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Geotechnical Engineering

Environmental Engineering

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Building Science

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Supplemental Geotechnical Investigation

Proposed Residential Development
Riverside South - Phase 12
708 River Road
Ottawa, Ontario

Prepared For

Urbandale Corporation

November 26, 2014

Report PG3320-1

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TABLE OF CONTENTS

PAGE

APPENDICES

1.0 INTRODUCTION

Paterson Group (Paterson) was commissioned by Urbandale Corporation to conduct a supplemental geotechnical investigation for Phase 12 of the Riverside South residential development to be located at 708 River Road, in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan presented in Appendix 2 of this report).

The objectives of the investigation were to:

- ❏ determine the subsoil and groundwater conditions at this site by means of boreholes and test pits;
- ❏ conduct an assessment of the stability of the slope along the east riverbank of the Rideau River; and
- ❏ based on the results of the test holes, provide geotechnical recommendations pertaining to the proposed development.

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

Investigating the presence or potential presence of contamination on the subject property was not part of the scope of work of this present investigation.

2.0 PROPOSED DEVELOPMENT

It is understood that the current phase of the development will consist of residential buildings along with associated access lanes, parking and landscaped areas. It is further anticipated that the site will be serviced by future municipal services.

The subject property is undeveloped and bordered to the east by River Road, to the south by residential properties, to the north by the Strandherd/Armstrong bridge and to the west by the Rideau River. Debris from former buildings located within the site were noted along the east property line in the central portion of the site. Debris, including building materials and tires, were also observed in close proximity of the building debris.

The site was formerly used as agricultural lands, and is mostly grass covered with some treed areas. Generally, the terrain slopes downward towards the Rideau River. A drainage ditch runs through the central portion of the site from River Road to the Rideau River. Also, a small natural drainage ditch running in a north-south direction was noted within the north portion of the site.

3.0 METHOD OF INVESTIGATION

3.1 Field Investigation

A supplemental investigation was carried out on August 28, 2014. At that time, three (3) boreholes were advanced to depths ranging from 10.6 to 13 m. The locations were determined in the field by Paterson personnel taking into consideration site features and underground services.

The fieldwork program for the original investigation was carried out on June 22 and 23, 2006. At that time five (5) boreholes (BHs 1 to 5) were advanced to depths ranging from 2.5 to 15.4 m. The boreholes were distributed in a manner to provide general coverage of the subject site. One probe hole was completed at BH 3 to verify the practical refusal to augering depth.

The approximate locations of the test holes are shown on Drawing PG3320-2 - Test Hole Location Plan included in Appendix 2.

The test holes were put down using a track-mounted auger drill rig operated by a crew of two. All fieldwork was conducted under the full-time supervision of our personnel under the direction of a senior engineer. The drilling procedures consisted of advancing each test hole to the required depths at the selected locations and sampling the overburden. Sampling and testing the overburden was completed in general accordance with ASTM D5434-12 - Guide for Field Logging of Subsurface Explorations of Soil and Rock.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon (SS) sampler, using 73 mm diameter thin walled (TW) Shelby tubes in conjunction with a piston sampler, or from the auger flights. The thin walled Shelby samples were done in general accordance with ASTM D1587-08 (2012)e1 - Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes.

The depths at which the auger, split spoon, Shelby tube and grab samples were recovered from the test holes are shown as AU, SS, TW and G, respectively, on the Soil Profile and Test Data sheets in Appendix 1.

A Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split spoon samples. 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. This testing was done in general accordance with ASTM D1586-11 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils.

The thickness of the overburden layer was evaluated during the course of the investigation by dynamic cone penetration testing (DCPT) at BHs 1, 2 and 3. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at its tip, using a 63.5 kg hammer falling from a height of 760 mm. The number of blows required to drive the cone into the soil is recorded for each 300 mm increment.

Undrained shear strength testing was carried out at regular depth intervals in cohesive soils. Undrained shear strength testing in test pits was completed using a handheld, portable vane apparatus (field inspection vane tester Roctest Model H-60). Undrained shear strength testing in boreholes was completed using a MTO field vane apparatus. This testing was done in general accordance with ASTM D2573-08 - Standard Test Method for Field Vane Shear Test in Cohesive Soil.

All soil samples were classified on site, placed in sealed plastic bags and were transported to our laboratory for visual inspection. Transportation of the samples was completed in general accordance with ASTM D4220-95 (2007) - Standard Practice for Preserving and Transporting Soil Samples.

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

Flexible standpipe piezometers were installed in all boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program. All groundwater observations are noted on the Soil Profile and Test Data sheets presented in Appendix 1.

Sample Storage

All samples will be stored in the laboratory for a period of one month after issuance of this report. They will then be discarded unless we are otherwise directed.

3.2 Field Survey

The test hole locations were selected by Paterson and located and surveyed in the field by Annis O'Sullivan Vollebekk Ltd. All test hole elevations are referenced to a geodetic datum.

The ground surface elevations at the test hole locations are presented on Drawing PG3320-2 - Test Hole Location Plan included in Appendix 2.

Boreholes that were instrumented with piezometers were not decommissioned at this time. Additional groundwater information, if required, can be obtained from the existing piezometers. It is anticipated that the existing boreholes can be decommissioned at the time of construction.

In addition, the top of slope and bottom of slope lines, as well as typical cross-sections of the existing slope were determined by Annis O'Sullivan Vollebekk.

3.3 Laboratory Testing

The soil samples recovered from the subject site were visually examined in our laboratory to review the results of the field logging. The subsurface soils were classified in general accordance with ASTM D2488-09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

3.4 Analytical Testing

One (1) 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 submitted to determine the concentration of sulphate and chloride, the resistivity and the pH of the samples. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 OBSERVATIONS

4.1 Surface Conditions

The subject property is former farmland and is presently undeveloped. Treed areas were observed along the north, west and south property boundaries, and along the drainage ditch running east-west within the central portion of the site. A small natural ditch was noted within the north portion of the site.

Generally, the ground surface slopes downwards toward the east bank of the Rideau River. A 3.5 to 8 m high slope, consisting of the east valley corridor wall of the Rideau River, runs north-south within along the west property boundary. The slope was noted to be vegetated and stable.

4.2 Subsurface Profile

Generally, the subsoil conditions encountered at the boreholes consist of topsoil overlying a thin silty sand layer and stiff to very stiff silty clay. Glacial till/inferred glacial till was encountered below the silty clay deposit. Practical refusal to augering/DCPT was observed at all test holes, except BH 5 (PG2012), at depths ranging from 2.5 to 15.4 m. Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for the details of the soil profile encountered at each test hole location.

Practical refusal to augering/DCPT testing was observed at depths ranging from 2.5 to 13 m. Based on available geological mapping, the bedrock in the area consists of sandstone and dolomite of the March formation, and is expected to be encountered at depths ranging from 15 to 25 m.

Silty Clay

Silty clay was encountered below the topsoil and/or silty sand at all test hole locations.

The upper portion of the silty clay has been weathered to a brown crust which frequently contains silty sand/sandy silt seams. The crust extends to depths varying between 2.3 and 8.0 m.

In-situ shear vane field testing carried out within the silty clay crust yielded undrained shear strength values ranging from approximately 45 kPa to more than 200 kPa. These values are indicative of a stiff to very stiff consistency.

Grey silty clay was encountered below the weathered crust at BHs 1-14, 2-14 and 3-14. In-situ shear vane field testing carried out within the grey silty clay crust yielded undrained shear strength values ranging from 45 kPa to more than 120 kPa. These values are indicative of a firm to very stiff consistency. Generally, the consistency was noted to be stiff.

Glacial Till/Inferred Glacial Till

Glacial till, which consists of a fine soil matrix mixed with gravel, cobbles and boulders, was encountered or was inferred to be encountered at all borehole locations, except BH 5. The fine soil matrix consists of silty sand. The glacial till was encountered or inferred to have been encountered at depths ranging from 2.3 to 15 m, respectively.

Based on the results of the DCPTs, with blow counts ranging from about 10 to more than 30 blows per 300 mm increment of penetration, the state of compactness of this layer is estimated to be compact to dense.

4.3 Groundwater

The groundwater levels were measured in the standpipes in all boreholes on September 3, 2014. The measured groundwater levels are presented in Table 1. The groundwater level can also be estimated based on moisture levels, colouring and consistency of the recovered soil samples. Based on these observations at the borehole locations, the long-term groundwater table is expected between a 4.5 to 6 m depth.

It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater levels could be higher at the time of construction.

Table 1
Summary of Groundwater Level Readings

Test hole Number	Ground Elevation, m	Groundwater Levels, m		Recording Date
		Depth	Elevation	
BH 1-14	88.33	--	--	September 3, 2014
BH 2-14	85.43	3.16	82.27	September 3, 2014
BH 3-14	88.11	2.47	85.64	September 3, 2014

5.0 DISCUSSION

5.1 Geotechnical Assessment

The site is considered to be satisfactory from a geotechnical perspective for a residential development. It is anticipated that the dwellings will be founded on shallow footing foundations placed either on an undisturbed, silty clay or glacial till bearing surface.

The proposed development is bordered to the west by the east valley corridor wall of the Rideau River. A geotechnical limit of hazard lands line, from the top of slope, was established based on the City of Ottawa guidelines for slope stability assessment. The limit of hazard lands line is indicated in Drawing PG3320-2 - Test Hole Location Plan presented in Appendix 2.

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

5.2 Site Grading and Preparation

Stripping Depth

Topsoil and deleterious fill, such as those containing organic materials, should be stripped from under any buildings, paved areas, pipe bedding and other settlement sensitive structures.

Existing foundation walls and other construction debris should be entirely removed from within the proposed buildings. Under paved areas, existing construction remnants, such as foundation walls should be excavated to a minimum depth of 1 m below final grade.

Fill Placement

Fill used for grading beneath the buildings should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or B Type II. These materials 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 buildings 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. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to reduce 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. Separation will be required to remove all stones greater than 300 mm in their longest dimension prior to reusing the glacial till. 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 Foundation Design

Based on the subsurface profile encountered at the site, it is expected that a stiff to very stiff, silty clay or a dense, glacial till will be encountered at the anticipated founding levels. Engineered fill below the footings may also be required for lots where a significant grade raise is proposed.

