REPORT

Geotechnical Investigation Proposed Residential Development Fernbank Road and Terry Fox Drive Kanata, Ontario

Submitted to:

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for Phase II of the Bridlewood Trails residential development to be located on lands southeast of the intersection of Fernbank Road and Terry Fox Drive in Kanata (Ottawa), Ontario.

The purpose of this subsurface investigation was to determine the general soil and groundwater conditions across Phase II of the development by means of a limited number or boreholes and, based on an interpretation of the factual information obtained, to provide engineering guidelines on the geotechnical design aspects of the project, including construction considerations which could affect design decisions.

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 to develop Phase II of the Bridlewood Trails residential subdivision which is located on lands southeast of the intersection of Fernbank Road and Terry Fox Drive in Ottawa, Ontario (see Key Plan, in Figure 1).

This phase of the development, which is located about 120 metres south of the intersection of Fernbank Road and Terry Fox Drive, and immediately west of Phase I of the development, measures approximately 500 metres by 155 metres in plan dimension.

It is understood that this phase of the development is proposed to consist of conventional townhouse blocks.

The site is currently undeveloped and is used as agricultural (crops) lands, although it is currently fallow.

Golder Associates carried out a geotechnical investigation for Phase I of this development in 2005. The results of that investigation were provided in a report to Claridge Homes titled “*Geotechnical Investigation, Proposed Residential Development, Eagleson Road at Fernbank Road, Ottawa, Ontario*” dated August 2005 (report number 05-1120-079).

Based on the results of the above investigations, the subsurface conditions on this site are expected to consist of limited thicknesses of surficial silts and sands overlying a thick deposit of sensitive silty clay.

Published geological maps indicate that the underlying bedrock in the area of the site consists of limestone of the Gull River formation.

3.0 PROCEDURE

The field work for this investigation was carried out in two phases, as follows:

- ***First Phase:*** The first phase of the investigation was carried out between March 20 and 23, 2007, and included four boreholes (numbered 07-1 to 07-4, inclusive). The boreholes were advanced to depths ranging from about 6.4 to 8.5 metres below the existing ground surface.
- ***Second Phase:*** The second phase of the investigation was carried out between September 23 and 27, 2010, and included 3 boreholes (numbered 10-1 to 10-3, inclusive). The boreholes were advanced to depths ranging from about 14 to 35 metres below the existing ground surface. At each location, two or three separate borings were required to complete the sampling, testing, and/or piezometer installations (labelled “A”, “B”, or “C”, as required).

The approximate borehole locations are 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.

Within all of the boreholes, standard penetration tests were carried out at regular intervals of depth and samples of the soils encountered were recovered using drive open sampling equipment to depths varying from about 3.7 to 8.5 metres. Within boreholes 07-1 to 07-4, the undrained shear strength of the silty clay was measured using a conventional N-vane. Within boreholes 10-1 to 10-3, the undrained shear strength of the silty clay was measured using an electric Nilcon vane.

In addition to the samples recovered using drive open sampling equipment, relatively undisturbed 73 millimetre diameter thin walled Shelby tube samples of the silty clay were obtained from boreholes 07-1, 07-3, 07-4, 10-1, and 10-3 using a fixed piston sampler.

Standpipes were sealed into boreholes 07-2, 10-1, and 10-3 to allow subsequent measurement of the groundwater level at the site.

The field work for this investigation was supervised by a technician from our staff who located the boreholes, directed the drilling operations, logged the boreholes and samples, directed the in situ testing, and took custody of the soil samples retrieved.

On completion of the drilling operations, samples of the soils encountered in the boreholes were transported to our laboratory for examination by the project engineer and for laboratory testing. The laboratory testing included natural water content and Atterberg limit tests. As well, four of the Shelby tube samples were submitted for laboratory oedometer consolidation testing to assess the consolidation characteristics of the silty clay.

The groundwater level in the standpipe in borehole 07-2 was measured on April 30, 2007. The groundwater levels in the standpipes in boreholes 10-1 and 10-3 were measured on November 8, 2010.

Samples of soil from boreholes 07-2, and 10-2 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.

The borehole locations were selected and picketed in the field by Golder Associates prior to commencement of the field work. The final locations and elevations of boreholes 07-1 to 07-4 were surveyed by Annis O’Sullivan Vollebekk Ltd. The final locations and elevations of boreholes 10-1 to 10-3 were surveyed by Novatech Engineering Consultants Ltd. It is understood that the borehole elevations are referenced to Geodetic datum.

4.0 SUBSURFACE CONDITIONS

4.1 General

The subsurface conditions encountered in the boreholes are shown on the Record of Borehole Sheets in Appendix A. The results of the water content and Atterberg limit testing carried out on selected samples are given on the Record of Borehole Sheets. The results of the grain size distribution testing carried out on two samples of soil are provided on Figure 3. Summaries of the results of the oedometer consolidation tests are provided on Figures 4 to 7 (inclusive).The results of the basic chemical analysis on soil samples from boreholes 07-2 and 10-2 are provided in Appendix B.

In general, the subsurface conditions on this site consist of up to about 0.4 metres of topsoil overlying about 1.4 to 3.4 metres of sandy silt, silty sand, and clayey silt, which in turn overlie a thick deposit of sensitive silty clay.

The following sections present a summarized overview of the subsurface conditions encountered in the boreholes.

4.2 Fill Material and Topsoil

Fill material exists at the ground surface at boreholes 07-2 and 10-3. At these locations, the fill material has a thickness of about 120 and 130 millimetres, respectively, and consists of silty clay and sandy silt.

Topsoil underlies the fill material in boreholes 07-2 and 10-3 and exists at the ground surface at all of the remaining borehole locations. The topsoil ranges between 150 and 370 millimetres in thickness.

4.3 Upper Silts

The topsoil is underlain by layered deposits of clayey silt, sandy silt, and silty sand. These deposits range from about 1.4 to 3.4 metres in thickness.

The results of standard penetration tests carried out in the layered deposits gave ‘N’ values ranging from about 1 to 8 blows per 0.3 metres of penetration, indicating a very loose to loose state of packing and/or firm to stiff consistency.

The results of grain size distribution testing carried out on 2 samples from the upper silts are provided on Figure 3.

The measured water contents of samples of these deposits ranged from about 18 to 42 percent.

4.4 Sensitive Silty Clay

The layered deposits of clayey silt, sandy silt, and silty sand are underlain by a thick deposit of sensitive silty clay.

The upper portion of the silty clay in borehole 07-4 has been weathered to a firm grey brown crust. The weathered crust has a thickness of about 0.5 metres and extends down to a depth of about 2.1 metres below the existing ground surface.

One standard penetration test carried out within the weathered silty clay crust gave an SPT ‘N’ value of 1 blow per 0.3 metres of penetration, indicating a firm consistency.

The measured water content of one sample of the weathered silty clay crust was about 29 percent.

The silty clay below the depth of weathering in borehole 07-4 and the full depth of the silty clay in boreholes 07-1, 07-2, 07-3, 10-1, 10-2, and 10-3 is unweathered and grey in colour. The silty clay was not fully penetrated by the individual boreholes but was proven to depths which vary from about 6.1 to 35 metres below the existing ground surface. The silty clay deposit contains occasional black organic matter, shells, and sand seams.

The results of in situ vane testing in this material gave undrained shear strengths ranging from 17 to greater than 96 kilopascals, increasing with depth, indicating a soft to very stiff consistency.

The results of Atterberg limit testing carried out on four samples of the silty clay gave plasticity index values ranging from 8 to 22 percent and liquid limit values ranging from 24 to 41 percent, indicating a low to medium plasticity soil. The measured water content of the grey silty clay ranges from 27 to 51 percent which is generally in excess of the measured liquid limit.

Oedometer consolidation testing was carried out on four relatively undisturbed samples of the silty clay and the results of this testing are summarized on Figures 4 to 7. The results of that testing are summarized below.

Borehole/ Sample No.	Sample Depth/Elev.(m)	Unit Wt. (kN/m^3)	σ_P' (kPa)	σ_{vo}' (kPa)	Cc	Cr	e_o	OCR
07-3 / 3	3.50 / 93.18	18.0	80	38	0.45	0.017	1.05	2.1
07-3 / 4	5.00 / 91.68	18.3	80	50	0.45	0.013	1.01	1.6
10-3 / 4	2.76 / 93.68	17.8	95	28	0.68	0.003	1.22	3.4
10-3 / 6	4.98 / 91.46	18.2	100	48	0.51	0.005	1.04	2.1

Notes:

σ_P' - Apparent preconsolidation pressure
σ_{VO}' - Computed existing vertical effective stress
Cc - Compression index
Cr - Recompression index
e_o - Initial void ratio
OCR - Overconsolidation ratio

The above results therefore indicate an apparent overconsolidation in the deposit, which is the difference between the deposit's preconsolidation pressure (i.e., yield stress) and the existing effective stress level, of about 30 to 65 kilopascals.

4.5 Groundwater

The groundwater level in the piezometer in borehole 07-2 was measured on April 30, 2007.At that time, the groundwater level was approximately 0.6 metres below the existing ground surface. The groundwater levels in the piezometers in boreholes 10-1 and 10-3 were measured on November 8, 2010. At that time, the groundwater levels were approximately 0.5 metres below the existing ground surface.

It should be noted that groundwater levels are expected to fluctuate seasonally. Higher and lower groundwater levels are expected during wet and dry periods of the year.

5.0 PROPOSED RESIDENTIAL DEVELOPMENT

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of this project based on our interpretation of the borehole information 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 Site Grading

In general, the subsurface conditions on this site consist up to about 0.4 metres of topsoil overlying up to about 3.5 metres of layered clayey silt, sandy silt, and silty sand, which in turn overlie a thick deposit of compressible and sensitive silty clay.

The silty clay has limited capacity to accept additional load from the weight of grade raise fill placed across the site and from the foundations of houses without undergoing significant consolidation settlement. To leave sufficient remaining capacity for the silty clay to support house foundations with reasonable footing sizes, the thickness of grade raise fill on this site will need to be limited.

In making the site grading assessment, certain assumptions have been made regarding the footing depths, width, and loads, as discussed subsequently in Section 5.3 of this report.

Based on the above, it is considered that the grade across this site should be raised no higher than 0.9 metres above the existing ground surface level in the area of houses and no higher than 1.2 metres in the area of roadways and parking lots. For Block 14, where the grade raise exceeds 1.2 metres in the areas of roadways and parking lots, consideration can be given to raising the grade with expanded polystyrene (EPS) Geofoam light weight fill, as discussed in Section 5.10 of this report.

Our assessment also indicates that conventional house construction, which typically provides about 2.3 to 2.4 metres of soil cover from the underside of footing level to the finished grade, may only be marginally feasible, and would require wider footings designed with lower bearing pressures (i.e., the footings will be wider than 0.6 metres and designed for bearing pressures less than 75 kilopascals). Our analysis also indicates that a minimum grade raise of 0.5 metres will be required to limit the stress imparted by the footings on the underlying compressible grey silty clay (i.e., if the footings are founded deeper than 1.8 metres below the ***existing*** grade, the loads from the footings would not be sufficiently distributed prior to reaching the grey silty clay).

If a minimum of 0.5 metres of grade raise fill cannot be accommodated with conventional depth basements, consideration could be given to restricting the houses to “High Ranch” style with the footings having only 1.8 metres of earth cover. By using “High Ranch” style houses, the house footings will be shallower (i.e. higher), which allows the stress from the foundations to be more distributed prior to reaching the compressible grey silty clay.

If the two grading restrictions given above cannot be accommodated, (i.e., maximum and minimum grade raises) the following four additional options could be considered:

1) Expanded polystyrene (EPS) could be used for the backfilling of the garages (and porches) for both conventional house foundation depths and “High Ranch” style houses. The use of EPS as backfill within the garages would allow for the beneficial ‘unloading’ effect of the foundation excavation to be considered in the analyses. Although the removal of soil to construct the basement results in an unloading effect on the soil beneath the house that at least partially compensates for the loads from the foundations and surrounding fill weight, that beneficial effect cannot usually be considered because the garage excavation is backfilled. As such, the stress conditions beneath the garage area, for which there is no unloading effect, typically govern the assessment of the permissible grading. If, however, EPS backfill materials are used within the garages and porches, then a compensating unloading effect can be considered for the entire house footprint. Our analyses indicate that if EPS is used in the garages and porches (as the full backfill), then a grade raise of up to 1.2 metres can be permitted around the “High Ranch” style houses.

2) The additional required grade raising could be accomplished using expanded polystyrene (EPS) light weight fill. As a preliminary guideline, the additional fill required within about 3 metres of the foundation walls would consist of the EPS fill. However, this guideline can be refined and it may in fact be preferable, from a constructability perspective, to replace a portion of the overall wall backfill, from footing level up to finished grade, with the EPS, and extend a lesser distance out from the wall. This alternative arrangement may be feasible; however, the details of the EPS fill placement can only be confirmed once the grade level and footing levels have been established.

3) The area could be preloaded and allowed to settle in advance of house construction. The subgrade settlements would need to be monitored to establish when sufficient settlements had occurred such that house construction could proceed. To reduce the time required for the pre-loading, it is likely that a temporary surcharge above the existing grade would need to be considered, however in either case the pre-load time is likely between 9 months and 2 years, with more analysis needed to refine these timeframes.

4) The houses could be supported on deep foundations, which derive their support from more competent bearing below the “softer” silty clay.

Additional geotechnical guidelines would need to be provided if options 2, 3, and 4 are selected. Additional investigation could also be required (in particular for Options 3 and 4) before those guidelines could be finalized.

As a general guideline regarding the site grading, the preparation for filling of the site should include stripping the fill material and topsoil for predictable performance of structures and services. The topsoil is not suitable as engineered fill and should be stockpiled separately for re-use in landscaping applications only. In areas with no proposed structures, services, or roadways, the fill material and topsoil may be left in-place provided some settlement of the ground surface following filling can be tolerated.

5.3 Foundations

It is considered that the proposed residences may generally be supported on spread footings on or within the layered sand and silt materials, at depths less than about 1.8 metres below the existing ground surface.

As discussed in the preceding section, the silty clay deposit has limited capacity to accept the combined load from site grading fill and foundation loads. The allowable bearing pressures for spread footing foundations at this site are therefore based on limiting the stress increases on the soft, compressible, grey silty clay to an acceptable level so that foundation settlements do not become excessive. Four important parameters in calculating the stress increase on the grey silty clay are:

- The thickness of soil below the underside of the footings and above the compressible silty clay;
- The size (dimensions) of the footings;
- The amount of surcharge in the vicinity of the foundation due to grade raise/landscape fill, underslab fill, floor loads, etc., as described in Section 5.2; and,
- The effects of groundwater lowering caused by this or other construction.

Conventional house foundation design, in accordance with Part 9 of the Ontario Building Code, is based on there being an available bearing pressure of 75 kilopascals for footing widths of about 0.6 metres. It is not however considered to be generally feasible at this site, in conjunction with the maximum permitted site grade raises given in Section 5.2 of this report, to support the house footings at that bearing pressure. In fact, to achieve bearing pressures that will be sufficient to support the house foundations, albeit with somewhat wider than typical footings, some deviation from typical house construction will be required. Typical house construction also involves footings placed at about 2.3 to 2.4 metres depth beneath the finished exterior grade level. However, for this site, by using shallower footings, located no more than 1.8 metres below the finished grade level, the stress increase from the footing loads onto the soft silty clay layer is reduced.

