GEOTECHNICAL INVESTIGATION

EROSON AND SLOPE STABILITY AT PIPER STREET, AYR, NORTH DUMFRIES,

Submitted To:

THE CORPORATION OF THE TOWNSHIP OF NORTH DUMFRIES

Submitted By:

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14130 –KONRAD CRESCENT
Markham, ON
Canada L3R 0G5

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SAFFA File No. SEP-330_Phase II

TABLE OF CONTENTS

LIST OF APPENDICES

1.0 INTRODUCTION

The Township of North Dumfries (the Township) contracted SAFFA Engineering Inc (SAFFA) to conduct geotechnical investigation to assess the existing slope of Nith River on the northern bank between #286 and #326 Piper Street (the Site), Ayr, North Dumfries.

Based on information provided by the township, erosion has been ongoing at the site for past few years. The township wants to investigate the reason(s) and assess the existing stability of slope. Also, to provide remediation measures if slope is found to be unstable or seems to worsen with time and become unstable with passage of time.

2.0 SITE DESCRIPTION

Piper street is generally oriented in east-west direction at the project location. The street is surrounded by residential properties on the north side and trees & bushes are on the south side. The street is generally 7 m wide and has a walkway on northern side. The Nith River is on the south side of the river. The Nith River's northern bank has a steep slope covered with grass, trees and shrubs.

There is an existing guardrail on the south side of Piper Street, starting from east of 286 Piper Street all the way to the ramp entrance. The existing guardrail consists of wooden post with W-beam. There is an overhead Hydro Line on the south side runs parallel to Piper Street. Hydro-poles are generally at a distance within 1.5 m from southern edge of the road.

Based on the topographic survey (provided in **Appendix A**), Piper Street at proposed section is generally flat and elevations varies between EL 292.06 m and EL 292.42 m. The river is approximately at an elevation of 276.86 m. The river bank slope generally varies between 1V:1.10H and 1V:1.33V.

3.0 SITE RECONNAISSANCE

Site visits were conducted on May 31st, 2021 and August 26, 2021. During these visits, the key features of the river bank slopes were noted and was photographically documented. The site photos taken during these visits are shown in **Appendix B**. In addition to these visits, some photos were also taken on March 9, 2022 to observe river flow in high recharge conditions.

During these visits, it was noted that the slope was generally covered with thick vegetation, traces and shrubs. And at places, garbage was dumped near the crest of the slope. The nature of dumped material is unknow but considering the steepness of the slope, the dumped layer is not considered to be thick enough (generally <1.5 m). The probability of the dumped material flowing into the river is highly likely, as some dump remains were found near the toe end of the river (**Photos 1 and 2**).

A ramp is located on the east side of the project site that gives access to the abandoned suspension bridge over the Nith River. SAFFA used this access ramp to reach the toe of the slope. At the toe, localized erosion was noticeable at various locations. The erosion was most prominent in the slope section from 80 m downstream to 130 m downstream of the suspension bridge. It was also noted that the erosion was in the vertical zone of 3 m starting from river water level (measured in September 2021) and upward. The extent of erosion is sizable and may contribute to larger slide failure if the measures are not taken in timely manner. The extent of erosion can be seen in a photos (**Photos 3 and 4**)

There could be various obvious factors for the observed erosion. Based on the field visits, it appears that the key factors that have contributed to the erosion of this extent, could be geometry, rapid river flow, river meandering and slope surface run-off. These factors may have acted individually/simultaneously to create existing slope worsening conditions. The simplest sequence of factors that may have acted, could be that the river flow had eroded the toe at first instance by creating an unstable toe slope. The unstable toe slope may have further deteriorated due to uncontrolled surface run-off.

Groundwater seepage can be added to the list of factors mentioned above. The seepage was noted at places generally in range of 2 to 4 m above the river level. Within this zone (between 2 m to 4 m above river level), overhang slopes were observed (**Photos 5 to 7**). These overhangs could have been created due to the difference in erosion rates in saturated zone and partially saturated zone. It is to be noted that in partially saturated state additional capillary forces can lead to an increase in shear strength parameters. The plant roots could be another factor that retain the soil around the roots (**Photo 8**).

The surface vegetation and network of plant roots has also acted against the erosion. The vegetation cover is generally missing in vertical zone of 4 m above the river level that has also contributed towards the overhanging slopes at places.

Based on the observations, it seems that the storm water system at the site is not efficient enough to avoid trickling of surface runoff to the slope.

One of the residents in the vicinity approached our team and conveyed that during the time of heavy rainfall, some burble sounds are being heard and these sounds become heavier as the rainfall intensity increases. These burble sound could be due to the rapid flow of water down the slope that creates noise especially at the overhangs near the toe of the slope.

4.0 SCOPE OF WORK

The scope of work (SOW) for this project was prepared by SAFFA in coordination with the township. Township of North Dumfries provided authorization to conduct the investigation on July 27, 2021. The scope generally includes drilling of five boreholes, field sampling and testing. Borehole location plan is provided in **Appendix A**. The scope also includes to conduct laboratory testing on the selected soil samples to categorise the soil type. The scope of work is summarized as below

1. Drilling and sampling of five (5) boreholes at Piper Street on southern shoulder to investigate subsurface soil conditions and measure groundwater levels.

2. If possible, drilling of five (5) shallow boreholes with hand augur and sampling at the toe end of the slope to investigate soil conditions near the eroded portion of the slope.

3. Installation of a vibrating wire piezometer (VWP) to measure long-term stabilized groundwater level in the borehole drilled at the crest (Piper Street shoulder).

4. Carryout topographic survey of the proposed area to establish slope gradients and use this information in the analysis.

5. Reconnaissance survey to observe salient slope feature to be identified in the report.

6. Conduct slope stability analysis to assess factor of safety of the existing slope using soil parameters developed based on the subsurface information revealed through site visits, drilling and laboratory testing.

It is to be noted that shallow boreholes at the toe of the slope was unable to be drilled due to very dense subsurface soil conditions and very shallow refusal was noted.

4.1 Ground Disturbance Checks and Safety

Ontario One Call was made for marking the public utilities. Ground disturbance checks were completed before August 24, 2021. Ontario One Call marked the location of the underground services registered with them. As part of SAFFA's safety program, a toolbox meeting was held at the site before starting the fieldwork. Representatives from both SAFFA and the drilling subcontractor attended the meeting.

4.2 Field Investigation

SAFFA arranged a truck mounted drill rig equipped with 150 mm diameter solid stem auger. Drilling was carried down to a maximum depth of 18.3 m.

The soil sampling and testing sequences are shown on the borehole logs provided in **Appendix C**. In general, standard penetration test (SPT) and disturbed auger samples were obtained at approximately 0.75 m depth intervals for the determination of in-situ compaction and moisture profiles in each borehole.

The field classification of the soil types was based on the auger cuttings and SPT samples. The retrieved soils samples were logged according to the Modified Unified Soil Classification System, which is described in the Explanation of Terms and Symbols in **Appendix D**. Due to the method by which the soil cuttings are returned to the surface, the depths noted on the borehole logs may vary ± 0.3 m from those recorded.

All boreholes were left open after completion of drilling to observe short term groundwater seepage and sloughing conditions. The boreholes were backfilled with drill cuttings and bentonite.

Soil samples obtained during the field investigation were labelled and sealed in plastic bags to limit moisture loss and transported to SAFFA's Markham laboratory for further visual examination and laboratory testing.

Borehole logs were prepared to record the descriptions and the relative positions of the various soil strata, location of samples obtained, and the results of the field test.

4.3 Laboratory Testing

Visual classification was performed on all soil samples. The geotechnical laboratory testing program consisted of:

- Soil moisture contents on all samples
- Grain size distribution measurements of the material finer than 0.075mm

Laboratory testing results can be found in **Appendix C**.

5.0 RESULTS OF INVESTIGATION

5.1 Subsurface Conditions

In general, the overburden stratigraphy encountered in the boreholes consisted of:

- A ground surface cover consisting of asphalt in all boreholes except borehole BH05; underlain by,
- A granular layer consisted of sandy gravel in all boreholes (BH01 to BH05); underlain by,
- A fill layer consisted of sand and gravel in boreholes BH04 and BH05; underlain by,
- Sand, sand with silt to gravelly sand layer in all boreholes; underlain by
- Silt, silt with sand to sandy silt in all boreholes.

No bedrock was encountered within the maximum termination depth of the boreholes (e.g., 18.3 m below existing grade).

Groundwater was encountered at depths ranging from 9.0 m to 10.5 m below grade.

The subsurface conditions observed in the boreholes are presented in detail on the Borehole logs provided in **Appendix C**. A generalized 2D subsurface soil profile has been generated by interpolating the stratigraphy encountered at drilling location and the results are shown in **Figure 1**, **Appendix C**.

5.2 Ground Surface Cover

At all borehole locations except borehole BH05, the ground surface was consisted of asphalt. The asphalt was in the range of 50 mm to 75 mm thick in all boreholes drilled at site.

Borehole BH05 was drilled on side of the road. A 150 mm thick topsoil layer was encountered in borehole BH05.

5.3 Granular Fill

The asphalted layer mentioned in the above section was underlain by a layer of granular fill consisting of sandy gravel. Thicknesses of this layer varied between 250 and 310 mm in all boreholes (except borehole BH05).

Based on visual and textural examination, the granular fill materials were assessed as dry. Moisture content tests carried on samples of the granular material yielded results below 3 % conducted on the samples recovered from boreholes.

5.4 Construction Fill

The granular layer mentioned in the above section was underlain by a layer of construction fill consisting of sand and gravel. Thicknesses of this layer was 2.4 m and 1.0 m in boreholes BH04 and BH05, respectively.

Based on visual and textural examination, the construction fill materials were assessed as dry to moist. Moisture content tests carried on samples of the construction fill material yielded results less then 3 %.

5.5 Sand, Sand with Silt to Gravelly Sand

A brown layer consisted of sand, sand with silt to gravelly sand was encountered in all boreholes (BH01 to BH05) underlying the layers referenced in the above sections. The sand layer extended to depths ranging from 8.2 to 10.7 m below grade in all boreholes (BH01 to BH05). The layer was found in compact to very dense state.

Based on visual and textural examination, the sand, sand with silt to gravelly sand was assessed as moist to damp. Moisture content tests carried on samples of sand, yielded results between 3 % and 10 %.

Grain size distribution testing was carried on two samples of sand, sand with silt to gravelly sand layer. The results are described in the respective log and are shown in the laboratory test results given in **Appendix B**. The results are summarized in **Table 5.1** below.

***Table 5.1**: Summary Sieve Analysis Test Results.*

Borehole /Location	Depth (m)	Soil Type	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH03	9.1	Sand	3	96	1	
BH04	9.1	Sandy Silt	0	9	84	7
BH05	7.0	Sand with Silt	2	70	29	

5.5.1 Silt, Silt with Sand to Sandy Silt

A brown layer consisted of silt, silt with sand to sandy silt was encountered in all boreholes below the layers referenced in the above sections. Silt, silt with sand to sandy silt layer extended to the maximum depth of investigation.

Based on SPT N-values, gravelly sand was in very dense state of compactness. The visual inspection of soil samples revealed that the native layer was generally in moist to damp conditions with moisture contents generally less than 11 %.

Grain size distribution testing was carried on a four (4) sample of silt, silt with sand to sandy silt layer. The results are described in the respective log and are shown in the laboratory test results given in **Appendix B**. The results are summarized in **Table 5.2** below.

***Table 5.2**: Summary Sieve Analysis Test Results.*

Borehole /Location	Depth (m)	Soil Type	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
BH03	10.7	Sandy Silt	3	33	56	8
BH04	12.2	Silt with Sand	1	25	63	11
BH05	12.2	Sandy Silt	14	31	48	7
BH05	15.2	Sandy Silt	6	28	56	10

5.6 Groundwater Conditions

All boreholes were open and dry upon completion of drilling. Vibrating wire piezometers were installed in borehole BH03. Groundwater was encountered at depth ranging from 9.0 m to 10.5 m below grade. Groundwater encountered in each borehole is summarized in below table.

***Table 5.3:** Groundwater level measured at borehole locations*

Borehole	Date	Groundwater Level (m)	Groundwater Elevation (m)	Remarks
BH01	August 25, 2021	9.5	282.0	At drilling completion
BH02	August 26, 2021	9.7	282.2	At drilling completion
BH03	June 28, 2022	10.4	282.3	2 weeks after completion
BH04	September 11, 2021	9.0	282.3	At drilling completion
BH05	September 11, 2021	10.5	282.0	At drilling completion

6.0 ANALYSIS AND DISCUSSION

A stratigraphic cross-section was created through middle of the bank close to the location of BH04 on the southern bank of Nith River. The section is considered the most critical (i.e. highest with steepest slope faces) from a stability perspective. The stratigraphic cross-section was developed based on the combined information from the recent topographic survey of the site and the results of the borehole investigation and associated laboratory testing.

6.1 Seepage Analysis

A seepage model using Seep/W module, was carried to generate phreatic water line to be used in the slope stability model. For this purpose, the groundwater level was assumed at an El 282.3 m.

The model geometry (Section A) shown in **Figure 1**, **Appendix E** was used in the analysis. The boundary conditions to run the seep model were used as given in below table;

Table 6.1: *Boundary Conditions for SEEP/W*

Section Location	Boundary Area	Type of Boundary	Boundary Value
Section A	Top of the Model (natural ground)	Infiltration	630 mm / year
	Toe Boundary	Total Head	277 m
	Left extreme end of model (north)	Total Head	282.3 m (GWL)

The boundary conditions were selected based on the field observations and annual precipitation record. At the toe (south), the boundary conditions were determined based on observed water levels at the river recorded at the time of topographic survey. On northern end (left side of the model), total head boundary conditions were applied using observed long-term groundwater level. A surface recharge of 630 mm/year was considered as surface boundary conditions for natural ground considering annual precipitation in the region.

The saturated hydraulic conductivities for the soil layers used in the model are summarized in Table 6.2. The conductivity values were assessed based on engineering judgement with similar type of soil and the values given in the Ontario Building Code (OBC).

Table 6.2 *Summary of Saturated Horizontal Hydraulic Conductivity*

Material	Saturated Horizontal Hydraulic Conductivity, k_h (m/s)	k_h to k_v ratio
Sandy Gravel	1×10^{-3}	1
Sandy Silt	1×10^{-5}	1
Sand with Silt	1×10^{-4}	1

Seepage analyses results for Section A are shown in **Figure 1**, Appendix E.

The results indicate that all the inflow due to anticipated precipitation is collected by river basin. Moreover, the groundwater level in the area is generally controlled by the river level.

6.2 Slope Stability

6.2.1 Soil Profile

The stability analysis was carried out using Slope/W computer modelling software using Morgenstern-Price analysis method. The stability model was setup based on the project requirements and subsurface information gathered from the field investigation program, groundwater scheme generated using Seep/W model.

The soil parameters provided in below table (Table 6.3) were used to represent the subsurface soil conditions encountered at the site and back-analysis of the existing failure surface near the toe. In absence of specific testing, following parameters have been established based on professional practice and pervious experience dealing with similar type of soils.

***Table 6.3**: Summary of Estimated Soil Parameters for Slope Stability Analyses*

Soil Type	**γ (kN/m^3)**	**c' (kPa)**	**ϕ' (deg.)**
Topsoil	16	60	18
Sandy Gravel	21	0	39
Sand with Silt	20.5	0	36.5
Sandy Silt with gravel	21.5	0	41.5

The angle of internal friction was estimated using a correlation ($\phi' = (15.4*(N1)_{60})^{0.5} + 20°$). The scattered plot of angle of internal based on the SPT N-value is shown in **Figure 1**, Appendix F.

6.2.2 Slope Stability Analysis

Slope stability analyses were performed for static and seismic conditions. Seismic hazard was evaluated based on the 2015 National Building Code of Canada seismic hazard calculator (National Resources Canada). The calculated peak ground acceleration of the site at 2 % probability per 50 years is 0.081g (refer to **Appendix F**).

Factors of Safety (FOS) are generally introduced in the slope stability assessments, which may vary from 1.3 to 1.5; however, the selection of an appropriate FOS for a slope depends on many factors such as importance of the structure, potential failure consequences, uncertainties involved in the design loads and soil parameters, the additional cost associated with a higher FOS, and the risk the owner is willing to accept in case of failure. Slopes with factors of safety (FOS) of less than 1 indicate that the available shear strength to resist failure is less than driving forces required to initiate failure. A minimum FOS of 1.5 is considered acceptable against deep-seated failure surfaces under static conditions.

A surcharge load of 5 kPa was assumed incorporating the effect generated due to the flow of traffic on Piper Street.

The results of the stability analyses, considering long-term parameters, indicate that the FOS against instability of a failure surface initiating near the crest of the slope at the site is over unity (1.15).

The results of these slope stability analyses are displayed on **Figure 2 and Figure 3** in Appendix E. Stability analyses was carried out for short-term pseudo-static and long-term conditions.

Based on the slope stability analyses results for the slope are provided in below table (Table 6.5) are and are presented in **Figure 2 and 3**.

Table 6.5: *Global stability analysis for rock armor wall*

Structures	**Failure Mode**	**FOS**
River Bank Slope	Static	1.15
	Seismic	1.07

6.2.3 Discussion and Recommendations

The results of the stability analyses, considering long-term parameters, indicate that the FOS against instability of a failure surface initiating near the crest is just over unity. These analyses also do not account for loss of strength of surficial soils that can occur due to environmental conditions (e.g. saturation or freeze/thaw cycles) which could further reduce the FOS of shallow failure surfaces. In contrast, the model is also not accounted for the effect of root action, which most probably would nullify the possibility of near surface failure.

Based on the results of the stability analyses and site observations, the slope is considered to be just more than marginally stable under current site conditions.

The site reconnaissance identified an area of slope instability/sloughing at toe of the bank slope generally all along the proposed section. The slope face along the proposed section is steep (generally varies between 1.10H:1V to 1.30H:1V) which is considered to be the primary factor leading to the observed sloughing near the toe. Other factors (e.g. river flow, saturation of the surficial materials due to precipitation, loss of strength due to freeze-thaw cycles, etc.) may also have contributed to the instability. The results of the stability analyses (**Figure 4**, Appendix E) indicate that the FOS against instability for a failure surface similar to the area of instability noted at the site is slightly over unity.

