1600 Kerns Road, City of Burlington, Ontario

Type of Document:
Slope Stability Analysis

Project Name:
1600 Kerns Road, City of Burlington, Ontario

Project Number:

BRM-00801554-G0

Submitted By:

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Date Submitted:

February 11, 2022

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1. Introduction

This report was originally issued on October 18, 2018. Reported physical site conditions at that time were based on observations made during a site visit by EXP Services Inc. (EXP) on September 17, 2018. Follow-up site visits were made by EXP on February 24, 2021 and November 7, 2021. Physical site conditions observed during the February 24, 2021 site visit were found to be the essentially the same as those observed during the September 17, 2018 site visit. However, during the visual examination on November 7, 2021, localized slope toe erosion was observed by EXP, which confirmed the previous observations of the owner and Conservation Halton (CH) staff.

This report presents the results of a slope stability evaluation to verify the potential impact on the existing slopes along the west property boundary due to construction of a proposed residential development at 1600 Kerns Road, Burlington, Ontario. This report provides the stability analysis results and toe erosion allowance for the interpreted post construction conditions.

The slope stability analyses were carried out using the subsurface conditions from the following reports.

- Preliminary Geotechnical Report. 1600 Kerns Road, Burlington, Ontario. EXP Project No. BRM-00801554-B0, dated October 18, 2018.

- Environmental Subsurface Investigation. 1600 Kerns Road, Burlington, Ontario. EXP Project No. BRM-00801554-D0, dated December 1, 2018.

For this study, EXP was provided with Grading Plan Contour (Reference No. 18-30-288-00-A, J.D. Barnes, dated September 14, 2018) and Survey Plan (Reference No. 18-30-288-01-6, J.D. Barnes, dated January 8, 2020 and Reference No. 18-30-288-02-D, J.D. Barnes, dated November 6, 2020). The Survey Plan presents the Physical Top of Bank as staked by CH on November 29, 2019. The proposed Grading Plan with level spreader has been reviewed. We understand that the proposed residential building will be at least 7.5 m from the setback of stable top of slope and toe erosion allowance. Hence, the proposed foundation will not impinge on the stable slope and it will not change the slope conditions. The post-construction conditions and pre-construction conditions will be the same.

2. Visual Examination

2.1 Previous Slope Inspection

The study included site visits to visually inspect the conditions of the slope and to record the general slope conditions, including signs of instability (if any), vegetative cover, and any internal or surface erosion.

The subject slopes are located on the west side of the proposed residential redevelopment, at 1600 Kerns Road, Burlington, Ontario.

The height of the slope is approximately 9.0 to 10.9 m. The overall slope gradient varies from approximately 1.3H:1V to 3.4H:1V. The slope is covered with tall grasses and some mature trees.

During the site visit on September 17, 2018 and February 24, 2021, no visible signs of instability (e.g., surface failure, leaning trees, tension cracks, etc.) were noted. Approximately 0.3 m deep stream flow off the toe of the slope was observed during the site visit.

2.2 Current Visual Examination

The previous slope inspection focused on slope stability only. However, according to the provided information from the other sources, erosion at a portion of the slope toe has been noticed years ago. To improve the understanding of the whole slope, a visual examination of the slope toe was undertaken on October 7, 2021. The water flow to the site originates from a concrete culvert installed through a gabion basket headwall at the north end of the slope toe.

During the site visit, no toe erosion feature was found on the north and south portions of the toe of the slope. However, in the middle portion of the slope toe, some erosion was observed. The exposed strata were clayey silt till along the north and majority of the middle portions of the toe area, and shale bedrock near the south end of the slope toe. The eroded area was covered with matured tress and scattered small vegetation such as shrubs. The southward flowing Upper Hager Creek is located on the west side of the slope toe. During the visual examination, the bankful width of the water course within the project limits was about 0.5 – 2.0 m. The depth of the creek was less than 0.2 m at the time of the visit. This watercourse is about 0 to 3 m from the identified toe of the slope. The site photographs showing the general conditions of the slope at the time of current visual examination are presented in Appendix A.

Based on the observations of the previous and current visual examinations in different months, the flow is anticipated to be normally very minor except during heavy storms where significant flows will occur. On the west side of the watercourse, the ground surface of the flood plain is relatively flat, especially for the middle and south portions. Therefore, during heavy storms,

the whole valley floor would likely be flooded and provide a much greater area for the flow. In addition, the concrete culvert orientation will generally direct the water more to the west when the flow volume is significant and not against the slope at this site.

3. Subsurface Conditions

The detailed soil profiles encountered in each borehole and the results of laboratory testing are indicated on the attached borehole logs in Appendix B. It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change.

The following is a brief description of the subsurface conditions encountered during the previous geotechnical investigation within the study area, in terms of slope stability and toe erosion.

3.1 Section 1-1 (Boreholes 6 and 7)

Borehole 6 was drilled on the crest of the slope and Borehole 7 was advanced at the slope toe.

Asphalt Concrete Pavement Structure

Present at the ground surface at the top of the slope is a 135 mm asphalt concrete surface finish over 250 mm granular base (pavement structure).

Existing Fill

The existing fill consisting of clayey silt with trace gravel was encountered below the asphalt concrete pavement structure to a depth of 7.2 m below the existing ground surface in Borehole 6. The fill is brown to grey in colour and has a natural moisture content of 6 to 27 percent. The SPT N-values of the fill ranged from 5 to 9 blows/0.3 m.

Clayey Silt

A deposit of clayey silt was encountered below the fill in Borehole 6 to a borehole termination depth of 8.2 m below the existing ground surface. The clayey silt was encountered from ground surface to approximately 1.4 m depth in Borehole 7. The clayey silt is grey to black in colour and has a natural moisture content of 48 percent. The SPT N-values of the clayey silt were 4 to 16 blows/0.3 m, which indicates a soft to very stiff consistency.

Clayey Silt Till

A clayey silt glacial till was found below the clayey silt in Borehole 7 and extends to a borehole termination depth of about 1.9 m. This cohesive till is generally grey in colour. The SPT N-value of the clayey silt till was 85 blows/0.25 m, which indicates a hard consistency.

Groundwater

The groundwater condition at this cross section was assessed by observing the water levels in the open holes during the field work and observations from the monitoring well in Borehole 6. Groundwater was observed at 4.7 m depth upon completion of drilling of the borehole and 3.6 m four days after drilling. Seasonal fluctuations of the groundwater level at the site should be anticipated.

3.2 Section 2-2 (Borehole 4)

Borehole 4 was drilled on the slope crest.

Asphalt Concrete Pavement Structure

Present at the ground surface of the slope is a 90 mm asphalt concrete surface finish over 125 mm granular base (pavement structure).

Clayey Silt Till

A deposit of clayey silt till was found below the asphalt concrete pavement structure in Borehole 4 and extends to the borehole termination depth of 9.8 m below the existing ground surface. The clayey silt till is generally reddish brown in colour. This deposit has a natural moisture content of 12 to 18 percent. The SPT N-values of the till were 13 to 63 blows/0.3 m, which indicates stiff to hard consistency.

Groundwater

The groundwater condition at the site was assessed by observing the water level in the open hole during the field work. No groundwater was observed upon completion of drilling of the borehole. Seasonal fluctuations of the groundwater level at the site should be anticipated.

3.3 Section 3-3 (Boreholes 4 and HA 3)

Borehole 4 was drilled on the crest of the slope and Borehole HA 3 was advanced at the slope face.

Asphalt Concrete Pavement Structure

Present at the ground surface of the slope crest in Borehole 4 is a 90 mm asphalt concrete surface finish over 125 mm granular base (pavement structure).

Existing Fill

A deposit of existing fill consisting of clayey silt with trace sand, trace gravel and trace organics was encountered from surface to a depth of 1.2 m below the existing ground surface in Borehole HA 3. The fill is brown in colour.

Clayey Silt Till

A deposit of clayey silt till was found below the existing fill in Borehole HA 3 or below the asphalt concrete surface finish in Borehole 4 and extends to the borehole termination depths of 3.1 to 9.8 m below the existing ground surface. The clayey silt till is described as clayey silt on the log of Borehole HA 3. The clayey silt till is generally reddish brown in colour. This deposit has a natural moisture content of 12 to 18 percent. The SPT N-values of the clayey silt till were 13 to 53 blows/0.3 m, which indicates stiff to hard consistency.

Groundwater

The groundwater condition at the site was assessed by observing the water level in the open holes during the field work. No groundwater was observed upon completion of drilling of the boreholes. Seasonal fluctuations of the groundwater level at the site should be anticipated.

4. Slope Stability Analysis

Based on the visual examinations during 2018 and 2021, the slope configuration has no significant change. Therefore, the slope stability analyses in the previous slope stability reports are considered to be valid.

For the slope stability study, the site conditions, contour drawing and available plan showing pre-construction site conditions were reviewed. EXP carried out analyses on three (3) slope cross sections, namely Cross Sections 1-1, 2-2 and 3-3, as shown on the attached Drawing No. 1 in Appendix B. The Survey Plan (J.D. Barnes, dated November 6, 2020) is included in this report following Drawing No. 1 in Appendix B.

4.1 Methodology

The selected three (3) cross sections are considered to be critical, in terms of slope stability for pre-construction and post-construction conditions. Slope geometry in the provided Survey Plan was utilized in the analyses for the cross sections.

All stability analyses were carried out using the Slope/W software (GeoStudio 2012), and subsurface conditions revealed by the boreholes referenced for the respective slope sections. The factor of safety (F.S.) against slope failure was evaluated based on the limit equilibrium analysis method proposed by Morgenstern and Price for circular sliding surfaces.

The soil parameters adopted in the analyses are summarized in Table 1. These parameters are estimated from the index properties of the soil units, and are considered to be realistic and slightly conservative.

Table 1: Soil Parameters Used in Analysis

Material	Unit Weigh (kN/m^3)	Effective Cohesion (kPa)	Friction Angle (degree)
Existing Fill	19	0	28
Clayey Silt	19	0	22
Clayey Silt Till	22	0	36

Each cross section was analyzed under static and seismic conditions. Design ground acceleration for the project site was determined from the Earthquake Hazards Program Website by interpolating 2015 National Building Code of Canada Seismic Hazard values. The map indicates a peak horizontal ground acceleration (PGA) value of approximately 0.156 g at

the project site[1]. The value is associated with an earthquake having 2 percent probability of exceedance in a 50-year period (0.000404 per annum probability).

The results of the analyses are shown in Figures 1 to 6 in Appendix C and are summarized in the following Table 2.

Table 2: Slope Stability Analysis Results

Sections	Minimum Factor of Safety			
	Static	Figure No.	Seismic	Figure No.
1-1	1.41	1	1.00	2
2-2	1.36	3	1.09	4
3-3	1.44	5	1.09	6

The failure surfaces representing the minimum F.S. for each cross section from the analyses are shown with hatched lines in the figures with the corresponding F.S. identified in red font.

In general, according to guidelines of CH, acceptable minimum Factors of Safety under static and seismic conditions are 1.5 and 1.1, respectively. Where minimum F.S. less than these values were returned by the analyses, the failure surfaces associated with the minimum acceptable F.S. as indicated by the analyses and in accordance with CH guidelines, are indicated with their centres identified in black font.

4.2 Results of Slope Stability Analyses

Section 1-1 – North Portion of Slope (Figures 1 and 2, Appendix C)

The existing slope at this cross section is about 10.9 m high, and the slope gradient is gentle at about 1.3H:1V at the toe and 2.3H:1V in the upper slope. The minimum calculated values of F.S. for this section are 1.41 and 1.00 under static and seismic conditions, respectively. To meet the requirement of CH, these failure surfaces in the analyses were forced into the slope until a static F.S. of 1.5 and a seismic F.S. of 1.1 were achieved, see Figures 1 and 2, Appendix C. The results indicate that the physical top of slope will be the long term stable top of slope.

