Foundation Investigation and Design Report – Highbury Avenue Interchange Improvement-Highway 401 Rehabilitation from Wellington Road to Highbury Avenue, Design-Build Project

Highway 401 City of London, ON
West Region

DB Contract Number: 2022-3004
GWP 3032-11-00

Latitude 42.936489
Longitude -81.179303

Geocres No. 40I14-209

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1.0 INTRODUCTION

CRH Canada Group Inc. (CRH) is constructing the Highway 401 Five Structure Replacement project, which includes the Highbury Avenue Interchange improvements, and the Highway 401 rehabilitation and improvements in the City of London, on behalf of the Ontario for the Ministry of Transportation (MTO), under a Design-Build (DB) agreement. Stantec Consulting Ltd. (Stantec) was retained by CRH to undertake additional foundation investigations and detailed foundation designs for the project.

The overall project extends along Highway 401 from 675 m east of Wellington Road easterly 5.5 km to 630 m west of Old Victoria Road, along Pond Mill Road from 60 m north to 60 m south of Highway 401, and along Highbury Avenue from Bradley Avenue to Wilton Grove Road. The project includes following foundations engineering components:

- All deep cut areas and foundations for the new bridge structures, including:
  - CNR Overhead (London-Port Stanley Railway (Site No. 19X-0371/B0);
  - Pond Mills Overpass (Site No. 19X-0372/B0);
  - Highbury Avenue Underpass (Site No. 19X-0373/B0);
- Structural culvert replacements, including:
  - Tributary to Murray Drain Culvert (Site No. 19X-650/C0);
  - Elliot-Laidlaw Drain Culvert (Site No. 19X-651/C0);
- High mast lighting;
- Overhead signs;
- Retaining walls (at the bridges and Overhead sign footings);
- 1.5:1 reinforced side slope between Station 25+110 and Station 25+270 westbound (changed to 2H:1V slopes); and
- Sewers and storm water management facilities.

The MTO reference numbers for this DB project are as follows:

GWP: 3032-11-00
DB Contract Number: 2022-3004

This foundation investigation report has been prepared specifically for the proposed Highbury Avenue Interchange Improvement, which includes the bridge replacement (structure 19X-0373/B0), and the approach embankment grade raise and widening. Other foundation engineering elements such as high mast light poles, median sewer, and signs are reported under separate cover.

2.0 SITE DESCRIPTION

2.1 SITE LOCATION

The site location is shown on the Key Plan inset to Drawing Nos. 1 to 3 included in Appendix A.

2.2 GENERAL SITE DESCRIPTION

The existing Highbury Avenue Interchange is a partial cloverleaf interchange, located in the southern portion of the City of London, Ontario. The existing interchange has six ramps including two loop ramps in the northeast (S-W ramp) and southwest quadrants (N-E ramp) of the interchange. There is no existing high mast lighting pole within the interchange area. The existing Highbury Avenue Underpass carries Highbury Avenue over Highway 401 at the interchange. Highway 401 runs approximately in the southwest-northeast direction at the site, while Highbury Avenue runs generally northwest -southeast.

It is assumed that Highway 401 runs west-east and Highbury Avenue runs north-south for the reporting purposes. Highbury Avenue has two lanes of traffic in each direction and Highway 401 is a six-lane (three lanes in each direction) divided highway.

The area adjacent to the interchange mainly consists of open green fields with some industrial and commercial lands located to the west and south of the interchange.

2.3 EXISTING BRIDGE AND APPROACH EMBANKMENT

The existing underpass is a three-span, cast-in-place reinforced concrete structure, constructed in 1960. The total bridge length is 61.6 m at the centre of the abutment bearings. The overall width of the bridge is 19.08 m, with a total paved width of 17.0 m. The original bridge abutments were constructed with 2H:1V abutment foreslopes, and in 1994, vertical retained soil system (RSS) walls were added to the abutments to enlarge the opening between the piers and abutments. As per the available structural drawings, the existing underpass piers are supported on spread footings, and the abutments are supported on piles driven to about elevation ± 270 m (el. ± 887 ft).

The existing approach embankments have a maximum height in the order of 6 to 7 m above the adjacent prevailing ground surface. The embankment side slopes are close to 2H:1V, and are well vegetated. No visible signs of embankment settlement, nor of slope instability, were noted during the site reconnaissance and the investigation period.

2.4 GEOLOGICAL INFORMATION

This interchange area lies within a physiographic region known as the Westminster Moraine and Mount Elgin Ridges which are generally characterized by undrumlinized till plane (Chapman and Putnam, 1984). Geology mapping indicates that the surficial material consists of Port Stanley till and glaciolacustrine granular soils deposits (Ministry of Northern Development and Mines, M2556, 1991). The rock formation in the area is described as limestone, dolostone and shale of the Dundee Formation which belongs to the Hamilton Group of Middle Devonian Age. The bedrock surface is estimated to be at about elevation 205 m, which is approximately 65 m below ground surface at the interchange (Ontario Department of Mines, P.482, 1968).

3.0 REVIEW OF PREVIOUS INVESTIGATIONS

The following GEOCRES reports were provided as part of the DB RFP:

- GEOCRES No 40I14-165 Foundation Investigation and Design Report - Highway 401/Highbury Avenue Interchange Reconstruction, City of London, Ontario, GWP 3032-11-00 (dated April 26, 2016, prepared by Thurber Engineering LTD.)- the RFP document #68
- GEOCRES No 40I14-148 Preliminary Foundation and Design Report - Proposed Highway 401 Underpass Structure at Highbury Avenue, City of London, County of Middlesex, GWP 3032-11-00, Agreement # 3011-0019 (dated July 20, 2012, prepared by Infrastructure Engineering Group Inc.) – appended to the RFP as the document #29 Highway 401 At Highbury Avenue Interchange Improvement (dated May 2013, prepared by Dillion Consulting)
- GEOCRES No 40I14-63 Foundation Report on New Bridge at Highway #401 and Highbury Avenue Extension (Line ‘A’) Crossing in Westminster Township (date and author are not presented) – appended to the above Infrastructure Engineering Group Inc. Report (GEOCRES No 40I14-148)

Due to the age and quality of the investigation data, GEOCRES No 40I14-63 may be not useful for the current project. Another two GEOCRES reports were reviewed as part of the bid phase design, as part of the additional foundation investigation program development, and for preparation of the current report. Infrastructure Engineering Group drilled two bridge abutment foundation boreholes west of the existing bridge for the preliminary foundation investigation and design in 2012, and Thurber Engineering advanced two bridge abutment foundation boreholes, one bridge central pier foundation borehole, two approach embankment boreholes, and four ramp realignment boreholes for the detailed foundation investigation and design in 2016. The Thurber Engineering and Infrastructure Engineering Group investigation findings are incorporated in the borehole location plan and stratigraphic section drawings included in Appendix A of this report. For reference, copies of borehole records, borehole location plan &

stratigraphic sections and laboratory test results from Thurber Engineering and Infrastructure Engineering Group reports are also included in Appendix B.

Review of the existing information from previous investigations indicates that the subsurface stratigraphy within the interchange area consists generally of concrete or asphalt pavement overlying granular fill and embankment fill, which is in turn was underlain by native soil consisting of upper deposits of silty clay till and silty sand to sandy silt, underlain by a silt layer and silty clay interlayer, a lower silty sand deposit, and a lower silty clay till deposit. Topsoil was also noted in the boreholes drilled from the landscaped areas. Stabilized groundwater elevations recorded in the piezometers ranged from about elevation 263 m to 272 m (about 4 m to 13 m below the original grade, assuming the original grade at about elevation 276 m).

4.0 STANTEC INVESTIGATION PROCEDURES

4.1 FIELD INVESTIGATION (2022)

The additional foundation investigation for the design-build interchange improvement (bridge replacement, minor grade raise & embankment widening, high mast light poles and signs) consisted of a total of 17 boreholes within the partial cloverleaf interchange footprint. The foundation investigation program included advancement of a single borehole at the proposed bridge central pier location (BH HB-01) and 15 boreholes for the proposed high mast lighting poles signs and median sewer (BHs HL-09 to HL 18, BH S-04, BH S-07 and MS-9). The new boreholes and previously drilled boreholes are well distributed within the interchange area to capture sufficient subsurface and groundwater information to support the proposed interchange improvement design and construction.

The locations of the boreholes specific to the bridge structure and the approach embankment, as well as those drilled for the high mast lights and the proposed sewer, are shown on the Borehole Locations and Soil Strata Drawing Nos. 1, 2 and 3, presented in Appendix A.

Prior to carrying out the investigation, Stantec contacted the public utility authorities to clear the borehole locations of both private and public utilities. MTO locates were also obtained from the MTO West Region.

The field drilling program was carried out between July 19 and August 12, 2022. The deep boreholes were advanced using continuous flight hollow and solid stem augers. Drilling was carried out with truck-mounted and track-mounted drill rigs, both equipped for soil sampling. Boreholes proposed at two high mast light pole locations were advanced using manual drilling methods (BHs HL-10 and HL-12) with a half-weight SPT hammer (37.5 kg) due to drill rig accessibility issues. The manual boreholes were supplemented by drill rig boreholes (BHs HL-10-1 and HL-12-1), advanced at the closest drill rig accessible locations, in order to anticipate the deeper soil conditions at those specific high mast light pole locations.

The subsurface stratigraphy encountered in each borehole was recorded in the field by an experienced Stantec field technician. Standard Penetration Tests (SPT) were carried out in the drilled holes and split spoon samples were collected at regular intervals (0.75 m interval for the shallow depth / critical zone, 1.5 m interval to a depth of 20 m below ground surface, and 3.0 m interval below 20 m depth to meet the typical MTO subsurface investigation sampling requirements) in accordance with ASTM D1586. All recovered SPT samples were returned to our Markham laboratory for detailed classification and testing. The undrained shear strength of cohesive soils was determined using an in-situ shear vane (MTO N-vane) in accordance with ASTM D2573 wherever applicable. A pocket penetrometer was also used to estimate the shear strength/consistency of clayey soil samples at the site.

A 50 mm diameter monitoring well was installed in BH HB-01. The slotted portion of the monitoring well, the screen, was installed at a depth spanning from 9.1 m to 12.1 m below the existing highway grade. The borehole annulus around the screen was backfilled with sand. The borehole annulus below and above the screen was backfilled with bentonite.

The groundwater level at BH HB-01 was measured on September 12, 2022. At other locations, the groundwater level was estimated based on observations within open boreholes, during and upon completion of drilling.

After completion of drilling, the boreholes were backfilled with a mix of bentonite and drill cuttings.

Boreholes advanced on Highway 401 and on Highbury Avenue were sealed with cold patch asphalt.

4.2 INVESTIGATION HOLE LOCATION AND ELEVATION SURVEY

The borehole locations and respective ground surface elevations were surveyed by Stantec Geomatics personnel using Trimble R10-2 (horizontal accuracy of 8 mm+0.5 ppm and vertical accuracy of 15 mm+0.5 ppm as per the Trimble GNSS datasheet) to meet the survey accuracy requirements (vertical accuracy of 0.1 m and horizontal accuracy of 0.5 m) of the Guideline for MTO Foundation Engineering Services V2. Summary information pertaining to the Stantec boreholes included in this report is given in Table 4.1.

Table 4.1: Borehole Information Summary

Investigation Hole	MTM Zone 11 Coordinates		Ground surface elevation (m)	Total depth drilled or advanced (m)	End of borehole elevation (m)	Number of soil samples
	Northing	Easting				
HB-01	4756033.6	412576.4	275.9	37.2	238.7	24
HL-09	4755963.3	412348.9	271.4	12.8	258.6	14
HL-10	4755935.1	412463.8	271.6	3.8	267.8	5
HL-10-1	4755968.7	412426.5	272.8	12.6	260.2	14
HL-11	4756053.8	412431.0	272.3	12.8	259.5	14
HL-12	4755933.6	412614.1	273.1	2.1	271.0	3
HL-12-1	4755923.8	412665.3	281.0	12.8	268.2	14
HL-13	4755811.2	412759.8	277.1	12.8	264.3	14

Investigation Hole	MTM Zone 11 Coordinates		Ground surface elevation (m)	Total depth drilled or advanced (m)	End of borehole elevation (m)	Number of soil samples
	Northing	Easting				
HL-14	4755994.6	412737.8	274.2	12.8	261.4	14
HL-15	4756113.4	412834.3	275.9	12.5	263.4	14
HL-16	4756111.5	412543.1	281.5	12.8	266.9	14
HL-17	4756137.1	412720.5	275.2	12.8	262.4	14
HL-18	4756235.7	412411.6	275.5	12.8	262.7	14
MS-09	4755971.5	412376.4	271.9	6.7	265.2	11
MS-10	4756003.4	412478.7	274.3	6.7	267.6	9
S-04	4755952.9	412641.4	281.7	8.2	273.5	12
S-07	4755762.8	412823.2	276.9	8.2	268.7	11

4.3 LABORATORY TESTING

All samples were taken to Stantec's Markham laboratories where they were subjected to a detailed visual and tactile examination. The geotechnical laboratory testing program completed on the borehole samples is summarized in Table 4.2. Thirteen (13) soil samples were tested for pH, soluble sulphate content, chloride content, and resistivity. Samples remaining after testing will be placed in storage for a period of one year after issuance of the final report. After the storage period, the samples will be discarded unless we are directed otherwise by MTO.

Table 4.2: Geotechnical Laboratory Testing Program

Test Description	Number of Tests	Testing Firm
Moisture Content	239	By Stantec
Atterberg Limits	22	By Stantec
Grain Size Distribution (sieve & hydrometer)	55	By Stantec

5.0 SUBSURFACE CONDITIONS

5.1 OVERVIEW

The detailed subsurface soil and groundwater conditions encountered in the boreholes and the results of in situ and laboratory testing are displayed on the Record of Borehole sheets contained in Appendix C. An explanation of the symbols and terms used to describe the Borehole Records is also provided in Appendix B. The results of geotechnical laboratory testing are also presented on Figures D1 to D12 contained in Appendix C.

Borehole location plans are provided on Drawings. 1, 2 and 3, in Appendix A. A stratigraphic section of the soils encountered within the boreholes along and across the proposed bridge are shown on Drawings 2 to 3.

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 conditions will vary beyond the borehole locations. The stratigraphy generally consisted of:

- Near-surface asphalt, concrete, topsoil and/or fill materials (pavement, grading and embankment fills)
- Localized surficial deposit of clayey silt to silty clay till
- Upper silt and sandy silt to silty sand
- Silt and Silty clay to clayey silt
- Lower silty sand
- Basal silty clay to clayey silt till with about 5 m thick silty sand interlayer

Similar to what Thurber Engineering identified throughout their 2016 foundation investigation and design, the subsurface conditions identified during the current investigation are also in good agreement with all previous investigations' findings (e.g. soil composition, compactness, consistency and stratigraphy) and very consistent subsurface and groundwater conditions were revealed throughout the interchange area.

Detailed descriptions of the subsurface and groundwater conditions found in the current investigation program are provided in the following sections.

5.2 OVERBURDEN

5.2.1 Ground Surface Cover

5.2.1.1 Pavement

The boreholes drilled on the highway (Boreholes HB-01, HL-09, HL-10-1, HL-15, MS-09 and MS-10) and Highbury Avenue (Boreholes HL-13, S-04 and S-07) encountered 50 mm to 350 mm thick asphalt pavement.

The asphalt was underlain by approximately 350 to 1300 mm of sand and gravel fill material except for BH S-07 where asphalt was underlain by a silty sand embankment fill.

5.2.1.2 Topsoil

Boreholes HL-10, HL-11, HL-12, HL-12-1, HL-14, HL-16, HL-17 and HL-18 were advanced in the interchange ramp landscaped areas covered by grass and weeds. The surficial overburden materials were characterized as topsoil and ranged in thickness from 100 mm to 700 mm. The topsoil thickness may vary across the site and measured topsoil thickness at specific borehole locations should not be relied on for stripping quantity estimate.

5.2.2 Fill Materials

Pavement granular fill materials ranging from gravelly sand to sand and gravel (mostly sand and gravel) were encountered under the Highway asphalt pavement (in Boreholes HL-09, HL-10-1, HL-15, MS-09 and MS-10) and Highbury Avenue pavement (in Boreholes HL-13 and S-04). The granular fill thickness ranged from 50 mm to 1300 mm. Standard Penetration Test (SPT) N-values measured within the granular fill materials ranged from 17 to 70 blows per 0.3 m, indicating a compact to very dense relative density. The measured moisture content ranged from approximately 4% to 5%.

Granular fill materials ranged from sandy silt to silty sand to sand were also encountered below the pavement granular fill along the highway and within the top 2 m to 3 m portion of the Highbury Avenue embankment (Boreholes HB-01, HL-12, HL-12-1, HL-13, HL-14, HL-18, MS-09, MS-10 and S-17). The remaining embankment and fills have somewhat complex material composition ranging from silt, silty clay to clayey silt, silty sand to sandy silt, and sand. Trace of organic, rootlets and buried topsoil were also noted within the lower portion of the embankment fill (in Boreholes S-07 and HL-18). Relatively thinner interchange grading fill under the topsoil was also noted in Boreholes HL-12 and HL-14.

Overall pavement, grading and embankment fill materials thickness at the interchange ranged from 0.8 m to 7.5 m and extended to elevations ranging from 274.9 m to 268.9 m.

SPT N-values ranging from 3 to 48 blows per 0.3 m penetration (average 18 blows per 0.3 m penetration) were obtained from the SPTs advanced in the fill materials. The undrained shear strength interpreted from the pocket penetrometer tests conducted on the cohesive fill materials ranged from approximately 54 kPa to greater than 241 kPa. No undrained shear strength measurements were made using MTO N-vane due to the undrained shear strength being greater than 100 kPa. Based on these results, the grading and embankment fill materials at the interchange area generally have firm to very stiff consistency (cohesive fills) or compact relatively density (granular fills). The measured moisture content ranged from approximately 2% to 27%.

Index tests carried out on representative samples of the grading and embankment fill yielded the following results:

<u>Granular fills</u>

- Gravel: 0 to 28%
- Sand: 4 to 70%
- Silt: 12 to 88%
- Clay: 7 to 26%

The Unified Soil Classification (USCS) group symbol for the granular fill is silty sand/ silty sand with gravel (SM), silty clayey sand/silty clayey sand with gravel (SC-SM) and silt (ML).

<u>Cohesive fills</u>

- Gravel: 0 to 11%

- Sand: 5 to 31%
- Silt: 26 to 45%
- Clay: 31 to 49%

Atterberg limit tests carried out on cohesive samples of the fill materials measured Liquid Limits of 23% to 34%, Plastic Limits of 11% to 18%, and corresponding Plasticity Indices of 10 to 18. The Unified Soil Classification System (USCS) group symbol for the cohesive fill material is clayey silt to silty clay (CL).

The results of grain size distribution testing for the granular and cohesive fill materials are presented on Figure No. D1 and D2, respectively. The corresponding plasticity charts for samples of the clayey fill materials are displayed on Figure D3 of Appendix D. Test results are also presented on the Records of Borehole Sheets included in Appendix C.

5.2.3 Surficial Clayey Silt to Silty Clay Till

Below topsoil, grading fill and embankment fill, a surficial clayey silt to silty clay till layer was encountered in Boreholes HB-01, HL 10-1, HL-11, HL-12, HL 12-1, HL-13, HL-16, HL-18, S-04, and S-07. Trace of gravel and trace to some sand were also noted in this soil deposit. The surficial clayey silt to silty clay till thickness ranged from 0.3 m to 2.3 m and extended to depths ranging from 1.8 to 9.6 m below ground surface (elevations 274.9 to 268.7 m).

SPT N-values measured within this deposit ranged from 13 to 55 blows per 0.3 m (average 27 blows per 0.3 m). The undrained shear strength interpreted from the pocket penetrometer tests conducted on these materials ranged from approximately 94 kPa to greater than 241 kPa. No undrained shear strength measurements were made using MTO N-vane due to the undrained shear strength being greater than 100 kPa. Based on these results, the clayey silt to silty clay till generally has a stiff to hard consistency.

Index tests carried out on representative samples from the surficial clayey silt to silty clay till layer yielded the following results:

- Gravel: 0 to 7%
- Sand: 8 to 24%
- Silt: 32 to 54%
- Clay: 29 to 56%

- Moisture Content: 14 to 21%

Atterberg limit tests carried out on representative samples from this layer measured Liquid Limits of 23% to 47%, Plastic Limits of 14% to 20% and corresponding Plasticity Indices of 9% to 27%. The USCS group symbol for this layer is clayey silt to silty clay (CL to CI).

The results of grain size distribution testing and the corresponding plasticity charts for samples of the upper clayey silt till layer are displayed on Figures D4 and D5 of Appendix D. It should be noted that some index test results are beyond the typical ranges of cohesive glacial tills. However, based on the visual and tactile examination, natural moisture contents and consistency of retrieved soil samples, this soil deposit is generally considered as a till.

Due to its mode of deposition, all glacial tills inherently contain cobbles and boulders.

5.2.4 Upper Silt and Silty Sand to Sandy Silt

A layer of Silt and silty sand and sandy silt was encountered in all boreholes under the topsoil, grading & embankment fill, and clayey silt to silty clay till. This deposit varied in composition and included zones of silt, sand and sand with some clay. About 1.5 m thick clayey silt interlayer was also noted within this deposit in borehole HL-15. Trace of clay and gravel were also noticed throughout the deposit. The upper silt and silty sand to sandy silt layer in thickness ranged from 7.6 m to 10.9 m and extended to depths ranged from 11.7 m and 12.4 m below ground surface (elevations 264.2 m to 261.8 m) in Boreholes HB-01 and HL-14. All other boreholes were terminated within this deposit after 0.3 m to 10.6 m penetration into the deposit.

SPT N-values measured within this deposit ranged from 11 to more than 100 blows per 0.3 m penetration suggesting the sand deposit is loose to very dense (typically dense, average SPT N-value of 45 blows per 0.3 m).

Index tests carried out on a representative sample of the silt and silty sand to sandy silt yielded the following results:

- Gravel: 0 to 1%
- Sand: 8 to 73%
- Silt: 22% to 78%
- Clay: 4 to 18%

- Moisture Content: 5 to 30%

Grain size distribution plots for the upper silty sand to sandy silt are displayed on Figure D6 in Appendix D. The USCS group symbol for this layer is silty sand (SM) and sandy silt to silt (ML).

5.2.5 Silt

A lower silt layer was encountered in borehole HB-01 below the upper silt and silty sand to sandy silt deposit at a depth of 11.7 m below ground surface (elevations 264.2 m) and extended to a depth of 16.3 m (elevation 259.6 m) in borehole HB-01. Traces of sand and clay were noted within this soil deposit. SPT N-values measured within this layer ranged from 58 to more than 100 blows per 0.3 m penetration suggesting the lower silt deposit is very dense.

Index tests carried out on a representative sample of the silt yielded the following results:

- Gravel: 0%
- Sand: 1%

- Silt: 90%
- Clay: 9%

- Moisture Content: 18 to 19%

An Atterberg limit test was also carried out on a single representative sample from this layer and the test results indicated that the silt is non-plastic. The USCS group symbol for this layer is silt (ML).

A grain size distribution plot for the representative sample of this layer is presented on Figure D7 in Appendix D.

5.2.6 Clayey Silt to Silty Clay

A layer of clayey silt to silty clay was contacted below the silt in Borehole HB-01 and below the upper silt and silty sand to sandy silt in Borehole HL-14. The clayey silt to silty clay layer thickness is 3.1 m and extended to a depth of 19.4 m below ground surface (corresponding elevation 256.5 m) in BH HB-01. BH HL-14 was terminated within this layer after the 0.4 m penetration. SPT N-values measured within this layer ranged from 14 to 48 blows per 0.3 m. An undrained shear strength of 80 kPa was interpreted from the single pocket penetrometer test conducted in the clayey silt to silty clay layer in Borehole HB-01. These results suggest the clayey silt to silty clay has a firm to hard consistency.

Index tests carried out on a representative sample from the clayey silt to silty clay layer yielded the following results:

- Gravel: 0%
- Sand: 0%
- Silt: 38%
- Clay: 62%

- Moisture Content: 18 to 23%

Atterberg limit tests carried out on a representative sample from this layer measured a Liquid Limit of 36%, a Plastic Limits of 17%, and a corresponding Plasticity Index of 19. The USCS group symbol for this layer is silty clay (CI).

The results of grain size distribution testing and the corresponding plasticity charts for the sample of the clayey silt to silty clay are presented on Figures D8 and D9 of Appendix D, respectively.

5.2.7 Lower Silty Sand

A lower silty sand layer was encountered below the silty clay to clayey silt layer in BH HB-01 at a depth of 19.4 m below ground surface and extended to a depth of 25.5 m (elevation 250.4 m). SPT N-values within this silty sand layer ranged from 53 to 113 blows per 0.3 m penetration, indicating very dense relative density.

Index tests carried out on a representative sample of the silty sand yielded the following results:

Gravel:	0%
Sand:	81%
Silt:	13%
Clay:	6%

Moisture Content: 16 to 23%

The USCS group symbol for this layer is silty sand (SM).

A grain size distribution plot for a representative sample of this layer is displayed on Figure D10 in Appendix D.

5.2.8 Basal Silty Clay to Clayey Silt Till

A basal silty clay to clayey silt till, interlayered with a silty sand, was encountered in Borehole HB-01 at a depth of 25.5 m below ground surface and borehole was terminated within the basal silty clay deposit at a depth of 37.2 m (elevation 238.7 m). A silty sand interlayer was encountered at a depth of 30.6 m below ground surface and extended to a depth of 35.5 m. SPT N-values in the basal silty clay to clay till ranged from 21 to 27 and an undrained shear strength of 121 kPa was interpreted from the single pocket penetrometer test conducted in this layer, indicating a very stiff consistency. The silty sand interlayer is very dense based on the measured SPT N-values of 83 and 85 blows per 0.3 m of penetration. The measured natural moisture contents for the basal silty clay to clayey silt, and silty sand interlayer ranged from approximately 12% to 20% and 17% to 18%, respectively.

Index tests carried out on a representative sample from the clayey silt till yielded the following results:

- Gravel: 4%
- Sand: 25%
- Silt: 40%
- Clay: 31%

Atterberg limits testing carried out on a representative sample from this layer measured a Liquid Limit of 20%, a Plastic Limit of 12**%,** and a corresponding Plasticity Index of 8. The USCS group symbol for this layer is clayey silt (CL).

The results of grain size distribution testing and the corresponding plasticity charts for the sample of the clayey silt to silty clay are presented on Figures D11 and D12 of Appendix D, respectively.

Due to its mode of deposition, glacial tills inherently contain cobbles and boulders.

5.2.9 Bedrock

Bedrock was not encountered in any of the boreholes; the boreholes were terminated prior to achieving the bedrock.

5.2.10 Groundwater

A monitoring well was installed in Borehole HB-01 to observe the long-term groundwater levels. At other boreholes, the groundwater level was inferred based on observations made during drilling operations, and in the open boreholes upon completion of drilling. Cave-in depths, which can be indicative of the groundwater level in granular soils, were also recorded. The groundwater level recorded in HB-01 and inferred in the other boreholes are summarized in Table 5.1 below.

Table 5.1: Measured and Inferred Groundwater Levels

Borehole No	Date	Groundwater Level (m)		Remark
		Depth	Elevation	
HB-01	September 12, 2022	5.3	270.6	
HL-09	Upon completion	dry	-	Caved-in @ 4.3 m
HL-10	Upon completion	1.8	269.8	Caved-in @ 2.4 m
HL-10-1	Upon completion	3.6	269.2	Caved-in @ 3.6 m
HL-11	Upon completion	dry	-	Caved-in @ 3.0 m
HL-12	Upon completion	dry	-	Caved-in @ 2.0 m
HL-12-1	Upon completion	10.1	270.9	Caved-in @ 10.7 m
HL-13	Upon completion	6.8	270.3	Caved-in @ 7.0 m
HL-14	Upon completion	dry	-	Caved-in @ 3.0 m
HL-15	Upon completion	dry	-	Caved-in @ 6.4 m
HL-16	Upon completion	9.6	-	Caved-in @ 9.6 m
HL-17	Upon completion	dry	-	Caved-in @ 3.0 m
HL-18	Upon completion	dry	-	Caved-in @ 3.5 m
MS-09	Upon completion	3.8	268.1	Caved-in @ 4.2 m
MS-10	Upon completion	4.9	269.4	Caved-in @ 5.8 m
S-04	Upon completion	dry	-	Open
S-07	Upon completion	6.7	270.2	Caved-in @ 7.0 m

Fluctuations in the groundwater level due to seasonal variations or in response to a particular precipitation event should be anticipated.

5.3 CHEMICAL TESTING

The results of the chemical analysis on thirteen (13) samples of the fill and native soils are provided in Table 5.2 below.

Table 5.2: Results of Chemical Analysis

Borehole No	Sample No.	Depth (m)	pH	Chloride (µg/g)	Sulphate (µg/g)	Resistivity (Ohm-cm)
HB-01	SS6	4.6 – 5.2	9.04	816	30	699
HL-09	SS4	2.3 – 2.9	7.68	1030	20	535

HL-10	SS4	2.3 – 2.9	9.31	214	11	2310
HL-11	SS6	3.8 – 4.4	8.76	14	5	9090
HL-12	SS2	0.8 – 1.4	8.43	20	14	5380
HL-13	SS12	9.2 – 9.8	8.08	733	16	781
HL-14	SS4	2.3 – 2.9	8.85	23	6	8060
HL-15	SS9	6.1 – 6.7	8.91	89	187	2130
HL-16	SS13	10.7 – 11.4	8.38	253	20	1880
HL-17	SS5	3.1 – 3.7	9.08	14	5	9010
HL-18	SS8	5.3 – 5.9	10.8	1790	196	272
S-04	SS8	5.3 – 5.9	9.41	449	23	1050
S-07	SS8	5.3 – 5.9	7.09	1090	35	478

6.0 MISCELLANEOUS

The field work was carried out under the supervision of Mr. Akshat Shukla, EIT, Mr. Justin Moleta, EIT, Mr. Wuhib Tamrat, EIT, and Ms. Katarina Morgenroth, EIT; under the direction of Mr. Gwangha Roh, Ph.D., P. Eng.

The drilling equipment was supplied and operated by Landshark Drilling based in Brantford, DBW Drilling Inc. based in North York, and Sonic Soil Ltd. based in Etobicoke.

The location and elevation survey of the completed boreholes was carried out by Stantec's Geomatics Group based in London.

Traffic control service was provided by CRH Group Inc.

Geotechnical laboratory testing was carried out at Stantec's Markham laboratory. Chemical testing for pH, soluble sulphate, and chloride content, and resistivity was carried out by Agat Laboratories based in Mississauga.

This report was prepared by Gwangha Roh, Ph.D., P. Eng., and Ms. Roshan Rashed, P. Eng., and reviewed by Raymond Haché, M.Sc., P. Eng., Designated Principal MTO Foundation 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 investigation hole locations. Some variation in conditions between and beyond these locations must be anticipated. Should any conditions at the site be encountered which differ from those described for the investigation hole locations, we request that we be notified immediately to review the additional information and assess if revisions or changes to the content of this report are warranted.

Respectfully Submitted,

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FOUNDATION DESIGN REPORT
For
GWP 3032-11-00
DB Contract Number 2022-3004
Highbury Avenue Interchange Improvement
Highway 401 Rehabilitation from Wellington Road to Highbury Avenue, Design-Build Project
West Region
City of London, Ontario

8.0 DISCUSSION AND ENGINEERING RECOMMENDATIONS

8.1 PROJECT DESCRIPTION AND BACKGROUND

8.1.1 Project Purpose/Description

This project involves the replacement of five structures, Highbury Avenue Interchange improvements, and Highway 401 pavement rehabilitation and improvements. As part of the project, the existing three-span Highbury Avenue bridge carrying Highbury Avenue over Highway 401 will be replaced with a new two-span structure. The interchange improvement will also include the following components: existing bridge approach embankment widening & grade change, median sewer construction, high mast light pole installations, and sign replacement.

This report is for the design and construction of the Highbury Avenue bridge foundations and the approach embankments. Separate reports have been prepared for the remaining foundation elements, including the high mast lights, the overhead signs, and the median sewer.

8.1.2 Proposed Bridge Replacement

Based on the General Arrangement Drawing provided by Stantec Structural team, the proposed bridge will be constructed at a similar alignment (with 22°6' skew angle to the existing Highway 401 centreline) as the existing bridge. The proposed bridge will have two 37 m long spans with a total structural length of 87.4 m (between the wingwall ends) and will be 36.3 m in width. The new bridge will be supported on two abutments and one central pier. The two bridge abutments are designed to be supported on a single row of driven steel H-piles (integral abutments with retaining walls) and the central pier is designed to be supported on a spread footing. The new bridge will be constructed in stages, and existing bridge will be removed. The existing bridge approach embankments will be widened and raised to accommodate the profile of the new bridge.

Key approximate elevations associated with the proposed new underpass are as follows:

• Existing Highway 401 grade	Approximately elevation 276 m
• Propose bridge north abutment bottom	elevation 279.75 m
• Proposed bridge south abutment bottom	elevation 279.53 m
• Proposed Highbury Avenue grade at the central pier	elevation 284.02 m

8.1.3 Degree of Site Understanding and Consequence Classification

The Canadian Highway Bridge Design Code (CHBDC S6-19) requires an assessment of the "degree of site and prediction model understanding" as a component of the geotechnical engineering investigation and/or services. The site and prediction model understanding consider the geotechnical properties of the soils underlying the site and the accuracy and degree of confidence regarding the numerical performance prediction models to be used to estimate the geotechnical serviceability limit states reactions and ultimate limit states resistances.

Based on the scope of subsurface investigations completed and available subsurface information related to this site, a "Typical Understanding" has been adopted for foundation design assessment purposes, except that a "High" degree of understanding has been adopted for assessment of embankment stability where slip surfaces develop through imported/manufactured granular fill materials. MTO highway Standards Branch Provincial Memorandum #2020-01 (dated March 23, 2020) was also considered for the embankment global stability assessment when the majority of critical slip surface is located within the proposed widening section which will be built using controlled materials (high degree of understanding).

The consequence classification has been assumed as "Typical Consequence" in accordance with Section 6.5 of the Commentary on CHBDC S6-19. Should the consequence classification change, the foundation assessment and recommendations provided below should be reviewed and revised accordingly.

8.2 GEOTECHNICAL DESIGN PARAMETERS

The soil conditions encountered at the underpass site generally consist of variable embankment and grading fill materials underlain by native soils consisting of upper deposits of silty clay till and silty sand to sandy silt, underlain by a silt layer and silty clay interlayer, a lower silty sand deposit, and a lower silty clay till deposit.

The results of the current investigation and previous investigations indicated a great consistency of site subsurface conditions both vertically and horizontally throughout the interchange area.

The soil profiles are summarized in Table 8.1 and on Figure E1 in Appendix E. The geotechnical parameters identified in the soil profiles were developed based on a synthesis of the borehole data, the measured penetration resistance values, and laboratory index test results (including moisture contents) of soil samples obtained in the investigation.

Table 8.1: Geotechnical Model for Highway 401 Highbury Avenue Bridge

Elevation (m)		Soil Type	Design Soil Parameters			
From	To		Total Unit Weight γ^3 (kN/m^3)	Drained Friction Angle $\phi'^{\,2}$ (°)	Undrained Shear Strength S_u^2 (kPa)	E(MPa)
Ground Surface	275	FILL: Firm to very stiff SILTY CLAY / loose to dense SILT to SILT and SAND / loose to very dense gravelly SAND.	21.0	32 (granular fill)[4] / 30 (cohesive fills)[4]	75 (cohesive fills)[4]	50 (granular fills)[4] 30 (cohesive fills)[4]
275	272	Very stiff to hard CLAYEYS SILT TO SILTY CLAY (TILL, except for north abutment)	21.0	30	150	50
275	262	Compact to very dense SANDY SILT to SILTY SAND (with SILT zones and interlayers at south abutment)	21.0	33	-	75
262	258	Dense to very dense SILT	20.5	30-32		40
260	257	Stiff to hard SILTY CLAY (Central pier only, below SILT)	21.0	30	125	40
258	248	Compact to very dense SILTY SAND	21.5	34	-	100
248	240	Very stiff to hard, SILTY CLAY (TILL)	22.0	32	275	75

Notes:
N/A Not Applicable
1 Compressibility Parameters: E = Soil Modulus
2 The friction angles are applicable to drained conditions only and the shear strengths are applicable to undrained conditions only
3 A static groundwater level at elevations of 272.5 m is recommended for use in bridge foundation design Submerged unit weight (γ') should be used below the groundwater level.
4 Based on the existing embankment fill performance

The elevations provided on the drawing and table reflect a synthesis of the borehole data; reference should be made to the Borehole Records for the range of conditions encountered.

8.3 FROST PENETRATION

In accordance with OPSD 3090.101, the design frost penetration depth for foundations, f, at the site is 1.2 m. Therefore, all foundation elements such as footings and pile caps should be provided with a minimum of 1.2 m of soil cover or equivalent insulation for protection against frost heaving.

This depth of frost penetration should also be considered in the design of frost tapers adjacent to the bridge abutment and retaining wall backfill zones.

8.4 SEISMIC DESIGN CONSIDERATIONS

8.4.1 Site Class

The seismic site class determination is based on the soil conditions in the upper 30 m of the stratigraphy as encountered in the boreholes for the Geotechnical Investigation.

Based on the current and previously done geotechnical investigations' findings, this site is assessed to be Seismic Site Class D as per CHBDC S6-19 Commentary Table 4.1.

8.4.2 Seismic Performance Category

As per the CHBDC S6-19 Section 4.4.4., a seismic performance category is assigned for each bridge based on the site-specific spectral acceleration, for a 2% in 50-year probability of exceedance, the fundamental period of the bridge, T, in the direction under consideration as well as the importance category. Spectral Sa(0.2) and Sa(1.0) values for NBCC2015 Site Class C are provided in Appendix G.Due to the low spectral acceleration values for the site, even after adjusted for Site Seismic Class D (e.g. F(0.2) x Sa(0.2) and F(1.0) x Sa(1.0)), a Seismic Performance Category (SPC) 1 would apply for this bridge regardless of the bridge return period and importance. As noted below Table 4.10 of the CHBDC S6-19, for lifeline bridges in SPC1, detailing of structural elements shall adopt requirements for SPC 2 as a minimum. As per the CHBDC S 6-19 Section 4.4.5.1., seismic analysis of bridges in SPC1 is not required. However, design forces for retaining elements and bridge support lengths should meet the requirements specified in the CHBDC S6-19 Sections 4.4.10.2 and 4.4.10.5.

8.4.3 Peak Ground Acceleration (PGA)

Seismic hazard values for the Highbury Avenue Interchange site were obtained from Natural Resources Canada (2015 National Building Code Canada, based on Site Class C). Table 8.2 below summarizes the parameters obtained and recommended for use in the design based on a 2475-year return period.

Table 8.2: Peak Ground Acceleration Data

PGA Site Class C	$S_a(0.2)$	PGA_{ref}	Site Class	Site Adjusted PGA
0.067g	0.111g	0.054g	D	0.086g

The 2015 NBC Seismic Hazard calculation sheet is provided in Appendix G.

8.4.4 Liquefaction Potential

The potential liquefaction of the site soil under seismic loading conditions was assessed. The evaluation indicated that liquefaction of the foundation soils is not a concern for this site due to:

(a) low seismic hazards, and
(b) compact to very dense & stiff to hard nature of the site soils

8.5 REPLACEMENT BRIDGE FOUNDATION ENGINEERING DESIGN INPUT

The design recommendations presented in the following sections have been developed in accordance with the requirements and methods described in the Canadian Highway Bridge Design Code (CHBDC, 2019).

8.5.1 Foundation Options

The use of both shallow and deep foundation options was initially evaluated for the proposed bridge replacement.

- Infrastructure Engineering Group (IEG) recommended both shallow and deep foundations for the abutments and piers for their preliminary foundation design (dated July 2012). Due to the shallow depth of high SPT N-values of over 100 blows, recorded consecutively for more than 3 m, IEG recommended relatively short pile length similar to the existing bridge abutment; 6.5 m to 10 m HP 310 x 110 piles, with a factored axial resistance of 1600 kN at ULS and axial resistance of 1100 kN at SLS. The Structural Design Report prepared by Dillon, adopted the Infrastructure Engineering Group foundation recommendations.
- Thurber Engineering (Thurber) carried out the detailed foundation investigation and design for this project in 2016 and recommended driven steel H-piles for the abutments and spreading footing for the central pier. Although the soil stratigraphy reported by Thurber was almost identical to that reported by IEG, for the abutments, they recommended significantly longer pile lengths, possibly due to the lower SPT N-values presented in their report. Thurber recommended the use of over 35 m long piles, with factored axial geotechnical capacities (for HP 310 x 110) of 1200 kN at ULS and 1000 kN at SLS. For the central pier, they recommended shallow foundations constructed on undisturbed native soil below the frost depth.

Stantec's geotechnical investigation revealed SPT N-values that were similar to those reported by Thurber, and therefore the high values reported by IEG have not be considered for design purposes. Based on a detail analysis of the soil type and the SPT N-values, Stantec's analysis shows that the capacities recommended by Thurber can be achieved with shorter piles, which we believe that could avoid the need for pile splicing on site.

Table 8.3 presents the advantages, disadvantages, relative assessment of cost and the risks/consequences for various foundation options for the pier and abutment foundations for the proposed bridge replacement, from a foundation's design and constructability perspective.

Table 8.3: Comparison of Foundation Options for Highway 401 Highbury Avenue Bridge

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
Driven Steel H Piles	• Higher geotechnical resistances than spread footings	• Higher construction cost than spread footings	Medium	• Cobbles and boulders may be encountered in glacially derived soils that could impede pile

Option	Advantages	Disadvantages	Relative Cost	Risk/Consequences
	• Ease of construction • Feasible for integral abutments •	• Possible traffic impact due to large crane and pile driving equipment		penetration to required depths • Possible pile relaxation
Driven Steel Pipe Piles	• Higher geotechnical resistances than spread footings and driven steel H piles	• Higher construction cost than spread footings • Maybe not feasible for integral abutments • More vibration than driven steel H-piles and not good for the proposed staged construction • More driving problems than Steel H-piles • Possible traffic impact due to large crane and pile driving equipment	Medium	• Cobbles and boulders may be encountered in glacially derived soils that could impede pile penetration to required depths • Possible pile relaxation
Drilled Caissons	• Can support/resist higher axial and lateral loads than steel driven piles • Use of caissons at the central pier would reduce excavation and temporary support requirements compared to shallow or pile foundations	• Not suitable for integral abutments • Higher construction cost than other foundation options • Possible traffic impact due to large caisson drilling equipment	High	• Liners and drilling mud likely required due to presence of groundwater. • Use of "wet" installation methods precludes ability to review/confirm materials at the base of the caissons and assess the potential for reduced capacity.
Spreading Footings	• Ease of construction • Maybe suitable for central pier • Lower foundation costs than deep foundations	• Not suitable for integral abutments • Relatively lower geotechnical capacity than deep foundation • Larger foundation areas required compared to pile caps or drilled piers • May increase requirements for roadway protection	Low to medium	• Potential excessive settlement under large loads • Increased potential for differential settlement

Based on the above, the preferred option from a geotechnical/foundations perspective is to support the central pier on spread footings and to support the abutments on driven steel H-piles that derive their load carrying capacity from both shaft adhesion and tip resistance. The steel H-piles would permit the use in an integral abutment configuration.

The use of steel pipe piles in an integral abutment configuration is generally not used in Ontario and would need to be further assessed by the structural designer due to the possible pile flexibility issues. The use of pipe piles and caissons as a foundation option are not discussed further in this report.

Further details on the preferred foundation options are provided in the following sections.

8.5.2 Driven H-Pile Foundations

8.5.2.1 Design Considerations

Driven pile foundations consisting of steel H-piles, deriving their load-carrying capacity from both shaft friction and tip resistance, can be used to support the abutments and pier (if required) of the proposed replacement bridge structure.

The driving of steel H-piles for the new bridge is not expected to adversely affect the existing and newly built structure(s) and approach embankment. However, vibration monitoring should be carried out during the pile driving to confirm this.

Piles should be supplied and installed/constructed in accordance with the requirements of DB SP 903 (amendment to OPSS.PROV 903) – Construction Specification for Deep Foundations.

8.5.2.2 Geotechnical Axial Resistance

Axial Resistance in Compression

The axial resistances at Ultimate Limit State (ULS) for driven steel HP 310x110 were assessed using the Federal Highway Administration (FHWA) and API (American petroleum institute) design methods using the program APILE (Ensoft, 2019). The geotechnical model outlined in Table 8.1 and on Figure E1 were used as input to these analyses.

The factored geotechnical resistances at Ultimate Limit States (ULS) and Serviceability Limit State (SLS) outlined in 4 may be used in design.

Table 8.4: Factored Geotechnical Resistances at ULS and at SLS – Pile Foundations

Pile Type	Anticipated Pile Length[1] (m)	Anticipated Pile Tip Elevation[1] (m)	Factored Geotechnical Resistance at ULS (kN)	Factored Geotechnical Resistance at SLS (kN)
North Abutment				
HP 310 X 110	27.4	253	1200	1000
South Abutment				
HP 310 X 110	27.1	253	1200	1000

Note:

1 Pile lengths and tip elevations are based on the underside of the abutment walls as provided above in Section8.1. plus 600 mm pile embedment into abutment walls.

2 The pile tip elevation target is also to ensure a minimum tip penetration of at least 2 m past the bottom of silt and clayey silt layer which is at el. 258 m.

3 The above pile tip elevations were selected based on a targeted factored ULS geotechnical resistance of 1200 kN using a geotechnical resistance factor of 0.4.

4 If possible, it is recommended that in the early stages of initial pile driving that at least three piles be driven to elevation 256 m and tested using the PDA equipment, no sooner than seven days after initial drive, to determine if targeted pile capacities at ULS can be obtained using shorter piles. The use of early-stage PDA testing would allow an increase of the geotechnical resistance factor from 0.4 to 0.5, which with favourable results could allow for the piles tip elevation to be moved up to elevation 256 m; at elevation 256 m, the pile tips would still be at least 2 m past the bottom of the silt to clayey silt layer.

The unfactored ultimate pile capacity curves are also presented on Figure E2.

In accordance with Table 6.1 in the CHBDC, the ULS Geotechnical Resistances were determined based on a consequence level of “Typical” with a consequence factor equal to 1.

In accordance with Table 6.2 in the CHBDC S6-19 and the site and prediction model understanding classification of “Typical”, a resistance factor of 0.4 (static analysis, compression) has been used in calculating the factored geotechnical resistance at Ultimate Limit State (ULS) and a resistance factor of 0.8 (static analysis, settlement) has been used in calculating a factored geotechnical resistance at Serviceability Limit State (SLS).

8.5.2.3 Downdrag

The proposed underpass structure will be constructed along the similar centreline as the existing bridge. The proposed grade raise in the vicinity of the new underpass is typically less than 1.5 m above existing site grades and majority of embankment widening with higher fill placement will be constructed beyond the new foundation footprint. In addition, the site soils consist predominantly of dense to very dense granular soils and piles are designed to use both shaft and tip resistances. Based on above conditions, the piles are not anticipated to be subjected to significant downdrag loads.

8.5.2.4 Soil Setup, Relaxation and Pile Capacity Validation

No significant soil set up is anticipated for the proposed driven steel H-piles since piles will be predominantly driven through and into the dense to very dense silty sand to sandy silt and silt. However, due to the possible soil particle dilation and negative pore pressure development during pile driving, the ultimate pile capacity may decrease after initial pile driving (known as a "pile relaxation"). It should be noted that actual pile relaxation has not been commonly observed in Ontario. It should also be noted that relaxation is more problematic for end bearing piles and the pile design for this bridge replacement is not purely end bearing (combination of end bearing and shaft resistances) and possible relaxation impact on overall pile capacity will likely not be significant. As well, the targeted tip bearing layer contains approximately 72% to 81% sand size particles, suggesting that excess/negative pore pressures developed during pile driving activities would be dissipated within a few days.

The final pile capacity should be confirmed using a PDA (pile driving analyzer, high strain dynamic testing) after possible pore pressure dissipation. With consideration of site subsurface and groundwater conditions, a seven-day waiting period is suggested for re-tapping and the additional PDA testing.

While driving, as per the RFP section 2.4.9.5 Foundation Design and Construction, and related subsequent bid enquiries (#166 and 176), piles should be driven to a specified ultimate resistance. The specified ultimate resistance should also be validated using dynamic formula analysis (Hiley Formula as per MTO Structural Drawing SS103-11) and high strain dynamic testing at end of drive (EOD) and re-tap/re-strike after sufficient time has passed to allow soil set up. In each pile group, 10% of the piles rounded up to the next whole number, but no fewer than two piles, should be re-tapped to confirm that the ultimate axial geotechnical resistance has been achieved and/or sustained. Pile driving records and testing results should be provided to MTO Foundation Section for information purposes.

Piles should be installed and monitored in accordance with DB SP 903. The following "Pile Driving Note" should be included on the structural drawings:

- Piles to be driven in accordance with Standard SS 103-11 and PDA testing using an ultimate geotechnical resistance of 2400 kN per pile (HP 310X110) based a geotechnical resistance factor of 0.5, but must be driven below EL. 253 m.

As noted above, upon completion of PDA testing, the maximum pile tip elevation will be re-evaluated to determine if the use of shorter piles is appropriate for the project site.

8.5.2.5 Drivability

The pile driving equipment shall be appropriate to the driving conditions and capable of achieving the design pile capacity. The pile termination or set criteria should be dependent on the pile driving hammer type, helmet, select pile size and length. The set criteria should be established at the time of pile driving once the equipment is decided. Based on the hard-driving conditions anticipated and the target pile lengths, it is anticipated that a hammer with a rated energy of about 70 to 80 J/blow will be required, however the piling contractor is responsible for selecting the appropriate pile driving hammer.

The site soil generally consists of compact to very dense granular soils and very stiff cohesive soils including glacial tills. No early termination/refusal of boreholes than the designated hole depths were noted at the site due to possible cobbles and boulders although some auger grindings, gravel and rock fragments within auger cutting and split spoon samples were noticed during Stantec investigation. More than three consecutive SPT N-values more than 100 blows/0.3 m were recorded within the upper sandy silt to silty sand deposit (above elevation 260 m) during the Infrastructure Engineering Group preliminary foundation investigation and it should be considered for a pile drivability evaluation. It is our opinion that those higher SPT blow counts may be due to possible SPT hammer efficiency differences between different investigation phases. Based on Thurber Engineering and current Stantec investigations' findings, no significant pile driving issues are anticipated for the piles driven to elevations 253 m in the interchange area.

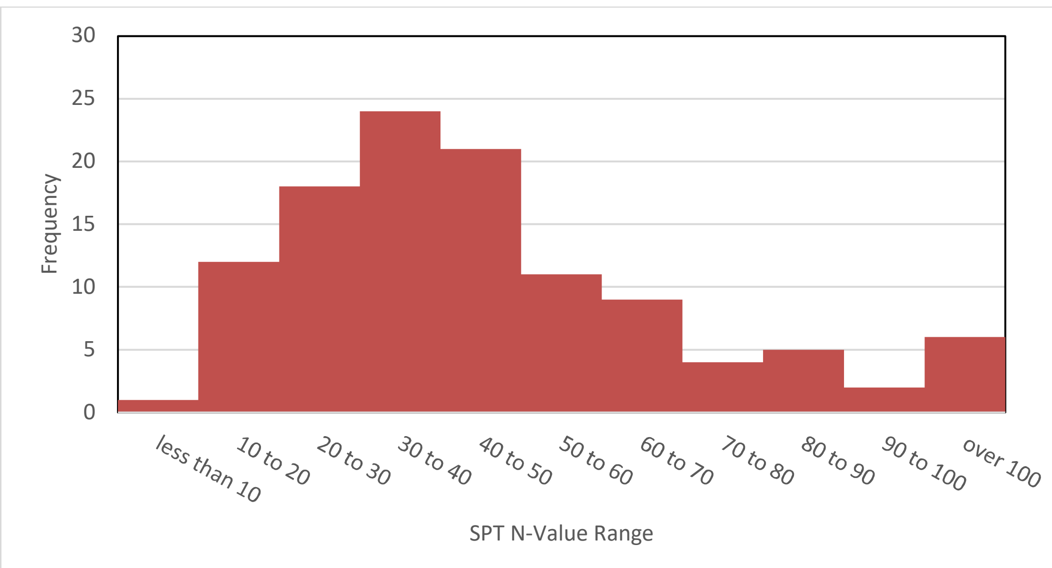

Figure 8.1 Stantec Investigation SPT N-value distribution for the upper sandy silt to silty sand and Silt

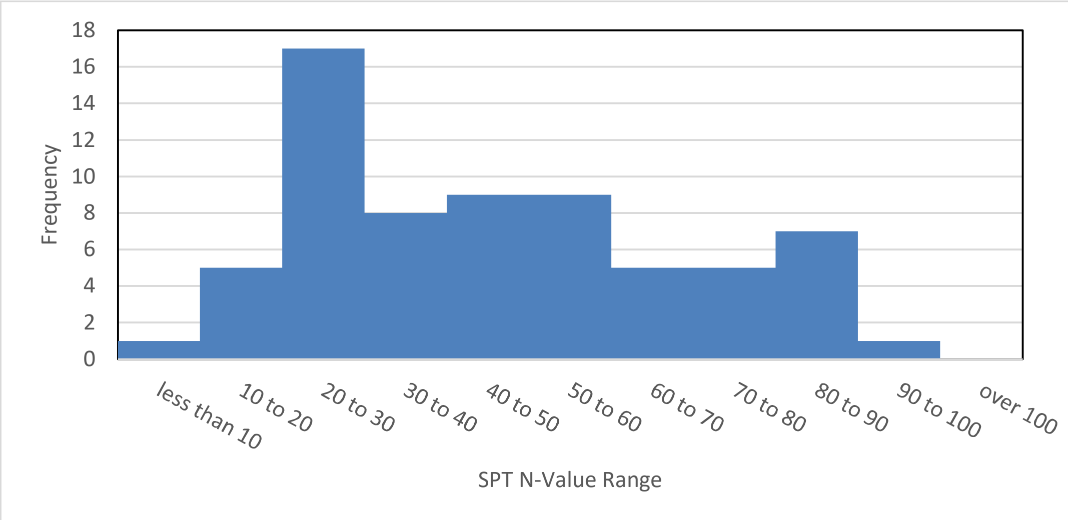

Figure 8.2 Thurber Investigation SPT N-value distribution for the upper sandy silt to silty sand and Silt

8.5.2.6 Pile Lateral Resistance

The response of a pile to lateral loads is a non-linear relationship. Non-linear elastic-plastic springs (i.e. p-y curves representing the load intensity per unit length of pile (p) versus the lateral deflection of the pile) can be used in evaluating the structural response of the pile in response to lateral loads.

The program LPile 2019 developed by Ensoft, Inc. (Ensoft, 2019) was used to develop p-y curves for a single 310x110 H-pile. The geotechnical input parameters that were used in the analyses for the piles for abutments are presented in Table 8.1. with strength parameters associated with the loose sand backfill placed within the CSP liners.

The p-y curve values versus depth for the HP 310x110 are presented in Figure E-3 in Appendix E. These table provide a series of curves obtained from the LPILE program generated for selected depths below the pile head. The p-y curves can be used in the structural evaluation of the H-piles noting that the p-y curves provided are unfactored and that appropriate resistance factors (i.e. as outlined in Table 6.2 of the CHBDC, 2019) should be applied when assessing the geotechnical lateral resistances of the piles at ULS and SLS. Group reduction factors as per CHBDC S6-19 Commentary should also be applied for p-y curves to account for pile group action as necessary.

When carrying out p-y based analysis, the ultimate lateral resistance of the pile (ULS) is generally taken as the structural capacity of the pile laterally supported by the p-y springs or a maximum displacement defined by the structural engineer.

Based on the LPILE analysis carried out using the soil properties provided in Table 8.1, the following unfactored lateral pile capacities have been calculated a HP310x110 pile with a fixed head condition (as per the MTO Report S0-96-01 Integral Abutment Bridges). No pile axial loads were considered for this analysis.

- Strong axis – 175kN with a corresponding 10 mm of pile head deformation
- Strong axis – 340 kN with a limiting 50 mm deformation at the pile head
- Weak axis – 110 kN with a corresponding 10 mm of pile head deformation
- Weak axis – 210 kN with a limiting 50 mm deformation at the pile head

Where no limiting deformation is applied to the pile head, the LPILE result represents the structural capacity of the pile.

A geotechnical resistance factor of 0.5 and 0.8 should be applied to obtain the lateral resistances at ULS and SLS, respectively.

8.5.2.7 Axial Resistance in Tension

For design against uplift, the tensile resistance provided in Table 8.5 is recommended.

Table 8.5: Recommended Uplift Resistance – Pile Foundations

Pile Type	Assumed Pile Length (m)	Factored Geotechnical Resistance (Tension) at ULS (kN)
HP 310 X 110	27*	550

*The 27 m pile length includes up to about 5 m within a CSP flex zone and 0.6 m embedement into the concrete abutment which have not been included as part of the factored geotechnical resistance.

A resistance factor, ϕ_{gu}, of 0.3 has been applied to calculate the ULS resistance. The factored geotechnical resistance (tension) at ULS provided above does not include the self-weight of the pile.

8.5.2.8 Other Pile Details

To facilitate pile installations, embankment fill through which piles will be driven must not contain any material with particle sizes greater than 75 mm. Pre-augering may be required through the existing embankment fill and surficial clayey silt till if large obstructions are noted during initial construction phase.

Due to the mode of deposition, glacial derived soils may contain cobbles and boulders. To be able to penetrate boulders, cobbles and hard/very dense zones to achieve the required pile resistance, it is recommended that the pile tips be reinforced with driving shoes such as the Titus Standard Points / APF hard bite for H Piles or approved equivalent. Further consideration can also be given to use heavier pile section to minimize potential pile damages.

Piles supporting integral abutments require a minimum 3 m long flex zone which is a CSP filled with loose uniform sand to maintain the pile flexibility. The flex zone sand fill gradation should meet the requirements in the MTO integral abutment Bridges Report SO-96-01 and SP BRDG0007.

8.5.3 Spread Footings

Based on the latest GA drawing, available workspace and prevailing subsurface conditions at the proposed central pier location, consideration can be given to using spreading footings placed on undisturbed native silt and sand or clayey silt till above groundwater table. The highest groundwater table measured at the central pier location is about 5.3 m (about elevation 270.6 m) below the existing highway grade. Roadway protection system will be required for the footing construction.

All footing excavations will need to be inspected, assessed, and approved by a Geotechnical Engineer to confirm the founding subgrade conforming the design requirements and has been properly prepared to receive concrete. If a siltier subgrade which could be more susceptible to disturbance and degradation on exposure to environments and construction traffic, is encountered during the foundation excavation, a concrete working slab should be considered to protect the founding subgrade. All unsuitable material within foundation footprint should be sub-excavated and backfilled with approved granular material with proper construction quality control.

All footings should be provided with a minimum of 1.2 m of earth cover or equivalent thermal insulation over the footing base as protection against frost action.

8.5.3.1 Vertical and Lateral Resistances

The geotechnical resistances and founding elevation provided in Table 8. below can be used for the bridge central pier foundation design

Table 8.6: Recommended Vertical Resistances -Spread Footings

Foundation Element	Founding Elevation (m)	Footing Width (m)	Factored Geotechnical Resistance at ULS (kPa)	Factored Geotechnical Resistance at SLS (kPa)
Central Pier (Spread Footing)	273	3 to 5 m	385	250

The above geotechnical resistances are for a concentric vertical load only. In accordance with Table 6.2 in the CHBDC S6-19 and the site and prediction model understanding classification of “Typical”, a resistance factor of 0.5 (bearing, analysis) has been used in calculating the factored geotechnical resistance at Ultimate Limit State (ULS) and a resistance factor of 0.8 (analysis, settlement) has been used in calculating a factored geotechnical resistance at Serviceability Limit State (SLS).

The unfactored horizontal resistance of the mass concrete footing may be calculated using the following unfactored coefficients of friction:

- 0.55 between OPSS Granular A and cast in place concrete
- 0.45 between clayey silt till and cast in place concrete
- 0.45 between sandy silt to silty sand, and silt to sand, and cast in place concrete

In accordance with Table 6.2 of the CHBDC S6-19, a resistance factor against sliding of 0.8 should be applied to obtain the resistance at ULS.

8.6 LATERAL EARTH PRESSURES

8.6.1 Abutment Backfill

Ontario Provincial Standard Drawing (OPSD) 3101.150 outlines the required extent of the granular backfill zone at the bridge abutments. The materials used as backfill behind the proposed bridge abutments should consist of free-draining granular fill placed and compacted using methods and equipment appropriate to the type of structure. For the purpose of this report, it is assumed that backfill materials meeting the requirements of OPSS Granular B (Type I or Type II) or Granular A materials will be used.

Excavation and backfill for the new bridge structure should be carried out in accordance with DB SP 902 (amendment to OPSS 902) Construction Specification for Excavation and Backfilling – Structures. Backfill materials should meet the requirements of OPSS.PROV 1010 and be placed and compacted in accordance with the requirements of OPSS.PROV 206 and OPSS.PROV 501, respectively.

8.6.2 Static Lateral Earth Pressures

Static lateral earth pressures will need to be considered in the design of abutments, retaining walls (wingwalls) and retained soil systems. These structures should be backfilled using imported free-draining granular fill materials meeting the gradation requirements of OPSS Granular A or Granular B Type I materials.

Computation of earth pressures should be in accordance with Section 6.12 of the CHBDC. For retaining walls that are designed to allow rotation, active earth pressure may be used for design. For rigidly tied and unyielding structures, the at-rest earth pressure should be used for design. The effects of compaction should be accounted for by applying a compaction surcharge as outlined in Section 6.12.3 and as shown in Figure 6.8 of the CHBDC. Where applicable (i.e. where unbalanced water pressures may develop), the structures should also be designed to account for hydrostatic pressures.

The total at rest, (P_O) active (P_A) and passive (P_P) thrusts can be calculated using the following equations:

$$P_A = \frac{1}{2} K_a \gamma H^2$$
$$P_O = \frac{1}{2} K_o \gamma H^2$$
$$P_P = \frac{1}{2} K_p \gamma H^2$$

where H is the height of the wall and γ is the unit weight of the backfill soil. Values for K_a, K_p, K_o and γ are provided in Table 8.7 for horizontal backfill conditions. These values should be adjusted if sloped backfill is considered. The thrust acts at a point one third up the height of the wall.

Table 8.7: Recommended Non-Seismic Earth Pressure Parameters (Horizontal Backfill)

Parameter	OPSS Gran B Type I	OPSS Gran A and Gran B Type II	Existing Fill Materials
Bulk Unit Weight, γ (kN/m^3)	22	22	21
Effective Friction Angle, Φ (°)	32	35	28

Coefficient of Earth Pressure at Rest, K_o	0.47	0.43	0.53
Coefficient of Active Earth Pressure, K_a	0.31	0.27	0.36
Coefficient of Passive Earth Pressure, K_p	3.25	3.69	2.77

*this granular material should be tested to confirm the friction angle and compacted density as per relevant OPSSs

8.6.3 Seismic Lateral Earth Pressures

The following design parameters are provided for use in assessing the earth pressures induced on the bridge abutment and wingwalls under seismic loading conditions.

The total active and passive thrusts under seismic loading conditions can be calculated using the following equations:

$$P_{AE} = \tfrac{1}{2} K_{AE}\, \gamma\, H^2 (1 - k_V)$$

$$P_{PE} = \tfrac{1}{2} K_{PE}\, \gamma\, H^2 (1 - k_V)$$

where:

K_{AE} = active earth pressure coefficient (combined static and seismic)

K_{PE} = passive earth pressure coefficient (combined static and seismic)

H = height of wall

k_h = horizontal acceleration coefficient

k_v = vertical acceleration coefficient

γ = total unit weight

For this site, the following design parameters were used to develop the recommended K_{AE} and K_{PE} values as per CHBDC 2019.

Table 8.8: Seismic Design Parameters to Estimate Lateral Earth Pressures

Site Adjusted PGA	Horizontal Acceleration Coefficient, k_{ho}	Horizontal Acceleration Coefficient, k_h
	Non-Yielding	Yielding $(wall\ movements\ of\ 25\ mm\ to\ 50\ mm)$
0.0864g	0.086	0.043
Note: k_{ho} is the seismic horizontal acceleration coefficient that corresponds to zero wall movement and is equal to the site-adjusted PGA estimated at ground surface. The vertical acceleration coefficient (k_v) should be ignored in the calculations as per CHBDC 2019, section C4.14.7.2.		

The angle of friction between the soil and the wall has been set at 0° to provide a conservative estimate.

The seismic earth pressures may be calculated using the parameters detailed in Table 8.9 for horizontal backfill configuration. These values should be adjusted if sloped backfill is considered.

Table 8.9: Recommended Seismic Earth Pressure Parameters (Horizontal Backfill)

Parameter	OPSS Gran B Type I	OPSS Gran A and Gran B Type II	Existing Fill Materials
Bulk Unit Weight, γ (kN/m3)	**22**	**22**	**21**
Effective Friction Angle	**32**	**35**	**28**
Passive Earth Pressure, (KPE)	**3.18**	**3.61**	**2.70**
Height of Application of PPE from base as a ratio of wall height, (H)	**0.327**	**0.327**	**0.326**
Yielding Wall			
Active Earth Pressure (K_{AE}) for Yielding Wall	0.33	0.29	0.39
Height of Application of P_{AE} from base as a ratio of wall height, (H) for Yielding Wall	0.353	0.354	0.352
Non-Yielding Wall			
Active Earth Pressure (K_{AE}) for Non-Yielding Wall	0.36	0.32	0.42
Height of Application of P_{AE} from base as a ratio of wall height, (H) for Non-Yielding Wall	0.372	0.374	0.369

8.7 APPROACH EMBANKMENT GRADE RAISE AND WIDENING

The maximum height of the existing bridge approach embankments is about 6.5 m above the surrounding grade, and existing embankment side slope is slightly flatter than 2H:1V. As mentioned earlier, no visible signs of embankment instability or settlement were noted during the site reconnaissance and borehole investigation.

Widening and grade raise of the existing bridge approach embankment are proposed as part of the Highbury Avenue interchange improvement. As per the cross-sections provided, a 1.0 m to 1.5 m grade raise, accompanied with a 5 m to 10 m wide embankment widening, is proposed at each abutment location, at the embankment crest level, on both sides of the existing embankment. The proposed embankment widening will gradually narrow down to match to the existing embankment cross-sections within 75 m of the new bridge abutments. and only minor widenings and grade raises will be required beyond those distances. In addition to the bridge approach embankment widening, about 50 m long section of Highbury Avenue embankment near the existing W-N/S ramp will be widened. The existing embankment height at that section is about 3-4 m above the surrounding grade.

The proposed embankment widening will include typical 2H:1V side slopes, and if the overall embankment height will be more than 8 m; a mid-slope bench will be provided for maintenance as per OPSD 202.010. It is assumed that all widening works on embankments taller than 4.5 m will be carried out using OPSS 1010 SSM (or other compactible inorganic granular materials which can have an internal friction angle greater than 30 degrees after placement) and that embankment widening will be carried out in accordance with relevant MTO standards such as OPSS.PROV 206 (subgrade preparation embankment construction) and OPSS.PROV 501 (compaction, quality control).

