APPENDIX F

Geotechnical Investigation

March 16, 2015

GEOTECHNICAL INVESTIGATION

Municipal Class Environmental Assessment Study for Sidney Street Corridor Improvements (Bell Boulevard to Tracey Street), City of Belleville, Ontario

Submitted to:
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REPORT

Report Number: 1403140

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This report presents the results of a geotechnical investigation carried out at the site, as shown on the Key Plan, Figure 1. The purpose of this geotechnical investigation was to characterize the existing pavement structures, subgrade soil conditions, and shallow groundwater conditions at the site by means of a limited number of shallow boreholes. Based on our interpretation of the subsurface information, this report provides geotechnical comments and recommendations in support of the design of the proposed Sidney Street Corridor improvements, including installation and/or replacement of underground services.

The factual data, interpretations 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. If the project is modified in concept, location or elevation, or if the project is not initiated within eighteen months of the date of the report, confirmation that the geotechnical recommendations are still valid is recommended.

This report should be read in conjunction with the "Important Information and Limitations of This Report" attached in Appendix A. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

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1.0 SITE LOCATION, BACKGROUND AND PROJECT DESCRIPTION

The section of Sidney Street in the project area is presently a four-lane north-south collector consisting of an urban road cross-section with sidewalk, curb and gutter. Under the current configuration, the intersections of Tracey Street and Tracey Park Drive at Sidney Street are off-set and do not include turning lanes from Sidney Street to the intersecting roads. In anticipation of commercial development on the east side of Sidney Street, corridor improvements that include a centre turn lane are envisioned to accommodate traffic and allow for safe turning movements.

In regards to the above, it is understood that intersection improvements at Sidney Street and Bell Boulevard, and Sidney Street and Tracey Street/Tracey Park Drive, as well as corridor improvements between these two intersections will be required to increase traffic capacity to accommodate the current and future traffic needs.

It is further understood that underground utility replacement/upgrades will be required within the project limits. The final invert elevations for the proposed services are not yet known. It is assumed that the final alignment of the new sewer and watermain will generally be located within the existing road right-of-ways (ROWs).

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2.0 GEOLOGIC SETTING

The Project Area lies within the physiographic region of Southern Ontario known as the Napanee Plain (Chapman and Putnam, 1984). Physiographic mapping in the immediate vicinity of the site indicates Bevelled till plains bordering Limestone Plains (Map 2556, Barnett, Cowan and Henry, 1991). These soil and bedrock conditions are generally consistent with the results of this investigation. The bedrock within the vicinity of the site is typically comprised of grey limestone thinly interbedded with shale.

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3.0 INVESTIGATION PROCEDURE

The subsurface investigation was carried out between August 12, 2014 and September 15, 2014, during which time fifteen (15) boreholes (BH14-1 to BH14-10, and BH14-2A, BH14-4A, BH14-5A, BH14-6A and BH14-8A) were advanced at the locations shown on the Borehole/Monitoring Well Location Plan, Figure 2, attached.

Boreholes BH14-1 to BH14-10 were drilled using a truck mounted drill rig supplied and operated by a specialist drilling contractor, subcontracted to Golder Associates Ltd (Golder). Standard penetration testing and sampling were carried out at regular intervals of depth in the boreholes using conventional 35 mm internal diameter split spoon sampling equipment advanced using an automatic hammer. Boreholes BH14-1 to BH14-10 extended to a depth of about 3.5 metres below ground surface (mbgs) or to refusal to further auger/spoon penetration on inferred bedrock surface. The shallow groundwater conditions were noted in the open boreholes during drilling and a 19 mm diameter piezometer was installed in Boreholes BH14-5 and BH14-9 to further monitor groundwater levels. The remaining boreholes were loosely backfilled and sealed/patched upon completion of drilling. Boreholes BH14-2A, BH14-4A, BH14-5A, BH14-6A and BH14-8A were advanced using a hand auger to shallow depths ranging from about 0.5 mbgs to 0.8 mbgs to determine the topsoil thicknesses and to identify the underlying subgrade soils at the areas of potential widening. All of the soil samples obtained during this investigation were visually examined and selected samples identified for soil classification testing in the laboratory.

The field work for this investigation was directed by members of our engineering staff who determined the borehole locations, observed the drilling and sampling operations, prepared the stratigraphic logs, observed groundwater conditions and cared for the recovered samples. Elevations and as-drilled locations of the boreholes were provided by CIMA+.

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4.0 SUBSURFACE CONDITIONS

The results of the field and laboratory testing are shown in detail in Appendix B and in Attachment 1. To assist in the interpretation of the borehole logs, the method of soil classification, symbols and terms used on the records of boreholes are explained in Appendix C. The boundaries between the soil strata have been inferred from drilling observations and non-continuous samples. They generally represent a transition from one soil type to another but should not be inferred to represent an exact plane of geological change. Further, conditions will vary between and beyond the boreholes.

The following is a summarized account of the subsurface conditions encountered in the boreholes, followed by more detailed descriptions of the major soil strata and shallow groundwater conditions. Where groundwater observations and measurements are reported and discussed, they reflect the shallow groundwater conditions encountered in the boreholes during the time of the field investigation and some seasonal fluctuations should be anticipated.

Underlying the pavement structures and shallow fills, the subsurface soil conditions generally consist of glacial tills ranging in gradations from clayey silt and sand till to gravelly silty sand till that are underlain by granular soils containing limestone fragments. The granular soils generally consist of sand and gravel and sandy gravel. Inferred bedrock was encountered below the tills and/or granular soils in Boreholes BH14-1 to BH14-4, BH14-8 and BH14-10, at depths ranging from 2.4 mbgs to 3.3 mbgs. Groundwater was measured at depths of 1.3 mbgs and 3.2 mbgs in the piezometers installed in Boreholes BH14-5 and BH14-9, respectively, on September 15, 2014.

4.1 Existing Pavement Structure

Based on the results of the geotechnical investigation, the existing pavement structures on the various road sections and the subgrade conditions are summarized in the following table:

Borehole Number	Asphalt (mm)	Granular Base/ Subbase (mm)	Total Thickness (m)	Subgrade Classification*	Moisture Condition	Water Level (m)
SIDNEY STREET						
BH14-1 (Tie-in)	210	130/200	540	Clayey Silt and Sand Till (LSFH)	Moist to Dry	–
BH14-4	180	150/180	510	Clayey Silt Fill (LSFH)	Moist to Wet	–
BH14-4A	–	–	–	Silty Sand Fill (LSFH)	Moist	–
BH14-5	150	150/190	490	Silty Sand to Silty Clay Fill (LSFH)	Moist to Wet	1.3
BH14-5A	–	–	–	Silt and Sand Fill (LSFH)	Moist	–
BH14-6	160	160/200	520	Silty Sand Till (LSFH)	Moist to Dry	3.5
BH14-6A	–	–	–	Silt and Sand (LSFH)	Moist	–
BH14-7	160	180/170	510	Silty Sand to Sand Fill (LSFH)	Moist to Dry	–
BH14-10 (Tie-in)	300	160/180	640	Silty Clay Fill to Clayey Silt and Sand Till (LSFH)	Moist to Wet	–
BELL BOULEVARD						
BH14-2	180	140/210	530	Clayey Silt Fill to Clayey Silt and Sand Till (LSFH)	Moist	–
BH14-2A	–	–	–	Sand and Gravel Fill to Clayey Silt with Sand (LSFH)	Moist	–
BH14-3	150	200/170	520	Clayey Silt Fill to Clayey Silt and Sand Till (LSFH)	Moist to Dry	2.1

Borehole Number	Asphalt (mm)	Granular Base/ Subbase (mm)	Total Thickness (m)	Subgrade Classification*	Moisture Condition	Water Level (m)
TRACEY PARK DRIVE / TRACEY STREET						
BH14-8	80	240/190	510	Silt and Sand Till (LSFH)	Moist to Dry	–
BH14-8A	–	–	–	Silty Sand Fill (LSFH)	Moist	–
BH14-9	70	270/180	520	Clayey Silt Fill (LSFH)	Moist to Dry	3.2

Note: LSFH=Low Susceptibility to Frost Heaving; MSFH=Moderate Susceptibility to Frost Heaving; HSFH=High Susceptibility to Frost Heaving

The existing pavement structures on Sidney Street and Bell Boulevard, within the project limits, typically consisted of 150 mm to 180 mm of asphalt (maximum thickness of 300 mm at Borehole 14-10) and 330 mm to 360 mm of granular base/subbase material. The existing pavement structure on Tracey Park Drive and Tracey Street consisted of 70 mm to 80 mm of asphalt and 430 mm to 450 mm of granular base/subbase.

The subgrade soil varied from silty sand/silt and sand to clayey silt, judged to have low susceptibility to frost heaving. The subgrade soils were generally moist to wet along Sidney Street. Groundwater was encountered at the completion of drilling in Borehole BH14-3 and BH14-6, and in the piezometers installed in Boreholes BH14-5 and BH14-9. A resilient modulus of 30 MPa has been assigned to the subgrade for pavement design.

4.2 Fill Materials

Shallow fill materials were encountered underlying the pavement structure in all boreholes except Boreholes BH14-6, BH14-6A and BH14-8, and extended to an approximate depth of between 0.4 m and 2.1 m below the existing ground surface.

4.2.1 Non-Cohesive Fill

Non-cohesive fill was encountered in Boreholes BH14-2A, BH14-4A, BH14-5, BH14-5A, BH14-6A, BH14-7, BH14-8A and BH14-9, and generally consisted of sand to sandy silt. Boreholes BH14-4A, BH14-5A, BH14-6A and BH14-8A were terminated within the non-cohesive fills due to refusal to further penetration with a hand auger. Standard penetration tests carried out within the non-cohesive fill materials gave N values ranging from 4 blows to 22 blows per 0.3 m of penetration, indicating it to be very loose to compact. The in-situ water contents of the non-cohesive fill samples generally ranged from about 6% to 10%.

4.2.2 Cohesive Fill

Cohesive fill was encountered in Boreholes BH14-2, BH14-3, BH14-4, BH14-5, BH14-9 and BH14-10, and generally consisted of sandy clayey silt to silty clay and organic clayey silt. Standard penetration tests carried out within the cohesive fill materials gave N values ranging from 10 blows to 23 blows per 0.3 m of penetration, indicating a stiff to very stiff consistency. The in-situ water contents of the cohesive fill samples generally ranged from about 10% to 29%.

4.3 Clayey Silt and Sand Till

Clayey silt and sand till was encountered below the fill materials in Boreholes BH14-1 to BH14-5, BH14-2A and BH14-10. Standard penetration tests carried out within the clayey silt and sand till gave N values ranging from 9 blows to 43 blows per 0.3 m of penetration, indicating a stiff to hard consistency. A single grain size distribution curve for a sample of clayey silt and sand till is shown on Figure 3.

4.4 Gravelly Silty Sand Till

Deposits of gravelly silty sand till were encountered below the pavement structure in Boreholes BH14-6 to BH14-8. Standard penetration tests carried out within the gravelly silty sand till gave N values ranging from 13 blows to 60 blows per 0.3 m of penetration, indicating it to be compact to very dense. Cobbles and boulders were inferred to be present within the gravelly silt and sand till encountered at Borehole BH14-8. A single grain size distribution curve for a sample of gravelly silty sand till is shown on Figure 4.

4.5 Sand and Gravel and Sandy Gravel

Non-cohesive native granular deposits consisting of sand and gravel and sandy gravel containing limestone fragments were encountered below the glacial tills in Boreholes BH14-1, BH14-3, BH14-7 and BH14-9. Standard penetration tests carried out within the granular soils gave N values ranging from 14 blows to greater than 100 blows per 0.3 m of penetration, with higher N-values indicating the presence of inferred bedrock. A single grain size distribution curve for a sample of gravel and sand is shown on Figure 5.

4.6 Inferred Bedrock

Boreholes BH14-1 to BH14-4, BH14-8 and BH14-10 were terminated at effective refusal to progress of the augers or upon split spoon refusal, in what was inferred to be limestone bedrock. The inferred bedrock surface at these borehole locations was encountered at depths ranging from 2.4 mbgs to 3.3 mbgs, which correspond to elevations ranging from 90.5 m to 92.0 meters above sea level (masl) as summarized in the table below.

Borehole ID	Depth to Inferred Bedrock (mbgs)	Inferred Bedrock Elevation (masl)
BH14-1	2.4	92.0
BH14-2	2.7	91.7
BH14-3	3.3	91.4
BH14-4	2.5	91.5
BH14-8	2.7	90.5
BH14-10	2.7	90.6

4.7 Shallow Groundwater

Details of the groundwater levels encountered during and upon completion of drilling are shown on the record of borehole sheets (Appendix B). Subsequent groundwater levels measured in the piezometers installed in Boreholes BH14-5 and BH14-9 were at depths of 1.3 mbgs and 3.2 mbgs, respectively, on September 15, 2014.

The reported groundwater levels reflect conditions during the time of the investigation (i.e., August and September 2014) and seasonal fluctuations should be anticipated.

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5.0 DISCUSSION

This section of the report provides engineering information for the geotechnical design aspects of the project, based on our interpretation of the borehole data and on our understanding of the project requirements. The information in this portion of the report is provided for the guidance of the design engineers and technicians. Where comments are made on construction, they are provided to highlight aspects of construction that could affect the design of the project. Contractors bidding on or undertaking any work at the site should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction and make their own interpretation of the factual data as it affects their proposed construction techniques, schedule, equipment capabilities, costs, sequencing and the like.

