August 2017

GEOTECHNICAL EXPLORATIONS AND TESTING

Ninth Line (Regional Road 13) Transportation Corridor Improvements From Dundas Street (Regional Road 5) to 407 Express Toll Route Regional Municipality of Halton, Ontario

Submitted to:
Mr. Stephen Keen, Associate Partner
CIMA+
3027 Harvester Road, Suite 400
Burlington, Ontario
L7N 3G7

REPORT

Report Number: 1648031-4000-R01

Distribution:

1 E-Copy - CIMA+
1 E-Copy - Golder Associates Ltd.

Table of Contents

TABLES

FIGURES

1.0 INTRODUCTION

This report presents the results of the geotechnical explorations and testing carried out to support the design of the proposed widening of Ninth Line (Regional Road 13) from Dundas Street East to Highway 407 Express Toll Route in the Regional Municipality of Halton, Ontario. The existing bridges were not investigated as part of this assignment. The location of the subject section of Ninth Line is shown on the Key Plan, Figure 1.

The purpose of the work was to explore the subsurface soil and groundwater conditions at the site and to provide geotechnical engineering recommendations for the design of the widening. The work was carried out in general accordance with our proposal P1648031 dated January 11, 2016. Authorization to proceed with the work was provided by CIMA+.

Important information on the limitations of this report is attached.

2.0 FIELD PROCEDURES

Field work was carried out on June 6 and 7, 2017 during which time 27 boreholes were drilled at the approximate locations shown on the Location Plans, Figures 1 to 3. Boreholes were drilled using a truck-mounted drill rig supplied and operated by a specialist drilling subcontractor under the direction of a member of our engineering staff. The subsurface conditions encountered in the boreholes are detailed in Table I, attached, and summarized on Figure 4.

Representative samples of the major strata encountered were obtained during the drilling operations. All of the samples obtained were transported to our London laboratory for further examination and routine laboratory testing. The results of the laboratory testing are provided in Table I and on Figures 5 to 8.

Groundwater seepage conditions were noted in each borehole during drilling and these observations are included in Table I. A groundwater observation well was installed in BH-116 to permit future measurements of groundwater levels and in situ testing, if required, in association with the surface water component of the project. The well was provided with a flush-mount protective casing. Following drilling and well installation, the boreholes were backfilled in accordance with current regulations and the pavement surface restored, where required, using good quality cold mix asphalt.

The boreholes were located in the field by members of our engineering staff who also arranged for underground utility clearances, supervised the drilling, logged the boreholes and cared for the samples. Temporary traffic control during the work was provided by a specialist traffic control subcontractor.

3.0 SUBSURFACE CONDITIONS

The subsurface conditions encountered in the boreholes drilled at the site are detailed in Table I and summarized on Figure 4. The following discussion has been simplified in terms of major strata for the purposes of geotechnical design. The soil boundaries have been inferred from non-continuous samples and observations of drilling resistance. They may represent a transition from one soil type to another and should not necessarily be interpreted to represent exact planes of geological change. Further, the subsurface conditions will vary between and beyond the borehole locations.

3.1 Pavement and Soil Conditions

In general, the boreholes generally encountered the existing pavement structure overlying silty clay. Buried topsoil was encountered in six boreholes.

3.1.1 Pavement Structure

Conventional flexible pavements were encountered in most of the boreholes drilled through the existing Ninth Line pavements. The boreholes drilled through the existing flexible pavements encountered the following:

Component	Thickness (mm)			No. of Occurrences
	Minimum	Maximum	Average	
Asphalt	120	180	150	11
Granular Base	140	410	250	11
Granular Subbase	200	810	425	10

Three of the boreholes (BH-123, BH-124 and BH-127), which were drilled through the existing Ninth Line pavements within one kilometre of Dundas Street, encountered composite pavements. These boreholes encountered:

Component	Thickness (mm)			No. of Occurrences
	Minimum	Maximum	Average	
Asphalt	120	150	140	3
Concrete	150	270	210	3
Granular Base or Subbase	260	290	275	3

The boreholes drilled in the shoulders generally encountered granular materials at the shoulder surface. However, paved shoulders are present north of the 407 ETR East to Highway 403 South bridge structure. The granular shoulders consisted of about 350 millimetres to 1.3 metres of sand and gravel to silty sand and gravel with an average thickness of about 680 millimetres. The paved shoulders consisted of about 100 to 170 millimetres of asphalt, 200 to 220 millimetres of granular base and 370 to 400 millimetres of granular subbase.

Grain size distribution curves for samples of the granular base and subbase recovered during the investigation are provided on Figures 5 and 6.

3.1.2 Fill and Buried Topsoil

Layers of silty clay fill were encountered beneath the pavement structure in seven boreholes. The silty clay fill layers were about 150 to 580 millimetres thick at the borehole locations with an average of about 300 millimetres. The fill was noted to contain varying amounts of topsoil.

Layers of buried topsoil were encountered in six boreholes. The depths at which the topsoil was encountered and the topsoil thicknesses are summarized in the table below:

Borehole	Depth to Buried Topsoil (m)	Thickness of Buried Topsoil (mm)
BH-109	1.2	250
BH-110	1.3	200
BH-114	0.8	1,200
BH-116	0.6	310
BH-120	0.9	180
BH-121	1.0	120

Samples of the buried topsoil recovered during the field work had water contents of about 14 and 23 per cent.

3.1.3 Silty Clay

Beneath the pavement structure, fill and/or buried topsoil, all of the boreholes encountered silty clay. All but three of the boreholes were terminated in the silty clay. At some locations, cobbles were noted in the silty clay and the presence of boulders should be expected. Samples of the silty clay recovered during the field work had water contents ranging from about 14 to 21 per cent with an average water content of about 17 per cent. The silty clay had average plastic and liquid limits of about 17 and 31 per cent, respectively, based on three Atterberg limits determinations.

A grain size distribution curve for a sample of the silty clay is shown on Figure 7.

3.1.4 Silty Sand and Sandy Silt

Layers of silty sand and sandy silt were encountered beneath the silty clay in BH-111, BH-116 and BH-122. BH-116 encountered a layer of sandy silt about 2.5 metre thick beneath the silty clay and was then terminated in sandy silt after exploring it for about 0.9 metres. In BH-111 and BH-122, the sandy silt layers were about 0.9 and 1.0 metres thick, respectively. Samples of the silty sand and sandy silt had water contents of about 13 to 20 per cent.

Grain size distribution curves for samples of the sandy silt and silty sand are provided on Figure 8.