[1] g = the acceleration of gravity = ~9.81 m/sec^2

Section 2-2 – South Portion of Slope (Figures 3 and 4, Appendix C)

The existing slope at this cross section is about 9.0 m high, and the slope gradient is at about 1.7H:1V in the upper slope and 3.4H:1V at the lower slope. The minimum calculated F.S. values for this cross section are 1.36 and 1.09 under static and seismic conditions, respectively. These failure surfaces in the analyses were forced into the slope until a static F.S. of 1.5 and a seismic F.S. of 1.1 were achieved. The results indicate that the physical top of slope will be the long term stable top of slope.

Section 3-3 – Middle Portion of Slope (Figures 5 and 6, Appendix C)

The existing slope at this cross section is about 8.5 m high, and the slope gradient is at about 1.3H:1V. The minimum calculated values of F.S. for this proposed section are 1.44 and 1.09 under static and seismic conditions, respectively. These failure surfaces in the analyses were forced into the slope until a static F.S. of 1.5 and a seismic F.S. of 1.1 were achieved. The results indicate that the physical top of slope will be the long term stable top of slope.

5. Toe Erosion Allowance

Based on the observations, under normal flow conditions, there would be no toe erosion to the subject slope as the flow velocity is very low and the volume of water is small. During heavy storms (50 to 100 year events), there could be some slope toe erosion due to the flow.

According to EXP geotechnical investigation in 2018, the soil at the slope toe consists of very stiff to hard clayey silt till and shale bedrock. In general, for a cohesive soil, the rate at which erosion of slope toe occurs can be viewed as being a function of the relative strength of the 'assailing forces' (water flow action) and the 'resisting forces' (the strength of the cohesive soil). Therefore, at low flow conditions, the potential for toe erosion is not anticipated given the identified stratum. It has been shown through previous research that the strength of over-consolidated clayey tills decreases close to the surface over time, due to expansion and to weathering processes such as wetting and drying and freeze-thaw actions. For shale bedrock, the erosion by the water flow under low flow conditions are not anticipated. During a short duration from a heavy storm, the erosion of the shale is expected to be minimal.

The mechanism of slope toe erosion is quite complex and difficult to predict. However, measurements of historic slope toe recession rates can provide a good engineering estimate of future rates along the toe. According to Policies and Guidelines for the Administration of Ontario Regulation 162/06 and Land Use Planning Policy Document, Conservation Halton (dated November 26, 2020), the toe erosion allowance is defined as 100 times the average annual recession rate where a minimum of 35 years of recession information is available.

EXP reviewed historical aerial photographs for this site available from the website of the City of Burlington and the database of Google Earth Pro. The reviewed photographs are from the years 1985 to 2021, extending 36 years. Four (4) selected historical aerial photographs from those reviewed were used in support of this study and are included in Figures 1 to 4, Appendix D. The comparison of the slope toe over years are shown in Figures 5 and 6, Appendix D. Based on this desktop study, the north portion of the slope toe is considered to be an accession area, the middle portion of the slope toe is considered to be a recession area, in terms of the slope toe areas of interest. The south portion of slope toe is not of accession or recession.

Based on the historic photographs, there is no recession of the slope in the north and south portions. On the northern portion, the watercourse has moved away from the slope toe and the toe has gained ground in the past 36 years. In these two areas, it is our opinion that no toe erosion allowance is required.

The historic information indicated that for the middle portion of the site, the average annual recession rate of the toe is about 0.02 m/year, and therefore a toe erosion allowance of 2 m is recommended. The portion of slope that requires the erosion allowance is shown on Drawing No. 7, Appendix D.

For the middle portion, the slope stability analysis of cross section 3-3 (Figure 5, Appendix C) shows that the long term stable top of slope is at the physical top of slope, with a slope of 1.3H:1V. Therefore, if the slope toe is eroded for 2 m, the slope gradient will not be changed with 2 m erosion allowance at the slope crest. In this case, the stable top of slope will be shifted to 2 m east from the current physical top of slope.

On the slope face, where there is limited vegetation cover, this weathered layer may be subjected to rapid erosion by rain splash, running water and the development of small rills. In the spring and during heavy rainfalls, the soil may become saturated, and shallow slides and slumps can take place bringing material to the slope toe where it is easily removed by water flow. Where the slope is protected by heavy vegetation and is not subject to overland flow of water and gully development, the slope is expected to be stable as long as it is not subject to the surface erosions. **Based on EXP visual examinations in 2018 and 2021, the slope is covered with heavy vegetation and no surface erosions are evident.**

6. General Recommendations

For the long-term stability of the slope, the vegetation on the slope face should be maintained and surface water should not be discharged uncontrolled over the slope face. Discharge points down the slope should be provided with surface protections to minimize the risk of surface erosion. During construction, stockpiles of construction materials should not be placed on the slope crest (within about 10 m from the physical top of slope) or on the existing slope surface.

Based on the Civil Engineer's (KWA Site Development Consulting) level spreader design, the calculated flow velocity at the spreader outlet is about 0.003 m/s. This value is well below the critical velocity of a hard clayey silt till (0.079 m/s)[2] to resist erosion. The clayey silt till is expected near the spreader outlet at the ground surface. No erosion is anticipated to occur on the slope below the spreader outlet.

[2] Technical Guide, River & Stream Systems: Erosion Hazard Limit. Ontario Ministry of Natural Resources (2002).

7. General Comments

When design and specifications based on the results reported herein are required, EXP should be retained for a general review to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, EXP will assume no responsibility for interpretation of the recommendations in the report.

This report has been prepared for and is intended for the exclusive use of Fieldgate Properties Limited, Conservation Halton, Municipality of Burlington and its clients and engineers. Any use which a third party makes of this report, or any part thereof, of any reliance on or decision to be made based on it, are the responsibility of such third parties. EXP accepts no responsibility for damages, if any, suffered by any third party as a result of decision made or actions based on this report. The contents of this report should not be relied upon by any other party without the express written consent of EXP. The findings are relevant for the dates of our site visits and should not be relied upon to represent conditions at later dates.

We trust that this report is sufficient for your purposes. Should you have any questions regarding this report, please do not hesitate to contact the undersigned.

EXP Services Inc



Hongliu Wang, Ph.D., P.Eng.
Senior Geotechnical Engineer
Earth & Environmental

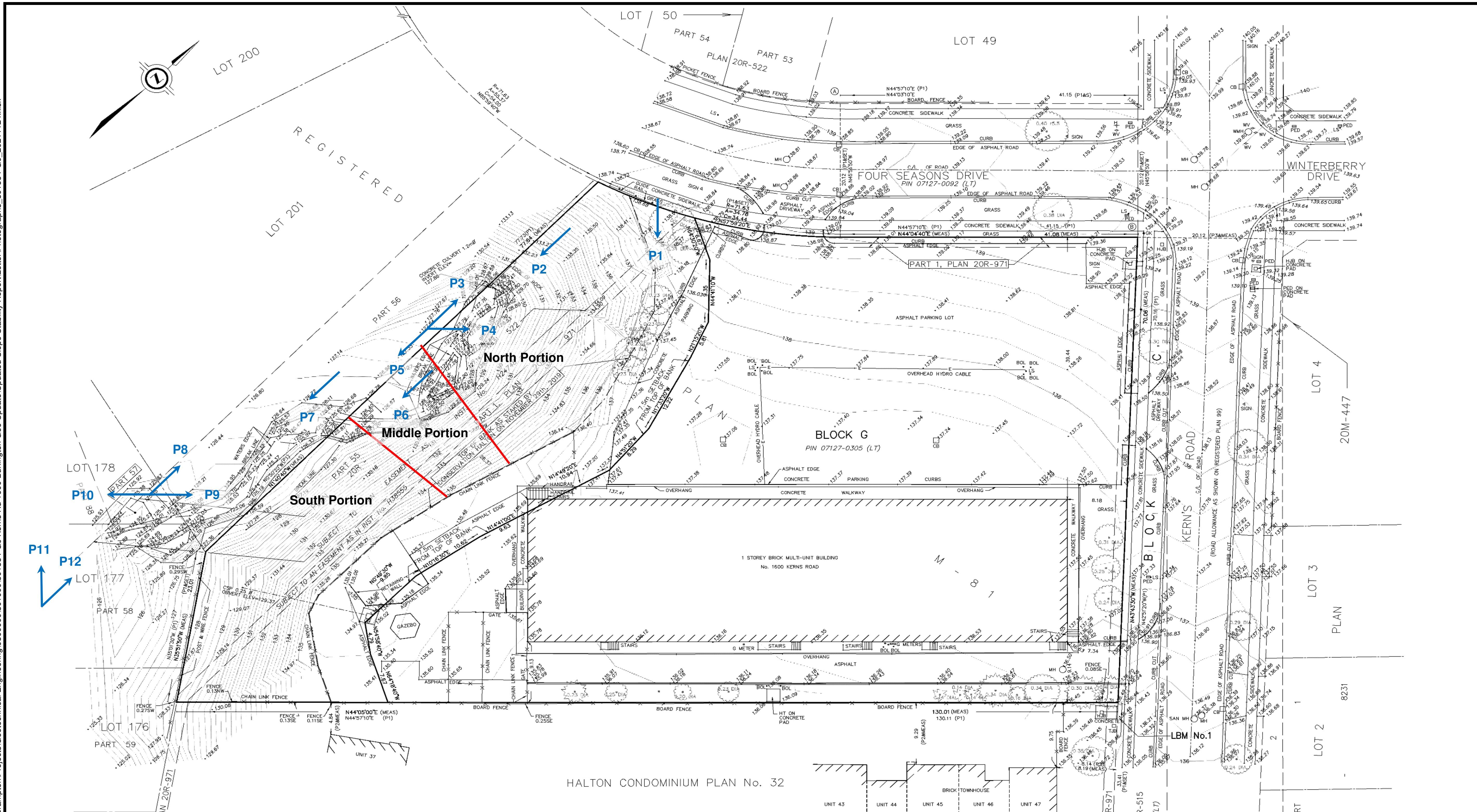
Stephen S. M. Cheng
Digitally signed by Stephen S. M. Cheng
Date: 2022.02.11 13:12:31 -05'00'

Stephen S. M. Cheng, P.Eng.
Discipline Manager
Geotechnical Division

APPENDICES

APPENDIX A

Site Photographs



LEGEND:

(red line)	Boundary Line
(blue arrow)	Photo Location and Direction

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

Site Photograph Location and Direction

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 1

\\PBRMFSG001\Data_Zeus\2003-Brampton\Projects\Geotechnical Engineering\0800000\801000\801554-G0 Kerns Rd 1600 Burlington Geo Update\Updated Slope Stability Report\Letter\Photographs_801554-G0_20211124.xlsx



Photograph #1: North portion, slope crest, looking southeast



Photograph #2: North portion, slope face, on top of concrete culvert, looking south



Photograph #3: North portion, slope toe, south of concrete culvert, looking north



Photograph #4: North portion, slope toe, south of concrete culvert, looking northeast



Photograph #5: North portion, slope toe, south of concrete culvert, looking south



