Geotechnical Investigation

Proposed Apartment Buildings
Block 9 Eric Czapnik Way
Orleans, Ontario

Prepared for:

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TABLE OF CONTENTS

LIST OF TABLES

APPENDICES

Appendix A	**Site and Borehole Location Plans**
Appendix B	**Borehole Logs**
Appendix C	**Symbols and Terms Used in Borehole Logs**
Appendix D	**Laboratory Results**
Appendix E	**Slope Stability Analysis Results**

1 INTRODUCTION

LRL Associates Ltd. (LRL) was retained by Landric Homes Inc. to perform a geotechnical investigation for two (2) proposed four (4) storey apartment buildings, to be located within Block 9 Eric Czapnik Way, Orleans (Ottawa), Ontario.

The purpose of the investigation was to identify the subsurface conditions across the site by the completion of a borehole drilling program. Based on the visual and factual information obtained, this report will provide guidelines on the geotechnical engineering aspects of the design of the project, including construction considerations.

This report has been prepared in consideration of the terms and conditions noted above. Should there be any changes in the design features, which may relate to the geotechnical recommendations provided in the report, LRL should be advised in order to review the report recommendations.

2 SITE AND PROJECT DESCRIPTION

The site under investigation can be described as Block 9, located along Eric Czapnik Way, in Orleans Ontario. At the time of the investigation, there was a large pile of fill material that had been stockpiled on site. The site was vacant, with no structures present. The site is vegetated with wild grasses, some mature trees and shrubbery. The total surface area of the site is about 5,100 m^2 (1.3 acres). A slope is located at the southern portion of the site, that slopes downwards in the south to north direction. Currently the site is accessible by Eric Czapnik Way or Recolte Private. The location is presented in Figure 1 included in **Appendix A**.

This development will consist of two (2) apartment buildings, consisting of four (4) storeys, and having a building area of about 900 m^2. The apartment buildings will have a basement level that will consist of underground ground parking. A one (1) storey common amenity area is proposed between the two apartment buildings. To the south of the buildings, asphaltic parking areas and access roads will be constructed consisting of light and heavy duty pavement structures. A retaining wall is also proposed as part of the development, and will be constructed at the north and south property lines. The apartment buildings will be serviced with municipal services.

3 PROCEDURE

The fieldwork for this investigation was carried out on June 30, July 2, and July 3, 2020. The site was cleared for the presence of any underground services and utilities. Prior to the fieldwork, an excavator created a path for the drill machine to access the site and advance the boreholes. A total of six (6) boreholes were drilled onsite where possible to do so, and labelled BH1 through BH6. The approximate locations of the boreholes are shown in Figure 2 included in **Appendix A**.

The boreholes were advanced using a track mounted CME 75 drill rig equipped with 200 mm diameter continuous flight hollow stem auger supplied and operated by CCC Geotechnical and Environmental Drilling Ltd. A “two man” crew experienced with geotechnical drilling operated the drill rig and equipment.

Sampling of the overburden materials encountered in the boreholes was carried out at regular depth intervals using a 50.8 mm diameter drive open conventional spoon sampler in conjunction with standard penetration testing (SPT) "N" values. The SPTs were conducted following the method **ASTM D1586** and the results of SPT, in terms of the number of blows per 0.3 m of split-spoon sampler penetration after first 0.15 m designated as the "N" value.

All boreholes were advanced until practical auger refusal over inferred bedrock or large boulders, three (3) of the boreholes consisted of NQ-size (Ø47.6mm) rock coring. The boreholes were terminated at depths ranging from 0.3 to 7.6 m below ground surface (bgs). Upon completion, the boreholes were backfilled and compacted using a combination of bentonite, and overburden cuttings.

The fieldwork was supervised throughout by a member of our engineering staff who oversaw the drilling activities, cared for the samples obtained and logged the subsurface conditions encountered within each of the boreholes. All soil samples were transported back to our office for further evaluation. The recovered soil samples collected from the boreholes were classified based on visual examination of the materials recovered and the results of the in-situ testing.

Furthermore, all boreholes were located using a Garmin Etrex Legend GPS (Global Positioning System) receiver using NAD 83 datum (North American Datum). LRL's field personnel determined the existing grade elevations at the borehole locations through a topographic survey carried out using the site bench mark (Fire Hydrant – top of flange bolt (66.17 m)). Ground surface elevations of the boring locations are shown on their respective borehole logs.

4 SUBSURFACE SOIL AND GROUNDWATER CONDITIONS

4.1 General

A review of local surficial geology maps provided by the Department of Energy, Mines and Resources Canada suggest that the surficial geology for this area is Abandoned River Channel Deposits, consisting of silt and silty clay, generally underlain at variable depths by blue-grey clay. The maps indicate the bedrock is called the Ottawa Formation, consisting of limestone with shaly partings.

The subsurface conditions encountered in the boreholes were classified based on visual and tactile examination of the materials recovered from the boreholes. The soil descriptions presented in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil were conducted according to the procedure **ASTM D2487** and judgement, and LRL does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The subsurface soil conditions encountered are given in their respective borehole logs presented in **Appendix B**. A greater explanation of the information presented in the borehole logs can be found in **Appendix C** of this report. These logs indicate the subsurface conditions encountered at a specific test location only. Boundaries between zones on the logs are often not distinct, but are rather transitional and have been interpreted as such.

4.2 Fill

At the surface of all boring locations, a deposit of fill material was encountered, and extended to depths ranging between 0.30 and 5.26 m bgs. At the surface of BH1, BH2, and BH3, the fill can generally be described as sand and crushed stone, moist, and grey in colour. Standard Penetration Tests (SPT) were carried out in this layer and the SPT "N" value was found to be 10, indicating the material is loose. At the surface of BH4, BH5, and BH6, and underlying the sand and crushed stone fill in BH1, BH2, and BH3, the fill material can generally be described as silty clay, trace to some sand, moist, and brownish grey. The SPT "N" values were found ranging between 4 and 50+. However, the "N" values of 50+ indicate the presence of boulders or cobbles, and does not demonstrate the consistency of the material and are considered outliers. Thus, the fill material can be considered to be soft to stiff. The natural moisture contents were found to range between 10 and 42%.

Two (2) soil samples were submitted for laboratory gradation analyses. The gradation analyses comprised of a sieve and hydrometer were conducted following the procedure **ASTM D422.** Details of laboratory analysis are reflected in **Table 1.**

Table 1: Gradation Analysis Summary

Sample Location	Depth (m)	Percent for Each Soil Gradation						
		Gravel		Sand			Fines	
		Coarse (%)	Fine (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)
BH1	4.6 – 5.2	0.0	0.0	0.0	0.3	6.3	27.9	65.5
BH4	0.8 – 1.4	0.0	0.0	0.5	1.3	4.4	31.8	62.0

4.3 Silty Clay

Underlying the fill material in BH1, a deposit of silty clay was encountered, and extended to a depth of 7.57 m bgs (after practical auger refusal). The material can be described as having trace sand, moist, and grey in colour. The "N" values were found to be 13 and 16, indicating the deposit is stiff to very stiff. The natural moisture content was determined to be 36 and 38%.

Atterberg limits and moisture contents were conducted on the soil sample collected between depths 5.33 and 5.93 m in BH1. Based on the test result, the sample yielded a plastic limit of 29% and corresponding liquid limit of 73%. These values indicate that the subsoil contains inorganic clays of high plasticity. A summary of these values are provided below in **Table 2**.

Table 2: Summary of Atterberg Limits and Water Contents

Sample Location	Parameter					
	Depth (m)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Water Content (%)	USCS Group Symbol
BH1	5.33 – 5.93	73	29	44	38	CH

4.4 Topsoil

Underlying the fill in BH2, a 250 mm thick layer of topsoil was encountered. It can be described as clayey, and mixed with black organics.

4.5 Bedrock/Refusal

Practical auger refusal was encountered in all boring locations at depths ranging between 0.30 and 7.57 m bgs. Upon encountering refusal, NQ rock coring was carried out to confirm the presence of bedrock in BH3, BH4, and BH5. The bedrock formation in this area can be described as consisting of limestone, with shaly partings, and grey to dark grey in colour.

The Rock Quality Designation (RQD) was determined after the rock was cored, this is done by summing the lengths of the intact recovered cores which are greater than 100 mm in length and dividing by the total length of the core run. The RQD values, expressed as a percent, ranged from 47 to 93%, indicating the rock was poor to excellent quality, with the majority of the values being in the good quality range.

Four (4) rock core samples were selected to determine the unconfined compressive strengths at various depths. The results are summarized below in **Table 3.**

Table 3: Unconfined Compressive Strength of Select Rock Cores

Sample		Bedrock Type	Strength (MPa)
Borehole	Depth (m)		
BH3	3.90 – 4.10	Limestone	137.5
BH4	5.90 – 6.10	Limestone	120.0
BH5	1.65 – 1.90	Limestone	102.6

The laboratory analysis reports can be found in **Appendix D** of this report.

4.6 Groundwater Conditions

Groundwater conditions were carefully monitored during the field investigation. During drilling within the overburden material no water was encountered. BH1 was left open for six (6) hours after completion of drilling, the water level was measured and found to be dry. It is believed the groundwater table is found at deeper depths, within the bedrock.

It should be noted that groundwater levels could fluctuate with seasonal weather conditions, (i.e.: rainfall, droughts, spring thawing) and due to construction activities at or near the vicinity of the site.

5 GEOTECHNICAL CONSIDERATIONS

This section of the report provides general geotechnical recommendations for the design aspect of the proposed development based on our interpretation of the information gathered from the borehole data performed at this site and from the project requirements.

5.1 Foundations

Based on the subsurface soil conditions established at this site, it is recommended that the footings for the proposed apartment buildings be founded on a structural fill pad (consisting of OPSS Granular B Type II) having a minimum thickness of 300 mm, overlying bedrock at boring locations BH2 through BH6 and overlying the silty clay at boring location

BH1. Therefore, all of the bedrock and fill material shall be excavated from the proposed buildings' footprint in order to properly install a structural fill pad that has a minimum thickness of 300 mm.

5.2 Shallow Foundation on Structural Fill

Conventional strip and column footings set over properly compacted and approved structural fill conforming to OPSS Granular B Type II may be designed for a maximum allowable bearing pressure of **150** kPa for Serviceability Limit State (SLS) and **225** kPa for Ultimate Limit State (ULS) factored bearing resistance. The factored ULS value includes the geotechnical resistance factor of 0.5. The structural fill shall be compacted to a minimum of 98% of its Standard Proctor Maximum Dry Density (SPMDD), and not exceed lift thicknesses of 300 mm during placement. For footings founded on properly prepared and compacted structural fill, there are no restrictions for maximum footing sizes and grade raise fill thickness.

Prior to placing the approved structural fill, the subgrade (which will consist of a combination of bedrock and silty clay) shall be inspected and assessed by a geotechnical engineer, or a representative to identify any localised incompetent/unstable areas of the subgrade. Any incompetent subgrade areas as identified must be sub-excavated and backfilled with approved structural fil. Furthermore, during excavation of the fill material in the vicinity of BH1, it is recommended to have geotechnical personnel monitor the excavation to ensure all the fill material has been removed, and the competent silty clay material has been reached.

In order to allow the spread of load beneath the footings and to prevent undermining during construction, the structural fill should extend minimum 0.75 m beyond the outside edges of the footings and then outward and downward at 1 horizontal to 1 vertical profile (or flatter) over a distance equal to the depth of the structural fill below the footing.

To limit the risk of any differential settlement of the footings, the entirety of the footings shall be founded on structural fill.

5.3 Bedrock Excavation

It is expected that some bedrock excavation will be required. It is anticipated that bedrock removal will be possible with the use of heavy excavation equipment, but that removal of most of the bedrock could be facilitated by means of a hoe ramming operation. Both horizontal and vertical overbreak of the bedrock excavation face/bottom can be expected due to the hoe ramming operation. If control of potential bedrock overbreak is required, line drilling at the proposed excavation face is recommended. The smaller the distance between the drill holes, the fewer overbreaks is expected. It is generally considered that the drilling at 150 mm horizontal spacing to the full depth of the excavation should control overbreak to an acceptable level. Considering the proximity of the existing structures adjacent to the site and the potential for vibration during excavating and removal of the bedrock, monitoring of the hoe ramming shall be carried out throughout the operation on nearby buildings to ensure that the vibration limit is not exceeded. As outlined in **OPSS 120, Table 4** below summarizes the following vibration limits for the nearest existing structures.

In addition, a pre and post construction excavation condition survey of nearby structures is required to be carried out.

Table 4: Vibration Frequency and Limit

Frequency of Vibration (HZ)	**Vibration Limit, PPV (Peak Particle Velocity) mm/sec**
≤ 40	20
> 40	50

5.4 Lateral Earth Pressure

The following equation should be used to estimate the intensity of the lateral earth pressure against any earth retaining structure/foundation walls.

$$P = K (\gamma h + q)$$

Where;

P = Earth pressure at depth h;

K = Appropriate coefficient of earth pressure;

γ = Unit weight of compacted backfill, adjacent to the wall;

h = Depth (below adjacent to the highest grade) at which P is calculated;

q = Intensity of any surcharge distributed uniformly over the backfill surface (usually surcharge from traffic, equipment or soil stockpiled and typically considered 10 kPa).

The coefficient of earth pressure at rest (K_0) should be used in the calculation of the earth pressure on the storm water manhole/basement walls, which are expected to be rather rigid and not to deflect.

The above expression assumes that perimeter drainage system prevents the build-up of any hydrostatic pressure behind the foundation wall.

5.5 Retaining Walls and Shoring

The following **Table 5** below provides the suggested soil parameters for the design of retaining walls and/or shoring systems. For excavations near existing services and structures, the coefficient of earth pressure at rest (K_o) should be used.

Table 5: Materials Properties for Shoring and Permanent Wall Design (Static)

Types of Material	Bulk Density (kg/m^3)	Friction angle (degree)	Pressure Coefficient			Combined static and seismic active earth pressure coefficient (K_{AE})
			At Rest (K_O)	Active (K_A)	Passive (K_P)	
Silty Clay	18.0	28	0.48	0.36	2.76	0.48
Granular B Type I	20.0	31	0.49	0.32	3.12	0.44
Granular B Type II	23.0	32	0.47	0.31	3.25	0.43
Granular A	23.0	35	0.43	0.27	3.69	0.39

The above values are for a flat surface behind the wall, a straight wall and a wall friction angle of 0 degree. The designer should consider any difference between these coefficients and make appropriate corrections for a sloped surface behind the wall, angled wall or wall friction as required. The bearing capacity for the design of a retaining wall are the same as provided for the building structure provided it is founded over the same soil stratum.

Retaining walls should also be designed to resist the earth pressures produces under seismic conditions. The Canadian Building Code recommends the use of combined coefficients of static and seismic earth pressure, referred to as K_{AE} for active conditions and K_{PE} for passive conditions, for routine design purposes.

The total active and passive loads under seismic conditions can be calculated using the following two equations;

$$P_{AE} = ½ K_{AE} γ H^2 (1-k_V)$$

$$P_{PE} = ½ K_{PE} γ H^2 (1-k_V)$$

Where;

K_{AE} = Combined Static and Seismic Active Earth Pressure Coefficient

K_{PE} = Combined Static and Seismic Passive Earth Pressure Coefficient

H = Total Height of the Wall (m)

K_h = horizontal acceleration coefficient

K_v = vertical acceleration coefficient

γ = bulk density (kg/m^3)

These equations are based on a horizontal slope behind the wall and a vertical back of the retaining wall and zero wall friction. For this site, the following design parameters were used to develop the recommended K_{AE} and K_{PE} values.

