



**Foundation Investigation Report -  
Sewer Crossing, Highway 401  
Station 14+370, East of Colonel  
Talbot Road Underpass**

Highway 401 and Colonel Talbot Road  
Interchange Improvement, London,  
Ontario

Agreement 3019-E-0009, Work Item 10  
G.W.P. 3030-11-00

Geocres No. 40114-203

October 2022

Prepared for:

Ministry of Transportation Ontario

Prepared by:

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Project No. 165001268



**FOUNDATION INVESTIGATION REPORT**  
**SEWER CROSSING, HIGHWAY 401 STATION 14+370, EAST OF COLONEL TALBOT ROAD**

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# **FOUNDATION INVESTIGATION REPORT - SEWER CROSSING, HIGHWAY 401 STATION 14+370, EAST OF COLONEL TALBOT ROAD UNDERPASS**

Introduction  
October 2022

## **FOUNDATION INVESTIGATION REPORT**

For  
Agreement 3019-E-0009

G.W.P. 3030-11-00

Proposed Sewer Crossing at Approximate Station 14+370  
Highway 401 East of Colonel Talbot Road Underpass, London, Ontario

## **1.0 INTRODUCTION**

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation, Ontario (MTO) to provide Owner's Engineer services to support the delivery of a Design-Build Ready (DB Ready) package for improvements to the Highway 401 and Colonel Talbot Road interchange in the City of London, Ontario.

A component of the engineering services to be provided included foundation investigation and the associated preparation of a foundation investigation report (FIR) related to the proposed sewer crossing of Highway 401 at approximate Station 14+370 east of Colonel Talbot Road Underpass.

The purpose of the foundation investigation was to collect the subsurface information in the vicinity of the proposed sewer crossing by drilling two (2) boreholes (one on each side of the highway), carrying out in-situ testing, and completing a laboratory testing program on selected soil samples obtained from the boreholes.

This foundation investigation report has been prepared specifically and solely for the proposed sewer crossing of Highway 401 at approximately Station 14+370, east of Colonel Talbot Road Underpass within the project limits.

## **2.0 SITE DESCRIPTION AND GEOLOGY**

### **2.1 SITE LOCATION**

The project involves improvements to Highway 401 and Colonel Talbot Road interchange in London, Ontario. The proposed sewer crossing discussed in this report is located at approximately Station 14+370 of Highway 401, about 100 m northeast of the existing Colonel Talbot Road Underpass, as shown on the Key Plan inset to Drawing 1 in Appendix A.

### **2.2 SITE DESCRIPTION**

At the project site, Highway 401 is a four-lane, divided freeway with two lanes in each direction that runs in approximately southwest-northeast. For the purposes of this report, the highway is considered to be



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Site Description and Geology  
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aligned in an east-west orientation. The chainage on Highway 401 increases from west to east. In addition to the main highway through-lanes, the N-W on-ramp lane and E-N off-ramp for the Colonel Talbot Road Interchange are also present near the proposed sewer location on the north and south sides of the highway, respectively. The photograph of the site, viewed from the west, is shown in the following photograph.



The paved surface of Highway 401 at the crossing location varies from elevations of about 252 m to 252.5 m (Geodetic Datum). The terrain surrounding the highway is generally flat with ground surface elevations varying from about 251 m to 252 m. Regionally, the ground surface slopes gently towards the south.

Drainage of the highway at the crossing site currently consists of a series of catchbasins (in paved highway median and on the shoulders of the on/off-ramp lanes) connected to a storm sewer system. Two catchbasins, one either side of the N-E on-ramp lane, are located in close proximity to the north side of the proposed sewer crossing.

## **2.3 PROJECT DESCRIPTION**

The overall project involves improvements to the Colonel Talbot and Highway 401 interchange including construction of a new underpass structure and realignment of the interchange ramps. As a component of this project, a new storm sewer crossing of Highway 401 is planned to be installed approximately 100 m east of the existing underpass (approximate location of Cross-Section A-A line depicted on Drawing No. 1 in Appendix A. Details on the depth and diameter of the proposed sewer were not available at the time of preparation of this report.

## **2.4 PHYSIOGRAPHIC DESCRIPTION**

The site is located within a physiographic region known as the Westminster Moraine, and the physiography mapping indicates that the site is situated on a till moraine (Chapman and Putnam, 1984). Based on the available surficial geological mapping, the general soil conditions for the area consist of Port Stanley clayey silt to silty clay till covered by localized lacustrine silt.

Drift thickness and bedrock topography maps and review of available water well records indicate a depth to bedrock ranging from about 60 to 100 m, and the bedrock surface in the area of the site at



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Previous Investigations / Available Information  
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approximately Elevation 150 m to 190 m. The bedrock has been mapped as limestone, dolostone, shale belonging to the Dundee Formation of Middle Devonian Age.

### **3.0 PREVIOUS INVESTIGATIONS / AVAILABLE INFORMATION**

Prior to carrying out the subsurface investigation, Stantec reviewed subsurface information available within the MTO GEOCRES database. The following provides a summary of reports that provided information near to the proposed sewer crossing location.

#### **3.1 PROPOSED COLONEL TALBOT ROAD UNDERPASS**

The results of an investigation conducted for the proposed Colonel Talbot Road replacement underpass were available from the following document:

- GEOCRES Report titled “Preliminary Foundation Investigation and Design Report, Proposed Colonel Talbot Road Underpass, Highway 401, GWP 476-89-00, Agreement Number 3005-A-000117” prepared by Golder Associates Ltd. and dated February 20, 2006 (GEOCRES Reference No. 40114-134).

Two (2) boreholes, designated as Borehole No. 1 and No. 2 were advanced at the north and south sides of Highway 401 to the depths of 30.94 m and 51.97 m, respectively. Borehole No. 1 from the investigation was drilled approximately 70 m west of the proposed sewer crossing. The approximate location of Borehole No. 1 is shown on Drawing No. 1 (Borehole Locations & Soil Strata) included in Appendix A.

The subsurface conditions encountered at the location of Borehole No. 1 consisted of:

- Surficial topsoil from ground surface (Elevation 252.3 m) to Elevation 251.7 m;
- Very stiff to stiff clayey silt fill from Elevation 251.7 to 250.6 m;
- Topsoil from Elevation 250.6 to 250.1 m;
- Stiff silty clay from Elevation 250.1 to 249.4 m;
- Stiff to hard silty clay till from Elevation 249.4 to 244.8 m; and
- Very stiff to hard clayey silt till with interbedded layers of silt and silty sand from Elevation 244.8 to 221.3 m (termination depth of borehole).

The groundwater level in the borehole was recorded at elevations of between about 243.4 m and 229.1 m during the drilling. However, the Golder report identified that the groundwater level at the site is expected to be at an elevation of about 250 m.

The Record of Borehole sheet for Borehole No. 1 is included in Appendix B for reference. The results of laboratory testing conducted on samples from that borehole are included in Appendix C for reference.



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Investigation procedures  
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## 4.0 INVESTIGATION PROCEDURES

### 4.1 FIELD INVESTIGATION

The current subsurface investigation program consisted of advancing two (2) boreholes, identified as Boreholes No. BH22-1 and BH22-2 in the vicinity of the proposed sewer crossing. Borehole No. BH22-1 was drilled in the grass-surfaced area to the north of N-W on-ramp lane while Borehole BH22-2 was drilled in the grass-surfaced area to the south of the Highway 401 EBL. The locations of these boreholes are shown on Drawing No. 1 (Borehole Locations and Soil Strata), in Appendix A.

Prior to carrying out the investigation, Stantec contacted public utility authorities to mark and clear the borehole locations of public and MTO owned utilities.

The boreholes were advanced using a Dietrich D-50T track-mounted drill rig equipped for soil sampling on August 29<sup>th</sup>, 2022. The boreholes were advanced using continuous flight hollow-stem augers.

The subsurface stratigraphy encountered in the boreholes was recorded in the field by a member of Stantec's geotechnical staff. Standard Penetration Tests (SPT) (ASTM D1586) were carried out in the boreholes and split spoon samples were collected at regular intervals (typically every 760 mm to approximately 6 m depth and 1500 mm thereafter). An in-situ shear vane test was conducted at a depth of about 2.5 m in Borehole BH22-1 to assess the undrained shear strength (undisturbed and remoulded) of the cohesive soil present at that location.

