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Proposed Storm Water Management Facility
Kanata North Development
March Road - Ottawa, Ontario

Prepared For

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Report PG4258-1 - Revision 2

Table of Contents

Page

Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Novatech Engineering Consultants Ltd. (Novatech) to conduct a geotechnical and hydrogeological investigation for the proposed storm water management facility (SWMF) to be located within the Kanata North Development on the west side of March Road, in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2).

The objectives of the investigation were to:

❏ Determine the subsurface soil and groundwater conditions by means of boreholes.

❏ Provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. This report contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as understood at the time of writing this report.

2.0 Proposed Project

Based on preliminary design details, it is understood that a two-bay (upper and lower) storm water management facility (SWMF) is proposed along with the associated inlet trench and access roads.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the investigation was conducted on October 19 and 20, 2017. The current investigation consisted of drilling three boreholes and excavating three test pits, extending to a maximum depth of 6.2 and 2.1 m below ground surface, respectively. The test hole locations were selected in a manner to provide general coverage of the proposed SWMF and outlet channel. The findings at the test pit locations of our previous investigations from 2008, 2009 and 2013 for the subject site are also discussed in the present report. The test hole locations are shown on Drawing PG4258-1 - Test Hole Location Plan included in Appendix 2.

The test holes were advanced with a track-mounted drill rig or a rubber-tire backhoe operated by a two-person crew. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer from the geotechnical division. The drilling and excavation procedure consisted of augering or digging to the required depth at the selected locations, sampling and testing the overburden.

Sampling and In Situ Testing

Soil samples collected from the boreholes were either recovered directly from the auger flights (AU) or collected using a 50 mm diameter split-spoon (SS) sampler. Soil samples from the test pits were recovered from the side walls of the open excavation. All soil samples were visually inspected and initially classified on site. The auger and split-spoon samples were placed in sealed plastic bags and transported to our laboratory for further examination and classification. The depths at which the auger, split spoon and grab samples were recovered from the boreholes are shown as AU, SS and G, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

In conjunction with the recovery of the split spoon samples, the Standard Penetration Test (SPT) was conducted. The SPT results are recorded as “N” values on the Soil Profile and Test Data sheets. The “N” value is the number of blows required to drive the split spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

The recovery value and a Rock Quality Designation (RQD) value were calculated for each drilled section of bedrock and are presented on the borehole logs. The recovery value is the length of the bedrock sample recovered over the length of the drilled section. The RQD value is the total length of intact rock pieces longer than 100 mm over the length of the core run. The values indicate the bedrock quality.

Subsurface conditions observed in the test holes were recorded in detail in the field. Reference should be made to the Soil Profile and Test Data sheets presented in Appendix 1 for specific details of the soil profile encountered at the test hole locations.

Groundwater

Monitoring wells were installed in the boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program.

Hydraulic Conductivity Testing

Hydraulic conductivity testing was completed in the three monitoring wells. Falling head and rising head tests (“slug tests”) were completed in accordance with ASTM Standard Test Method D4404 - Field Procedure for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers.

Slug testing was completed on November 14, 2017 by Paterson personnel. The general test method consisted of the measurement of the static water level in the well, followed by inducing a near-instantaneous change of head in the monitoring well and subsequent monitoring of water level recovery with an electronic water level tape and a Mini Diver water level logger. The change in head was induced by the introduction of an aluminum slug, 1 m in length and 40 mm in diameter. The slug was introduced to raise the groundwater level in the monitoring well, following which the decrease in water level over time was monitored (falling head test). Once the water level had stabilized (or nearly stabilized), the slug was then removed to lower the groundwater level, following which the increase in water level over time was monitored (rising head test).

3.2 Field Survey

The boreholes were located in the field and surveyed by Novatech. The ground surface elevations at the borehole locations were referenced to a geodetic datum. The location and ground surface elevations at the borehole locations are presented on Drawing PG4258-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging. Soil samples will be stored for a period of one month after this report is completed, unless otherwise directed.

3.4 Analytical Testing

One soil sample was submitted for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The sample was analysed to determine the concentrations of sulphate and chloride, the resistivity and the pH of the sample. The analytical test results are presented in Appendix 1 and discussed in Subsection 5.11.

4.0 Observations

4.1 Surface Conditions

The subject site is currently undeveloped and used as agricultural land. The ground surface is generally flat and gently slopes down from west to east towards March Road. An existing creek flows from west to east across the subject site; the creek is approximately aligned with the proposed inlet trench.

4.2 Subsurface Profile

Overburden

Generally, the subsurface profile encountered at the test hole locations consists of a native, stiff to hard silty clay deposit followed by a layer of glacial till which in turn is overlying bedrock. The glacial till consisted of a silty clay fine soil matrix with trace to some sand and gravel, and trace cobbles and boulders. Grey limestone bedrock was encountered underneath the glacial till at approximately 2.1 to 3.5 m depth. Generally, the bedrock quality is fair to good within the upper 0.5 to 1 m and good to excellent quality at depth based on the RQD values. Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Bedrock

Based on geological mapping, the local bedrock consists of sandstone and dolomite of the March Formation. The overburden thickness is expected to range from approximately 2 to 3 m.

4.3 Groundwater

The groundwater level (GWL) readings were recorded at the borehole locations on November 14, 2017 and are presented in Table 1 below and in the Soil Profile and Test Data sheets. It is important to note that based on observations of the soil samples recovered from the borehole locations, such as colouring, moisture levels and consistency, the long-term groundwater level is not expected within the overburden soils. The groundwater level readings within the monitoring wells indicate that an artesian pressure is present below the bedrock surface. It should be noted that groundwater levels are subject to seasonal fluctuations and therefore groundwater levels could differ at the time of construction.

Table 1 - Summary of Groundwater Level Readings

Borehole Number	Ground Elevation, m	Groundwater Levels, m		Recording Date
		Depth	Elevation	
BH 1	83.20	0.04	83.16	November 14, 2017
BH 2	82.43	0.50	81.93	November 14, 2017
BH 3	81.77	-0.04	81.81	November 14, 2017

Notes:

- ☐ The test hole locations were located in the field and surveyed by Novatech Engineering Consultants Ltd. The ground surface elevations are referenced to a geodetic datum.
- ☐ The negative depth at BH 3 denotes water level recorded in the monitoring well above ground surface.

Hydraulic Conductivity

Following the completion of the slug testing, the test data was analyzed as per the method set out by Hvorslev (1951). Assumptions inherent in the Hvorslev method include a homogeneous and isotropic aquifer of infinite extent, zero-storage assumption, and a screen length significantly greater than the monitoring well diameter. The assumption regarding aquifer storage is considered to be appropriate for groundwater flow through the overburden aquifer. The assumption regarding screen length and well diameter is considered to be met based on a typical screen length of 1.52 m and a diameter of 0.05 m.

While the idealized assumptions regarding aquifer extent, homogeneity, and isotropy are not strictly met in this case (or in any real-world situation), it has been our experience that the Hvorslev method produces effective point estimates of hydraulic conductivity in conditions similar to those encountered at the subject site.

Hvorslev analysis is based on the line of best fit through the field data (hydraulic head recovery vs. time), plotted on a semi-logarithmic scale. In cases where the initial hydraulic head displacement is known with relative certainty, such as in this case where a physical slug has been introduced, the line of best fit is considered to pass through the origin. In cases where the initial hydraulic head displacement is known with less certainty (e.g. a bail test, where water is pumped rapidly from the well), the best-fit line is drawn regardless of the origin.

Based on the above test methods, the monitoring wells from the current investigation displayed hydraulic conductivity values ranging from 1.1×10^{-5} to 5.8×10^{-5} m/sec, with a geometric mean of 3.3×10^{-5} m/sec. The results of the hydraulic conductivity testing are presented in Appendix 1.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is adequate for the proposed stormwater management facility. It is expected that the proposed inlet and outlet structures will be founded on an undisturbed, compact to dense glacial till or bedrock bearing surface.

Bedrock removal will be required to complete the SWMF excavation based on the current design details. Moderate to high groundwater infiltration through the excavated bedrock is expected during construction of the pond. It is also anticipated that artesian groundwater pressure issues will be encountered during excavation and construction of the subject pond. Therefore, groundwater control measures should be implemented, such as a clay liner above the bedrock surface.

The above and other considerations are further discussed in the following sections.

5.2 Site Preparation

Stripping Depth

Topsoil and deleterious materials, such as those containing significant amounts of organics, should be removed from within any settlement sensitive structure.

Bedrock Removal

Based on the bedrock encountered in the area, it is expected that hoe-ramming or controlled blasting will be required to remove the bedrock. In areas of weathered bedrock and where only a small quantity of bedrock is to be removed, bedrock removal may be possible by hoe-ramming.

Prior to considering blasting operations, the effects for any nearby existing buildings or structures should be addressed. A pre-blast or construction survey located in proximity of the blasting operations should be conducted prior to commencing construction. The extent of the survey should be determined by the blasting consultant and sufficient to respond to any inquiries/claims related to the blasting operations.

Precaution should be taken to limit blasting effects below the base and sidewalls of the SWMF, which could increase infiltration rates of the groundwater into the SWMF.

To further reduce the potential increase infiltration rates the sidewalls of the SWMF, it is recommended that the final 150 to 300 mm of the bedrock removal be carried out using a rock grinder mounted to a hydraulic excavator. This method of bedrock grinding will provide a smoother surface to finalize the shape of the sidewall and will also lessen the potential for over breaks that typically occur with the use of high energy mechanical methods such as hoe-ramming.

As a general guideline, peak particle velocity (measured at the property line) should not exceed 25 mm/s during the blasting program to reduce the risks of damage to the existing nearby buildings.

The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is an experienced blasting consultant.

Any bedrock removed via hoe-ramming or blasting methods may be stockpiled at the site and reviewed by the geotechnical consultant for use as backfill below building footprints and as general landscaping fill.

Vibration Considerations

Construction operations are also the cause of vibrations, and possibly, sources of nuisance to the community. Therefore, means to reduce the vibration levels as much as possible should be incorporated in the construction operations to maintain, as much as possible, a cooperative environment with the residents.

The following construction equipments could be the source of vibrations: piling rig, hoe ram, compactor, dozer, crane, truck traffic, etc. The construction of the shoring system using soldier piles or sheet piling will require the use of these equipments. Vibrations, whether it is caused by blasting operations or by construction operations, could be the cause of the source of detrimental vibrations on the adjoining buildings and structures. Therefore, it is recommended that all vibrations be limited.

Two parameters are used to determine the permissible vibrations, namely, the maximum peak particle velocity and the frequency. For low frequency vibrations, the maximum allowable peak particle velocity is less than that for high frequency vibrations. As a guideline, the peak particle velocity should be less than 15 mm/s between frequencies of 4 to 12 Hz, and 50 mm/s above a frequency of 40 Hz (interpolate between 12 and 40 Hz). It should be noted that these guidelines are for today's construction standards. Considering that these guidelines are above perceptible human level and, in some cases, could be very disturbing to some people, it is recommended that a pre-construction survey be completed to minimize the risks of claims during or following the construction of the proposed building.

Fill Placement

Fill used for grading beneath any settlement sensitive structures should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. This material should be tested and approved prior to delivery to the site. The fill should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the proposed building areas should be compacted to at least 98% of its standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill where settlement of the ground surface is of minor concern. In landscaped areas, these materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If these materials are to be used to build up the subgrade level for areas to be paved, they should be compacted in thin lifts to a minimum density of 95% of their respective SPMDD. Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

5.3 Bearing Resistance Values

Concrete structures placed on a clean, surface sounded bedrock surface can be designed using an allowable bearing capacity of **500 kPa**. The settlement of structures placed on bedrock is expected to be negligible.

Concrete structures placed on an undisturbed, compact to dense glacial till, engineered fill or approved blast rock fill bearing surface can be designed using an allowable bearing capacity of **200 kPa**. Structures designed using the bearing resistance value given at SLS will be subjected to potential post-construction total and differential settlements of 25 and 20 mm, respectively.

An undisturbed soil bearing surface consists of a surface from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, whether in situ or not, have been removed, in the dry, prior to the placement of concrete for footings.

The above noted allowable bearing capacities are provided for design purposes and should be confirmed in the field prior to placement of concrete for structures.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to engineered fill or native soil above the groundwater table when a plane extending down and out from the bottom edge of the footing at a minimum of 1H:1V passes only through in situ soil of the same or higher capacity as the bearing medium soil.

Adequate lateral support is provided to a sound bedrock bearing medium when a plane extending down and out from the bottom edge of the footing at a minimum of 1H:6V (or flatter) passes only through sound bedrock or a material of the same or higher capacity as the bedrock, such as concrete. A weathered bedrock bearing medium will require a lateral support zone of 1H:1V (or flatter).

5.4 Stormwater Management Facility (SWMF)

Based on preliminary design details, it is our understanding that the proposed stormwater management facility (SWMF) will consist of the following:

Upper pond

❏	Pond bottom elevation.	80.5 m
❏	Normal water level..	82.0 m
❏	Elevation of top of pond.	85.0 m

Lower pond

❏	Pond bottom elevation.	78.0 m
❏	Normal water level..	79.5 m
❏	Elevation of top of pond.	82.3 m

The construction of the proposed SWMF is adequate from a geotechnical perspective. However, a significant volume of bedrock removal will be required based on the current design. The main area of concern for the SWMF construction from a geotechnical perspective are summarized as follows:

❏ the groundwater infiltration rate within the excavation side slopes and along the bottom of the pond

The proposed SWMF will be located in an area where water infiltration from the bedrock will require management during the construction phase. Based on the test hole program carried out as part of our investigation, water infiltration rates within the overburden soil were moderate to low. The infiltration rate through bedrock was high; managing the infiltration rate during bedrock removal operations will be critical during the construction program.

Where bedrock is exposed within the excavation, a clay layer acting as an impermeable liner will be required. Additional bedrock removal will be required to accommodate the material thickness. To further reduce the potential infiltration rates the sidewalls of the SWMF, it is recommended that the final 150 to 300 mm of the bedrock removal be carried out using a rock grinder mounted to a hydraulic excavator. This method of bedrock grinding will provide a smoother surface to finalize the shape of the sidewall and will also lessen the potential for over breaks that typically occur with the use of high energy mechanical methods such as hoe-ramming.

Clay Liner

A minimum 500 mm thick clay liner is recommended to be placed over the grinded bedrock surface to provide an impermeable layer over the bedrock. The clay material used for the liner should consist of brown, workable clay that can be placed and compacted using a sheep’s foot roller making several passes and approved in the field by Paterson.

It’s expected that the perched groundwater will be significantly reduced during the site redevelopment and after post-construction servicing. No significant groundwater hydrostatic pressure is expected to affect the subject SWMF.

Excavation side Slopes

The long term performance of the proposed SWMP will depend on the stability of their excavation side slopes. It is expected that the excavation side slopes between approximately 3H:1V to 5H:1V will be acceptable. The long term stability of the excavation side slopes will depend on the cohesiveness of the subsoil material encountered. The soils encountered during this investigation should be considered to be stable at the design slopes provided.

5.5 Pavement Structure

Paved walkways and access roads are anticipated surrounding the proposed SWMF to be used as maintenance vehicle access and pedestrian walkways. For design purposes, the pavement structure presented in Table 2 is recommended for SWMF walkways and access roads.

Table 2 - Recommended Pavement Structure - Walkways/Access Roads for SWMF

Thickness (mm)	Material Description
50	**Wear Course -** HL-3 or Superpave 12.5 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
300	**SUBBASE** - OPSS Granular B Type II
	SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project.

If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be excavated and replaced with OPSS Granular B Type II material. Weak subgrade conditions may be experienced over service trench fill materials. This may require the use of a geotextile, such as Terratrack 200 or equivalent, thicker subbase or other measures that can be recommended at the time of construction as part of the field observation program.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 100% of the material's SPMDD using suitable vibratory equipment.

5.6 Protection Against Frost Action

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for any exterior unheated footings or concrete pads to insulate against the deleterious effects of frost action.

It is expected that the inlet pipe for the proposed SWMF has limited frost cover (i.e. less than 2.1 m) and is open to air at both sides. From a geotechnical perspective, the pipe does not require insulation due to the limited frost cover. However, the pipe should be surrounded by non-frost susceptible granular material, such as OPSS Granular A or Granular B Type I or II, below settlement sensitive features, such as paved areas, to limit any differential frost heave issues. It is further recommended that a frost taper be provided as part of the backfilling program below any paved areas. It is recommended that a frost taper starting at the frost line (approximately 2.1 m below finished grade) extend along a 2H:1V slope leading to subgrade level of the pavement structure. Backfill within the frost taper should consist of clean imported granular fill, such as OPSS Granular A or Granular B Type I or II. The trench backfill should be placed in maximum lift thicknesses of 300 mm and compacted to a minimum 95% of its SPMDD.

The above noted recommendations should be confirmed by Paterson when the finalized design drawings are available for review and commentary.

5.7 Pipe Bedding and Backfill

A minimum of 300 mm of OPSS Granular A should be placed for bedding for sewer or water pipes when placed on bedrock subgrade. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to a minimum of 300 mm above the pipe obvert should consist of OPSS Granular A (concrete or PSM PVC pipes) or sand (concrete pipe). The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to a minimum of 95% SPMDD.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) should match the soils exposed at the trench walls to reduce potential differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% SPMDD.

Clay seal recommendations at the creek crossings have been provided in memorandum PG4258-MEMO.01 dated June 13, 2018 presented in Appendix 1.

5.8 Groundwater Control

Groundwater Control for Pond Construction

The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium.

Infiltration levels are anticipated to be high within the bedrock layers through the excavation operations. The groundwater infiltration should be controllable with the recommended pumping system in Subsection 5.5, prior to commencing the excavation operations of the proposed SWMF.

A temporary Ministry of the Environment and Climate Change (MOECC) permit to take water (PTTW) Category 3 will be required for this project since it is expected that more than 400,000 L/day of ground and/or surface water is to be pumped during the construction phase. A minimum 4 to 5 months should be allowed for completion of the PTTW application package and issuance of the permit by the MOECC.

Impacts on Neighbouring Structures

Based on the shallow bedrock encountered across the subject site, the neighbouring buildings are expected to be founded on glacial till or bedrock. Therefore, temporary dewatering of the area during construction is not expected to adversely affect the neighbouring structures.

5.9 Hydrogeological Considerations

It should be noted that Paterson prepared a hydrogeological existing conditions report, PH2223-3 - Revision 4 dated May 18, 2016 in conjunction with a supplemental memorandum, PH2223-MEMO.01 dated June 24, 2016 in response to City of Ottawa comments dated June 21, 2016.

Existing Wells

Existing water supply wells in the vicinity of the SWMF are completed at significant depths within the March/Nepean and Oxford Formation bedrock aquifers. The majority of these wells were reported as encountering water-bearing zones significantly below the bottom of the proposed SWMF proposed at the subject site. As such, these wells are considered to have a relatively low potential to be impacted by construction dewatering activities at the subject site. No environmental concerns were identified with respect to the existing water supply wells.

If the proposed SWMF necessitates the redevelopment of existing residential properties, decommissioning of existing on-site water wells may be required. These wells should be decommissioned by licensed water well contractors as per Ontario Regulation 903 (Wells) under the Ontario Water Resources Act. Without proper decommissioning, wells may act as downward conduits for the migration of contaminants. Additionally, the potential for artesian conditions (elevation of piezometric surface above upper confining layer elevation) has been identified at the subject site, and well decommissioning by a licensed contractor will ensure any artesian conditions are properly addressed, if encountered.

As a due diligence measure, prior to the commencement of site excavation works for the SWMF, it is recommended that a baseline monitoring program be completed at selected existing water wells in the vicinity of the subject site. The baseline monitoring program should be completed at all wells within 250 m of the subject site, and may be expanded on an as-required basis. The following program is proposed:

- ☐ Wells within an area of approximately 250 m from the subject site boundary will be included in the baseline monitoring program. This area will include the majority of lots within adjacent country estate lot subdivisions. This area may be expanded based on the results of the baseline monitoring program and/or sentry well monitoring.

- ☐ A visual inspection of the well will be completed. The details of the well (location, casing type, address, well tag number) will be verified with the published well record, if possible. Any discrepancies will be noted.

- ☐ Wells will be surveyed to a geodetic benchmark.

- ☐ The water level at the well will be recorded, using an electronic water level meter that has been properly cleaned and disinfected in accordance with industry best practices.

- ☐ A water sample will be obtained either directly from the well or from a suitable tap prior to any treatment process (disinfection, softening, etc.). The water sample will be submitted for analytical testing for the City of Ottawa "subdivision package" suite of parameters.

- ☐ Based on the results of the above-noted methodology, specific wells may be selected for installation of automatic water level logging devices. Level loggers will be installed in accordance with industry best practices. Wells selected for level logger installation will be determined in consultation with landowners and the City of Ottawa.

In addition to the monitoring program proposed above, it is proposed that baseline monitoring of on-site wells continue, for the purpose of observing seasonal fluctuations in water levels prior to construction. As an additional measure, and in consultation with City of Ottawa staff, it is recommended that sentry wells be installed near the boundaries of the proposed SWMF for the purpose of early detection of drawdown effects related to the construction of the SWMF.

The installation of these sentry wells will be considered mandatory to the development, although their locations may be altered as necessary to provide optimal coverage. It is recommended that baseline water level monitoring data be obtained at these wells for a period of at least one event prior to site development. It is recommended that sentry wells be completed at depths of 6-8 m as well as 10-15 m, in order to observe potential effects at the proposed maximum depth of the SWMF and associated services as well as at the depth at which the shallowest surrounding wells are completed.

In the event of impacts to surrounding wells by on-site construction activities, an alternative source of water will immediately be provided to the impacted properties by the proponents of the project. In the event of short-term impacts, tanked or bottled water may be provided, and in the event of long-term impacts which are confirmed to be a result of construction activities at the subject site, consideration will be given to deepening the pumps in affected wells where significant available drawdown is present, or potentially drilling a new well. In areas where affected wells are completed in the Oxford Formation, the underlying March-Nepean Formation represents a suitable aquifer in which to complete these wells.

Sentinel Monitoring Wells

Paterson conducted a field program to install sentinel monitoring wells at the Kanata North Urban Expansion Area (KNUEA) along March Road at the subject site.

The field program consisted of the installation of 10 monitoring wells at five locations on December 15 to 21, 2016. Each location consists of a pair of monitoring wells extending to a depth of 6 and 12 m below ground surface (bgs). Reference should be made to the Soil Profile and Test Data sheets attached to this report for specific details of the overburden and bedrock profile encountered at the monitoring well locations.

On December 22, each monitoring well at the subject site was equipped with a Van Essen Instruments Mini-Diver Water Level Logger (10m) for long-term groundwater monitoring. In addition, a Van Essen Instruments Baro-Diver was installed in BH2-DW to monitor the changes in atmospheric pressure. The Mini-Divers have been programmed to continuously measure and record groundwater levels throughout the subject site at a fixed rate of 1 reading every 30 minutes. The results of the groundwater fluctuations and correlated precipitation events for each monitoring well location between December 22, 2016 and May 17, 2018 have been summarized in Figure 2 through Figure 6 presented in Appendix 2.

The data presented in Figure 2 through Figure 6 suggest seasonal variations in groundwater levels to a maximum difference in groundwater depth of approximately 2.5 m. It should be noted that groundwater levels were measured to be periodically at or above existing ground surface in BH 1-16, BH 2-16, BH 4-16 and BH 5-16.

Blasting Operations

In general, bedrock removal by means of blasting within the shallow bedrock at the site has limited potential to impact the water quantity and quality in neighbouring water wells, which are generally completed at depths significantly below the depth of the proposed SWMF.

As noted in the preceding section, a baseline monitoring program will be completed prior to any blasting operations at the subject site and will provide water quantity and quality date which may be compared to conditions observed during blasting if problems are reported.

As a general guideline, peak particle velocities (measured at the property boundary) should not exceed 25 mm/s second at frequencies above 40 hz during the blasting program to reduce the risk of damage or impact to surround wells or structures. The blasting operations should be planned and conducted under the supervision of a licensed engineer who is also an experienced blasting consultant. These vibrations are considered minimal and will not affect the nearby water wells.

Storm Water Management Facility (SWMF)

As noted in the preceding sections, the proposed SWMF will be located in an area where water infiltration from the bedrock will require management during the construction phase. Based on the test hole program carried out as part of our investigation, water infiltration rates within the overburden soil were moderate to low. The infiltration rate through bedrock was high; managing the infiltration rate during bedrock removal operations will be critical during the construction program.

Where bedrock is exposed within the excavation, an impermeable liner will be required. The liner must have sufficient thickness to resist the uplift pressures caused by the high groundwater table observed at the site. Additional bedrock removal will be required to accommodate the material thickness required to resist uplift pressure.

Clay Liner

A minimum 500 mm thick clay liner is recommended to be placed over the bedrock surface to resist the uplift pressure at the bottom and sidewalls where bedrock is encountered. The clay liner will also improve the imperviousness of the excavation side slope during fluctuations in the pond water level. The clay used for the liner should consist of brown, workable clay that can be placed and compacted using a sheep's foot roller making several passes and approved in the field by Paterson.

5.10 Winter Construction

Precautions must be taken if winter construction is considered for this project.

In the event of construction during below zero temperatures, the founding stratum should be protected from freezing temperatures by the installation of straw, propane heaters and tarpaulins or other suitable means. The base of the excavations should be insulated from sub-zero temperatures immediately upon exposure and until such time as heat is adequately supplied to the building and the footings are protected with sufficient soil cover to prevent freezing at founding level.

Trench excavations and pavement construction are difficult activities to complete during freezing conditions without introducing frost in the subgrade or in the excavation walls and bottoms. Precautions should be taken if such activities are to be carried out during freezing conditions. Additional information could be provided, if required.

5.11 Corrosion Potential and Sulphate

The results of analytical testing show that the sulphate content is less than 0.1%. This result is indicative that Type 10 Portland cement (normal cement) would be appropriate for this site. The chloride content and the pH of the sample indicate that they are not significant factors in creating a corrosive environment for exposed ferrous metals at this site, whereas the resistivity is indicative of a low corrosive environment.

6.0 Recommendations

A materials testing and observation services program is a requirement for the provided foundation design data to be applicable. The following aspects of the program should be performed by the geotechnical consultant:

- ☐ Review of the finalized pond design drawings from a geotechnical perspective, once available.
- ☐ Periodic site visits during controlled blasting operations and to monitoring the groundwater influx during construction.
- ☐ Observation of all bearing surfaces prior to the placement of concrete and/or precast structures.
- ☐ Sampling and testing of the concrete and fill materials used.
- ☐ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.
- ☐ Observation of all subgrades and bearing surfaces prior to backfilling.
- ☐ Field density tests to determine the level of compaction achieved.

A report confirming that these works have been conducted in general accordance with our recommendations could be issued, upon request, following the completion of a satisfactory materials testing and observation program by the geotechnical consultant.

7.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. We request permission to review the grading plan once available. Also, our recommendations should be reviewed when the drawings and specifications are complete.

The client should be aware that any information pertaining to soils and all test hole logs are furnished as a matter of general information only and test hole descriptions or logs are not to be interpreted as descriptive of conditions at locations other than those of the test holes.

A soils investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Novatech Engineering Consultants Ltd. or their agent(s) is not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

Richard Groniger, C. Tech.

