

Niagara - // // Region

REGIONAL MUNICIPALITY OF NIAGARA SOUTH NIAGARA FALLS WASTEWATER SOLUTIONS

# V3.9 – Geotechnical Investigations

Niagara Region is committed to reviewing its practices, processes and the built environment for barriers to access for persons with disabilities. If you require additional or other formats for communicating the details of the appendices in this attached report, please contact the project team <u>new.treatment.plant@niagararegion.ca</u>



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REGIONAL MUNICIPALITY OF NIAGARA SOUTH NIAGARA FALLS WASTEWATER SOLUTIONS

# **Geotechnical Investigation**

Geotechnical Baseline - Study Area





## REPORT

# **Geotechnical Desktop Study Report**

South Niagara Falls Wastewater Solutions Schedule C Class Environmental Assessment

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# **Distribution List**

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# 1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by GM BluePlan Engineering Ltd. (GMBP) to prepare a geotechnical desktop study report in support of the South Niagara Falls Wastewater Solutions Schedule 'C' Municipal Class Environmental Assessment (EA) Project (the Project).

This report was prepared for the exclusive use of GMBP and The Regional Municipality of Niagara (the Region) and is only intended to be used for planning and early stage design purposes as well as recommendations for aspects of future geotechnical investigations. Any use that a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of the third party. The report is based solely on the review of historical and publicly available information and data obtained by Golder and/or provided by GMBP/the Region as described in this report. Additional explorations of subsurface conditions will need to be carried out to better define the local geologic stratigraphy, groundwater levels, and the engineering properties of the subsurface materials for any further design activities.

The factual data, conceptual interpretations, considerations, and 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. In addition, this report should be read in conjunction with the "Important Information and Limitations of This Report" contained following the text of this report. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

# 2.0 PROJECT AND SITE DESCRIPTION

The Region recently completed their 2041 Growth Plan, which identified significant growth in residents and employment within the Municipality by 2041. In 2017, the Region updated their Water and Wastewater Master Servicing Plan Update (MSP), which evaluated the ability of existing and planned water and wastewater infrastructure to efficiently and effectively service the Region's existing users, service anticipated growth and evaluate and develop recommended strategies. The Region is to select a new Wastewater Treatment Plant (WWTP) within South Niagara Falls as the preferred South Niagara Falls servicing strategy to service the anticipated growth for Niagara Region. It is currently anticipated that the proposed new WWTP would be located on one of the Sites of Interest while associated infrastructure upgrades may take place within the wider Regional Study Area.

A key map of the Regional Study Area is shown on Figure 1. The approximate eastern and western extents of Regional Study Area reach from the Welland Canal area to the Niagara River, and extends to Church's Lane to the north and to Marshall Road in the south.

The Sites of Interest are located in the southern part of the Regional Study Area as shown on Figure 2. There are ten Sites of Interest (Sites 1 to 10), encompassing numerous lots and concessions for a total area of approximately 400.8 hectare (ha). Sites of Interest occupy the following lots and concessions:

Sites 1, 3 to 7, and 9 occupy portions or the entirety of Lots 187, 197, 205, and 209-216, Geographic Township of Stamford, former County of Welland, now the City of Niagara Falls, Regional Municipality of Niagara.

- Sites 8 and 10 occupy portions of Lots 5-8, Broken Front on Chippawa Creek, Geographic Township of Willoughby, former County of Welland, now the City of Niagara Falls, Regional Municipality of Niagara.
- Site 2 occupies portions of Lot 5-6, Broken Front Concession, Geographic Township of Crowland, former County of Welland, now the City of Niagara Falls, Regional Municipality of Niagara.

The land use in the Sites of Interest is primarily agricultural with some industrial or residential developments throughout the Regional Study Area.

# 3.0 SOURCES OF INFORMATION

Databases of publicly available documents which were not subjected to non-disclosure agreements (NDAs) or containing any sensitive environmental (contamination) issues were reviewed in development of this desktop study. Water well records provided by the Ministry of the Environment, Conservation and Parks (MECP) and boreholes from the Ministry of Transportation of Ontario (MTO) database were used for this study. MTO boreholes are generally available along the Queen Elizabeth Way (QEW) and in some cases are far from the proposed alignment. Near the Welland Canal, available boreholes are about 50 m away from the proposed alignment. Where available, the overburden information from the MECP boreholes could not be relied upon since the MECP water wells were drilled primarily for measuring groundwater levels and the information related to the geotechnical conditions were not included during drilling.

The following documents, provided to Golder by GMBP, were also reviewed in preparation of this desktop geotechnical study report.

- Palmer Environmental Consulting Group Inc., "Geotechnical Memo in support of the Environmental Assessment Amendment – Niagara Falls WTP Water Intake, Niagara Falls, Ontario", dated, July 8, 2011.
- Trow Associates Inc., "Preliminary Geotechnical Investigation Niagara Falls Water Treatment Plant, Intake Relocation, City of Niagara Falls, Ontario", dated, August 8, 2007.
- Peto Associates Limited, "Soil Investigation Report High Lift Pumping Station, Niagara Falls, Ontario for Regional Municipality of Niagara Public Works Department", dated January 1972.
- The Hydro-Electric Power Commission of Ontario "Canal Rehabilitation Plan and Geological Section Ch. 97+100 to Ch. 328+000, Sir Adam Back-Niagara G.S. No. 1, Drawing No. 7-3-1798-e", dated May 1964.
- The Hydro-Electric Power Commission of Ontario "Canal Rehabilitation Cut-off Grout Curtain Closure Gates at Sta. 412+25, Sir Adam Back-Niagara G.S. No. 1, Drawing No. 7-3-1825", dated September 1964.
- MTO Geocres No. 30M03-307, Thurber Engineering Ltd. titled "Foundation Investigation and Design Report Replacement of Welland River Twin Bridge Structures Queen Elizabeth Way (QEW) City of Niagara Falls, Ontario", dated October 2, 2018.
- MTO Geocres No. 30M03-280, Golder Associates Ltd. titled "Preliminary Foundation Investigation and Design Report Tee Creek Bridges, QEW Structure Replacements at Black Creek, Lyons Creek, Seventh Street and Tee Creek, Regional Municipality of Niagara, G.W.P. 2177-08-00", dated December 15, 2014.

- MTO Geocres No. 30M03-279, Golder Associates Ltd. titled "Preliminary Foundation Investigation and Design Report Lyons Creek Bridges (Site Nos. 36-66/1 and 36-66/2), QEW Structure Replacements at Black Creek, Lyons Creek, Seventh Street and Tee Creek, Regional Municipality of Niagara, G.W.P. 2177-08-00", dated February 11, 2015.
- MTO Geocres No. 30M03-289, Terraprobe titled "Foundation Investigation and Design Report Tee, Lyons and Black Creeks Bridge Structures, Tee Creek North Bound Bridge Replacement Queen Elizabeth Way (QEW), MTO, Ontario ", dated July 15, 2016.
- MTO Geocres No. 30M03-288, Terraprobe titled "Foundation Investigation and Design Report Tee, Lyons and Black Creeks Bridge Structures, Lyons Creek North Bound and South Bound Bridge Replacements Queen Elizabeth Way (QEW), MTO, Ontario", dated July 15, 2016.
- MTO Geocres No. 30M03-212, Ministry of Transportation Technical Memorandum Subject titled "South Approach Embankment, QEW SBL Structure Over Welland River and NYC Railway WO 93-11022, dated December 19, 1994.
- MTO Geocres No. 30M03-111, Ministry of Transportation Technical Memorandum Subject titled "Foundation Investigation Report for Proposed S-E.W. Ramp Crossing at Lyons Creek QEW and Lyons Creek Interchange District No. 4 (Hamilton), dated March 20, 1968.
- Chapman, L.J., and Putnam, D.F., "The Physiography of Southern Ontario, Ontario Geological Survey Special Volume 2, Third Edition, Ministry of Natural Resources, Ontario", 1984.
- Karrow, P.F. and O.L. White. Urban Geology of Canadian Cities Geological Association of Canada (GAC) Special Paper 42 (1998). Chapter on Urban Geology od St. Cathartines - Niagara Falls, Regional Niagara by J. Menzies and E.M. Taylor, pages 287 to 321.
- Ministry of Northern Development and Mines (MNDM). Bedrock Geology Ontario Geological Survey 2011.
   1:25000 Scale, Bedrock Geology of Ontario.
- MNDM. Surficial Geology Ontario Geological Survey 2011. 1:250 000 Scale, Surficial Geology of Ontario.
- MECP Water Well Records.

# 4.0 SITE GEOLOGY AND SUBSURFACE CONDITIONS

# 4.1 Regional Geology

The Regional Study Area is generally located within the Haldimand Clay Plain physiographic region with the northwest corner of the Regional Study Area extending to the Niagara Escarpment physiographic region to Lake Erie, as delineated in The Physiography of Southern Ontario (Chapman and Putnam 1984).

The Haldimand Clay Plain was submerged by glacial Lake Warren and much of it is covered by lacustrine clay deposits. The general topography of this region is generally flat, gentle sloping landscape dominated by clayey soils. At its highest ground where the Haldimand Clay Plain meets the Niagara Escarpment, recessional moraines were built by ice globe that occupies the Lake Ontario basin. Aside from the gravel hills of Fonthill, the moraines

consist of heavy boulder clay and have a much-subdued relief due to having been formed under water (Chapman and Putnam 1984). These clayey soils are presented by the fine-textured glaciolacustrine deposits that are mapped across the majority of the Haldimand Clay physiographic region. Coarser-textured soils were mapped beneath the central part of the Niagara Falls built up area while minor areas of alluvial deposits were mapped along the Region's creeks and rivers. The surficial geology mapping shows several areas of man-made deposits within the physiographic region as shown on Figure 3. These are interpreted to be areas of fill soils resulting from large scale construction works and industrial sites. Fill soils should also be expected near roadways. Most of the Sites of Interest are underlain by the fine-textured glaciolacustrine deposits with smaller area of alluvial deposits along the Welland River/Chippawa Creek.

The Niagara peninsula of the Niagara Escarpment consists of Palaeozoic sedimentary strata bedrock of the Silurian and Devonian age. The bed dips to the south under Lake Erie with a shallow inclination of approximately 5.7 m/km. The massive dolomitic limestone is from the Salina Formation within the Welland area and Salina Formation contains siltstone and calcareous shaly interbeds with occasional limestone layers and inclusions of gypsum within the dolomite. The lower Welland River subwatershed are predominantly underlain with bedrock from the middle to upper Silurian period; Eramosa Formation (dolostone), Guelph Formation (dolostone), and the Salina Formation (dolostone, shale and gypsum) as described in the Urban Geology of Canadian Cities (Menzies and Taylor 1984). These bedrock units are generally oriented horizontally with a slight dip towards the south as shown on Figure 4.

During the middle Silurian period, the tropical sea that covered the Niagara Peninsula deepened and the Guelph formation was deposited. The Guelph formation consists of reef and inter-reef deposits, characterized by tan, sugary, fossiliferous dolostone (Ministry of Northern Development 2011). During the upper Silurian period, the seas become shallower resulting in land surfaces becoming more arid, and deposition of shale and fine grained dolostone occurred. Restricted circulation and increased evaporation of the sea resulted in deposition of evaporites (halite, gypsum, and anhydrite), evaporitic carbonates and shales of the Salina Formation (Ministry of Northern Development 2011).

The bedrock predominately at the Sites of Interest is Guelph formation and Salina Formation composing of dolomite and shale.

# 4.2 Subsurface Conditions

A desktop review of the available subsurface information near the proposed trunk sewer alignment has been carried out, obtained from publicly available sources listed in Section 3.0. The available borehole records are contained in Appendix A. The detailed subsurface soil, bedrock and groundwater conditions encountered in the boreholes and the results of in situ and laboratory test results are provided on the borehole records. The borehole locations are shown on Figures 6 to 10 and projected on a profile line along the proposed trunk sewer alignment. Consideration should be given to the distance between the proposed alignment and WWTP and the borehole locations when interpreting the borehole information.

Based on available borehole information, the subsurface conditions along the proposed sewer alignment beneath any at/near surface layers of topsoil, organics and fill consist of up to about 30 m thick glaciolacustrine cohesive soils overlying a dense to very dense non-cohesive soils comprised of sandy silt to silty sand, with varying amount of gravel. Generally, the glaciolacustrine cohesive deposit has a consistency of very soft to very stiff.

The depth to bedrock (thickness of overburden soils) varies from approximately 12 m to deeper than 30 m along the proposed trunk sewer alignment.

A summary of subsurface conditions encountered in the available boreholes are provided below.

#### 4.2.1 Fill

An approximately 2 m to 10 m thick layer of fill was encountered in boreholes advanced near the Welland Canal. The fill consists of cohesive and non-cohesive layers.

The Standard Penetration Test (SPT) "N"-values measured within the fill layer range from 2 blows to 63 blows per 0.3 m of penetration, suggesting loose to dense state of compactness.

## 4.2.2 Cohesive Layer

An approximately 9 m to 25 m thick layer of cohesive soils comprised of clayey silt to silty clay was encountered below the fill in the boreholes advanced near the Welland Canal. The deposit in places contain non-cohesive pockets of silt to sand.

The SPT "N"-values measured within the cohesive layer range from 1 blow to 26 blows per 0.3 m of penetration, suggesting a very soft to very stiff consistency. In situ shear vane tests were carried out within the cohesive layer and measured undrained shear strengths of 25 kPa to 96 kPa, indicating soft to stiff consistency.

## 4.2.3 Non-cohesive Layer

Below the cohesive layer, boreholes penetrated a layer of non-cohesive soils. The non-cohesive soils grades from silt to sandy silt to silt and sand to silty sand to sand and contain variable amount of gravel. The layer is up to about 10 m thick and overlies the bedrock at this site.

The SPT "N"-values measured within the non-cohesive layer range from 12 blows per 0.3 m of penetration to 100 blows per 0.02 m of penetration, indicating a compact to very dense compactness.

## 4.2.4 Bedrock Conditions

The overburden soils are underlain by bedrock of the Upper Silurian with sedimentary limestone, shale, sandstone, and dolostone.

Bedrock typically consists of completely weathered to fresh, grey, fine to very fine grained, medium strong to very strong limestone and dolomite layers and very weak to medium strong shale of Salina Formation. The bedrock generally transitions with depth from completely weathered at bedrock surface to fresh bedrock. Completely to highly weathered dolostone/residual soil/till and dolostone mixture zone should be expected at the overburden and bedrock interface.

Based on the available information, the depth of bedrock in the vicinity of the proposed sewer alignment generally ranges from 12 m (north) to deeper than 30 m (south) below ground surface. The depths to bedrock as encountered in the existing boreholes are shown on Figures 8 and 9.

It is possible that the upper few meters of bedrock may be more weathered and fractured. Below the more weathered/fractured zone, the bedrock is expected to be of moderately weathered to fresh.

Shale is expected to have strength grades of very weak (R1) to Medium Strong (R3) and limestone/siltstone is expected to have strength grades of Medium Strong (R3) to Very Strong (R5).

## 4.2.5 Groundwater Conditions

Based on the limited available information, the prevalent groundwater level at the Sites of Interest can be assumed to be approximately 1 m to 3 m below ground surface. The MECP water well record locations are provided in Figure 5. The groundwater level should be 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. Perched groundwater conditions are expected within the till soils.

# 5.0 CONCEPTUAL DESIGN CONSIDERATIONS

It is understood that the Region proposes a new WWTP and associated infrastructure within one of the Sites of Interest. At the time of preparing this report, the final location of the WWTP is not confirmed.

# 5.1 Wastewater Treatment Facility Foundations

The details of the proposed wastewater facilities and associated structures are not available at the time of preparing this report. Considering the shallow soil conditions within the Regional Study Area, comprised of soft to stiff cohesive soils, it is expected that settlement sensitive structures would have to be supported on a system of deep foundations. Lightly loaded structures with more tolerance for settlements may be supported on conventional spread footings or deep foundations.

The final foundation types should be selected based on the subsurface conditions at the actual locations, structural loads, and settlement tolerance.

# 5.2 Trunk Sewer System

The conceptual sketches indicate that a trunk sewer system will be installed from Sta 0+00 to Sta 4+554 with the invert of the trunk sewer ranges from about 8 m to 17 m as shown on Figures 6 to 10. It is expected that the trunk sewer will be installed by means of tunnelling (i.e., trenchless method). This section of the report provides conceptual geotechnical recommendations and considerations as part of the Municipal Class EA for the installation of the sewer pipes.

## 5.2.1 Tunnelling Installations

Based on the proposed invert elevations and limited subsurface information, the trenchless installations will likely be excavated mostly through overburden soils with a possibility of installation in bedrock.

The project planning should consider the cost, schedule, space for entry and exit points, and availability of local contractors and equipment. The appropriateness of the trenchless installation methods will depend greatly on the subsurface conditions at the site and size of the installation (diameter and length). A detailed subsurface exploration should be carried out for trenchless installations.

The advantages, disadvantages, and risks/consequences associated with various trenchless construction methods, are compared in Table 1 on the basis of anticipated ground conditions, depth of cover, vertical and horizontal alignment, length of pipe installation, availability of equipment, and levels of risk of successfully completing the installation.

Installation Method	Advantages	Disadvantages	Risk / Consequences
Micro-tunnelling Boring Machine (MTBM) with Slurry	<ul> <li>Slurry-type MTBM is able to counterbalance earth (soil and/or rock) and groundwater pressures in a controlled manner, providing continuous face support and eliminating need for dewatering at the tunnel face along the alignment.</li> <li>Can be steered continuously, providing good control over line and grade.</li> <li>Tunnel is fully lined as excavation progresses (i.e., casing pipe is installed behind the MTBM during forward advancement).</li> <li>No personnel entry is required.</li> <li>Potential effects on structures and underground utilities next to the tunnel alignment can be better controlled than most other methods.</li> <li>Machines can include rock-cutting face tools and internal crushers.</li> </ul>	For some systems, slurry processing systems / separation plants are required along with additional working areas at shaft locations.	<ul> <li>Relatively low risk of ground loss during tunnelling when a counterbalancing and appropriately viscous slurry and pressure is used.</li> <li>Greater risk of fluid losses to the surface compared to other methods that do not utilize slurries, but the potential of fluid losses to the surface depends on slurry composition, viscosity, pressure and the existence of available pathways (old boreholes or wells, utility bedding, etc.).</li> <li>Subsurface conditions at interface of fill and native ground may include risks of encountering wood debris or other materials that obstruct tunnelling.</li> </ul>

Installation Method	Advantages	Disadvantages	Risk / Consequences
Tunnelling with Earth-pressure balance tunnel boring machine (EPB TBM)	<ul> <li>EPB TBM is able to counterbalance earth (soil and/or rock) and groundwater pressures in a controlled manner, providing continuous face support and eliminating the need for dewatering at the tunnel face along the alignment.</li> <li>Can be steered continuously, providing good control over line and grade.</li> <li>Tunnel is fully lined as excavation progresses (i.e., precast segmental liner is installed behind the EPB TBM during forward advancement).</li> <li>Potential effects on structures and underground utilities next to the tunnel alignment can be better controlled than most other methods.</li> <li>Machines can include rock-cutting face tools and older systems that use load or pressure-controlled gates for spoil discharge from forward chamber can pass some larger potential obstructions depending on face opening and relieving gate sizes.</li> </ul>	<ul> <li>Susceptible to ground losses depending on operator control of face pressures, relieving gate or screw conveyor operations.</li> <li>Addition of appropriate conditioning agents (e.g., bentonite) may be required to modify spoil for appropriate consistency and face pressure control.</li> </ul>	<ul> <li>Relatively low risk of ground loss during tunnelling when a counterbalancing face pressure is used, and conditioning agents may be required.</li> </ul>

Installation Method	Adv	vantages	Dis	advantages	Ris	k / Consequences
Rock Tunnel Boring Machine (TBM)	•	Man-entry and access to the tunnel face is possible.	-	Rock TBM is not suitable for high groundwater level and gases present in the shale bedrock. This method is not suitable for tunnelling on overburden soils.		The tunnel face is not pressurized. Not suitable for mixed face conditions. Groundwater need to be controlled.
Traditional Jack and Bore		Tunnel is fully lined as excavation progresses (i.e., casing pipe is installed behind the boring head during forward advancement).	-	Traditional jack and bore is considered not suitable for granular material below water levels, or in granular soils above water levels if a plug of soil cannot be maintained in lead end of casing. Traditional jack and bore is considered not suitable for squeezing soils (soft cohesive soils). Difficult to control line and grade using jack and bore, potentially requiring installation of a larger culvert/casing pipe than that specified to accommodate variation during installation.		Significant potential for loss of ground into casing/pipe without dewatering of bore alignment, especially in wet/flowing conditions and even with plug of soil ahead of augers. Obstructions can result in deflection of the casing/pipe resulting in misalignment of the sewer. Cutter head can be specified to have capability for cutting through boulders.



Installation Method	Advantages	Disadvantages	Risk / Consequences
Pipe Ramming	<ul> <li>Less risk of subsidence above sewer alignment when compared to jack and bore installation methods.</li> <li>Better suited for penetrating through potential obstructions such as cobbles and boulders when compared to jack and bore methods.</li> <li>Better suited to site soils below the groundwater level when compared to jack and bore methods.</li> <li>Potentially slightly smaller footprint for entry/exit shafts than that required for jack and bore and MTBM.</li> </ul>	<ul> <li>Limited drive length.</li> <li>Difficult to control line and grade using pipe ramming.</li> <li>Potential for heaving at ground surface (where cover is thin) as a long plug of soil is maintained inside pipe – may require periodic removal of soil plug which is not recommended in saturated ground.</li> <li>Ramming vibration could affect adjacent service lines (if any).</li> <li>Noise can be a public nuisance.</li> </ul>	<ul> <li>Less risk of ground loss during tunnelling when compared to jack and bore methods.</li> <li>Obstructions can result in deflection of the casing/pipe resulting in misalignment of the sewer.</li> <li>Vibration from pipe ramming may impact adjacent buried service lines.</li> </ul>



Installation Method	Advantages	Disadvantages	Risk / Consequences
Jack and Bore with Guided Boring Machine (Pilot Tube Boring)	<ul> <li>Tunnel is fully lined as excavation progresses (i.e., sewer pipe is installed behind the boring head during forward advancement).</li> <li>Pilot tube is steered, providing better line and grade control for final installation as compared to traditional jack and bore.</li> </ul>	<ul> <li>Jack and bore with guided boring machine (GBM) are no more suitable to penetrate through granular material above and below the water table when compared to traditional jack and bore.</li> <li>Dewatering likely required along tunnel alignment to be used successfully.</li> <li>Very stiff/hard or very dense subsurface material may limit penetration of the pilot tube, depending on equipment used for advancement of pilot tube.</li> </ul>	<ul> <li>Significant potential for loss of ground into casing/pipe without dewatering of bore alignment, especially in wet/flowing conditions and even with plug of soil ahead of auger.</li> <li>Obstructions can result in deflection of the pilot tube resulting in misalignment of the sewer, although this can be better managed than for traditional jack and bore.</li> <li>Unexpectedly hard/dense ground conditions can halt penetration of the pilot tube, depending on equipment details.</li> </ul>



Installation Method	Advantages	Disadvantages	Risk / Consequences
Mechanically Assisted and Hand Mining (Shield Tunnelling)	<ul> <li>Obstructions can be easily removed by personnel at the tunnel face.</li> </ul>	<ul> <li>Typically, shield mining is not considered suitable for "flowing" conditions unless dewatering and special provisions are used to manage groundwater issues or squeezing conditions.</li> <li>Dewatering likely required along alignment to be used successfully, particularly if the tunnel is to be advanced through both existing and new embankments given water levels at north end.</li> <li>"Hooded" or angled-face shield required, and poling plates or spilling needed to control ravelling of ground near crown and above spring-line of tunnel.</li> </ul>	<ul> <li>Significant potential for loss of ground into the tunnel without proactive control of saturated conditions.</li> </ul>



#### 5.2.2 SHAFT DESIGN and CONSTRUCTION CONSIDERATIONS

Trenchless installation requires shafts as entry and exit points. The construction of shafts should consider subsurface soil and groundwater conditions. At this stage, it is recommended to assume that the support of excavations for the shafts should be constructed using a relatively watertight structure to minimize groundwater seepage into the excavation and ground movements adjacent to the shafts.

# 6.0 RECOMMENDED GEOTECHNICAL INVESTIGATIONS DURING DESIGN PHASES

## 6.1 Data Gap

The available geotechnical and hydrogeological information is limited along the proposed tunnel alignment. Most of the publicly available boreholes along the alignment were drilled to the north and south of Welland Canal, located approximately 50 m away from the proposed alignment. The location of MTO boreholes are provided in Figures 6 to 11 and borehole logs are provided in Appendix A. The database search provided very limited background geotechnical information within the study areas and very limited borehole information was available near the exit location of the sewer alignment, as shown on Figures 9 and 10, which present boreholes located approximately 700 m away from the sewer alignment.

# 6.2 Geotechnical and Hydrogeological Program

Due to insufficient information available for the design development, the following section provides information for the proposed geotechnical and hydrogeological investigations within the boundaries of the Site. During the design phases, site-specific geotechnical investigations and in-situ and laboratory testing will be required to assist with subsurface risk management and construction cost objectives. Consideration should be given to conducting the following tests during the geotechnical field surveys:

- 1) Conventional boreholes including SPT to obtained SPT and undisturbed soil samples from subsurface strata and Cone Penetration Tests (CPT) through very soft to firm/very loose to compact layers.
- 2) Continuous PQ or Sonic boreholes at shaft locations.
- 3) Monitoring well installations and in-situ hydrogeological testing of soil and rock including pumping tests.
- 4) Laboratory classification testing including water content determination; Atterberg limits tests; and grain size distributions.
- 5) Laboratory and in-situ strength testing in soil and bedrock.

# 7.0 CLOSURE

We trust this report these meets your current needs. If you have any questions, please contact the undersigned.

# Signature Page

Golder Associates Ltd.

Manahe

Manisha Ahuja, P.Eng., P.E. *Geotechnical Engineer* 

Bubble

Dave Walters, Ph.D., P.Eng. Senior Geotechnical Engineer, Principal

MA/AV/DW/ml/wlm

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https://golderassociates.sharepoint.com/sites/29902g/technical work/02\_environmental/06\_geotechnical/final/18104462-r-revd-19june2020-geotechstudy-snf wwf.docx





# IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

**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 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. GM BluePlan Engineering Ltd.

June 19, 2020

South Niagara Falls Wastewater Solutions Schedule C Class EA

# **FIGURES**







REFERENCE(S) 1. BASE DATA - MNRF LIO, OBTAINED 2019 2. PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, © QUEENS PRINTER 2019 3. IMAGERY: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY 4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT REGIONAL MUNICIPALITY OF NIAGARA

PROJECT

SOUTH NIAGARA FALLS WASTEWATER SOLUTIONS SCHEDULE C CLASS ENVIRONMENTAL ASSESSMENT

**REGIONAL STUDY AREA LOCATION PLAN** 

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- EXISTING GROUND CONTOURS AND APPROXIMATE 1800 mm I.D. TRUNK SEWER PROVIDED BY GM BLUEPLAN ENGINEERING LIMITED, RECEIVED FEBRUARY 13, 2020. EXISTIN GROUND SURFACE WAS NOT AVAILABLE BETWEEN STA. 0+000 AND STA. 0+800.
- BEDROCK TOPOGRAPHY AND OVERBURDEN THICKNESS MAPPING, SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE-DATA 207 (MRD 207), 2006.

- 3. REGION OF NIAGARA, SOUTHWESTERN ONTARIO ORTHOPHOTOGRAPHY PROJECT

# (SWOOP), 2015.

PROJECT

SOUTH NIAGARA FALLS WASTEWATER SOLUTIONS SCHEDULE C CLASS ENVIRONMENTAL ASSESSMENT

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#### PROJECT SOUTH NIAGARA FALLS WASTEWATER SOLUTIONS SCHEDULE C CLASS ENVIRONMENTAL ASSESSMENT

(SWOOP), 2015.

- 3. REGION OF NIAGARA, SOUTHWESTERN ONTARIO ORTHOPHOTOGRAPHY PROJECT
- BEDROCK TOPOGRAPHY AND OVERBURDEN THICKNESS MAPPING, SOUTHERN ONTARIO; ONTARIO GEOLOGICAL SURVEY, MISCELLANEOUS RELEASE-DATA 207 (MRD 207), 2006.

EXISTING GROUND CONTOURS AND APPROXIMATE 1800 mm I.D. TRUNK SEWER PROVIDED BY GM BLUEPLAN ENGINEERING LIMITED, RECEIVED FEBRUARY 13, 2020.

REFERENCE(S)
GM BluePlan Engineering Ltd.

June 19, 2020

South Niagara Falls Wastewater Solutions Schedule C Class EA

**APPENDIX A** 

# **MTO Boreholes**



				RI	ECO	RD O	DF BO	DRE	HOL	.E N	0 18	3-01		10	OF 4		ME	IRIC	,	
GWP#	2430-15-00	_ LOC	CATIC	DN _	Welland	d River Bi	ridge Re	placem	nent, M	TM NAI	D83-10	:N47	67 217.	4 E 3	35 654.	1	ORIG	INATED	BY <u>es</u>	
DIST _	HWY QEW	BOF	REHC		/PE_1	NW Casir	ng										СОМ	PILED B	Y MP	
DATUM	Geodetic	_ DAT	E 2	018.04.	11 - 20	18.04.11	LAT	TUDE	4	3.04414	47	LON	GITUE	)E	-79.12	1259	CHEC	CKED BY	GRL	
	SOIL PROFILE		5	Sampl	ES	ITER VS	CALE	DYNA RESIS	MIC CO STANC	DNE PE E PLOT				PLASTIC		TURAL STURE	LIQUID	нт	REMA	RK
EEV EPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WA CONDITIO	ELEVATION S	2 SHEA 0 UI • QI	AR ST NCONF		TH kF	Pa FIELD LAB V	VANE	WP WA			WL NT (%)	MEIO N	GRAIN DISTRIB (%	SI IUT
183.7 0.0	GROUND SURFACE											80 1		4	20 4	+0 (	60	kN/m <sup>3</sup>	GR SA	SI
0.2	SAND and GRAVEL Dense to Compact Grey		1	SS	39		400							þ						
82.4	Moist (FILL)		2	SS	29		100							0						
1.3	Silty CLAY, some sand, trace gravel					-														
	Very Stiff Reddish Brown Moist (FILL)		3	SS	18		182								0					
			4	SS	21	_	181								2 					
			5	SS	20	-									ρ					
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76.5							177													
7.2	Silty <b>CLAY</b> , trace to some sand Very Stiff to Hard Reddish Brown Moist						176													
			8	SS	29										0					
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				RI	ECO	RD C	F B	ORE	HOL	E N	o 18	8-01		2 0	)F 4		ME	TRIC	
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DIST _	HWYQEW	_ BOF	REHC	ר DLE די	PE_	NW Casi	ng										COM	PILED B	Y <u>MP</u>
DATUN	Geodetic	_ DAT	Е <u>2</u>	018.04.	11 <del>-</del> 20	18.04.11	LAT	TUDE	4	3.04414	7	LON	GITUE	DE	-79.12	1259	CHE	CKED BY	GRL
<u>ELEV</u> DEPTH	SOIL PROFILE	RAT PLOT	NUMBER	SAMPI JAL	I" VALUES	ROUND WATER	EVATION SCALE	DYNA RESIS SHEA O U	MIC CO STANCI 20 2 AR ST NCONF			ATION 30 1 Pa FIELD				URAL ITURE TENT V D NTFN	⊔QUID ЦМІТ ——↓ ПТ (%)	Junit Weight	REMARKS & GRAIN SIZI DISTRIBUTIO (%)
	Continued From Previous Page	ST			-	GF	ELE	• Q	010KT 20 ∠	RIAXIA 10 6 1		LAB V 30 1	00	2	0 4	0 6	50 I	kN/m <sup>3</sup>	GR SA SI
	Continued From Previous Page Silty CLAY, trace to some sand Very Stiff Reddish Brown Moist		10	SS	15 PH	-	173 172 171			2.9					0				
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	Silty CLAY, trace to some sand, trace gravel Firm to Stiff Reddish Brown		14	SS	6	-	100							0				0 11 50
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	THEN ASPHALT TO SURFACE.																		
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		- KX					177												
													ſ						
		$\otimes$																	
		$\bigotimes$																	
		$\otimes$	8	SS	25										0				
		$\otimes$					176												
		$\otimes$																	
5.5																			
3.7 3.7	Silty CLAY, trace sand	Ŕ																	
	Hard	1																	
	Reddish Brown Moist		$\vdash$				175												
		H.	a	92	30										r				
				00	53										-				
		W.K				I					1					1	1		1

				RI	ECO	RDC	)F B	ORE	HOL	E N	o 18	-04		2 0	)F 4		ME	TRIC	
GWP#	2430-15-00	LOC	ATIC	2N 1	Wellan	d River B	ridae Re	placen	nent. M		D83-10	N 4 767	7 238.	2 E 33	5 634.	7	ORIG		BY ES
DIST	HWY QEW	BOR	REHC		PE_	NW Casi	ng/NQ (	oring	,								СОМ	PILED B	Y MP
 МОТОМ	Geodetic	DAT	Е <u>2</u>	018.04.	20 - 20	)18.04.20		TUDE	43	3.04434	43	LONG	ITUD	E	-79.12	1488		CKED BY	GRL
	SOIL PROFILE		6	SAMPL	ES	~	ш	DYNA				ATION							
LEV PTH	DESCRIPTION	AT PLOT	UMBER	ТҮРЕ	VALUES	DUND WATER ONDITIONS	ATION SCAL	SHEA O U	AR STI		50 8 TH kP +	a FIELD V	0 /ANE			URAL STURE ITENT W O		▲ UNIT WEIGHT	REMAR & GRAIN S DISTRIBU (%)
	Continued From Previous Page	STF	z		, z	GRO	ELE	• Q	UICK T	RIAXIA 0 6	ιL × 50 ε	LAB VA	NE D	2 WA1	ER CO	JNTEN 10 (	IT (%) 50	kN/m <sup>3</sup>	GR SA S
	Silty CLAY, trace sand Stiff Reddish Brown Wet						174												
			1	тw	РН		173								0				
											<u>3.</u> 6								
	Firm		10	SS	3	_	172								0				
							171			<u>3.0</u>									
			11	SS	3	-	170								0				
							170		5. +	3									
			2	тw	РН	-	169								0				
						_	168				1								
			12	SS	8	-									0				
							167			3.3 +									
			13	ss	5	-	166								0				
						-	165			3.3									
										+									

				R	ECO	RD C	F B	DREHOL	E No 18	3-04	3 OF 4	1 M	ETRIC	HURDER
GWP#_	2430-15-00	_ LOC	CATIC	DN _\	Velland	d River B	ridge Re	placement, MT	M NAD83-10	): N 4 767 238.	2 E 335 63	4.7 OR	GINATED	BY ES
DIST _	HWY QEW	_ BOF	REHO	DLE TY	′PE	NW Casi	ng/NQ C	oring				CO	MPILED B	Y MP
DATUM	1 _Geodetic	_ DAT	Е <u>2</u>	018.04.	20 <b>-</b> 20	18.04.20	LAT	TUDE43.	044343	LONGITUE	DE79.	121488 CH	ECKED B	YGRL
					50			DYNAMIC CO		ATION			1	
ELEV	DESCRIPTION	AT PLOT	UMBER		VALUES	DUND WATER	ATION SCALE	RESISTANCE 20 40 SHEAR STR O UNCONFI	PLOT 0 60 ENGTH ki NED +	 80 100 Pa FIELD VANE		NATURAL LIQUI IOISTURE LIM CONTENT LIM W W L		REMARK & GRAIN SI DISTRIBUT
		STF	z		z	GRO	ELEV	QUICK TF 20 40	NAXIAL ×	LAB VANE	WATER	40 60	)	
	Continued From Previous Page Silty CLAY, trace sand Stiff Reddish Brown Wet		14	SS	8		164							0 0 64
							400		4.0 +					
							163							
							162						-	
	Very Stiff		15	SS	16	-	161				0			
							160						_	
							159							
			16	SS	12	-	158							
						-								
							157						_	
							156							
			17	SS	16		155				0		-	
154.2			 											

Minis Trans Ontario	stry of sportation														M	ГО	307	-4	THURBER
				RI	ECO	RD C	)F B	ORE	HOL	E N	lo 18	8-04		4 (	)F 4		ME	TRIC	;
GWP#_	2430-15-00	LOC	CATIO	_ אכ	Welland	d River B	ridge Re	placen	nent, M	TM NA	D83-10	:N47	67 238	.2 E 33	35 634.	7		INATED	BY <u>es</u>
DIST _	HWY QEW	BOF	REHO	CLE ריד	YPE_	NW Casi	ng/NQ (	Coring									_ СОМ	PILED B	Y <u>MP</u>
DATUM	Geodetic	DAT	Е <u>2</u>	018.04.	.20 - 20	18.04.20	LAT	ITUDE	4	3.0443	43	LON	GITUE	DE	-79.12	1488		CKED BY	GRL
	SOIL PROFILE			SAMPL	LES	Ř	Ë	DYNA RESIS	MIC CO STANCI	DNE P E PLO		ATION			. NAT	URAL			REMARKS
ELEV DEPTH	DESCRIPTION	RAT PLOT	JUMBER	TYPE	" VALUES	OUND WATE	VATION SCA	SHE/ OU	AR ST		60 8 STH kF +	30 1 Pa FIELD						UNIT WEIGH	& GRAIN SIZE DISTRIBUTIO (%)
	Continued From Previous Page	ST			Z.	GR	ELE		UICK T 20 4	RIAXIA 10	AL X 60 8	LAB V 30 1	ANE	2	20 4	io (	60 60	kN/m <sup>3</sup>	GR SA SI C
30.0	Silty <b>CLAY</b> , some sand, trace gravel, containing cobbles Hard Reddish Brown Wet (TILL)						154												
			18	ss	31	_	152								0				
150.7	casing refusal, switch to coring gravel and cobbles (max. 150mm) from 32.6m to 35.1m						151												
33.5	SILT and SAND, some clay, some gravel, containing cobbles Very Dense Reddish Brown Moist (TILL)	• • • • • • • •					150												
		. o																	
148.9 35.3	DOLOSTONE BEDROCK slightly weathered, very strong, grey horizontal fracture at 35.4m, 35.5m, 35.8m, 36.1m, 36.4m, 36.6m and 36.7m sub vertical fracture at 35.5m and 35.6m		19	RUN	0.225	-	149							0					RUN #1 TCR=100% SCR=95% RQD=92% UCS=147.8MF (average)
	horizontal fracture at 36.9m, 37.0m, 37.1m and 37.2m sub vertical fracture at 37.1m, (50mm) at 37.2m, 37.4m, (100mm) at 37.4m and (75mm) at 37.7m		2	RUN		-	147												RUN #2 TCR=100% SCR=100% RQD=34% UCS=123.6MF (average)
145.7			3	RUN			146												RUN #3 TCR=100% SCR=100% RQD=100% UCS=180MPa (average)
50.0	BOREHOLE BOCKFILLED WITH BENTONITE HOLEPLUG TO 0.8m, SAND TO 0.2m, CEMENT TO 0.1m THEN ASPHALT TO SURAFCE.																		

ONTMT4S2 MTO-18426.GPJ 2017TEMPLATE(MTO).GDT 10/2/18

+ <sup>3</sup> , × <sup>3</sup> : Numbers refer to Sensitivity

 $15 \stackrel{20}{\oplus} 5_{10}$  (%) STRAIN AT FAILURE

			P	FCO					EN	o 19	2_07		4			МЕ				
0\M/D#	0.400.45.00											-07			0 - 3	~				
GVVP#	2430-15-00	LOC		ע <u>י</u> אר	Vellan	d River B	ridge Re	placem	ent, M		<u></u>	: N 4 /	57 278.	<u>7 E 3</u>	35 638.	.2			ВҮ <u>Е</u>	<u>.</u>
		BOR	EHC		rpe	Hollow S	tem Aug		Casin	g/NQ C	oring								Y <u>M</u>	P
DATUN	/ Geodetic	DAT	E <u>2</u>	018.03.	.28 - 20	18.03.28		TUDE	4;	3.04470	02	LON	JUUL	»Е _	-79.12	1495	_ CHE	CKED BY	(GI	RL
	SOIL PROFILE		5	SAMPL	ES	Ř	ΓE	DYNAI RESIS	MIC CO TANCI	DNE PE E PLOT		ATION		DIAST	o NA	TURAL		⊢	REM	<i>M</i> ARKS
		от	~		S	NATE	SC/	2	0 4	io e	50 8	30 1	00	UMIT	C MOI	STURE	LIQUD			&
ELEV	DESCRIPTION	TPL	ABEF	ΡE	ALUE			SHEA	R ST	RENG	TH kF	'a		<sup>₩</sup> P ⊢		w 0	<sup>w</sup> L	_ ₹	DISTR	
DEPTH	BESCHI HON	TRA.	Ŋ	F	> z	ROU	EVA.		ICONF	FINED RIAXIA	+ L X	FIELD		WA	TER C	ONTE	NT (%)	۲		(%)
175.4	GROUND SURFACE	S			-	U	Ц	2	0 4	ю е	50 E	30 1	00		20 4	40	60	kN/m <sup>3</sup>	GR SA	A SI
8:8	TOPSOIL: (50mm)																			
	Silty <b>SAND</b> , some clay, trace gravel,		1	SS	10		175								0			-		
174.7	Compact	$\otimes$	<b> </b>																	
0.7	Dark Brown	/\$	<u> </u>			-														
	(FILL)	' 🕅	2	99	14															
	Clayey SILT, some sand, trace	$\otimes$	<b>É</b>	00	'4										Ŭ					
	gravel, trace organics	$\otimes$	-			-	174											-		
	Reddish Brown																			
	Moist		3	SS	14										þ					
172.0																				
2.2	Silty CLAY, trace sand	X	<b></b>																	
	Very Stiff to Stiff		1.				173													
	Reddish Brown Moist		4	SS	16										0					
			-			-														
						-														
			5	ss	10		173												0 0	61
							1/2													
							171													
			<u> </u>			-														
	Wet		6	55	5										0					
			├──			-														
							170											-		
										2.7										
	Firm		7	SS	4		169								0					
						-														
			1							2.9										
							168													
			1	тw	PH										0					
							167											-		
									З.	2										
			1			1			+											
		H				1														
					-	1														
			8	ss	3	1	166									-		-	0 0	57
		H	Ī			1								'	.				ĺ	
		n///	1	L	1	-				1	1	1	1	1	1	1	1	1	1	

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				R	ECO		F B	DRE	ног	ENC	o 18	-07		2 (	)F 3		ME	TRIC	THURBER
GW/P#	2430-15-00	100	ΔΤΙΟ	 NN N	_ ⊂ ⊂	d River B	ridae Re	nlacem	ent M		83-10-	N 4 7	67 278	7 5 33	5 638	2	ORIG		BY ES
DIST	HWY OFW	BOR	FHC		/PF	Hollow St		ers/NW	/ Casin		os-10.	IN 47	01 210.	<u> </u>	55 050.	<u> </u>			ы <u>ез</u> У мр
DATUM	Geodetic	DATI	E 2	018.03.	28 - 20	18.03.28	LAT	TUDE	. 4:	3.044702	2	LON	GITUD	)E	-79.12	1495	CHE	CKED BY	GRL
					FS			DYNA			NETR/	ATION							
						ATER	SCALI	RESIS	20 4	0 60	$\geq$	30 1	00	PLASTIC LIMIT	MOIS CON	URAL STURE	LIQUID LIMIT	EHT B	REMARKS &
ELEV	DECODIDITION	L PLO	IBER	ЪЕ		ND W	NOL	SHEA	AR ST	RENGT	ΓH kP	a	1	₩ <sub>P</sub>		w 0	w L	UN N	GRAIN SIZE
DEPTH	DESCRIPTION	TRAI	NUN	Υ	/∧ 	CON	EVA1	0 U 0 Q	NCONF UICK T	INED RIAXIAL	+ . ×	FIELD LAB V	VANE ANE	WAT	ER CO	ONTER	VT (%)	Ŷ	(%)
	Continued From Previous Page				-	0	Ш	2	20 4	0 60	) E	80 1	00	2	:0 ∠	10 (	50 	kN/m <sup>3</sup>	GR SA SI CL
	Silty <b>CLAY</b> , trace sand Firm								4.	þ									
	Grey Wet						165												
			2	ΤW	PH										0				
							164												
									-	-									
			9	SS	9		163								0				
			-		-														
									7.0										
							162												
			10	SS	8										0				0 4 50 46
						-	161												
									+										
			11	SS	9		160								0				
				00															
							159		-	3.6									
							100												
	stiff to very stiff		12	SS	13										0				
						-	158												
						-													
			13	SS	16		157							0					
		Ħ												ľ					
		Ħ																	
							156												
		Ħ																	
						1													
	Continued Next Page					+ 3,2	× <sup>3</sup> : N	umber	s refer t	0	20 15 🕁 5	5 /0/>	STD A.			:			



Ministry of Transportation

				R	ECO	RD C	)F B(	DRE	HOL	E N	o 18	-07		3 C	)F 3		ME	TRIC	7
GWP#	2430-15-00	LOC	ΑΤΙΟ	) N _\	Welland	l River B	ridge Re	placem	ent, M1	'M NAE	083 <b>-</b> 10:	N 4 76	67 278.	7 E 33	5 638.2	2	ORIG	INATED	BY <u>es</u>
DIST _	HWY QEW	BOR	EHC	DLE T	′PE_⊦	Hollow S	tem Aug	ers/NW	Casing	g/NQ C	oring						СОМ	PILED B	<b>Y</b>
DATUM	Geodetic	DAT	E <u>2</u>	018.03.	28 <b>-</b> 20′	18.03.28	LAT	TUDE	43	8.04470	2	LON	GITUD	E	-79.12 <sup>-</sup>	1495	CHE	CKED BY	GRL
	SOIL PROFILE		S	SAMPL	.ES	ER	ALE	DYNA RESIS	MIC CC TANCE	DNE PE E PLOT		ATION		PLASTIC	NAT	JRAL		. F	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WAT CONDITION	ELEVATION SC	2 SHEA 0 UI • QI	0 4 R STH NCONF	0 6 RENG INED RIAXIA	τΗ kP + L ×	a FIELD					UMIT WL IT (%)	veigt	& GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page Silty CLAY, trace sand	- KK	14	SS	19			2	0 4	0 0					0 4 			kN/m <sup>3</sup>	GR SA SI CL
	Very Stiff Grey Wet		1				155												0 0 55 47
			16	SS	15		152								0				
151 5																			
23.9	SILT and SAND, trace clay, trace gravel, containing cobbles Very Dense Reddish Brown Wet (TILL) gravel and cobbles (max. 75mm) from 24.4m to 25.3m	0	-17	<del>_\$\$_</del>	<u>100/</u> 0.050		151							0					
150.1							150											FI	RUN #1
20.0	weathered, very strong, grey horizontal fracture at 25.4m and 25.6m		1	RUN			100											4 0 0	SCR=79% RQD=79% UCS=171.5MPa (average)
	horizontal fracture at 26.9m and 27.1m		2	RUN			149											0 0 0	RUN #2 TCR=100% SCR=100% RQD=100% UCS=168.8MPa
	sub vertical fracture (25mm) at 27.3m	$\square$	_			-	148											2	(average)
	horizontal fracture at 27.5m		3	RUN			147											1 0 0 1	RUN #3 TCR=100% SCR=100% RQD=100% UCS=158.8MPa
146.7 28.7	END OF BOREHOLE AT 28.7m.																		(average)
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																		



+ <sup>3</sup> , × <sup>3</sup> : Numbers refer to Sensitivity

20 15 **4** 5 10 (%) STRAIN AT FAILURE

ONTMT4S2 MTO-18426.GPJ 2017TEMPLATE(MTO).GDT 10/2/18

Minis Trans Ontario	try of sportation															MT	O 3	07-10		JRRF	R
				RI	ECO	RD C	F B	ORE	HOL	.E No	o 18	-10		1 (	OF 4		ME	TRIC		JKDE	×
GWP#_	2430-15-00	LOC	CATIC	DN _\	Nelland	d River B	ridge Re	placem	ent, M		83 <b>-</b> 10:	N 4 7	67 343.	7 E 3	35 631.	3	ORIG	INATED	BY _E	S	
DIST _	HWY QEW	BOF	REHC	DLE T	(PE	Hollow St	tem Aug	ers/NW	Casing	g/NQ Co	ring						сом	PILED B	YN	1P	
DATUM	Geodetic	DAT	E _2	018.03.	16 <b>-</b> 20	18.03.17	LAT	TUDE	43	3.045286	3	LON	GITUE	DE	-79.12	1577	CHE	CKED BY		BRL	
	SOIL PROFILE		5	SAMPL	ES	ER (	ALE	DYNA RESIS	MIC CO TANCE	DNE PEN		ATION		PLAST		TURAL	LIQUID	Ŧ	RE	MAR	ĸs
ELEV DEPTH		STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WAT CONDITION	ELEVATION SC.	2 SHEA 0 Ur • QI	NCONF	RENGT	) ε TH kP + . ×	30 1 FIELD LAB V	VANE				иміт <sup>W</sup> L IT (%)	VEIGF	GR, DIST	& AIN S RIBU (%)	IZE TION
0.0 0.1	TOPSOIL: (75mm) Silty CLAY, some sand, trace gravel, trace rootlets, occasional wood fibres Firm		1	SS	5		175							0						<u>,,, ,</u>	
<u>174.4</u> 0.9	Dark Brown Moist Silty CLAY, trace to some sand, trace gravel Very Stiff to Stiff		2	SS	15		174							(	>				0 (	0 6 <sup>.</sup>	7 33
	Reddish Brown Moist		3	SS	16										¢						
			4	SS	18		173								0						
			5	SS	12	-	172								þ						
							171														
			6	SS	7		170								•I				0	5 3 <sup>.</sup>	1 69
							170					3.1 +									
	Firm Wet		7	SS	3	-	169								0						
							168		2.8 +												
			8	SS	4		167							ŀ	1				0	0 5	3 44
									2. +	7											
			9	SS	2		166								0						
	Continued Next Page	W/	1								20										