A = Zonal acceleration ratio = 0.28

K_h = Horizontal acceleration coefficient = 0.14

K_v = Vertical acceleration coefficient = 0.094

The above value of K_h corresponds to ½ of the A value and the value K_v of corresponds to 0.67 of the K_h value. The angle of friction between the soil and the wall has been set at 0 degrees to provide a conservative estimate. The total active thrust PAE can be divided into a static component, P and a dynamic (seismic) component ΔPAE (i.e. PAE = P+ΔPAE) and may be considered to act at a height, h (m), from the base of the wall,

$$h = [P\ (H/3) + \Delta P_{AE}\ (0.6H)]/\ P_{AE}$$

5.6 Settlement

The estimated total settlement of the shallow foundations, designed using the recommended serviceability limit state capacity value, as well as other recommendations given above, will be less than 25 mm. The differential settlement between adjacent column footings is anticipated to be 15 mm or less.

5.7 Liquefaction

As recommended in Canadian Foundation Engineering Manual 4th edition (*Bray et al. 2004)*, the following criteria can be used to determine liquefaction susceptibility of fine grained soils.

- $w/w_L \geq 0.85$ and $I_p \leq 12$: Susceptible to liquefaction or cyclic mobility
- $w/w_L \geq 0.8$ and $12 \leq I_p \leq 20$: Moderately susceptible to liquefaction or cyclic mobility
- $w/w_L < 0.8$ and $I_p \leq 20$: No liquefaction or cyclic mobility, but may undergo significant deformations if cyclic shear stress > static undrained shear strength.

Laboratory plasticity test results on the split spoon sample collected exhibit a ratio of water content to liquid limit of approximately 0.52, and I_p is 44. Based on the test results, the silty clay deposit is not susceptible to liquefaction, and liquefaction is not considered a concern for this site.

5.8 Seismic

Based on the results of this geotechnical investigation and in accordance with the Ontario Building Code 2012 (table 4.1.8.4.A.) and Canadian Foundation Engineering Manual (4th edition), the site can be classified as Class "D" as per the Site Classification for Seismic Site Response. It should be noted that a greater seismic site response class may be obtained by conducting seismic velocity testing using a multichannel analysis of surface waves (MASW).

The above classifications were recommended based on conventional method exercised for Site Classification for Seismic Site Response and in accordance with the generally accepted geotechnical engineering practice.

5.9 Frost Protection

All exterior footings located in any unheated portions of the proposed building should be protected against frost heaving by providing a minimum of 1.5 m of earth cover. Areas that are to be cleared of snow (i.e. sidewalks, paved areas, etc.) should be provided with at least 1.8 m of earth cover for frost protection purposes. Alternatively, the required frost protection could be provided using a combination of earth cover and extruded polystyrene insulation. Detailed guidelines for footing insulation frost protection can be provided upon request.

In the event that foundations are to be constructed during winter months, the foundation soils are required to be protected from freezing temperatures using suitable construction techniques. The base of all excavations should be insulated from freezing temperatures immediately upon exposure, until heat can be supplied to the building interior and the footings have sufficient soil cover to prevent freezing of the subgrade soils.

5.10 Foundation Walls Backfill

To prevent possible lateral loading, the backfill material against any foundation walls, grade beams, isolated walls, or piers should consist of free draining, non-frost susceptible material such as sand or sand and gravel meeting OPSS Granular B Type I, II or Select Subgrade Material (SSM).

The foundation wall backfill should be compacted to minimum 95% of its SPMDD using light compaction equipment, where no loads will be set over top. The compaction shall be increased to 98% of its SPMDD under walkways, slabs or paved areas close to the foundation or retaining walls. Backfilling against foundation walls should be carried out on both sides of the wall at the same time where applicable.

5.11 Slab-on-grade Construction

Concrete slab-on-grade should rest over compacted, free draining and well graded structural fill only. Therefore, all fill or otherwise deleterious material shall be removed from the proposed buildings' footprint down to the subgrade surface. The subgrade should then be inspected and approved by qualified geotechnical personnel.

Any underfloor fill needed to raise the general floor grade shall consist of OPSS Granular B Type I, II, or SSM, compacted to 95% of its SPMDD. The final lift shall Granular B Type II, and compacted to 98% of its SPMDD. A 150 mm Granular A meeting the **OPSS 1010** shall be placed underneath the slab and compacted to 100% of its SPMDD.

It is also recommended that the area of extensive exterior slab-on-grade (sidewalks, ramp etc.) shall be constructed using Granular A base of thickness 150 mm. The modulus of subgrade reaction (ks) for the design of the slabs set over structural fill is **18 MPa/m.**

In order to further minimize and control cracking, the floor slab shall be provided with wire or fibre mesh reinforcement and construction or control joints. The construction or control joints should be spaced equal distance in both directions and should not exceed 4.5 m. The wire or fibre mesh reinforcement shall be carried out through the joints.

If any areas of the proposed building area are to remain unheated during the winter period, thermal protection of the slab on grade may be required. The "Guide for Concrete Floor and Slab Construction", **ACI 302.1R-04** is recommended to follow for the design and construction of vapour retarders below the floor slab. Further details on the insulation requirements could be provided, if necessary.

5.12 Corrosion Potential and Cement Type

A soil sample was submitted to Paracel Laboratories Ltd. for chemical laboratory testing. The following **Table 6** below summarizes the results.

Table 6: Results of Chemical Analysis

Sample Location	Depth (m)	pH	Sulphate (µg/g)	Chloride (µg/g)	Resistivity (Ohm.cm)
BH1	1.5 – 2.1	7.8	373	26	2250
BH4	2.3 – 2.9	8.0	23	20	6080

The above results revealed a measured sulphate concentration between 23 and 373 µg/g in the sample. Based on the CAN/CSA-A23.1 standards (Concrete Materials and Methods of Concrete Construction), a sulphate concentration of less than 1000 µg/g falls within the negligible category for sulphate attack on buried concrete. The test results from the soil samples were below the noted threshold. As such, buried concrete for footings and foundations walls will not require any special additive to resist sulphate attack and the use of normal Portland cement is acceptable.

The pH, resistivity and chloride concentration provide an indication of the degree of corrosiveness of the sub-surface environment. The soil resistivity was measured to be 2250 and 6080 ohm.cm, which indicates a moderate to highly corrosive environment.

6 EXCAVATION AND BACKFILLING REQUIREMENTS

6.1 Excavation

It is anticipated that the maximum depth of excavation (which will occur at boring location BH1) for the buildings will be about 5.3 m bgs. Excavation must be carried-out in accordance with the Occupational Health and Safety Act and Regulations for Construction Projects.

According to the Ontario's Occupational Health and Safety Act (OHSA), O. Reg. 213/91 and its amendments, the surficial overburden expected to be excavated into at this site can be classified as Type 3 for fully drained excavations. Therefore, shallow temporary excavations in the overburden soil can be cut at 1 horizontal to 1 vertical, for a fully drained excavation starting from the base of the excavation and as per requirements of the OHSA regulations.

In the event that the aforementioned slopes are not possible to achieve due to space restrictions, the excavation shall be shored according to OHSA O. Reg. 213/91 and its amendments. The shoring shall be designed from the parameters provided in **Table 5** in **Section 5.5**.

When excavating into bedrock, the side of the excavation does not need to be sloped and can be cut vertically from the base of excavation.

Any excavated material stockpiled near an excavation or trench should be stored at a distance equal to or greater than the depth of the excavation/trench and construction equipment traffic should be limited near open excavation.

6.2 Groundwater Control

Based on the subsurface conditions encountered at this site, groundwater seepage or infiltration into the temporary excavations during construction is expected to be minor in nature, if any. This will be able to be controlled by pumping with sump pumps. Surface water runoff into the excavation should be minimized and diverted away from the excavation.

A permit to take water (PTTW) is required from Ministry of Environment and Climate Change (MOECC), Ontario Reg. 387/04, if more than 400,000 litres per day of groundwater will be pumped during a construction period less than 30 days. Registration in the Environmental Activity and Sector Registry (EASR) is required when water takings range between 50,000 and 400,000 litres per day.

The actual amount of groundwater inflow into open excavations will depend on several factors such as the contractor's schedule, rate of excavation, the size of excavation, depth below the groundwater level, and at the time of year which the excavation is executed. It is expected that pumping rates will be less than 50,000 litres per day. As such, EASR registration is not required for the construction at this site.

6.3 Pipe Bedding Requirements

It is anticipated that any underground services required as part of this project will be founded over properly prepared and approved structural fill. Consequently all organic material should be removed down to a suitable bearing layer. Any sub-excavation of disturbed soil should be removed and replaced with a Granular B Type II or I, or an approved equivalent, laid in loose lifts of thickness not exceeding 300 mm and compacted to 95% of its SPMDD. Bedding, thickness of cover material and compaction requirements for watermains and sewer pipes should conform to the manufacturer's design requirements and to the detailed installations outlined in the Ontario Provincial Standard Specifications (OPSS) or any other applicable standards.

6.4 Trench Backfill

All service trenches should be backfilled using compactable material, free of organics, debris and large cobbles or boulders. Acceptable native materials (if encountered and where possible) should be used as backfill between the roadway subgrade level and the depth of seasonal frost penetrations (i.e. 1.8 m below finished grade) in order to reduce the potential for differential frost heaving between the new excavated trench and the adjacent section of roadway. Where native backfill is used, it should match the native materials exposed on the trench walls. Backfill below the zone of seasonal frost penetration could consist of either acceptable native material or imported granular material conforming to OPSS Granular B Type II. Any boulders larger than 150 mm in size should not be used as trench backfill.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the roadway, the trench should be compacted in maximum 300 mm thick lifts to at least 95% of its SPMDD. The specified density may be reduced where the trench backfill is not located within or in close proximity to existing roadways or any other structures.

For trenches carried out in existing paved areas, transitions should be constructed to ensure that proper compaction is achieved between any new pavement structure and the existing pavement structure to minimize potential future differential settlement between the existing and new pavement structure. The transition should start at the subgrade level and extend to the underside of the asphaltic concrete level (if any) at a 1 horizontal to 1 vertical slope. This is especially important where trench boxes are used and where no side slopes are provided to the excavation. Where asphaltic concrete is present, it should be cut back to a minimum of 150 mm from the edge of the excavation to allow for proper compaction between the new and existing pavement structures.

7 REUSE OF ON-SITE SOILS

The existing surficial overburden materials consists of fill material. This material is considered to be frost susceptible and should not be used as backfill material directly against foundation walls or underneath unheated concrete slabs. However, it could be reused as general backfill material (service trenches, general landscaping/backfilling) if it can be compacted according to the specifications outlined herein at the time of construction and found free from any waste, organics and debris.

It should be noted that the adequacy of any material for reuse as backfill will depend on its water content at the time of its use and on the weather conditions prevailing prior to and during that time. Therefore, all excavated materials to be reused shall be stockpiled in a manner that will prevent any significant changes in their moisture content, especially during wet conditions, and approved for reuse by a geotechnical engineer.

8 RECOMMENDED PAVEMENT STRUCTURE

It is anticipated that the subgrade soils for the new parking and access lanes will consist of either fill material or bedrock. The construction of access lanes and parking areas will be acceptable over these materials once all organic, or otherwise deleterious materials are removed from the subgrade area. Furthermore, the subgrade must be compacted (except where bedrock is encountered) using a suitable heavy duty compacting equipment and approved by a geotechnical engineer prior to placing any granular base material.

The following **Table 7** presents the recommended pavement structures to be constructed over a stable subgrade along the proposed parking areas and access lane as part of this project.

Table 7: Recommended Pavement Structure

Course	Material	Thickness (mm)	
		Light Duty Parking Area (mm)	Heavy Duty Parking Area (Access Roads, Fire Routes and Trucks) (mm)
Surface	HL3/SP12.5	50	40
Binder	HL8/SP19.0	-	50
Base course	Granular A	150	150
Sub-base	Granular B Type II	300	450**
Total:		500	690

Performance Graded Asphaltic Cement (PGAC) **58-34** is recommended for this project.

**The sub-base thickness may be reduced to 300 mm if the subgrade consists of bedrock.

The base and subbase granular materials shall conform to **OPSS 1010** material specifications. Any proposed materials shall be tested and approved by a geotechnical engineer prior to delivery to the site and shall be compacted to 98% of its SPMDD. Asphaltic concrete shall conform to **OPSS 1150** and be placed and compacted to at least

95% of the Marshall Density. The mix and its constituents shall be reviewed, tested and approved by a geotechnical engineer prior to delivery to the site.

8.1 Paved Areas & Subgrade Preparation

The access lanes and parking areas shall be stripped of vegetation, debris and other obvious objectionable fill material. Following the backfilling and satisfactory compaction of any underground service trenches up to the subgrade level, the subgrade shall be shaped, crowned and proof-rolled. A loaded Tandem axle, dual wheel dump truck or approved equivalent heavy duty smooth drum roller shall be used for proof-rolling. Any resulting loose/soft areas should be sub-excavated down to an adequate bearing layer and replaced with approved backfill.

The preparation of subgrade shall be scheduled and carried out in manner so that a protective cover of overlying granular material (if required) is placed as quickly as possible in order to avoid unnecessary circulation by heavy equipment, except on unexcavated or protected surfaces. Frost protection of the surface shall be implemented if works are carried out during the winter season.

The performance of the pavement structure is highly dependent on the subsurface groundwater conditions and maintaining the subgrade and pavement structure in a dry condition. To intercept excess subsurface water within the pavement structure granular materials, sub-drains with suitable outlets should be installed below the pavement area's subgrade if adequate overland flow drainage is not provided (i.e. ditches). The surface of the pavement should be properly graded to direct runoff water towards suitable drainage features. It is recommended that the lateral extent of the subbase and base layers not be terminated vertically immediately behind the curb/edge of pavement line but be extended beyond the curb.

9 SLOPE STABILITY ANALYSIS

The slope modelling program, Slide 5.0 (Rocscience), was used to implement the Bishop simplified method of slices. Two (2) slope profiles were selected to be ran in the modelling program, and labelled Section A-A and B-B. The location of these profiles in relation in the proposed building locations' can be found attached in **Appendix E.** Both of the slope profiles ran in the modelling program are the proposed cross sections. These cross sections were obtained using a combination of the "Grading and Drainage Plan", generated by LRL, and field measurements gathered while onsite for the geotechnical investigation. The slope was analyzed under both the undrained (short-term) and drained (long-term) conditions.

The field measurements in conjunction with known published data of the material within the region were used for selection of appropriate soil modelling parameters in the slope stability analyses.

The results of the analyses are potentially dependent on the assumption of groundwater condition. As a conservative approach the analysis was completed assuming full saturation throughout the slope.

The following soil parameters found below in **Table 8** were used as part of the analyses.