Carlos P. Da Silva, P.Eng., ing., QP_{ESA}

LICENSED PROFESSIONAL ENGINEER
June 14, 2018
C. P. DA SILVA
PROVINCE OF ONTARIO

Report Distribution:

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- ☐ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

HYDRAULIC CONDUCTIVITY TEST DATA SHEETS

ANALYTICAL TEST RESULTS

PG4258-MEMO.01 DATED JUNE 13, 2018

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical investigation
Proposed Stormwater Management Facility
1053 March Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

FILE NO. PG4258

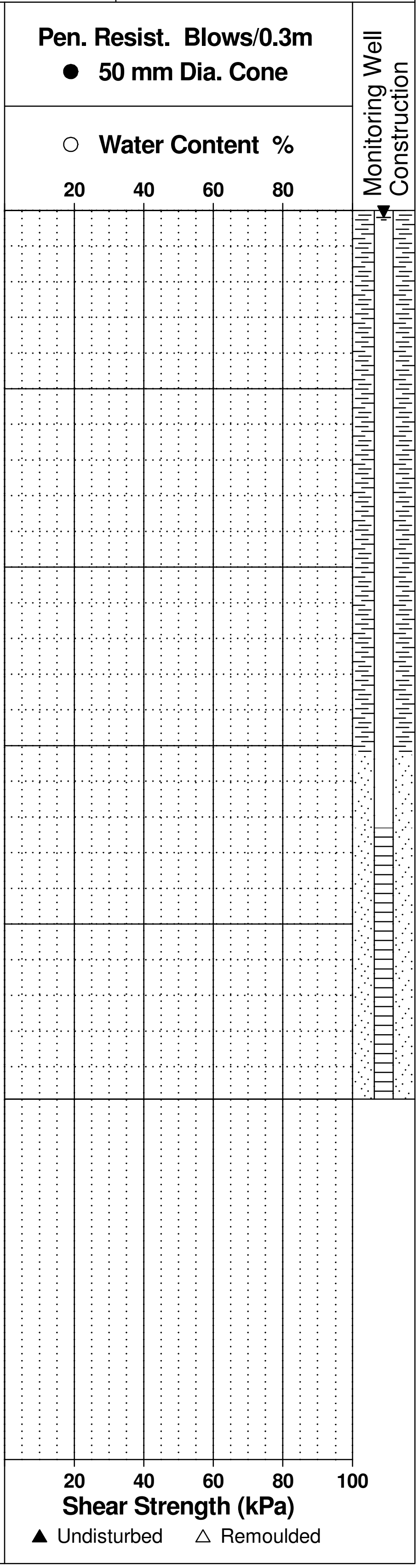
REMARKS

HOLE NO. BH 1

BORINGS BY CME 55 Power Auger

DATE October 20, 2017

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	83.20
TOPSOIL 0.40						
Very stiff to stiff, brown **SILTY CLAY,** trace sand	SS	1	92	10	1	82.20
1.68 **GLACIAL TILL:** Dense, brown silty clay with sand, gravel, cobbles, some boulders 2.13	SS	2	96	30	2	81.20
	RC	1	96	76	3	80.20
BEDROCK: Grey limestone						
	RC	2	98	87	4	79.20
4.98 End of Borehole						
(GWL @ 0.04m depth - Nov 14/17)						



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical investigation
Proposed Stormwater Management Facility
1053 March Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

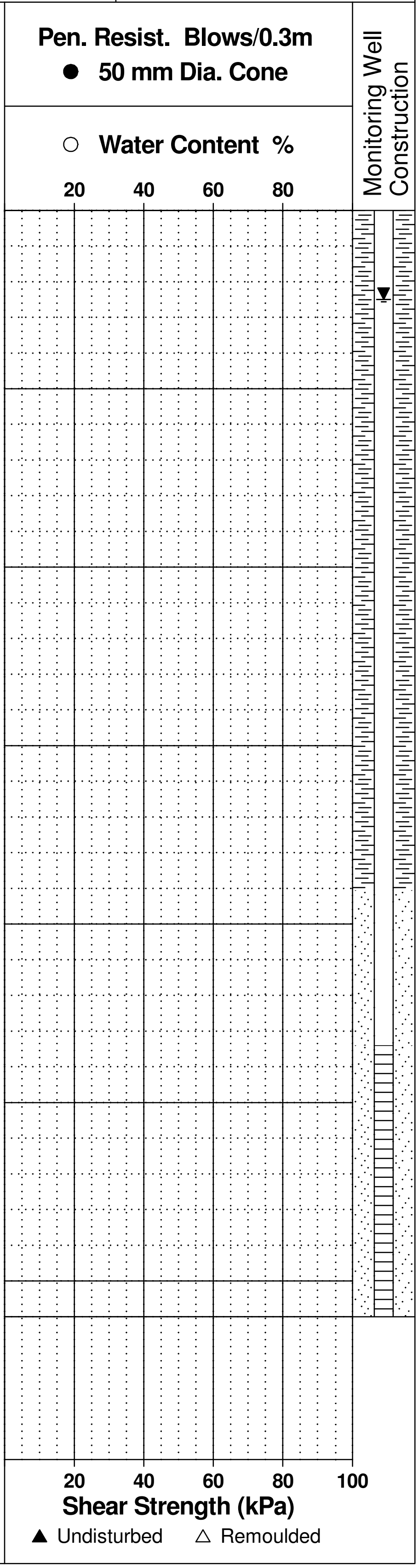
DATE October 20, 2017

FILE NO. PG4258

HOLE NO. BH 2

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.40				
Stiff to hard, brown **SILTY CLAY,** trace sand	SS	1	100	11
	SS	2	100	10
2.72	SS	3	100	50+
GLACIAL TILL: Very dense, brown silty clay with sand, gravel, cobbles, trace boulders 3.48	SS	4	71	50+
BEDROCK: Grey limestone	RC	1	100	67
6.20	RC	2	100	69
End of Borehole (GWL @ 0.5 m depth - Nov 14/17)				

DEPTH (m)	ELEV. (m)
0	82.43
1	81.43
2	80.43
3	79.43
4	78.43
5	77.43
6	76.43



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SOIL PROFILE AND TEST DATA

Geotechnical investigation
Proposed Stormwater Management Facility
1053 March Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

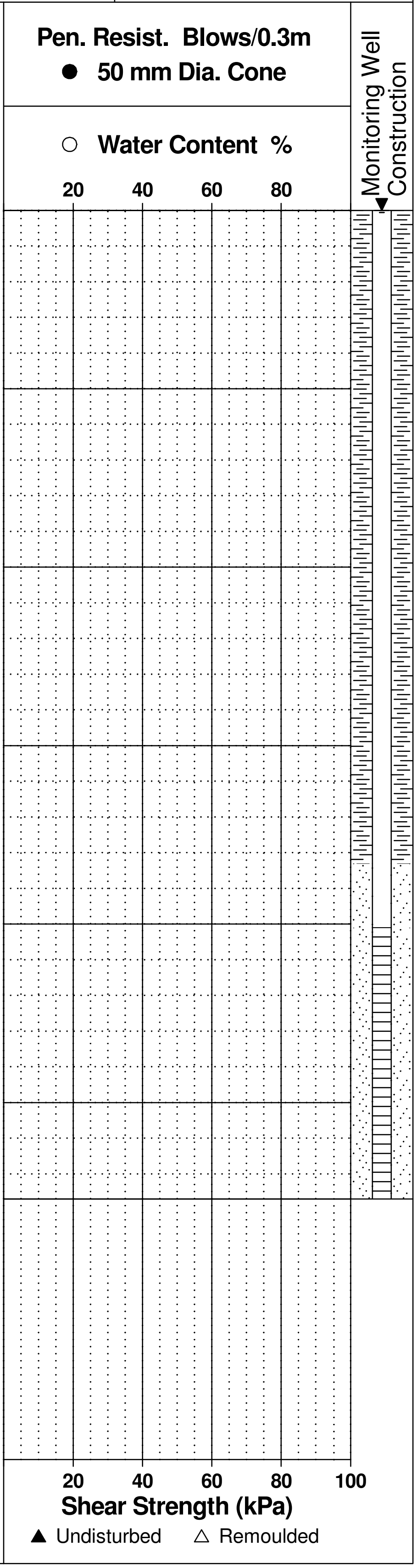
BORINGS BY CME 55 Power Auger

DATE October 20, 2017

FILE NO. PG4258

HOLE NO. BH 3

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	81.77
TOPSOIL 0.35	AU	1				
Very stiff to stiff, brown **SILTY CLAY,** trace sand	SS	2	92	10	1	80.77
	SS	3	100	8	2	79.77
2.59	SS	4	75	13		
GLACIAL TILL: Compact to very dense, brown silty clay with sand, gravel, cobbles, trace boulders					3	78.77
	SS	5	50	50+		
3.45	RC	1	100	0		
BEDROCK: Grey limestone					4	77.77
	RC	2	100	91		
					5	76.77
	RC	3	92	79		
5.54 End of Borehole (GWL @ 0.04 m above ground surface - Nov 14/17)						



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5025679.5; Easting 348531.2

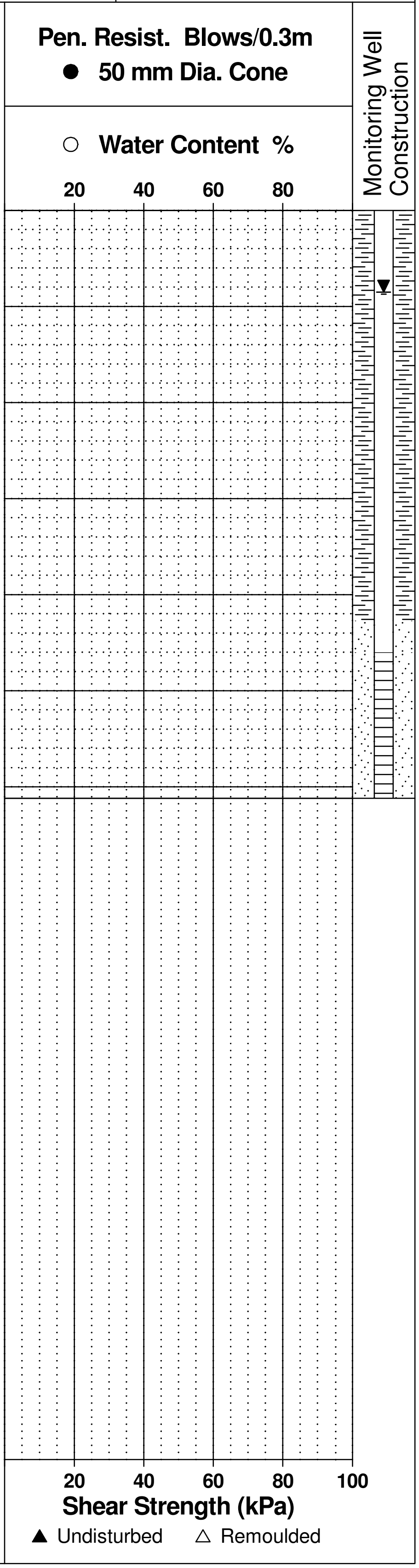
BORINGS BY CME 55 Power Auger

DATE November 15, 2017

FILE NO. PG3975

HOLE NO. BH 1A-16

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	73.08
OVERBURDEN						1	72.08
2.21						2	71.08
BEDROCK: Good to poor quality, grey limestone, some shale partings		RC	1	100	85	3	70.08
		RC	2	100	40	4	69.08
						5	68.08
		RC	3	100	45		
6.12						6	67.08
End of Borehole							
(GWL @ 0.85m-Dec. 20, 2016)							



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5025679.5; Easting 348531.2

BORINGS BY CME 55 Power Auger

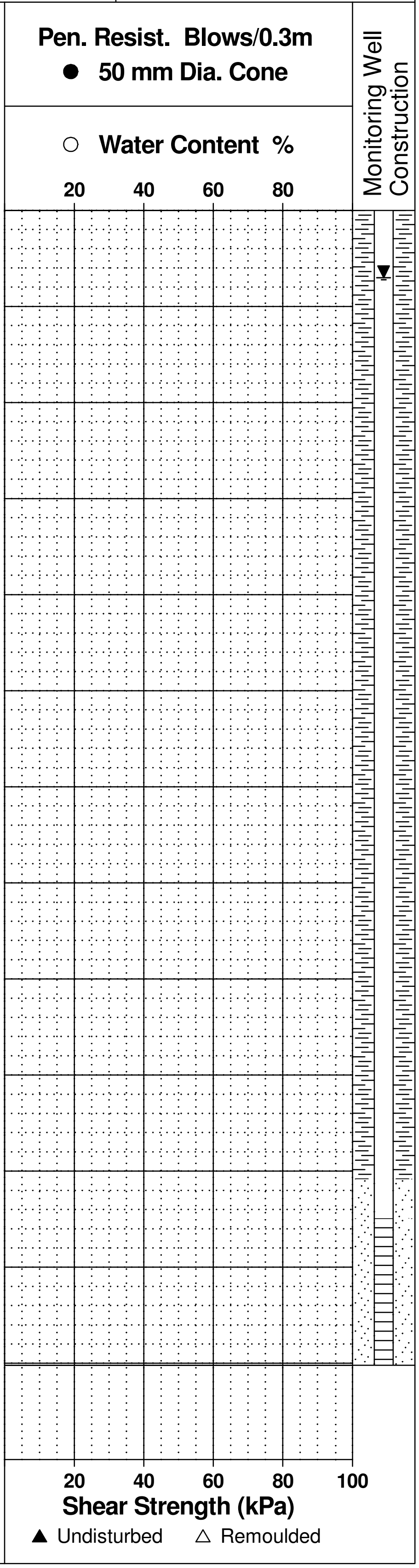
DATE November 15, 2017

FILE NO. PG3975

HOLE NO. BH 1B-16

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE					
OVERBURDEN					
2.36					
BEDROCK: Fair to excellent quality, grey limestone, some shale partings		RC	1	100	75
		RC	2	100	40
		RC	3	100	60
		RC	4	100	95
		RC	5	100	66
		RC	6	100	86
		RC	7	100	100
12.02					
End of Borehole (GWL @ 0.70m-Dec. 20, 2016)					

DEPTH (m)	ELEV. (m)
0	73.08
1	72.08
2	71.08
3	70.08
4	69.08
5	68.08
6	67.08
7	66.08
8	65.08
9	64.08
10	63.08
11	62.08
12	61.08



SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5025146.3; Easting 348117.8

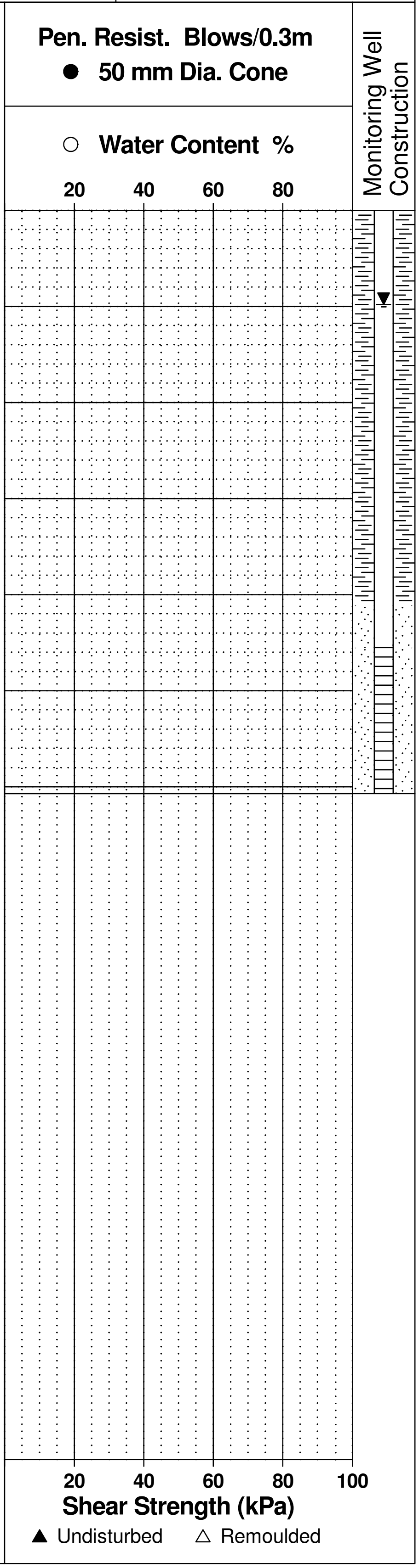
BORINGS BY CME 55 Power Auger

DATE November 16, 2017

FILE NO. PG3975

HOLE NO. BH 2A-16

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	82.95
OVERBURDEN						1	81.95
						2	80.95
2.51							
BEDROCK: Poor to fair quality, grey limestone, some shale partings		RC	1	100	47	3	79.95
		RC	2	100	80	4	78.95
						5	77.95
		RC	3	100	69		
6.07						6	76.95
End of Borehole (GWL @ 0.98m-Dec. 20, 2016)							



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5025146.3; Easting 348117.8

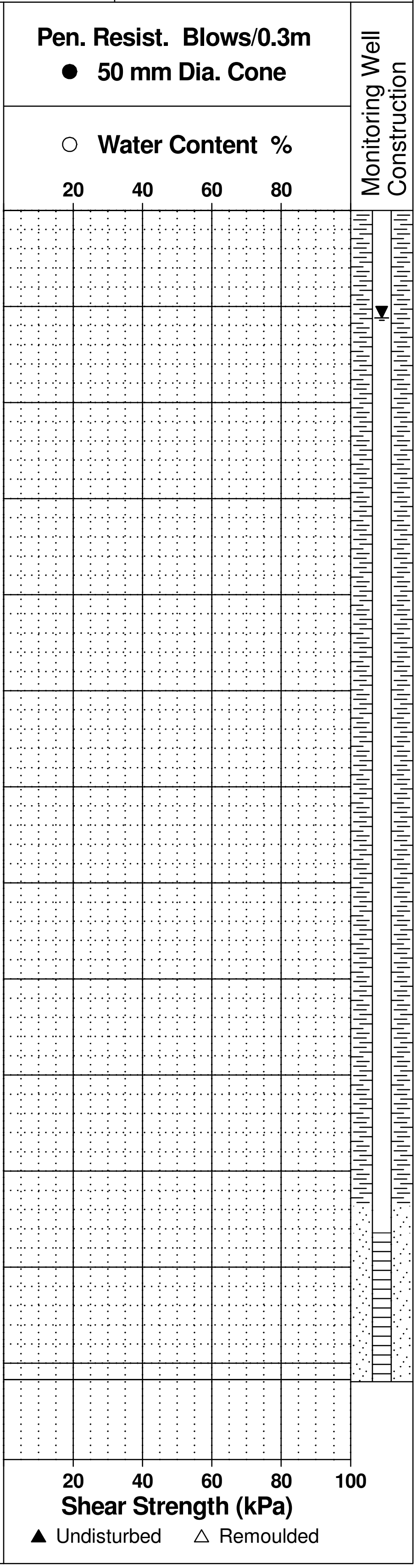
BORINGS BY CME 55 Power Auger

DATE November 16, 2017

FILE NO. PG3975

HOLE NO. BH 2B-16

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	82.95
						1	81.95
OVERBURDEN							
						2	80.95
3.02		RC	1	100		3	79.95
		RC	2	100	67	4	78.95
						5	77.95
		RC	3	100	66	6	76.95
BEDROCK: Fair to excellent quality, grey limestone, some shale partings		RC	4	100	61	7	75.95
		RC	5	100	93	8	74.95
						9	73.95
		RC	6	100	95	10	72.95
						11	71.95
		RC	7	100	90	12	70.95
12.17							
End of Borehole (GWL @ 1.12m-Dec. 20, 2016)							



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5025257.5; Easting 347719.2

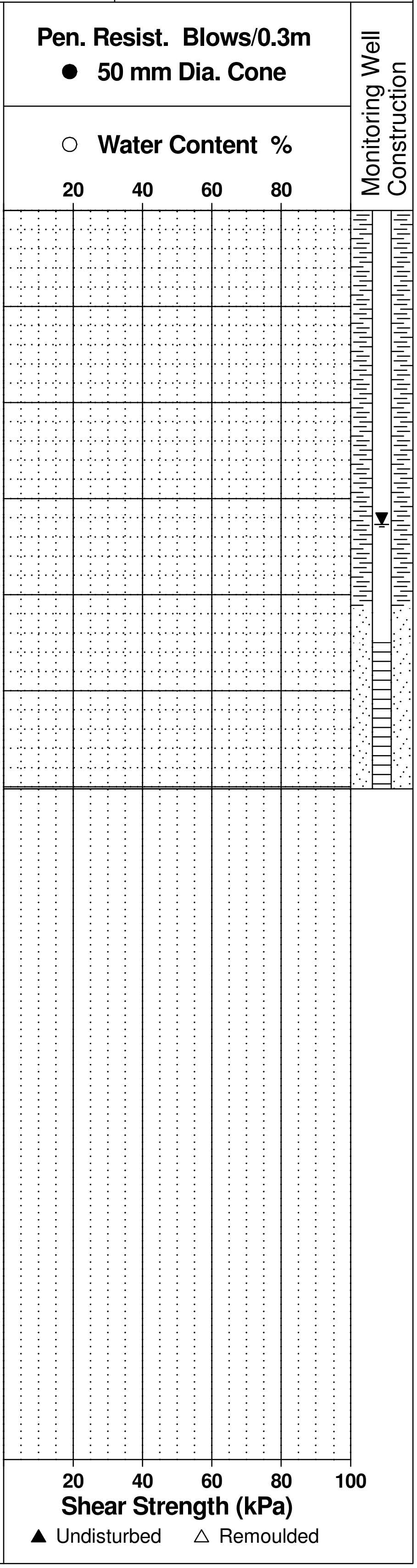
BORINGS BY CME 55 Power Auger

DATE November 18, 2017

FILE NO. PG3975

HOLE NO. BH 3A-16

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.84
OVERBURDEN					1	87.84
1.73						
	RC	1	100	67	2	86.84
	RC	2	100	86	3	85.84
BEDROCK: Fair to good qualtiy, grey limestone, some shale partings					4	84.84
	RC	3	100	68	5	83.84
6.02					6	82.84
End of Borehole (GWL @ 3.27m-Dec. 20, 2016)						



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5025257.5; Easting 347719.2

BORINGS BY CME 55 Power Auger **DATE** November 18, 2017

FILE NO. PG3975

HOLE NO. BH 3B-16

GROUND SURFACE

OVERBURDEN

1.73

BEDROCK: Good to fair quality, grey limestone, some shale partings

- excellent to good quality by 7.5m depth

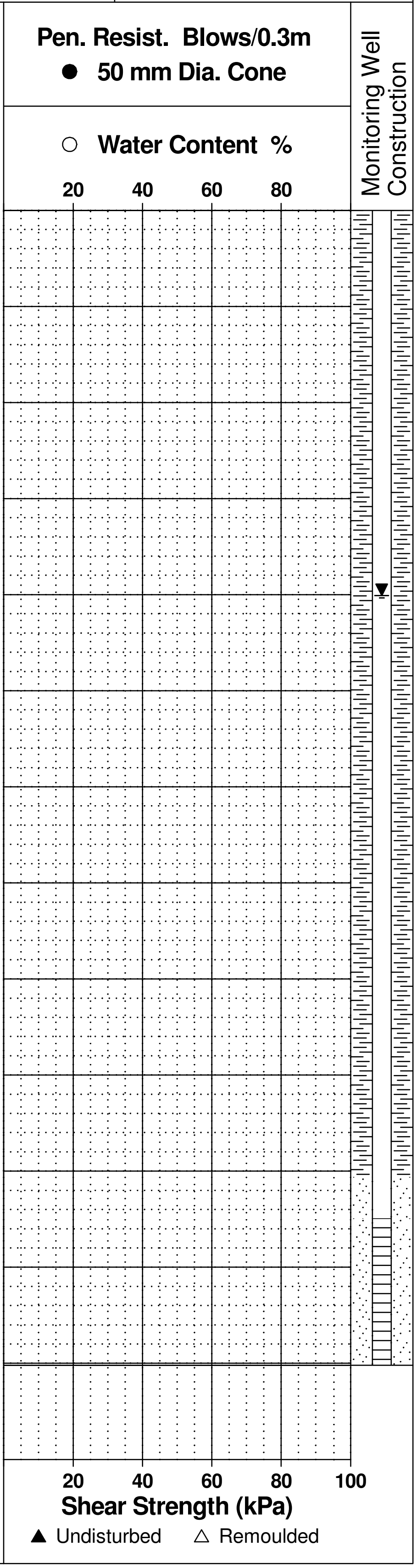
12.02

End of Borehole

(GWL @ 4.01m-Dec. 20, 2016)

TYPE	NUMBER	% RECOVERY	N VALUE or RQD
RC	1	100	81
RC	2	95	41
RC	3	100	58
RC	4	100	58
RC	5	100	100
RC	6	100	93
RC	7	100	81

DEPTH (m)	ELEV. (m)
0	88.84
1	87.84
2	86.84
3	85.84
4	84.84
5	83.84
6	82.84
7	81.84
8	80.84
9	79.84
10	78.84
11	77.84
12	76.84



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5024849.7; Easting 347680.5

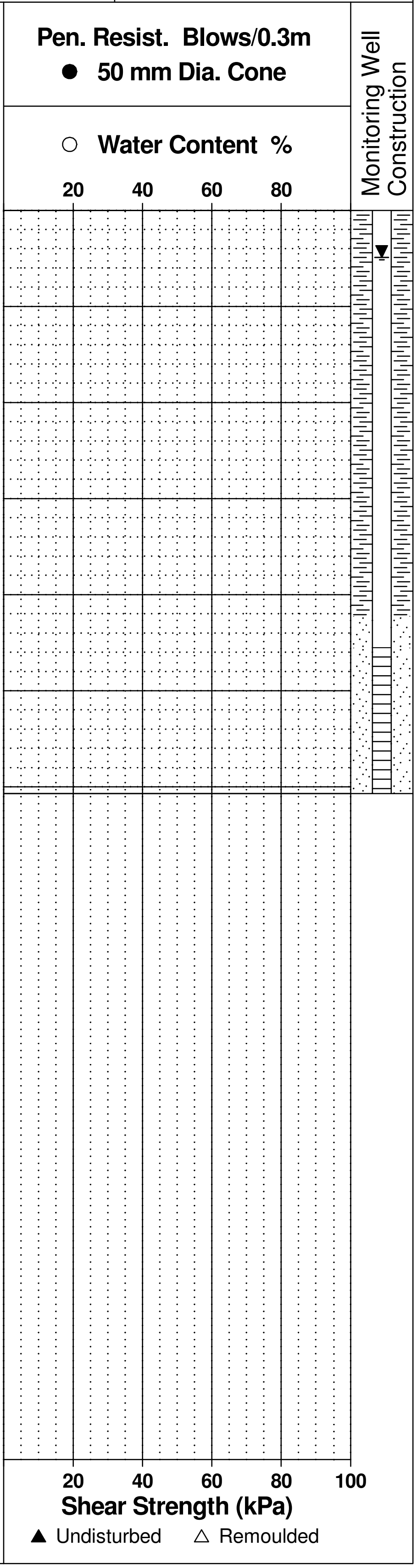
BORINGS BY CME 55 Power Auger

DATE November 18, 2017

FILE NO. PG3975

HOLE NO. BH 4A-16

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.34
OVERBURDEN						1	88.34
2.03						2	87.34
		RC	1	100	88	3	86.34
BEDROCK: Good to excellent qualtiy, grey limestone, some shale partings		RC	2	100	97	4	85.34
						5	84.34
		RC	3	95	90		
6.07						6	83.34
End of Borehole							
(GWL @ 0.49m-Dec. 20, 2016)							



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5024849.7; Easting 347680.5

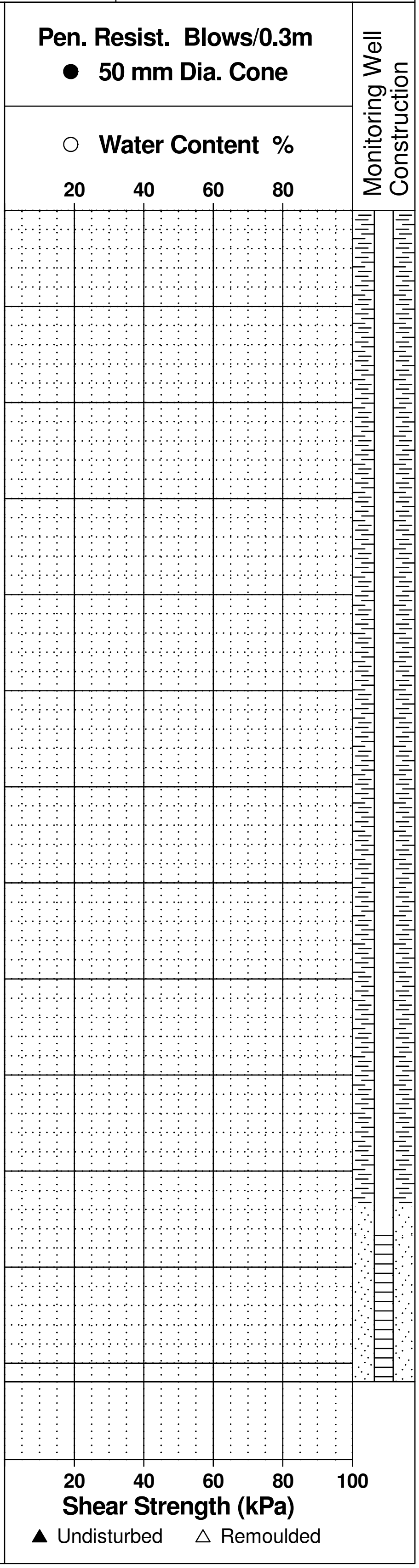
BORINGS BY CME 55 Power Auger

DATE November 16, 2017

FILE NO. PG3975

HOLE NO. BH 4B-16

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.34
OVERBURDEN						1	88.34
						2	87.34
2.26							
		RC	1	100	91		
						3	86.34
		RC	2	100	97		
						4	85.34
						5	84.34
		RC	3	100	98		
						6	83.34
		RC	4	100	100		
						7	82.34
BEDROCK: Excellent qualtiy, grey limestone, some shale partings							
						8	81.34
		RC	5	100	81		
						9	80.34
		RC	6	100	88		
						10	79.34
						11	78.34
		RC	7	100	93		
						12	77.34
12.19							
End of Borehole (MW blocked at 0.35m depth - Dec. 20, 2016)							



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SOIL PROFILE AND TEST DATA

Sentinel Monitoring Wells
Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5024538.9; Easting 348324.3

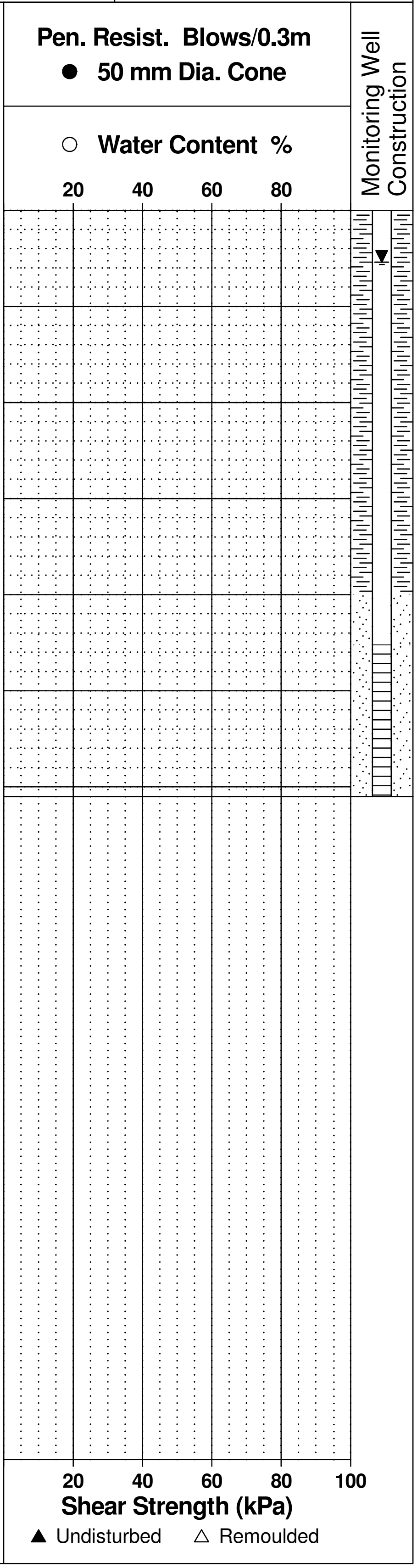
BORINGS BY CME 55 Power Auger

DATE November 21, 2017

FILE NO. PG3975

HOLE NO. BH 5A-16

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	84.22
OVERBURDEN						
0.76						
BEDROCK: Good to excellent quality, grey limestone, some shale partings	RC	1	100	75	1	83.22
	RC	2	100	85	2	82.22
					3	81.22
	RC	3	100	81	4	80.22
	RC	4	97	95	5	79.22
6.10					6	78.22
End of Borehole (GWL @ 0.54m-Dec. 20, 2016)						



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SOIL PROFILE AND TEST DATA

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Kanata North Community Design Plan
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Consulting Engineering Ltd.

