
APPENDIX 6

PRELIMINARY GEOTECHNICAL ASSESSMENT



REPORT

PRELIMINARY GEOTECHNICAL ASSESSMENT

Oxford Street West and Gideon Drive Intersection Improvements, London, Ontario

Submitted to:

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Submitted by:

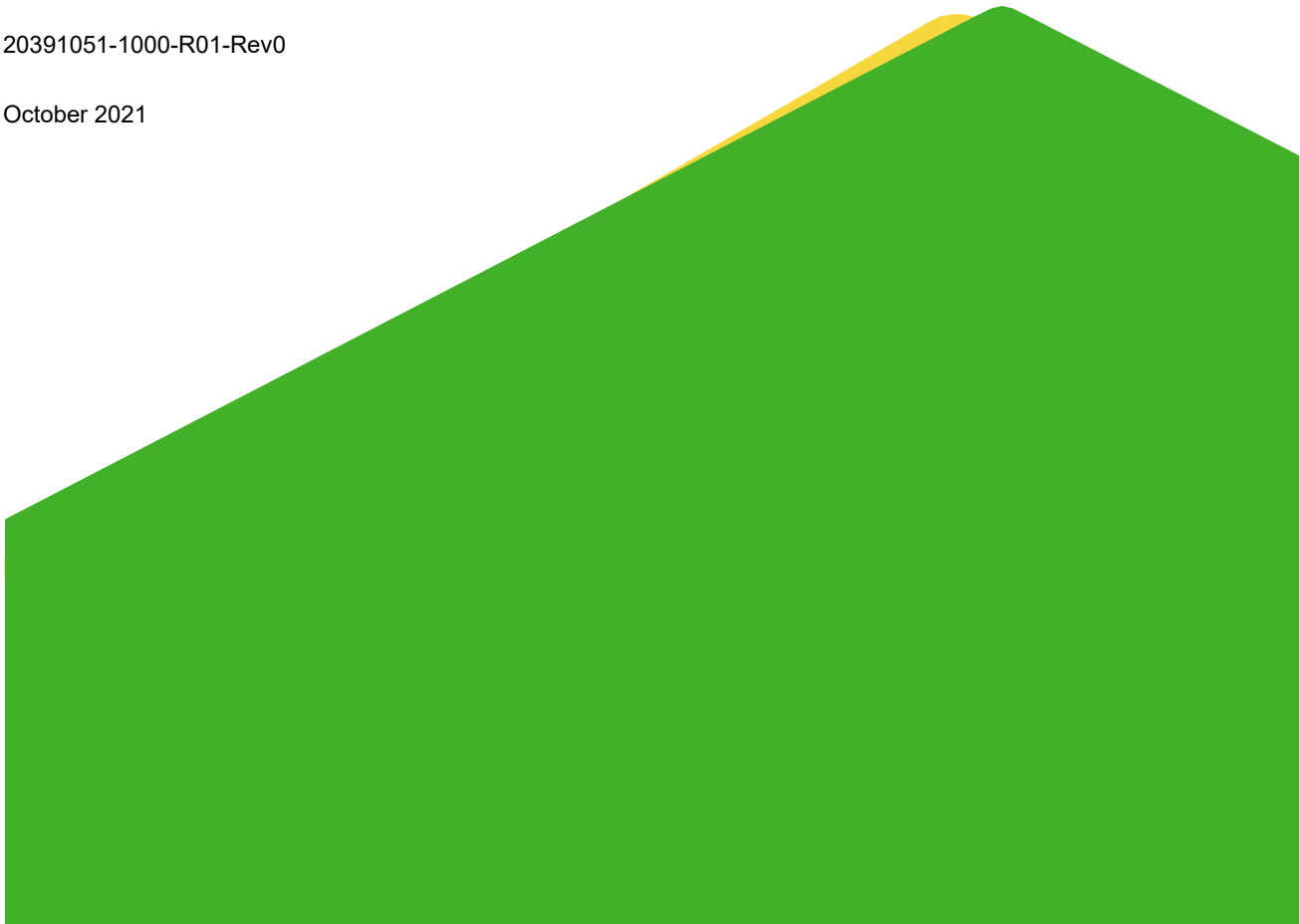
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Distribution List

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1.0 INTRODUCTION

This report provides the results of the preliminary geotechnical assessment for the above-noted project. It is understood that the project involves assessing design alternatives for future intersection improvements at Oxford Street West and Gideon Drive and the future Kains Road to the north. Based on the information provided, the intersection improvement alternatives include single or multiple lane roundabout options or a signalized intersection. The proposed work also includes installation of a sanitary sewer within the area of the intersection.

The purpose of the geotechnical assessment was to evaluate the subsurface soil and groundwater conditions within the study area based on borehole data from previous geotechnical work along the alignments of the project and provide preliminary geotechnical engineering recommendations for the proposed work. In addition, recommendations for additional site-specific geotechnical exploration and testing are provided.

Authorization to proceed with the preliminary geotechnical assessment was provided by Mr. Henry Huotari, P.Eng., of R.V. Anderson Associates Limited (RVA) in an email dated February 3, 2021.

This report should be read in conjunction with the attached "Important Information and Limitations of This Report" which comprises an integral part of this document. The reader's attention is specifically drawn to this material, as it is essential for proper use and interpretation of the information presented and discussed herein.

2.0 METHODOLOGY

To evaluate the existing subsurface conditions along the subject sections of roadway, existing geotechnical information in the area of the site readily available from our files was compiled and reviewed. The information consisted of topographical mapping, aerial mapping, soils and bedrock mapping, geological data, and site-specific geotechnical data from previous site explorations carried out on or adjacent to the site. The previous site explorations are identified as follows:

- Golder Report No. 001-3139 titled "Geotechnical Investigation, Westdel Bourne and Shore Road Feeder Watermains, London, Ontario" dated October 2000; and
- Golder Report No. 1542537-2000 titled "Geotechnical Investigation, Detailed Design of Tributary "C" Stormwater Management Facility, London, Ontario" dated May 26, 2016.

A field reconnaissance was carried out by a geotechnical engineer from our staff on June 24, 2021 to provide a geotechnical overview of the general site conditions and to carry out a visual pavement condition survey in conjunction with the preparation of this report. The previous Record of Borehole Sheets and selected site photographs are attached in Appendices A and B, respectively, and the approximate locations of the previous boreholes used in the development of this report are illustrated on the Location Plan, Figure 1.

