REPORT

**May 19, 2017**

# PRELIMINARY FOUNDATION INVESTIGATION AND DESIGN REPORT

# Duffins Creek Bridges
# Structure Site No. 22-120
# Highway 401 Widening from Brock Road to Courtice Road
# Regional Municipality of Durham
# W.O. 10-20011

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# 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by AECOM on behalf of the Ministry of Transportation, Ontario (MTO) to provide preliminary foundation engineering services for the future improvements and widening of Highway 401 from Brock Road to Courtice Road in the Regional Municipality of Durham, Ontario.

This report addresses the proposed widening of the existing Duffins Creek bridges. This report was developed with information from previous geotechnical/foundation investigations at the site, as follows:

- **MTO GEOCRES No. 30M14-007**: Report titled "Foundation Investigation Report for Widening of Duffins Creek Bridge on Highway 401, District 6 (Toronto), W.O. 72-11119, W.P. 44-71-02," prepared by Ministry of Transportation and Communications, Ontario, dated January 22, 1973.
- **MTO GEOCRES No. 30M14-252**: Report titled "Foundation Investigation and Design Report For Highway 401 Bridge Widening at Church Street/Duffins Creek, Town of Pickering, W.P. 137-95-00, Site 22-120," prepared by Golder Associates Ltd., dated December 18, 1997.

The terms of reference for the preliminary foundation engineering services are outlined in MTO's Request for Proposals (RFP) for Assignment No. 2010-E-0062, dated June 2011. The scope of work for the preliminary foundation engineering services is presented in Section 5.8 of URS's *Technical Proposal* for this assignment, as well as Golder's Scope Change for Foundations Engineering Services letter dated December 8, 2014.

# 2.0 SITE DESCRIPTION

The Duffins Creek bridges are located approximately 1.7 km east of Brock Road in the City of Pickering, in the Regional Municipality of Durham, Ontario. The existing bridges are six-span structures that were originally constructed in 1940, and it is understood that the original structures were founded on spread footings supported on shale bedrock. The eastbound and westbound bridges were widened approximately 6 m toward the outside under Contract 75-07, and widened again in the late 1990s; for both phases of outward widening of the structures, the widened abutments and piers are supported on steel H-piles either driven to bedrock or placed in pre-augered holes extended to the bedrock.

The Duffins Creek channel is at approximately Elevation 77.5 m to 78 m, and the floodplain adjacent to the creek is at approximately Elevation 78.5 m to 81 m, rising to the west and east away from the creek. The natural ground surface elevation outside of the creek valley in the vicinity of the bridge is at approximately Elevation 86 m, with a relatively level topography. The Church Street grade is at approximately Elevation 81 m, along the west side of the creek. Highway 401 has been constructed near the existing ground surface outside of the creek valley, with its grade varying from about Elevation 88 m on the west side to about Elevation 87 m on the east side of the creek.

# 3.0 INVESTIGATION PROCEDURES

Two previous investigations have been completed at this site, including one in November 1972 by the Ministry of Transportation and Communications, Ontario and one in September 1997 by Golder. The locations of the boreholes are shown on Drawing 1, appended to this report, and further details regarding both investigation programs is provided in the following sections.

## 3.1 1972 Investigation (GEOCRES No. 30M14-007)

Twenty-two boreholes were advanced at this site as part of the previous geotechnical investigation completed by the Ministry of Transportation and Communications, Ontario in November 1972. Boreholes 3, 6, 10, 13, 16, 19, and 22 were advanced on the north side of Highway 401 in the area of the existing bridge structure; Boreholes 2, 5, 9, 12, 15, 18, and 21 were advanced in the median area of Highway 401; and Boreholes 1, 4, 7, 8, 11, 14, 17, and 20 were advanced on the south side of Highway 401 in the area of the existing bridge structure. The boreholes were advanced using hollow stem augers on a track-mounted drill rig through the overburden and using diamond drilling equipment through the bedrock. The drill rigs were supplied and operated by Canadian Longyear Ltd. and Dominion Soils Ltd. Soil samples were obtained using a 50 mm outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedure. BX or BXL core samples were obtain from the bedrock, where encountered. Two dynamic cone penetration tests were carried in Boreholes 7 and 8.

The water level in the open boreholes was observed throughout the drilling operations.

## 3.2 1997 Investigation (GEOCRES No. 30M14-252)

Seven boreholes were advanced at this site as part of a 1997 investigation completed by Golder, for the outward widening of the bridges. Boreholes 101 through 103 were advanced on the north side of Highway 401, while Boreholes 104 through 107 were advanced on the south side of Highway 401. The boreholes were advanced using a track-mounted CME 55 drill rig, supplied and operated by Eastern Soil Investigation Limited.

Standard Penetration Testing (SPT) was carried out at intervals of depth of about 0.75 m and 1.5 m, and samples of the soils and rock were recovered using conventional drive open (split-spoon) sampling equipment. Bedrock was cored using an NQ size core barrel in Borehole 102.

The water level in the open boreholes was observed throughout the drilling operations, and piezometers were installed in select boreholes to allow monitoring of the groundwater level.

# 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

## 4.1 Regional Geology

This section of Highway 401 is located within the Iroquois Plain physiographic region, as delineated in *The Physiography of Southern Ontario* (Chapman and Putnam, 1984) and *Urban Geology of Canadian Cities* (Brennand, 1998). 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.

The surficial soils in this area of the Iroquois Plain are typically comprised of glaciolacustrine clays, silts and sands to gravelly sands, which are underlain by an extensive till deposit that is mapped in this area as the Bowmanville Till. More recent alluvial deposits of gravel, sand, silt and/or clay are present in the creek valleys.

## 4.2 Subsurface Conditions

The detailed subsurface soil and groundwater conditions encountered in the boreholes advanced as part of the previous investigation, together with the results of in situ and laboratory testing are presented on the borehole records in Appendices A (1972 investigation) and B (1997 investigation). The borehole locations are shown on Drawing 1, and interpreted stratigraphic profiles along the bridge are shown on Drawing 2.

The stratigraphic boundaries shown on the borehole records and on the interpreted stratigraphic profiles are inferred from observations of drilling progress and non-continuous sampling and, therefore, represent transitions between soil types rather than exact planes of geological change. The subsoil and bedrock conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions at the site consist of relatively thin layers of topsoil and/or fill underlain by a non-cohesive deposit of interlayered sands, silts, and sand and gravel. Thin layers of clayey silt to silty clay are present within the non-cohesive deposit. The overburden soils are underlain by shale bedrock, which was generally encountered at depths ranging from about 5.5 m to 10 m below ground surface. A detailed description of the subsurface conditions encountered in the boreholes is provided in the following sections.

### 4.2.1 Topsoil

Topsoil was encountered in Boreholes 105 to 107 on the south side of the existing bridge, immediately below the ground surface at the time of the 1997 investigation. Approximately 50 mm of topsoil was encountered immediately below the then-existing ground surface in Boreholes 105 and 107 and approximately 600 mm of topsoil was encountered immediately below the then-existing ground surface in Borehole 106.

### 4.2.2 Fill

Fill material was encountered in five of the seven boreholes drilled during Golder's 1997 investigation. The fill material was encountered immediately below the then-existing ground surface in Boreholes 101, 103, and 104 and underlying the topsoil in Boreholes 105 and 106. The thickness of the fill ranged from approximately 0.6 m in Borehole 105 to approximately 2.9 m in Borehole 104. The base of the fill was encountered between about Elevations 76.1 m and 80.1 m.

The encountered fill material typically consists of variable proportions of sand, silt, and gravel and is classified as sand, silty sand, and sand and gravel. The fill material contained organics, asphalt fragments, metal fragments, glass fragments, and silty clay lenses. In Borehole 104, approximately 1.5 m of silty clay fill containing organics was encountered underlying the sand and gravel fill.

The Standard Penetration Test (SPT) 'N'-values measured in the non-cohesive fill ranged from 3 to 30 blows per 0.3 m of penetration, indicating a very loose to compact relative density. The SPT 'N'-values measured in the silty clay fill encountered in Borehole 104 were 3 and 6 blows per 0.3 m of penetration, suggesting a soft to firm consistency. The natural water content measured on selected samples of the fill varied between 6 per cent and 18 per cent.

### 4.2.3 Sand to Silt Deposit

A non-cohesive deposit consisting of variable proportions of sand and silt was encountered immediately below the ground surface, or underlying the topsoil or fill, in all boreholes from both investigations with the exception of Borehole 104 form the 1997 investigation. It has been interpreted as the predominant deposit at this site, within which interlayers of coarser sand/gravel and finer clayey silt to silty clay are present; these interlayers are described in Sections 4.2.4 and 4.2.5, respectively. The base of the overall sand to silt deposit was encountered between approximately Elevations 76.4 m and 69.6 m in the boreholes, and the encountered thickness (inclusive of interlayers) ranges from about 1.4 m to 9.9 m.

The deposit consists of layers of non-cohesive soil that vary in composition from sand, to sandy silt/silty sand, to sand and silt, to silt, containing trace to some clay and trace to some gravel. Organic matter was observed in samples recovered near the then-existing ground surface, and shell and shale fragments were observed in some samples. Cobbles and boulders were also observed or inferred in some boreholes, as noted on the borehole records. The results of grain size distribution tests completed on selected samples of this deposit are shown on Figures 1 and 2 in Appendix B.

The SPT 'N'-values measured in the sand to silt deposit range from about 1 blow per 0.3 m of penetration to in excess of 100 blows per 0.3 m of penetration, indicating a very loose to very dense relative density. The SPT 'N'-value typically increased with depth.

The measured water contents of samples of the silt to sand deposit range from about 5 to 45 per cent, but are generally less than 20 per cent.

### 4.2.4 Sand to Gravel to Gravelly Sand Layers

Discontinuous layers consisting of variable proportions of sand and gravel were encountered within the sand to silt deposit. These coarser sand to gravel layers were encountered in Boreholes 1, 2, 4, 6, 11, 12, 13, 15, 20, 102, 104, 106, and 107. The thickness of these coarser interlayers ranges from about 0.8 m to 5 m. The sand and gravel to gravelly sand layers generally contain trace to some silt and trace clay; cobbles and/or boulders were observed or inferred in association with these layers, as noted on the borehole records. The result of a grain size distribution test on a sample of the sand and gravel layer is shown on Figure 3 in Appendix B.

The SPT 'N'-values measured in the sand and gravel to gravelly sand layers range from 2 blows per 0.3 m of penetration to in excess of 100 blows per 0.3 m of penetration, indicating a very loose to very dense, but typically dense to very dense relative density.

The measured water contents of samples of the sand to gravel deposit ranged from about 5 per cent to 30 per cent, but were generally less than 15 per cent.

### 4.2.5 Silty Clay to Clayey Silt Layers

Discontinuous layers consisting of clayey silt to silty clay were encountered within the sand to silt deposit. The cohesive layers were encountered in Boreholes 101, 102, 104, 105, and 107. The thickness of the layers ranges from about 0.5 m to 1.5 m. The silty clay to clayey silt layers were observed to contain trace gravel, shell fragments, and shale fragments.

The SPT 'N'-values measured in the silty clay to clayey silt layers range from about 2 to 140 blows per 0.3 m of penetration, indicating a very soft to hard consistency.

The measured water contents of samples of the silty clay to clayey silt layers range from about 8 to 35 per cent.

### 4.2.6 Shale Bedrock

Shale bedrock of the Whitby Formation was encountered in all of the boreholes from both investigations. The weathered upper portion of the bedrock was penetrated and recovered by augering. Bedrock coring was carried out in Boreholes 1, 2, 5, 6, 8, 9, 11, 13, 15 to 18, 22 and 102, using BX or BXL-size coring equipment in the 1972 boreholes, and NQ-size coring equipment in the 1997 borehole.

The depth to bedrock ranged from 5.5 m to 10.9 m below the ground surface at the time of the 1972 and 1997 investigations, and the bedrock surface elevation varies from about 69.6 m to 73.5 m. The depth to bedrock and approximate bedrock surface elevation at the borehole locations are summarized in the following table.

| Widening Area | Borehole No. | Foundation Element | Depth to Bedrock Surface (m) | Bedrock Surface Elevation (m) |
|---|---|---|---|---|
| North Side of WBL Bridge | 3 | West Abutment | 9.9 | 70.5 |
| | 101<br>6 | Pier A | 10.9<br>9.0 | 69.6<br>70.7 |
| | 10 | Pier B | 7.3 | 72.2 |
| | 102<br>13 | Pier C | 7.4<br>5.7 | 71.4<br>72.1 |
| | 16 | Pier D | 5.9 | 72.8 |
| | 19 | Pier E | 6.2 | 73.0 |
| | 103<br>22 | East Abutment | 7.7<br>7.2 | 73.0<br>73.5 |
| Median | 2<br>5 | West Abutment | 8.2<br>8.3 | 71.7<br>71.7 |
| | 9 | Pier B | 7.6 | 71.9 |
| | 12 | Pier C | 6.1 | 72.1 |
| | 15 | Pier D | 5.5 | 73.0 |
| | 18 | Pier E | 6.4 | 72.7 |
| | 21 | East Abutment | 6.5 | 73.5 |
| South Side of EBL Bridge | 106<br>1<br>4 | West Abutment | 8.0<br>9.2<br>8.2 | 72.7<br>71.5<br>72.1 |
| | 105<br>7<br>8 | Pier B | 6.5<br>6.8<br>7.3 | 72.8<br>72.3<br>72.2 |
| | 11 | Pier C | 5.9 | 71.8 |
| | 107<br>14 | Pier D | 6.5<br>5.9 | 72.6<br>73.0 |
| | 104<br>17 | Pier E | 6.1<br>7.0 | 72.9<br>72.0 |
| | 20 | East Abutment | 6.1 | 73.5 |

In general, the bedrock is described as thinly bedded, grey shale of the Whitby Formation, containing occasional thin limestone interlayers. Based on observations from the recovered rock core, the upper 1.0 m to 2.7 m of the shale is highly fractured and weathered; below this zone, the bedrock becomes moderately weathered to fresh.

The Rock Quality Designation (RQD) values measured on the core samples retrieved ranged between 17 per cent and 100 per cent, indicating a rock mass of variable, very poor to excellent quality.

## 4.3 Groundwater Conditions

During the 1997 investigation, water levels were observed in the open boreholes at the completion of drilling and in the standpipe piezometers following drilling, and these measurements are summarized below. The groundwater conditions from the 1972 investigation have not been included, as the borehole records do not include details regarding the state of the borehole or the date the water level was taken.

| Borehole No. | Ground Surface Elevation (m) | Depth to Water Level (m) | Groundwater Elevation (m) | Date |
|---|---|---|---|---|
| 101 | 80.5 | 4.4 | 76.1 | Sep 11, 1997 - Completion |
| 102 | 78.8 | 3.3<br>2.5 | 75.5<br>76.3 | Sep 16, 1997 - Piezo<br>December 11, 1997 - Piezo |
| 103 | 80.7 | Dry<br>3.5<br>3.0 | -<br>77.2<br>77.7 | Sep 12, 1997 – Completion<br>Sep 16, 1997 - Piezometer<br>Dec 11, 1997 - Piezometer |
| 104 | 79.0 | 2.9<br>3.7<br>2.4 | 76.1<br>75.3<br>76.6 | Sep 12, 1997 – Completion<br>Sep 16, 1997 - Piezometer<br>Dec 11, 1997 – Piezometer |
| 105 | 79.3 | 3.2 | 76.1 | Sep 11, 1997 – Completion |
| 106 | 80.6 | 2.6<br>2.6<br>2.5 | 78.0<br>78.0<br>78.1 | Sep 11, 1997 - Completion<br>Sep 16, 1997 – Piezometer<br>Dec 11, 1997 – Piezometer |
| 107 | 79.0 | 2.6 | 76.4 | Sep 12, 1997 – Completion |

The water levels observed in the open boreholes on completion of drilling may not represent long-term stabilized groundwater levels. Measurements taken in the piezometers on December 11, 1997 indicate that the groundwater level was at a depth of 2.4 m to 3.0 m below ground surface, corresponding to about Elevation 76.3 m to 78.1 m. The water level at the site is expected to fluctuate seasonally in response to changes in precipitation and snow melt, and is expected to be higher during the spring and periods of precipitation.