Based on the slope configuration and the results of the stability analyses, the slope southern bank slope is considered to be susceptible to ongoing instability in the future. This may include continuing slope movement in the area of the currently identified instability and/or sloughing/instability of the slope face in new areas. Although the currently noted sloughing is relatively shallow in nature, ongoing instability may cause the failure surface(s) to retrogress (i.e. extend further back into the embankment) which could generate deep seated failure. The deep-seated failure may destroy the Piper Street completely/partially, depending upon the curvature and initiation point of the failure line. Therefore, remedial works are recommended to improve the long-term stability of the slope.

Due to space limitation, flattering of the slope is not an option. Therefore, slope stabilization by intervention is recommended.

Based on the analysis, it is found that the slope sloughing/instability is generally at the toe and it is envisaged that this may retrogress into the slope that is expected to initiate major slope failure. Therefore, stabilizing the toe of the slope will protect it from sloughing and also will shift the failure line further deeper into the slope.

A gravity wall consisting of armour stone (or other similar) is recommended to be constructed at the toe just above the maximum river water level. The wall is recommended to be constructed at maximum flood line and should be grounded minimum 1.0 m below the river bed. The front face of rock armour wall is recommended to be protected from river erosion using rip-rap layer extending into the river bed. The wall is to be constructed on a stable pad constructed using granular material fulfilling requirements of Granular B having thickness not less that 500 mm. The granular pad should be covered with geotextile. The wall should be slightly back-inclined having mild slope (say 8V:1H). A filter layer is recommended behind the wall to avoid accumulation of pore-pressure.

The results of stability analyses for a modified section including rock armour wall with slope face constructed by placing rip-rap on the downslope of the wall are displayed on **Figure 5**, Appendix D. As shown on this figure, the FOS against instability for a failure surface extending past the crest of the slope is 1.51 which is considered acceptable. Therefore, inclusion armour stone wall at the toe of the slope is recommended to address stability concerns.

The granular pad is recommended to be constructed using granular fill materials meeting the requirements of Ontario Provincial Standard Specification (OPSS) Granular B Type 1 or Type 2 materials. The imported fill should be placed in maximum of 200 mm thick lifts and compacted to a minimum of 98% of the material’s Standard Proctor maximum dry density (SPMDD).

Materials testing and inspection should be carried out during construction of the granular pad and wall to confirm the materials used meet project specifications and required level of compaction.

6.3 Slope Monitoring

The current conditions suggest that slope toe is deteriorating continuously due to various factors, like, river flow, surface runoff, absence of vegetation. Based on the assessment, the overall slope is generally slightly stable having FOS of 1.15. It is anticipated that the FOS will continue on worsening due to retrogression of toe erosion. Therefore, it recommended that the slope should be monitored continuously until the proposed remediation is completed.

It is recommended to monitor the slope using inclinometer to be used in predrilled boreholes (BH03 to BH05). Base-line readings (comprised of Horizontal/vertical controls) should be carried for the installed inclinometer casing in the boreholes (BH03 to BH05). Then carry out inclinometer measurement immediately after the completion of Horizontal/vertical control for all three installed inclinometers casings in the boreholes. The slope should be monitored at a frequent time interval to assess slope movement. The monitoring plan can be continued until it is assured that the slope is inactive and no further movements in the slope are expected or the slope rehabilitation scheme has been completed. Following scheme of measurements is considered at this stage.

- Six (6) once a week reading including horizontal control;
- Six (6) once bi-weekly readings including horizontal control; and
- Nine (9) once monthly readings including horizontal control.

Each measurement should inclinometer reading, horizontal control reading using survey crew, and a factual data report. The data report be submitted in a week time after the field measurement. However, the information should be conveyed verbally within a 24-hour period or right away if needed and/or movement in the slope is expected to reach the alert limit.

The readings obtained during monitoring are "classified" in the context of the magnitude and potential risk to the infrastructure being monitored. In this respect, the following ranges apply.

- Allowable Limit: 0 to < 4 mm displacement (for vertical and horizontal movement)
- Review Limit: 4 mm to < 12 mm displacement (for horizontal/vertical movement)
- Alarm Limit: Greater than 12 mm displacement (for horizontal/vertical movement)

The limits stated also consider the typical industry standard accuracy for the survey which is in the order of +/- 2 mm.

7.0 CLOSURE

The findings and recommendations of this report were based on the results of the field and laboratory investigations, combined with an interpolation of the soil and groundwater conditions between the boreholes. If conditions are encountered that appear to be different from those observed in the boreholes drilled at this site, a qualified Geotechnical Consultant should be notified in order that the recommendations can be reviewed and adjusted if necessary.

Soil conditions by their nature can be highly variable across the site. The placement of fill and prior construction activities on a site can contribute to the variability especially in the near surface soil conditions.

This report was prepared exclusively for the use of the Corporation of The Township of North Dumfries and their agents for the proposed redevelopment of Nith River Northern bank on Piper Street. The findings and recommendations of this report are prepared in accordance with generally accepted professional engineering principles and practices.

We trust that the information presented in this report meets your current requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

SAFFA Engineering Inc.

Fiaz Ahmad, MASc., P. Eng.
Geotechnical Engineer

Fawad Khan, MASc.
Technical Professional - Geotechnical

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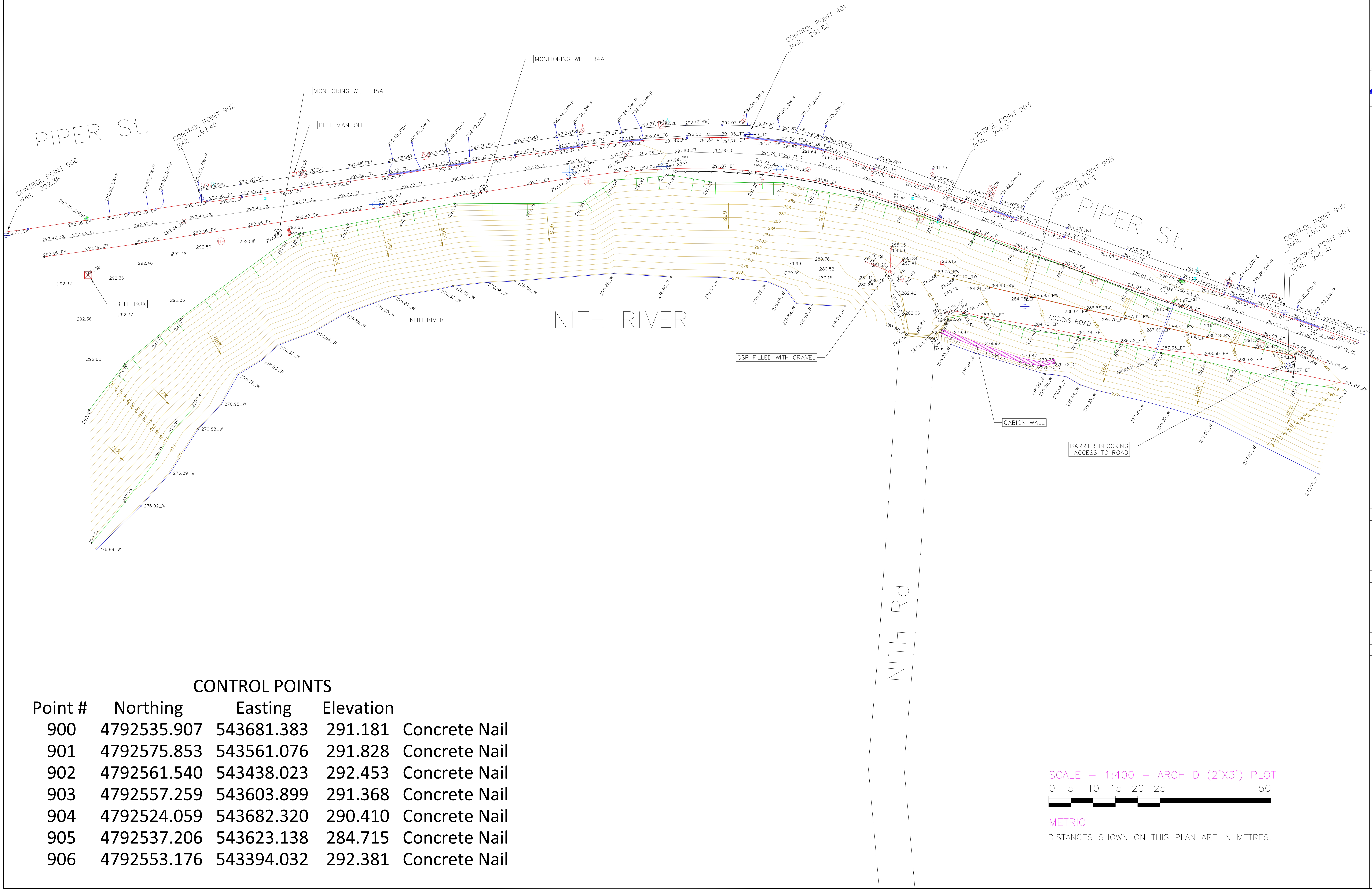
Principal, Geotechnical Engineer

Appendix A Topographic Survey Drawing
Borehole Location Plan



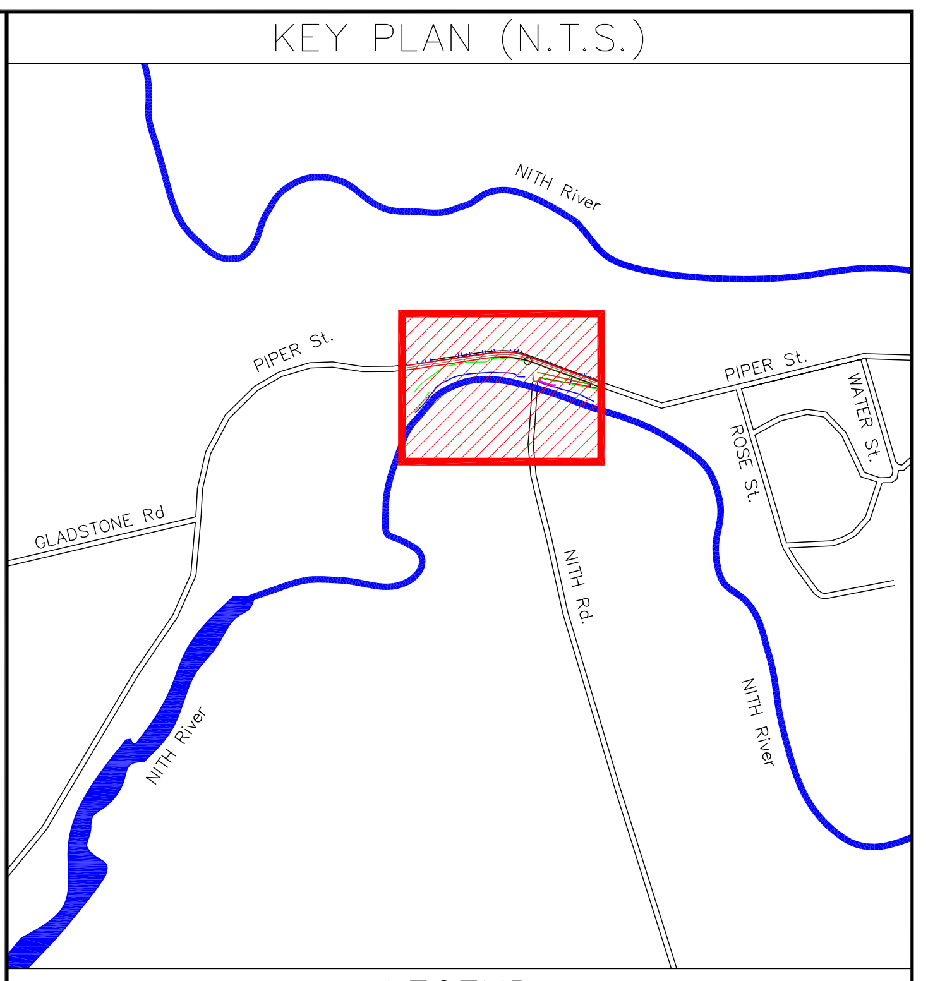
CONTROL POINTS

Point #	Northing	Easting	Elevation	
900	4792535.907	543681.383	291.181	Concrete Nail
901	4792575.853	543561.076	291.828	Concrete Nail
902	4792561.540	543438.023	292.453	Concrete Nail
903	4792557.259	543603.899	291.368	Concrete Nail
904	4792524.059	543682.320	290.410	Concrete Nail
905	4792537.206	543623.138	284.715	Concrete Nail
906	4792553.176	543394.032	292.381	Concrete Nail

SCALE – 1:400 – ARCH D (2'X3') PLOT
0 5 10 15 20 25 50

METRIC
DISTANCES SHOWN ON THIS PLAN ARE IN METRES.

KEY PLAN (N.T.S.)



LEGEND

BARRIER
BORE HOLE
CATCH BASIN
CATCH BASIN MANHOLE
FIRE HYDRANT
GABION
GUY WIRE
HYDRO POLE
HYDRO VAULT
MANHOLE
MONITORING WELL
POST
UTILITY PEDESTAL
UTILITY POLE
VALVE BOX

BH	BORE HOLE
CB	CATCH BASIN
CBMH	CATCH BASIN MANHOLE
CL	CENTRE LINE OF ROAD
DW-G	DRIVEWAY–GRAVEL
DW-I	DRIVEWAY–INTERLOCK BRICK
DW-P	DRIVEWAY–PAVED
EP	EDGE OF PAVEMENT
G	GABION
MH	MANHOLE
RW	RETAINING WALL TOP
SW	SIDEWALK
TC	TOP BACK OF CURB
TCD	TOP BACK OF DEPRESSED CURB
W	WATER

NOTES

1. SURVEYED: 2021/11/11, 12/01 & 14
2.
3.

REFERENCE

BENCHMARKS : CVGD–1928 '78 ADJ.
Geoid model HT 2.0 GNSS Observations

GEODETIC SYSTEM : UTM Z17 NAD 83 CSRS
via TRIMBLE CANNET GNSS Observations

REVISIONS

NO.	DATE	DESCRIPTION	BY	CKD.
1.				
2.				
3.				

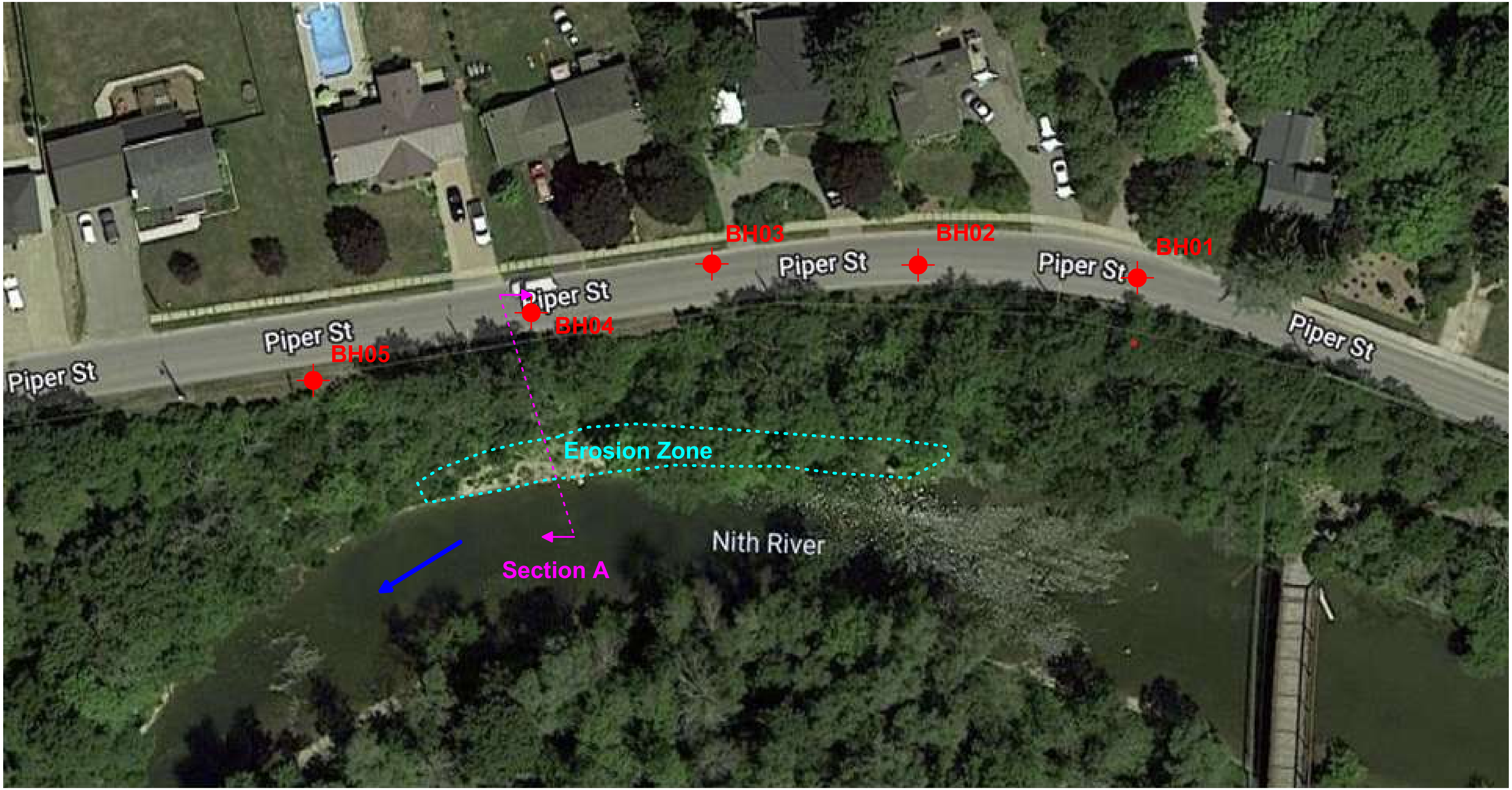
CSS INC.
COMPLETE SURVEY SOLUTIONS
2A–7170 West Credit Ave., Mississauga, ON. L5N 6C6
Tel (905) 821–8696, Fax (905) 821–9078

EXISTING CONDITIONS
AYR: PIPER St. AND SOUTHWARD TO Riv. NITH SHORE ~BETWEEN ROSE St. & GLADSTONE Rd.