Strip footings, up to 4 m wide, and pad footings, up to 5 m wide, founded on an undisturbed, stiff silty clay, an undisturbed, dense glacial till bearing surface or engineered fill prepared as detailed in Subsection 5.2 can be designed using a bearing resistance value at serviceability limit states (SLS) of **150 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **250 kPa**. Footings designed using the above-noted bearing resistance value at SLS will be subjected to potential post-construction total and differential settlements of 25 and 20 mm, respectively. In areas where cohesive soils are encountered below footing level, a permissible grade raise of 2 m is recommended for the proposed development.

An undisturbed soil bearing surface consists of one 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 the concrete for the footings.

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 silty clay, glacial till or engineered fill when a plane extending down and out from the bottom edges of the footing, at a minimum of 1.5H:1V, passes only through in situ soil of the same or higher capacity as the bearing medium soil.

5.4 Design for Earthquakes

The proposed site can be taken as seismic site response Class C as defined in the Ontario Building Code 2012 (OBC 2012; Table 4.1.8.4.A) for foundations considered at this site. The soils underlying the site are not susceptible to liquefaction.

5.5 Slab-on-Grade Construction/Basement Slab

With the removal of topsoil and fill, containing organic matter or deleterious materials, within the footprint of the proposed buildings, the native soil surface will be considered an acceptable subgrade surface on which to commence backfilling for floor slab construction. Any soft areas should be removed and backfilled with appropriate backfill material prior to placing any fill.

OPSS Granular A or Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab. It is recommended that the upper 200 mm of sub-floor fill consists of OPSS Granular A crushed stone for slab on grade construction. If consideration is given to a basement level, the upper 200 mm of sub-floor fill should consist of a 19 mm clear crushed stone. All backfill material within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

5.6 Pavement Design

For design purposes, the pavement structures presented in the following tables could be used for the design of car only parking areas and local roadways.

Table 2 - Recommended Pavement Structure - Car Only Parking Areas

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 in situ soils or OPSS Granular B Type I or II material placed over in situ soil	

Table 3 - Recommended Pavement Structure - Local Roadways

Thickness (mm)	Material Description
40	**WEAR COURSE -** Superpave 12.5 Asphaltic Concrete
50	**BINDER COURSE -** Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
450	**SUBBASE** - OPSS Granular B Type II
	SUBGRADE - Either in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill.

The pavement thickness should be increased if bus traffic or other frequent heavy truck traffic is expected. 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.

The pavement granulars (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 compaction equipment.

Pavement Structure Drainage

Satisfactory performance of the pavement structure is largely dependent on keeping the contact zone between the subgrade material and the base stone in a dry condition. Failure to provide adequate drainage under conditions of heavy wheel loading can result in the fine subgrade soil being pumped into the voids in the stone subbase, thereby reducing its load carrying capacity.

Due to the impervious nature the subgrade materials consideration should be given to installing subdrains during the pavement construction. These drains should be installed on both sides of the pavement with their inverts approximately 300 mm below the subgrade level. The clear stone surrounding the drainage lines or the pipe itself, should be wrapped with a suitable filter cloth. The drains should be connected to a positive outlet. The subgrade surface should be crowned to promote water flow to the drainage lines.

5.7 Limit of Hazard Lands

Existing Slope Conditions and Soils Information

The east valley corridor wall of the Rideau River along the west property boundary of the subject site was noted to be well grassed along the north portion of the slope face and mostly treed within the south portion. A well vegetated 15 to 50 m wide flood plain exists between the toe of slope and the Rideau River. The water depth was noted to vary between approximately 0.2 to 0.3 m.

No erosional activities were observed along the toe of the existing slope and no evidence of slope movement was observed.

Slope Stability Analysis

The slope stability analysis was completed using topographical survey information provided by Annis O'Sullivan Vollebekk and City of Ottawa topographic mapping information, as well as, a current slope condition review by Paterson field personnel. Two (2) slope cross-sections were studied as the worst case scenarios. The cross section locations are presented on Drawing PG3320-2 - Test Hole Location Plan in Appendix 2.

The analysis of the stability of the slope was carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including the Bishop's method, which is a widely used and accepted analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favoring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsoil and groundwater conditions, a factor of safety greater than one is usually required to ascertain the risks of failure are acceptable. A minimum factor of safety of 1.5 is generally recommended for conditions where the failure of the slope would endanger permanent structures.

Subsoil conditions at the cross-sections were inferred based on the findings at nearby test hole locations and general knowledge of the area's geology.

Static Conditions with Groundwater at Surface

The results for the existing slope conditions under static loading at Sections A and B are shown in Figures 2 and 4, respectively, presented in Appendix 2. The slope stability factor of safety at Section A was found to be less than 1.5 and greater than 1.5 at Section B. A 6.5 m stable slope allowance from top of slope is required at Section A, as indicated in Figure 2 in Appendix 2.

Seismic Loading Analysis

An analysis considering seismic loading was also completed. A horizontal seismic acceleration, K_h, of 0.21G was considered for the analyzed sections. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The results of the analyses including seismic loading are shown in Figures 3 and 5 for the slope sections. The minimum factor of safety is greater than 1.1 at both sections analyzed.

Limit of Hazard Lands

The geotechnical limit of hazard lands taken from top of slope for the subject site is indicated on Drawing PG3320-2 - Test Hole Location Plan in Appendix 2. The limit of hazard lands includes a 6 m erosion access allowance and a 2 m toe erosion allowance, where the toe of slope is less than 15 m from the edge of watercourse. Also, where required a stable slope allowance based on our slope stability analysis results is included in the limit of hazard lands.

The toe erosion allowance for the slope was based on the nature of the soils, the observed current erosional activities and the location of the Rideau River. No signs of active erosion were noted along the slope face.

A stable slope allowance of 6.5 m is required for the north portion of the slope based on our analysis, which is included in the limit of hazard lands line indicated on Drawing PG3320-2 - Test Hole Location Plan in Appendix 2.

The existing vegetation on the slope face should not be removed as it contributes to the stability of the slope and reduces erosion. If the existing vegetation needs to be removed, it is recommended that 100 to 150 mm of topsoil mixed with a hardy seed or an erosional control blanket be placed across the exposed slope face.

6.0 DESIGN AND CONSTRUCTION PRECAUTIONS

6.1 Foundation Drainage and Backfill

It is recommended that a perimeter foundation drainage system be provided for the proposed structures. The system should consist of a 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 10 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls unless a composite drainage system (such as Miradrain G100N or system Platon) connected to a perimeter drainage system is provided. Imported granular materials, such as clean sand or OPSS Granular B Type I material, should be used for this purpose.

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effects of frost action. A minimum 1.5 m thick soil cover (or equivalent insulation) should be provided in this regard. In unheated areas, the thickness of the soil cover should be increased to a minimum of 2.1 m (or insulation equivalent).

6.3 Excavation Side Slopes

The side slopes of the shallow excavations anticipated at this site should either be cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is assumed that sufficient room will be available for the greater part of the excavation to be undertaken by open-cut methods (i.e. unsupported excavations). Where space restrictions exist, or to reduce the trench width, where applicable, the excavation can be carried out within the confines of a fully braced steel trench box or other acceptable shoring systems.

Above the groundwater level, the excavation side slopes extending to a maximum depth of 3.5 m should be cut back at 1H:1V or shallower; the lowermost 1.2 m of the trench side slope can be cut vertically, provided the in situ soil at that depth consists of silty clay. Flatter slope will be required below the groundwater level. The subsoil at this site is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

Excavated soil should not be stockpiled at the top of excavations and heavy equipment should be kept away from the excavation sides.

Slopes in excess of 3 m in height should be periodically inspected by the geotechnical consultant in order to detect if the slopes are exhibiting signs of distress.

It is recommended that a trench box be used at all times to protect personnel working in trenches with steep or vertical sides. It is expected that services will be installed by “cut and cover” methods and excavations will not be left open for extended periods of time.

Where sufficient space does not exist, temporary shoring may be required to complete the required excavations. The shoring requirements will depend on the depth of the excavation, the proximity of the adjacent buildings and underground structures and the elevation of the adjacent building foundations and underground services. Additional information can be provided when the above details are known.

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with the most recent Material Specifications & Standard Detail Drawings from the Department of Public Works and Services, Infrastructure Services Branch of the City of Ottawa.

At least 150 mm of OPSS Granular A should be used for pipe bedding for sewer and water pipes. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe should consist of OPSS Granular A. The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to a minimum of 95% of the material’s SPMDD.

It should generally be possible to re-use site excavated silty sand, glacial till and upper portion of the silty clay crust above the cover material if the excavation and filling operations are carried out in dry weather conditions. Any stones greater than 300 mm in their longest dimension should be removed from these materials prior to placement. Wet grey silty clay will be difficult, if not impractical, to reuse without a long drying period.

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% of the material's SPMDD.

To reduce long term lowering of the groundwater level at this site, clay seals should be provided in the service trenches. The seals should be at least 1.5 m long (in the trench direction) and should extend from trench wall to trench wall. Generally, the seals should extend from the frost line and fully penetrate the bedding, subbedding and cover material. The barriers should consist of relatively dry and compactable brown silty clay placed in maximum 225 mm thick loose layers compacted to a minimum of 95% of the material's SPMDD. The clay seals should be placed at the site boundaries and at strategic locations at no more than 50 m intervals in the service trenches.

6.5 Groundwater Control

Groundwater Control for Building Construction

It is anticipated that groundwater infiltration into the excavation should be low and controllable using open sumps. Pumping from the open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations. The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the foundation medium.

A temporary MOE permit to take water (PTTW) will be required for this project if more than 50,000 L/day are to be pumped during the construction phase. At least 4 to 5 months should be allowed for completion of the application and issuance of the permit by the MOE.

6.6 Landscaping Considerations

Tree Planting Restrictions

It is recommended that trees placed within 4 m of the foundation wall should consist of low water demanding trees with shallow roots systems that extend less than 1.5 m in depth. Trees placed greater than 4 m from the foundation wall may consist of typical street trees, which are typically moderate water demand species with roots extending to a maximum depth of 2 m below ground surface.

It is well documented in the literature, and is our experience, that fast-growing trees located near buildings founded on cohesive soils that shrink on drying can result in long-term differential settlements of the structures. Tree varieties that have the most pronounced effect on foundations are seen to consist of poplars, willows and some maples (i.e. Manitoba Maples) and, as such, they should not be considered in the landscaping design.