3.0 SITE DESCRIPTION AND PROPOSED PROJECT

Based on the information provided, the study area is located at the intersection of Oxford Street and Gideon Drive and extends to the north to join future Kains Road. The conceptual design of the proposed work is shown on the Location Plan, Figure 1.

It is understood that the major components of the proposed project will consist of installation of a sanitary sewer and construction of a single/multi-lane roundabout or signalled intersection at Oxford Street and Gideon Drive. The conceptual design of the proposed work is shown on the Location Plan, Figure 1.

The subject section of Oxford Street West consists of single westbound and eastbound lanes with turning lanes at the intersection to Gideon Drive and to Kains Road. Relatively wide grassed boulevards are located along the subject section of Oxford Street West and Gideon Drive.

The condition of the existing Oxford Street West and Gideon Drive is generally fair to good throughout the project area. However, localized areas of longitudinal, transverse cracking were observed along both roads. Selected site photographs (Photographs 1 to 4) showing the existing condition of the pavements are attached in Appendix B.

Based on topographic mapping within the study area, the ground surface ranges from about elevation 269 metres at the west end to about 254 metres at the east end. Land use in the study area is residential and agricultural.

4.0 SITE GEOLOGY

The site is currently covered with wild grasses with small, wooded areas along the ditches, boulevards and median island. The north side of the proposed intersection has a residential building development and the south side, several private properties surrounded by farmland.

The site is located on the boundary of the physiographic regions of southwestern Ontario known as the Mount Elgin Ridges and Caradoc Sand Plains and Annex as indicated in "The Physiography of Southern Ontario", by Chapman and Putnam (1984). The Mount Elgin Ridges is a succession of ridges and vales where the lowlands are generally covered by alluvium consisting of gravel, sand and silt. The crests of the ridges are typically covered moraine tills composed of clay and silty clay. The Caradoc Sand Plains and Annex consists of sand or other light-textured, water-laid deposits.

Based on the Ontario Department of Mines Preliminary Geological Map No. P.238 titled "Pleistocene Geology of the St. Thomas Area (West Half)", the surficial soils at the site consist of valley trains and silty sand to fine sands.

The site is reportedly underlain by middle Devonian-age limestone of the Dundee Formation of the Hamilton Group. The upper member consists of microcrystalline limestone and the lower member consists of crinoidal limestone containing quartz sand grains and chert. Based on the Ontario Department of Mines, Preliminary Map P.482 titled "Bedrock Topography Series, St. Thomas Sheet, Southern Ontario", the bedrock surface is at about elevation 192 metres or some 62 to 77 metres below the ground surface.

5.0 SUBSURFACE CONDITIONS

The subsurface conditions encountered in the previous boreholes advanced in the vicinity of the project are detailed on the attached Record of Borehole sheets in Appendix A, and the location of the boreholes are shown on the Location Plan, Figure 1. The following discussion has been simplified in terms of major soil strata for the purposes of preliminary geotechnical design. The soil boundaries indicated are inferred from non-continuous samples and observations of drilling and sampling resistance and typically represent transitions from one soil type to another rather than exact planes of geological change. Further, subsurface conditions may vary significantly between and beyond the borehole locations.

Borehole data used for this report was gathered during previous explorations that date from 2000 and 2015 and, therefore, conditions since the time of the explorations may have changed due to roadway reconstruction, impacts on drainage patterns, or other development that occurred since the boreholes were drilled.

5.1 Soil Conditions - General

Based on our review of available geotechnical and geological data, the soil conditions in the study area are generally consistent with the geological mapping described above. The soil conditions encountered in the boreholes, generally consisted of topsoil or granular fill materials overlying, sandy silt, sand, sand and gravel and occasionally layers of clayey silt till.

5.2 Topsoil/Fill

Topsoil was encountered in the boreholes drilled north of the intersection of Oxford Street West and Gideon Drive. The topsoil thickness varied from about 0.3 to 0.6 metres, with an average thickness of about 0.4 metres at the borehole locations. Fill materials were encountered in boreholes drilled in the area of the intersection of Oxford Street and Westdel Bourne and consisted of roadway granulars, sand and gravel, sandy silt and clayey silt. The thickness of the fill was about 1.0 to 2.2 metres.

5.3 Sandy Silt/Silty Sand

Beneath the topsoil, layers of silty sand and sandy silt were encountered in boreholes 103, 104, 105, 108 and 109 (1542537). Where fully penetrated, the sandy silt to silty sand was about 0.8 to 2.1 metres thick. Borehole 109 (1542537) was terminated in silty sand at a depth about 12 metres. In borehole 13 (001-3139), a 0.8-metre-thick layer of sandy silt was encountered beneath the fill. The sandy silt to silty sand had N^1 values, as determined by the standard penetration tests, of 2 to 10 blows per 0.3 metres with water contents of about 11 to 24 per cent, respectively, for the samples obtained.

5.4 Sand/Sand and Gravel

Boreholes 101, 103, 104, 105, 108 and 109 (1542537) and borehole 11, 13 and 14 (001-3139) encountered sand and sand and gravel layers. Where fully penetrated, the sand and sand and gravel layers varied in thickness from about 1.1 to 8.9 metres. The sand and sand and gravel layers had N values ranging from 2 blows per 0.3 metres to 60 blows per 0.15 metres and water contents ranging from about 2 to 21 per cent.

5.5 Silt

Borehole 104 (1542537) encountered silt layers beneath the sandy silt and sand layers. The silt layers were about 2.0 and 0.4 metres thick, respectively. The silt had N values of 9 to 24 blows per 0.3 metres and water

¹ The SPT N value is defined as the number of blows required by a 63.5-kilogram hammer dropped from a height of 760 millimetres to drive a split spoon sampler a distance of 300 millimetres into the soil after having first penetrated 150 millimetres.

contents of about 21 to 29 per cent. A 0.5-metre-thick silt layer was also encountered in borehole 14 (001-3139) and had an N value of 19 blows per 0.3 metres and a water content about 19 per cent.

5.6 Clayey Silt and Silty Clay

Layers of clayey silt and silty clay were encountered beneath the silt and sand in boreholes 11, 13 and 14 (001-3139). Borehole 108 (1542537) was terminated in silty clay at the depth about 5 metres below ground surface.

The clayey silt and silty clay had N values ranging from 14 to 32 blows per 0.3 metres and had water contents ranging from 11 to 20 per cent.

