FOUNDATION INVESTIGATION REPORT

Highway 406 S - Geneva Street N/S Ramp, Structure Site 18-168, Highway 406 Structural Rehabilitation from Fourth Avenue to Westchester Avenue, St. Catharines, Ontario
Ministry of Transportation, Ontario G.W.P. 2453-13-00

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Table of Contents

Appendix B – Current Investigation – Record of Boreholes

Appendix C – Geotechnical Laboratory Test Results

Appendix D – Analytical Laboratory – Results of Analysis of Soil

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide foundation engineering services for the replacement of the Highway 406 S – Geneva Street north/south (N/S) off-ramp structure associated with the Highway 406 rehabilitation project from Fourth Avenue to Westchester Avenue in the City of St. Catharines, Regional Municipality of Niagara, Ontario.

The purpose of this investigation is to establish the subsurface soil and groundwater conditions at the existing ramp structure by borehole drilling and geotechnical/analytical laboratory testing on selected soil samples.

The Terms of Reference and scope of work for the foundation investigation are outlined in MTO's Request for Proposal, dated September 2015, which forms part of the Consultants Agreement for Assignment No. 2014-E-0075 for this project. The scope of work for the Geneva Street N/S Off-Ramp structure site is outlined in Golder's Revised Change Request, dated May 25, 2017. The work has been carried out in accordance with Golder's Supplementary Specialty Plan for this project, dated June 2016.

2.0 SITE DESCRIPTION

The Highway 406 S - Geneva Street S N/S Off-Ramp structure is located north of the Highway 406 underpass structure at Westchester Avenue and connects Highway 406 northbound vehicle traffic to Geneva Street, near downtown St. Catharines at the location shown on the Key Plan on Drawing 1. The structure spans the broad gully that was part of the old second Welland Canal (now called the Canal Valley adjacent to Twelve Mile Creek), of which the crest-to-crest width is about 210 m. The General Plan of the site available in GEOCRES 30M3-43 (Drawing D 5147-2, dated May 1963) shows topographic contours indicating that the crest of the valley bank was about 8.3 m above the ground surface of the base of the valley. The General Plan drawing shows the location of the original Old Welland Canal and indicates that a culvert was constructed to the east of the Old Welland Canal. It is understood that Old Welland Canal discharged to Twelve Mile Creek approximately 680 m to the west of the Ramp Bridge through a three-cell buried structural culvert that was constructed between Piers 1 and 2 of the Ramp Bridge. The General Plan further indicates that Old Welland Canal was filled to Elevation 87.5 m, and that in the vicinity of Pier 4 and between Pier 1 and the east abutment the "gravely clay fill, miscellaneous fill, ash and rubble fill" was to be subexcavated to "firm strata" and the subexcavation replaced with "select earth fill".

The existing Ramp is a five-span bridge that was constructed in about 1964, and has a total length of approximately 114 m. The current grade of the Ramp is at about Elevation 97 m near the east abutment and rises to about Elevation 102 m at the west abutment.

Drawing No. D 5147-3 titled "Foundation Layout" indicates that the abutments and piers are reportedly supported on pile caps founded on 14BP73 steel H-piles (equivalent to HP360x108), driven into a till stratum underlying the silty clay deposit, to practical refusal as determined by the Hiley Formula (D.H.O. Std. BD 16-3,4).

3.0 INVESTIGATION PROCEDURES

3.1 Previous Investigation

The results of a previous geotechnical investigation carried out at the site of the existing Highway 406 south Geneva Street N/S Off-Ramp between May 3 and October 4, 1962 are obtained from the MTO GEOCRES library, and are summarized in the report prepared by the Materials and Research Division (Foundation Section) titled, "Highway #58 and Geneva Street, Access Ramp at Old Welland Canal, City of St. Catharines, Dist. #4" dated July 12, 1962, GEOCRES No. 30M03-043. During the 1962 investigation, a total of nineteen boreholes (Boreholes 2 to 20) were advanced in the general vicinity of the existing ramp structure. The location of the boreholes advanced during the

previous investigation are shown on Figure A1 in Appendix A. The relevant records for eighteen borehole (Boreholes 3 to 20) advanced in the immediate vicinity of the structure during the 1962 investigation are presented in Appendix A.

The GEOCRES foundation investigation report indicates that soil samples were obtained at 0.75 m to 3 m depth intervals using 50 mm outside diameter split-spoon samplers driven by manual hammers, in accordance with the Standard Penetration Test (SPT) procedure. In the soft to stiff cohesive deposit, thin-walled Shelby tube samples were also taken and in situ field vane testing was conducted to measure the undrained shear strength of the deposit. Dynamic Cone Penetration Testing (DCPT) was conducted from the ground surface in the immediate vicinity of Boreholes 3, 4 and 6 to 11.

Observations of the water levels in the boreholes were recorded on some boreholes logs; however, piezometers were not installed in any of the boreholes.

Selected samples obtained from the boreholes were subjected to classification testing and the results are resented the Record of Borehole sheets in Appendix A.

The boreholes locations as provided on the Record of Borehole sheets in Station and Off-set were plotted on the General Arrangement Drawing No. R2-1, dated Nov. 2016, provided by MTO on January 31, 2017, and the borehole coordinates were interpreted from the coordinate system superimposed on the plan. The borehole locations in MTM NAD 83 Zone 10 Coordinates, geographic coordinates (latitude / longitude) the ground surface elevations in Geodetic Datum and the drilled depths as presented on or derived from the 1962 borehole records are summarized below.

Borehole No.	Location (MTM NAD 83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude, °)	Easting (Longitude,°)		
3	4779872.8 (43.158411)	326101.6 (-79.238065)	88.1	14.2
4	4779919.8 (43.158835)	326064.9 (-79.238514)	90.5	15.4
5	4779944.1 (43.159055)	326041.6 (-79.238800)	96.3	20.3
6	4779894.3 (43.158605)	326083.7 (-79.238285)	87.3	20.3
7	4779859.3 (43.158289)	326118.1 (-79.237863)	88.8	15.7
8	4779866.7 (43.158355)	326140.7 (-79.237585)	89.0	15.2
9	4779844.5 (43.158155)	326163.9 (-79.237300)	89.7	15.5
10	4779855.2 (43.158250)	326189.6 (-79.236984)	90.2	15.8

Borehole No.	Location (MTM NAD 83 Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude, °)	Easting (Longitude,°)		
11	4779908.1 (43.158729)	326068.2 (-79.238106)	90.8	18.4
12	4779860.7 (43.158301)	326155.0 (-79.237409)	89.5	15.7
13	4779850.7 (43.158211)	326141.3 (-79.237578)	89.3	4.6
14	4779879.9 (43.158474)	326139.3 (-79.237601)	88.7	3.5
15	4779882.6 (43.158498)	326153.6 (-79.237426)	89.0	3.5
16	4779875.5 (43.158433)	326175.7 (-79.237154)	89.6	4.6
17	4779933.1 (43.158955)	326063.1 (-79.238536)	91.1	3.5
18	4779899.4 (43.158652)	326050.5 (-79.238693)	90.5	5.5
19	4779905.9 (43.158711)	326032.6 (-79.238913)	90.2	14.8
20	4779922.9 (43.158864)	326033.8 (-79.238897)	91.4	2.3

3.2 Current Investigation

The field work for the current foundation investigation was carried out between October 30 and November 1, 2017 and between April 9 and May 1, 2018, during this time, a total of ten boreholes, (designated as Boreholes 17-1, 17-2, 17-2A, 17-3, 17-3A, 17-4, 17-5, 17-6, 17-7 and 17-8) were advanced near the footprint of the foundation elements, at the locations shown on Drawing 1 as follows:

Foundation Element	Nearest Relevant Boreholes
West Abutment	17-1
Pier 4	17-2, 17-2A
Pier 3	17-3, 17-3A
Pier 2	17-4
Pier 1	17-5

Foundation Element	Nearest Relevant Boreholes
East Abutment	17-6
Proposed Crane Pad	17-7, 17-8

The field borehole investigation was completed using a track-mounted CME 850 drill rig, supplied and operated by Aardvark Drilling Inc., of Guelph, Ontario, and a track-mounted CME 55 drill rig, supplied and operated by Davis Drilling, of Milton, Ontario. The boreholes were advanced through the overburden using 150 mm outer diameter solid stem augers or 203 mm outer diameter hollow stem augers. All boreholes, with the exception of Borehole 17-2 and 17-3, also used an 86 mm diameter tricone with wash boring techniques and used drilling mud to balance hydrostatic heads and to maintain the boreholes open. Soil samples were obtained at 0.75 m and 1.5 m intervals of depth, using a 50 mm outer diameter split-spoon sampler operated by an automatic hammer on the drill rigs, performed in accordance with Standard Penetration Test (SPT) procedures (ASTM D1586[1]). In situ field vane shear testing, using MTO standard "N"-sized vanes, was carried out to measure the undrained shear strength of cohesive soils (ASTM D2573[2]). Dynamic cone penetration tests (DCPT) were advanced immediately adjacent to Boreholes 17-2A, 17-3A, 17-4 and 17-5 from depths ranging from 12.2 m to 21.3 m below ground surface.

The groundwater conditions and water levels in the open boreholes were observed during and immediately following drilling operations. A standpipe piezometer was installed in Borehole 17-4 to permit monitoring of the groundwater level over time. The standpipe piezometer consists of a 50 mm diameter PVC pipe with a slotted screen sealed at a selected depth within the borehole. The borehole and annulus surrounding the piezometer pipe above the screen sand pack was backfilled to the ground surface with bentonite pellets. The remaining boreholes were backfilled with bentonite upon completion in accordance with Ontario Regulation 903: Wells (as amended).

The field work was observed by members of Golder's engineering and technical staff, who located the boreholes, arranged for the clearance of underground services, observed the drilling, sampling and in situ testing operations, logged the boreholes, and examined and cared for the soil samples. The samples were identified in the field, placed in appropriate containers, labelled and transported to Golder's Mississauga geotechnical laboratory where the samples underwent further visual examination and laboratory testing. All of the laboratory tests were carried out to MTO and/or ASTM Standards, as appropriate. Classification testing (water content, Atterberg limits and grain size distribution) was carried out on selected soil samples.

Three selected soil samples were submitted to Maxxam Analytics, a Standards Council of Canada (SCC) accredited laboratory of Mississauga, Ontario, for chemical analysis. The soil samples were analysed for a suite of corrosivity parameters, including conductivity, resistivity, soluble chloride, soluble sulphate, and pH.

The borehole locations and ground surface elevations were obtained using a GPS (Trimble XH 3.5G), having an accuracy of 0.1 m in the vertical and 0.1 m in the horizontal directions. The borehole locations, given on the borehole records and shown on Drawing 1 are positioned relative to MTM NAD 83 (Zone 10) northing and easting coordinates and the ground surface elevations referenced to Geodetic Datum. The borehole locations including geographic coordinates (latitude / longitude), ground surface elevations and borehole depths are summarized below.

[1] ASTM D1586-11 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils, ASTM International, West Conshohocken, PA, 2011

[2] ASTM D2573-15 Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils, ASTM International, West Conshohocken, PA, 2015

Borehole No.	Location (MTM NAD 83, Zone 10)		Ground Surface Elevation (m)	Borehole Depth (m)
	Northing (Latitude, °)	Easting (Longitude, °)		
17-1	4,779,913.3 (43.158778)	326,043.0 (-79.238784)	98.0	32.6
17-2	4,779,907.6 (43.158725)	326,069.7 (-79.238456)	90.3	8.2
17-2A	4,779,907.6 (43.158725)	326,070.1 (-79.238451)	90.5	21.2
17-3	4,779,896.7 (43.158627)	326,090.3 (-79.238203)	87.4	8.8
17-3A	4,779,896.0 (43.158620)	326,089.7 (-79.238211)	87.7	21.3
17-4	4,779,889.0 (43.158557)	326,105.4 (-79.238018)	88.1	23.5
17-5	4,779,880.2 (43.158477)	326,126.3 (-79.237761)	88.3	20.4
17-6	4,779,867.0 (43.158358)	326,151.9 (-79.237447)	96.8	28.0
17-7	4,779,898.7 (43.158644)	326,114.1 (-79.237911)	87.2	11.3
17-8	4,779,910.2 (43.158748)	326,105.8 (-79.238012)	86.9	11.3

4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

4.1 Regional Geology

This section of Highway 406 is located within the Iroquois Plains physiographic region, as delineated in the *Physiography of Southern Ontario* (Chapman and Putnam, 1984)[3]. The Iroquois Plain extends around the western shores of Lake Ontario. The Plain is comprised of the flat to undulating lakebed and beaches of the former glacial Lake Iroquois, which occupied this area during the last glacial recession. This site is bound to the north by shoreline beach deposits from Glacial Lake Iroquois such as the Homer Bar on which downtown St Catharines is located, and the Niagara Escarpment located some 3 km to the south.

Surficial soil in this area of the Iroquois Plain is typically comprised of silty and clayey till of the Halton Till sheet according to the *Quaternary Geology of the Niagara-Welland Area* (Ontario Geological Survey Map 2496; Feenstra,

[3] Chapman, L.J. and Putnam, D. F. 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2, Third Edition. Accompanied by Map P.2715, Scale 1:600,000.

1984)[4]. The Halton Till sheet is underlain by an older red sandy and silty till, possibly the Wentworth Till sheet (OGS Preliminary Map 764, Feenstra, 1972)[5]. Shallow depressions on the surface of the clay plain upslope of the Homer Bar are infilled with bog sediments while fill materials comprised of earth and rock fill associated with the canal construction occur in the vicinity of the former Welland Canal (OGS Preliminary Map 764, Feenstra 1972)[5].

4.2 Subsurface Conditions

Detailed subsurface soil and groundwater conditions as encountered in the boreholes advanced during the current investigation, including details of the standpipe piezometer installation and water level reading, and the results of the laboratory tests carried out on selected soil samples are presented on the Record of Borehole sheets provided in Appendix B. List of Abbreviations and symbols are also provided in Appendix B to assist in the interpretation of the borehole records. The results of the in situ field tests (i.e. SPT "N"-values, field vane and dynamic cone penetration test (DCPT)) as presented on the Record of Borehole sheets and in sub-sections of Section 4.2 are uncorrected. The geotechnical laboratory testing plots are contained in Appendix C. The results of the analytical testing of these soil samples are presented in Appendix D.

The stratigraphic boundaries shown on the Record of Borehole sheets and on the stratigraphic profile on Drawing 1 are inferred from non-continuous sampling, observations of drilling progress and the results of Standard Penetration Tests. These boundaries, therefore, represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole locations, however, the factual data presented in the borehole records govern any interpretation of the site conditions. It should be noted that the interpreted stratigraphy shown on Drawing 1 is a simplification of the subsurface conditions.

In general, the subsurface conditions consist of pavement structure (borehole advanced at the east abutment) or topsoil (all the remaining of boreholes) underlain by fill associated with the construction of the existing off-ramp structure in turn, underlain by a cohesive clayey silt to clay deposit, underlain by a cohesive till deposit. The till deposit is underlain by a layered granular deposit consisting of silt to silt and sand to sand, as well as cohesive interlayers of clayey silt, at some borehole locations.

A more detailed description of the subsurface conditions encountered in the boreholes from the current investigation is provided in the following sections.

4.2.1 Pavement Structure

Borehole 17-6 was advanced from the off-ramp pavement surface and encountered an approximately 203 mm thick layer of asphalt and a 366 mm thick layer of concrete (including a reinforcing steel bars).

4.2.2 Topsoil

A 30 mm to 152 mm thick layer of topsoil was encountered at the ground surface in Boreholes 17-1, 17-5, 17-7 and 17-8.

4.2.3 Cohesive Fill

Cohesive fill comprised of sandy clayey silt to clayey silt to silty clay was encountered in Boreholes 17-1 below the surficial top soil layer and 17-6 below the sand to sand and gravel fill underlying the pavement, advanced at the west and east abutments, respectively. The fill extends to depths of 7.2 m and 11.2 m below ground surface

[4] Feenstra, B.H. 1984. Quaternary Geology of the Niagara-Welland Area. Ontario Geological Survey, Map 2496, Quaternary Geology Series. Scale 1:50,000

[5] Feenstra, B.H. 1972. Quaternary Geology of the Niagara Area, Southern Ontario. Ontario Division of Mines, Preliminary Map P.764, Geological Survey. Scale 1:50,000

(Elevations 90.8 m and 85.6 m), respectively. In Boreholes 17-2 to 17-5 advanced at the bottom of the valley, the cohesive fill was encountered at ground surface and extended to depths of between about 1.3 m and 3.0 m below ground surface (between Elevations 87.3 m and 85.3 m). In Boreholes 17-7 and 17-8 the fill layer was underlying the topsoil and extends to depth of 0.7 m and 0.9 m below ground surface (Elevations 86.5 m and 86.0 m), respectively.

The SPT "N"-values measured within the cohesive fill deposit generally range from 3 blows to 14 blows per 0.3 m of penetration, suggesting a soft to stiff consistency. The SPT "N"-values recorded at Borehole 17-3 are 100 blows per 0.05 m of penetration and 100 blows per 0.08 m of penetration, inferred due to the presence of concrete fragments in the fill material and these values are not considered representative of the overall fill composition.

A grain size distribution test was completed on one sample of the cohesive fill material and the result is shown on Figure C-1 in Appendix C. The cohesive fill deposit consists of trace to some gravel, trace rootlets and deleterious material including brick and asphalt fragments. An organic odour was noted in Borehole 17-2, at a depth of 2.3 m below ground surface. An Atterberg limits test carried out on one sample of the cohesive fill material measured a liquid limit of about 44 per cent, a plastic limit of about 21 per cent, and a plastic index of about 23 per cent. The result, which is plotted on a plasticity chart on Figure C-2 in Appendix C, indicates that the fill material consists of silty clay of medium plasticity.

The water content measured on select samples of the fill deposit ranges from about 10 per cent to 29 per cent.

4.2.4 Non-Cohesive Fill

Non-cohesive fill consisting of silty sand to sand to sand and gravel to gravel was encountered in Boreholes 17-2, 17-3, 17-5, 17-6 and 17-8, underlying the asphalt and concrete pavement (in Borehole 17-6) or topsoil (in boreholes advanced at the base of the valley). A layer of fill consisting of black sand exhibiting a hydrocarbon odour was also encountered underlying the cohesive fill in Borehole 17-6 at a depth of 11.2 m (Elevation 85.6 m) and is about 1.5 m thick. The surface of the non-cohesive fill was encountered at depths between about 0.6 m and 3.0 m, (between Elevations 96.2 m and 85.3 m) below ground surface, respectively and the thickness of the non-cohesive fill ranges from 0.7 m to 4.0 m. Hydrocarbon odours were noted at Borehole 17-5 at depths between 3.0 m and 5.2 m below ground surface (Elevation 85.3 m and 83.0 m, respectively.

The SPT "N"-values measured within the non-cohesive fill range from 2 blows to 27 blows per 0.3 m of penetration, indicating that the fill layer has a very loose to compact compactness condition.

A grain size distribution test was carried out on one sample of the non-cohesive fill material and the result is shown on Figure C-3 in Appendix C. The non-cohesive fill contains of trace to some silt, trace clay, clayey silt pockets, inferred cobbles and glass fragments.

The water content measured on select samples of the fill deposit ranges from about 17 per cent to 61 per cent.

4.2.5 Clayey Silt with Sand to Clay

Underlying the fill deposit in all boreholes advanced for the current investigation, a cohesive deposit consisting of clayey silt with sand to sandy clayey silt to clayey silt to silty clay to clay was encountered at depths between about 0.7 m and 12.7 m. At Boreholes 17-1 and 17-6 advanced at the west and east abutment, respectively the cohesive deposit extends to depths of about 22.4 m and 22.6 m (Elevations 75.6 and 74.2 m), below ground surface, respectively. At Boreholes 17-1 and 17-6 the overall thickness of the cohesive deposit is about 15.2 m and 9.9 m, respectively. At Boreholes 17-2 to 17-5, advanced at the bottom of the valley the cohesive deposit extends to depths of between about 13.3 m and 15.9 m (between Elevation 75.0 m and 70.3 m), below ground surface and the

thickness of the deposit ranges from about 7.7 m to 14.9 m. Boreholes 17-7 and 17-8 were terminated within this deposit at a depth of 11.3 m (Elevation 75.9 m and 75.6 m), below ground surface. In Borehole 17-7, a 1.5 thick layer of sand was encountered within this cohesive deposit at a depth of 3.1 m (Elevation 84.1 m) below ground surface.

The SPT "N"-values recorded within the cohesive deposit range from 1 blow to 25 blows per 0.3 m of penetration. In situ field vane tests carried out within the cohesive stratum measured undrained shear strengths ranging from about 34 kPa to greater than 96 kPa, with sensitivities ranging from about 1 to 4. The field vane test results together with the SPT "N"-values indicate that the cohesive deposit has a generally firm to very stiff consistency. The SPT "N"-value recorded within the gravel layer is 31 blows per 0.3 m of penetration, indicating a dense compactness condition.

The results of grain size distribution tests carried out on nine samples of the deposit are shown on Figures C-4A, C-4B and C-4C, in Appendix C. Hydrocarbon odours were encountered within the cohesive deposit at Borehole 17-2 from depths between 3.8 m and 4.4 m (Elevation 86.5 m and 85.9 m) below ground surface, respectively and in Borehole 17-3 from depths between 2.3 m and 2.9 m (Elevation 85.1 m and 84.5 m) below ground surface, respectively.