All recovered soil samples were returned to Stantec's Ottawa laboratory for detailed classification and testing. The boreholes were backfilled with bentonite chips and soil cuttings on completion of drilling.

### 4.2 LOCATION AND ELEVATION SURVEY

The borehole locations and respective ground surface elevations were surveyed by Stantec Geomatics division. The borehole survey data is considered accurate to 0.1 m for coordinates and elevations. Table 4.1 below summarizes the borehole survey information and includes the drilling depth, end of borehole elevation and number of samples recovered for each borehole.

**Table 4.1: Borehole Information Summary**

	Borehole Number	
	BH22-1	BH22-2
MTM Zone 11 Coordinates Northing Easting	4746811.9 404930.8	4746789.8 404968.3
Ground Surface Elevation, m	252.2	252.2
Total Depth Drilled, m	8.2	8.2
End of Borehole Elevation, m	244.0	244.0
Number of soil samples	10	11



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Subsurface Conditions  
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## 4.3 LABORATORY TESTING

All samples were visually examined by a Geotechnical Engineer. Selected soil samples were submitted for gradation analysis, Atterberg Limits testing and moisture content testing. The geotechnical laboratory testing program completed on the borehole samples is summarized below in Table 4.2.

**Table 4.2: Laboratory Testing Program**

Laboratory Test Type	Number of Tests
Moisture Content	21
Gradation Analysis	7
Atterberg Limits	7
Chemical Analysis	2

The chemical analysis referenced in the table consisted of analysis of pH, sulphate content, chloride content and resistivity and was completed by Paracel Laboratories in Ottawa.

The results of the laboratory testing are presented in Appendix C.

Samples remaining after testing will be placed in storage for a period of one year after issue of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

## 5.0 SUBSURFACE CONDITIONS

### 5.1 FRAMEWORK & OVERVIEW

The detailed soil and groundwater conditions encountered in the boreholes and the results of the in-situ and laboratory testing are shown on the Borehole Records included in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix B. The results of the geotechnical laboratory testing are presented on Figures C1 to C5 contained in Appendix C.

A borehole location plan and stratigraphic section of the soils encountered in the boreholes are provided on Drawing No. 1 in Appendix A. The stratigraphic boundaries on the borehole records and the strata plot are inferred from non-continuous sampling and therefore represent transitions between soil types rather than exact boundaries between geological units. The subsurface conditions will vary between and beyond the borehole locations.

In general, the subsurface stratigraphy encountered in the boreholes consists of surficial topsoil and surficial/near-surface fill materials ranging in composition from silty sand to clayey silt/silty clay/ clay. The fill materials are underlain by glacial till deposits ranging in composition from clayey silt to silty clay. Sandy silt deposits were encountered below the glacial till deposits at depths of about 7.5 m below ground surface and extended to the borehole termination depths in both boreholes.





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Subsurface Conditions  
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More detailed descriptions of the subsurface conditions encountered in the boreholes are provided in the following sections.

## 5.2 OVERBURDEN

### 5.2.1 Topsoil

A 150 mm thick layer of topsoil was encountered at the ground surface in BH22-1.

### 5.2.2 Fill

Fill materials were encountered below the topsoil and at the ground surface at the locations of Boreholes BH22-1 and BH22-2, respectively. The fill was heterogeneous in nature, varied in composition from silty sand to clayey silt/silty clay/clay and was noted to contain trace rootles and organic matter in localized areas.

The fill materials were encountered to depths of 2.7 m and 0.8 m below ground surface, corresponding to elevations of about 249.5 m and 251.5 m in BH22-1 and BH22-2, respectively.

SPT 'N' values recorded in the fill materials ranged from 5 to 7 blows per 0.3 m of penetration. The in-situ undrained shear strength ( $S_u$ ) of the cohesive fill materials encountered at a depth of about 2.5 m in BH22-1 was determined by conducting a Field Vane Shear test using N-vane equipment. The test indicated that the undrained shear strength was about 53 kPa and sensitivity was 22.5. Based on the field testing during drilling, the fill materials are considered to be in a loose or firm to stiff state.

Laboratory tests conducted on samples of the fill materials yielded natural moisture contents ranging from 7% to 23%, expressed as a percentage of the dry weight of the soil.

A gradation analysis was carried out on one (1) representative sample of the cohesive fill materials. The test results are illustrated on the borehole records in Appendix B and by the gradation curve on Figure No. C1 in Appendix C.

An Atterberg Limits test was also carried out on the sample referenced above. The test yielded a Liquid Limit of 54%, a Plastic Limit of 22%, and a corresponding Plasticity Index of 32%. The results of the Atterberg Limits test are illustrated on the borehole records in Appendix B and on Figure No. C2 in Appendix C.

Based on the results of the laboratory tests, the sample of the cohesive fill tested is classified as clay of high plasticity and has a group symbol of CH in accordance with the Unified Soil Classification System (USCS).

### 5.2.3 Clayey Silt/Silty Clay Till

The fill materials were underlain by native glacial till deposits varying in composition from clayey silt to silty clay till containing trace sand and gravel. Although not encountered during the current investigation,



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Subsurface Conditions  
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the till deposits of southern Ontario are known to contain cobbles and boulders and these materials should be anticipated to be present within the till deposit at this site.

The till deposits were encountered to depths of about 7.5 m below ground surface (corresponding to Elevation 244.7 m) in both boreholes.

SPT 'N' values recorded within the clayey silt/silty clay till deposit ranged from 9 to 28 blows per 0.3 m of penetration. Based on the field testing during drilling and manual examination of the samples obtained, the till deposit was assessed to generally have a stiff to very stiff consistency.

Laboratory testing of samples of the till deposit yielded moisture contents ranging from 15% to 22%.

Gradation analyses were carried out on five (5) representative samples of the till deposit obtained from the boreholes. The test results are illustrated on the borehole records in Appendix B and on the gradation curves on Figure No. C3 in Appendix C.

Atterberg Limits tests were also carried out on the samples referenced above. The tests yielded Liquid Limits of 33% to 38%, Plastic Limits of 17% to 19%, and corresponding Plasticity Indices of 16% to 20%. The results of the Atterberg Limits tests are illustrated on the borehole records in Appendix B and on Figure No. C4 in Appendix C.

Based on the results of the laboratory tests, the soil samples tested can be classified as clayey silt (CL) to silty clay (CI) according to the USCS.

### **5.2.4 Sandy Silt**

A sandy silt deposit was encountered beneath the glacial till deposit in both boreholes. The sandy silt deposit contained varying amounts of gravel (ranging from trace gravel to some gravel) and trace clay, and clumps/pockets of clayey silt. Cobbles were inferred to be present in this deposit in BH22-1 based on observations made during the drilling process.

Both boreholes were terminated in this deposit at depths of 8.2 m below ground surface (corresponding to an elevation of 244.0 m).

SPT 'N' values recorded within the sandy silt varied from 12 to 24 blows per 0.3 m of penetration, indicating these materials are in a compact state.

Laboratory testing of samples of the sandy silt yielded moisture contents of 12% and 19%

A gradation analysis was carried out on one (1) representative sample of the sandy silt. The test results are illustrated on the borehole records in Appendix B and the gradation curve on Figure No. C5 in Appendix C.

An Atterberg Limits test was also carried out on the sample referenced above. The test indicated the sample was non-plastic.



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Miscellaneous  
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Based on the results of the laboratory tests, the soil samples tested can be classified as sandy silt with a group symbol of ML in accordance with the USCS.

## 5.3 BEDROCK

Bedrock was not encountered to the termination depth of the boreholes.

## 5.4 GROUNDWATER CONDITIONS

Upon completion of drilling, groundwater level was measured at the depth of 5.2 m below ground surface (corresponding to an elevation of 247.0 m) in the open borehole of BH22-1, and groundwater was not observed in the open borehole of BH22-2. These are not considered to represent stabilized water level conditions. Previous investigations at the site identified that the groundwater level at the site is expected to be at about Elevation 250 m.

Groundwater levels at the site will be subject to fluctuations due to seasonal changes, precipitation events, and the water level in the ditches at the site. The water levels should be expected to be higher during the spring season or during and following periods of heavy precipitation or snow melt.