3.1.5 Bedrock

BH-117 encountered bedrock beneath the sandy silt. The bedrock was identified in the field as Queenston Formation shale. The bedrock was explored for about 0.5 metres prior to terminating the borehole. Borehole BH-122 was terminated at 3.5 metres depth due to practical refusal to augering, possibly on bedrock.

3.2 Groundwater Conditions

All but three of the boreholes remained dry during drilling on June 6 and 7, 2017. In BH-111, seepage was noted from the granular subbase at about 0.6 metres depth likely representing water perched on the underlying low permeability silty clay. In BH-112, the subbase was noted to be wet. Wet conditions were noted at about 5.2 metres depth in BH-116 near the sandy silt/silty sand interface. An observation well was installed in BH-116 following drilling. Groundwater and seepage levels should be expected to fluctuate seasonally and in response to significant precipitation events.

4.0 PAVEMENT CONDITIONS

During borehole layout and the field work, the condition of the existing pavements was visually assessed. In general, the pavements in this section of Ninth Line are considered to be in good condition. The relevant observations regarding the pavement conditions are summarized below:

North of Dundas Street to South of Burnhamthorpe Road

- Good condition;
- Single and multiple longitudinal centreline cracks generally throughout;
- Extensive slight single and multiple transverse cracks;
- Frequent to extensive very slight to slight longitudinal midlane and/or wheel path cracks;
- Single and multiple very slight to slight pavement edge cracks throughout; and
- Extensive slight to moderate flushing.

Adjacent to Burnhamthorpe Road

- Fair to poor condition;
- Several asphalt patches; and
- Moderate to severe alligatored transverse and longitudinal cracks.

North of Burnhamthorpe Road

- Good condition; and
- Single and multiple longitudinal centreline cracks generally throughout.

5.0 DISCUSSION

This section of the report provides recommendations based on our interpretation of the factual information obtained during the geotechnical explorations and testing and is intended for the guidance of the design engineer. Where comments are made on construction, they are provided only to highlight those aspects which could affect the design of the project. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

Based on the information provided to Golder, it is understood that the subject section of Ninth Line, from Dundas Street northerly to the 407 ETR, will be widened from two to four lanes, generally symmetrically about the existing pavement centreline, with an urban cross-section incorporating curbs and gutters. The area of the William Halton Parkway roundabout, which extends about 260 metres north and 285 metres south of the centre of the roundabout on Ninth Line, is not included within this project.

5.1 Pavement Design

5.1.1 Traffic Volumes

The traffic data provided by CIMA+ for Ninth Line are summarized below:

Location	AADT		% Heavy Vehicles
	Existing	2031	
South of Burnhamthorpe Road	15,040	22,295	10
North of Burnhamthorpe Road	16,580	17,410	6

5.1.2 Traffic Analysis and Pavement Design

The traffic volumes in terms of equivalent single axle loads (ESALs) for a twenty year service life (typical initial service life for flexible pavements) were calculated for the two sections of Ninth Line based on the traffic data. A truck factor of 1.6 was used to represent the heavy vehicle fraction of the traffic and a design lane distribution factor of 0.9 was used (which assumes 90 per cent of the heavy vehicles remain in the design lane).

Using the above information, the following cumulative twenty year traffic loadings were calculated:

- South of Burnhamthorpe Road – 11.4 million
- North of Burnhamthorpe Road – 6.7 million

The new pavement sections were developed using the American Association of State Highway and Transportation Officials (AASHTO) design method. The various model inputs used are:

- A reliability factor of 95 per cent;
- A subgrade resilient modulus of 35 megapascals (MPa); and
- Initial Serviceability and Terminal Serviceability Indices of 4.5 and 2.5.

Utilizing the above information, the following pavement structures were developed:

Component	Thickness (mm)	
	South of Burnhamthorpe Road	North of Burnhamthorpe Road
Asphalt	170	170
Granular A Base	150	150
Granular B Subbase	550	450

These pavement sections were also checked using empirical methods developed by Golder. The empirical methods indicate that the empirical designs summarized below are generally consistent with the pavement structures generated using the AASHTO method.

Component	Thickness (mm)	
	South of Burnhamthorpe Road	North of Burnhamthorpe Road
Asphalt	160	140
Granular A Base	150	150
Granular B Subbase	600	500

5.1.3 Recommended Pavement Structures

Based on our review of the field information and our analyses, the new pavements on the subject section of Ninth Line should consist of the following material thicknesses constructed on a properly prepared and shaped native silty clay subgrade:

Component	Thickness (mm)	
	South of Burnhamthorpe Road	North of Burnhamthorpe Road
HL1 Surface Asphalt	50	50
HL8 Binder Asphalt	120 (2@60)	120 (2@60)
Granular A Base	150	150
Granular B Type III Subbase	550	450

The above-noted pavement components should conform to Ontario Provincial Standard Specifications (OPSS) requirements.

5.1.4 Reuse of Existing Pavement Structure

As summarized above, the typical existing pavement structure on Ninth Line consists of about 150 millimetres of asphalt, 250 millimetres of granular base and 425 millimetres of granular subbase. The granular base equivalency (GBE) concept was used to assess the capacity of the existing pavement. The existing pavement has an average GBE of 723 millimetres. In comparison, the pavements required for nominal 20 year service lives have GBEs of

859 millimetres and 790 millimetres for the sections south and north of Burnhamthorpe Road, respectively, indicating deficiencies of about 136 and 67 millimetres of Granular A (or 70 and 35 millimetres of asphalt).

Based on the above information, two alternatives are considered appropriate should there be a desire to utilize the existing pavements:

i) If grade raises of 70 millimetres south of Burnhamthorpe Road and 35 millimetres to the north can be accommodated, additional asphalt can be used to increase the structural capacity of the pavements. However, this would require corresponding increases in the asphalt thickness in the widened areas for consistency and constructability purposes;

ii) If grade raises cannot be tolerated, milling and overlaying of the existing pavements could be considered provided that a somewhat reduced service life of the new inside lanes can be tolerated.

It should be clearly noted that reuse of the existing pavements will not address the presence of buried topsoil beneath the existing lanes. Based on our assessment of the existing pavements, the buried topsoil does not appear to currently be problematic; however, this should not be construed that it will not be problematic in the future.

Should the above-noted items not meet the requirements of the Region, it is suggested that the existing pavements be reconstructed using the pavement structures outlined in Section 5.1.3. In addition, in areas of grade change, the pavements will require reconstruction.

5.1.5 Construction Considerations

If the pavement are to be used, excavation to subgrade level for the widenings should be constructed by means of a vertical cut along the existing edge of pavement. Otherwise, the existing pavements should be removed and excavated to the new subgrade level. Following excavation to subgrade level and stripping of any unsuitable fill and buried topsoil, the new subgrade should be appropriately shaped, graded and heavily proofrolled under the direction of the geotechnical engineer. Any poorly performing areas identified during proofrolling should be further subexcavated and reinstated with approved earth fill or OPSS Granular B. Any fill required to address existing ditches should consist of compacted silty clay borrow.