5.1 Project Description

It is understood that Sidney Street and the two intersections at Bell Boulevard and Tracey Park Drive/Tracey Street in the City of Belleville will receive upgraded underground servicing, comprising watermain and sewers. The proposed works will include widening and improvements to Sidney Street and the two identified intersections. Although the final inverts for the underground utilities are currently unknown, it is anticipated that the future underground utilities (i.e., watermain, sanitary and storm sewers) will match the existing sewers and watermain inverts. Based on the information provided, it is understood that the existing watermain and the storm sewer inverts are up to 2.5 m depth below the existing road surface, and the existing sanitary sewer invert is at about 3 m depth at the Sidney Street/Bell Boulevard intersection and at about 5.5 m depth at the Sidney Street/Tracey Street intersection.

5.2 Trench Excavations for Underground Services

It is anticipated that the proposed watermain and sewer installations will require trench excavations between about 1.7 m and 5.5 m in depth below the existing road/ground surface. As previously noted, the finalized design pipe alignments and invert elevations are not available at this time. As such, the following generalized geotechnical information and recommendations are provided to facilitate the detail design process. Once the finalized watermain and sewer alignments and invert depths are available, these recommendations should be reviewed and amended by the geotechnical engineer, as required. Additional investigation should be carried out in identified areas of insufficient subsurface information, if any.

Based on the results of the geotechnical investigations, the subgrade soils at the pipe inverts will vary and will generally consist of fill materials, glacial tills, native granular deposits or bedrock. The native soils underlying the shallow fill materials are considered to be suitable for supporting the pipes, provided the integrity of the base can be maintained during construction. The suitability of the existing fill materials to support the pipes, if encountered at the base of the trench, should be further assessed during construction. This will require inspection during construction by qualified geotechnical personnel, to determine the suitability of any existing fills for supporting the pipes. Some difficulty may be encountered in excavating the dense/hard tills at some locations. In addition, these tills may contain cobbles and boulders.

Based on the groundwater conditions encountered in the boreholes and considering the trench excavation depths anticipated, the sanitary sewer will generally be below the local water table at most locations and the watermain and storm sewer will be near the local groundwater table at most locations. Groundwater control within the glacial tills can likely be handled, as required, by passive techniques using conventional pumping equipment in sumps.

Sumps should be properly constructed and filtered to prevent loss of ground. However, more significant groundwater seepage may be expected in the wet non-cohesive granular soil encountered just above the bedrock and from fractures within the bedrock. Depending upon the actual thickness and extent of these wet non-cohesive sand/gravel deposits and bedrock fractures, some form of positive groundwater control may be required to maintain the stability of the base and side slopes of the trench excavations in these areas, in addition to pumping from sumps.

Dewatering systems should be installed and maintained by an Ontario Ministry of the Environment and Climate Change (MOECC)-licensed Water Well Contractor in accordance with applicable legislation. The responsibility for the design, equipment selection and operation of construction dewatering methods for the proposed construction activities should entirely be that of the contractor.

In this regard, it would be prudent to carry out a "public digging" (i.e., test pitting) during the tender stage, to allow prospective bidders to assess the subsurface conditions, and determine the type of groundwater control required, consistent with their equipment capabilities and the actual groundwater conditions at that time. The locations of the test pits should be determined in consultation with the geotechnical engineer.

Groundwater control measures that extract more than 50,000 L/day of water are subject to a Permit to Take Water (PTTW), as regulated by the MOECC.

5.2.1 Soil Excavation

It is anticipated that the majority of the construction of the pipe installations will be carried out using vertically excavated, unsupported excavations (using a properly engineered trench liner box for protection, certified by a qualified engineer); or by a supported (sheeted) excavation, if conditions warrant in close proximity to adjacent underground services. It must be emphasized that a trench liner box provides protection for construction personnel but does not provide any lateral support for adjacent excavation walls, underground services or existing structures. It is imperative that underground services and existing structures adjacent to the trench excavations be accurately located prior to construction and adequate support provided where required, as per current municipal design standards.

Where excavations are conducted by conventional temporary open cuts through fill deeper than 1.2 m, side slopes should not be steeper than 1 horizontal to 1 vertical. However, depending upon the construction procedures adopted by the contractor, actual groundwater seepage conditions, the success of the contractor's groundwater control methods and weather conditions at the time of construction, some flattening and/or blanketing of the slopes may be required. Care should be taken to direct surface runoff away from the open excavations and all excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA) and Regulations for Construction Projects. According to OHSA, the shallow fill materials and non-cohesive granular soils would be classified as Type 3 soils and the glacial till soils would be classified as Type 2 soils.

Where trench boxes are utilized, it is anticipated that in the non-cohesive soils, the unsupported soils on the trench sides will relax, filling the void between the trench walls and trench box. This may lead to loss of ground below the pavement and potentially undermine and reduce the stability of the pavement structure adjacent to the open traffic lanes. To minimize this effect, the gap between the trench walls and trench box should be minimized during the excavation and trench box installation.

5.2.2 Rock Excavation

Rock excavation can be carried out with vertical side walls. It is expected that blasting will not be permitted by the municipality and that rock excavation will be carried out using mechanical equipment. It may be possible to excavate the upper highly weathered zone of the bedrock, using an excavator and hoe ram. It is anticipated that line drilling, together with hoe ramming, will be required below the highly weathered zone to maintain neat excavation lines and minimize overbreak or over excavation. Some overbreak should be expected within the harder bedrock layers, which will tend to break along vertical or near vertical joint sets, resulting in a rough "saw-tooth" profile.

Vibration monitoring of the adjacent utilities and buildings is recommended during rock excavation.

5.3 Pipe Bedding and Cover

The bedding for the underground services should be compatible with the type and class of pipe, the surrounding subsoil/rock and anticipated loading conditions and should be designed in accordance with the City of Belleville standards. Where granular bedding is deemed to be acceptable, it should consist of OPSS Granular A or 19 mm crusher run limestone from at least 150 mm below invert to springline. Depending upon the design invert elevations and success of the contractor's groundwater control methods, a thicker bedding layer, in the order of 300 mm, may be required at some locations where wet loose/disturbed base soil conditions are present during construction, to facilitate the pipe installations. Clear stone bedding material should not be used in any case for pipe bedding or to stabilize the base. All bedding and cover material should be placed in 150 mm loose lifts and uniformly compacted to at least 98% of Standard Proctor maximum dry density. Any section of the sewer pipe that may have less than 1.5 m soil cover should be insulated for frost protection.

5.4 Trench Backfill

The excavated materials from the site will vary from clayey (cohesive) subsoils to silty/sandy (non-cohesive) subsoils. The majority of the native subsoils that are anticipated to be excavated during underground service installation are generally near their estimated optimum water contents for compaction. The excavated materials at suitable water contents may be reused as trench backfill provided they are free of significant amounts of topsoil, organics or other deleterious material, and are placed and compacted as outlined below. Some drying of the wetter shallow layers of sand and gravel and gravelly silty sand deposits may be required prior to placement. It should also be noted that due to the predominantly fine-grained, silty/clayey nature of the majority of the native subsoils, some difficulty would be expected in achieving adequate compaction during wet weather. All topsoil and organic materials should be wasted or used for landscaping purposes. All oversized cobbles and boulders, and large rock fragments (i.e., greater than 150 mm in size) should be removed from the backfill.

All trench backfill, from the top of the cover material to 1 m below pavement subgrade elevation, should be placed in maximum 300 mm loose lifts and uniformly compacted to at least 95% of standard Proctor maximum dry density. For the top 1 m of the subgrade, the materials should be placed in maximum 300 mm loose lifts and uniformly compacted to at least 98% of standard Proctor maximum dry density.

Alternatively, if placement water contents at the time of construction are too high and there is insufficient space and/or time available to adequately dry the trench backfill material, or if there is a shortage of suitable in-situ material, then an approved imported sandy material which meets the requirements for OPSS Select Subgrade Material (SSM) could be used. It should be placed in loose lift thicknesses as indicated above and uniformly compacted to at least 95% of standard Proctor maximum dry density. Backfilling operations during cold weather should avoid inclusions of frozen lumps of material, snow and ice.

Normal post-construction settlement of the compacted trench backfill should be anticipated, with the majority of such settlement taking place within about 6 months following the completion of trench backfilling operations. This settlement will be reflected at the ground surface and in pavement reconstruction areas, and may be compensated for where necessary by placing additional granular material prior to asphalt paving. However, since it is anticipated that the asphalt binder course will be placed shortly following the completion of trench backfilling operations, any settlement that may be reflected by subsidence of the surface of the binder asphalt should be compensated for by placing additional asphalt thickness.

To minimize the potential for differential frost heaving between the restored roadway portions and the remaining portions of the pavement, the backfill materials should be placed in the same sequence as they were excavated trying to avoid (to the extent possible) mixing of materials, especially those within the 1.5 m frost penetration depth.

In some cases, even though the compaction requirements have been met, the subgrade strength in the trench backfill areas may not be adequate to support heavy construction loading, especially during wet weather or where backfill materials wet of optimum have been placed. The subgrade should be proofrolled and inspected by qualified geotechnical personnel prior to placing additional fill, subbase and base material, as required, consistent with the prevailing weather conditions and anticipated use by construction traffic.

5.5 Excess soil management

5.5.1 Soil Submission

In order to provide information regarding the chemical quality of the subsurface soil, the following soil samples were submitted to AGAT Laboratories Ltd. of Mississauga, Ontario (“AGAT”) for metals and inorganic parameter analyses:

Composite Sample ID	Fill/Native	Soil Sample Depth (mbgs)
BH14-2 SA1	Fill	0.76 to 1.22
BH14-5 SA2	Fill	1.52 to 1.98
BH14-9 SA1A	Fill	0.76 to 0.91

At the time of the sampling, no obvious visual or olfactory evidence of environmental impact (i.e., staining or odours) was observed at the sampling locations. For a summary of subsurface conditions observed, refer to Section 4.0 and the Record of Borehole Sheets for further details.

5.5.2 Soil Analytical Results

The soil sample analytical results were compared to the MOE *“Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act”*, April 15, 2011, Table 1 Full Depth Background Site Condition Standards for All Other Types of Property Use (“MOE Table 1 Standards”) and Table 2 (potable groundwater conditions) Full Depth Generic Site Condition Standards for Industrial/Commercial/Community Property Use ("MOE Table 2 Standards").

A summary of the soil analytical results and the MOE Table 1 Standards is provided on the Laboratory Certificates of Analysis, included in Appendix D. Based on the results of the analyses and the Standards comparison, the following parameters were identified to be above the MOE Table 1 Standards:

- Sodium Absorption Ratio (SAR) detected in soil samples BH14-2 SA1 (5.73), BH14-5 SA2 (2.57) and BH14-9 SA1A (16.5) were above the MOE Table 1 Standard of 2.4; and
- Electrical Conductivity (EC) detected in the soil sample BH14-9 SA1A (0.921 mS/cm) was above the MOE Table 1 Standard of 0.57 mS/cm.

The following parameters were also found to be above the MOE Table 2 Standards:

- SAR detected in the soil sample BH14-9 SA1A (16.5) was above the MOE Table 2 Standard of 12.

5.5.3 Discussion of Analytical Results

Three of the soil samples submitted for analysis contained SAR and/or EC levels which are above the MOE Table 1 Standards. Further, the SAR level in one of the samples is also above the respective MOE Table 2 Standard. Elevated SAR and/or EC values in soils beneath roadways and parking lots are often attributable to the application of de-icing salts. Although the levels identified are above one or more of the MOE generic full-depth remediation standards, some receivers (depending on their intended land use) may consider accepting materials for which only SAR and/or have been identified as potential contaminants of concern. For example, such materials may be considered environmentally suitable for re-use as road base materials. Available analytical data pertaining to this material should be forwarded to the potential receiver for review. Written authorization, indicating that this data was received and reviewed, and that the receiver accepts the excavated material, should be provided to the site representative by the potential receiver. It should be noted that receiving sites may be subject to filling or other land use restrictions, which could affect the importation and placement of fill on their sites. An assessment of the appropriateness for individual sites to accept and place fill material is beyond the scope of this work program and has not been investigated or addressed.

Further, with the introduction of the recent amendments to Ontario Regulation (O.Reg.) 153/04, as described in O.Reg. 511/09, movement of soil to a site that is the subject of a Record of Site Condition requires that specific testing protocols are followed and that the material must satisfy the applicable MOE standards. The level of testing outlined herein is meant to provide a broad indication of soil quality based on the soil samples tested and is not intended to be fully compliant with the excess soil characterization provisions contained in O.Reg. 511/09 amending O.Reg 153/04. If full compliance with O.Reg. 153/04 is desired, a much higher sampling frequency and other site assessment work will be required.

If excess soil materials generated during construction vary in composition from the samples tested by Golder, additional testing is recommended to determine their suitability for disposal/reuse. Note that the excess soil reuse options as discussed herein are limited to the environmental quality of the soil.

5.6 Pavement Design

The City is planning to widen Sidney Street between Bell Boulevard and Tracey Street on both the west and east sides of the roadway in conjunction with proposed intersection improvements. The pavement design and analysis was carried out in accordance with "*Procedures for Estimating Traffic Loads for Pavement Design, 1995*" and "*1993 AASHTO Guide for Design of Pavement Structures*". Details of the AASHTO pavement design analysis are provided in Tables E1 to E3, Appendix E.