NORTH

PROJECT No.: 21–2038	DRAFTED BY: V.A.K.
CLIENTS BASE FILE NAME:	CHECKED BY:
CADD FILE NAME:	DATE: 2021/12/15

Dec 15, 2021 – 2:29pm – USER vkosztowniak
J:\2021\2000\212038 – North Dumfries Piper Street, Rose Street to Gladstone Road – Saffa\Ayr–PiperSt–C3D.dwg



SAFFA
Engineering Inc.

Drawing:

Borehole Layout Plan

Project: SEP330

Title: **Borehole Layout Plan, Piper Street,**
Ayr, North Dumfries.

Client: Township of North Dumfries

Jun 28, 2022

Figure: 01

Scale: NTS

Rev: 01

Appendix B Site Photography

Photo 1: Garbage fill near crest (taken from Piper St.)

Photo 2: Scattered garbage on the slope.

Photo 3: Erosion on the norther slope of Nith River.

Photo 4: Erosion on the norther slope of Nith River (closer view).

Photo 5: Overhanging slope due to roots on the slope

Photo 6: Overhanging slope due to roots on the slope with seepage

Photo 7: Overhanging slope due to roots on the slope

Photo 8: Roots action to prevent slope surface erosion

Photo 9: River flow in September 2021.

Photo 10: Slope surface vegetation.

Photo 10: Slope surface vegetation in winter

Photo 10: Extent of eroded slope.

Photo 11A: Closer look of eroded slope surface.

Photo 11B: Closer look of eroded slope surface.

Photo 11C: Closer look of eroded slope surface.

Photo 11D: Closer look of eroded slope surface.

Photo 12: A ramp access to abandoned suspension bridge.

Photo 13: River Flow in March 2022 (taken from suspension bridge facing west)

Photo 3: A hydro pole at eastern end of proposed section (app. 20 m from suspension bridge)

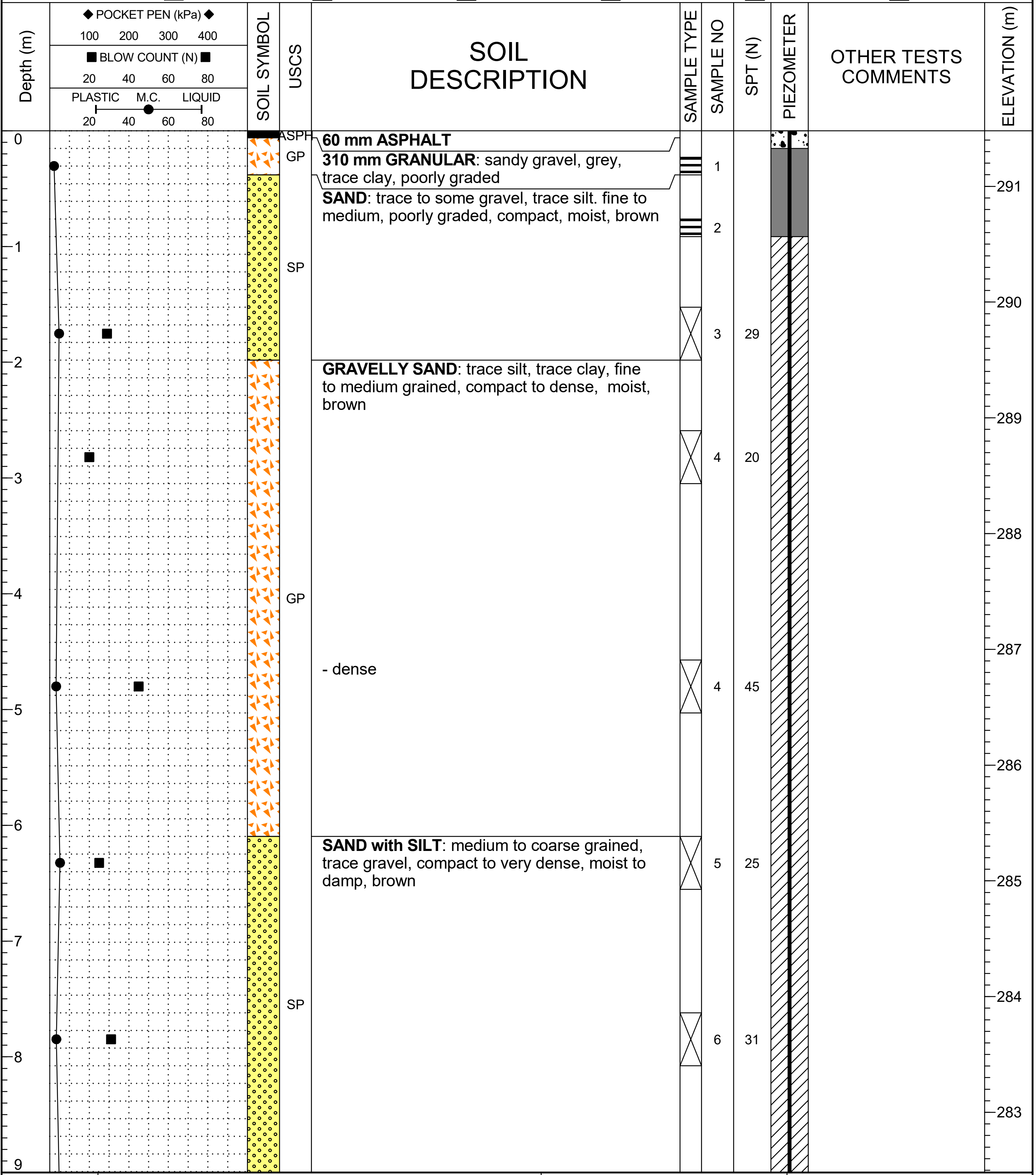
Appendix C Borehole Logs

Grain Size Distribution Analysis
A generalized 2D subsurface soil profile

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH01**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792567 E:543575	ELEVATION: 291.5 m

SAMPLE TYPE ■ Shelby Tube ◪ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ▮ Core

BACKFILL TYPE ▩ Bentonite ⬚ Pea Gravel ▥ Slough ⁘ Grout ▨ Drill Cuttings ⁘ Sand



SOIL DESCRIPTION

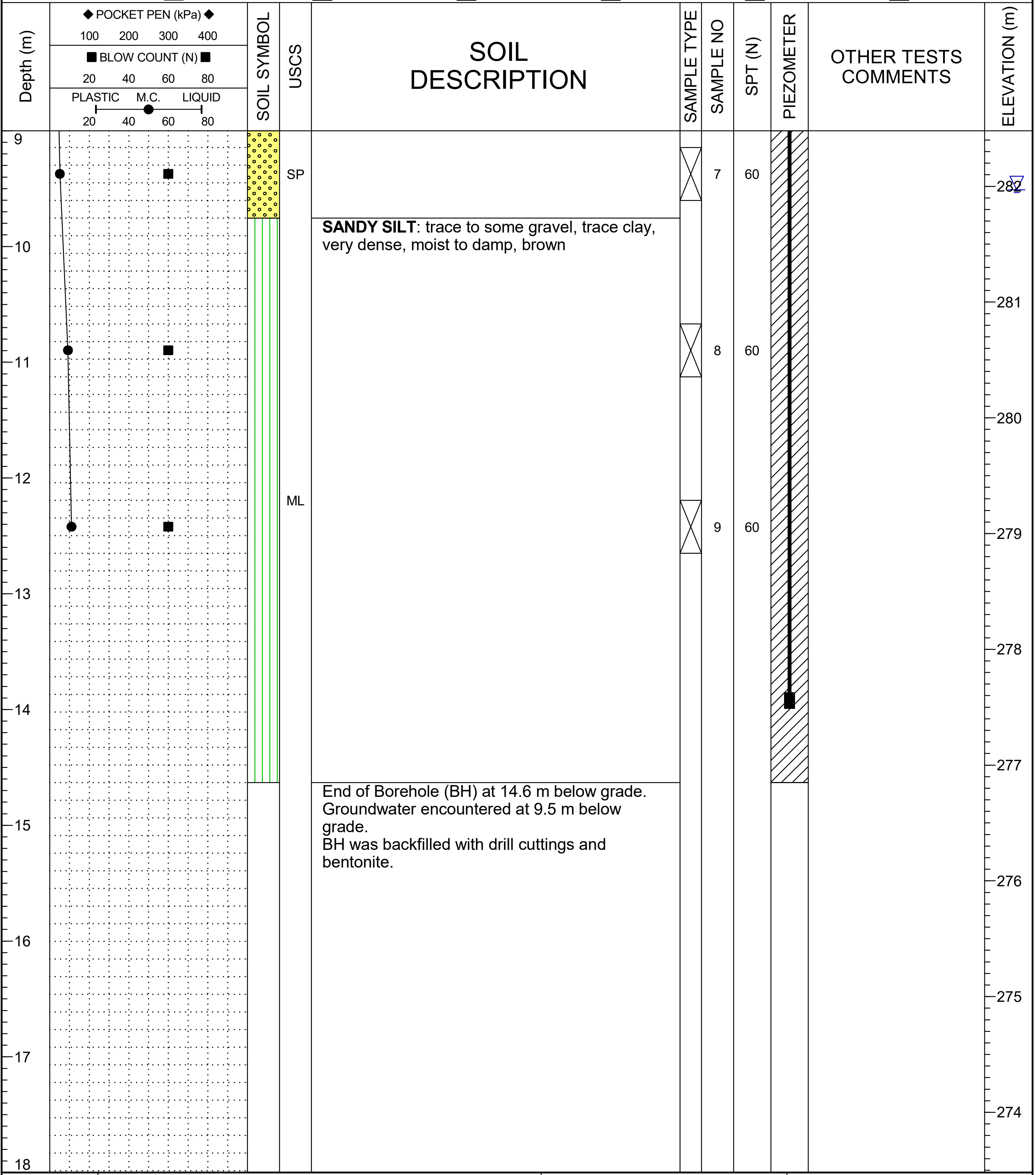
USCS	SOIL DESCRIPTION
ASPH	**60 mm ASPHALT**
GP	**310 mm GRANULAR**: sandy gravel, grey, trace clay, poorly graded
SP	**SAND**: trace to some gravel, trace silt. fine to medium, poorly graded, compact, moist, brown
GP	**GRAVELLY SAND**: trace silt, trace clay, fine to medium grained, compact to dense, moist, brown - dense
SP	**SAND with SILT**: medium to coarse grained, trace gravel, compact to very dense, moist to damp, brown

SAMPLE TYPE	SAMPLE NO	SPT (N)
☰	1	
☰	2	
☒	3	29
☒	4	20
☒	4	45
☒	5	25
☒	6	31

SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 14.6 m
	LOGGED BY: FA	COMPLETION DATE: 8/25/21
	REVIEWED BY: FK	Page 1 of 2

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH01**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792567 E:543575	ELEVATION: 291.5 m

SAMPLE TYPE	■ Shelby Tube	◺ No Recovery	☒ SPT Test (N)	☰ Grab Sample	▥ Split-Pen	▮ Core
BACKFILL TYPE	■ Bentonite	⁚ Pea Gravel	▥ Slough	⁘ Grout	▨ Drill Cuttings	⁙ Sand



SAMPLE NO	SPT (N)
7	60
8	60
9	60

SANDY SILT: trace to some gravel, trace clay, very dense, moist to damp, brown

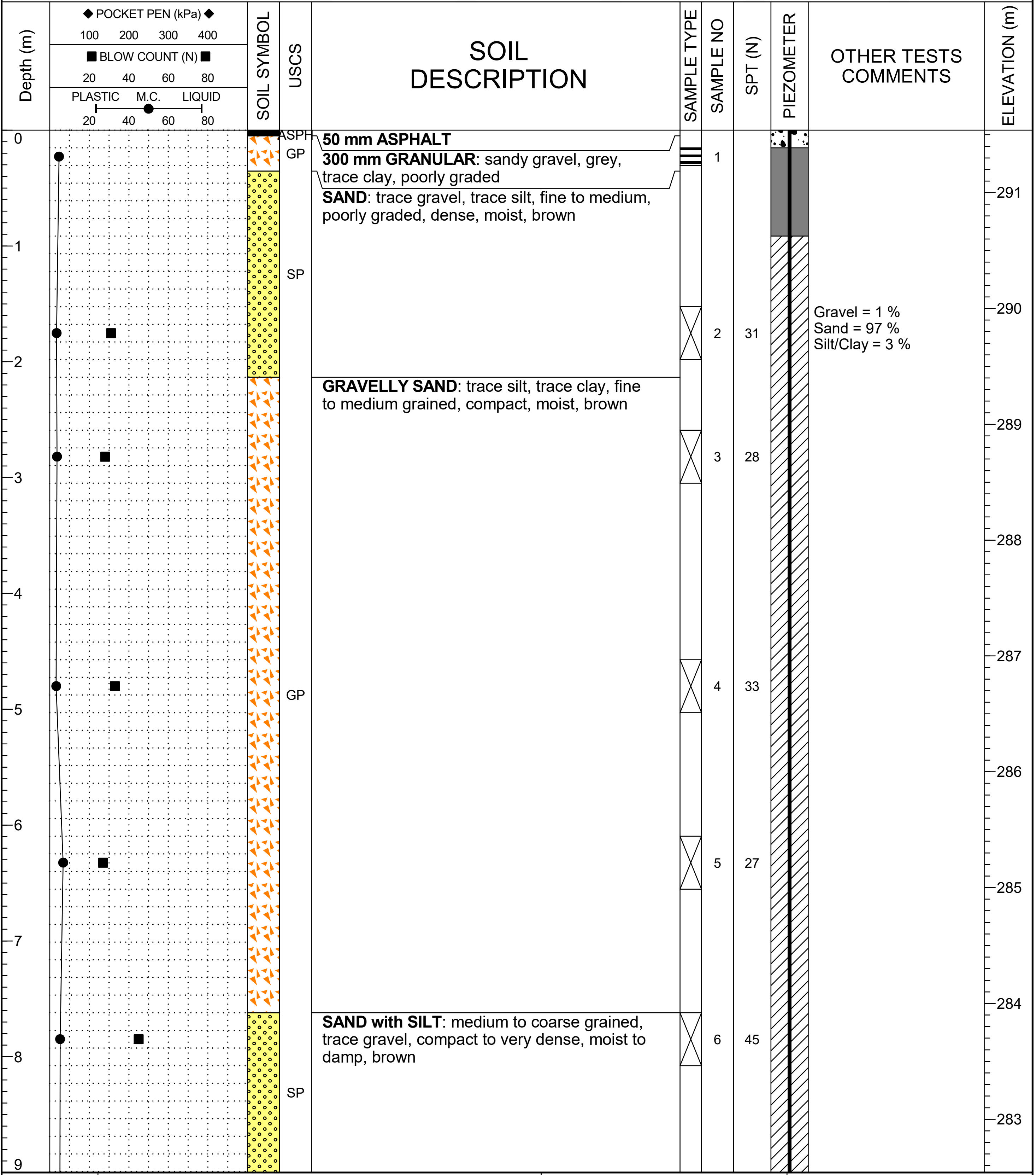
End of Borehole (BH) at 14.6 m below grade.
Groundwater encountered at 9.5 m below grade.
BH was backfilled with drill cuttings and bentonite.

SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 14.6 m
	LOGGED BY: FA	COMPLETION DATE: 8/25/21
	REVIEWED BY: FK	Page 2 of 2

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH02**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792569 E:543545	ELEVATION: 291.5 m

SAMPLE TYPE ■ Shelby Tube ▧ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ▮ Core

BACKFILL TYPE ▩ Bentonite ⬚ Pea Gravel ▥ Slough ⁘ Grout ▨ Drill Cuttings ⁙ Sand



50 mm ASPHALT

300 mm GRANULAR: sandy gravel, grey, trace clay, poorly graded

SAND: trace gravel, trace silt, fine to medium, poorly graded, dense, moist, brown

GRAVELLY SAND: trace silt, trace clay, fine to medium grained, compact, moist, brown

SAND with SILT: medium to coarse grained, trace gravel, compact to very dense, moist to damp, brown

SAMPLE TYPE	SAMPLE NO	SPT (N)
☰	1	
☒	2	31
☒	3	28
☒	4	33
☒	5	27
☒	6	45

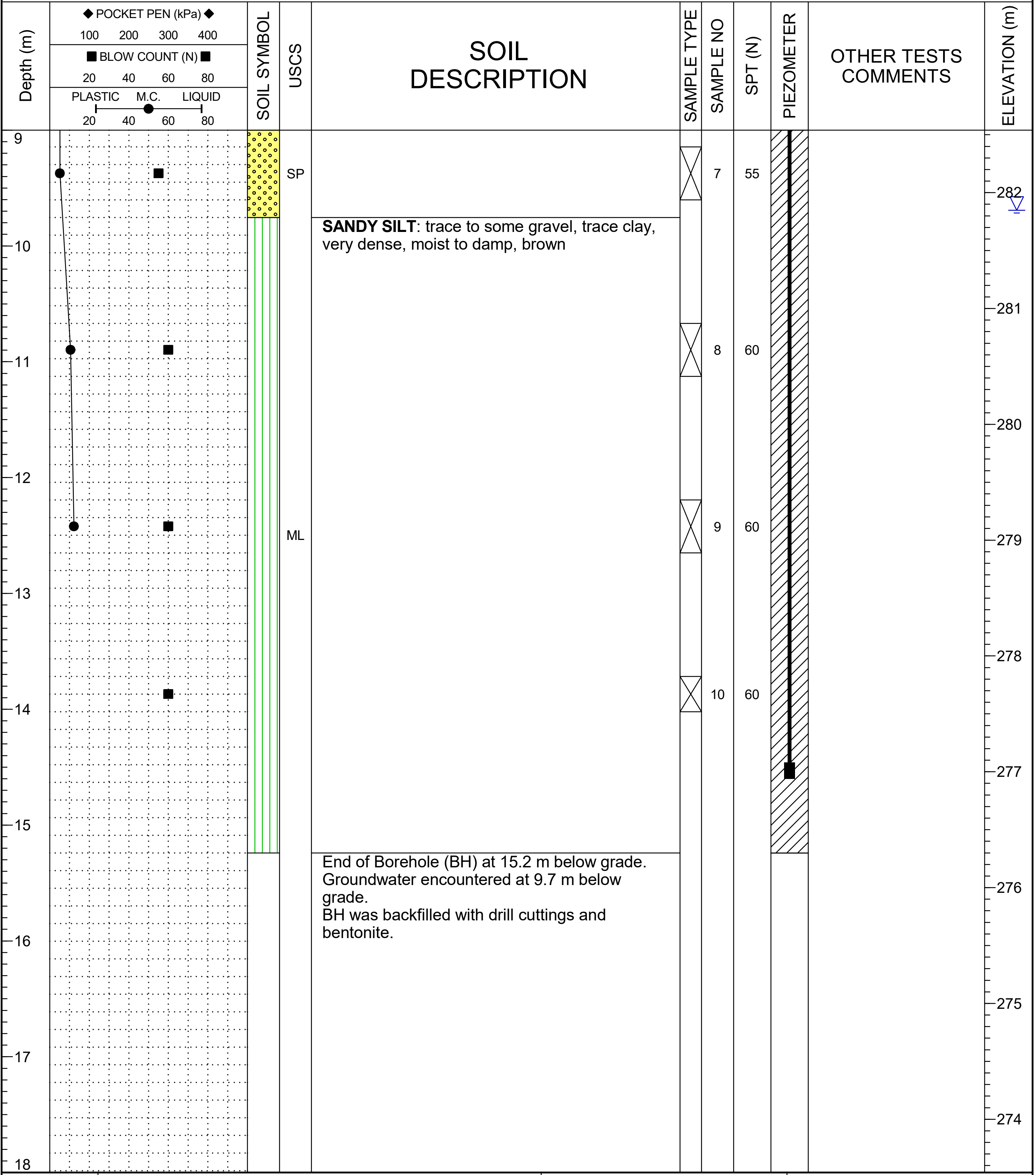
Gravel = 1 %
Sand = 97 %
Silt/Clay = 3 %

SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 15.2 m
	LOGGED BY: FA	COMPLETION DATE: 8/26/21
	REVIEWED BY: FK	Page 1 of 2

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH02**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792569 E:543545	ELEVATION: 291.5 m

SAMPLE TYPE ■ Shelby Tube ◺ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ▮ Core

BACKFILL TYPE ■ Bentonite ⬚ Pea Gravel ▥ Slough ▨ Grout ▨ Drill Cuttings ⁘ Sand



SANDY SILT: trace to some gravel, trace clay, very dense, moist to damp, brown

End of Borehole (BH) at 15.2 m below grade.
Groundwater encountered at 9.7 m below grade.
BH was backfilled with drill cuttings and bentonite.

