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Geotechnical
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Noise & Vibration Studies

Geotechnical Investigation
Proposed Residential Development
Conservancy Lands West
Ottawa, Ontario

Prepared For

Caivan Communities

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Report: PG5036-2 Revision 1

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Caivan Communities to prepare a geotechnical report for the proposed residential development to be located at the Conservancy Lands West, 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

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 November 5 through 9, 2018. The geotechnical investigation consisted of 33 boreholes advanced to a maximum depth of 9.1 m below the existing ground surface. The locations of the boreholes are shown on Drawing PG5036-4 - Test Hole Location Plan included in Appendix 2.

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.

Reference should be made to the Soil Profile and Test Data sheets, prepared by others, 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 32 boreholes by others to permit monitoring of the groundwater levels subsequent to the completion of the sampling program. All groundwater observations by others are noted on the Soil Profile and Test Data sheets presented in Appendix 1.

3.2 Field Survey

The ground surface elevations at the borehole locations were surveyed by others and 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 PG5036-4 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

A total of 8 Shelby tube samples collected from the boreholes during the geotechnical investigation were submitted for unidimensional consolidation testing by others. The results of the consolidation testing are summarized in Section 5.3.

A total of 35 representative soil samples were submitted for Atterberg limit testing by others from the geotechnical investigation. The results of the Atterberg testing are presented in Section 4.2 and are discussed in Section 6.7.

3.4 Analytical Testing

Four (4) 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 Subsection 6.9 and shown in Appendix 1.

4.0 Observations

4.1 Surface Conditions

Generally, the subject site consists of agricultural fields and is bordered by Highway 416 to the west, a railroad to the northwest, a stormwater retention pond to the northeast, the Foster Drain to the east, vacant City Lands to the southeast, and the Jock River to the southwest. The existing ground surface across the site is relatively level at approximate geodetic elevation 91 to 92 m.

4.2 Subsurface Profile

Overburden

The subsurface profile encountered at the borehole locations generally consisted of an approximate 50 to 360 mm thick layer of topsoil underlain by a silty clay deposit.

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

However, near the western boundary of the site, a glacial till deposit was encountered underlying the silty clay at depths varying from 1.5 to 7.5 m below the existing ground surface. The glacial till was generally observed to consist of a loose to compact, grey silty clay to silty sand with some gravel, cobbles and boulders.

Laboratory Testing

Atterberg limit testing, as well as associated moisture content testing, was completed by others on 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 following page.

Table 1 - Atterberg Limits Results

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)
BH 17-1	1.5	42	15	28	32
BH 17-2	0.8	53	16	37	35
BH 17-3	0.8	67	22	44	43
BH 17-4	0.8	68	23	45	33
BH 17-5	0.8	42	19	22	31
BH 17-9	1.5	43	19	24	35
BH 17-16	0.8	66	22	44	42
BH 17-17	1.5	42	17	25	34
BH 17-18	1.5	38	15	23	37
BH 17-19	0.8	67	21	46	41
BH 17-20	0.6	52	17	35	32
BH 17-21	0.8	40	20	20	33
BH 17-22	0.8	35	20	15	32
BH 17-23	1.5	44	16	28	37
BH 17-24	0.8	56	17	39	46
BH 17-25	1.4	30	17	13	33
BH 17-26	0.8	60	18	42	37
BH 17-27	0.8	61	21	40	44
BH 17-28	0.8	54	21	33	38
BH 17-29	0.8	37	19	18	31
BH 17-30	0.6	43	16	27	32
BH 18-1	0.8	51	21	30	59
BH 18-2	1.5	36	16	20	45
BH 18-3	0.7	66	26	40	50
BH 18-4	1.5	35	17	18	37
BH 18-5	0.8	56	23	33	39
BH 18-6	0.8	64	26	38	46
BH 18-7	0.8	42	21	21	30

Table 1 - Atterberg Limits Results (continued)

Sample	Depth (m)	LL (%)	PL (%)	PI (%)	w (%)
BH 18-8	1.5	54	21	33	45
BH 18-9	0.8	55	22	33	40
BH 18-10	1.5	35	16	19	33
BH 18-11	0.8	30	19	11	29
BH 18-12	1.5	47	20	27	37
BH 18-13	0.8	31	18	13	30
BH 18-14 1.5	1.5	38	18	20	33

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

The results of the shrinkage limit test indicate a shrinkage limit of 17.7% and a shrinkage ratio of 1.85.

Bedrock

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

4.3 Groundwater

Groundwater levels (GWL) were measured by others in 32 boreholes following completion of the geotechnical investigation. The measured GWL readings are presented in Table 2 below. It should be noted that surface water can become trapped within a backfilled borehole, which can lead to higher than normal groundwater level readings. It should be noted that long-term groundwater levels within a silty clay deposit 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 a 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

Borehole Number	Ground Elevation (m)	Measured Groundwater Level (m)		Recording Date
		Depth	Elevation	
17-01	91.76	0.69	91.07	February 21, 2017
17-05	91.12	1.22	89.90	February 21, 2017
17-09	90.87	0.81	90.06	February 21, 2017
17-16	91.27	0.93	90.34	April 13, 2017
17-17A	91.82	0.61	91.21	March 31, 2017
17-18A	91.40	0.45	90.95	March 31, 2017
17-19	91.24	1.35	89.89	April 13, 2017
17-20A	91.03	0.66	90.37	March 31, 2017
17-22	91.36	0.37	90.99	April 13, 2017
17-23	91.41	0.06	91.36	April 13, 2017
17-24	90.90	0.31	90.59	April 13, 2017
17-25A	91.09	0.01	91.08	March 31, 2017
17-26	91.54	0.26	91.28	March 31, 2017
17-28A	91.10	0.32	90.78	March 31, 2017
17-30	90.92	0.46	90.46	April 13, 2017
18-01	92.12	-0.19	92.31	April 30, 2019
18-02	91.65	0.46	91.19	April 30, 2019
18-03	91.32	0.22	91.09	April 30, 2019
18-04A	91.28	0.06	91.22	April 30, 2019
18-04B	91.28	0.22	91.06	April 30, 2019
18-05	91.29	0.19	91.10	April 30, 2019
18-06	91.25	0.18	91.07	April 30, 2019
18-07A	91.43	0.51	90.92	April 30, 2019
18-07B	91.43	0.25	91.18	April 30, 2019
18-08	91.48	0.32	91.16	April 30, 2019
18-09	91.12	0.07	91.05	April 30, 2019
18-10	91.24	0.18	91.06	April 30, 2019
18-11	91.26	0.05	91.21	April 30, 2019
18-12A	91.14	0.08	91.06	April 30, 2019

Table 2 - Summary of Groundwater Level Readings (continued)

Borehole Number	Ground Elevation (m)	Measured Groundwater Level (m)		Recording Date
		Depth	Elevation	
18-12B	91.14	0.04	91.10	April 30, 2019
18-13	91.07	0.49	90.57	April 30, 2019
18-14	91.38	0.37	91.01	April 30, 2019

Notes:
- Borehole elevations are understood to be referenced to a geodetic datum.

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 firm silty clay bearing surface or an engineered fill pad over an approved subgrade soil.

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

A construction setback defined as the Limit of Hazard Lands has been defined for the slope face along the adjacent segment of the Jock River, as presented on Drawing PG5036-4 - 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.

It is anticipated that the existing fill, free of deleterious materials and topsoil can be left in place below the proposed park blocks. However, it is recommended that the existing fill layer be thoroughly proof-rolled under dry conditions and in above freezing temperatures, using several passes of a vibratory drum roller and approved by the geotechnical consultant at the time of construction. Any poor performing areas noted during the proof-rolling operation should be removed and replaced with approved fill material, such as OPSS Granular B, Type II.

Fill Placement

Fill used for grading beneath the building areas, including the park blocks, should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. Consideration could be given to using an alternative granular fill provided that the geotechnical engineer provides fill placement recommendations for the selected material. 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 **150 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 **90 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.

Park Block Structures

Thickened edge concrete slabs or footings supported on the proof-rolled and approved existing fill can be designed using a bearing resistance value at serviceability limit states (SLS) for **100 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **180 kPa**, provided that the bearing surface is inspected and approved by the geotechnical consultant at the time of construction. The total and differential settlements for the proposed structures are 25 and 20 mm, respectively.

Where the existing fill material is encountered at the foundation subgrade, the existing fill shall be proof-rolled under dry conditions and above freezing temperatures, using a vibratory drum roller making several passes and approved by the geotechnical consultant at the time of construction. Any poor performing areas noted during the proof-rolling operation should be removed and replaced with approved fill material, such as OPSS Granular B, Type II.

The bearing medium under thickened edge concrete slab supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to silty clay and engineered fill above the groundwater table when a plane extending horizontally and vertically from the underside of the foundation at a minimum of 1.5H:1V passing through in situ soil of the same or higher bearing capacity as the bearing medium soil.

Consideration can be given to slab-on-grade construction within the park blocks. With the removal of fill, containing significant amounts of deleterious or organic materials, the existing fill or native soil subgrade approved by the geotechnical consultant at the time of excavation will be considered an acceptable subgrade surface on which to commence backfilling for slab-on-grade construction. Where the subgrade consists of existing fill, a vibratory drum roller should complete several passes over the subgrade surface as a proof-rolling program. Any poor performing areas should be removed and reinstated with an engineered fill such as OPSS Granular B Type II.

It is recommended the the upper 400 mm of sub-floor fill consist of OPSS Granular A crushed stone. All backfill material required to raise grade within the footprint of settlement sensitive structures should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

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. Eight (8) site specific consolidation tests were conducted by others as part of the geotechnical investigation at the subject site. The results of the consolidation testing 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
17-01	3	3.60	110.0	35.0	0.055	0.760
17-05	5	5.00	85.0	50.0	0.055	0.800
17-16	7	8.10	115.0	65.0	0.006	1.470
17-17	4	4.90	105.0	45.0	0.011	1.070
17-19	4	5.00	90.0	50.0	0.004	1.100
17-21	5	6.50	110.0	60.0	0.007	1.330
18-03	5	3.40	58.0	35.0	0.011	0.540
18-07	5	5.00	115.0	42.0	0.004	1.110

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 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 PG5036-5 - 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 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 211 m/s and 176 m/s. A **Site Class D** is therefore applicable for design across the majority of the site. However, a **Site Class E** is applicable for an area within the northeast portion of the site, as shown on Drawing PG5036-4 in Appendix 2. 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.

5.5 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 or approved fill subgrade 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.

5.6 Pavement Structure

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

Table 4 - Recommended Pavement Structure - Park Block Pathways

Thickness (mm)	Material Description
50	**Wear Course** - HL 3 or Superpave 12.5 Asphaltic Concrete
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 - Driveways / Car Only Parking Areas / Park Block Parking Areas and Access Pathways

Thickness (mm)	Material Description
50	**Wear Course** - HL 3 or Superpave 12.5 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
300	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either 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 - Local Roads

Thickness (mm)	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Binder Course -** Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
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 7 - Recommended Pavement Structure - Roadways with Bus Traffic

Thickness mm	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
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, such as structures within the park blocks.

It is recommended that Paterson review the proposed frost protection for each structure at the time of detailed design.

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 - Area 1 - 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 PG5036-6 - 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 7.5 m) 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.

Tree Planting Restrictions - Area 2 - High Sensitivity Area

High sensitivity clay soils were encountered between the anticipated design underside of footing elevations and 3.5 m below finished grade as per City Guidelines at the areas outlined in PG5036-6 - Tree Planting Setback Recommendations in Appendix 2. Based on our Atterberg limits test results, the modified plasticity index generally exceeds 40% in these areas. The following tree planting setbacks are recommended for these high sensitivity areas. 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 are 7.5 m for small (mature height up to 7.5 m) and medium size trees (mature tree height 7.5 to 14 m), provided that the following conditions 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. Two (2) 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 PG5036-4 - 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 below.

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 and B are shown on Figures 2 and 4, attached to the present report. The factor of safety was found to be greater than 1.5 at Sections A and B. 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 and 5 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 an 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 PG5036-4 - 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

Four (4) soil sample was submitted for analytical testing. The analytical test results of the soil sample 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 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.

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 and subdrains prior to placing backfilling materials.
- ❏ Observation of proof-rolling operations for subgrade within park blocks
- ❏ 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.

O.Canton

Owen Canton, E.I.T.

LICENSED PROFESSIONAL ENGINEER
Oct.19-2021
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

David J. Gilbert, P.Eng.

Report Distribution:

- ☐ Caivan Communities (e-mail copy)
- ☐ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

SEISMIC SITE CLASS TESTING RESULTS BY OTHERS

SHRINKAGE LIMIT TESTING RESULTS BY OTHERS

ANALYTICAL TEST RESULTS

PROJECT: 1771847

RECORD OF BOREHOLE: 17-01

SHEET 1 OF 1

LOCATION: N 5013143.8 ;E 361309.9

BORING DATE: February 2, 2017

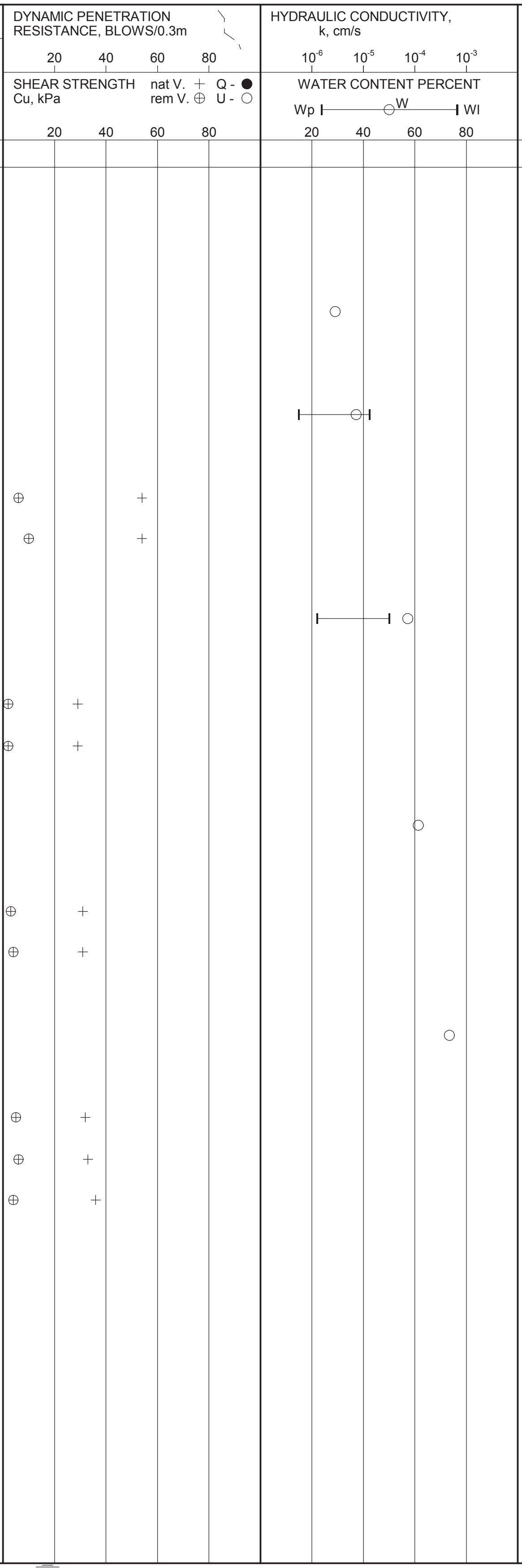
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

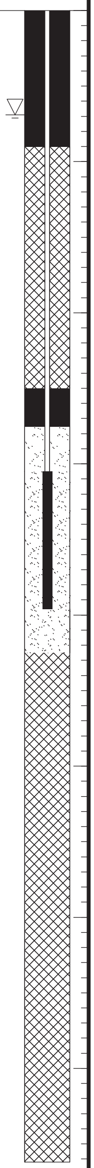
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
		GROUND SURFACE		91.76
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	▨	0.16
		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm	▨	89.02 2.74
		End of Borehole		84.14 7.62

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



PIEZOMETER OR STANDPIPE INSTALLATION



- Bentonite Seal
- Bentonite and Cuttings Mix
- Bentonite Seal
- Silica Sand
- Standpipe
- Silica Sand
- Native Backfill

W.L. in Standpipe at Elev. 91.07 m on February 21, 2017

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-02

SHEET 1 OF 1

LOCATION: N 5013269.0 ;E 361573.3

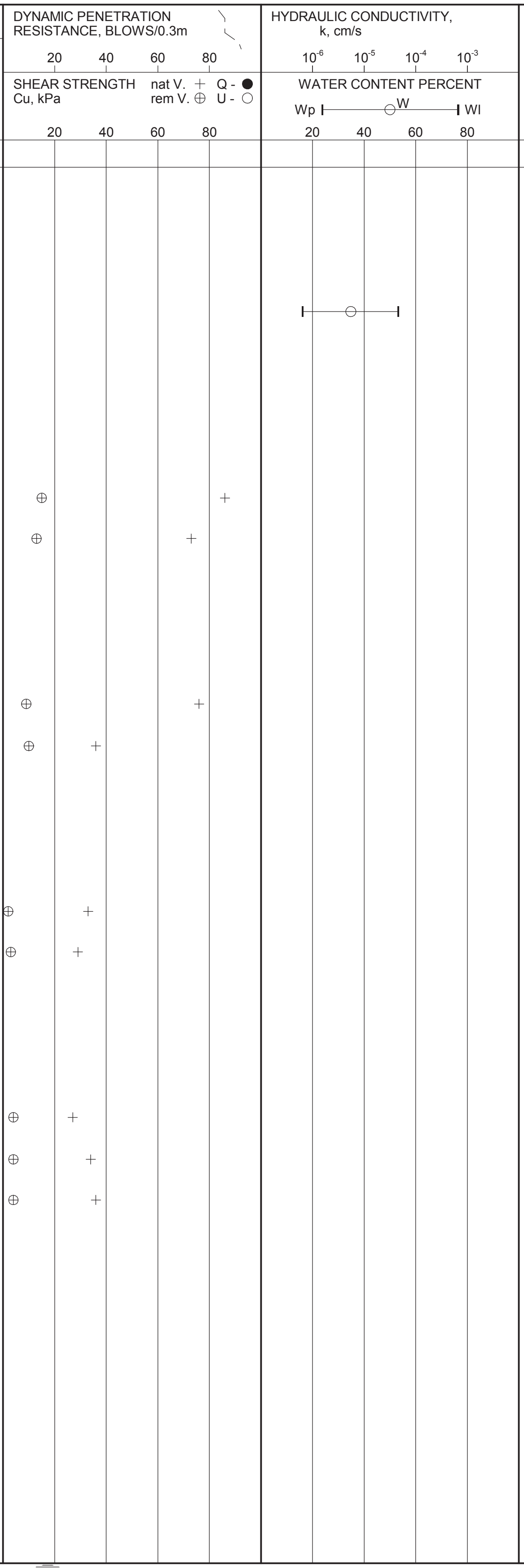
BORING DATE: February 1, 2017

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		91.75					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.07					
		(CL/CI/CH) SILTY CLAY to CLAY, some sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff			1	SS	8		
1					2	SS	4		
					3	SS	2		
2									
		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, stiff to firm		89.01 2.74					
3					4	SS	WH		
4									
5					5	SS	WH		
6					6	SS	WH		
7									
		End of Borehole		84.13 7.62					
8									
9									
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: DG

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-03

SHEET 1 OF 1

LOCATION: N 5012851.9 ;E 361409.3

BORING DATE: February 1, 2017

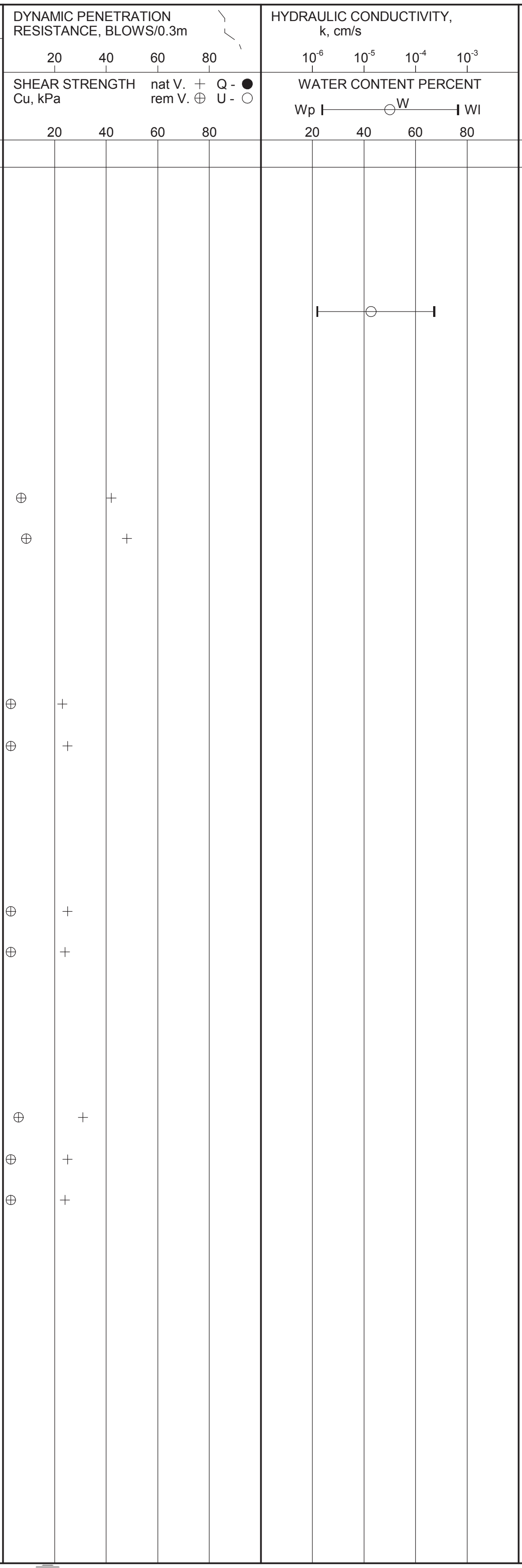
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	91.20
	TOPSOIL - (SM) sandy SILT; dark brown; moist	0.00
Power Auger 200 mm Diam. (Hollow Stem)	(CL/CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.13
	(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.46 2.74
	End of Borehole	83.58 7.62

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



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: 17-04

SHEET 1 OF 1

LOCATION: N 5013010.7 ;E 361684.6

BORING DATE: February 1, 2017

DATUM: CGVD28

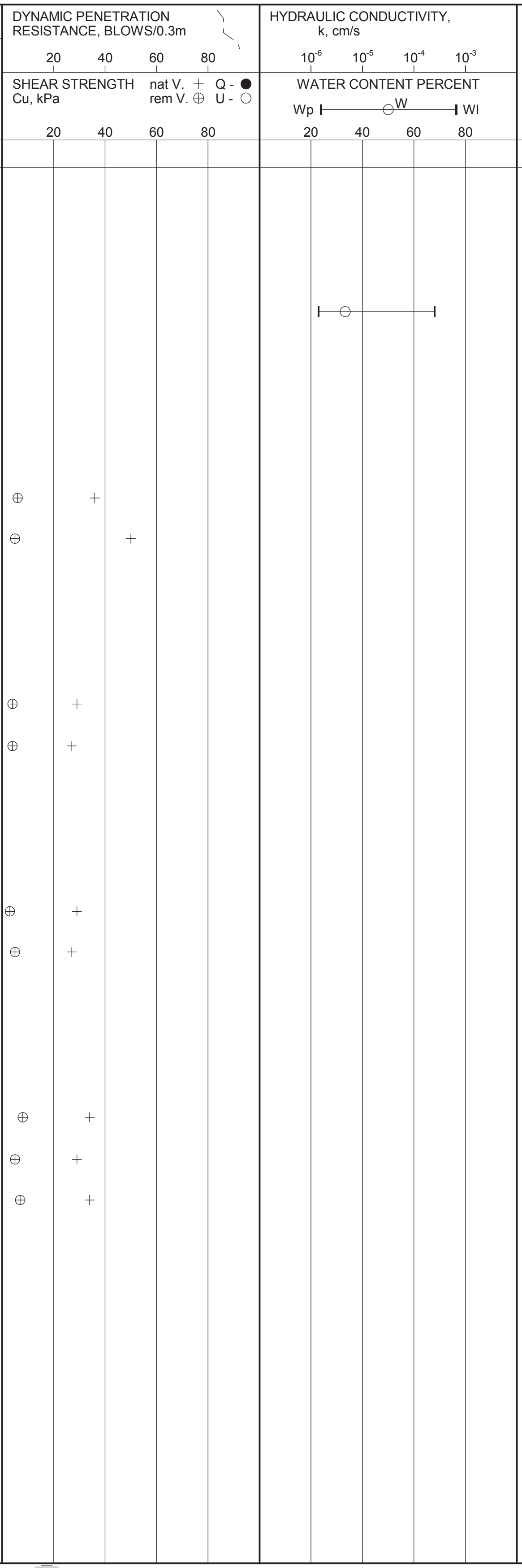
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)
GROUND SURFACE		91.21
TOPSOIL - (SM) SILTY SAND; dark brown; moist		0.00
(CL/CI/CH) SILTY CLAY to CLAY, some sand; grey brown, contains silt layers (WEATHERED CRUST); cohesive, w>PL, very stiff to firm		0.10
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm		88.47 2.74
End of Borehole		83.59 7.62

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



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: 17-05

SHEET 1 OF 1

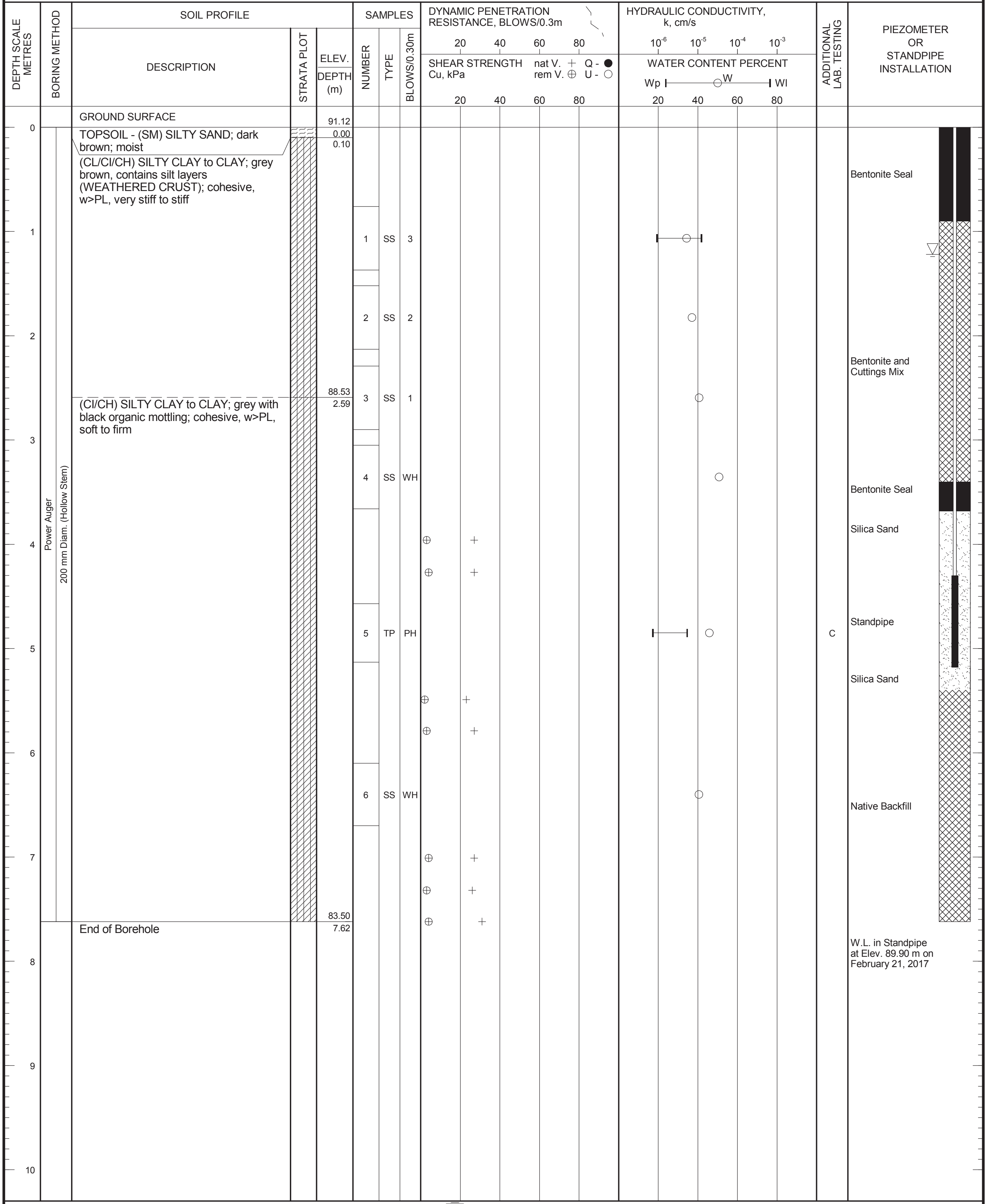
LOCATION: N 5012743.9 ;E 361739.5

BORING DATE: February 1, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.12
TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silt layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.10
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.53 2.59
End of Borehole	83.50 7.62