ONTMT4S2 MT0-18426.GPJ 2017TEMPLATE(MT0).GDT 10/2/18

7	Ministry of Transportation
Ontar	o



GWP#_2430-15-00         LOCATION         Welland River Bridge Replacement. MTM MADB3-10: N4 767 343.7 E 333 631.3         ORGINATED BY ES           DIST	
DIST         HWY         GEW         BOREHOLE TYPE         Holdew Stem Augens/NW Casing/NO Coring         COMPILED BY         M           DATUM         Geodetic         DATE         2018.03.16 - 2018.03.17         LATTUDE         43.045286         LONGTUDE         -79.12177         CHECKD BY         Geodetic           SOL PROFILE         SAMPLES         H         W <td< td=""><td></td></td<>	
DATUM         Geodetic         DATE         2018.03.16 - 2018.03.17         LATITUDE         43.049296         LONGITUDE	
SOIL PROFILE         SAMPLES         H 10 SS         Solt PROFILE         SAMPLES         H 10 SS         Solt PROFILE         PATTO MUMAL COME PROFILE <td></td>	
ELEV         DESCRIPTION         Image: second secon	RKS
ELEC         DESCRIPTION         End by an original system         Water content (%) r         r         Distribution of the system           Continued from Previous Page         Sing CLAY trace sand From Reddsh Brown Wet         Image: Sing CLAY trace sand From Reddsh Brown	SIZE
Continued From Providus Page         0         1         0         1         20         40         60         80         100         20         40         60         kMm <sup>3</sup> GR 5/           Shly CLAV trace sand Frim Reddsh Brown Wet         10         SS         3         166         3.5         1         1         10         SS         3         166         4         1	UTION )
Sity CLA, trace sand Fim Reddish Brown Wet       10       SS       3         10       SS       3         10       SS       3         11       SS       5         11       SS       5         11       SS       5         12       SS       9         Stiff       164       164         12       SS       9         161       164       164         162       164       164         164       164       164         164       164       164         164       164       164         164       164       164         164       164       164         165       164       164         164       164       164         164       164       164         165       164       164         164       164       164         165       164       164         164       164       164         165       164       164         166       164       164	SI CL
Reddish Brown       Image: Construction of the second	
switch to casing cobbles from 13.0m to 13.9m       11       SS       9       164       -	
10     SS     3       10     SS     3       11     SS     5       11     SS     5       11     SS     5       12     SS     9       161     161       162     161       163     164       163     164       163     164       163     164       163     164       163     164       163     164       164     163       162     164       162     164       162     164       162     164       162     164       162     164       162     164       162     164       164     164       164     164       164     164	
switch to casing cobbles from 13.0m to 13.9m     11     SS     5       11     SS     5       12     SS     9       12     SS     9       161     161       162     161       163     161       164     161       165     161	
switch to casing cobbles from 13.0m to 13.9m         11         SS         5           Stiff         12         SS         9           161         161         161           162         161         161           161         161         161	
switch to casing cobbles from 13.0m to 13.9m         11         SS         5           12         SS         9           161         161         161         161           162         161         161         161         161         161           163         164         164         164         164         164         165	
switch to casing cobbles from 13.9m         11         SS         5           11         SS         5           12         SS         9           160         160         161           161         161         161	
switch to casing cobbles from 13.0m to 13.9m       11       SS       5       162       162       162       161       161       161       161       161       161       161       161       161       161       161       161       161       160       16	
switch to casing cobbles from 13.0m to 13.9m         12         SS         9           12         SS         9           161         161         161           161         161           160         161	57 43
Stiff         12         SS         9           Stiff         10         10         10         10         10	
Stiff     12     SS     9       12     SS     9       161     161       160     100	
Stiff     12     SS     9       12     SS     9       161     161       161     161       160     160	
Stiff     12     SS     9       101     161     161       161     161       160     160	
Stiff	
13 SS 9 0	
109	
14 SS 11 0	
17.8 SILT and SAND, gravelly, trace clay	
Compact     Image: Compact in the second secon	
(TILL) 0 15 SS 12 0 0	

+ <sup>3</sup>, × <sup>3</sup>: Numbers re Sensitivity

15 - 5 (%) STRAIN AT FAILURE

Unitario																			THURBER
				RI	ECO	RD C	)F B(	DRE	HOI	E N	0 18	3-10		3 0	DF 4		ME	TRIC	;
GWP#_	2430-15-00	LOC	CATIC	DN _	Welland	d River B	ridge Re	placen	nent, M	TM NA	D83-10	): N47	767 343.	7 E 33	35 631.	3		INATED	BY ES
DIST _	HWY QEW	BOF	REHO	ר DLE די	PE_	Hollow S	tem Aug	ers/NV	/ Casir	g/NQ C	Coring						сом	P <b>I</b> LED B	Y <u>MP</u>
DATUM	Geodetic	DAT	E <u>2</u>	018.03.	16 <b>-</b> 20	18.03.17	LAT	TUDE	4	3.04528	86	LON	IG <b>I</b> TUE	)E	-79.12	1577	CHE	CKED B	GRL
	SOIL PROFILE		5	SAMPL	ES	ъ	ш	DYNA RESIS	MIC C	ONE PE					NAT				REMARKS
		01	~		S	NATE	SCA	2	20	40 6	50	80	100	PLASTIC	, WOI	STURE	LIQUID LIMIT	INIT	
ELEV	DESCRIPTION	T PL	MBEF	ΥPE	ALUE		TION	SHE/			TH ki			₩ <sub>P</sub> ⊢		w 0	w L	₩	DISTRIBUTION
DEPTH		STR/	R		z.	GROI	ELEV#	• Q	UICK 1	RIAXIA	AL X	LAB \	ANE	WAT			NT (%)	<b>7</b>	(%)
	Continued From Previous Page		16	22	13				1	40 6	50	80 .	100	0	20 2	40 (	50	kN/m <sup>3</sup>	GR SA SI CI
	Compact Reddish Brown		1				155												
	Wet	: . <i>0</i>																	
		0																	
			1																
154.0 21.3	SILT clavey, trace sand, containing		1				154												
	cobbles Very Dense																		
	Reddish Brown																		
	Molot						150												
							100												
			17	SS	100/									0					0 5 69 26
	casing refusal, switch to coring				0.250		152						_						
	23.1m to 25.9m																		
							151												
							150												
			18	SS	100/	-									ρ				
149.0					0.175		149											FI	
26.3	DOLOSTONE BEDROCK slightly weathered, very strong, grey		1															>10	
	horizontal fracture at 26.5m, 26.6m, 26.8m, 26.9m, 27.0m and 27.4m	$\mathbb{N}$																4	RUN #1
			1'	KUN														3	TCR=94% SCR=83%
	sub horizontal fracture (25mm) at 27.3m	$\left \right\rangle$	1				148											2	RQD=75% UCS=153.8MP
			]															1	(average)
	horizontal fracture at 27.9m, 28.0m,	$\triangleright$																1	
	28.4m and 28.5m		1															1	
		$\square$	2	RUN			147											2	RUN #2 TCR=100%
			1															2	SCR=100% RQD=100%
		$\otimes$									1							0	UCS=148.1MPa (average)
		K					146											1	RUN #3 TCR=100%
	sub vertical fracture (50mm) at 29.3m	$\otimes$	3	RUN														1	SCR=100% RQD=93%
145.5		- X	1															0	(average)
29.8	END OF BOREHOLE AT 29.8m.		1																

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				R	ECO	RD C	F B	ORE	HOL	E N	o 18	-10		4 C	)F 4		ME	TRIC	
GWP	<b>#</b> 2430-15-00	LOC	CATIO	DN _\	Welland	River B	ridge Re	placem	ient, M	FM NAC	83 <b>-</b> 10:	N 4 76	67 343.	7 E 33	35 631.3	3	ORIG	INATED	BY <u>es</u>
DIST	HWYQEW	BOF	REHO	DLE T	′PE_⊦	Hollow St	tem Aug	ers/NW	/ Casing	g/NQ Co	oring						СОМ	P <b>I</b> LED אי	1
DATU	M Geodetic	DAT	ГЕ <u>2</u>	018.03.	16 <b>-</b> 20 <sup>-</sup>	18.03.17	LAT	TUDE	43	3.04528	6	LONG	GITUD	E	-79.12	1577	CHE	CKED BY	GRL
	SOIL PROFILE		5	Sampl	.ES	н К	ALE	DYNA RESIS	MIC CO	DNE PE E PLOT		ATION		BLASTIC	NAT	URAL		F	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WATE CONDITIONS	ELEVATION SC/	2 SHEA 0 UI • QI 2	AR STI NCONF UICK T	0 6 RENG <sup>-</sup> INED RIAXIA 0 6	0 8 TH kP + - × 0 8	a FIELD LAB VA	VANE	WP WAT		STURE ITENT DOMTEN	шалы шміт <sup>W</sup> L IT (%)	MeIGH	& GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																		

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				RI	ECO	RD O	F BO	DREI	HOL	ΕN	o 18	8-13		1 C	)F 3		ME	TRIC	,		
GWP#_	2430-15-00		ATIC	_ אכ	Nelland	d River Br	idge Re	placem	ent, MT	'M NA[	083 <b>-</b> 10	N 4 7	67 383.	6 E 33	5 623.	2	ORIG	INATED	BY _E	S	
DIST _	HWY QEW	BOF	REHC	ר DLE די	PE_	Hollow St	em Aug	ers/NW	Casing	/NQ C	oring						СОМ	PILED B	Y№	/IP	
DATUN	1 Geodetic	DAT	Е <u>2</u>	018.03.	18 - 20	18.03.19	LAT	TUDE	43	.04578	8	LON	GITUE	)E	-79.12	1632	CHE	CKED BY		GRL	
	SOIL PROFILE		5	Sampl	.ES	R	ALE	DYNAM RESIS	MIC CC TANCE	NE PE		ATION		PLASTIC	NAT	URAL		μ	RE	MAR	₹KS
		LOT	к		IES	WAT	N SC	20	04	06	50 E	30 1	00		CON	STURE NTENT W		UNIT ÆIGH	GR/	& AIN S	SIZE
ELEV DEPTH	DESCRIPTION	AT PI	JMBE	ТУРЕ	VALL	UND JUNC	'ATIO	SHEA O UN	R STF	RENG INED	TH kP +	'a FIELD	VANE	<del>-</del>		o		> •	DIST		ITION
172.0		STR	ž		z	GRC CC	ELEV	• QL 21		RIAXIA 0 6	L X	LAB V 30 1	ANE	WAT	TER C0	DNTEN	IT (%) 50	<i>k</i> N/m 3		(70) :A C	
0.0	TOPSOIL: (175mm)												1					KIN/III	GR 3	A C	
0.2	Silty CLAY, trace rootlets		1	SS	2										0						
	Brown to Reddish Brown					-															
	vvet						173														
	occasional wood fibres		2	SS	6									1	-0	1			0 (	03	2 68
172.3																					
1.5	Silty CLAY, trace sand						170														
	Reddish Brown		3	SS	8		172								0						
	Wolst																				
				60	12										0						
					12		171								-						
			5	SS	6										o						
							170														
			1							3.1 +											
			6	SS	4		169								<b>⊢</b> ∘	-			0 0	0 2	8 7:
			1																		
									2. +	7											
							168														
			7	SS	3										0						
			<u> </u>			-	167														
										2.6											
									Ŧ												
				0.0			166														
			8	55	3										0						
										2.6											
							165						+								
			9	ss	3										0				0 4	45	i3 4'
		Ħ																			
							164														

																			THURBER
				R	ECO	RD O	F BO	DRE	HOL	E N	o 18	-13		2 (	)F 3		ME	TRIC	•
GWP#_	2430-15-00	_ LOC	ATIC	DN _	Welland	l River Bri	idge Re	placen	nent, M	rm nae	083-10	N 4 7	67 383.	6 E 33	85 623.	2	ORIG	INATED	BY_ <u>ES</u>
DIST _	HWY QEW		REHO	DLE T	YPE_	Hollow Ste	em Aug	ers/NV	/ Casing	g/NQ C	oring						сом	PILED B	Y MP
DATUN	1 Geodetic	_ DAT	Е <u>2</u>	018.03	.18 - 20	18.03.19	LAT	TUDE	43	3.04578	8	LON	GITUD	)E	-79.12	1632	CHEC	CKED BY	GRL
	SOIL PROFILE			SAMPI	LES	~	щ	DYNA				ATION							DEMO
ELEV DEPTH	DESCRIPTION	RAT PLOT	NUMBER	ТҮРЕ	" VALUES	OUND WATER	VATION SCAL	SHEA	20 4 AR STI NCONF	0 6 RENG	τΗ kP +	a FIELD	00 VANE					A UNIT WEIGHT	GRAIN SIZE DISTRIBUTIOI (%)
	Continued From Previous Page	ST			P R	GR	ELE	l Q	UICK TI 20 4	RIAXIA 0 6	L Χ 10 ε	LAB V 30 1	ANE 00		0 4		50	kN/m <sup>3</sup>	GR SA SI C
	Silty CLAY, trace sand Stiff Reddish Brown to Grey Wet					-	163			3+	.2								
			10	SS	4										0				0 0 51 4
							162				4.0 +								
			11	SS	4										0				
							161					3.3							
							400				-	1.0							
			12	SS	4		100								0				
							159				3.5								
			13	SS	5		450							F					0 4 51 4
							158				-	4 <u>.</u> 0							
	gravelly at 17.7m switch to casing		14	SS	5		157								0				
156.0 17.8	SILT and SAND, gravelly, some clay,	0					156												
	containing cobbles Dense to Very Dense Grey Wet (THI)	0	15	SS	48									0					22 35 30 1
	(1862)	0					155												
		0	16	SS	100/		154												

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				R	ECO	RD O	F BO	DRE	HOL	EN	o 18	-13		3 0	)F 3		ME	TRIC	
GWP#_	2430-15-00	LOC	ATIC	DN _\	Nelland	I River Br	idge Re	placem	ient, M1	'M NAE	083 <b>-</b> 10:	N 4 7	67 383.	6 E 33	35 623.2	2	ORIG	INATED	BY <u>es</u>
DIST _	HWY QEW	BOF	REHC	DLE TY	/PE <u>⊦</u>	Hollow St	em Aug	ers/NV	/ Casing	g/NQ C	oring						COM	PILED B	<b>′</b>
DATUM	Geodetic	DAT	Е <u>2</u>	018.03.	18 <b>-</b> 20	18.03.19	LAT	TUDE	43	8.04578	8	LON	GITUD	E	-79.12	1632	CHE	CKED BY	GRL
ELEV		Τ ΡLΟΤ	ABER	SAMPL	ALUES	IND WATER	TION SCALE	DYNA RESIS 2 SHE/	MIC CC STANCE 20 4 AR STI	PLOT PLOT 0 6 RENG		ATION 30 1 a	po	PLASTIC UMIT W P	NAT MOIS CON	URAL TURE TENT V		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION
DEPTH		STRA	N	F	>N	GROL	LEVA	0 U • Q	UICK TI	INED RIAXIA	+ L ×	LAB V	VANE ANE	WAT	ER CO	NTEN	IT (%)	Ŷ	(%)
	Continued From Previous Page	0			0.050	0	152	2	20 4	06	iΟ ε	30 11		2	0 4	06	80	kN/m <sup>3</sup>	GR SA SI CL
	casing refusal, switch to coring gravel and cobbles (max. 150mm) from 21.4m to 22.1m	0	17	ss	<u>100/</u> 0.075		153								0				
454.5	rubble zone from 22.1m to 22.3m		<u> </u>			-												FI	
22.3	DOLOSTONE BEDROCK slightly weathered, very strong, grey horizontal fracture at 22.4m, 22.5m, 22.6m, 23.0m, 23.1m and 23.3m		1	RUN			151											>25 4 1 4 1	RUN #1 TCR=98% SCR=87% RQD=87% UCS=159.2MPa (average)
	horizontal fracture (50mm) at 23.9m and 24.7m		2	RUN			150											2 1 0 1	RUN #2 TCR=100% SCR=100% RQD=100% UCS=197.7MPa (average) RUN #3 TCR=100%
		$\bigvee$	3	RUN														0	SCR=100% RQD=100%
	END OF BOREHOLE AT 25.3m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																	0	UCS=193.0MPe (average)

+ <sup>3</sup> ,  $\times$  <sup>3</sup> : Numbers refer to Sensitivity

20 15 ⊕ 5 10 (%) STRAIN AT FAILURE

Trans Ontario	portation																	10	THURBER
				R	ECO	RD C	F B	ORE	HOL	E N	lo 18	3-16		1 (	OF 3		ME	TRIC	
GWP#	2430-15-00	_ LOC	ATIC	DN _	Wellan	d River B	ridge Re	placen	nent, M	TM NA	D83-10	): N47	67 490.	0 E 3	35 622.	.7	ORIG	INATED	BY <u>es</u>
DIST _	HWY QEW	_ BOF	REHO	DLE T	YPE_	Hollow S	tem Aug	ers/NV	V Casin	g/NQ C	Coring						сом	PILED B	Y MP
DATUM	Geodetic	_ DAT	Е <u>2</u>	018.03	.23 - 20	18.03.24	LAT	TUDE	E4	3.0466	05	LON	GITUD	)E	-79.12	1673	CHE	CKED BY	GRL
	SOIL PROFILE		5	SAMPI	LES	с	щ	DYNA	MIC CO	one pe e plot		ATION			NA	TURAL			DEMADKS
<u>ELEV</u> DEPTH	DESCRIPTION	RAT PLOT	JUMBER	ТҮРЕ	" VALUES	OUND WATE	VATION SCAI	SHE/ OU	20 AR ST NCONF	RENG	50 51 51 51 51 51 51 51 51 51 51 51 51 51	80 1 Pa FIELD	00 VANE					JUNIT WEIGHT	GRAIN SIZE DISTRIBUTIC (%)
171.5	GROUND SURFACE	ST			, z	E C	ELE		UICK I 20 4	RIAXIA 10 (	AL X 50	LAB V 80 1	ANE 00		20 4	40	50	kN/m <sup>3</sup>	GR SA SI (
0.0 0.1	TOPSOIL: (75mm)	/\$																	
	Silty <b>CLAY</b> , with sand, trace roots, occasional wood fibres Firm to Soft Brown		1	SS	5	-	171								0				
170.1	Moist (FILL)		2	SS	17										o				0 38 35 2
1.4	Organic <b>SILT</b> , trace roots Very Soft Dark Brown			99	3		170												
	Wet				5	-											0		
			4	ss	2		169										125	þ	
			5	SS	1	-										 	127	)	
						-	168												
								+											
166.9 4.6	Silty CLAY, trace sand Firm Reddish Brown		6	SS	3	_	167									>			
	Wet																		
							166		6 <u>.</u> 0										
			7	ss	2		165								0				
						-													
							164		+										
			8	SS	4									ŀ					0 6 48 4
							163			3.3									
										+									
			1	тw	PH		162								0				
		H.	╞			1					1								

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																			THURBER
				R	ECO	RD O	F B	ORE	HOL	ΕN	o 18	3-16		2 0	DF 3		ME	TRIC	;
GWP#	2430-15-00		CATIC	ON _	Welland	d River Br	idge Re	placem	ent, MI	M NA	083-10	<b>N4</b> 7	67 490.	0 E 33	35 622.	.7	ORIG	INATED	BY <u>es</u>
DIST	HWY QEW	BOF	REHC	DLE T	YPE	Hollow St	em Aug	ers/NW	Casing	/NQ C	oring						COM	PILED B	Y <u>MP</u>
DATU	M Geodetic	DAT	E <u>2</u>	018.03	.23 - 20	18.03.24	LAT	TUDE	43	.04660	)5	LON	GITUE	)E	-79.12	1673	CHE	CKED BY	GRL
	SOIL PROFILE		5	Sampi	ES	ж	TE	DYNA RESIS	MIC CC TANCE	NE PE PLOT		ATION -		DI AGTI	NAT	TURAL		ь	REMARKS
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WATE CONDITIONS	ELEVATION SCA	21 SHEA O UN • QL	0 4 R STH ICONF	0 6 RENG INED RIAXIA	TH kF	B0 1 Pa FIELD LAB V			FER C			veigh	& GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page Silty CLAY, trace sand	H	$\vdash$						0 4	0 e 3.0						40 6		kN/m <sup>3</sup>	GR SA SI C
	Firm to Stiff Reddish Brown Wet					-	161			-									
			9	SS	7	_										o			
							160				3.5 +								
			10	SS	8	-	159								-0				
158.2						_													
13.3	SILT and SAND, clayey, trace gravel, containing cobbles Comapct to Very Dense Reddish Brown					-	158												
	Moist (TILL)		11	SS	21	-	157							0					10 40 28 22
		  					137												
			12	ss	34	-	156							0					
	gravelly zone with cobbles	. 0				-	155							0					
153.8	casing relusar, switch to coning				0.125	-	154												
17.7	Sandy <b>SILT</b> , trace clay, trace gravel Very Dense Reddish Brown Wet																		
			14	SS	68		153							- c					
							152												
	Operformation of Device		15	SS	50/		102							0					

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				R	ECO	RD C	)F B(	DRE	HOL	E N	o 18	-16		3 0	DF 3		ME	TRIC	
GWP#_	2430-15-00	LOC	ATIC	DN _\	Welland	l River B	ridge Re	placem	ent, M	rm nae	083 <b>-</b> 10:	N 4 76	67 490.	0 E 33	35 622.	7	ORIG	INATED	BY <u>es</u>
DIST _	HWY QEW	BOF	REHC	DLE T	/PE	Hollow S	tem Aug	ers/NW	Casing	g/NQ C	oring						СОМ	PILED B	′ <u>м</u> р
DATUM	Geodetic	DAT	Е <u>2</u>	018.03.	23 <b>-</b> 20	18.03.24	LAT	TUDE	43	3.04660	15	LON	GITUD	E	-79.12	1673	CHE	CKED BY	GRL
	SOIL PROFILE		5	SAMPL	ES	н К	ALE	DYNA RESIS	MIC CO TANCE	DNE PE E PLOT		ATION		PLASTIC	NAT	URAL		F	REMARKS
		LOT	Ř		JES	WATE	N SC/	2	0 4	06	0 8	80 10	00		Ó MOIS CON	TURE		UNIT	& GRAIN SIZE
ELEV DEPTH	DESCRIPTION	RAT P	UMBE	ТҮРЕ	NALL		ATIO	SHEA O UI	NR STI	RENG	TH kP +	a FIELD	VANE			>	—	y s	DISTRIBUTION
	Continued From Previous Page	STF	z		ž	GRG	ELEV	• Q 2	JICK T	RIAXIA 0 6	L X 10 8	LAB V/	ANE DO	2 VVA	1 ER CC	ρνιέν Έ	ii (%) 50	kN/m <sup>3</sup>	GR SA SI CL
	Continuou riolin rionodo riago				0.100														
							151											. FI	
150.9 20.7	DOLOSTONE BEDROCK slightly	$\mathbb{R}$	$\left  - \right $															>5	RUN #1
	weathered, very strong, grey	$\otimes$	1	RUN														1	SCR=88%
	sub vertical fracture (100mm) at 21.1m		<u> </u>															2	UCS=149.2MPa (average)
		$\otimes$					150											0	DUN #0
			2	RUN														0	TCR=100% SCR=100%
		$\square$																	RQD=100% UCS=176.1MPa
							149											0	(average)
		$\square$																0	
																		0	RUN #3 TCR=100%
		$\otimes$	3	RUN														0	SCR=100% RQD=100%
	quartz interbed at 23.3m horizontal fracture at 23.4m						148											. 1	UCS=191.9MPa (average)
147.5		$\otimes$																0	
147.5	END OF BOREHOLE AT 24.0m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.																		

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+ <sup>3</sup> ,  $\times$  <sup>3</sup> : Numbers refer to Sensitivity

				RI	ECO	RD O	FB	ORE	HOL	E N	o 18	8-19		1 0	OF 4		ME	TRIC	
GWP#	2430-15-00	LOC	CATIC	<u>אכ</u>	Nelland	d River Br	idge Re	placen	nent, M	TM NAC	<b>)83-10</b> :	N 4 7	67 537.	5 E 33	35 611.	4		INATED	BY <u>es</u>
DIST	HWYQEW	BOF	REHO	ר SLE	(PE	NW Casin	ng/NQ C	oring									сом	PILED B	Y MP
DATU	M Geodetic	DAT	Е <u>2</u>	018.04.	18 - 20	18.04.18	LATI	TUDE	E4	3.04703	6	LON	GITUE	)E	-79.12	1755	CHE	CKED BY	GRL
	SOIL PROFILE		9	SAMPL	ES	S ER	ALE	DYNA RESI	MIC CO STANCI	DNE PE E PLOT		ATION		PLASTIC		URAL		. F	REMARKS
ELEV DEPTH 180.1	DESCRIPTION GROUND SURFACE	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WAT CONDITION	ELEVATION SC	: SHE/ 0 U • Q	AR ST NCONF UICK T	06 RENG INED RIAXIA	0 8 TH kP + L × 0 8	30 1 <b>2a</b> FIELD LAB V 30 1	VANE ANE 00				UMIT <sup>W</sup> L IT (%) 50	NUN AND AND AND AND AND AND AND AND AND AN	& GRAIN SIZE DISTRIBUTION (%) GR SA SI C
0.0	ASPHALT		_				180												
0.2	SAND and GRAVEL Dense Grey		1	SS	41	-								0					
179.2	Moist (FILL) Silty <b>SAND</b> , trace clay Compact Reddish Brown		2	ss	29		179							0					
1/8.6	Moist (FILL) Silty CLAY, trace sand, trace gravel Very Stiff to Stiff Reddish Brown	$\bigotimes$	3	ss	17		178								0				
	Moist (FILL)		4	ss	13										o				
			5	ss	14		177								0				
							176												
			6	ss	18		175								0				
							175												
			7	ss	14	-	174								0				
							173												
	Wet		8	ss	8		172								0				0 0 46 54
171.4	Silly CLAV trace could trace regulate						172				3.5								
	Firm Reddish Brown			тw	PH		171									0			
	Continued Next Page										20								

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ntario																			THURBE
				RI	ECO	RDC	DF B	DRE	HOL	E N	o 18	3-19		2 (	OF 4		ME	TRIC	
GWP#_	2430-15-00	LOC	ATIC	<u>`</u> N	Welland	d River B	ridge Re	placem	ient, M	TM NAI	083 <b>-</b> 10	): N47	67 537.	5 E 30	35 611.	.4		INATED	BY <u>es</u>
DIST _	HWYQEW	BOF	REHC	LE די	YPE	NW Casi	ng/NQ (	oring										PILED B	Y <u>MP</u>
DATUM	Geodetic	_ DAT	E <u>2</u>	018.04.	.18 - 20	18.04.18			4	3.04703	36		GITUD	<sup>NE</sup>	-79.12	21755	_ CHEO	CKED BY	GRL
	SOIL PROFILE	L	S	ampl	_ES	VATER ONS	SCALE	DYNA RESIS 2		DNE PE E PLOT		ATION 	oo	PLASTIC LIMIT	C NA MOI COI	TURAL STURE NTENT	LIQUID LIMIT	INIT	REMAR
ELEV EPTH	DESCRIPTION	STRAT PLO	NUMBEF	ТҮРЕ	"N" VALUE	GROUND V CONDITI	EVATION	SHEA 0 UI • QI	AR ST NCONF	RENG INED RIAXIA	TH kF + L ×	Pa FIELD LAB V	VANE	WP WA			₩L → NT (%)	<b>7</b>	DISTRIBL (%)
	Continued From Previous Page Silty CLAY, trace sand, trace rootlets Firm Reddish Brown Wet						170	2	4.7					2				kN/m <sup>3</sup>	GR SA S
			9	SS	5		169								0				
									3 <u>.</u> +	2									
			10	SS	3		168								0				
							167												
			2	TW	РН				-	4.5					0				
						-	166		2.	7									
							165		+										
	trace silt seams		11	SS	8										0				
	Stiff						164			2.8 +									
			12	тw	РН		163								0				
							162												
			13	SS	10									0					
160.9 19.2	SILT and SAND, some clay, some gravel, containing cobbles						161												
	Dense Reddish Brown Wet	0																	

ONTMT4S2 MTO-18426 GPJ 2017TEMPLATE(MTO) GDT 10/2/18

ntario																			THURBER
				RI	ECO	RD O	F B(	DRE	HOL	E N	o 18	8-19		3 C	)F 4		ME	TRIC	;
GWP#_	2430-15-00	LOC	CATIO	ON	Welland	River Br	idge Re	placem	ent, M⁻	rm nai	083-10	N47	67 537.	5 E 33	5 611.4	4	ORIG		BY <u>es</u>
	HWYQEW	BOF	<ΕΗ( Έ		(PE <u>)</u>	NW Casir				0.4705					70.40	4765			Y <u>MP</u>
DATON		DAI		016.04.	10 - 20	10.04.10	LAT		4	NE PE			GITUL	/	-/9.12	1755			
<u>ELEV</u>	DESCRIPTION	AT PLOT	JMBER		ALUES	DUND WATER DNDITIONS	'ATION SCALE	SHEA	R STI	PLOT 0 6 RENG INED	TH kP	30 1 Pa FIELD	00 VANE	PLASTIC LIMIT W P		URAL ITURE TENT W			REMARK & GRAIN SI DISTRIBUT (%)
	Continued From Previous Page	STF	z		z	GRC	ELE/	• QL 2	ЛСКТ 0 4	RIAXIA 0 6	L X 50 E	LAB V 30 1	ANE 00	WAT	ER CC 0 4	ONTEN 0 (	IT (%) 50	kN/m <sup>3</sup>	GR SA SI
	(TILL) casing refusal, switch to coring boulder (350mm) at 19.6m	0 0					160												
		. o.	14	SS	33									0					11 36 34
							158												
<u>156.9</u> 23.2	Silty SAND, trace clay						157												
	Very Dense Reddish Brown Wet																		
			15	SS	100/	-	156							0					0 70 25
					0.275	-	155												
							154												
	gravel and cobbles (max. 125mm) from		16	SS	100/ 0.250		153							0					
	27.7m to 29.1m						152												
151.0 29.1	DOLOSTONE BEDROCK slightly						151											FI	
	weathered, very strong, grey horizontal fracture at 29.2m, 29.4m, 29.6m, 29.8m, 30.0m and 30.1m		1	RUN														1	RUN #1 TCR=100% SCR=100% RQD=83% UCS=153.1

MTO 307-19	
	THURBER

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				R	ECO	RD C	)F B(	ORE	HOL	E N	o 18	8-19		4 C	)F 4		ME	TRIC	;
GWP#	2430-15-00	LOC	ATIC	DN _\	Nellanc	l River B	ridge Re	placem	nent, M	TM NA	D83-10	N 4 7	67 537.	5 E 33	35 611.4	4	ORIC	INATED	BY <u>es</u>
DIST	HWY QEW	BOR	REHC	DLE T	/PE_1	NW Casi	ng/NQ (	Coring									COM	PILED B	<b>Ý</b> <u>MP</u>
DATUN	I Geodetic	DAT	Е <u>2</u>	018.04.	18 <b>-</b> 20	18.04.18	LAT	ITUDE	4	3.0470	36	LON	GITUD	E	-79.12	1755	CHE	CKED BY	GRL
	SOIL PROFILE	T	5	Sampl	.ES	ATER	SCALE	DYNA RESIS		DNE PE E PLOT		ATION  30 1	00	PLASTIC LIMIT	NAT MOIS CON	URAL TURE TENT	LIQUID LIMIT	NIT IGHT	REMARKS &
<u>ELEV</u> DEPTH	DESCRIPTION	SAT PLO	UMBER	ТҮРЕ	. VALUE		ATION	SHE/ O U	AR ST		TH kP	a FIELD	VANE	₩ <sub>₽</sub> ₩	(	» >		-5 ⊒ γ	GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page	STF	Z		z	GR	ELE	• Q	UICK T 20 4	RIAXIA 10 (	NL X 50 8	LAB V. 30 1	ANE 00	2	ER CC	0 6	50 50	kN/m <sup>3</sup>	GR SA SI CL
	Continued From Fromodo Frago						150											1	
	horizontal fracture at 30.4m, 30.5m, 30.7m, 30.9m, 31.4m and 31.6m sub vertical fracture at 30.7m		2	RUN			149											3 6 1 0	RUN #2 TCR=100% SCR=100% RQD=88% UCS=211.5MPa (average)
	horizontal fracture at 31.8m																	1	RUN #3 TCR=100% SCR=100%
			3	RUN			148											0	RQD=100% UCS=172.4MPa (average)
32.6	END OF BOREHOLE AT 32.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG, CEMENT AND ASPHALT TO SURFACE.						× 3. N		s refer 1		200								

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Intario																			THURBER
				RI	ECO	RD O	F B	ORE	HOL	E N	o 18	3-22		1 0	)F 3		ME	TRIC	;
GWP#	2430-15-00		CATIO	ON _	Nelland	l River Br	idge Re	placem	ent, M	TM NAI	D83 <b>-</b> 10	<b>N4</b> 7	67 565.	9 E 33	35 601.8	3	ORIG	INATED	BY <u>es</u>
DIST	HWY QEW	BOF	REHO	DLE T	/PE_1	NW Casir	ng										СОМ	PILED B	Y MP
DATU	M _Geodetic	_ DAT	TE _2	018.04.	06 <b>-</b> 20	18.04.06	LAT	ITUDE	4	3.04728	34	LON	GITUE	)E	-79.12	1990	CHEC	CKED BY	GRL
	SOIL PROFILE			Sampl	.ES	۲	Щ	DYNA RESIS	MIC CO TANC	ONE PE E PLOT		ATION			NATI	IRAI			REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	TRAT PLOT	NUMBER	ТҮРЕ	N" VALUES	ROUND WATE CONDITIONS	EVATION SCAI	2 SHEA 0 UN		10 6 RENG FINED	50 TH kF +	Pa FIELD			ER CC			JUNIT VEIGHT	GRAIN SIZE DISTRIBUTIC (%)
179.4	GROUND SURFACE	ω'			-	Ū	E	2	0 4	10 E	50 i	80 1	00	2	0 4	06	0	kN/m <sup>3</sup>	GR SA SI (
0.0	ASPHALT																		
178.7	Brown Moist		_	GS		-	179								•				
0.7	(FILL) SAND and GRAVEL Dense Brown		1	ss	43									0					
177.9	Moist (FILL)	X					178												
177.5 1.9	SAND, trace gravel Compact Brown Moist		2	ss	24									0					
	(FILL) Silty CLAY, trace sand, trace gravel Very Stiff		3	SS	16		177							 					0 0 49 5
	Grey Moist					-													
			4	SS	19	-	176								0				
							175												
	trace rootlets		5	ss	15	-									c	>			
						Ţ	174												
	Wet		6	SS	16		173									0			
	occasional wood fibre					-													
							172												
			7	SS	16									ŀ	-0				0 0 53 4
170.7							171												
8.7	Silty CLAY, trace sand Very Stiff Reddish Brown to Grey Wet																		
			8	SS	21		170								0				
		H																	

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				RI	ECO	RD O	F B(	ORE	HOL	.E No	o 18	-22		2 0	)F 3		ME	TRIC	INORDER
GWP#_	2430-15-00	_ LOC	атю	<u>^</u> אכ	Nelland	l River Br	idge Re	placem	ient, M	TM NAD	83 <b>-</b> 10:	N 4 7	67 565.	9 E 33	5 601.8	8	ORIG	INATED	BY <u>es</u>
DIST _	HWY QEW		REHC	DLE T	(PE_1	NW Casin	ng										СОМ	PILED B	Y MP
DATUN	I Geodetic	_ DAT	Е <u>2</u>	018.04.	06 <b>-</b> 20	18.04.06	LAT	TUDE	43	3.047284	4	LON	GITUD	E	-79.12	1990	CHE	CKED BY	GRL
	SOIL PROFILE		5	Sampl	.ES	н Н	ALE	DYNA RESIS	MIC CO	DNE PER		ATION		PLASTIC	NAT	URAL		F	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WATE CONDITIONS	ELEVATION SCA	2 SHEA 0 UI • QI 2	AR ST NCONF UICK T	RENGT	) 8 [H kP + - ×	80 1 Pa FIELD LAB V	00 VANE ANE 00			STURE ITENT N D DNTEN	шалы шмп — Ц Т (%) 0	NUNT MEIGH	& GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page Silty CLAY, trace sand Very Stiff to Stiff Reddish Brown to Grey Wet						169											NN/III	
			9	ss	17										o				
							168												
	Firm		10	SS	1		167								0				
							400		2.8 +										
			11	ss	2		100								<b></b> þ				0 0 62 38
							165			3.0									
							164			-									
			12	ss	11	-								F	<b>- − −</b>				0 0 50 50
12/18							163												
MT0).GDT 10			13	SS	13		162							0					
7TEMPLATE(																			
18426.GPJ 201	Hard		14	SS	100/ 0 <u>.175</u>		161								0				
01W 160.2 19.2 19.2	SILT and SAND, some clay, trace gravel, occasional cobbels Very Dense	0					160												
O 159.5	Reddish Brown	, l.Pl.	15	ss	50/									•					
	Continued Next Page	_/		00	<u> </u>	+ <sup>3</sup> , ×	< <sup>3</sup> : N S	umbers	s refer t ty	0	20 15 + 5 10	; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ; ;	STRAI		ILURE				

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				R	ECO	RD O	F B	ORE	HOL	E N.	0 18	3-22		3 C	)F 3		ME	TRIC	•
GWP#	2430-15-00	LOC	CATIC	ом _	Nelland	River Br	idge R	eplacem	ent, M	TM NAI	D83-10	<b>N4</b> 7	67 565.	9 E 33	5 601.	8		INATED	BY <u>es</u>
DIST _	HWY QEW	BOF	REHC	DLE T	/PE_N	W Casir	ng											PILED B	Y <u>MP</u>
DATUM	Geodetic	DAT	Е <u>2</u>	018.04.	06 <b>-</b> 20′	18.04.06	LAT	TUDE	4	3.04728	34	LON	GITUD	E	-79.12	1990	CHE	CKED BY	GRL
	SOIL PROFILE		5	Sampl	.ES	VER VS	CALE	DYNA RESIS	MIC CO TANCI	DNE PE E PLOT				PLASTIC	NAT	URAL STURE		л НТ	REMARKS
<u>ELEV</u> )EPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	ROUND WA CONDITION	EVATION S		NCONF	ID E RENG INED RIAXIA	50 1 TH kF + (L ×	Pa FIELD LAB V	VANE ANE	W P H	ER CO		<sup>W</sup> L ——– NT (%)	MEIO MEIO	GRAIN SIZ DISTRIBUTI (%)
19.9	Continued From Previous Page (TILL) END OF BOREHOLE AT 19.9m. WATER LEVEL AT 5.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.3m, CEMENT TO 0.07m THEN ASPHALT TO SURFACE.				0.075				0 2						0 2			kN/m <sup>3</sup>	GR SA SI

				R	ECO	RD 0	F B	ORE	HOL	E N	o 18	8-23		1 (	OF 3		ME	TRIC	;
GWP#_	2430-15-00	LOC	ATIC	DN _	Welland	d River Br	idge Re	placem	nent, M	TM NAC	83-10	N 4 7	67 641.	.2 E 3	35 603.	2		INATED	BY <u>es</u>
DIST _	HWY QEW	BOF	REHC	DLE T	YPE_I	NW Casir	ng/NQ (	oring										PILED B	Y <u>MP</u>
DATUN	I Geodetic	DAT	E <u>2</u>	018.04	.19 - 20	18.04.19	LAT	TUDE	E4	3.04796	8	LON	G <b>I</b> TUE	DE _	-79.12	1829	_ CHE	CKED BY	GRL
	SOIL PROFILE	L.	5	SAMPI	LES o	/ATER DNS	SCALE	DYNA RESIS	MIC CO STANC	DNE PE E PLOT		ATION  30 1	00	PLASTIC LIMIT	C NAT MOL COT	TURAL STURE NTENT	LIQUID LIMIT	NIT IGHT	REMARKS &
<u>ELEV</u> DEPTH	DESCRIPTION	TRAT PLC	NUMBER	ТҮРЕ	'N" VALUE	ROUND M CONDITIC	EVATION	SHEA OU	AR ST NCONF	RENG INED	TH kP + L ×	'a FIELD LAB V	VANE ANE	WP WA	TER C	o ONTEI	₩∟  NT (%)	רי דע וויי	GRAIN SIZE DISTRIBUTIO (%)
177.7	GROUND SURFACE	o v				0	Ш	2	20 4	10 6	<u>ه</u> 0	30 1	00	2	20 4	40 	60	kN/m <sup>3</sup>	GR SA SI C
0.0	ASPHALT SAND and GRAVEL, some silt Very Dense		1	SS	50/ 0.125	-								0					
	Grey Moist (FILL)		2	66	62	-	177							0					35 48 17
176.3 1.4	Silty CLAY, some sand, trace rootlets		2	55	02	-													(SI+C
	Stiff to Firm Dark Brown/Grey Moist (FILL)		3	ss	13		176									0			
			4	ss	5	-	175								0				
						-													
			5	SS	7	-	174								0				
173.6 4.1	Silty <b>CLAY</b> , trace sand, trace gravel Hard to Stiff																		
	Reddish Brown Moist		6	SS	40	-	173								0				
							170												
						_	172												
			7	ss	13	_	171								0				0 0 40 6
					10	-	170												
			°	33	13														
							169												
	Wet		9	SS	8									+	-4				0 4 48 4
		Ħ	-				168						1			1		1	
	Continued Next Page	n⁄1⁄	I	I	1	1		I			20		1	<u> </u>	1	1	1	I	

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				R	ECO	RD C	F B	DRE	HOL	E N.	o 18	3-23		2 0	)F 3		ME	TRIC	,
GWP#	2430-15-00	_ LOC	ATIC	DN _\	Vellanc	d River Br	idge Re	placem	ient, M	ΓΜ ΝΑΙ	083 <b>-</b> 10	:N47	67 641.	2 E 33	35 603.	2	ORIG	INATED	BY <u>es</u>
DIST _	HWY QEW	BOF	REHC	DLE TY	′PE_1	NW Casir	ng/NQ C	oring									сом	PILED B	Y MP
DATUM	Geodetic	_ DAT	E _2	018.04.	19 <b>-</b> 20	18.04.19	LAT	TUDE	4	3.04796	88	LON	GITUD	E	-79.12	1829	CHE	CKED BY	GRL
	SOIL PROFILE		s	SAMPL	.ES	к	Ш	DYNA RESIS	MIC CO	DNE PE E PLOT		ATION			. NAT	URAL			REMARKS
ELEV DEPTH	DESCRIPTION Continued From Previous Page	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WATE CONDITIONS	ELEVATION SCA	2 SHEA O UI • QI 2	AR ST NCONF UICK T	IO E RENG INED RIAXIA	50 8 TH kP + L × 50 8	30 1 Pa FIELD LAB V 30 1	00 VANE ANE 00					kNeight	GRAIN SIZ DISTRIBUTI (%) GR SA SI
	Silty CLAY, trace sand Firm Reddish Brown Wet					-	167			2.9 +									
			1	τw	PH	_									0				
						_	166		<u>2.</u> 8 +										
			10	SS	4	_	165								0				
							164		-	3.0									
			11	SS	3		104							F	-10				0 0 62
							163		2.	,									
			2	τw	PH		162								0				
										2.9 4									
			12	SS	3	-	161								0				
159.8 17.8	SILT and SAND, some clay, some	0.					160												
	gravel, occasional cobbles Very Dense Grey Wet (TILL)		13	SS	100/ -0.200	-	159							o					
		· · · · · · · · · · · · · · · · · · ·																	
		Ø					158												

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				RI	ECO	RD C	)F B	ORE	HOL	E N	o 18	-23		3 (	DF 3		ME	TRIC	
GWP#	2430-15-00	LOC	ATIC	<u>_</u> NC	Welland	l River B	ridge Re	placem	ent, M	rm nae	083-10:	N 4 7	67 641.	2 E 33	35 603.2	2	ORIG	INATED	BY <u>es</u>
DIST	HWYQEW	BOF	REHC	ר DLE רי	YPE <u>I</u>	NW Casi	ng/NQ (	Coring									COM	PILED BY	́
DATU	M <u>Geodetic</u>	DAT	Έ <u>2</u>	018.04.	.19 - 20	18.04.19			43	3.04796	8		GITUD	E	-79.12	1829	CHE	CKED BY	GRL
	SOIL PROFILE		5	Sampl	_ES	ts ts	CALE	RESIS	TANCE	E PLOT				PLASTIC	NAT MOIS	URAL		т НТ	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	SROUND WA	LEVATION SC	2 SHEA 0 UI • QI	NCONF	0 6 RENG INED RIAXIA	ο ε TH kP + L ×	30 1 <b>a</b> FIELD LAB V/					₩L ₩L IT (%)	NEIG WEIG	GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page				-		Ξ	2	0 4	0 6	ο ε 	30 1	00	2	0 4	10 E	50	kN/m <sup>3</sup>	GR SA SI CL
	Casing refusal, switch to coring gravel and cobbles (max. 100mm) from 20.4m to 22.9m	0		55	60		157												
		. ö.					156												
		0																	
		0					155												
			15	SS	100/ 0.275									0					
		. 0					154												
		0																	
	gravel and cobbles from 24.5m to 25.9m	0	16	SS	100/ 0.125		153								0				
		0																	
151.6		. o.	17	SS	100/	-	152								0				
151.6 26.1	END OF BOREHOLE AT 26.1m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.8m, SAND TO 0.2m THEN CEMENT TO SURAFCE.		17	SS	100/										0				

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+ <sup>3</sup> , × <sup>3</sup> : Numbers refer to Sensitivity

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				R	ECO	RD C	)F B(	ORE	HOI	E N	lo 1	8-24		1 0	OF 4		ME	TRIC		
GWP#	2430-15-00	LOC	атю	DN _\	Velland	d River B	ridge Re	placer	nent, M	TM NA	.D83-1	D: N 4	767 139	.8 E 33	35 646.	2		INATED	BY <u>es</u>	
DIST _	HWY QEW	BOF	REHC	DLE T	′PE	NW Casi	ng/NQ C	Coring									_ СОМ	PILED B	<u>мр</u>	
DATUM	Geodetic	DAT	Е <u>2</u>	018.04.	21 <b>-</b> 20	18.04.21	LAT	ITUDI	Ξ4	3.0434	58	LON	IGITU	DE	-79.12	1369	CHE	CKED BY	GRI	-
	SOIL PROFILE		5	Sampl	.ES	ATER NS	CALE	DYN/ RESI	AMIC C STANC	ONE P E PLO			1	PLASTIC		TURAL	LIQUID LIMIT	TH CHT	REMA 8	ARKS
<u>ELEV</u> DEPTH	DESCRIPTION	TAT PLO	IUMBER	ТҮРЕ	' VALUES	OUND W	VATION S	SHE O L	AR ST	RENG	GTH k	Pa FIELI						r γ	GRAIN DISTRIE (%	N SIZE BUTION 6)
181.5	GROUND SURFACE	STI	2		Ż	GR	ELE	• 0	20 VICK 1	riaxi/ 40	AL × 60	LAB \ 80	/ANE 100	2		40 (	41 (%) 60	kN/m <sup>3</sup>	GR SA	SI CL
0.0	ASPHALT																			
0.2	SAND and GRAVEL Very Dense to Compact Grey		1	SS	63		181							0						
180.2	Moist (FILL)		2	SS	12									0						
1.3	Silty CLAY, some sand, trace gravel Very Stiff	×					180													
	Readish Brown Moist (FILL)		3	SS	17										o					
							179													
178.5			4	SS	18										0				0 0	44 56
3.0	Stiff		5	SS	12		178								o					
177 4							110													
4.1		×					177													
			6	SS	15										o					
							176													
			7	SS	15		175								0					
81/2/01																				
MIO).GD							474													
			8	SS	20		174								<u> </u>				0 0	34 66
18426.GF							173													
482 MIO				66	26															
			3	33	20		172													
	Continued Next Page	$\mathbb{N}$	1			I	L	<u> </u>		<u> </u>	20			<u> </u>						