The new pavement granulars should be placed in maximum 300 millimetre thick lifts and compacted to 100 per cent of standard Proctor maximum dry density. The granular materials should be hydraulically connected to continuous, filtered subdrains 100 millimetres in diameter that outlet by gravity to the storm sewer system or by daylighting them to open ditches with inverts at least 0.5 metres below subgrade level.

The new asphalt should be produced, placed and compacted in accordance with the current Ontario Provincial Standard Specifications. Where new construction abuts existing pavements, a 500 millimetre wide by 40 millimetre deep notch should be provided to create a staggered joint. Care will be required to properly tack coat all butt joints and milled surfaces.

5.2 Culverts

It is understood that new culverts will be installed in conjunction with this project. The culverts locations and preliminary details are:

- Station 1+355 – new 1200 millimetre CSP (replacing existing 750 millimetre CSP)
- Station 1+725 – new 1200 millimetre CSP (replacing existing 700 millimetre CSP)
- Station 2+265 – new 1050 millimetre CSP (replacing existing 400 millimetre CSP)
- Station 2+580 – new 900 millimetre box culvert
- Station 2+780 – new 4000 by 1000 millimetre box culvert
- Station 2+985 – new 2000 by 1500 millimetre box culvert (replacing existing 1200 millimetre CSP)
- Station 3+275 – new 3000 by 1200 millimetre box culvert (replacing existing 1900 by 1300 millimetre box)

During detailed design, location-specific boreholes should be drilled to confirm the founding conditions and groundwater seepage conditions. In the interim, the following recommendations are provided to facilitate the preliminary design of the new culverts to support the EA process.

5.2.1 Foundation Design

It is expected that the new box culverts will be founded in the native silty clay or sandy silt. For box culverts founded on the native materials, a factored geotechnical resistance at Ultimate Limit States (ULS) of 150 kilopascals (kPa) and a geotechnical reaction at Serviceability Limit States (SLS) of 100 kPa can be used for preliminary design. The SLS value corresponds to 25 millimetres of settlement. Prior to pouring concrete or placement of a granular levelling course, all topsoil, fill, organic, deleterious and/or excessively soft or loose materials should be removed from the founding surfaces. If the concrete or levelling pad cannot be placed promptly following excavation and inspection, a 75 millimetre thick working mat of lean concrete should be provided over the founding soils to protect them from disturbance.

5.2.2 Excavations and Groundwater Control

Excavations for the culverts (both box culverts and CSPs) are expected to encounter the existing pavement structure, layers of silty clay fill, buried topsoil and fill associated with the existing culvert backfill and extend into the silty clay and, potentially, the sandy silt. Cobbles and boulders should be expected in the silty clay and sandy silt. Based on the current Occupational Health and Safety Act and Regulations for Construction Projects (Act and Regulations) criteria, the existing fill and buried topsoil would be classified as Type 3 soils where these are above the groundwater levels. The silty clay and sandy silt would be classified as Type 2 soils where these are above the groundwater levels.

All excavations should be carried out in accordance with the current Act and Regulations criteria. Temporary excavation side slopes should be maintained no steeper than 1 horizontal to 1 vertical. Flatter side slopes and/or blanketing of the slopes with free draining material may be necessary in areas with saturated or loose granular fill to enhance stability.

The excavations are expected to be terminated above the inferred groundwater level. However, depending on precipitation and localized drainage conditions, saturated conditions and seepage may be encountered at the interface of any granular fill or native granular soils and the underlying native silty clay soils. It is anticipated that groundwater seepage into the open excavation can be addressed using properly constructed and filtered sumps in the base of the excavation. Depending on the timing of construction, seasonal variations potentially resulting in groundwater levels higher than those encountered during the investigation should be expected. Care should be taken to direct all surface water away from open excavations.

It is also expected that the flows in the existing watercourses will be appropriately redirected.

5.2.3 Backfilling

Backfill for the culverts should consist of free-draining, non-frost susceptible granular materials such as OPSS Granular B, Type III or Granular A placed in maximum 300 millimetre thick loose lifts and uniformly compacted to 98 per cent of standard Proctor maximum dry density. Heavy compaction equipment should not be used immediately adjacent to the walls and roof of the box culverts. The height of backfill adjacent to the box culvert walls should be maintained as equal as possible on both sides of the culvert during all stages of backfill placement. The height of the backfill on each side of the culvert should differ by no more than 500 millimetres at any time. For the new CSPs, a uniform degree of compaction around the culvert is considered critical to reduce the risk of local buckling.

The excavations for the culverts should exceed the width of the culvert by at least 1.0 metre on each side to allow for good workmanship and effective compaction of the fill.

The lateral pressures acting on the box culverts can be estimated using a coefficient of lateral earth pressure of 0.5 and a bulk unit weight of 2.2 megagrams per cubic metres based on Granular B Type III or Granular A backfill.

5.2.4 Other Design Considerations

Given the founding conditions, camber of the culverts is not expected to be required. Erosion protection for the culvert backfill should be provided to protect the roadway, embankment and culvert, as appropriate. Erosion protection should also be provided at the inlets and outlets. Consideration could be given to using suitable non-woven geotextile and rip rap, as required, to provide erosion protection based on hydraulic requirements. Temporary erosion protection and sediment control measures should be provided. In addition, sediment control such as silt fences and erosion control blankets may be required during construction together with diversion of any flows to mitigate migration of fine soil particles.

Once the details of the culverts have been finalized, the need for inlet seals and outlet filters can be assessed.

5.3 Retained Soil System Walls

It is understood that retained soil system (RSS) walls may be constructed in the area of the wetlands, generally between about Station 2+500 and 2+750. RSS wall systems generally use an interlocking block system and geogrid or metallic strip reinforcement embedded in the granular wall backfill. The RSS wall backfill and reinforcing usually extends back from the block facing a distance of roughly 0.6 to 0.7 times the wall height. RSS walls are proprietary systems which are designed by the supplier and constructed in accordance with their specifications. The internal stability of these walls should be checked by the RSS supplier/designer. The geotechnical aspects of the global stability of detailed wall design should be reviewed by the geotechnical engineer prior to bedding and construction once retaining wall locations and heights are fully defined.

The RSS walls may be designed such that the facing blocks are constructed on a levelling pad of Granular A at least 300 millimetres thick. Depending on the design selected by the RSS wall designer, it may not be necessary to provide frost cover, but the foundations should have sufficient embedment for stability. It is critical that effective drainage of the retained backfill be provided.