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

Bentonite Seal

Bentonite and Cuttings Mix

Bentonite Seal

Silica Sand

Standpipe

Silica Sand

Native Backfill

W.L. in Standpipe at Elev. 89.90 m on February 21, 2017

DEPTH SCALE

1 : 50

LOGGED: DG

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-09

SHEET 1 OF 1

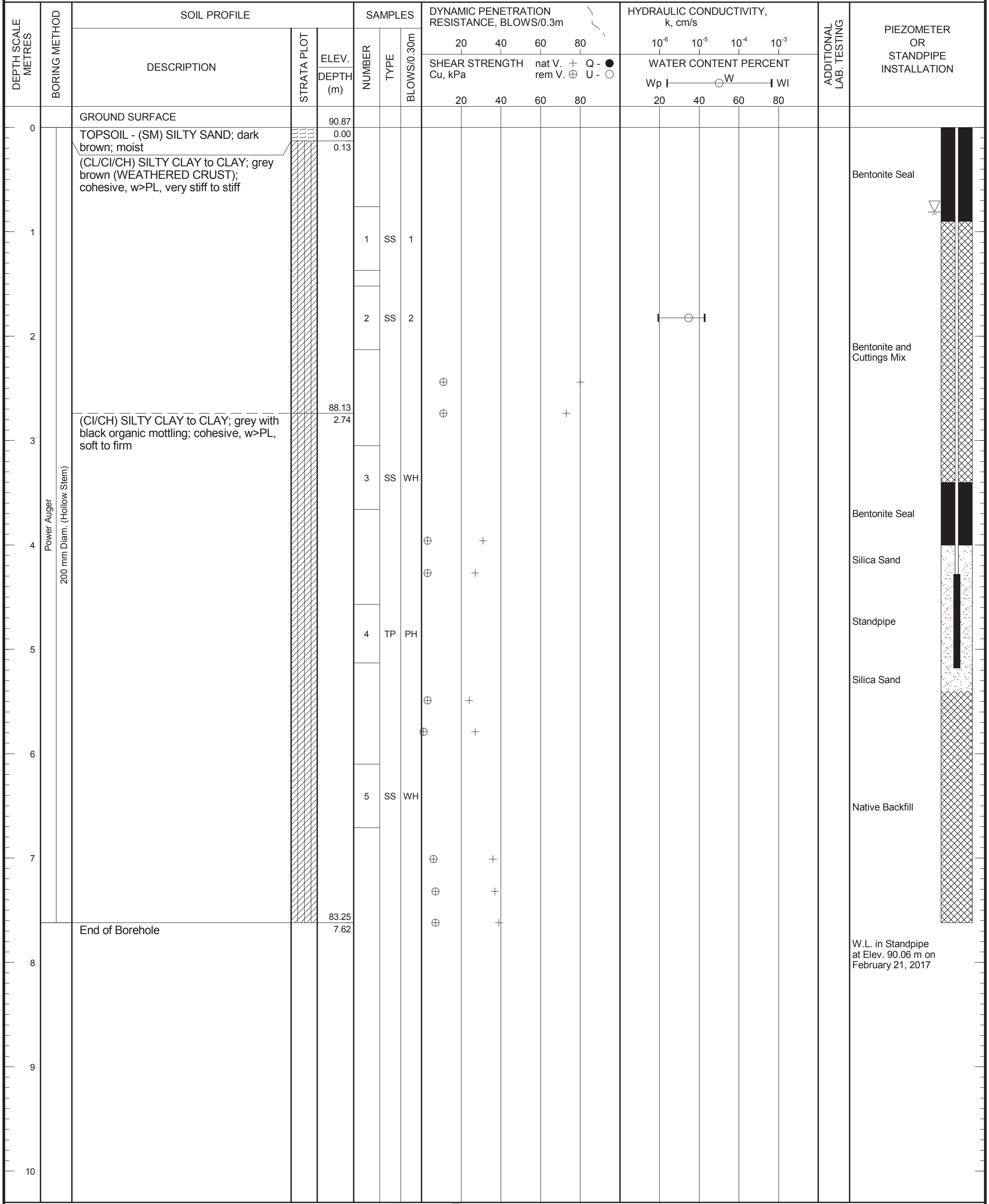
LOCATION: N 5012670.0 ;E 362072.9

BORING DATE: February 3, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	90.87
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	0.13
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.13 2.74
End of Borehole	83.25 7.62

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

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: DG
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-16

SHEET 1 OF 1

LOCATION: N 5012987.6 ;E 361366.8

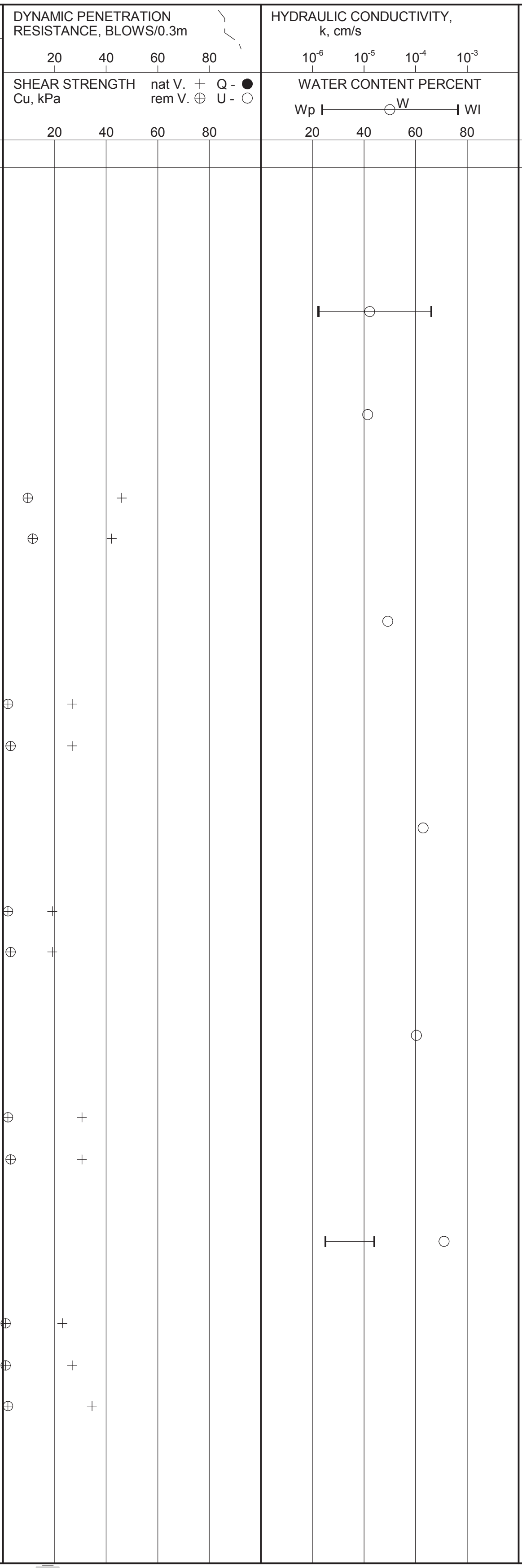
BORING DATE: March 31, 2017

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		91.27					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; brown, contains 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 stiff		0.15	1	GRAB	-		Bentonite Seal
1					2	SS	4		
2					3	SS	1		
		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm		88.83 2.44					
3					4	SS	WH		Cuttings
4									
5					5	SS	WH		
6					6	SS	WH		Bentonite Seal Silica Sand
7									Standpipe
8					7	TP	PH	C	W.L. in Standpipe at Elev. 90.34 m on April 13, 2017
9		End of Borehole		82.13 9.14					
10									



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SN

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-17

SHEET 1 OF 1

LOCATION: N 5013210.1 ;E 361450.6

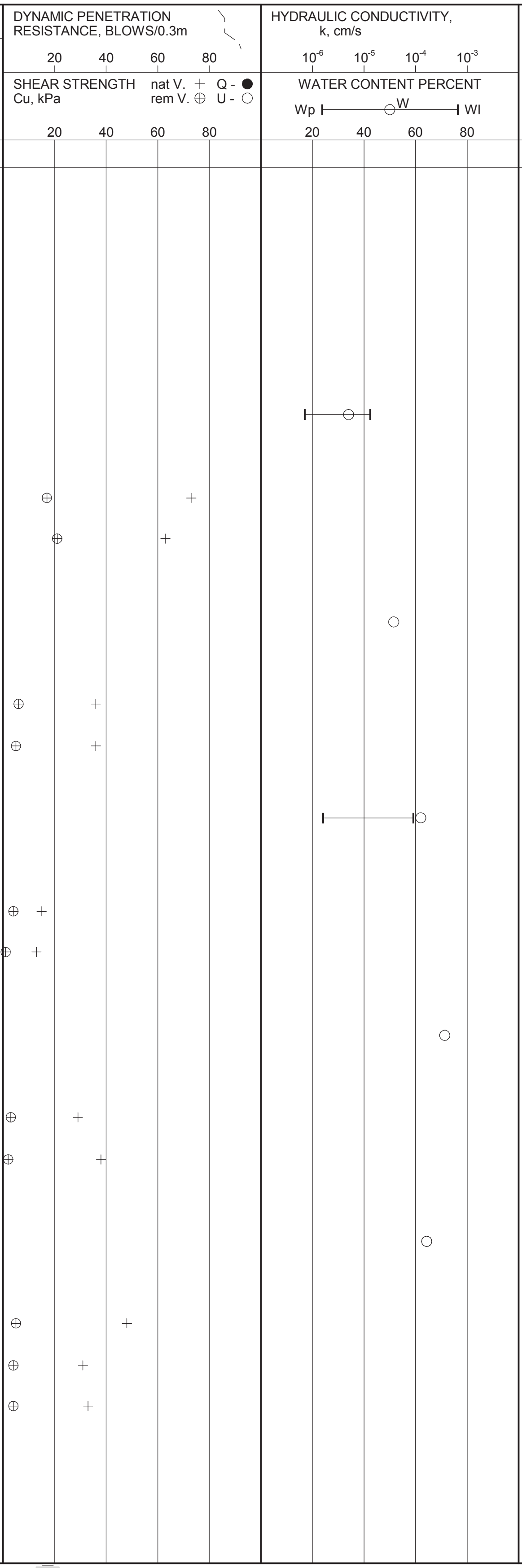
BORING DATE: March 23 & 24, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE	91.82					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark 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	0.09					
1				1	SS	4		
2				2	SS	3		
		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, soft to firm	89.08 2.74					
3				3	SS	1		
4								
5				4	TP	PH	C	
6				5	SS	WH		
7								
8				6	SS	WH		
9		End of Borehole	82.68 9.14					
10								



DEPTH SCALE

1 : 50

LOGGED: KM

CHECKED: SD

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

PROJECT: 1771847

RECORD OF BOREHOLE: 17-17A

SHEET 1 OF 1

LOCATION: Adjacent to BH 17-17

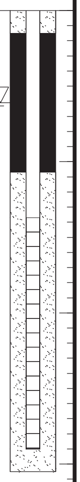
BORING DATE: March 24, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	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		91.82							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-17 for Stratigraphy		0.00							Bentonite Seal
1											Silica Sand
2											51 mm Diam. PVC #10 Slot Screen
3		End of Borehole		88.77 3.05							Silica Sand WL in Screen at Elev. 91.21 m on March 31, 2017
4											
5											
6											
7											
8											
9											
10											



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-18

SHEET 1 OF 1

LOCATION: N 5013064.6 ;E 361497.9

BORING DATE: March 23, 2017

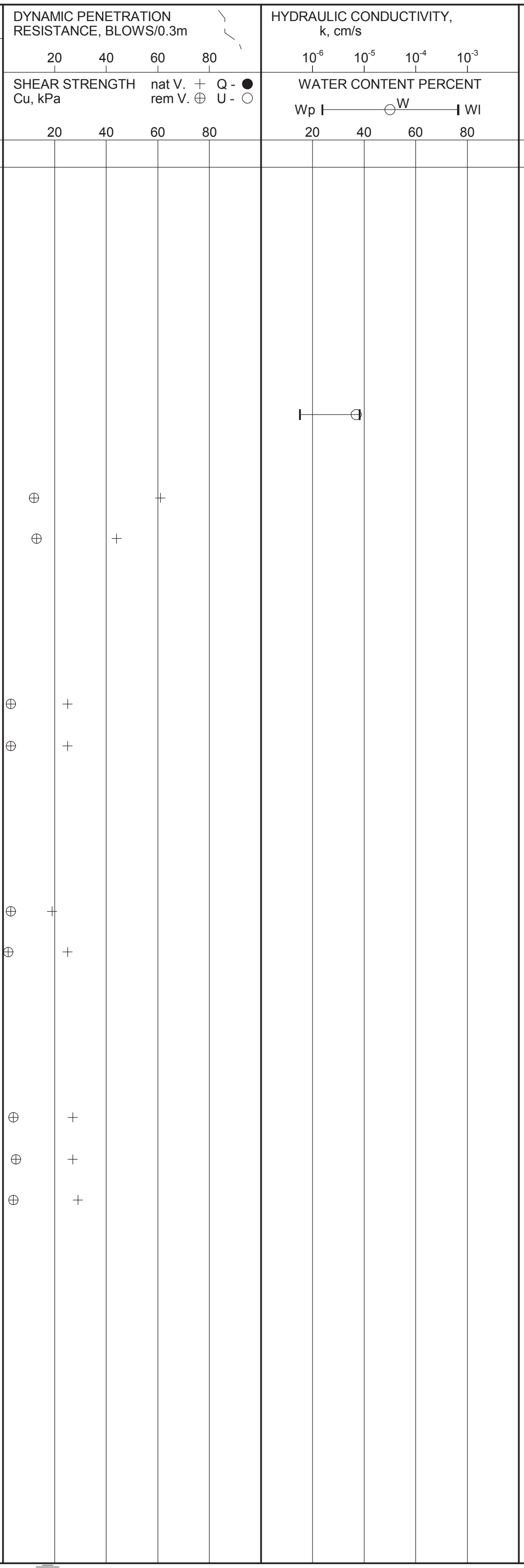
DATUM: CGVD28

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	91.40			
0	TOPSOIL - (ML) sandy SILT; dark 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 firm	0.10			
1			1	SS	6
2			2	SS	WH
	(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, soft to firm	88.66 2.74			
3			3	SS	WH
5			4	SS	WH
6			5	SS	WH
7	End of Borehole	83.78 7.62			
8					
9					
10					



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM/SM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-18A

SHEET 1 OF 1

LOCATION: Adjacent to BH 17-18

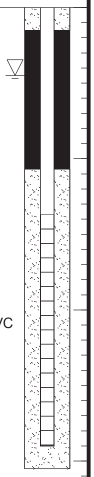
BORING DATE: March 23, 2017

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	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		91.40							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-18 for Stratigraphy		0.00							Bentonite Seal
1											Silica Sand
2											51 mm Diam. PVC #10 Slot Screen
3		End of Borehole		88.35 3.05							Silica Sand WL in Screen at Elev. 90.95 m on March 31, 2017
4											
5											
6											
7											
8											
9											
10											



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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM/SM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-19

SHEET 1 OF 1

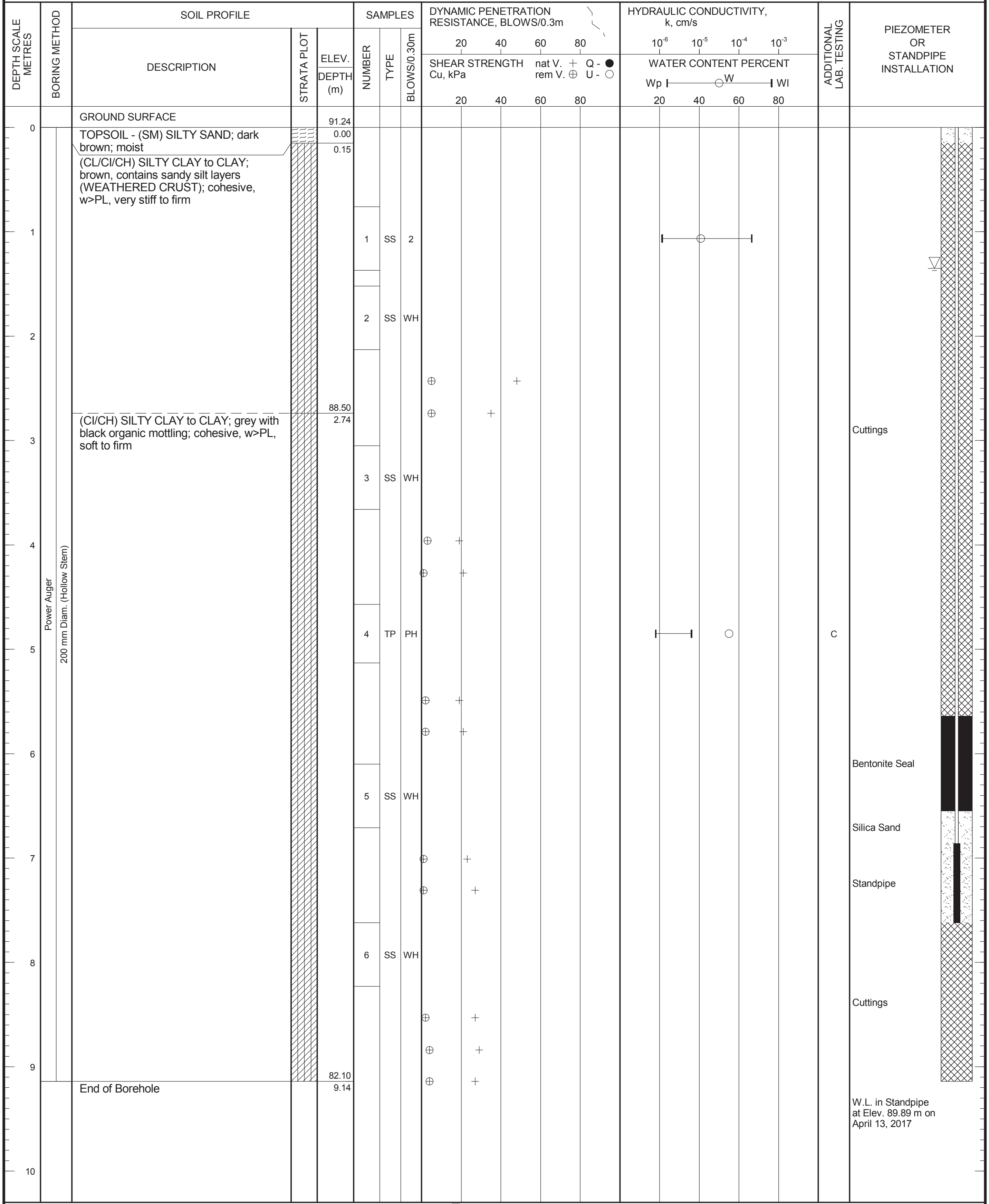
LOCATION: N 5012932.6 ;E 361556.3

BORING DATE: March 30, 2017

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



SOIL PROFILE

DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.24
TOPSOIL - (SM) SILTY SAND; dark brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; brown, contains sandy silt layers (WEATHERED CRUST); cohesive, w>PL, very stiff to firm	0.15
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, soft to firm	88.50 2.74
End of Borehole	82.10 9.14

SAMPLES

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

W.L. in Standpipe at Elev. 89.89 m on April 13, 2017

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: SM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-20

SHEET 1 OF 1

LOCATION: N 5012801.4 ;E 361573.1

BORING DATE: March 20, 2017

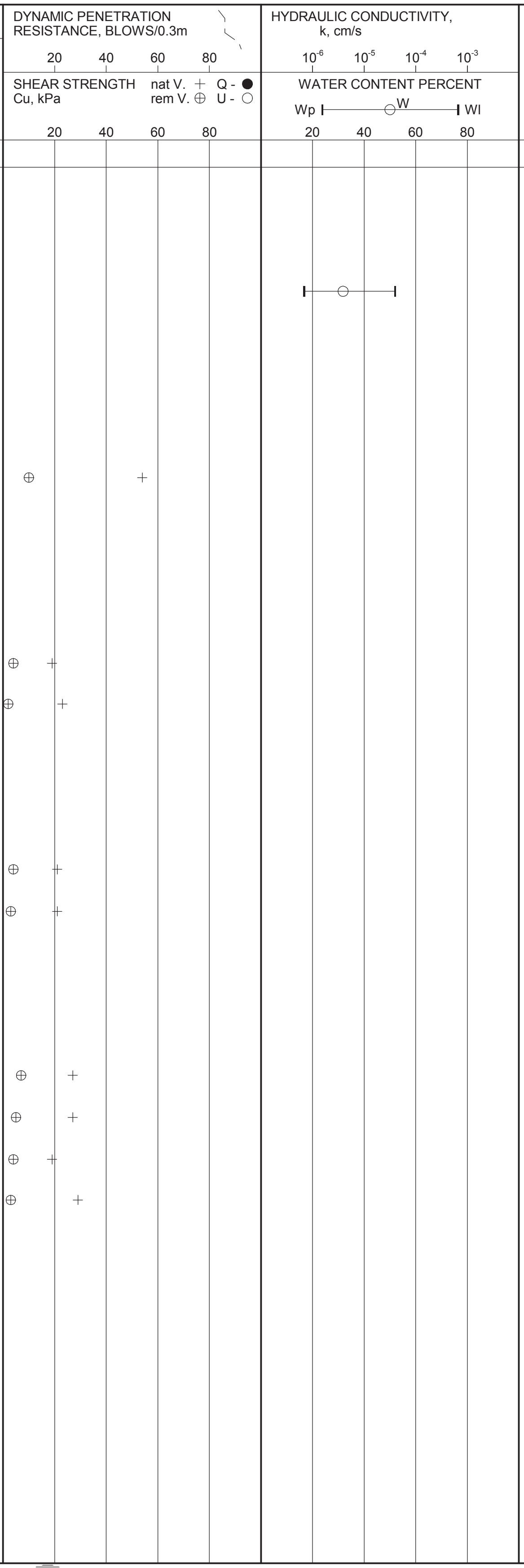
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE			SAMPLES		
DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m
GROUND SURFACE		91.03			
TOPSOIL - (ML) sandy SILT; dark 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		0.10	1	SS	4
			2	SS	WH
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains sandy silt seams; cohesive, w>PL, soft to firm		88.74 2.29	3	SS	WH
			4	SS	WH
			5	SS	WH
End of Borehole		83.41 7.62			



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: KM
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-20A

SHEET 1 OF 1

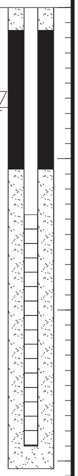
LOCATION: Adjacent to BH 17-20

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	SOIL PROFILE STRATA PLOT	SOIL PROFILE 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		91.03							
0 1 2	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-20 for Stratigraphy		0.00							 Bentonite Seal Silica Sand 51 mm Diam. PVC #10 Slot Screen Silica Sand
3 4 5 6 7 8 9 10		End of Borehole		87.98 3.05							WL in Screen at Elev. 90.37 m on March 31, 2017

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-21

SHEET 1 OF 1

LOCATION: N 5012670.3 ;E 361616.6

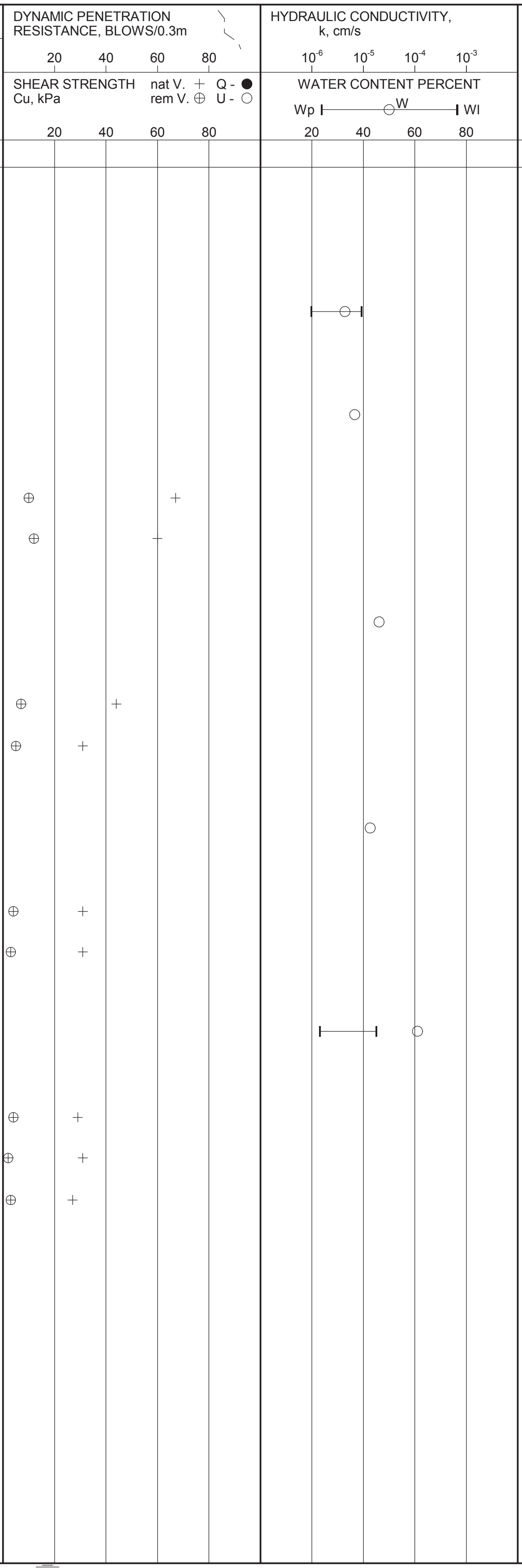
BORING DATE: March 29, 2017

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)	SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		91.24					
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark 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		0.10					
1					1	SS	4		
2					2	SS	WH		
3		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, firm		88.19 3.05	3	SS	WH		
5					4	SS	WH		
6					5	TP	PH	C	
7		End of Borehole		83.62 7.62					
8									
9									
10									



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DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-22