2430-15-00 HWYQEW  Geodetic SOIL PROFILE	LOC		R	ECO	RD O	F B	DRE	HOL	EN	0 18	2_24		20		N	IFTRI	
2430-15-00 HWY QEW Geodetic SOIL PROFILE	LOC										. 24		20	/ 4	14		~
Geodetic QEW	BOE		<u>N</u>	Welland	d River Br	idge Re	placem	ent, M1	'M NAE	083-10	:N47	67 139.	8 E 33	35 646.2	0	RIGINATE	D BY <u>ES</u>
Geodetic SOIL PROFILE	_ 001	REHC	DLE TY	′PE	NW Casir	ng/NQ C	oring								C	OMPILED	BY <u>MP</u>
SOIL PROFILE	_ DAT	Έ <u>2</u>	018.04.	21 - 20	18.04.21	LAT	TUDE	43	3.04345	8	LON	GITUD	<sup>PE</sup>	-79.121	369 C	HECKED E	3Y <u>GRL</u>
		5	SAMPL	.ES	N ER	CALE	RESIS	TANCE	E PLOT		ATION -		PLASTIC	NATU MOIST	RAL LIC	ᄢᆝᄂᆂ	REMARK
	PLOT	ËR	ш	UES	-MA TION	DS NC	2 SHEA	0 4 Р сти		0 8 	30 1	00	имн w <sub>P</sub>	CONT	ENT		GRAIN SI
DESCRIPTION	RATE	NUMB	ΤYΡ	I" VAL		VATIO			INED	+	FIELD	VANE		ER CO			DISTRIBUT (%)
Continued From Previous Page	ST	-		Ę	99 9	ELE	• QU 2'	0 4	RIAXIA 0 6	L X 10 1	LAB V 30 1	ANE 00	2	0 40	) 60	kN/m	<sup>3</sup> GR SA SI
Very Stiff to Stiff						171										_	
Moist																	
		10	SS	15										0			
						170										_	
		1															
		1	τ\Λ/	рц		400											
						169											
					]												
											4.2 +						
						168										_	
		╞															
Wet		11	SS	12										0			
		<u> </u>															
						167			3	7							
Firm									т								
		12	SS	7		166								0		_	0 0 42
									0.7								
									÷.′								
		1				165											
	Ħ	1,	т\л/	рн													
	Ħ	Ĺ															
						164										_	
								3.: +	2								
						160											
		13	SS	4		100								0			
								3.	2								
		]				162										_	
	Ħ																
	Wet	Wet	10         1 <t< td=""><td>10       SS         1       TW         1       TW         11       SS         11       SS         11       SS         12       SS         13       SS         13       SS         13       SS</td><td>10       SS       15         1       TW       PH         1       TW       PH         11       SS       12         Firm       12       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4         14       I       I</td><td>10       SS       15         1       TW       PH         1       TW       PH         1       SS       12         Frm       12       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4</td><td>10       SS       15         1       TW       PH         1       TW       PH         11       SS       12         11       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4         14       14       16         15       17       16         16       16       16         16       16       16         170       11       16         16       16       16         16       16       16         16       16       16         170       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         17       16       16     &lt;</td><td>Vet       11       SS       15         11       TW       PH         11       SS       12         11       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4         13       SS       4         14       14       164         15       164         164       164         164       164</td><td>Wet       10       SS       15         1       TW       PH         1       TW       PH         11       SS       12         11       SS       12         12       SS       7         13       SS       4         13       SS       4         13       SS       4         14       14       16         15       12       16         16       16       16         17       16       16         18       16       16         19       16       16         10       17       16         11       12       16       16         16       16       16       16         16       16       16       16         18       16       16       16         18       16       16       16         18       16       16       16         18       16       16       16         18       16       16       16         19       16       16       16         16       &lt;</td><td>Vet Fim Fim Fim Contrued Not Page Contrued Not Page Final 10 SS 15 11 SS 15 12 SS 7 13 SS 4 + 3. x<sup>3</sup>. Numbers refer to Sensitive S</td><td>10       SS       15         1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         11       SS       12         11       SS       7         12       SS       7         13       SS       4         13       SS       4         + 3, × 3:       Numbers fer       3,2</td><td>10       SS       15         1       TW       PH         1       TW       PH         11       TS       12         11       SS       12         11       SS       12         12       SS       7         12       SS       7         13       SS       4         14       S       12         13       SS       4         14       S       12         15       12       165         164       3+2         163       164         164       3+2         165       164         164       3+2         165       164         164       164         165       164         164       3+2         165       164         164       3+2         165       164         165       164         165       164      <t< td=""><td>10       SS       15         1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         12       SS       7         13       SS       4         13       SS       4         13       SS       4         +<sup>3</sup>, x<sup>3</sup>:       Number serier       10<sup>2</sup>/<sub>2</sub>         0       10<sup>2</sup>/<sub>2</sub>       (y) STRAU</td><td>Vel       1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         12       SS       7         13       SS       4         14       SS       7         15       Smetswirg*       162         163       163       163         164       3+2       164         165       164       3+2         164       3+2       164         165       164       3+2         164       3+2       164         165       164       3+2         165       164       164         164       3+2       164         165       164       164         164       3+2       164         165       164       164</td><td>10         SS         15           1         TW         PH           1         TW         PH           1         TW         PH           11         SS         12           11         SS         12           12         SS         7           12         SS         7           12         SS         7           13         SS         4           13         SS         4           12         TS         12           13         SS         4           15         12           13         SS         4           15         12         TW           15         12         TW           16         3         3           164         3         10           154         10         0           155         10         0           154         10         0           155         10         0           155         10         0           156         10         0           155         0         0           15</td><td>Wet         1         TW         PH         1         TW         PH           1         TW         PH         1         188         4         <td< td=""><td>Viet       11       55       15         11       55       12         11       55       12         12       55       7         13       55       4         13       55       4         13       55       4         13       55       4         14       14       14         15       12       14         16       16       16         17       16       16         16       17       16         17       16       16         16       17       16         17       16       17         15       17       16         16       17       16         17       16       16         18       16       16         19       16       16         19       16       16         19       16       16         19       16       16         19       16       16         10       16       16         10       16       16         10       16</td></td<></td></t<></td></t<>	10       SS         1       TW         1       TW         11       SS         11       SS         11       SS         12       SS         13       SS         13       SS         13       SS	10       SS       15         1       TW       PH         1       TW       PH         11       SS       12         Firm       12       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4         14       I       I	10       SS       15         1       TW       PH         1       TW       PH         1       SS       12         Frm       12       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4	10       SS       15         1       TW       PH         1       TW       PH         11       SS       12         11       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4         14       14       16         15       17       16         16       16       16         16       16       16         170       11       16         16       16       16         16       16       16         16       16       16         170       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         16       16       16         17       16       16     <	Vet       11       SS       15         11       TW       PH         11       SS       12         11       SS       7         12       SS       7         13       SS       4         13       SS       4         13       SS       4         13       SS       4         14       14       164         15       164         164       164         164       164	Wet       10       SS       15         1       TW       PH         1       TW       PH         11       SS       12         11       SS       12         12       SS       7         13       SS       4         13       SS       4         13       SS       4         14       14       16         15       12       16         16       16       16         17       16       16         18       16       16         19       16       16         10       17       16         11       12       16       16         16       16       16       16         16       16       16       16         18       16       16       16         18       16       16       16         18       16       16       16         18       16       16       16         18       16       16       16         19       16       16       16         16       <	Vet Fim Fim Fim Contrued Not Page Contrued Not Page Final 10 SS 15 11 SS 15 12 SS 7 13 SS 4 + 3. x <sup>3</sup> . Numbers refer to Sensitive S	10       SS       15         1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         11       SS       12         11       SS       7         12       SS       7         13       SS       4         13       SS       4         + 3, × 3:       Numbers fer       3,2	10       SS       15         1       TW       PH         1       TW       PH         11       TS       12         11       SS       12         11       SS       12         12       SS       7         12       SS       7         13       SS       4         14       S       12         13       SS       4         14       S       12         15       12       165         164       3+2         163       164         164       3+2         165       164         164       3+2         165       164         164       164         165       164         164       3+2         165       164         164       3+2         165       164         165       164         165       164 <t< td=""><td>10       SS       15         1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         12       SS       7         13       SS       4         13       SS       4         13       SS       4         +<sup>3</sup>, x<sup>3</sup>:       Number serier       10<sup>2</sup>/<sub>2</sub>         0       10<sup>2</sup>/<sub>2</sub>       (y) STRAU</td><td>Vel       1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         12       SS       7         13       SS       4         14       SS       7         15       Smetswirg*       162         163       163       163         164       3+2       164         165       164       3+2         164       3+2       164         165       164       3+2         164       3+2       164         165       164       3+2         165       164       164         164       3+2       164         165       164       164         164       3+2       164         165       164       164</td><td>10         SS         15           1         TW         PH           1         TW         PH           1         TW         PH           11         SS         12           11         SS         12           12         SS         7           12         SS         7           12         SS         7           13         SS         4           13         SS         4           12         TS         12           13         SS         4           15         12           13         SS         4           15         12         TW           15         12         TW           16         3         3           164         3         10           154         10         0           155         10         0           154         10         0           155         10         0           155         10         0           156         10         0           155         0         0           15</td><td>Wet         1         TW         PH         1         TW         PH           1         TW         PH         1         188         4         <td< td=""><td>Viet       11       55       15         11       55       12         11       55       12         12       55       7         13       55       4         13       55       4         13       55       4         13       55       4         14       14       14         15       12       14         16       16       16         17       16       16         16       17       16         17       16       16         16       17       16         17       16       17         15       17       16         16       17       16         17       16       16         18       16       16         19       16       16         19       16       16         19       16       16         19       16       16         19       16       16         10       16       16         10       16       16         10       16</td></td<></td></t<>	10       SS       15         1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         12       SS       7         13       SS       4         13       SS       4         13       SS       4         + <sup>3</sup> , x <sup>3</sup> :       Number serier       10 <sup>2</sup> / <sub>2</sub> 0       10 <sup>2</sup> / <sub>2</sub> (y) STRAU	Vel       1       TW       PH         1       TW       PH         1       TW       PH         11       SS       12         12       SS       7         13       SS       4         14       SS       7         15       Smetswirg*       162         163       163       163         164       3+2       164         165       164       3+2         164       3+2       164         165       164       3+2         164       3+2       164         165       164       3+2         165       164       164         164       3+2       164         165       164       164         164       3+2       164         165       164       164	10         SS         15           1         TW         PH           1         TW         PH           1         TW         PH           11         SS         12           11         SS         12           12         SS         7           12         SS         7           12         SS         7           13         SS         4           13         SS         4           12         TS         12           13         SS         4           15         12           13         SS         4           15         12         TW           15         12         TW           16         3         3           164         3         10           154         10         0           155         10         0           154         10         0           155         10         0           155         10         0           156         10         0           155         0         0           15	Wet         1         TW         PH         1         TW         PH           1         TW         PH         1         188         4 <td< td=""><td>Viet       11       55       15         11       55       12         11       55       12         12       55       7         13       55       4         13       55       4         13       55       4         13       55       4         14       14       14         15       12       14         16       16       16         17       16       16         16       17       16         17       16       16         16       17       16         17       16       17         15       17       16         16       17       16         17       16       16         18       16       16         19       16       16         19       16       16         19       16       16         19       16       16         19       16       16         10       16       16         10       16       16         10       16</td></td<>	Viet       11       55       15         11       55       12         11       55       12         12       55       7         13       55       4         13       55       4         13       55       4         13       55       4         14       14       14         15       12       14         16       16       16         17       16       16         16       17       16         17       16       16         16       17       16         17       16       17         15       17       16         16       17       16         17       16       16         18       16       16         19       16       16         19       16       16         19       16       16         19       16       16         19       16       16         10       16       16         10       16       16         10       16

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																			THURBER
				R	ECO	RD O	F B	DRE	HOL	E No	o 18	-24		3 C	)F 4		ME	TRIC	;
GWP#_	2430-15-00	LOC	ATIC	DN _\	Nelland	l River Br	idge Re	placem	ent, M	M NAD	83 <b>-</b> 10:	N 4 76	67 139.	B E 33	5 646.2	2	ORIG	INATED	BY <u>es</u>
DIST	HWY QEW	BOF	REHO	DLE TY	′PE_1	NW Casir	ng/NQ (	oring									сом	PILED B	Y MP
DATUM	I _Geodetic	_ DAT	Е <u>2</u>	018.04.	21 <b>-</b> 20	18.04.21	LAT	TUDE	43	3.043458	3	LON	GITUD	E	-79.12	1369	CHE	CKED BY	GRL
					FS			DYNA			NETR/	ATION							
<u>ELEV</u>	DESCRIPTION	AT PLOT	JMBER	ВАМ	VALUES	UND WATER	ATION SCAL	SHEA	AR STI	0 60 RENGT	Σ TH kP +	a FIELD		PLASTIC LIMIT W P	NAT MOIS CON	URAL STURE TENT V		<pre>UNIT WEIGHT</pre>	REMARKS & GRAIN SIZI DISTRIBUTIO
		STR	Ĩ		z	GRO CC	ELEV	• QI			. ×		ANE	WAT		ONTEN	IT (%) 50	<b>7</b>	(%)
	Silty <b>CLAY</b> , trace sand, trace gravel Firm Reddish Brown Wet		14	SS	6		161			2.6					0				
158.6	SILT, trace day	-					159												
158 1	Dense Reddish Brown		15	SS	33										0				0 0 91
23.4	Wet Silty CLAY, trace sand, trace gravel Very Stiff Reddish Brown Wet						158 157 156												
			16	SS	15		455							F	4				0 0 49
	possible cobbles						154												
							153												
			17	SS	17		152								0				
151.5		H	1																

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Minis Trans Ontario	try of sportation														Μ	ITO	307	7-24	THURBER
				R	ECO	RD C	)F B	ORE	HOI	E N	lo 18	3-24		4 0	)F 4		ME	TRIC	r 7
GWP#	2430-15-00	LOC	CATI	ом _	Welland	d River B	ridge Re	eplacem	nent, M	TM NA	D83-10	): N 4 7	67 139.	8 E 33	35 646.	2		INATED	BY <u>es</u>
DIST _	HWY QEW	BO	REH	OLE T	YPE_	NW Casi	ng/NQ (	Coring										PILED B	Y <u>MP</u>
DATUM	Geodetic	DAT	ΓE _2	2018.04	.21 - 20	18.04.21	LAT	TUDE	4	3.0434	58	LON	GITUE	)E	-79.12	1369	CHE	CKED BY	'GRL
	SOIL PROFILE	1.		SAMPI	LES	AS N	CALE	DYNA RESIS	MIC C STANC	ONE P E PLO				PLASTIC	, NAT MOR	URAL STURE		нт ВНТ	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WA	LEVATION S	2 SHEA 0 UI • Q	AR ST NCONI	RENG	50 GTH kF + AL ×	Pa FIELC		WP WAT	CON TER CO	NTENT W O ONTEN	₩L  IT (%)	NEIO MEIO	GRAIN SIZE DISTRIBUTION (%)
30.0	Continued From Previous Page	117	-					2	20 4	40	60	80 1	00	2	20 4	10 e	50	kN/m <sup>3</sup>	GR SA SI C
	SLI and SANU, some clay, trace gravel, containing cobbles Very Dense Reddish Brown Moist (TILL) casing refusal, switch to coring gravel and cobbles (max. 75mm) from 29.6m to 32.0m					-	151 150												
149.1		0	18 4	SS	58									0					5 31 44 2
	BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, SAND TO 0.3m, CEMENT TO 0.1m, THEN ASPHALT TO SURAFCE.																		

ONTMT4S2 MTO-18426.GPJ 2017TEMPLATE(MTO).GDT 10/2/18

+ <sup>3</sup> ,  $\times$  <sup>3</sup> : Numbers refer to Sensitivity

 $15 \stackrel{20}{\oplus} 5_{10}$  (%) STRAIN AT FAILURE

7
GWP# DIST DATUM	2430-15-00 HWY QEW			DN _\	Velland	l River B	idae Re	nlacom								-			<b>D</b> )/
DIST DATUM	HWY QEW	BOF						placen	nent, M	TM NAI	D83-10	:N47	67 090.	2 E 33	35 660.	/	ORIC	INATED	BY <u>ES/ISP</u>
DATUM	Geodetic		KEHC	DLE TY	'PE_I	Hollow St	em Aug	ers/NV	/ Casin	g							COM	PILED B	Y <u>мр</u>
		DAT	Е <u>2</u>	018.07.	10 <del>-</del> 20	18.07.10	LAT	TUDE	4	3.04300	04	LON	GITUD	)E	-79.12	1229	CHE	CKED B	GRL
	SOIL PROFILE		5	SAMPL	ES	с	Щ	DYNA RESIS	MIC CO STANCI	DNE PE E PLOT		ATION			NAT	URAI			REMARKS
<u>ELEV</u> EPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	SROUND WATE CONDITIONS	LEVATION SCA	2 SHE4 0 UI • Q	AR ST NCONF	io e RENG FINED RIAXIA	50 8 TH kP +	30 1 Pa FIELD LAB V						UNIT Weight	GRAIN SIZE DISTRIBUTIO (%)
180.8	GROUND SURFACE					Ŭ	ш	2	20 4	ю е 	50 E	30 1	00	2	20 4	ю е 	60 	kN/m <sup>3</sup>	GR SA SI C
0.2	Gravelly SAND, trace silt Compact Brown		1	GS		-								o					
179.5	Moist (FILL)		1	SS	24		180							0					
1.3	Silty CLAY, trace sand, trace gravel					-								0					
	Firm to Very Stiff Brown Moist (FILL)		2	SS	8	Ţ	179								o –				
			3	SS	6	-	178												No recovery
			4	SS	7	-									0				
						-	177												
			5	SS	9		176								0				
<u>175.2</u> 5.6	 Soft						175												
							110												
	occasional oxide staining		6	SS	3										⊢⊷	-1			0 0 33 6
							1/4			2	20.0								
173.2 7.6	Silty CLAY, trace sand Very Stiff to Firm Reddish Brown Moist		7	SS	25		173								Þ				0 0 46 5
	Most					-													
						-	172												
	Wet		8	SS	6	_	171								0				
I	Continued Next Page					. 3	.3 N	umber	s refer t	·	20	-							

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				RI	ECO	RD C	)F B(	DRE	HOL	E N	lo 18	8-25		2 0	DF 3		ME	TRIC	,
GWP#	2430-15-00	_ LOC	CATIC	_ אכ	Nelland	d River B	ridge Re	placem	ent, M	TM NA	D83-10	:N47	67 090.	2 E 33	35 660.	7	ORIC	INATED	BY <u>ES/ISP</u>
DIST _	HWY QEW	_ BOF	REHC	ר DLE די	PE_	Hollow S	tem Aug	ers/NW	Casin	g							сом	PILED B	Y <u>MP</u>
DATUN	M Geodetic	_ DAT	ГЕ <u>2</u>	018.07.	10 <b>-</b> 20	18.07.10	LAT	TUDE	4	3.0430	04	LON	GITUD	)E	-79.12	1229	CHE	CKED BY	GRL
ELEV		T PLOT	ABER	SAMPI	ALUES	IND WATER	TION SCALE	DYNA RESIS 2 SHEA	MIC CO TANC 0 4 R ST			ATION  30 1 Pa	00	PLASTIC LIMIT W P		URAL STURE ITENT W		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTIO
DEPTH		STRA	IN I	- F	>	GROL	ELEVA	0 Ur	JICK T	RIAXIA	AL X			WAT			IT (%)	<b>7</b>	(%)
	Continued From Previous Page Silty CLAY, trace sand Stiff to Firm Reddish Brown Wet							2				20.0		2				kN/m <sup>-3</sup>	GR SA SI C
			9	SS	0	_	170								0				
							169		5.0 +										
			1	тw	РН										0				
						-	168		2.5 +										
			2	тw	РН	-	167												No recovery
166.3 14.5	<b>SILT</b> and <b>SAND</b> , trace clay Compact to Dense Reddish Brown Wet						166												
			10	ss	27	-									0				
							165												
			11	SS	32	-	164								o				0 40 56
							163												
			12	SS	46		162								0				
161.4 19.4	Silty CLAY, trace sand																		
	Reddish Brown to Brown Wet						161												



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				R	ECO	RD C	F BC	ORE	HOL	E No	o 18	-25		3 C	)F 3		ME	TRIC	•
GWP#	2430-15-00	LOC	ATIC	DN _\	Velland	l River B	ridge Re	placem	nent, M	TM NAD	83-10:	N 4 7	67 090.	2 E 33	5 660.	7	ORIG	INATED	BY <u>ES/ISP</u>
DIST	HWYQEW	_ BOF	REHC	DLE TY	′PE_I	Hollow St	tem Aug	ers/NV	/ Casin	g							СОМ	PILED B	Y MP
DATU	M Geodetic	_ DAT	Е <u>2</u>	018.07.	10 <b>-</b> 20	18.07.10	LAT	TUDE	43	3.043004	4	LON	GITUD	E	-79.12	1229	CHE	CKED BY	GRL
	SOIL PROFILE	1	5	SAMPL	ES ທ	VATER ONS	SCALE	DYNA RESIS 2				ATION 30 1	oo	PLASTIC LIMIT	NAT MOIS CON	URAL STURE ITENT	LIQUID LIMIT	INIT EIGHT	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLO	NUMBER	ТҮРЕ	"N" VALUE	GROUND V CONDITI	ELEVATION	SHEA O UI	AR ST NCONF UICK T		ΓΗ kP + - ×	a FIELD LAB V		WP WAT	ER CO		₩∟ IT (%)	⊃ ⊮ 7	GRAIN SIZE DISTRIBUTION (%)
	Continued From Previous Page Silty CLAY, trace sand Stiff to Firm Reddish Brown to Brown		13	SS	15		Ш							C				kN/m <sup>-3</sup>	GR SA SI CI
	Wet						160												
			14	SS	5	-	159								0				
										+									
			15	SS	6	_	158								0				
							157					2.8 +							
			16	SS	8	-	156												No recovery
155.5 25.3	<b>SILT</b> and <b>SAND</b> , some clay, trace gravel Dense	0																	
154.3	Brown Moist (TILL)		17	SS	48	-	155							0					
	END OF BOREHOLE AT 26.5m. WATER LEVEL AT 1.8m UPON COMPELTION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT TO SURAFCE.																		
;																			

+ <sup>3</sup> ,  $\times$  <sup>3</sup> : Numbers refer to Sensitivity

20 15 <del>()</del> 5 10 (%) STRAIN AT FAILURE

											<u> </u>	20		4.0	<u>)                                    </u>		МЕ	TPIC	THURBER
				<b>R</b> 1	ECU		ים זי	JRE		-E IN	0 10	-20		10	JF 3				
GWP#_	2430-15-00	_ LOC		DN _	Wellan	d River B	ridge Re	placer	nent, M	TM NAE	083-10	N 4 7	67 040.	<u>3 E 33</u>	35 665.	2			BY <u>ES</u>
	HWYQEW	_ BOR			YPE	Hollow Si			V Casin	g 0.04055					70.40	4477			Y <u>MP</u>
DATUN	Geodetic	_ DAT		018.07	.11 - 20	18.07.11			= <u>4</u>	3.04255			GITUL	/E	-79.12	1177			GRL
	SOIL PROFILE		5	SAMPI	LES	S TER	SALE	RESI	STANC	E PLOT				PLASTIC		URAL	LIQUID	ᄂᄂ	REMARKS
		LOT	ER		UES	WA <sup>-</sup>	N SC			10 6		30 1	00	иміт МР	CON	ITENT N	UMIT W L	VEIG	GRAIN SIZE
ELEV DEPTH	DESCRIPTION	RAT F	UMB	ТҮР	NAL		ATIC	O U	NCONF	FINED	ін кр +	ra FIELD	VANE			>		y	DISTRIBUTIO
178 7	GROUND SURFACE	STF	z		, Z	GR(	ELEY	• c	UICK T 20 ∠	RIAXIA 10 6	LX 08	LAB V 30 1	ANE 00		1ER C0 20 4	DNIEN 10 6	NT (%) 50	kN/m <sup>3</sup>	GR SA SI C
0.0	ASPHALT (200mm)																		
0.2	Gravelly <b>SAND</b> , trace silt Very Dense	$\otimes$	1	GS										0					
	Brown					-	178												
	(FILL)		1	SS	50/		1/0							0					
					0.125	,													
176.9							177							0				-	
1.8	Silty CLAY, trace sand, trace gravel		2	SS	13									0					
	Stiff to Very Stiff Brown to Dark Brown					Į⊻													
	Moist (FILL)																		
			3	SS	15		176								•				0 0 28 7
			4	SS	13										0				
						-	175											-	
174.6																			
4.1	Silty CLAY, trace sand, trace	ТЙ																	
	organics, trace rootlets Stiff to Very Stiff	H																	
	Dark Brown Moist						174												
			5	SS	17										Þ				
		H				-													
		H																	
							173												
		H																	
		H.	6	SS	13										0				
							172												
		H																	
		H																	
							171												
	Firm	H	1	TW	PH										0				
		H																	
										7.0									
							170		1	+								1	
		H																	
		HH.		T\ • /															
							100												
		H			1	1	109	_	_					_					
	Continued Next Page					, 3		lumbe	s refer	io	20		1				1	•	



Ministry of Transportation

				R	ECO	RD O	F B	OREHOLE N	lo 18-2	26	2 OF 3	ME		*
GWP#_	2430-15-00	LOC	CATIC	ON _	Welland	d River Br	idge Re	placement, MTM NA	.D83-10: N	<b>1</b> 4 767 040.	3 E 335 665.		INATED	BY <u>ES</u>
DIST _	HWY QEW	BOF	REHO	DLE T	YPE_	Hollow St	em Aug	ers/NW Casing					PILED B	Y MP
DATUN	I Geodetic	DAT	<u>Е</u> 2	018.07	.11 - 20	18.07.11	LAT	TUDE	55 L	ONGITUD	E	<u>1177</u> CHE	CKED BY	GRL
	SOIL PROFILE		5	Sampi	ES	R	ALE	DYNAMIC CONE P RESISTANCE PLO		ION		URAL HOUR	<u> </u>	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SROUND WATE CONDITIONS	LEVATION SC/	20 40 SHEAR STRENC ○ UNCONFINED ● QUICK TRIAXI.	60 80 GTH kPa + FI AL × LA	100 ELD VANE AB VANE			UNIT WEIGH	& GRAIN SIZE DISTRIBUTIO (%)
	Continued From Previous Page	Ти					Ξ	20 40	60 80	100	20 4	0 60	kN/m <sup>3</sup>	GR SA SI C
	Sifty CLAY, trace sand Soft Reddish Brown Wet					-	168	+					-	
			7	ss	0	-					0			
167.0 11.7	SILT, some sand Reddish Brown Moist						167	<u>3</u> 0						
			3	тw	РН		166				0		-	
165.4 13.3	Silty CLAY, trace sand									3.: +	2			
	Reddish Brown Wet		4	тw	РН	-	165				0			
						-	164						-	
						-								
	Stiff		8	ss	2	-	163				о — — — — — — — — — — — — — — — — — — —			
							162		10.0				-	
			9	ss	3	-					o			
							161			80 +				
160.3 18.4	SILT, some sand, some clay, trace gravel Dense to Compact		10	ss	33	-	160				0		-	6 11 72 1
	Reddish Brown Wet													
							159							



10/2/18	
E(MTO).GDT	
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Minis Tran Ontario	stry of sportation															M	го :	307-2	
				R	ECO	RD C	)F B	ORE	HOL	E N	o 18	8-26		3 (	DF 3		ME	TRIC	;
GWP#_	2430-15-00	_ LOC	ATIC	DN _	Welland	d River B	ridge Re	eplacen	nent, M	ΓΜ ΝΑ	D83-10	: N 4 7	67 040.	3 E 33	35 665.	2	ORIC	INATED	BY <u>es</u>
DIST _	HWY QEW	_ BOF	REHO	DLE T	YPE	Hollow S	tem Aug	gers/NV	V Casin	g							COM	PILED B	Y MP
DATUM	Geodetic	_ DAT	Е <u>2</u>	018.07.	.11 - 20	18.07.11	_ LAT	ITUDE	E43	3.0425	55	LON	GITUD	E	-79.12	1177	CHE	CKED BY	GRL
	SOIL PROFILE		5	SAMPI	ES	ER	ALE	DYNA RESIS	MIC CO STANCI	DNE PE E PLOT		ATION		PLASTIC	NAT	URAL	LIQUID	ΗT	REMARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WAT CONDITION	ELEVATION SC.	2 SHE/ 0 U • Q	AR ST NCONF UICK T 20 4	RENG INED RIAXIA	50 8 TH kP + L × 50 8	30 1 Pa FIELD LAB V. 30 1	00 VANE ANE 00				⊔MIT <sup>₩</sup> L  IT (%) 50	WIT NIT	& GRAIN SIZE DISTRIBUTION (%)
158.6		- ##	11	SS	18									0					
20.1	Silty <b>CLAY</b> , trace sand, trace gravel Firm to Stiff Reddish Brown Wet		12	SS	5	-	158 157 156							0	0				
							155											-	
23.9	SILT and SAND, gravelly Dense to Very Dense Brown Moist (TILL)		14	SS	48	-	154												
	occasional cobble		1				153	; 											
152.7	END OF BOREHOLE AT 26.0m. WATER LEVEL AT 2.1m UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.1m, THEN ASPHALT TO SURAFCE.		15	SS	0.100														

ONTMT4S2 MTO-18426 GPJ 2017TEMPLATE(MTO) GDT 10/2/18

+ <sup>3</sup> , × <sup>3</sup> : Numbers refer to Sensitivity

20 15-**4**-5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
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				RI	ECO	RD C	F B	DRE	HOI	_E N	lo 18	8-27		10	)F 3		ME	TRIC	,	
GWP#_	2430-15-00		ATIC	ON _	Welland	d River B	ridge Re	placem	nent, M	TM NA	D83-10	D: N47	767 690	.4 E 33	35 601.	.8		INATED	BY <u>es</u>	
DIST _	HWY QEW	_ BOF	REHC	ר DLE די	PE_	Hollow S	tem Aug	ers/NW	/ Casin	ıg							_ СОМ	PILED B	YMP	
DATUM	Geodetic	_ DAT	Е <u>2</u>	018.07.	12 - 20	18.07.12	LAT	TUDE	4	3.0484	09	LON	IGITU	DE	-79.12	21919	_ CHE	CKED BY	GR	L
	SOIL PROFILE		5	Sampl	.ES	VTER VS	CALE	DYNA RESIS	MIC C STANC	ONE P E PLO			100	PLASTIC	NA" MOI	TURAL	LIQUID LIMIT	H H	REM	ARKS
ELEV DEPTH	DESCRIPTION	TRAT PLOT	NUMBER	ТҮРЕ	'N" VALUES	ROUND WA	EVATION S	2 SHEA 0 UI • QI	AR ST NCONI	40 RENC FINED	GU GTH ki + AL ×	Pa FIELD	VANE	WP WA	COI	NTENT W O ONTEI	WL 	MEIO MEIO	GRAII DISTRI (?	N SIZE IBUTIO %)
176.9	GROUND SURFACE	0			-	0	Ш	2	20 4	40	60	80	100	2	20 4	40	60	kN/m <sup>3</sup>	GR SA	SI C
0.0	ASPHALT: (200mm) Gravelly SAND, trace silt Dense		1	GS										o						
	Brown Moist (FILL)		1	SS	32		176							0						
175.5 1.4	Silty CLAY, trace sand, trace gravel,					-														
	Stiff to Very Stiff Brown Moist		2	ss	10	-	175								0					
			3	SS	13	_	174							c						
			4	SS	18									c	2					
							173													
			5	SS	6		172													
							171													
			6	SS	9	-									<b>-</b>	+1			0 0	37 6
						-	170													
			7	SS	6	-	169								0					
													2.7							
			 				168													
			8	ss	30										o					
	Continued Neut Daws	KX	1				167													

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### MTO 307-27



OVP/#_2430-16-2         LOCATION         Vehicle Bits Residement. NTM NADES-0. N.4 107 000-4 E.35501.2         ORIGINATE D Y 12.           DATUM         General         DATE         2010 F07-1100         Commence Supervise         Co					R	ECO	RD C	F BC	ORE	HOL	E N	o 18	-27		2 (	DF 3		ME	TRIC		
DBT         HWV         GOREHOLE TYPE         Listex Barn AgerWALGarrag         COMPLED BY         LP           DATU         Control         DATE         SMAPLES         LATUDE         ACCOMPLED MILE         Control         Contro         Contro	GWP#	2430-15-00	_ LOC	ATIC	DN _\	Velland	l River Bi	ridge Re	placem	nent, M	ΓΜ ΝΑΙ	083 <b>-</b> 10:	N 4 7	67 690.	4 E 33	35 601.	8		INATED	BY <u>ES</u>	
DATUM         Genedation         DATE         210.07.12         LATTUDE         32.04909         LONGTUDE         32.04919         CHECKED BV         GRL           SOIL PROFILE         SAMPLES         Sample	DIST	HWYQEW	BOF	REHC	DLE TY	′PE_I	Hollow St	tem Aug	ers/NV	/ Casing	3							сом	PILED BY	( <u>MP</u>	
SOIL PROPILE         SAMPLES         End of the second rule of the	DATU	M Geodetic	_ DAT	Е <u>2</u>	018.07.	12 <del>-</del> 20	18.07.12	LAT	TUDE	43	3.04840	)9	LON	GITUD	E	-79.12	1919	CHE	CKED BY	GR	L
Contrust From Provide Page         C </td <td>ELEV DEPTH</td> <td>SOIL PROFILE</td> <td>STRAT PLOT</td> <td>NUMBER</td> <td>SAMPL JAL</td> <td>'N" VALUES</td> <td>ROUND WATER CONDITIONS</td> <td>EVATION SCALE</td> <td>DYNA RESIS 2 SHEA 0 UI • Q</td> <td>MIC CC STANCE 20 4 AR STI NCONF UICK T</td> <td>NE PE E PLOT 0 6 RENG INED RIAXIA</td> <td></td> <td>ATION 30 1 a FIELD LAB V</td> <td>00 </td> <td></td> <td></td> <td>URAL STURE ITENT W O ONTEN</td> <td>цала піміт МГ ПТ (%)</td> <td><b>★</b> UNIT WEIGHT</td> <td>REM, { GRAII DISTRI (%</td> <td>ARKS &amp; N SIZE BUTION %)</td>	ELEV DEPTH	SOIL PROFILE	STRAT PLOT	NUMBER	SAMPL JAL	'N" VALUES	ROUND WATER CONDITIONS	EVATION SCALE	DYNA RESIS 2 SHEA 0 UI • Q	MIC CC STANCE 20 4 AR STI NCONF UICK T	NE PE E PLOT 0 6 RENG INED RIAXIA		ATION 30 1 a FIELD LAB V	00 			URAL STURE ITENT W O ONTEN	цала піміт МГ ПТ (%)	<b>★</b> UNIT WEIGHT	REM, { GRAII DISTRI (%	ARKS & N SIZE BUTION %)
Sey ULAY 2024 bind         1         TW         PH           1         TW         PH           1         TW         PH           2         TW         PH           9         SS         0           9         SS         0           10         SS         4           11         SS         4           10         SS         4           11         SS         14           10         SS         14           11         SS         14           11         SS         14           10         12         SS		Continued From Previous Page				-	0	Ш	2	20 4	0 e	60 E	80 1	00	2	20 4	10 e	50 	kN/m <sup>3</sup>	GR SA	SI C
1         TW         PH           1         TW         PH           2         TW         PH           2         TW         PH           9         SS         0           9         SS         0           10         SS         4           11         SS         14           11         SS         14           11         SS         14           11         SS         14           11         SS         74		Sitry CLAY, trace sand Stiff to Firm Brown Moist					-				-	5.1									
1580     111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       111     55     14       12     55     78				1	TW	PH	-	166								0					
100     12     TW     PH       1     1     1       1        1								165		2.5 +											
10     SS     0       10     SS     4       10     SS     4       11     SS     161       12     SS     78				2	τw	РН	-									0					
100         5         5         0         163								164		3.3 +											
10         55         4           10         55         4           11         55         4           11         55         14           11         55         14           11         55         14           11         55         14           158.8         0         0           158.8         0         0           158.8         0         0           158.8         0         0           158.8         0         0           158.8         0         0				9	SS	0	-	163							F	<del>•</del> 1				05	52 4
BYOOL UG0 Output         Image: Constraint of the second seco								162			4.0 +										
158.8         18.1         SILT and SAND, trace clay, trace gravel, occasional cobbles Very Dense Brown         0         11         SS         78				10	SS	4									o						
International company         Sill T and SAND, trace clay, trace         Image: scale of the secale o	8							161		+											
158.8     158.8       18.1     SILT and SAND, trace clay, trace gravel, occasional cobbles Very Dense Brown     1       18.1     SILT and SAND, trace clay, trace gravel, occasional cobbles     1       12     SS     78	ITO).GDT 10/2/			11	SS	14	-	160							0 0						
Silt and SAND, trace clay, trace     Image: split and split	U HEMPLAIE 158.8							159													
	10-18426.GPJ 201	SILT and SAND, trace clay, trace gravel, occasional cobbles Very Dense Brown Moist (TILL)		12	SS	78	-	158							0						
	ONTMT4S2 M		0					157													
Continued Next Page		Continued Next Page	<u>H</u> ]:	I	1	I	. 3		umber	l s refer t	۱ <u> </u>	20		1	I	I	1	1	1	l	

Minis Tran Ontario	sportation														MT	O 3	07-	27	THURBER
				RI	ECO	RD C	)F B	ORE	HOL	E N	o 18	8-27		3 O	F 3		ME	TRIC	;
GWP#_	2430-15-00	_ LOC	CATIC	<u>`</u> אכ	Welland	l River B	ridge Re	eplacem	ient, M	TM NAI	D83-10:	N 4 7	67 690.	.4 E 335	5 601.8	1	ORIC	INATED	BY <u>es</u>
DIST _	HWY QEW	_ BOF	REHC	ר DLE די	YPE <u>I</u>	Hollow S	tem Aug	ers/NW	/ Casin	g							СОМ	PILED B	Y MP
DATUM	Geodetic	_ DAT	<u>Е</u> 2	018.07.	.12 - 20	18.07.12	LAT	TUDE	4	3.04840	09	LON	GITUE	DE	79.121	919	CHE	CKED BY	GRL
	SOIL PROFILE	DT	5	Sampl	_ES 	/ATER DNS	SCALE	DYNA RESIS 2		ONE PE E PLOT 40 E		ATION 	00	PLASTIC LIMIT	NATU MOIST CONT	JRAL TURE TENT	LIQUID LIMIT	NIT IGHT	REMARKS &
<u>ELEV</u> DEPTH	DESCRIPTION	TRAT PLC	NUMBER	ТҮРЕ	'N" VALUE	ROUND V CONDITIO	EVATION	SHEA 0 UI 0 QI	AR ST NCONF	FINED	TH kP +	'a FIELD LAB V		W P WATI	——o ER CO		₩∟ —— IT (%)	ר ⊮ ר	GRAIN SIZE DISTRIBUTIO (%)
	Continued From Previous Page				-	0	Ш	2	20 4	40 e	50 8 	30 1 	00	20	) 40	о e	50 	kN/m <sup>3</sup>	GR SA SI C
	Dense		14	SS	67 47		156 155							0	0				
152.5	possible cobbles and boulders	. o .  0  	16		100/	-	153												No recovery
24.4	END OF BOREHOLE AT 24.4m. BOREHOLE BACKFILLED WITH CUTTINGS TO 0.1m, THEN ASPHALT TO SURAFCE.				0.025														

+ <sup>3</sup> , × <sup>3</sup> : Numbers refer to Sensitivity

<sup>15</sup> <del>0</del> 5 (%) STRAIN AT FAILURE

Orntaria	intairy of anaportation		)												IV	110	) 21:	2-2	Foundation Desi	gn
	. ,		F	REC	ORD	) OF	BO	REH	IOLI	ΕN	lo :	2		1	OF	1	M	ETRI	С	
w.o.	93-11022	LOC	ATIO	N	1	N 4 76	6903.4	E.3	135619	0.1					e of a state of a		ORI	GINATED	BY DK	
DIST	6 HWY QEW	BOR	REHO	LE T	rpe _l	H.S. Au	er	······					******			à matana Manana A	_ CON	IPILED E	BYDK	
DATU	M Geodetic	DAT	Έ		{	93 09 (	01										_ CHE	CKED B	YPP	
	SOIL PROFILE		s	AMPL	ES	S	ALE	RESIS	MIC CO	PLOT		TION		PLASTIC	NAT	TURE	UQUID	느도	REMARKS	
		5	æ		ES	NOT NOT	N SC	2	20 4	ο ε	io i	BD 11	çõ	W <sub>D</sub>	CON	TENT #	UMIT W1	LINI	. å	
ELEV	DESCRIPTION	P P	MBE	ΥPE	ALU	NDN	TIO	SHE	AR ST		STH k	Pa	VANE	3		o	<sup>-</sup>		GRAIN SIZ	E SN
100.0	france at the second	STRA	Ę	- 1	ż	88	EX I	• 01	JICK TH		×	LAB V	ANE	WATE	R CO	NTEN	ศ (%) เก	LN/m3	(%)	
0.0	Ground Surrace		1.	CS			Ξ		Ť	Ť	Ť	Ť	<u> </u>	<u> </u>		Ť	Ť	NAYIO	GR SA SI G	۶L
		X	2	SS	11	xxxx	180						ļ				<u> </u>			
	Trace Organics	K	3	55	6										o				0 1 52	47
		Ю	4	SS	3															
	Silty Cloy	Ю	5	SS	4	1	178	<b> </b>	1			1				<u> </u>	†			
	Grey and Brown	К				1														
	(F10)	K	6	SS	2		176													
		ľ×					1													
	r r	$\triangleright$	1-	SS	8							ļ								
		$\mathbb{X}$	1			1	174		<u> </u>											
173.0		K	8	55	7													, .		
7.9	Silty Clay	Ð	1							ſ										
	with Organic Inclusions	B	1.	- 22	13		172		<b> </b>			1	1				<u>†                                    </u>	1		
170.7	Dark Grey, Firm to Stiff	Z	Ē												L	L.			2.84	
10.2		R	<u>}</u>		<b></b>	1	170				1		100					-uncent	2.07	
		IJ	1	714	-								Ť							
		Ø	1	1.	РН															
	Silty Clay to Clayey Silt	K	1				168		+ +	د 		<b> </b>		<u> </u>			<b> </b>			
		Ø	12	TW	PH	×				_					<b>⊣∘</b> .			19.5		
	Firm to Stiff	И	1							+2		}								
		K	13	TW	PH		166								<b>P</b>		+	20.6		
	Grey and Reddish Brawn	Ĥ										3						1		
		Ø	<u><u></u></u>	SS	3												.			
		H	1				364			+2							1			
		Ø	15	TW	PH	, ři														
162.2	End of Borehole	pz	16	SS	4				l			+								_
																·	ľ			
								Ľ									Į			
	,	1																		
																			<i></i>	
			1																	
	94 10 25																			
	* GROUND WATER CONDITIONS														,					
	PIEZO. GROUND WATER																			
	1 173.1	1																		
Longer		Acres	L	L	<b>1</b>	i	1	L	I		1		1			1	1	L		

+<sup>3</sup>, x<sup>5</sup> : Numbers refer to Sensitivity 20 15-5-5 (%) STRAIN AT FAILURE 10

RECORD OF BOREHOLE No 3         10F 1         METRIC           W.0	Onterte	aany et naportution		)												02	12-	3	1	foundation Design
W.O.       JA-11322       COMING       W.Y. JDW       ODE CONTENT       COMMUNE BY _ ZM         DIST       DIST       DIST _ DO TO       ODE CONTENT       COMMUNE DY _ ZM       COMMUNE DY _ ZM         DIST       DIST       DIST _ DO TO       ODE CONTENT       COMMUNE DY _ ZM       COMMUNE DY _ ZM         Sold UP ROFILE       SAMPLES       DIST _ DO TO       ODE CONTENT (CM       DIST _ DO TO       DIST _ DO TO         Commune Strates       DIST _ DO TO         Commune Strates       DIST _ DO TO         DIST _ DO TO       DIST	Γ			F	REC	ORD	) OF	во	REH	IOLI	E N	0	3		1	OF 1	1	MI	ETRI	C
DST.       ORTONOL       THAT       DOBUGUE TYPE LIS. Journ       OWNER       OW	w.o.	93-11022	LOC	ATIC	)N	I	N 4 76	7011.1	<u> </u>	35609	0.0		****						SINATED	8Y_DK
DATU         EXAMPLES         Sold         CHECKED BY _ LPP           Soll PROFILE         SAMPLES         Sold Sold Sold Sold Sold Sold Sold Sold	DIST_	6 HWY QEW	_ BOR	REHO	LE TI	PE_	H.S. Aug	jer					والماسين والمالية	misure determine				_ CON	PILED B	Y DK
SOLL PROFILE         SAMPLES         Source of the second profilmions         Difference of the second pro	DATUN	Geodetic	_ DAT	E	-		93 09 (	02		,								_ CHE	CKED B	rpp
Level Level DESCRIPTION         Ist ist ist ist ist ist ist ist ist ist i	<u> </u>	SOIL PROFILE		l s	AMPL	ES	ШШ	Щ	DYNA	MIC CO	NE PE	NETRA	TION		<b></b>	NATI	URAL			
LICU DEDTITION         DESCRIPTION         Table is in the intervention of the interventinterenervention of the interventinterenervention of the	<b>I</b>		15		Í	[v]	NAT	SCA	RESI.	10 4	6 6	<u>ک</u>	30 1	00	plastic Limit	NOIS	TURE	LIQUID	HOL	REMARKS
Description         The bound Surface         The bound Surface <th< td=""><td>ELEV</td><td>DECODIDITION</td><td>PL</td><td>BER</td><td>ы Ш</td><td>ILUE</td><td>N</td><td>NO</td><td>SHE</td><td>AR ST</td><td>RENG</td><td>TH K</td><td>Pa</td><td></td><td>"₽ —</td><td>·····</td><td>ø Ø</td><td><sup>w</sup>L</td><td>, N</td><td>GRAIN SIZE</td></th<>	ELEV	DECODIDITION	PL	BER	ы Ш	ILUE	N	NO	SHE	AR ST	RENG	TH K	Pa		"₽ —	·····	ø Ø	<sup>w</sup> L	, N	GRAIN SIZE
118.0       Concrete       In       In <thin< th="">       In       In</thin<>	DEPTH	DESCRIPTION	RAT	NS.	۲	>	280 No	VAT	● UN ● QL	ICONFII JICK TR	NED RIAXIAL	+ *	FIELD	VANE ANE	WATE	R CO	NTEN	it (%)	7	DISTRIBUTION (%)
0.0         Converting         1 <th1< th=""> <th1< th="">         1         <th1< td=""><td>184.0</td><td>Ground Surface</td><td>- IS</td><td></td><td></td><td>,z</td><td>6</td><td>E</td><td>2</td><td>0 4</td><td>0 6</td><td>0 8</td><td>30 10</td><td>00</td><td>2</td><td>0 4</td><td>0 6</td><td>50 1</td><td>kN/m</td><td>GR SA SI CL</td></th1<></th1<></th1<>	184.0	Ground Surface	- IS			,z	6	E	2	0 4	0 6	0 8	30 10	00	2	0 4	0 6	50 1	kN/m	GR SA SI CL
122.4       uny. Unyect.       2       2       33       4         1.4       Silly Clay       4       35       4       12 <td< td=""><td>0.0</td><td>Granular Fill</td><td>×.</td><td></td><td>CS</td><td>-</td><td>DRY *</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>· ·</td><td></td></td<>	0.0	Granular Fill	×.		CS	-	DRY *												· ·	
132     3     3     4       Shy Day Trees bave and Organics Grayich flavan Very Stift     132     132     132     132     132       133     135     6     135     6     130     130     130     130       134     135     137     141     137     130     130     130     130     130       135     137     130     130     130     130     130     130     130     130       134     135     137     130     130     130     130     130     130     130       134     135     137     130     130     130     130     130     130     130       134     135     130     130     130     130     130     130     130       134     135     130     130     130     130     130     130     130       134     135     130     130     130     130     130     130     130       142     End of Brownore     130     130     130     130     130     130     130     130       143     End of Brownore     130     130     130     130     130     130     130     130	182.6	Grey, Compact	- <del>K</del>	Ê	SS	13	1													
Sile Cary     Image: Sine Cary			$\mathbb{N}$	13	55	4	1	182												
Trees drowed and Organics <ul> <li></li></ul>		Silty Clay	K	]		<u> </u>		1						100						
Induction of the number of		Trace Gravel and Ornanics	K	+	SS	6		100									1			
Correlate Brown     5     W     PH       Very SUIT     6     35     10       ( Fil )     7     W     PH       172.4     7     W     PH       9.1     7     W     PH       Silty Clay     8     85     0       172.4     9.1     172     172     172     172     172       9.1     7     NV     PH     172     172     172     172       9.1     7     NV     PH     172     172     172     172       9.1     8     172     172     172     172     172     172       14.2     End of Borrhole     1     1     1     1     1     1     1       14.2     End of Borrhole     1     1     1     1     1     1     1     1       14.2     End of Borrhole     1     1     1     1     1     1     1     1     1       14.2     End of Borrhole     1     1     1     1     1     1     1     1     1       14.2     End of Borrhole     1     1     1     1     1     1     1     1     1       14.2			К				[	100									Ι.			
Very Suff     0     55     10       ( fill )     7     19       9     7     19       9     7     19       9     7     19       104     1     10       105     10 <t< td=""><td></td><td>Greyish Brown</td><td>ĸ</td><td>5</td><td>TW</td><td>РН</td><td>4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td> <b>P</b></td><td>Н</td><td></td><td>20.4</td><td></td></t<>		Greyish Brown	ĸ	5	TW	РН	4									<b>P</b>	Н		20.4	
Image: constraint of the second consecond consecond constraint of the second constraint of		Very Stiff	K				1	178										ļ		
(Fill)       7       10       11			Ň	<u>↓</u> •	55	10														
174.9     7     TW     PH       9.1     Sity Cay     8     55     17       From to Very Stiff     9     55     6       169.5     10     10     10     10       169.5     10     10     10     10       14.2     End of Borehole     10     10     10       + 93.02     02     10     10     10       Hole dry upon completion     10     10     10     10			$\mathbf{\Sigma}$	1										>120k	-					
17.8     17.8     17.7     17.7     17.7       Sity Clay     17.7     17.7       Beddith Brown and Gray     17.7       18.2     End of Borehole       19.3     19.0       19.4     Integration       19.4     Integration       19.4     Integration       19.5     Integration       19.6     Integration       19.7     Integration       19.8     Integration       19.9       19.9       19.9       19.				1				176					<u> </u>	++			<u> </u>	<u> </u>		
9.1       7       W       PH         Slity Clay       8       35       17         9       35       0       174       174       174         182.8       172       172       172       172       174         182.8       172       172       172       172       174         182.8       172       172       172       174       174         182.8       170       170       170       170       170         182.8       170       170       170       170       170         182.8       170       170       170       170       170         182.8       170       170       170       170       170       170         182.8       170       170       170       170       170       170       170         182.9       180 07 020       1900 020       170       170       170       170       170       170         182.9       180 07 020       180 07       180 07       180 07       180 07       180 07       180 07       180 07         182.9       180 07       180 07       180 07       180 07       180 07       180 07<	174.9		Ķ	]	ļ	ļ														
Silty Clay       Firm to Very Stift     iss     iss       199.3     172     172       100 of Borehole     172     172       11.2     End of Borehole     172       19.3     172     172       10.4     172     172	9.1		H	尸	TW	Рн		174									<u> </u>			
Sity City     IB     IS     I7       Firm to Very SUIf     Image: Sity City     Image: Sity City     Image: Sity City       Reddlink Brown and Grey     Image: Sity City     Image: City     Image: City       162.8     Image: City City     Image: City     Image: City       162.8     Image: City City     Image: City     Image: City       162.8     Image: City     Image: City     Image: City       162.9     Image: City			H	1																
Firm to Very Stiff     Image: Stife and Stress and		Silty Clay	H	╞╸	SS	17	1		1											
Reddish Brown and Gray         9         95         6           199.8         Ind of Borshole         170         170         170         120k%a           • 93 09 02         Hole dry upon completion         1         1         1         1         1           Interview         • 93 09 02         Hole dry upon completion         1		Firm to Very Stiff	R				1	172												
169.8       170       120k <sup>2</sup> a       1         14.2       End of Borehole       • 93 09 02       • 100k <sup>2</sup> a       1		Reddish Brown and Grey	H	<u> </u>	55	6							İ							
14-2         End of Borehole         Y         170         Image: Completion         Ima		•	H	1										>120k	Po					
• \$3 09 02 Hole dry upon completion	169.8	End of Borehole	- Kr	1			<u> </u>	170											en ante ante	
Hole dy upon completion																				
		+ 95 09 02 Hole dry upon completion					]													
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		,																		
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	.																			
							1													
				Ŀ	<u> </u>	L	1		L				]			L				

+<sup>3</sup>, x<sup>5</sup> : Numbers refer to Sensitivity 20 15-0-5 (%) STRAIN AT FAILURE 10



### MTO 288-3

					REC	ORD	OF E	BOR	EHO	LEN	No 3			1	of 3		ME	TRIC	
G.W.	P <u>.</u>	LOC	CATIO	ом _		Coords	: E:3364	35.8 N	476578	2.8							ORIG	INATED	BY <u>AF</u>
DIST	HWY QEW	BOF	REH	OLE T	PE	HOLLC	W STEN	1 AUG	RS								_ co	MPILED	BY <u>sd</u>
DATU	JM GEODETIC	DAT	ΓE		-	2015-1	2-7 - 201	5-12-9									CH	IECKED	BY RA
			-	SAMO	ES			DYNA			NETRA			I			_		
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER			GROUND WATER CONDITIONS	LEVATION SCALE	SHEA	20 4 R STRE UNCOM	40 ENGTH NFINED	6 <u>0</u> (kPa)	80 + FIEL × LAB	100 LD VANE VANE	PLAST LIMIT W <sub>P</sub> I		URAL STURE ITENT W O ONTEN	LIQUID LIMIT WL T (%)	<b>Å</b> Weight	REMARKS & GRAIN SIZE DISTRIBUTION (%)
174.9	GROUND SURFACE				0,		ш	:	20 4	40 (	60	80	100		10	20 3	30	kN/m <sup>3</sup>	GR SA SI
174.6 0.3			8			-													
174.0	dense, brown, dry		1	SS	52									0					
0.9	<b>FILL</b> , sand, trace gravel, compact,	-		22	12		174												
<u>173.6</u> 1.3	reddish brown, moist		<u> </u>		12	-													
	FILL, silty clay, trace sand, trace gravel, trace organics, firm to stiff,		3	SS	7											c			
	brown, moist		§			-	173												
						-													
			4	55	6														
			¥				172												
			5	SS	6											<del> 0</del> -	LL=48		4 4 36 5
			6	SS	6		171												
			7	ss	9	1													
169.7	 containing organics black				-	-	170						1					1	
5.2	SILTY CLAY, trace sand, trace		-	6-	_	-													
	gravel, firm to very stiff, brown, moist		8	SS	5										F				0 1 67 3
			_				169												
			9	τw	РН														
							168					>	·+						
			10		6										Ι.				0 7 54 3
				- 33	0	-	167												0 7 54 5
											1.	8							
											+								
							166					+							
			11	тw	РН										⊢	0	I	20.0	0 7 55 3
							165				+	.6							
												<b> </b> <sup>+</sup>							
			1		-	1	104												
			12	55		-	164				1	1							
							100					#							
							163					>	·+						
			13	SS	7										⊢	0	4		1 7 53 3
							100												
							162					+1.6							
			-		_	-	104												
			14	SS	7	1	101												
160.2 14.7		-111	4				100												
	Continued Next Page		I	I		I	160		l	ļ.	i.	i	l	1	1		1	1	



					REC	ORD	OF E	BORI	EHO		lo 3			2 0	of 3		ME	TRIC	
G.W.F	p		САТЮ	ОМ _		Coords	: E:33648	35.8 N:	476578	2.8							ORIG	INATED	BY
DIST	HWY _QEW	_ во	REHO		/PE _	HOLLO	W STEM	1 AUGE	RS								_ co	MPILED	BY <u>SD</u>
DATU		_ DA	TE _			2015-12	2-7 - 201	5-12-9									_ C⊢	IECKED	BY <u>RA</u>
	SOIL PROFILE			Sampl	ES щ	VATER ONS	SCALE	DYNA RESIS	MIC CO TANCE	NE PEI PLOT		TION	•	PLASTI LIMIT	IC NATU MOIS CON	JRAL TURE TENT	LIQUID LIMIT	dHT GHT	REMARKS
<u>ELEV</u> EPTH (m)	DESCRIPTION	STRAT PLO	NUMBER	ТҮРЕ	PT 'N' VALL	GROUND V CONDITI	EVATION S	2 SHEA O	0 4 R STRE UNCON QUICK	0 6 NGTH IFINED TRIAXI/	<u>30</u> (kPa) AL	8 <u>0</u> + FI × L/	100 IELD VANE AB VANE	w <sub>P</sub> ⊢ ₩A <sup>-</sup>		w o DNTEN	w∟  T (%)	≤ ∦γ	& GRAIN SIZ DISTRIBUTI (%)
	(continued)				<u></u>		Ē	2	0 4	06	50	80	100	1	0 2	20 :	30	kN/m <sup>3</sup>	GR SA S
	SILT, trace clay, trace sand, compact, grey, wet		15	SS	28	-	450								(	þ			0 3 89
158.7 16.2	SILTY CLAY, trace to some sand, trace sand, trace gravel, stiff to very						159												
	stiff, brown to grey, wet		16	SS	10	-	158												
							157						>+						
			17	SS	10	-	156									0 1			4 14 49
			18	SS	3	-	155										0		1 2 56
							154						>+						
							153												
152.3 22.6	SILTY SAND, trace clay, compact to very dense, brown, wet		. 10	66	10	-	152												
			· · ·		10	_	151												
			•				101												Dec. 07, 201
			•				150												
			20	SS	76		149								0				0 62 34
			· · ·				148												
			· · ·				147												
		-	· • • •																
	some cla	y	21	SS	83	-	146												
		•	:				1/15											l .	