Photograph #6: Middle portion, slope toe, local failure, looking south



Photograph #7: Middle portion, slope toe, looking south



Photograph #8: South portion, slope toe, looking north



Photograph #9: South portion, slope toe, looking northeast



Photograph #10: South portion, slope toe, looking southwest



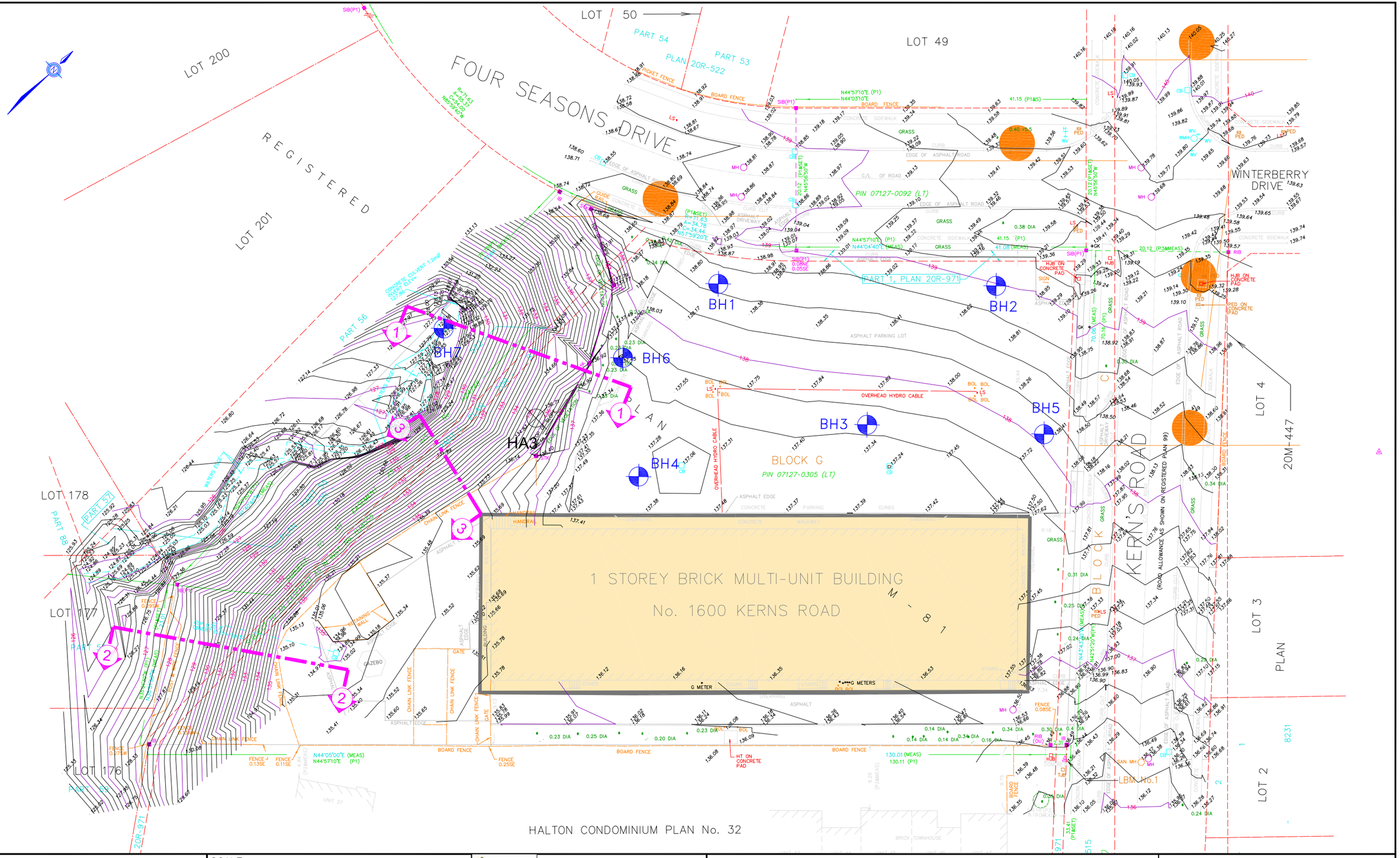
Photograph #11: South end of south portion, slope toe, looking northwest



Photograph #12: South end of south portion, slope toe, looking north

APPENDIX B

Borehole Location and Cross Section Plan, Borehole Logs



LEGEND:

- Borehole Location
- Hand auger Location

SCALE:

0 5 10 15 m

EXP Services Inc.

PROJECT:

Preliminary Geotechnical Investigation, Slope Stability Assessment
Residential Redevelopment, 1600 Kern's Road
Burlington, ON

TITLE:

BOREHOLE LOCATION PLAN

APPROVED BY:	DATE:	PROJECT NO.:
D.D.	December 20, 2019	BRM-00801554-E0
DRAWN BY:	SCALE:	DRAWING NO.:
S.H.	As Shown	1

SURVEYOR'S REAL PROPERTY REPORT
SHOWING TOPOGRAPHIC INFORMATION ON

BLOCK G
REGISTERED PLAN M-81
CITY OF BURLINGTON
REGIONAL MUNICIPALITY OF HALTON

SCALE 1 : 250

5 0 5 10 15 metres

J.D. BARNES LIMITED

© COPYRIGHT

METRIC DISTANCES AND/OR COORDINATES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048.

PART 2 - SURVEY REPORT

- DESCRIPTION
  BLOCK G, REGISTERED PLAN M-81, CITY OF BURLINGTON
- ADDITIONAL REMARKS
  PLAN PREPARED FOR FIELDGATE PROPERTIES

REGISTERED EASEMENTS AND/OR RIGHTS OF WAY

SUBJECT TO AN EASEMENT AS IN INST. No. H24748 OVER PART 55 ON PLAN 20R-522.
SUBJECT TO AN EASEMENT AS IN INST. No. H38555 OVER PART 1 ON PLAN 20R-971.

- BOUNDARY FEATURES
  NOTE THE LOCATION OF FENCES AS SHOWN ON THE PLAN

NOTES

BEARINGS ARE UTM GRID, DERIVED FROM (ORP's) OBSERVED REFERENCE POINTS A AND B, BY REAL TIME NETWORK (RTN) OBSERVATIONS, UTM ZONE 17, NAD83 (CSRS)(2010.0).

INTEGRATION DATA

OBSERVED REFERENCE POINTS (ORPs): UTM ZONE 17, NAD83 (CSRS) (2010.0).

COORDINATES TO URBAN ACCURACY PER SECTION 14 (2) OF O.REG 216/10.

POINT ID	EASTING	NORTHING
ORP (A)	594 128.12	4 799 342.19
ORP (B)	594 171.15	4 799 357.70

COORDINATES CANNOT, IN THEMSELVES, BE USED TO RE-ESTABLISH CORNERS OR BOUNDARIES SHOWN ON THIS PLAN.

DISTANCES ARE GROUND AND CAN BE CONVERTED TO GRID BY MULTIPLYING BY THE COMBINED SCALE FACTOR OF 0.999896.

BEARING COMPARISONS SHOWN FOR UNDERLYING PLANS, REGISTERED PLAN M-81, HALTON CONDOMINIUM PLAN No. 32 AND PLAN 20R-515 ARE WITH ASTRONOMIC BEARINGS.

ALL BUILDING TIES ARE TAKEN TO CONCRETE FOUNDATION.

LEGEND

	DENOTES BENCHMARK
■	DENOTES SURVEY MONUMENT FOUND
□	DENOTES SURVEY MONUMENT PLANTED
IB	DENOTES IRON BAR
SIB	DENOTES STANDARD IRON BAR
⊠ STK	DENOTES WOOD STAKE PLANTED
P1	DENOTES REGISTERED PLAN M-81
P2	DENOTES HALTON CONDOMINIUM PLAN No. 32
P3	DENOTES PLAN 20R-515
P4	DENOTES BUILDING LOCATION SURVEY BY J. D. BARNES LIMITED, DATED JUNE 23, 1988.
P5	DENOTES BUILDING LOCATION SURVEY BY J. D. BARNES LIMITED, DATED JUNE 23, 1988.
P6	DENOTES PLAN 20R-8231
MEAS	DENOTES MEASURED
OU	DENOTES ORIGIN UNKNOWN
□ CB	DENOTES SINGLE CATCHBASIN
□ HJB	DENOTES HYDRO JUNCTION BOX
• GK	DENOTES GAS KEY
• G METER	DENOTES GAS METER
◯ MH	DENOTES MANHOLE
◯ SAN MH	DENOTES SANITARY MANHOLE
◯ WMH	DENOTES WATER MANHOLE
• BOL	DENOTES BOLLARD
• LS	DENOTES LIGHT STANDARD
□ TJB	DENOTES TELEPHONE JUNCTION BOX
▣ PED	DENOTES TELEPHONE PEDESTAL
⊣ H	DENOTES FIRE HYDRANT
HT	DENOTES HYDRO TRANSFORMER
⋈ WV	DENOTES WATER VALVE
— E —	DENOTES OVERHEAD HYDRO CABLE
CSP	DENOTES CORRUGATED STEEL PIPE

ELEVATION NOTE

ELEVATIONS SHOWN ON THIS PLAN ARE DERIVED FROM CITY OF BURLINGTON BENCHMARK No. 1081
ELEVATION = 157.586m
AND
BENCHMARK No. 1082
ELEVATION = 139.47m

LOCAL BENCHMARK No. 1

BENCHMARK No. 503 FOUND ON SOUTHEAST CORNER OF HYDRO PAD ACROSS FROM LOT 2, 20M-447.
ELEVATION = 136.52m

BEFORE DIGGING, UNDERGROUND SERVICES SHOULD BE LOCATED ON SITE BY THE RESPECTIVE AGENCIES.

IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY THAT THE LOCAL BENCHMARKS HAVE NOT BEEN ALTERED OR DISTURBED AND THAT THE RELATIVE ELEVATONS AND DESCRIPTIONS AGREE WITH THE INFORMATION SHOWN ON THIS SKETCH.

SURVEYOR'S CERTIFICATE

I CERTIFY THAT:

1. THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS ACT, THE SURVEYORS ACT AND THE REGULATIONS MADE UNDER THEM.
2. THE SURVEY WAS COMPLETED ON SEPTEMBER 13, 2018.