# 5.0 CLOSURE

This Preliminary Foundation Investigation Report was prepared by Ms. Haley Schafer and was reviewed by Ms. Nikol Kochmanova, P.Eng. Ms. Lisa Coyne, P.Eng., a Principal and Designated MTO Foundations Contact for Golder, conducted an independent review of this report.

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# PART B

## PRELIMINARY FOUNDATION DESIGN REPORT
## DUFFINS CREEK BRIDGES
## STRUCTURE SITE NO. 22-120
## HIGHWAY IMPROVEMENTS FROM BROCK ROAD TO COURTICE ROAD
## REGIONAL MUNICIPALITY OF DURHAM
## W.O. 10-20011

# 6.0 DISCUSSION AND PRELIMINARY ENGINEERING RECOMMENDATIONS

## 6.1 General

This section of the report provides preliminary foundation recommendations in support of the proposed widening of the existing Duffins Creek bridges at Highway 401 (MTO Structure Site 22-120). These preliminary recommendations are based on interpretation of the factual data obtained from the boreholes advanced during previous subsurface investigations at this site. This Preliminary Foundation Design Report, including the interpretations and recommendations contained herein, are intended for the use of MTO to provide the designers with sufficient information to assess the feasible foundation alternatives and to carry out the preliminary design of the structure foundations. This Preliminary Foundation Design Report shall not be used or relied upon for any other purpose or by any other parties, including contractors. Further investigation and design will be required during the detailed design stage.

Where comments are made on construction, they are provided to highlight those aspects that could affect the design of the project, and for which special provisions or operational constraints may be required in the contract documents. Contractors must make their own interpretation of the factual information provided in the Preliminary Foundation Investigation Report, as such interpretation may affect equipment selection, proposed construction methods, scheduling and the like.

## 6.2 Foundation Options

It is understood that as part of the future improvements and widening of Highway 401 from Brock Road to Courtice Road, the existing six-span Duffins Creek bridges will be widened. Based on the preliminary General Arrangement (GA) drawing provided by AECOM, the existing bridges will be widened by about 3.4 m on the south side and about 7.2 m on the north side, along with median widening of the westbound and eastbound structures. The existing bridge substructure at the piers was built to sufficient width to accommodate the presently proposed structure widening. However, it is understood that widening of the abutment foundations will be required to support the widening of the superstructure.

The following design drawings are available for the Duffins Creek bridges:

- Contract No. 98-39, WP No. 137-95-00, Sheet 287: “Highway 401 Overpass at Church St/Duffins Creek, Foundation Layout and Reinforcement”, prepared by Cole Sherman, dated January 1998.
- WP No. 218-90-01/02, Sheets 13 and 14: “Highway 401/Church Street, Overpass Rehabilitation”, prepared by Cole Sherman, dated June September 1991.

Based on these drawings, the original eastbound and westbound structures are supported on spread footings founded within the shale bedrock or in very dense overburden soils, at a depth of approximately 5.5 m to 7.0 m below the ground surface. The bridges were widened by 6 m on the north and south sides in 1975 using HP310x110 piles driven to bedrock, and widened again in the late 1990s with piles placed within pre-augered holes and/or driven to bedrock.

Both shallow and deep foundation options have been considered for support of the required abutment widening for the Duffins Creek bridges. A summary of the advantages and disadvantages associated with each option is provided below, and a comparison of the alternative foundation options based on advantages, disadvantages, risks and relative costs is provided in Table 1 following the text of this report.

- **Strip or spread footings founded on the compact to dense sand to silt deposit:** Zones of very loose to loose sand to silt are present in the upper portion of the boreholes that were drilled at the west and east abutment locations; these soils extend as deep as 4.9 m (Elevation 75.5 m) at the west abutment, and 5.6 m (Elevation 74.4 m) at the east abutment. It would be necessary to either extend shallow foundations for the abutment widening to this depth, or subexcavate and replace the loose soils with engineered fill prior to construction footings at a higher elevation. Significant temporary protection systems would be required to protect the existing structure and highway approach embankment, and dewatering would be required. In addition, there would be potential for differential settlement between the existing pile-supported portions of the abutments and the new widening areas. As a result, this foundation option is not considered feasible for the abutment widening at this site.
- **Driven steel H-piles or pipe piles founded on the shale bedrock:** Driven steel H-piles or steel pipe (tube) piles are feasible for support of the abutment widening; they are compatible with the existing pile-supported abutments, would permit the pile cap to be maintained at a relatively high elevation to minimize excavation, shoring and dewatering requirements, and would permit the construction of integral abutments. Deep foundations are further considered to have a technical advantage over spread footings as the differential settlement between the widened and existing portions of the structure would be negligible. Based on the available borehole information, the surface of the bedrock is at about Elevation 70.5 m to 72.7 m at the west abutments, and Elevation 73 m to 73.5 m at the east abutments. As such, the minimum required pile length of 5 m for integral abutments will be achievable. It is anticipated, however, that "100-blow" soil will be encountered at shallow depths and pre-augering may be required for the pile installation. Pile driving shoes are recommended to protect the pile tips from damage during driving into the very dense till deposit.
- **Caissons founded in the shale bedrock:** Caissons are considered feasible for the support of the abutment widening; however this option would preclude integral abutment design, and may not be compatible with the existing integral abutments. As for piles, caissons are considered to have a technical advantage over spread footings as the differential settlement between the existing and widened portions of the bridges would be negligible. This option will be more expensive than pile foundations, although fewer caisson elements would be required in comparison to the number of steel piles that would be required. If caissons are adopted for support of the abutments, they would extend into and through water-bearing non-cohesive soil deposits; temporary liners would be required during construction to control potential ground losses and allow for cleaning of the caisson base.

Based on the above considerations, it is recommended that the abutment widening be supported on steel H-piles driven to the bedrock or placed within pre-augered holes that extend to the bedrock. Shallow foundations supported on the native soils or on the bedrock are not recommended for support of the widening, due to the depth of excavation and associated protection system and dewatering requirements, the risk of impact of such excavation on the existing foundations, and the potential for differential settlement between the existing and new portions of the foundation elements.

## 6.3 Assessment of Existing Pier Foundations for Support of Superstructure Widening

As-built records are not available for the H-pile installation associated with the north and south widening under Contract 98-39. Based on the borehole information, for the structural assessment of the superstructure widening, the existing HP310x110 piles that support the pier substructure may be taken to have a factored axial geotechnical resistance at Ultimate Limit States (ULS) of 1,800 kN, and a geotechnical reaction at Serviceability Limit States (SLS, for 15 mm of settlement) of 1,600 kN.

## 6.4 Driven Steel H-Pile or Steel Pipe (Tube) Pile Foundations

### 6.4.1 Founding Elevation

For preliminary design purposes, it has been assumed that the abutment pile caps would be constructed to match the existing east and west abutment pile caps. The pile caps should be founded at a minimum depth of 1.2 m below the lowest surrounding grade to provide adequate protection against frost penetration (per OPSD 3090.101 – *Foundation Frost Depths for Southern Ontario).* The table below provides pile tip levels for preliminary design of pile foundations driven to refusal within the shale bedrock, based on interpretation of the closest available borehole information. Based on the strength and weathering observed in the upper portion of the bedrock where it could be penetrated by augering and split-spoon sampling, these recommendations assume some penetration into the bedrock at the widened abutment locations.

| Foundation Element | Bedrock Surface Elevation (m) | Design Pile Tip Elevation (m) |
|---|---|---|
| West Abutment<br>WBL – North Widening | 70.5 | 68.0 |
| West Abutment<br>Median Widening | 71.7 | 69.0 |
| West Abutment<br>EBL – South Widening | 71.5 to 72.7 | 70.0 |
| East Abutment<br>WBL – North Widening | 73.0 to 73.5 | 72.0 |
| East Abutment<br>Median Widening | 73.5 | 72.0 |
| East Abutment<br>EBL – South Widening | 73.5 | 72.0 |

Based on the pile cap elevation, bedrock surface elevation and anticipated penetration into the bedrock, the piles are expected to be longer than the minimum length of 5 m that is required for integral abutments. The presence of very dense "100-blow" soil at relatively shallow depth in some of the boreholes may require pre-augering prior to driving of the piles, and this could be done in conjunction with the installation of the corrugated steel pipe (CSP) liners.

As discussed in Section 6.2, for the installation of steel H-piles or steel pipe piles, consideration must be given to the potential presence of cobbles and boulders within the glacially-derived soils at this site, as well as the potential for damage to the pile tips during seating on the bedrock. Steel H-piles are preferred over steel pipe piles as pipe piles are considered to pose a higher risk of experiencing refusal on boulders or being deflected away from the vertical/battered orientation during installation due to their larger end area. Piles should be reinforced at the tip with driving shoes and/or flange plates in accordance with OPSD 3000.100 (*Steel H-Pile Driving Shoe*) or OPSD 3001.100 (*Steel Tube Pile Driving Shoe*) Type II, as appropriate, to reduce the potential for damage to the piles during driving. In very dense strata containing cobbles and/or boulders, as encountered at this site, driving shoes (such as Titus Standard 'H' Bearing Pile Points) are preferred over flange plates.

### 6.4.2 Geotechnical Axial Resistance/Reaction

For HP 310x110 piles driven to the design tip elevations given above, the factored axial geotechnical resistance at ULS may be taken as 1,800 kN. The axial geotechnical reaction at SLS, for 15 mm of deflection, may be taken as 1,600 kN. The same axial resistances may be used in the design of closed-end, concrete-filled, 324 mm (12 ¾ in.) diameter steel pipe piles having a minimum wall thickness of 9.5 mm (3/8 in.). These preliminary geotechnical resistances/reactions will have to be re-evaluated and modified, as necessary, during detailed design in consideration of any additional subsurface investigation at the foundation elements.

Pile installation should be in accordance with OPSS.PROV 903 (Deep *Foundations*). The drawings should note that the piles should be equipped with driving shoes or bearing points and driven to bedrock. For piles driven to refusal on bedrock, it is a generally accepted practice to reduce the hammer energy after abrupt peaking is met on the bedrock surface, and to then gradually increase the energy over a series of blows to seat the pile.

## 6.5 Caisson Foundations

### 6.5.1 Founding Elevation

Caissons founded on or socketed into the shale bedrock could be considered for support of the abutment widening. For preliminary design purposes, it has been assumed that the abutment pile caps would be constructed to match the existing east and west abutment pile caps. The proposed caisson base elevation for widening of the abutments is summarized in the table below, based on a socket length extending approximately 2 m to 3 m below the bedrock surface.

| Foundation Element | Bedrock Surface Elevation (m) | Design Pile Tip Elevation (m) |
|---|---|---|
| West Abutment<br>WBL – North Widening | 70.5 | 68.0 |
| West Abutment<br>Median Widening | 71.7 | 69.0 |
| West Abutment<br>EBL – South Widening | 71.5 to 72.7 | 70.0 |
| East Abutment<br>WBL – North Widening | 73.0 to 73.5 | 71.0 |
| East Abutment<br>Median Widening | 73.5 | 71.0 |
| East Abutment<br>EBL – South Widening | 73.5 | 71.0 |

Due to the presence of strong limestone interbeds within the shale, the sockets may have to be advanced into the rock by churn drilling or rock coring.

If caisson foundations are adopted, a temporary liner and/or drilling slurry will be required to support the overburden soils during construction and balance groundwater pressures to minimize disturbance to the side walls, and to permit cleaning of the caisson base. In addition, placement of concrete by tremie methods would be required.

### 6.5.2 Geotechnical Axial Resistance/Reaction

The caissons will derive the majority of their capacity from base resistance, although some shaft friction has also been taken into account based on "socketting" approximately 1 m into the bedrock. Using the preliminary design elevations given above, the factored axial geotechnical resistance at ULS may be taken as 4,000 kN for a 0.9 m diameter caisson and 6,500 kN for a 1.2 m diameter caisson. The axial geotechnical reaction at SLS (for 25 mm of settlement) will be greater than the factored axial resistance at ULS and as such, the SLS condition does not apply.

The preliminary geotechnical resistances/reactions provided above will need to be re-evaluated and modified, as necessary, during detailed design in consideration of any additional subsurface investigation at the foundation elements.

## 6.6 Approach Embankments and Abutment Foreslopes

The Highway 401 approach embankments are low (generally less than 1 m to 2 m in height) relative to the natural ground surface beyond the Duffins Creek valley, and therefore they are not addressed in this foundation report. However, the global stability of the abutment foreslopes is addressed in the following section.

### 6.6.1 Global Slope Stability

Preliminary static slope stability analysis have been completed for the abutment foreslopes, using the commercially available program *Slide 6.0*, from Rocscience, to check that the target minimum factor of safety is achieved. A target minimum factor of safety of 1.3 is normally used in the design of slopes under static conditions. This minimum factor of safety is considered appropriate for the proposed slope widening on this project, considering the design requirements and the available field and laboratory testing data.

The following parameters have been used in the analyses for an overall 7 m high abutment foreslope slope in long-term (effective stress) conditions, based on field and laboratory test data as well as accepted correlations (Bowles, 1984 and Kulhawy and Mayne, 1990):

| Soil Deposit | Bulk Unit Weight ($kN/m^3$) | Effective Friction Angle | Undrained Shear Strength (kPa) |
|---|---|---|---|
| Fill | 21 | 32° | - |
| Loose to compact silt to sand | 21 | 30° | - |
| Dense to very dense sand | 21 | 34° | - |

The results of the static global stability analysis indicate that a minimum factor of safety of 1.3 is achieved for approximately 7 m high foreslopes in front of the abutments, oriented no steeper than 2H:1V, as shown on Figure 1. This preliminary assessment of the slope stability of the abutment foreslopes should be reviewed and confirmed during detailed design.

Shallow sloughing and surficial erosion could occur on the 2H:1V slope faces, which would be reduced by providing well-vegetated slopes.

## 6.7 Construction Considerations

The following sections identify future construction considerations that may impact the future detail design, and for which provision may be required in the contract documents produced as part of detail design.

### 6.7.1 Open-Cut Excavation and Temporary Protection Systems

The construction of the pile caps for the abutment widening will require excavations to about 3 m below the existing Highway 401 grade, through the existing embankment fill and into the native silt to sand deposit. The existing fill and the upper loose to compact silt to sand are classified as a Type 3 soil, while the native compact to very dense silt to sand deposits are classified as Type 2 soils, according to the Occupational Health and Safety Act (OHSA). Where space permits, temporary open-cut excavations above the groundwater level should be made with side slopes no steeper than 1H:1V. All excavations must be carried out in accordance with Ontario Regulation 213 (Ontario Occupational Health and Safety Act for Construction Projects) (as amended).

It is anticipated that due to space constraints, temporary protection systems will be required along the existing Highway 401 lanes to facilitate the widening of the abutments. Temporary protection systems should be designed and constructed in accordance with OPSS.PROV 539 (*Temporary Protection Systems).* The lateral movement of the temporary shoring system should meet Performance Level 2 as specified in OPSS.PROV 539, provided that any existing adjacent utilities can tolerate this magnitude of deformation. The selection and design of the protection system will be the responsibility of the Contractor.

### 6.7.2 Groundwater Control

Excavations for the widened abutment pile caps will be maintained above the groundwater level, which is anticipated to be at about Elevation 78 m. Therefore, minimal seepage and groundwater control is anticipated for the abutment widening.

Control of surface water should be maintained at all times and surface water should be directed away from all excavations and exposed subgrade soils.

### 6.7.3 Obstructions

The soils at this site are glacially derived and as such should be expected to contain cobbles and boulders, which could affect the installation of deep foundations or protection systems. Further observation is recommended in any future investigation at this site, to further assess the presence of cobbles and boulders and permit the contractor to assess the impact on foundation construction.

### 6.7.4 Vibration Monitoring During Pile Installation

A maximum peak particle velocity (PPV) of 100 mm/s is generally considered applicable for bridge structures in good condition; lower thresholds are applicable for nearby residential and commercial facilities (between

25 mm/s and 50 mm/s), and may be applicable for the rail line south of the structure site. Vibration monitoring is recommended during pile driving adjacent to the abutment areas to demonstrate/confirm that vibration levels do not exceed the threshold levels.

## 6.8 Recommendation for Future Work during Detail Design

During the detailed design phase, additional borehole investigation work is recommended at the abutment widening areas to confirm the foundation recommendations and to determine the current/stabilized groundwater level and further assess groundwater control and protection system requirements associated with excavations for the abutment widenings.