5.7 Groundwater

Groundwater levels were encountered in boreholes BH-101, BH-103, BH-104, BH-105, BH-108 and BH-109 (1542537) and 11, 13 and 14 (001-3139) during drilling and, on completion of drilling and sampling, standpipes and monitoring wells were installed in boreholes BH-101, BH-104, BH-105, BH-108, BH-109 (1542537) and BH-13 and BH-14 (001-3139).

The installations are shown in detail on the Record of Borehole sheets in Appendix A, together with the encountered and measured groundwater levels. A comprehensive summary of the encountered and measured groundwater levels in the previous boreholes is provided in Table I following the text of this report. As indicated, on the borehole logs, groundwater was encountered at depths ranging from about of 2.1 to 9.1 metres below ground surface (elevations of 250.8 to 261.4 metres).

It should be noted that the boreholes were drilled over a period of a couple of decades and during various seasons. Seasonal variations in groundwater levels should be anticipated. Development activities subsequent to the dates of the previous explorations can also significantly impact groundwater levels.

6.0 DISCUSSION

This section of the report provides our interpretation of the available geotechnical data and it is intended for the guidance of the design engineer during conceptual design within the context of the overall geotechnical assessment. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Based on information provided by RVA, the proposed works for this intersection improvement project will include a new 600 to 675 millimetre diameter sanitary sewer and construction of a proposed roundabout or signalized intersection. It is understood that the preferred design alternative is to construct a Turbo Roundabout.

6.1 Municipal Services

It is understood that a future sanitary sewer will be constructed within the area of the new intersection. Based on the preliminary design drawings provided by RVA, the future sanitary sewer will be 600 to 675 millimetres in diameter with an invert depth of about 10 metres below the road surface or approximately elevation 253.0 metres..

6.2 Excavations

It is anticipated that the excavations for the proposed sanitary sewer will be about 10 metres in depth to about elevation 253 metres and will primarily encounter the existing pavement structure, surficial fill or topsoil overlying fill, silt, sands, sand and gravel and cohesive deposits of silty clay and clayey silt. Groundwater was encountered in several of the boreholes previously drilled in the vicinity of the project. Based on the results of the previous boreholes, groundwater was encountered from about 2.1 to 9.1 metres below the ground/road surface, within silts and sands, and the depth of excavation below the groundwater level will depend on the time of year of construction and final designs.

Based on the groundwater level measurements and anticipated proposed invert depth, the excavation for the future sanitary sewer may extend below the groundwater level and a permit to take water (PTTW) or Environmental Activity and Sector Registry (EASR) may be required. Proactive groundwater lowering in the sands and silts would be required to ensure stability of both the base and the walls of the excavations. Such groundwater lowering could be accomplished by deep wells, well point systems or the like. Groundwater lowering methods should be developed by a specialist dewatering contractor. The use of proactive dewatering will aid in the potential reuse of the wet sands and other soils as trench backfill materials.

For conceptual planning, temporary open cut slopes should be planned to be no steeper than 1 horizontal to 1 vertical. It may be necessary to flatten the excavation side slopes in the surficial sands and silts in addition to blanketing portions of the cut slopes with free draining granular material to enhance the stability of the excavation walls.

To reduce the width of open cut excavations, consideration should be given to installing the services using a properly designed trench box. The trench box only provides protection for the workers once it is in place and does not preclude movement of the excavation walls or the flow of saturated materials under the influence of groundwater. Any gaps between the trench box and adjacent excavation side walls should be filled immediately to limit lateral movements.

All excavations should be carried out in accordance with the latest edition of the Ontario Occupational Health and Safety Act and Regulations for Construction Projects. The fill materials, sands, silts, silty clay, clayey silt and organic soils above the groundwater water level would be generally classified as Type 3 soils. The granular soils below the groundwater level would be classified as Type 4 soils. Care should be taken to direct all surface water away from open excavations.

6.3 Bedding

Bedding for the proposed services should consist of suitably graded granular material consistent with the type, size and class of pipe and City of London standards. Care should be taken to extend the bedding through all fill and topsoil to bear on native, undisturbed soils.

Bedding materials should be placed in maximum 300-millimetre-thick loose lifts and uniformly compacted to at least 95 per cent of standard Proctor maximum dry density (SPMDD). In areas where groundwater seepage may be of sufficient volume that the bedding material cannot be adequately compacted, it may be necessary to use 19-millimetre clear stone with a full-encapsulating non-woven geotextile surround. Where appropriate, the clear stone bedding would also facilitate groundwater control and pumping from sumps, as required. Should a trench liner box be employed, measures should be taken to ensure that the compacted pipe bedding is not disturbed when the liner box is moved.

6.4 Trench Backfill

Based on the results of the previous explorations, the excavated materials will consist primarily of fill, silt, sands, sand and gravel, silty clay and clayey silt.

Provided that all deleterious materials such as the existing asphalt, concrete, topsoil, organics and unsuitable fill materials, including the silts, are wasted together with any excessively wet materials, the remaining drier portions of the excavated materials are considered suitable for use as trench backfill.

The general trench backfill should be placed in maximum loose lift thicknesses of not greater than 300 millimetres and uniformly compacted to at least 95 per cent of SPMDD. The upper one metre of backfill in settlement sensitive areas and where the backfill forms the roadway subgrade should be placed in maximum 200-millimetre-thick lifts and uniformly compacted to at least 98 per cent of SPMDD.

The suitability of the excavated materials for backfill should be assessed on a site-specific basis. Geotechnical boreholes may be required to assess the current subsurface soil and groundwater conditions and chemical analyses carried out to provide comments on handling and off-site disposal options.

6.5 Roadway Widening and Roundabout Construction

Widening of the existing Oxford Street West and Gideon Drive roadway platforms will be required during construction of the roundabout. Based on the condition of the asphalt in the area of the intersection, we suggest that these pavements also be fully reconstructed. In general, all surficial topsoil, organic, loose, soft and/or deleterious materials should be stripped from the areas requiring widening. Subexcavations for pavement widening should extend from the existing edge of pavement and consist of a vertical cut to the proposed subgrade level.

Any fill required to bring the areas to subgrade level should consist of City of London Granular B or Granular C. Any fill materials required to achieve subgrade elevation should be carefully benched into the existing materials in accordance with Ontario Provincial Standard Drawing (OPSD) 209.010.

Geotechnical boreholes will be required in the area of the roundabout to assess the subsurface soil and groundwater conditions.