Table 8: Soil Parameters used in Slope Stability Analysis

Soil Type	Effective cohesion (c') - KPa	Angle of internal friction (ϕ') - degrees	Bulk unit weight (γ_B) – KN/m^3
Drained Parameters (Long Term)			
Fill Material	7	30	19.0
Structural Fill	1	32	23.0
Silty Clay	8	28	18.0
Undrained Parameters (Short Term)			
Fill Material	50	-	19.0
Structural Fill	1	32	23.0
Silty Clay	65	-	18.0

The factor of safety (FoS) against slope failure was run with the additional loading for the proposed apartment buildings planned for this site for both undrained and drained condition. The FoS values ranged between 1.55 and 16.63. A FoS of 1.50 or greater is considered to be safe with regards to slope stability. A value of 100 kPa for the buildings was assumed and included within the model.

These results indicate that the proposed construction will not negatively affect the stability of the slope and will remain safe in both the long and short term.

The model results are attached in **Appendix E** for your reference.

10 INSPECTION SERVICES

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed site do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design.

All footing areas and any structural fill areas for the proposed buildings should be inspected by LRL to ensure that a suitable subgrade has been reached and properly prepared. The placing and compaction of any granular materials beneath the foundations and slab-on-grade should be inspected to ensure that the materials used conform to the required gradation and compaction specifications.

If the footings are to be constructed during winter season, the footing subgrade should be protected from freezing temperatures using suitable construction techniques.

11 REPORT CONDITIONS AND LIMITATIONS

It is stressed that the information presented in this report is provided for the guidance of the designers and is intended for this project only. The use of this report as a construction document or its use by a third party beyond the client specifically listed in the report is neither intended nor authorized by LRL Associates Ltd. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

The professional services for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible contamination resulting from previous uses or activities at this site or adjacent properties, and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report.

The recommendations provided in this report are based on subsurface data obtained at the specific test pit locations only. Boundaries between zones presented on the test pit logs are often not distinct but transitional and were interpreted. Experience indicates that the subsurface soil and groundwater conditions can vary significantly between and beyond the test locations. For this reason, the recommendations given in this report are subject to a field verification of the subsurface soil conditions at the time of construction.

The recommendations are applicable only to the project described in this report. Any changes to the project will require a review by LRL Associates Ltd., to ensure compatibility with the recommendations contained in this project.

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report or if we may be of further services to you, please do not hesitate to contact the undersigned.

Yours truly,
LRL Associates Ltd.

LICENSED PROFESSIONAL ENGINEER
Aug 6, 2020
B. W. JOHNSON
100510537
PROVINCE OF ONTARIO

Brad Johnson, P. Eng.
Geotechnical Engineer
W:\FILES 2020\200041\05 Geotechnical\01 Investigation\05 Reports\2020-07-27_Geotechnical Investigation_Proposed Apartment Buildings_Block 9 Eric Czapnik Way_Landric Homes.docx

APPENDIX A

Site and Borehole Location Plan

ENGINEERING | INGÉNIERIE

5430 Canotek Road | Ottawa, ON, K1J 9G2
www.lrl.ca | (613) 842-3434

PROJECT

GEOTECHNICAL INVESTIGATION
PROPOSED APARTMENT BUILDINGS
BLOCK 9 ERIC CZAPNIK WAY
ORLEANS, ONTARIO

DRAWING TITLE

SITE LOCATION
SOURCE: GEO-OTTAWA

CLIENT

LANDRIC HOMES

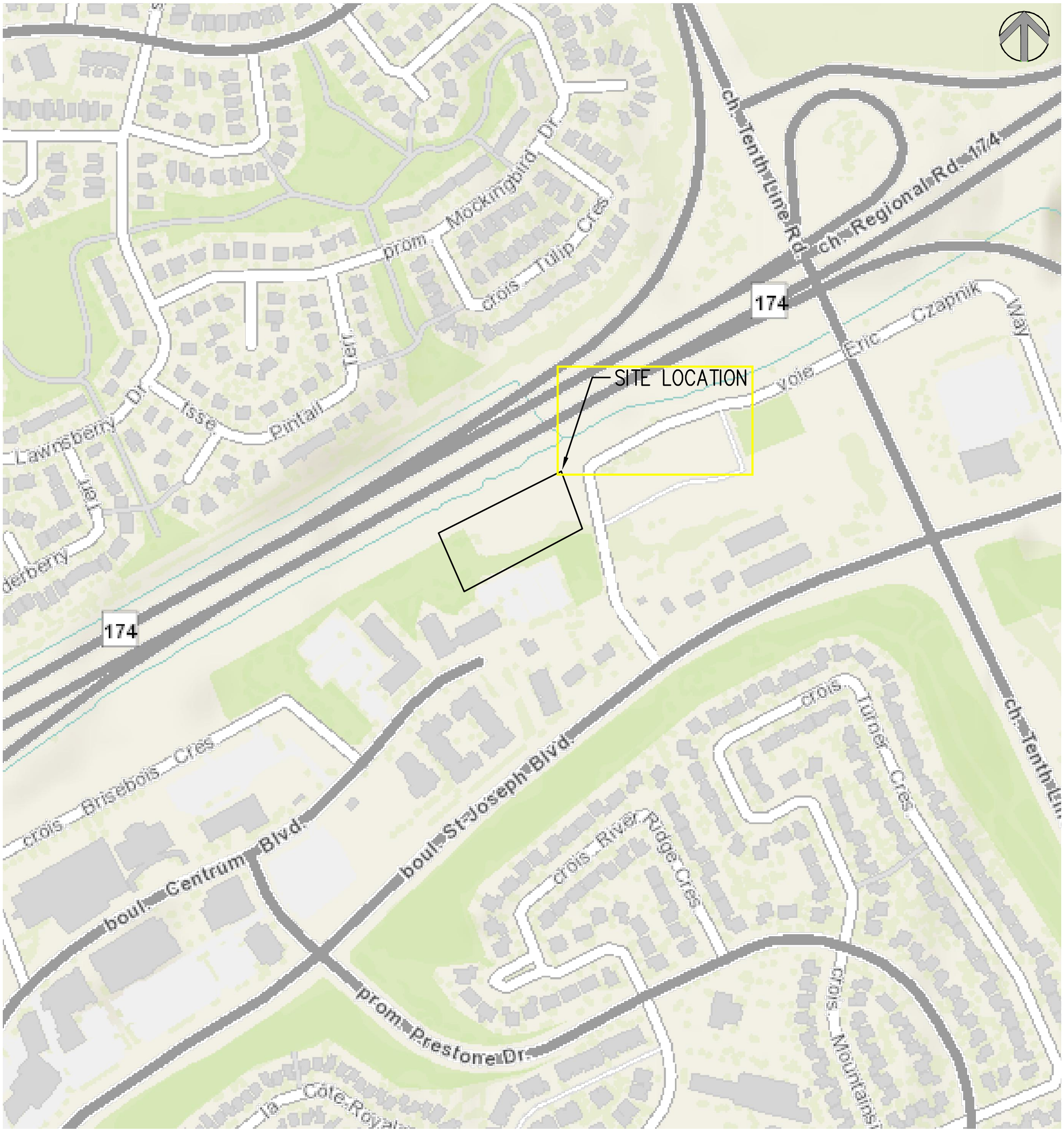
DATE

AUGUST 2020

PROJECT

200041

FIGURE 1



ENGINEERING I INGÉNIERIE
5430 Canotek Road I Ottawa, ON, K1J 9G2
www.lrl.ca I (613) 842-3434

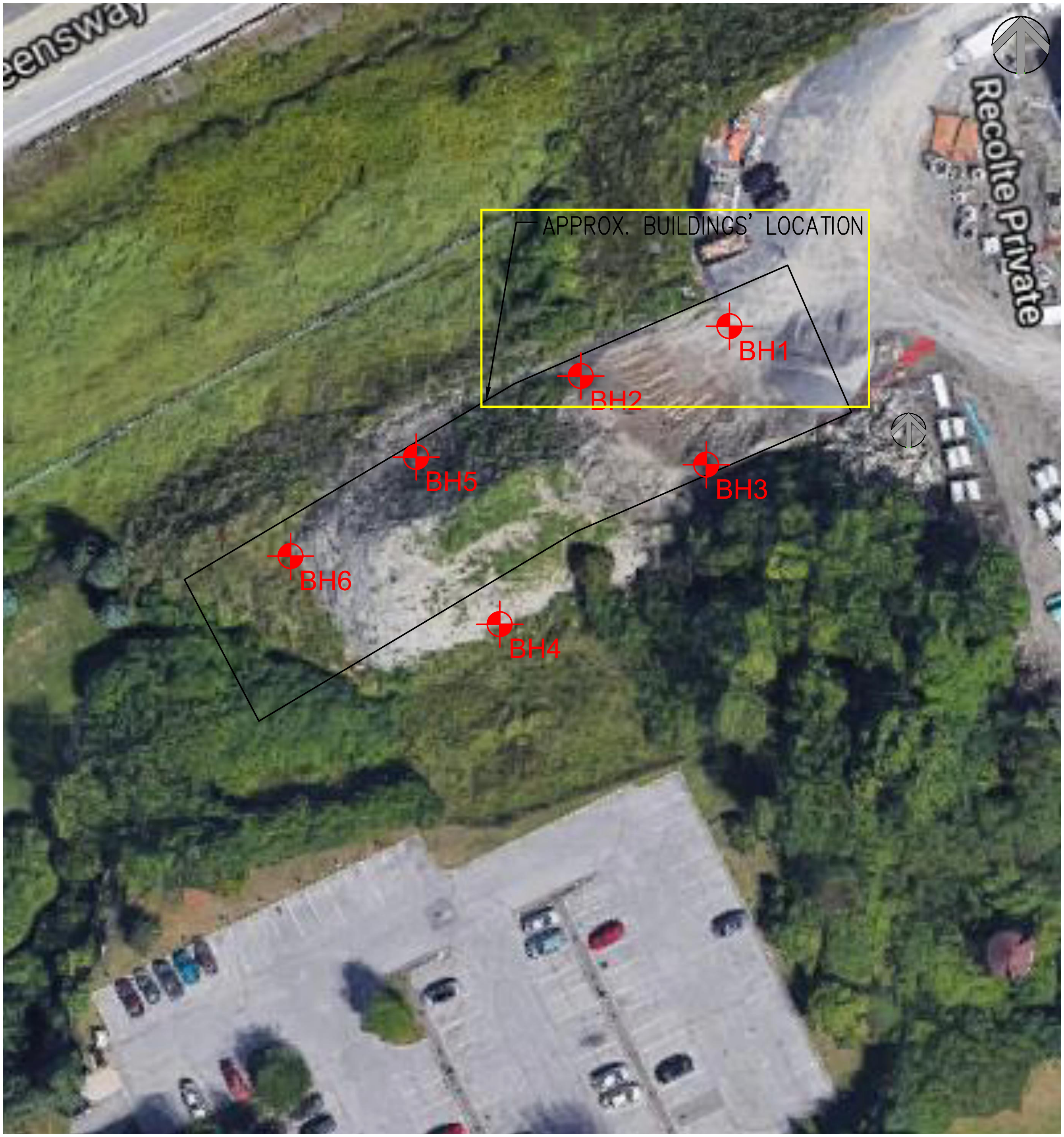
PROJECT

GEOTECHNICAL INVESTIGATION
PROPOSED APARTMENT BUILDINGS
BLOCK 9 ERIC CZAPNIK WAY
ORLEANS, ONTARIO

DRAWING TITLE

BOREHOLE LOCATION
SOURCE: Imagery 2020 Google, Digital Globe Map Data

CLIENT	DATE	PROJECT	
LANDRIC HOMES	AUGUST 2020	200041	FIGURE 2



APPENDIX B

Borehole Logs

Borehole Log: BH1

Project No.: 200041

Client: Landric Homes Inc.

Date: June 30, 2020

Project: Proposed Appartment Buildings

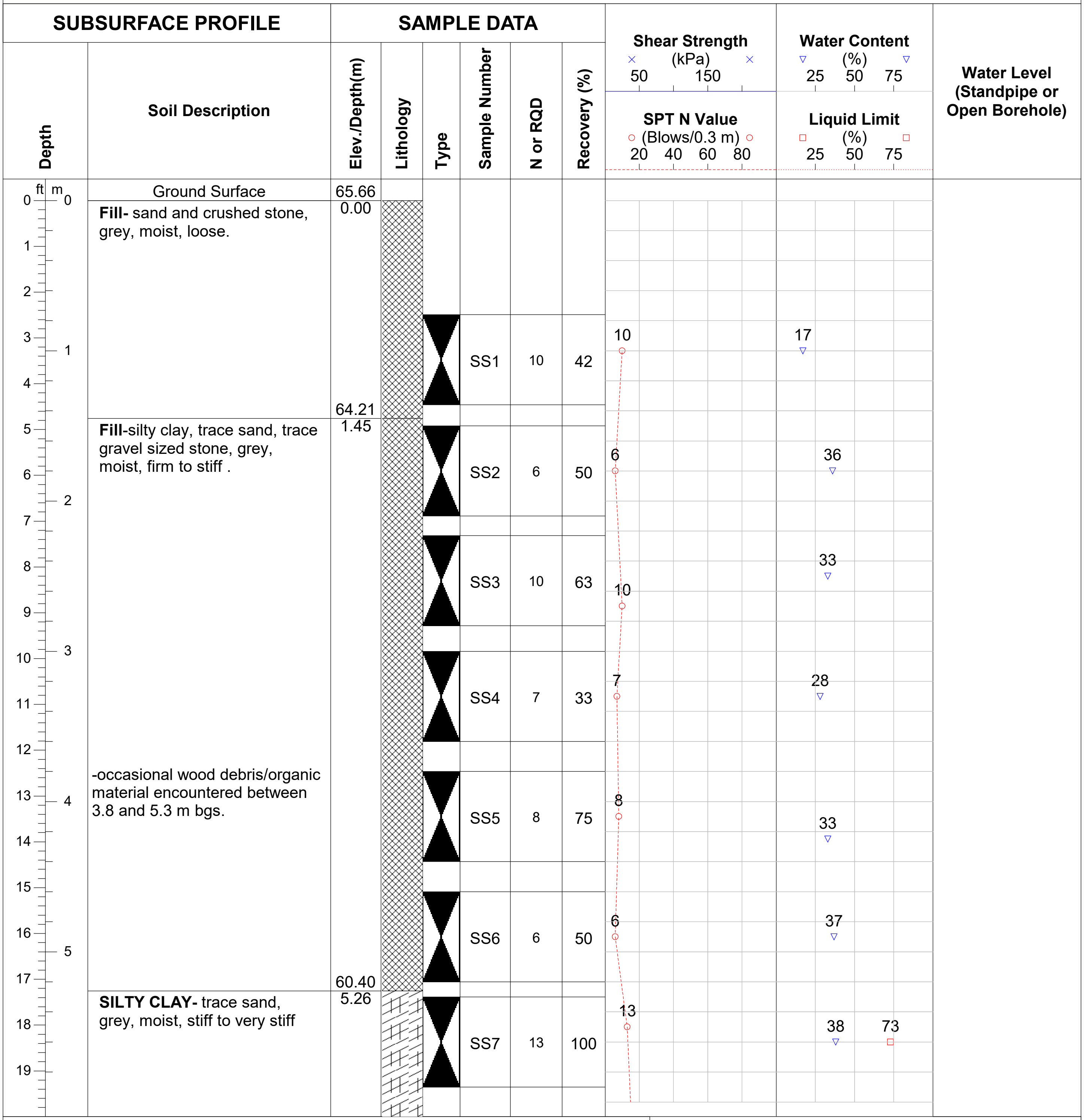
Location: Block 9 Eric Czapnik Way, Orleans ON

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger



Soil Description	Elev./Depth(m)
Ground Surface	65.66
Fill- sand and crushed stone, grey, moist, loose.	0.00
Fill-silty clay, trace sand, trace gravel sized stone, grey, moist, firm to stiff . -occasional wood debris/organic material encountered between 3.8 and 5.3 m bgs.	64.21 1.45
SILTY CLAY- trace sand, grey, moist, stiff to very stiff	60.40 5.26

Sample Number	N or RQD	Recovery (%)	SPT N Value	Water Content (%)	Liquid Limit (%)
SS1	10	42	10	17	
SS2	6	50	6	36	
SS3	10	63	10	33	
SS4	7	33	7	28	
SS5	8	75	8	33	
SS6	6	50	6	37	
SS7	13	100	13	38	73

Easting: 460488 m

Northing: 5036823 m

Site Datum: Site Benchmark - Top of Flange Bolt - Fire Hydrant (66.17 m)

Groundsurface Elevation: 65.66 m

Top of Riser Elev.: N/A

Hole Diameter: 200 mm

NOTES:

No water encountered while drilling.