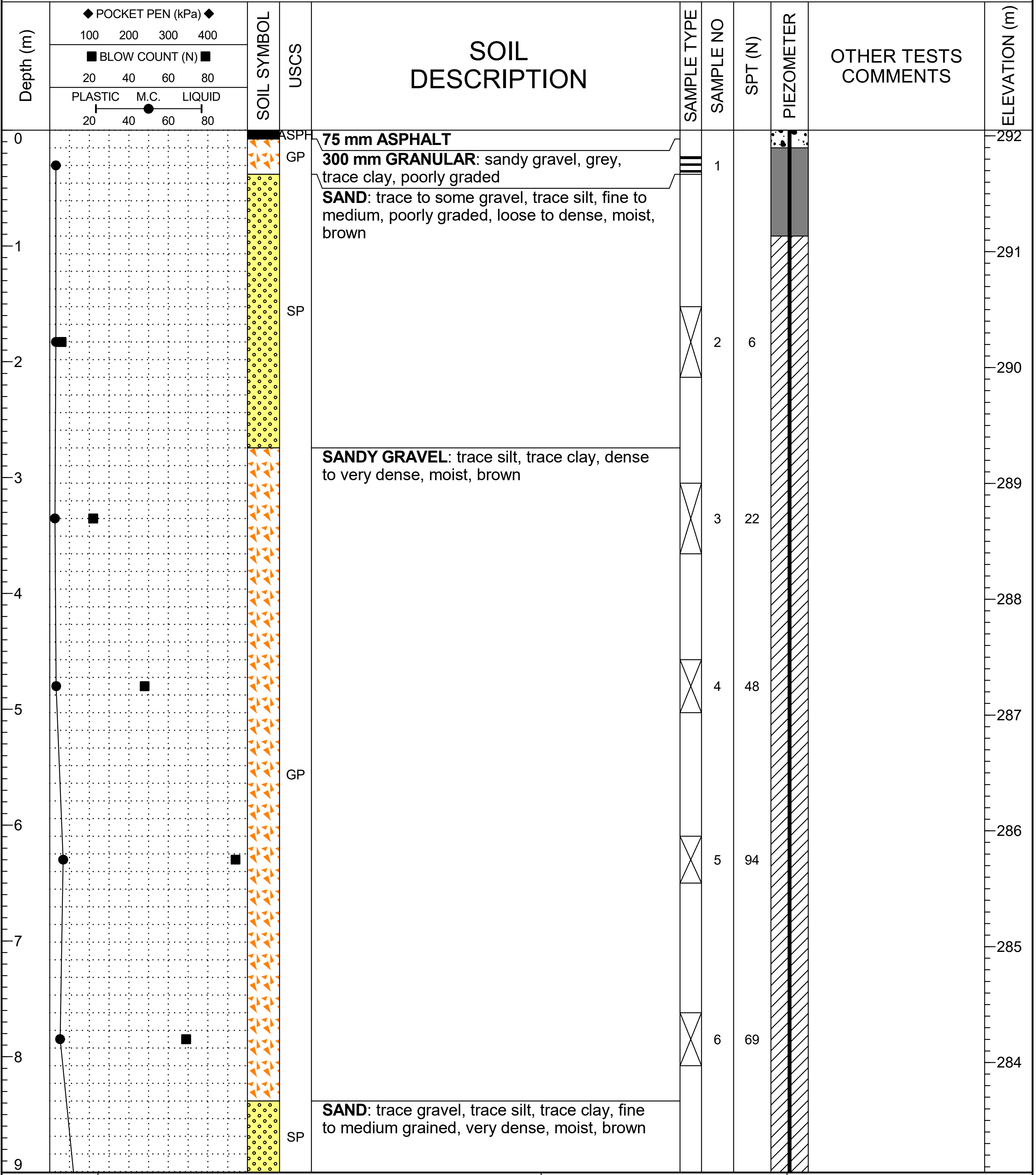
SAMPLE NO	SPT (N)
7	55
8	60
9	60
10	60

SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 15.2 m
	LOGGED BY: FA	COMPLETION DATE: 8/26/21
	REVIEWED BY: FK	Page 2 of 2

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH03**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792567 E:543516	ELEVATION: 292 m

SAMPLE TYPE ■ Shelby Tube ▨ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ▯ Core

BACKFILL TYPE ■ Bentonite ⬚ Pea Gravel ▥ Slough ⁘ Grout ▨ Drill Cuttings ⁘ Sand



75 mm ASPHALT

300 mm GRANULAR: sandy gravel, grey, trace clay, poorly graded

SAND: trace to some gravel, trace silt, fine to medium, poorly graded, loose to dense, moist, brown

SANDY GRAVEL: trace silt, trace clay, dense to very dense, moist, brown

SAND: trace gravel, trace silt, trace clay, fine to medium grained, very dense, moist, brown

SAMPLE NO	SPT (N)
1	
2	6
3	22
4	48
5	94
6	69

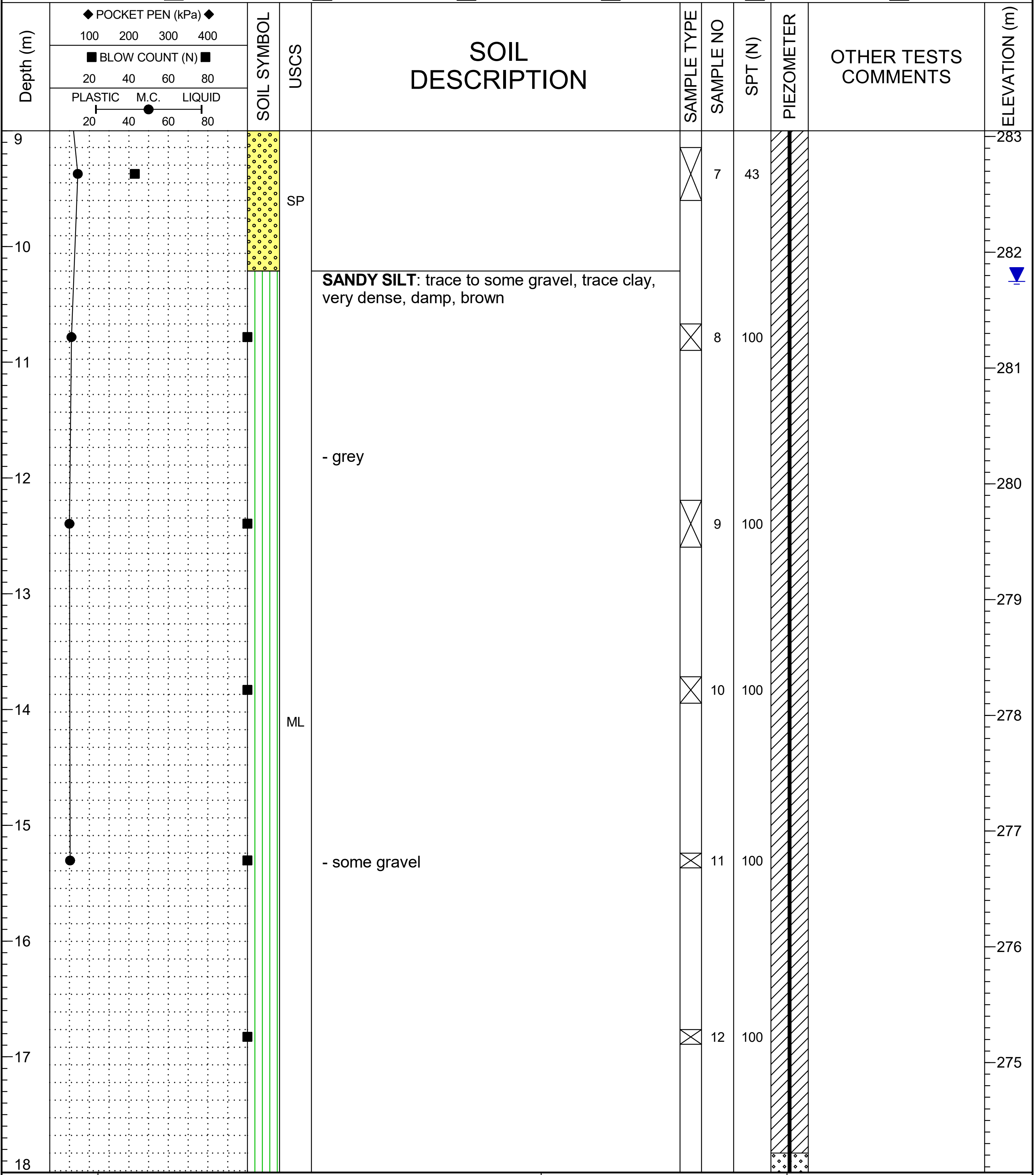
SAFFA Engineering Inc
Markham, Ontario

ENTERED BY: FA	COMPLETION DEPTH: 18.3 m
LOGGED BY: FA	COMPLETION DATE: 6/14/22
REVIEWED BY: FK	

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH03**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792567 E:543516	ELEVATION: 292 m

SAMPLE TYPE ■ Shelby Tube ◿ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ◧ Core

BACKFILL TYPE ▩ Bentonite ⬚ Pea Gravel ▥ Slough ⁘ Grout ▨ Drill Cuttings ⁘ Sand



SP

SANDY SILT: trace to some gravel, trace clay, very dense, damp, brown

- grey

ML

- some gravel

SAMPLE TYPE	SAMPLE NO	SPT (N)
☒	7	43
☒	8	100
☒	9	100
☒	10	100
☒	11	100
☒	12	100

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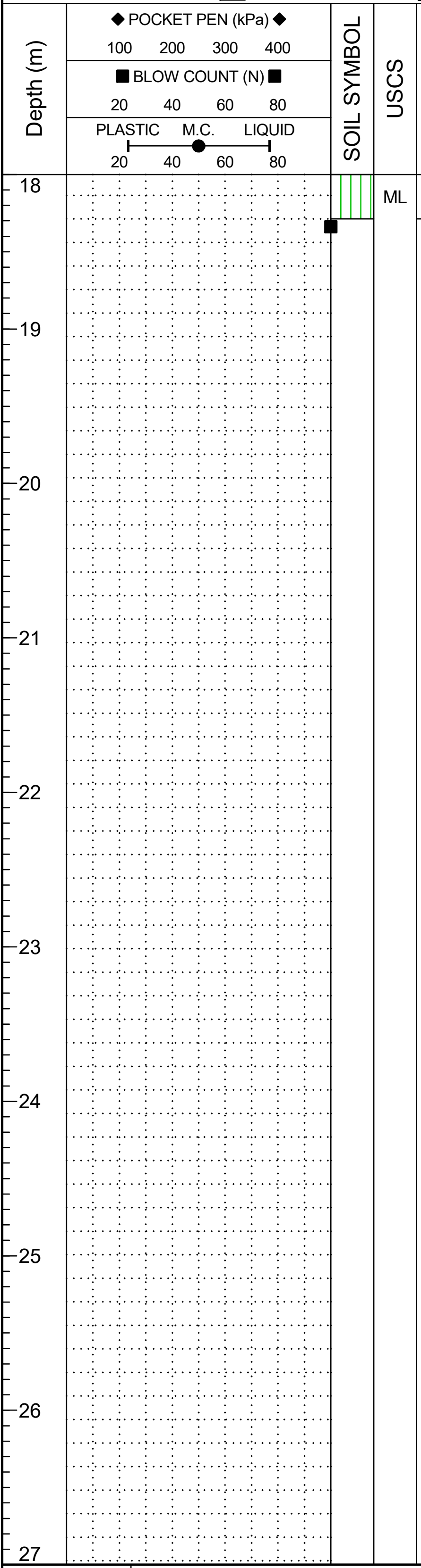
SAFFA Engineering Inc
Markham, Ontario

ENTERED BY: FA	COMPLETION DEPTH: 18.3 m
LOGGED BY: FA	COMPLETION DATE: 6/14/22
REVIEWED BY: FK	

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH03**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792567 E:543516	ELEVATION: 292 m

SAMPLE TYPE ■ Shelby Tube ◸ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ▮ Core

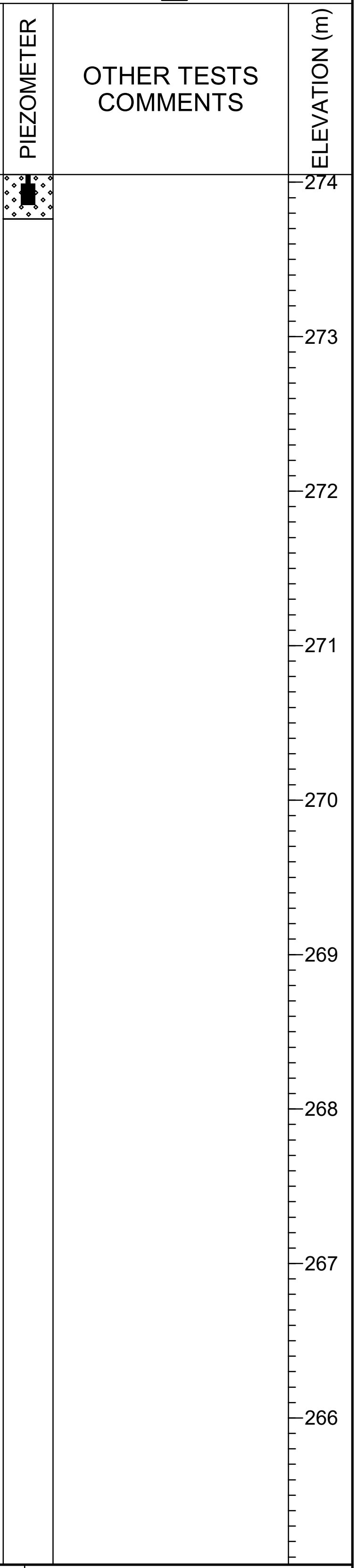
BACKFILL TYPE ▩ Bentonite ⬚ Pea Gravel ▥ Slough ▦ Grout ◸ Drill Cuttings ⁘ Sand



SOIL DESCRIPTION

End of Borehole (BH) at 18.3 m below grade.
Borehole was dry upon completion.
Vibrating Wire Piezomter (VWP#357153) was installed at 18.2 m below grade.
Inclinometer casing was installed to the full fepth of borehole (18.3 m)

SAMPLE TYPE	SAMPLE NO	SPT (N)
☒	13	100



SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 18.3 m
	LOGGED BY: FA	COMPLETION DATE: 6/14/22
	REVIEWED BY: FK	Page 3 of 3

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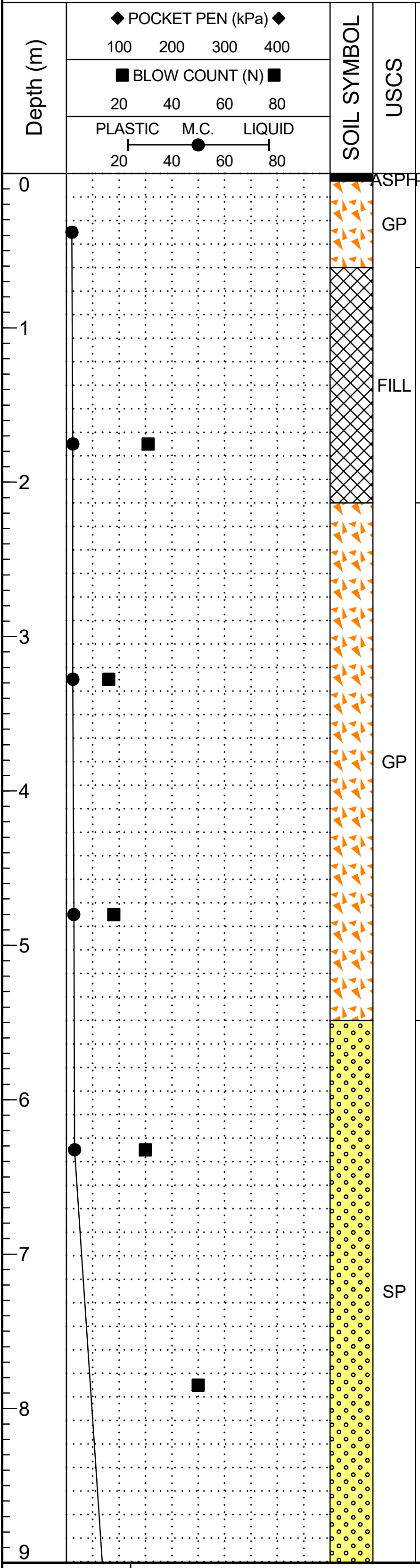
Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH04**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792564 E:543490	ELEVATION: 292.3 m

