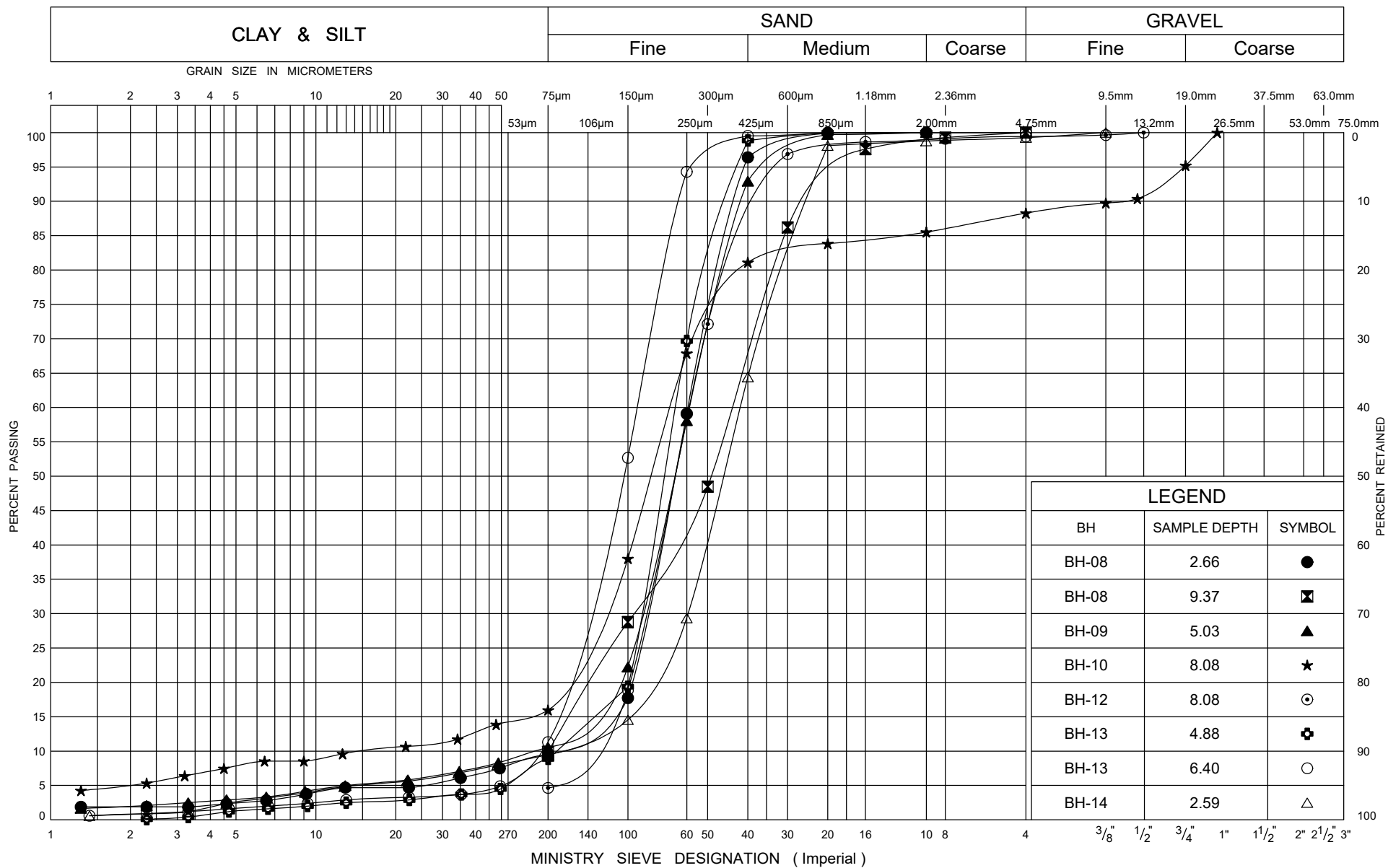








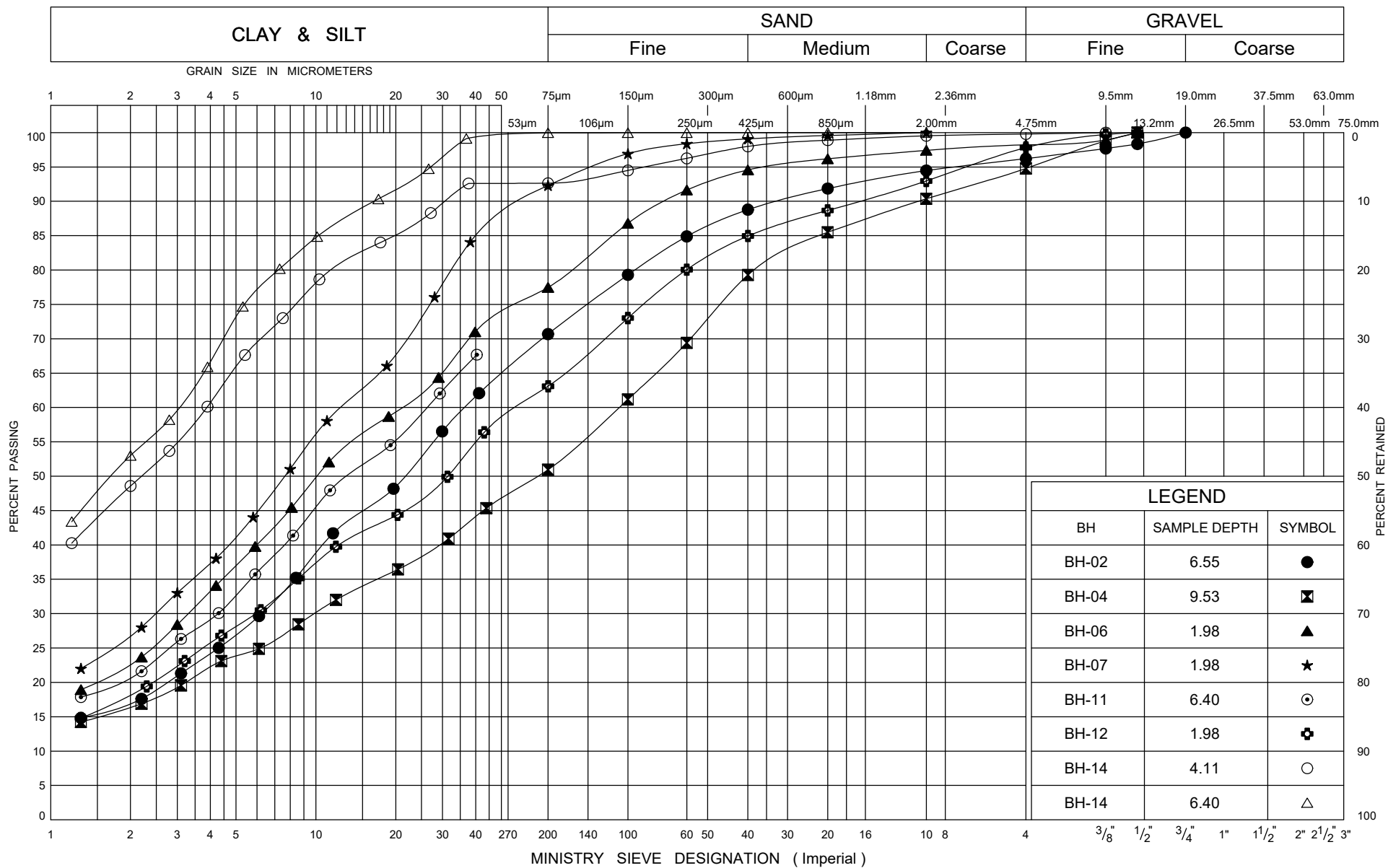


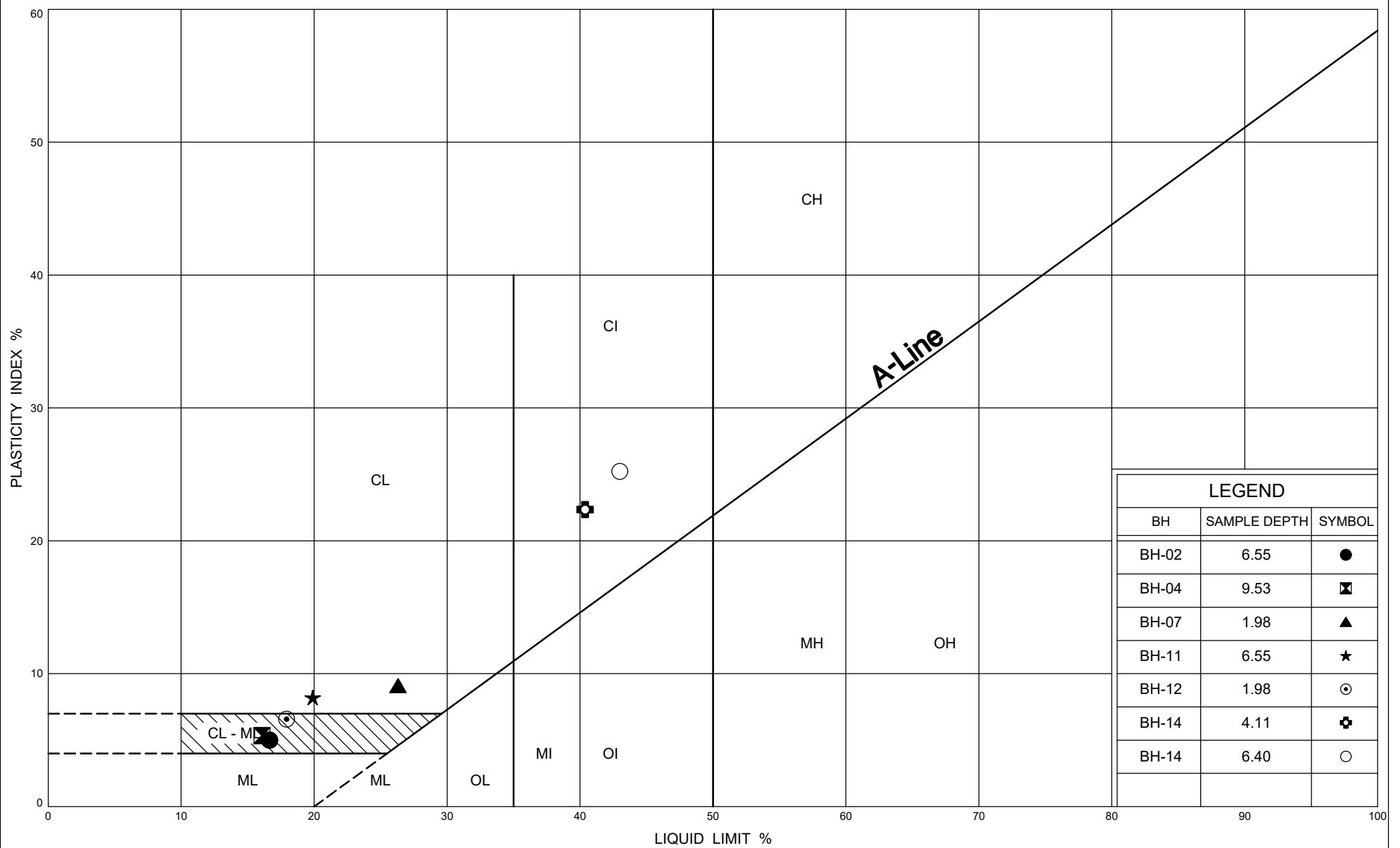




## FIG No 7

W.P. 408-88-00





Ministry of  
Transportation

## PLASTICITY CHART

Clayey SILT TILL

FIG No 9

W.P. 408-88-00



# Slug Test Analysis Report

Project: Frederick Street Utility Relocation

Number: 35707

Client: Ministry of Transportation Ontario

Location: Kitchener