It is anticipated that RSS walls will be founded on the native silty clay or sandy silt. RSS walls founded on the native materials may, for preliminary consideration, be designed using a factored geotechnical resistance at Ultimate Limit States (ULS) of 225 kPa and a geotechnical reaction at Serviceability Limit States (SLS) of 150 kPa. The SLS value corresponds to 25 millimetres of settlement. Prior to placement of the granular levelling pad and the general wall backfill, all topsoil, fill, organic, deleterious and/or excessively soft or loose materials should be removed from the founding surfaces. Once the founding elevations and locations of the RSS walls have been determined, a structure specific geotechnical investigation should be carried out to support the detailed design and evaluation of global stability.

Excavations for RSS walls are expected to encounter the existing pavement structure, layers of silty clay fill and buried topsoil and extended into the silty clay and, potentially, the sandy silt. Cobbles and boulders should be expected in the silty clay and sandy silt. Based on the current Occupational Health and Safety Act and Regulations for Construction Projects (Act and Regulations) criteria, the existing fill and buried topsoil would be classified as Type 3 soils. The silty clay and sandy silt would be classified as Type 2 soils.

All excavations should be carried out in accordance with the current Act and Regulations criteria. Temporary excavation side slopes should be maintained no steeper than 1 horizontal to 1 vertical. Flatter side slopes and/or blanketing of the slopes with free draining material may be necessary in areas with saturated or loose granular fill to enhance stability. However, depending on precipitation and localized drainage conditions, saturated conditions and seepage may be encountered at the interface of any granular fill or native granular soils and the underlying native silty clay soils.

The excavations are expected to be terminated above the inferred groundwater level. It is anticipated that groundwater seepage into the open excavation can be addressed using properly constructed and filtered sumps in the base of the excavation. Depending on the timing of construction, seasonal variations potentially resulting in groundwater levels higher than those encountered during the investigation should be expected. Care should be taken to direct all surface water away from open excavations. In addition, depending on the surface water level in the wetland, temporary cofferdams may be required to permit construction in the dry.

6.0 CLOSURE

We trust that this report provides sufficient information for your immediate requirements. If any point requires clarification, or if we can be of additional assistance, please contact this office.

GOLDER ASSOCIATES LTD.

Michael E. Beadle, P.Eng.
Associate

MEB/SJB/cr

n:\active\projects - other offices\whitby\2016\1648031 ninth line\report\1648031-4000-r01 aug 22 17 (final) geo inv - ninth line.docx

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.

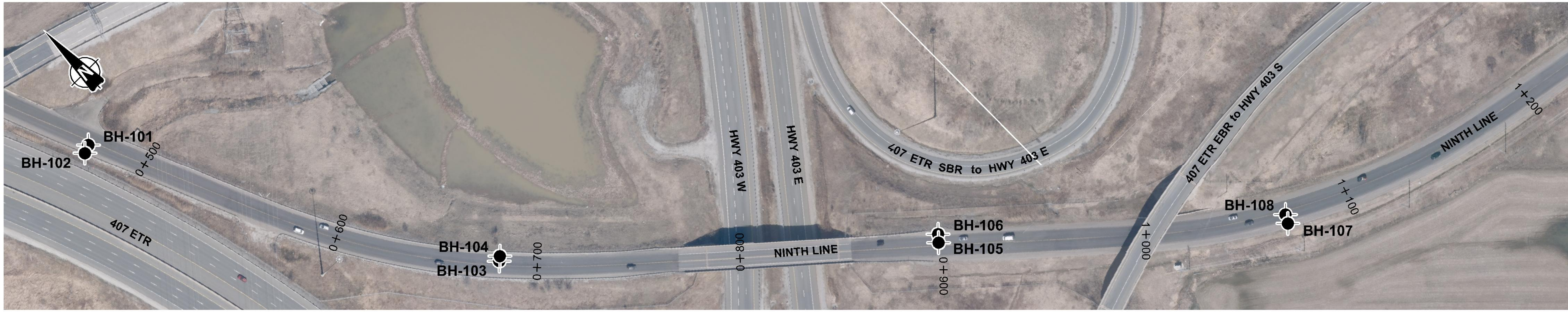
Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder’s report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder’s report.

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.

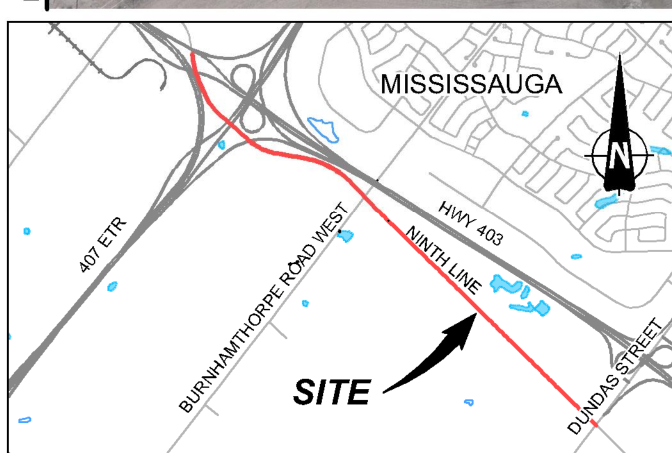
Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed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

MATCHLINE A



MATCHLINE B (REFER TO FIGURE 2)

MATCHLINE A



KEY PLAN

LEGEND

BOREHOLE

REFERENCE

DRAWING BASED ON MNR LIO, OBTAINED 2015, PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015;

2015 AERIAL IMAGERY PROVIDED BY THE REGION OF HALTON; AND

CANMAP STREETFILES V2008.4.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

SCALE IN METRES
0 40 80m
1:2,000

PROJECT
NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENT
FROM DUNDAS STREET to
HIGHWAY 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