As noted throughout this report, the preliminary assessment of founding elevation, geotechnical resistances, and global stability analysis should be revisited based on the additional borehole information, geometry and other requirements at the detailed design stage.

# 7.0 CLOSURE

This Preliminary Foundation Design Report was prepared by Ms. Nikol Kochmanová, P.Eng. Ms. Lisa Coyne, P.Eng., a Principal and Designated MTO Foundations Contact for Golder, conducted an independent review of this report.

**GOLDER ASSOCIATES LTD.**


Nikol Kochmanova, P.Eng.
Geotechnical Engineer


Lisa Coyne, P.Eng.
Designated MTO Foundations Contact, Principal

HS/NK/LCC/sm



n:\active\2011\1184\11-1184-0143 urs hwy 401 brock to courtice\6 - reports\2 - duffins creek bridge\11-1184-0143 rpt02 2017-05-19 duffins creek bridge.docx

# REFERENCES

Bowles, J.E., 1984. *Physical and Geotechnical Properties of Soils*, Second Edition, McGraw Hill Book Company, New York.

Brennand, T.A. 1998. Urban Geology Note: Oshawa Ontario. In P.F. Karrow, and O. L. White (Eds.), Geological Association of Canada, Special Paper 42: Urban Geology of Canadian Cities, p. 353-364.

Canadian Geotechnical Society, 1992. *Canadian Foundation Engineering Manual*, 3rd Edition. The Canadian Geotechnical Society, BiTech Published Ltd., British Columbia.

Canadian Geotechnical Society, 2006. *Canadian Foundation Engineering Manual*, 4th Edition. The Canadian Geotechnical Society, BiTech Publisher Ltd., British Columbia.

Canadian Standards Association (CSA), 2006. *Canadian Highway Bridge Design Code* and *Commentary on CAN/CSA S6 06*. CSA Special Publication, S6.1 06.

Chapman, L.J., and Putnam, D.F., 1984. *The Physiography of Southern Ontario*, 3rd Edition. Ontario Geological Survey, Special Volume 2. Ontario Ministry of Natural Resources.

Kulhawy, F.H. and Mayne, P.W., 1990. *Manual on Estimating Soil Properties for Foundation Design*. EL 6800, Research Project 1493 6. Prepared for Electric Power Research Institute, Palo Alto, California.

NAVFAC, 1982. *Design Manual DM 7.2: Soil Mechanics, Foundation and Earth Structures*. U.S. Navy. Alexandria, Virginia.

**ASTM International:**

ASTM D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

**Ontario Provincial Standard Specifications (OPSS)**

OPSS.PROV 539 Construction Specification for Temporary Protection Systems
OPSS.PROV 903 Construction Specification for Deep Foundations

**Ontario Provincial Standard Drawings (OPSD)**

OPSD 3000.100 Foundation, Piles, Steel H-Pile, Driving Shoe
OPSD 3001.100 Foundation, Piles, Steel Tube Piles, Driving Shoe
OPSD 3090.101 Foundation Frost Depths for Southern Ontario

**Other**

Ontario Regulation 213 Construction Projects (as amended)

## TABLE 1 – COMPARISON OF FEASIBLE FOUNDATION ALTERNATIVES

| Foundation Option | Feasibility | Advantages | Disadvantages | Estimated Costs | Risk / Consequences |
|---|---|---|---|---|---|
| Spread/strip footings | • Not recommended for support of widened abutments<br>• Very loose to loose soils extend as deep as 4.9 m and 5.6 m below original ground surface at the west and east abutments, requiring significant excavations and dewatering; also not compatible with existing pile-supported integral abutments | • None | • Significant excavations required to either remove very loose to loose soils, or extend footings below this level; would require more significant protection systems and dewatering as compared with perched pile caps for a deep foundation option<br>• Differential settlement between existing structure and widened abutments supported on spread footings on compact to very dense sand | • Estimated cost is approximately $600/m^3$ for construction of shallow foundations, plus the cost of protection systems and dewatering at this site | • This option not recommended |
| Steel H-piles or pipe piles | • Feasible for support of abutments<br>• H-piles compatible with existing integral abutments | • Conventional construction methods<br>• Abutment pile caps could be maintained higher than spread footings, reducing depth of excavation and protection system requirements<br>• Excavations would be maintained above the groundwater level at the site<br>• Steel H-piles allow for integral abutment | • Pre-augering may be required due to relatively short pile length and very dense soils, to ensure proper alignment of piles and to minimize damage to pile tips<br>• Potential for encountering cobbles and/or boulders | • Estimated cost is approximately $250/m length for pile installation and $600/m^3$ for pile cap construction | • Minor potential for pile damage / deflection if cobbles and boulders are encountered during pile driving<br>• Slightly greater risk in this regard for pipe piles as compared with H-piles if boulders are encountered during pile driving |

| Foundation Option | Feasibility | Advantages | Disadvantages | Estimated Costs | Risk / Consequences |
|---|---|---|---|---|---|
| | | configuration, and pipe piles for semi-integral abutment configuration<br>• Negligible differential settlement between existing structures and widening | | | |
| Caissons | • Feasible but not recommended for support of the abutment widening, as they are less compatible with the existing pile-supported integral abutments | • Abutment pile caps could be maintained higher than spread footings, reducing depth of excavation and protection system requirements relative to spread footings<br>• Higher capacity than for driven piles, so reduced number of deep foundation elements compared to piles<br>• Negligible differential settlement between existing structures and widening | • Caissons would extend below the groundwater level at the site into water-bearing cohesionless soils, with potential for loss of ground<br>• Temporary liners would be required, plus special measures such as use of drilling mud and tremie placement of concrete; likely not possible to inspect caisson base<br>• Precludes use of integral abutments | • Estimated cost is approximately \$1,000/m length for caisson installation and \$600/m$^3$ for pile cap construction; the cost may be higher to account for temporary liners | • Risk of loss of ground during construction of caissons through water-bearing layers, although this risk can be mitigated with the use of temporary liners |

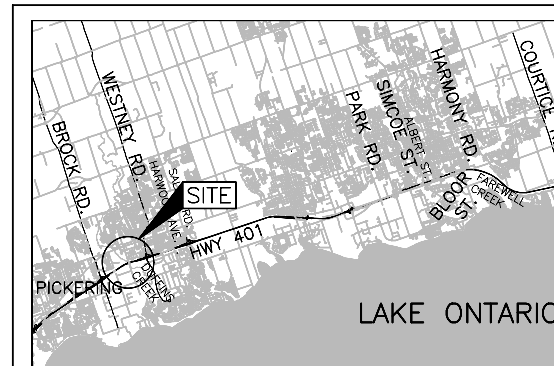
***METRIC***
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WO No. 10-20011

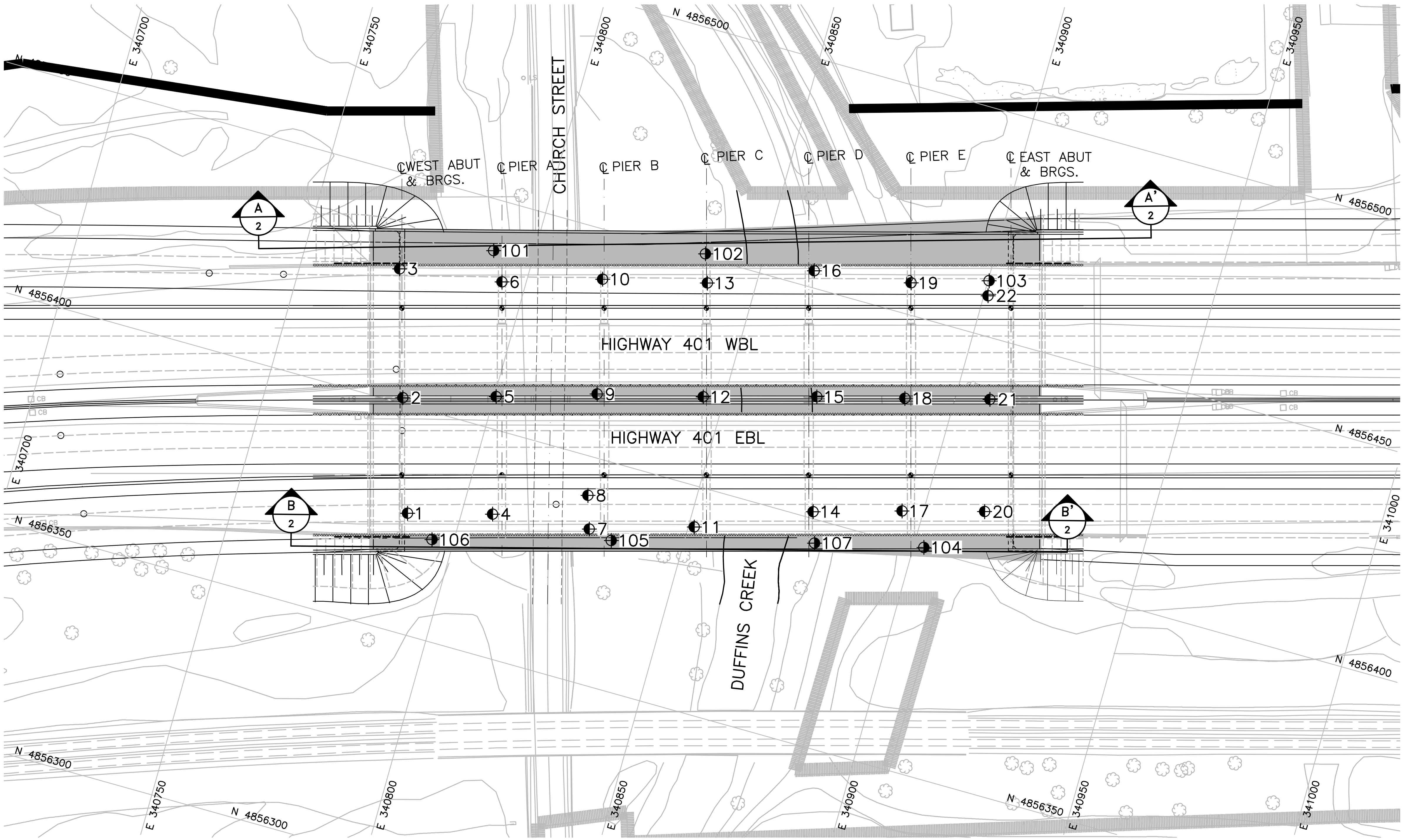
# DUFFINS CREEK BRIDGES
HIGHWAY 401 IMPROVEMENTS
## BOREHOLE LOCATIONS

SHEET

Golder Associates




KEY PLAN
SCALE
4 0 4 8 km




PLAN
SCALE
10 0 10 20 m

## LEGEND

- 1972 Boreholes – GEOCRES No. 30M14-007
- 1997 Boreholes – GEOCRES No. 30M14-252

| BOREHOLE CO-ORDINATES | | | |
|---|---|---|---|
| No. | ELEVATION | NORTHING | EASTING |
| 1 | 80.7 | 4856376.5 | 340788.3 |
| 2 | 79.9 | 4856401.3 | 340780.3 |
| 3 | 80.4 | 4856429.0 | 340771.8 |
| 4 | 80.3 | 4856381.5 | 340806.8 |
| 5 | 80.0 | 4856407.2 | 340800.4 |
| 6 | 79.7 | 4856432.4 | 340794.7 |
| 7 | 79.1 | 4856384.2 | 340828.7 |
| 8 | 79.5 | 4856391.4 | 340826.4 |
| 9 | 79.5 | 4856413.9 | 340822.2 |
| 10 | 79.5 | 4856439.1 | 340816.4 |
| 11 | 77.7 | 4856391.0 | 340851.3 |
| 12 | 78.2 | 4856419.7 | 340845.3 |
| 13 | 77.8 | 4856444.6 | 340839.3 |
| 14 | 78.9 | 4856401.5 | 340876.1 |
| 15 | 78.5 | 4856426.6 | 340869.9 |
| 16 | 78.7 | 4856453.8 | 340861.7 |
| 17 | 79.0 | 4856407.1 | 340895.3 |
| 18 | 79.1 | 4856431.7 | 340889.1 |
| 19 | 79.2 | 4856457.1 | 340883.5 |
| 20 | 79.6 | 4856411.9 | 340913.3 |
| 21 | 80.0 | 4856436.6 | 340907.6 |
| 22 | 80.7 | 4856458.9 | 340900.9 |
| 101 | 80.5 | 4856438.7 | 340791.0 |
| 102 | 78.8 | 4856450.9 | 340837.1 |
| 103 | 80.7 | 4856462.2 | 340900.2 |
| 104 | 79.0 | 4856400.5 | 340902.3 |
| 105 | 79.3 | 4856383.0 | 340834.1 |
| 106 | 80.6 | 4856372.3 | 340795.2 |
| 107 | 79.0 | 4856394.8 | 340878.3 |

### REFERENCE

Base plans provided in digital format by URS, drawing file nos. X-Base.dwg, X-Property.dwg and Street Names.dwg, and the Proposed Design obtained from drawing file x-design_130625.dwg, all dated July 05, 2013, received April 11, 2014. General Arrangement provided in digital format by AECOM file no. 01_Duffins Creek Overpass _GA.dgn, received February 25, 2015.

### NOTES

This drawing is for subsurface information only. The proposed structure details/works are shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Preliminary Design Report.

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

LICENSED PROFESSIONAL ENGINEER L.C. COYNE APR 05, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 APR 05, 2017 PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|
| . | . | . | . |

Geocres No. 30M14-455

| | | | |
|---|---|---|---|
| HWY. 401 | PROJECT NO. 11-1184-0143 | | DIST. CENTRAL |
| SUBM'D. HS | CHKD. NK | DATE: 4/5/2017 | SITE: 22-120 |
| DRAWN: JFC/DD | CHKD. NK | APPD. LCC | DWG. 1 |

MINISTRY OF TRANSPORTATION, ONTARIO

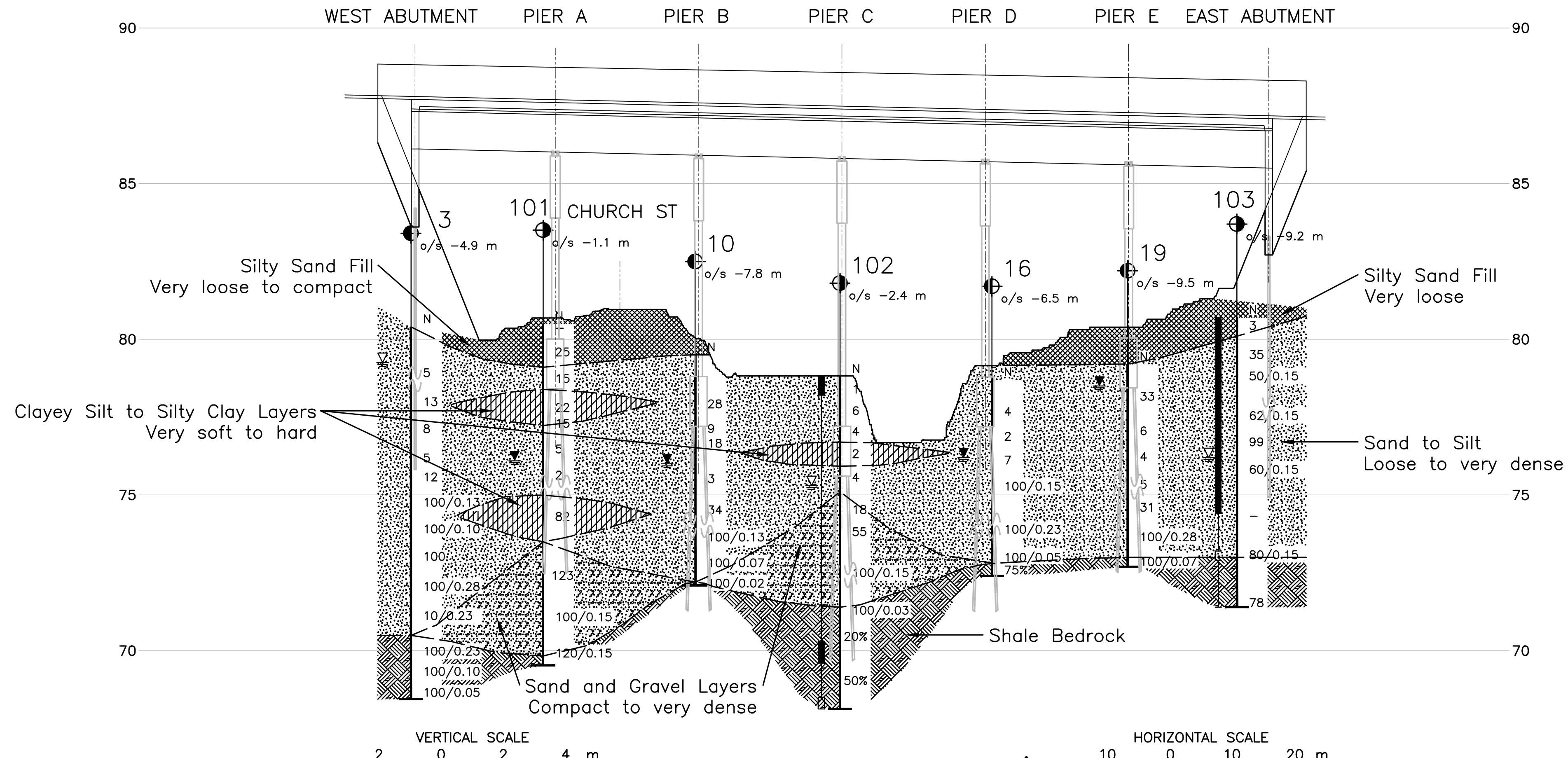
**METRIC**
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS IN KILOMETRES + METRES.