Slug Test: BH2

Test Well: BH2

Test Conducted by: JR

Test Date: 2023-03-01

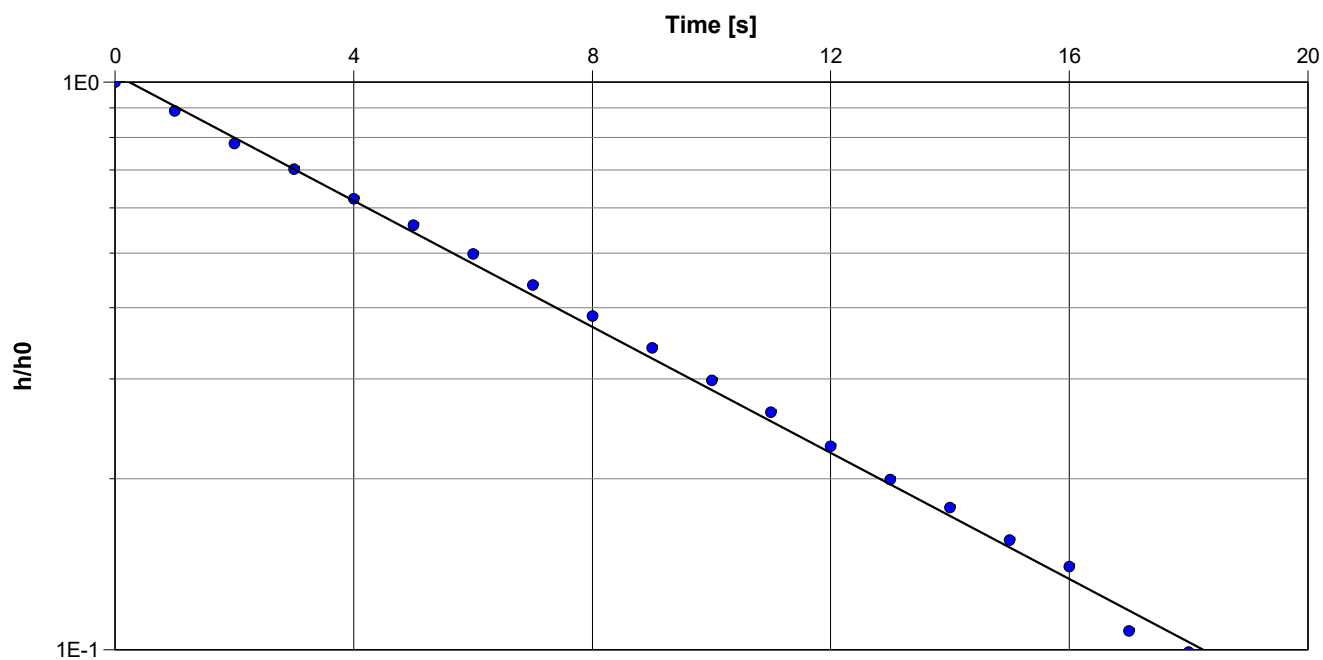
Analysis Performed by: JR

BH2 - SWRT Analysis

Analysis Date: 2023-03-14

Aquifer Thickness:

Reviewed by: AH



Calculation using Hvorslev

Observation Well

Hydraulic Conductivity  
[m/s]

BH2

$8.8 \times 10^{-5}$



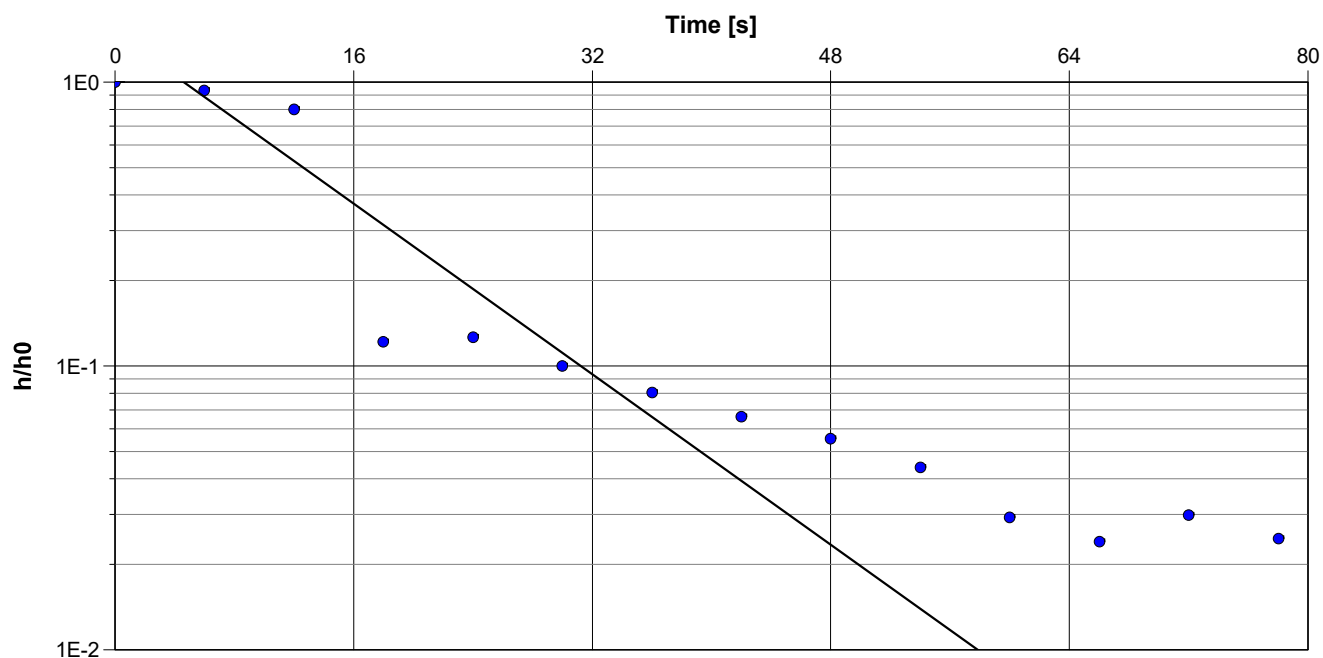
# Slug Test Analysis Report

Project: Frederick Street Utility Relocation

Number: 35707

Client: Ministry of Transportation Ontario

Location: Kitchener	Slug Test: BH5	Test Well: BH5
Test Conducted by: HC		Test Date: 2023-02-01
Analysis Performed by: JR	BH5 - SWRT Analysis	Analysis Date: 2023-03-14
Aquifer Thickness: 9.25 m		
Reviewed by: AH		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [m/s]	
BH5	$4.5 \times 10^{-5}$	