6.6 Preliminary Pavement Design

Current traffic data obtained from the City of London website indicated average annual daily traffic volumes of 15,500 to 18,500 vehicles for Oxford Street West and 2,500 vehicles for Gideon Drive. Data provided by RVA suggests a 1 per cent per annum growth rate for the intersection. The percentage of truck traffic in the traffic flow was not provided but has been assumed to be 5 per cent for both roadways for the purposes of this report.

Based on the City of London's Plan, Oxford Street West is classified as an Urban Throughfare, Gideon Drive as a Rural Throughfare and Kains Road as a Neighbourhood Connector. Based on the City Standards, the pavement structures may be designed using Benkelman beam design rebound criteria of 0.64 and 1.25 millimetres, respectively. Using the traffic volumes and estimated proportions of heavy vehicles noted above, together with the anticipated subgrade conditions, the following preliminary pavement structures are provided for the proposed widenings:

Roadway	Pavement Component Thickness (mm)			
	HL 1* / 3 Sheet Asphalt	HL 8 Binder Asphalt	Granular A Base	City of London Granular B Subbase
Oxford Street West	50*	130 (2 @ 65)	150	600
Gideon Drive	50	130 (2 @ 65)	150	600
Kains Road	60	70	150	450

Alternatively, SuperPave 12.5 and 19.0 surface and binder asphalt can be placed on Oxford Street West. The Superpave 12.5 surface asphalt shall use Performance Graded Asphalt Cement (PGAC) 64-28. The Superpave 19.0 binder asphalt may use PGAC 58-28. Based on the City of London specifications, Ontario Traffic Category D is applicable for the Oxford Street West pavements.

Any fill, organic or deleterious materials encountered at subgrade level should be removed prior to placement of subbase material. All subgrades should be heavily proofrolled under the direction of the geotechnical engineer and remedial work carried out as required.

The above preliminary pavement structures generally comply with the City of London standards and should be revised based on the specific subgrade conditions and actual traffic loadings. The indicated preliminary pavement structures are based on properly prepared and graded subgrades with appropriate drainage of the pavement granulars provided.

The Granular A base and Granular B subbase should be placed in maximum 300-millimetre-thick loose lifts and uniformly compacted to at least 100 per cent of SPMDD. Short, perforated stub drains should be provided at subgrade level at all catchbasin locations.

The asphaltic materials should be produced, placed and compacted in accordance with the current Ontario Provincial Standard Specifications (OPSS) and City of London requirements. Milled notches the depth of the surface course and 500 millimetres wide should be provided where new pavements abut existing pavements and care should be taken to properly tack coat all butt joints and milled surfaces.

During final design, the specific pavement structure requirements should be revisited and reassessed after a detailed geotechnical exploration has been completed.

6.7 Geotechnical Involvement

Geotechnical input will be required throughout the design of this project. A detailed geotechnical exploration program will be required during subsequent phases of design to address and refine the preliminary geotechnical recommendations discussed within this report. Specifically, additional explorations will be required in the area of the proposed roundabout to explore the subsurface conditions, delineate organic soils in these areas and measure groundwater levels to evaluate if a PTTW or EASR is required for this project. Chemical analyses should be completed on soil samples not suitable for re-use as backfill material to assess soil management and disposal options. A regular program of geotechnical monitoring, inspections and testing will be required during construction to confirm that the conditions being encountered are consistent with the results of the boreholes, to

ensure that the intent of the recommendations provided are being met and that the various project specifications are being consistently achieved.

The factual data, interpretation and preliminary recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. This report addresses only the geotechnical (physical) aspects of the subsurface conditions at this site. The geo-environmental (chemical) aspects, including the consequences of possible surface and/or subsurface contamination resulting from previous activities or uses of the site are outside the terms of reference for this report and have not been investigated or assessed.

We trust that this preliminary geotechnical assessment report provides sufficient information for your present requirements. Should any point require further clarification, please contact this office.

Signature Page

Golder Associates Ltd.



Lubomir Kosc, P.Eng.
Geotechnical Engineer

A handwritten signature in black ink, appearing to read "DRP Babcock".

Daniel R. P. Babcock, P.Eng.
Senior Geotechnical Engineer and CSME Supervisor

LK/DB/cr

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Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Ground Water Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

TABLE I

SUMMARY OF GROUNDWATER LEVELS

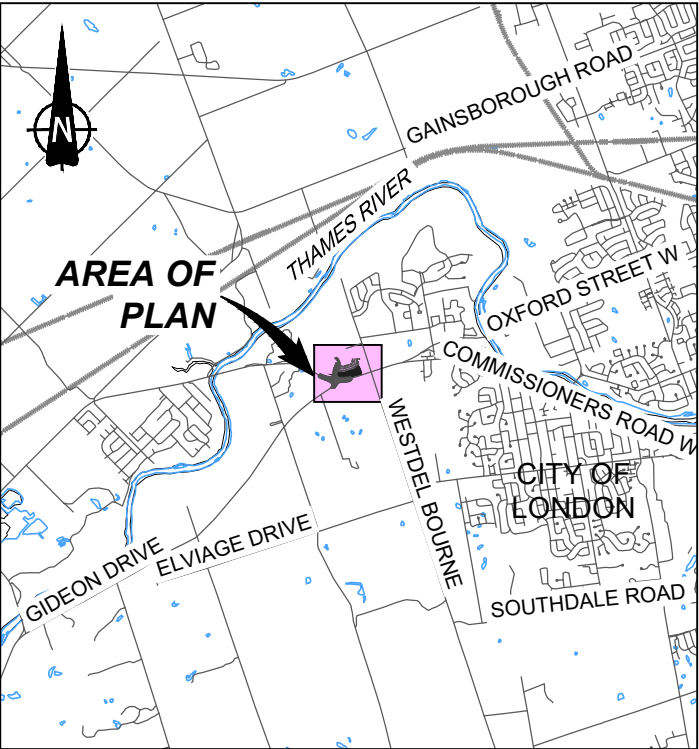
Preliminary Geotechnical Assessment
Oxford Street West and Gideon Drive Intersection Improvements
London, Ontario