CONT No.
WO No. 10–20011

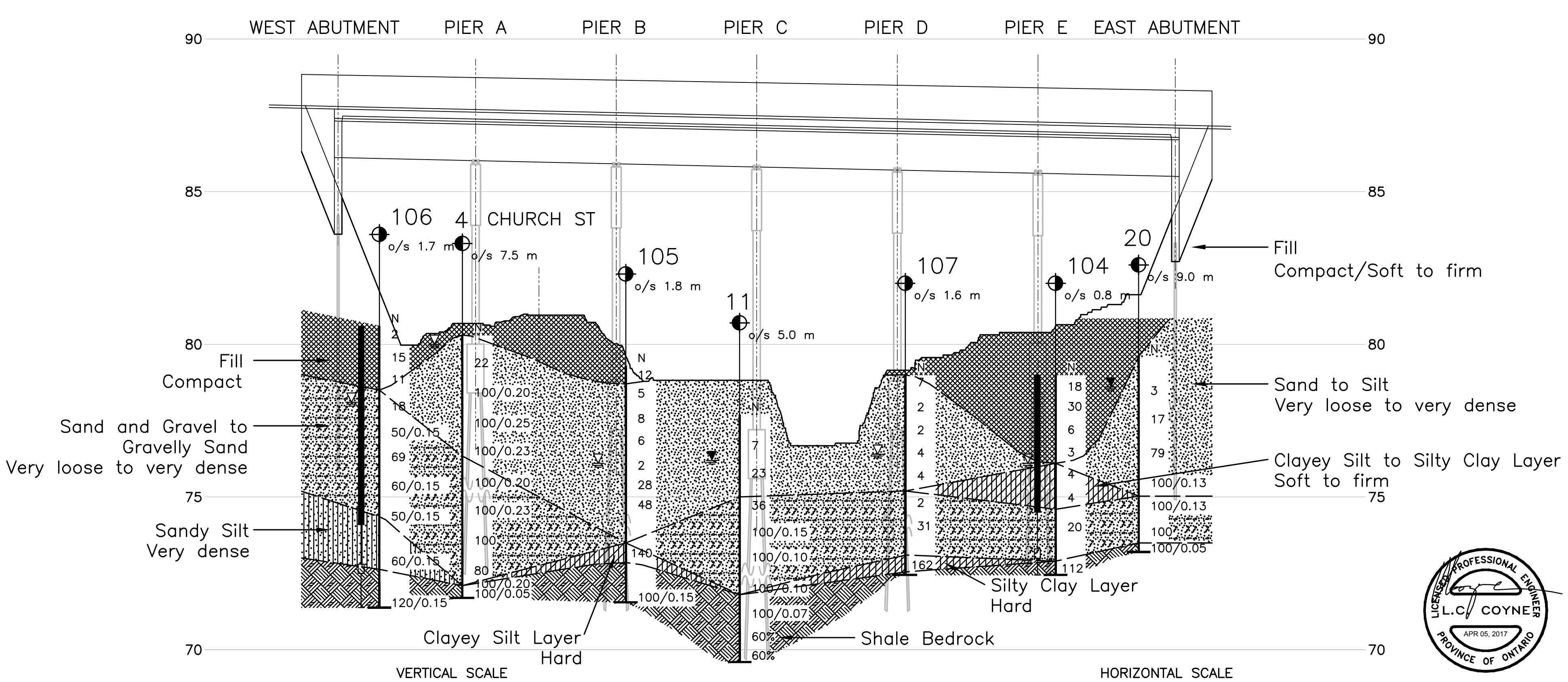
SHEET

# DUFFINS CREEK BRIDGES
HIGHWAY 401 IMPROVEMENTS
## SOIL STRATA

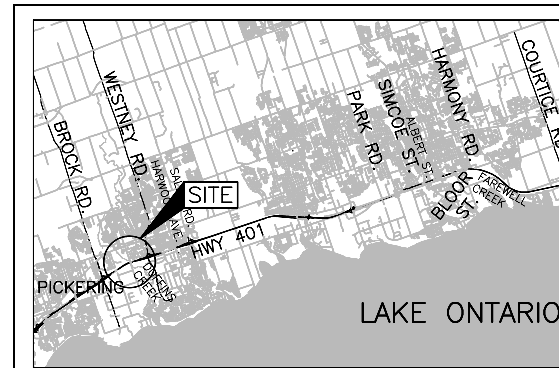
Golder Associates




NORTH SIDE SECTION A–A'




SOUTH SIDE SECTION B–B'




KEY PLAN
SCALE
4 0 4 8 km

## LEGEND

- 1972 Boreholes – GEOCRES No. 30M14–007
- 1997 Boreholes – GEOCRES No. 30M14–252
- Seal
- Piezometer
- N 16 — Standard Penetration Test Value Blows/0.3m unless otherwise stated (Std. Pen. Test, 475 j/blow)
- 100% — Rock Quality Designation (RQD)
- WL in piezometer, measured on 1997 CB
- WL upon completion of drilling

BOREHOLE CO–ORDINATES

| No. | ELEVATION | NORTHING | EASTING |
|---|---|---|---|
| 3 | 80.4 | 4856429.0 | 340771.8 |
| 4 | 80.3 | 4856381.5 | 340806.8 |
| 10 | 79.5 | 4856439.1 | 340816.4 |
| 11 | 77.7 | 4856391.0 | 340851.3 |
| 16 | 78.7 | 4856453.8 | 340861.7 |
| 19 | 79.2 | 4856457.1 | 340883.5 |
| 20 | 79.6 | 4856411.9 | 340913.3 |
| 101 | 80.5 | 4856438.7 | 340791.0 |
| 102 | 78.8 | 4856450.9 | 340837.1 |
| 103 | 80.7 | 4856462.2 | 340900.2 |
| 104 | 79.0 | 4856400.5 | 340902.3 |
| 105 | 79.3 | 4856383.0 | 340834.1 |
| 106 | 80.6 | 4856372.3 | 340795.2 |
| 107 | 79.0 | 4856394.8 | 340878.3 |

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LICENSED PROFESSIONAL ENGINEER L.C. COYNE APR 05, 2017 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER N. KOCHMAN 100117863 APR 05, 2017 PROVINCE OF ONTARIO

| NO. | DATE | BY | REVISION |
|---|---|---|---|

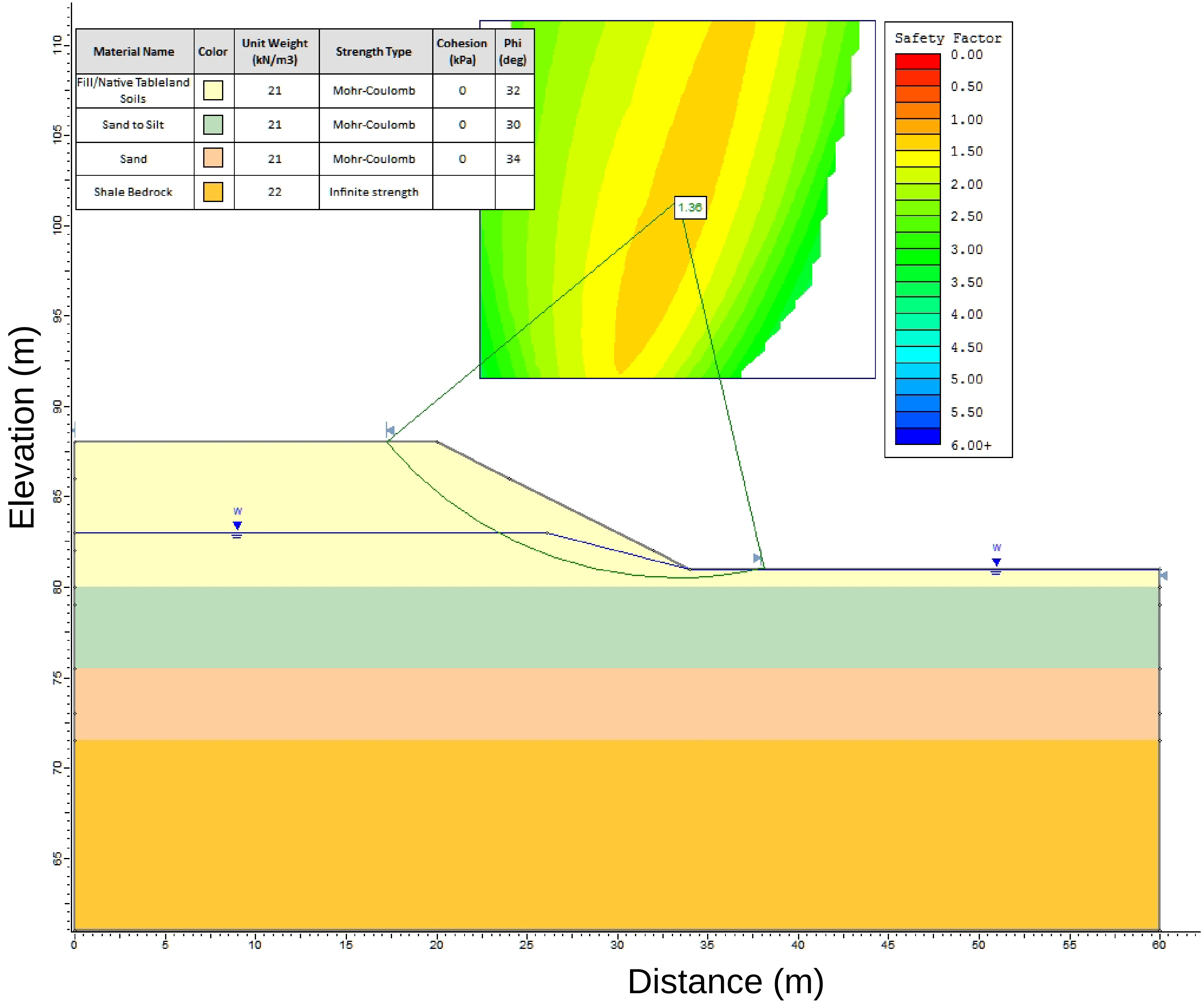
Geocres No. 30M14–455

| | | | |
|---|---|---|---|
| HWY. 401 | PROJECT NO. 11–1184–0143 | | DIST. CENTRAL |
| SUBM'D. NK | CHKD. NK | DATE: 4/5/2017 | SITE: 22–120 |
| DRAWN: JFC/DD | CHKD. NK | APPD. LCC | DWG. 2 |

PLOT DATE: April 5, 2017
FILENAME: T:\Projects\2011\11-1184-0143 (HWY 401 from Brock Rd to Courtice Rd)\-EA- Duffins Creek\11118401432EA002.dwg

## STATIC GLOBAL STABILITY
## DUFFINS CREEK BRIDGES – ABUTMENT FORESLOPES

# Figure 1




| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) |
|---|---|---|---|---|---|
| Fill/Native Tableland Soils | | 21 | Mohr-Coulomb | 0 | 32 |
| Sand to Silt | | 21 | Mohr-Coulomb | 0 | 30 |
| Sand | | 21 | Mohr-Coulomb | 0 | 34 |
| Shale Bedrock | | 22 | Infinite strength | | |

**Date:** October 2016 **Analysis By:** NK **Reviewed By:** LCC

**Project No:** 11-1184-0143

Golder Associates

# APPENDIX A

## Borehole Records
## GEOCRES No. 30M14-007 – 1972 Investigation

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº1

JOB 72-11119 | LOCATION Co-ords. 932,279 N; 118,029 E. | ORIGINATED BY EW

W.P. 44-71-02~~1~~ | BORING DATE November 15, 1972 | COMPILED BY EW

DATUM Geodetic | BOREHOLE TYPE Washboring | CHECKED BY [signature]

| ELEV. / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | REMARKS GR.SA.SI.CL. |
|---|---|---|---|---|---|---|
| 264.7 | Ground Level | | | | | |
| 0.0 | Silty sand, traces of clay & gravel. Compact | | | | | 2 52 42 4 |
| 260.7 | | 1 | SS | 20 | 260 | 27 34 38 1 |
| 4.0 | Sandy silt, some gravel trace of clay. Dense | 2 | SS | 31 | | 7 40 49 4 |
| 256.2 / 8.5 | Gravelly sand, traces of silt & clay. Very Dense | 3 | SS | 100 | | 43 41 15 1 |
| | | 4 | SS | 100/5" | | 60 33 (7) |
| | | 5 | SS | 100/5" | 250 | |
| 243.5 | | 6 | SS | 100/3" | | 16 74 (10) |
| 21.2 | Sandy silt, traces of gravel & clay. Very Dense | 7 | SS | 100/3" | | |
| | | 8 | SS | 100/6" | 240 | 5 34 52 9 |
| 234.5 | | 9 | SS | 100/6" | | 8 43 45 4 |
| | | 10 | SS | 100/2" | | |
| | | 11 | [illegible] | [illegible] | | |
| 233.0 | Shale | 12 | RC | 85% | | |
| 31.7 | End of Borehole | | | | 230 | |

SOIL PROFILE | SAMPLES | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT | SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | LIQUID LIMIT — $W_L$ PLASTIC LIMIT — $W_P$ WATER CONTENT — W | WATER CONTENT % 20 40 60 | BULK DENSITY γ P.C.F. | STRAT. PLOT

20 / 15 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

# RECORD OF BOREHOLE No 2

JOB 72-11119
W.P. 44-71-02
DATUM Geodetic

LOCATION Co-ords. 932,346 N; 118,005 E.
BORING DATE November 15, 1972
BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY EW
COMPILED BY EW
CHECKED BY

## Soil Profile

| ELEV. / DEPTH | DESCRIPTION |
|---|---|
| 262.3 | Ground Level |
| 0.0 | Silty sand, some gravel, trace clay. Very Loose to Compact. |
| 251.1 / 11.2 | Sand with gravel, trace silt. Very Dense |
| 237.3 | Sand, some silt, trace clay & gravel. |
| 235.3 / 27.0 | Shale |
| 233.1 / 29.2 | End of Borehole |

## Samples

| NUMBER | TYPE | BLOWS/FOOT | REMARKS GR. SA. SI. CL. |
|---|---|---|---|
| 1 | SS | 2 | 3 49 (48) |
| 2 | SS | 12 | 21 44 (35) |
| 3 | SS | 21 | |
| 4 | SS | 80 | 39 52 (9) |
| 5 | SS | 100/6" | |
| 6 | SS | 100/[illegible]" | 26 66 (8) |
| 7 | SS | 100/11" | |
| 8 | SS | 100/10" | 12 77 (11) |
| 9 | SS | 100/[illegible]" | 9 62 (29) |
| 10 | RC | 100% | |

ELEV. SCALE: 260, 250, 240, 230

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

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

BULK DENSITY γ P.C.F.

REMARKS GR. SA. SI. CL.