The following table summarizes the permissible bearing pressures and grade raises that correspond to various design options:

Footing Depth Below Finished Grade (metres)	Maximum Allowable Bearing Pressure (kilopascals)	Corresponding Maximum Footing Width (metres)	Garage and Porch Backfill	Maximum Permissible Grade Raise[(3)] (metres)
2.3	55	0.6	Conventional[(1)]	0.9
	50	>0.6 to 0.8	Conventional[(1)]	0.9
	45	>0.8 to 0.9	Conventional[(1)]	0.9
	40	>0.9 to 1.0	Conventional[(1)]	0.9
	70	0.6	LWF[(2)]	0.9
	65	>0.6 to 0.7	LWF[(2)]	0.9
	55	>0.7 to 0.9	LWF[(2)]	0.9
	50	>0.9 to 1.0	LWF[(2)]	0.9
1.8	75	0.6 to 1.0	Conventional[(1)]	0.9
	75	0.6 to 1.0	LWF[(2)]	1.2
1.8 – 1.9[(4)]	75	0.6 to 1.5	LWF[(2)]	1.7

Notes : (1) – The backfill within the garages and porches should have a maximum unit weight of 19 kilonewtons per cubic metre.

(2) – LWF should consist of EPS with a unit weight of no more than 1 kilonewton per cubic metre.

(3) – Minimum grade raise of 0.5 metres.

(4) – For Block 14, the grading plan (Drawing No. 114013-GR, Revision 9 (dated September 7, 2018) prepared by Novatech Engineering Consultants Ltd. – Project No. 114013) indicates that the grade raise at this Block ranges from about 1.2 to 1.7 metres above the existing ground surface. For the houses in this block, expanded polystyrene (EPS) Geofoam light weight fill is required in porches and above any exterior footing projections at the limits shown on GEO-01 (i.e., EPS should extend out from the foundation walls toward the edge of the footings), the EPS must extend a minimum of 1.0 metres out from the foundation walls, even if the footings do not.

The above allowable bearing pressures are based on the criteria of limiting the stress level within the silty clay at an acceptable margin below the deposit’s preconsolidation pressure. However, in assessing the needed level of margin, and noting that the total thickness of the clay deposit at this site is not known but is significant, it is considered that the post construction total and differential settlements of footings sized using the above maximum allowable bearing pressure and grading restrictions should be less than about 40 and 25 millimetres, respectively, provided that the soil at or below founding level is not disturbed during construction.

The tolerance of the house foundations to accept those settlements could be increased by providing a nominal amount of reinforcing steel in the top and bottom of the foundation walls. Houses without projecting garages, but rather with garages that are more integral with the overall house foundation/footprint, would also be more tolerant to these settlements. The above measures, though not necessarily essential for this site, should be given strong consideration.

There may be portions of the site where the shallow silty sand deposits will be exposed at footing/subgrade level. Prior to construction of footings or the placement of engineered fill within these areas, the surface of the native sandy material should be proof-rolled to provide surficial densification of any loose or disturbed material.

Since these shallow sandy deposits, wherever present, are typically loose, they could be potentially liquefiable in an earthquake (i.e., potentially subject to temporary strength loss and post-earthquake settlements). That potential issue is not however considered relevant to the house design because:

- The expected long-term groundwater level will generally be below these soils, such that they will be above the water level and therefore non-liquefiable
- The potential post-earthquake differential settlements would be relatively small in relation to the expected collapse potential of a house (and the objective of earthquake-resistant design is only to avoid collapse and to provide for safe exit).
- The proof rolling of the sandy subgrade soils, as specified above, would densify any such soils in the immediate area of the footings and therefore the directly supporting soils would be non-liquefiable.

5.4 Seismic Design and Considerations

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 bedrock below founding level. Based on the 2006 Ontario Building Code methodology, this site could be assigned a Site Class of E (for any structures requiring design under Part 4 of the Ontario Building Code).

5.5 Basement Excavations

Excavation for basements will be through the layered sandy silt, silty sand, clayey silt and possibly into the underlying silty clay. It is not expected that the excavations would extend into the underlying *soft* silty clay.

Based on present groundwater levels, excavations deeper than about 0.5 to 1.0 metres will extend below the groundwater level. Where this is the case, the excavation will be subject to time dependent disturbance to the fine grained granular soils caused by the upward flow of groundwater, resulting in possible disturbance of the excavation subgrade and potential instability of the excavation side slopes.

It is considered that it should generally be possible to handle the groundwater inflow by pumping from well filtered sumps in the floor of the excavations. Where the subgrade is found to be wet and sensitive to disturbance, consideration should be given to placing a mud slab of lean concrete over the subgrade (following inspection and approval by geotechnical personnel) or a 150 millimetre thick layer of OPSS Granular A underlain by a non-woven geotextile to protect the subgrade from construction traffic.

Some pre-drainage of the site using ditching or one or more shallow wells to lower the groundwater level to at least 0.5 metres below the floor of the excavation would assist in avoiding subgrade disturbance.

It should be noted that installation of the site services will likely result in some limited lowering of the general groundwater level and improved excavating conditions.

Where the groundwater level is lowered below the floor of the excavation in advance of construction, excavation side slopes should be stable in the short term at 1 horizontal to 1 vertical (i.e., Type 3 Soil). Excavation side slopes below groundwater level in the upper silt deposit will slough to a somewhat flatter inclination.
In accordance with the Occupational Health and Safety Act of Ontario, these excavation side slopes would likely need to be cut back at 3 horizontal to 1 vertical (i.e., Type 4 Soil).

5.6 Basement and Garage Floor Slabs

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

To prevent hydrostatic pressure build up beneath the basement 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 underfloor fill and the exterior drainage system.

The backfill material inside the garage should have a unit weight no greater than 19 kilonewtons per cubic metre (i.e., uniform fine sand or clear crushed stone). The garage backfill should be placed in maximum 300 millimetre thick lifts and be compacted to at least 95 percent of the materials standard Proctor maximum dry density using suitable compaction equipment. The granular base for the garage floor slab should consist of at least 150 millimetres of Granular A compacted to at least 95 percent of the materials standard Proctor maximum dry density using suitable compaction equipment. Further details will be required if it is decided to backfill the garages with EPS.

The general groundwater level at this site is estimated to be at about 0.5 to 1.0 metres depth. The upper silt deposit at this site are somewhat permeable and therefore long term groundwater inflow from these materials to the underslab drainage system could occur. Ideally, from a constructability perspective, excavations below the groundwater level in these soils should be avoided. However, if/where 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 OPSS 1860.

5.7 Frost Protection

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 and/or 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.

For houses without EPS light weight fill, insulation of the bearing surface with high density insulation could be considered as an alternative to earth cover for frost protection. The details for footing insulation could be provided, if and when required.

5.8 Basement Walls and Foundation Wall Backfill

The soils at this site are frost susceptible and 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. Alternatively, these foundation elements could be backfilled with non-frost susceptible sand, provided it meets the unit weight restriction of 19 kilonewtons per cubic metre.

Drainage of the wall backfill should be provided by means of a perforated pipe subdrain in a surround of 19 millimetre clear stone, 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.

Where design of basement walls in accordance with Part 4 of the 2006 Ontario Building Code is required, walls backfilled with granular material and effectively drained as described above should be designed to resist lateral earth pressures calculated using a triangular distribution of the stress with a base magnitude of $K_o\gamma H$, where:

K_o = The lateral earth pressure coefficient in the ‘at rest’ state, use 0.5;

γ = The unit weight of the granular backfill, use 22 kilonewtons per cubic metre; and,

H = The height of the basement wall in metres.

If Platon System sheeting or similar water barrier product is used against the foundation walls, then hydrostatic groundwater pressures should also be considered in the calculation of the lateral earth pressures.

5.9 Site Servicing

Excavation for the installation of site services will be made through the layered sandy silt, silty sand, clayey silt and silty clay, and will likely extend into the deeper *soft* silty clay.

No unusual problems are anticipated in trenching in the overburden using conventional hydraulic excavating equipment. As described above, the upper silt deposit above the water table and the firm silty clay would generally be classified as a Type 3 soil in accordance with the Occupational Health and Safety Act of Ontario. As such, these excavations may be made with side slopes at 1 horizontal to 1 vertical. However, excavations within the sandy soils below the water table as well as into the underlying soft silty clay would be classified as a Type 4 soil; side slopes as flat as 3 horizontal to 1 vertical would therefore be required. Alternatively, the excavations could be carried out using steeper side slopes with all manual labour carried out within a fully braced, steel trench box for worker safety. The stability of braced excavations which could extend into the soft grey silty clay should be assessed individually based on the length, width, and depth of the trench box. For example, the basal stability of a braced excavation 3 metres wide by 10 metres long to 4 metres depth would be about 2.0, which is acceptable. Shorter, more narrow, or shallower trenches will therefore also be stable. Further guidance on trenches that exceed the above limits can be provided.

Some groundwater inflow into the trenches should be expected. In particular, excavations below about 1.0 to 1.5 metres depths in the sandy silt and silty sand material would experience significant groundwater inflow. However, it should be possible to handle the groundwater inflow by pumping from well filtered sumps established in the floor of the excavations, provided suitably sized pumps are used.

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 compacted OPSS Granular B Type II beneath the Granular A or to thicken the Granular A bedding. The bedding material should in all cases extend to the spring line of the pipe and should be compacted to at least 95 percent of the standard Proctor maximum dry density. The use of clear crushed stone as a bedding layer should not be permitted anywhere on this project since fine particles from the sandy backfill materials or sandy soils on the trench walls 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 standard Proctor maximum dry density.

It should generally be possible to re-use the upper silt deposits as trench backfill. The upper silts may be difficult to compact due to its fine grained composition and relatively high water content. Some additional compactive effort should be anticipated. Where the trench will be covered with hard surfaced areas, 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. Trench backfill should be placed in maximum 300 millimetre thick lifts and should be compacted to at least 95 percent of the standard Proctor maximum dry density using suitable compaction equipment.

The high moisture content of the grey silty clay and clayey silt makes this soil difficult to handle and compact. If grey silty clay or clayey silt is excavated during installation of the site services, this material 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 grey silty clay or clayey silt is used in trenches under roadways, long term settlement of the pavement surface should be expected.

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 from the weathered zone.

5.10 Pavement Design

In preparation for pavement construction, all topsoil, disturbed, or otherwise deleterious materials should be removed 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 standard Proctor maximum dry density using suitable compaction equipment.

For the pavement areas in Block 14, where the grade raise exceeds 1.2 metres as discussed in Section 5.2 above. The EPS Geofoam light weight fill will be required for the full plan area of the roadways and parking lots with a thickness such that the grade raise fill is limited to a thickness of 1.2 metres (i.e., about 0.3 to 0.5 metres thick).

To minimize the potential of differential frost heaving at the curbs, and transition zones where there is no EPS, the EPS Geofoam light weight fill should be placed at the lowest elevation possible (i.e., the EPS should be placed on the approved subgrade prior to filling) and should be tapered at the edges. The taper should consist of 50 percent of the total thickness of the EPS for a horizontal length of at least 3.0 metres surrounding the required EPS footprint.

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 and parking lot areas should consist of:

Pavement Component	Thickness (millimetres)
Asphaltic Concrete	90
OPSS Granular A Base	150
OPSS Granular B Type II Subbase	450

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 II Subbase	600

The granular base and subbase materials should be uniformly compacted to at least 100 percent of the standard Proctor maximum dry density using suitable vibratory compaction equipment. The asphaltic concrete should be compacted in accordance with Table 9 of OPSS 310.

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

- Superpave 12.5 mm Surface Course - 40 millimetres
- Superpave 19 mm 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.

5.11 Corrosion and Cement Type

Samples of soil from boreholes 07-2, 07-5, and 10-2 were submitted to Exova Accutest Laboratories Ltd. for basic chemical analysis related to potential corrosion of buried steel elements and potential sulphate attack on buried 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 do however indicate an elevated potential for corrosion of exposed ferrous metal; this should be considered during the design of the utilities.

5.12 Trees

It should be noted that the silty clay at the site is highly sensitive to water depletion by trees of high water demand during periods of dry weather. When trees draw water from the silty clay, the silty clay undergoes shrinkage which can result in settlement of adjacent structures. The zone of influence of a tree is considered to be approximately equal to the height of the tree. Therefore, trees which have a high water demand should not be planted closer to structures than the ultimate height of the trees. Table 1 provides a list of the common trees in decreasing order of water demand and, accordingly, decreasing risk of potential effects on structures.

5.13 Pools, Decks and Additions

5.13.1 Above-ground and In-ground Pools

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.

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 edge of the house. The installation of an above-ground pool must also not alter the existing grades within 2 metres of the house (or possibly further is EPS backfill is used).

5.13.2 Decks

A geotechnical evaluation/assessment will be necessary for decks 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.

5.13.3 Additions

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 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 grading plan and specifications for this project prior to construction to ensure that the guidelines in this report have been adequately interpreted.

The groundwater level monitoring devices (i.e., standpipe piezometers or wells) 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 contract. If that is not the case or is not considered feasible, abandonment of the monitoring wells can be carried out separately.

Yours truly,

Golder Associates Ltd.