## 5.5 CHEMICAL ANALYSIS

Chemical analyses related to parameters associated with the potential for corrosion or sulphate attack (i.e., pH, resistivity, and chloride and sulphate content) were completed by Paracel Laboratories Inc. on two (2) representative samples of soils collected from boreholes. These analysis results are summarized in Table 5.1.

**Table 5.1: Results of Chemical Analysis**

Borehole No	Sample Number	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-m)
22-1	3	1.5 – 2.1	7.77	1080	38	6.0
22-2	6	3.8 – 4.4	7.86	102	91	23.9

The results of the chemical analyses are presented in Appendix C after Figure C5.

## 6.0 MISCELLANEOUS

The field work was carried out under the supervision of Akshat Shukla, EIT., under the direction of Kevin Nelson, P. Eng.

Utility locates were arranged by Stantec staff prior to initiation of drilling. The drilling equipment was supplied and operated by London Soil Test Ltd. based in London, Ontario. The traffic control service and equipment were provided by On Track Safety Ltd. based in Thornhill, Ontario.



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The borehole locations and elevations were surveyed by Stantec's Geomatics division. Geotechnical laboratory testing was carried out at Stantec's laboratories in Ottawa, Ontario.

This report was prepared by Gary Zhao, P.Eng., and reviewed by Kevin Nelson, P. Eng., MTO Designated Principal Contact.

## 7.0 CLOSURE

A subsurface investigation is a limited sampling of a site. The subsurface conditions described herein are based on information obtained at the specific borehole locations. Should any conditions at the site be encountered which differ from those at the borehole locations, we request that we be notified immediately to assess the additional information.

Respectfully Submitted;

**STANTEC CONSULTING LTD.**



Gary Zhao, M.E.Sc., P.Eng.  
Geotechnical Engineer



Kevin Nelson, P.Eng.  
Principal, Senior Geotechnical Engineer



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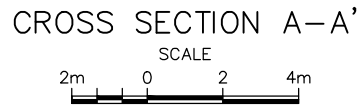
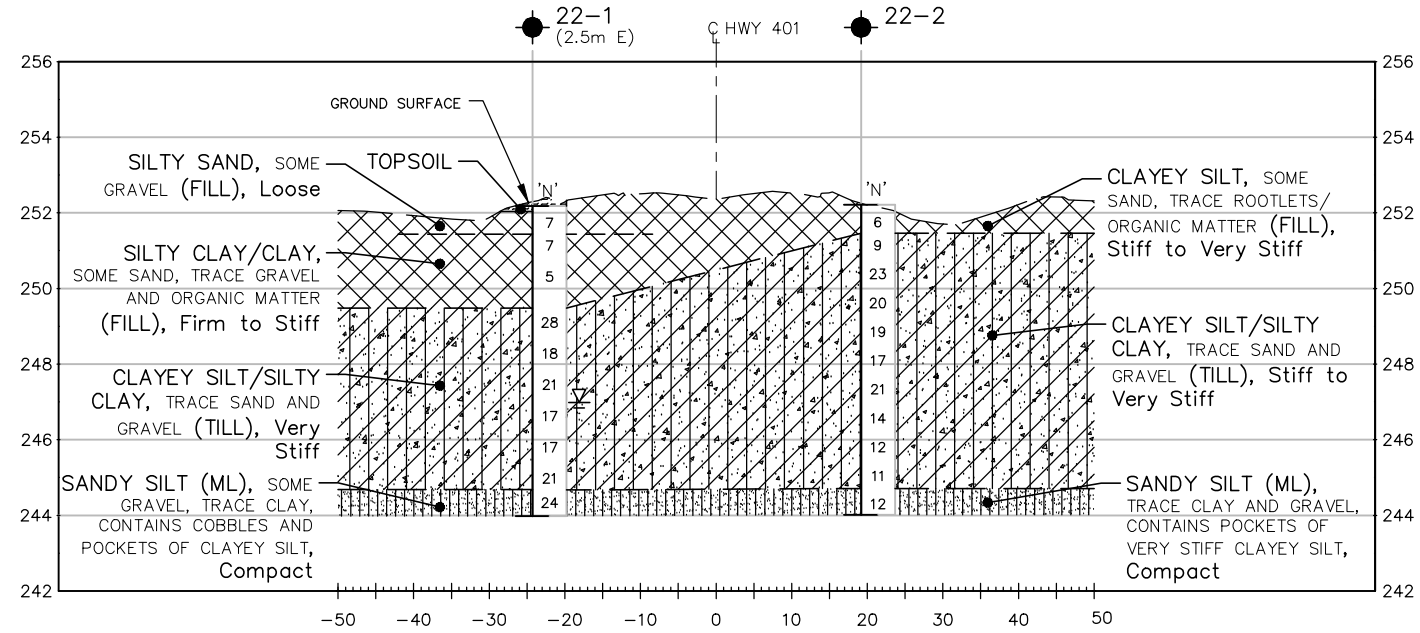
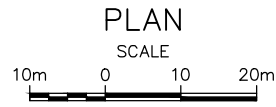
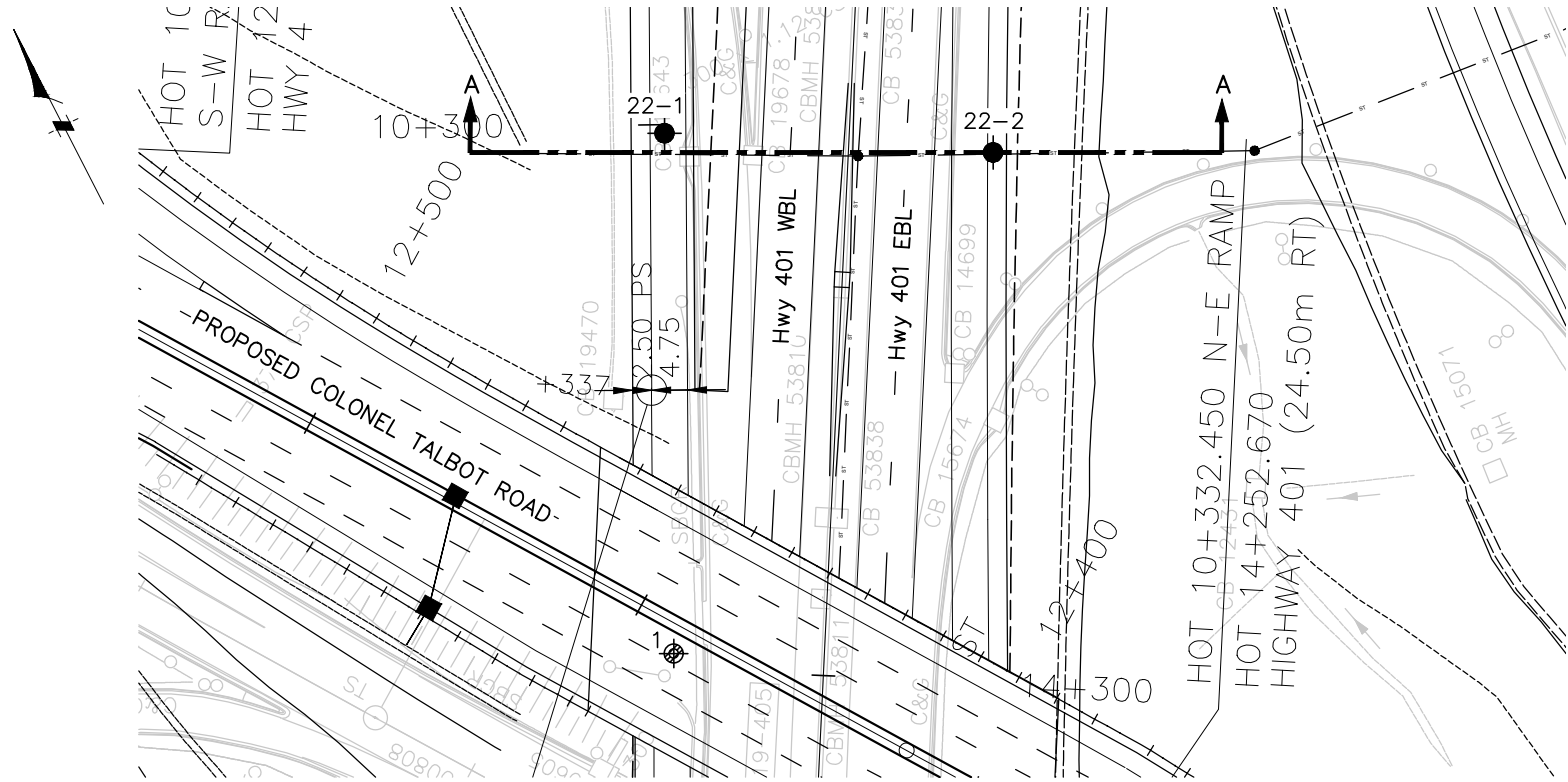
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EAST OF COLONEL TALBOT ROAD UNDERPASS**