20 / 15 – 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº3

JOB 72-11119
W.P. 44-71-028
DATUM Geodetic

LOCATION Co-ords. 932,417 N; 117,983 E.
BORING DATE November 14, 1972
BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY EW
COMPILED BY EW
CHECKED BY

| ELEV. / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | REMARKS GR.SA.SI.CL |
|---|---|---|---|---|---|---|
| 263.8 | Ground Level | | | | | |
| 0.0 | Sandy silt, some clay trace of gravel. Loose | 1 | SS | 5 | 260 | 8 38 45 9 |
| | | 2 | SS | 13 | | 2 37 53 10 |
| | | 3 | SS | 8 | | 4 52 (42) |
| | | 4 | SS | 5 | 250 | 1 36 52 11 |
| 247.8 | | 5 | SS | 12 | | |
| 16.0 | Sand, some gravel and silt. Very Dense | 6 | SS | 100/5" | | |
| | | 7 | SS | 100/4" | | 17 65 (18) |
| | | 8 | SS | 100 | 240 | |
| | | 9 | SS | 100/11" | | 30 61 ( 9 ) |
| 231.3 | | 10 | SS | 100/9" | | |
| 32.5 | Shale | 11 | SS | 100/9" | 230 | |
| | | 12 | SS | 100/4" | | |
| 224.5 | | 13 | SS | 100/2" | | |
| 39.2 | End of Borehole | | | | 220 | |

SOIL PROFILE · STRAT. PLOT · SAMPLES

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT $W_L$
PLASTIC LIMIT $W_P$
WATER CONTENT W

WATER CONTENT % 20 40 60

BULK DENSITY γ P.C.F.

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 4

JOB 72-11119

W.P. 44-71-02[illegible]

DATUM Geodetic

LOCATION Co-ords. 932,293 N; 118,077 E.

BORING DATE November 16, 1972

BOREHOLE TYPE Hollow Stem Auger

ORIGINATED BY EW

COMPILED BY EW

CHECKED BY [illegible]

| ELEV. / DEPTH | SOIL PROFILE – DESCRIPTION | SAMPLE NUMBER | TYPE | BLOWS/FOOT | REMARKS GR.SA.SI.CL. |
|---|---|---|---|---|---|
| 263.6 | Ground Level | | | | |
| 0.0 | Sand, some silt and gravel, trace clay. | | | | |
| | | 1 | SS | 22 | 2 63 (35) |
| | | 2 | SS | 100/[illegible]" | 45 37 (18) |
| | Compact to Very Dense | 3 | SS | 100/[illegible]0" | |
| 250.6 | | 4 | SS | 100/[illegible]" | 3 29 (68) |
| 13.0 | Gravelly sand, trace silt & clay. | 5 | SS | 100/[illegible]" | 46 45 ( 9 ) |
| | | 6 | SS | 100/[illegible]" | |
| | Very Dense | 7 | SS | 100 | |
| 236.6 | | 8 | SS | 80 | 9 81 (10) |
| | | 9 | SS | 100/[illegible]" | |
| 235.3 | Shale | 10 | SS | 100/[illegible]" | |
| 28.3 | End of Borehole | | | | |

ELEV. SCALE: 260, 250, 240, 230

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
o UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT — $W_L$
PLASTIC LIMIT — $W_P$
WATER CONTENT — W

WATER CONTENT % 20 40 60

BULK DENSITY γ P.C.F.

20 15 ◊ 5 10 % STRAIN AT FAILURE

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº5

JOB 72-11119 | LOCATION Co-ords. 932,360 N; 118,057 E. | ORIGINATED BY EW

W.P. 44-71-02 | BORING DATE November 10, 1972 | COMPILED BY EJ

DATUM Geodetic | BOREHOLE TYPE Hollow stem Auger | CHECKED BY

| ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | SAMPLE NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | WATER CONTENT % | REMARKS GR. SA. SI. CL. |
|---|---|---|---|---|---|---|---|---|
| 262.6 | Ground Level | | | | | | | |
| 0.0 | Silt, some sand and clay, trace of gravel. Loose | | 1 | SS | 3 | 260 | | 3 26 61 10 |
| | | | 2 | SS | 6 | | | |
| 251.6 | | | 3 | SS | 8 | | | |
| 11.0 | Sand, some silt, trace gravel & clay. Loose to Very Dense | | 4 | SS | 11 | 250 | | 6 72 ( 10 ) |
| | | | 5 | SS | 7 | | | |
| | | | 6 | SS | 43 | | | |
| | | | 7 | SS | 100/4" | 240 | | 9 71 ( 20 ) |
| | | | ~~8~~ | ~~SS~~ | ~~100/3"~~ | | | |
| 235.3 | | | 9 | SS | 100/4" | | | |
| 234.1 | Shale | | 10 | SS | 100 | | | |
| 28.5 | End of Borehole | | | | | 230 | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT $W$

WATER CONTENT % 20 40 60

BULK DENSITY γ P.C.F.

20 15 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 6

JOB 72-11119 | LOCATION Co-ords. 932,427 N; 118,042 E. | ORIGINATED BY EW

W.P. 44-71-020 | BORING DATE November 9, 1972 | COMPILED BY EW

DATUM Geodetic | BOREHOLE TYPE Hollow stem auger | CHECKED BY [signature]

| ELEV. / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | REMARKS (GR SA SI CL) |
|---|---|---|---|---|---|---|
| 261.6 | Ground Level | | | | | |
| 0.0 | Sandy silt, some clay, trace gravel. Loose | | | | 260 | |
| | | 1 | SS | 7 | | |
| | | 2 | SS | 5 | | 8 36 42 14 |
| | | 3 | SS | 5 | | |
| | | 4 | SS | 6 | 250 | 0 39 57 42 |
| 246.6 / 15.0 | Sand, with gravel, some silt, trace clay. Very Dense | 5 | SS | 22 | | 43 48 (9) |
| | | 6 | SS | 100/7" | | 2 71 (27) |
| | | 7 | SS | 100/3" | 240 | 30 50 14 6 |
| | | 8 | SS | 100/8" | | 27 62 (11) |
| | | 9 | SS | 100/5" | | |
| 231.9 / 29.7 | Shale | 10 | SS | 100/4" | 230 | |
| | | 11 | SS | 100/5" | | |
| | | 12 | RC | 100% | | |
| | | 13 | RC | 95% | 220 | |
| 218.2 / 43.4 | End of Borehole | | | | 210 | |

Column headings: SOIL PROFILE (ELEV. DEPTH, DESCRIPTION, STRAT. PLOT); SAMPLES (NUMBER, TYPE, BLOWS/FOOT); ELEV. SCALE; DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE); LIQUID LIMIT $W_L$, PLASTIC LIMIT $W_P$, WATER CONTENT $W$; WATER CONTENT % 20 40 60; BULK DENSITY γ P.C.F.; REMARKS GR.SA.SI.CL.

20 / 15 – 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

# RECORD OF BOREHOLE No 7

JOB 72-11119
W.P. 44-71-020
DATUM Geodetic

LOCATION Co-ords. 932,306 N; 118,154 E.
BORING DATE November 2, 1972
BOREHOLE TYPE Washboring & Cone Test

ORIGINATED BY IW
COMPILED BY EW
CHECKED BY

| ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100; SHEAR STRENGTH P.S.F. o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT W; WATER CONTENT % 20 40 6- | BULK DENSITY γ P.C.F. | REMARKS GR.SA.SI.CL. |
|---|---|---|---|---|---|---|---|---|---|---|
| 259.4 | Ground Level | | | | | | | | | |
| 0.0 | Silty sand, some gravel, trace clay. | | 1 | SS | 11 | | | | | 23 45 31 1 |
| | | | 2 | SS | 10 | | | | | |
| | Loose | | 3 | SS | 11 | 250 | | | | 15 55 (30) |
| 244.4 | | | 4 | SS | 1 | | | | | 8 63 (29) |
| 15.0 | Sandy silt, trace clay & gravel. | | 5 | SS | 56 | | | | | |
| | | | 6 | SS | 100 | 240 | | | | 2 40 (58) |
| 237.2 | Very Dense Shale | | 7 | SS | 100/10" | | | | | |
| 22.5 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 8

JOB 72-11119  LOCATION Co-ords. 932,322 N; 118,145 E.  ORIGINATED BY EW

W.P. 44-71-02A  BORING DATE November 1, 1972  COMPILED BY EW

DATUM Geodetic  BOREHOLE TYPE Washboring & Cone Test  CHECKED BY [signature]

| ELEV. DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | WATER CONTENT % | REMARKS GR SA SI CL |
|---|---|---|---|---|---|---|---|
| 260.8 | Ground Level | | | | | | |
| 0.0 | Silty sand, some gravel, trace clay. Very Loose to Compact | 1 | SS | 16 | 260 | o | 14 61 (25) |
| | | 2 | SS | 2 | | | |
| | | 3 | SS | 1 | 250 | o | 21 47 (32) |
| | | 4 | SS | 5 | | | |
| 241.8 | | 5 | WS | - | | | |
| 19.0 | Silt and sand, some gravel, trace clay. Very Dense | 6 | SS | 90 | 240 | o | 14 45 (41) |
| 236.8 / 24.0 | Shale | 7 | RC | 70% | | | |
| 233.8 | | 8 | RC | 0% | | | |
| 27.0 | End of Borehole | | | | 230 | | |

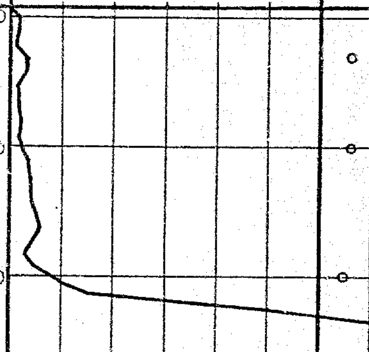
DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT 20 40 60 80 100

SHEAR STRENGTH P.S.F. o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT —— $W_L$ PLASTIC LIMIT —— $W_P$ WATER CONTENT —— W

WATER CONTENT % 20 40 60

BULK DENSITY γ P.C.F.



20 15 5 10 % STRAIN AT FAILURE

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE № 9

JOB 72-11119
W.P. 44-71-020
DATUM Geodetic

LOCATION Co-ords. 932,381 N; 118,132 E.
BORING DATE November 13, 1972
BOREHOLE TYPE Washboring

ORIGINATED BY EW
COMPILED BY EW
CHECKED BY JR

| ELEV. / DEPTH | DESCRIPTION | SAMPLE NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | REMARKS GR. SA. SI. CL. |
|---|---|---|---|---|---|---|
| 260.8 | Ground Level | | | | | |
| 0.0 | Silty sand, traces of clay and gravel. Loose | | | | 260 | |
| | | 1 | SS | 9 | | 5 58 31 6 |
| | | 2 | SS | 11 | | |
| | | 3 | SS | 2 | 250 | 1 55 37 7 |
| | | 4 | SS | 4 | | |
| | | 5 | SS | 13 | | 6 37 46 11 |
| | | 6 | SS | 6 | 240 | |
| 238.3 | Silt with sand, trace gravel & clay. V. Dense | 7 | SS | 72 | | 7 26 62 5 |
| 235.8 / 25.0 | Shale | 8 | SS | 100/1" | | |
| | | 9 | RC | 20% | | |
| 232.3 | | 10 | RC | 90% | | |
| 28.5 | End of Borehole | | | | 230 | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F.: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE
LIQUID LIMIT — $W_L$; PLASTIC LIMIT — $W_P$; WATER CONTENT — W
WATER CONTENT % 20 40 60
BULK DENSITY γ P.C.F.

20
15 ⌖ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 10

JOB 72-11119 | LOCATION Co-ords. 932,448 N; 118,114 E. | ORIGINATED BY EW

W.P. 44-71-026 | BORING DATE November 10, 1972 | COMPILED BY EW

DATUM Geodetic | BOREHOLE TYPE Washboring | CHECKED BY [illegible]

| SOIL PROFILE | | | SAMPLES | | | | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) | LIQUID LIMIT — $W_L$; PLASTIC LIMIT — $W_P$; WATER CONTENT — W; WATER CONTENT % 20 40 60 | BULK DENSITY γ P.C.F. | REMARKS GR.SA.SI.CL |
|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | | | | |
| 260.9 | Ground Level | | | | | | | | | |
| 0.0 | Silt with sand, some clay, trace gravel. | | 1 | SS | 28 | 260 | | | | 5 25 51 19 |
| | | | 2 | SS | 9 | | | | | |
| | Very Loose to Compact | | 3 | SS | 18 | 250 | | | | |
| 245.9 | | | 4 | SS | 3 | | | | | 4 27 64 5 |
| 15.0 | Sand, some silt, trace gravel. | | 5 | SS | 34 | | | | | |
| | Dense to Very Dense | | 6 | SS | 100/5" | | | | | 9 62 (26) |
| | | | 7 | SS | 100/3" | 240 | | | | 9 68 21 1 |
| ~~236.8~~ 236.9 | ~~Shale~~ | | ~~8~~ | ~~SS~~ | ~~100/1"~~ | | | | | |
| 24.1 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

20
15 ⯎ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

# RECORD OF BOREHOLE No. 11

JOB 72-11119
W.P. 44-71-026
DATUM Geodetic

LOCATION Co-ords. 932,326 N; 118,225 E.
BORING DATE November 3, 1972
BOREHOLE TYPE Washboring

ORIGINATED BY EW
COMPILED BY EW
CHECKED BY

| ELEV. / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | WATER CONTENT % | REMARKS GR.SA.SI.CL |
|---|---|---|---|---|---|---|---|
| 255.0 | Ground Level | | | | | | |
| 0.0 | Sand, some gravel and silt. Loose to Compact | 1 | SS | 7 | ▽ 250 | o | 19 63 (18) |
| | | 2 | SS | 23 | | | |
| 246.0 / 9.0 | Gravelly sand, some silt. Dense to Very Dense | 3 | SS | 36 | | o | 13 41 (46) |
| | | 4 | SS | 100/6" | 240 | o | 37 48 (15) |
| | | 5 | SS | 100/4" | | | |
| 235.5 | | 6 | SS | 100/4" | | o | 34 54 (12) |
| 19.5 | Shale | 7 | SS | 100/3" | | | |
| | | 8 | RC | | | | |
| | | 9 | RC | 60% | | | |
| 228.5 | | 10 | RC | 60% | 230 | | |
| 26.5 | End of Borehole | | | | 220 | | |

OFFICE REPORT ON SOIL EXPLORATION

20 / 15 / 5 / 10 % STRAIN AT FAILURE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS – ONTARIO

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# RECORD OF BOREHOLE Nº 12

JOB 72-11119

W.P. 44-71-020

DATUM Geodetic

LOCATION Co-ords. 932,403 N; 118,206 E.