DATE

THOMAS J. SALB
ONTARIO LAND SURVEYOR

J.D. BARNES LIMITED
LAND INFORMATION SPECIALISTS
SURVEYING MAPPING GIS
401 WHEELABRATOR WAY, SUITE A, MILTON, ON L9T 3C1
T: (905) 875-9955 F: (905) 875-9956 www.jdbarnes.com

DRAWN BY:	CHECKED BY:	REFERENCE NO.:
CE		18-30-288-00-A

FILE: G:\18-30-288\02\Drawing\18-30-288-02-D.dgn DATED: NOVEMBER 6th, 2020

PLOTTED: 11/6/2020

Log of Borehole 1

Project No. BRM-00801554-B0 | Drawing No. 2

Project: Geotechnical Investigation | Sheet No. 1 of 2

Location: 1600 Kerns Rd., Burlington

Date Drilled: October 12, 2018

Drill Type: CME 55, Solid Stem Augers

Datum: Geodetic

Auger Sample ☒ | Combustible Vapour Reading □

SPT (N) Value ○ ▨ | Natural Moisture ×

Dynamic Cone Test ——— | Plastic and Liquid Limit ⊢○

Shelby Tube ■ | Undrained Triaxial at % Strain at Failure ⊕

Field Vane Test S | Penetrometer ▲

Soil Description	ELEV. m	Depth (m)	SPT (N Value) / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	Sample	Natural Unit Weight kN/m³
~ 140 mm **ASPHALTIC CONCRETE** over ~ 180 mm **GRANULAR BASE** over **FILL**: Reworked clayey silt, some gravel, medium grained sand pockets, glass fragments, brown to grey, black pockets, moist	138.67 ~138.5	0 1	7 7	×		21.5
Becoming brown to reddish brown sand and gravel, red brick, glass and ceramic fragments, moist	~136.5	2 3	4 3	×		
Becoming wet	~134.2 ~133.9	4 5 6	7 3 2	×		

Groundwater ▽

Continued Next Page

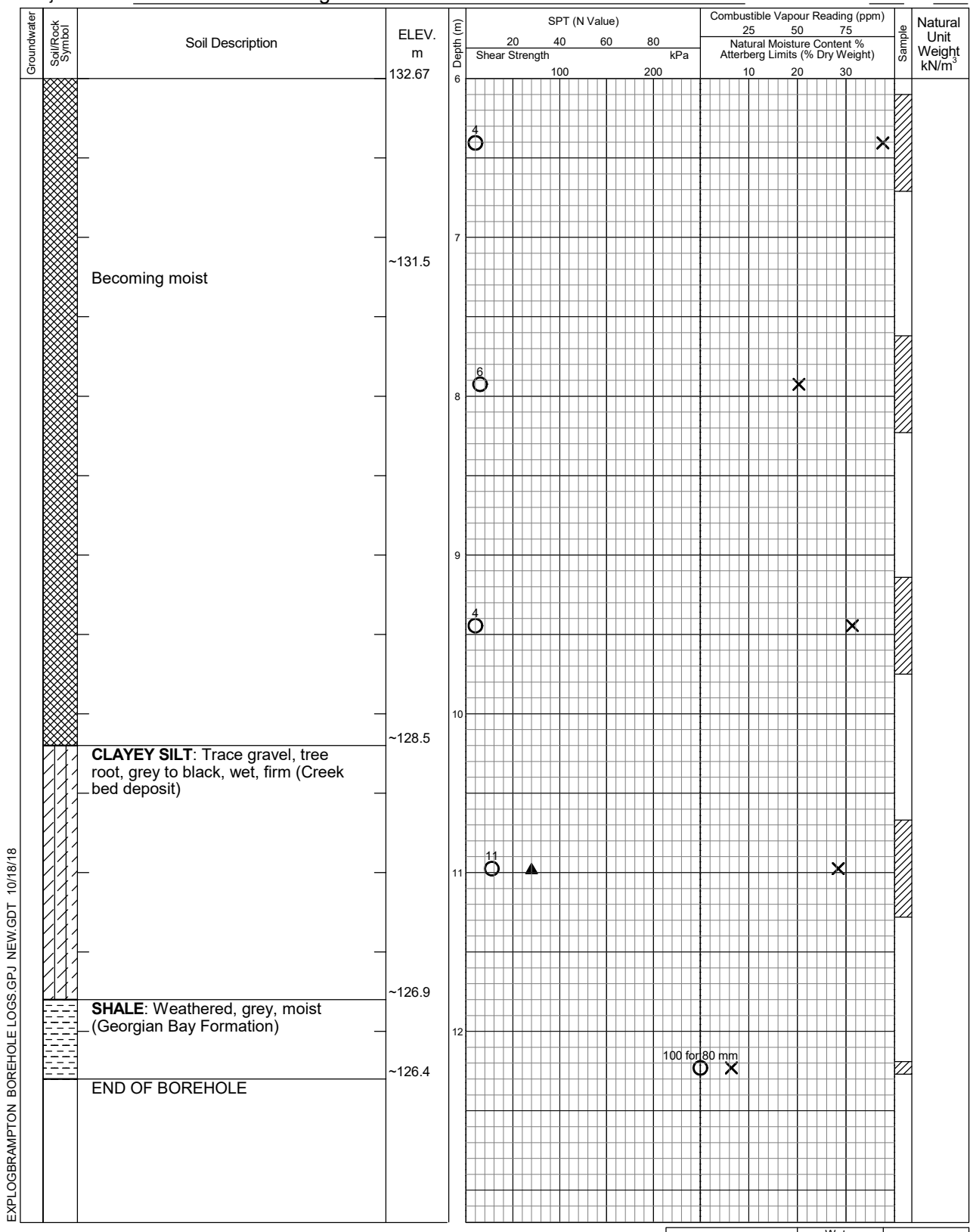
Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	4.82	8.61

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 1

Project No. BRM-00801554-B0 Drawing No. 2

Project: Geotechnical Investigation Sheet No. 2 of 2



EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	4.82	8.61

Log of Borehole 2

Project No. BRM-00801554-B0

Drawing No. 3

Project: Geotechnical Investigation

Sheet No. 1 of 2

Location: 1600 Kerns Rd., Burlington

Date Drilled: October 12, 2018

Drill Type: CME 55, Solid Stem Augers

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m	Depth (m)	SPT (N Value) / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	Sample	Natural Unit Weight kN/m³
		~ 145 mm **ASPHALTIC CONCRETE** over ~ 190 mm **GRANULAR BASE** over **CLAYEY SILT TILL**: Fine sand seams, trace gravel, brown, moist, hard	138.92 ~138.8	0 1 2 3 4 5 6	7 23 42 46 41 47			22.1 22.4 22.3 22.7

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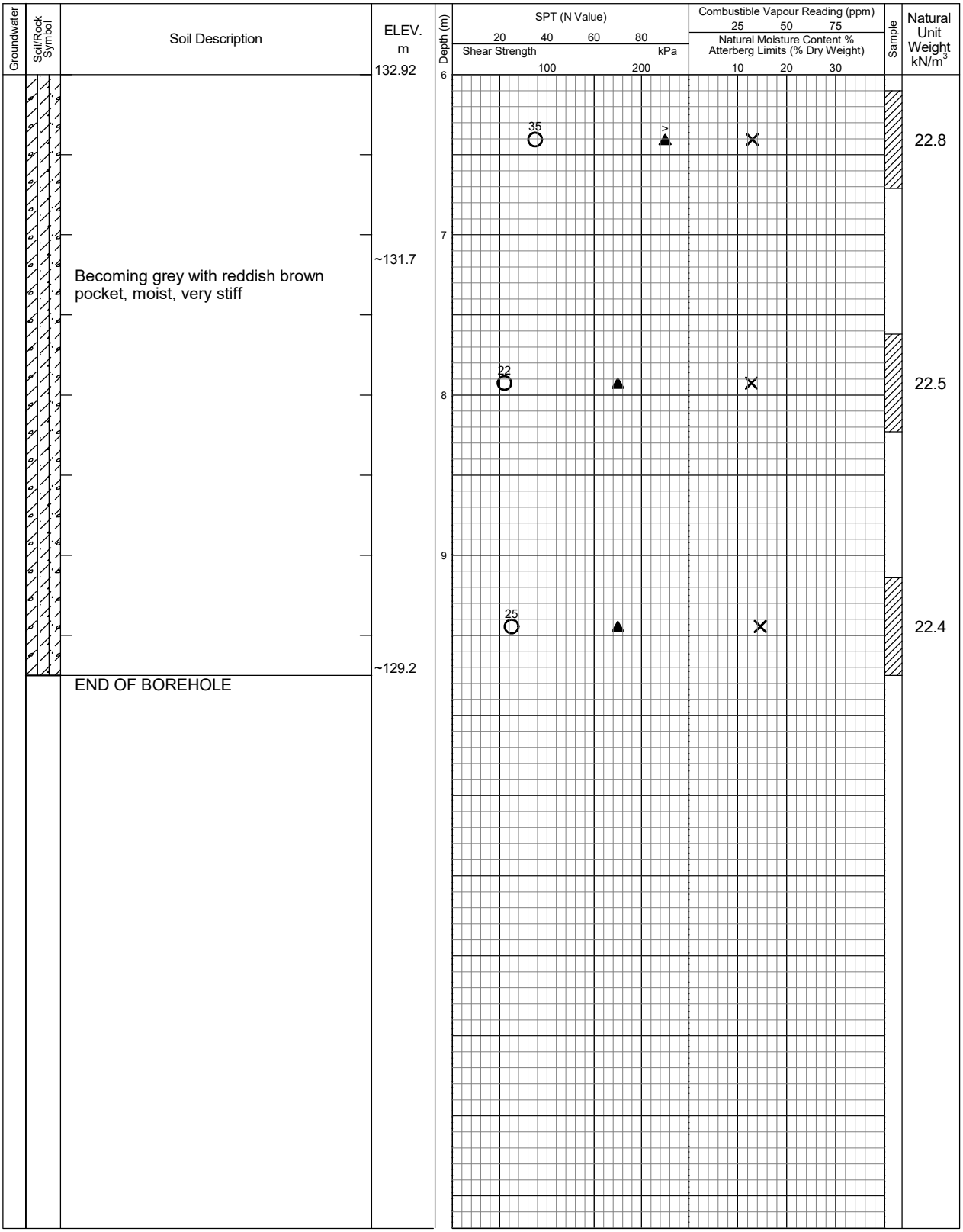
Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	Open

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 2

Project No. BRM-00801554-B0 Drawing No. 3

Project: Geotechnical Investigation Sheet No. 2 of 2



EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	Open

Log of Borehole 3

Project No. BRM-00801554-B0 | Drawing No. 4

Project: Geotechnical Investigation | Sheet No. 1 of 2

Location: 1600 Kerns Rd., Burlington

Date Drilled: October 11, 2018

Drill Type: CME 55, Solid Stem Augers

Datum: Geodetic

Auger Sample ☒ | Combustible Vapour Reading □

SPT (N) Value ○ ▨ | Natural Moisture ×

Dynamic Cone Test — | Plastic and Liquid Limit ⊢○

Shelby Tube ■ | Undrained Triaxial at % Strain at Failure ⊕

Field Vane Test S | Penetrometer ▲

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m	Depth (m)	SPT (N Value) / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	Sample	Natural Unit Weight kN/m³
		~ 100 mm **ASPHALTIC CONCRETE** over ~ 100 mm **GRANULAR BASE** over **CLAYEY SILT TILL**: Fine sand seams, trace gravel, occasional boulder fragments, brown, reddish brown pockets, moist, hard	137.63 ~137.5	0	19			21.5
				1	34			22.5
				2	38			22.5
				3	37			22.4
				4	40			23.2
				5	30			23.0
		Becoming grey with reddish brown pockets	~131.9	6				