RECORD OF BOREHOLE No 3 3													3	of 3		ME	TRIC		
G.W.F	٥ <u>.</u>		Coords	: E:3364	85.8 N:	476578	2.8							ORIG	INATED	BY <u>AF</u>			
DIST	HWY _QEW	EHC	DLE די	YPE _	HOLLC	W STEN	1 AUGE	ERS								_ co	MPILED	BY <u>sd</u>	
DATU	M <u>GEODETIC</u>	DAT	E _			2015-1	2 <b>-7 -</b> 201	5-12-9									_ C⊢	IECKED	BY <u>RA</u>
	SOIL PROFILE	SAMPL	ES.	S ER	Щ	DYNA RESI	MIC CC	NE PEN PLOT		ION		PLAST		JRAL	LIQUID	L			
		Ь.	Ч		LUE	TION:	N SCA		20 4	-	~~		00	LIMIT	CON	TENT	LIMIT	UNIT	REMARKS &
DEPTH	DESCRIPTION	AT PI	JMBE	ТҮРЕ	N' VA		ATION	SHEA		ENGTH (	kPa)							_ ≥ ∕	GRAIN SIZE DISTRIBUTION
	(a a satisficant a sl)	STR	ž		SPT	GR	ELEV	Ĭ	QUICK	TRIAXIA	L :	× LAB	VANE 00		n 2		T (%) 30	∎ kN/m <sup>3</sup>	(78)
	SILTY SAND, trace clay, compact to																	KIUTT	GR SA SI CL
	very dense, brown, wet																		
							144												
143.5 31.4																			
	silt, very dense, grey, wet	6 ()					143												
		. O	22	SS	138 / 275mm														
		0					142												
					161/														
		ن ن د	23	SS	250mm		141							0					29 49 17 5
		0																	
		60					140												
			24	SS	100 / 75mm/														
		• ()																	Dec. 08, 2015
138.9 36.0		. <i>.</i>	25	SS	100 /		139												 \Dec. 09, 2015/
	END OF BOREHOLE																		
	Borehole filled with drill water upon completion of drilling.																		
	Borehole extended with a Tricone bit below 29.0m.																		
	Consolidation test performed on TW11																		



PROJE	ECT <u>12-1111-0088</u>	_		REC	ORI	D OF	BOR	EHOLE	No ′	13-0	4	SHE	EET 1	OF	3		MET	RIC	)	
W.P.	2177-08-00		ATIC	ом _		N 47657	50.7 ;E 3	36512.4									INATED	BY <u>s</u>	В	
DIST_	Central HWY <u>QEW</u>		REHC	ר DLE די	PE_	108 mm	I.D. Con	tinuous Flight	Hollow S	Stem A	ugers					_ СОМ	PILED B	∕A	V	
DATU	M Geodetic	_ DAT	Έ_			July 9 to	11, 2013	3								_ CHE	CKED BY	M	1M	
	SOIL PROFILE		S	SAMPL	.ES	VS	CALE	DYNAMIC CORESISTANC				20	PLAST		TURAL STURE	LIQUID	нт ВНТ	RE	MARI	кs
ELEV EPTH	DESCRIPTION	STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WA CONDITIO	LEVATION S	SHEAR ST O UNCONI	RENGT	) 8 -H kP + ×	a FIELD REMO		w <sub>P</sub> I WA			WL WL IT (%)	NO NU NO	GRA DISTE	AIN S RIBU <sup>-</sup> (%)	ize Tioi
<u>174.5</u> 0.0	GROUND SURFACE Sand and gravel, some silt, trace clay (FILL) Loose to compact Brown		1	SS	7		ш 174	20	40 60	) 8	0 10	00	2	20 -	40	60	kN/m <sup>3</sup>	GR S	A SI	(
173.1			2	SS	14		470											40 4	4 13	3
1.4 <u>172.3</u>	Sand (FILL) Compact Brown Wet		3	SS	10		173							0						
2.2 <u>171.5</u>	Sity clay, trace organics (FILL) Firm Grey Wet		4	SS	5	-	172						0							
3.0	sand, trace rootlets Soft to stiff Dark grey to black Wet		5	SS	4	-	171							⊢⊸	-1		OC = 9.2%	0 4	4 41	15
							170				+ <sup>2</sup> >96 <sub>+</sub>									
169.0			6	SS	2	_	169		2							(	>			
5.5	gravel Soft to stiff Grey Wet		7	99	1	-			-	2 +				0						
							168		2											
			8	SS	wн		167				+			0						
							166		+2											
			9	SS	wн		165		+				╞	-						
							164			2+	2									
			10	SS	1	-	163							0						
									+2	+2										
			11	SS	1		162		2					0						
			12	55	1		161		+	_2 +								3 /	1 56	
							160		2											
	Continued Next Dese	[]]	1																	_



PROJE	ECT 12-1111-0088	_		REC	ORI	) OF	BOR	EHOLE	No	13-04	SH	EET 2	OF	3	ME	<b>FRIC</b>
W.P.	2177-08-00		ATIC	DN _		N 476575	50.7 ;E :	36512.4						OR	GINATED	BY <u>sb</u>
DIST_	Central HWY QEW	BOF	REHC	DLE T	PE_	108 mm	I.D. Cor	tinuous Flight	Hollow	Stem Aug	gers			CO	MPILED B	Y
DATU	M Geodetic	DAT	Е			July 9 to	11, 201	3						CHI	ECKED BY	<u>MM</u>
	SOIL PROFILE	T .	s	AMPL	.ES	ATER	SCALE	DYNAMIC C RESISTANC 20	ONE PE E PLOT 40 6	NETRATI	ON 	PLASTIC LIMIT	NATL MOIS CONT	JRAL LIQU TURE LIM TENT LIM		REMARK
ELEV EPTH	DESCRIPTION	STRAT PLC	NUMBER	ТҮРЕ	"N" VALUE	GROUND W CONDITIC	ELEVATION	SHEAR ST O UNCON O QUICK 1	RENG	TH kPa + Fli	ELD VANE			v w <sub>L</sub>	Υ Υ	GRAIN SIZ DISTRIBUTI (%)
	CONTINUED FROM PREVIOUS PAGE CLAYEY SILT, trace sand, trace						ш	20	40 6		100	2	0 4	0 60	kN/m <sup>3</sup>	GR SA SI
	gravel Soft to stiff Grey Wet		13	SS	5		159						0			
	Trace silt seams below a depth of					-	158									
	16.8 m.		14	SS	3	-	157			2			0		-	
156.2 18.3	Sandy CLAYEY SILT, some gravel (TILL) Hard		15	SS	50/0.10		156			1 + 		Þ	-1		-	13 21 41
	Grey Wet						155									
<u>54.7</u> 19.8	SILT and SAND, trace clay Very loose to loose Brown Wet						154								-	
			16	SS	3		153					c	, ,		-	0 45 52
							152								_	
							151								_	
			47		-	-	150									
					5		149									
48.3 26.2	Silt, some clay, trace sand						1/0									
	Brown Wet						148									
			18	SS	3		147						<b>o</b>		-	0 3 79
							146								-	
145.2 29.3	SAND, some gravel Compact Grey Wet						145								-	



	PROJ	ECT 12-1111-0088			REC	ORI	D OF	BOR	EHC	DLE	No	13-0	)4	SHE	EET 3	B OF	3		MET	RIC	
	W.P.	2177-08-00	LOC	CATIO	DN _		N 47657	50.7 ;E 3	36512.	.4								ORIG	INATED	BY <u>s</u> B	
	DIST_	Central HWY <u>QEW</u>	BOF	REHC	DLE T	PE_	108 mm	I.D. Con	tinuous	Flight	Hollow	Stem A	Augers					COM	PILED BY	′AV	
	DATU	M Geodetic	DAT	Е_			July 9 to	11, 2013	3									CHEC	KED BY	MM	
ł		SOIL PROFILE		5	SAMPL	ES	۲	Щ	DYNA RESIS		NE PE		ATION			NAT	IRAI			PEMA	DKG
-	<u>ELEV</u> DEPTH		STRAT PLOT	NUMBER	ТҮРЕ	"N" VALUES	GROUND WATE CONDITIONS	ELEVATION SCA	2 SHEA 0 UI • QI	20 4 AR STH NCONF UICK TI 20 4	0 6 RENG INED RIAXIAI	0 8 TH kP + L ×	a FIELD					LIQUID LIMIT WL T (%)		GRAIN DISTRIB (%	SIZE UTION
ł		SAND, some gravel		-				_							-				KIN/M	GR SA	SIUL
		Compact Grey Wet		<u> </u>			-	144													
		Wet		19	SS	21															
							1														
								143													
								142													
	141.0																				
Ī	33.5	CLAYEY SILT, trace to some sand		20	SS	41	1	141							H	-				08	53 39
1/8/15		Hard Grey		1			-								-	-					
DT		wet		1				140													
GTA.0				]																	
GAL-C	139.1							400													
GPJ	35.4	SAND and GRAVEL, trace to some silt, trace clay						139													
0088.		Brown Wet																			
111-								138													
G\12-				21	SS	8									0					34 57	63
V)/LO							1	127													
, QEJ				-				107													
MENT	136.4 38.1	END OF BOREHOLE																			
-ACEI																					
REPI		1. Depth to groundwater level																			
TURE		was not measured upon completion of drilling.																			
RUCI																					
JS ST																					
<b>RIOL</b>																					
ß, ∨µ																					
8 (UF																					
1-008																					
2-111																					
012\1																					
CTS/2																					
COLEC																					
T:\PR																					
001																					
MTC																					
GTA																					



PROJ	ECT <u>12-1111-0088</u>			REC	ORI	) OF	BOR	EHOLE	No	13-06	S	HEET	1 OF	3		MET	RIC	
W.P.	2177-08-00		CATIC	ОМ _		N 476579	98.4 ;E 3	36509.5							ORIG	INATED	BY <u>s</u> B	
DIST	Central HWY QEW	_ BOF	REHC	DLE T	YPE	108 mm	I.D. Con	tinuous Flight	Hollow	Stem Aug	gers				_ СОМ	PILED B	(AV	,
DATU	M Geodetic	DAT	ГЕ _			June 18	and 19,	2013							CHEC	CKED BY	MN	Λ
	SOIL PROFILE		5	SAMPL	.ES	к	Щ	DYNAMIC CORESISTANC	ONE PEI E PLOT		ON		TIO NA	TURAL			REM	ARKS
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	түре	"N" VALUES	SROUND WATE CONDITIONS	LEVATION SCA	20 SHEAR ST O UNCONI O QUICK T	40 60 RENGT FINED	) 80 FH kPa + FI × RI	100 ELD VAI		ATER C	ISTURE NTENT W -0		WEIGH	GRAI DISTRI ('	& N SIZE IBUTION %)
174.9	GROUND SURFACE							20 4	10 60	80	100	_	20	40 0	50	kN/m <sup>3</sup>	GR SA	SI CL
174.4	CONCRETE (300 mm)	A. 4	:															
0.5	Sand and gravel (FILL) Dense Brown Moist		1	SS	30		174					0						
<u>173.4</u> 1.5	Silty clay, trace sand, trace organics (FILL) Firm		2	SS	5		173						0					
	Mottled grey and brown Wet		3	SS	6								0					
			4	SS	4		172						0					
	Black staining below a depth of 3.8 m.		5	SS	4		171					_	ŀ₽	1			02	33 65
			6	SS	7		170											
169.4 5.5	CLAYEY SILT, trace to some sand. trace to some									>	96+							
	Stiff Brown becoming grey below a depth of 10.7 m Wet		7	SS	6		169						0					
							168			>	96+							
			8	SS	6	-	167						0					
							166			>	96 <sub>+</sub>							
			9	SS	4								⊦⊶1					
							165			_2 +	+2							
			10	SS	2		164						0					
						Ţ	163			+2	2							
			11	SS	3								0					
										>	+ <sup>2</sup> 96 <sub>+</sub>							
	Silt seams at a depth of 13.7 m.		12	SS	8		161						0					
	Continued Next Page						160				+3							



PROJ	ECT 12-1111-0088	_	l	REC	ORI	D OF	BOR	EHC	DLE	No	13-0	6	SHI	EET 2	OF	3		MEI	RIC		
W.P.	2177-08-00	LOC	ATIC	ом _	I	N 476579	98.4 ;E 3	36509	.5								ORIG	INATED	BY <u>se</u>	3	
DIST	Central HWY QEW	BOF	REHC	DLE TI	PE_	108 mm	I.D. Con	tinuous	s Flight	Hollow	Stem A	ugers						PILED BY	(AV	/	
DATU	M Geodetic	DAT	E			June 18 a	and 19, :	2013									CHEC	CKED BY	M	N	
	SOIL PROFILE	<sub>⊢</sub>	s	SAMPL	.ES	ATER	SCALE	DYNA RESIS	MIC CO STANCE			TION	າດ	PLASTI LIMIT			LIQUID LIMIT	uit GHT	REM	IARK &	s
<u>ELEV</u> DEPTH	DESCRIPTION	TRAT PLO	NUMBER	ТҮРЕ	N" VALUES	ROUND W. CONDITIO	EVATION 5	SHE/ OU	AR STI NCONF	RENGT	FH kPa	a FIELD		w <sub>P</sub> ► WA <sup>-</sup>			w∟ ∎ T (%)	Ϋ́	GRAI DISTR (	IN SIZ IBUTI (%)	ΖΕ ION
	CONTINUED FROM PREVIOUS PAGE				-	σ	EL		20 4	10 60	) 8	0 10		2	0	40 (	60	kN/m <sup>3</sup>	GR SA	s SI	CL
	Stiff Brown becoming grey below a		13	SS	3						+			1	•				96	45	40
	depth of 10.7 m Wet						159				+	2									
						-	158					+2									
157 1			14		3							206									
17.8	SILT, some sand, trace to some clay Very loose Brown						157					- 30+									
61 /8	Wet		15	SS	wн		156								0				0 13	80	7
							155														
<u>154.8</u> 20.1 סקר	SAND, some silt, trace to some clay Compact																				
000000	Brown Wet						154														
			16	SS	17		153								0						
MJILOGI							100														
							152														
							151														
			17	ss	18										0				0 78	14	8
						-	150								-				0.10		0
0, VANU							149														
0000																					
							148														
			18	SS	15		147								0						
145 6							146														
29.3																					
							145		1							1					

Continued Next Page

+<sup>3</sup>,×<sup>3</sup>: Numbers refer to Sensitivity



PRC	DJECT <u>12-1111-0088</u>			REC	OR	) OF	BOR	EHC	<b>)LE</b>	No	13-0	6	SHE	ET 3	OF	3		MET	RIC
W.F	2177-08-00	LOC	атю	ом _	1	V 476579	98.4 ;E 3	36509.	5								ORIG	INATED	BY <u>sb</u>
DIS	Γ <u>Central</u> HWY <u>QEW</u>	BOF	REHC		/PE	108 mm	I.D. Con	tinuous	Flight	Hollow	Stem A	ugers					COM	PILED BY	′
DAT	UM Geodetic	DAT	Е_			June 18 a	and 19, 2	2013									CHEC	KED BY	MM
	SOIL PROFILE		5	SAMPI	FS	~	ш	DYNA			NETRA	TION							
ELEV DEPTI		RAT PLOT	NUMBER	TYPE	" VALUES	ROUND WATER CONDITIONS	EVATION SCAL		AR STI	RENG	0 8 TH kP + >	0 1 a FIELD		PLASTIC LIMIT W <sub>P</sub> I WAT		JRAL TURE TENT V DNTEN		ل Weight	REMARKS & GRAIN SIZE DISTRIBUTION (%)
	CONTINUED FROM PREVIOUS PAGE	ST	-		F	5	ELE	• Q 2	0 4		_ X 0 8	REMO 0 10		2	0 4	0 6	i (70) i0	kN/m³	GR SA SI CL
	SAND and GRAVEL, some silt, trace to some clay Very dense	2.2																	
	Wet		19	SS	66		144							0					
			-				143 142												
Т 1/8/15	Split-spoon sampler bouncing.		20	SS	90/0.15		141							0					42 37 15 6
AL-GTA.GD	5		•				140												
GTA-MTO 001 T://PROJECTS/2012/12-1111-0088 (URS, VARIOUS STRUCTURE REPLACEMENT, QEW/)LOG/12-1111-0088.GPJ G	<ul> <li>AUGER REFUSAL END OF BOREHOLE NOTES:</li> <li>1. Sand blown up inside auger to a depth of 12.2 m (Elev. 162.7 m) during drilling at a depth of 18.9 m (Elev. 156.0 m).</li> <li>2. Water level inside auger at a depth of 9.1 m below ground surface (Elev. 165.8 m) during drilling.</li> </ul>																		

O<sup>3%</sup> STRAIN AT FAILURE



OFFICE REPORT ON SOIL EXPLORATION

MTO 111-1

I.P .	158-64-3	. 8	ORIN	IG DAT	Γ£	Feb	. 1, 1	1968	a di manana sa matang sa di manana kamana kaman Ingga manana kamana k			nge Sakishta ngasisiyang nagarita	La de la calego de la decidade de la compositional de la calego de la calego de la calego de la calego de la c		MPILE	) 8Y	VK	¢
ATU	« <u>Geodetic</u>	. 9	ORE	HOLE	TYPI	e Dia	mond 1	<u>brill</u>	- NX,	AX Cas	ing, A	XT Core	2	C1	ECKED	@Y	47	
hat generative	SOIL PROFILE		S A	MPLE	5		DYNA	AIC PEN	ETRATIO	N RESIS	TANCE		LIQUID	LINAT	**************************************	*.	1	
Alercano,	general den en e	Б			5	1	BLON	20	lio e	50	80	100	WATER	CONTE	NT	м: 	K ITY	
LEV		ā	95.9	. 44	140	S S	SHEAL	R STRE	NGTH P	SF			4 B 	¥	18 <sup>7</sup>	L.	BUL EKS	OF MARS
PTH	DESCRIPTION	RAT	1 Min	140	5 % 0	کر سر	4 19	leld V	aneu				VST &	TER C	ONTEN	T 9%	Ϋ́	
8.0	Ground Level	\$1 S	z		สี	ia.	1	1 <mark>00 8</mark>	00 12	200 10	500 2	000	2	0	10	60°°	PCF.	Gr.Sa.Si
0.0	Desiccated	$\mathbb{Z}$					N		1							1		
	gretbrown)	1	1	SS	28							+ >		¢				0 1 27
	Very stiff	M	3	SS.	72	560	- <u> </u>				4	3345				) 	1150	04 61
		M	L.	<u>IW</u>	FM		-		N	l		•>		for the second				2550.
		VA	5	TW	_PM_					$\geq$		0		المتعاد			121	
20	n naganaka generajing denaring sakaran saka man nan din Alash sakarak na	¥A	0	TW .	<u>M</u>	550	<b></b>		1	ļ		¥						
	A.A.	M	7	TW	FM				<								-	1
	bilty clay to clayey	$\nabla$					-	and a second		FOR				. ·		-	126	
t different and car	suit, trace of sand &	VA	8	TW	PM	540		ļ		s.2	1	1	₽4 	- <del>0</del>		ļ	4	device operation
	occasional gravel	VA	9	TW	PM		1.000										A T THE REPORT	No. March 1996
	(occasional seams of	1					No. Company		+8.2	* 10 miles							-	********
	eilt up to 2" thick	$\square$				520	Contraction of the second s											AND IN CONTRACTOR OF
	erro do no so minor	67	10	76	MA	00		4	0	1			H	- <del>0</del>			126	
ya Yanayoo	un ungran ()	$\mathcal{V}$		A 32	**3		-		1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	THE PART IN THE							
	(grey-brown)	M				5an			- statistica		- And Advantages of the					-		
		V/				520	-			-			-		<b>88 (1</b> 800) 1 1 <b>8</b> 10 000 000	1	-	
	Firm to stiff	VA	11	SS	14													
~ ~							- No. (Market Market										C. C	
8.0	anna (ang an ann ann an ann an Anna Anna Anna	ĥ				510				-							-	
	Sandy silt to silty																anar includes	- Contraction
	fine send																****	
	occasional boulders u		-			500												0 33 65
	to 6 to 12" in size		12	SS	18		-				No. of Concession, Name		9	•				و صدو ب
	below about elev.47?		-								and a second second							
						490											and	
			a (Linneda: Con	1			androspen											
	Compact to very dense		42	- <del>.</del>	50		n fulban kannak											-
	<b>Y</b>				1 all	480				-						+	1.	
				ļ			1.10	a chan the co								-	1)-Line	
			114	AXT	39%		Sec.										the second second	
			15	AXT	16%	470				ł							weeters	No. of Concession
					<u> </u>		124075000								a baran de a "Pad a			New York Control of Co
			16	AXT	11%		YACING SIN	- Makagina and Annota										
						460	<u>.</u>				-				<u> </u>		- mark	
			17	1	304	*-*	-										and the second second	
			↓ × (	AAL	£ U,#	Ę											Destruction	Source -
						150		-		0								
48.0	7)-7		18	AXT	13%		101000000		l t	5- 0-	<b>9</b> % 5	itrain to	failur	ç	and the bar - manth		March 199	
20.0 44.0	Bedrock (sound)	1/2 /2	19	AXT	100	6					<b>.</b>	+			ļ	<u> </u>		<u> </u>
24.0	End of Borehole	L	<u>}</u>	}	<u>}</u>	<u> </u>	1				dumme.	anten norman and a second	8		dananan meneratakan karang br>Karang karang k	ginerature contactores and	and the second sec	

TUNM	1161 M 1	120
66 45	4.0	
		18 A
		1000

OFFICE REPORT ON SUL EXPLORATION

**(1)** 

MTO 111-4

DEPART	WENT OF HIGHWAYS - ONTARIO						RECORD OF BOREHOLE NO h	TION SECTION
MATE	RIALS & TESTING DIVISIO 68-F-8	)N LO			Ramo	S-EW	) Sta. $h \neq 01$ 22.5' Rt. OBJOURNES BY VK	TON SECTION
	158-64-3	- LU - BO	RING	TON S	E.	Feb	. 19, 1968	7K
DATU	• <u>Geodetic</u>	. 80	REH	OLE	TYPE	Dia	mond Drill - NX, BX Casing - AXT Core CHECKED BY	
	ĸġĊĸĨĸIJŦŦĨŦġŦġĊŎĸŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎ							
	SOIL PROFILE		541	API E	S F	w	BLOWS / FOOT PLASTIC LIGHT	
		1074	a		100	9CAL	SHEAR STRENGTH PSF #P #L 5	
DEPTH	DESCRIPTION	AT	18	ЗЧХ	\$ 2	2	Unconfined     Field Vane	REMARKS
562.0	Ground Level	STR	C2	<b>h</b>	BLO	1	400 800 1200 1600 2000 20 40 40 pc	F. WI
0.0	Organic clayey silt.					560		anadananan <u>adam</u> a ana atala bakatan
	( <sup>D</sup> lack)		5	1W 1973	PM		+5.4	Org. 13.3
553.5	Very solt to solt		3 .	TN	IM		5-4	
8.5	Silty clay to clayey	A	4	IW	FM	550	124	
	silt, trace of sand	14	5	TW	-		+5.3	
	and occasional gravel	1					+5.2	
	(grey-brown)	(AP	6	TW	M	540		
		A	7	Th	TM			
	Firm to stiff	14		-			+5.3	
		14	ά	1.M	171	530	+5.2	
		行	9	TW	TM		$\sum_{\alpha}$	
		1	***	7016				
		14	10	TW		520		
516.0	and an an an and a state of the	F-4						
40.0	Sandy silt to silty		: •••	00	-			
	fine sand, occasional		11. 1	25		510		
	boulders up to 6-12"							
	in size below about		13	୯୯	- 20		$\bullet$	pr.0,Sa.19
	elev. 482.			يون		500		Si.76,Cl.5
			12	SS	75	1.00		
	Compact to dense.					490		
						1.80		
						400		
								1. Charles
		-				170		272
						417		12.12
						460		
			1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1					
		Accession in the				1,50		
H47.0	Dolomitic Limestone	13/37	1	AXT	100%			
117.0	End of Borehole			••••			0 15-0-5 % Strain to failure	
						10,0	dt dt	
-								



PROJECT <u>12-1111-0088</u>	-		REC	ORI	DOF	BOR	EHOLE	No 1	13-0	7	SHE	ET 1	I OF	3		MEI	RIC	,
G.W.P <u>.</u> 2177-08-00		CATIC	ОМ _		N 476557	74.3 ;E 3	36686.4								ORIG	INATED	BY <u>se</u>	3
DIST <u>Central</u> HWY <u>QEW</u>	BOF	REHC	T SLE רי	YPE_	108 mm	I.D. Cor	tinuous Flight	Hollow S	Stem A	ugers						PILED B	(A\	/
DATUM Geodetic	DAT	E _			July 4 an	d 5, 201	3								CHEC	CKED BY	M	М
SOIL PROFILE	STRAT PLOT	NUMBER	SAMPL	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CC RESISTANCI 20 SHEAR ST 0 UNCONF QUICK T	PLOT PLOT 0 60 RENGT INED RIAXIAL		TION 0 10 a FIELD V REMOU	00 VANE JLDED			URAL STURE JTENT W O ONTEN	LIQUID LIMIT WL T (%)	<b>λ</b> Weight	REN GRA DISTR	IARKS & IN SIZE IBUTIOI (%)
174.2         GROUND SURFACE           0.0         ASPHALT (225 mm)						17/			8		0			+0 6		kN/m <sup>3</sup>	GR SA	A SI C
0.2 Sand and gravel (FILL) Compact 173.4 Grey 0.8 Moist		1	SS	14		1/4						o						
172.8 Brown 1.4 Wet Silty clay, some sand, trace		2	SS	8		173						0					3 73	3 24 (
gravel, trace organics, trace rootlets to a depth of 2.1 m (FILL) Firm Grey				о 	-	172												
vvet		5	55	5	-	171							0					
						170												
4.1 SILTELAT to CLAT, trace sand, silt seams throughout Stiff Brown and grey Wet		6	SS	9		170							⊦⊷	1			0 2	27 7
					Į¥	169												
		7	SS	10		168							0					
167.0 7.2 CLAYEY SILT, trace sand, trace gravel Stiff Brown becoming grey below a					-	167												
depth of 10.7 m Wet		8	SS	10	_	166							0					
		9	SS	9	-	165						ł	•1					
						164												
		10	SS	5		163						ŀ	-					
						162				>96+ >96+								
		11	ss	3									0					
		1				161			+	2 + <sup>2</sup>								
		12	SS	5		160			2				0					
									+									



G.W.P	PROJ	ECT <u>12-1111-0088</u>			REC	ORI	D OF	BOR	EHO	<b>LE</b>	No	13-0	)7	SHE	EET 2	OF	3		MET	RIC	;
DBT         Control Documentation         Control Documentation <thcontrol documentation<="" th="">         Control Docume</thcontrol>	G.W.I	P. 2177-08-00	LOC	ATIC	ом _	1	N 476557	'4.3 ;E 3	36686.4	4								ORIG	INATED	BY <u>s</u>	В
DATE	DIST	Central HWY QEW	BOF	REHC	DLE TY	′PE	108 mm I	I.D. Con	tinuous	Flight I	Hollow	Stem A	Augers					COM	PILED BY	<u> </u>	v
SOUL PROFILE         SAMPLES         0	DATU	IM Geodetic	DAT	E			July 4 and	d 5, 201	3									CHEC	KED BY	M	M
Line         Descrappion         Line         Line <thline< th="">         Line         Line</thline<>		SOIL PROFILE		s	SAMPL	ES	ER (	ALE	DYNAN RESIS	MIC CC TANCE	NE PE		ATION		PLASTIC			LIQUID	. +	REM	MARKS
CLAMPY SLT. Take send take were for 10.7 m         Image: send take send to 2 m         Image: send take send take send to 2 m         Image: send take send take send take send take send take send take send	<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	түре	"N" VALUES	GROUND WAT CONDITION	ELEVATION SC	21 SHEA O UN • QL 21	0 4 R STF NCONF JICK TF 0 4	0 60 RENGT INED RIAXIAL 0 60	) 8 FH kP + . × ) 8	a FIELD REMO	VANE ULDEE	LIMIT ₩ <sub>P</sub> I WA1		o M NTENT NTEN 10 6	LIMIT W <sub>L</sub> T (%)	KN/m <sup>3</sup>	GRA DISTF	& IN SIZE RIBUTION (%) A SI CL
13       38       5         14       38       1         14       38       1         14       38       1         14       38       1         15       1       1         16       58       3         16       58       3         16       58       3         16       58       3         17       1       1         18       1       1         19       1       1         10       55       2         10       55       2         10       55       2         10       55       1         10       55       1         10       55       1         10       55       1         10       55       1         10       55       1         10       55       1         10       1       1       1       1         10       1       1       1       1       1       1         10       1       1       1       1       1       1		CLAYEY SILT, trace sand, trace gravel						159					+								
19.1       Sk1. Incere to some clay, prace         19.1       Sk1. Incere to some clay, prace         10.1       Sk1. Incere to some clay, prace         11       10         12.1       Sk1. Incere to some clay, prace         11       10         12       11         13       11         14       58         15       15         16       58         17       58         18       157         19       10         10       68         11       12         12       12         12       12         14       58         158       11         159       110         150       110         150       110         151       10         152       110         153       110         154       10         155       110         150       10         161       10       0         162       10       0       0         163       10       0       0         164       10		Stiff Brown becoming grey below a depth of 10.7 m Wet		13	SS	5	-									0					
11/1       15       35       3         15       15       35       3         15       15       35       3         15       15       35       3         15       15       3       15         15       15       15       15         15       15       15       15         15       15       15       15         15       15       15       15         15       15       15       15         15       15       15       15         15       15       15       15         15       15       15       15         15       15       15       15         15       15       15       15         150       150       10       10       10         160       140       10       10       10       10         140       140       10       10       10       10       10         140       140       10       10       10       10       10       10         140       140       140       10       10       10								158					+ +	2							
151.1         SLT, these to some day, tase mide to compact boxes with wet         16         55         1<				14	SS	3	-	157								0					
15:       15:       S8:       3         15:       15:       15:       15:         16:       S2:       15:       15:         17:       S8:       5:       148         18:       S1:       148       140       140         18:       S1:       148       147       148       141         148       147       148       141       141       141       141         148       149       141       141       141       141       141       141         144       144       144       144       144       144       144       144       144       144       144       144       144       144       144       144       144<								156				+	2 1 +								
151.1     SET, trace to some day, trace and the trace and trace an	1			15	SS	3	-								1	-					
151.1     SLT. Hade to some day, trace     0     0     0       23.1     SLT. Hade to some day, trace     16     SS     2       151     152     2     152       152     152     152       151     151     0       100     17     SS     5       18     85     15       18     85     15       18     85     15       18     85     15       146     140     140								155				+1	+2								
151.1       16       SS       2         152       +2       -       -         151       -       -       -         23.1       SUT, trace to some citay, trace       -       -         150       -       -       -       -         151       -       -       -       -       -         152       +2       +2       -       -       -         151       -       -       -       -       -       -         152       -       -       -       -       -       -       -         150       -       -       -       -       -       -       -       -         143       - <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>154</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>								154													
151.1       SLT, trace to some clay, trace and Loose to compact have move meters.       152       + + 2 + + - + - + - + - + - + - + - + -	10.0000-1						-	153													
151.1       SLT race to some day, trace some day, trac				16	SS	2	-	150								0					
151.1       SIL 7, trace to some clay, trace some c								192				+ + +									
Continued Net Page       000000000000000000000000000000000000	23.1	SILT, trace to some clay, trace sand Loose to compact						151													
Image: continued Net Pare       Image:		Brown Wet						150													
				17	SS	5	-	149								0				03	85 12
Image: continued Next Page     Image: continued Next Page     Image: continued Next Page     Image: continued Next Page								0													
144.3     Continued Next Page								148													
144.3     Continued Next Page								147													
				18	SS	15		146								0					
144.3         145         145           Continued Next Page         14.1																					
								145													
	144.3	Continued Next Page																			

+<sup>3</sup>,×<sup>3</sup>: Numbers re Sensitivity

0<sup>3%</sup> STRAIN AT FAILURE



PROJE	CT <u>12-1111-0088</u>			REC	ORI	) OF	BOR	EHC	DLE	No	13-0	)7	SHE	ET 3	OF	3		MET	RIC
G.W.P.	2177-08-00	LOC	атю	ОМ _	I	N 476557	74.3 ;E 3	36686.	4								ORIG	INATED	BY_SB
DIST_	Central HWY QEW	BOF	REHC	DLE T	/PE	108 mm	I.D. Con	tinuous	Flight	Hollow	Stem A	Augers					СОМ	PILED BY	′
DATUN	Geodetic	DAT	Е_			July 4 an	d 5, 201	3									CHE	CKED BY	MM
	SOIL PROFILE		5	Sampl	ES	ATER NS	SCALE	DYNA RESIS		DNE PE E PLOT			20	PLASTI LIMIT		JRAL TURE		THS BHT	REMARKS &
<u>ELEV</u> DEPTH	DESCRIPTION	STRAT PLO	NUMBER	ТҮРЕ	"N" VALUES	SROUND W/	LEVATION S	SHEA O UI O QI	NR STI	RENG INED RIAXIAI	TH kP + - ×	a FIELD REMO		W <sub>P</sub>			w∟ —_∎ T (%)	ND MAIN	GRAIN SIZE DISTRIBUTION (%)
29.9	CONTINUED FROM PREVIOUS PAGE Silty SAND, trace to some gravel.		_					2	0 4	0 6	8 0	0 1	0	2	0 4	0 e	50 	kN/m <sup>3</sup>	GR SA SI CL
	trace clay Loose						144												
	Grey Wet		19	SS	5									0					6 71 22 1
			╞			-	143												
142.0 32.2		1.1.1					142												
	AUGER REFUSAL																		
	1. Water level inside auger at a																		
	depth of 5.1 m below ground surface (Elev. 169.1 m) upon																		
	completion of drilling.																		
5																			

GTA-MT0 001 T:\PROJECTS\2012/12-1111-0088 (URS, VARIOUS STRUCTURE REPLACEMENT, QEW)\LOG\12-1111-0088.GPJ GAL-GTA.GDT 12/15/14



## MTO 289-1

					REC	ORD	OF E	BORE	EHO		10 1			1 (	of 3		ME	IRIC	
G.W.F	<u> </u>	LOC	CATI	_ ис		Coords	: E:3367	43.2 N:4	76555	7.5							ORIG	INATED	BY <u>SD</u>
DIST	HWY _QEW	BOF	REHO	OLE T	PE.	HOLLC	W STEN	1 AUGE	RS/CA	SING A	ND WA	SH BO	RING				_ co	MPILED	BY <u>ha</u>
DATU		DAT	ГЕ _			2015-1	1-23 - 20	15-11-2	5								_ CH	IECKED	BY <u>ra</u>
ELEV EPTH (m)	SOIL PROFILE	STRAT PLOT	NUMBER	SAMPL	PT 'N' VALUE	GROUND WATER CONDITIONS	EVATION SCALE	DYNAM RESIS 24 SHEAF 0	MIC CC TANCE 0 4 R STRE UNCOM	NE PEI PLOT NGTH	NETRAT	10N 0 1 + FIEL × LAB	Q0 D VANE VANE	PLASTI LIMIT W <sub>P</sub> 	IC NATI MOIS CON	URAL STURE ITENT W O ONTEN	LIQUID LIMIT WL T (%)	κ UNIT WEIGHT	REMARKS & GRAIN SIZ DISTRIBUTI (%)
174.3	GROUND SURFACE				S		ш	2	0 4	0 6	30 E	0 1	<u> 00</u>	1	0 2	20 :	30	kN/m <sup>3</sup>	GR SA SI
0.2	165mm ASPHALTIC CONCRETE FILL, gravelly sand, trace to some silt, trace clay, dense, brown, dry		1	AS	-	-	174												
172.9 1.4	FILL sand trace sit loose brown		2	SS	39		173							0					43 42 12
<u>172.7</u> / 1.6	FILL, silty clay, trace sand, trace gravel, firm to stiff, brown, moist to wet		3	SS	6	-	172												sampler wet a
			4	SS	6	-	172												2.3m
			5	SS	11	-	171									FO	LL=46		0238
169.9 4.4	some organics, grey SILTY CLAY, trace sand, firm to stiff.		6 XXXX	SS	5	-	170												
	grey, moist to wet		7	SS SS	4	-	169												0 1 47
						-													
			9	TW	PH	-	168			+	.9								
						-	167				+2.4								
				55	5	-	166				+	2.4							
			11	TW	РН	-	165				-	2.1			F	0	4	20.0	0 3 59
							164					+	2.7						
			12	SS	6	-						+2	.2		F	0	4		0 3 58
							163				+2.2	3							
			13	τw	РН	-	162				+								
							161			+1.4	2.1								
			14	SS	7	-	160				+				F	-			1 4 50
											+2.8								



		REC	CORD	OF E	BORE	IOLE	No 1			2	of 3		ME	TRIC				
G.W.F	p		CATIO	_ ис		Coords	: E:3367	43.2 N:476	5557.5							ORIG	INATED	BY
DIST	HWY _QEW	BOF	REHO	OLE T	YPE	HOLLO	W STEM	1 AUGERS	/CASING	AND WA	SH BC	RING				_ co	MPILED	ВҮ <u>на</u>
DATU		DAT	TE _			2015-1	1-23 - 20	15-11-25								_ CF	IECKED	BY <u>ra</u>
<u>ELEV</u> DEPTH	SOIL PROFILE	VT PLOT	MBER	SAMPL	I' VALUE	UND WATER	TION SCALE	DYNAMIC RESISTA 20 SHEAR S	CONE F NCE PLC 40 TRENGT	PENETRAT	ION 	100	PLAST LIMIT W <sub>P</sub>	IC MATI MOIS CON	URAL STURE TENT W	LIQUID LIMIT W <sub>L</sub>		REMARKS & GRAIN SIZE DISTRIBUTION
(m)		STR/	N		PT 1	GRO	LEVA	0 UN • QI	ICONFINE	D - XIAL X	+ FIEL × LAB	D VANE VANE	WA <sup>*</sup>	TER CO	ONTEN	T (%)	Y	(%)
	(continued)				0		Ξ	20	40	60 8	0 1	100	1	0 2	20 :	30	kN/m <sup>3</sup>	GR SA SI
	grey, moist to wet		15	SS	-*		159											Nov. 23, 2015 Nov. 24, 2015
							158			+ <sup>1.9</sup>								
			16	SS	5	1									0			
							157			+1.9								
			17	SS	6	-	156			+".9					0	-1		2 4 55 3
							165			+1.9								
							155			+1.5								
			18	SS	8		154			1.9	9							
							153			+ <sup>1.6</sup>								
							152											
150 <u>.</u> 5			19	SS	-*		151									0		
23.8	SILT, trace clay, trace to some sand, dense, brown, wet						150											
							149											
			20	SS	40	-	148							c	þ			0390
							110											
							147											
							146											
145.0			21	SS	148 /													Nov. 24, 2015
29.3	SANDY GRAVEL, containing cobbles and boulders, very dense, grey, moist to wet		H Ž		250mr	n	145											Nov. 25, 2015



		RECORD OF BOREHOLE No 1 3 of 3														ME	TRIC		
G.W.F	<u> </u>	LOC	ATIC	N _		Coords	: E:3367	43.2 N	:476555	57.5							_ ORIG	INATED	BY <u>sd</u>
DIST	HWY _QEW	BOR	REHO	LE T۱	PE_	HOLLC	OW STEN	1 AUG	ERS/CA	SING	AND V	VASH E	ORING				_ co	MPILED	ВҮ <u>на</u>
DATU	M <u>GEODETIC</u>	DAT	Έ			2015-1	1-23 - 20	15-11-	25								_ CF	IECKED	BY <u>ra</u>
ELEV DEPTH (m)		STRAT PLOT	NUMBER	SAMPL Jak	SPT 'N' VALUE	GROUND WATER CONDITIONS	ELEVATION SCALE	DYN/ RESI SHE/ C	AMIC CO STANCI 20 AR STRI 0 UNCO 0 QUICK 20	AO ENGTH NFINEI	ENETR 60 H (kPa) D (IAL 60	8,0 + FII × LA	100 ELD VAN B VANE 100		ATER C	TURAL ISTURE NTENT W -0			REMARKS & GRAIN SIZE DISTRIBUTION (%)
141.6	SANDY GRAVEL, containing cobbles and boulders, very dense, grey, moist to wet		22 23 24 25	RC RC SS	100/ 100/ 100mm		144 143 142												GR SA SI CI
32.7	END OF BOREHOLE		<u> </u>		75mm														
	Borehole filled with drill water upon completion of drilling.																		
	*Rods slipped while attempting SPT Test																		
	Consolidation test performed on TW11.																		
	Borehole extended with a Tricone bit from 31,3m to 32,6m,																		

#### Borehole 6

Ground Surface elevation 592.04 Top of bedrock depth 40'-4" " " elevation 551.71 B X L core was recovered from 40'-4" to 55"-5" and is described as follows.

40"-4"-42"4" Grey Dolomite, Genereally sound with some slight weathering. 42"-4"-46"-4" Grey Dolomite, sound. At 43"-4" lost some drilling water, no evidence in the core. 46"-4"-55"5" Grey Dolomite, Generally sound with vuggy texture, porous rock with water worn cavities up to 1"X¼"X½". some brown and white crystals in cavities probably calcite.

#### Piezometer 7

Ground surface elevation - 593.00 Continuous 3" diatmeter shelby tube samples were taken within the upper reddish silt stratuen from 15'-17', 17'-19' and 19'-21'. A piezometer was installed at 19 feet and sealed within the upper silty clay stratum.

The water level within the supper silt stratum has been establised at 6ft. 6 in.

#### Piezometer 8

Ground surface elevation - 592.34 Continuous 3" diatmeter shelby tube samples were taken within the lower reddish silt stratum from 30'-32', 32'-34' and 34'-36'. A piezometer was installed at 34ft 6in. and sealed within the lower sily clay stratum. The water level within the lower silt stratum has been established at llft 6in. A gradation curve of this stratum is attached.



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REGIONAL MUNICIPALITY OF NIAGARA SOUTH NIAGARA FALLS WASTEWATER SOLUTIONS

# **Geotechnical Investigation**

Preliminary Geotechnical Investigations – Preferred WWTP Site and Trunk Sewer





# REPORT ON PRELIMINARY GEOTECHNICAL INVESTIGATION FOR PROPOSED SOUTH NIAGARA FALLS WASTEWATER TREATMENT PLANT (WWTP) AND ASSOCIATED TRUNK SEWER, TOWNSHIP OF WILLOUGHBY, REGION OF NIAGARA

**REGION OF NIAGARA** 

PROJECT NO.: 201-11602-00 MAY 27, 2022

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Contr



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Report on Preliminary Geotechnical Investigation for Proposed South Niagara Falls Wastewater Treatment Plant (WWTP) and Associated Trunk Sewer, Township of Willoughby, Region of Niagara Project No. 201-11602-00 Region of Niagara WSP May 2022 Page ii The original of this digital file will be conserved by WSP Canada Inc. for a period of not less than 10 years. As the digital file transmitted to the intended recipient is no longer under the control of WSP Canada Inc., its integrity cannot be assured. As such, WSP Canada Inc. does not guarantee any modifications made to this digital file subsequent to its transmission to the intended recipient.

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- C RESULTS OF ROCK UNCONFINED COMPRESSIVE STRENGTH TESTS
- D PHOTOGRAPHS OF ROCK CORE
- E ONE-DIMENSIONAL CONSOLIDATION TEST
- F TUNNELMAN'S GROUND CLASSIFICATION AND PROBABLE WORKING CONDITIONS

## 1 Introduction

WSP Canada Inc. (WSP) was retained by the Region of Niagara to undertake a preliminary geotechnical investigation for the proposed trunk sewer installation from the existing High Lift Sewage Pumping Station (SPS), along Montrose, Brown and Reixinger Roads, to the proposed location of a new Wastewater Treatment Plant (WWTP) at 6811 Reixinger Road.

The purpose of the investigation was to determine the subsurface conditions at the borehole locations and from the findings in the boreholes to make geotechnical engineering recommendations for the proposed watermain.

It is understood the proposed 1500 mm and 1800 mm concrete trunk sewer will be installed as part of South Niagara Falls Wastewater Solution project. It is further understood the invert of the proposed pipe will be at about 9.8m to 22.0m below existing ground.

This report is provided on the basis of the terms of reference presented above and, on the assumption, that the design will be in accordance with the applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning the geotechnical aspects of the codes and standards, this office should be contacted to review the design. It may then be necessary to carry out additional borings and reporting before the recommendations of this office can be relied upon.

The site investigation and recommendations follow generally accepted practice for geotechnical consultants in Ontario. The format and contents are guided by client specific needs and economics and do not conform to generalized standards for services. Laboratory testing for most part follows ASTM or CSA Standards or modifications of these standards that have become standard practice.

This report has been prepared for the Region of Niagara. Use of this report by third party without WSP consent is prohibited.

## 2 Field and Laboratory Works

### 2.1 Geotechnical Boreholes and Field Testing

The field investigation consisted of drilling a total of seventeen (17) exploratory boreholes (BH20-1 through BH20-12S/D and BH-P01 to BH-P03, see **Drawings 2** to **10** for borehole locations) to depths ranging from 4.6 of 39.6 m below ground surface.

A summary of the borehole data is presented in **Table 2.1**.

Location	Easting		Northing	Approximate Ground Elevation (m)	Depth of Borehole (m)	Note
		NAD83, UT	M Zone 17			
High Lift	BH20-01	653265.4	4769584.2	180.5	16.8	Monitoring
Montrose	BH20-02	652816.7	4769568.12	181.2	16.8	-
Brown	BH20-03	652136.1	4769057.2	178.1	20.1	Monitoring
Montrose	BH20-04	652847.8	4769091.2	178.9	19.9	-
Montrose	BH20-05	652873.2	4768160.9	177.8	25.0	-
Montrose	BH20-	652872.7	4767709.7	175.8	30.5	Monitoring
Montrose	BH20-	652872.6	4767710.5	175.8	15.2	Monitoringg
Montrose	BH20-	652880.1	4767374.6	177.1	30.7	Monitoring
Montrose	BH20-	652880.3	4767373.8	177.0	19.8	Monitoring
Reixinger	BH20-08	654312.3	4766690.0	176.9	39.6	Monitoring
Montrose	BH20-09	652916.4	4766605.9	176.0	29.3	-
Future	BH20-10	654268.2	4766859.2	176.7	9.8	Monitoring
Future	BH20-11	654318.8	4766986.7	176.5	9.8	Monitoring
Future	BH20-	654078.5	4767290.4	174.9	9.8	Monitoring
Future	BH20-	654080.1	4767289.9	174.9	4.6	Monitoring
Montrose	BH-P01	653228.0	4769629.8	180.5	7.6	Monitoring
Brown	BH-P03	4769057.188	652135.2	178.1	5.2	Monitoring

Table 2.1Summary of Borehole Information

Borehole locations for this investigation were established by WSP personnel in accordance with the Region of Niagara requirements. Prior to drilling operations, all underground utilities were cleared at the borehole locations.