BORING DATE November 7, 1972

BOREHOLE TYPE Washboring

ORIGINATED BY EW

COMPILED BY EW

CHECKED BY

| SOIL PROFILE: ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | SAMPLES: NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | LIQUID LIMIT — $W_L$; PLASTIC LIMIT — $W_P$; WATER CONTENT — W; WATER CONTENT % 20 40 60 | BULK DENSITY γ P.C.F. | REMARKS GR.SA.SI.C |
|---|---|---|---|---|---|---|---|---|---|---|
| 256.4 | Ground Level | | | | | | | | | |
| 0.0 | Sand with silt, trace clay and gravel. | | | | | | | | | |
| | | | 1 | SS | 6 | | | ○ | | 8 54 (38 |
| | Loose | | 2 | SS | 3 | ▼ 250 | | | | |
| 245.4 | | | 3 | SS | 7 | | | | | |
| 11.0 | Gravelly sand, some silt. | | 4 | SS | 58 | | | ○ | | 37 40 (2 |
| 240.4 | Very Dense | | 5 | SS | 67 | 240 | | | | |
| 16.0 | Silty sand, traces of gravel & clay. V. Dense | | 6 | SS | 100/3" | | | ○ | | 6 48 41 |
| 236.4 | | | | | | | | | | |
| ~~23[illegible].3~~ | ~~Shale~~ | | ~~7~~ | ~~SS~~ | ~~100/1"~~ | | | | | |
| 20.1 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE № 13

JOB 72-11119  LOCATION Co-ords. 932,468 N; 118,187 E.  ORIGINATED BY EW

W.P. 44-71-02& BORING DATE November 8, 1972  COMPILED BY EW

DATUM Geodetic  BOREHOLE TYPE Washboring  CHECKED BY [signature]

| SOIL PROFILE | | | SAMPLES | | | | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) | LIQUID LIMIT $w_L$, PLASTIC LIMIT $w_P$, WATER CONTENT $w$; WATER CONTENT % 20 40 60 | BULK DENSITY $\gamma$ P.C.F. | REMARKS GR.SA.SI.C |
|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | | | | |
| 255.1 | Ground Level | | | | | | | | | |
| 0.0 | Sand, some silt, trace gravel. | | | | | | | | | |
| 250.6 | Very Loose | | 1 | SS | 3 | 250 | | | | 4 79 (17) |
| 4.5 | Sand with gravel, some silt, trace clay. | | ~~2~~ | ~~SS~~ | ~~100~~/6" | | | | | |
| | | | 3 | SS | 19 | | | | | 48 38 12 |
| | | | ~~4~~ | ~~SS~~ | ~~100~~/2" | | | | | 25 44 28 |
| | Very Dense | | ~~5~~ | ~~SS~~ | ~~100~~/5" | 240 | | | | |
| 236.7 | | | ~~6~~ | ~~SS~~ | ~~100~~/6" | | | | | 28 47 (25) |
| 18.4 | Shale | | 7 | RC | 0% | | | | | |
| | | | ~~8~~ | ~~SS~~ | ~~100~~/3" | | | | | |
| | | | | | | 230 | | | | |
| | | | 9 | RC | 40% | | | | | |
| | | | 10 | RC | 75% | | | | | |
| 221.1 | | | 11 | RC | 100% | | | | | |
| 34.0 | End of Borehole | | | | | 220 | | | | |

20 / 15 ✧ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS–ONTARIO

DESIGN SERVICES BRANCH | FOUNDATIONS OFFICE

# RECORD OF BOREHOLE № 14

JOB 72-11119 | LOCATION Co-ords. 932,358 N; 118,307 E. | ORIGINATED BY EW

W.P. 44-71-02~~0~~ | BORING DATE November 21, 1972 | COMPILED BY EW

DATUM Geodetic | BOREHOLE TYPE Washboring | CHECKED BY

| ELEV. / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | WATER CONTENT % | REMARKS GR.SA.SI.CL. |
|---|---|---|---|---|---|---|---|
| 258.9 | Ground Level | | | | | | |
| 0.0 | Silty sand, trace clay. Loose | 1 | SS | 6 | | o | 1 55 (44) |
| | | 2 | SS | 8 | 250 | | |
| 249.9 / 9.0 | Silt, with sand, trace clay. Very loose to very dense. | 3 | SS | 2 | | o | 0 25 73 2 |
| | | 4 | SS | 8 | | | |
| | | 5 | SS | 100/9" | | o | 0 38 (62) |
| 239.4 | | 6 | SS | 100/3" | 240 | | |
| 239.1 | Shale | 7 | SS | 100/3" | | | |
| 19.8 | End of Borehole | | | | 230 | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.: o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

LIQUID LIMIT $W_L$; PLASTIC LIMIT $W_P$; WATER CONTENT $W$

WATER CONTENT %: 20 40 60

BULK DENSITY γ P.C.F.

20 / 15 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 15

| | | | |
|---|---|---|---|
| JOB 72-11119 | LOCATION Co-ords. 932,425 N; 118,288 E. | ORIGINATED BY EW | |
| W.P. 44-71-020 | BORING DATE November 20, 1972 | COMPILED BY EW | |
| DATUM Geodetic | BOREHOLE TYPE Washboring | CHECKED BY | |

| SOIL PROFILE | | | SAMPLES | | | | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (o UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) | LIQUID LIMIT $w_L$; PLASTIC LIMIT $w_P$; WATER CONTENT $w$; WATER CONTENT % (20, 40, 60) | BULK DENSITY γ P.C.F. | REMARKS GR. SA. SI. CL. |
|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | | | | |
| 257.4 | Ground Level | | | | | | | | | |
| 0.0 | Sand, with silt, traces of clay and gravel. Loose | | 1 | SS | 8 | | | o | | 16 48 (36) |
| | | | 2 | SS | 5 | 250 | | | | |
| | | | 3 | SS | 2 | | | o | | 0 73 (27) |
| 245.9 | Gravel with sand, trace silt. Compact | | 4 | SS | 19 | | | o | | 67 30 ( 3 ) |
| 243.4 / 14.0 | Silt with sand, some clay, trace gravel. Very Dense | | 5 | SS | 100/?" | | | o | | 2 38 50 10 |
| 239.4 | | | 6 | SS | 100/?" | 240 | | | | |
| 238.1 | Shale | | 7 | RC | [illegible] | | | | | |
| | | | 8 | SS | 100/?" | | | | | |
| 19.3 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

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DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 16

JOB 72-11119

W.P. 44-71-02Ø

DATUM Geodetic

LOCATION Co-ords. 932,497 N; 118,268 E.

BORING DATE November 17, 1972

BOREHOLE TYPE Washboring

ORIGINATED BY EW

COMPILED BY EW

CHECKED BY

| ELEV. DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | WATER CONTENT % | REMARKS GR.SA.SI.CL |
|---|---|---|---|---|---|---|---|---|
| 258.1 | Ground Level | | | | | | | |
| 0.0 | Sandy silt, traces of clay and gravel. Loose | | 1 | SS | 4 | | o | 0 37 46 9 |
| | | | 2 | SS | 2 | 250 | | |
| | | | 3 | SS | 7 | | | |
| 244.1 | | | 4 | SS | 100/6" | | o | 8 45 40 7 |
| 14.0 | Sand with silt, some gravel, trace clay. Very Dense | | 5 | SS | 100/9" | | o | 12 48 35 5 |
| 238.9 | | | 6 | SS | 100/2" | 240 | o | 9 73 12 6 |
| 237.4 | Shale | | 7 | RC | 75% | | | |
| 20.7 | End of Borehole | | | | | 230 | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F. O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT $W_L$ PLASTIC LIMIT $W_P$ WATER CONTENT W

WATER CONTENT % 20 40 60

BULK DENSITY γ P.C.F.

20 15 ◇ 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH — FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº17

JOB 72-11119
W.P. 44-71-020
DATUM Geodetic
LOCATION Co-ords. 932,377 N; 118,369 E.
BORING DATE November 21, 1972
BOREHOLE TYPE Washboring
ORIGINATED BY EW
COMPILED BY EW
CHECKED BY [signature]

| ELEV. / DEPTH | DESCRIPTION (SOIL PROFILE) | SAMPLE NUMBER | SAMPLE TYPE | BLOWS/FOOT | ELEV. SCALE | WATER CONTENT % | REMARKS (GR.SA.SI.CL) |
|---|---|---|---|---|---|---|---|
| 259.1 | Ground Level | | | | | | |
| 0.0 | Sandy silt, traces of gravel and clay. Loose | 1 | SS | 8 | | o | 5 42 48 5 |
| | | 2 | SS | 7 | ▼ 250 | | |
| 247.6 | | 3 | SS | 7 | | | |
| 11.5 | Sand, some silt, trace gravel and cobbles. Loose to Very Dense | 4 | SS | 7 | | o | 1 78 20 1 |
| | | 5 | WS | - | | | |
| | | 6 | SS | 18 | | | |
| | | ~~7~~ | ~~SS~~ | ~~100/4"~~ | 240 | | |
| 236.1 | | 8 | RC | 10% | | | |
| ~~235.6~~ | ~~Shale~~ | ~~9~~ | ~~RC~~ | ~~30%~~ | | | |
| 23.5 | End of Borehole | | | | 230 | | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT
SHEAR STRENGTH P.S.F.: o UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE
LIQUID LIMIT $W_L$; PLASTIC LIMIT $W_P$; WATER CONTENT W; WATER CONTENT % 20 40 60
BULK DENSITY γ P.C.F.

20 / 15 -5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 18

JOB 72-11119
W.P. 44-71-02?
DATUM Geodetic

LOCATION Co-ords. 932,443 N; 118,351 E.
BORING DATE November 22, 1972
BOREHOLE TYPE Washboring

ORIGINATED BY EW
COMPILED BY EW
CHECKED BY [signature]

| ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | LIQUID LIMIT $W_L$, PLASTIC LIMIT $W_P$, WATER CONTENT W; WATER CONTENT % 20 40 60 | BULK DENSITY γ P.C.F. | REMARKS GR.SA.SI.CL |
|---|---|---|---|---|---|---|---|---|---|---|
| 259.6 | Ground Level | | | | | | | | | |
| 0.0 | Sandy silt, traces of clay & gravel. | | 1 | SS | 5 | | | o | | 6 45 (49) |
| | | | 2 | SS | 2 | ▼ | | | | |
| | Very Loose to Loose | | 3 | SS | 3 | 250 | | | | |
| 244.6 | | | 4 | SS | 4 | | | o | | 4 38 (58) |
| 15.0 | Sand, some gravel and silt, trace clay. | | 5 | SS | 7 | | | o | | 25 45 23 7 |
| | Very Dense | | 6 | SS | 93 | | | o | | 21 67 (12) |
| 238.6 | Shale | | 7 | SS | 100/1" | 240 | | | | |
| 21.5 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

OFFICE REPORT ON SOIL EXPLORATION

20
15 ✧ 5 % STRAIN AT FAILURE
10

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº 19

| | | | |
|---|---|---|---|
| JOB 72-11119 | LOCATION Co-ords. 932,509 N; 118,332 E. | ORIGINATED BY EW |
| W.P. 44-71-026 | BORING DATE November 20, 1972 | COMPILED BY EW |
| DATUM Geodetic | BOREHOLE TYPE Hollow stem auger | CHECKED BY |

| SOIL PROFILE | | | SAMPLES | | | | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE) | LIQUID LIMIT $w_L$, PLASTIC LIMIT $w_P$, WATER CONTENT $w$; WATER CONTENT % 20 40 60 | BULK DENSITY γ P.C.F. | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | | | | GR.SA.SI.CL. |
| 259.9 | Ground Level | | | | | | | | | |
| 0.0 / 254.4 | Silty sand, some gravel, trace clay. Dense | | 1 | SS | 33 | | | | | |
| 5.5 | Silt with sand, trace clay. | | 2 | SS | 6 | | | | | 2 11 80 7 |
| | | | 3 | SS | 4 | 250 | | | | 0 40 56 4 |
| 247.2 | Loose | | 4 | SS | 5 | | | | | 0 64 (36) |
| 12.7 | Sand with silt, some gravel, trace clay. | | 5 | SS | 31 | | | | | 25 46 (29) |
| 239.4 | Loose to Very Dense | | 6 | SS | 100/11" | 240 | | | | 2 61 (37) |
| 238.7 | Shale | | 7 | SS | 100/3" | | | | | |
| 21.2 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE Nº20

JOB 72-11119

W.P. 44-71-02~~0~~

DATUM Geodetic

LOCATION Co-ords. 932,394 N; 118,429 E.

BORING DATE November 21, 1972

BOREHOLE TYPE Hollow stem auger

ORIGINATED BY EW

COMPILED BY EW

CHECKED BY [illegible]

| SOIL PROFILE: ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | SAMPLES: NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. (O UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, X LAB VANE) | LIQUID LIMIT $W_L$, PLASTIC LIMIT $W_P$, WATER CONTENT W; WATER CONTENT % 20 40 60 | BULK DENSITY γ P.C.F. | REMARKS GR.SA.SI.CL. |
|---|---|---|---|---|---|---|---|---|---|---|
| 261.3 | Ground Level | | | | | | | | | |
| 0.0 | Silt with sand, some clay, trace gravel. | | | | | 260 | | | | |
| | | | 1 | SS | 3 | | | | | 8 29 49 14 |
| 254.8 | Very Loose | | | | | | | | | |
| 6.5 | Sand with silt, traces of gravel & clay. | | 2 | SS | 17 | | | | | |
| | | | 3 | SS | 79 | 250 | | | | 0 63 33 4 |
| 246.3 | Compact to Very Dense | | 4 | SS | 100/5" | | | | | |
| 15.0 | Sandy gravel, traces of silt & clay. | | 5 | SS | 100/5" | | | | | |
| 241.0 | Very Dense | | 6 | SS | 100 | | | | | 58 35 ( 7 ) |
| 240.1 | Shale | | 7 | SS | 100/2" | | | | | |
| 21.2 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

20
15 ◇ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE №21

JOB 72-11119

W.P. 44-71-020

DATUM Geodetic

LOCATION Co-ords. 932,459 N; 118,410 E.

BORING DATE November 21, 1972

BOREHOLE TYPE Hollow stem auger

ORIGINATED BY EW

COMPILED BY EW

CHECKED BY [signature]

| SOIL PROFILE | | | SAMPLES | | | | DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT; SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE | LIQUID LIMIT — $W_L$ PLASTIC LIMIT — $W_P$ WATER CONTENT — W; WATER CONTENT % 20 40 60 | BULK DENSITY γ P.C.F. | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| ELEV. / DEPTH | DESCRIPTION | STRAT. PLOT | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | | | | GR.SA.SI.CL. |
| 262.5 | Ground Level | | | | | | | | | |
| 0.0 | Silt with sand, some gravel, trace clay. | | | | | 260 | | | | |
| | | | 1 | SS | 3 | | | | | 9 25 59 7 |
| | Very Loose | | 2 | SS | 3 | | | | | |
| 253.5 | | | | | | | | | | |
| 9.0 | Sand with silt, some gravel, trace clay. | | 3 | SS | 2 | | | | | 26 39 25 10 |
| | | | 4 | SS | 2 | 250 | | | | |
| | Very Loose | | 5 | SS | 3 | | | | | 17 46 28 9 |
| 244.0 / 18.5 | Sand, some silt, trace grav. Dense to V. Dense | | 6 | SS | 32 | | | | | 9 79 (12) |
| 241.2 | | | | | | | | | | |
| 240.0 | Shale | | 7 | SS | 100/5" | | | | | |
| 22.5 | End of Borehole | | | | | | | | | |
| | | | | | | 230 | | | | |

20
15 ⌖ 5 % STRAIN AT FAILURE
10

OFFICE REPORT ON SOIL EXPLORATION

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS—ONTARIO

DESIGN SERVICES BRANCH

FOUNDATIONS OFFICE

# RECORD OF BOREHOLE № 22

JOB 72-11119
W.P. 44-71-020
DATUM Geodetic

LOCATION Co-ords. 932,520 N; 118,390 E.
BORING DATE November 20, 1972
BOREHOLE TYPE Hollow stem auger

ORIGINATED BY EW
COMPILED BY EW
CHECKED BY

| ELEV. / DEPTH | DESCRIPTION | NUMBER | TYPE | BLOWS/FOOT | ELEV. SCALE | REMARKS GR. SA. SI. CL |
|---|---|---|---|---|---|---|
| 264.6 | Ground Level | | | | | |
| 0.0 | Sand with silt, some gravel, trace clay. | 1 | SS | 3 | 260 | 3 50 (47) |
| | | 2 | SS | 1 | | 32 53 (15) |
| V. | Loose to very dense. | 3 | SS | 84 | | |
| | | 4 | SS | 100/8" | | 9 46 (45) |
| 249.6 | | | | | 250 | |
| 15.0 | Sand, some gravel and silt, trace clay. | 5 | SS | 100 | | |
| | | 6 | SS | 100/6" | | 5 74 (11) |
| 244.1 | Very Dense | | | | | |
| 20.5 | Silt with sand, some clay. Very Dense | 7 | SS | 100/6" | | 0 31 (69) |
| 241.1 | | | | | | |
| 23.9 | Shale | 8 | SS | 100/3" | 240 | |
| 238.8 | | 9 | RC | 15% | | |
| 25.8 | End of Borehole | | | | | |
| | | | | | 230 | |

DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT

SHEAR STRENGTH P.S.F.
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

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

WATER CONTENT % 20 40 60

BULK DENSITY $\gamma$ P.C.F.