5.6.1 Existing Pavement Structure and Subgrade

The road section of Sidney Street is a two-way four-lane roadway running north-south through the west end of the City, with an urban cross-section. The existing pavement is in fair to good condition with the predominant distresses in the form of intermittent transverse cracking and longitudinal cracking.

The typical existing pavement structure along Sidney Street and Bell Boulevard, as described in Section 4.1, consists of 170 mm of asphalt, 150 mm of granular base, and 190 mm of granular subbase. Based on the results of the investigation and laboratory testing, the structural coefficients for AASHTO pavement design for the asphalt concrete, the granular base, and the granular subbase materials are 0.28, 0.12 and 0.08, respectively, and the drainage coefficient for the granular materials is about 0.9. The typical Structural Number (SN) of the existing pavement structure on the Sidney Road is estimated to be approximately 77 mm.

The subgrade soils along the roadway and within the proposed widening area are variable and predominantly consist of silty sand and occasionally clayey silt. A resilient modulus of 30 MPa has been used in the pavement design.

5.6.2 Traffic Loading

The pavement design and analysis was carried out in accordance with "*Procedures for Estimating Traffic Loads for Pavement Design, 1995*" and "*1993 AASHTO Guide for Design of Pavement Structures*".

Traffic information provided by CIMA+ was used as input to the pavement design. The information provided indicates that for the subject section of Sidney Street, the Average Annual Daily Traffic (AADT) is approximately 17,383 for year 2014 and 21,867 for year 2031, with an annual rate of increase in traffic of approximately 1.4 percent. The commercial truck component is estimated at 2.6 percent.

The section of Sidney Street under consideration is classified as urban minor arterial. A 16 year design life is considered in the pavement design and analysis for both the rehabilitation and widening of Sidney Street.

Based on the traffic data, the road configuration and the condition of the subgrade, the estimated Equivalent Single Axle Loads (ESALs) for a 16-year design period is approximately 1.3 million and the required structural number is 102 mm. The structural deficiency of the existing pavement on Sidney Street is approximately 25 mm in structural number (i.e., 102 – 77).

5.6.3 Pavement Design Recommendations

The pavement design recommendations for widening, intersection improvements, restoration and rehabilitation, where applicable, are provided below.

To maximize the performance of the upgraded roadway, timely maintenance (i.e., crack sealing) should be carried on a periodic basis over the expected service life.

Rehabilitation of Existing Sidney Street including Bell Boulevard at Intersection

Option 1 – Mill and Pave (20 mm Grade Raise)

- Mill 120 mm of the existing pavement, and pave with 140 mm of hot mix asphalt as follows:

40 mm	HL1	Surface Course
50 mm	HL8	Upper Binder Course
50 mm	HL8	Lower Binder Course
Padding as required		

For areas where crown shift is proposed in conjunction with the widening, padding is recommended over the milled surface prior to the placement of the three lifts of hot mix asphalt.

Option 2 – Removal and Replacement (No Grade Raise)

- Remove the existing asphalt completely and partial depth of granular to a depth of 310 mm from the existing top of pavement, and provide:

40 mm	HL1	Surface Course
50 mm	HL8	Upper Binder Course
70 mm	HL8	Lower Binder Course
150 mm	New Granular A	

Both Options 1 and 2 will provide serviceable pavement for the required design period. However, Option 2, which replaces all the old asphalt, will have lower future maintenance costs. With Option 1 there is a potential for some cracking in the existing pavement to propagate through the new asphalt over time.

Widening of Sidney Street including Bell Boulevard at Intersection

- Excavate from the existing edge of pavement to a depth of 570 mm below the existing top of pavement and provide 590 mm of new pavement structure to accommodate 20 mm of grade raise (Option 1); or excavate from the existing edge of pavement to a depth of 610 mm below the top of existing pavement and provide 610 mm of new pavement structure without grade raise (Option 2):

40 mm	HL1	Surface Course
50 mm	HL8	Upper Binder Course
50 mm	HL8	Lower Binder Course (Option 1)
70 mm	HL8	Lower Binder Course (Option 2)
150 mm	New Granular A	
300 mm	New Granular B, Type I (*min. or match the existing bottom of granular subbase*)	

If Option 2 is selected, the lower binder course should be increased to 70 mm to provide a consistent three lifts of asphalt across the road platform for more uniform performance.

Rehabilitation of Existing Tracey Street or Tracey Park Drive (Tie-in)

- Mill 40 mm of the existing pavement, and pave with 40 mm of hot mix asphalt as follows:

40 mm	HL1 Surface Course
Padding as required	

For areas where crown shift is proposed in conjunction with the widening, padding is recommended over the milled surface prior to the placement of the three lifts of hot mix asphalt.

Widening of Tracey Street or Tracey Park Drive beyond Intersection

- Excavate from the existing edge of pavement to a depth of 540 mm below the finished grade of pavement and provide 540 mm of new pavement structure:

40 mm	HL1 Surface Course
50 mm	HL8 Binder Course
150 mm	New Granular A
300 mm	New Granular B, Type I (*min. or match the existing bottom of granular subbase*)

5.6.4 Subgrade Preparation and Granular Placement

In preparation for widening the road platform, any deleterious fill materials (e.g., containing debris, organics, or topsoil) should be stripped to expose a competent subgrade. Prior to placing any granular material, the exposed subgrade, should be heavily proofrolled in conjunction with an inspection by qualified geotechnical personnel. Remedial work should be carried out on any disturbed, softened or poorly performing zones, as directed by geotechnical personnel.

The granular subbase and base materials should be uniformly compacted to 100% of their standard Proctor maximum dry densities. The HL1 and HL8 hot mix asphalt layers should be compacted to at least 92 % of their respective Maximum Relative Densities (MRD), when measured in the field using a nuclear density gauge.

5.6.5 Drainage

A proper drainage system is critical for good long-term performance of the pavement. It is understood that the widened roadway along the pavement sections within the project limits will be designed to urban standards including a catchbasin and subdrain drainage system.

The drainage system should consist of a 150 mm diameter, perforated corrugated plastic pipe wrapped in filtercloth, placed inside a trench and surrounded by concrete sand (minimum of 50 mm at the bottom). The trench should be lined with a suitable geotextile prior to placing the concrete sand. At the top of the trench, the geotextile should overlap a minimum of 300 mm.

5.6.6 Pavement Transitions

Where new pavement abuts existing pavement, proper transverse lap joints should be constructed to key the new asphalt into the existing surface by 40 mm in depth and 2 m in length at tie-ins. The existing asphalt edges should be provided with a proper saw cut edge prior to keying in the new asphalt. Any undermining or broken edges resulting from the construction activities should be removed by the saw cut.

6.0 MONITORING AND TESTING

As noted above, the geotechnical aspects of the final design drawings and specifications should be reviewed by geotechnical personnel prior to tendering and construction, to confirm that the intent of this report has been met. During construction, sufficient inspections and in-situ materials testing should be carried out to confirm that the conditions exposed are consistent with those encountered in the boreholes and to monitor conformance to the pertinent project specifications. Asphalt testing should be carried out in a Canadian Council of Independent Laboratories (CCIL) certified laboratory.

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7.0 CLOSURE

We trust that this report provides sufficient geotechnical engineering and environmental information to facilitate the detailed design of this project. If you have any questions regarding the contents of this report or require additional information, please do not hesitate to contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

Alan Mohammad, P.Eng. Geotechnical Engineer	Michael Maher, P.Eng. Principal, Pavement and Materials Engineering

AM/XW/HD/TJG/MLJM/am/kg

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TABLE 1
RECORD OF BOREHOLES

Sydney Street
from Belle Boulevard to Tracey Street

Borehole No.	BOREHOLE LOG					LABORATORY TESTING	
	Depth (mm)	Description	Sample Depth (mm)	Sample No.	N Value	Water Content	Gradation
Location	See Figure 2						
BH14-2A	0 - 190	Topsoil					
	190 - 370	FILL - (SW/GP) SAND and GRAVEL, fine to coarse, some non-plastic fines; dark brown to black; non-cohesive, wet	190 - 370	1			
	370 - 820	(ML) CLAYEY SILT and SAND, some gravel; brown (TILL), cohesive, w>PL	400 - 700	2			
Location	See Figure 2						
BH14-4A	0 - 180	Topsoil					
	180 - 500	FILL - (SM) SILTY SAND, fine to medium, trace to some gravel, containing cobbles; brown; non-cohesive, moist	200 - 300	1			
	500	No Further Penetration					
Location	See figure 2						
BH14-5A	0 - 190	Topsoil					
	190 - 700	PROBABLY FILL - (ML) SILT AND SAND, trace gravel, occasional cobble; brown, moist	400 - 700	1			
	700	No Further Penetration					
Location	See Figure 2						
BH14-6A	0 - 200	Topsoil					
	200 - 900	(ML) SILT AND SAND, trace gravel; brown, moist	300 - 600	1			
	900	No Further Penetration					
Location	See Figure 2						
BH14-8A	0 - 220	Topsoil					
	220 - 750	FILL - (SM) SILTY SAND, fine to medium, trace to some gravel, containing cobbles; brown; non-cohesive, moist	250 - 550	1			
	750	No Further Penetration					

Inputted by: JS
Checked by: AM

FIGURES

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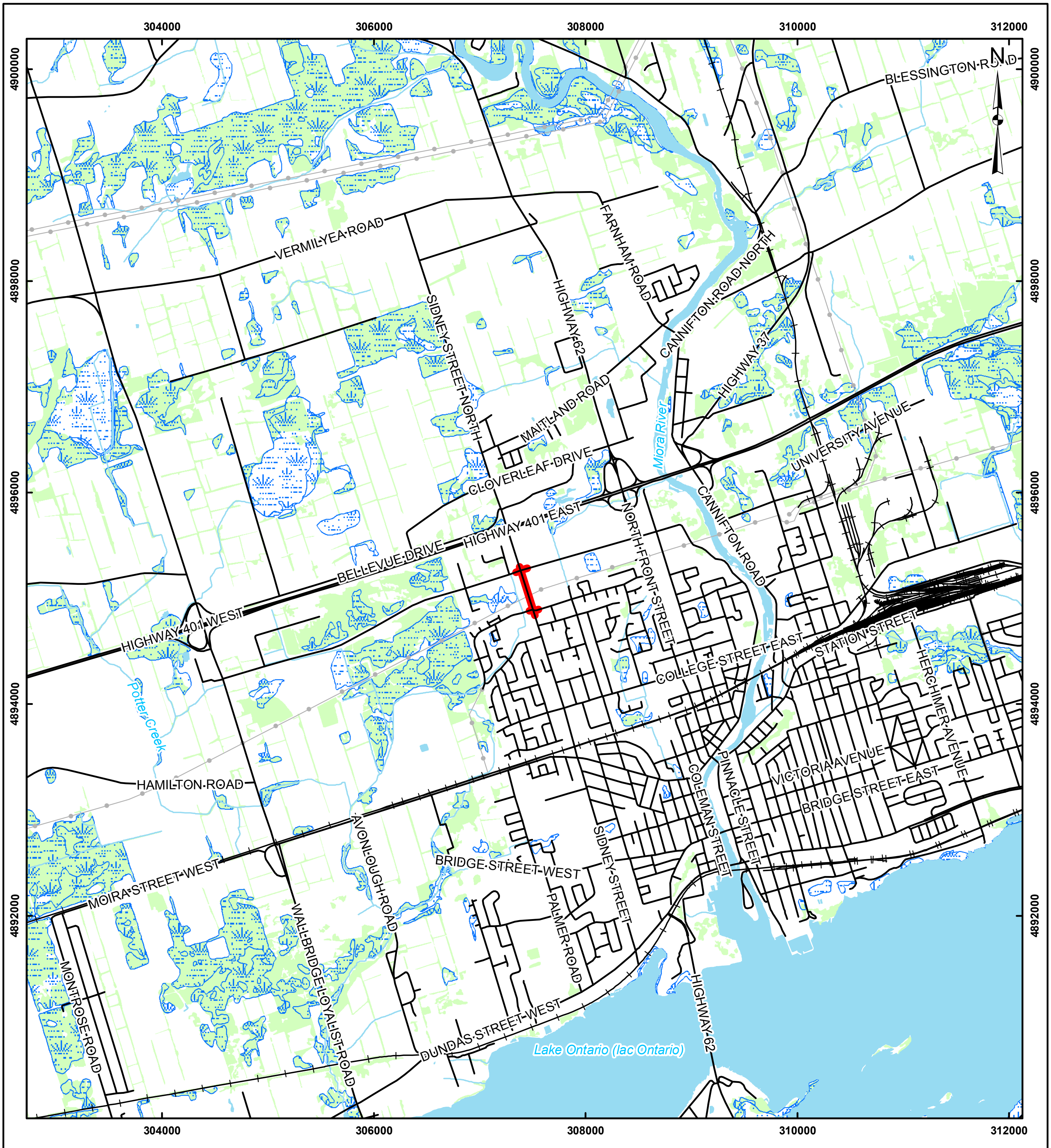


1,000 0 1,000 2,000

SCALE 1:50,000 METRES

LEGEND

🟥 Approximate Site Limits

Road

Watercourse

Railway

Utility Line

Waterbody

Wetland

Wooded Area

REFERENCE

Base Data - MNR LIO, obtained 2013
Produced by Golder Associates Ltd under licence from
Ontario Ministry of Natural Resources, © Queens Printer 2014
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 18N