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## **APPENDIX A**

### **A.1 DRAWING NO. 1 – BOREHOLE LOCATION PLAN AND SOIL STRATA PLOT**





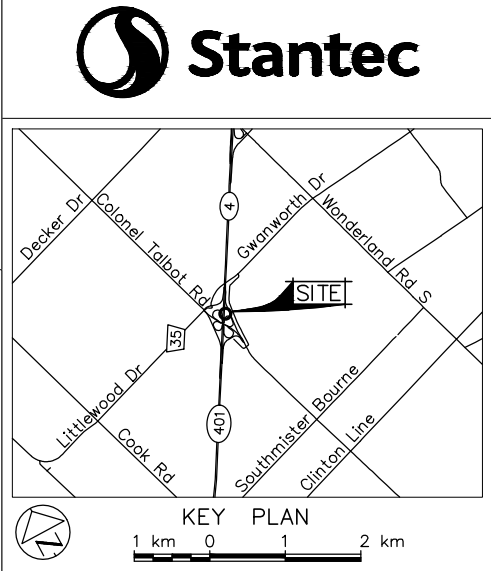
METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN



PLATE No  
**CONT 3011-E-0046**  
**WP 3030-11-00**

HWY 401 & COLONEL TALBOT  
ROAD INTERCHANGE-NEW SEWER CROSSING  
BOREHOLE LOCATIONS & SOIL STRATA

SHEET  
—



LEGEND			
	Borehole (Stantec, 2022)		
	Borehole (Golder, 2004)		
(x.x m)	Offset from Cross Section Line in meters		
N	Blows/0.3m (Std Pen Test, 475 J/blow)		
	WL at time of investigation August 2022		
No	ELEVATION	MTM ZONE 11 NORTH	COORDINATES EAST
22-1	252.18	4 746 811.9	404 930.8
22-2	252.21	4 746 789.8	404 968.3
1	252.3	4 746 750.1	404 900.5

==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.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REVISIONS				
	DATE	BY	DESCRIPTION	
GEOCREs No 40114-203				
HWY No 401				DIST WEST
SUBM'D KN	CHECKED	DATE 2022-10-07		SITE
DRAWN GBB	CHECKED	APPROVED		DWG 1

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## **APPENDIX B**

### **B.1 SYMBOLS AND TERMS USED ON BOREHOLE RECORDS**

### **B.2 BOREHOLE RECORDS**

### **B.3 SUBSURFACE INFORMATION**



## SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

### SOIL DESCRIPTION

#### Terminology describing common soil genesis:

<i>Rootmat</i>	- vegetation, roots and moss with organic matter and topsoil typically forming a mattress at the ground surface
<i>Topsoil</i>	- mixture of soil and humus capable of supporting vegetative growth
<i>Peat</i>	- mixture of visible and invisible fragments of decayed organic matter
<i>Till</i>	- unstratified glacial deposit which may range from clay to boulders
<i>Fill</i>	- material below the surface identified as placed by humans (excluding buried services)

#### Terminology describing soil structure:

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

#### Terminology describing soil types:

The classification of soil types are made on the basis of grain size and plasticity in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 or D 2488) which excludes particles larger than 75 mm. For particles larger than 75 mm, and for defining percent clay fraction in hydrometer results, definitions proposed by Canadian Foundation Engineering Manual, 4<sup>th</sup> Edition are used. The USCS provides a group symbol (e.g. SM) and group name (e.g. silty sand) for identification.

#### Terminology describing cobbles, boulders, and non-matrix materials (organic matter or debris):

Terminology describing materials outside the USCS, (e.g. particles larger than 75 mm, visible organic matter, and construction debris) is based upon the proportion of these materials present:

<i>Trace, or occasional</i>	Less than 10%
<i>Some</i>	10-20%
<i>Frequent</i>	> 20%

#### Terminology describing compactness of cohesionless soils:

The standard terminology to describe cohesionless soils includes compactness (formerly "relative density"), as determined by the Standard Penetration Test (SPT) N-Value - also known as N-Index. The SPT N-Value is described further on page 3. A relationship between compactness condition and N-Value is shown in the following table.

Compactness Condition	SPT N-Value
<i>Very Loose</i>	<4
<i>Loose</i>	4-10
<i>Compact</i>	10-30
<i>Dense</i>	30-50
<i>Very Dense</i>	>50

#### Terminology describing consistency of cohesive soils:

The standard terminology to describe cohesive soils includes the consistency, which is based on undrained shear strength as measured by *in situ* vane tests, penetrometer tests, or unconfined compression tests. Consistency may be crudely estimated from SPT N-Value based on the correlation shown in the following table (Terzaghi and Peck, 1967). The correlation to SPT N-Value is used with caution as it is only very approximate.

Consistency	Undrained Shear Strength		Approximate SPT N-Value
	kips/sq.ft.	kPa	
<i>Very Soft</i>	<0.25	<12.5	<2
<i>Soft</i>	0.25 - 0.5	12.5 - 25	2-4
<i>Firm</i>	0.5 - 1.0	25 - 50	4-8
<i>Stiff</i>	1.0 - 2.0	50 - 100	8-15
<i>Very Stiff</i>	2.0 - 4.0	100 - 200	15-30
<i>Hard</i>	>4.0	>200	>30



## ROCK DESCRIPTION

Except where specified below, terminology for describing rock is as defined by the International Society for Rock Mechanics (ISRM) 2007 publication "The Complete ISRM Suggested Methods for Rock Characterization, Testing and Monitoring: 1974-2006"

### Terminology describing rock quality:

RQD	Rock Mass Quality
0-25	Very Poor Quality
25-50	Poor Quality
50-75	Fair Quality
75-90	Good Quality
90-100	Excellent Quality

Alternate (Colloquial) Rock Mass Quality	
Very Severely Fractured	Crushed
Severely Fractured	Shattered or Very Blocky
Fractured	Blocky
Moderately Jointed	Sound
Intact	Very Sound

**RQD (Rock Quality Designation)** denotes the percentage of intact and sound rock retrieved from a borehole of any orientation. All pieces of intact and sound rock core equal to or greater than 100 mm (4 in.) long are summed and divided by the total length of the core run. RQD is determined in accordance with ASTM D6032.

**SCR (Solid Core Recovery)** denotes the percentage of solid core (cylindrical) retrieved from a borehole of any orientation. All pieces of solid (cylindrical) core are summed and divided by the total length of the core run (It excludes all portions of core pieces that are not fully cylindrical as well as crushed or rubble zones).

**Fracture Index (FI)** is defined as the number of naturally occurring fractures within a given length of core. The Fracture Index is reported as a simple count of natural occurring fractures.

### Terminology describing rock with respect to discontinuity and bedding spacing:

Spacing (mm)	Discontinuities	Bedding
>6000	Extremely Wide	-
2000-6000	Very Wide	Very Thick
600-2000	Wide	Thick
200-600	Moderate	Medium
60-200	Close	Thin
20-60	Very Close	Very Thin
<20	Extremely Close	Laminated
<6	-	Thinly Laminated

### Terminology describing rock strength:

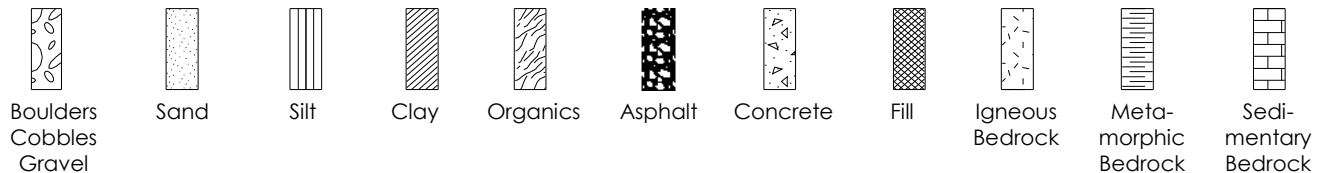
Strength Classification	Grade	Unconfined Compressive Strength (MPa)
Extremely Weak	R0	<1
Very Weak	R1	1 – 5
Weak	R2	5 – 25
Medium Strong	R3	25 – 50
Strong	R4	50 – 100
Very Strong	R5	100 – 250
Extremely Strong	R6	>250

### Terminology describing rock weathering:

Term	Symbol	Description
Fresh	W1	No visible signs of rock weathering. Slight discoloration along major discontinuities
Slightly	W2	Discoloration indicates weathering of rock on discontinuity surfaces. All the rock material may be discolored.
Moderately	W3	Less than half the rock is decomposed and/or disintegrated into soil.
Highly	W4	More than half the rock is decomposed and/or disintegrated into soil.
Completely	W5	All the rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
Residual Soil	W6	All the rock converted to soil. Structure and fabric destroyed.