BOREHOLE	GROUND SURFACE ELEVATION (m)	DRILLING DATE (2015)	INSTALLATION	GROUNDWATER ELEVATION (m)					
				Encountered During Drilling	Dec. 16, 2015	Dec. 17, 2015	Measured Dec. 18, 2015	Jan 7, 2016	Jan 25, 2016
(1542537)									
BH-101	255.27	Dec. 15	Monitoring Well	251.3	251.31	-	-	251.31	251.42
BH-102	254.01	Dec. 15	Monitoring Well	251.9	254.72			251.69	251.82
BH-103	255.76	Dec. 16	-	251.2	-	-	-	-	-
BH-104	259.48	Dec. 15	Monitoring Well	250.8	251.71	-	-	251.71	251.84
BH-105	258.02	Dec. 15	Monitoring Well	251.9	251.95	-	-	251.95	252.01
BH-108	260.65	Dec. 16	Monitoring Well	258.1	-	257.82	-	258.00	258.11
BH-109	270.51	Dec. 17	Monitoring Well	261.4	-	-	261.03	260.91	260.96
(001-3139)									
		(2000)			Sept. 18, 2000				
BH-11	265.43	Sept. 6	-	Dry	-				
BH-13	264.27	Sept. 6	Standpipe	259.7	259.24				
BH-14	261.99	Sept. 7	Standpipe	258.3	258.64				

- NOTES:
1. See Record of Borehole sheets for installation details.
 2. For borehole locations, see Location Plan, Figure 1.
 3. Table to be read in conjunction with accompanying report.

Prepared By: LK
Checked By: DB

Drawing file: 20391051-1000-R01001.dwg Oct 14, 2021 — 3:15pm 0 25mm Original Format is Tabloid 279mm x 432mm Client: RV Anderson and Associates Limited



LEGEND

- BOREHOLE (Previous Golder Report 1542537-R01)
- BOREHOLE (Previous Golder Report 001-3139)
- FUTURE SANITARY SERVICE

REFERENCE

DRAWING BASED ON CITY OF LONDON OPEN DATA SET, 2019; R.V. ANDERSON AUTOCAD FILE "205505-OxfordGideon-Base Plan w Options.dwg", JUNE 18, 2021; ENGINEERS LANDSCAPE ARCHITECTS AND BUILDING DESIGNERS, GIDEON DRIVE, PROJECT No. 03.171, SHEET No. 19, Rev 9, MARCH 17 - 2014, PROVIDED BY R.V. ANDERSON IN PDF FORMAT ON OCTOBER 6 - 2021; AND CANMAP STREETFILES V2008.4.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.
ALL LOCATIONS ARE APPROXIMATE.

PROJECT

PRELIMINARY GEOTECHNICAL ASSESSMENT
FOR OXFORD STREET WEST AND GIDEON DRIVE
INTERSECTION IMPROVEMENTS
LONDON, ONTARIO

TITLE

LOCATION PLAN

 GOLDER MEMBER OF WSP	PROJECT No.		20391051	FILE No. 20391051-1000-R01001	
	CADD	DCH	Oct 14/21	SCALE	AS SHOWN
	CHECK	DB		REV.	
				FIGURE 1	

APPENDIX A

Records of Previous Borehole Sheets

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

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

III. SOIL DESCRIPTION

(a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Consistency

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

(b) Cohesive Soils

Dynamic Cone Penetration Resistance; N_d :

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (Q_t), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

IV. SOIL TESTS

w	water content
w_p	plastic limit
w_l	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
γ	unit weight

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

LIST OF SYMBOLS

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

I. General

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

- Notes:**
- 1 $\tau = c' + \sigma' \tan \phi'$
 - 2 shear strength = (compressive strength)/2
 - * density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)

PROJECT: 001-3139

RECORD OF BOREHOLE 11

SHEET 1 OF 1

LOCATION: SEE LOCATION PLAN

BORING DATE: SEPT. 6, 2000

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s					ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		20 40 60 80					10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³						
									SHEAR STRENGTH Cu, kPa					WATER CONTENT PERCENT Wp ———— W ———— WI						
0	POWER AUGER (UNCASED)	PAVEMENT SURFACE		265.43				265											Borehole dry during drilling Sept. 6, 2000	
		TAR AND CHIP		0.03																
		GRANULAR ROADBASE		264.91																
				0.52																
1		Loose brown sandy silt, trace gravel, clay (FILL)		264.36	1A	50 DO	14													
				1.07	1B															
		Compact brown SAND some gravel		264.06				264												
				1.37																
2		Stiff brown CLAYEY SILT (TILL)		263.14	2	50 DO	15													
				2.29																
	Very dense brown fine SAND, some gravel		262.53	3	50 DO	62	263													
			2.90																	
3	Very dense brown SAND AND GRAVEL, trace cobbles		261.77	4	50 DO	60/150mm		262												
			3.66																	
4	Dense brown FINE SAND			5	50 DO	40	261													
5				6	50 DO	43														
		END OF BOREHOLE		260.40																
				5.03																
6																				
7																				
8																				
9																				

Borehole dry during
drilling Sept. 6, 2000

DEPTH SCALE

1 : 50



LOGGED: D.J.M.

CHECKED:

PROJECT: 001-3139

RECORD OF BOREHOLE 13

SHEET 1 OF 1

LOCATION: SEE LOCATION PLAN

BORING DATE: SEPT. 6, 2000

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m						HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		SHEAR STRENGTH Cu, kPa			WATER CONTENT PERCENT								
									20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³				
0	POWER AUGER (UNCASED)	GROUND SURFACE		264.27 0.00				264												
1		Dense brown sand and gravel (FILL)			1	50 DO	47	263												
2					2	50 DO	35													
		Loose brown SANDY SILT, trace topsoil		262.14 2.13				262												
3		Compact brown SAND AND GRAVEL, clayey silt layers		261.37 2.90				261												
4					4	50 DO	22													
		Compact brown fine to medium SAND, trace silt, trace gravel		260.61 3.66				260												
5					5	50 DO	16													
6					6	50 DO	22													
								259												
7		Hard brown CLAYEY SILT (TILL)		258.02 6.25	7A	50 DO	32	258												
				257.72 6.55	7B															
8		END OF BOREHOLE																		
9																				

MH

Backfill Material

Standpipe

Caved Material

Water level encountered in borehole at Elev. 259.70m during drilling Sept. 6, 2000

Water level measured in standpipe at Elev. 259.24m Sept. 18, 2000

Backfill Material

(WL Enc)

09/18/00

Standpipe

Caved Material

Water level
encountered in
borehole at Elev.
259.70m during drilling
Sept. 6, 2000

Water level measured
in standpipe at Elev.
259.24m Sept. 18, 2000

DEPTH SCALE

1 : 50



LOGGED: D.J.M.