The results of grain size distribution testing carried out on one sample of the gravel inter layer encountered in Borehole 17-7 is shown on Figure C-5, in Appendix C.

Atterberg limits tests were carried out on eleven samples of the cohesive deposit and measured liquid limits ranging between about 28 per cent and 52 per cent, plastic limits ranging between about 14 per cent and 24 per cent, and plastic indices ranging between about 12 per cent and 31 per cent. These results, which are plotted on a plasticity chart on Figures C-6A and C-6B in Appendix C, indicate that the deposit consists of clayey silt of low plasticity to clay of high plasticity.

The natural water content measured on samples of the cohesive deposit ranges from about 18 per cent to 53 per cent. The natural water content measured on a sample of the gravel interlayer encountered at Borehole 17-7 is about 10 per cent.

4.2.6 Sandy Silt to Sandy Clayey Silt to Clayey Silt (Till)

A till deposit was encountered underlying the cohesive deposit in Boreholes 17-1, 17-2A, 17-3A, 17-4, 17-5 and 17-6. In Boreholes 17-1 and 17-6 advanced at the west and east abutments the surface of the till deposit was encountered at depths of 22.4 m and 22.6 m below ground surface (Elevations 75.6 m and 74.2 m), and the thickness of the deposit is 1.5 m and 1.7 m, respectively. In Boreholes 17-2A, 17-3A, 17-4 and 17-5, advanced at the base of the valley, the surface of the till deposit was encountered at depths between about 13.3 m and 17.1 m (between Elevations 75.0 m and 70.3 m) below ground surface and the thickness of the deposit ranges between 1.2 m and 3.0 m. A 0.2 m thick layer of gravelly sand was encountered within the till deposit at Borehole 17-4 at a depth of 15.3 m (Elevation 72.8 m) below ground surface.

SPT "N"-values measured within the till deposit range from 28 blows to 76 blows per 0.3 m of penetration, suggesting a very stiff to hard consistency. As SPT "N"-value of 8 blows per 0.3 m of penetration was measured across the interface of the till and overlying clayey silt deposit in Borehole 17-3A, indicating a loose compactness condition.

The results of grain size distribution tests carried out on six samples from the till deposit are shown on Figure C-7 in Appendix C. The till is composed of primarily of clayey silt with sand to sandy clayey silt to clayey silt with a zone of sandy silt trace to some clay in Borehole 17-3A. Atterberg limits testing carried out on seven samples of this

deposit measured liquid limits ranging from about 17 per cent to 22 per cent, plastic limits ranging from about 13 per cent to 14 per cent, and plastic indices ranging from about 3 per cent to 7 per cent. These results, which are plotted on a plasticity chart on Figure C-8 in Appendix C, indicate that the deposit consists of clayey silt of low plasticity and a zone of sandy silt of slight plasticity.

The natural water content measured on samples of the till deposit ranges from about 9 per cent to 15 per cent.

4.2.7 Sand to Silt and Sand to Sandy Silt to Silt

A granular deposit consisting of interlayered silt to sandy silt to silt and sand to sand was encountered underlying the till in Boreholes 17-1, 17-2A, 17-3A, 17-4 and 17-6, and underlying a clayey silt interlayer in Borehole 17-5 (see Section 4.2.8). The surface of this granular deposit was encountered at depths between about 23.0 m and 24.3 m (Elevations 74.1 m and 72.5 m) below ground surface in Boreholes 17-1 and 17-6 advanced at the west and east abutments, respectively and in Boreholes 17-1, 17-2A, 17-3A, 17-4 and 17-5, advanced at the bottom of the valley the granular deposit was encountered at depths of between 16.3 m and 19.7 m (between Elevations 73.2 m and 67.7 m) below ground surface. All boreholes advanced during the current investigation, with the exception of Borehole 17-3A, 17-7 and 17-8, terminated within this granular deposit at depths between 20.4 m and 23.5 m below the bottom of the valley and at depths of 32.6 m (Elevation 65.4 m) and 28.0 m (Elevation 68.8 m), below ground surface at the west and east abutment, respectively.

SPT “N”-values measured within the various layers of the granular deposit generally range between 18 blows per 0.3 m of penetration with one “N”-value of 102 blows per 0.26 m of penetration, indicating a compact to very dense compactness condition.

The results of grain size distribution tests carried out on ten samples of the granular deposit are shown on Figures C-9A and C-9B in Appendix C. Atterberg limits testing was carried out on one sample of the silt and sand layer of this deposit from Borehole 17-5 and the test indicates that the silt and sand portion of the deposit is non-plastic.

The natural water content measured on samples of this granular deposit ranges from about 14 per cent to 21 per cent.

4.2.8 Clayey Silt

A cohesive layer of clayey silt was encountered underlying the glacial till deposit in Borehole 17-5 at Elevation 72.0 m and underlying the silt deposit in Borehole 17-3A at Elevation 66.5 m. The thickness of the clayey silt layer encountered in Borehole 17-5 is about 1.5 m and Borehole 17-3A was terminated within the clayey silt layer after penetrating into it for a depth of 0.6 m.

The SPT “N”-values recorded within this deposit are 39 blows and 41 blows per 0.3 m of penetration, suggesting a hard consistency.

Atterberg limits testing was carried out on two samples of this deposit and measured liquid limits at about 20 per cent and 23 per cent, plastic limits at about 13 per cent and 16 per cent, and plastic indices at about 7 per cent. The results, which are plotted on a plasticity chart on Figure C-10 in Appendix C, indicates that the material comprising these cohesive layers is a clayey silt of low plasticity.

The natural water content measured two samples of this cohesive deposit ranges from about 11 per cent to about 21 per cent.

4.2.9 Groundwater

The overburden samples obtained from the borehole investigation were generally moist to wet. The groundwater levels in the open borehole or inside the drill casing were measured upon completion of drilling operations whenever possible; however, water drilling mud was used to advance all borehole with the exception of Boreholes 17-2 and 17-3. Upon advancement of Borehole 17-2A at a depth of about 4.6 m below ground surface (Elevation 85.7 m), artesian conditions were recorded with the water level rising to about 0.4 m above ground surface.

A standpipe piezometer was installed in Borehole 17-4 to permit the monitoring of groundwater level at this site. The piezometer at Borehole 17-4, screened within the granular deposit underlying the sandy clayey silt till deposit. Details of the piezometer installation and measured groundwater levels are shown on the borehole records in Appendix B. The groundwater levels recorded are summarized below.

Borehole / Test Pit No.	Ground Surface Elevation (m)	Depth to Water Level (m)	Groundwater Elevation (m)	Date	Comments
17-2A	90.3	2.5	87.8	Oct 13, 2017	Open Borehole
17-3A	87.4	3.4	84.0	Nov 1, 2017	
17-4	88.1	0.0	88.1	Nov 1, 2017	Measured in Standpipe Piezometer
		1.2	86.9	April 4, 2018	
		1.2	86.9	May 1, 2018	

It should be noted that the groundwater level in the area is subject to seasonal fluctuations and precipitation events, and should be expected to be higher during wet periods of the year.

4.2.10 Analytical Testing Results

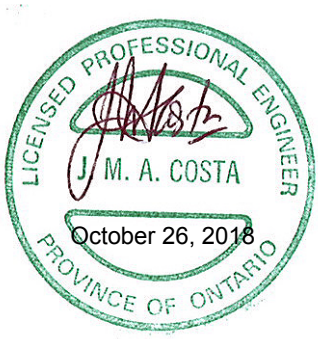
Analytical testing was carried out on selected soil samples recovered from Borehole 17-4. The soil samples were submitted to Maxxam Analytics of Mississauga, Ontario for corrosivity testing. Detailed analytical laboratory test results are provided on the Certificate of Analysis presented in Appendix D, and summarized below.

Borehole No.	Sample ID	Depth (m)	Parameters				
			Resistivity (ohm-cm)	Electrical Conductivity (mS/cm)	Soluble Sulphate (So_4) Content (µg-g)	Chlorides (CL) Content (µg-g)	pH (pH)
17-4	SS7	6.1 – 6.7	3,200	317	62	81	7.7
17-4	SS12	13.7 – 14.3	2,200	460	170	130	8.4
17-4	SS16	19.8 – 20.4	2,200	460	140	180	8.6

5.0 CLOSURE

This Foundation Investigation Report was prepared by Ms. Katelyn Nero, and was reviewed by Ms. Sandra McGaghran, M.Eng., P.Eng., a senior geotechnical engineer and Associate with Golder. Mr. Jorge Costa, P.Eng., a MTO Foundations Designated Contact for Golder and Senior Consultant conducted a technical and quality control review of the report.

Golder Associates Ltd.



Sandra McGaghran, M.Eng., P.Eng.
Senior Geotechnical Engineer, Associate

Jorge M.A. Costa, P.Eng.
MTO Foundations Designated Contact, Senior Consultant

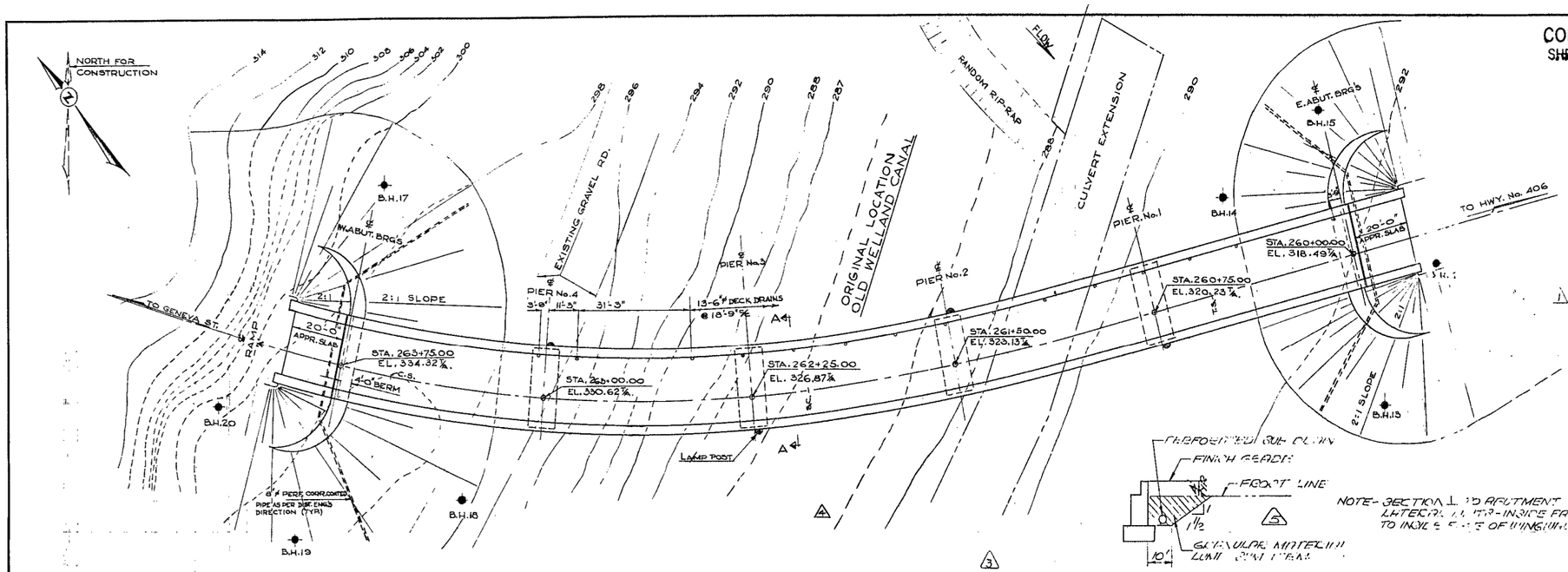
KN/SMM/JMAC/rb

https://golderassociates.sharepoint.com/sites/19544g/2000 foundation/5 - reports/4 - geneva street ramp investigation/final/1541610 fir geneva street ns ramp structure 2018oct26.docx

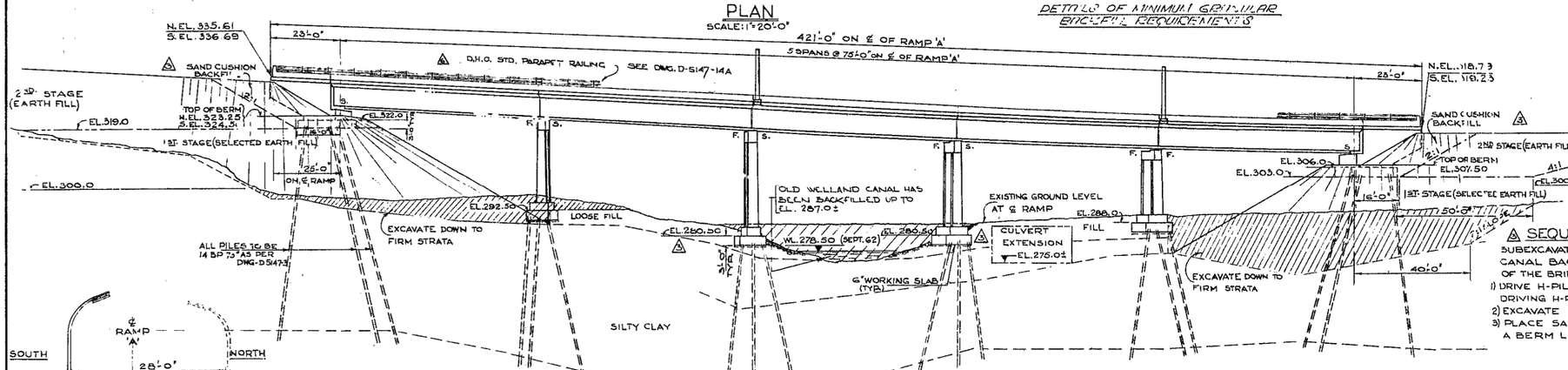
APPENDIX A

Appendix A – Previous Investigation – MTO GEOCRES No. 30M03-43

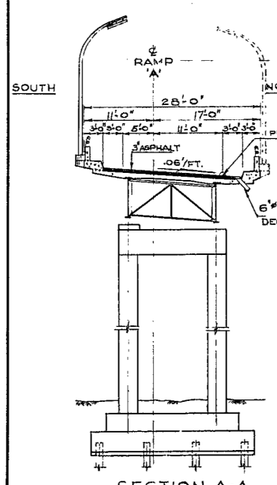
CONT 79-21
SHEET 192



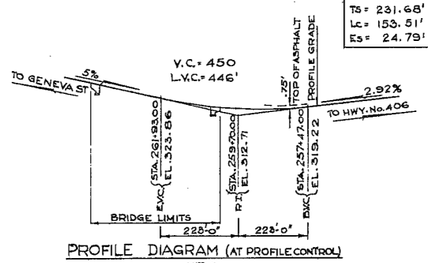
PLAN
SCALE: 1"=20'-0"



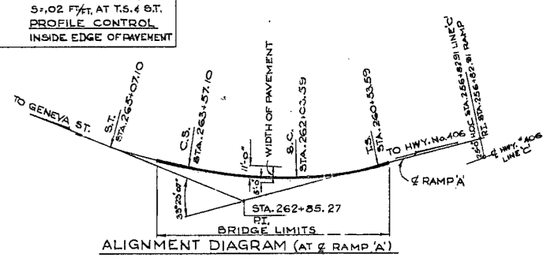
SOUTH ELEVATION
SCALE: 1"=20'-0"



SECTION A-A
SCALE: 1"=10'-0"



PROFILE DIAGRAM (AT PROFILE CONTROL)
N.T.S.

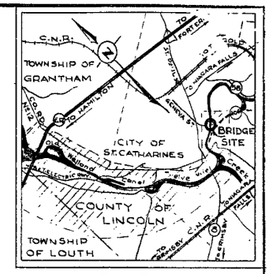


ALIGNMENT DIAGRAM (AT ℄ RAMP 'A')
N.T.S.

CURVE DATA	
Δ = 83°23'07"	Ls = 150.00'
Δc = 16°53'07"	Θs = 8°15'00"
D = 11°00' RT.	SUPERELEVATION DATA
R = 520.87'	S=.06 FT/FT. AT S.C. & C.S.
Ts = 231.68'	S=.02 FT/FT. AT T.S. & S.T.
Lc = 153.51'	PROFILE CONTROL
Es = 24.79'	INSIDE EDGE OF PAVEMENT

DETAILS OF MINIMUM GRANULAR BACKFILL REQUIREMENTS

NOTE- SECTION 1 TO ABUTMENT LATERAL LIMITS INSIDE FACE TO INSIDE FACE OF WINGWALL



KEY PLAN
SCALE: 1 IN. = 1 MI.

NOTES

TO ENGINEER

CONCRETE WORK ON THIS STRUCTURE MUST NOT BE COMMENCED UNTIL MONUMENTS TO FIX CONTROL POINTS HAVE BEEN ERECTED AND CHECKED BY THE DISTRICT ENGINEER.

TO CONTRACTOR

STRUCTURE TO BE BUILT IN ACCORDANCE WITH FORM No. 8 AND THE SPECIAL PROVISIONS, EXTRA COPIES OF WHICH MAY BE OBTAINED FROM THE DISTRICT ENGINEER.

CONCRETE MIX

	MINIMUM STRENGTH AT 28 DAYS	MAXIMUM SIZE OF AGGREGATE
DECK	4000 P.S.I.	¾"
FOOTINGS, PIERS & ABUTMENTS	3000 P.S.I.	1½"

APPROVED ADMIXTURES SUPPLIED BY THE CONTRACTOR WILL BE ADDED TO ALL CONCRETE AS SPECIFIED BY THE EGINEER.

BORING DATA

THE COMPLETE SOIL INVESTIGATION REPORT FOR THIS STRUCTURE MAY BE EXAMINED AT THE BRIDGE OFFICE OR FOUNDATION OFFICE, DOWNSVIEW OR AT THE REGIONAL OFFICE AND AT THE HAMILTON DISTRICT OFFICE.

CLEAR COVER ON REINFORCING STEEL.

FOOTINGS-3", ABUTMENTS-3", DECK-1"

CONSTRUCTION NOTES.

ALL EXPOSED EDGES TO BE CHAMFERED 1½" EXCEPT AS NOTED.
ALL CONSTRUCTION JOINTS MUST BE APPROVED BY THE BRIDGE ENGINEER.
THE GENERAL CONTRACTOR IS RESPONSIBLE FOR FINISHING THE BRIDGE SEATS DEAD LEVEL TO THE SPECIFIED ELEVATIONS WITH A TOLERANCE OF PLUS OR MINUS ⅛ INCH. IF THEY ARE CAST TOO HIGH THEY SHALL BE GROUND DOWN BY THE GENERAL CONTRACTOR. IF THEY ARE CAST TOO LOW THE GENERAL CONTRACTOR SHALL PROVIDE FULL BEARING SHIMS TO BRING THEM UP TO THE CORRECT ELEVATIONS. THE USE OF GROUT IS PROHIBITED.
THE GENERAL CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING THAT THE FINAL DECK ELEVATIONS COMPLY WITH THE ELEVATIONS SHOWN.
NO CONCRETE SHALL BE PLACED ABOVE THE BRIDGE SEATS UNTIL THE STRUCTURAL STEEL HAS BEEN PLACED.

⚠ SEQUENCE OF CONSTRUCTION

SUBEXCAVATION, 1ST. STAGE FILL, CULVERT EXTENSION AND CANAL BACKFILL SHALL BE COMPLETED PRIOR TO COMMENCEMENT OF THE BRIDGE PROJECT.
1) DRIVE H-PILES. ALL H-PILES FOR PIERS TO BE PLACED PRIOR TO DRIVING H-PILES FOR ABUTMENTS.
2) EXCAVATE AND POUR FOOTINGS.
3) PLACE SAND CUSHION BACKFILL AT ABUTMENTS UP TO A BERM LEVEL PRIOR TO ERECTION OF STRUCTURAL STEEL.