## STRATA PLOT

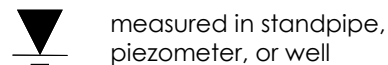
Strata plots symbolize the soil or bedrock description. They are combinations of the following basic symbols. The dimensions within the strata symbols are not indicative of the particle size, layer thickness, etc.



## SAMPLE TYPE

SS	Split spoon sample (obtained by performing the Standard Penetration Test)
ST	Shelby tube or thin wall tube
DP	Direct-Push sample (small diameter tube sampler hydraulically advanced)
PS	Piston sample
BS	Bulk sample
HQ, NQ, BQ, etc.	Rock core samples obtained with the use of standard size diamond coring bits.

## WATER LEVEL MEASUREMENT



measured in standpipe, piezometer, or well



inferred

## RECOVERY

For soil samples, the recovery is recorded as the length of the soil sample recovered. For rock core, recovery is defined as the total cumulative length of all core recovered in the core barrel divided by the length drilled and is recorded as a percentage on a per run basis.

## N-VALUE

Numbers in this column are the field results of the Standard Penetration Test: the number of blows of a 140 pound (63.5 kg) hammer falling 30 inches (760 mm), required to drive a 2 inch (50.8 mm) O.D. split spoon sampler one foot (300 mm) into the soil. In accordance with ASTM D1586, the N-Value equals the sum of the number of blows (N) required to drive the sampler over the interval of 6 to 18 in. (150 to 450 mm). However, when a 24 in. (610 mm) sampler is used, the number of blows (N) required to drive the sampler over the interval of 12 to 24 in. (300 to 610 mm) may be reported if this value is lower. For split spoon samples where insufficient penetration was achieved and N-Values cannot be presented, the number of blows are reported over sampler penetration in millimetres (e.g. 50/75). Some design methods make use of N-values corrected for various factors such as overburden pressure, energy ratio, borehole diameter, etc. No corrections have been applied to the N-values presented on the log.

## DYNAMIC CONE PENETRATION TEST (DCPT)

Dynamic cone penetration tests are performed using a standard 60 degree apex cone connected to 'A' size drill rods with the same standard fall height and weight as the Standard Penetration Test. The DCPT value is the number of blows of the hammer required to drive the cone one foot (300 mm) into the soil. The DCPT is used as a probe to assess soil variability.

## OTHER TESTS

S	Sieve analysis
H	Hydrometer analysis
k	Laboratory permeability
y	Unit weight
G <sub>s</sub>	Specific gravity of soil particles
CD	Consolidated drained triaxial
CU	Consolidated undrained triaxial with pore pressure measurements
UU	Unconsolidated undrained triaxial
DS	Direct Shear
C	Consolidation
Q <sub>u</sub>	Unconfined compression
I <sub>p</sub>	Point Load Index (I <sub>p</sub> on Borehole Record equals I <sub>p</sub> (50) in which the index is corrected to a reference diameter of 50 mm)

	Single packer permeability test; test interval from depth shown to bottom of borehole
	Double packer permeability test; test interval as indicated
	Falling head permeability test using casing
	Falling head permeability test using well point or piezometer

# RECORD OF BOREHOLE No BH22-1

1 OF 1

METRIC

W.P. 3030-11-00 LOCATION Highway 401 - Colonel Talbot N: 4746811.9 E: 404930.8 ORIGINATED BY AS  
 DIST West HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY RR  
 DATUM Geodetic DATE 2022.08.29 - 2022.08.29 LATITUDE 42.854517 LONGITUDE -81.274797 CHECKED BY KN

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							WATER CONTENT (%)			
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							20	40	60
252.2	Topsoil																	
252.0	150 mm TOPSOIL																	
0.2	Silty SAND (SM), some gravel (FILL) Loose Brown to black Moist		1	SS	7		252											
251.4																		
0.8	SILTY CLAY (CI) / CLAY (CH), some sand, trace gravel and organic matter (FILL) Firm to Stiff Mottled grey-brown-black Moist		2	SS	7		251											
			3	SS	5													
							250											
249.5																		
2.7	CLAYEY SILT (CL) / SILTY CLAY (CI), trace sand and gravel (TILL) Very Stiff Brown Moist		5	SS	28		249											
			6	SS	18		248											
			7	SS	21													
							247											
			8	SS	17													
			9	SS	17		246											
			10	SS	21		245											
244.7																		
7.5	Sandy Silt (ML), some gravel, trace clay. Contains cobbles and pockets of clayey silt. Compact Brown Wet		11	SS	24													
244.0																		
8.2	End of Borehole						244											
	Water level measured at 5.2 m below grade upon completion of drilling.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO 165001268\_HIGHWAY 401\_TALBOT\_20221007.GPJ ONTARIO MTO.GDT 10/7/22

# RECORD OF BOREHOLE No BH22-2

1 OF 1

METRIC

W.P. 3030-11-00 LOCATION Highway 401 - Colonel Talbot N: 4746789.8 E: 404968.3 ORIGINATED BY AS  
 DIST West HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY RR  
 DATUM Geodetic DATE 2022.08.29 - 2022.08.29 LATITUDE 42.854311 LONGITUDE -81.274343 CHECKED BY KN

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 (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED      + FIELD VANE									
								● QUICK TRIAXIAL      × LAB VANE									
						20	40	60	80	100							
252.2 0.0	CLAYEY SILT (CL), some sand, trace rootlets/organic matter (FILL) Stiff to very stiff Brown Moist																
251.5 0.8	CLAYEY SILT (CL) / SILTY CLAY (Cl), trace sand and gravel (TILL) Stiff to very stiff Grey-brown Moist		1	SS	6												
			2	SS	9											2 6 49 43	
			3	SS	23												
			4	SS	20												
			5	SS	19												
			6	SS	17											2 5 48 46	
			7	SS	21												
			8	SS	14											1 6 46 47	
			9	SS	12												
	Stiff below 6.7 m.		10	SS	11												
244.7 7.5	Sandy SILT (ML), trace clay and gravel. Contains pockets of very stiff clayey silt. Compact Brown Moist		11	SS	12											3 17 71 9 Non-Plastic	
244.0 8.2	End of Borehole  Borehole open and dry upon completion of drilling.																