15 20 5 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

# APPENDIX B

## Borehole Records and Laboratory Test Results
## GEOCRES No. 30M14-252 – 1997 Investigation

MTO101.BHS

W.P. 137-95-00

DIST. 6, HWY 401

LOCATION: N 4856214.747; E 340774.557

# RECORD OF BOREHOLE 101

BORING DATE: SEPT.11/97

SHEET 1 OF 2

DATUM: GEODETIC

PROJECT: 971-8036

BORING METHOD: BOMBARDIER MOUNTED CME-55, 200mm O.D. HOLLOW STEM AUGERS

| SOIL PROFILE – DESCRIPTION | ELEV. / DEPTH (m) | SAMPLE NUMBER | TYPE | BLOWS/0.3m | ADDITIONAL LAB. TESTING |
|---|---|---|---|---|---|
| GROUND SURFACE | 80.51 | | | | |
| Silty Sand, trace clay, trace to some gravel, occ. silty clay lenses<br>Very loose to compact<br>Brown<br>Moist<br>(FILL) | 0.00 | 1 | 50 DO | - | |
| | | 2 | 50 DO | 25 | |
| Sand and Silt, trace gravel, trace clay, trace organics<br>Compact<br>Brownish grey<br>Moist | 79.11<br>1.40 | 3 | 50 DO | 15 | MH |
| Silty Clay, trace sand, trace gravel<br>Very stiff<br>Grey<br>Moist<br>(TILL) | 78.41<br>2.10 | 4 | 50 DO | 22 | |
| Sand, trace silt, trace gravel and trace shell fragments<br>Very loose to loose<br>Grey<br>Wet | 77.24<br>3.27 | 5 | 50 DO | 15 | |
| | | 6 | 50 DO | 5 | |
| | | 7 | 50 DO | 2 | |
| Silty Clay, trace gravel, some sand<br>Hard<br>Grey<br>Moist | 75.01<br>5.50 | 8 | 50 DO | 82 | |
| Sand, some gravel to Sand and Gravel, trace silt<br>Very dense<br>Grey<br>Wet | 73.51<br>7.00 | 9 | 50 DO | 123 | |
| | | 10 | 50 DO | 100 /15 | |

CONTINUED ON NEXT PAGE

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, cm/s

SHEAR STRENGTH Cu, kPa — nat V - + Q - ● rem V - ⊕ U - O

WATER CONTENT, PERCENT — Wp W Wl — 10 20 30 40

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MO

CHECKED: AMP

OHA INPUT ... DEC.3/97

W.P. 137-95-00

DIST. 6, HWY 401

LOCATION: N 4856214.747; E 340774.557

# RECORD OF BOREHOLE 101

BORING DATE: SEPT.11/97



DATUM: GEODETIC

PROJECT: 971-8036

MTO101.BHS

| DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE DESCRIPTION | STRATA PLOT | ELEV. DEPTH (m) | SAMPLES NUMBER | TYPE | BLOWS/0.3m | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / SHEAR STRENGTH Cu, kPa (nat V - +, rem V - ⊕, Q - ●, U - O) | HYDRAULIC CONDUCTIVITY, k, cm/s / WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | BOMBARDIER MOUNTED CME-55; 200mm O.D. HOLLOW STEM AUGERS | CONTINUED FROM PREVIOUS PAGE | | | | | | | | | |
| 10 | | Sand, some gravel to Sand and Gravel, trace silt<br>Very dense<br>Grey<br>Wet<br>-approx. 200mm of silty clay/ residual soil encountered in the sampler overlying weathered shale | | 69.64<br>10.87 | 11 | 50 DO | 120 /15 | | | | |
| 11 | | Grey, weathered SHALE BEDROCK (WHITBY FORMATION) | | 10.97 | | | | | | | Note: Water level in open borehole at 4.4m during drilling operations. |
| | | END OF BOREHOLE | | | | | | | | | |
| 12 | | | | | | | | | | | |
| 13 | | | | | | | | | | | |
| 14 | | | | | | | | | | | |
| 15 | | | | | | | | | | | |
| 16 | | | | | | | | | | | |
| 17 | | | | | | | | | | | |
| 18 | | | | | | | | | | | |
| 19 | | | | | | | | | | | |
| 20 | | | | | | | | | | | |

DATA INPUT: FS DEC.3/97

DEPTH SCALE
1 to 50

**Golder Associates**

LOGGED: MO
CHECKED: AMP

M8036102.BHR

W.P. 137-95-00

DIST. 6, HWY 401

LOCATION: N 4856227.382; E 340820.807

# RECORD OF BOREHOLE 102

BORING DATE: SEPT.10/97



DATUM: GEODETIC

PROJECT: 971-8036

BORING METHOD: BOMBARDIER MOUNTED CME-55, N SIZE CASING

| DEPTH SCALE METRES | SOIL PROFILE: DESCRIPTION | STRATA PLOT | ELEV. / DEPTH (m) | SAMPLES: NUMBER | TYPE | BLOWS/0.3m | PIEZOMETER OR STANDPIPE INSTALLATION |
|---|---|---|---|---|---|---|---|
| 0 | GROUND SURFACE | | 78.84 / 0.00 | | | | BENTONITE SEAL |
| | Sand, trace to some silt to Silty Sand, trace organics; Very loose to loose; Light brown; Moist | | | 1 | 50 DO | 1 | |
| 1 | | | | 2 | 50 DO | 6 | |
| | | | | 3 | 50 DO | 4 | |
| 2 | Silty Clay, some sand, trace organics, trace shell fragments; Very soft; Brown, occ. oxidation; Moist to wet | | 76.74 / 2.10 | 4 | 50 DO | 2 | |
| 3 | Sand, some silt, trace clay; Loose; Brown; Moist | | 75.94 / 2.90 | 5 | 50 DO | 4 | SAND |
| 4 | Sand and Gravel, trace to some silt, trace clay, trace organics, occ. boulder; Compact to very dense; Grey; Wet | | 75.14 / 3.70 | 6 | 50 DO | 18 | |
| 5 | | | | 7 | 50 DO | 55 | |
| 6 | | | | 8 | 50 DO | 100 /15 | |
| 7 | Black to dark grey, weathered Shale (BEDROCK) | | 71.44 / 7.40 | | | | |
| | Borehole continued; for bedrock coring details refer to sheet 2. | | 71.22 / 7.62 | | 50 DO | 100 /03 | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | CONTINUED ON NEXT PAGE | | | | | | |

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, cm/s

SHEAR STRENGTH Cu, kPa — nat V - + Q - ● ; rem V - ⊕ U - ○

WATER CONTENT, PERCENT — Wp ⊢—○W—⊣ Wl — 10 20 30 40

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 to 50

LOGGED: MO

CHECKED: AMP

Golder Associates

DATA INPUT: ... DEC.3/97

PROJECT: 971-8036

# RECORD OF BOREHOLE 102

SHEET 2 OF 2

LOCATION: N 4856227.382; E 340820.807

INCLINATION: AZIMUTH:

DRILLING DATE: SEPT.10/97

DRILL RIG: BOMBARDIER

DRILLING CONTRACTOR:

DATUM: GEODETIC

FR-FRACTURE, CL-CLEAVAGE, SH-SHEAR, VN-VEIN, F-FAULT, J-JOINT, P-POLISHED, S-SLICKENSIDED, SM-SMOOTH, R-ROUGH, ST-STEPPED, PL-PLANAR, FL-FLEXURED, UE-UNEVEN, W-WAVY, C-CURVED

| DEPTH SCALE METRES | DRILLING RECORD | DESCRIPTION | ELEV. DEPTH (m) | RUN No. | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | NOTES WATER LEVELS INSTRUMENTATION |
|---|---|---|---|---|---|---|
| 7 | | CONTINUED FROM PREVIOUS PAGE | | | | |
| | | Borehole continued | 71.22 | | | |
| | SEPT.10/97 NQ CORE | Shale<br>Highly weathered becoming moderately weathered to fresh below 8.9m depth, grey, fine grained, thinly bedded, occ. thin limestone layers.<br>(WHITBY FORMATION) | 7.62 | 1 | 12mm clay seam | |
| 8 | | | | | 12mm clay seam<br>25mm broken core | SAND |
| | | | | | 150mm broken core<br>300mm broken core | |
| 9 | | | | | PL | BENTONITE SEAL |
| | | | | 2 | 20mm broken core | SAND |
| 10 | | | | | 40mm broken core | |
| | | END OF DRILLHOLE | 68.17<br>10.67 | | | |
| 11 | | | | | | Note:<br>Water level in piezometer at Elev. 75.5m on Sept.16/97. |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| 17 | | | | | | |

DEPTH SCALE:
1 to 50

**Golder Associates**

LOGGED: MO

DATE:

CHECKED: AMP

DATA INPUT: PS NOV.3/97

# RECORD OF BOREHOLE 103

W.P. 137-95-00
DIST. 6, HWY 401
LOCATION: N 4856239.433; E 340884.371

BORING DATE: SEPT.12/97

SHEET 1 OF 1
DATUM: GEODETIC
PROJECT: 971-8036

M8036103.BHS

DEPTH SCALE METRES | BORING METHOD | SOIL PROFILE: DESCRIPTION, STRATA PLOT, ELEV. DEPTH (m) | SAMPLES: NUMBER, TYPE, BLOWS/0.3m | DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m | SHEAR STRENGTH Cu, kPa nat V - + Q - ● rem V - ⊕ U - O | HYDRAULIC CONDUCTIVITY, k, cm/s | WATER CONTENT, PERCENT Wp ⊢—O W—⊣ Wl 10 20 30 40 | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION

BORING METHOD: BOMBARDIER MOUNTED CME-55, 200mm O.D. HOLLOW STEM AUGERS

| DESCRIPTION | ELEV. / DEPTH (m) |
|---|---|
| GROUND SURFACE | 80.71 |
| Silty Sand, trace clay, trace gravel, some organics, occ. glass and metal fragments<br>Very loose<br>Dark grey<br>Moist (FILL) | 0.00 |
| Sand and Silt, trace clay, some gravel<br>Dense to very dense<br>Grey<br>Dry to moist | 80.11<br>0.60 |
| Sand, trace silt, trace clay, trace to some gravel<br>Very dense<br>Grey<br>Moist | 77.11<br>3.60 |
| Sandy Silt, trace clay, trace gravel<br>Very dense<br>Grey<br>Moist<br>-trace black shale fragments below 6m depth<br>-boulder at 6.2m depth inferred from resistance to augering | 76.31<br>4.40 |
| Shale, weathered, grey (WHITBY FORMATION) | 73.01<br>7.70 |
| END OF BOREHOLE | 71.41<br>9.30 |

| NUMBER | TYPE | BLOWS/0.3m |
|---|---|---|
| 1 | 50 DO | 3 |
| 2 | 50 DO | 35 |
| 3 | 50 DO | 50/.15 |
| 4 | 50 DO | 62/.15 |
| 5 | 50 DO | 99 |
| 6 | 50 DO | 60/.15 |
| 7 | 50 DO | - |
| 8 | 50 DO | 80/.15 |
| 9 | 50 DO | 78 |

ADDITIONAL LAB. TESTING: MH

PIEZOMETER OR STANDPIPE INSTALLATION: BENTONITE SEAL; SAND; BENTONITE SEAL

Note:
Open borehole dry on completion of drilling. Water level in piezometer at Elev. 77.2m on Sept.16/97.

DEPTH SCALE
1 to 50

Golder Associates

LOGGED: MO
CHECKED: AMP

DATA INPUT: PS DEC.3/97

# RECORD OF BOREHOLE 104

W.P. 137-95-00
DIST. 6, HWY 401
LOCATION: N 4856176.940; E 340887.039

BORING DATE: SEPT.12/97

SHEET 1 OF 1
DATUM: GEODETIC
PROJECT: 971-8036

BORING METHOD: BOMBARDIER MOUNTED CME-55, 200mm O.D. HOLLOW STEM AUGERS

| Description | Elev. / Depth (m) | Sample Number | Type | Blows/0.3m | Additional Lab. Testing | Piezometer or Standpipe Installation |
|---|---|---|---|---|---|---|
| GROUND SURFACE | 79.04 | | | | | |
| Sand and Gravel, trace silt, trace clay, occ. silty clay lenses, trace asphalt fragments<br>Compact<br>Brown<br>Dry<br>(FILL) | 0.00 | 1 | 50 DO | 18 | | BENTONITE SEAL |
| | | 2 | 50 DO | 30 | | |
| Silty Clay, some sand, trace gravel, trace organics<br>Soft to firm<br>Brown to greenish grey<br>Moist<br>(FILL) | 77.64<br>1.40 | 3 | 50 DO | 6 | | |
| | | 4 | 50 DO | 3 | | |
| Clayey Silt, some sand, some organics, occ. shell fragments<br>Soft<br>Dark brown to black<br>Moist | 76.14<br>2.90 | 5 | 50 DO | 4 | | |
| Silty Clay, some sand, trace gravel, trace organics<br>Soft<br>Grey<br>Wet | 75.44<br>3.60 | 6 | 50 DO | 4 | | |
| Sand and Gravel, some silt, trace shale fragments<br>Compact<br>Brown<br>Wet | 74.64<br>4.40 | 7 | 50 DO | 20 | | SAND |
| Shale, weathered<br>Grey<br>(WHITBY FORMATION) | 72.94<br>6.10 | 8 | 50 DO | 112 | | BENTONITE SEAL |
| END OF BOREHOLE | 72.49<br>6.55 | | | | | |

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
HYDRAULIC CONDUCTIVITY, k, cm/s
SHEAR STRENGTH Cu, kPa — nat V - + Q - ● rem V - ⊕ U - ○
WATER CONTENT, PERCENT — Wp W Wl — 10 20 30 40

Water content plotted at sample 5: >62.2

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

Note:
Water level in open borehole at 2.9m depth on completion of drilling. Water level in piezometer at Elev. 75.3m on Sept.16/97.

DEPTH SCALE
1 to 50

**Golder Associates**

LOGGED: MO
CHECKED: AMP

M8036105.BHS

W.P. 137-95-00

DIST. 6, HWY 401

LOCATION: N 4856159.36; E 340818.282

# RECORD OF BOREHOLE 105

BORING DATE: SEPT.11/97

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 971-8036

BORING METHOD: BOMBARDIER MOUNTED CME-55, 200mm O.D. HOLLOW STEM AUGERS

## SOIL PROFILE

| DESCRIPTION | ELEV. / DEPTH (m) |
|---|---|
| GROUND SURFACE | 79.28 |
| TOPSOIL | [illegible] / 0.05 |
| Silty Sand to Sand, trace clay, some organics, occ. asphalt fragments<br>Compact<br>Brown<br>Moist<br>(FILL) | 78.68 / 0.60 |
| Silty Sand, trace clay, trace gravel, trace organics, trace shell fragments<br>Very loose to dense<br>Brown to grey<br>Moist becoming wet below 2.1m depth | 73.48 / 5.80 |
| Clayey Silt, trace gravel, some sand, some shale fragments<br>Hard<br>Grey<br>Moist (Residual Soil) | 72.83 / 6.45 |
| Shale, weathered<br>Black and grey<br>(WHITBY FORMATION) | 71.53 / 7.75 |
| END OF BOREHOLE | |

## SAMPLES

| NUMBER | TYPE | BLOWS/0.3m | ADDITIONAL LAB. TESTING |
|---|---|---|---|
| 1 | 50 DO | 12 | |
| 2 | 50 DO | 5 | |
| 3 | 50 DO | 8 | |
| 4 | 50 DO | 6 | |
| 5 | 50 DO | 2 | MH |
| 6 | 50 DO | 28 | |
| 7 | 50 DO | 46 | |
| 8 | 50 DO | 140 | |
| 9 | 50 DO | 100 /15 | |

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

SHEAR STRENGTH Cu, kPa — nat V - + Q - ● rem V - ⊕ U - ○

HYDRAULIC CONDUCTIVITY, k, cm/s

WATER CONTENT, PERCENT — Wp ⊢—○ W —⊣ Wl — 10 20 30 40

PIEZOMETER OR STANDPIPE INSTALLATION

Note: Water level in open borehole at 3.2m depth on completion of drilling.