Borehole Log (continued): BH1

Project No.: 200041

Client: Landric Homes Inc.

Date: June 30, 2020

Project: Proposed Appartment Buildings

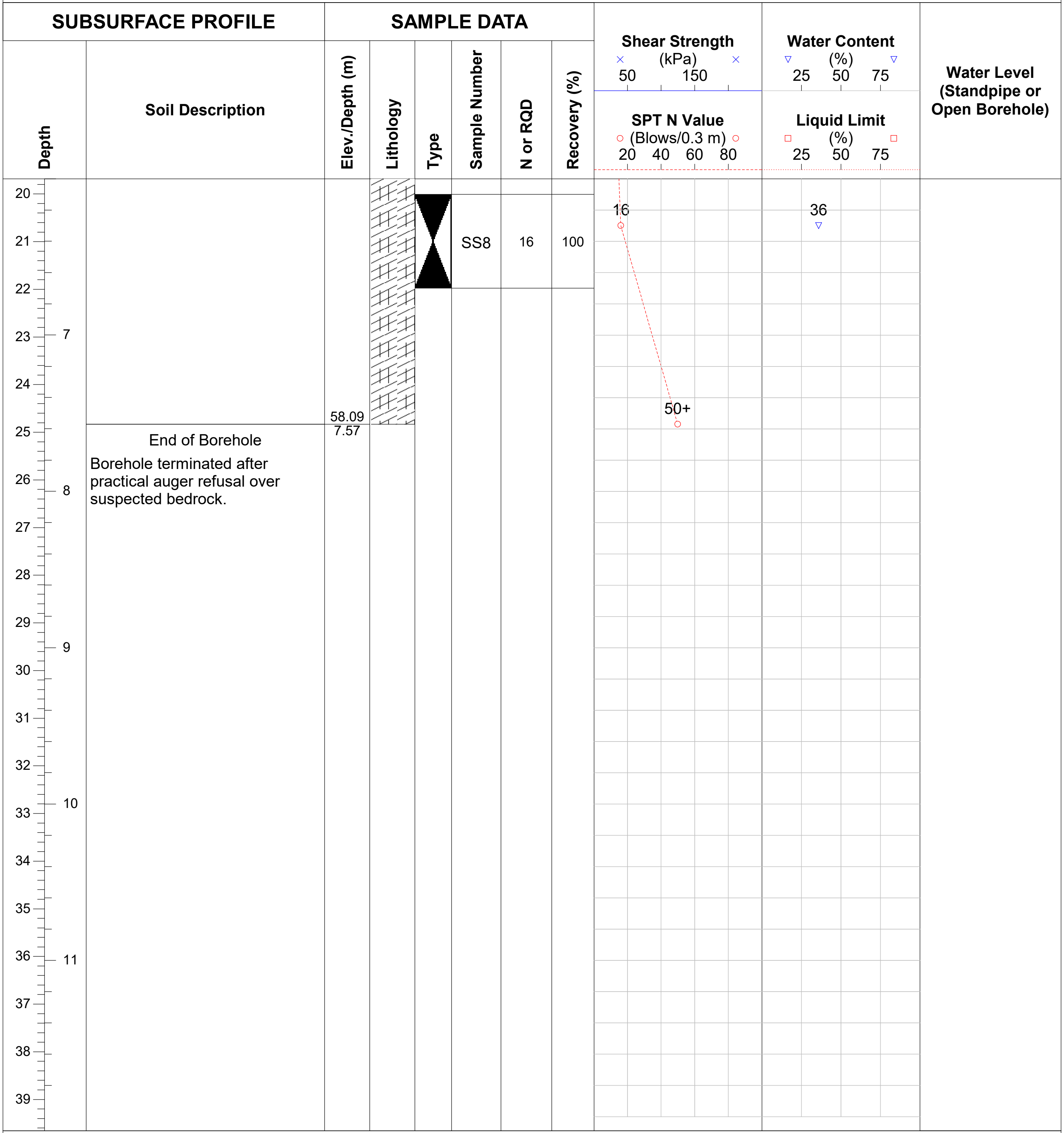
Location: Block 9 Eric Czapnik Way, Orleans ON

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger



End of Borehole

Borehole terminated after practical auger refusal over suspected bedrock.

NOTES

Borehole Log: BH2

Project No.: 200041

Project: Proposed Appartment Buildings

Client: Landric Homes Inc.

Location: Block 9 Eric Czapnik Way, Orleans ON

Date: June 30, 2020

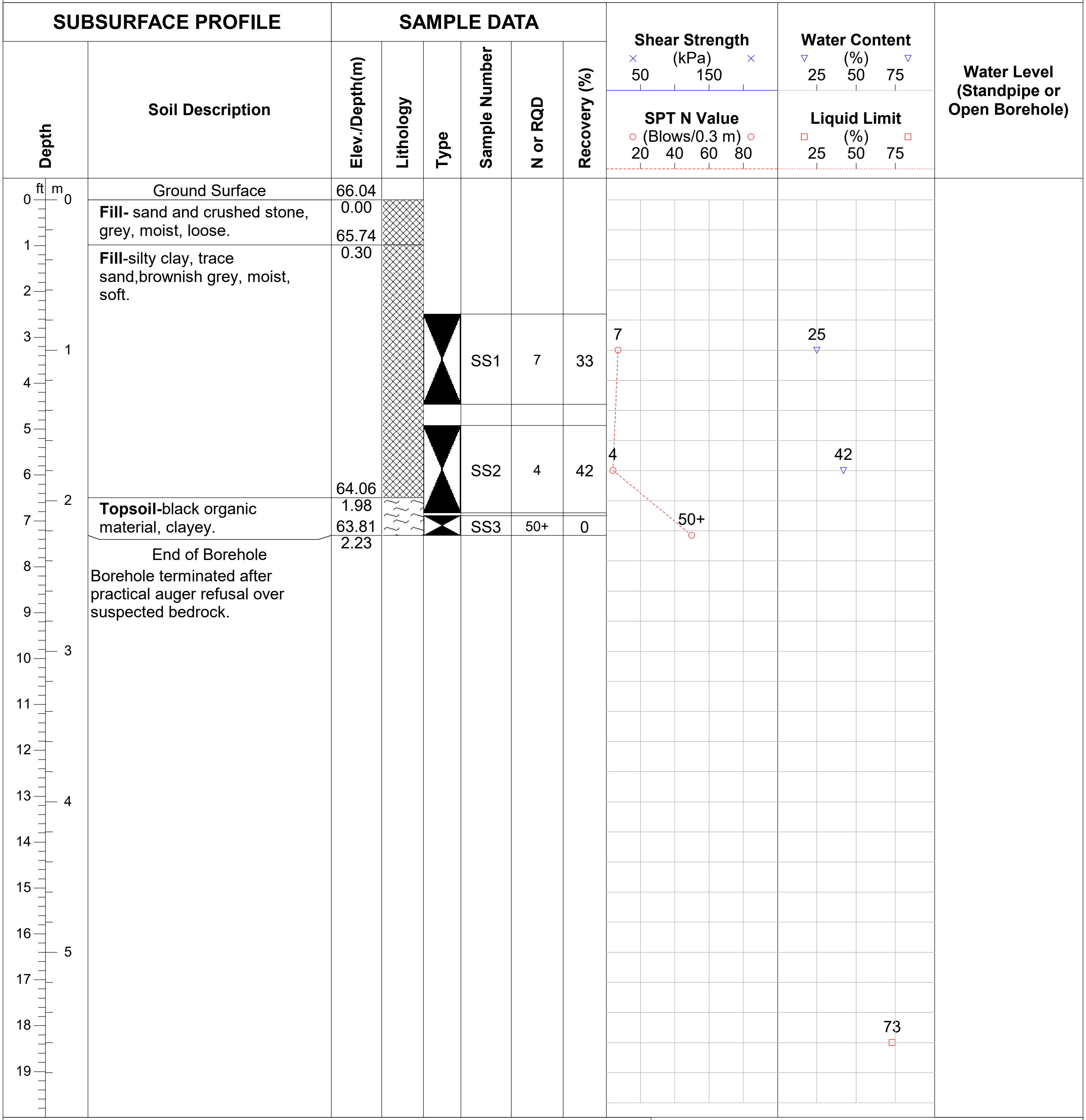
Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger

SUBSURFACE PROFILE / SAMPLE DATA



Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)
Ground Surface	66.04					
Fill- sand and crushed stone, grey, moist, loose.	0.00	▨				
Fill-silty clay, trace sand,brownish grey, moist, soft.	65.74 0.30	▨	⧗	SS1	7	33
		▨	⧗	SS2	4	42
Topsoil-black organic material, clayey.	64.06 1.98		⧗	SS3	50+	0
End of Borehole Borehole terminated after practical auger refusal over suspected bedrock.	63.81 2.23					

Easting: 460479 m

Northing: 5036819 m

Site Datum: Site Benchmark - Top of Flange Bolt - Fire Hydrant (66.17 m)

Groundsurface Elevation: 66.04 m

Top of Riser Elev.: N/A

Hole Diameter: 200 mm

NOTES:

No water encountered while drilling.

Borehole Log: BH3

Project No.: 200041

Client: Landric Homes Inc.

Date: July 2, 2020

Project: Proposed Appartment Buildings

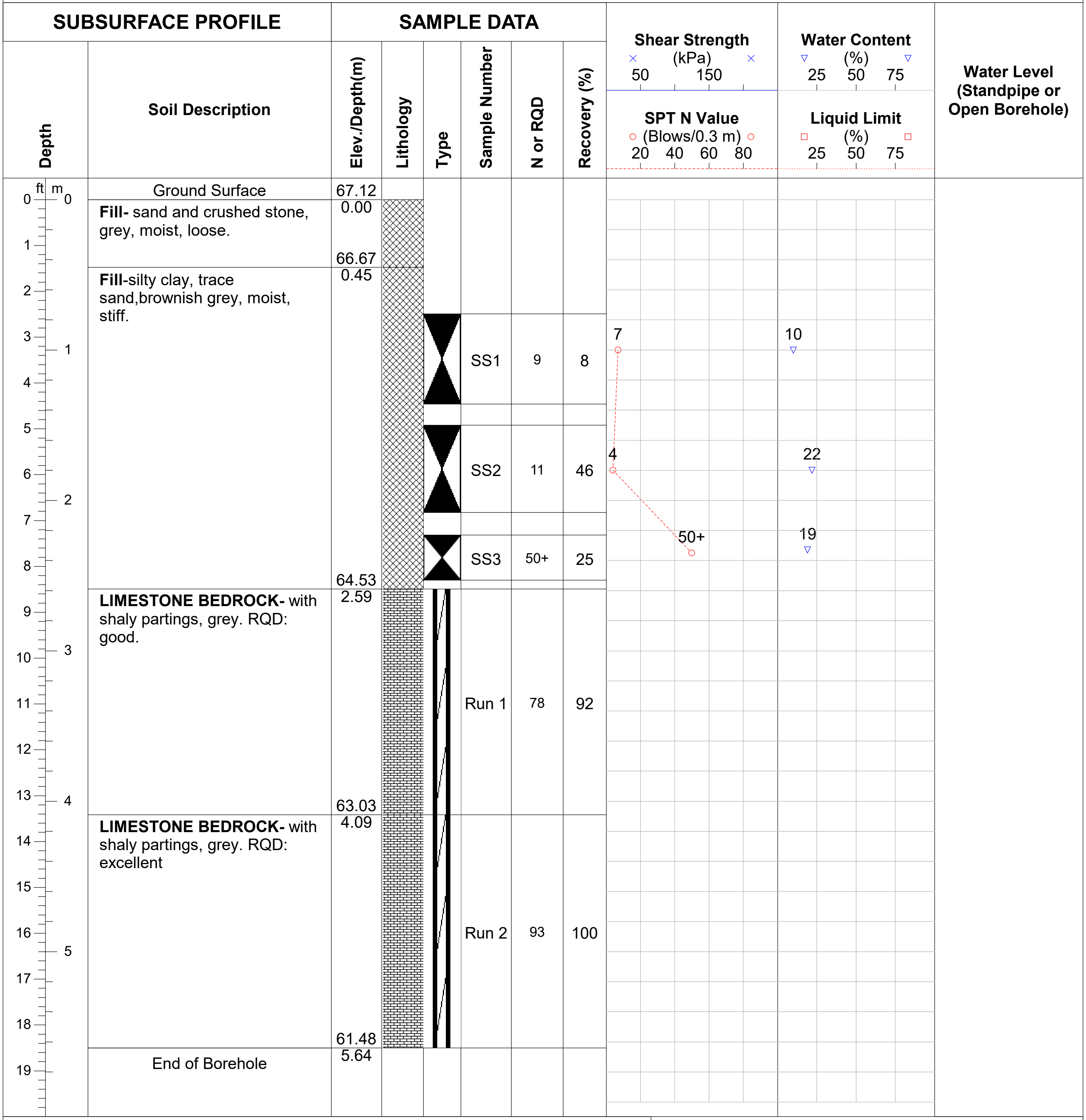
Location: Block 9 Eric Czapnik Way, Orleans ON

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger



Soil Description	Elev./Depth(m)	Sample Number	N or RQD	Recovery (%)
Ground Surface	67.12			
Fill- sand and crushed stone, grey, moist, loose.	0.00 66.67			
Fill-silty clay, trace sand,brownish grey, moist, stiff.	0.45 64.53	SS1 SS2 SS3	9 11 50+	8 46 25
LIMESTONE BEDROCK- with shaly partings, grey. RQD: good.	2.59 63.03	Run 1	78	92
LIMESTONE BEDROCK- with shaly partings, grey. RQD: excellent	4.09 61.48	Run 2	93	100
End of Borehole	5.64			

Easting: 460491 m

Northing: 5036809 m

Site Datum: Site Benchmark - Top of Flange Bolt - Fire Hydrant (66.17 m)

Groundsurface Elevation: 67.12 m

Top of Riser Elev.: N/A

Hole Diameter: 200 mm

NOTES:

No water encountered while drilling.

Borehole Log: BH4

Project No.: 200041

Project: Proposed Appartment Buildings

Client: Landric Homes Inc.