6.7 Corrosion Potential and Sulphate

The analytical test results are presented in Table 4 along with industry standards for the applicable threshold values. The results are indicative that Type 10 Portland cement (Type GU).

Table 4 - Corrosion Potential

Parameter	Laboratory Results	Threshold	Commentary
	BH3- SS4		
Chloride	<5 µg/g	Chloride content less than 400 mg/g	Negligible concern
pH	7.59	pH value less than 5.0	Neutral Soil
Resistivity	4130 ohm.m	Resistivity greater than 1,500 ohm.cm	Moderate Corrosion Potential
Sulphate	101 µg/g	Sulphate value greater than 1 mg/g	Negligible Concern

7.0 RECOMMENDATIONS

It is a requirement for the foundation design data provided herein to be applicable that a material testing and observation services program including the following aspects be performed by the geotechnical consultant.

☐ Review of the grading plan once available.

☐ Observation of the placement of the foundation insulation, if applicable.

☐ Observation of all bearing surfaces prior to the placement of concrete.

☐ Sampling and testing of the concrete and fill materials used.

☐ Periodic observation of the condition of unsupported excavation side slopes in excess of 3.0 m in height, if applicable.

☐ Observation of all subgrades prior to backfilling

☐ Field density tests to determine the level of compaction achieved.

☐ Sampling and testing of the bituminous concrete including mix design reviews.

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.

8.0 STATEMENT OF LIMITATIONS

The recommendations made in this report are in accordance with our present understanding of the project. We request that we be permitted to review our recommendations 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 Urbandale Developments 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.

Stephanie A. Boisvenue, P.Eng.

David J. Gilbert, P.Eng.

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Report Distribution:

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APPENDIX 1

SOIL PROFILE & TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

SOIL PROFILE AND TEST DATA

Supplemental Geotechnical Investigation
Riverside South - Phase 12, 708 River Road
Ottawa, Ontario

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

FILE NO. **PG3320**

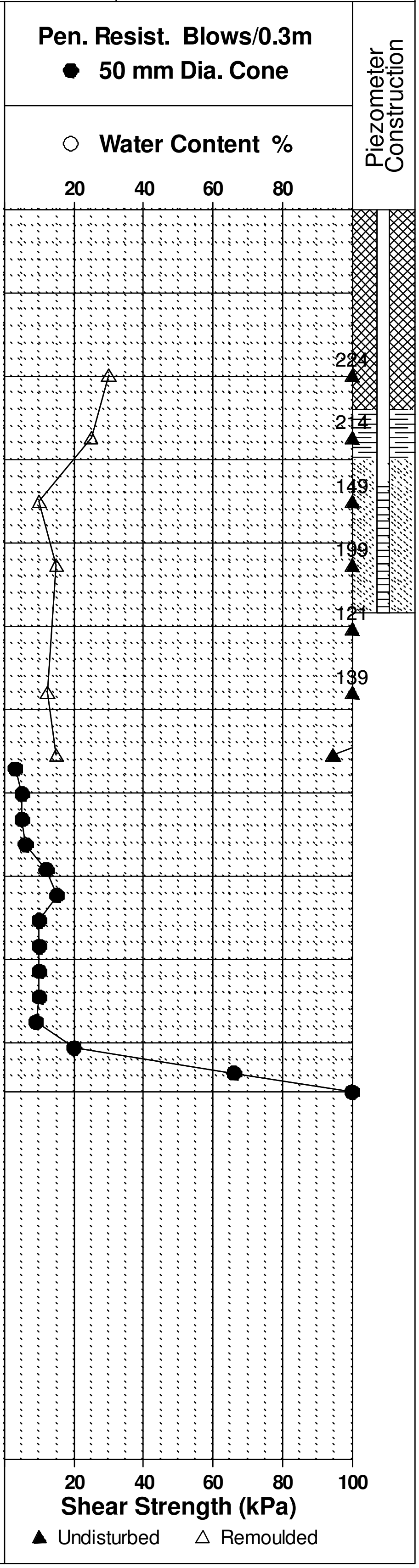
REMARKS

HOLE NO. **BH 1-14**

BORINGS BY CME 55 Power Auger

DATE August 28, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.30		AU	1			0	88.33
Brown **SILTY SAND** 0.69		AU	2				
		SS	3	83	14	1	87.33
						2	86.33
Hard to very stiff, brown **SILTY CLAY**						3	85.33
						4	84.33
						5	83.33
- stiff by 5.9m depth 6.55						6	82.33
Dynamic Cone Penetration Test commenced at 6.55m depth.						7	81.33
						8	80.33
						9	79.33
10.59						10	78.33
End of Borehole Practical DCPT refusal at 10.59m depth in glacial till. (BH dry to 4.84m depth - Sept. 3, 2014)							



SOIL PROFILE AND TEST DATA

Supplemental Geotechnical Investigation
Riverside South - Phase 12, 708 River Road
Ottawa, Ontario

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

FILE NO. **PG3320**

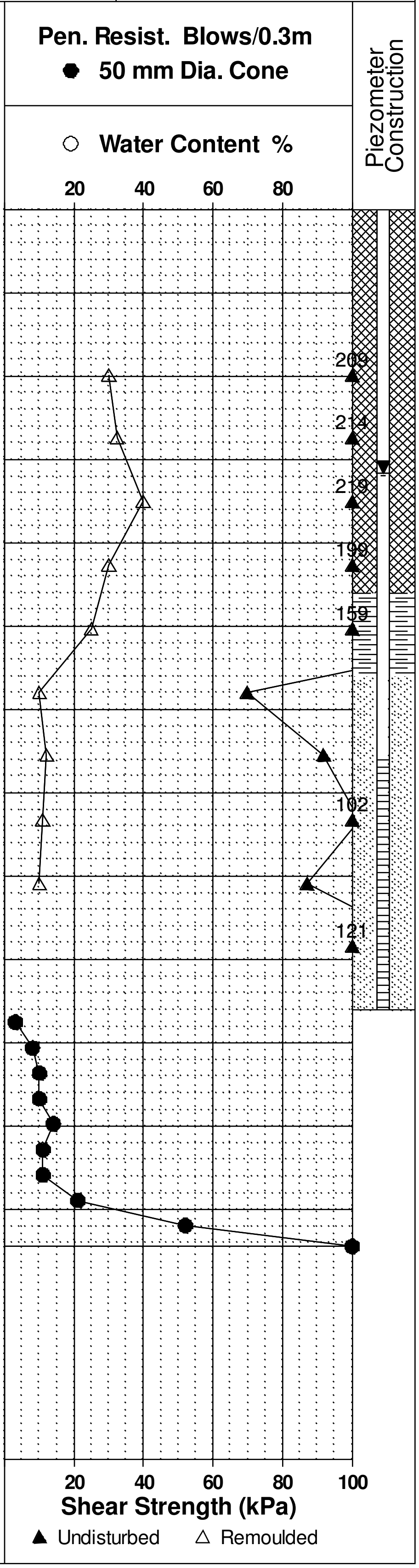
REMARKS

HOLE NO. **BH 2-14**

BORINGS BY CME 55 Power Auger

DATE August 28, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	85.43
TOPSOIL 0.23							
		SS	1	83	12	1	84.43
						2	83.43
Hard to very stiff, brown **SILTY CLAY**						3	82.43
						4	81.43
- stiff to very stiff by 5.2m depth						5	80.43
						6	79.43
						7	78.43
						8	77.43
8.99							
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders 9.60						9	76.43
Dynamic Cone Penetration Test commenced at 9.60m depth.						10	75.43
Inferred **GLACIAL TILL**						11	74.43
						12	73.43
12.44							
End of Borehole Practical DCPT refusal at 12.44m depth in glacial till. (GWL @ 3.16m-Sept. 3, 2014)							



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Supplemental Geotechnical Investigation
Riverside South - Phase 12, 708 River Road
Ottawa, Ontario

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

FILE NO. **PG3320**

REMARKS

HOLE NO. **BH 3-14**

BORINGS BY CME 55 Power Auger

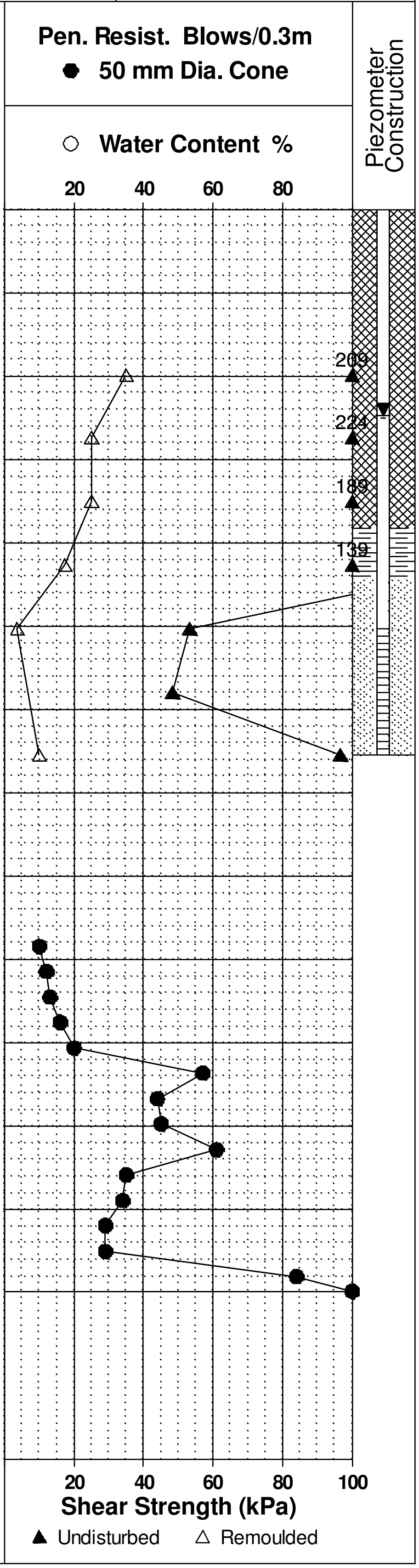
DATE August 28, 2014

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	88.11
TOPSOIL 0.20	AU	1				
	AU	2				
	SS	3	83	10	1	87.11
					2	86.11
Hard to very stiff, brown **SILTY CLAY**					3	85.11
					4	84.11
- stiff by 4.4m depth					5	83.11
6.55					6	82.11
Dynamic Cone Penetration Test commenced at 6.55m depth.					7	81.11
					8	80.11
					9	79.11
					10	78.11
					11	77.11
12.98					12	76.11

End of Borehole

Practical DCPT refusal at 12.98m depth in glacial till.