In areas where new fill is to abut the existing embankment fill, the existing fill surface should be properly benched in accordance with OPSD 208.01. To reduce surface water erosion on the granular embankment side slopes, topsoil and seeding as per OPSS.MUNI 802 (Topsoil) and OPSS.PROV 804 (Seed and Cover) should be carried out as soon as possible after widening of the embankments. It is also imperative that the designs include provisions for preventing surface water flow on the embankment side slope face. Consideration can be given to using a mountable curb and gutter arrangement to control and divert surface water away from the top of the slope. Surface water must be properly directed to armoured outfalls/outlets designed to drain into road and highway ditches.

In addition to the embankment widenings, interchange ramps S-W and N-E will be realigned The proposed ramp realignments will be done over the existing and widened Highbury Avenue embankment side slopes (typically 2H:1V) and existing highway ramp side slopes. The proposed ramp realignment will also have typical 2H:1V or flatter side slopes. As mentioned above, all relevant OPSSs and OPSDs should also be implemented for the proposed ramp realignment. Embankment side slope protection and surface water control will also be required for the ramp realignment.

For reference, selected Highbury Avenue embankment cross sections are included in Appendix F.

8.7.1 Embankment Stability

Slope stability analyses were carried out at the critical sections of the Highbury Avenue embankments, at the north and south abutments where the embankment is highest and the side slope is steepest, using the commercially available slope stability analysis software, SLOPE/W (GeoStudio 2020). The input geotechnical design parameters are summarized in Table 8.1.

A minimum factor of safety of 1.3 to 1.4, corresponding to resistance factor 0.7 and 0.75 as per the MTO Provincial Engineering Memorandum # 2020-01 dated March 23, 2020, was considered to evaluate the risk of a static, deep-seated embankment instability (global). The target factor of safety used for specific cases depended on the materials intercepted by the critical slip circles.

The results of a slope stability analysis of bridge approach embankment and embankment widening are presented on Figures E4 to E14 in Appendix E. The results of these stability analyses indicate that the proposed embankment grade raise and widening with a 2H:1V side slope are acceptable (FOS>1.3 to 1.4), and there are no significant concerns about global slope instability due to the proposed interchange improvement. Pseudo-static slope stability analyses were also carried out on selected embankment sections and factors of safety higher than 1.2 were obtained. No specific stability analyses were carried out for the proposed ramp realignment but based on the anticipated embankment height, 2H:1V or flatter side slopes and consistent site subsurface conditions, no global stability concerns are expected for the proposed ramp realignment.

8.7.2 Embankment Settlements

The proposed embankment grade raise and widening, and the ramp realignment will induce settlement of existing embankment fills and native soils (immediate settlement for granular soils and recompression of cohesive soils). A two-dimensional finite element analysis using Rocscience RS 2 (2D finite element analysis) was carried out for the most critical embankment cross-section to check the magnitude of settlements across the crest of the embankment(for the proposed road pavement portion). The soil parameters provided in Table 8.1 were used and the FEM analysis results are presented in Figures E15 to E17in Appendix E. Based on the prevailing subsurface conditions (predominantly granular soils and limited over-consolidated clayey till), it is expected that majority of the settlement will occur during the planned staged construction. If possible, it would be beneficial to place all major embankment widening before the winter shutdown period to minimize any long-term settlement potential (especially for the ramp realignments).

In addition to the above settlement, the self-weight settlement of new fill (for the grade raise and embankment widening) should also be considered. Approximately 0.5% of the new fill height is typically considered as a self-weight settlement for well-compacted inorganic granular earth fills, which can take one to two years to complete. Self-weight settlement of well- compacted OPSS 1010 SSM, and Granular A and B materials are generally significantly less than that of inorganic granular earth fill.

The results of the post-construction and self-weight fill settlement analyses will be generally under the MTO Embankment Settlement Criteria for Design, dated July 2010 (total settlement of 50/75 mm and differential settlement of 200:1/100:1 for freeways/non-freeways & longitudinal transitions). In conclusion, there are no significant post-construction settlement concerns for the proposed interchange improvement including ramp realignments. As per the RFP, embankment and road pavement settlements should be monitored.

8.8 RETAINED SOIL SYSTEM (RSS) WALL

The RSS false abutments are shown on the latest GA drawing. For the design of the RSS walls, the guidelines included in the following documents should be considered:

- CHBDC Section 6.19 – Mechanically Stabilized Earth Wall Systems (CHBDC S6-19)
- Design, Construction, Maintenance, and Inspection Guide for Mechanically Stabilized Earth Walls (TAC, 2017)
- RSS Design Guidelines (MTO, 2008)
- CFEM Chapter 27 – Reinforced Soil Walls (CFEM, 2006)

Retained soil systems are listed in the MTO Designated Sources of Materials (DSM) and under Special Provisions 599S22 and 599S23.

The proposed RSS walls are in the order of 5 m in height. The proposed RSS wall height may be limited to 5 m to meet the MTO Bridge office #2019-02 Provincial Engineering Memorandum requirements for

RSS false abutment walls to minimize potential serviceability issues. The vertical RSS wall shown on the GA drawing should be "high performance" and "high appearance" RSS wall system as per the MTO DSM.

The subsurface conditions encountered at the bridge abutment locations were found suitable to support 5 m high vertical face RSS wall. The bearing capacities and founding level provided in Section 8.5.3 Spread Footings may be considered for a preliminary RSS mass (soil with reinforcement) stability and serviceability assessment. Depending on the actual reinforced zone dimension, those bearing capacities should be adjusted.

Since the proposed RSS wall will be mostly constructed within the area of existing bridge approach embankment, which will be removed due to the proposed longer bridge, no significant settlement related RSS serviceability issues are expected.

An unfactored friction coefficient of 0.4 between silty sand to clay silt till subgrade to the RSS mass base can be considered for a sliding stability evaluation.

The earth pressure input provided in Section 8.6 should also be used for stability evaluation. As per the GA drawing, the embankment above the RSS wall will be retained by the concrete abutment stem and wing walls; the soils retained by the abutment wall should be considered as a surcharge load to be supported by RSS wall.

Typically, the RSS facing panels are supported on a row of concrete blocks supported on a compacted granular levelling pad. The required minimum wall embedment, bench width and other detail dimensions can be found in the CHBDC S6-16 Section 6.19, and in the MTO RSS design guidelines.

A global RSS wall stability assessment was carried out using the commercially available slope stability software Slope/W by GeoStudio. Since the proposed RSS reinforcement length is not provided on the GA drawing, an RSS width of 6.2 m was assumed for our analyses; typically the reinforcement length is at least 70% of the RSS wall height, but may need longer for this site due to the overall bridge abutment height being about 8-9 m. For the analysis, it was assumed that the whole integral abutment stem, wing wall, and RSS consisted of a monolithic high-strength block to force the theoretical slip surfaces beneath the block. Based on the analysis results, no global stability issues are noted. The analysis results (including pseudo-static analysis) are presented in Figures E18 to E21 in Appendix E.

Since RSS wall systems are proprietary products, an internal stability of RSS wall and other details are the responsibility of RSS wall supplier(s). The back cut slope of RSS wall should also be discussed with RSS wall designer to evaluate proper earth thrust from the backfill. All RSS backfill materials and compaction control should meet the RSS supplier's minimum requirements

8.9 CEMENT TYPE AND CORROSION POTENTIAL

The results of the analytical tests on thirteen (13) samples of the fill and native soils are presented in Section 5.3 and Appendix D.

As per the MTO Structural Manual (2021) section 2.8.5, concrete is considered subject to sulphate attack when

- Water-soluble sulphate (SO_4) content of the adjacent soil is equal to or greater than 0.10%; or,
- Sulphate (SO_4) in groundwater is equal to or greater than 150 mg/L.

When concrete is identified as subject to sulphate attack, the concrete shall be resistant to sulphate attack as required by Special Provision CONC0006. Based on the test results, concrete will not be subject to sulphate attack for the proposed interchange improvement area (water soluble sulphate in soil samples <0.10% which is equivalent to 1000µg/g).

In addition, the analytical test results were compared to CSA A23.1 Table 3 Additional requirements for concrete subject to sulphate attack on concrete. The sulphate concentrations measured in the tested samples are below the exposure class of S-3 (Moderate). Similar corrosivity test results were obtained by Thurber Engineering. Therefore, based on the samples tested, when the designer is selecting the exposure class for the structure, the effects of sulphates may not need to be considered.

Based on the results of the samples tests and given that the structure is located across the highway and local road and will be exposed to de-icing salt, consideration should be given by the designer to designing for a “C” type exposure class as defined by CSA A23.1 Table 1.

The analytical test results were also compared to Table 7.2 of the U.S. Federal Highway Administration Publication No. FHWA-NHI-14-007 (2015) Criteria for Assessing Ground Corrosion Potential for the potential attack on buried steel. The results are provided below in Table 8.10.

Table 8.10: Results of Corrosion Potential Assessment (FHWA-NHI-14-007)

Borehole No	Sample No.	Depth (m)	Ground Corrosion Potential
HB-01	SS6	4.6 – 5.2	Aggressive
HL-09	SS4	2.3 – 2.9	Aggressive
HL-10	SS4	2.3 – 2.9	Aggressive
HL-11	SS6	3.8 – 4.4	Non-Aggressive
HL-12	SS2	0.8 – 1.4	Non-Aggressive
HL-13	SS12	9.2 – 9.8	Aggressive
HL-14	SS4	2.3 – 2.9	Non-Aggressive
HL-15	SS9	6.1 – 6.7	Aggressive
HL-16	SS13	10.7 – 11.4	Aggressive
HL-17	SS5	3.1 – 3.7	Aggressive
HL-18	SS8	5.3 – 5.9	Aggressive
S-04	SS8	5.3 – 5.9	Aggressive
S-07	SS8	5.3 – 5.9	Aggressive
16-04 (Thurber)(	SS6	3.0-3.6	Aggressive
16-05 (Thurber)	SS5	3.0-3.6	Aggressive

Borehole No	Sample No.	Depth (m)	Ground Corrosion Potential
16-06 (Thurber)	SS9	9.0-9.6	Aggressive

It should be noted that the final selection of exposure class and corrosion mitigation measures is the responsibility of the design engineer who will take into account all design considerations including CSA A23.1 Section 4.1.1 durability requirements.

9.0 CONSTRUCTION CONSIDERATIONS

9.1 CONSTRUCTION STAGING

As per the staging drawing, a part of the new Highbury Avenue bridge will be constructed first to maintain the road traffic prior to demolition of existing bridge. The construction of the foundations for the new central bridge pier is anticipated to involve staging and lane-reductions on Highway 401 using appropriate traffic control. The use of a temporary roadway protection system will also be required near the centerline of existing Highway 401.

9.2 TEMPORARY PROTECTION SYSTEMS

Temporary protection systems (TPS) may be required to protect traffic on Highway 401 or to maintain traffic on Highbury Avenue during construction of the approach embankments and the new bridge.

The contractor will ultimately be responsible to develop and implement a roadway protection system meeting the requirements of SP DB 539 (amendment to OPSS.PROV 539), including establishing appropriate geotechnical design parameters.

The following table compares the available roadway protection options considered for the proposed rehabilitation:

Table 9.1: Comparison of Roadway Protection Systems

Option	Advantages	Disadvantages	Relative Cost	Risk & Consequences
Soldier Piles with timber lagging; struts/rakers or tiebacks/anchors	• simple installation process	• Additional labour required • Groundwater seepage into the excavation can occur without groundwater control • Removal of soldier piles can be difficult	Low	• Potential for groundwater seepage and loss of ground unless groundwater control measures are implemented • Potential for minor loss of ground at rear of lagging

Option	Advantages	Disadvantages	Relative Cost	Risk & Consequences
Steel sheet piles (SSP) with/without tiebacks/anchors	• Simple installation process • Provides cut-off to groundwater seepage	• Difficult to drive/install in soils where cobbles/boulders are present • May require large sections where cantilever design is adopted	Medium	• Potential for sheet piles to either be damaged, deflected or meet refusal due to obstructions

Both temporary support systems described in the table are considered feasible for use. The use of interlocking steel sheet piles may be more viable option for the central pier foundation construction to maintain a dry excavation during footing construction.

The temporary support systems should be supported with struts or rakers from the construction side or tiebacks/ground anchors.

Roadway protection design should generally meet the requirements of Performance Level 2 in accordance with DB SP 539 and should consider traffic loading. Performance Level 2 specifies a Maximum Angular Distortion of 1:200 and a Maximum Horizontal Displacement of 25 mm. Strut, raker, or tieback design, if and as required, must be designed not to exceed these limits. Horizontal movement of the temporary roadway protection system should be monitored throughout the bridge replacement process as described in DB SP 539. If more stringent temporary excavation support performance criteria is considered to be necessary for the proposed staged construction immediately next to the existing and newly built bridge structures, a roadway protection design should be developed in accordance with relevant performance levels of DB SP 539.

9.3 EXCAVATION AND BACKFILLING

Excavation and backfilling for the new bridge structure should be carried out in accordance with OPSS.PROV 902 Construction Specification for Excavation and Backfilling – Structures.

Any vegetation, fill, organic soils, and other deleterious materials must be removed from beneath the areas of the proposed bridge foundations and associated retaining/wing walls. Where deleterious materials are encountered at the foundation subgrade level, the materials should be excavated, removed, and replaced with compacted granular fill materials. The lateral extent of the zone of sub-excavation (and replacement) should include all deleterious material within the influence zone of any/all foundation elements.

All side slopes for open cut excavations should conform to the Occupational Health and Safety Act regulations for Construction Projects (OHSA). The construction of the new center pier will require excavation through the existing highway pavement structure and underlying fill materials and native soils. The construction of the new bridge abutments will require excavation through the existing materials in the Highbury Avenue approach embankment fill and additional fill material placed for the proposed embankment widening and grade raise. The lower portion of the fill in the existing approach embankment is likely to consist of general earth fill. The underlying native soils consist of very stiff clayey silt till and compact to dense sandy silt to silty sand. Where space permits, these excavations may be developed using open-cut methods. The fill materials (above the water table) and the native soils above groundwater table would be classified as Type 3 soils.

OHSA indicates that temporary excavations made within Type 3 soils that are above the water table and/or dewatered prior to excavation should be developed with side slopes no steeper than 1H:1V.

Grading work should be carried out in accordance with OPSS.PROV 206 Construction Specification for Grading and SP 206S03. For the proposed embankment widening, the new fill materials should be benched into the existing embankments in accordance with OPSD 208.010.

9.4 GRADE RAISE, EMBANKMENT WIDENING, RAMP REALIGNMENT AND RSS WALL CONSTRUCTION

All unsuitable materials within the proposed embankment widening, ramp realignment and RSS wall footprints should be removed, and the exposed subgrade should be inspected and approved by geotechnical engineer. If required, sub-excavation and backfill with proper material will be required to support the embankment widening, ramps and RSS wall. All excavation should be done in accordance with the OHSA outlined in Section 9.3.

The proposed embankment widening and ramp realignment will include typical 2H:1V side slopes, and if the overall embankment height will be more than 8 m; a mid-slope bench will be provided for maintenance as per OPSD 202.010. It is recommended that embankment and ramp higher than 4.5 m should be constructed using OPSS 1010 SSM material (or other compactible inorganic granular materials which can have an internal friction angle greater than 30 degrees after the placement) to maintain the embankment slope stability. The use of inorganic compactible granular and/or low plasticity clayey fill materials may be considered for lower than 4.5 m high embankment and ramp construction which are typically beyond the foundation work scope. To minimize the possible self-weight fill settlement, construction difficulties and side slope maintenance, consideration can be given to the use of OPSS 1010 Granular materials. All embankment widening and ramp realignment should be carried out in accordance with relevant MTO standards such as OPSS.PROV 206 (subgrade preparation embankment construction) and OPSS.PROV 501 (compaction, quality control). In areas where new fill is to abut the existing embankment fill, the existing fill surface should be properly benched in accordance with OPSD 208.01.

All RSS fill materials and compaction control should meet the RSS supplier’s minimum requirements

To reduce surface water erosion on the granular embankment side slopes, topsoil and seeding as per OPSS.MUNI 802 (Topsoil) and OPSS.MUNI 804 (Seed and Cover) should be implemented as soon as possible after the embankment widening and ramp realignment. Temporary erosion control during construction should also be carried out as per OPSS.PORV 804.

9.5 UNWATERING (GROUNDWATER CONTROL)

The groundwater level was measured at elevations of approximately 266.0 m, 272.5 m, and 270.6 m in the monitoring wells installed in Borehole BHs16-04, BH 16-06 and BH HB-01, respectively. These elevations are about 2.5 m to 10 m below the existing ground surface adjacent the highway.

Excavation required for the central pier foundation will likely be above the static groundwater level. Temporary unwatering, using conventional sump and pump techniques, should be anticipated for excavations and should be satisfactory to handle seepage and infiltration of groundwater into excavations within the underlying native clayey silt till and the silty sand to sandy silt deposits.

All groundwater control systems required for the construction of the replacement bridge should be designed and implemented in accordance with NSSP FOUN0003.

Ultimately, the design of dewatering/unwatering systems is the responsibility of the contractor. Depending on the water taking/dewatering volumes and source(s) of water, the dewatering activities may require a Permit to Take Water (PTTW) from the Ministry of Environment, Conservation and Parks (MECP) or registration of the water taking activity in the Environmental Activity and Sector Registry (EASR). The permit/registration requirements are outlined in Table 1.0 of CDED B517.

9.6 INSTRUMENTATION AND MONITORING

An Instrumentation and Monitoring Plan should be prepared at least 3 months prior to commencement of earthworks for the construction widening of the approach embankments and bridge replacement. The Plan should include the following:

- Monitoring before, during and after construction to check the safety of the work
- Discussion of potential for ground movements and impacts to Highbury Avenue, Highway 401, existing and newly built bridge structures;
- Construction vibration monitoring;
- Buried utility monitoring within the earthwork zone of influence;
- Temporary protection system monitoring as per DB SP 539.
- Settlement surveys should be carried out before, during, and following construction. As a minimum, monitoring is expected to include survey points along the existing road surface and on the existing bridge abutments. Post-construction differential settlement between abutments and abutment approaches should be taken at months 3, 6, 12, 18 and 24 of the general warranty period, starting immediately after paving is complete; elevations at the centreline of each lane should be measured at all bridge abutments, and at distances of 20 m, 50 m, 75 m, and 100 m from the abutments.

10.0 SPECIFICATIONS

The following specifications are referenced in this report:

Table 10.1: Specifications Referenced in Report

Table 10.1: Specifications Referenced in the Report

Document	Title
NSSP FOUN0003	Dewatering Structure Excavations
OPSS.PROV 206	Grading
OPSD 202.010	Slope Flattening Using Surplus Excavated Material on Earth or Rock Embankment
OPSD 208.010	Benching of Earth Slopes
OPSS.PROV 212	Construction Specification for Earth Borrow
OPSD 3000.100	Foundation, Piles, Steel H-Pile Driving Shoe
OPSD 3090.101	Foundation Frost Depths for Southern Ontario
OPSD 3101.150	Walls, abutment, backfill – Minimum Granular Requirements
OPSS.PROV 206	Construction Specification for Grading
OPSS.PROV 501	Construction Specification for Compacting
OPSS.PROV 539	Construction Specification for Temporary Protection System
OPSS.PROV 902	Construction Specification for Excavation and Backfilling – Structures
OPSS.MUNI 802	Construction Specification for Topsoil
OPSS.MUNI 804	Construction Specification for Seed and Cover
OPSS.PROV 804	Construction Specification for Temporary Erosion Control
OPSS 805	Construction Specification for Temporary Erosion and Sediment Control Measures
OPSS.PROV 902	Construction Specification for Excavating and Backfilling-Structures
OPSS.PROV 903	Construction Specification for Deep Foundations
OPSS.PROV 1010	Material Specification for Aggregates
SP517F01	Amendment to OPSS 517, July 2017
SP105S10	Construction Specification for Compaction
SP109S12	Amendment to OPSS 902, November 2010
SP 206S03	Earth Excavation, Grading
SP 599S22	Retained Soil System, (Design and Construction Requirements)
SP 599S23	Retained Soil System (Requirements for Materials and QC/QA testing)
DB SP 539	Amendment to OPSS 539
DB SP 902	Amendment to OPSS 902
DB SP 903	Amendment to OPSS 903
SP BRDG0007	CSP for Integral Abutment

11.0 CLOSURE

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations when the drawings and specifications are complete.

A soil investigation is a limited sampling of a site. The conclusions given herein are based on information gathered 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 in order to assess the additional information and its effects on the above recommendations.

We trust the information presented herein meets your present requirements. Should you have any questions or require additional information, please do not hesitate to contact us.

Respectfully submitted,

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12.0 REFERENCES

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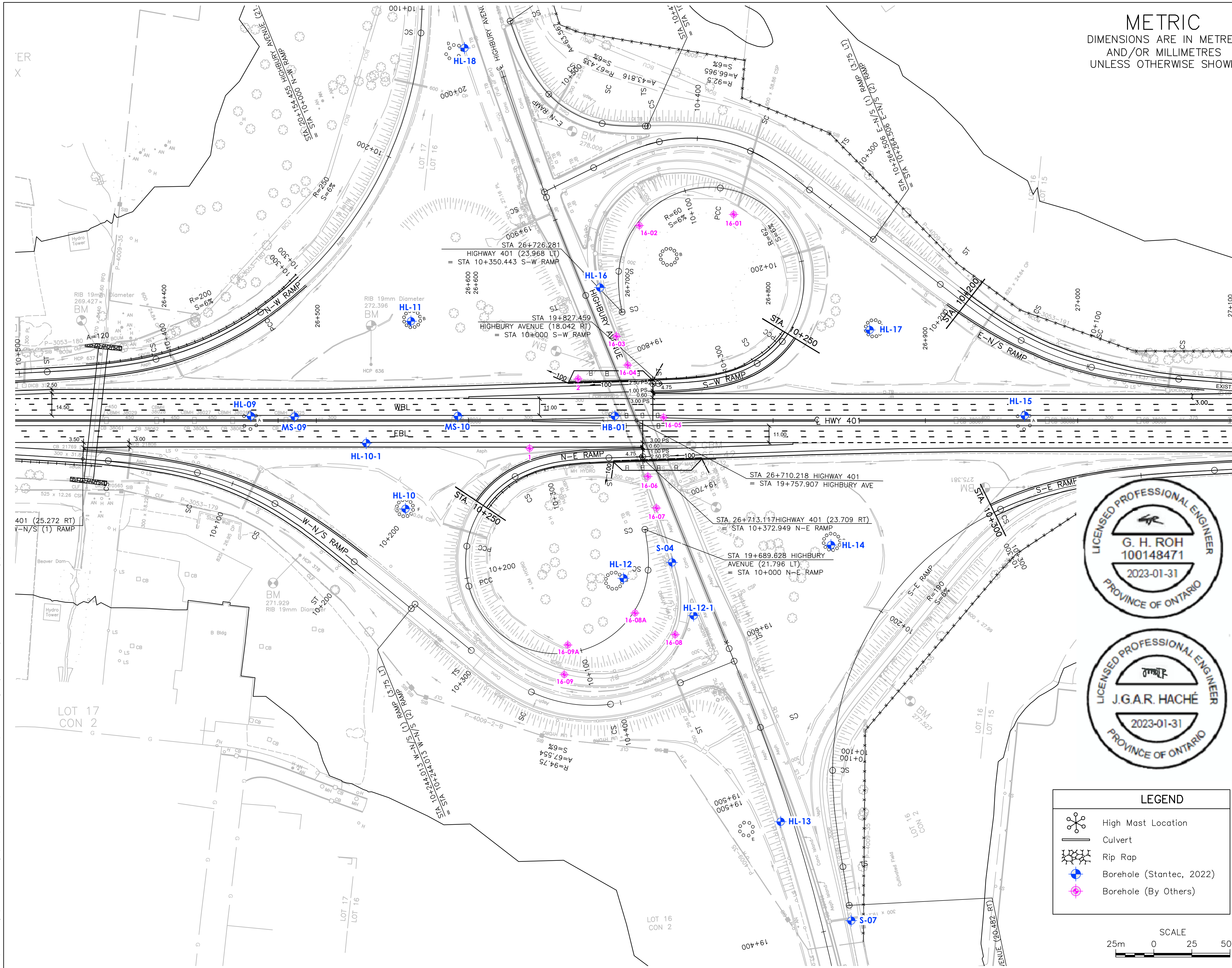
APPENDIX A

A.1 DRAWING NOS. 1, 2 AND 3 – BOREHOLE LOCATION PLAN AND SOIL STRATA PLOTS

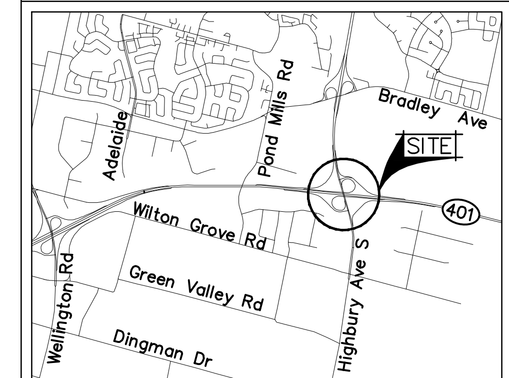
HWY 401/HIGHBURY AVE. INTERCHANGE–UNDERPASS BOREHOLE LOCATIONS PLAN

Stantec

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



KEY PLAN



800m 0 800 1600m

No	ELEV	MTM ZONE 11 COORDINATES NORTH	EAST
HB–01	275.9	4 756 033.8	412 577.2
HL–09	271.4	4 755 963.3	412 348.9
HL–10	271.6	4 755 935.1	412 463.8
HL–10–1	272.8	4 755 968.7	412 426.5
HL–11	272.3	4 756 053.8	412 431.0
HL–12	273.1	4 755 933.6	412 614.1
HL–12–1	281.0	4 755 923.8	412 665.3
HL–13	277.1	4 755 811.2	412 759.8
HL–14	274.2	4 755 994.6	412 737.8
HL–15	275.9	4 756 113.4	412 834.3
HL–16	281.5	4 756 111.5	412 543.1
HL–17	275.2	4 756 137.1	412 720.5
HL–18	275.5	4 756 235.7	412 411.6
MS–09	271.9	4 755 971.5	412 376.4
S–04	281.7	4 755 953.0	412 641.4
S–07	276.9	4 755 762.8	412 823.2
16–01	272.7	4 756 183.3	412 612.8
16–02	272.6	4 756 158.1	412 555.7
16–03	282.1	4 756 084.2	412 562.8
16–04	282.5	4 756 068.3	412 575.4
16–05	276.1	4 756 042.3	412 608.1
16–06	282.5	4 756 002.3	412 609.7
16–07	282.2	4 755 984.1	412 621.1
16–08	280.3	4 755 908.3	412 657.4
16–08A	273.2	4 755 914.0	412 628.0
16–09	277.8	4 755 861.7	412 595.5
16–09A	272.6	4 755 881.0	412 592.0
1	275.0	4 755 997.0	412 530.0
2	275.4	4 756 050.0	412 547.0

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2023-01-31
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J.G.A.R. HACHÉ
2023-01-31
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LEGEND

- High Mast Location
- Culvert
- Rip Rap
- Borehole (Stantec, 2022)
- Borehole (By Others)

SCALE
25m 0 25 50m

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 40I14-209

HWY No 401			DIST
SUBM'D GR	CHECKED	DATE 2022–10–21	SITE 19X–0373/B0
DRAWN GBB	CHECKED	APPROVED	DWG 1

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

PLATE No
CONT 2022-3004
WP 3032-11-00

HWY 401/HIGHBURY AVE. INTERCHANGE-UNDERPASS
BOREHOLE LOCATIONS & SOIL STRATA

SHEET -

Stantec

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2023-01-31
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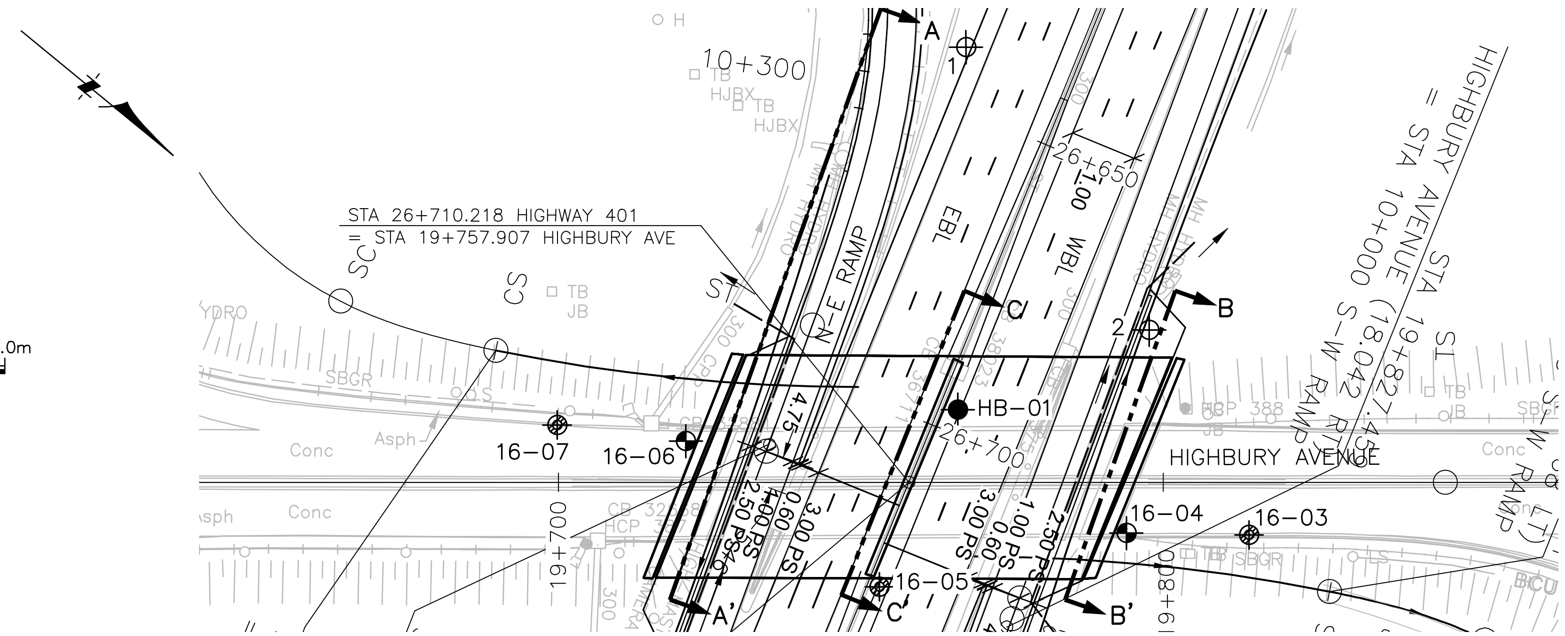
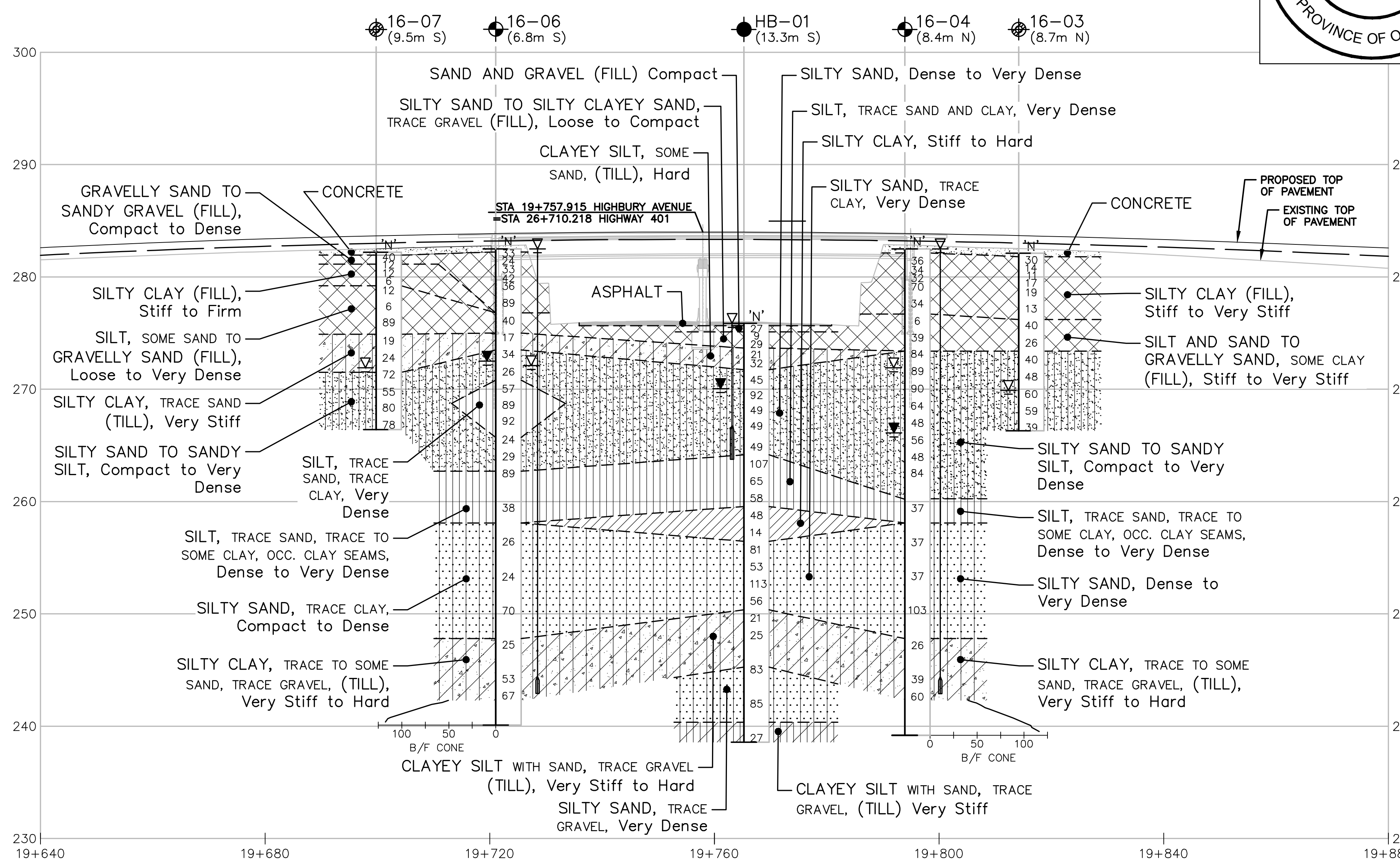
PLAN

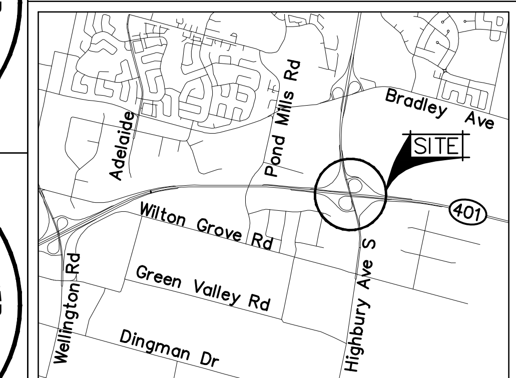
SCALE 12.5m 0 12.5 25.0m



PROFILE ALONG CL HIGHBURY AVENUE

SCALE
10m 0 10 20m HORIZONTAL
5m 0 5 10m VERTICAL





KEY PLAN
800m 0 800 1600m

LEGEND

- Borehole (Stantec, 2022)
- Borehole (Thurber, 2016)
- Borehole and Cone (Thurber, 2016)
- Borehole and Cone (MTO, 2012)
- (x.x m) Offset from Alignment Centreline
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL at time of investigation February 2012 & February 2016
- WL Measured on May 2012, April 2016 & September 2022
- Piezometer

No	ELEVATION	MTM ZONE 11 COORDINATES NORTH	EAST
HB-01	275.9	4 756 033.8	412 577.2
16-03	282.1	4 756 084.2	412 562.8
16-04	282.5	4 756 068.3	412 575.4
16-05	276.1	4 756 042.3	412 608.1
16-06	282.5	4 756 002.3	412 609.7
16-07	282.2	4 755 984.1	412 621.1
1	275.0	4 755 997.0	412 530.0
2	275.4	4 756 050.0	412 547.0

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.

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REVISIONS	DATE	BY	DESCRIPTION

GEOCRES No 40I14-209

HWY No 401			DIST
SUBM'D GR	CHECKED	DATE 2023-01-25	SITE 19X-0373/B0
DRAWN GBB	CHECKED	APPROVED	DWG 2

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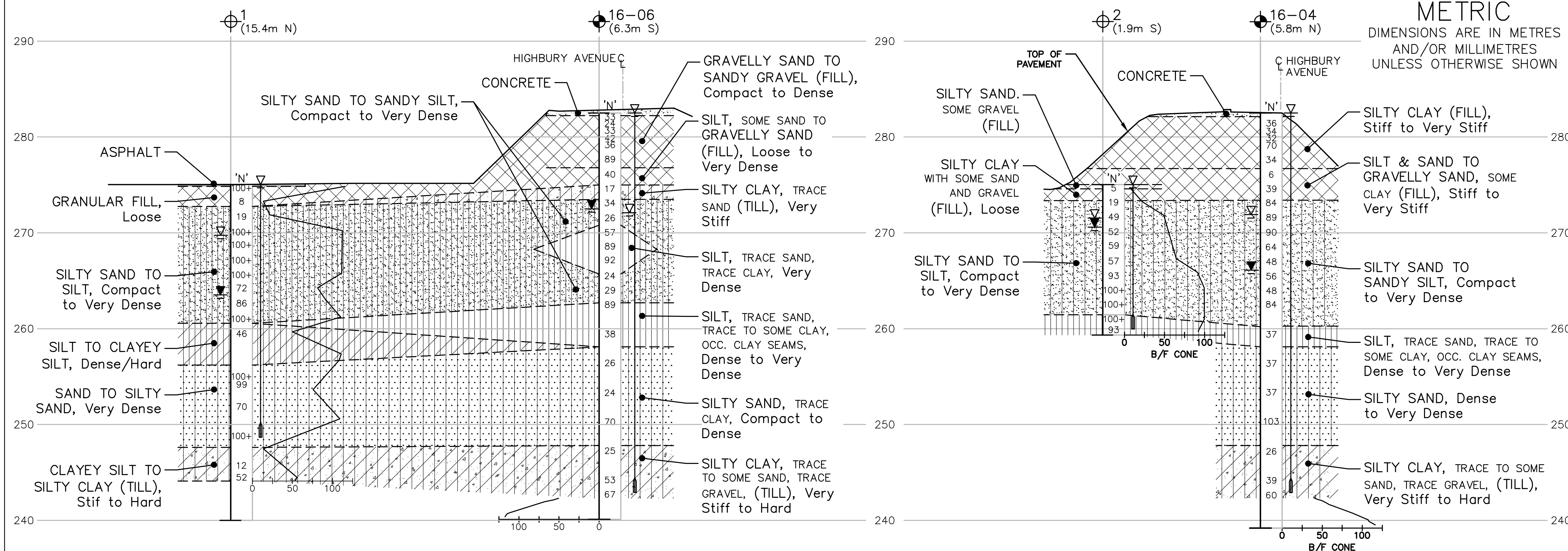
MINISTRY OF TRANSPORTATION, ONTARIO PH-D-707 88-05

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



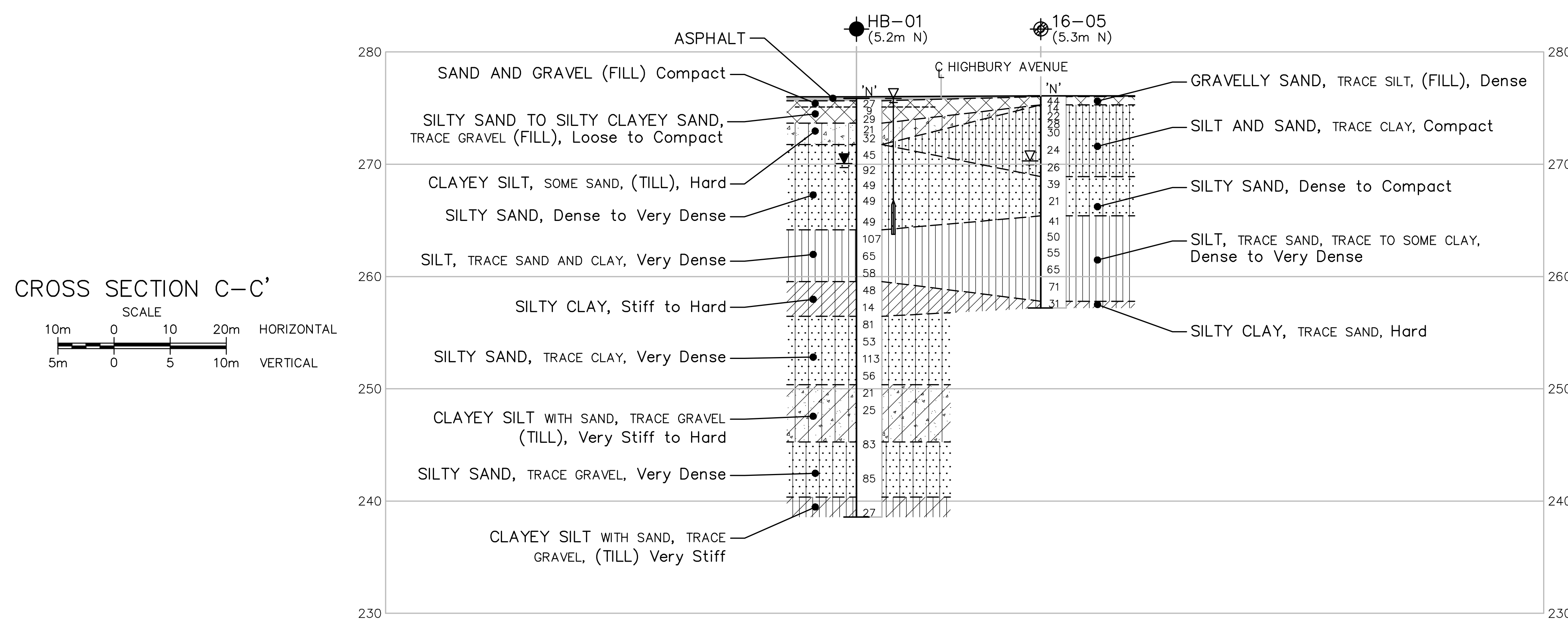


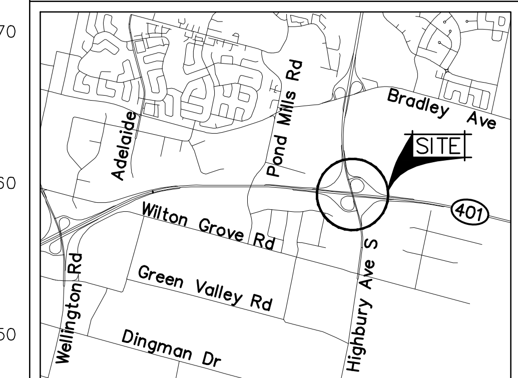
PLATE No

CONT 2022–3004
WP 3032–11–00

HWY 401/HIGHBURY AVE. INTERCHANGE–UNDERPASS SOIL STRATA

SHEET –

Stantec



KEY PLAN

800m 0 800 1600m

LEGEND

- Borehole (Stantec, 2022)
- Borehole (Thurber, 2016)
- Borehole and Cone (Thurber, 2016)
- Borehole and Cone (MTO, 2012)
- (x.x m) Offset from Alignment Centreline
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL at time of investigation February 2012 & February 2016
- WL Measured on May 2012, April 2016 & September 2022
- Piezometer

No	ELEVATION	MTM ZONE 11 COORDINATES NORTH	EAST
HB–01	275.9	4 756 033.8	412 577.2
16–03	282.1	4 756 084.2	412 562.8
16–04	282.5	4 756 068.3	412 575.4
16–05	276.1	4 756 042.3	412 608.1
16–06	282.5	4 756 002.3	412 609.7
16–07	282.2	4 755 984.1	412 621.1
1	275.0	4 755 997.0	412 530.0
2	275.4	4 756 050.0	412 547.0

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.

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2023-01-31
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REVISIONS	DATE	BY	DESCRIPTION

GEOCRES No 40I14–209

HWY No 401			DIST
SUBM'D GR	CHECKED	DATE 2023–01–25	SITE 19X–0373/B0
DRAWN GBB	CHECKED	APPROVED	DWG 3

DRAWING NAME: 165001239_Highbury Avenue_P&CS_2023–01–25.dwg
CREATED BY: GBB MODIFIED:
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MINISTRY OF TRANSPORTATION, ONTARIO PR–D–707 88–05

APPENDIX B

B.1 GEOCRES NO 40I14-165

B.2 GEOCRES NO 40I14-148

B.3 GEOCRES NO 40I14-63

B.1 GEOCRES NO 40I14-165

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

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

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

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

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

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

NOTE: Hierarchy of Soil Strength Prediction

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

4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

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

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

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

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

▼ Water Level

C_{pen} Shear Strength Determination by Pocket Penetrometer

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

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

<u>UNIFIED SOILS CLASSIFICATION</u>

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			

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-01

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 183.3 E 412 612.8 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.08 - 2016.02.08 | CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
272.7	GROUND SURFACE										
0.0	**TOPSOIL:** (150mm)										
0.2	Silty **CLAY**, some sand, trace gravel Firm to Very Stiff Brown Moist (TILL)(CL)	1	SS	10			○				
						272					
		2	SS	6			wP—○—wL	0	16	45	39
						271					
		3	SS	22			○				
270.4 / 2.3	Silty **SAND** Loose Brown Wet	4	SS	8			○				
						270					
269.7 / 3.0	Sandy **SILT**, trace clay Compact Brown Wet				▽						
		5	SS	18			○				
						269					
						268					
		6	SS	26			○	0	25	69	6
267.1 / 5.6	Silty **SAND**, trace clay Dense to Compact Brown Wet					267					
		7	SS	30			○				
						266					
						265					
		8	SS	28			○				
						264					
		9	SS	23			○	0	78	20	2
						263					

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT wP, NATURAL MOISTURE CONTENT w, LIQUID LIMIT wL; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-01

METRIC

W.P. 3032-11-00	LOCATION N 4 756 183.3 E 412 612.8	ORIGINATED BY GA
HWY 401	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY AN
DATUM Geodetic	DATE 2016.02.08 - 2016.02.08	CHECKED BY MEF

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20, 40, 60, 80, 100
SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%): 20, 40, 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT	GR	SA	SI	CL
	Silty **SAND**, trace clay Very Dense Brown Wet				262					
		10	SS	64		○				
					261					
260.5 / 12.2	**SILT**, trace sand, trace clay Very Dense Brown Wet	11	SS	86		○	0	10	84	6
					260					
					259					
		12	SS	51		○				
					258					
257.5 / 15.2	Silty **CLAY** Very Stiff Grey Wet	13	SS	27	257	○				
256.8 / 15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 15.8m AND WATER LEVEL AT 3.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.									

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-02

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 158.1 E 412 555.7	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.09 - 2016.02.09	CHECKED BY	MEF

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
272.6	GROUND SURFACE								
0.0	**TOPSOIL:** (175mm)								
0.2	Sandy **SILT**, Loose, Brown, Moist	1	SS	6					
271.9 / 0.7	Silty **CLAY**, some sand, Stiff, Brown, Moist (TILL)	2	SS	10	∇ (approx. El. 271.2)	0	11	42	47
271.0 / 1.5	Silty **SAND**, Compact, Brown, Wet	3	SS	16					
		4	SS	23					
269.5 / 3.0	**SILT**, some sand, trace clay, Dense, Brown, Wet	5	SS	34		0	17	79	4
		6	SS	49					
266.5 / 6.0	Silty **SAND**, trace clay, Dense to Very Dense, Brown, Wet	7	SS	44					
		8	SS	51		0	62	34	4
		9	SS	62					

Elevation scale: 272, 271, 270, 269, 268, 267, 266, 265, 264, 263

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity

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

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-02

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 158.1 E 412 555.7	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.09 - 2016.02.09	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	Silty **SAND**, trace clay Very Dense Brown Wet				262		
		10	SS	72			
260.4					261		
12.2	Clayey **SILT** Hard to Very Stiff Grey Wet (CL-ML)	11	SS	45	260		0 0 79 21
					259		
		12	SS	26	258		
257.3 15.2	Silty **CLAY** Hard Grey Wet (CI)	13	SS	53	257		0 0 43 57
256.7 15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 15.8m AND WATER LEVEL AT 1.4m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m3

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-03

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 084.2 E 412 562.8	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.16 - 2016.02.16	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
282.1	GROUND SURFACE										
0.0	**CONCRETE:** (300mm)						282				
281.8 / 0.3	**SAND** and **GRAVEL**, some silt Dense Brown Moist (FILL)		1	SS	30			48	40	12 (SI+CL)	
281.3 / 0.8	Silty **CLAY**, some sand, trace gravel Stiff to Very Stiff Brown Moist (FILL)(CL)		2	SS	14		281				
			3	SS	11		280				
			4	SS	17			0	22	46	32
			5	SS	19		279				
							278				
			6	SS	13		277				
276.1 / 5.9	**SILT** and **SAND**, some clay Dense Grey Moist (FILL)						276				
			7	SS	40			0	45	45	10
							275				
274.5 / 7.6	Gravelly **SAND**, some silt Compact Brown Moist (FILL)		8	SS	26		274				
273.4 / 8.7	Silty **SAND**, trace clay Dense to Very Dense Brown Moist						273				
			9	SS	40						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-03

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 084.2 E 412 562.8 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.16 - 2016.02.16 | CHECKED BY MEF

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m3	GR	SA	SI	CL
	Silty **SAND**, trace clay Dense to Very Dense Brown Moist						272						
			10	SS	48		271	~12		0	76	21	3
	becoming Wet					▽	270						
			11	SS	60		269	~14					
			12	SS	59		268	~15					
			13	SS	39		267	~14					
266.2 15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 15.8m AND WATER LEVEL AT 12.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 1.5m, BENTONITE HOLEPLUG TO 0.9m, THEN CONCRETE TO SURFACE.												

Column headings: SOIL PROFILE; SAMPLES; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-04

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 068.3 E 412 575.4 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.16 - 2016.02.17 | CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
282.5	GROUND SURFACE								
0.0	**CONCRETE:** (375mm)								
282.1 / 0.4	Gravelly **SAND**, some silt, Dense to Compact, Brown, Moist (FILL)	1	GS		282	25	60	15 (SI+CL)	
		2	SS	36		23	63	14 (SI+CL)	
		3	SS	24	281				
	some gravel	4	SS	32	280	18	63	19 (SI+CL)	
279.5 / 3.0	Very Dense	5	SS	70	279				
278.5 / 4.0		6	SS	34	278, 277				
276.7 / 5.8	**SILT** and **SAND**, some clay, Loose to Dense, Brown/Grey, Moist (FILL)	7	SS	6	276	0	36	47	17
		8	SS	39	275, 274				
273.4 / 9.1	Silty **SAND**, trace clay, Very Dense, Brown, Moist	9	SS	84	273				

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

Continued Next Page

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

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

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-04

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 068.3 E 412 575.4 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.16 - 2016.02.17 | CHECKED BY MEF

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **SAND**, trace clay Very Dense Brown Moist				272					
		10	SS	89		~4				
270.9 11.7	Sandy **SILT**, trace clay Very Dense Brown Moist				271					
		11	SS	90	270	~13	0	27	69	4
	becoming Wet				269					
		12	SS	64		~15				
	Dense				268					
		13	SS	48	267	~14				
266.2 16.3	Silty **SAND**, trace clay Very Dense to Dense Brown Wet				266 (water level ▼)					
		14	SS	56		~17				
					265					
		15	SS	48	264	~20	0	75	23	2
263.0 19.5	Sandy **SILT**, trace clay Very Dense Brown				263					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

RECORD OF BOREHOLE No 16-04

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 068.3 E 412 575.4	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.16 - 2016.02.17	CHECKED BY	MEF

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
	Sandy **SILT**, trace clay Very Dense Brown Wet	16	SS	84	○ (~19)				
260.3 22.3	**SILT**, some clay, occasional clay seams Dense Grey/Brown Wet	17	SS	37	○ (~24)	0	0	83	17
258.1 24.4	Silty **SAND** Dense Grey Wet	18	SS	37	○ (~17)				
		19	SS	37	○ (~19)				

Elevation scale: 262, 261, 260, 259, 258, 257, 256, 255, 254, 253

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20, 40, 60, 80, 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE — 20, 40, 60, 80, 100

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

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-04

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 068.3 E 412 575.4 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.16 - 2016.02.17 | CHECKED BY MEF

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	Water Content (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **SAND** Dense Grey Wet					
	Very Dense	20	SS	103	○	0 72 28 (SI+CL)
247.8 34.7	Silty **CLAY**, trace to some sand, trace gravel Very Stiff to Hard Grey Wet (TILL)(CL)	21	SS	26	○	
		22	SS	39	├○┤	0 22 54 24
		23	SS	60	○	

Elevation scale: 252, 251, 250, 249, 248, 247, 246, 245, 244, 243

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-04

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 068.3 E 412 575.4	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.16 - 2016.02.17	CHECKED BY	MEF

ELEV DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
242.3 / 40.2	End of sampling and start of DCPT						242, 241, 240				
239.2 / 43.3	END OF BOREHOLE AT 43.3m. BOREHOLE OPEN TO 43.3m AND WATER LEVEL AT 10.6m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2016.02.23	17.9	264.6
2016.04.01	16.4	266.1

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-05

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 042.3 E 412 608.1 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.22 - 2016.02.22 | CHECKED BY MEF

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%) (approx.)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
276.1	GROUND SURFACE							
0.0 / 0.1	**ASPHALT:** (75mm)					276		
	Gravelly **SAND**, trace silt, Dense, Brown, Moist (FILL)	1	SS	44			~13	
275.3 / 0.8	**SILT** and **SAND**, trace clay, Compact, Brown, Moist	2	SS	14		275	~17	
		3	SS	22		274	~12	0 39 57 4
		4	SS	28			~13	
		5	SS	30		273	~14	
	becoming Wet	6	SS	24		272 / 271	~18	0 41 53 6
					∇ (water level)	270		
		7	SS	26			~20	
268.9 / 7.2	Silty **SAND**, Dense to Compact, Brown, Wet					269		
		8	SS	39		268	~18	
		9	SS	21		267	~23	

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-05

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 042.3 E 412 608.1 | ORIGINATED BY GA
HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN
DATUM Geodetic | DATE 2016.02.22 - 2016.02.22 | CHECKED BY MEF

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	NATURAL MOISTURE CONTENT (approx. %)	GR	SA	SI	CL
	Silty **SAND**, Compact, Brown, Wet								
265.4 / 10.7	**SILT**, trace sand, trace to some clay, Dense to Very Dense, Grey, Wet	10	SS	41		0	6	90	4
		11	SS	50					
		12	SS	55		0	0	81	19
		13	SS	65					
		14	SS	71					
257.8 / 18.3	Silty **CLAY**, trace sand, Hard, Grey, Wet (CI)	15	SS	31		0	0	43	57
257.2 / 18.9	END OF BOREHOLE AT 18.9m. BOREHOLE OPEN TO 18.9m AND WATER LEVEL AT 5.8m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 1.5m, CONCRETE								

Elevation scale: 266, 265, 264, 263, 262, 261, 260, 259, 258

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity; 20 / 15 / 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 16-05

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 042.3 E 412 608.1	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.22 - 2016.02.22	CHECKED BY	MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	TO 0.2m, THEN ASPHALT PATCH TO SURFACE.										

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-06

METRIC

W.P. 3032-11-00	LOCATION N 4 756 002.3 E 412 609.7	ORIGINATED BY GA
HWY 401	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY AN
DATUM Geodetic	DATE 2016.02.18 - 2016.02.18	CHECKED BY MEF

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.5	GROUND SURFACE				
282.2 / 0.0	**CONCRETE:** (275mm)				
0.3	Gravelly **SAND**, trace to some silt Compact to Dense Brown Moist (FILL)	1	SS	33	
		2	SS	24	
		3	SS	33	
		4	SS	42	
		5	SS	36	
	Very Dense	6	SS	89	30 52 18 (SI+CL)
276.8 / 5.7	Silty **SAND** Dense Brown Moist (FILL)	7	SS	40	
275.1 / 7.5	Silty **CLAY**, trace sand Very Stiff Dark Brown Moist (TILL)	8	SS	17	
273.4 / 9.1	Silty **SAND** Dense Brown Moist	9	SS	34	

Elevation scale: 282, 281, 280, 279, 278, 277, 276, 275, 274, 273

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-06

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 002.3 E 412 609.7	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.18 - 2016.02.18	CHECKED BY	MEF

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **SAND** Compact Brown Wet	10	SS	26	
270.8 / 11.7	**SILT**, trace sand, trace clay Very Dense Brown Wet	11	SS	57	0 6 88 6
		12	SS	89	
		13	SS	92	
265.8 / 16.8	Silty **SAND** Compact Brown Wet	14	SS	24	
		15	SS	29	
262.7 / 19.8					

Elevation scale: 272, 271, 270, 269, 268, 267, 266, 265, 264, 263

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m^3

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-06

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 002.3 E 412 609.7 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.18 - 2016.02.18 | CHECKED BY MEF

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILT, trace sand, trace clay Dense Grey Wet	16	SS	89		~19	0	6	90	4
					262					
					261					
					260					
		17	SS	38		~18				
					259					
258.1 24.4	Silty **SAND**, trace clay Compact Grey Wet				258					
					257					
		18	SS	26		~19	0	75	20	5
					256					
					255					
					254					
		19	SS	24		~19				
					253					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-06

METRIC

W.P. 3032-11-00 | LOCATION N 4 756 002.3 E 412 609.7 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.18 - 2016.02.18 | CHECKED BY MEF

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **SAND**, trace clay Very Dense Grey Wet				252					
					251					
		20	SS	70		~18				
					250					
					249					
					248					
247.8 / 34.7	Silty **CLAY**, trace to some sand, trace gravel Very Stiff to Hard Grey Wet (TILL)(CL)									
		21	SS	25	247	~14				
					246					
					245					
		22	SS	53	244	~13				
					243					
		23	SS	67		~11 (Wp–WL range shown)	0	21	50	29

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-06

METRIC

W.P.	3032-11-00	LOCATION	N 4 756 002.3 E 412 609.7	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.18 - 2016.02.18	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT (kN/m³)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
242.3	Continued From Previous Page										
40.2	End of sampling and start of DCPT						242				
							241				
240.2 / 42.4	END OF BOREHOLE AT 42.4m BOREHOLE OPEN TO 39.6m AND WATER LEVEL AT 10.4m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2016.02.23 10.8 271.7 2016.04.01 10.0 272.5										

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

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

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

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

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-07

METRIC

W.P. 3032-11-00	LOCATION N 4 755 984.1 E 412 621.1	ORIGINATED BY GA
HWY 401	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY AN
DATUM Geodetic	DATE 2016.02.18 - 2016.02.18	CHECKED BY MRF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
282.2	GROUND SURFACE						
0.0 / 281.9	**CONCRETE:** (263mm)				282		
0.3 / 281.3	Sandy **GRAVEL**, some silt, Dense, Brown, Moist (FILL)	1	SS	40		○	62 28 10 (SI+CL)
0.8	Silty **CLAY**, some sand to sandy, trace gravel, Stiff to Firm, Brown, Moist (FILL)	2	SS	12	281	○	
		3	SS	12	280	○	
		4	SS	6		○	4 29 37 30
279.1 / 3.0	**SILT**, some sand, some clay, trace gravel, Compact to Loose, Brown, Wet (FILL)	5	SS	12	279	○	
					278		
		6	SS	6	277	○	
276.4 / 5.8	Gravelly **SAND**, trace silt, Very Dense, Brown, Moist (FILL)	7	SS	89	276	○	
					275		
274.6 / 7.6	Silty **CLAY**, trace sand, Very Stiff, Brown, Moist (TILL)(CI)	8	SS	19	274	w_P ○ w_L	0 10 49 41
					273		
		9	SS	24		○	

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-07

METRIC

W.P. 3032-11-00 | LOCATION N 4 755 984.1 E 412 621.1 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.18 - 2016.02.18 | CHECKED BY MRF

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m³	GR	SA	SI	CL
	Silty **CLAY**, trace sand, Very Stiff, Brown, Moist (TILL)(CI)				∇	272						
271.5 / 10.7	Sandy **SILT**, trace clay, Very Dense, Brown, Wet	10	SS	72		271	○		0	24	72	4
		11	SS	55		270	○					
268.9 / 13.3	**SILT** and **SAND**, trace clay, Very Dense, Brown, Wet	12	SS	80		269, 268	○		0	37	58	5
		13	SS	78		267	○					
266.3 / 15.8	END OF BOREHOLE AT 15.8m. BOREHOLE OPEN TO 15.8m AND WATER LEVEL AT 10.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 1.5m, BENTONITE HOLEPLUG TO 0.9m, THEN CONCRETE TO SURFACE.											

Legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20, 40, 60; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+ 3, × 3: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 16-08

METRIC

W.P. 3032-11-00 | LOCATION N 4 755 908.3 E 412 657.4 | ORIGINATED BY GA

HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN

DATUM Geodetic | DATE 2016.02.23 - 2016.02.23 | CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
280.3	GROUND SURFACE										
0.0	**ASPHALT:** (275mm)					280					
0.2	Gravelly **SAND**, some silt, Dense, Brown, Moist (FILL)	1	SS	47							
		2	SS	38		279		27	56	17 (SI+CL)	
278.7 / 1.5	Sandy **SILT**, trace gravel, Compact, Brown, Moist (FILL)	3	SS	19		278					
277.8 / 2.4	Silty **CLAY**, some sand, trace gravel, Stiff, Brown, Moist (FILL)(CL)	4	SS	13				3	19	42	36
		5	SS	9		277, 276					
		6	SS	8		275					
274.6 / 5.7	**SAND** and **SILT**, trace clay, Compact, Brown, Moist (FILL)	7	SS	14		274		0	52	42	6
273.3 / 7.0	Sandy **SILT**, trace clay, Compact to Dense, Brown, Wet	8	SS	12		273, 272					
					∇	271					
		9	SS	49							

SOIL PROFILE | SAMPLES | STRAT PLOT | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 | SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L | WATER CONTENT (%) 20 40 60 | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

+3, ×3: Numbers refer to Sensitivity

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

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-08

METRIC

W.P.	3032-11-00	LOCATION	N 4 755 908.3 E 412 657.4	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.23 - 2016.02.23	CHECKED BY	MEF

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	Sandy **SILT**, trace clay Very Dense Brown Wet				270				
		10	SS	62		0	28	67	5
					269				
268.4 11.9	Silty **SAND**, trace clay Very Dense Brown Wet								
					268				
		11	SS	67					
					267				
		12	SS	81					
					266				
					265				
		13	SS	59					
					264				
		14	SS	71		0	74	23	3
					263				
					262				
	Compact	15	SS	28					
261.4 18.9	END OF BOREHOLE AT 18.9m. BOREHOLE OPEN TO 18.9m AND WATER LEVEL AT 9.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.9m, CONCRETE TO 0.2m, THEN ASPHALT PATCH								

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 16-08

METRIC

W.P.	3032-11-00	LOCATION	N 4 755 908.3 E 412 657.4	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.23 - 2016.02.23	CHECKED BY	MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L / WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	TO SURFACE.										

+ ³, × ³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-08A

METRIC

W.P. 3032-11-00	LOCATION N 4 755 914.0 E 412 628.0		ORIGINATED BY GA
HWY 401	BOREHOLE TYPE Hand Augers		COMPILED BY MFA
DATUM Geodetic	DATE 2016.02.24 - 2016.02.24		CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
273.2	GROUND SURFACE										
0.0	**TOPSOIL:** (175mm)					∇					
0.2	Silty **CLAY** Brown Wet (TILL)						273				
272.3 0.9	END OF BOREHOLE AT 0.9m. BOREHOLE OPEN TO 0.9m AND WATER LEVEL AT 0.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.										

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+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 16-09

METRIC

W.P. 3032-11-00 | LOCATION N 4 755 861.7 E 412 595.5 | ORIGINATED BY GA
HWY 401 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY AN
DATUM Geodetic | DATE 2016.02.23 - 2016.02.23 | CHECKED BY MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
277.8	GROUND SURFACE							
0.0 / 0.1	**ASPHALT:** (100mm)							
	Sandy **GRAVEL**, Dense, Brown, Moist, (FILL)	1	SS	44				64 27 9 (SI+CL)
		2	SS	40		277		
276.3 / 1.5	Silty **CLAY**, some sand, trace gravel, Stiff to Very Stiff, Brown, Moist, (FILL)(CI)	3	SS	14		276		
		4	SS	12		275		0 18 44 38
		5	SS	19		274		
		6	SS	10		273		0 19 44 37
272.4 / 5.5	Sandy **SILT**, trace clay, Compact to Very Dense, Brown, Wet				▽	272		
		7	SS	35		271		
		8	SS	54		270		0 23 72 5
		9	SS	23		269 / 268		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³

Continued Next Page

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

ONTMT4S 10552.GPJ 2015TEMPLATE(MTO).GDT 4/26/16

RECORD OF BOREHOLE No 16-09

METRIC

W.P.	3032-11-00	LOCATION	N 4 755 861.7 E 412 595.5	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.23 - 2016.02.23	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION (Continued From Previous Page)	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT w (%)	GR	SA	SI	CL
	Sandy **SILT**, trace clay Dense Brown Wet	10	SS	36	267	~20				
266.1 / 11.7	**SAND**, trace silt, trace clay Dense Brown Wet	11	SS	44	266, 265	~20	0	89	9	2
		12	SS	47	264	~19				
		13	SS	34	263, 262	~20				
261.4 / 16.5	**SILT**, some sand Very Dense Brown Wet	14	SS	67	261, 260	~20				
259.6 / 18.3	Silty **CLAY** Hard Brown Wet (CL)	15	SS	37	259	~20 (wP–wL range shown)	0	0	52	48
258.9 / 18.9	END OF BOREHOLE AT 18.9m. BOREHOLE OPEN TO 18.9m AND WATER LEVEL AT 6.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.9m, CONCRETE									

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 16-09

METRIC

W.P.	3032-11-00	LOCATION	N 4 755 861.7 E 412 595.5	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.02.23 - 2016.02.23	CHECKED BY	MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	TO 0.2m, THEN ASPHALT PATCH TO SURFACE.										

+ ³, × ³ : Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 16-09A

METRIC

W.P.	3032-11-00	LOCATION	N 4 755 881.0 E 412 592.0	ORIGINATED BY	GA
HWY	401	BOREHOLE TYPE	Hand Augers	COMPILED BY	MFA
DATUM	Geodetic	DATE	2016.02.24 - 2016.02.24	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.6	GROUND SURFACE										
0.0	**TOPSOIL:** (200mm)					∇					
0.2	Silty **CLAY** Brown Wet (TILL)						272				
271.7 0.9	END OF BOREHOLE AT 0.9m. BOREHOLE OPEN TO 0.9m AND WATER LEVEL AT 0.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.										