LIST OF DRAWINGS

REFERENCE DRAWINGS

SITE PLAN
PROFILE - CONTR. No. 62-31 G SHEET No 30
PLAN ——— 31
SOILS REPORT BA 1463 & 1463A

REVISIONS			
9.7.69	R.T.		AS-CONSTR. Y.T. SUPPLIED
24.11.64	V.V.	2	SID. & RAILS CHANGED TO PARAPET RAILING.
15/7/64	W.M.	1	GUIDANCE FOR PLAN REV.
24/10/63	J.G.G.	4	GRAVEL ROAD REMOVED, PLAN REV.
29/8/63	A.U.	3	NOTES & SOUTH ELEVATION-PLAN-I REV.
~~16/8/63~~	~~J.G.G.~~	~~2~~	~~NOTES REV.~~
6/8/63	J.G.G.	1	NOTE 5 & ELEVATION REV.
DATE	BY		DESCRIPTION

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

BRIDGE OVER OLD WELLAND CANAL

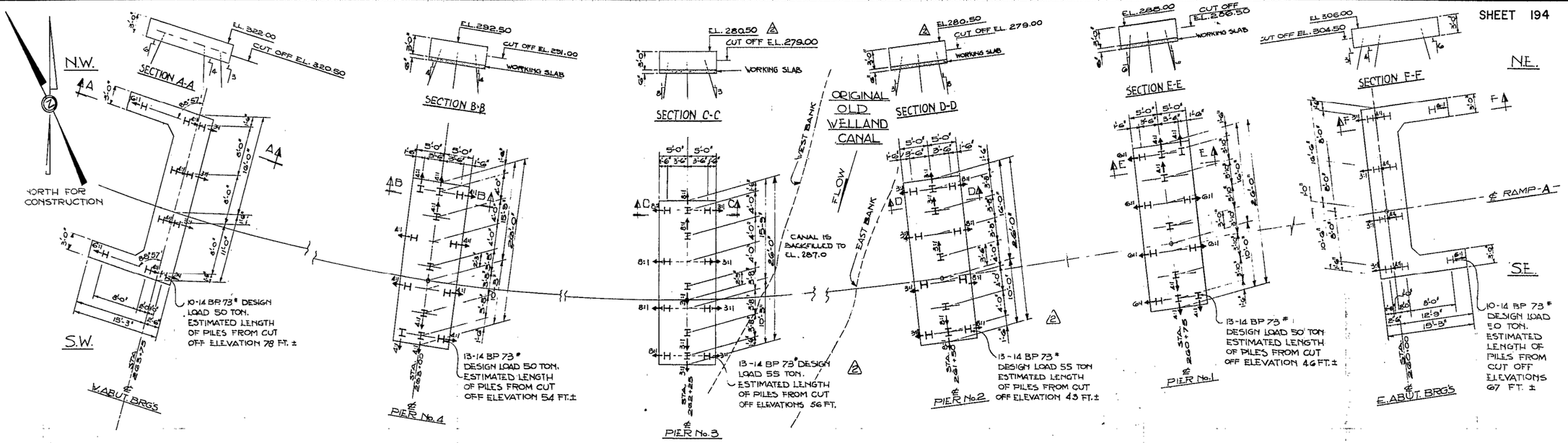
CONNECTION BETWEEN HWY. No. 406 AND GENEVA ST.
IN ST. CATHARINES

KING'S HIGHWAY No. ——— DIST. No. 4
CO. LINCOLN
TWP. CITY OF ST. CATHARINES LOT ——— CON. ———

GENERAL PLAN

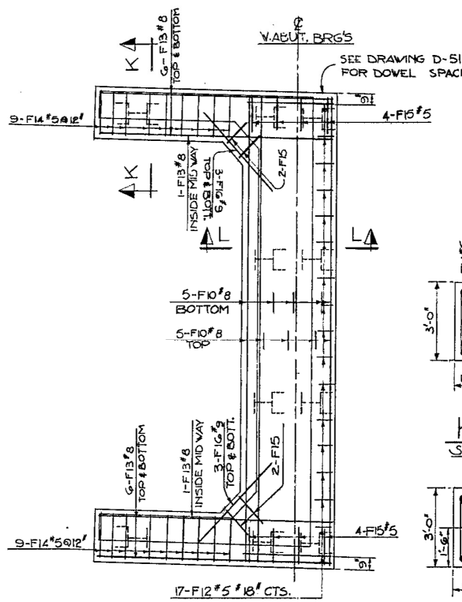
APPROVED _____ BRIDGE ENGINEER
SITE No. 19-168 W.P. No. 274-62

DESIGN	A.U.	CHECK	J.G.G.	CONTRACT Nos.	1-05 GA-295
DRAWING	H.M.	CHECK	J.G.G.		
DATE	MAY 62	LOADING	H 20 S 16	DRAWING No.	D-5147



FOUNDATION LAYOUT SHOWING H-PILES

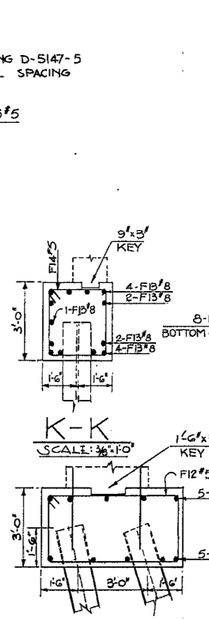
SCALE: 1/8"=1'-0"



PLAN OF W. ABUTMENT SHOWING FOOTING REINFORCEMENT

(REINFORCEMENT OF E. ABUT. SIMILAR)

SCALE: 1/4"=1'-0"

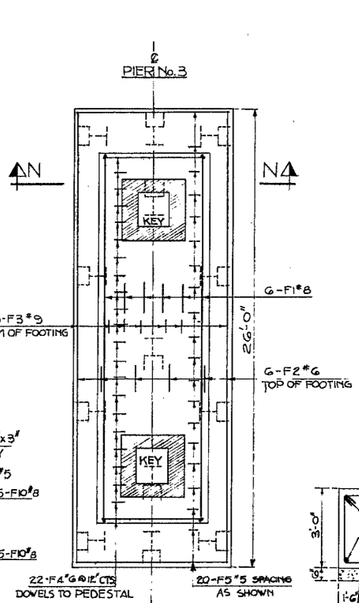


K-K

SCALE: 3/8"=1'-0"

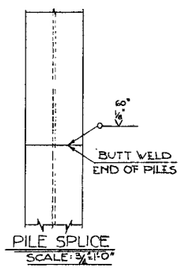
L—L

SCALE: 3/8"=1'-0"



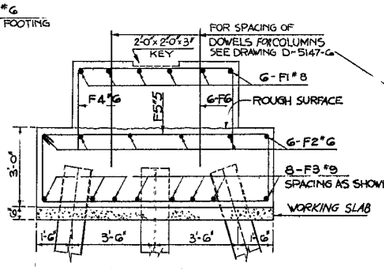
PLAN OF PIER #3 SHOWING FOOTING REINFORCEMENT

SCALE: 1/8"=1'-0"



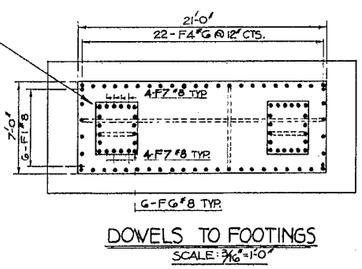
PILE SPLICE

SCALE: 3/4"=1'-0"



N—N

SCALE: 3/8"=1'-0"



DOWELS TO FOOTINGS

SCALE: 3/16"=1'-0"

NOTES:

SETTING:

1. PIERS & ABUTMENTS TO BE SET IN FIELD USING DATA GIVEN ON DRAWING D-5147-4. TABLE 2. THESE POINTS SHALL NOT BE SET BY USE OF STATIONS ON ℄ OF RAMP A. STATIONS GIVEN FOR FUTURE REFERENCE ONLY.
2. ALL ℄ PIERS AND ℄ ABUTMENTS BRGS ARE RADIAL.
3. LOCATION OF PIERS #2 & #3 SHALL BE CHECKED TO BE AS SHOWN ON DRAWINGS IN RELATION TO THE OLD WELLAND CANAL.

SOIL DATA AND PILING

⚠ 4. FOR SOILS INFORMATION CONTRACTOR SHALL SEE THE SOILS REPORT. THE FOLLOWING POINTS ARE MENTIONED IN THE REPORT
- PRESENCE OF ⚠ BOULDERS AT PIERS #2 & #3 (REMOVE BEFORE PILING)
- NEED FOR TEMPORARY SHEET PILING FOR DEWATERING PURPOSES

5. ALL 'H' PILES TO BE DRIVEN TO A PRACTICAL REFUSAL AS DETERMINED BY HILEY FORMULA (SEE D.H.O. STD. BD KG-3,4) ALL LOADS ARE VERTICAL.
SYMBOL: H 6|1 → BATTER IN DIRECTION OF ARROW.

6. BACKFILLING OF EXCAVATION IN VICINITY OF PIER FOOTINGS TO BE IN 6" COMPACTED LAYERS UP TO TOP OF FOOTING ELEVATIONS.

REVISIONS	DATE	BY	DESCRIPTION
	9.7.69	R.T.	REVISED AS-CONSTR.
	24 10 63	JGG	⚠ WORD 'SURFACE' REMOVED
	29/8/63	A.U.	⚠ REV ELEVATION NOTES - PIER 3. PIER 2
	6/8/63	JGG	⚠ NOTES REV.

DEPARTMENT OF HIGHWAYS ONTARIO
BRIDGE DIVISION

BRIDGE OVER OLD WELLAND CANAL

CONNECTION BETWEEN HWY. No. 406 AND GENEVA ST. IN ST. CATHARINES

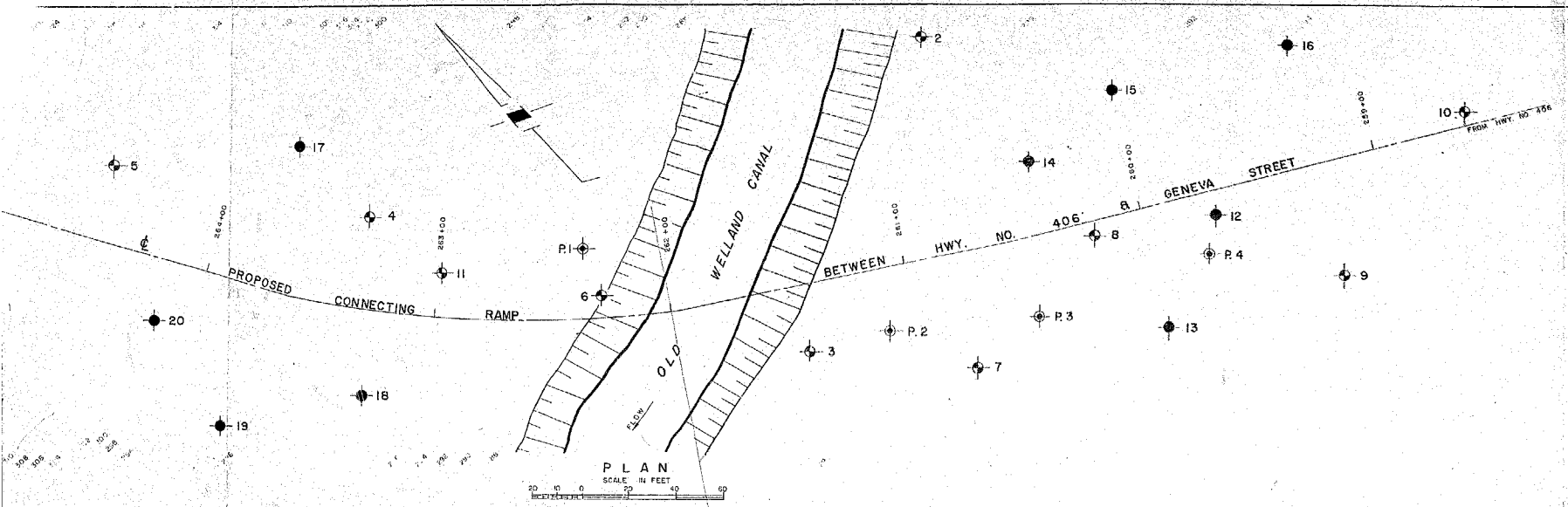
KING'S HIGHWAY No. ____ DIST. No. 4

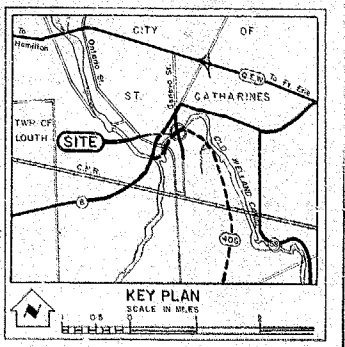
CO. LINCOLN

~~TWP.~~ CITY OF ST. CATHARINES LOT ____ CON. ____

FOUNDATION LAYOUT

APPROVED	BRIDGE ENGINEER			SITE No. 19-168	W.P. No. 274-62		
DESIGN	A.U.	CHECK	J.S.	CONTRACT Nos.		ST. SURFACE & BASE	
DRAWING	N.T.	CHECK	J.S.		64-05	64-235	
DATE	MAY. 63	LOADING	H-20 S-16	DRAWING No.	D-~~5147-3~~		



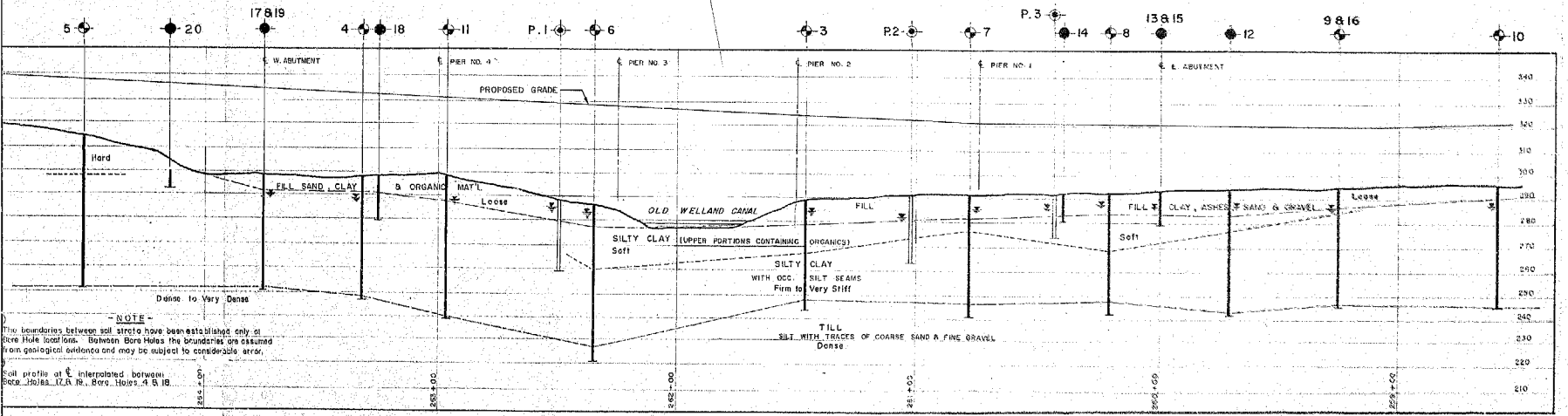


LEGEND

- Bore Hole
- Cone Penetration Hole
- Bore & Cone Penetration Hole
- Piezometer Hole
- Water Level established at time of field investigation June, 1966

NO.	ELEVATION	STATION	OFFSET
2	289.0	260+78	90'RT.
3	290.0	261+46	28'LT.
4	297.0	263+38	38'RT.
5	310.0	264+49	31'RT.
6	290.2	262+35	9'LT.
7	291.3	260+70	48'LT.
8	292.0	260+21	6'LT.
9	294.3	259+28	48'LT.
10	295.8	258+89	5'RT.
11	298.0	262+97	18'RT.
12	293.5	259+70	10'LT.
13	293.0	260+00	50'LT.
14	291.0	260+10	30'RT.
15	292.0	260+00	80'RT.
16	294.0	259+26	90'RT.
17	299.0	263+75	60'RT.
18	297.0	263+25	35'LT.
19	296.0	263+75	60'LT.
20	300.0	264+15	85'LT.

NO.'S 1 & 21 NOT SHOWN ON PLAN



- 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.

Soil profile at ℄ interpolated between Bore Holes 17 & 19, Bore Holes 4 & 18.

℄ PROFILE

SCALE IN FEET

20 10 0 20 40 60

THIS DRAWING SUPERSEDES DWG. 62-F-62A

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH SECTION

OLD WELLAND CANAL AND HWY. NO. 406 - GENEVA ST. CONNECTION

ST. CATHARINES

DESIGNED G. CHERRINGTON	DISTRICT NO. 4	DATE OCT. 18, 1966
DRAWN F. CLARK	W.P. NO. 126-66-1	JOB NO. 62-F-62
CHECKED	CONT. NO.	DRAWING NO. 62-F-62 E
APPROVED		

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

CONSISTENCY	'N' BLOWS / FT.	c LB. / SQ. FT.	DENSENESS	'N' BLOWS / FT.
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKE SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUPE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Qu	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Qcu	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Qd	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX $= \frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX $= \frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX $= \frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE $= \frac{-\Delta e}{(1+e)\Delta \sigma'}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX $= \frac{\Delta e}{\Delta \log_{10} \sigma'}$
T_v	TIME FACTOR $= \frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF EFFECTIVE STRESS $\tau_f = c' + \sigma' \tan \phi'$
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
	IN TERMS OF TOTAL STRESS $\tau_f = c_u + \sigma \tan \phi$
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3·1416
e	BASE OF NATURAL LOGARITHMS 2·7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
σ'	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNGS MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_o	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC. IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

FORM OB-ML-126 REV 1961 OFFICE REPORT ON SOIL EXPLORATION

61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 2

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 260+75 (90' Rt.) ORIGINATED BY B.K.

W.P 126-58(-1) BORING DATE May 7, 1962. COMPILED BY B.K.

DATUM 288.3' BOREHOLE TYPE Washboring. CHECKED BY M.D

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS / FOOT
289.0	Groundlevel Topsoil				
	Fill-of sand silt and clay pockets grey and brown some org. material.		1	TW	P
279.8	Very loose.		2	SS	2
8.5	Grey-black silty clay with org. matter.		3	TW	P
273.3	Soft to med. stiff.		4	TW	P
15.0	Grey to grey-brown silty clay with seams of silty sand. Soft to stiff.		5	TW	P
			6	TW	P
			7	TW	P
			8	TW	P
255.3					
33.0	End of borehole.				

ELEV. SCALE: 290, 280, 270, 260, 250

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT 10 20 30 40 50

SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
O - Triaxial
500 1000 1500 2000 2500

+ 3.6
⊕ 3.3
+ 2.5
+ 5.3
+ 2.3
1.8 +
+ 1.9

LIQUID LIMIT ——— w_L
PLASTIC LIMIT ——— w_P
WATER CONTENT ——— w
w_P w w_L
WATER CONTENT % 20 40 60

BULK DENSITY γ P.C.F.
121.0

REMARKS
▽wl 282.0

FORM OB-ML-126 REV. 1961 OFFICE REPORT ON SOIL EXPLORATION

61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 3

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 261+46 (28' Lt.) ORIGINATED BY B.K.

W.P. 126-58(-1) BORING DATE May 8, 1962. COMPILED BY B.K.

DATUM 288.9ft. BOREHOLE TYPE Washboring. CHECKED BY M.D.

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE
289.0	Groundlevel					290
	Topsoil					
	Fill of sand, silt and clay pockets, some org. material and gravel, grey and brown.		1	SS	56	
			2	TW	P	
278.9						280
10.0	Grey-black silty clay with org. material		3&3A	TW	P	
	Soft to med. stiff.		4	TW	P	
272.9						
16.0	Silty clay with seams of silty sand.		5	TW	P	
	Soft to stiff.		6	TW	P	270
			6A	TW	P	
	Grey to grey brown.		7&7A	TW	P	
						260
			8&8A	TW	P	
			9	TW	P	
			10	TW	P	
						250
			11	SS	120	
246.9						
42.0	Red glacial till					
242.4	V. dense.					
46.5	End of borehole.					240

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT — 350 ft/lb.
10 20 30 40 50

SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
○ - Triaxial
500 1000 1500 2000 2500

2.9
2.3
5.0
4.3
1.9
3.8
9.0

LIQUID LIMIT —— w_L
PLASTIC LIMIT —— w_P
WATER CONTENT —— w

w_P w w_L

WATER CONTENT %
20 40 60

BULK DENSITY γ P.C.F.

117.0
129.0
142.0
131.0

REMARKS

∇ wl 286.0

FORM 08-ML-126 REV. 1961
61-4391

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 263+32 (38' Rt. ℄) ORIGINATED BY B.K.

W.P. 126-58-1 BORING DATE May 9, 1962. COMPILED BY B.K.

DATUM 297.0' BOREHOLE TYPE Washboring. CHECKED BY M.D.

ELEV. / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT
297.0	Groundlevel				
	Topsoil				
	Fill of sand, silt & clay pockets, some org. mat'l. Gravel & cinders; brown to red brown.		1	SS	10
			2	SS	3
287.0	Loose to very loose.		3	SS	5
10.0			4	TW	32
	Grey to grey-brown silty clay with varying amounts of silt and sand, hard to stiff.		5	TW	P
			6	TW	P
	Layer of red-brown gravel, sandy firm clay between elev 285.0 and 281.0'		7	TW	P
			8	TW	P
			9	TW	P
			10	TW	P
			11	TW	P
248.0					
246.5	Red till-Very dense.		12	SS	115
50.5	End of borehole.				

ELEV. SCALE: 300, 290, 280, 270, 260, 250, 240

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT — 350 ft./lb.
10 20 30 40 50

SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
○ - Triaxial
500 1000 1500 2000 2500

+ 3.1
+ 4.8
+ 4.3
+ 1.7
+ 1.8
+ 4.3
+ 1.8

LIQUID LIMIT — W_L
PLASTIC LIMIT — W_P
WATER CONTENT — W
W_P W W_L
WATER CONTENT %
20 40 60

BULK DENSITY γ P.C.F.
115
123

REMARKS
wl 289.0

FORM OB-ML-[illegible] REV. 1961
61-4391

OFFICE REPORT — SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 5

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 264+49 (31' Rt.) ORIGINATED BY G.C.
W.P 126-58-1 BORING DATE June 20,1962. COMPILED BY G.C.
DATUM Geodetic BOREHOLE TYPE Washboring. CHECKED BY M.D.

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	REMARKS
316.0 / 0.0	Groundlevel						
	Brown clay to silty clay. Hard to stiff.		1	SS	38	310	
			2	SS	29		
			3	SS	24	300	
			4	SS	17		
291.0 / 25.0			5	SS	10	290	
			6	TW	P		
	Gray clay to silty clay. Med. stiff to stiff.		7	TW	P	280	
			8	TW	P		
			9	TW	P	270	
			10	TW	P		
			11	TW	P	260	
251.0							
249.5 / 66.5	Till (Dense) End of borehole.		12	SS	34	250	

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT
10 20 30 40 50

SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
O - Triaxial
500 1000 1500 2000 2500

LIQUID LIMIT — w_L
PLASTIC LIMIT — w_P
WATER CONTENT — w
w_P w w_L
WATER CONTENT %
20 40 60

BULK DENSITY γ P.C.F.
109
125
134
134

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 6

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 262+35 (7' Rt.) ORIGINATED BY B.K.