(GWL @ 2.47m-Sept. 3, 2014)



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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

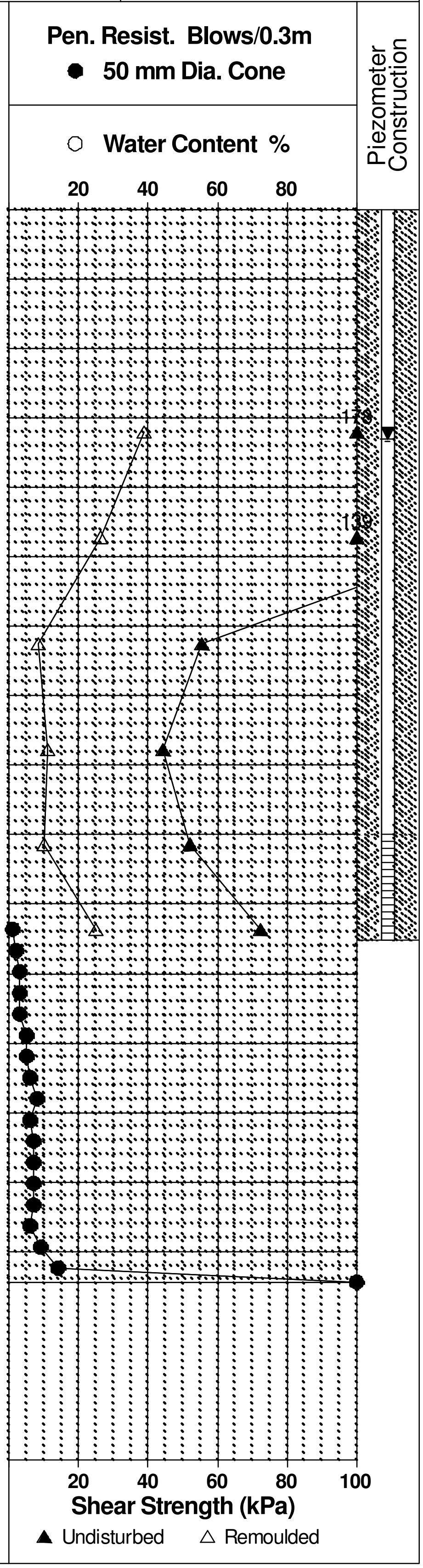
BORINGS BY CME 55 Power Auger

DATE 22 Jun 06

FILE NO. PG0831

HOLE NO. BH 1

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	86.73
TOPSOIL 0.23						
	SS	1	75	9	1	85.73
	SS	2	100	5	2	84.73
Very stiff, brown **SILTY CLAY**, trace sand to 2.9m depth	SS	3	100	6		
					3	83.73
	SS	4	100	7	4	82.73
- stiff and grey by 4.8m depth					5	81.73
	SS	5	100	2		
					6	80.73
- firm by 7.0m depth	TW	6	0		7	79.73
					8	78.73
	TW	7	44			
- stiff by 9.0m depth					9	77.73
					10	76.73
10.52						
Dynamic Cone Penetration Test commenced @ 10.52m depth					11	75.73
					12	74.73
Inferred **SILTY CLAY**					13	73.73
					14	72.73
15.00					15	71.73
Inferred **GLACIAL TILL** 15.44						
End of Borehole DCPT refusal @ 15.44m depth (GWL @ 3.30m-July 11/06)						



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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

FILE NO. **PG0831**

REMARKS

HOLE NO. **BH 2**

BORINGS BY CME 55 Power Auger

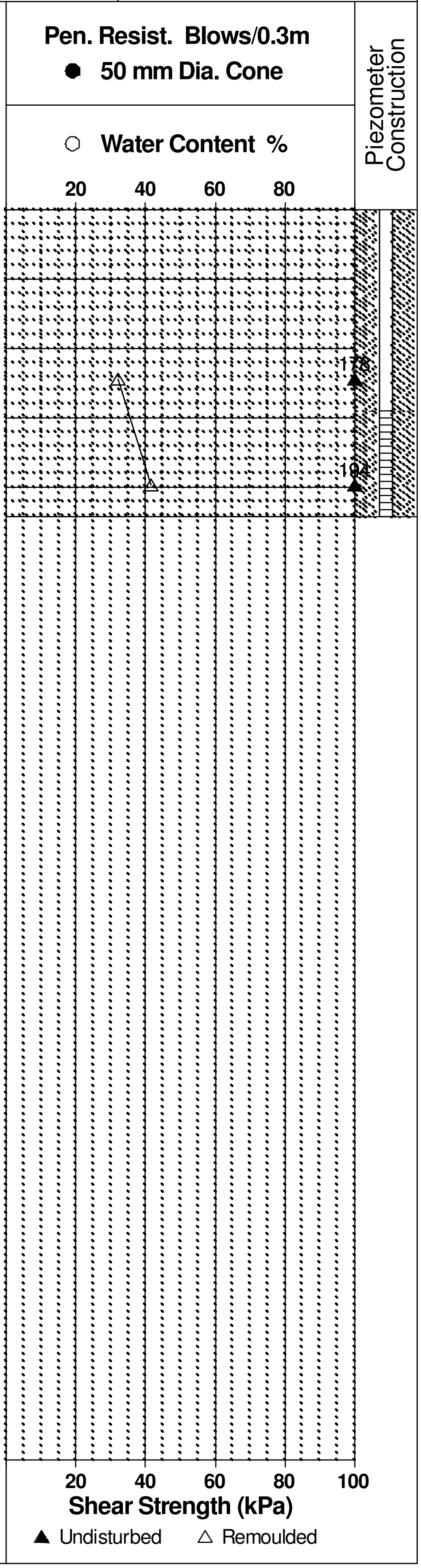
DATE 22 Jun 06

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	88.75
TOPSOIL 0.36		AU	1				
Grey-brown **SILTY SAND** 0.60		SS	2	100	11	1	87.75
Very stiff, brown **SILTY CLAY**, trace sand		SS	3	100	6	2	86.75
						3	85.75
		SS	4	100	5		
4.22						4	84.75
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders 4.42							

End of Borehole

Practical refusal to augering @ 4.42m depth

(BH dry-July 11/06)



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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY CME 55 Power Auger

DATE 22 Jun 06

FILE NO. PG0831

HOLE NO. BH 3

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	86.76
TOPSOIL 0.23						
Brown **SILTY** fine to medium **SAND** 0.60	AU	1				
Very stiff, brown **SILTY CLAY**	SS	2	75	6	1	85.76
	SS	3	100	6	2	84.76
2.34						
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders 2.46	SS	4		50+		
End of Borehole						

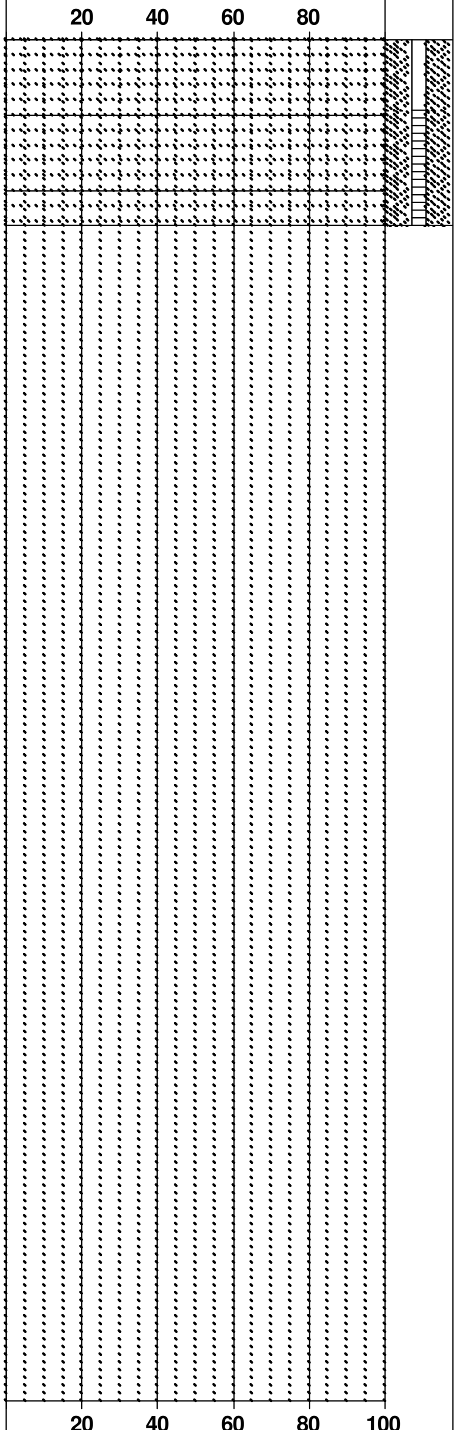
End of Borehole

Practical refusal to augering @ 2.46m depth

(BH dry-July 11/06)

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

○ Water Content %



Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY CME 55 Power Auger

DATE 22 Jun 06

FILE NO. PG0831

HOLE NO. BH 4

SOIL DESCRIPTION	Depth (m)
GROUND SURFACE	
TOPSOIL	0.25
Brown **SILTY SAND**, trace clay	0.46
Very stiff, brown **SILTY CLAY**, trace sand to 2.1m depth - stiff and grey by 8.0m depth	9.45
Dynamic Cone Penetration Test commenced @ 9.45m depth Inferred **SILTY CLAY**	11.00
Inferred **GLACIAL TILL**	13.03