# Slug Test Analysis Report

Project: Frederick Street Utility Relocation

Number: 35707

Client: Ministry of Transportation Ontario

Location: Kitchener

Slug Test: BH8

Test Well: BH8

Test Conducted by: JR

Test Date: 2023-03-01

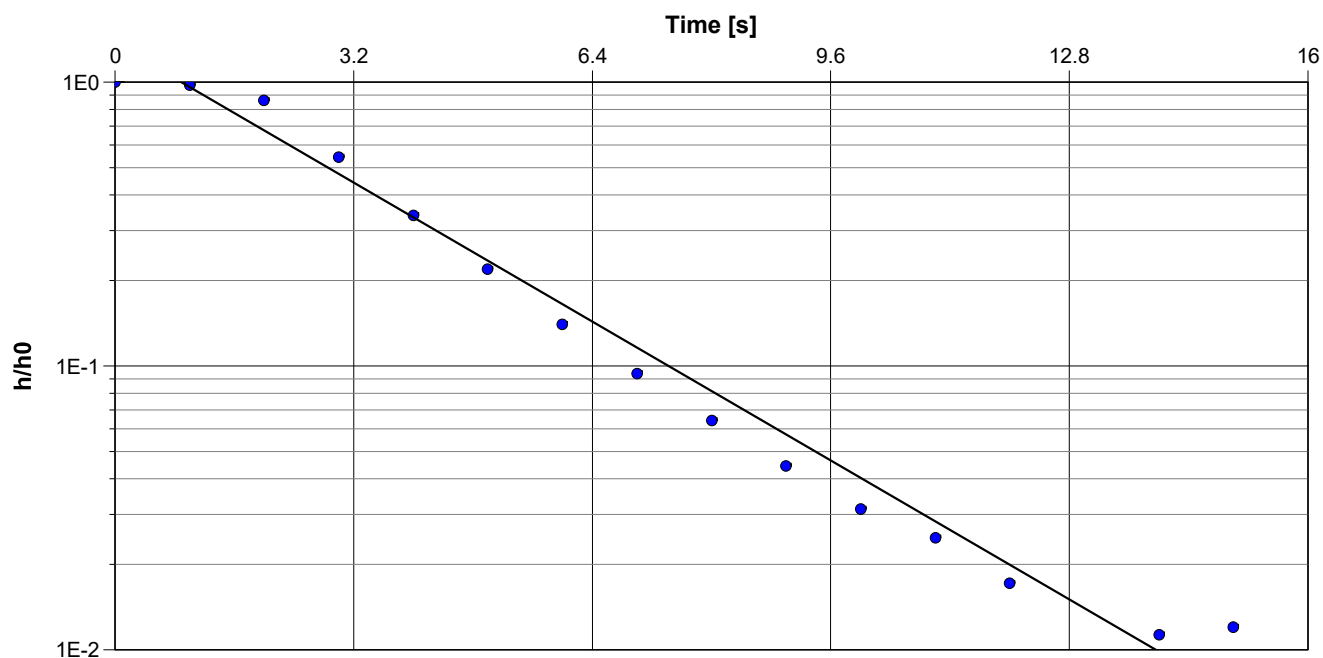
Analysis Performed by: JR

BH8 - SWRT Analysis

Analysis Date: 2023-03-14

Aquifer Thickness: 9.25 m

Reviewed by: AH



Calculation using Hvorslev

Observation Well

Hydraulic Conductivity  
[m/s]