SHEET 1 OF 1

LOCATION: N 5012555.0 ;E 361697.8

BORING DATE: March 29, 2017

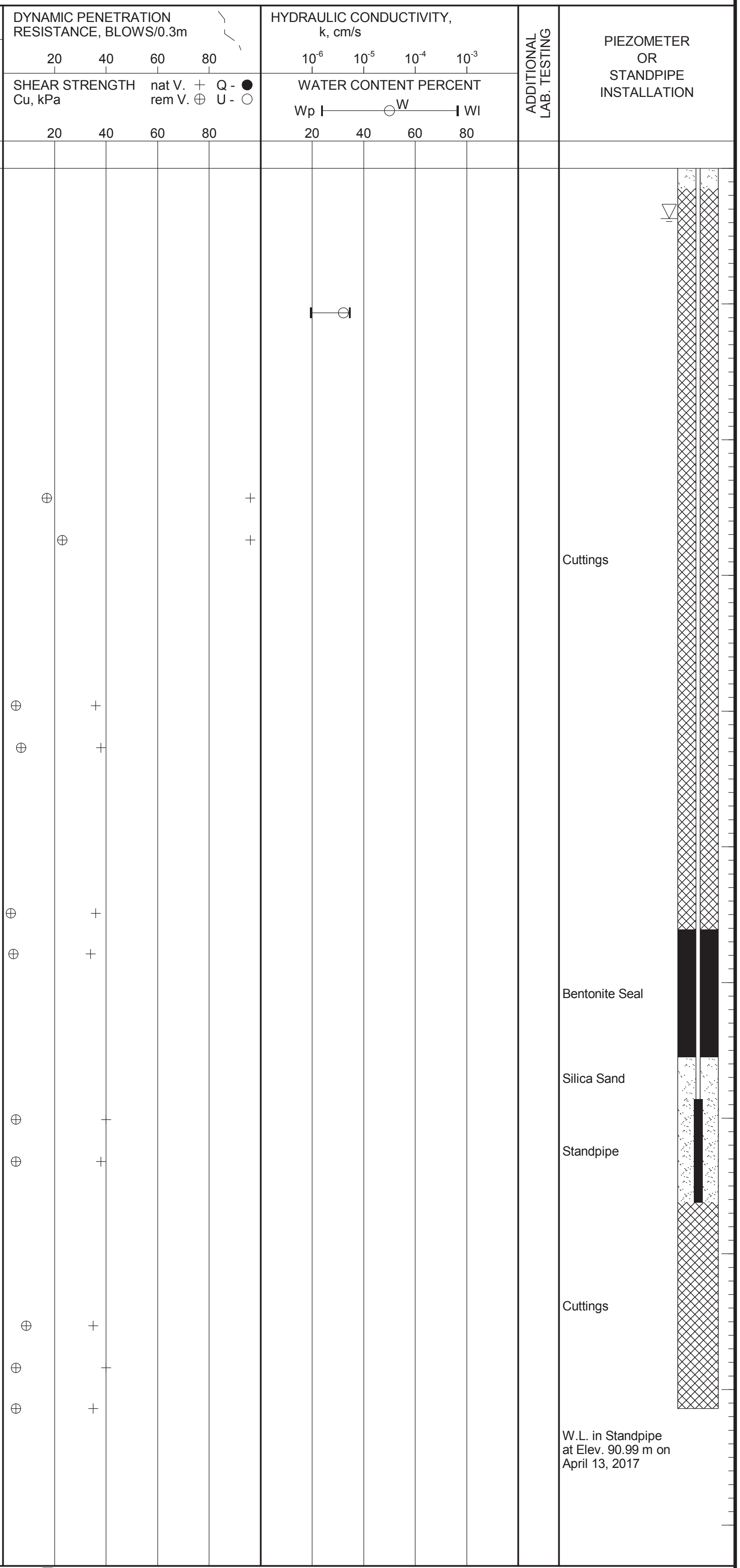
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

ELEV. DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	BLOWS/0.30m
91.36	GROUND SURFACE			
0.00	TOPSOIL - (ML) sandy SILT; dark brown; moist			
0.09	(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silty sand layers (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	1	SS	2
		2	SS	2
88.31 3.05	(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, firm	3	SS	WH
		4	SS	WH
		5	SS	WH
		6	TP	PH
82.22 9.14	End of Borehole			



W.L. in Standpipe at Elev. 90.99 m on April 13, 2017

DEPTH SCALE

1 : 50

LOGGED: KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-23

SHEET 1 OF 1

LOCATION: N 5013132.3 ;E 361640.7

BORING DATE: March 30, 2017

DATUM: CGVD28

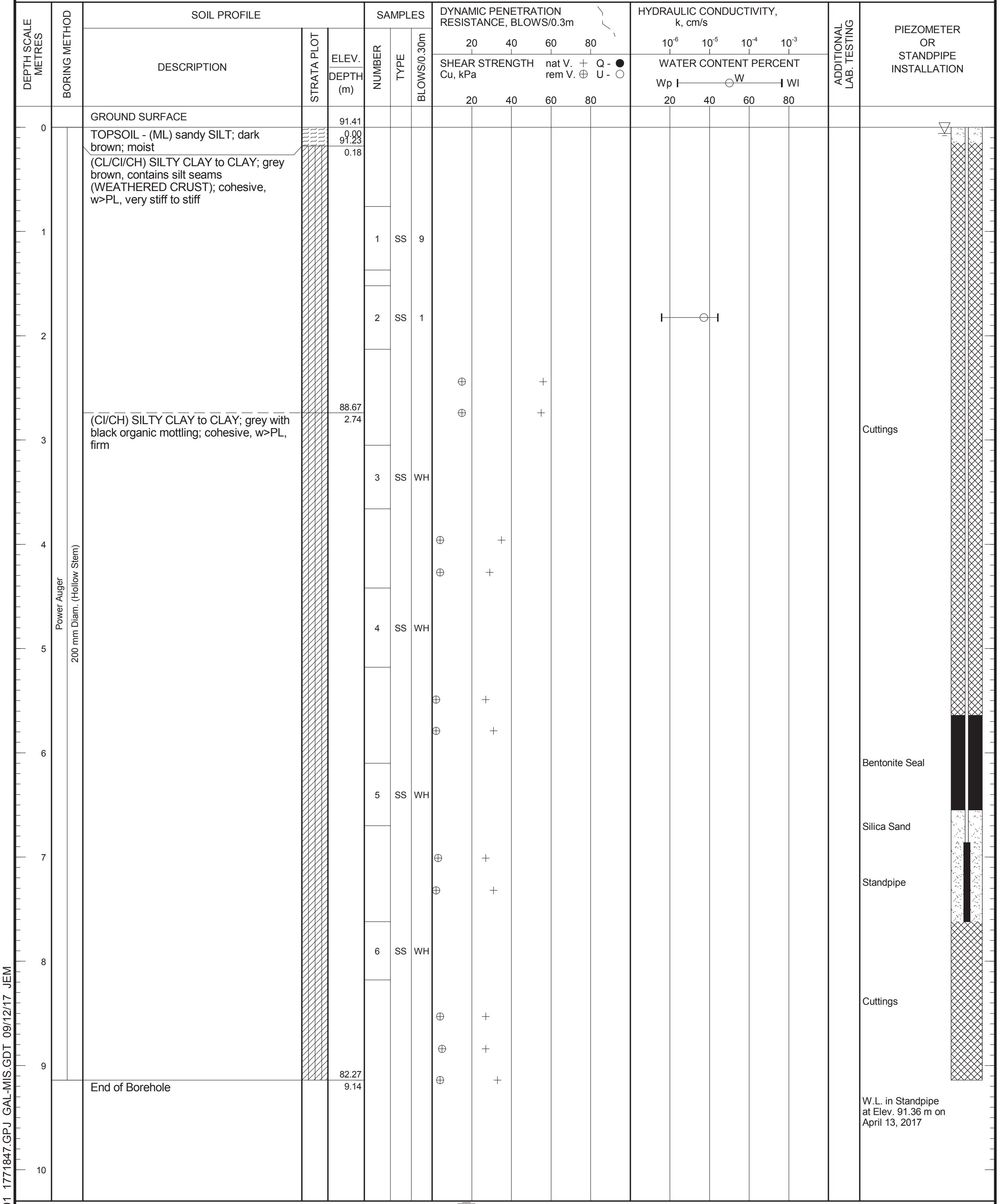
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.41
TOPSOIL - (ML) sandy SILT; dark brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains silt seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.23 0.18
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling; cohesive, w>PL, firm	88.67 2.74
End of Borehole	82.27 9.14

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	9
2	SS	1
3	SS	WH
4	SS	WH
5	SS	WH
6	SS	WH



DEPTH SCALE

1 : 50

LOGGED: SM

CHECKED: SD

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

PROJECT: 1771847

RECORD OF BOREHOLE: 17-24

SHEET 1 OF 1

LOCATION: N 5012870.0 ;E 361739.6

BORING DATE: March 29, 2017

DATUM: CGVD28

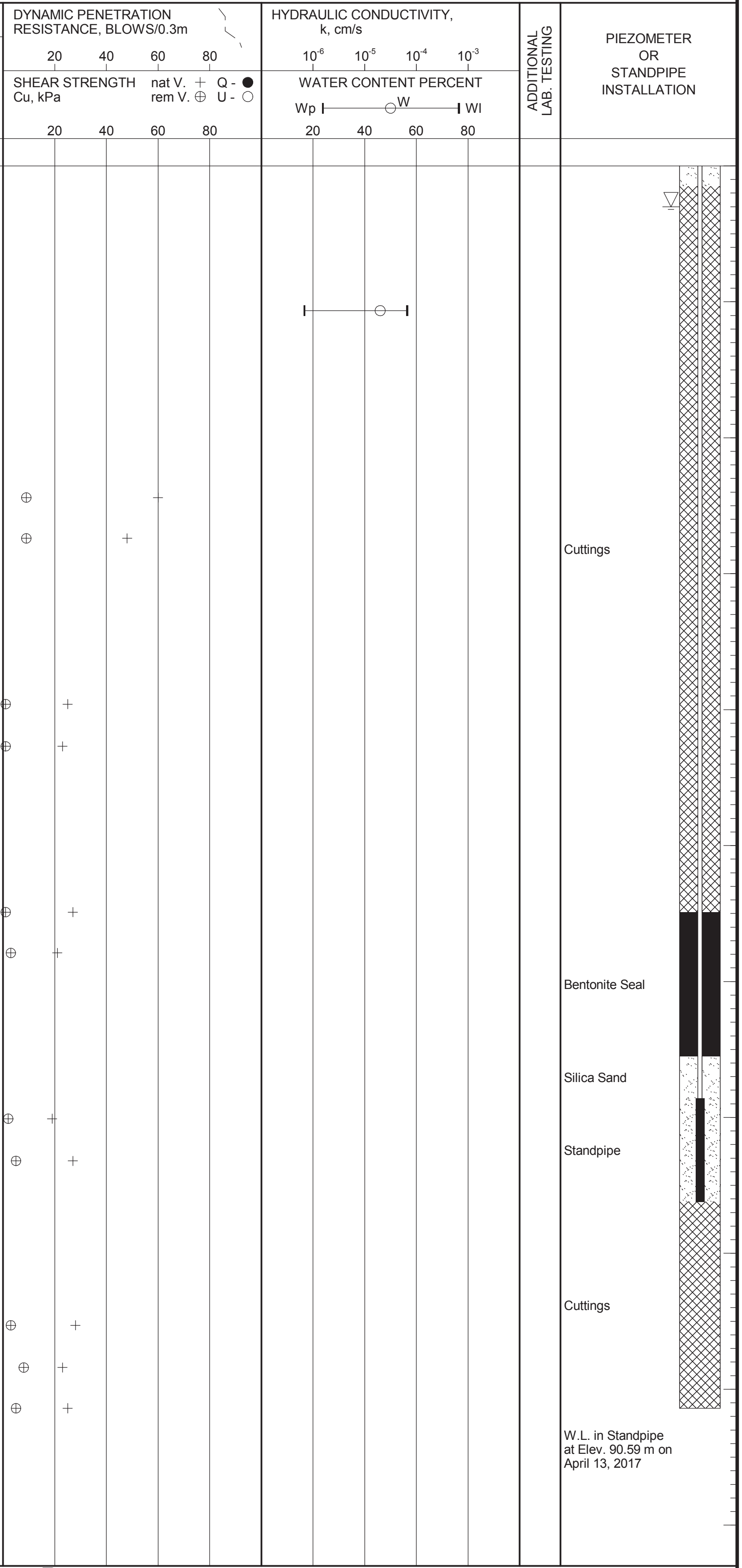
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	90.90
TOPSOIL - (ML) sandy SILT; dark brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sandy silt seams (WEATHERED CRUST); cohesive, w>PL, stiff to firm	0.11
(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, soft to firm	88.16 2.74
End of Borehole	81.76 9.14

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



DEPTH SCALE 1 : 50

LOGGED: KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-25

SHEET 1 OF 1

LOCATION: N 5012633.8 ;E 361839.8

BORING DATE: March 24, 2017

DATUM: CGVD28

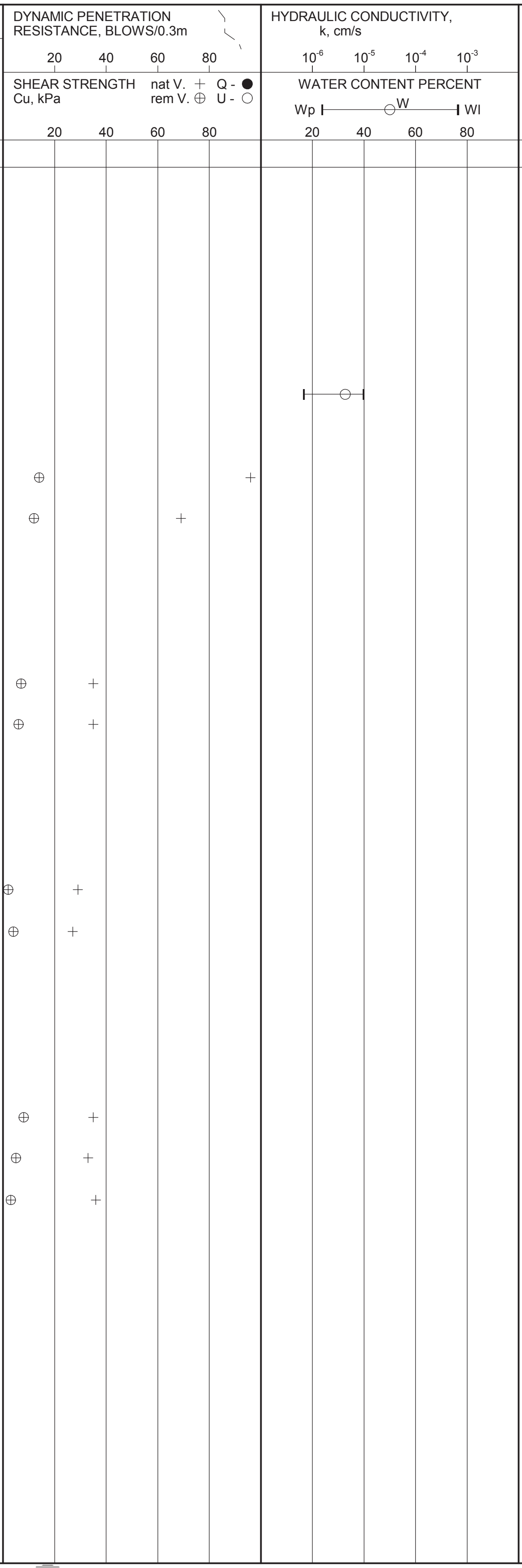
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.09
TOPSOIL - (ML) sandy SILT; dark 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	0.08
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, firm	88.19 2.90
End of Borehole	83.47 7.62

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: SM/KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-25A

SHEET 1 OF 1

LOCATION: Adjacent to BH 17-25

BORING DATE: March 24, 2017

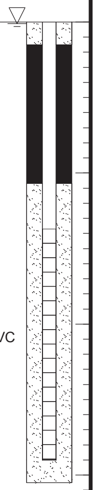
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES 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		91.09							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-25 for Stratigraphy		0.00							
3		End of Borehole		88.04 3.05							

Depth scale marks: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10



Bentonite Seal

Silica Sand

51 mm Diam. PVC
#10 Slot Screen

Silica Sand

WL in Screen at
Elev. 91.08 m on
March 31, 2017

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: SM/KM
CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-26

SHEET 1 OF 1

LOCATION: N 5013197.9 ;E 361757.1

BORING DATE: March 23, 2017

DATUM: CGVD28

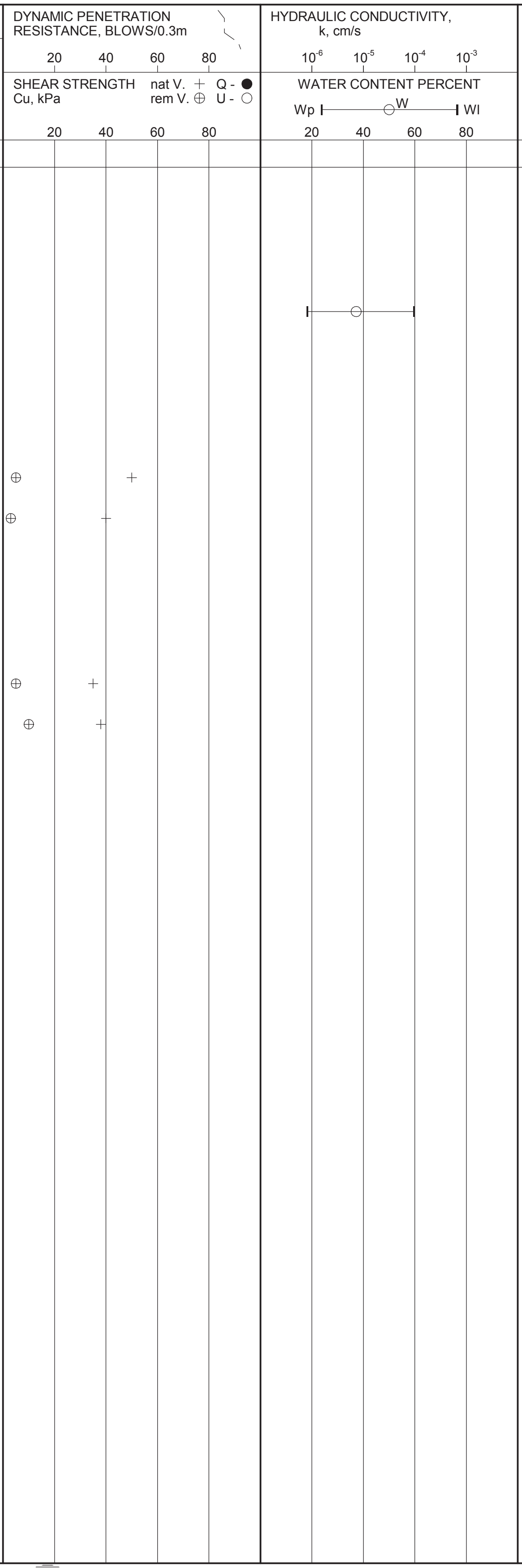
SAMPLER HAMMER, 64kg; DROP, 760mm

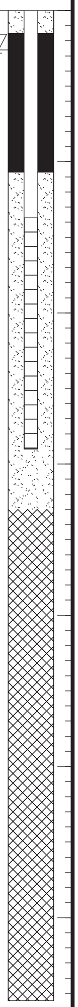
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.54
TOPSOIL - (ML) sandy SILT; dark brown; moist	0.00
(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sandy silt seams (WEATHERED CRUST); cohesive, w>PL, very stiff to firm	0.09
(CI/CH) SILTY CLAY to CLAY; grey, contains silt seams; cohesive, w>PL, firm	88.95 2.59
(SM) gravelly SILTY SAND; grey, contains cobbles and boulders (GLACIAL TILL); non-cohesive, wet, loose to compact	87.12 4.42
End of Borehole	84.99 6.55

NUMBER	TYPE	BLOWS/0.30m
1	SS	12
2	SS	6
3	SS	1
4	SS	WH
5	SS	7
6	SS	10
7	SS	6





WL in Screen at Elev. 91.28 m on March 31, 2017

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: KM/SM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-27

SHEET 1 OF 1

LOCATION: N 5013051.5 ;E 361831.3

BORING DATE: March 28, 2017

DATUM: CGVD28

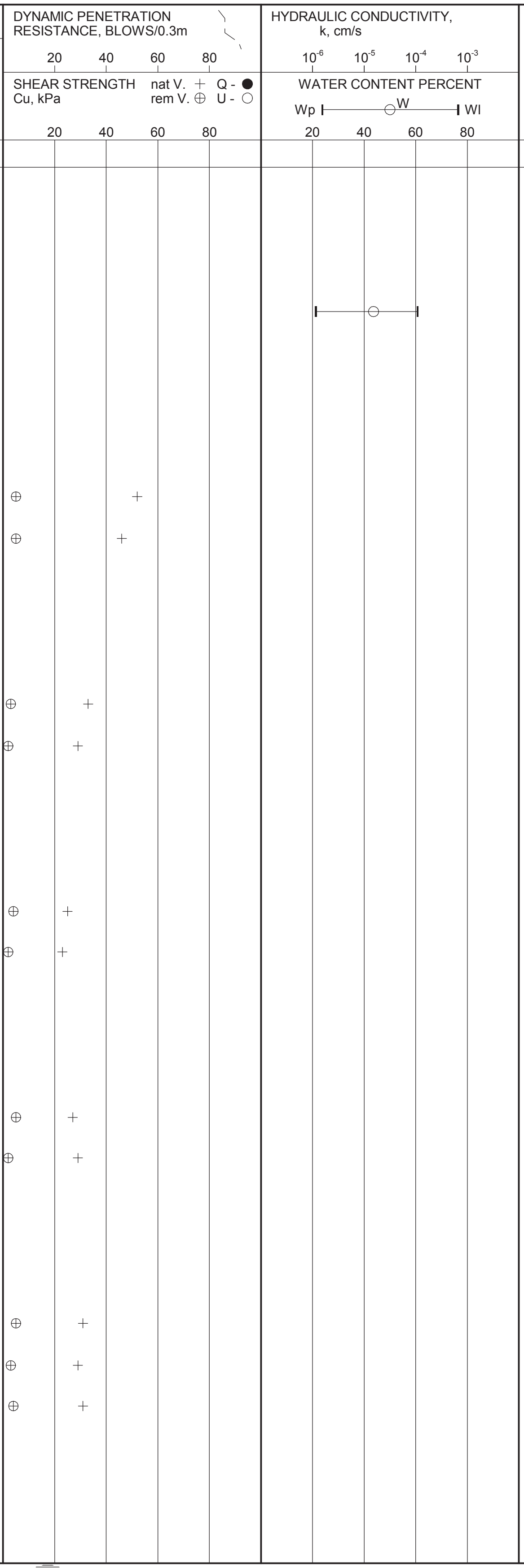
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE – DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	91.21
0	TOPSOIL - (ML) sandy SILT; dark brown; moist	0.00
	(CL/CI/CH) SILTY CLAY to CLAY; grey brown, contains sandy silt layers (WEATHERED CRUST); cohesive, w>PL, stiff to firm	0.09
	(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, soft to firm	88.47 2.74
9	End of Borehole	82.07 9.14

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: KM

CHECKED: SD

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

PROJECT: 1771847

RECORD OF BOREHOLE: 17-28

SHEET 1 OF 1

LOCATION: N 5012922.4 ;E 361888.7

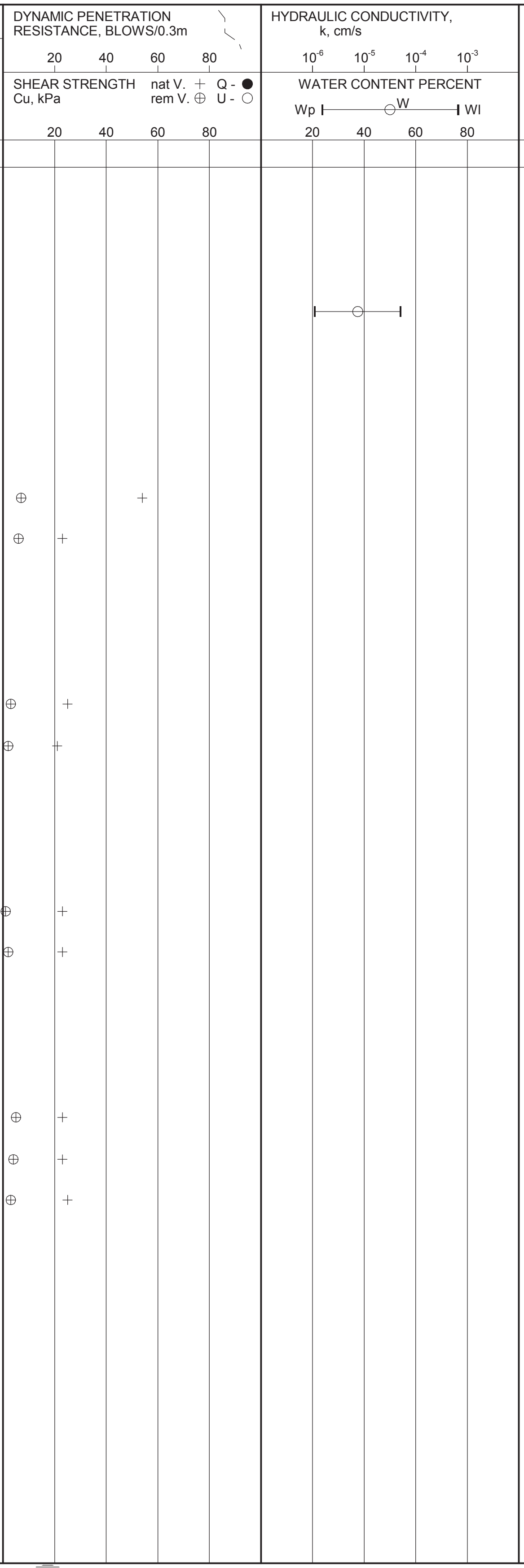
BORING DATE: March 20, 2017

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
		GROUND SURFACE		91.10			
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark 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	▨	0.10	1	SS	13
1					2	SS	5
2					3	SS	WH
		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, soft to firm	▨	88.36 2.74			
3					4	SS	WH
5					5	SS	WH
6					6	SS	WH
		End of Borehole		83.48 7.62			
8							
9							
10							



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-28A

SHEET 1 OF 1

LOCATION: Adjacent to BH 17-28

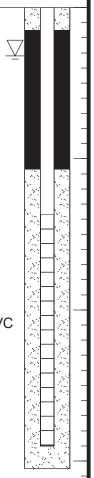
BORING DATE: March 20, 2017

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	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		91.10							
0	Power Auger 200 mm Diam. (Hollow Stem)	Refer to Borehole 17-28 for Stratigraphy		0.00							
1											
2											
3		End of Borehole		88.05 3.05							
4											
5											
6											
7											
8											
9											
10											



Bentonite Seal

Silica Sand

51 mm Diam. PVC
#10 Slot Screen

Silica Sand

WL in Screen at
Elev. 90.78 m on
March 31, 2017

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

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: SD

PROJECT: 1771847

RECORD OF BOREHOLE: 17-29

SHEET 1 OF 1

LOCATION: N 5012811.0 ;E 361925.0

BORING DATE: March 28, 2017

DATUM: CGVD28

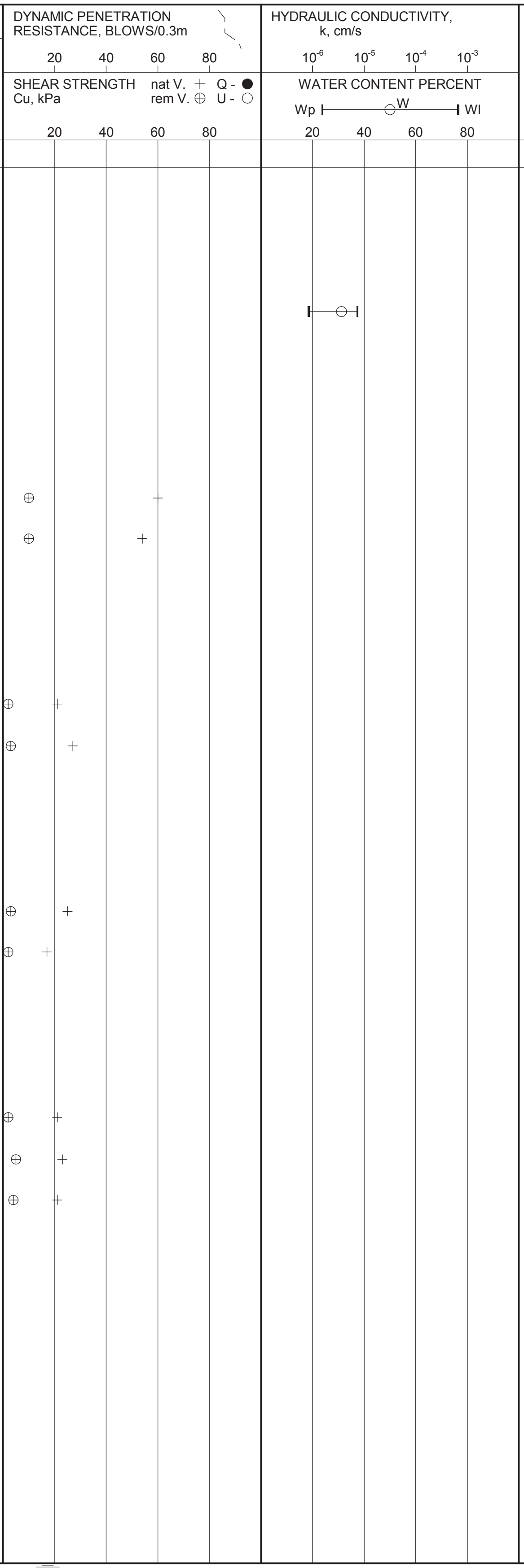
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
	GROUND SURFACE	92.08
0	TOPSOIL - (ML) sandy SILT; dark 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	0.08
	(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, soft to firm	89.34 2.74
	End of Borehole	84.46 7.62

