Geotechnical Investigation

Proposed Residential Development

Conservancy Lands East
Ottawa, Ontario

Prepared for Caivan Communities

Report PG5036-1 Revision 7, dated March 14, 2024

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1.0 Introduction

Paterson Group (Paterson) was commissioned by Caivan Communities to complete a geotechnical report based on existing soils information for the proposed Conservancy Lands East residential development to be located along Borrisokane Road in the City of Ottawa (refer to Figure 1 - Key Plan presented in Appendix 2). The objective of the geotechnical investigation was to:

❒ Review available subsurface soil and groundwater information prepared by others.

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

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

2.0 Proposed Development

Although, detailed development plans were not available during preparation of this report, it is understood that the proposed residential development will consist of single- family dwellings and townhouses with associated driveways, local roadways, landscaping areas, and park lands.

It is further anticipated that the proposed development will be serviced by future municipal water, sanitary and storm services.

3.0 Method of Investigation

3.1 Field Investigation

A geotechnical investigation was previously completed by others at the subject site during the periods of January 31 through March 31, 2017, and October 25 through November 2, 2018. The geotechnical investigation consisted of 45 boreholes advanced to a maximum depth of 9.3 m below the existing ground surface. The boreholes were advanced using a track-mounted auger drill rig operated by a two-person crew. The drilling procedure consisted of augering to the required depths and sampling the overburden soils.

A supplemental geotechnical investigation was carried out by Paterson from September 30 to November 30, 2022, and consisted of advancing a total of eight (8) test pits to a maximum depth of 2.1 m below the existing ground surface. The test pits were excavated using a hydraulic excavator and backfilled using the site excavated soil upon completion. All field work was conducted under the full-time supervision of Paterson personnel under the direction of a supervising engineer.

The locations of the boreholes and test pits are shown on Drawing PG5036-1 - Test Hole Location Plan included in Appendix 2.

Reference should be made to the Record of Borehole sheets prepared by others and the Soil Profile and Test Data Sheets prepared by Paterson which are presented in Appendix 1 for specific details of the soil profile encountered at the test hole locations.

Groundwater

Groundwater monitoring wells and standpipes were installed in thirty-four (34) boreholes by others to permit monitoring of the groundwater levels subsequent to the completion of the sampling program. Groundwater infiltration into the test pits was also recorded, where encountered. All groundwater observations by others are noted on the Record of Borehole sheets presented in Appendix 1.

3.2 Field Survey

The ground surface elevations at the borehole and test pit locations are understood to be referenced to a geodetic datum. The locations of the boreholes and the ground surface elevation for each borehole location are presented on Drawing PG5036-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from the subject site were examined in our laboratory to review the results of the field logging.

A total of seven (7) Shelby tube samples collected from the boreholes during the geotechnical investigation by others were submitted for unidimensional consolidation testing. The results of the consolidation testing are summarized in Section 5.3.

A total of forty-five (45) representative soil samples were submitted for Atterberg limit testing from the geotechnical investigation conducted by others. The results of the Atterberg limit testing are presented in Section 4.2.

3.4 Analytical Testing

Three soil samples were submitted to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The sample was analyzed to determine the concentration of sulphate and chloride, the resistivity, and the pH of the sample. The results are discussed in Section 6.8 and shown in Appendix 1.

4.0 Observations

4.1 Surface Conditions

The subject site generally consists of agricultural fields and is bordered by the Borrisokane Road to the west, agricultural lands to the north and east, and the Jock River to the south. The existing ground surface across the site is relatively level with approximate ground surface elevation varying between 91 to 92m.

4.2 Subsurface Profile

Overburden

The subsurface profile encountered at the borehole locations generally consisted of an approximate 50 to 460 mm thick layer of topsoil underlain by a silty clay deposit.

The silty clay deposit was generally observed to have a very stiff to firm, brown silty clay crust, becoming a soft to firm, grey silty clay at approximate depths of 2.5 to 3 m below the existing ground surface. The silty clay deposit generally extended to the bottom of the boreholes at depths of up to 9 m.

However, near the southeastern corner of the site, a glacial till deposit was encountered underlying the silty clay at depths varying from 3.7 to 6.3 m below the existing ground surface. The glacial till was generally observed to consist of a loose to compact, grey silty sand with some gravel and occasional cobbles and boulders.

Laboratory Testing

Atterberg limit testing, as well as associated moisture content testing, was completed by others on the recovered silty clay samples at selected locations throughout the subject site.

The results of the Atterberg limit tests are presented in Table 1 on the next page.

Table 1 - Atterberg Limits Results

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)
BH 17-11	0.8	39	15	24	34
BH 17-12	0.8	41	18	23	29
BH 17-13	0.8	43	19	24	28
BH 17-14	1.5	43	16	27	31
BH 17-39	0.8	26	19	7	32
BH 17-40	0.8	43	20	23	30
BH 17-41	0.8	29	19	10	28
BH 17-42	0.8	38	15	23	34
BH 17-43	0.8	39	16	23	33
BH 17-44	0.8	29	20	9	33
BH 17-45	0.8	29	18	11	30
BH 17-46	0.8	32	19	13	34
BH 17-47	0.8	47	20	27	38
BH 17-48	0.8	37	15	22	27
BH 17-49	0.8	49	19	30	32
BH 17-50	0.8	51	16	35	33
BH 17-51	0.8	53	22	31	32
BH 17-52	0.8	55	22	33	33
BH 17-53	0.8	50	20	30	34
BH 17-55	0.8	56	16	40	35
BH 17-58	0.8	48	15	33	31
BH 17-60	0.8	40	14	26	31
BH 18-15	1.5	44	18	26	35
BH 18-16	0.8	22	Non-Plastic		
BH 18-17	0.8	42	21	21	36
BH 18-18	1.5	40	18	22	33
BH 18-19	1.5	46	18	28	45
BH 18-20	1.5	48	19	29	43
BH 18-21	0.8	40	17	23	30

Table 1 - Atterberg Limits Results (continued)

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)
BH 18-22	1.5	36	17	19	31
BH 18-23	0.8	40	17	23	34
BH 18-24	1.5	63	29	37	50
BH 18-25	0.8	24	18	6	28
BH 18-26	1.5	47	22	25	40
BH 18-27	0.8	26	16	10	27
BH 18-28	1.5	45	19	27	43
BH 18-29	0.8	44	22	22	35
BH 18-30	1.5	41	19	22	35
BH 18-31	0.8	47	18	29	33
BH 18-32	1.5	34	19	15	36
BH 18-33	0.8	40	17	23	33
BH 18-34	1.5	63	25	38	50
BH 18-35	0.8	41	20	21	32
BH 18-36	1.5	42	18	24	38
BH 18-37	0.8	47	19	28	30

Notes: LL: Liquid Limit; PL: Plastic Limit; PI: Plasticity Index; w: water content

Bedrock

Based on available geological mapping, bedrock in the area consists of interbedded limestone and dolomite of the Gull River formations with overburden drift thicknesses ranging between 5 and 15 m.

4.3 Groundwater

Groundwater levels (GWL) were measured in thirty-four (34) boreholes following completion of the geotechnical investigation. The measured GWL readings are presented in Table 2 below. Groundwater levels can also be estimated based on the observed colour, moisture levels and consistency of the recovered soil samples. Based on these observations, the long-term groundwater level is expected between 2 to 3 m depth.

However, it should be noted that the groundwater levels can fluctuate periodically throughout the year and higher levels could be encountered at the time of construction.

Table 2 - Summary of Groundwater Level Readings

Test Pit ID	Ground Elevation (m)	Measured Groundwater Level (m)		Recording Date
		Depth	Elevation	
TP 1-22	91.55	1.05	90.55	September 30, 2022
TP 2-22	91.41	Dry	-	September 30, 2022
TP 3-22	91.40	0.90	90.50	September 30, 2022
TP 4-22	91.55	1.05	90.55	September 30, 2022
TP 5-22	91.58	1.10	91.48	September 30, 2022
TP 6-22	91.55	1.00	90.55	September 30, 2022
TP 7-22	91.55	1.00	90.55	September 30, 2022
TP 8-22	91.68	Dry	-	September 30, 2022
TP 9-22	91.67	Dry	-	November 30, 2022
TP 10-22	91.50	Dry	-	November 30, 2022
TP 11-22	91.68	Dry	-	November 30, 2022
TP 12-22	91.69	Dry	-	November 30, 2022
TP 13-22	91.86	1.40	90.46	November 30, 2022
TP 14-22	91.18	1.40	89.78	November 30, 2022
TP 15-22	91.27	1.30	89.97	November 30, 2022

Table 2 - Summary of Groundwater Level Readings (Continued)				
Borehole Number	**Ground Elevation (m)**	**Measured Groundwater Level (m)**		**Recording Date**
		Depth	**Elevation**	
17-11	91.19	0.73	90.46	February 21, 2017
17-42	91.16	0.22	90.94	April 13, 2017
17-43A	91.52	-0.08	91.60	March 31, 2017
17-46A	91.63	0.27	91.36	March 31, 2017
17-52A	91.43	-0.03	91.46	March 31, 2017
18-15A	91.23	-0.15	91.38	April 30, 2019
18-15B	91.23	-0.06	91.29	April 30, 2019
18-16	91.48	0.13	91.35	April 30, 2019
18-17	91.47	-0.02	91.49	April 30, 2019
18-18A	91.54	0.37	91.17	April 30, 2019
18-18B	91.54	0.43	91.11	April 30, 2019
18-19	91.26	0.41	90.85	April 30, 2019
18-20	91.29	0.23	91.06	April 30, 2019
18-21	91.36	0.17	91.19	April 30, 2019
18-22A	91.31	-0.18	91.49	April 30, 2019
18-22B	91.31	0.16	91.15	April 30, 2019
18-23	91.32	0.15	91.17	April 30, 2019
18-24	91.23	0.12	91.11	April 30, 2019
18-25	91.24	0.08	91.16	April 30, 2019
18-26A	91.45	0.45	91.00	April 30, 2019
18-26B	91.45	0.38	91.07	April 30, 2019
18-27	91.38	0.01	91.37	April 30, 2019
18-28	91.17	0.23	90.94	April 30, 2019
18-29	91.04	0.19	90.85	April 30, 2019
18-30A	90.95	-0.30	91.25	April 30, 2019
18-30B	90.95	0.01	90.94	April 30, 2019
18-31	91.06	0.13	90.94	April 30, 2019
18-32	90.83	0.09	90.74	April 30, 2019
18-33	91.13	0.32	90.81	April 30, 2019
18-34A	91.30	0.50	90.80	April 30, 2019

Table 2 - Summary of Groundwater Level Readings (Continued)

Borehole Number	Ground Elevation (m)	Measured Groundwater Level (m)		Recording Date
		Depth	Elevation	
18-34B	91.30	0.70	90.60	April 30, 2019
18-35	91.56	0.68	90.88	April 30, 2019
18-36	91.19	0.00	91.19	April 30, 2019
18-37	91.29	0.46	90.83	April 30, 2019

Notes: Test pit elevations are understood to be referenced to a geodetic datum.
Groundwater infiltration was observed on the base and sidewall of test pits if present.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is suitable for the proposed residential development. It is expected that the proposed residential buildings will be founded on conventional shallow footings placed on an undisturbed, stiff to soft silty clay bearing surface or engineered fill over an approved subgrade surface.

Consideration should be given to the side slopes of long-term structures, such as stormwater management facilities. Safe side slopes of 3H:1V should be maintained for all long-term structures.

Due to the presence of a silty clay deposit, permissible grade raise restrictions are recommended for this site.

The Geotechnical Limit of Hazard Lands has been defined based on our slope stability analysis and review of the adjacent slope along the Jock River, as presented on Drawing PG5036-1 - Test Hole Location Plan. This is discussed further in Section 6.8.

The above and other considerations are discussed in the following paragraphs.

5.2 Site Grading and Preparation

Stripping Depth

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

Fill Placement

Fill used for grading beneath the building areas should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. Granular material should be tested and approved prior to delivery to the site. The fill should be placed in loose lifts of 300 mm thick or less and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the building areas should be compacted to at least 98% of the Standard Proctor Maximum Dry Density (SPMDD).

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

5.3 Foundation Design

Bearing Resistance Values

Strip footings, up to 2 m wide, and pad footings, up to 5 m wide, placed on an undisturbed, stiff silty clay bearing surface can be designed using a bearing resistance value at serviceability limit states (SLS) of **100 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **180 kPa**. Strip footings, up to 2 m wide, and pad footings, up to 5 m wide, placed on an undisturbed, firm silty clay bearing surface can be designed using a bearing resistance value at SLS of **60 kPa** and a factored bearing resistance value at ULS of **100 kPa**. A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance values at ULS.

Footings placed over an engineered pad, consisting of a Granular A or Granular B Type II or approved granular fill alternative placed in maximum 300 mm loose lifts and compacted to 98% of its SPMDD, can be designed using a bearing resistance value at SLS of 100 kPa and a factored bearing resistance value at ULS of 200 kPa.

Bearing resistance values for footing design should be determined on a per lot basis at the time of construction. The bearing resistance values are provided on the assumption that the footings will be placed on undisturbed soil bearing surfaces. An undisturbed soil bearing surface consists of one from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, whether in situ or not, have been removed, in the dry, prior to the placement of concrete for footings.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to the in-situ bearing medium soils above the groundwater table when a plane extending down and out from the bottom edge of the footing at a minimum of 1.5H:1V passes only through in situ soil of the same or higher capacity as the bearing medium soil.

Permissible Grade Raise Recommendations

Consideration must be given to potential settlements which could occur due to the presence of the silty clay deposit and the combined loads from the proposed footings, any groundwater lowering effects, and grade raise fill. The foundation loads to be considered for the settlement case are the continuously applied loads which consist of the unfactored dead loads and the portion of the unfactored live load that is considered to be continuously applied. For dwellings, a minimum value of 50% of the live load is recommended by Paterson.

Generally, the potential long-term settlement is evaluated based on the compressibility characteristics of the silty clay. These characteristics are estimated in the laboratory by conducting unidimensional consolidation tests on undisturbed soil samples collected using Shelby tubes in conjunction with a piston sampler. A total of 7 site specific consolidation tests were conducted by others as part of the geotechnical investigation. The results of the consolidation tests are presented in Table 3 below.

Table 3 - Summary of Consolidation Test Results

Borehole No.	Sample	Depth (m)	p'_c (kPa)	p'_o (kPa)	C_{cr}	C_c
17-48	5	4.90	95.0	45.0	0.006	1.240
18-15	8	8.10	110.0	62.0	0.009	1.330
18-17	6	5.10	95.0	46.0	0.006	0.870
18-19	4	3.50	125.0	108.0	0.008	0.740
18-26	7	6.00	140.0	49.0	0.008	1.210
18-32	6	6.50	155.0	51.0	0.006	1.180
18-36	5	4.90	110.0	39.0	0.006	2.280

The value for p'_c is the preconsolidation pressure and p'_o is the effective overburden pressure of the test sample. The difference between these values is the available preconsolidation. The increase in stress on the soil due to the cumulative effects of the fill surcharge, the footing pressures, the slab loadings and the lowering of the groundwater should not exceed the available preconsolidation if unacceptable settlements are to be avoided.

The values for C_{cr} and C_c are the recompression and compression indices, respectively. These soil parameters are a measure of the compressibility due to stress increases below and above the preconsolidation pressures. The higher values for the C_c, as compared to the C_{cr}, illustrate the increased settlement potential above, as compared to below, the preconsolidation pressure.

The values of p'_c, p'_o, C_{cr} and C_c are determined using standard engineering testing procedures and are estimates only. Natural variations within the soil deposit will affect the results. The p'_o parameter is directly influenced by the groundwater level. Groundwater levels were measured during the site investigation. Groundwater levels vary seasonally which has an impact on the available preconsolidation. Lowering the groundwater level increases the p'_o and therefore reduces the available preconsolidation. Unacceptable settlements could be induced by a significant lowering of the groundwater level. The p'_o values for the consolidation tests carried out for the present investigation are based on the long-term groundwater level observed at each borehole location. The groundwater level is based on the colour and undrained shear strength profile of the silty clay.

The total and differential settlements will be dependent on characteristics of the proposed buildings. For design purposes, the total and differential settlements are estimated to be 25 and 20 mm, respectively. A post-development groundwater lowering of 1 m was assumed.

The potential post construction total and differential settlements are dependent on the position of the long-term groundwater level when buildings are situated over deposits of compressible silty clay. Efforts can be made to reduce the impacts of the proposed development on the long-term groundwater level by placing clay dykes in the service trenches, reducing the sizes of paved areas, leaving green spaces to allow for groundwater recharge or limiting planting of trees to areas away from the buildings. However, it is not economically possible to control the groundwater level.

To reduce potential long term liabilities, consideration should be given to accounting for a larger groundwater lowering and to provide means to reduce long term groundwater lowering (e.g. clay dykes, restriction on planting around the dwellings, etc). Buildings on silty clay deposits increases the likelihood of movements and therefore of cracking. The use of steel reinforcement in foundations placed at key structural locations will tend to reduce foundation cracking compared to unreinforced foundations.

Based on the consolidation testing results, test fill settlement monitoring results and undrained shear strength values at the borehole locations and our experience with local Ottawa clays, we have determined our permissible grade raise recommendations for the current phase of the proposed development. Our permissible grade raise recommendations are presented in Drawing PG5036-2 - Permissible Grade Raise Plan in Appendix 2.

Based on the above discussion, several options could be considered to accommodate proposed grade raises with respect to our permissible grade raise recommendations, such as the use of lightweight fill, which allow for raising the grade without adding a significant load to the underlying soils. Alternatively, it is possible to preload or surcharge the subject site in localized areas provided sufficient time is available to achieve the desired settlements.

5.4 Test Fill Pile Settlement Monitoring Program

Between January 30, 2020 and February 11, 2020, a test fill pile settlement monitoring program consisting of two (2) test fill piles (Piles E and EE) was initiated. The test fill piles were strategically placed across the subject site to provide additional information regarding our permissible grade raise recommendations for the area. The test fill piles consisted of a 30 m x 30 m pile, ranging in height from 2.5 to 3.1 m at the time of construction. Two (2) settlement plates were installed in each of the two (2) test fill piles. An initial baseline survey was conducted on each settlement plate at the time of installation to accurately monitor settlement contributed by the test fill piles.

The results of the monitoring program indicate that up to 79 mm of settlement at Test Fill Pile E and EE have occurred since the initial baseline survey. The monitoring results to date are considered to have confirmed that our original permissible grade raise recommendations for the site.

The test fill piles are outlined in Drawing PG5036-1 - Test Hole Location Plan in Appendix 2. The periodic readings, including most recent results, from our test fill pile settlement monitoring program are presented in Figure 12 - Test Fill Pile Settlement Monitoring Program in Appendix 2.

5.5 Design for Earthquakes

The results of seismic shear wave velocity testing performed by others indicated an average shear wave velocity, Vs_{30}, at this site of 198 m/s, 176 m/s, and 268 m/s. A **Site Class D** is therefore applicable for design across the majority of the site. The soils underlying the subject site are not susceptible to liquefaction.

Reference should be made to the latest revision of the Ontario Building Code (OBC) 2012 for a full discussion of the earthquake design requirements.

5.6 Basement Slab / Slab-on-Grade Construction

With the removal of all topsoil and deleterious fill from within the footprint of the proposed buildings, the native soil surface will be considered an acceptable subgrade on which to commence backfilling for floor slab construction.

Any soft areas should be removed and backfilled with appropriate backfill material prior to placing any fill. OPSS Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab.

For structures with slab-on-grade construction, the upper 200 mm of sub-slab fill is recommended to consist of OPSS Granular A crushed stone. All backfill material within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose layers and compacted to a minimum of 98% of the SPMDD.

For structures with basement slabs, it is recommended that the upper 200 mm of sub- floor fill consists of 19 mm clear crushed stone.

5.7 Pavement Structure

For design purposes, the pavement structure presented in the following tables is recommended for the design of car only parking areas, local roadways and arterial roadways with bus traffic.

Table 4 - Recommended Pavement Structure - Driveways / Car Only Parking Areas

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

Table 5 - Recommended Pavement Structure - Local Roads

Thickness (mm)	Material Description	Traffic Category
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete	**B**
50	**Binder Course -** Superpave 19.0 Asphaltic Concrete	
150	**BASE** - OPSS Granular A Crushed Stone	
400	**SUBBASE** - OPSS Granular B Type II	
SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill		

Table 6 - Recommended Pavement Structure - Roadways with Bus Traffic

Thickness (mm)	Material Description	Traffic Category
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete	**D**
50	**Upper Binder Course** - Superpave 19.0 Asphaltic Concrete	
50	**Lower Binder Course** - Superpave 19.0 Asphaltic Concrete	
150	**BASE** - OPSS Granular A Crushed Stone	
600	**SUBBASE** - OPSS Granular B Type II	
SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill		

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

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for driveways and local roadways and PG 64-34 asphalt cement should be used for roadways with bus traffic. The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 100% of the material's SPMDD using suitable vibratory equipment.

Pavement Structure Drainage

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

Due to the low permeability of the subgrade materials consideration should be given to installing subdrains during the pavement construction as per City of Ottawa standards. The subdrain inverts should be approximately 300 mm below subgrade level. The subgrade surface should be crowned to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

A perimeter foundation drainage system is recommended for each proposed structure. The system should consist of a 100 to 150 mm diameter, geotextile-wrapped, perforated, corrugated plastic pipe, surrounded on all sides by 150 mm of 10 mm clear crushed stone which is placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of free draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a drainage geocomposite, such as Delta Drain 6000, connected to the perimeter foundation drainage system. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should otherwise be used for this purpose.

6.2 Protection Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum 1.5 m thick soil cover (or equivalent) should be provided in this regard.

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for other exterior unheated footings.

6.3 Excavation Side Slopes

The side slopes of excavations in the soil and fill overburden materials should either be cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is assumed that sufficient room will be available for the greater part of the excavations to be undertaken by open-cut methods (i.e. unsupported excavations).

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or flatter. The flatter slope is required for excavation below groundwater level. The subsoil at this site is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

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

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

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

6.4 Pipe Bedding and Backfill

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

The pipe bedding for sewer and water pipes placed on a relatively dry, undisturbed subgrade surface should consist of at least 150 mm of OPSS Granular A material. Where the bedding is located within the firm grey silty clay, the thickness of the bedding material should be increased to a minimum of 300 mm. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD. The bedding material should extend at least to the spring line of the pipe.

The cover material, which should consist of OPSS Granular A, should extend from the spring line of the pipe to at least 300 mm above the obvert of the pipe. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD.

Generally, it should be possible to re-use the moist (not wet) brown silty clay above the cover material if the excavation and filling operations are carried out in dry weather conditions. Wet silty clay material will be difficult to re-use, as the high water contents make compacting impractical without an extensive drying period.

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

To reduce long-term lowering of the groundwater at this site, clay seals should be provided within the service trenches excavated through the silty clay deposit. The seals should be at least 1.5 m long (in the trench direction) and should extend from trench wall to trench wall. The seals should extend from the frost line and fully penetrate the bedding, subbedding and cover material. The barriers should consist of relatively dry and compactable brown silty clay placed in maximum 225 mm thick loose layers and compacted to a minimum of 95% of the SPMDD. The clay seals should be placed at the site boundaries and at strategic locations at no more than 60 m intervals in the service trenches excavated through the silty clay deposit.

6.5 Groundwater Control

Due to the relatively impervious nature of the silty clay materials, it is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium.

A temporary Ministry of the Environment, Conservation, and Parks (MECP) permit to take water (PTTW) may be required for this project if more than 400,000 L/day of ground and/or surface water is to be pumped during the construction phase. A minimum 4 to 5 months should be allowed for completion of the PTTW application package and issuance of the permit by the MECP.

For typical ground or surface water volumes being pumped during the construction phase, between 50,000 to 400,000 L/day, it is required to register on the Environmental Activity and Sector Registry (EASR). A minimum of two to four weeks should be allotted for completion of the EASR registration and the Water Taking and Discharge Plan to be prepared by a Qualified Person as stipulated under O.Reg. 63/16. If a project qualifies for a PTTW based upon anticipated conditions, an EASR will not be allowed as a temporary dewatering measure while awaiting the MECP review of the PTTW application.

6.6 Winter Construction

The subsurface conditions at this site mostly consist of frost susceptible materials. In presence of water and freezing conditions ice could form within the soil mass. Heaving and settlement upon thawing could occur. Precautions should be taken if winter construction is considered for this project.

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

The trench excavations should be constructed in a manner that will avoid the introduction of frozen materials into the trenches. As well, pavement construction is difficult during winter. The subgrade consists of frost susceptible soils which will experience total and differential frost heaving as the work takes place. In addition, the introduction of frost, snow or ice into the pavement materials, which is difficult to avoid, could adversely affect the performance of the pavement structure. Additional information could be provided, if required.

6.7 Landscaping Considerations

Tree Planting Restrictions - Low to Medium Sensitivity Area

A low to medium sensitivity clay soil was encountered between the anticipated design underside of footing elevations and 3.5 m below finished grade as per City Guidelines in the areas outlined in Drawing PG5036-3 - Tree Planting Setback Recommendations in Appendix 2. Based on our Atterberg limits test results, the modified plasticity index does not exceed 40% in these areas.

The following tree planting setbacks are recommended for the low to medium sensitivity area. Large trees (mature height over 14 m) can be planted within these areas provided a tree to foundation setback equal to the full mature height of the tree can be provided (e.g. in a park or other green space). Tree planting setback limits may be reduced to **4.5 m** for small (mature height up to 7.5m) and medium size trees (mature tree height 7.5 to 14 m), provided that the conditions noted below are met.

☐ The underside of footing (USF) is 2.1 m or greater below the lowest finished grade for footings within 10 m from the tree, as measured from the centre of the tree trunk and verified by means of the Grading Plan.

☐ A small tree must be provided with a minimum of 25 m^3 of available soils volume while a medium tree must be provided with a minimum of 30 m^3 of available soil volume, as determined by the Landscape Architect. The developer is to ensure that the soil is generally un-compacted when backfilling in street tree planting locations.

- ❐ The tree species must be small (mature tree height up to 7.5 m) to medium size (mature tree height 7.5 m to 14 m) as confirmed by the Landscape Architect.

- ❐ The foundation walls are to be reinforced at least nominally (minimum of two upper and two lower 15M bars in the foundation wall).

- ❐ Grading surrounding the tree must promote drainage to the tree root zone in such a manner as not to be detrimental to the tree), as noted on the subdivision Grading Plan.

Aboveground Swimming Pools

The in-situ soils are considered to be acceptable for in-ground swimming pools. Above ground swimming pools must be placed at least 5 m away from the residence foundation and neighbouring foundations. Otherwise, pool construction is considered routine, and can be constructed in accordance with the manufacturer’s recommendations.

Aboveground Hot Tubs

Additional grading around hot tubs should not exceed permissible grade raises. Otherwise, hot tub construction is considered routine, and can be constructed in accordance with the manufacturer’s specifications.

Decks and Building Additions

Additional grading around proposed decks or additions should not exceed permissible grade raises. Otherwise, standard construction practices are considered acceptable.

6.8 Slope Stability Assessment

A slope stability analysis was carried out to determine the required construction setback from the top of the bank. Five (5) slope cross-sections were studied as the worst-case scenarios.

Erosional and access allowances were also considered in the determination of limits of hazard lands and are discussed in the following sections. The cross-section locations and the proposed limit of hazard lands are shown on Drawing PG5036-1 - Test Hole Location Plan attached to the current report.

Slope Stability Assessment

The analyses of the stability of the slopes were carried out using SLIDE, a computer program which permits a two-dimensional slope stability analysis using several methods including the Bishop's method, which is a widely used and accepted analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to those favouring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsoil and groundwater conditions, a factor of safety greater than one is usually required to ascertain that the risks of failure are acceptable.

A minimum factor of safety of 1.5 is generally recommended for conditions where the failure of the slope would endanger permanent structures.

The cross-sections were analyzed based on our review of the available topographic mapping. The slope stability analysis was completed at each slope cross-section under worst-case-scenario by assigning cohesive soils under fully saturated conditions. Subsoil conditions at the cross-sections were inferred based on nearby boreholes and general knowledge of the area's geology.

The effective strength soil parameters used for static analysis were chosen based on the subsoil information recovered during the geotechnical investigation. The effective strength soil parameters used for static analysis are presented in Table 7 below.

Table 7 - Effective Soil and Material Parameters (Static Analysis)

Soil Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
Brown Silty Clay Crust	17	33	5
Grey Silty Clay	16	33	10
Glacial Till	20	33	0

The total strength parameters for seismic analysis were chosen based on the in situ, undrained shear strengths recovered within the open boreholes completed at the time of the geotechnical investigation and based on our general knowledge of the geology in the area. The strength parameters used for seismic analysis at the slope cross- sections are presented in Table 8 on the next page.

Table 8 - Total Stress Soil and Material Parameters (Seismic Analysis)

Soil Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Undrained Shear Strength (kPa)
Brown Silty Clay Crust	17	-	150
Grey Silty Clay	16	-	25 to 40
Glacial Till	20	33	0

Static Loading Analysis

The results for the slope stability analyses under static conditions at Sections A, B, C, D and E are shown on Figures 2, 4, 6, 8 and 10, attached to the present report. The factor of safety was found to be greater than 1.5 at Sections A, B, C, D, and E. Based on these results, the slopes are considered to be stable under static loading.

Seismic Loading Analysis

An analysis considering seismic loading was also completed. A horizontal acceleration of 0.16 g was considered for all slopes. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The results of the slope stability analyses under seismic conditions are shown on Figures 3, 5, 7, 9, and 11 in Appendix 2. The results indicate that the factors of safety are greater than 1.1 under seismic conditions. Based on these results, the slopes are considered to be stable under seismic loading. Therefore, when considering seismic loading, no geotechnical setback from the top of the slope is required to achieve a factor of safety of 1.1 for the limit of the hazard lands.

Geotechnical Setback - Limit of Hazard Lands

Based on site reconnaissance completed by others, signs of active erosion were noted along portions of the slope. A 5 m toe erosion allowance is deemed appropriate for this slope based on the cohesive nature of the soils, the observed erosion areas and the current watercourse depth and width. It is considered that a toe erosion allowance of 5 m and a toe erosion access allowance of 6 m is required from the top of stable slope (ie.- slope with factor of safety greater than 1.5).

The limit of hazard lands, which include these allowances, is indicated on Drawing PG5036-1 - Test Hole Location Plan attached to the present report.

It is recommended that any existing vegetation on the slope faces not be removed as it contributes to the stability of the slope and reduces erosion.

6.9 Corrosion Potential and Sulphate

Three (3) soil samples were submitted for analytical testing. The analytical test results of the soil samples indicate that the sulphate content is less than 0.01%. These results along with the chloride and pH value are indicative that Type 10 Portland cement (normal cement) would be appropriate for this site. The chloride content and the pH of the sample indicate that they are not significant factors in creating a corrosive environment for exposed ferrous metals at this site, whereas the resistivity is indicative of a moderate to aggressive corrosive environment.

6.10 Global Stability Review

A global stability analysis has been conducted to determine the geotechnical stability for the proposed retaining wall PG5036-Figure 1 Retaining Wall Design Revision 4, located on the south side of the paved way loop at the east boundary of the subject site.

The highest section of the retaining wall (Section F-F’) was studied for the proposed global stability analysis at the site under static and seismic conditions based on finished grades presented on the survey plan and borehole data collected from the geotechnical investigation. The cross-section location is presented on Drawing PG5036-1 Revision 6 - Test Hole Location Plan which is included in Appendix 2. The analysis is discussed further below.

Global Stability Analysis

The global stability analysis was modeled in Fine Geo 5, a computer program which permits a two-dimensional slope stability analysis calculating several methods including the Bishop’s method, which is a widely accepted slope analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to forces favoring failure.

Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsurface soil and groundwater conditions, a factor of safety greater than 1.0 is generally required for the failure risk to be considered acceptable.

A minimum factor of safety of 1.5 is generally recommended for conditions where the slope failure would comprise permanent structures. An analysis considering seismic loading was also completed. A horizontal acceleration of 0.16 g was considered for the sections for the seismic loading condition.

A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The retaining wall section was reviewed using the design loading according to CHBDC 2015.

Analysis Results

The factor of safety for the retaining wall section was greater than 1.5 for static conditions. Similarly, the results under seismic loading yielded a factor of safety for this section greater than 1.1.

Based on these results, the slopes and retaining wall are considered to be stable under static and seismic loading. Analysis and results completed in Geo5 are presented in Appendix 3.

7.0 Recommendations

It is recommended that the following be completed once the master plan and site development are determined:

☐ Review detailed grading plan(s) from a geotechnical perspective.

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

☐ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.

☐ Observation of all subgrades prior to placing backfilling materials.

☐ Field density tests to ensure that the specified level of compaction has been achieved.

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

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

8.0 Statement of Limitations

The recommendations made in this report are in accordance with Paterson's present understanding of the project. Paterson requests permission to review the grading plan once available. Paterson's recommendations should also be reviewed when the drawings and specifications are complete.

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

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

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

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
March 14, 2024
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Kevin A. Pickard, P.Eng.

David J. Gilbert, P.Eng.

Report Distribution:

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☐ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

SOIL PROFILE AND TEST DATA SHEETS BY OTHERS SYMBOLS AND TERMS BY OTHERS

SEISMIC SITE CLASS TESTING RESULTS BY OTHERS SHRINKAGE LIMIT RESULTS BY OTHERS

ANALYTICAL TESTING RESULTS

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-Conservancy Lands East
Ottawa, Ontario

DATUM Geodetic

REMARKS

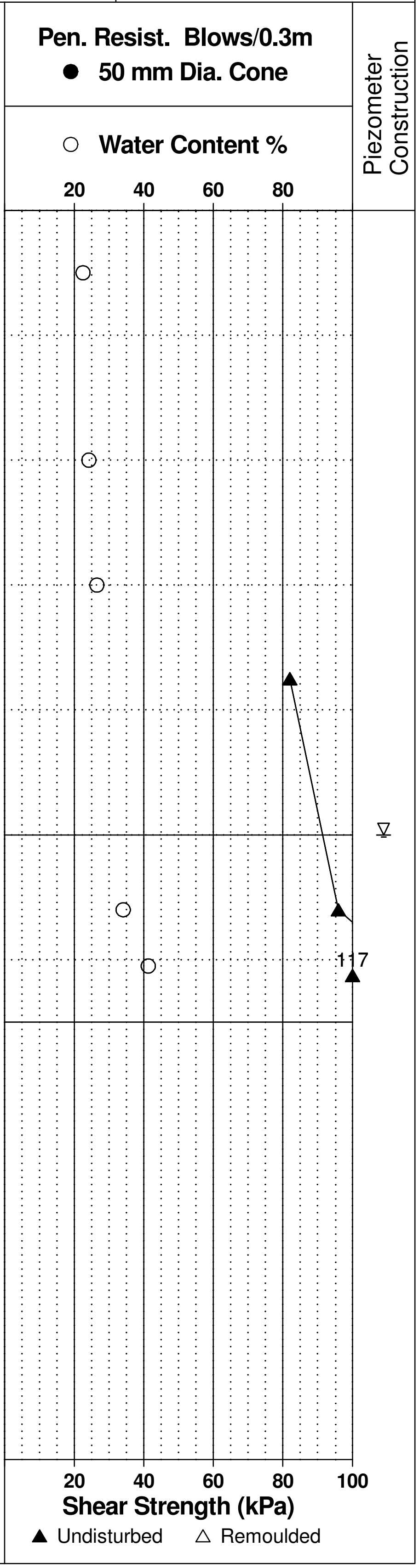
BORINGS BY Excavator

DATE September 30, 2022

FILE NO. PG5036

HOLE NO. TP 1-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.55
FILL: Brown silty clay, some organics		G	1				
0.23							
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace clay and organics		G	2				
0.50							
Stiff to very stiff, brown **SILTY CLAY,** trace to some sand		G	3				
						1	90.55
		G	4				
1.25		G	5				
End of Test Pit (Groundwater infiltration at 1.05m depth)							



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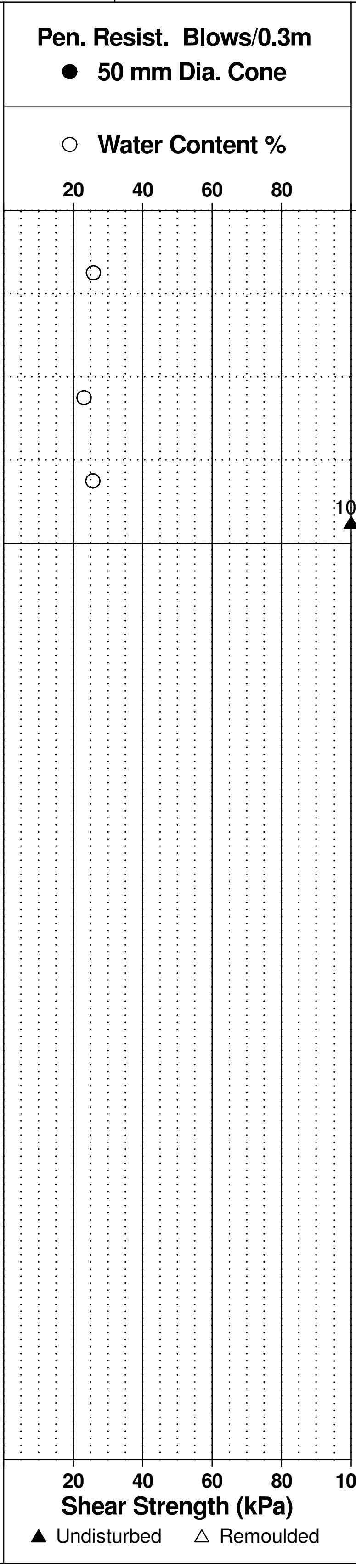
FILE NO. PG5036

HOLE NO. TP 2-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.41
FILL: Brown silty clay, some sand, occasional gravel and cobbles 0.36		G	1				
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace to some clay 0.59		G	2				
Very stiff, brown **SILTY CLAY,** some sand 0.80		G	3				
End of Test Pit (TP dry upon completion)							



Piezometer Construction

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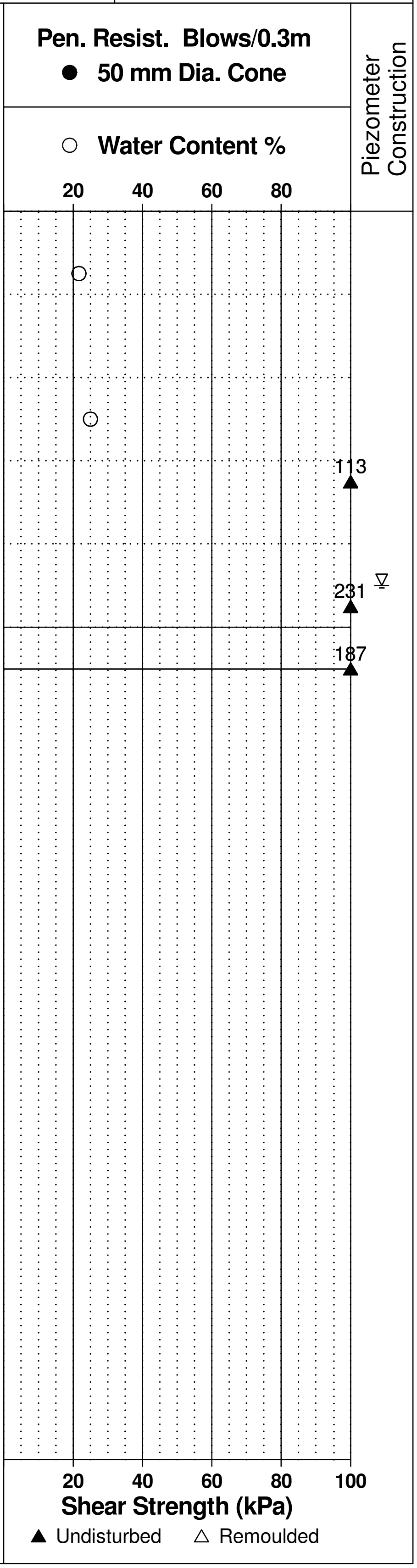
FILE NO. PG5036

HOLE NO. TP 3-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.40
FILL: Brown silty clay, some sand 0.10							
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace clay 0.35		G	1				
Hard to very stiff, brown **SILTY CLAY,** some sand - sand seams at 0.4 to 0.45m and 0.5 to 0.6m depths 1.10		G	2			1	90.40
End of Test Pit (Groundwater infiltration at 0.9m depth)							



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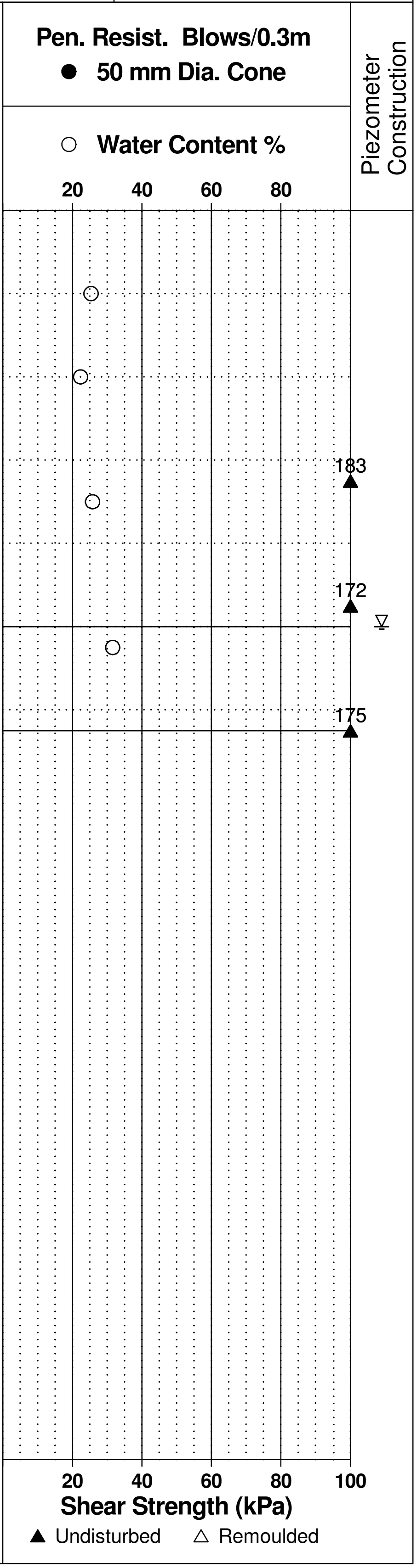
FILE NO. PG5036

HOLE NO. TP 4-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.55
FILL: Brown silty clay with sand 0.30		G	1				
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace to some clay 0.53		G	2				
Very stiff, brown **SILTY CLAY,** trace sand 1.25		G G	3 4			1	90.55
End of Test Pit (Groundwater infiltration at 1.0m depth)							



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FILE NO. PG5036

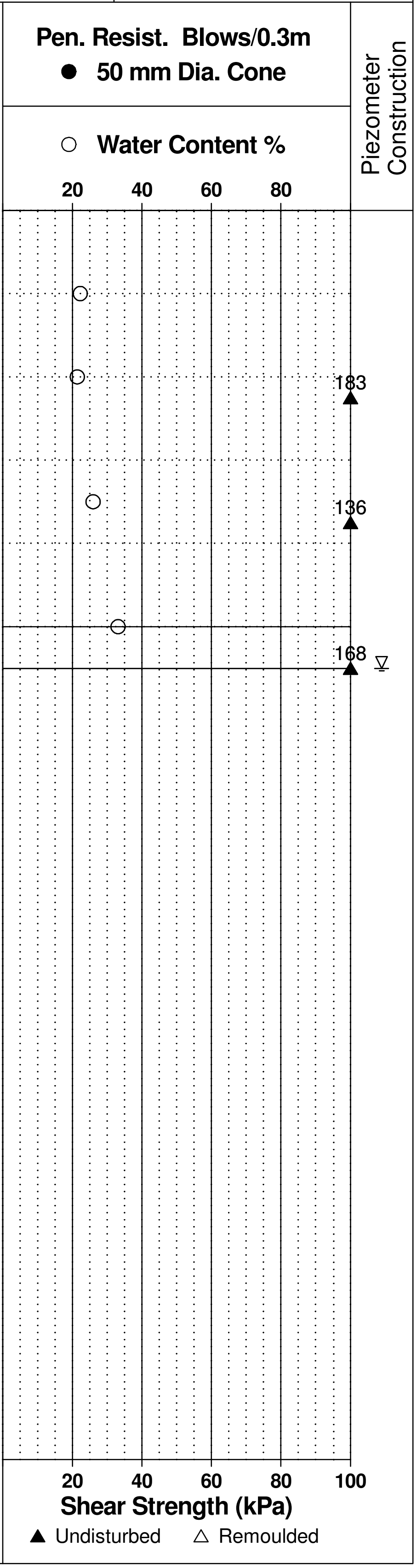
REMARKS

HOLE NO. TP 5-22

BORINGS BY Excavator

DATE September 30, 2022

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.58
FILL: Brown silty clay, some sand 0.30		G	1				
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace clay 0.51		G	2				
Very stiff, brown **SILTY CLAY,** trace sand		G	3				
1.10		G	4			1	90.58
End of Test Pit (Groundwater infiltration at bottom of test pit)							



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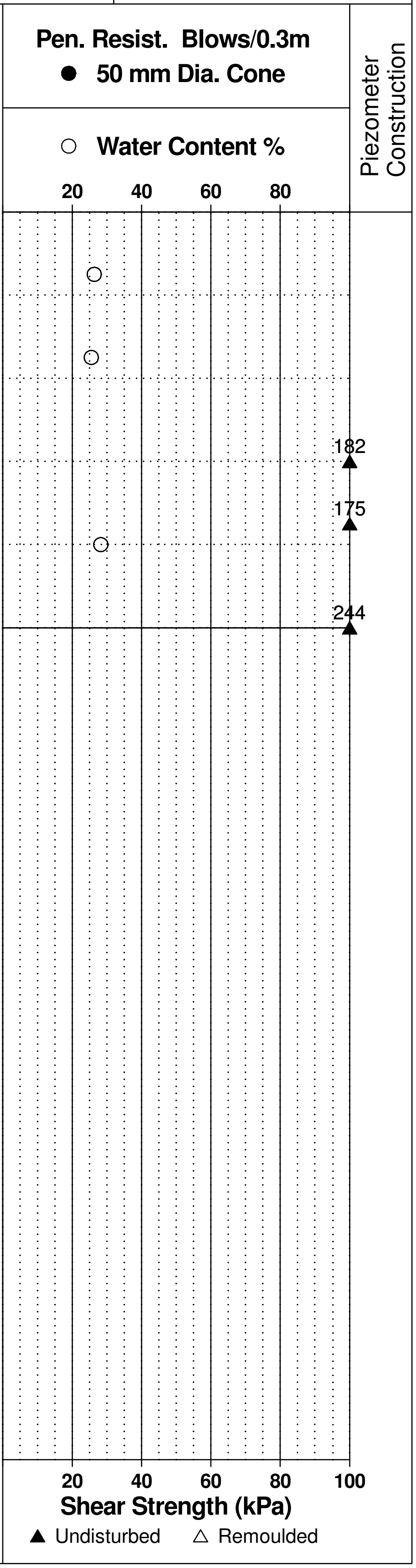
DATE September 30, 2022

FILE NO. PG5036

HOLE NO. TP 6-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.55
FILL: Brown silty clay, trace sand 0.24		G	1				
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace clay 0.46		G	2				
Very stiff to hard, brown **SILTY CLAY,** some sand 1.00		G	3			1	90.55
End of Test Pit (Low groundwater infiltration at bottom of test pit)							



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REMARKS

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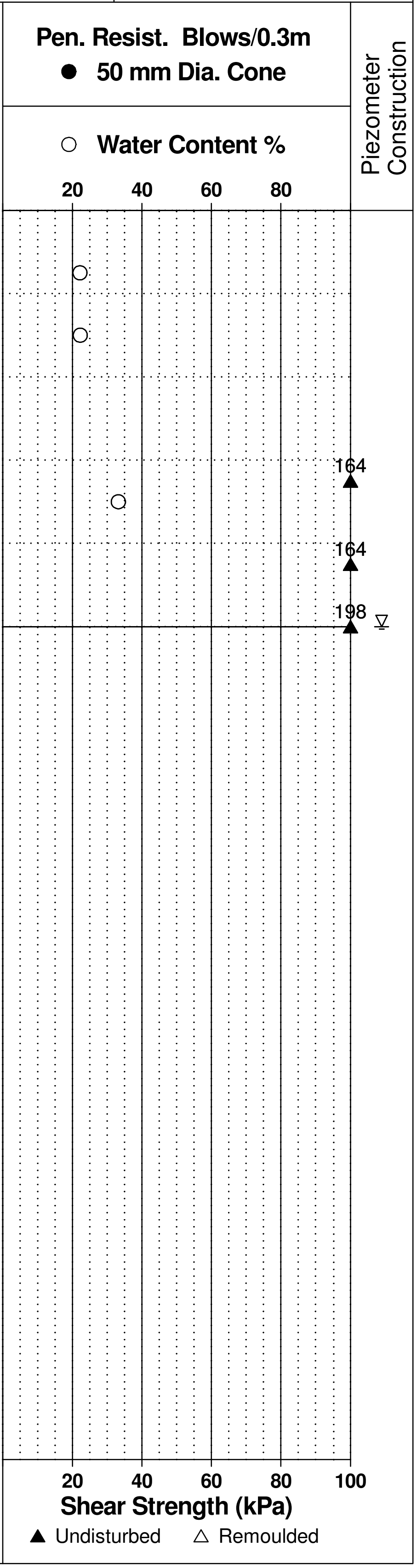
DATE September 30, 2022

FILE NO. PG5036

HOLE NO. TP 7-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	91.55
FILL: Brown sitly clay, some sand 0.20	▨	G	1				
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace clay and topsoil 0.41		G	2				
Very stiff, brown **SILTY CLAY,** trace sand 1.00	▨	G	3			1	90.55
End of Test Pit (Groundwater infiltration at bottom of test pit)							



SOIL PROFILE AND TEST DATA

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REMARKS

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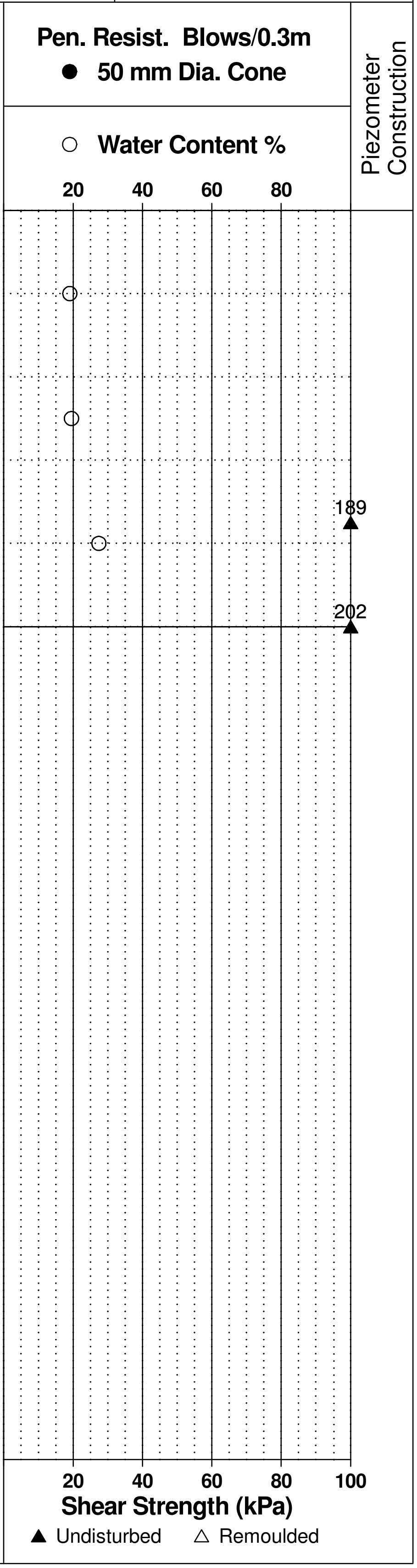
DATE September 30, 2022

FILE NO. **PG5036**

HOLE NO. **TP 8-22**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.68
TOPSOIL 0.10							
FILL: Brown silty clay, some sand, trace debris 0.35		G	1				
Loose to compact, dark brown **SILTY SAND to SANDY SILT,** trace clay 0.60		G	2				
Very stiff to hard, brown **SILTY CLAY,** some sand 1.00		G	3			1	90.68
End of Test Pit (TP dry upon completion)							