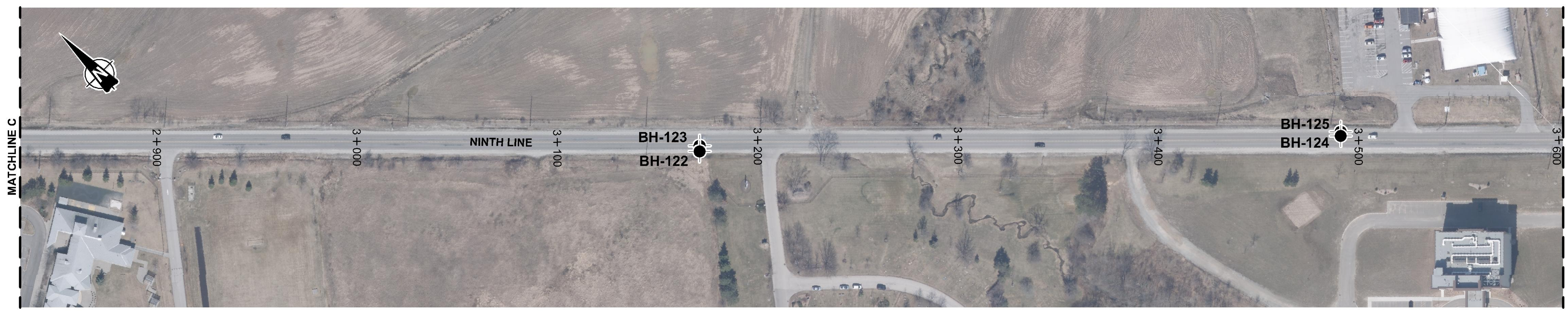
TITLE
BOREHOLE LOCATION PLAN (1 OF 3)

Golder Associates

PROJECT No.	1648031	FILE No.	1648031-4000-R01001
		SCALE	AS SHOWN
		REV.	0
CADD	DCH/ZJB	July 11/17	
CHECK			

FIGURE 1

Drawing file: 1648031-4000-R01001.dwg Jul 11, 2017 - 3:51pm



SCALE IN METRES
0 40 80m
1:2,000

LEGEND

● BOREHOLE

REFERENCE

DRAWING BASED ON MNR LIO, OBTAINED 2015, PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015; AND

2015 AERIAL IMAGERY PROVIDED BY THE REGION OF HALTON.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT

NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENT
FROM DUNDAS STREET to
HIGHWAY 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

TITLE

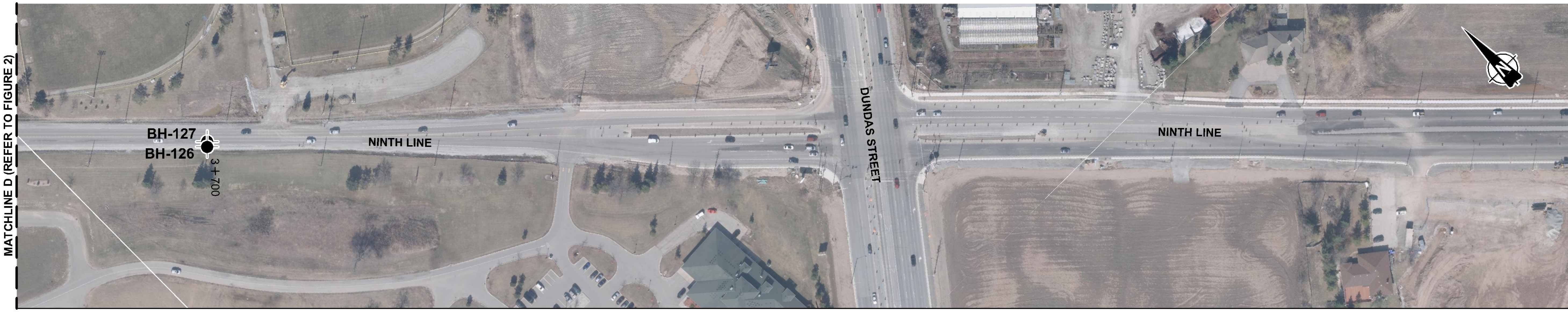
BOREHOLE LOCATION PLAN (2 OF 3)

Golder Associates

PROJECT No.	1648031	FILE No.	1648031-4000-R01001
		SCALE	AS SHOWN
CADD	DCH/ZJB	July 11/17	REV. 0
CHECK			

FIGURE 2

Drawing file: 1648031-4000-R01001.dwg Jul 12, 2017 — 12:22pm



SCALE IN METRES
0 40 80m
1:2,000

LEGEND

● BOREHOLE

REFERENCE

DRAWING BASED ON MNR LIO, OBTAINED 2015, PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2015; AND

2015 AERIAL IMAGERY PROVIDED BY THE REGION OF HALTON.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT

NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENT
FROM DUNDAS STREET to
HIGHWAY 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