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

LOGGED: KM

CHECKED: SD

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

PROJECT: 1771847

RECORD OF BOREHOLE: 17-30

SHEET 1 OF 1

LOCATION: N 5012708.4 ;E 361971.8

BORING DATE: March 29, 2017

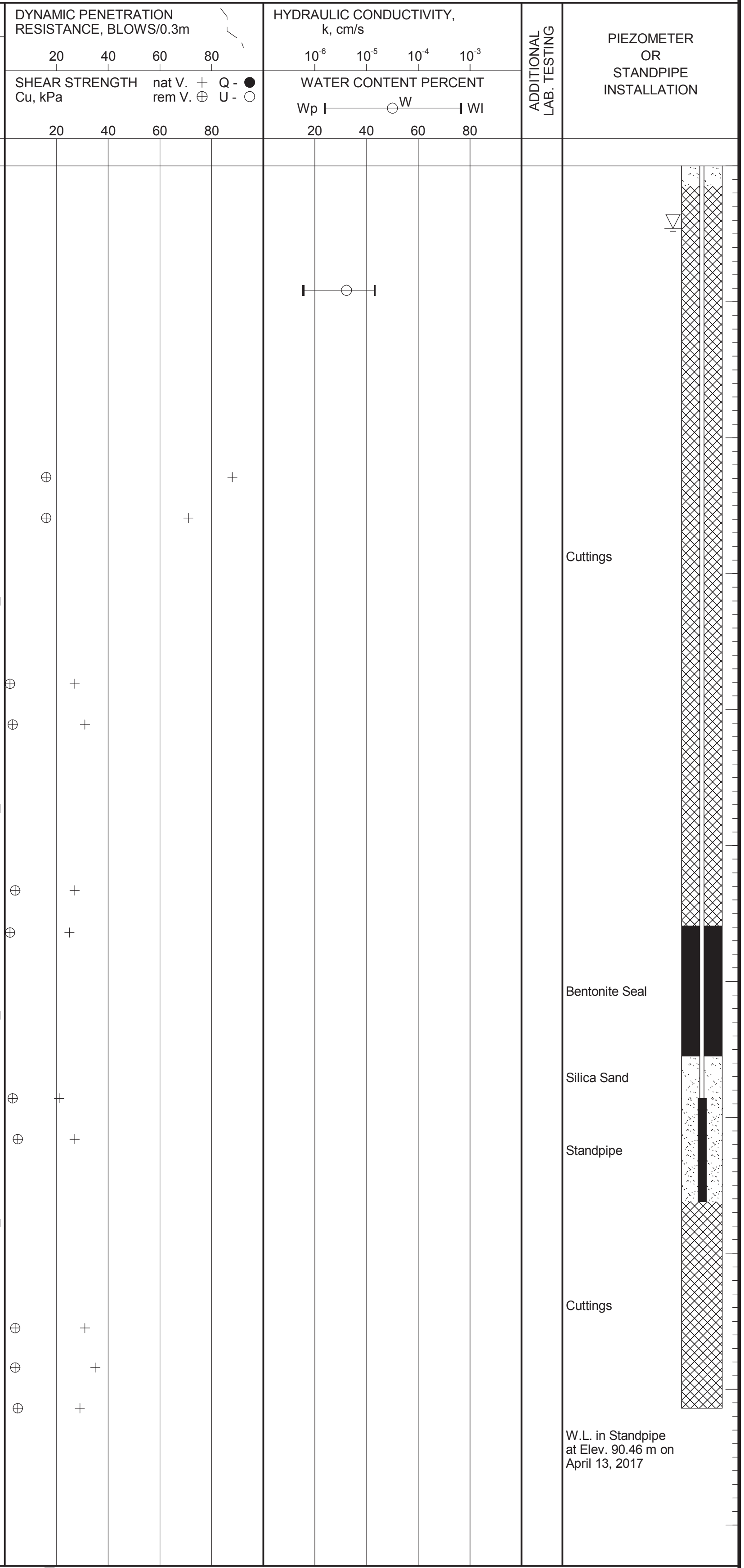
DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
		GROUND SURFACE	90.92
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark 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	0.09
2.90		(CI/CH) SILTY CLAY to CLAY; grey with black organic mottling, contains silt seams; cohesive, w>PL, soft to firm	88.02 2.90
9.14		End of Borehole	81.78 9.14

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



W.L. in Standpipe at Elev. 90.46 m on April 13, 2017

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: KM

CHECKED: SD

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-01

SHEET 1 OF 1

LOCATION: N 5012964.6 ;E 361071.4

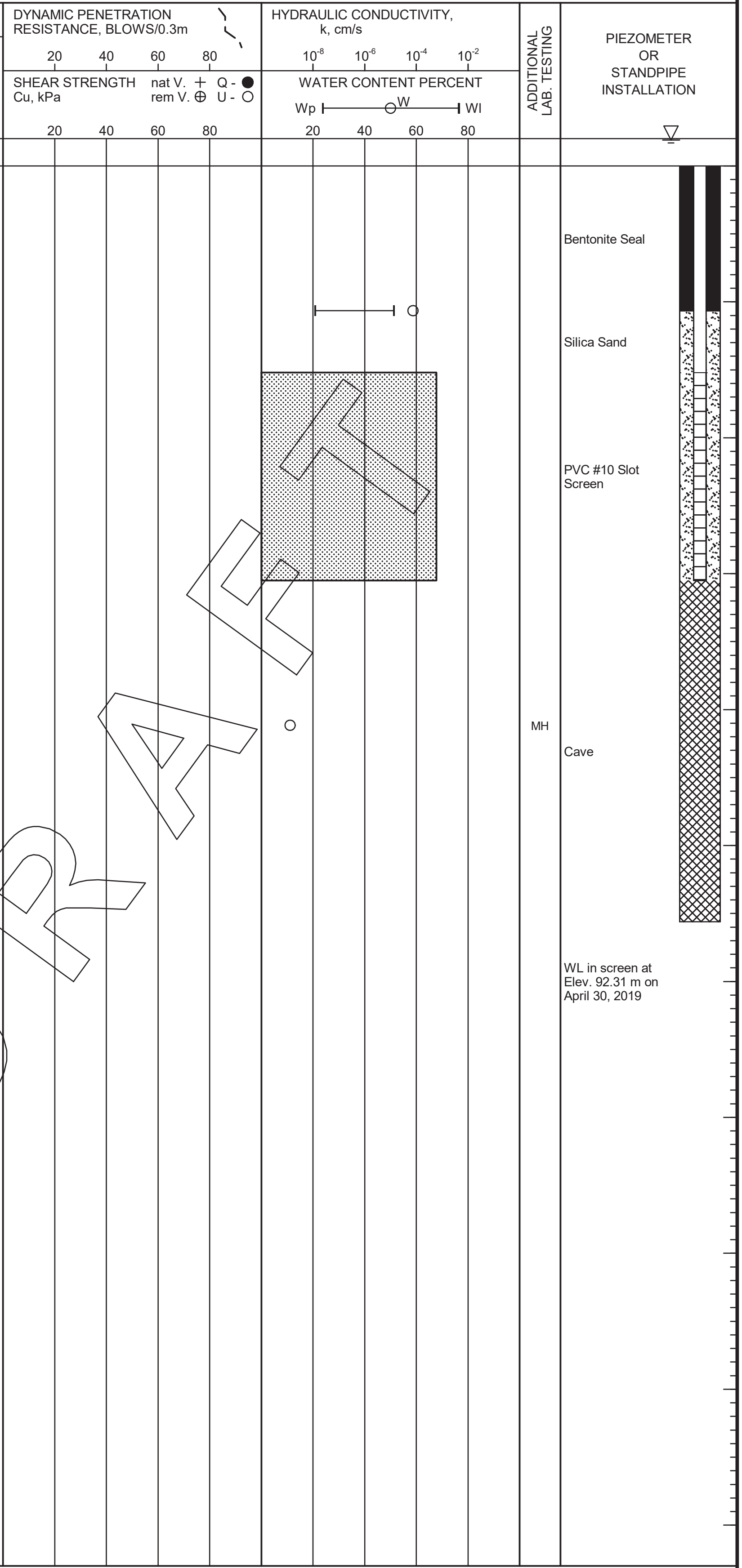
BORING DATE: November 5, 2018

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	ADDITIONAL LAB. TESTING
		GROUND SURFACE	92.12				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (CI/CH) SILTY CLAY, trace sand; dark brown	0.00				
		(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.94 0.18	1	SS	8	
1		(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	91.05 1.07	2	SS	1	
		(ML) gravelly sandy SILT; grey (GLACIAL TILL); non-cohesive, wet, compact to loose	90.60 1.52	3	SS	10	
2		(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, compact to loose	89.99 2.13	4	SS	10	
3		(SW) SAND, trace gravel; non-cohesive, wet, dense	89.07 3.05				
		(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, dense to very dense	88.77 3.35	5	SS	33	
4				6	SS	31	MH
5				7	SS	34	
				8	SS	>50	
		End of Borehole	86.56 5.56				
6							
7							
8							
9							
10							



DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-02

SHEET 1 OF 1

LOCATION: N 5013068.6 ;E 361173.1

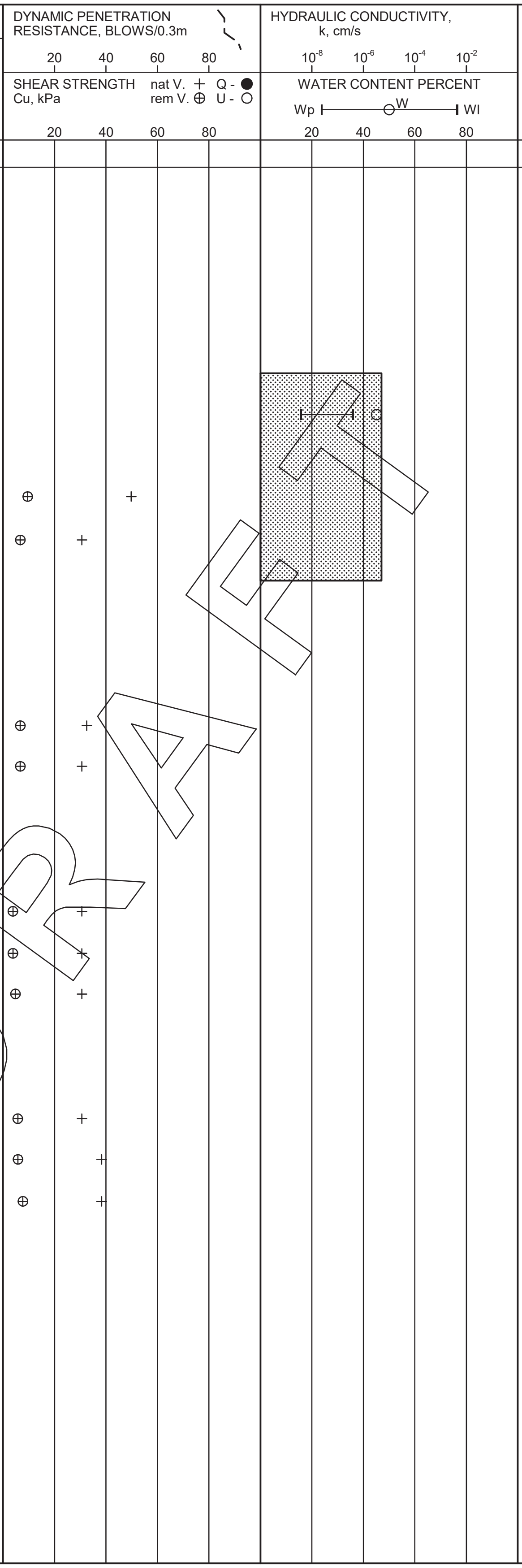
BORING DATE: November 6, 2018

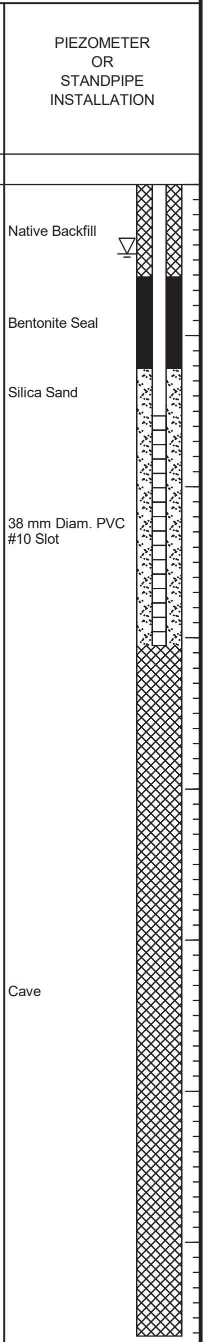
DATUM: CGVD28

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	ADDITIONAL LAB. TESTING
		GROUND SURFACE	91.65				
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (CI/CH) SILTY CLAY	0.00				
		(CI/CH) SILTY CLAY to CLAY to CLAY; brown (WEATHERED CRUST); cohesive, w>PL	0.15	1	SS	8	
1				2	SS	7	
				3	SS	2	MH
2		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	89.52 2.13				
3				4	SS	WH	
4							
5				5	ST	PM	
6				6	SS	WH	
7		End of Borehole	84.03 7.62				
8							
9							
10							





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

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

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RA
CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-03

SHEET 1 OF 1

LOCATION: N 5012861.1 ;E 361112.0

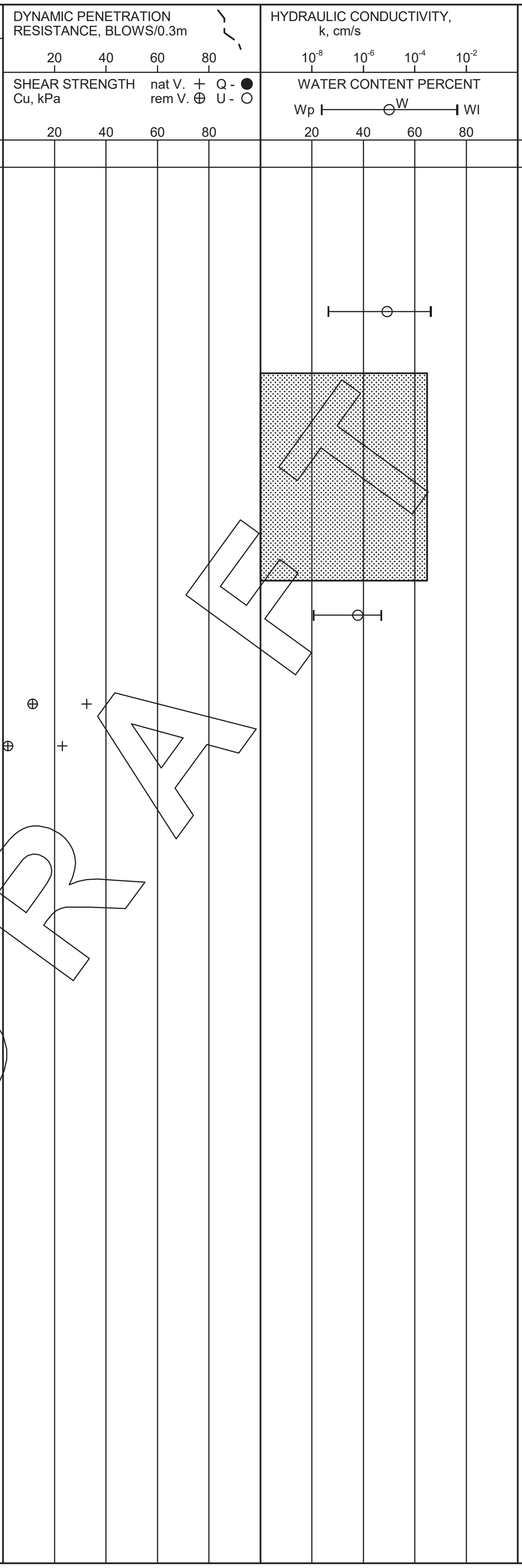
BORING DATE: November 6, 2018

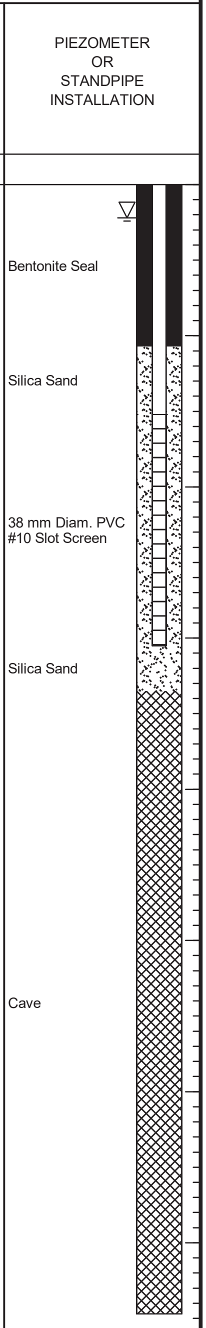
DATUM: CGVD28

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
	GROUND SURFACE	91.32				
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (CI/CH) SILTY CLAY to CLAY, trace to some sand	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	91.07 0.25	1	SS	5	
			2	SS	2	MH
			3	SS	4	
	(CI/C) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm to soft	89.03 2.29	4	SS	WH	
			5	TP	PH	C
			6	SS	3	
	(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, very loose to loose	86.37 4.95	7	SS	6	
			8	SS	1	
			9	SS	5	
	End of Borehole	83.85 7.47				





WL in screen at Elev. 91.09 m on April 30, 2019

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

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-04

SHEET 1 OF 1

LOCATION: N 5012942.7 ;E 361222.8

BORING DATE: November 7, 2018

DATUM: CGVD28

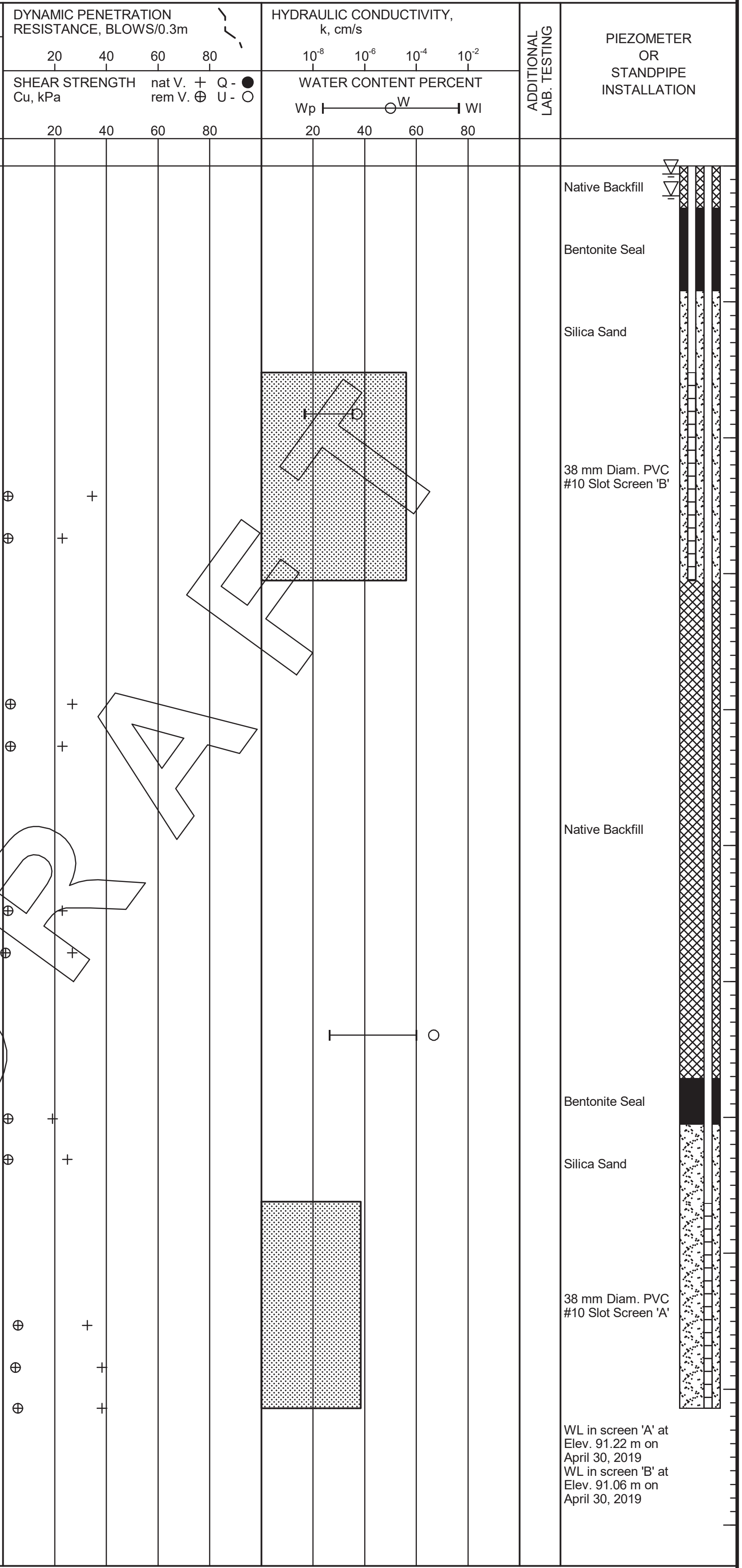
SAMPLER HAMMER, 64kg; DROP, 760mm

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	91.28
0	TOPSOIL - (CL/CI) SILTY CLAY; brown	0.00
	(CI/CH) SILTY CLAY to CLAY; grey (WEATHERED CRUST); cohesive, w>PL, stiff to very stiff	0.15
2	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, soft to firm	89.15 2.13
9	End of Borehole	82.14 9.14

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



WL in screen 'A' at Elev. 91.22 m on April 30, 2019
WL in screen 'B' at Elev. 91.06 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RA
CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-05

SHEET 1 OF 1

LOCATION: N 5012741.6 ;E 361151.9

BORING DATE: November 7, 2018

DATUM: CGVD28

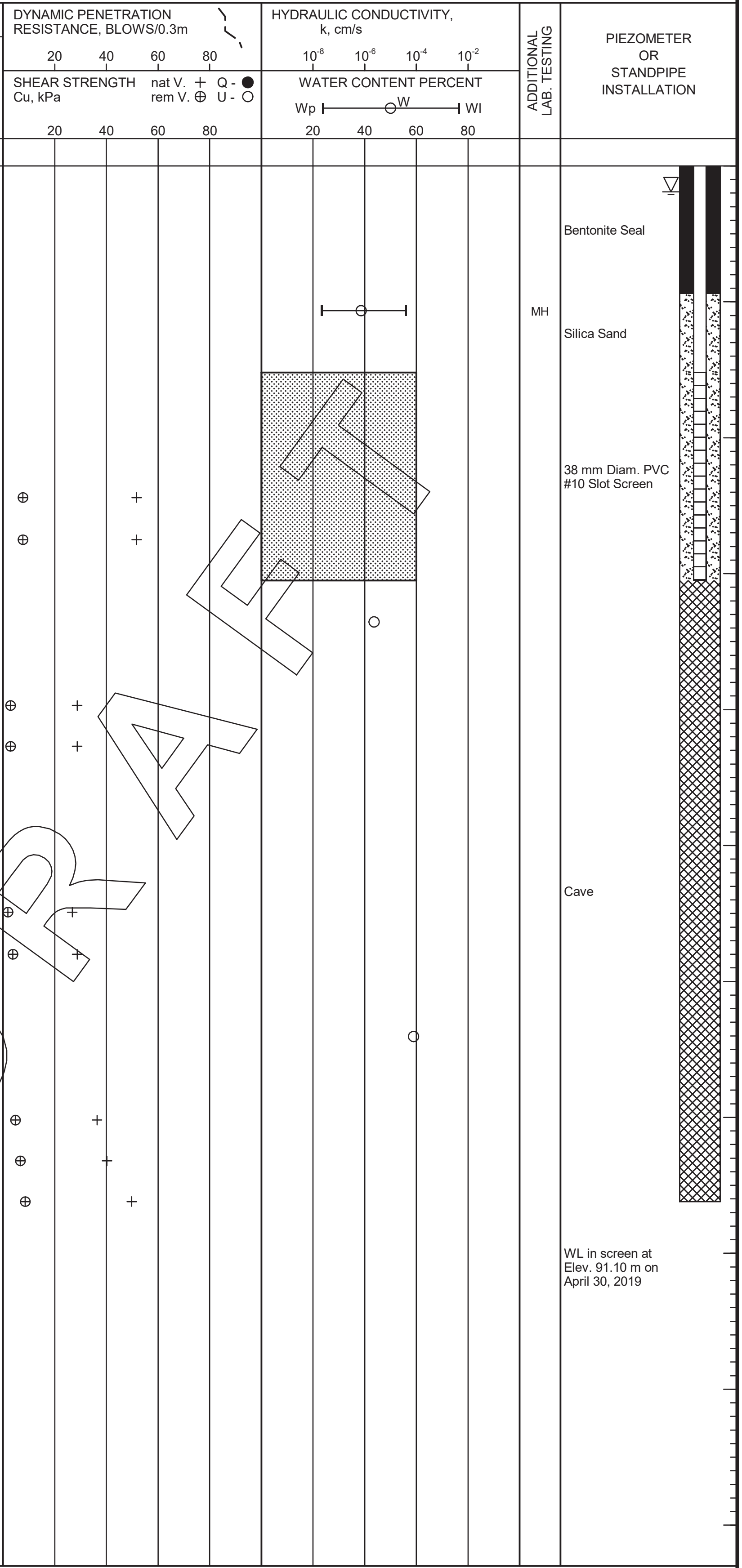
SAMPLER HAMMER, 64kg; DROP, 760mm

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)	SAMPLES – NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
GROUND SURFACE	91.29				
TOPSOIL - (CI/CH) SILTY CLAY to CLAY, trace sand; dark brown	0.00				
(SM/ML) SILTY SAND to sandy SILT; grey brown; non-cohesive, moist to wet, loose	91.04 0.25	1	SS	7	
(CI/CH) SILTY CLAY to CLAY, trace sand; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.38 0.91	2 3	SS SS	3 WH	MH
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	89.16 2.13	4 5 6	SS SS SS	PM PM PM	
End of Borehole	83.67 7.62				



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

Cave

WL in screen at Elev. 91.10 m on April 30, 2019

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RA

CHECKED:

RECORD OF BOREHOLE: 18-06

PROJECT: 18108333-2000

SHEET 1 OF 1

LOCATION: N 5012825.6 ;E 361270.4

BORING DATE: November 7, 2018

DATUM: CGVD28

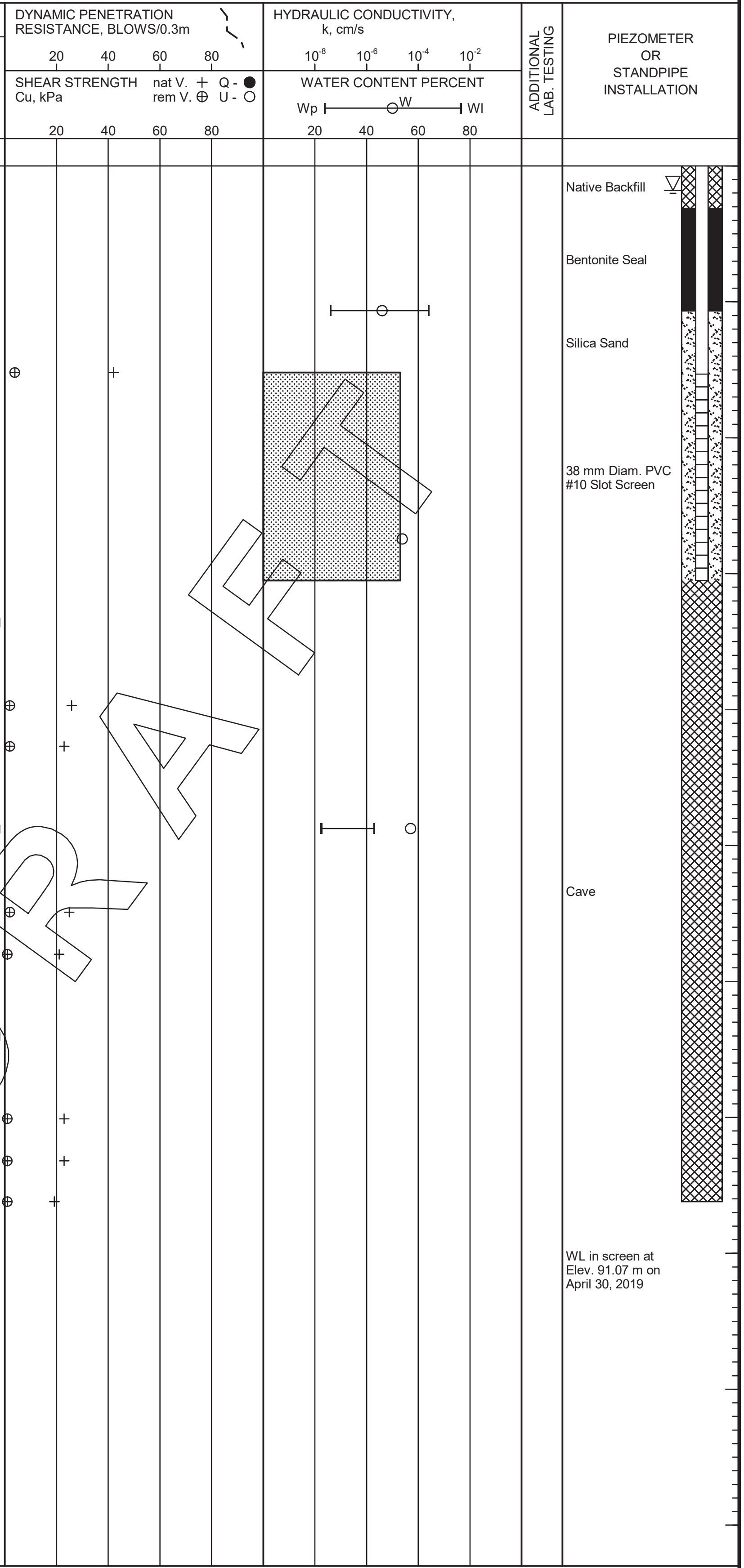
SAMPLER HAMMER, 64kg; DROP, 760mm

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	91.25
0	TOPSOIL - (CL/CU) SILTY CLAY; brown	0.00
	(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff to firm	0.15
2	(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, soft	88.96 2.29
7	End of Borehole	83.63 7.62

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



WL in screen at Elev. 91.07 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RA
CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-07

SHEET 1 OF 1

LOCATION: N 5012600.1 ;E 361205.1

BORING DATE: November 7, 2018

DATUM: CGVD28

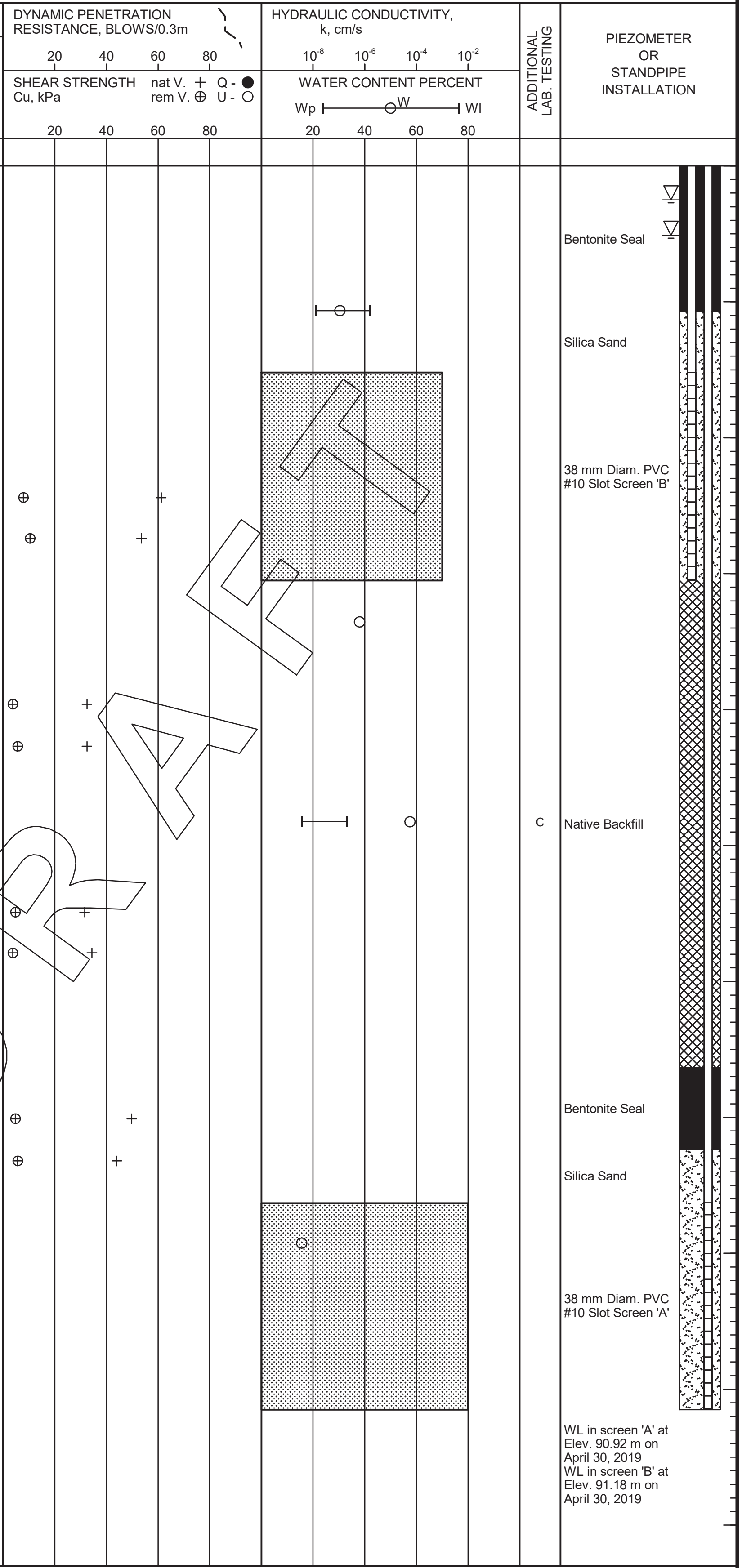
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.43
TOPSOIL - (CI/CH) SILTY CLAY to CLAY, trace to some sand	0.00
(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown, contain silty sand seams (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	91.13 0.30
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	88.38 3.05
(SM) gravelly SILTY SAND: grey (GLACIAL TILL); non-cohesive, wet, compact to loose	83.81 7.62
End of Borehole	82.28 9.15

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	5
2	SS	2
3	SS	WH
4	SS	WH
5	TP	PM
6	SS	PM
7	SS	11
8	SS	5



WL in screen 'A' at Elev. 90.92 m on April 30, 2019
WL in screen 'B' at Elev. 91.18 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-08

SHEET 1 OF 1

LOCATION: N 5012701.2 ;E 361309.6

BORING DATE: November 8, 2018

DATUM: CGVD28

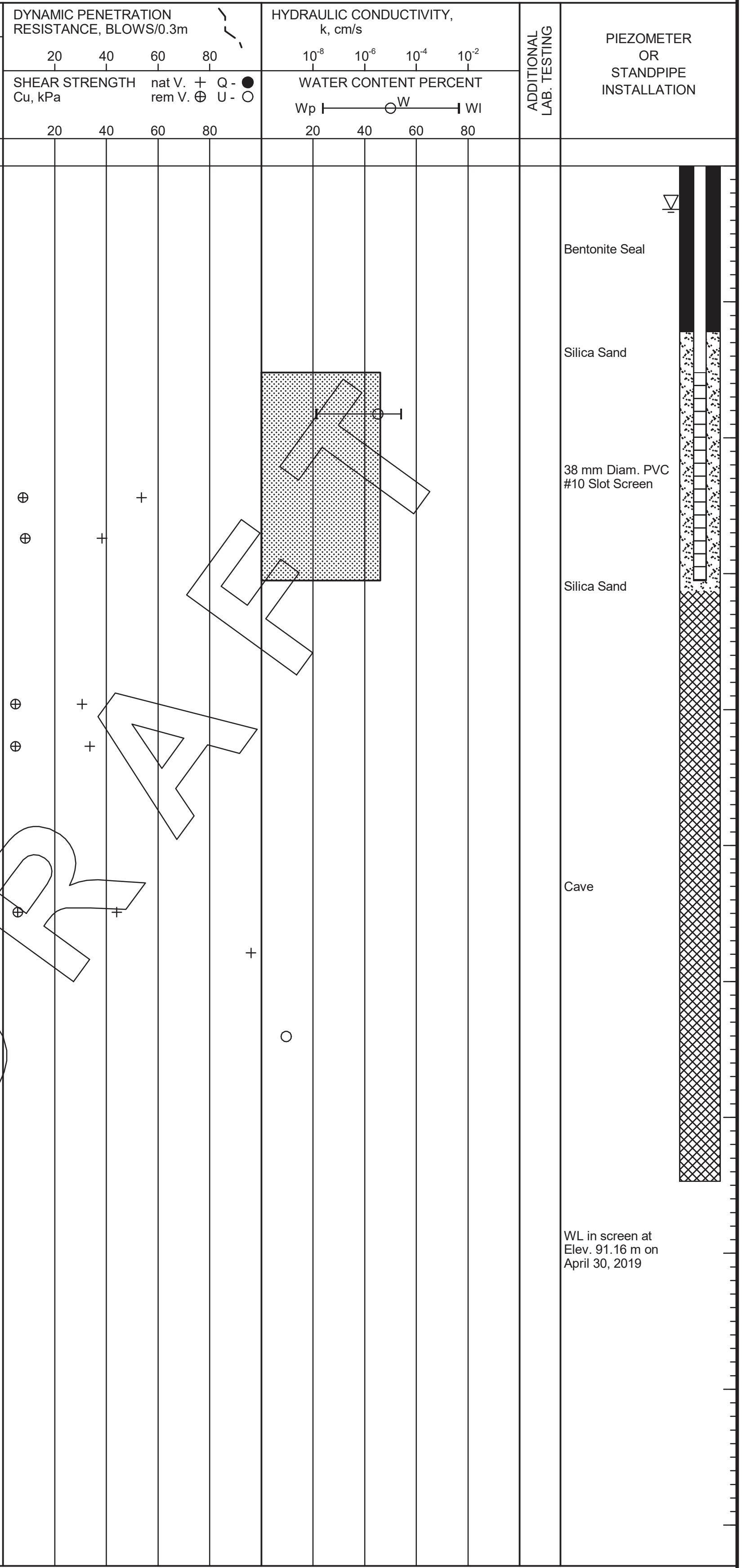
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

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

SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.48
TOPSOIL - (CI/CH) SILTY CLAY to CLAY, 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	91.12 0.36
(CI/CH) SILTY CLAY to CLAY, trace sand; grey, contains silty sand seams; cohesive, w>PL, firm	89.35 2.13
(SM) gravelly SILTY SAND; grey (GLACIAL TILL); non-cohesive, wet, very loose to loose	85.99 5.49
End of Borehole	84.01 7.47

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



WL in screen at Elev. 91.16 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-09

SHEET 1 OF 1

LOCATION: N 5012730.1 ;E 361453.5

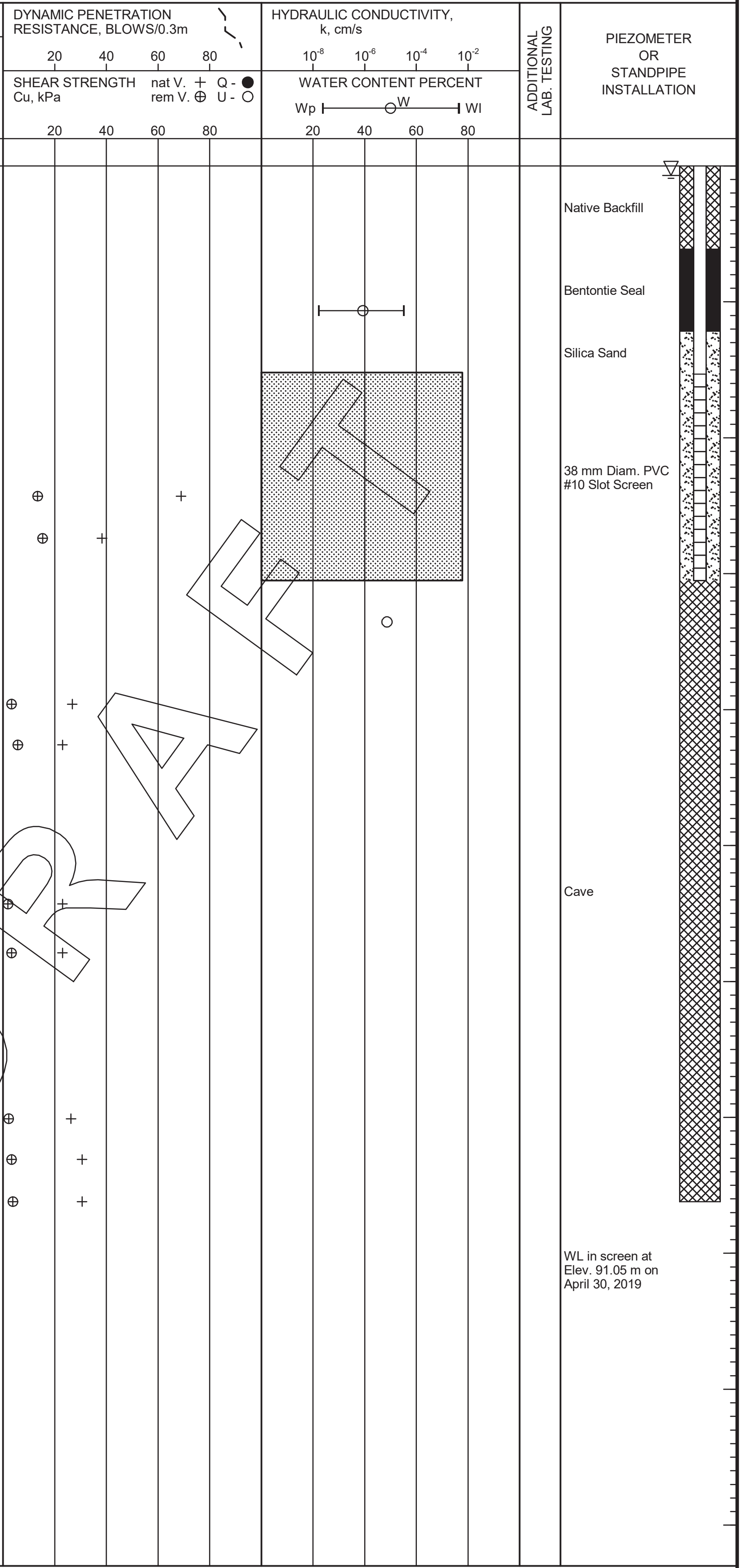
BORING DATE: November 8, 2018

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		91.12			
0		TOPSOIL - (CL/CI) SILTY CLAY; brown		0.00 90.92			
		(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff		0.20	1	SS	8
1					2	SS	4
2					3	SS	1
		(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, soft to firm		88.69 2.43			
3					4	SS	WH
4	Power Auger 200 mm Diam. (Hollow Stem)						
5					5	SS	WH
6					6	ST	PM
7							
		End of Borehole		83.50 7.62			
8							
9							
10							



WL in screen at Elev. 91.05 m on April 30, 2019

DEPTH SCALE

1 : 50

GOLDER

LOGGED: RA

CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-10

SHEET 1 OF 1

LOCATION: N 5012493.1 ;E 361243.6

BORING DATE: November 7, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

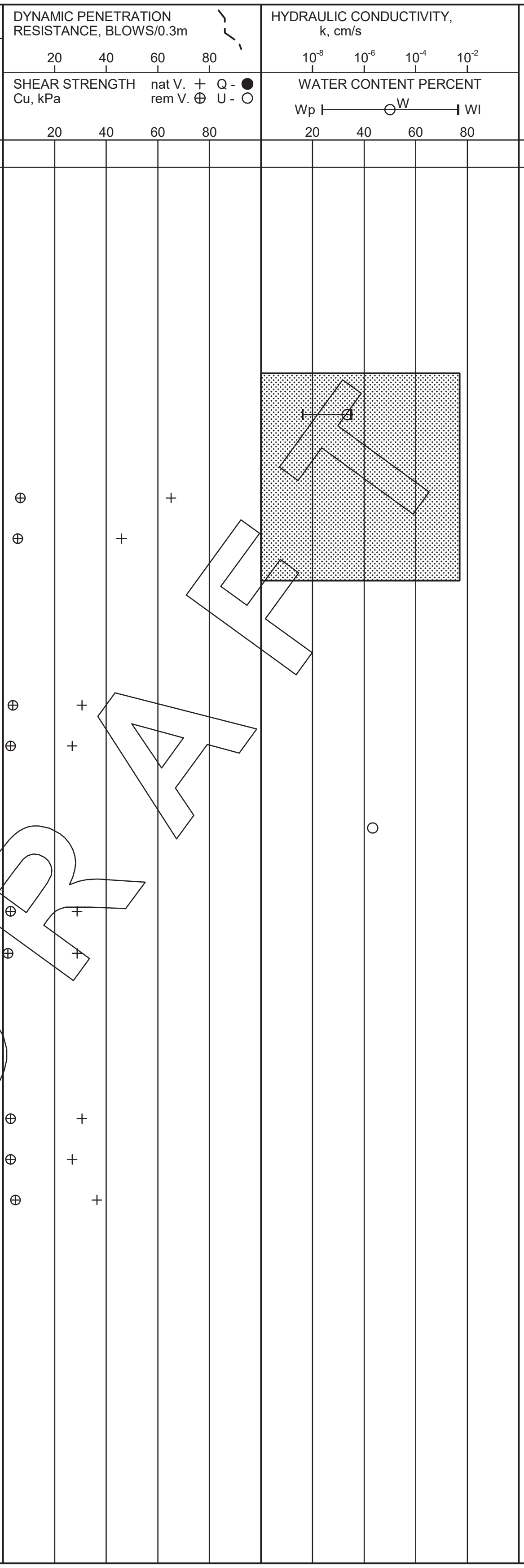
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

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

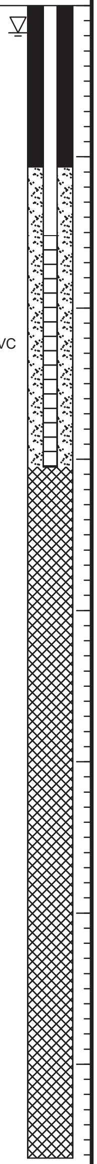
SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.24
TOPSOIL - (CI/CH) SILTY CLAY to CLAY, trace to some sand; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY, trace to some sand; grey brown (WEATHERED CRUST); cohesive, w>PL, stiff to firm	91.01 0.23
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	89.11 2.13
End of Borehole	83.62 7.62

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



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

Cave

WL in screen at Elev. 91.06 m on April 30, 2019

DEPTH SCALE 1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-11

SHEET 1 OF 1

LOCATION: N 5012581.7 ;E 361340.0

BORING DATE: November 8, 2018

DATUM: CGVD28

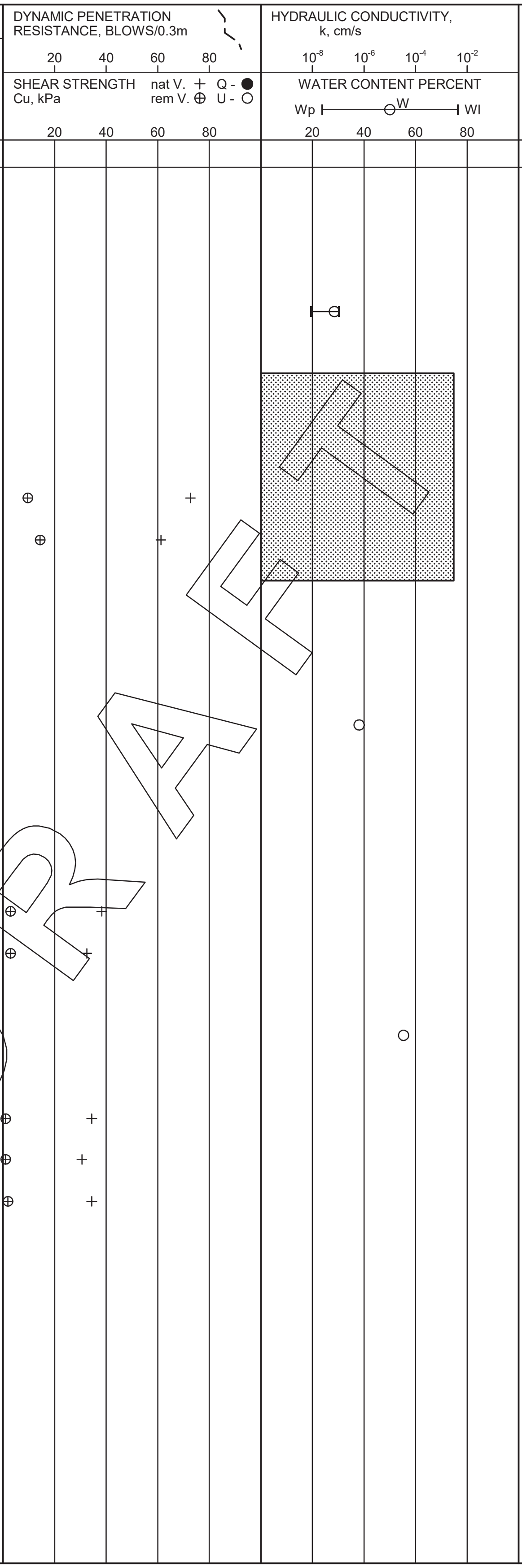
SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

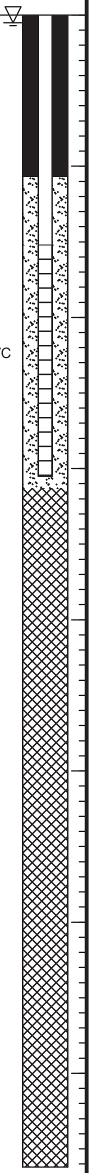
BORING METHOD: Power Auger, 200 mm Diam. (Hollow Stem)

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.26
TOPSOIL - (CI/CH) SILTY CLAY to CLAY, 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	90.96 0.30
(CI/CH) SILTY CLAY to CLAY, trace sand; grey, contains silty sand seams; cohesive, w>PL, firm	88.21 3.05
(CI/CH) SILTY CLAY to CLAY, some gravel; grey; cohesive, w>PL, firm	87.91 3.35
(CI/CH) SILTY CLAY to CLAY, trace sand; grey, contains silty sand seams; cohesive, w>PL, firm	87.60 3.66
End of Borehole	83.64 7.62

SAMPLES NUMBER	TYPE	BLOWS/0.30m	ADDITIONAL LAB. TESTING
1	SS	4	
2	SS	2	MH
3	SS	1	
4	SS	12	
5	SS	WH	
6	SS	WH	
7	SS	PM	



PIEZOMETER OR STANDPIPE INSTALLATION



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

Silica Sand

Cave

WL in screen at Elev. 91.21 m on April 30, 2019

DEPTH SCALE 1 : 50

GOLDER

LOGGED: RI

CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-12

SHEET 1 OF 1

LOCATION: N 5012613.5 ;E 361486.7

BORING DATE: November 8, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

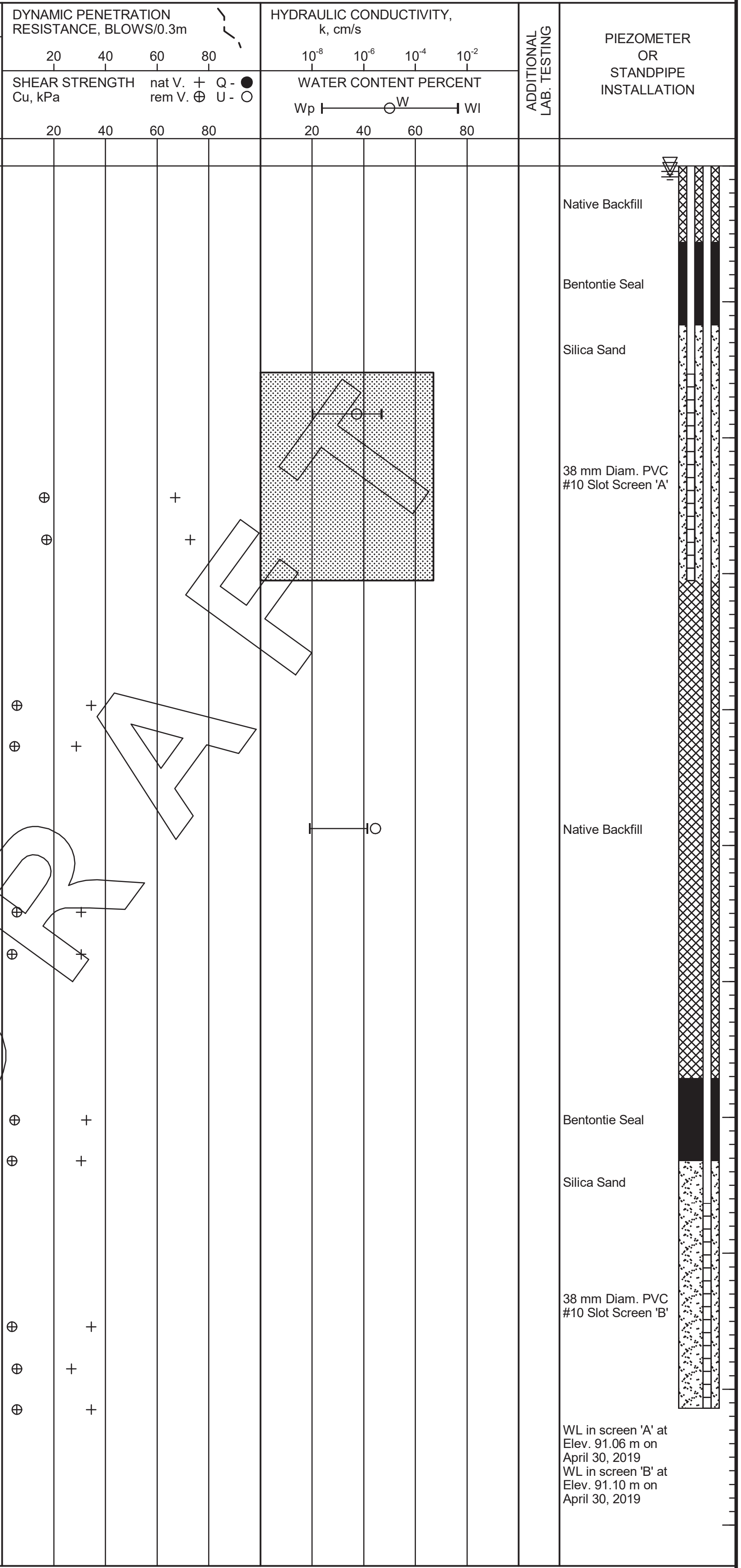
PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES: 0 – 10