REMARKS Northing 5024538.9; Easting 348324.3

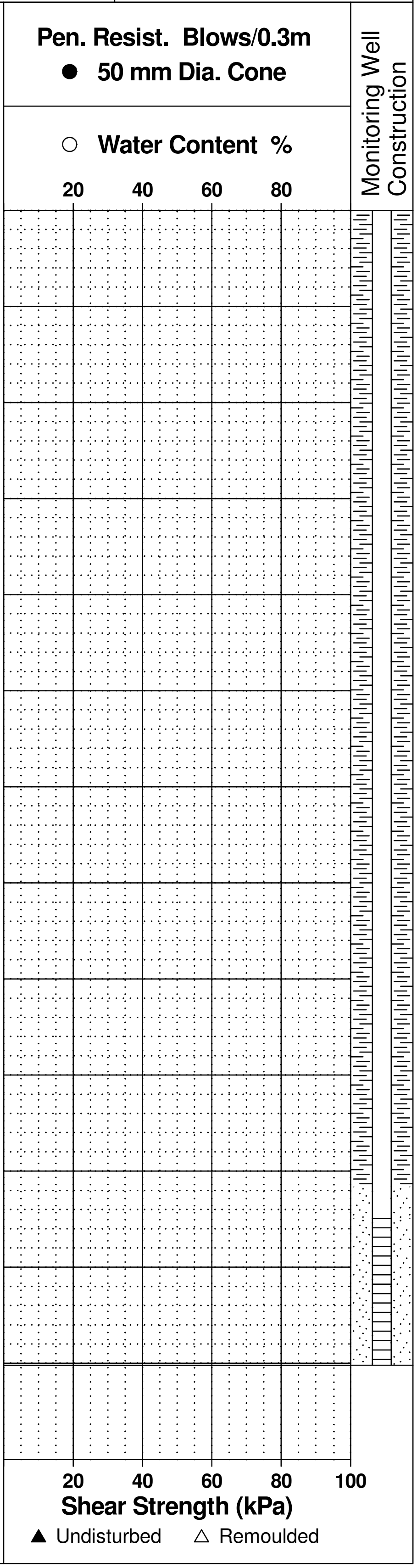
BORINGS BY CME 55 Power Auger

DATE November 21, 2017

FILE NO. PG3975

HOLE NO. BH 5B-16

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	84.22
OVERBURDEN 0.66						
	RC	1	100	71	1	83.22
	RC	2	100	95	2	82.22
					3	81.22
	RC	3	100	100	4	80.22
	RC	4	100	97	5	79.22
BEDROCK: Fair to excellent quality, grey limestone,some shale partings					6	78.22
	RC	5	100	100	7	77.22
	RC	6	100	95	8	76.22
					9	75.22
	RC	7	100	97	10	74.22
	RC	8	100	98	11	73.22
12.02					12	72.22
End of Borehole (MW blocked at 0.60m depth - Dec. 20, 2016)						



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SOIL PROFILE AND TEST DATA

Geotechnical investigation
Proposed Stormwater Management Facility
1053 March Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY Backhoe

DATE October 19, 2017

FILE NO. PG4258

HOLE NO. TP 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	85.22		
TOPSOIL 0.40	■								
Stiff, brown **SILTY CLAY,** trace sand 0.56	▨								
BEDROCK: Grey limestone 0.66	▤								
End of Test Pit (TP dry upon completion)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical investigation
Proposed Stormwater Management Facility
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DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

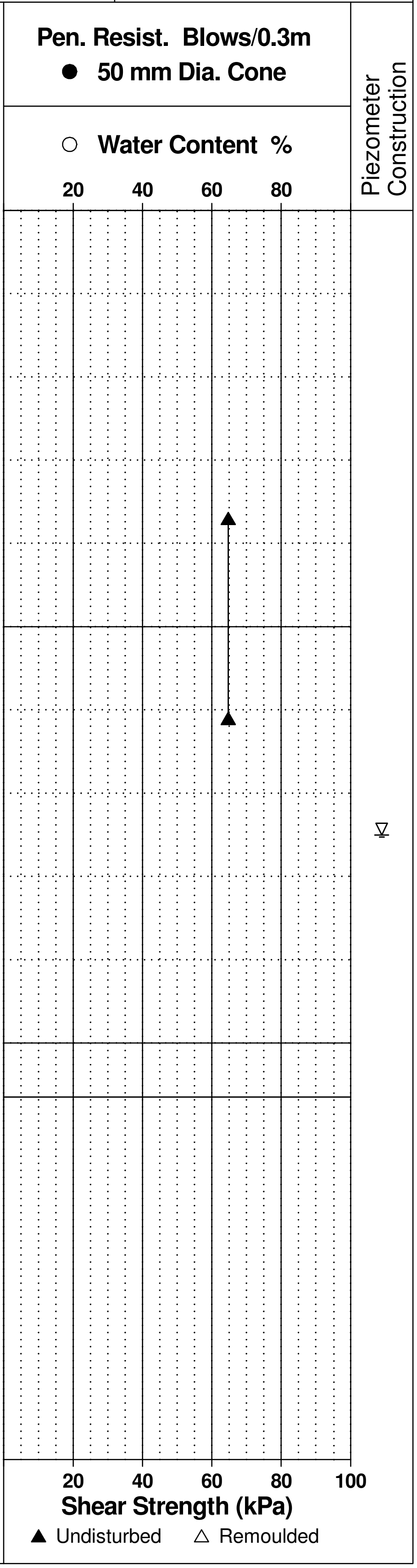
BORINGS BY Backhoe

DATE October 19, 2017

FILE NO. PG4258

HOLE NO. TP 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.12
TOPSOIL 0.30							
Very stiff to stiff, brown **SILTY CLAY,** trace sand 1.65						1	87.12
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, trace boulders 2.16						2	86.12
End of Test Pit TP terminated on bedrock surface at 2.16m depth (GWL @ 1.5m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

Geotechnical investigation
Proposed Stormwater Management Facility
1053 March Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

FILE NO. PG4258

REMARKS

HOLE NO. TP 3

BORINGS BY Backhoe

DATE October 19, 2017

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	89.87		
TOPSOIL 0.30									
Very stiff to stiff, brown **SILTY CLAY,** trace sand 1.42						1	88.87		∇
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, trace boulders 2.13						2	87.87		
End of Test Pit TP terminated on bedrock surface at 2.13m depth (GWL @ 1.4m depth based on field observations)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425287; 5023780

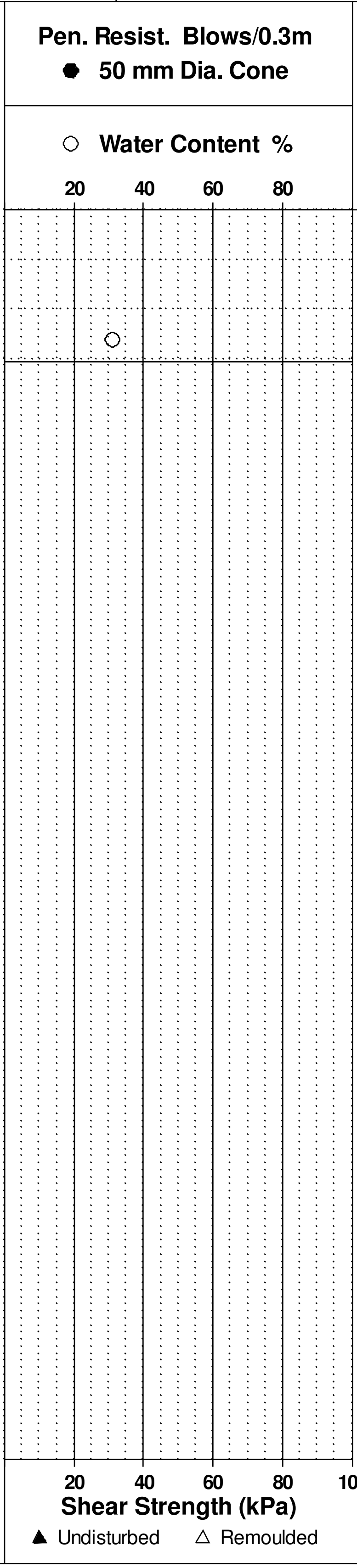
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP25

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.66
TOPSOIL 0.30	■						
Very stiff to stiff, brown **SILTY CLAY** 0.61	▨	G	1				
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 0.61m depth (TP dry upon completion)							



Piezometer Construction

patersongroup Consulting Engineers

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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425362; 5023727

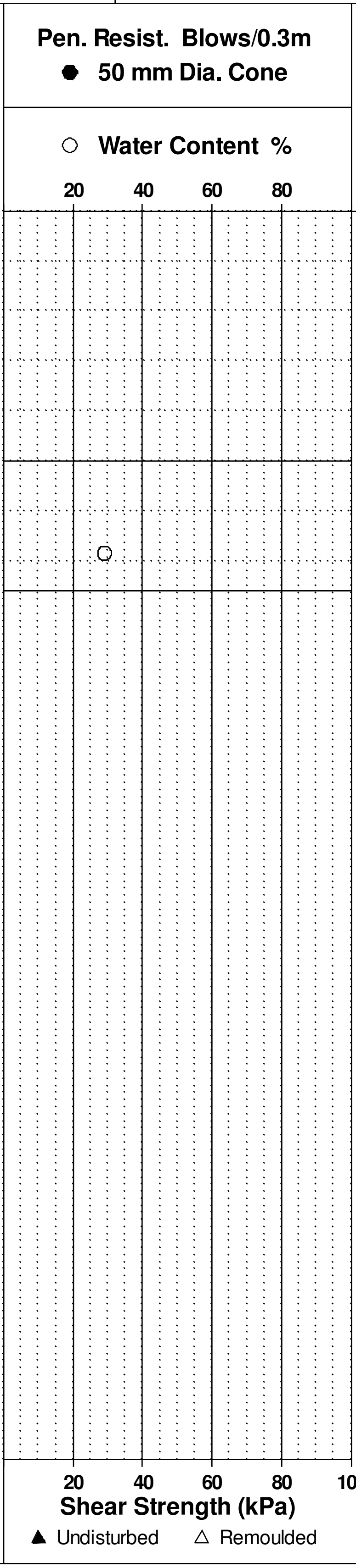
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP26

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.74
TOPSOL — 0.60							
Very stiff to stiff, brown **SILTY CLAY** — 1.22						1	88.74
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders — 1.52		G	1				
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 1.52m depth (TP dry upon completion)							



Piezometer Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425446; 5023599

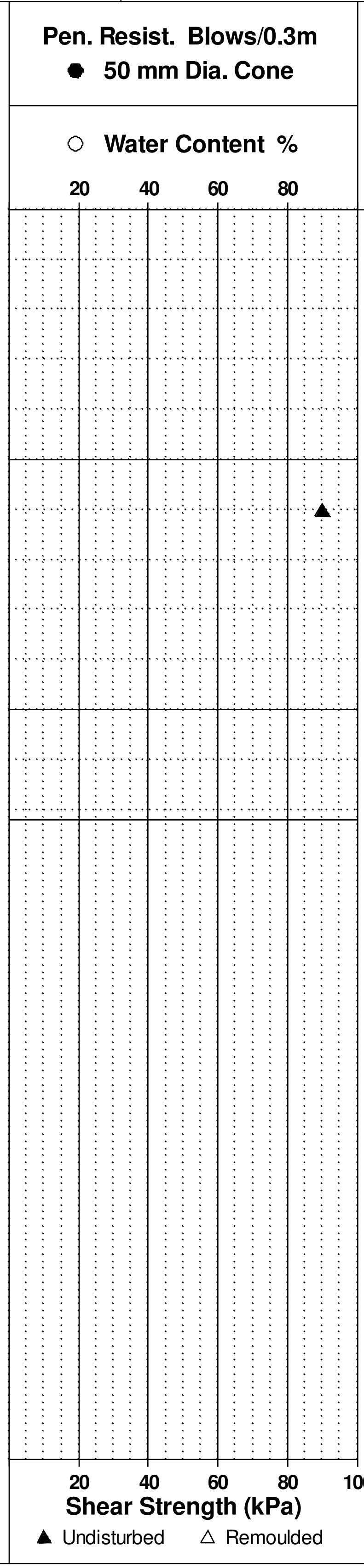
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP27

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD			
GROUND SURFACE						0	88.96	
TOPSOIL 0.60	■							
Very stiff to stiff, brown **SILTY CLAY,** trace sand 2.44	▨					1	87.96	
						2	86.96	
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 2.44m depth (TP dry upon completion)								



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425582; 5023702

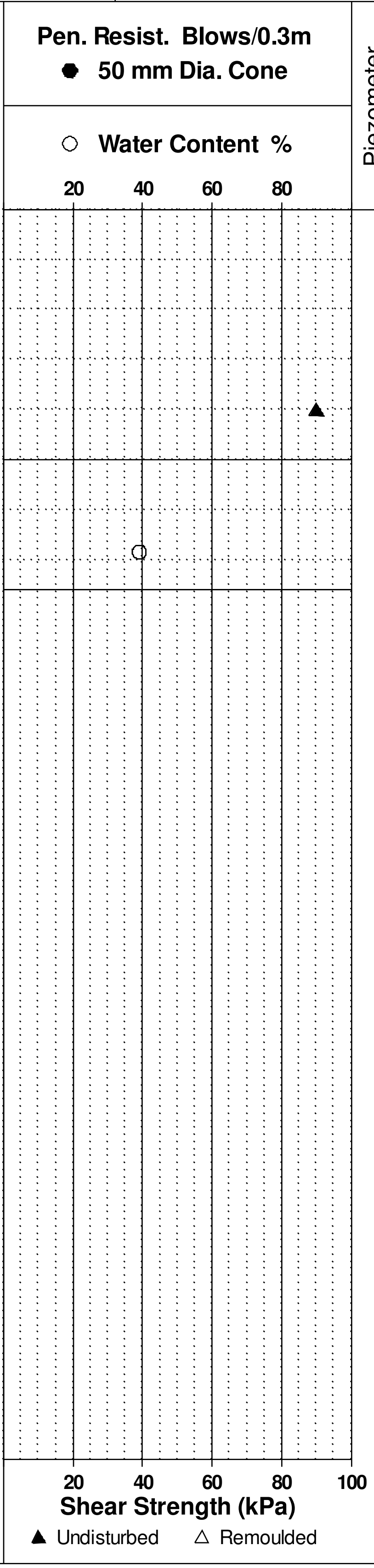
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP28

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	86.85	
TOPSOIL 0.41								
Very stiff to stiff, brown **SILTY CLAY** 1.52		G	1			1	85.85	
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 1.52m depth (TP dry upon completion)								



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425480; 5023826

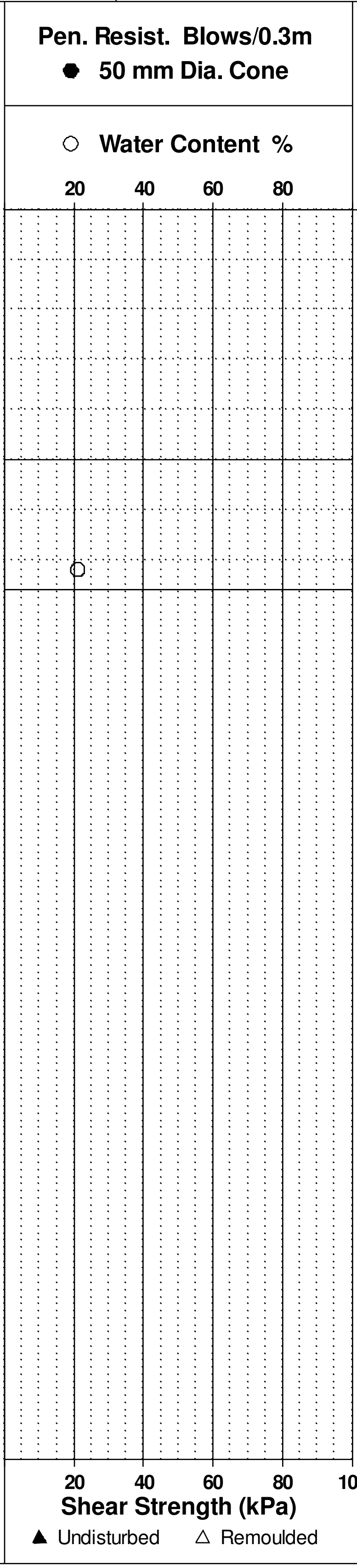
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP29

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	86.13	
TOPSOIL 0.41	■							
Firm to stiff, brown **SILTY CLAY** 1.07	▨							∇
						1	85.13	
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles, boulders 1.52		G	1					
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 1.52m depth (GWL @ 0.7m depth based on field observations)								



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425420; 5023875

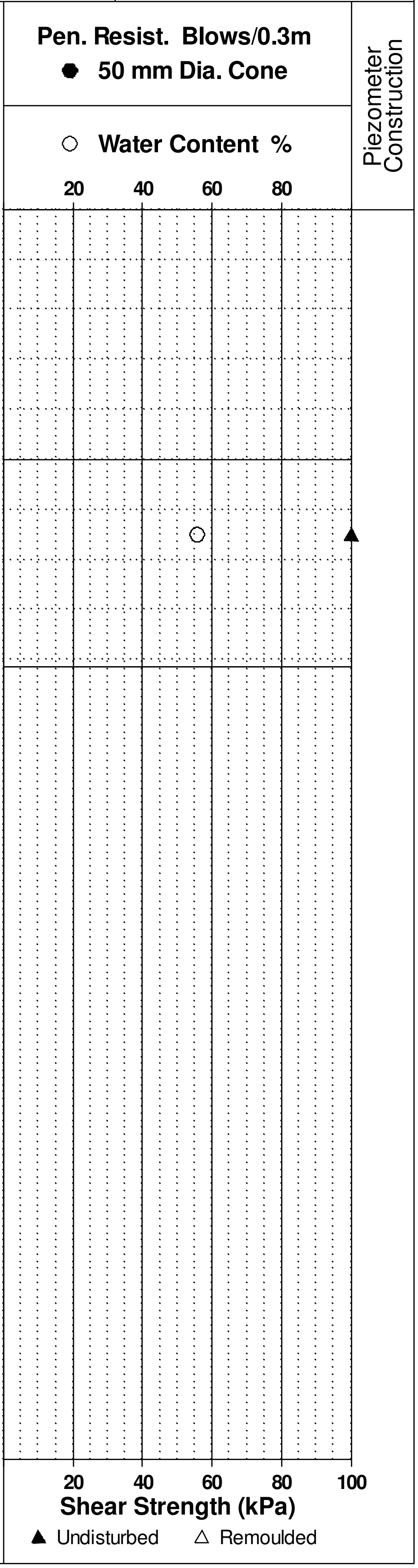
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP30

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	86.42
TOPSOIL 0.38	■						
Very stiff to stiff, brown **SILTY CLAY,** trace sand	▨					1	85.42
	▨	G	1				
1.83	▨						
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 1.83m depth (TP dry upon completion)							



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425562; 5023981

BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP31

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	88.37		
TOPSOIL 0.41	■								
Stiff, brown **SILTY CLAY,** some sand, trace gravel 0.81	▨								
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 0.81m depth (TP dry upon completion)									

Water Content % scale: 20 40 60 80

Shear Strength (kPa) scale: 20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425629; 5023917

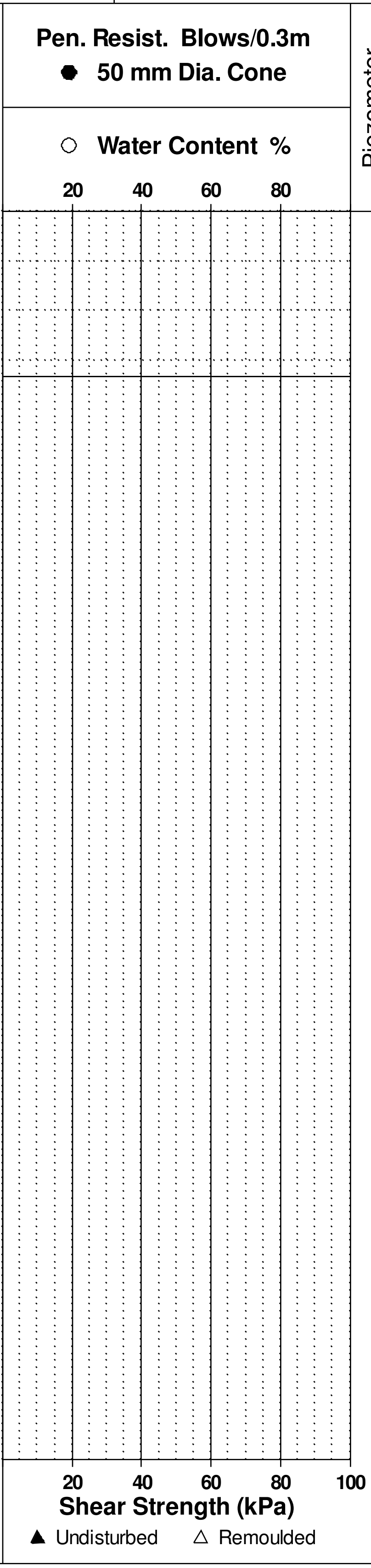
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP32

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	86.81	
TOPSOIL	■							
0.66								
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 0.66m depth (TP dry upon completion)								



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425702; 5023822

BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP33

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	84.00		
TOPSOIL 0.61	■								
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 0.61m depth (TP dry upon completion)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425799; 5023895

BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

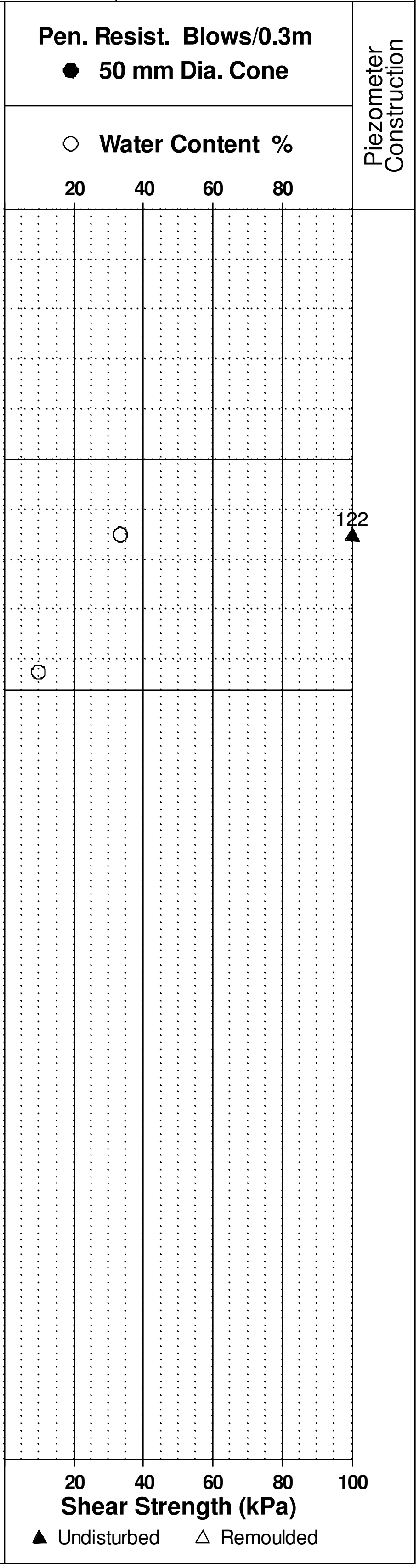
HOLE NO. TP34

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	84.02
TOPSOIL 0.41							
Hard to very stiff, brown **SILTY CLAY**						1	83.02
1.52		G	1				
GLACIAL TILL: Brown silty sand with gravel, cobbles, boulder, 1.92		G	2				

End of Test Pit

Practical refusal to excavation on inferred bedrock surface at 1.92m depth

(TP dry upon completion)



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425826; 5024040

BORINGS BY Hydraulic Excavator

DATE March 21, 2013

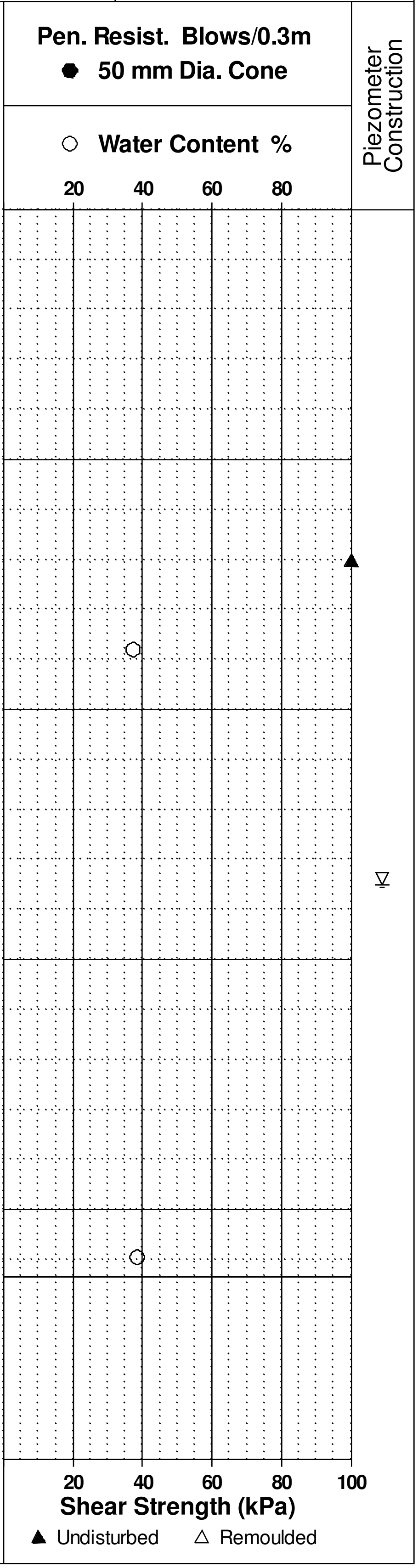
FILE NO. PG2878

HOLE NO. TP35

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	82.99
TOPSOIL	■						
0.46							
						1	81.99
		G	1				
						2	80.99
Hard to very stiff, brown **SILTY CLAY**	▨						
						3	79.99
						4	78.99
4.27		G	2				