W. Alex Meacoe

Alex Meacoe, P.Eng.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
W. Alex Meacoe
W. A. MEACOE
100162115
SEPT 13, 2018
PROVINCE OF ONTARIO

Michael Snow

Michael Snow, P.Eng.
Principal, Senior Geotechnical Engineer

WAM/MSS/mvrd
\\golder.gds\gal\ottawa\active\2007\1121 - geotechnical\07-1121-0037 novatech bridlewood ii kanata\07-1121-0037 rpt-001 rev.02 bwt phase 5 sept 2018.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 practicing 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, **Claridge Homes Corporation.** 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

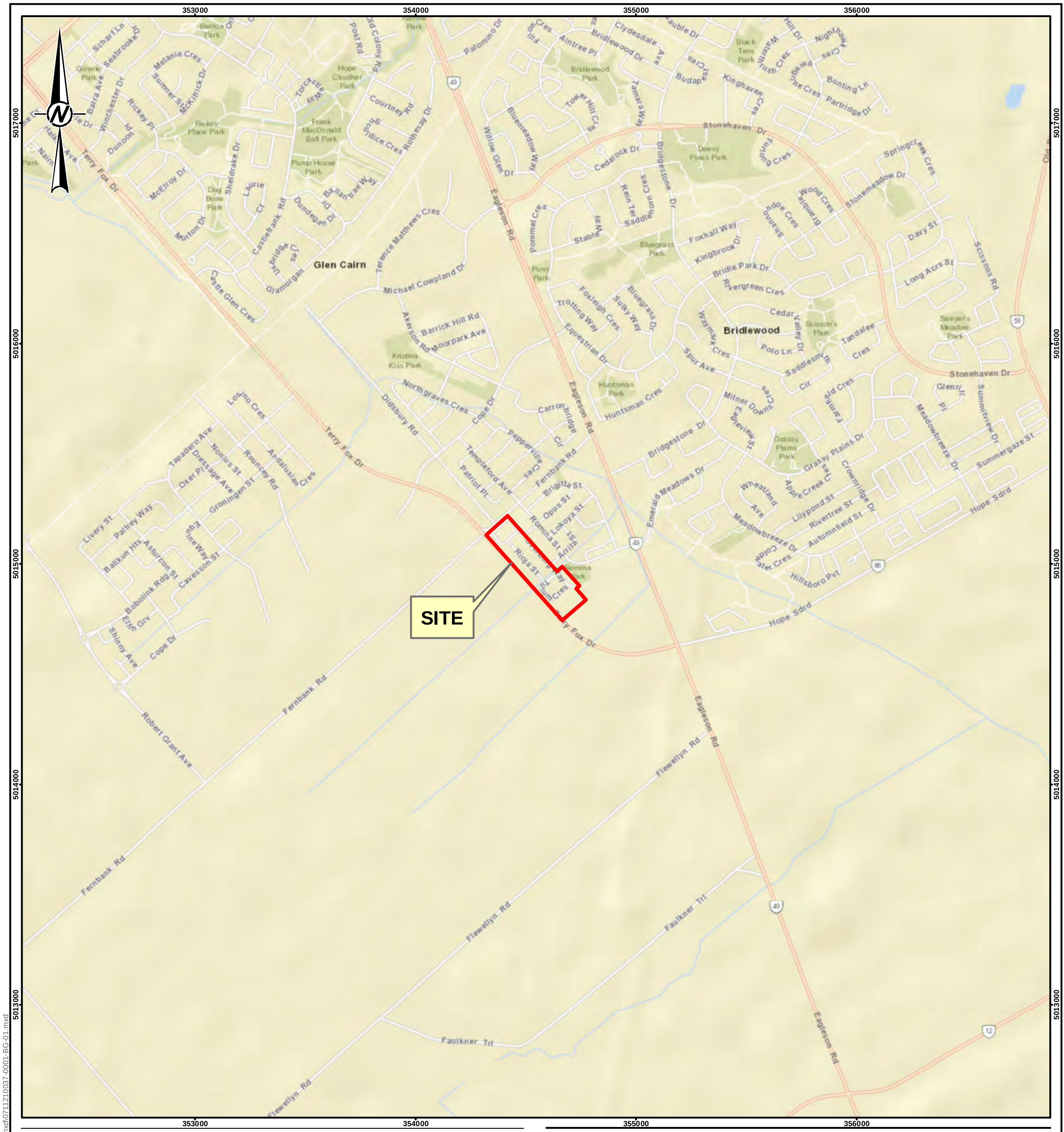
Larch

Evergreen Conifers

Spruce

Fir

Pine



0 250 500 1,000

1:25,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1. SERVICE LAYER CREDITS SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. PROJECTION: MERCATOR AUXILIARY SPHERE DATUM: WGS 84

CLIENT

CLARIDGE HOMES CORPORATION

PROJECT

GEOTECHNICAL INVESTIGATION
BRIDLEWOOD TRAILS PHASE II - OTTAWA, ONTARIO

TITLE

KEY PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2018-03-29
DESIGNED	----
PREPARED	PJM
REVIEWED	WAM
APPROVED	MSS

PROJECT NO.	CONTROL	REV.	FIGURE
07-1121-0037	0001	A	**1**

Path: N:\Active\2007\1121 - Geotechnical\07-1121-0037 Novatech Bridlewood II Kanata\GIS\mxd\0711210037-0001-BG-01.mxd

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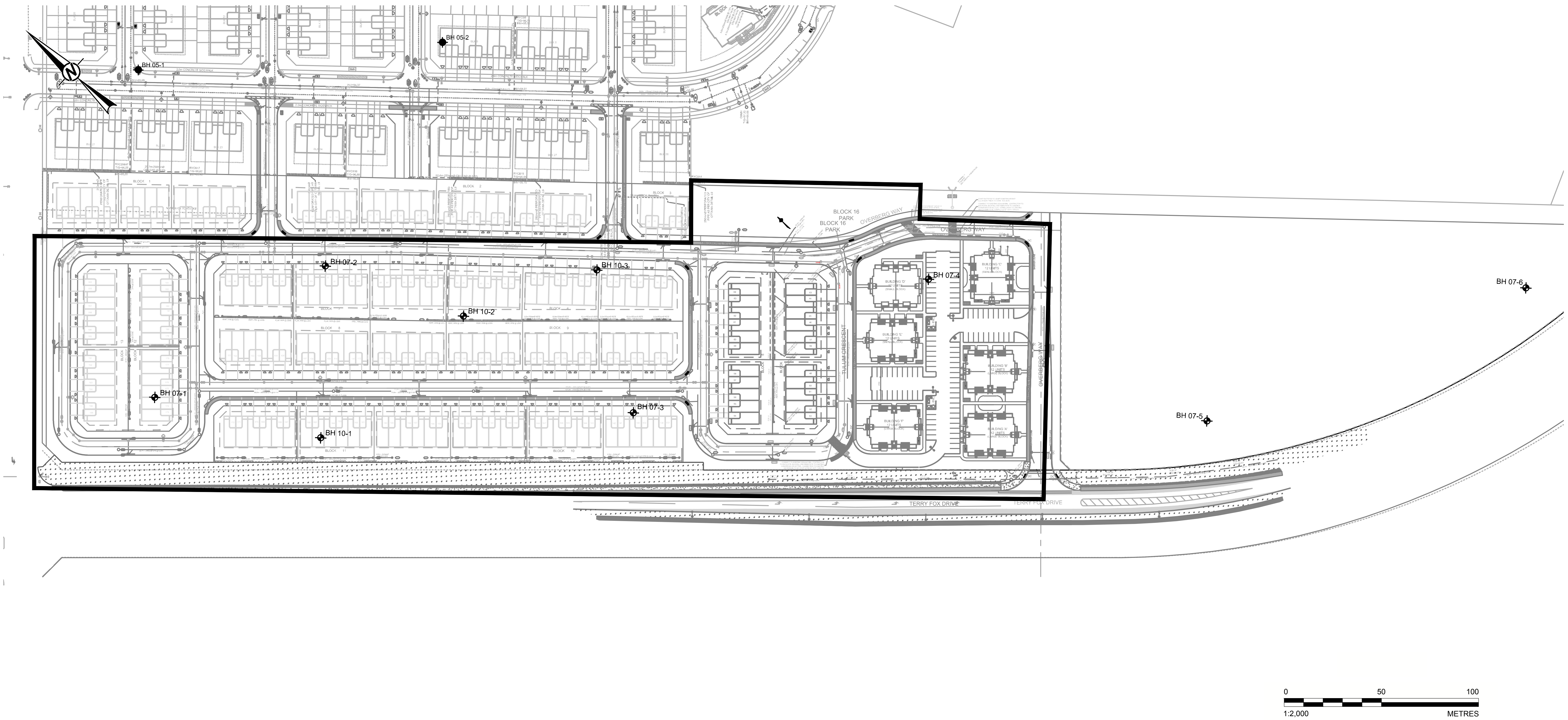
25mm

0



LEGEND

- ◆ BOREHOLE LOCATION IN PLAN- PREVIOUS INVESTIGATION (05-1120-0079)
- ⊕ BOREHOLE LOCATION IN PLAN- CURRENT INVESTIGATION
- ▬ LIMIT OF PHASE II

NOTE(S)

1. FOR CROSS-SECTION LOCATIONS REFER TO FIGURE GEO-02

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR, DATUM: NAD 83, COORDINATE SYSTEM: MTM ZONE 9, VERTICAL DATUM: CGVD28
2. BASE PLAN PROVIDED IN ELECTRONIC FORMAT BY NOVATECH ENGINEERING, (JUNE 20, 2013)

CLIENT
CLARIDGE HOMES

PROJECT
GEOTECHNICAL INVESTIGATION PHASE II - BRIDLEWOOD TRAILS DEVELOPMENT OTTAWA, ONTARIO

TITLE
SITE PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2017-07-18
DESIGNED	----
PREPARED	ABD
REVIEWED	WAM
APPROVED	MSS

PROJECT NO.	CONTROL	REV.	FIGURE
07-1121-0037	0001	----	2

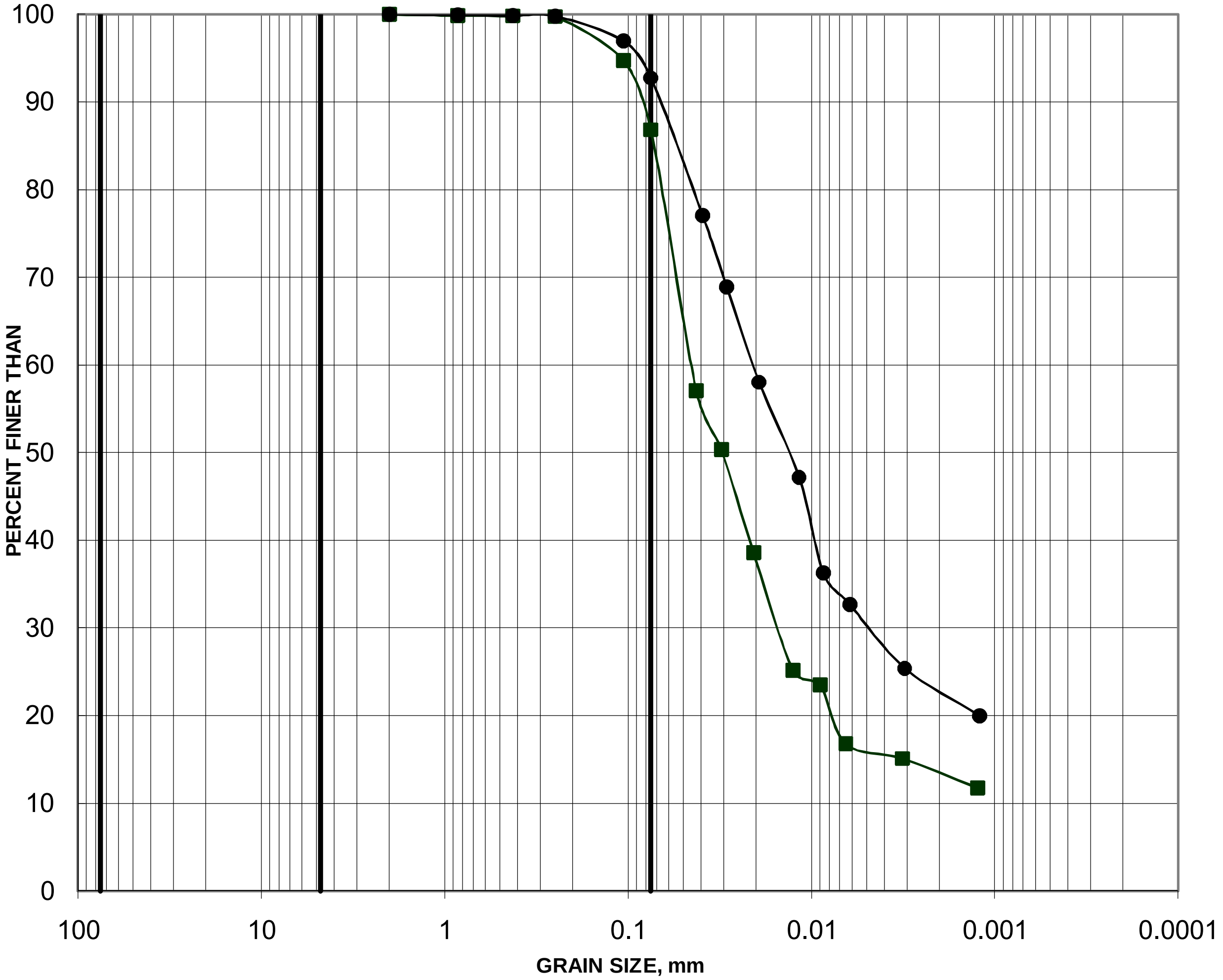
Path: \\golder.gds\gal\ottawa\Active\Spatial_IM\ClaridgeHomes\BridleWood_Trails\99_PROJ\0711210037_Claridge_Geotech\40_PROD\0001_Geotech\ | File Name: 0711210037-0001-BG-0004.dwg | Last Edited By: abrunsveld-dewar Date: 2018-07-18 Time:4:27:10 PM | Printed By: abrunsveld-dewar Date: 2018-07-18 Time:4:27:31 PM

25 mm
0
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

GRAIN SIZE DISTRIBUTION

FIGURE 3

LAYERED CLAYEY SILT AND SANDY SILT



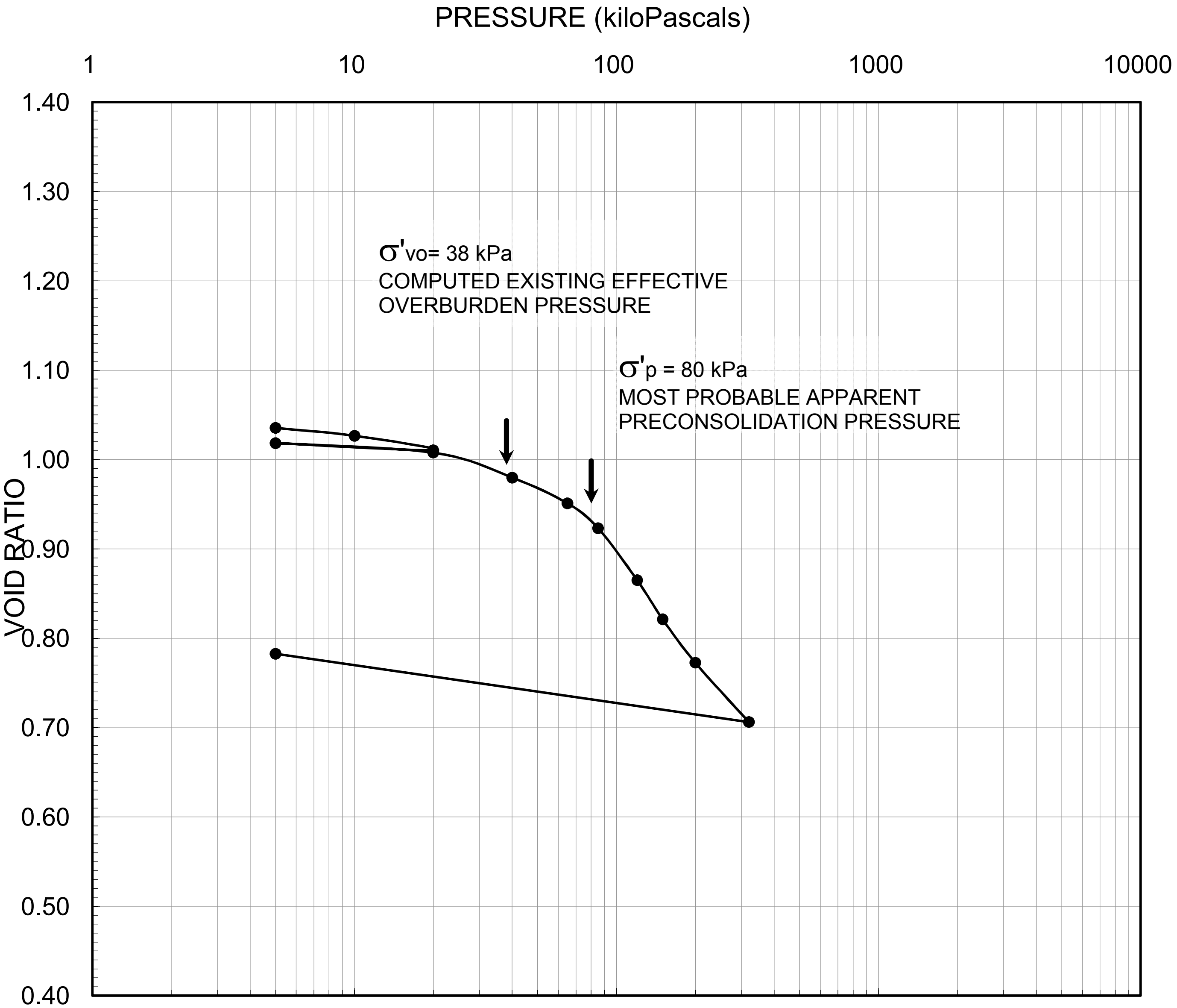
Cobble	coarse	fine	coarse	medium	fine	SILT AND CLAY
Size	GRAVEL SIZE		SAND SIZE			