The field investigation work of drilling the boreholes were undertaken on December 2 to 23, 2020 by a drilling sub-contractor under the direction and supervision of WSP personnel. Borehole logging services were provided by the engineering staff of WSP. The boreholes were advanced with power auger drilling machines equipped with hollow stem augers. The soil stratigraphy was recorded by observing the quality and changes of augered materials which were retrieved from the boreholes, and by sampling the soils at regular intervals of depth using a 50 mm O.D. split spoon sampler, in accordance with the Standard Penetration Test (ASTM D 1586) method. This sampling method recovers samples from the soil strata, and the number of blows (SPT 'N'-values) required to drive the sampler 0.3 m depth into the undisturbed soil gives an indication of the compactness condition or consistency of the sampled soil material. The SPT 'N' values are indicated on the borehole log sheets (Refer to **Appendix A**). Soil samples were visually classified in the field and later re-evaluated in our laboratory.

Upon encountering bedrock in BH20-01, BH20-03 to BH20-05, BH20-07D, BH20-08 and BH20-09, coring of the rock was affected with HQ-2 size double tube wireline equipment, allowing recovery of 63mm diameter rock cores. The monitoring technician recorded the standard penetration test resistances and visually described the soil and rock samples. The Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) values and Fracture Indices (FI) were recorded for the rock cores in accordance with the conventions used by the International Society for Rock Mechanics (ISRM). An explanation of these terms is presented in the fly sheet at the beginning of **Appendix A**. Photographs of the recovered cores are provided in **Appendix D**.

The ground surface elevations at the borehole locations were surveyed by WSP and referenced to a geodetic datum.

Groundwater monitoring wells were installed in thirteen (13) boreholes and the groundwater level measured from the monitoring wells are provided in Section 3.7.

## 2.2 Geotechnical Laboratory Testing

The soil samples were taken to our laboratory where they were re-examined. Representative samples were selected for geotechnical index testing. The testing program consisted of the measurement of the natural moisture content of all available soil samples, grain size analyses on twenty-one (21) selected samples and consistency (Atterberg) limits for nine (7) soil samples and two (2) soil unit weight. A one-dimensional consolidation test performed on undisturbed sample collected from soft clay and the results are attached in **Appendix E**. Test results are

shown on the individual borehole logs presented in **Appendix A**. The grain size analysis curves and results of the consistency (Atterberg) limit tests are plotted on **Figures 1 to 9** attached to this report in **Appendix B**.

Testing of the rock cores consisted of point load index strength tests on six (6) samples, unconfined compressive strength (UCS) tests on six (6) rock samples with measurement of unit weight ( $\gamma$ ). These test results are provided in **Appendix D**. Results of point load tests and unconfined compressive strength are also presented on the borehole log sheets of **Appendix A**.

## **3 Subsurface Conditions**

The borehole location plan and profiles are shown in **Drawings 1** to **10** and explanation of terms used in the record of borehole are presented in **Appendix A**. The subsurface conditions in the boreholes are presented on individual borehole logs (Refer to **Appendix A**). The subsurface conditions in the boreholes are summarized in the following paragraphs.

## 3.1 Pavement/Topsoil/Fill Material

The boreholes BH20-10 to BH20-12 were drilled on agricultural land and encountered about 150mm to 230mm of topsoil at the surface.

Five boreholes (BH20-02, BH20-03, BH20-05, BH20-06D, and BH20-09) were encountered 100mm to 150mm thick asphalt at the surface. 50mm and 700mm granular base material encountered in borehole BH20-05 and BH20-09, respectively. Below asphalt, 6.4 m thick crushed run limestone was encountered in BH20-02; 1.3 m thick granular fill was encountered in BH20-03; 50 mm granular fill and 0.9m crusher run limestone were encountered in BH20-05; 1.7 m thick crushed run limestone was encountered in BH20-06D; and 0.7 m thick granular fill was encountered in BH20-09. 0.8 m thick crushed run limestone was also encountered within the silty clay fill in BH20-06D

0.1 to 0.8 m thick crushed run limestone was encountered at ground surface in BH20-04 and BH20-07D.

Silty clay fill was encountered in some boreholes to depths varying from 1.1 to 5.7 m below ground surface (mbgs). Trace to some inclusions of organics were noted in the fill material. Fill was present in soft to very stiff consistency, with measured SPT 'N' values varying from 3 to 27 blows per 300 mm of penetration.

One (1) selected silty clay fill samples (BH20-3/SS6) were subjected to grain size analysis. Gradation curve is presented in **Figure 1** of **Appendix B** and summarized below:

Gravel:	0 %
Sand:	1 %
Silt and clay:	99 %

Atterberg limit testing was performed on the same sample (BH20-3/SS6) and the results is provided on **Figure 2** in **Appendix B**. The results of this testing indicated liquid limits of 54, plastic limits of 25, and plasticity indexes of 29. Based on this, the soil is classified as silty clay to clay of high plasticity (CH) according to the Unified Soil Classification System.

## 3.2 Silty Clay

Below the fill material in all boreholes a deposit of silty clay was encountered at depths of 1.1 to 6.6 mbgs and extended to depths of 4.6 to 23.2 mbgs. The borehole BH20-10 to BH20-12 were terminated within this cohesive deposit.

The cohesive deposit was found to be in a very soft to hard consistency with measured SPT 'N' value of nil blows to 30 blows per 300 mm of penetration. The water content obtained from the samples revealed from this deposit were 6 to 40%.

A layer of organic clay was embedded within the silty clay deposit in borehole BH20-06 at depths of 7.2 to 9.3 mbgs with measured SPT 'N' value of 0 to 4 blows per 300 mm of penetration and natural moisture content of 102 to 117%. The SPT 'N' value of 0 blow per 300 mm means the sampler settles more than 300 under the weight of 63.5 kg hammer.

Shear vane in-situ test was carried out within the silty clay deposit at regular intervals where the SPT 'N' values below 10 blows for 300 mm penetration. Shear vane testing within the silty clay deposit yielded shear strengths 28 to 59 kPa, indicating a firm to stiff consistency. The sensitivity ranged from 1.0 to 3.3.

One oedometer test was conducted on the silty clay sample at a depth of 6.6 mbgs. The test shows a compression index of 0.72, recompression index of 0.06, void ratio of 1.0, unit weight of 18.3 kN/m<sup>3</sup> and preconsolidation pressure of 180 kPa.

A layer of silt was interbedded within the silty clay deposit in borehole BH20-03, BH20-08 and BH20-09 at depths of 4.6 to 13.3 mbgs and extended to depths of 5.3 to 14.8 mbgs. The silt deposit was found to be in loose to compact state of compactness with measured SPT 'N' value of 8 to 24 blows per 300 mm penetration. The natural moisture content obtained from the sample reveled from silt layer was 24 to 27%.

Seventeen (17) selected silty clay samples were subjected to grain size analysis and Atterberg limit testing was performed on eight (8) samples and the results are provided on **Figure 3** in **Appendix B**. Gradation curves are presented in **Figure 4** of **Appendix B** and the result of gradation and Atterberg limit test are summarized in table below:

Borehole No.	Sample No.	Gravel %	Sand %	Silt and Clay %	Plastic Limit	Liquid Limit	Plastic Index
BH20-01	SS5	0	1	99	23	51	28
BH20-01	SS9	0	1	99	20	37	17
BH20-02	SS11	0	0	100	-	-	-

Report on Preliminary Geotechnical Investigation for Proposed South Niagara Falls Wastewater Treatment Plant (WWTP) and Associated Trunk Sewer, Township of Willoughby, Region of Niagara Project No. 201-11602-00 Region of Niagara

BH20-03	SS5	0	0	100	17	31	14
BH20-04	SS9	0	4	96	16	31	15
BH20-04	SS12	0	0	100	-	-	-
BH20-04	SS14	0	0	100	-	-	-
BH20-05	SS9	0	2	98	19	37	18
BH20-05	SS14	0	5	95	17	26	9
BH20-06	SS16	4	3	93	-	-	-
BH20-07	SS18	0	15	85	-	-	-
BH20-09	SS12	0	5	95	17	27	10
BH20-09	SS15	5	8	87	18	34	16
BH20-09	SS17	0	4	96	-	-	-
BH20-10	SS11	1	5	94	-	-	-
BH20-11	SS11	0	4	96	-	-	-
BH20-12	SS11	1	6	93	-	-	-

Based on this, the soil is classified as low to high plasticity silty clay or clay (CL or CH) according to the Unified Soil Classification System.

## 3.3 Clayey Silt Till

A deposit of clayey silt till deposit was encountered below the silty clay layer in borehole BH20-1 and below silt layer in boreholes BH20-2 and BH20-7 locations at depths of 10.2 to 24.7 mbgs. The clayey silt deposit was extended to the borehole depths of 11.7 to 26.4 mbgs.

Boulders/cobbles within the till deposit were interfered during the borehole drilling due to high SPT 'N' value and nature of deposit. The current investigation method could not determine the size and frequency of boulder and cobbles.

In general, SPT 'N' values in this deposit ranged from 7 to more than 50 blows per 300mm penetration, corresponding to firm to hard consistency. The moisture content of samples recovered from cohesionless deposit ranged between 8% to 24%.

A selected clayey silt till sample (BH20-1/SS12) was subjected to grain size analyses. Gradation curve is presented on **Figures 5** of **Appendix B** and summarized below:

Gravel:	11%
Sand:	32%
Silt:	45%
clay:	12%

## 3.4 Sandy Gravel/Sand/Silt and Sand/Silt

Below the silty clay layer or below clayey silt till deposit in all boreholes, a deposit of cohesionless soils comprised of silt, silt and sand & sandy gravel was encountered at depths of 11.7 to 23.2 mbgs and extended to depths of 14.3 to 27.4 mbgs. The cohesionless deposit was found in very loose to very dense state of compactness with measured SPT 'N' value of 2 to over 50 blows per 300 mm penetration. Water contents ranged from 9% to 27%.

Boulders/cobbles should be expected within the cohesionless deposit due to their nature of deposit.

Three (3) selected silt to silty sand samples (BH20-1/SS13, BH20-3/SS17 and BH20-4/SS15) were subjected to grain size analyses. Gradation curves are presented on **Figures 6** of **Appendix B** and summarized below:

Gravel:	3 to 26%
Sand:	5 to 40%
Silt And Clay:	34 To 92%

## 3.5 Clayey Silt (Residual Soil)

Localized clayey silt (residual soil) clay deposit in borehole BH20-09. The residual soil deposit extended to a depth of 19.9 mbgs. The deposit hard clayey silt matrix containing extensive broken bedrock slabs and fragments. This stratum was difficult to auger due to the fragmented dolostone content and given its hard condition. The natural moisture content measured in the test sample from these materials was 13%.

This complex is a transitional deposit between bedrock and the overlying soil or may be the completely to highly weathered bedrock. This deposit has characteristics of both the bedrock and soil. The rock slabs found within the soil matrix can be quite large in size (0.5m to 1m or more).

## 3.6 Bedrock

Dolostone of Salina Formation was cored and inferred due to auger/spoon refusal in boreholes BH20-01, BH20-03, BH20-04, BH20-05, BH20-06D, BH20-07D, BH20-08 and BH20-09 at depths ranging from 14.3 to 29.3 m below the existing ground surface, corresponding to Elevation 147.6 to 166.1 m, as listed in **Table 3.1**. Bedrock was proven by bedrock coring in boreholes BH20-01, BH20-03, BH20-04, BH20-05, BH20-07, BH20-08 and BH20-09. Rock core logs are provided on borehole logs appended in **Appendix A** and the photographs of the rock cores are provided in **Appendix D** of this report. The rock core mainly consists of dolostone.

Borehole No.	Existing Ground Surface Elevation (M)	Depth Of Bedrock Surface Below Existing Ground (M)	Approximate Elevation of Bedrock Surface (M)	Notes
BH20-01	180.5	14.3	166.1	Bedrock coring
BH20-03	178.1	15.2	162.9	Bedrock coring
BH20-04	178.9	16.5	162.5	Bedrock coring
BH20-05	177.8	23.8	154.1	Bedrock coring
BH20-	175.8	27.4	148.4	Augering
BH20-	177.1	26.4	150.7	Bedrock coring
BH20-08	176.9	29.3	147.6	Bedrock coring
BH20-09	176.0	20.9	155.1	Bedrock coring

#### Table 3.1 Approximate Depth and Elevation of Bedrock Surface

Because of the method of drilling and sampling, the surface elevations of the bedrock may be different than indicated on the borehole logs. With augering, the auger may penetrate some of the more weathered dolostone and the coring may therefore begin below the bedrock surface. As such, the interred bedrock surface level should not be considered accurate to better than +/-1.5m.

The descriptive terms used on the record of rock cores and throughout this report are explained on the "Explanation of Terms Used in the Bedrock Core Log" sheet in **Appendix A**. In general, the conventions of the International Society for Rock Mechanics (ISRM) are

adopted herein. Detailed descriptions of the index properties and results of laboratory testing are presented in the following paragraphs.

Six-point load index strength tests were performed on dolostone rock samples. The test results are presented in individual borehole logs. The equivalent unconfined compressive strength of rock samples was inferred to range from 40.0 to 189.0 MPa in axial direction with average strength of 92.8 MPa and from 24.0 to 96.0 MPa in the diametral direction with average strength of 56.8 MPa. The values are indicative "weak" to "very Strong", but generally "medium strong" to "very strong" rock under ISRM strength convention.

The UCS of the tested samples of bedrock ranged from 100 to 223.5 MPa. The test results indicated that the dolostone samples are "strong" to "very strong" rock under the ISRM strength convention. Results of point load tests and unconfined compressive strength are also presented on the borehole log sheets and appended in **Appendix C**.

#### 3.6.1 Total Core Recovery (Tcr)

The total core recovery indicates the total length of rock core recovered, expressed as a percentage of the actual length of the core run. The total core recovery ranged from 58% to 100%. Generally, low core recovery was experienced only near the surface of the rock, where the formation is more weathered.

#### 3.6.2 Solid Core Recovery (Scr)

The solid core recovery is the total length of solid, full diameter rock core that was recovered, expressed as a percentage of the length of the core run. Solid core recovery ranged from 23% to 100% but generally was found to be in the range of 70% to 100% generally improving with depth. The SCR index is influenced by the orientations of the fractures.

#### 3.6.3 Rock Quality Designation (Rqd)

The rock quality designation index is obtained by measuring the total length of recovered rock core pieces which are longer than 100 mm and expressing the sum total length as a percentage of the length of the core run. RQD is a function of the frequency of joints, bedding plane partings and fractures in the rock cores. On the basis of the recorded RQD values which range from nil to 100%, the rock quality is estimated to be "very poor" to "excellent", and the average value of 64.3% suggests a rock of generally "fair" quality.

#### 3.6.4 Fracture Index

When logging the rock cores, the fracture Index (i.e. the number of fractures for each 0.3 m length of core) was also recorded. It was observed that the planes of weaknesses along which the cores tended to break, included planes of fissility and bedding, and some oblique and subvertical joints.

## 3.7 Groundwater Conditions

The groundwater levels measured in the monitoring wells installed along proposed trunk sewer and WWTP investigation are summarized in **Table 3.2**.

Borehole No.	Date Of Drilling	Existing Ground Elevation (m)	Date Of Water Measurement	Screen Depth (m)		Groundwater Level Depth (m)	Groundwater Level Elevation (m)
				From	То		
BH20-01	Dec. 9, 2020	180.5	Dec. 18, 2020 Dec. 23, 2020	15.3	16.8	9.9 9.8	170.5 170.7
BH20-03	Dec. 2, 2020	178.1	Jan. 13, 2021	4.6	7.6	3.5	174.6
BH20- 06D	Dec. 15, 2020	175.8	Jan. 13, 2021	28.4	30.5	3.5	172.3
BH20- 06S	Dec. 15, 2020	175.8	Jan. 13, 2021	12.2	15.2	3.9	171.9
BH20- 07D	DEC. 21, 2020	177.1	Jan. 13, 2021	27.4	30.5	5.3	171.8
BH20- 07S	DEC. 23, 2020	177.0	Jan. 13, 2021	16.8	19.8	4.6	172.4
BH20-08	DEC. 18, 2020	176.9	Dec. 23, 2020 Jan. 13, 2020 Jan. 26, 2021	36.6	39.6	6.5 4.6 4.7	170.4 172.3 172.2

 Table 3.2
 Summary of Groundwater Observations in Monitoring Wells

Borehole No.	Date Of Drilling	Existing Ground Elevation (m)	Date Of Water Measurement	Screen Depth (m)		Groundwater Level Depth (m)	Groundwater Level Elevation (m)
				From	То		
BH20-10	DEC. 11, 2020	176.7	Dec. 18, 2020 Dec. 23, 2020	6.7	9.7	6.2 5.2	170.6 171.5
BH20-11	DEC. 11, 2020	176.5	Dec. 18, 2020 Dec. 23, 2020	6.7	9.7	7.1 6.7	169.3 169.8
BH20- 12D	DEC. 10, 2020	174.9	Dec. 18, 2020 Dec. 23, 2020	6.7	9.7	7.0 6.9	167.9 168.0
BH20- 12S	DEC. 10, 2020	174.9	Dec. 18, 2020 Dec. 23, 2020	1.5	4.5	4.0 3.7	170.9 171.2
BH-P01	DEC. 9, 2020	180.5	DEC. 18, 2020 DEC. 23, 2020	4.6	7.6	3.5 2.3	177.0 178.2
BH-P03	DEC. 3, 2020	178.1	JAN. 13, 2020	2.2	5.2	3.3	174.8

It should be noted that the groundwater levels can vary and are subject to seasonal fluctuations in response to major weather events. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Refer to WSP's report entitled "Preliminary Hydrogeological Investigation – South Niagara Falls WW Solutions EA, Niagara Region, ON", dated May 27, 2022 for detailed discussions on the groundwater.

## 4 Geotechnical Interpretation and Recommendations

In this section, the subsurface conditions are interpreted as relevant to the design and construction of the proposed sewer trunk installation in Section 4.4, shaft installation in Section 4.5, and construction of wastewater treatment plant in Section 4.6 at the aforementioned sites. Comments relating to construction are intended for the guidance of Region of Niagara and its designers to establish the construction method.

The construction methods described in this report must not be considered as being specifications or direct recommendations to contractors, or as being the only suitable methods. Prospective contractors should evaluate all of the factual information, obtain additional subsurface information as they might deem necessary and should select their construction methods, sequencing and equipment based on their own experience in similar ground conditions. The readers of this report are also reminded that the conditions are known only at the borehole locations and in view of the generally wide spacing of the boreholes, conditions may vary significantly between boreholes.

## 4.1 Overview Of Subsurface Conditions and Recommended Geotechnical Parameters

#### 4.1.1 Overview Of Subsurface Conditions

In simplified terms, the subsurface profile consists of pavement structure, topsoil or surficial fill material underlain by a native very soft to very stiff (occasional hard spot) cohesive silty clay textures, the cohesive deposit followed by sand to gravelly sand deposit or clayey silt till deposit. The bedrock underlaying the site at depths of 14.3 to 29.3 mbgs (Elev. 147.6 to 166.1 m). At the monitoring well locations, the groundwater table lies between 2.3 and 11.0 mbgs (between Elev. 167.9 m and 178.2 m). Perched water should be expected in the shallow granular fill and in any granular fill in the existing nearby utility trenches.

Borehole locations and subsurface profiles of the trenchless and open cut sections are presented in **Drawing Nos. 1** through **10**.

#### 4.1.2 Recommended Design Parameters For Soil And Groundwater

Suggested soil parameters (unfactored) for the design of pumping station, chambers/manholes and ground support systems are summarized in **Table 4.1**. The suggested soil parameters are based on SPT 'N'-values, soil laboratory test results and supplemented by the judgement based on local and regional experience with these soil types.

New Granular Soil Type Fill Spt 'N'			Existing Fill	Cohesive Native Soils - Silty Clay/Clayey Silt				Non-Cohesive Native Soils –Sand, Sandt Gravel, Silty Sand Gravely nd Silt			
	' <b>A</b> '	'B'	2-18	1-7	8-14	15-29	≥30	1-9	10- 19	20-49	≥50
UNIT WEIGHT (kN/m³)	22	21	20.5	19	20.5	21	21.5	19	20	21.5	22.5
EFFECTIVE ANGLE OF INTERNAL FRICTION ( <sup>0</sup> ), Ø'	35	32	28	26	28	30	32	28	30	32	37
EFFECTIVE COHESION, C' (kPa)	-	-	1	0	5	10	15	-	-	-	-
UNDRAINED SHEAR STRENGTH (kPa) (**)	-	-	50	30	75	100	200	-	-	-	-
	C	OEFFIC	IENT OF	LATEF	RAL EAI	RTH PI	RESSL	JRE			
ACTIVE, Ka	0.27	0.31	0.36	0.39	0.36	0.33	0.31	0.36	0.33	0.31	0.25
AT REST, Ko	0.43	0.47	0.53	0.56	0.53	0.50	0.60	0.53	0.50	0.55	0.80
PASSIVE, Kp	3.69	3.25	2.77	2.56	2.77	3.00	3.25	2.77	3.0	3.25	4.03
ELASTIC MODULUS (MPa)	-	-	4	4	8	15	30	4	5	30	50
POISSION'S RATIO	-	-	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

 Table 4.1
 Recommended Unfactored Soil Parameters

Soil Type Spt 'N'	New Granular Ex Fill		Existing Fill	Cohesive Native Soils - Silty Clay/Clayey Silt			Non-Cohesive Native Soils –Sand, Sandt Gravel, Silty Sand Gravely nd Silt				
	'A'	'B'	2-18	1-7	8-14	15-29	≥30	1-9	10- 19	20-49	≥50
MODULUS OF SUBGRADE REACTION, K (MN/m³) (*)	-	-	4/B	4/B	8/B	15/B	30/B	4/B	5/B	30/B	50/B
LATERAL MODULUS OF SUBGRADE REACTION, Ks (MN/m <sup>3</sup> ) (*)	-	-	4/B	4/B	8/B	15/B	30/B	4/B	5/B	30/B	50/B

(\*) B is the width of footing/Pipe in metres.

(\*\*) The recommended undrained shear strength is used for the structural design, not for the selection of the excavation machine for which an undrained shear strength of up to 1000 kPa should be considered.

For the design purpose the groundwater level must be taken as the higher of 1m higher than the measured groundwater level in the nearest monitoring wells and the regional flood level.

#### 4.1.3 Cobbles and Boulders

Boulders/cobbles were inferred based on auger grindings and high SPT 'N' value in the cohesionless and till deposit as well as residual soils. A very slow rate of drilling advancement was experienced during augering of these deposits given their heavily overconsolidated nature and presence of cobbles/boulders. The current investigation method of borehole drilling could not determine the size and frequency of the cobbles and boulder.

Cobbles are defined as rock fragments that cannot pass through a screen with 75 mm square openings and are less than 300 mm in maximum dimension. Boulders are defined as rock fragments with their maximum dimension being equal to or greater than 300 mm. Removal of cobbles during open cut excavations is considered part of routine construction and these materials will not be considered as obstructions for this project.

Boulders and other obstructions including but not limited to construction debris will be randomly distributed within the fill. Considering that the fill materials extend from the ground

surface to relatively shallow depths, it is not considered necessary, and it is not feasible, to estimate the frequency of obstruction within the fill.

The majority of boulders within the cohesionless deposit are expected to be generally less than 1 m in diameter; however, boulders with maximum dimensions of between 2 and 3 m have been encountered in excavations in the soil deposits of Southern Ontario. Cobbles and boulders shall be assumed to be comprised of Canadian Shield derived igneous or metamorphic rock of "extremely high" Cerchar abrasiveness and "very strong to extremely strong" unconfined strength (100 MPa to 250 MPa), as defined by ISRM (International Society for Rock Mechanics).

For preliminary geotechnical design, boulders (maximum dimension > 300mm) will comprise the following percentages by total volume of excavated soils based on local and regional experience:

- Cohesionless deposit 0.5%
- Glacial till deposit 0.5%
- Residual soil 2.5%

## 4.2 Frost Depth

All pipes and footings must have at least 1.1 m of earth cover for frost protection.

## 4.3 Seismic Site Classification

Based on the borehole information and according to Table 4.1.8.4.A of OBC 2012, the subject site for the proposed structures founded on native soils and bedrock can be classified as 'Class D' and "Class C' for seismic site response, respectively.

### 4.4 Trunk Sewer Installation with Trenchless Method

Based on information provided in the preliminary design drawing the majority of the proposed sewer trunk will be installed using trenchless techniques. The information provided by borehole BH20-1 to BH20-5 and BH20-9 as shown in **Drawing Nos. 2** to **10** indicate that within the proposed trunk sewer alignment, the soils mainly consist of soft to firm silty clay and compact to very dense silty sand to sand and gravel, and the soil will be very stiff to hard silty clay or loose to very dense cohesionless deposit at alignment with the location of boreholes BH20-06D/S to BH20-07D/S . Obstructions such as boulders/cobbles in the dense to very dense

cohesionless deposit should be expected. The groundwater level was varying from 2.3 m to 11.0 m below existing ground surface corresponding to elevation 167.9 to 178.2 m.

The soft to firm silty clay for the purpose of tunnelling can be categorized as "squeezing" and the cohesionless deposit below groundwater table should be consider as "flowing", "fast ravelling" and "bouldery" ground in accordance with the behaviouristic ground classification system established by Terzaghi in 1950. (Refer to **Appendix F** for definitions of ground performance in tunnelling). The silty clay should be considered as "sticky" clay for tunnelling. In general, trenchless condition is considered to be challenging due to presence of the soil deposits ranged from soft cohesive soil to very dense cohesionless soils as well as cobbles/boulders within the cohesionless soils and high groundwater table.

It is understood that microtunnel boring machine (MTBM) will be used for the installation of trunk sewer. In this case, following should be considered:

The MTBM is capable to operate within the soft to firm clay with lowest SPT N-value of 2. Alternatively, consideration should be given to improve the soft to firm soils using soil improvement methods such as jet grout or other methods; and

Additional geotechnical investigation with borehole drilling, piezocone penetration tests and laboratory tests for the design of concrete pipe and soil improvement.

Alternatively, consideration should be given to lower the proposed trunk sewer alignment into the bedrock or dense to very cohesionless soil from Sta. 1+020 to approximately 3+080. Additional deep borehole drilling, rock coring and testing are required to conform the bedrock surface and properties.

### 4.5 Sealed Shafts

It is proposed to construct seven (7) sealed shafts (six shafts will be of diameter 3 m and one will be of 1.8 m diameter) that will be used to launch and receive the tunneling equipment, including the sanitary sewers. On completion of the tunneling work, all the seven shafts will be converted to sanitary sewer manholes. The excavation for the shafts will penetrate through fill, cohesive soils (till and non-till silty clay) and cohesionless soils (silt, sand, sand and gravel, gravelly sand). The shafts can consist of cast-in-place concrete circular shafts constructed top-down, excavated in–the-wet progressively as the concrete ring segments are cast and pushed down. Mass concrete plug is recommended to be placed at the shaft bottom to form a working base.

Alternatively contiguous caisson walls or Continuous interlocked steel sheet piles toed into the bedrock can be considered to minimize the need of dewatering for the construction of shafts.

The groundwater inflow during construction within a sealed shaft can be removed using sump pumps.

The design and construction of the permanent shaft support will be the responsibility of the contractor who must retain a specialist shoring design engineer. All shoring designs shall be in accordance with the 4th Edition of the Canadian Foundation Engineering Manual and must be reviewed by a Geotechnical Consultant. For cast-in-place concrete circular shafts, the coefficient of earth pressure at rest ( $K_0$ ) as recommended in Table 4.1 should be used.

#### 4.5.1 Lateral Earth Pressure

The lateral earth pressure can be evaluated from the following equation.

 $P = K_0 (\gamma h + q) + \gamma_W h$ 

where p = lateral earth pressure in kPa acting at depth h

 $K_0$  = coefficient of lateral earth pressure, taken the value from Table 4.1

 $\gamma$  = unit weight of backfill, taken the value from Table 4.1

h = depth below ground surface, m

q = surcharge load at ground surface kN/m<sup>2</sup>

 $\gamma_W$  = unit weight of water = 10 kN/m<sup>3</sup>

For design purpose, the groundwater level must be taken as the higher of 1m higher than the measured groundwater level in the nearest monitoring wells and the regional flood level.

If the ground surface is not horizontal due to excavation for the open cut section or because of the natural ground, then the uneven portion can be treated as an equivalent surcharge.

During freezing conditions, the shored walls must be protected against frost penetration and the build-up of frost pressure behind the wall.

#### 4.5.2 Uplift Pressure

The sealed shafts and the permanent structures (the MHs) should be designed as water-tight structure, and uplift forces on the shaft structure should assume buoyancy forces corresponding to the high design ground water level shall be taken as the higher of 1m higher than the measured groundwater level in the nearest monitoring wells and the regional flood level.

If the combination of the weight of the structure and the mobilized frictional resistance between the buried portion of the exterior walls and the backfill materials is insufficient to resist the uplift forces during any stage of the construction and/or during the operation of the structure, then a fail-safe system of grouted ground anchors is needed.

Post tensioned pressure-grouted soil anchors bonded into firm to stiff silty clay and compact gravelly sand can be designed using an allowable bond resistance of 30 kPa, but in no case should the bonded length be less than 4m. The group ground anchor capacity should be the minimum of (a) the sum of the individual anchor capacity or (b) the sum of the shear (bond) resistance mobilised on the surface perimeter area of the group and the effective weight of anchor/soil enclosed by this perimeter.

Pressure-grouted rock anchors can be designed using an allowable bond resistance of 300 kPa, but in no case should the bonded length be less than 4m.

The actual capacity (bond resistance) of the anchors should be established by at least two (2) full scale pull-out tests ("performance test") in accordance with Canadian Foundation Manual (4th edition), testing to 200% of working load. Each installed anchor must be proof loaded to 1.33 times the design working load, in accordance with Post-Tensioning Institute (PTI) guidelines.

Permanent ground anchors should be double-corrosion protected (i.e. PTI Class I).

Friction between the exterior walls and the granular backfill materials should only be taken into account if it is absolutely certain that no excavations will be undertaken around the exterior walls any time in the future. In this case, an ultimate friction factor of 0.4 applied to the horizontal earth pressure on the wall could be used, the average coefficient of earth pressure of 0.53, and unit weight of 10.7 kN/m<sup>3</sup> below groundwater table can be used in the calculation of horizontal earth pressure. When checking the overall stability of the structure, the design should incorporate a minimum safety factor of 1.1 when using only the dead weight of the structures. The safety factor to be used for the frictional resistance should not be less than 2.0.

### 4.6 Wastewater Treatment Plant

We understand that buildings, chambers, tanks, pumping station, roadways and yard piping will be constructed at the proposed wastewater treatment plant (WWTP).

#### 4.6.1 Foundations

Boreholes BH20-8 and BH20-10 to BH20-12 were drilled in the area of WWTP. Boreholes BH20-10 to BH20-12 were drilled to a depth of 9.8 m and were terminated within the overburden. However, Borehole BH20-8 was drilled and cored to a depth of 39.6 m below existing grade. As per borehole BH20-8, the subsurface conditions in general consisted of firm to stiff clayey fill extending to a depth of 1.5m below the existing grade, which in-turn was

followed by very soft to stiff silty clay extending to a depth of 13.3 m, further underlain by a compact dilatant silt extending to a depth of 14.8 m, further underlain by very soft to stiff silty clay extending to a depth of 23.2 m, further underlain by compact dilatant silt extending to a depth of 29.3 m below the existing ground surface. Bedrock of Salina Formation was encountered at a depth of 29.3 m below existing grades. The highest groundwater level measured in monitoring wells installed at BH20-8, BH20-10, BH20-11 and BH20-12 (shallow and deep) range from 3.7 m (Elev. 171.2 m) to 6.7 m (Elev. 169.8 m) below existing ground surface.

The geotechnical conditions at the site are suitable to support the buildings and chambers on steel H-piles.

Based on the borehole, it is likely that steel H-piles (HP310x110) extended approximate depth of 32 m long, driven at least 1 m into the bedrock can support a geotechnical reaction of 1000 kN/pile at the Serviceability Limit States (SLS) and a factored geotechnical bearing resistance of 1300 kN/pile at the Ultimate Limit States (ULS) in compression, provided the factored geotechnical resistance at ULS and geotechnical reaction at SLS are confirmed by dynamic testing procedures, ASTM D4945, using the Pile Driving Analyzer (PDA). Piles shall be driven about 1 m above the design elevation and then PDA testing must be carried out. Piles will need to be driven until the required ultimate capacity is achieved. A factor of safety of minimum 2.0 should be adopted to derive the factored geotechnical resistance of pile at ULS from the unfactored ultimate bearing capacity of pile. A minimum factor of safety equal to three (3) will be required to derive the geotechnical reaction at SLS from the ultimate bearing capacity of pile. Higher geotechnical reaction at SLS and factored geotechnical resistance at ULS could be used, provided it is confirmed by the field-testing using PDA.

The pile-driving hammer must be capable of driving the piles to the required capacity without damaging it. To achieve this, the hammer should have a rated energy of about 100 kilojoules per blow. An energy transfer of at least 40 percent of the pile driven rating is assumed. The cap-block may be modified to minimize over stressing of the pile.

Pile driving should be observed, on a full-time basis, by an experienced soil technician, who will record penetration resistance, pile toe elevation, etc. The technician must be supervised by a professional engineer experienced in this type of work.

If the piles encounter refusal before sufficiently penetrating into the recommended bearing zone, then pile capacities may need to be revisited and alternative measures sought. Therefore, pile driving records should be kept particularly, if refusal is met above the recommended bearing zone.

It should be noted that the pile tip elevation provided above is for initial guidance and estimating purposes only. Due to potentially variable soil conditions, the actual pile tip

elevation will vary. The contract should allow for some variation in pile lengths and this aspect should be taken into consideration when ordering the piles. The possibility of piles encountering potential cobbles and boulders or any other obstruction during angering or driving should be anticipated. In view of this, the tips of the piles should be stiffened to minimize damage to the piles while penetrating in recommended bearing zone. Care must be taken to avoid overdriving and damaging the pile tip (i.e., the structural capacity of the piles should not be exceeded). Stiffening of the tops of the piles may also be required.

During the driving process, piles that have already been driven will need to be monitored to assess if heaving occurred due to the effects of driving of adjacent piles. If this phenomenon occurs, the affected piles will need to be re-driven. Re-tapping, to check that relaxation has not occurred, will be necessary. Furthermore, it may be necessary to stagger the driving of the piles. The piles should be provided with reinforced tips, as per OPSD 3000.100.

The passive resistance and horizontal sub-grade coefficient of the soil (ks) are likely required to evaluate the lateral capacity of piles.

The soil parameters generally required to assess the passive earth pressure on the pile are presented in **Table 4.2**.

Soil	Passive Earth Pressure Coefficient, K <sub>P</sub>	Effective unit weight, □ <sup>□</sup> (kN/m³)
Well compacted 'Granular B' or equivalent Fill: adjacent to pile cap, extending at least 3 times its size vertically and laterally	3.3	12.0
Existing Fill (sandy or clayey), assuming angle of internal friction (22 degrees)	2.2	10.7
Native: very soft to stiff silty clay, assuming angle of internal friction 26 degrees	2.6	9.2
Native: compact Silt, assuming angle of internal friction (30 degrees)	3.0	10.2
Notes: i. To err on the conservative side, for the p table was assumed at the existing groun	oile analyses, the Id surface. The e	groundwater ffective or

 Table 4.2
 Soil Parameters for Ultimate Lateral Earth Resistance on Piles

	submerged unit weight must be used below the groundwater level for
	long term passive resistance.
ii.	The contribution of passive resistance within 1.1m below the finished
	grade (frost depth) must be ignored, unless it is approved by WSP.

The horizontal sub-grade coefficient of the soil  $(k_s)$  can be required to evaluate the lateral deflection of piles.

Where the soil is primarily cohesive, the undrained shear strength of the soil is given in Table 4.3.

In this case,

ks=67 cu/d	
Where	$k_s$ = coefficient of horizontal subgrade reaction $c_u$ = undrained shear strength d = pile width or diameter

In cohesionless soils, the coefficient of horizontal sub-grade reaction can be estimated from:

#### ks=nhz/d

Where	ks = coefficient of horizontal sub-grade reaction					
	z = depth					
	d = pile width					
	n <sub>h</sub> = coefficient related to soil density as given in Table 4.3					

Soil Type	Clayey Soil and Shale Bedrock, C <sub>u</sub> (kPa)	Granular Soils, n⊦ (kN/m³)
Well compacted 'Granular B' or equivalent Fill: adjacent to pile cap, extending at least 3 times its size vertically and laterally		4,400
Existing Fill (sandy or clayey)		1300
Native: very soft to stiff silty clay	12	
Native: compact Silt		4400

#### Table 4.3 Recommended Unfactored Soil Parameters for Calculation of ks

Note: The contribution of lateral resistance within 1.1 m below the finished grade (frost depth) must be ignored, unless it is approved by WSP.

The lateral resistance of the piles can be supplemented, if desired, by horizontal components of battered piles. In this instance, it is recommended that the batter be limited to no more than 4:1 as in practice greater batter may be difficult to install.

If the centre-to-centre distance between adjacent piles is less than three (3) times the pile size, group effect on the vertical bearing resistance should be considered. If the centre-to-centre distance between adjacent piles is equal to or greater than three (3) times the pile size, the group effect for the vertical bearing resistance can be ignored.

#### 4.6.2 Yard Piping

The anticipated behaviour of the soils as related to the support of the pipe and the stability of open cut excavations are summarized on **Table 4.4** and are also briefly discussed in the following sections.

Soil Type	Pipe Support	Stability During Construction in Open Excavation	Possible Means of Groundwater Control Below Groundwater Table	
Firm Fill and very soft to firm Silty clay	Not suitable	Stable at 1.5H:1V to 3H:1V	Pumping from filtered sumps established inside the base of trench	
Stiff to very stiff silty clay fill and native silty clay;	Satisfactory	Stable at 1.5H:1V to 1H:1V		
Compact sandy fill and native silt	Satisfactory if properly dewatered or stabilized	Stable at 1.5H:1V (unstable below water table for silt to sand)	Closely spaced well points/eductors for trenches	

Table 4.4 Soil Behaviour in Open Cut

#### 4.6.3 Excavation and Dewatering

Excavations of overburden can be carried out with heavy hydraulic backhoe. The stabilized groundwater table in the overburden in the WWTP area is anticipated to be lying at Elev. 169.8 to 172.3 m. As the majority of soils is cohesive based on borehole information, no major problems with groundwater are anticipated for the excavation of proposed yard piping. The groundwater seepage can be handled generally by pumping from filtered sumps in the bottom of the excavation. Increasing dewatering will be locally required when excavation reaches the saturated silt within the cohesive soils at a depth of 13.3m (or below) below the ground surface at the borehole location of BH20-08.

More comments regarding the type and extent of groundwater control required is provided in the WSP's report entitled "Preliminary Hydrogeological Investigation – South Niagara Falls WW Solutions EA, Niagara Region, ON", dated May 27, 2022.

The excavation for yard piping is expected through the fill followed by silty clay locally interbedded with silt layer. Possible large obstructions such as buried concrete / bricks are also anticipated in the fill material. Provisions must be made in the excavation contract for the removal of possible obstructions in the fill material.

All excavations must be carried out in accordance with the most recent Occupational Health and Safety Act (OHSA). In accordance with OHSA, the fill material can be classified as Type 3 Soil above the groundwater table. The firm to stiff cohesive deposit can be classified as Type 3 Soil above the groundwater table and Type 4 Soil below the groundwater table. The very soft to soft cohesive deposit classified as Type 4 soil.

#### 4.6.3.1 Trench Boxes

Where permissible under the OHSA and where its use is considered to be a safe alternative for shoring and bracing, contractors may decide to utilize trench boxes for temporary trench wall support for trenches less than 6 m deep in Type 2 and Type 3 Soils. Where trench depths exceed 6 m, Engineered Support Systems are required under the OHSA as defined in the Regulation. In such cases, the use of prefabricated support systems (trench boxes) is not permitted.

While the use of trench boxes is an effective and economical trench-support method, its use can cause increased loss of ground relative to properly braced shoring, especially when working close to granular base courses below the existing pavements or along existing utility trenches backfilled with granular materials. Trench boxes also reduce the contractor's ability to compact backfill materials placed between the trench wall and the outer trench box shell, thereby increasing the likelihood of post-construction settlements along the trench walls.

It is important that the trench not be over-excavated to ensure a tight fit between the box and the trench walls. Trench boxes need to be installed expediently. When moving the box, the void space between its outer walls and the trench must be backfilled and compacted. This may require raising the box sequentially prior to sliding it laterally.

When trench boxes are used along existing roadways, settlements frequently occur along the trench wall, which may manifest months after completion of backfilling. In such cases, following the backfilling of the trench, road reconstruction should include a provision for saw-cutting the asphalt at least 1.5 m back from the trench walls, recompacting the upper trench backfill, and then repaying.

All excavated spoils should be placed at least the depth of the trench away from the trench's edge to mitigate the risk of excavation instability.

It is recommended that the excavations for service trenches below the groundwater table be carried out in short sections using a suitable 'geofabric' below the bedding (fine migration prevention) and backfilling the trench section immediately after pipe placement.

#### 4.6.3.2 Pipe Support and Bedding

The borehole records indicate that shallow compact fill and stiff to very stiff silty clay are capable of providing adequate pipe support using the OPSD 802.031. The subgrade condition must be inspected and verified by geotechnical personnel. If very soft to firm clayey soil or fill (SPT 'N' value < 8) are present at the proposed pipe invert or trench invert elevation, the unsuitable soil should be sub-excavated and replaced using conventional Class "B" bedding. The replacement fill should be placed in loose lifts not exceeding 150 mm in thickness and then compacted to 100% of Standard Proctor Maximum Dry Density (SPMDD) at a placement water content of  $\pm 2\%$  of optimum. Each loose layer shall be compacted to 100% SPMDD prior to the placement of the next upper layer.

If the very soft to firm clayey soil (encountered at depths of 3.1 to 5.3 m below the existing ground surface in BH20-08, BH20-10, BH20-11, and BH20-12S) could not be removed, consideration should be given to use flexible pipe to allow big long-tern differential settlements. Consideration can be also given to soil improvement method (such as geopiers, soil/cement mixed columns) or deep foundation (such as helical piles) to support the yard piping.

The compacted granular base and the cover material for all pipes should consist of Granular "A" material in accordance to OPSS.MUNI 1010 for concrete pipes. Granular D (Limestone Screenings) is recommended for the bedding material of PVC pipes. All granular materials should be placed in maximum 200mm thickness. The granular bedding and cover materials should be compacted to 100% Standard Proctor Maximum Dry Density (SPMDD). Care should be exercised when compacting the cover material on top of the pipes to avoid damaging them. The use of light, hand operated compaction equipment is recommended in these areas.

#### 4.6.3.3 Backfilling

Based on visual and tactile examination, the on-site excavated granular fill and native cohesionless soils are considered to be suitable for re-use as backfill in the service trenches provided their moisture contents at the time of construction are at or near ( $\pm 2\%$ ) optimum.

The very soft to firm silty clay deposit is considered as not suitable for backfill due to its highwater content and compressibility.

The backfill should be placed in maximum 200 mm thick layers at or near ( $\pm 2\%$ ) their optimum moisture content and each layer should be compacted to at last 95% SPMDD. The degree of compaction should be increased to 100% within the top 2.0 m of the subgrade. Unsuitable materials such as organic soils, boulders, cobbles, frozen soils, etc. should not be used for backfilling. The existing road pavement structure should be reinstated. The granular pavement sub-base and base materials should be compacted to at least 100% of their respective

SPMDD. New granular material must match into the undersides of existing to ensure unimpeded cross drainage.

### 4.7 Issues and Data Gaps

The following issues and data gaps were identified in the geotechnical data with warrant further investigation:

- Large zones of insufficient geological and geotechnical data;
- Specific data at river, creek and road crossings;
- Precise definition of the transition from overburden to bedrock;
- Definition of the bedrock channels/valleys;
- Depth of fill material;
- Depth of highly weathered bedrock and/or bedrock surface;
- Strength of overburden and bedrock;
- Zone of very soft to firm silty clay;
- Definition of the qualities of cobbles and boulders;
- Presence of naturally occurring gases including Methane gas within the bedrock;
- Data on till and bedrock potential for abrasiveness during tunnelling;
- Groundwater table; and
- Soil and bedrock environmental quality

The recommendations for further geotechnical investigation are as follows:

- Additional boreholes with spacing of approximately 150m along the proposal alignment of trunk sewer;
- Additional boreholes with monitoring wells at both sides of watercourses;
- Additional boreholes with monitoring well at both sides of QWE and CN Rail;
- Additional boreholes within the footing of proposed structure and access road in the WWTP site;
- Additional boreholes with soil coring to determine the quantity of cobbles/boulders;
- Geophysical survey along the proposal alignment of trunk sewer to determine the bedrock surface;
- Laboratory tests including consolidation tests and triaxial tests on the soft soils;

- Laboratory tests including unconfined compression tests, triaxial compression tests, tensile tests, punch penetration tests, and CERCHAR abrasivity tests, and slake durability on the bedrock if tunneling in bedrock is selected; and
- Geotechnical baseline report (GBR) for tunnelling

## 5 General Comments and Limitations of Report

WSP should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, WSP will assume no responsibility for interpretation of the recommendations in the report.

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole and test pit results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to WSP at the time of preparation. Unless otherwise agreed in writing by WSP, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the test hole locations. The information contained herein in no way reflects on the environment aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the test holes may differ from those encountered at the test hole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation. The benchmark and elevations used in this report are primarily to establish relative elevation differences between the test hole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. WSP accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. We accept no responsibility for any decisions made or actions taken as a result of this report unless we are specifically advised of and participate in such action, in which case our responsibility will be as agreed to at that time.

We trust that the information contained in this report is satisfactory. Should you have any questions, please do not hesitate to contact this office.

# Drawings

Borehole Location Plan (Drawing No. 1 To 10) Earth Pressure Distribution on Braced Excavations (Drawing No. 11) Risk Zone (Drawing No. 12)



100	0	100	200	400 (m
























	REGION OF NIAGARA	201-11602-00	9				
	TITLE: BOREHOLE LOCATION PLAN AND PROFILE	DRAWN BY:	CHECKED BY:				
	STA 5+000 TO STA 5+760						
•	PROJECT:	DATE:	SCALE:				
INTERNATIONAL BLVD	PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT FOR	OCT. 28, 2021	AS SHOWN				
D, ONTARIO CANADA M9W 1A2	PROPOSED SOUTH NIAGARA FALLS WASTEWATER TREATMENT PLANT (WWTP) AND	ORIGINAL SIZE:	REV. #				
	ASSOCIATED TRUNK SEWER, TOWINSHIP OF WILLOUGHBT, REGION OF NIAGARA	ARCH D	N/A				



# LEGEND

BOREHOLE LOCATION

BOREHOLE WITH MONITORING WELL LOCATION





	CLIENT:	PROJECT NO:	DRAWING NO:		
	REGION OF NIAGARA	201-11602-00	10		
		DRAWN BY:	CHECKED BY:		
	BOREHOLE LOCATION FLAN	WSL	MK		
	PROJECT:	DATE:	SCALE:		
	PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT FOR	OCT. 28, 2021	AS SHOWN		
OM	PROPOSED SOUTH NIAGARA FALLS WASTEWATER TREATMENT PLANT (WWTP) AND	ORIGINAL SIZE:	REV. #		
	ASSOCIATED TRUNK SEWER, TOWNSHIP OF WILLOUGHBY, REGION OF NIAGARA	ARCH D	N/A		



g' = submerged unit weight of soil (i.e. below ground water level)= 11.2 kN/m<sup>3</sup>

# IN COMPACT TO VERY DENSE NON-COHESIVE SOILS (SANDS AND SILTS)



- g = unit weight of soil =  $19.0 \text{ kN/m}^3$
- g' = submerged unit weight of soil (i.e. below ground water level)= 9.2 kN/m  $^3$
- Ka = 0.36

# IN LOOSE OR DISTURBED NON-COHESIVE SOILS (SANDS AND SILTS)

# g = unit weight of soil = $21.5 \text{ kN/m}^3$

g' = submerged unit weight of soil (i.e. below ground water level)= 11.7 kN/m<sup>3</sup>

0.25H

0.75H

H (m)

# IN COHESIVE CLAYS OR CLAYEY SOILS



- $g = unit weight of soil = 19.0 kN/m^3$
- 9' = submerged unit weight of soil (i.e. below ground water level)= 9.2 kN/m<sup>3</sup>

Su = 10 KPa

# IN VERY SOFT TO FIRM COHESIVE CLAYS OR CLAYEY SOILS

	CLIENT:		PROJECT NO:	DRAWING NO:
<ul> <li>Notes:</li> <li>1. Check system for partial excavation condition.</li> <li>2. If the free water level is above the base of the excavation, the hydrostatic pressure must be added to the above pressure distribution.</li> <li>3. If surcharge loadings are present near the excavation, these must be included in the lateral pressure calculation.</li> </ul>		THE REGIONAL MUNICIPALITY OF NIAGARA	201-11602-00	11
	TITLE:		DRAWN BY:	CHECKED BY:
		EARTH PRESSURE DISTRIBUTION ON BRACED EXCAVATIONS	ZMO	LC
	PROJECT:		DATE:	SCALE:
		GEOTECHNICAL INVESTIGATION - NIAGARA REGION SANITARY	FEB 26, 2021	N.T.S
		SEWER	ORIGINAL SIZE:	REV. #
			LETTER	N/A

Ka = 0.3





# **Explanation of Terms Used in the Record of Borehole**

# Sample Type

- AS Auger sample
- BS Block sample
- CS Chunk sample
- DO Drive open
- DS Dimension type sample
- FS Foil sample
- NR No recovery
- RC Rock core
- SC Soil core
- SS Spoon sample
- SH Shelby tube sample
- ST Slotted tube
- TO Thin-walled, open
- TP Thin-walled, piston
- WS Wash sample

# **Penetration Resistance**

# Standard Penetration Resistance (SPT), N:

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

WH - Samples sinks under "weight of hammer"

### Dynamic Cone Penetration Resistance, Nd:

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,  $60^{\circ}$  cone attached to "A" size drill rods for a distance of 300 mm (12 in).

