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REPORT ON

Geotechnical Investigation Proposed Residential Development Lakeland Meadows Phase 2 Ottawa, Ontario

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REPORT

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out at the site of the proposed Lakeland Meadows Phase 2 residential development to be located west of Old Prescott Road and north of Mary Anne Drive, in Ottawa, Ontario.

The purpose of the geotechnical investigation was to assess the subsurface conditions at the site by means of a limited number of boreholes and laboratory tests. Based on an interpretation of the factual information available for this site, a general description of the subsurface conditions across the site is presented. These interpreted subsurface conditions and available project details were used to prepare engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could influence design decisions.

This report has been revised from our original report, dated June 2012, to include a new site plan for the development. The new site plan has been updated on Figure 2 of this report.

The reader is referred to the "Important Information and Limitations of This Report" which follows the text but forms an integral part of this document.

2.0 DESCRIPTION OF PROJECT AND SITE

Plans are being prepared for the construction of the Lakeland Meadows Phase 2 residential development to be located west of Old Prescott Road in Ottawa, Ontario (see Key Plan, Figure 1).

The property is located to the north of Mary Anne Drive and the existing Shadow Ridge Phase 1 residential development. To the north of the site is agricultural land that is planned for the proposed Quinn Farm Subdivision, and to the west is forested land that is planned for the proposed Phase 1 of Lakeland Meadows. The proposed Lakeland Meadows Phase 2 development will occupy about forty one hectares.

The site is currently undeveloped and moderately forested. The ground topography is relatively flat to gently undulating, with the elevations measured at the borehole locations generally ranging from about 99 to 102 metres.

It is anticipated that the residential development will consist of a mixture of single and multi-unit family dwellings and multi-unit apartment and townhouse buildings. It is proposed that all units in Phase 2 will be serviced through the communal water and sewage treatment and conveyance systems in the adjacent Shadow Ridge Subdivision. Stormwater will be collected and transported to a stormwater pond in the Shadow Ridge Subdivision property south of the Lakeland Meadows Subdivision, pending resolution of a cost-sharing agreement.

A previous geotechnical investigation was carried out by Golder Associates for Phase 1 of the Lakeland Meadows development (Report 05-1120-894-2000, dated July 2007). Relevant boreholes from the previous investigation have been referenced in this report.

Published geological maps indicate that the subsurface conditions consist of sand and gravel with an organic deposit at the central area of the site; however, a deposit of silty clay to clayey silt was observed underlying the majority of the site. The geological maps indicate that bedrock in the area consists of dolomite of the Oxford formation and the bedrock surface is indicated to be at depths ranging from 5 to 15 metres below ground surface.

3.0 PROCEDURE

The field work for this investigation was carried out between February 29 and March 12, 2012. During that time, 21 boreholes (numbered 12-1 to 12-21, inclusive) were put down at the general locations shown on Figure 2.

The boreholes were advanced using a track-mounted hollow-stem auger drill rig supplied and operated by Marathon Drilling Company Ltd. of Ottawa, Ontario. Fifteen of the 21 boreholes were terminated within the native soil at depths ranging from about 6 to 8 metres below existing ground surface. The remaining six boreholes (numbered 12-2, 12-3, 12-4, 12-5, 12-10 and 12-11) were terminated at shallower depths, between about 2 to 5.6 metres below ground surface, due to auger refusal.

Standard penetration tests (SPT) were carried out at regular intervals of depth in general conformance with ASTM D1586, and samples of the soils encountered were recovered using drive-open sampling equipment. In situ vane testing was carried out in the silty clay to determine the undrained shear strength of this soil unit.

Standpipes were sealed into boreholes 12-3, 12-8, 12-15 and 12-20 to allow subsequent measurement of the stabilized groundwater level at the site.

One supplemental borehole (numbered 12-21A) was advanced beside borehole 12-21 to retrieve two relatively undisturbed, 75-millimetre diameter thin-walled Shelby tube samples of the silty clay using a fixed piston sampler and to install a standpipe piezometer.

Since the boreholes encountered saturated granular soil, a head of water was maintained in the augers when drilling and sampling below the groundwater level to avoid disturbance (and incorrect in situ testing results) associated with an unbalancing hydrostatic head.

The field work was supervised by an experienced technician from our staff who directed the drilling operations, logged the soils encountered, took custody of the samples, and directed the in situ testing. The soil samples obtained during the field work were brought to our laboratory for further examination by the project engineer and for laboratory testing, including water content determinations and grain size distribution testing.

The groundwater levels were measured in the standpipes on March 21, 2012.

The borehole locations were selected, staked in the field, and subsequently surveyed by Golder Associates personnel. The positions and ground surface elevations at the borehole locations were determined using a Trimble R8 GPS unit. The elevations are referenced to Geodetic datum. Only the positions were surveyed for boreholes 09-21 and 09-21A. The elevations were not determined for these boreholes.

Three samples of soil from boreholes 12-3, 12-7 and 12-20 were submitted to Exova Accutest Laboratories Ltd. for basic chemical analysis related to potential sulphate attack on buried concrete elements and corrosion of buried ferrous elements.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes put down for the current investigation are shown on the Record of Borehole sheets in Appendix A. The results of the laboratory water content testing on the selected soil samples are given on the Record of Borehole sheets. The results of the grain size analyses on selected soil samples are provided on Figures 3, 4 and 5.

The subsurface conditions encountered in relevant boreholes put down during the previous investigation within Phase 1 of the development are provided in Appendix B.

The results of the basic chemical analyses are provided in Appendix C.

The following sections present an overview of the subsurface conditions encountered in the boreholes advanced during the present investigation.

Based on the subsurface conditions encountered, the site has been divided into two general areas, Area A and B, (see Site Plan, Figure 2). The following sections present a more detailed overview of the subsurface conditions for each assessment area.

4.2 Area A

Area A consists of the majority of west and north portions the site, as shown on Figure 2 (subdivided into Area A1 and Area A2). Boreholes numbered 12-6 to 12-8, 12-11 to 12-21 (inclusive) and previous boreholes 07-5, 07-6, and 05-3 of the Phase 1 site define this area. In general, the subsurface conditions in this Area A consist of topsoil overlying successive deposits of sand, silty clay to clayey silt, and silty fine sand to sandy silt. A layer of fill was encountered at borehole 12-11.

Topsoil and Fill

A layer of topsoil, ranging from about 150 to 300 millimetres in thickness, was encountered at all of the borehole locations in this area, with the exception of borehole 12-11.

A layer of fill was encountered from the ground surface at borehole 12-11. The fill varies in composition from organic silty sand to silty sand and gravel with cobbles. This borehole was terminated within the fill at a depth of about 1.9 metres below the existing ground surface due to auger refusal. The auger refusal likely represents the presence of cobbles and/or a boulder within the fill.

Sand

A surficial deposit of sand was generally encountered underlying the topsoil at the borehole locations in this area. The sand extends to depths of about 0.3 to 2.9 metres below existing ground surface. In general, the sand deposit is thicker towards the north and west portions of the site (boreholes 12-1 to 12-5, inclusive), where it extends to depths of about 1.9 to 2.9 metres below the ground surface. Underlying the remainder of the site, the sand is thinner and extends to about 0.3 to 0.8 metres below the ground surface.

This deposit generally consists of fine to medium sand with trace to some silt. Localised layers of sand and gravel were also encountered within the deposit.

Standard penetration tests carried out within the surficial sand gave 'N' values ranging from 1 to 33 blows per 0.3 metres of penetration, which indicates a very loose to dense (but generally loose to compact) state of packing. Two grain size distribution tests carried out on samples of the sand in this area (from boreholes 12-15 and 12-19) are provided in Figure 3.

Silty Clay and Clayey Silt

The surficial sand in Area A is underlain by a deposit of silty clay to clayey silt.

At boreholes 12-6, 12-7 and 12-13, the upper portion of the deposit has been weathered to a very stiff grey brown crust. The weathered clay in these boreholes ranges in thickness from about 0.5 to 1.7 metres and generally extends to depths of about 2.7 to 3.5 metres below existing ground surface. Standard penetration tests carried out within the weathered clay gave 'N' values ranging from 2 to 7 blows per 0.3 metres of penetration, indicating a very stiff consistency for the weathered crust.

Beneath the weathered crust in boreholes 12-6, 12-7 and 12-13, and beneath the sand in the remaining boreholes, the silty clay to clayey silt deposit is unweathered and grey in colour. This deposit was fully penetrated at most of the other boreholes and extends to depths ranging from about 2.9 to 5.9 metres below the existing ground surface. The deposit is locally deeper at borehole 12-21, where it was proven to a depth of about 7.2 metres below the existing ground surface before being terminated within the deposit.

At borehole 12-15, this deposit is interbedded with sandy silt between about 2.9 and 5. 9 metres below ground existing surface.

Standard penetration tests carried out within this deposit generally gave 'N' values of 'weight-of-hammer' to 6 blows per 0.3 metres of penetration. The results of in situ vane testing in this material gave undrained shear strengths ranging from about 25 to greater than 95 kilopascals. The results of this in situ testing indicate a firm to very stiff consistency.

Results of natural water content determinations carried out on nine samples of silty clay ranged from about 21 to 56 percent.

Silty Fine Sand to Sandy Silt

A deposit of silty fine sand to sandy silt was encountered underlying the silty clay to clayey silt at all of the borehole locations in this area, with the exception of borehole 12-21, which did not fully penetrate the silty clay. The boreholes did not fully penetrate this deposit, but it was proven to depths ranging from about 5.9 to 8.1 metres below the existing ground surface.

At borehole 12-12, this deposit is interbedded with clayey silt between about 5.3 and 6.6 metres below existing ground surface.

Standard penetration tests carried out within this deposit gave 'N' values ranging from 8 to 67 blows per 0.3 metres of penetration, indicating a loose to very dense (but generally compact to dense) state of packing.

4.3 Area B

Area B consists of the eastern portion of the site, as shown on Figure 2. Borehole numbered 12-1 to 12-5 (inclusive), 12-9 and 12-10 are located within this area. In general, the subsurface conditions in this Area B consist of topsoil overlying a thick deposit of sand.

Topsoil and Pavement Structure

A layer of topsoil, about 200 to 250 millimetres in thickness, was encountered at the surface of all the boreholes, except at borehole 12-4, which was located on a paved area. The pavement structure at borehole 12-4 consisted of about 70 millimetres of asphaltic concrete pavement overlying about 130 millimetres of grey crushed stone base.

Sand

In Area B, a deposit of sand was encountered underlying the topsoil or pavement structure. The sand deposit was fully penetrated in boreholes 12-5 and 12-10 at depths of about 3.7 and 2.9 metres below existing ground surface, respectively. The remaining boreholes were terminated in the sand layer at depths ranging from about 4.8 to 6.6 metres below the existing ground surface.