W.P 126-58-1 BORING DATE June 19, 1962. COMPILED BY B.K.

DATUM 286.5' BOREHOLE TYPE Washboring. CHECKED BY M.D.

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT (10 20 30 40 50); SHEAR STRENGTH P.S.F. ⊕ - Unconfined, + - Vane, O - Triaxial (500 1000 1500 2000 2500)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w; WATER CONTENT % (20 40 60)	BULK DENSITY γ P.C.F.	REMARKS
286.5 / 0.0	Groundlevel Fill					290				
▽282.0 / 4.5	Ashes, sand clay & gravel.		1	TW	P	280	+ 3.0		100	106% organics
278.5 / 8.0	Gray silty clay mixed with organics. Soft to med. stiff.		2	TW	P		+ 5.0		126	2.3% organics
			3	TW	P	270	+8.7		116.5	0.7% organics
			4	TW	P		+ 4.0		116	
260.0 / 26.5	Brown silty clay (stiff) changing to gray clayey silt. Med. stiff to stiff.		5	TW	P	260	+3.7		122	
			6	TW	P		+2.0		126	
			7	TW	P	250	+ 1.8		131	
			8	TW	P		+ 1.9		132	
			9	TW	P	240	+ 2.1		132	
			10	TW	P		+ 4.4			
						230				
227.0 / 59.5	Till		11	SS	42					
220.0 / 66.5	Very dense. End of borehole.		12	SS	76	220				

FORM OB-ML-126 REV. 1961
61-4391

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 7

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 260+79 (48' Lt.) ORIGINATED BY B.K.

W.P. 126-58-1 BORING DATE June 21, 1962. COMPILED BY B.K.

DATUM 291.3' BOREHOLE TYPE Washboring. CHECKED BY M.D.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE
291.3	Groundlevel					
0.0	Fill Ashes, sand and gravel. Very loose.		1	SS	2	290
281.8						
9.5	Clay with organics. Soft.		2	TW	P	280
273.3						
13.0	Silty clay. Soft to med. stiff.		3	TW	P	
			4	TW	P	270
268.3						
23.0	Clayey silt. Med. stiff to stiff. (Occasional silt seams).		5	TW	P	
			6	TW	P	260
			7	TW	P	
			8	TW	P	250
245.8			9	TW	P	
45.5	Till Med. dense to very dense.		10	SS	22	
239.6			11	SS	120	240
51.5	End of borehole.					
						230

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT
10 20 30 40 50

SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
○ - Triaxial
500 1000 1500 2000 2500

+4.0
+5.8
+6.3
+2.2
+2.0

LIQUID LIMIT ——— w_L
PLASTIC LIMIT ——— w_P
WATER CONTENT ——— w
w_P w w_L
WATER CONTENT %
20 40 60

BULK DENSITY
P.C.F.
125.0
128.0
125.0

REMARKS

▽ wl 285.3

FORM OB-ML-12 REV 1961 OFFICE REPORT ON SOIL EXPLORATION

61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 8

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 260+21 (6' Lt.) ORIGINATED BY B.K.

W P 126-58-1 BORING DATE June 22, 1962. COMPILED BY B.K.

DATUM 292.0' BOREHOLE TYPE Washboring CHECKED BY M.D.

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT 10 20 30 40 50 / SHEAR STRENGTH P.S.F. ⊕ - Unconfined + - Vane ○ - Triaxial 500 1000 1500 2000 2500	LIQUID LIMIT w_L PLASTIC LIMIT w_P WATER CONTENT w WATER CONTENT % 20 40 60	BULK DENSITY γ P.C.F.	REMARKS
292.0	Groundlevel					300				
0.0	Fill Clay, ashes, sand					290				
	Loose.		1	SS	4					wl 286.0
283.5										
8.5	Clay with organics.		2	TW	P	280	⊕		102.0	Air Dry Oven dry.
277.0	Very soft.						3.0			
15.0			3	TW	P		○ ⊕ + 10.0		106.0	
	Gray clayey silt with silt seams.		4	TW	P	270	○ ⊕		125	Brown.
			5	SS	2					
	Soft to very stiff.		6	TW	P		+4.0			
			7	TW	P	260	+ 3.8			
			8	TW	P		○ ⊕ + 2.5		128	
						250	+ 3.3			
247.0										
45.0	Till		9	SS	53					
242.0	Very dense.		10	SS	100					
50.0	End of borehole.					240				

236

FORM 08-ML-126 REV. 1961 OFFICE REPORT ON SOIL EXPLORATION

61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 9

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 259+25 (49' Lt.) ORIGINATED BY G.C.

W.P. 128-58-1 BORING DATE June 18&19, 1962. COMPILED BY G.C.

DATUM Geodetic BOREHOLE TYPE Washboring. CHECKED BY M.D

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE
294.3	Groundlevel					
0.0	Fill Ashes, sand, gravel and clay, Very loose.		1	SS	2	290
288.3 6.0			2	TW	P	
	Brown to grey-brown silty clay with occasional silt seams.		3	TW	P	
			4	SS	26	280
	Very stiff to med. stiff.		5	TW	P	
			6	TW	P	270
			7	TW	P	
			8	TW	P	260
			9	TW	P	
			10	TW	P	250
245.3 49.0						
	Till		11	SS	159	
243.3 51.0	Very dense. End of borehole.					240

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT
20 40 60 80 100

SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
O - Triaxial
500 1000 1500 2000 2500

LIQUID LIMIT ——— w_L
PLASTIC LIMIT ——— w_P
WATER CONTENT ——— w
w_P w w_L
WATER CONTENT %
20 40 60

BULK DENSITY γ P.C.F.

BULK DENSITY	REMARKS
	$\bar{\nabla}$ wl 286.3
113.0	3.8% organic content
125.0	0.4% org. content.
122.0	
131.0	
129.0	
118.0	

FORM OB - ML - 126 REV. 1961
61-4391

OFFICE REPORT ON SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 10

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 258+59 (5' Rt.) ORIGINATED BY G.C.

W.P. 126-58-1 BORING DATE June 21, 1962. COMPILED BY G.C.

DATUM Geodet. ? BOREHOLE TYPE Washboring. CHECKED BY M.D

SOIL PROFILE ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE
295.8	Groundlevel					
0.0	Fill					
292.3	Sand, gravel & clay.					
3.5	Brown silty clay. Very stiff to med. stiff.		1	SS	22	
			2	SS	21	
			3	TW	P	
277.8						
18.0	Gray brown silty clay. Very stiff to med. stiff.		4	TW	P	
			5	TW	P	
			6	TW	P	
			8	TW	P	260
			9	TW	P	
						250
244.8						
51.0	Till					
52.0						240

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT 20 40 60 80 100
SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
○ - Triaxial
500 1000 1500 2000 2500

LIQUID LIMIT — w_L
PLASTIC LIMIT — w_P
WATER CONTENT — w
w_P w w_L
WATER CONTENT % 20 40 60

BULK DENSITY P.C.F.

122
115
130.0
129.0
127.0

REMARKS

$\bar{\nabla}$ wl 284.3

Top
Middle
Bottom

+4.0
+3.0
+2.0
+1.7

FORM 08-ML-126 REV 1961 OFFICE REPORT ON SOIL EXPLORATION
61-4361

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 11

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 262+97 (18' Rt.) ORIGINATED BY G.C.

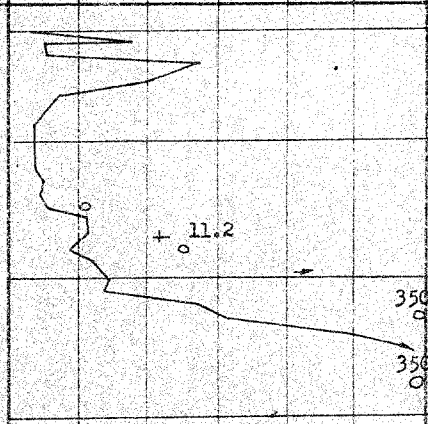
W.P 126-58-1 BORING DATE June 21, 1962. COMPILED BY G.C.

DATUM Geodetic BOREHOLE TYPE Washboring. CHECKED BY M.D.

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE
298.0	Groundlevel					
0.0	Fill. Sand, clay, gravel & organics. Loose to very loose.		1	SS	10	290
			2	SS	2	
287.0						
11.0	Gray clay mixed with organics. Med. stiff to stiff.		3	TW	P	
			4	TW	14	280
280.0						
18.0	Brown clay. Very stiff.		5	SS	42	
			6	SS	35	270
270.0						
28.0	Gray clayey silt with occasional silt seams. Stiff to med. stiff.		7	TW	P	
			8	TW	P	
			9	TW	P	260
			10	TW	P	
			10A	SS	16	
			11	TW	P	250
246.0						
52.0	Till Very dense.		12	SS	56	
			13	SS	69	240
237.5						
60.5	End of borehole.					

DYNAMIC PENETRATION RESISTANCE
BLOWS / FOOT 20 40 60 80 100
SHEAR STRENGTH P.S.F.
⊕ - Unconfined + - Vane
○ - Triaxial
500 1000 1500 2000 2500

LIQUID LIMIT ——— w_L
PLASTIC LIMIT ——— w_P
WATER CONTENT ——— w
WATER CONTENT % 20 40 60



BULK DENSITY γ P.C.F.	REMARKS
	▽ wl 289.0
118.0	
119.0	Air Dry Oven Dry
130.0	
	Lost
133.0	
129.0	
142.0	
107.0	
	Lost

FORM OB-ML-126 REV. 1961 OFFICE REPORT ON SOIL EXPLORATION
61-4091

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO 12

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 259 + 70 (10' Lt.) ORIGINATED BY * JP
W P BORING DATE 27th Sept. and 1st Oct. 1962 COMPILED BY MC
DATUM BOREHOLE TYPE Augerhole CHECKED BY JP

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT — SHEAR STRENGTH P.S.F. ⊕ - Unconfined, Field vane test + (1000 2000 3000 4000 5000)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w — WATER CONTENT %	BULK DENSITY P.C.F.	REMARKS
293.5	Ground level									
0.0	Grey-brown gravelly clay fill									
289.0			1	SS	21	290				
4.5	Rubble fill (ash, clay, gravel sand, organics)		2	SS	14					285.8 / 7.7 / 1/10/62
			3	SS	2	285				
283.2										
10.3	Soft black organic clay		4	SS	2		3.0			
281.5										
12.0	grey		5	TW	p	280				
			6	SS	2		2.0			
			7	SS	9	275	2.3			
23.0										
			8	TW	p	270				
266.5			9	SS	6		2.0			
27.0							1.3			
	grey with traces of red Clay silty		10	SS	6	265	2.2			
			11	TW	p	260				
			12	SS	11		1.7			
40.0						255				
			13	SS	6		2.2			
43.0	grey with red seams (varved very silty, many silt seams					250				
			14	SS	9		1.7			
						245				
242.5	Reddish brown silt till		15a							
51.0			15b	SS	92	242.0				

51.5 End of borehole

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

FORM OB-ML-126 REV. 1961 OFFICE REPORT ON SOIL EXPLORATION
61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 13

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 260 + 00 (50' Lt.) ORIGINATED BY * JP
W.P. BORING DATE Oct. 1, 1962 COMPILED BY MC
DATUM BOREHOLE TYPE Augerhole CHECKED BY JP

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT / SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w — WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
293.0	Ground level									
0.0	Gravelly clay fill					290				
289.0 4.0										
	Rubble fill (ash, clay, gravel, sand, organics)		1	SS	6	285				285.4 7.6 1/10/62
283.5 9.5	Organics		2	SS	2					
281.7 11.3	Soft black organic clay					280				
280.5 12.5	Soft grey clay									
278.0 15.0	End of borehole									

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

FORM OB-ML-126 REV 1961 OFFICE REPORT ON SOIL EXPLORATION
61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 14

FOUNDATION SECTION

JOB 62-P-62 LOCATION Sta. 260 + 40 (30' Rt.) ORIGINATED BY * JP
W.P. BORING DATE 2nd Oct. 1962 COMPILED BY MC
DATUM BOREHOLE TYPE Augerhole CHECKED BY JP

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT / SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w — WATER CONTENT %	BULK DENSITY P.C.F.	REMARKS
291.0	Ground level									
0.0	Gravelly clay fill, trace of organics					290				
285.5										285.2 5.8 5/10/62
5.5	Rubble fill (ash, clay, gravel, sand, organics)		1	SS	5	285				
283.0										
8.0	Soft black organic clay									
280.5										
10.5	Soft grey clay		2	SS	0	280				
279.5										
11.5	End of borehole									

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 15

FOUNDATION SECTION

JOB 62-F-62
W.P.
DATUM
LOCATION Sta. 260 + 00 (50' Rt.)
BORING DATE 1st October 1962
BOREHOLE TYPE Augerhole
ORIGINATED BY * JP
COMPILED BY MC
CHECKED BY JP

ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F.	WATER CONTENT % (LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w)	BULK DENSITY γ P.C.F.	REMARKS
292.0	Ground level									
0.0	Miscellaneous fill (clay, gravel, sand, ash, organics) Loose					290		307 / 282 / 21		
			1	SS	4	285				285.7 / 6.3 / 1/10/62
283.5 / 8.5	Soft black organic clay									
281.2 / 10.8	Soft grey clay		2	SS	0					
280.5 / 11.5	End of borehole					280				

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 16

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 259 + 25 (50' Rt.) ORIGINATED BY * JP
W.P. BORING DATE 1st Oct. 1962 COMPILED BY MC
DATUM BOREHOLE TYPE Augerhole CHECKED BY JP

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT — SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L — PLASTIC LIMIT w_P — WATER CONTENT w — WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
294.0	Ground level									
0.0	Gravelly clay fill, some organics					290				
288.5										
5.5	Rubble fill, (clay, gravel, sand, ash, organics) Loose		1	SS	13	285				▽ 286.7 7.3 1/10/62
282.7			2	SS	4					
11.3	Soft black organic clay					280				
281.0										
13.0	Soft grey clay									
279.0										
15.0	End of borehole									

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

FORM OB - ML - 126 REV. 1961 OFFICE REPORT ON SOIL EXPLORATION

61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 17

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 263 + 75 (60' Rt.) ORIGINATED BY * JP

W.P. BORING DATE 3rd Oct. 1962 COMPILED BY MC

DATUM BOREHOLE TYPE Augerhole CHECKED BY JP

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT / SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w / WATER CONTENT %	BULK DENSITY P.C.F.	REMARKS
299.0	Ground level									
0.0	Clay, gravel and ash fill									Open and dry 5/10/62
297.0										
2.0						295				
	Stiff brown clay		1	SS	10					
						290				
287.5			2	SS	10					
11.5	End of borehole									

* Compiled by Dominion Soil Investigation Limited, Ref: 2-9-L6

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61-4391

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 18

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 263 + 25 (35' Lt.) ORIGINATED BY * JP

W.P. BORING DATE 3rd Oct. 1962 COMPILED BY MC

DATUM BOREHOLE TYPE See remarks CHECKED BY JP

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT / SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w / WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
297.0	Ground level									
0.0	Fill gravelly					295				0 - 5'0" - wash bore
2.0										5'0" - 18'0" - auger
			1	SS	11	290				297.0 / 3.0
	Stiff Silty Clay with traces of organics - Brown to Grey-Brown.		2	SS	20	285				5/10/62 (apparently rain water)
			3	SS	33					Open and dry 3/10/62
279.0			4	SS	19	280				
18.0	End of borehole									

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 19

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 263 + 75 (60' Lt.) ORIGINATED BY * JP
W.P. BORING DATE 2nd and 3rd Oct. 1962 COMPILED BY MC
DATUM BOREHOLE TYPE See remarks CHECKED BY JP

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	TYPE	BLOWS / FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT — SHEAR STRENGTH P.S.F. ⊕ - Unconfined, Field vane test + (1000 2000 3000 4000 5000)	LIQUID LIMIT w_L, PLASTIC LIMIT w_P, WATER CONTENT w — WATER CONTENT %	BULK DENSITY P.C.F.	REMARKS
296.0	Ground level									
0.0	Sandy gravelly clay fill					295				0 -35'0" auger
291.5										35'0" - 48'6" washbore
4.5	Ash		1	SS	1	290				▽ 290.0 = 6.0 5/10/62
288.5										
7.5	Layers of brown and black organic clay Soft		2	SS	0	285	+ 1.7			
281.5										
14.5			3	TW	p	280	⊕			
			4	SS	10		+ 3.0			
						275				
			5	SS	11		+ 2.3			
	Reddish-brown clay, stiff to very stiff		6	TW	p	270				
			7	SS	11		+ 1.5			
						265				
			8	TW	p					
			9	TW	p	260	⊕			
			10	SS	16		+ 1.5			
						255				
			11	SS	9		+ 2.5			
251.5										
44.5			12	TW	p		⊕			
	Reddish-brown sandy silt till		13	SS	23	250				
247.5			14	SS	101					
48.5	End of borehole									

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

FORM OB - ML - 126 REV 861
61-4391

OFFICE REPORT OF SOIL EXPLORATION

DEPARTMENT OF HIGHWAYS - ONTARIO
MATERIALS & RESEARCH DIVISION

RECORD OF BOREHOLE NO. 20

FOUNDATION SECTION

JOB 62-F-62 LOCATION Sta. 264 + 15 (25' Lt.) ORIGINATED BY * JP

W.P. BORING DATE 4 October 1962 COMPILED BY MC

DATUM BOREHOLE TYPE Augerhole CHECKED BY JP

ELEV. / DEPTH	SOIL PROFILE DESCRIPTION	STRAT. PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/FOOT	ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT / SHEAR STRENGTH P.S.F.	LIQUID LIMIT w_L / PLASTIC LIMIT w_P / WATER CONTENT w — WATER CONTENT %	BULK DENSITY γ P.C.F.	REMARKS
300.0	Ground level									
0.0 / 299.0	Organic clayey topsoil									Open and dry 5/10/62
1.0	Stiff brown clay					295				
292.5			1	SS	20					
7.5	End of Borehole									

* Compiled by Dominion Soil Investigation Limited. Ref: 2-9-L6

APPENDIX B

Appendix B – Record of Boreholes - Current Investigation

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
FoS	factor of safety

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split-spoon
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open sampler for a distance of 300 mm (12 in.)

Dynamic Cone Penetration Resistance; N_d:

The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60º cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Non-Cohesive (Cohesionless) Soils

Compactness Condition	N Blows/300 mm or Blows/ft
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) Cohesive Soils

Consistency

	c_u, s_u kPa	c_u, s_u psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

Note: 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

V. MINOR SOIL CONSTITUENTS

Per cent by Weight	Modifier	Example
0 to 5	Trace	Trace sand
5 to 12	Trace to Some (or Little)	Trace to some sand
12 to 20	Some	Some sand
20 to 30	(ey) or (y)	Sandy
over 30	And (non-cohesive (cohesionless)) or With (cohesive)	Sand and Gravel Silty Clay with sand / Clayey Silt with sand

GOLDER

RECORD OF BOREHOLE No 17-1

SHEET 1 OF 3 **METRIC**

PROJECT 1541610
G.W.P. 2453-13-00 LOCATION N 4779913.3; E 326043.0 MTM NAD 83 ZONE 10 (LAT. 43.158778; LONG. -79.238784) ORIGINATED BY KN
DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH
DATUM Geodetic DATE October 30-31, 2017 CHECKED BY SMM

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 ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (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
98.0	GROUND SURFACE										
0.0	TOPSOIL (76 mm)										
0.1	Sandy clayey silt, trace gravel, trace rootlets, trace asphalt and brick fragments (FILL) Stiff Brown Moist		1	SS	14						
			2	SS	9		97		○		
96.7											
1.3	Clayey silt to silty clay, some sand, trace to some gravel, trace organics (FILL) Firm to very stiff Brown to grey-brown Moist to moist-wet		3	SS	16						
			4	SS	9		96		○		
			5	SS	12		95				
							94				
			6	SS	13		93		⊢●⊣		
							92				
			7	SS	17						
90.8							91				
7.2	Sandy CLAYEY SILT, trace gravel Hard Reddish-brown Moist		8	SS	15		90		○		
	- Organic odour from depths between 9.2 m and 11.3 m - Grey to black-grey from depths between 9.2 m and 11.3 m		9	SS	15		89		○⊢●		3 19 45 33
	- Trace organics and shell fragments from depths between 10.7 m and 11.3 m		10	SS	4		88				
							87		○		
	- Wood fragments / organics from depths between 12.2 m and 12.8 m		11	SS	13		86				
							85				
			12	SS	14		84				

Continued Next Page

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

GOLDER

PROJECT 1541610

RECORD OF BOREHOLE No 17-1

SHEET 2 OF 3

METRIC

G.W.P. 2453-13-00 LOCATION N 4779913.3; E 326043.0 MTM NAD 83 ZONE 10 (LAT. 43.158778; LONG. -79.238784) ORIGINATED BY KN

DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH

DATUM Geodetic DATE October 30-31, 2017 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 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 ---										
	Sandy CLAYEY SILT, trace gravel Hard Reddish-brown Moist		13	SS	5		82				
	- No recovery in Shelby tube 1		1	TO	PH						
			14	SS	6		81				
	- No recovery in Shelby tube 2		2	TO	PH		80	+ 2			
							79	>96 +			
			15	SS	13		78				3 15 45 37
	- Sand lens at 21.7 m		16	SS	14		77				
75.6							76				
22.4	Sandy CLAYEY SILT, trace gravel (TILL) Hard Redish-brown Moist		17	SS	76		75				4 24 58 14
74.1							74				
23.9	SILT and SAND, trace clay Very dense Grey to reddish-grey Moist to wet		18	SS	102/0.28		73				0 53 44 3
			19	SS	78		72				
71.0							71				
27.0	SAND, some silt, trace clay, trace to some gravel Compact to dense Grey to brown-grey Wet		20	SS	38		70				0 82 15 3
			21	SS	28		69				

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No 17-1

SHEET 3 OF 3 **METRIC**

PROJECT 1541610
G.W.P. 2453-13-00
DIST Central HWY 406
DATUM Geodetic

LOCATION N 4779913.3; E 326043.0 MTM NAD 83 ZONE 10 (LAT. 43.158778; LONG. -79.238784)
BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud
DATE October 30-31, 2017

ORIGINATED BY KN
COMPILED BY DH
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
	SAND, some silt, trace clay, trace to some gravel Compact to dense Grey to brown-grey Wet										
			22	SS	29		67				
65.4			23	SS	38		66				
32.6	END OF BOREHOLE										

NOTES:

1. Borehole dry prior to beginning of wash boring operations at a depth of 4.6 m (Elev. 93.4 m) below ground surface.

2. Water level measurement in the casing at the beginning of each work shift

Date	Depth (m)	Elev. (m)
31/10/17	0.1	97.9

The water level measurement are not considered representative of the groundwater level due to introduction of water / drilling mud during wash boring operations.