Borehole	Sample	Depth (m)
■ 10-1A	1	0.76-1.37
● 10-3A	2	1.52-2.13

Project: 07-1121-0037

Golder Associates

Created by: CNM
Checked by: HT



LEGEND

Borehole: 07-3
Sample: 3
Depth (m): 3.50

w_i = 36.5%
w_f = 28.8%
w_l = 34.1%
w_p = 17.8%

S_o = 96%
C_c = 0.45
C_r = 0.017

Golder Associates

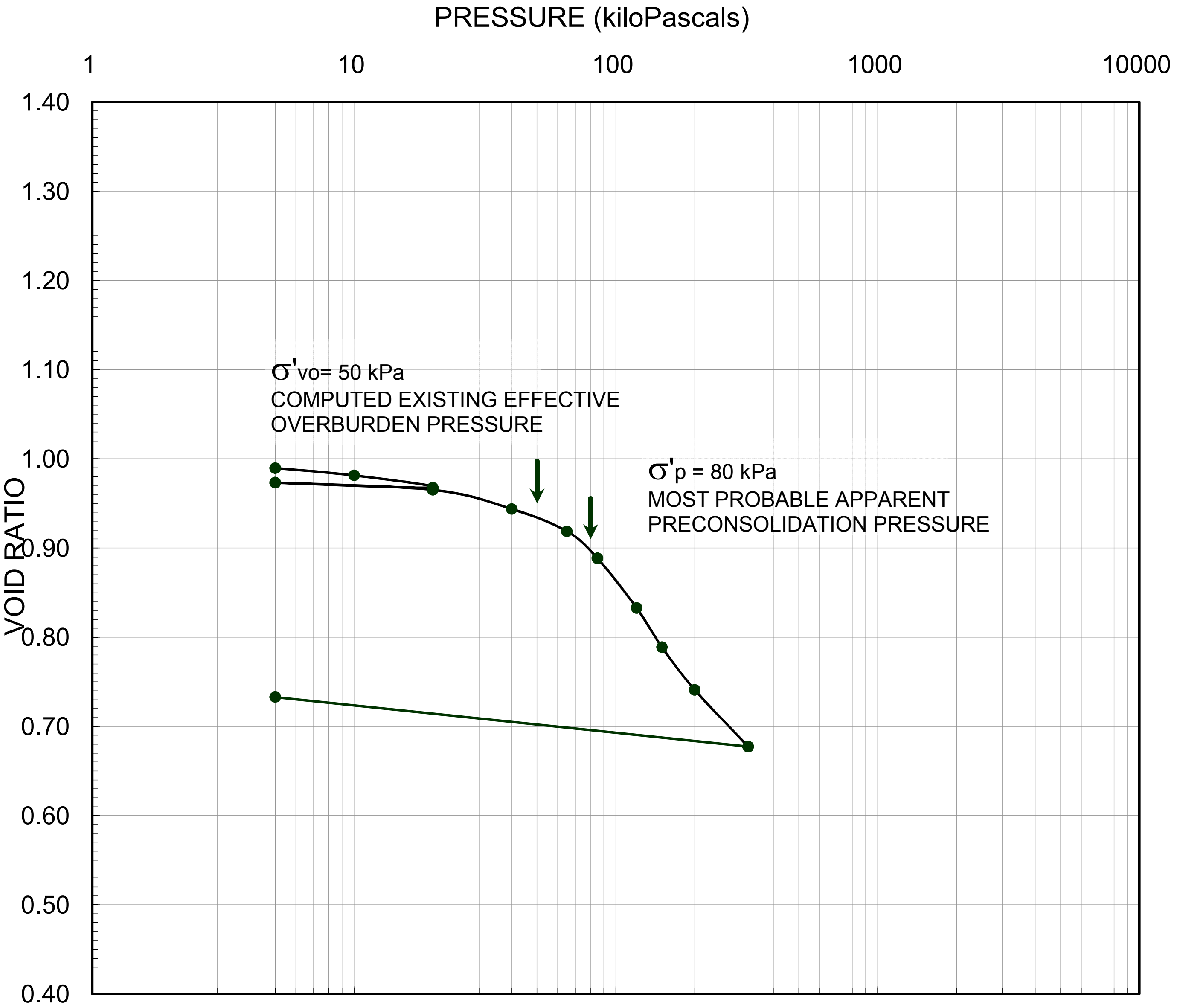
FILE No. Consolidation summary
PROJECT No. 0711210037 REV. 3

SCALE AS SHOWN
DATE 02/01/11
DESIGN
CADD
CHECK
REVIEW

TITLE

CONSOLIDATION TEST RESULTS

FIGURE 4



LEGEND

Borehole: 07-3
Sample: 4
Depth (m): 5.00

w_i = 36.4%
w_f = 28.1%
w_l = 25.2%
w_p = 17.3%

S_o = 99%
C_c = 0.45
C_r = 0.013

Golder Associates

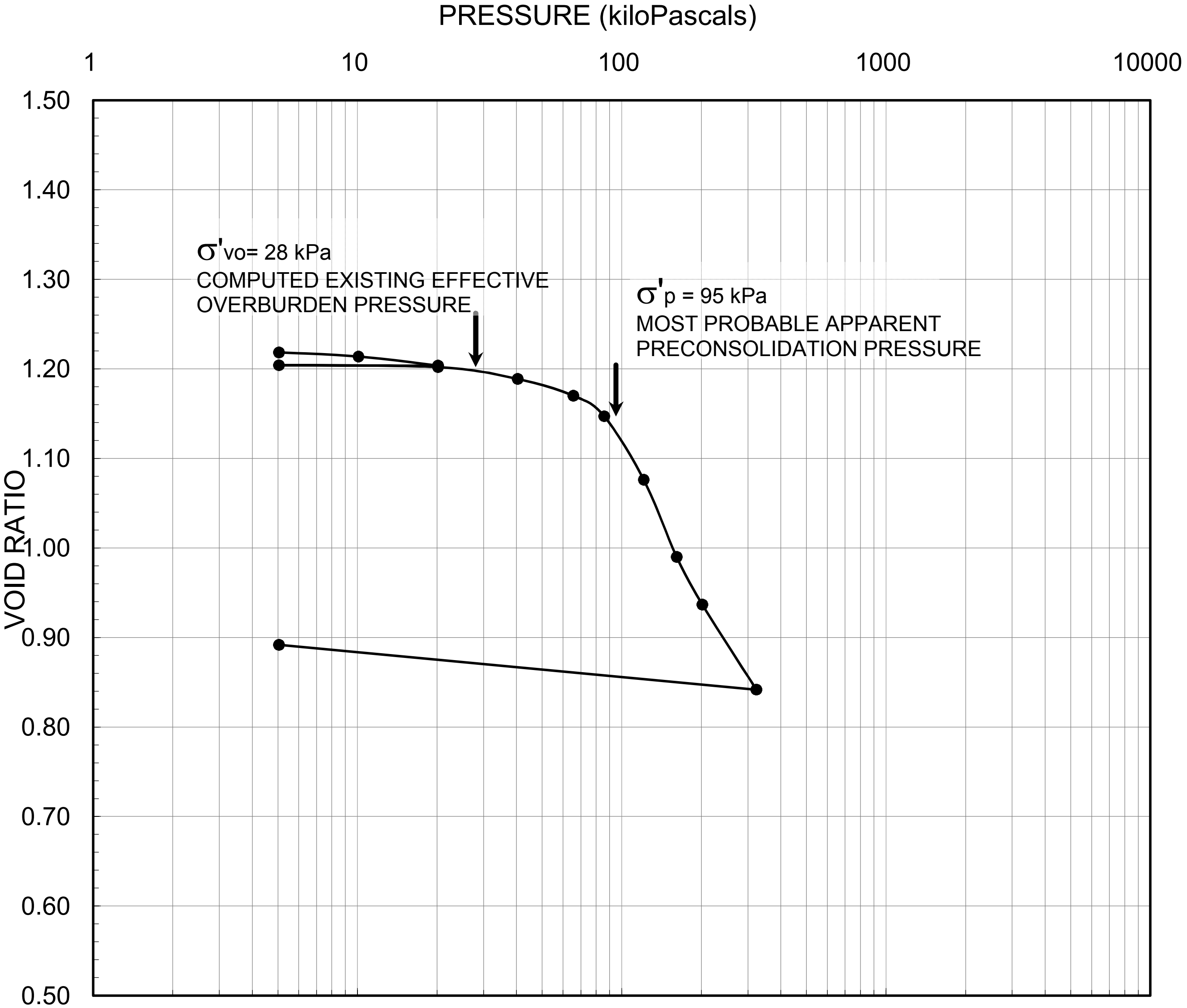
FILE No. Consolidation summary
PROJECT No. 0711210037
REV. 3

SCALE AS SHOWN
DATE 02/01/11
DESIGN
CADD
CHECK CNM
REVIEW

TITLE

CONSOLIDATION TEST RESULTS

FIGURE 5



LEGEND

Borehole: 10-3
Sample: 4
Depth (m): 2.76

w_i = 44.2%
w_f = 32.4%
w_l = 41.3%
w_p = 19.7%

S_o = 100%
C_c = 0.68
C_r = 0.003

Golder Associates

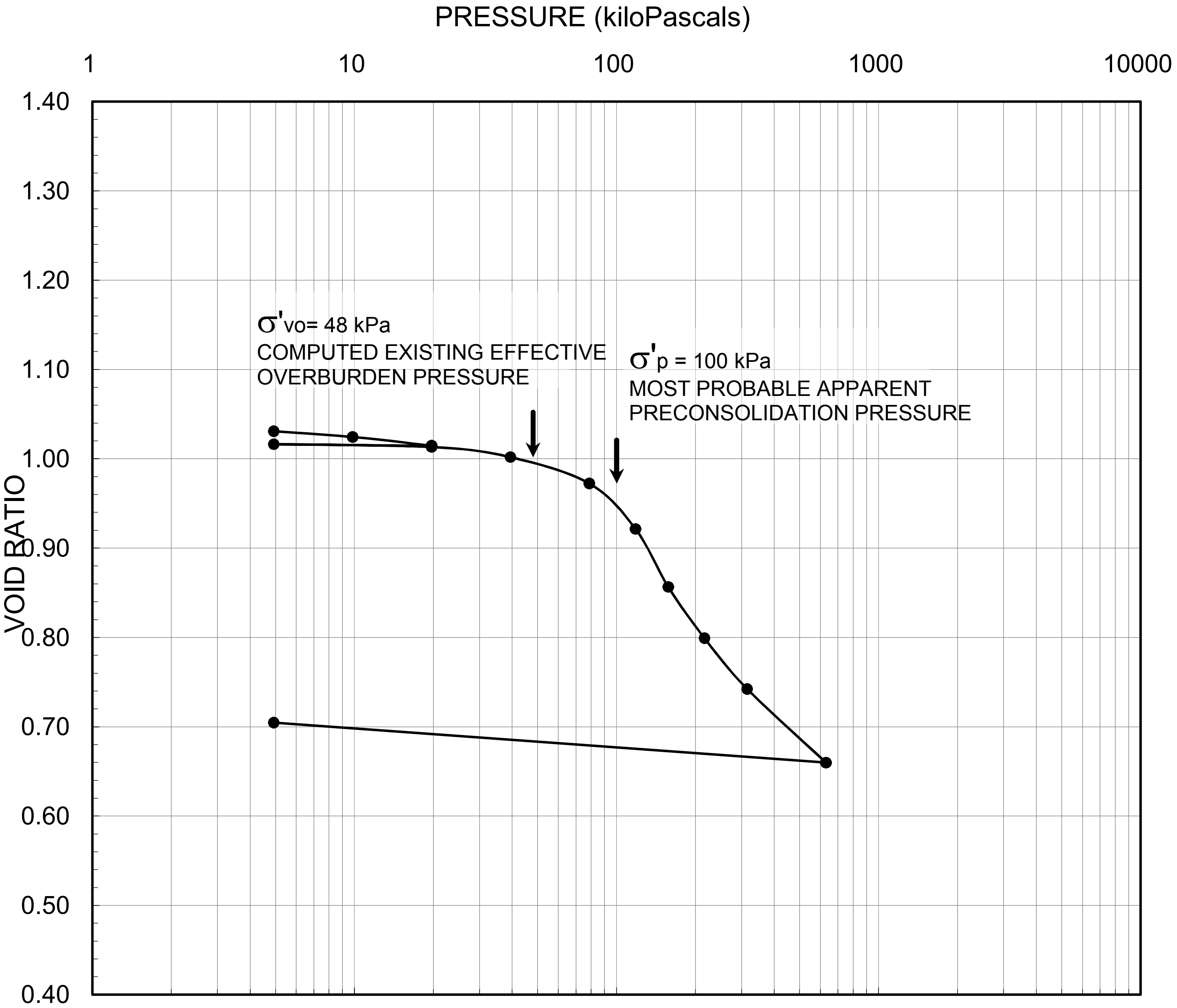
SCALE AS SHOWN
DATE 02/01/11
DESIGN NA
CADD NA
CHECK CNM
REVIEW

TITLE

CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary
PROJECT No. 07-1121-0037 REV. 3

FIGURE **6**



LEGEND

Borehole:	10-3	w_i	= 37.1%	S_o	= 98%
Sample:	6	w_f	= 25.6%	C_c	= 0.51
Depth (m):	4.98	w_l	= 23.7%	C_r	= 0.005
		w_p	= 15.8%		