PROJECT

PRELIMINARY GEOTECHNICAL INVESTIGATION
PRELIMINARY DESIGN FOR THE SIDNEY STREET CORRIDOR IMPROVEMENTS
BELL BOULEVARD TO TRACEY STREET
BELLEVILLE, ONTARIO

TITLE

KEY PLAN

Golder Associates
Whitby, Ontario

PROJECT NO. 1403140		
DESIGN	JT	17 Sep. 2014
GIS	JT	17 Sep. 2014
CHECK	AM	17 Sep. 2014
REVIEW	XW	13 Dec. 2015

SCALE AS SHOWN

REV. 0.0

FIGURE: 1

S:\Clients\CIMA\Sidney_Street_Belleville\99_PROJ\1403140_SidneyStreet_EA40_PROJ\0004_Geotechnical_Investigation\1403140-0004-BG-0001.mxd

25 12.5 0 25 50

SCALE 1:1,250 METRES

LEGEND

- ⯐ Approximate Borehole Location
- ⊕ Approximate Monitoring Well Location
- •—— Utility Line

REFERENCE

Base Data - MNR LIO, obtained 2013.
Base Imagery - ESRI, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo and the GIS User Community
Produced by Golder Associates Ltd under licence from Ontario Ministry of Natural Resources, © Queens Printer 2014
Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 18N

PROJECT
PRELIMINARY GEOTECHNICAL INVESTIGATION
PRELIMINARY DESIGN FOR THE SIDNEY STREET CORRIDOR IMPROVEMENTS
BELL BOULEVARD TO TRACEY STREET
BELLEVILLE, ONTARIO

TITLE

BOREHOLE/MONITORING WELL LOCATION PLAN

Golder Associates
Whitby, Ontario

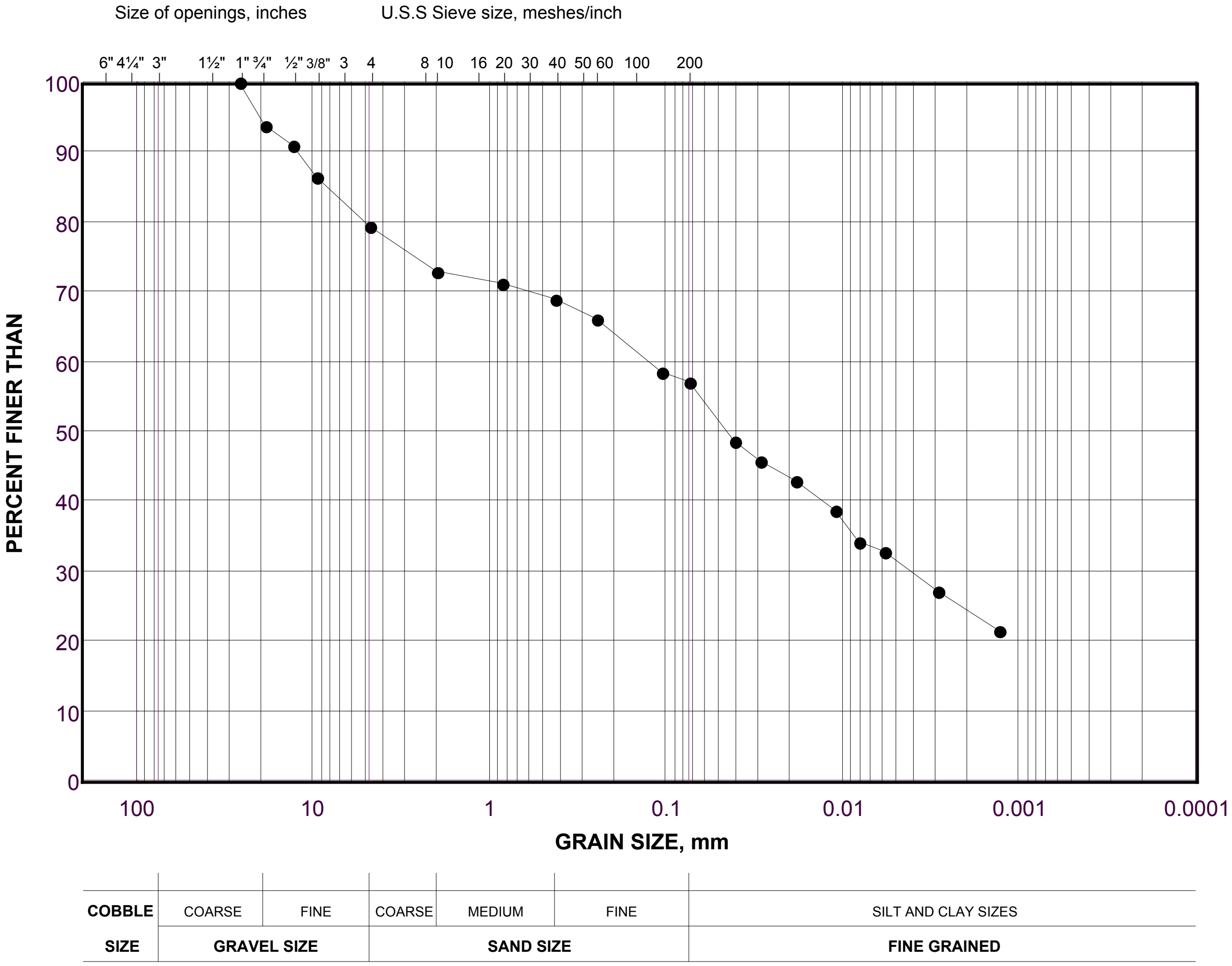
PROJECT NO. 1406140			SCALE AS SHOWN	REV. 0.0
DESIGN	JT	17 Sep. 2014	FIGURE: 2	
GIS	JT	17 Sep. 2014		
CHECK	AM	17 Sep. 2014		
REVIEW	XW	13 Dec. 2015		

S:\Clients\CIMA\Sidney_Street_Belleville\99_PROJ\1403140_SidneyStreet_EA\40_PROD\0004_Geotechnical_Investigation\1403140-0004-BG-0002.mxd

GRAIN SIZE DISTRIBUTION

(ML) CLAYEY SILT and SAND TILL

FIGURE 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	14-3	2	1.50 - 2.0

Project Number: 14-03140

Checked By: AM

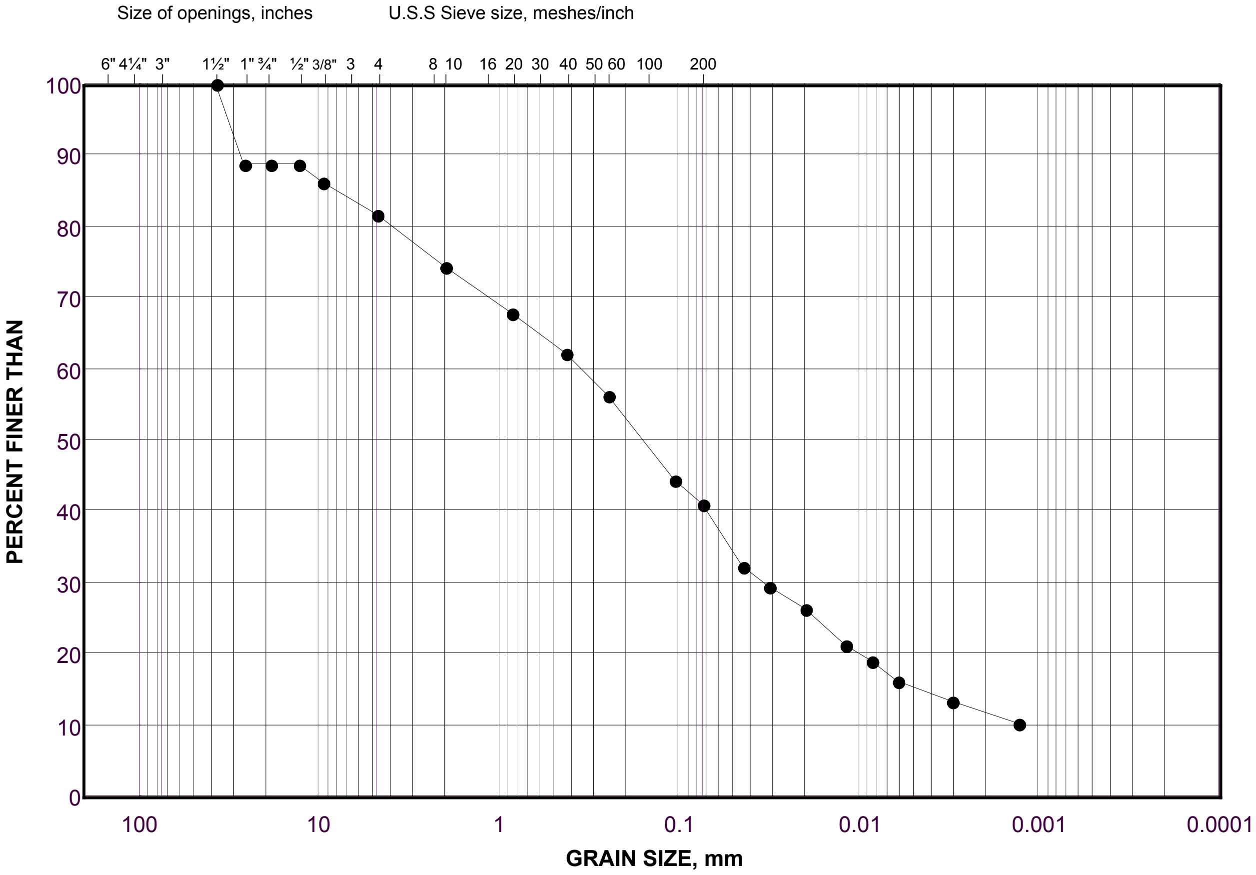
Golder Associates

Date: 22-Sep-14

GRAIN SIZE DISTRIBUTION

(SM) gravelly SILT and SAND TILL

FIGURE 4



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	14-6	3	2.30 - 2.70

Project Number: 14-03140

Checked By: AM

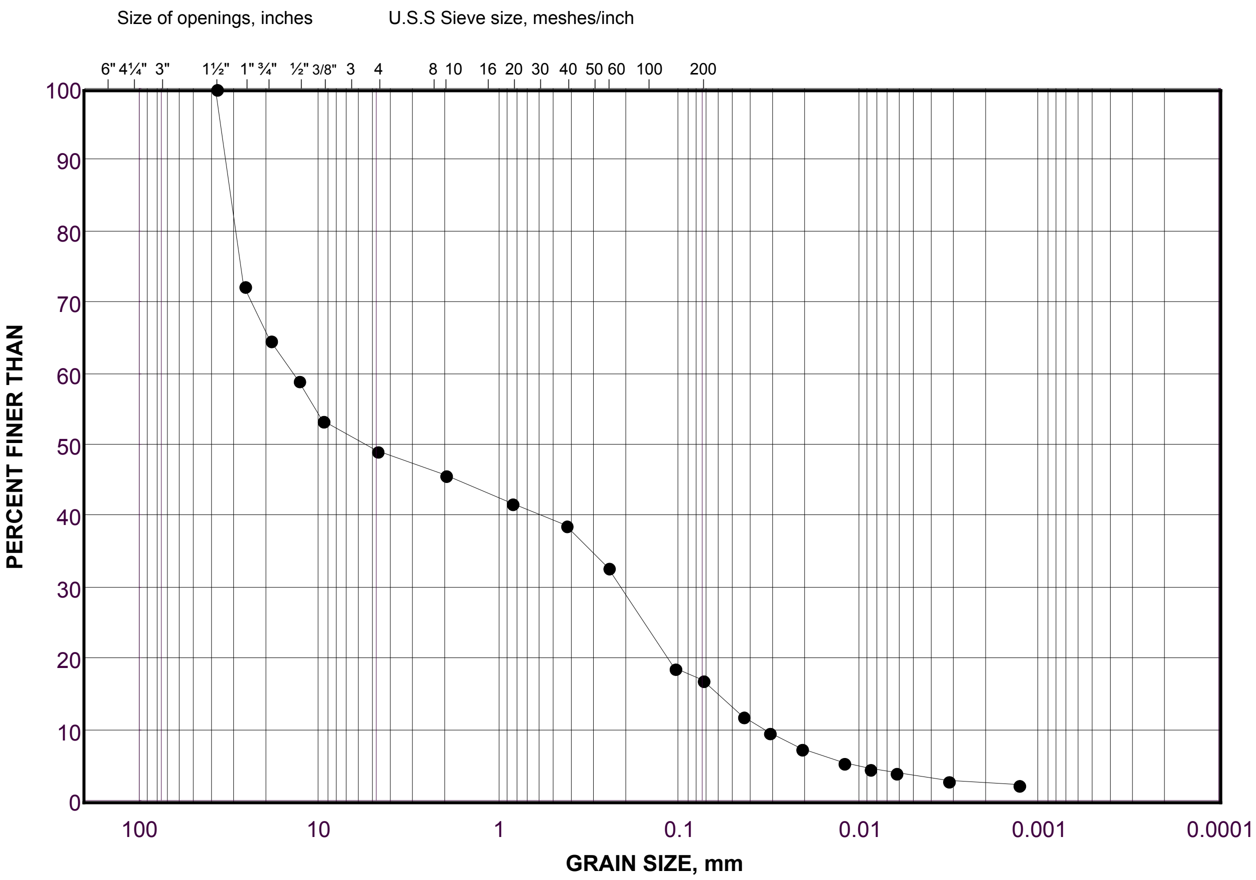
Golder Associates

Date: 22-Sep-14

GRAIN SIZE DISTRIBUTION

(GW) GRAVEL and SAND

FIGURE 5



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

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	14-9	4	3.10 - 3.50

Project Number: 14-03140

Checked By: AM

Golder Associates

Date: 22-Sep-14

APPENDIX A

Important Information and Limitations of This Report

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 can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

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

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

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

Soil, Rock and Groundwater 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.