CHECKED:

LDN_BHS 001-3139.GPJ GLDR LDN.GDT 7/8/02 DATA INPUT: B. GALLERNO

PROJECT: 001-3139

RECORD OF BOREHOLE 14

SHEET 1 OF 1

LOCATION: SEE LOCATION PLAN

BORING DATE: SEPT. 7, 2000

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m					HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ⊙			WATER CONTENT PERCENT					
									20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	Wp		
									20	40	60	80		10	20	30	40		
0	POWER AUGER (UNCASED)	GROUND SURFACE		261.99 0.00				261											
		Brown sand and gravel, cobble (FILL)		261.62 0.37															
1		Stiff brown clayey silt, trace sand, gravel (FILL)			1	50 DO	12												
				260.62 1.37															
		Compact grey sand and gravel (FILL)			2A	50 DO	15												
2				260.16 1.83															
		Loose black silty TOPSOIL			2B														
				259.09 2.90															
3		Compact brown SILT, some clay, some sand			4A	50 DO	19												
				258.64 3.35															
4		Compact brown fine to medium SAND AND GRAVEL, some silt			4B														
			257.88 4.11																
		Stiff brown CLAYEY SILT (TILL), trace sand			5A	50 DO	14	258											
			257.57 4.42																
		END OF BOREHOLE			5B														
5																			
6																			
7																			
8																			
9																			

Standpipe

09/18/00

(WL Enc)

Water level encountered in borehole at Elev. 258.33m during drilling Sept. 7, 2000

Water level measured in standpipe at Elev. 258.64m Sept. 18, 2000

Backfill Material

Standpipe

09/18/00

(WL Enc)

Caved Material

Water level
encountered in
borehole at Elev.
258.33m during drilling
Sept. 7, 2000

Water level measured
in standpipe at Elev.
258.64m Sept. 18, 2000

DEPTH SCALE

1 : 50



LOGGED: D.J.M.

CHECKED:

PROJECT: 001-3139

RECORD OF BOREHOLE 15

SHEET 1 OF 1

LOCATION: SEE LOCATION PLAN

BORING DATE: SEPT. 7, 2000

DATUM: GEODETIC

SAMPLER HAMMER, 63.5kg; DROP, 760mm

PENETRATION TEST HAMMER, 63.5kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m						HYDRAULIC CONDUCTIVITY, k, cm/s					ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE		BLOWS/0.3m	SHEAR STRENGTH Cu, kPa		nat V. + Q - rem V. ⊕ U - ⊙		WATER CONTENT PERCENT							
									20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴	10 ⁻³	Wp	W		
								20	40	60	80		10	20	30	40				
0	POWER AUGER (UNCASED)	PAVEMENT SURFACE		259.85																
		TAR AND CHIP		0.06																
		GRANULAR ROADBASE		259.48																
				0.37																
		Black silty TOPSOIL		259.18																
				0.67																
1		Dense brown SAND AND GRAVEL		258.48	1	50 DO	38	259						○						
				1.37																
2					2	50 DO	20	258						○						
3		Compact brown fine to coarse SAND, trace gravel			3	50 DO	18	257						○						
4					4	50 DO	15							○						
5					5	50 DO	20	256						○						
6																				
7																				
8																				
9																				
		END OF BOREHOLE		255.43																
				4.42																

Borehole dry during
drilling Sept. 7, 2000

DEPTH SCALE

1 : 50



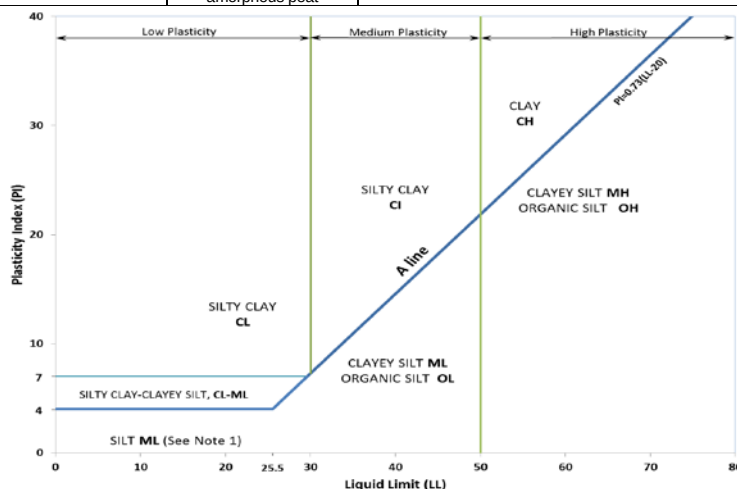
LOGGED: D.J.M.

CHECKED:

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$		$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$			Organic Content	USCS Group Symbol	Group Name	
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4		≤1 or ≥3			≤30%	GP	GRAVEL	
				Well Graded	≥4		1 to 3				GW	GRAVEL	
			Gravels with >12% fines (by mass)	Below A Line	n/a						GM	SILTY GRAVEL	
				Above A Line	n/a						GC	CLAYEY GRAVEL	
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6		≤1 or ≥3				SP	SAND	
				Well Graded	≥6		1 to 3				SW	SAND	
			Sands with >12% fines (by mass)	Below A Line	n/a						SM	SILTY SAND	
				Above A Line	n/a						SC	CLAYEY SAND	
Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name		
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)					
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT		
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT		
			Liquid Limit ≥50	Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT		
				Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT		
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30%	CL	SILTY CLAY		
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium	(see Note 2)	CI	SILTY CLAY		
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY		
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT		
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT		



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.

Note 2 – For soils with <5% organic content, include the descriptor “trace organics” for soils with between 5% and 30% organic content include the prefix “organic” before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.

For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between “clean” and “dirty” sand or gravel.

For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.