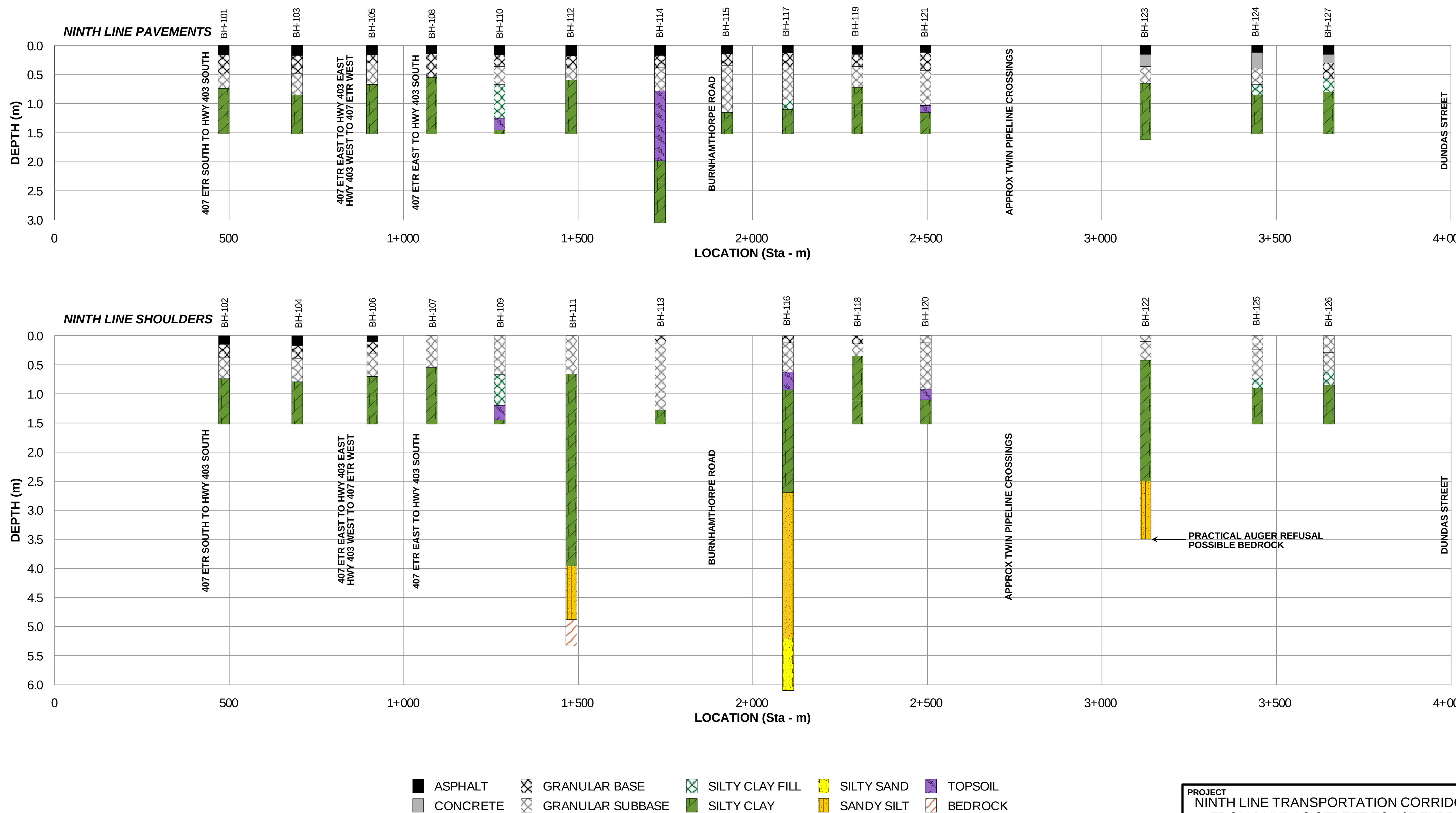
TITLE

BOREHOLE LOCATION PLAN (3 OF 3)

PROJECT No.	1648031	FILE No.	1648031-4000-R01001
		SCALE	AS SHOWN	REV. 0
CADD	DCH/ZJB	July 11/17	
CHECK			FIGURE 3

Golder Associates

Drawing file: 1648031-4000-R01001.dwg Jul 12, 2017 – 12:20pm



NOTES:
DRAWING IS SCHEMATIC ONLY. FOR DETAILS, SEE LOCATION PLAN, FIGURE 1, AND TABLE I.
DRAWING TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT.

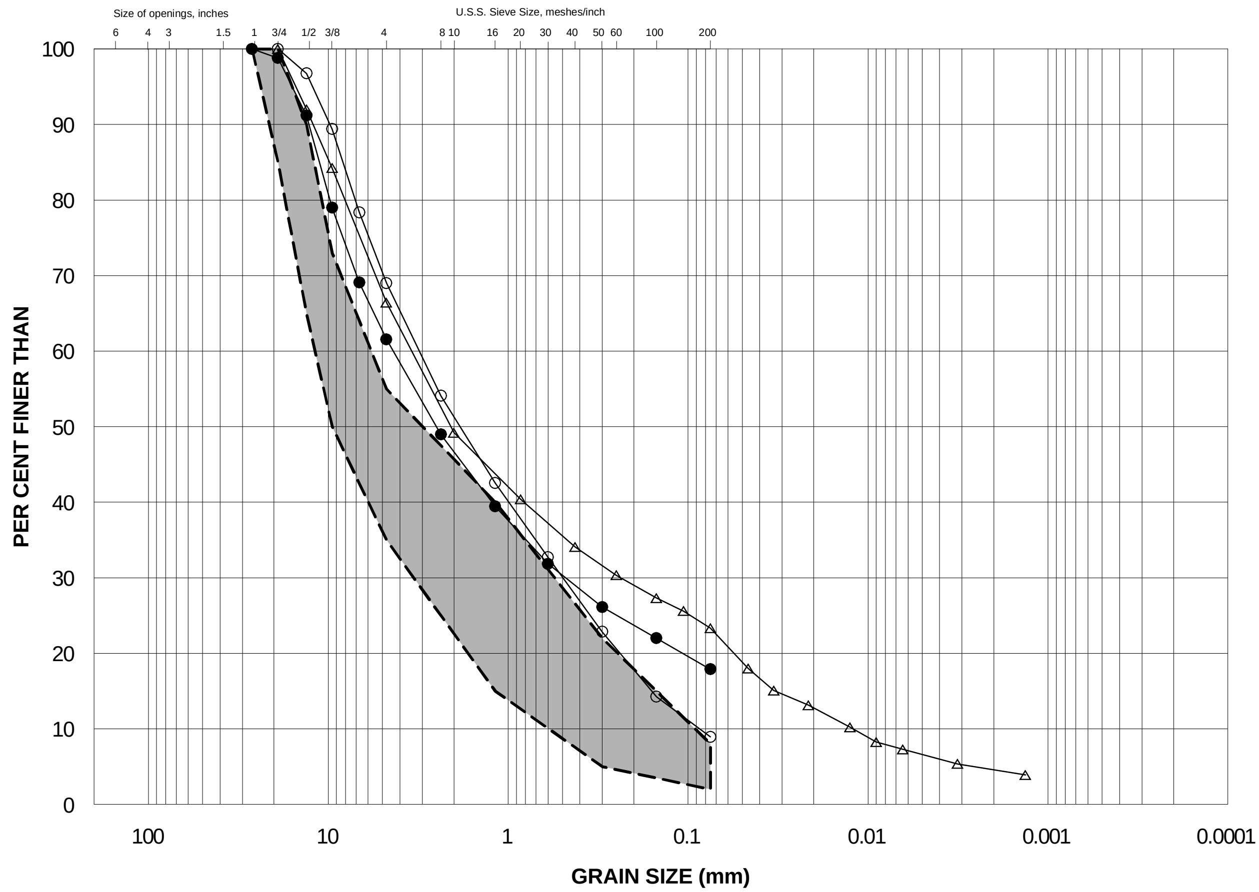
PROJECT
NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENTS
FROM DUNDAS STREET TO 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

TITLE
SUMMARY OF BOREHOLES

Golder Associates

PROJECT No.	1648031	FILE No.	1648013-4000-R01004
		SCALE	AS SHOWN REV. 0
DRAWN	MEB JUN 9-17		
CHECK		FIGURE 4	

N:\Active\PROJECTS - other offices\Whitby\2016\1648031 Ninth Line\Pavement\1648013-4000-R01004.grf



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

SAMPLE 3
SAMPLE 14
SAMPLE 21
OPSS GRANULAR A GRADATION SPECIFICATION

N:\Active\PROJECTS - other offices\Whitby\2016\1648031\Pavement\1648013-4000-R01005.grf