Location: Block 9 Eric Czapnik Way, Orleans ON

Date: July 2, 2020

Field Personnel: BJ

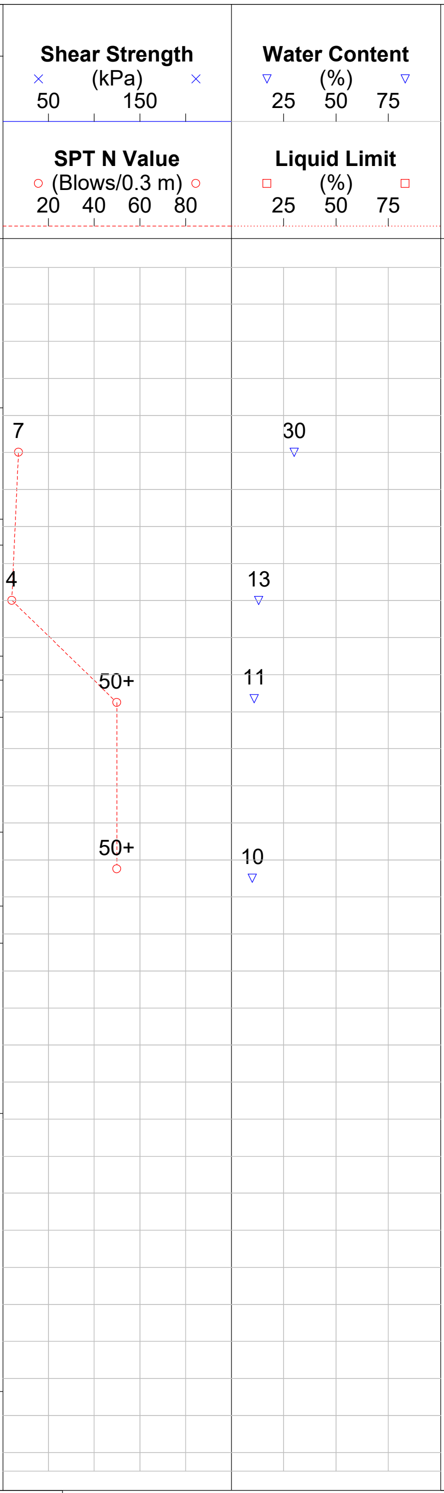
Driller: CCC Geotech and Enviro Drilling

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger

SUBSURFACE PROFILE / SAMPLE DATA

Soil Description	Elev./Depth(m)	Sample Number	N or RQD	Recovery (%)	SPT N Value (Blows/0.3 m)	Water Content (%)
Ground Surface	68.03					
Fill-silty clay, trace sand, some boulders and cobbles, mixed with some black organic material, brownish grey, loose to compact.	0.00					
		SS1	9	50	7	30
		SS2	15	42	4	13
		SS3	50+	50	50+	11
Cored through boulders from about 2.5 to 3.6 m bgs.						
		SS4	50+	33	50+	10
LIMESTONE BEDROCK- with shaly partings, grey. RQD: poor.	64.38 3.65	Run 1	47	83		
LIMESTONE BEDROCK- with shaly partings, grey. RQD: fair.	63.46 4.57	Run 2	73	100		
End of Borehole	61.93 6.10					



Water Level (Standpipe or Open Borehole)

Easting: 460469 m

Northing: 5036794 m

Site Datum: Site Benchmark - Top of Flange Bolt - Fire Hydrant (66.17 m)

Groundsurface Elevation: 68.03 m

Top of Riser Elev.: N/A

Hole Diameter: 200 mm

NOTES:

No water encountered while drilling.

Borehole Log: BH5

Project No.: 200041

Project: Proposed Appartment Buildings

Client: Landric Homes Inc.

Location: Block 9 Eric Czapnik Way, Orleans ON

Date: July 3, 2020

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger

SUBSURFACE PROFILE		SAMPLE DATA								
Depth (ft / m)	Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	Shear Strength × (kPa) × 50 150 SPT N Value ○ (Blows/0.3 m) ○ 20 40 60 80	Water Content ▽ (%) ▽ 25 50 75 Liquid Limit □ (%) □ 25 50 75	Water Level (Standpipe or Open Borehole)
	Ground Surface	63.22								
	Fill-silty clay, some sand, some gravel sized stone, brownish grey, moist, loose.	0.00	▩	⧗	SS1	9	33	9 ○	19 ▽	
	LIMESTONE BEDROCK- with shaly partings, grey. RQD: good.	61.72 1.50	▤	▯	Run 1	80	100			
	LIMESTONE BEDROCK- with shaly partings, grey. RQD: good.	60.22 3.00	▤	▯	Run 2	83	100			
	End of Borehole	58.65 4.57								

Easting: 460458 m

Northing: 5036811 m

Site Datum: Site Benchmark - Top of Flange Bolt - Fire Hydrant (66.17 m)

Groundsurface Elevation: 63.22 m

Top of Riser Elev.: N/A

Hole Diameter: 200 mm

NOTES:

No water encountered while drilling.

Borehole Log: BH6

Project No.: 200041

Project: Proposed Appartment Buildings

Client: Landric Homes Inc.

Location: Block 9 Eric Czapnik Way, Orleans ON

Date: July 3, 2020

Field Personnel: BJ

Driller: CCC Geotech and Enviro Drilling

Drilling Equipment: Track Mount CME 75

Drilling Method: Hollow Stem Auger

SUBSURFACE PROFILE		SAMPLE DATA								
Depth	Soil Description	Elev./Depth(m)	Lithology	Type	Sample Number	N or RQD	Recovery (%)	Shear Strength ✕ (kPa) ✕ 50 150 SPT N Value ○ (Blows/0.3 m) ○ 20 40 60 80	Water Content ▽ (%) ▽ 25 50 75 Liquid Limit □ (%) □ 25 50 75	Water Level (Standpipe or Open Borehole)
ft 0 / m 0	Ground Surface	62.69								
	Fill-silty clay, some sand, some gravel sized stone, brownish grey, moist, loose.	0.00	▨							
		62.39 0.30		⋈	SS1	50+		50+ ○		
	End of Borehole Borehole terminated after practical auger refusal on suspected bedrock.									

Easting: 460443 m

Northing: 5036802 m

Site Datum: Site Benchmark - Top of Flange Bolt - Fire Hydrant (66.17 m)

Groundsurface Elevation: 62.69 m

Top of Riser Elev.: N/A

Hole Diameter: 200 mm

NOTES:

No water encountered while drilling.

APPENDIX C

Symbols and Terms used in Borehole Logs

Symbols and Terms Used on Borehole and Test Pit Logs

1. Soil Description

The soil descriptions presented in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves some judgement and LRL Associates Ltd. does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice. Boundaries between zones on the logs are often not distinct but transitional and were interpreted.

a. Proportion

The proportion of each constituent part, as defined by the grain size distribution, is denoted by the following terms:

Term	Proportions
"trace"	1% to 10%
"some"	10% to 20%
prefix (i.e. "sandy" silt)	20% to 35%
"and" (i.e. sand "and" gravel)	35% to 50%

b. Compactness and Consistency

The state of compactness of granular soils is defined on the basis of the Standard Penetration Number (N) as per ASTM D-1586. It corresponds to the number of blows required to drive 300 mm of the split spoon sampler using a metal drop hammer that has a weight of 62.5 kg and free fall distance of 760 mm. For a 600 mm long split spoon, the blow counts are recorded for every 150 mm. The "N" value is obtained by adding the number of blows from the 2nd and 3rd count. Technical refusal indicates a number of blows greater than 50.

The consistency of clayey or cohesive soils is based on the shear strength of the soil, as determined by field vane tests and by a visual and tactile assessment of the soil strength.

The state of compactness of granular soils is defined by the following terms:

State of Compactness Granular Soils	Standard Penetration Number "N"	Relative Density (%)
Very loose	0 – 4	<15
Loose	4 – 10	15 – 35
Compact	10 - 30	35 – 65
Dense	30 - 50	65 - 85
Very dense	> 50	> 85

The consistency of cohesive soils is defined by the following terms:

Consistency Cohesive Soils	Undrained Shear Strength (C_u) (kPa)	Standard Penetration Number "N"
Very soft	<12.5	<2
Soft	12.5 - 25	2 - 4
Firm	25 - 50	4 - 8
Stiff	50 - 100	8 - 15
Very stiff	100 - 200	15 - 30
Hard	>200	>30

c. Field Moisture Condition

Description (ASTM D2488)	Criteria
Dry	Absence of moisture, dusty, dry to touch.
Moist	Dump, but not visible water.
Wet	Visible, free water, usually soil is below water table.

2. Sample Data

a. Elevation depth

This is a reference to the geodesic elevation of the soil or to a benchmark of an arbitrary elevation at the location of the borehole or test pit. The depth of geological boundaries is measured from ground surface.

b. Type

Symbol	Type	Letter Code
⌇	Auger	AU
⧗	Split Spoon	SS
‖	Shelby Tube	ST
⫽	Rock Core	RC

c. Sample Number

Each sample taken from the borehole is numbered in the field as shown in this column.

LETTER CODE (as above) – Sample Number.

d. Recovery (%)

For soil samples this is the percentage of the recovered sample obtained versus the length sampled. In the case of rock, the percentage is the length of rock core recovered compared to the length of the drill run.

3. Rock Description

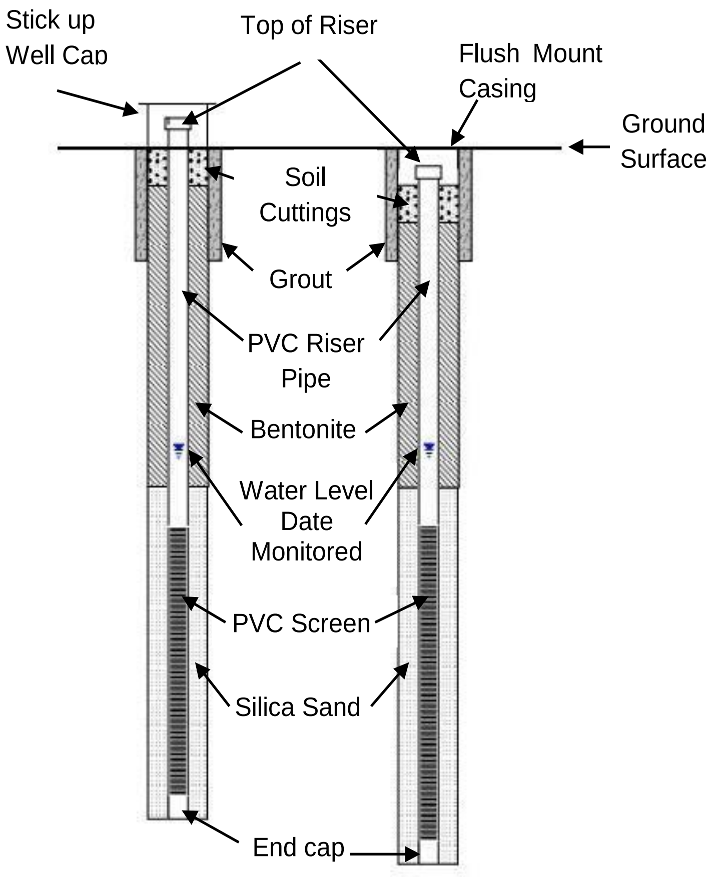
Rock Quality Designation (RQD) is a rough measure of the degree of jointing or fracture in a rock mas. The RQD is calculated as the cumulative length of rock pieces recovered having lengths of 100 mm or more divided by the length of coring. The qualitative description of the bedrock based on RQD is given below.

Rock Quality Designation (RQD) (%)	Description of Rock Quality
0 –25	Very poor
25 – 50	Poor
50 – 75	Fair
75 – 90	Good
90 – 100	Excellent

Strength classification of rock is presented below.

Strength Classification	Range of Unconfined Compressive Strength (MPa)
Extremely weak	< 1
Very weak	1 – 5
Weak	5 – 25
Medium strong	25 – 50
Strong	50 – 100
Very strong	100 – 250
Extremely strong	> 250

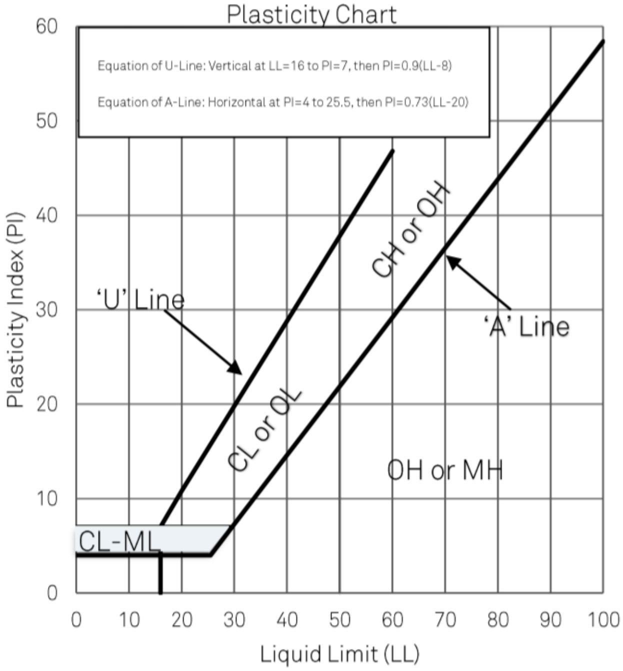
4. General Monitoring Well Data



5. Classification of Soils for Engineering Purposes (ASTM D2487)

(United Soil Classification System)

Major divisions			Group Symbol	Typical Names	Classification Criteria			
Coarse-grained soils More than 50% retained on No. 200 sieve* (>0.075 mm)	Gravels More than 50% of coarse fraction retained on No. 4 sieve(4.75 mm)	Clean gravels <5% fines	GW	Well-graded gravel	If 15% sand add "with sand" to group name.	Classification on basis of percentage of fines: Less than 5% pass No. 200 sieve - GW, GP, SW, SP More than 12% pass No. 200 sieve - GM, GC, SM, SC 5 to 12% pass No. 200 sieve - Borderline classifications, use of dual symbols	$C_u = \frac{D_{60}}{D_{10}} \geq 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravel			Not meeting either Cu or Cc criteria for GW	
		Gravels with >12% fines	GM	Silty gravel			Atterberg limits below "A" line or PI less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravel			Atterberg limits on or above "A" line and PI > 7	If fines are organic add "with orgnic fines" to group name
	Sands 50% or more of coarse fraction passes No. 4 sieve(<4.75 mm)	Clean sands <5% fines	SW	Well-graded sand	If 15% gravel add "with gravel to group name		$C_u = \frac{D_{60}}{D_{10}} \geq 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sand			Not meeting either Cu or C ccriteria for SW	
		Sands with >12% fines	SM	Silty sand			Atterberg limits below "A" line or PI less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sand			Atterberg limits on or above "A" line and PI > 7	If fines are organic add "with orgnic fines" to group name
Fine-grained soils50% or more passes No. 200 sieve* (<0.075 mm)	Silts and Clays Liquid Limit <50%	Inorganic	ML	Silt	If 15 to 29% coarse-grained, add "with sand" or "with gravel" as appropriate. If > 30% coarse-grained, add "sandy" or "gravelly" as appropriate. Class as organic when oven dried liquid limit is < 75% of undried liquid limit.			
			CL	Lean Clay -low plasticity				
		Organic	OL	Organic clay or silt (Clay plots above 'A' Line)				
	Silts and Clays Liquid Limit >50%	Inorganic	MH	Elastic silt				
			CH	Fat Clay -high plasticity				
		Organic	OH	Organic clay or silt (Clay plots above 'A' Line)				
	Highly Organic Soils		PT	Peat, muck and other highly organic soils				