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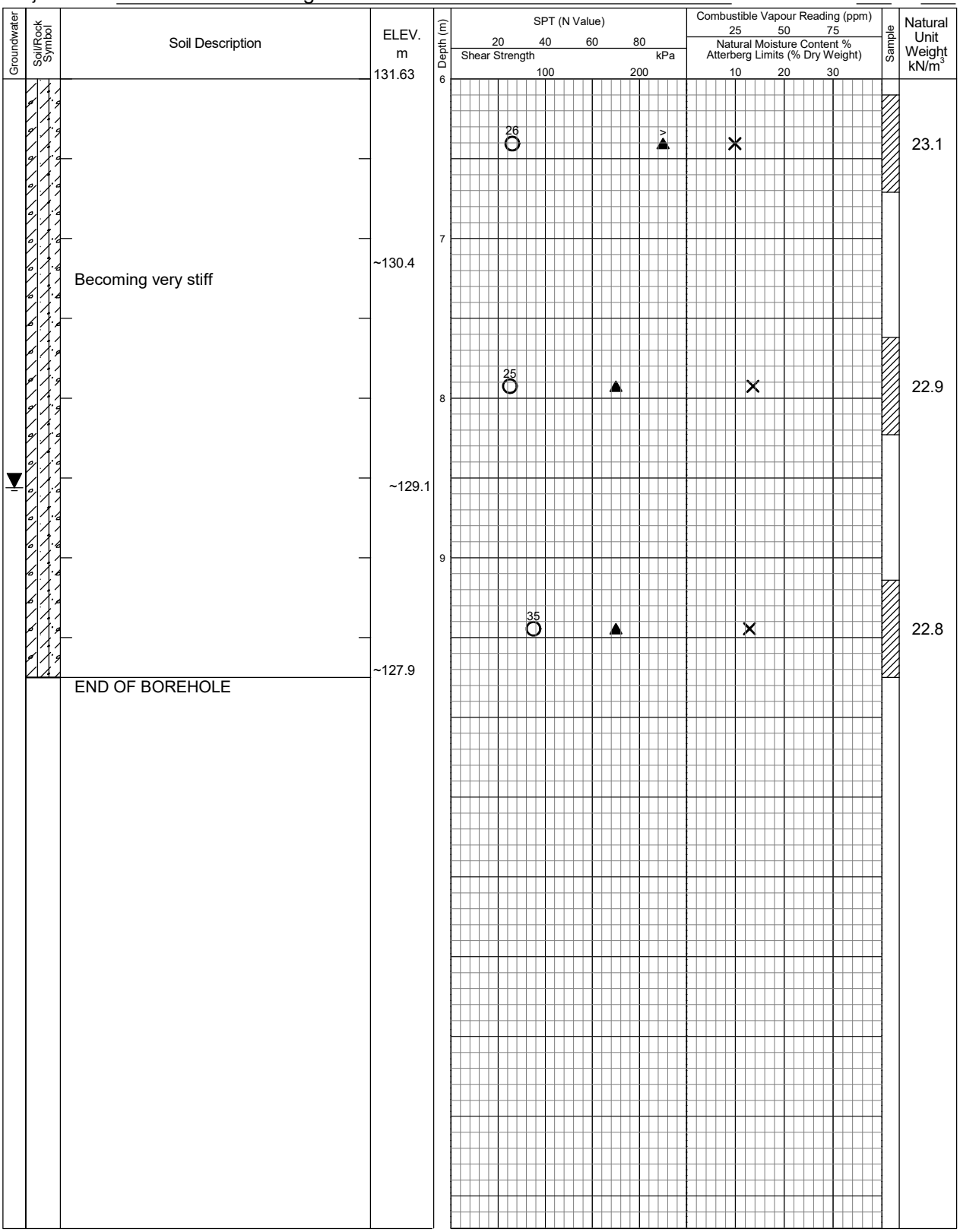
Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	8.58	9.19

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 3

Project No. BRM-00801554-B0 Drawing No. 4

Project: Geotechnical Investigation Sheet No. 2 of 2



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	8.58	9.19

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 4

Project No. BRM-00801554-B0 | Drawing No. 5

Project: Geotechnical Investigation | Sheet No. 1 of 2

Location: 1600 Kerns Rd., Burlington

Date Drilled: October 11, 2018

Drill Type: CME 55, Solid Stem Augers

Datum: Geodetic

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test (S)

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

Soil Description	ELEV. m	Depth (m)	SPT (N Value) / Shear Strength kPa	Natural Moisture Content % / Atterberg Limits (% Dry Weight)	Natural Unit Weight kN/m³
~ 90 mm **ASPHALTIC CONCRETE** over ~ 125 mm **GRANULAR BASE** over **CLAYEY SILT TILL**: Fine sand seams, trace gravel, occasional boulder fragments, brown, reddish brown and grey pockets, moist, hard	137.35 ~137.3	0	13		
		1	22		22.0
		2	26		22.1
		2.5	52		
		3	29		22.3
		4			
		4.5	30		22.3
Becoming grey with reddish brown pockets, stiff to very stiff	~131.8	5			
		6			

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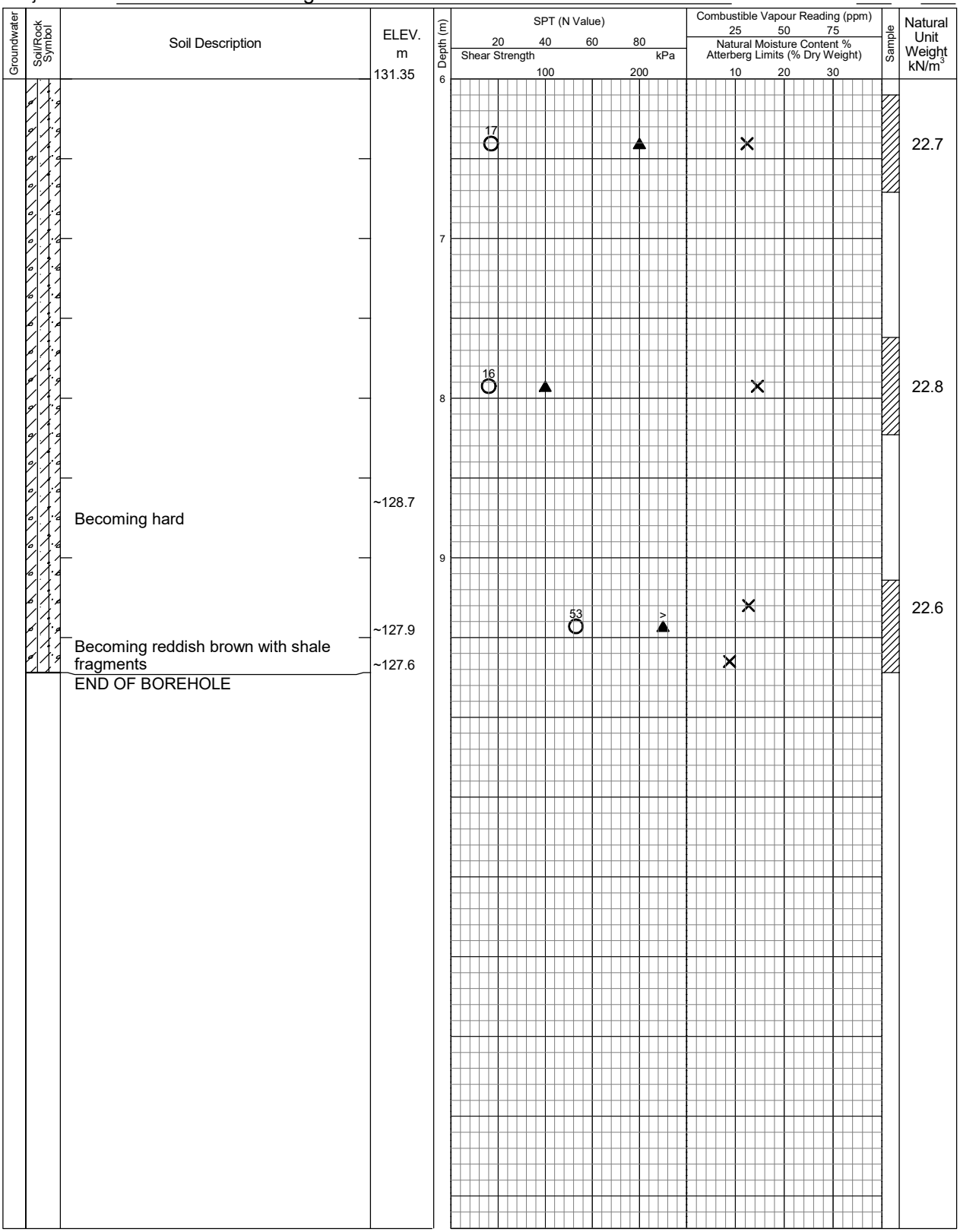
Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	9.7

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 4

Project No. BRM-00801554-B0 Drawing No. 5

Project: Geotechnical Investigation Sheet No. 2 of 2



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	9.7

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 5

Project No. BRM-00801554-B0 | Drawing No. 6

Project: Geotechnical Investigation | Sheet No. 1 of 2

Location: 1600 Kerns Rd., Burlington

Date Drilled: October 11, 2018

Drill Type: CME 55, Solid Stem Augers

Datum: Geodetic

Auger Sample ☒
SPT (N) Value ○ ▨
Dynamic Cone Test —
Shelby Tube ■
Field Vane Test ✚ S

Combustible Vapour Reading □
Natural Moisture ×
Plastic and Liquid Limit ⊢○
Undrained Triaxial at % Strain at Failure ⊕
Penetrometer ▲

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m	Depth (m)	SPT (N Value) 20 40 60 80 / Shear Strength 100 200 kPa	Combustible Vapour Reading (ppm) 25 50 75 / Natural Moisture Content % Atterberg Limits (% Dry Weight) 10 20 30	Sample	Natural Unit Weight kN/m³
		~ 110 mm **ASPHALTIC CONCRETE** over ~ 290 mm **GRANULAR BASE** over **CLAYEY SILT TILL**: Fine sand seams, trace gravel, occasional boulder fragments, brown with reddish brown pockets, moist, hard	138.16 ~138.1	0	11			
				1	28			22.1
				2	44			22.5
				3	41			22.4
				4	40			22.9
				5	35			22.4
		Becoming grey with reddish brown pockets	~132.5	6				

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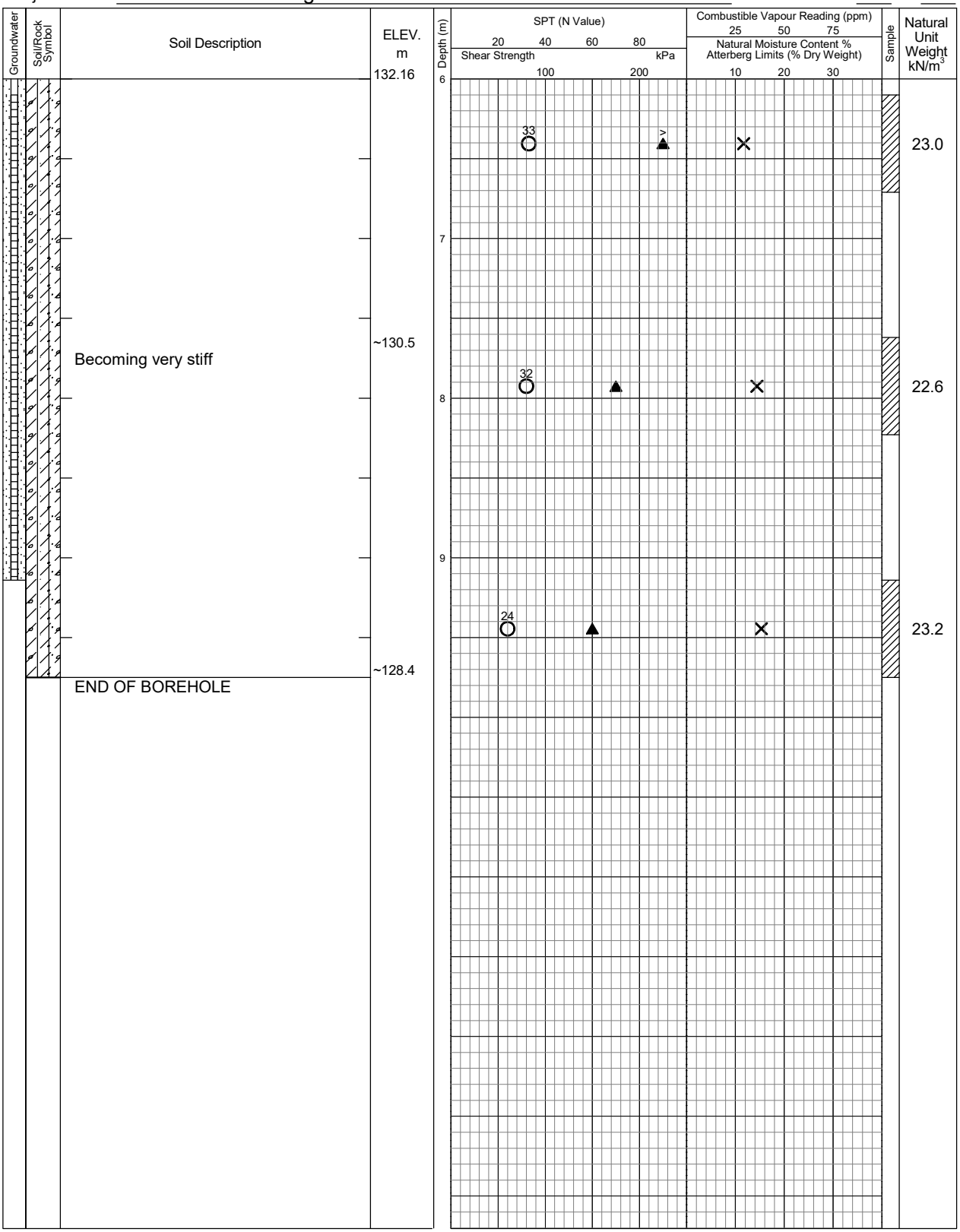
Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	Open
October 12, 2018	8.47	9.19
October 15, 2018	7.82	
October 16, 2018	6.31	