DEPTH SCALE (METRES): 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MO

CHECKED: AMP

DATA INPUT: DEC.3/97

M8036106.BHS

W.P. 137-95-00

DIST: 6, HWY 401

LOCATION: N 4856148.080; E 340779.626

# RECORD OF BOREHOLE 106

BORING DATE: SEPT.11/97

SHEET 1 OF 1

DATUM: GEODETIC

PROJECT: 971-8036

| DEPTH SCALE METRES | BORING METHOD | DESCRIPTION | ELEV. DEPTH (m) | NUMBER | TYPE | BLOWS/0.3m | WATER CONTENT, PERCENT (w) | ADDITIONAL LAB. TESTING | PIEZOMETER OR STANDPIPE INSTALLATION |
|---|---|---|---|---|---|---|---|---|---|
| 0 | BOMBARDIER MOUNTED CME-55 200mm O.D. HOLLOW STEM AUGERS | GROUND SURFACE | 80.63 | | | | | | |
| | | Silty sand with organics, trace gravel Very loose Brown Moist (TOPSOIL) | 0.00 | 1 | 50 DO | 2 | ~26 | | |
| | | Sand, some gravel, trace silt, trace organics Compact Brown Moist (FILL) | 80.03 0.60 | 2 | 50 DO | 15 | ~12 | | |
| | | Sandy Silt, trace clay, trace organics, occ. silty clay lenses. Compact Brown to black Moist (FILL) | 79.23 1.40 | 3 | 50 DO | 11 | ~27 | | |
| | | Sand and Gravel, some silt, some clay, trace organics Compact to very dense Grey Wet -grey shale fragments with depth | 78.53 2.10 | 4 | 50 DO | 18 | ~13 | MH | BENTONITE SEAL |
| | | | | 5 | 50 DO | 50/ .15 | ~6 | | |
| | | | | 6 | 50 DO | 69 | | | |
| | | | | 7 | 50 DO | 60/ .15 | ~5 | | |
| | | Sandy Silt, trace clay Very dense Grey Moist | 74.38 6.25 | 8 | 50 DO | 50/ .15 | | | SAND |
| | | | | 9 | 50 DO | 60/ .15 | ~10 | | |
| | | Shale, weathered, grey. (WHITBY FORMATION) | 72.66 7.97 | | | | | | CUTTINGS |
| | | END OF BOREHOLE | 71.41 9.22 | 10 | 50 DO | 120 /15 | | | |

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m

HYDRAULIC CONDUCTIVITY, k, cm/s

SHEAR STRENGTH Cu, kPa — nat V - + Q - ● rem V - ⊕ U - O

WATER CONTENT, PERCENT Wp —O W— Wl; 10 20 30 40

Note:
Water level in open borehole at 2.8m depth on completion of drilling.
Water level in piezo. at Elev. 78.0m on Sept.16/97.

DEPTH SCALE 1 to 50

Golder Associates

LOGGED: MO

CHECKED: AMP

DATA INPUT: PS NOV.3/97

SOILMO

M8036107.BHS

W.P. 137-95-00
DIST. 6, HWY 401
LOCATION: N 4856170.930; E 340862.675

# RECORD OF BOREHOLE 107

BORING DATE: SEPT.12/97

SHEET 1 OF 1
DATUM: GEODETIC
PROJECT: 971-8036

BORING METHOD: BOMBARDIER MOUNTED CME-55, 200mm O.D. HOLLOW STEM AUGERS

| Description | Elev. / Depth (m) | Sample Number | Type | Blows/0.3m | Water Content (%) | Additional Lab. Testing |
|---|---|---|---|---|---|---|
| GROUND SURFACE | 79.03 | | | | | |
| TOPSOIL | 0.00 | | | | | |
| Silty Sand, trace organics, some gravel, little clay. Very loose to loose. Brown. Moist | | 1 | 50 DO | 7 | ~10 | |
| | | 2 | 50 DO | 2 | | |
| | | 3 | 50 DO | 2 | ~16 | |
| | | 4 | 50 DO | 4 | ~12 | MH |
| | | 5 | 50 DO | 4 | ~17 | |
| Sand and Gravel, trace silt, trace clay and cobbles, trace shell and wood fragments. Very loose becoming dense below 4.4m depth. Grey. Wet | 75.23 / 3.80 | 6 | 50 DO | 2 | ~27 | |
| | | 7 | 50 DO | 31 | | |
| Silty Clay, trace sand, some gravel, some shale fragments. Hard. Grey. Moist (Residual Soil) | 73.13 / 5.90 | | | | | |
| Shale, weathered, grey. (WHITBY FORMATION) | | 8 | 50 DO | 162 | | |
| END OF BOREHOLE | 72.55 / 6.55 | | | | | |

Chart columns: DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V - +, Q - ●, rem V - ⊕, U - O); HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT, PERCENT (Wp, W, Wl; 10 20 30 40); PIEZOMETER OR STANDPIPE INSTALLATION.

Note: Water level in open borehole at 2.6m depth on completion of drilling.

DEPTH SCALE 1 to 50

Golder Associates

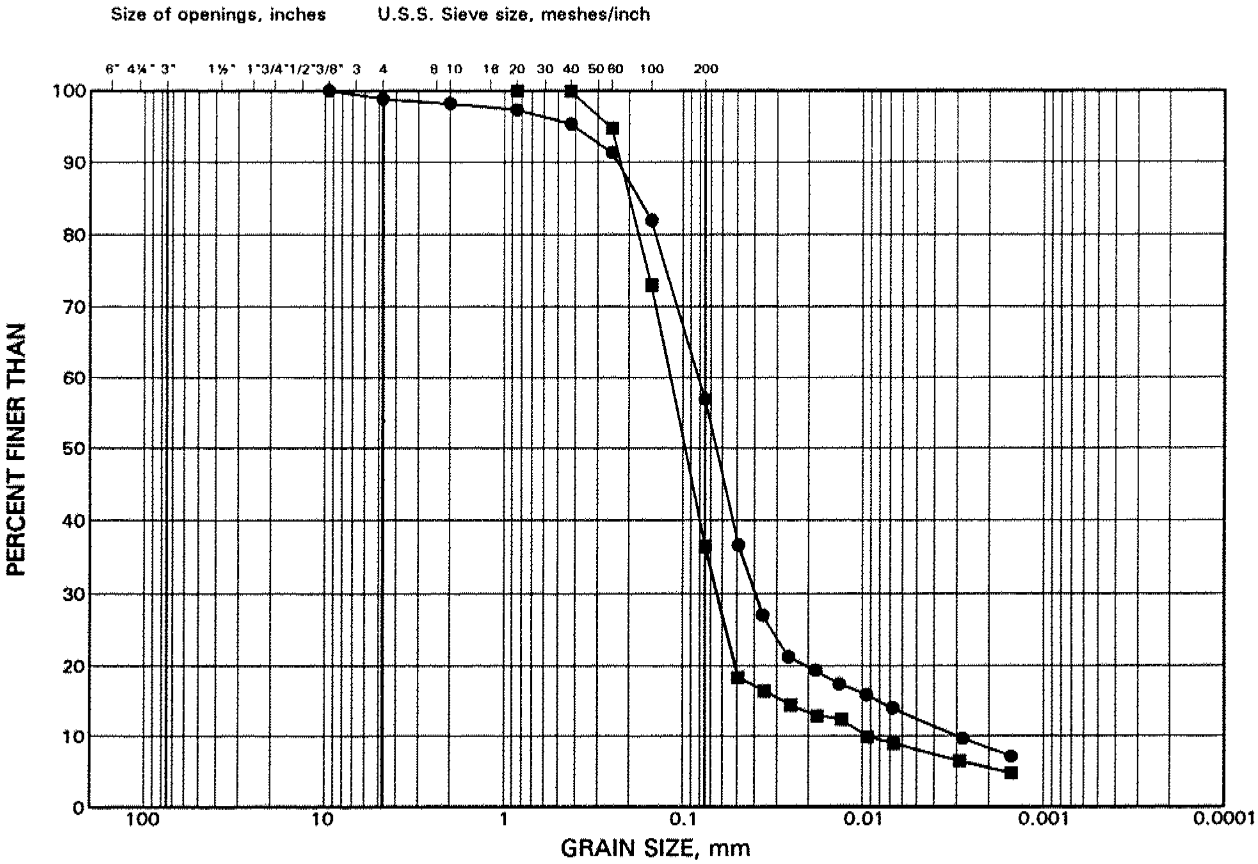
LOGGED: MO
CHECKED: AMP

DATA INPUT: PS DEC.3/97

SOILMS

# GRAIN SIZE DISTRIBUTION
Silty Sand

FIGURE 1




| COBBLE | COARSE | FINE | COARSE | MEDIUM | FINE | SILT AND CLAY SIZES |
|---|---|---|---|---|---|---|
| SIZE | GRAVEL SIZE | | SAND SIZE | | | FINE GRAINED |

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 101 | 3 | 77.7 |
| ■ | 105 | 5 | 76.0 |

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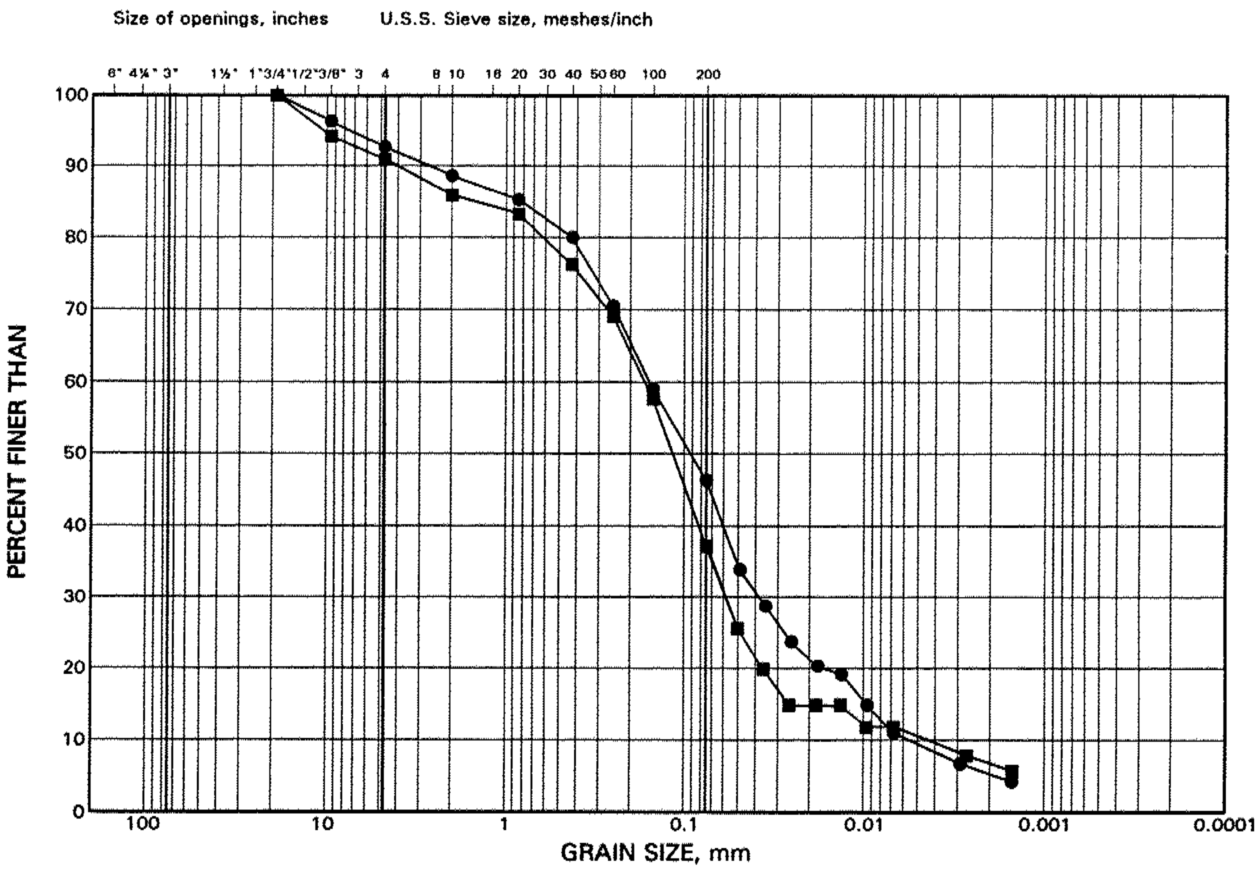
# GRAIN SIZE DISTRIBUTION
Silty Sand to Sand and Silt some Gravel

FIGURE 2




| COBBLE | COARSE | FINE | COARSE | MEDIUM | FINE | SILT AND CLAY SIZES |
|---|---|---|---|---|---|---|
| SIZE | GRAVEL SIZE | | SAND SIZE | | | FINE GRAINED |

## LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 103 | 4 | 77.5 |
| ■ | 107 | 4 | 76.6 |

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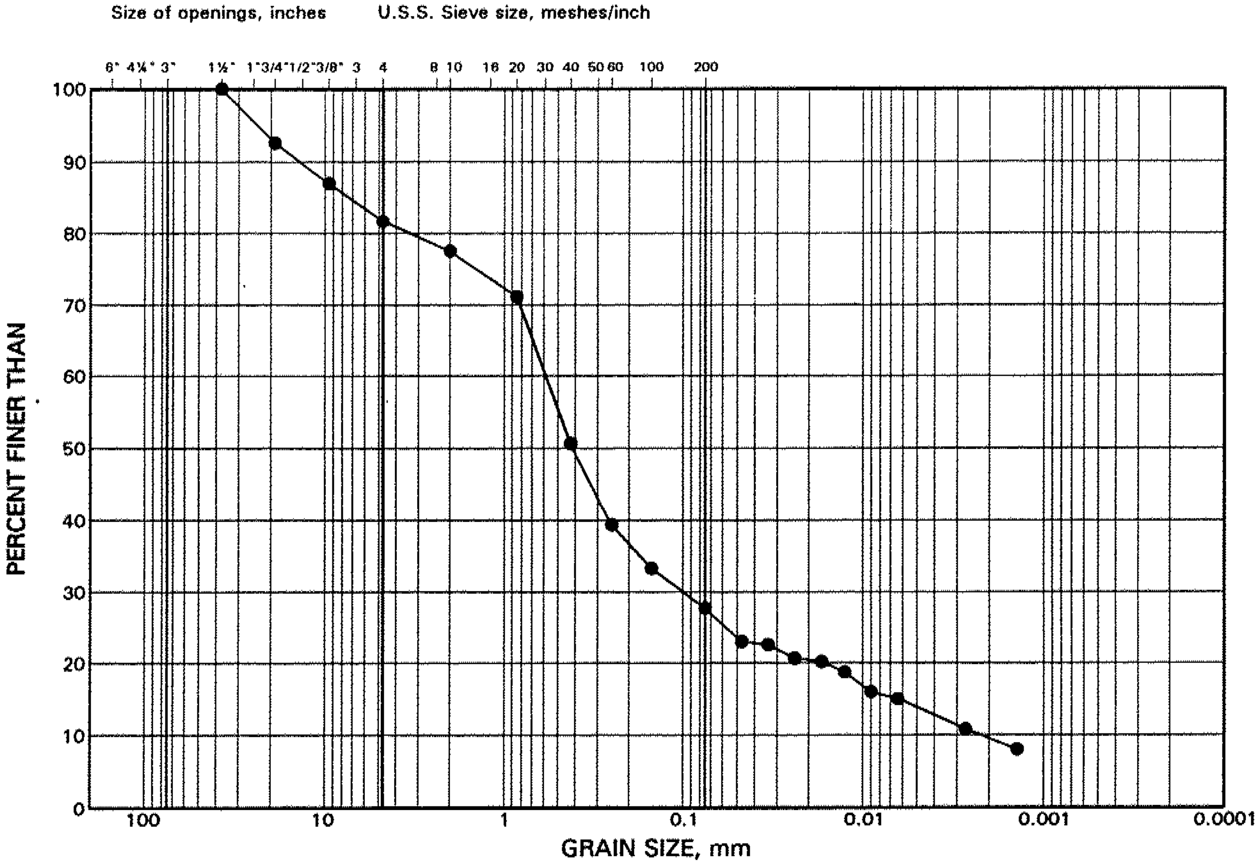
# GRAIN SIZE DISTRIBUTION
Sand and Gravel

FIGURE 3




| COBBLE | COARSE | FINE | COARSE | MEDIUM | FINE | SILT AND CLAY SIZES |
|---|---|---|---|---|---|---|
| SIZE | GRAVEL SIZE | | SAND SIZE | | | FINE GRAINED |

LEGEND

| SYMBOL | BOREHOLE | SAMPLE | ELEVATION(m) |
|---|---|---|---|
| ● | 106 | 4 | 78.0 |

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