The sand generally varies in composition from silty sand, to fine to medium sand, to sand and gravel. Layers and/or seams of silt or sandy silt were observed within the deposit in boreholes 12-3 and 12-9. Three grain size distribution tests carried out on samples of the deposit in this area (from boreholes 12-2, 12-3, and 12-9) are provided in Figures 3, 4 and 5.

Standard penetration tests carried out within this deposit gave 'N' values ranging from 2 to greater than 50 blows per 0.3 metres of penetration, indicating a very loose to very dense (but generally loose to compact) state of packing.

Glacial Till

A deposit of glacial till was encountered underlying the sand in boreholes 12-5 and 12-10 at depths of about 3.7 and 2.9 metres below the existing ground surface, respectively. These boreholes were terminated within this deposit at depths of about 5.2 and 3.8 metres, respectively. The glacial till consists of gravel, cobbles and boulders in a matrix of silty sand with trace clay.

Standard penetration tests carried out in this material gave 'N' values ranging from 26 to 37 blows per 0.3 metres of penetration, indicating a compact to dense state of packing.

Auger Refusal

Auger refusal was encountered at boreholes 12-2 to 12-5 (inclusive) and 12-10 at depths ranging from about 3.8 to 5.6 metres below the existing ground surface. In addition, refusal to sampling (i.e., spoon refusal) was encountered at borehole 12-1 at a depth of about 6.5 metres. Auger and spoon refusal may represent the bedrock surface; however, it could also reflect the presence of cobbles and/or boulders within (or at the surface) of the glacial till.

4.4 Groundwater

The groundwater levels in the standpipes were measured on March 21, 2012 and are presented in the following table:

Borehole	Ground Surface Elevation (m)	Groundwater Level	
		Depth Below Ground Surface (m)	Elevation (m)
12-3	98.96	3.85	95.11
12-8	100.13	1.87	98.26
12-15	99.97	0.48	99.49
12-20	100.42	0.50	99.92
12-21A	-	1.56	-

Open hole groundwater measurements were taken in most of the remaining boreholes upon the completion of drilling.

In general, the groundwater level underlying Area A is at a relatively shallow depth (i.e., less than about 2 metres below ground surface.

Within Area B, 'wet' conditions were generally observed at greater depths, with the groundwater being encountered at depths ranging from about 2.1 to 4.6 metres below the existing ground surface. The ground water level was higher at borehole 12-10, which is located close to boundary with Area A, where the ground water was encountered at a depth of about 0.6 metres below the ground surface upon completion of drilling.

Groundwater levels are expected to fluctuate seasonally. Higher groundwater levels are expected during wet periods of the year, such as spring.

5.0 DISCUSSION

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the available information described herein and project requirements and is subject to the limitations in the “Important Information and Limitations of This Report” attachment which follows the text of this report.

5.2 Seismic Considerations

5.2.1 Site Classification for Seismic Site Response

The seismic Site Class is not directly applicable to structures designed in accordance with Part 9 of the OBC (i.e., conventional housing); however, an assessment is provided to address the requirements for the liquefaction assessment given below.

The seismic design provisions of the 2006 Ontario Building Code depend, in part, on the shear wave velocity of the upper 30 metres of soil and/or rock below founding level. The OBC permits the Site Class to be specified based solely on the stratigraphy and in situ testing data (i.e., shear strengths and standard penetration test results), rather than from direct measurements of the shear wave velocity.

Using that methodology, for the proposed development, a Site Class of D can be used for liquefaction assessment based on Table 4.1.8.4.A of the OBC 2006.

5.2.2 Liquefaction Assessment

Seismic liquefaction occurs when earthquake vibrations cause an increase in pore water pressures within the soil. The presence of excess pore water pressures reduces the effective stress between the soil particles, and the soil’s frictional resistance to shearing. This phenomenon, which leads to a temporary reduction in the shear strength of the soil, may cause:

- Large lateral movements of even gently sloping ground, referred to as “lateral spreading”;
- Reduced shear resistance (i.e., bearing capacity) of soils which support foundations, as well as reduced resistance to sliding; and,
- Reduced shaft resistance for deep foundations as well as reduced resistance to lateral loading.

In addition, ‘seismic settlements’ may occur once the vibrations and shear stresses have ceased. Seismic settlement is the process whereby the soils stabilize into a denser arrangement after an earthquake, causing potentially large surface settlements.

The following conditions are more prone to experiencing seismic liquefaction:

- Coarse grained soils (i.e., more probable for sands than for silts);
- Soils having a loose state of packing; and,
- Soils located below the groundwater level.

An assessment of the liquefaction potential of the sand deposit was carried out using the Seed and Idriss (1971) simplified procedure based on SPT N_{60}-values from the boreholes. The SPT N-values reported on the borehole records were corrected for overburden stress, rod length during sampling, and hammer energy efficiencies. The results of this assessment suggest that localized zones of the native submerged sands would be classified as potentially liquefiable under the *existing* conditions, based on an earthquake with a magnitude of 6.2 and a peak ground acceleration of 0.46g (Ottawa area specified design values for a Site Class D site). However, it is understood that at least 1 metre of fill will be required to raise the grade for this site. Based on our assessment, the additional weight of this fill will sufficiently reduce the cyclic stress ratio induced by the design earthquake, and therefore the site would not be classified as liquefiable under the *proposed* conditions.

5.3 Site Grading and Permissible Grade Raise

Area A1 (as indicated on Figure 2) is underlain by a deposit of firm, unweathered silty clay, which has a limited capacity to support additional stress, such as could be imposed by:

- The foundation loads of buildings/houses;
- The weight of grade raise fill placed on the site; and,
- The effects of groundwater level lowering (which reduces the buoyant forces that act between the soil particles), which could result from servicing and development of the site.

An increase in stress, if excessive (i.e., increasing the magnitude of stress above, or even close to, the clay's preconsolidation pressure), could lead to significant consolidation settlement. Due to the low hydraulic conductivity of the clay, and the need to expel water for settlement to occur, the settlement would be long-term in nature, possibly taking many months or years to complete. The grade raise on areas underlain by compressible clay will therefore need to be restricted, based on leaving sufficient remaining capacity for the clay to also support the structure foundation loads and the effects of groundwater level lowering, without being overstressed. If the grade is raised excessively, then consolidation settlement will occur.

Based on a preliminary assessment, the maximum permissible grade raise in Area A1 is 1.8 metres. This limitation has been assessed based on leaving sufficient remaining capacity in the silty clay deposit such that strip footings up to 0.6 metres in width can be designed using a maximum allowable bearing pressure of at least 75 kilopascals, consistent with design in accordance with Part 9 of the Ontario Building Code.

If a grade raise larger than 1.8 metres is required in Area A1, additional geotechnical analysis and recommendations should be provided. The final grading plans should be reviewed by the geotechnical engineer once they are available.

For Area A1, a minimum grade raise will also be required. For conventional house construction, which typically provides 2.4 metres of soil cover from the underside of footing level to the finished grade, it is not feasible to construct foundations with no grade raise, due to the stress imparted by the relatively deeper footings on the underlying compressible grey silty clay (i.e., the loads from the footings are not sufficiently distributed enough prior to reaching the grey silty clay). Therefore, to leave sufficient remaining capacity for the house foundations in Area A1, a minimum grade raise of 0.3 metres would be required. Alternatively, the houses could be restricted to elevated "High Ranch" style footings, or the footings could be supported on very wide spread footings or on a raft slab foundation. Additional information can be provided for these alternatives, if required.

The subsurface conditions across the remaining site (i.e., Area A2 and Area B) generally consist of stiff to very stiff silty clay or sand. Based on the results of this investigation, there is no practical restriction on the height of grade raise fill that can be placed on these areas.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the topsoil for predictable performance of structures and services.

The topsoil is not suitable as general fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no proposed structures, services, or roadways, the topsoil may be left in place provided some settlement of the ground surface following filling can be tolerated.

5.4 Foundations

5.4.1 Shallow Footings

It is considered that conventional houses could be supported on shallow footings founded on or within the inorganic overburden soils on this site. The topsoil would not be considered suitable to support the house foundations. The area of fill identified in the vicinity of borehole 12-11 will have to be completely removed if it falls within the footprint of a building or within the founding depth for a service.

If native loose sand is encountered at the founding level, the subgrade should be prepared by compacting the sand to 95 percent of the materials standard Proctor maximum dry density (SPMDD) with suitable vibratory equipment. The groundwater level should be lowered in advance of compaction to below the bottom of the sand layer.

If unweathered grey silty clay is encountered at the founding level, this subgrade will be sensitive to disturbance from construction traffic. The subgrade should therefore be protected with a mud slab of lean concrete which should be placed immediately following exposure and inspection/approval of the subgrade.

Provided that the grade raises are restricted to those indicated in Section 5.3, strip footing foundations up to 0.6 metres in width can be designed using a maximum allowable bearing pressure of 75 kilopascals. As such, the house footings may be sized in accordance with Part 9 of the Ontario Building Code.

The post-construction total and differential settlements of footings sized using the above maximum allowable bearing pressure should be less than about 25 and 15 millimetres, respectively, provided that the subgrade at or below the founding level is not disturbed during construction.

The maximum allowable bearing pressure provided for footings founded within the silty clay corresponds to settlement resulting from consolidation of these deposits. Consolidation of the silty clay is a process which takes months or longer and, as such, results from sustained loading. Therefore, the foundation loads to be used in conjunction with the allowable bearing pressure should be the full dead load plus sustained live load.

5.4.2 Frost Protection

The sand deposit underlying the site is generally non frost susceptible. However, there are localized areas on the site where frost susceptible seams could exist within the frost penetration depth. Therefore, all exterior perimeter foundation elements or foundation elements in unheated areas should be provided with a minimum of 1.5 metres of earth cover for frost protection purposes. Isolated, unheated exterior footings adjacent to surfaces which are cleared of snow cover during winter months should be provided with a minimum of 1.8 metres of earth cover. Houses with conventional depth basements would satisfy these requirements.

5.4.3 Basement and Garage Floor Slabs

In preparation for the construction of the basement and garage floor slabs, all loose, wet, and disturbed material should be removed from beneath the floor slabs. Provision should be made for at least 200 millimetres of 19 millimetre crushed clear stone to form the base of the floor slabs.

To prevent hydrostatic pressure build up beneath the basement and garage floor slabs, it is suggested that the granular base for the floor slabs be positively drained. This could be achieved by providing a hydraulic link between the underslab fill material and the exterior perimeter drainage system.