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 5

Project No. BRM-00801554-B0 Drawing No. 6

Project: Geotechnical Investigation Sheet No. 2 of 2



EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	Dry	Open
October 12, 2018	8.47	9.19
October 15, 2018	7.82	
October 16, 2018	6.31	

Log of Borehole 6

Project No. BRM-00801554-B0

Drawing No. 7

Project: Geotechnical Investigation

Sheet No. 1 of 2

Location: 1600 Kerns Rd., Burlington

Date Drilled: October 12, 2018

Drill Type: CME 55, Solid Stem Augers

Datum: Geodetic

Auger Sample

SPT (N) Value

Dynamic Cone Test

Shelby Tube

Field Vane Test

Combustible Vapour Reading

Natural Moisture

Plastic and Liquid Limit

Undrained Triaxial at % Strain at Failure

Penetrometer

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m	Depth (m)	SPT (N Value) / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	Sample	Natural Unit Weight kN/m³
		~ 135 mm **ASPHALTIC CONCRETE** over ~ 250 mm **GRANULAR BASE** over **FILL**: Clayey silt, trace gravel, brown to grey, reddish brown pockets, moist to wet	137.58 ~137.4	0 1 2 3 4 5 6	7 8 5 6 8 9			21.6
			~132.9					

Continued Next Page

Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	4.65	Open
October 12, 2018	3.29	7.69
October 15, 2018	3.57	
October 16, 2018	3.57	

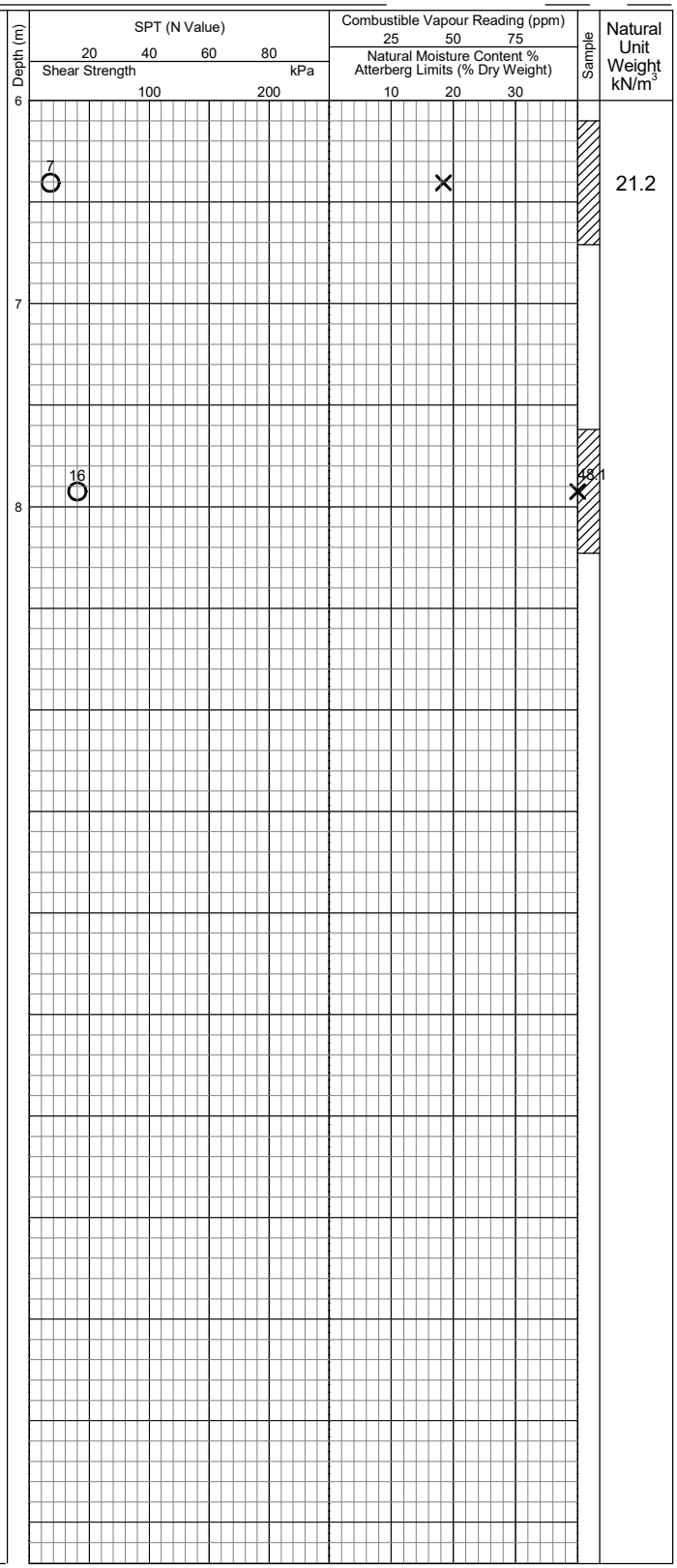
EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 6

Project No. BRM-00801554-B0 Drawing No. 7

Project: Geotechnical Investigation Sheet No. 2 of 2

Soil Description	ELEV. m
	131.58
	~130.4
CLAYEY SILT: Sand and gravel layers, decayed tree roots, silt pockets, grey to black, wet, compact (Creek bed deposit)	
	~129.4
END OF BOREHOLE	



Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	4.65	Open
October 12, 2018	3.29	7.69
October 15, 2018	3.57	
October 16, 2018	3.57	

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole 7

Project No. BRM-00801554-B0

Drawing No. 8

Project: Geotechnical Investigation

Sheet No. 1 of 1

Location: 1600 Kerns Rd., Burlington

Date Drilled: October 16, 2018

Drill Type: Manual Hammer (70 lb)

Datum: Geodetic

Auger Sample

SPT (N) Value

Dynamic Cone Test

Shelby Tube

Field Vane Test (S)

Combustible Vapour Reading

Natural Moisture

Plastic and Liquid Limit

Undrained Triaxial at % Strain at Failure

Penetrometer

Groundwater	Soil/Rock Symbol	Soil Description	ELEV. m	Depth (m)
▼		**CLAYEY SILT**: Trace gravel, reddish brown, black seams in upper ~300 mm, wet, soft	127.86	0
			~127.7	
				1
			~126.5	
		CLAYEY SILT TILL: Fine sand seams, trace gravel, shale lenses, olive grey, moist hard		
			~126.0	
		TERMINATED UPON PRACTICAL REFUSAL TO SAMPLING EQUIPMENT		

SPT (N Value): 20 40 60 80

Shear Strength: 100 200 kPa

Combustible Vapour Reading (ppm): 25 50 75

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 10 20 30

Sample

Natural Unit Weight kN/m³

3

4

85 for 250 mm

Elapsed Time	Water Level (m)	Hole Open to (m)
On Completion	0.2	0.91

EXPLOGBRAMPTON BOREHOLE LOGS.GPJ NEW.GDT 10/18/18

Log of Borehole HA3

Project No. BRM-00801554-D0 Drawing No. 5

Project: Subsurface Environmental Investigation Sheet No. 1 of 1

Location: 1600 Kerns Road, Burlington, ON

Refer to Borehole Location Plan

Date Drilled: Nov. 29, 2018

Drill Type: ATCO Handheld

Datum:

Chemical Analysis

BTEX	Benzene, Toluene, Ethylbenzene and Xylenes	*	Duplicate Sample
ING	Metals and Inorganics	PCB	Polychlorinated Biphenyls
MET	Metals	PHC	Petroleum Hydrocarbons (F1-F4)
PAH	Polycyclic Aromatic Hydrocarbons	VOC	Volatile Organic Compounds
PEST	Organochlorine Pesticides		

GWL	SYMBOL	Soil Description	ELEV. m	DEPTH	N Value	Combustible Vapour Reading (ppm)	SAMPLES	% RECOV	SAMPLE ID	ANALYSIS
		CLAYEY SILT FILL: Brown, trace sand, trace gravel, trace organics, moist		0	20 40 60	25 50 75		60	SS1	
				1		0 ppm (HEX)		70	SS2	ING PAH
		CLAYEY SILT: Brown, trace gravel, damp		2		0 ppm		100	SS3	
				3		0 ppm		50	SS4	
		End of borehole at 3.1 m bgs		4		0 ppm		40	SS5	
		NOTES: - To be read with the subject report. - Soil vapour readings measured using an RKI Eagle instrument calibrated with hexane.		5						
				6						
				7						
				8						
				9						
				10						
				11						
				12						

ENVIRONMENTAL-EXP 1600 KERNS BH LOGS.GPJ 12/10/18

Time	Water Level (m)	Depth to Cave (m)

EXP Services Inc.
Brampton, Ontario
Telephone: 905-793-9800
Facsimile: 905-793-0641