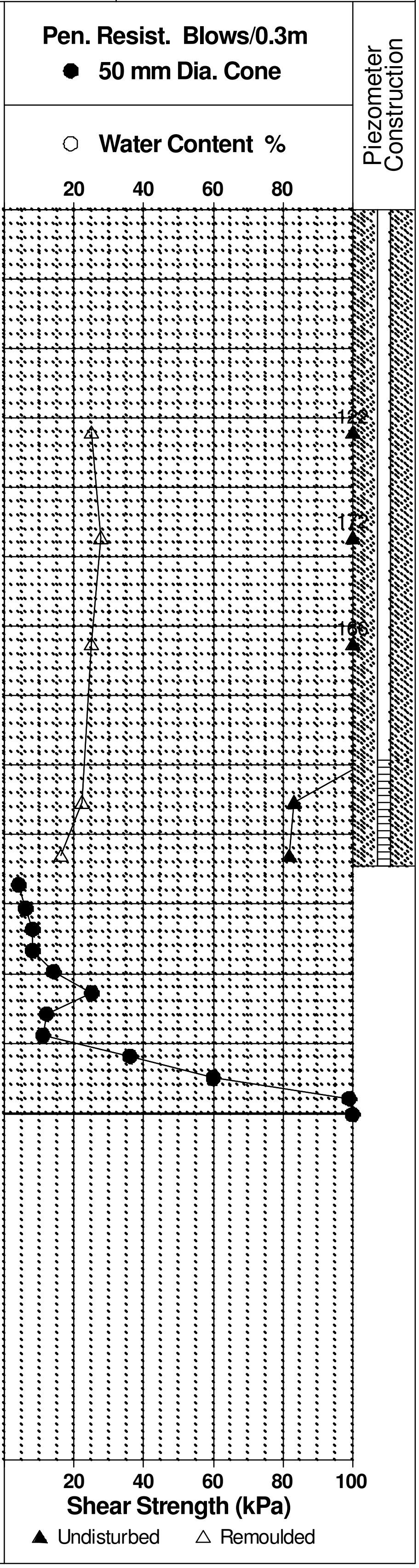
End of Borehole

DCPT refusal @ 13.03m depth

(BH dry-July 11/06)

SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD
SS	1	75	7
SS	2	100	5
SS	3	100	4
SS	4	100	5
SS	5	100	4
SS	6	50	4

DEPTH (m)	ELEV. (m)
0	86.86
1	85.86
2	84.86
3	83.86
4	82.86
5	81.86
6	80.86
7	79.86
8	78.86
9	77.86
10	76.86
11	75.86
12	74.86
13	73.86



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY CME 55 Power Auger

DATE 23 Jun 06

FILE NO. PG0831

HOLE NO. BH 5

SOIL DESCRIPTION

GROUND SURFACE

TOPSOIL 0.25

Loose, brown **SILTY** fine **SAND** 0.91

Very stiff to firm, brown **SILTY CLAY**

- sand seams between 3.3 and 7.6m depth

- firm and grey by 4.9m depth

- stiff to very stiff by 6.0m depth

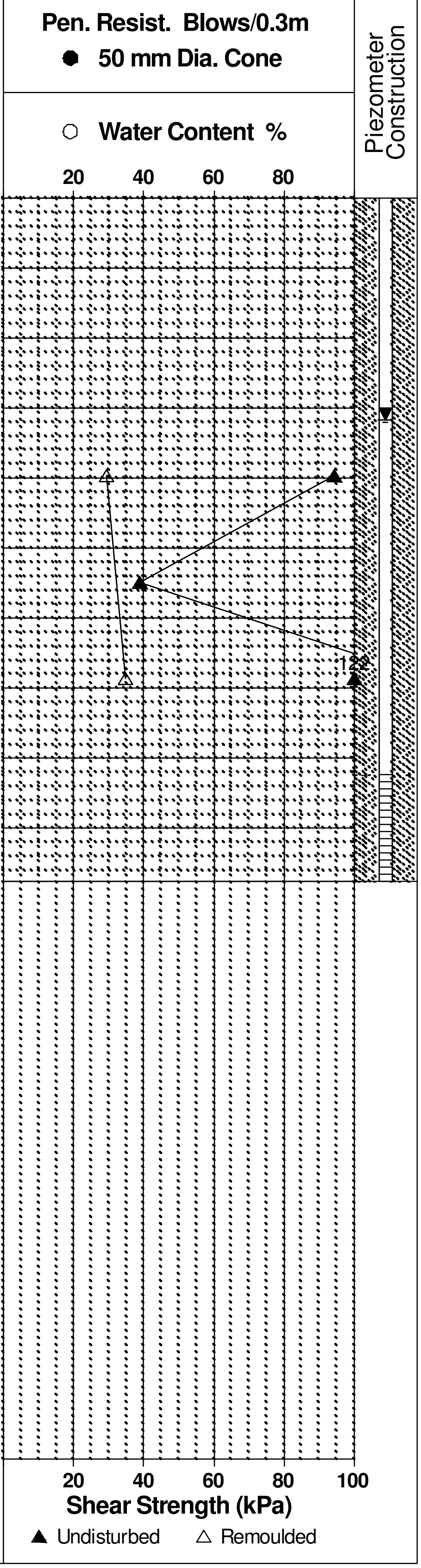
9.75

End of Borehole

(GWL @ 3.17m-July 11/06)

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
SS	1	75	5
SS	2	96	6
SS	3	100	6
SS	4	100	6
SS	5	100	2
TW	6	75	
SS	7	100	8
SS	8	100	5
SS	9	100	4

DEPTH (m)	ELEV. (m)
0	88.47
1	87.47
2	86.47
3	85.47
4	84.47
5	83.47
6	82.47
7	81.47
8	80.47
9	79.47



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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS Completed by BH 3.

BORINGS BY CME 55 Power Auger

DATE 22 Jun 06

FILE NO. PG0831

HOLE NO. PH 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			
TOPSOIL	0.23									
Brown **SILTY SAND**	0.56									
Very stiff, brown **SILTY CLAY**	2.29						1 2			
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders	2.46									
End of Probehole Practical refusal to augering @ 2.46m depth										

Water Content % axis: 20 40 60 80

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

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY Back Hoe

DATE 16 Jun 09

FILE NO. PG0831

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	80.34
TOPSOIL							
0.61							
Compact brown **SILTY SAND** with gravel		G	1			1	79.34
1.10							
GLACIAL TILL: Silty sand with gravel, cobbles, and boulders		G	2			2	78.34
2.40							
End of Test Pit (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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY Back Hoe

DATE 16 Jun 09

FILE NO. PG0831

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	79.84		
TOPSOIL 0.40									
Compact brown **SILTY SAND** with gravel 0.90		G	1						
GLACIAL TILL: Compact to dense silty sand, trace clay, with gravel, cobbles, and boulders.						1	78.84		
		G	2						
						2	77.84		
2.40		G	3						
End of Test Pit (TP dry upon completion)									

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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

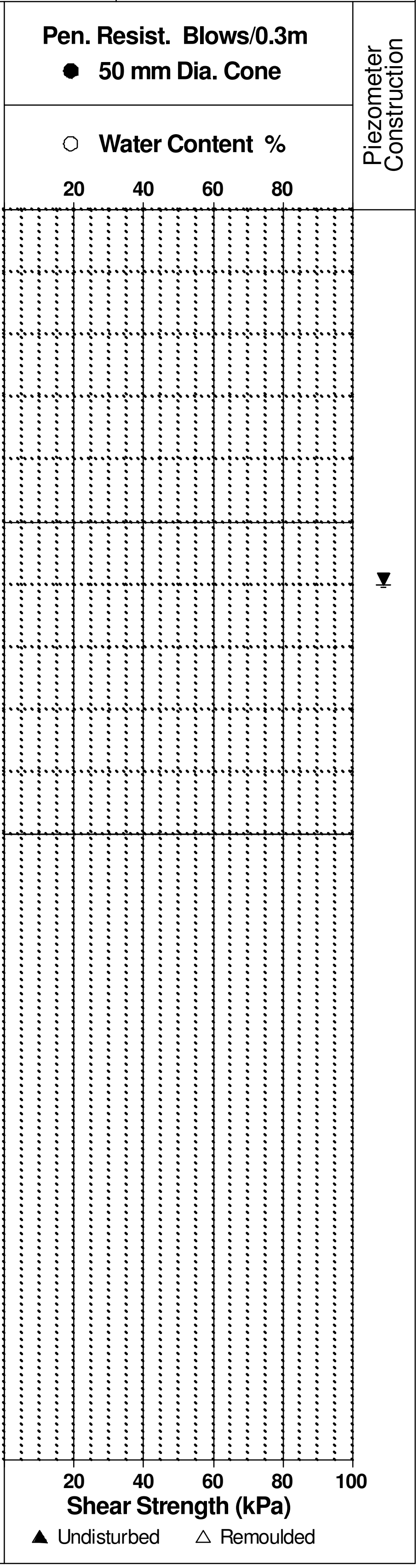
BORINGS BY Back Hoe

DATE 16 Jun 09

FILE NO. PG0831

HOLE NO. TP 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	79.33
TOPSOIL 0.40							
Compact **SILTY SAND** with clay 1.40		G	1			1	78.33
GLACIAL TILL: Compact to dense silty sand with gravel, cobbles, and boulders 2.00		G	2			2	77.33
End of Test Pit (Open hole GWL @ 1.2m depth)							



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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY Back Hoe

DATE 16 Jun 09

FILE NO. PG0831

HOLE NO. TP 4

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.40	G	1		
Compact **SILTY SAND**, clay	1.00	G	2		
GLACIAL TILL: Compact to dense grey silty clay with gravel, cobbles, and boulders.	2.00	G	3		
GLACIAL TILL: Compact to dense, grey sandy silt with gravel, cobbles and boulders	3.50	G	4		
End of Test Pit (Open hole GWL @ 1.0m depth)					

DEPTH (m)	ELEV. (m)
0	79.01
1	78.01
2	77.01
3	76.01

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

▼ (1.0 m)

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

SOIL PROFILE AND TEST DATA

**Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario**

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY Back Hoe

DATE 16 Jun 09

FILE NO. PG0831

HOLE NO. TP 5

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	79.38		
TOPSOIL 0.40									
Compact, brown **SILTY SAND** 1.10		G	1						
						1	78.38		
GLACIAL TILL: Compact to dense, grey silty sand with gravel and cobbles									
						2	77.38		▼
		G	2						
2.40		G	3						
End of Test Pit (Open hole GWL @ 2.0m 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