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

$\circ^{3\%}$ STRAIN AT FAILURE

GOLDER

RECORD OF BOREHOLE No 17-2/2A

SHEET 1 OF 2

METRIC

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779907.6; E 326069.7 MTM NAD 83 ZONE 10 (LAT. 43.158725; LONG. -79.238456) ORIGINATED BY KN

DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH/SK

DATUM Geodetic DATE October 31, 2017 and April 12 and 17, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (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
90.3	GROUND SURFACE										
0.0	Sandy clayey silt to clayey silt, trace rootlets, trace to some gravel, trace sand, trace brick fragments (FILL) Stiff to soft Brown to black Moist to moist-wet		1	SS	6		90				
			2	SS	14						
			3	SS	12		89				
	- Organic odour at a depth below 2.3 m		4	SS	4	▽	88				
87.3											
3.0	Silty sand, trace clay, trace glass fragments, black clayey silt pockets (FILL) Very loose Grey Wet		5	SS	2		87		○		
86.6											
3.7	SILTY CLAY to CLAY, trace wood / organics, trace sand, trace gravel Firm to very stiff Grey to brown Wet to moist - Hydrocarbon odour from depths between 3.8 m and 4.4 m		6	SS	6		86		○		
			7	SS	12		85				
			8	SS	23		84		⊢●⊣		0 4 38 58
83.1											
7.2	Sandy CLAYEY SILT, trace gravel Very stiff Brown Moist		9	SS	16		83				
82.1											
8.2	END OF BOREHOLE 17-2 Advanced Borehole 17-2A 0.4 m east of Borehole 17-2.						82				
							81				
							80				
							79				
							78				
							77				
76.6	START OF SAMPLING BOREHOLE 17-2A										
13.7	CLAYEY SILT, trace sand, trace to some gravel Soft to stiff Grey Moist to wet		1	SS	14		76				
			2	SS	3						

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No 17-2/2A

SHEET 2 OF 2 **METRIC**

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779907.6; E 326069.7 MTM NAD 83 ZONE 10 (LAT. 43.158725; LONG. -79.238456) ORIGINATED BY KN

DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH/SK

DATUM Geodetic DATE October 31, 2017 and April 12 and 17, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	--- *CONTINUED FROM PREVIOUS PAGE* ---							20 40 60 80 100	20 40 60		
	CLAYEY SILT, trace sand, trace to some gravel Soft to stiff Grey Moist to wet		3	SS	10		75				
74.4											
15.9	Sandy CLAYEY SILT, trace to some gravel (TILL) Stiff to hard Grey to brown Moist		4	SS	28		74				6 23 58 13
73.2			5A 5B 5C	SS	36		73				
17.1	SILT, some sand, trace to some gravel, some silty clay seams Dense to very dense Grey Wet		6A 6B 6C	SS	60						6 15 64 15
72.1							72	123			
18.2	SAND, some silt, trace clay Compact to dense Grey Wet - Clayey silt layer between depth of about 18.2 and 18.6 m		7A 7B	SS	30						
			8	SS	22		71	160			0 79 18 3
			9	SS	21		70	164 173 181			
69.1			10	SS	24						
21.2	END OF BOREHOLE										

NOTES:

1. Borehole 17-2 was terminated at a depth of 8.2 m below ground surface (Elev. 82.1 m) on October 31, 2017. Borehole 17-2A was terminated at a depth of 21.2 m (Elev. 69.1 m) below ground surface on April 12, 2018.

2. Water level measurement in borehole at a depth of about 2.5 m below ground surface (Elev. 87.8 m) upon completion of drilling Borehole 17-2 on October 31, 2017.

3. Borehole 17-2 cave to a depth of about 4.3 m below ground surface (Elev. 86.0 m) upon completion of drilling on October 31, 2017.

4. Artesian conditions noted in Borehole 17-2A at a depth of about 4.6 m below ground surface (Elev. 85.7 m) on April 12, 2018. Water level measured at 0.4 m above ground surface.

5. In a seperate borehole casing advanced to Elev. 73.0 m then carried out a Dynamic Cone Penetration Test to refusal at Elev. 68.8 m.

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

GOLDER

PROJECT 1541610

RECORD OF BOREHOLE No 17-3/3A

SHEET 1 OF 2

METRIC

G.W.P. 2453-13-00 LOCATION N 4779896.7; E 326090.3 MTM NAD 83 ZONE 10 (LAT. 43.158627; LONG. -79.238203) ORIGINATED BY KN

DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH/SK

DATUM Geodetic DATE November 1, 2017 and April 12 and 18, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED 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
87.4	GROUND SURFACE										
0.0	Clayey silt, trace rootlets organics at surface, some gravel, containing concrete fragments (FILL) Hard Brown Moist		1	SS	100/0.05						
			2	SS	100/0.08						
86.1											
1.3	Gravel, some sand, some clay (FILL) Compact Brown		3	SS	19						
85.2	Moist										
2.2	CLAYEY SILT with SAND, trace gravel Firm to stiff Brown - grey Wet - Hydrocarbon odour from depths between 2.3 m and 2.9 m - Black between depths of 2.3 m and 2.9 m		4	SS	6						
			5	SS	11	▽					
			6	SS	7						1 38 40 21
			7	SS	3						
			8	SS	8						
78.6											
8.8	END OF BOREHOLE 17-3 Advanced Borehole 17-3A 0.7 m southeast of Borehole 17-3.										

Continued Next Page

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

GOLDER

PROJECT 1541610

RECORD OF BOREHOLE No 17-3/3A

SHEET 2 OF 2

METRIC

G.W.P. 2453-13-00 LOCATION N 4779896.7; E 326090.3 MTM NAD 83 ZONE 10 (LAT. 43.158627; LONG. -79.238203) ORIGINATED BY KN

DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH/SK

DATUM Geodetic DATE November 1, 2017 and April 12 and 18, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%): GR	SA	SI	CL
	--- CONTINUED FROM PREVIOUS PAGE ---										
72.1	START OF SAMPLING BOREHOLE 17-3A										
15.3	CLAYEY SILT, trace sand, trace gravel Firm Brown Moist to wet		1	SS	7						
			2	SS	5						
70.3			3A 3B	SS	8						
17.1	Sandy SILT, trace to some clay, trace gravel (TILL) Loose to dense Brown Moist		4	SS	28			4	25	60	11
			5	SS	41						
67.7			6	SS	28						
19.7	SILT, trace to some sand, trace to some clay, trace gravel Very dense Brown Moist		7A 7B	SS	61			3	5	85	7
66.5			8A	SS	39						
66.2	CLAYEY SILT, some sand, some gravel Hard Brown Moist		8B								
21.2	END OF BOREHOLE										

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

ELEVATION SCALE: 72, 71, 70, 69, 68, 67

152

134

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

NOTES:

1. Borehole 17-3 was terminated at a depth of 8.8 m below ground surface (Elev. 78.6 m) on November 1, 2018. Borehole 17-3A was terminated at a depth of 21.3 m below ground surface (Elev. 66.1 m) on April 12, 2018.

2. Water level measurement recorded in borehole at a depth of about 3.4 m below ground surface (Elev. 84.0 m) upon completion of drilling Borehole 17-3.

3. Borehole caved to a depth of 6.7 m below ground surface (Elev. 80.7 m) upon completion of drilling Borehole 17-3 on November 1, 2017.

4. In a seperate borehole casing was advanced to Elev. 72.0 m, then a Dynamic Cone Penetration Test was carried out to refusal at Elev. 66.2 m.

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

GOLDER

RECORD OF BOREHOLE No 17-4

SHEET 1 OF 2

METRIC

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779889.0; E 326105.4 MTM NAD 83 ZONE 10 (LAT. 43.158557; LONG. -79.238018) ORIGINATED BY KN

DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH

DATUM Geodetic DATE November 1, 2017 and April 19, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (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
88.1	GROUND SURFACE						88				
0.0	Sandy clayey silt to clayey silt, some gravel, trace rootlets, trace brick fragments (FILL) Firm to stiff Brown Moist		1	SS	11				○		
			2	SS	7	▼	87				
			3	SS	5				○		
85.9							86				
2.2	CLAYEY SILT, trace gravel, trace to some sand, sand layers Firm to stiff Brown to grey to reddish grey Moist to wet		4	SS	10				○		
			5	SS	11		85				
	- Wood / organics from depths between 4.6 m and 5.2 m		6	SS	5		84				
							83	>96 +			
			7	SS	6		82		○ H		1 5 59 35
								>96 +			
			8	SS	3		81				
							80	3 + 2 +			
			9	SS	11		79		○		
	- Silty sandy gravel layer (50 mm thickness) at a depth of about 10.7 m		10	SS	11		78				
							77				
			11	SS	10		76		○		
74.8							75				
13.3	CLAYEY SILT, some sand, trace gravel (TILL) Hard Reddish brown Moist		12	SS	40		74	126	○ H		9 19 60 12

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No 17-4

SHEET 2 OF 2 **METRIC**

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779889.0; E 326105.4 MTM NAD 83 ZONE 10 (LAT. 43.158557; LONG. -79.238018) ORIGINATED BY KN

DIST Central HWY 406 BOREHOLE TYPE 150mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH

DATUM Geodetic DATE November 1, 2017 and April 19, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (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 ---										
72.8	CLAYEY SILT (TILL)						73	184			
15.5	Gravelly SAND, some silt, trace clay Dense Grey Wet		13A 13B 13C	SS	37			193 159 180			
71.8	Sandy CLAYEY SILT, trace gravel (TILL) Hard Brown Moist						72	164 212			
16.3	SILT, some sand, trace to some clay Dense Grey Wet		14	SS	32		71				0 17 76 7
			15	SS	36		70				
68.7							69				
19.4	SILT and SAND, trace clay Compact to dense Reddish grey Wet		16	SS	26		68				0 56 43 1
			17	SS	32		67				
							66				
64.6			18	SS	39		65				
23.5	END OF BOREHOLE										

NOTES:

1. Water level at ground surface upon completion of drilling.

2. Water level measurements in standpipe piezometer

Date	Depth (m)	Elev. (m)
01/11/17	0	88.1
09/04/18	1.2	86.9
01/05/18	1.2	86.9

3. In a seperate borehole casing was advanced to Elev. 75.8 m, then a Dynamic Cone Penetration Test was carried out to refusal at Elev. 71.5 m.

4. Borehole advanced by mud-rotary, water level not representitive of in situ groundwater conditions.

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

GOLDER

RECORD OF BOREHOLE No 17-5

SHEET 1 OF 2

METRIC

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779880.2; E 326126.3 MTM NAD 83 ZONE 10 (LAT. 43.158477; LONG. -79.237761) ORIGINATED BY TP

DIST Central HWY 406 BOREHOLE TYPE 203mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY SK

DATUM Geodetic DATE April 9 and 11, 2018 CHECKED BY SMM

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 ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (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
88.3	GROUND SURFACE						88				
0.0	TOPSOIL (30 mm)										
	Silty clay, some sand, trace gravel (FILL) Soft to firm Brown Moist to wet		1	SS	6						
			2	SS	8		87				
			3	SS	3						
85.3			4	SS	8		86				
3.0	Sand and gravel, trace silt, trace clay (FILL) Compact Brown to black Wet		5	SS	17		85				
			6	SS	22						41 53 4 2
	- Hydrocarbon odour from depths between 3.0 m and 5.2 m		7A 7B	SS	15		84				
82.7							83				
5.6	CLAYEY SILT, trace to some sand, trace gravel Firm to stiff Grey Moist to wet		8	SS	1		82	1			
			9	TO	PH		81				
			10	SS	5		80	2 1			
							79	3			
			11	SS	2		78	1			3 11 46 40
							77	3 2			
			12	SS	3		76				
75.0								2			
13.3	CLAYEY SILT, trace to some sand, trace gravel (TILL) Hard Brown Moist		13	SS	49		75	1			
							74	146 195			

Continued Next Page

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

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GOLDER

RECORD OF BOREHOLE No 17-5

SHEET 2 OF 2 **METRIC**

PROJECT 1541610
G.W.P. 2453-13-00
DIST Central HWY 406
DATUM Geodetic

LOCATION N 4779880.2; E 326126.3 MTM NAD 83 ZONE 10 (LAT. 43.158477; LONG. -79.237761)
BOREHOLE TYPE 203mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud
DATE April 9 and 11, 2018

ORIGINATED BY TP
COMPILED BY SK
CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100 250) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED	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 ---										
	CLAYEY SILT, trace to some sand, trace gravel (TILL) Hard Brown Moist		14	SS	57		73				2 14 68 16
72.0											
16.3	CLAYEY SILT, some sand Hard Grey Moist		15	SS	41		72				
70.5							71				
17.8	SILT and SAND, trace clay Compact to dense Grey Wet		16A 16B 16C	SS	22		70				
							69				
67.9			17	SS	44		68				Non-plastic 0 56 42 2
20.4	END OF BOREHOLE NOTES: 1. In a seperate borehole casing was advanced to Elev. 76.0 m, then a Dynamic Cone Penetration Test was carried out to refusal at Elev. 73.2 m. 2. Borehole advanced by mud-rotary, water level not representitive of in situ groundwater conditions.										

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

GOLDER

RECORD OF BOREHOLE No 17-6

SHEET 1 OF 3

METRIC

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779867.0; E 326151.9 MTM NAD 83 ZONE 10 (LAT. 43.158358; LONG. -79.237447) ORIGINATED BY LK

DIST Central HWY 406 BOREHOLE TYPE 178mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY KN

DATUM Geodetic DATE April 30 and May 1, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
96.8	GROUND SURFACE					
0.0	ASPHALT (203 mm)					
96.2	CONCRETE with steel rebar (366 mm)					
0.6	Sand and gravel, trace silt (FILL) Compact Grey Moist		1	SS	22	
94.2						
2.6	Sand, trace gravel, trace silt (FILL) Compact Reddish brown Moist		2	SS	13	▽
92.2						
4.6	Clayey silt, trace sand, trace gravel (FILL) Stiff to very stiff Brown Moist		3A 3B	SS	6	
			4	TO	PH	
			5	SS	17	
			6	SS	14	
85.6			7A 7B	SS	25	
11.2	Sand, some gravel (FILL) Compact Black Moist - Hydrocarbon odour from depths between 11.2 m and 12.7 m		8	SS	20	
84.1			9A 9B	SS	10	
12.7	CLAYEY SILT, trace sand, trace gravel Soft to stiff Grey to greyish brown Moist to wet		10	SS	9	

ELEVATION SCALE: 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

GOLDER

PROJECT 1541610

RECORD OF BOREHOLE No 17-6

SHEET 2 OF 3

METRIC

G.W.P. 2453-13-00 LOCATION N 4779867.0; E 326151.9 MTM NAD 83 ZONE 10 (LAT. 43.158358; LONG. -79.237447) ORIGINATED BY LK

DIST Central HWY 406 BOREHOLE TYPE 178mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY KN

DATUM Geodetic DATE April 30 and May 1, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × REMOULDED (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 ---										
	CLAYEY SILT, trace sand, trace gravel Soft to stiff Grey to greyish brown Moist to wet		11	SS	5		81				3 4 53 40
			12	SS	3		80				
			13	SS	4		79				
			14	SS	5		78				
			15	SS	6		77				
74.2							76				
22.6	Sandy CLAYEY SILT, trace to some gravel (TILL) Hard Grey - Brown Moist		16	SS	49		75				4 23 59 14
72.5			17	SS	35		74				
24.3	SILT and SAND, trace clay Very dense Grey Moist		18	SS	78		73				0 65 32 3
71.0			19A 19B	SS	62		72				
25.8	SILT, clayey silt lenses, trace sand Dense Grey Moist		20	SS	35		71				
70.2											
26.6	Sandy SILT, trace to some clay, trace gravel Compact Grey Moist to wet		21	SS	18		70				2 24 67 7
68.8			22	SS	24		69				
28.0	END OF BOREHOLE NOTES: 1. Water level measurements in casing at the beginning of each work shift:										

Continued Next Page

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

GOLDER

RECORD OF BOREHOLE No 17-6

SHEET 3 OF 3 **METRIC**

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779867.0; E 326151.9 MTM NAD 83 ZONE 10 (LAT. 43.158358; LONG. -79.237447) ORIGINATED BY LK

DIST Central HWY 406 BOREHOLE TYPE 178mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY KN

DATUM Geodetic DATE April 30 and May 1, 2018 CHECKED BY SMM

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 × REMOULDED 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	--- CONTINUED FROM PREVIOUS PAGE ---										
	Date Depth(m) Elev.(m) 30/04/18 3.9 92.9 01/05/18 3.9 92.9 2. Borehole advanced by mud-rotary, water level not representitive of in situ groundwater conditions.										

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

GOLDER

RECORD OF BOREHOLE No 17-7

SHEET 1 OF 1

METRIC

PROJECT 1541610

G.W.P. 2453-13-00

LOCATION N 4779898.7; E 326114.1 MTM NAD 83 ZONE 10 (LAT. 43.158644; LONG. -79.237910)

ORIGINATED BY TP

DIST Central HWY 406

BOREHOLE TYPE 203mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud

COMPILED BY DH

DATUM Geodetic

DATE April 18, 2018

CHECKED BY SMM

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 ● QUICK TRIAXIAL + FIELD VANE × REMOULDED) (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
87.2	GROUND SURFACE						87				
0.0	TOPSOIL (152 mm)										
0.2	Sandy clayey silt, trace gravel, trace rootlets, trace concrete fragments (FILL)		1	SS	6				○		
86.5							86				
0.7	Firm Brown Moist CLAY, some silt, trace to some gravel, trace sand Firm to stiff Brown Moist		2	SS	12						
			3	SS	12		85		○		
			4	SS	6				○—		
84.1											
3.1	GRAVEL, some sand, trace to some silt, trace clay, inferred cobbles Dense Brown Wet		5A 5B	SS	31		84		○		73 19 6 2
83.5											
3.7	CLAYEY SILT, trace to some sand, trace gravel Very soft to stiff Grey and brown Moist to wet		6	SS	7		83				
			7	SS	2				○		
			8	TO	PH		82				
			9	SS	1		81		—○—		2 11 54 33
								+			
							80	2 +			
			10	SS	6						
							79	3 +			
								1 +			
			11	SS	5		78				
							77				
			12	SS	3				○		
75.9							76				
11.3	END OF BOREHOLE NOTE: 1. Borehole advanced by mud-rotary, water level not representitive of in situ groundwater conditions.										