Golder Associates

SCALE	AS SHOWN	TITLE	
DATE	02/01/11		
DESIGN	NA		
CADD	NA		
CHECK	CNM		
REVIEW		FIGURE	7

FILE No. Consolidation summary

PROJECT No. 07-1121-0037 REV. 2

CONSOLIDATION TEST RESULTS

APPENDIX A

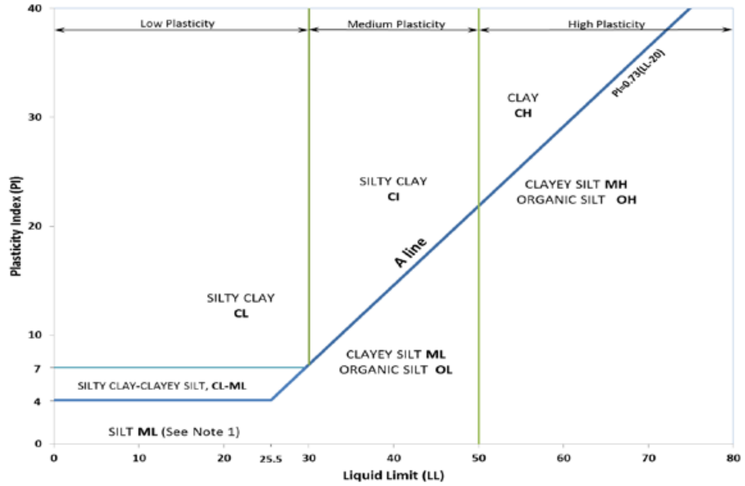
List of Abbreviations and Symbols
Record of Borehole Sheets

METHOD OF SOIL CLASSIFICATION

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

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

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



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

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

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

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

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

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

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

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

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

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

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

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

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

Cone Penetration Test (CPT)

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

Dynamic Cone Penetration Resistance (DCPT); N_d:

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

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

SAMPLES

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

SOIL TESTS

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

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

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

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

Field Moisture Condition

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

COHESIVE SOILS

Consistency

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

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

Water Content

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

LIST OF SYMBOLS

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

I. GENERAL

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

II. STRESS AND STRAIN

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

III. SOIL PROPERTIES

(a) Index Properties

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

(a) Index Properties (continued)

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

(b) Hydraulic Properties

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

(c) Consolidation (one-dimensional)

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

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan 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 $\tau = c' + \sigma' \tan \phi'$
2 shear strength = (compressive strength)/2

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

PROJECT: 05-1120-079

RECORD OF BOREHOLE: 05-1

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: June 28, 2005

DATUM: Geodetic

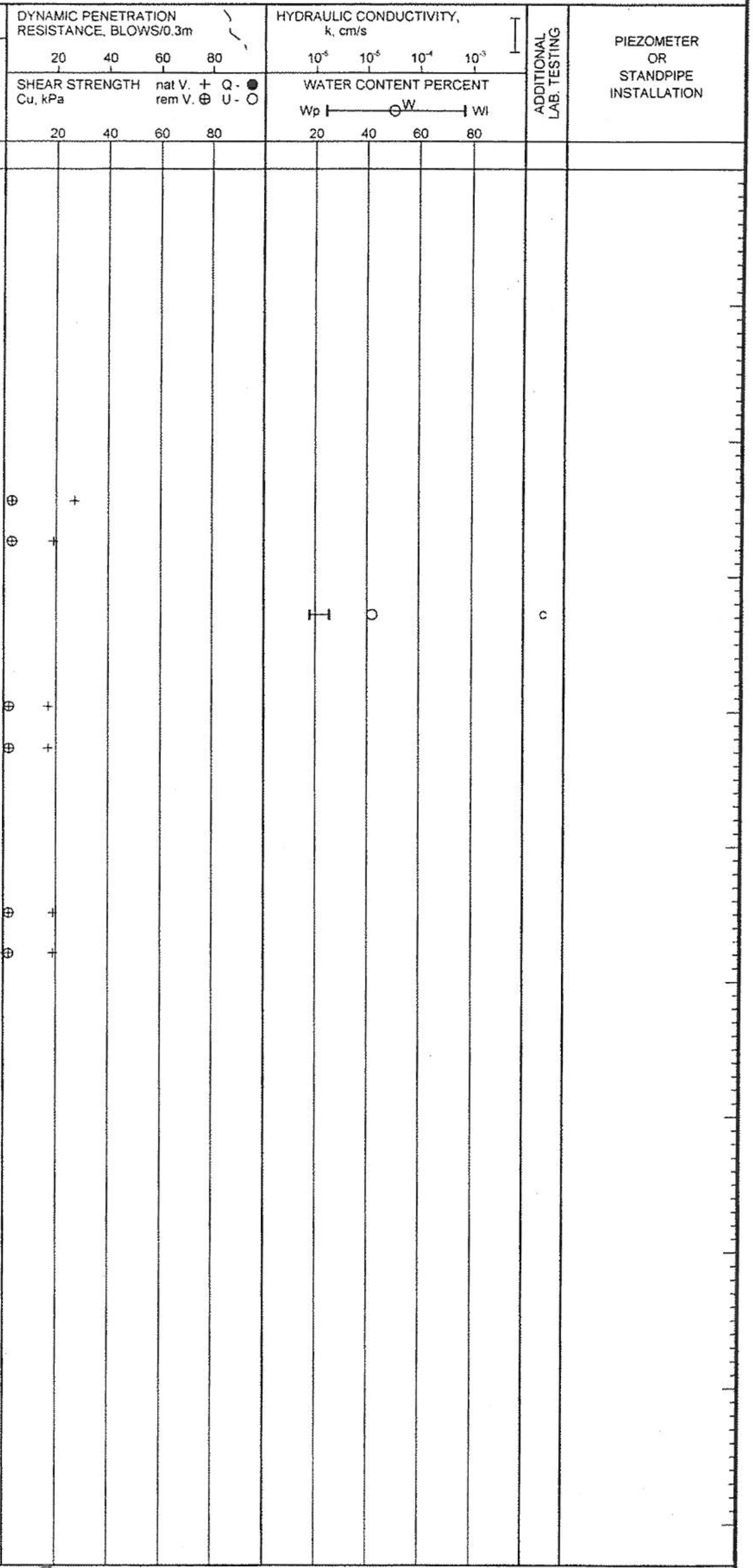
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	96.19
TOPSOIL	0.00
Very loose grey brown layered SANDY SILT and CLAYEY SILT, occasional silty sand seam	95.98 0.21
Soft to firm grey SILTY CLAY, some black organic matter	94.21 1.98
End of Borehole	90.40 5.79

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	2	
2	50 DO	3	
3	73 TP	PH	C
4	50 DO	PM	



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED: MAL

PROJECT: 05-1120-079

RECORD OF BOREHOLE: 05-2

SHEET 1 OF 1

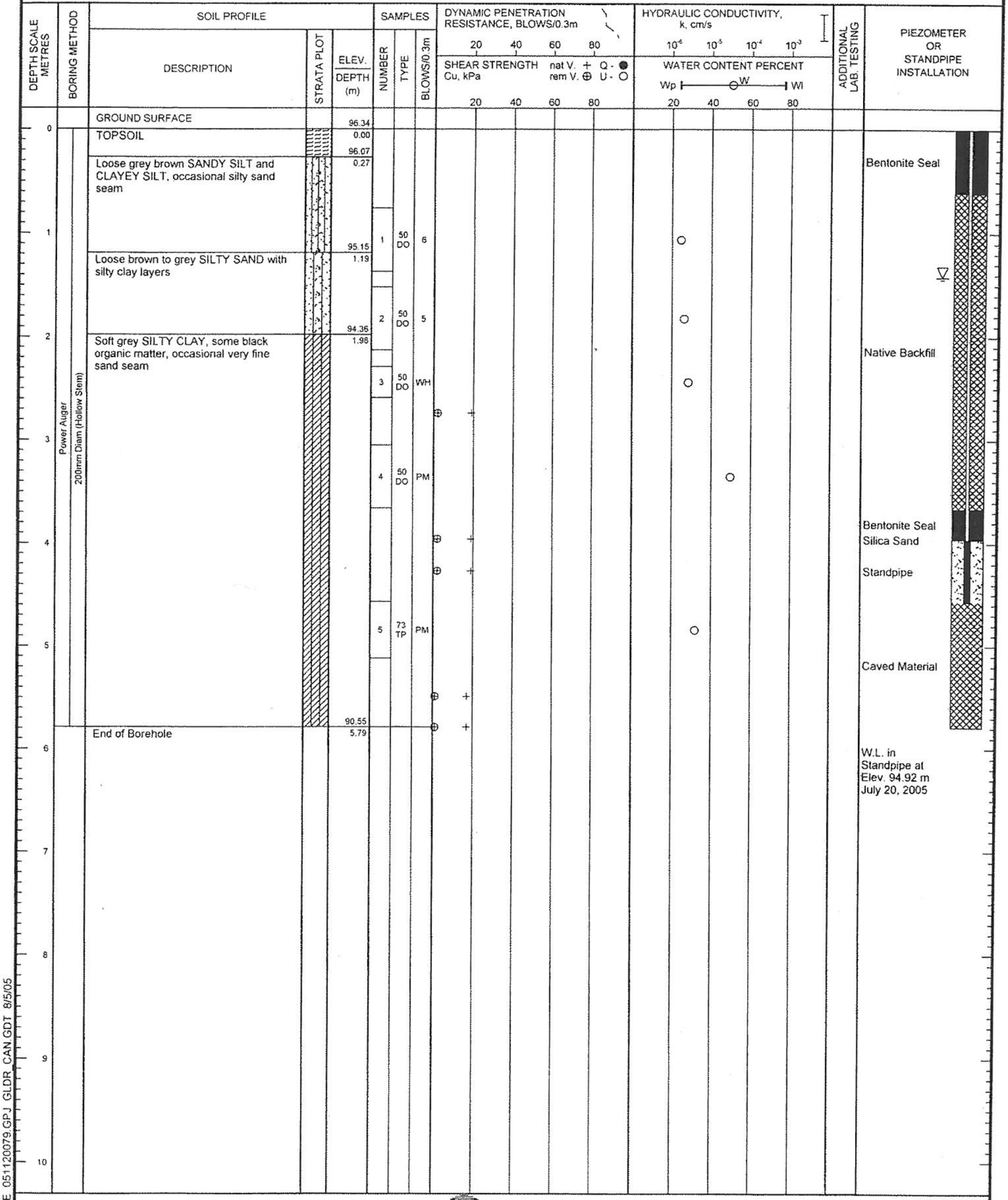
LOCATION: See Site Plan

BORING DATE: June 29, 2005

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
GROUND SURFACE	96.34			
TOPSOIL	0.00			
Loose grey brown SANDY SILT and CLAYEY SILT, occasional silty sand seam	96.07 0.27	1	50 DO	6
Loose brown to grey SILTY SAND with silty clay layers	95.15 1.19	2	50 DO	5
Soft grey SILTY CLAY, some black organic matter, occasional very fine sand seam	94.36 1.98	3	50 DO	WH
		4	50 DO	PM
		5	73 TP	PM
End of Borehole	90.55 5.79			

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED:

BOREHOLE 051120079.GPJ GLDR_CAN.GDT 8/5/05

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 07-1

SHEET 1 OF 1

LOCATION: See Site Plan

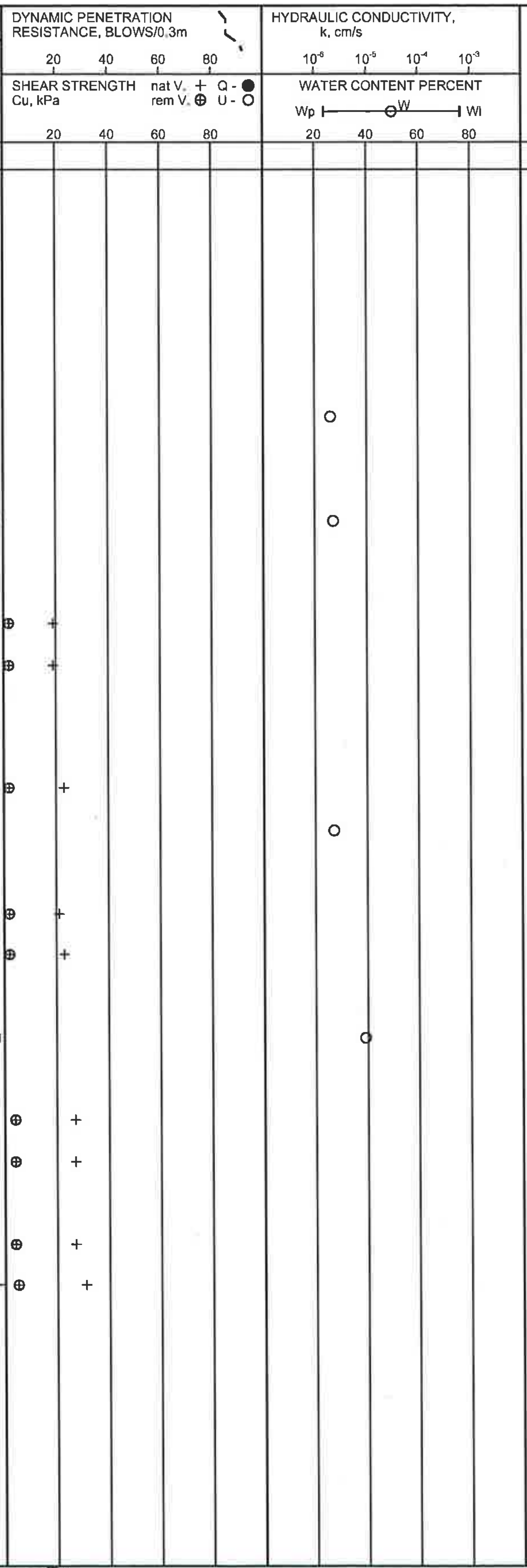
BORING DATE: Mar. 22, 2007

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
		GROUND SURFACE		96.54			
0	Power Auger 200mm Diam. (Power Auger)	TOPSOIL	▤	0.00			
		Layered brown CLAYEY SILT and SANDY SILT, occasional silty sand layer	▨	96.17 0.37			
1					1	50 DO	5
					2	50 DO	3
2		Soft to firm grey SILTY CLAY, some black organic matter, occasional very fine sand seam	▨	94.41 2.13			
					3	50 DO	WH
4					4	73 TP	PH
5					5	50 DO	PM
6					6	50 DO	WH
8		End of Borehole		88.31 8.23			



ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED: ---------------

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 07-2

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Mar. 20, 2007

DATUM: Geodetic

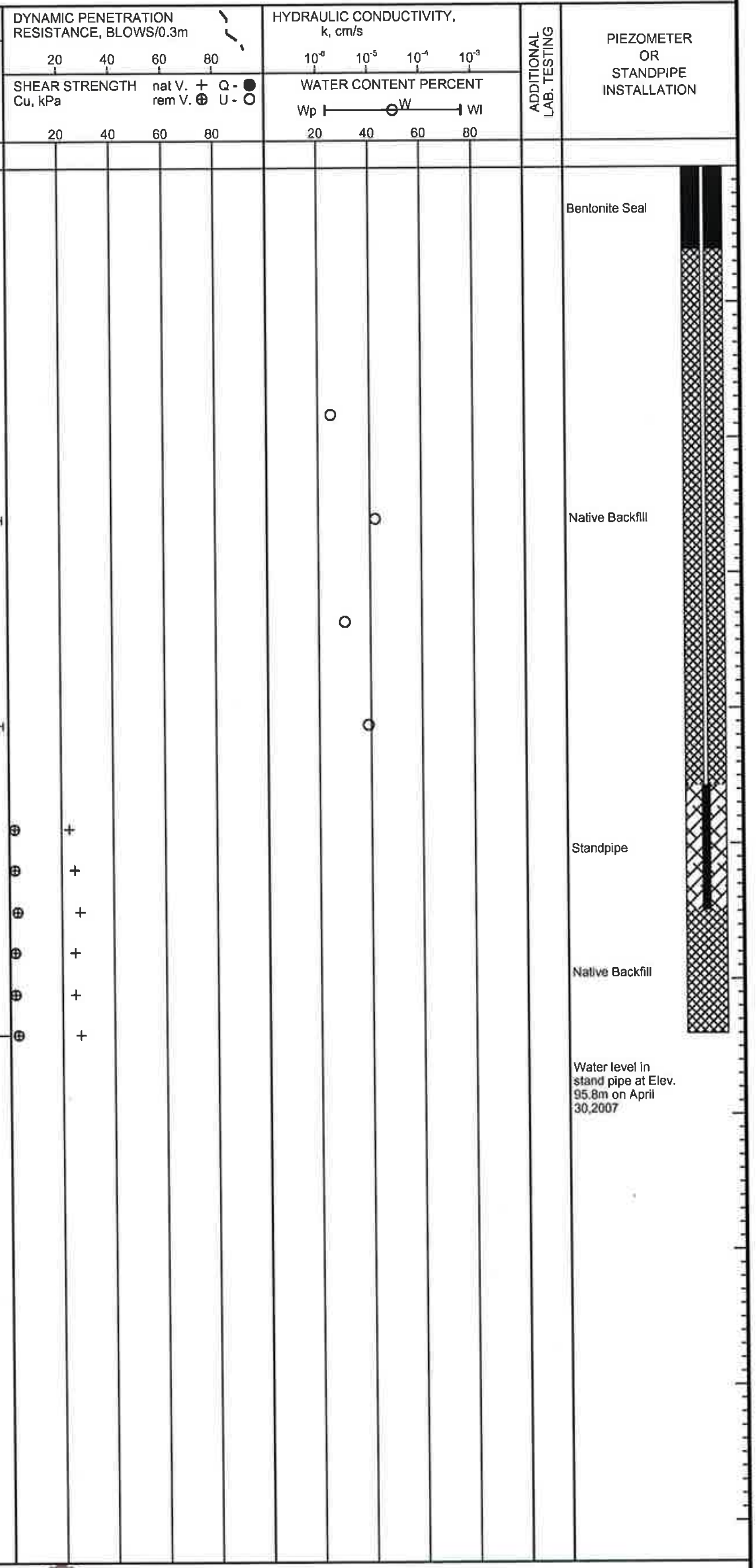
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	96.42
Brown silty clay (FILL)	0.00
TOPSOIL	0.12
Layered brown to grey SANDY SILT and SILTY SAND, occasional clayey silt seam	95.99 0.43
Soft to firm grey SILTY CLAY, trace fine sand seams and black organic matter	92.61 3.81
End of Borehole	90.02 6.40

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	50 DO	7
2	50 DO	4
3	50 DO	WH
4	50 DO	1
5	50 DO	WH



Water level in stand pipe at Elev. 95.8m on April 30,2007

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED: --------------

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 07-3

SHEET 1 OF 1

LOCATION: See Site Plan

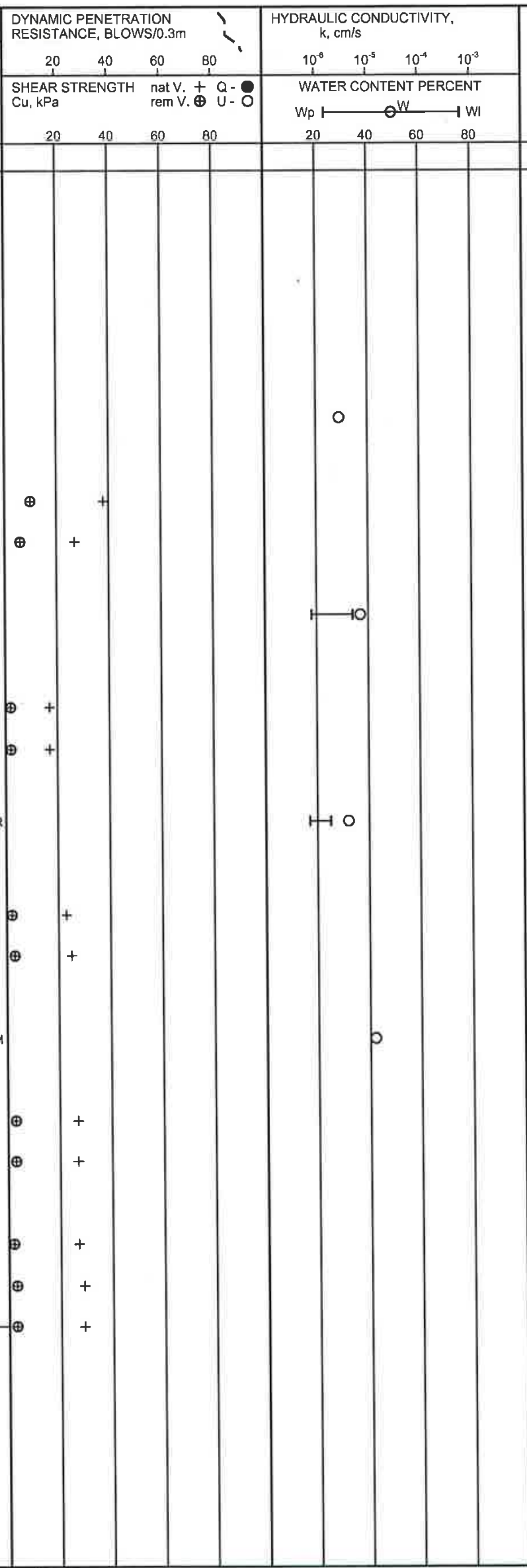
BORING DATE: Mar. 23, 2007

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.68					
0	Power Auger 200mm Diam. (Power Auger)	TOPSOIL		0.00					
		Layered brown CLAYEY SILT and SANDY SILT, occasional silty sand seam		96.38 0.31					
1					1	50 DO	8		
					2	50 DO	1		
2									
		Soft to firm grey SILTY CLAY, some black organic matter, occasional fine sand seam		94.18 2.50					
3					3	73 TP	PH	C	
4									
					4	73 TP	WR	C	
5									
6					5	50 DO	PM		
7									
8									
		End of Borehole		88.15 8.53					
9									
10									



DEPTH SCALE

1 : 50

LOGGED: D.J.S.

CHECKED: ---------------

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 07-4

SHEET 1 OF 1

LOCATION: See Site Plan

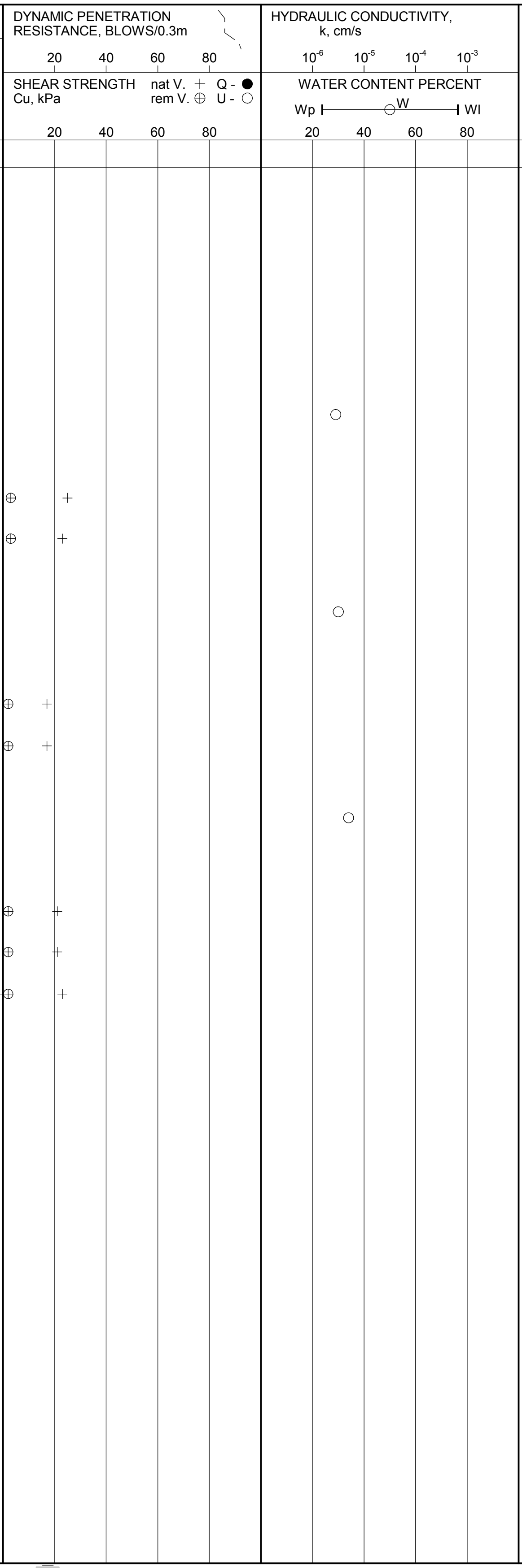
BORING DATE: Mar. 21, 2007

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/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.28					
0	Power Auger 200mm Diam. (Power Auger)	TOPSOIL		0.00					
		Loose brown SANDY SILT and CLAYEY SILT, occasional silty sand seam		96.01 0.27					
1					1	50 DO	6		
		Firm grey brown SILTY CLAY, occasional fine sand seam (Weathered Crust)		94.60 1.68	2	50 DO	1		
2		Soft grey SILTY CLAY, some black organic matter, occasional very fine sand seam		94.15 2.13					
3					3	73 TP	PH		
4									
5					4	73 TP	PH		
6		End of Borehole		90.18 6.10					
7									
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED: --------------

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 07-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Mar. 23, 2007

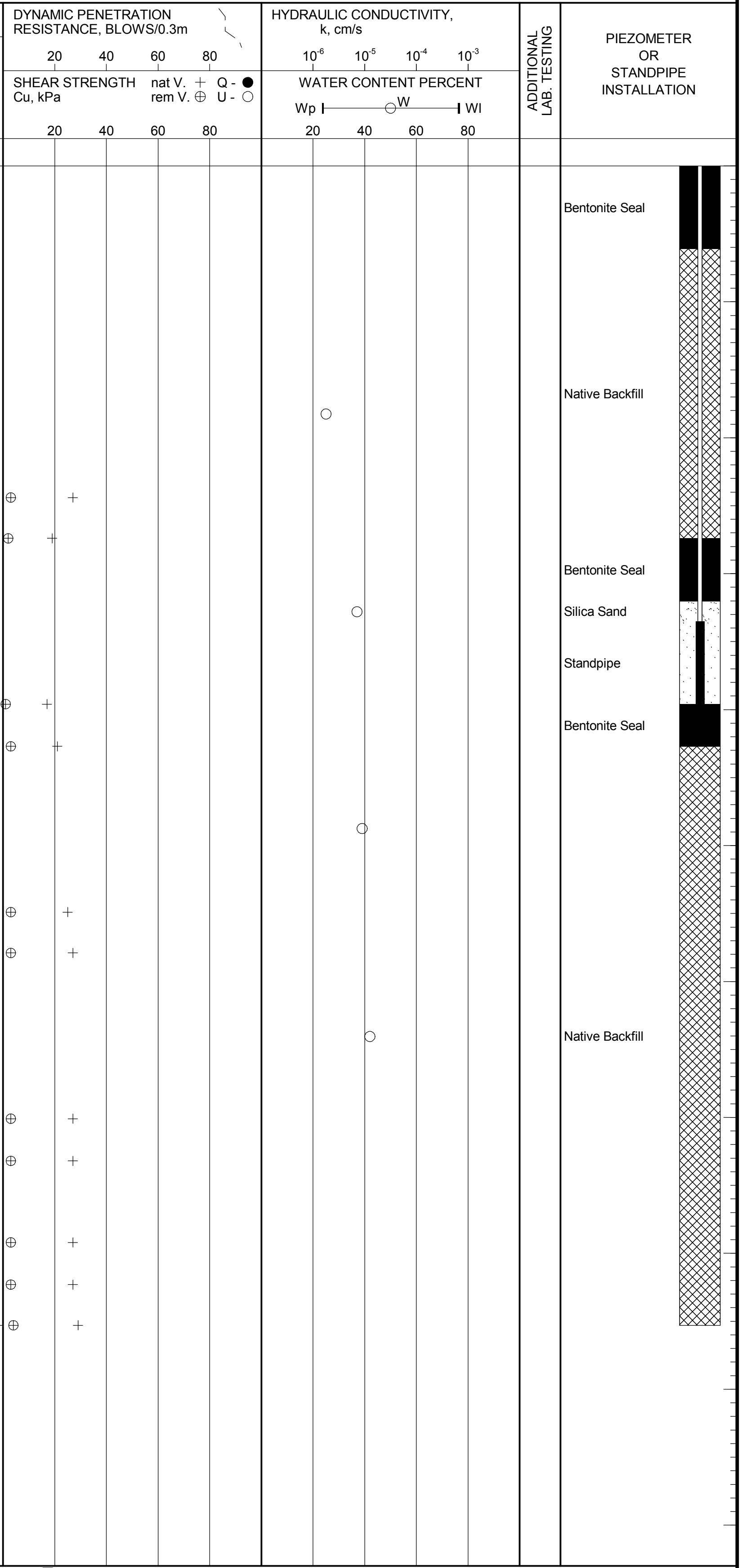
DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	96.55
Power Auger 200mm Diam. (Power Auger)	TOPSOIL	0.00
	Loose brown layered CLAYEY SILT and SANDY SILT, occasional silty sand layer	96.28 0.27
	Firm grey brown SILTY CLAY, occasional sand seam (Weathered Crust)	94.93 1.62
	Soft grey SILTY CLAY	94.42 2.13
	Soft to firm grey SILTY CLAY, some black organic matter, occasional fine sand seam	92.89 3.66
	End of Borehole	88.02 8.53

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	50 DO	8
2	50 DO	1
3	73 TP	PH
4	50 DO	PM
5	50 DO	PM



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: D.J.S.