SAMPLE TYPE	■ Shelby Tube	◿ No Recovery	☒ SPT Test (N)	☰ Grab Sample	▥ Split-Pen	▮ Core
BACKFILL TYPE	■ Bentonite	⁘ Pea Gravel	▥ Slough	⁘ Grout	▨ Drill Cuttings	⁘ Sand



SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT (N)	SLOPE INCLINOMETER	OTHER TESTS COMMENTS
50 mm ASPHALT					
250 mm GRANULAR: sandy gravel, grey, trace clay, poorly graded	☰	1			
FILL : sand and gravel, trace silt, trace cobbles, dense, dry to moist, brown	☒	2	31		
SANDY GRAVEL: trace silt, trace clay, trace cobbles, compact, moist, brown	☒ ☒	3 4	16 18		
SAND: medium to coarse grained, trace silt, trace clay, trace gravel, compact, moist to damp, brown - some gravel - dense	☒ ☒	5 6	30 50		

ELEVATION (m): 292, 291, 290, 289, 288, 287, 286, 285, 284

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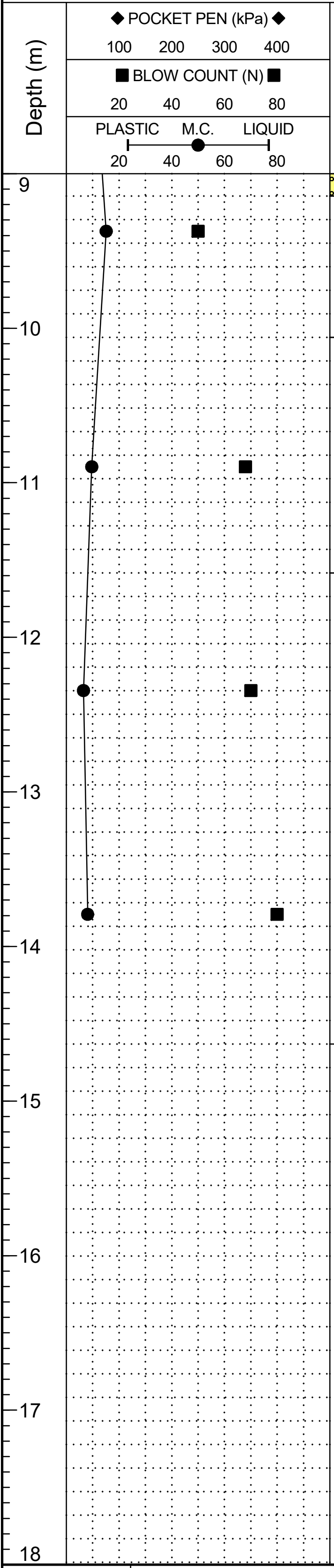
SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 12.5 m
	LOGGED BY: FA	COMPLETION DATE: 9/11/21
	REVIEWED BY: FK	Page 1 of 2

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH04**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792564 E:543490	ELEVATION: 292.3 m

SAMPLE TYPE ■ Shelby Tube ▨ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ▮ Core

BACKFILL TYPE ■ Bentonite ░ Pea Gravel ▥ Slough ▨ Grout ▨ Drill Cuttings ░ Sand



SOIL SYMBOL	USCS	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT (N)	SLOPE INCLINOMETER	OTHER TESTS COMMENTS
░	SP						
▥	ML	**SILT**: trace sand, trace clay, dense, compact, seepage between 8.2 and 10 m, moist to wet, brown	☒	7	50	░	Gravel = 0 % Sand = 9 % Silt = 87 % Clay = 7 %
▥	ML	**SANDY SILT**: trace clay, trace gravel, very dense, compact, moist to damp, brown	☒	8	68	░	Gravel = 3 % Sand = 33 % Silt = 56 % Clay = 8 %
▥	ML	**SILT with SAND**: some clay, trace gravel, very dense, compact, moist to wet, brown	☒	9	70	░	Gravel = 1 % Sand = 25 % Silt = 63 % Clay = 11 %
			☒	10	80	▨	

End of Borehole (BH) at 14.6 m below grade.
Groundwater encountered at 9.0 m below grade.
Inclinometer pipe was installed down to 12.5 m below grade.

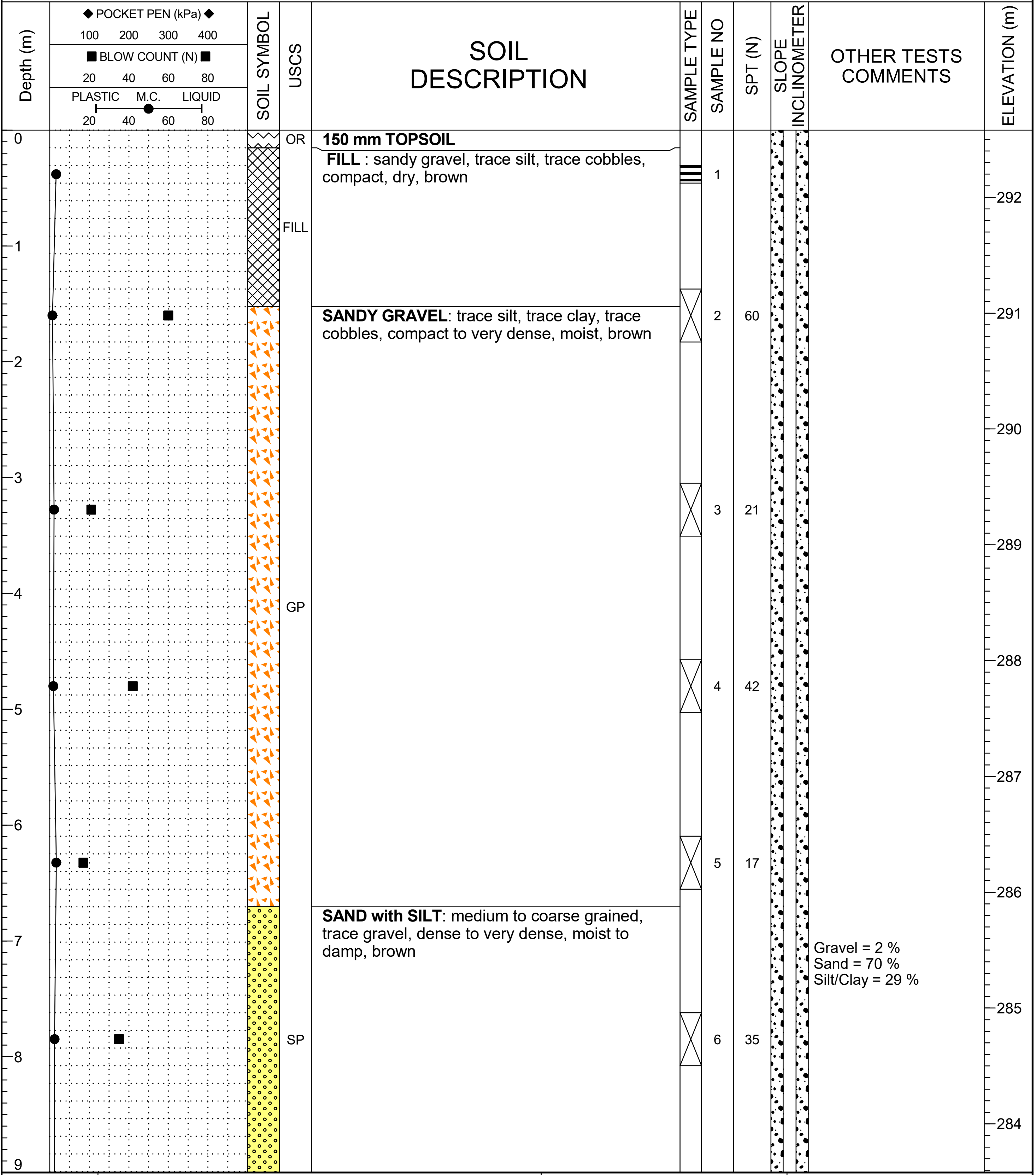
ELEVATION (m): 283, 282, 281, 280, 279, 278, 277, 276, 275

SAFFA Engineering Inc
Markham, Ontario

ENTERED BY: FA	COMPLETION DEPTH: 12.5 m
LOGGED BY: FA	COMPLETION DATE: 9/11/21
REVIEWED BY: FK	

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH05**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792555 E:543458	ELEVATION: 292.6 m

SAMPLE TYPE	■ Shelby Tube	▨ No Recovery	☒ SPT Test (N)	☰ Grab Sample	▥ Split-Pen	▮ Core
BACKFILL TYPE	■ Bentonite	⁘ Pea Gravel	▥ Slough	⁘ Grout	▨ Drill Cuttings	⁘ Sand



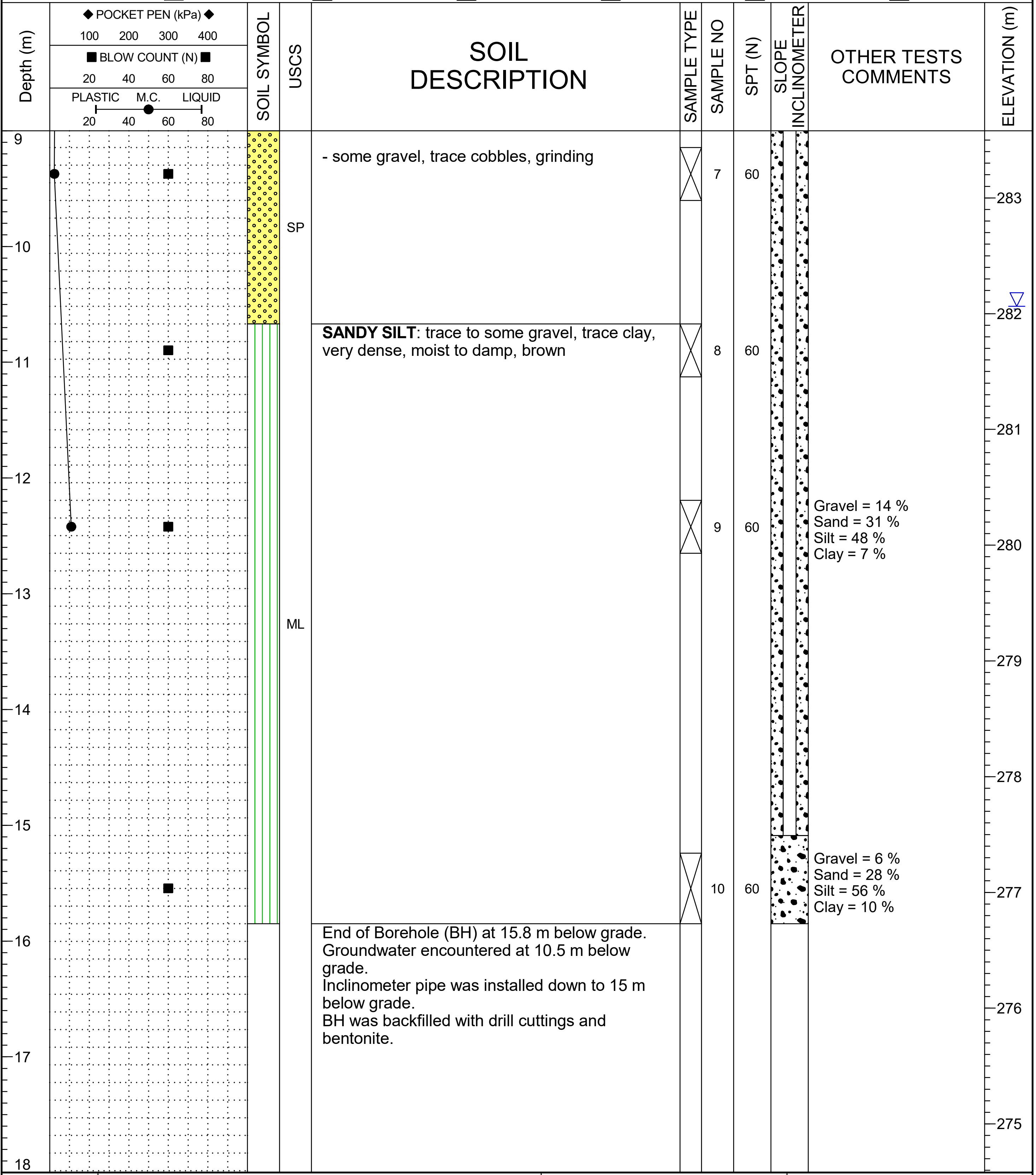
USCS	SOIL DESCRIPTION	SAMPLE NO	SPT (N)	OTHER TESTS COMMENTS
OR	**150 mm TOPSOIL**			
FILL	**FILL** : sandy gravel, trace silt, trace cobbles, compact, dry, brown	1		
GP	**SANDY GRAVEL**: trace silt, trace clay, trace cobbles, compact to very dense, moist, brown	2 3 4 5	60 21 42 17	
SP	**SAND with SILT**: medium to coarse grained, trace gravel, dense to very dense, moist to damp, brown	6	35	Gravel = 2 % Sand = 70 % Silt/Clay = 29 %

SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 15.9 m
	LOGGED BY: FA	COMPLETION DATE: 9/11/21
	REVIEWED BY: FK	Page 1 of 2

Township of North Dumfries	Erosion and slope stability, Nith River	BOREHOLE NO: **BH05**
Saffa Engineering Inc.	SITE: Piper Street, Ayr, North Dumfries, ON	PROJECT NO: SEP 330_2
Solid Stem Auger	Piper St, Ayr, ON N:4792555 E:543458	ELEVATION: 292.6 m

SAMPLE TYPE ■ Shelby Tube ◩ No Recovery ☒ SPT Test (N) ☰ Grab Sample ▥ Split-Pen ▮ Core

BACKFILL TYPE ▨ Bentonite ⛶ Pea Gravel ▥ Slough ⁘ Grout ◩ Drill Cuttings ⁘ Sand



- some gravel, trace cobbles, grinding

SANDY SILT: trace to some gravel, trace clay, very dense, moist to damp, brown

End of Borehole (BH) at 15.8 m below grade.
Groundwater encountered at 10.5 m below grade.
Inclinometer pipe was installed down to 15 m below grade.
BH was backfilled with drill cuttings and bentonite.

Gravel = 14 %
Sand = 31 %
Silt = 48 %
Clay = 7 %

Gravel = 6 %
Sand = 28 %
Silt = 56 %
Clay = 10 %

SAFFA Engineering Inc Markham, Ontario	ENTERED BY: FA	COMPLETION DEPTH: 15.9 m
	LOGGED BY: FA	COMPLETION DATE: 9/11/21
	REVIEWED BY: FK	

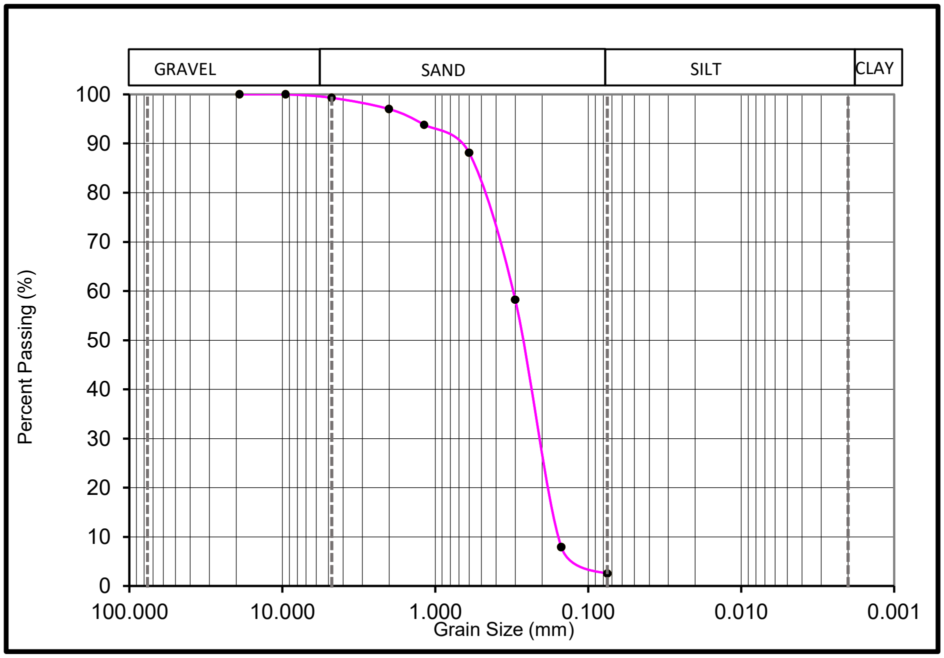
SAFFA
Engineering Inc.