BH8

$1.8 \times 10^{-4}$



# Slug Test Analysis Report

Project: Frederick Street Utility Relocation

Number: 35707

Client: Ministry of Transportation Ontario

Location: Kitchener

Slug Test: BH11

Test Well: BH11

Test Conducted by: HC

Test Date: 2023-03-08

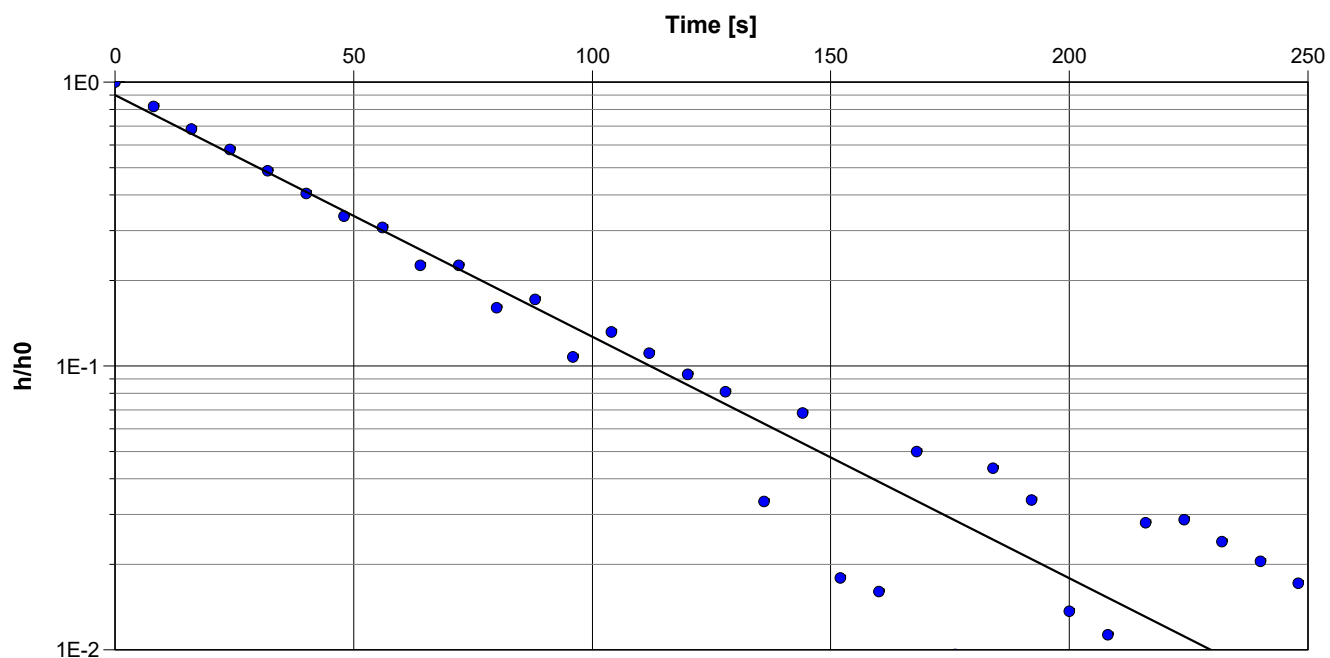
Analysis Performed by: JR

BH11 - SWRT Analysis

Analysis Date: 2023-03-14

Aquifer Thickness: 7.86 m

Reviewed by: AH



Calculation using Bouwer & Rice

Observation Well

Hydraulic Conductivity  
[m/s]

BH11

$7.8 \times 10^{-6}$



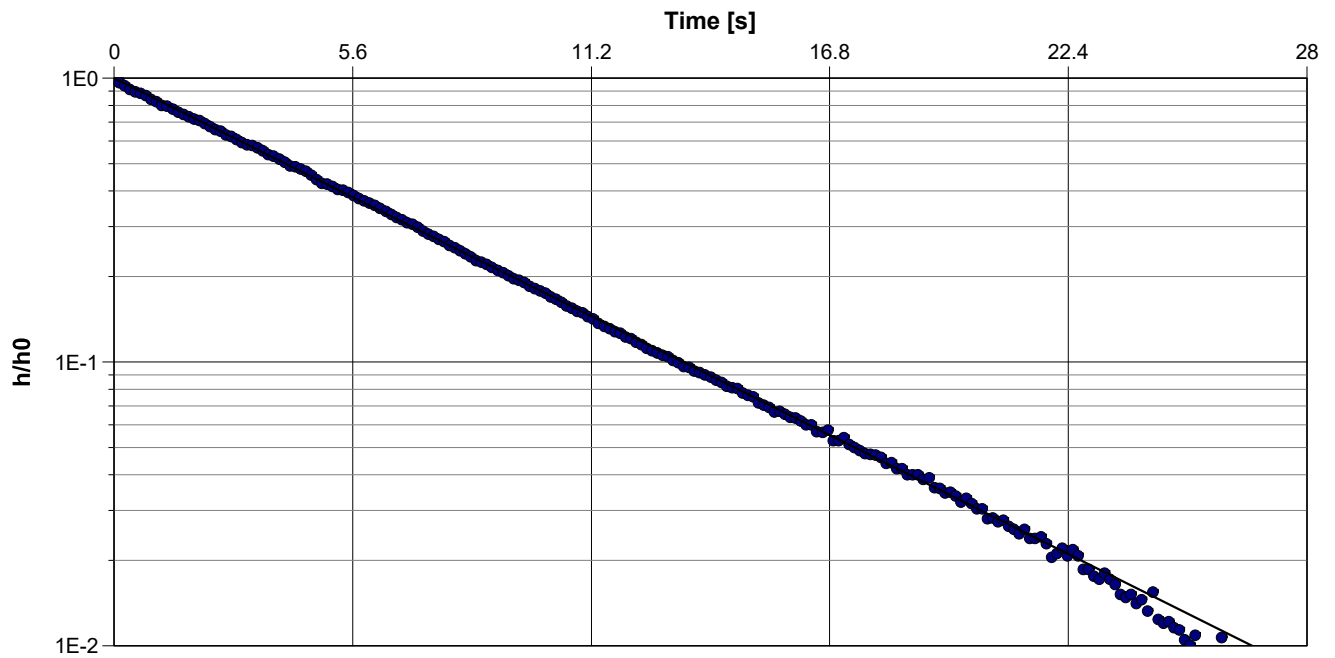
### Slug Test Analysis Report

Project: Frederick Street Structure Replacement

Number: 43743

Client:

Location:	Slug Test: BH13	Test Well: BH13
Test Conducted by: HC		Test Date: 2023-11-23
Analysis Performed by: JR	BH13 - SWRT Analysis	Analysis Date: 2023-11-27
Aquifer Thickness: 7.22 m		
	Reviewed by: AH	



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [m/s]	
BH13	$7.3 \times 10^{-5}$	