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

$\circ^{3\%}$ STRAIN AT FAILURE

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GOLDER

RECORD OF BOREHOLE No 17-8

SHEET 1 OF 1 **METRIC**

PROJECT 1541610

G.W.P. 2453-13-00 LOCATION N 4779910.2; E 326105.8 MTM NAD 83 ZONE 10 (LAT. 43.158748; LONG. -79.238012) ORIGINATED BY TP

DIST Central HWY 406 BOREHOLE TYPE 203mm O.D. Continuous Flight Solid Stem Auger & Wash Boring with Drilling Mud COMPILED BY DH

DATUM Geodetic DATE April 16, 2018 CHECKED BY SMM

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
86.9	GROUND SURFACE								
0.0	TOPSOIL (152 mm)								
0.2	Sandy clayey silt, trace to some gravel (FILL) Firm Brown Moist		1	SS	6				
86.0 0.9	Sand and gravel, some silt, inferred cobbles (FILL) Loose to compact Grey Wet		2A 2B	SS	27		86		7 24 29 40
85.1 1.8	SILTY CLAY, trace sand, trace gravel Soft to stiff Brown to grey and brown Moist		3A 3B	SS	6		85		
			4	SS	2		84		
			5	SS	2				
			6	SS	7		83		1 2 49 48
			7	SS	6		82		
			8	SS	6		81		
			9	SS	5		80		
			10	SS	6		79		
			11	SS	7		78		
75.6							77		
11.3	END OF BOREHOLE NOTE: 1. Borehole advanced by mud-rotary, water level not representitive of in situ groundwater conditions.						76		

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

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

PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

+ 4 (Sensitivity)

+ 2 (Sensitivity)

+ 3 (Sensitivity)

+ 1 (Sensitivity)

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

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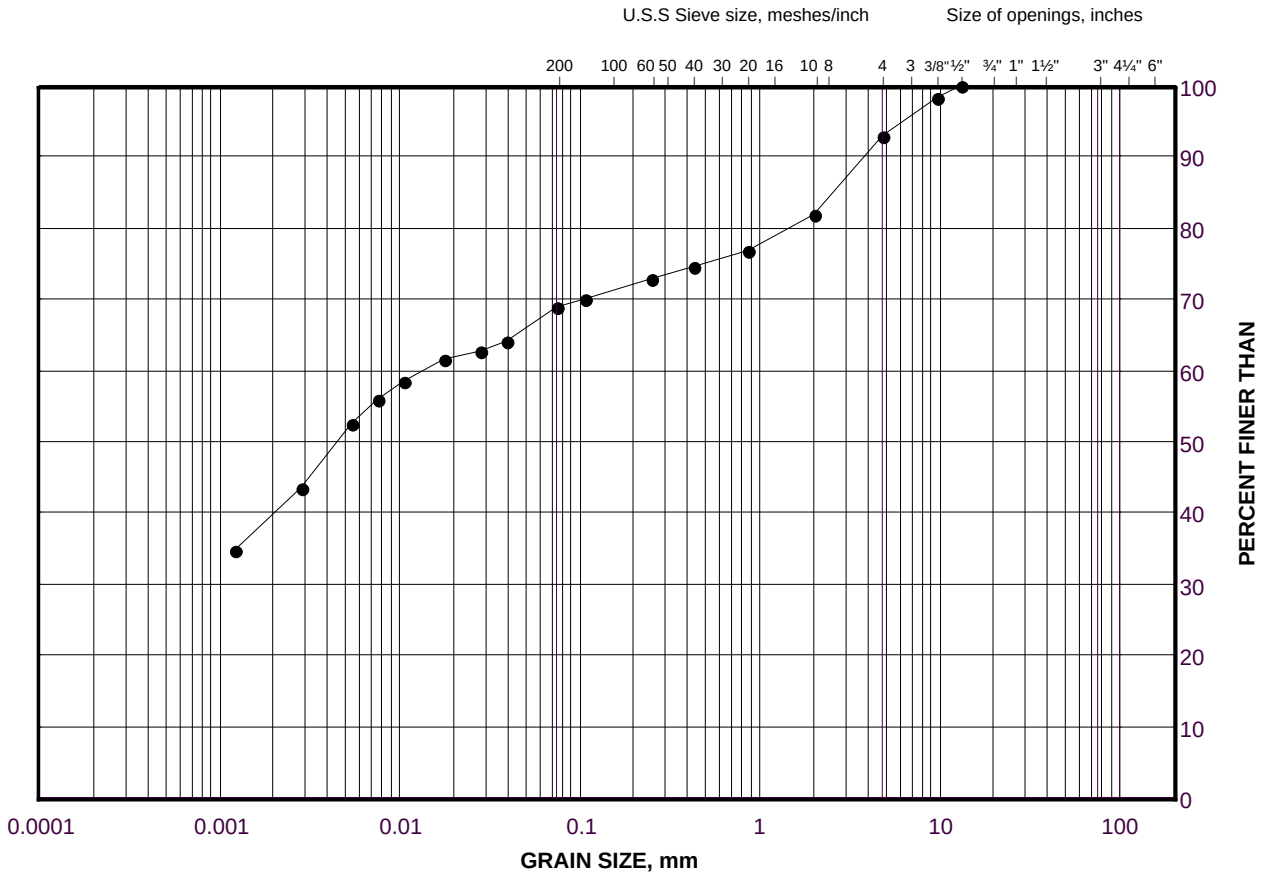
APPENDIX C

Appendix C – Geotechnical Laboratory Test Results

GRAIN SIZE DISTRIBUTION

Sandy Clayey Silt (Fill)

FIGURE C-1



LEGEND

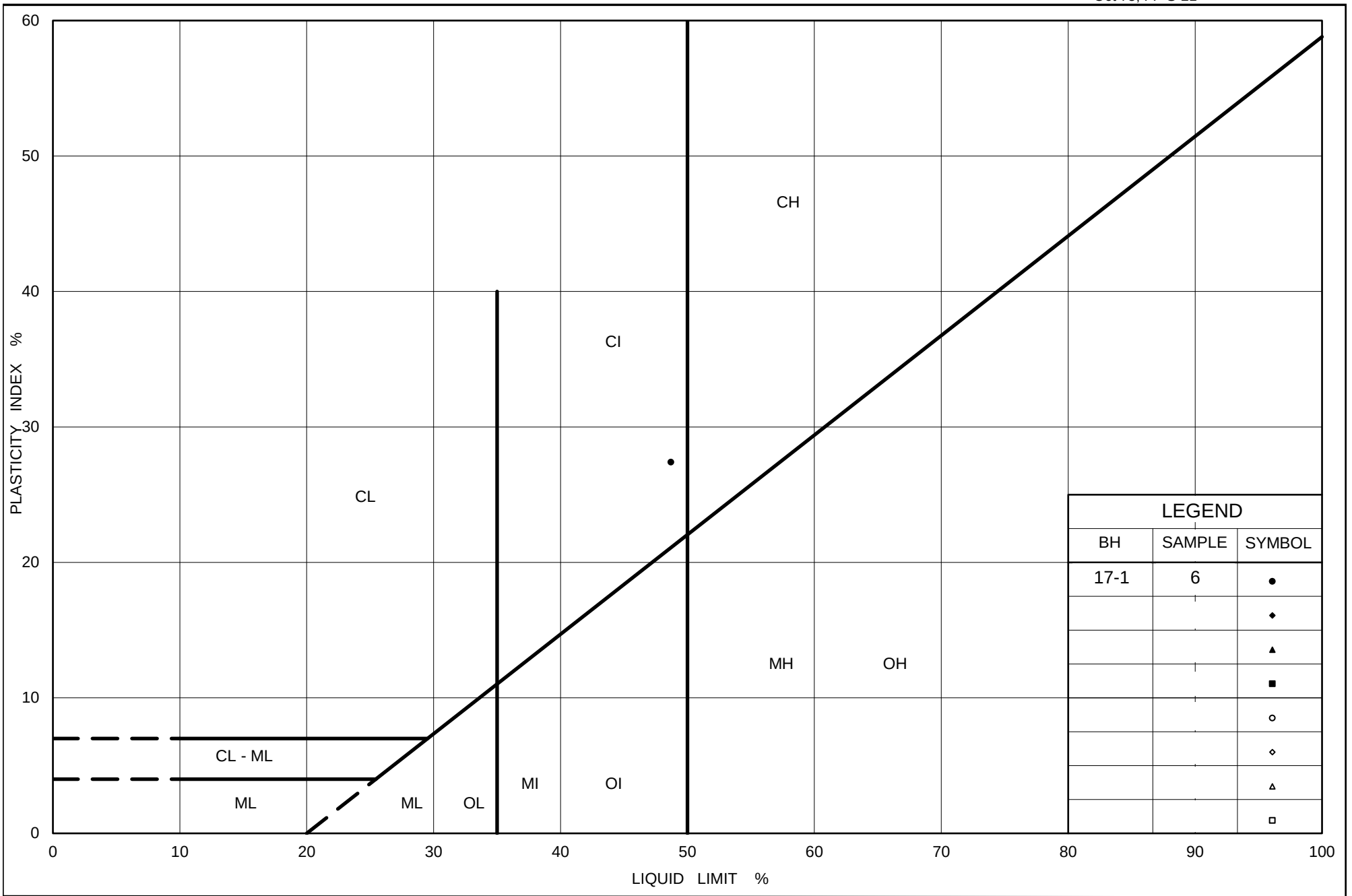
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-8	2A	86.1

Project Number: 1541610

Checked By: SMM

Golder Associates

Date: 23-Jul-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Silty Clay (Fill)

Figure No. C-2

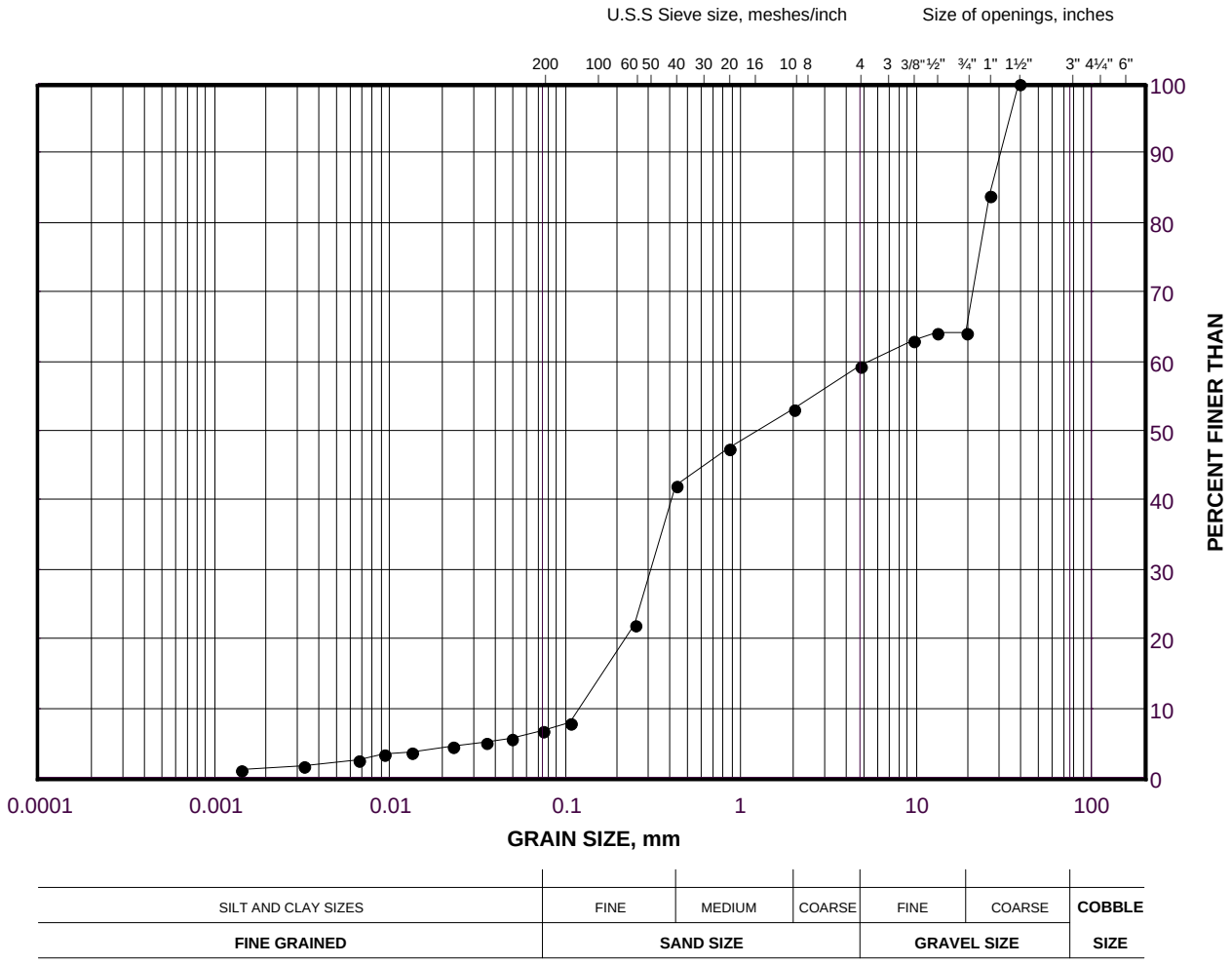
Project No. 1541610

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Sand and Gravel (Fill)

FIGURE C-3



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-5	6	84.2

Project Number: 1541610

Checked By: SMM

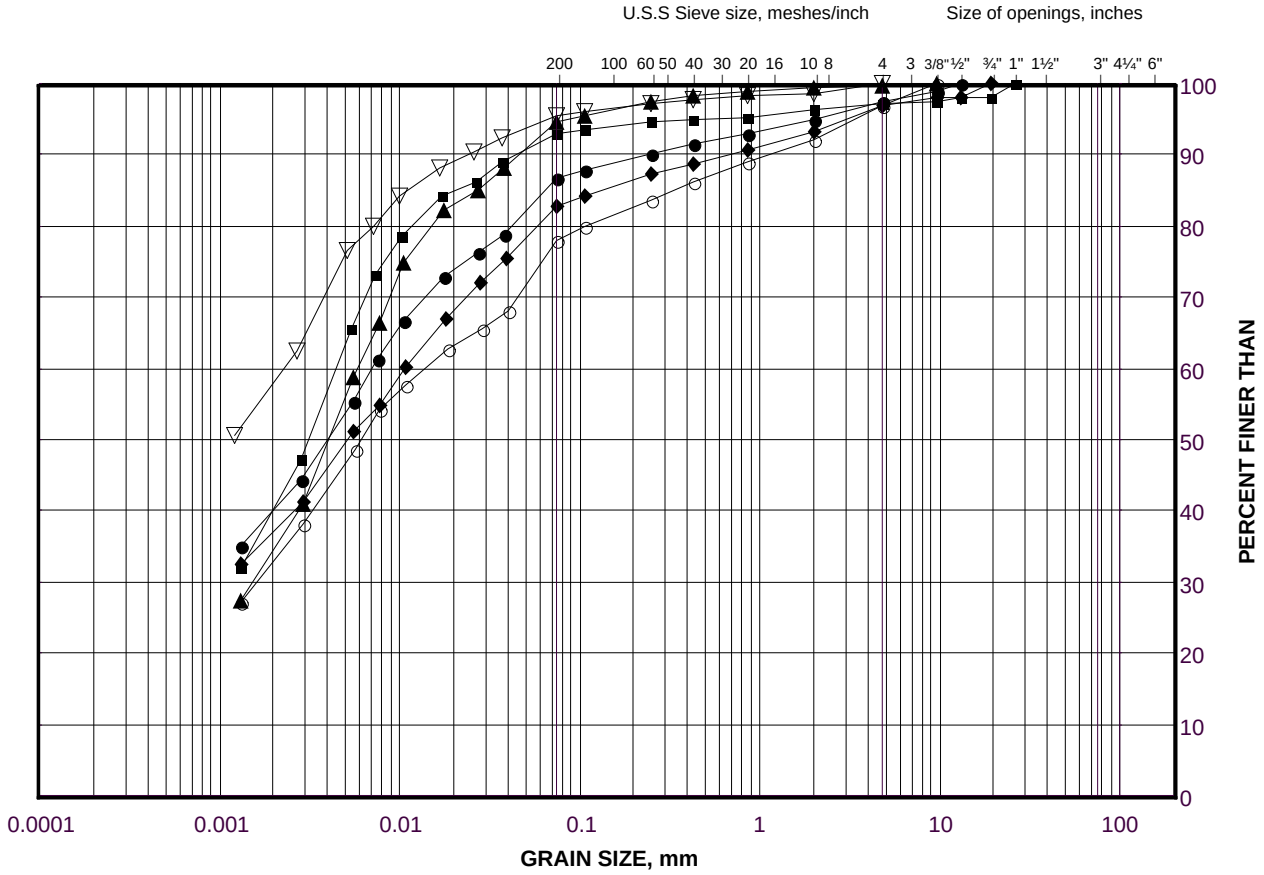
Golder Associates

Date: 23-Jul-18

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay to Clay

FIGURE C-4A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-5	11	77.2
■	17-6	11	81.2
◆	17-1	15	77.9
▲	17-4	7	81.7
▽	17-2	8	83.9
❍	17-1	9	88.6