In general, the groundwater level at this site varies from relatively shallow depths (i.e., less than 2.0 metres below ground surface) towards the west side of the site, to 2 to 4.5 metres below ground surface towards the east. The sand at this site is somewhat permeable. If the groundwater level is encountered above subgrade level, a geotextile could be required between the clear stone underslab fill and the sandy subgrade soils, to avoid loss of fine soil particles from the subgrade soil into the voids in the clear stone and ultimately into the drainage system. In the extreme case, loss of fines into the clear stone could cause ground loss beneath the slab and plugging of the drainage system. Where a geotextile is required, it should consist of a Class II non-woven geotextile with a Filtration Opening Size (FOS) not exceeding about 100 microns, in accordance with Ontario Provincial Standard Specification (OPSS) 1860.

5.5 Basement Wall and Foundation Wall Backfill

The clayey and silty soil at this site are frost susceptible and, if excavated for foundations, should not be used as backfill directly against exterior, unheated, or well insulated foundation elements. To avoid problems with frost adhesion and heaving, a bond break such as Platon system sheeting should be placed against the foundation walls.

For Area A1 (as indicated on Figure 2), the backfill material should have a unit weight not exceeding 19.5 kilonewtons per cubic metre. The silty clay and sandy soils to be excavated on this site would be suitable. Glacial till and blast rock would be too heavy. The native fine sand, with gradation similar to that shown on Figure 3, would also be acceptable for wall backfill.

Drainage of the wall backfill should be provided by means of a perforated pipe subdrain in a surround of 19 millimetre clear stone, fully wrapped in geotextile, which leads by gravity drainage to an adjacent storm sewer or sump pit. Conventional damp proofing of the basement walls is appropriate with the above design approach.

Should the foundation walls need to be designed in accordance with Part 4 of the Ontario Building Code, further guidelines on the foundation wall design will be required.

5.6 Services

5.6.1 Excavations

The proposed inverts of the site services are not known at the time of preparing this report. Excavation for basements and site services will be made through sand and/or silty clay/clayey silt. No unusual problems are anticipated in excavating the overburden soil using large hydraulic excavating equipment. Some boulders could also be encountered in the existing fill in proximity to borehole 12-11.

The founding soils for the services may generally consist of sands, silty clay/clayey silt and sandy silt. The founding soils are considered to be suitable for supporting the pipes, provided the integrity of the base can be maintained during construction. Based on the groundwater conditions encountered during the investigation, the services pipes will generally be below the local water table at the site. Groundwater control during excavation within the silty clay/clayey silt soils can probably be handled, as required, by pumping from properly constructed and filtered sumps located within the excavations. However, more significant groundwater seepage should be expected from the sand and some form of positive groundwater control may be required to maintain the stability of the base and side slopes of the trench in addition to pumping from sumps.

Groundwater control measures that extract more than 50,000 L/day of water are subject to a Permit to Take Water (PTTW) regulated by the MOE. Additional specialized hydrogeological assessment would be required in support of the PTTW application.

It is anticipated that the trench excavations will likely consist of conventional temporary open cuts; side slopes should not be steeper than 1 horizontal to 1 vertical (1H:1V). 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 water runoff away from the open excavations and all excavations should be carried out in accordance with the Occupational Health and Safety Act and Regulations (OHSA) for Construction Projects. According to OHSA, the silty clay and sandy soils above the water table at this site would be classified as a Type 3 soil. As such, excavation side slopes should be stable in the short term at 1H:1V. However, the unweathered silty clay, present at depth, should generally be considered as a Type 4 soil, and therefore side slopes as flat as 3H:1V would be required. Should excavations within the sandy soils encounter the water table (and if the groundwater is not lowered as the excavation progresses); this material should also be considered a Type 4 soil.

Where the side slopes of excavations are required to be steepened to limit the extent of the excavation, then some form of trench support will be required. Some trench excavations could be carried out using a vertically excavated, unsupported excavations (using a properly engineered trench liner box for protection, certified by an experienced engineer); or by a supported (sheeted) excavation if conditions warrant in wet areas and/or 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. Steepened excavations should be left open for as short a duration as possible and completely backfilled at the end of each working day.

It is envisioned that conventional service installation (bedding, cover, backfill, etc.) will be appropriate for this site.

5.6.2 Bedding and Cover

At least 150 millimetres of OPSS Granular A should be used as pipe bedding for sewer and water pipes. Where unavoidable disturbance to the subgrade surface does occur, it may be necessary to place a sub-bedding layer consisting of 300 millimetres of compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. The bedding should in all cases extend to the spring line of the pipe and should be compacted to at least 95 percent of the material's SPMDD. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project since fine particles from native sand or silty sand backfill could potentially migrate into the voids in the clear crushed stone and cause loss of lateral pipe support.

Cover material, from spring line of the pipe to at least 300 millimetres above the top of pipe, should consist of OPSS Granular A or Granular B Type I with a maximum particle size of 25 millimetres. The cover material should be compacted to at least 95 percent of the material's SPMDD.

5.6.3 Trench Backfill

It should generally be possible to re-use the drier (grey brown) silty clay and sandy soil as trench backfill. However, the high moisture content of the deeper (grey) silty clay deposit makes the grey silty clay difficult to handle and compact. If the unweathered grey silty clay is excavated during installation of the site services, it should be wasted or should only be used as backfill in the lower portion of the trenches to limit the amount of long term settlement of the roadway surface. If the unweathered grey silty clay is used in trenches under roadways, long term settlement of the pavement surface should be expected. Some significant padding of the roadways may be required prior to final paving. In that case, it would also be prudent to delay final paving for as long as practical.

Where the trench will be covered with a hard surfaced area, the type of native material placed in the frost zone (between subgrade level and 1.8 metres depth) should match the soil exposed on the trench walls for frost heave compatibility. Alternatively, 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 considered. However, special measures, such as frost tapers on the trench side walls, could be required.

All trench backfill should be placed in maximum 300 millimetre loose lifts and be uniformly compacted to at least 95 percent of the material's SPMDD using suitable compaction equipment. Backfilling operations carried out during cold weather should avoid inclusions of frozen lumps of soil, snow and ice.

Within Area A1, which is underlain by firm silty clay, impervious dykes or cut-offs should be constructed at 100 metre intervals in the service trenches to reduce groundwater lowering at the site due to the 'french drain' effect of the granular bedding and surround for the service pipes. It is important that these barriers extend from trench wall to trench wall and that they fully penetrate the granular materials to the trench bottom. The dykes should be at least 1.5 metres wide and could be constructed using relatively dry (i.e., compactable) grey brown silty clay.

5.7 Pavement Design

In preparation for pavement construction, all topsoil, disturbed, or otherwise deleterious materials (i.e., those materials containing organic matter) should be stripped from the roadway areas.

Pavement areas requiring grade raising to proposed subgrade level should be filled using acceptable (compactable and inorganic) earth borrow or OPSS Select Subgrade Material. These materials should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the materials' SPMDD using suitable compaction equipment.

The surface of the pavement subgrade should be crowned to promote drainage of the roadway granular structure. Perforated pipe sub-drains should be provided at subgrade level extending from the catch basins for a distance of at least 3 metres longitudinally, parallel to the curb in two directions.

The required pavement structure for the roadways will depend upon the quality of the backfill in the service trenches. Previous experience with the construction of roadways in this area indicates the shallow subgrade soils to be generally wet of the optimum for compaction and sensitive to disturbance, weather, and precipitation. It is therefore proposed that the following pavement structures be planned for these roadways, subject to review at the time of construction. It should also be expected that the subgrade will need to be covered with a suitable woven geotextile.

The pavement structure for local roads should consist of:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type I or II Subbase	300

The pavement structure for collector roadways should consist of:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type I or II Subbase	600

The native fine to medium sand will meet the gradation requirement for Granular B Type I and could therefore be used as pavement subbase.

The granular base and subbase materials should be uniformly compacted to at least 100 percent of the material's SPMDD using suitable vibratory compaction equipment. The asphaltic concrete should be compacted in accordance with Table 10 of OPSS 310.

The composition of the asphaltic concrete pavement should be as follows:

Superpave 12.5 Surface Course – 40 millimetres

Superpave 19.0 Base Course – 50 millimetres

The asphaltic cement should consist of PG 58-34 and the design of the mixes should be based on a Traffic Category B for local roads and Category C for collector roads.

The above pavement designs are based on the assumption that the pavement subgrade has been acceptably prepared (i.e., where the trench backfill and grade raise fill have been adequately compacted to the required density and the subgrade surface not disturbed by construction operations or precipitation). Depending on the actual conditions of the pavement subgrade at the time of construction, it could be necessary to increase the thickness of the subbase and/or to place a woven geotextile beneath the granular materials.

5.8 Cement Type and Corrosion

Three samples of sand from boreholes 12-3, 12-7 and 12-20 were submitted to EXOVA Accutest Laboratories Ltd. for chemical analysis related to potential corrosion of exposed buried steel and potential sulphate attack on concrete elements. The results of this testing are provided in Appendix B.

The results indicate that concrete made with Type GU Portland cement should be acceptable for substructures. The results also indicate a slight potential for corrosion of exposed ferrous metal.

5.9 Trees

The clayey soils encountered within Area A1 (as indicated on Figure 2) are potentially sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the clayey soil, the clay undergoes shrinkage which can result in settlement of adjacent structures. The radial zone of influence of a tree is conventionally considered to be approximately equal to the height of the tree. Some restrictions will therefore need to be imposed on the planting of trees of higher water demand in close proximity to the foundations of houses in this area. Table 1 provides a list of the common trees in decreasing order of water demand and, accordingly, decreasing risk of potential effects on structures.

5.10 Pools, Decks and Additions

5.10.1 Above Ground and In Ground Pools

For Area A2 and Area B, no special geotechnical considerations are necessary for the installation of in-ground or above ground pools.

For Area A1, no special geotechnical considerations are necessary for the installation of in-ground pools, provided that the pool (including piping) does not extend deeper than the house footing level. A geotechnical assessment will be required if the pool extends deeper than the house foundations.

For Area A1, due to the additional loads that would be imposed by the construction of *above-ground pools*, these should be located no closer than 2 metres from the outside wall of the house. In addition, the installation of an above-ground pool should not be permitted to alter the existing grades within 3 metres of the house (or possibly further if EPS backfill is used). Provided these restrictions are adhered to, no further geotechnical assessment should be required for above-ground pools.

5.10.2 Decks

For Area A2 and Area B, no special geotechnical considerations area necessary for decks.

For Area A1, a geotechnical evaluation/assessment will be necessary for future decks, added by the homeowners, that:

- Are attached to the house;
- Require changes to the existing grades; or,
- Are heavily loaded and require spread footing or drilled pier foundations.

The geotechnical evaluation must consider the proposed grading, foundation types and sizes, depths of foundations, and design bearing pressures. Written approval from a geotechnical engineer should be required by the City prior to a building permit being issued.