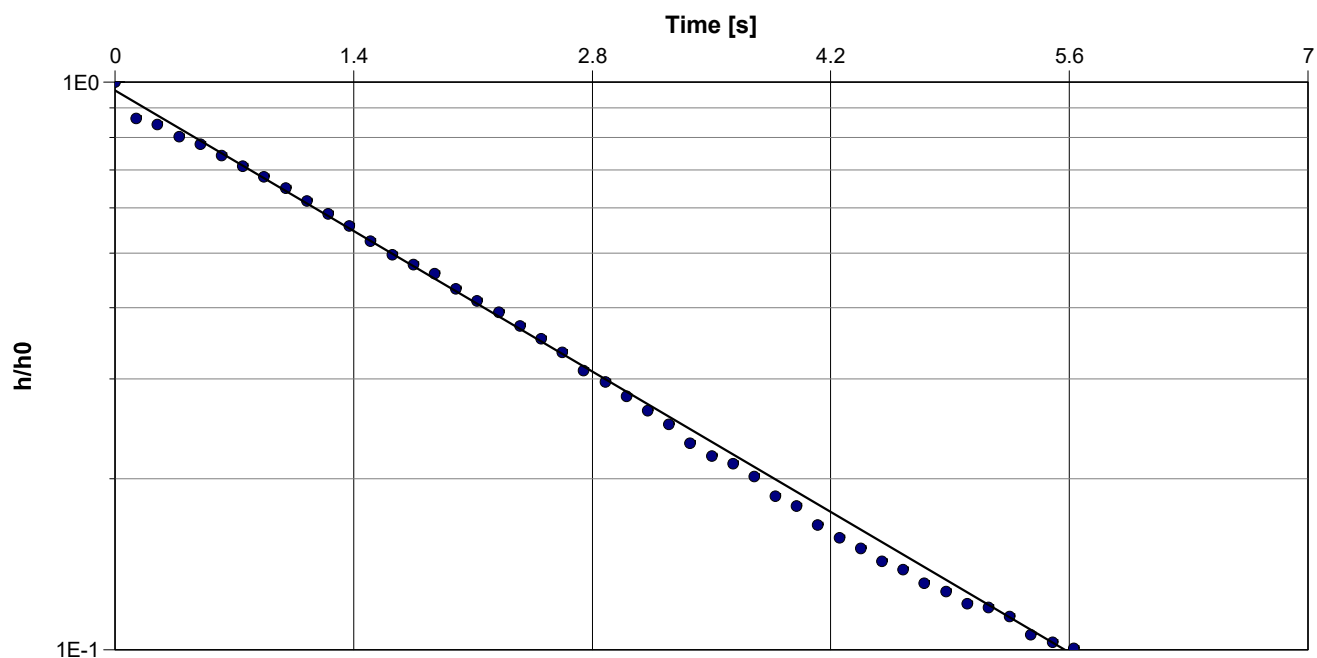
# Slug Test Analysis Report

Project: Frederick Street Structure Replacement

Number: 43743

Client:

Location:	Slug Test: BH15	Test Well: BH15
Test Conducted by: HC		Test Date: 2023-11-23
Analysis Performed by: JR	BH15 - SWRT Analysis	Analysis Date: 2023-11-27
Aquifer Thickness: 9.15 m		
	Reviewed by: AH	



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [m/s]	
BH15	$1.7 \times 10^{-4}$	

## **APPENDIX D**

### Analytical Test Results



## FINAL REPORT

CA40275-JAN23 R1

35707, Kitchener

Prepared for

**Thurber Engineering Ltd.**

## First Page

### CLIENT DETAILS

Client **Thurber Engineering Ltd.**

Address **103, 2010 Winston Park Drive  
Oakville, ON  
L6H 5R7, Canada**

Contact **Geoff Lay**

Telephone **905-829-8666**

Facsimile

Email **glay@thurber.ca**

Project **35707, Kitchener**

Order Number

Samples **Soil (12)**

### LABORATORY DETAILS

Project Specialist **Brad Moore Hon. B.Sc**

Laboratory **SGS Canada Inc.**

Address **185 Concession St., Lakefield ON, K0L 2H0**

Telephone **705-652-2143**

Facsimile **705-652-6365**

Email **brad.moore@sgs.com**

SGS Reference **CA40275-JAN23**

Received **01/27/2023**

Approved **02/06/2023**

Report Number **CA40275-JAN23 R1**

Date Reported **02/06/2023**

### COMMENTS

Temperature of Sample upon Receipt: 8 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: n/a

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

### SIGNATORIES

Brad Moore Hon. B.Sc

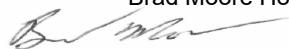




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# FINAL REPORT

CA40275-JAN23 R1

**Client:** Thurber Engineering Ltd.

**Project:** 35707, Kitchener

**Project Manager:** Geoff Lay

**Samplers:** Greg Stanhope

MATRIX: SOIL

Sample Number	5	6	7	8	9	10	11	12
Sample Name	BH-01 SS-1 (0'-2')	BH-02 SS-5 (10'-12')	BH-03 SS-5 (10'-12')	BH-04 SS-4 (7'6"-9'6")	BH-05 SS-4 (7'6"-9'6")	BH-06 SS-6 (15'-17')	BH-07 SS-6 (15'-17')	BH-08 SS-5 (10'-12')
Sample Matrix	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Sample Date	16/12/2022	20/12/2022	16/12/2022	11/01/2023	16/01/2023	21/12/2022	22/12/2022	09/01/2023

Parameter	Units	RL	Result	Result	Result	Result	Result	Result	Result	Result
-----------	-------	----	--------	--------	--------	--------	--------	--------	--------	--------

## Corrosivity Index

Corrosivity Index	none	1		14	3	3	4	4	3	3	3
Soil Redox Potential	mV	no		276	303	242	317	231	243	371	252
Sulphide (Na <sub>2</sub> CO <sub>3</sub> )	%	0.04		< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
pH	pH Units	0.05		8.99	9.05	9.20	8.55	9.16	9.30	9.28	9.32
Resistivity (calculated)	ohms.cm	-9999		1090	4610	7040	4080	3330	5320	8330	8850

## General Chemistry

Conductivity	uS/cm	2		915	217	142	245	300	188	120	113
--------------	-------	---	--	-----	-----	-----	-----	-----	-----	-----	-----

## Metals and Inorganics

Moisture Content	%	0.1		13.2	2.6	2.3	11.8	7.6	1.9	1.7	2.6
Sulphate	µg/g	0.4		28	5.0	3.4	4.3	8.8	4.2	3.4	2.8

## Other (ORP)

Chloride	µg/g	0.4		350	58	31	83	56	40	22	14
----------	------	-----	--	-----	----	----	----	----	----	----	----



# FINAL REPORT

CA40275-JAN23 R1

**Client:** Thurber Engineering Ltd.

**Project:** 35707, Kitchener

**Project Manager:** Geoff Lay

**Samplers:** Greg Stanhope

MATRIX: SOIL

Sample Number	13	14	15	16
Sample Name	BH-09 SS-3 (5'-7')	BH-10 SS-5 (10'-12')	BH-11 SS-3 (5'-7')	BH-12 SS-6 (15'-17')
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	11/01/2023	16/01/2023	12/01/2023	12/01/2023

Parameter	Units	RL		Result	Result	Result	Result
<b>Corrosivity Index</b>							
Corrosivity Index	none	1		6	3	6	4
Soil Redox Potential	mV	no		306	329	280	309
Sulphide (Na <sub>2</sub> CO <sub>3</sub> )	%	0.04		< 0.04	< 0.04	< 0.04	< 0.04
pH	pH Units	0.05		8.86	9.42	9.13	8.91
Resistivity (calculated)	ohms.cm	-9999		2280	3980	2240	5710
<b>General Chemistry</b>							
Conductivity	uS/cm	2		439	251	446	175
<b>Metals and Inorganics</b>							
Moisture Content	%	0.1		6.6	2.6	10.2	15.1
Sulphate	µg/g	0.4		12	5.4	10	5.6
<b>Other (ORP)</b>							
Chloride	µg/g	0.4		160	82	97	43