A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (i.e., SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm² pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

PH: Sampler advanced by hydraulic pressure

PM: Sampler advanced by manual pressure

WH: Sampler advanced by static weight of hammer

WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w _p	plastic limit
LL , w _L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test ¹
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement ¹
D _R	relative density (specific gravity, G _s)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO ₄	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness²

Term	SPT 'N' (blows/0.3m) ¹
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

- SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
- Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grain size. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N' ^{1,2} (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

- SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
- SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes: 1
2

$$\tau = c' + \sigma' \tan \phi'$$

$$\text{shear strength} = (\text{compressive strength})/2$$

HAMMER TYPE: Auto Hammer

BORING DATE: December 15, 2015
DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DATUM: GEODETIC

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	HYDRAULIC CONDUCTIVITY, k, cm/s	ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER		TYPE	BLOWS/0.3m			20 40 60 80	10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³
											SHEAR STRENGTH Cu, kPa	nat V. + rem V. ⊕ U -
							20 40 60 80	10 20 30 40				
0	POWER AUGER 108mm ID HOLLOW STEM	GROUND SURFACE		255.27								
		TOPSOIL, sand; black		0.00								
				255.00								
				0.27								
1					1	SS	14					
2			(SW-SM) SAND, some silt, trace gravel; brown; compact to dense			2	SS	26				
3					3	SS	22					
4				4	SS	40				MH		
5		(SW-SM) gravelly SAND, some silt; brown; compact to dense		5	SS	17						
6				6	SS	30				MH		
		END OF BOREHOLE										
7												
8												
9												

Concrete

Granular bentonite

Filter sand

50mm Diam.
Slot 10
Schedule 40
PVC Screen

Jan. 25/16
Dec. 16/15 &
Jan. 7/16
Enc WL

Groundwater
encountered at about
elev. 251.3m during
drilling on
December 15, 2015.

Water level measured in
well at elev. 251.31m on
December 16, 2015.

Water level measured in
well at elev. 251.31m on
January 7, 2016.

Water level measured in
well at elev. 251.42m on
January 25, 2016.

1 : 50



CHECKED: *W*

HAMMER TYPE: Auto Hammer

BORING DATE: December 15, 2015
DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DATUM: GEODETIC

Concrete

Granular bentonite

Filter sand

Enc. WL
Jan. 25/16
Dec. 16/15
Jan. 7/16

50mm Diam.
Slot 10
Schedule 40
PVC Screen

Groundwater encountered at about elev. 251.9m during drilling on December 15, 2015.

Water level measured in well at elev. 251.72m on December 16, 2015.

Water level measured in well at elev. 251.69m on January 7, 2016.

Water level measured in well at elev. 251.82m on January 25, 2016.

1 : 50



LOGGED: BT
CHECKED: *[Signature]*

PROJECT: 1542537

RECORD OF BOREHOLE BH-103

SHEET 1 OF 1

LOCATION: REFER TO LOCATION PLAN

BORING DATE: December 16, 2015

DATUM: GEODETIC

HAMMER TYPE: Auto Hammer

DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES			ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS			
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE		BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT PERCENT							
									20 Cu, kPa	40	60	80	nat V. rem V.	+ ⊕	Q - U -			● ○	10 ⁻⁶	10 ⁻⁵
								20	40	60	80									
0	POWER AUGER 108mm ID HOLLOW STEM	GROUND SURFACE		255.76				256												
		TOPSOIL, sandy; black		0.00																
				255.33																
				0.43																
1		(SM) SILTY SAND, trace gravel; brown; very loose			1	SS	3	255												
					2	SS	2	254												
2				253.78																
				1.98																
					3	SS	2	253												
3	(SP-SM) SAND, fine to medium, some silt; brown; very loose to loose																			
				4	SS	9	253													
4																				
				251.95				252												
				3.81																
		(SW) SAND, fine to coarse, trace gravel, trace silt; brown; compact																		
5				250.73				251												
				5.03																
		END OF BOREHOLE																		
6								250												
7																				
8																				
9																				

Groundwater encountered at about elev. 251.2m during drilling on December 16, 2015.

Groundwater
encountered at about
elev. 251.2m during
drilling on
December 16, 2015.

LDN BHS 07 1542537-1000.GPJ GLDR LON GDT 29/03/16 DATA INPUT: LMK

DEPTH SCALE

1 : 50



LOGGED: BT
CHECKED: *W*

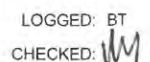
HAMMER TYPE: Auto Hammer

BORING DATE: December 15, 2015
DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DATUM: GEODETIC

— CONTINUED NEXT PAGE —

1 : 50



DN_BHS_07 1542537-1000.GPJ GLDR LON.GDT 29/03/16 DATA INPUT: LMK

PROJECT: 1542537

RECORD OF BOREHOLE BH-104

SHEET 2 OF 2

LOCATION: REFER TO LOCATION PLAN

BORING DATE: December 15, 2015

DATUM: GEODETIC

HAMMER TYPE: Auto Hammer

DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS	
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE		BLOWS/0.3m										
									20	40	60	80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴			10 ⁻³
								SHEAR STRENGTH Cu, kPa	nat V. + rem V. ⊕	Q - ● U - ○								
								20	40	60	80							
													</					

DEPTH SCALE

1 : 50



LOGGED: BT

CHECKED: *W*

HAMMER TYPE: Auto Hammer

BORING DATE: December 15, 2015
DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DATUM: GEODETIC

.DN_BHS_07 1542537-1000.GPJ GLDR_LON.GDT 29/03/16 DATA INPUT: LMK

1 : 50



CHECKED: *lw*

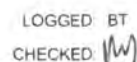
HAMMER TYPE Auto Hammer

BORING DATE: December 16, 2015
DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DATUM: GEODETIC

LDN BHS 07 1542537-1000.GPJ GLDR_LON.GDT 29/03/16 DATA INPUT: LMK

1.50



LOCATION: REFER TO LOCATION PLAN

BORING DATE: December 16, 2015

DATUM: GEODETIC

HAMMER TYPE: Auto Hammer

DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, K, cm/s		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER		TYPE	BLOWS/0.3m	SHEAR STRENGTH				WATER CONTENT PERCENT	
									Cu, kPa	nat V. rem V. ⊕			Q - U - ○	Wp — W — Wi
							20 40 60 80		10 ⁻⁶ 10 ⁻⁵ 10 ⁻⁴ 10 ⁻³					
0	POWER AUGER 100mm ID HOLLOW STEM	GROUND SURFACE		259.88										
		TOPSOIL, sandy, brown		259.54										
				0.34										
1					1	SS	4							
2			(SP-SM) SAND, fine to medium, some silt; brown; very loose to loose		2	SS	2							
					3	SS	1							
3														
					4	SS	2							
4														
				5	SS	5								
5		(SW-SM) SAND, fine to coarse, some silt, trace gravel; very loose to dense		6	SS	21								
				7	SS	22								
6														
				8	SS	31								
7		END OF BOREHOLE		253.33										
				6.55										
8														
9														

Concrete

Granular bentonite

Filter sand

50mm Diam.
Slot 10
Schedule 40
PVC Screen

MH

Borehole dry during
drilling on
December 16, 2015.