End of Test Pit
Practical refusal to excavation on inferred bedrock surface at 4.27m depth

(GWL @ 2.7m depth based on field observations)



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Future Development Lands - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS 18T 0425699; 5024001

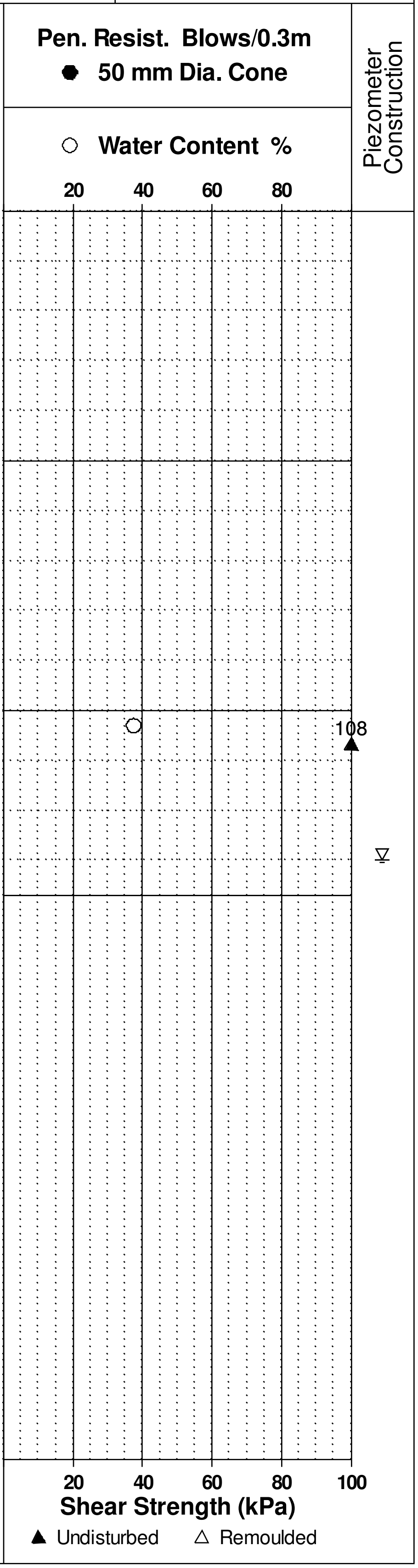
BORINGS BY Hydraulic Excavator

DATE March 21, 2013

FILE NO. PG2878

HOLE NO. TP36

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	84.76
TOPSOIL 0.41	■						
						1	83.76
Hard to very stiff, brown **SILTY CLAY** 2.74	▨	G	1			2	82.76
End of Test Pit Practical refusal to excavation on inferred bedrock surface at 2.74m depth (GWL @ 2.6m depth based on field observations)							



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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

FILE NO. PG1823

HOLE NO. TP 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	88.10	20 40 60 80	
TOPSOIL 0.18									
Brown **SILTY SAND**, trace organic matter 0.55		G	1						
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders 0.70									
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 0.70m depth (TP dry upon completion)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

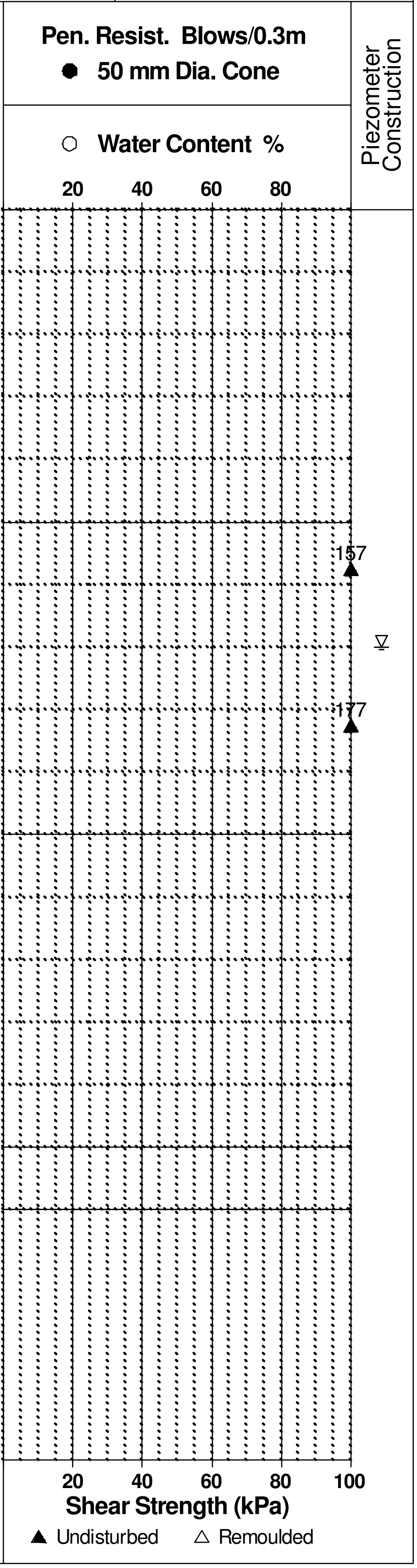
BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

FILE NO. PG1823

HOLE NO. TP 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.57
TOPSOIL 0.25							
Very stiff, brown **SILTY CLAY**		G	1				
- grey by 0.75m depth		G	2				
						1	87.57
						2	86.57
2.90							
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders 3.20						3	85.57
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 3.20m depth (Open hole GWL @ 1.4m depth)							



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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

FILE NO. PG1823

HOLE NO. TP 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	85.48		
TOPSOIL 0.18									
Brown **SILTY CLAY** 0.47		G	1						
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders		G	2						
						1	84.48		
1.90									
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 1.90m depth (TP dry upon completion)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

FILE NO. PG1823

HOLE NO. TP 4

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	88.13		
TOPSOIL 0.20									
Brown **SILTY SAND** 0.50		G	1						
GLACIAL TILL: Grey clayey silt, some gravel, trace sand, cobbles and boulders 1.40		G	2			1	87.13		
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 1.40m depth (TP dry upon completion)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

FILE NO. **PG1823**

REMARKS

HOLE NO. **TP 5**

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % (20, 40, 60, 80)	Piezometer Construction
GROUND SURFACE						0	88.50		
TOPSOIL 0.26									
Brown **SANDY SILT**, trace gravel 0.80		G	1						
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders 1.15		G	2			1	87.50		
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 1.15m depth (TP dry upon completion)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

FILE NO. **PG1823**

REMARKS

HOLE NO. **TP 6**

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	89.10
TOPSOIL 0.25	■						
Brown **SILTY CLAY** 0.85	▨	G	1				
GLACIAL TILL: Grey silty clay with sand, gravel, cobbles and boulders 2.20	^^^	G	2			1	88.10
						2	87.10
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 2.20m depth (TP dry upon completion)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

Piezometer Construction

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

FILE NO. PG1823

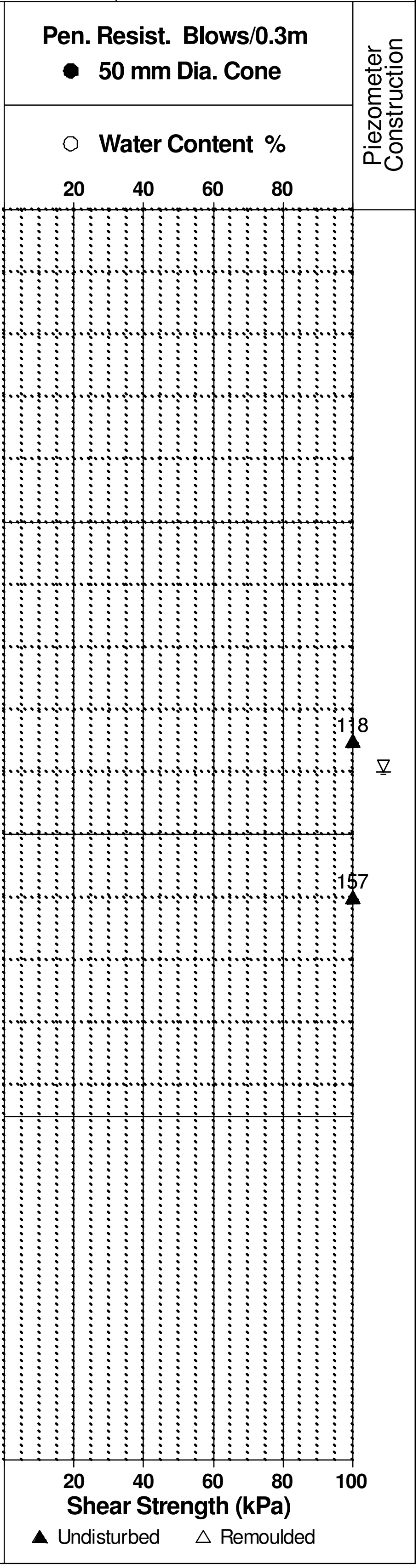
HOLE NO. TP 7

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.06
TOPSOIL 0.20	■						
	▨	G	1				
	▨					1	87.06
Very stiff, brown **SILTY CLAY** - grey-brown by 1.4m depth	▨						
	▨	G	2				
	▨					2	86.06
2.60	▨						
GLACIAL TILL: Grey-brown silty sand with clay, gravel, cobbles and boulders	^^^	G	3				
2.90							

End of Test Pit

Practical refusal to excavation on inferred bedrock surface @ 2.90m depth

(Open hole GWL @ 1.8m depth)



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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

FILE NO. PG1823

HOLE NO. TP 8

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	89.86		
TOPSOIL 0.25	■								
Brown **SANDY SILT** , trace organic matter 0.60	⁙	G	1						
Brown **SILTY CLAY** 1.40	▨	G	2			1	88.86		∇

End of Test Pit

Practical refusal to excavation on inferred bedrock surface @ 1.40m depth

(Open hole GWL @ 1.1m depth)

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

FILE NO. PG1823

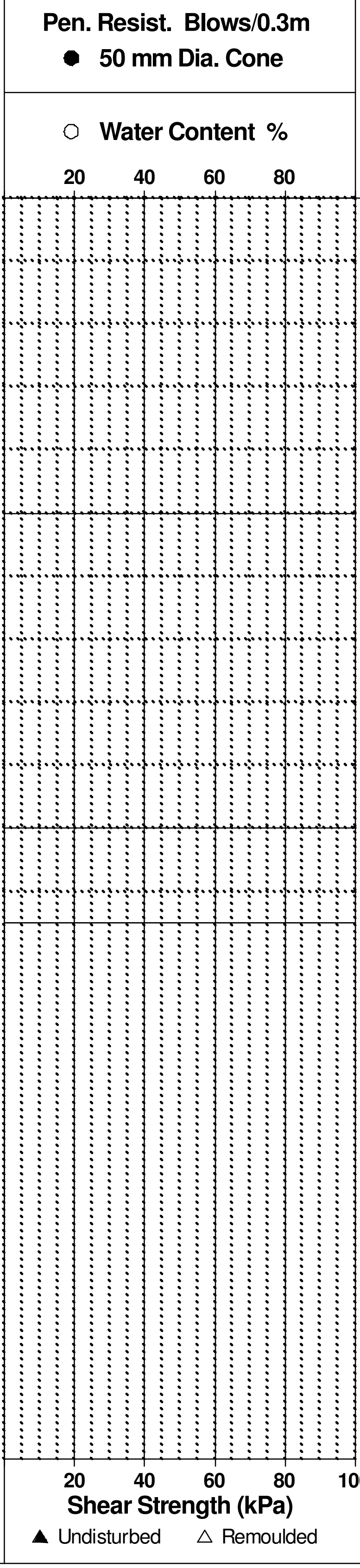
REMARKS

HOLE NO. TP 9

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	91.42	
TOPSOIL 0.20								
Brown **SILTY CLAY**		G	1			1	90.42	
1.30								
GLACIAL TILL: Grey-brown clayey silt with gravel, cobbles and boulders, trace sand		G	2			2	89.42	∇
2.30								
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 2.30m depth (Open hole GWL @ 1.9m depth)								



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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

FILE NO. **PG1823**

REMARKS

HOLE NO. **TP10**

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						0	90.76		
TOPSOIL 0.20									
Brown **SANDY SILT** , some organic matter 0.70		G	1						
GLACAIL TILL: Grey silty sand with gravel, cobbles and boulders		G	2			1	89.76		
		G	3			2	88.76		
2.90									∇
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 2.90m depth (Open hole GWL @ 2.5m depth)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

FILE NO. PG1823

REMARKS

HOLE NO. TP11

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	90.22		
TOPSOIL 0.25									
Brown **SILTY SAND** , some organic matter 0.90		G	1						
GLACIAL TILL: Grey-brown silty sand with clay and gravel 1.20		G	2			1	89.22		∇
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 1.20m depth (Open hole GWL @ 1.0m depth)									

Water Content %: 20 40 60 80

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Proposed Residential Development - March Road
Ottawa, Ontario

DATUM Ground surface elevations provided by Novatech Engineering Consultants Ltd.

REMARKS

BORINGS BY Hydraulic Shovel

DATE 9 Feb 09

FILE NO. PG1823

HOLE NO. TP12

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	89.26		
TOPSOIL 0.20									
Brown **SILTY SAND** 1.00						1	88.26		
GLACIAL TILL: Grey silty sand with clay and gravel 1.60									
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 1.60m depth (TP dry upon completion)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

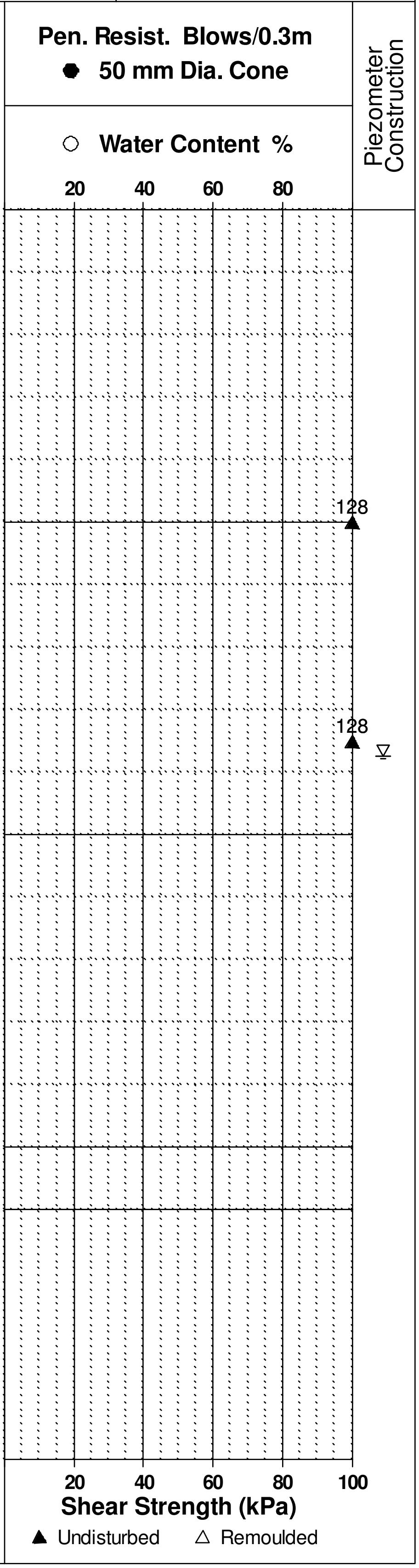
BORINGS BY Hydraulic Shovel

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	81.70
TOPSOIL 0.25	■						
Very stiff, brown **SILTY CLAY** - grey by 0.5m depth 2.10	▨					1	80.70
						2	79.70
GLACIAL TILL: Compact to dense grey silty clay, trace sand and gravel 3.20		G	1			3	78.70
End of Test Pit Practical refusal to excavation @ 3.20m depth (Open hole WL @ 1.75m depth)							



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	83.10		
TOPSOIL 0.40	■	G	1						
End of Test Pit Practical refusal to excavation @ 0.40m depth									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

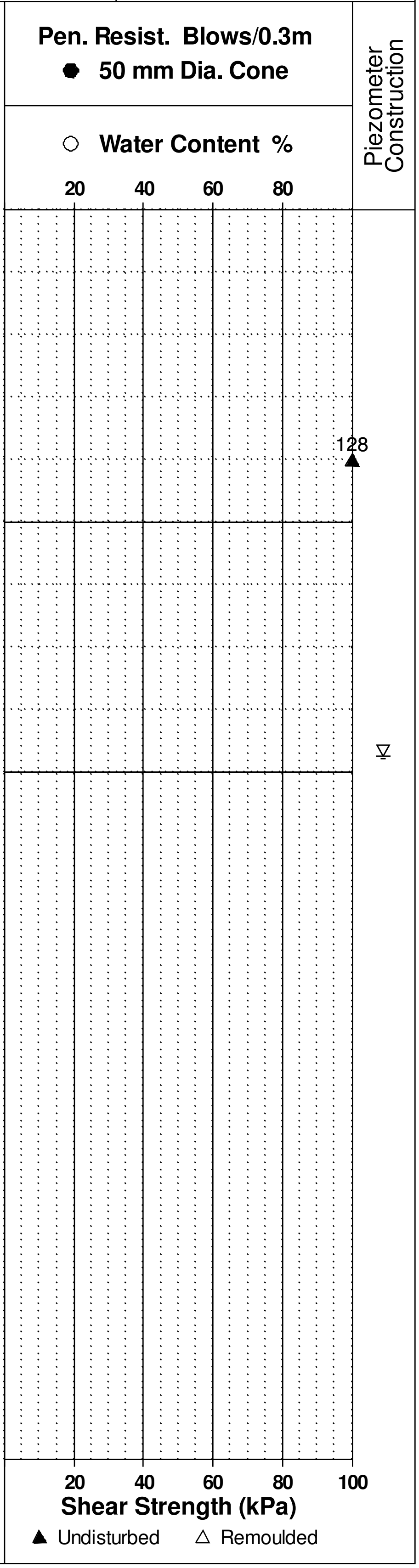
BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	83.80
TOPSOIL 0.25							
Hard, brown **SILTY CLAY** 1.10		G	1			1	82.80
GLACIAL TILL: Dense brown silty clay, trace gravel and cobbles 1.80		G	2				
End of Test Pit Practical refusal to excavation on inferred bedrock surface @ 1.80m depth (Open hole WL @ 1.75m depth)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

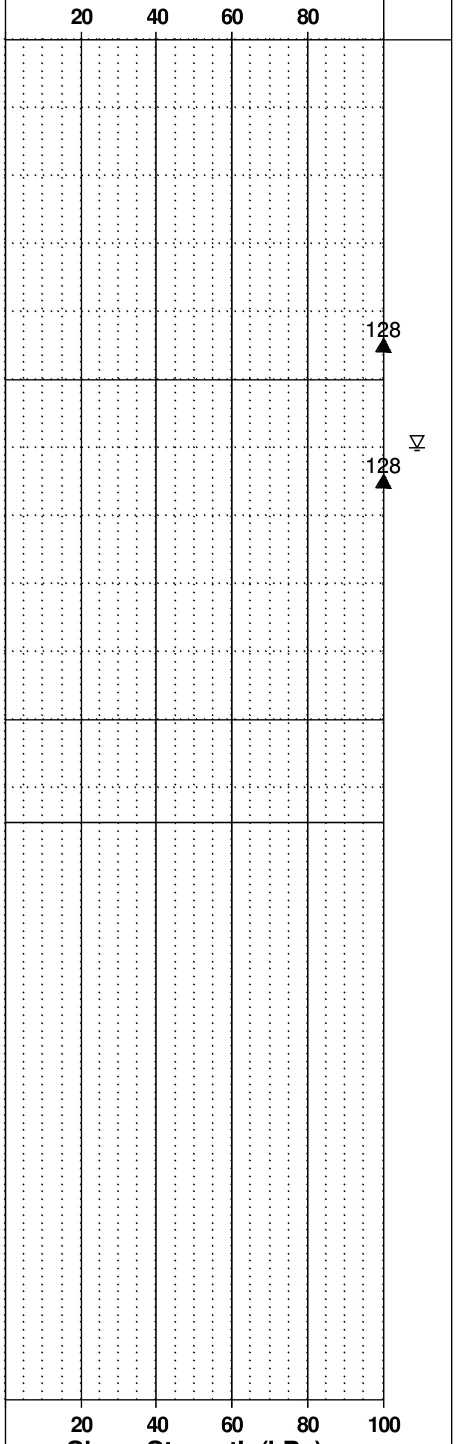
HOLE NO. TP 4

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	86.20
TOPSOIL 0.30	■						
Hard, brown **SILTY CLAY** 1.55	▨					1	85.20
GLACIAL TILL: Brown-grey silty clay, some sand and cobbles 2.30		G	1			2	84.20
End of Test Pit Practical refusal to excavation @ 2.30m depth (Open hole WL @ 1.2m depth)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

Piezometer Construction



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

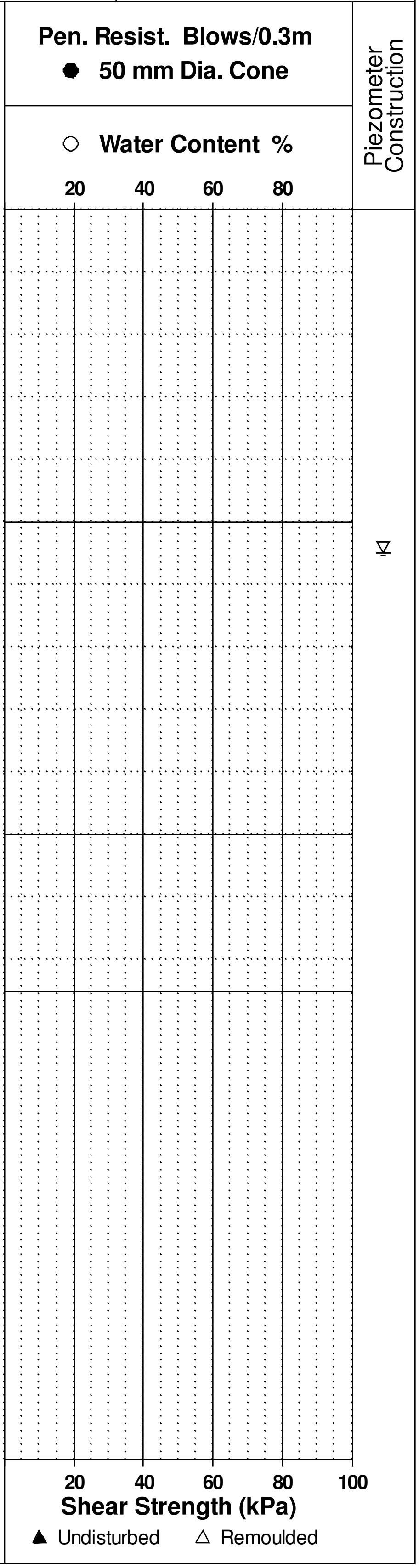
BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 5

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	86.80
TOPSOIL 0.23	■						
Very stiff, brown **SILTY CLAY** 1.60	▨	G	1			1	85.80
GLACIAL TILL: Compact to dense grey-brown silty clay, some gravel and cobbles 2.50		G	2			2	84.80
End of Test Pit Practical refusal to excavation @ 2.50m depth (Open hole WL @ 1.1m depth)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 6

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
GROUND SURFACE						0	90.70		
TOPSOIL 0.30	■								
End of Test Pit Practical refusal to excavation on bedrock surface @ 0.30m depth									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 7

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	89.40		
TOPSOIL 0.15									
GLACIAL TILL: Silty sand with gravel, cobbles and boulders 0.54									
BEDROCK: Weathered limestone 1.35						1	88.40		
End of Test Pit (TP dry upon completion)									

Water Content % scale: 20 40 60 80

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

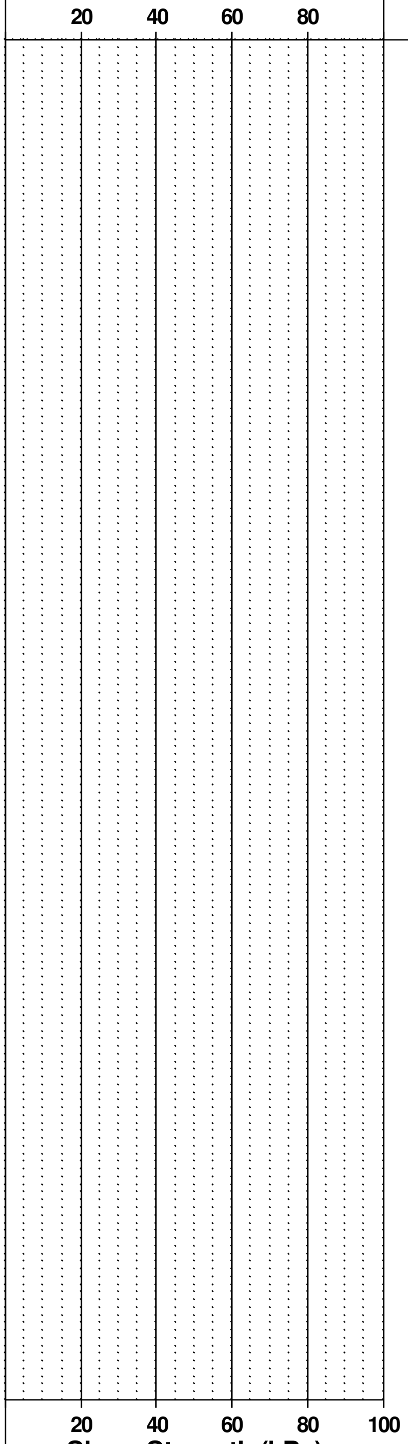
BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 8

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	88.80		
Bedrock at surface									



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

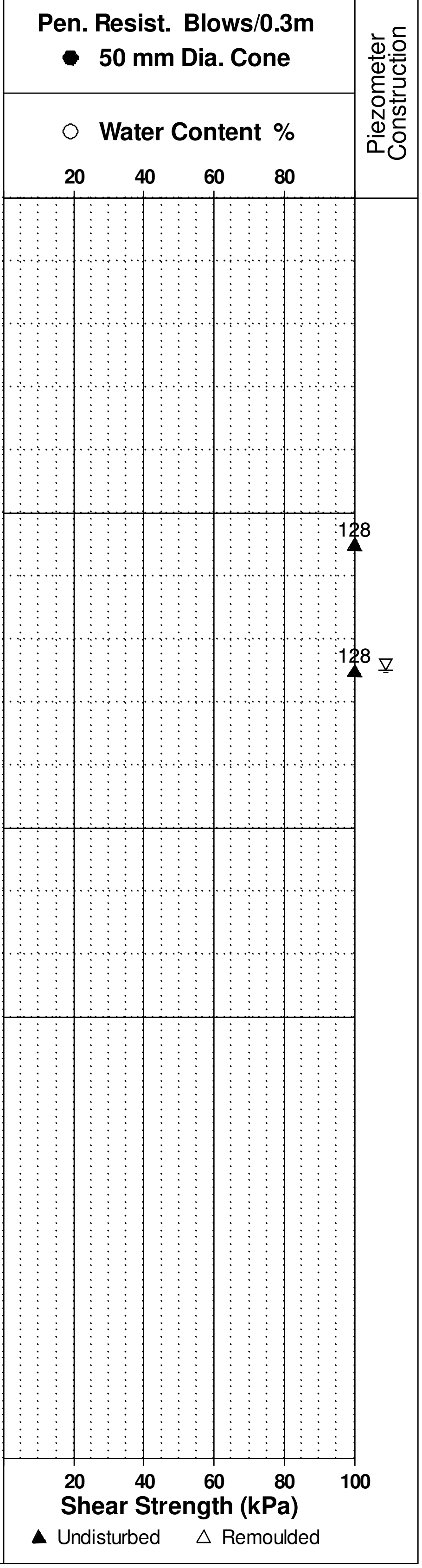
BORINGS BY Hydraulic Shovel

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP 9

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	81.90
TOPSOIL							
0.30							
Very stiff, grey-brown **SILTY CLAY**		G	1			1	80.90
1.60							
GLACIAL TILL: Compact to dense brown-grey silty clay, trace gravel, cobbles and boulders						2	79.90
2.60		G	2				
End of Test Pit Practical refusal to excavation @ 2.60m depth (Open hole WL @ 1.5m depth)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

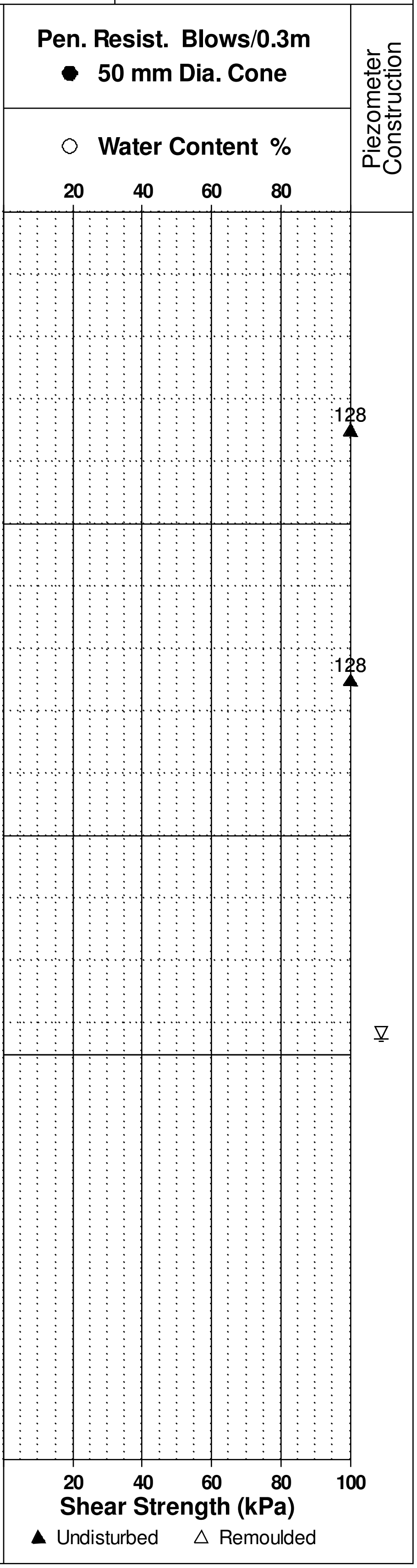
BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.40
TOPSOIL 0.35	■						
Very stiff, brown **SILTY CLAY** 1.60	▨					1	87.40
GLACIAL TILL: Brown-grey silty clay, some gravel and cobbles 2.70	^^^					2	86.40
End of Test Pit Practical refusal to excavation @ 2.70m depth (Open hole WL @ 2.65m depth)							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development - Foley Lands
Ottawa, Ontario

DATUM TBM - Centreline of March Road, adjacent to the north property limit, assumed geodetic elevation = 82.00m.