APPENDIX B

Records of Boreholes BH14-1 to BH14-10

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-1

BORING DATE: August 12, 2014

SHEET 1 OF 1

DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ├──○W──┤ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.47							
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT	■	0.00 94.26							
		GRANULAR BASE	▨	0.21							
		GRANULAR SUBBASE	▨	0.34 93.93							
		(ML) CLAYEY SILT and SAND, some gravel; brown (TILL); cohesive, w<PL to w>PL, very stiff to hard		0.54							
1					1	SS	25		○		
					2	SS	35		○		
2				92.34							
		(GP) SANDY GRAVEL, coarse; brown; non-cohesive, wet, very dense		2.13 92.03	3	SS	50/ .08		○		
		END OF BOREHOLE DUE TO AUGER REFUSAL		2.44							1. Water encountered during drilling at a depth of 2.3 m below ground surface, Aug. 12/14 2. Borehole open and dry upon completion of drilling, Aug. 12/14
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JG

CHECKED:

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-2

SHEET 1 OF 1

BORING DATE: August 13, 2014

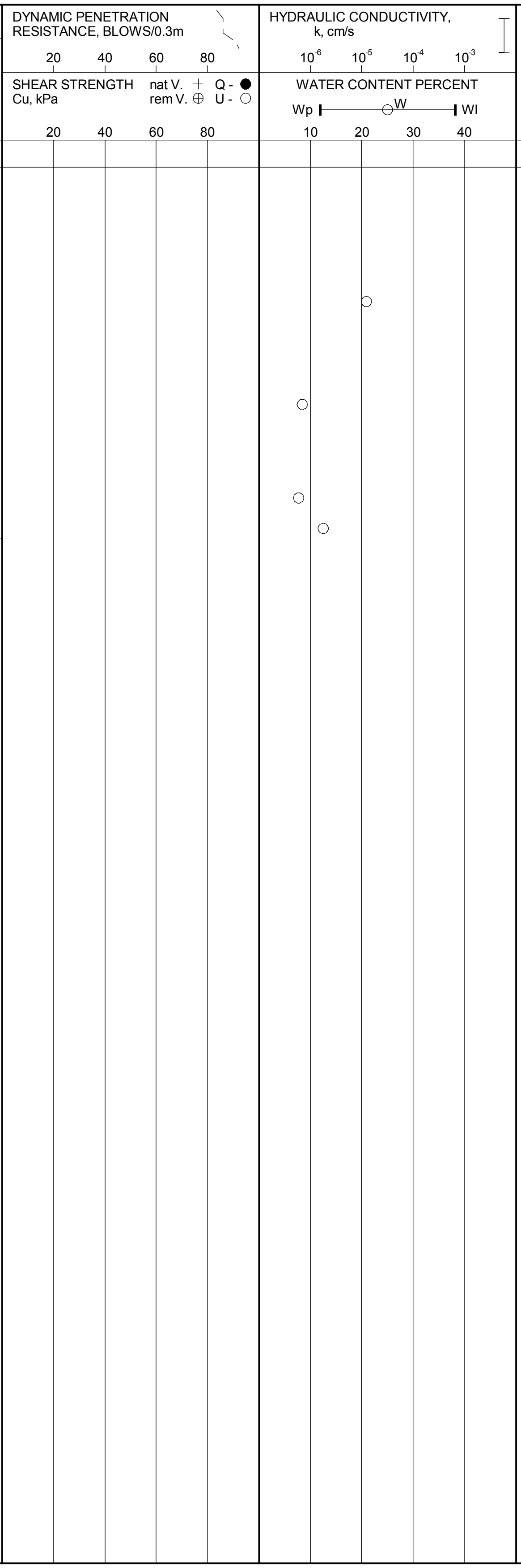
DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

BORING METHOD: TRACK MOUNTED CME 75, 150 mm Solid Stem Augers

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	94.41			
ASPHALT	0.00 94.23			
GRANULAR BASE	0.18			
GRANULAR SUBBASE	0.32 93.88			
FILL - (ML) CLAYEY SILT, some sand, trace gravel; mottled brown, grey, with organic inclusions; cohesive, w<PL, very stiff	0.53	1	SS	20
(ML) CLAYEY SILT and SAND, some gravel; brown (TILL); cohesive, w>PL, stiff to very stiff	93.04 1.37	2	SS	10
		3A		
(ML) SILT, some sand, some clay, very thinly bedded with clay; grey; non-cohesive, wet, compact	91.82 2.59	3B	SS	19
END OF BOREHOLE DUE TO AUGER REFUSAL	2.74			



PIEZOMETER OR STANDPIPE INSTALLATION

1. Water encountered during drilling at a depth of 2.6 m below ground surface, Aug. 13/14

2. Borehole open and dry upon completion of drilling, Aug. 13/14

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JG

CHECKED:

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-3

BORING DATE: August 13, 2014

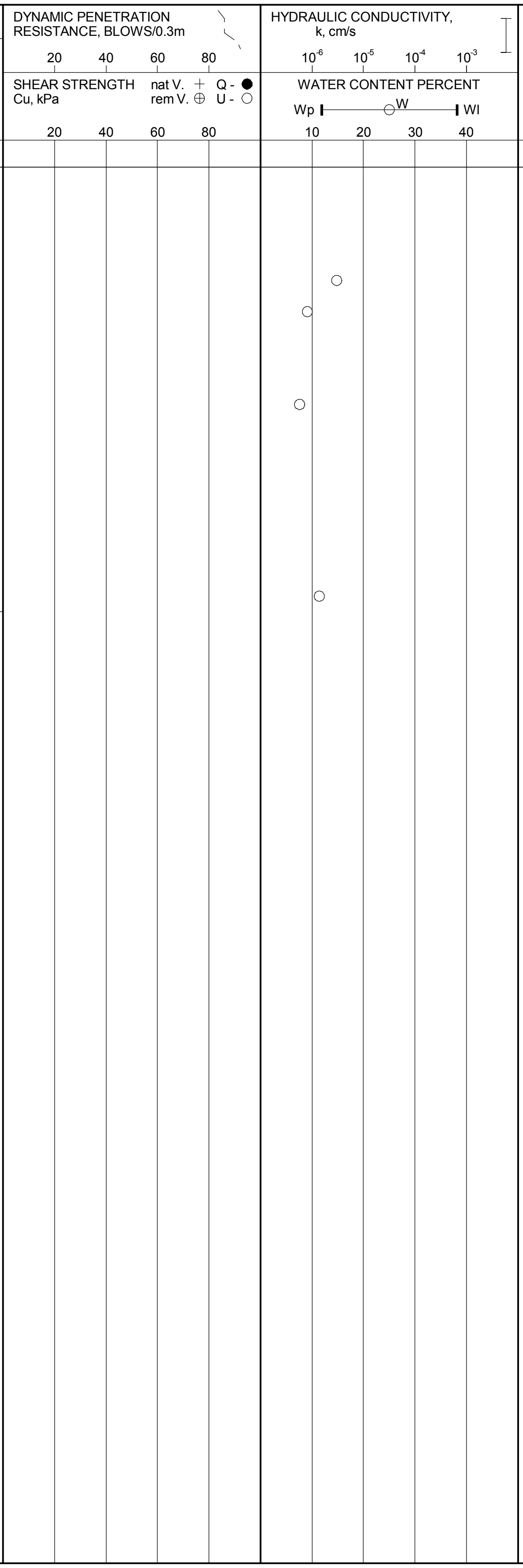
SHEET 1 OF 1

DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.72					
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT	■	0.00					
		GRANULAR BASE		0.15 94.37					
		GRANULAR SUBBASE		0.35					
		FILL - (ML) sandy CLAYEY SILT; mottled dark brown, grey, with organic inclusions; cohesive, w<PL, very stiff		0.52 93.81	1A	SS	18		
1		(ML) CLAYEY SILT and SAND, some gravel; brown to grey (TILL); cohesive, w>PL to w~PL, very stiff to stiff		0.91	1B				
					2	SS	9	MH	
2					3	SS	17		
				91.82					
3		(SW/GP) SAND and GRAVEL, some fines; grey; non-cohesive, wet, very dense		2.90 91.44	4	SS	50/ .08		
		END OF BOREHOLE DUE TO SPOON REFUSAL		3.28					1. Water level encountered during drilling at a depth of 2.1 m below ground surface, Aug. 13/14 2. Water level measured at a depth of 2.1 m below ground surface upon completion of drilling, Aug. 13/14
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

LOGGED: JG

CHECKED:

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-4

BORING DATE: August 13, 2014

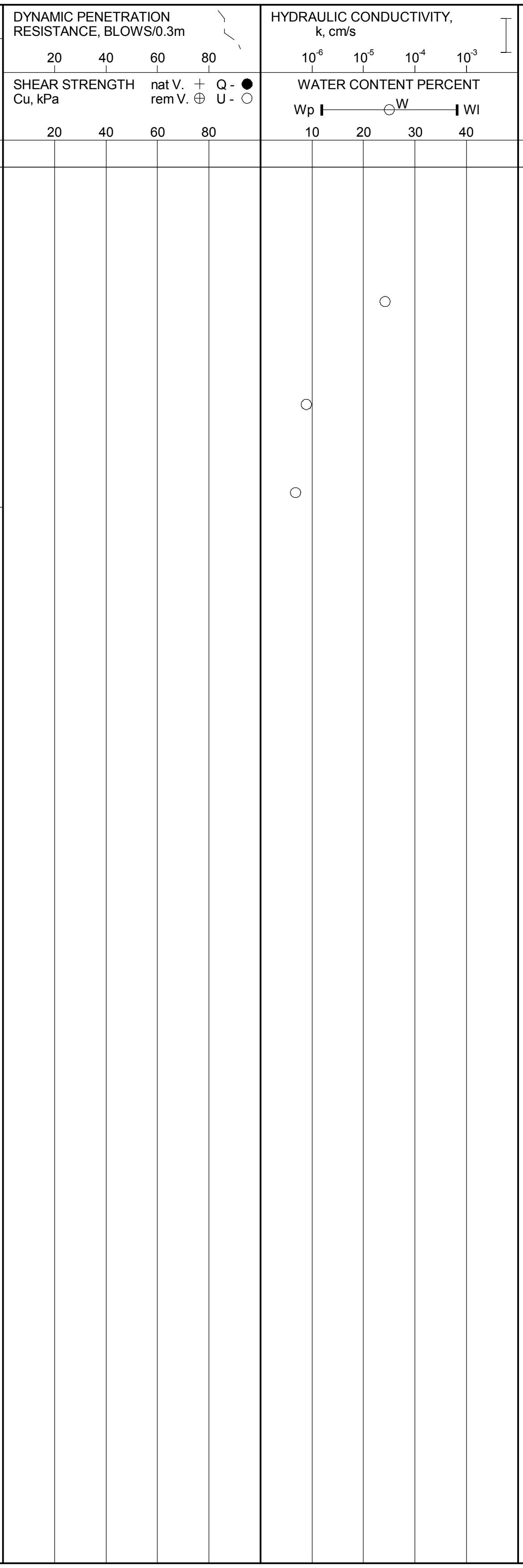
SHEET 1 OF 1

DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.00					
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT	■	0.00 93.82					
		GRANULAR BASE	▨	0.18					
		GRANULAR SUBBASE	▨	0.33 93.49					
1		FILL - ORGANIC CLAYEY SILT and PEAT, trace sand, trace gravel; dark brown to black, organically stained, w>PL	▨	0.51	1	SS	17		
		(ML) CLAYEY SILT and SAND, some gravel; pale brown (TILL); cohesive, w>PL, stiff		92.63 1.37	2	SS	11		
2		Becoming grey below a depth of approximately 2.1 m			3	SS	50/ .08		
		END OF BOREHOLE DUE TO AUGER REFUSAL		91.49 2.51					1. Borehole open and dry upon completion of drilling, Aug. 13/14
3									
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JG

CHECKED:

GTA-BHS 001 S:\CLIENTS\CIMA\SIDNEY_STREET_BELLEVILLE\02_DATA\GINT\1403140.GPJ GAL-MIS.GDT 1/8/15 MK Sept. 2014

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-5

SHEET 1 OF 1

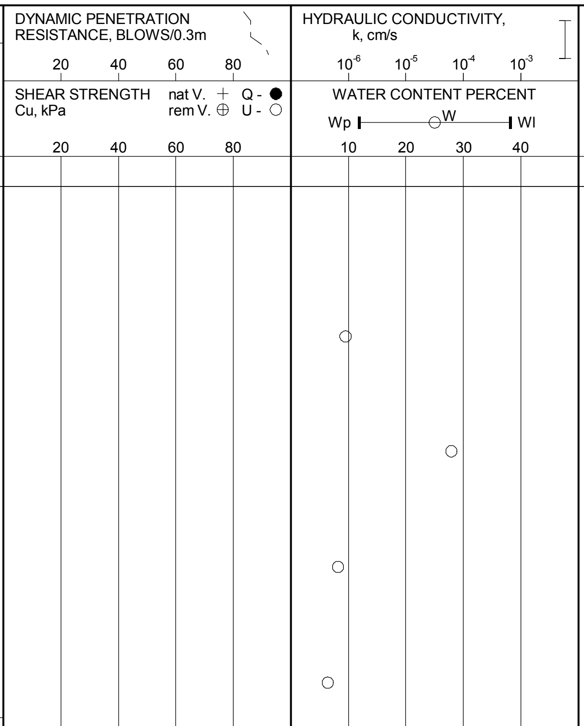
BORING DATE: August 13, 2014

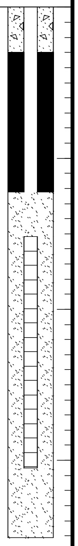
DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	93.67				
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT	0.00				Concrete
		GRANULAR BASE	0.15				
		GRANULAR SUBBASE	0.30				25 mm Piezometer
		FILL - (SM) SILTY SAND, with pockets of clay; brown; non-cohesive, moist, compact	93.18 0.49				Bentonite Seal
1				1	SS	22	
		FILL - (CL) sandy SILTY CLAY, trace gravel; grey; cohesive, w<PL, stiff	92.30 1.37	2	SS	12	
2		(ML) CLAYEY SILT and SAND, trace gravel; grey (TILL); cohesive, w<PL to w>PL, stiff to hard	91.54 2.13	3	SS	11	Silica Sand Filter
3				4	SS	43	
		END OF BOREHOLE	90.16 3.51				1. Borehole open and dry upon completion of drilling, Aug. 13/14 2. Water level measured in piezometer at a depth of 1.3 m below ground surface, Sept. 15/14





Depth scale: 4, 5, 6, 7, 8, 9, 10

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DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JG

CHECKED:

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-6

SHEET 1 OF 1

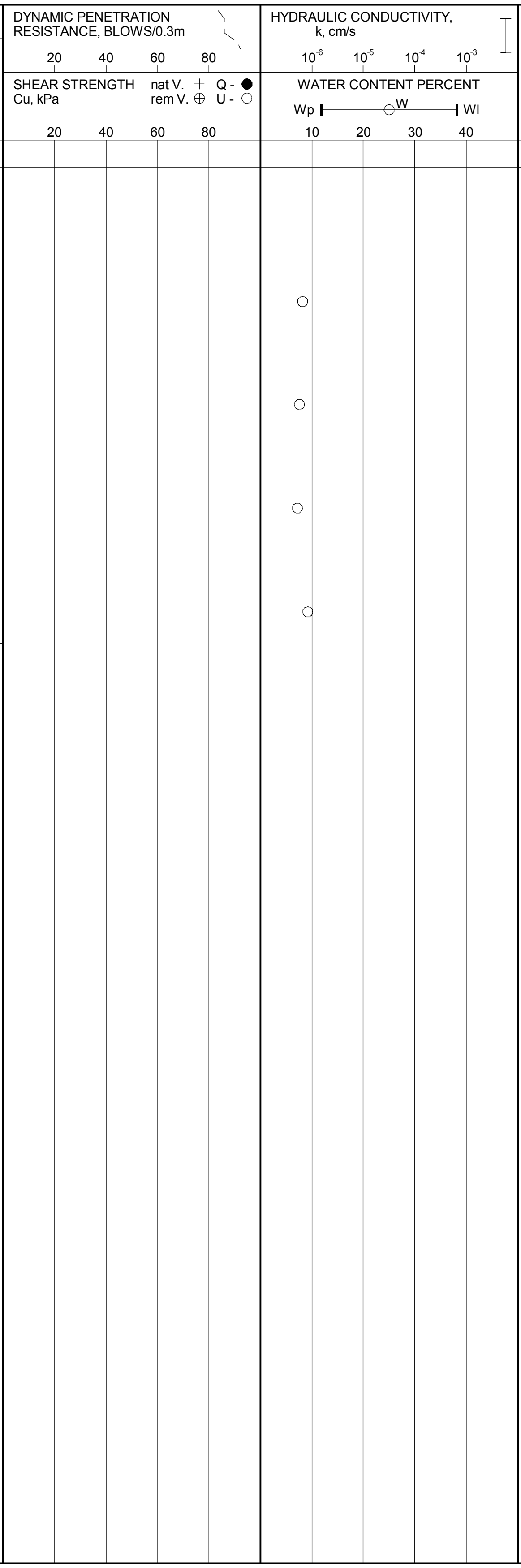
BORING DATE: August 13, 2014

DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		94.18					
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT		0.00					
		GRANULAR BASE		0.16					
		GRANULAR SUBBASE		0.32					
		(SM) gravelly SILTY SAND, some clay, isolated wet sand seams, zones of clayey silt till; brown (TILL); non-cohesive, moist, compact to dense		93.66 0.52					
1					1	SS	36		
2					2	SS	26		
					3	SS	18	MH	
3		Becoming grey below a depth of approximately 2.9 m							
					4	SS	13		
		END OF BOREHOLE		90.67 3.51					1. Water level measured at a depth of 3.5 m below ground surface upon completion of drilling, Aug. 13/14
4									
5									
6									
7									
8									
9									
10									



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DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JG

CHECKED:

PROJECT: 1403140
LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-7

BORING DATE: August 13, 2014

SHEET 1 OF 1
DATUM: Geodetic
HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}
WATER CONTENT PERCENT: Wp ⊢ ○W ⊣ Wl 10 20 30 40

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	93.68					
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT	0.00					
		GRANULAR BASE	0.16					
		GRANULAR SUBBASE	93.34 0.34					
1		FILL - (SM) SILTY SAND, some clay, some gravel; brown, with organic inclusions; non-cohesive, moist to wet, compact	0.51	1	SS	11		
		PROBABLY FILL - (SP) SAND, fine to medium, some silt, trace to some gravel; brown, with organic inclusions; non-cohesive, moist, loose to compact	92.31 1.37	2	SS	10		
2		(SM) gravelly SILTY SAND, some clay, trace gravel; light brown to grey (TILL); non-cohesive, moist, dense	91.55 2.13	3	SS	36		
3		(SW/GP) SAND and GRAVEL, some silt, fine to coarse; grey; non-cohesive, moist to wet, very dense	90.78 2.90	4	SS	55		
		END OF BOREHOLE	90.17 3.51					1. Water encountered during drilling at a depth of 3.4 m below ground surface, Aug. 13/14 2. Borehole open and dry upon completion of drilling, Aug. 13/14
4								
5								
6								
7								
8								
9								
10								

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DEPTH SCALE
1 : 50

Golder Associates

LOGGED: JG
CHECKED:

PROJECT: 1403140

RECORD OF BOREHOLE: 14-8

SHEET 1 OF 1

LOCATION: SEE FIGURE 2

BORING DATE: August 13, 2014

DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.19							
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT	■	0.00							
		GRANULAR BASE	▨	0.08							
		GRANULAR SUBBASE	▨	92.87 0.32							
		(SM) gravelly SILT and SAND, some clay to clayey, trace gravel; brown (TILL); non-cohesive, moist to wet, compact to very dense		92.68 0.51							
1					1	SS	60		○		
		Encountering boulder/cobble at a depth of approximately 1.2 m									
					2	SS	15		○		
2		Becoming grey below a depth of approximately 2.1 m									
					3	SS	36		○		
		END OF BOREHOLE DUE TO AUGER REFUSAL		90.45 2.74							
3											1. Borehole open and dry upon completion of drilling, Aug. 13/14
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JG

CHECKED:

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-9

BORING DATE: August 13, 2014

SHEET 1 OF 1

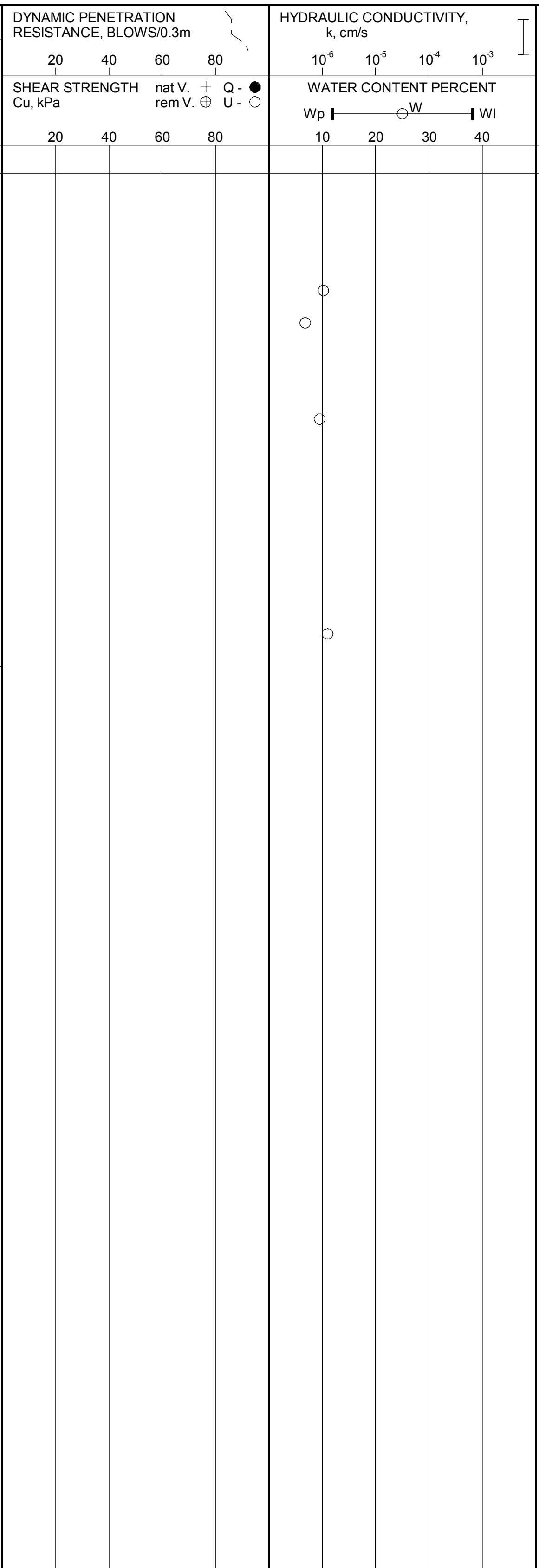
DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

BORING METHOD: TRACK MOUNTED CME 75
150 mm Solid Stem Augers

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
GROUND SURFACE	93.54				
ASPHALT	0.00 0.07				
GRANULAR BASE	93.20				
GRANULAR SUBBASE	0.34 93.02				
FILL - (ML) CLAYEY SILT, some sand, some gravel; mottled black, grey, brown; cohesive, w<PL, very stiff	0.52 92.44	1A 1B	SS	23	
PROBABLY FILL - (SM) SILTY SAND, some gravel; brown; non-cohesive, moist to wet, compact to very loose	1.10 91.41	2	SS	4	
(GW) GRAVEL and SAND; some silt; grey; non-cohesive, moist to wet, compact	2.13 90.03	3 4	SS SS	15 14	MH
END OF BOREHOLE	3.51				



PIEZOMETER OR STANDPIPE INSTALLATION

Concrete

Bentonite Seal

Silica Sand Filter

1. Water encountered during drilling at a depth of 1.8 m below ground surface, Aug. 13/14

2. Borehole open and dry upon completiong of drilling, August 13/14

3. Water level measured in piezometer measured at a depth of 3.2 m below ground surface, Sept. 15/14

DEPTH SCALE

1 : 50

LOGGED: JG

CHECKED:

PROJECT: 1403140

LOCATION: SEE FIGURE 2

RECORD OF BOREHOLE: 14-10

SHEET 1 OF 1

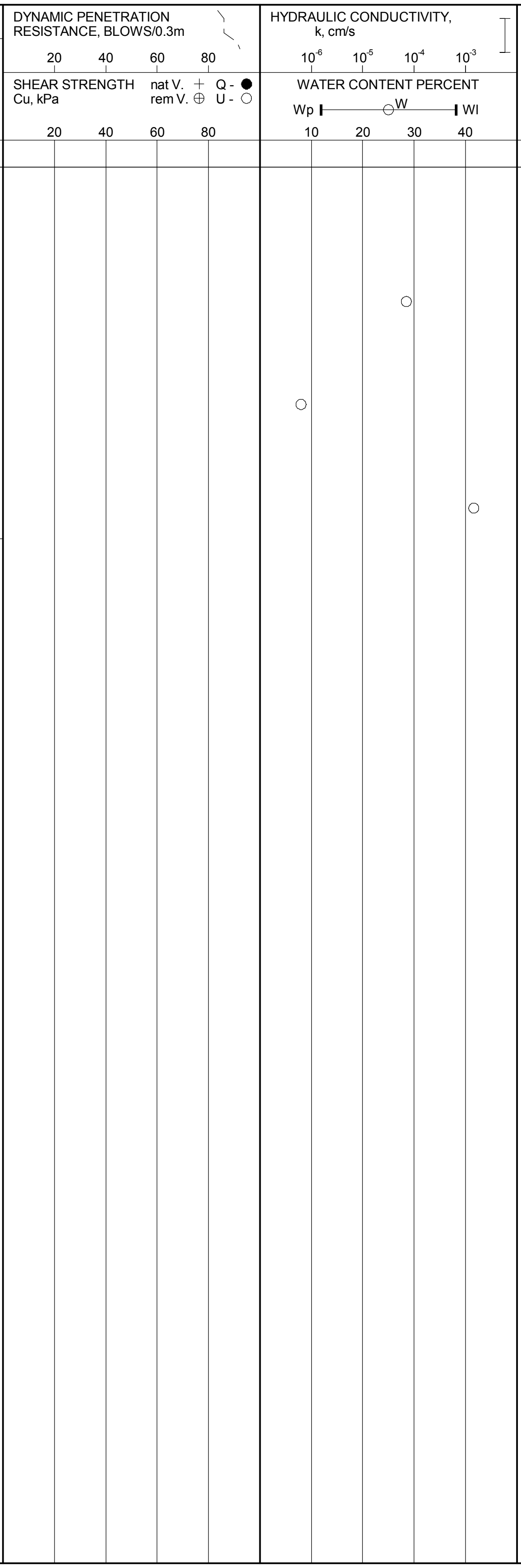
BORING DATE: August 13, 2014

DATUM: Geodetic

HAMMER TYPE: AUTOMATIC

SPT/DCPT HAMMER: MASS, 63kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		93.36					
0	TRACK MOUNTED CME 75 150 mm Solid Stem Augers	ASPHALT	■	0.00					
		GRANULAR BASE	▨	93.06 0.30					
		GRANULAR SUBBASE	▨	0.46					
1		FILL - (CL) SILTY CLAY, some sand; brown to dark brown, with organic inclusions; cohesive, w<PL, stiff	▨	92.72 0.64	1	SS	11		
2		(ML) CLAYEY SILT and SAND, some gravel; brown (TILL); cohesive, w>PL, very stiff to hard	▨	91.99 1.37	2	SS	16		
					3	SS	38		
3		END OF BOREHOLE DUE TO AUGER REFUSAL		90.62 2.74					1. Borehole opn and dry upon completion of drilling, Aug. 13/14
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: JG

CHECKED:

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APPENDIX C

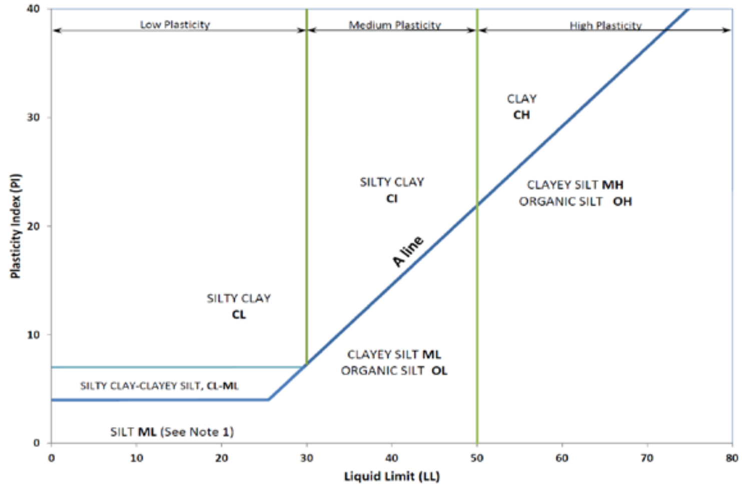
Method of Soil Classification and Symbols and Terms Used on Records of Boreholes and Test Pits

METHOD OF SOIL CLASSIFICATION

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

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

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

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

Notes:
1 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

APPENDIX D

Laboratory Certificates of Analysis

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

CLIENT NAME: GOLDER ASSOCIATES LTD.
100 SCOTIA COURT
WHITBY, ON L1N8Y6
(905) 723-2727

ATTENTION TO: Joel Gopaul

PROJECT: 1403140

AGAT WORK ORDER: 14T884785

SOIL ANALYSIS REVIEWED BY: Parvathi Malemath, Data Reviewer

DATE REPORTED: Sep 12, 2014

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 14T884785

PROJECT: 1403140

CLIENT NAME: GOLDER ASSOCIATES LTD.

SAMPLING SITE:

ATTENTION TO: Joel Gopaul

SAMPLED BY:Joel Gopaul

O. Reg. 153(511) - Metals & Inorganics (Soil)

DATE RECEIVED: 2014-09-05

DATE REPORTED: 2014-09-12

				SAMPLE DESCRIPTION:	14-2 SA1	14-5 SA2	14-9 SA1A
				SAMPLE TYPE:	Soil	Soil	Soil
				DATE SAMPLED:	8/13/2014	8/13/2014	8/13/2014
Parameter	Unit	G / S: A	G / S: B	RDL	5774696	5774702	5774703
Antimony	µg/g	1.3	40	0.8	<0.8[<A]	<0.8[<A]	<0.8[<A]
Arsenic	µg/g	18	18	1	<1[<A]	2[<A]	2[<A]
Barium	µg/g	220	670	2	152[<A]	182[<A]	73[<A]
Beryllium	µg/g	2.5	8	0.5	<0.5[<A]	0.6[<A]	<0.5[<A]
Boron	µg/g	36	120	5	8[<A]	9[<A]	9[<A]
Boron (Hot Water Soluble)	µg/g	NA	2	0.10	0.11[<B]	0.11[<B]	0.37[<B]
Cadmium	µg/g	1.2	1.9	0.5	<0.5[<A]	<0.5[<A]	<0.5[<A]
Chromium	µg/g	70	160	2	14[<A]	34[<A]	18[<A]
Cobalt	µg/g	21	80	0.5	4.1[<A]	10.8[<A]	6.1[<A]
Copper	µg/g	92	230	1	7[<A]	22[<A]	10[<A]
Lead	µg/g	120	120	1	5[<A]	7[<A]	7[<A]
Molybdenum	µg/g	2	40	0.5	<0.5[<A]	<0.5[<A]	<0.5[<A]
Nickel	µg/g	82	270	1	<1[<A]	17[<A]	8[<A]
Selenium	µg/g	1.5	5.5	0.4	<0.4[<A]	<0.4[<A]	<0.4[<A]
Silver	µg/g	0.5	40	0.2	<0.2[<A]	<0.2[<A]	<0.2[<A]
Thallium	µg/g	1	3.3	0.4	<0.4[<A]	<0.4[<A]	<0.4[<A]
Uranium	µg/g	2.5	33	0.5	<0.5[<A]	0.7[<A]	<0.5[<A]
Vanadium	µg/g	86	86	1	15[<A]	43[<A]	22[<A]
Zinc	µg/g	290	340	5	16[<A]	57[<A]	29[<A]
Chromium VI	µg/g	0.66	8	0.2	<0.2[<A]	<0.2[<A]	<0.2[<A]
Cyanide	µg/g	0.051	0.051	0.040	<0.040[<A]	<0.040[<A]	<0.040[<A]
Mercury	µg/g	0.27	3.9	0.10	<0.10[<A]	<0.10[<A]	<0.10[<A]
Electrical Conductivity (2:1)	mS/cm	0.57	1.4	0.005	0.544[<A]	0.418[<A]	0.921[A-B]
Sodium Adsorption Ratio (2:1)	NA	2.4	12	NA	5.73[A-B]	2.57[A-B]	16.5[>B]
pH, 2:1 CaCl2 Extraction	pH Units				7.72	7.59	7.92

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: A Refers to T1(ALL) - Current, B Refers to T2(ICC) - Current

5774696-5774703 EC & SAR were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

Certified By: Parvathi Malemath

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

Guideline Violation

AGAT WORK ORDER: 14T884785

PROJECT: 1403140

CLIENT NAME: GOLDER ASSOCIATES LTD.

ATTENTION TO: Joel Gopaul

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
5774696	14-2 SA1	T1(ALL) - Current	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1)	2.4	5.73
5774702	14-5 SA2	T1(ALL) - Current	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1)	2.4	2.57
5774703	14-9 SA1A	T1(ALL) - Current	O. Reg. 153(511) - Metals & Inorganics (Soil)	Electrical Conductivity (2:1)	0.57	0.921
5774703	14-9 SA1A	T1(ALL) - Current	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1)	2.4	16.5
5774703	14-9 SA1A	T2(ICC) - Current	O. Reg. 153(511) - Metals & Inorganics (Soil)	Sodium Adsorption Ratio (2:1)	12	16.5

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http://www.agatlabs.com

Quality Assurance

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 1403140
SAMPLING SITE:

AGAT WORK ORDER: 14T884785
ATTENTION TO: Joel Gopaul
SAMPLED BY:Joel Gopaul

Soil Analysis

RPT Date: Sep 12, 2014			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
O. Reg. 153(511) - Metals & Inorganics (Soil)															
Antimony	1	5774696	< 0.8	< 0.8	0.0%	< 0.8	74%	70%	130%	96%	80%	120%	103%	70%	130%
Arsenic	1	5774696	< 1	< 1	0.0%	< 1	105%	70%	130%	99%	80%	120%	102%	70%	130%
Barium	1	5774696	152	138	9.7%	< 2	104%	70%	130%	105%	80%	120%	110%	70%	130%
Beryllium	1	5774696	< 0.5	< 0.5	0.0%	< 0.5	95%	70%	130%	97%	80%	120%	84%	70%	130%
Boron	1	5774696	8	7	13.3%	< 5	70%	70%	130%	92%	80%	120%	80%	70%	130%
Boron (Hot Water Soluble)	5774696	5774696	0.11	0.11	0.0%	< 0.10	84%	60%	140%	106%	70%	130%	104%	60%	140%
Cadmium	1	5774696	< 0.5	< 0.5	0.0%	< 0.5	98%	70%	130%	116%	80%	120%	107%	70%	130%
Chromium	1	5774696	14	14	0.0%	< 2	84%	70%	130%	104%	80%	120%	103%	70%	130%
Cobalt	1	5774696	4.1	4.2	2.4%	< 0.5	98%	70%	130%	104%	80%	120%	101%	70%	130%
Copper	1	5774696	7	7	0.0%	< 1	104%	70%	130%	105%	80%	120%	102%	70%	130%
Lead	1	5774696	5	5	0.0%	< 1	98%	70%	130%	102%	80%	120%	96%	70%	130%
Molybdenum	1	5774696	< 0.5	< 0.5	0.0%	< 0.5	101%	70%	130%	102%	80%	120%	111%	70%	130%
Nickel	1	5774696	< 1	< 1	0.0%	< 1	87%	70%	130%	98%	80%	120%	98%	70%	130%
Selenium	1	5774696	< 0.4	< 0.4	0.0%	< 0.4	122%	70%	130%	84%	80%	120%	105%	70%	130%
Silver	1	5774696	< 0.2	< 0.2	0.0%	< 0.2	80%	70%	130%	103%	80%	120%	111%	70%	130%
Thallium	1	5774696	< 0.4	< 0.4	0.0%	< 0.4	86%	70%	130%	95%	80%	120%	95%	70%	130%
Uranium	1	5774696	< 0.5	< 0.5	0.0%	< 0.5	100%	70%	130%	99%	80%	120%	98%	70%	130%
Vanadium	1	5774696	15	16	6.5%	< 1	84%	70%	130%	105%	80%	120%	109%	70%	130%
Zinc	1	5774696	16	15	6.5%	< 5	101%	70%	130%	102%	80%	120%	102%	70%	130%
Chromium VI	5776089		< 0.2	< 0.2	0.0%	< 0.2	97%	70%	130%	97%	80%	120%	97%	70%	130%
Cyanide	5774696	5774696	< 0.040	< 0.040	0.0%	< 0.040	95%	70%	130%	103%	80%	120%	100%	70%	130%
Mercury	1	5774696	< 0.10	< 0.10	0.0%	< 0.10	106%	70%	130%	95%	80%	120%	104%	70%	130%
Electrical Conductivity (2:1)	5774696	5774696	0.544	0.554	1.8%	< 0.005	105%	90%	110%	NA			NA		
Sodium Adsorption Ratio (2:1)	5774696	5774696	5.73	5.64	1.6%	NA	NA			NA			NA		
pH, 2:1 CaCl2 Extraction	5774696	5774696	7.72	7.76	0.5%	NA	100%	80%	120%	NA			NA		

Comments: NA signifies Not Applicable.

Certified By: Parvathi Malemath

Method Summary

CLIENT NAME: GOLDER ASSOCIATES LTD.
PROJECT: 1403140
SAMPLING SITE:

AGAT WORK ORDER: 14T884785
ATTENTION TO: Joel Gopaul
SAMPLED BY:Joel Gopaul

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Antimony	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Barium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Boron (Hot Water Soluble)	MET-93-6104	EPA SW 846 6010C; MSA, Part 3, Ch.21	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Copper	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Lead	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Nickel	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Selenium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Silver	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Thallium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Uranium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Zinc	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Chromium VI	INOR-93-6029	SM 3500 B; MSA Part 3, Ch. 25	SPECTROPHOTOMETER
Cyanide	INOR-93-6052	MOE CN-3015 & E 3009 A;SM 4500 CN	TECHNICON AUTO ANALYZER
Mercury	MET-93-6103	EPA SW-846 3050B & 6020A	ICP-MS
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sodium Adsorption Ratio (2:1)	INOR-93-6007	McKeague 4.12 & 3.26 & EPA SW-846 6010B	ICP/OES
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER

AGAT Laboratories

5835 Coopers Avenue
Mississauga, ON
L4Z 1Y2
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Chain of Custody Record

Laboratory Use Only

Arrival Temperature: 14T884785
AGAT WO #:
Lab Temperature: 6.7/7.4/7.0
Notes:

Client Information

Company: Golder Associates
Contact: Joel Gopaul
Address: 100 Scotia Ct.
Whitby
Phone: 905-723-2727
Fax:
Project: 1403140
PO:
AGAT Quotation #:

Please note, if quotation number is not provided, client will be billed full price for analysis.