# Textural Classification of Soils (ASTM D2487-10)

Classification	Particle Size					
Boulders	> 300 mm					
Cobbles	75 mm - 300 mm					
Gravel	4.75 mm - 75 mm					
Sand	0.075 mm - 4.75 mm					
Silt	0.002 mm - 0.075 mm					
Clay	<0.002 mm(*)					
(*) Canadian Foundation Engineering Manual (4 <sup>th</sup> Edition)						

### Coarse Grain Soil Description (50% greater than 0.075 mm)

Terminology	Proportion							
Trace	0-10%							
Some	10-20%							
Adjective (e.g. silty or sandy)	20-35%							
And (e.g. sand and gravel)	> 35%							

### **Soil Description**

a) Cohesive Soils(\*)

Consistency	Undrained Shear Strength (kPa)	SPT "N" Value				
Very soft	<12	0-2				
Soft	12-25	2-4				
Firm	25-50	4-8				
Stiff	50-100	8-15				
Very stiff	100-200	15-30				
Hard	>200	>30				

(\*) Hierarchy of Shear Strength prediction

- 1. Lab triaxial test
- 2. Field vane shear test
- 3. Lab. vane shear test
- 4. SPT "N" value
- 5. Pocket penetrometer

### b) Cohesionless Soils

### Density Index (Relative Density) SPT "N" Value

Very loose	<4
Loose	4-10
Compact	10-30
Dense	30-50
Very dense	>50

# Soil Tests

- w Water content
- w<sub>p</sub> Plastic limit
- wı Liquid limit
- C Consolidation (oedometer) test
- CID Consolidated isotropically drained triaxial test
- CIU consolidated isotropically undrained triaxial test with porewater pressure measurement
- D<sub>R</sub> Relative density (specific gravity, Gs)
- DS Direct shear test
- ENV Environmental/ chemical analysis
- 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
- U Unconsolidated Undrained Triaxial Test
- V Field vane (LV-laboratory vane test)
- γ Unit weight

# Explanation of Terms Used in the Bedrock Core Log

# Strength (ISRM)

#### Grade Description Unconfined Term **Compressive Strength** (MPa) (psi) Extremely RO Indented by thumbnail 0.25-1.0 36-145 weak rock Very weak R1 Crumbles under firm 1.0-5.0 145-725 blows with point of geological hammer, can be peeled by a pocket knife Weak rock R2 Can be peeled by a pocket 5.0-25 725-3625 knife with difficulty, shallow indentations made by firm blow with point of geological hammer Cannot be scraped or peeled 25-50 Medium R3 3625-7250 Strong with a pocket knife, specimen can be fractured with single firm blow of geological hammer Strong rock R4 Specimen require more than 50-100 7250-14500 one blow of geological hammer to fracture it Very strong R5 Specimen requires many 100-250 14500-36250 blows of geological hammer rock to fracture it Extremely R6 Specimen can only be >250 >36250 strong rock chipped with geological hammer

# Bedding (Geological Society Eng. Group Working Party, 1970. Q.J. of Eng. Geol. Vol. 3)

Term	Bed Thickness	
Very thickly bedded	>2 m	>6.5 ft
Thickly bedded	600 mm-2 m	2.00-6.50 ft
Medium bedded	200 mm-600 mm	0.65-2.00 ft
Thinly bedded	60 mm-200 mm	0.20-0.65 ft
Very thinly bedded	20 mm-60 mm	0.06-0.20 ft
Laminated	6 mm-20 mm	0.02-0.06 ft
Thinly laminated	<6 mm	<0.02 ft

# TCR (Total Core Recovery)

Sum of lengths of rock core recovered from a core run, divided by the length of the core run and expressed as a percentage.

# SCR (Solid Core Rocovery)

Sum length of solid, full diameter drill core recovered expressed as a percentage of the total length of the core run.

# RQD (Rock Quality Designation, after Deere, 1968)

Sum of lengths of pieces of rock core measured along centreline of core equal to or greater than 100 mm from a core run, divided by the length of the core run and expressed as a percentage. Core fractured by drilling is considered intact. RQD normally quoted for N-size or H-size core.

<i>i</i> .	
RQD(%)	Rock Qualit
90-100	Excellent
75-90	Good
50-75	Fair
25-50	Poor
0-25	Very poor

# Weathering (ISRM)

<b>Term</b> Fresh	Grade W1	<b>Description</b> No visible sign of rock material weathering
Slightly weathered	W2	Discolouration indicates weathering of rock material and discontinuity surface. All the rock material may be discoloured by weathering and may be somewhat weaker than in its fresh condition
Moderatel weathered	y W3 I	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a either as a continuous framework or as corestones
Highly weathered	W4	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones
Completely weathered	y W5 I	All rock material is decomposed and/or disintegrated to a soil. The original mass structure is still largely intact
Residual so	bil W6	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported
(E1) E	and the states.	

# (FI) Fracture Index

Expressed as the number of discontinuities per 300mm (1 ft). Excludes drill-induced fractures and fragmented zones. Reported as ">25" if frequency exceeds 25 fractures/0.3m.

### **Broken Zone**

Zone of full diameter core of very low RQD which may include some drillinduced fractures.

# **Fragmented Zone**

Zone where core is less than full diameter and RQD = 0.

# **Discontinuity Spacing (ISRM)**

Term	Average Spacing							
Extremely widely spaced	>6 m	>20.00 ft						
Very widely spaced	2 m-6 m	6.50-20.00 ft						
Widely spaced	600 mm-2 m	2.00-6.50 ft						
Moderately spaced	200 mm-600 mm	0.65-2.00 ft						
Closely spaced	60 mm-200 mm	0.20-0.65 ft						
Very closely spaced	20 mm-60 mm	0.06-0.20 ft						
Extremely closely spaced	<20 mm	>0.06 ft						
Note: Excludes drill-induced fractures and fragmented rock.								

### **Discontinuity Orientation**

Discontinuity, fracture and bedding plane orientations are cited as the acute angle measured with respect to the core axis. Fractures perpendicular to the core axis are at  $90^\circ$  and those parallel to the core axis are at 0°.

#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO .: 1D ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-09-2020 to Dec-09-2020 COMPILED BY MK Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY BH LOCATION: See Borehole Location Plan N 4769584.2 E 653265.365 SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 40 60 100 20 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEVATION ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 20 40 60 80 100 10 20 30 GR SA SI CL 180.5 Ground Surface FILL: silty clay, some sand to Concrete 0.0 sandy, trace gravel, trace organics, SS 11 1 trace rootlet, brownish grey, moist, Sand ເວັບ stiff to very stiff. 2 SS 15 178.9 179 SILTY CLAY: trace sand, contains 1.5 silt seams, brown, moist, very stiff 3 SS 23 0 to very soft. 178 SS 13 4 0 51 7 5 SS F 8.4 0 1 (99) 177 brownish grey 6 SS 4 0 176 +3.31 Vane 125mm reddish brown silt layer 175 8 SS 4 0 grey, wet тw 1 174 0 1 55 44 9 SS 4 0 173 Holeplug 10 SS 1 172 1.3 +28 2 Vane 171 W. L. 170.7 m Continued Next Page $+3, \times 3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH GROUNDWATER ELEVATIONS NOTES to Sensitivity

LOG OF BOREHOLE BH20-01

Measurement  $\overset{1st}{\checkmark} \overset{2nd}{\checkmark} \overset{3rd}{\checkmark} \overset{4th}{\checkmark}$ 

**\\S**D

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CLIE	NT: Regional Municipality of Niagara								Meth	od: Ho	llow St	tem A	ugers/	HQ Co	ore			ENC	L NC	D.: 1D	)
PRO	JECT LOCATION: Niagara Region Sanit	tary S	Sewe	r					Diam	eter: 2	03 mn	n/63m	ım					ORIO	GINA	TED	BY SL
DATI	JM: Geodetic								Date:	Dec-	09-202	20 to	Dec-0	9-202	0			CON	1PILE	ED B	y BW
BH L	OCATION: See Borehole Location Plan	N 47	76958	34.2 E	65326	5.36	5		Equip TOVNA	ment:	Pontil			/IE 75	(Truck)	)		CHE	CKE	D BY	/ MK
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F	Coring began at 14 02m	$\bigotimes$	1	RC				100	-												
-	Refer to Rock Core Log								-												
<u>15</u> -								Sand	Ē												
E		$\otimes$			]	ŀΕ			-												
F		$\mathbb{K}$				ΙE		165	-												
-		$\langle \rangle \rangle$				[∷]⊧			Ē												
16		$\mathbb{N}$	2	RC		ΙE	14	Scree	n												
E						ŀΕ			-												
È.		$\bigotimes$				ŀ⊧		164											-		
163.7		K	1			ŀΕ	1.		-												
16.8	Note:																				
	1) TW denotes thin wall shelby tube sample																				
	2) 50 mm monitoring well was																				
	between 15.24m and 16.76m.																				
	Water Level measured in																				
	monitoring well:																				
	Dec. 18, 2020 10.96																				
1	Dec. 23, 2020 9.77														1					1	
															1					1	
															1					1	
3PJ 2122															1					1	
11602-00.0																					
L L 06 201															1					1	
W\$P 50																					
									~		,										

**\\SD** 

# LOG OF ROCK CORE BH20-01

1	OF	1
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PRC	UECT: Geotechnical Investigation							Hollow Stem Augers/HQ Core	REF	. NC	D.: 20 O.: 11	)1-116 D	j02-00	)		
LOC	ATION: Niagara Region Sanitary Sewer							Dia	meter	: 203 mm/63mm	ORI	GIN/		BY	SL	
		NI 4700		E 05	0005	005		Dat	e: De	ec-09-2020 to Dec-09-2020	CON		ED B	Y		
ВНІ	CCATION: See Borehole Location Plan	N 4769	584.2	E 65. RE	3265.	365		Equ	lipmei	nt: Pontil Drilling CME 75 (Truck)		:CK ୁ	ED B.	Y fe	TIVIC TIVIC	
(m) <u>ELEV</u> DEPTH 166. <sup>-</sup>	ROCK DESCRIPTION	GROUND WATER CONDITIONS	NUMBER	<u>PLE</u> SIZE	TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES	Weathering Index	HYDRAULIC CONDUCTIVITY (cm/se	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MP.	UNIAXIAL COMPRESSION (MF	DENSITY (g/cm <sup>3</sup> ) E (GPa)
- 14.3 - - - <u>15</u> -	SALINA FORMATION: Bedding almost horizontal (€=90°)		1	HQ	100	95		95	0 5 0	Fragmented zone: 14.67m-14.72m	W2 to W1					
- 165.4 - 15.4 -	1								 0 	Fracture: 15.88m-15.90m, <b>θ</b> =0° and 15°, two sets 16.34m-16.35m, <b>θ</b> =80°	W1		108	40		
- 163.7			2	HQ	100	93		80	4 1 5	Soft lays 16.17m ~ 16.2m (W 16.69m ~ 16.74m (W)	,r (i) (i) (i)		66	68		
16.8	<ul> <li><b>END OF BOREHOLE</b>     Note:     1) 50 mm monitoring well was         installed upon completion, screened         between 15.24m and 16.76m.     </li> <li>Water Level measured in monitoring         well:         Date         W.L.Depth (m)         Dec. 18, 2020         10.96         Dec. 23, 2020         9.92     </li> </ul>															

#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers ENCL NO.: 2 ORIGINATED BY AKJ PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-14-2020 to Dec-14-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4769568.12 E 652816.68 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 80 100 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w $W_{L}$ ELEVATION SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEV DEPTH DISTRIBUTION -0 -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) ТҮРЕ QUICK TRIAXIAL × LAB VANE ż 20 40 60 80 100 10 20 30 GR SA SI CL 181.2 Ground Surface ASPHALT: 150mm 18**0.0** 181 FILL: crusher run limestone mix with silty clay pockets, grey, moist, compact. SS 16 0 1 180 2 SS 15 <u>178.9</u> 2.3 179 FILL: crusher run limestone, grey, moist, compact to loose. SS 3 16 0 178 4 SS 8 0 5 SS 20 0 177 6 SS 14 о 176 7 SS 8 0 175 8 SS 6 0 -174.7 SILTY CLAY: trace sand, contains 6.6 silt seams, reddish brown, moist, firm to very soft. 174 9 SS 2 0 173 172 +2.7 1 Vane Continued Next Page $+3, \times 3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS to Sensitivity

Measurement  $\overset{1st}{\checkmark} \overset{2nd}{\checkmark} \overset{3rd}{\checkmark} \overset{4th}{\checkmark}$ 

# LOG OF BOREHOLE BH20-02

1 OF 2

11	5	)

	LOG OF BOREHOLE BH20-02     2 OF 2       PROJECT: Geotechnical Investigation     REF. NO.: 201-11602-00																				
PROJ	ECT: Geotechnical Investigation																REF.	. NO.	: 201	1-11602-0	00
CLIEN	NT: Regional Municipality of Niagara							Meth	od: Ho	llow St	em Au	ugers					ENC	L NO	.: 2		
PROJ	IECT LOCATION: Niagara Region Sanit	ary S	Sewe	r				Diam	eter: 2	03 mm	ı						ORIC	GINA	TED	BY AKJ	J
DATU	IM: Geodetic							Date:	Dec-	14-202	20 to	Dec-1	4-2020	)			COM	1PILE	D BY	y BW	
BH LC	OCATION: See Borehole Location Plan	N 47	6956	8.12 E	6528	16.68		Equip	ment:	Pontil	Drillin	g CN	IE 75 (	Truck	)		CHE	CKE	) BY	MK	
	SOIL PROFILE		s	AMPL	ES	~		DYNA RESIS	MIC CO	DNE PE E PLOT		ATION			_ NAT	URAL			μ	REMAR	RKS
(m)		DT				ATEF		2	20 4	0 6	0 8	80 1	00	LIMIT	C MOIS	STURE	LIQUID	a) BEN.	NIT N	ANE	)
ELEV	DESCRIPTION	A PLO	۲		3 m	N OI	NOL	SHE/	AR ST	RENG	TH (ki	- Pa)		w <sub>P</sub> 		w o	WL	u) (kF	KAL L	DISTRIBL	JTION
DEPTH		ZAT/	MBE	Ш	<u>B</u> .	NUO	EVAI		NCONF UICK T	·INED RIAXIAI	+ L ×	& Sensiti LAB V	vity	WA	FER CO	ONTEN	IT (%)	8 O	NATU	(%)	
	Continued	STF	N	ТҮ	,	GR CO	ELE	2	20 4	0 6	0 8	80 1	00	1	0 2	20 3	30			GR SA S	SI CL
	SILTY CLAY: trace sand, contains silt seams, reddish brown, moist.	H					171	-													
-	firm to very soft.(Continued)	K	1					-													
Ē		Ĥ						Ē													
-	grey, wet	R.		~~				-													
<u>11</u> -		H	10	SS	3			-													
-		H.	}				170	-													
E		K	1																		
-		H						-													
12		R.						-													
E		H			-		169											-			
-		H.	1	тw				_													
-		K	1					-													
13		Ĥ			1			-													
E		R					168	_													
-		1					100	_													
-		H						-													
Ē		H																			
14	contains dilatant reddish brown silt	Hł.	11	SS	3												<b>•</b>			006	63 37
-	layers	12					167	-										1			
-		11						-													
166.4			1					_													
[ 14.8	SILT: some clay to clayey, trace sand. dilatant. reddish brown. wet.							_													
-	compact.						166	-													
165 7								-													
15.5	CLAYEY SILT TILL: sandy, trace		12	SS	15											0					
-	gravel, contains shale/limestone fragments, reddish brown, moist,							-													
<u>16</u> -	stiff to hard.	jø,						-													
-		PH.	1				165	_													
-		[14.]	13	SŞ <sub>ni</sub>	>50/ tial50r	m								0							
164.4		ĺłł			laiou			_													
16.8																					
22.22																					
2.00-2081																					
- 100																					

**NSD** 

					LOC	<b>G</b> O	FB	BOR	EHO	LEE	3H20	0-03									1 OF 3
PRO,	JECT: Geotechnical Investigation																	REF.	NO.	: 20	1-11602-00
CLIE	NT: Regional Municipality of Niagara								Metho	d: Ho	llow S	tem A	ugers/	'HQ Co	ore			ENCL		).: 3	
PRO.	JECT LOCATION: Niagara Region Sanit	tary S	Sewe	r					Diame	eter: 2	03 mr	n/63m	ım					ORIG	SINA	TED	BY SL
DATI	JM: Geodetic								Date:	Dec-	02-202	20 to	Dec-0	3-202	C			СОМ	PILE	D B۱	y BW
BH L	OCATION: See Borehole Location Plan	N 47	6905	57.248	E 652	136.	.143		Equip	ment:	Pontil	Drillir	ng CM	ME 75	(Truck	)		CHE	CKEI	D BY	MK
	SOIL PROFILE		5	SAMPL	ES				DYNA	VIC CO			ATION		Ì						DEMARKO
(m) <u>ELEV</u> DEPTH	DESCRIPTION	ATA PLOT	ABER	ш	BLOWS 0.3 m	DUND WATER	NDITIONS	VATION	SHEA		RENG	50 TH (k	B0 1 Pa) FIELD \ & Sensi	ANE				LIQUID LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	LATURAL UNIT WT (kN/m <sup>3</sup> )	AND GRAIN SIZE DISTRIBUTION (%)
178 1	Ground Surface	STR	NN	ТҮР	ż	GRO	S	ELE	2	0 4		50 i	цар v 80 1	IQ0	1	0 2	20 3	30		2	GR SA SI CI
178.0	ASPHALT: 150mm						E	178													
 	GRANULAR FILL: sand and gravel, trace silt, trace clay, grey, moist, very dense to dense,		1	SS	58				-						0						
. <u>1</u> - -			2	SS	35			177	-						0						
<u>176.6</u> 1.5	FILL: silty clay, trace sand, trace	$\bigotimes$							E												
- - 2	gravel, trace organics, brown, moist, firm.		3	SS	7			176	-								0				
-		$\mathbb{X}$	}																		
-	reddish brown	$\bigotimes$	4	SS	5				-									0			
<u>-</u> 175.0		K.	1	Vane				175	-												
. 3.1 -	occasional gravel, reddish brown, moist, firm.		6	SS	6	_ 	<u>Z</u>	N. L.	174.6 r	n							⊢	54			0 1 (99)
			1	тw				174	-												
<u>-173.5</u> 4.6	SILT: trace to some clay, trace sand, dilatant, reddish brown, wet, compact.		8	SS	26				-								0				
<u>-</u>								173													
172.8	SILTY CLAY: trace sand	₩							[												
	occasional gravel, contains dilatant silt seams/layers,reddish brown, wet, firm to soft		9	SS	4				-		3.0							o			
-			2	Vane				172			+42										
-			11	SS	4				-								c				
. <u>7</u>			2	тw				171	- - - - -												
- - - <u>8</u>			13	SS	6				-									43			
								170	-												
- - 9								169	-	.2.3											
- - -			3	Vane					-	+24											
GROU	Continued Next Page		1			GRA	<u>PH</u> FS	+ 3,	۲ ׳: ۲	Numbe	rs refer	· c	<b>8</b> =3%	<sup>6</sup> Strain	at Failu	Ire	<u> </u>	<u> </u>	I	L	<u> </u>

vsp

	יוי				LOC	G OF I	BOR	EHC	DLE E	3H20	0-03										2 OF 3
PRO	JECT: Geotechnical Investigation																REF.	. NO	.: 20	1-116	02-00
CLIEN	NT: Regional Municipality of Niagara							Meth	od: Ho	llow S	tem A	ugers/	'HQ Co	ore			ENC	L NC	).: 3		0
PRO	JECT LOCATION: Niagara Region Sani	tary S	Sewe	r				Diam	neter: 2	:03 mr	n/63m	m					ORIC	SINA	TED	BY	SL
DATU	JM: Geodetic							Date	: Dec-	02-202	20 to	Dec-(	)3-202	0			COM	1PILE	ED BY	Y ,	BAA
BHLO	CATION: See Borehole Location Plan	N 47	690	57.248	E 652	136.143	3	Equi DYN/	oment:	Pontil	Drillir ENETR	ng CI ATION	ME 75	(Iruck	)		CHE		D BY		IVIN
		-		SAMPL	.ES	н		RESI	STANC	E PLOT	$\geq$			PLAST	IC NAT	TURAL STURE		) 	±∧.	RE	MARKS
(m)		LOT			SIC	NS NS	z		20 4			30 1	100	- WP	CON	NTENT W	WL	ET PEN KPa)	""UNIT	GR	AIN SIZE
ELEV DEPTH	DESCRIPTION	IA PI	Ш		0.3 n		ATIO	SHE. O U	AR ST	RENG FINED	ін (к +	Pa) FIELD \	/ANE	l i		o		OCKE (Cu)	URAL (KN/	DIST	
		TRA	UMB	YPE		ROU	LEV	• 0		RIAXIA	LX	LAB V	ANE	WA	TER CO		IT (%)	Ľ	Γ¥		(70)
	Continued SILTY CLAY: trace sand.	s XX	z	-	f	00	ш 169		20 2							20 .	50	+	┢	GR S	SA SI CL
-	occasional gravel, contains dilatant		1				100	-													
-	wet, firm to soft(Continued)		1					-													
		R						-													
- 11			15	SS	3			-							⊢		<b>-</b>   •			0	0 67 33
-							167	-										1			
-								È .													
-			1					-													
12			1					-													
-			1		-		166	-										1			
-				T\//				-													
E		R		1 1 1 1				-													
-					1			-													
164.8							165											-			
13.3	SILT: trace to some clay, trace	ffif	1					-													
-	sand, dilatant, reddish brown, wet to saturated, very loose.							-													
<u>14</u> -			17	SS	2		164									[Non-Pla	ustic]	_		3	5 (92)
-							-	È													
F								Ē													
-								-													
15							163	-												spoo hard	n got
162.9 15.2	BEDROCK:	$\mathbb{H}$	_		-		103	-										]			
- 10.2	Coring bogon at 15 24m							F													
	Refer to Rock Core Log			RC																	
16			<u>}</u>		-			-													
-							162	-										1			
E			2	RC				-													
-								-													
17																					
-					]		161	-										1			
-								-													
			1					-													
-			3	RC				-													
-							160	-										-			
			1																		
-			}		-			È.													
E								Ē													
<u>19</u>							159										<u> </u>	1			
GPJ 213-		$\otimes$	4	RC				F										1	1		
1 1602-00						<b> </b> :目:		Ē										1	1		
01 100 20								ŀ										1	1		
20	Continued Next Page	K	1			· 目 ·		-													
GROUM	NDWATER ELEVATIONS					<u>GRAPH</u> NOTES	+ 3	׳∶	Numbe to Sens	rs refer itivity	Ċ	<b>8</b> =3%	<sup>6</sup> Strain	at Failu	lre						
Measur	rement $\overset{1  \text{st}}{\underline{\nabla}}$ $\overset{2  \text{nd}}{\underline{\nabla}}$ $\overset{3  \text{rd}}{\underline{\nabla}}$ $\overset{4  \text{th}}{\underline{\nabla}}$																				

**NSD** 

					LUG		BOK	EHO	LEE	5H20	-03									3 OF 3
PROJ	ECT: Geotechnical Investigation																REF.	NO.	: 20	1-11602-00
CLIEN	IT: Regional Municipality of Niagara							Metho	od: Hol	low St	em Au	ugers/l	HQ Co	re			ENCL	- NO	).: 3	
PROJ	ECT LOCATION: Niagara Region Sanit	ary S	Sewe	r				Diam	eter: 2	03 mm	n/63mi	m					ORIG	SINA	TED	BY SL
DATU	IM: Geodetic							Date:	Dec-	)2-202	20 to	Dec-0	3-2020	)			COM	PILE	D B)	/ BW
BH LO	OCATION: See Borehole Location Plan	N 47	76905	57.248	E 652	136.143	3	Equip	ment:	Pontil	Drillin	g CN	1E 75 (	Truck)	)		CHE	CKE	D BY	MK
	SOIL PROFILE		5	SAMPL	ES			DYNA RESIS	MIC CO	NE PE		ATION				JRAL			F	REMARKS
(m)		⊢				Ë.		2	20 4	0 6	0 8	30 1	00	LIMIT	C MOIS	TURE	LIQUID	ż.	N⊥	AND
		PLO			SΝ	NNS NO	N	SHEA	AR STI	RENG	L TH (kf	⊥ Pa)	1	W <sub>P</sub>	V	N	WL	(kPa	AL UN	
DEPTH	DESCRIPTION	ATA	BER		<u>BLO</u> 0.3	DND	ITA/	O UI	NCONF	INED	+	FIÉLD V & Sensiti	ANE				T (%)	DO DO	ATUR (K	(%)
	Continued	STR	NUM	IYPE	ż	GRO CON	ELE		UICK TI 20 4	RIAXIAI 0 6	L X 0 8	LAB V. 30 1	ANE 00	1	0 2	20 3	i (%) i0		Ż	GR SA SI CI
- 158.0		Ŵ.			-	: H:	158													
20.1	END OF BOREHOLE																			
	1) TW denotes thin wall shelby tube																			
	sample. 2) 50 mm monitoring well was																			
	installed upon completion, screened																			
	between 4.50m and 7.60m.																			
	Water Level measured in monitoring well:																			
	Date W.L.Depth (m)																			
	Jan. 13, 2021 3.5																			
			1																	
			1																	
			1																	
			1																	
			1																	
		1		1	1		1		1	1	1	1	1		1	1	1			

19-2017.GLB

WSP SOIL ROCKAM WSP SOIL LOG 201

# LOG OF ROCK CORE BH20-03

ſ	PRO	ECT: Geotechnical Investigation										REF	. NC	).: 20	)1-116	602-0	0
	CLIEN	NT: Regional Municipality of Niagara							Met	hod: l	Hollow Stem Augers/HQ Core	ENC	CL N	0.: 3			
	LOCA	TION: Niagara Region Sanitary Sewer							Dia	meter	: 203 mm/63mm	ORI	GIN/	ATED	BY	SL	
	DATU	JM: Geodetic							Dat	e: De	ec-02-2020 to Dec-03-2020	CON	MPIL	ED B	Y	BW	
	BH LO	OCATION: See Borehole Location Plan	N 4769	057.2	48 E	65213	86.143	;	Equ	ipme	nt: Pontil Drilling CME 75 (Truck)	CHE	CK	ED BN	(	MK	
	(m)	ROCK	ATER	CC SAN	DRE MPLE	≡ (%)	: (%)	(%) ک		NDEX		dex	Y (cm/sec)	EST ba)*	EST AL (MPa)*	ON (MPa)	sm³)
	ELEV DEPTH	DESCRIPTION	OUND W	MBER	щ	TAL COR	LID CORE COVERY	RD LAYEI	(%) Qi	ACTURE r 0.3 m)	DISCONTINUITIES	athering Ir	DRAULIC NDUCTIVIT	INT LOAD T S AXIAL (MI	INT LOAD T	IAXIAL MPRESSI	NSITY (g/c GPa)
	162.9 15.2	Rock Surface SALINA FORMATION: Bedding almost horizontal ( <b>9</b> =90°)	GR CO CO	NZ	SIZ	0 7 8 7	S R S R	НА	RO	범 <u>에</u> >25	Fragmented zone:15.24m-15.57m 15.81m-15.95m	Ne	н СО	LCC LCC	0 0 0 0	NO C N	
	162.2			1	HQ	100	23		18	10	Fracture: 15.57m-15.61m, <b>θ</b> =45° 15.57m-15.65m, <b>θ</b> =10°	W2					
	16.0									>25	15.65m-15.67m, <b>9</b> =65 <sup>°</sup> 15.75m-15.81m, <b>9</b> =20° Lost zone: 15.95m-16.33m(inferred) Fragmented zone: 16.33m-16.54m	W1					
	-		1670 167	2	HQ	64	38		17	3	Fracture: 16.74m-16.80m, <b>θ</b> =40° 16.83m-16.87m, <b>θ</b> =70°	W4 to					
	17.0			•						_4	16.92m-16.94m, <b>θ</b> =50° 16.93m-16.97m, <b>θ</b> =60° 16.97m-17.02m, <b>θ</b> =45°					045.4	5
	-  -				ЦО	100	07		65	6	Fragmented zone: 17.02m-17.04m	o W1		189	87	215.1	2.7
	-					100	51		00	0	Fracture: 17.46m-17.48m, <b>θ</b> =80° 17.61m-17.67m, <b>θ</b> =40°	W2 t					
	_ <u>159.6</u> _ 18.5									1	18.42m-18.44m, <b>θ</b> =70°	$\vdash$					
	- - 1 <u>9</u> -			•						7	Fracture	Ч		40	26		
-	- - 			4	HQ	95	92		81	1	18.85m-18.90m, <b>θ</b> =0° and 5°, two sets 18.94m-18.96m, <b>θ</b> =80°	W4 to M					
	20 . 158.0									0	18.98m-19.01m, <b>θ</b> =65°						
ſ	20.1	END OF BOREHOLE Note: 1) 50 mm monitoring well was installed upon completion, screeped															
		between 4.50m and 7.60m. Water Level measured in															
		monitoring well: Date W.L.Depth (m) Jan. 13, 2021 3.5															
-																	
017.GLB 1-11602-00.GPJ 21-3-																	
SP SOIL-ROCK/MY-29-2 SP ROCK OD E 2016 20																	

#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 4 ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-07-2020 to Dec-08-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4769091.167 E 652847.816 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 100 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEVATION ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL 178.9 Ground Surface FILL: crusher run limestone, 0.0 contains silty sand pockets, SS 26 1 0 brownish grey, moist, compact. 178.2 FILL: silty clay, trace sand, trace 0.8 gravel, trace organics, trace rootlet, brownish grey, moist, stiff. 178 <u>1</u>177.9 2 SS 9 1.1 SILTY CLAY: trace sand, contains silt seams, brown, moist, very stiff to very soft. 3 SS 20 177 4 SS 16 0 176 reddish brown 5 SS 12 0 175 6 SS 9 0 SS 7 7 174 C 7 8 SS ο 173 9 SS 8 0 4 (96) н 172 grey, wet 10 SS 2 171 170 +35 Vane 1 169 Continued Next Page $+3, \times 3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS to Sensitivity Measurement $\overset{1st}{\checkmark} \overset{2nd}{\checkmark} \overset{3rd}{\checkmark} \overset{4th}{\checkmark}$

# LOG OF BOREHOLE BH20-04

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1 OF 3

					LOC	GOFI	BOR	EHO	LE E	3H20	-04									2 OI	F 3
PROJ	ECT: Geotechnical Investigation																REF.	. NO.	.: 20	-11602-00	)
CLIEN	IT: Regional Municipality of Niagara							Meth	od: Hol	low St	em Au	ugers/	HQ Co	ore			ENC	L NO	0.: 4		
PROJ	ECT LOCATION: Niagara Region Sani	tary S	Sewe	r				Diam	eter: 2	03 mm	1/63m	m		~			ORIC	GINA	TED	BY SL	
	M: Geodetic	NI 47	26000	1 167	E 652	017 016		Date:	Dec-	07-202 Dontil	20 to Drillin	Dec-0	18-202 115 75	(Truck	`		CON		D BI	MK	
	SOIL PROFILE	IN 47	5908	SAMPL	E 052	.047.010	)	DYNA	MIC CC		NETR/	ATION			)		UNE				
						TER		RESK	20 4	- PLOT	2	30 1	00	PLAST LIMIT	IC MOIS	URAL TURE	LIQUID LIMIT	z.	IT WT	REMARH AND	KS
(m)		PLOI			SΝ	WA ONS	NO	SHE	AR STI	RENG	TH (kl	Pa)	1	WP	N CON	N	WL	(KPa) (KPa)	AL UN N/m <sup>3</sup> )	GRAIN SI	IZE
DEPTH	DESCRIPTION	ATA	1BER	ш	<u>BLO</u> 0.3		VATI	0 0			+	FIÉLD \ & Sensit	ANE ivity	WA	TER CO		Т (%)	DOC DOC	ATUR. (KI	(%)	non
	Continued	STR	NUN	ТΥР	ŗ	GRO	ELE		20 4	0 6	L X 10 8	цав v 30 1	00	1	0 2	20 3	30		ľ	GR SA SI	I CL
-	SILTY CLAY: trace sand, contains																				
:	to very soft.(Continued)		1					-													
-			1					-													
				~~~			168	_												0 0 00	
		R	12	55	2		100	-									Ű			0 0 68	5 32
:								-													
-								-													
_							167	_													
-							107	-													
-								-													
-		H	1	ΤW																	
			1—		-		400	-													
<u>13</u>			1				166	-										1			
.			1					-													
-			1					_													
.								-													
-			14	SS	6		165	-								0	c			0 0 70	) 30
-			1					-													
164.3			1					_													
- 14.6	SILT: some sand, trace gravel, trace clay, contains clayey silt							-													
15	layers/pockets, dilatant, reddish brown, wet, loose.						164	_													
.								-													
-	trace gravel, contains shale fragments		15	SS	6			-							[Non-F	Plastic]				8 20 64	48
.								-													
16							163	-													
400 5					-			-													
162.5	BEDROCK:	$\mathbb{W}$						-													
-	Coring began at 16.31m	$\langle \rangle \rangle$	1	RC																	
17	Refer to Rock Core Log		1				162	-													
.			1																		
-		$\bigotimes$						-													
-				PC																	
- 18				1.C			161	-													
			1																		
-			1					-													
-								-													
- 19		$\otimes$					160	-										1			
			3	RC				-													
-								-										1			
150.0		$\otimes$						-										1			
109.0		///																			
<u>GROUN</u>	IDWATER ELEVATIONS					GRAPH	+ 3,	× <sup>3</sup> :	Number	rs refer itivitv	С	8=3%	<sup>6</sup> Strain	at Failu	ire						
Measure	ement $\overset{1 \text{st}}{\underbrace{\bigvee}} \overset{2 \text{rd}}{\underbrace{\bigvee}} \overset{3 \text{rd}}{\underbrace{\bigvee}} \overset{4 \text{th}}{\underbrace{\bigvee}}$									,											

# LOG OF BOREHOLE BH20-04

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PROJECT:	Geotechnical	Investigation	

# CLIENT: Regional Municipality of Niagara

PROJECT LOCATION: Niagara Region Sanitary Sewer

SOIL PROFILE

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4769091.167 E 652847.816 SAMPLES

# Method: Hollow Stem Augers/HQ Core

Diameter: 203 mm/63mm Date: Dec-07-2020 to Dec-08-2020

Equipment: Pontil Drilling CME 75 (Truck) 

REF. NO.: 201-11602-00 ENCL NO.: 4 ORIGINATED BY SL BW COMPILED BY MK CHECKED BY REMARKS ₹ LIQUID

(m)		01			က	VATE JS	7	2	0 4	0 6	8 0	0 10	00	LIMIT W-	CON	TENT	LIMIT W.	r PEN Pa)	UNIT ("	AND GRAIN SIZE
ELEV	DESCRIPTION	A PL	к		.3 M.		TION	SHEA			TH (kF	Pa) FIELD V/	ANE .	₩P				CKEI Su) (k	JRAL (KN/m	DISTRIBUTION
DEPTH		ZAT,	MBE	Щ			EVA.		JICK TF		+ L X	& Sensiti LAB V/	/ity ANE	WAT	TER CO	ONTEN	T (%)	55	NATL	(%)
	Continued	STF	NN	Ţ	"Z	GR	ELE	2	0 4	0 6	8 0	0 10	00	1	0 2	20 3	0			GR SA SI CL
19.9	END OF BOREHOLE																			
	1) TW denotes thin wall shelby tube																			
	sample.																			
2.26																				
7.GLB 0.GPJ 21																				
AY-29-20																				
L LOG 20																				
NSP 5 01																				

# LOG OF ROCK CORE BH20-04

PRO	JECT: Geotechnical Investigation								REI	=. N	O.: 20	01-11	602-0	0		
	NT: Regional Municipality of Niagara							Met	hod: H	Hollow Stem Augers/HQ Core	EN		10.: 4		SI	
								Dia	meler e: De	. 203 mm/osmm pc-07-2020 to Dec-08-2020	CO	MPI			BW	
BHL	OCATION: See Borehole Location Plan	N 4769	091.1	67 E (	65284	7.816	;	Εαι	uipmei	nt: Pontil Drilling CME 75 (Truck)	СН	ECK	ED B	Y	MK	
			CC	RE			_		×	3		Sec)		Pa)*	IPa)	
(m) <u>ELEV</u> DEPTH	ROCK DESCRIPTION	ROUND WATER CONDITIONS		IZE	OTAL CORE ECOVERY (%)	OLID CORE ECOVERY (%)	IARD LAYER (%)	(%)	RACTURE INDE ber 0.3 m)	DISCONTINUITIES	Veathering Index	YDRAULIC	OINT LOAD TEST CS AXIAL (MPa)*	OINT LOAD TEST CS DIAMETRAL (M	INIAXIAL OMPRESSION (N	ENSITY (g/cm <sup>3</sup> ) (GPa)
162.5	Rock Surface SALINA FORMATION:	00	z	S	⊢œ	ωщ	I	Ľ.	<u>ш</u> <u>е</u>	Fragmented zone:	5	τc		۵⊃	50	
-	Bedding almost horizontal ( <b>9</b> =90°)		1	HQ	100	44		44	>25	16.46m-16.81m Fracture:	W2					
<sup>17</sup> 161.8									6	16.81m-16.82m, <b>θ</b> =0° to 50°						
- 17.1 - - - - - - - - - - - - - - - - - - -			2	HQ	100	100		97	0 0 0 2 0	Joint: 17.09m-17.25m, <b>θ</b> =0° 17.42m-17.50m, <b>θ</b> =0°	W2 to W1				100	2.61
18.6		Joint: 18.69m-18.71m, <b>9</b> =65°											48	24		
- 19									<u> </u>	18.69m-18.71m, <b>€</b> =65° 18.75m-18.77m, <b>€</b> =70°	_					
-											to V1					
-									0		W2					
-									0							
159.0	END OF BOREHOLE															
100% 31% Stringuigu 1533																

#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 5 ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-04-2020 to Dec-04-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4768160.887 E 652873.207 CHECKED BY Equipment: Pontil Drilling CME 75 (Truck) SAMPLES SOIL PROFILE PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 40 60 100 20 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m SHEAR STRENGTH (kPa) O UNCONFINED + <sup>FIELD VANE</sup> & Sensitivity Wp w WL ELEVATION ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL 177.8 Ground Surface ASPHALT: 150mm 179.0 GRANULAR FILL: 50mm SS 50/ 170.0 initial125 0.2 nm FILL: crusher run limestone, contains silty sand pockets, brownish grey, moist, very dense to compact. 177 <u>1</u>176.8 2 SS 13 0 FILL: silty clay, trace sand, trace 1.1 gravel, trace organics, trace rootlet, brownish grey, moist, stiff. 176.0 3 SS 14 176 SILTY CLAY: trace sand, contains 1.8 2 silt seams, brown, moist, very stiff to very soft. 4 SS 19 175 5 SS 18 0 174 brown to reddish brown 6 SS 6 +3.0\_ 173 1 Vane 8 SS 11 172 contains grey silt seams 9 SS 10 2 (98) 0 171 170 10 SS 9 0 169 SS 9 0 8.4 11 168 Continued Next Page + <sup>3</sup>,×<sup>3</sup>: Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS to Sensitivity

LOG OF BOREHOLE BH20-05

1 OF 3

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					LOC				סחצנ	-03										2 05
PRO	JECT: Geotechnical Investigation															REF.	NO.	: 20	1-1160	02-00
CLIEI	NT: Regional Municipality of Niagara							Method: Ho	llow S	tem A	ugers/	HQ Co	ore			ENC	L NO	).: 5		
PRO	JECT LOCATION: Niagara Region Sanit	ary S	Sewe	er				Diameter: 2	03 mr	n/63m	m					ORIC	SINA	TED	BY	SL
DATU	JM: Geodetic							Date: Dec-	04-202	20 to	Dec-0	4-2020	)			CON	PILE	DB	(	BW
BH LO	OCATION: See Borehole Location Plan	N 47	76816	60.887	E 652	873.207	7	Equipment	Pontil	Drillin		/IE 75	(Truck)	)		CHE	CKE	D BY		MK
	SOIL PROFILE		5	SAMPL	ES	۲		RESISTANC	E PLOT		ATION -		PLASTI	C NAT	URAL	LIQUID		ŕ	RE	MARKS
(m)		5			(0)	'ATE S	_	20	0 6	50 8	80 1	00	LIMIT	CON	ITENT	LIMIT	PEN.	UNIT (	GR	AND
ELEV	DESCRIPTION	APL	к		.3 m		TION	SHEAR ST		TH (k	Pa) FIELD V	ANE	w <sub>P</sub> ⊢		~		CKET OU) (K	(KN/m	DIST	RIBUTIO
EPIH		RAT,	IMBE	Щ			EVA.		RIAXIA	L X	& Sensit LAB V	ivity ANE	WA	TER CO	ONTEN	T (%)	e S	NATL		(%)
	Continued	ST	z	⊢≿	Ż	9 0 9 0	EL	20	10 E	50 8	B0 1	00	1	0 2	20 3	80			GR S	SA SI C
	silt seams, brown, moist, very stiff	12						-												
	to very soft.(Continued)	H.						-												
		K	1					-												
	grey, wet	11		0.00			167	-												
		W2		55	2			-								0				
		H	┢					-												
		H	1																	
		H	1				166	-												
		Ĥ	1				100	-												
		W2						-												
		H	2	Vane				- +	2.5 35											
		K	1					-												
		H			1		165	-												
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		B						-												
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		K	14	SS	2		164	-						-	-0				0 5	5 (95
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		H2						-												
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		H	1				400	-												
i		H	1				163	-												
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		W2	1					-												
		H.	1	TW				-												
,		K	}—				162	-												
		H	1					-												
161.5 16.3	SAND AND GRAVEL: trace silt.		:					-												
	trace clay, reddish brown, wet,	0																		
	compact to loose.		<u> </u>				161	-												
		0	16	SS	15		101	-						0						
		. o						-						-						
		0						-												
		0																		
i.							160	-			-									
		0						-												
159.4		· °						-												
18.4	SILTY CLAY: trace sand, trace gravel_trace shale fragments	K	17	SS	8			-					0							
	reddish brown, wet, stiff to firm.	H	1				159	-												
		[h	1															1		
			1					-										1		
		Hł.																		
		KY.	1	1				t			1		1				1	1		
		XX		-			450													

Measurement  $\underline{\underline{\nabla}}^{1st}$   $\underline{\underline{\nabla}}^{2nd}$   $\underline{\underline{3}}^{rd}$   $\underline{\underline{4}}^{th}$ 

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2 OF 3

	-																			
PRO	JECT: Geotechnical Investigation																REF.	NO.	: 201	1-11602-00
CLIE	NT: Regional Municipality of Niagara							Meth	od: Hol	low St	tem Au	ugers/l	HQ Co	re			ENC	L NC	0.: 5	
PRO	JECT LOCATION: Niagara Region Sani	tary S	Sewe	r				Diam	eter: 2	03 mn	n/63m	m					ORIC	SINA	TED	BY SL
DAT	UM: Geodetic							Date	Dec-	04-202	20 to	Dec-0	4-2020	)			COM	IPILE	DBY	y BW
BH L	OCATION: See Borehole Location Plan	N 47	76816	60.887	E 652	873.207	7	Equip	oment:	Pontil	Drillin	g CN	1E 75 (	Truck)	)		CHE	CKE	D BY	MK
	SOIL PROFILE		5	SAMPL	ES	~		RESIS	MIC CO	DNE PE		ATION				URAL			F	REMARKS
(m)		F							20 4	0 6	50 E	30 1	00	LIMIT	MOIS CON	TURE	LIQUID	EN.	N LIN	AND
ELEV		PLC	~		N N N N	/M C	NO	SHE	AR STI	RENG	TH (ki	Pa)		W <sub>P</sub>	\	w 0	WL	(kP	AL U	GRAIN SIZE
DEPTH	DESCRIPTION	ATA	IBEF	ш	<u>BLC</u> 0.3		VATI	0 0	NCONF	INED	+	FIELD V & Sensiti	ANE vity	WAT			T (%)	02 Q	ATUR (F	(%)
	Continued	STR	N	TYP	z	GRC CON	ELG.		20 4	-0 6	L X 60 8	LAB V. 80 1	ANE DO	1	0 2	20 3	30		z	GR SA SI (
-	SILTY CLAY: trace sand, trace	1/1	18	SS	5			Ŀ								0				
-	gravel, trace shale fragments,							Ł												
F	firm.(Continued)	R				1		Ŀ												
-		11	1					Ŀ												
21		K	1				157													
-		1	1					È.												
E		11	_		-			È.												
E		K	1	.,				F			2.4									
-		1	3	Vane			450	F		-	-59									
22		1	<u> </u>		-		156	-												
ł		R	1					F												
-		12						E												
È.								E												
ŀ		R	1				155	-												
23		12	1					È.												
F								È.												
F		R	1					F												
E 15/ 1		12	1					F												
23.8	BEDROCK:	K			1		154											-		
-	Coring began at 23 77m	$\bigotimes$						Ē												
ł	Refer to Rock Core Log	$\mathbb{K}$	1					F												
È.		$\langle \rangle \rangle$	1	RC				F												
-								E												
152.9		$\mathbb{V}$					153													
25.0	END OF BOREHOLE		1																	
	Notes: 1) Borehole was sealed with																			
	bentonite and cement grouting.																			
	2) I W denotes thin wall shelby tube sample.																			
0 212.26																				
02-00.GP																				
3 201-116																				
SOLLO																				
SM S	1		<b>I</b>	1	I	L	I	I		l	I		I	I		1	1	<b>I</b>	L	<u> </u>
						GRAPH	. 3	$\sqrt{3}$	Numbei	s refer	~	8=3%	- · ·							





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# LOG OF ROCK CORE BH20-05

PRC	JECT: Geotechnical Investigation										RE	F. N(	O.: 20	)1-116	602-00	0
CLIE	NT: Regional Municipality of Niagara							Met	hod: H	Hollow Stem Augers/HQ Core	EN	CL N	IO.: 5			
LOC	ATION: Niagara Region Sanitary Sewer							Dia	meter	: 203 mm/63mm	OR	IGIN	ATED	BY	SL	
DAT	UM: Geodetic							Date	e: De	ec-04-2020 to Dec-04-2020	CO	MPIL	ED B	Y	BW	
BHL	OCATION: See Borehole Location Plan	N 4768	160.8	87 E 6	65287	3.207	,	Equ	ipmer	nt: Pontil Drilling CME 75 (Truck)	СН	ECK	ED B	Y	MK	
(m) <u>ELEV</u> DEPTH	ROCK DESCRIPTION	COUND WATER	SAN		TAL CORE COVERY (%)	LID CORE COVERY (%)	RD LAYER (%)	(%) (%)	ACTURE INDEX r 0.3 m)	DISCONTINUITIES	athering Index	DRAULIC NDUCTIVITY (cm/sec	INT LOAD TEST S AXIAL (MPa)*	INT LOAD TEST S DIAMETRAL (MPa)	IAXIAL MPRESSION (MPa	NSITY (g/cm³) GPa)
154.1	Rock Surface	<u></u> В О	R	SIZ	C II	Sh	HA	RO	FR pe		Š	ΗS	δΩ	δŋ	ЧS	ШÜ
23.8 24 - - - - - - - - - - - - - - - - - -	SALINA FORMATION: Bedding almost horizontal ( <b>0</b> =90°)		1	HQ	100	71		48	17 5 3 3	Fragmented zone: 23.91m-24.09m Fracture: 24.42m-24.47m, <b>9</b> =0° 24.83m-24.99m, <b>9</b> =10° 24.84m-24.94m, <b>9</b> =30°	W2 to W1					
- <u>152.5</u> 25.0	END OF BOREHOLE Note:															

#### LOG OF BOREHOLE BH20-06D PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/Mud Rotory ENCL NO .: 6D ORIGINATED BY AKJ PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-15-2020 to Dec-16-2020 COMPILED BY MK Equipment: Pontil Drilling CME 75 (Truck) BH LOCATION: See Borehole Location Plan N 4767709.7 E 652872.7 CHECKED BY SAMPLES SOIL PROFILE PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 40 60 100 20 80 (m) STRATA PLOT BLOWS 0.3 m **GRAIN SIZE** Wp w W ELEVATION SHEAR STRENGTH (kPa) ELEV DEPTH + FIELD VANE & Sensitivity DISTRIBUTION -0 -1 DESCRIPTION NUMBER O UNCONFINED (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 175.8 Ground Surface GR SA SI CL ASPHALT: 100mm 17**9.9** FILL: crusher run limestone, grey, 70/ SS 1 0 moist, very dense to compact. 200mr 175 2 SS 35 contains silty sand pockets, 0 174.0 174 3 SS 10 FILL: silty clay, some sand, trace 1.8 R 2 gravel, trace organics, greyish brown, moist, stiff to firm. 4 SS 7 0 173 5 SS 8 0 W. L. 172.3 m Jan 13, 2020 172.0 FILL: crusher run limestone, grey, 3.8 wet, very loose to loose. 6 SS 4 0 -171.2 FILL: clayey silt, sandy, trace 4.6 gravel, trace organics, brown, moist 171 7 SS 4 0 to wet, firm to soft. SS 3 8 0 170.1 75mm crushed stone layer 170 5.7 SILTY CLAY: some sand, trace gravel, trace organics, trace peat, grey, moist, soft (Alluvial Deposit). 1 Vane 169 168.6 **ORGANIC CLAYEY SILT:** interval 7.2 with peat seams and layer, sandy, trace rootlets, dark brown, moist, soft to firm. 168 10 SS 4 167 166.5 9.3 SILTY CLAY: trace sand, contains SS 0 11 reddish brown silt layers, grey, wet, very soft to hard. 166

Continued Next Page GROUNDWATER ELEVATIONS



to Sensitivity

O <sup>8=3%</sup> Strain at Failure

1 OF 4

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PRO	JECT: Geotechnical Investigation																REF.	NO.	: 20	1-11602-00
	INT: Regional Municipality of Niagara	any S	-	r				Diameter	- 2010	3 mm	em Al	lgers/	iviua R	otory					.: 6L	) ⊳v AK.I
		ary c	bewe	I				Date: De	. 20 c-1!	5-202	0 to	Dec-1	6-202	n			COM		ים ו איז ס	A BW
BHL	OCATION: See Borehole Location Plan	N 47	6770	)9.7 E	65287	2.7		Equipme	nt: P	ontil l	Drillin	a CN	ME 75	(Truck)	)		CHE		D BY	MK
	SOIL PROFILE		5	SAMPL	ES			DYNAMIC RESISTAN		NE PEI PLOT		ATION	-	Ì	, NAT		-	1		DEMARKS
(m) <u>ELEV</u> DEPTH	DESCRIPTION	TRATA PLOT	UMBER	үре	V" BLOWS 0.3 m	ROUND WATER ONDITIONS	LEVATION	20 SHEAR S O UNCC O QUICH		ENGT NED IAXIAL	) 8 TH (kF + . ×	BO 1 Pa) FIELD V & Sensit LAB V	IOO /ANE tivity /ANE			ONTEN	LIQUID LIMIT W <sub>L</sub> T (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT W <sup>-</sup> (kN/m <sup>3</sup> )	AND GRAIN SIZE DISTRIBUTION (%)
	SILTY CLAY: trace sand, contains	K.X	2	-	-	00	ш	-			, ,			'						GR SA SI CL
	reddish brown silt layers, grey, wet, very soft to hard.(Continued)						105	-												
<u>1</u>			2	Vane			165	+	1.0 28											
2							164	-												
-	reddish grey		13	SS	1			-								0				
3							163	-										-		
								- - - -												
4			1	тw			162													
							161	-												
<u>-</u>	150mm wet grey sandy silt layer		15	SS	16			- - - - -							0					
6							160	- - -										_		
								-												
7	contains reddish brown silt seams		16	SS	31		159									0				4 3 51 42
								-												
<u>158.0</u> 17.8	SANDY GRAVEL: trace silt, trace clay, reddish grey, wet, dense.						158													
		0 0	17	SS	48		157	-							•					
9 156 5		.0 .0						-												
19.4	<b>COARSE SAND:</b> trace to some gravel, trace silt, trace clay, grey, wet, compact to very dense.						156	-												