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+ 3, × 3: Numbers refer to Sensitivity

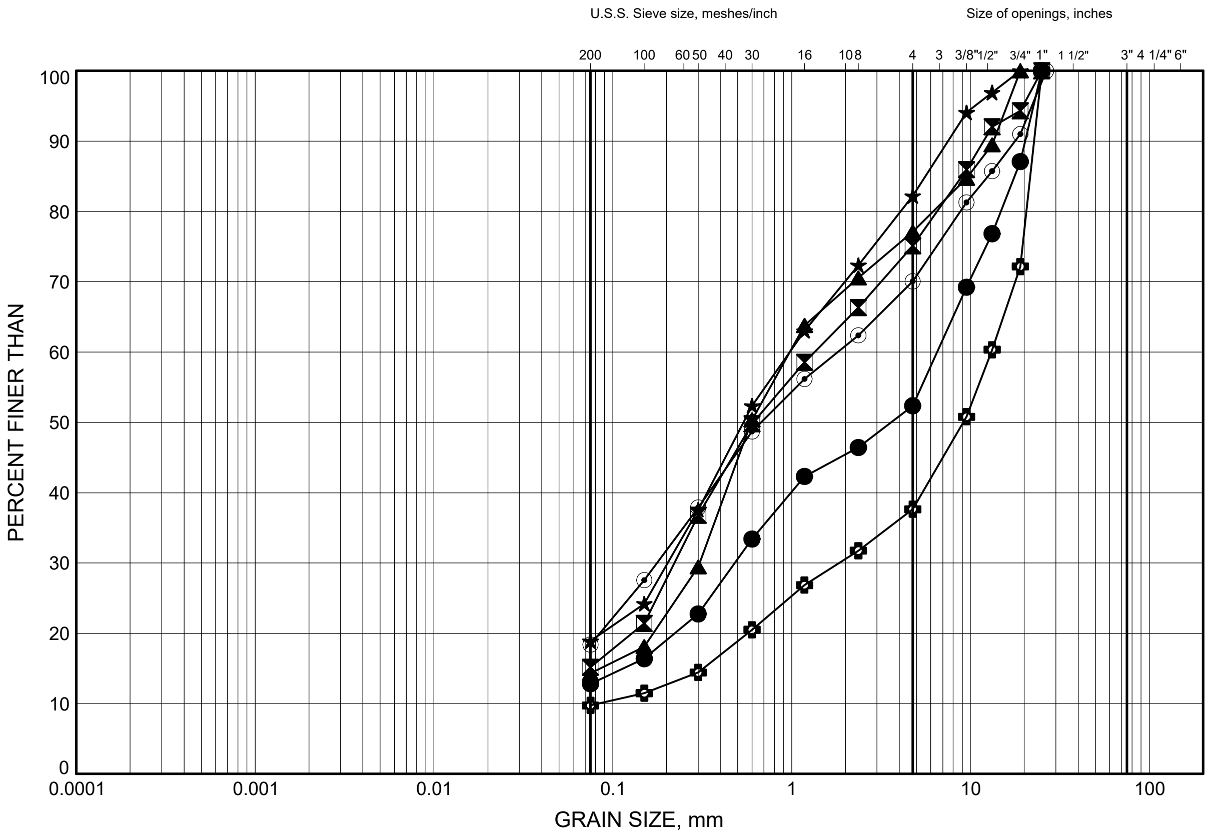
20 / 15 ◐ 5 / 10 (%) STRAIN AT FAILURE

Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B1

Granular FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	0.53	281.54
⧗	16-04	0.61	281.90
▲	16-04	1.07	281.44
★	16-04	2.59	279.92
⊙	16-06	4.88	277.65
✿	16-07	0.53	281.64

GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Date April 2016

W.P. 3032-11-00

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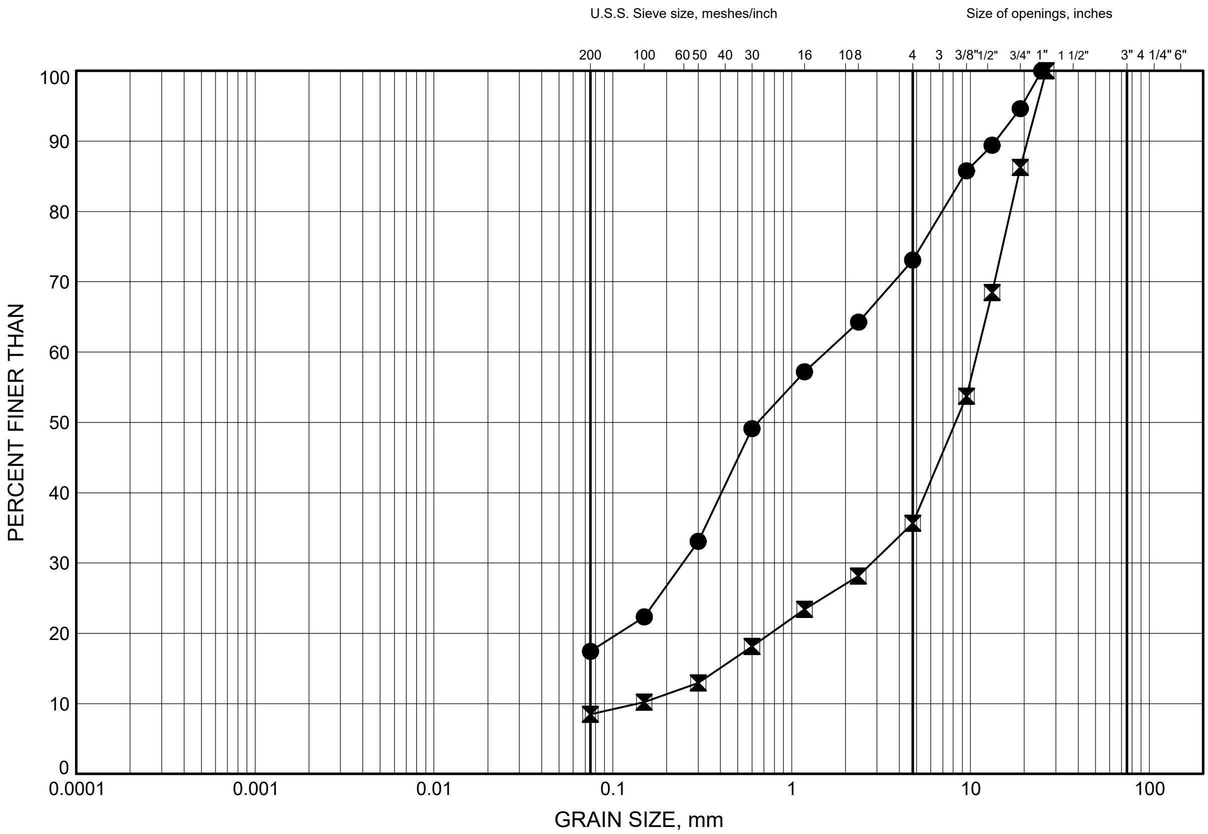
Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B2

Granular FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-08	1.07	279.20
⧗	16-09	0.46	277.38

GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Date April 2016

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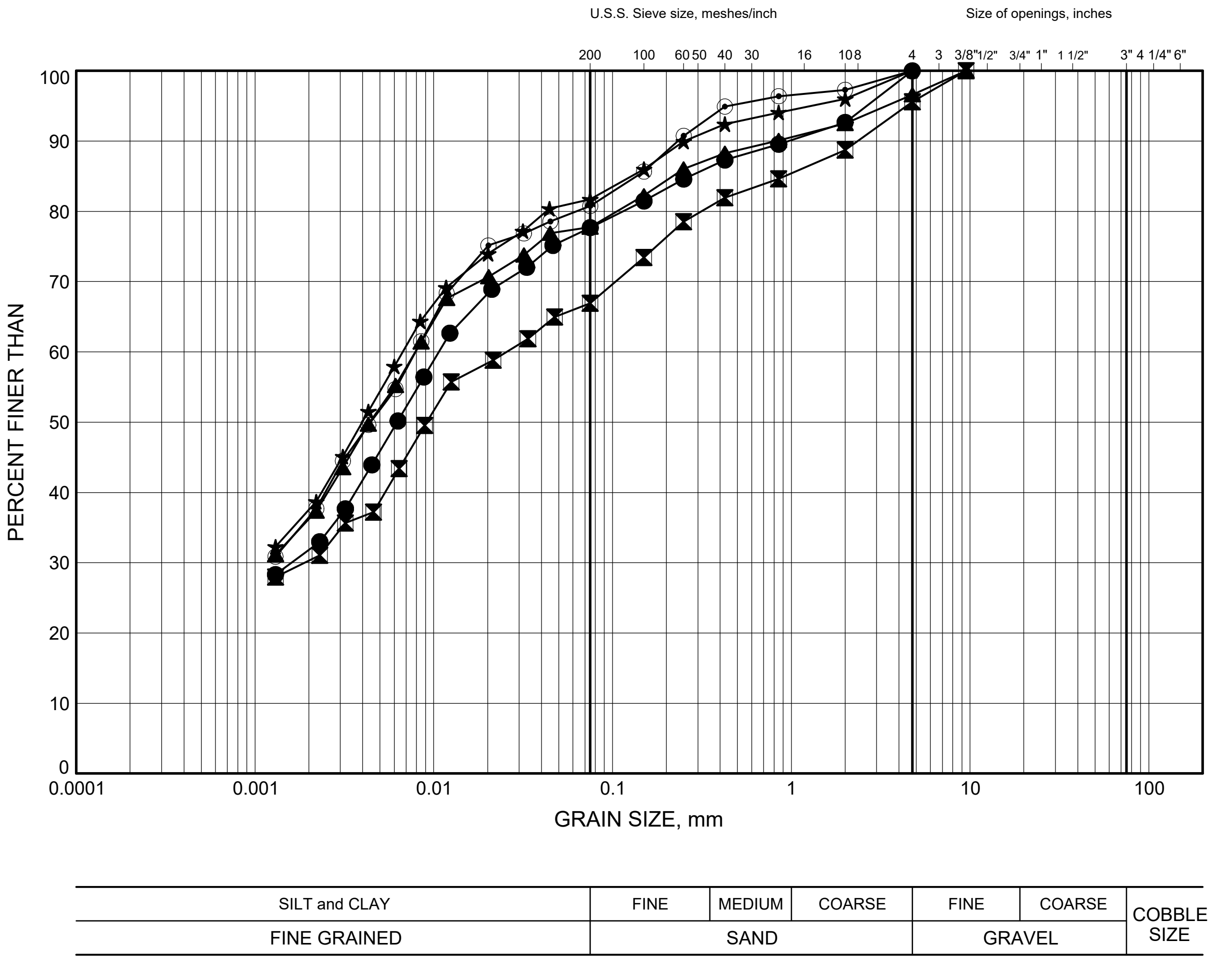
GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	2.59	279.48
⧗	16-07	2.59	279.58
▲	16-08	2.59	277.68
★	16-09	2.59	275.25
⊙	16-09	4.88	272.96

Date April 2016

W.P. 3032-11-00

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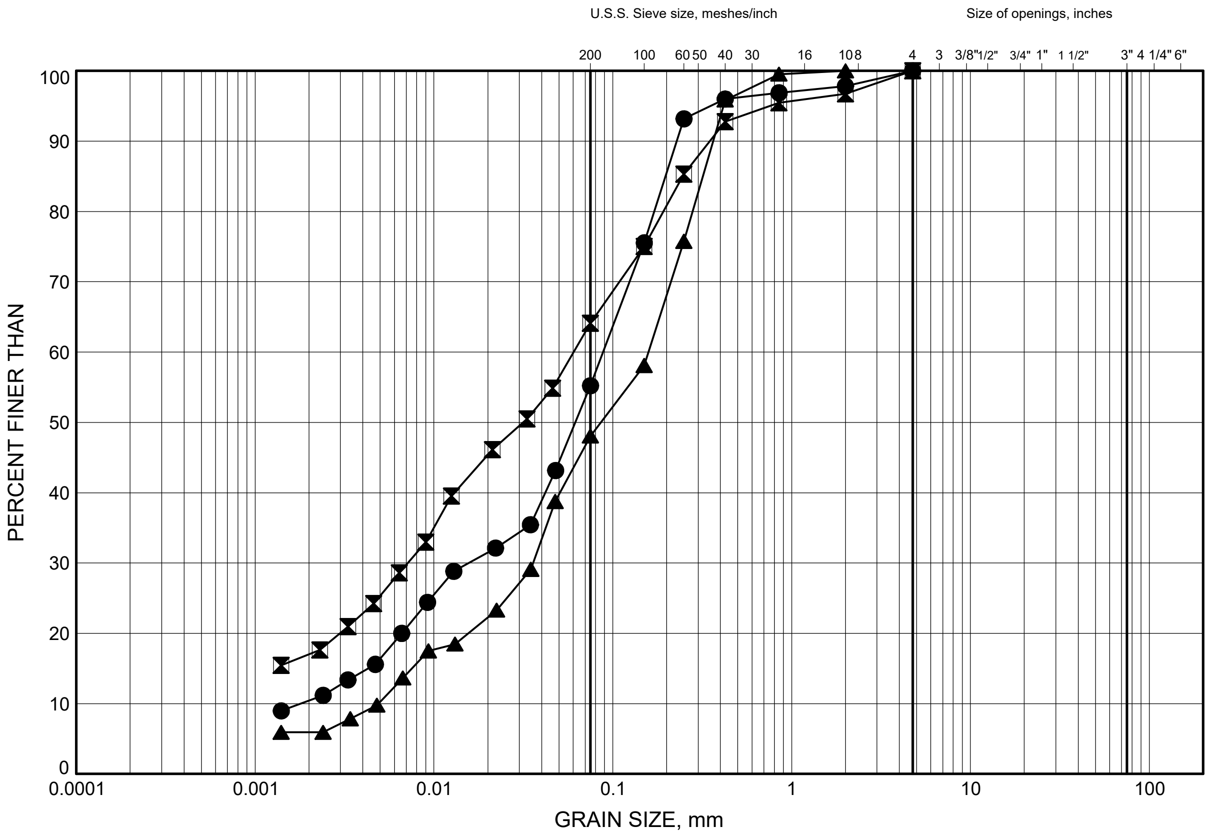
GRAIN SIZE DISTRIBUTION

FIGURE B4

SILT, Some Sand FILL to Gravelly SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	6.40	275.67
⧗	16-04	6.40	276.11
▲	16-08	6.40	273.87

GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Date April 2016

W.P. 3032-11-00

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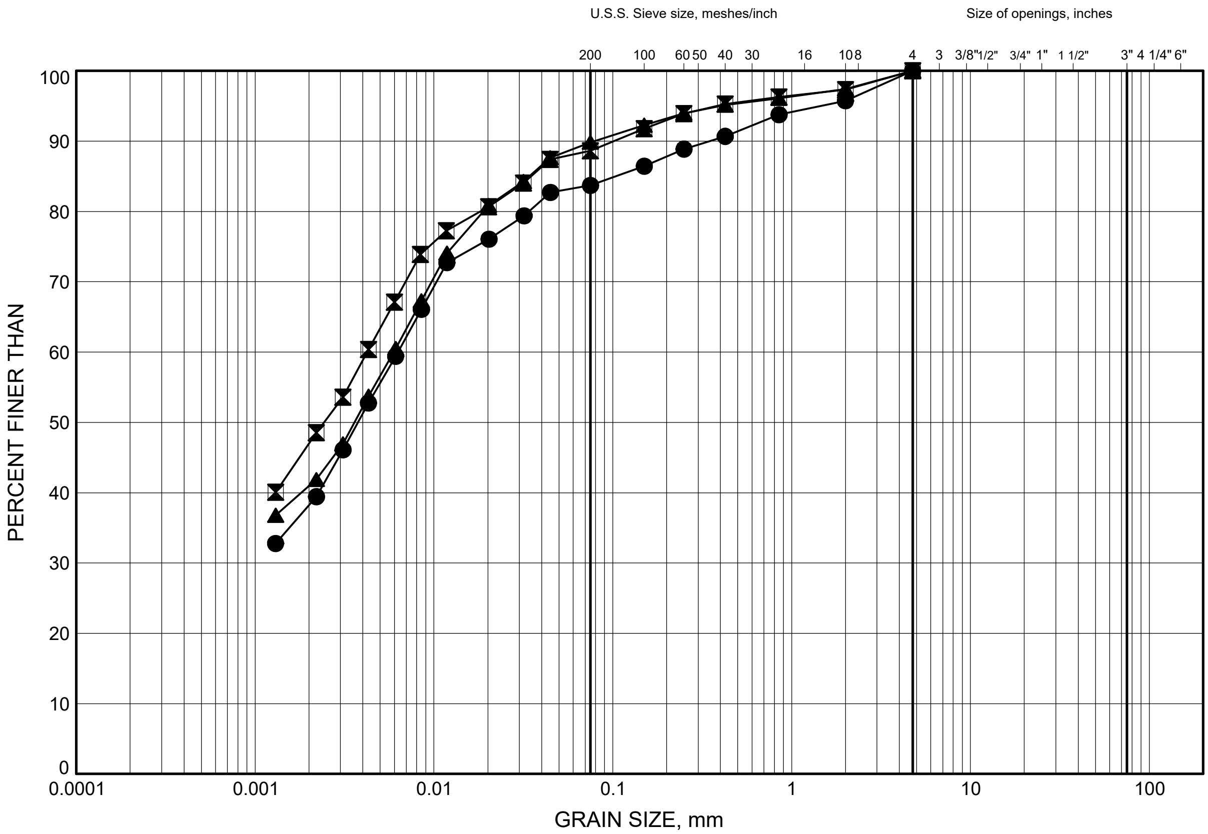
GRAIN SIZE DISTRIBUTION

FIGURE B5

Upper Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	1.07	271.62
⧗	16-02	1.07	271.49
▲	16-07	7.92	274.25

Date April 2016

W.P. 3032-11-00

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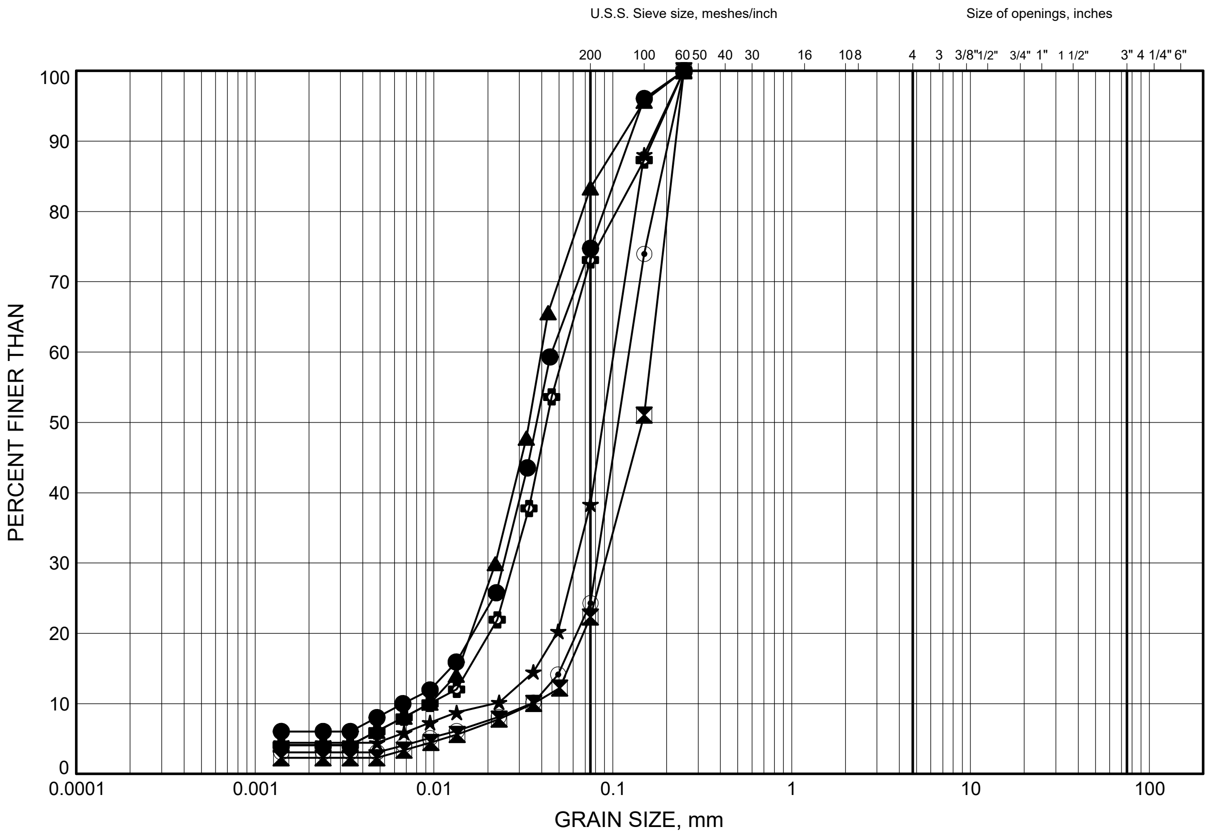
GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B6

Upper Silty SAND to Sandy SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	4.88	267.81
⧗	16-01	9.45	263.24
▲	16-02	3.35	269.21
★	16-02	7.92	264.64
⊙	16-03	10.97	271.10
✿	16-04	12.50	270.01

GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Date April 2016

W.P. 3032-11-00

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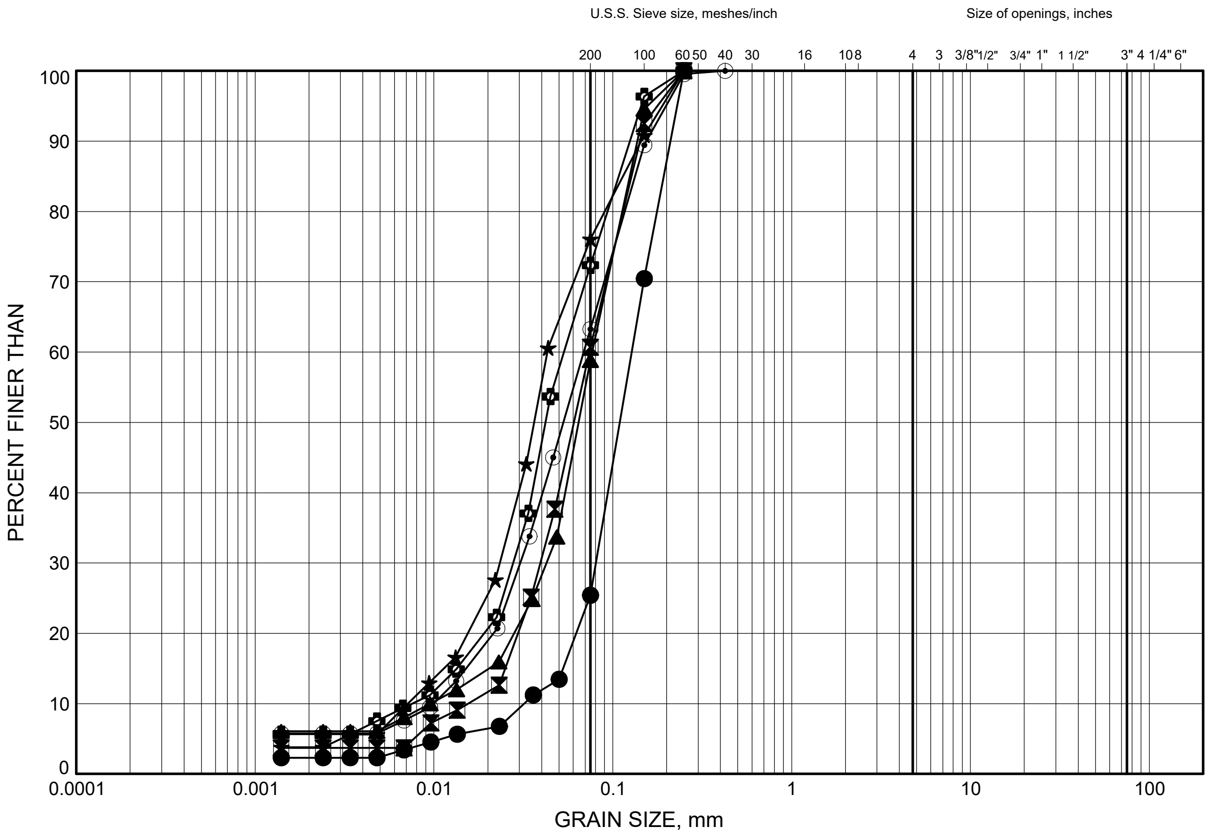
Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B7

Upper Silty SAND to Sandy SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-04	18.59	263.92
⧗	16-05	1.83	274.27
▲	16-05	4.88	271.22
★	16-07	10.97	271.20
⊙	16-07	14.02	268.15
✿	16-08	10.97	269.30

Date April 2016

W.P. 3032-11-00

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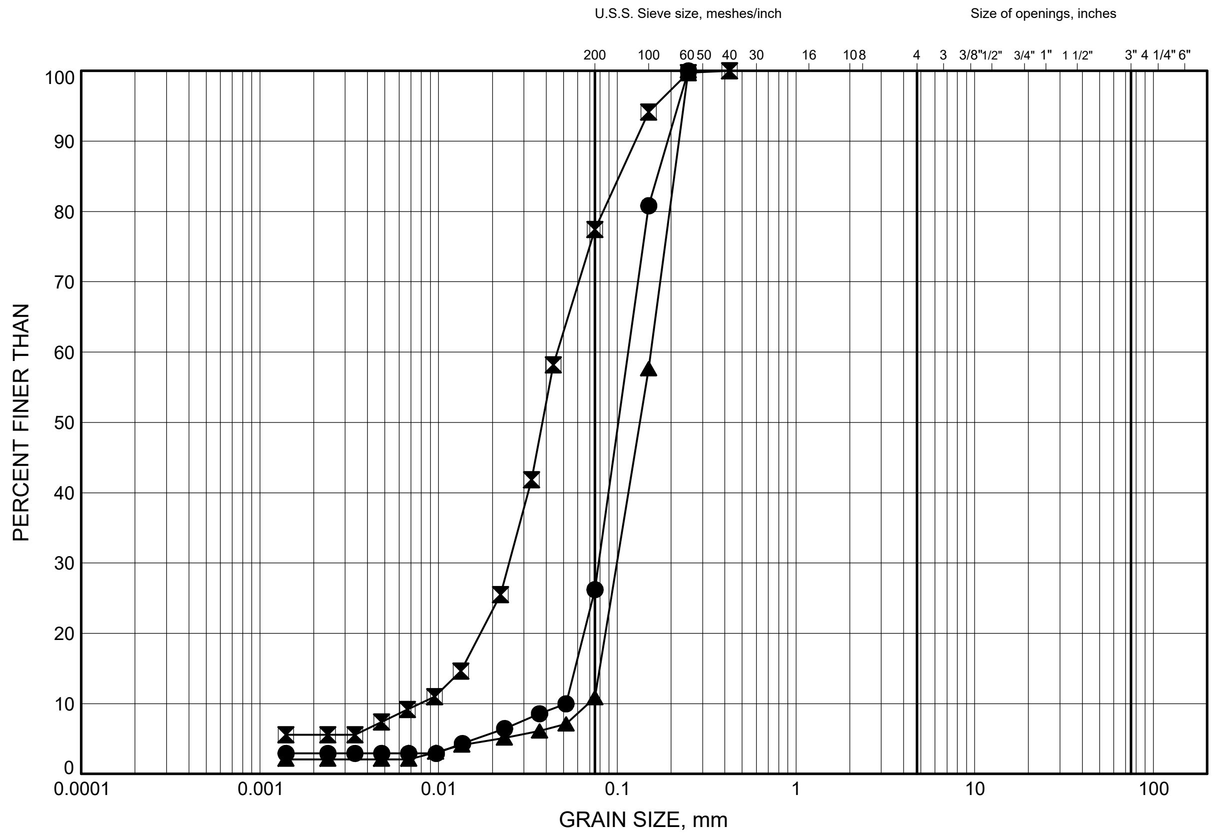
GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B8

Upper Silty SAND to Sandy SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-08	17.07	263.20
⧗	16-09	7.92	269.92
▲	16-09	12.50	265.34

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

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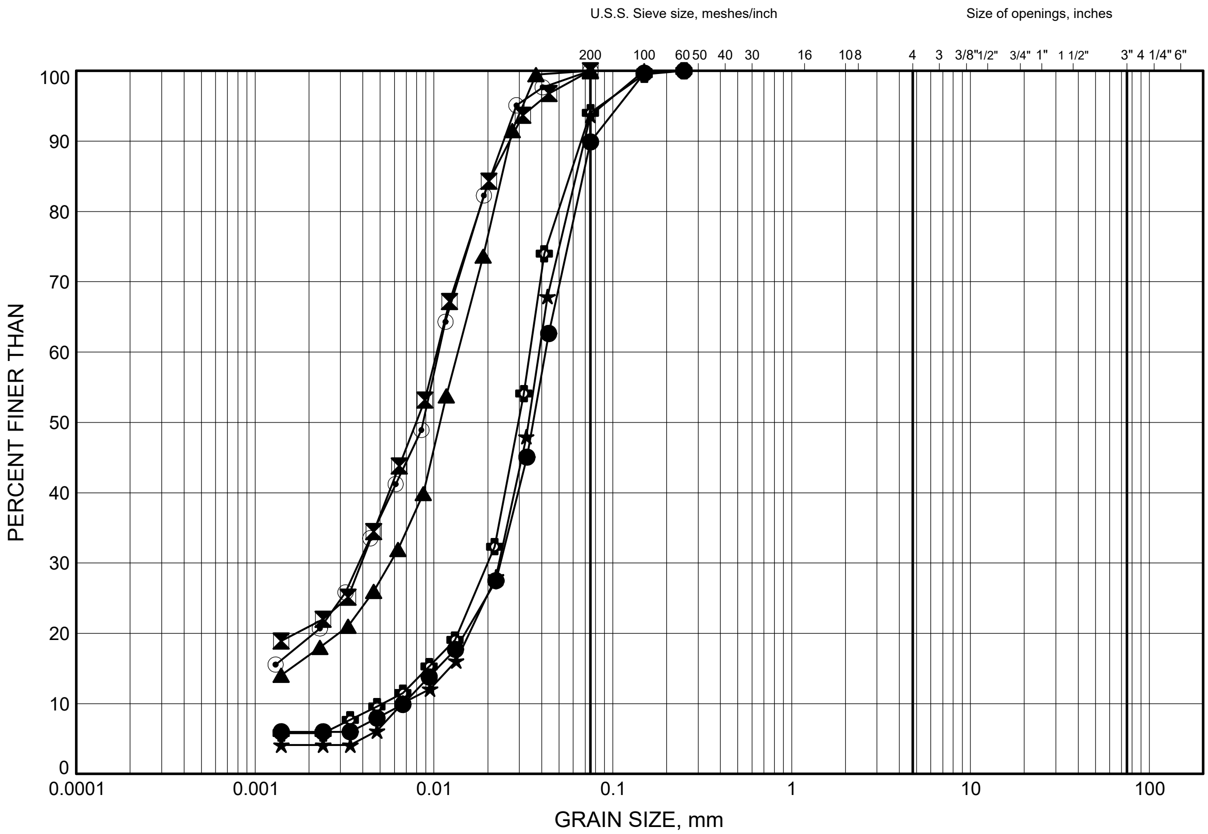
Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B9

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	12.50	260.19
⧗	16-02	12.50	260.06
▲	16-04	23.16	259.35
★	16-05	10.97	265.13
⊙	16-05	14.02	262.08
✿	16-06	12.50	270.03

Date April 2016

W.P. 3032-11-00

THURBER

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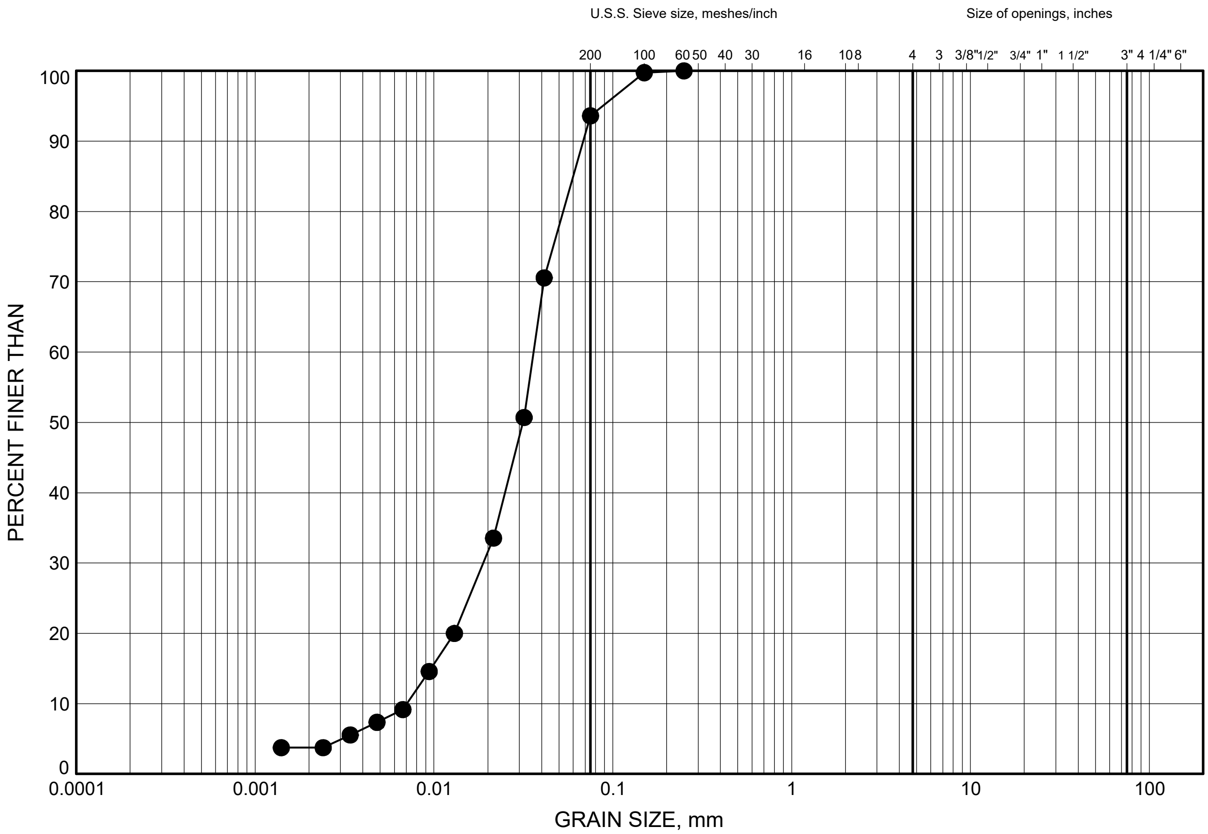
Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B10

SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-06	20.12	262.41

Date April 2016
W.P. 3032-11-00

THURBER

Prep'd AN
Chkd. MEF

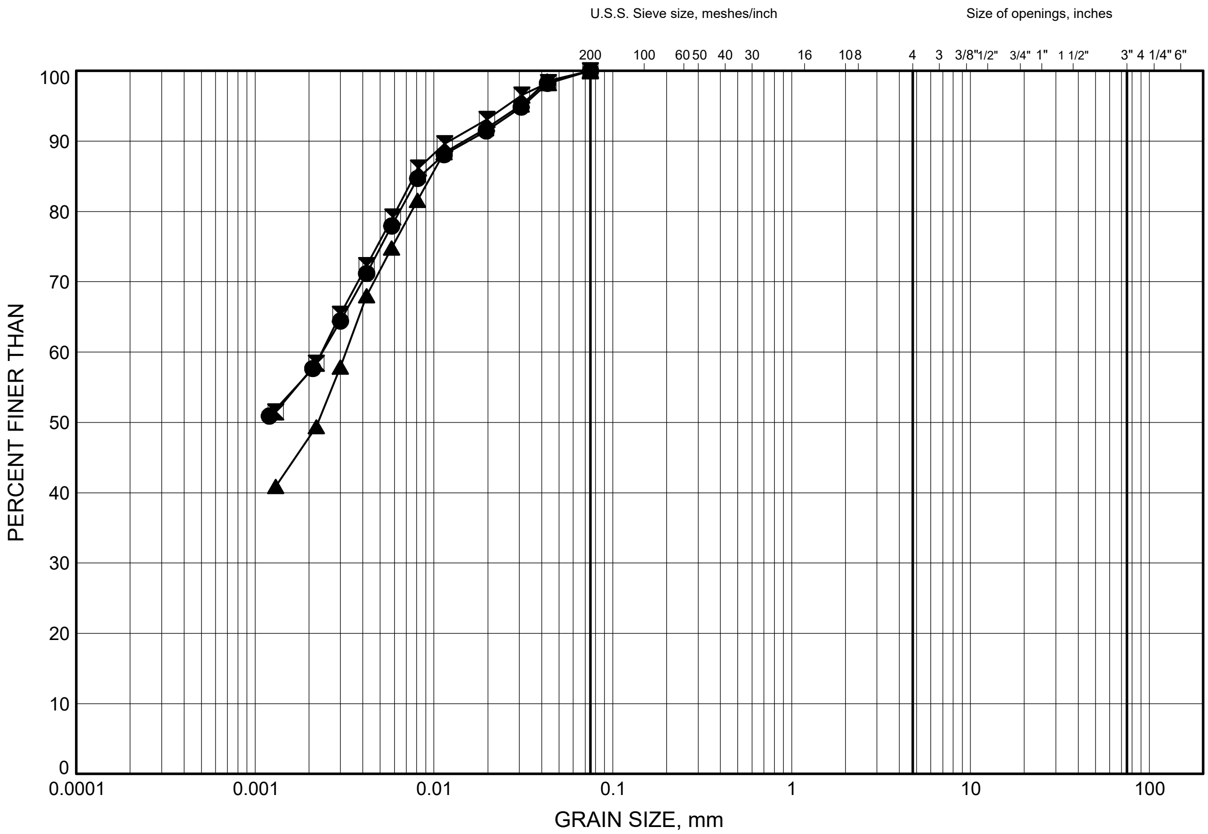
GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B11

Silty CLAY



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	15.54	257.02
⧗	16-05	18.59	257.51
▲	16-09	18.59	259.25

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

Chkd. MEF

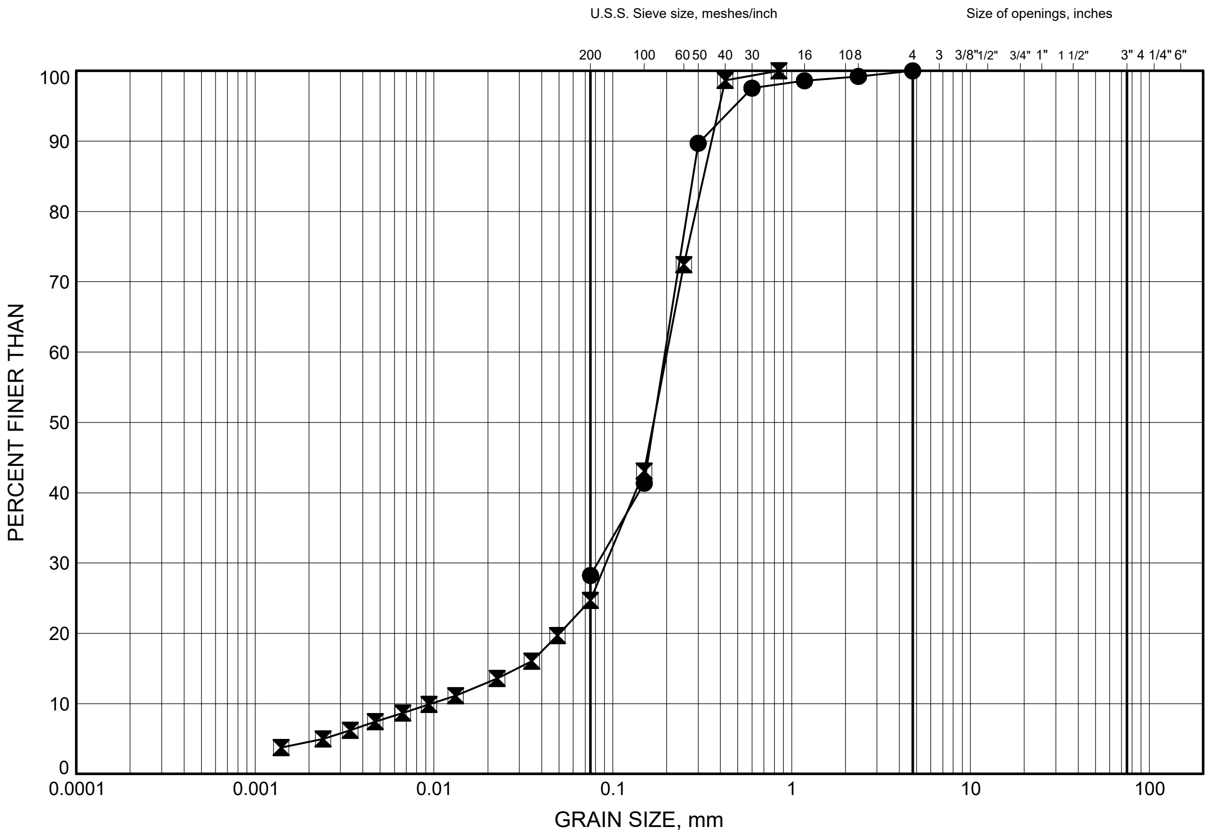
GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B12

Lower Silty SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-04	32.23	250.28
⧗	16-06	26.21	256.32

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

Chkd. MEF

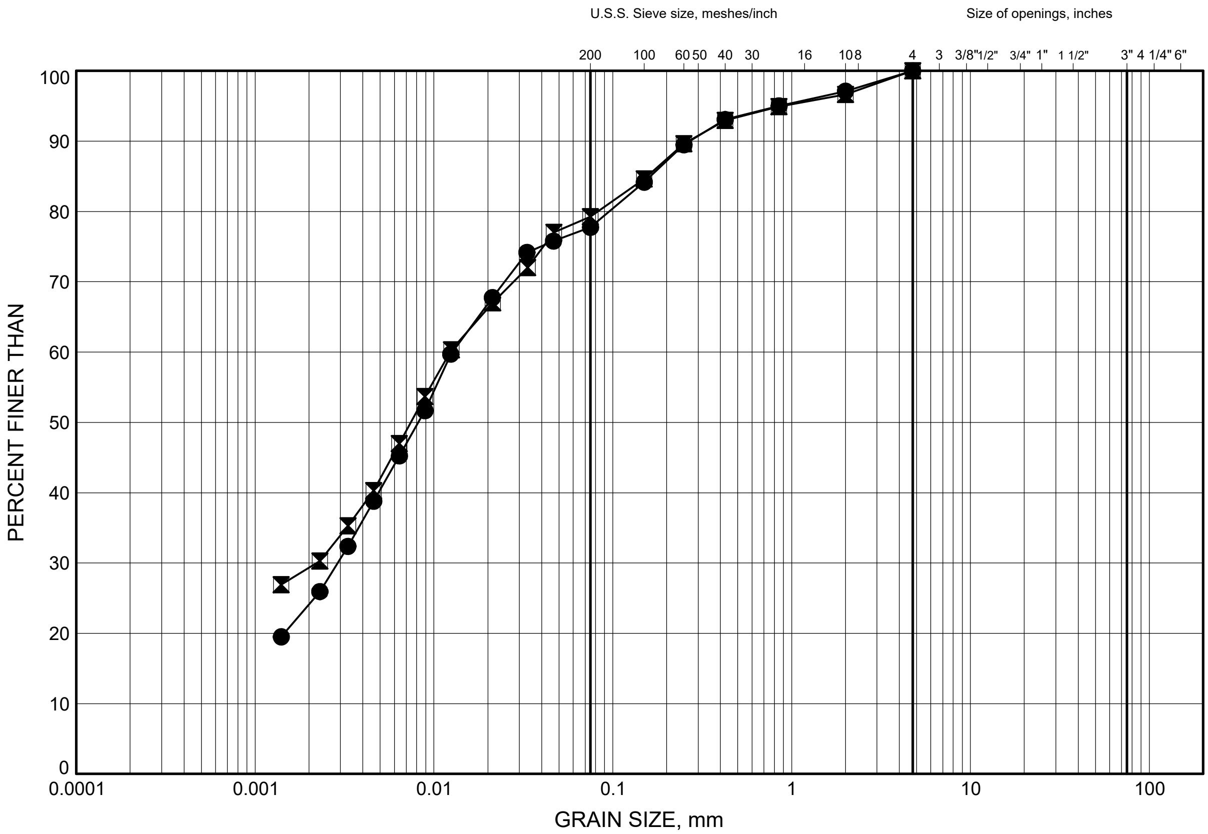
GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Hwy 401 - Highbury Avenue Interchange

GRAIN SIZE DISTRIBUTION

FIGURE B13

Lower Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-04	38.40	244.11
⧗	16-06	39.93	242.60

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

Chkd. MEF

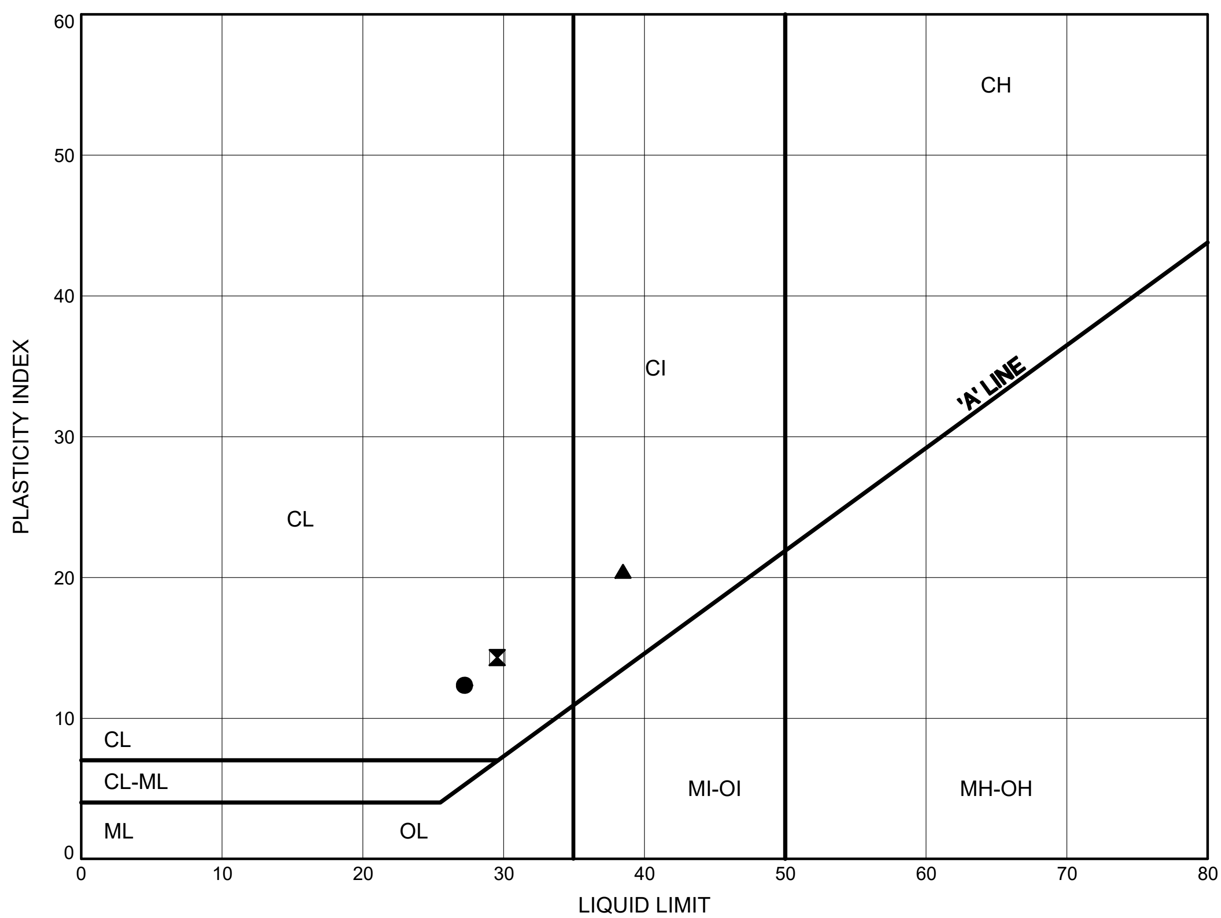
GRAIN SIZE DISTRIBUTION - THURBER 10552.GPJ 4/26/16

Hwy 401 - Highbury Avenue Interchange

ATTERBERG LIMITS TEST RESULTS

FIGURE B14

Silty CLAY FILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-03	2.59	279.48
⧗	16-08	2.59	277.68
▲	16-09	4.88	272.96

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

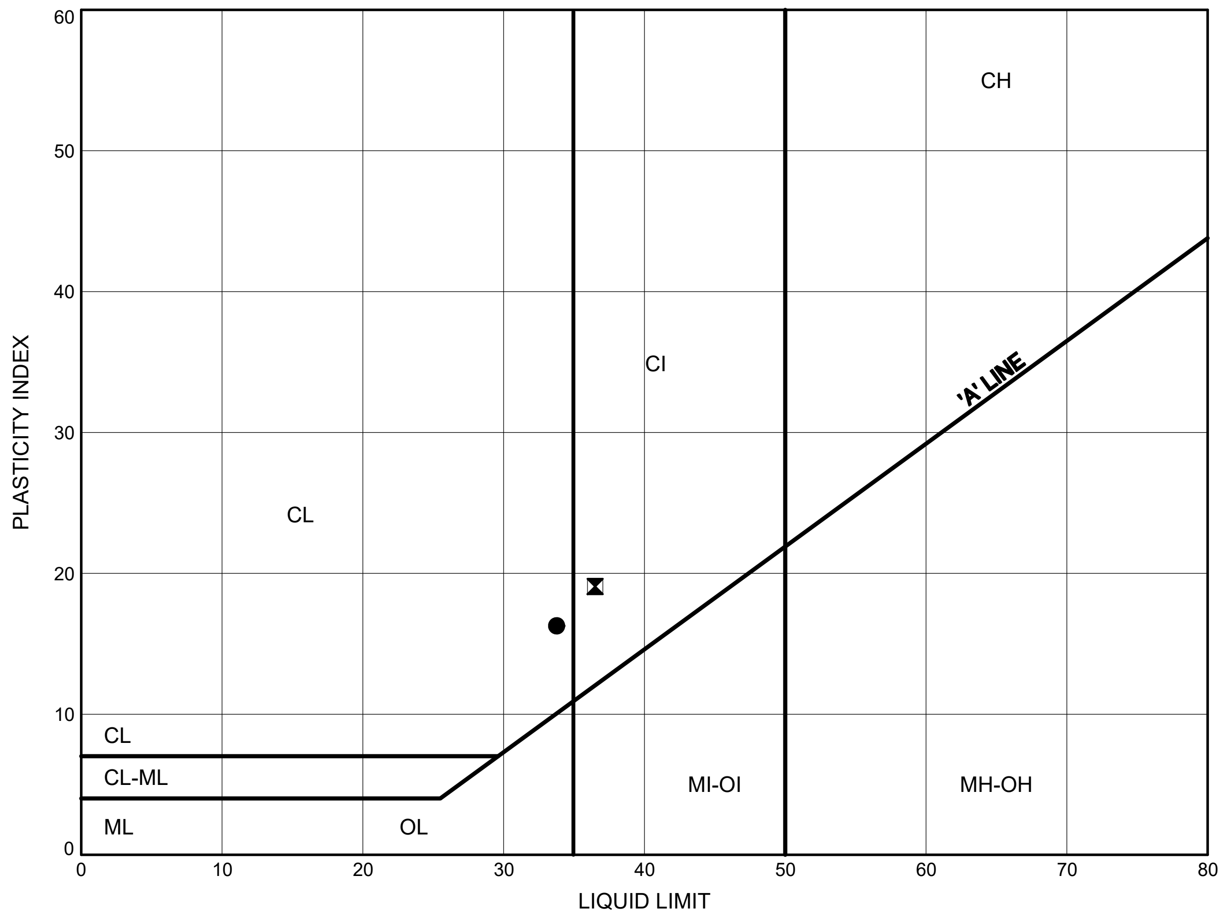
Chkd. MEF

Hwy 401 - Highbury Avenue Interchange

ATTERBERG LIMITS TEST RESULTS

FIGURE B15

Upper Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-01	1.07	271.62
⧗	16-07	7.92	274.25

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

Chkd. MEF

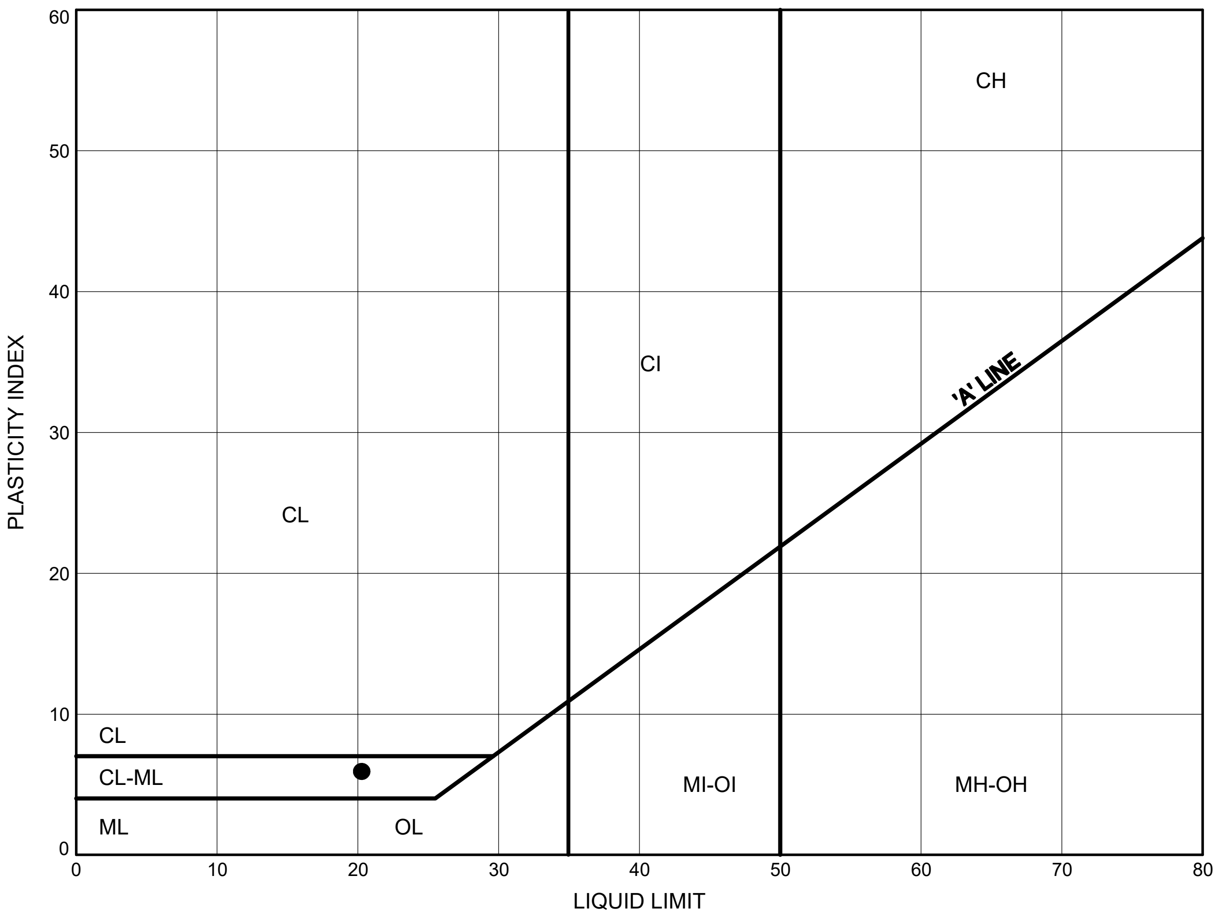
THURBALT 10552.GPJ 4/26/16

Hwy 401 - Highbury Avenue Interchange

ATTERBERG LIMITS TEST RESULTS

FIGURE B16

SILT



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	12.50	260.06

THURBALT 10552.GPJ 4/26/16

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

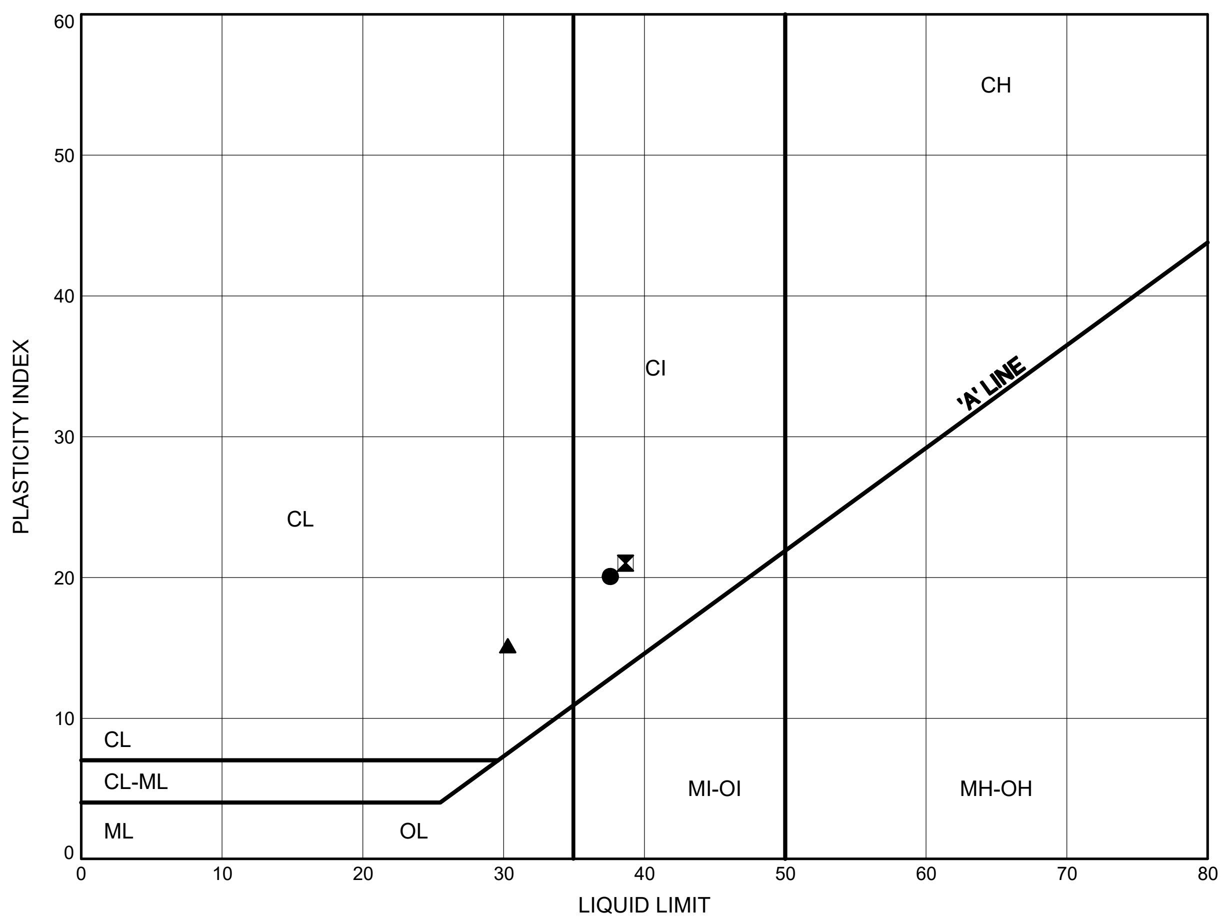
Chkd. MEF

Hwy 401 - Highbury Avenue Interchange

ATTERBERG LIMITS TEST RESULTS

FIGURE B17

Silty CLAY



LEGEND

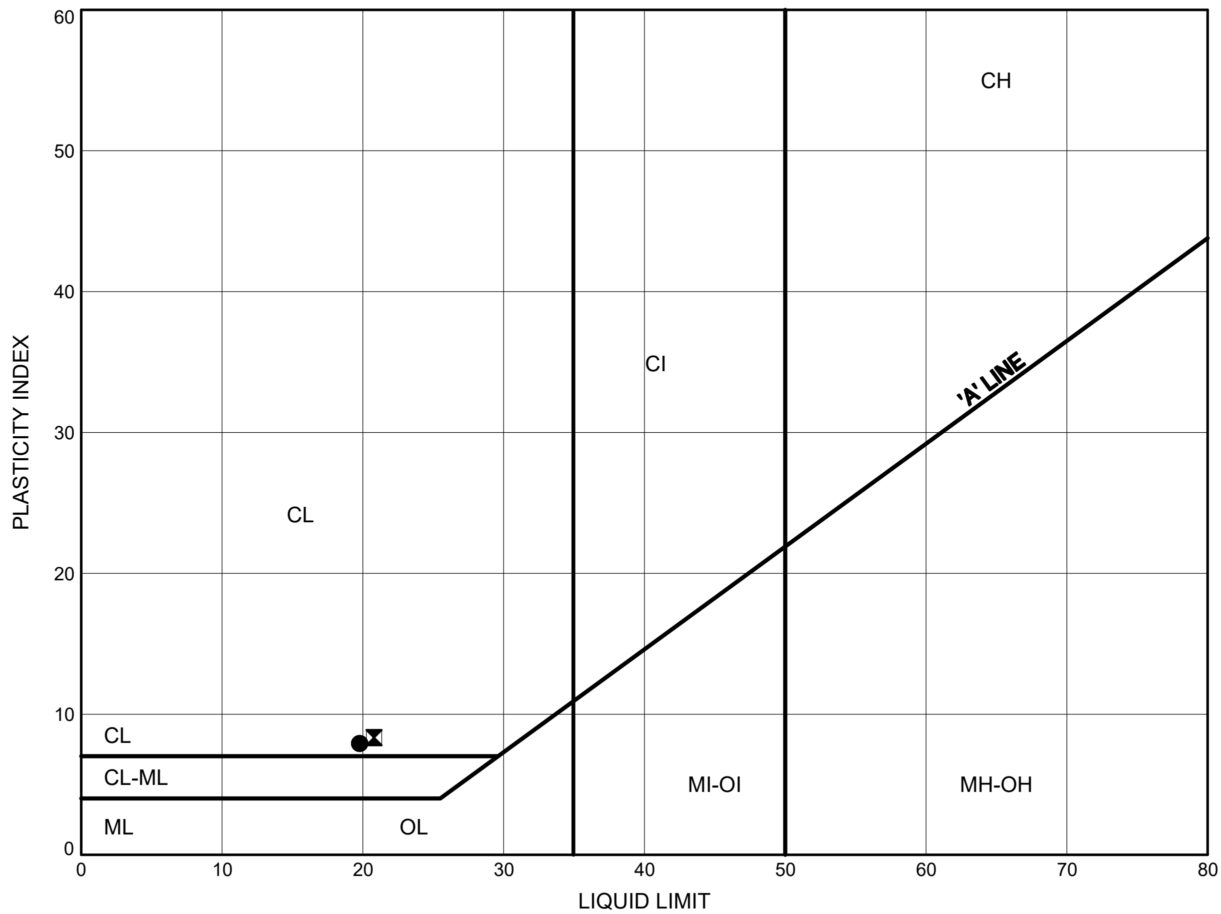
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-02	15.54	257.02
⧗	16-05	18.59	257.51
▲	16-09	18.59	259.25

Hwy 401 - Highbury Avenue Interchange

ATTERBERG LIMITS TEST RESULTS

FIGURE B18

Lower Silty CLAY TILL



LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	16-04	38.40	244.11
⧗	16-06	39.93	242.60

Date April 2016

W.P. 3032-11-00

THURBER

Prep'd AN

Chkd. MEF

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 16T083603

PROJECT: Highbury Ave

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: MARK FARRANT

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2016-04-08

DATE REPORTED: 2016-04-11

Parameter	Unit	G / S	RDL	7476431	RDL	7476443	RDL	7476444
SAMPLE DESCRIPTION:				16-04, SS#6, 15'-17'		16-05, SS#5, 10'-12'		16-06, SS#9, 30'-32'
SAMPLE TYPE:				Soil		Soil		Soil
DATE SAMPLED:				4/7/2016		4/7/2016		4/7/2016
Sulphide	%		0.05	<0.05	0.05	<0.05	0.05	<0.05
Chloride (2:1)	µg/g		8	2220	4	709	2	494
Sulphate (2:1)	µg/g		8	43	4	13	2	21
pH (2:1)	pH Units		NA	8.95	NA	9.65	NA	8.72
Electrical Conductivity (2:1)	mS/cm		0.005	3.53	0.005	1.25	0.005	0.868
Resistivity (2:1)	ohm.cm		1	283	1	800	1	1150
Redox Potential (2:1)	mV		5	238	5	216	5	279

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

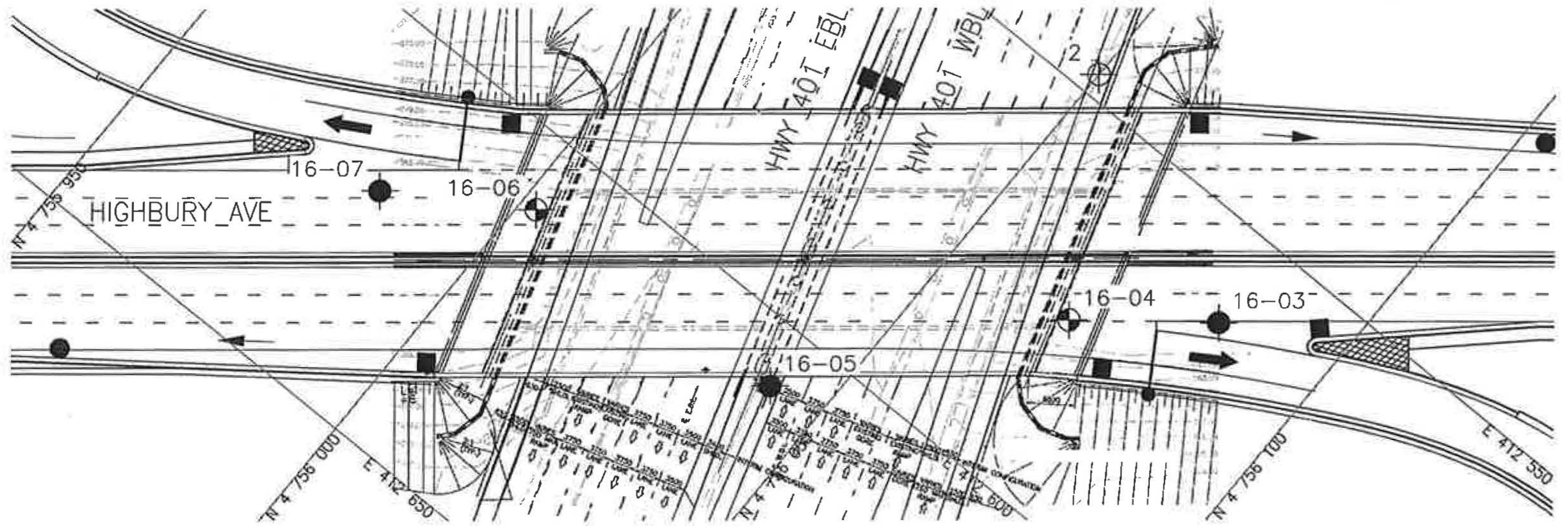
7476431-7476443 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).
Elevated RDL indicates the degree of sample dilution prior to the analysis for Anions in order to keep analyte within the calibration range of the instrument and to reduce matrix interference.