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

SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)
GROUND SURFACE	91.14
TOPSOIL - (CL/CI) SILTY CLAY; brown	0.00
(CI/CH) SILTY CLAY to CLAY; grey brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	90.96 0.18
(CI/CH) SILTY CLAY; grey; cohesive, w>PL< firm	88.09 3.05
End of Borehole	82.00 9.14

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



WL in screen 'A' at Elev. 91.06 m on April 30, 2019
WL in screen 'B' at Elev. 91.10 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RA
CHECKED:

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

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-13

SHEET 1 OF 1

LOCATION: N 5012467.9 ;E 361426.7

BORING DATE: November 8, 2018

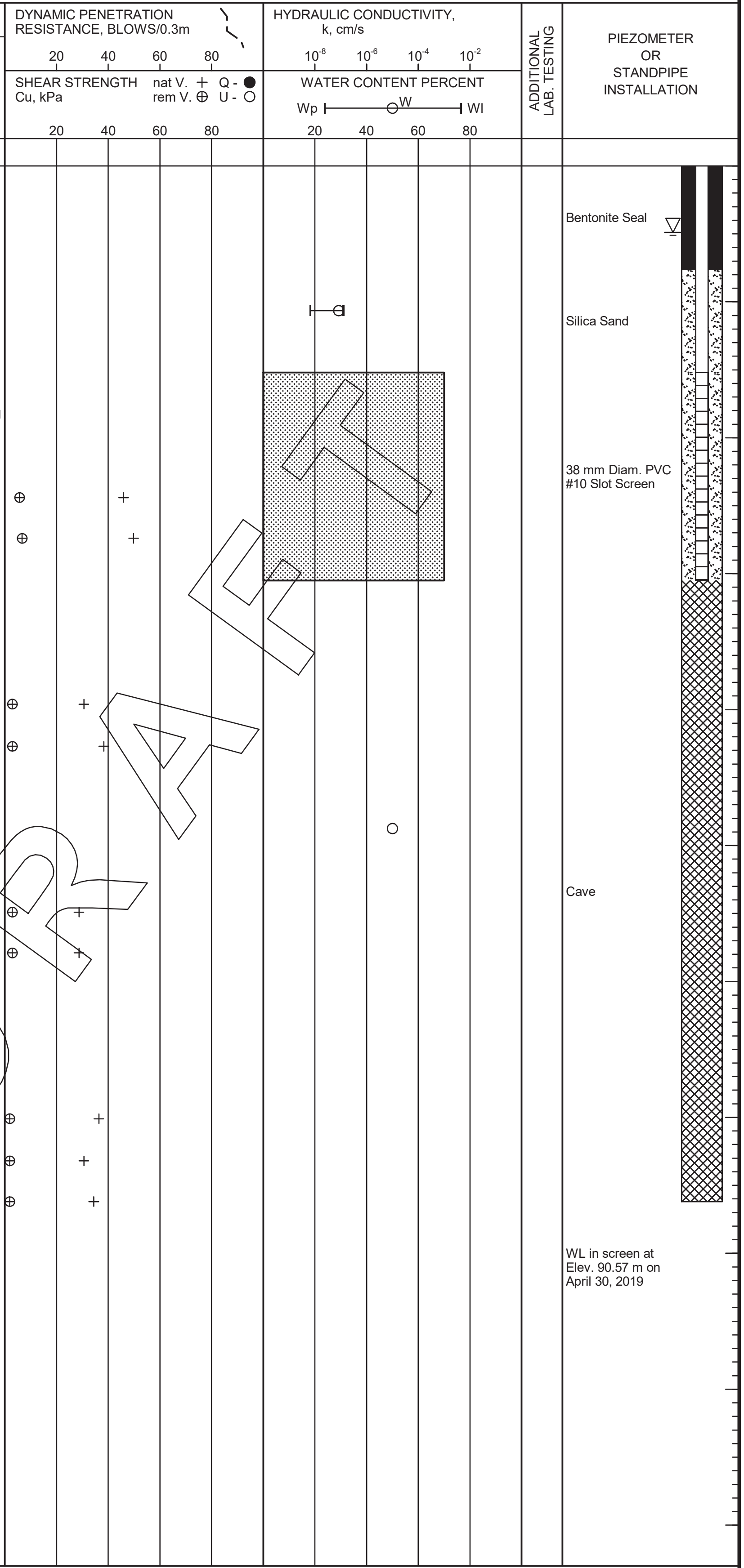
DATUM: CGVD28

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	91.07			
TOPSOIL - (CI/CH) SILTY CLAY to CLAY, 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, stiff	90.79 0.28	1	SS	3
		2	SS	3
		3	SS	WH
(CI/CH) SILTY CLAY to CLAY; grey, contains silty sand seams; cohesive, w>PL, firm	88.78 2.29			
		4	TP	PM
		5	SS	PM
		6	SS	PM
End of Borehole	83.45 7.62			



Bentonite Seal

Silica Sand

38 mm Diam. PVC #10 Slot Screen

Cave

WL in screen at Elev. 90.57 m on April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RI
CHECKED:

PROJECT: 18108333-2000

RECORD OF BOREHOLE: 18-14

SHEET 1 OF 1

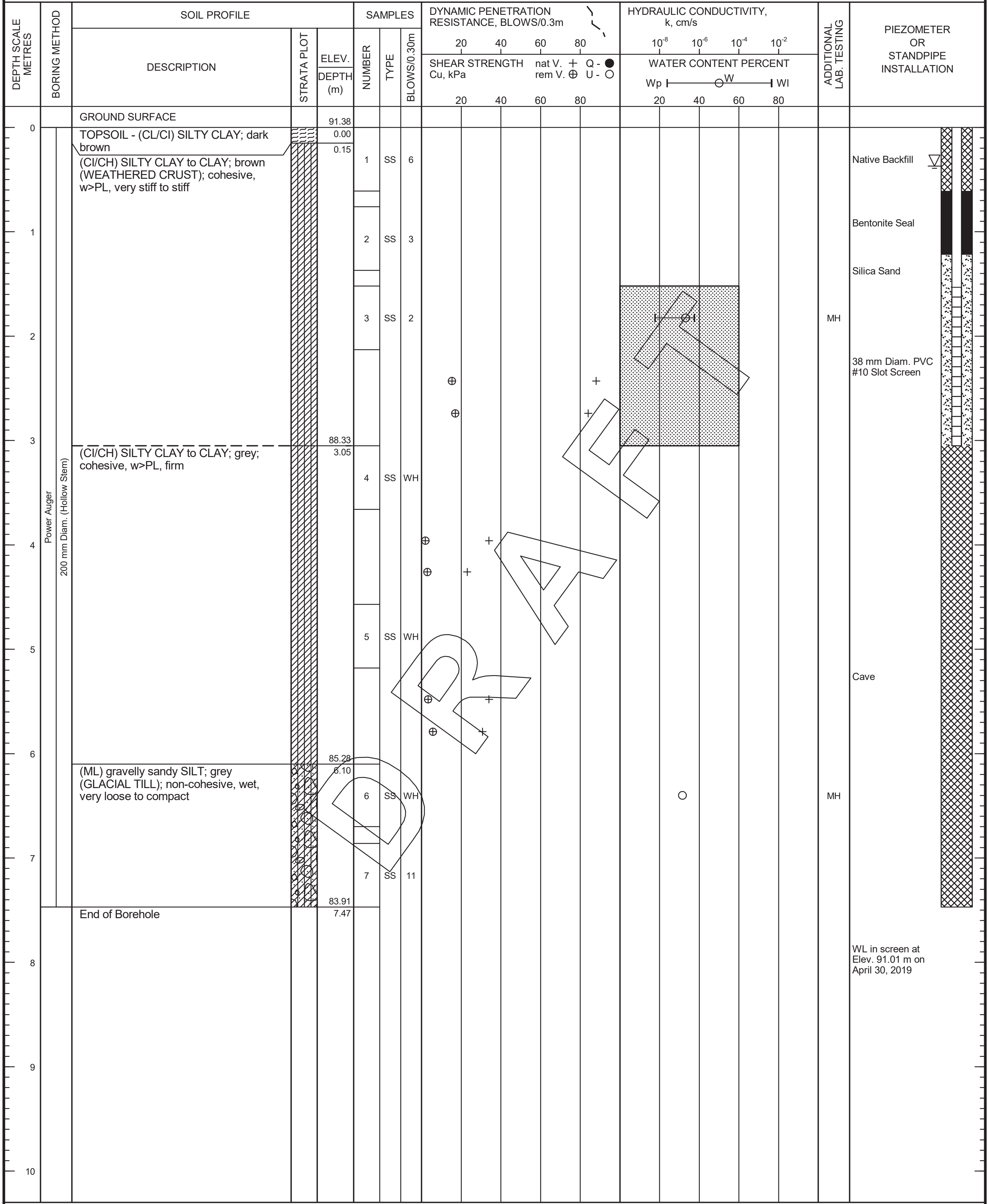
LOCATION: N 5012533.4 ;E 361557.7

BORING DATE: November 9, 2018

DATUM: CGVD28

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
GROUND SURFACE	91.38
TOPSOIL - (CL/CI) SILTY CLAY; dark brown	0.00
(CI/CH) SILTY CLAY to CLAY; brown (WEATHERED CRUST); cohesive, w>PL, very stiff to stiff	0.15
(CI/CH) SILTY CLAY to CLAY; grey; cohesive, w>PL, firm	88.33 3.05
(ML) gravelly sandy SILT; grey (GLACIAL TILL); non-cohesive, wet, very loose to compact	85.28 6.10
End of Borehole	83.91 7.47

SAMPLES NUMBER	TYPE	BLOWS/0.30m
1	SS	6
2	SS	3
3	SS	2
4	SS	WH
5	SS	WH
6	SS	WH
7	SS	11

Native Backfill

Bentonite Seal

Silica Sand

38 mm Diam. PVC
#10 Slot Screen

Cave

WL in screen at
Elev. 91.01 m on
April 30, 2019

DEPTH SCALE
1 : 50

GOLDER

LOGGED: RA

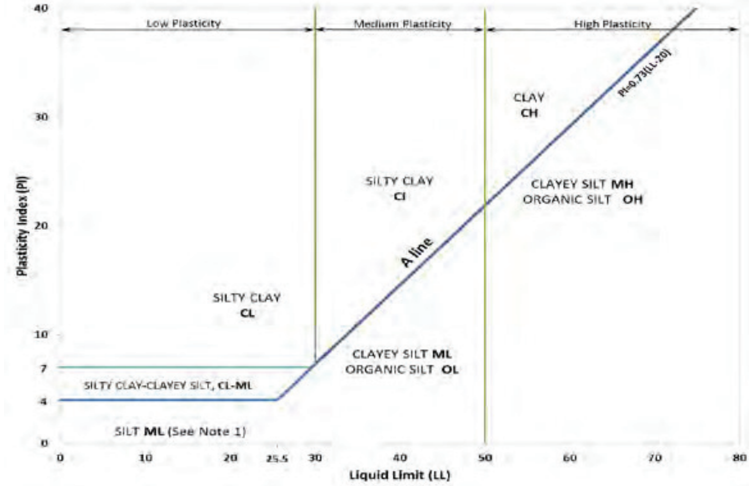
CHECKED:

METHOD OF SOIL CLASSIFICATION

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 = σ'_p / σ'_{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

* 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.

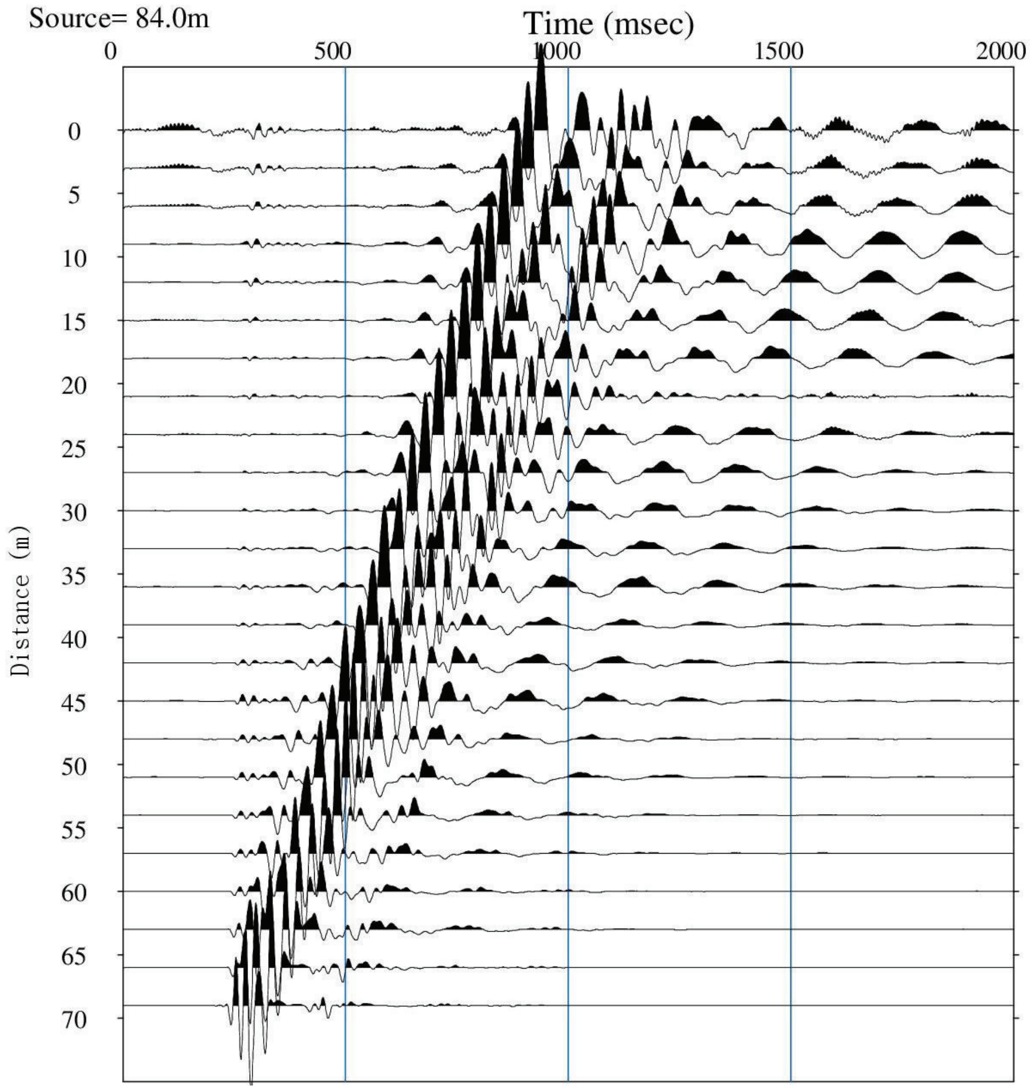


Figure 2: Typical seismic record collected at the site of the MASW Line 1.

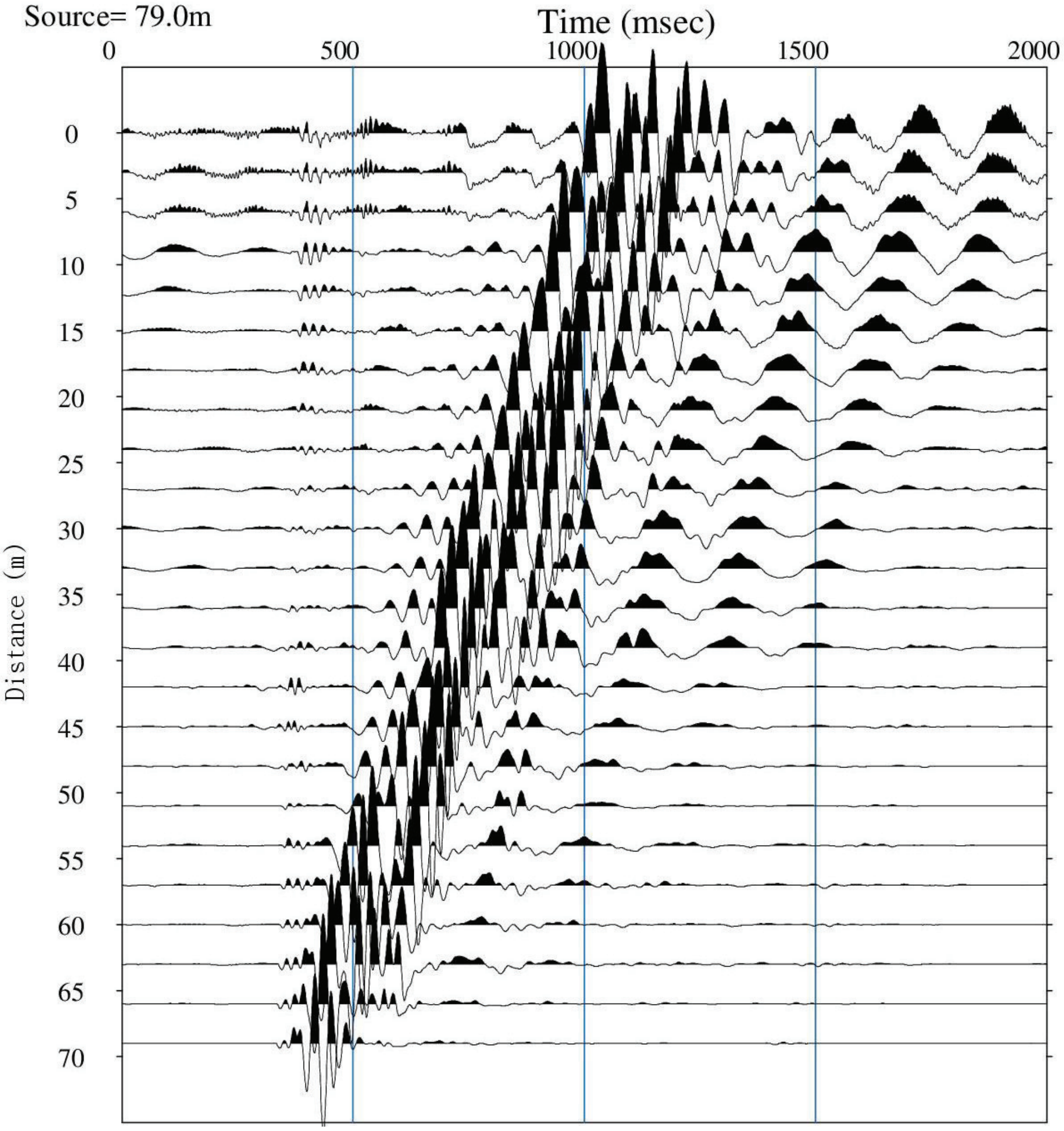


Figure 3: Typical seismic record collected at the site of the MASW Line 2.

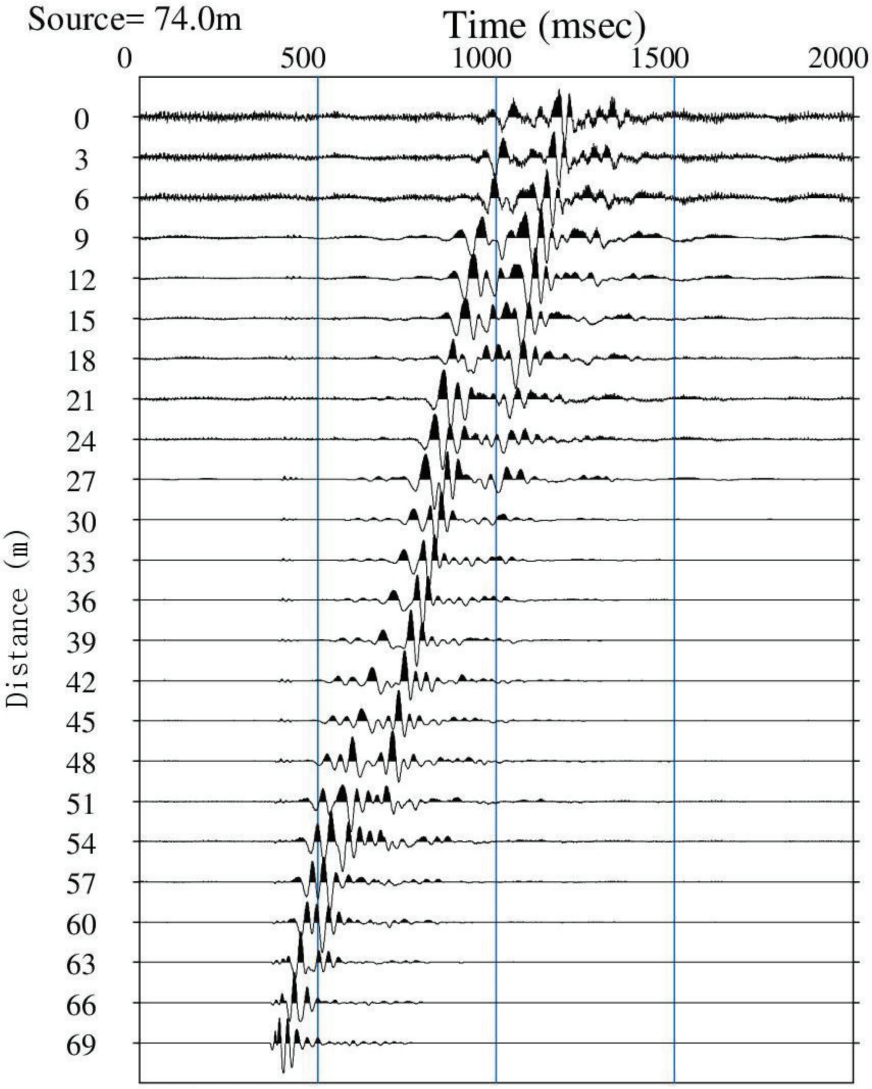


Figure 4: Typical seismic record collected at the site of the MASW Line 3.

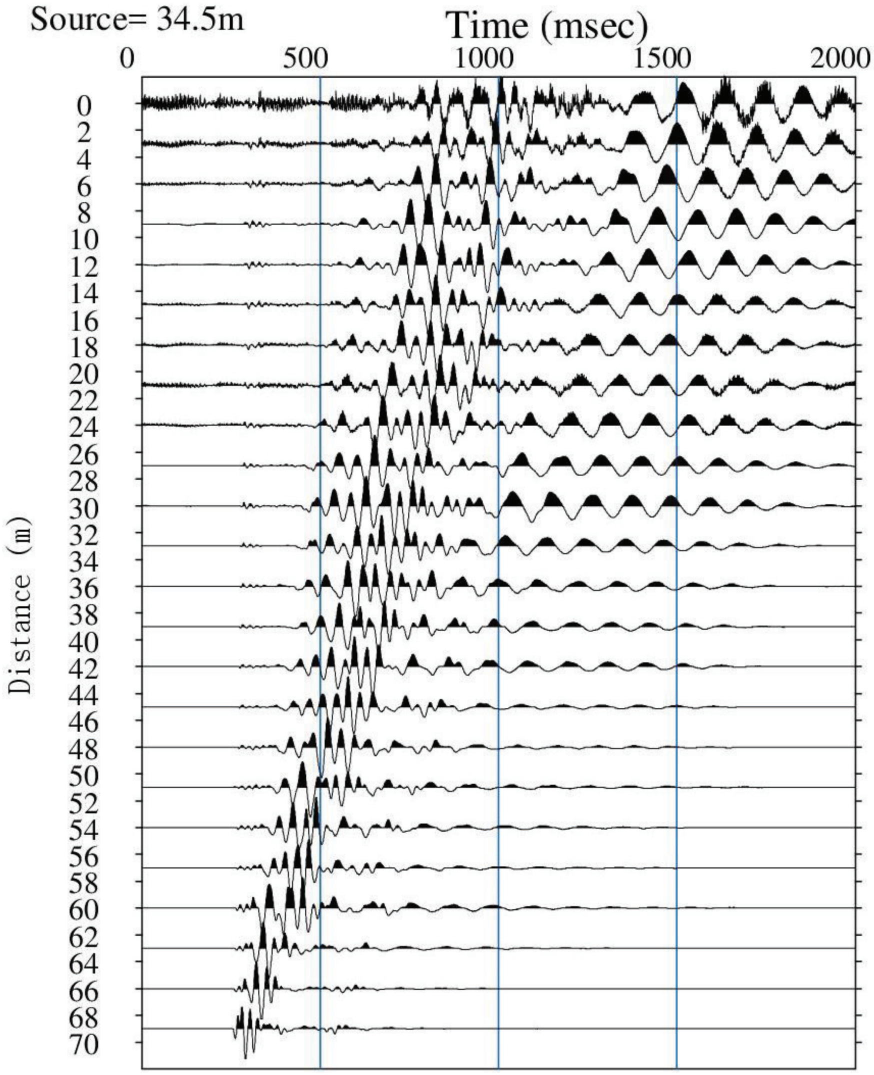


Figure 5: Typical seismic record collected at the site of the MASW Line 4.