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO 165001268\_HIGHWAY 401\_TALBOT\_20221007.GPJ ONTARIO MTO.GDT 10/7/22

**RECORD OF BOREHOLE No 1**

1 OF 3

**METRIC**


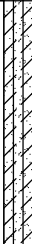
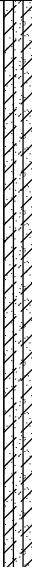
PROJECT 001-3225-3  
G.W.P. 476-89-00 LOCATION N 4746750.113; E 404900.478 ORIGINATED BY MR  
DIST HWY HIGHWAY 4 & 401 BOREHOLE TYPE POWER AUGER (HOLLOW STEM) COMPILED BY BG  
DATUM GEODETIC DATE March 15, 2004 - March 17, 2004 CHECKED BY DJM

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	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)	
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE							
252.27	GROUND SURFACE																	
0.00	TOPSOIL, silty, Black						252											
251.66							251											
0.61	FILL, clayey silt, trace sand, trace gravel, trace topsoil, Very stiff to stiff Brown		1	SS	21								○					
250.59																		
1.68	TOPSOIL, silty, Stiff Black		2	SS	14													
250.14																		
2.13	SILTY CLAY, trace sand, trace gravel Stiff		3	SS	12		250							○				
249.37	Mottled brown and grey																	
2.90	SILTY CLAY (TILL), trace sand, trace gravel Stiff to hard Brown		4	SS	14		249											
			5	SS	32		248						○					
			6	SS	25		247						○					
			7	SS	29		246						○					
			8	SS	26		245						○					
244.80							244											
7.47	CLAYEY SILT (TILL), trace sand, trace gravel, with cobbles and boulders Hard Grey		10	SS	32		243						○					
			11	SS	48		242											
242.21																		
10.06	CLAYEY SILT (TILL), trace sand, trace gravel Hard Grey		12	SS	29		241											
			13	SS	33		240						○					
							239											
			14	SS	31		238											

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

PROJECT <u>001-3225-3</u>		<b>RECORD OF BOREHOLE No 1</b>		2 OF 3		<b>METRIC</b>	
G.W.P. <u>476-89-00</u>		LOCATION <u>N 4746750.113; E 404900.478</u>		ORIGINATED BY <u>MR</u>			
DIST <u></u> HWY <u>HIGHWAY 4 &amp; 401</u>		BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM)</u>		COMPILED BY <u>BG</u>			
DATUM <u>GEODETIC</u>		DATE <u>March 15, 2004 - March 17, 2004</u>		CHECKED BY <u>DJM</u>			

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	w <sub>p</sub>			w
	CLAYEY SILT (TILL), trace sand, trace gravel Hard Grey		15	SS	31						○				
			16	SS	41										
			17	SS	36							○			
232.15			18	SS	48										
20.12	SILT, trace sand, some clay, Dense Grey														
231.54															
20.73	CLAYEY SILT (TILL), trace sand, trace gravel Hard Grey		19	SS	32						○				
			20	SS	32										
229.10															
23.17	SILTY FINE SAND, Dense Grey														
228.50	CLAYEY SILT (TILL), trace sand, trace gravel Very stiff to hard, Grey		21	SS	25						○				
23.77			22	SS	42										
			23	SS	38							○			
			24	SS	31										

ON\_MTO 001-3225-3.GPJ ON MOT.GDT 2/22/06

Continued Next Page

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

PROJECT <u>001-3225-3</u>		<b>RECORD OF BOREHOLE No 1</b>		3 OF 3		<b>METRIC</b>	
G.W.P. <u>476-89-00</u>		LOCATION <u>N 4746750.113; E 404900.478</u>		ORIGINATED BY <u>MR</u>			
DIST <u></u> HWY <u>HIGHWAY 4 &amp; 401</u>		BOREHOLE TYPE <u>POWER AUGER (HOLLOW STEM)</u>		COMPILED BY <u>BG</u>			
DATUM <u>GEODETIC</u>		DATE <u>March 15, 2004 - March 17, 2004</u>		CHECKED BY <u>DJM</u>			

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					WATER CONTENT (%)				
								20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>		
221.33 30.94	CLAYEY SILT (TILL), trace sand, trace gravel Very stiff to hard, Grey		25	SS	24		222										
	<b>END OF BOREHOLE</b>  Groundwater encountered in borehole at elev. 243.43m and 229.10m during drilling Mar 15 to 17, 2004																

**FOUNDATION INVESTIGATION REPORT - SEWER CROSSING, HIGHWAY 401 STATION 14+370,  
EAST OF COLONEL TALBOT ROAD UNDERPASS**