Professional Engineers
Ontario

Grain Size Distribution Analysis Report

(CSA A23.2-2A / LS-602)

Date:	14-Mar-22		
Client:	Township of North Dumfries	Copies to:	
Address:	Piper Street, Ayr, North Dumfries, ON	Lab #:	21-173
Project:	SEP 330	Test Requested by:	Fiaz
Location:	BH02 (5ft)	Sampled By:	Fiaz
Material Type:	Soil	Date Sampled:	25-Aug-21
Source:	Drilling	Specification:	



Sieve Size (mm)	Percent Passing (%)	
19.00	100	
9.50	100	
4.75	99.3	
2.00	97	
1.180	93.8	
0.600	88.1	
0.300	58.2	
0.150	7.9	
0.075	2.5	
0.0394		
0.0281		
0.0180		
0.0106		
0.0076		
0.0054		
0.0026		
0.0012		

Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1	97	3	

Remarks:

Fawad Khan, MaSc, EIT
Laboratory Manager

CERTIFIED BY CCIL

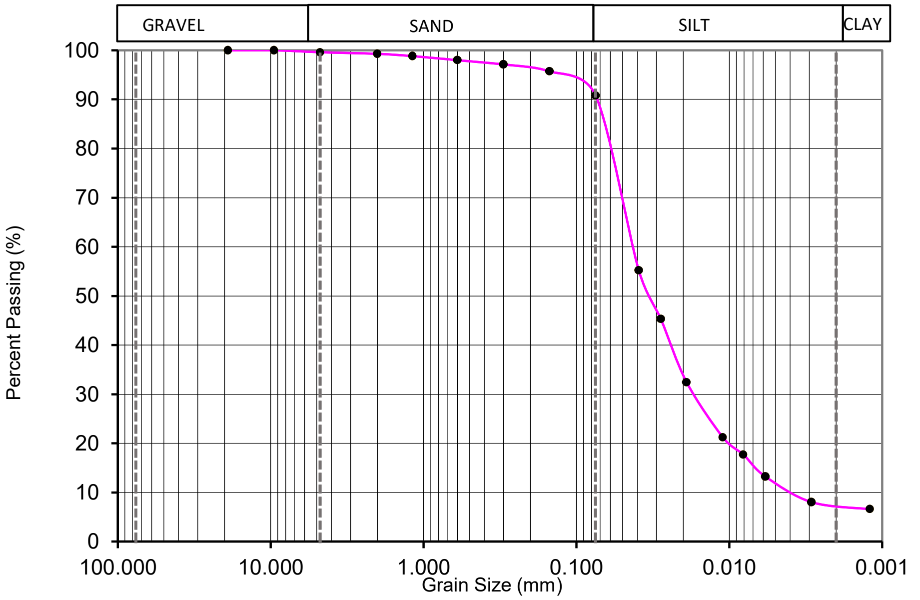
Grain Size Distribution Analysis Report

(CSA A23.2-2A / LS-602)

Date: 14-Mar-22

Client: Township of North Dumfries
Address: Piper Street, Ayr, North Dumfries, ON
Project: SEP 330
Location: BH04 (30ft)
Material Type: Soil
Source: Drilling

Copies to:
Lab #: 21-184
Test Requested by: Fiaz
Sampled By: Fiaz
Date Sampled: 11-Sep-21
Specification:



Gravel (%)	Sand (%)	Silt (%)	Clay (%)
0	9	84	7

Sieve Size (mm)	Percent Passing (%)	
19.00	100	
9.50	100	
4.75	99.6	
2.00	99.3	
1.180	98.8	
0.600	98	
0.300	97.1	
0.150	95.7	
0.075	90.8	
0.0390	55.2	
0.0280	45.3	
0.0190	32.4	
0.0110	21.2	
0.0081	17.7	
0.0058	13.2	
0.0029	8.0	
0.0012	6.6	

Remarks:

Fawad Khan, MaSc, EIT
Laboratory Manager

CERTIFIED BY CCIL

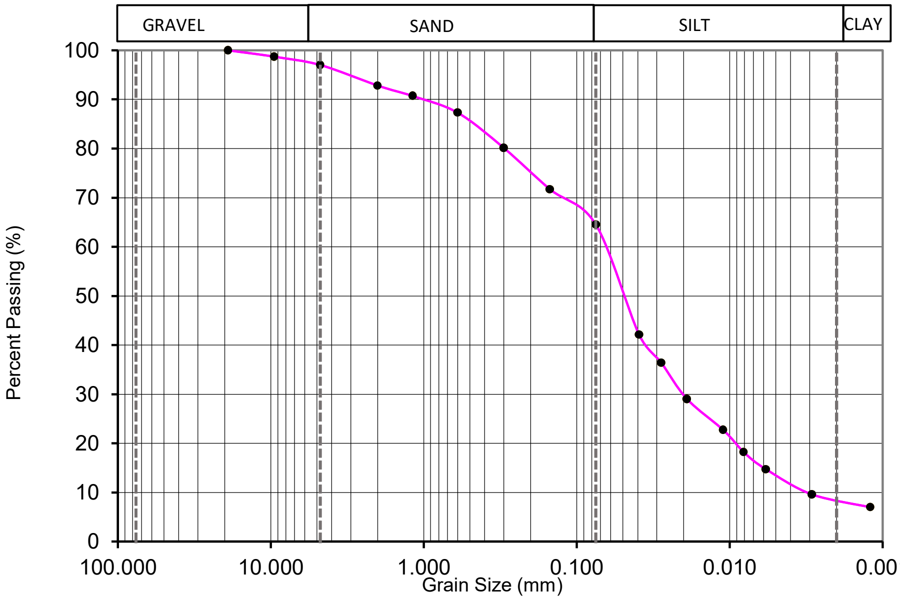
Grain Size Distribution Analysis Report

(CSA A23.2-2A / LS-602)

Date: 14-Mar-22

Client: Township of North Dumfries
Address: Piper Street, Ayr, North Dumfries, ON
Project: SEP 330
Location: BH04 (35ft)
Material Type: Soil
Source: Drilling

Copies to:
Lab #: 21-185
Test Requested by: Fiaz
Sampled By: Fiaz
Date Sampled: 11-Sep-21
Specification:



Sieve Size (mm)	Percent Passing (%)	
19.00	100	
9.50	98.7	
4.75	97	
2.00	92.8	
1.180	90.7	
0.600	87.3	
0.300	80.1	
0.150	71.7	
0.075	64.5	
0.0390	42.1	
0.0280	36.4	
0.0190	29.0	
0.0110	22.7	
0.0081	18.2	
0.0058	14.7	
0.0029	9.6	
0.0012	7.0	

Gravel (%)	Sand (%)	Silt (%)	Clay (%)
3	33	56	8

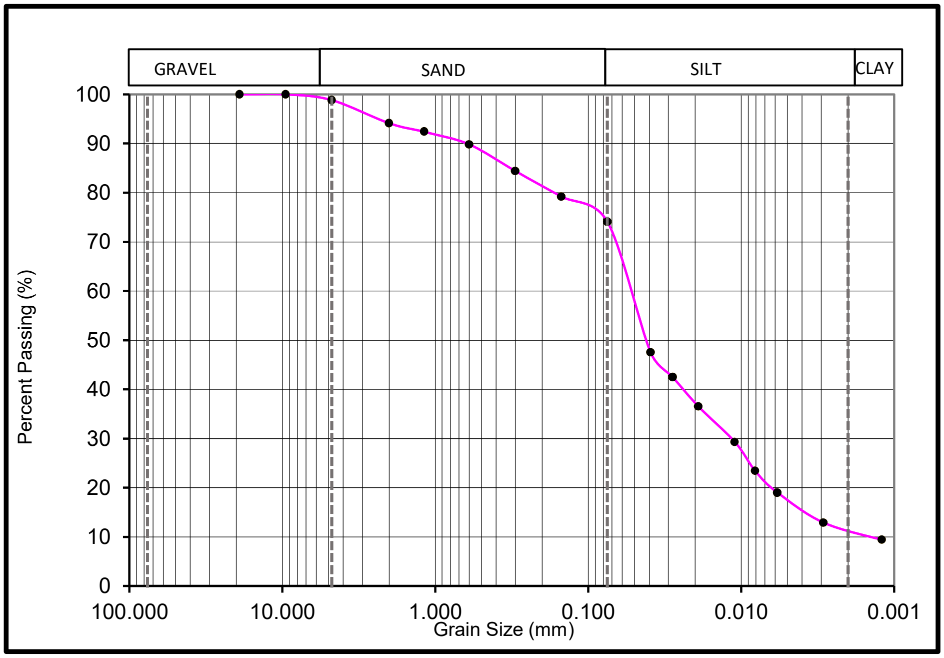
Remarks:

Fawad Khan, MaSc, EIT
Laboratory Manager

Grain Size Distribution Analysis Report

(CSA A23.2-2A / LS-602)

Date:	14-Mar-22		
Client:	Township of North Dumfries	Copies to:	
Address:	Piper Street, Ayr, North Dumfries, ON	Lab #:	21-186
Project:	SEP 330	Test Requested by:	Fiaz
Location:	BH04 (40ft)	Sampled By:	Fiaz
Material Type:	Soil	Date Sampled:	11-Sep-21
Source:	Drilling	Specification:	



Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1	25	63	11

Sieve Size (mm)	Percent Passing (%)	
19.00	100	
9.50	100	
4.75	98.8	
2.00	94.1	
1.180	92.4	
0.600	89.8	
0.300	84.4	
0.150	79.2	
0.075	74.1	
0.0390	47.5	
0.0280	42.5	
0.0190	36.5	
0.0110	29.3	
0.0081	23.4	
0.0058	19.0	
0.0029	12.9	
0.0012	9.4	

Remarks:

Fawad Khan, MaSc, EIT
Laboratory Manager

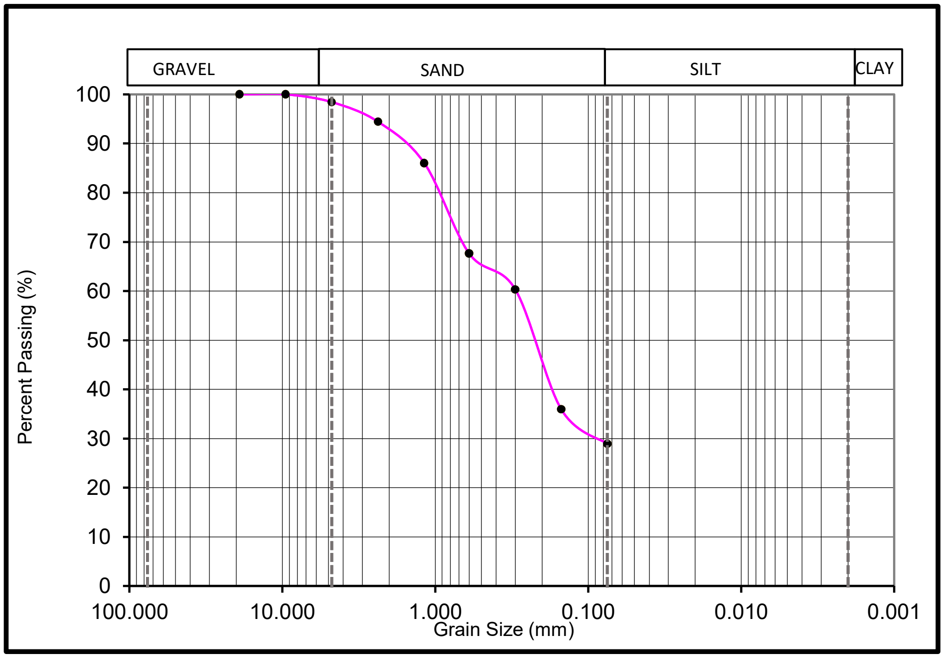
SAFFA
Engineering Inc.

Professional Engineers
Ontario

Grain Size Distribution Analysis Report

(CSA A23.2-2A / LS-602)

Date:	14-Mar-22		
Client:	Township of North Dumfries	Copies to:	
Address:	Piper Street, Ayr, North Dumfries, ON	Lab #:	21-174
Project:	SEP 330	Test Requested by:	Fiaz
Location:	BH05 (23ft)	Sampled By:	Fiaz
Material Type:	Soil	Date Sampled:	11-Sep-21
Source:	Drilling	Specification:	



Sieve Size (mm)	Percent Passing (%)	
19.00	100	
9.50	100	
4.75	98.4	
2.36	94.4	
1.180	86	
0.600	67.6	
0.300	60.3	
0.150	35.9	
0.075	28.9	
0.0394		
0.0281		
0.0180		
0.0106		
0.0076		
0.0054		
0.0026		
0.0012		

Gravel (%)	Sand (%)	Silt (%)	Clay (%)
2	70	29	

Remarks:

Fawad Khan, MaSc, EIT
Laboratory Manager

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Professional Engineers
Ontario

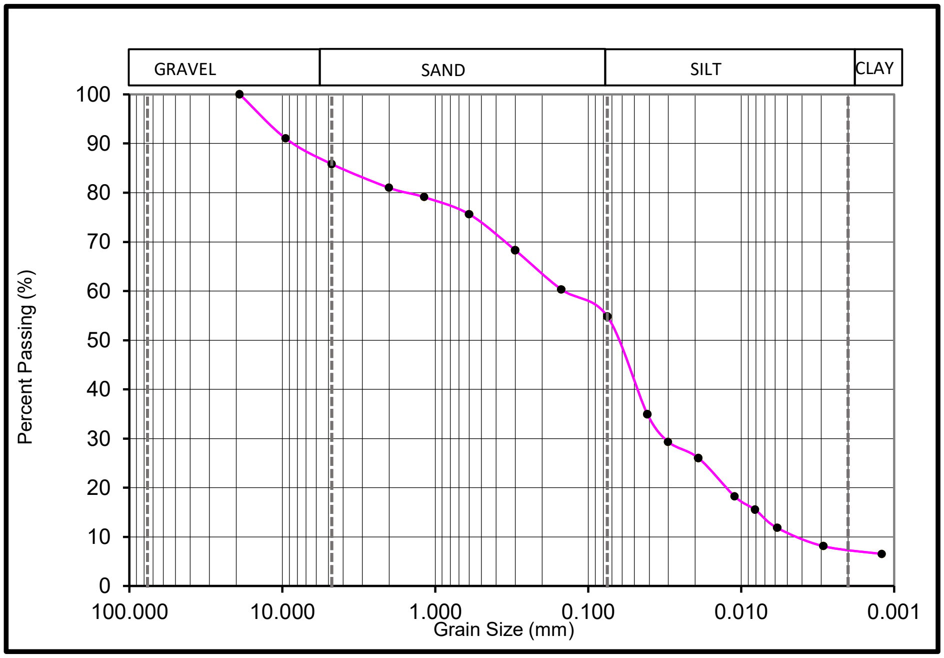
Grain Size Distribution Analysis Report

(CSA A23.2-2A / LS-602)

Date: 14-Mar-22

Client: Township of North Dumfries
Address: Piper Street, Ayr, North Dumfries, ON
Project: SEP 330
Location: BH05 (40ft)
Material Type: Soil
Source: Drilling

Copies to:
Lab #: 21-183
Test Requested by: Fiaz
Sampled By: Fiaz
Date Sampled:
Specification:



Sieve Size (mm)	Percent Passing (%)	
19.00	100	
9.50	91	
4.75	85.8	
2.00	81	
1.180	79.1	
0.600	75.6	
0.300	68.3	
0.150	60.3	
0.075	54.8	
0.0410	34.9	
0.0300	29.3	
0.0190	26.0	
0.0110	18.2	
0.0081	15.5	
0.0058	11.8	
0.0029	8.1	
0.0012	6.5	

Gravel (%)	Sand (%)	Silt (%)	Clay (%)
14	31	48	7

Remarks:

Fawad Khan, MaSc, EIT
Laboratory Manager

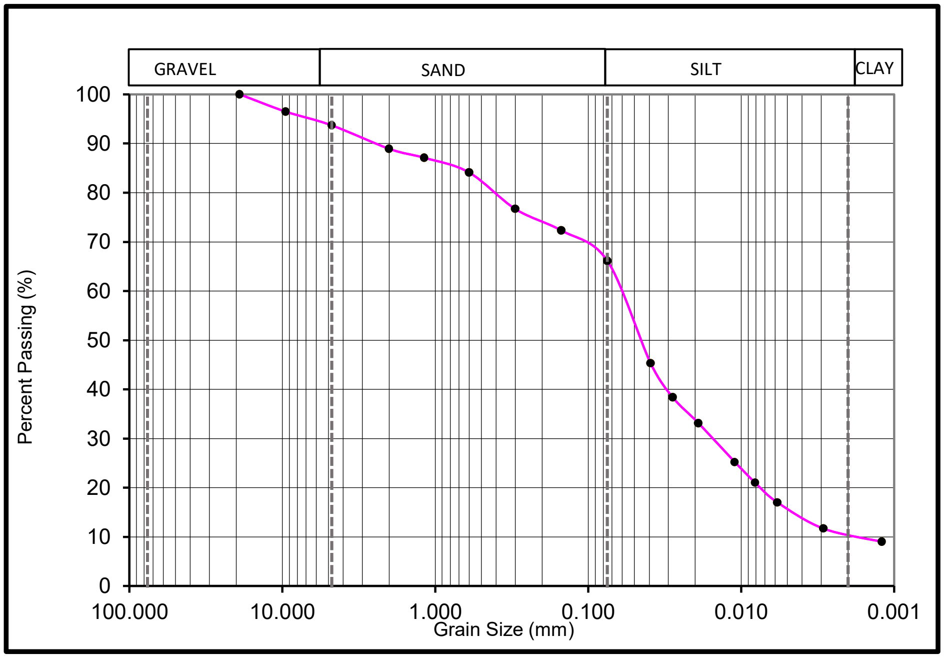
SAFFA Engineering Inc.