APPENDIX C

Slope Stability Analysis Results

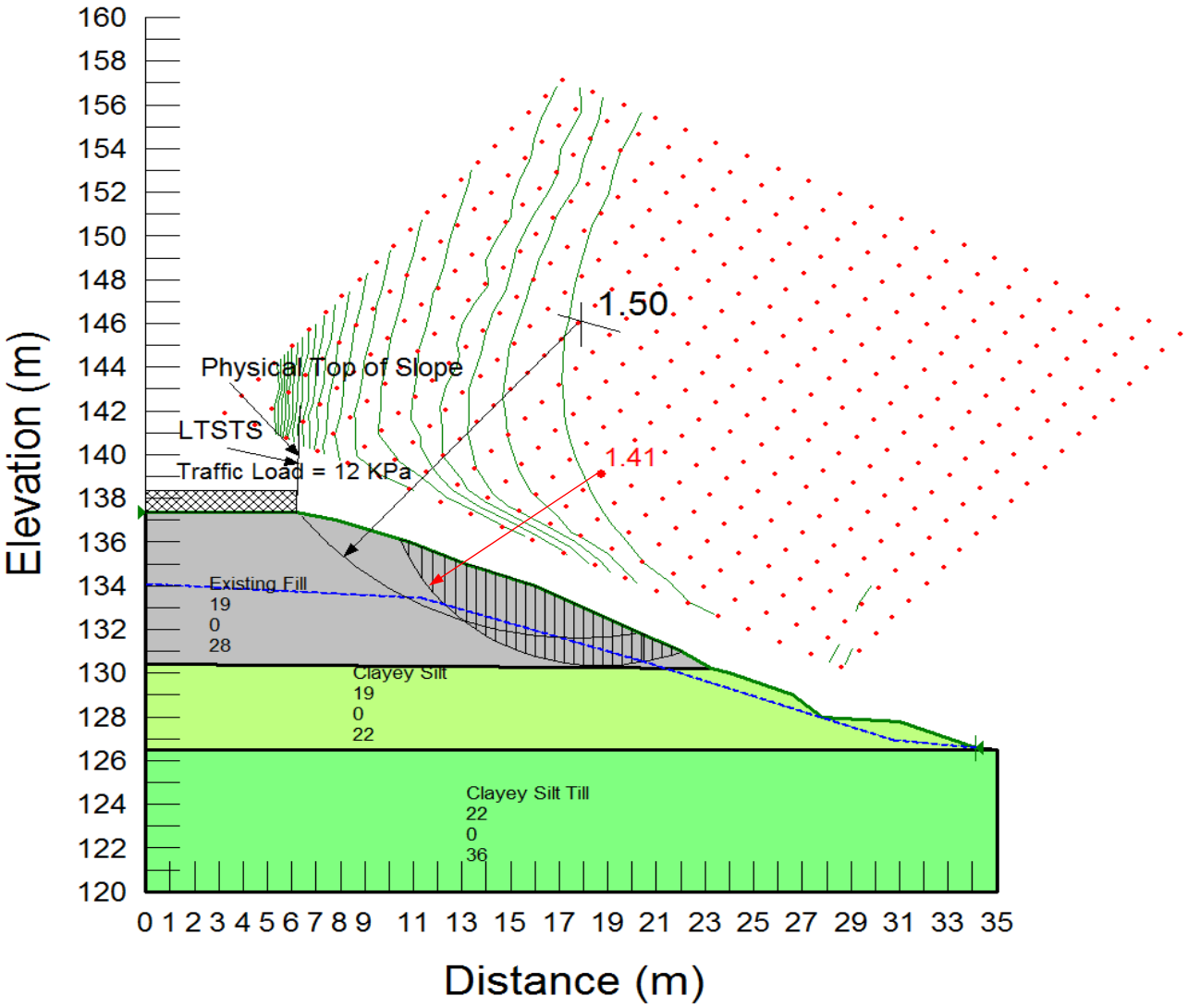


Figure 1
Section 1-1 Existing Condition (Static)

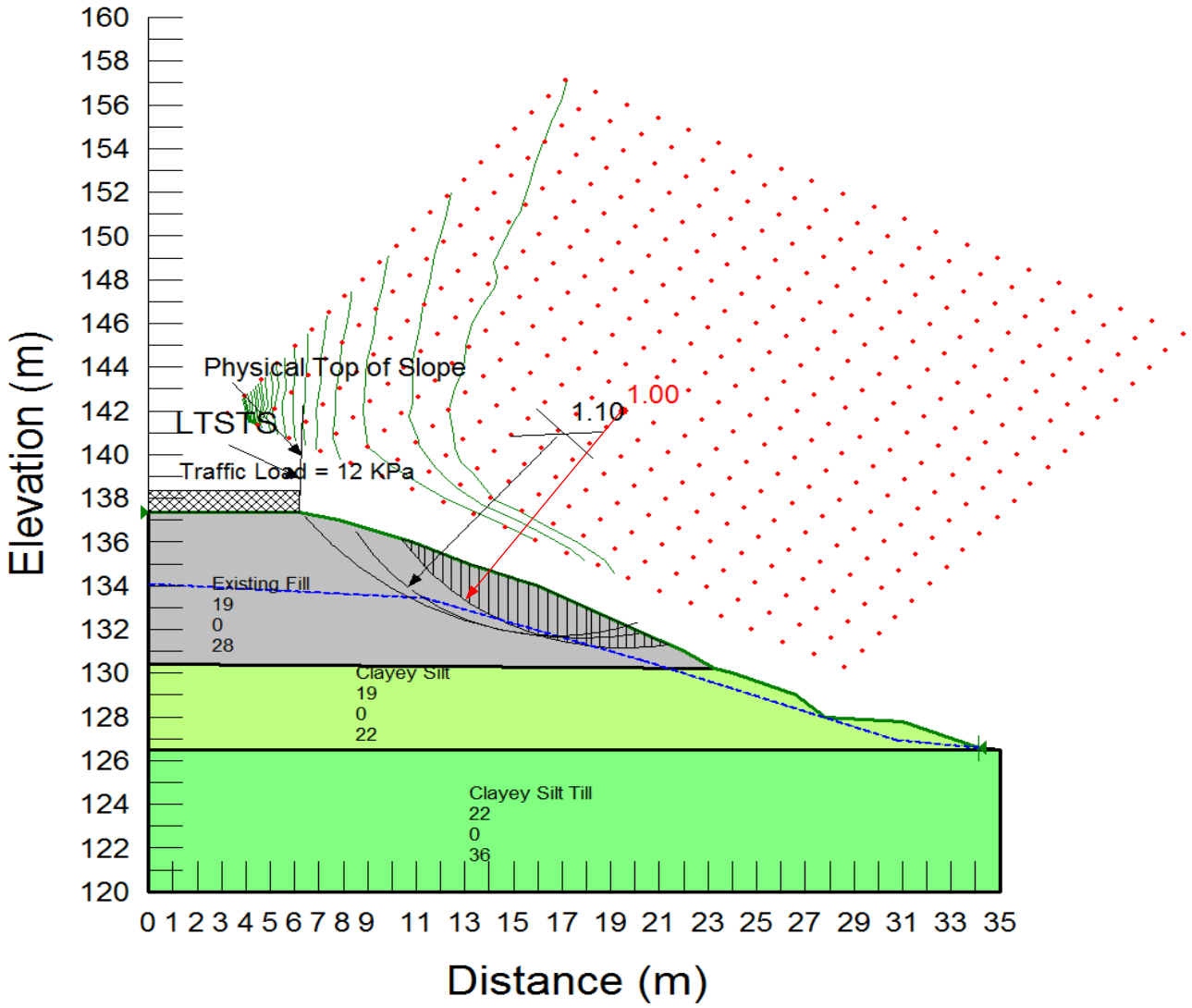


Figure 2
Section 1-1 Existing Condition (Seismic)

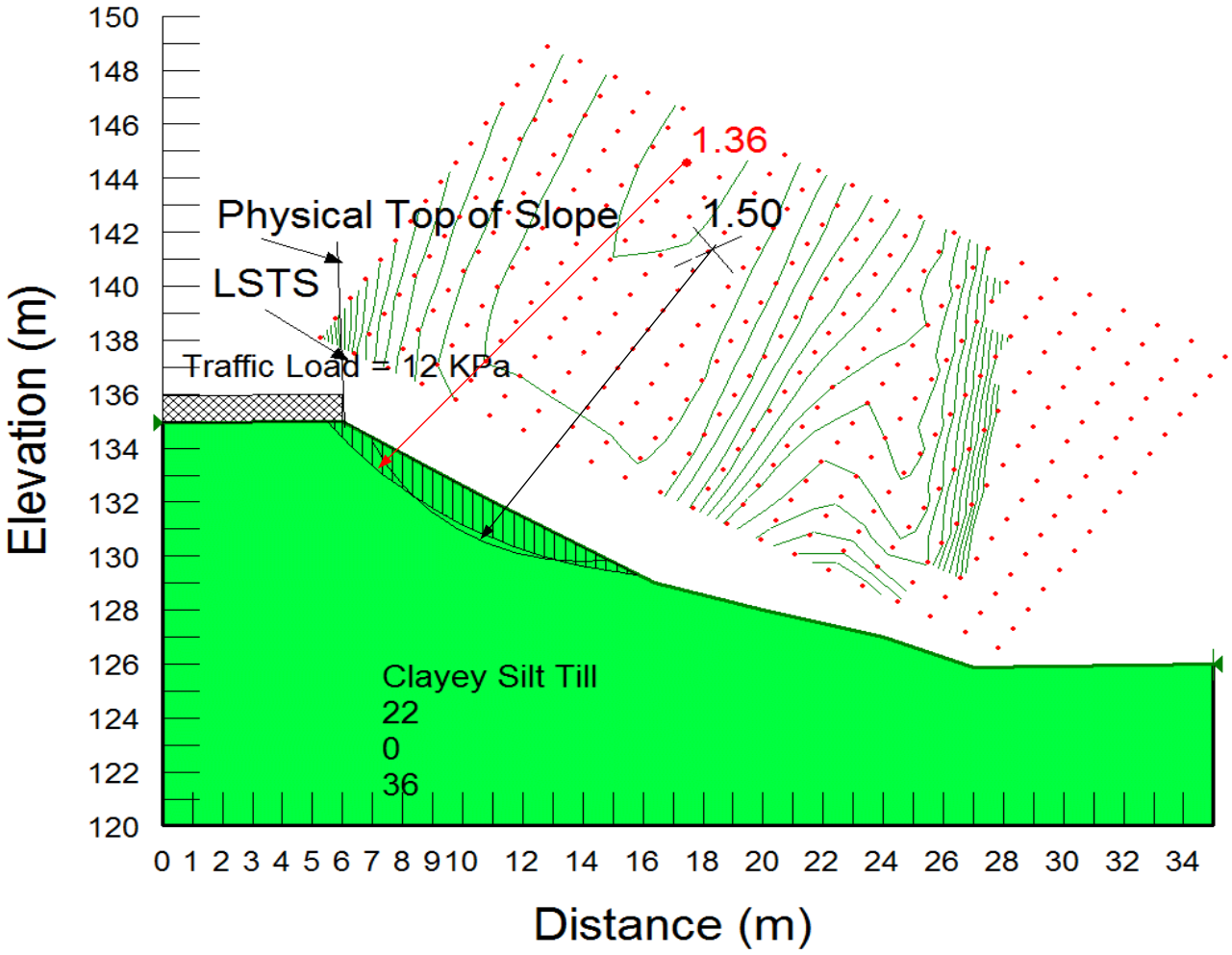


Figure 3
Section 2-2 Existing Condition (Static)