7476444 EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By: Amanjot Bhela

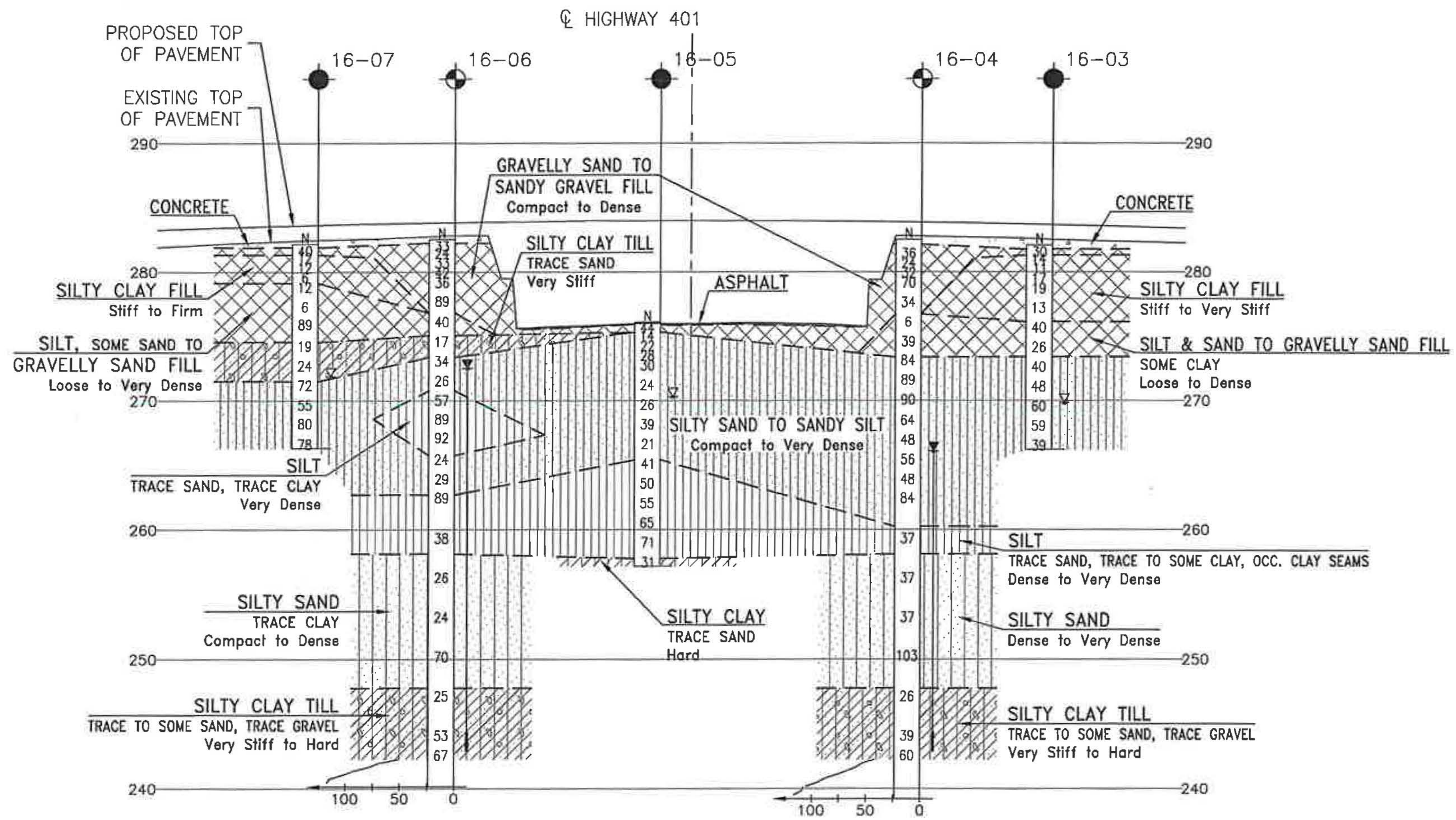
Results relate only to the items tested and to all the items tested

MINISTRY OF TRANSPORTATION, ONTARIO



PLAN

SCALE 1:1000 (20 0 20 40m)



PROFILE ALONG ℄ HIGHBURY AVENUE

H 1:1000 (20 0 20 40m)

V 1:500 (10 0 10 20m)

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
S. PANG
Apr 26/16
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Apr 26/16
PROVINCE OF ONTARIO

CONT No

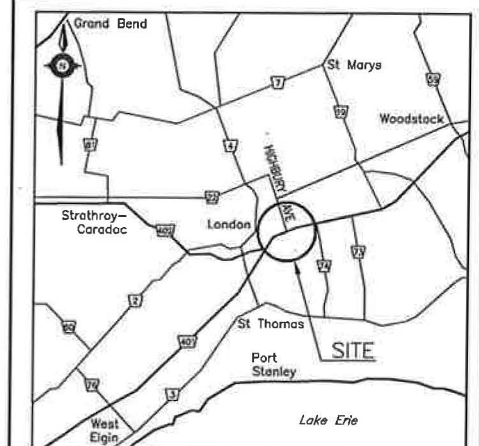
WP No 3032-11-00

SHEET

HIGHWAY 401
HIGHBURY AVENUE
INTERCHANGE – OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

Ontario

THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

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

NO	ELEVATION	NORTHING	EASTING
16-01	272.7	4 756 183.3	412 612.8
16-02	272.6	4 756 158.1	412 555.7
16-03	282.1	4 756 084.2	412 562.8
16-04	282.5	4 756 068.3	412 575.4
16-05	276.1	4 756 042.3	412 608.1
16-06	282.5	4 756 002.3	412 609.7
16-07	282.2	4 755 984.1	412 621.1
16-08	280.3	4 755 908.3	412 657.4
16-08A	273.2	4 755 914.0	412 628.0
16-09	277.8	4 755 861.7	412 595.5
16-09A	272.6	4 755 881.0	412 592.0
1	275.0	4 755 997.0	412 530.0
2	275.4	4 756 050.0	412 547.0

-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.

GEOCRES No. 40I14-165

REVISIONS	DATE	BY	DESCRIPTION

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PLOTDATE: 4/21/2016 2:10 PM

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

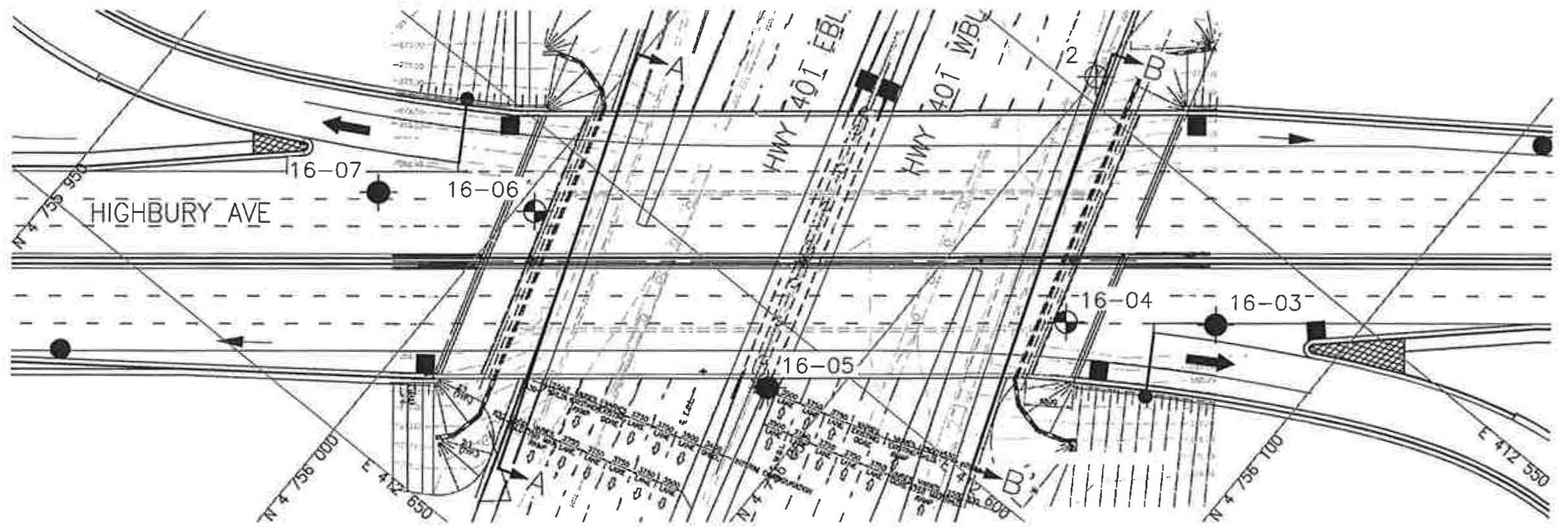
CONT No
WP No 3032-11-00

HIGHWAY 401
HIGHBURY AVENUE
INTERCHANGE – ABUTMENTS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario

THURBER ENGINEERING LTD.

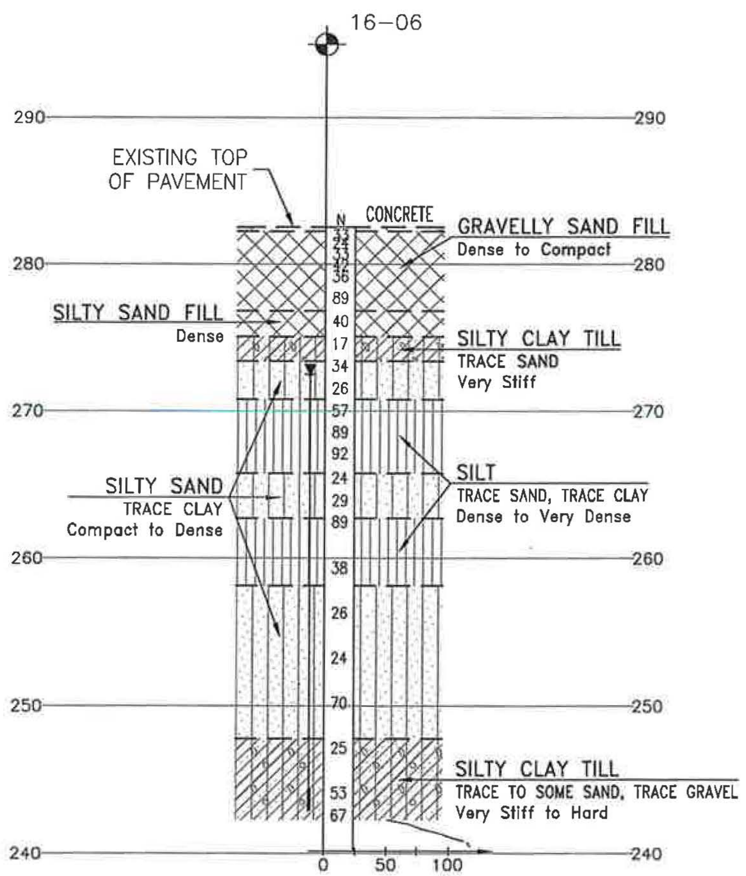


PLAN

SCALE 1:1000

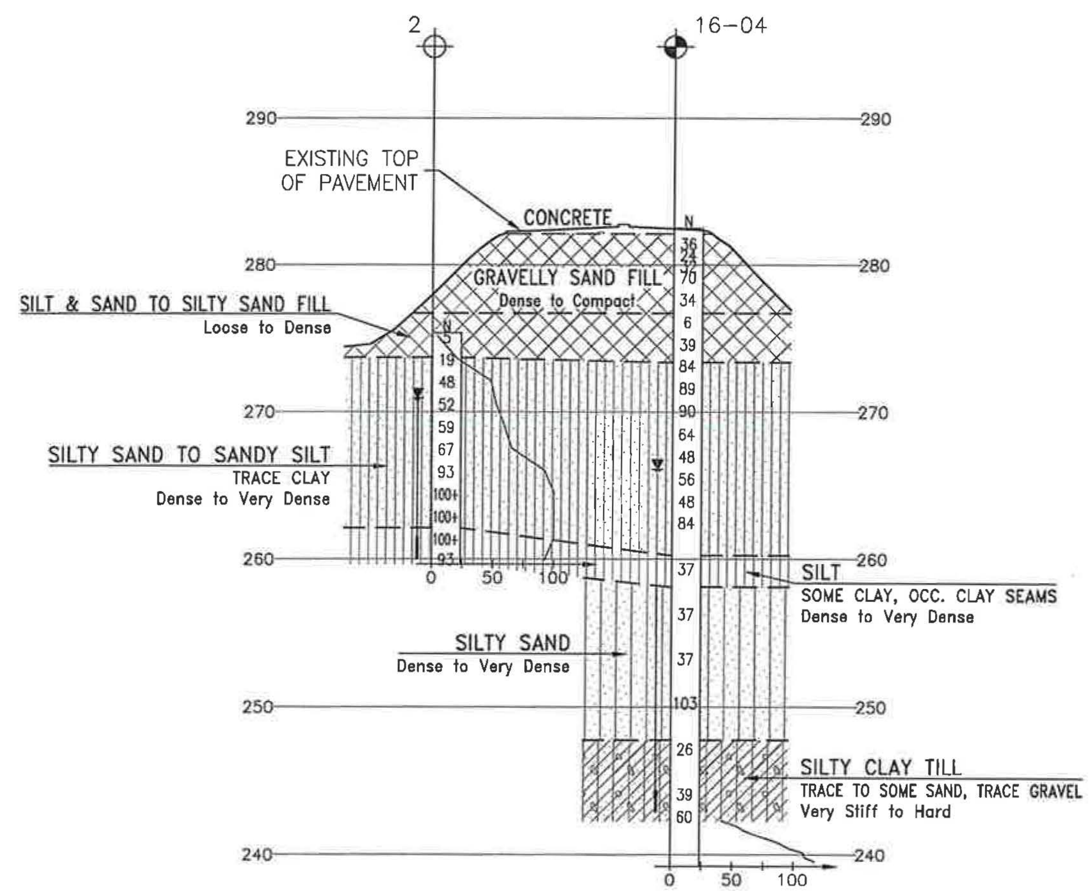
LICENSED PROFESSIONAL ENGINEER
G. PANG
Apr 26/16
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
April 26/16
PROVINCE OF ONTARIO



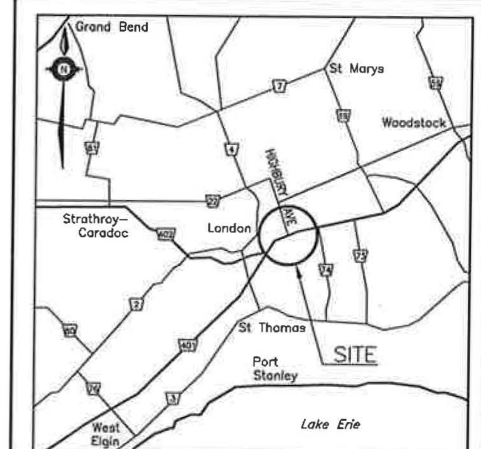
SECTION A-A'

H 1:1000
V 1:500



SECTION B-B'

H 1:1000
V 1:500



KEYPLAN

LEGEND

Symbol	Description
●	Borehole (Present Investigation)
◈	Borehole and Cone (Present Investigation)
⊕	Borehole and Cone (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
⊻	Water Level
⊻	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16-01	272.7	4 756 183.3	412 612.8
16-02	272.6	4 756 158.1	412 555.7
16-03	282.1	4 756 084.2	412 562.8
16-04	282.5	4 756 068.3	412 575.4
16-05	276.1	4 756 042.3	412 608.1
16-06	282.5	4 756 002.3	412 609.7
16-07	282.2	4 755 984.1	412 621.1
16-08	280.3	4 755 908.3	412 657.4
16-08A	273.2	4 755 914.0	412 628.0
16-09	277.8	4 755 861.7	412 595.5
16-09A	272.6	4 755 881.0	412 592.0
1	275.0	4 755 997.0	412 530.0
2	275.4	4 756 050.0	412 547.0

-NOTES-

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2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 40I14-165

REVISIONS	DATE	BY	DESCRIPTION

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METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

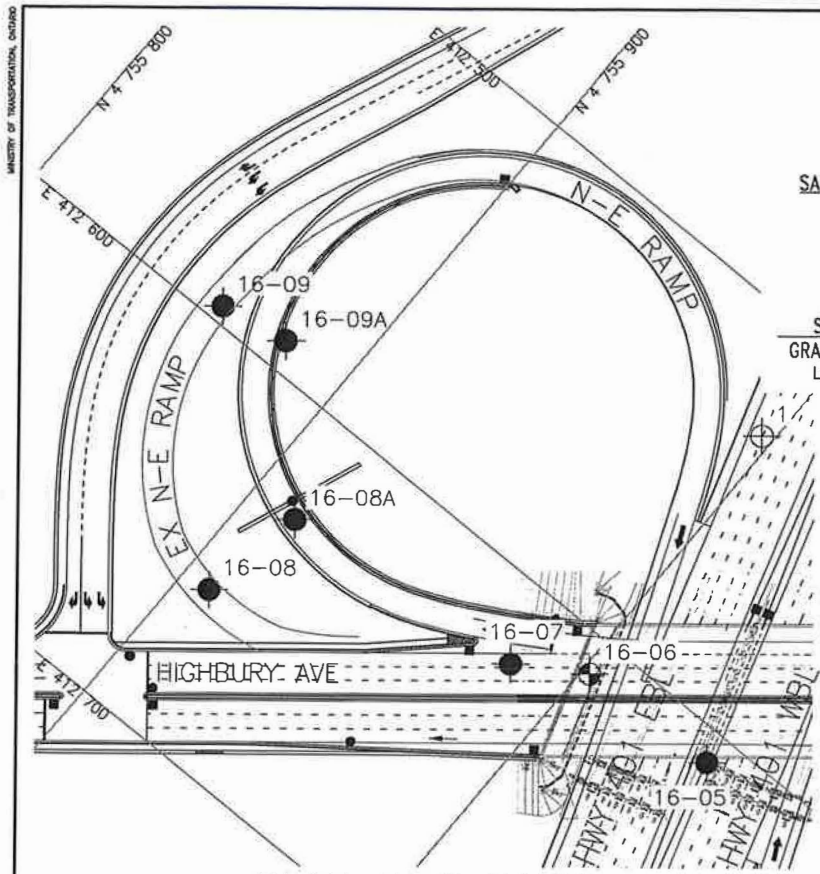
CONT No
WP No 3032-11-00

HIGHWAY 401
HIGHBURY AVENUE
INTERCHANGE – RAMPS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

Ontario

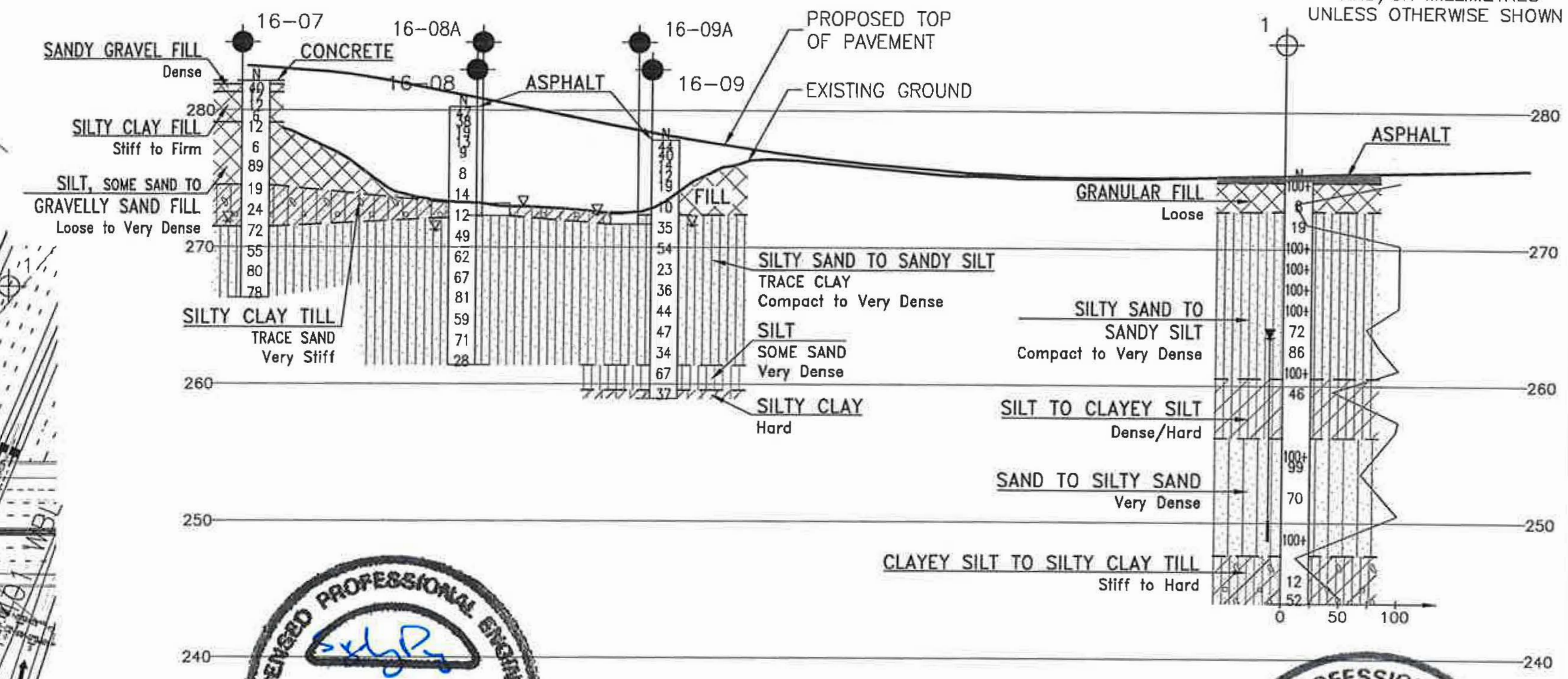
THURBER ENGINEERING LTD.



PLAN N–E RAMP

40 0 40 80m

SCALE 1:2000



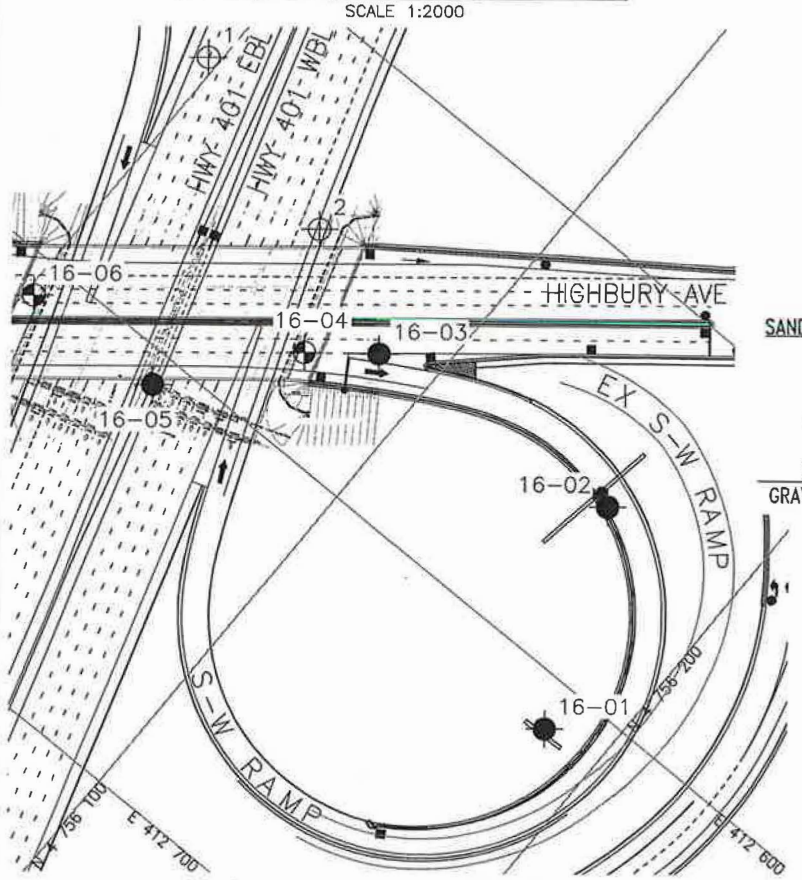
LICENSED PROFESSIONAL ENGINEER
G. PANG
Apr 26/16
PROVINCE OF ONTARIO

PROFILE ALONG ℄ N–E RAMP

40 0 40 80m H 1:2000

10 0 10 20m V 1:500

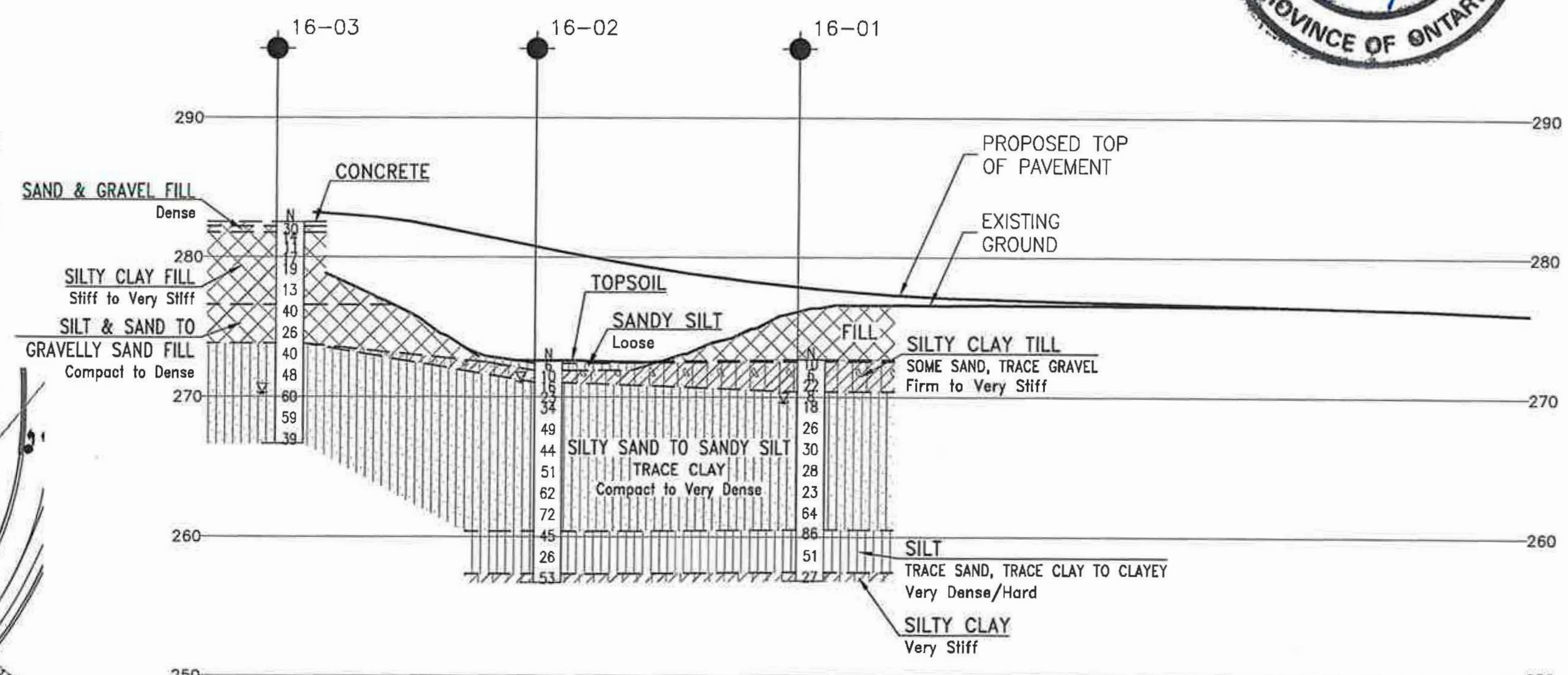
LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
April 26/16
PROVINCE OF ONTARIO



PLAN S–W RAMP

40 0 40 80m

SCALE 1:2000



PROFILE ALONG ℄ S–W RAMP

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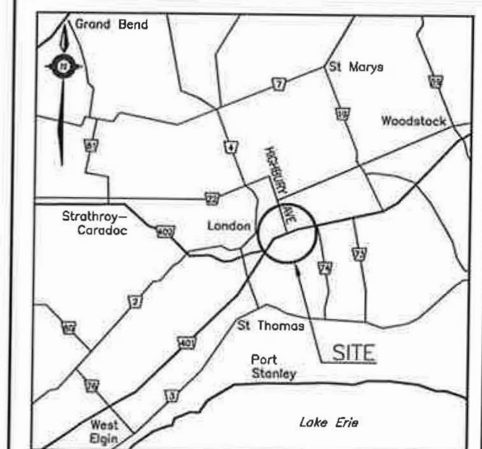
10 0 10 20m V 1:500



KEYPLAN

LEGEND

Symbol	Description
●	Borehole (Present Investigation)
⊕	Borehole and Cone (Present Investigation)
⊕	Borehole and Cone (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
⊻	Water Level
⊻	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
16–01	272.7	4 756 183.3	412 612.8
16–02	272.6	4 756 158.1	412 555.7
16–03	282.1	4 756 084.2	412 562.8
16–04	282.5	4 756 068.3	412 575.4
16–05	276.1	4 756 042.3	412 608.1
16–06	282.5	4 756 002.3	412 609.7
16–07	282.2	4 755 984.1	412 621.1
16–08	280.3	4 755 908.3	412 657.4
16–08A	273.2	4 755 914.0	412 628.0
16–09	277.8	4 755 861.7	412 595.5
16–09A	272.6	4 755 881.0	412 592.0
1	275.0	4 755 997.0	412 530.0
2	275.4	4 756 050.0	412 547.0

-NOTES-

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2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 40I14-165

REVISIONS	DATE	BY	DESCRIPTION

DESIGN MEF	CHK PKC	CODE		LOAD		DATE	APR 2016
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PLOTDATE: 4/21/2016 2:11 PM

B.2 GEOCRES NO 40I14-148

METRIC

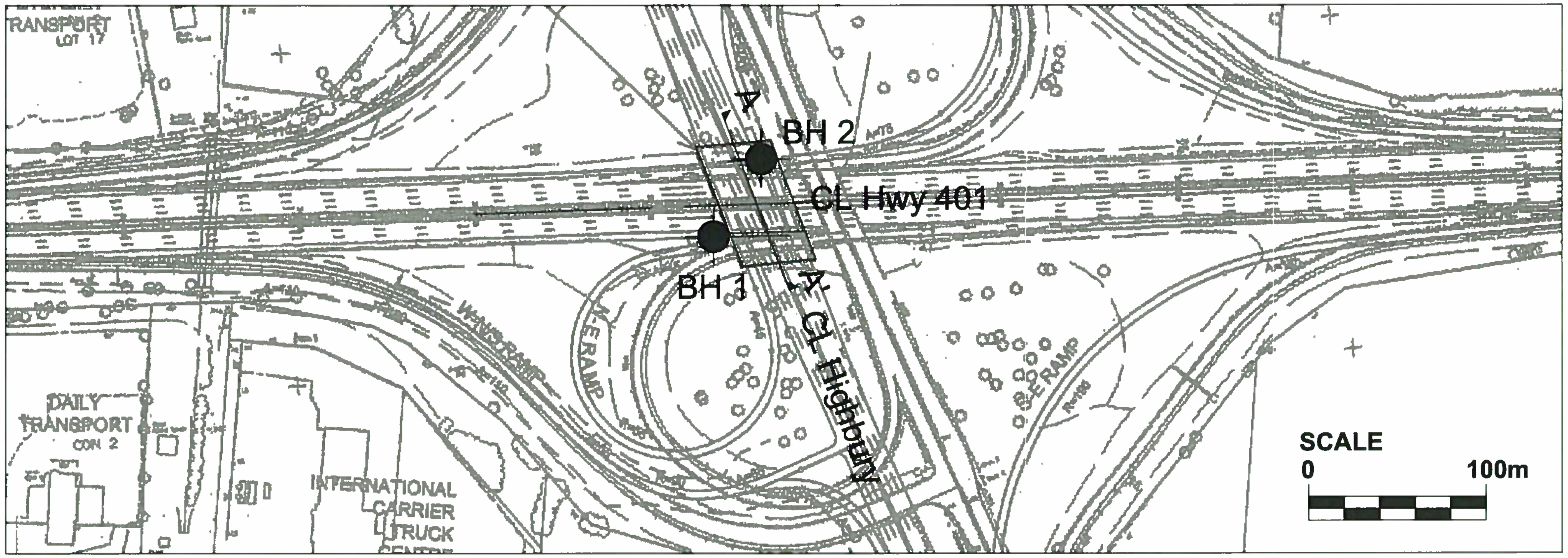
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No xxxx–xxxx
WP No GWP 3032–11–00

Highbury Avenue
Highway 401 Underpass
BOREHOLE LOCATION PLAN & PROFILE

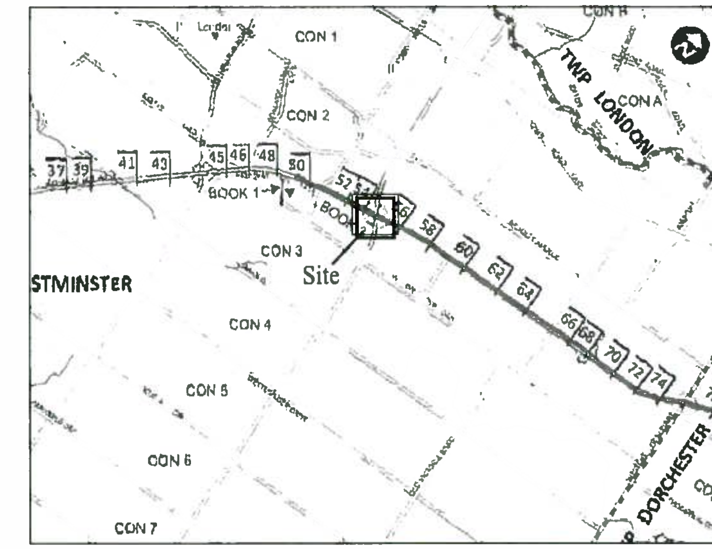
SHEET 1

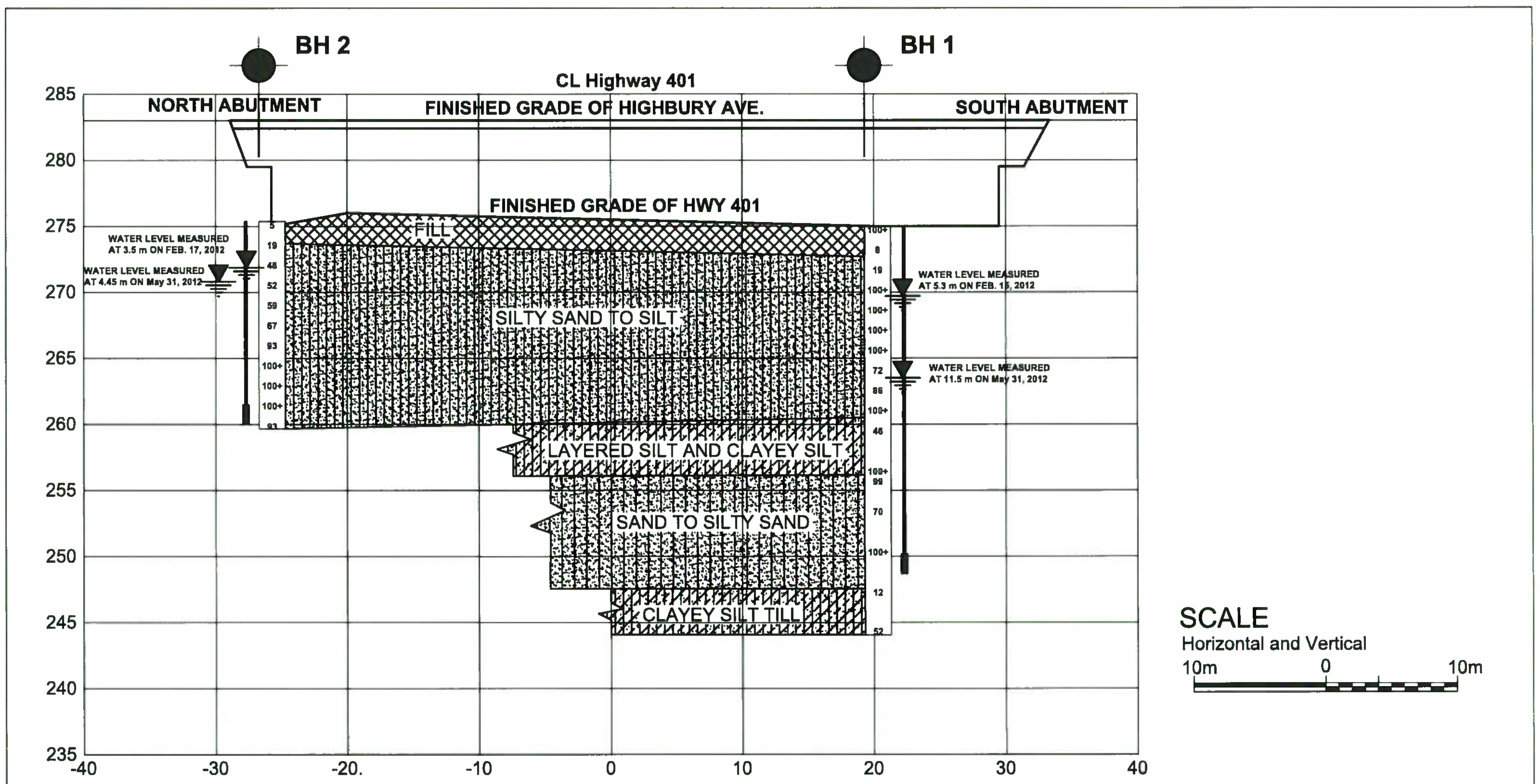
I.E. Group — Infrastructure Engineering Group Inc. Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor



BOREHOLE LOCATION PLAN

KEYPLAN NTS





SECTION A-A'

SCALE
Horizontal and Vertical
10m 0 10m

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
- Standpipe

NOTES

1. 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 ARE SPECIFICALLY EXCLUDED IN ACCORDANCE WITH THE CONDITIONS OF SECTION GC2.01 of OPS GEN. COND.
2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES AND BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.
3. SUBGRADE ELEVATION OF THE EXISTING FOOTING NOT KNOWN AND IS ESTIMATED TO BE AT A MINIMUM OF 1.2m BELOW THE FINISHED GRADE.
4. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

BOREHOLE NO.	ELEVATION	MTM:11 CO-ORDINATES NORTH	EAST
1	275.04	4755997	412530
2	275.37	4756050	412547

REVISIONS DATE	BY	DESCRIPTION
16/07/12	J.L.	Final
02/06/12	J.L.	Draft

MTO GEOCRES No. 40114–148

HWY No. HWY 401			DIST LONDON
SUBM'D J.L.	CHECKED E.C.	DATE 24/05/12	SITE Not Known
DRAWN J.L.	CHECKED J.L.	APPROVED E.C.	DWG 1

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY $= \frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX $= w_L - w_P$
I_L	1	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C		CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE

e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No 1

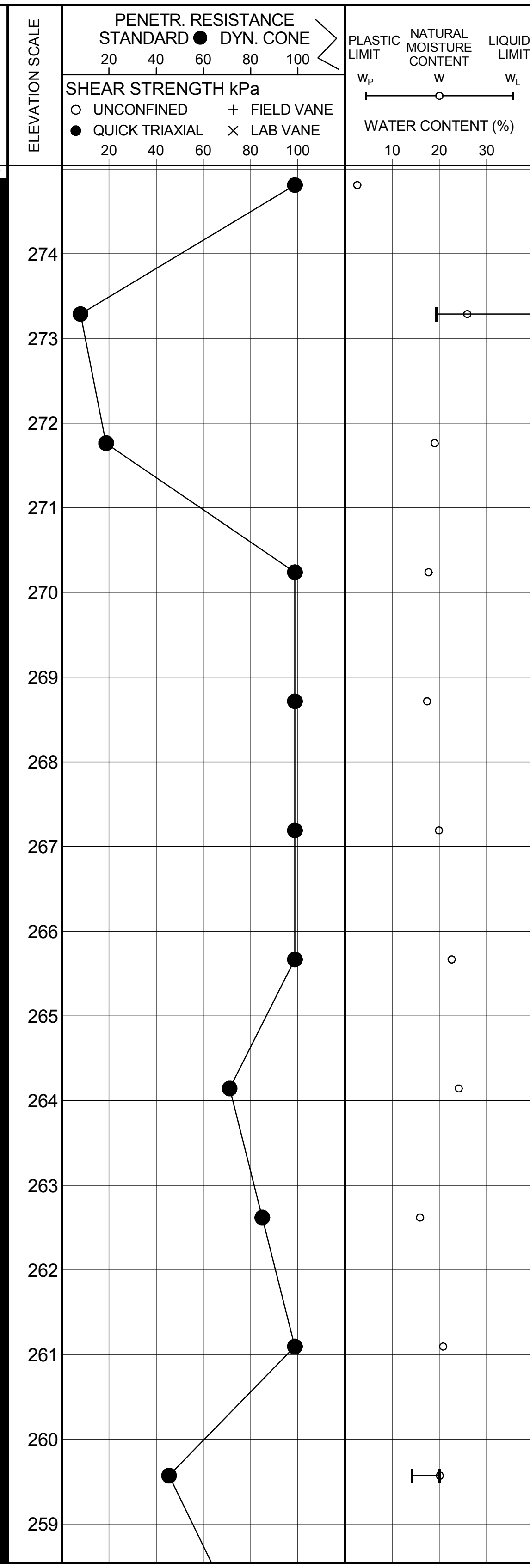
METRIC

W.P. GWP 3032-11-00 LOCATION Highbury Ave. South Side Northing - 4755997, Easting - 412530 ORIGINATED BY JL

DIST London HWY 401 BOREHOLE TYPE 110 mm H/S and Wash Boring COMPILED BY JL

DATUM Geodetic DATE 14.2.12 - 16.2.12 CHECKED BY EC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
275.04	Ground					
0.00	200 mm Asphalt	1	SPT	100+		Top of casing @ Elev. 274.98 m.
	710 mm Dark Brown Granular Fill.					
274.13 / 0.91	FILL Brown, moist, loose, consisting mainly of silty clay with some sand and gravel, trace organics.	2	SPT	8	42 15.9	1 11 50 38 (88)
272.75 / 2.29	Silty SAND to SILT, SM to ML Wet to saturated, compact to very dense. Brown	3	SPT	19		0 19 77 4 (81)
		4	SPT	100+		0 19 80 2 (81)
						Water level measured @ 5.3 m on Feb. 15, 2012
		5	SPT	100+		1 44 53 2 (55)
		6	SPT	100+		0 42 54 4 (58)
		7	SPT	100+		0 73 26 2 (27)
						Water level measured @ 11.5 m on May 31, 2012
		8	SPT	72		0 65 34 2 (35)
	Grey	9	SPT	86		0 3 84 13 (97)
		10	SPT	100+		0 6 91 3 (94)
260.56 / 14.48	Layered SILT and Clayey SILT, ML to CL-ML, layered Grey, wet to saturated, dense to very dense or hard.	11	SPT	46		0 1 80 19 (99)



Continued Next Page

+ [3], × [3]: Numbers refer to Sensitivity ○ [150] UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 1

METRIC

W.P. GWP 3032-11-00 | LOCATION Highbury Ave. South Side Northing - 4755997, Easting - 412530 | ORIGINATED BY JL

DIST London HWY 401 | BOREHOLE TYPE 110 mm H/S and Wash Boring | COMPILED BY JL

DATUM Geodetic | DATE 14.2.12 - 16.2.12 | CHECKED BY EC

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	NATURAL MOISTURE CONTENT / LIMITS	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Layered SILT and Clayey SILT, ML to CL-ML, layered Grey, wet to saturated, dense to very dense or hard. *(continued)*	12	SPT	100+			17.3	0	33	39	29 (67)
256.20 / 18.84	SAND to Silty SAND , SP to SM Grey, saturated, very dense.	13	SPT	99				0	95		(5)
		14	SPT	70				0	83	14	3 (17)
		15	SPT	100+				0	75	21	4 (25)
247.61 / 27.43	Clayey Silt, CL-ML Grey, wet to moist, stiff to hard, with embedded sand and gravel (TILL). frequent wet silt seams	16	SPT	12				2	8	68	22 (90)
		17	SPT	52		225+	22.8	4	17	53	26 (79)
244.10 / 30.94	End of borehole										

Elevation scale: 258, 257, 256, 255, 254, 253, 252, 251, 250, 249, 248, 247, 246, 245

PENETR. RESISTANCE: STANDARD ● DYN. CONE (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity ○¹⁵⁰ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 2

METRIC

W.P. GWP 3032-11-00	LOCATION Highbury Ave. North Side Northing - 4756050, Easting - 412547		ORIGINATED BY JL
DIST London	HWY 401	BOREHOLE TYPE 110 mm H/S and Wash Boring	COMPILED BY JL
DATUM Geodetic		DATE 16.2.12 - 17.2.12	CHECKED BY EC

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; PENETR. RESISTANCE STANDARD ● DYN. CONE (20 40 60 80 100); SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (10 20 30); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

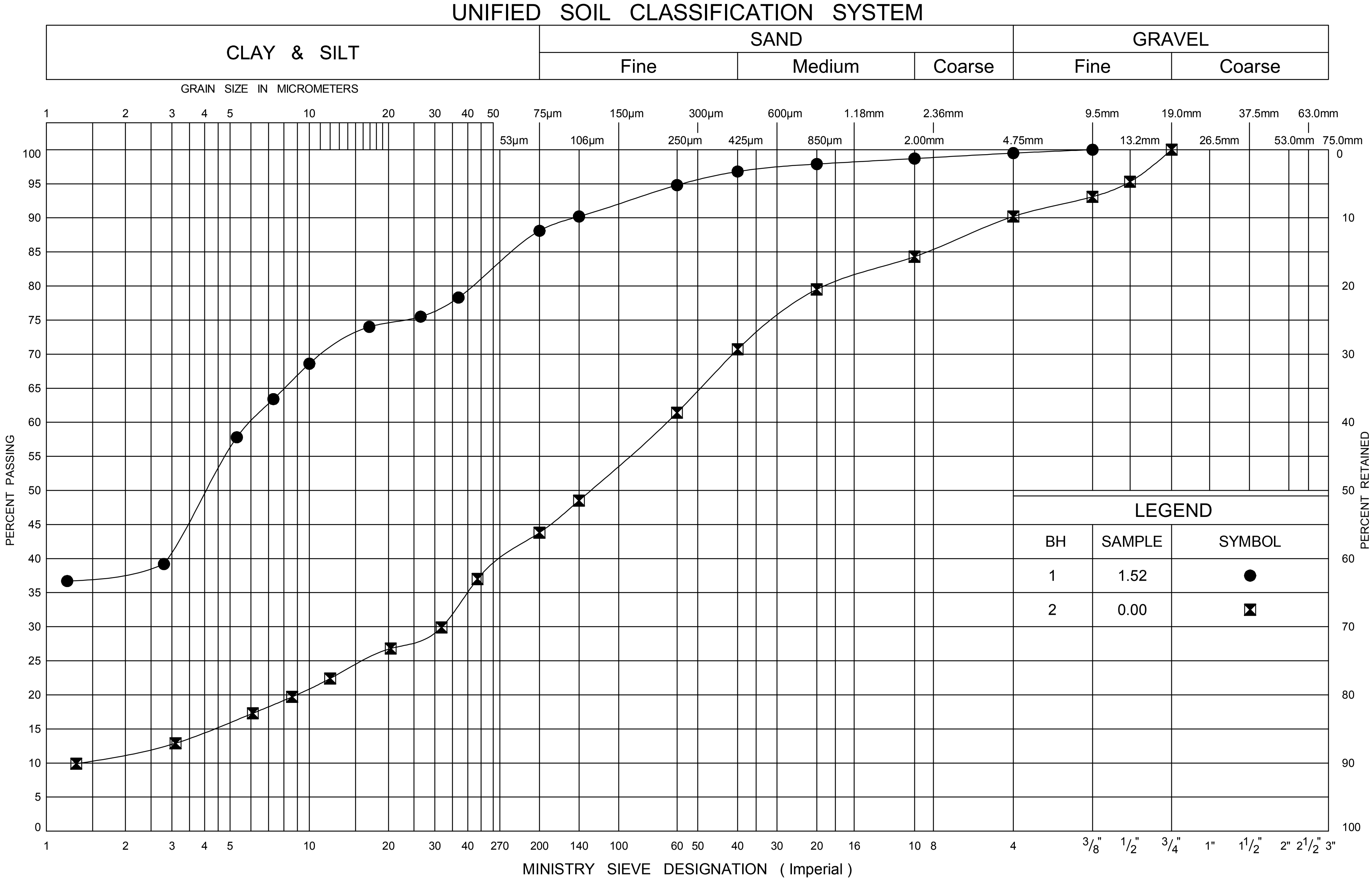
ELEV / DEPTH	DESCRIPTION
275.37	Ground
0.00 / 274.91 / 0.46	460 mm silty sand FILL, some gravel.
	FILL Brown, moist, loose, consisting mainly of silty clay with some sand and gravel, trace organics.
273.69 / 1.68	Silty SAND to SILT, SM to ML Moist to saturated, compact to very dense, occasional silty clay seams. Brown Grey
259.67 / 15.70	End of Borehole

NUMBER	TYPE	"N" VALUES	REMARKS / GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SPT	5	10 46 32 11 (44)
2	SPT	19	
3	SPT	48	Water level measured at 3.5 m on Feb. 17, 2012. 0 76 22 2 (24)
			Water level measured @ 4.45 m on May 31, 2012
4	SPT	52	2 76 19 4 (23)
5	SPT	59	0 49 48 2 (51)
6	SPT	67	0 4 88 8 (96)
7	SPT	93	0 0 88 12 (100)
8	SPT	100+	0 80 18 2 (20)
9	SPT	100+	0 43 53 4 (57)
10	SPT	100+	0 13 83 5 (87)
11	SPT	93	0 0 90 10 (100)

Elevation scale: 275, 274, 273, 272, 271, 270, 269, 268, 267, 266, 265, 264, 263, 262, 261, 260

+³, ×³: Numbers refer to Sensitivity ○¹⁵⁰ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

78 12 M



Ministry of Transportation Ontario

GRAIN SIZE DISTRIBUTION

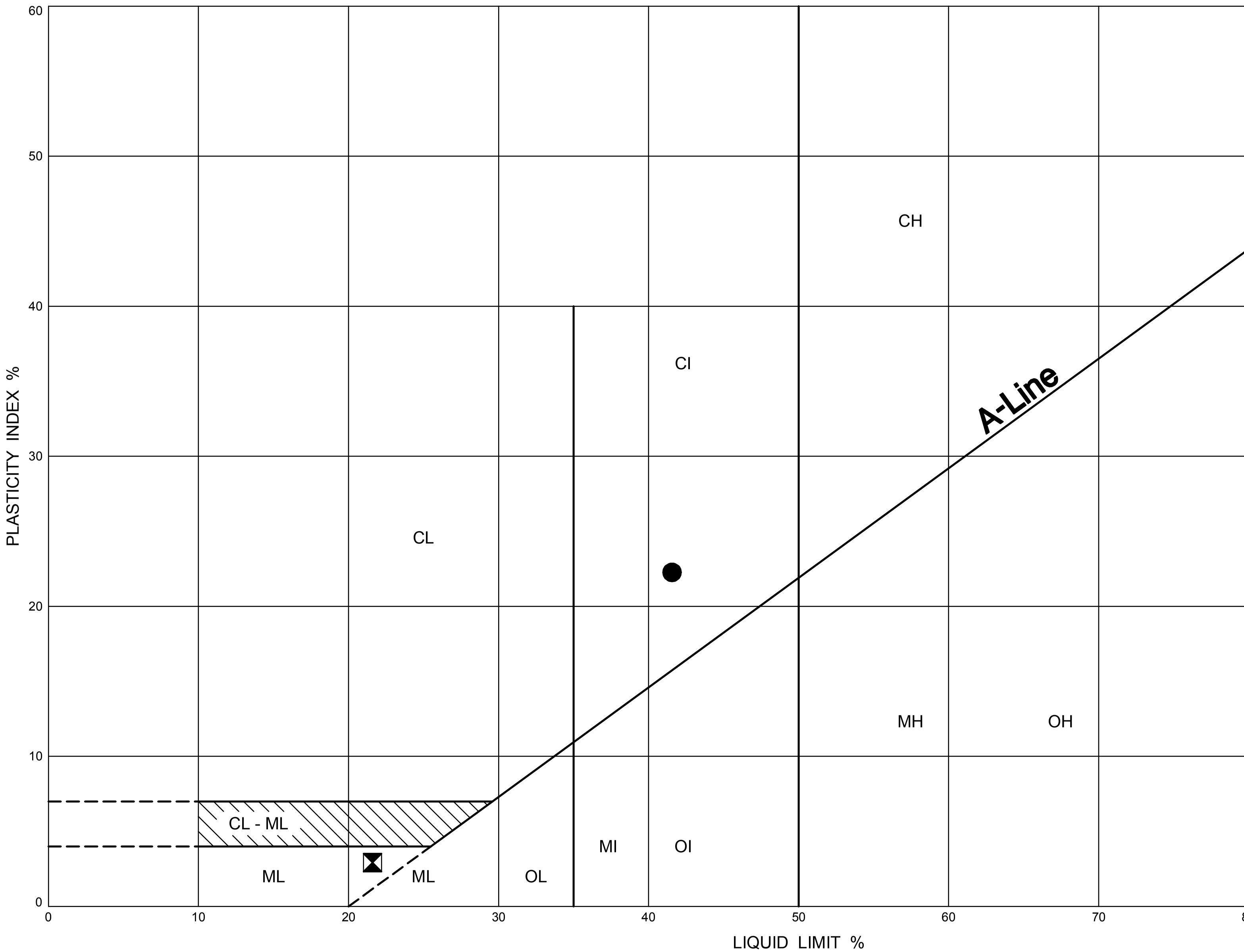
Fill

FIG No 1

GWP 3032-11-00

Highbury Interchange Reconfiguration

Oct 75, FF - S - 21



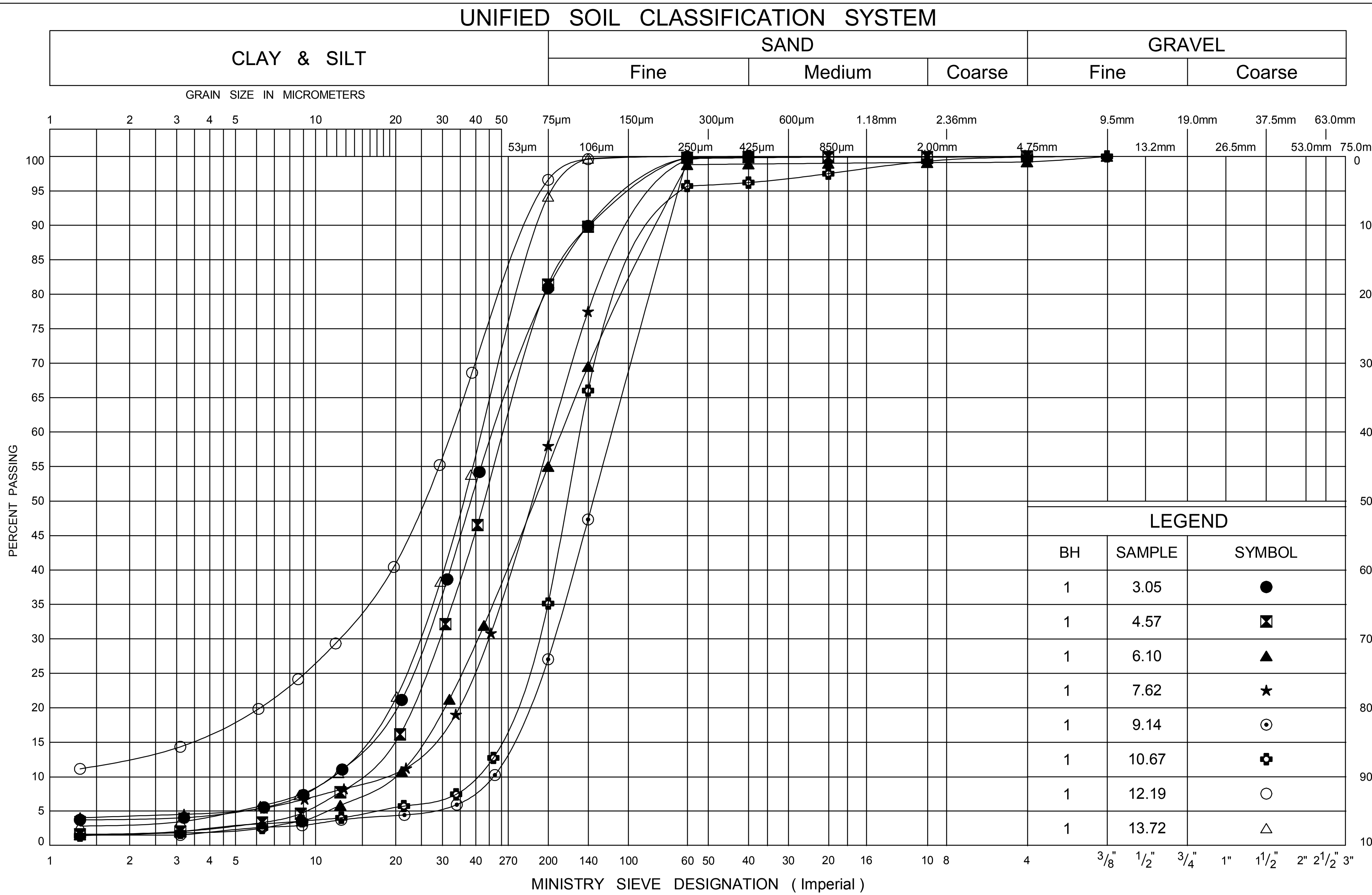
LEGEND		
BH	SAMPLE	SYMBOL
1	1.52	●
2	0.00	⧗

Ministry of Transportation
Ontario

PLASTICITY CHART
Fill

FIG No 2
GWP 3032-11-00
Highbury Interchange Reconfiguration

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
1	3.05	●
1	4.57	⊠
1	6.10	▲
1	7.62	★
1	9.14	⊙
1	10.67	✪
1	12.19	○
1	13.72	△

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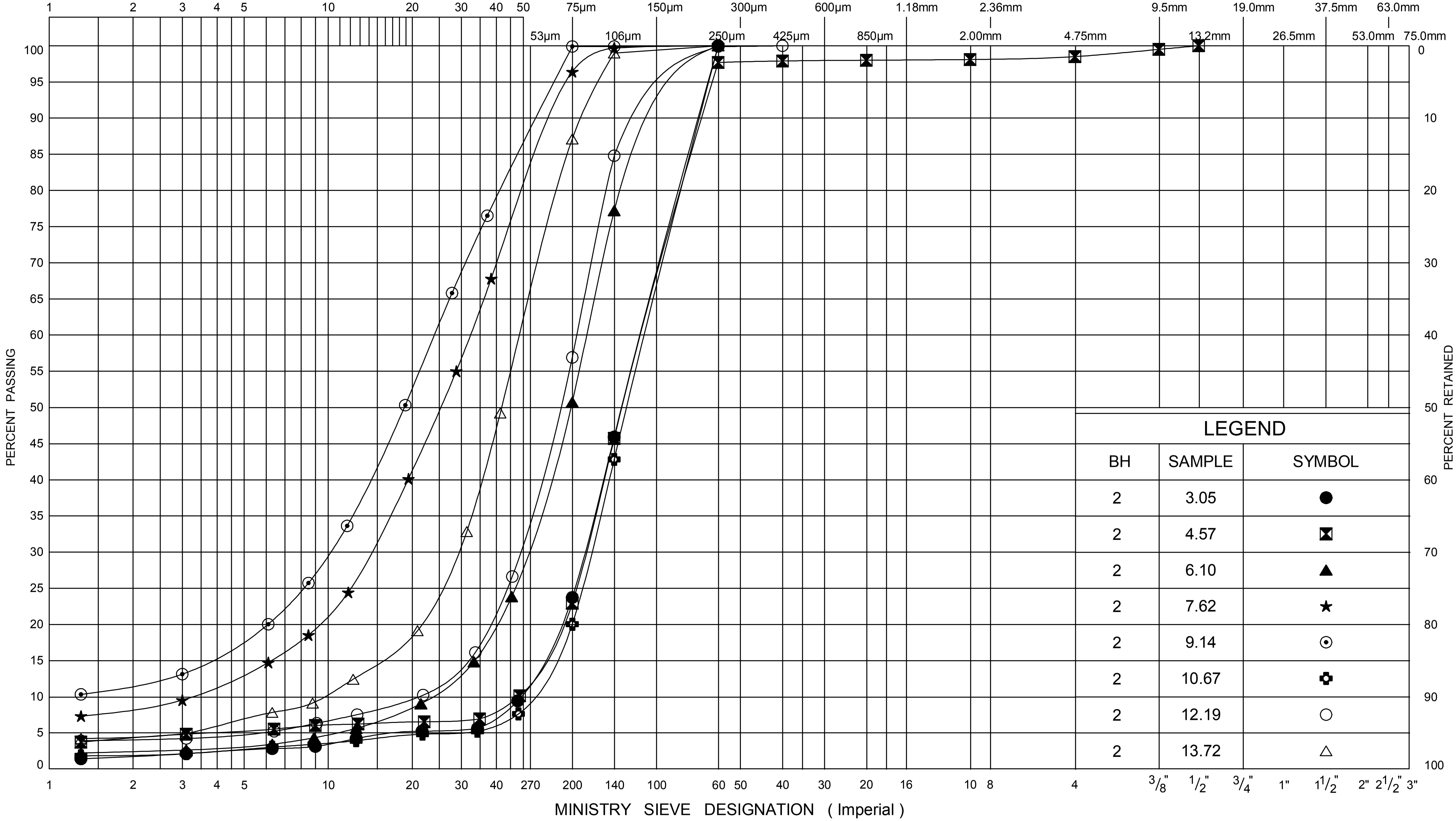
GRAIN SIZE DISTRIBUTION

Upper Silty Sand to Silt, SM to ML

FIG No 3

GWP 3032-11-00

Highbury Interchange Reconfiguration



BH	SAMPLE	SYMBOL
2	3.05	●
2	4.57	⧗
2	6.10	▲
2	7.62	★
2	9.14	⊙
2	10.67	✤
2	12.19	○
2	13.72	△

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GRAIN SIZE DISTRIBUTION

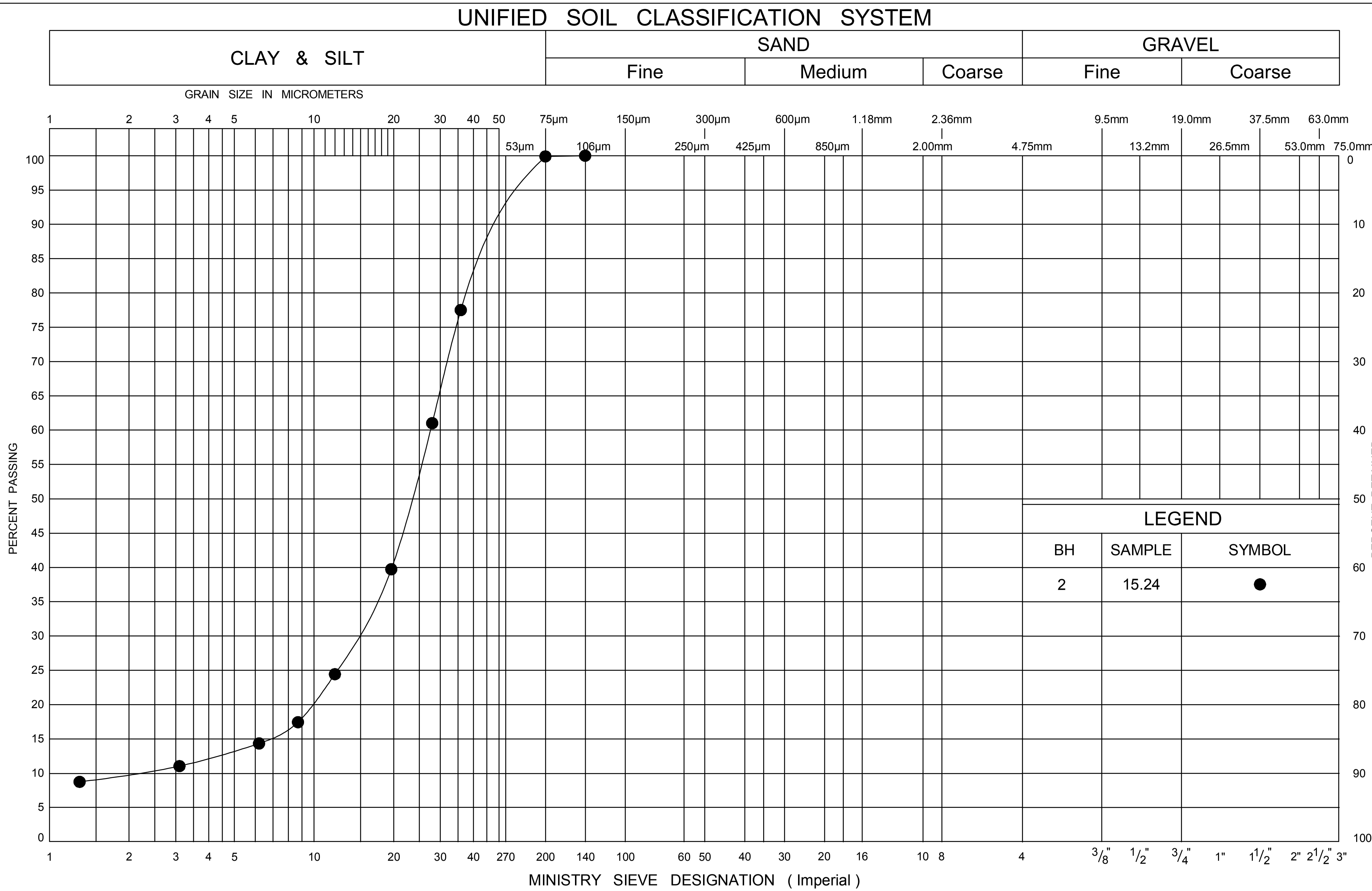
Upper Silty Sand to Silt, SM to ML

FIG No 4

GWP 3032-11-00

Highbury Interchange Reconfiguration

78 12 M



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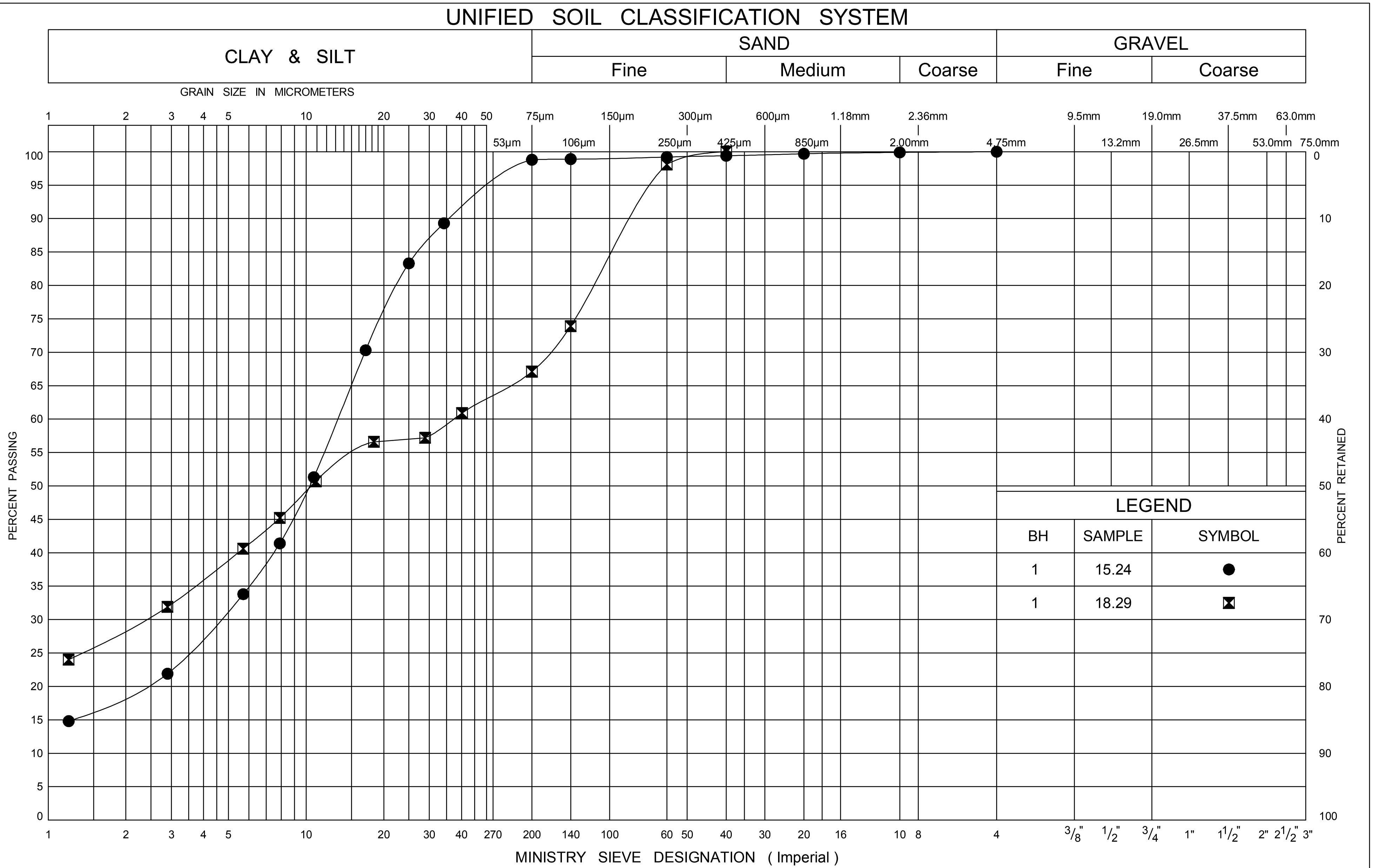
GRAIN SIZE DISTRIBUTION