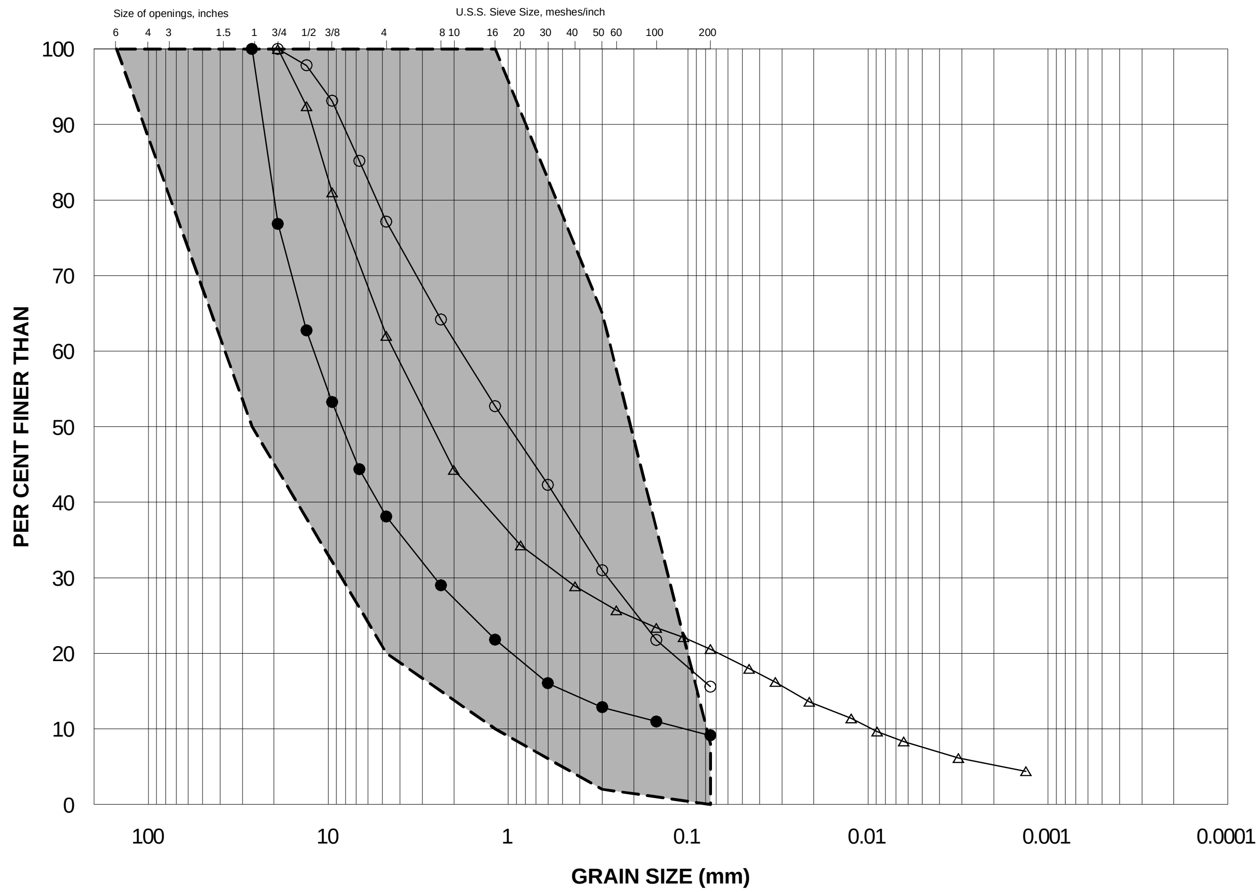
PROJECT
NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENTS
FROM DUNDAS STREET TO 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

TITLE

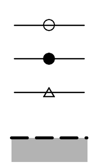
GRAIN SIZE DISTRIBUTION GRANULAR BASE

Golder Associates

PROJECT No.		1648031	FILE No.	1648013-4000-R01005
			SCALE AS SHOWN	REV. 0
DRAWN	MEB	JUN 26-17		
CHECK			FIGURE 5	



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



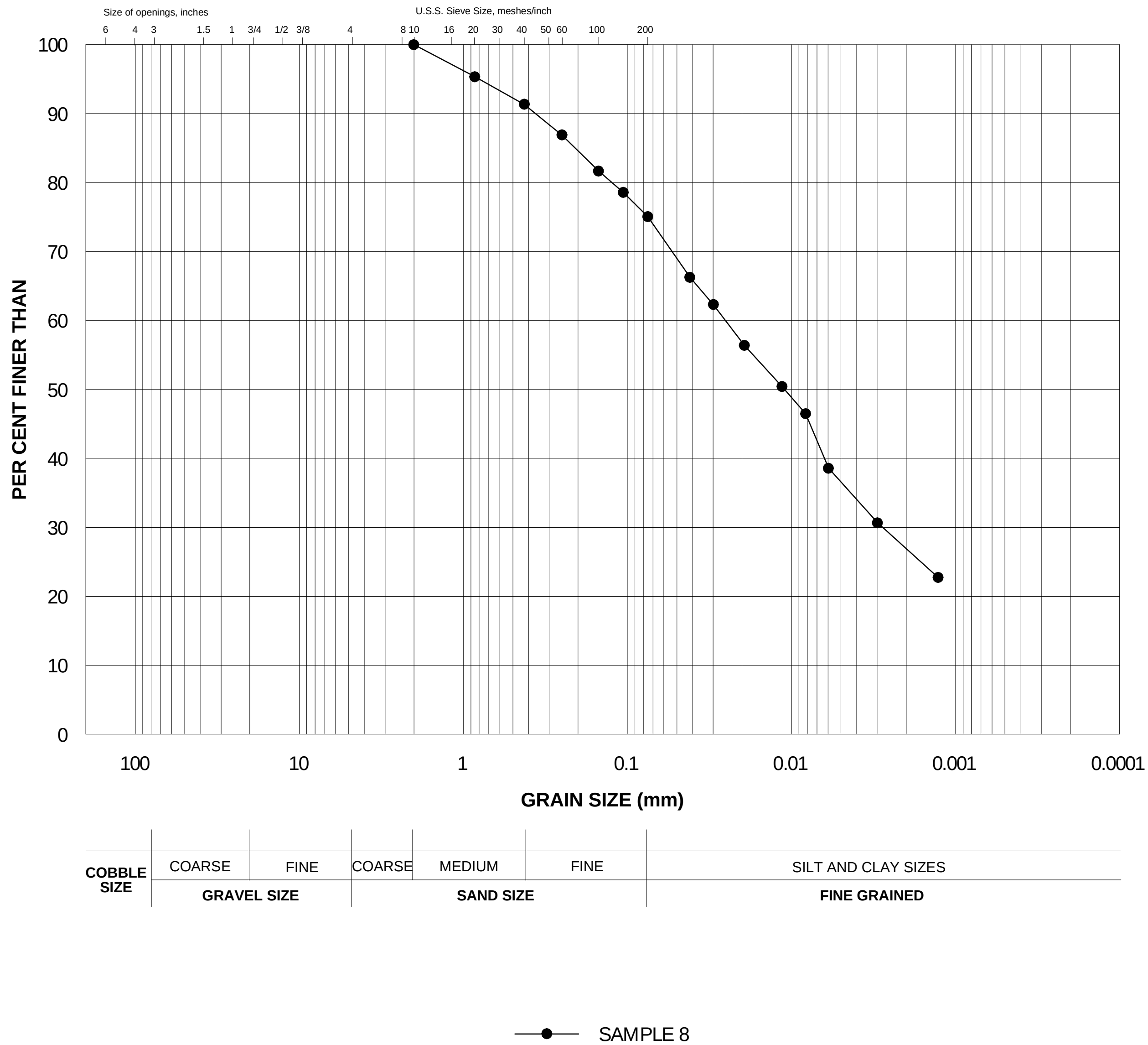
PROJECT
NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENTS
FROM DUNDAS STREET TO 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