FINAL REPORT

CA40275-JAN23 R1

QC SUMMARY

Anions by IC  
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-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	DIO0647-JAN23	µg/g	0.4	<0.4	4	35	94	80	120	92	75	125
Sulphate	DIO0647-JAN23	µg/g	0.4	<0.4	8	35	91	80	120	89	75	125

Carbon/Sulphur  
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0087-JAN23	%	0.04	< 0.04	ND	20	115	80	120			



FINAL REPORT

CA40275-JAN23 R1

QC SUMMARY

Conductivity

Method: SM 2510 | Internal ref.: ME-CA-1ENVIEWL-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	EWL0472-JAN23	uS/cm	2	< 2	0	20	99	90	110	NA		
Conductivity	EWL0486-JAN23	uS/cm	2	< 2	1	20	99	90	110	NA		

pH

Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-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	EWL0472-JAN23	pH Units	0.05	NA	0		100			NA		
pH	EWL0486-JAN23	pH Units	0.05	NA	0		100			NA		



# FINAL REPORT

CA40275-JAN23 R1

## QC SUMMARY

---

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

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

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

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

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

**RL:** Reporting limit

**RPD:** Relative percent difference

**AC:** Acceptance criteria

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

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

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

## LEGEND

### FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

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

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

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This report supersedes all previous versions.

-- End of Analytical Report --

## Request for Laboratory Services and CHAIN OF CUSTODY

Received By: LEO

Received Date (mm/dd/yy): 1-27-23

Received Time: 10:45

Received By (signature): [Signature]

Custody Seal Present: ☒

Custody Seal Init.: ☐

Cooling Agent Present: ☒

Temperature Upon Receipt (°C): 8.3

LAB LIMS #: 240075-1

### REPORT INFORMATION

Company: Thurber Engineering Ltd.

Contact: Geoff Lay

Address: 103-2010 Winston Park Drive  
Oakville, Ontario

Phone: 905-829-8666

Email: glay@thurber.ca

### INVOICE INFORMATION

☒ (same as Report Information)

Company: \_\_\_\_\_

Contact: \_\_\_\_\_

Address: \_\_\_\_\_

Phone: \_\_\_\_\_

Email: accounting@thurber.ca

### REGULATIONS

Regulation 153/04:

Table 1: ☐ R/P/I      Soil Texture: ☐ Coarse      ☐ PM10      ☐ MMEER      ☐ Sanitary

Table 2: ☐ I/C/C      ☐ Fine      ☐ CCME      ☐ Other: \_\_\_\_\_      ☐ Storm

Table 3: ☐ A/O      ☐ MISA      ☐ Municipality: \_\_\_\_\_

### Other Regulations:

Reg 347/556 (3 Day min TAT)

☐ PM10      ☐ MMEER      ☐ Sanitary

☐ CCME      ☐ Other: \_\_\_\_\_      ☐ Storm

☐ MISA      ☐ Municipality: \_\_\_\_\_

RECORD OF SITE CONDITION (RSC)				YES	NO
SAMPLE IDENTIFICATION					
1	BH-01 SS-1 (0'-2')	12/16/22	1		
2	BH-02 SS-5 (10'-12')	12/20/22	1		
3	BH-03 SS-5 (10'-12')	12/16/22	1		
4	BH-04 SS-4 (7'6"-9'6")	01/11/23	1		
5	BH-05 SS-4 (7'6"-9'6")	01/16/22	1		
6	BH-06 SS-6 (15'-17')	12/21/22	1		
7	BH-07 SS-6 (15'-17')	12/22/22	1		
8	BH-08 SS-5 (10'-12')	01/09/23	1		
9	BH-09 SS-3 (5'-7')	01/11/23	1		
10	BH-10 SS-5 (10'-12')	01/16/23	1		
11	BH-11 SS-3 (5'-7')	01/12/23	1		
12	BH-12 SS-6 (15'-17')	01/12/23	1		

### ANALYSIS REQUESTED

Field Filtered (Y/N) ☐

Metals & Inorganics ☐

PAH ☐ ABN ☐ SVOC(all) ☐

PCB Total ☐ Aroclor ☐

PHC F1-F4 ☐ VOC ☐

BTEX ☐ BTEX/F1 ☐ F2-F4 ☐

VOC ☐ BTEX ☐ THM ☐

Pesticides OC ☐ OP ☐

TCLP M&I ☐ VOC ☐ PCB ☐

B(a)P ☐ ABN ☐ Ignit. ☐

Water Pkg Gen. ☐ Ext. ☐

Sewer Use: ☐

Corrosivity ☐

Organic Content ☐

### COMMENTS:

Sampled By (NAME): Greg Stanhope

Signature: [Signature]

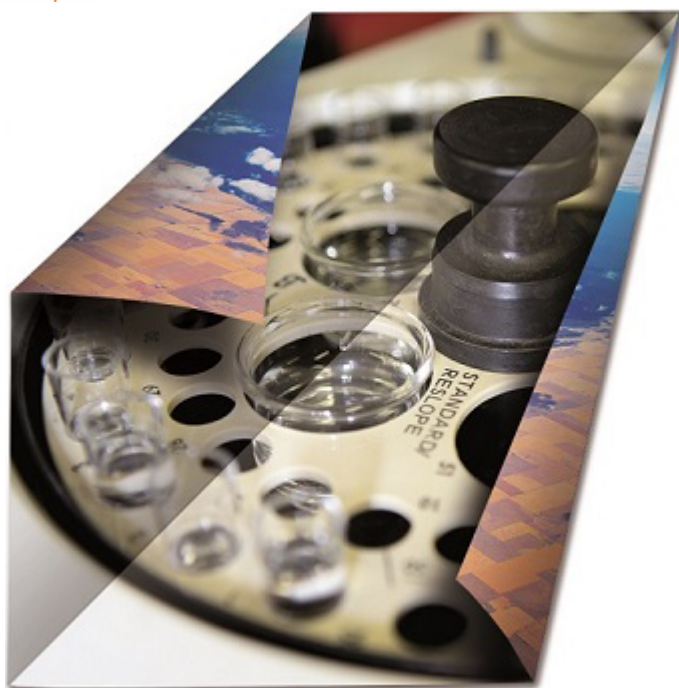
Date: Jan 13, 2022

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

Yellow & White Copy - SGS

Pink Copy - Client



## FINAL REPORT

CA40107-NOV23 R1

43743

Prepared for

**Thurber Engineering Ltd.**



# FINAL REPORT

CA40107-NOV23 R1

## First Page

### CLIENT DETAILS

Client                   Thurber Engineering Ltd.