Upper Silty Sand to Silt, SM to ML

FIG No 5

GWP 3032-11-00

Highbury Interchange Reconfiguration



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GRAIN SIZE DISTRIBUTION

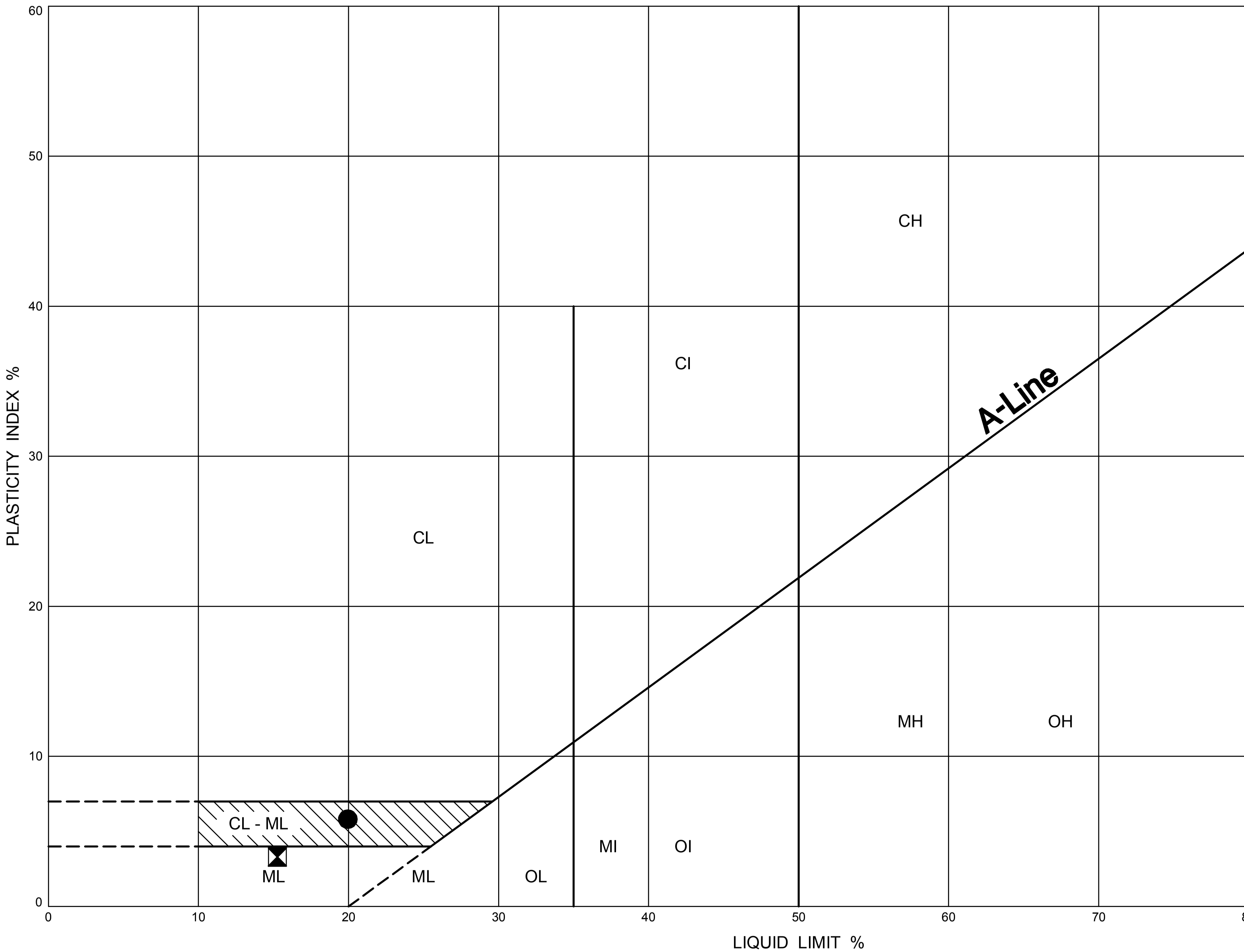
Layered Silt and Clayey Silt, ML to CL-ML

FIG No 6

GWP 3032-11-00

Highbury Interchange Reconfiguration

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
1	15.24	●
1	18.29	⧗

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Ontario

PLASTICITY CHART

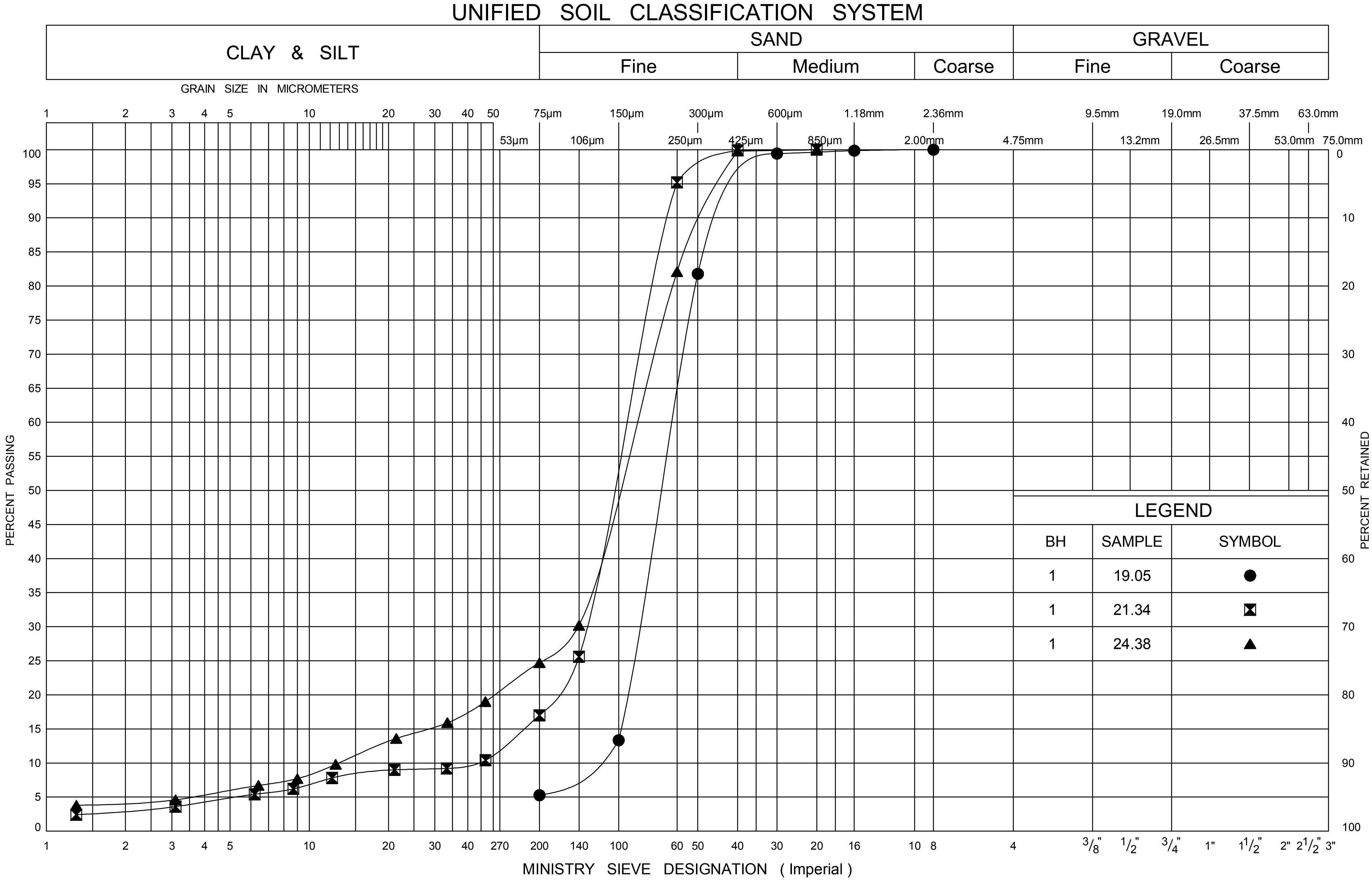
Layered Silt and Clayey Silt, ML to CL-ML

FIG No 7

GWP 3032-11-00

Highbury Interchange Reconfiguration

78 12 M



BH	SAMPLE	SYMBOL
1	19.05	●
1	21.34	⊠
1	24.38	▲

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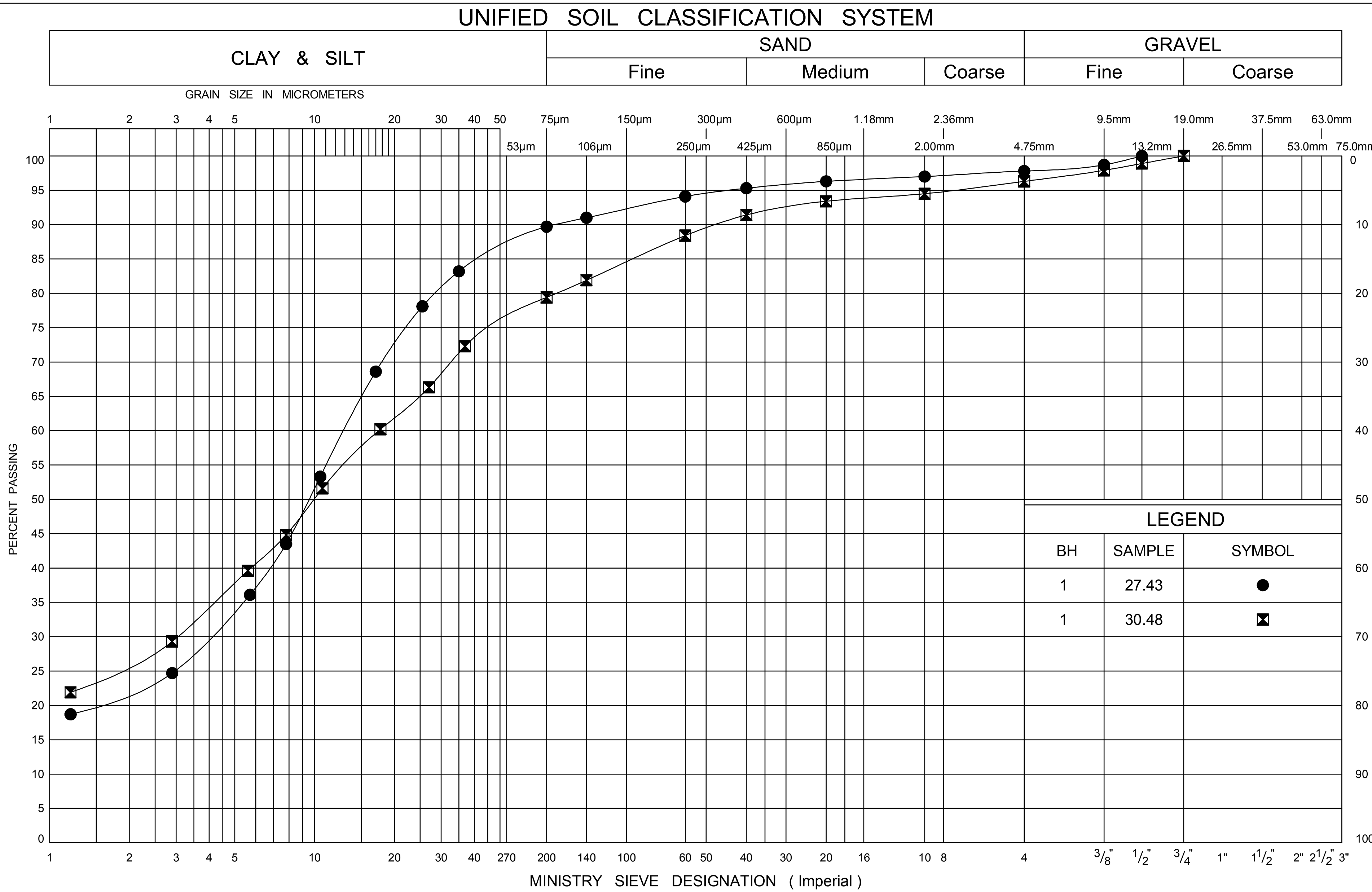
GRAIN SIZE DISTRIBUTION

Lower Sand to Silty Sand, SP to SM

FIG No 8

GWP 3032-11-00

Highbury Interchange Reconfiguration



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GRAIN SIZE DISTRIBUTION

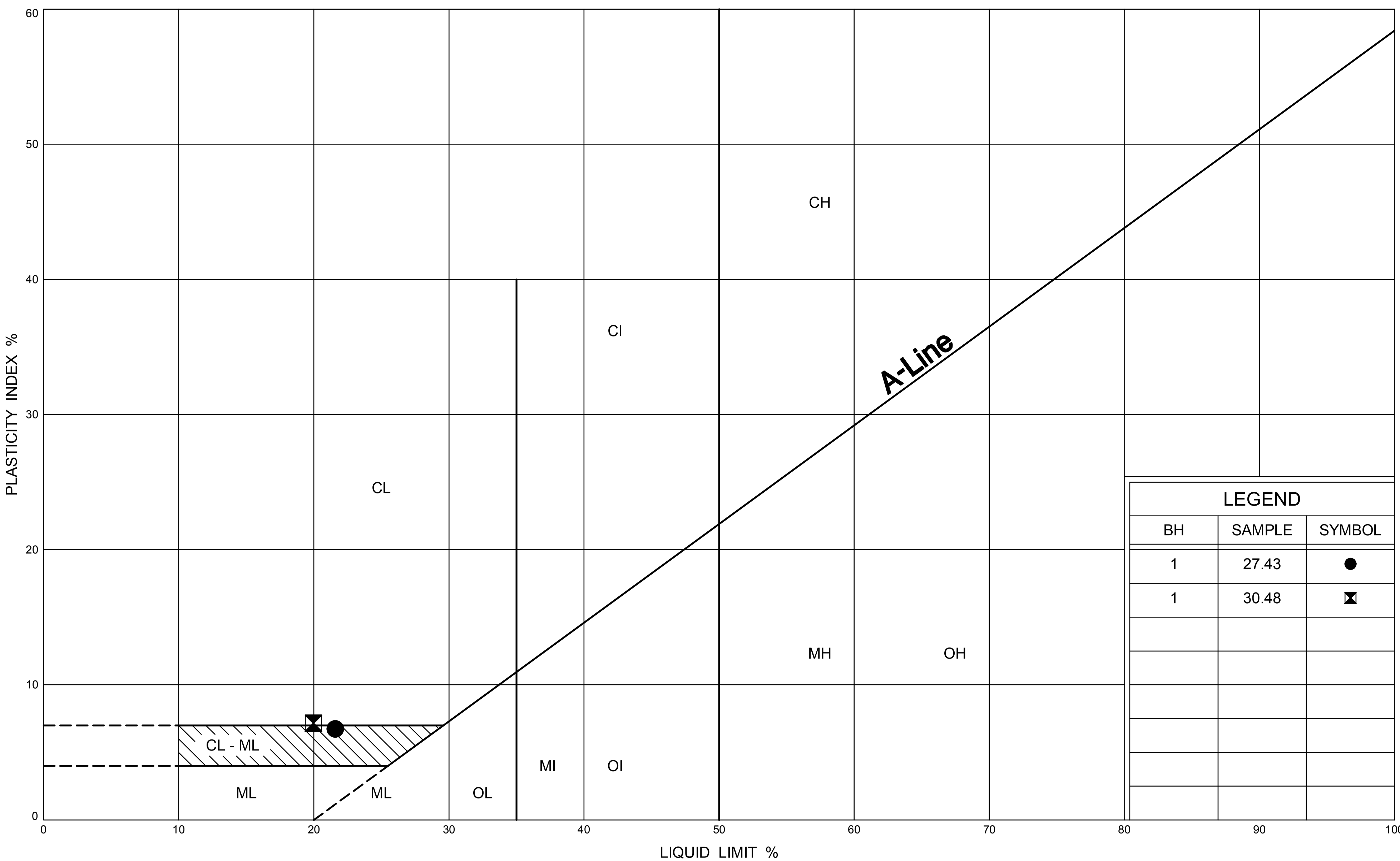
Lower Clayey Silt, CL-ML

FIG No 9

GWP 3032-11-00

Highbury Interchange Reconfiguration

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
1	27.43	●
1	30.48	⧗

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Ontario

PLASTICITY CHART

Lower Clayey Silt, CL-ML

FIG No 10

GWP 3032-11-00

Highbury Interchange Reconfiguration

B.3 GEOCRES NO 40I14-63

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#59-F-15
W.P.# 31-55
Hwy. # 401
CROSSING
HIGHBURY AVE. EXT.
WESTMINSTER TWP.

FOUNDATION REPORT

on

New Bridge at Highway #401 and
Highbury Ave. Extension (Line 'A')
Crossing in Westminister Township.

Profile No: F-3775-2
Plan No: F-3775-1
Chainage: Station 223+75.

Distribution:

Mr. A. M. Toye, Bridge Engineer.	(2)
Mr. H. A. Tregaskes, Construction Engineer.	(1)
Mr. D. G. Ramsay, Design Engineer.	(1)
Mr. H. Orlando, Project Design Engr., London.	(1)
Mr. W. L. Fraser, District Engineer, London.	(1)
Mr. J. Roy, Regional Soils Engr., London.	(1)
Mr. A. Watt, Ont. Water Resources Commission.	(1)
Foundation Section.	(1)
Gen. Files.	(1)

W.P. 31-55
W.J. F-59-15.

INTRODUCTION:

Reported herein are the results of a foundation investigation recently completed at the above noted site. A brief description of the field work carried out and our recommendations pertaining to footing design based upon the factual data obtained are given in the following paragraphs:-

SITE LOCATION AND DESCRIPTION:

The structure is located at the intersection of Highway #401 and the proposed extension of Highbury Avenue (Line 'A') in Westminster Township (see Profile No. F-3529-12, chainage - 223+75).

The site is located in the physiographic region known as the Carodoc Sand Plains which is a well drained formation with gently rolling to flat topography.

INVESTIGATION PROCEDURE:

Field work consisted of two detailed sampled borings and four dynamic cone penetration tests located on either side of the centre line of Hwy. 401 as shown on enclosed plan numbered F 59-15A.

Samples were recovered at a maximum depth interval of five feet in each boring. The granular nature of the subsoil precluded the taking of relatively undisturbed samples; disturbed samples were recovered using a 2-inch diameter split barrelled sampling spoon. The driving energy used in driving the sampler conformed to the requirements of the empirical Standard Penetration Test, and 'N' values were recorded and have been presented on the data sheets included with this report.

cont'd. /2 ...

INVESTIGATION PROCEDURE: (cont'd.) ...

Borings were terminated in the underlying sand stratum at a depth of 26 1/2 feet below existing ground surface.

Elevation of the top of the borings and the chainage locations have been noted on the profiles appended to this report.

SOIL TYPES ENCOUNTERED:

In order of stratigraphic succession from existing ground surface to the depth investigated by the borings, the following subsoil strata were encountered:-

(1) Fill: A surface layer of brown silty clay, containing some gravel sizes was intersected in each of the two borings. This material is believed to be embankment fill placed during grading operations during construction of Hwy. 401. The thickness of this fill layer varied from 4 1/2 feet at the location of Hole No. 1, to 3 feet at the location of Hole No. 2.

(2) Dense Brown Fine to Medium Sand: Underlying the surface veneer of recently placed fill material, a deep deposit of dense fine to medium dry sand was intersected at each borehole location. Standard Penetration test resistance values (N) are in excess of 25 blows/ft. throughout this stratum. Ground water was not encountered in either of the two borings during the period of the field work.

Representative strength and in-situ density values for this sand stratum are as follows:-

'N' value - 30 blows/ft.
Unit Weight in-situ - 115 p.c.f.
Angle of Shearing Resistance = ϕ = 36°.

cont'd. /3 ...

APPENDIX I.

FORM OB-ML-126 (REV. 1959.) — 58-5691

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. 31-55 BORE HOLE NO. 1

JOB F-59-15 STATION 223+86 (70' R)

DATUM Geodetic COMPILED BY B.K.

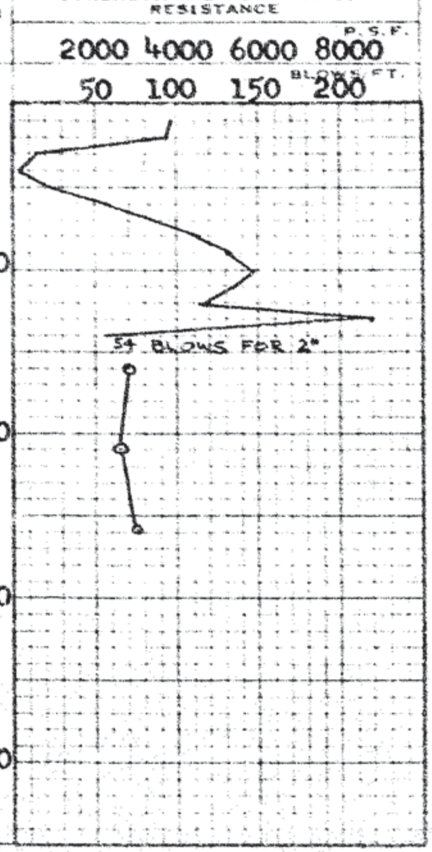
BORING DATE Feb 25/59. CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) ○
VANE TEST (C) AND SENSITIVITY (S) +S
NATURAL MOISTURE AND LIQUIDITY INDEX LI X
LIQUID LIMIT
PLASTIC LIMIT

DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE	CONSISTENCY / MOIST. CONTENT - % DRY WT.	SAMPLE	NATURAL UNIT WT. P.C.F.
Groundlevel	903.0					
Brown clay	898.5				TW1	
Fine light brown sand (dry)					SS2	
		10			SS3	
					SS4	
		20			SS5	
	876.5				SS6	
End of borehole						
Note: No water encountered		30				
		40				



FORM OB-ML-126 (REV. 1959.) —58-5691

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. -

BORE HOLE NO. 2

JOB F-59-15

STATION 224/18 (70' R.)

DATUM Geodetic

COMPILED BY B.K.

BORING DATE Feb.26/59.

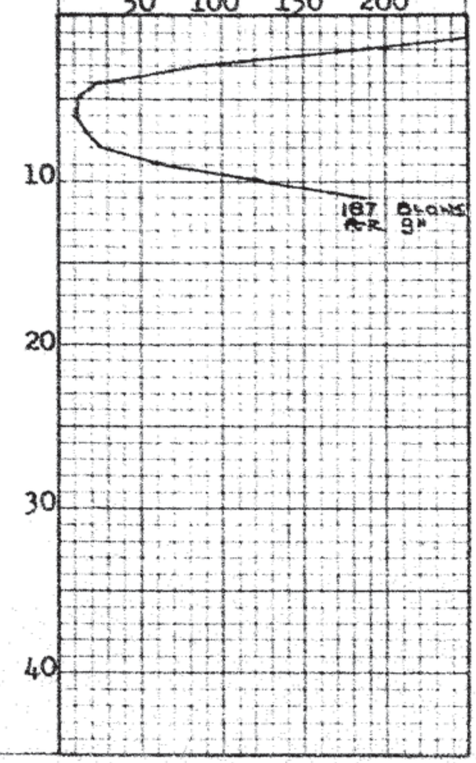
CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) — O
VANE TEST (C) AND SENSITIVITY (S) — +S
NATURAL MOISTURE AND LIQUIDITY INDEX — LI X
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE (P.S.F. 2000 4000 6000 8000; BLOWS/FT. 50 100 150 200)	CONSISTENCY (MOIST. CONTENT - % DRY WT. 10 20 30)	SAMPLE	NATURAL UNIT WT. P.C.F.
⊥	Groundlevel	903.0					



FORM OB-ML-126 (REV. 1959.) — 58-5691

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. -

BORE HOLE NO. 3

JOB F-59-15

STATION 223+63 (60' L)

DATUM Geodetic

COMPILED BY B.K.

BORING DATE Feb.26/59.

CHECKED BY V.K.

2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

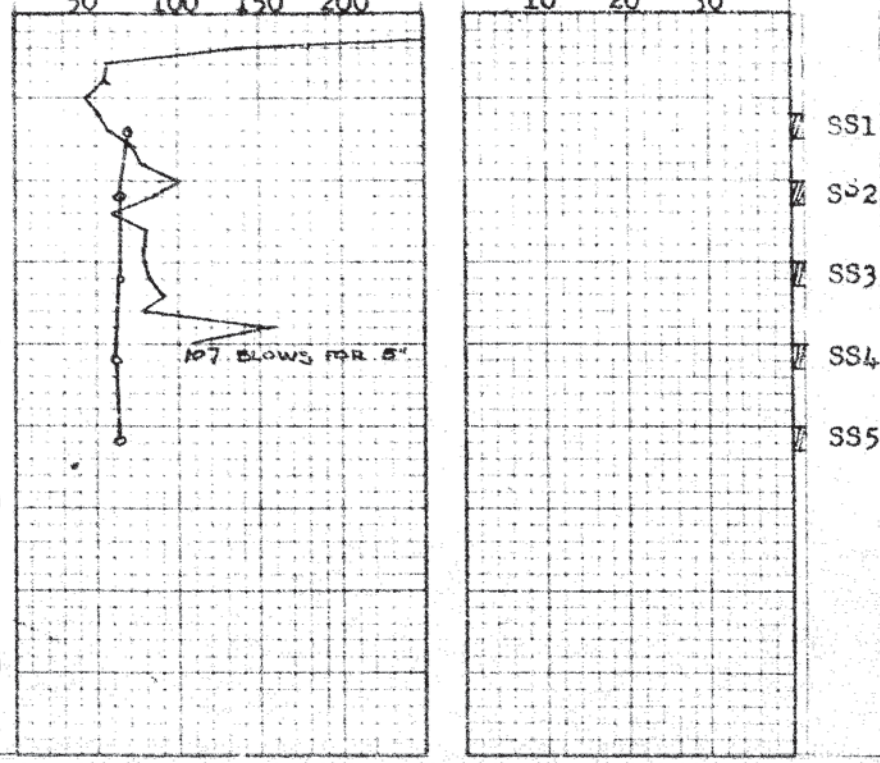
1/2 UNCONFINED COMPRESSION (Qu) — O
VANE TEST (C) AND SENSITIVITY (S) — +S
NATURAL MOISTURE AND LIQUIDITY INDEX — X LI
LIQUID LIMIT
PLASTIC LIMIT

SOIL	DESCRIPTION	ELEV. FEET	DEPTH FEET
	Groundlevel	904.0	
	Brown clay	901.0	
	Fine light brown sand (dry)		10
			20
		877.5	
	End of borehole		30
			40

STRENGTH AND PENETRATION RESISTANCE — P.S.F.: 2000 4000 6000 8000 — BLOWS FT.: 50 100 150 200

CONSISTENCY — MOIST. CONTENT - % DRY WT.: 10 20 30

SAMPLE — NATURAL UNIT WT. P.C.F.



FORM OB-ML-126 (REV. 1959.)—58-5691

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS AND RESEARCH SECTION

W.P. ______ BORE HOLE NO. 4

JOB F-59-15 STATION 223+30 (60' L)

DATUM Geodetic COMPILED BY B.K.

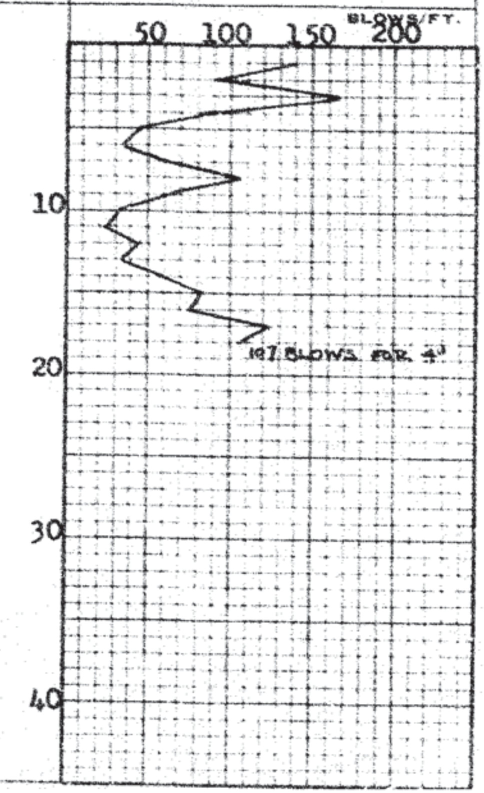
BORING DATE Feb. 27/59 CHECKED BY V.K.

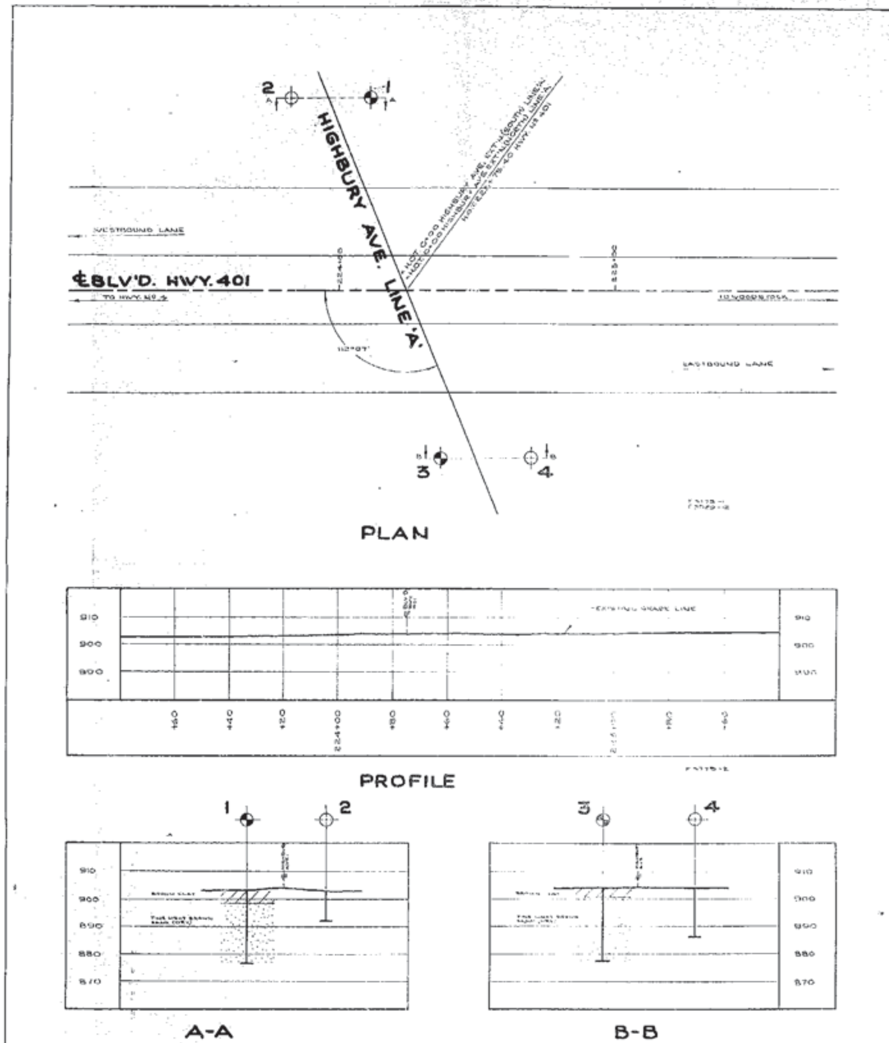
2" DIA. SPLIT TUBE
2" SHELBY TUBE
2" SPLIT TUBE
2" DIA. CONE
2" SHELBY
CASING

LEGEND

1/2 UNCONFINED COMPRESSION (Qu) — O
VANE TEST (C) AND SENSITIVITY (S) — +S
NATURAL MOISTURE AND LIQUIDITY INDEX — X LI
LIQUID LIMIT
PLASTIC LIMIT

SYMBOL	DESCRIPTION	ELEV. FEET	DEPTH FEET	STRENGTH AND PENETRATION RESISTANCE P.S.F.	CONSISTENCY MOIST. CONTENT - % DRY WT.	SAMPLE	NATURAL UNIT WT P.C.F.
	Groundlevel	904.0					





KEY PLAN

SCALE: 1 in. = 1 mi.

LEGEND	
BORE HOLE	●
PENETRATION HOLE	⊕
BORE & PENETRATION HOLE	◐

HOLE NO.	ELEVATION	STATION	DISTANCE FROM ℄
1	905.0	223+86	70' RT
2	905.0	224+18	70' RT
3	904.0	223+63	60' LT.
4	904.0	223+30	60' LT

- NOTE -

THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BORE HOLE LOCATIONS. BETWEEN BORE HOLES THE BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE AND MAY BE SUBJECT TO CONSIDERABLE ERROR.

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH SECTION

HIGHBURY AVE. EXT'N. PROPOSED CROSSING

SHOWING POSITIONS & ELEVATIONS OF HOLES

HWY. 401	DISTRICT 2	COUNTY MIDDLESEX
TOWNSHIP WESTMINSTER	LOT 16	CON. II
LOCATION APP. 3 MI. S. OF LONDON		
DRAWN BY: T. MELLORS	CHECKED BY:	W.P. 31-58
DATE 5 JUNE 1959	APPROVED BY:	DRAWING NO. F59-15A
SCALE 1 IN. = 50 FT.		

APPENDIX C

C.1 SYMBOLS AND TERMS USED ON BOREHOLE RECORDS

C.2 BOREHOLE RECORDS

SYMBOLS AND TERMS USED ON BOREHOLE AND TEST PIT RECORDS

SOIL DESCRIPTION

Terminology describing common soil genesis:

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

Terminology describing soil structure:

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

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, 4th 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:

Trace, or occasional	Less than 10%
Some	10-20%
Frequent	> 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
Very Loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>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	
Very Soft	<0.25	<12.5	<2
Soft	0.25 - 0.5	12.5 - 25	2-4
Firm	0.5 - 1.0	25 - 50	4-8
Stiff	1.0 - 2.0	50 – 100	8-15
Very Stiff	2.0 - 4.0	100 - 200	15-30
Hard	>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.

Boulders Cobbles Gravel	Sand	Silt	Clay	Organics	Asphalt	Concrete	Fill	Igneous Bedrock	Meta-morphic Bedrock	Sedi-mentary Bedrock

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
γ	Unit weight
G_s	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_U	Unconfined compression
I_p	Point Load Index (I_p on Borehole Record equals $I_p(50)$ 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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No HB-01

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY AS

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.07.24 - 2022.07.27 LATITUDE 42.9364777 LONGITUDE -81.1794905 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
275.9 / 0.0	200 mm ASPHALT						
275.7 / 0.2	FILL: SAND and GRAVEL (SP/GP) Brown Compact Dry to moist	1	SS	27			
275.1 / 0.8	FILL: Silty SAND (SM) to Silty Clayey SAND (SC-SM), trace gravel Brown Loose to compact Moist	2	SS	9	275		
		3	SS	29	274		
273.7 / 2.2	CLAYEY SILT (CL), some sand (TILL) Brown Very stiff to hard Moist	4	SS	21	273		
		5	SS	32			0 12 49 40 PP=4.25 Su= 228 kPa
271.7 / 4.1	Silty SAND (SM), trace clay Brown Dense to very dense Moist				272		
		6	SS	45	271		
					270		
		7	SS	92	269		
		8	SS	49	268		
					267		
		9	SS	49	266		0 64 30 6

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity ○ ³% STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No HB-01

METRIC

W.P. 3032-11-00	LOCATION Highway 401/ Highbury, London, Ontario		ORIGINATED BY AS
DIST West HWY 401	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY RR
DATUM Geodetic	DATE 2022.07.24 - 2022.07.27	LATITUDE 42.9364777 LONGITUDE -81.1794905	CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND (SM), trace clay, Brown, Dense to very dense, Moist *(continued)*	10	SS	49	~19	
264.2 / 11.7	SILT (ML), trace sand and clay, Brown, Very dense, Moist to wet	11	SS	107	~19	
		12	SS	65	~19	0 1 90 9 Non-Plastic
		13	SS	58	~19	
259.6 / 16.3	SILTY CLAY (CI), Grey, Stiff to hard, Moist to wet	14	SS	48	~20	PP=1.5 Su= 80 kPa
		15	SS	14	~22 (wP ~18, wL ~36)	0 0 38 62
256.5 / 19.4	Silty SAND (SM), trace clay, Brown, Very dense, Moist to wet					

Elevation scale: 265, 264, 263, 262, 261, 260, 259, 258, 257, 256

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No HB-01

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY AS

DIST West HWY 401 BOREHOLE TYPE Hollow Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.07.24 - 2022.07.27 LATITUDE 42.9364777 LONGITUDE -81.1794905 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND (SM), trace clay Brown Very dense Moist to wet *(continued)*	16	SS	81		
					255	
		17	SS	53	254	
					253	
		18	SS	113		0 81 13 6
					252	
		19	SS	56	251	
250.4 25.5	CLAYEY SILT with Sand (CL), trace gravel (TILL) Grey Very stiff to hard Wet				250	
		20	SS	21	249	
		21	SS	25	248	4 25 40 31 PP=2.25 Su= 121 kPa
					247	
					246	

Continued Next Page

+³, ×³: Numbers refer to Sensitivity   ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No HB-01

METRIC

W.P.	3032-11-00	LOCATION	Highway 401/ Highbury, London, Ontario	ORIGINATED BY	AS
DIST	West HWY 401	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	RR
DATUM	Geodetic	DATE	2022.07.24 - 2022.07.27 LATITUDE 42.9364777 LONGITUDE -81.1794905	CHECKED BY	GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	CLAYEY SILT with Sand (CL), trace gravel (TILL) Grey Very stiff to hard Wet *(continued)*					
245.3 / 30.6	Silty SAND (SM), trace gravel Grey Very dense Wet	22	SS	83	245	
					244	
					243	
		23	SS	85	242	
					241	
240.4 / 35.5	CLAYEY SILT with Sand (CL), trace gravel (TILL) Grey Very stiff Wet				240	
		24	SS	27	239	PP=2.25 Su= 121 kPa
238.7 / 37.2	END OF BOREHOLE Monitoring well installed in borehole, screened from approximately 9.1 m to 12.1 m below grade. Groundwater level measured in monitoring well at approximately 5.8 m below grade on September 12, 2022.					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No HL-09

METRIC

W.P. 3032-11-00 | LOCATION Highway 401/ Highbury, London, Ontario | ORIGINATED BY AS

DIST West | HWY 401 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY RR

DATUM Geodetic | DATE 2022.07.28 - 2022.07.28 | LATITUDE 42.9358772 | LONGITUDE -81.1822911 | CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
271.4 / 0.0	180 mm ASPHALT					
271.2 / 0.2	FILL: SAND and GRAVEL (SP/GP) Brown Compact to very dense Dry	1	SS	70	271	
		2	SS	17		
270.0 / 1.4	FILL: SILTY CLAY with Sand (CL), some gravel Brown Firm Moist	3	SS	7	270	11 31 26 31
268.9 / 2.5	SILT to Sandy SILT (ML), some clay Brown Compact to very dense Moist	4	SS	29	269	
		5	SS	20	268	
		6	SS	25		0 8 76 16
	Wet below 4.6 m	7	SS	54	267	
		8	SS	42	266	
		9	SS	53	265	
	Grey below 6.8 m	10	SS	27		
		11	SS	23	264	
					263	
		12	SS	47	262	0 23 61 15

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-09

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY AS

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.07.28 - 2022.07.28 LATITUDE 42.9358772 LONGITUDE -81.1822911 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	SILT to Sandy SILT (ML), some clay Brown Compact to very dense Moist *(continued)*				261	
		13	SS	36		
					260	
		14	SS	22	259	
258.6 / 12.8	END OF BOREHOLE Borehole dry and cave-in measured at approximately 4.3 m below grade upon completion of drilling.					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-10

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY KM

DIST West HWY 401 BOREHOLE TYPE Manual Equipment (37.5 kg hammer) COMPILED BY RR

DATUM Geodetic DATE 2022.08.11 - 2022.08.11 LATITUDE 42.9356071 LONGITUDE -81.1808889 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
271.6	Grass								
0.0	230 mm TOPSOIL								
271.4 / 0.2	Silty SAND (SM), trace clay with silt partings Brown Compact to dense Moist	1	SS	11					
		2	SS	23					
	Grey and wet below 1.8 m	3	SS	26	∇ (approx. 1.8 m)				
		4	SS	23		0	63	33	5
		5	SS	38					
267.8 / 3.8	END OF BOREHOLE Grounwater level and cave-in measured at approximately 1.8 m and 2.4 m below grade, respectively upon completion of drilling.								

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (271, 270, 269, 268); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

+³, ×³: Numbers refer to Sensitivity ○³% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-10-1

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY JM

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.07 - 2022.08.07 LATITUDE 42.9359148 LONGITUDE -81.1813392 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.8	Asphalt					
0.0 / 272.6	200 mm ASPHALT					
0.2	FILL: SAND and GRAVEL, trace construction debris, Brown, Compact to very dense, Dry	1	SS	51		
		2	SS	17		
271.4 / 1.5	SILTY CLAY (CL), trace sand and gravel, TILL, Grey, Very stiff, Moist	3	SS	21		1 8 35 56; PP=3.0; Su= 161 kPa
		4	SS	25		PP=1.75; Su= 94 kPa
269.8 / 3.0	SILT (ML), some sand and clay, Grey, Dense to very dense, Moist	5	SS	33	▽	
	Wet below 3.8 m	6	SS	34		
	Inferred cobbles/boulder based on auger grinding at 4.6 m	7	SS	37		0 16 77 7
		8	SS	53		
		9	SS	75		
		10	SS	38		
265.3 / 7.5	Sandy SILT (ML), trace clay, Brown, Compact, Wet	11	SS	24		
		12	SS	25		
262.8						

Elevation scale: 272, 271, 270, 269, 268, 267, 266, 265, 264, 263

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

$+^3$, $\times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-10-1

METRIC

W.P. 3032-11-00 | LOCATION Highway 401/ Highbury, London, Ontario | ORIGINATED BY JM

DIST West HWY 401 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY RR

DATUM Geodetic | DATE 2022.08.07 - 2022.08.07 | LATITUDE 42.9359148 | LONGITUDE -81.1813392 | CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	Sandy SILT (ML), trace clay Grey Very dense Wet					
					262	
		13	SS	50/75		
					261	
		14	SS	50/75		0 38 56 6
260.2 / 12.6	END OF BOREHOLE Groundwater level and cave-in measured at approximately 3.6 m below grade upon completion of drilling.					

Column headings: SOIL PROFILE; SAMPLES; STRAT PLOT; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

Foundation Design

RECORD OF BOREHOLE No HL-11

METRIC

W.P.	3032-11-00	LOCATION	Highway 401/ Highbury, London, Ontario	ORIGINATED BY	WT
DIST	West HWY 401	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	RR
DATUM	Geodetic	DATE	2022.08.11 - 2022.08.11 LATITUDE 42.9366801 LONGITUDE -81.1812675	CHECKED BY	GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
272.3	Grass				
0.0	TOPSOIL: Silty SAND, some gravel Brown Loose Dry	1	SS	8	
271.6 / 0.7	Silty CLAY (CI), trace sand and gravel, TILL Brown Very stiff to hard Moist	2	SS	23	4 9 32 55 PP=4.5 Su= 241 kPa
		3	SS	21	PP=4.5 Su= 241 kPa
269.7 / 2.6	SILT with sand (ML), trace clay Brown Dense to very dense wet	4	SS	46	
		5	SS	31	0 23 70 6
		6	SS	40	
		7	SS	50	
		8	SS	40	
266.3 / 6.0	Silty SAND (SM) to Sandy SILT (ML), trace clay Brown to grey Compact to dense Wet	9	SS	19	
		10	SS	35	0 53 43 4
		11	SS	25	
		12	SS	18	0 34 61 5

Elevation scale: 272, 271, 270, 269, 268, 267, 266, 265, 264, 263

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-11

METRIC

W.P. 3032-11-00	LOCATION Highway 401/ Highbury, London, Ontario		ORIGINATED BY WT
DIST West HWY 401	BOREHOLE TYPE Solid Stem Augers		COMPILED BY RR
DATUM Geodetic	DATE 2022.08.11 - 2022.08.11	LATITUDE 42.9366801 LONGITUDE -81.1812675	CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND (SM) to Sandy SILT (ML), trace clay Brown to grey Compact to dense Wet *(continued)* SS13 contains rock fragments						262				
			13	SS	79				○ (≈18)		
							261				
							260				
			14	SS	17				○ (≈20)		
259.5 12.8	END OF BOREHOLE Borehole dry and cave-in measured at approximately 3.0 m below grade upon completion of drilling.										

$+^3, \times^3$: Numbers refer to Sensitivity ○ $^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-12

METRIC

W.P. 3032-11-00 | LOCATION Highway 401/ Highbury, London, Ontario | ORIGINATED BY KM

DIST West | HWY 401 | BOREHOLE TYPE Manual Equipment | COMPILED BY RR

DATUM Geodetic | DATE 2022.08.11 - 2022.08.11 | LATITUDE 42.9355726 | LONGITUDE -81.1790483 | CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
273.1	Grass							
273.0 / 0.0	100 mm TOPSOIL					273		
0.1	FILL: Sandy SILT (ML), trace gravel, clay and rootlets Brown to grey Compact Moist	1	SS	19				
272.4 / 0.8	SILTY CLAY (CI), trace sand, TILL Brown/grey Very stiff to hard Moist	2	SS	29		272		0 8 42 50
		3	SS	35				
271.3 / 1.8	Silty SAND (SM), trace gravel Grey Dense Wet							
271.0 / 2.1	END OF BOREHOLE Borehole dry and cave-in measured at approximately 2.0 m below grade upon completion of drilling.							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-12-1

METRIC

W.P. 3032-11-00 | LOCATION Highway 401/ Highbury, London, Ontario | ORIGINATED BY WT

DIST West HWY 401 | BOREHOLE TYPE Solid Stem Augers | COMPILED BY RR

DATUM Geodetic | DATE 2022.08.04 - 2022.08.04 | LATITUDE 42.9354769 | LONGITUDE -81.1784223 | CHECKED BY GR

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
281.0	Grass				
280.9 0.0	150 mm TOPSOIL				
0.2	FILL: SAND and GRAVEL (SP/GP) Brown Compact to dense Dry	1	SS	18	
		2	SS	37	
		3	SS	21	
278.8 2.2	FILL: CLAYEY SILT (CL), some sand, trace gravel Dark brown Very stiff Moist	4	SS	20	4 18 37 40 PP=2.0 Su= 107 kPa
		5	SS	21	PP=4.5 Su= 241 kPa
276.9	100 mm sand seam at 4 m				
4.1	FILL: SILTY CLAY (CL), some sand, trace gravel and organics Brown to black Stiff Moist	6	SS	20	PP=1.75 Su= 94 kPa
		7	SS	14	PP=3.25 Su= 174 kPa
		8	SS	12	3 20 35 42 PP=1.5 Su= 80 kPa
	230 mm sand zone at 6.4 m	9	SS	8	PP=3.5 Su= 188 kPa
273.9 7.1	CLAYEY SILT (CL), some sand, TILL Brown Stiff to very stiff Wet	10	SS	11	
		11	SS	22	0 17 54 29
272.5 8.5	Sandy SILT (ML), trace clay Brown Dense to very dense Wet				
		12	SS	90	

Elevation scale: 280, 279, 278, 277, 276, 275, 274, 273, 272

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100

PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L — WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-12-1

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY WT

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.04 - 2022.08.04 LATITUDE 42.9354769 LONGITUDE -81.1784223 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy SILT (ML), trace clay Brown Dense to very dense Wet *(continued)*				▽			
		13	SS	45		270	~20	0 28 67 5
						269		
268.2		14		100			~18	
12.8	END OF BOREHOLE Groundwater level and cave-in measured at approximately 10.1 m and 10.7 m below grade, respectively; upon completion of drilling.							

+3, ×3: Numbers refer to Sensitivity   ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-13

METRIC

W.P. 3032-11-00	LOCATION Highway 401/ Highbury, London, Ontario		ORIGINATED BY JM
DIST West HWY 401	BOREHOLE TYPE Solid Stem Augers		COMPILED BY RR
DATUM Geodetic	DATE 2022.08.07 - 2022.08.07	LATITUDE 42.9344504 LONGITUDE -81.1772869	CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
277.1	Asphalt							
276.9 / 0.0	180 mm ASPHALT							
0.2	FILL: SAND and GRAVEL (SP/GP), trace clay Brown Compact to dense Moist	1	SS	31				
		2	SS	19				
		3	SS	48				
274.9 / 2.2	FILL: CLAYEY SILT with Sand (CL), trace gravel Brown Stiff Moist	4	SS	14	6	20	33	41
		5	SS	12				
		6	SS	11				
272.6 / 4.5	FILL: Silty SAND (SM), trace clay and gravel Brown Compact Moist	7	SS	15	2	66	25	8
		8	SS	12				
271.0 / 6.1	CLAYEY SILT (CL), trace sand and gravel, TILL Brown Hard Moist	9	SS	44	1	8	37	54
270.7 / 6.4	SILT with Sand (ML), trace clay Brown Dense to very dense Moist	10	SS	63				
	SS11 contains 100 mm clayey silt seam	11	SS	38				
	Wet below 9.1 m	12	SS	67	0	16	78	6

Ground water level symbol shown at approx. elevation 270.4.

Chart columns: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%). ELEVATION SCALE 277–268.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity $\bigcirc^{3\%}$ STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-13

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY JM

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.07 - 2022.08.07 LATITUDE 42.9344504 LONGITUDE -81.1772869 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILT with Sand (ML), trace clay Brown Dense to very dense Moist *(continued)*						267				
			13	SS	82		266		○		
	SS14 compact						265				
264.3			14	SS	19				○		
12.8	END OF BOREHOLE Groundwater level and cave-in measured at approximately 6.8 m and 7.0 m below grade, respectively; upon completion of drilling.										

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-14

METRIC

W.P. 3032-11-00	LOCATION Highway 401/ Highbury, London, Ontario		ORIGINATED BY WT
DIST West HWY 401	BOREHOLE TYPE Solid Stem Augers		COMPILED BY RR
DATUM Geodetic	DATE 2022.08.05 - 2022.08.05	LATITUDE 42.9361044 LONGITUDE -81.1775209	CHECKED BY GR

ELEV / DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
274.2						
274.1 / 0.0	180 mm TOPSOIL					
0.2	FILL: Silty Clayey SAND (SC-SM), Brown, Loose to compact, Moist	1	SS	8	274	
		2	SS	29	273	0 70 13 16
272.8 / 1.5	Sandy SILT (ML) to Silty SAND (SM), trace clay, Brown, Dense to very dense, Moist	3	SS	63		
		4	SS	67	272	0 35 59 5
		5	SS	71	271	
		6	SS	36	270	
		7	SS	33	269	
		8	SS	66		0 53 42 5
		9	SS	82	268	
		10	SS	40	267	
	Grey and wet below 7.6 m	11	SS	59	266	
		12	SS	29	265	0 73 22 5

Chart headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; GROUND WATER CONDITIONS; STRAT PLOT.

Continued Next Page

+³, ×³: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-14

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY WT

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.05 - 2022.08.05 LATITUDE 42.9361044 LONGITUDE -81.1775209 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy SILT (ML) to Silty SAND (SM), trace clay Brown Dense to very dense Moist *(continued)*						264				
			13	SS	50/ 75						
							263				
							262				
261.8 12.4	CLAYEY SILT (CL), trace sand Grey Hard Wet		14	SS	45						
261.4 12.8	END OF BOREHOLE Borehole dry and cave-in measured at approximately 3 m below grade.										

Legend: SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L.

+3, ×3: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-15

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY JM

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.07.27 - 2022.07.27 LATITUDE 42.9371596 LONGITUDE -81.1763162 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
275.9 / 0.0	350 mm ASPHALT							
275.5 / 0.4	FILL: SAND and GRAVEL (SP/GP)	1	SS	45				
275.1 / 0.8	FILL: SILT (ML), trace clay and sand Brown Dense Moist	2	SS	31				
		3	SS	33	0	4	88	8
273.7 / 2.2	Silty SAND (SM), trace clay Brown Dense to very dense Moist	4	SS	58	0	71	22	6
		5	SS	48				
		6	SS	44				
		7	SS	52				
270.6 / 5.3	Clayey SILT (CL) Grey Hard Wet	8	SS	84				
		9	SS	72				
269.1 / 6.8	Silty SAND (SM), trace clay Grey Compact to very dense Wet	10	SS	22				
		11	SS	46				
		12	SS	58	0	73	22	5

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (275, 274, 273, 272, 271, 270, 269, 268, 267, 266); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+³, ×³: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No HL-15

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY JM

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.07.27 - 2022.07.27 LATITUDE 42.9371596 LONGITUDE -81.1763162 CHECKED BY GR

SOIL PROFILE: ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty SAND (SM), trace clay Grey Compact to very dense Wet *(continued)*						
		13	SS	55		265	
						264	
263.4		14	SS	50/ 125			
12.5	END OF BOREHOLE Borehole dry and cave-in measured at approximately 6.4 m below grade upon completion of drilling.						

Column headings: STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20, 40, 60; UNIT WEIGHT γ kN/m^3

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

ONTARIO MTO 165001239_MTO_HWY_401_HIGHBURY.GPJ ONTARIO MTO.GDT 1/25/23

RECORD OF BOREHOLE No HL-16

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY JM

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.07 - 2022.08.07 LATITUDE 42.937184 LONGITUDE -81.1798836 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
281.5 / 0.0	FILL: SAND and GRAVEL (SP/GP) Brown Compact Dry	1	SS	16				
280.8 / 0.7	FILL: CLAYEY SILT with Sand (CL), trace gravel Brown Firm Moist	2	SS	6	9	23	34	35
		3	SS	6				
279.3 / 2.2	FILL: SILT (ML), some sand, trace clay and gravel Brown Compact Moist	4	SS	18				
278.5 / 3.0	FILL: CLAYEY SAND with Gravel (SC) Brown Compact Moist	5	SS	16				
		6	SS	13				
		7	SS	24	19	32	23	26
		8	SS	24				
		9	SS	30				
274.7 / 6.8	FILL: Sandy SILT (ML), some clay, trace gravel Grey Compact Moist	10	SS	22				
274.0 / 7.5	SILTY CLAY with sand (CL), trace gravel, TILL Black to grey Stiff Moist	11	SS	13	7	24	33	35
		12	SS	13				
271.9 / 9.6								

Chart columns: GROUND WATER CONDITIONS; ELEVATION SCALE (281 to 272); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20, 40, 60, 80, 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%).

Continued Next Page

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-16

METRIC

W.P.	3032-11-00	LOCATION	Highway 401/ Highbury, London, Ontario	ORIGINATED BY	JM
DIST	West HWY 401	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	RR
DATUM	Geodetic	DATE	2022.08.07 - 2022.08.07 LATITUDE 42.937184 LONGITUDE -81.1798836	CHECKED BY	GR

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy SILT (ML), some clay, trace gravel Brown Dense to very dense Moist *(continued)*						271				
			13	SS	48				o (~18)		1 31 50 18
							270				
268.9			14	SS	50/75		269		o (~19)		
12.6	END OF BOREHOLE Bottom of borehole moist and cave-in measured at approximately 9.6 m below grade upon completion of drilling.										

Legend: ○ UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

RECORD OF BOREHOLE No HL-17

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY WT

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.03 - 2022.08.03 LATITUDE 42.9373892 LONGITUDE -81.1777061 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
275.2 / 0.0	120 mm TOPSOIL				
275.1 / 0.1	FILL: CLAYEY SILT (CL), trace sand Brown Soft to hard Dry	1	SS	6	
		2	SS	31	
		3	SS	17	0 5 45 49 PP=4.5 Su= 241 kPa
273.0 / 2.2	Sandy SILT (ML) to Silty SAND (SM), trace clay Brown Compact to very dense Moist to wet	4	SS	65	
		5	SS	42	0 38 56 6
		6	SS	53	
		7	SS	61	
		8	SS	35	
		9	SS	25	
		10	SS	31	
		11	SS	47	
		12	SS	32	

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE (275, 274, 273, 272, 271, 270, 269, 268, 267, 266); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO 165001239_MTO_HWY_401_HIGHBURY.GPJ ONTARIO MTO.GDT 1/25/23

Ministry of Transportation
Ontario

Foundation Design

RECORD OF BOREHOLE No HL-17

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY WT

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.03 - 2022.08.03 LATITUDE 42.9373892 LONGITUDE -81.1777061 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
	Sandy SILT (ML) to Silty SAND (SM), trace clay Brown Compact to very dense Moist to wet *(continued)* Grey and wet below 10.7 m						265							
			13	SS	57						0	71	24	5
							264							
							263							
			14	SS	99									
262.4 12.8	END OF BOREHOLE Borehole dry and cave-in measured at approximately 3.0 m below grade upon completion of drilling.													

Legend: SHEAR STRENGTH kPa: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L. REMARKS & GRAIN SIZE DISTRIBUTION (%).

$+^3, \times^3$: Numbers refer to Sensitivity   O $^{3\%}$ STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No HL-18

METRIC

W.P. 3032-11-00	LOCATION Highway 401/ Highbury, London, Ontario		ORIGINATED BY WT
DIST West HWY 401	BOREHOLE TYPE Solid Stem Augers		COMPILED BY RR
DATUM Geodetic	DATE 2022.08.12 - 2022.08.12	LATITUDE 42.9383203 LONGITUDE -81.1814699	CHECKED BY GR

ELEV / DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
275.5 / 0.0	350 mm TOPSOIL	1	SS	6	
275.2 / 0.4	FILL: Silty SAND (SM), trace clay and gravel, construction debris Dark brown Loose to compact Moist	2	SS	15	
		3	SS	27	
273.3 / 2.2	FILL: SILTY CLAY (CL), some sand, trace gravel and organics Brown/black Stiff to very stiff Moist	4	SS	14	PP>4.5 Su> 241 kPa
		5	SS	15	3 18 36 42 PP>4.5 Su> 241 kPa
		6	SS	27	PP=4.25 Su= 228 kPa
271.0 / 4.5	SILTY CLAY (CL to CI), some sand, trace gravel, TILL Brown Hard Moist SS8 contains sand and gravel, trace silt and rock fragments	7	SS	41	2 11 37 50 PP>4.5 Su> 241 kPa
		8	SS	55	
		9	SS	47	PP>4.5 Su> 241 kPa
268.7 / 6.8	Sandy SILT (ML), trace clay Grey Compact to dense Wet	10	SS	36	
		11	SS	18	0 34 60 5
		12	SS	38	

Column headings also include: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (275, 274, 273, 272, 271, 270, 269, 268, 267, 266); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m^3.

Continued Next Page

$+^3, \times^3$: Numbers refer to Sensitivity ○$^{3\%}$ STRAIN AT FAILURE

ONTARIO MTO 165001239_MTO_HWY_401_HIGHBURY.GPJ ONTARIO MTO.GDT 1/25/23

RECORD OF BOREHOLE No HL-18

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY WT

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY RR

DATUM Geodetic DATE 2022.08.12 - 2022.08.12 LATITUDE 42.9383203 LONGITUDE -81.1814699 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Sandy SILT (ML), trace clay Grey Compact to dense Wet *(continued)*					265	
	SS13 contains trace clay	13	SS	29			
						264	
		14	SS	27		263	
262.7 12.8	END OF BOREHOLE Borehole dry and cave-in measured at approximately 3.5 m below grade upon completion of drilling.						

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE, 20 40 60 80 100; PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

$+^3, \times^3$: Numbers refer to Sensitivity   O 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No MS-09

METRIC

W.P.	3032-11-00	LOCATION	Highway 401/ Highbury, London, Ontario	ORIGINATED BY	WT
DIST	West HWY 401	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	JM
DATUM	Geodetic	DATE	2022.07.19 - 2022.07.19 LATITUDE 42.935947 LONGITUDE -81.1819525	CHECKED BY	GR

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
271.9								
271.8 0.0	150 mm ASPHALT							
0.2	480 mm GRANULAR FILL	1	SS	54				
271.3 0.6	FILL: Silty SAND with Gravel (SM), trace clay Brown Dense Dry	2	SS	36	28	54	12	7
270.4 1.5	FILL: CLAYEY SILT (CL), trace gravel Black Stiff Moist	3	SS	14				
269.7 2.2	SILT with Sand (ML) Brown Compact to very dense Moist	4	SS	13				
		5	SS	21				
		6	SS	39				
		7	SS	83	0	24	68	8
		8	SS	33				
		9	SS	49				
265.2 6.7	END OF BOREHOLE Groundwater level and cave-in measured at approximately 3.8 m and 4.3 m below grade, respectively; in open borehole.							

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (271, 270, 269, 268, 267, 266); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity   ○ 3% STRAIN AT FAILURE

ONTARIO MTO 165001239_MTO_HWY_401_HIGHBURY.GPJ ONTARIO MTO.GDT 1/25/23

RECORD OF BOREHOLE No MS-10

METRIC

W.P. 3032-11-00 LOCATION Highway 401/ Highbury, London, Ontario ORIGINATED BY WT

DIST West HWY 401 BOREHOLE TYPE Solid Stem Augers COMPILED BY JM

DATUM Geodetic DATE 2022.07.19 - 2022.07.19 LATITUDE 42.9362198 LONGITUDE -81.1806927 CHECKED BY GR

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
274.3 / 0.0	330 mm ASPHALT	1	SS	38	
274.0 / 0.3	355 mm GRANULAR FILL				
273.6 / 0.7	FILL: Silty Clayey SAND with Gravel (SC-SM) Brown Compact Moist	2	SS	24	
		3	SS	10	24 47 17 12
272.1 / 2.2	FILL: SILTY CLAY (CL), trace sand Brown Stiff Moist	4	SS	14	
		5	SS	14	0 9 45 46
270.5 / 3.8	SILT (ML), trace sand and clay Brown Dense to very dense Moist	6	SS	63	
		7	SS	43	
		8	SS	40	0 15 77 8
		9	SS	48	
267.6 / 6.7	END OF BOREHOLE Groundwater level and cave-in measured at approximately 4.9 m and 5.8 m below grade, respectively; in open borehole.				

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (274, 273, 272, 271, 270, 269, 268); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³.