APPENDIX D

Laboratory Results

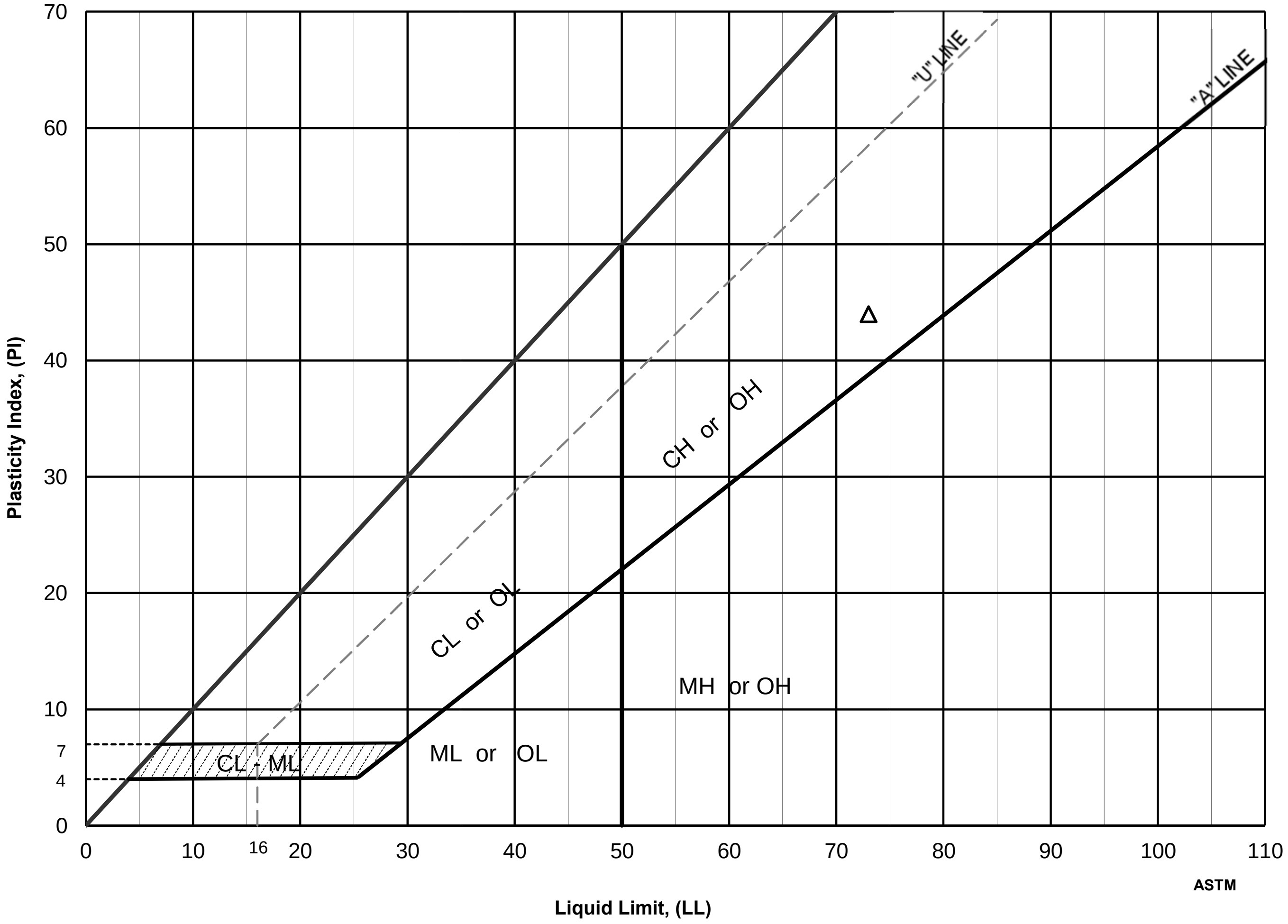
LRL Associates Ltd.

PLASTICITY INDEX

ASTM D 4318 / LS-703/704

Client: Landric Homes
Project: Geotechnical Investigation
Location: Block 9, Eric Czapnick Way, Orleans, ON.
File No.: 200041
Report No.: 1
Date: July 3, 2020

Plasticity Chart



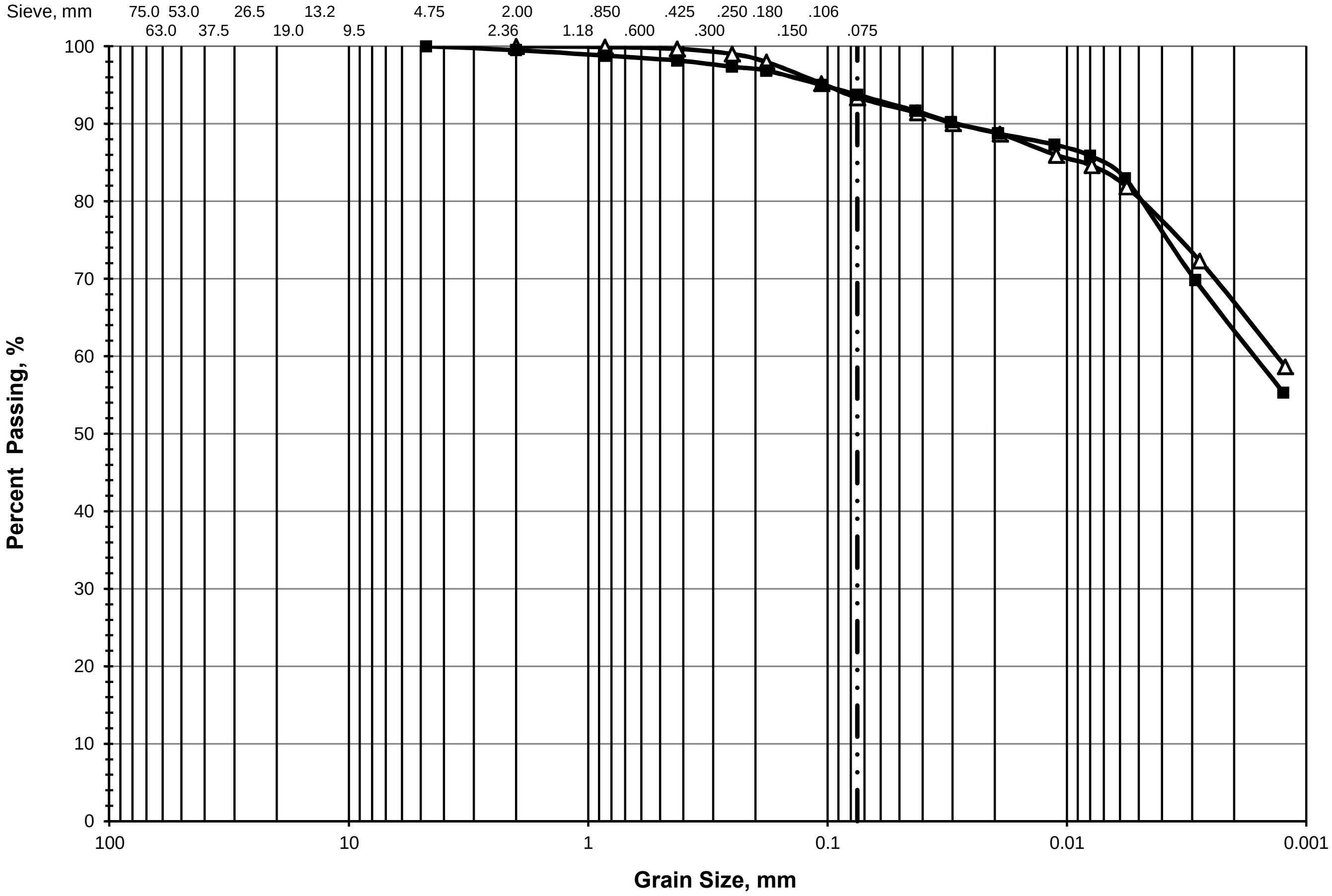
	Location	Sample	Depth, m	Moisture Content, %	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Activity Number	USCS
△	BH 1	SS-7	5.33 - 5.93	38	73	29	44	0.19	0.67	CH

LRL Associates Ltd.

PARTICLE SIZE ANALYSIS

ASTM D 422 / LS-702

Client: Landric Homes
Project: Geotechnical Investigation
Location: Block 9, Eric Czapnick Way, Orleans, ON.
File No.: 200041
Report No.: 2
Date: July 3, 2020



Unified Soil Classification System

	> 75 mm	**% GRAVEL**		**% SAND**			**% FINES**	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
△	0.0	0.0	0.0	0.0	0.3	6.3	27.9	65.5
■	0.0	0.0	0.0	0.5	1.3	4.4	31.8	62.0

	Location	**Sample**	**Depth, m**	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
△	BH 1	SS-6	4.57 - 5.18	0.0014						
■	BH 4	SS-1	0.76 - 1.37	0.0018						

LRL Associates Ltd.

Unconfined Compressive Strength of Intact Rock Core

ASTM D 7012: Method C

Client: Landric Homes
Project: Geotechnical Investigation
Location: Block 9, Eric Czapnick Way, Orleans, ON.

File No.: 200041
Report No.: 3
Date: July 3, 2020

Drill Core Information

Date(s) Sampled: June 30, 2020 & July 3, 2020
Sampled By: LRL Associates Ltd.
Date Received: July 8, 2020

Laboratory Identification	Core No.	Field Identification	Borehole	Run	Depth, m	Location / Description
C01169	1		BH 3	n/a	3.90 - 4.10	
C01170	2		BH 4	n/a	5.90 -6.10	
C01171	3		BH 5	n/a	1.65 - 1.90	

Rock Core Unconfined Compressive Strength Test Data

	Core No.	Conditioning	Length, mm	Diameter, mm	Density, kg/m^3	MPa	Description of Failure
C01169	1	As received	91.2	44.9	2677	137.5	Columnar, relatively well formed cone on each end
C01170	2	As received	90.3	44.9	2670	120.0	Columnar, relatively well formed cone on one end
C01171	3	As received	90.2	44.9	2667	102.6	Columnar, relatively well formed cone on one end

Comments:

Date Issued: July 14, 2020

Reviewed By: W.A.McLaughlin

W.A.M^{c}Laughlin, Geo.Tech., C.Tech.

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Certificate of Analysis

LRL Associates Ltd.

5430 Canotek Road
Ottawa, ON K1J 9G2
Attn: Brad Johnson

Client PO:
Project: 200041
Custody: 55459

Report Date: 14-Jul-2020
Order Date: 9-Jul-2020

Order #: 2028392

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	**Client ID**
2028392-01	BH1 5-7'
2028392-02	BH4 7.5-9.5

Approved By:

Dale Robertson, BSc
Laboratory Director

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	13-Jul-20	13-Jul-20
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	10-Jul-20	11-Jul-20
Resistivity	EPA 120.1 - probe, water extraction	14-Jul-20	14-Jul-20
Solids, %	Gravimetric, calculation	11-Jul-20	11-Jul-20

Certificate of Analysis

Client: **LRL Associates Ltd.**

Client PO:

Report Date: 14-Jul-2020

Order Date: 9-Jul-2020

Project Description: 200041

	Client ID:	BH1 5-7'	BH4 7.5-9.5	-	-
	Sample Date:	30-Jun-20 08:30	03-Jul-20 12:00	-	-
	Sample ID:	2028392-01	2028392-02	-	-
	MDL/Units	Soil	Soil	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	73.0	85.4	-	-
General Inorganics					
pH	0.05 pH Units	7.78	7.97	-	-
Resistivity	0.10 Ohm.m	22.5	60.8	-	-
Anions					
Chloride	5 ug/g dry	26	20	-	-
Sulphate	5 ug/g dry	373	23	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Resistivity	ND	0.10	Ohm.m						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	347	5	ug/g dry	311			10.8	20	
Sulphate	71.2	5	ug/g dry	66.3			7.2	20	
General Inorganics									
pH	11.65	0.05	pH Units	11.76			0.9	2.3	
Resistivity	31.4	0.10	Ohm.m	31.8			1.3	20	
Physical Characteristics									
% Solids	88.2	0.1	% by Wt.	89.1			1.0	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	413	5	ug/g	311	101	82-118			
Sulphate	170	5	ug/g	66.3	103	80-120			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.
NC: Not Calculated

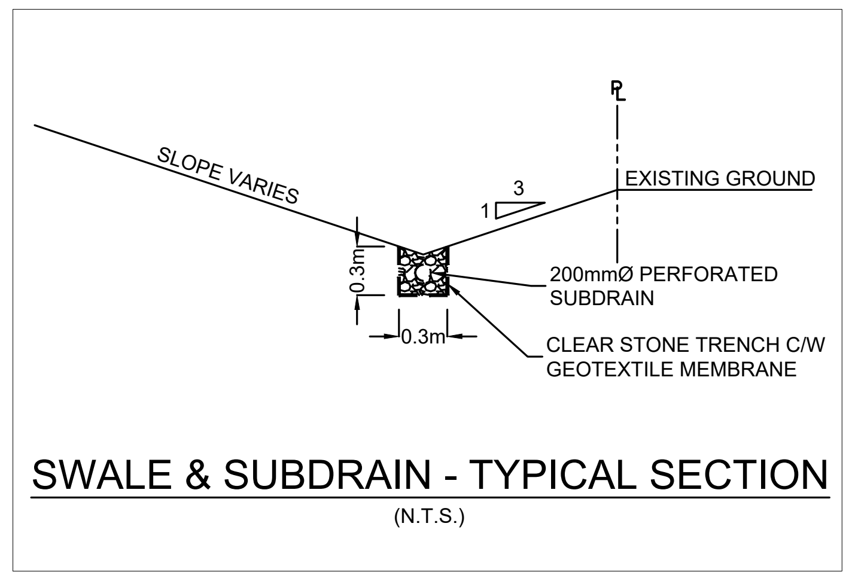
Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