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

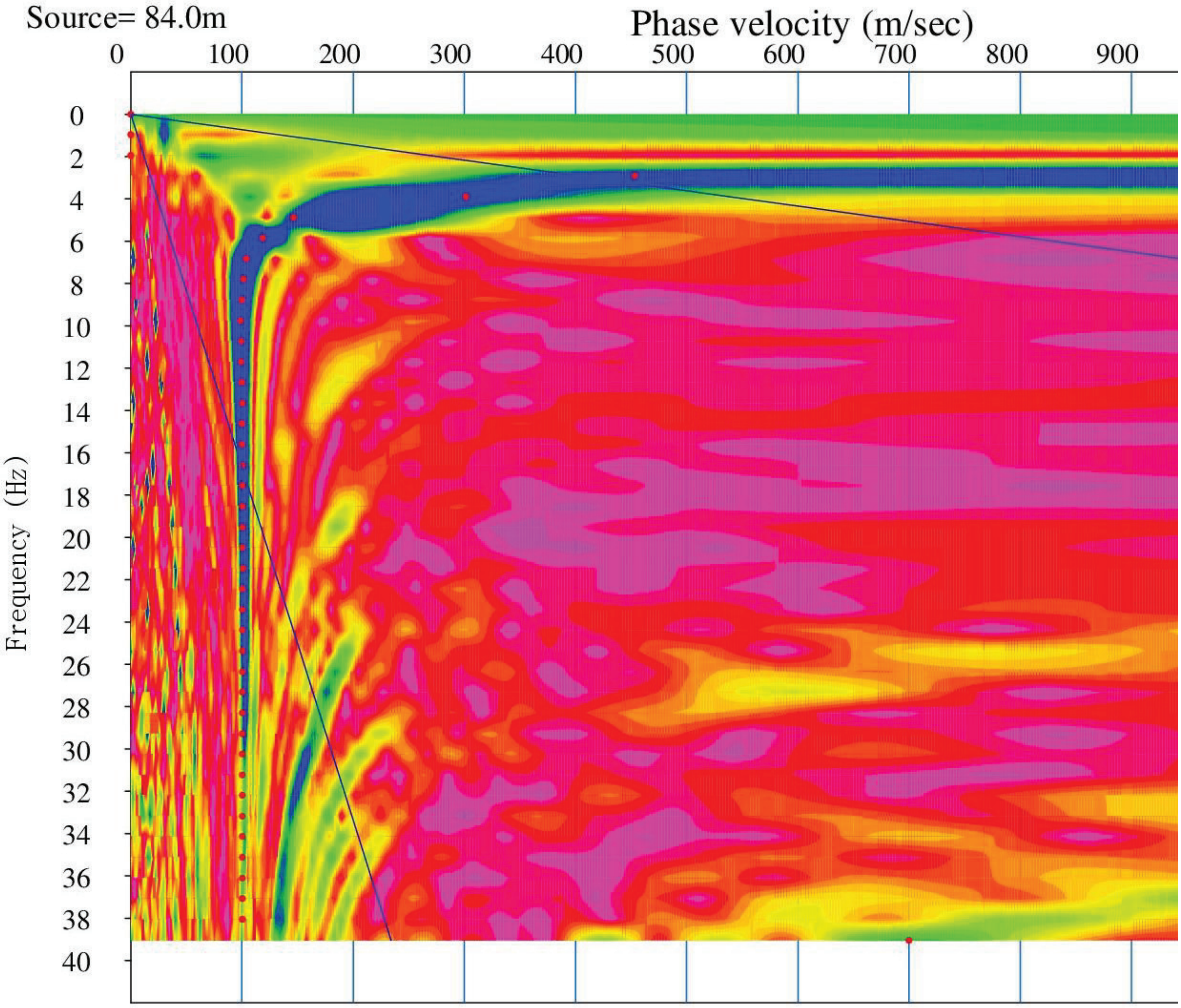


Figure 6: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 1

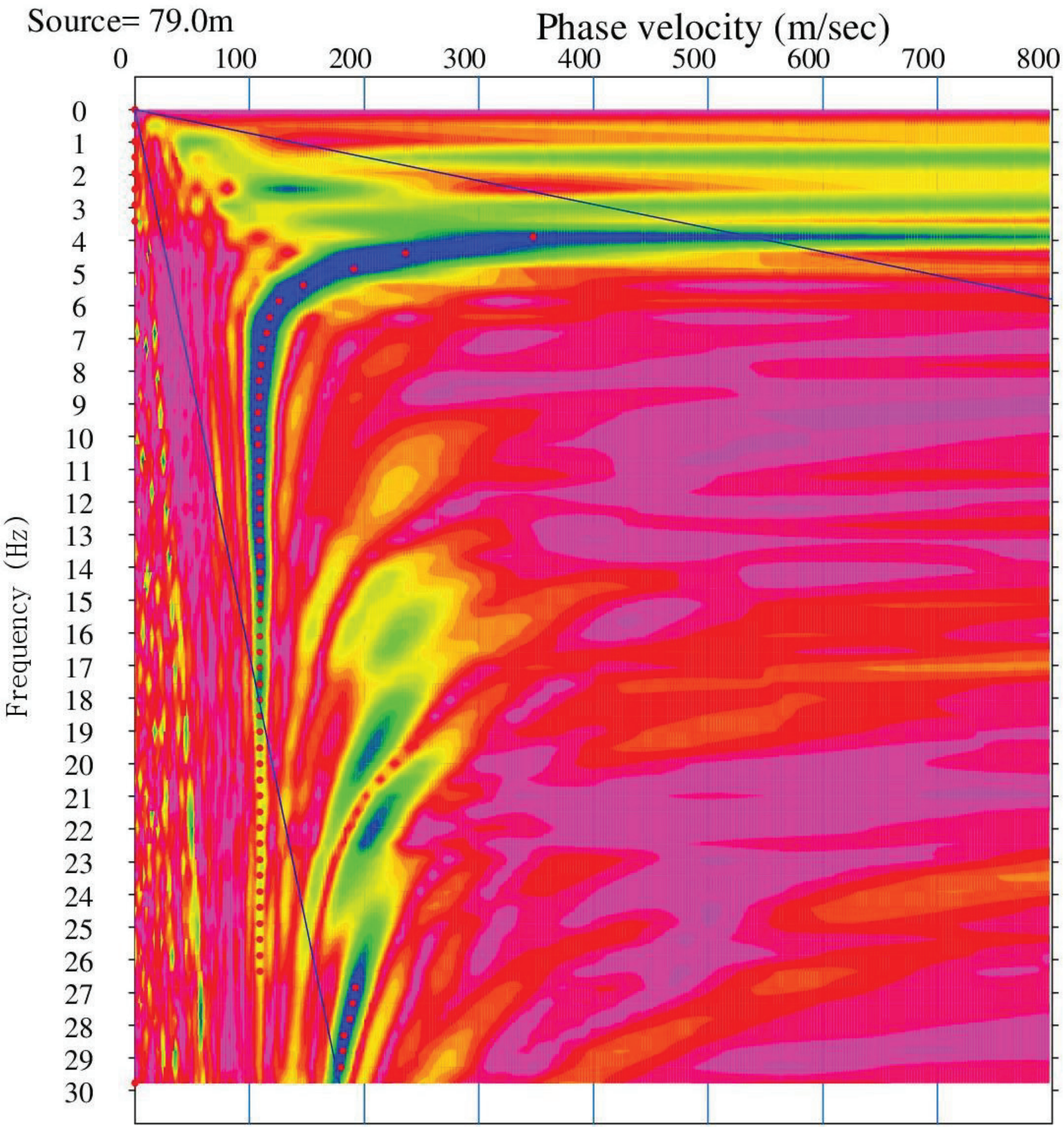


Figure 7: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 2

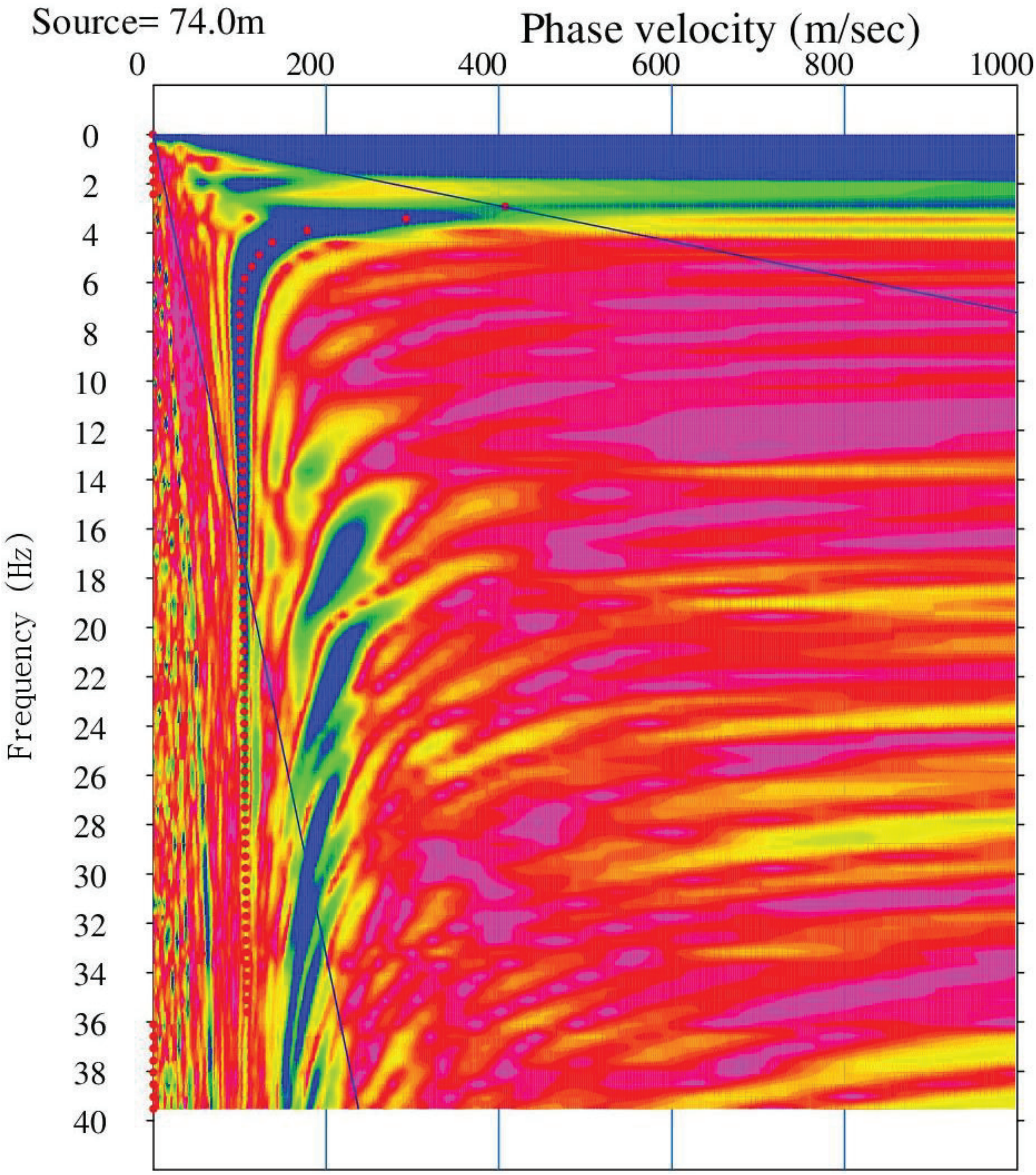


Figure 8: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 3

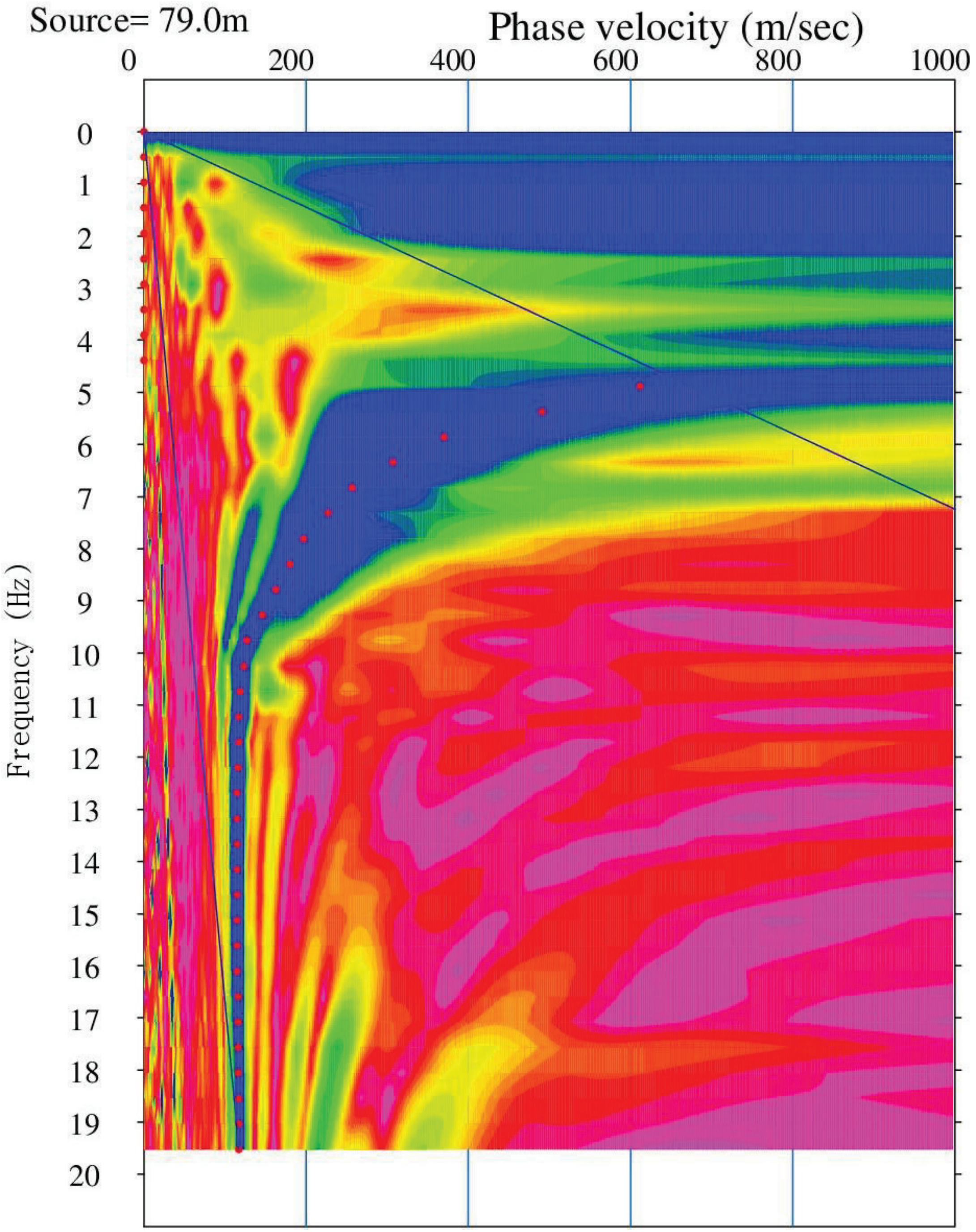


Figure 9: Active MASW Dispersion Curve Picks (red dots) along the MASW Line 4

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.