Regulatory Requirements

☑ **Regulation 153/04** *(reg. 511 Amend.)*
Table 1 *Indicate one*
☐ Ind/Com
☐ Res/Park
☐ Agriculture
Soil Texture *(check one)*
☐ Coarse ☐ Fine

☐ **Sewer Use**
Region *Indicate one*
☐ Sanitary
☐ Storm

☐ **Regulation 558**
☐ **CCME**
☐ **Other** *(specify)*
☐ **Prov. Water Quality Objectives (PWQO)**
☐ **None**

Turnaround Time Required (TAT) Required*

Regular TAT
☑ 5 to 7 Working Days

Rush TAT (please provide prior notification)
Rush Surcharges Apply
☐ 3 Working Days
☐ 2 Working Days
☐ 1 Working Day

OR

Date Required (Rush surcharges may apply):

**TAT is exclusive of weekends and statutory holidays*

Invoice To

Same: Yes ☑ No ☐
Company:
Contact:
Address:

Is this a drinking water sample?
(potable water intended for human consumption)
☐ Yes ☐ No
If "Yes", please use the *Drinking Water Chain of Custody Form*

Is this submission for a **Record of Site Condition?**
☐ Yes ☐ No

Legend Matrix

GW	Ground Water	**O**	Oil
SW	Surface Water	**P**	Paint
SD	Sediment	**S**	Soil

Report Information – reports to be sent to:

1. Name: Joel Gopaul
   Email: joel_gopaul@golder.com
2. Name:
   Email:

Sample Identification	Date Sampled	Time Sampled	Sample Matrix	# of Containers	Comments Site/Sample Information	Metals and Inorganics	Metal Scan	Hydride Forming Metals	Client Custom Metals	**ORPs:** ☐ B-HWS ☐ Cl- ☐ CN- ☐ EC ☐ FOC ☐ Cr+6- ☐ SAR ☐ NO_3/NO_2 ☐ N- Total ☐ Hg ☐ pH	**Nutrients:** ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3/NO_2	**VOC:** ☐ VOC ☐ THM ☐ BTEX	CCME Fractions 1 to 4	ABNs	PAHs	Chlorophenols	PCBs	Organochlorine Pesticides	TCLP Metals/Inorganics	Sewer Use									
14-2 SA1	Aug.13/14		S	1		✓																							
14-5 SA2						✓																							
14-9 SA1A	↓		↓	↓		✓																							

Samples Relinquished By (Print Name and Sign): Joel Gopaul Joel Gopaul	Date/Time Sep.5/14	Samples Received By (Print Name and Sign): Sharmin Sept 5/14	Date/Time 9:50	Pink Copy - Client Yellow Copy - AGAT White Copy- AGAT
Samples Relinquished By (Print Name and Sign):	Date/Time	Samples Received By (Print Name and Sign):	Date/Time	

Page 1 of 1

Nº: 48214

APPENDIX E

AASHTO Pavement Design Sheets

Table E1

AASHTO DESIGN OF PAVEMENT STRUCTURES

Improvement of Sidney Street from Bell Boulevard to Tracey Street, City of Belleville, Ontario

Pavement Design for Rehabilitation of Existing Sidney Street - Option 1 - Minimal Grade Raise

TRAFFIC ANALYSIS AND ESAL CALCULATION

Road Classification			***Urban Minor Arterial***		
Design Year			**2015**		
Design Period			**16**	Years	
Traffic Data Year			2014	2021	2031
Traffic Analysis Period				7	10
Average Annual Daily Traffic (AADT)			17,383	19,107	21,867
Average Rate of Increase in Traffic (%)				1.4	1.4
Truck Fraction of Total Traffic			2.5%	2.5%	2.5%
Average Rate of Increase in Truck Fraction (%)				0.0	0.0
Number of Lanes in One Direction			2	2	2
Directional Factor			0.5	0.5	0.5
Lane Distribution Factor			0.8	0.8	0.8
Daily Truck Volume			**176**	**191**	**219**
Truck Class	Proportion	Truck Factor	2014	2021	2031
Class 1	65%	0.5	57	62	71
Class 2	5%	2.3	20	22	25
Class 3	20%	1.9	67	73	83
Class 4	10%	5.5	97	105	120
	100%				
Total Daily ESALs in Design Lane			**241**	**262**	**300**
Number of Days of Truck Traffic			300	300	300
Total ESALs for Base Year			**72,416**	**78,530**	**89,873**
Year Span of Design Periods			*2015 to 2021*	*2021 to 2031*	
Average Rate of Increase in Truck Volume (%)			1.360	1.358	
Years of Design Periods			6	10	
Growth Factor			6.21	10.63	
			449,540	835,084	
Cumulative ESALs for the Design Period				1,284,624	

FLEXIBLE PAVEMENT STRUCTURAL DESIGN

Desired Initial Serviceability Index	4.4	
Terminal Seviceability Index	2.2	
Allowable Total Loss in Serviceability Index	2.2	
Reliability Level	85	%
Overall Standard Deviation	0.47	
Roadbed Soil Resilient Modulus	30,000	kPa
Calculated Design Structural Number	**102**	mm

LAYERED THICKNESS DESIGN - FATIGUE CHECK

Layer	Material Description	Struct Coef. (Aj)	Drain Coef. (Mi)	Elastic Modulus (kPa)	Thickness Di (mm)	Calculated SN (mm)
1	New HMA	0.42	1.0	2,750,000	**122**	51
2	New Granular A, Base	0.14	1.0	210,000	107	15
3	New Granular B, Type I	0.09	1.0	105,000	402	36
Total					**631**	**102**

RECOMMENDED PAVEMENT STRUCTURE

Layer	Material Description	Struct Coef. (Aj)	Drain Coef. (Mi)	Elastic Modulus	Thickness Di (mm)	Calculated SN (mm)
	Mill Existing Asphalt				120	
1	New HMA	0.42	1.0		**140**	59
2	Existing Asphalt	0.28	1.0		**50**	14
3	Existing Granular Base	0.12	0.9		**150**	16
4	Existing Granular Subbase	0.08	0.9		**190**	14
Total					**530**	**103**
				Grade Raise	20	

Note: The pavement design is based on the "*AASHTO Guide for Design of Pavement Structures 1993* ".

`

Designed by: ____________
Reviewed by: ____________

Table E2

AASHTO DESIGN OF PAVEMENT STRUCTURES

Improvement of Sidney Street from Bell Boulevard to Tracey Street, City of Belleville, Ontario

Pavement Design for Rehabilitation of Existing Sidney Street - Option 2 - No Grade Raise

TRAFFIC ANALYSIS AND ESAL CALCULATION

Road Classification			***Urban Minor Arterial***		
Design Year			**2015**		
Design Period			**16**	Years	
Traffic Data Year			*2014*	*2021*	*2031*
Traffic Analysis Period				7	10
Average Annual Daily Traffic (AADT)			17,383	19,107	21,867
Average Rate of Increase in Traffic (%)				1.4	1.4
Truck Fraction of Total Traffic			2.6%	2.6%	2.6%
Average Rate of Increase in Truck Fraction (%)				0.0	0.0
Number of Lanes in One Direction			2	2	2
Directional Factor			0.5	0.5	0.5
Lane Distribution Factor			0.8	0.8	0.8
Daily Truck Volume			**183**	**199**	**227**
Truck Class	Proportion	Truck Factor	2014	2021	2031
Class 1	65%	0.5	60	65	74
Class 2	5%	2.3	21	23	26
Class 3	20%	1.9	70	76	86
Class 4	10%	5.5	101	109	125
	100%				
Total Daily ESALs in Design Lane			**251**	**272**	**312**
Number of Days of Truck Traffic			300	300	300
Total ESALs for Base Year			**75,312**	**81,671**	**93,468**
Year Span of Design Periods			*2015 to 2021*	*2021 to 2031*	
Average Rate of Increase in Truck Volume (%)			1.360	1.358	
Years of Design Periods			6	10	
Growth Factor			6.21	10.63	
			467,522	868,487	
Cumulative ESALs for the Design Period				1,336,009	

FLEXIBLE PAVEMENT STRUCTURAL DESIGN

Desired Initial Serviceability Index	4.4	
Terminal Seviceability Index	2.2	
Allowable Total Loss in Serviceability Index	2.2	
Reliability Level	85	%
Overall Standard Deviation	0.47	
Roadbed Soil Resilient Modulus	30,000	kPa
Calculated Design Structural Number	**103**	mm

LAYERED THICKNESS DESIGN - FATIGUE CHECK

Layer	Material Description	Struct Coef. (Aj)	Drain Coef. (Mi)	Elastic Modulus (kPa)	Thickness Di (mm)	Calculated SN (mm)
1	New HMA	0.42	1.0	2,750,000	**123**	52
2	New Granular A, Base	0.14	1.0	210,000	107	15
3	New Granular B, Type I	0.09	1.0	105,000	405	36
Total					**635**	**103**

RECOMMENDED PAVEMENT STRUCTURE

Layer	Material Description	Struct Coef. (Aj)	Drain Coef. (Mi)	Elastic Modulus	Thickness Di (mm)	Calculated SN (mm)
	Removal				310	
1	New HMA	0.42	1.0		**160**	67
2	New Granular A	0.14	1.0		**150**	21
3	Existing Granular Base	0.12	0.9		**10**	1
4	Existing Granular Subbase	0.08	0.9		**190**	14
Total					**510**	**103**
				Grade Raise	0	

Note: The pavement design is based on the "*AASHTO Guide for Design of Pavement Structures 1993* ".
Traffic loadding was estimated based on Jerry Hajek's "Procedures for Estimating Traffic Loads for Pavement Design, 1995".

Designed by: __________
Reviewed by: __________

Table E3

AASHTO DESIGN OF PAVEMENT STRUCTURES

Improvement of Sidney Street from Bell Boulevard to Tracey Street, City of Belleville, Ontario

Pavement Design for Widening of Sidney Street

TRAFFIC ANALYSIS AND ESAL CALCULATION

Road Classification			***Urban Minor Arterial***		
Design Year			**2015**		
Design Period			**16**	Years	
Traffic Data Year			*2014*	*2021*	*2031*
Traffic Analysis Period				7	10
Average Annual Daily Traffic (AADT)			17,383	19,107	21,867
Average Rate of Increase in Traffic (%)				1.4	1.4
Truck Fraction of Total Traffic			2.6%	2.6%	2.6%
Average Rate of Increase in Truck Fraction (%)				0.0	0.0
Number of Lanes in One Direction			2	2	2
Directional Factor			0.5	0.5	0.5
Lane Distribution Factor			0.8	0.8	0.8
Daily Truck Volume			**183**	**199**	**227**
Truck Class	Proportion	Truck Factor	2014	2021	2031
Class 1	65%	0.5	60	65	74
Class 2	5%	2.3	21	23	26
Class 3	20%	1.9	70	76	86
Class 4	10%	5.5	101	109	125
	100%				
Total Daily ESALs in Design Lane			**251**	**272**	**312**
Number of Days of Truck Traffic			365	365	365
Total ESALs for Base Year			**91,630**	**99,367**	**113,720**
Year Span of Design Periods			*2015 to 2021*	*2021 to 2031*	
Average Rate of Increase in Truck Volume (%)			1.360	1.358	
Years of Design Periods			6	10	
Growth Factor			6.21	10.63	
			568,818	1,056,659	
Cumulative ESALs for the Design Period				1,625,477	

FLEXIBLE PAVEMENT STRUCTURAL DESIGN

Desired Initial Serviceability Index	4.4	
Terminal Seviceability Index	2.2	
Allowable Total Loss in Serviceability Index	2.2	
Reliability Level	85	%
Overall Standard Deviation	0.47	
Roadbed Soil Resilient Modulus	30,000	kPa
Calculated Design Structural Number	**106**	mm

LAYERED THICKNESS DESIGN - FATIGUE CHECK

Layer	Material Description	Struct Coef. (Aj)	Drain Coef. (Mi)	Elastic Modulus (kPa)	Thickness Di (mm)	Calculated SN (mm)
1	New HMA	0.42	1.0	2,750,000	**127**	53
2	New Granular A, Base	0.14	1.0	210,000	111	16
3	New Granular B, Type I	0.09	1.0	105,000	413	37
Total					**651**	**106**

RECOMMENDED PAVEMENT STRUCTURE

Layer	Material Description	Struct Coef. (Aj)	Drain Coef. (Mi)	Elastic Modulus	Thickness Di (mm)	Calculated SN (mm)
1	New HMA	0.42	1.0		**140**	59
2	New Granular A Base	0.14	1.0		**150**	21
3	New Granular B, Type I	0.09	1.0		**300**	27
Total					**590**	**107**

Note: The pavement design is based on the "*AASHTO Guide for Design of Pavement Structures 1993*".
Traffic loadding was estimated based on Jerry Hajek's "Procedures for Estimating Traffic Loads for Pavement Design, 1995".

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Designed by: ____________
Reviewed by: ____________

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