Professional Engineers Ontario

Grain Size Distribution Analysis Report

(CSA A23.2-2A / LS-602)

Date:	14-Mar-22		
Client:	Township of North Dumfries	Copies to:	
Address:	Piper Street, Ayr, North Dumfries, ON	Lab #:	21-187
Project:	SEP 330	Test Requested by:	Fiaz
Location:	BH05 (50ft)	Sampled By:	Fiaz
Material Type:	Soil	Date Sampled:	11-Sep-21
Source:	Drilling	Specification:	



Sieve Size (mm)	Percent Passing (%)	
19.00	100	
9.50	96.5	
4.75	93.7	
2.00	88.9	
1.180	87.1	
0.600	84.1	
0.300	76.7	
0.150	72.3	
0.075	66.1	
0.0390	45.3	
0.0280	38.4	
0.0190	33.1	
0.0110	25.2	
0.0081	21.0	
0.0058	17.0	
0.0029	11.7	
0.0012	9.0	

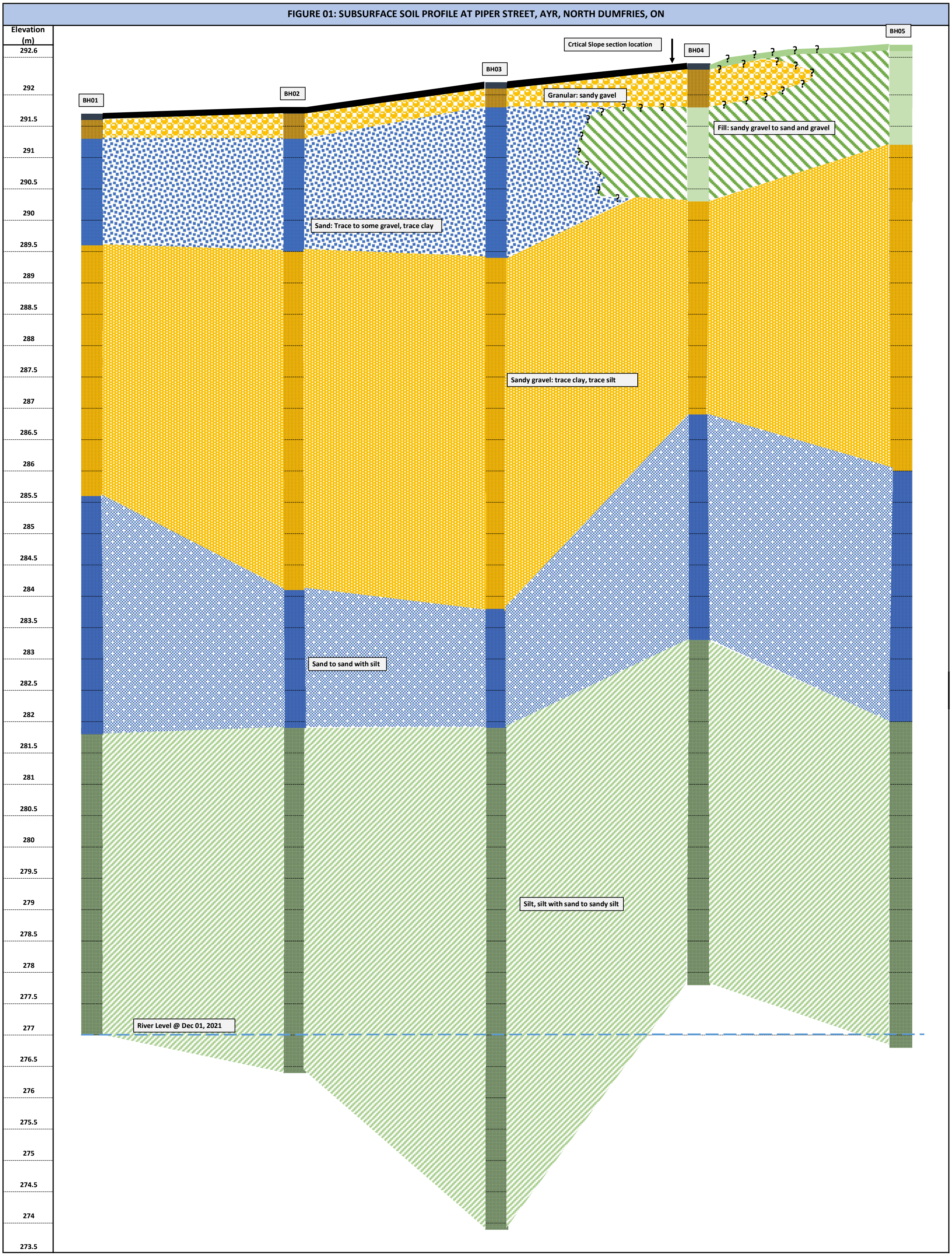
Gravel (%)	Sand (%)	Silt (%)	Clay (%)
6	28	56	10

Remarks:

Fawad Khan, MaSc, EIT
Laboratory Manager

CERTIFIED BY CCIL

FIGURE 01: SUBSURFACE SOIL PROFILE AT PIPER STREET, AYR, NORTH DUMFRIES, ON



Appendix D Explanation of Terms and Symbols

EXPLANATION OF TERMS AND SYMBOLS

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in these pages.

It should be noted that materials, boundaries and conditions have been established only at the borehole locations at the time of investigation and are not necessarily representative of subsurface conditions elsewhere across the site.

TEST DATA

Data obtained during the field investigation and from laboratory testing are shown at the appropriate depth interval.

Abbreviations, graphic symbols, and relevant test method designations are as follows:

*C	Consolidation test	*ST	Swelling test
D_R	Relative density	TV	Torvane shear strength
*k	Permeability coefficient	VS	Vane shear strength
*MA	Mechanical grain size analysis and hydrometer test	w	Natural Moisture Content (ASTM D2216)
		w_l	Liquid limit (ASTM D 423)
N	Standard Penetration Test (CSA A119.1-60)	w_p	Plastic Limit (ASTM D 424)
N_d	Dynamic cone penetration test	E_f	Unit strain at failure
NP	Non plastic soil	γ	Unit weight of soil or rock
pp	Pocket penetrometer strength	γ_d	Dry unit weight of soil or rock
*q	Triaxial compression test	ρ	Density of soil or rock
q_u	Unconfined compressive strength	ρ_d	Dry Density of soil or rock
*SB	Shearbox test	C_u	Undrained shear strength
SO_4	Concentration of water-soluble sulphate	→	Seepage
		▼	Observed water level

* The results of these tests are usually reported separately

Soils are classified and described according to their engineering properties and behaviour.

The soil of each stratum is described using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized.

The modifying adjectives used to define the actual or estimated percentage range by weight of minor components are consistent with the Canadian Foundation Engineering Manual[2].

Relative Density and Consistency:

Cohesionless Soils

Relative Density	SPT (N) Value
Very Loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Cohesive Soils

Consistency	Undrained Shear Strength c_u (kPa)	Approximate SPT (N) Value
Very Soft	0-12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Standard Penetration Resistance ("N" value)
The number of blows by a 63.6kg hammer dropped 760 mm to drive a 50 mm diameter open sampler attached to "A" drill rods for a distance of 300 mm after an initial penetration of 150 mm.

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[1] "Unified Soil Classification System", Technical Memorandum 36-357 prepared by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S. Army. Vol. 1 March 1953.

[2] "Canadian Foundation Engineering Manual", 3rd Edition, Canadian Geotechnical Society, 1992.

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOUR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (TRACE OR NO FINES)	GW	△	RED	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			GP	▲	RED	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM	▥	YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC	▨	YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (TRACE OR NO FINES)	SW	⁘	RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6$; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3	
			SP	○	RED	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM	▥	YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			SC	▨	YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML	▥	GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L < 50\%$	MH	▥	BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDS OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL	▨	GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS		
		$30\% < W_L < 50\%$	CI	▨	GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50\%$	CH	▨	BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL	▥	GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINES CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH	▨	BLUE	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt	〰	ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBEROUS TEXTURE	

SPECIAL SYMBOLS

LIMESTONE	▦	OILSAND	▩
SANDSTONE	⁘	SHALE	▤
SILTSTONE	▤	FILL (UNDIFFERENTIATED)	▩

SOIL COMPONENTS

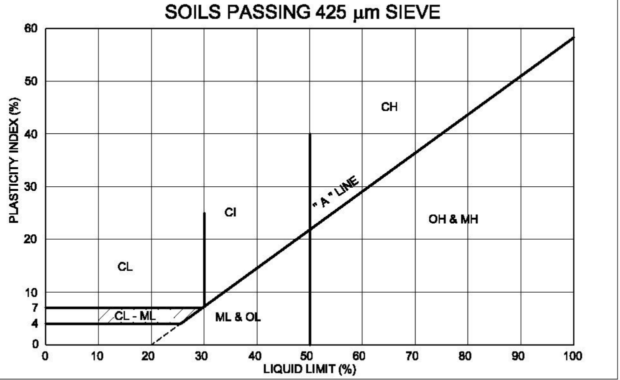
FRACTION	U.S. STANDARD SIEVE SIZE	
GRAVEL	PASSING	RETAINED
COARSE	76mm	19mm
FINE	19mm	4.75mm
SAND		
COARSE	4.75mm	2.00mm
MEDIUM	2.00mm	425µm
FINE	425µm	75µm
FINES (SILT OR CLAY BASED ON PLASTICITY)	75µm	

DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
PERCENT	DESCRIPTOR
35-50	AND
20-35	Y/EY
10-20	SOME
1-10	TRACE

OVERSIZED MATERIAL

ROUNDED OR SUBROUNDED:	NOT ROUNDED:
COBBLES 76mm TO 200mm	ROCK FRAGMENTS > 76mm
BOULDERS > 200mm	ROCKS > 0.76 CUBIC METRE IN VOLUME

PLASTICITY CHART FOR SOILS PASSING 425 µm SIEVE



NOTES:

1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD A.S.T.M. E.11
2. COARSE GRAIN SOILS WITH 5 TO 12% FINES GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5 AND 12% FINES.

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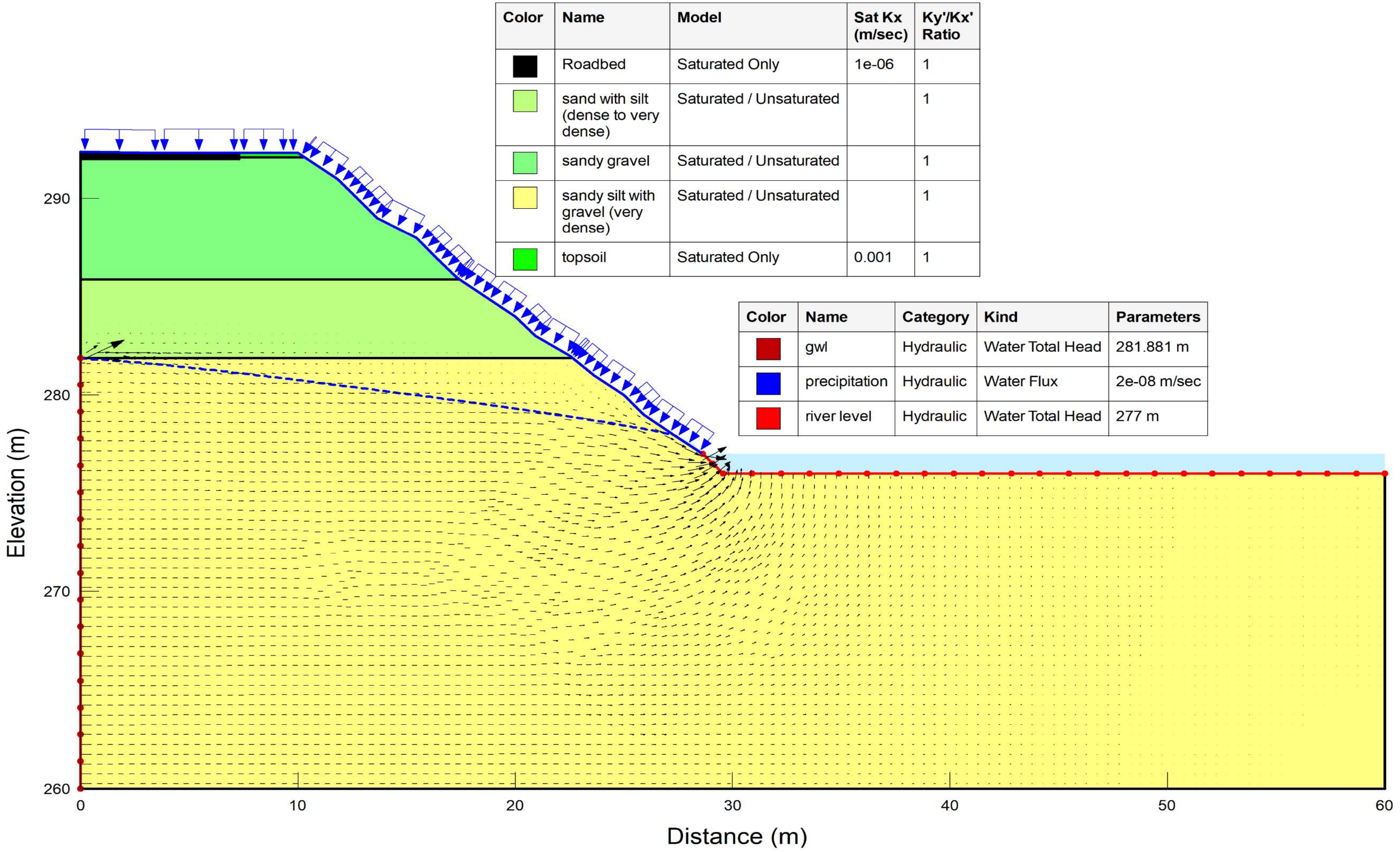
Appendix E Seep/W and Slope/W Analysis Results



Color	Name	Model	Sat Kx (m/sec)	Ky'/Kx' Ratio
⬛	Roadbed	Saturated Only	1e-06	1
🟩	sand with silt (dense to very dense)	Saturated / Unsaturated		1
🟩	sandy gravel	Saturated / Unsaturated		1
🟨	sandy silt with gravel (very dense)	Saturated / Unsaturated		1
🟩	topsoil	Saturated Only	0.001	1

Color	Name	Category	Kind	Parameters
🟥	gwl	Hydraulic	Water Total Head	281.881 m
🟦	precipitation	Hydraulic	Water Flux	2e-08 m/sec
🟥	river level	Hydraulic	Water Total Head	277 m

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Drawing:

Seepage Analysis: Northern Bank Nith River, Ayr

CLIENT: The Township of North Dumfries

PROJECT: SEP330

TITLE: Seepage Analysis Model - Boundary Conditions

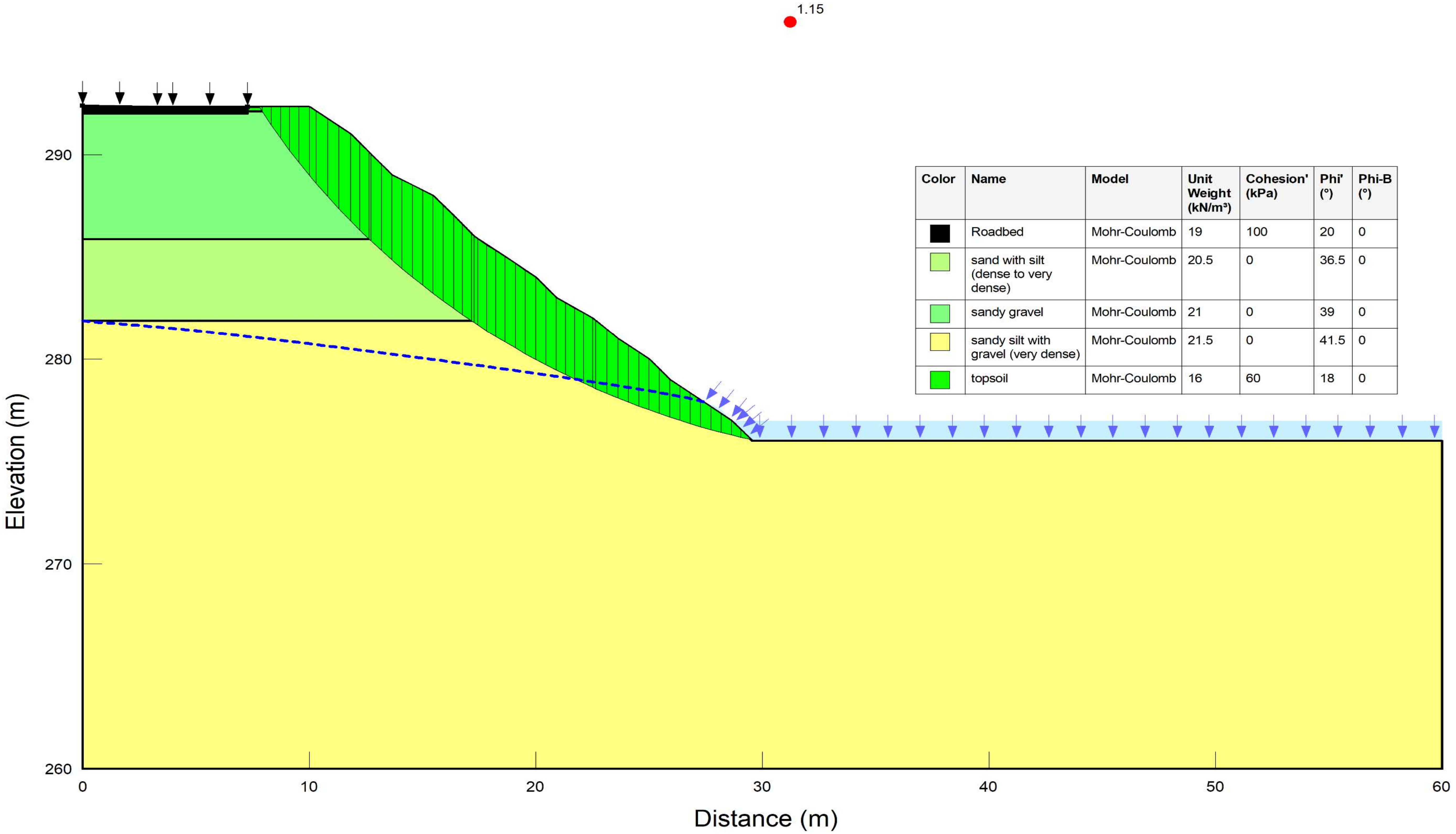
DATE: July 2022

JOB No.: SEP 330

Scale ,1:175

FIGURE No.: 1

REV. 0



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)
⬛	Roadbed	Mohr-Coulomb	19	100	20	0
🟩	sand with silt (dense to very dense)	Mohr-Coulomb	20.5	0	36.5	0
🟩	sandy gravel	Mohr-Coulomb	21	0	39	0
🟨	sandy silt with gravel (very dense)	Mohr-Coulomb	21.5	0	41.5	0
🟩	topsoil	Mohr-Coulomb	16	60	18	0

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Engineering Inc.