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No S-04

METRIC

W.P.	3032-11-00	LOCATION	Highway 401/ Highbury, London, Ontario	ORIGINATED BY	JM
DIST	West HWY 401	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	RR
DATUM	Geodetic	DATE	2022.08.08 - 2022.08.08 LATITUDE 42.9357431 LONGITUDE -81.1787093	CHECKED BY	GR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
281.7	Asphalt										
281.7 0.0 / 0.1	50 mm ASPHALT 380 mm GRANULAR FILL	1	SS	33							
281.3 / 0.4	FILL: CLAYEY SILT with Sand (CL), trace gravel and construction debris Brown Soft to stiff Moist	2	SS	14		281					
		3	SS	5		280					
279.5 / 2.2	FILL: SILTY CLAY (CL), some sand, trace gravel Brown Firm Moist to wet	4	SS	4		279		1	19	34	45
	trace organics in SS5	5	SS	5		278					
	trace gravel in SS6	6	SS	4							
276.9 / 4.8	FILL: Silty Clayey SAND (SC-SM) interbedded with Silty Clay layers Brown Loose to compact Moist	7	SS	27		277					
		8	SS	7		276		0	61	20	18
	SS9 contains rock fragments	9	SS	3							
274.9 / 6.8	SILTY CLAY (CI), some sand, trace gravel, TILL Brown Stiff Moist	10	SS	15		275		1	12	35	52
273.8 / 7.9	Silty SAND (SM), trace gravel Light brown Compact Moist	11	SS	20		274					
273.5 / 8.2	END OF BOREHOLE Borehole open and dry upon completion of drilling.										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

REMARKS & GRAIN SIZE DISTRIBUTION (%)

+³, ×³: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No S-07

METRIC

W.P.	3032-11-00	LOCATION	Highway 401/ Highbury, London, Ontario	ORIGINATED BY	JM
DIST	West HWY 401	BOREHOLE TYPE	Solid Stem Augers	COMPILED BY	RR
DATUM	Geodetic	DATE	2022.07.29 - 2022.07.29 LATITUDE 42.9340007 LONGITUDE -81.1765141	CHECKED BY	GR

SOIL PROFILE / SAMPLES

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
275.3	Asphalt							
0.1	75 mm ASPHALT							
	FILL: Silty SAND (SM), trace gravel, asphalt and cement Brown Dense Dry to moist		1	SS	34		275	
			2	SS	40			
273.9 / 1.5	FILL: CLAYEY SILT with Sand (CL), trace gravel Brown to black Firm to very stiff Moist						274	
			3	SS	26			PP=2.75 Su= 148 kPa
			4	SS	14		273	5 24 34 38 PP=2.25 Su= 121 kPa
			5	SS	14		272	PP=3.75 Su= 201 kPa
	SS6 contains trace rootlets and topsoil		6	SS	4			PP=1.0 Su= 54 kPa
270.8 / 4.5	SILTY CLAY (CL), some sand, trace gravel, TILL Brown Very stiff Moist						271	
			7	SS	17			4 15 35 45 PP=4.5 Su= 241 kPa
			8	SS	20		270	PP=4.5 Su= 241 kPa
269.3 / 6.0	Silty SAND (SM), trace clay Brown Dense Moist to wet		9	SS	47	∇	269	
			10	SS	35		268	
			11	SS	47			0 53 43 4
267.1 / 8.2	END OF BOREHOLE Groundwater level and cave-in measured at approximately 6.7 m and 7.0 m below grade, respectively; upon completion of drilling.							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

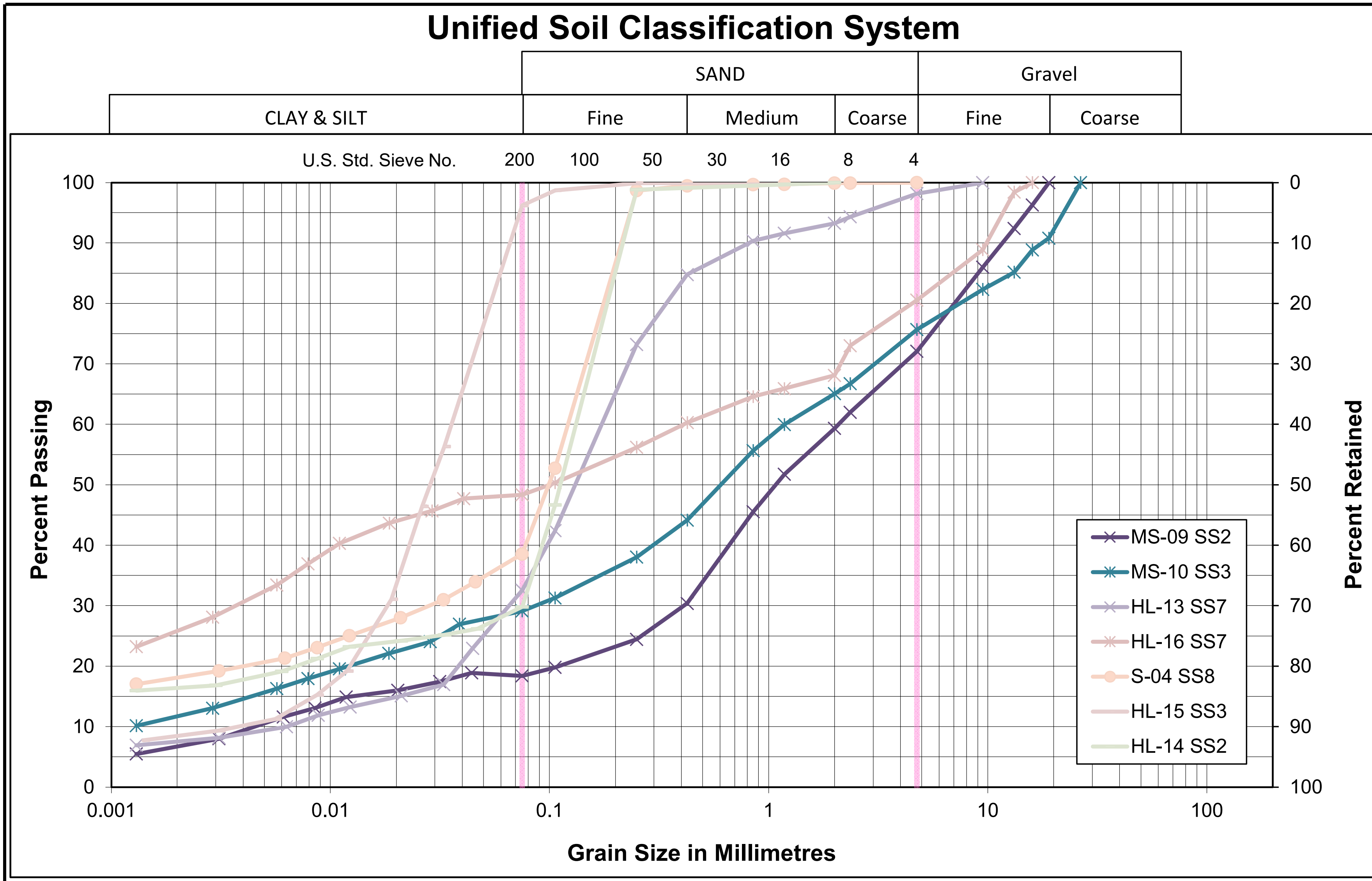
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

+3, ×3: Numbers refer to Sensitivity ○3% STRAIN AT FAILURE

APPENDIX D

D.1 LABORATORY TEST RESULTS



Stantec

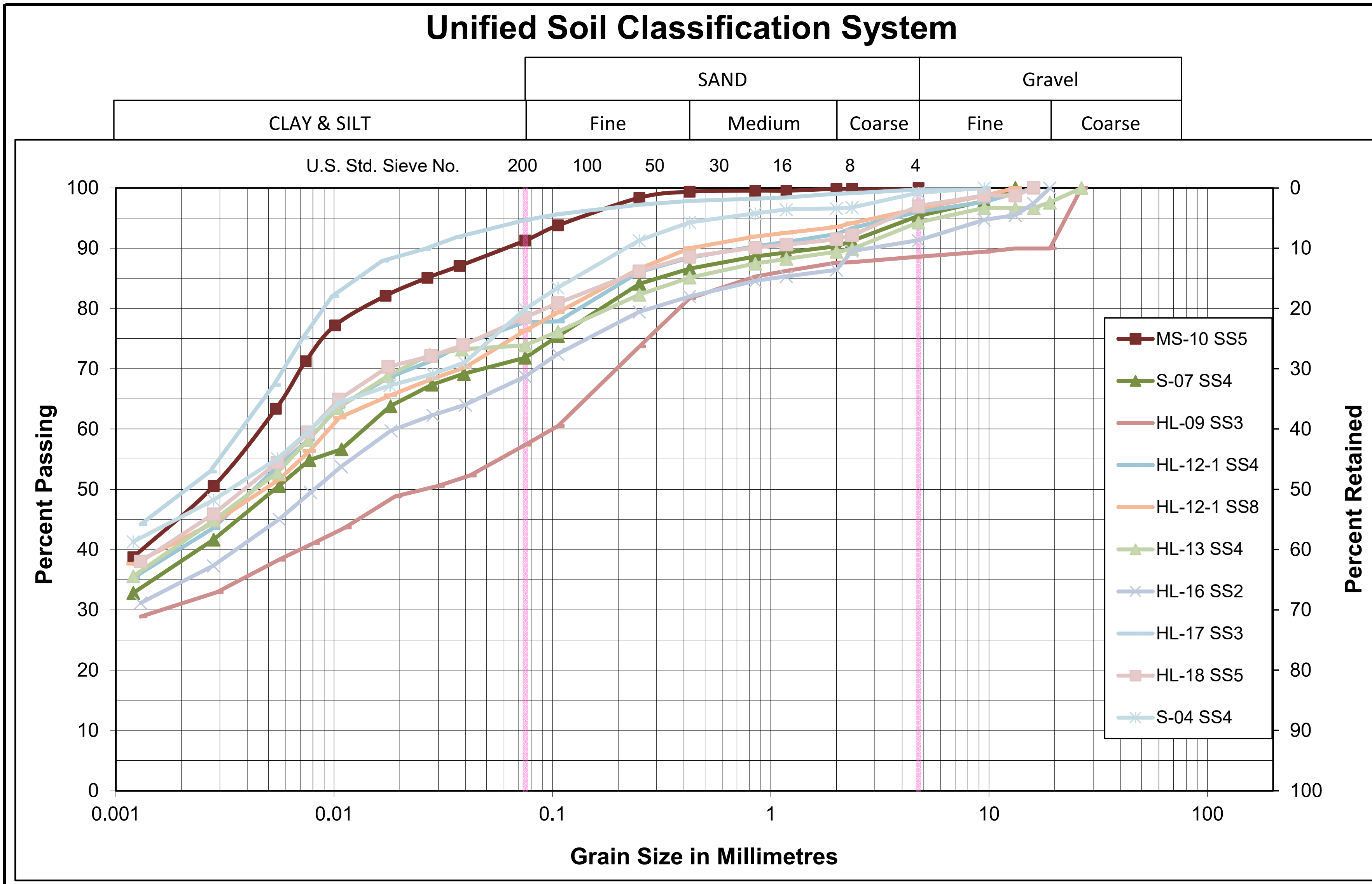
FILL: Silty SAND with Gravel (SM) to Silty Clayey SAND with Gravel (SC-SM) to SILT (ML)

Ministry of Transportation (MTO)

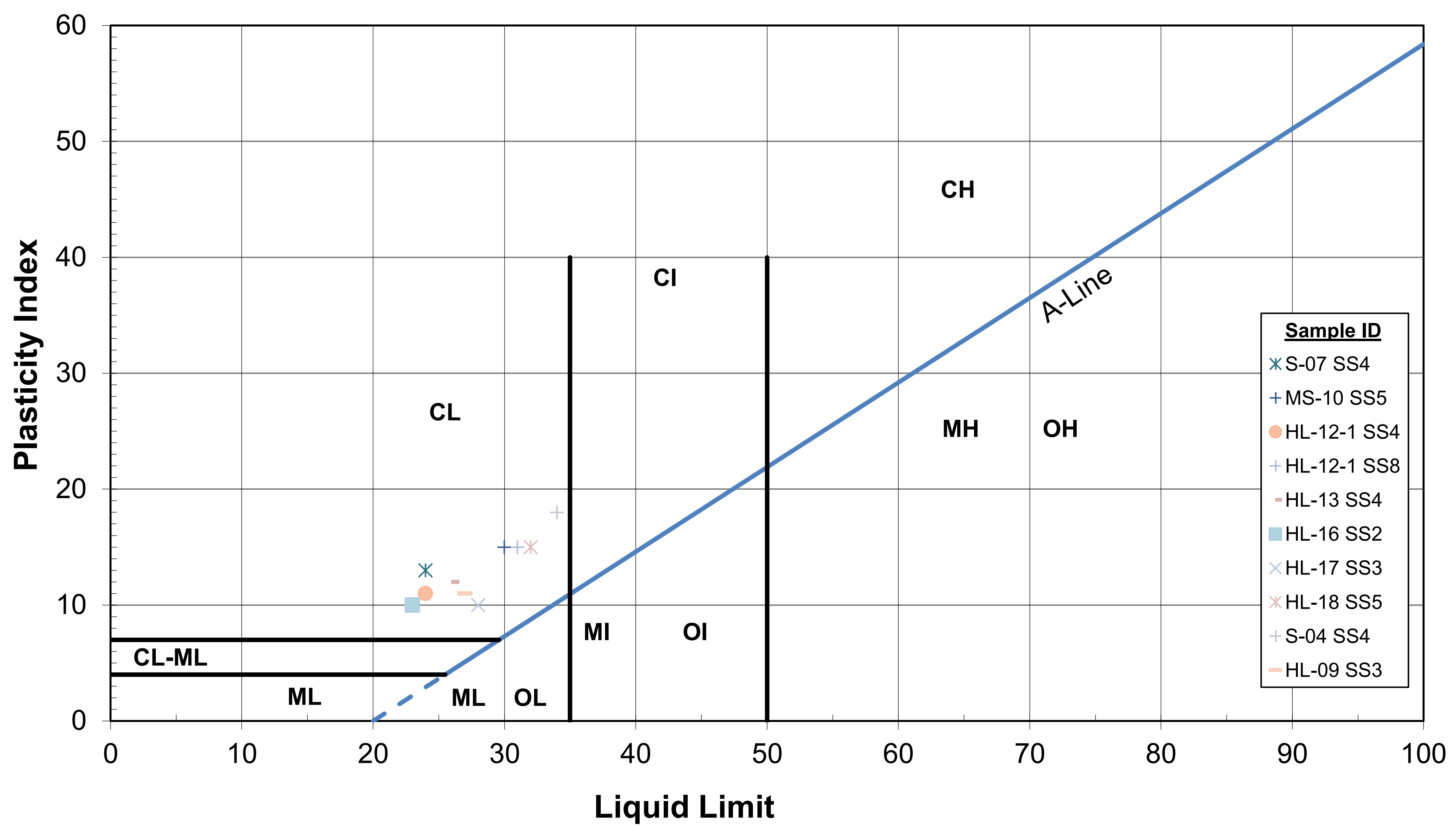
HWY 401 RECONSTRUCTION - Highbury Avenue Interchange

Figure No. D1

Project No. 165001239



Stantec	CLAYEY SILT to SILTY CLAY (CL) Ministry of Transportation (MTO) HWY 401 RECONSTRUCTION - Highbury Avenue Interchange	Figure No. D2 Project No. 165001239



Stantec

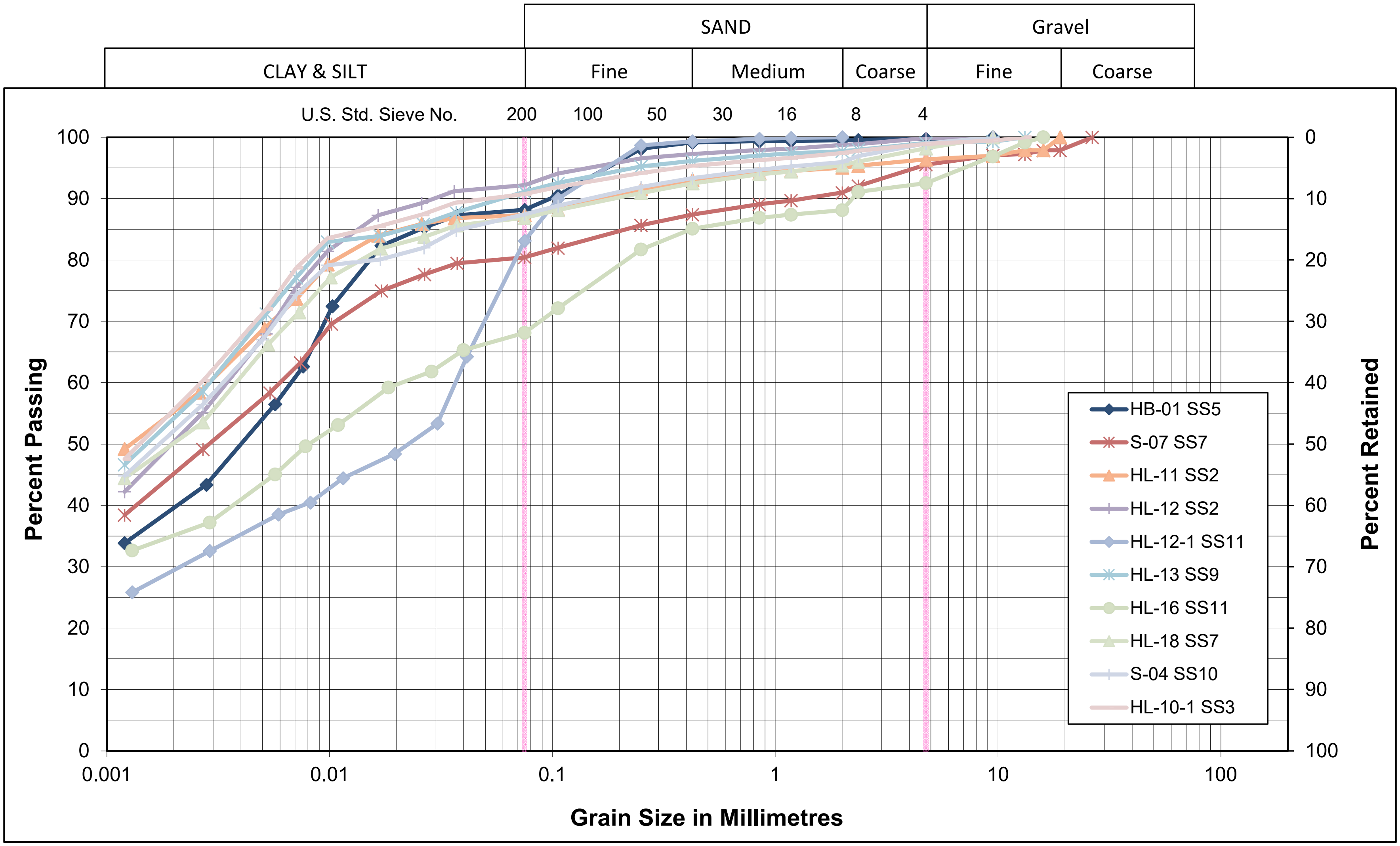
Ministry of Transportation (MTO)
HWY 401 RECONSTRUCTION
Highbury Avenue Interchange

CLAYEY SILT to SILTY CLAY (CL)

Figure No. D3

Project No. 165001239

Unified Soil Classification System



Stantec

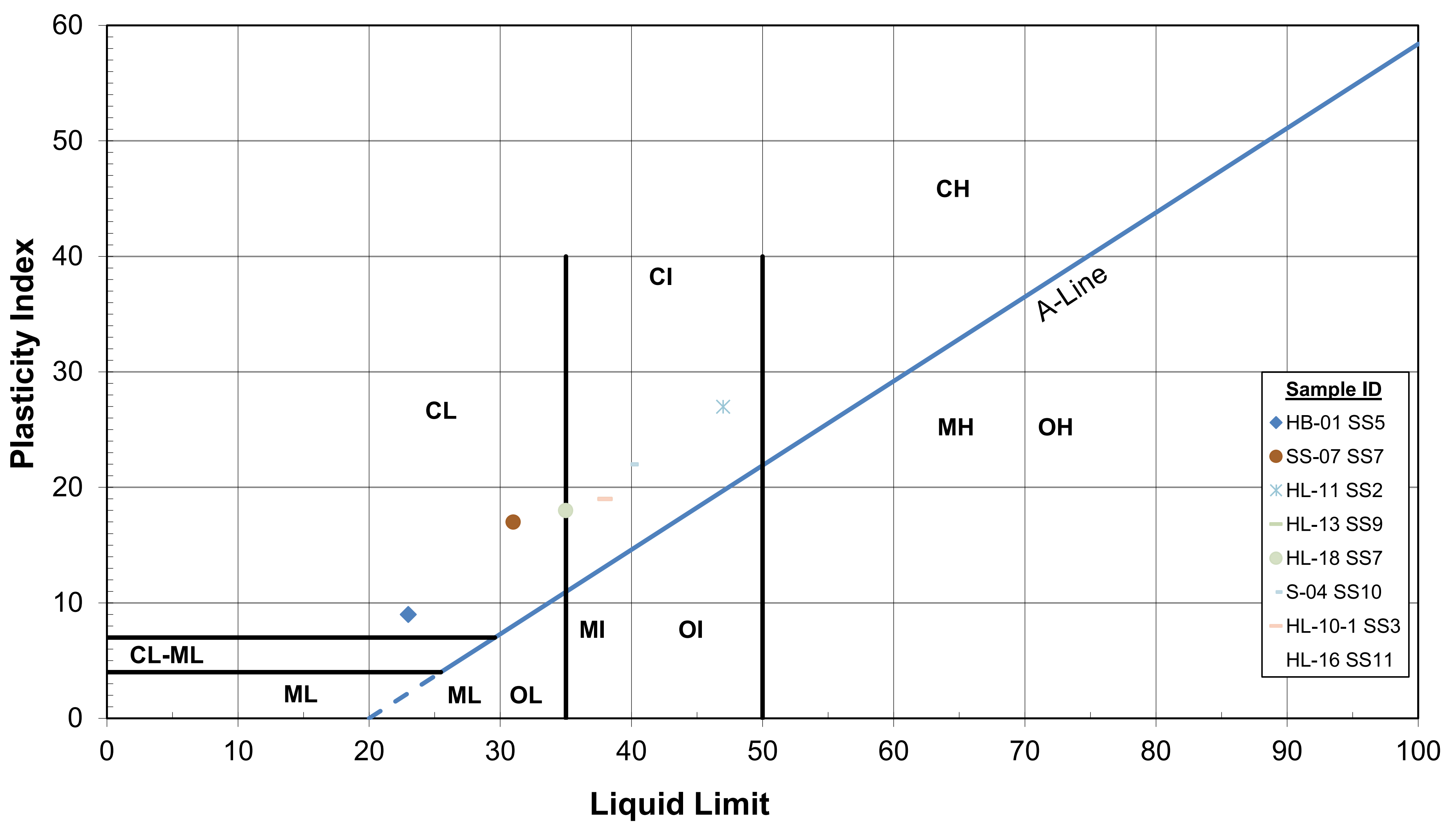
CLAYEY SILT to SILTY CLAY (CL to CI), Till

Ministry of Transportation (MTO)

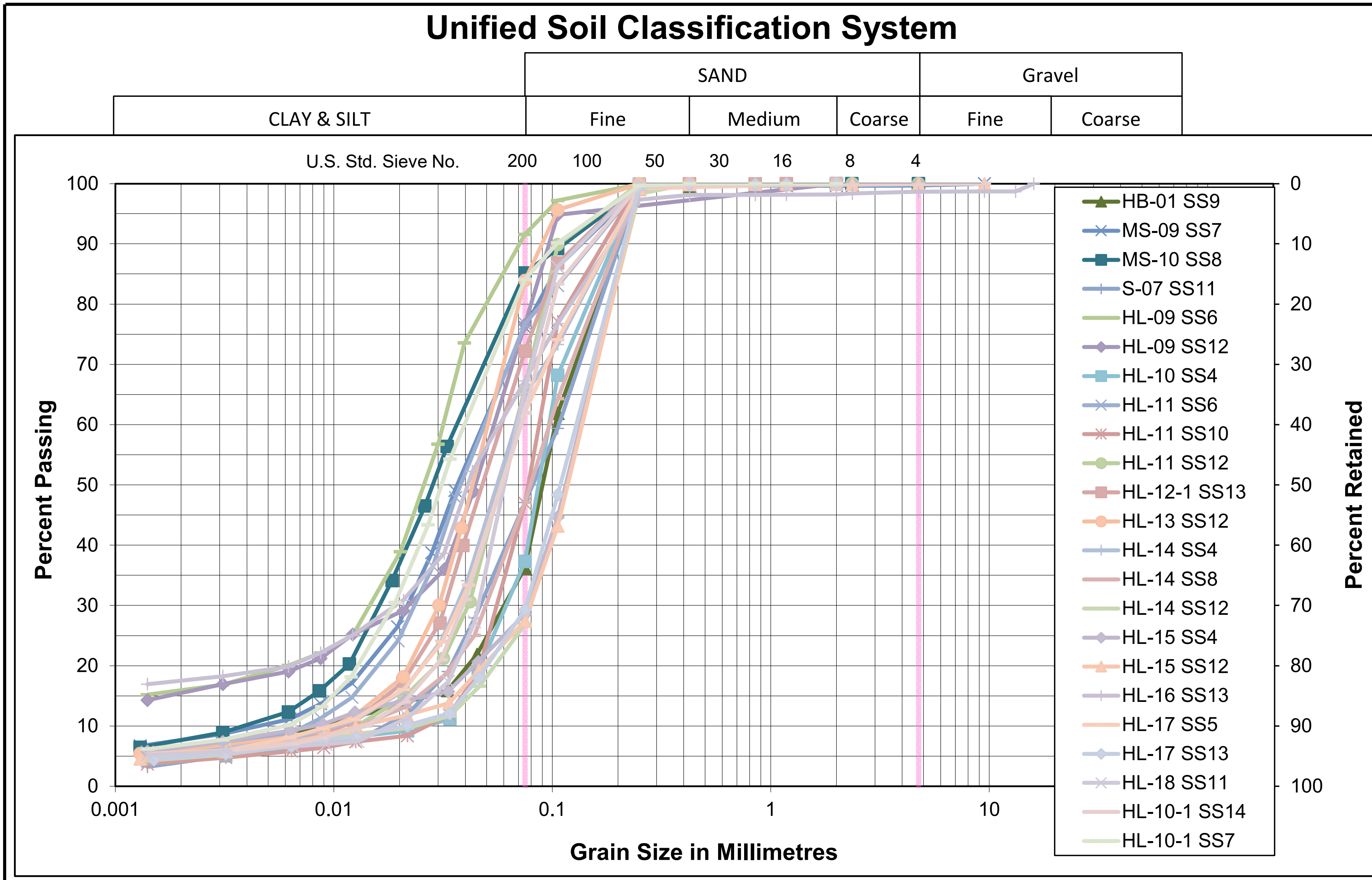
HWY 401 RECONSTRUCTION - Highbury Avenue Interchange

Figure No. D4

Project No. 165001239



Stantec	Ministry of Transportation (MTO) HWY 401 RECONSTRUCTION Highbury Avenue Interchange CLAYEY SILT to SILTY CLAY (CL to CI), Till	Figure No. D5 Project No. 165001239



Stantec

Silty SAND (SM) to Sandy SILT to SILT (ML)

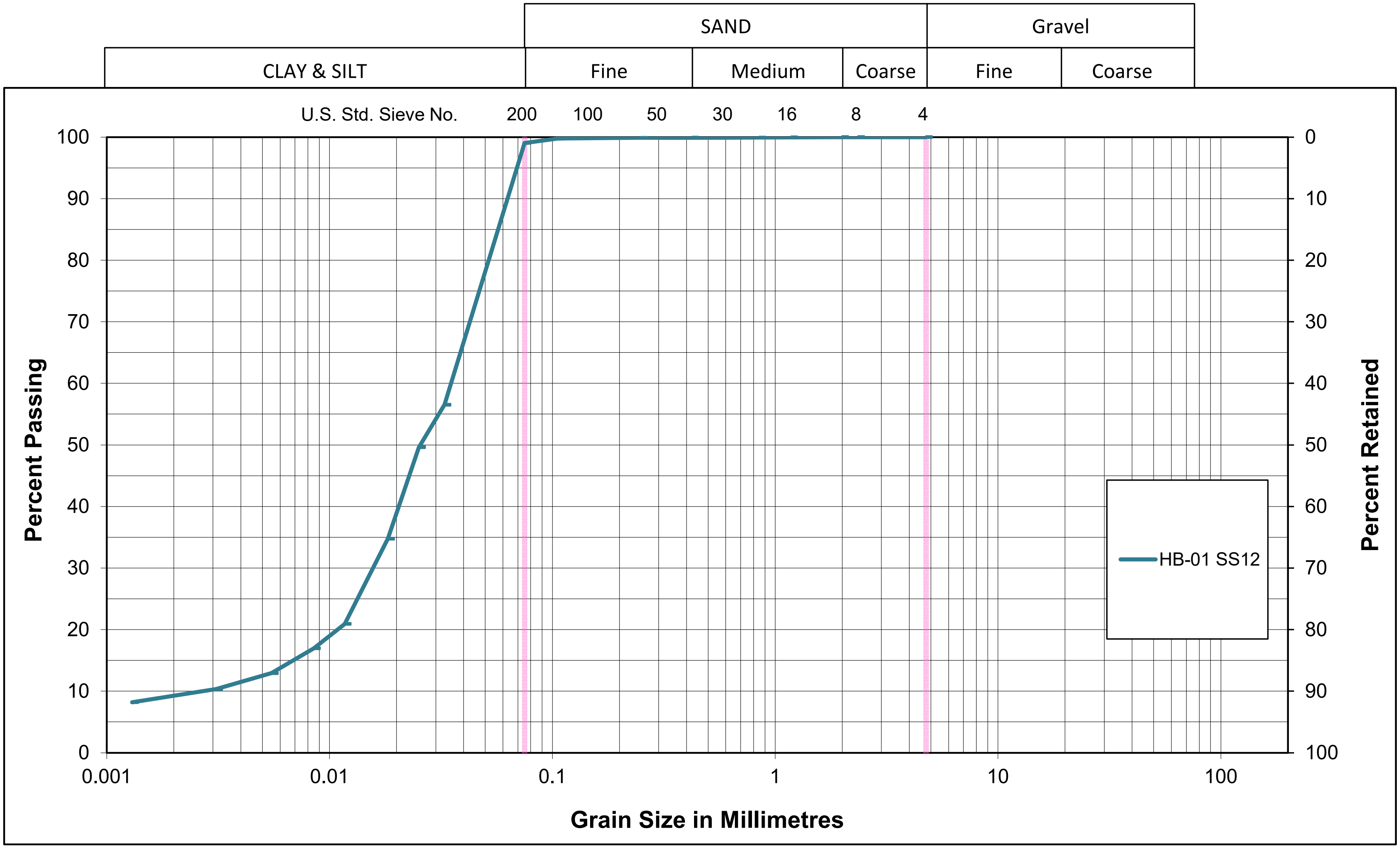
Ministry of Transportation (MTO)

HWY 401 RECONSTRUCTION - Highbury Avenue Interchange

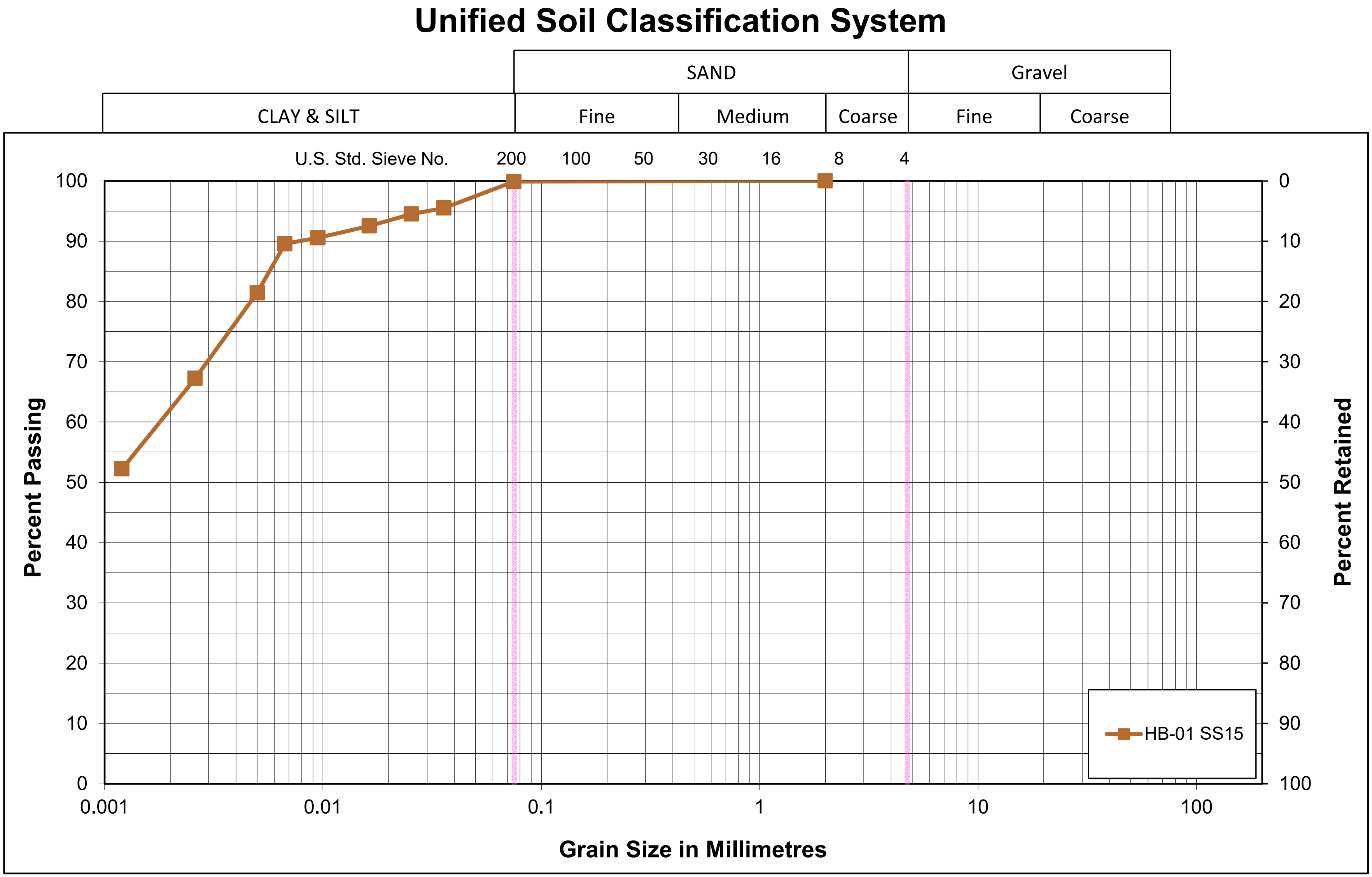
Figure No. D6

Project No. 165001239

Unified Soil Classification System



Stantec	SILT (ML) Ministry of Transportation (MTO) HWY 401 RECONSTRUCTION - Highbury Avenue Interchange	Figure No. D7 Project No. 165001239



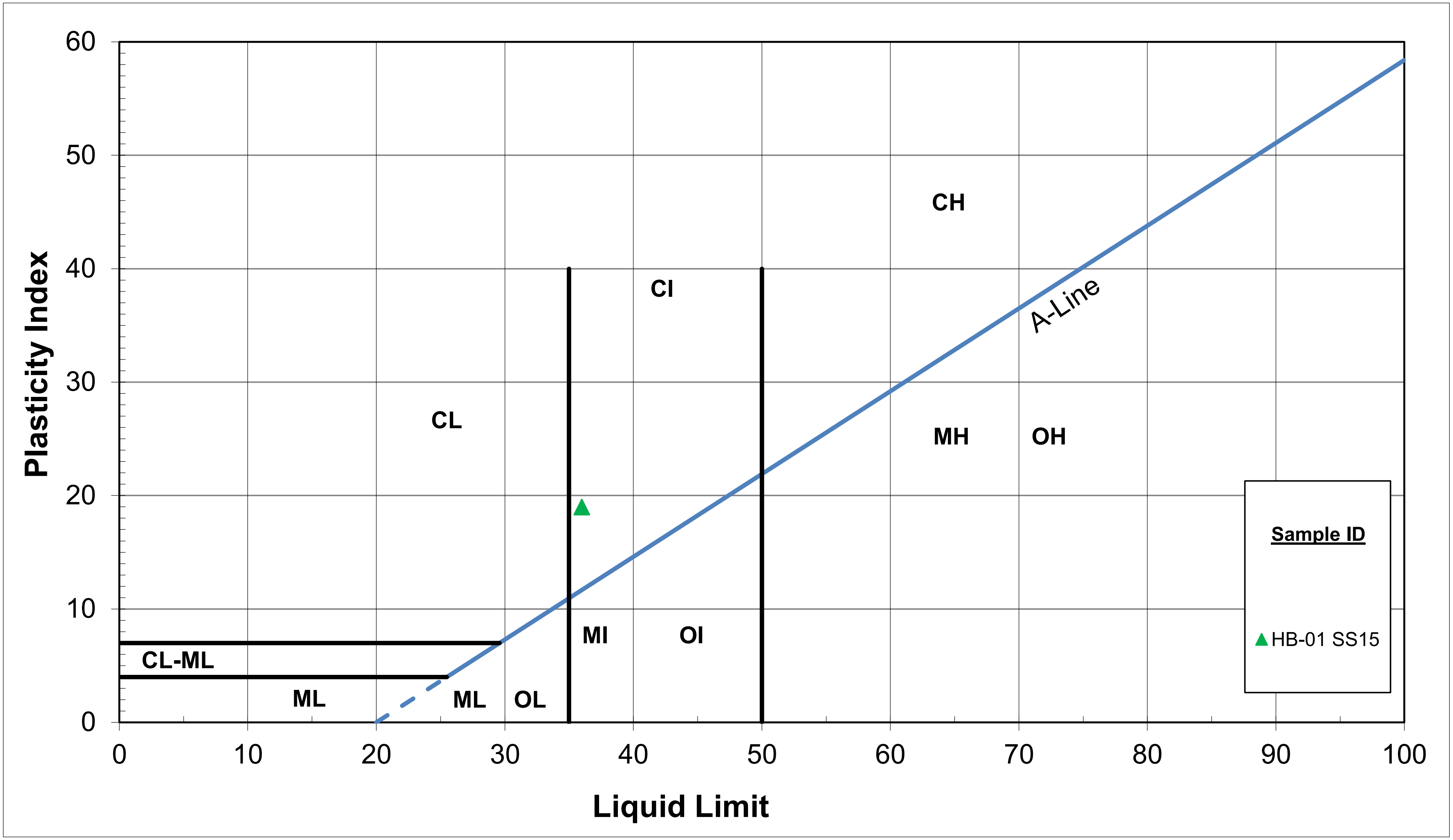
Silty CLAY (CI)

Ministry of Transportation (MTO)

HWY 401 RECONSTRUCTION - Highbury Avenue Interchange

Figure No. D8

Project No. 165001239



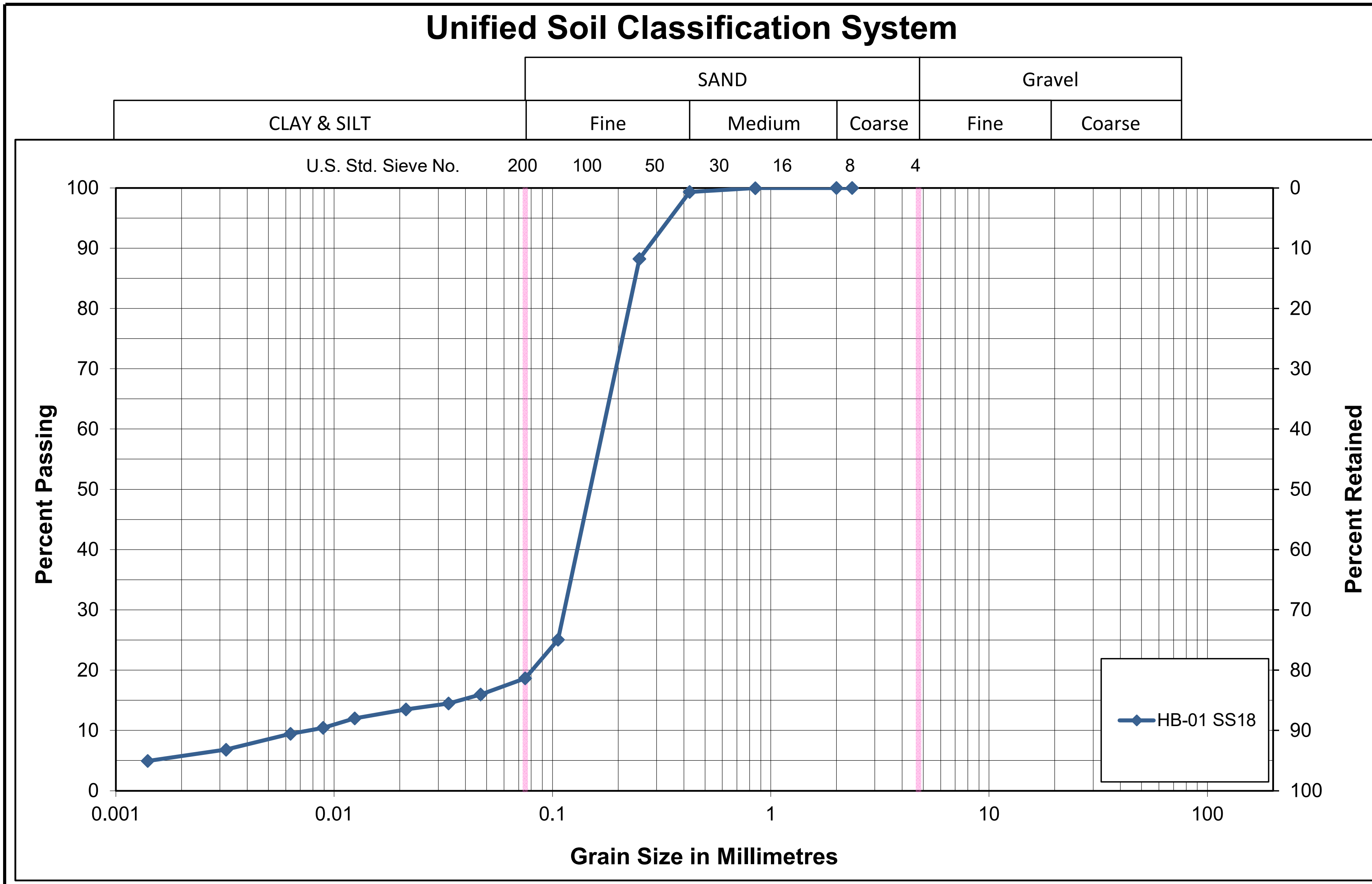
Stantec

Ministry of Transportation (MTO)
HWY 401 RECONSTRUCTION
Highbury Avenue Interchange

Silty CLAY (CI)

Figure No. D9

Project No. 165001239



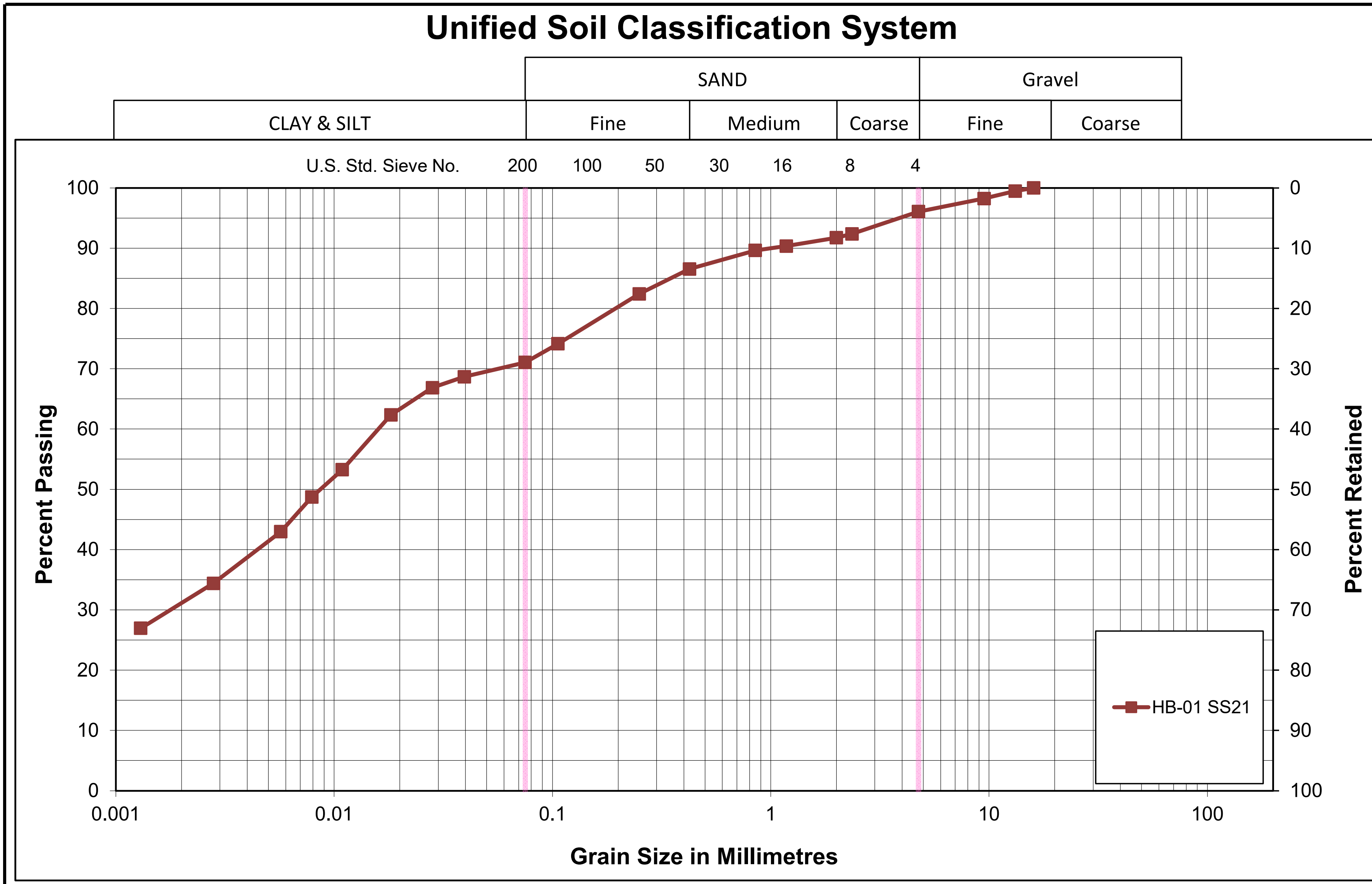
Silty SAND (SM)

Ministry of Transportation (MTO)

HWY 401 RECONSTRUCTION - Highbury Avenue Interchange

Figure No. D10

Project No. 165001239



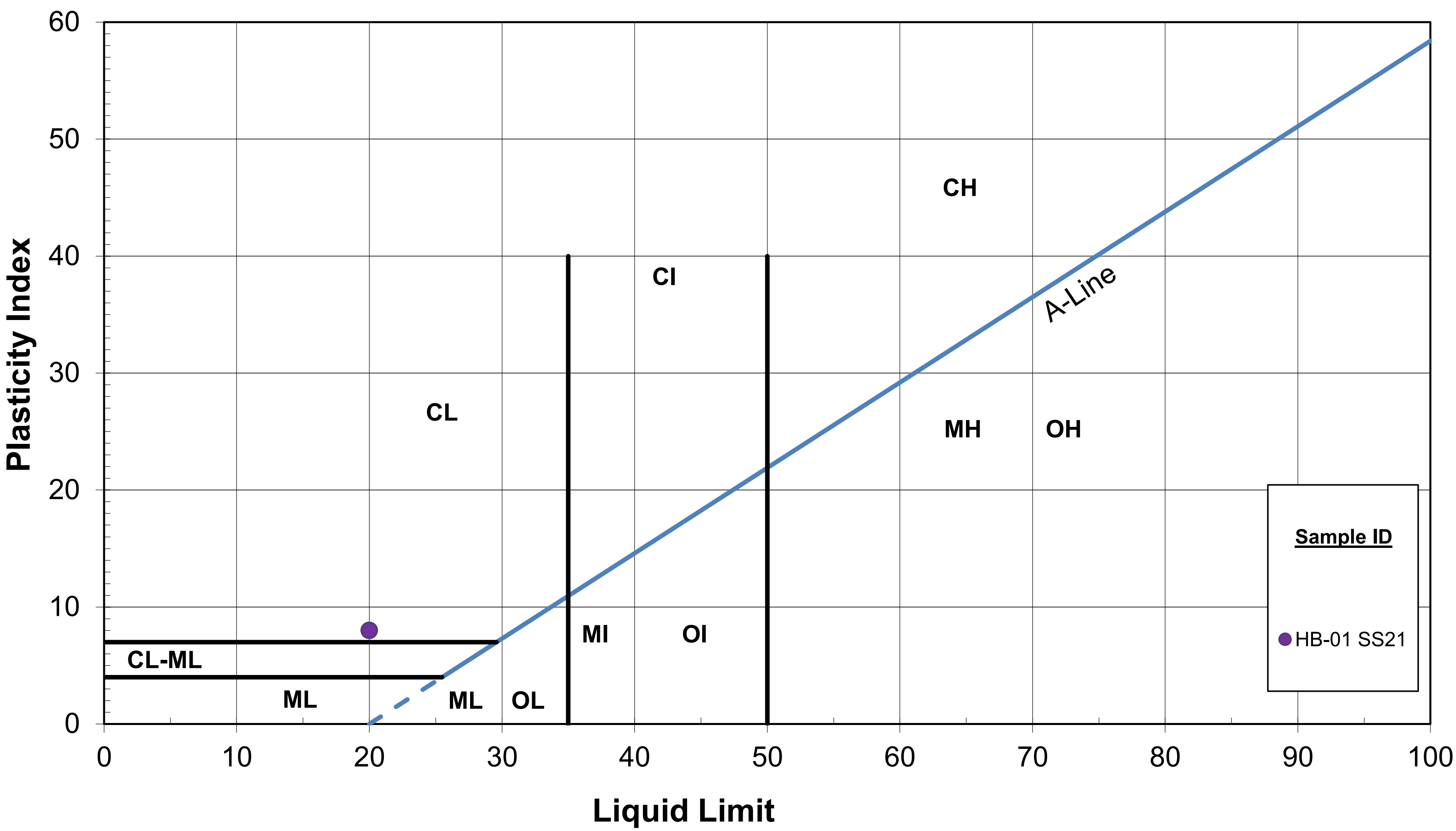
CLAYEY SILT (CL), Till

Ministry of Transportation (MTO)

HWY 401 RECONSTRUCTION - Highbury Avenue Interchange

Figure No. D11

Project No. 165001239



Ministry of Transportation (MTO)
HWY 401 RECONSTRUCTION
Highbury Avenue Interchange

CLAYEY SILT (CL), Till

Figure No. D12

Project No. 165001239

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

CLIENT NAME:	STANTEC CONSULTING LTD 300-675 Cochrane Drive MARKHAM, ON L3R0B8 (905) 444-7777
ATTENTION TO:	Amoldeep Gill
PROJECT:	165001239.651
AGAT WORK ORDER:	22T944869
ROCK ANALYSIS REVIEWED BY:	Meredith White, Senior Technician
SOIL ANALYSIS REVIEWED BY:	Nivine Basily, Inorganics Report Writer
DATE REPORTED:	Sep 23, 2022
PAGES (INCLUDING COVER):	7
VERSION*:	1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*Notes

Certificate of Analysis

AGAT WORK ORDER: 22T944869
PROJECT: 165001239.651

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

CLIENT NAME: STANTEC CONSULTING LTD
SAMPLING SITE:

ATTENTION TO: Amoldeep Gill
SAMPLED BY:

(283-042) Sulfide (CGY)

DATE RECEIVED: 2022-09-14

DATE REPORTED: 2022-09-23

			SAMPLE DESCRIPTION:	(MC-01) - SS8	(S-06-3) - SS8	(S-08-1) - SS8	(PM-03-2) - SS8	(PM-02-1) - SS6	(S-02) - SS6	(S-07) - SS8	(EL-02-1) - SS6
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12
Parameter	Unit	G / S	RDL	4302866	4302868	4302869	4302870	4302871	4302872	4302873	4302874
Sulfide	%		0.01	0.02	0.06	0.05	0.07	<0.01	0.01	0.01	0.05

			SAMPLE DESCRIPTION:	(MC-02) - SS8	(MS-01) - SS4
			SAMPLE TYPE:	Soil	Soil
			DATE SAMPLED:	2022-09-12	2022-09-12
Parameter	Unit	G / S	RDL	4302875	4302881
Sulfide	%		0.01	0.07	0.03

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Calgary (unless marked by *)

Certified By:

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 22T944869
PROJECT: 165001239.651

CLIENT NAME: STANTEC CONSULTING LTD
ATTENTION TO: Amoldeep Gill
SAMPLING SITE:
SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2022-09-14
DATE REPORTED: 2022-09-23

			SAMPLE DESCRIPTION:	(MC-01) - SS8	(S-06-3) - SS8	(S-08-1) - SS8	(PM-03-2) - SS8	(PM-02-1) - SS6	(S-02) - SS6	(S-07) - SS8	(EL-02-1) - SS6
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12	2022-09-12
Parameter	Unit	G / S	RDL	4302866	4302868	4302869	4302870	4302871	4302872	4302873	4302874
Chloride (2:1)	µg/g		2	470	89	199	8	206	486	1090	1290
Sulphate (2:1)	µg/g		2	97	120	98	96	16	62	35	155
pH (2:1)	pH Units		NA	6.68	6.65	6.81	6.79	6.62	7.31	7.09	7.38
Electrical Conductivity (2:1)	mS/cm		0.005	0.916	0.390	0.571	0.221	0.471	0.990	2.09	2.66
Resistivity (2:1) (Calculated)	ohm.cm		1	1090	2560	1750	4520	2120	1010	478	376
Redox Potential 1	mV		NA	417	415	343	321	295	257	317	202
Redox Potential 2	mV		NA	417	415	348	323	304	265	317	211
Redox Potential 3	mV		NA	416	415	349	324	309	274	317	207

			SAMPLE DESCRIPTION:	(MC-02) - SS8	(MS-01) - SS4
			SAMPLE TYPE:	Soil	Soil
			DATE SAMPLED:	2022-09-12	2022-09-12
Parameter	Unit	G / S	RDL	4302875	4302881
Chloride (2:1)	µg/g		2	287	296
Sulphate (2:1)	µg/g		2	403	29
pH (2:1)	pH Units		NA	6.66	7.45
Electrical Conductivity (2:1)	mS/cm		0.005	0.920	0.687
Resistivity (2:1) (Calculated)	ohm.cm		1	1090	1460
Redox Potential 1	mV		NA	216	243
Redox Potential 2	mV		NA	226	249
Redox Potential 3	mV		NA	233	248

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

4302866-4302881 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO — CHARTERED — NIVINE BASILY — CHEMIST

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Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD
PROJECT: 165001239.651
SAMPLING SITE:

AGAT WORK ORDER: 22T944869
ATTENTION TO: Amoldeep Gill
SAMPLED BY:

Rock Analysis

RPT Date: Sep 23, 2022			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
(283-042) Sulfide (CGY)															
Total Sulfur	4302866	4302866	0.02	0.02	NA	< 0.01									
Sulfate	4302866	4302866	0.01	0.01	1.5%	< 0.01	101%								

Certified By:

AGAT Laboratories

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Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD
AGAT WORK ORDER: 22T944869
PROJECT: 165001239.651
ATTENTION TO: Amoldeep Gill
SAMPLING SITE:
SAMPLED BY:

Soil Analysis

RPT Date: Sep 23, 2022			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
Corrosivity Package															
Chloride (2:1)	4305151		77	74	4.0%	< 2	98%	70%	130%	102%	80%	120%	100%	70%	130%
Sulphate (2:1)	4305151		70	68	2.9%	< 2	107%	70%	130%	105%	80%	120%	104%	70%	130%
pH (2:1)	4302866	4302866	6.68	6.67	0.1%	NA	101%	80%	120%						
Electrical Conductivity (2:1)	4302866	4302866	0.916	0.920	0.4%	< 0.005	92%	80%	120%						
Redox Potential 1	4302866						100%	90%	110%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Certified By: [stamp: Association of the Chemical Profession of Ontario, Chartered Chemist, Nivine Basily] [signature]

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Method Summary

CLIENT NAME: STANTEC CONSULTING LTD

PROJECT: 165001239.651

SAMPLING SITE:

AGAT WORK ORDER: 22T944869

ATTENTION TO: Amoldeep Gill

SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE

AGAT Laboratories

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Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Laboratory Use Only
Arrival Temperature: 20.8/20.9/21.4
AGAT WO #: 22T944869
Lab Temperature:
Notes: 1 box / No Ice

Chain of Custody Record

Client Information:
Company: Stantec Consulting Ltd.
Contact: Amoldeep Gill
Address: 300-675 Cochran Drive West Tower
Phone: 905-479-9345 Fax: 905-944-9889
Project: 165001239.651 PO:
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:
☐ Regulation 153/09 (reg. 511 Amend.)
Table ____ Indicate one
☐ Ind/Com ☐ Res/Park ☐ Agriculture
Soil Texture (check one) ☐ Coarse ☐ Fine
☐ Sewer Use
Region ____ Indicate one
☐ Sanitary ☐ Storm
☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*
Regular TAT
☑ 5 to 7 Working Days
Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day
OR
Date Required (Rush surcharges may apply):
*TAT is exclusive of weekends and statutory holidays

Invoice To: Same: Yes ☑ No ☐
Company:
Contact:
Address:

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix
GW Ground Water O Oil
SW Surface Water P Paint
SD Sediment S Soil

Report Information – reports to be sent to:
1. Name: Amoldeep Gill
Email: amoldeep.gill@stantec.com
2. Name: Gwangha Roh
Email: gwangha.roh@stantec.com

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	TCLP:	Sewer Use	Corrosivity Pckg (pH, Redox Potential,	sulphates and sulphides contents,	chlorides contents and resistivity)					
(MC-01) - SS8	12-Sep-22			1	17.5'																	X	X	X					
(S-06-3) - SS8	12-Sep-22			1	17.5'																	X	X	X					
(S-08-1) - SS8	12-Sep-22			1	17.5'																	X	X	X					
(PM-03-2) - SS8	12-Sep-22			1	25'																	X	X	X					
(PM-02-1) - SS6	12-Sep-22			1	15'																	X	X	X					
(S-02) - SS6	12-Sep-22			1	12.5'																	X	X	X					
(S-07) - SS8	12-Sep-22			1	17.5'																	X	X	X					
(EL-02-1) - SS6	12-Sep-22			1	12.5'																	X	X	X					
(MC-02) - SS8	12-Sep-22			1	17.5'																	X	X	X					
(MS-01) - SS4	12-Sep-22			1	7.5'																	X	X	X					

Samples Relinquished by (print name & sign): Date/Time
Samples Received by (Print name & sign): Anthony Dasilva [signature] Date/Time
Samples Relinquished by (print name & sign): Date/Time
Samples Received by (Print name & sign): Date/Time

Pink Copy – Client
Yellow + Golden Copy AGAT
White Copy – AGAT

Page ____ of ____
NO:

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CLIENT NAME: STANTEC CONSULTING LTD
300-675 Cochrane Drive
MARKHAM, ON L3R0B8
(905) 444-7777

ATTENTION TO: Amoldeep Gill

PROJECT: 165001239.651

AGAT WORK ORDER: 22T948205

ROCK ANALYSIS REVIEWED BY: Heather Offord, Client Service Representative

SOIL ANALYSIS REVIEWED BY: Nivine Basily, Inorganics Report Writer

DATE REPORTED: Sep 30, 2022

PAGES (INCLUDING COVER): 11

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (403) 735-2005

*Notes

Disclaimer:

- All work conducted herein has been done using accepted standard protocols, and generally accepted practices and methods. AGAT test methods may incorporate modifications from the specified reference methods to improve performance.
- All samples will be disposed of within 30 days after receipt unless a Long Term Storage Agreement is signed and returned. Some specialty analysis may be exempt, please contact your Client Project Manager for details.
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- All reportable information as specified by ISO/IEC 17025:2017 is available from AGAT Laboratories upon request.

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AGAT Laboratories

Certificate of Analysis

AGAT WORK ORDER: 22T948205
PROJECT: 165001239.651

CLIENT NAME: STANTEC CONSULTING LTD
ATTENTION TO: Amoldeep Gill
SAMPLING SITE:
SAMPLED BY:

(283-042) Sulfide (CGY)

DATE RECEIVED: 2022-09-22
DATE REPORTED: 2022-09-30

Parameter	Unit	G / S	RDL	(S-04-1)-SS8	(S-01-1)-SS5	(HL-08)-SS5	(S-03)-SS6	(EL-04-4)-SS6	(HB-01)-SS6	(HL-11)-SS6	(HL-15-1)-SS9
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20
				4335332	4335453	4335454	4335455	4335456	4335457	4335458	4335459
Sulfide	%		0.01	0.01	0.01	0.01	0.01	<0.01	0.02	0.01	0.03

Parameter	Unit	G / S	RDL	(HL-10)-SS4	(HL-17)-SS5	(HL-14)-SS4	(HL-12)-SS2	(HF-10)-SS5	(HF-11)-SS6	(HL-05)-SS7	(HL-03)-SS5
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20
				4335460	4335461	4335462	4335463	4335480	4335481	4335482	4335483
Sulfide	%		0.01	0.01	0.01	0.01	<0.01	<0.01	0.01	0.01	0.01

Parameter	Unit	G / S	RDL	(HL-01)-SS4	(HL-16-1)-SS13	(HL-04)-SS3	(HL-13-1)-SS12	(HL-07)-SS4	(HL-06)-SS8	(HL-02)-SS5	(HL-09-1)-SS5
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20
				4335484	4335485	4335486	4335487	4335488	4335489	4335490	4335491
Sulfide	%		0.01	<0.01	0.01	<0.01	0.01	<0.01	0.03	0.02	0.02

Parameter	Unit	G / S	RDL	(S-05-1)-SS8	(HL-18-1)-SS8
SAMPLE TYPE:				Soil	Soil
DATE SAMPLED:				2022-09-20	2022-09-20
				4335571	4335572
Sulfide	%		0.01	0.04	<0.01

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Calgary (unless marked by *)

Certified By:

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CLIENT NAME: STANTEC CONSULTING LTD

ATTENTION TO: Amoldeep Gill

SAMPLING SITE:

SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2022-09-22

DATE REPORTED: 2022-09-30

			SAMPLE DESCRIPTION:	(S-04-1)-SS8	(S-01-1)-SS5	(HL-08)-SS5	(S-03)-SS6	(EL-04-4)-SS6	(HB-01)-SS6	(HL-11)-SS6	(HL-15-1)-SS9
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20
Parameter	Unit	G / S	RDL	4335332	4335453	4335454	4335455	4335456	4335457	4335458	4335459
Chloride (2:1)	µg/g		2	449	438	702	1080	713	816	14	89
Sulphate (2:1)	µg/g		2	23	27	28	32	83	30	5	187
pH (2:1)	pH Units		NA	9.41	7.30	9.68	9.15	9.26	9.04	8.76	8.91
Electrical Conductivity (2:1)	mS/cm		0.005	0.950	0.875	1.36	1.99	1.44	1.43	0.110	0.470
Resistivity (2:1) (Calculated)	ohm.cm		1	1050	1140	735	503	694	699	9090	2130
Redox Potential 1	mV		NA	320	270	251	268	290	236	240	236
Redox Potential 2	mV		NA	331	283	262	279	295	240	240	238
Redox Potential 3	mV		NA	343	290	273	286	298	242	242	239

			SAMPLE DESCRIPTION:	(HL-10)-SS4	(HL-17)-SS5	(HL-14)-SS4	(HL-12)-SS2	(HF-10)-SS5	(HF-11)-SS6	(HL-05)-SS7	(HL-03)-SS5
			SAMPLE TYPE:	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
			DATE SAMPLED:	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20
Parameter	Unit	G / S	RDL	4335460	4335461	4335462	4335463	4335480	4335481	4335482	4335483
Chloride (2:1)	µg/g		2	214	14	23	20	83	129	337	304
Sulphate (2:1)	µg/g		2	11	5	6	14	24	33	28	19
pH (2:1)	pH Units		NA	9.31	9.08	8.85	8.43	8.06	7.91	7.85	7.72
Electrical Conductivity (2:1)	mS/cm		0.005	0.433	0.111	0.124	0.186	0.314	0.372	0.688	0.629
Resistivity (2:1) (Calculated)	ohm.cm		1	2310	9010	8060	5380	3180	2690	1450	1590
Redox Potential 1	mV		NA	261	252	273	236	248	229	242	221
Redox Potential 2	mV		NA	264	258	284	246	253	243	253	237
Redox Potential 3	mV		NA	265	264	293	253	258	249	259	229

Certified By:

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO CHARTERED NIVINE BASILY CHEMIST

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Certificate of Analysis

AGAT WORK ORDER: 22T948205
PROJECT: 165001239.651

CLIENT NAME: STANTEC CONSULTING LTD
SAMPLING SITE:
ATTENTION TO: Amoldeep Gill
SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2022-09-22
DATE REPORTED: 2022-09-30

Parameter	Unit	G / S	RDL	(HL-01)-SS4	(HL-16-1)-SS13	(HL-04)-SS3	(HL-13-1)-SS12	(HL-07)-SS4	(HL-06)-SS8	(HL-02)-SS5	(HL-09-1)-SS5
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20	2022-09-20
				4335484	4335485	4335486	4335487	4335488	4335489	4335490	4335491
Chloride (2:1)	µg/g		2	460	253	985	733	1650	423	253	1030
Sulphate (2:1)	µg/g		2	36	20	61	16	83	142	28	20
pH (2:1)	pH Units		NA	8.18	8.38	8.47	8.08	8.50	7.95	7.84	7.68
Electrical Conductivity (2:1)	mS/cm		0.005	0.920	0.533	2.00	1.28	3.43	0.916	0.569	1.87
Resistivity (2:1) (Calculated)	ohm.cm		1	1090	1880	500	781	292	1090	1760	535
Redox Potential 1	mV		NA	250	285	255	268	259	272	255	255
Redox Potential 2	mV		NA	254	292	258	277	269	277	262	259
Redox Potential 3	mV		NA	256	293	260	285	271	280	263	264

Parameter	Unit	G / S	RDL	(S-05-1)-SS8	(HL-18-1)-SS8
SAMPLE TYPE:				Soil	Soil
DATE SAMPLED:				2022-09-20	2022-09-20
				4335571	4335572
Chloride (2:1)	µg/g		2	165	1790
Sulphate (2:1)	µg/g		2	126	196
pH (2:1)	pH Units		NA	7.66	10.8
Electrical Conductivity (2:1)	mS/cm		0.005	0.492	3.68
Resistivity (2:1) (Calculated)	ohm.cm		1	2030	272
Redox Potential 1	mV		NA	271	222
Redox Potential 2	mV		NA	286	226
Redox Potential 3	mV		NA	287	228

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

4335332-4335572 EC, pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.
Redox potential measured on as received sample. Due to the potential for rapid change in sample equilibrium chemistry with exposure to oxidative/reduction conditions laboratory results may differ from field measured results.
Redox potential measurement in soil is quite variable and non reproducible due in part, to the general heterogeneity of a given soil. It is also related to the introduction of increased oxygen into the sample after extraction. The interpretation of soil redox potential should be considered in terms of its general range rather than as an absolute measurement.

Analysis performed at AGAT Toronto (unless marked by *)

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Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD
PROJECT: 165001239.651
SAMPLING SITE:

AGAT WORK ORDER: 22T948205
ATTENTION TO: Amoldeep Gill
SAMPLED BY:

Rock Analysis

RPT Date: Sep 30, 2022			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper	Recovery	Acceptable Limits Lower	Acceptable Limits Upper
(283-042) Sulfide (CGY)															
Total Sulfur	4335332	4335332	0.01	0.01	NA	< 0.01	102%								
Sulfate	4335332	4335332	<0.01	<0.01	NA	< 0.01	94%								
(283-042) Sulfide (CGY)															
Total Sulfur	2	4335488	0.02	0.01	NA	< 0.01	102%								
Sulfate	4335487	4335487	<0.01	<0.01	NA	< 0.01	97%								
(283-042) Sulfide (CGY)															
Total Sulfur	4335488	4335488	<0.01	0.02	0%	< 0.01									

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Quality Assurance

CLIENT NAME: STANTEC CONSULTING LTD AGAT WORK ORDER: 22T948205

PROJECT: 165001239.651 ATTENTION TO: Amoldeep Gill

SAMPLING SITE: SAMPLED BY:

Soil Analysis

RPT Date: Sep 30, 2022			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Corrosivity Package															
Chloride (2:1)	4335332	4335332	449	445	0.9%	< 2	99%	70%	130%	100%	80%	120%	NA	70%	130%
Sulphate (2:1)	4335332	4335332	23	22	4.4%	< 2	105%	70%	130%	102%	80%	120%	101%	70%	130%
pH (2:1)	4336014		6.58	6.87	4.3%	NA	113%	80%	120%						
Electrical Conductivity (2:1)	4336014		0.227	0.232	2.2%	0.006	97%	80%	120%						
Redox Potential 1	4335332					NA	99%	90%	110%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Matrix spike NA: Spike level < native concentration. Matrix spike acceptance limits do not apply and are not calculated.

PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Lower	Upper	Recovery	Lower	Upper	Recovery	Lower	Upper
Corrosivity Package															
pH (2:1)	4335332	4335332	9.41	9.54	1.4%	NA	101%	80%	120%						
Electrical Conductivity (2:1)	4335332	4335332	0.950	0.959	0.9%	< 0.005	92%	80%	120%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Lower	Upper	Recovery	Lower	Upper	Recovery	Lower	Upper
Corrosivity Package															
Chloride (2:1)	4335488	4335488	1650	1650	0.5%	< 2	99%	70%	130%	100%	80%	120%	NA	70%	130%
Sulphate (2:1)	4335488	4335488	83	83	0.0%	< 2	105%	70%	130%	102%	80%	120%	101%	70%	130%

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.

Matrix spike NA: Spike level < native concentration. Matrix spike acceptance limits do not apply and are not calculated.

Certified By:

AGAT Laboratories

2910 12TH STREET NE
CALGARY, ALBERTA
CANADA T2E 7P7
TEL (403)735-2005
FAX (403)735-2771
http://www.agatlabs.com

Method Summary

CLIENT NAME: STANTEC CONSULTING LTD
AGAT WORK ORDER: 22T948205
PROJECT: 165001239.651
ATTENTION TO: Amoldeep Gill
SAMPLING SITE:
SAMPLED BY:

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Electrical Conductivity (2:1)	INOR-93-6075	modified from MSA PART 3, CH 14 and SM 2510 B	PC TITRATE
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION
Redox Potential 1	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 2	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE
Redox Potential 3	INOR-93-6066	G200-20, SM 2580 B	REDOX POTENTIAL ELECTRODE

5835 Coopers Avenue
Mississauga, Ontario
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com

AGAT Laboratories

Chain of Custody Record

Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Laboratory Use Only
Arrival Temperature: See attached
AGAT WO #: 22T948205
Lab Temperature:
Notes: 3 boxes / No Ice

Client Information:
Company: Stantec Consulting Ltd.
Contact: Amoldeep Gill
Address: 300-675 Cochran Drive West Tower
Phone: 905-479-9345 Fax: 905-944-9889
Project: 165001239.651 PO:
AGAT Quotation #:
Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:
☐ Regulation 153/09 (reg. 511 Amend.)
Table ______ Indicate one
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine
☐ Sewer Use
Region ______ Indicate one
☐ Sanitary
☐ Storm
☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*
Regular TAT
☑ 5 to 7 Working Days
Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ ~~1 Working Day~~
OR
Date Required (Rush surcharges may apply):
*TAT is exclusive of weekends and statutory holidays

Invoice To: Same: Yes ☑ No ☐
Company:
Contact:
Address:

Is this a drinking water sample? (potable water intended for human consumption) ☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?** ☐ Yes ☐ No

Legend Matrix
GW Ground Water O Oil
SW Surface Water P Paint
SD Sediment S Soil

Report Information – reports to be sent to:
1. Name: Amoldeep Gill
Email: amoldeep.gill@stantec.com
2. Name: Gwangha Roh
Email: gwangha.roh@stantec.com

Analysis columns: Metals and Inorganics; Metal Scan; Hydride Forming Metals; Client Custom Metals; ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH; Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_3; VOC: ☐ VOC ☐ THM ☐ BTEX; CCME Fractions 1 to 4; ABNs; PAHs; Chlorophenols; PCBs; Organochlorine Pesticides; TCLP Metals/Inorganics; TCLP:; Sewer Use; Corrosivity Pckg (pH, Redox Potential, sulphates and sulphides contents, chlorides contents and resistivity)

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Corrosivity Pckg (pH, Redox Potential,	sulphates and sulphides contents,	chlorides contents and resistivity)
(S-04-1) - SS8	20-Sept-22			1	17.5'	X	X	X
(S-01-1) - SS5	20-Sept-22			1	10'	X	X	X
(HL-08) - SS5	20-Sept-22			1	10'	X	X	X
(S-03) - SS6	20-Sept-22			1	12.5'	X	X	X
(EL-04-4) - SS6	20-Sept-22			1	12.5'	X	X	X
(HB-01) - SS6	20-Sept-22			1	15'	X	X	X
(HL-11) - SS6	20-Sept-22			1	12.5'	X	X	X
(HL-15-1) - SS9	20-Sept-22			1	20'	X	X	X
(HL-10) - SS4	20-Sept-22			1	7.5'	X	X	X
(HL-17) - SS5	20-Sept-22			1	10'	X	X	X
(HL 14) SS4	20 Sept 22			1	7.5'	X	X	X
(HL-12) - SS2	20-Sept-22			1	2.5'	X	X	X

Samples Relinquished by (print name & sign): Date/Time
Samples Received by (Print name & sign): Date/Time
Samples Relinquished by (print name & sign): Date/Time
Samples Received by (Print name & sign): Anthony Dasilva [signature] Date/Time

Pink Copy – Client
Yellow + Golden Copy – AGAT
White Copy – AGAT

Page ____ of ____
NO:

Document ID: DIV-78-1511.006
Date Issued: July 20, 2011

'22 SEP 22 9:41AM

AGAT Laboratories

5835 Coopers Avenue
Mississauga, Ontario
L4Z 1Y2
www.agatlabs.com · webearth.agatlabs.com
Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Chain of Custody Record

Laboratory Use Only
Arrival Temperature:
AGAT WO #:
Lab Temperature:
Notes:

Client Information:
Company: Stantec Consulting Ltd.
Contact: Amoldeep Gill
Address: 300-675 Cochran Drive West Tower
Phone: 905-479-9345 Fax: 905-944-9889
Project: 165001239.651 PO:
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:
☐ Regulation 153/09 (reg. 511 Amend.)
Table ______ Indicate one
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture (check one)
☐ Coarse ☐ Fine

☐ Sewer Use
Region ______ Indicate one
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other (specify)
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*
Regular TAT
☑ 5 to 7 Working Days
Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day
OR
Date Required (Rush surcharges may apply):
*TAT is exclusive of weekends and statutory holidays

Invoice To:
Same: Yes ☑ No ☐
Company:
Contact:
Address:

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix
GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:
1. Name: Amoldeep Gill
Email: amoldeep.gill@stantec.com
2. Name: Gwangha Roh
Email: gwangha.roh@stantec.com

Analysis columns: Metals and Inorganics; Metal Scan; Hydride Forming Metals; Client Custom Metals; ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ Cr+6- ☐ SAR ☐ FOC ☐ N-Total ☐ Hg ☐ pH ☐ NO_3/NO_2; Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2; VOC: ☐ VOC ☐ THM ☐ BTEX; CCME Fractions 1 to 4; ABNs; PAHs; Chlorophenols; PCBs; Organochlorine Pesticides; TCLP Metals/Inorganics; TCLP:; Sewer Use; Corrosivity Pckg (pH, Redox Potential, sulphates and sulphides contents, chlorides contents and resistivity)

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Corrosivity Pckg (pH, Redox Potential,	sulphates and sulphides contents,	chlorides contents and resistivity)
(HF-10) - SS5	20-Sept-22			1	15'	X	X	X
(HF-11) - SS6	20-Sept-22			1	15'	X	X	X
(HL-05) - SS7	20-Sept-22			1	15'	X	X	X
(HL-03) - SS5	20-Sept-22			1	10'	X	X	X
(HL-01) - SS4	20-Sept-22			1	7.5'	X	X	X
(HL-16-1) - SS13	20-Sept-22			1	35'	X	X	X
(HL-04) - SS3	20-Sept-22			1	5'	X	X	X
(HL-13-1) - SS12	20-Sept-22			1	30'	X	X	X
(HL-07) - SS4	20-Sept-22			1	7.5'	X	X	X
(HL-06) - SS8	20-Sept-22			1	17.5'	X	X	X
(HL-02) - SS5	20-Sept-22			1	10'	X	X	X
(HL-09-1) - SS5	20-Sept-22			1	10'	X	X	X

Samples Relinquished by (print name & sign):	Date/Time	Samples Received by (Print name & sign):	Date/Time
Samples Relinquished by (print name & sign):	Date/Time	Samples Received by (Print name & sign):	Date/Time

Pink Copy – Client
Yellow + Golden Copy – AGAT
White Copy – AGAT

Page ____ of ____
NO:

Document ID: DIV-78-1511.006
Date Issued: July 20, 2011

AGAT Laboratories

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www.agatlabs.com · webearth.agatlabs.com
Ph.: 905.712.5100 · Fax: 905.712.5122 · Toll Free: 800.856.6261

Chain of Custody Record

Laboratory Use Only

Arrival Temperature: ____
AGAT WO #: ____
Lab Temperature: ____
Notes: ____

Client Information:

Company: Stantec Consulting Ltd.
Contact: Amoldeep Gill
Address: 300-675 Cochran Drive West Tower
Phone: 905-479-9345 Fax: 905-944-9889
Project: 165001239.651 PO: ____
AGAT Quotation #: ____

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements:

☐ Regulation 153/09 (reg. 511 Amend.)
Table ____ *Indicate one*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(check one)*
☐ Coarse ☐ Fine

☐ Sewer Use
Region ____ *Indicate one*
☐ Sanitary
☐ Storm

☐ Regulation 558
☐ CCME
☐ Other *(specify)* ____
☐ Prov. Water Quality Objectives (PWQO)
☐ None

Turnaround Time Required (TAT) Required*

Regular TAT
☑ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day

OR

Date Required (Rush surcharges may apply): ____

TAT is exclusive of weekends and statutory holidays

Invoice To:

Same: Yes ☑ No ☐
Company: ____
Contact: ____
Address: ____

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix

GW Ground Water **O** Oil
SW Surface Water **P** Paint
SD Sediment **S** Soil

Report Information – reports to be sent to:

1. Name: Amoldeep Gill
Email: amoldeep.gill@stantec.com
2. Name: Gwangha Roh
Email: gwangha.roh@stantec.com

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	ORPs: ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N-Total ☐ Hg ☐ pH	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	VOC: ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	TCLP:	Sewer Use	Corrosivity Pckg (pH, Redox Potential,	sulphates and sulphides contents,	chlorides contents and resistivity)					
(S-05-1) - SS8	20-Sept-22			1	17.5'																	X	X	X					
(HL-18-1) - SS8	20-Sept-22			1	17.5'																	X	X	X					

Samples Relinquished by (print name & sign):	Date/Time	Samples Received by (Print name & sign):	Date/Time
Samples Relinquished by (print name & sign):	Date/Time	Samples Received by (Print name & sign):	Date/Time

Pink Copy – Client
Yellow + Golden Copy – AGAT
White Copy – AGAT

Page ____ of ____
NO:

AGAT Laboratories

Sample Temperature Log

Client: STANTEC

COC# or Work Order#: ______

# of Coolers: 3 boxes

# of Submissions: ______

Arrival Temperatures - Branch/Driver

Cooler #1	19.8	20.0	20.1
Cooler #2	18.7	18.8	19.3
Cooler #3	19.7	19.8	19.9
Cooler #4			
Cooler #5			
Cooler #6			
Cooler #7			
Cooler #8			
Cooler #9			
Cooler #10			

IR Gun ID: ______

Taken By: ______

Date (yyyy/mm/dd): ______ Time: ___:___ AM / PM

Arrival Temperatures - Laboratory

Cooler #1:			
Cooler #2:			
Cooler #3:			
Cooler #4:			
Cooler #5:			
Cooler #6:			
Cooler #7:			
Cooler #8			
Cooler #9:			
Cooler #10:			

IR Gun ID: ______

Taken By: ______

Date (yyyy/mm/dd): ______ Time: ___:___ AM / PM

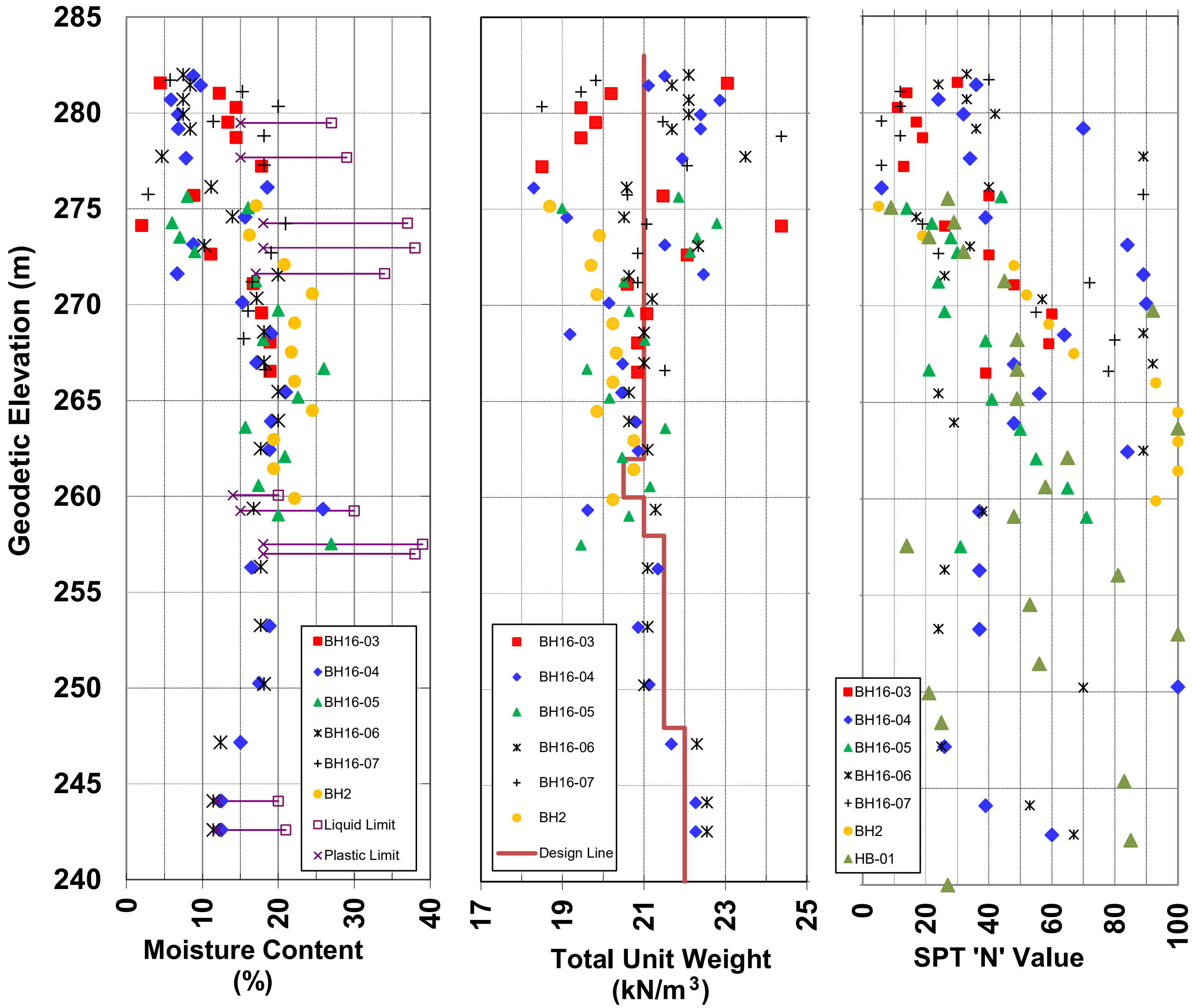
Instructions for use of this form: 1) complete all fields of info including total # of coolers and # of submissions [illegible] copy and place in each submission prior to giving a WO#, 3) Proceed as normal, write the WO# and scan (please make sure [illegible])

Document ID: SR-78-9511.003
Date Issued: 2017-2-23

Page: ______ of ______

APPENDIX E

E.1 FIGURES



Stratigraphy and Design Parameters

Ground surface

FILL : Firm to very stiff SILTY CLAY / loose to dense SILT to SILT and SAND / loose to very dense gravelly SAND.

Very stiff to hard, CLAYEY SILT to SILTY CLAY (TILL), γ = 21 kN/m³, E = 50 MPa, ϕ' = 30°, Su = 150 kPa

Compact to very dense SANDY SILT to SILTY SAND, γ = 21 kN/m³, E = 75 MPa, ϕ' = 33°

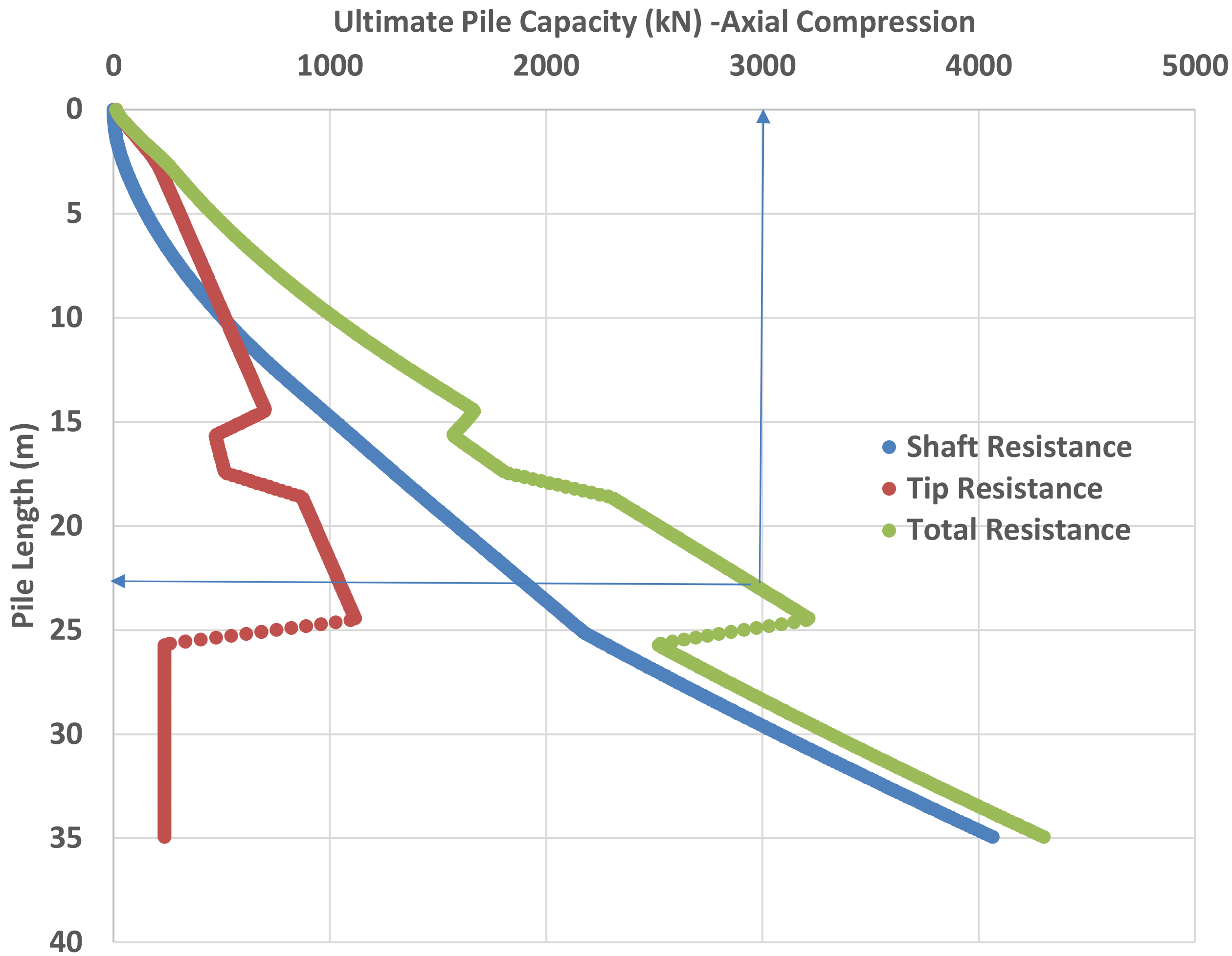
Dense to very dense SILT, γ = 20.5 kN/m³, E = 40 MPa, ϕ' = 30°-32°

Stiff to hard, SILTY CLAY, γ = 21 kN/m³, E = 40 MPa, ϕ' = 30°, Su = 125 kPa

Compact to very dense SILTY SAND γ = 21.5 kN/m³, E = 100 MPa, ϕ' = 34°

Very stiff to hard, SILTY CLAY (TILL) γ = 22 kN/m³, E = 75 MPa, ϕ' = 32°, Su = 275 kPa

Stantec Consulting Ltd.	Geotechnical Model Highway 401 - Highbury Ave. Underpass	Figure No. E1



* Note: pile length estimated from the expected flex zone base level (elevation 276 m)

Stantec

Pile Axial Capacity

Highway 401 Highbury Avenue Interchange

Figure E2

Project No. 165001239

GWP No. 3032-11-00

p-y Curves

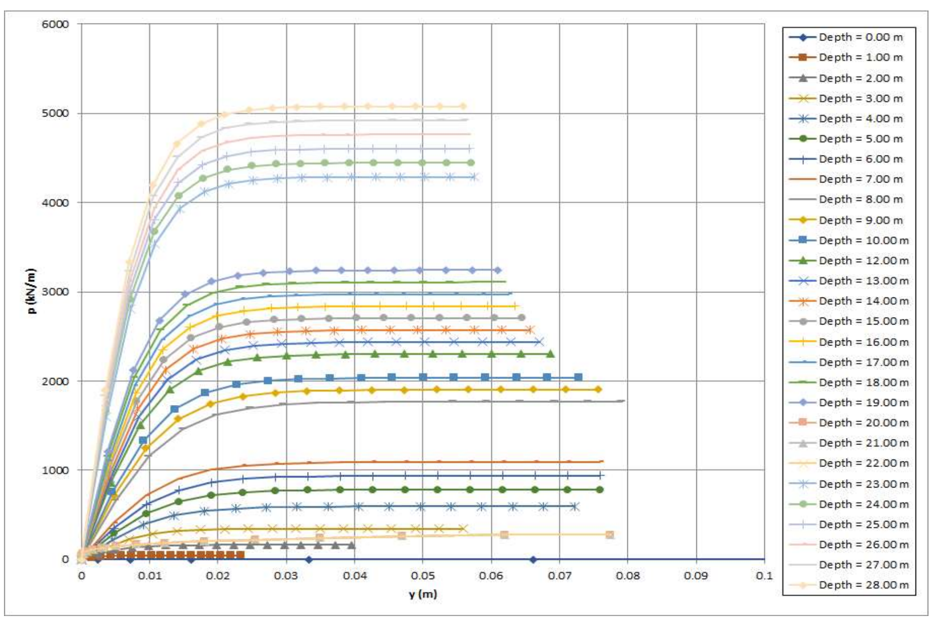
X y (m)

Y p (kN/m)

Depth = 0.00 m		Depth = 1.00 m		Depth = 2.00 m		Depth = 3.00 m		Depth = 4.00 m		Depth = 5.00 m		Depth = 6.00 m		Depth = 7.00 m		Depth = 8.00 m		Depth = 9.00 m		Depth = 10.00 m	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	17.96	0.00	60.99	0.00	129.10	0.00	222.28	0.00	292.20	0.00	350.64	0.00	409.08	0.00	661.23	0.00	711.26	0.00	761.29
0.00	0.00	0.00	31.52	0.00	107.04	0.01	226.56	0.01	390.09	0.01	512.79	0.01	615.35	0.01	717.91	0.01	1160.42	0.01	1248.22	0.01	1336.02
0.00	0.00	0.00	39.74	0.01	134.96	0.01	285.66	0.01	491.84	0.01	646.55	0.01	775.86	0.01	905.17	0.01	1463.11	0.01	1573.80	0.01	1684.50
0.01	0.00	0.01	44.08	0.01	149.70	0.01	316.86	0.02	545.56	0.02	717.16	0.02	860.59	0.02	1004.02	0.02	1622.90	0.02	1745.68	0.02	1868.47
0.01	0.00	0.01	46.20	0.01	156.91	0.02	332.13	0.02	571.85	0.02	751.72	0.02	902.07	0.02	1052.41	0.02	1701.11	0.02	1829.82	0.02	1958.52
0.01	0.00	0.01	47.20	0.01	160.31	0.02	339.33	0.03	584.25	0.03	768.02	0.03	921.62	0.03	1075.22	0.03	1737.99	0.03	1869.48	0.03	2000.97
0.01	0.00	0.01	47.67	0.02	161.89	0.02	342.66	0.03	589.99	0.03	775.56	0.03	930.67	0.03	1085.78	0.03	1755.06	0.03	1887.84	0.03	2020.63
0.01	0.00	0.01	47.88	0.02	162.61	0.03	344.19	0.04	592.62	0.04	779.02	0.04	934.83	0.04	1090.63	0.04	1762.90	0.04	1896.28	0.04	2029.65
0.01	0.00	0.01	47.98	0.02	162.94	0.03	344.89	0.04	593.83	0.04	780.61	0.04	936.73	0.04	1092.85	0.04	1766.48	0.04	1900.13	0.04	2033.78
0.01	0.00	0.01	48.02	0.02	163.09	0.03	345.21	0.05	594.38	0.05	781.33	0.05	937.60	0.05	1093.87	0.05	1768.12	0.05	1901.89	0.05	2035.67
0.01	0.00	0.02	48.04	0.03	163.16	0.04	345.36	0.05	594.63	0.05	781.66	0.05	938.00	0.05	1094.33	0.05	1768.87	0.05	1902.70	0.05	2036.53
0.02	0.00	0.02	48.05	0.03	163.19	0.04	345.42	0.05	594.74	0.06	781.81	0.06	938.18	0.06	1094.54	0.06	1769.21	0.06	1903.06	0.05	2036.92
0.02	0.00	0.02	48.05	0.03	163.21	0.05	345.45	0.06	594.79	0.06	781.88	0.06	938.26	0.06	1094.63	0.06	1769.37	0.06	1903.23	0.06	2037.10
0.02	0.00	0.02	48.06	0.03	163.21	0.05	345.47	0.06	594.82	0.07	781.91	0.07	938.30	0.07	1094.68	0.07	1769.44	0.07	1903.31	0.06	2037.18
0.02	0.00	0.02	48.06	0.04	163.22	0.05	345.47	0.07	594.83	0.07	781.93	0.07	938.31	0.07	1094.70	0.07	1769.47	0.07	1903.34	0.07	2037.22
0.02	0.00	0.02	48.06	0.04	163.22	0.06	345.48	0.07	594.83	0.08	781.93	0.08	938.32	0.08	1094.71	0.08	1769.48	0.08	1903.36	0.07	2037.23

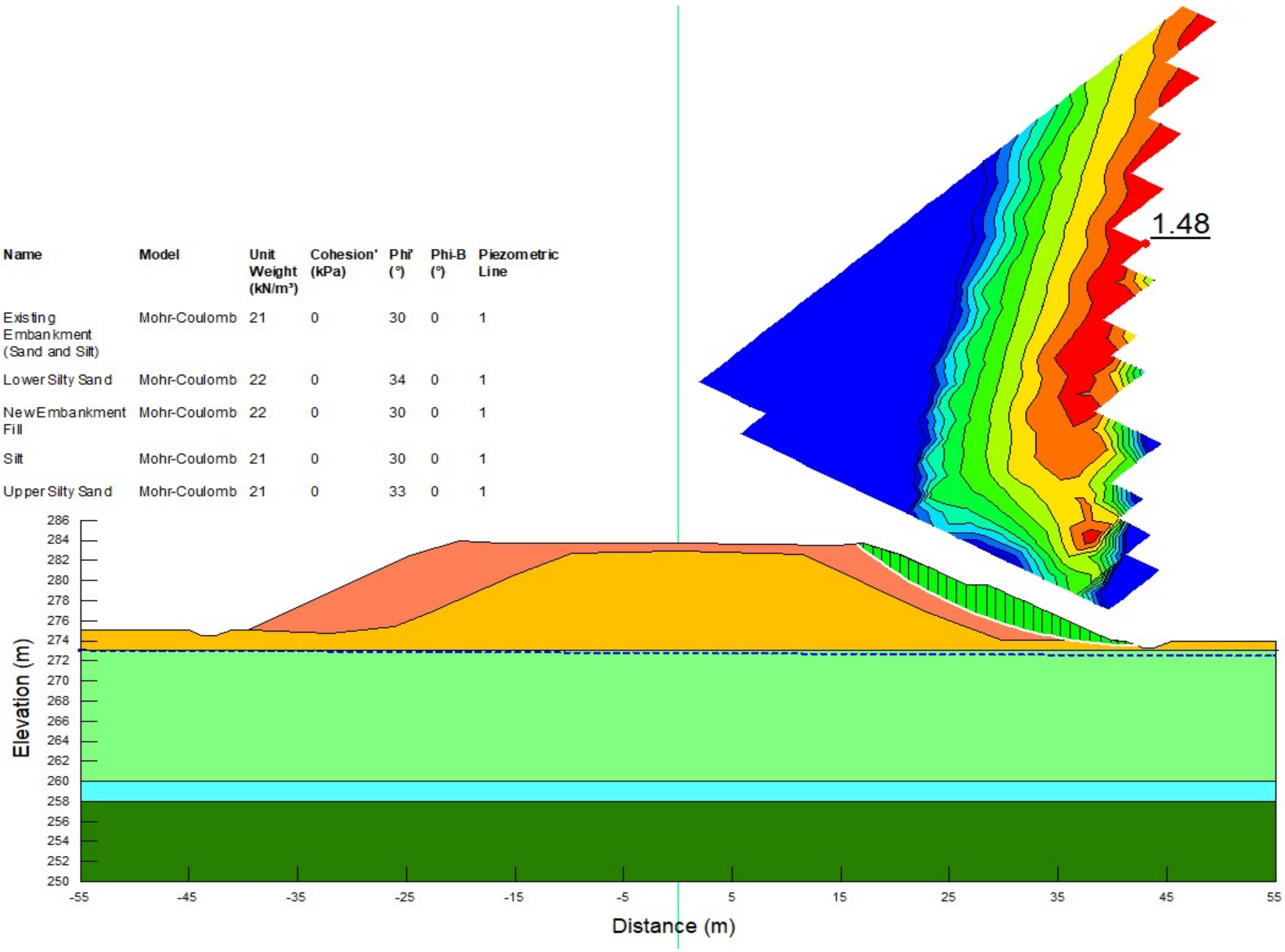
Depth = 12.00 m		Depth = 13.00 m		Depth = 14.00 m		Depth = 15.00 m		Depth = 16.00 m		Depth = 17.00 m		Depth = 18.00 m		Depth = 19.00 m		Depth = 20.00 m		Depth = 21.00 m		Depth = 22.00 m	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	861.34	0.00	911.37	0.00	961.40	0.00	1011.43	0.00	1061.45	0.00	1111.48	0.00	1161.51	0.00	1211.54	0.00	18.60	0.00	18.60	0.00	18.60
0.01	1511.61	0.01	1599.40	0.01	1687.20	0.01	1774.99	0.01	1862.79	0.01	1950.58	0.01	2038.38	0.01	2126.17	0.00	37.20	0.00	37.20	0.00	37.20
0.01	1905.89	0.01	2016.59	0.01	2127.28	0.01	2237.98	0.01	2348.67	0.01	2459.37	0.01	2570.07	0.01	2680.76	0.00	55.80	0.00	55.80	0.00	55.80
0.02	2114.04	0.02	2236.82	0.02	2359.61	0.02	2482.39	0.02	2605.18	0.02	2727.96	0.02	2850.75	0.02	2973.53	0.00	74.40	0.00	74.40	0.00	74.40
0.02	2215.93	0.02	2344.63	0.02	2473.33	0.02	2602.03	0.02	2730.74	0.02	2859.44	0.02	2988.14	0.02	3116.84	0.00	93.00	0.00	93.00	0.00	93.00
0.03	2263.96	0.03	2395.45	0.02	2526.94	0.02	2658.43	0.02	2789.93	0.02	2921.42	0.02	3052.91	0.02	3184.40	0.00	111.60	0.00	111.60	0.00	111.60
0.03	2286.20	0.03	2418.98	0.03	2551.76	0.03	2684.55	0.03	2817.33	0.03	2950.12	0.03	3082.90	0.03	3215.68	0.00	130.20	0.00	130.20	0.00	130.20
0.03	2296.41	0.03	2429.79	0.03	2563.16	0.03	2696.54	0.03	2829.92	0.03	2963.29	0.03	3096.67	0.03	3230.05	0.01	148.80	0.01	148.80	0.01	148.80
0.04	2301.08	0.04	2434.73	0.04	2568.38	0.04	2702.02	0.04	2835.67	0.04	2969.32	0.03	3102.97	0.03	3236.62	0.01	167.40	0.01	167.40	0.01	167.40
0.04	2303.21	0.04	2436.98	0.04	2570.76	0.04	2704.53	0.04	2838.30	0.04	2972.07	0.04	3105.85	0.04	3239.62	0.01	186.00	0.01	186.00	0.01	186.00
0.05	2304.18	0.05	2438.01	0.05	2571.84	0.04	2705.67	0.04	2839.50	0.04	2973.33	0.04	3107.16	0.04	3240.99	0.02	204.60	0.02	204.60	0.02	204.60
0.05	2304.63	0.05	2438.48	0.05	2572.34	0.05	2706.19	0.05	2840.05	0.05	2973.90	0.05	3107.76	0.05	3241.61	0.03	223.20	0.03	223.20	0.03	223.20
0.06	2304.83	0.05	2438.70	0.05	2572.56	0.05	2706.43	0.05	2840.30	0.05	2974.16	0.05	3108.03	0.05	3241.90	0.03	241.80	0.03	241.80	0.03	241.80
0.06	2304.92	0.06	2438.80	0.06	2572.67	0.06	2706.54	0.06	2840.41	0.05	2974.28	0.05	3108.15	0.05	3242.03	0.05	260.40	0.05	260.40	0.05	260.40
0.06	2304.97	0.06	2438.84	0.06	2572.71	0.06	2706.59	0.06	2840.46	0.06	2974.34	0.06	3108.21	0.06	3242.09	0.06	279.00	0.06	279.00	0.06	279.00
0.07	2304.98	0.07	2438.86	0.07	2572.74	0.06	2706.61	0.06	2840.49	0.06	2974.36	0.06	3108.24	0.06	3242.11	0.08	279.00	0.08	279.00	0.08	279.00

Depth = 23.00 m		Depth = 24.00 m		Depth = 25.00 m		Depth = 26.00 m		Depth = 27.00 m		Depth = 28.00 m	
X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1601.83	0.00	1661.07	0.00	1720.30	0.00	1779.54	0.00	1838.77	0.00	1898.01
0.01	2811.12	0.01	2915.07	0.01	3019.03	0.01	3122.98	0.01	3226.94	0.01	3330.89
0.01	3544.37	0.01	3675.44	0.01	3806.51	0.01	3937.58	0.01	4068.65	0.01	4199.72
0.01	3931.45	0.01	4076.84	0.01	4222.22	0.01	4367.61	0.01	4512.99	0.01	4658.38
0.02	4120.93	0.02	4273.32	0.02	4425.72	0.02	4578.11	0.02	4730.50	0.02	4882.89
0.02	4210.26	0.02	4365.95	0.02	4521.65	0.02	4677.34	0.02	4833.04	0.02	4988.73
0.03	4251.61	0.02	4408.84	0.02	4566.06	0.02	4723.29	0.02	4880.51	0.02	5037.74
0.03	4270.61	0.03	4428.53	0.03	4586.46	0.03	4744.39	0.03	4902.31	0.03	5060.24
0.03	4279.29	0.03	4437.54	0.03	4595.79	0.03	4754.04	0.03	4912.28	0.03	5070.53
0.04	4283.26	0.04	4441.65	0.04	4600.05	0.04	4758.44	0.04	4916.84	0.03	5075.23
0.04	4285.07	0.04	4443.53	0.04	4601.99	0.04	4760.45	0.04	4918.91	0.04	5077.38
0.04	4285.89	0.04	4444.39	0.04	4602.88	0.04	4761.37	0.04	4919.86	0.04	5078.35
0.05	4286.27	0.05	4444.78	0.05	4603.28	0.05	4761.79	0.05	4920.29	0.05	5078.80
0.05	4286.44	0.05	4444.95	0.05	4603.47	0.05	4761.98	0.05	4920.49	0.05	5079.00
0.05	4286.52	0.05	4445.03	0.05	4603.55	0.05	4762.07	0.05	4920.58	0.05	5079.10
0.06	4286.56	0.06	4445.07	0.06	4603.59	0.06	4762.11	0.06	4920.62	0.06	5079.14



The response of a pile to lateral loads is a nonlinear relationship. The p-y geotechnical approach was used to estimate the anticipated deformation of a pile within the soil medium. The p-y curves represent the load-deformation characteristics of elastic-plastic springs with a non-linear response within the elastic range. These non-linear elastic-plastic springs provide a more realistic representation or modeling of the soil pressure response against the face of the pile. The table presents the Load Intensity per unit length of pile p (kN/m) vs Lateral Deflection y (m). The p-y points can be used for the structural design of the pile in response to lateral loads. Where spring spacings of less than 1.0 m are proposed, the tabulated "p" values are to be multiplied by the actual spring spacing; i.e. by 0.25 for 0.25 m spacings.

Stantec	p-y curve for South and North Abutments	Figure E3
		Project No. 165001239
		GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0	1
	Lower Silty Sand	Mohr-Coulomb	22	0	34	0	1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0	1
	Silt	Mohr-Coulomb	21	0	30	0	1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0	1

Stantec

Slope Stability Analysis (Static)

Deep Seated Failure

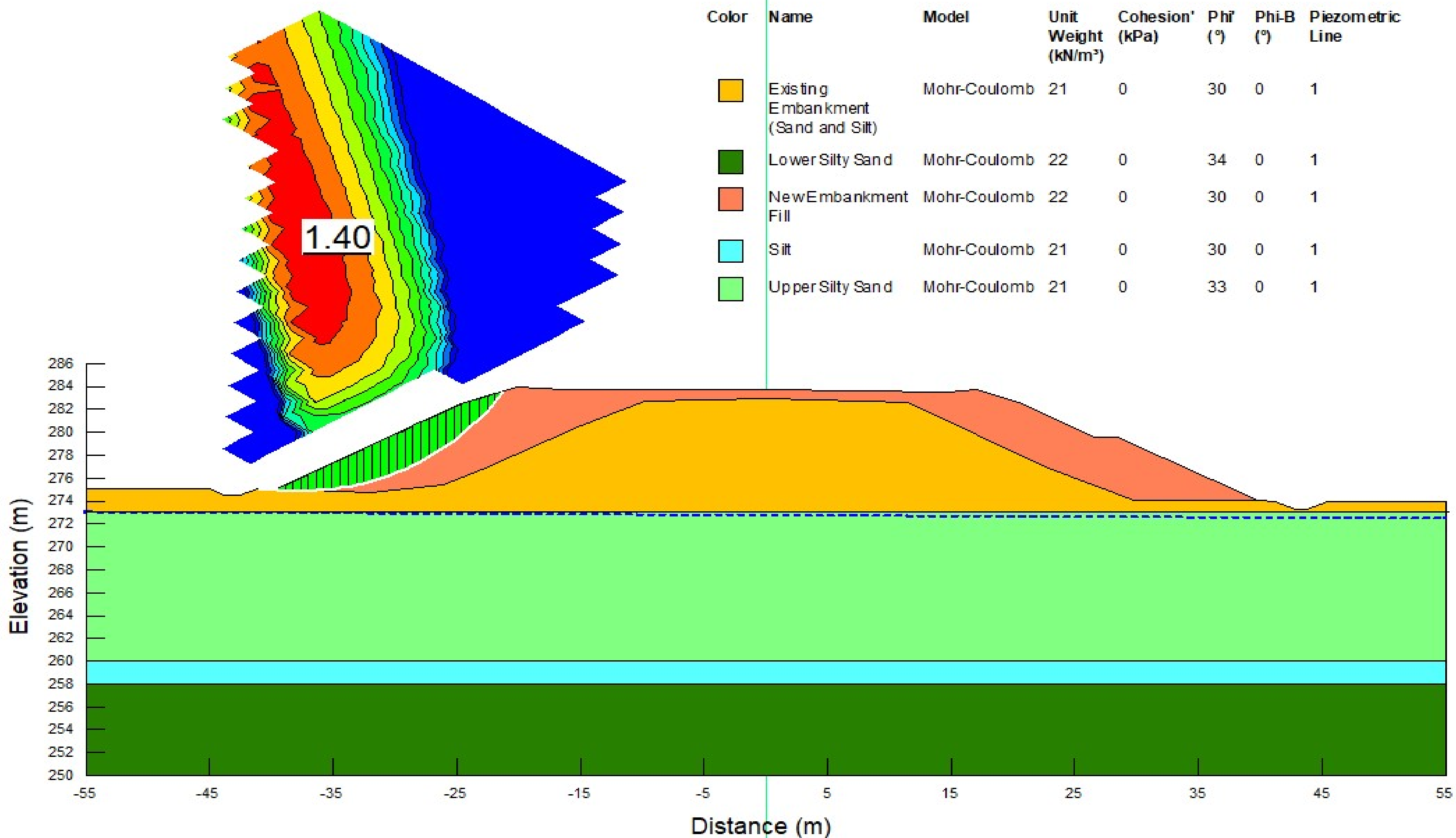
North Abutment RT

Highway 401 Highbury Avenue Interchange

Figure E4

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0	1
	Lower Silty Sand	Mohr-Coulomb	22	0	34	0	1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0	1
	Silt	Mohr-Coulomb	21	0	30	0	1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0	1

Stantec

Slope Stability Analysis (Static)

Deep Seated Failure

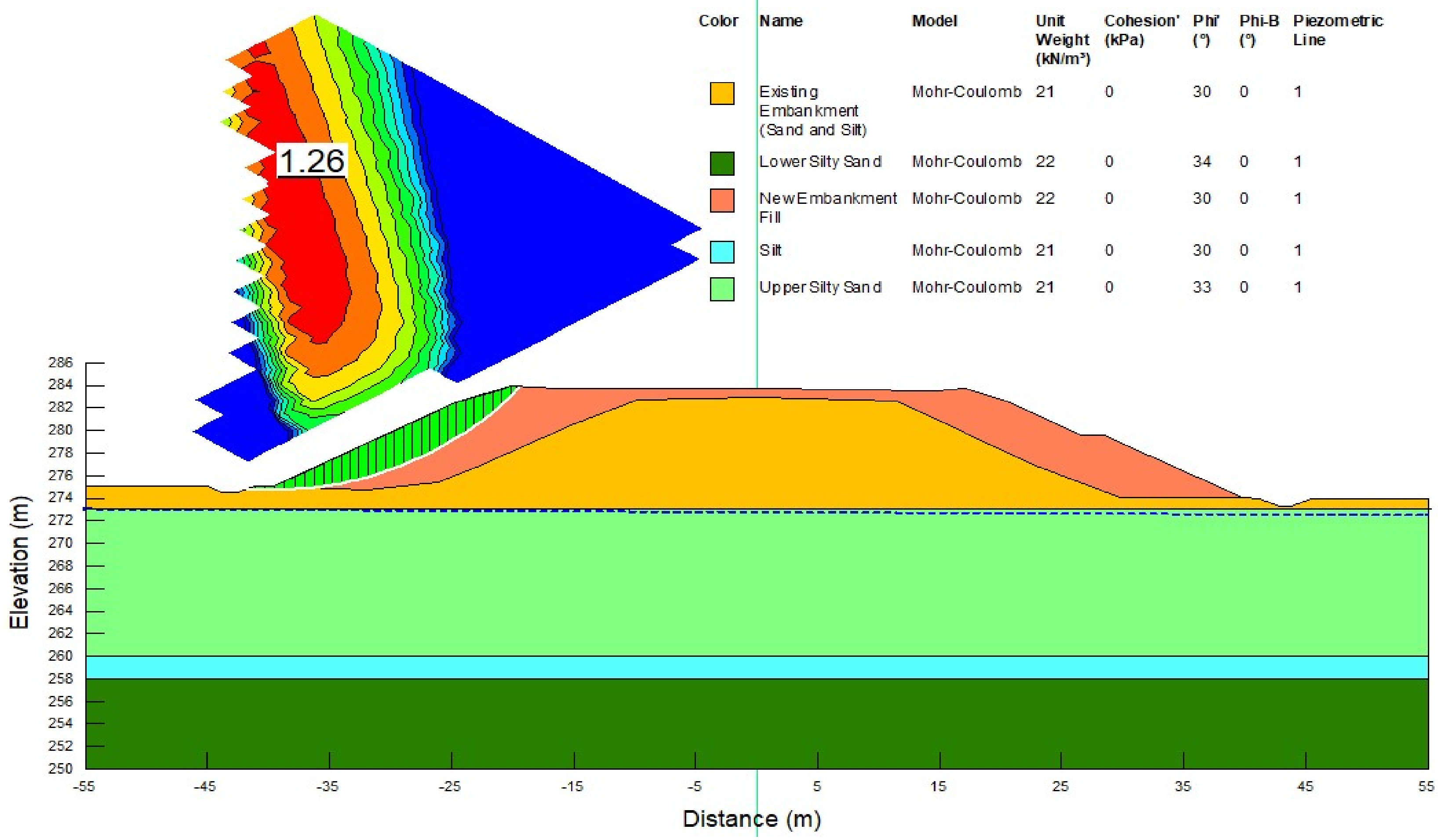
North Abutment LT

Highway 401 Highbury Avenue Interchange

Figure E5

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0	1
	Lower Silty Sand	Mohr-Coulomb	22	0	34	0	1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0	1
	Silt	Mohr-Coulomb	21	0	30	0	1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0	1

Stantec

Slope Stability Analysis (Pseudo-static)

Deep Seated Failure

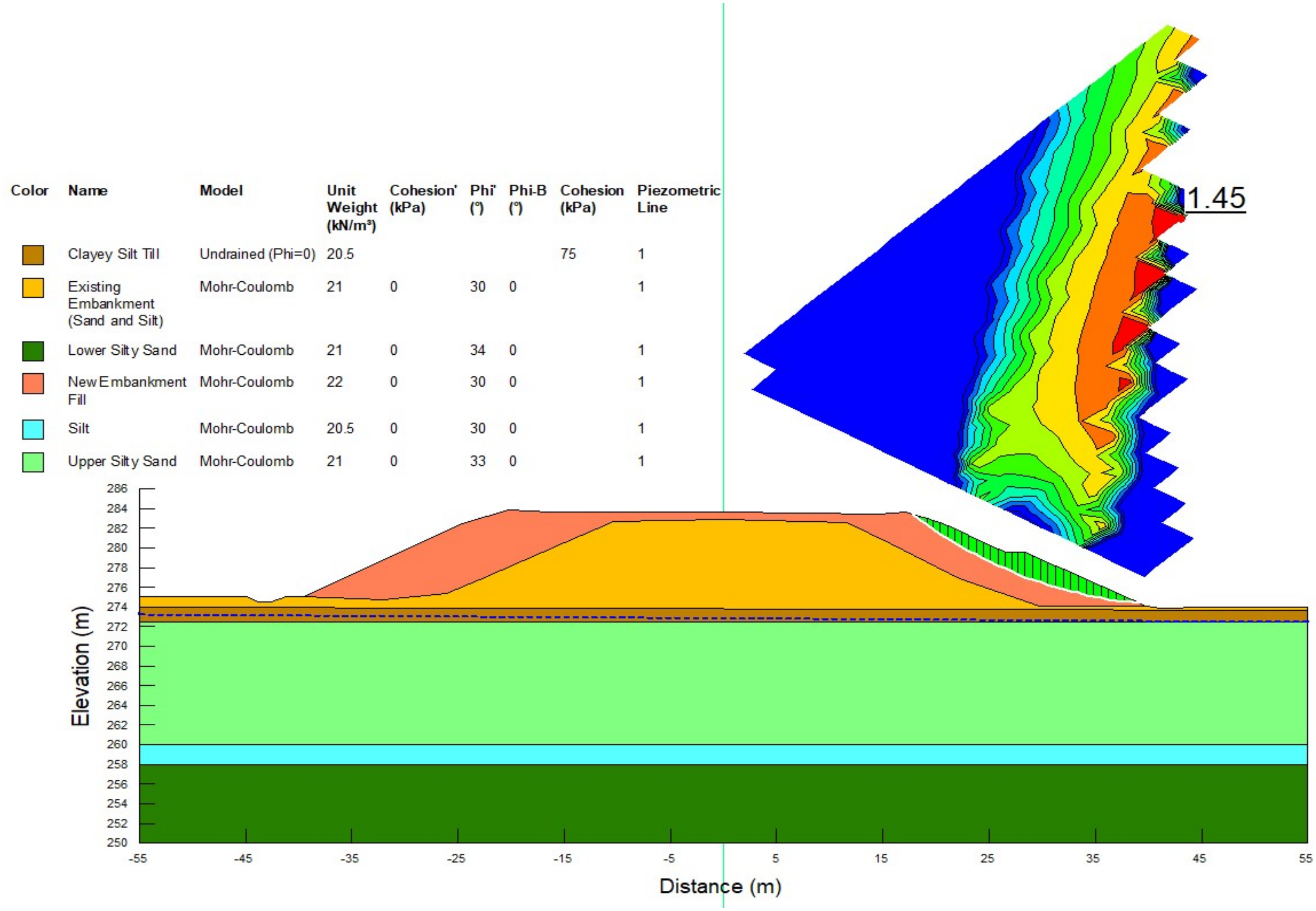
North Abutment LT

Highway 401 Highbury Avenue Interchange

Figure E6

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion (kPa)	Piezometric Line
	Clayey Silt Till	Undrained (Phi=0)	20.5				75	1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0		1
	Lower Silty Sand	Mohr-Coulomb	21	0	34	0		1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0		1
	Silt	Mohr-Coulomb	20.5	0	30	0		1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0		1

Stantec

Slope Stability Analysis (Static)

Deep Seated Failure (Undrained)

South Abutment RT

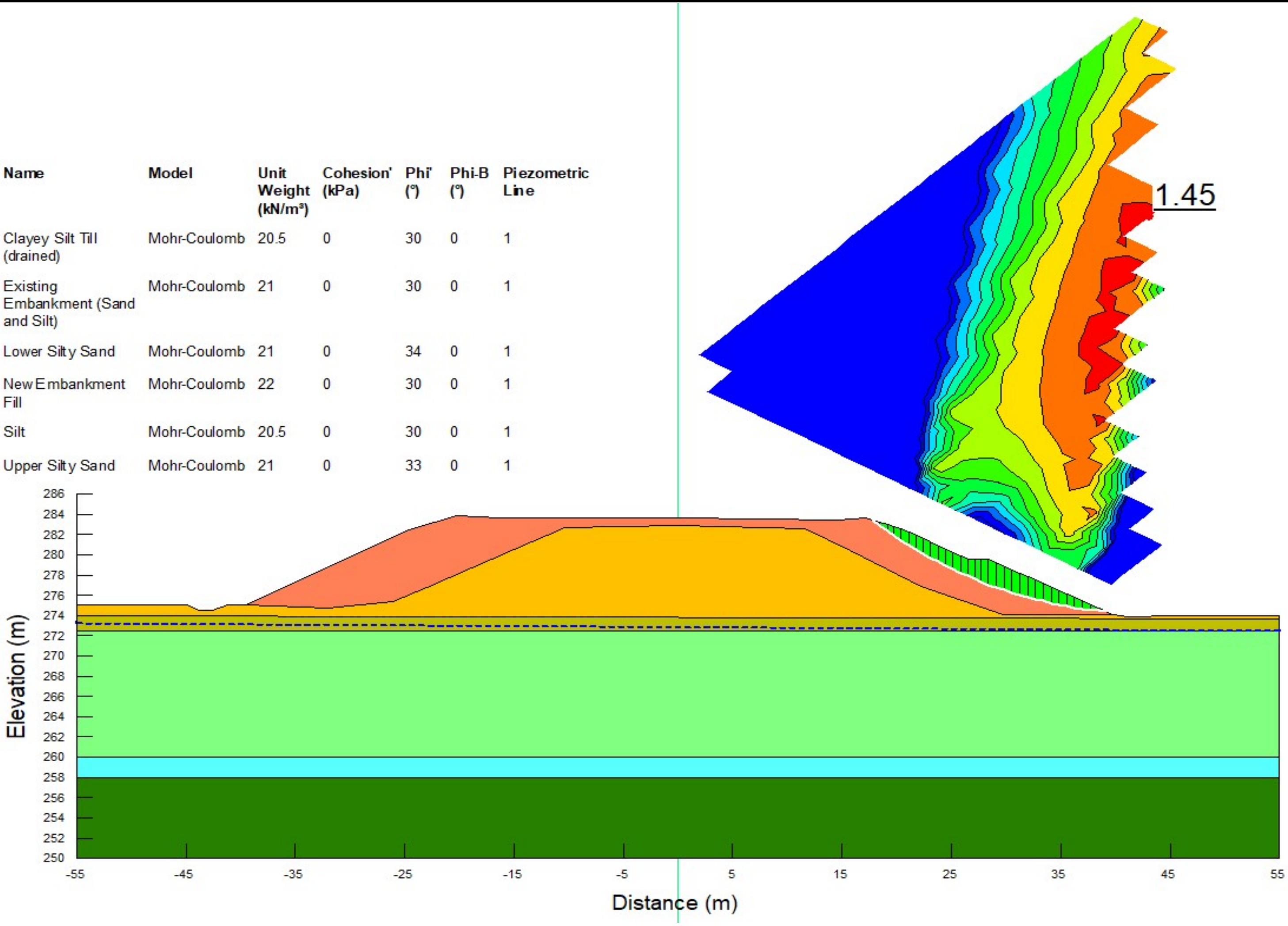
Highway 401 Highbury Avenue Interchange

Figure E7

Project No. 165001239

GWP No. 3032-11-00

Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Clayey Silt Till (drained)	Mohr-Coulomb	20.5	0	30	0	1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0	1
	Lower Silty Sand	Mohr-Coulomb	21	0	34	0	1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0	1
	Silt	Mohr-Coulomb	20.5	0	30	0	1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0	1



Stantec

Slope Stability Analysis (Static)

Deep Seated Failure (Drained)

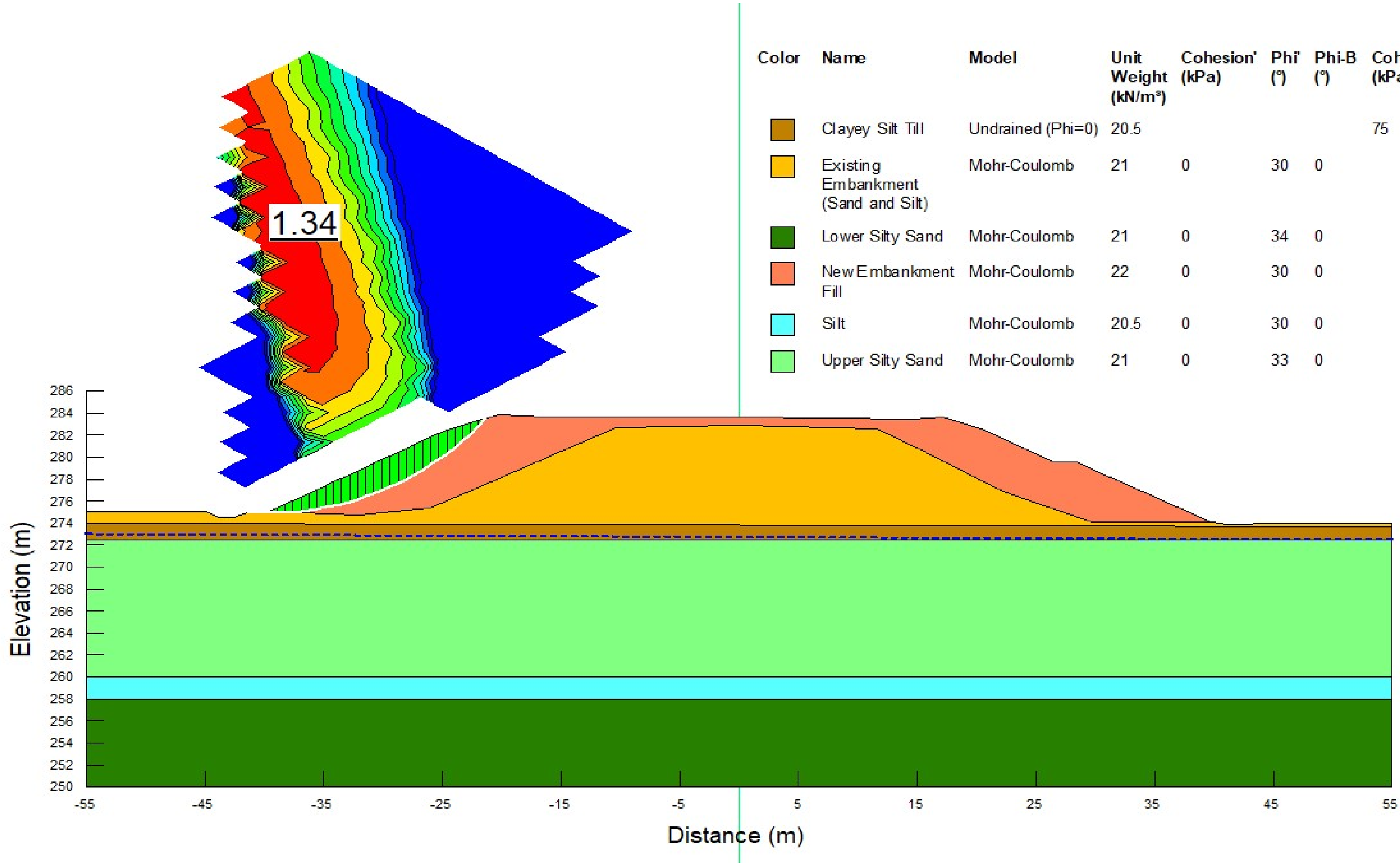
South Abutment RT

Highway 401 Highbury Avenue Interchange

Figure E8

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion (kPa)	Piezometri Line
	Clayey Silt Till	Undrained (Phi=0)	20.5				75	1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0		1
	Lower Silty Sand	Mohr-Coulomb	21	0	34	0		1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0		1
	Silt	Mohr-Coulomb	20.5	0	30	0		1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0		1

Stantec

Slope Stability Analysis (Static)

Deep Seated Failure (Undrained)

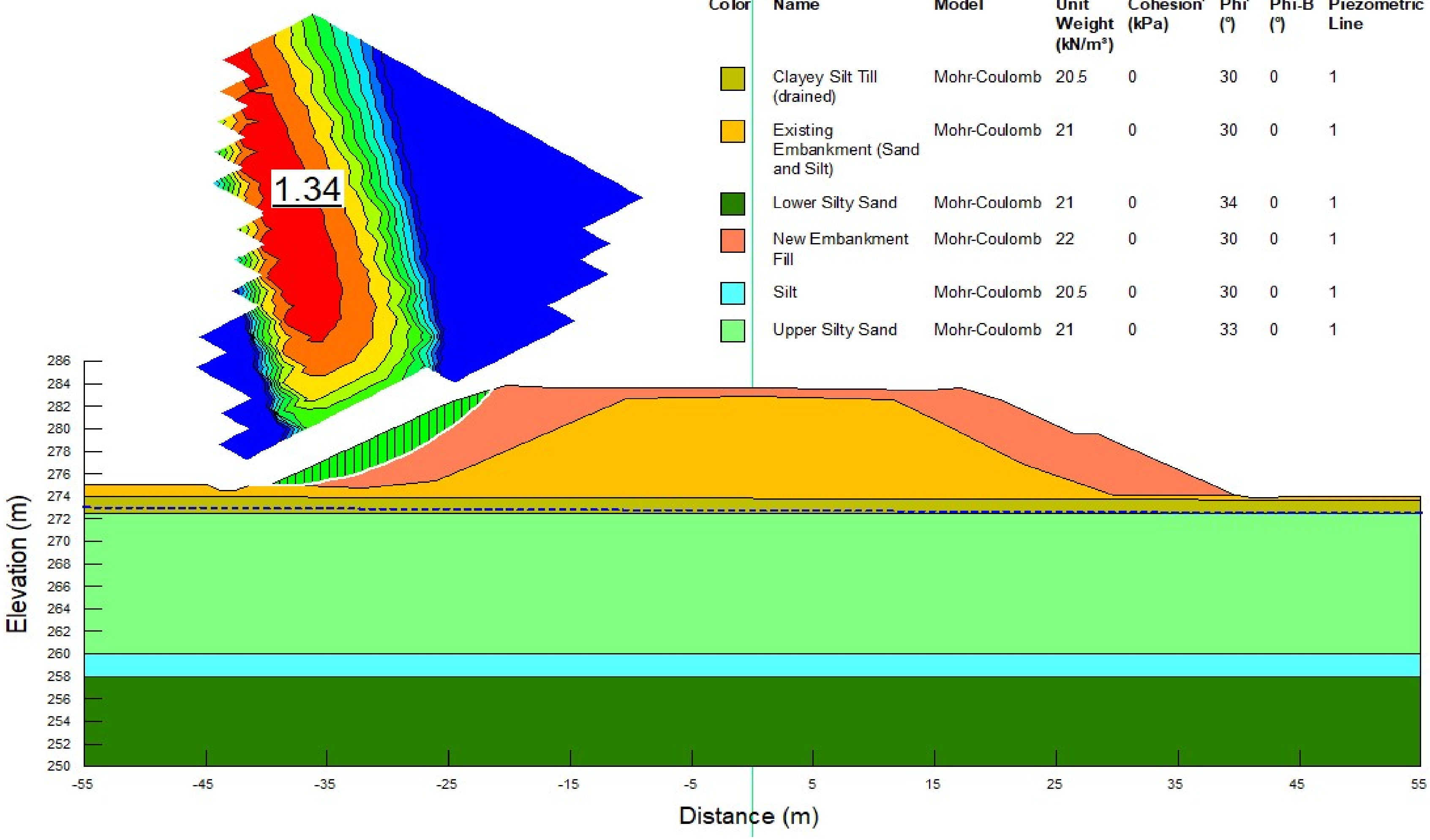
South Abutment LT

Highway 401 Highbury Avenue Interchange

Figure E9

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Piezometric Line
	Clayey Silt Till (drained)	Mohr-Coulomb	20.5	0	30	0	1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0	1
	Lower Silty Sand	Mohr-Coulomb	21	0	34	0	1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0	1
	Silt	Mohr-Coulomb	20.5	0	30	0	1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0	1

Stantec

Slope Stability Analysis (Static)

Deep Seated Failure (Drained)

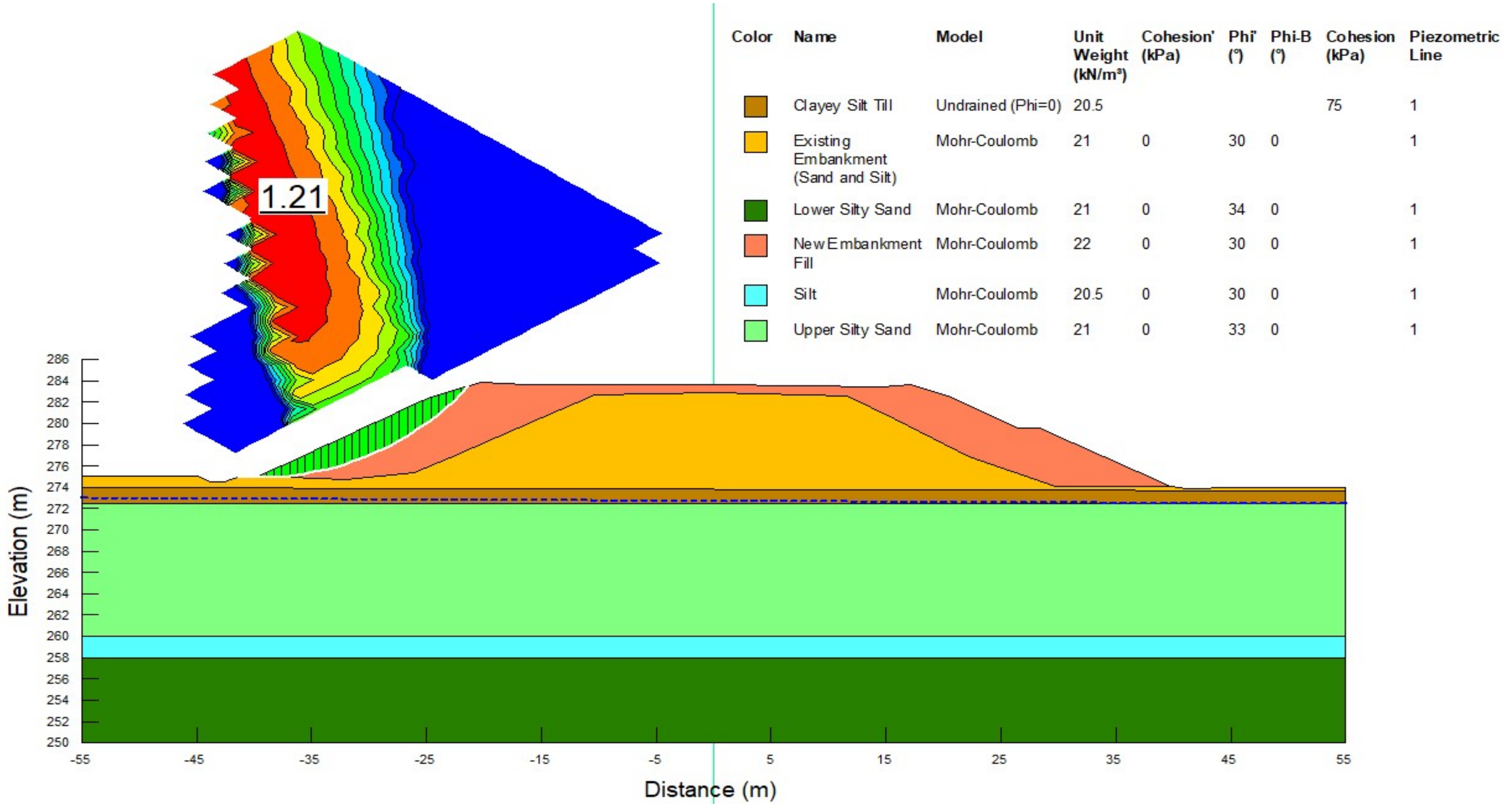
South Abutment LT

Highway 401 Highbury Avenue Interchange

Figure E10

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion (kPa)	Piezometric Line
	Clayey Silt Till	Undrained (Phi=0)	20.5				75	1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0		1
	Lower Silty Sand	Mohr-Coulomb	21	0	34	0		1
	New Embankment Fill	Mohr-Coulomb	22	0	30	0		1
	Silt	Mohr-Coulomb	20.5	0	30	0		1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0		1

Stantec

Slope Stability Analysis (Pseudo-static)