2 OF 4

#### LOG OF BOREHOLE BH20-06D PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/Mud Rotory ENCL NO .: 6D ORIGINATED BY AKJ PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-15-2020 to Dec-16-2020 COMPILED BY MK Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY BH LOCATION: See Borehole Location Plan N 4767709.7 E 652872.7 SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 100 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL ELEVATION SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL Continued COARSE SAND: trace to some 18 SS 28 0 gravel, trace silt, trace clay, grey, wet, compact to very dense.(Continued) 155 92/ 150mm dilatant reddish brown SS 19 0 300mr sandy silt layer, trace 154 cobbles/boulders 153.4 SANDY GRAVEL: trace silt, trace ò 0 clay, trace cobbles, grey, wet, very dense. 153 152 .o 50/ 20 SS 0 o 100 o 151 0 o 150 149 ò. ċ 148.4 0 Ż 21/SS/NR 50/ BEDROCK: 27.4 initial0m 148 147 22 SS 50/ 0 146 Continued Next Page + <sup>3</sup>,×<sup>3</sup>: Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS to Sensitivity

Measurement  $\overset{1st}{\checkmark} \overset{2nd}{\checkmark} \overset{3rd}{\checkmark} \overset{4th}{\checkmark}$ 

**\\SD** 

3 OF 4

# LOG OF BOREHOLE BH20-06D

PROJ	ECT: Geotechnical Investigation																REF.	NO.	: 201	-11602-00
CLIEN	IT: Regional Municipality of Niagara							Metho	d: Hol	low St	em Au	igers/N	/lud Ro	otory			ENCL	NO	.: 6D	
PROJ	ECT LOCATION: Niagara Region Sanit	tary S	Sewei	r				Diam	eter: 2	03 mm	1						ORIG	<b>INA</b>	ΓED	BY AKJ
DATU	M: Geodetic							Date:	Dec-	15-202	0 to I	Dec-16	6-2020	)			COM	PILE	D BY	BW
BH LC	OCATION: See Borehole Location Plan	N 47	6770	9.7 E	65287	2.7		Equip	ment:	Pontil	Drillin	g CM	E 75 (	Truck)			CHEC	CKE	) BY	MK
	SOIL PROFILE		s	AMPL	ES	~		DYNAI RESIS	MIC CC TANCE	NE PE		TION				JRAL			F	REMARKS
(m)		L L				ATEF S		2	0 4	0 6	0 8	0 10	00	LIMIT	MOIS CON	TURE TENT	LIMIT	PEN. a)	NIT (	AND
ELEV	DESCRIPTION	PLO	~		3 MS	NON:	NOI	SHEA	R STF	RENG	TH (kF	Pa)		W <sub>P</sub>		v >	WL	CKET u) (kP	RN/m <sup>3</sup>	DISTRIBUTION
DEPTH	DESCRIPTION	<b>MTA</b>	ABEI	щ	0.: 0		VAT			INED RIAXIAI	+ ×	& Sensitiv	/ity	WAT	ER CO	DNTEN	T (%)	90 00	NATUF )	(%)
	Continued	STF	ΝÑ	ТҮР	"z	GR( COI	ELE	2	0 4	0 6	0 8	0 10	00	1	0 2	0 3	0		-	GR SA SI CI
-	BEDROCK:(Continued)	$\mathbb{N}$						-												
-						目		-									41			
30.5	END OF BOREHOLE		23/	ss /	50/	· H·		_									41			
	Note: 1) TW denotes thin wall shelby tube			Ini	tial25n	ım														
	sample.																			
	2) 50 mm monitoring well was installed upon completion, screened																			
	between 28.35m and 30.48m.																			
	Water Level measured in																			
	monitoring well: Date W.L.Depth (m)																			
	Jan. 13, 2021 3.5																			
I		1														1	1			

11	5	)

# LOG OF BOREHOLE BH20-06S

# REF. NO.: 201-11602-00

ENCL NO.: 6S

PROJECT: Geotechnical Investigation CLIENT: Regional Municipality of Niagara

PROJECT LOCATION: Niagara Region Sanitary Sewer

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4767710.5 E 652872.6

Method: Hollow Stem Augers

Diameter: 203 mm

Date: Dec-17-2020

Equipment: Pontil Drilling CME 75 (Truck)

SOIL PROFILE		SA		ES			DYNA	MIC CO		NETRA	ATION			NATI						
	⊢				TER		2	20 4	0 6		30 10	00	PLASTI LIMIT	MOIS CON	JRAL TURE TENT	LIQUID LIMIT	EN	IT WT	AND	1
(m)	0			SN E	WA.	z	SHEA	AR ST	RENG	ΓΗ (kf	Pa)	<u> </u>	WP	v	V	WL	(KPa)	AL UN	GRAIN S	SIZE
DEPTH DESCRIPTION	ATA	BER		0.3		ATIC	οU	NCONF	INED	÷	FIÉLD V. & Sensiti	ANE vity				T (0/.)	POCP (CU)	ATUR (ki	(%)	TION
175.8 Ground Surface	STR	NUM	IγPE	ż	GRO	ELE	• Q 2	UICK T 20 4	RIAXIAL 0 61	. × 0 8	LAB V/ 30 10	ANE 00	1	2 ER	0 3	1 (%) 80		Ż	GR SA S	
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Without Sampling	$\bigotimes$						-													
Lithology Inferred from BH-06	$\bigotimes$					1	-													
(Deep)	$\bigotimes$					175	-													
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Continued Next Page GROUNDWATER ELEVATIONS				(		+ 3,	׳:	Numbe	rs refer	0	<b>8</b> =3%	Strain	at Failu	re						
Measurement $\overset{1st}{\checkmark}$ $\overset{2nd}{\checkmark}$ $\overset{3rd}{\checkmark}$ $\overset{4th}{\checkmark}$				1																

PRO	IECT: Geotechnical Investigation																REF.	. NO.	: 20′	I-11602-00
CLIE	NT: Regional Municipality of Niagara		Metho	od: Hol	low Ste	em Au	gers					ENC	L NO	0.: 6S						
PRO	IECT LOCATION: Niagara Region Sanit	ary S	ewei	•				Diamo	eter: 2	03 mm	0									
		NI 47	6774	055	65007	0.6		Date:	Dec-	17-202 Dentil	U Drillin	~ ~ ~ ~ ~	F 76 /	Truck						
BHL		N 47	6//1		65287.	2.6		DYNA	MIC CC	Pontii DNE PEI	NETRA		E /5 (	Truck)						
						ER		RESIS	TANCE	E PLOT	$\geq$			PLASTI	C NATU MOIS	URAL		z	T WT	
(m)		LOT			S R	WAT NS	z	2 SUE A			) 8  ГЦ /VE	0 10	00	WP	CON	TENT N	WL	ET PEI (kPa)	L UNI /m³)	GRAIN SIZE
ELEV DEPTH	DESCRIPTION	TAP	BER		<u>3LOV</u>		ATIC		VCONF	INED	+	FIELD VA & Sensitiv	ANE rity	-		>		(CU)	TURA (kN	DISTRIBUTION
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15		K					161	-										1		
160.6								-												
15.2	Note:																			
	bentonite.																			
	2) 50 mm monitoring well was installed upon completion screened																			
1	between 12.19m and 15.24m.																	1		
1	Water Level measured in																	1		
	monitoring well:																	1		
	Jan. 13, 2021 3.9																			
																		1		
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01-11-0024																		1		
C LOG																		1		
5 day																				



# vsp

#### **\\S**D LOG OF BOREHOLE BH20-07D PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers//Mud Rotory/HQ Core ENCL NO .: 7D ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm DATUM: Geodetic Date: Dec-21-2020 to Dec-22-2020 COMPILED BY Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY BH LOCATION: See Borehole Location Plan N 4767374.6 E 652880.1 SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) 40 60 100 20 80 (m) STRATA PLOT BLOWS 0.3 m Wp w WL ELEVATION SHEAR STRENGTH (kPa) ELEV DEPTH + FIELD VANE & Sensitivity -0 -1 DESCRIPTION NUMBER O UNCONFINED WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 177.1 Ground Surface GRANULAR FILL: crusher run 177 178.0 imestone, grey, moist, compact. SS 19 1 0 FILL: silty clay, trace sand, trace gravel, trace organics, grey, moist, very stiff to stiff. 2 SS 9 176 175.4 SILTY CLAY: trace sand, contains 1.7 3 SS 18 0 reddish brown silt seams, brown, moist, very stiff to very soft. 175 4 SS 17 a 174 5 SS 14 173 6 SS 7 SS 8 7 0 172 W. L. 171.8 m grey Jan 13, 2020 7 8 SS 0 171 9 SS 4 170

Continued Next Page GROUNDWATER ELEVATIONS

contains dilatant silt layers

# Measurement $\overset{1st}{\checkmark} \overset{2nd}{\checkmark} \overset{3rd}{\checkmark} \overset{4th}{\checkmark}$

 $+3, \times 3$ : Numbers refer GRAPH NOTES to Sensitivity

169

168

1 Vane

> SS 2

11

+35

O <sup>8=3%</sup> Strain at Failure

1 OF 4

BW

MK

REMARKS

AND

GRAIN SIZE

DISTRIBUTION

(%)

GR SA SI CL
#### REF. NO.: 201-11602-00 PROJECT: Geotechnical Investigation CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers//Mud Rotory/HQ Core ENCL NO .: 7D ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-21-2020 to Dec-22-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4767374.6 E 652880.1 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 80 100 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w $W_{L}$ ELEVATION SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEV DEPTH -0 DISTRIBUTION н -1 NUMBER DESCRIPTION (%) WATER CONTENT (%) ТҮРЕ QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL Continued SILTY CLAY: trace sand, contains 167 reddish brown silt seams, brown, moist, very stiff to very soft.(Continued) тw 1 166 165 13 SS 1 164 +2.0 2 Vane 163 162.3 SILT: trace to some clay, trace 14.8 sand, dilatant, reddish brown, wet, 162 loose to very dense. SS 15 8 0 161 some sand to sandy between 16.8m to 20.4m 17 SS 50 160 159 18 SS 58 0 15 81 4 158 Continued Next Page $+3, \times3$ : Numbers refer GRAPH NOTES O <sup>8=3%</sup> Strain at Failure GROUNDWATER ELEVATIONS to Sensitivity

2 OF 4

### LOG OF BOREHOLE BH20-07D

#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers//Mud Rotory/HQ Core ENCL NO .: 7D ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-21-2020 to Dec-22-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4767374.6 E 652880.1 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 40 60 100 20 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEVATION ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL Continued SILT: trace to some clay, trace 157 19 SS 55 sand, dilatant, reddish brown, wet, loose to very dense.(Continued) 156 20 SS 56 ο 155 154 153 152.4 21 SS 13 0 24.7 CLAYEY SILT TILL: sandy, trace to ١ĥ some gravel, grey, moist to wet, stiff 152 151 150.7 26.4 BEDROCK: Coring began at 27.13m Refer to Rock Core Log 150 RC 1 149 2 RC 148 RC 3 Continued Next Page $+3, \times 3$ : Numbers refer GRAPH NOTES O <sup>8=3%</sup> Strain at Failure GROUNDWATER ELEVATIONS to Sensitivity

LOG OF BOREHOLE BH20-07D

# wsp

## LOG OF BOREHOLE BH20-07D

	PROJ CLIEN PROJ	ECT: Geotechnical Investigation IT: Regional Municipality of Niagara IECT LOCATION: Niagara Region Sanit	ary S	Sewei	r				Metho Diamo	od: Hol eter: 2	low St 03 mm	em Au n/63mr	igers// m	Mud R	otory/ł	HQ Co	ore	REF. ENCL ORIG		: 20' .: 7D FED	I-11602-00 BY SL , BW
	BHLC	DCATION: See Borehole Location Plan	N 47	6737	4.6 E	65288	0.1		Equip	ment:	Pontil	Drillin	a CN	ie 75 (	, Truck)	)		CHEC		D BY	MK
		SOIL PROFILE		s	SAMPL	ES			DYNA RESIS	MIC CC	NE PE PLOT		ATION			- NAT	JRAL			F	REMARKS
	(m) <u>ELEV</u> DEPTH	DESCRIPTION Continued BEDROCK: Coring began at 27.13m	STRATA PLOT	NUMBER	TYPE	"N" BLOWS	GROUND WATER	NOLLEVATION		0 4 R STF NCONF JICK TF 0 4	0 6 RENG INED RIAXIAI 0 6	0 8 TH (kF + - × 0 8	Pa) FIELD V & Sensiti LAB V	ANE vity ANE DO	WA1	TER CC		цоло LIMIT w <sub>L</sub> 	POCKET PEN. (Cu) (kPa)	NATURAL UNIT W (kN/m <sup>3</sup> )	AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
Ē	146.4	Refer to Rock Core Log(Continued)	$\mathbb{N}$				·· – [· ·		-												
CL-45/24/MA28/17 GA 50L L02 24/14/06/06/ 2/2431	<u>146.4</u> 30.7	<ul> <li>END OF BOREHOLE Note:</li> <li>1) TW denotes thin wall shelby tube sample.</li> <li>2) 50 mm monitoring well was installed upon completion, screened between 27.43m and 30.48m.</li> <li>Water Level measured in monitoring well: Date W.L.Depth (m) Jan. 13, 2021 5.3</li> </ul>																			

# vsp

## LOG OF ROCK CORE BH20-07D

F	PROJ	ECT: Geotechnical Investigation IT: Regional Municipality of Niagara							Met	hod: I	Hollow Stem Augers//Mud Rotory/HQ Core	REF.	. NC CL N	D.: 20 O.: 70	1-116 )	02-00	D
L		TION: Niagara Region Sanitary Sewer							Dia	neter	: 203 mm/63mm	ORIC	GIN/	ATED	BY	SL	
		M: Geodetic		074.0	E 05	2000			Dat	e: De	c-21-2020 to Dec-22-2020	CON	/IPIL	ED B	Y	BAA	
F		JCATION: See Borenole Location Plan	N 4767	374.6 CC	E 652 RE	2880.	1		Equ	ipme	nt: Pontil Drilling CME 75 (Truck)		CKI ම	ED BI	( a)*		
( <u>E</u> DE	(m) <u>:LEV</u> EPTH 50.0	ROCK DESCRIPTION Rock Surface	GROUND WATER CONDITIONS	NUMBER	IPLE SIZE	TOTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RQD (%)	FRACTURE INDEX (per 0.3 m)	DISCONTINUITIES	Weathering Index	HYDRAULIC CONDUCTIVITY (cm/s	POINT LOAD TEST UCS AXIAL (MPa)*	POINT LOAD TEST UCS DIAMETRAL (MP	UNIAXIAL COMPRESSION (MF	DENSITY (g/cm³) E (GPa)
- - - - - 1	27.1 49.3	SALINA FORMATION: Bedding almost horizontal ( <b>0</b> =90°) (continued)		1	НQ	100	84		34	15 5	Fragmented zone:27.37m-27.42m 27.51m-27.55m Fracture: 27.13m-27.23m, <b>0</b> =10° 27.27m-27.33m <b>0</b> =15° to 0°	W2				223.5	2.75
- - - - - - - - - - - - - - - - - - -	27.8			2	HQ	100	95		75	3 3 6 0 4	Fragmented zone: 27.87m-27.88m;28.65m-28.68m Fracture: 28.15m-28.16m, <b>θ</b> =70° 28.33m-28.36m, <b>θ</b> =60° to 65° 29.07m-29.10m, <b>θ</b> =0° and 0°,two sets Joint: 28.18m-28.19m, <b>θ</b> =75° 28.27m-28.28m, <b>θ</b> =80°	W2 to W1					
- - - - - - - - - - - - - - - - - - -	29.2			3	HQ	100	93		70	6 4 2 1 2	Soft laye 29.29m ~ 29.31m (W5 Fracture: 29.16m-29.21m, <b>9</b> =0° and 5°,two sets 29.74m-29.76m, <b>9</b> =75°	W2 to W1					
1 1	46.4	END OF BOREHOLE Note: 1) 50 mm monitoring well was installed upon completion, screened between 27.43m and 30.48m. Water Level measured in monitoring well: Date W.L.Depth (m) Jan. 13, 2021 5.3															

### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers ENCL NO .: 7S ORIGINATED BY AKJ PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-23-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4767373.8 E 652880.3 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 40 20 60 80 100 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m w WL SHEAR STRENGTH (kPa) O UNCONFINED + <sup>FIELD VANE</sup> & Sensitivity Wp ELEVATION ELEV DEPTH DISTRIBUTION -0 -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) ТҮРЕ QUICK TRIAXIAL × LAB VANE z 20 40 60 80 100 10 20 30 GR SA SI CL 177.0 Ground Surface Ŕ -17**8**.9 Direct Drilling to Depth of 19.81 Without Sampling Lithology Inferred from BH-07 (Deep) 176 <u>175.3</u> 1.7 175 174 173 W. L. 172.4 m Jan 13, 2020 172 171 170 169 168 Continued Next Page +<sup>3</sup>,×<sup>3</sup>: Numbers refer to Sensitivity O <sup>8=3%</sup> Strain at Failure

GRAPH NOTES

1 OF 3

### LOG OF BOREHOLE BH20-07S

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	יור			I	LOG	OF B	ORE	HOL	E B	H20-	07S									2	OF 3
PRO	JECT: Geotechnical Investigation																REF.	NO.:	: 201	-11602	-00
CLIE	NT: Regional Municipality of Niagara							Metho	d: Ho	llow St	em Au	ugers					ENC	L NO	.: 7S		
PRO	JECT LOCATION: Niagara Region Sanit	ary S	Sewer	-				Diam	eter: 2	03 mn	ı						ORIG	SINAT	TED	BY Ał	٢J
DATI	JM: Geodetic							Date:	Dec-	23-202	20						COM	IPILE	D BY	B\	V
BH L	OCATION: See Borehole Location Plan	N 47	6737	3.8 E	65288	0.3		Equip	ment:	Pontil	Drillin	g CN	1E 75	(Truck)	)		CHE	CKEE	D BY	М	<
	SOIL PROFILE		s	AMPL	ES	~		DYNA RESIS	MIC CO	DNE PE		ATION				URAL			F	REM	ARKS
(m)		Т				ATEF S		2	0 4	40 G	0 8	30 1	00	LIMIT	MOIS CON	TURE	LIQUID	PEN. a)	NIT (	A	ND
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DEPTH		ZAT/	MBE	Щ	<u> </u>		EVAT	0 UI	NCONF	-INED RIAXIA	+ L X	& Sensiti		WA	FER CC	ONTEN	T (%)	õ <u>0</u>	NATU	(%	6)
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**NSD** 

### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers ENCL NO .: 7S PROJECT LOCATION: Niagara Region Sanitary Sewer ORIGINATED BY AKJ Diameter: 203 mm BW DATUM: Geodetic Date: Dec-23-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4767373.8 E 652880.3 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY DYNAMIC CONE PENETRATION RESISTANCE PLOT SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT W (kN/m<sup>3</sup>) AND 40 20 60 80 100 (m) STRATA PLOT BLOWS 0.3 m GRAIN SIZE w WL SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity WP ELEVATION ELEV DEPTH DISTRIBUTION -0--1 H DESCRIPTION NUMBER (%) TYPE WATER CONTENT (%) QUICK TRIAXIAL × LAB VANE z 20 40 60 80 100 10 20 30 Continued GR SA SI CL Note: 1) 50 mm monitoring well was installed upon completion, screened between 16.76m and 19.81m. Water Level measured in monitoring well: Date W.L.Depth (m) Jan. 13, 2021 4.6



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PR	OJECT: Geotechnical Investigation																	REF.	NO.	: 201	1-11602-00
CL	ENT: Regional Municipality of Niagara							N	/letho	d: Ho	llow S	Stem /	Augers	s/HQ C	ore			ENC	L NC	9.: 8	
PR	OJECT LOCATION: Niagara Region Sanit	tary S	Sewe	r				D	Diame	eter: 2	203 m	m/63r	nm					ORIG	SINA	TED	BY SL
DA	TUM: Geodetic							D	Date:	Dec-	18-20	20 to	Dec-	18-202	0			COM	IPILE	D BY	V BW
BH	LOCATION: See Borehole Location Plan	N 47	76669	0.054	E 654	312.34 T	4	E		ment: /IC C	Ponti	I Drill	ing C	ME 75	(Truck	:)		CHE		D BY	MK
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ELE	DESCRIPTION	IA PI	н		<u>1.3 π</u>		IOITA	S	SHEA O UN	R S I ICONI	REN( FINED	) H I 6 +	kPa) - <sup>FIELD</sup>	VANE	i-		-o	—	OCKE (Cu)	URAL (KN/i	DISTRIBUTION
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176	9 Ground Surface 0 FILL: topsoil with silty clay pockets	is XX	z	í-	£			cret	te 20	) 4	10	60	80	100		10	20 3	30	-		GR SA SI C
Ē	trace sand, trace gravel, greyish	$\bigotimes$		55	5		·	Ę										0			
È	brown, moist, firm.	$\bigotimes$					.+Sand	╡┝										Ĩ			
- 176	.1	$\bigotimes$					•	F													
= 0 1	.8 <b>FILL:</b> silty clay, trace sand, trace gravel trace organics grevish	$\mathbb{X}$					176	6					_						-		
E	brown, stiff.	$\bigotimes$	2	SS	11			F									0				
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- 1	5 SILTY CLAY: trace sand, brown,	Ŕ						Ē													
E	moist, very stiff to very soft.	1	3	SS	17		17	5									0				
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Mea	surement $\underline{ abla}$ $\underline{ abla}$ $\underline{ abla}$ $\underline{ abla}$																				

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PRO	IECT: Geotechnical Investigation																REF.	. NO.	: 20	1-11602-00
CLIE	NI: Regional Municipality of Niagara	ta- 0	·	-				Meth	od: Ho	now S	tem A	ugers/l	HQ Co	re			ENC		).: 8 TES	
PRO	JECT LOCATION: Niagara Region Sani	tary S	ewe	r				Diam	ieter: 2	03 mn	n/63m	m Daa 4	0 0000				ORIC			A B/W
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(m)		LOT			SIE	WAT	z	SHE			00 8 L TH (k	20 1 Pa)	00	WP	CON	TENT N	WL	ET PE (kPa)	(m <sup>3</sup> )	GRAIN SIZE
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	moist, very stiff to very soft.(Continued)							_												
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#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 8 ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-18-2020 to Dec-18-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766690.054 E 654312.344 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT W (KN/m<sup>3</sup>) AND 20 40 60 100 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m SHEAR STRENGTH (kPa) O UNCONFINED + <sup>FIELD VANE</sup> & Sensitivity Wp w WL ELEVATION ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL Continued fragments, contains dilatant silt 18 SS 7 0 1 5 59 35 layers SILTY CLAY: trace sand, contains dilatant silt seams, grey, wet, very soft to stiff.(Continued) 156 19 SS 12 o 155 154 153.7 23.2 SILT: trace to some clay, trace sand, trace gravel, dilatant, reddish brown, wet, compact. 153 20 SS 26 0 152 151 150 some gravel, trace shale fragments 21 SS 14 0 149 148 147.6 29.3 BEDROCK: Coring began at 29.26m RC Refer to Rock Core Log 1 147 Continued Next Page $+3, \times3$ : Numbers refer GRAPH NOTES O <sup>8=3%</sup> Strain at Failure GROUNDWATER ELEVATIONS to Sensitivity

LOG OF BOREHOLE BH20-08

3 OF 5

#### LOG OF BOREHOLE BH20-08 REF. NO.: 201-11602-00 PROJECT: Geotechnical Investigation CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 8 PROJECT LOCATION: Niagara Region Sanitary Sewer ORIGINATED BY SL Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-18-2020 to Dec-18-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766690.054 E 654312.344 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT ⋝ POCKET PEN. (Cu) (kPa) NATURAL UNIT W (kN/m<sup>3</sup>) AND 40 20 60 80 100 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w $W_{L}$ ELEVATION SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEV DEPTH -0--1 DISTRIBUTION H NUMBER DESCRIPTION (%) WATER CONTENT (%) ТҮРЕ QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL Continued BEDROCK: Coring began at 29.26m 2 RC Refer to Rock Core Log(Continued) 146 3 RC 145 4 RC 144 143 RC 5 142 6 RC 141 -Sand 140 7 RC 139 Screen RC 8 138 137.3 END OF THE BOREHOLE 39.6 Note: 1) 50 mm monitoring well was Continued Next Page $+3, \times 3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS to Sensitivity

## LOG OF BOREHOLE BH20-08

PROJECT:	Geotechnical	Investigat	ion

CLIENT: Regional Municipality of Niagara

PROJECT LOCATION: Niagara Region Sanitary Sewer

SOIL PROFILE

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4766690.054 E 654312.344

SAMPLES

Method: Hollow Stem Augers/HQ Core

Diameter: 203 mm/63mm Date: Dec-18-2020 to Dec-18-2020

Equipment: Pontil Drilling CME 75 (Truck) DYNAMIC CONE PENETRATION RESISTANCE PLOT

ORIGINATED BY SL BW COMPILED BY MK CHECKED BY PLASTIC NATURAL MOISTURE CONTENT REMARKS AND

REF. NO.: 201-11602-00

ENCL NO.: 8

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(m)		PLO			MS m	.WN	NO	SHEA		RENG	с ТН (kF	Pa)		WP	V	N	WL	KET PE (kPa)	AL UN N/m <sup>3</sup> )	GRAIN SIZE
DEPTH	DESCRIPTION	ATA	IBER	ш	<u>BLO</u> 0.3		VATI			INED	+	FIÉLD V/ & Sensitiv	ANE /ity	W/ Δ1			F (%)	POCI (Cu	ATUR. (KI	(%)
	Continued	STR	NUN	ТΥΡΙ	"Z	GRC CON	ELEV	• QL 2	JICK 11 0 4		_ × 0 8	LAB VA 0 10	ANE 00	1	0 2	20 3	0		Ż	GR SA SI CL
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	Dec. 23, 2020 6.50 Jan. 13, 2021 4.61																			
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## LOG OF ROCK CORE BH20-08

PROJ	IECT: Geotechnical Investigation										REF	. NC	D.: 20	)1-116	302-0	0
CLIEN	NT: Regional Municipality of Niagara							Met	hod: H	Hollow Stem Augers/HQ Core	ENC	CL N	O.: 8			
LOCA	TION: Niagara Region Sanitary Sewer							Dia	meter	:: 203 mm/63mm	ORI	GIN/	ATED	BY	SL	
DATU	JM: Geodetic							Dat	e: De	ec-18-2020 to Dec-18-2020	COI	ИРIL	ED B	Y	BW	
BH LO	OCATION: See Borehole Location Plan	N 4766 I	690.0	54 E (	65431 I	2.344		Equ	iipmei	nt: Pontil Drilling CME 75 (Truck)	CHE	ECKI	ED B	۲ ج	MK	T
(m) <u>ELEV</u> DEPTH	ROCK DESCRIPTION	ROUND WATER DNDITIONS	NMBER SA		DTAL CORE ECOVERY (%)	DLID CORE ECOVERY (%)	ARD LAYER (%)	(%) DC	RACTURE INDEX er 0.3 m)	DISCONTINUITIES	eathering Index	'DRAULIC NNDUCTIVITY (cm/se	DINT LOAD TEST SS AXIAL (MPa)*	DINT LOAD TEST SS DIAMETRAL (MP∂	VIAXIAL OMPRESSION (MP	ENSITY (g/cm³) (GPa)
147.6		50	ž	S	ЧЧ	ΥЗК	Ť	Ř	Щē	Fragmented zene:20.26m 20.42m	Š	£β	20	82	Ξŭ	Вщ
29.3 - - - <u>-</u> <u>-</u> - - - - - - - - - - - - -	SALINA FORMATION: Bedding almost horizontal ( <b>θ</b> =90°)		1	HQ	100	78		36	20 7 3	Fragmented 20ne:29.20m-29.43m Gysum:30.12m-30.13m Fracture: 29.51m-29.63m, $\theta$ =5° 29.63m-29.67m, $\theta$ =0° and 0°,two sets 29.83m-29.92m, $\theta$ =5°	4 W2				149.4	2.72
- 30.2			2	HQ	58	58		58	13	Lost zone:30.38m-30.51m(inferred) Joint:31.28m-31.29m.9=75°	to V					
321 44. 9			3	HQ	100	98		98	0 2 1 1 0	Gysum: 31.23m-31.24m 31.28m-31.29m 31.67m-31.69m	W2 to W1 W2					
3330 - 32.0 			4	HQ	100	100		100		Gysum: 32.03m-32.04m;32.51m-32.53m 32.91m-32.92m;32.96m-32.97m 33.05m-33.06m;33.10m-33.11m 33.13m-33.14m;33.19m-33.20m 33.29m-33.30m;33.31m-33.32m 33.34m-33.35m;33.39m-33.41m 33.47m-33.48m Joint: 32.04m-32.51m, <b>0</b> =75° 32.75m-32.92m, <b>0</b> =75°	W2 to W1					
- 33.5 - - - - - - - - - - - - - - - - - - -			5	HQ	100	97		90	4 2 2 2 1	Fragmented zone: 33.53m-33.55m Gysum: 33.57m-33.58m;33.62m-33.63m 33.67m-33.68m;33.80m-33.81m 34.06m-34.07m;34.42m-34.44m 34.54m-34.55m	W2 to W1					
- 35.0 - - - - - - - - - - - - - - - - - - -			6	HQ	100	98		78	1 0 3 1 5	Gysum: 35.32m-35.33m;35.84m-35.85m 35.92m-35.93m;36.02m-36.03m 36.04m-36.05m;36.13m-36.14m 36.25m-36.26m;36.35m-36.36m 36.40m-36.41m;36.46m-36.47m Fracture: 35.65m-35.67m, <b>θ</b> =55° 36.25m-36.26m, <b>θ</b> =80°	W2 to W1					
36.6			7	HQ	100	100		87	3 0 0 1 0	Fracture: 37.55m-37.57m, <b>θ</b> =0° Joint: 37.57m-37.62m, <b>θ</b> =0°	W2 to W1					
- 38.1 - 38.1 	Continued Next Rose		8	HQ	100	100		85	1 4 2 2	Gysum: 38.48m-38.49m;38.55m-38.56m 38.62m-38.63m;38.95m-38.96m 39.27m-39.28m;39.38m-39.39m 39.45m-39.46m;39.54m-39.55m 39.59m-39.60m Fracture: 38.95m-38.96m, <b>θ</b> =0°	W2 to W1				160.4	2.78

Weathering Index: W1-Fresh, W2-Slightly weathered, W3-Moderately weathered, W4-Highly weathered, W5-Completely weathered 9 = angle to the core axis

E = Modulus of Elasticity \*: UCS [Mpa]≈ 24 I<sub>S(50)</sub>

## LOG OF ROCK CORE BH20-08 2 OF 2 REF. NO.: 201-11602-00 PROJECT: Geotechnical Investigation CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 8 SL LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm ORIGINATED BY BW DATUM: Geodetic Date: Dec-18-2020 to Dec-18-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766690.054 E 654312.344 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY CORE SAMPLE UNIAXIAL COMPRESSION (MPa POINT LOAD TEST UCS DIAMETRAL (MPa)' INDEX GROUND WATER CONDITIONS TOTAL CORE RECOVERY (%) SOLID CORE RECOVERY (%) HARD LAYER (%) HYDRAULIC CONDUCTIVITY (cm. DENSITY (g/cm<sup>3</sup>) E (GPa) Weathering Index POINT LOAD TEST UCS AXIAL (MPa)\* ROCK (m) FRACTURE I (per 0.3 m) DISCONTINUITIES DESCRIPTION NUMBER ELEV DEPTH RQD (%) SIZE Continued SALINA FORMATION: <u>i i i i</u> Bedding almost horizontal (9=90°) 1 137.3 39.6 END OF THE BOREHOLE Note: 1) 50 mm monitoring well was installed upon completion, screened between 36.55m and 39.60m. Water Level measured in monitoring well: W.L.Depth (m) Date Dec. 23, 2020 Jan. 13, 2021 Jan. 28, 2021 6.50 4.61 4.71

115

#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 9 ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-09-2020 to Dec-10-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766605.863 E 652916.408 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY DYNAMIC CONE PENETRATION RESISTANCE PLOT SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 100 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w $W_{L}$ ELEVATION SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEV DEPTH -0 DISTRIBUTION н -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE z 20 40 60 80 100 10 20 30 176.0 Ground Surface GR SA SI CL 179.9 GRANULAR FILL: sand and gravel, trace silt, trace clay, grey, SS 30 ο 1 moist, compact to dense, 175.2 FILL: crusher run limestone. 0.8 contains silty sand pockets, grey, moist, compact to loose. 175 2 SS 19 0 3 SS 8 0 174 4 SS 10 0 173 5 SS 18 0 172 6 SS 8 171.2 4.7 SILTY CLAY: trace sand, contains 7 SS 4 0 silt seams, grey, moist, very soft to 171 stiff. 8 SS 1 170 +49 Vane 1 169 reddish brown,wet 10 SS 4 168 167 тw 1 Continued Next Page $+3, \times 3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS to Sensitivity

LOG OF BOREHOLE BH20-09

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#### REF. NO.: 201-11602-00 PROJECT: Geotechnical Investigation CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 9 ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-09-2020 to Dec-10-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766605.863 E 652916.408 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 100 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL ELEVATION SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEV DEPTH -0 DISTRIBUTION -1 NUMBER DESCRIPTION (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 20 40 60 80 100 10 20 30 GR SA SI CL Continued SILTY CLAY: trace sand, contains silt seams, grey, moist, very soft to stiff.(Continued) SS 10 165 0 5 (95) 12 164.2 SILT: trace clay, trace sand, 11.7 dilatant, reddish brown, wet, firm to 164 stiff. 13 SS 8 0 163 162.7 SILTY CLAY: trace sand, trace 13.3 gravel, contains dilatant silt seams and shale fragments, reddish brown, wet, stiff to firm. 162 14 SS 10 0 161 SS 15 4 5 8 (87) ŀ 0 160 159 2 Vane +56 158 17 SS 8 0 0 4 58 38 157 156.1 19.9 Continued Next Page $+3, \times 3$ : Numbers refer GRAPH NOTES O <sup>8=3%</sup> Strain at Failure GROUNDWATER ELEVATIONS to Sensitivity

Measurement  $\overset{1st}{\nabla}$   $\overset{2nd}{\Psi}$   $\overset{3rd}{\Psi}$   $\overset{4th}{\Psi}$ 

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### LOG OF BOREHOLE BH20-09

2 OF 4

#### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers/HQ Core ENCL NO.: 9 PROJECT LOCATION: Niagara Region Sanitary Sewer ORIGINATED BY SL Diameter: 203 mm/63mm BW DATUM: Geodetic Date: Dec-09-2020 to Dec-10-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766605.863 E 652916.408 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 80 100 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w $W_{L}$ ELEVATION SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEV DEPTH -0 DISTRIBUTION н -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 20 40 60 80 100 10 20 30 GR SA SI CL Continued CLAYEY SILT TILL (RESIDUAL 18 SS 54 о SOIL): sandy, trace gravel, contains dolostone/limestone fragments, grey, wet, hard.(Continued) 155.1 1 20.9 BEDROCK: 155 Coring began at 21.34m Refer to Rock Core Log 1 RC 154 2 RC 153 152 RC 3 151 4 RC 150 149 5 RC 148 6 RC 147 146.7 29.3 END OF BOREHOLE Notes: 1) Borehole was sealed with bentonite and cement grouting. 2) TW denotes thin wall shelby tube Continued Next Page $+3, \times 3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure

## GROUNDWATER ELEVATIONS



Measurement  $\overset{1st}{\checkmark} \overset{2nd}{\checkmark} \overset{3rd}{\checkmark} \overset{4th}{\checkmark}$ 

GRAPH NOTES to Sensitivity

### LOG OF BOREHOLE BH20-09

### 3 OF 4

115	

## LOG OF BOREHOLE BH20-09

REF. NO.: 201-11602-00

ORIGINATED BY SL

ENCL NO.: 9

PROJECT: Geotechnical Investigation	
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CLIENT: Regional Municipality of Niagara

PROJECT LOCATION: Niagara Region Sanitary Sewer

SOIL PROFILE

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4766605.863 E 652916.408

SAMPLES

Method: Hollow Stem Augers/HQ Core

Diameter: 203 mm/63mm

Date: Dec-09-2020 to Dec-10-2020

BW COMPILED BY MK Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY PLASTIC NATURAL MOISTURE CONTENT REMARKS ₹ LIQUID LIMIT KET PEN. (KPa) (KPa) AL UNIT V AND 20 40 60 80 100 GRAIN SIZE WP w SHEAR STRENGTH (kPa)

<u> </u>						К		RESIS	TANCE	PLUI	$\geq$			PLASTI	D NATI	URAL	LIQUID	<b>_</b>	¥	REMARKS
(m)		01			ပ၊	VATE IS	-	2	0 4	0 6	08	0 1	00	LIVII I W_	CON			Pa)	۲» (UNIT	GRAIN SIZE
ELEV		\ PL	ъ		3 m	N OI	٩ ٥	SHEA	R STI	RENG	TH (kF	Pa)		₩ <sub>P</sub>			•••L	CKEI (K	RAL KN/m	DISTRIBUTION
DEPTH		ATA	1BE	ш	<u>BL(</u>		VAT				+	& Sensiti	vity	WAT	ER CO		T (%)	ğ,	MTU	(%)
	Continued	STR	N N	Ц	ż	SRC	Ē	2	010KI 104		- × 0 8	LAB V.		1	0 2	20 3	0		Ź	GRSASIC
<u> </u>	sample.		-	-	-			-				-	-		-			1	-	UN UN DI UL
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GLB

# wsp

## LOG OF ROCK CORE BH20-09

PRO	JECT: Geotechnical Investigation										REF.	NC	).: 20	)1-116	302-0	0
CLIER	VI: Regional Municipality of Niagara							Met	hod: I	Hollow Stem Augers/HQ Core			0.: 9 ^ TED		SI	
	IN Goodetic							Dia	meter	203 mm/63mm				Bĭ	BW	
		N 4766	60E 0	62 E 1	65201	6 100	<b>)</b>	Dau	ie. De					r v	MK	
	JCATION. See Borenole Location Plan	N 4700	005.0 CC		55291	0.400	> 	Equ				<u>ू</u>		ر چ		
(m) <u>ELEV</u> DEPTH	ROCK DESCRIPTION	SROUND WATER	NUMBER	IPLE JZIS	OTAL CORE RECOVERY (%)	SOLID CORE RECOVERY (%)	HARD LAYER (%)	RAD (%)	FRACTURE INDEX per 0.3 m)	DISCONTINUITIES	Veathering Index	17 URAULIC	OINT LOAD TEST JCS AXIAL (MPa)*	OINT LOAD TEST JCS DIAMETRAL (MP	JNIAXIAL COMPRESSION (MF	ENSITY (g/cm <sup>3</sup> ) E (GPa)
155.8	Rock Surface	00	2	<u></u>	μœ	ЮĽ	<u> </u>		ш.е			-0			50	
- 20.1 - - - - - - - - - - - - - - - - - - -	Bedding almost horizontal ( <b>θ</b> =90°)															
21.3 154.2			1	HQ	100	80		0	19	Fragmented zone:21.34m-21.39m 21.48m-21.49m Gysum:21.64m-21.65m	W2		1			
- 21.7 22									23	21.70m-21.71m Fracture: 21.46m 21.48m <b>9</b> =0° and 0° two acts						
-			2	но	100	67		31	17	21.49m-21.64m, <b>0</b> =10°	io W1					
-			_			01			9	22.06m-22.16m;22.71m-22.73m 22.89m-22.97m;23.15m-23.19m	W21				180.3	72
23 152.8								<u> </u>	13	21.93m-21.98m, <b>9</b> =5° 22.00m-22.03m, <b>9</b> =45°		_			<u> </u>	
-									11	$22.03\text{m}-22.06\text{m}, \Theta = 0^{\circ} \text{ and } 20^{\circ}, \text{ two}$ sets $22.25\text{m}-22.30\text{m}, \Theta = 35^{\circ} \text{ and } 65^{\circ}, \text{ two}$						
- - <u>24</u>			3	НО	100	85		50	6	sets 22.30m-22.35m, <b>9</b> =0° 22.40m-22.42m, <b>9</b> =70°	to W1		106	96		
-									5	22.45m-22.48m, <b>θ</b> =65° 22.86m-22.89m, <b>θ</b> =20° 22.97m-23.00m, <b>θ</b> =0°	W2					
- - <u>151.1</u>									16	23.11m-23.13m, <b>9</b> =75° Soft layer Joint: 24.57m ~ 24.65m (W5 to W4) 22.24m-22.27m, <b>9</b> =75°						
- - - -									2	22.52m-22.59m, <b>9</b> =0° Fragmented zone: 23.28m-23.34m						
-									17	Gysum: 24.37m-24.48m	ž					
-			4	HQ	95	79		44	5	Fracture: 23.25m-23.28m, <b>θ</b> =0°	W4 to					
<u>26</u> -									16	23.58m-23.62m, <b>9</b> =0° 24.08m-24.09m, <b>9</b> =15° Joint						
<u>149.7</u> 26.3				<u> </u>				<u> </u>	4	$22.34m-22.39m$ , $\theta = 5^{\circ}$	$\vdash$	_			<u> </u>	<u> </u>
-									6	25.41m-25.46m;25.57m-25.60m 25.78m-25.82m:25.98m-26.04m						
-									1	Gysum:25.91m-25.92m Eracture:	5					
-			5	HQ	98	95		77	2	25.22m-25.25m, <b>0</b> =0° 25.25m-25.34m, <b>0</b> =0°	W4 to \					
-									2	25.34m-25.36m, <b>θ</b> =50° 25.87m-25.88m, <b>θ</b> =10°						
148.2 27.8				<u> </u>				<u> </u>	8	26.04m-26.21m, <b>⊎</b> =0° Gysum:27.25m-27.27m 27.62m-27.63m;27.65m-27.66m		_			<u> </u>	
-									4	27.69m-27.70m;27.71m-27.72m 27.74m-27.75m Fracture:						
-			6	HQ	100	96		77	3	26.29m-26.33m, <b>9</b> =5° 26.38m-26.41m, <b>9</b> =0°	2 to W1					
- - <u>29</u>									0	Fragmented zone:27.81m-27.86m Gysum:28.02m-28.03m 28.13m-28.14m;28.16m-28.17m 28.21m 28.22m;28.24m 28.25m	3		1			
- 146.7	END OF BOREHOLE			<u> </u>	<u> </u>			├──	0	28.45m 28.46m;28.40m 28.50m	++	$\neg$			├──	
32-11020	Note:									20.0011-20.0911 Fracture:						
SP ROCK CORE -20 16										∠1.88m-21.90m,♥=0°						

#### LOG OF BOREHOLE BH20-10 PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 Method: Hollow Stem Augers CLIENT: Regional Municipality of Niagara ENCL NO.: 10 ORIGINATED BY AKJ PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-11-2020 to Dec-11-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766859.246 E 654268.177 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SAMPLES SOIL PROFILE PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 100 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL ELEVATION SHEAR STRENGTH (kPa) ELEV DEPTH + FIELD VANE & Sensitivity -0 DISTRIBUTION -1 DESCRIPTION NUMBER O UNCONFINED (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL 176.7 Ground Surface TOPSOIL: 200mm <u>``</u>`*`*, Concrete 178:8 FILL: silty clay, trace sand, trace 02 K SS 6 1 0 gravel, trace organics, greyish -Sand brown, moist, firm to very stiff. 176 2 SS 14 ο 175.1 SILTY CLAY: trace sand, contains 175 1.7 21 3 SS 0 silt seams, brown, moist, very stiff to firm. reddish brown 4 SS 19 0 174 5 SS 13 0 Holeplug 173 6 SS 11 0 172 SS 9 7 0 brownish grey W. L. 171.5 m Dec 23, 2020 grey, wet 8 SS 6 0 17 W. L. 170.6 m 9 SS 5 Dec 18, 2020 Sand 170 169 +28 1 Vane -Screen 168 contains reddish brown silt layers SS 1 5 54 40 11 6 0 167 ( END OF THE BOREHOLE 9.8 Continued Next Page $+3, \times3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS



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### 1 OF 2

# wsp

## LOG OF BOREHOLE BH20-10

PRO.	ECT: Geotechnical Investigation																REF	. NO.	: 20	1-11602-00
CLIE	NT: Regional Municipality of Niagara			Metho	d: Hol	low St	em Au	ugers					ENC	L NO	0.: 10					
PRO	ECT LOCATION: Niagara Region Sanit	ary S	Sewe	r				Diame	eter: 2	03 mm	1	_					ORIC	GINA	TED	BY AKJ
DATU	JM: Geodetic						_	Date:	Dec-	11-202	20 to	Dec-1	1-2020	)			COM	1PILE	D B	
BH LO	DCATION: See Borehole Location Plan	N 47	6685	59.246	E 654	268.177 I	7	Equip	ment:	Pontil		IG CM	IE 75 (	Truck)	)		CHE	CKE	D BY	IVIK
(m) <u>ELEV</u> DEPTH	DESCRIPTION	TA PLOT	3ER		SICOWS	JND WATER DITIONS	ATION	RESIS 2 SHEA 0 UN	TANCE 0 4 R STI		10 8 10 8 11 (kF +	30 10 Pa) FIELD V/ & Sensiti		PLASTI LIMIT W <sub>P</sub>	C NAT MOIS CON	URAL STURE ITENT W O	LIQUIE LIMIT W <sub>L</sub>	POCKET PEN. (Cu) (kPa)	TURAL UNIT WT (kN/m <sup>3</sup> )	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
		STRA	IUME	ΥPE	ž	SROL	ELEV	• QI	JICK TI 0 4	RIAXIAI	LX 08	LAB V/	AŃE DO	WA1	TER CO	ONTEN	T (%) 30	-	¥	
	Continued Note: 1) 50 mm monitoring well was installed upon completion, screened between 6.71m and 9.75m. Water Level measured in monitoring well: Date W.L.Depth (m) Dec. 18, 2020 6.16 Dec. 23, 2020 5.23	STRAT		Т		GROU	ELEVA						ANE DO				T (%) 30			(%) <u>GR SA SI C</u>

#### LOG OF BOREHOLE BH20-11 1 OF 2 PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 Method: Hollow Stem Augers CLIENT: Regional Municipality of Niagara ENCL NO.: 11 ORIGINATED BY AKJ PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-11-2020 to Dec-11-2020 COMPILED BY MK BH LOCATION: See Borehole Location Plan N 4766986.744 E 654318.837 Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 100 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEVATION ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 20 40 60 80 100 10 20 30 GR SA SI CL 176.5 Ground Surface TOPSOIL: 150mm 711 Concrete - 17**0:0** - 0.2 FILL: silty clay, trace sand, trace R SS 7 0 1 gravel, trace organics, brown, Sand moist, firm to very stiff. 2 SS 27 ο 175 174.6 3 SS 19 0 SILTY CLAY: trace sand, contains ŀ 1.8 2 silt seams, brown, moist, very stiff to very soft. reddish brown 174 SS 4 14 0 5 SS 8 0 Holeplug 6 SS 8 0 172 SS 10 7 o 171 grey SS 8 6 wet 9 SS 2 0 17∩ -Sand W. L. 169.8 m Dec 23<u>,</u> 2020 W. L. 169.3 m Dec 18, 2020 169 $^{+1.0}_{+24}$ 1 Vane -Screen 168 SS 4 0 4 49 47 11 167 166.7 END OF THE BOREHOLE 9.8 Continued Next Page $+3, \times3$ : Numbers refer O <sup>8=3%</sup> Strain at Failure GRAPH NOTES GROUNDWATER ELEVATIONS to Sensitivity

 $\frac{\text{GROUNDWATER ELEVATIONS}}{\text{Measurement}} \stackrel{\text{1st}}{\underbrace{\checkmark}} \stackrel{\text{2nd}}{\underbrace{\checkmark}} \stackrel{\text{3rd}}{\underbrace{\checkmark}} \stackrel{\text{4th}}{\underbrace{\checkmark}}$ 

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11	2	)	