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REMARKS

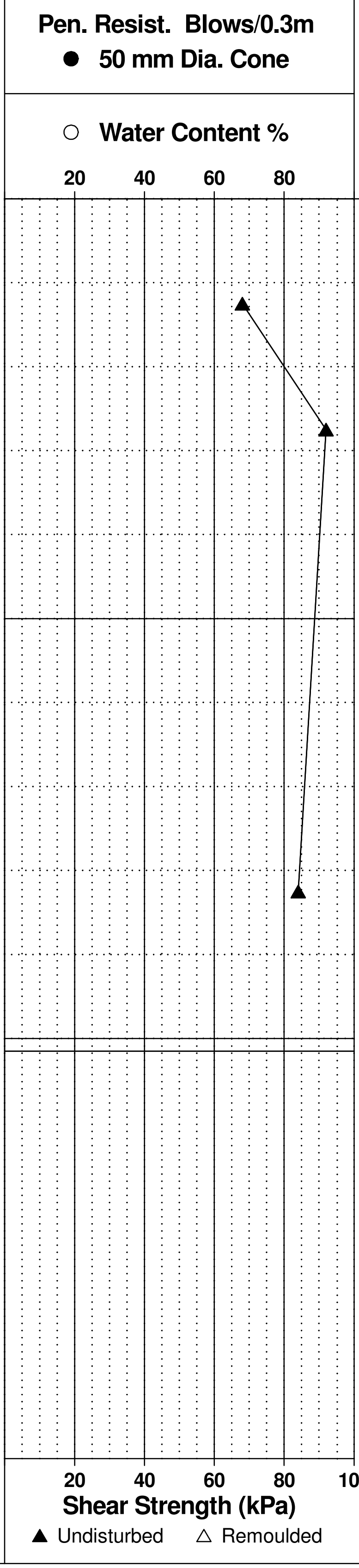
BORINGS BY Excavator

DATE November 18, 2022

FILE NO. PG5036

HOLE NO. TP 9-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	91.67	
	▨	G	1					
	▨	G	2					
Stiff, brown **SILTY CLAY,** trace some sand	▨					1	90.67	
	▨	G	8					
2.03						2	89.67	
End of Test Pit								



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REMARKS

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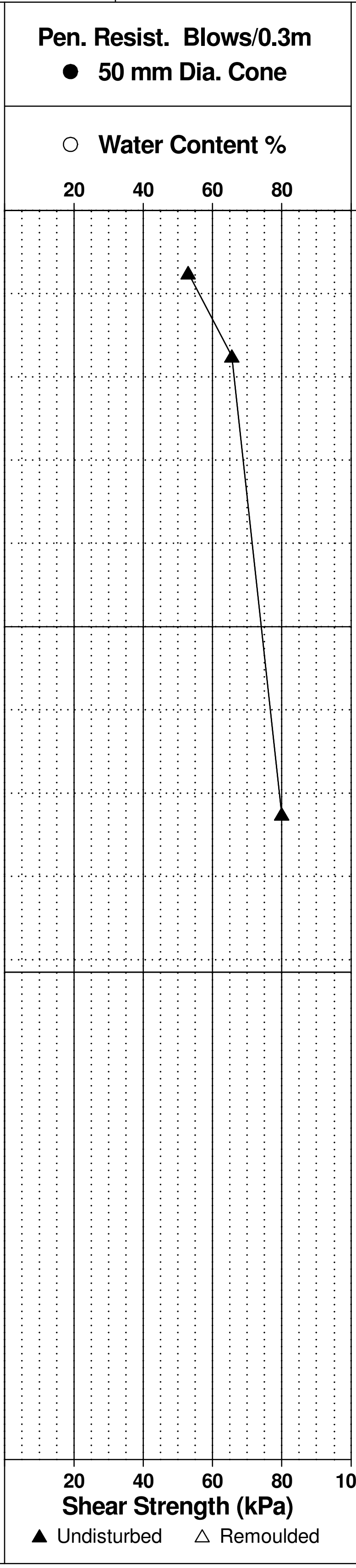
DATE November 18, 2022

FILE NO. PG5036

HOLE NO. TP10-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	91.50	
Stiff, brown **SILTY CLAY,** trace to some sand	▨	G	1					
	▨	G	2					
	▨					1	90.50	
	▨	G	3					
1.83 End of Test Pit								



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SOIL PROFILE AND TEST DATA

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REMARKS

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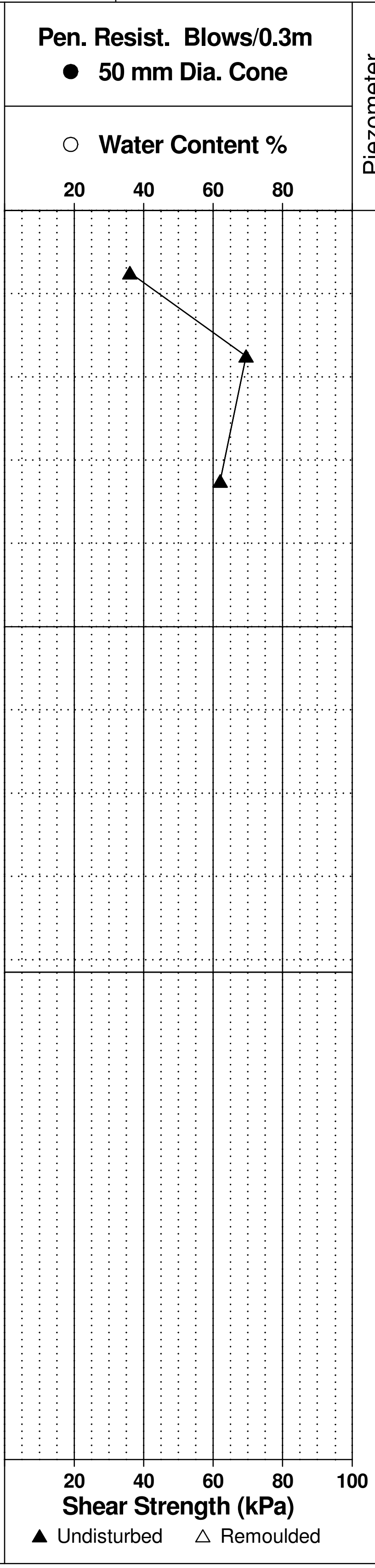
DATE November 18, 2022

FILE NO. PG5036

HOLE NO. TP11-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.68
Firm to stiff, brown **SILTY CLAY,** trace to some sand	▨	G	1				
	▨	G	2				
	▨	G	3				
	▨					1	90.68
	▨	G	4				
1.83							
End of Test Pit							



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-Conservancy Lands East
Ottawa, Ontario

DATUM Geodetic

REMARKS

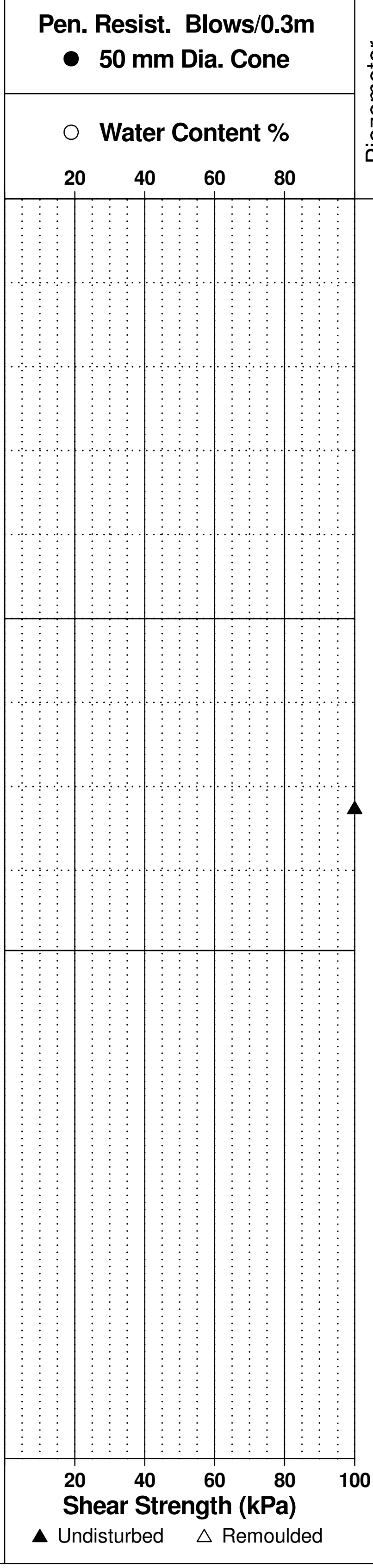
BORINGS BY Excavator

DATE November 30, 2022

FILE NO. PG5036

HOLE NO. TP12-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.69
FILL: Grey-brown silty clay with sand and organics	☒	G	1				
0.49							
Stiff, brown **SILTY CLAY,** trace to some sand	▨	G	2				
						1	90.69
		G	3				
1.79							
End of Test Pit							



Piezometer Construction

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-Conservancy Lands East
Ottawa, Ontario

DATUM Geodetic

REMARKS

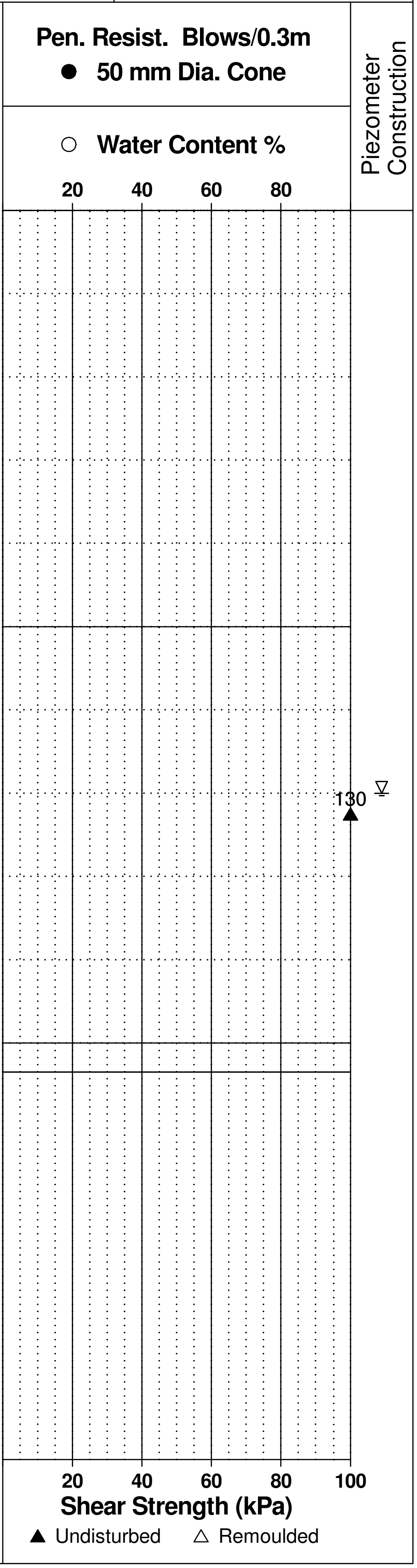
BORINGS BY Excavator

DATE November 30, 2022

FILE NO. PG5036

HOLE NO. TP13-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	91.86	
FILL: Brown to grey silty clay, trace sand, organics, topsoil	▨	G	1					
		G	2					
0.60								
Stiff, brown **SILTY CLAY,** trace to some sand	▨	G	3			1	90.86	
		G	4					
						2	89.86	
2.07								
End of Test Pit (Groundwater infiltration at 1.4m depth)								



patersongroup Consulting Engineers

9 Auriga Drive, Ottawa, Ontario K2E 7T9

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-Conservancy Lands East
Ottawa, Ontario

DATUM Geodetic

REMARKS

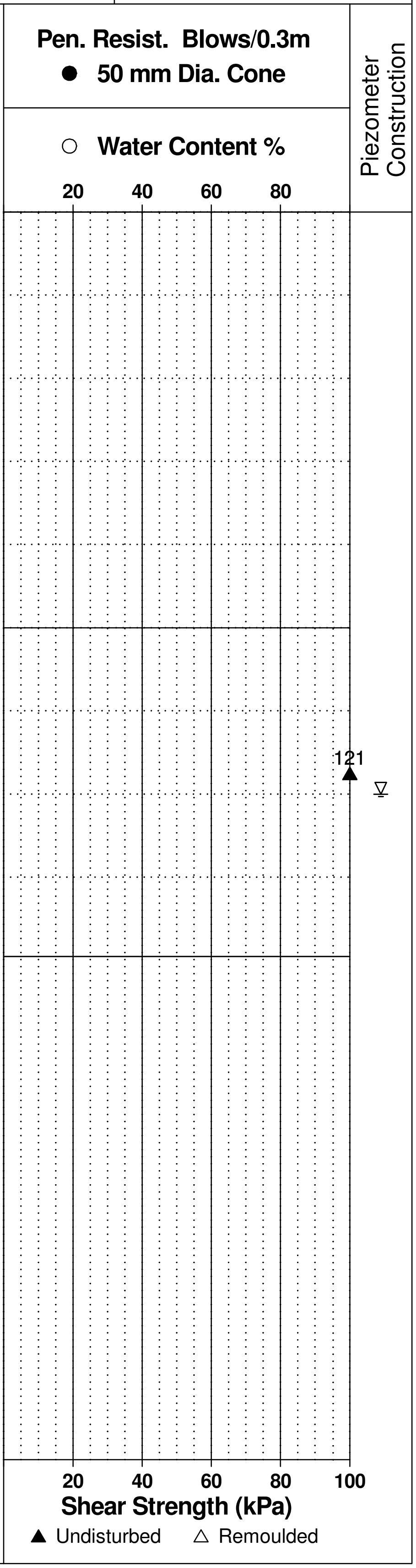
BORINGS BY Excavator

DATE November 30, 2022

FILE NO. **PG5036**

HOLE NO. **TP14-22**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.18
FILL: Brown silty clay with topsoil — 0.19	▨	G	1				
Very stiff, brown **SILTY CLAY,** trace to some sand	▨	G	2				
	▨					1	90.18
	▨	G	3				
1.79 — End of Test Pit (Groundwater infiltration at 1.4m depth)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development-Conservancy Lands East
Ottawa, Ontario

DATUM Geodetic

REMARKS

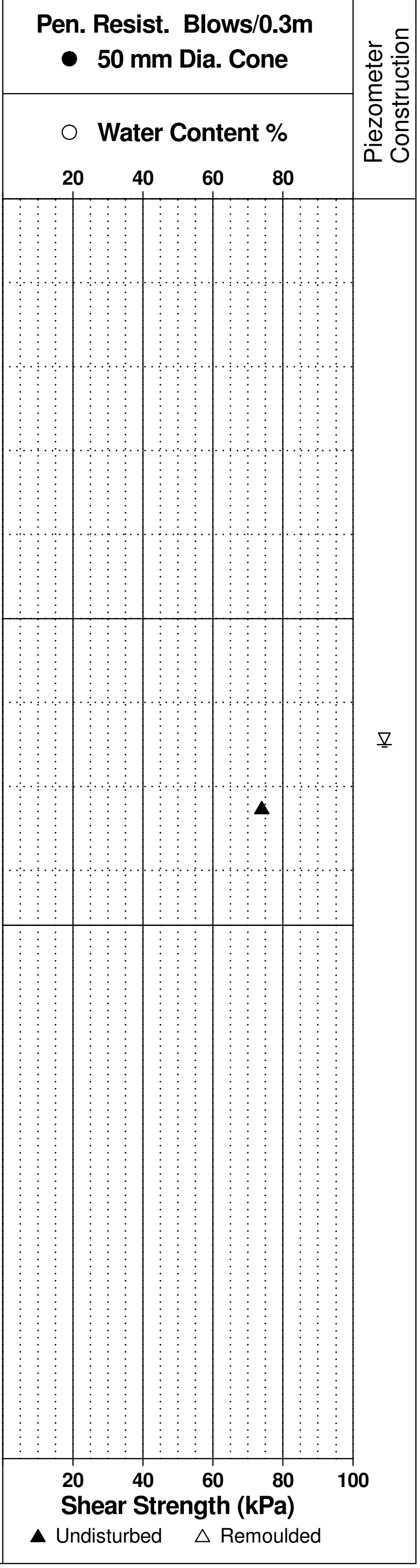
BORINGS BY Excavator

DATE November 30, 2022

FILE NO. PG5036

HOLE NO. TP15-22

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	91.27
FILL: Brown silty clay with topsoil		G	1				
0.21							
Stiff, brown **SILTY CLAY,** trace some sand		G	2				
						1	90.27
		G	3				
1.73							
End of Test Pit (Groundwater infiltration at 1.3m depth)							



SYMBOLS AND TERMS

SOIL DESCRIPTION

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

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

The standard terminology to describe the relative strength of cohesionless soils is the compactness condition, usually inferred from the results of the Standard Penetration Test (SPT) ‘N’ value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm. An SPT N value of “P” denotes that the split-spoon sampler was pushed 300 mm into the soil without the use of a falling hammer.

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

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory shear vane tests, unconfined compression tests, or occasionally by the Standard Penetration Test (SPT). Note that the typical correlations of undrained shear strength to SPT N value (tabulated below) tend to underestimate the consistency for sensitive silty clays, so Paterson reviews the applicable split spoon samples in the laboratory to provide a more representative consistency value based on tactile examination.

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

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity, S_t, is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil. The classes of sensitivity may be defined as follows:

Low Sensitivity:	$S_t < 2$
Medium Sensitivity:	$2 < S_t < 4$
Sensitive:	$4 < S_t < 8$
Extra Sensitive:	$8 < S_t < 16$
Quick Clay:	$S_t > 16$

ROCK DESCRIPTION

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

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

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

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube, generally recovered using a piston sampler
G	-	"Grab" sample from test pit or surface materials
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size BQ, NQ, HQ, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

PLASTICITY LIMITS AND GRAIN SIZE DISTRIBUTION

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

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

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

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

CONSOLIDATION TEST

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

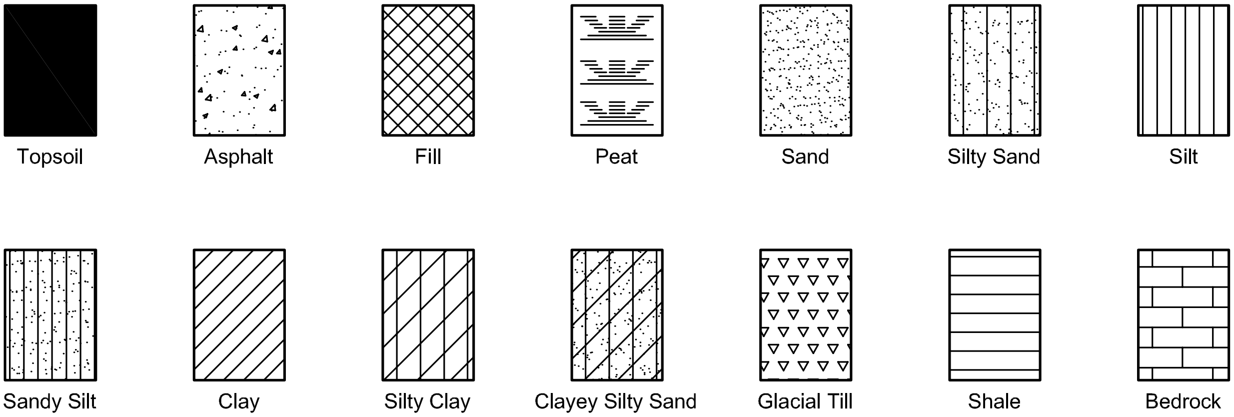
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

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

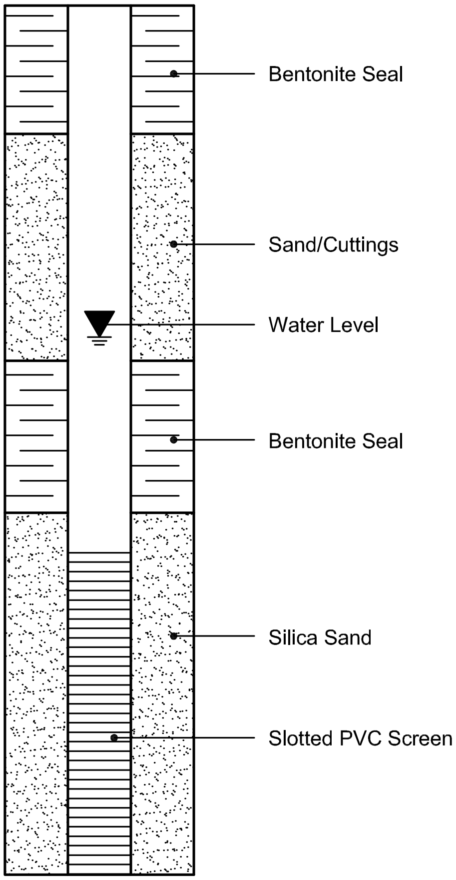
SYMBOLS AND TERMS (continued)

STRATA PLOT

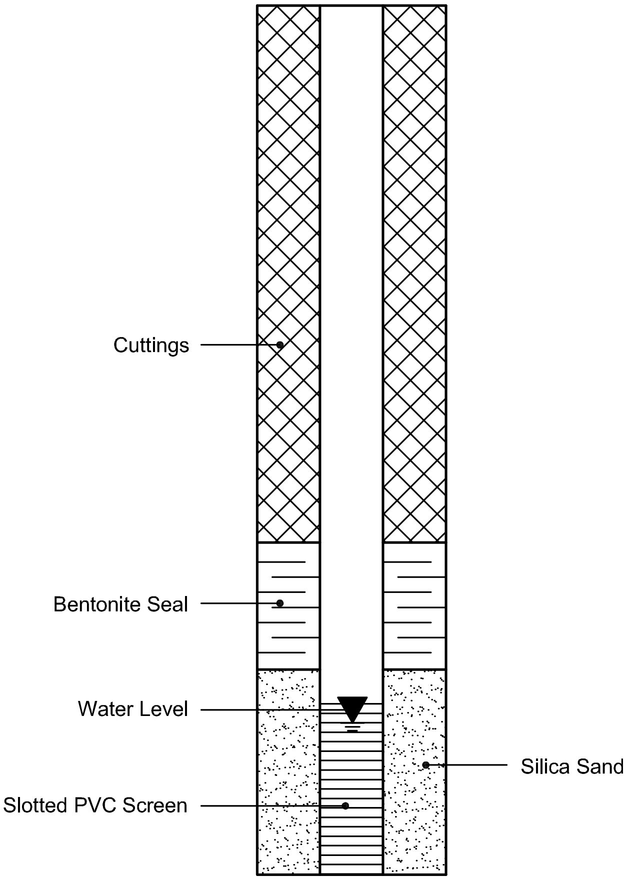


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



PROJECT: 1771847

RECORD OF BOREHOLE: 17-11

SHEET 1 OF 1

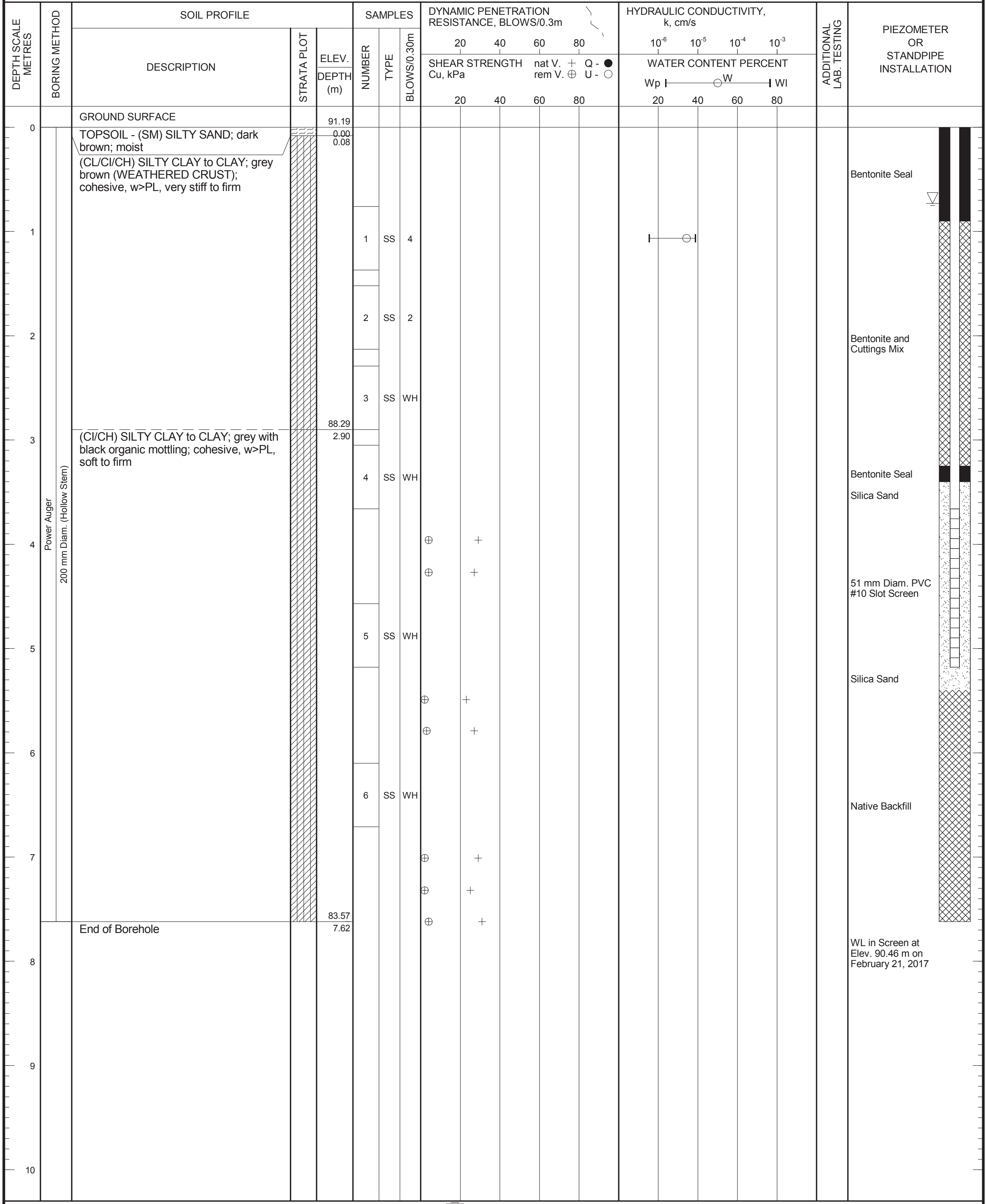
LOCATION: N 5013105.9 ;E 362455.0

BORING DATE: February 15, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.19
TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to firm	0.08
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.29 2.90
End of Borehole	83.57 7.62

NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	2
3	SS	WH
4	SS	WH
5	SS	WH
6	SS	WH

Bentonite Seal

Bentonite and Cuttings Mix

Bentonite Seal

Silica Sand

51 mm Diam. PVC #10 Slot Screen

Silica Sand

Native Backfill

WL in Screen at Elev. 90.46 m on February 21, 2017

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

PROJECT: 1771847

RECORD OF BOREHOLE: 17-12

SHEET 1 OF 1

LOCATION: N 5013250.9 ;E 362714.3

BORING DATE: February 15, 2017

DATUM: CGVD28

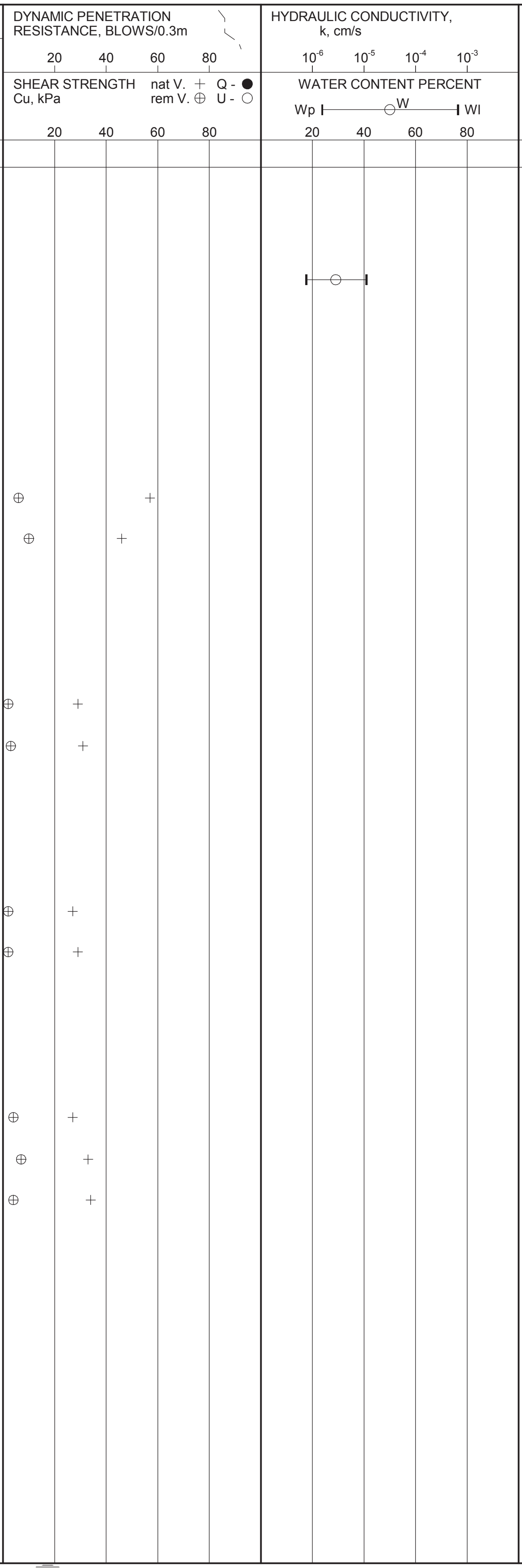
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

ELEV. / DEPTH (m)	SOIL PROFILE DESCRIPTION
91.47	GROUND SURFACE
0.00	TOPSOIL - (SM) SILTY SAND; dark grey; moist
0.08	(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sandy silt to silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to firm
88.73 2.74	(CI/CH) SILTY CLAY to CLAY, with sandy silt layers; grey with black organic mottling; cohesive, w>PL, firm
83.85 7.62	End of Borehole

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	2
3	SS	WH
4	SS	WH
5	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-13

SHEET 1 OF 1

LOCATION: N 5013391.6 ;E 362965.1

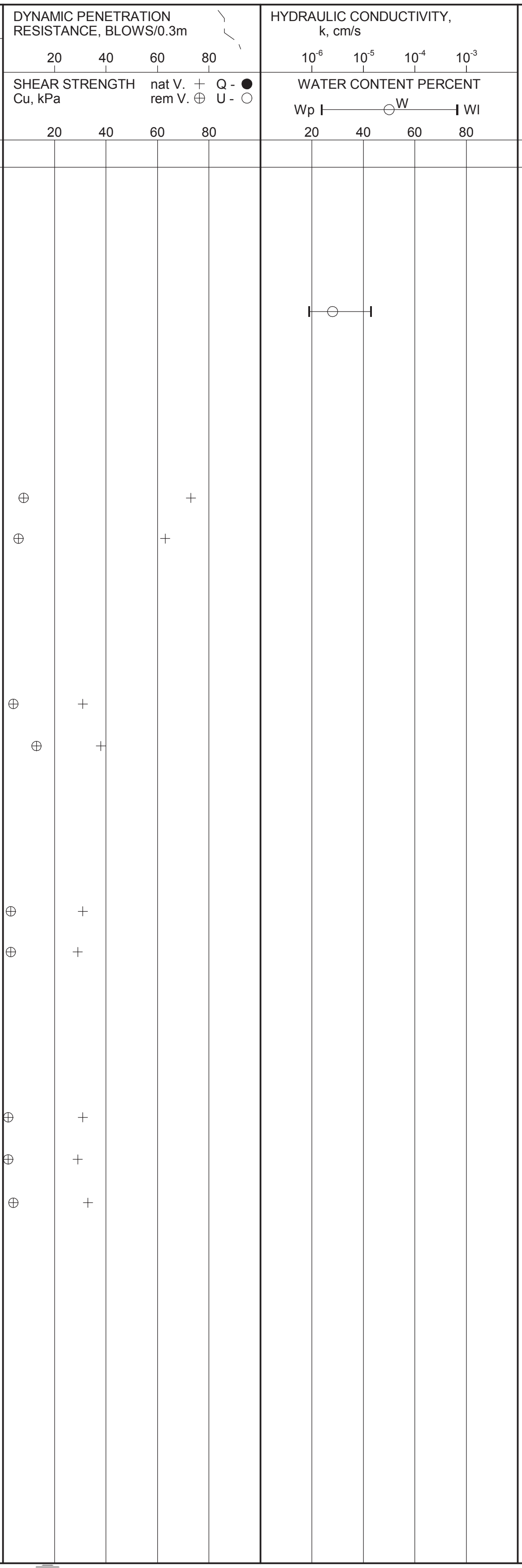
BORING DATE: February 15, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.68					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00					
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.08					
1					1	SS	4		
2					2	SS	1		
		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm		88.94 2.74					
3					3	TP	PH		
4									
5					4	SS	WH		
6									
7					5	SS	WH		
		End of Borehole		84.06 7.62					
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

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PROJECT: 1771847

RECORD OF BOREHOLE: 17-14

SHEET 1 OF 1

LOCATION: N 5013544.1 ;E 363225.4

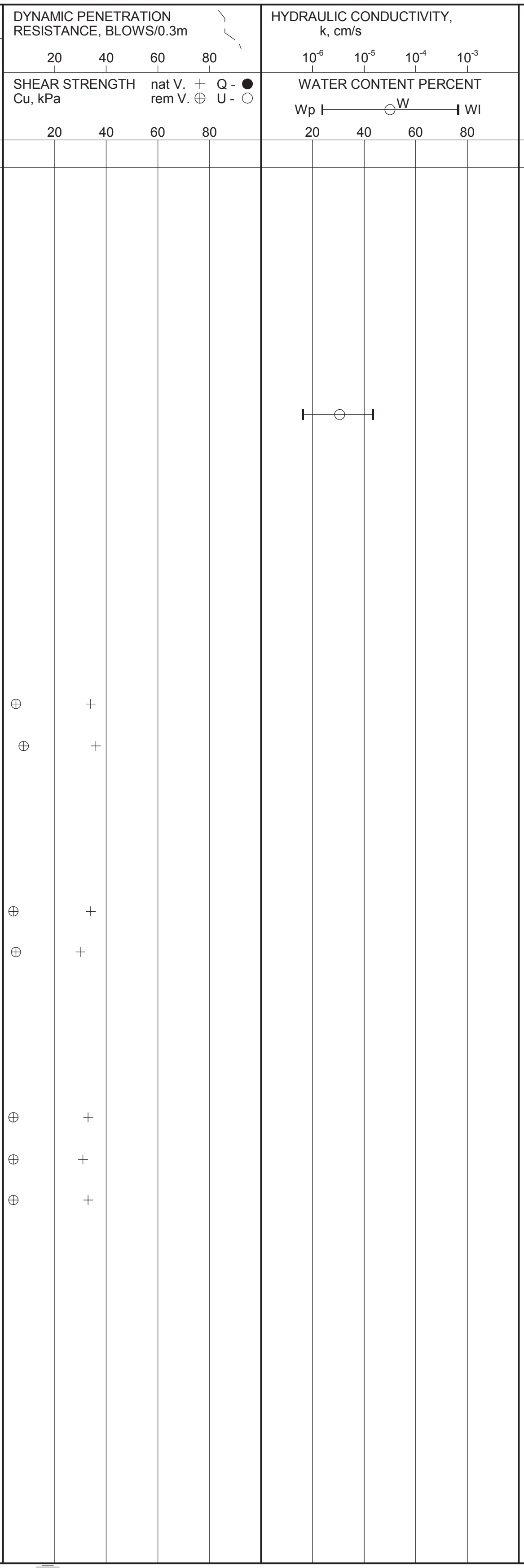
BORING DATE: February 14, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	91.27			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00			
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.16			
1				1	SS	4
				2	SS	2
2						
				3	SS	1
		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm	88.37 2.90			
3				4	SS	WH
4						
				5	SS	WH
5						
6				6	SS	WH
7						
		End of Borehole	83.65 7.62			
8						
9						
10						



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-39

SHEET 1 OF 1

LOCATION: N 5013209.6 ;E 362401.9

BORING DATE: March 23, 2017

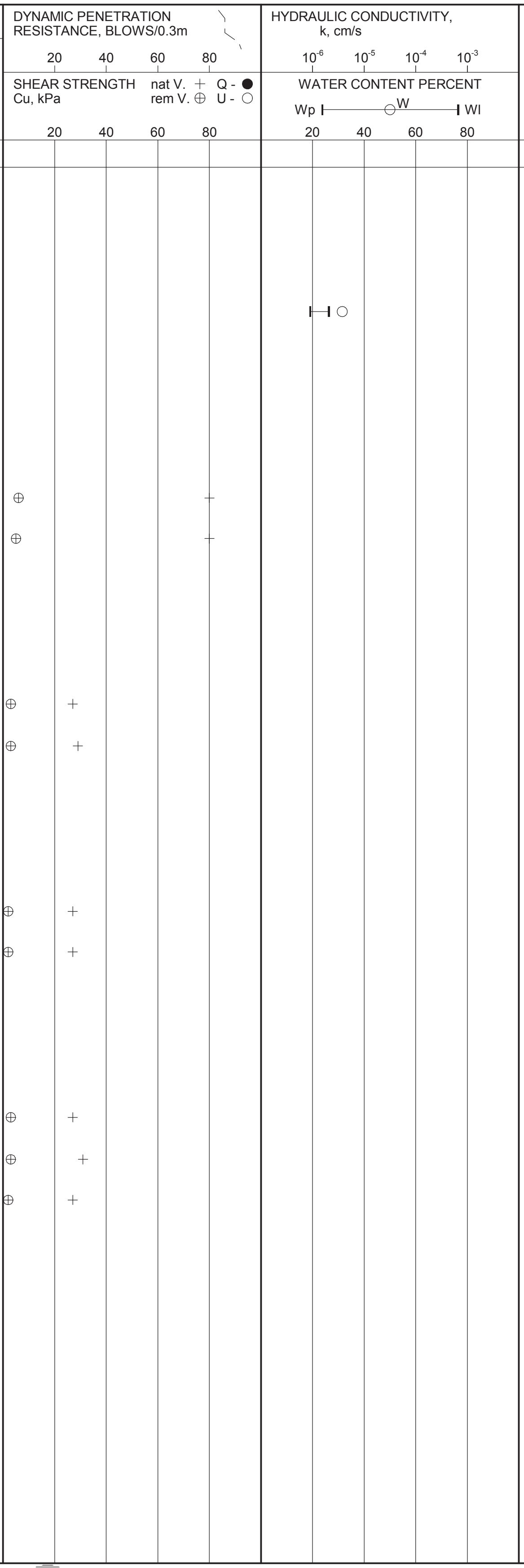
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
		GROUND SURFACE		91.23
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, trace gravel; brown; moist		0.00
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, stiff		0.15
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm		88.18 3.05
7.62		End of Borehole		83.61 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	2
3	SS	2
4	SS	WH
5	SS	WH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SN
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-40

SHEET 1 OF 1

LOCATION: N 5013015.1 ;E 362511.5

BORING DATE: March 24, 2017

DATUM: CGVD28

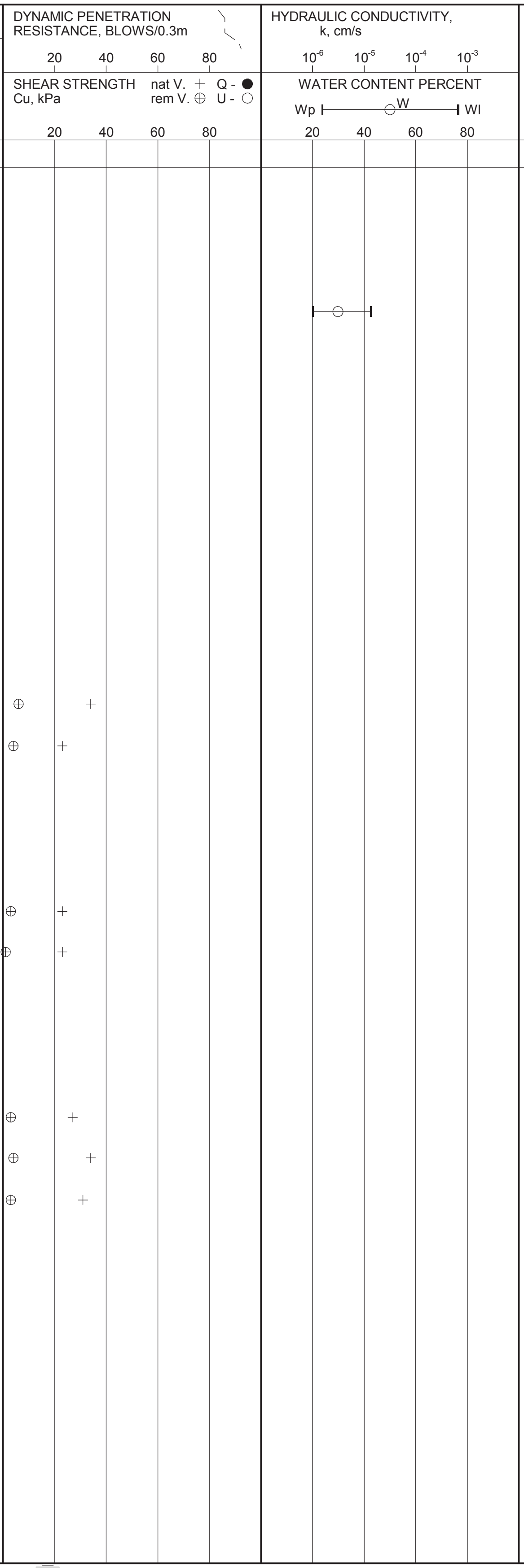
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger
200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.27
TOPSOIL - (SM) SILTY SAND; brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sand layers and possible cobbles or boulders (WEATHERED CRUST); cohesive, w>PL, stiff - augers grinding from 1.5 to 2.1 m depth	0.15
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.37 2.90
End of Borehole	83.65 7.62

NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	2
3A	SS	>50
3B	SS	2
4	SS	WH
5	SS	WH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

PROJECT: 1771847

RECORD OF BOREHOLE: 17-41

SHEET 1 OF 1

LOCATION: N 5013282.6 ;E 362535.2

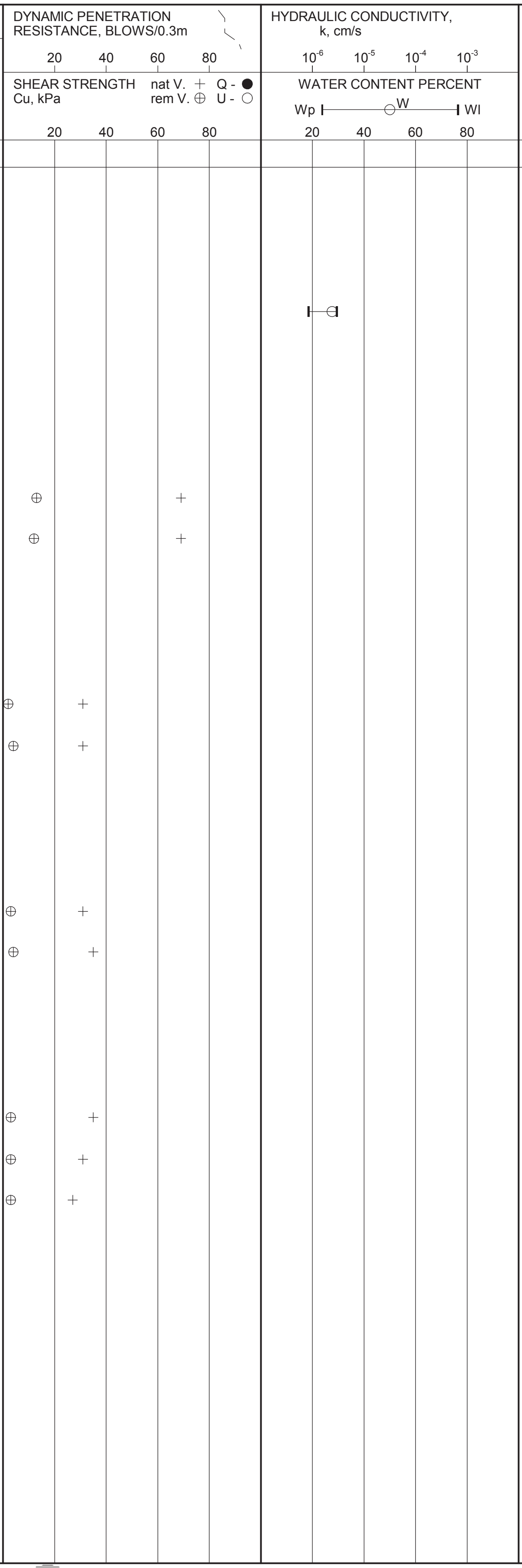
BORING DATE: March 23, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE		91.51			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown; moist		0.00			
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sandy silt layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.13	1	GRAB	-
1					2	SS	2
2					3	SS	2
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains sand seams; cohesive, w>PL, firm		88.46 3.05	4	SS	WH
5					5	SS	WH
6					6	SS	WH
7		End of Borehole		83.89 7.62			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

PROJECT: 1771847

RECORD OF BOREHOLE: 17-42

SHEET 1 OF 1

LOCATION: N 5013169.5 ;E 362589.9

BORING DATE: March 30, 2017

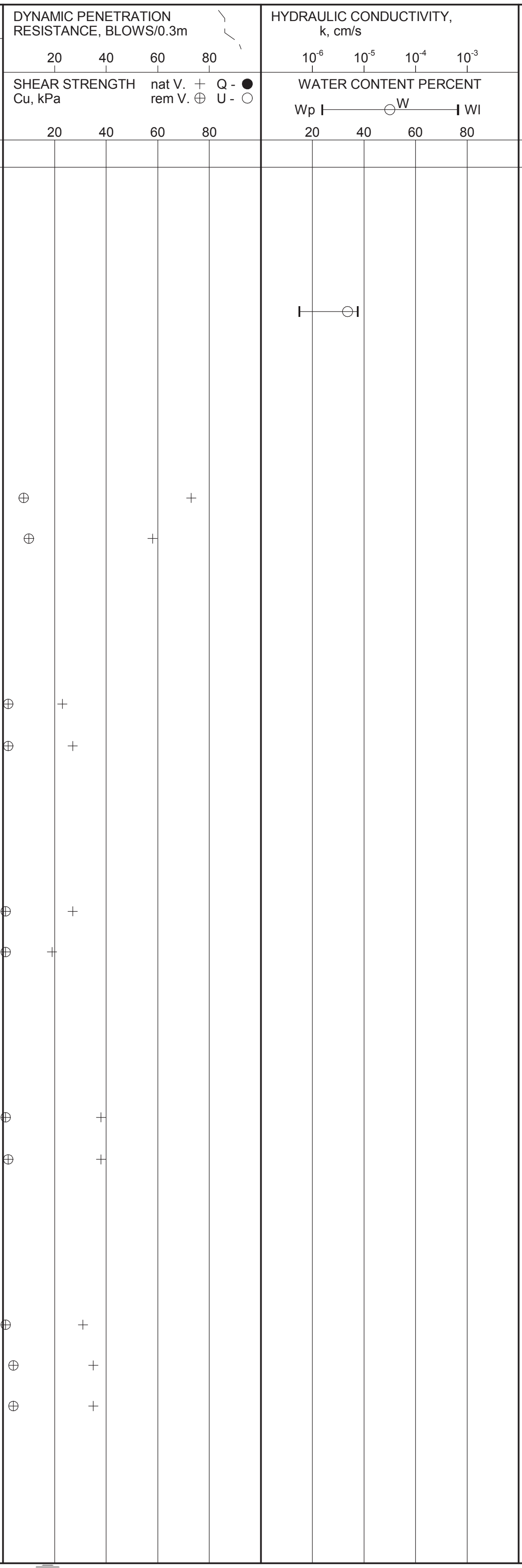
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

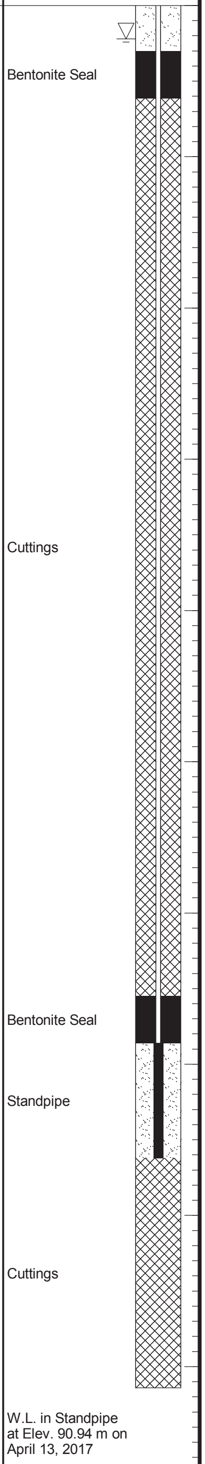
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	91.16			
0	TOPSOIL - (SM) SILTY SAND; brown; moist	0.00			
	(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, stiff to firm	0.15	1	GRAB	-
1			2	SS	1
2			3	SS	1
	(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains sand seams; cohesive, w>PL, soft to firm	88.42 2.74			
3			4	SS	WH
5			5	SS	WH
6			6	SS	WH
8			7	TP	PH
9	End of Borehole	82.02 9.14			
10					



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



DEPTH SCALE

1 : 50

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-43

SHEET 1 OF 1

LOCATION: N 5013089.3 ;E 362640.6

BORING DATE: March 20, 2017

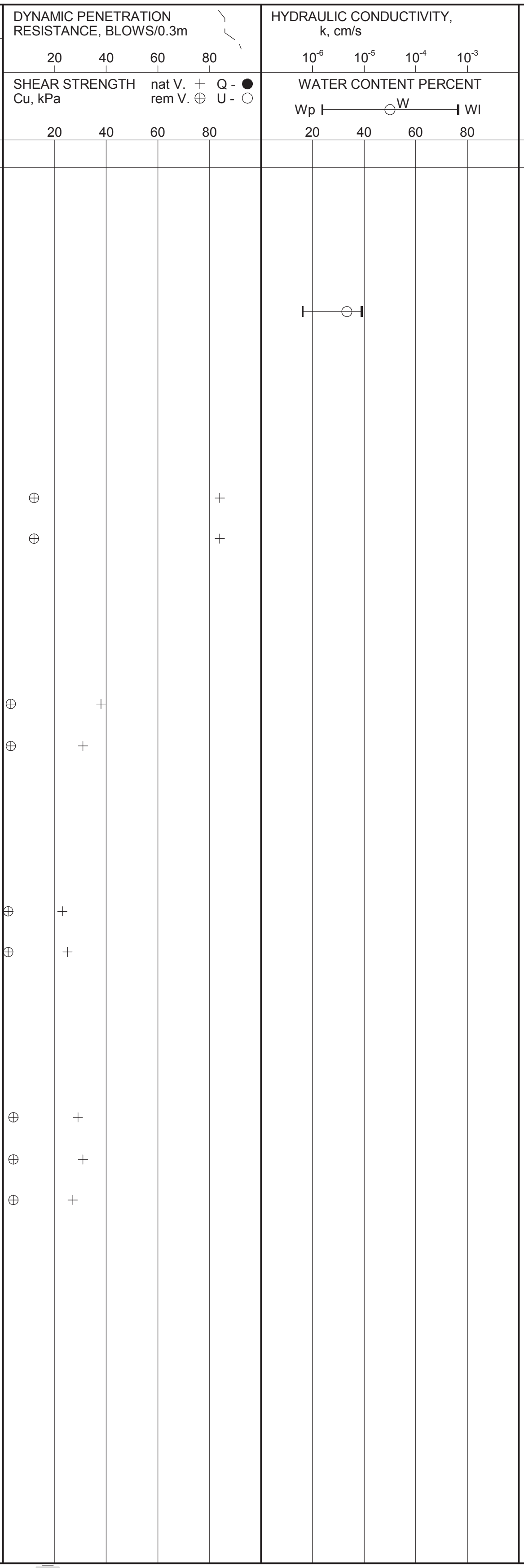
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	91.52
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.15
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains sand seams; cohesive, w>PL, soft to firm	88.47 3.05
		End of Borehole	83.90 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	2
2	SS	2
3	SS	WH
4	SS	WH
5	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-43A

SHEET 1 OF 1

LOCATION: Adjacent to BH 17-43

BORING DATE: March 20, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

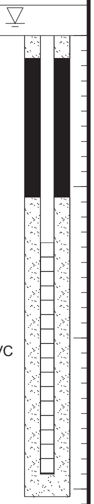
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

SHEAR STRENGTH Cu, kPa: nat V. + Q - ● rem V. ⊕ U - ○ — 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT: Wp ⊢—○W—⊣ Wl — 20 40 60 80

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.52					
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-43 for Stratigraphy		0.00					Bentonite Seal Silica Sand 51 mm Diam. PVC #10 Slot Screen
1									
2									
3		End of Borehole		88.47 3.05					Silica Sand WL in Screen at Elev. 91.60 m on March 31, 2017
4									
5									
6									
7									
8									
9									
10									