5.10.3 Additions

For all areas, any proposed addition to a house (regardless of size) will require a geotechnical assessment. The geotechnical assessment must consider the proposed grading, foundation types and sizes, depths of foundations, and design bearing pressures. Written approval from a geotechnical engineer should be required by the City prior to the building permit being issued.

6.0 ADDITIONAL CONSIDERATIONS

The guidelines in this report have been developed on the basis of the structures on this site being designed in accordance with Part 9 of the Ontario Building Code. For any portions of the site where the structures will need to be designed in accordance with Part 4 of the Ontario Building Code, additional geotechnical investigation may be required and additional guidelines would need to be provided.

The soils at this site are sensitive to disturbance from ponded water, construction traffic and frost.

All footing and subgrade areas should be inspected by experienced geotechnical personnel prior to filling or concreting to ensure that soil having adequate bearing capacity has been reached and that the bearing surfaces have been properly prepared. The placing and compaction of any engineered fill as well as sewer bedding and backfill should be inspected to ensure that the materials used conform to the specifications from both a grading and compaction point of view.

At the time of the writing of this report, only preliminary details for the proposed subdivision were available. Golder Associates should be retained to review the final drawings and specifications for this project prior to construction to ensure that the guidelines in this report have been adequately interpreted. In particular, the grading plan will need to be reviewed to identify any areas where special measures will be required, such as restrictions on the backfill unit weight or the use of EPS Geofoam light weight fill.

The groundwater level monitoring devices (i.e., standpipe piezometers) installed at the site will require decommissioning at the time of construction in accordance with Ontario Regulation 128/03. However, it is expected that most of the wells will either be destroyed during construction or can be more economically abandoned as part of the construction. If that is not the case, or is not considered feasible, abandonment of the monitoring wells can be carried out separately.

7.0 CLOSURE

We trust that this report contains sufficient information for your present purposes. If you have any questions regarding this report or if we can be of further service to you on this project, please contact us.

GOLDER ASSOCIATES LTD.

LICENSED PROFESSIONAL ENGINEER
S. W. DUNLOP
100151238
Nov. 6/13
PROVINCE OF ONTARIO

Stephen Dunlop, P.Eng.
Geotechnical Engineer

Terry Nicholas, P.Eng.
Principal

RA/SD/TJN/bg

n:\active\2010\1125 - land engineering\10-1125-0034 lakeland meadows\geotechnical investigation\10-1125-0034 rpt phase 2 final rev 1.docx

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

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

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client, 2246557 Ontario Inc. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder cannot be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then the client may authorize the use of this report for such purpose by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process, provided this report is not noted to be a draft or preliminary report, and is specifically relevant to the project for which the application is being made. 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 cannot 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 cannot 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.

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT (cont'd)

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

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

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

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

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

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

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

TABLE 1

SOME COMMON TREES
IN DECREASING ORDER OF WATER DEMAND

Broad Leaved Deciduous

Poplar

Alder

Aspen

Willow

Elm

Maple

Birch

Ash

Beech

Oak

Deciduous Conifer

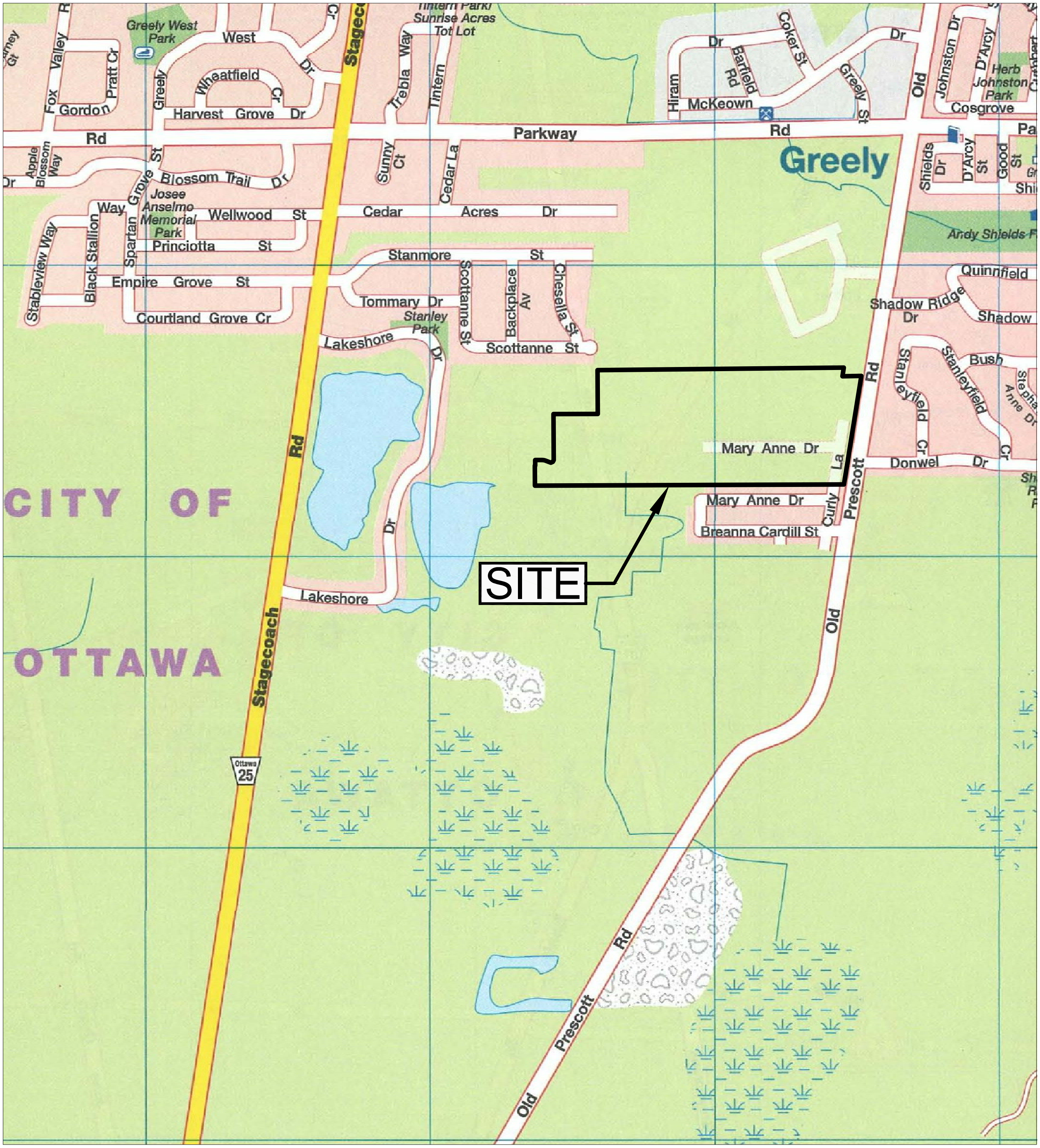
Larch

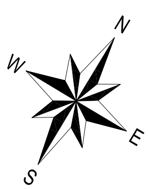
Evergreen Conifers

Spruce

Fir

Pine





NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT No. 10-1125-0034 - Rev. 1

400 0 400

SCALE 1:20,000 METRES

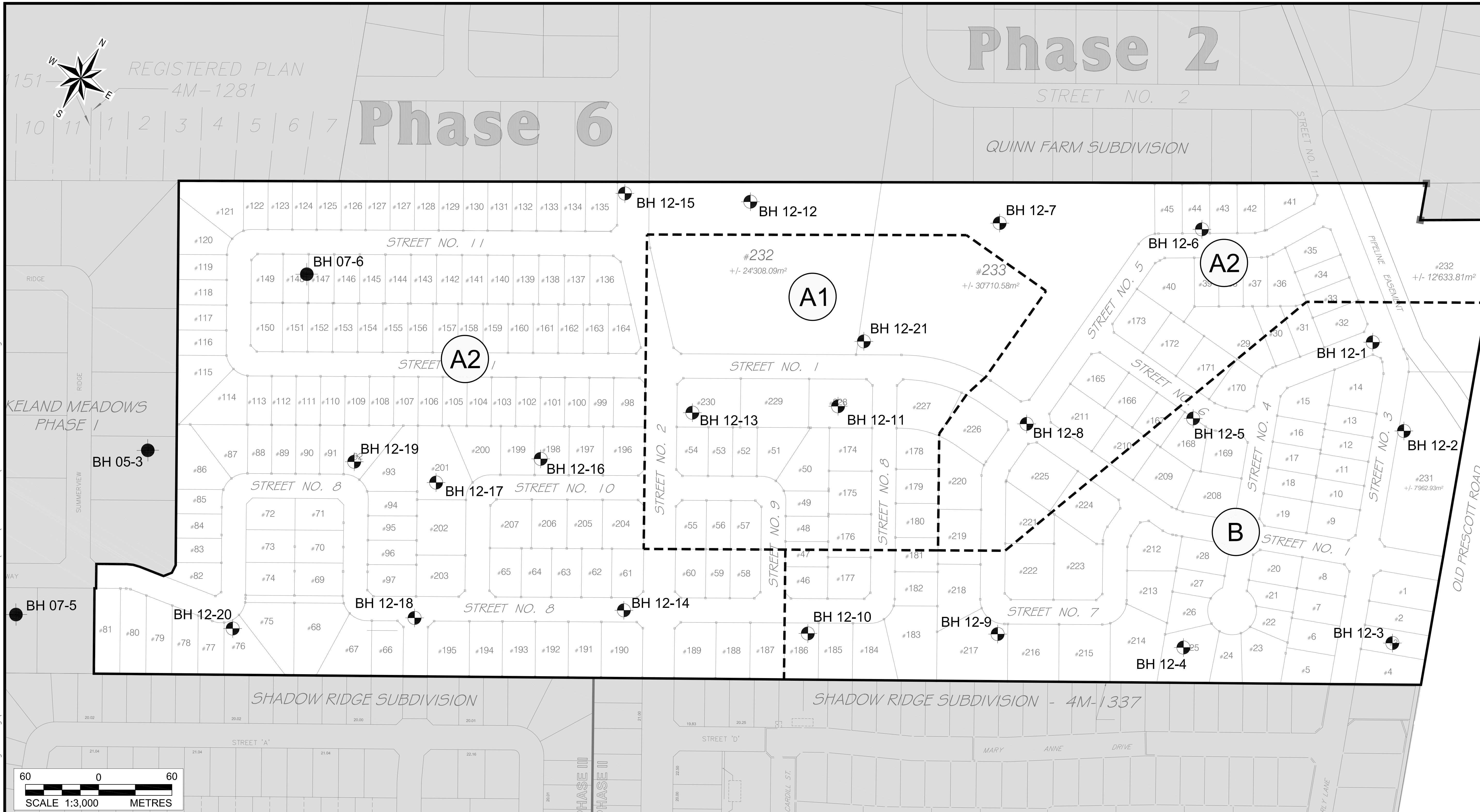
Golder Associates
Ottawa, Ontario, Canada

SCALE	1:20,000	TITLE	KEY PLAN
DATE	March 2013		
DESIGN	S.D.		
CAD	P.L.G.		
CHECK	S.D.	LAKELAND MEADOWS PHASE II OTTAWA, ONTARIO	FIGURE 1
REVIEW	T.J.N.		