REMARKS

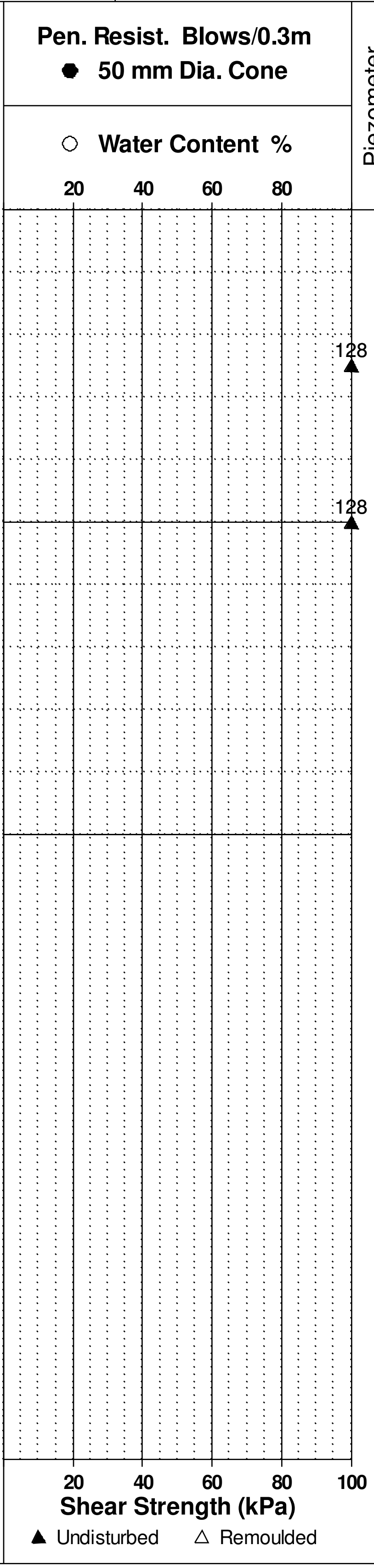
BORINGS BY Rubber Tired Backhoe

DATE July 9, 2008

FILE NO. PG1716

HOLE NO. TP11

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	89.50	
TOPSOIL — 0.25								
Very stiff, brown **SILTY CLAY** — 1.20						1	88.50	
GLACIAL TILL: Dense brown-grey silty clay, trace gravel and cobbles - boulders at 1.7m — 2.00						2	87.50	
End of Test Pit Practical refusal to excavation @ 2.00m depth (TP dry upon completion)								



SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

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

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	ROCK QUALITY
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC% - Natural moisture content or water content of sample, %
LL - Liquid Limit, % (water content above which soil behaves as a liquid)
PL - Plastic limit, % (water content above which soil behaves plastically)
PI - Plasticity index, % (difference between LL and PL)

Dxx - Grain size which xx% of the soil, by weight, is of finer grain sizes
These grain size descriptions are not used below 0.075 mm grain size
D10 - Grain size at which 10% of the soil is finer (effective grain size)
D60 - Grain size at which 60% of the soil is finer

Cc - Concavity coefficient = $(D30)^2 / (D10 \times D60)$
Cu - Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay
(more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

p'_o - Present effective overburden pressure at sample depth
p'_c - Preconsolidation pressure of (maximum past pressure on) sample
Ccr - Recompression index (in effect at pressures below p'_c)
Cc - Compression index (in effect at pressures above p'_c)

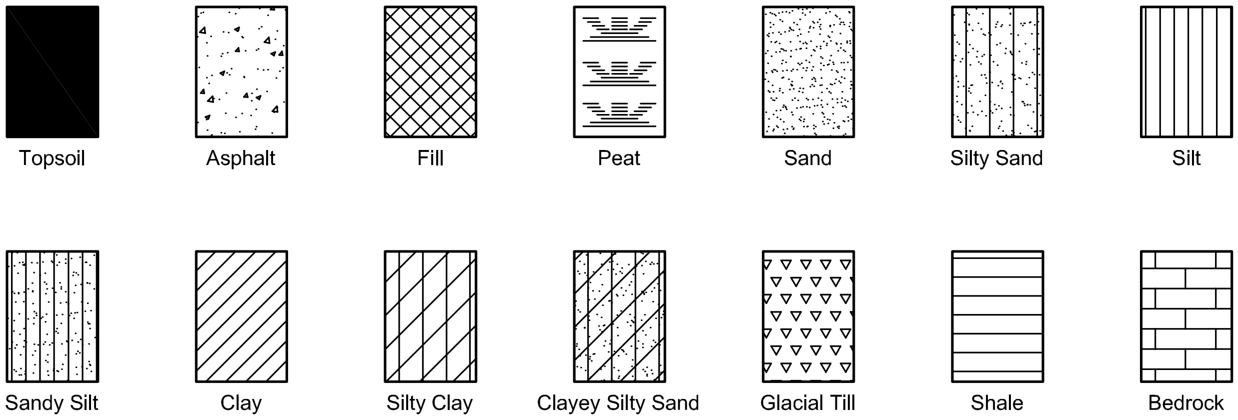
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

k - Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

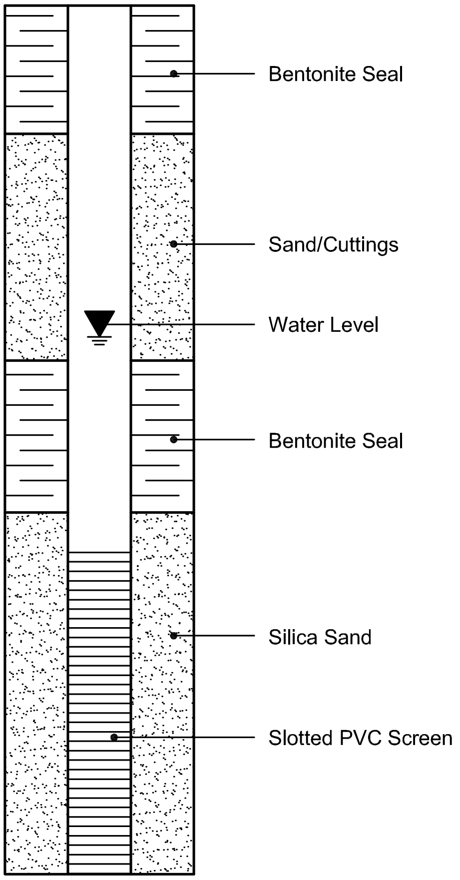
SYMBOLS AND TERMS (continued)

STRATA PLOT

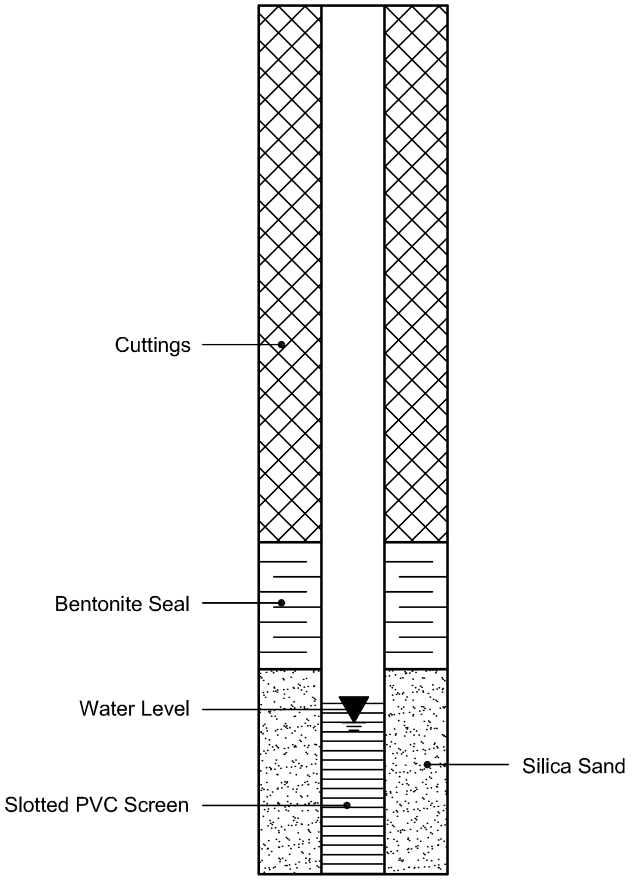


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION

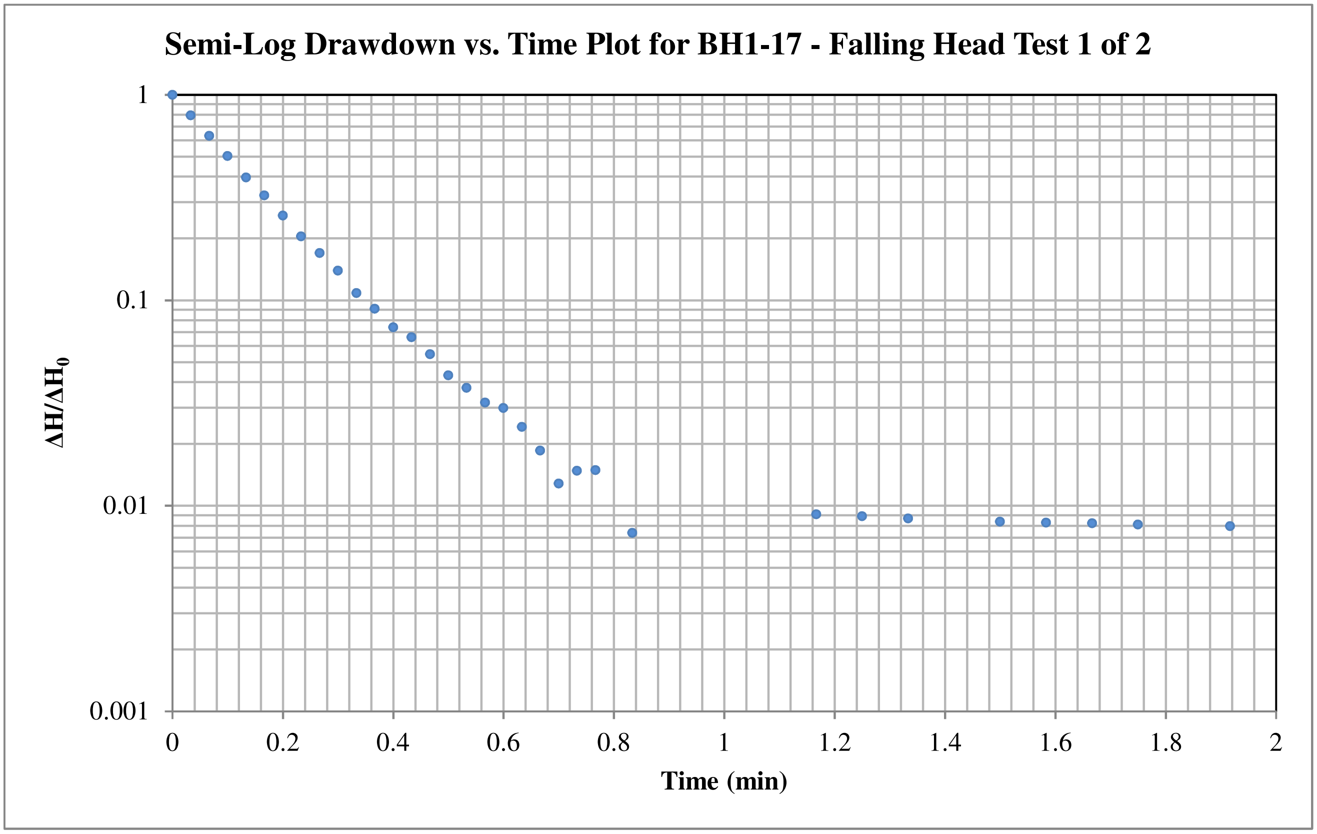


PIEZOMETER CONSTRUCTION



Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH1-17
Test: Falling Head 1 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$\boxed{K = \frac{\pi r_c^{2}}{F}\frac{1}{t^{*}}\ln\left(\frac{\Delta H^{*}}{\Delta H_0}\right)}$$

Hvorslev Shape Factor

$$\boxed{F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}}$$

Valid for L>>D

Hvorslev Shape Factor F: 5.36336

Well Parameters:

L	4.4	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

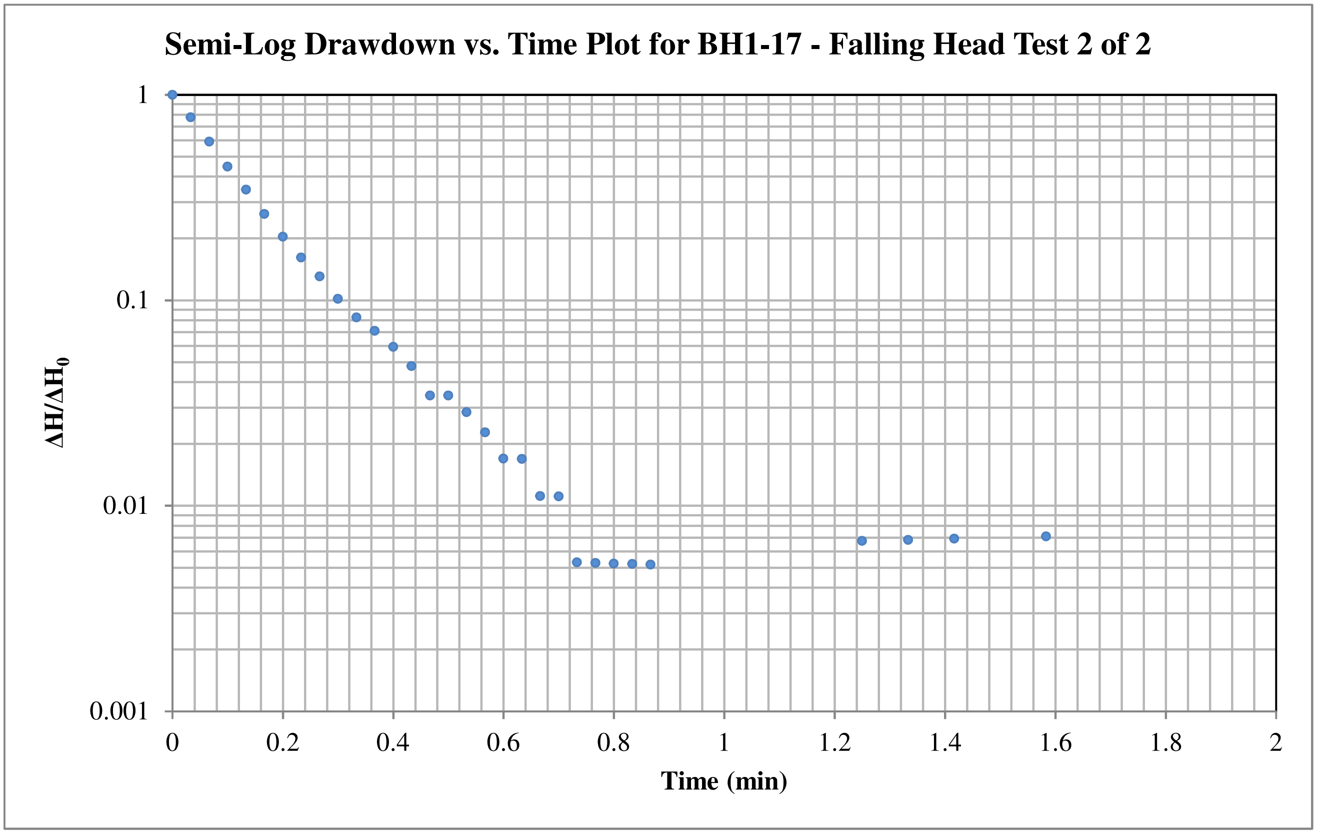
Data Points (from plot):

t*: 0.144 minutes $\Delta H^{*}/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 4.35E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH1-17
Test: Falling Head 2 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$\boxed{K = \frac{\pi r_c^2}{F}\frac{1}{t^*}\ln\left(\frac{\Delta H^*}{\Delta H_0}\right)}$$

Hvorslev Shape Factor

$$\boxed{F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}}$$

Valid for L>>D

Hvorslev Shape Factor F: 5.36336

Well Parameters:

L	4.4	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

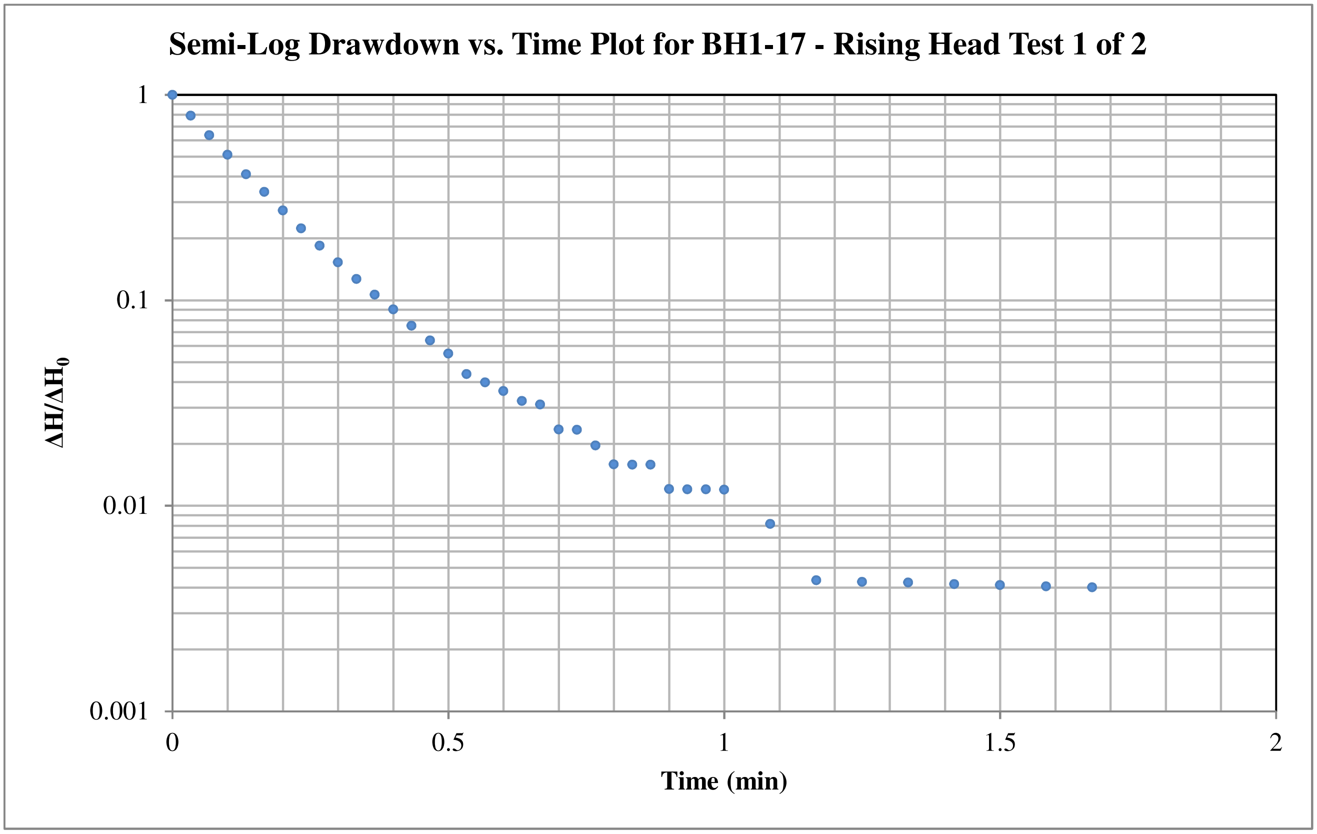
Data Points (from plot):

t^*: 0.125 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 5.01E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH1-17
Test: Rising Head 1 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^2}{F} \frac{1}{t^*} \ln\left(\frac{\Delta H^*}{\Delta H_0}\right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 5.36336

Well Parameters:

L	4.4	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

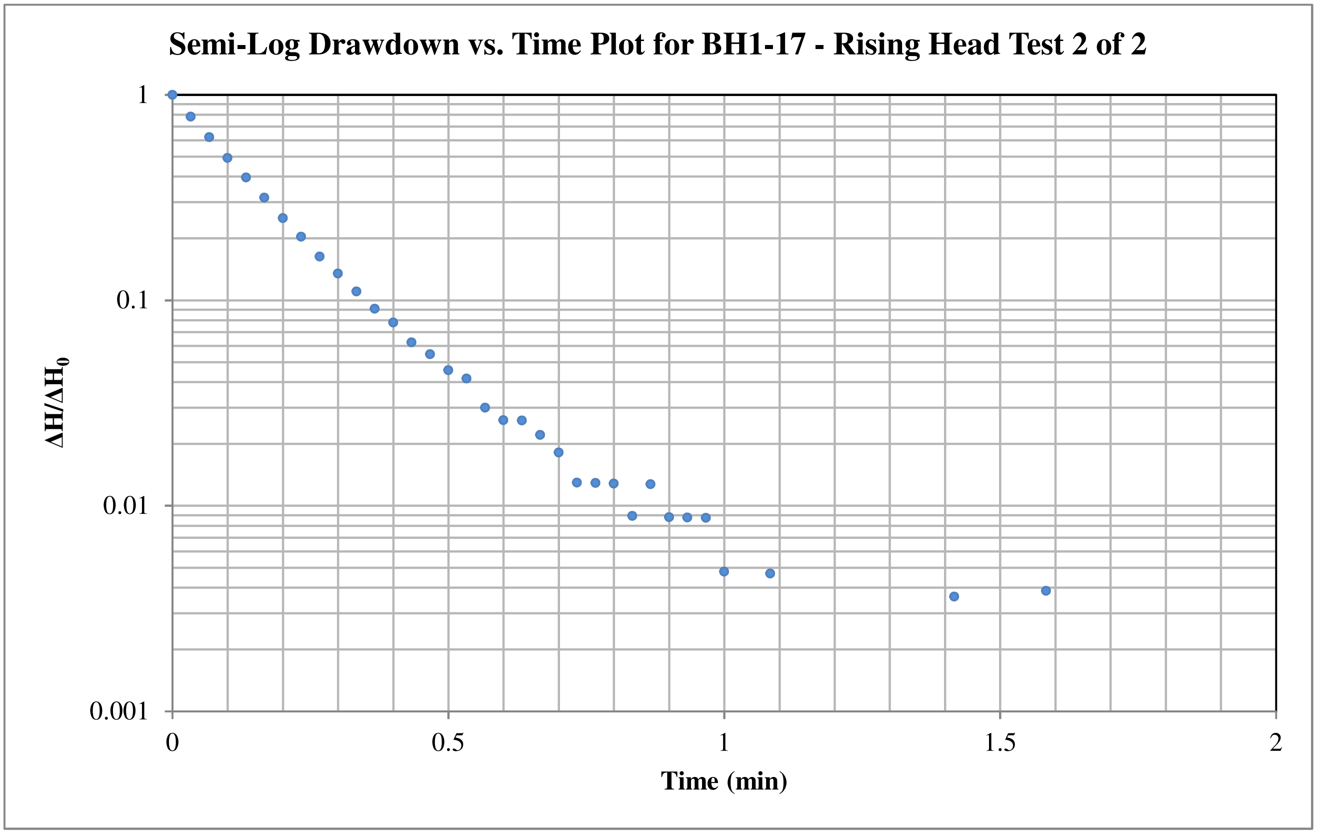
Data Points (from plot):

t*: 0.151 minutes ΔH*/ΔH_0: 0.37

Horizontal Hydraulic Conductivity
K = 4.15E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH1-17
Test: Rising Head 2 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^{\ 2}}{F}\frac{1}{t^*}\ln\left(\frac{\Delta H^*}{\Delta H_0}\right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 5.36336

Well Parameters:

L	4.4	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

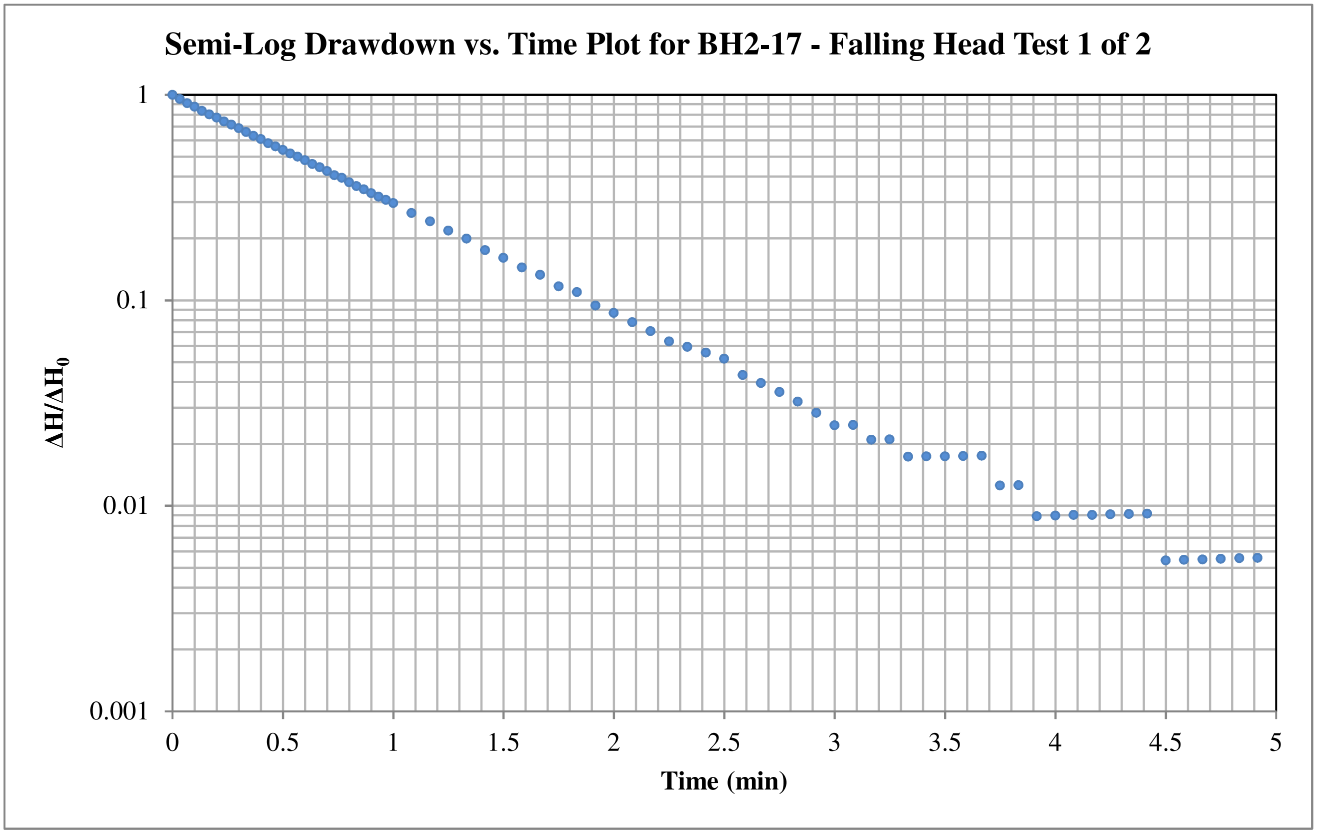
Data Points (from plot):

t*: 0.143 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 4.37E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4259 - Kanata North
Test Location: BH2-17
Test: Falling Head 1 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^2}{F} \frac{1}{t^*} \ln\left(\frac{\Delta H^*}{\Delta H_0}\right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.33409

Well Parameters:

L	1.52	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

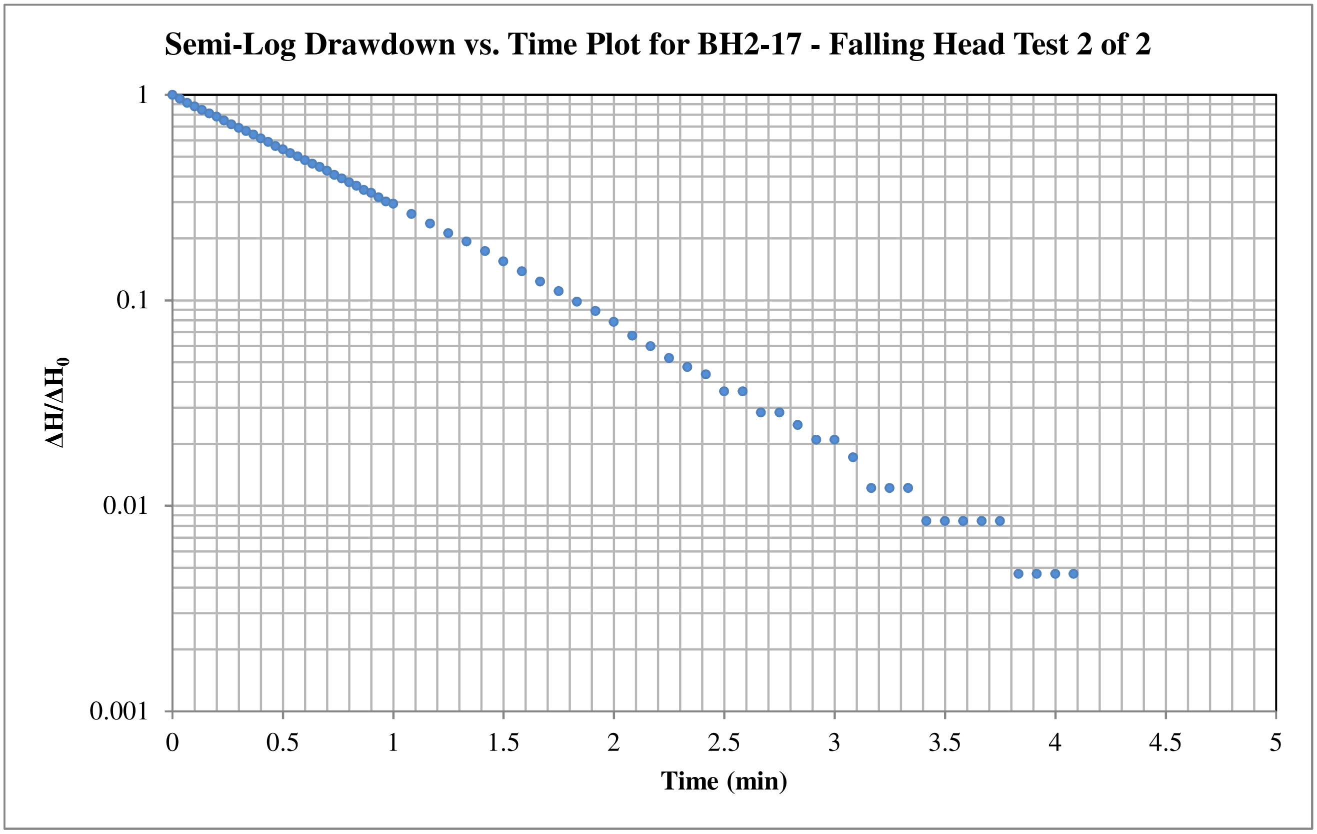
Data Points (from plot):

t*: 0.818 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 1.76E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH2-17
Test: Falling Head 2 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^2}{F} \frac{1}{t^*} \ln\left(\frac{\Delta H^*}{\Delta H_0}\right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.33409

Well Parameters:

L	1.52	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

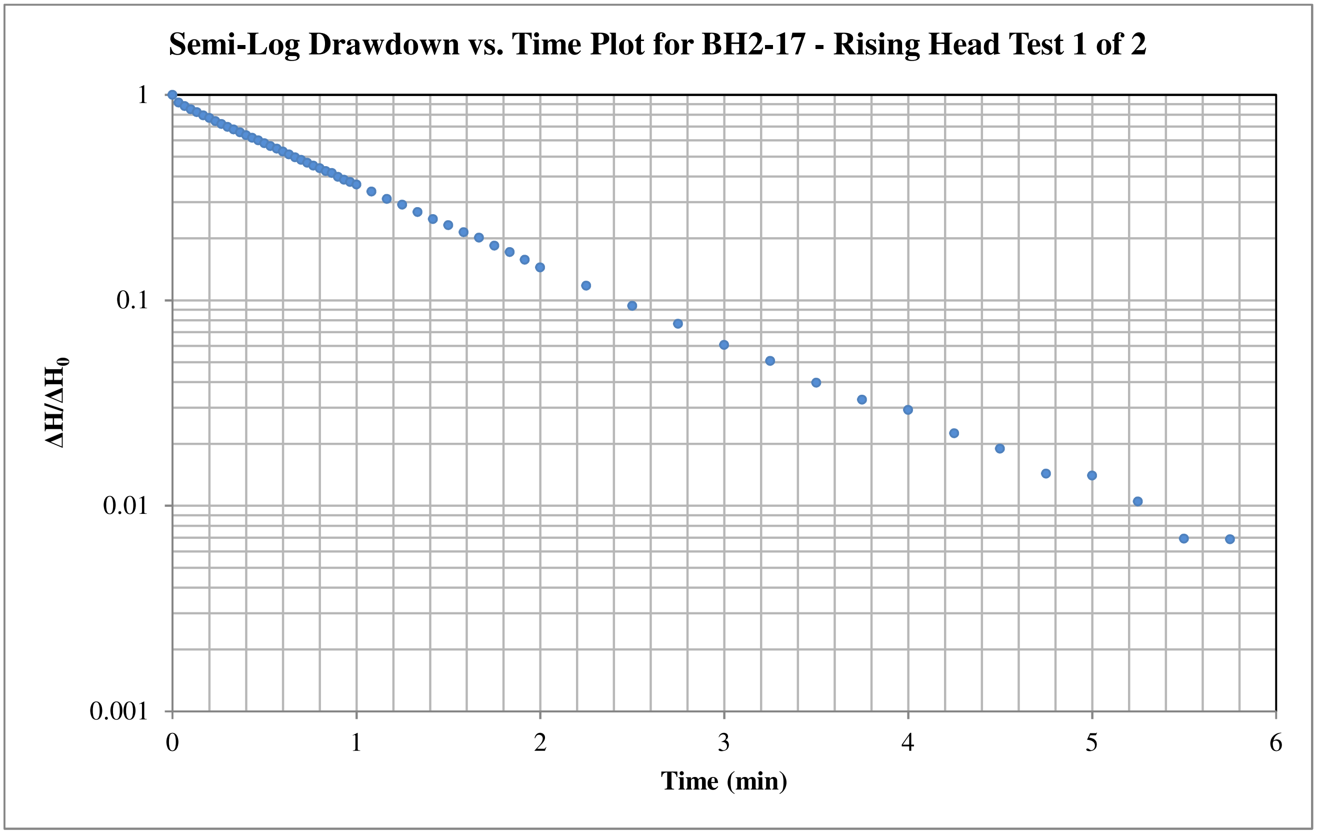
Data Points (from plot):

t*: 0.813 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 1.77E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH2-17
Test: Rising Head 1 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^2}{F} \frac{1}{t^*} \ln\left(\frac{\Delta H^*}{\Delta H_0} \right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D} \right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.42652

Well Parameters:

L	1.6	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

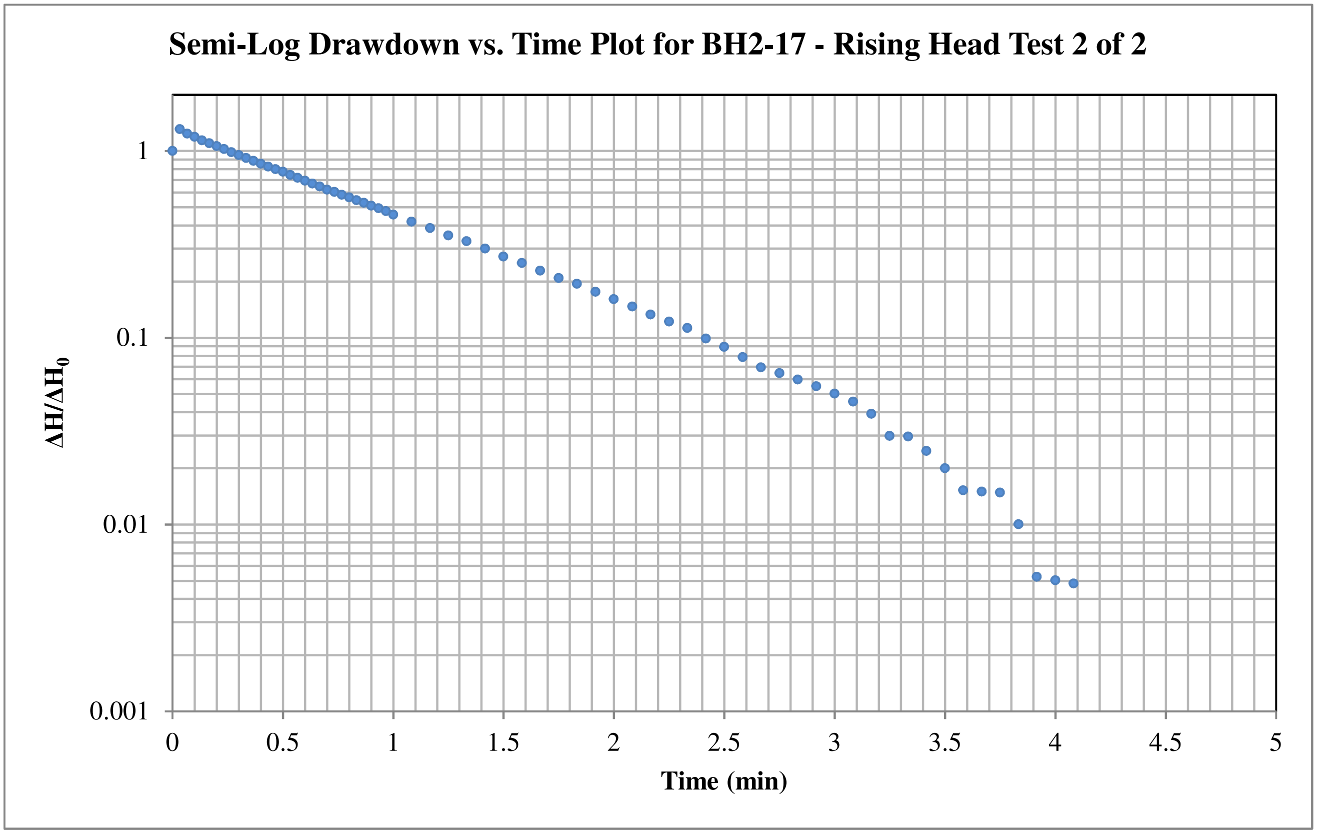
Data Points (from plot):

t*: 0.988 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 1.40E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH2-17
Test: Rising Head 2 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$\boxed{K = \frac{\pi r_c^2}{F} \frac{1}{t^*} \ln\left(\frac{\Delta H^*}{\Delta H_0}\right)}$$

Hvorslev Shape Factor

$$\boxed{F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.42652

Well Parameters:

L	1.6	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

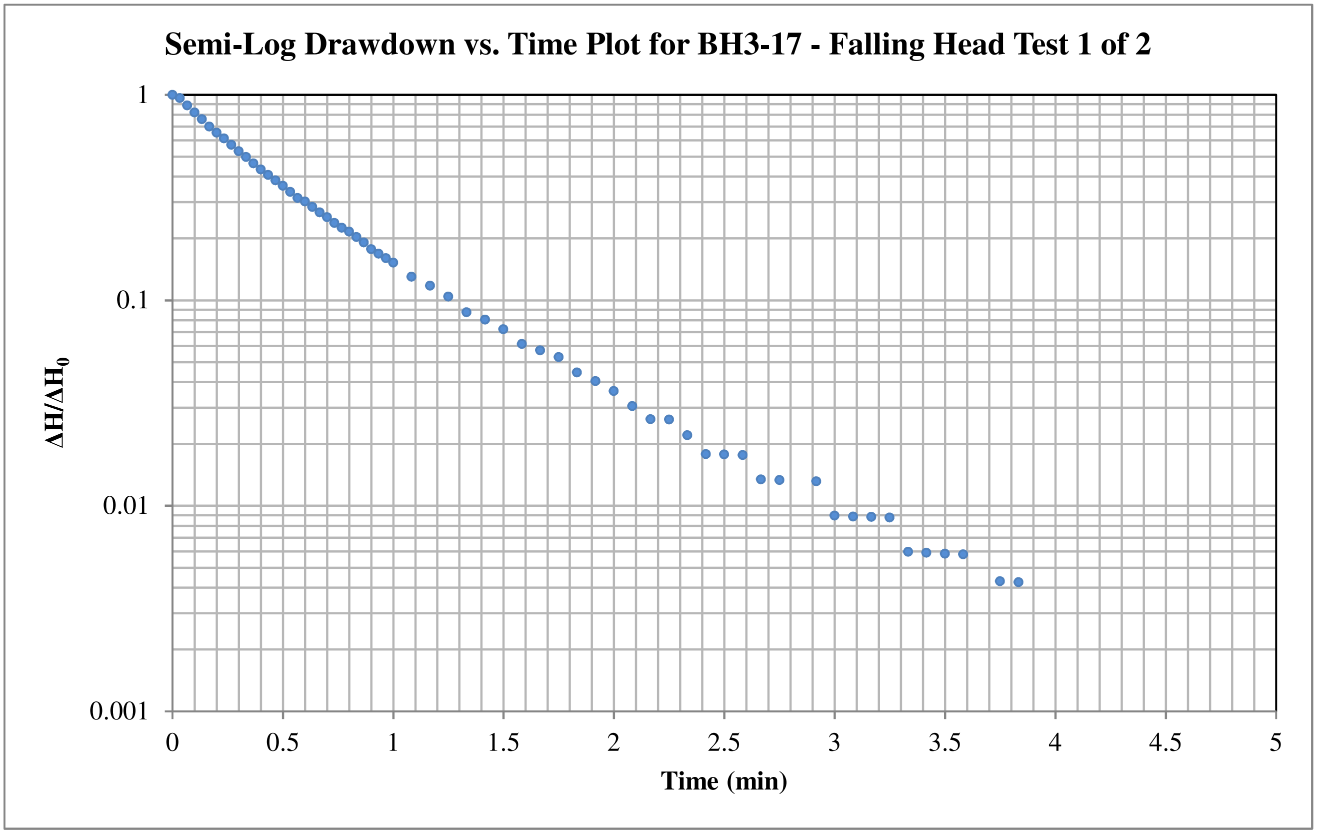
Data Points (from plot):

t*: 1.211 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 1.14E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH3-17
Test: Falling Head 1 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^2}{F} \frac{1}{t^*} \ln\left(\frac{\Delta H^*}{\Delta H_0}\right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.3804

Well Parameters:

L	1.56	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

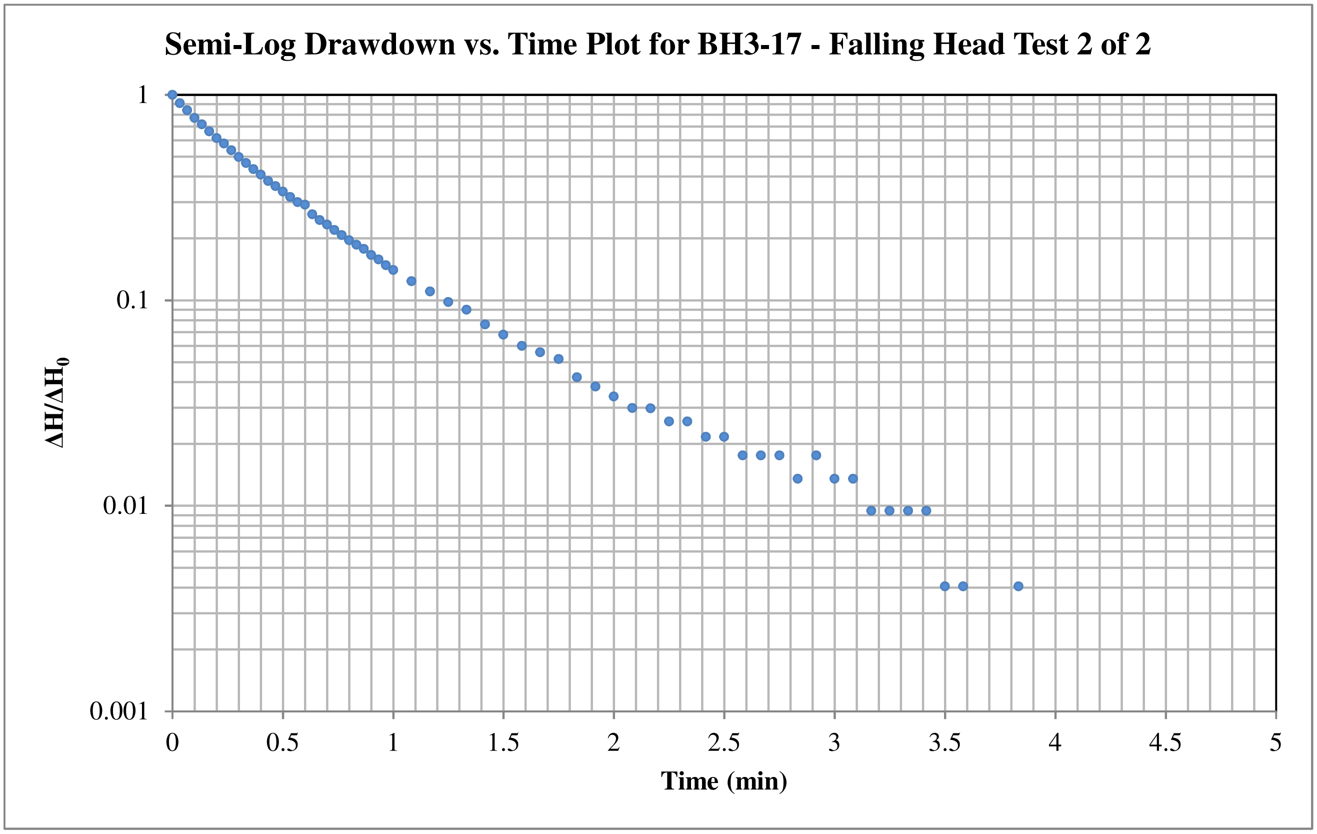
Data Points (from plot):

t*: 0.489 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 2.88E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH3-17
Test: Falling Head 2 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^2}{F} \frac{1}{t*} \ln\left(\frac{\Delta H *}{\Delta H_0}\right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.3804

Well Parameters:

L	1.56	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

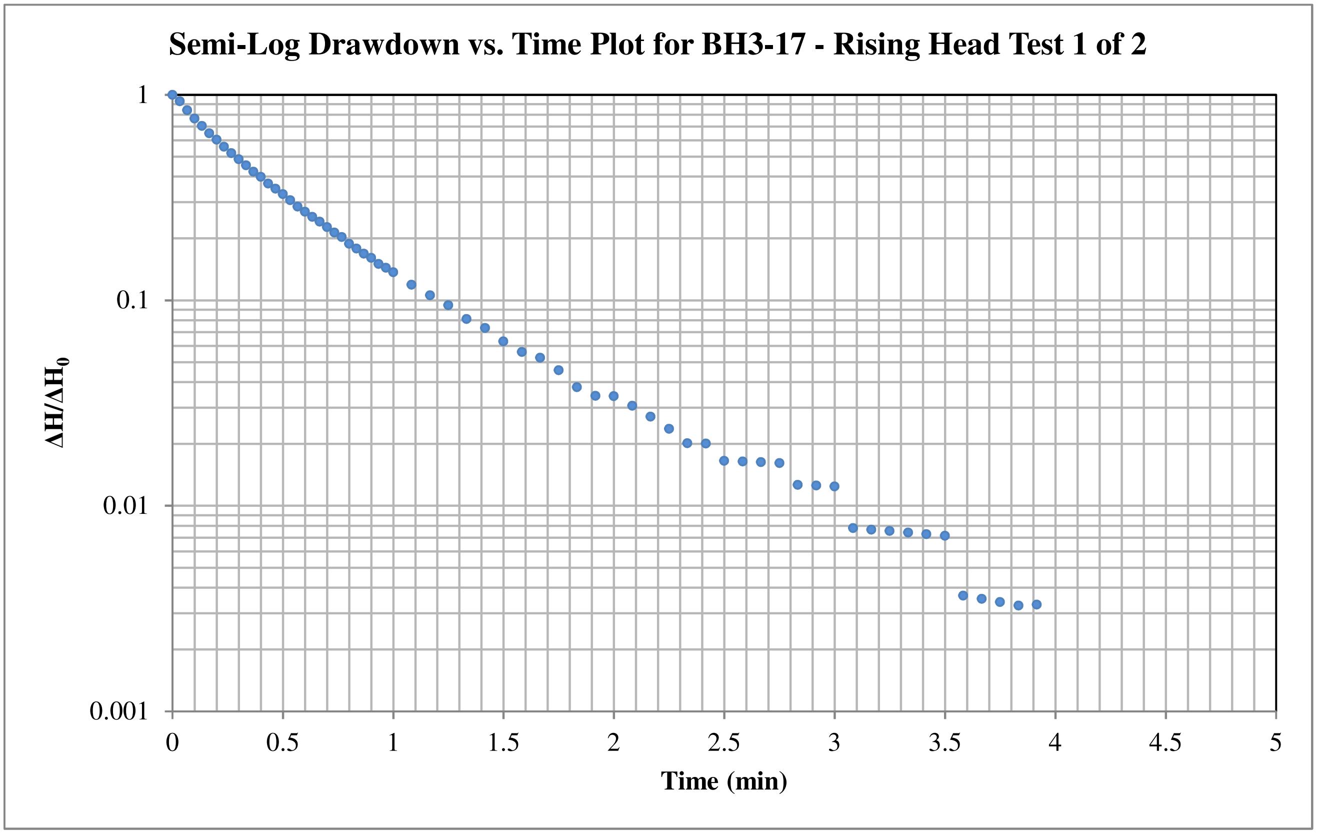
Data Points (from plot):

t*: 0.422 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 3.34E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH3-17
Test: Rising Head 1 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$\boxed{K = \frac{\pi r_c^2}{F}\frac{1}{t^*}\ln\left(\frac{\Delta H^*}{\Delta H_0}\right)}$$

Hvorslev Shape Factor

$$\boxed{F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.3804

Well Parameters:

L	1.56	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

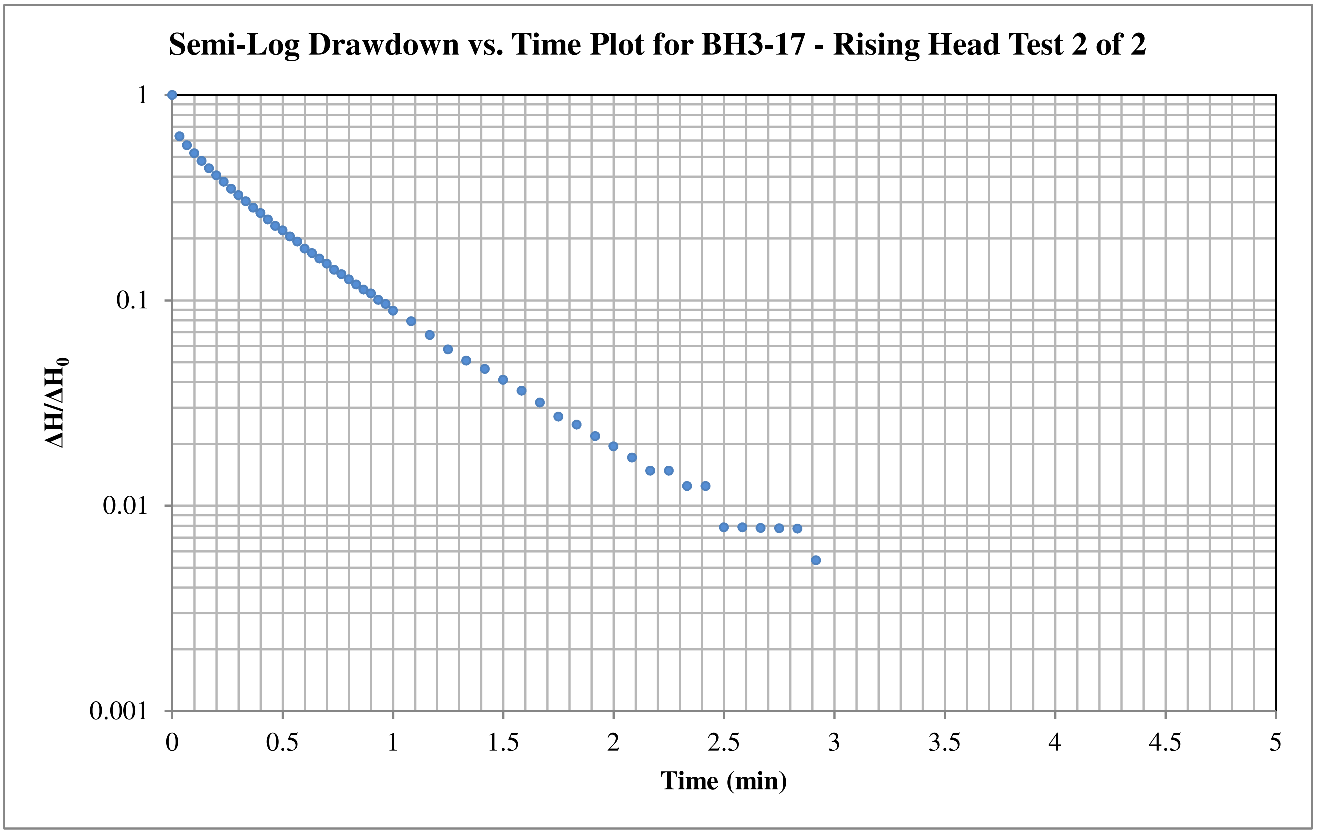
Data Points (from plot):

t*: 0.434 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 3.25E-05 m/sec

Hvorslev Hydraulic Conductivity Analysis

Project: PG4258 - Kanata North
Test Location: BH3-17
Test: Rising Head 2 of 2
Date: November 14, 2017



Hvorslev Horizontal Hydraulic Conductivity

$$K = \frac{\pi r_c^{2}}{F} \frac{1}{t^*} \ln\left(\frac{\Delta H^*}{\Delta H_0}\right)$$

Hvorslev Shape Factor

$$F = \frac{2\pi L}{\ln\left(\frac{2L}{D}\right)}$$

Valid for L>>D

Hvorslev Shape Factor F: 2.3804

Well Parameters:

L	1.56	m	Saturated length of screen or open hole
D	0.0508	m	Diameter of well
r_c	0.0254	m	Radius of well

Data Points (from plot):

t^*: 0.243 minutes $\Delta H^*/\Delta H_0$: 0.37

Horizontal Hydraulic Conductivity
K = 5.82E-05 m/sec

Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 22658

Report Date: 01-Nov-2017

Order Date: 26-Oct-2017

Project Description: PG4258

	Client ID:	BH2-SS4	-	-	-
	Sample Date:	20-Oct-17	-	-	-
	Sample ID:	1743469-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	86.5	-	-	-
General Inorganics					
pH	0.05 pH Units	7.90	-	-	-
Resistivity	0.10 Ohm.m	67.8	-	-	-
Anions					
Chloride	5 ug/g dry	9	-	-	-
Sulphate	5 ug/g dry	16	-	-	-

patersongroup
consulting engineers

memorandum

re: **Geotechnical Recommendations - Creek Crossing**
Claridge / Uniform Developments Inc. (KNUEA)
March Road - Ottawa (Kanata)

to: Novatech Engineering - **Mr. John Riddell** - j.riddell@novatech-eng.com

cc: Novatech Engineering - **Mr. Marc St. Pierre** - m.stpierre@novatech-eng.com

date: June 13, 2018

file: PG4258-MEMO.01

Further to your request and authorization, Paterson Group (Paterson) reviewed our geotechnical findings to provide a geotechnical design along with construction recommendations for the piping at the creek crossings for the aforementioned site.