DEPTH SCALE

1 : 50

LOGGED: SN

CHECKED: SD

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

PROJECT: 1771847

RECORD OF BOREHOLE: 17-44

SHEET 1 OF 1

LOCATION: N 5013362.7 ;E 362667.1

BORING DATE: March 30, 2017

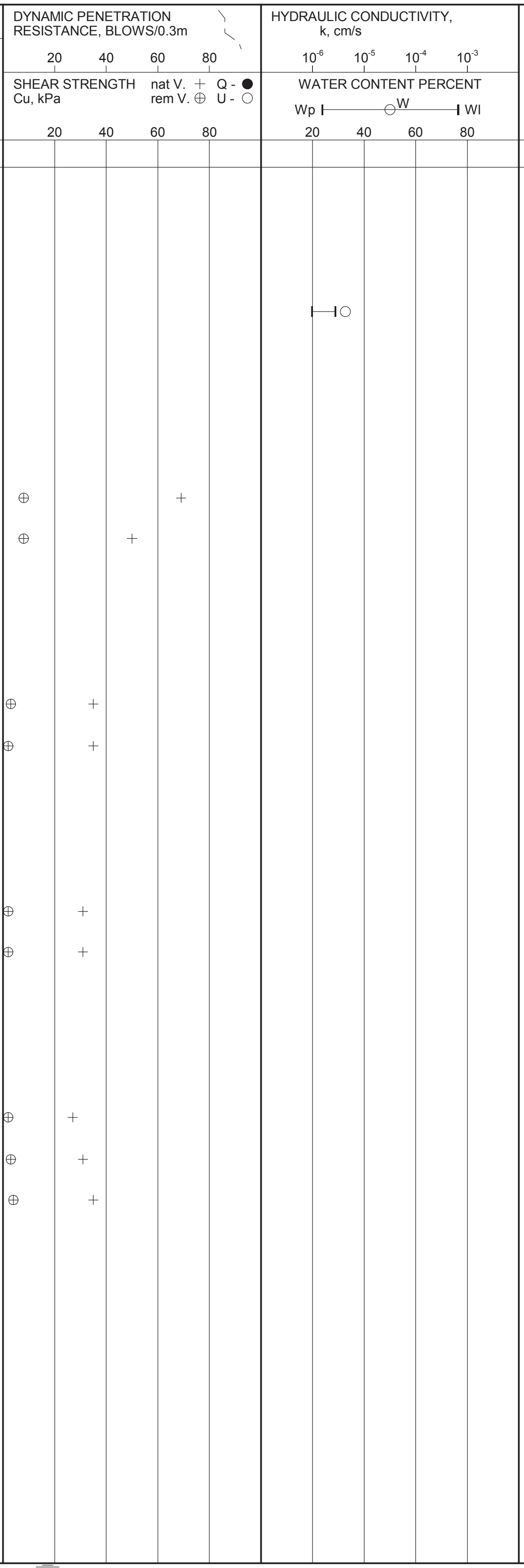
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
		GROUND SURFACE		91.54
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown; moist		0.00
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.15
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains sand seams; cohesive, w>PL, firm		88.49 3.05
7.62		End of Borehole		83.92 7.62

SAMPLE NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	2
3	SS	2
4	SS	WH
5	SS	WH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

DEPTH SCALE
1 : 50

LOGGED: SN
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-45

SHEET 1 OF 1

LOCATION: N 5013163.8 ;E 362766.6

BORING DATE: March 24, 2017

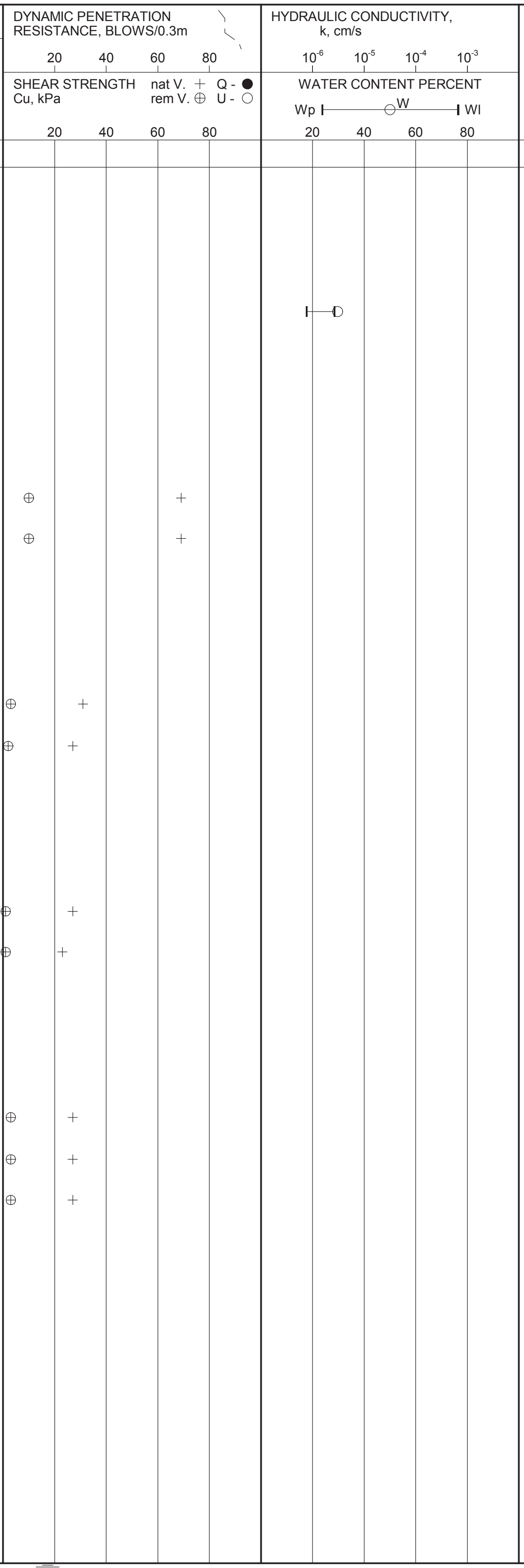
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	91.60
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, trace gravel; dark brown; moist	0.00
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.38 0.22
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.55 3.05
		End of Borehole	83.98 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	3
3	SS	2
4	SS	WH
5	SS	WH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-46

SHEET 1 OF 1

LOCATION: N 5013430.6 ;E 362784.4

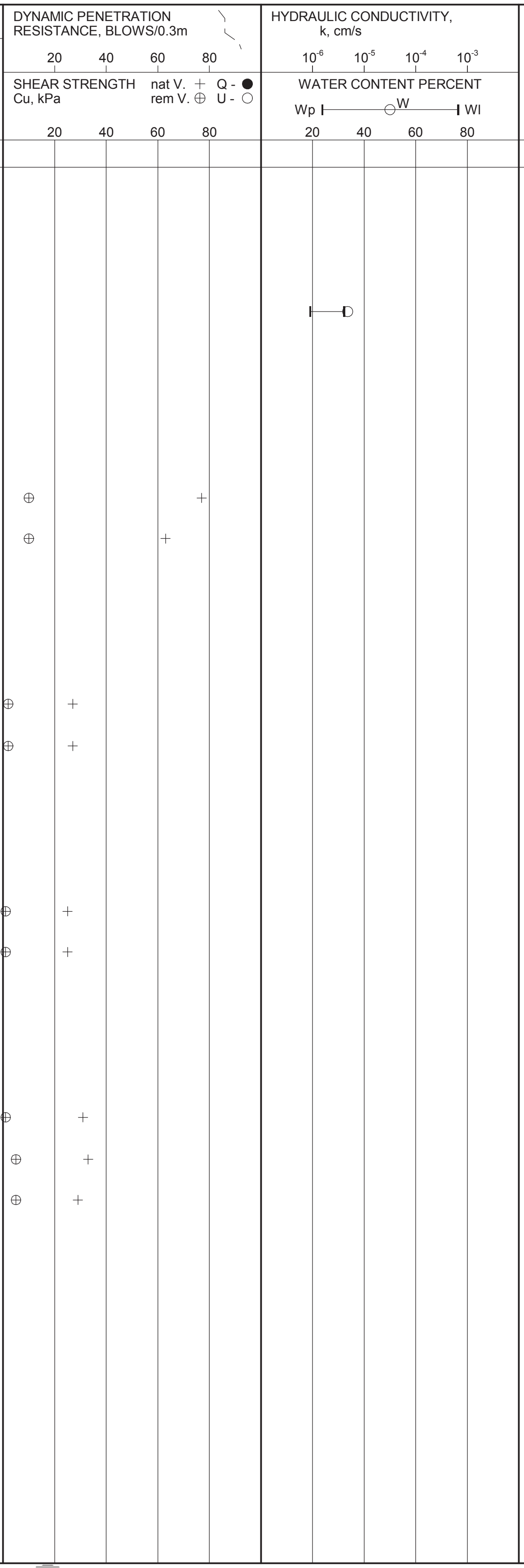
BORING DATE: March 20, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.63					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown; moist		0.00					
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.15	1	GRAB	-		
1					2	SS	4		
2					3	SS	2		
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains sand seams; cohesive, w>PL, firm		88.58 3.05	4	SS	WH		
5					5	SS	WH		
6					6	SS	WH		
7		End of Borehole		84.01 7.62					
8									
9									
10									



DEPTH SCALE

1 : 50

LOGGED: SN

CHECKED: SD

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

PROJECT: 1771847

RECORD OF BOREHOLE: 17-46A

SHEET 1 OF 1

LOCATION: Adjacent to BH 17-46

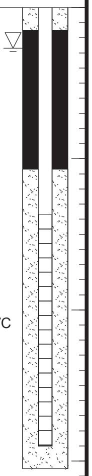
BORING DATE: March 20, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.63							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-46 for Stratigraphy		0.00							Bentonite Seal Silica Sand 51 mm Diam. PVC #10 Slot Screen Silica Sand
3		End of Borehole		88.58 3.05							WL in Screen at Elev. 91.36 m on March 31, 2017



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-47

SHEET 1 OF 1

LOCATION: N 5013313.3 ;E 362843.7

BORING DATE: March 30, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

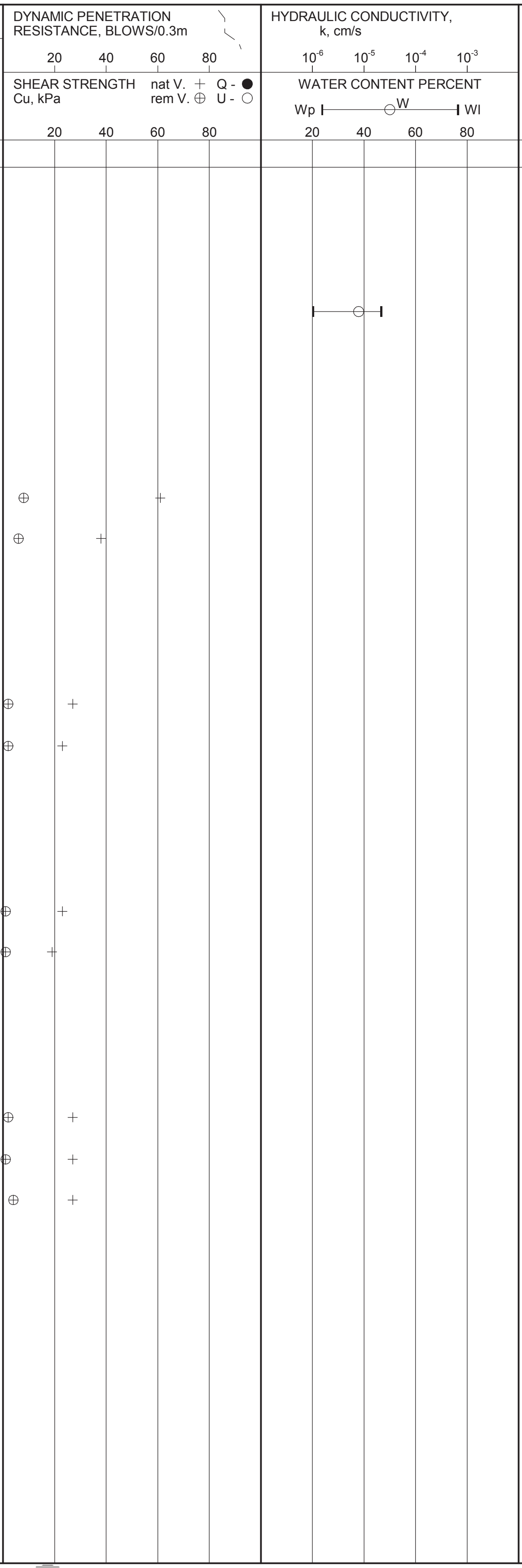
BORING METHOD: Power Auger 200 mm Diam. (Hollow Stem)

SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.53
TOPSOIL - (SM) SILTY SAND; brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, stiff	0.15
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, soft to firm	89.09 2.44
End of Borehole	83.91 7.62

SAMPLES

NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	2
3	SS	WH
4	SS	WH
5	SS	WH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-48

SHEET 1 OF 1

LOCATION: N 5013231.8 ;E 362893.8

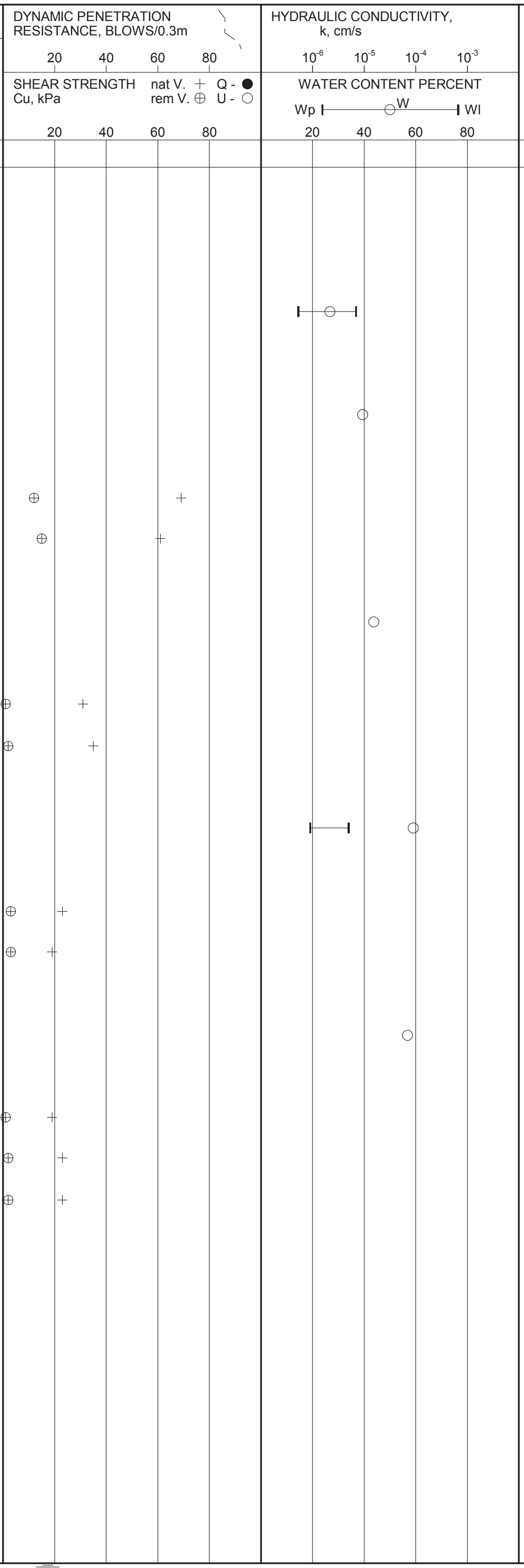
BORING DATE: March 24, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
	GROUND SURFACE	91.54					
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, trace gravel; brown; moist	0.00					
	(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.32 0.22	1	GRAB	-		
			2	SS	5		
			3	SS	2		
	(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.49 3.05	4	SS	WH		
			5	TP	PH	C	
			6	SS	WH		
	End of Borehole	83.92 7.62					



DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-49

SHEET 1 OF 1

LOCATION: N 5013509.6 ;E 362910.4

BORING DATE: March 29, 2017

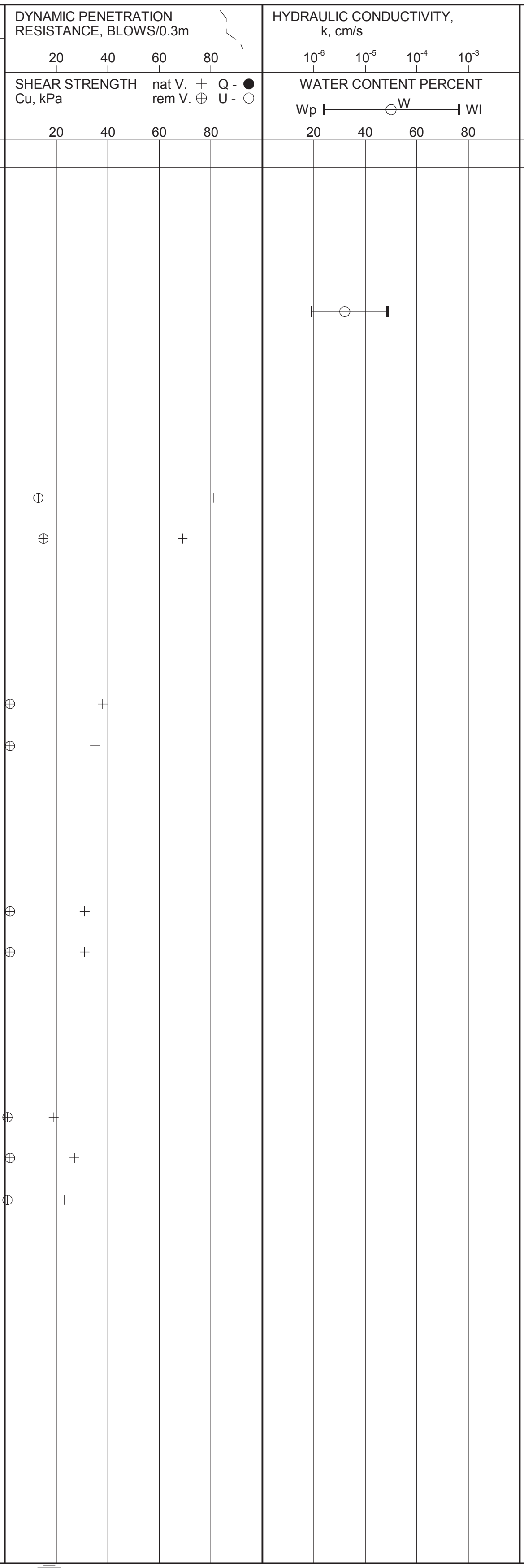
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
		GROUND SURFACE		91.64
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown; moist		0.00
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.15
3		(CI/CH) SILTY CLAY to CLAY; grey with black orgnanic mottling, contains silty sand seams; cohesive, w>PL, soft to firm		88.59 3.05
		End of Borehole		84.02 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	5
3	SS	3
4	SS	WH
5	SS	WH
6	TP	PH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-50

SHEET 1 OF 1

LOCATION: N 5013302.0 ;E 363015.6

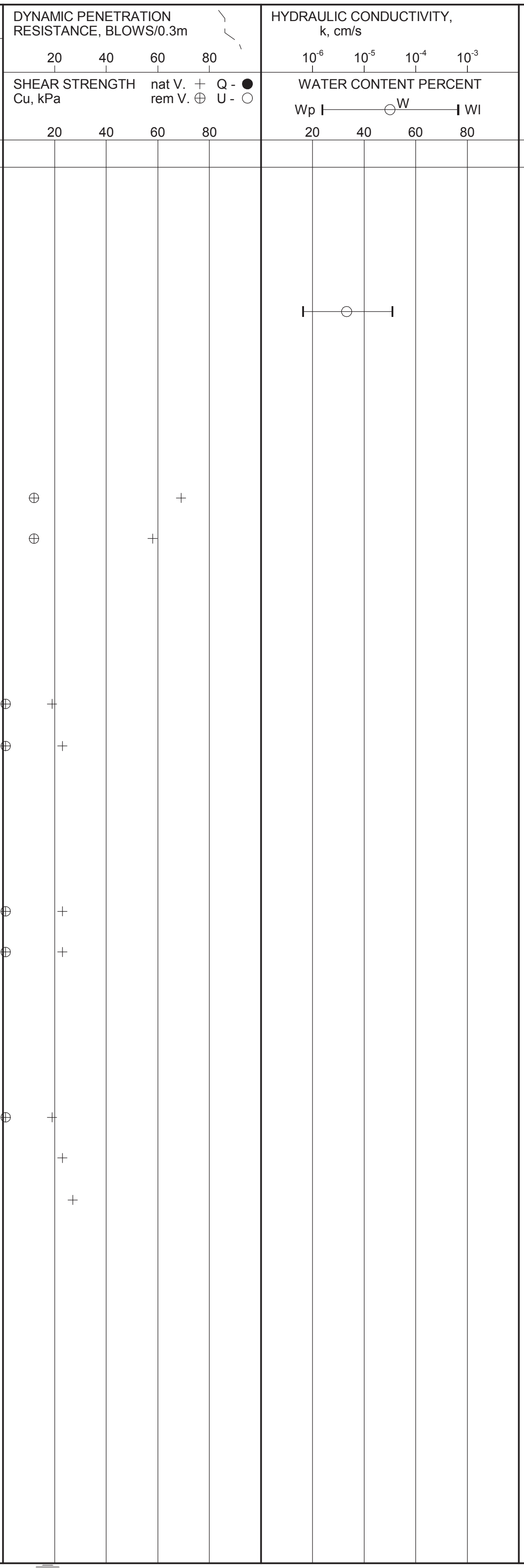
BORING DATE: March 27, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	91.44					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND, trace gravel; brown; moist	0.00					
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.15	1	GRAB	-		
1				2	SS	5		
2				3	SS	1		
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.39 3.05	4	SS	WH		
4								
5				5	SS	WH		
6				6	SS	WH		
7								
		End of Borehole	83.82 7.62					
8								
9								
10								



DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SN
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-51

SHEET 1 OF 1

LOCATION: N 5013578.8 ;E 363036.0

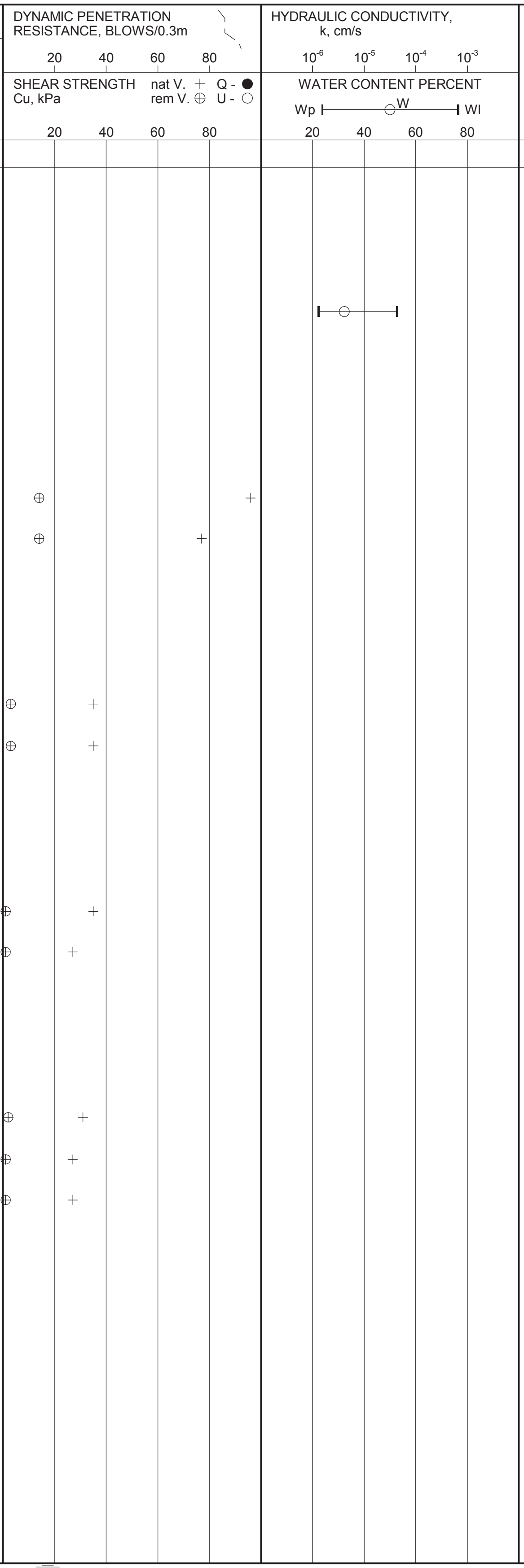
BORING DATE: March 28, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.43					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown; moist	▤	0.00					
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	▨	0.15	1	GRAB	-		
1					2	SS	5		
2					3	SS	3		
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm	▨	88.38 3.05	4	SS	WH		
5					5	SS	WH		
6					6	SS	WH		
7		End of Borehole		83.81 7.62					
8									
9									
10									



DEPTH SCALE
1 : 50

LOGGED: SN
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-52

SHEET 1 OF 1

LOCATION: N 5013458.3 ;E 363093.2

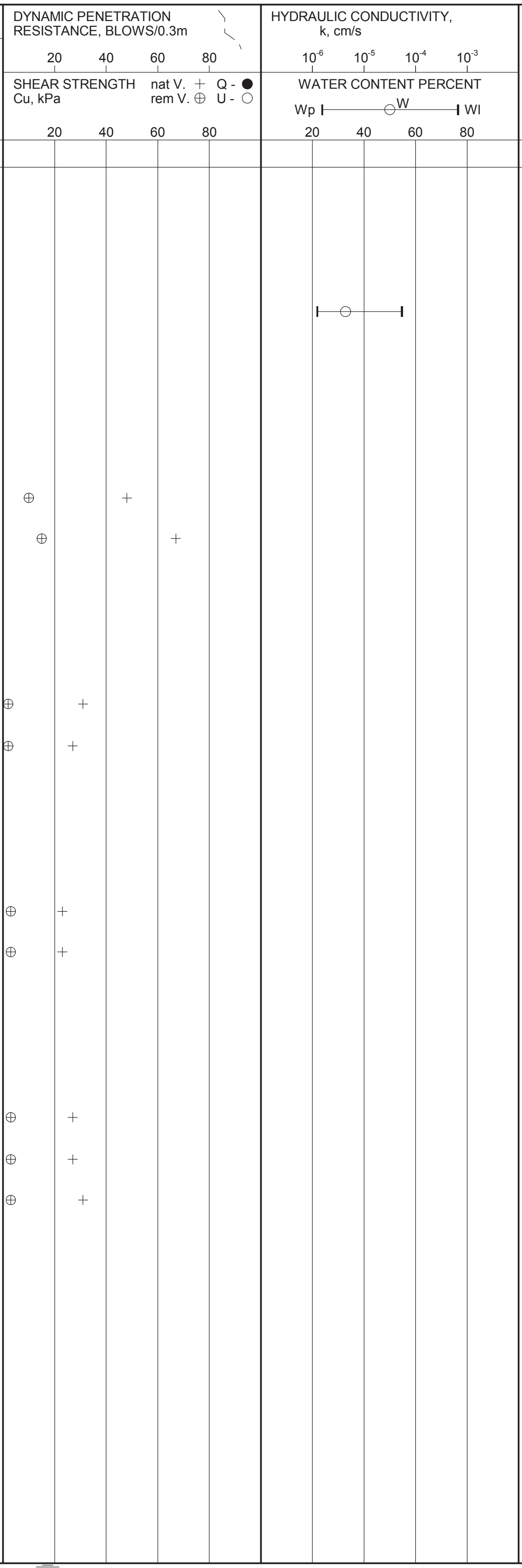
BORING DATE: March 20, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE: DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	91.43			
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM/ML) SILTY SAND to sandy SILT, trace gravel; brown; moist	0.00			
	(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to firm	91.13 0.30	1 2 3	GRAB SS SS	- 5 2
	(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, soft to firm	88.38 3.05	4 5 6	SS SS SS	WH WH WH
	End of Borehole	83.81 7.62			



DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-52A

SHEET 1 OF 1

LOCATION: Adjacent to BH 17-52

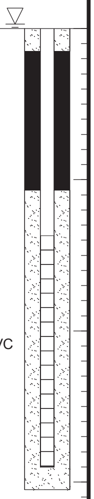
BORING DATE: March 20, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢ ○W ⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.43							▽
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-52 for Stratigraphy		0.00							Bentonite Seal
1											Silica Sand
2											51 mm Diam. PVC #10 Slot Screen
3											Silica Sand
		End of Borehole		88.38 3.05							WL in Screen at Elev. 91.46 m on March 31, 2017
4											
5											
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-53

SHEET 1 OF 1

LOCATION: N 5013382.6 ;E 363144.5

BORING DATE: March 29, 2017

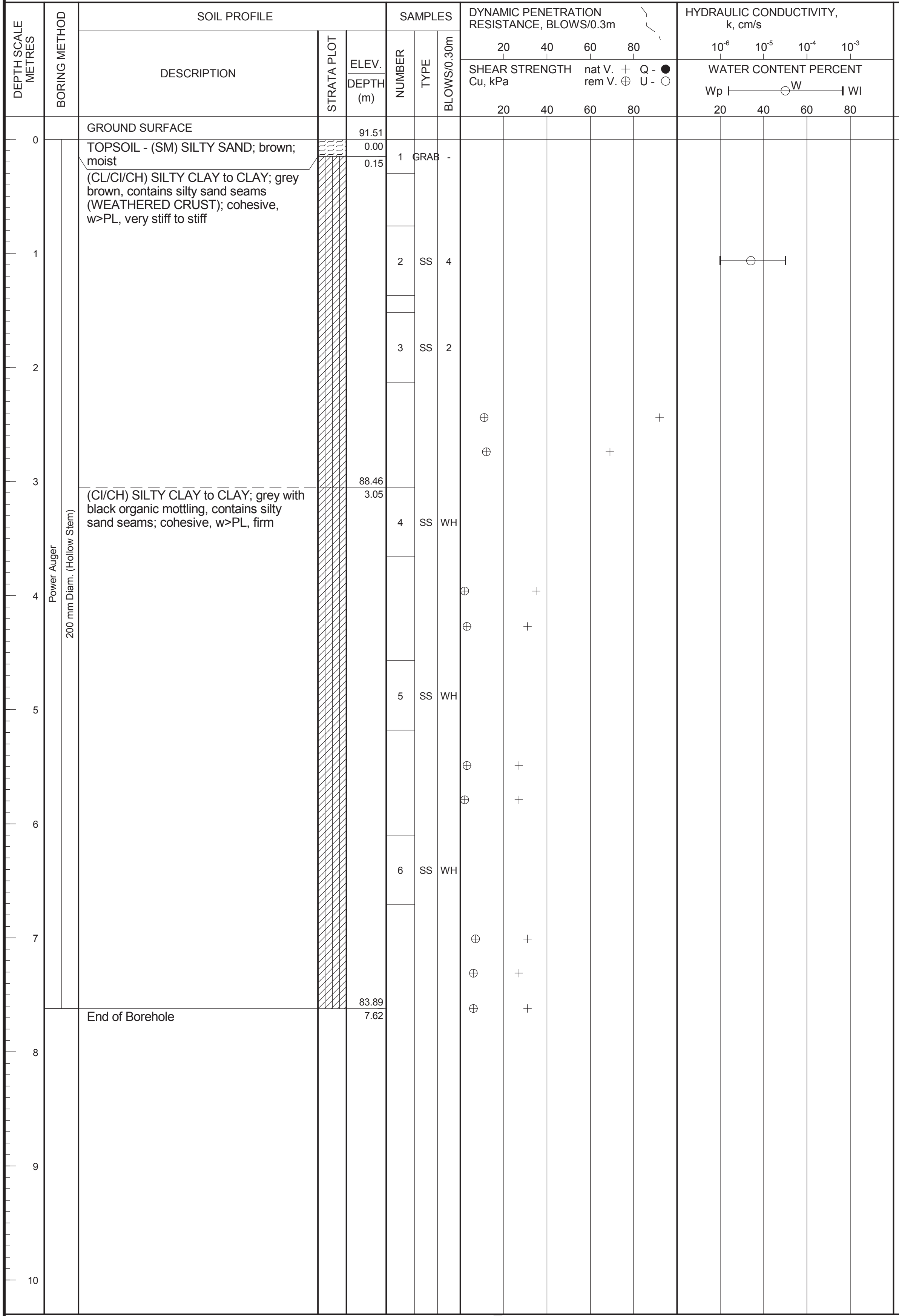
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger 200 mm Diam. (Hollow Stem)

DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	91.51			
TOPSOIL - (SM) SILTY SAND; brown; moist	0.00	1	GRAB	-
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.15	2	SS	4
		3	SS	2
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.46 3.05	4	SS	WH
		5	SS	WH
		6	SS	WH
End of Borehole	83.89 7.62			



MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-55

SHEET 1 OF 1

LOCATION: N 5013455.1 ;E 363274.4

BORING DATE: March 29, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

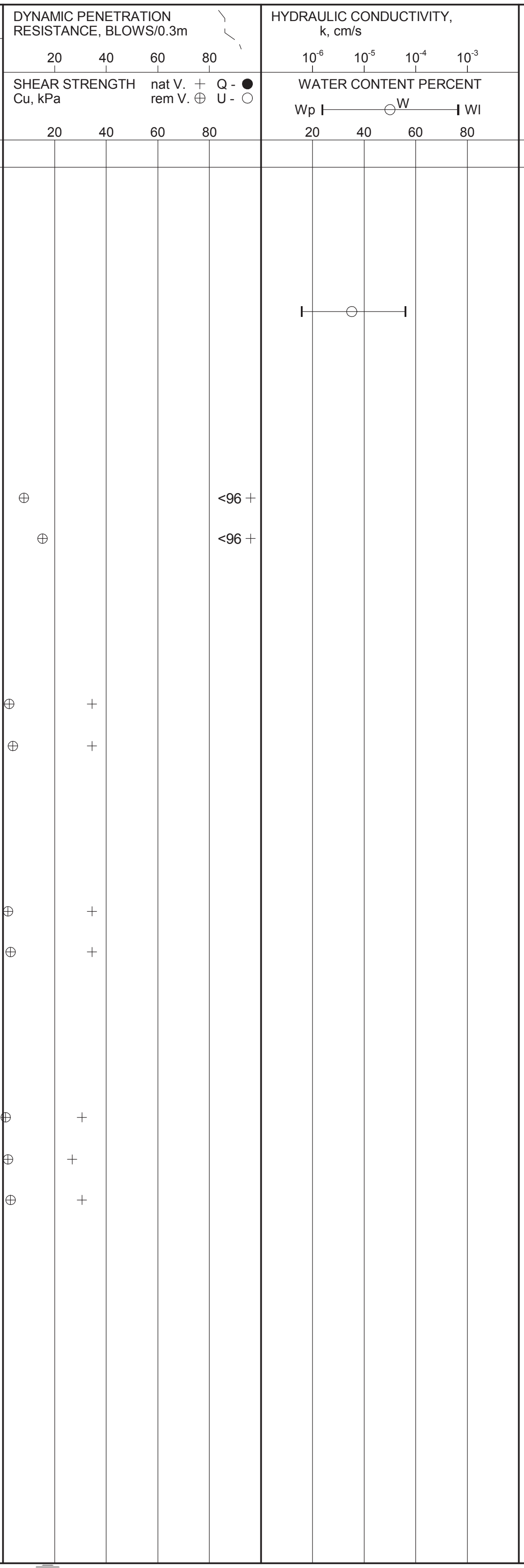
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0–10

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.44
TOPSOIL - (SM) SILTY SAND; brown, contains organic matter (rootlets); moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff	0.15
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.39 3.05
End of Borehole	83.82 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	GRAB	-
2	SS	4
3	SS	2
4	SS	WH
5	SS	WH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SN
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-58

SHEET 1 OF 1

LOCATION: N 5013537.8 ;E 363416.5

BORING DATE: March 28, 2017

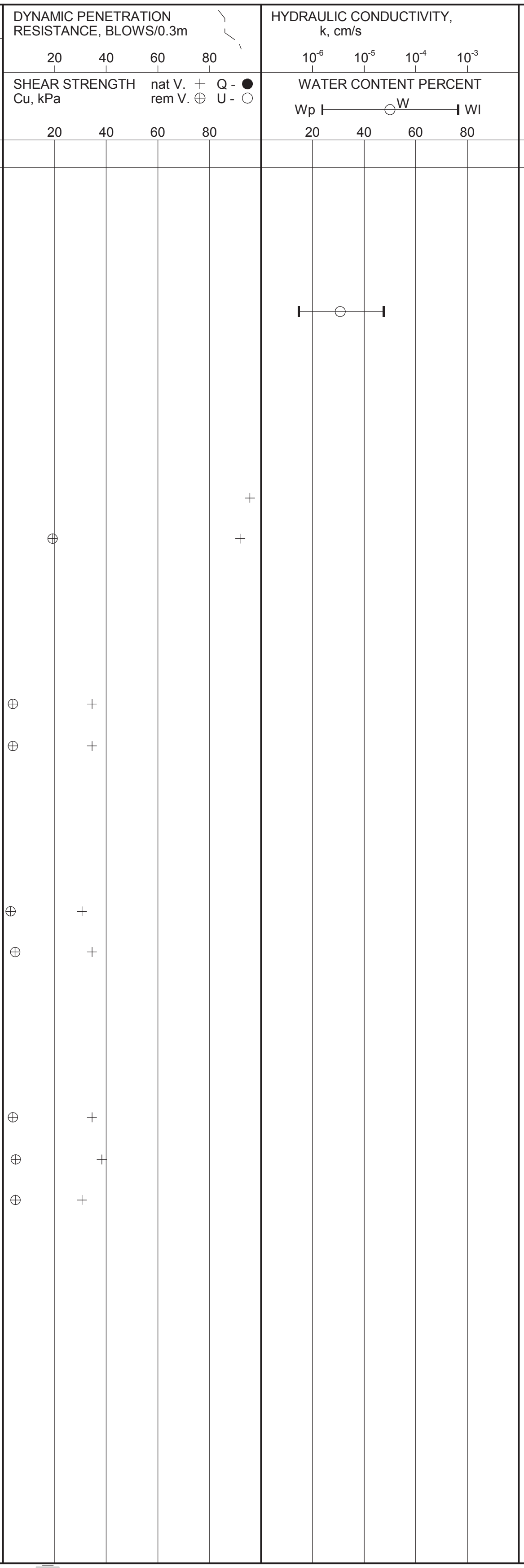
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
0		GROUND SURFACE	91.37
	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown; moist	0.00
		(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.15
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm	88.32 3.05
7.62		End of Borehole	83.75 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.3m
1	GRAB	-
2	SS	5
3	SS	4
4	SS	WH
5	TP	PH
6	SS	WH



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-60

SHEET 1 OF 1

LOCATION: N 5013618.3 ;E 363548.7

BORING DATE: March 28, 2017

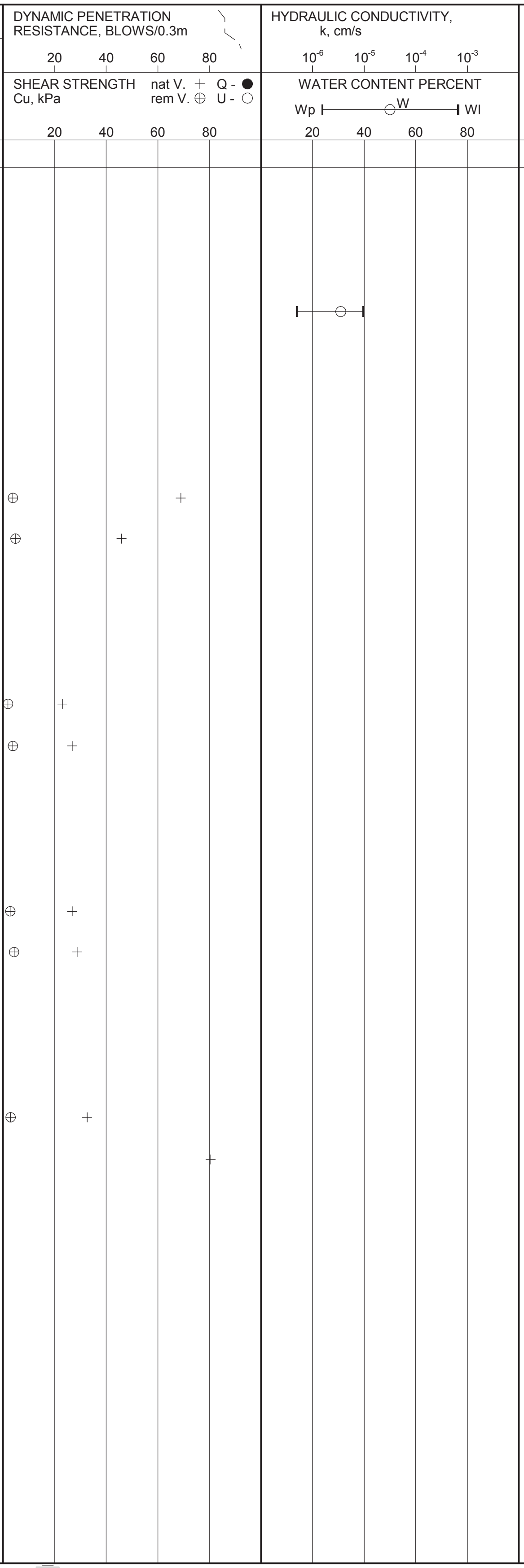
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem) (0 to 7.62 m)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	91.23			
TOPSOIL - (SM) SILTY SAND; brown, contains organic matter (rootlets); moist	0.00			
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to firm	0.15	1	GRAB	-
		2	SS	4
		3	SS	2
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to stiff	88.33 2.90	4	SS	WH
		5	SS	WH
		6	SS	WH
(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, very loose	83.91 7.32	7	SS	2
End of Borehole	83.61 7.62			



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE 1 : 50

LOGGED: SN

CHECKED: SD

MIS-BHS 001 1771847.GPJ GAL-MIS.GDT 09/12/17 JEM

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-15

SHEET 1 OF 1

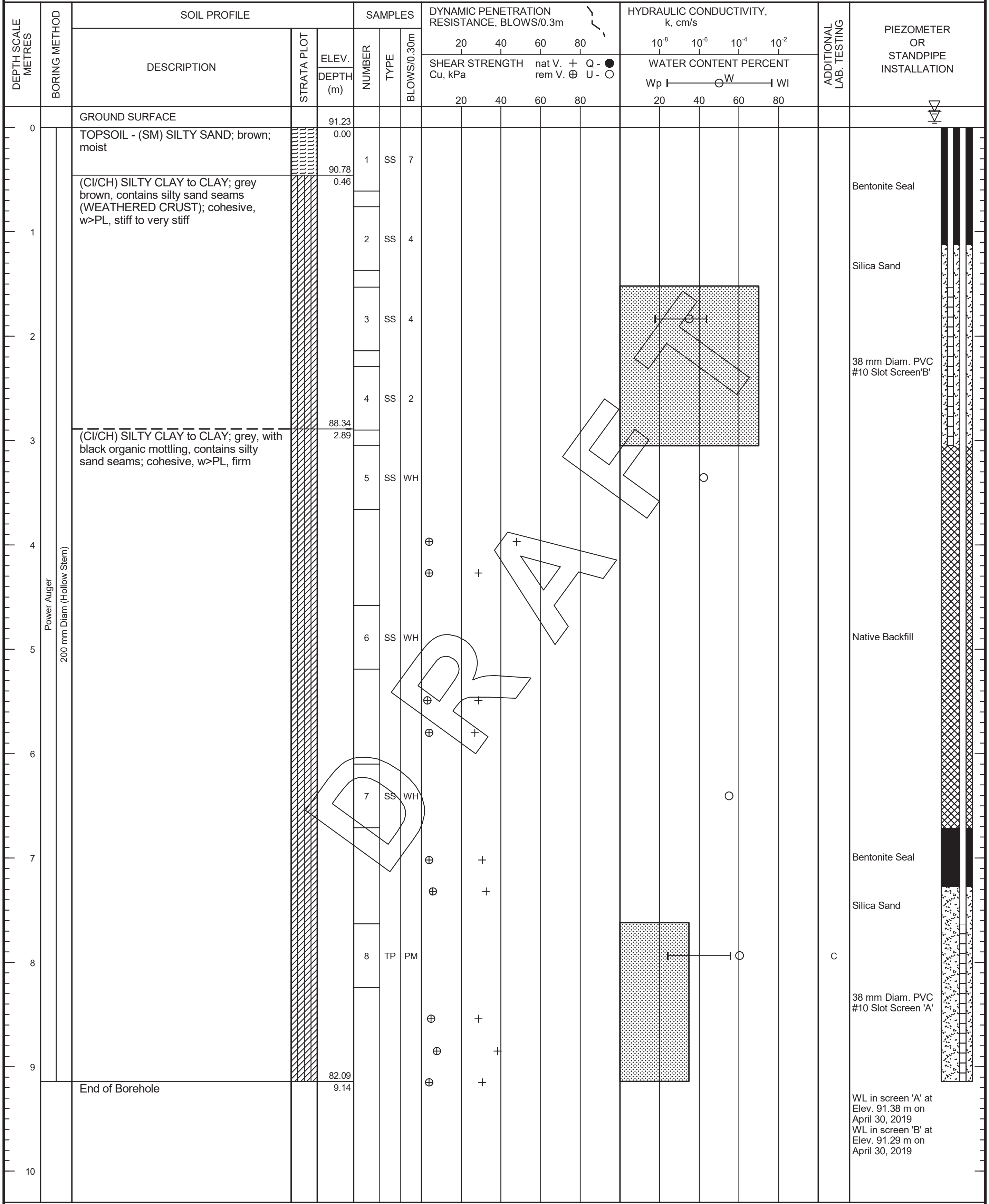
LOCATION: N 5012915.4 ;E 362536.2

BORING DATE: October 25, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.23
TOPSOIL - (SM) SILTY SAND; brown; moist	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	90.78 0.46
(CI/CH) SILTY CLAY to CLAY; grey, with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.34 2.89
End of Borehole	82.09 9.14

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	7	
2	SS	4	
3	SS	4	
4	SS	2	
5	SS	WH	
6	SS	WH	
7	SS	WH	
8	TP	PM	C

PIEZOMETER OR STANDPIPE INSTALLATION

Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen'B'

Native Backfill

Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen 'A'

WL in screen 'A' at Elev. 91.38 m on April 30, 2019

WL in screen 'B' at Elev. 91.29 m on April 30, 2019

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DJG

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-16

SHEET 1 OF 1

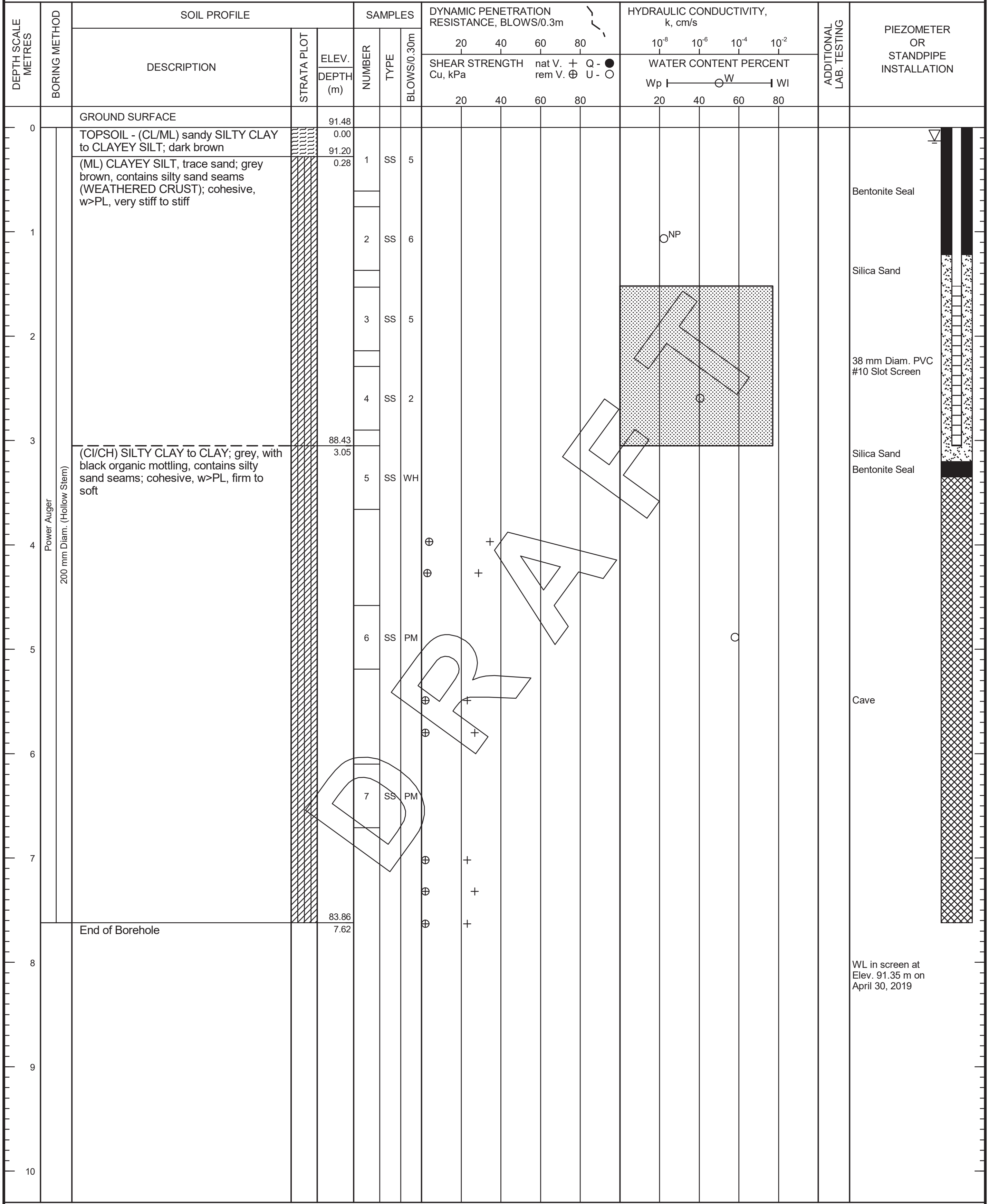
LOCATION: N 5012991.9 ;E 362674.2

BORING DATE: October 25, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.48
TOPSOIL - (CL/ML) sandy SILTY CLAY to CLAYEY SILT; dark brown	0.00
(ML) CLAYEY SILT, trace sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.20 0.28
(CI/CH) SILTY CLAY to CLAY; grey, with black organic mottling, contains silty sand seams; cohesive, w>PL, firm to soft	88.43 3.05
End of Borehole	83.86 7.62

NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	6
3	SS	5
4	SS	2
5	SS	WH
6	SS	PM
7	SS	PM

MIS-BHS 001 18108333.GPJ GAL-MIS.GDT 19-5-10 ZS

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-17

SHEET 1 OF 1

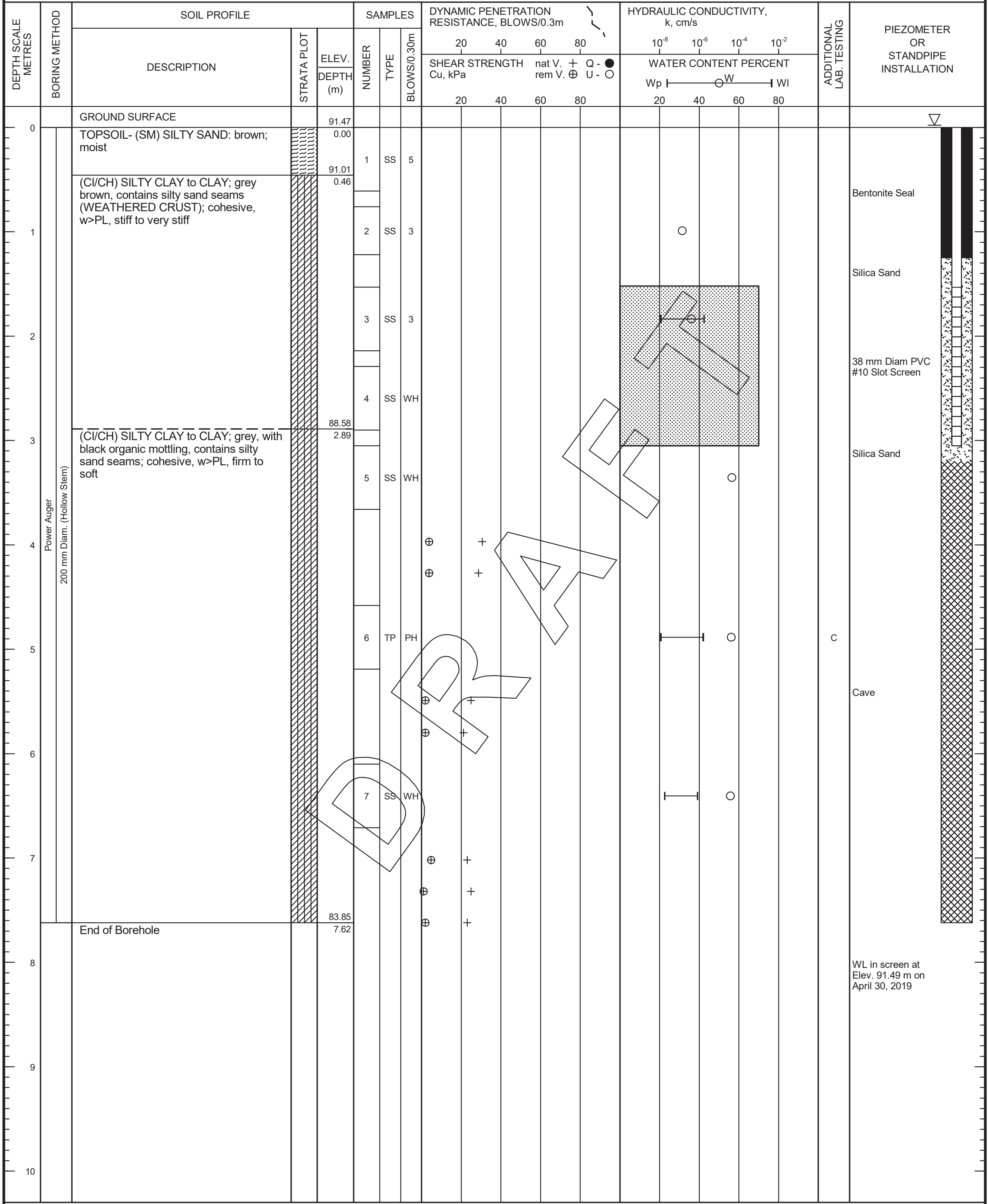
LOCATION: N 5013066.6 ;E 362813.3

BORING DATE: October 25-26, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.47
TOPSOIL- (SM) SILTY SAND: brown; moist	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	91.01 0.46
(CI/CH) SILTY CLAY to CLAY; grey, with black organic mottling, contains silty sand seams; cohesive, w>PL, firm to soft	88.58 2.89
End of Borehole	83.85 7.62

NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	5	
2	SS	3	
3	SS	3	
4	SS	WH	
5	SS	WH	
6	TP	PH	C
7	SS	WH	

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DJG

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-18

SHEET 1 OF 1

LOCATION: N 5013140.7 ;E 362950.3

BORING DATE: October 26, 2018

DATUM: CGVD28

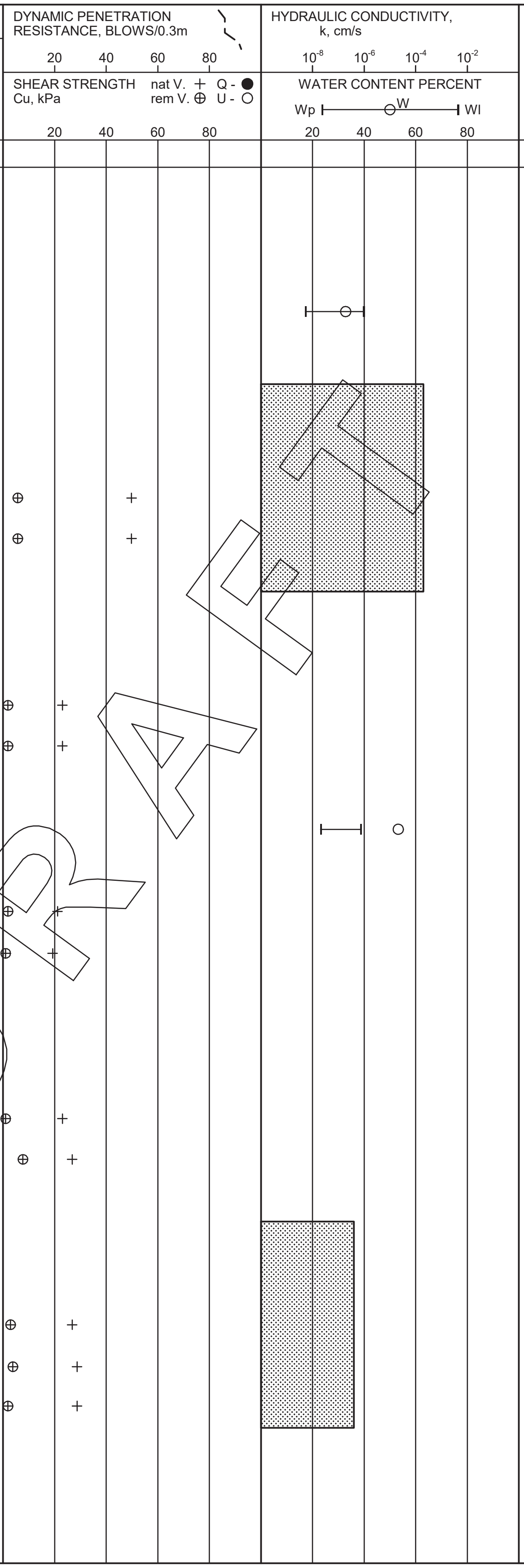
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

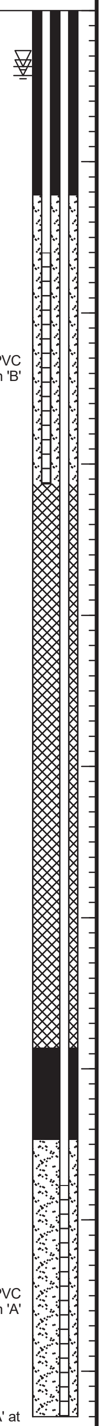
BORING METHOD: Power Auger 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.54
TOPSOIL- (CL/ML) sandy SILTY CLAY to CLAYEY SILT; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY; trace to some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.31 0.23
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, soft to firm	88.65 2.89
End of Borehole	82.24 9.30

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	8	
2	SS	4	MH
3	SS	1	
4	SS	PM	
5	SS	WR	
6	SS	WR	
7	SS	WR	



PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen 'B'

Native Backfill

Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen 'A'

WL in screen 'A' at Elev. 91.17 m on April 30, 2019

WL in screen 'B' at Elev. 91.11 m on April 30, 2019

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-19

SHEET 1 OF 1

LOCATION: N 5013203.9 ;E 363070.7

BORING DATE: October 26, 2018

DATUM: CGVD28

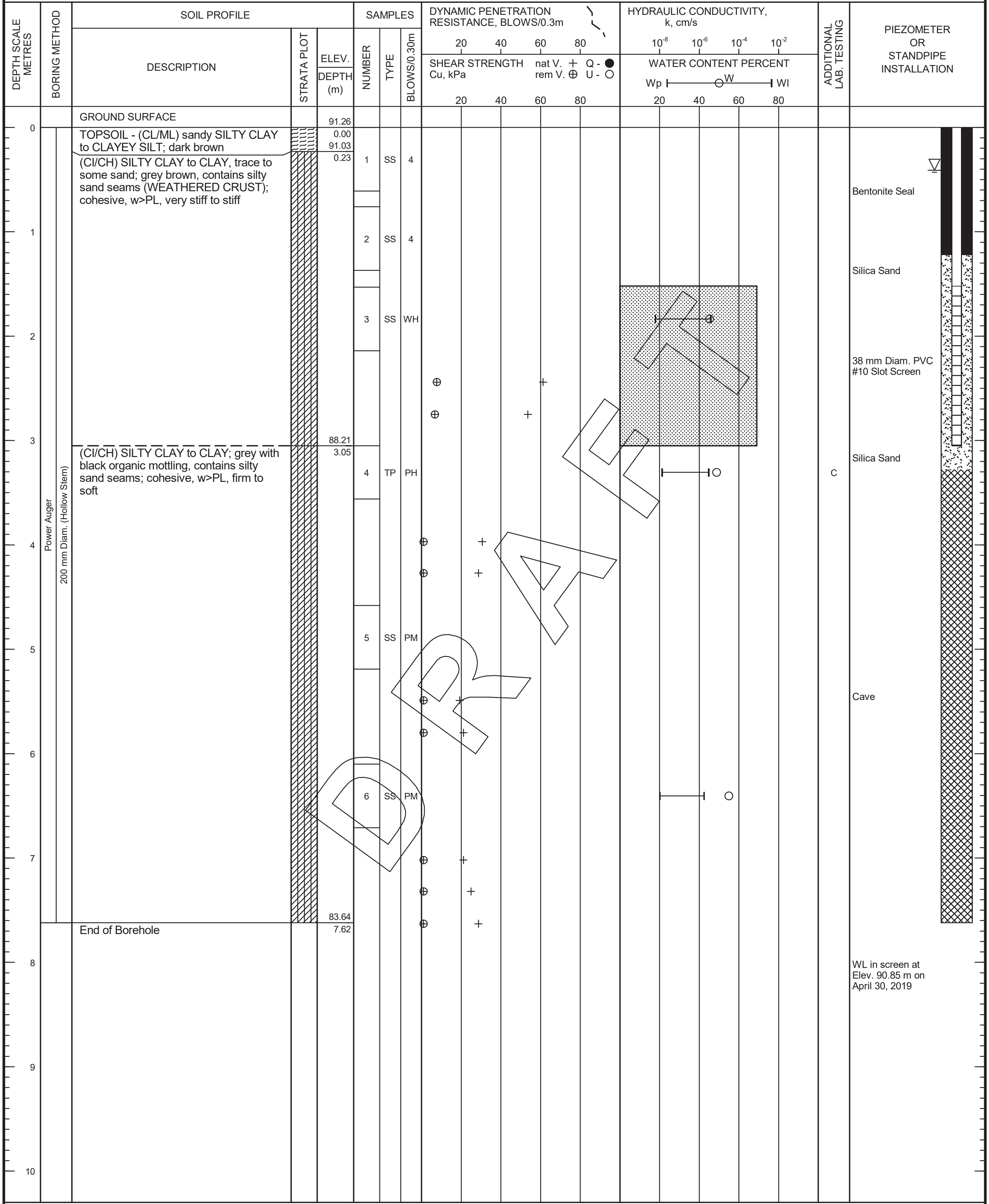
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.26
TOPSOIL - (CL/ML) sandy SILTY CLAY to CLAYEY SILT; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.03 0.23
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm to soft	88.21 3.05
End of Borehole	83.64 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	4	
2	SS	4	
3	SS	WH	
4	TP	PH	C
5	SS	PM	
6	SS	PM	



DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-20

SHEET 1 OF 1

LOCATION: N 5013313.4 ;E 363192.4

BORING DATE: October 26, 2018

DATUM: CGVD28

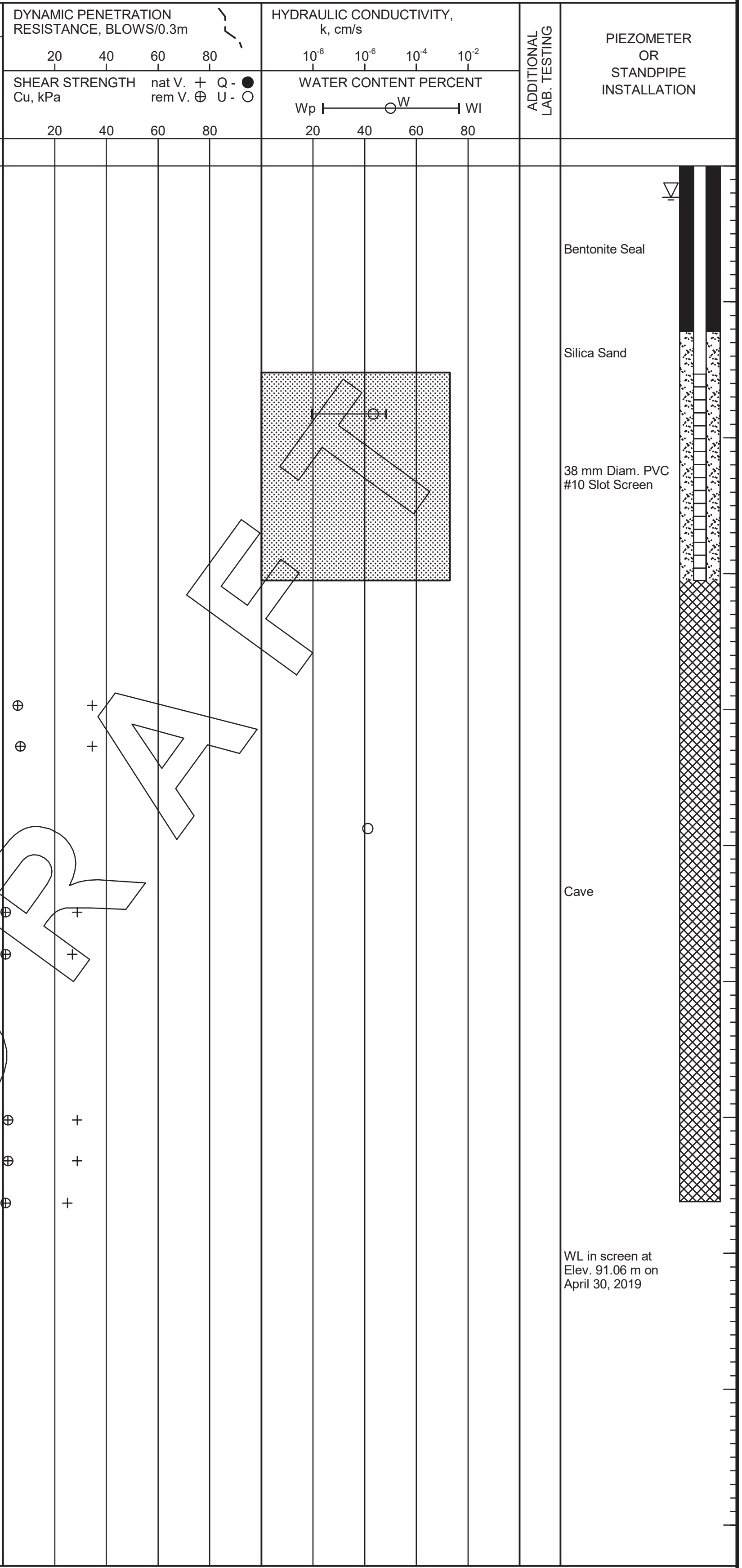
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.29
TOPSOIL - (SM) SILTY SAND: brown	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	90.99 0.30
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.40 2.89
End of Borehole	83.67 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	8
2	SS	4
3	SS	3
4	SS	3
5	SS	WH
6	SS	WH
7	SS	WH



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DJG
CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-21

SHEET 1 OF 1

LOCATION: N 5013407.0 ;E 363310.1

BORING DATE: October 26, 2018

DATUM: CGVD28

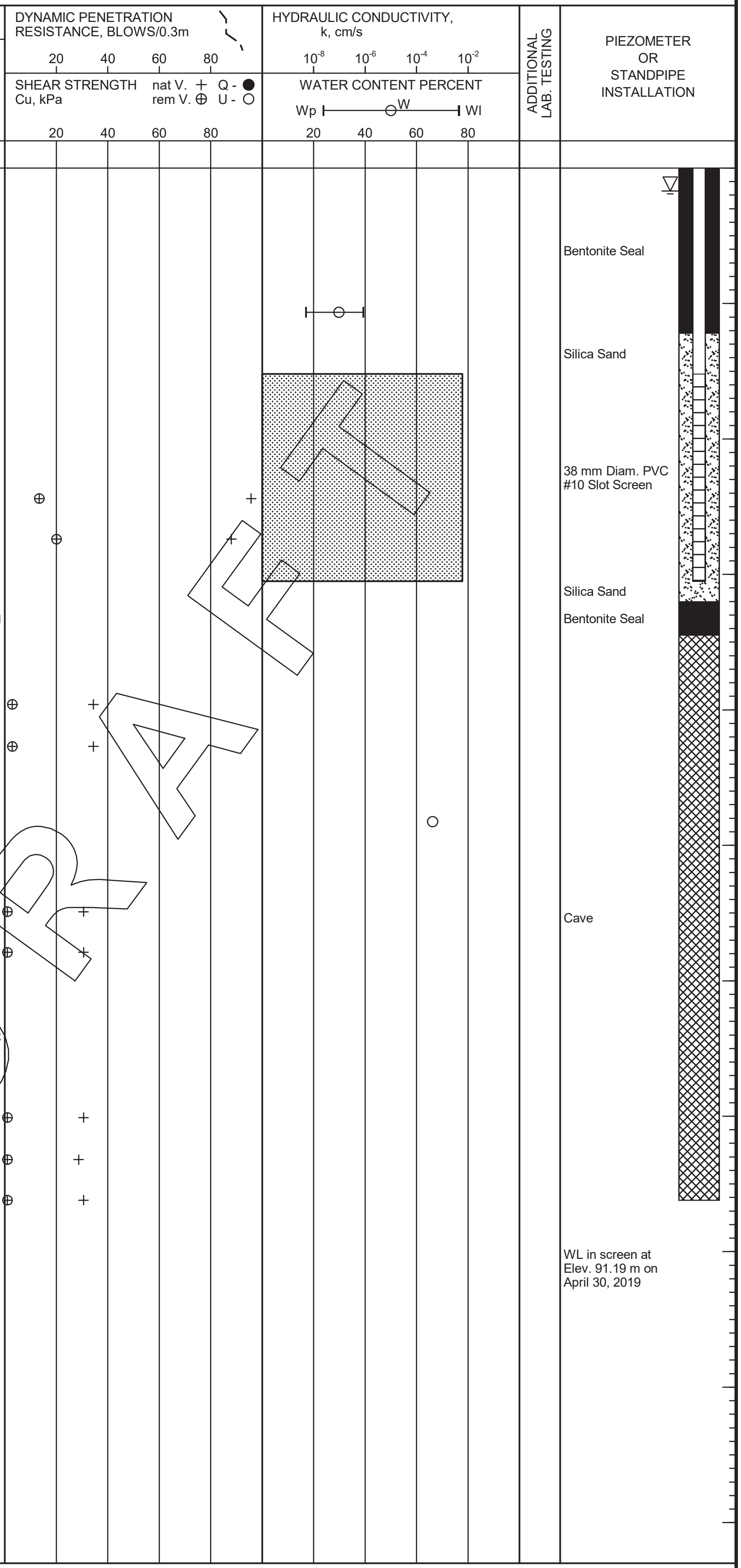
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.36
TOPSOIL - (CL/ML) sandy SILTY CLAY to CLAYEY SILT, trace gravel; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.95 0.41
(CI/CH) SILTY CLAY to CLAY; grey, with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.31 3.05
End of Borehole	83.74 7.62

NUMBER	TYPE	BLOWS/0.30m
1	SS	6
2	SS	5
3	SS	2
4	SS	WH
5	TP	PH
6	SS	WR



DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-22

SHEET 1 OF 1

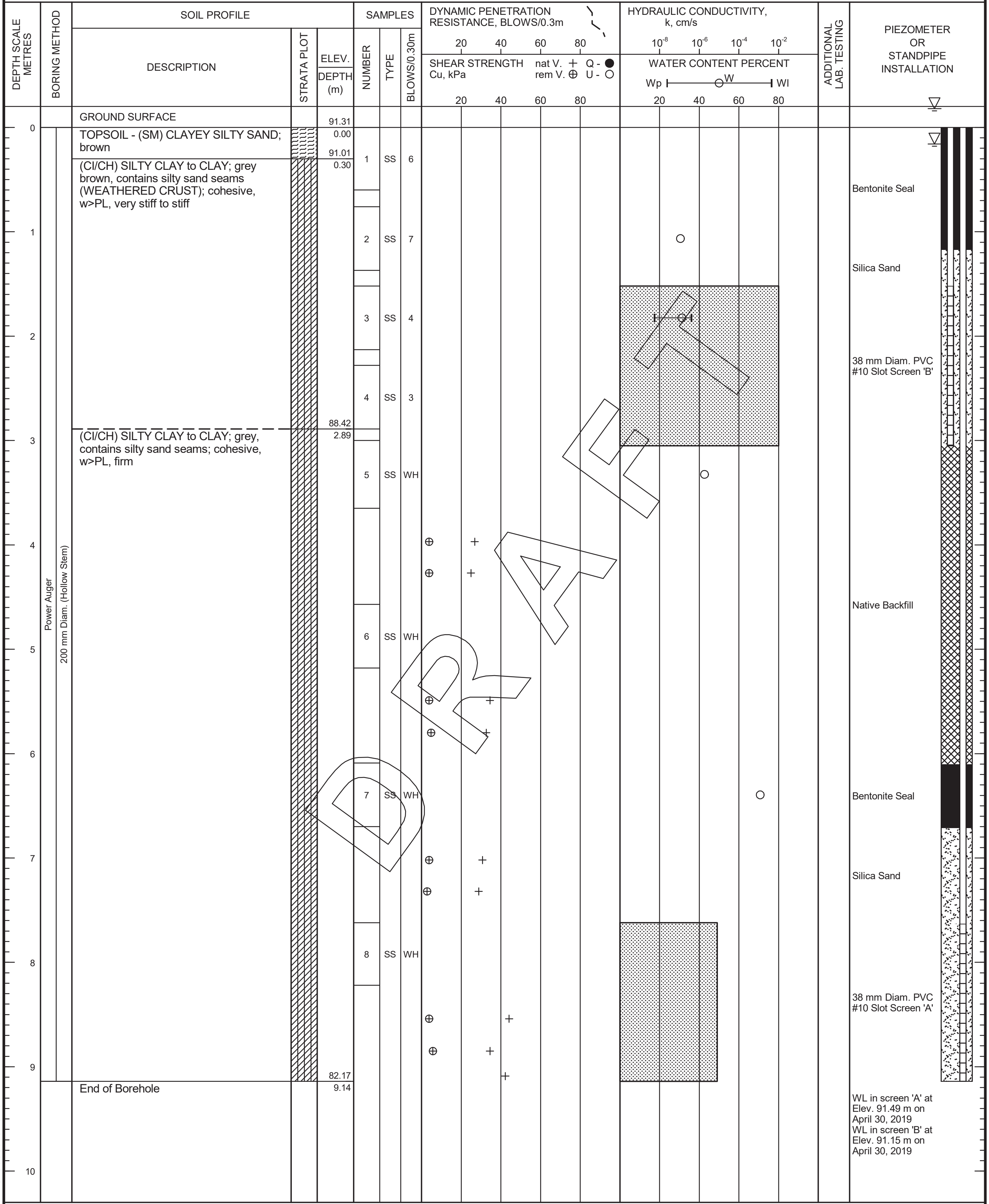
LOCATION: N 5013468.7 ;E 363456.4

BORING DATE: October 26, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.31
TOPSOIL - (SM) CLAYEY SILTY SAND; brown	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.01 0.30
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	88.42 2.89
End of Borehole	82.17 9.14

NUMBER	TYPE	BLOWS/0.30m
1	SS	6
2	SS	7
3	SS	4
4	SS	3
5	SS	WH
6	SS	WH
7	SS	WH
8	SS	WH

Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen 'B'

Native Backfill

Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen 'A'

WL in screen 'A' at Elev. 91.49 m on April 30, 2019
WL in screen 'B' at Elev. 91.15 m on April 30, 2019

DEPTH SCALE

1 : 50

GOLDER

LOGGED: DJG

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-23

SHEET 1 OF 1

LOCATION: N 5013542.8 ;E 363593.8

BORING DATE: November 1, 2018

DATUM: CGVD28

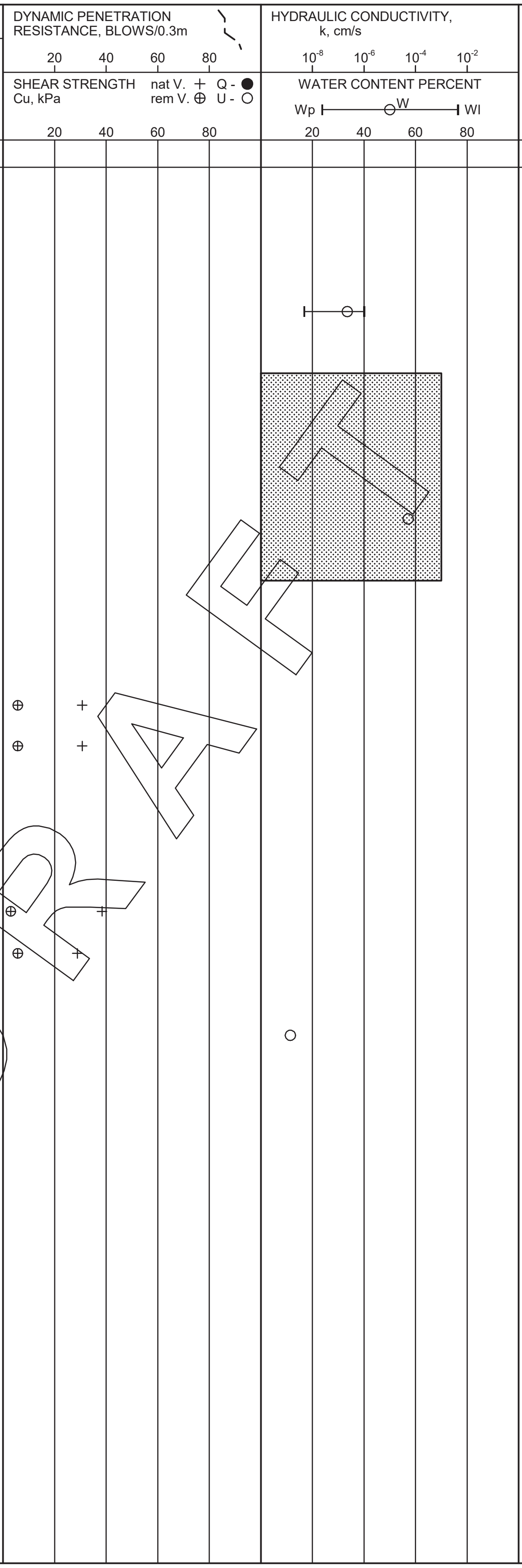
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

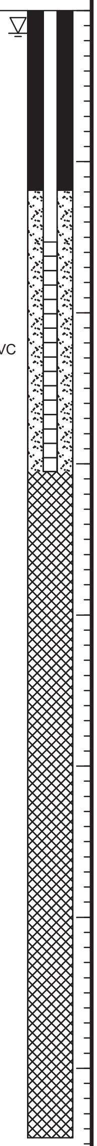
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	91.32	
TOPSOIL - (ML) CLAYEY SILT; dark brown		0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	91.06	0.25
(CI/CH) SILTY CLAY to CLAY; grey brown to grey, contains silty sand seams; cohesive, w>PL, stiff to firm	88.43	2.89
(SM) gravelly SILTY SAND; grey, contains silty clay seams (GLACIAL TILL); non-cohesive, wet, loose	85.23	6.09
End of Borehole	83.86	7.46

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	3	
2	SS	4	
3	SS	3	
4	SS	3	
5	SS	PM	
6	TP	PH	
7	SS	7	MH
8	SS	5	



PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

Cave

WL in screen at Elev. 91.17 m on April 30, 2019

DEPTH SCALE 1 : 50

GOLDER

LOGGED: DJG

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-24

SHEET 1 OF 1

LOCATION: N 5013596.7 ;E 363722.6

BORING DATE: November 1, 2018

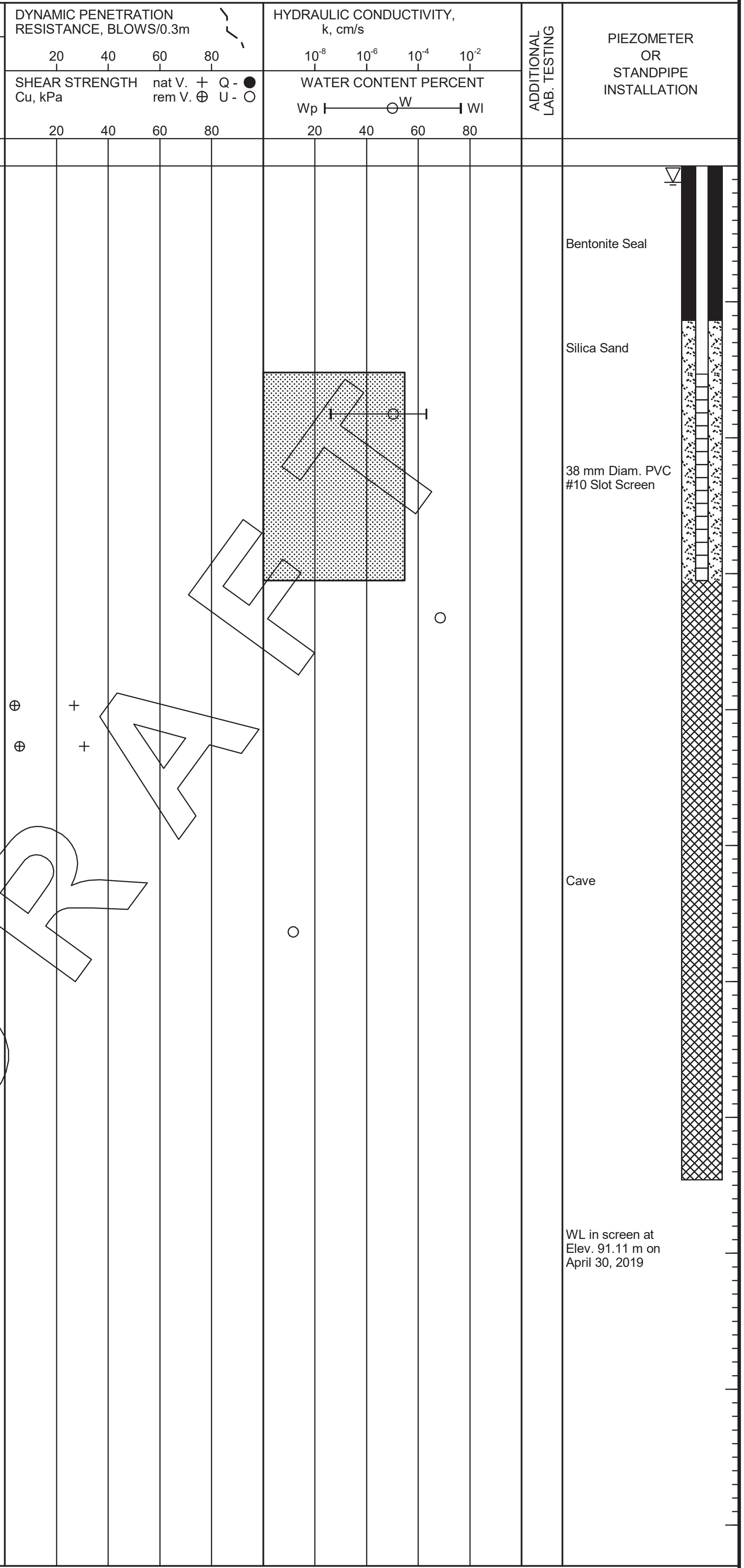
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	91.23
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT; dark brown	0.00
	(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.93 0.30
	CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	89.10 2.13
	(SM/ML) gravelly SILTY SAND to sandy SILT; grey, contains silty clay seams (GLACIAL TILL); non-cohesive, wet, very loose to compact	86.10 5.13
	End of Borehole	83.77 7.46

NUMBER	TYPE	BLOWS/0.30m
1	SS	3
2	SS	5
3	SS	3
4	SS	3
5	SS	PM
6	SS	PM
7	SS	4
8	SS	4
9	SS	19



Bentonite Seal

Silica Sand

38 mm Diam. PVC
#10 Slot Screen

Cave

WL in screen at
Elev. 91.11 m on
April 30, 2019

MIS-BHS 001 18108333.GPJ GAL-MIS.GDT 19-5-10 ZS

DEPTH SCALE
1 : 50

LOGGED: DJG

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-25

SHEET 1 OF 1

LOCATION: N 5012863.7 ;E 362664.5

BORING DATE: October 29, 2018

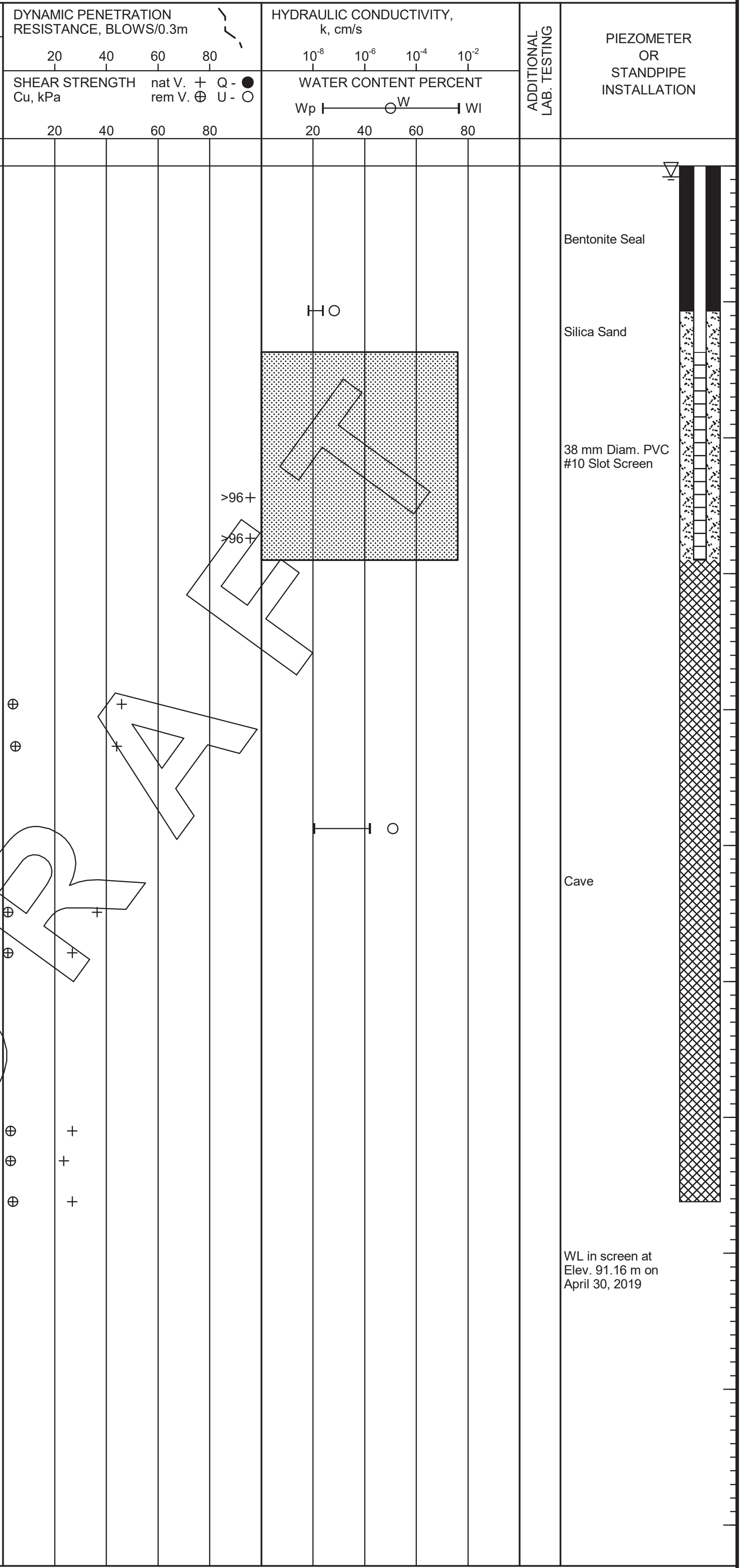
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE: DESCRIPTION	ELEV. DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE	91.24			
TOPSOIL- (ML/CL) SILTY CLAY to CLAYEY SILT; dark brown	0.00			
(CL-ML) SILTY CLAY to CLAYEY SILT, trace to some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.01 0.23	1	SS	5
		2	SS	2
		3	SS	2
(CI/CH) SILTY CLAY to CLAY; grey, with black organic mottling; cohesive, w>PL, firm to soft	88.19 3.05	4	SS	1
		5	SS	WH
		6	SS	WH
End of Borehole	83.62 7.62			



DEPTH SCALE 1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-26

SHEET 1 OF 1

LOCATION: N 5012929.0 ;E 362807.5

BORING DATE: October 29, 2018

DATUM: CGVD28

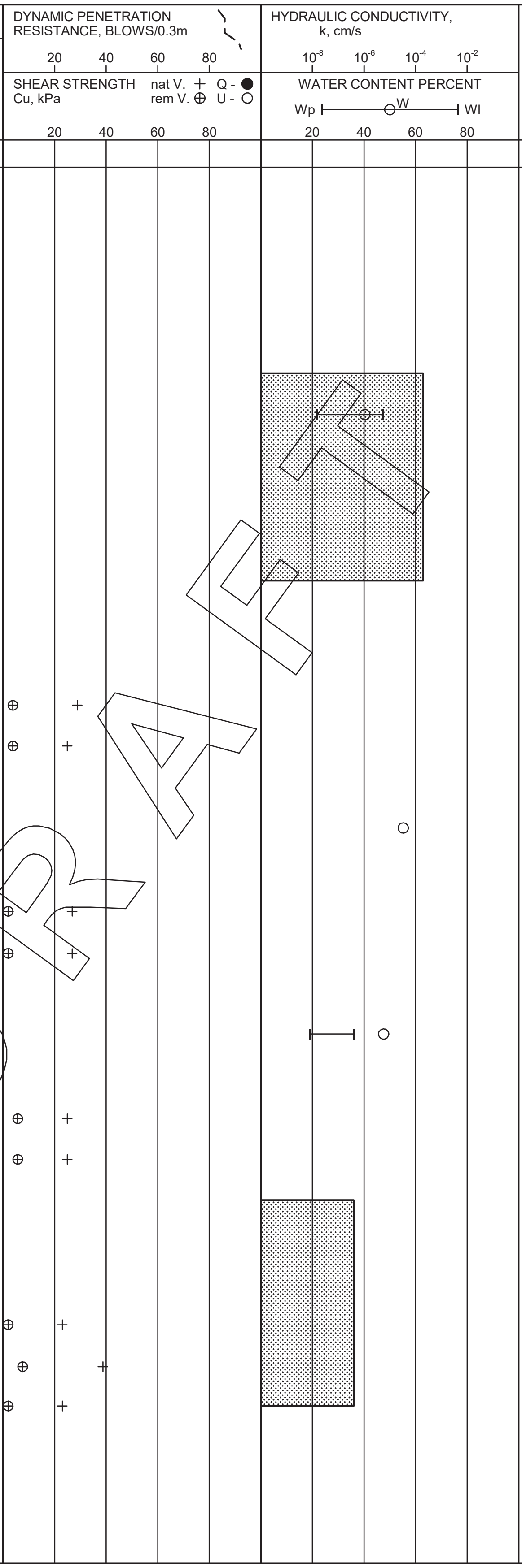
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

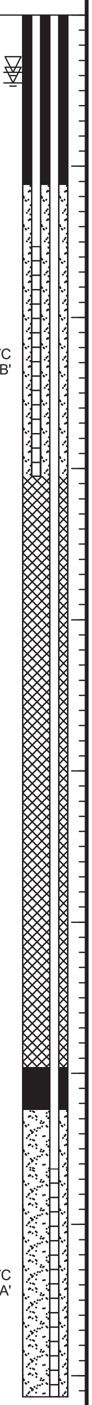
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.45
TOPSOIL - (SM) SILTY SAND; dark brown	0.00
(CL/ML) CLAYEY SILT to sandy SILT; grey brown; non-cohesive, moist, loose	91.15 0.30
(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.08 1.37
(CI/CH) SILTY CLAY to CLAY; grey, with black organic mottling, contains silty sand seams; cohesive, w>PL, firm to soft	88.56 2.89
End of Borehole	82.31 9.14

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	5	
2	SS	4	
3	SS	3	
4	SS	3	
5	SS	WH	
6	SS	WH	
7	TP	PH	C
8	SS	PM	



PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen 'B'

Native Backfill

Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen 'A'

WL in screen 'A' at Elev. 91.00 m on April 30, 2019
WL in screen 'B' at Elev. 91.07 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DJG
CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-27

SHEET 1 OF 1

LOCATION: N 5012986.9 ;E 362954.7

BORING DATE: October 29, 2018

DATUM: CGVD28

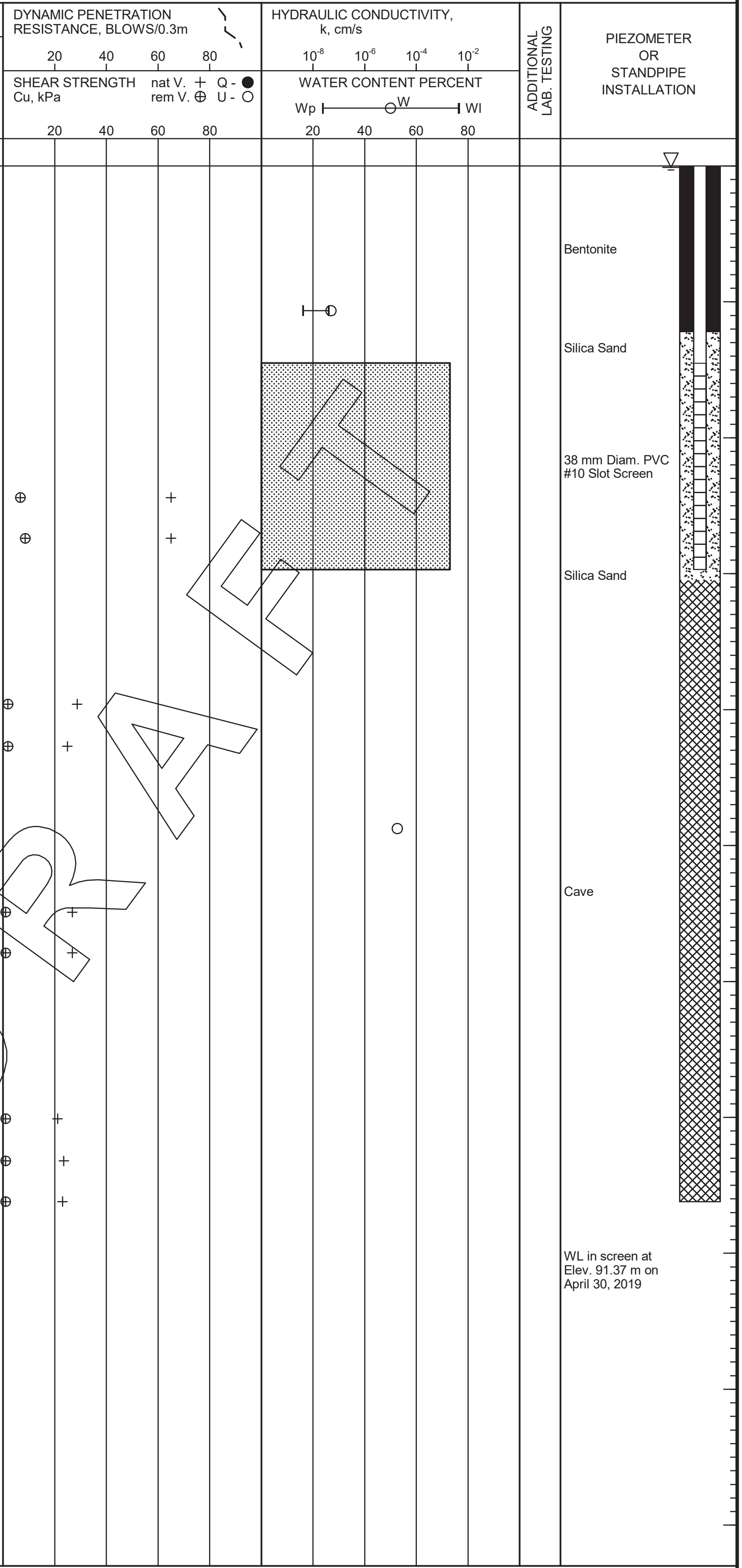
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.38
TOPSOIL - (ML) CLAYEY sandy SILT, trace gravel; dark brown	0.00 91.18
(CL) sandy CLAYEY SILT; grey brown, (WEATHERED CRUST) cohesive, w>PL, stiff to very stiff	0.20 89.86
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	1.52 88.33
(CI/CH) SILTY CLAY to CLAY; grey, with black organic mottling, contains silty sand seams; cohesive, w>PL, firm to soft	3.05 83.76
End of Borehole	7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	4
2	SS	1
3	SS	1
4	SS	PM
5	SS	PM
6	SS	PM



DEPTH SCALE
1 : 50

LOGGED: RI
CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-28

SHEET 1 OF 1

LOCATION: N 5013120.1 ;E 363120.3

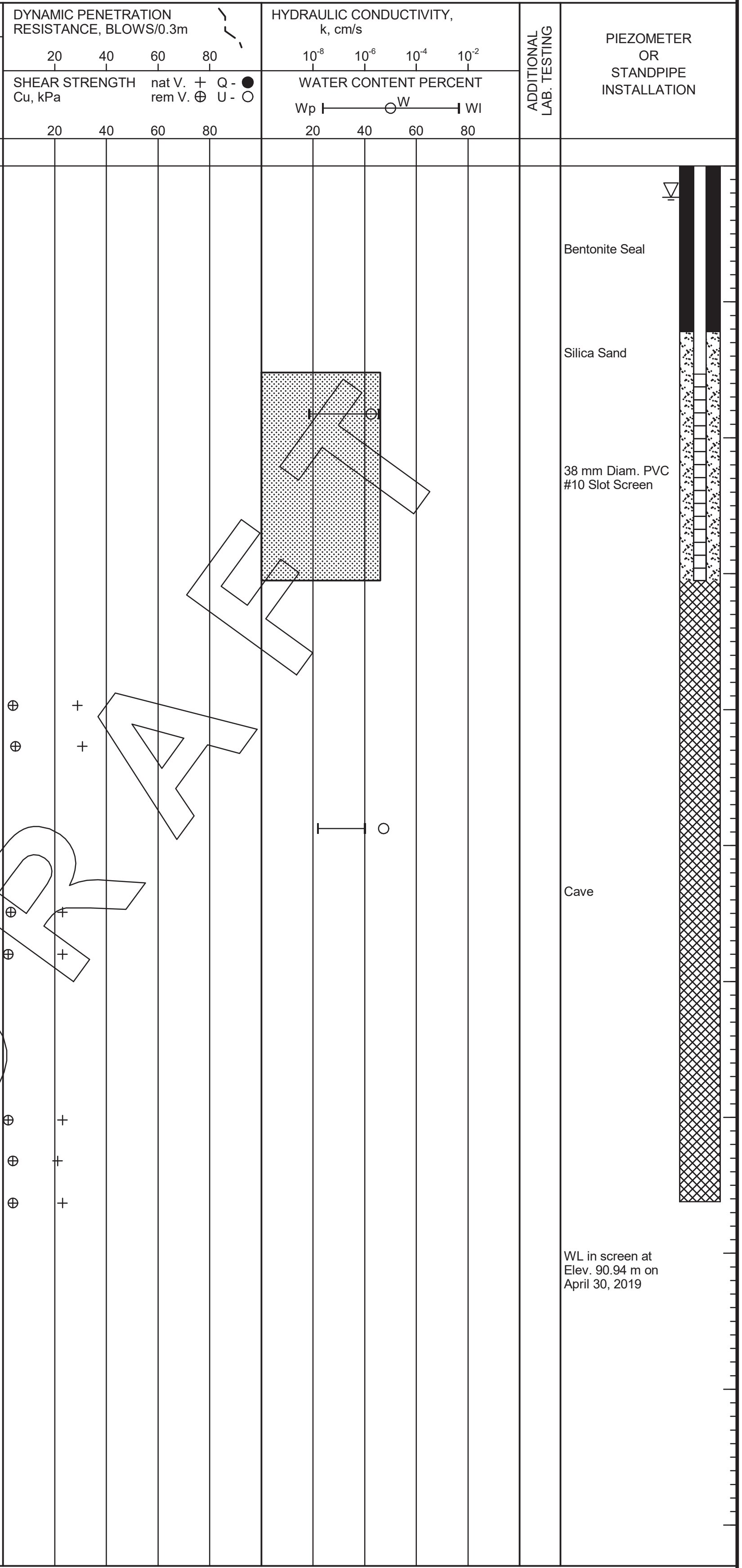
BORING DATE: October 30, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
		GROUND SURFACE	91.17			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) CLAYEY SILT; dark brown	0.00			
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.87 0.30	1	SS	4
1				2	SS	5
2				3	SS	3
				4	SS	3
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm to soft	88.28 2.89	5	SS	WH
5				6	SS	WH
6				7	SS	WH
7		End of Borehole	83.55 7.62			



DEPTH SCALE
1 : 50

GOLDER

LOGGED: DJG

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-29

SHEET 1 OF 1

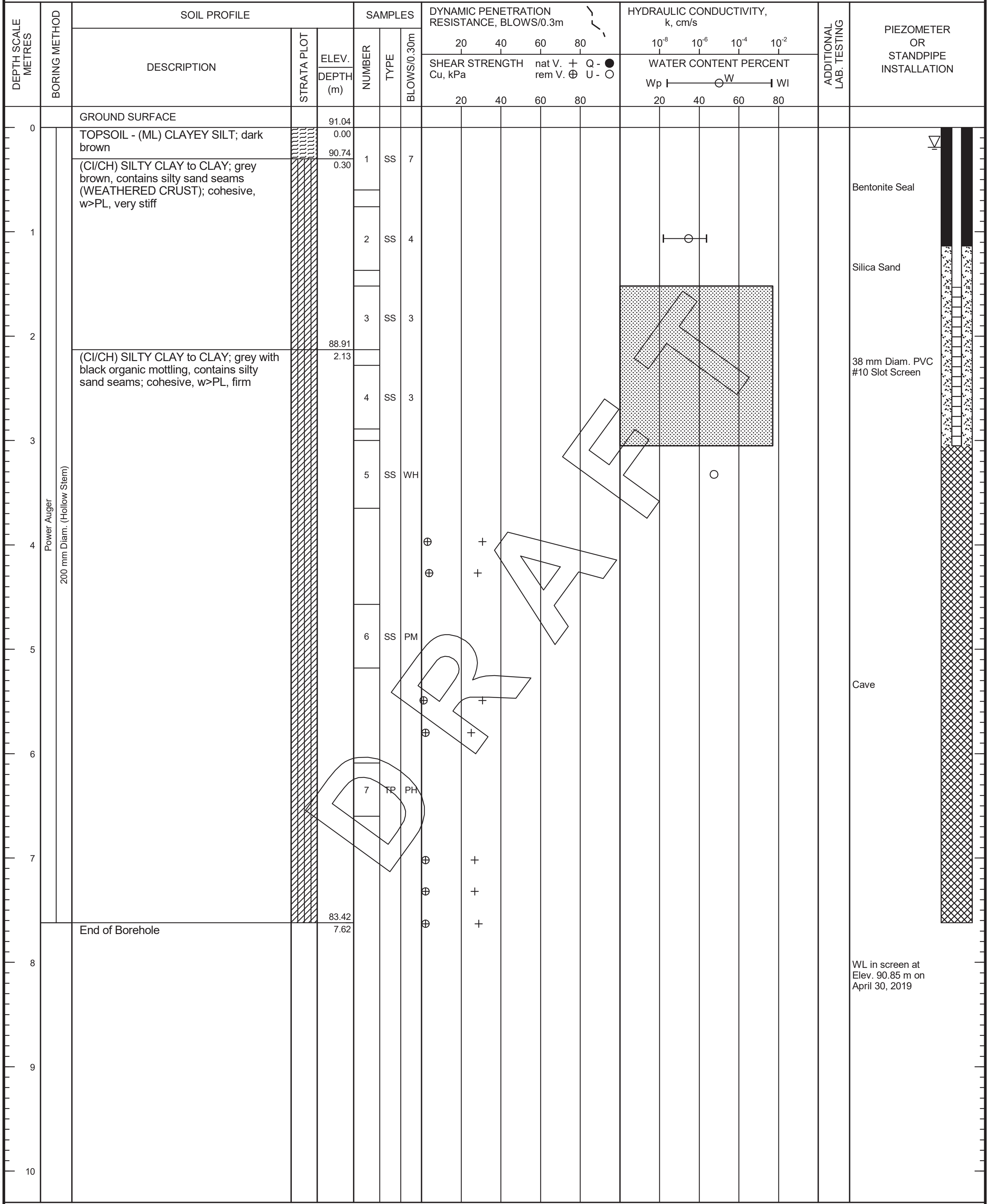
LOCATION: N 5013204.1 ;E 363249.1

BORING DATE: October 30, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.04
TOPSOIL - (ML) CLAYEY SILT; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff	90.74 0.30
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.91 2.13
End of Borehole	83.42 7.62

NUMBER	TYPE	BLOWS/0.30m
1	SS	7
2	SS	4
3	SS	3
4	SS	3
5	SS	WH
6	SS	PM
7	TP	PH

WL in screen at Elev. 90.85 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: DJG
CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-30

SHEET 1 OF 1

LOCATION: N 5013258.1 ;E 363330.0

BORING DATE: October 30, 2018

DATUM: CGVD28

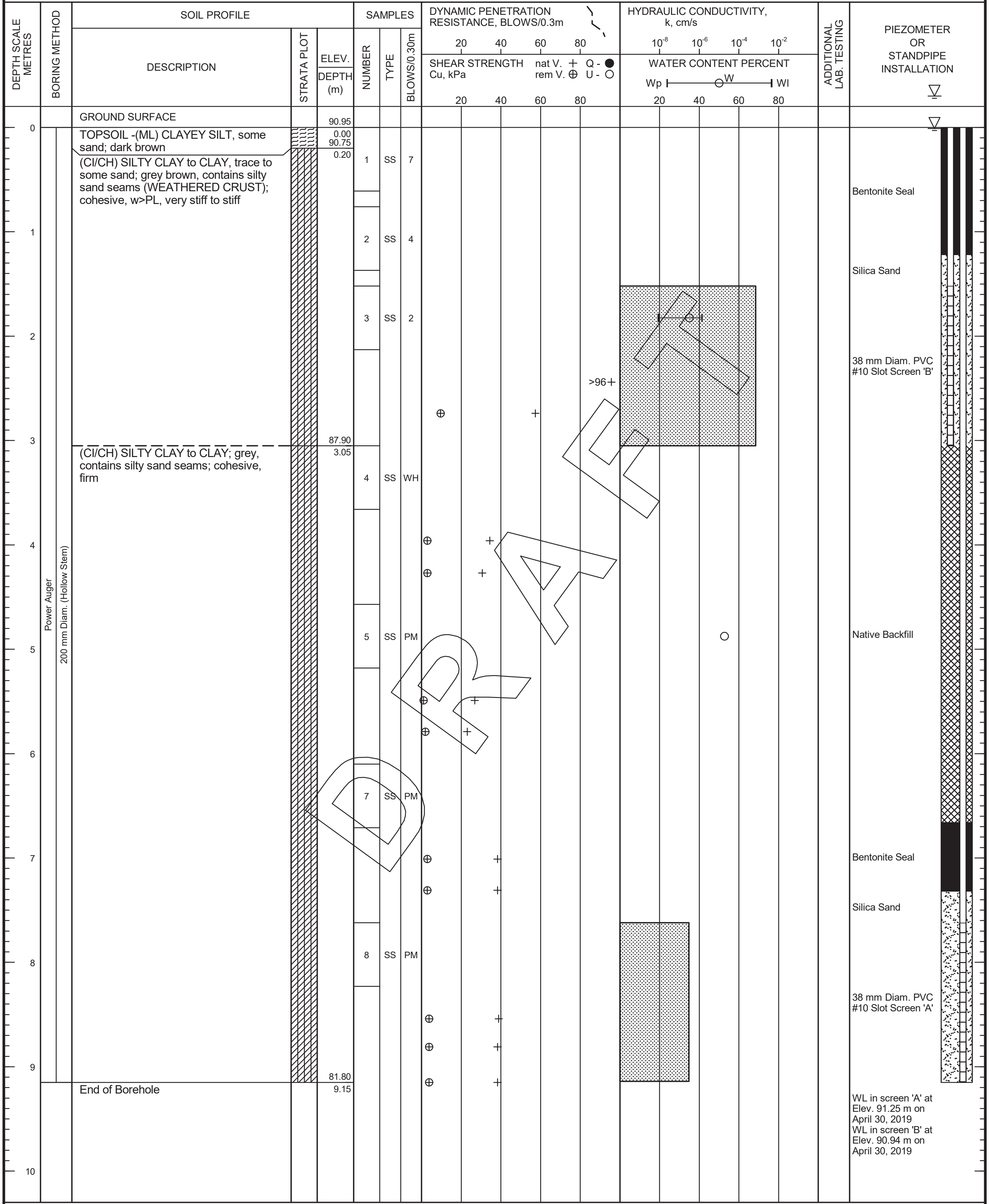
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	90.95
TOPSOIL -(ML) CLAYEY SILT, some sand; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.75 0.20
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, firm	87.90 3.05
End of Borehole	81.80 9.15