APPENDIX E

Slope Stability Analysis Results

GENERALGRADING NOTES

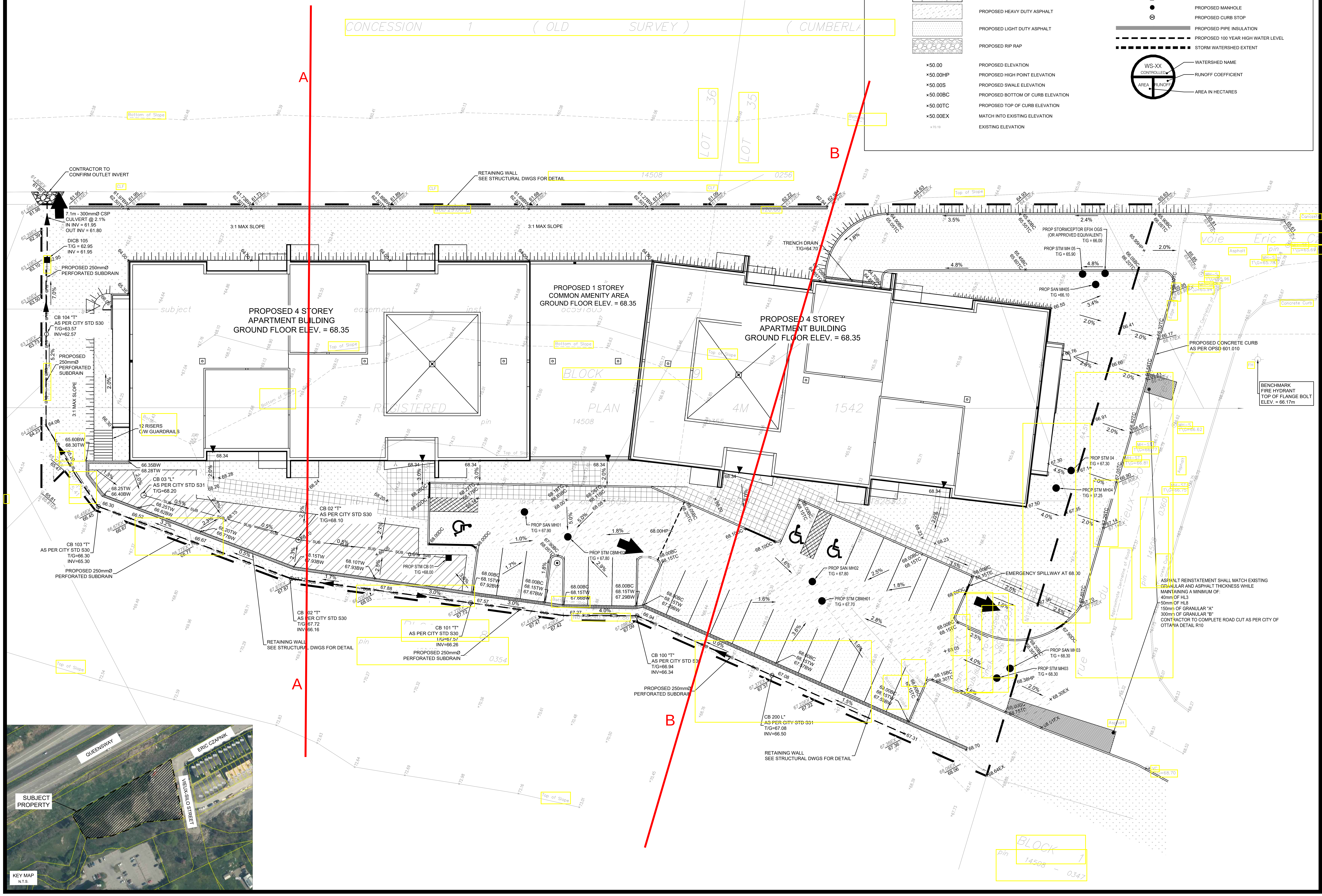
1. ANY MODIFICATIONS IN ELEVATION BETWEEN THE SURVEY AND CONSTRUCTION THAT WILL AFFECT THE PROJECT ARE TO BE COMMUNICATED WITH THE ENGINEER PRIOR TO START OF CONSTRUCTION.
2. PRIOR TO START OF ANY WORK ON SITE, THE CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY EXISTING GRADES AND ENSURE OVERLAND DRAINAGE IS FEASIBLE WITH ACTUAL SITE CONDITIONS.
3. ANY DISCREPANCIES ARE TO BE COMMUNICATED WITH THE ENGINEER PRIOR TO CONSTRUCTION.
4. NO EXCESS DRAINAGE, EITHER DURING OR AFTER CONSTRUCTION, WILL BE DIRECTED TOWARDS NEIGHBOURING PROPERTIES.
5. NO ALTERATION OF EXISTING GRADES AND DRAINAGE PATTERNS ON PROPERTY BOUNDARIES.
6. ENSURE POSITIVE DRAINAGE AWAY FROM FOUNDATION.



SWALE & SUBDRAIN - TYPICAL SECTION
(N.T.S.)

LEGEND:

▬ ▬	EXISTING PROPERTY LINE TO REMAIN
═	PROPOSED CURB
═ DC	PROPOSED DEPRESSED CURB
╨╨╨╨	PROPOSED TERRACING (3:1 MIN.)
─□─□─	PROPOSED SILT FENCE AS PER OPSD 219.110
─○─○─	PROPOSED FENCE
▼	PROPOSED DOOR ENTRANCE/EXIT
▨	PROPOSED GRASS AREA (100mm TOP SOIL & SOD)
▨	PROPOSED CONCRETE FEATURES/SLAB
▨	PROPOSED HEAVY DUTY ASPHALT
▨	PROPOSED LIGHT DUTY ASPHALT
▨	PROPOSED RIP RAP
×50.00	PROPOSED ELEVATION
×50.00HP	PROPOSED HIGH POINT ELEVATION
×50.00S	PROPOSED SWALE ELEVATION
×50.00BC	PROPOSED BOTTOM OF CURB ELEVATION
×50.00TC	PROPOSED TOP OF CURB ELEVATION
×50.00EX	MATCH INTO EXISTING ELEVATION
×70.19	EXISTING ELEVATION
➡	PROPOSED OVERLAND MAJOR FLOW ROUTE
— SUB — SUB — SUB —	PROPOSED 100mmØ PERFORATED SUBDRAIN
— STM — STM — STM —	PROPOSED STORM SEWER
— SAN — SAN — SAN —	PROPOSED SANITARY SEWER
— WTR — WTR — WTR —	PROPOSED WATERMAIN
— STM — STM — STM —	EXISTING STORM SEWER
— SAN — SAN — SAN —	EXISTING SANITARY SEWER
— WTR — WTR — WTR —	EXISTING WATERMAIN
— GAS — GAS — GAS —	EXISTING GAS LINE
●	EXISTING MANHOLE
■	EXISTING CATCHBASIN
■	PROPOSED CATCHBASIN-MANHOLE/CATCHBASIN
●	PROPOSED MANHOLE
⊗	PROPOSED CURB STOP
▬	PROPOSED PIPE INSULATION
▬ ▬ ▬	PROPOSED 100 YEAR HIGH WATER LEVEL
■ ■ ■	STORM WATERSHED EXTENT
WS-XX	WATERSHED NAME
CONTROLLED RUNOFF	RUNOFF COEFFICIENT
AREA	AREA IN HECTARES



NOT FOR CONSTRUCTION TENDER OR PERMIT

USE AND INTERPRETATION OF DRAWINGS

GENERAL CONDITIONS OF THE CONTRACT FOR CONSTRUCTION ARE PART OF THE CONTRACT DOCUMENTS AND DESCRIBE USE AND INTENT OF THE DRAWING. THE CONTRACT DOCUMENTS INCLUDE NOT ONLY THE DRAWINGS, BUT ALSO THE OWNER-CONTRACTOR AGREEMENTS, CONDITIONS OF THE CONTRACT, THE SPECIFICATIONS, ADDENDA, AND MODIFICATIONS ISSUED AFTER EXECUTION OF THE CONTRACT. THESE CONTRACT DOCUMENTS ARE COMPLEMENTARY, AND WHAT IS REQUIRED BY ANY ONE SHALL BE BINDING AS IF REQUIRED BY ALL. WORK NOT COMPLETELY DELINEATED HEREON SHALL BE CONSTRUCTED OF THE SAME MATERIALS AND DETAILED SIMILARLY AS WORK SHOWN MORE COMPLETELY ELSEWHERE IN THE CONTRACT DOCUMENTS.

BY USE OF THE DRAWINGS FOR CONSTRUCTION OF THE PROJECT, THE OWNER CONFIRMS THAT HE HAS REVIEWED AND APPROVED THE DRAWINGS. THE CONTRACTOR CONFIRMS THAT HE HAS VISITED THE SITE, FAMILIARIZED HIMSELF WITH THE LOCAL CONDITIONS, VERIFIED FIELD DIMENSIONS AND CORRELATED HIS OBSERVATIONS WITH THE REQUIREMENTS OF THE CONTRACT DOCUMENTS.

AS INSTRUMENTS OF SERVICE, ALL DRAWINGS, SPECIFICATIONS, CADD FILES OR OTHER ELECTRONIC MEDIA AND COPIED THERE OF FURNISHED BY THE ENGINEER ARE HIS PROPERTY. THEY ARE TO BE USED ONLY FOR THIS PROJECT AND ARE NOT TO BE USED ON ANY OTHER PROJECT, INCLUDING REPEATS OF THE PROJECT. CHANGES TO THE DRAWINGS MAY ONLY BE MADE BY THE ENGINEER.

UNLESS THE REVISION TITLE IS "ISSUED FOR CONSTRUCTION", THESE DRAWINGS SHALL BE CONSIDERED PRELIMINARY AND SHALL NOT BE USED AS A CONSTRUCTION DOCUMENT.

THESE DRAWINGS ILLUSTRATES THE WORK TO BE DONE. THE ENGINEER IS NOT RESPONSIBLE FOR THE MEANS, METHODS, TECHNIQUES, SEQUENCES, AND PROCEDURES USED TO DO THE WORK, OR THE SAFETY ASPECTS OF CONSTRUCTION, AND NOTHING ON THESE DRAWINGS EXPRESSED OR IMPLIED CHANGES THIS CONDITION. CONTRACTOR SHALL DETERMINE ALL CONDITIONS AT THE SITE AND SHALL BE RESPONSIBLE FOR KNOWING HOW THEY AFFECT THE WORK. SUBMITTAL OF A BID TO PERFORM THIS WORK IS ACKNOWLEDGEMENT OF THE RESPONSIBILITIES, AND THAT THEY HAVE BEEN FULLY CONSIDERED IN PLANNING OF THE WORK, AND THE BID PRICE. NO CLAIMS FOR EXTRA CHARGES DUE TO THESE CONDITIONS WILL BE FORTHCOMING.

UNAUTHORIZED CHANGES:

IN THE EVENT THE CLIENT, THE CLIENT'S CONTRACTORS OR SUBCONTRACTORS, OR ANYONE FOR WHOM THE CLIENT IS LEGALLY LIABLE MAKES OR PERMITS TO BE MADE ANY CHANGES TO ANY REPORTS, PLANS, SPECIFICATIONS OR OTHER CONSTRUCTION DOCUMENTS PREPARED BY LRL ASSOCIATES LTD. (LRL) WITHOUT OBTAINING LRL'S PRIOR WRITTEN CONSENT, THE CLIENT SHALL ASSUME FULL RESPONSIBILITY FOR THE RESULTS OF SUCH CHANGES. THEREFORE THE CLIENT AGREES TO WAIVE ANY CLAIM AGAINST LRL AND TO RELEASE LRL FROM ANY LIABILITY ARISING DIRECTLY OR INDIRECTLY FROM SUCH UNAUTHORIZED CHANGES.

IN ADDITION, THE CLIENT AGREES, TO THE FULLEST EXTENT PERMITTED BY LAW, TO INDEMNIFY AND HOLD HARMLESS LRL FROM ANY DAMAGES, LIABILITIES OR COST, INCLUDING REASONABLE ATTORNEY'S FEES AND COST OF DEFENSE, ARISING FROM SUCH CHANGES.

IN ADDITION, THE CLIENT AGREES TO INCLUDE IN ANY CONTRACTS FOR CONSTRUCTION APPROPRIATE LANGUAGE THAT PROHIBITS THE CONTRACTOR OR ANY SUBCONTRACTORS OF ANY TIER FROM MAKING ANY CHANGES OR MODIFICATIONS TO LRL'S CONSTRUCTION DOCUMENTS WITHOUT THE PRIOR WRITTEN APPROVAL OF LRL AND THAT FURTHER REQUIRES THE CONTRACTOR TO INDEMNIFY BOTH LRL AND THE CLIENT FROM ANY LIABILITY OR COST ARISING FROM SUCH CHANGES MADE WITHOUT SUCH PROPER AUTHORIZATION.

GENERAL NOTES:

EXISTING SERVICES AND UTILITIES SHOWN ON THESE DRAWINGS ARE TAKEN FROM THE BEST AVAILABLE RECORDS, BUT MAY NOT BE COMPLETE OR TO DATE. CONTRACTOR SHALL VERIFY IN FIELD FOR LOCATION AND ELEVATION OF PIPES AND CHECK WITH THE UTILITY COMPANIES BEFORE DIGGING OR PERFORMING WORK.

CONTRACTOR IS ADVISED TO COLLECT INFORMATION ON SOIL CONDITIONS BEFORE START OF CONSTRUCTION.

THE ENGINEER WAIVES ANY AND ALL RESPONSIBILITY AND LIABILITY FOR PROBLEMS WHICH ARISE FROM FAILURE TO FOLLOW THESE PLANS, SPECIFICATIONS AND THE DESIGN INTENT THEY CONVEY, OR FOR PROBLEMS WHICH ARISE FROM OTHERS' FAILURE TO OBTAIN AND/OR FOLLOW THE ENGINEER'S GUIDANCE WITH RESPECT TO ANY ERRORS, OMISSIONS, INCONSISTENCIES AMBIGUITIES OR CONFLICTS WHICH ARE ALLEGED.

CONTRACTOR TO VERIFY ALL DIMENSIONS AND NOTIFY THE ENGINEER OF ANY DISCREPANCIES BEFORE WORK COMMENCES. DO NOT SCALE DRAWINGS.

5m 2 0 5m
SCALE: 1:200

No.	REVISIONS	BY	DATE
01	ISSUED FOR APPROVAL	A.S.	17 JUL 2020

M. BASNET
100501996
2020-07-17

NOT AUTHENTIC UNLESS SIGNED AND DATED

LRL
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www.lrl.ca | (613) 842-3434

CLIENT
LANDRIC HOMES INC.

DESIGNED BY:	DRAWN BY:	APPROVED BY:
A.S.	A.S.	M.B.