FILE No. 1011250034-2000-01r1.dwg

PROJECT No. 10-1125-0034 REV.

PLOT DATE: March 6, 2013
FILENAME: N:\Active\2010\1125 - Land Engineering\10-1125-0034 Lakeland Meadows\ACAD\Phase 2000\1011250034-2000-01r1.dwg



LEGEND

- APPROXIMATE BOREHOLE LOCATION IN PLAN, CURRENT INVESTIGATION BY GOLDER ASSOCIATES LTD.
- APPROXIMATE BOREHOLE LOCATION IN PLAN, PREVIOUS INVESTIGATIONS BY GOLDER ASSOCIATES LTD.
- SITE BOUNDARY
- LIMITS OF ASSESSMENT AREAS

REFERENCE

BASE PLAN PROVIDED IN ELECTRONIC FORMAT BY HOLZMAN CONSULTANTS INC.

NOTE

THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT No. 10-1125-0034 - Rev. 1

Golder Associates
Ottawa, Ontario

SCALE	1:3,000	TITLE	SITE PLAN
DATE	March 2013		
DESIGN	W.A.M.		
CADD	P.L.G./M.L.F.		
CHECK	S.D.		LAKELAND MEADOWS PHASE II OTTAWA, ONTARIO
REVIEW	T.J.N.	FIGURE	2

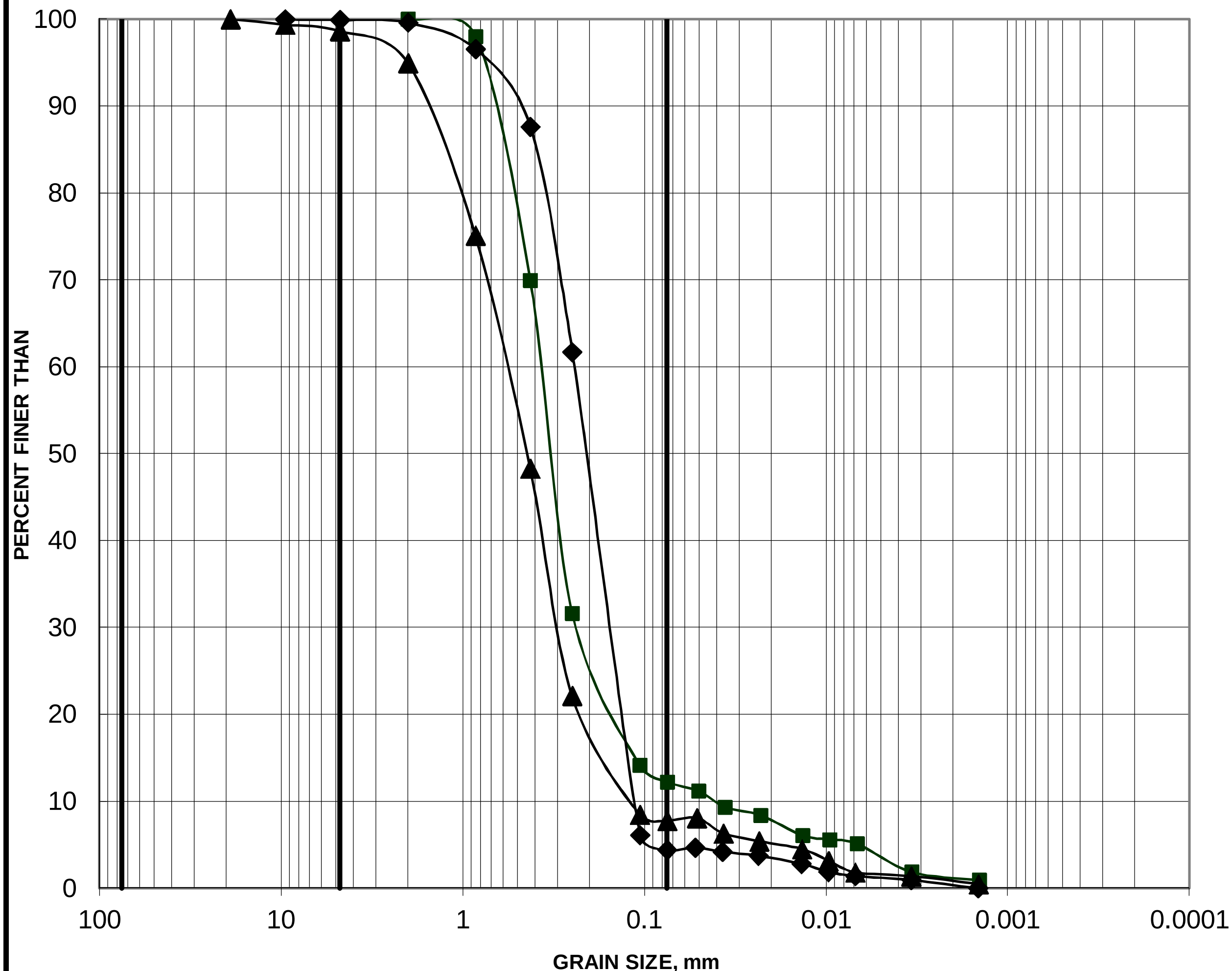
FILE No. 1011250034-2000-02r1.dwg
PROJECT No. 10-1125-0034 REV. 1

FILENAME: N:\Active\2010\1125 - Land Engineering\10-1125-0034 Lakeland Meadows\ACAD\Phase 2000\1011250034-2000-02r1.dwg

GRAIN SIZE DISTRIBUTION

Figure 3

Fine to Medium SAND



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
12-2	1	0.61-1.22
12-15	2	0.61-1.22
12-19	2	1.37-1.98