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	7
2	SS	4
3	SS	2
4	SS	WH
5	SS	PM
7	SS	PM
8	SS	PM



DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-31

SHEET 1 OF 1

LOCATION: N 5013362.7 ;E 363389.5

BORING DATE: October 31, 2018

DATUM: CGVD28

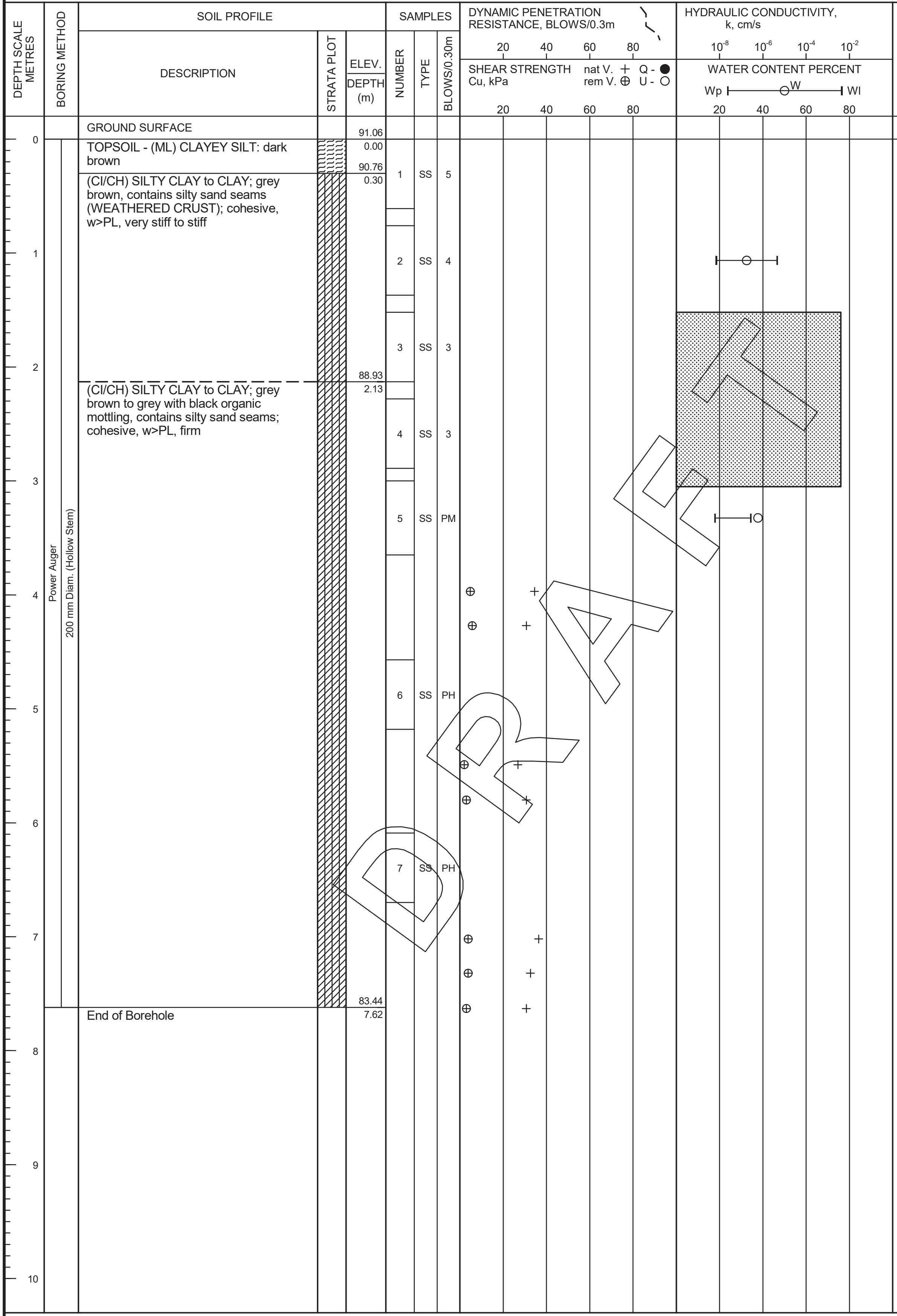
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

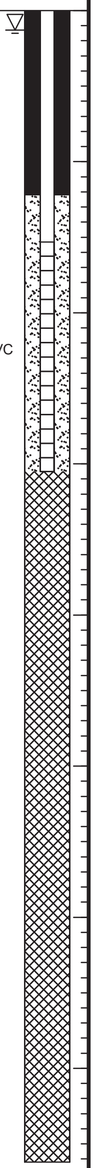
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.06
TOPSOIL - (ML) CLAYEY SILT: dark brown	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.76 0.30
(CI/CH) SILTY CLAY to CLAY; grey brown to grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.93 2.13
End of Borehole	83.44 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	5	
2	SS	4	MH
3	SS	3	
4	SS	3	
5	SS	PM	
6	SS	PH	
7	SS	PH	



PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

Cave

WL in screen at Elev. 90.94 m on April 30, 2019

DEPTH SCALE 1 : 50

GOLDER

LOGGED: DJG

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-32

SHEET 1 OF 1

LOCATION: N 5013379.1 ;E 363514.2

BORING DATE: October 31, 2018

DATUM: CGVD28

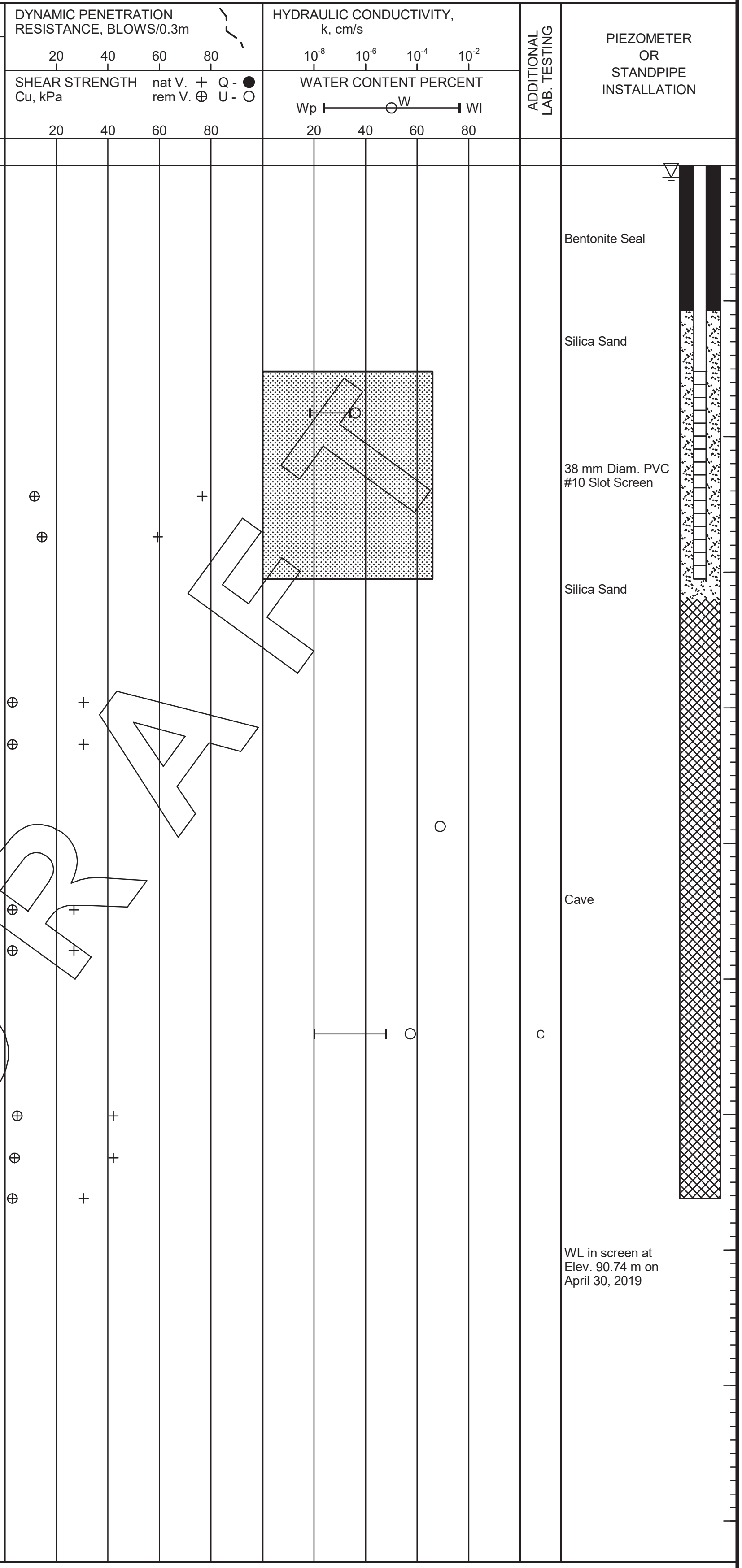
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	90.83
TOPSOIL- (CL/ML) SILTY CLAY to CLAYEY SILT, trace to some sand; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.58 0.25
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	87.78 3.05
End of Borehole	83.21 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	10	
2	SS	7	
3	SS	1	
4	SS	PM	
5	SS	PM	
6	SS	PM	C



DEPTH SCALE
1 : 50

LOGGED: RI
CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-33

SHEET 1 OF 1

LOCATION: N 5013454.9 ;E 363649.3

BORING DATE: November 2, 2018

DATUM: CGVD28

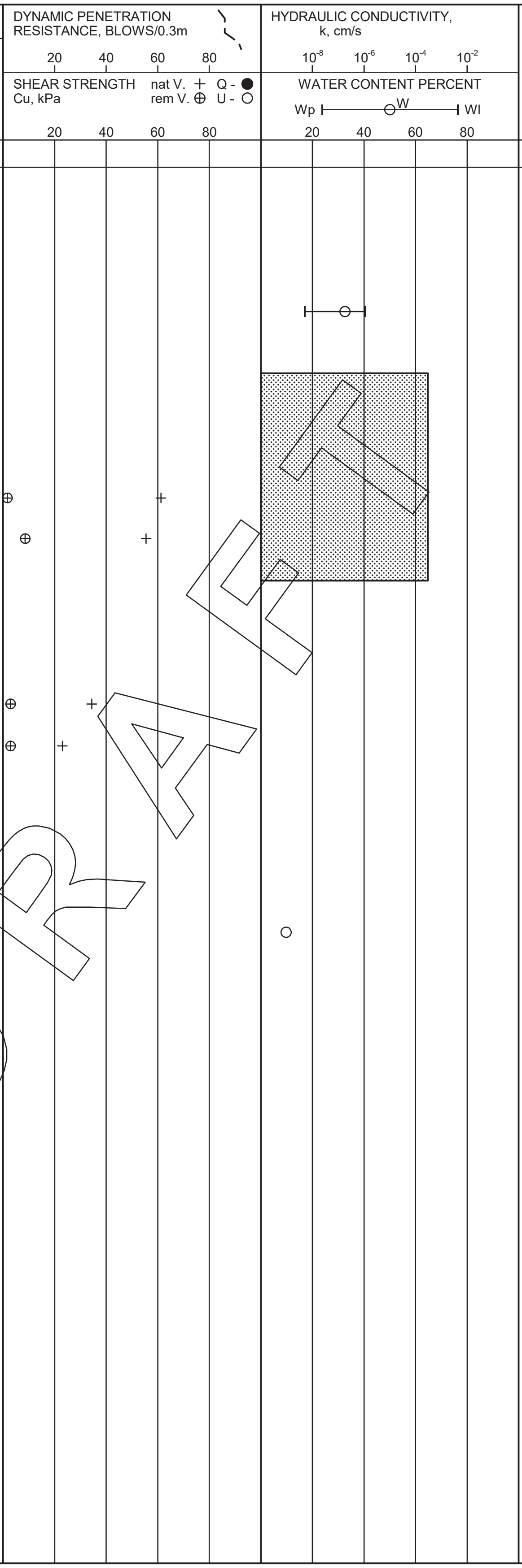
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

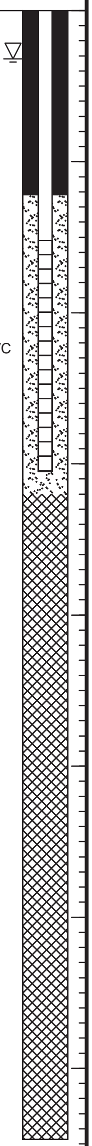
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.13
TOPSOIL - (CL/ML) SILTY CLAY to CLAYEY SILT, trace to some sand; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silty sand (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.90 0.23
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to soft	88.08 3.05
(SM) gravelly SILTY SAND; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, compact	85.95 5.18
(SP) SAND, trace to some gravel; grey; non-cohesive, wet, very loose to loose	85.03 6.10
(SM) gravelly SILTY SAND; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, very loose	84.58 6.55
End of Borehole	83.66 7.47

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	7	
2	SS	4	MH
3	SS	2	
4	SS	WH	
5	SS	1	
6	SS	13	MH
7	SS	4	
8	SS	1	



PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC
#10 Slot Screen

Silica Sand

Cave

WL in screen at
Elev. 90.81 m on
April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-34

SHEET 1 OF 1

LOCATION: N 5013533.9 ;E 363753.5

BORING DATE: November 1, 2018

DATUM: CGVD28

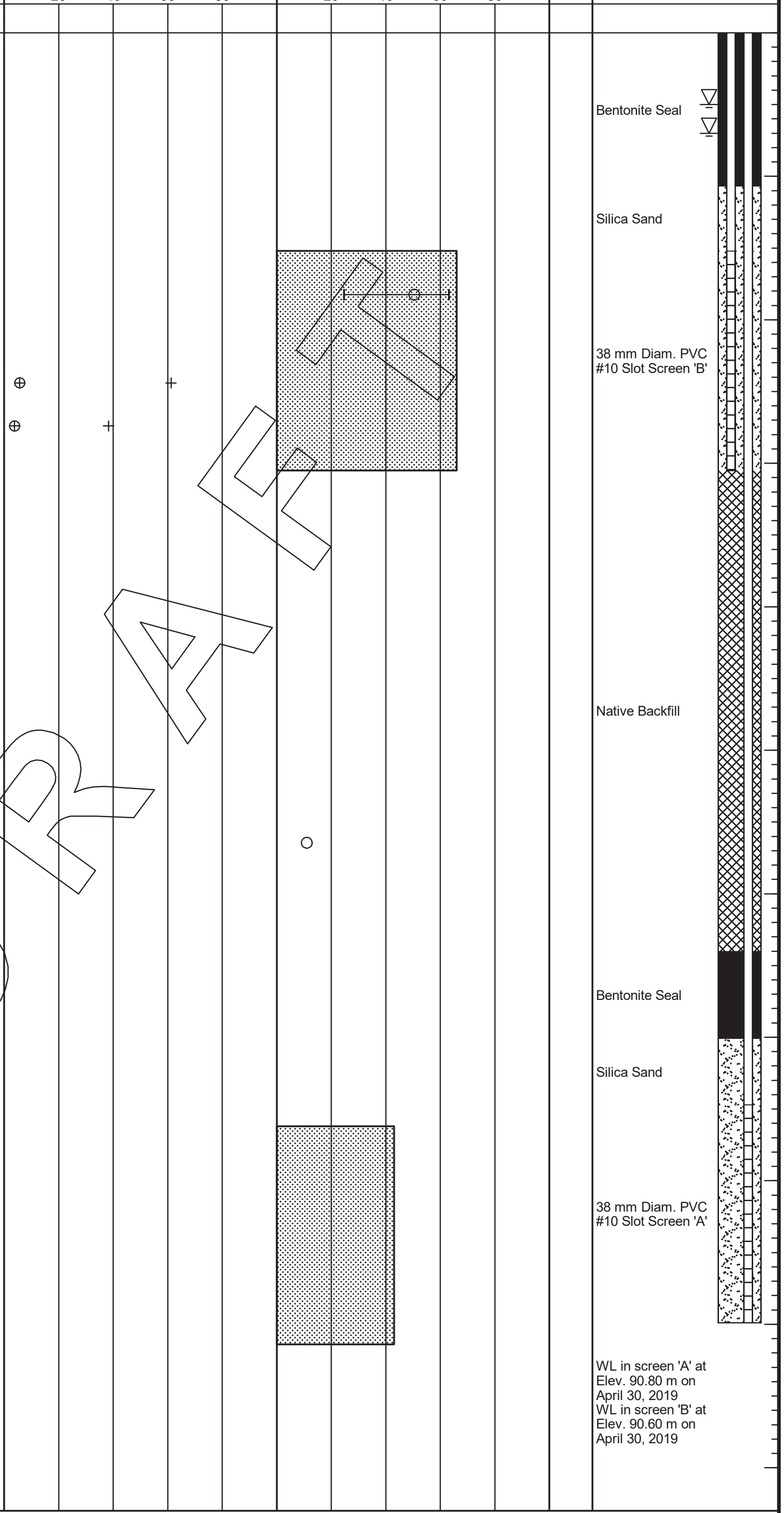
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	91.30
0	TOPSOIL - (CL/ML) SILTY CLAY to CLAYEY SILT, trace to some sand; dark brown	0.00
	(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.05 0.25
	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	88.56 2.74
	(SM) gravelly SILTY SAND; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, very loose to compact	87.64 3.66
	(SM) gravelly SILTY SAND; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, dense	83.68 7.62
	End of Borehole Auger Refusal	82.31 8.99

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	9
2	SS	5
3	SS	3
4	TP	PH
5	SS	4
6	SS	6
7	SS	6
8	SS	12
9	SS	4
10	SS	48
11	SS	30



WL in screen 'A' at Elev. 90.80 m on April 30, 2019
WL in screen 'B' at Elev. 90.60 m on April 30, 2019

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-35

SHEET 1 OF 1

LOCATION: N 5013586.4 ;E 363871.9

BORING DATE: November 1, 2018

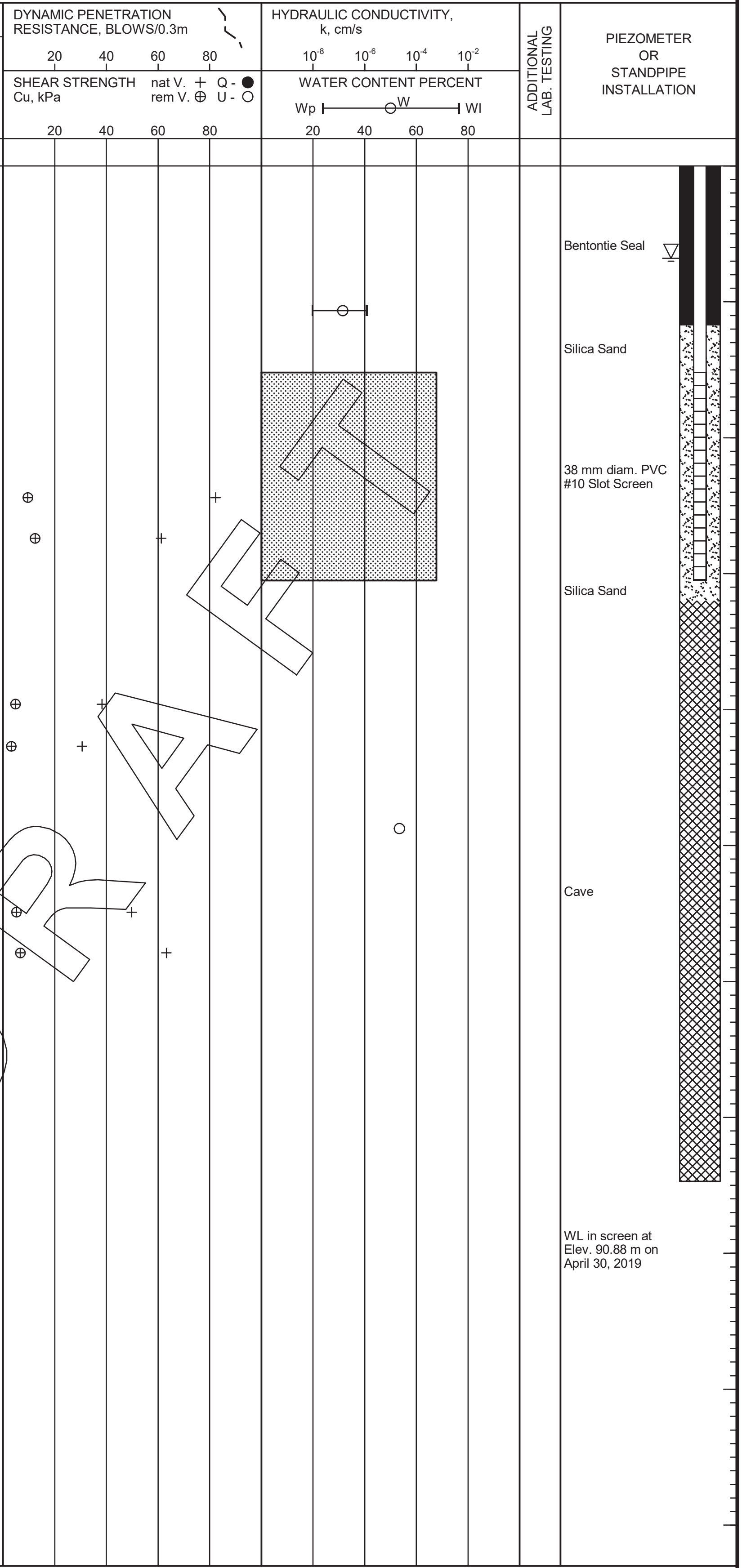
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m
	GROUND SURFACE	91.56			
0	TOPSOIL - (SM/ML) SILTY SAND to sandy SILT; dark brown	0.00			
	(SM/ML) SILTY SAND to sandy SILT; grey brown, contains silty clay seams; non-cohesive, moist, loose	91.33 0.23	1	SS	6
	(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.87 0.69			
1			2	SS	4
2			3	SS	3
3	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm to stiff	88.51 3.05	4	SS	PM
4					
5			5	SS	PM
6	(SM) gravelly silty sand; grey, contains cobbles (GLACIAL TILL); non-cohesive, wet, loose to very loose	85.31 6.25	6	SS	5
7			7	SS	4
	End of Borehole	84.09 7.47			
8					
9					
10					



WL in screen at Elev. 90.88 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-36

SHEET 1 OF 1

LOCATION: N 5013000.9 ;E 363099.9

BORING DATE: October 30, 2018

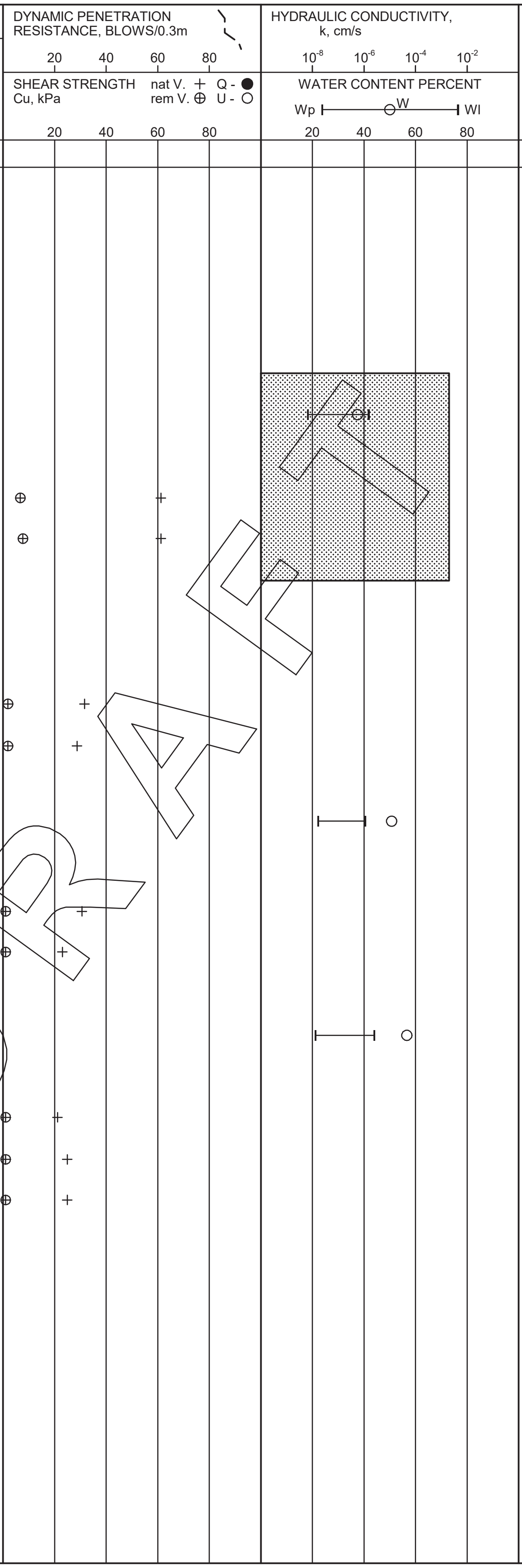
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

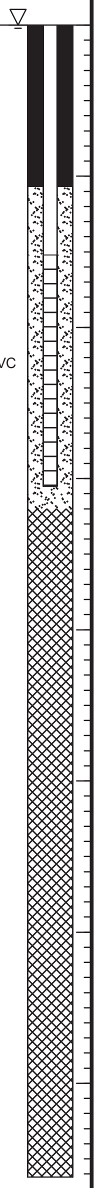
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
GROUND SURFACE	91.19				
TOPSOIL - (SM/ML) SILTY SAND to sandy SILT; dark brown	0.00				
(ML/SM) SILTY SAND to sandy SILT; grey brown; non-cohesive, moist to wet, loose	90.94 0.25	1	SS	6	
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown, contains silty sand seams(WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	90.43 0.76	2	SS	3	
		3	SS	1	
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm to soft	88.14 3.05	4	SS	PM	
		5	TP	WR	C
		6	SS	PM	
End of Borehole	83.57 7.62				



PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

Silica Sand

Cave

WL in screen at Elev. 91.19 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED:

PROJECT: 18108333-1000

RECORD OF BOREHOLE: 18-37

SHEET 1 OF 1

LOCATION: N 5013045.5 ;E 363220.1

BORING DATE: October 30, 2018

DATUM: CGVD28

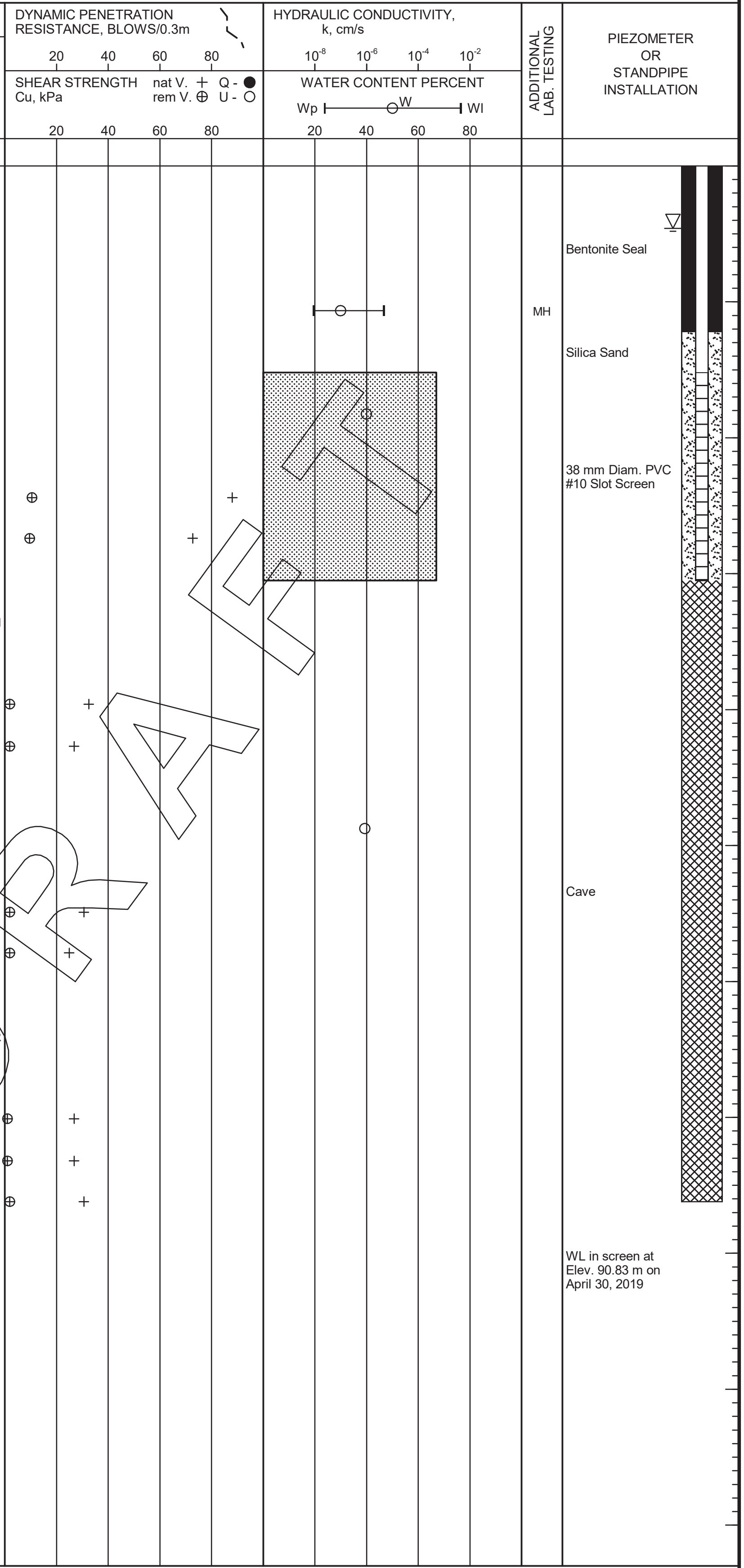
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV.	DEPTH (m)
GROUND SURFACE	91.29	
TOPSOIL - (SM/ML) SILTY SAND to sandy SILT; dark brown		0.00
(SM/ML) SILTY SAND to sandy SILT; grey brown; non-cohesive, moist, loose	91.04	0.25
(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown, contains silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.39	0.90
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silty sand seams; cohesive, w>PL, firm	88.24	3.05
End of Borehole	83.67	7.62

NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	7	
2	SS	8	MH
3	SS	3	
4	SS	WH	
5	SS	PM	
6	SS	WR	



DEPTH SCALE
1 : 50

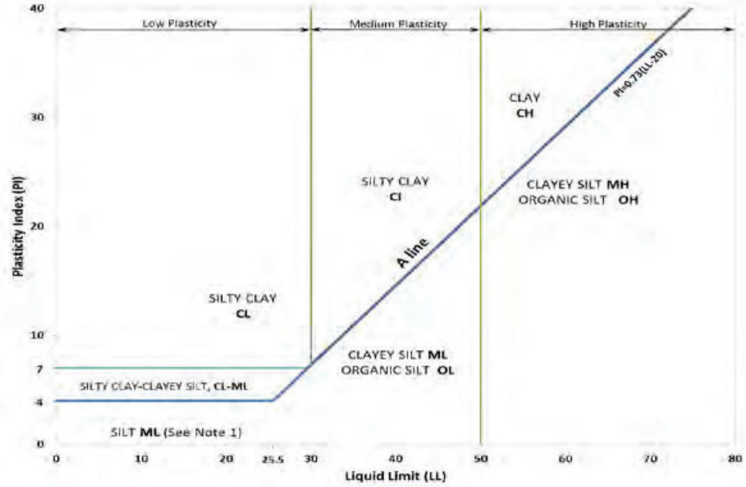
GOLDER

LOGGED: RI
CHECKED:

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% (see Note 2)	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH:	Sampler advanced by hydraulic pressure
PM:	Sampler advanced by manual pressure
WH:	Sampler advanced by static weight of hammer
WR:	Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta \sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index $= (w_l – w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index $= (w – w_p) / I_p$
I_C	consistency index $= (w_l – w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index $= (e_{max} – e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction $= \tan \delta$
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

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* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

TECHNICAL MEMORANDUM

DATE July 16, 2018 **Project No.** 18100364/2000

TO Andrew Finnson, CAIVAN Communities

CC

FROM Stephane Sol, Christopher Phillips **EMAIL** ssol@golder.com; cphillips@golder.com

NBCC SEISMIC SITE CLASS TESTING RESULTS BORRISOKANE RD, OTTAWA, ONTARIO

This technical memorandum presents the results of four Multichannel Analysis of Surface Waves (MASW) tests performed for the National Building Code of Canada (NBCC 2015). The seismic testing was carried out near Cedarview Rd/Borrisokane Rd in Ottawa, Ontario and location of each MASW line is shown on Figure 1. The geophysical testing was performed by Golder Associates Ltd. (Golder) personnel on May 16 and 17 and June 26, 2018.

Figure 1: MASW Location Site Map (MASW Lines in red)

Methodology

The MASW method measures variations in surface-wave velocity with increasing distance and wavelength and can be used to infer the rock/soil types, stratigraphy and soil conditions.

A typical MASW survey requires a seismic source, to generate surface waves, and a minimum of two geophone receivers, to measure the ground response at some distance from the source. Surface waves are a special type of seismic wave whose propagation is confined to the near surface medium.

The depth of penetration of a surface wave into a medium is directly proportional to its wavelength. In a non-homogeneous medium, surface waves are dispersive, i.e., each wavelength has a characteristic velocity owing to the subsurface heterogeneities within the depth interval that particular wavelength of surface wave propagates through. The relationship between surface-wave velocity and wavelength is used to obtain the shear-wave velocity and attenuation profile of the medium with increasing depth.

The seismic source used can be either active or passive, depending on the application and location of the survey. Examples of active sources include explosives, weight-drops, sledge hammer and vibrating pads. Examples of passive sources are road traffic, micro-tremors, and water-wave action (in near-shore environments).

The geophone receivers measure the wave-train associated with the surface wave travelling from a seismic source at different distances from the source.

The participation of surface waves with different wavelengths can be determined from the wave-train by transforming the wave-train results into the frequency domain. The surface-wave velocity profile with respect to wavelength (called the ‘dispersion curve’) is determined by the delay in wave propagation measured between the geophone receivers. The dispersion curve is then matched to a theoretical dispersion curve using an iterative forward-modelling procedure. The result is a shear-wave velocity profile of the tested medium with depth, which can be used to estimate the dynamic shear-modulus of the medium as a function of depth.

Field Work

The MASW field work was conducted on May 16 and 17 and June 26, 2018, by personnel from the Golder Mississauga and Ottawa office. For the three MASW lines, a series of 24 low frequency (4.5 Hz) geophones were laid out at 3 metre intervals. Both active and passive readings were recorded along the MASW line. For the active investigation, a seismic drop of 45 kg and a 9.9 kg sledge hammer were used as seismic sources. Active seismic records were collected with seismic sources located 5, 10, and 15 metres from and collinear to the geophone array. Examples of active seismic record collected along each MASW line are shown on Figures 2, 3, 4, and 5 below.

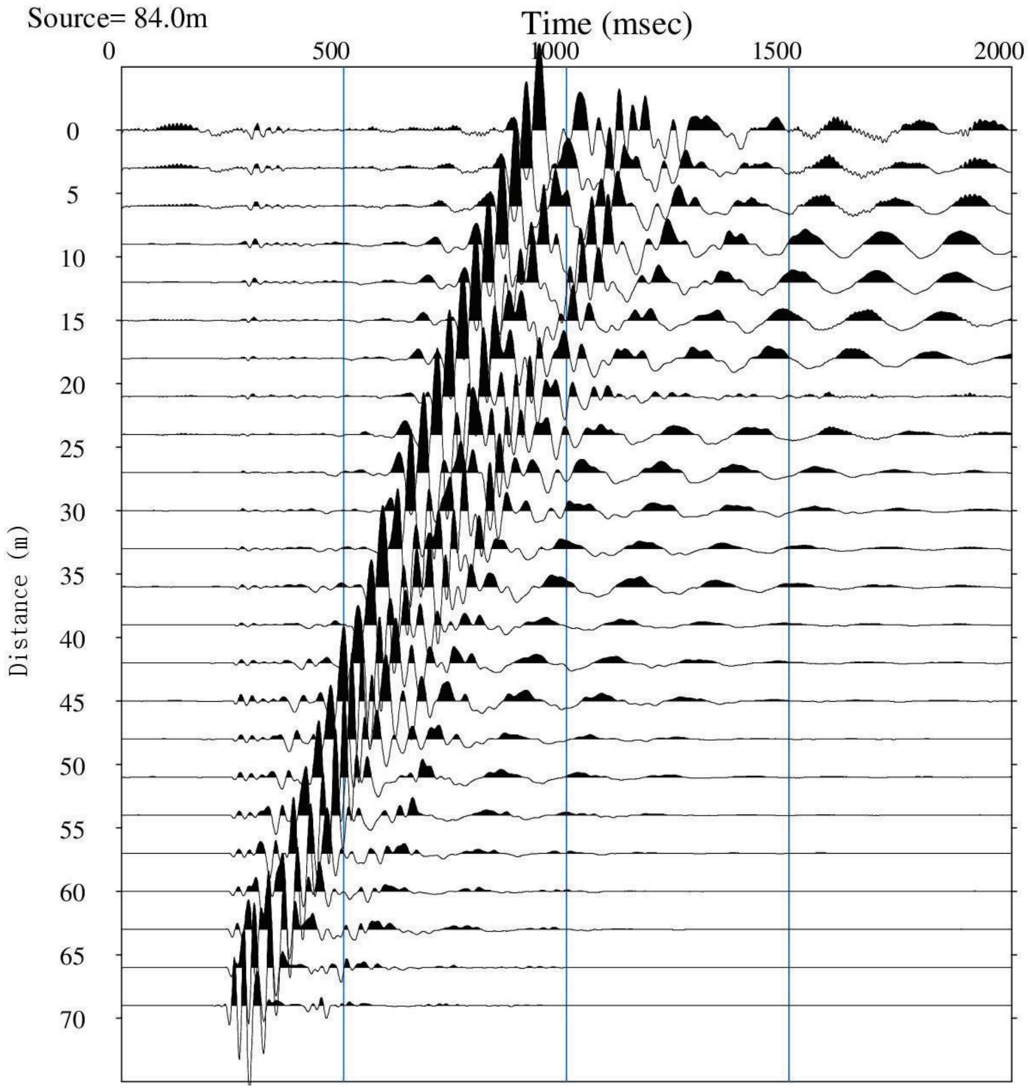

Figure 2: Typical seismic record collected at the site of the MASW Line 1.

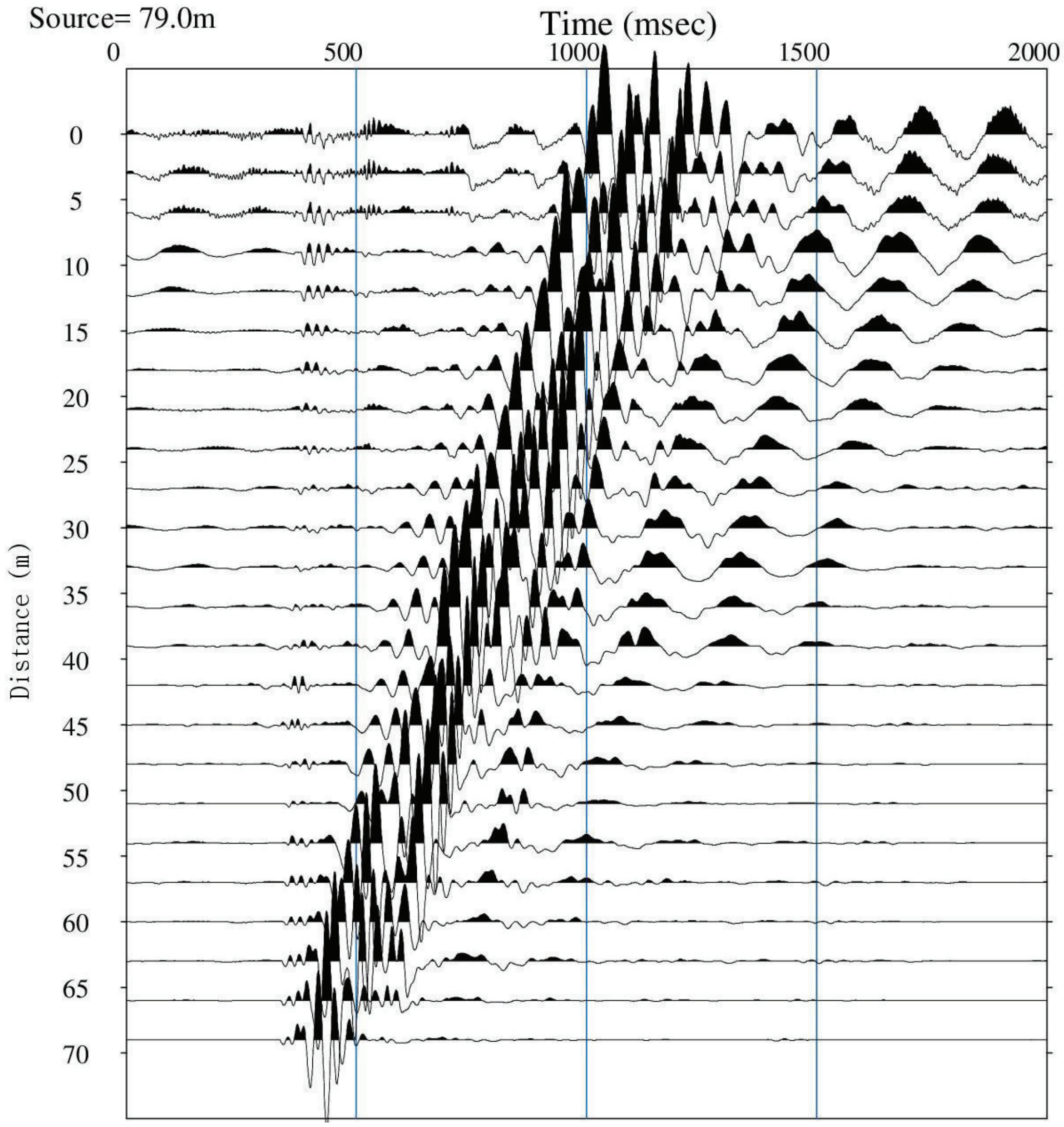

Figure 3: Typical seismic record collected at the site of the MASW Line 2.

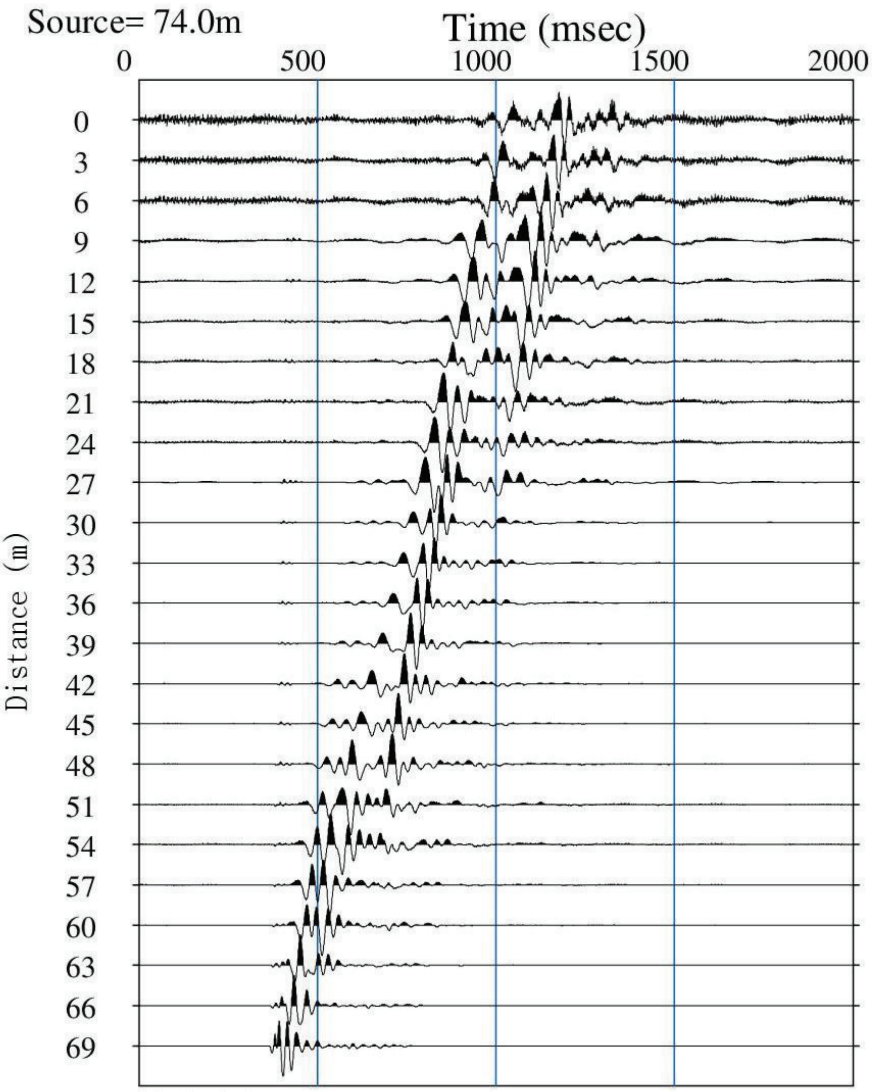

Figure 4: Typical seismic record collected at the site of the MASW Line 3.

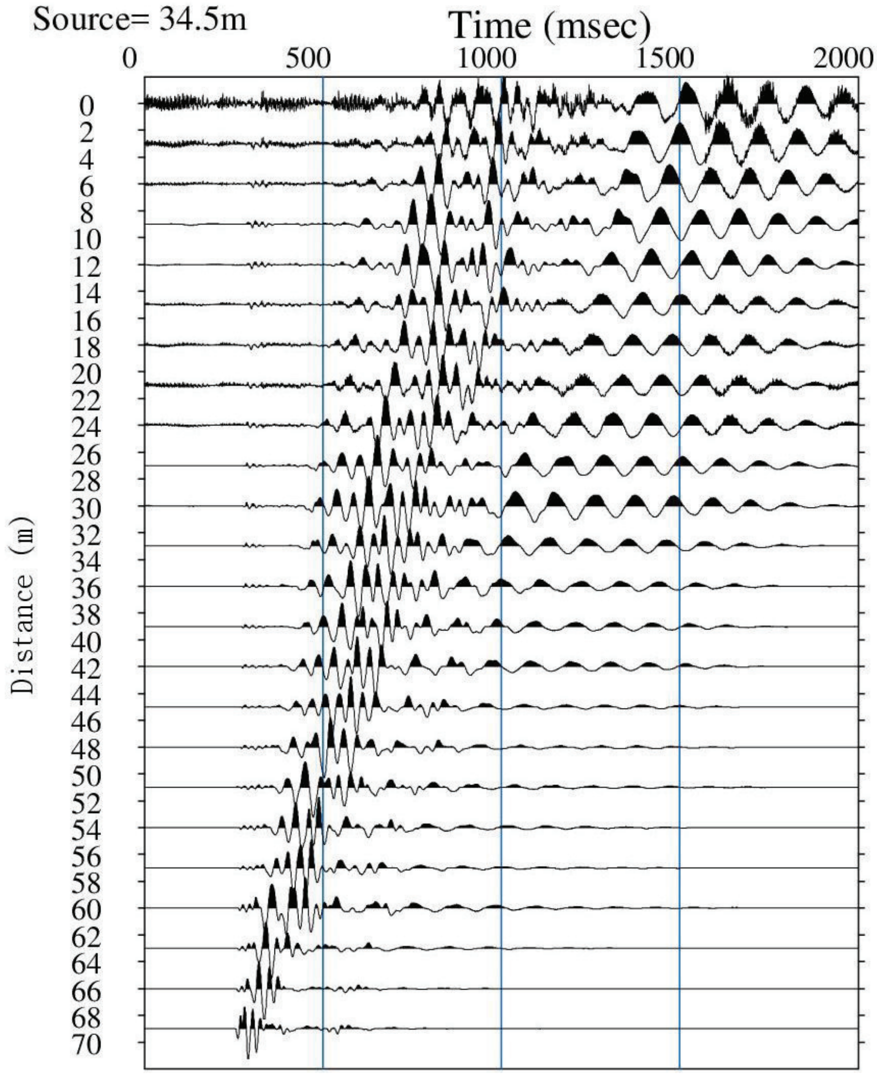

Figure 5: Typical seismic record collected at the site of the MASW Line 4.

Data Processing

Processing of the MASW test results consisted of the following main steps:

1) Transformation of the time domain data into the frequency domain using a Fast-Fourier Transform (FFT) for each source location;

2) Calculation of the phase for each frequency component;

3) Linear regression to calculate phase velocity for each frequency component;

4) Filtering of the calculated phase velocities based on the Pearson correlation coefficient (r2) between the data and the linear regression best fit line used to calculate phase velocity;

5) Generation of the dispersion curve by combining calculated phase velocities for each shot location of a single MASW test; and,

6) Generation of the stiffness profile, through forward iterative modelling and matching of model data to the field collected dispersion curve.

Processing of the MASW data was completed using the SeisImager/SW software package (Geometrics Inc.). The calculated phase velocities for a seismic shot point were combined and the dispersion curve generated by choosing the minimum phase velocity calculated for each frequency component as shown on Figures 6, 7, 8 and 9 for MASW Lines 1, 2, 3, and 4, respectively. Shear wave velocity profiles were generated through inverse modelling to best fit the calculated dispersion curves. The active survey of MASW Lines provided a dispersion curve with a suitable frequency range as summarized in Table 1, below.