Project Number: 1541610

Checked By: SMM

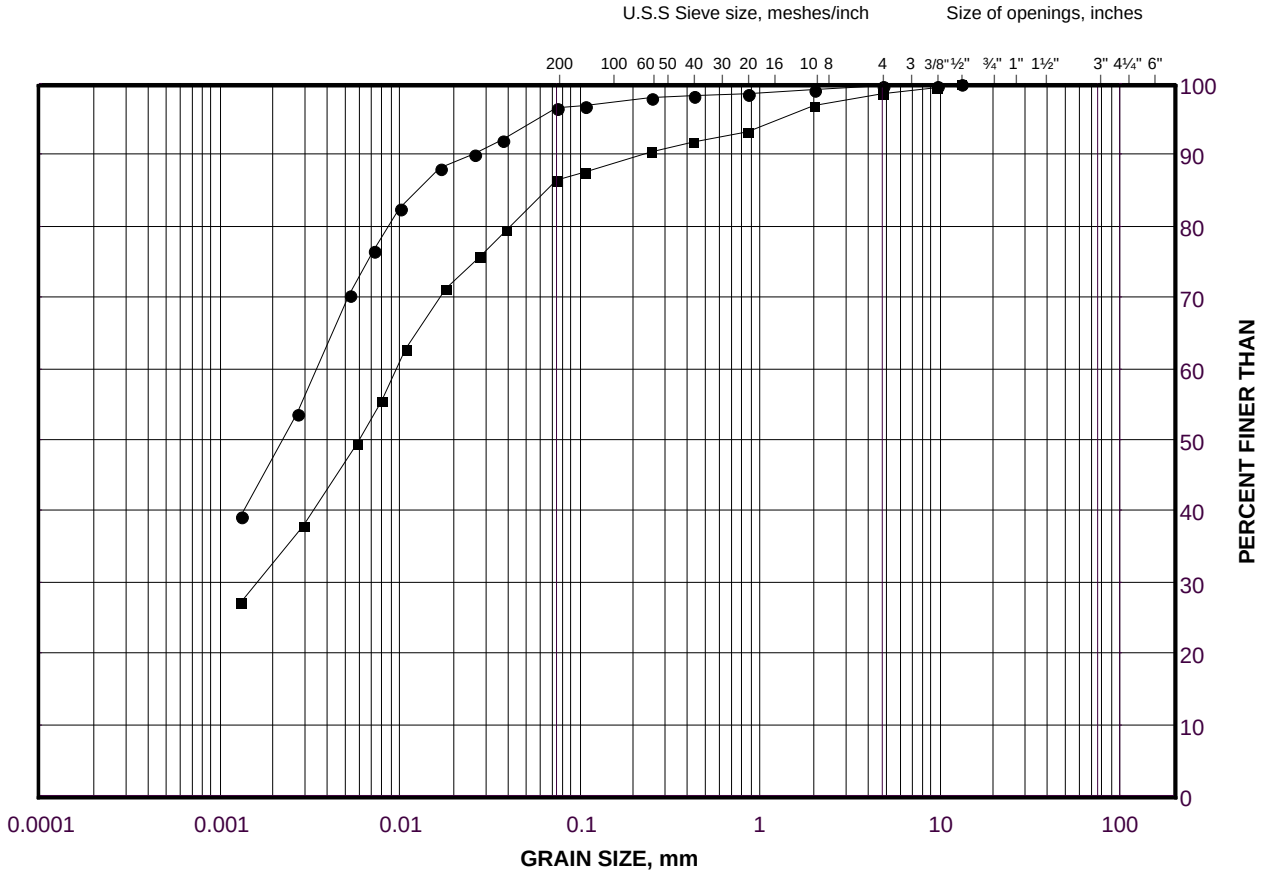
Golder Associates

Date: 23-Jul-18

GRAIN SIZE DISTRIBUTION

Clayey Silt to Silty Clay

FIGURE C-4B



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-8	6	82.8
■	17-7	9	80.8

Project Number: 1541610

Checked By: SMM

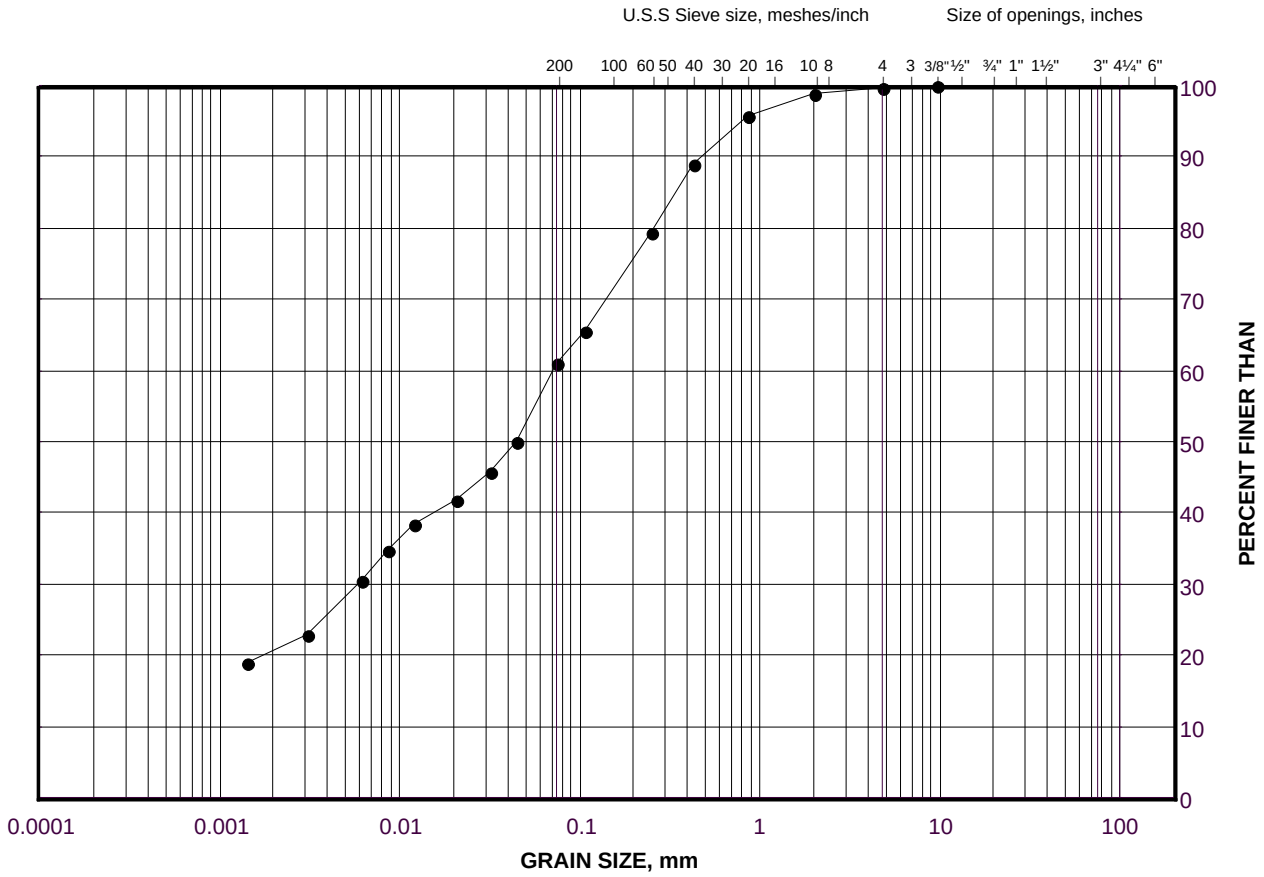
Golder Associates

Date: 23-Jul-18

GRAIN SIZE DISTRIBUTION

Clayey Silt with Sand

FIGURE C-4C



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-3	6	83.3

Project Number: 1541610

Checked By: SMM

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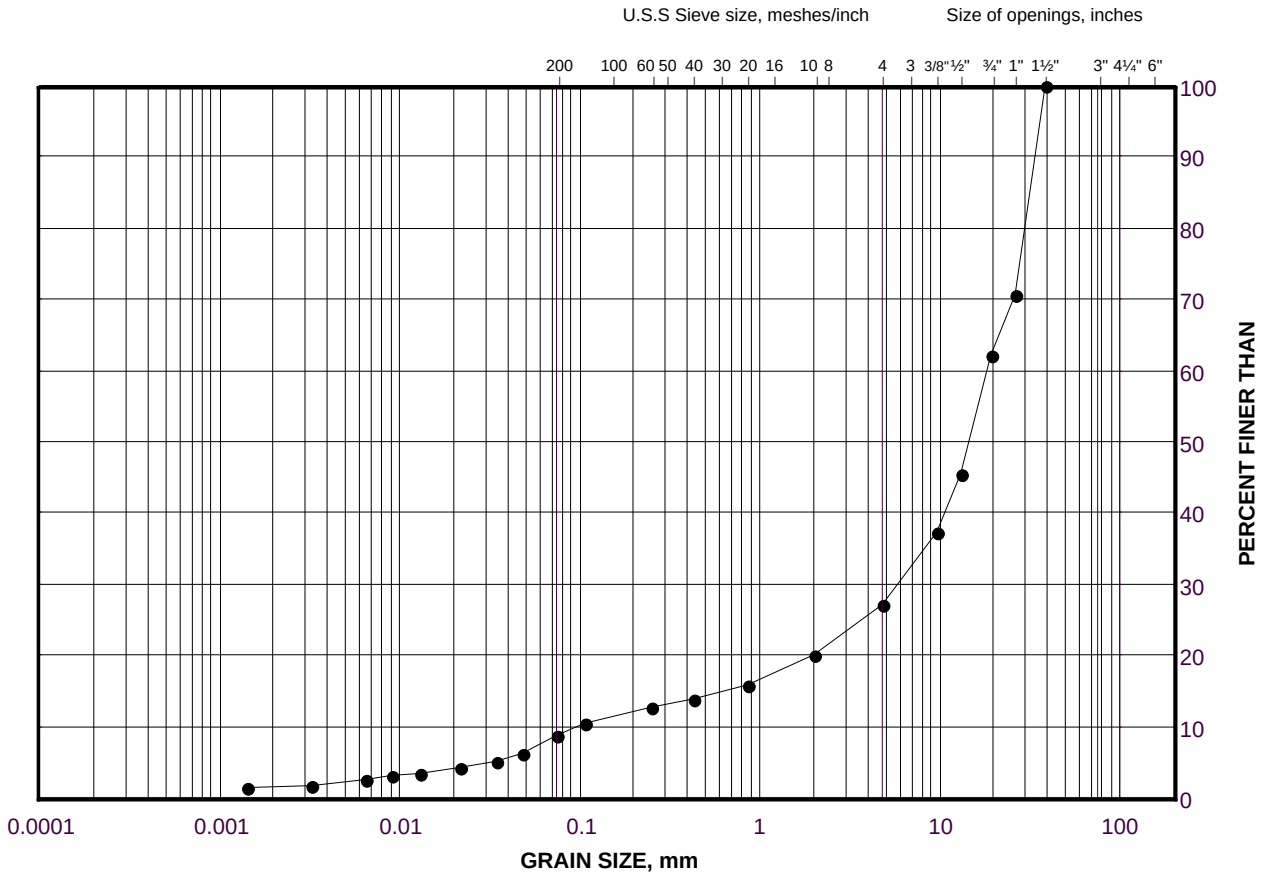
Date: 23-Jul-18

GRAIN SIZE DISTRIBUTION

Gravel (Interlayer)

FIGURE C-5



LEGEND

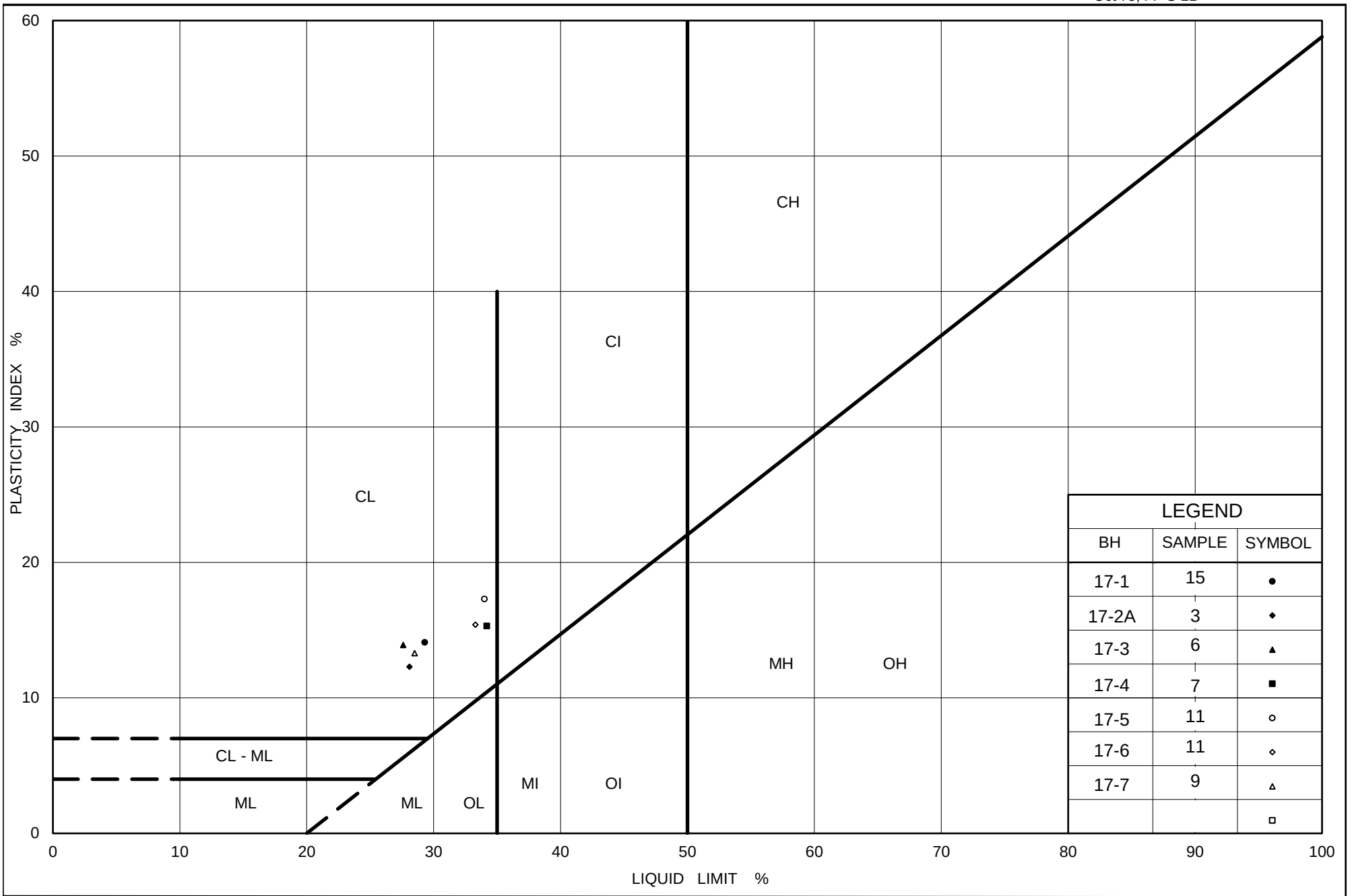
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-7	5B	83.8

Project Number: 1541610

Checked By: SMM

Golder Associates

Date: 23-Jul-18



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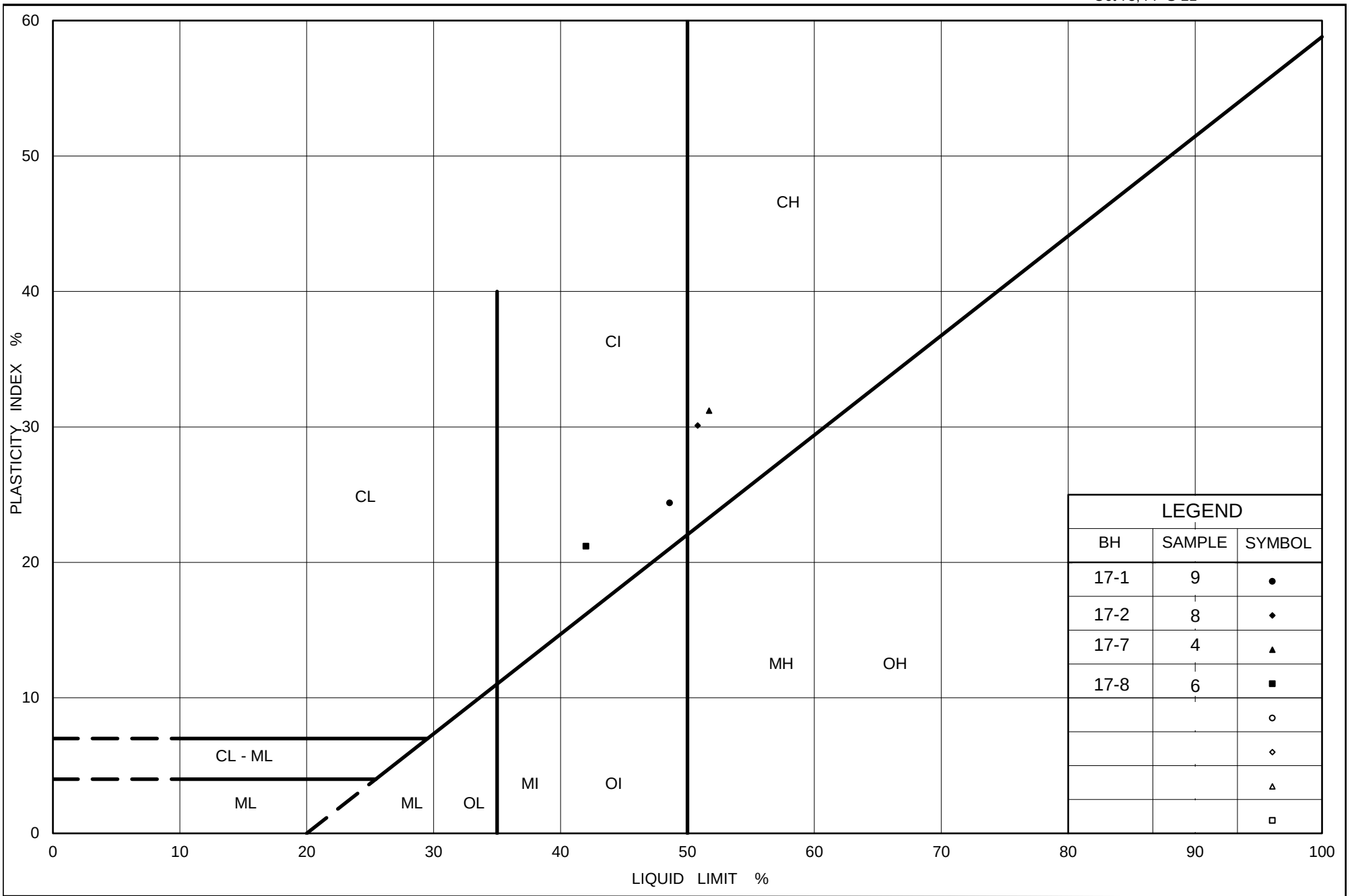
PLASTICITY CHART
Clayey Silt with Sand to Clayey Silt

Figure No. C-6A

Project No. 1541610

Checked By: SMM



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PLASTICITY CHART
Silty Clay to Clay

Figure No. C-6B

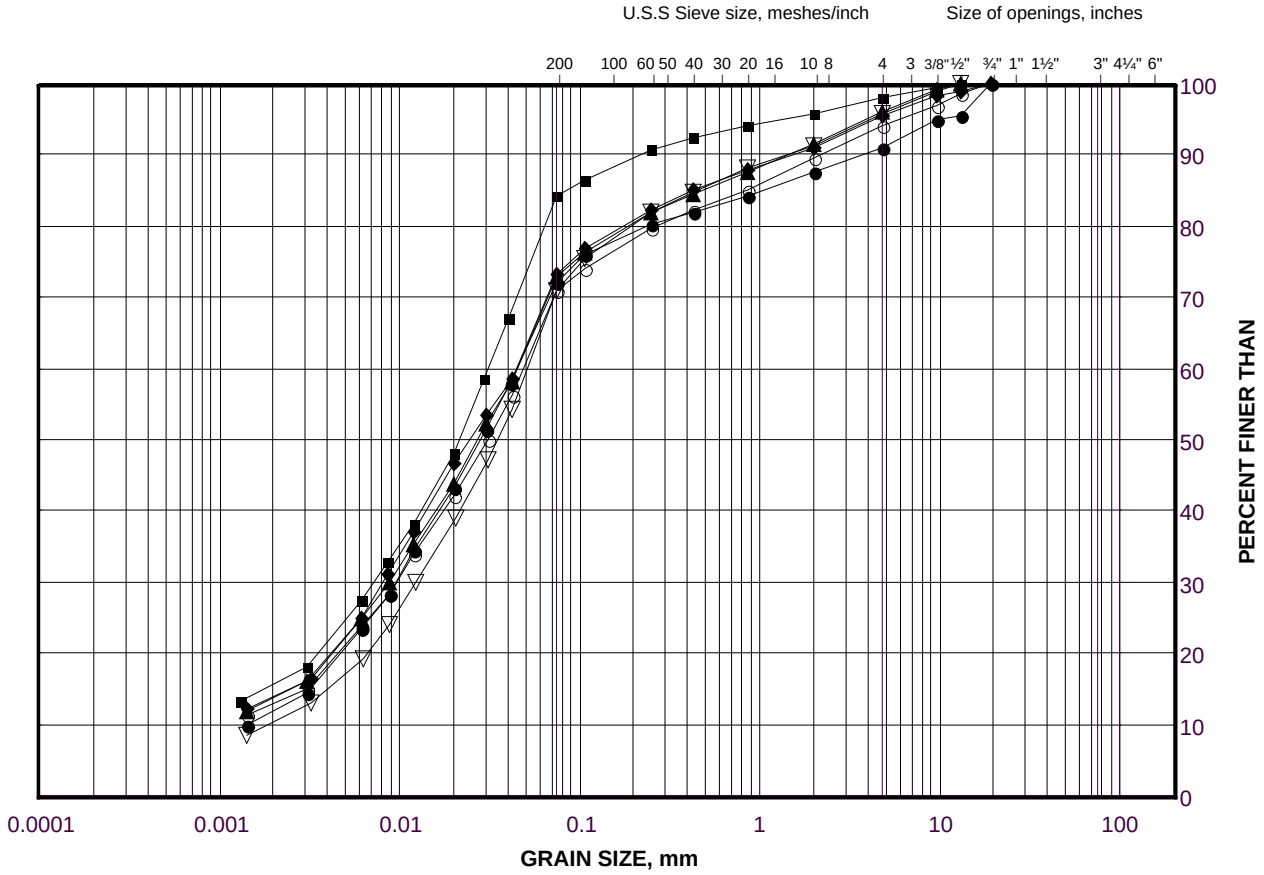
Project No. 1541610

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Sandy Silt to Sandy Clayey Silt to Clayey Silt (Till)

FIGURE C-7



LEGEND

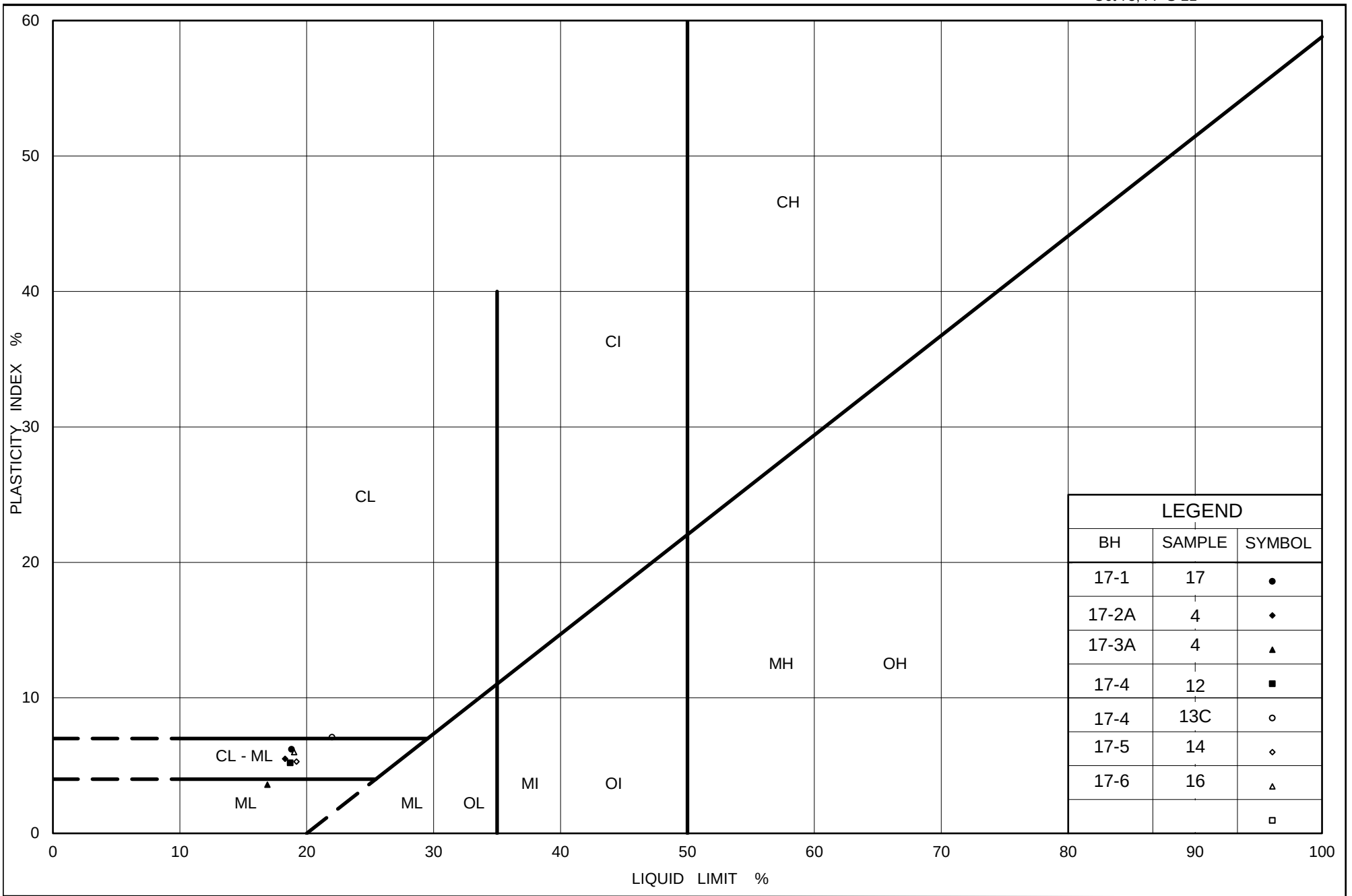
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-4	12	74.1
■	17-5	14	72.8
◆	17-6	16	73.7
▲	17-1	17	74.8
▽	17-3A	4	69.6
❍	17-2A	4	74.0

Project Number: 1541610

Checked By: SMM

Golder Associates

Date: 23-Jul-18



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PLASTICITY CHART

Sandy Silt to Sandy Clayey Silt to Clayey Silt (Till)