Created by: CW

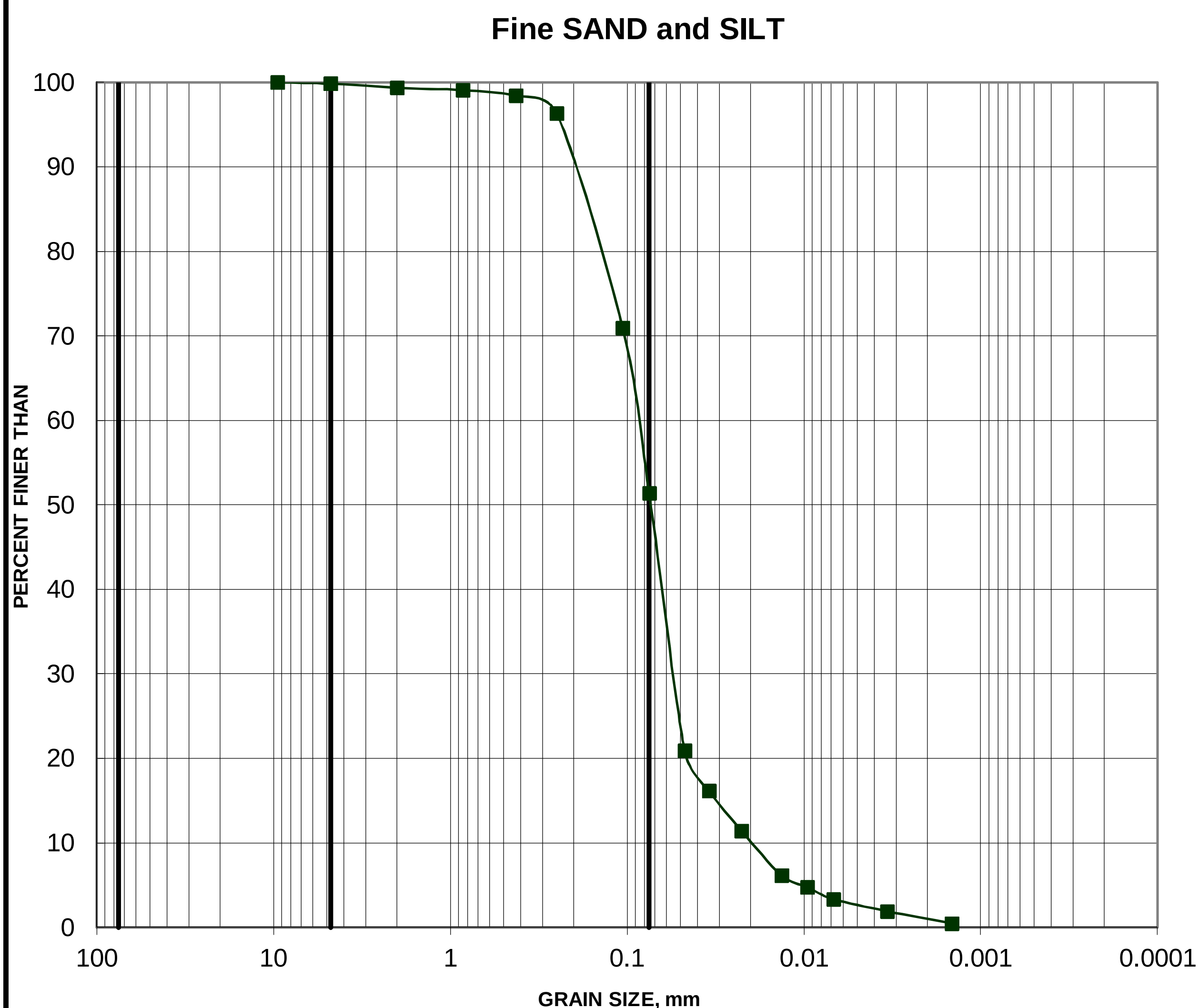
Checked by: CNM

Project: 10-1125-0034

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure 4

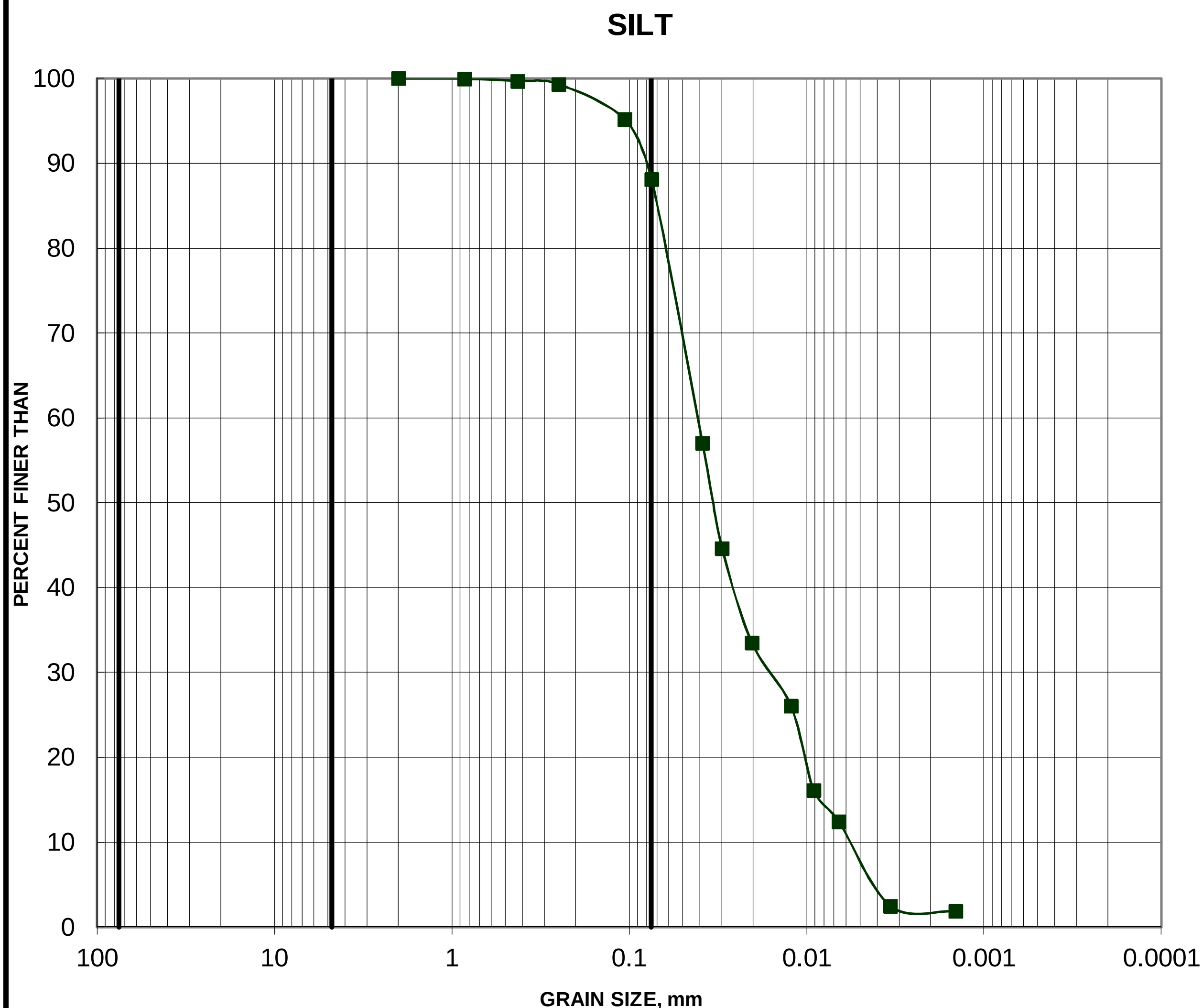


Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
12-3	4	2.90-3.51

GRAIN SIZE DISTRIBUTION

Figure 5



Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
12-9	4	2.90-3.51

Project: 10-1125-0034

Golder Associates

Created by: CW

Checked by: CNM

APPENDIX A

List of Abbreviations and Symbols
Record of Borehole Sheets
Current Investigation

LIST OF ABBREVIATIONS

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

I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO	Drive open
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample
DT	Dual Tube sample

II. PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:
The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) drive open Sampler for a distance of 300 mm (12 in.)
DD- Diamond Drilling

Dynamic Penetration Resistance; N_d:
The number of blows by a 63.5 kg (140 lb.) hammer dropped 760 mm (30 in.) to drive Uncased a 50 mm (2 in.) diameter, 60^0 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

Peizo-Cone Penetration Test (CPT):
An electronic cone penetrometer with a 60^0 conical tip and a projected 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 (PWP) and friction along a sleeve are recorded Electronically at 25 mm penetration intervals.

III. SOIL DESCRIPTION

(a) Cohesionless Soils

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

(b) Cohesive Soils

Consistency	**C_u or S_u** Kpa	Psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	Over 200	Over 4,000

IV. SOIL TESTS

w	water content
w_p	plastic limited
w_1	liquid limit
C	consolidaiton (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, G_s)
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	modified Proctor compaction test
SPC	standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane test (LV-laboratory vane test)
γ	unit weight

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma'$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
ν	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma''$-u)
σ'_{vo}	initial effective overburden stress
$\sigma_1\sigma_2\sigma_3$	principal stresses (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 ($D_R= p_s/p_w$) formerly (G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is p. Unit weight symbol is γ where γ=pg(i.e. mass density x acceleration due to gravity)

(a) Index Properties (cont'd.)

w	water content
w_1	liquid limit
w_p	plastic limit
I_p	plasticity Index=(w_1-w_p)
w_s	shrinkage limit
I_L	liquidity index=$(w-w_p)/I_p$
I_c	consistency index=$(w_1-w)/I_p$
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 (overconsolidated range)
C_s	swelling index
C_a	coefficient of secondary consolidation
m_v	coefficient of volume change
c_v	coefficient of consolidation
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation pressure
OCR	Overconsolidation ratio=σ'_p/σ'_{vo}

(d) Shear Strength

$\tau_p\tau_r$	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 (ϕ=0 analysis)
p	mean total stress $(\sigma_1+\sigma_3)/2$
p'	mean effective stress $(\sigma'_1+\sigma'_3)/2$
q	$(\sigma_1-\sigma_3)/2$ or $(\sigma'_1-\sigma_3)/2$
q_u	compressive strength $(\sigma_1-\sigma_3)$
S_t	sensitivity

Notes: 1. τ=c'σ' tan |'
2. Shear strength=(Compressive strength)/2

RECORD OF BOREHOLE: 12-1

PROJECT: 10-1125-0034

LOCATION: See Site Plan

BORING DATE: March 8, 2012

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	99.52			
0	Power Auger, 200mm Diam. Hollow Stem	TOPSOIL	0.00			
		Very loose to loose grey brown fine to medium SAND, trace to some silt, with silty sand seams	99.27 / 0.25			
1				1	SS	9
2				2	SS	10
				3	SS	2
3		Compact grey SILTY SAND and GRAVEL	96.47 / 3.05			
				4	SS	10
4				5	SS	27
				6	SS	22
5		Dense grey SAND, some silt, trace to some gravel	94.49 / 5.03			
				7	SS	35
6				8	SS	>50
		End of Borehole Spoon Refusal	93.00 / 6.52			
7						
8						
9						
10						

Other columns (no data recorded): 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; 20, 40, 60, 80); ADDITIONAL LAB. TESTING; PIEZOMETER OR STANDPIPE INSTALLATION.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-2

PROJECT: 10-1125-0034
LOCATION: See Site Plan
BORING DATE: February 29, 2012
SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam. Hollow Stem

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	99.02					
TOPSOIL	0.00					
Loose red brown and grey brown fine to medium SAND, trace to some silt	98.82 / 0.20	1	SS	8	MH	
Compact grey brown SILTY fine SAND	97.80 / 1.22	2	SS	12		
		3	SS	11		▽
Compact to dense grey brown SAND and GRAVEL, some silt	95.97 / 3.05	4	SS	16		
		5	SS	28		
		6	SS	46		
End of Borehole Auger Refusal	93.78 / 5.24					W.L. in open hole at 2.90 m below ground surface upon completion of drilling

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 — 20 40 60 80

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

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH
CHECKED: SD

RECORD OF BOREHOLE: 12-3

PROJECT: 10-1125-0034

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: February 29, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Boring method: Power Auger, 200mm Diam. Hollow Stem (0.00 to 4.80 m)

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	98.96					
TOPSOIL	0.00					Native Backfill
Loose red brown and grey brown fine SAND, trace silt	98.74 / 0.22	1	SS	5		Bentonite Seal
Compact grey brown to grey fine SAND, with silty fine sand seams	97.59 / 1.37	2	SS	16		
		3	SS	14		Sand and Bentonite mix
Loose to compact grey and brown SILTY fine SAND to SANDY SILT	96.06 / 2.90	4	SS	9	MH	
		5	SS	8		
		6	SS	13		Standpipe
End of Borehole Auger Refusal	94.16 / 4.80					W.L. in Standpipe at Elev. 95.11 m on March 21, 2012

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 ; 20 40 60 80

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

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 10-1125-0034

RECORD OF BOREHOLE: 12-4

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 6, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Boring method: Power Auger, 200mm Diam. Hollow Stem

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	100.17			
ASPHALTIC CONCRETE	0.07			
Grey crushed stone (FILL)	0.20			
Loose brown to grey brown fine SAND, trace silt		1	SS	8
		2	SS	9
Compact grey brown fine SAND, trace silt	98.34 / 1.83	3	SS	12
		4	SS	11
		5	SS	11
Loose grey fine SAND, some silt	95.75 / 4.42	6	SS	10
		7	SS	6
End of Borehole Auger Refusal	94.53 / 5.64			

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 : 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

W.L. in open hole at 4.57 m below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-5

PROJECT: 10-1125-0034

LOCATION: See Site Plan

BORING DATE: February 29, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (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 (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		100.33							
0	Power Auger 200mm Diam. Hollow Stem	TOPSOIL		0.00							
		Loose to compact red brown fine SAND		100.08 / 0.25							
1		Compact grey brown fine SAND, trace silt		99.42 / 0.91	1	SS	11				
					2	SS	11				
2					3	SS	15				∇
3		Loose grey brown medium to fine SAND, trace silt		97.28 / 3.05	4	SS	8				
4		Compact to dense grey brown SAND and GRAVEL, some silt, with cobbles (GLACIAL TILL)		96.67 / 3.66	5	SS	27				
5					6	SS	37				
		End of Borehole Auger Refusal		95.12 / 5.21							W.L. in open hole at 2.90 m below ground surface upon completion of drilling
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-6

PROJECT: 10-1125-0034
SHEET 1 OF 1
LOCATION: See Site Plan
BORING DATE: March 8, 2012
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	101.28						
0	Power Auger, 200mm Diam. Hollow Stem	TOPSOIL	0.00						
		Compact SAND and GRAVEL, with cobbles	101.08 / 0.20	1	GRAB				
1		Compact to loose brown fine SAND, trace silt	100.67 / 0.61	2	SS	10			
				3	SS	9			
2		Very stiff grey brown CLAYEY SILT, with fine sand seams (Weathered Crust)	99.45 / 1.83	4	SS	5			
3				5	SS	4			
4		Stiff grey SILTY CLAY to CLAYEY SILT	97.77 / 3.51	6	SS	WH	rem V. ≈17; nat V. ≈57		
5		Compact to dense grey SILTY fine SAND	96.46 / 4.82	7	SS	29			
6				8	SS	48			
		End of Borehole	94.73 / 6.55						

Other chart headings: 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 (20, 40, 60, 80).