Table 1: Summary of Dispersion Curves with Suitable Frequency Ranges

MASW Line	Minimum Frequency (Hz)	Maximum Frequency (Hz)
MASW Line 1	3	38
MASW Line 2	4	26
MASW Line 3	3	35
MASW Line 4	4	22

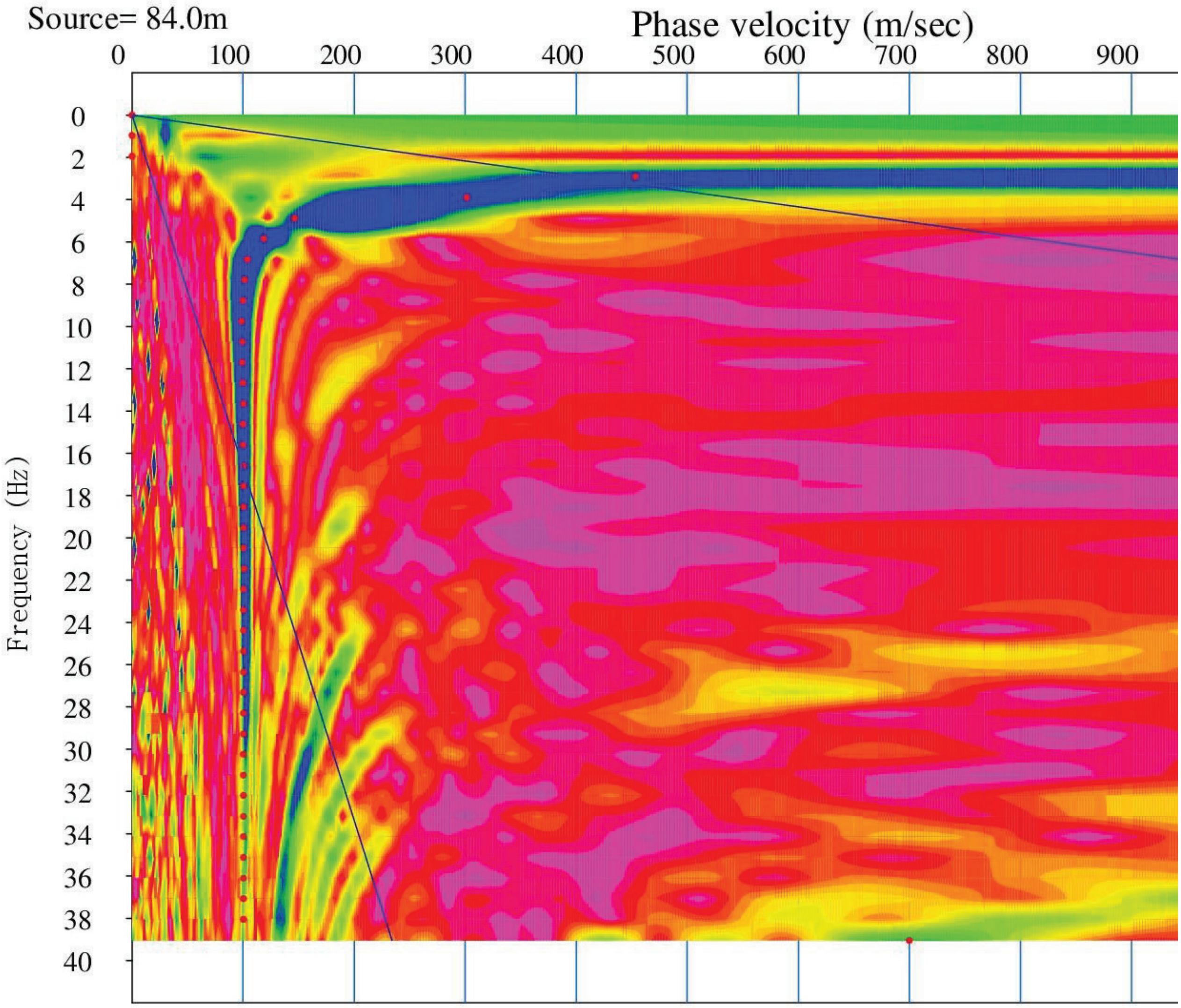

Figure 6: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 1

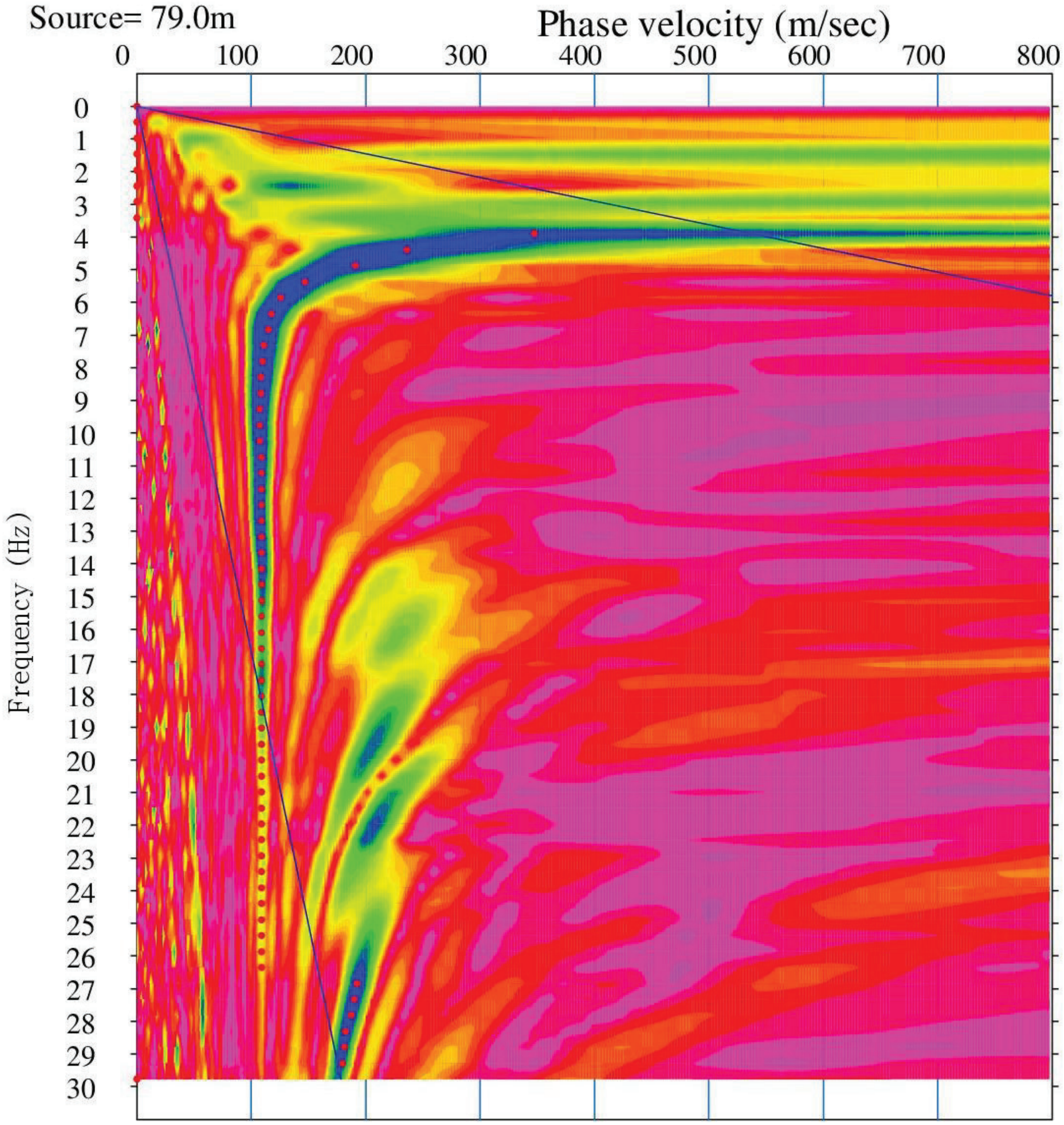

Figure 7: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 2

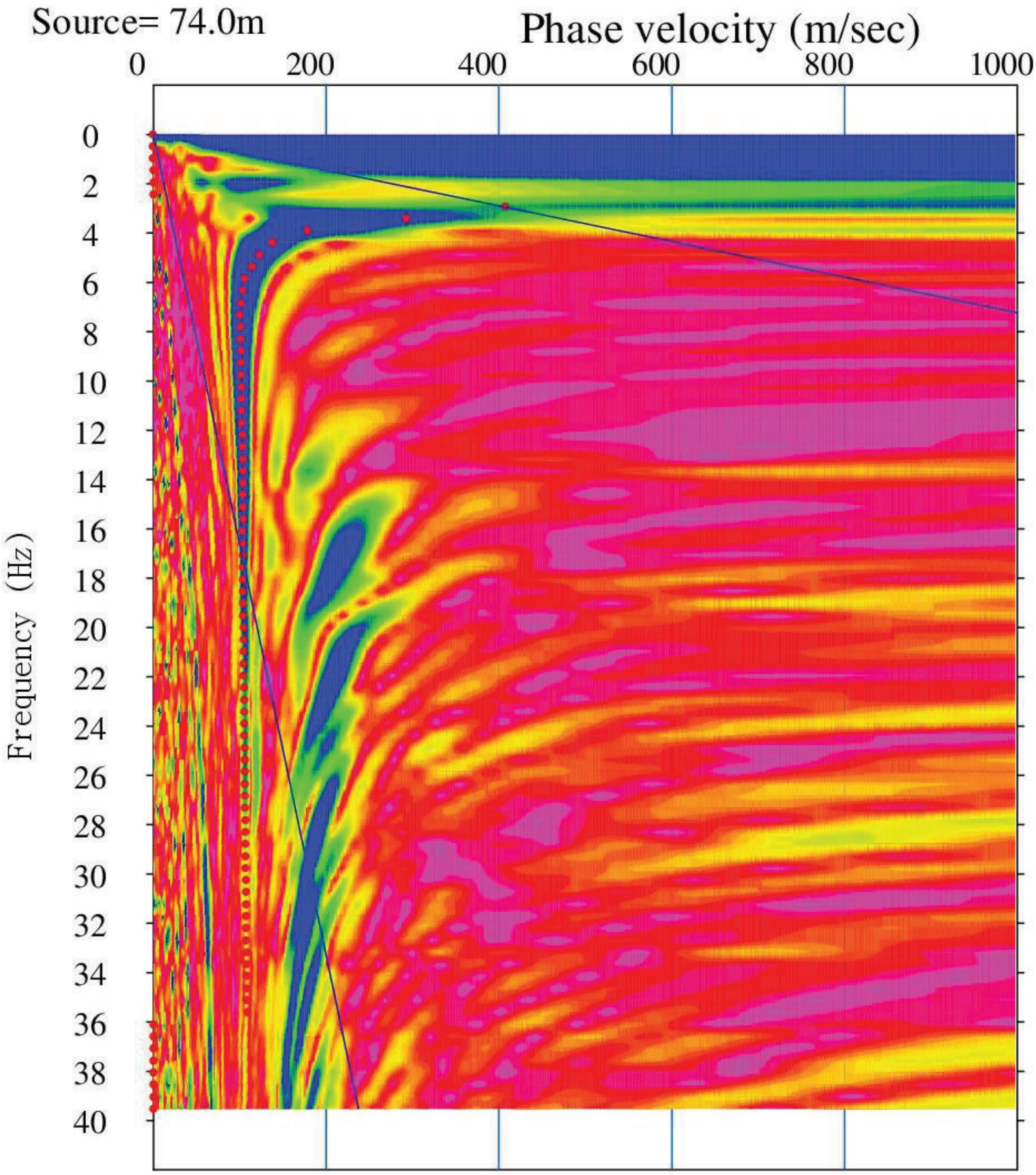

Figure 8: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 3

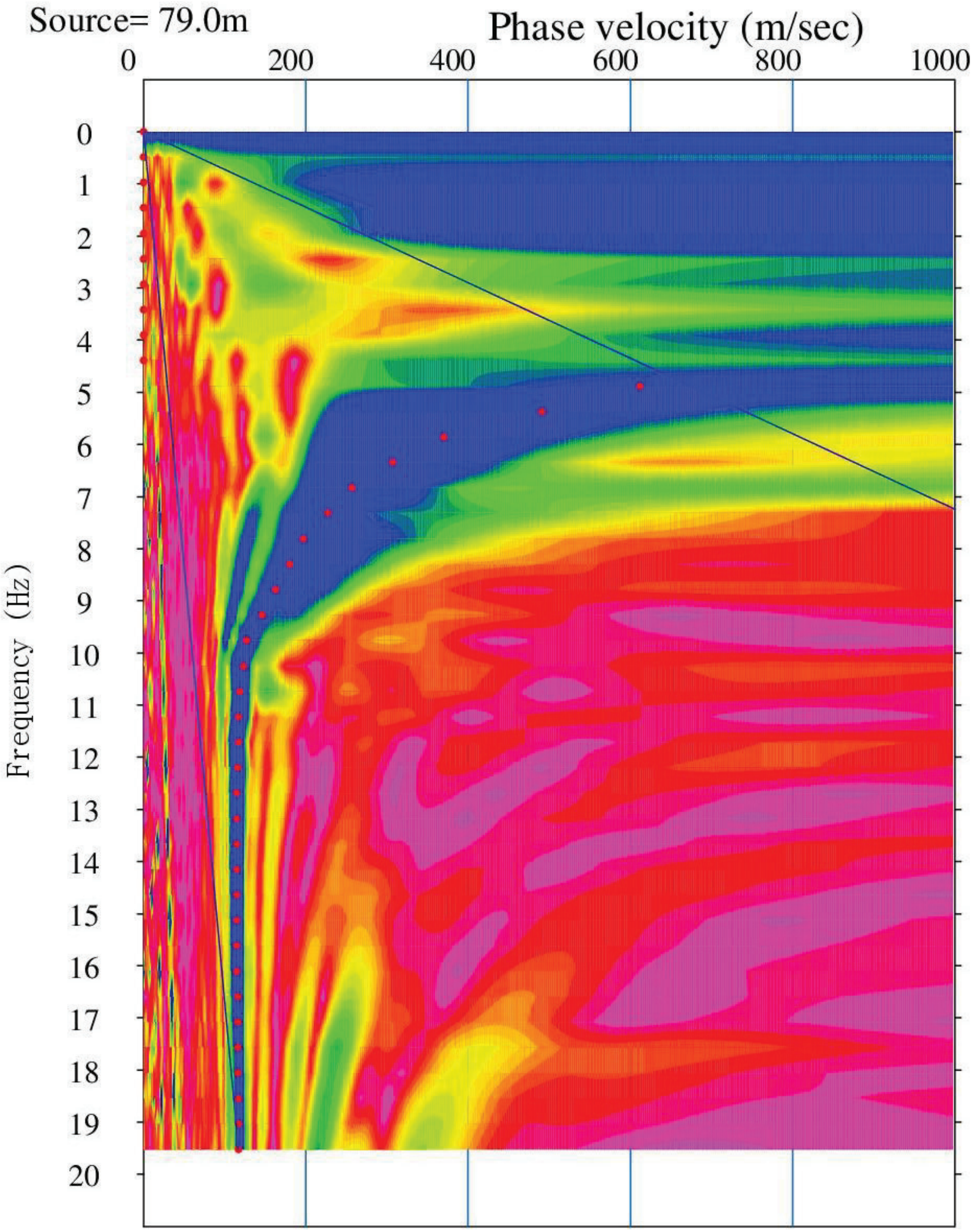

Figure 9: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 4

Results

The MASW test results are presented in Figures 10, 11, 12, and 13 for MASW Lines 1, 2, 3, and 4, respectively. These results present the calculated shear wave velocity profiles derived from the field testing along each MASW line. The field collected dispersion curves are compared with the model generated dispersion curves on Figures 14, 15, 16 and 17 for MASW Lines 1, 2, 3, and 4, respectively. There is a satisfactory correlation between the field collected and model calculated dispersion curves, with a root mean squared error of less than 3% along each MASW line.

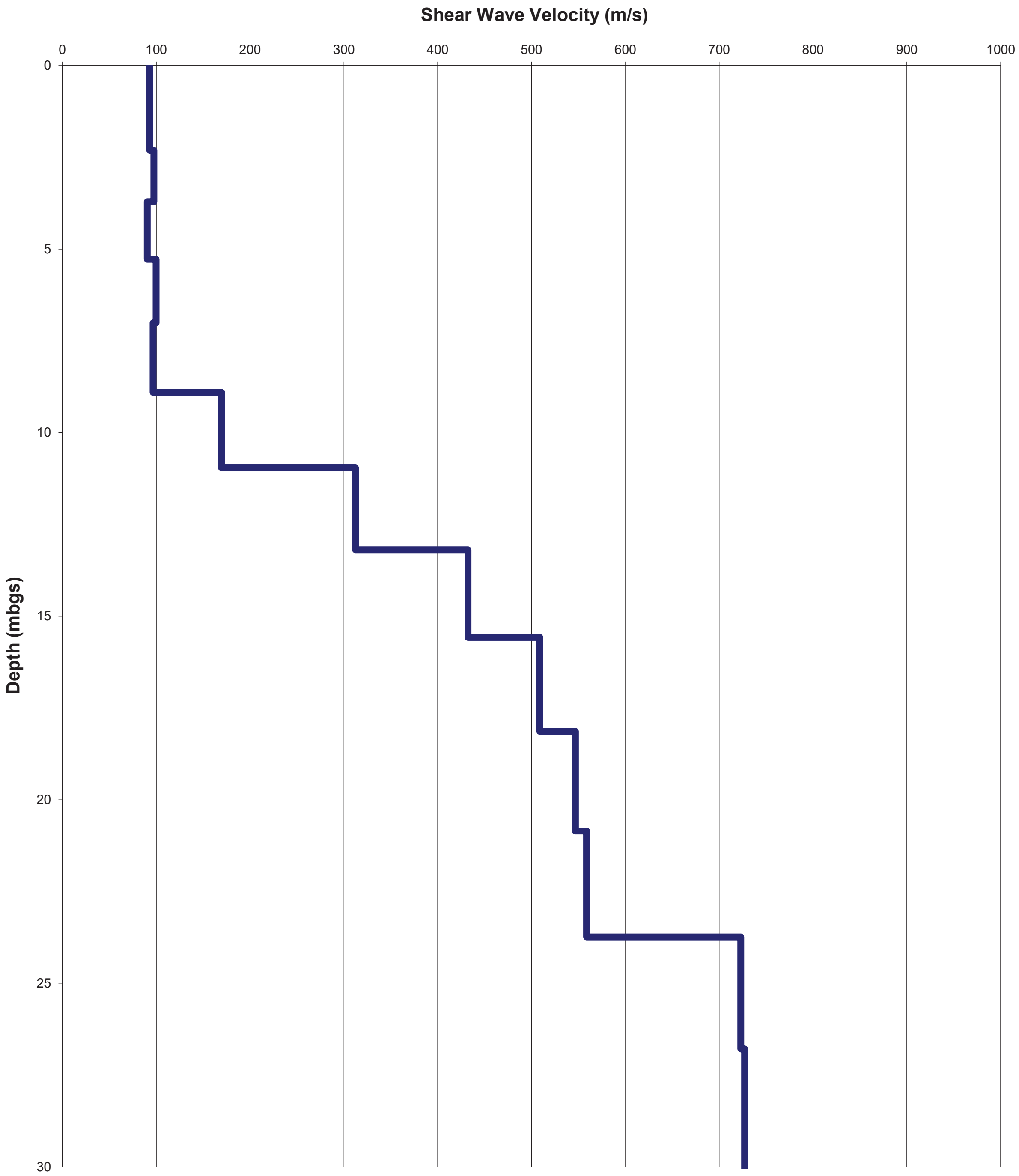

Figure 10: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 1

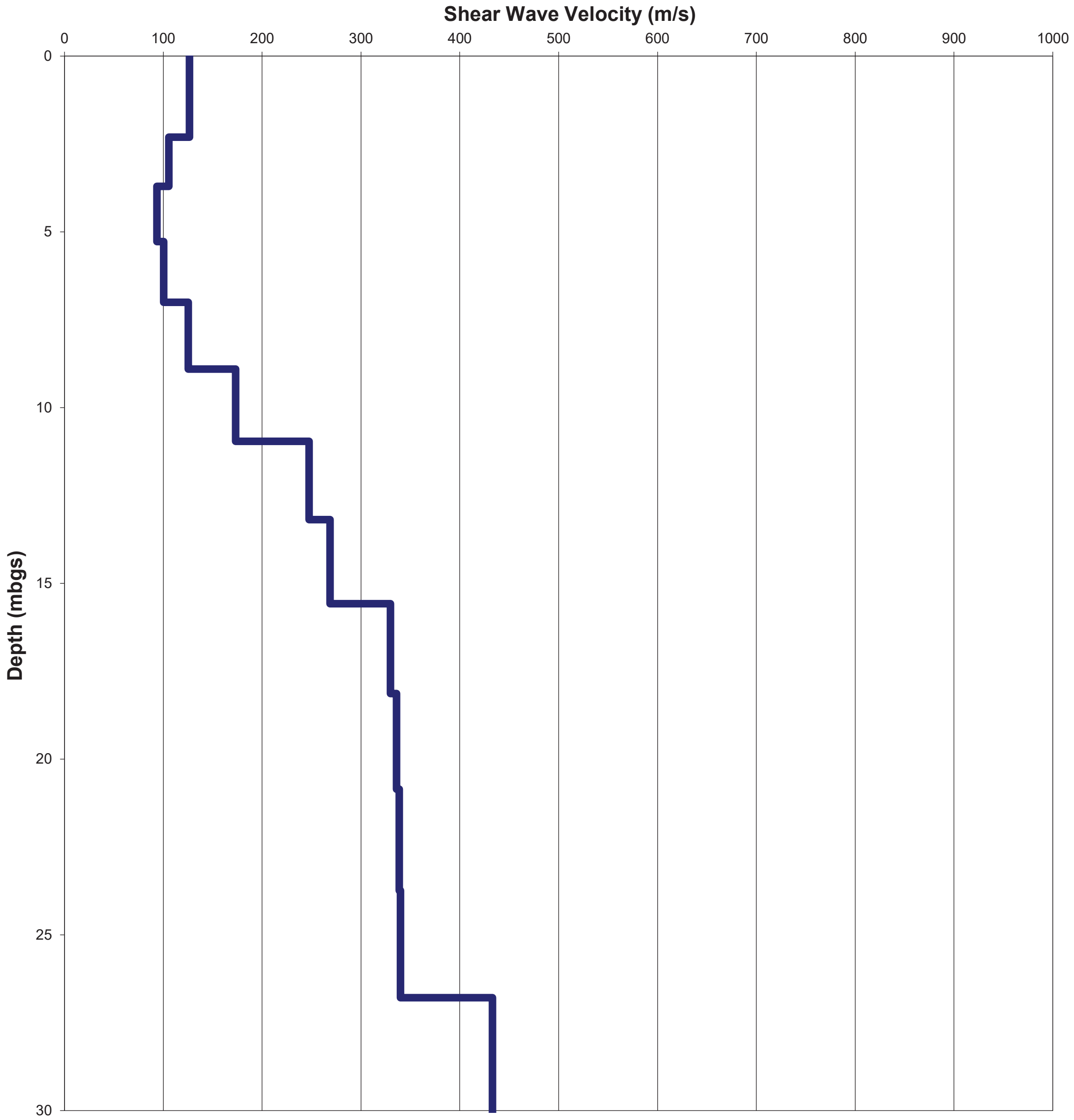

Figure 11: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 2

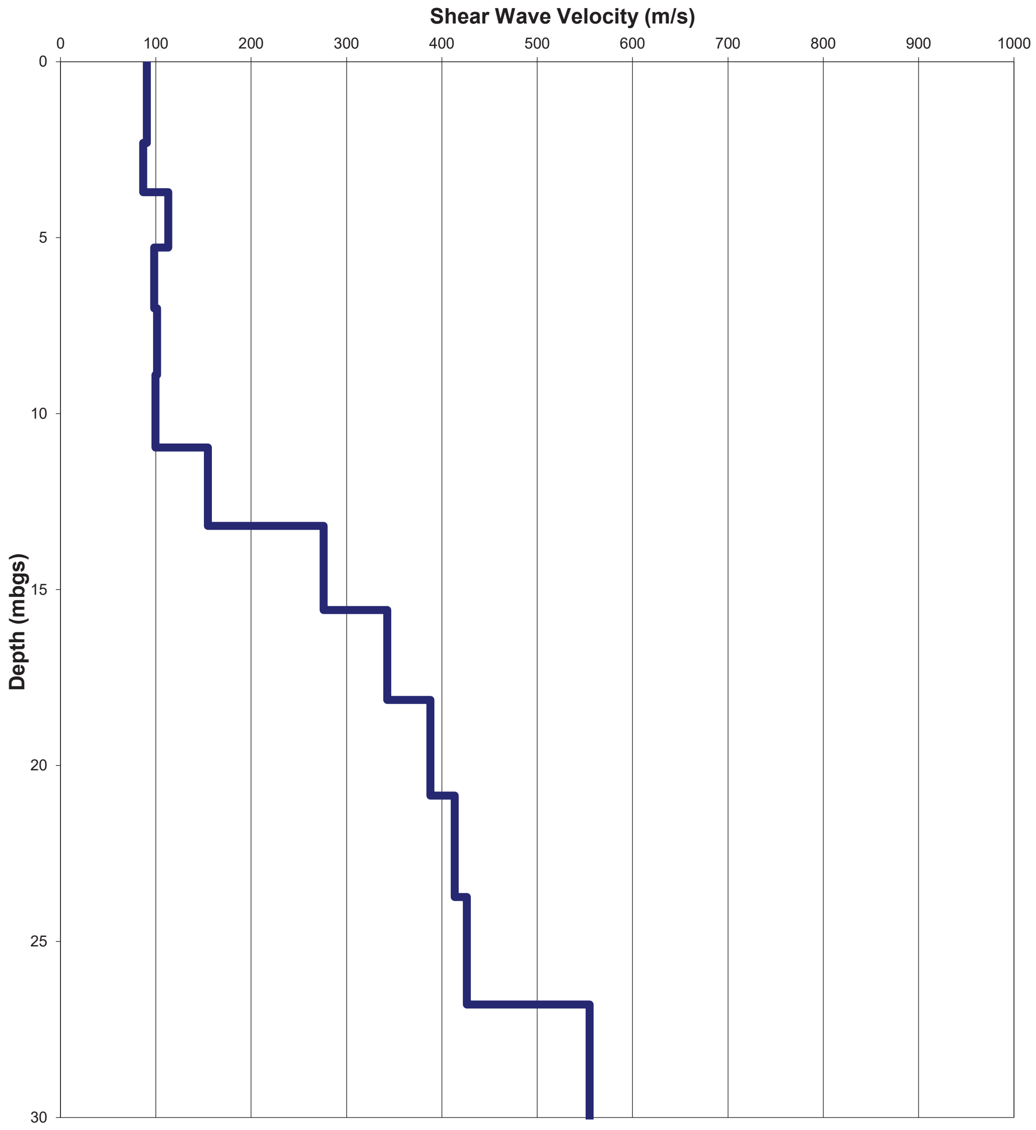

Figure 12: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 3

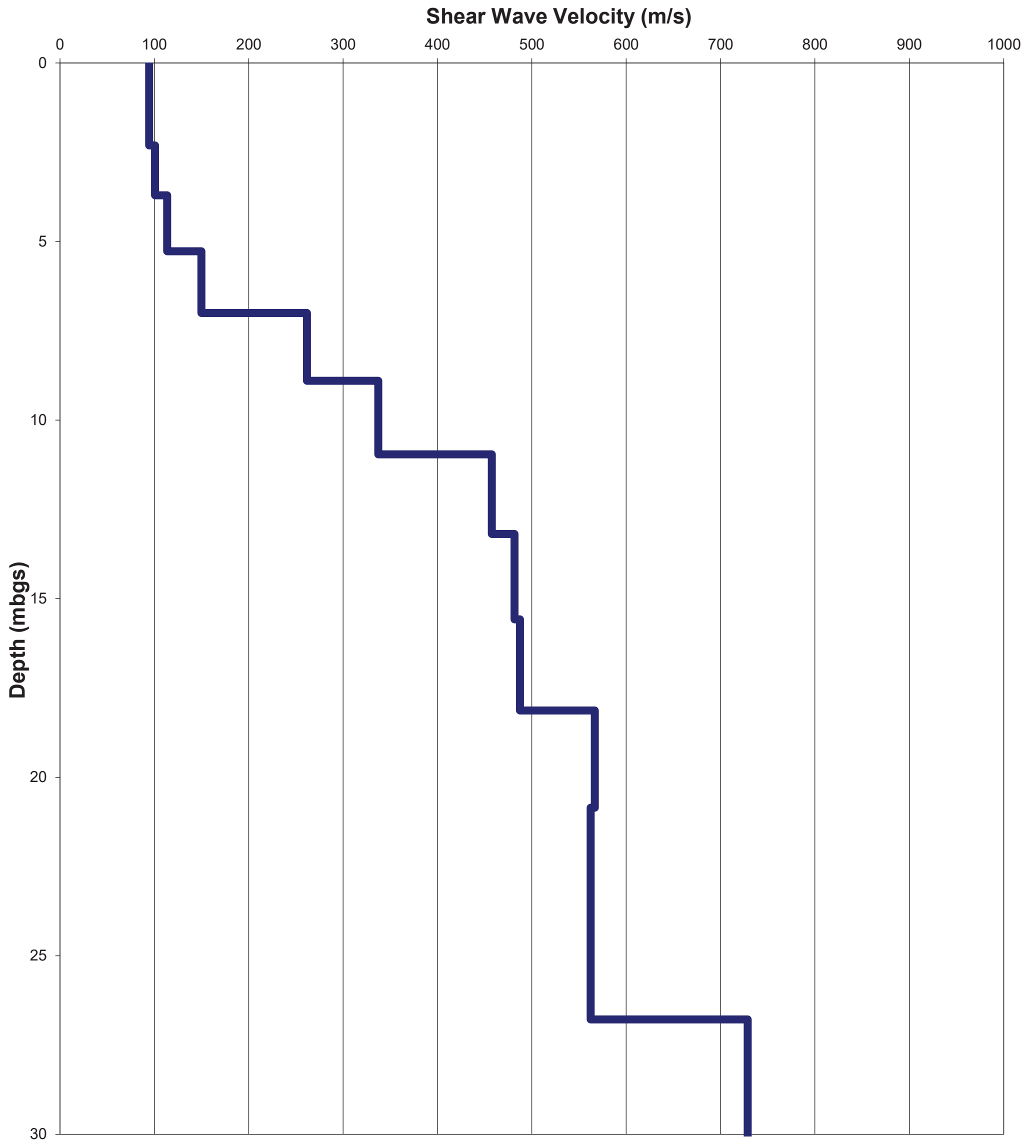

Figure 13: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 4

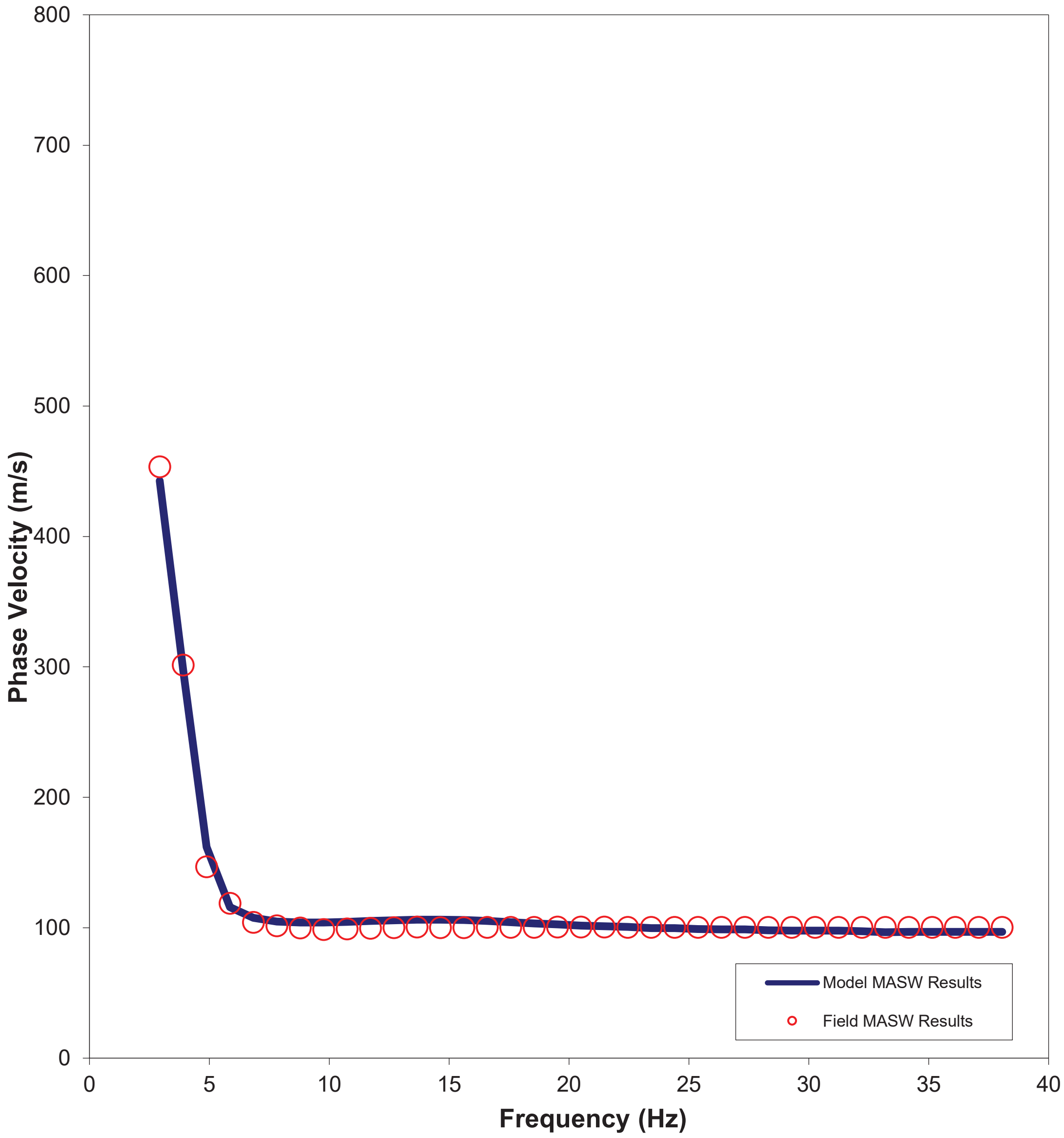

Figure 14: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 1

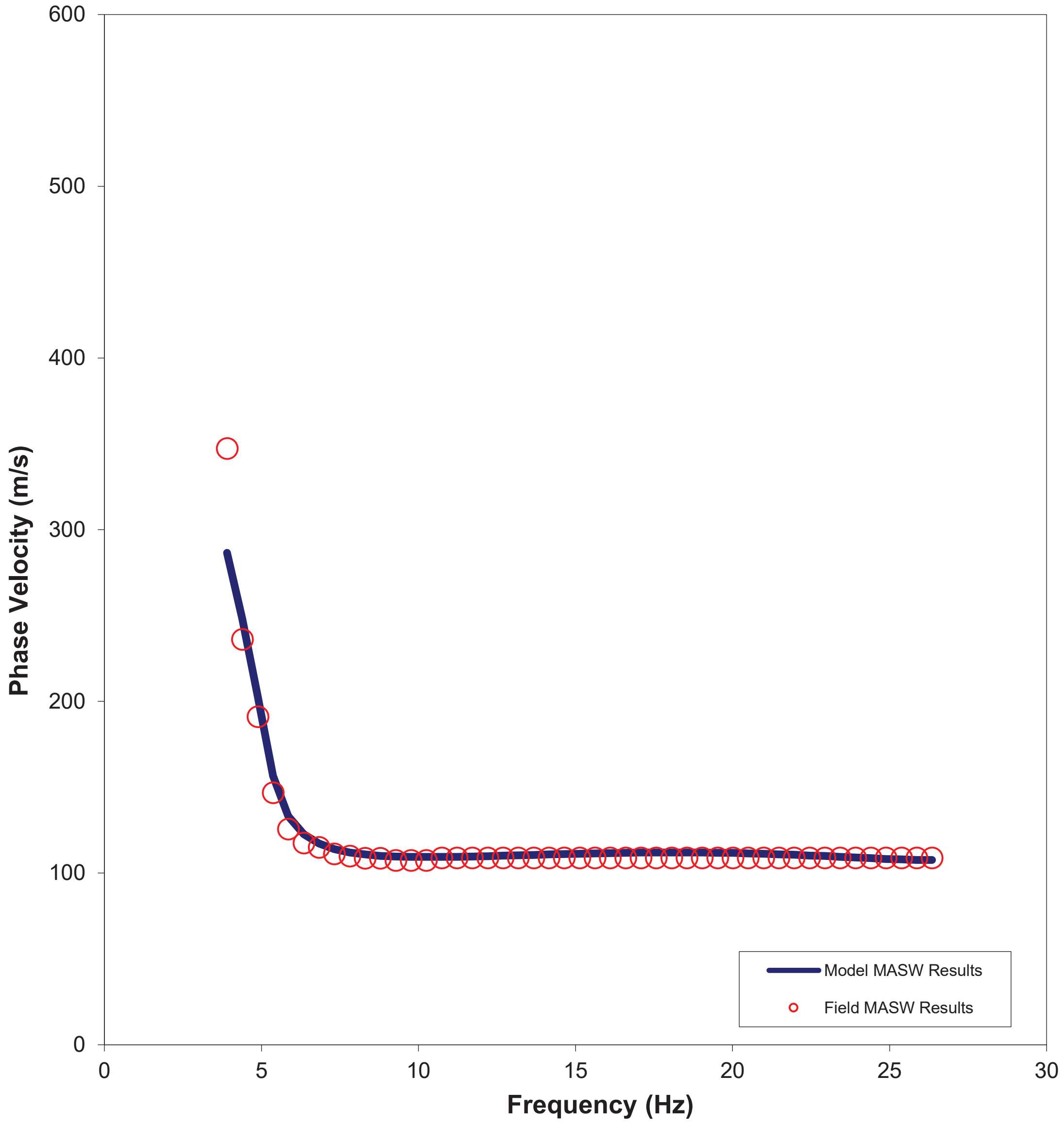

Figure 15: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 2

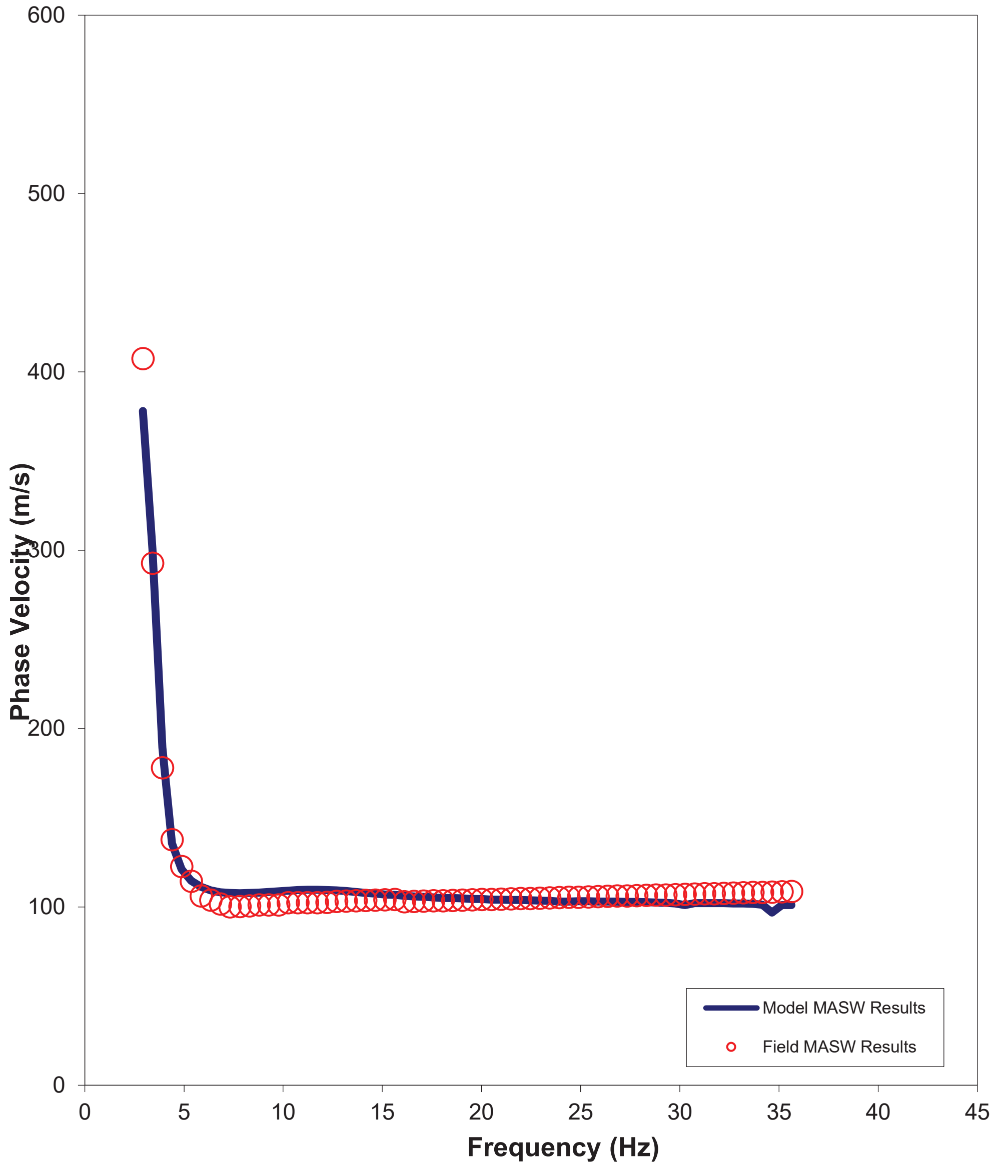

Figure 16: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 3

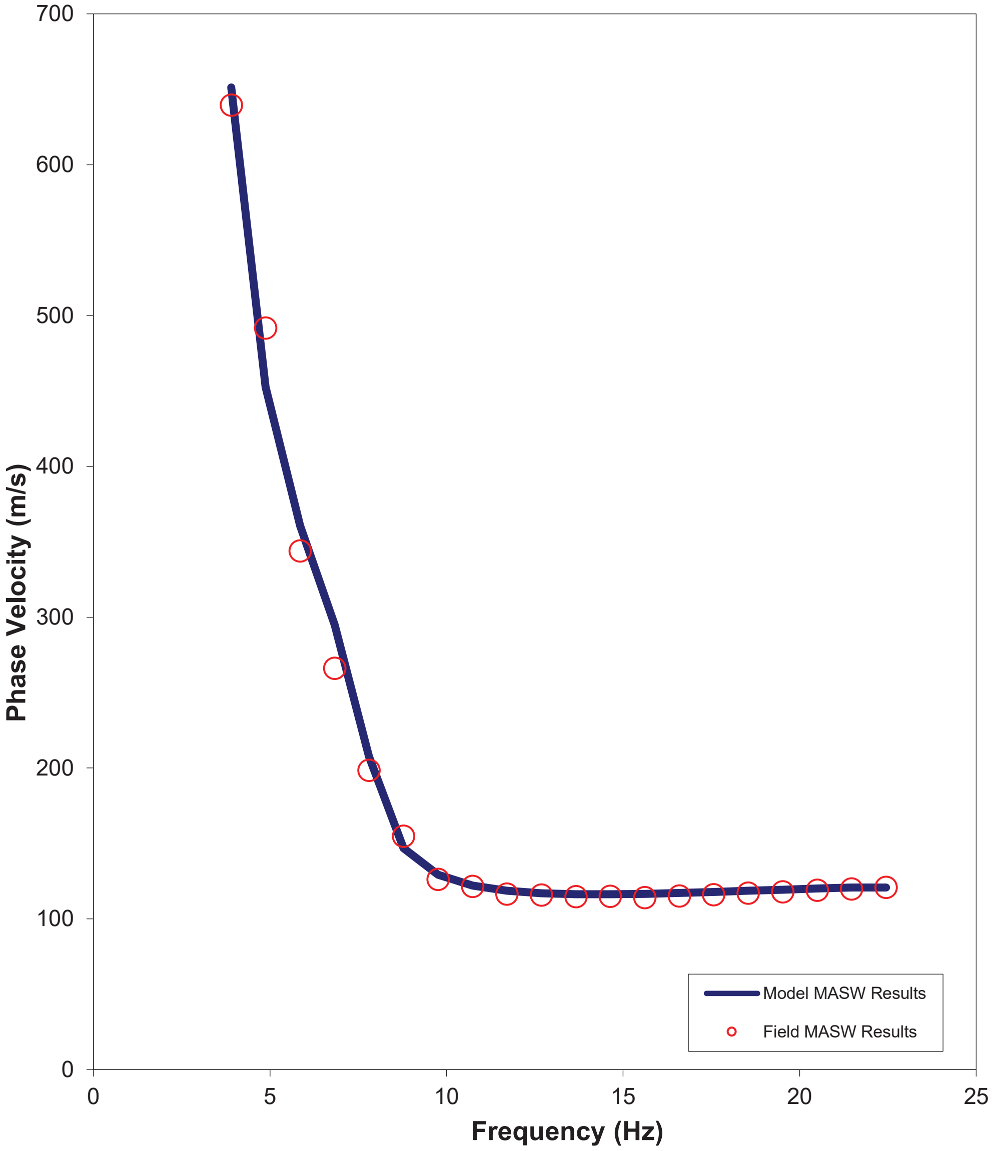

Figure 17: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 4

To calculate the average shear-wave velocity as required by the National Building Code of Canada (NBCC 2015), the results were modelled to 30 metres below ground surface. The average shear-wave velocity along MASW Line 1 was found to be 211 m/s (Table 2). The average shear-wave velocity along MASW Line 2 was found to be 198 m/s (Table 3). The average shear-wave velocity along MASW Line 3 was found to be 176 m/s (Table 4). The average shear-wave velocity along MASW Line 4 was found to be 268 m/s (Table 5).

The NBCC 2015 requires special site specific evaluation if certain soil types are encountered on the site, so the site classification stated here should be reviewed, and modified if necessary, according to borehole stratigraphy, standard penetration resistance results, and undrained shear strength measurements, if available for this site.

Table 2: Shear-Wave Velocity Profile along the MASW line 1

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	93	0.011498
1.07	2.31	1.24	93	0.013267
2.31	3.71	1.40	98	0.014353
3.71	5.27	1.57	90	0.017329
5.27	7.01	1.73	100	0.017316
7.01	8.90	1.90	97	0.019599
8.90	10.96	2.06	170	0.012140
10.96	13.19	2.23	312	0.007123
13.19	15.58	2.39	432	0.005528
15.58	18.13	2.55	509	0.005023
18.13	20.85	2.72	547	0.004975
20.85	23.74	2.88	559	0.005163
23.74	26.79	3.05	723	0.004217
26.79	30.00	3.21	727	0.004420
			Vs Average to 30 mbgs (m/s)	**211**

Table 3: Shear-Wave Velocity Profile along the MASW line 2

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	126	0.008475
1.07	2.31	1.24	126	0.009779
2.31	3.71	1.40	106	0.013266
3.71	5.27	1.57	94	0.016742
5.27	7.01	1.73	100	0.017247
7.01	8.90	1.90	125	0.015147
8.90	10.96	2.06	173	0.011895
10.96	13.19	2.23	248	0.008989
13.19	15.58	2.39	269	0.008896
15.58	18.13	2.55	330	0.007747
18.13	20.85	2.72	336	0.008092
20.85	23.74	2.88	339	0.008512
23.74	26.79	3.05	340	0.008967
26.79	30.00	3.21	433	0.007423
			Vs Average to 30 mbgs (m/s)	**198**

Table 4: Shear-Wave Velocity Profile along the MASW line 3

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	91	0.011826
1.07	2.31	1.24	91	0.013646
2.31	3.71	1.40	87	0.016153
3.71	5.27	1.57	113	0.013867
5.27	7.01	1.73	98	0.017616
7.01	8.90	1.90	101	0.018731
8.90	10.96	2.06	100	0.020696
10.96	13.19	2.23	155	0.014399
13.19	15.58	2.39	276	0.008661
15.58	18.13	2.55	343	0.007453
18.13	20.85	2.72	388	0.007012
20.85	23.74	2.88	414	0.006976
23.74	26.79	3.05	426	0.007158
26.79	30.00	3.21	555	0.005790
			Vs Average to 30 mbgs (m/s)	**176**

Table 5: Shear-Wave Velocity Profile along the MASW line 4

Model Layer (mbgs)		Layer Thickness (m)	Shear Wave Velocity (m/s)	Shear Wave Travel Time Through Layer (s)
Top	Bottom			
0.00	1.07	1.07	94	0.011341
1.07	2.31	1.24	94	0.013085
2.31	3.71	1.40	101	0.013903
3.71	5.27	1.57	114	0.013779
5.27	7.01	1.73	150	0.011561
7.01	8.90	1.90	262	0.007243
8.90	10.96	2.06	337	0.006109
10.96	13.19	2.23	458	0.004864
13.19	15.58	2.39	481	0.004964
15.58	18.13	2.55	487	0.005242
18.13	20.85	2.72	567	0.004800
20.85	23.74	2.88	562	0.005131
23.74	26.79	3.05	562	0.005424
26.79	30.00	3.21	729	0.004411
			Vs Average to 30 mbgs (m/s)	**268**

Limitations

This technical memorandum is based on data and information collected by Golder Associates Ltd. and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder Associates Ltd. as described in this memo.

Golder Associates Ltd. has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The services performed, as described in this memo, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this memo, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this memo.

The findings and conclusions of this memo are valid only as of the date of this memo. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this memo, and to provide amendments as required.

Closure

We trust that this technical memorandum meets your needs at the present time. If you have any questions or require clarification, please contact the undersigned at your convenience.

GOLDER ASSOCIATES LTD.

Stephane Sol, Ph.D., P. Geo.
Senior Geophysicist

Christopher Phillips, M.Sc., P. Geo.
Senior Geophysicist, Principal

SS/CRP/jl

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TABLE 2 - SHRINKAGE LIMIT DETERMINATIONS

Borehole Number	18-20	
Sample Number	5	
Depth, m	3.05-3.66	
Shrinkage Dish Number	3	4
Mass of the dry soil pat, g	15.48	15.54
Mass of dry soil pat + shrinkage dish, g	37.08	38.81
Mass of shrinkage dish, g	21.60	23.27
Volume of shrinkage dish, cm^3	13.30	13.33
Mass of wet soil + shrinkage dish, g	44.71	46.44
Moisture content of the soil	49.29	49.10
Mass of dry soil pat before waxing, g	15.48	15.54
Volume of dry soil pat + wax, cm^3	13.10	13.68
Mass of dry soil pat + wax in air, g	19.41	19.94
Mass of dry soil pat + wax in water, g	6.31	6.26
Mass of wax, g	3.93	4.40
Volume of wax, cm^3	4.25	4.76
Specific gravity of wax	0.925	0.925
Volume of dry soil pat, cm^3	8.85	8.92
SHRINKAGE LIMIT, SL	**20.55**	**20.74**
SHRINKAGE RATIO, R	**1.75**	**1.74**

Project Numb 18108333 (1000) Date Tested December 3, 2018

Tested By X. Meng Checked By

Notes:

Shrinkage limits of samples determined according to ASTM D4943-18 standard.

Test carried out using wax method.