CHECKED: --------------

MIS-BHS 001 07-1121-0037.GPJ GAL-MIS.GDT 06/28/13 JM

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-1

SHEET 1 OF 1

LOCATION: See Site Plan

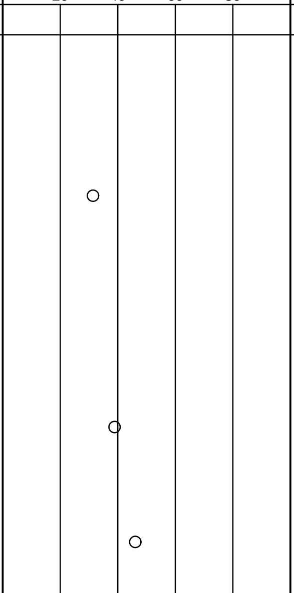
BORING DATE: September 27, 2010

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.69							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Brown SILTY SAND, trace clay		96.37 0.32	5	GRAB					
		Very loose grey brown SANDY SILT to SILTY SAND, occasional clayey silt seam		96.14 0.55							
1					1	50 DO	4				
					2	50 DO	WH			MH	
2		Soft to firm grey SILTY CLAY, occasional silty sand seam, trace black organic mottling and shells		94.71 1.98							
					3	50 DO	PM				
3					4	50 DO	PM				
		End of Borehole		93.03 3.66							
4											
5											
6											
7											
8											
9											
10											



MIS-BHS 001 0711210037-1000.GPJ GAL-MIS.GDT 12/16/10 BR

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-1A

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 27, 2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

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

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

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

ADDITIONAL LAB. TESTING

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
GROUND SURFACE	96.69				
TOPSOIL	0.00				
Brown SILTY SAND, trace clay	96.37 0.32				
Very loose grey brown SANDY SILT to SILTY SAND, occasional clayey silt seam	96.14 0.55				Native Backfill
Soft to firm grey SILTY CLAY, occasional silty sand seam, trace black organic mottling and shells	94.71 1.98	6	73 TP	PH	
		7	73 TP	PH	Bentonite Seal
		8	73 TP	PH	Silica Sand Standpipe
End of Borehole Note: Soil stratigraphy inferred from record of Borehole 10-1	91.20 5.49				W.L. in Standpipe at Elev. 96.23 m on November 8, 2010

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

MIS-BHS 001 0711210037-1000.GPJ GAL-MIS.GDT 12/16/10 BR

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: ______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-1B

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: September 23, 2010

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

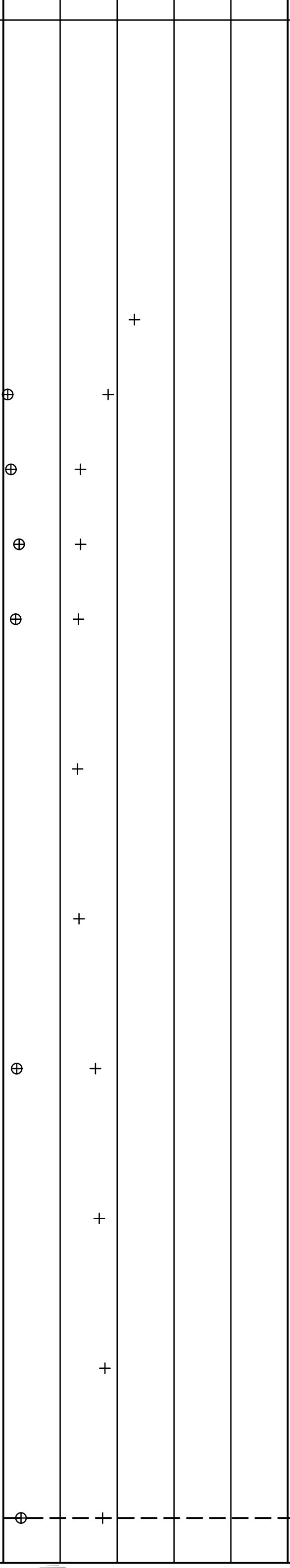
DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.69					
0	Power Auger 200 mm	TOPSOIL		0.00					
		Brown SILTY SAND, trace clay		96.37 0.32					
		Very loose grey brown SANDY SILT to SILTY SAND, occasional clayey silt seam		96.14 0.55					
1	Electric Nilcon Direct Push								
2		Soft to firm grey SILTY CLAY, trace sand, occasional fine sand seam		94.71 1.98					
3									
4									
5									
6									
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



CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

LOGGED: R.I.

CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-1B

SHEET 2 OF 2

LOCATION: See Site Plan

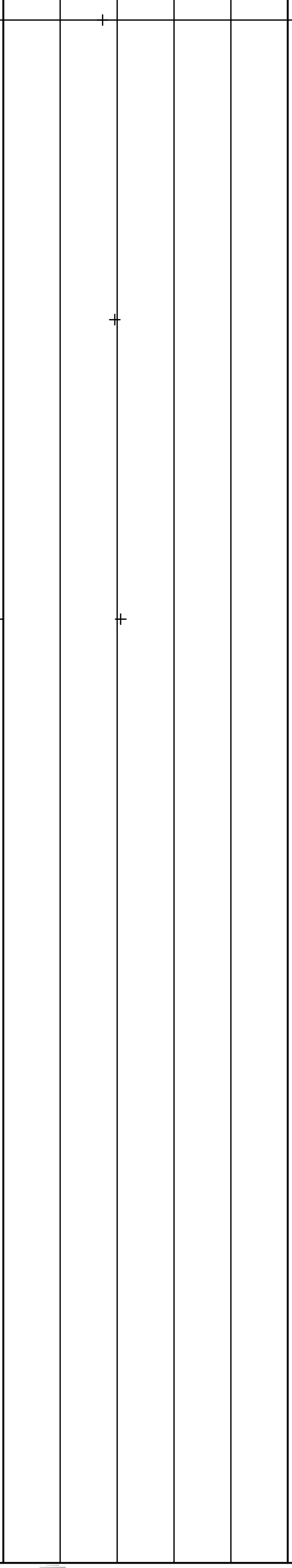
BORING DATE: September 23, 2010

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
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Electric Nilcon Direct Push	Soft to firm grey SILTY CLAY, trace sand, occasional fine sand seam	▨								
14		End of Borehole Note: Soil stratigraphy inferred from record of Borehole 10-1		82.69 14.00							



DEPTH SCALE

1 : 50

LOGGED: R.I.

CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-2

SHEET 1 OF 1

LOCATION: See Site Plan

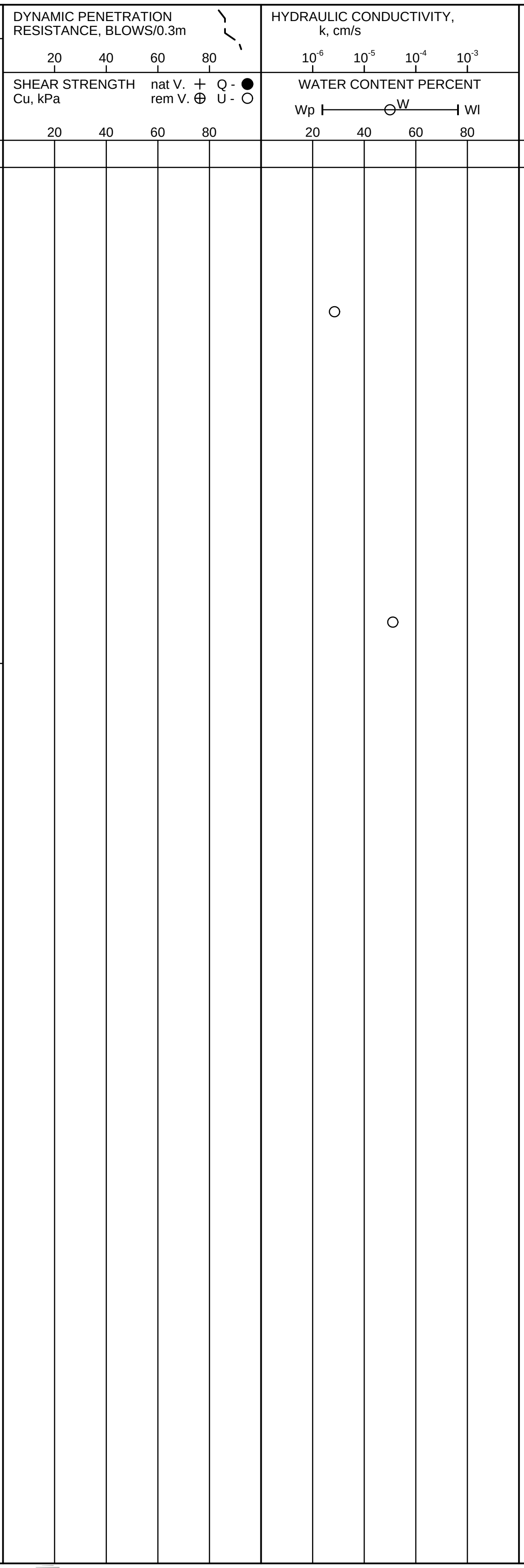
BORING DATE: September 27, 2010

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	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.48					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00					
		Brown SILTY SAND, trace clay		0.15					
		Very loose grey brown SANDY SILT to SILTY SAND, with occasional clayey silt seam		96.13 0.35					
1					1	50 DO	3		
2		Soft to firm grey SILTY CLAY, occasional silty sand seam		94.65 1.83	2	50 DO	WH		
					3	50 DO	PM		
3					4	50 DO	WH		
		End of Borehole		92.82 3.66					
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-2B

SHEET 1 OF 4

LOCATION: See Site Plan

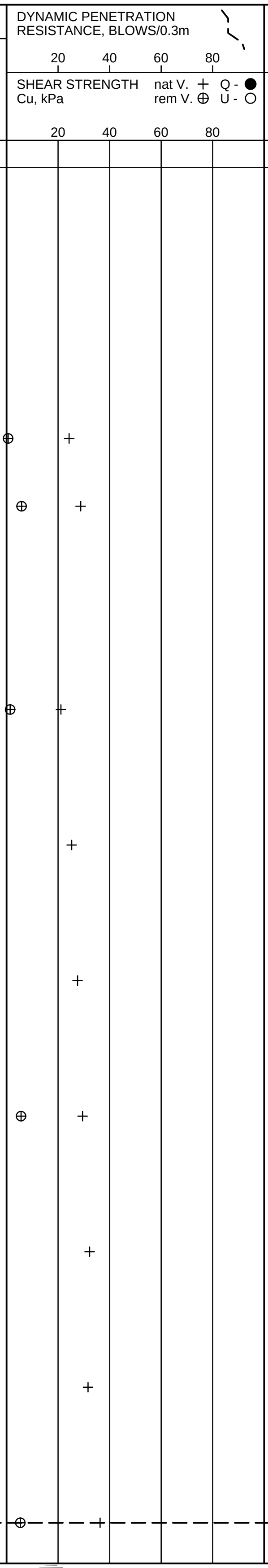
BORING DATE: September 24, 2010

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.48					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00					
		Brown SILTY SAND, trace clay		0.15					
		Very loose grey brown SANDY SILT to SILTY SAND, with occasional clayey silt seam		96.13 0.35					
2		Soft to firm grey SILTY CLAY, occasional silty sand seam		94.65 1.83					
4	Electric Nilcon Direct Push								
10									



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

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

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 50

LOGGED: R.I.
CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-2B

SHEET 2 OF 4

LOCATION: See Site Plan

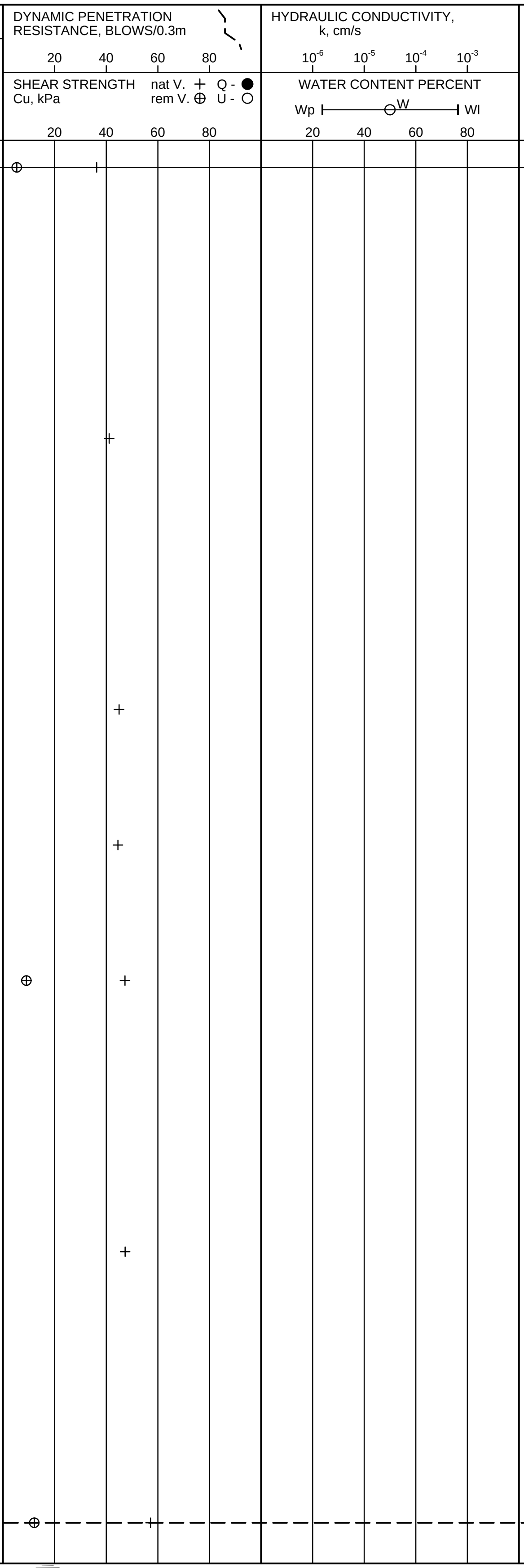
BORING DATE: September 24, 2010

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10	Electric Nilcon Direct Push	Soft to firm grey SILTY CLAY, occasional silty sand seam	▨						
11									
12									
13									
14									
15									
16									
17									
18									
19		Stiff grey SILTY CLAY	▨	77.48 19.00					
20									
		CONTINUED NEXT PAGE							



DEPTH SCALE

1 : 50

LOGGED: R.I.

CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-2B

SHEET 3 OF 4

LOCATION: See Site Plan

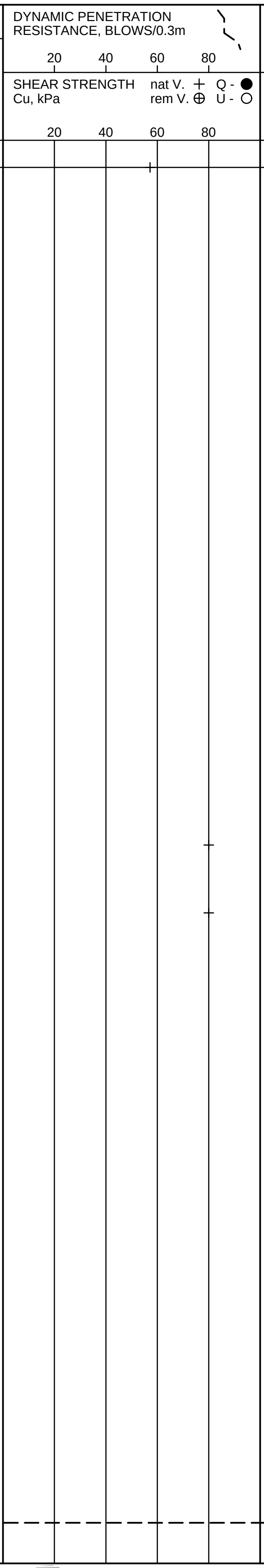
BORING DATE: September 24, 2010

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
20	Electric Nilcon Direct Push	Stiff grey SILTY CLAY	▨						
25		Stiff to very stiff SILTY CLAY		71.48 25.00					
30		*CONTINUED NEXT PAGE*							



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

LOGGED: R.I.