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH
CHECKED: SD

RECORD OF BOREHOLE: 12-7

PROJECT: 10-1125-0034
SHEET 1 OF 1
LOCATION: See Site Plan
BORING DATE: March 7, 2012
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam. Hollow Stem

DESCRIPTION (SOIL PROFILE)	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	101.94			
TOPSOIL	0.00	1	GRAB	
Red brown SILTY SAND, some gravel	101.74 / 0.20	2	GRAB	
Dense grey brown SAND and GRAVEL, with cobbles	101.44 / 0.50	3	SS	33
Compact grey brown fine to medium SAND, trace silt	100.60 / 1.34	4	SS	15
Very stiff grey brown SILTY CLAY (Weathered Crust)	99.50 / 2.44	5	SS	12
Stiff grey SILTY CLAY	99.04 / 2.90	6	SS	WH
		7	SS	WH
Compact to dense SILTY fine SAND to SANDY SILT	96.54 / 5.40	8	SS	10
		9	SS	15
		10	SS	49
End of Borehole	93.86 / 8.08			

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 ; 20 40 60 80
ADDITIONAL LAB. TESTING
PIEZOMETER OR STANDPIPE INSTALLATION

W.L. in open hole at 1.98 m below ground surface upon completion of drilling

DEPTH SCALE 1 : 50
Golder Associates
LOGGED: PAH
CHECKED: SD

PROJECT: 10-1125-0034

RECORD OF BOREHOLE: 12-8

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 1, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Boring method: Power Auger, 200mm Diam. Hollow Stem (0.00 m to 6.25 m)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	100.13				
0	Peaty TOPSOIL	0.00				
	Loose grey fine SAND, trace to some silt	99.83 / 0.30	1	GRAB		
	Very stiff grey SILTY CLAY to CLAYEY SILT	99.28 / 0.85	2	SS	8	Native Backfill
1			3	SS	4	
2						Bentonite Seal
3	Compact grey SILTY fine SAND to SANDY SILT	97.23 / 2.90	4	SS	9	
			5	SS	27	Silica Sand
4			6	SS	30	
5	Dense grey fine SAND, some silt	95.41 / 4.72	7	SS	47	
6			8	SS	44	Standpipe
	End of Borehole	93.88 / 6.25				W.L. in Standpipe at Elev. 98.26 m on March 21, 2012
7						
8						
9						
10						

Other column headings: 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) (20, 40, 60, 80); ADDITIONAL LAB. TESTING; STRATA PLOT.

Shear strength (nat V.): two readings of + at approximately 2.1 m and 2.4 m depth, beyond 80 kPa.

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 10-1125-0034

RECORD OF BOREHOLE: 12-9

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 7, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE - DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	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 (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	99.93							
0	Power Auger, 200mm Diam. Hollow Stem	TOPSOIL	0.00							
		Red brown fine SAND, trace to some silt	99.73 / 0.20							
1		Compact grey brown fine SAND, trace to some silt	99.17 / 0.76	1	SS	10				
				2	SS	12				
2				3	SS	12				∇
3		Loose brown SILT, trace sand and clay	97.19 / 2.74	4	SS	5			MH	
4		Compact brown fine to medium SAND, trace silt	96.27 / 3.66	5	SS	19				
5				6	SS	20				
				7	SS	21				
6				8	SS	25				
		End of Borehole	93.38 / 6.55							
7										W.L. in open hole at 2.13 m below ground surface upon completion of drilling
8										
9										
10										

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-10

PROJECT: 10-1125-0034

LOCATION: See Site Plan

BORING DATE: March 6, 2012

SHEET 1 OF 1

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam. Hollow Stem

DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	100.07
TOPSOIL	0.00
Compact grey brown to grey fine SAND, trace to some silt	99.87 / 0.20
Compact grey SILTY SAND, some gravel, trace clay, with cobbles and boulders (GLACIAL TILL)	97.17 / 2.90
End of Borehole Auger Refusal	96.26 / 3.81

NUMBER	TYPE	BLOWS/0.3m
1	SS	11
2	SS	13
3	SS	13
4	SS	26

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 : 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

W.L. in open hole at 0.55 m below ground surface upon completion of drilling

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

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

PROJECT: 10-1125-0034

RECORD OF BOREHOLE: 12-11

LOCATION: See Site Plan

BORING DATE: March 7, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (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 (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		102.68							
0	Power Auger 200mm Diam. Hollow Stem	Dark brown organic silty sand, some gravel and cobbles (FILL)		0.00	1	GRAB					
		Compact grey brown silty sand and gravel (FILL)		101.98 0.70	2	SS	13				
1		Very dense grey brown sandy gravel, with cobbles (FILL)		101.61 1.07	3	SS	73				
2		End of Borehole Auger Refusal		100.78 1.90							Borehole dry upon completion of drilling

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-12

PROJECT: 10-1125-0034
SHEET 1 OF 1
LOCATION: See Site Plan
BORING DATE: March 12, 2012
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam. Hollow Stem

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	99.65			
TOPSOIL	0.00	1	GRAB	
Compact to loose grey fine to medium SAND	0.15	2	50 DO	12
		3	50 DO	9
Stiff grey SILTY CLAY to CLAYEY SILT	97.52 / 2.13	4	50 DO	2
Dense to very dense grey SANDY SILT	96.60 / 3.05	5	50 DO	33
		6	50 DO	67
		7	50 DO	32
Compact grey SILTY fine SAND	94.77 / 4.88			
Interbedded grey CLAYEY SILT and SANDY SILT	94.32 / 5.33	8	50 DO	10
		9	50 DO	21
End of Borehole	93.09 / 6.56			

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 (20 40 60 80)
ADDITIONAL LAB. TESTING
PIEZOMETER OR STANDPIPE INSTALLATION

At approximately 3.0 m depth: shear strength rem V. ⊕ at about 10 kPa; nat V. + at about 58 kPa.

W.L. in open hole at 0.30 m below ground surface upon completion of drilling

DEPTH SCALE 1 : 50
Golder Associates
LOGGED: PAH
CHECKED: SD

MIS-BHS 001 1011250034.GPJ GAL-MIS.GDT 06/28/12 P.L.G.

RECORD OF BOREHOLE: 12-13

PROJECT: 10-1125-0034

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 9, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam. Hollow Stem (0.00 to 8.08 m)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	100.13				
	TOPSOIL	0.00				
	Red brown SILTY SAND, some gravel	99.93 / 0.20	1	GRAB		∇
	Loose brown fine to medium SAND, trace silt	99.57 / 0.56	2	SS	5	
	Very stiff grey brown SILTY CLAY (Weathered Crust)	98.61 / 1.52	3	SS	7	
			4	SS	2	
	Firm to stiff grey SILTY CLAY	97.39 / 2.74				
			5	SS	2	
6	Loose to compact grey SANDY SILT	94.19 / 5.94	6	SS	8	
			7	SS	16	
			8	SS	13	
8	End of Borehole	92.05 / 8.08				W.L. in open hole at 0.40 m below ground surface upon completion of drilling

The plotted data points are read from the chart's axes and are approximate.

Field vane shear strength (Cu, kPa), in the firm to stiff grey SILTY CLAY:

Approx. depth (m)	rem V. (⊕)	nat V. (+)
3.0	~8	~60
3.3	~14	~79
3.9	~5	~44
4.2	~10	~44
5.3	~12	~79
5.6	~20	~75

Chart headings:
- 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 (20, 40, 60, 80)
- ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-14

PROJECT: 10-1125-0034
LOCATION: See Site Plan
BORING DATE: March 5, 2012
SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (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 (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		99.74							
0	Power Auger 200mm Diam. Hollow Stem	TOPSOIL		0.00	1	GRAB					
		Loose to compact brown SAND, trace silt		99.49 0.25							▽
1					2	SS	8				
					3	SS	16				
2		Stiff to very stiff grey SILTY CLAY		97.45 2.29	4	SS	2				
3								⊕ (~15), + (~63), + (~> 100)			
		Compact grey SANDY SILT		96.31 3.43							
4					5	SS	12				
		Dense grey SAND, with silty fine sand seams		95.63 4.11							
5					6	SS	36				
					7	SS	40				
6		End of Borehole		93.80 5.94							W.L. in open hole at 0.55 m below ground surface upon completion of drilling
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH
CHECKED: SD

RECORD OF BOREHOLE: 12-15

PROJECT: 10-1125-0034
LOCATION: See Site Plan
BORING DATE: March 9, 2012
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm
SHEET 1 OF 1
DATUM: Geodetic

BORING METHOD: Power Auger, 200mm Diam. Hollow Stem

Depth Scale (m)	Description	Elev. / Depth (m)	Sample No.	Type	Blows/0.3m	Dynamic Penetration / Shear Strength	Additional Lab. Testing	Piezometer or Standpipe Installation
	GROUND SURFACE	99.97						
0	TOPSOIL	0.00						
	Compact to loose grey brown to grey fine to medium SAND, trace silt	0.15	1	50 DO	10			Native Backfill
			2	50 DO	9		MH	
2	Stiff to very stiff grey SILTY CLAY	97.91 / 2.06	3	50 DO	WH	>96		Bentonite Seal
3	Interbedded grey CLAYEY SILT and SANDY SILT	97.07 / 2.90	4	50 DO	6			Native Backfill
			5	50 DO	17			
			6	SS	5			
			7	SS	5			
6	Compact grey SANDY SILT to SILTY fine SAND	94.03 / 5.94	8	SS	20			Standpipe
	End of Borehole	93.42 / 6.55						

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; 20, 40, 60, 80

W.L. in Standpipe at Elev. 99.49 m on March 21, 2012

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH
CHECKED: SD

PROJECT: 10-1125-0034

RECORD OF BOREHOLE: 12-16

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 1, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
		GROUND SURFACE	99.98			
0	Power Auger, 200mm Diam. Hollow Stem	TOPSOIL	0.00			
		Brown fine SAND, some silt	99.76 / 0.22			
		Loose grey SAND, trace gravel	99.22 / 0.76	1	SS	9
1		Compact grey fine to medium SAND, trace silt	98.76 / 1.22	2	SS	14
2		Very stiff grey SILTY CLAY to CLAYEY SILT	97.69 / 2.29	3	SS	4
3				4	SS	1
4		Compact to dense grey SANDY SILT, some clay	95.71 / 4.27	5	SS	15
5				6	SS	33
6				7	SS	36
		End of Borehole	93.43 / 6.55			
7						
8						
9						
10						

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 ; 20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

MIS-BHS 001 1011250034.GPJ GAL-MIS.GDT 06/28/12 P.L.G.