Microsere Wax 5214.

eurofins | Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Mr. Alex Meacoe
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1821076
Date Submitted: 2018-11-20
Date Reported: 2018-11-27
Project: 18108333/1000
COC #: 838159

				Lab I.D.	1400203	1400204	1400205	1400206
				Sample Matrix	Soil	Soil	Soil	Soil
				Sample Type				
				Sampling Date	2018-11-01	2018-10-29	2018-10-30	2018-11-07
				Sample I.D.	18-24 sa3/5-7'	18-25 sa3/5-7'	18-29 sa3/5-7'	18-06 sa3A/5.5-6'8"
Group	**Analyte**	**MRL**	**Units**	**Guideline**				
Anions	Cl	0.002	%		<0.002	<0.002	<0.002	<0.002
	SO4	0.01	%		<0.01	<0.01	<0.01	0.05
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.30	0.18	0.19	0.24
	pH	2.00			7.43	7.96	8.00	7.15
	Resistivity	1	ohm-cm		3330	5880	5260	4170

				Lab I.D.	1400207
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2018-11-08
				Sample I.D.	18-09 sa3/5-7'
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Anions	Cl	0.002	%		<0.002
	SO4	0.01	%		0.01
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.18
	pH	2.00			7.97
	Resistivity	1	ohm-cm		5560

Guideline = *** = Guideline Exceedence**

Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range eurofins | Environment Testing

Certificate of Analysis

Client: Golder Associates Ltd. (Ottawa)
1931 Robertson Road
Ottawa, ON
K2H 5B7
Attention: Mr. Steve Dunlop
PO#:
Invoice to: Golder Associates Ltd. (Ottawa)

Report Number: 1705915
Date Submitted: 2017-04-21
Date Reported: 2017-04-28
Project: 1771847
COC #: 817524

				Lab I.D.	1289218	1289219	1289220	1289221
				Sample Matrix	Soil	Soil	Soil	Soil
				Sample Type				
				Sampling Date	2017-03-30	2017-03-30	2017-03-30	2017-03-30
				Sample I.D.	BH17-19 sa2 5-7	BH17-29 sa2 5-7	BH17-37 sa2 5-7	BH17-47 sa2 5-7
Group	**Analyte**	**MRL**	**Units**	**Guideline**				
Agri. - Soil	pH	2.0			8.0	8.0	8.0	8.1
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.22	0.19	0.20	0.19
	Resistivity	1	ohm-cm		4540	5260	5000	5260
	SO4	0.01	%		<0.01	<0.01	<0.01	<0.01
Subcontract	Cl	0.002	%		<0.002	0.003	0.002	<0.002

				Lab I.D.	1289222
				Sample Matrix	Soil
				Sample Type	
				Sampling Date	2017-03-30
				Sample I.D.	BH17-57 sa2 5-7
Group	**Analyte**	**MRL**	**Units**	**Guideline**	
Agri. - Soil	pH	2.0			8.0
General Chemistry	Electrical Conductivity	0.05	mS/cm		0.16
	Resistivity	1	ohm-cm		6250
	SO4	0.01	%		<0.01
Subcontract	Cl	0.002	%		<0.002

Guideline = *** = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURE 2 TO 11 - SLOPE STABILITY ANALYSIS SECTIONS

FIGURE 12 - TEST FILL PILE SETTLEMENT MONITORING PROGRAM DRAWING

DRAWING PG5036-1 - TEST HOLE LOCATION PLAN

DRAWING PG5036-2 - PERMISSIBLE GRADE RAISE PLAN

DRAWING PG5036-3 - TREE PLANTING SETBACK RECOMMENDATION

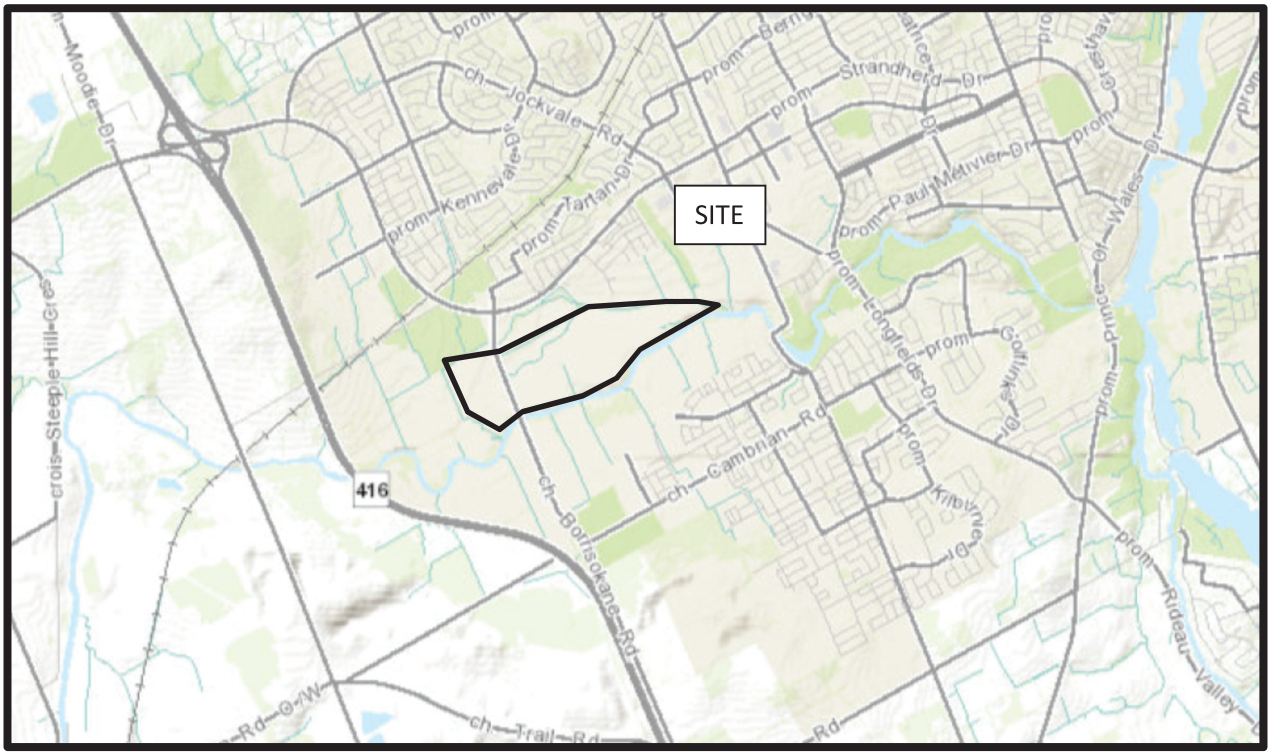


FIGURE 1

KEY PLAN

Figure 2 - Section A - Static Analysis

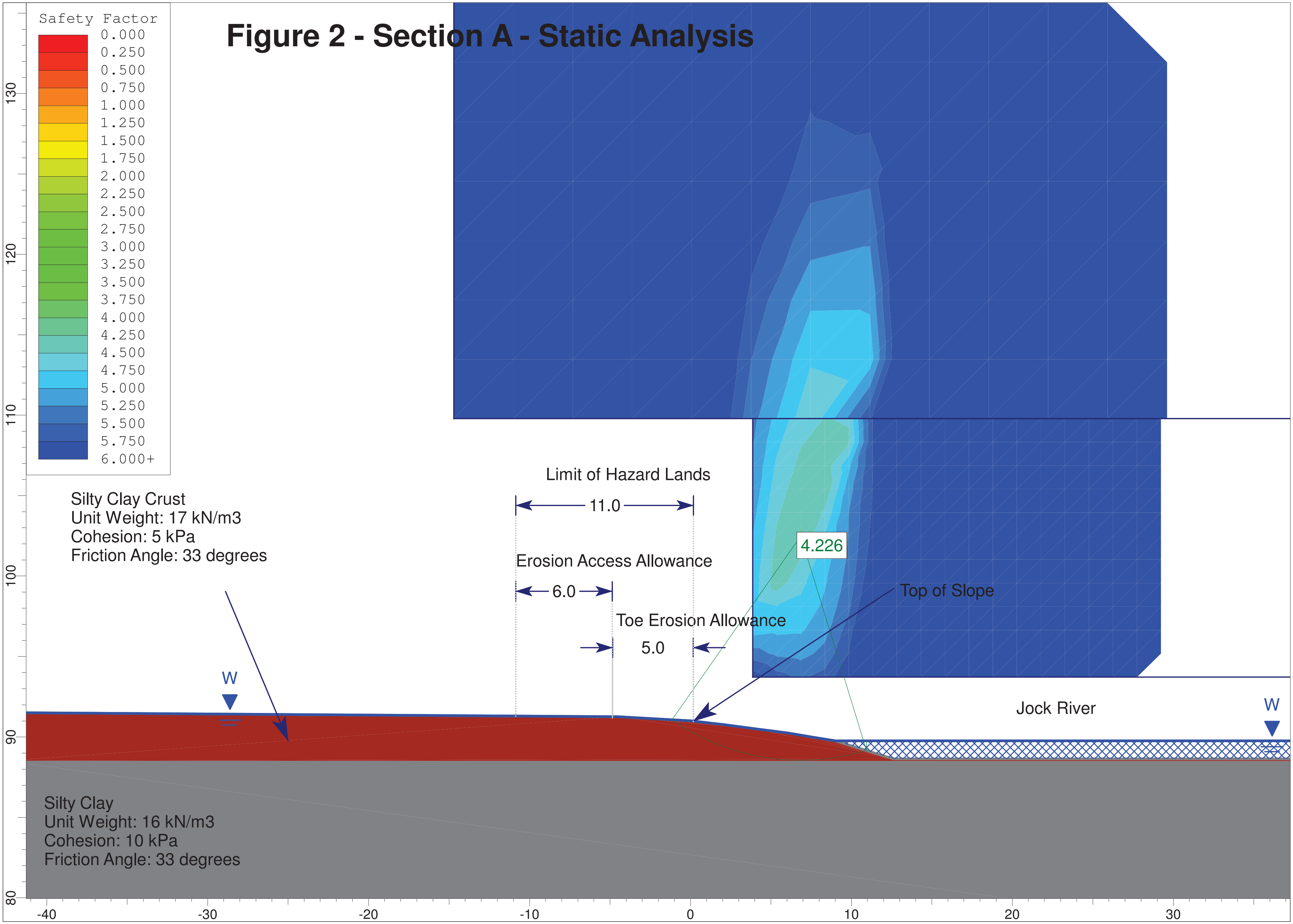


Figure 3 - Section A - Seismic Analysis

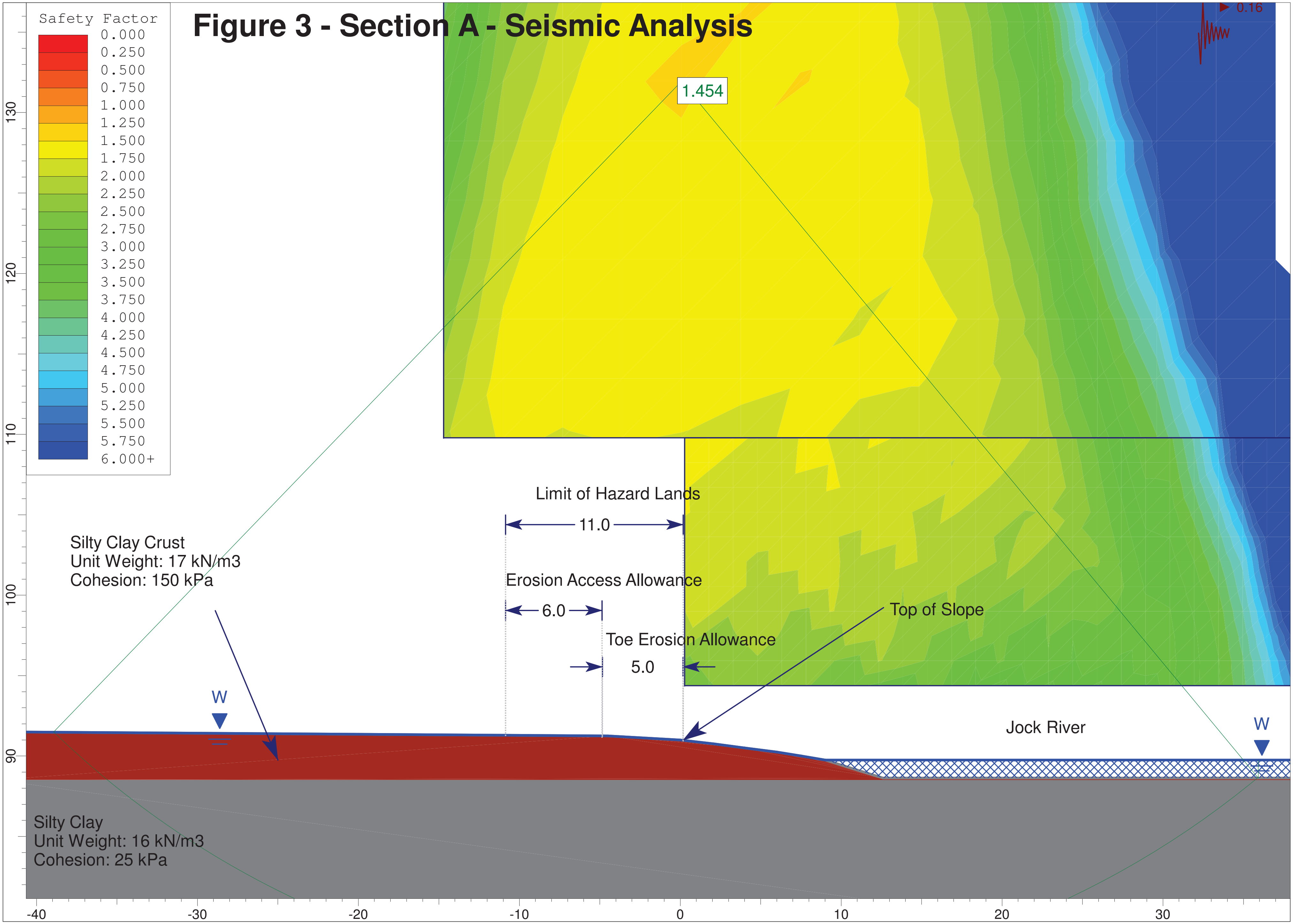


Figure 4 - Section B - Static Analysis

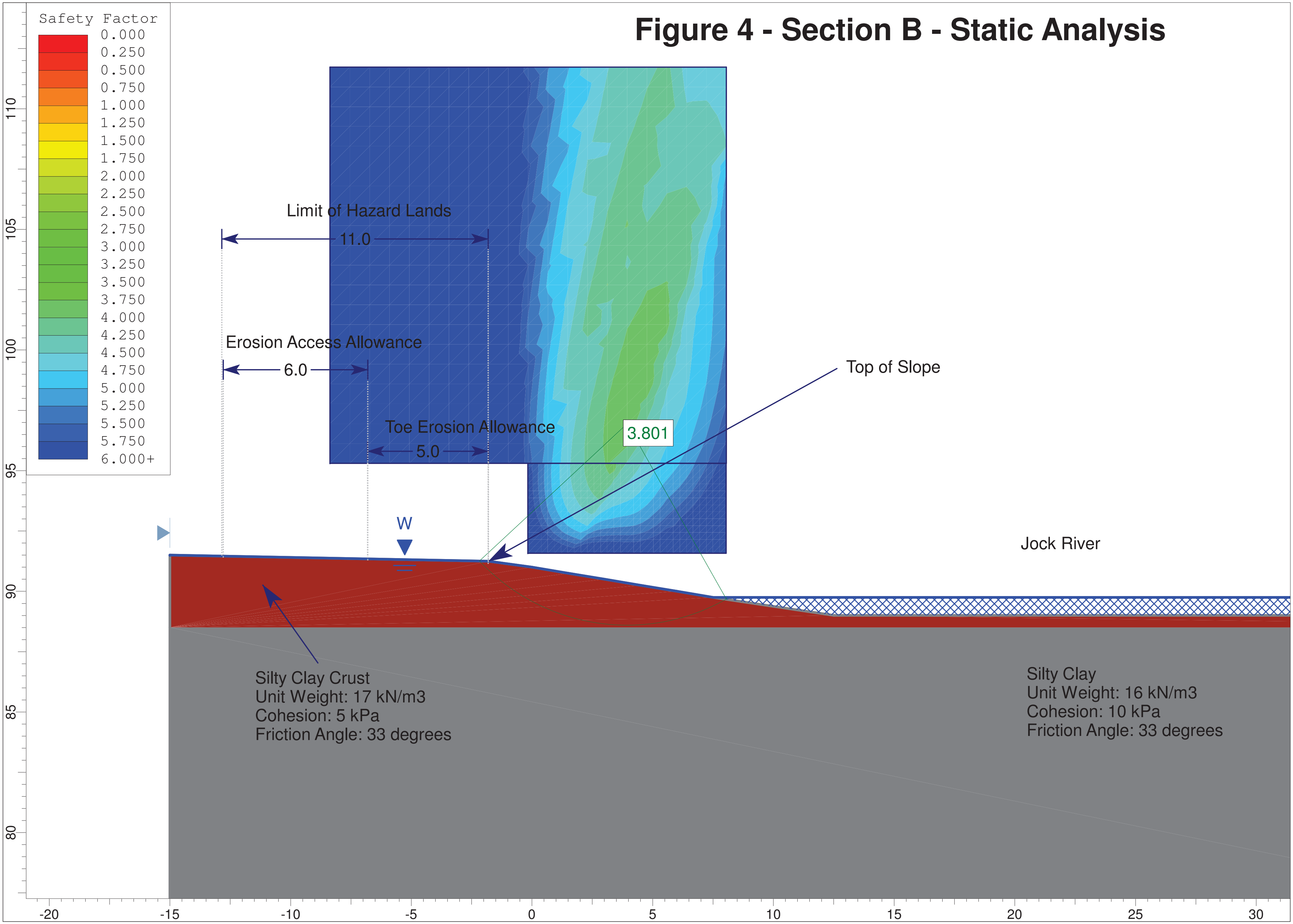
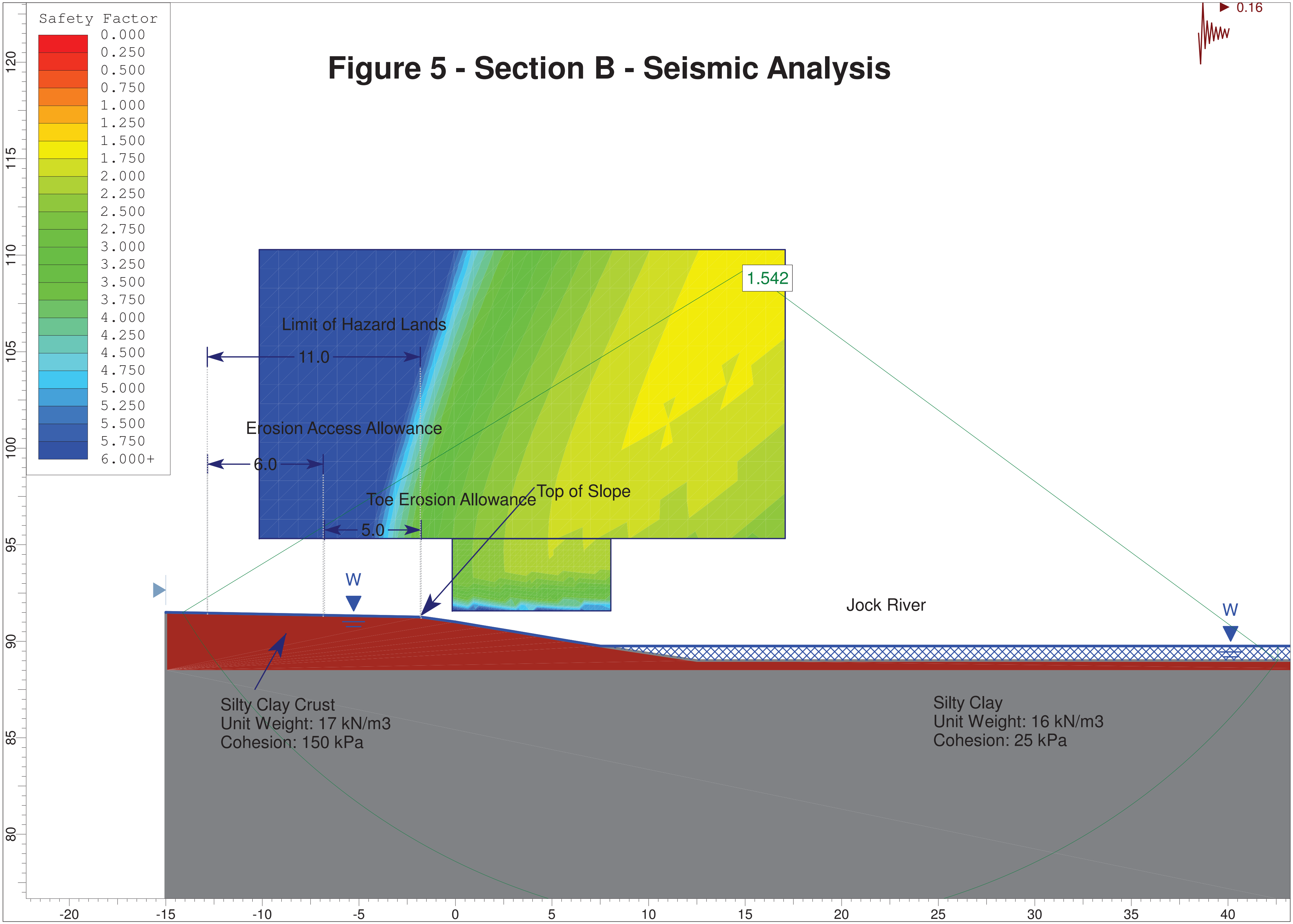


Figure 5 - Section B - Seismic Analysis



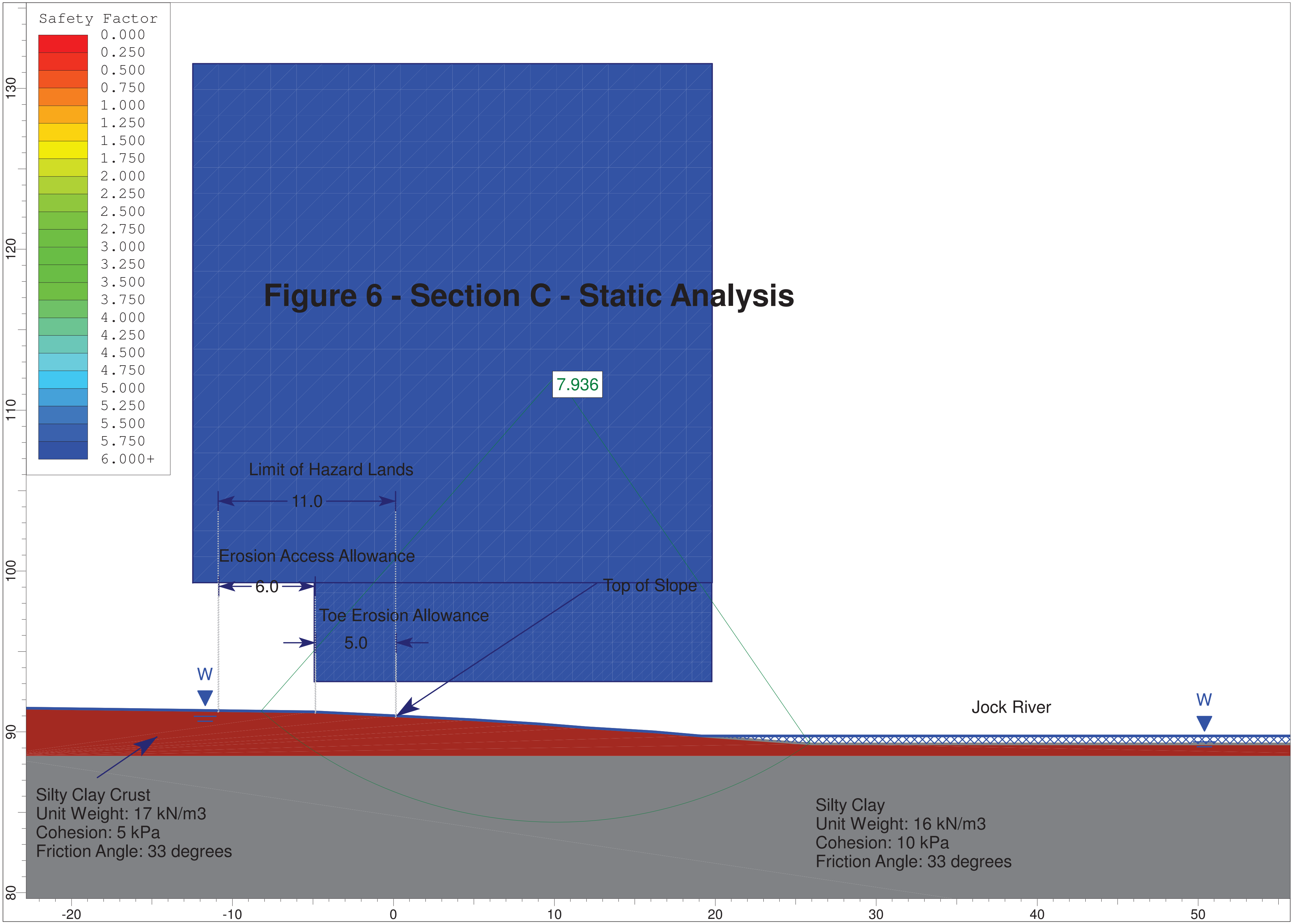


Figure 6 - Section C - Static Analysis

Figure 7 - Section C - Seismic Analysis

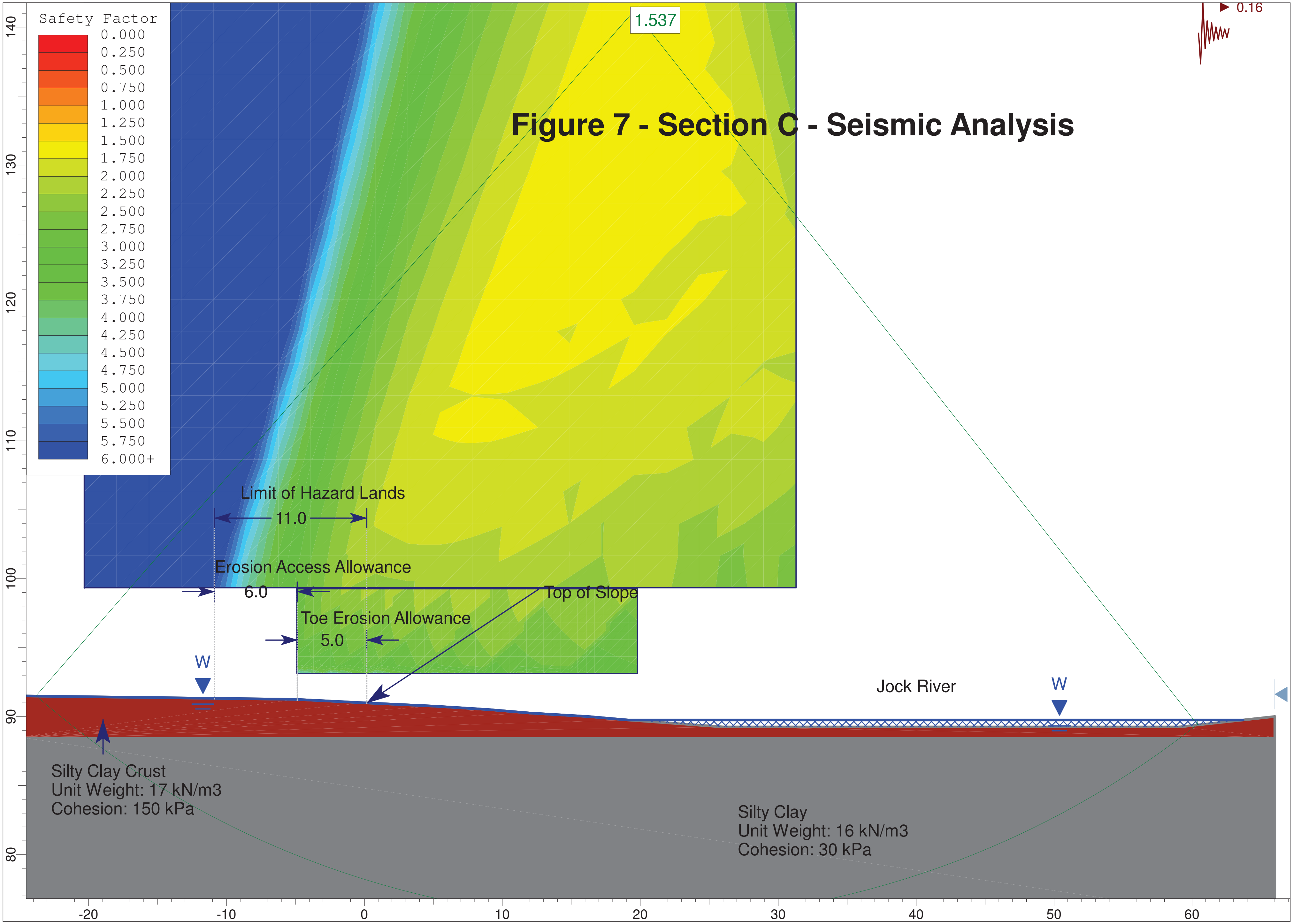
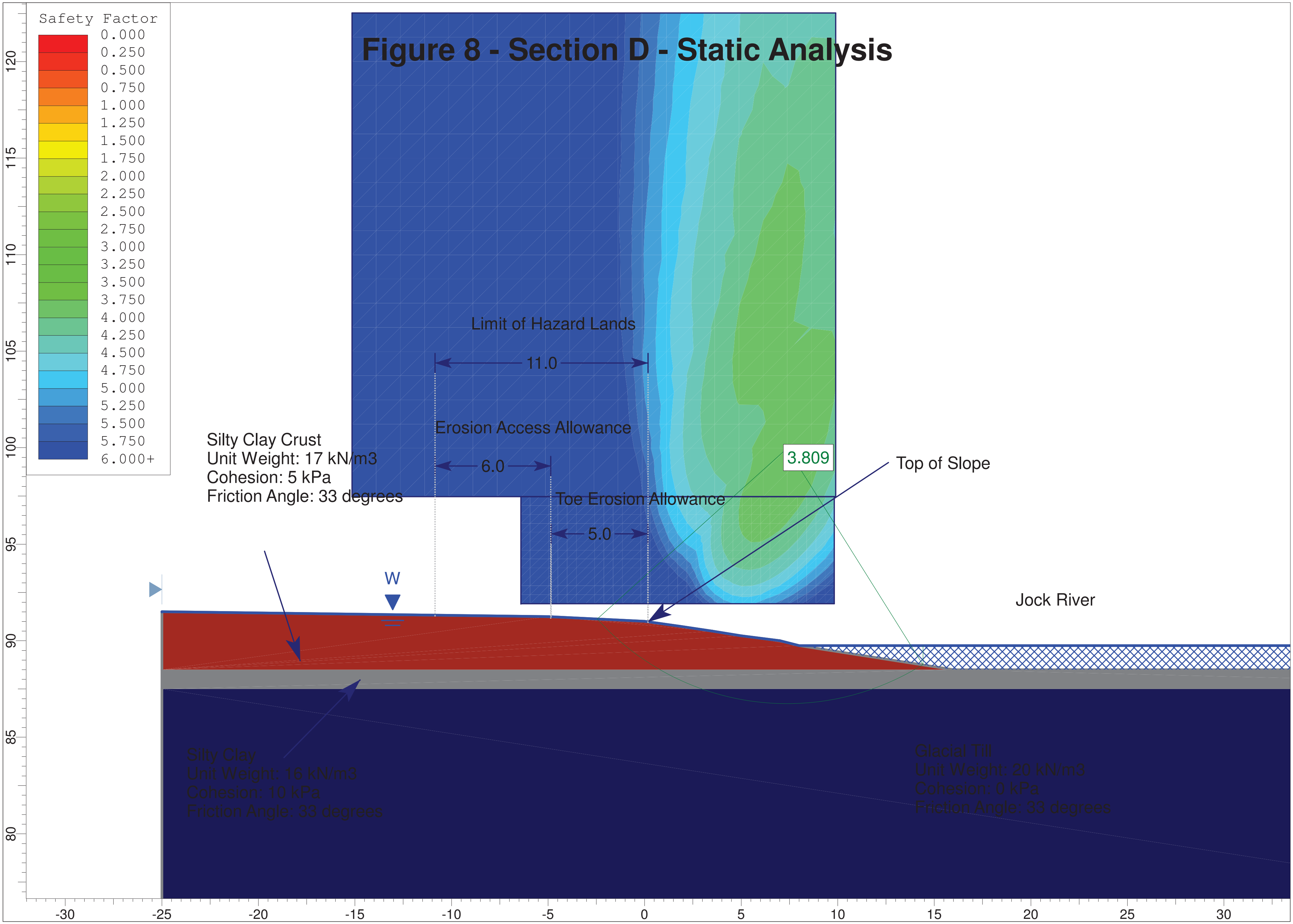


Figure 8 - Section D - Static Analysis



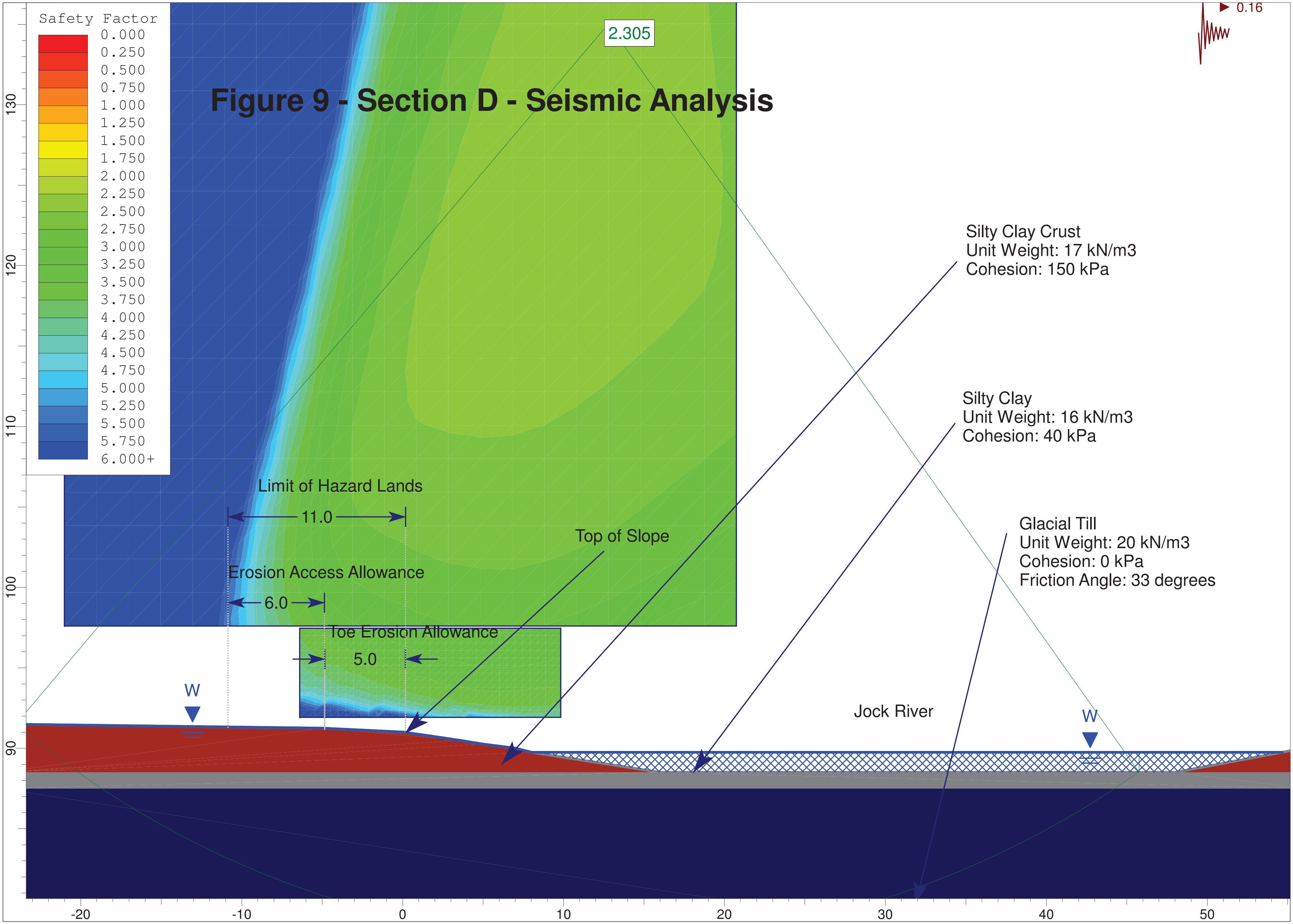


Figure 9 - Section D - Seismic Analysis

Limit of Hazard Lands

11.0

Erosion Access Allowance

6.0

Toe Erosion Allowance

5.0

Top of Slope

Silty Clay Crust
Unit Weight: 17 kN/m3
Cohesion: 150 kPa

Silty Clay
Unit Weight: 16 kN/m3
Cohesion: 40 kPa

Glacial Till
Unit Weight: 20 kN/m3
Cohesion: 0 kPa
Friction Angle: 33 degrees

Jock River

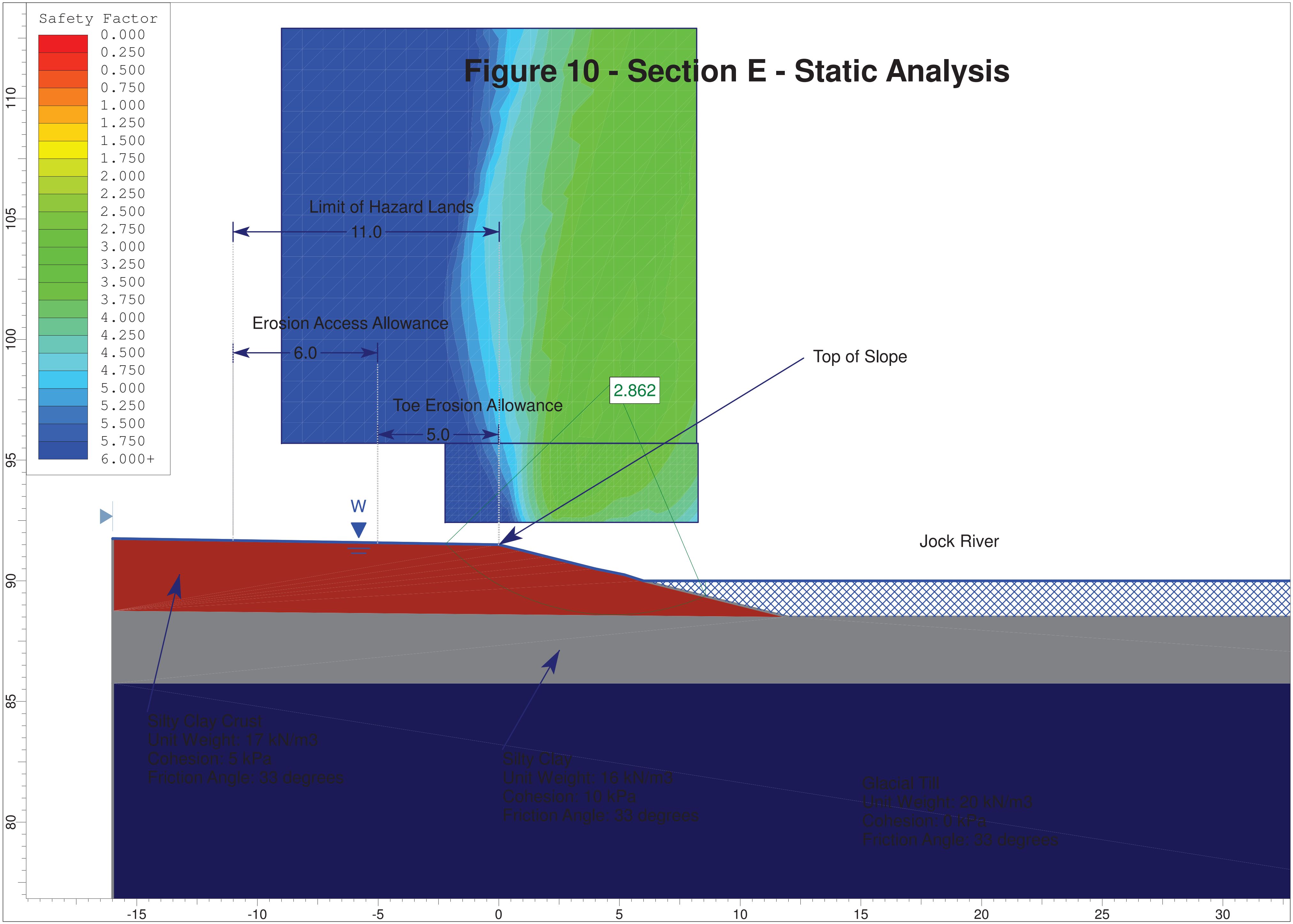


Figure 10 - Section E - Static Analysis

Figure 11 - Section E - Seismic Analysis

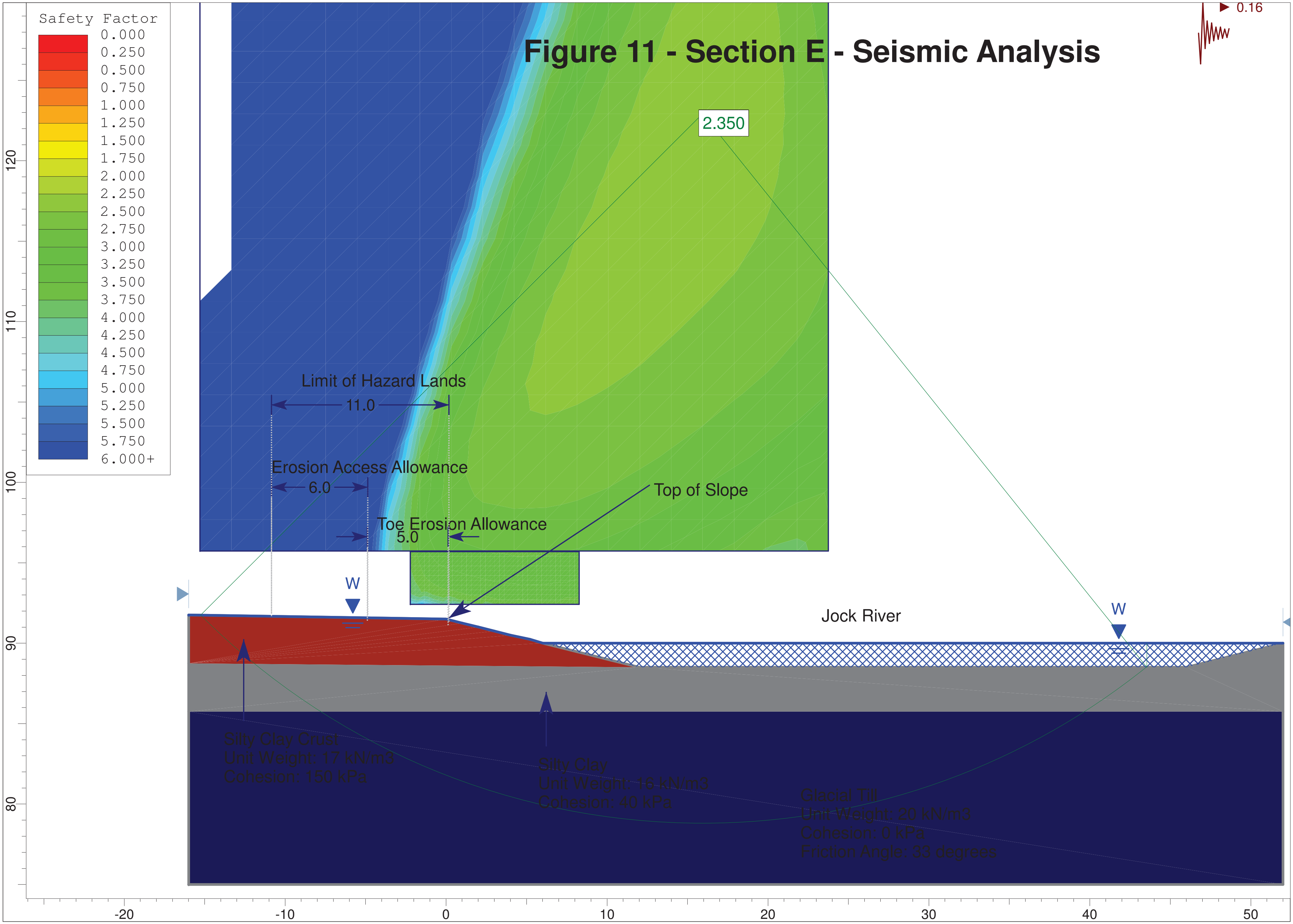
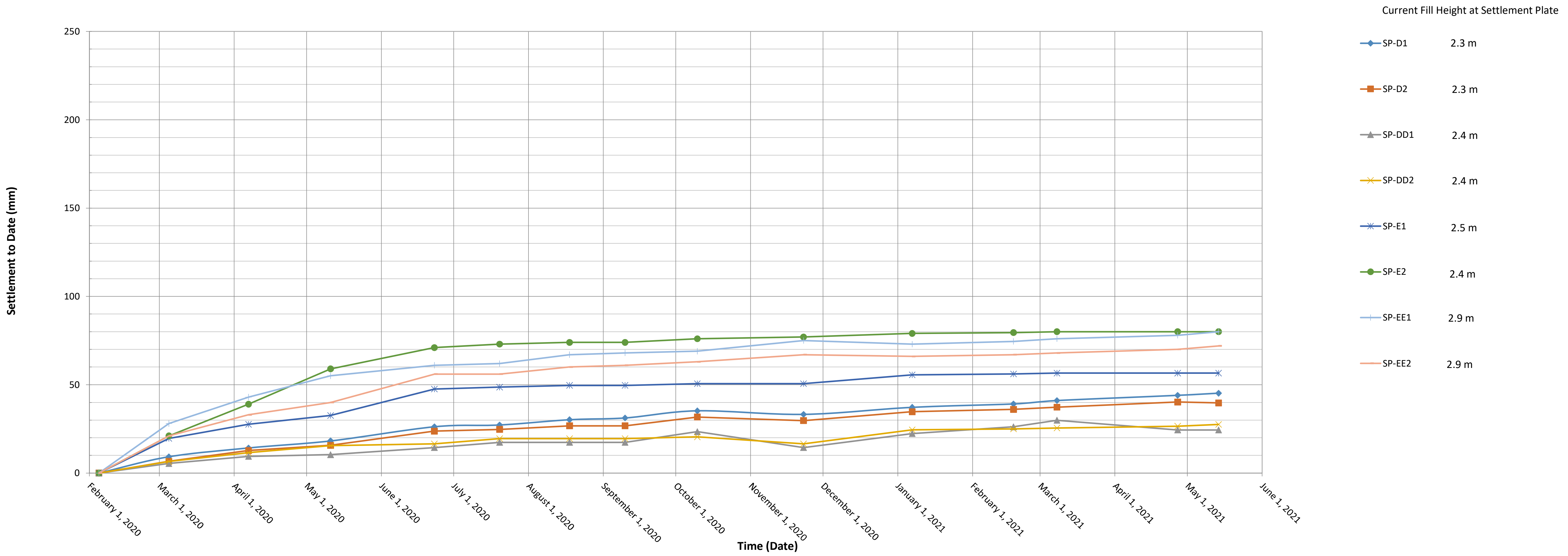
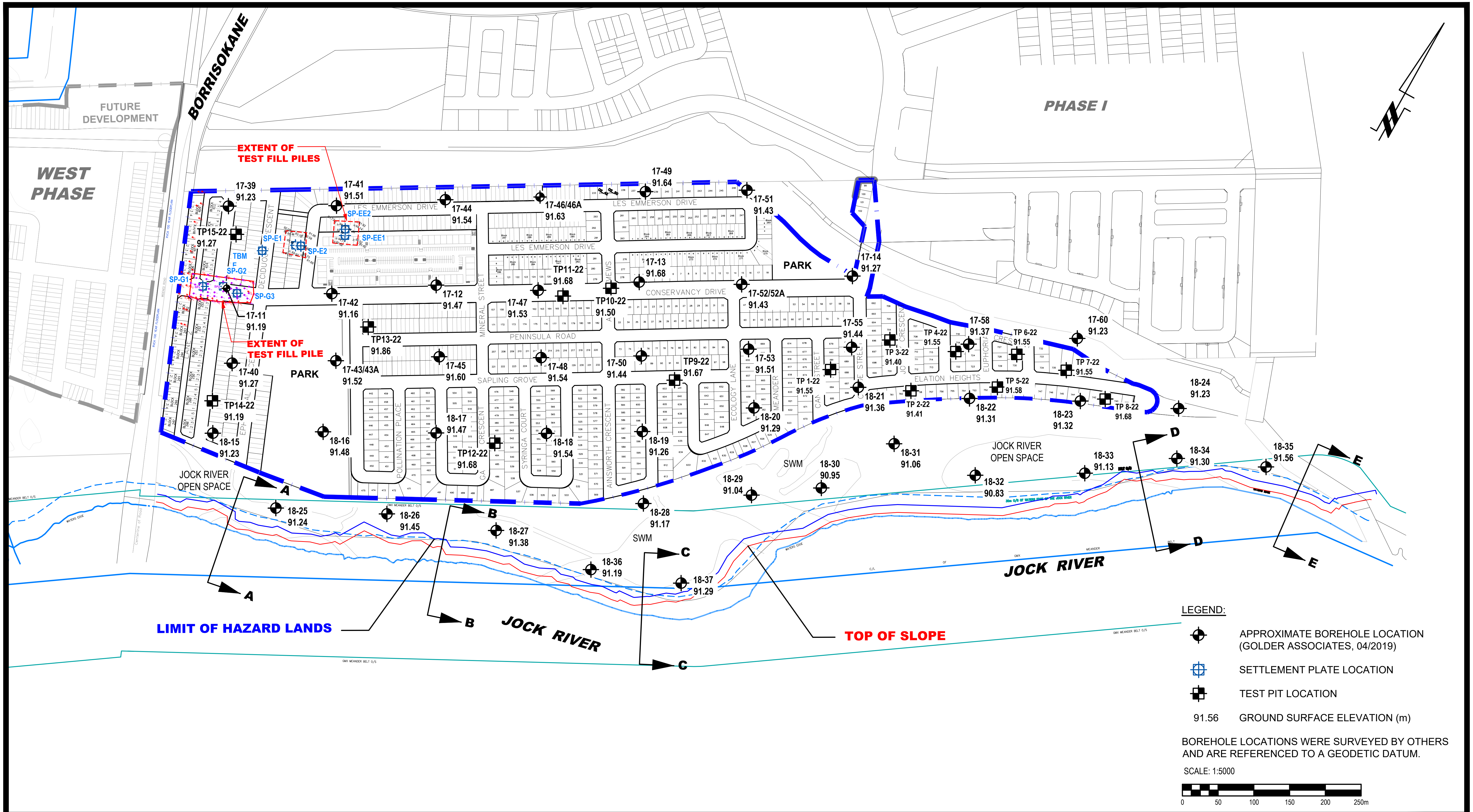


Figure 12 - Test Fill Pile Settlement Monitoring Program
Caivan - Conservancy Lands East - Borrisokane Road - Ottawa





LEGEND:

⌖	APPROXIMATE BOREHOLE LOCATION (GOLDER ASSOCIATES, 04/2019)
⌖	SETTLEMENT PLATE LOCATION
■	TEST PIT LOCATION
91.56	GROUND SURFACE ELEVATION (m)

BOREHOLE LOCATIONS WERE SURVEYED BY OTHERS AND ARE REFERENCED TO A GEODETIC DATUM.

SCALE: 1:5000

0 50 100 150 200 250m

PATERSON GROUP

9 AURIGA DRIVE
OTTAWA, ON
K2E 7T9
TEL: (613) 226-7381

NO.	REVISIONS	DATE	INITIAL
7	UPDATED TO LATEST CONCEPTUAL PLAN REVISED SITE BOUNDARIES	04/03/2024	KP
6	UPDATED TO LATEST CONCEPTUAL PLAN	07/12/2022	DJG
5	SURCHARGE PILE ADDED TO PLAN SETTLEMENT PLATES SP-G1 - SP-G3 ADDED TO PLAN	14/07/2022	OC
4	SURCHARGE PILE ADDED TO PLAN SETTLEMENT PLATES SP-F1 - SP-F6 ADDED TO PLAN	01/02/2022	OC
3	REVISED CONCEPTUAL PLAN	17/07/2021	OC

CAIVAN COMMUNITIES

GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - CONSERVANCY LANDS EAST
OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:5000
Date: 09/2019
Drawn by: RCG
Report No.: PG5036-1
Checked by: OC
Dwg. No.: PG5036-1
Approved by: DJG
Revision No.: 7

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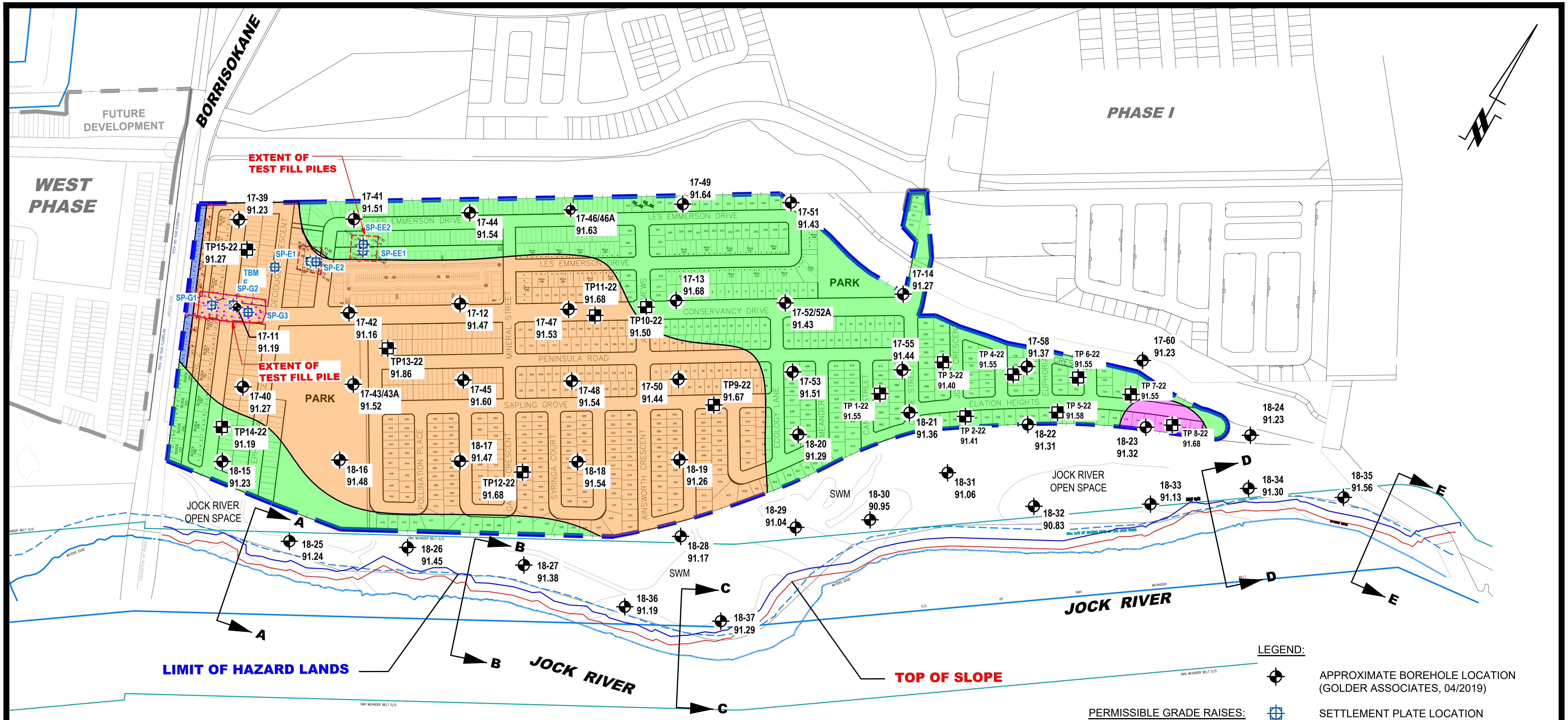
11x17



LEGEND:

⊕	APPROXIMATE BOREHOLE LOCATION (GOLDER ASSOCIATES, 04/2019)
⌖	SETTLEMENT PLATE LOCATION
▣	TEST PIT LOCATION
91.56	GROUND SURFACE ELEVATION (m)

BOREHOLE LOCATIONS WERE SURVEYED BY OTHERS AND ARE REFERENCED TO A GEODETIC DATUM.