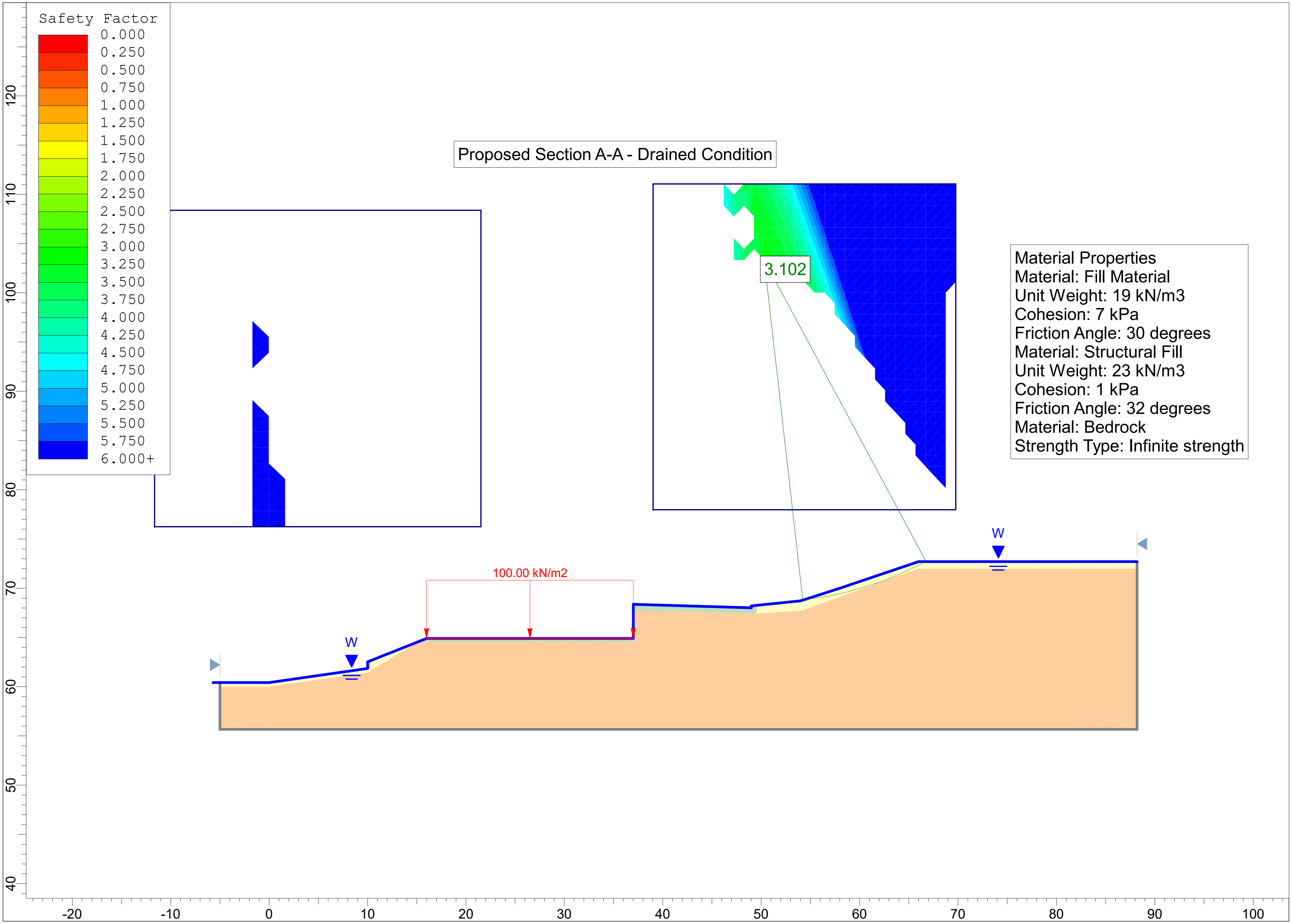
PROJECT
BLOCK 9
APARTMENT BUILDINGS
ERIC CZAPNIK WAY, ORLEANS

DRAWING TITLE
GRADING AND DRAINAGE PLAN

PROJECT NO.
200041

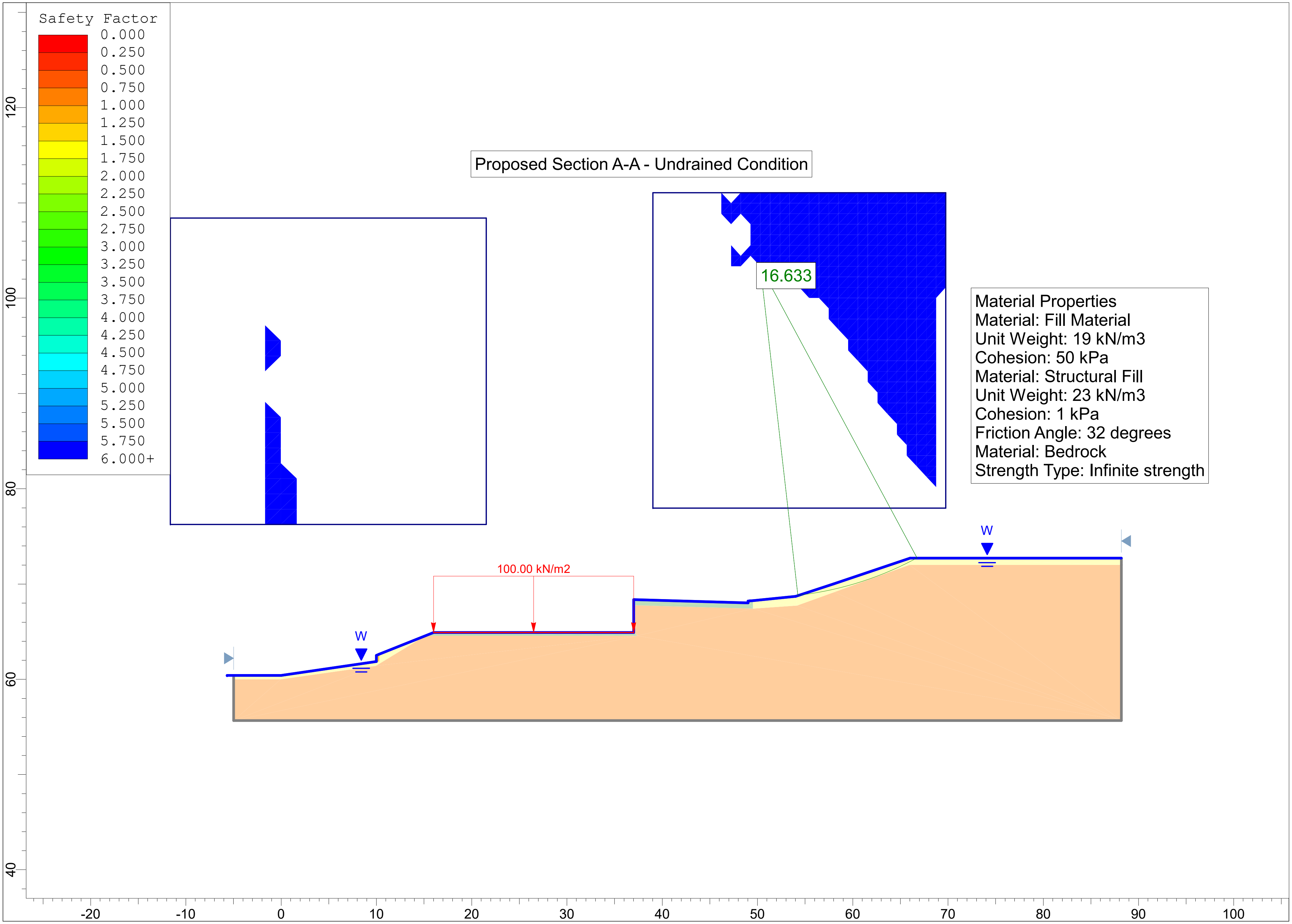
DATE
APRIL 2020

C301



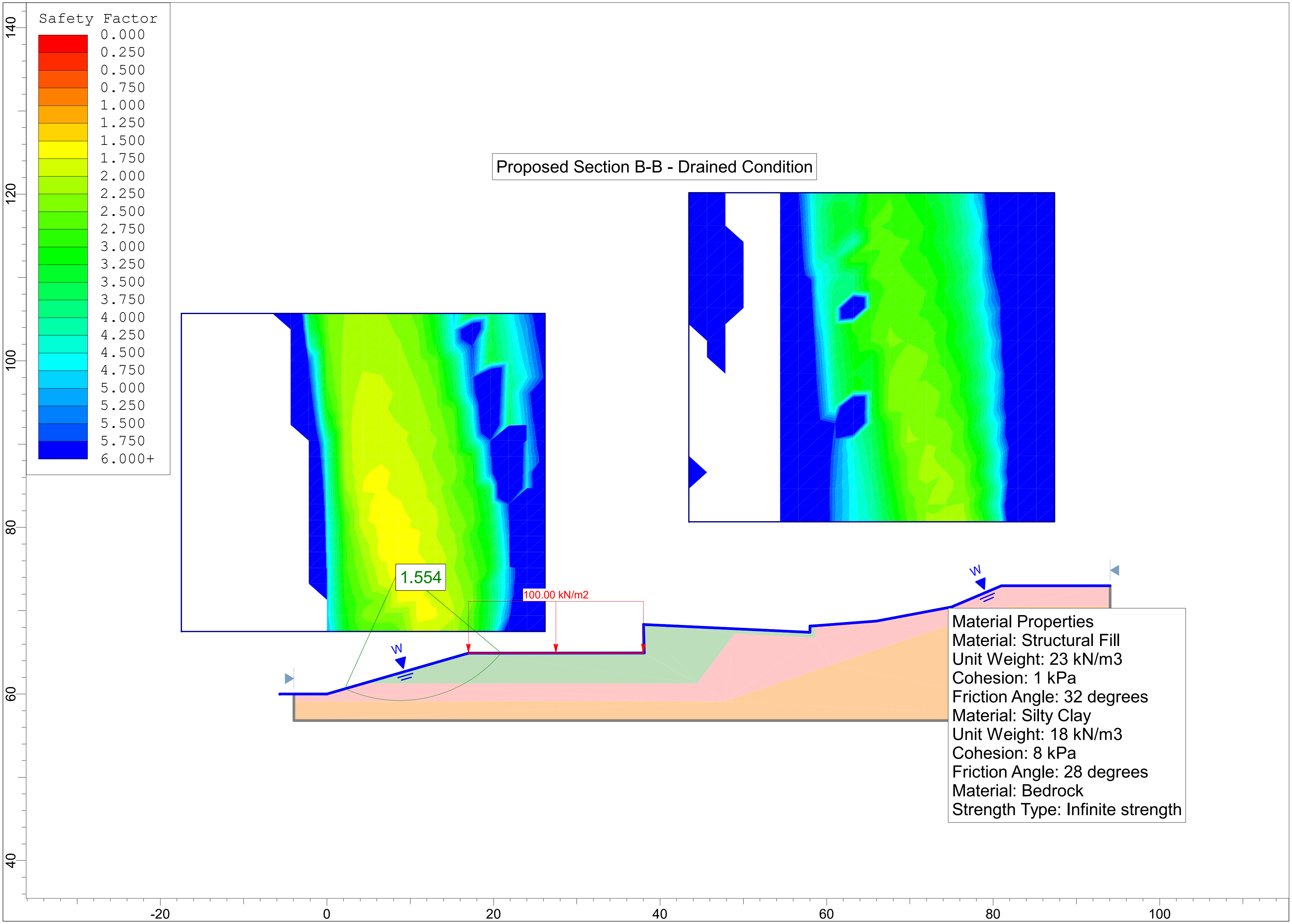
Proposed Section A-A - Drained Condition

Material Properties
Material: Fill Material
Unit Weight: 19 kN/m3
Cohesion: 7 kPa
Friction Angle: 30 degrees
Material: Structural Fill
Unit Weight: 23 kN/m3
Cohesion: 1 kPa
Friction Angle: 32 degrees
Material: Bedrock
Strength Type: Infinite strength



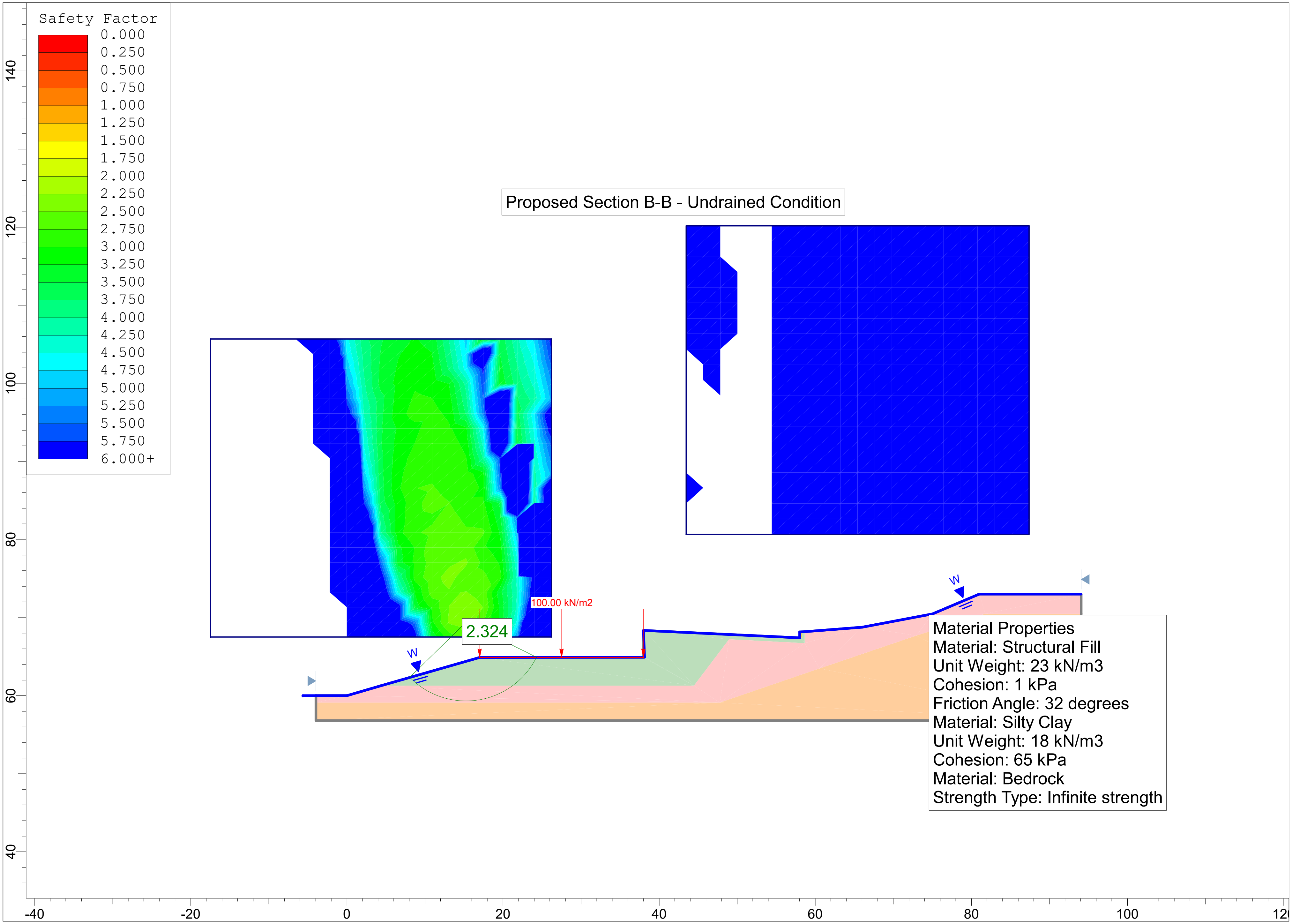
Proposed Section A-A - Undrained Condition

Material Properties
Material: Fill Material
Unit Weight: 19 kN/m3
Cohesion: 50 kPa
Material: Structural Fill
Unit Weight: 23 kN/m3
Cohesion: 1 kPa
Friction Angle: 32 degrees
Material: Bedrock
Strength Type: Infinite strength



Proposed Section B-B - Drained Condition

Material Properties
Material: Structural Fill
Unit Weight: 23 kN/m3
Cohesion: 1 kPa
Friction Angle: 32 degrees
Material: Silty Clay
Unit Weight: 18 kN/m3
Cohesion: 8 kPa
Friction Angle: 28 degrees
Material: Bedrock
Strength Type: Infinite strength



Proposed Section B-B - Undrained Condition

Material Properties
Material: Structural Fill
Unit Weight: 23 kN/m3
Cohesion: 1 kPa
Friction Angle: 32 degrees
Material: Silty Clay
Unit Weight: 18 kN/m3
Cohesion: 65 kPa
Material: Bedrock
Strength Type: Infinite strength