Well dry to elev. 253.78m
on December 17, 2015.

Well dry to elev. 253.69m
on January 7, 2016.

Well dry to elev. 253.69m
on January 25, 2016.

DEPTH SCALE

1 : 50

LOGGED: BT

CHECKED: 

PROJECT: 1542537

RECORD OF BOREHOLE BH-108

SHEET 1 OF 1

LOCATION: REFER TO LOCATION PLAN

BORING DATE: December 16, 2015

DATUM: GEODETIC

HAMMER TYPE: Auto Hammer

DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS				
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER TYPE		BLOWS/0.3m	SHEAR STRENGTH Cu, kPa		WATER CONTENT PERCENT						
								20	40	60			80	10 ⁻⁶	10 ⁻⁵	10 ⁻⁴
							20	40	60	80	10	20	30	40		
							nat V. + Q - rem V. ⊕ U -					Wp — W — WI				
0	POWER AUGER 106mm ID HOLLOW STEM	GROUND SURFACE		260.65												
		TOPSOIL, sandy; brown		0.00												
				260.10												
				0.55												
1		(ML) sandy SILT, trace topsoil; brown; loose		259.28	1	SS	5									
				1.37												
2		(ML) sandy SILT, some clay; brown; loose		258.06	2	SS	6									
				2.59												
3		(SP-SM) SAND, fine to medium, some silt, trace gravel; brown; loose to compact		256.99	3	SS	7									
				3.66												
4	(ML) sandy SILT; brown; compact		256.23	4	SS	28										
			4.42													
5	(CL) SILTY CLAY, trace sand; brown; very stiff		255.62	5	SS	28										
			5.03													
6	END OF BOREHOLE				6	SS	16									
7																
8																
9																

Concrete

Granular bentonite

Jan. 25/16
Enc WL
Jan. 7/16
Dec. 17/15

50mm Diam.
Slot 10
Schedule 40
PVC Screen

Groundwater encountered at about elev. 258.1m during drilling on December 16, 2015.

Water level measured in well at elev. 257.82m on December 17, 2015.

Water level measured in well at elev. 258.00m on January 7, 2016.

Water level measured in well at elev. 258.11m on January 25, 2016.

Concrete

Granular bentonite

Jan. 25/16
Enc WL
Jan. 7/16
Dec. 17/15

50mm Diam.
Slot 10
Schedule 40
PVC Screen

Groundwater
encountered at about
elev. 258.1m during
drilling on
December 16, 2015.

Water level measured in
well at elev. 257.82m on
December 17, 2015.

Water level measured in
well at elev. 258.00m on
January 7, 2016.

Water level measured in
well at elev. 258.11m on
January 25, 2016.

DEPTH SCALE

1 : 50



LOGGED: BT

CHECKED: M

LON_BHS_07_1542537-1000.GPJ GLDR LON.GDT 2903/16 DATA INPUT: LMK

LOCATION: REFER TO LOCATION PLAN

BORING DATE: December 17, 2015

DATUM: GEODETIC

HAMMER TYPE: Auto Hammer

DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m		HYDRAULIC CONDUCTIVITY, k, cm/s		ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS		
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE		BLOWS/0.3m	SHEAR STRENGTH Cu, kPa		WATER CONTENT PERCENT				
									20	40	60			80	10 ⁻⁶
								20	40	60	80				
								nat V. + Q - ● rem V. ⊕ U - ○							
								Wp ——— W ——— WI							
								20	40	60	80	10	20	30	40
0		GROUND SURFACE		270.51			271								
		TOPSOIL, silty; brown		270.23											
				0.28											
1					1	SS	5								
2					2	SS	19								
3					3	SS	27								
4					4	SS	21								
5					5	SS	19								
6					6	SS	24								
7					7	SS	20								
8					8	SS	27								
9					9	SS	31								
					10	SS	35								
					11	SS	32								
												</			

— CONTINUED NEXT PAGE —

DEPTH SCALE

1 : 50

LOGGED: BT

CHECKED: *LM*

PROJECT: 1542537

RECORD OF BOREHOLE BH-109

SHEET 2 OF 2

LOCATION: REFER TO LOCATION PLAN

BORING DATE: December 17, 2015

DATUM: GEODETIC

HAMMER TYPE: Auto Hammer

DRILLING CONTRACTOR: Lantech Drilling Services Inc.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE		SAMPLES		ELEVATION	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m				HYDRAULIC CONDUCTIVITY, k, cm/s				ADDITIONAL LAB. TESTING	INSTALLATION AND GROUNDWATER OBSERVATIONS
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER		TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa		WATER CONTENT PERCENT					
									20	40	60	80	10 ⁻⁶	10 ⁻⁵		
9	POWER AUGER 108mm ID HOLLOW STEM	--- CONTINUED FROM PREVIOUS PAGE ---														
			261.37													
			9.14	12	SS	27										
10				13	SS	28										
				14	SS	46										
11		(SM) SILTY SAND, fine, with silt layers; brown; compact to dense														
				15	SS	26										
12		END OF BOREHOLE		258.47												
				12.04												
13						258										
14																
15																
16																
17																
18																
19																

Enc WL

Dec. 18/15
Jan. 25/16
Jan. 7/1650mm Diam.
Slot 10
Schedule 40
PVC ScreenGroundwater
encountered at about
elev. 261.4m during
drilling on
December 17, 2015.Water level measured in
well at elev. 261.03m on
December 18, 2015.Water level measured in
well at elev. 260.91m on
January 7, 2016.Water level measured in
well at elev. 260.96m on
January 25, 2016.

DEPTH SCALE

1 : 50



LOGGED: BT

CHECKED:

APPENDIX B

Site Photographs



Photograph 1: Gideon Drive, south gravel shoulder, looking north to intersection. Note alligator and edge cracking of eastbound lane and transverse cracks.



Photograph 2: Oxford Street West and Gideon Drive intersection, looking west. Note longitudinal cracks.



Photograph 3: Oxford Street West and Gideon Drive intersection, looking east. Note transverse cracks.



Photograph 4: Gideon Drive N/E ramp lane to Oxford Street West, looking southwest. Note transverse cracks.



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