Deep Seated Failure (Undrained)

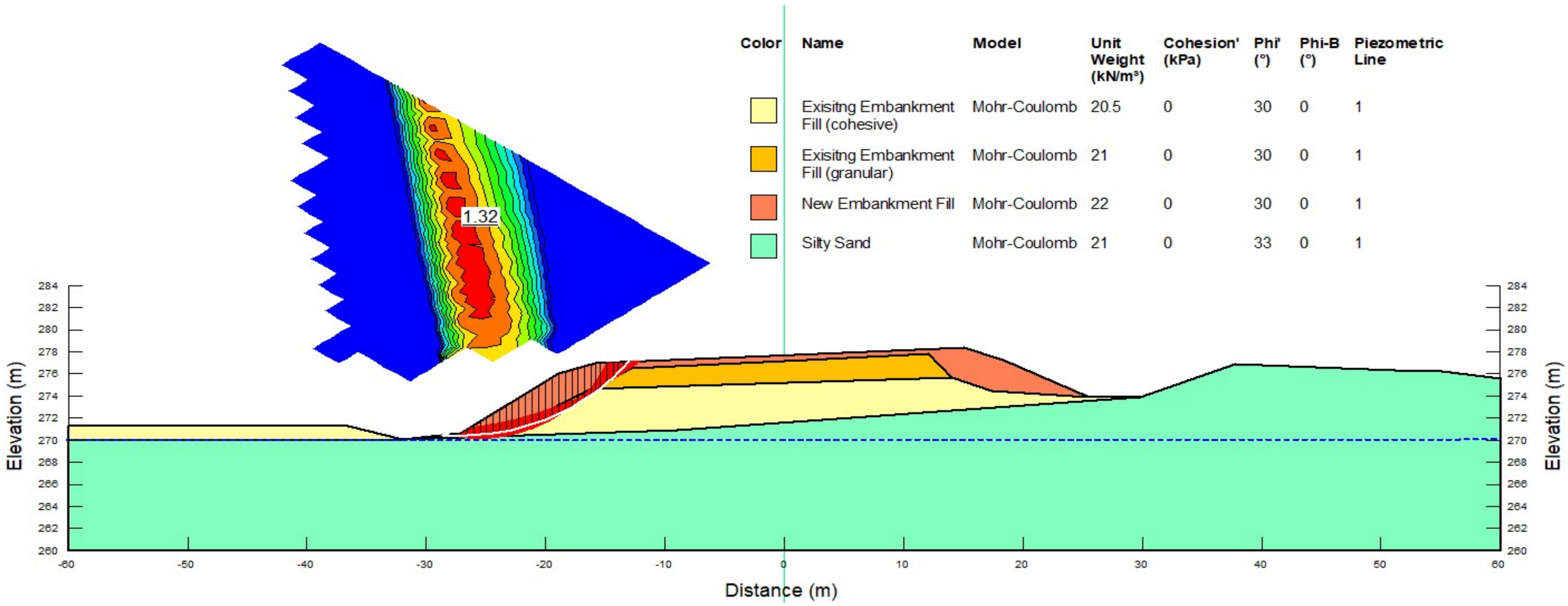
South Abutment LT

Highway 401 Highbury Avenue Interchange

Figure E11

Project No. 165001239

GWP No. 3032-11-00



Stantec

Slope Stability Analysis (Static)

Deep Seated Failure

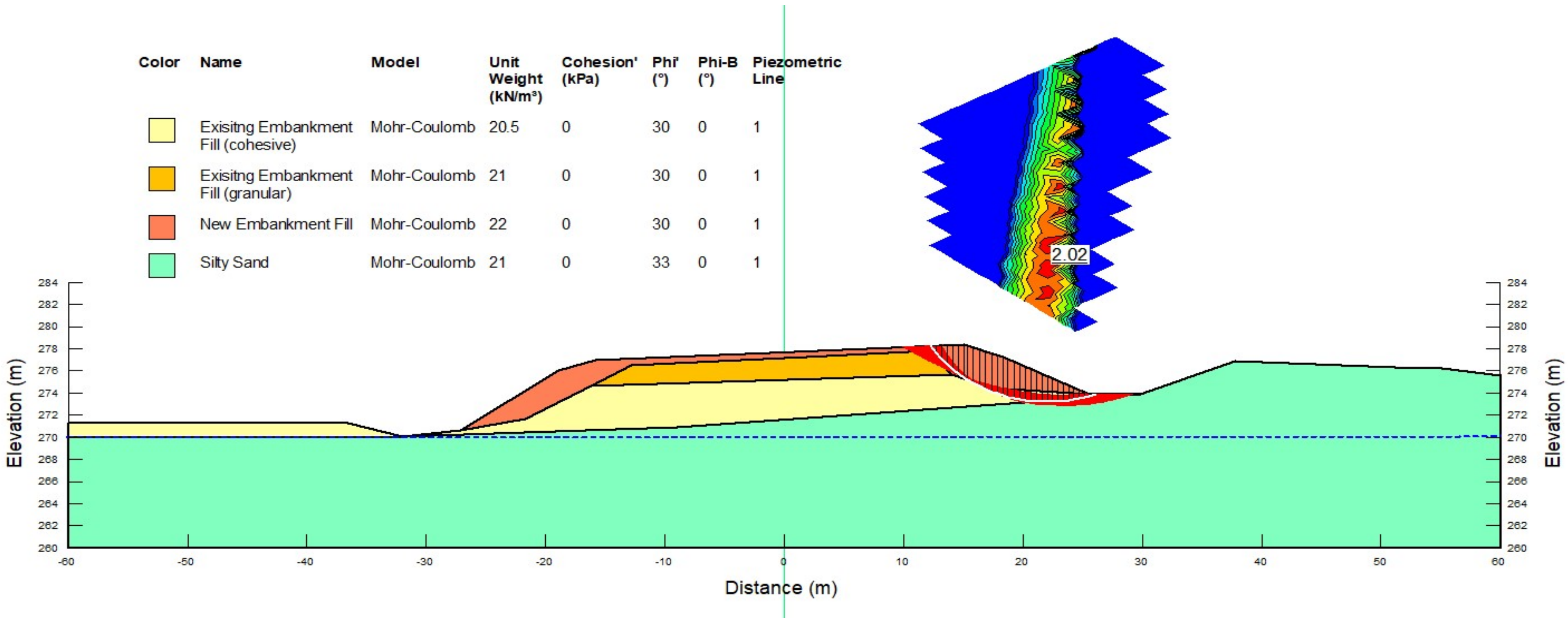
19+525 LT

Highway 401 Highbury Avenue Interchange

Figure E12

Project No. 165001239

GWP No. 3032-11-00



Stantec

Slope Stability Analysis (Static)

Deep Seated Failure

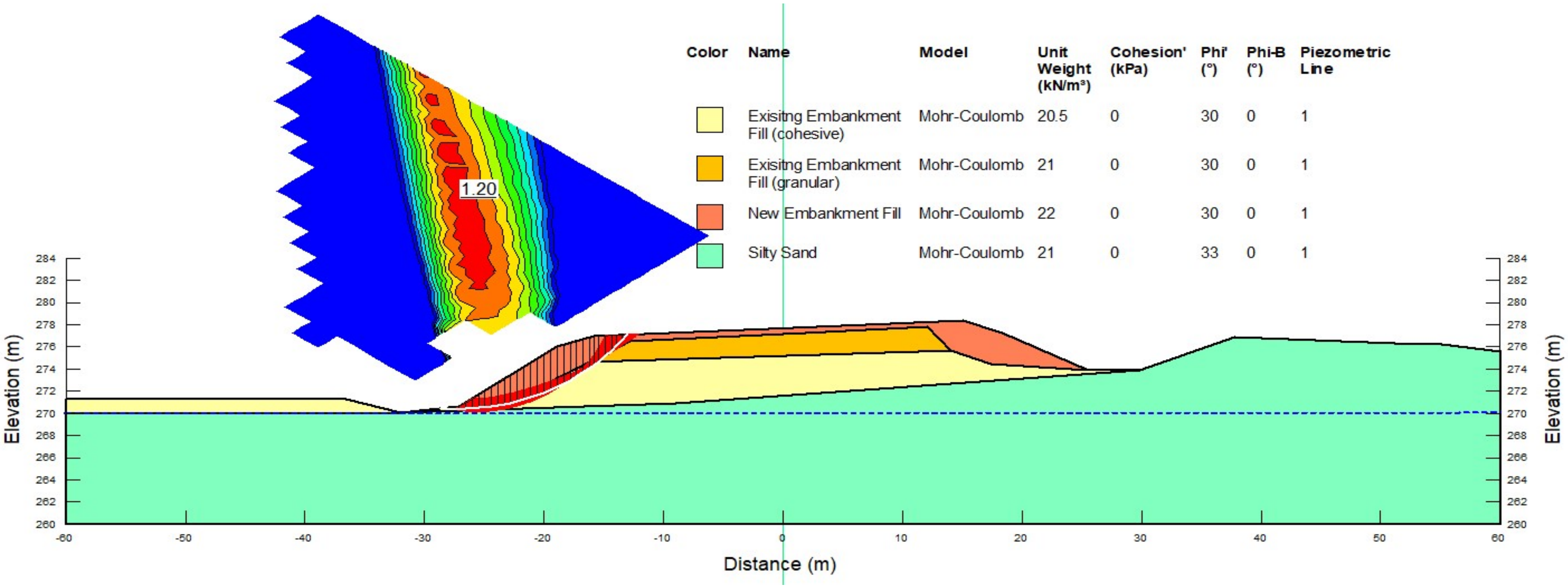
19+525 RT

Highway 401 Highbury Avenue Interchange

Figure E13

Project No. 165001239

GWP No. 3032-11-00



Stantec

Slope Stability Analysis (Pseudo-static)

Deep Seated Failure

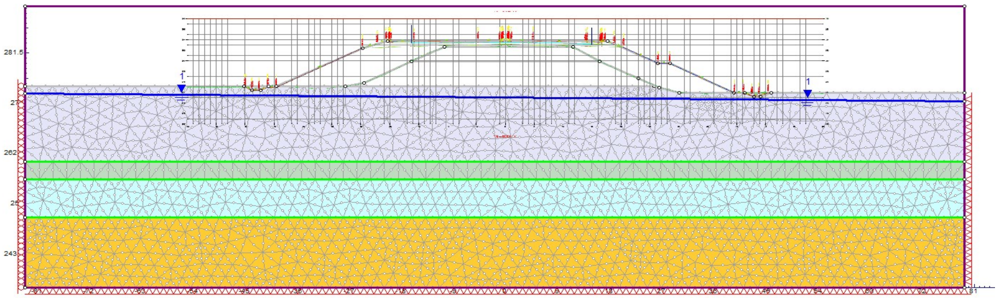
19+525 LT

Highway 401 Highbury Avenue Interchange

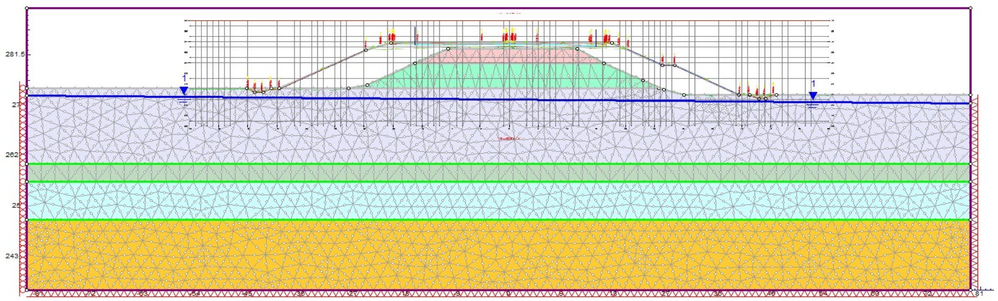
Figure E14

Project No. 165001239

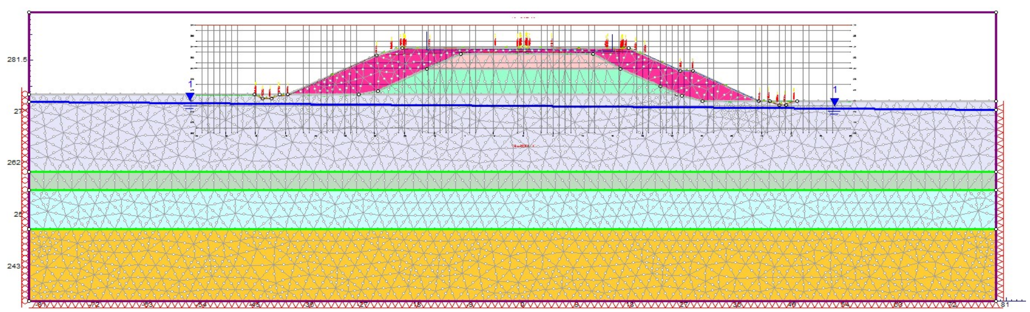
GWP No. 3032-11-00



Initial condition



Existing Embankment
(displacement reset)



Proposed Widening

Embankment Settlement Assessment

2D Finite Element Analysis Scheme

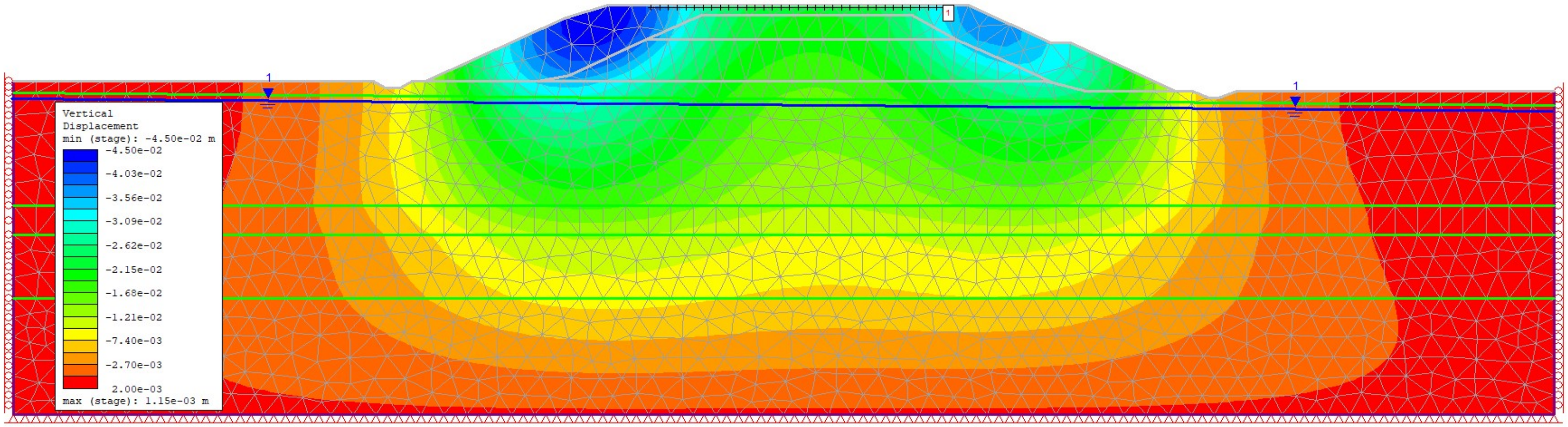
Highway 401 Highbury Avenue Interchange

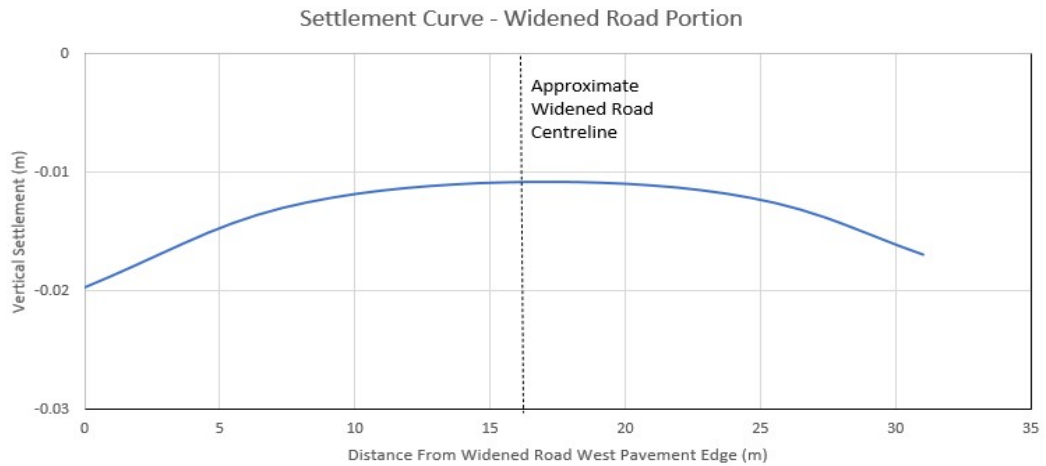
Stantec

Figure E15

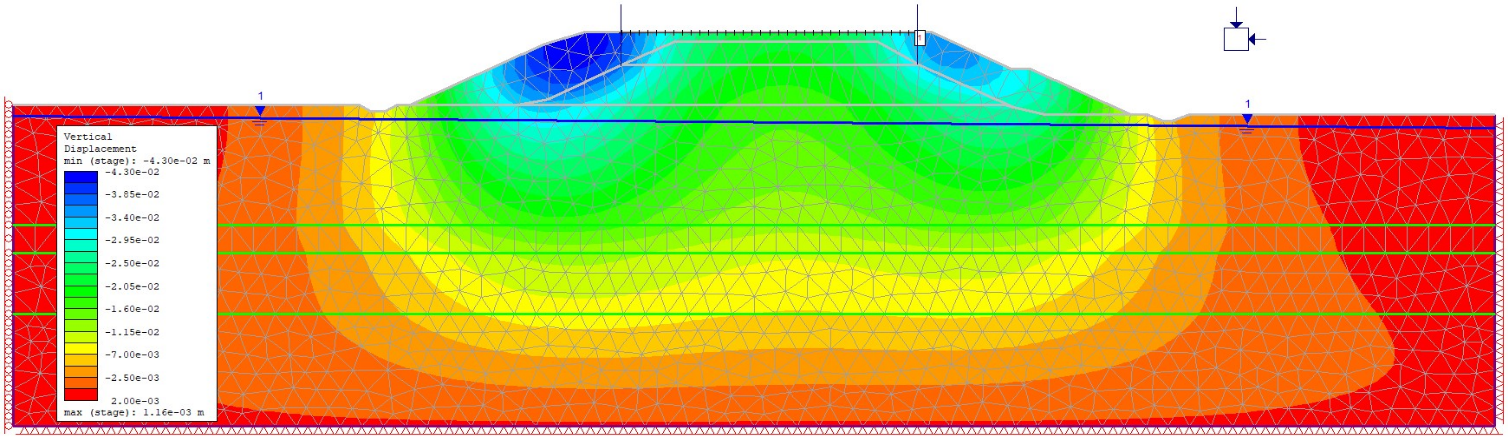
Project No. 165001239

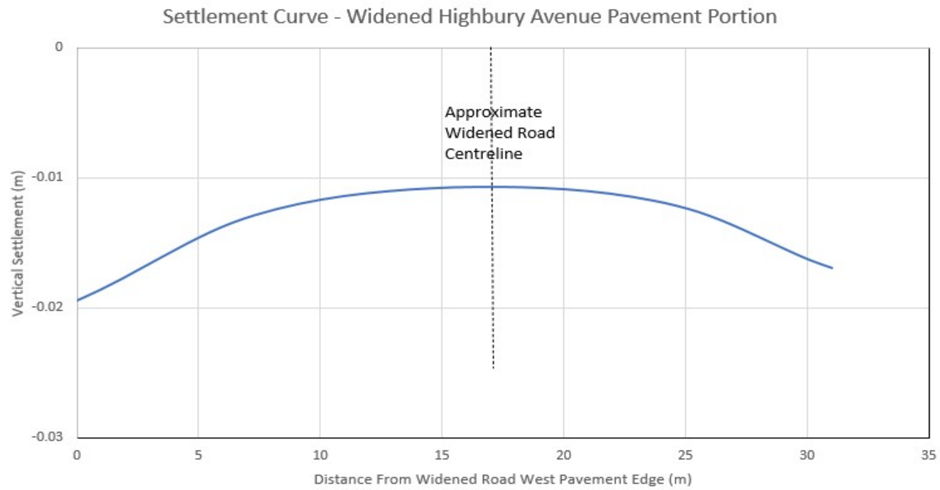
GWP No. 3032-11-00



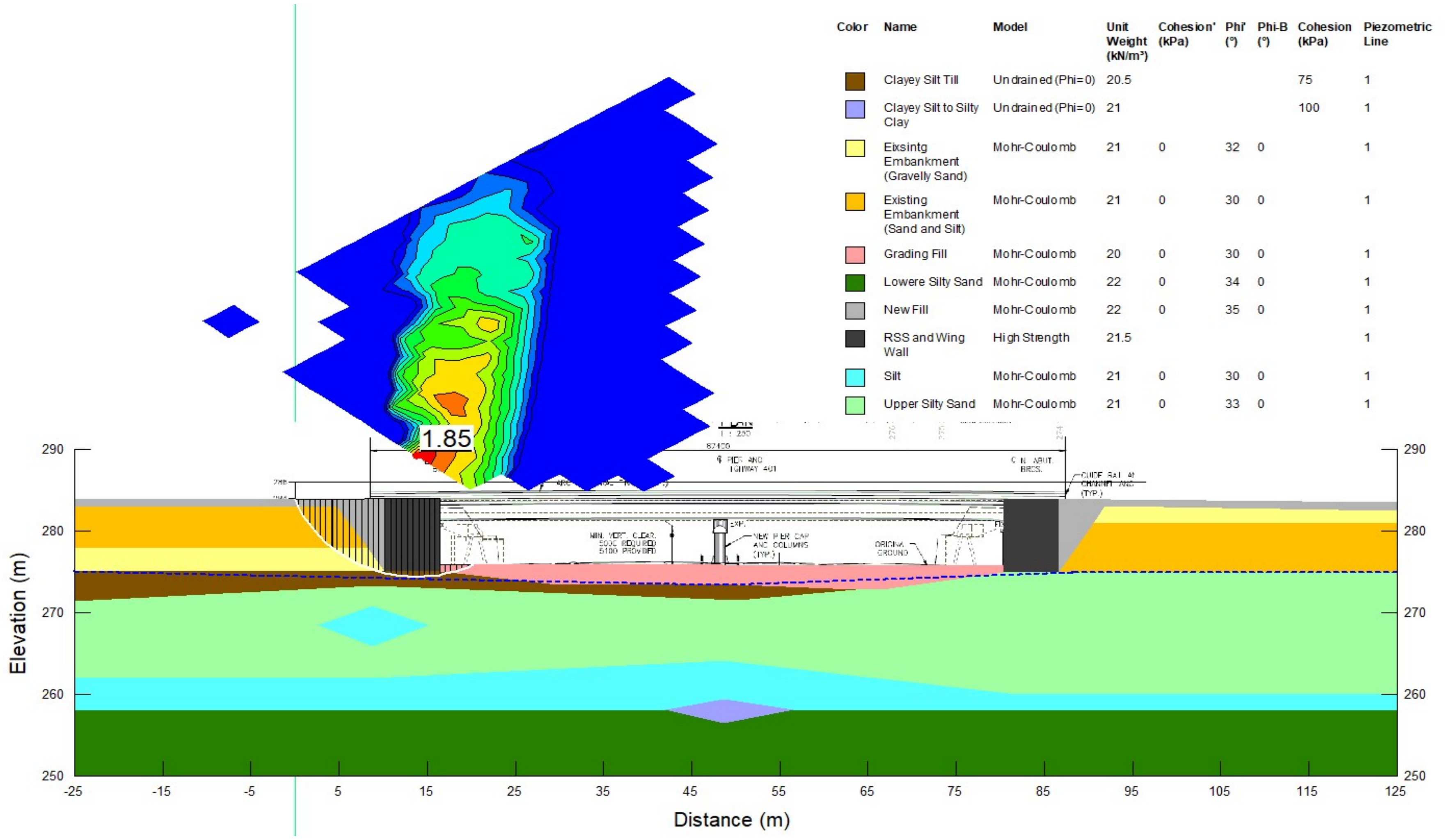


Stantec	Embankment Settlement Assessment Estimated Residual Ground Settlement Close to the South Abutment Highway 401 Highbury Avenue Interchange	Figure E16 Project No. 165001239 GWP No. 3032-11-00





Stantec	Embankment Settlement Assessment Estimated Residual Ground Settlement Close to the North Abutment Highway 401 Highbury Avenue Interchange	Figure E17 Project No. 165001239 GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion (kPa)	Piezometric Line
	Clayey Silt Till	Undrained (Phi=0)	20.5				75	1
	Clayey Silt to Silty Clay	Undrained (Phi=0)	21				100	1
	Exisintg Embankment (Gravelly Sand)	Mohr-Coulomb	21	0	32	0		1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0		1
	Grading Fill	Mohr-Coulomb	20	0	30	0		1
	Lowere Silty Sand	Mohr-Coulomb	22	0	34	0		1
	New Fill	Mohr-Coulomb	22	0	35	0		1
	RSS and Wing Wall	High Strength	21.5					1
	Silt	Mohr-Coulomb	21	0	30	0		1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0		1

Stantec

Slope Stability Analysis (Static)

Deep Seated Failure (Undrained)

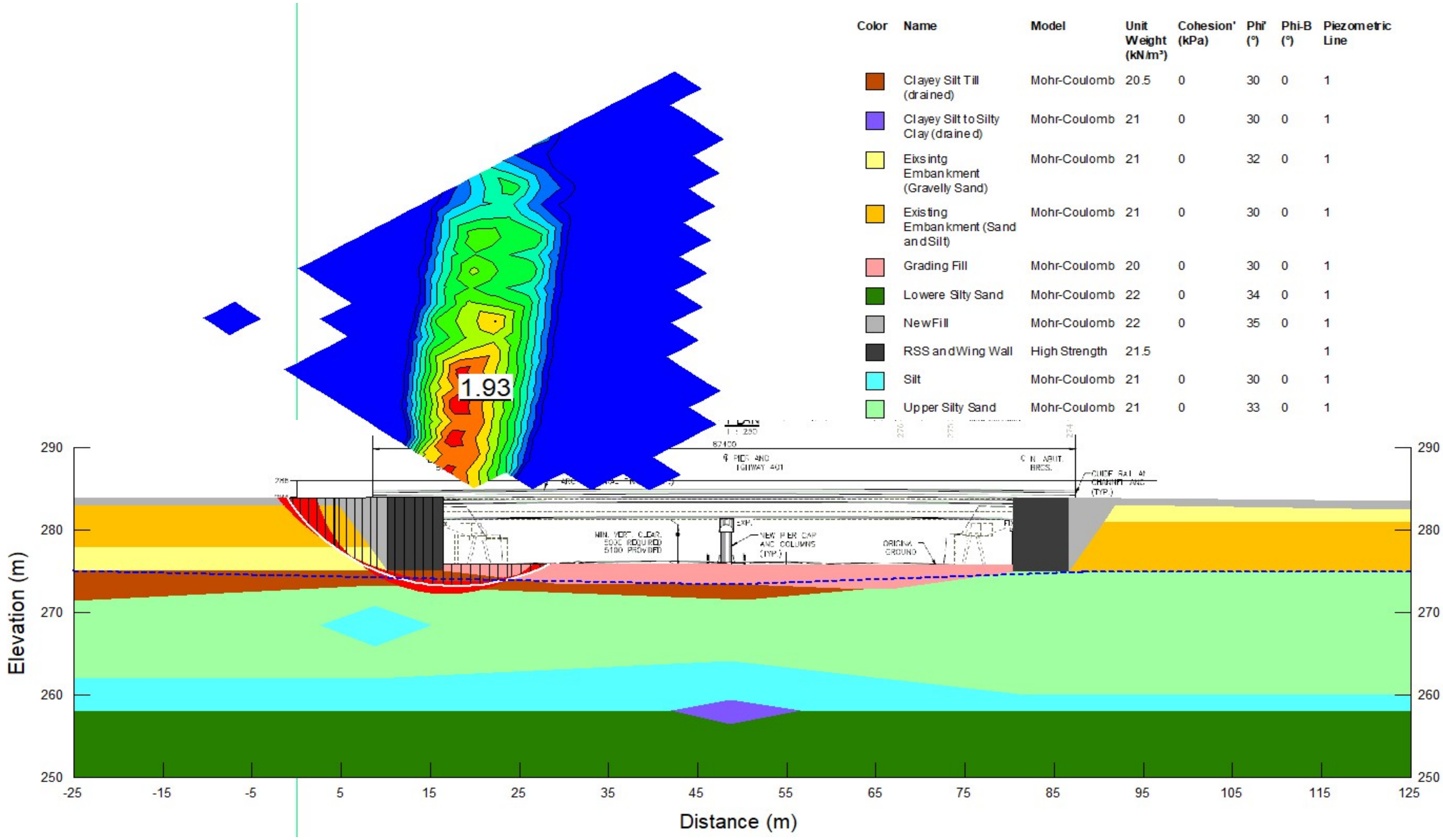
South Abutment RSS

Highway 401 Highbury Avenue Interchange

Figure E18

Project No. 165001239

GWP No. 3032-11-00



Slope Stability Analysis (Static)

Deep Seated Failure

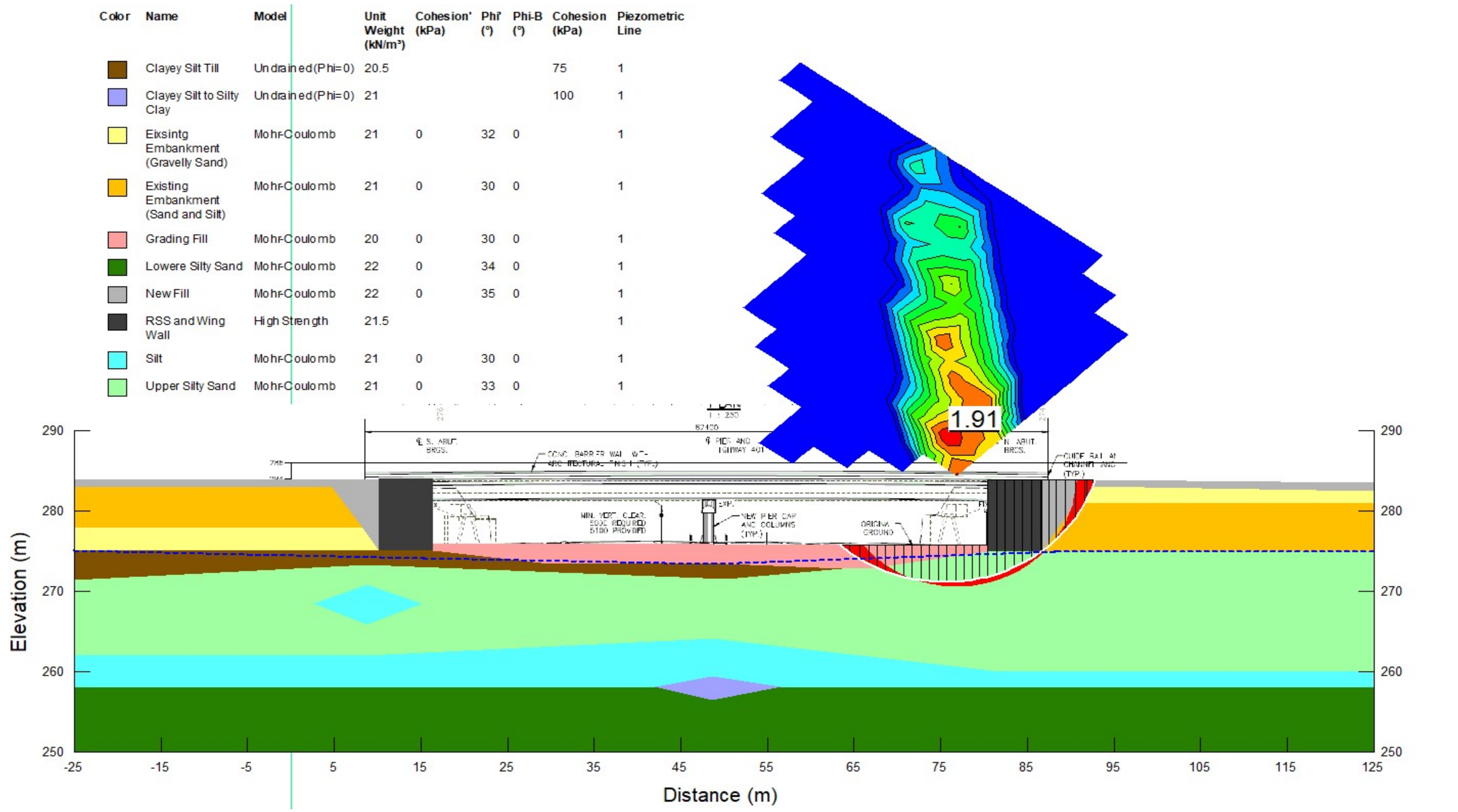
South Abutment RSS (Drained)

Highway 401 Highbury Avenue Interchange

Figure E19

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion (kPa)	Piezometric Line
	Clayey Silt Till	Undrained (Phi=0)	20.5				75	1
	Clayey Silt to Silty Clay	Undrained (Phi=0)	21				100	1
	Eixsintg Embankment (Gravelly Sand)	Mohr-Coulomb	21	0	32	0		1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0		1
	Grading Fill	Mohr-Coulomb	20	0	30	0		1
	Lowere Silty Sand	Mohr-Coulomb	22	0	34	0		1
	New Fill	Mohr-Coulomb	22	0	35	0		1
	RSS and Wing Wall	High Strength	21.5					1
	Silt	Mohr-Coulomb	21	0	30	0		1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0		1

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Slope Stability Analysis (Static)

Deep Seated Failure

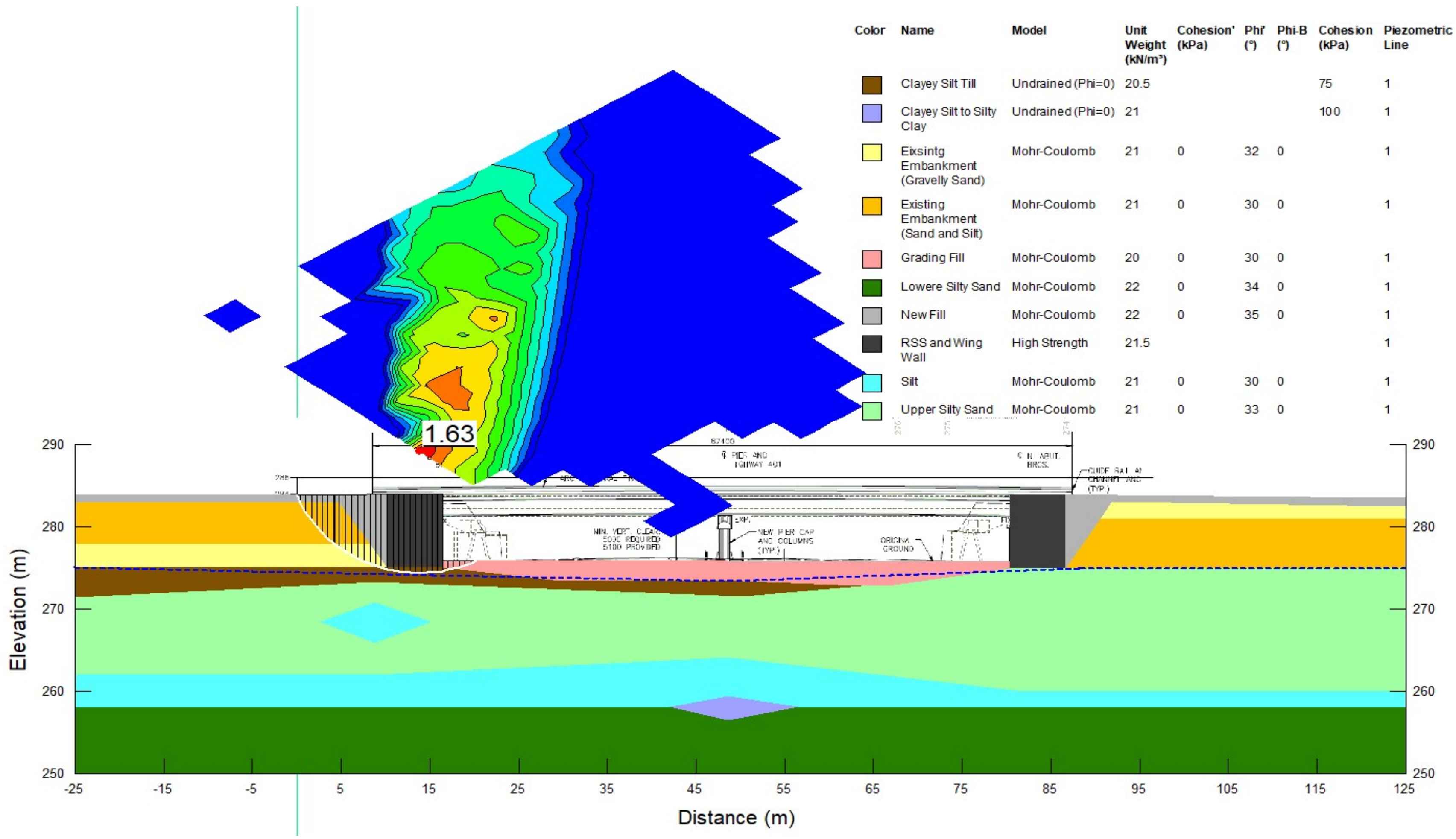
North Abutment RSS

Highway 401 Highbury Avenue Interchange

Figure E20

Project No. 165001239

GWP No. 3032-11-00



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)	Cohesion (kPa)	Piezometric Line
	Clayey Silt Till	Undrained (Phi=0)	20.5				75	1
	Clayey Silt to Silty Clay	Undrained (Phi=0)	21				100	1
	Eixsintg Embankment (Gravelly Sand)	Mohr-Coulomb	21	0	32	0		1
	Existing Embankment (Sand and Silt)	Mohr-Coulomb	21	0	30	0		1
	Grading Fill	Mohr-Coulomb	20	0	30	0		1
	Lowere Silty Sand	Mohr-Coulomb	22	0	34	0		1
	New Fill	Mohr-Coulomb	22	0	35	0		1
	RSS and Wing Wall	High Strength	21.5					1
	Silt	Mohr-Coulomb	21	0	30	0		1
	Upper Silty Sand	Mohr-Coulomb	21	0	33	0		1

Stantec

Slope Stability Analysis (Pseudo-static)

Deep Seated Failure (Undrained)

South Abutment RSS

Highway 401 Highbury Avenue Interchange

Figure E21

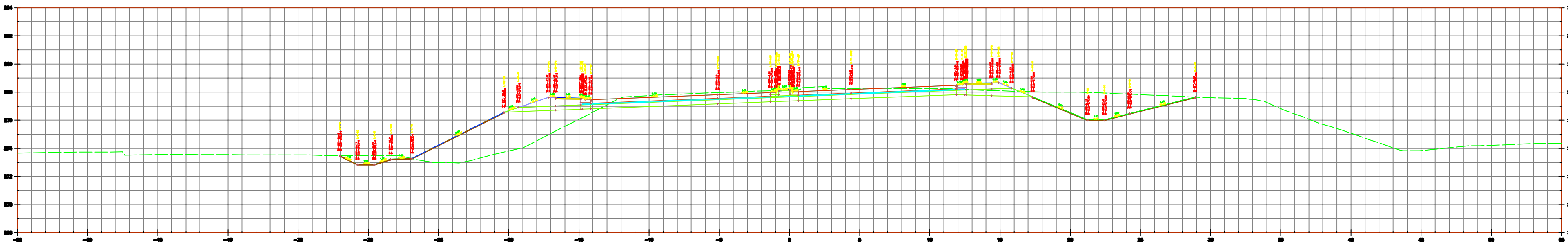
Project No. 165001239

GWP No. 3032-11-00

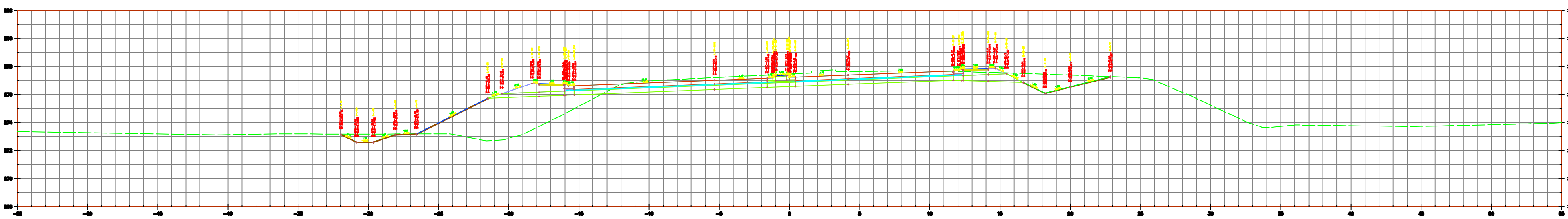
APPENDIX F

F.1 SELECTED EMBANKMENT CROSS SECTIONS

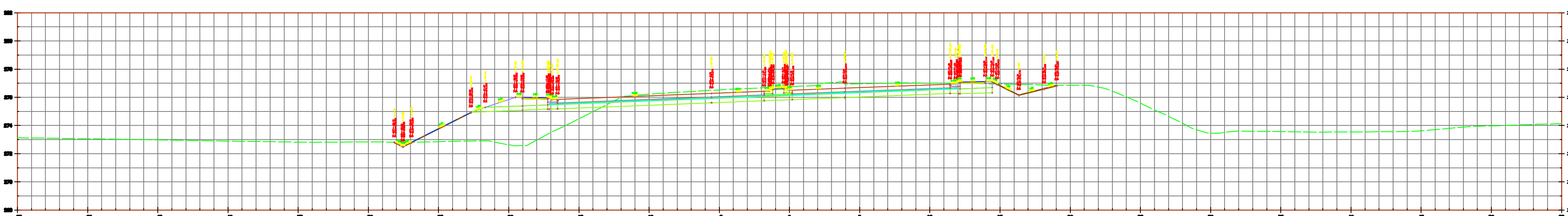
STA 19+442.78 TO STA 19+500.00



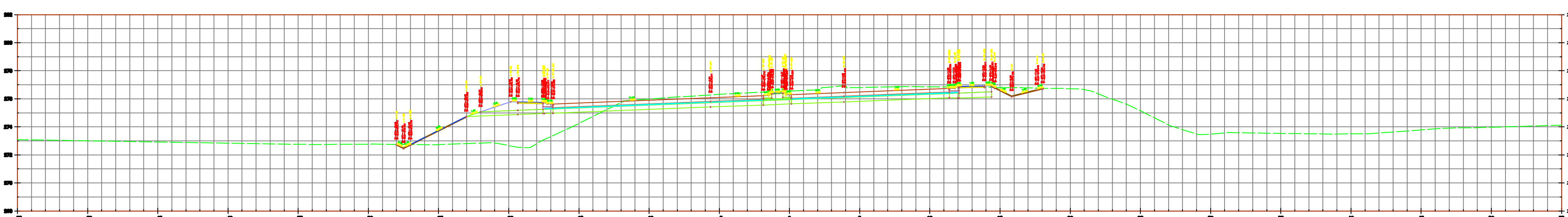
19+500.00



19+475.00

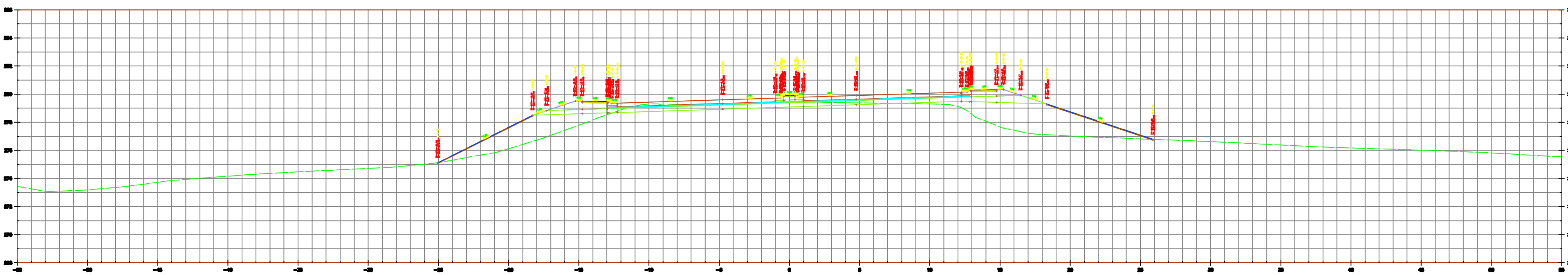


19+450.00

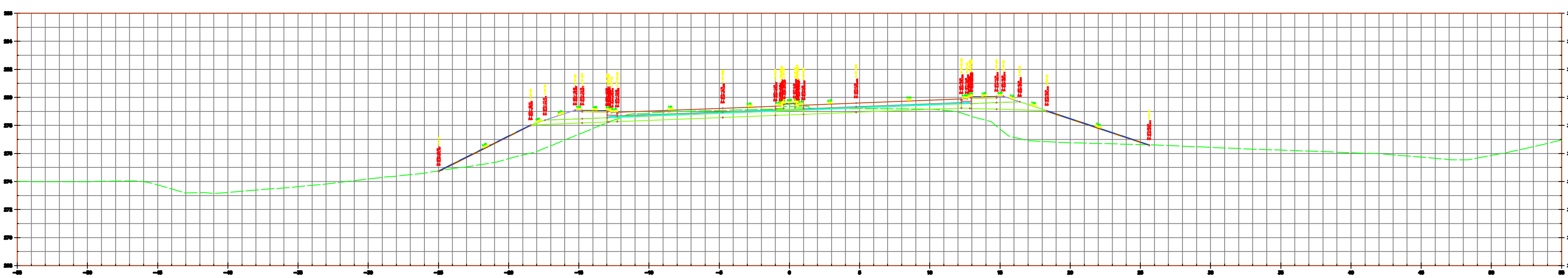


19+442.78

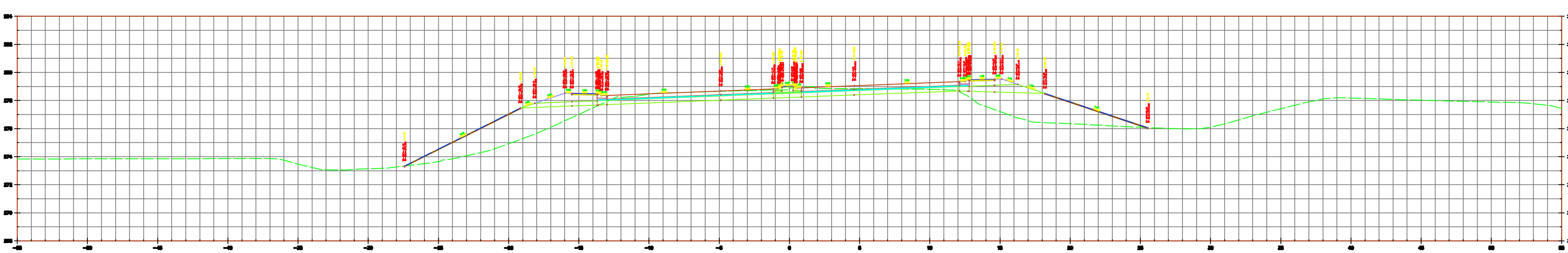
STA 19+525.00 TO STA 19+550.00



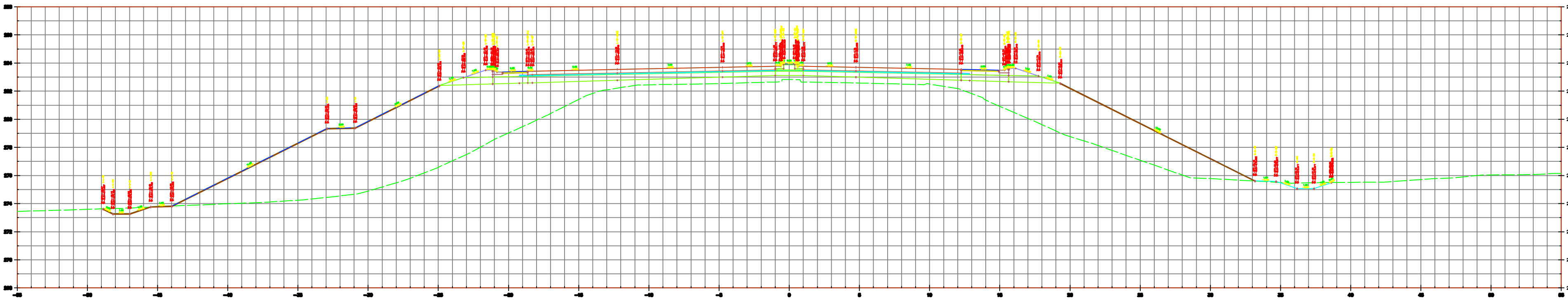
19+550.00



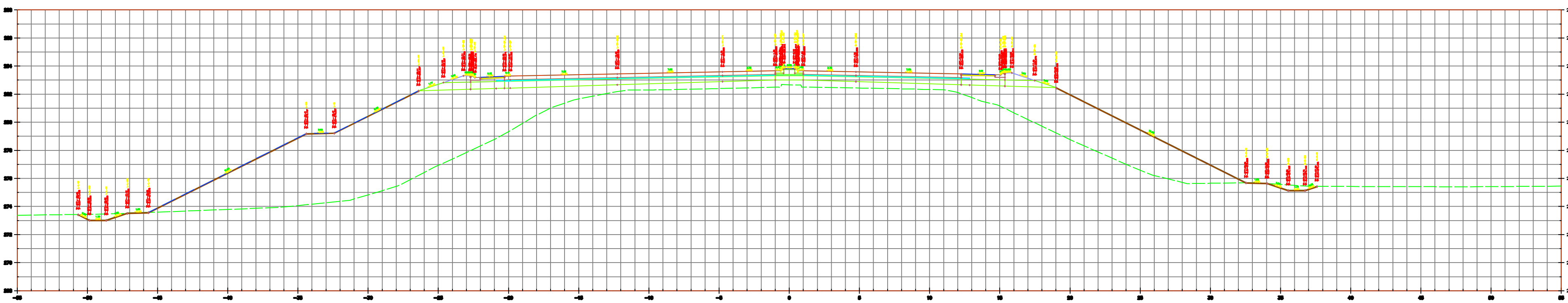
19+540.51



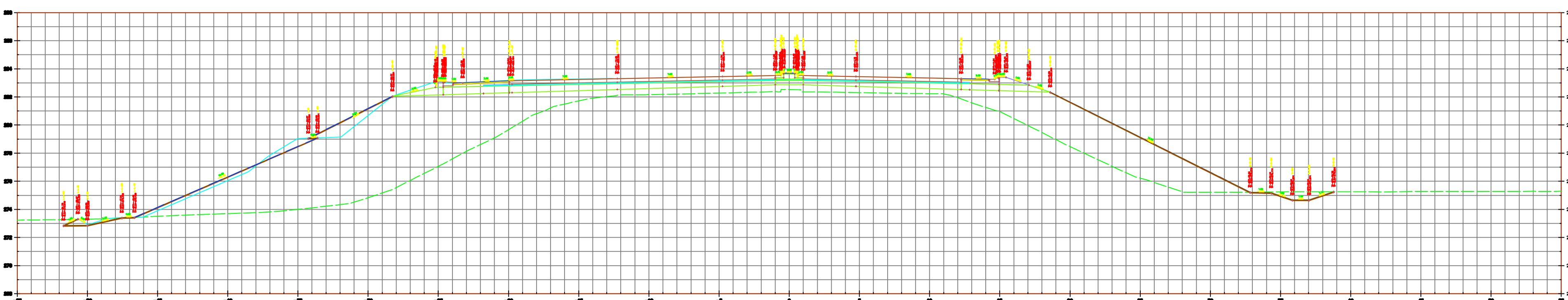
19+525.00



19+710.52

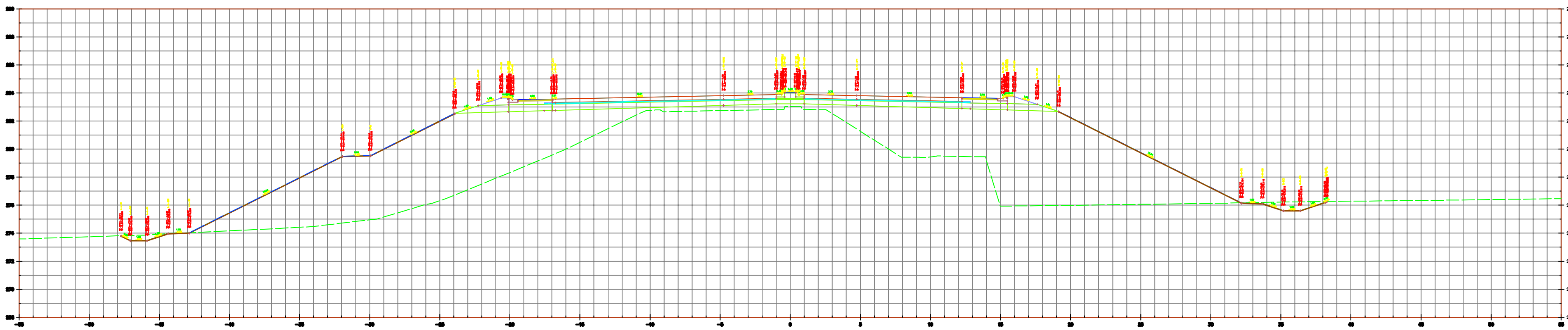


19+700.00

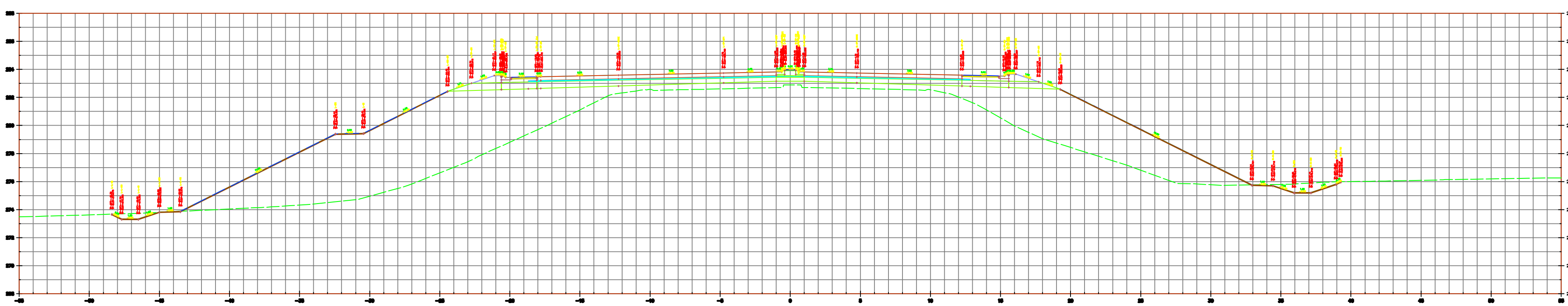


19+689.63

STA 19+689.63 TO STA 19+710.52

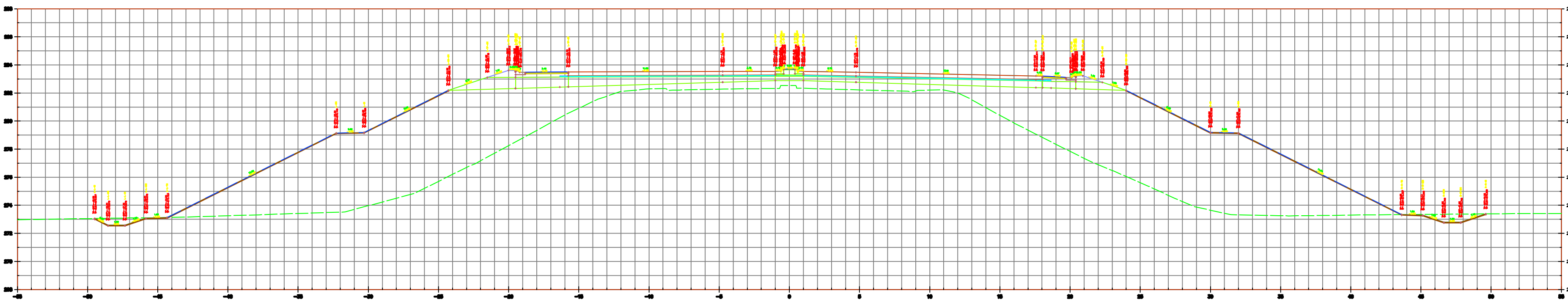


19+725.00

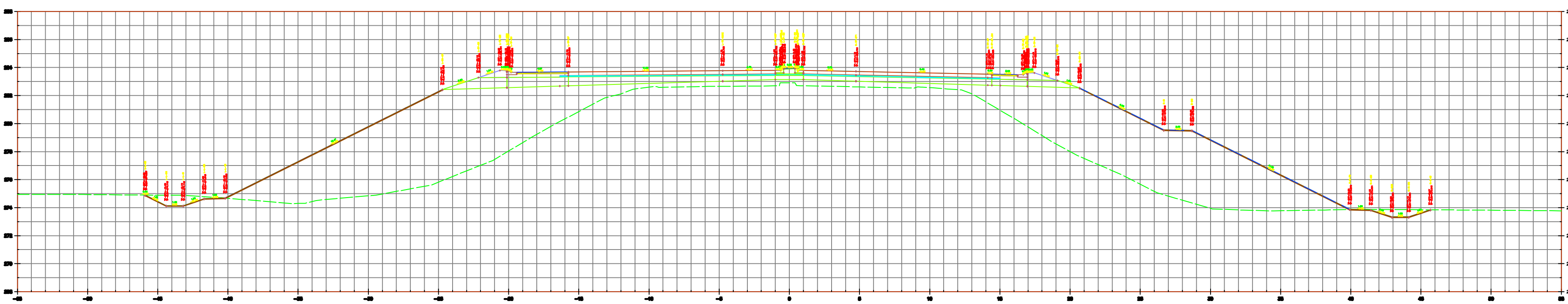


19+714.63

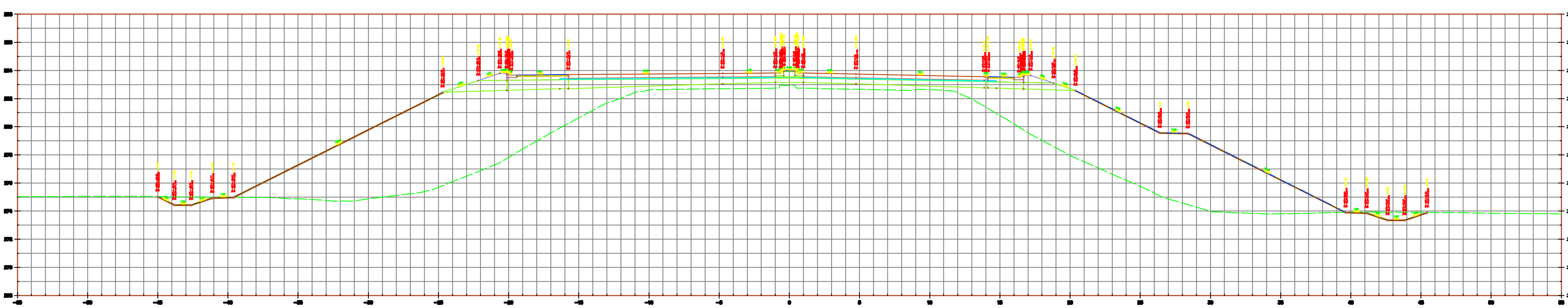
STA 19+714.63 TO STA 19+725.00



19+825.00

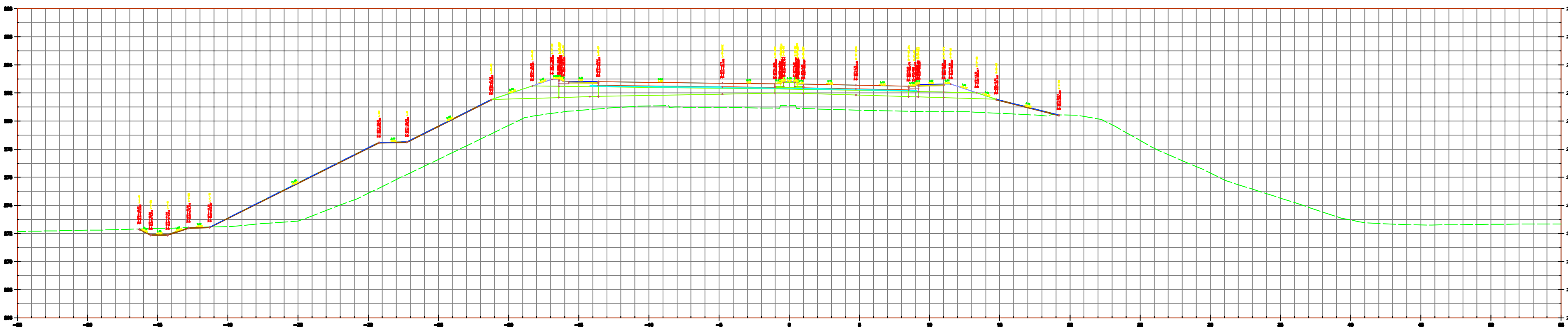


19+802.46

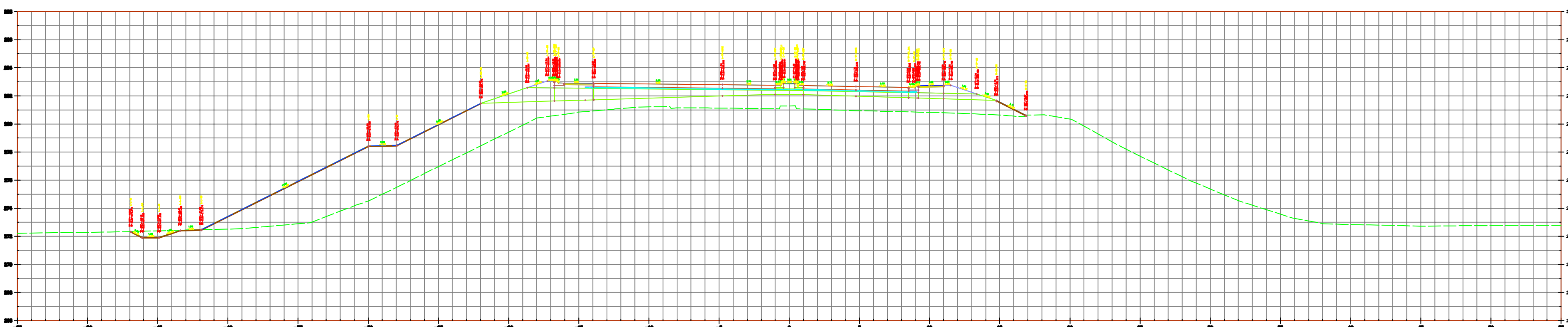


19+800.00

STA 19+800.00 TO STA 19+825.00

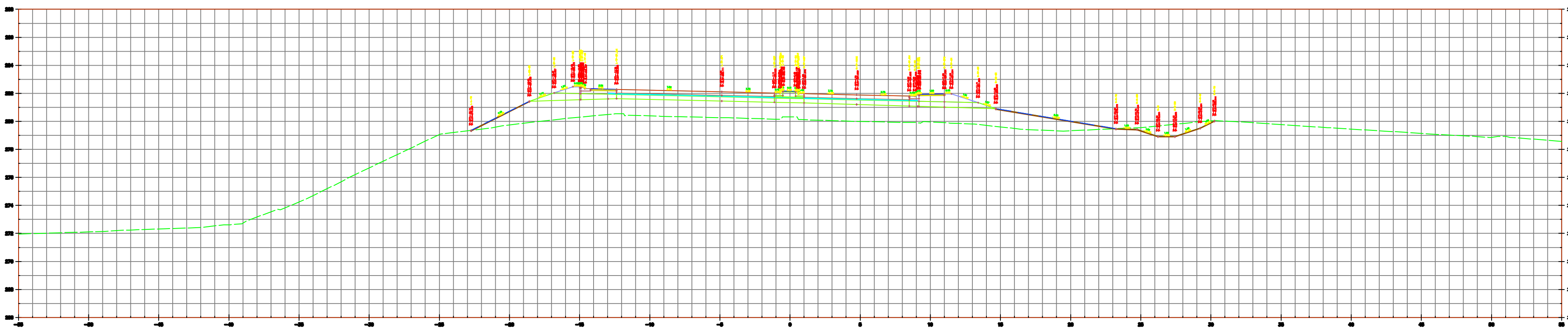


19+875.00

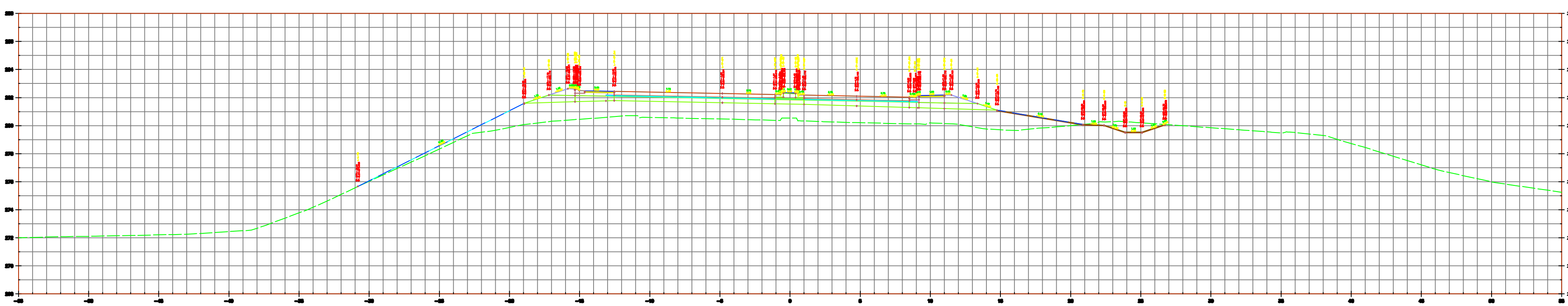


19+869.71

STA 19+869.71 TO STA 19+875.00



19+900.00



19+892.81

STA 19+892.81 TO STA 19+900.00

APPENDIX G

G.1 2015 NATIONAL BUILDING CODE SEISMIC HAZARD CALCULATIONS

2015 National Building Code Seismic Hazard Calculation

INFORMATION: **Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836**
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 42.936N 81.179W **User File Reference:** Highbury Avenue 2022-09-17 03:50 UT

Requested by: Gwangha Roh, Stantec

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.089	0.051	0.031	0.009
Sa (0.1)	0.120	0.072	0.045	0.014
Sa (0.2)	0.111	0.069	0.044	0.015
Sa (0.3)	0.092	0.057	0.038	0.014
Sa (0.5)	0.071	0.045	0.030	0.011
Sa (1.0)	0.041	0.027	0.018	0.005
Sa (2.0)	0.021	0.013	0.008	0.002
Sa (5.0)	0.005	0.003	0.002	0.001
Sa (10.0)	0.002	0.001	0.001	0.000
PGA (g)	0.067	0.040	0.025	0.008
PGV (m/s)	0.056	0.034	0.021	0.006

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Natural Resources Canada Ressources naturelles Canada

Canada