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY Back Hoe

DATE 16 Jun 09

FILE NO. PG0831

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 %	Piezometer Construction
GROUND SURFACE						0	79.72		
TOPSOIL 0.40									
Compact, brown **SILTY SAND** 0.90									
						1	78.72		
GLACIAL TILL: Compact to dense, grey silty sand with gravel, cobbles and boulders.									
						2	77.72		
- grey sandy silt noted at 2.3m depth 2.50									
End of Test Pit (TP dry upon completion)									

20 40 60 80

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

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

REMARKS

BORINGS BY Back Hoe

DATE 16 Jun 09

FILE NO. PG0831

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 % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						0	79.62		
TOPSOIL 0.30	■								
		G	1						
Compact to dense brown **SILTY SAND** 0.90									
						1	78.62		
GLACIAL TILL: Compact to dense, grey silty sand with gravel, cobbles, and boulders									
		G	2						
2.15						2	77.62		
End of Test Pit (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

Geotechnical Investigation
Proposed Residential Development, River Road
Ottawa, Ontario

DATUM Geodetic, as provided by Annis O'Sullivan Vollebekk

FILE NO. PG0831

REMARKS

HOLE NO. TP 8

BORINGS BY Back Hoe **DATE** 16 Jun 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	79.74		
TOPSOIL 0.40									
Compact brown **SILTY SAND** some clay 1.50						1	78.74		▼
GLACIAL TILL: Compact to dense, grey sandy silt with clay, gravel, cobbles and boulders 2.50		G	1			2	77.74		
		G	1						
End of Test Pit (Open hole GWL @ 1.5m 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

Slope Stability Analysis
Fish Habitat Compensation Plan-River Road
Ottawa, Ontario

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

REMARKS

BORINGS BY Hydraulic Shovel

DATE 28 Jan 10

FILE NO. PG2012

HOLE NO. TP 9

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	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	77.89		
						1	76.89		
Stiff, grey **SILTY CLAY**	▨	G	1						
		G	2			2	75.89		
2.67									
End of Test Pit (TP dry upon completion)									

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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

SOIL PROFILE AND TEST DATA

Slope Stability Analysis
Fish Habitat Compensation Plan-River Road
Ottawa, Ontario

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

REMARKS

BORINGS BY Hydraulic Shovel

DATE 28 Jan 10

FILE NO. PG2012

HOLE NO. TP10

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	83.46		
	▨	G	1						
Very stiff, brown **SILTY CLAY** - grey-brown by 1.1m depth	▨					1	82.46		
	▨	G	2						
	▨					2	81.46		
	▨	G	3						
	▨					3	80.46		∇
3.58									
End of Test Pit (GWL @ 3.1m depth based on field observations)									

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

Slope Stability Analysis
Fish Habitat Compensation Plan-River Road
Ottawa, Ontario

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

FILE NO. **PG2012**

REMARKS

HOLE NO. **TP11**

BORINGS BY Hydraulic Shovel

DATE 28 Jan 10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	78.16
Stiff, brown **SILTY CLAY** - grey by 1.1m depth	▨	G	1				
	▨	G	2			1	77.16
	▨	G	3			2	76.16
3.07	▨					3	75.16
End of Test Pit (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

patersongroup **Consulting Engineers**

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

SOIL PROFILE AND TEST DATA

Slope Stability Analysis
Fish Habitat Compensation Plan-River Road
Ottawa, Ontario

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

FILE NO. **PG2012**

REMARKS

HOLE NO. **TP12**

BORINGS BY Hydraulic Shovel

DATE 28 Jan 10

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	83.35		
Stiff to very stiff, brown **SILTY CLAY** - grey by 1.2m depth	▨	G	1						
	▨					1	82.35		
	▨	G	2						
	▨					2	81.35		
	▨	G	3						
	▨	G	4						
	▨					3	80.35		
3.50									
End of Test Pit (TP dry upon completion)									

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

SOIL PROFILE AND TEST DATA

Slope Stability Analysis
Fish Habitat Compensation Plan-River Road
Ottawa, Ontario

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

REMARKS

BORINGS BY Hydraulic Shovel

DATE 28 Jan 10

FILE NO. PG2012

HOLE NO. TP13

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	79.00
Stiff to very stiff, brown **SILTY CLAY** - grey-brown by 1.0m depth	▨	G	1				
		G	2			1	78.00
		G	3				
		G	4			2	77.00
2.95							
End of Test Pit (GWL @ 2.5m depth based on field observations)							

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

▽

patersongroup Consulting Engineers

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

SOIL PROFILE AND TEST DATA

Slope Stability Analysis
Fish Habitat Compensation Plan-River Road
Ottawa, Ontario

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

FILE NO. **PG2012**

REMARKS

HOLE NO. **TP14**

BORINGS BY Hydraulic Shovel

DATE 28 Jan 10

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	80.54		
Stiff to very stiff, brown **SILTY CLAY** - grey-brown by 1.1m depth	▨	G	1						
	▨	G	2						
	▨					1	79.54		
	▨	G	3						
	▨					2	78.54		
	▨	G	4						
	▨								∇
3.00						3	77.54		
End of Test Pit (GWL @ 2.6m depth based on field observations)									

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

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)

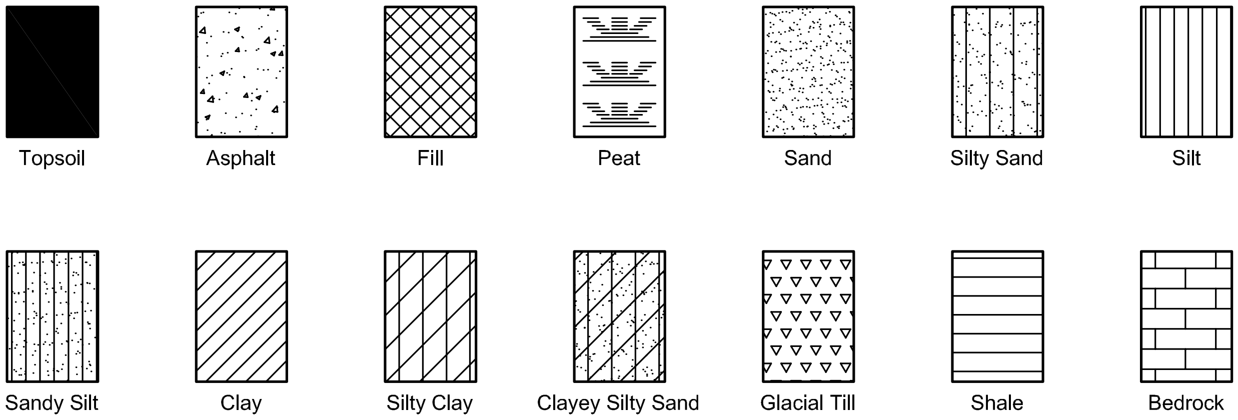
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

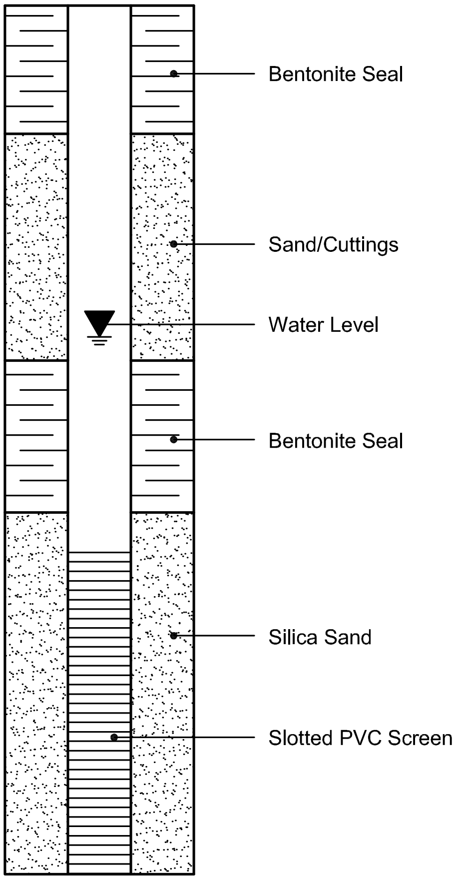
SYMBOLS AND TERMS (continued)

STRATA PLOT

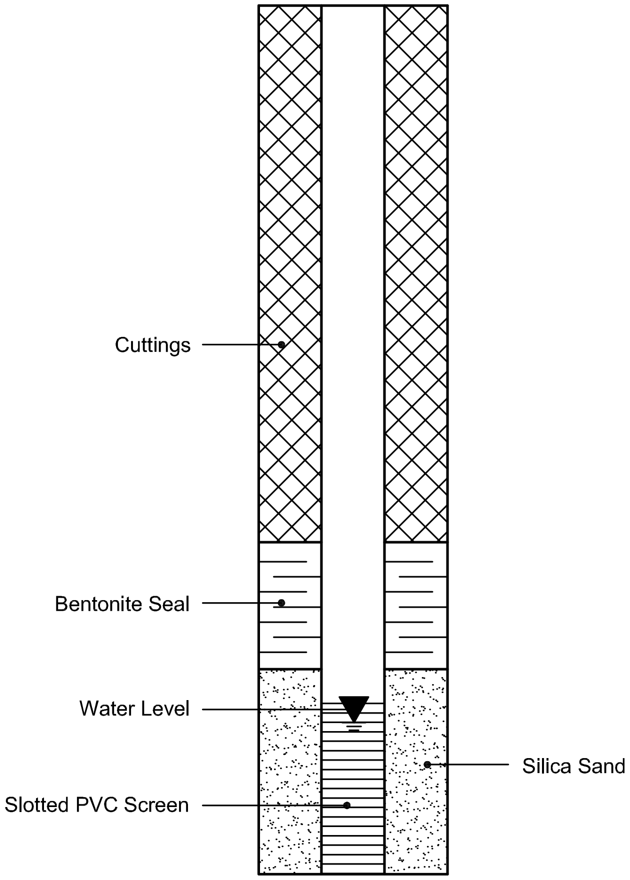


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Report Date: 09-Sep-2014
Order Date:3-Sep-2014

Client: **Paterson Group Consulting Engineers**
Client PO: 16412
Project Description: PG3320