Available Drawings

The following drawings, prepared by Novatech Engineering, were reviewed as part of this review:

- ☐ Claridge / Uniform Developments Inc. (KNEUC), Creek Plan and Profile - Station 50+300 to 50+600, Project No. 116132, Drawing No. 116132-CRK2-DRAFT, Revision 1 dated June 6, 2018.

- ☐ Claridge / Uniform Developments Inc. (KNEUC), Creek Plan and Profile - Station 50+600 to 50+850, Project No. 116132, Drawing No. 116132-CRK3-DRAFT, Revision 1 dated June 6, 2018.

Background Information

Based on our review of the aforementioned drawings prepared by Novatech Engineering, it is our understanding that two roadway structures and associated services will cross the existing 40 m wide creek corridor at two locations identified as Street 1 and Street B on the above drawings. In addition, it is also understood that a storm outlet pipe and associated headwall (Headwall 2) will extend into the 40 m wide creek corridor through Block 287 of the proposed development.

Creek Crossing - Street 1

Street 1 is located between Station 50+325 and Station 50+375 and consists of a two lane roadway, pedestrian sidewalk and landscaped area elevated approximately 3 m above the centre of the existing watercourse. A 200 mm diameter watermain within the roadway alignment will be placed at a minimum depth of 1 m below the proposed 1800 mm x 1200 mm concrete box culvert with the appropriate frost protection requirements.

It is expected that the service trench of the proposed watermain will marginally extend into the underlying bedrock.

Creek Crossing - Street B

Street B is located between Station 50+750 and Station 50+775 and consists of a two lane roadway, pedestrian sidewalk and associated landscaped area elevated approximately 3 m above the centre of the existing watercourse. A 1500 mm diameter storm sewer and 250 mm diameter sanitary sewer within the roadway alignment will be placed at a minimum depth of 1.5 m below the proposed 1800 mm x 1200 mm concrete box culvert with the appropriate frost protection requirements. It is expected that the service trench for the proposed sanitary and storm sewer will extend into the underlying bedrock.

Storm Outlet Structure

The 900 mm diameter storm sewer pipe located within Block 287 marginally extends into the 40 m wide creek corridor at Station 50+550. It is expected that the service trench will be excavated through a very stiff to stiff silty clay and/or glacial till.

Geotechnical Recommendations

To protect the historical behaviour of the existing creek, it will be important to protect the watercourse within the 40 m wide valley corridor from hydraulic pathways contributed, but not limited to blasting operations, trench backfill and pipe bedding material of the service pipes at the creek crossing locations. This can be effectively completed with the use of longitudinally placed clay seals wrapped a minimum of 600 mm around the perimeter of the service pipes and bedding material according to the recommendations outlined below and further illustrated on the marked-up drawings enclosed:

❑ The service trench should be over excavated to accommodate a minimum of 600 mm of a relatively dry, workable weathered silty clay (approved by the geotechnical consultant at the time of construction) around the perimeter of the service pipe and associated bedding material.

❑ To permit the proper placement and achieve the required compaction of the clay seal, it is recommended that the approved silty clay be placed within the lower portion of the service trench (extended to a minimum of 600 mm above the obvert level) prior to the installation of the service pipes. The silty clay should be placed within the over excavated service trench in maximum 300 mm loose lifts under dry conditions and compacted using a sheepsfoot roller (5 to 6 passes per lift).

- The silty clay within the service trench should extend longitudinally (in the trench direction) a minimum of 10 m beyond the centre of the meandering creek.

- Upon completion of the placement of the clay seal within the lower portion of the service trench, the service pipe and bedding material can be conventionally installed in accordance with the geotechnical recommendations in Subsection 5.5 - Pipe Bedding and Backfill in report PG4285-1 dated March 1, 2018.

- The remaining trench backfill up to the level of the valley corridor within 10 m of the centre of the meandering creek (in the trench direction) should be backfilled with a relatively dry, workable brown silty clay approved by the geotechnical consultant at the time of construction.

In addition to the longitudinal clay seals noted above, it is further recommended that conventional vertical clay seals be provided within the service trench at the boundaries of the 40 m wide valley corridor.

- The conventional vertical clay seals should be at least 1.5 m long (longitudinally in the trench direction) and should extend from the trench wall to trench wall.

- The seals should extend from the frost line and fully penetrate the bedding, pipe surround and cover material.

- The approved silty clay should be placed within the over excavated service trench in maximum 300 mm loose lifts under dry conditions and compacted using a sheepsfoot roller (5 to 6 passes per lift).

It is further recommended that the installation of the clay seals be periodically inspected by the geotechnical consultant for conformance purposes.

The approximate location of the longitudinal and conventional vertical clay seals are further illustrated on the marked-up drawing attached to the current report.

We trust that this information satisfies your requirements.

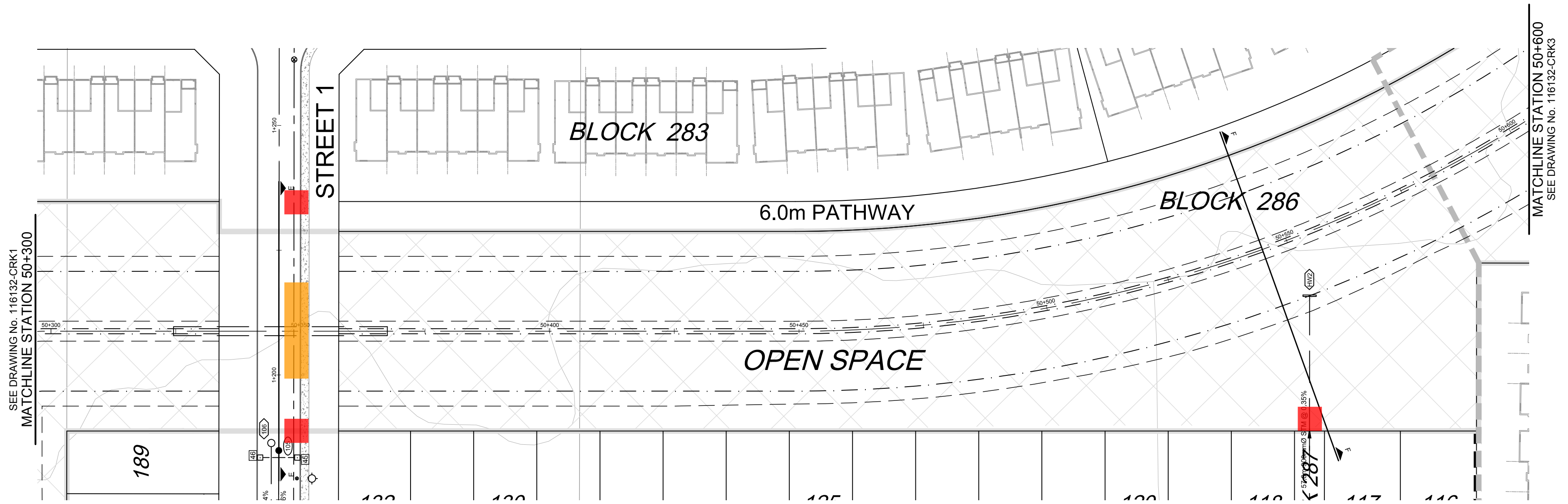
Best Regards,

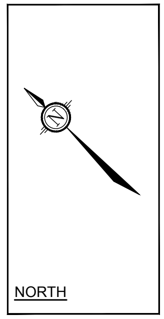
Paterson Group Inc.

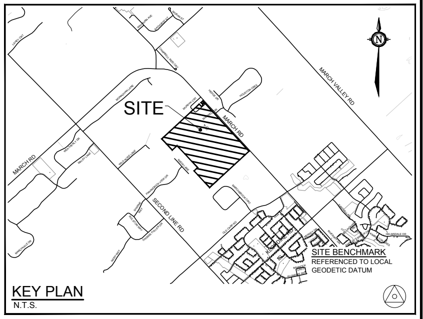
Richard Groniger, C. Tech.

Carlos P. Da Silva, P.Eng.

LICENSED PROFESSIONAL ENGINEER
June 13, 2018
C. P. DA SILVA
PROVINCE OF ONTARIO

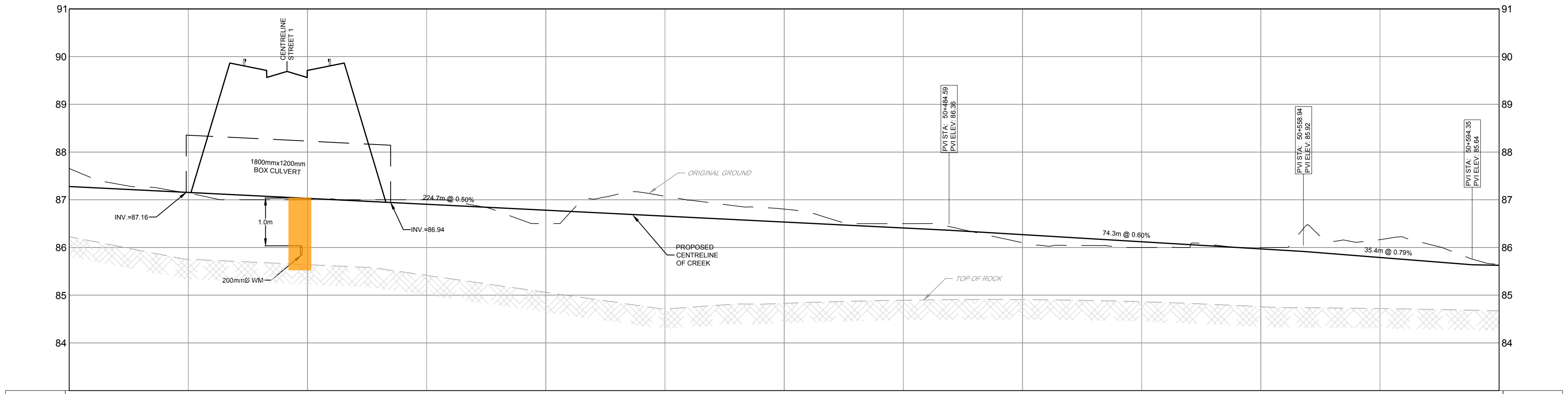






LEGEND

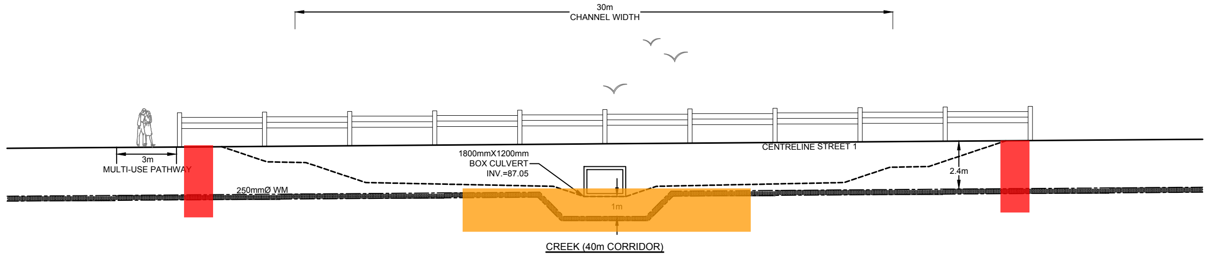
	PROPERTY LINE
	RIGHT OF WAY LIMITS
D.C.	PROPOSED DEPRESSED CURB
	PROPOSED BARRIER CURB OR MOUNTABLE CURB
	PROPOSED BARRIER CURB & SIDEWALK
507 200mmØ	PROPOSED SANITARY MANHOLE & SEWER
300mmØ	PROPOSED SANITARY FORCE MAIN
304 675mmØ	PROPOSED STORM MANHOLE & SEWER
CB 224 250mmØ	PROPOSED CATCHBASIN/MANHOLE & LEAD
CB 34	PROPOSED CATCHBASIN & LEAD
RYCB 6 250mmØ	PROPOSED REAR YARD CATCHBASIN & SUB-DRAIN
	PROPOSED SWALE
200mmØ	PROPOSED WATERMAIN
V&VB	PROPOSED VALVE & VALVE BOX LOCATION
HYD	PROPOSED FIRE HYDRANT C/W LEAD
45°	PROPOSED WATERMAIN BEND
	DIRECTION OF FLOW
▲	PROPOSED SERVICES LOCATION
HW2	PROPOSED HEAD WALL
	PROPOSED RETAINING WALL
	PROPOSED PEDESTIRAN CROSSOVER
	PROPOSED PHASING LIMITS
	EXISTING ℄ DITCH
7A 450mmØ	*EXISTING SANITARY MANHOLE & SEWER*
300mmØ	*EXISTING WATERMAIN*
HYD	*EXISTING FIRE HYDRANT C/W LEAD*
V&VB	*EXISTING VALVE & VALVE BOX LOCATION*
V&VC	*EXISTING VALVE & VALVE CHAMBER LOCATION*
UP	*EXISTING UTILITY POLE*
OHW	*EXISTING OVER HEAD WIRE*
	EXISTING SIDEWALK



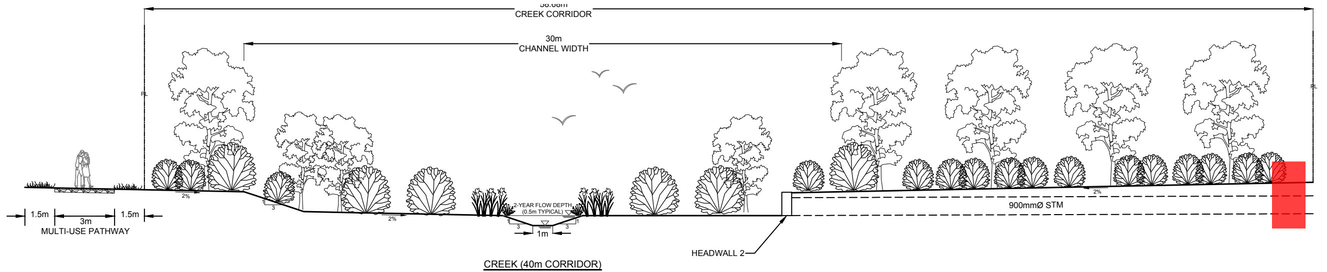
EXISTING ELEVATION	87.66	87.14	87.00	87.00	86.50	87.07	86.80	86.50	86.10	86.00	86.00	86.17	85.64
PROPOSED ELEVATION	87.28	87.15	87.03	86.91	86.78	86.66	86.53	86.41	86.27	86.12	85.97	85.79	85.63
CHAINAGE	50+300	50+325	50+350	50+375	50+400	50+425	50+450	50+475	50+500	50+525	50+550	50+575	50+600

🟧 **Longitudinal Clay Seal - Refer to report PG4258-MEMO.01 dated June 13, 2018 for details**

🟥 **Conventional Vertical Clay Seal - Refer to report PG4258-MEMO.01 dated June 13, 2018 for details**



CREEK (40m CORRIDOR)
CROSS-SECTION E-E



CREEK (40m CORRIDOR)
CROSS-SECTION F-F

REFER TO ____________ FOR ADDITIONAL NOTES

NOTE:
THE POSITION OF ALL POLE LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND AND OVERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, DETERMINE THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES AND ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

**PRELIMINARY
NOT FOR
CONSTRUCTION**

No.	REVISION	DATE	BY
1.	ISSUED FOR DRAFT PLAN OF SUBDIVISION APPLICATION	JUNE 6/18	SAZ

SCALE
1:750
1:750
0 10 20 30

DESIGN SAZ
CHECKED DDB
DRAWN RBG
CHECKED SAZ
APPROVED DDB

FOR REVIEW ONLY

LICENSED PROFESSIONAL ENGINEER
S.A.N. ZORGEL
100191487
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
D.D. BLAIR
100122737
PROVINCE OF ONTARIO

NOVATECH
Engineers, Planners & Landscape Architects
Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario, Canada K2M 1P6
Telephone (613) 254-9643
Facsimile (613) 254-5867
Website www.novatech-eng.com

LOCATION
CITY of OTTAWA
CLARIDGE / UNIFORM DEVELOPMENTS INC. (KNUEA)

DRAWING NAME
CREEK PLAN AND PROFILE
STATION 50+300 TO 50+600

PROJECT No. 116132
REV REV # 1
DRAWING No. 116132
CRK2-DRAFT

PLANB1.DWG - 1000mmx707mm

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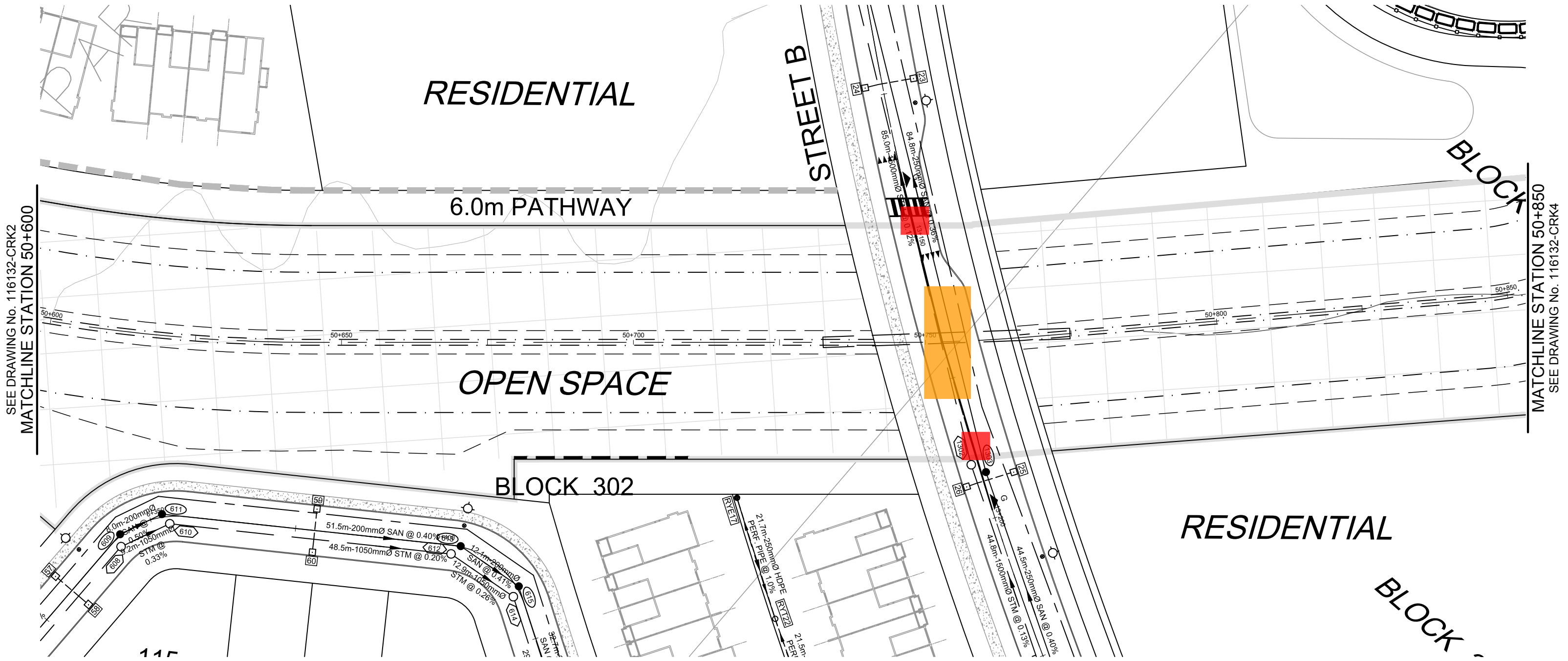
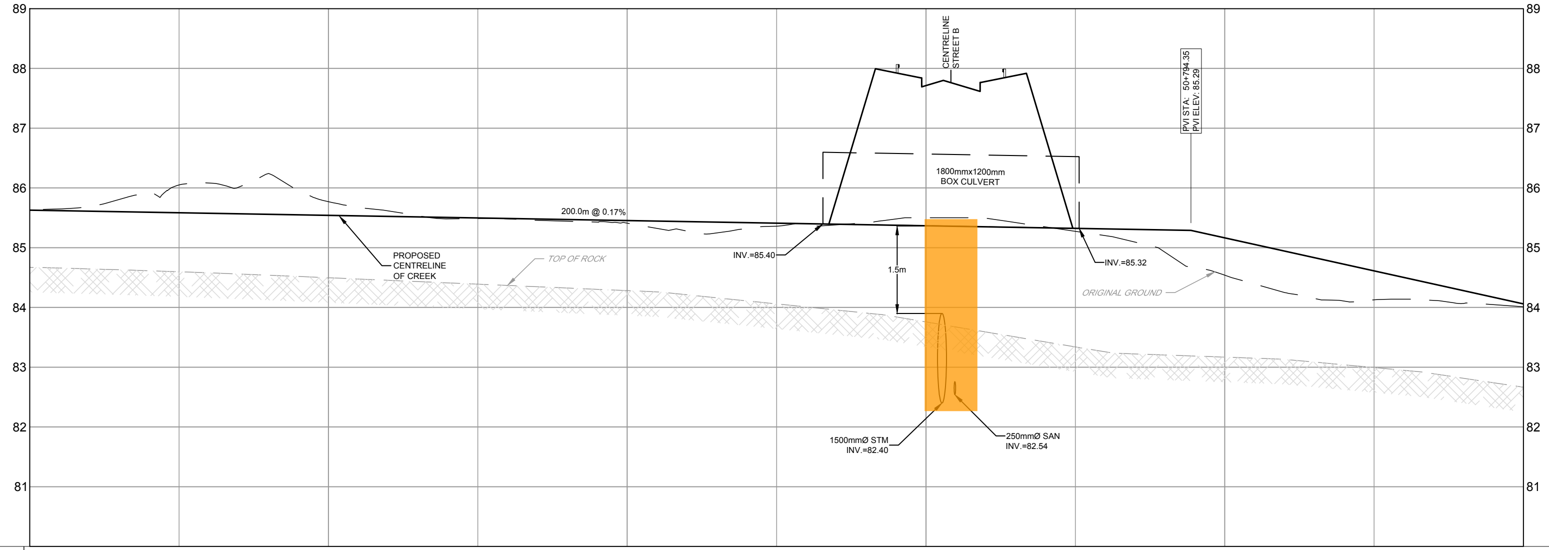
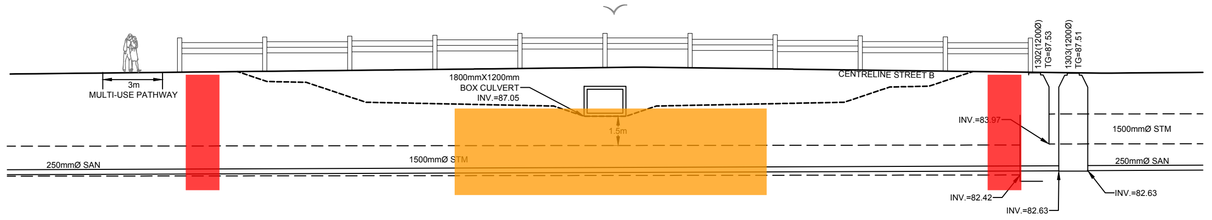




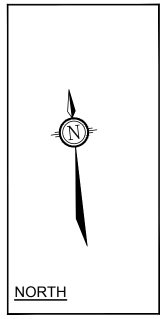
EXISTING ELEVATION	85.64	86.05	85.77	85.49	85.41	85.36	85.50	85.27	84.54	84.13	84.01	EXISTING ELEVATION
PROPOSED ELEVATION	85.63	85.58	85.54	85.50	85.45	85.41	85.37	85.32	85.16	84.61	84.06	PROPOSED ELEVATION
CHAINAGE	50+600	50+625	50+650	50+675	50+700	50+725	50+750	50+775	50+800	50+825	50+850	CHAINAGE

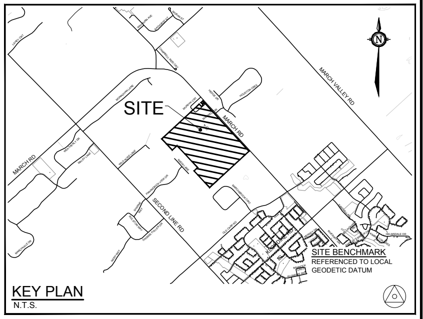


CREEK (40m CORRIDOR)
CROSS-SECTION G-G
SCALE 1:150

🟧 **Longitudinal Clay Seal - Refer to report PG4258-MEMO.01 dated June 13, 2018 for details**

🟥 **Conventional Vertical Clay Seal - Refer to report PG4258-MEMO.01 dated June 13, 2018 for details**





LEGEND

- PROPERTY LINE
- RIGHT OF WAY LIMITS
- D.C. PROPOSED DEPRESSED CURB
- PROPOSED BARRIER CURB OR MOUNTABLE CURB
- PROPOSED BARRIER CURB & SIDEWALK
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- PROPOSED PHASING LIMITS
- *EXISTING ℄ DITCH*
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- HYD *EXISTING FIRE HYDRANT C/W LEAD*
- V&VB *EXISTING VALVE & VALVE BOX LOCATION*
- V&VC *EXISTING VALVE & VALVE CHAMBER LOCATION*
- UP *EXISTING UTILITY POLE*
- OHW *EXISTING OVER HEAD WIRE*
- *EXISTING SIDEWALK*

REFER TO ____________ FOR ADDITIONAL NOTES

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SCALE
1:750
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0 10 20 30

DESIGN SAZ
CHECKED DDB
DRAWN RBG
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LOCATION
CITY of OTTAWA
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DRAWING NAME
CREEK PLAN AND PROFILE
STATION 50+600 TO 50+850

PROJECT No. 116132
REV
REV # 1
DRAWING No. 116132
CRK3-DRAFT

PLANB1.DWG - 1000mmx707mm

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURE 2 to FIGURE 6 - GROUNDWATER MONITORING LEVELS