Figure No. C-8

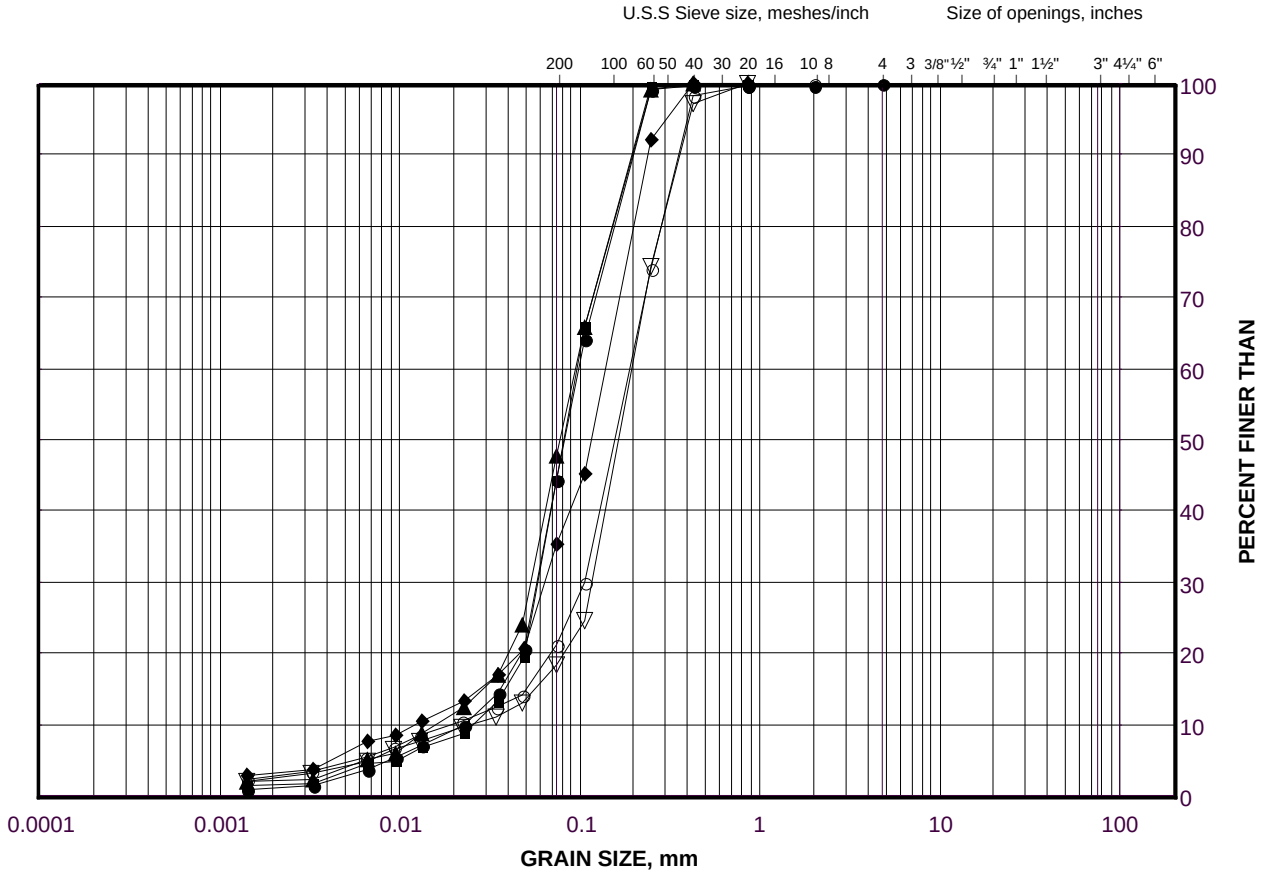
Project No. 1541610

Checked By: SMM

GRAIN SIZE DISTRIBUTION

Silt and Sand to Sand

FIGURE C-9A



LEGEND

SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-4	16	68.0
■	17-5	17	68.2
◆	17-6	18	72.1
▲	17-1	18	73.3
▽	17-1	20	70.3
❍	17-2A	8	70.9

Project Number: 1541610

Checked By: SMM

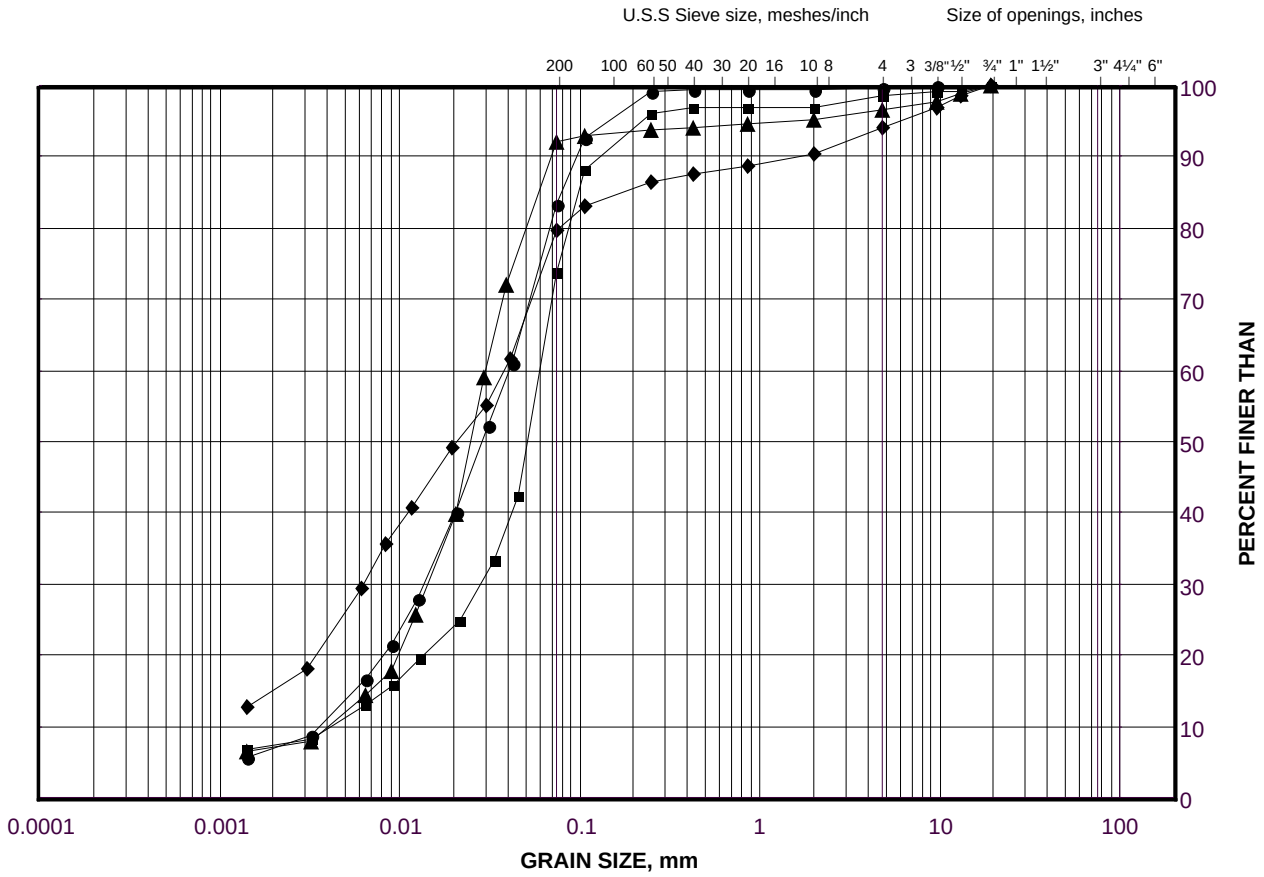
Golder Associates

Date: 23-Jul-18

GRAIN SIZE DISTRIBUTION

Silt to Sandy Silt

FIGURE C-9B



LEGEND

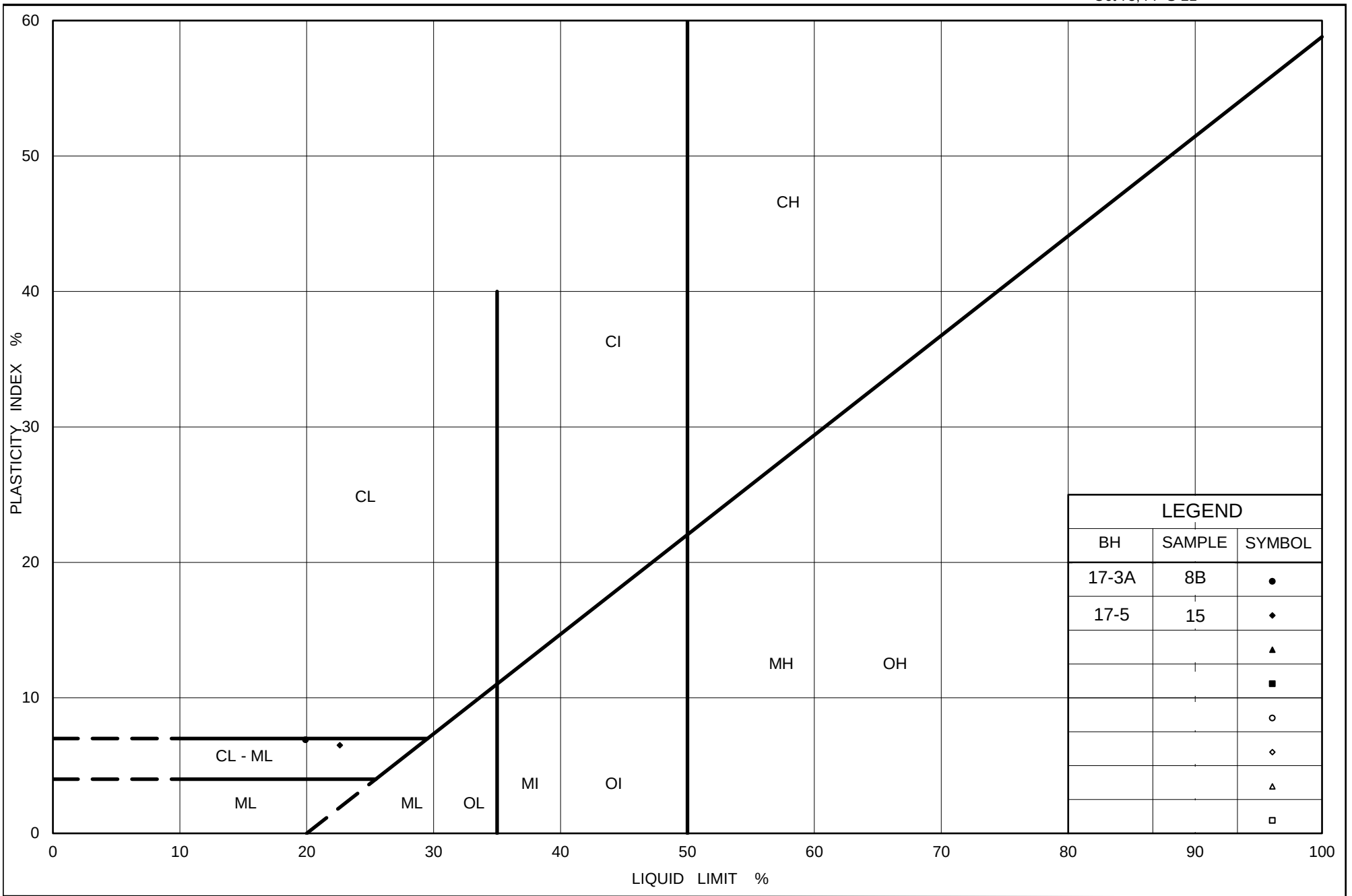
SYMBOL	Borehole	SAMPLE	ELEVATION(m)
●	17-4	14	71.0
■	17-6	21	69.9
◆	17-2A	6A	72.7
▲	17-3A	7A	67.5

Project Number: 1541610

Checked By: SMM

Golder Associates

Date: 23-Jul-18



Ministry of Transportation

Ontario

PLASTICITY CHART
Clayey Silt

Figure No. C-10

Project No. 1541610

Checked By: SMM

APPENDIX D

Analytical Laboratory – Results of Analysis of Soil

Maxxam
A Bureau Veritas Group Company

Your Project #: 1541610
Site Location: HWY 406
Your C.O.C. #: 81816

Attention:Sandra McGaghran

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
L5N 7K2

Report Date: 2017/11/14
Report #: R4857144
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7O8316
Received: 2017/11/06, 12:31

Sample Matrix: Soil
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Chloride (20:1 extract)	3	N/A	2017/11/10	CAM SOP-00463	EPA 325.2 m
Conductivity	3	N/A	2017/11/09	CAM SOP-00414	OMOE E3530 v1 m
pH CaCl2 EXTRACT	3	2017/11/07	2017/11/07	CAM SOP-00413	EPA 9045 D m
Resistivity of Soil	3	2017/11/06	2017/11/09	CAM SOP-00414	SM 22 2510 m
Sulphate (20:1 Extract)	3	N/A	2017/11/10	CAM SOP-00464	EPA 375.4 m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

Your Project #: 1541610
Site Location: HWY 406
Your C.O.C. #: 81816

Attention:Sandra McGaghran

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
L5N 7K2

Report Date: 2017/11/14
Report #: R4857144
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7O8316
Received: 2017/11/06, 12:31

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Ema Gitej, Senior Project Manager
Email: EGitej@maxxam.ca
Phone# (905)817-5829

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B7O8316
Report Date: 2017/11/14

Golder Associates Ltd
Client Project #: 1541610
Site Location: HWY 406
Sampler Initials: KN

RESULTS OF ANALYSES OF SOIL

Maxxam ID		FML476	FML477	FML478	FML478		
Sampling Date		2017/11/01	2017/11/01	2017/11/01	2017/11/01		
COC Number		81816	81816	81816	81816		
	UNITS	BH17-4-SS7	BH17-4-SS12	BH17-4-SS16	BH17-4-SS16 Lab-Dup	RDL	QC Batch
Calculated Parameters							
Resistivity	ohm-cm	3200	2200	2200			5250950
Inorganics							
Soluble (20:1) Chloride (Cl)	ug/g	81	130	180	170	20	5257424
Conductivity	umho/cm	317	460	460		2	5257050
Available (CaCl2) pH	pH	7.71	8.42	8.64	8.66		5252165
Soluble (20:1) Sulphate (SO4)	ug/g	62	170	140	130	20	5257431

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B7O8316
Report Date: 2017/11/14

Golder Associates Ltd
Client Project #: 1541610
Site Location: HWY 406
Sampler Initials: KN

TEST SUMMARY

Maxxam ID: FML476
Sample ID: BH17-4-SS7
Matrix: Soil

Collected: 2017/11/01
Shipped:
Received: 2017/11/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5257424	N/A	2017/11/10	Deonarine Ramnarine
Conductivity	AT	5257050	N/A	2017/11/09	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5252165	2017/11/07	2017/11/07	Tahir Anwar
Resistivity of Soil		5250950	2017/11/09	2017/11/09	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5257431	N/A	2017/11/10	Deonarine Ramnarine

Maxxam ID: FML477
Sample ID: BH17-4-SS12
Matrix: Soil

Collected: 2017/11/01
Shipped:
Received: 2017/11/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5257424	N/A	2017/11/10	Deonarine Ramnarine
Conductivity	AT	5257050	N/A	2017/11/09	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5252165	2017/11/07	2017/11/07	Tahir Anwar
Resistivity of Soil		5250950	2017/11/09	2017/11/09	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5257431	N/A	2017/11/10	Deonarine Ramnarine

Maxxam ID: FML478
Sample ID: BH17-4-SS16
Matrix: Soil

Collected: 2017/11/01
Shipped:
Received: 2017/11/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5257424	N/A	2017/11/10	Deonarine Ramnarine
Conductivity	AT	5257050	N/A	2017/11/09	Neil Dassanayake
pH CaCl2 EXTRACT	AT	5252165	2017/11/07	2017/11/07	Tahir Anwar
Resistivity of Soil		5250950	2017/11/09	2017/11/09	Automated Statchk
Sulphate (20:1 Extract)	KONE/EC	5257431	N/A	2017/11/10	Deonarine Ramnarine

Maxxam ID: FML478 Dup
Sample ID: BH17-4-SS16
Matrix: Soil

Collected: 2017/11/01
Shipped:
Received: 2017/11/06

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Chloride (20:1 extract)	KONE/EC	5257424	N/A	2017/11/10	Deonarine Ramnarine
pH CaCl2 EXTRACT	AT	5252165	2017/11/07	2017/11/07	Tahir Anwar
Sulphate (20:1 Extract)	KONE/EC	5257431	N/A	2017/11/10	Deonarine Ramnarine

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Maxxam Job #: B7O8316
Report Date: 2017/11/14

Golder Associates Ltd
Client Project #: 1541610
Site Location: HWY 406
Sampler Initials: KN

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	4.0°C

Results relate only to the items tested.

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Maxxam Job #: B7O8316
Report Date: 2017/11/14

QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1541610
Site Location: HWY 406
Sampler Initials: KN

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5252165	Available (CaCl2) pH	2017/11/07			99	97 - 103			0.15 (1)	N/A
5257050	Conductivity	2017/11/09			100	90 - 110	<2	umho/cm	1.4 (2)	10
5257424	Soluble (20:1) Chloride (Cl)	2017/11/10	NC (3)	70 - 130	103	70 - 130	<20	ug/g	4.1 (1)	35
5257431	Soluble (20:1) Sulphate (SO4)	2017/11/10	NC (3)	70 - 130	103	70 - 130	<20	ug/g	9.7 (1)	35

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

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

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

(1) Duplicate Parent ID [FML478-01]

(2) Duplicate Parent ID

(3) Matrix Spike Parent ID [FML478-01]

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Maxxam Job #: B7O8316
Report Date: 2017/11/14

Golder Associates Ltd
Client Project #: 1541610
Site Location: HWY 406
Sampler Initials: KN

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Brad Newman, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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CAM FCD-01191/2

CHAIN OF CUSTODY RECORD 81816

Page 1 of 1

Invoice Information	Report Information (if differs from invoice)	Project Information (where applicable)	Turnaround Time (TAT) Required
Company Name: Golder Associates	Company Name:	Quotation #:	[X] Regular TAT (5-7 days) Most analyses
Contact Name: Sandra McGaghran	Contact Name:	P.O. #/ AFE#:	PLEASE PROVIDE ADVANCE NOTICE FOR RUSH PROJECTS
Address: 6925 Century Avenue #100, Mississauga ON L5N 7K2	Address:	Project #: 1541610	Rush TAT (Surcharges will be applied)
Phone: 905-567-4444 Fax: 905-567-6561	Phone: Fax:	Site Location: HWY 406	[ ] 1 Day [ ] 2 Days [ ] 3-4 Days
Email: Sandra_McGaghran@golder.com	Email:	Site #:	Date Required:
		Sampled By: K. Nero	Rush Confirmation #:

MOE REGULATED DRINKING WATER OR WATER INTENDED FOR HUMAN CONSUMPTION MUST BE SUBMITTED ON THE MAXXAM DRINKING WATER CHAIN OF CUSTODY

Regulation 153
[ ] Table 1 [ ] Res/Park [ ] Med/ Fine
[ ] Table 2 [ ] Ind/Comm [ ] Coarse
[ ] Table 3 [ ] Agri/ Other
[ ] Table ____
FOR RSC (PLEASE CIRCLE) Y / N

Other Regulations
[ ] CCME [ ] Sanitary Sewer Bylaw
[ ] MISA [ ] Storm Sewer Bylaw
[ ] PWQO Region ____
[ ] Other (Specify) ____
[ ] REG 558 (MIN. 3 DAY TAT REQUIRED)

Include Criteria on Certificate of Analysis: Y / N

SAMPLES MUST BE KEPT COOL (< 10 °C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

Analysis Requested

	SAMPLE IDENTIFICATION	DATE SAMPLED (YYYY/MM/DD)	TIME SAMPLED (HH:MM)	MATRIX	# OF CONTAINERS SUBMITTED	FIELD FILTERED (CIRCLE) Metals / Hg / CrVI	BTEX/ PHC F1	PHCs F2 - F4	VOCs	REFER TO BACK OF COC: REG 153 METALS & INORGANICS	REG 153 ICPMS METALS	REG 153 METALS (Hg, Cr VI, ICPMS Metals, HWS - B)	Corrosivity Package (pH, Sulphate, Chloride, resistivity, electrical conductivity)							HOLD- DO NOT ANALYZE
1	BH17-4-SS7	2017/11/01	AM	Soil	1								X							
2	BH17-4-SS12	"	AM	Soil	1								X							
3	BH17-4-SS16	"	AM	Soil	1								X							
4																				
5																				
6																				
7																				
8																				
9																				
10																				

LABORATORY USE ONLY

CUSTODY SEAL Y / N		COOLER TEMPERATURES
Present	Intact	
		4.1.3

COOLING MEDIA PRESENT: Y / N

COMMENTS: standard Corrosivity Package " "

06-Nov-17 12:31
Ema Gitej
B7O8316
TSP ENV-612

RELINQUISHED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	RECEIVED BY: (Signature/Print)	DATE: (YYYY/MM/DD)	TIME: (HH:MM)	MAXXAM JOB #
Katie Nero / Katie Nero	2017/11/06	12:30	Tanvir Tanvir	2017/11/06	12:31	

COC-1004 (10/14) - ENV. ENG.

White: Maxxam ~ Yellow: Client

golder.com