## LOG OF BOREHOLE BH20-11

PRC	DJECT: Geotechnical Investigation																REF.	NO.	: 201	-11602-00	
CLIE	ENT: Regional Municipality of Niagara							Metho	d: Hol	low St	em Au	igers					ENC	L NO	.: 11		
PRC	DJECT LOCATION: Niagara Region Sanit	tary S	Sewe	r				Diam	eter: 2	03 mm	ı						ORIC	SINA	TED	BY AKJ	
DAT	UM: Geodetic							Date:	Dec-	11-202	0 to	Dec-1	1-2020	)			CON	IPILE	DBY	BW	
BHI	LOCATION: See Borehole Location Plan	N 47	76698	36.744	E 654	318.837 I	7	Equip	ment:	Pontil			IE 75 (	Truck	)		CHE		) BY	MK	
	SOIL PROFILE		5	SAMPL	ES	Ľ.		RESIS	TANCE	PLOT	$\geq$			PLASTI			LIQUID		Ψ	REMARK	s
(m) <u>ELEV</u> DEPTI		FRATA PLOT	JMBER	PE	BLOWS 0.3 m	ROUND WATE	EVATION	2 SHEA 0 UI • QI	0 4 R STI NCONF	0 6 RENG INED RIAXIAI	0 8 TH (kF + - ×	0 10 Pa) FIELD V/ & Sensitiv LAB V/	ANE vity ANE	LIMIT W <sub>P</sub> I			LIMIT WL T (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT ( (kN/m <sup>3</sup> )	AND GRAIN SIZ DISTRIBUTI (%)	E ON
	Continued	ST	ž	È	ž	50	Ш	2	0 4	0 6	0 8	0 10	00	1	0 2	20 3	30			GR SA SI	CL
	Continued Note: 1) 50 mm monitoring well was installed upon completion, screened between 6.71m and 9.75m. Water Level measured in monitoring well: Date W.L.Depth (m) Dec. 18, 2020 7.12 Dec. 23, 2020 6.66	STF									0 8	0 10			0 2	20 3				<u>GR SA SI</u>	CL
P 501-4001401 23-017 0.19 P 501-1002 201-11902400 GPJ 21-226																					

| IECT: Geotechnical Investigation                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                          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|                                                                    | IT: Regional Municipality of Niagara<br>IECT LOCATION: Niagara Region Sanit<br>M: Geodetic<br><u>DCATION: See Borehole Location Plan</u><br>SOIL PROFILE<br>DESCRIPTION<br>Ground Surface<br>TOPSOL: 230mm<br>FILL: silty clay, trace sand, trace<br>gravel, trace organics, greyish<br>brown, moist, stiff.<br>100mm silty sand layers<br>SILTY CLAY: trace sand, contains<br>silt seams, reddish brown, moist,<br>very stiff to very soft.<br>reddish brown to grey<br><br>grey<br><br>contains dilatant silt layers<br>trace shale fragments<br>END OF THE BOREHOLE | T: Regional Municipality of Niagara<br>IECT LOCATION: Niagara Region Sanitary S<br>IM: Geodetic<br>CATION: See Borehole Location Plan N 47<br>SOIL PROFILE<br>DESCRIPTION<br>Ground Surface<br>TOPSOIL: 230mm<br>FILL: silty clay, trace sand, trace<br>gravel, trace organics, greyish<br>brown, moist, stiff.<br>100mm silty sand layers<br>SILTY CLAY: trace sand, contains<br>silt seams, reddish brown, moist,<br>very stiff to very soft.<br>reddish brown to grey<br>grey<br>wet<br>contains dilatant silt layers<br>trace shale fragments<br>END OF THE BOREHOLE | TI: Regional Municipality of Niagara<br>IECT LOCATION: Niagara Region Sanitary Sewe<br>M: Geodetic<br><u>DCATION: See Borehole Location Plan N 476725</u><br><u>DESCRIPTION</u><br><u>Ground Surface</u><br>TOPSOIL: 230mm<br>FILL: silty clay, trace sand, trace<br>gravel, trace organics, greyish<br>brown, moist, stiff.<br>100mm silty sand layers<br>2<br>SILTY CLAY: trace sand, contains<br>silt seams, reddish brown, moist,<br>very stiff to very soft.<br>reddish brown to grey<br>f<br><u>Ground Surface</u><br><u>Ground Surface</u><br><u>Ground Surface</u><br><u>Contains dilatant silt layers</u><br><u>Contains dilatant silt layer</u><br><u>Contains dilatant</u> | T: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         CATION: See Borehole Location Plan N 4767290.374         Ground Surface       SAMPL         TOPSOIL: 230mm       1         SSILTY CLAY: trace sand, trace       2         Ground Surface       1         SSILTY CLAY: trace sand, contains silt seams, reddish brown, moist, very stiff to very soft.       3         SSILTY CLAY: trace sand, contains       3         Vert silt very soft.       4         SS       5         SS       1         Vert silt very soft.       4         SS       5         SS       5         SS       5         SS       1         Very stiff to very soft.       4         Wet       6         SS       1         Very stiff to very soft.       1         Very stiff to very soft. <td< td=""><td>T: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         2CATION: See Borehole Location Plan N4767290.374 E 654         SOIL PROFILE       SAMPLES         DESCRIPTION       Industry Sewer         Ground Surface       1       SS         TOPSOIL: 230mm       1.1       SS         FILL: sitty Clay, trace sand, trace gravel, trace organics, greyish brown, moist, stiff       1       SS       1         SILTY CLAY: trace sand, contains sitt seams, reddish brown, moist, very stiff to very soft.       3       SS       10         greey       5       SS       8       10         greey       6       SS       5         wet       6       SS       5         it vane       1       Vane       1         It vane       1       Vane       1         It vane       1       Vane       1       1         It vane       1       It vane       1       It vane         It vane       1       It vane       1       1       It vane         It vane       1       It vane       1       1       It vane       1         It vane       1       It vane&lt;</td><td>T: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         SOIL PROFILE       SAMPLES         Image: Contained Surface       Image: Contained Surface         TOPSOIL: 230mm       1       SS         FILL: sitty clay, trace sand, trace       1       SS       9         gravel, trace organics, greyish       1       SS       9         brown, moist, stiff.       100mm silty sand layers       2       SS       11         SILTY CLAY: trace sand, contains silt seams, reddish brown, moist, wery stiff to very soft.       1       Vane       1         greey       5       SS       8       1       1       Vane       1         very stiff to very soft.       1       Vane       1       Vane       1       1         Mit and trace shale fragments       11       SS       1       1       1       1</td><td>HT: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         SOIL PROFILE         DESCRIPTION         Use and Surface         TOPSOL: 230mm         FILL: silly clay, trace sand, trace         gravel, trace organics, greyish         Drown, moist, stiff.         100mm silty sand layers         2       SS         SILTY CLAY: trace sand, contains silt seams, reddish brown, moist, very stiff to very soft.         grey       5         SS       8         SS       1         Very stiff to very soft.         grey       5         SS       8         SS       1         Very stiff to very soft.       1     &lt;</td><td>HT: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         COLTION: See Borehole Location Plan N 4767290.374 E 654078.539         Image: Solut PROFILE       SAMPLES         Image: Solut PROFILE       Image: Solut PROFILE         Image: Solut PROFILE       Image: Solut PROFILE         Image: Solut PROFILE       Image: Solut PROFILE         Image: Solut Profile Solutions       Image: Solut PROFILE         Image: Solut Profile Solutions       Image: Solut Profile Solutions         Image: Solut Profile Solutions       Image: Solut Profile Solutions         Image: Solut Profile Solutions       Image: Solut Profile Solutions         Image: Solut Profile Solutions       Image: Solut Profile Solutions<td>4T: Regional Municipality of Niagara       Meth.         IECT LOCATION: Niagara Region Sanitary Sewer       Diamond Science         Additional Science       Soil PROFILE         SOIL PROFILE       SAMPLES         Usedetic       Soil PROFILE         DESCRIPTION       Usedetic         OF The Soil Profile       Soil Profile         DESCRIPTION       Usedetic         Ground Surface       1         TOPSOL: 230mm       1         100mm silty sand layers       2         2       SS         100mm silty sand layers       2         9       5         9       5         9       173         11       Value         9       1         12       SS         13       SS         14       SS         15       SS         16       SS         172       172         9       5         100mm silty and layers       1         11       Value         11       Value         11       Value         11       Value         11       Value         10</td><td>4T: Regional Municipality of Niagara       Method: Inb         IECT LOCATION: Niagara Region Sanitary Sever       Diameter: 2         MC: Geodeiro       Date: Dec-         2CATION: See Borehole Location Plan N 4767290.374 E 654078.539       Equipment:         SOIL PROFILE       SAMPLES       mg of the second /td><td>4T: Regional Municipality of Niagara       Method:: Holdow S         IECT LOCATION: Nagara Region Sanitary Sewer       Diameter: 203 mr         MC Geodeir       Date: Dec1-0:20         2CATION: See Borehole Location Plan N 4767290.374 E 654078.539       Equipment: Ponti         SOIL PROFILE       SAMPLES       market: 203 mr         VIC TopSolL:       SOIL PROFILE       SAMPLES       market: 203 mr         OESCRIPTION       If an analysis       If an analysis       If an analysis         Ground Surface       If an analysis       If an analysis       If an analysis         TOPSOL:       230mm       If an analysis       If an analysis       If an analysis         100mm sity sand layers       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis<!--</td--><td>4T. Regional Municipality of Niagara       Method: Hollow Stem A         IECT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         MC Geodeir       Date: Dec-10-2020 to 10         SOLL PROFILE       SAMPLES       Equipment: PonID Dilli         MC Geodeir       DESCRIPTION       User Hole School State /td><td>Tr. Regional Municipality of Niagara       Method: Holdwissen Augers         IGCT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         M Geodelic       Data Decision         SOIL PROFILE       SAMPLES         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         TORSOL: status       Samotion         User Soll PROFILE       Samotion         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         Samotion       Samotion         User Soll Profile       Samotion         User So</td><td>17. Regional Municipality O Negara       Method: Holdw Stem Augers         MC Geodelic       Diameter: 203 mm         DCATION: See Borehole Location Plan N 4767220.374 E 654076.539       Equipment: Pontil Drilling: CME 75         SOLL PROFILE       SMAPLES       Washed Strates         ToroBOL: 230mm       DESCRIPTION       SMAPLES       Washed Strates         ToroBOL: 230mm       Concrete       Residence Functional Market Strates       Concrete         ToroBOL: 230mm       SS       1       SS       9       Concrete       -         ToroBOL: 230mm       Concrete       1       SS       9       -       -       -         ToroBOL: 230mm       SS       1       SS       9       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -</td><td>17. Regional Municipality O Nagara       Method: Holdow Side Augers         IM: Geodetic       Diameter: 203 mm         DCTLON: See Borehole Location Plan N 4767220.374 E 65(07853)       Diameter: 203 mm         SOLL PROFILE       SMMPLES         DESCRIPTION       Variation of the set of the</td><td>The Regional Municipality of Nagara     Method: Holdow Stem Augers       Mc Geodelic     Date: Dec-10-2020. to Dec-10-2020.       INC Reported Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       SOLL PROFILE     SMMULES       INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       INC PROFILE     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       OTOPSOL: 230mm     Inc See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       TRUE 10); Gitting Trace sand, contains still seems, redefine brown, moist, way soll to very soll.     Inc See S       Int See S     S     Int N       Int See S     Int N     Int N       Int See S     Int N     Int N       Int See S     Int N       Int See S     Int N       Int N</td><td>Tr. Rogional Municipality of Nagara     Method: Hollow Stem Augers       DECT LOCATION: Nagara Region Sanitary Sever     Date: bac-10-2020 to Dec-10-2020       SOUL PROFILE     SAMPLES       SOUL PROFILE     SAMPLES       DESCRIPTION     Supersonal Stream St</td><td>T. Regional Municipality of Nagara       Method: Holdwark Same Regions       Exclore         M. Geodetic       Description       Solut PROPILE       Solut PROPILE       Solut PROPILE       Solution       Solution&lt;</td><td>Attraction       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Model</td></td></td></td<> <td>CT: Regional Municipality of Nagaria       Method: Holder Stein Auges       EXALLAND: IX       EXALUATION: AND IX         DEC TUCATION       South Proof Leader on N 4767290.374 E 55078.555       Exal Proof Leader on N 4767.5757.5757.5757.5757.5757.5757.5757.</td> | T: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         2CATION: See Borehole Location Plan N4767290.374 E 654         SOIL PROFILE       SAMPLES         DESCRIPTION       Industry Sewer         Ground Surface       1       SS         TOPSOIL: 230mm       1.1       SS         FILL: sitty Clay, trace sand, trace gravel, trace organics, greyish brown, moist, stiff       1       SS       1         SILTY CLAY: trace sand, contains sitt seams, reddish brown, moist, very stiff to very soft.       3       SS       10         greey       5       SS       8       10         greey       6       SS       5         wet       6       SS       5         it vane       1       Vane       1         It vane       1       Vane       1         It vane       1       Vane       1       1         It vane       1       It vane       1       It vane         It vane       1       It vane       1       1       It vane         It vane       1       It vane       1       1       It vane       1         It vane       1       It vane< | T: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         SOIL PROFILE       SAMPLES         Image: Contained Surface       Image: Contained Surface         TOPSOIL: 230mm       1       SS         FILL: sitty clay, trace sand, trace       1       SS       9         gravel, trace organics, greyish       1       SS       9         brown, moist, stiff.       100mm silty sand layers       2       SS       11         SILTY CLAY: trace sand, contains silt seams, reddish brown, moist, wery stiff to very soft.       1       Vane       1         greey       5       SS       8       1       1       Vane       1         very stiff to very soft.       1       Vane       1       Vane       1       1         Mit and trace shale fragments       11       SS       1       1       1       1 | HT: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         SOIL PROFILE         DESCRIPTION         Use and Surface         TOPSOL: 230mm         FILL: silly clay, trace sand, trace         gravel, trace organics, greyish         Drown, moist, stiff.         100mm silty sand layers         2       SS         SILTY CLAY: trace sand, contains silt seams, reddish brown, moist, very stiff to very soft.         grey       5         SS       8         SS       1         Very stiff to very soft.         grey       5         SS       8         SS       1         Very stiff to very soft.       1     < | HT: Regional Municipality of Niagara         IECT LOCATION: Niagara Region Sanitary Sewer         M: Geodetic         COLTION: See Borehole Location Plan N 4767290.374 E 654078.539         Image: Solut PROFILE       SAMPLES         Image: Solut PROFILE       Image: Solut PROFILE         Image: Solut PROFILE       Image: Solut PROFILE         Image: Solut PROFILE       Image: Solut PROFILE         Image: Solut Profile Solutions       Image: Solut PROFILE         Image: Solut Profile Solutions       Image: Solut Profile Solutions         Image: Solut Profile Solutions       Image: Solut Profile Solutions         Image: Solut Profile Solutions       Image: Solut Profile Solutions         Image: Solut Profile Solutions       Image: Solut Profile Solutions <td>4T: Regional Municipality of Niagara       Meth.         IECT LOCATION: Niagara Region Sanitary Sewer       Diamond Science         Additional Science       Soil PROFILE         SOIL PROFILE       SAMPLES         Usedetic       Soil PROFILE         DESCRIPTION       Usedetic         OF The Soil Profile       Soil Profile         DESCRIPTION       Usedetic         Ground Surface       1         TOPSOL: 230mm       1         100mm silty sand layers       2         2       SS         100mm silty sand layers       2         9       5         9       5         9       173         11       Value         9       1         12       SS         13       SS         14       SS         15       SS         16       SS         172       172         9       5         100mm silty and layers       1         11       Value         11       Value         11       Value         11       Value         11       Value         10</td> <td>4T: Regional Municipality of Niagara       Method: Inb         IECT LOCATION: Niagara Region Sanitary Sever       Diameter: 2         MC: Geodeiro       Date: Dec-         2CATION: See Borehole Location Plan N 4767290.374 E 654078.539       Equipment:         SOIL PROFILE       SAMPLES       mg of the second /td> <td>4T: Regional Municipality of Niagara       Method:: Holdow S         IECT LOCATION: Nagara Region Sanitary Sewer       Diameter: 203 mr         MC Geodeir       Date: Dec1-0:20         2CATION: See Borehole Location Plan N 4767290.374 E 654078.539       Equipment: Ponti         SOIL PROFILE       SAMPLES       market: 203 mr         VIC TopSolL:       SOIL PROFILE       SAMPLES       market: 203 mr         OESCRIPTION       If an analysis       If an analysis       If an analysis         Ground Surface       If an analysis       If an analysis       If an analysis         TOPSOL:       230mm       If an analysis       If an analysis       If an analysis         100mm sity sand layers       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis<!--</td--><td>4T. Regional Municipality of Niagara       Method: Hollow Stem A         IECT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         MC Geodeir       Date: Dec-10-2020 to 10         SOLL PROFILE       SAMPLES       Equipment: PonID Dilli         MC Geodeir       DESCRIPTION       User Hole School State /td><td>Tr. Regional Municipality of Niagara       Method: Holdwissen Augers         IGCT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         M Geodelic       Data Decision         SOIL PROFILE       SAMPLES         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         TORSOL: status       Samotion         User Soll PROFILE       Samotion         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         Samotion       Samotion         User Soll Profile       Samotion         User So</td><td>17. Regional Municipality O Negara       Method: Holdw Stem Augers         MC Geodelic       Diameter: 203 mm         DCATION: See Borehole Location Plan N 4767220.374 E 654076.539       Equipment: Pontil Drilling: CME 75         SOLL PROFILE       SMAPLES       Washed Strates         ToroBOL: 230mm       DESCRIPTION       SMAPLES       Washed Strates         ToroBOL: 230mm       Concrete       Residence Functional Market Strates       Concrete         ToroBOL: 230mm       SS       1       SS       9       Concrete       -         ToroBOL: 230mm       Concrete       1       SS       9       -       -       -         ToroBOL: 230mm       SS       1       SS       9       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -</td><td>17. Regional Municipality O Nagara       Method: Holdow Side Augers         IM: Geodetic       Diameter: 203 mm         DCTLON: See Borehole Location Plan N 4767220.374 E 65(07853)       Diameter: 203 mm         SOLL PROFILE       SMMPLES         DESCRIPTION       Variation of the set of the</td><td>The Regional Municipality of Nagara     Method: Holdow Stem Augers       Mc Geodelic     Date: Dec-10-2020. to Dec-10-2020.       INC Reported Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       SOLL PROFILE     SMMULES       INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       INC PROFILE     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       OTOPSOL: 230mm     Inc See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       TRUE 10); Gitting Trace sand, contains still seems, redefine brown, moist, way soll to very soll.     Inc See S       Int See S     S     Int N       Int See S     Int N     Int N       Int See S     Int N     Int N       Int See S     Int N       Int See S     Int N       Int N</td><td>Tr. Rogional Municipality of Nagara     Method: Hollow Stem Augers       DECT LOCATION: Nagara Region Sanitary Sever     Date: bac-10-2020 to Dec-10-2020       SOUL PROFILE     SAMPLES       SOUL PROFILE     SAMPLES       DESCRIPTION     Supersonal Stream St</td><td>T. Regional Municipality of Nagara       Method: Holdwark Same Regions       Exclore         M. Geodetic       Description       Solut PROPILE       Solut PROPILE       Solut PROPILE       Solution       Solution&lt;</td><td>Attraction       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Model</td></td> | 4T: Regional Municipality of Niagara       Meth.         IECT LOCATION: Niagara Region Sanitary Sewer       Diamond Science         Additional Science       Soil PROFILE         SOIL PROFILE       SAMPLES         Usedetic       Soil PROFILE         DESCRIPTION       Usedetic         OF The Soil Profile       Soil Profile         DESCRIPTION       Usedetic         Ground Surface       1         TOPSOL: 230mm       1         100mm silty sand layers       2         2       SS         100mm silty sand layers       2         9       5         9       5         9       173         11       Value         9       1         12       SS         13       SS         14       SS         15       SS         16       SS         172       172         9       5         100mm silty and layers       1         11       Value         11       Value         11       Value         11       Value         11       Value         10 | 4T: Regional Municipality of Niagara       Method: Inb         IECT LOCATION: Niagara Region Sanitary Sever       Diameter: 2         MC: Geodeiro       Date: Dec-         2CATION: See Borehole Location Plan N 4767290.374 E 654078.539       Equipment:         SOIL PROFILE       SAMPLES       mg of the second | 4T: Regional Municipality of Niagara       Method:: Holdow S         IECT LOCATION: Nagara Region Sanitary Sewer       Diameter: 203 mr         MC Geodeir       Date: Dec1-0:20         2CATION: See Borehole Location Plan N 4767290.374 E 654078.539       Equipment: Ponti         SOIL PROFILE       SAMPLES       market: 203 mr         VIC TopSolL:       SOIL PROFILE       SAMPLES       market: 203 mr         OESCRIPTION       If an analysis       If an analysis       If an analysis         Ground Surface       If an analysis       If an analysis       If an analysis         TOPSOL:       230mm       If an analysis       If an analysis       If an analysis         100mm sity sand layers       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis         If an analysis       If an analysis       If an analysis       If an analysis       If an analysis       If an analysis </td <td>4T. Regional Municipality of Niagara       Method: Hollow Stem A         IECT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         MC Geodeir       Date: Dec-10-2020 to 10         SOLL PROFILE       SAMPLES       Equipment: PonID Dilli         MC Geodeir       DESCRIPTION       User Hole School State /td> <td>Tr. Regional Municipality of Niagara       Method: Holdwissen Augers         IGCT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         M Geodelic       Data Decision         SOIL PROFILE       SAMPLES         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         TORSOL: status       Samotion         User Soll PROFILE       Samotion         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         Samotion       Samotion         User Soll Profile       Samotion         User So</td> <td>17. Regional Municipality O Negara       Method: Holdw Stem Augers         MC Geodelic       Diameter: 203 mm         DCATION: See Borehole Location Plan N 4767220.374 E 654076.539       Equipment: Pontil Drilling: CME 75         SOLL PROFILE       SMAPLES       Washed Strates         ToroBOL: 230mm       DESCRIPTION       SMAPLES       Washed Strates         ToroBOL: 230mm       Concrete       Residence Functional Market Strates       Concrete         ToroBOL: 230mm       SS       1       SS       9       Concrete       -         ToroBOL: 230mm       Concrete       1       SS       9       -       -       -         ToroBOL: 230mm       SS       1       SS       9       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -</td> <td>17. Regional Municipality O Nagara       Method: Holdow Side Augers         IM: Geodetic       Diameter: 203 mm         DCTLON: See Borehole Location Plan N 4767220.374 E 65(07853)       Diameter: 203 mm         SOLL PROFILE       SMMPLES         DESCRIPTION       Variation of the set of the</td> <td>The Regional Municipality of Nagara     Method: Holdow Stem Augers       Mc Geodelic     Date: Dec-10-2020. to Dec-10-2020.       INC Reported Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       SOLL PROFILE     SMMULES       INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       INC PROFILE     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       OTOPSOL: 230mm     Inc See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       TRUE 10); Gitting Trace sand, contains still seems, redefine brown, moist, way soll to very soll.     Inc See S       Int See S     S     Int N       Int See S     Int N     Int N       Int See S     Int N     Int N       Int See S     Int N       Int See S     Int N       Int N</td> <td>Tr. Rogional Municipality of Nagara     Method: Hollow Stem Augers       DECT LOCATION: Nagara Region Sanitary Sever     Date: bac-10-2020 to Dec-10-2020       SOUL PROFILE     SAMPLES       SOUL PROFILE     SAMPLES       DESCRIPTION     Supersonal Stream St</td> <td>T. Regional Municipality of Nagara       Method: Holdwark Same Regions       Exclore         M. Geodetic       Description       Solut PROPILE       Solut PROPILE       Solut PROPILE       Solution       Solution&lt;</td> <td>Attraction       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Model</td> | 4T. Regional Municipality of Niagara       Method: Hollow Stem A         IECT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         MC Geodeir       Date: Dec-10-2020 to 10         SOLL PROFILE       SAMPLES       Equipment: PonID Dilli         MC Geodeir       DESCRIPTION       User Hole School State | Tr. Regional Municipality of Niagara       Method: Holdwissen Augers         IGCT LOCATION: Nagara Region Sanitary Sever       Diameter: 203 mm         M Geodelic       Data Decision         SOIL PROFILE       SAMPLES         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         TORSOL: status       Samotion         User Soll PROFILE       Samotion         User Soll PROFILE       Samotion         TOPSOL: 230mm       Samotion         Samotion       Samotion         User Soll Profile       Samotion         User So | 17. Regional Municipality O Negara       Method: Holdw Stem Augers         MC Geodelic       Diameter: 203 mm         DCATION: See Borehole Location Plan N 4767220.374 E 654076.539       Equipment: Pontil Drilling: CME 75         SOLL PROFILE       SMAPLES       Washed Strates         ToroBOL: 230mm       DESCRIPTION       SMAPLES       Washed Strates         ToroBOL: 230mm       Concrete       Residence Functional Market Strates       Concrete         ToroBOL: 230mm       SS       1       SS       9       Concrete       -         ToroBOL: 230mm       Concrete       1       SS       9       -       -       -         ToroBOL: 230mm       SS       1       SS       9       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       -       - | 17. Regional Municipality O Nagara       Method: Holdow Side Augers         IM: Geodetic       Diameter: 203 mm         DCTLON: See Borehole Location Plan N 4767220.374 E 65(07853)       Diameter: 203 mm         SOLL PROFILE       SMMPLES         DESCRIPTION       Variation of the set of the | The Regional Municipality of Nagara     Method: Holdow Stem Augers       Mc Geodelic     Date: Dec-10-2020. to Dec-10-2020.       INC Reported Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       SOLL PROFILE     SMMULES       INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Equipment: Point Diffing. CME 75 (Truck)       INC PROFILE     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       DESCRIPTION     INC See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       OTOPSOL: 230mm     Inc See Borehole Location Plan N 4767200.374 E 6540785.00     Inc See Borehole Location Plan N 4767200.374 E 6540785.00       TRUE 10); Gitting Trace sand, contains still seems, redefine brown, moist, way soll to very soll.     Inc See S       Int See S     S     Int N       Int See S     Int N     Int N       Int See S     Int N     Int N       Int See S     Int N       Int See S     Int N       Int N | Tr. Rogional Municipality of Nagara     Method: Hollow Stem Augers       DECT LOCATION: Nagara Region Sanitary Sever     Date: bac-10-2020 to Dec-10-2020       SOUL PROFILE     SAMPLES       SOUL PROFILE     SAMPLES       DESCRIPTION     Supersonal Stream St | T. Regional Municipality of Nagara       Method: Holdwark Same Regions       Exclore         M. Geodetic       Description       Solut PROPILE       Solut PROPILE       Solut PROPILE       Solution       Solution< | Attraction       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Method       Model       Model | CT: Regional Municipality of Nagaria       Method: Holder Stein Auges       EXALLAND: IX       EXALUATION: AND IX         DEC TUCATION       South Proof Leader on N 4767290.374 E 55078.555       Exal Proof Leader on N 4767.5757.5757.5757.5757.5757.5757.5757. |

 $\begin{array}{c} 1 \\ \text{Measurement} & \underline{1} \\ \underline{$ 

wsp

1 OF 2

# **NSD**

	·1·	HOL	E B	H20-	12D									2 OF	2						
PRO	JECT: Geotechnical Investigation																REF.	NO.	: 20	1-11602-00	
CLIE	NT: Regional Municipality of Niagara							Metho	od: Hol	low St	em Au	igers					ENC	L NO	).: 12	A	
PRO	JECT LOCATION: Niagara Region Sanit	ary S	Sewe	r				Diam	eter: 2	03 mm	ı						ORIG	SINA	TED	BY AKJ	
DAT	JM: Geodetic							Date:	Dec-	10-202	20 to	Dec-1	)-2020	)			COM	IPILE	D B)	Ø BW	
BH L	OCATION: See Borehole Location Plan	N 47	6729	90.374	E 654	078.539	9	Equip	ment:	Pontil	Drillin	g CM	IE 75 (	Truck)	)		CHE	CKE	D BY	MK	
	SOIL PROFILE		S	SAMPL	ES	<u>د</u>		RESIS	TANCE	E PLOT		ATION		PLASTI	C NAT	URAL			₽	REMARK	3
(m)		ы			(A)	/ATEI IS	_	2	0 4	0 6	0 8	0 10	00	LIMIT	CON	ITENT	LIMIT	PEN.	UNIT V	AND GRAIN SIZ	F
	DESCRIPTION	APL	н К		.3 m	ND N	NOL	SHEA			TH (kF	Pa) FIELD V	ANE	•• <sub>P</sub>		o		OCKET Cu) (k	(kN/m	DISTRIBUTI	ON
		<b>IRAT</b>	JMBE	PE			EVA	• QI	UICK TI	RIAXIAI	L ×	& Sensitiv	ANE	WA	TER CO	ONTEN	Т (%)	80	NAT	(%)	
	Continued	'v	ž	F	ŗ	σŏ	Ш	2	0 4	0 6	8 0	0 10	00	1	0 2	20 3	30			GR SA SI	CL
	1) 50 mm monitoring well was installed upon completion, screened between 6.71m and 9.75m.																				
	Water Level measured in monitoring well: Date W.L.Depth (m) Dec. 18, 2020 5.93																				
	Dec. 23, 2020 5.80																				
1.069 J 21 2 2 5																					
68 50L LOG 2011160201																					

#### LOG OF BOREHOLE BH20-12S PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 ENCL NO.: 12B CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers ORIGINATED BY AKJ PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-10-2020 to Dec-10-2020 COMPILED BY MK Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY BH LOCATION: See Borehole Location Plan N 4767289.917 E 654080.153 SAMPLES SOIL PROFILE PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 40 60 100 20 80 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m Wp w WL SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEVATION ELEV DEPTH -0 DISTRIBUTION -1 DESCRIPTION NUMBER (%) WATER CONTENT (%) TYPE QUICK TRIAXIAL × LAB VANE ż 40 60 80 100 10 20 30 20 GR SA SI CL 174.9 Ground Surface - 17**4**.0 0.2 TOPSOIL: 150mm Concrete FILL: silty clay, trace sand, trace ß SS 1 11 0 gravel, trace organics, brownish grey, moist, stiff to very stiff. -Sand 300mm silty sand layers Holeplug 2 SS 17 173.6 SILTY CLAY: trace sand, contains Sand 1.3 silt seams, reddish brown, moist, very stiff to firm. 3 SS 17 0 173 4 SS 13 0 172 Screen grey 5 SS 6 0 Y W. L. 171.3 m Dec 23, 2020. W. L. 170.9 m Dec 18, 2020 wet 6 SS 6 0 170.4 4.6 END OF THE BOREHOLE Note: 1) 50 mm monitoring well was installed upon completion, screened between 1.52m and 4.57m. Water Level measured in monitoring well: Date W.L.Depth (m) Dec. 18, 2020 4.01 3.67 Dec. 23, 2020



### PROJECT: Geotechnical Investigation REF. NO.: 201-11602-00 CLIENT: Regional Municipality of Niagara Method: Hollow Stem Augers ENCL NO .: 1S ORIGINATED BY SL PROJECT LOCATION: Niagara Region Sanitary Sewer Diameter: 203 mm BW DATUM: Geodetic Date: Dec-09-2020 to Dec-09-2020 COMPILED BY MK Equipment: Pontil Drilling CME 75 (Truck) CHECKED BY BH LOCATION: See Borehole Location Plan N 4769629.776 E 653228.046 DYNAMIC CONE PENETRATION RESISTANCE PLOT SOIL PROFILE SAMPLES PLASTIC NATURAL MOISTURE CONTENT REMARKS GROUND WATER CONDITIONS LIQUID LIMIT POCKET PEN. (Cu) (kPa) NATURAL UNIT M (kN/m<sup>3</sup>) AND 20 40 60 80 100 (m) STRATA PLOT GRAIN SIZE BLOWS 0.3 m WL Wp w SHEAR STRENGTH (kPa) O UNCONFINED + FIELD VANE & Sensitivity ELEVATION ELEV DEPTH -0 DISTRIBUTION н -1 NUMBER DESCRIPTION (%) WATER CONTENT (%) ТҮРЕ QUICK TRIAXIAL × LAB VANE ż 20 40 60 80 100 10 20 30 GR SA SI CL 180.5 Ground Surface 0.0 Direct Drilling to Depth of 7.62 $\bigotimes$ Concrete Without Sampling Sand Lithology Inferred from BH-06 180 (Deep) 179.0 179 1.5 W. L. 178.2 m Dec 23, 2020 W. L. 177.1 m Dec 18, 2020 Sand 175 -Screen 174 173 172.9 END OF BOREHOLE 7.6 Note: 1) 50 mm monitoring well was installed upon completion, screened between 4.57m and 7.62m. Water Level measured in monitoring well: Date W.L.Depth (m) Dec. 18, 2020 3.5 2.3 Dec. 23, 2020



## LOG OF BOREHOLE BH-P01

11	5	

PROJ	ECT: Geotechnical Investigation																	REF.	NO.	: 20′	1-11602-00
CLIENT: Regional Municipality of Niagara										nod: Ho	bllow S	tem Aı	ugers					ENCI	L NO	.: 3S	
PROJ	ECT LOCATION: Niagara Region Sanit	ary S	Sewei	-					Dian	neter: 2	203 mr	n									
DATU	IM: Geodetic								Date	: Dec	-11-202	20									
BH LC	OCATION: See Borehole Location Plan	N 65	2135	.207 E	4769	057.1 T	88		Equi	pment	: Pontil	Drillin		/IE 75 (	Truck)	)			_		
(m)	SOIL PROFILE	ЪТ	S	ampl	ES	ATER	0		RES	20	40 6			00	PLASTI LIMIT	C NAT MOIS CON	URAL TURE TENT	LIQUID LIMIT	PEN. a)	) )	REMARKS AND
<u>ELEV</u> DEPTH	DESCRIPTION	ATA PLO	IBER	ш	BLOWS 0.3 m			VATION	SHE O (	AR ST	RENG	TH (kl	Pa) FIELD V & Sensit	ANE				W <sub>L</sub> →	POCKET (Cu) (kP	ATURAL U (kN/m <sup>3</sup>	DISTRIBUTION (%)
178.1	Ground Surface	STR	NUN	ТΥР	ŗ	GRO	5	ĒLĒ	•	2010K	40 6	.L X 50 8	LAB V 80 1	OO	1	0 2	20 3	30		z	GR SA SI CI
0.0	FILL: granular sand and gravel,	$\boxtimes$					3	Concr	ete_												
0.3	SILTY CLAY: trace sand, occasional gravel, reddish brown, moist, firm.		1	SS	10		-	Sand	-							0					
- - - - -			2	SS	18			177	-							o					
-			3	SS	17			Holep	L L lug						o						
 - -								176	-										-		
			4	SS	13				-						o						
- - - -			5	SS	11			Sand 175 W. L. Jan 13	174.8 , 202	5 m 20					0				-		
- - - -			6	SS	12			Scree	- - - - - - - -						o				-		
			7	SS	7				-						o						
172.9						. 目		173	-												
5.2	END OF BOREHOLE Note: 1) 50 mm monitoring well was installed upon completion, screened between 3.70m and 5.20m. Water Level measured in monitoring well: Date W.L.Depth (m) Jan. 13, 2021 3.3			55											0						



## REF. NO.: 201-11602-00

# B GRAIN SIZE DISTRIBUTION CURVES AND ATTERBERG LIMITS TESTS RESULTS






















# C RESULTS OF ROCK UNCONFINED COMPRESSIVE STRENGTH TESTS

GHD		Uniaxial Compressive Strength of Intact Rock Core S (ASTM D7012 - N								
CLIENT:		WSP Canada	i Inc.	LAB No.:	WLT507-1					
PROJECT/ SI	TE:	2020 Testing Se	rvices	PROJECT No.:	11189956					
Borehole No.:		BH20-7	Sampled ID:	Run	1					
Depth:		27.56 - 27.71 m (90'5" - 90'11")	) Date Sampled:	n/a						
Lithological De	escription	Dolostone								
Г			imon Devenetore							
-	Diamatar		Imen Parameters	62.2						
-	Diameter,	, mm		62.3						
-	Height, m	M Diamatar Datia		2.1						
-	Height-to-			2.1						
	volume, o	Sm		400.4						
-	Nass, g	aite les les 3		2700						
-	Moisturo	Sily, Kg/m	Δει							
-	Moisture		AST	0.1						
Ľ	MOISTUIE	Content, 70		0.1						
Γ	Maximum	Applied Load, kN		650.5						
-	Compres	sive Strength, MPa		213.5						
		BH20-7 RUN1	BH20-7	7 RUN1						
REMARKS:	<u></u> WS	SP #201-11602-00								
PERFORMED	BY:	Owen Reynolds	DATE:	February 8	, 2021					
VERIFIED BY:		Michael Braverman	DATE:	February 1 <sup>°</sup>	1, 2021					

GHD	Uniaxia	Uniaxial Compressive Strength of Intact Rock Core Spe (ASTM D7012 - Me									
CLIENT:	WSP Canada In	С.	LAB No.:	WLT507-2							
PROJECT/ SIT	E: 2020 Testing Service	ces	PROJECT No.:	11189956							
Borehole No.:	BH20-8	Sampled ID:	Run 1								
Depth:	29.93 - 30.11 m (98'2.5" - 98'9.5")	Date Sampled:	n/a								
Lithological Des	scription: Dolostone										
Г	Initial Specime	n Parameters									
	liameter mm		62.0								
			144.0								
	leight, min		2.3								
			2.5								
V	loume, cm		440.9								
IV B	ulk Density ka/m <sup>3</sup>		2774								
	loisture Condition	Ast	Received								
N N	loisture Content. %	,	0.3								
N	laximum Applied Load, kN		463.7								
C	compressive Strength, MPa		149.4								
	Z 21-11622-00 RH20-8 RUN1	BH20-8	RUN1								
REMARKS:	WSP #201-11602-00										
PERFORMED B	Y: Keisuke Adachi	DATE:	January 26	, 2021							
VERIFIED BY:	Michael Braverman	DATE:	February 5	, 2021							

GHD			Uniaxial Compressive Strength of Intact Rock ( (ASTM D7								
CLIENT:	-		WSP Canada Ir	1C.	LAB No.:	WLT507-3					
PROJECT/ SI	ITE:		2020 Testing Servi	ces	PROJECT No.:	11189956					
Borehole No.:	-		BH20-8	Sampled ID:	Run 8	}					
Depth:	-	38.25 - 3	88.4 m (125'6" - 126'0")	Date Sampled:	n/a						
Lithological De	escrip	tion:	Dolostone								
			Initial Specime	en Parameters							
	Diamo	ter mm			63.1						
	Height	mm			139.3						
	Height	., IIIII	er Ratio		2.2						
	Volum	$\frac{1}{2}$ cm <sup>3</sup>			135.9						
	Mass	α. οπ		1	236.6						
	Bulk D	9 Jensity ka/i	m <sup>3</sup>		2837						
	Moistu	re Conditio	on	As F							
	Moistu	ire Content			0.0						
			,								
	Maxim	um Applied	d Load, kN	Į	502.0						
	Comp	ressive Stre	ength, MPa		160.4						
		ВН20-8	B RUN8	BH20-8 RI	JIN8						
REMARKS:		WSP #201	-11602-00								
PERFORMED	BY:		Owen Reynolds	DATE:	February 8	, 2021					
VERIFIED BY:	-		Michael Braverman	DATE:	February 11	, 2021					

GHD		Uniaxi	al Compressive S	trength of Intact Roc (ASTM)	k Core Specimen D7012 - Method C
CLIENT:		WSP Canada I	nc.	LAB No.:	WLT 499-1
PROJECT/ SIT	ſE:	2021 Testing Servi	ces	PROJECT No.:	11222768-B1
Borehole No.:		BH20-3	Sampled ID:	Run	3
Depth:	17.27 -	17.45 m (56'8" - 57'3")	Date Sampled:	n/a	l
Lithological De	scription:	Siltstone/Limeston	e		
Γ		Initial Specim	en Parameters		
[	Diameter, mm			63.3	
ŀ	Height, mm			127.1	
ŀ	Height-to-Diame	ter Ratio		-	
1	/olume, cm <sup>3</sup>		:	-	
Ν	Mass, g		1	-	
E	Bulk Density, kg	/m <sup>3</sup>		2766	-
Ν	Moisture Conditi	on	As F	Received	-
Ν	Moisture Conten	t, %		0.3	
Г	Vaximum Annlie	dload kN	6	376.4	1
(	Compressive St	rength MPa		215.1	-
Ľ					]



BH20-3 RUN3 56'8" **REMARKS**: WSP Job Number: 201-11602-00 PERFORMED BY: Owen Reynolds DATE: January 4, 2021 VERIFIED BY: Michael Braverman DATE: January 13, 2021



#### Uniaxial Compressive Strength of Intact Rock Core Specimens (ASTM D7012 - Method C)

CLIENT:	WSP Canada In	Canada Inc. LAB No.: WLT				
PROJECT/ SITE:	2021 Testing Servic	es	<b>PROJECT No.:</b> 112227			
Borehole No.:	BH20-4	Sampled ID:	Run	2		
Depth:	17.91 - 18.08 m (58'9" - 59'4")	Date Sampled:	n/a			
Lithological Descr	iption: Limestone/Siltstone	)				
	Initial Specime	n Parameters				
Diar	neter, mm		63.1			
Heig	yht, mm		128.4			
Heig	ht-to-Diameter Ratio		2.0			
Volu	ime, cm <sup>3</sup>		401.1			
Mas	s, g	1	066.7			
Bulk	a Density, kg/m <sup>3</sup>		2659			
Mois	sture Condition	As F	Received			
Mois	sture Content, %					
		1		1		
Max	imum Applied Load, kN	:	312.4			
Com	pressive Strength, MPa		100.0	]		
	BH20-4 RUN2 58'9''	BH20-4 R	UN2 58'9"			
REMARKS:	WSP Job Number: 201-11602-00					
PERFORMED BY:	Owen Reynolds	DATE:	January 4	., 2021		
VERIFIED BY:	Michael Braverman	DATE:	January 1	3, 2021		

GHD		Uniaxia	I Compressive S	trength of Intact Roc (ASTM	k Core Specimens D7012 - Method C)
CLIENT:		WSP Canada In	С.	LAB No.:	WLT 499-3
PROJECT/ SI	TE:	2021 Testing Servic	es	PROJECT No.:	11222768-B1
Borehole No.:		BH20-9	Sampled ID:	Run	2
Depth:		22.73 - 22.91 m (74'7" - 75'2")	Date Sampled:	n/a	
Lithological De	escrip	tion: Siltstone/Limestone	)		
[		Initial Specime	n Parameters		
	Diame	eter, mm		62.8	
	Heigh	t, mm		117.0	
	Heigh	t-to-Diameter Ratio		1.9	
-	Volum	ie, cm <sup>3</sup>	:	362.8	
-	Mass,	g	1	006.0	
-	Bulk D	Density, kg/m <sup>3</sup>		2773	
-	Moist	ure Condition	As l	Received	
Ĺ	Moisti	ure Content, %		0.4	l
]	Maxim	num Applied Load, kN		559.1	
	Comp	ressive Strength, MPa		180.3	
	BH	20-9 RUN2 74'7"	BH20-5	PRUN2 74'7"	
REMARKS:		WSP Job Number: 201-11602-00			
PERFORMED	BY:	Owen Reynolds	DATE:	January 4	, 2021
VERIFIED BY:		Michael Braverman	DATE:	January 13	3, 2021

# PHOTOGRAPHS OF ROCK CORE



Run 1: 47' 0" - 50' 6" (14.33m - 15.39m)

Run 2: 50' 6" – 55' 0" (15.39m – 16.76m)



Run 1: 50' 0" - 52' 4" (15.24m - 15.95m)

Run 2: 52' 4" - 55' 10" (15.95m - 17.02m)

Run 3: 55' 10" - 60' 10" (17.02m - 18.54m)

201-11602-00 BH20-3 Run4: 60' 10" ~ 66' 0"

Run 4: 60' 10" - 66' 0" (18.54m - 20.12m)



Run 1: 54' 0" – 56' 1" (16.46m – 17.09m) Run 2: 56' 1" – 61' 0" (17.09m – 18.59m)



Run 3: 61' 0" - 65' 3" (18.59m - 19.89m)



Run 1: 78' 0" - 82' 0" (23.77m - 24.99m)



Run 1: 89' 0" – 91' 1" (27.13m – 27.76m) Run 2: 91' 1" – 95' 8" (27.76m – 29.16m)



Run 3: 95' 8" - 100' 8" (29.16m - 30.68m)

Run 7: 119' 11" - 123' 10" (36.55m - 37.74m)

Run 6: 114' 11" - 119' 11" (35.03m - 36.55m)



Run 5: 110' 0" - 114' 11" (33.53m - 35.03m)





Run 1: 96' 0" - 99' 1" (29.26m - 30.20m) Run 2: 99' 1" - 100' 1" (30.20m - 30.51m) Run 3: 100' 1" - 105' 1" (30.51m - 32.03m)





Run 7: 123' 10" – 125' 0" (37.74m – 38.10m) Run 8: 125' 0" – 129' 11" (38.10m – 39.60m)

Run 6: 91' 3" – 96' 0" (27.81m – 29.26m)

Run 5: 86' 3" - 91' 3" (26.29m - 27.81m)



Run 3: 76' 1" – 81' 6" (23.19m – 24.84m) Run 4: 81' 6" – 86' 3" (24.84m – 26.29m)



Run 1: 70' 0" – 71' 3" (21.34m – 21.72m) Run 2: 71' 3" – 76' 1" (21.72m – 23.19m)







#### **One-Dimensional Consolidation Test**

(ASTM D2435/D2435M-11R20)

LAB NO.: 1528 Specimen & Test Data

Client	Niagara Region	Project ID	201-11602-00	Depth (ft)	21'6-21'7''
Project Name	a Region Sanitary - Geote	Borehole ID	Borehole ID BH-01		23-Dec-20
<b>Project Location</b>	Niagara	Sample ID	<b>SS</b> 9	Test End Date	07-Jan-21

Apparatus/Test Procedu	ıre	Specimen I	Data		Sample Description		
ASTM Testing Method	В	Initial Final Silty Clay					
Equipment	GDS-3	Wet Mass of Sample (g)	Mass of Sample (g) 117.86 108.16 Specific Gravity Gs (ass		Specific Gravity Gs (assumed):	2.72	
Ring Height (mm)	19.93	Dry Mass of the Sample (g)		84.82	Sand (%)	1	
Ring Int. Diameter (mm)	63.44	Water Content, Trimmings (%)	38.95		Silt (%)	55	
Ring Int. Area (mm <sup>2</sup> )	3160.94	Water Content, Specimen (%)	36.86	25.59	Clay (%)	44	
Ring Mass (g)	107.21	Wet Density (kg/m <sup>3</sup> )	1870.87	2132.35	Liquid Limit (%)	37	
Trimming Procedure	Cutting Shoe	Dry Density (kg/m <sup>3</sup> )	1346.431	1672.246	Plastic Limit (%)	20	
Test Condition	Inundated	Void Ratio	1.02	0.53	Pre-consolidation Pressure, P'c (kPa)	N/A	
Interpretation Procedure	Root Time	Saturation (%)	100.0	100.0	Compression Index, C <sub>c</sub>	0.72	
		Heights of Specimen (mm)	19.930	16.047	Recompression Index, C <sub>r</sub>	0.06	

Load Incr.	Axial Stress	Deformation	Specimen Height	Axial Strain	Void Ratio	Modulus of vol. change	Deformation	Specimen Height	Axial Strain	Void Ratio	Time	Coef. of Consolidation	Hydraulic Conductivity
	σ,	$\Delta \mathbf{H}$	Н	£a	e	m <sub>v</sub>	$\Delta H_{50}$	H <sub>50</sub>	E <sub>2 50</sub>	e <sub>50</sub>	t.00	c <sub>v</sub>	k
	(kPa)	(mm)	(mm)	(%)	()	$(m^2/kN)$	(mm)	(mm)	(%)	()	(min)	(m <sup>2</sup> /year)	(m/s)
Initial	Seating										Root Ti	me Method	
1	10	0.147	19.783	0.74	1.01								
2	25	0.310	19.620	1.56	0.99	5.39E-04	0.247	19.683	1.24	1.00	2.0	88.14	1.48E-08
3	50	0.515	19.416	2.58	0.97	4.10E-04	0.419	19.511	2.10	0.98	2.9	58.75	7.50E-09
4	100	0.742	19.188	3.72	0.94	2.29E-04	0.612	19.318	3.07	0.96	2.0	82.57	5.87E-09
5	200	1.138	18.793	5.71	0.90	1.98E-04	0.909	19.021	4.56	0.93	3.2	49.82	3.07E-09
6	400	2.231	17.699	11.19	0.79	2.74E-04	1.462	18.468	7.33	0.87	4.0	38.03	3.25E-09
7	100	1.953	17.977	9.80	0.82	4.64E-05							
8	200	2.059	17.871	10.33	0.81	5.33E-05							
9	400	2.283	17.647	11.46	0.79	5.62E-05							
10	800	3.187	16.743	15.99	0.70	1.13E-04	2.614	17.316	13.12	0.76	3.6	37.16	1.31E-09
11	200	2.878	17.052	14.44	0.73	2.58E-05							
12	400	3.016	16.914	15.13	0.71	3.45E-05							
13	800	3.304	16.626	16.58	0.69	3.62E-05							
14	1600	4.099	15.831	20.57	0.60	4.99E-05	3.622	16.308	18.17	0.65	3.2	36.63	5.68E-10
15	3200	4.856	15.074	24.37	0.53	2.37E-05	4.379	15.551	21.97	0.58	2.4	44.90	3.31E-10
16	100	3.883	16.047	19.48	0.63	1.58E-05							

Remarks:

M. Macquarrie	2021-01-06	H. Rashid	07-Jan-21
TESTED BY	DATE	REVIEWED BY	DATE
Laifa, Cao, P. Eng	Control		
REVIEWED BY			



#### One-Dimensional Consolidation Test (ASTM D2435/D2435M-11R20)

LAB NO.: 1528 Graph-1

Client		N	liagara	Regio	1		Projec	t ID				201-11602	-00		1	Deptl	1 (ft)			21'6-	21'7''		_
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Project Loca	ation		Niag	ara			Sampl	e ID				SS9			Te	st En	d Date			07-Ja	an-21		
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### **One-Dimensional Consolidation Test**

(ASTM D2435/D2435M-11R20)

LAB NO.: 1528 Graph-2

Client	Niagara Region	Project ID	201-11602-00	Depth (ft)	21'6-21'7''
Project Name	a Region Sanitary - Geote	Borehole ID	BH-01	Test Start Date	23-Dec-20
Project Location	Niagara	Sample ID	SS9	Test End Date	07-Jan-21





#### One-Dimensional Consolidation Test (ASTM D2435/D2435M-11R20)

LAB NO.: 1528 Graph-3

Client	Niagara Region	Project ID	201-11602-00	Depth (ft)	21'6-21'7''
Project Name	a Region Sanitary - Geote	Borehole ID	BH-01	Test Start Date	23-Dec-20
Project Location	Niagara	Sample ID	<b>SS9</b>	Test End Date	07-Jan-21



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TUNNELMAN'S GROUND CLASSIFICATION AND PROBABLE WORKING CONDITIONS

## Tunnelman's Ground Classification and Probable Working Conditions

Soil Classification	Representative Soil Samples	Tunnel Working Conditions
Hard	Very hard calcareous clay; Cemented sand and gravel	Tunnel heading may be advanced without roof support.
Firm	Loess above GWT; Various calcareous clay with low plasticity	Tunnel heading may be advanced without roof support. Permanent support can be constructed before the ground will start to move.
Slow Ravelling and Fast Ravelling	Fast ravelling occurs in residual soils or in sand with clay binder below the GWT. Above the GWT, the same soils may be <u>Slow Ravelling</u> or even <u>Firm</u> .	Chunks of material may drop out of the crown or the sides some me after the ground has been exposed. In <u>Fast Ravelling</u> ground, the process starts within a few minutes; otherwise, it is classed as <u>Slow Ravelling</u> .
Squeezing	Soft or medium-soft clay	Ground slowly advances into tunnel without fracturing and without perceptible increase of water content in ground surrounding the tunnel.
Swelling	Heavily pre-compressed clays with a plasticity index greater than 30. Sedimentary formations containing layers of anhydrite.	Like squeezing ground, moves slowly into tunnel, but the movement is associated with a very considerable volume increase in the ground surrounding the tunnel.
Cohesive Running and Running	Occurs in clean, fine moist sand Occurs in clean, coarse or medium sand above the GWT	Removal of the lateral support of any surface rising at an angle of more than about 34° to the horizontal is followed by a 'run', whereby the material flows like granulated sugar until the slope angle is approx. 34°. If the 'run' is preceded by a brief period of ravelling, the ground is called <u>Cohesive Running</u> .
Very Soft Squeezing	Clays and silts with high plasticity indices	Ground advances rapidly into the tunnel in a plastic flow
Flowing	Any ground below the GWT that has an effective grain size in excess of about 0.00mm	Flowing ground moves like a viscous liquid. It can invade the tunnel not only through the roof and the sides, but also through the invert. If the flow is not stopped, it will eventually completely fill the tunnel.
Bouldery	Boulder glacial till; riprap fill; some land slide deposits, some residual soils. The matrix between boulders may be gravel, sand, silt, clay and in any combination.	Problems incurred in advancing shield or in forepoling; blasting or hand mining ahead of machine may become necessary.