DRAWING PG4258-1 - TEST HOLE LOCATION PLAN

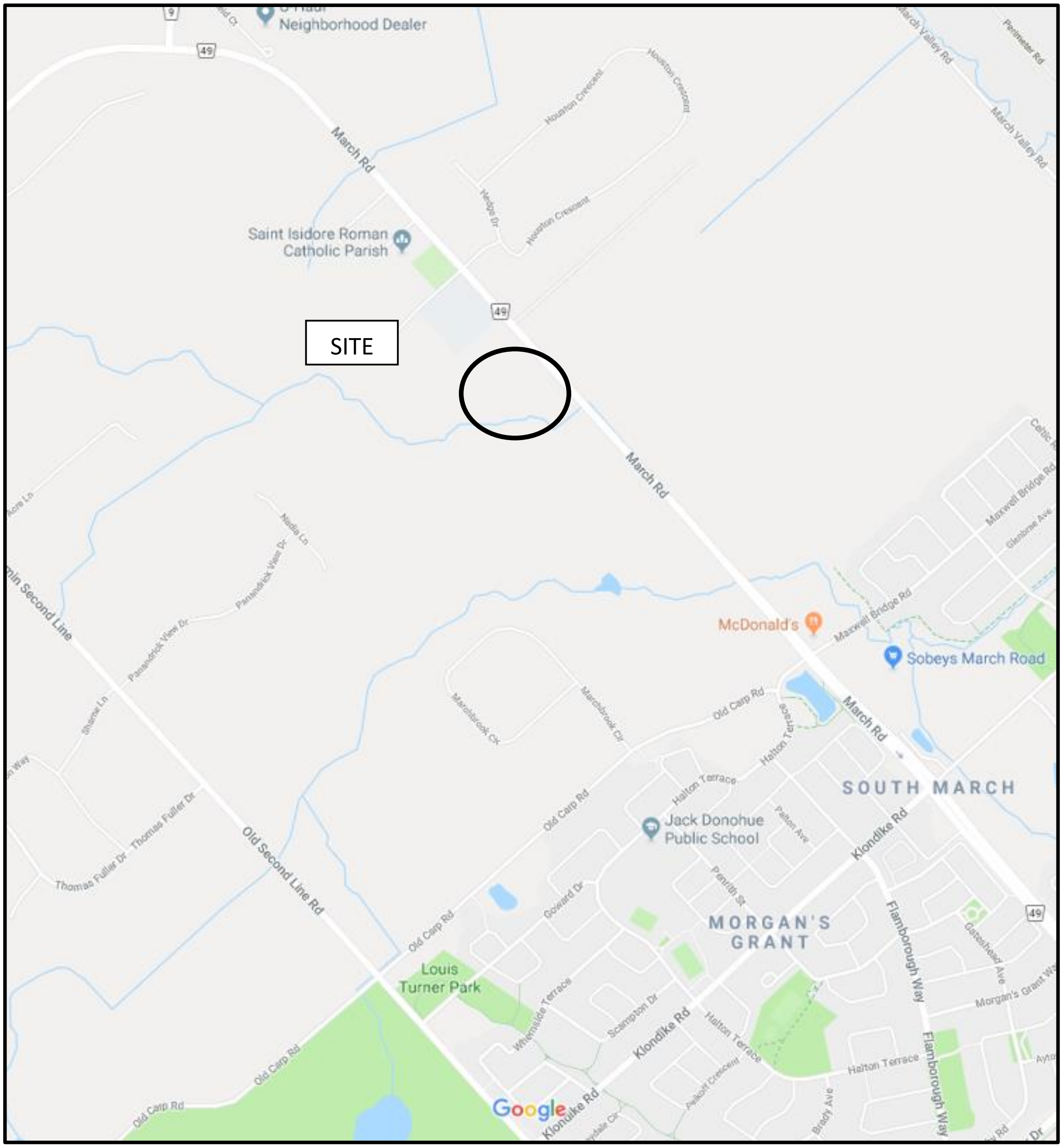

FIGURE 1

KEY PLAN

Figure 2: BH1 - Groundwater Monitoring Levels vs Precipitation Data

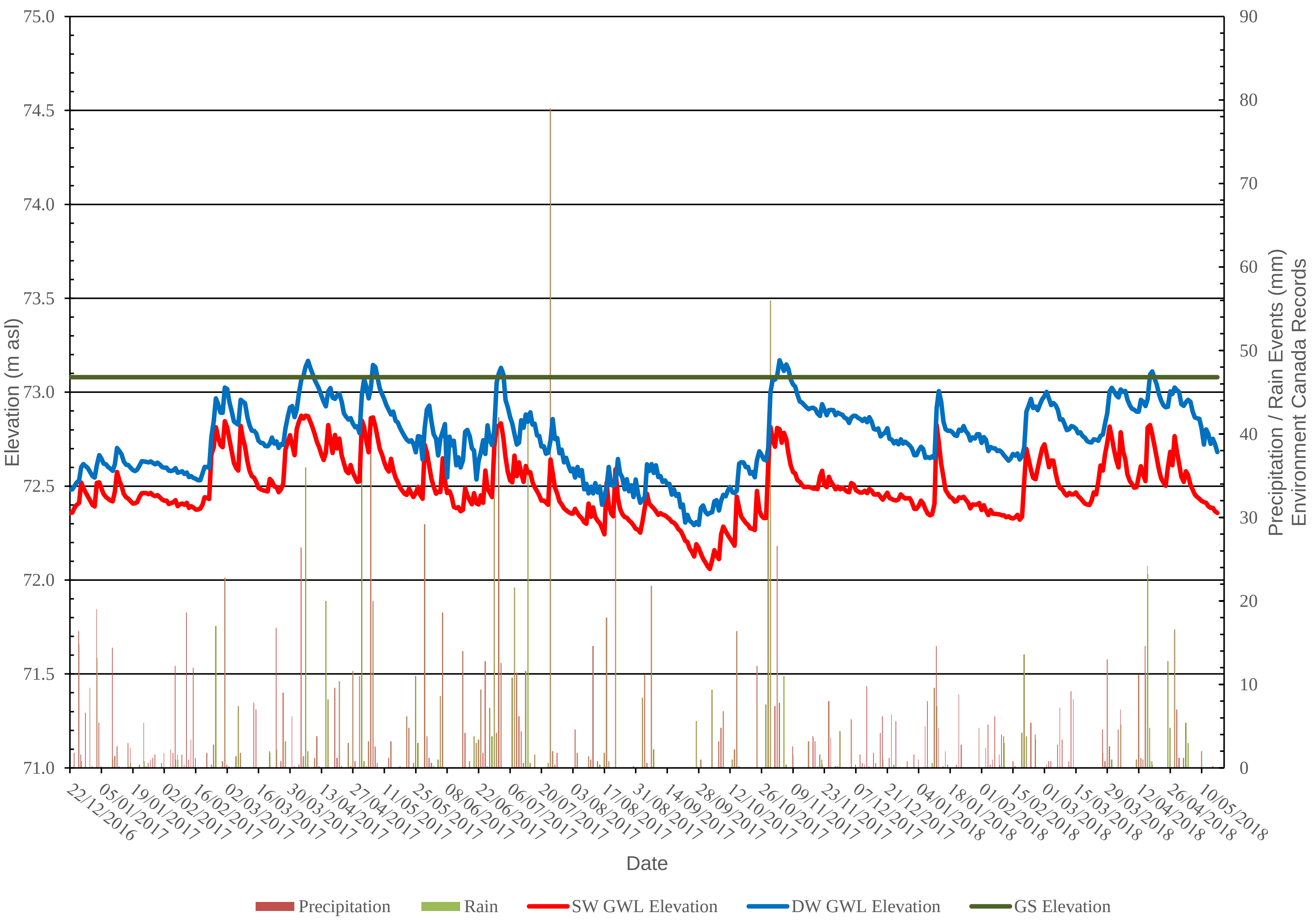

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Figure 3: BH2 - Groundwater Monitoring Levels vs Precipitation Data

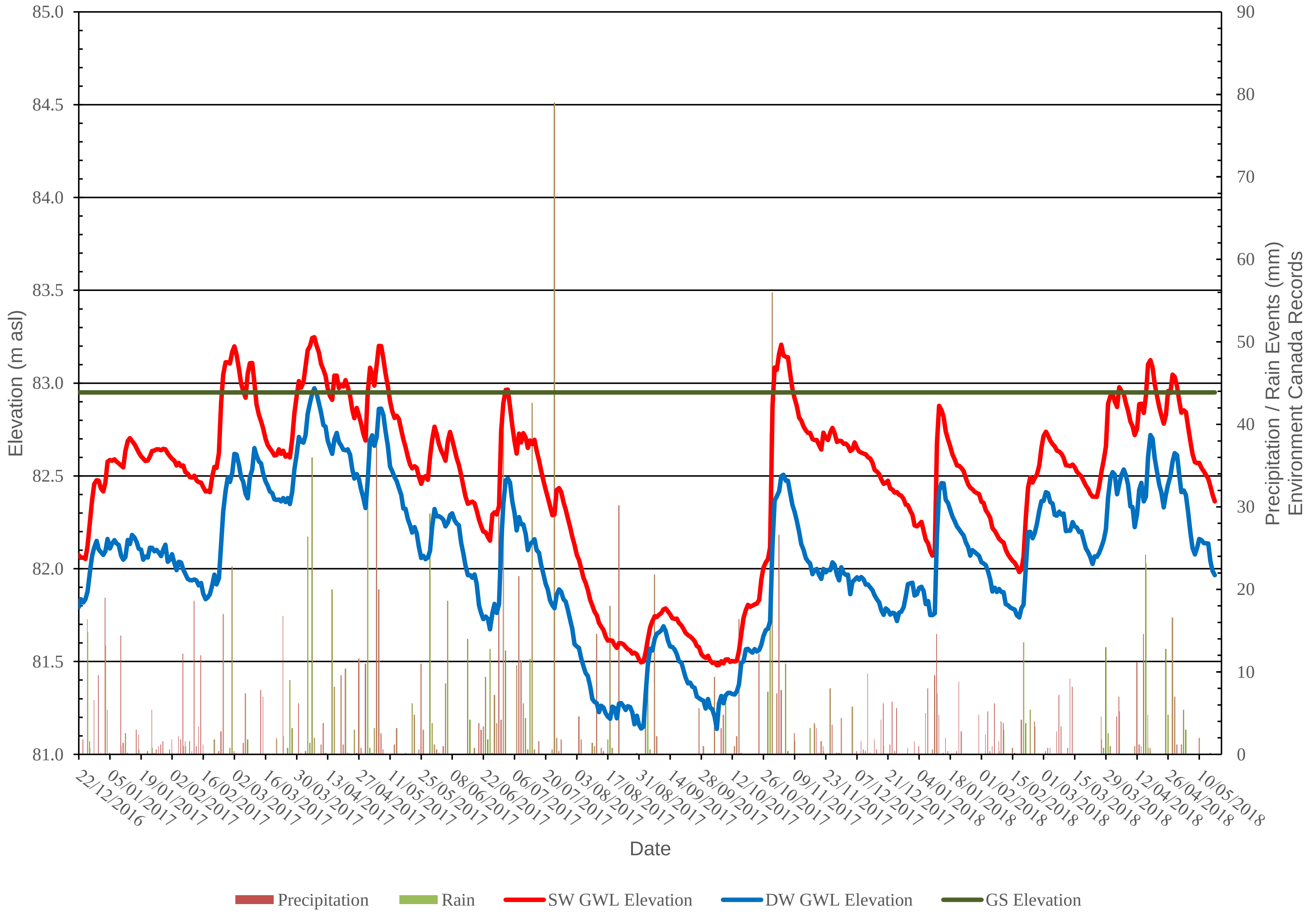


Figure 4: BH3 - Groundwater Monitoring Levels vs Precipitation Data

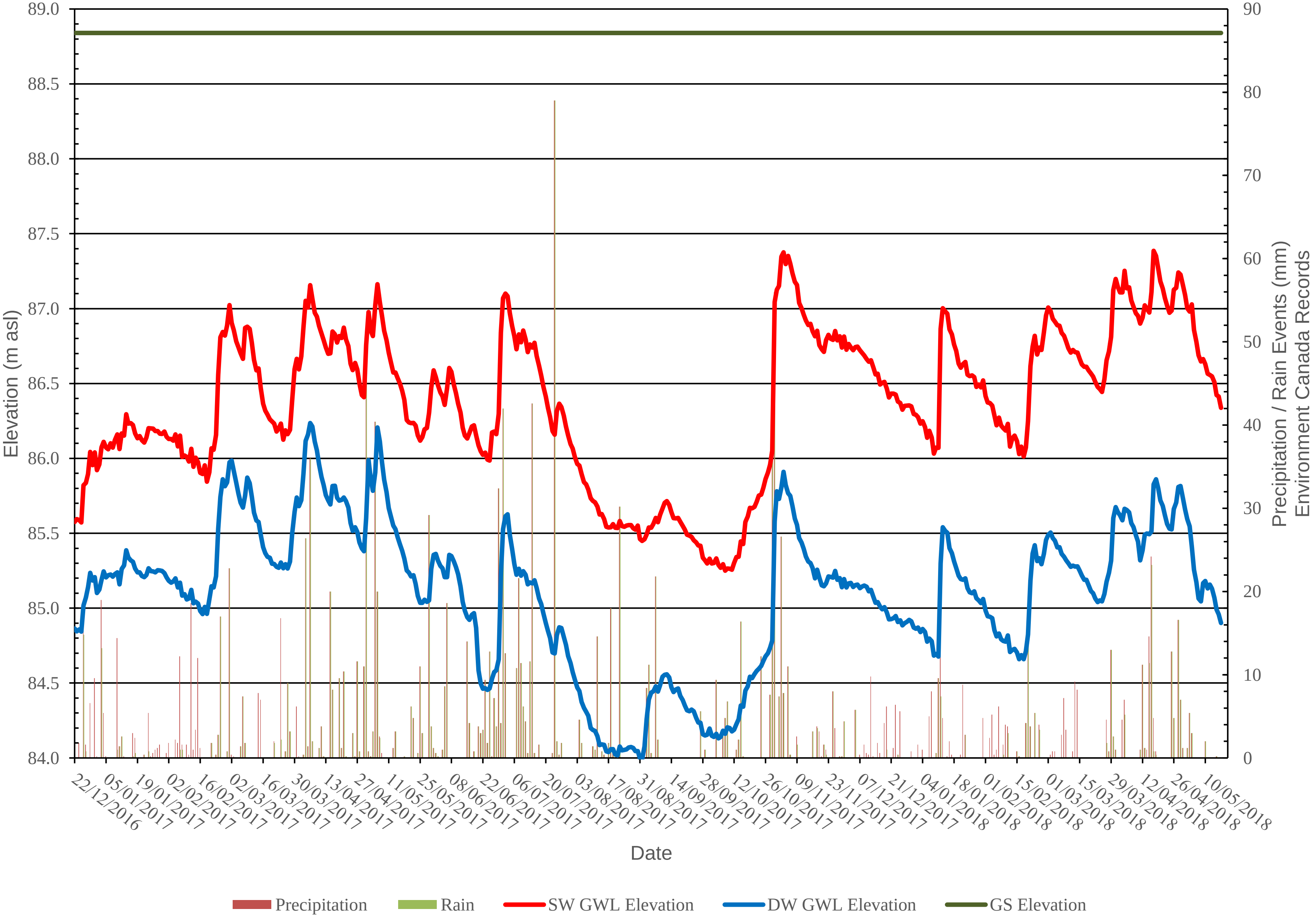
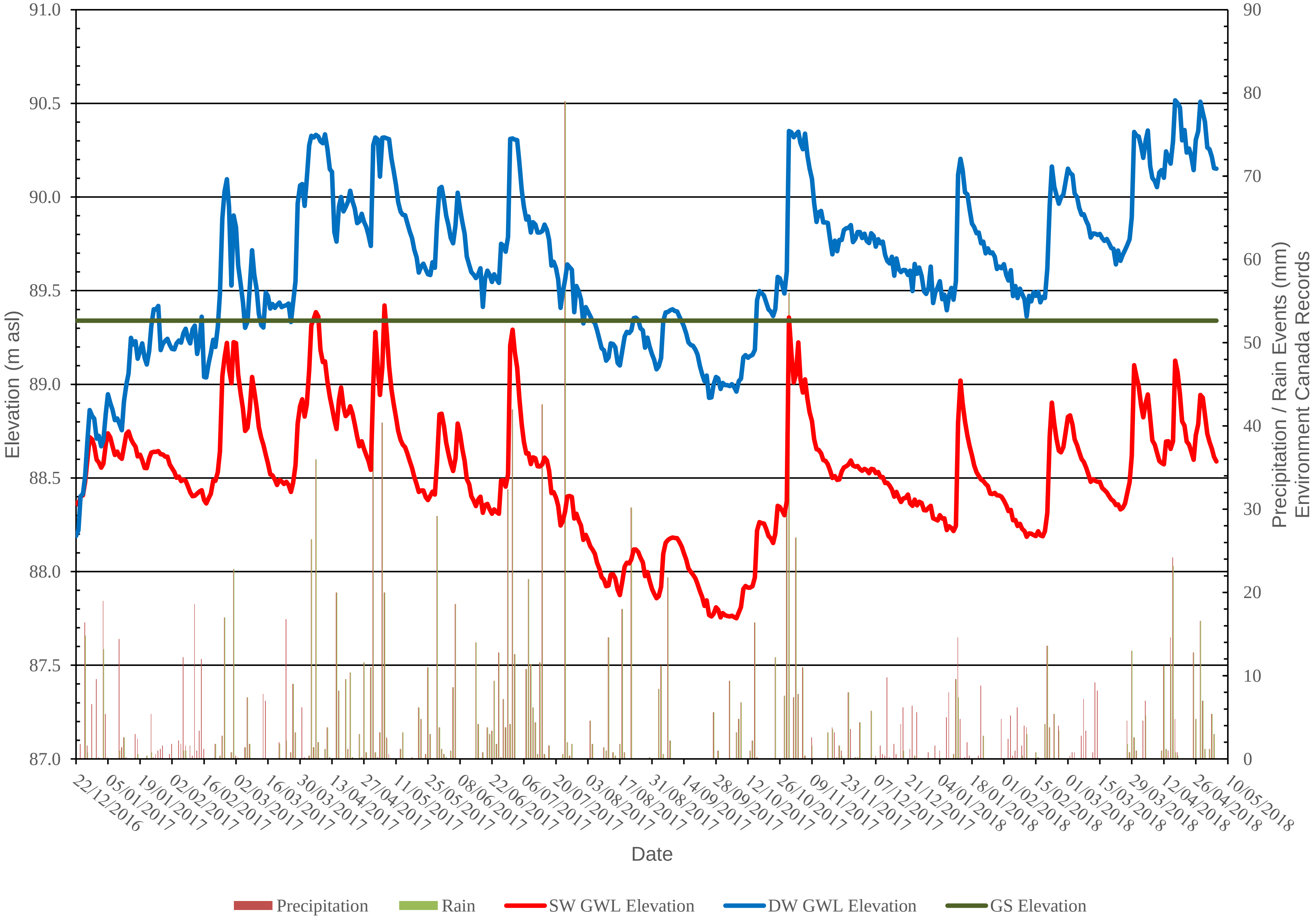


Figure 5: BH4 - Groundwater Monitoring Levels vs Precipitation Data



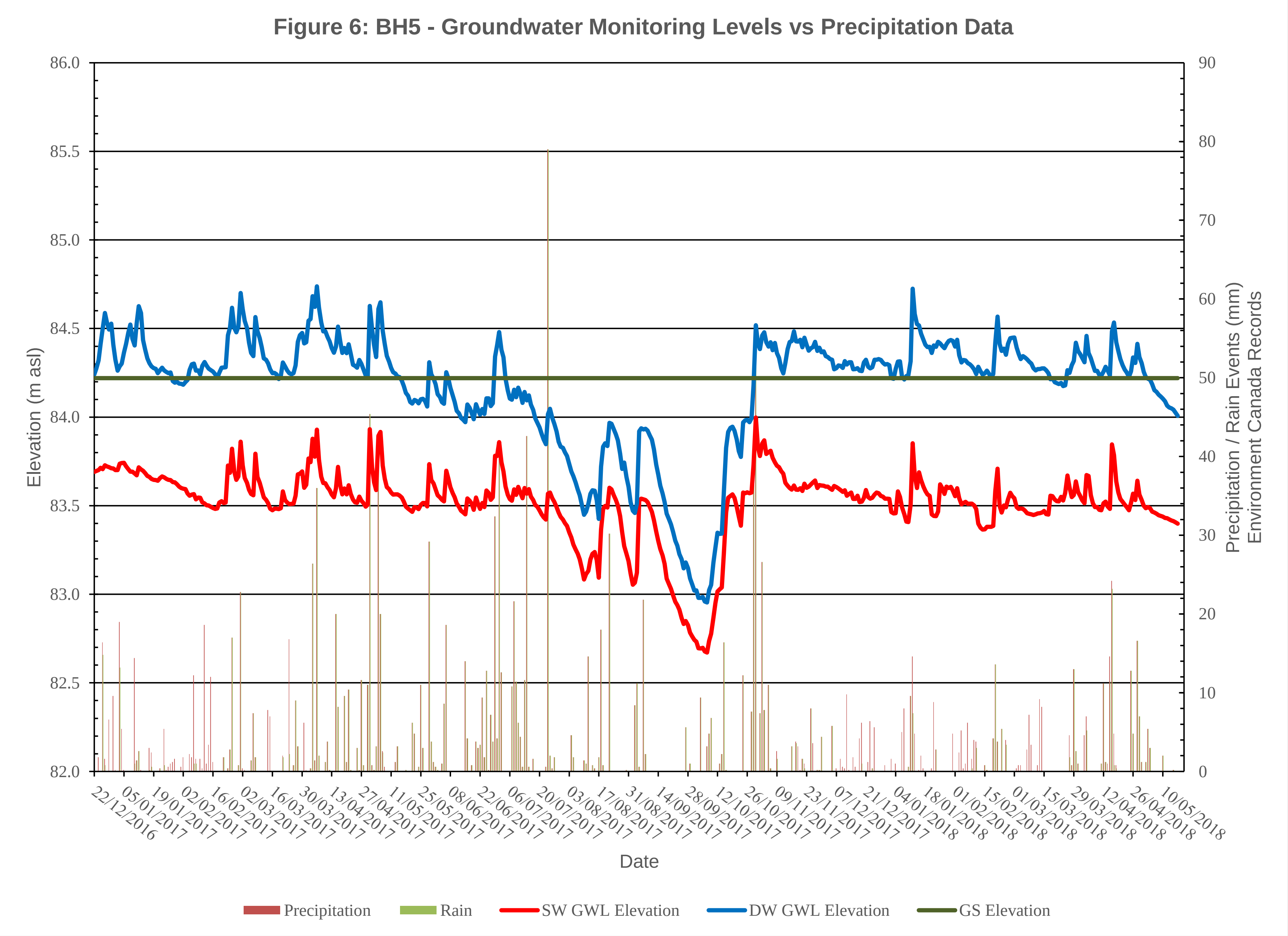
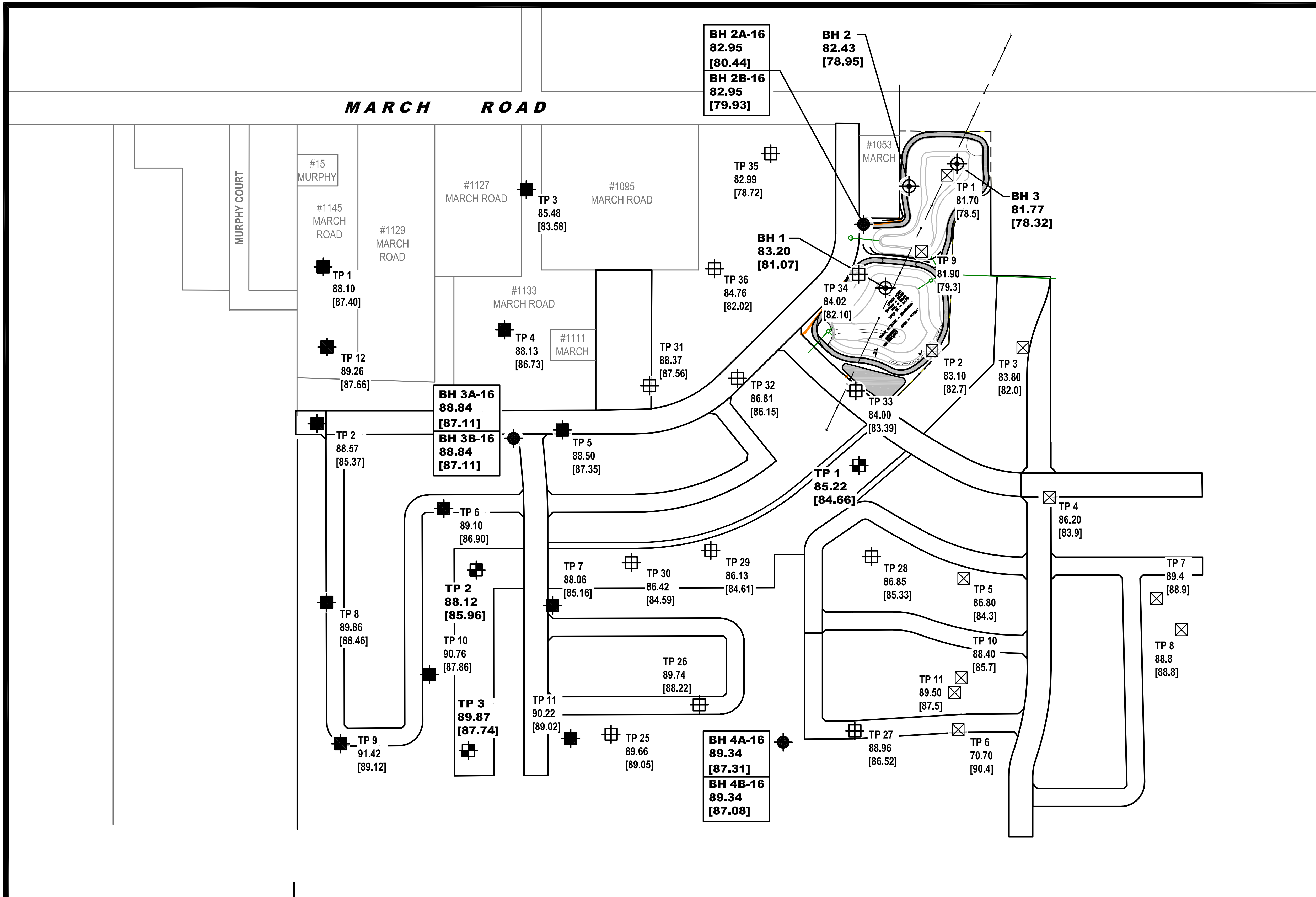


Figure 6: BH5 - Groundwater Monitoring Levels vs Precipitation Data
Elevation (m asl)
86.0
85.5
85.0
84.5
84.0
83.5
83.0
82.5
82.0
Precipitation / Rain Events (mm)
Environment Canada Records
90
80
70
60
50
40
30
20
10
0
22/12/2016
05/01/2017
19/01/2017
02/02/2017
16/02/2017
02/03/2017
16/03/2017
30/03/2017
13/04/2017
27/04/2017
11/05/2017
25/05/2017
08/06/2017
22/06/2017
06/07/2017
20/07/2017
03/08/2017
17/08/2017
31/08/2017
14/09/2017
28/09/2017
12/10/2017
26/10/2017
09/11/2017
23/11/2017
07/12/2017
21/12/2017
04/01/2018
18/01/2018
01/02/2018
15/02/2018
01/03/2018
15/03/2018
29/03/2018
12/04/2018
26/04/2018
10/05/2018
Date
Precipitation
Rain
SW GWL Elevation
DW GWL Elevation
GS Elevation



LEGEND:

⌖	BOREHOLE WITH MONITORING WELL LOCATION, CURRENT INVESTIGATION
■	TEST PIT LOCATION, CURRENT INVESTIGATION
●	SENTINEL MONITORING WELL LOCATION, PATERSON GROUP REPORT PG3975, 2017
⊞	TEST PIT LOCATION, PATERSON GROUP REPORT PG2878, 2013
■	TEST PIT LOCATION, PATERSON GROUP REPORT PG1823, 2009
☒	TEST PIT LOCATION, PATERSON GROUP REPORT PG1716, 2008
83.20	GROUND SURFACE ELEVATION (m)

[81.7] BEDROCK SURFACE ELEVATION (m)

TEST HOLE LOCATIONS AND GROUND SURFACE ELEVATIONS PROVIDED BY NOVATECH ENGINEERING CONSULTANTS LTD.

SCALE: 1:4000

0 50 100 150 200 250m

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consulting engineers

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NO.	REVISIONS	DATE	INITIAL
2	SENTINEL MONITORING WELLS ADDED	23/05/2018	RG
1	TEST PITS FROM PREVIOUS INVESTIGATIONS ADDED	19/02/2018	RG

NOVATECH ENGINEERING CONSULTANTS LIMITED
GEOTECHNICAL INVESTIGATION
PROP. STORMWATER MANAGEMENT FACILITY - MARCH ROAD
OTTAWA, ONTARIO

Title:
TEST HOLE LOCATION PLAN

Scale: 1:4000
Date: 11/2017
Drawn by: MPG
Report No.: PG4258-1
Checked by: NZ
Dwg. No.: PG4258-1
Approved by: DJG
Revision No.: 2

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