	Client ID:	BH1 SS3	-	-	-
	Sample Date:	28-Aug-14	-	-	-
	Sample ID:	1436086-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	76.9	-	-	-
General Inorganics					
pH	0.05 pH Units	7.59	-	-	-
Resistivity	0.10 Ohm.m	41.3	-	-	-
Anions					
Chloride	5 ug/g dry	<5	-	-	-
Sulphate	5 ug/g dry	101	-	-	-

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NIAGARA
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KINGSTON
1058 Gardiners Rd.
Kingston, ON K7P 1R7

Page 3 of 7

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURES 2 to 5 - SECTIONS FOR SLOPE STABILITY ANALYSIS

DRAWING PG3320-2 - TEST HOLE LOCATION PLAN

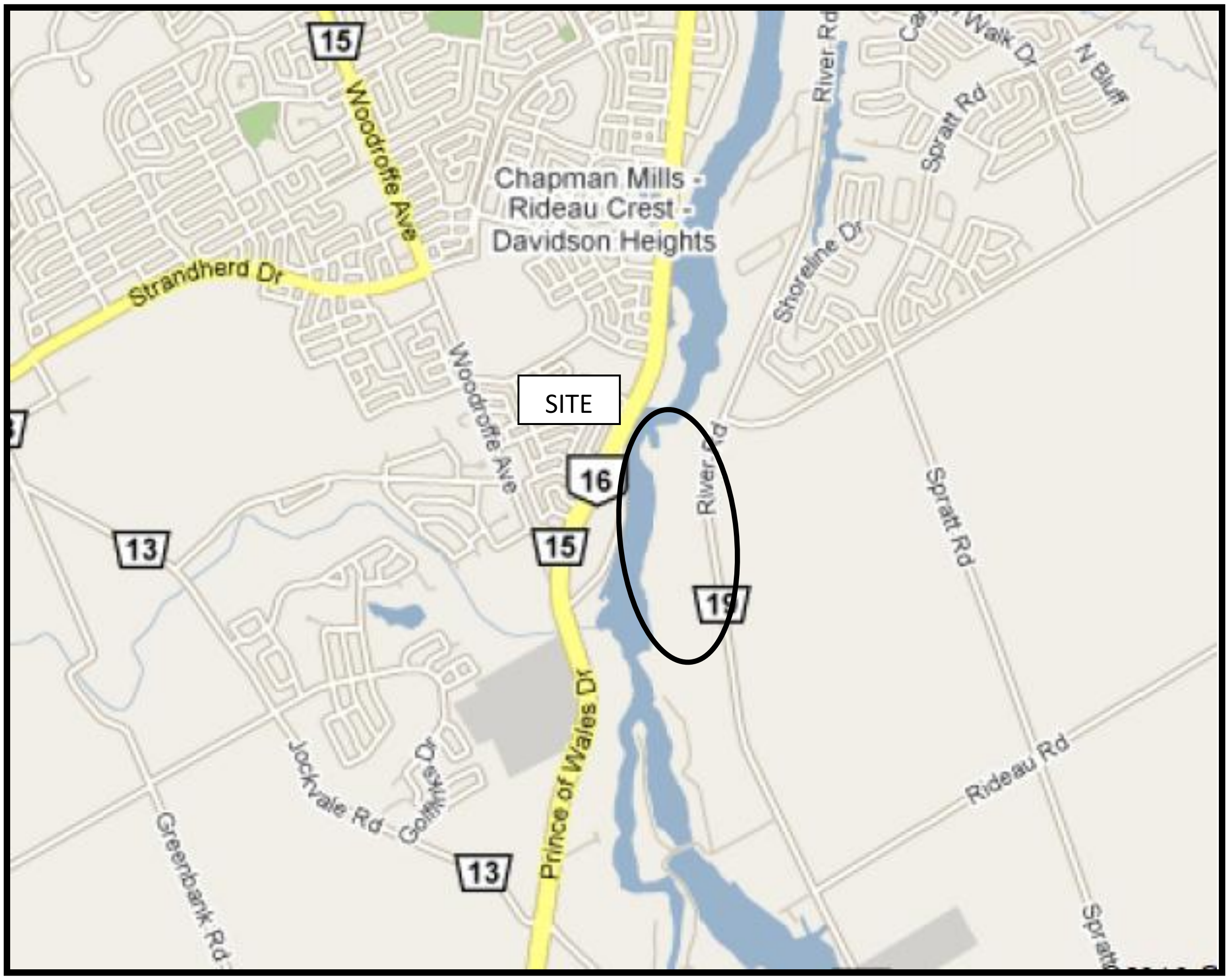

FIGURE 1

KEY PLAN