Closure  
October 2022

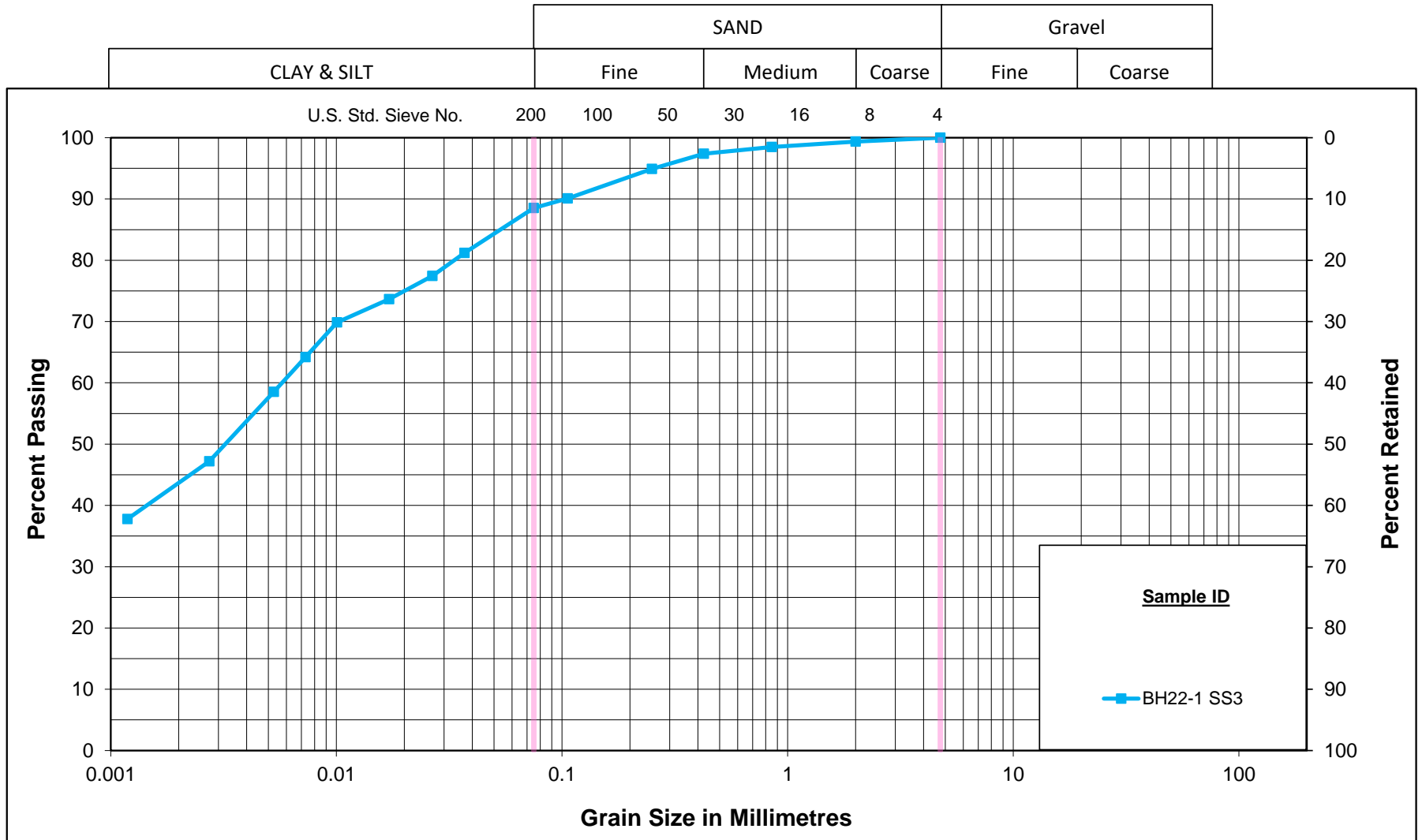
## **APPENDIX C**

### **C.1 LABORATORY TEST RESULTS**





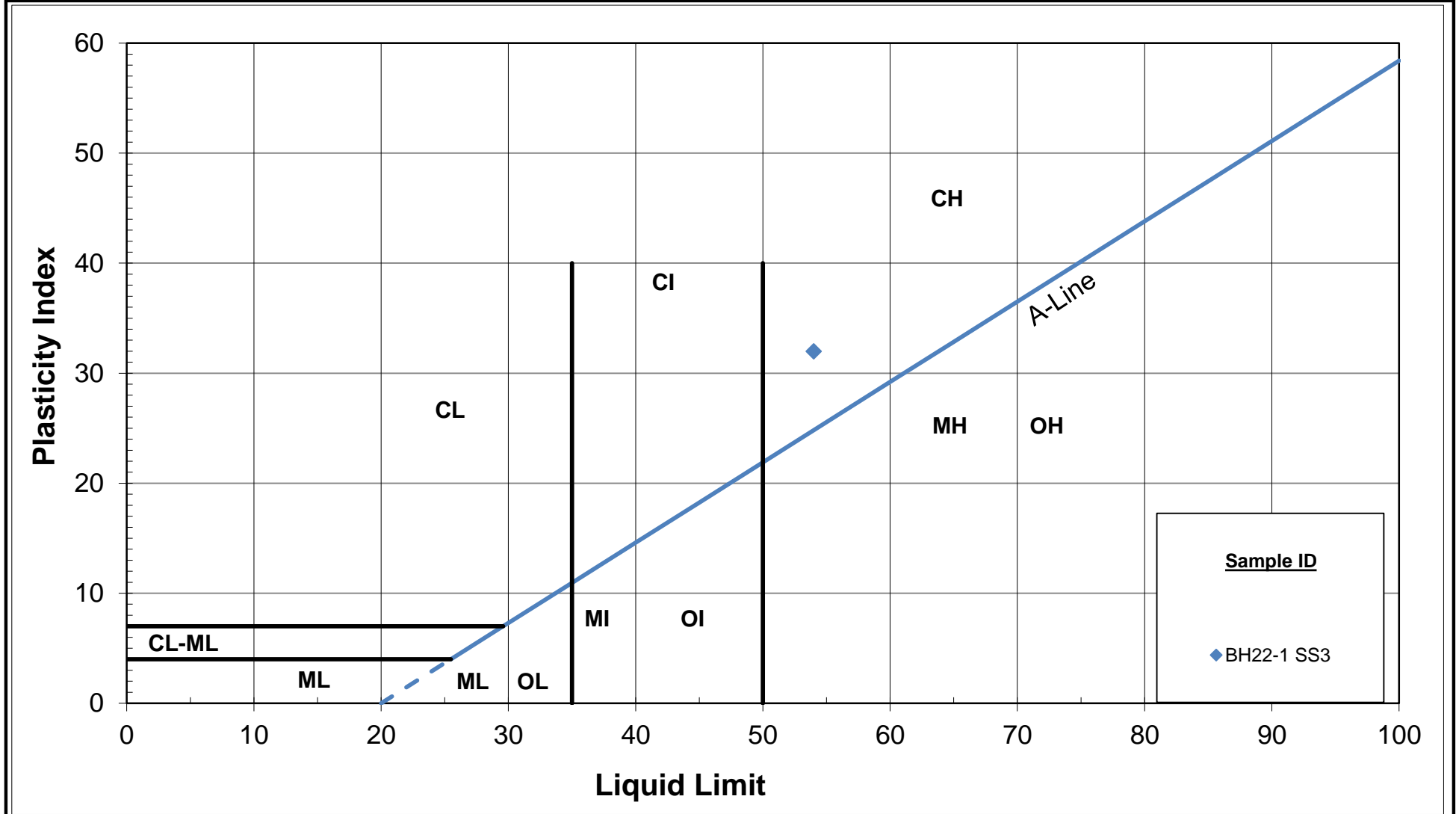
# Unified Soil Classification System



**GRAIN SIZE DISTRIBUTION**  
 FILL: CLAY (CH)  
 HWY 401 - Colonel Talbot Improvements

Figure No. C1

Project No. 165001268.340

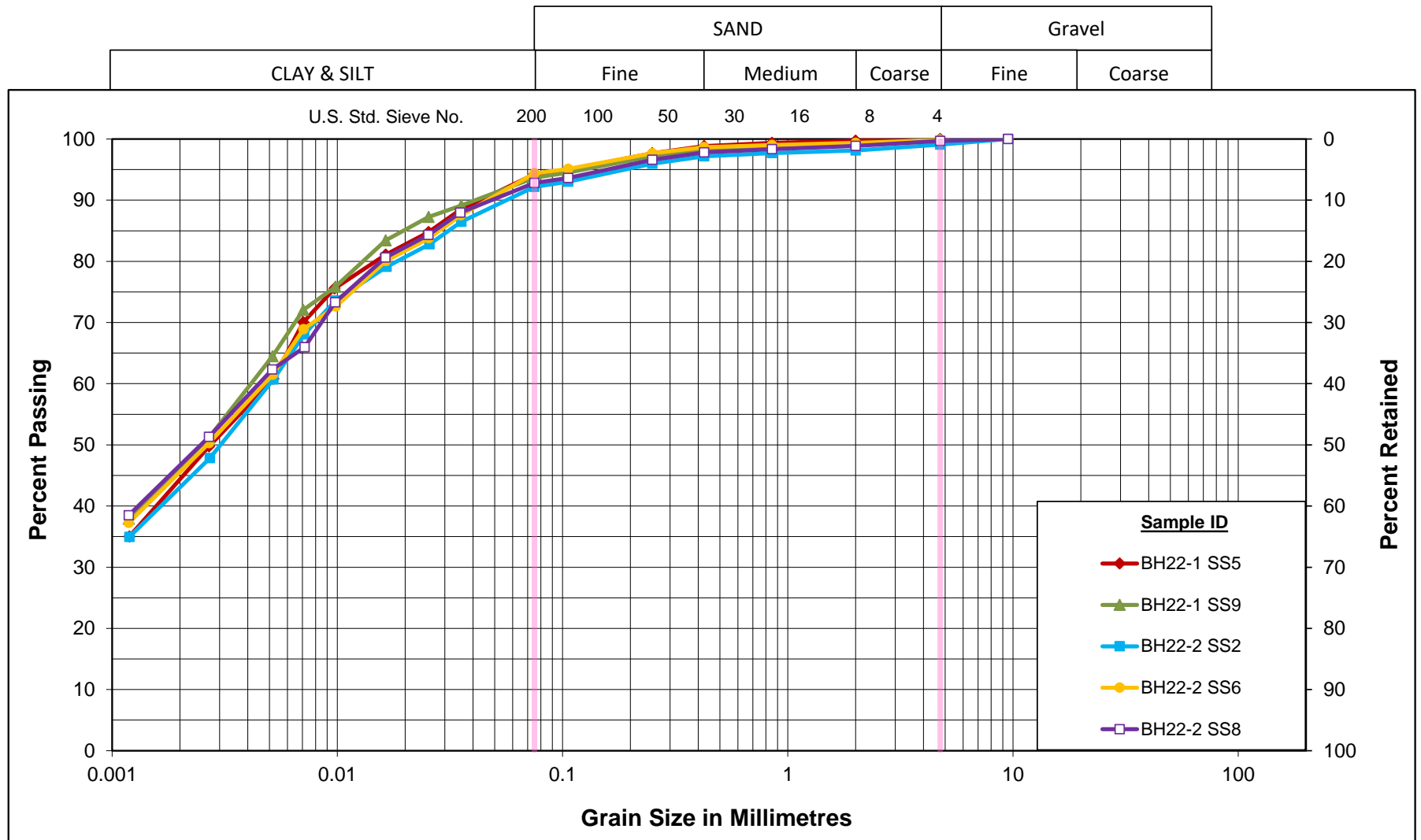


FILL: CLAY (CH)  
HWY 401 - Colonel Talbot Improvements  
**PLASTICITY CHART**

Figure No. C2

Project No. 165001268.340

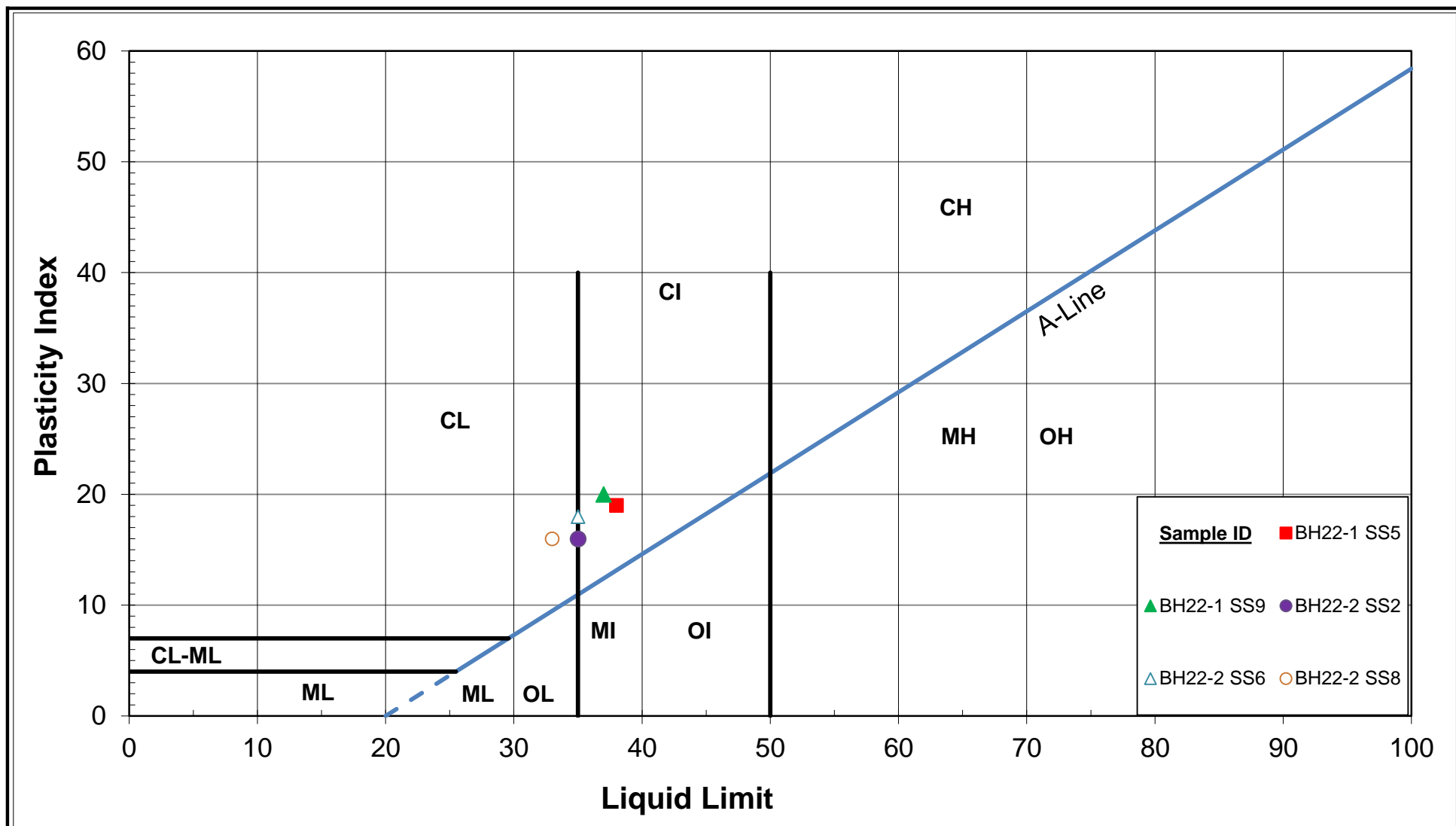
# Unified Soil Classification System



**GRAIN SIZE DISTRIBUTION**  
 TILL: CLAYEY SILT (CL) / SILTY CLAY (CI)  
 HWY 401 - Colonel Talbot Improvements

Figure No. C3

Project No. 165001268.340

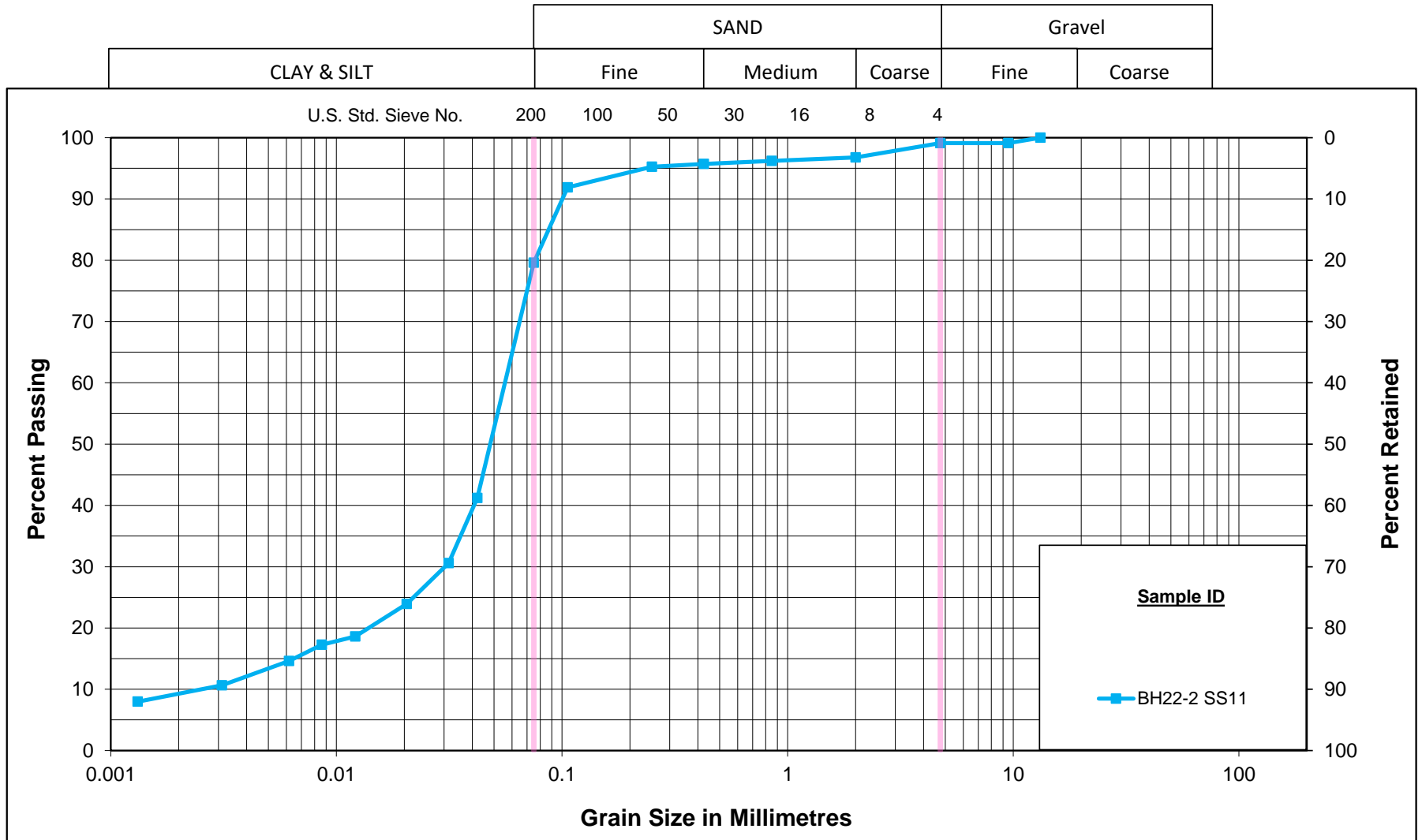


TILL: CLAYEY SILT (CL) / SILTY CLAY (CI)  
 HWY 401 - Colonel Talbot Improvements  
**PLASTICITY CHART**

Figure No. C4