TITLE

GRAIN SIZE DISTRIBUTION
GRANULAR SUBBASE

Golder Associates	PROJECT No.	1648031	FILE No.	1648013-4000-R01006
			SCALE AS SHOWN	REV. 0
	DRAWN MEB	JUN 26-17		
	CHECK		FIGURE 6	

N:\Active\PROJECTS - other offices\Whitby\2016\1648031\Pavement\1648013-4000-R01006.grf



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

PROJECT

NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENTS
FROM DUNDAS STREET TO 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

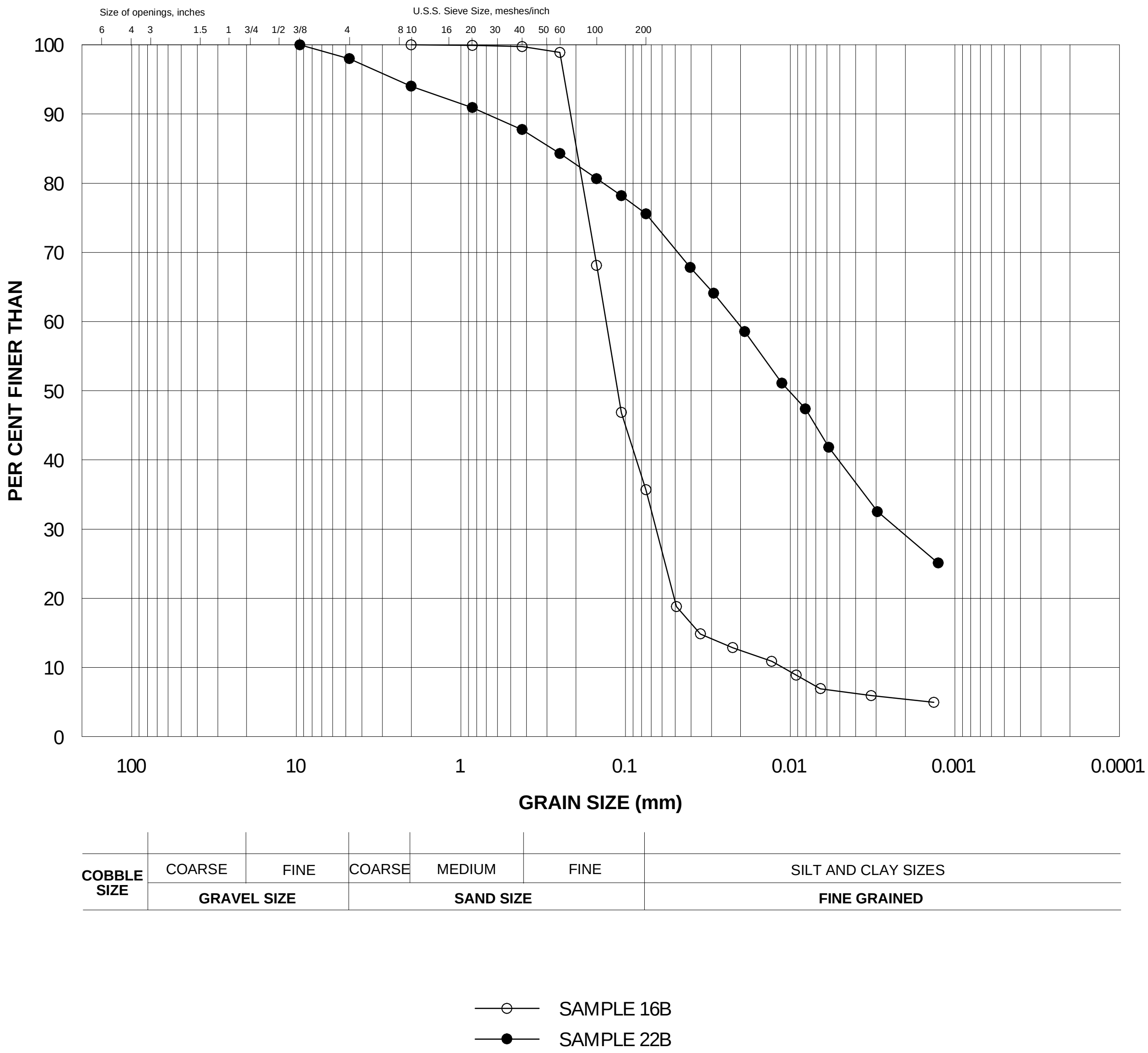
TITLE

GRAIN SIZE DISTRIBUTION
SILTY CLAY

Golder Associates

PROJECT No.	1648031	FILE No.	1648013-4000-R01007	
		SCALE	AS SHOWN	REV. 0
DRAWN	MEB	JUN 26-17		
CHECK			FIGURE 7	

N:\Active\PROJECTS - other offices\Whitby\2016\1648031\Pavement\1648013-4000-R01007.grf



N:\Active\PROJECTS - other offices\Whitby\2016\1648031\Pavement\1648013-4000-R01008.grf

PROJECT
NINTH LINE TRANSPORTATION CORRIDOR IMPROVEMENTS
FROM DUNDAS STREET TO 407 EXPRESS TOLL ROUTE
REGIONAL MUNICIPALITY OF HALTON, ONTARIO

TITLE
GRAIN SIZE DISTRIBUTION
SILTY SAND AND SANDY SILT

Golder Associates

PROJECT No.		1648031	FILE No.	1648013-4000-R01008
			SCALE AS SHOWN	REV. 0
DRAWN	MEB	JUN 26-17		
CHECK			**FIGURE 8**	

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
309 Exeter Road, Unit #1
London, Ontario, N6L 1C1
Canada
T: +1 (519) 652 0099

Golder Associates