SCALE: 1:5000

0 50 100 150 200 250m

PERMISSIBLE GRADE RAISES:

🟦	UP TO 1.4m
🟧	UP TO 1.6m
🟩	UP TO 1.8m
🟦	UP TO 2.0m
🟪	UP TO 2.2m

PATERSON GROUP

9 AURIGA DRIVE
OTTAWA, ON
K2E 7T9
TEL: (613) 226-7381

NO.	REVISIONS	DATE	INITIAL
6	UPDATED TO LATEST CONCEPTUAL PLAN REVISED SITE BOUNDARIES	04/03/2024	KP
5	TP 1-22 - TP 8-22 ADDED TO PLAN	19/10/2022	KP
4	UPDATED TO LATEST CONCEPTUAL PLAN	07/17/2022	DJG
3	REVISED CONCEPTUAL PLAN ADDED TEST FILL PILES	14/07/2021	OC
2	REVISED CONCEPTUAL PLAN ADDED TEST FILL PILES	04/02/2021	OC

CAIVAN COMMUNITIES

GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - CONSERVANCY LANDS EAST
OTTAWA, ONTARIO

Title:

PERMISSIBLE GRADE RAISE PLAN

Scale: 1:5000
Date: 09/2019
Drawn by: NFRV
Report No.: PG5036-1
Checked by: OC
Dwg. No.: PG5036-2
Approved by: DJG
Revision No.: 6

11x17

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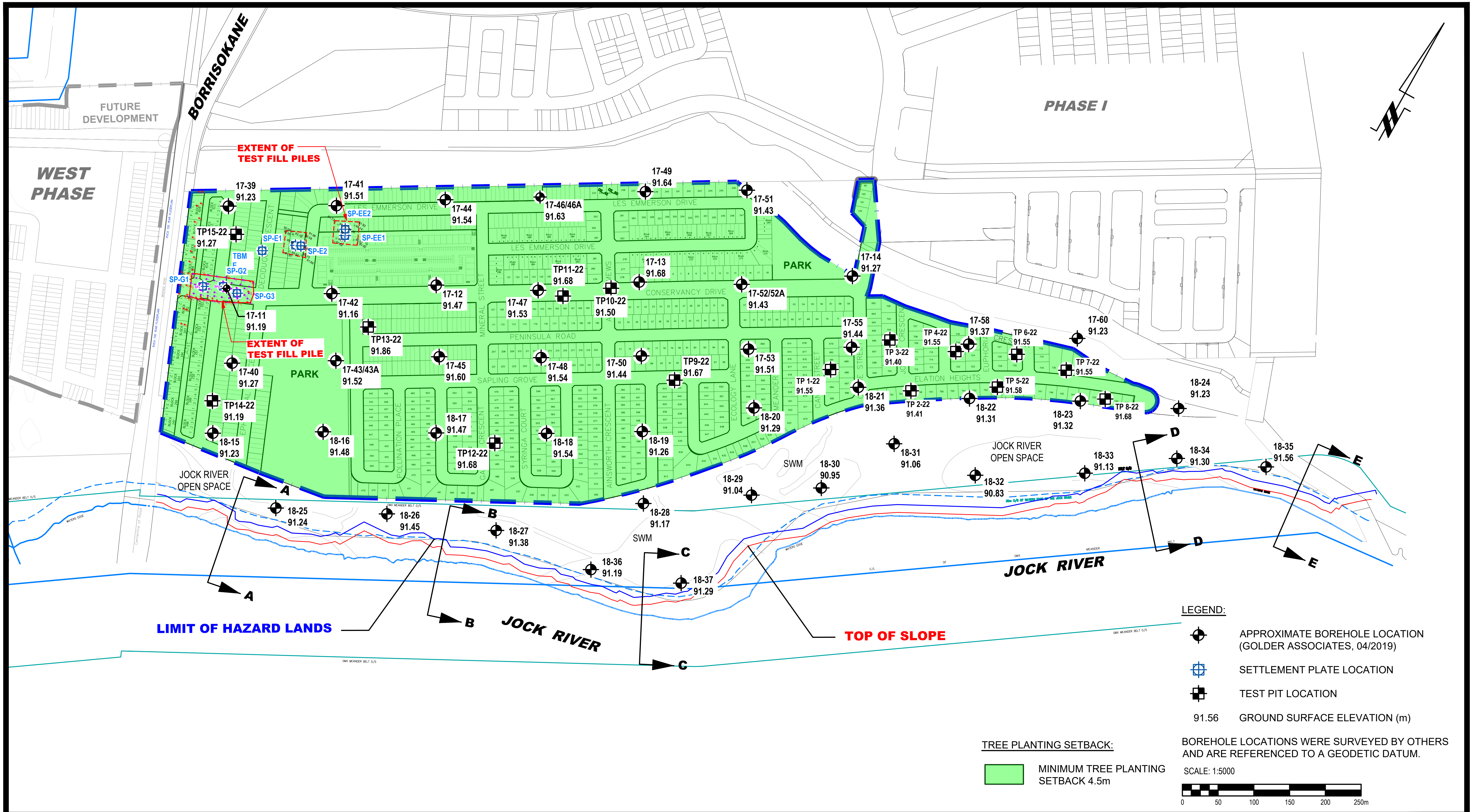

LEGEND:

⌖ APPROXIMATE BOREHOLE LOCATION (GOLDER ASSOCIATES, 04/2019)

⊕ SETTLEMENT PLATE LOCATION

■ TEST PIT LOCATION

91.56 GROUND SURFACE ELEVATION (m)

BOREHOLE LOCATIONS WERE SURVEYED BY OTHERS AND ARE REFERENCED TO A GEODETIC DATUM.

SCALE: 1:5000

0 50 100 150 200 250m

TREE PLANTING SETBACK:

🟩 MINIMUM TREE PLANTING SETBACK 4.5m

PATERSON GROUP

9 AURIGA DRIVE
OTTAWA, ON
K2E 7T9
TEL: (613) 226-7381

NO.	REVISIONS	DATE	INITIAL
6	UPDATED TO LATEST CONCEPTUAL PLAN REVISED SITE BOUNDARIES	04/03/2024	KP
5	TP 1-22 - TP 8-22 ADDED TO PLAN	19/10/2022	KP
4	SURCHARGE PILES ADDED TO PLAN SETTLEMENT PLATES SP-F1 - SP-F6 ADDED TO PLAN	01/02/2022	OC
3	REVISED CONCEPTUAL PLAN	14/02/2021	OC
2	REVISED CONCEPTUAL PLAN ADDED TEST FILL PILES	04/02/2021	OC

CAIVAN COMMUNITIES

GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - CONSERVANCY LANDS EAST
OTTAWA, ONTARIO

Title:

TREE PLANTING SETBACK PLAN

Scale: 1:5000
Date: 09/2019
Drawn by: RCG
Report No.: PG5036-1
Checked by: OC
Dwg. No.: PG5036-3
Approved by: DJG
Revision No.: 6

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11x17

APPENDIX 3

RETAINING WALL GLOBAL STABILITY ANALYSIS

Slope stability analysis

Input data (Construction stage 1)

Project

Settings

Canadian Highway and Bridge Design Code

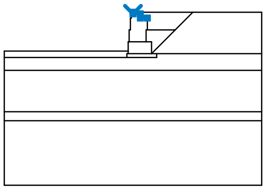
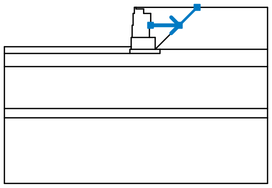
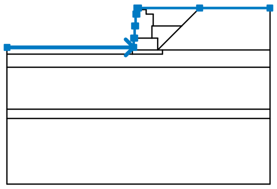
Stability analysis

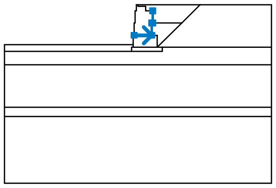
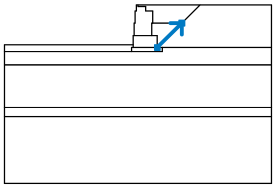
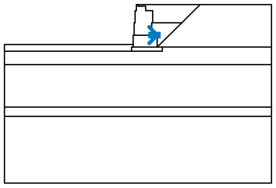
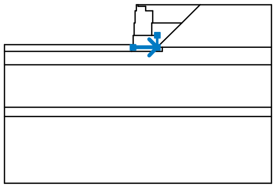
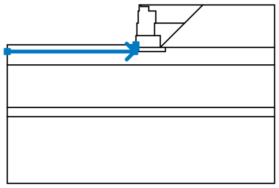
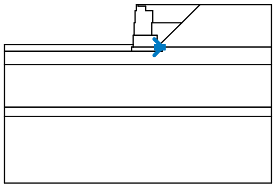
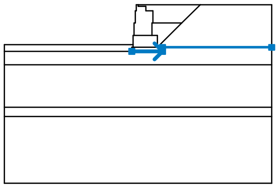
Verification methodology : according to LRFD
Earthquake analysis : Standard

Load factors					
Design situation - Service I					
		Minimum		Maximum	
Earth surcharge load (permanent) :	ES =	1.00	[–]	1.00	[–]
Live load surcharge :	LL =	0.00	[–]	1.00	[–]

Resistance factors			
Design situation - Service I			
Resistance factor on stability :	φ_{SS} =	0.65	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	0.00	-0.13	0.58	-0.13
		0.58	-0.46	1.11	-0.46		
2		1.11	-1.37	3.28	-1.37	4.65	0.00
3		-10.00	-3.00	-0.37	-3.00	-0.37	-2.29
		-0.29	-2.29	-0.29	-1.37	-0.21	-1.37
		-0.21	-0.46	-0.13	-0.46	-0.13	0.00
		0.00	0.00	4.65	0.00	10.00	0.00

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		-0.29	-2.29	1.03	-2.29	1.03	-1.37
		1.11	-1.37	1.11	-0.46		
5		1.45	-3.20	3.28	-1.37		
6		1.03	-2.29	1.45	-2.29		
7		-0.37	-3.20	1.45	-3.20	1.45	-2.29
8		-10.00	-3.50	-0.47	-3.50	-0.47	-3.20
		-0.37	-3.20	-0.37	-3.00		
9		1.45	-3.20	1.83	-3.20		
10		-0.47	-3.50	1.83	-3.50	1.83	-3.20
		10.00	-3.20				

No.	Interface location	Coordinates of interface points [m]					
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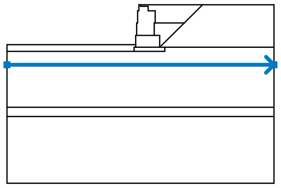
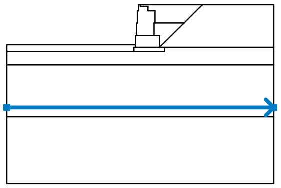
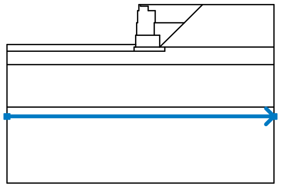
11		-10.00	-4.50	10.00	-4.50		
12		-10.00	-7.70	10.00	-7.70		
13		-10.00	-8.40	10.00	-8.40		

Soil parameters - effective stress state

No.	Name	Pattern	ϕ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Granular B Type II	▨	36.00	0.00	22.00
2	Silty Clay	▨	33.00	5.00	18.00
3	Grey Silty Clay	▨	33.00	5.00	17.00
4	Glacial Till	▨	33.00	1.00	22.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Granular B Type II	▨	22.00		

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
2	Silty Clay	▨	18.00		
3	Grey Silty Clay	▨	17.00		
4	Glacial Till	▨	22.00		

Soil parameters

Granular B Type II
Unit weight : γ = 22.00 kN/m³
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m³

Silty Clay
Unit weight : γ = 18.00 kN/m³
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 18.00 kN/m³

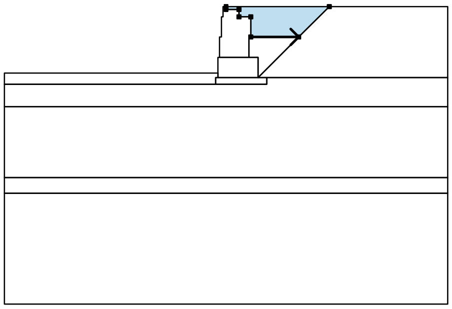
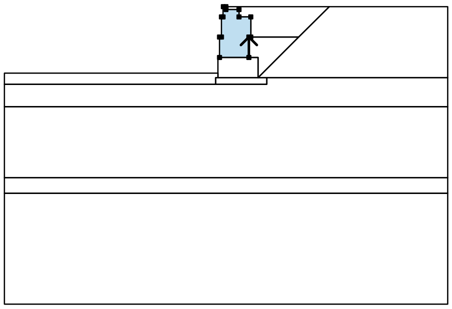
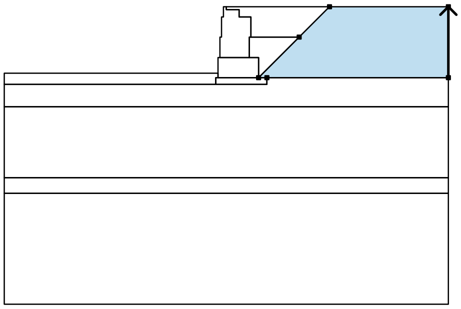
Grey Silty Clay
Unit weight : γ = 17.00 kN/m³
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m³

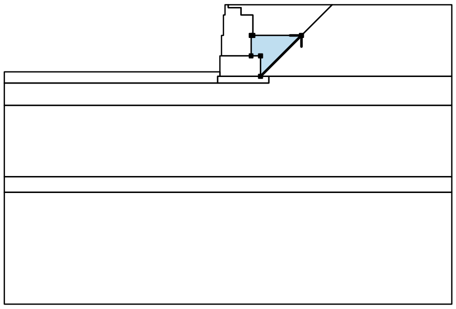
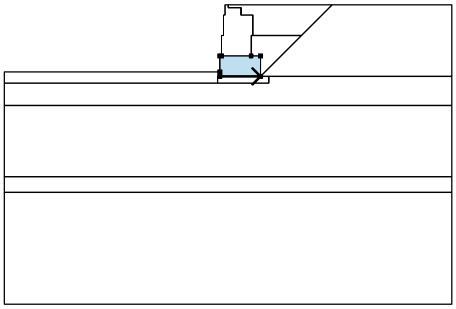
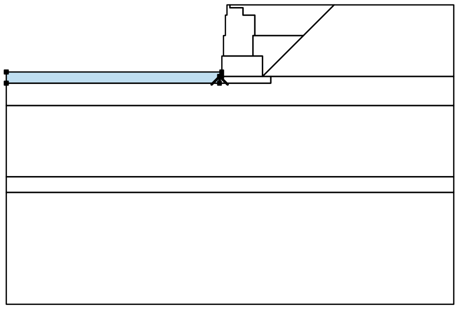
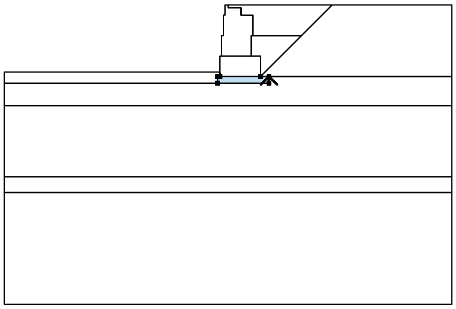
Glacial Till
Unit weight : γ = 22.00 kN/m³
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 1.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m³

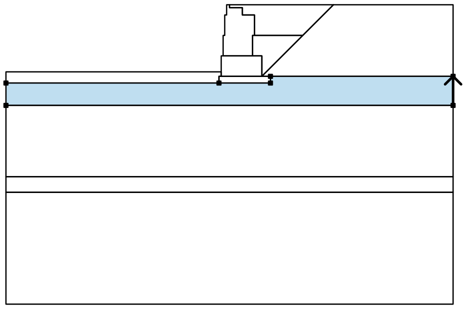
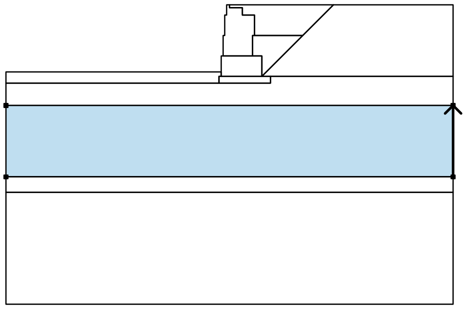
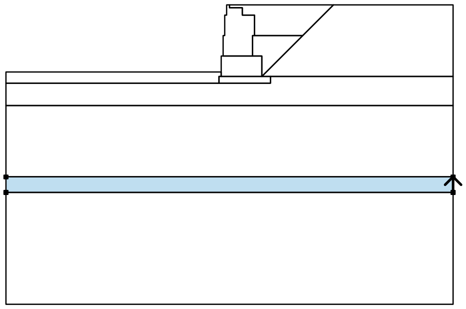
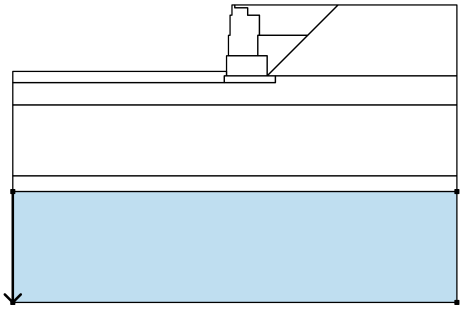
Rigid Bodies

No.	Name	Sample	γ [kN/m³]
1	Material of structure	🟥	18.85
2	Foundation	🟥	25.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		1.11	-1.37	3.28	-1.37	Granular B Type II ▨
		4.65	0.00	0.00	0.00	
		0.00	-0.13	0.58	-0.13	
		0.58	-0.46	1.11	-0.46	
2		1.03	-2.29	1.03	-1.37	Material of structure 🟥
		1.11	-1.37	1.11	-0.46	
		0.58	-0.46	0.58	-0.13	
		0.00	-0.13	0.00	0.00	
		-0.13	0.00	-0.13	-0.46	
		-0.21	-0.46	-0.21	-1.37	
		-0.29	-1.37	-0.29	-2.29	
3		10.00	-3.20	10.00	0.00	Silty Clay 🟫
		4.65	0.00	3.28	-1.37	
		1.45	-3.20	1.83	-3.20	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
4		1.45	-3.20	3.28	-1.37	Granular B Type II ▨
		1.11	-1.37	1.03	-1.37	
		1.03	-2.29	1.45	-2.29	
5		-0.37	-3.20	1.45	-3.20	Material of structure 🟥
		1.45	-2.29	1.03	-2.29	
		-0.29	-2.29	-0.37	-2.29	
		-0.37	-3.00			
6		-0.47	-3.50	-0.47	-3.20	Silty Clay 🟫
		-0.37	-3.20	-0.37	-3.00	
		-10.00	-3.00	-10.00	-3.50	
7		1.83	-3.50	1.83	-3.20	Foundation 🟥
		1.45	-3.20	-0.37	-3.20	
		-0.47	-3.20	-0.47	-3.50	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
8		10.00	-4.50	10.00	-3.20	Silty Clay
		1.83	-3.20	1.83	-3.50	▨
		-0.47	-3.50	-10.00	-3.50	
		-10.00	-4.50			
9		10.00	-7.70	10.00	-4.50	Grey Silty Clay
		-10.00	-4.50	-10.00	-7.70	▨
10		10.00	-8.40	10.00	-7.70	Glacial Till
		-10.00	-7.70	-10.00	-8.40	▨
11		-10.00	-8.40	-10.00	-13.40	Glacial Till
		10.00	-13.40	10.00	-8.40	▨

Surcharge

No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	q_2, z	unit
1	strip	permanent	on terrain	x = 1.53	l = 8.00		0.00	17.50		kN/m2

Surcharges

No.	Name
1	Traffic

Water

Water type : No water

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : Service I

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-0.77	[m]	Angles :	α_1 =	-39.92	[°]
	z =	0.95	[m]		α_2 =	79.37	[°]
Radius :	R =	5.15	[m]				
The slip surface after optimization.							

Total weight of soil above the slip surface: 341.00 kN/m

Slope stability verification (Bishop)

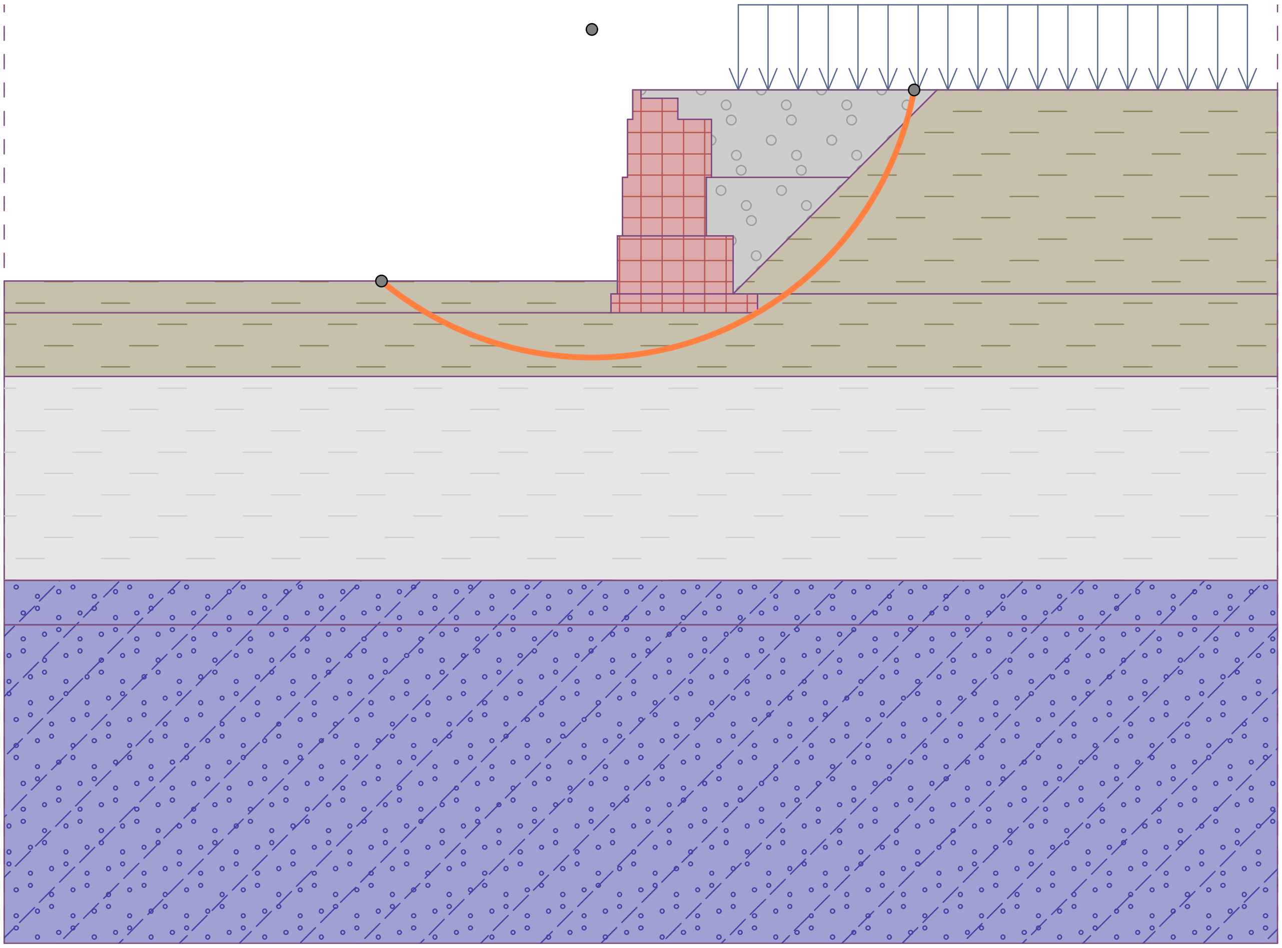
Sum of active forces : F_a = 152.53 kN/m
Sum of passive forces : F_p = 313.47 kN/m
Factor of Safety: FS = 2.0

Sliding moment : M_a = 785.55 kNm/m
Resisting moment : M_p = 1049.34 kNm/m
Utilization : 74.9 %

Capacity demand ratio CDR: 1.336

Slope stability ACCEPTABLE

Name : Analysis | **Stage - analysis : 1 - 1**



Slope stability analysis

Input data (Construction stage 1)

Project

Settings

Canadian Highway and Bridge Design Code

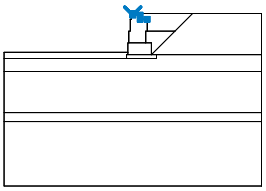
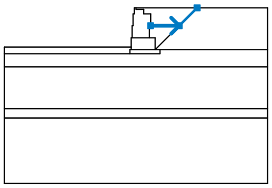
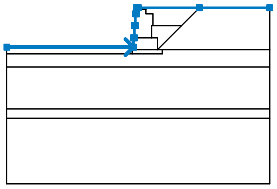
Stability analysis

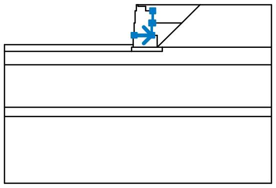
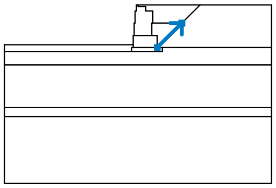
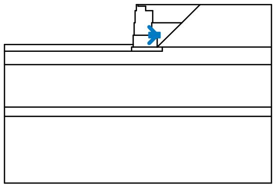
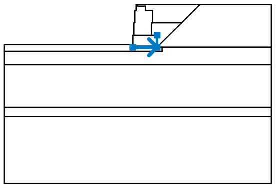
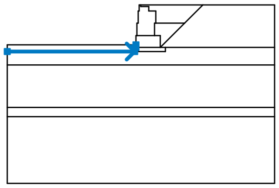
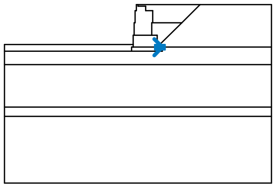
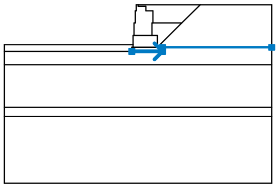
Verification methodology : according to LRFD
Earthquake analysis : Standard

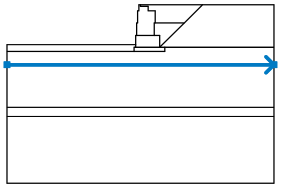
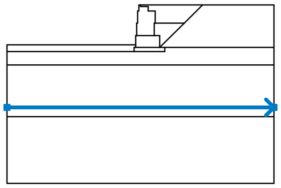
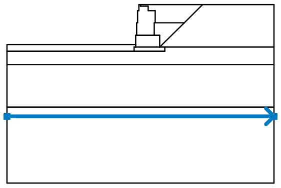
Load factors					
Design situation - Service I					
		Minimum		Maximum	
Earth surcharge load (permanent) :	ES =	1.00	[–]	1.00	[–]
Live load surcharge :	LL =	0.00	[–]	1.00	[–]

Resistance factors			
Design situation - Service I			
Resistance factor on stability :	φ_{SS} =	0.65	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	0.00	-0.13	0.58	-0.13
		0.58	-0.46	1.11	-0.46		
2		1.11	-1.37	3.28	-1.37	4.65	0.00
3		-10.00	-3.00	-0.37	-3.00	-0.37	-2.29
		-0.29	-2.29	-0.29	-1.37	-0.21	-1.37
		-0.21	-0.46	-0.13	-0.46	-0.13	0.00
		0.00	0.00	4.65	0.00	10.00	0.00

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		-0.29	-2.29	1.03	-2.29	1.03	-1.37
		1.11	-1.37	1.11	-0.46		
5		1.45	-3.20	3.28	-1.37		
6		1.03	-2.29	1.45	-2.29		
7		-0.37	-3.20	1.45	-3.20	1.45	-2.29
8		-10.00	-3.50	-0.47	-3.50	-0.47	-3.20
		-0.37	-3.20	-0.37	-3.00		
9		1.45	-3.20	1.83	-3.20		
10		-0.47	-3.50	1.83	-3.50	1.83	-3.20
		10.00	-3.20				

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
11		-10.00	-4.50	10.00	-4.50		
12		-10.00	-7.70	10.00	-7.70		
13		-10.00	-8.40	10.00	-8.40		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Granular B Type II	▨	36.00	0.00	22.00
2	Silty Clay	▨	33.00	5.00	18.00
3	Grey Silty Clay	▨	33.00	5.00	17.00
4	Glacial Till	▨	33.00	1.00	22.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Granular B Type II	▨	22.00		

No.	Name	Pattern	γ_{sat} $[kN/m^3]$	γ_s $[kN/m^3]$	n [–]
2	Silty Clay	▨	18.00		
3	Grey Silty Clay	▨	17.00		
4	Glacial Till	▨	22.00		

Soil parameters

Granular B Type II
Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Clay
Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

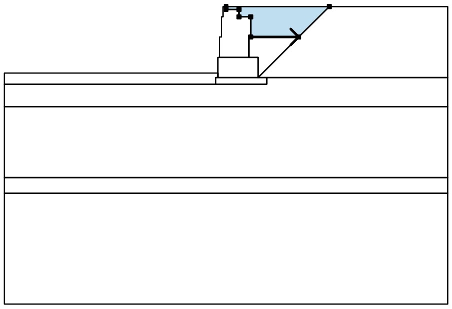
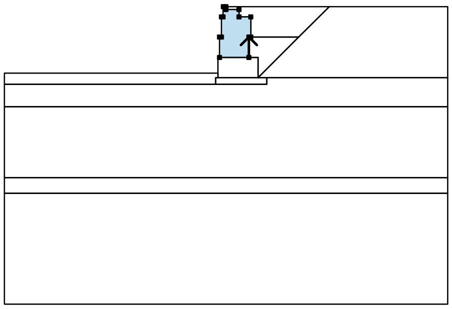
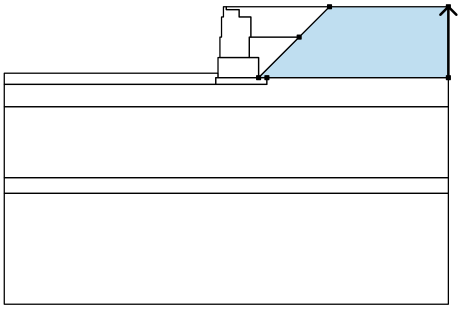
Grey Silty Clay
Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

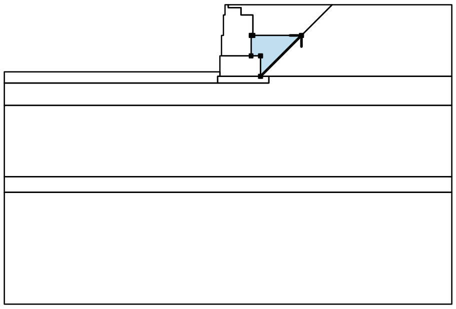
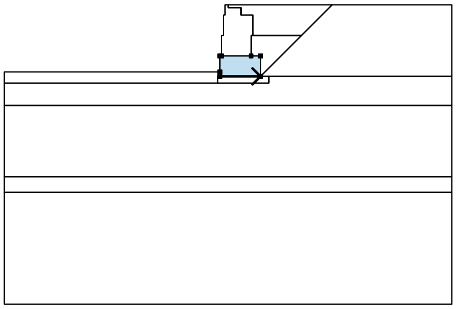
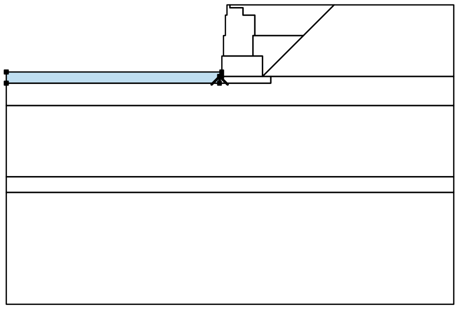
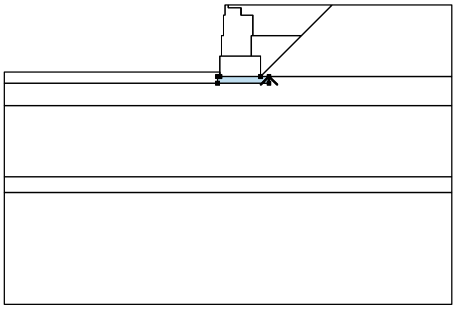
Glacial Till
Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 1.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

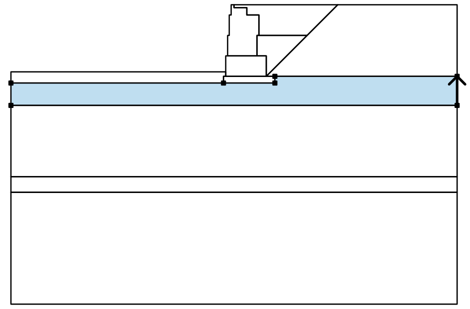
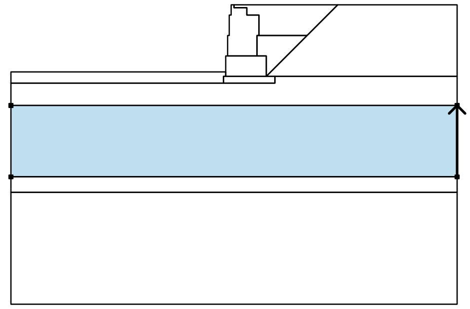
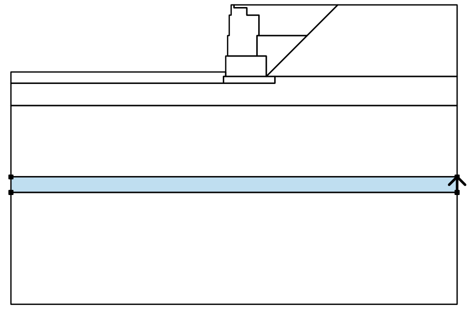
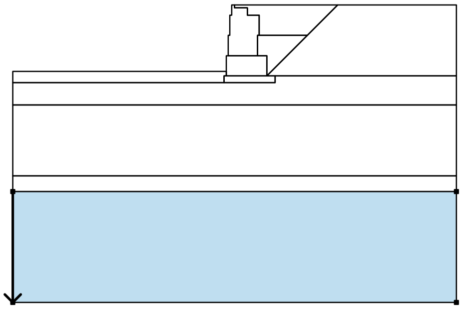
Rigid Bodies

No.	Name	Sample	γ [kN/m³]
1	Material of structure	🟥	18.85
2	Foundation	🟥	25.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		1.11	-1.37	3.28	-1.37	Granular B Type II
		4.65	0.00	0.00	0.00	▨
		0.00	-0.13	0.58	-0.13	
		0.58	-0.46	1.11	-0.46	
2		1.03	-2.29	1.03	-1.37	Material of structure
		1.11	-1.37	1.11	-0.46	🟥
		0.58	-0.46	0.58	-0.13	
		0.00	-0.13	0.00	0.00	
		-0.13	0.00	-0.13	-0.46	
		-0.21	-0.46	-0.21	-1.37	
		-0.29	-1.37	-0.29	-2.29	
3		10.00	-3.20	10.00	0.00	Silty Clay
		4.65	0.00	3.28	-1.37	🟫
		1.45	-3.20	1.83	-3.20	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
4		1.45	-3.20	3.28	-1.37	Granular B Type II
		1.11	-1.37	1.03	-1.37	
		1.03	-2.29	1.45	-2.29	▨
5		-0.37	-3.20	1.45	-3.20	Material of structure
		1.45	-2.29	1.03	-2.29	
		-0.29	-2.29	-0.37	-2.29	🟥
		-0.37	-3.00			
6		-0.47	-3.50	-0.47	-3.20	Silty Clay
		-0.37	-3.20	-0.37	-3.00	
		-10.00	-3.00	-10.00	-3.50	🟫
7		1.83	-3.50	1.83	-3.20	Foundation
		1.45	-3.20	-0.37	-3.20	
		-0.47	-3.20	-0.47	-3.50	🟥

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
8		10.00	-4.50	10.00	-3.20	Silty Clay ▨
		1.83	-3.20	1.83	-3.50	
		-0.47	-3.50	-10.00	-3.50	
		-10.00	-4.50			
9		10.00	-7.70	10.00	-4.50	Grey Silty Clay ▨
		-10.00	-4.50	-10.00	-7.70	
10		10.00	-8.40	10.00	-7.70	Glacial Till ▨
		-10.00	-7.70	-10.00	-8.40	
11		-10.00	-8.40	-10.00	-13.40	Glacial Till ▨
		10.00	-13.40	10.00	-8.40	

Surcharge

No.	Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F, x	q_2, z	unit
1	strip	permanent	on terrain	x = 1.53	l = 8.00		0.00	17.50		kN/m^2

Surcharges

No.	Name
1	Traffic

Water

Water type : No water

Tensile crack

Tensile crack not input.

Earthquake

Horizontal seismic coefficient : K_h = 0.1600
Vertical seismic coefficient : K_v = 0.0000

Settings of the stage of construction

Design situation : Service I

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-0.98	[m]	Angles :	α_1 =	-32.13	[°]
	z =	2.97	[m]		α_2 =	65.08	[°]
Radius :	R =	7.05	[m]				
The slip surface after optimization.							

Total weight of soil above the slip surface: 379.92 kN/m

Slope stability verification (Bishop)

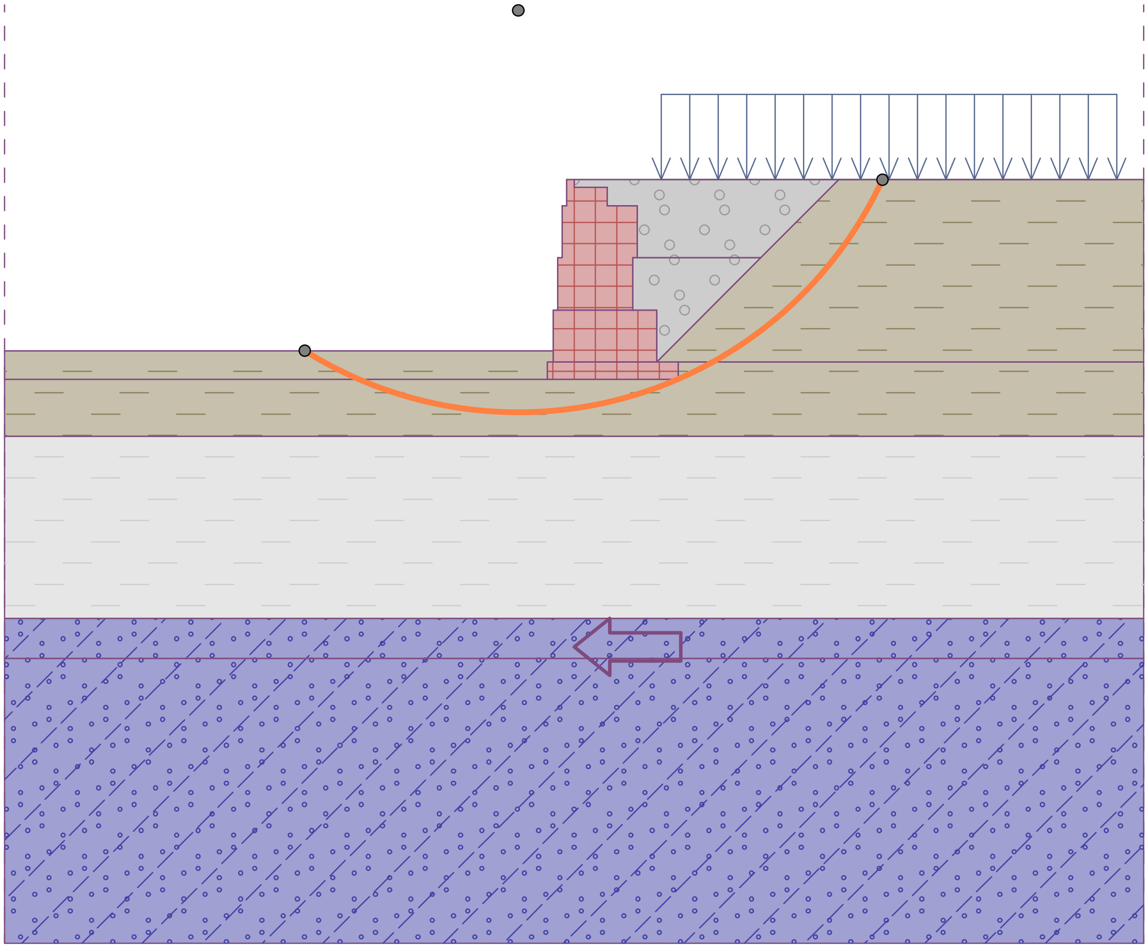
Sum of active forces : F_a = 211.44 kN/m
Sum of passive forces : F_p = 340.33 kN/m
Factory of Safety: FS = 1.6

Sliding moment : M_a = 1490.64 kNm/m
Resisting moment : M_p = 1559.56 kNm/m
Utilization : 95.6 %

Capacity demand ratio CDR: 1.046

Slope stability ACCEPTABLE

Name : Analysis **Stage - analysis : 1 - 1**



Slope stability analysis

Input data (Construction stage 1)

Project

Settings

Canadian Highway and Bridge Design Code

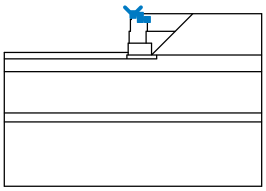
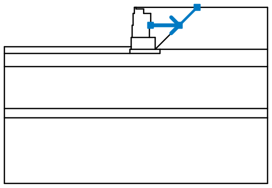
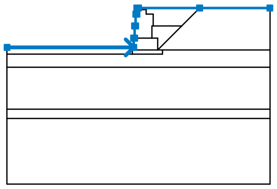
Stability analysis

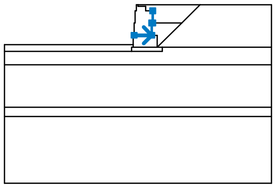
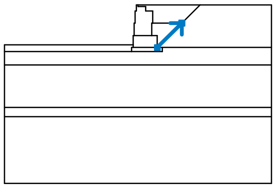
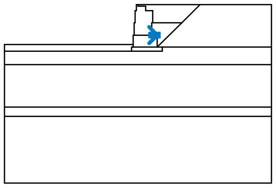
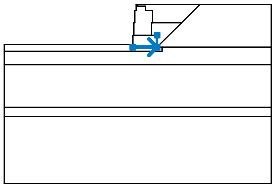
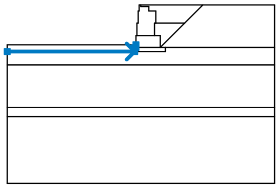
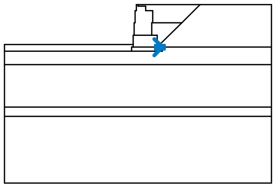
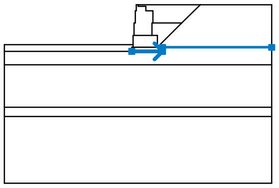
Verification methodology : according to LRFD
Earthquake analysis : Standard

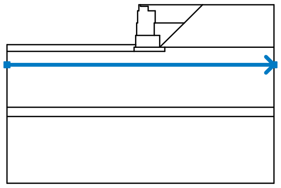
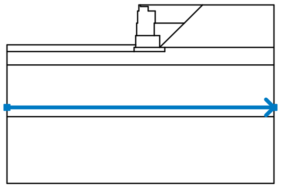
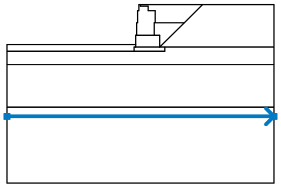
Load factors					
Design situation - Strength I					
		Minimum		Maximum	
Earth surcharge load (permanent) :	ES =	0.75	[–]	1.50	[–]
Live load surcharge :	LL =	0.00	[–]	1.75	[–]

Resistance factors			
Design situation - Strength I			
Resistance factor on stability :	φ_{SS} =	0.65	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	0.00	-0.13	0.58	-0.13
		0.58	-0.46	1.11	-0.46		
2		1.11	-1.37	3.28	-1.37	4.65	0.00
3		-10.00	-3.00	-0.37	-3.00	-0.37	-2.29
		-0.29	-2.29	-0.29	-1.37	-0.21	-1.37
		-0.21	-0.46	-0.13	-0.46	-0.13	0.00
		0.00	0.00	4.65	0.00	10.00	0.00

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		-0.29	-2.29	1.03	-2.29	1.03	-1.37
		1.11	-1.37	1.11	-0.46		
5		1.45	-3.20	3.28	-1.37		
6		1.03	-2.29	1.45	-2.29		
7		-0.37	-3.20	1.45	-3.20	1.45	-2.29
8		-10.00	-3.50	-0.47	-3.50	-0.47	-3.20
		-0.37	-3.20	-0.37	-3.00		
9		1.45	-3.20	1.83	-3.20		
10		-0.47	-3.50	1.83	-3.50	1.83	-3.20
		10.00	-3.20				

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
11		-10.00	-4.50	10.00	-4.50		
12		-10.00	-7.70	10.00	-7.70		
13		-10.00	-8.40	10.00	-8.40		

Soil parameters - effective stress state

No.	Name	Pattern	ϕ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Granular B Type II	▨	36.00	0.00	22.00
2	Silty Clay	▨	33.00	5.00	18.00
3	Grey Silty Clay	▨	33.00	5.00	17.00
4	Glacial Till	▨	33.00	1.00	22.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Granular B Type II	▨	22.00		

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
2	Silty Clay	🟫	18.00		
3	Grey Silty Clay	⬜	17.00		
4	Glacial Till	🟦	22.00		

Soil parameters

Granular B Type II
Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Clay
Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

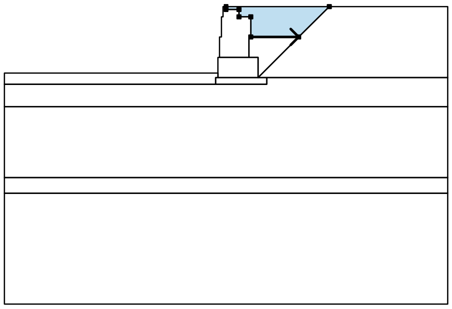
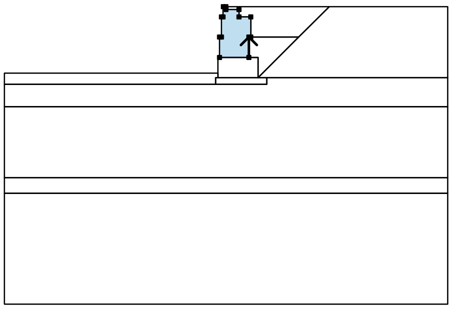
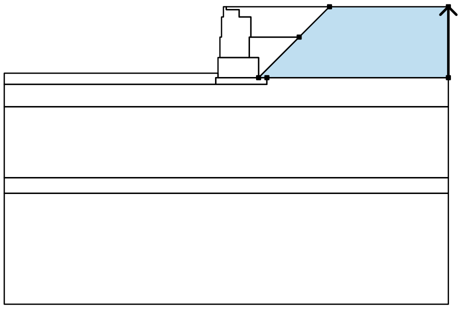
Grey Silty Clay
Unit weight : γ = 17.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 17.00 kN/m^3

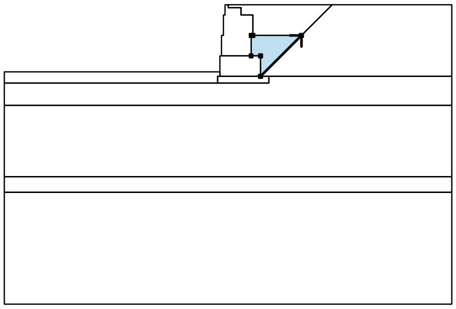
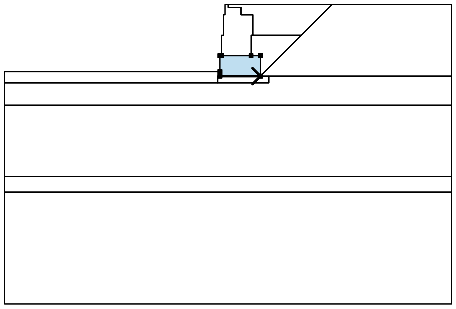
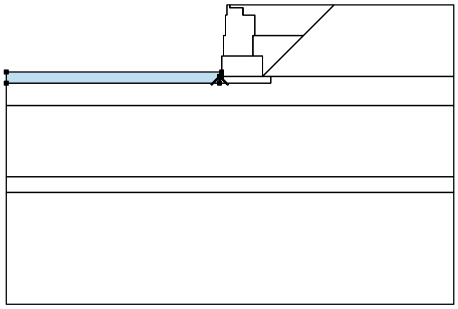
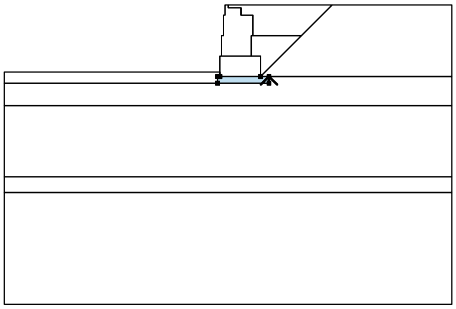
Glacial Till
Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 1.00 kPa
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

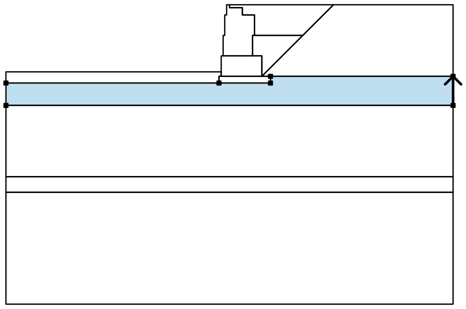
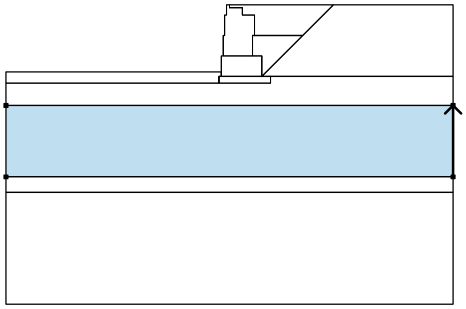
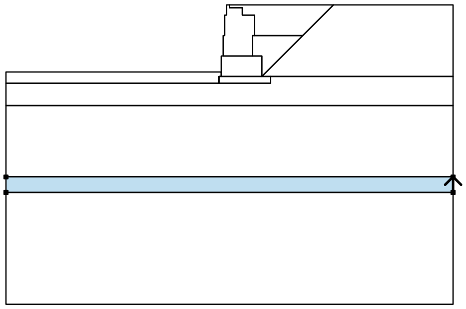
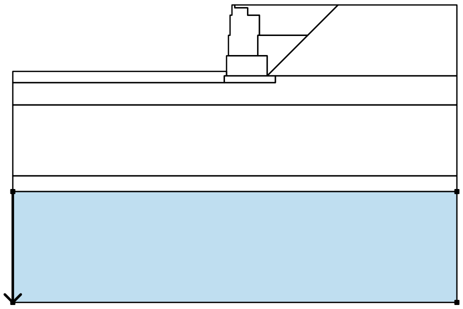
Rigid Bodies

No.	Name	Sample	γ [kN/m³]
1	Material of structure	▦	18.85
2	Foundation	▦	25.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		1.11	-1.37	3.28	-1.37	Granular B Type II ▒
		4.65	0.00	0.00	0.00	
		0.00	-0.13	0.58	-0.13	
		0.58	-0.46	1.11	-0.46	
2		1.03	-2.29	1.03	-1.37	Material of structure ▦
		1.11	-1.37	1.11	-0.46	
		0.58	-0.46	0.58	-0.13	
		0.00	-0.13	0.00	0.00	
		-0.13	0.00	-0.13	-0.46	
		-0.21	-0.46	-0.21	-1.37	
		-0.29	-1.37	-0.29	-2.29	
3		10.00	-3.20	10.00	0.00	Silty Clay ▤
		4.65	0.00	3.28	-1.37	
		1.45	-3.20	1.83	-3.20	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
4		1.45	-3.20	3.28	-1.37	Granular B Type II
		1.11	-1.37	1.03	-1.37	▨
		1.03	-2.29	1.45	-2.29	
5		-0.37	-3.20	1.45	-3.20	Material of structure
		1.45	-2.29	1.03	-2.29	▦
		-0.29	-2.29	-0.37	-2.29	
		-0.37	-3.00			
6		-0.47	-3.50	-0.47	-3.20	Silty Clay
		-0.37	-3.20	-0.37	-3.00	▤
		-10.00	-3.00	-10.00	-3.50	
7		1.83	-3.50	1.83	-3.20	Foundation
		1.45	-3.20	-0.37	-3.20	▦
		-0.47	-3.20	-0.47	-3.50	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
8		10.00	-4.50	10.00	-3.20	Silty Clay ▨
		1.83	-3.20	1.83	-3.50	
		-0.47	-3.50	-10.00	-3.50	
		-10.00	-4.50			
9		10.00	-7.70	10.00	-4.50	Grey Silty Clay ▨
		-10.00	-4.50	-10.00	-7.70	
10		10.00	-8.40	10.00	-7.70	Glacial Till ▨
		-10.00	-7.70	-10.00	-8.40	
11		-10.00	-8.40	-10.00	-13.40	Glacial Till ▨
		10.00	-13.40	10.00	-8.40	

Surcharge

No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	Magnitude q_2, z	unit
1	strip	permanent	on terrain	x = 1.53	l = 8.00		0.00	17.50		kN/m2

Surcharges

No.	Name
1	Traffic

Water

Water type : No water

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : Strength I

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-0.37	[m]	Angles :	α_1 =	-37.76	[°]
	z =	0.85	[m]		α_2 =	79.95	[°]
Radius :	R =	4.87	[m]				
The slip surface after optimization.							

Total weight of soil above the slip surface: 321.52 kN/m

Slope stability verification (Bishop)

Sum of active forces : F_a = 189.31 kN/m

Sum of passive forces : F_p = 306.56 kN/m

Factor of Safety: FS = 1.6

Sliding moment : M_a = 921.92 kNm/m

Resisting moment : M_p = 970.41 kNm/m

Utilization : 95.0 %

Capacity demand ratio CDR: 1.053

Slope stability ACCEPTABLE

Name : Analysis **Stage - analysis : 1 - 1**