Drawing:

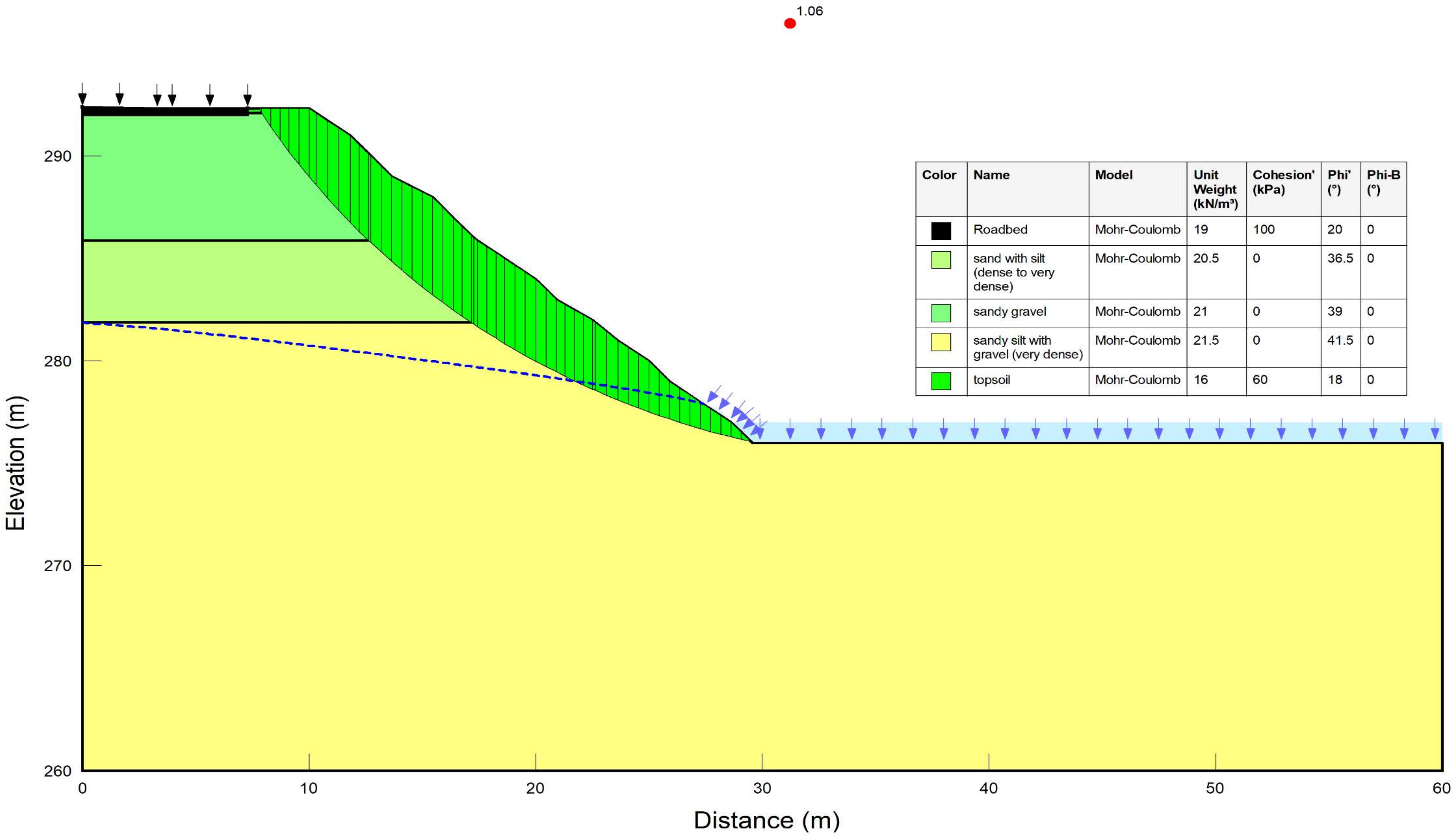
Slope Stability Analysis: Northern Bank Nith River, Ayr

CLIENT: The Township of North Dumfries

PROJECT: SEP330

TITLE: Slope Stability (static) - Insitue Slope Conditions

DATE:	JOB No.:	Scale	FIGURE No.:	REV.
July 2022	SEP 330	,1:175	2	0



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)
⬛	Roadbed	Mohr-Coulomb	19	100	20	0
🟩	sand with silt (dense to very dense)	Mohr-Coulomb	20.5	0	36.5	0
🟩	sandy gravel	Mohr-Coulomb	21	0	39	0
🟨	sandy silt with gravel (very dense)	Mohr-Coulomb	21.5	0	41.5	0
🟩	topsoil	Mohr-Coulomb	16	60	18	0

SAFFA
Engineering Inc.

Drawing:

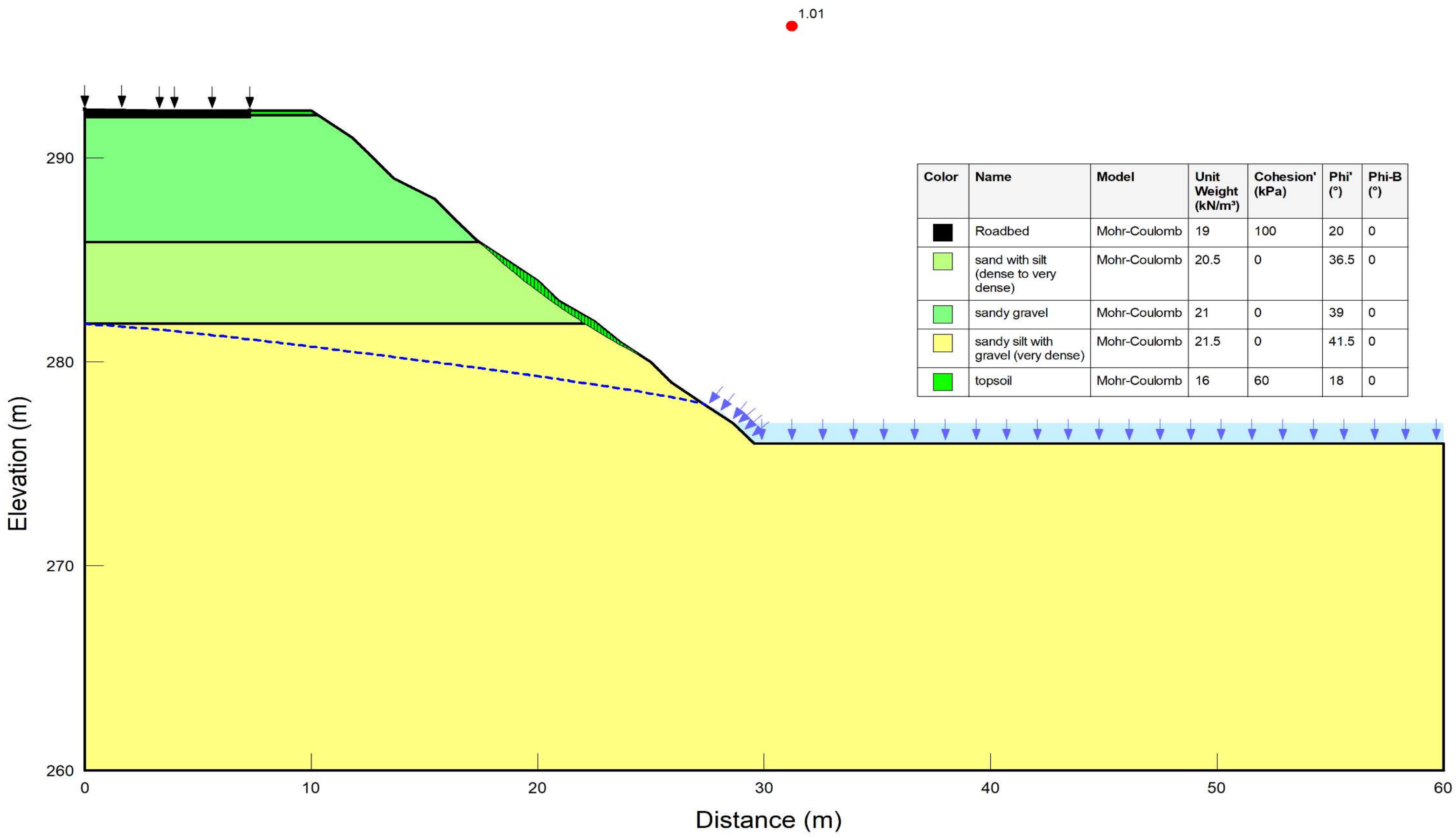
Slope Stability Analysis: Northern Bank Nith River, Ayr

CLIENT: The Township of North Dumfries

PROJECT: SEP330

TITLE: Slope Stability (pesudo-static) - Insitue-conditions

DATE:	JOB No.:	Scale	FIGURE No.:	REV.
July 2022	SEP 330	,1:175	3	0



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)
⬛	Roadbed	Mohr-Coulomb	19	100	20	0
🟩	sand with silt (dense to very dense)	Mohr-Coulomb	20.5	0	36.5	0
🟩	sandy gravel	Mohr-Coulomb	21	0	39	0
🟨	sandy silt with gravel (very dense)	Mohr-Coulomb	21.5	0	41.5	0
🟩	topsoil	Mohr-Coulomb	16	60	18	0

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Drawing:

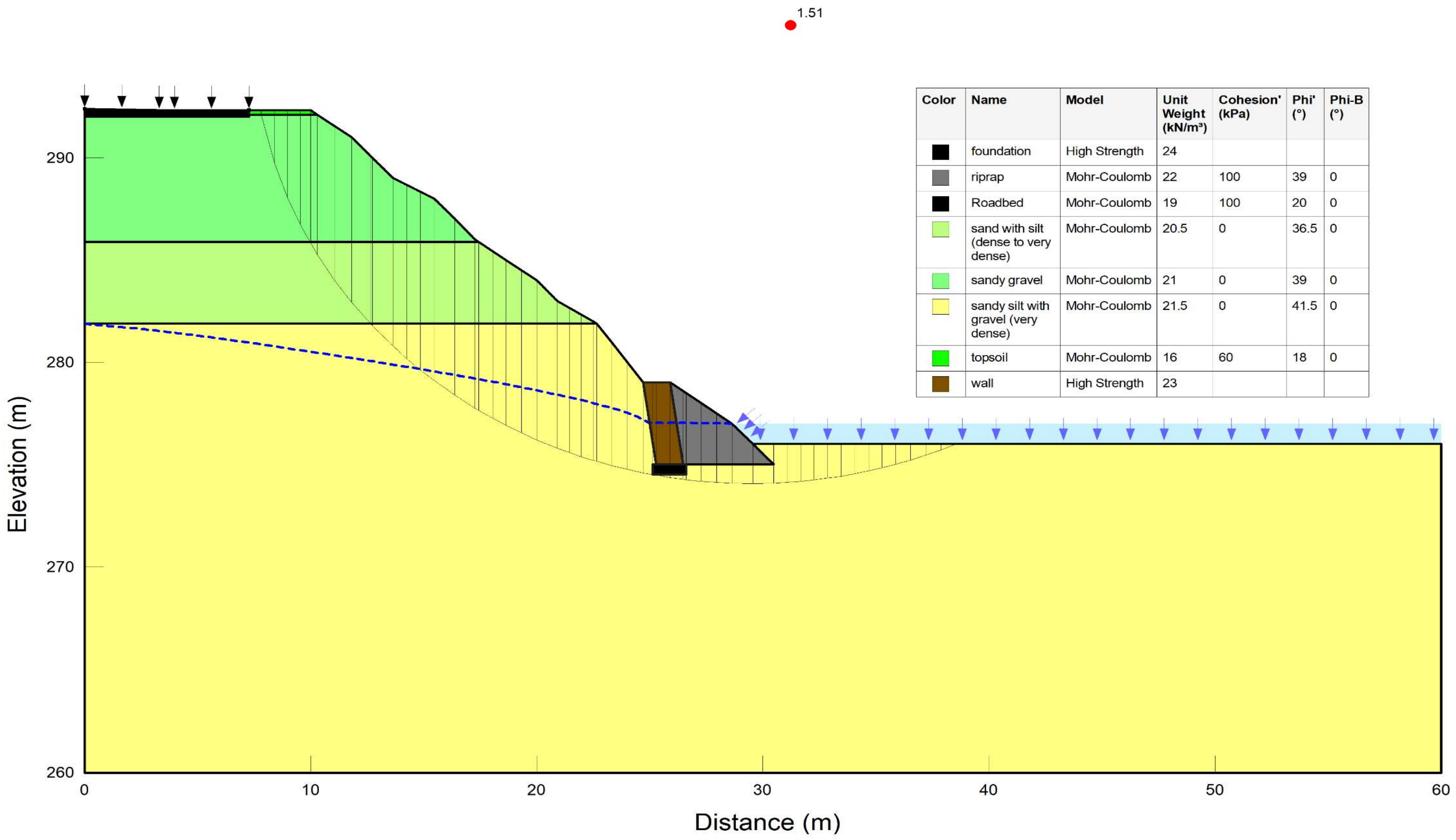
Slope Stability Analysis: Northern Bank Nith River, Ayr

CLIENT: The Township of North Dumfries

PROJECT: SEP330

TITLE: Slope Stability (static) - back analysis for existing slope conditions

DATE:	JOB No.:	Scale	FIGURE No.:	REV.
July 2022	SEP 330	,1:175	4	0



Color	Name	Model	Unit Weight (kN/m³)	Cohesion' (kPa)	Phi' (°)	Phi-B (°)
⬛	foundation	High Strength	24			
▩	riprap	Mohr-Coulomb	22	100	39	0
⬛	Roadbed	Mohr-Coulomb	19	100	20	0
🟩	sand with silt (dense to very dense)	Mohr-Coulomb	20.5	0	36.5	0
🟩	sandy gravel	Mohr-Coulomb	21	0	39	0
🟨	sandy silt with gravel (very dense)	Mohr-Coulomb	21.5	0	41.5	0
🟩	topsoil	Mohr-Coulomb	16	60	18	0
🟫	wall	High Strength	23			

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Engineering Inc.

Drawing:

Slope Stability Analysis: Northern Bank Nith River, Ayr

CLIENT: The Township of North Dumfries

PROJECT: SEP330

TITLE: Slope Stability (Steady State) - Gravity Wall (Armour Stone)

DATE: July 2022

JOB No.: SEP 330

Scale ,1:195

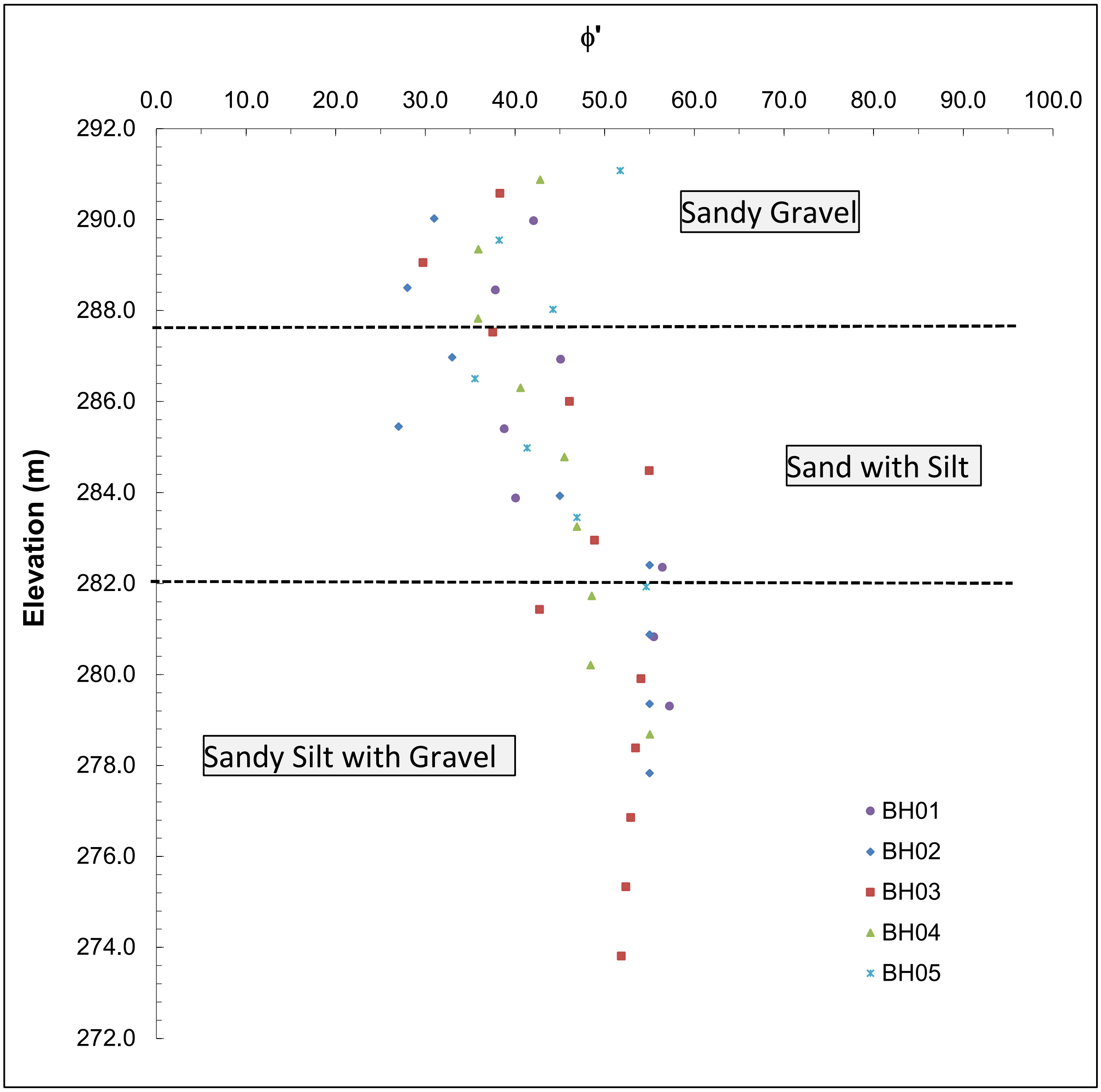
FIGURE No.: 5

REV. 0

Appendix F Scattered plot of angle of internal based on the SPT N-values
2015 National Building Code of Canada seismic hazard calculator

Angle of Internal Friction, ϕ'

0



ϕ' = Estimated Angle of Internal Friction based on $(N_1)_{60}$ values

SEP300: Piper Street, Ayr, ON

2015 National Building Code Seismic Hazard Calculation

INFORMATION: **Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836**
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 43.285N 80.464W

2022-05-07 11:48 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.113	0.063	0.037	0.010
Sa (0.1)	0.147	0.086	0.053	0.015
Sa (0.2)	0.132	0.080	0.051	0.017
Sa (0.3)	0.106	0.066	0.043	0.015
Sa (0.5)	0.081	0.051	0.034	0.012
Sa (1.0)	0.046	0.029	0.019	0.006
Sa (2.0)	0.023	0.014	0.009	0.002
Sa (5.0)	0.006	0.003	0.002	0.001
Sa (10.0)	0.002	0.001	0.001	0.000
PGA (g)	0.081	0.047	0.029	0.008
PGV (m/s)	0.064	0.039	0.024	0.007

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information