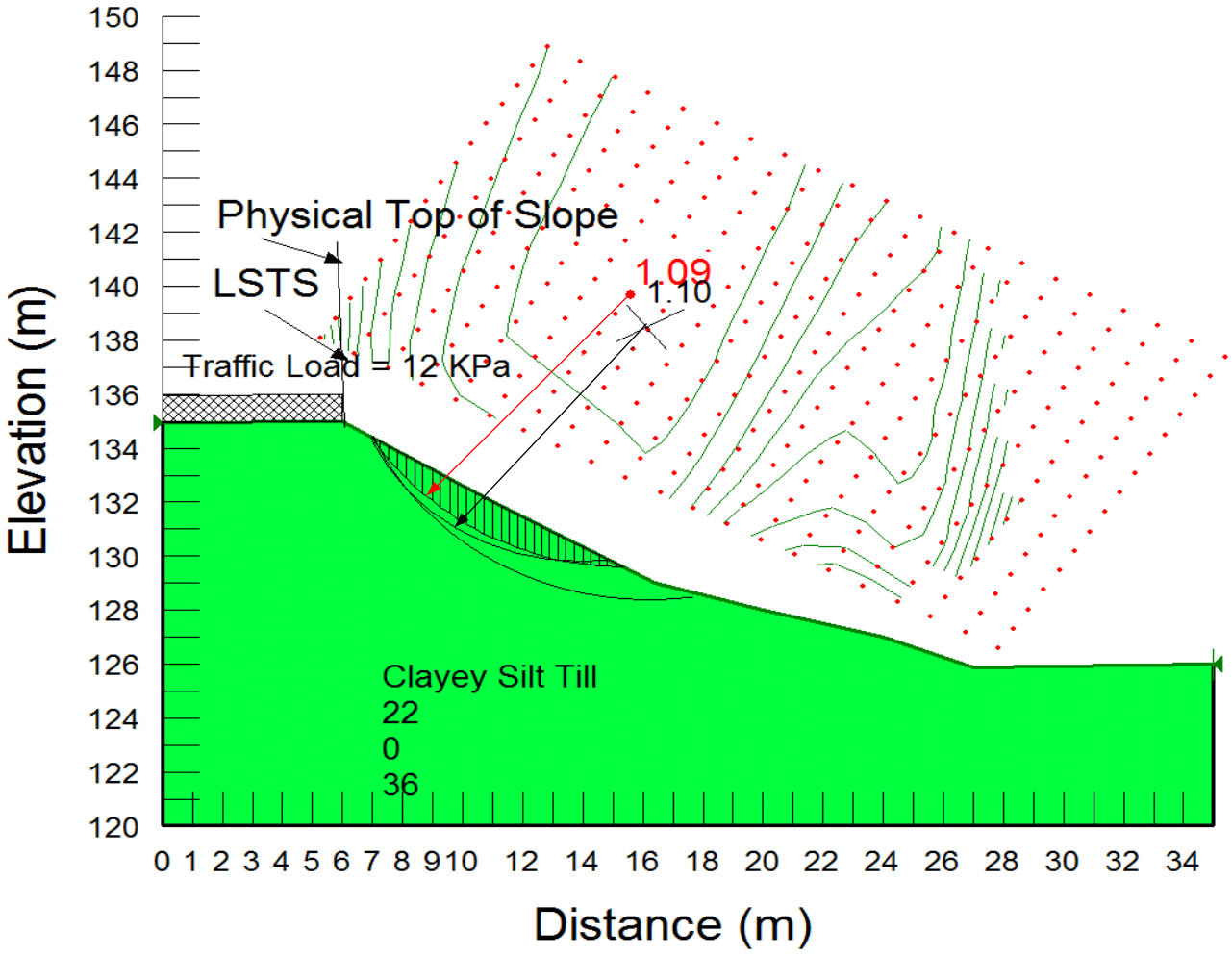


Figure 4
Section 2-2 Existing Condition (Seismic)

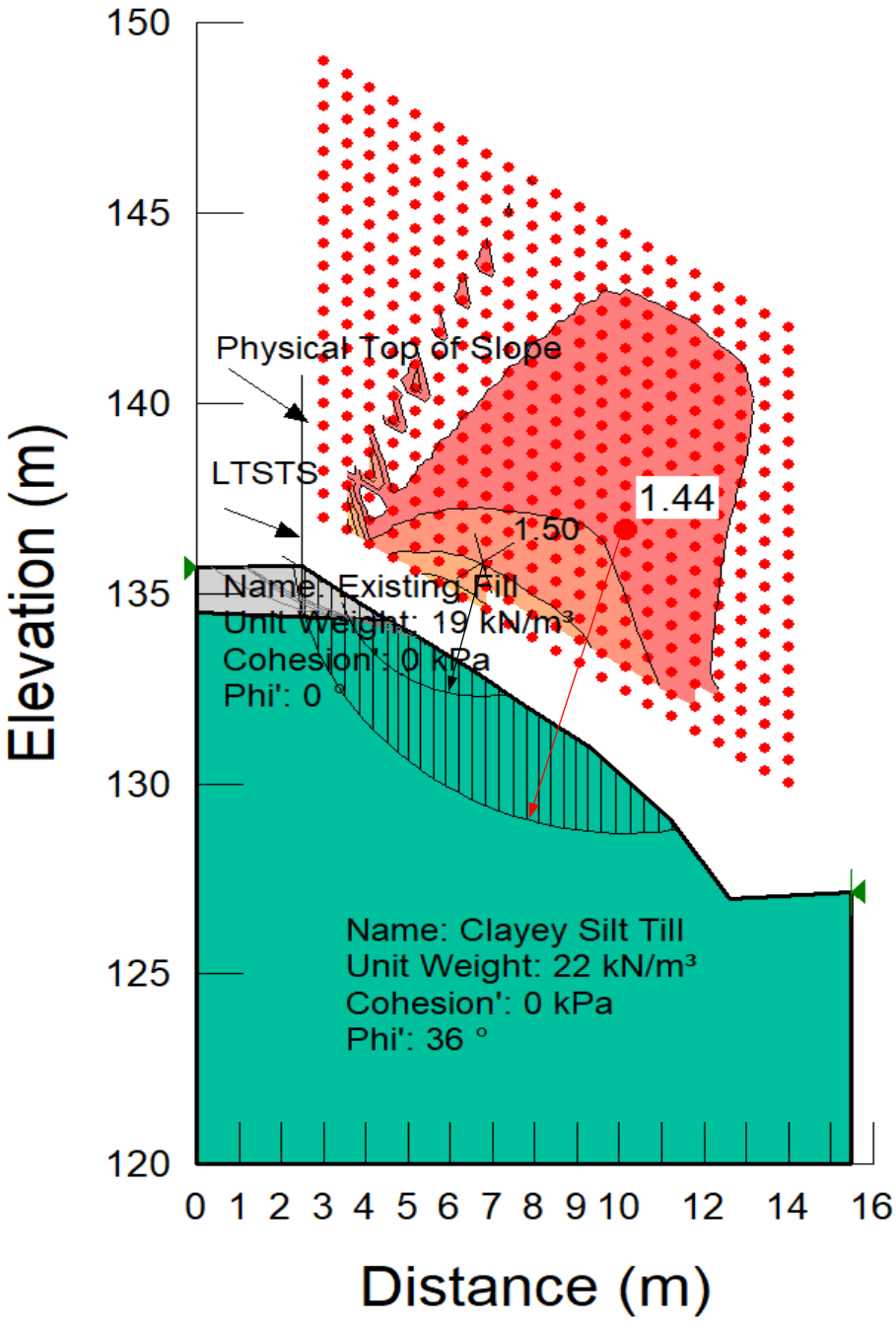


Figure 5
Section 3-3 Existing Condition (Static)

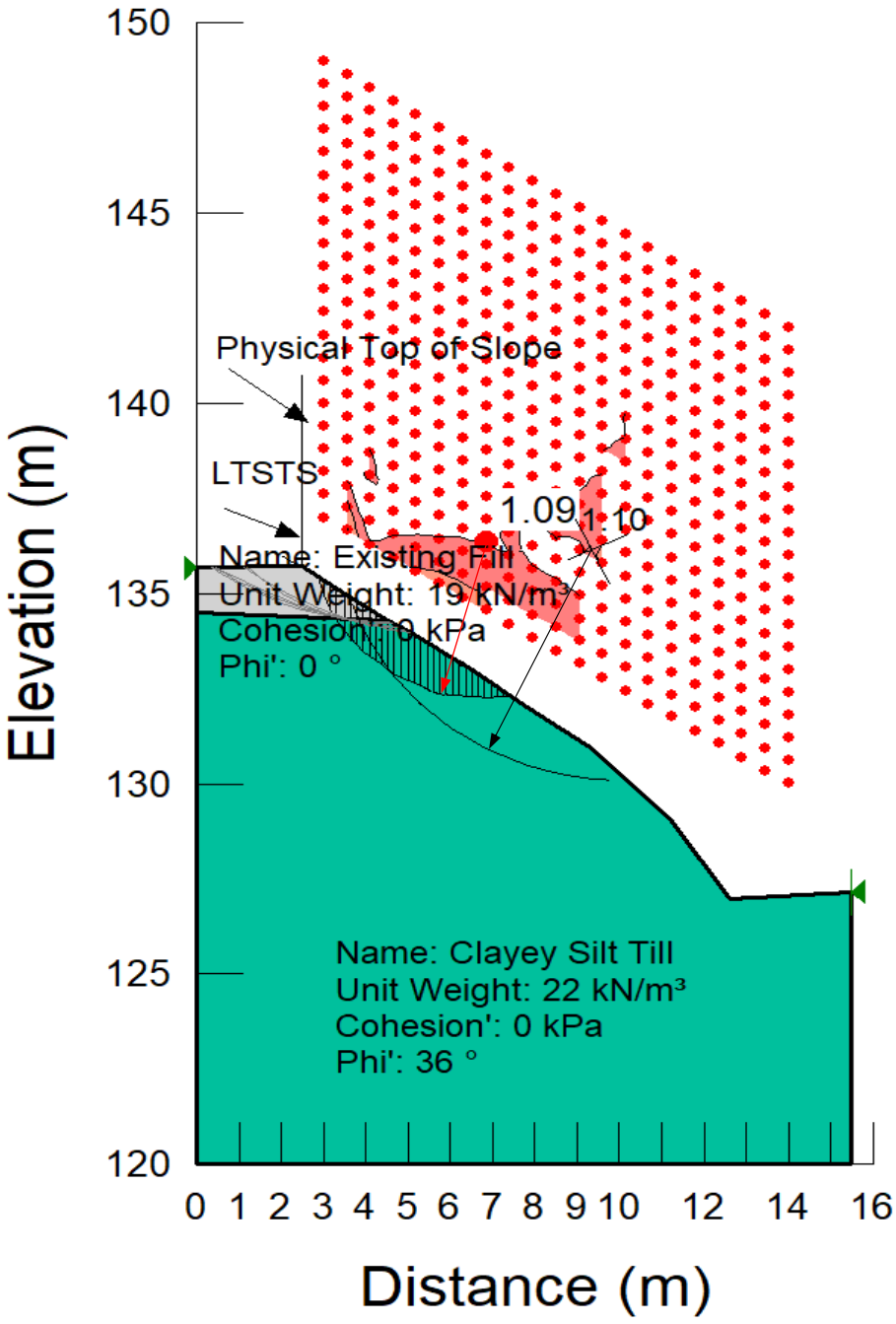


Figure 6
Section 3-3 Existing Condition (Seismic)

APPENDIX D

Historic Aerial Photographs



SOURCE:

The City of Burlington

LEGEND:

Approximate Slope Toe

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

Historic Aerial Photographs

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 1

C:\Users\WangH\OneDrive - EXP\Documents\Project\801554-G0 1600 Kerns Rd, Burlington\DWG_801554-G0.xlsx



SOURCE:

The City of Burlington

LEGEND:

Approximate Slope Toe

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

Historic Aerial Photographs

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 2

C:\Users\WangH\OneDrive - EXP\Documents\Project\801554-G0 1600 Kerns Rd, Burlington\DWG_801554-G0.xlsx



SOURCE:

Google Earth Pro

LEGEND:

Approximate Slope Toe

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

Historic Aerial Photographs

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 3

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SOURCE:

Google Earth Pro

LEGEND:

Approximate Slope Toe

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

Historic Aerial Photographs

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 4

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SOURCE:

The City of Burlington

LEGEND:

Approximate Slope Toe

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

Historic Aerial Photographs

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 5

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SOURCE:

Google Earth Pro

LEGEND:

Approximate Slope Toe

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

Historic Aerial Photographs

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 6

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North Portion

Middle Portion

South Portion

LEGEND:

Boundary Line

EXP Services Inc.

DRAWN :	HW
CHECKED :	SC
P.M. :	SC
SCALE :	NFS
PAPER SIZE :	11 x 17

North, Middle and South Portions of The Slope

Proposed Residential Redevelopment

1600 Kerns Road

Burlington, Ontario

REFERENCE : BRM-00801554-G0

DRAWING NO. : 7

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