RECORD OF BOREHOLE: 12-17

PROJECT: 10-1125-0034

LOCATION: See Site Plan

BORING DATE: March 5, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Boring method: Power Auger, 200mm Diam. Hollow Stem

DEPTH (m)	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	99.88					
0	TOPSOIL	0.00					
	Loose brown fine to medium SAND	99.66 / 0.22					▽
1			1	SS	4		
	Compact grey interbedded fine SAND and medium to coarse SAND	98.51 / 1.37	2	SS	15		
2	Stiff to very stiff grey SILTY CLAY to CLAYEY SILT	97.59 / 2.29	3	SS	1		
3						rem V. ⊕; nat V. + ; nat V. +	
4			4	SS	3		
	Dense grey SANDY SILT	95.61 / 4.27	5	SS	41		
5			6	SS	37		
6	End of Borehole	93.94 / 5.94					W.L. in open hole at 0.55 m below ground surface upon completion of drilling

Column headings also include: 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 (20, 40, 60, 80); ADDITIONAL LAB. TESTING.

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-18

PROJECT: 10-1125-0034
LOCATION: See Site Plan
BORING DATE: March 5, 2012
SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Boring method: Power Auger, 200mm Diam. Hollow Stem

DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	99.66			
TOPSOIL	0.00			
Red brown SILTY fine SAND	99.51 / 0.15			
Loose brown SAND	99.30 / 0.36	1	SS	8
Compact grey SAND, with silty clay seams	98.59 / 1.07	2	SS	10
		3	SS	13
Very stiff grey SILTY CLAY to CLAYEY SILT	96.92 / 2.74	4	SS	3
Compact to dense grey SANDY SILT to SILTY fine SAND	95.39 / 4.27	5	SS	22
		6	SS	26
		7	SS	34
End of Borehole	93.11 / 6.55			

Piezometer or Standpipe Installation: W.L. in open hole at 0.45 m below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH
CHECKED: SD

MIS-BHS 001 1011250034.GPJ GAL-MIS.GDT 06/28/12 P.L.G.

RECORD OF BOREHOLE: 12-19

PROJECT: 10-1125-0034

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 2, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

Boring method: Power Auger, 200mm Diam. Hollow Stem

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	100.04			
TOPSOIL	0.00			
Brown and red brown fine SAND, trace silt	99.79 / 0.25			
Very loose grey brown fine to medium SAND	99.28 / 0.76	1	SS	3
Very loose to loose grey fine to medium SAND, trace silt	98.67 / 1.37	2	SS	2
		3	SS	8
Very stiff grey SILTY CLAY	97.54 / 2.50	4	SS	2
Dense grey SANDY SILT to SILTY fine SAND	95.77 / 4.27	5	SS	51
		6	SS	39
		7	SS	36
End of Borehole	93.49 / 6.55			

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20, 40, 60, 80)

SHEAR STRENGTH Cu, kPa (nat V. +, Q - ●, rem V. ⊕, U - ○): nat V. values plotted beyond 80 at approx. 3.8 m and 4.1 m depth.

HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3})

WATER CONTENT PERCENT (Wp, W, Wl; 20, 40, 60, 80)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: ▽ at 0.76 m

W.L. in open hole at 0.76 m below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

RECORD OF BOREHOLE: 12-20

PROJECT: 10-1125-0034
LOCATION: See Site Plan
BORING DATE: March 2, 2012
SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam. Hollow Stem

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	100.42				
TOPSOIL	0.00	1	GRAB		Native Backfill
Brown and red brown fine SAND	100.20 / 0.22				Bentonite Seal
Loose grey brown fine to medium SAND, trace gravel	99.81 / 0.61	2	SS	7	Native Backfill
		3	SS	4	
Very loose grey SAND, trace gravel	98.44 / 1.98	4	SS	1	Standpipe
					Native Backfill
Very stiff grey SILTY CLAY to CLAYEY SILT	97.22 / 3.20	5	SS	6	Bentonite Seal
		6	SS	3	
		7	SS	7	Cave
Dense grey SANDY SILT	94.48 / 5.94	8	SS	36	
		9	SS	51	
End of Borehole	92.80 / 7.62				W.L. in Standpipe at Elev. 99.92 m on March 12, 2012

Shear strength (nat V. +): two readings at approx. 3.8 m and 4.1 m depth, beyond 80 kPa.

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 : 20 40 60 80
ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: PAH
CHECKED: SD

RECORD OF BOREHOLE: 12-21

PROJECT: 10-1125-0034
LOCATION: See Site Plan
BORING DATE: March 7, 2012
SHEET 1 OF 1
DATUM: Geodetic
SAMPLER HAMMER, 64kg; DROP, 760mm
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE					
0	Power Auger, 200mm Diam. Hollow Stem	TOPSOIL	0.00				
		Red brown SILTY SAND, some gravel	0.15				
		Compact brown SAND, trace silt	0.61	1	SS	21	∇
2		Firm to stiff grey SILTY CLAY	1.98	2	SS	WH	
				3	SS	1	
				4	SS	WH	
		Stiff to very stiff grey SILTY CLAY to CLAYEY SILT	6.40				
		End of Borehole	7.16				W.L. in open hole at 1.37 m below ground surface upon completion of drilling

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 (20 40 60 80)
ADDITIONAL LAB. TESTING

Depth scale: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: PAH
CHECKED: SD

RECORD OF BOREHOLE: 12-21A

PROJECT: 10-1125-0034

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: March 12, 2012

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	SHEAR STRENGTH Cu, kPa (rem V. ⊕ / nat V. +)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 200mm Diam. Hollow Stem	GROUND SURFACE							
0		Red brown SILTY SAND, some gravel	0.00						Native Backfill
		Compact brown SAND, trace silt	0.61						
2		Firm to stiff grey SILTY CLAY	1.98						
3				1	73 TP	PH			
~3.7							⊕ ~2; + ~42		
4–5									Bentonite Seal; Silica Sand
5.3				2	73 TP	PH			Standpipe
6							⊕ ~9; + ~48		Silica Sand
6		End of Borehole Note: Stratigraphy inferred from Borehole 12-21	5.94						W.L in Standpipe at 1.56 m depth below ground surface on March 21, 2012

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: PAH

CHECKED: SD

APPENDIX B

Record of Borehole Sheets
Previous Investigation

PROJECT: 05-1120-894

RECORD OF BOREHOLE: 05-3

SHEET 1 OF 1

LOCATION: See Site Plan N 242.170 E 1104.200

BORING DATE: Oct. 11, 2005

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (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 (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		97.89							
0	Power Auger 200mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Brown SILTY SAND, trace gravel, organic matter		97.66 0.23	2	GS					
		Compact brown grey SAND, trace gravel		97.33 0.56							
1					1	50 DO	12				Native Backfill
		Loose to compact grey SAND, trace silt		96.21 1.68	3	50 DO	21				
2					4	50 DO	8				
		Firm to stiff grey SILTY CLAY, trace sand		95.15 2.74							
3					5	50 DO	4				Silica Sand
4					6	50 DO	6				Standpipe
		End of Borehole		93.32 4.57							
5											Water level in standpipe at elev. 97.39m on Nov. 2, 2005
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: E.L.

RECORD OF BOREHOLE: 07-5

PROJECT: 05-1120-894-2000

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: May 22, 2007

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200mm Diam. (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m
	GROUND SURFACE	100.10			
0	TOPSOIL	0.00			
	Yellow brown SILTY SAND	99.80 0.30			
	Very loose brown fine to medium SAND	99.55 0.55	1	50 DO	3
1	Loose brown fine to coarse SAND	98.88 1.22	2	50 DO	15
	Compact brown to grey fine SAND	98.27 1.83	3	50 DO	17
2–3	Firm to stiff grey SILTY CLAY	97.42 2.68			
4	Stiff to very stiff grey SILTY CLAY, scattered trace gravel	95.99 4.11	4	50 DO	3
	Compact grey SANDY SILT and CLAYEY SILT	94.31 5.79	5	50 DO	5
6	End of Borehole	94.00 6.10			

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 (20 40 60 80)

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION: ∇ (at 0.7 m)

Water level in open hole at 0.7m depth below ground surface upon completion of drilling

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED: TMS

RECORD OF BOREHOLE: 07-6

LOCATION: See Site Plan

BORING DATE: May 18, 2007

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE	100.06				
	Power Auger, 200mm Diam. (Hollow Stem)	TOPSOIL	100.06 / 0.00				
		Yellow brown SILTY SAND	99.76 / 0.30				∇
		Loose brown to grey fine SAND, trace silt	99.39 / 0.67	1	50 DO	6	
				2	50 DO	9	
		Loose grey fine to medium SAND	97.93 / 2.13				
		Loose grey SANDY SILT with clayey silt seams	97.47 / 2.59	3	50 DO	7	
				4	50 DO	9	
		Firm to very stiff grey layered SILTY CLAY and CLAYEY SILT	96.34 / 3.72	5	50 DO	2	
		Compact grey SANDY SILT with clayey silt layers	95.18 / 4.88	6	50 DO	6	
				7	50 DO	12	
		End of Borehole	94.27 / 5.79				Water level in open hole at 0.6m depth below ground surface upon completion of drilling

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - O; 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—O^W—⊣ Wl; 20 40 60 80

ADDITIONAL LAB. TESTING

DEPTH SCALE 1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED: TMS

APPENDIX C

Results of Chemical Analysis
Exova Accutest Report No. 1205762

Certificate of Analysis

Exova

Client:	Golder Associates Ltd. (Ottawa) 32 Steacie Drive Kanata, ON K2K 2A9
Attention:	Mr. Alex Meacoe
PO#:	
Invoice to:	Golder Associates Ltd. (Ottawa)

Report Number:	1205762
Date Submitted:	2012-03-30
Date Reported:	2012-04-09
Project:	10-1125-0034
COC #:	156827

Group	Analyte	MRL	Units	Guideline	948968	948969	948970
				Lab I.D. Sample Matrix Sampling Date Sample I.D.	948968 Soil 2012-03-20 BH 12-20 SA 3	948969 Soil 2012-03-20 BH 12-3 SA 1	948970 Soil 2012-03-07 BH 12-7 SA 3
Agri. - Soil	Electrical Conductivity	0.05	mS/cm		<0.05	<0.05	0.07
	pH	2.0			7.2	7.5	8.3
General Chemistry	Cl	0.002	%		<0.002	<0.002	<0.002
	Resistivity	1	ohm-cm		>20000	>20000	14300
	SO4	0.01	%		0.01	0.03	<0.01

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective.

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