CHECKED: _______

MIS-BHS 001 0711210037-1000.GPJ GAL-MIS.GDT 12/16/10 BR

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-2B

SHEET 4 OF 4

LOCATION: See Site Plan

BORING DATE: September 24, 2010

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
30	Electric Nilcon Direct Push	Stiff to very stiff SILTY CLAY									
31											
32											
33											
34											
35		End of Borehole Note: Soil stratigraphy inferred from record of Borehole 10-2		61.48 35.00							
36											
37											
38											
39											
40											

MIS-BHS 001 0711210037-1000.GPJ GAL-MIS.GDT 12/16/10 BR

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-3

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: September 27, 2010

DATUM: Geodetic

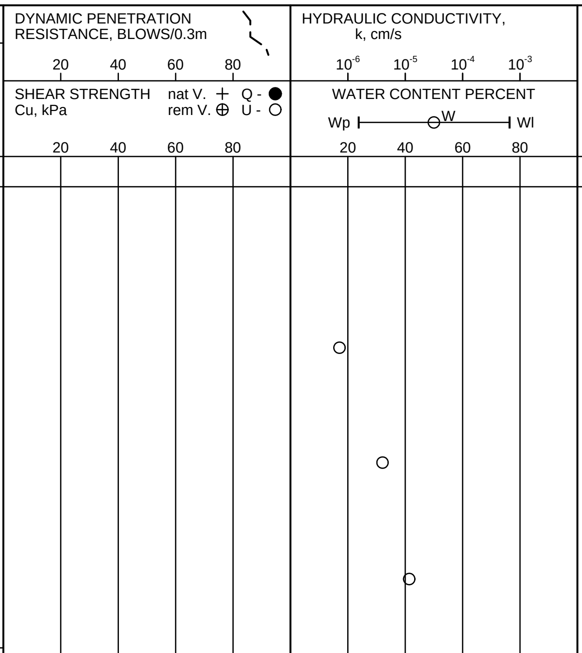
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	96.44	
Grey brown sandy silt, trace clay (FILL)		0.00
TOPSOIL		0.13
Very loose to loose grey brown SANDY SILT to SILTY SAND, occasional clayey silt seam	96.10	0.34
Soft grey SILTY CLAY , occasional silty sand seam and black organic mottling	94.15	2.29
End of Borehole	93.39	3.05

SAMPLES NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING
1	50 DO	6	
2	50 DO	1	MH
3	50 DO	WH	



PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: R.I.

CHECKED: _______

MIS-BHS 001 0711210037-1000.GPJ GAL-MIS.GDT 12/16/10 BR

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-3A

SHEET 1 OF 1

LOCATION: See Site Plan

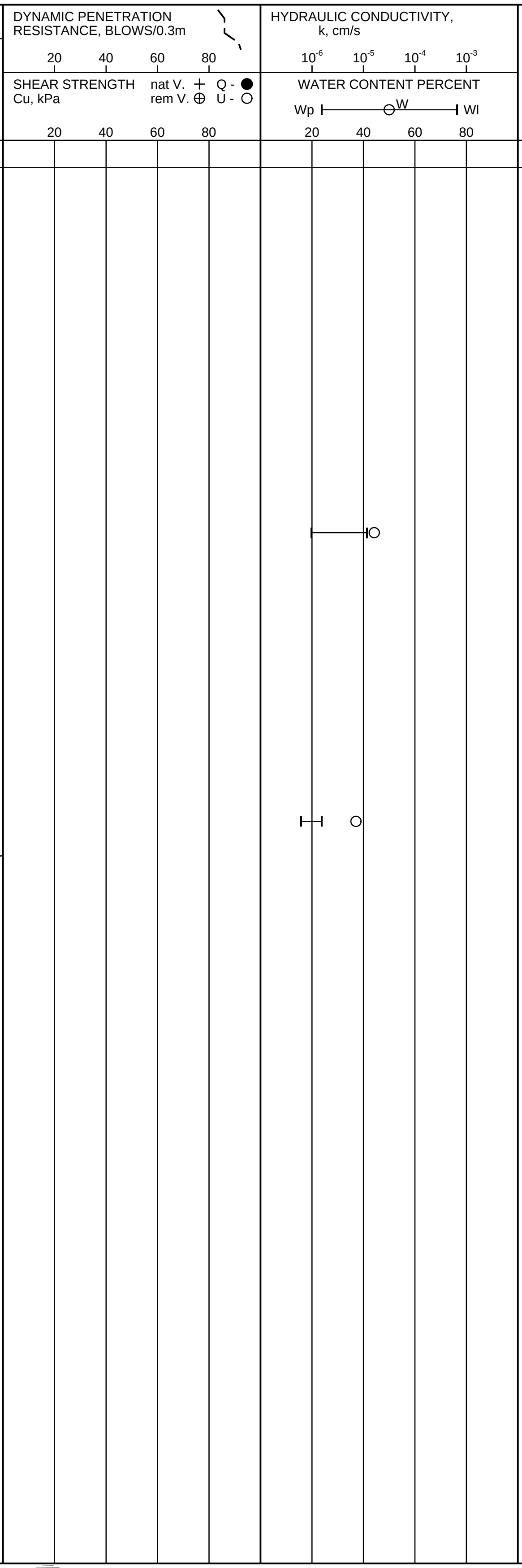
BORING DATE: September 27, 2010

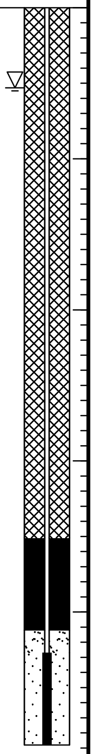
DATUM: Geodetic

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	SAMPLES TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.44					
0	Power Auger 200 mm Diam. (Hollow Stem)	Grey brown sandy silt, trace clay (FILL)	▨	0.00					
		TOPSOIL		0.13					
		Very loose to loose grey brown SANDY SILT to SILTY SAND, occasional clayey silt seam		96.10 0.34					Native Backfill
2		Soft grey SILTY CLAY , occasional silty sand seam and black organic mottling		94.15 2.29					
					4	73 TP	PH		
					5	73 TP	PH		Bentonite Seal
									Silica Sand
									Standpipe
					6	73 TP	PH		
5		End of Borehole Note: Soil stratigraphy inferred from record of Borehole 10-3		91.36 5.08					W.L. in Standpipe at Elev. 95.91 m on November 8, 2010





DEPTH SCALE

1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: ______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-3B

SHEET 1 OF 2

LOCATION: See Site Plan

BORING DATE: September 24, 2010

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	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		96.44					
0	Power Auger 200 mm	Grey brown sandy silt, trace clay (FILL)		0.00					
		TOPSOIL		0.13					
		Very loose to loose grey brown SANDY SILT to SILTY SAND, occasional clayey silt seam		96.10 0.34					
1	Electric Nilcon Direct Push								
2		Soft grey SILTY CLAY , occasional silty sand seam and black organic mottling		94.15 2.29					
3		Soft to firm grey SILTY CLAY, occasional silty sand seam		93.39 3.05					
4									
5									
6									
7									
8									
9									
10									

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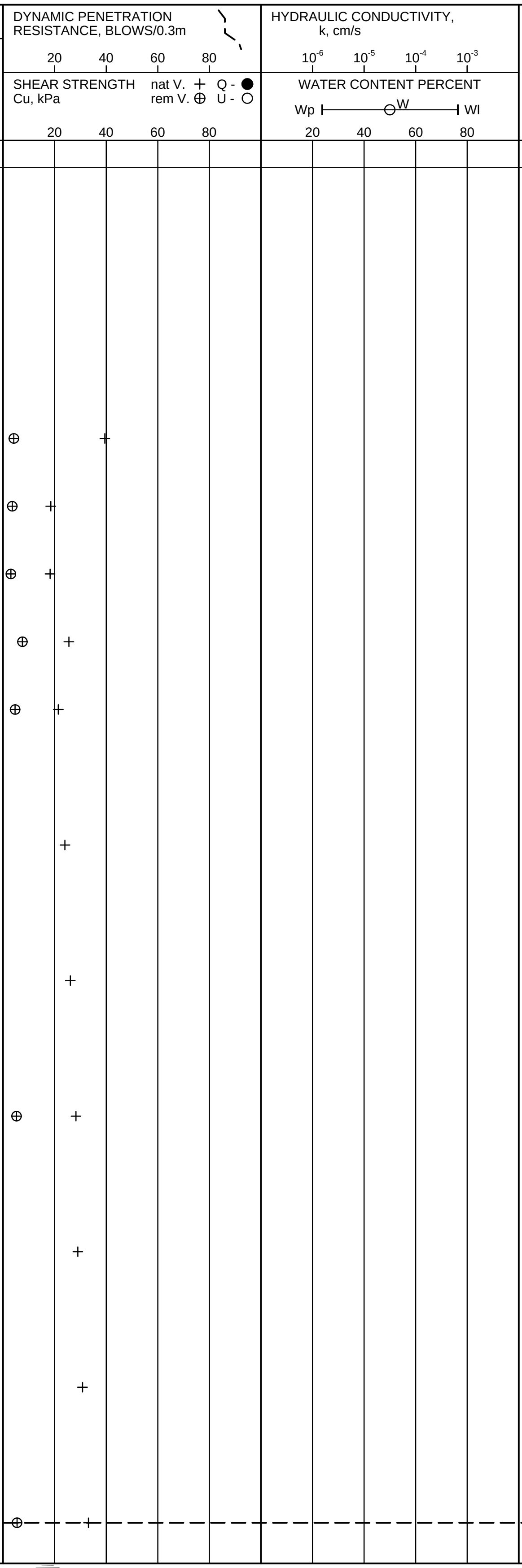


DEPTH SCALE

1 : 50

LOGGED: R.I.

CHECKED: _______

PROJECT: 07-1121-0037

RECORD OF BOREHOLE: 10-3B

SHEET 2 OF 2

LOCATION: See Site Plan

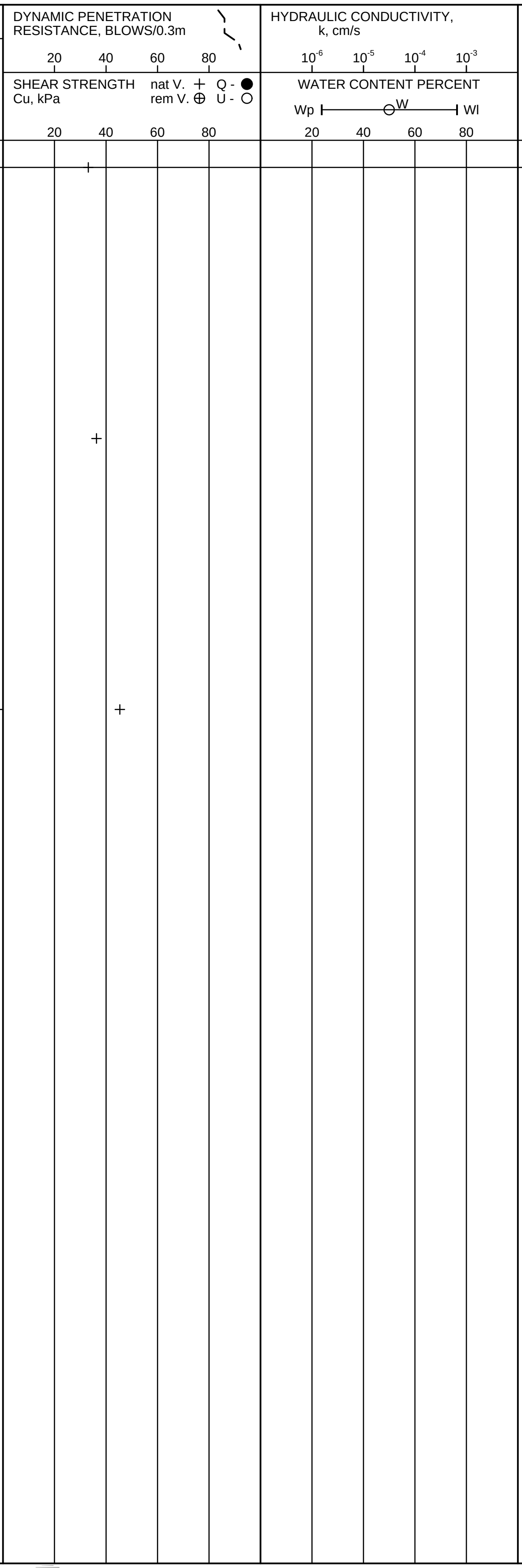
BORING DATE: September 24, 2010

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	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---							
10	Electric Nilcon Direct Push	Soft to firm grey SILTY CLAY, occasional silty sand seam	▨						
11									
12									
13									
14		End of Borehole Note: Soil stratigraphy inferred from record of Borehole 10-3		82.44 14.00					
15									
16									
17									
18									
19									
20									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: R.I.

CHECKED: _______

APPENDIX B

Results of Chemical Analysis
EXOVA Accutest Report Nos. 2707278 and 1024662

ACCUTEST LABORATORIES LTD

REPORT OF ANALYSIS

Client: **Golder Associates Ltd. (Ottawa)**
32 Steacie Drive
Kanata, ON
K2K 2A9
Attention: **Mr. Troy Skinner**

Report Number: 2707278
Date: 2007-04-20
Date Submitted: 2007-04-13

Project: 07-1121-0037

P.O. Number:
Matrix: Soil

Chain of Custody Number: 58242

		LAB ID:	535365	535366				**GUIDELINE**		
		Sample Date:	2007-03-21	2007-03-23						
		Sample ID:	BH 07-2 SA#2	BH 07-5 SA#2						
PARAMETER	**UNITS**	**MDL**						**TYPE**	**LIMIT**	**UNITS**
Chloride	%	0.001	0.005	0.003						
Electrical Conductivity	mS/cm	0.01	0.20	0.19						
pH			8.8	8.5						
Sulphate	%	0.01	0.01	<0.01						

MDL = Method Detection Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

APPROVAL:
Lorna Wilson
Agriculture Lab Supervisor

REPORT OF ANALYSIS

Client: **Golder Associates Ltd. (Ottawa)**
32 Steacie Drive
Kanata, ON
K2K 2A9
Attention: **Ms. Kim Lesage**

Report Number: 1024662
Date: 2010-10-15
Date Submitted: 2010-10-07

Project: 07-1121-0037

P.O. Number:
Matrix: Soil

Chain of Custody Number: **114651**

								GUIDELINE		
		LAB ID:	834961							
		Sample Date:	2010-09-27							
		Sample ID:	BH10-2 SA#2A							
PARAMETER	**UNITS**	**MRL**						**TYPE**	**LIMIT**	**UNITS**
Chloride	%	0.002	0.007							
Electrical Conductivity	mS/cm	0.05	0.24							
pH			7.8							
Resistivity	ohm-cm	1	4170							
Sulphate	%	0.01	0.02							

MRL = Method Reporting Limit INC = Incomplete AO = Aesthetic Objective OG = Operational Guideline MAC = Maximum Allowable Concentration IMAC = Interim Maximum Allowable Concentration

Comment:

APPROVAL:
Lorna Wilson
Agriculture Lab Supervisor

Methods references and/or additional QA/QC information available on request.

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golder.com