Project No. 165001268.340

# Unified Soil Classification System



**GRAIN SIZE DISTRIBUTION**  
 Sandy SILT (ML)  
 HWY 401 - Colonel Talbot Improvements

Figure No. C5

Project No. 165001268.340



Certificate of Analysis

Report Date: 20-Sep-2022

Client: Stantec Consulting Ltd. (Ottawa)

Order Date: 9-Sep-2022

Client PO: 165001268.340

Project Description: 165001268.340

Client ID:	BH 22-1 SS3 @1.52-2.13 m	BH 22-2 SS6 @3.81-4.42 m	-	-	
Sample Date:	29-Aug-22 09:00	29-Aug-22 09:00	-	-	-
Sample ID:	2237411-01	2237411-02	-	-	-
Matrix:	Soil	Soil	-	-	-
MDL/Units					

**Physical Characteristics**

% Solids	0.1 % by Wt.	77.7	84.1	-	-	-	-
----------	--------------	------	------	---	---	---	---

**General Inorganics**

pH	0.05 pH Units	7.77	7.86	-	-	-	-
Resistivity	0.1 Ohm.m	6.04	23.9	-	-	-	-

**Anions**

Chloride	5 ug/g	1080	102	-	-	-	-
Sulphate	5 ug/g	38	91	-	-	-	-