Address                250 Thompson Drive  
Cambridge, ON  
N1T 2H9, Canada

Contact                Puneet Verma

Telephone             905-829-8666

Facsimile

Email                  pverma@thurber.ca

Project                43743

Order Number

Samples               Soil (3)

### LABORATORY DETAILS

Project Specialist     Jill Campbell, B.Sc.,GISAS

Laboratory            SGS Canada Inc.

Address                185 Concession St., Lakefield ON, K0L 2H0

Telephone             2165

Facsimile             705-652-6365

Email                  jill.campbell@sgs.com

SGS Reference        CA40107-NOV23

Received              11/09/2023

Approved             11/16/2023

Report Number        CA40107-NOV23 R1

Date Reported        11/16/2023

### COMMENTS

Temperature of Sample upon Receipt: 9 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: n/a

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

### SIGNATORIES



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FINAL REPORT

CA40107-NOV23 R1

**Client:** Thurber Engineering Ltd.  
**Project:** 43743  
**Project Manager:** Puneet Verma  
**Samplers:** Hayden Clarke

MATRIX: SOIL

Sample Number	5	6	7
Sample Name	BH 13 SS 1	BH 14 SS 4	BH 15 GS 2
Sample Matrix	Soil	Soil	Soil
Sample Date	06/11/2023	03/11/2023	06/11/2023

Parameter	Units	RL		Result	Result	Result
Corrosivity Index						
Corrosivity Index	none	1		4	5	1
Soil Redox Potential	mV	no		232	238	267
Sulphide (Na2CO3)	%	0.01		< 0.01	< 0.01	< 0.01
pH	pH Units	0.05		9.15	9.04	8.48
Resistivity (calculated)	ohms.cm	-9999		3830	2630	9010

General Chemistry

Conductivity	uS/cm	2		261	380	111
--------------	-------	---	--	-----	-----	-----

Metals and Inorganics

Moisture Content	%	0.1		16.4	15.0	14.4
Sulphate	µg/g	0.4		7.8	7.9	7.0

Other (ORP)

Chloride	µg/g	0.4		54	96	14
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FINAL REPORT

CA40107-NOV23 R1

QC SUMMARY

Anions by IC  
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-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	DIO0386-NOV23	µg/g	0.4	<0.4	7	35	98	80	120	119	75	125
Sulphate	DIO0386-NOV23	µg/g	0.4	<0.4	7	35	98	80	120	87	75	125

Carbon/Sulphur  
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0048-NOV23	%	0.01	< 0.01								

Conductivity  
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-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	EWL0271-NOV23	uS/cm	2	< 2	0	20	101	90	110	NA		



QC SUMMARY

pH  
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-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	EWL0271-NOV23	pH Units	0.05	NA	0		101			NA		

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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.

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## LEGEND

### FOOTNOTES

**NSS** Insufficient sample for analysis.

**RL** Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

**NA** The sample was not analysed for this analyte

**ND** Non Detect

Results relate only to the sample tested.

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This report supersedes all previous versions.

-- End of Analytical Report --

[illegible]



**THURBER** ENGINEERING LTD.

## **APPENDIX E**

List of OPSS and OPSD Documents and NSSP's

**1. List of OPSS and OPSD Documents relevant to this Project**

- OPSS.MUNI 401 (Construction Specification for Trenching, Backfilling, and Compacting)
- OPSS.MUNI 402 (Construction Specification for Excavating, Backfilling, and Compacting for Maintenance Holes, catch Basins, Ditch Inlets, and Valve Chambers)
- OPSS.MUNI 539 (Construction Specifications for Temporary Protection Systems)
- OPSS.MUNI 404 (Construction Specification for Support System)
- OPSS.MUNI 407 (Construction Specification for New Maintenance Hole, catch Basin, Ditch Inlet, and Valve Chamber Installation)
- OPSS.MUNI 410 (Construction Specification for Pipe Sewer Installation in Open Cut)
- OPSS.MUNI 412 (Construction Specification for Forcemain Installation in Open Cut)
- OPSS.MUNI 441 (Construction Specification for Watermain Installation in Open Cut)
- OPSS.MUNI 501 (Construction Specification for Compacting)
- OPSD 802.010 (Flexible Pipe Embedment and Backfill – Earth Excavation)
- OPSD 802.031 (Rigid Pipe Bedding, Cover, and Backfill – Type 3 Soil – Earth Excavation)
- OPSD 802.032 (Rigid Pipe Bedding, Cover, and Backfill – Type 4 Soil – Earth Excavation)

**2. Suggested Text for NSSP on Temporary Excavation**

It is Contractor's responsibility to maintain stable excavations throughout open-cut construction. Excavation for utility installation will extend to approximately 6 m below the existing ground surface through existing fill, native sand to sand and silt, and clayey silt till with groundwater table close to or above the base of excavation. The temporary cut slopes and base of excavation must be maintained in a stable condition to ensure worker safety and avoid any negative impact on the adjacent structures and utilities until the excavation is fully backfilled.

**3. Suggested Text for NSSP on Construction Dewatering**

Construction dewatering is required to permit subgrade preparation and compaction of bedding, cover and backfill material in the dry. The design of an effective dewatering system is the responsibility of the Contractor and shall be undertaken by a dewatering specialist retained by the Contractor. The dewatering system must be capable of lowering the groundwater table and maintaining the groundwater table at a minimum of 0.5 m below the base of excavation. The dewatering system shall effectively prevent any seepage in the base or side slopes that could destabilize the exposed soil.