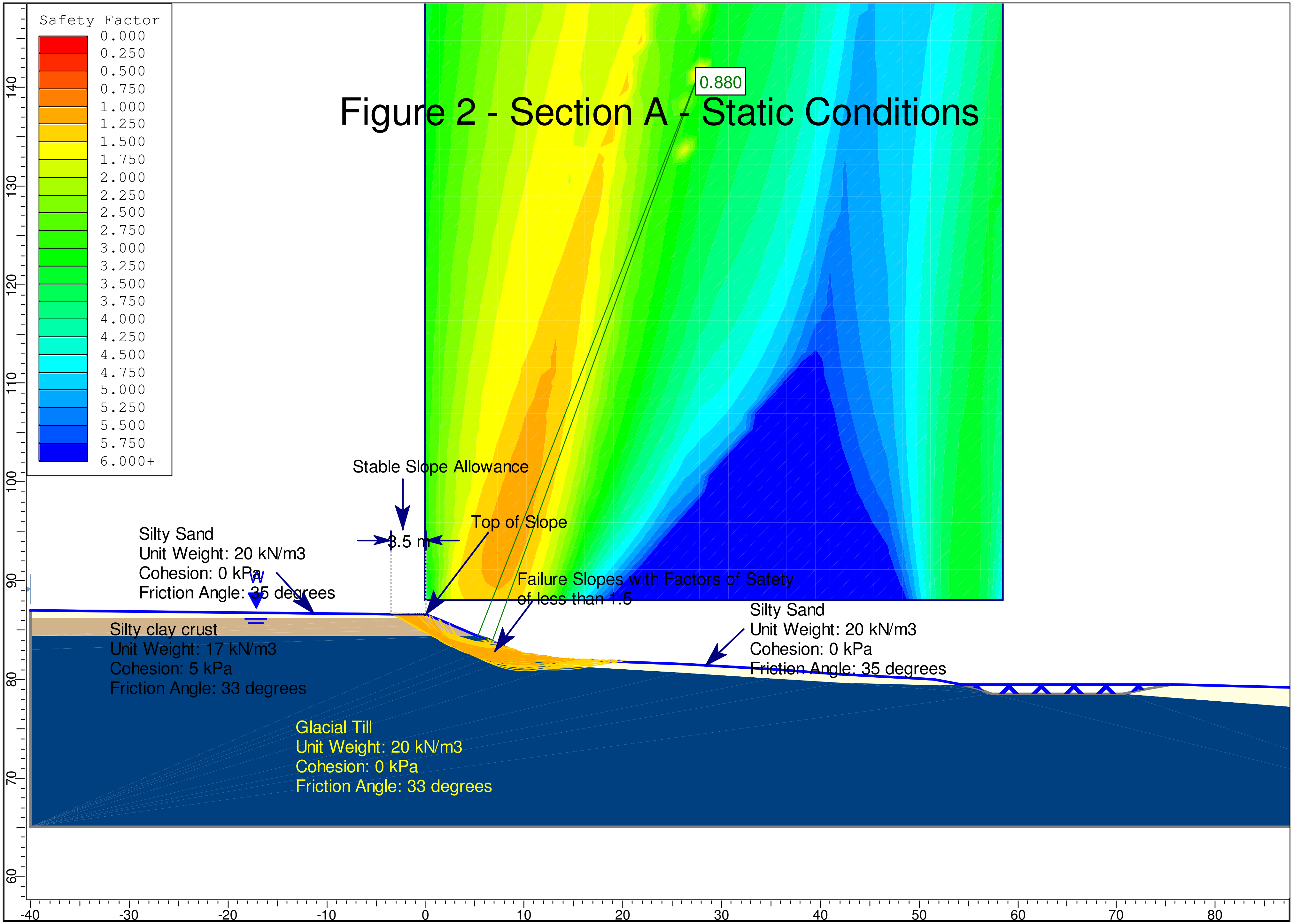

Figure 2 - Section A - Static Conditions

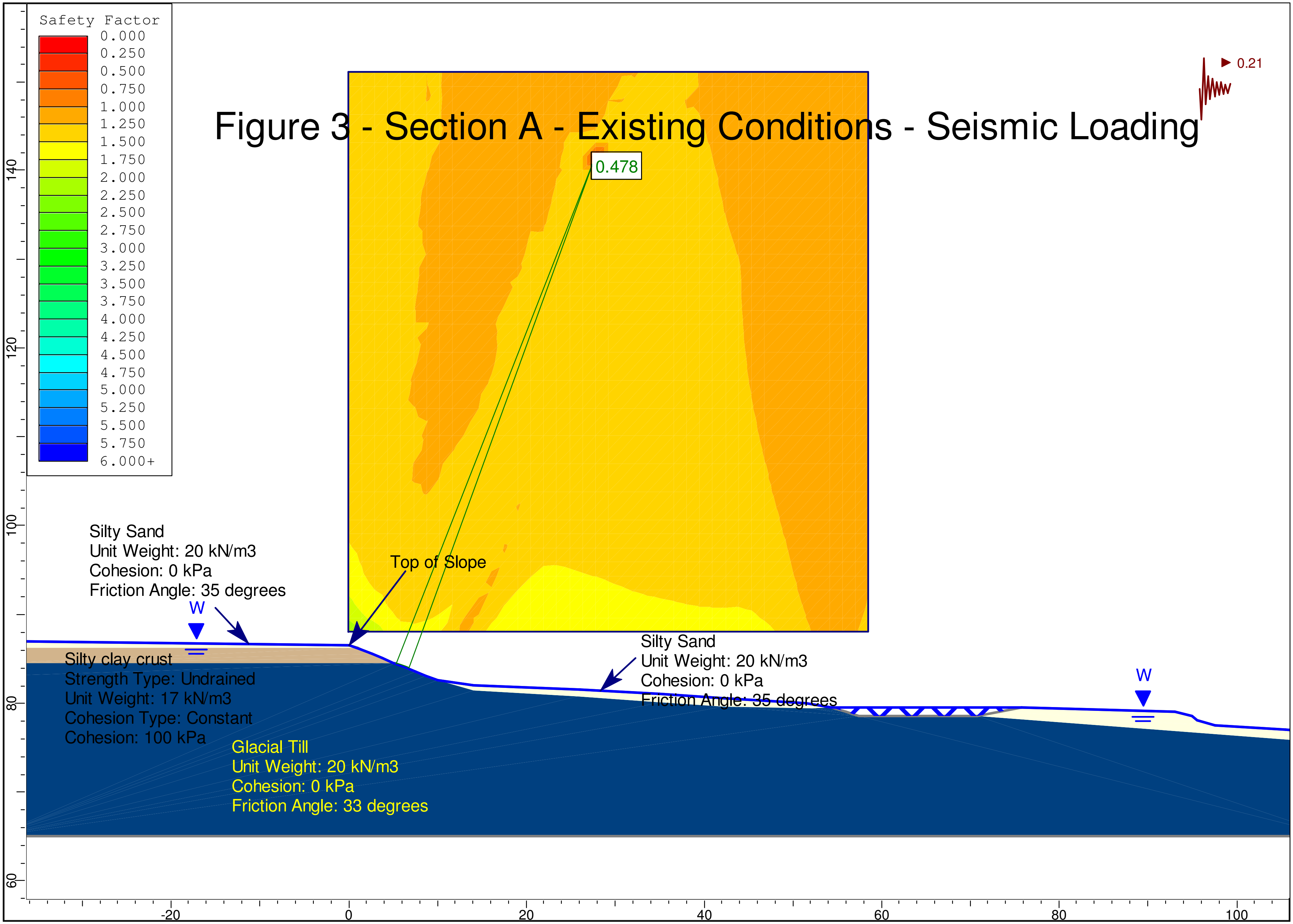

Figure 3 - Section A - Existing Conditions - Seismic Loading

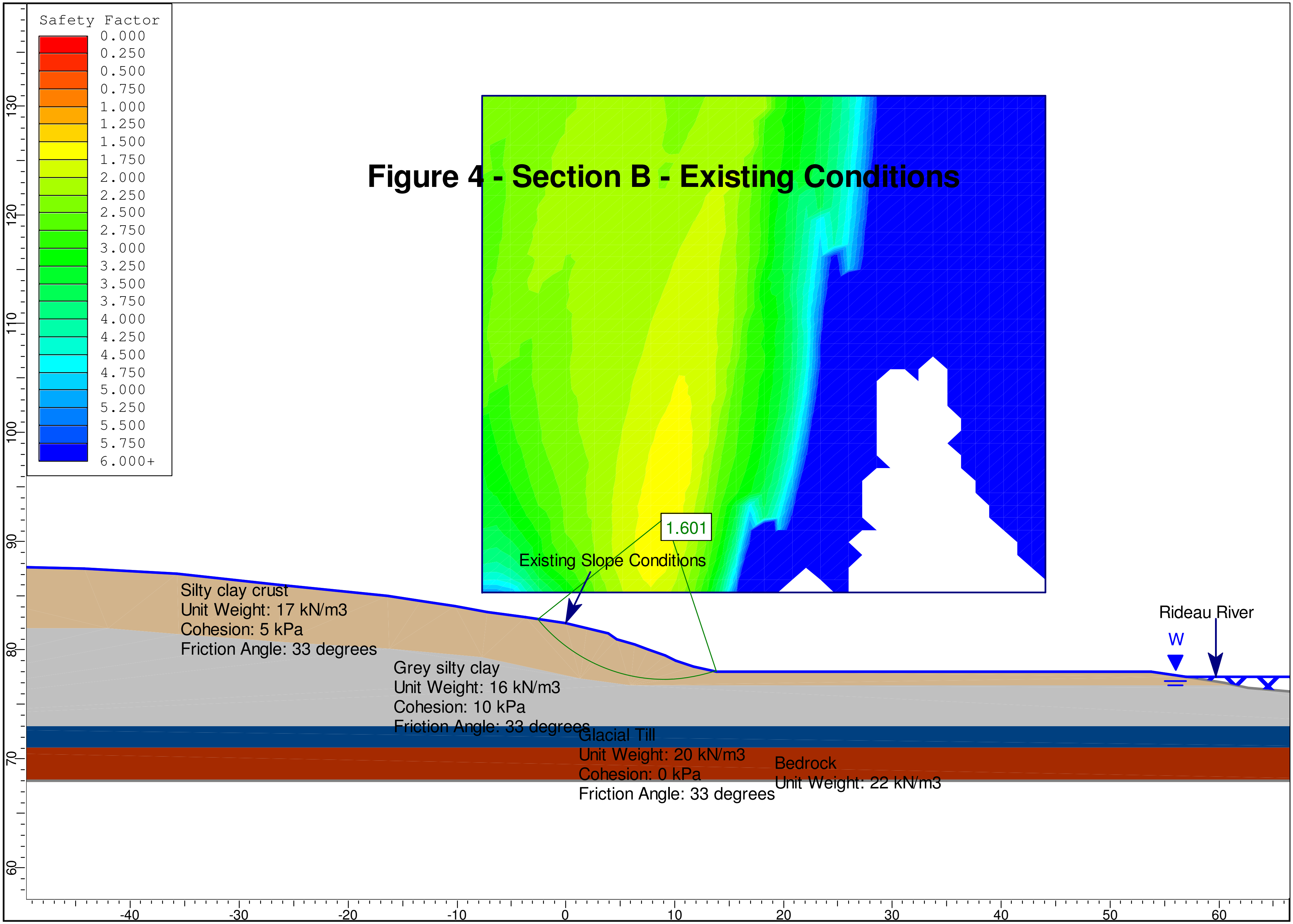

Figure 4 - Section B - Existing Conditions

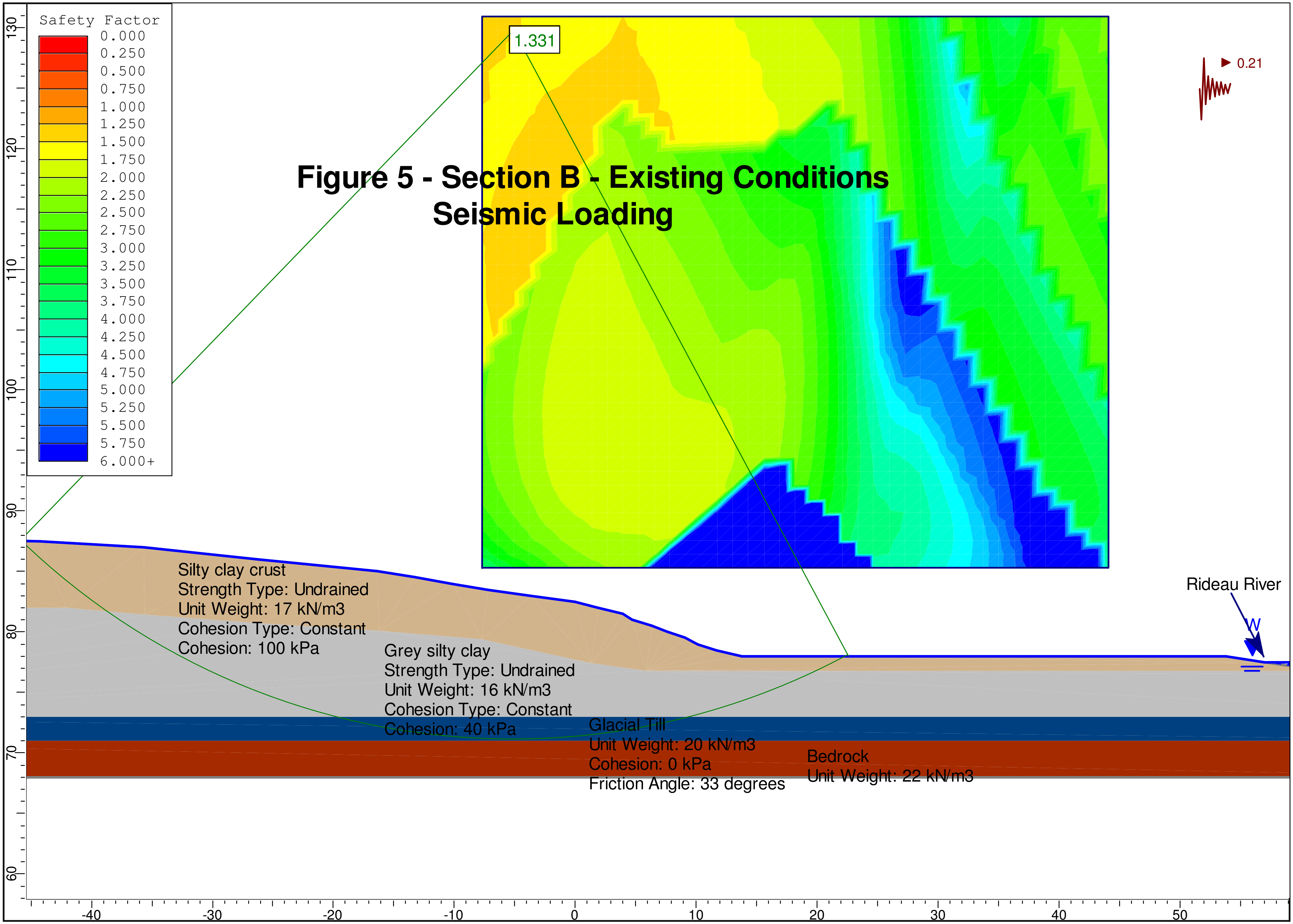

Figure 5 - Section B - Existing Conditions
Seismic Loading

NO.	REVISIONS	DATE	INITIAL

patersongroup
consulting engineers
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SCALE: 1:1000
DESIGN: DG
DRAWN: MPG
CHECKED: DG
DATE: 10/2015

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
RIVERSIDE SOUTH, PHASE 12
OTTAWA, ONTARIO

DWG. NO. PG3320–2

URBANDALE CORPORATION

TEST HOLE LOCATION PLAN

A1