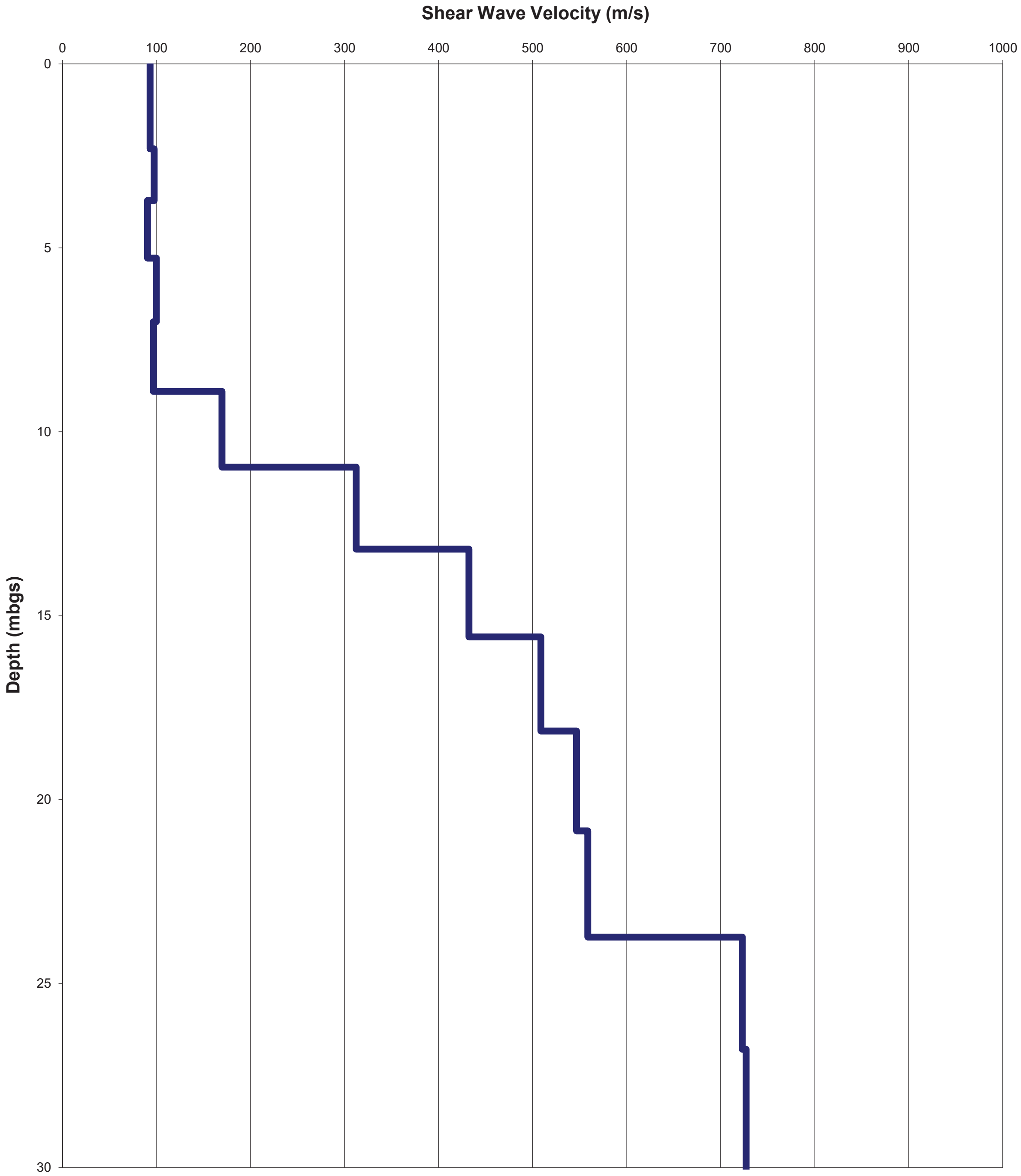


Figure 10: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 1

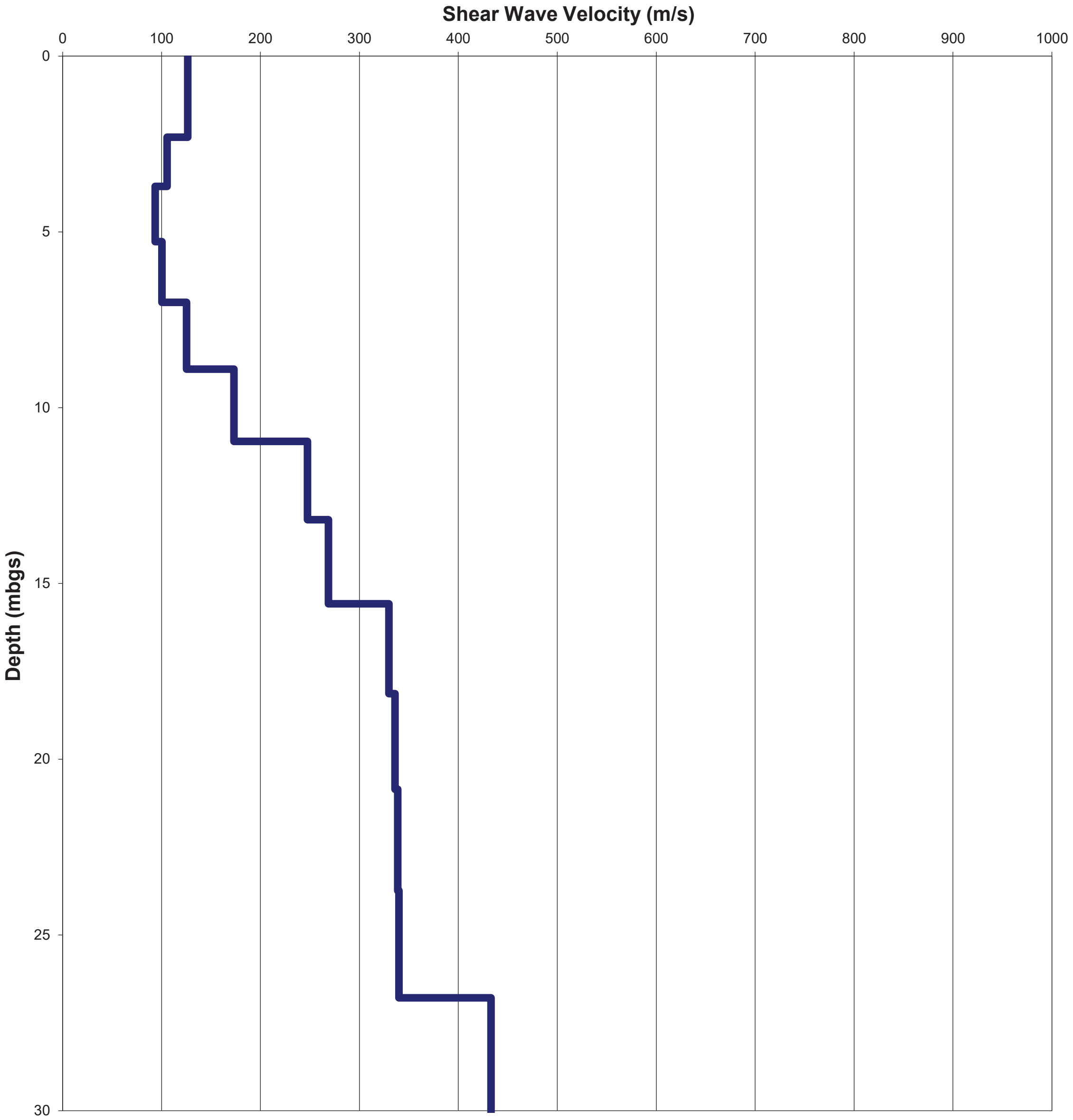


Figure 11: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 2

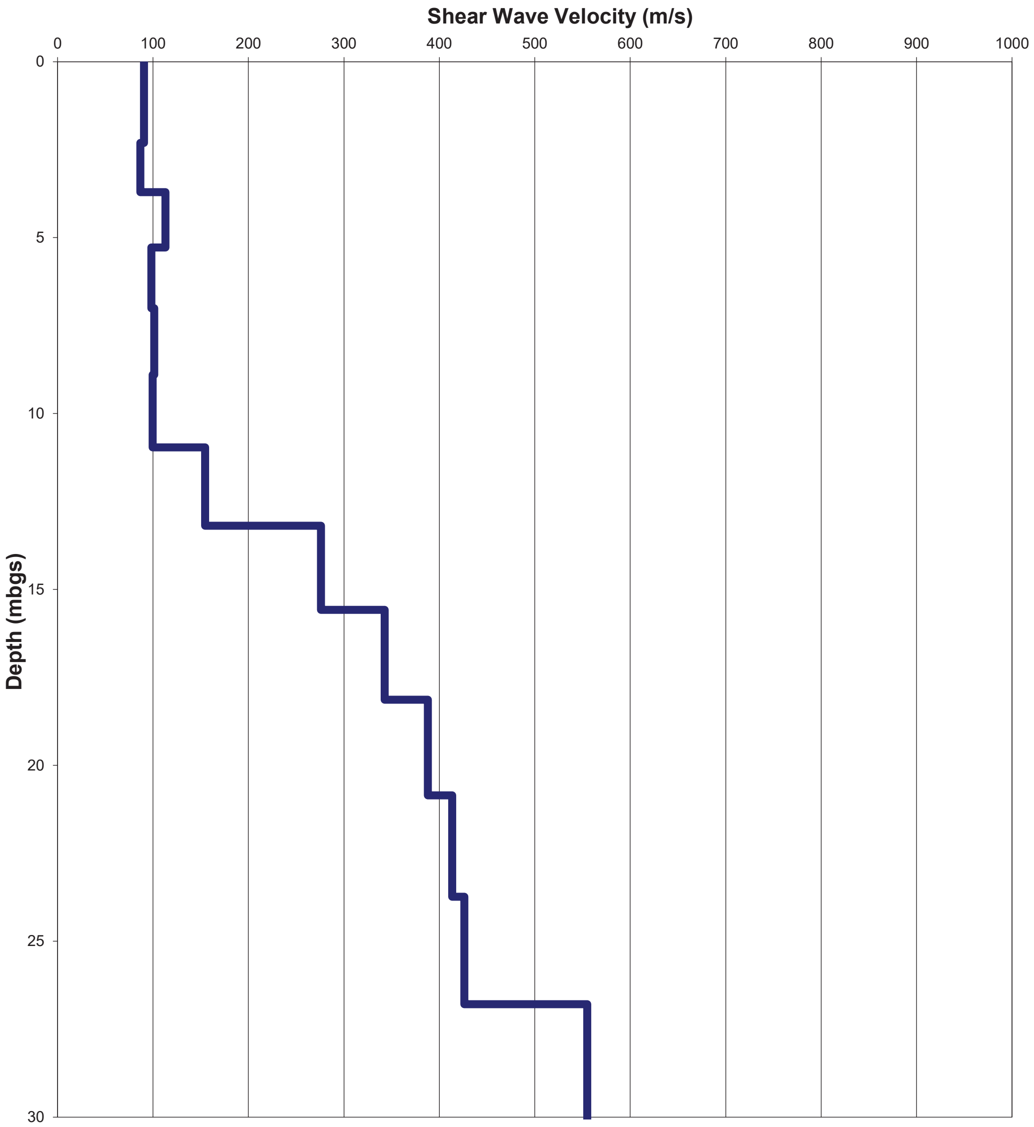


Figure 12: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 3

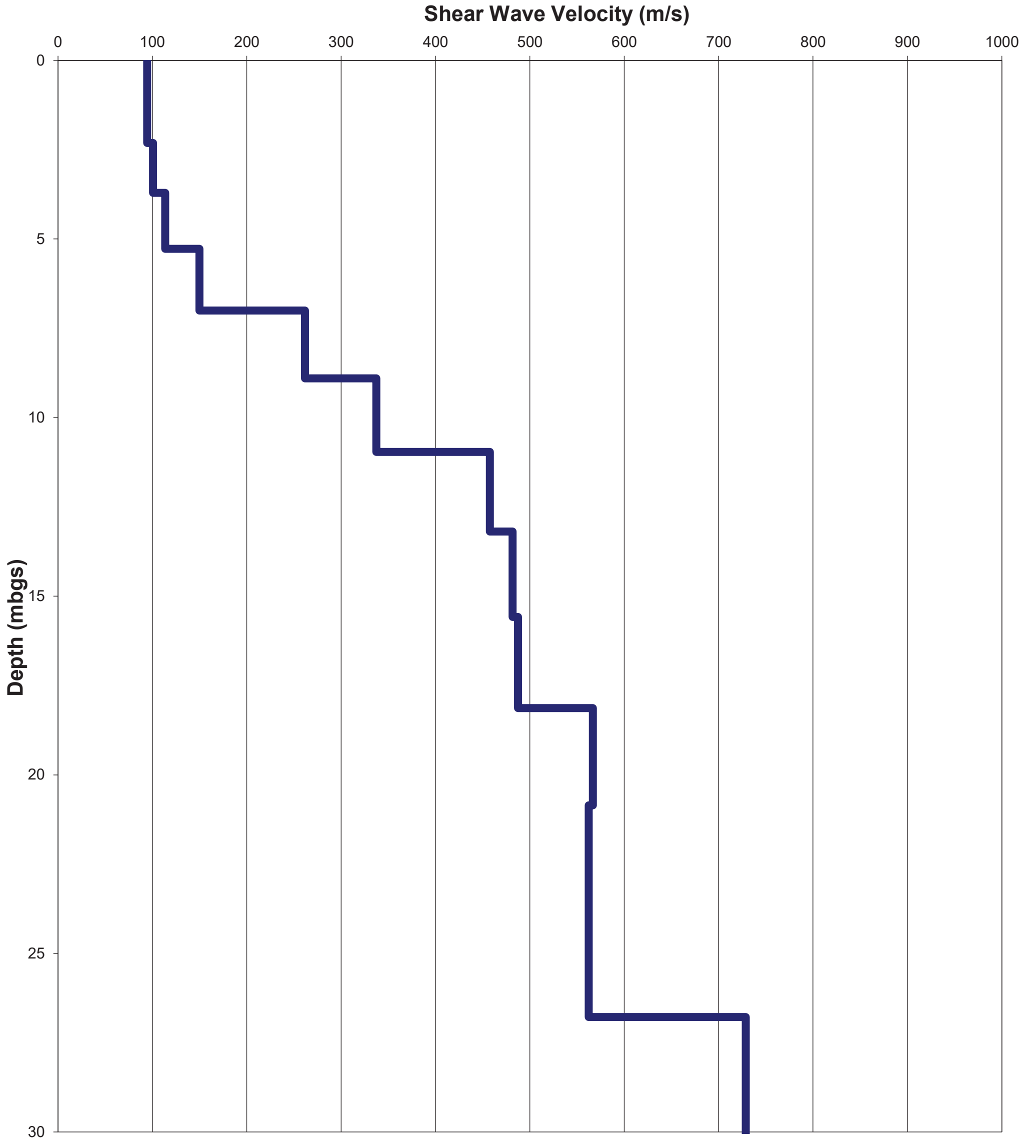


Figure 13: MASW Modelled Shear-Wave Velocity Depth profile along the MASW Line 4

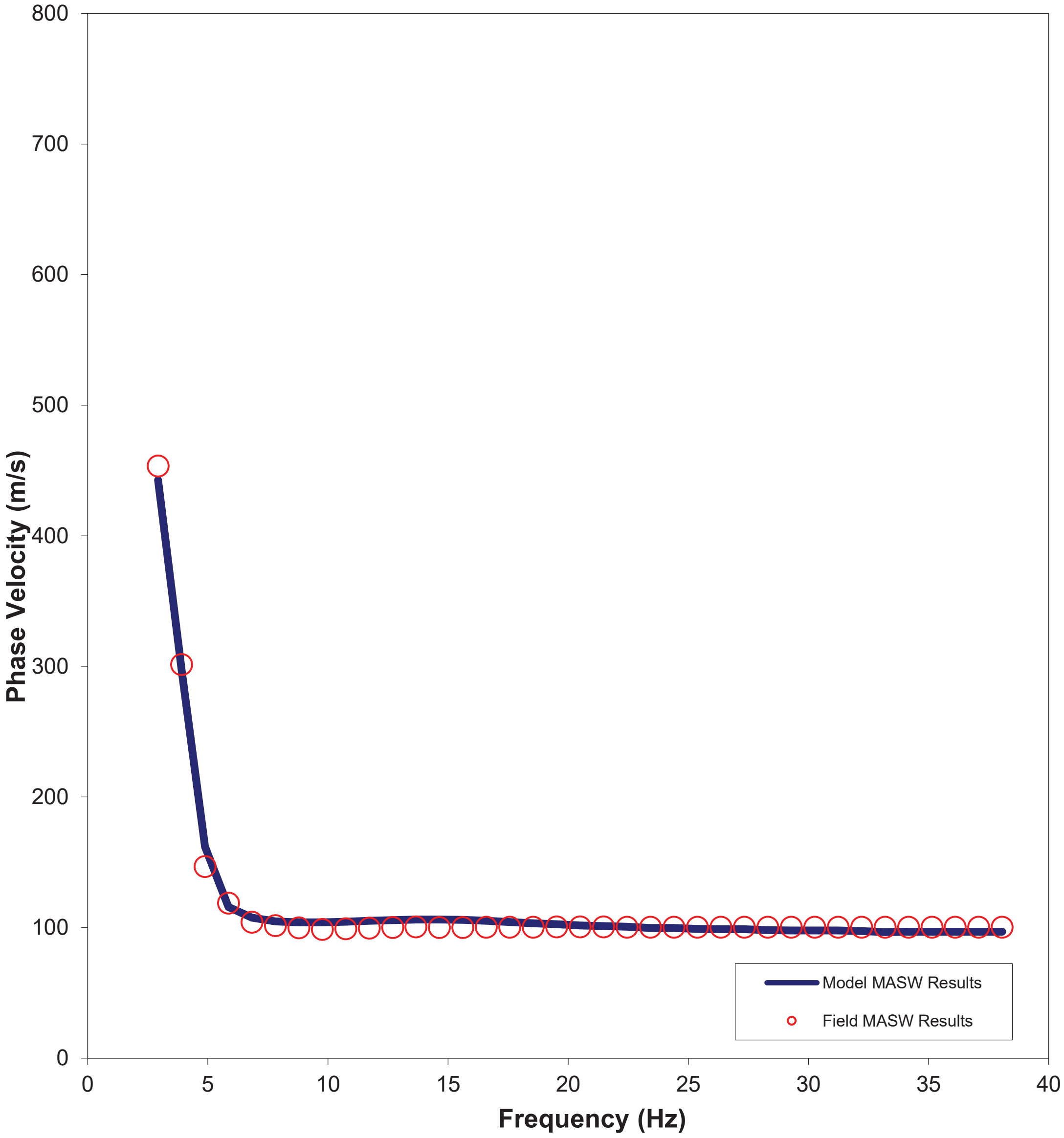


Figure 14: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 1

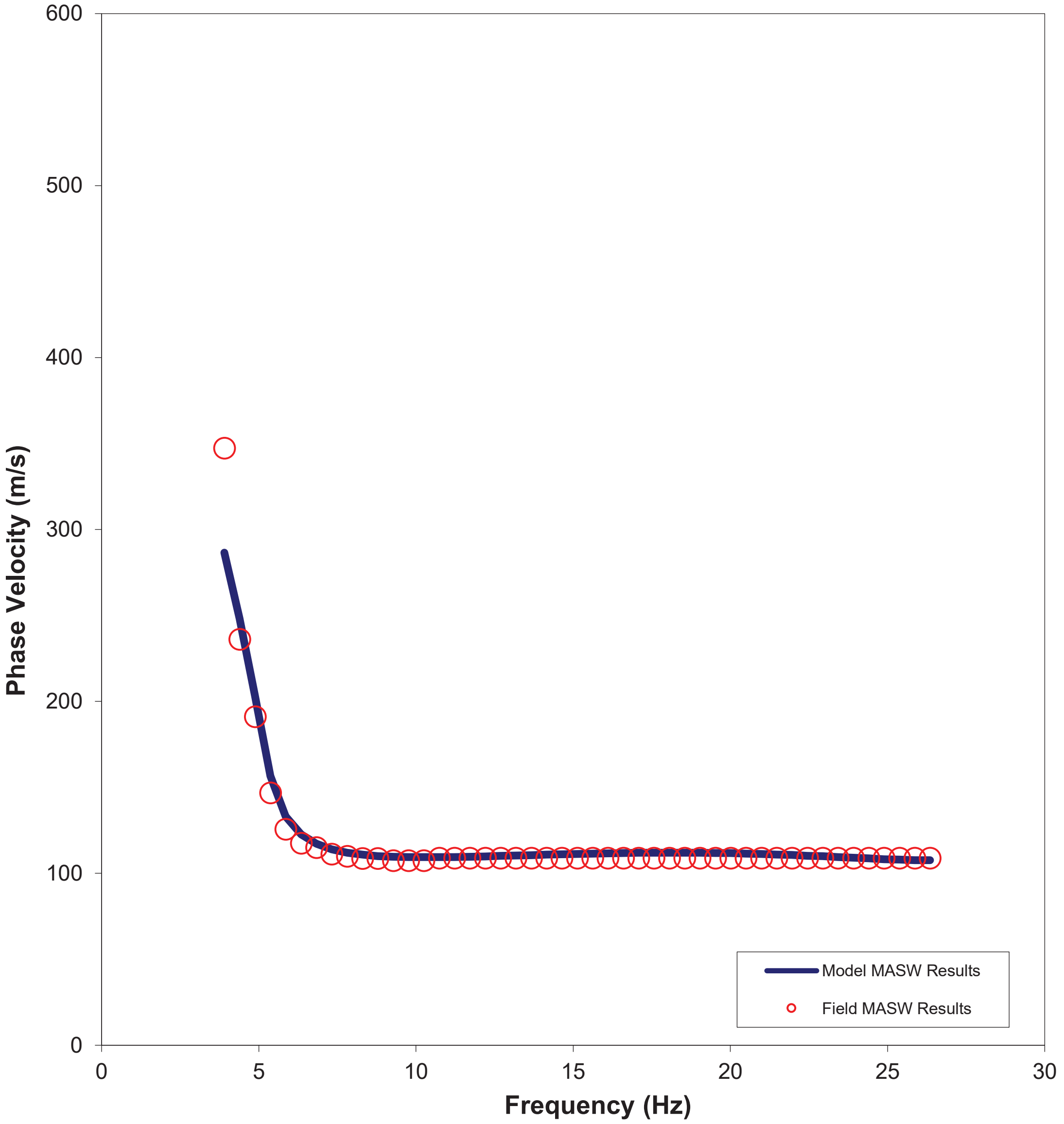


Figure 15: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 2

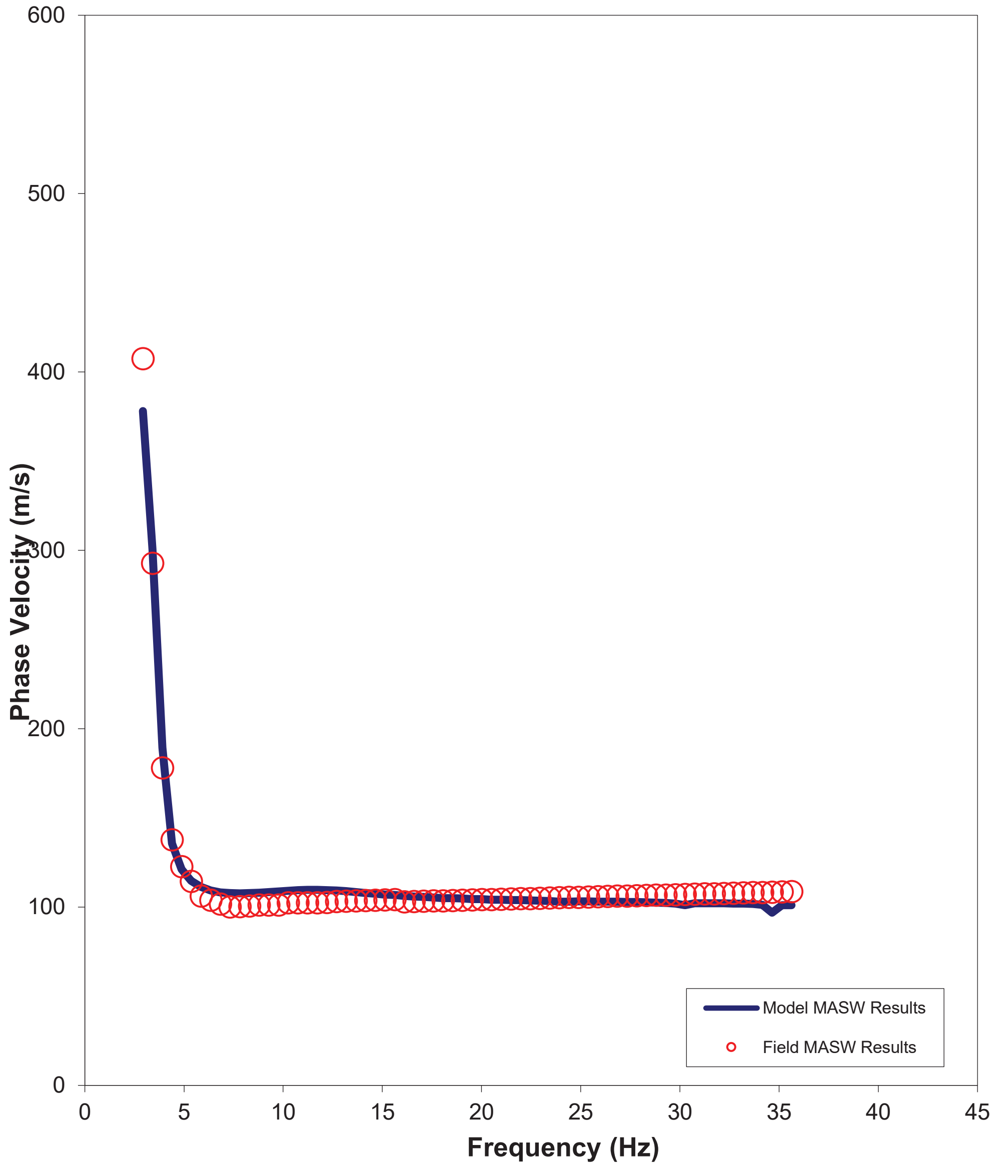


Figure 16: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 3

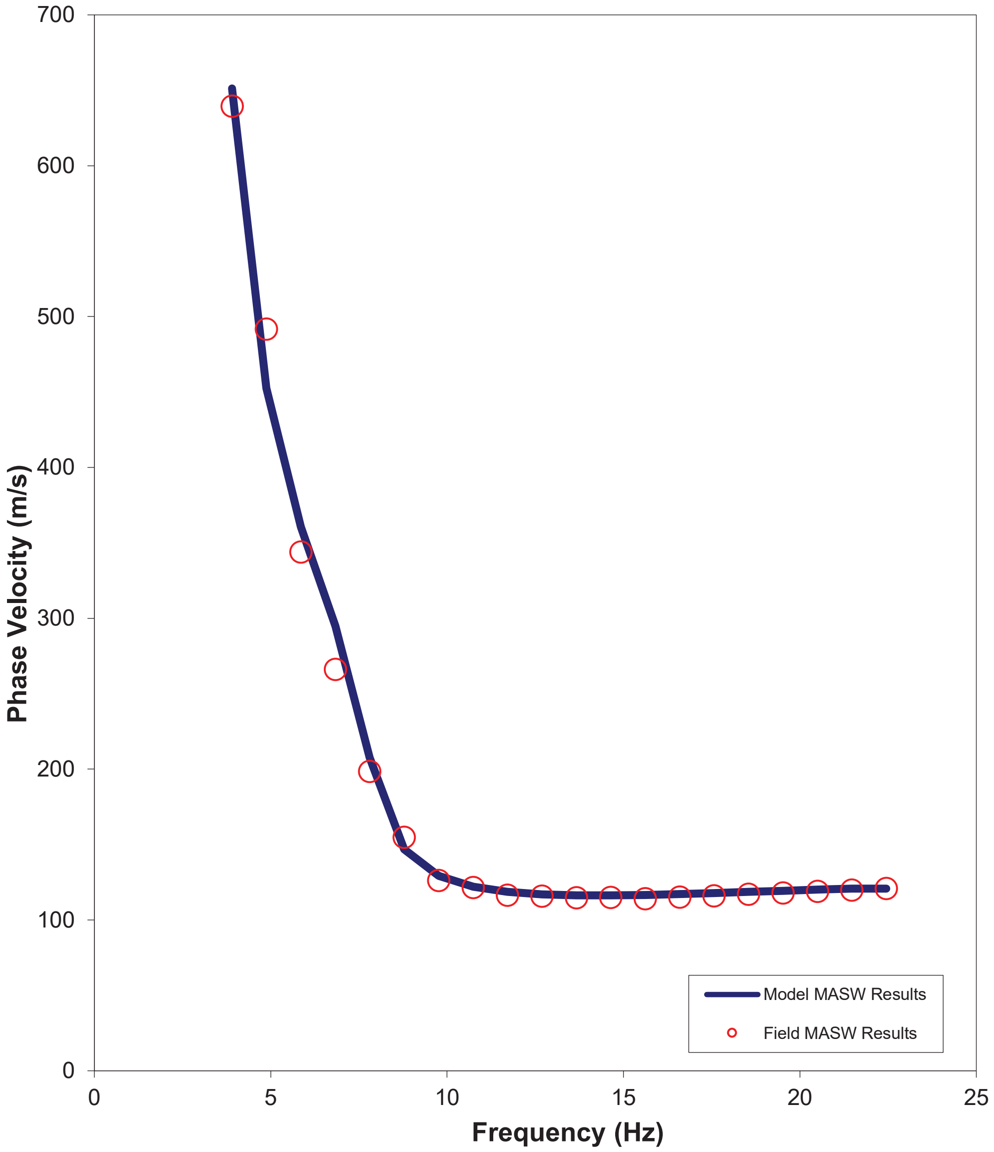


Figure 17: Comparison of Field (red dots) vs. Modelled Data (blue line) along the MASW Line 4

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	18-08	
Sample Number	4	
Depth, m	3.05-3.66	
Shrinkage Dish Number	1	2
Mass of the dry soil pat, g	17.68	17.48
Mass of dry soil pat + shrinkage dish, g	40.84	39.71
Mass of shrinkage dish, g	23.16	22.23
Volume of shrinkage dish, cm^3	13.40	13.33
Mass of wet soil + shrinkage dish, g	47.81	46.61
Moisture content of the soil	39.42	39.47
Mass of dry soil pat before waxing, g	17.68	17.48
Volume of dry soil pat + wax, cm^3	14.46	15.79
Mass of dry soil pat + wax in air, g	22.22	23.28
Mass of dry soil pat + wax in water, g	7.76	7.49
Mass of wax, g	4.54	5.80
Volume of wax, cm^3	4.91	6.27
Specific gravity of wax	0.925	0.925
Volume of dry soil pat, cm^3	9.55	9.52
SHRINKAGE LIMIT, SL	**17.66**	**17.68**
SHRINKAGE RATIO, R	**1.85**	**1.84**
Project Numb 18108333 (2000)	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.

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Certificate of Analysis

Client:	Golder Associates Ltd. (Ottawa) 1931 Robertson Road Ottawa, ON K2H 5B7	Report Number:	1821076
		Date Submitted:	2018-11-20
		Date Reported:	2018-11-27
		Project:	18108333/1000
		COC #:	838159
Attention:	Mr. Alex Meacoe		
PO#:			
Invoice to:	Golder Associates Ltd. (Ottawa)		

				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

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Environment Testing

Certificate of Analysis

Client:	Golder Associates Ltd. (Ottawa) 1931 Robertson Road Ottawa, ON K2H 5B7
Attention:	Ms. Kim MacDonald
PO#:	
Invoice to:	Golder Associates Ltd. (Ottawa)

Report Number:	1702391
Date Submitted:	2017-02-17
Date Reported:	2017-02-22
Project:	1771847
COC #:	815762

				Lab I.D.	1281581	1281582	1281583
				Sample Matrix	Soil	Soil	Soil
				Sample Type			
				Sampling Date	2017-02-02	2017-02-03	2017-02-14
				Sample I.D.	BH 17-1 SA 1/2.5-4.5	BH 17-10 SA2/2.5-4.5	BH 17-14 SA1/2.5-4.5
Group	**Analyte**	**MRL**	**Units**	**Guideline**			
General Chemistry	Cl	0.002	%		0.003	0.003	0.004
	Electrical Conductivity	0.05	mS/cm		0.20	0.15	0.18
	pH	2.0			7.4	7.1	6.9
	Resistivity	1	ohm-cm		5000	6670	5560
	SO4	0.01	%		0.01	<0.01	<0.01

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

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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

FIGURES 2 TO 5 - SLOPE STABILITY ANALYSIS SECTIONS

DRAWING PG5036-4 - TEST HOLE LOCATION PLAN

DRAWING PG5036-5 - PERMISSIBLE GRADE RAISE PLAN

DRAWING PG5036-6 - TREE PLANTING SETBACK RECOMMENDATIONS

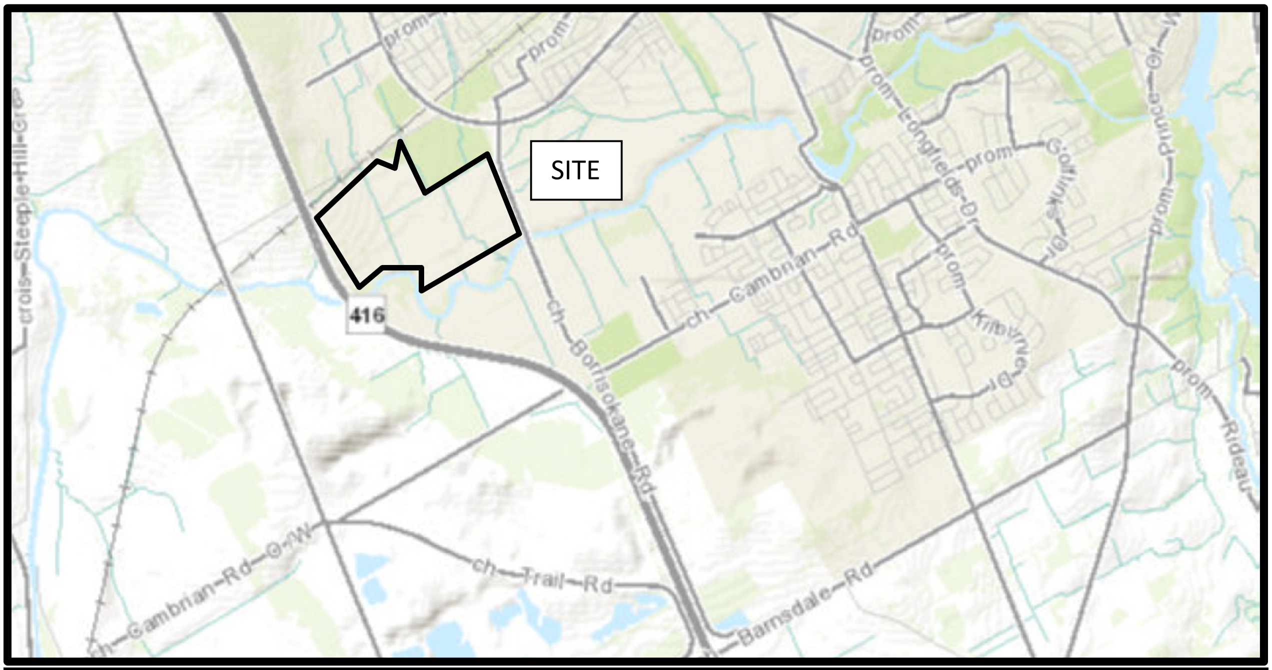
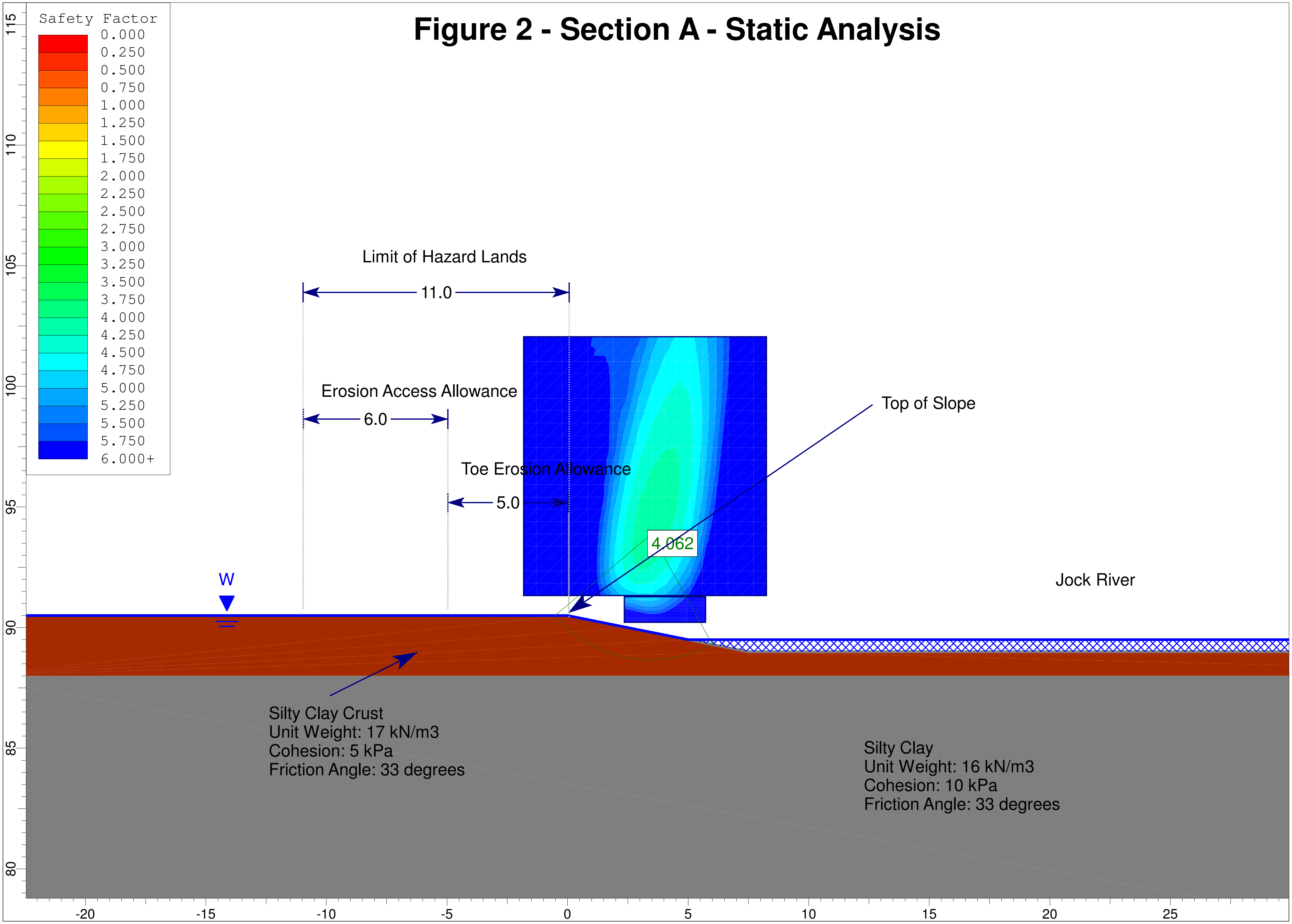


FIGURE 1

KEY PLAN

Figure 2 - Section A - Static Analysis



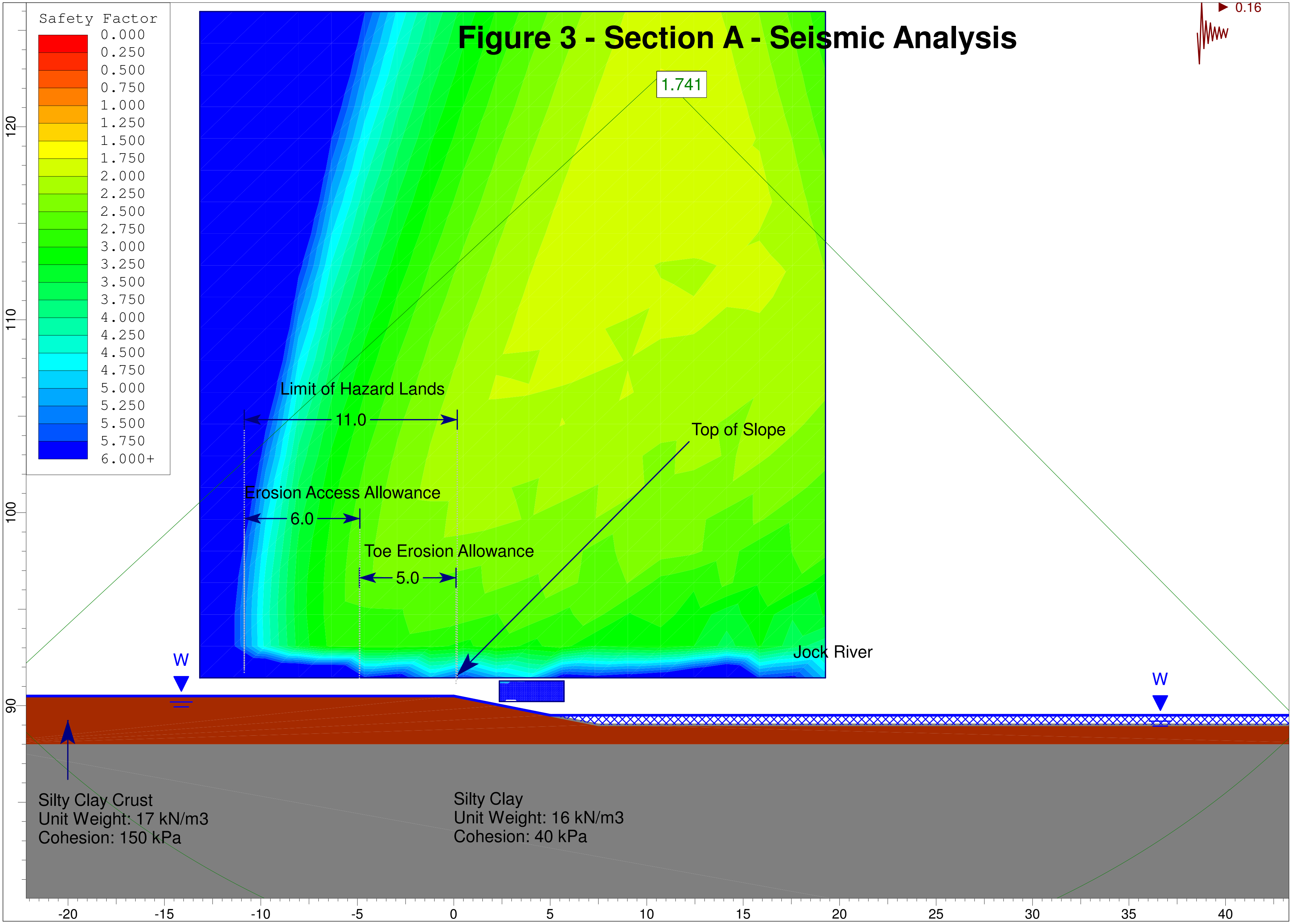


Figure 3 - Section A - Seismic Analysis

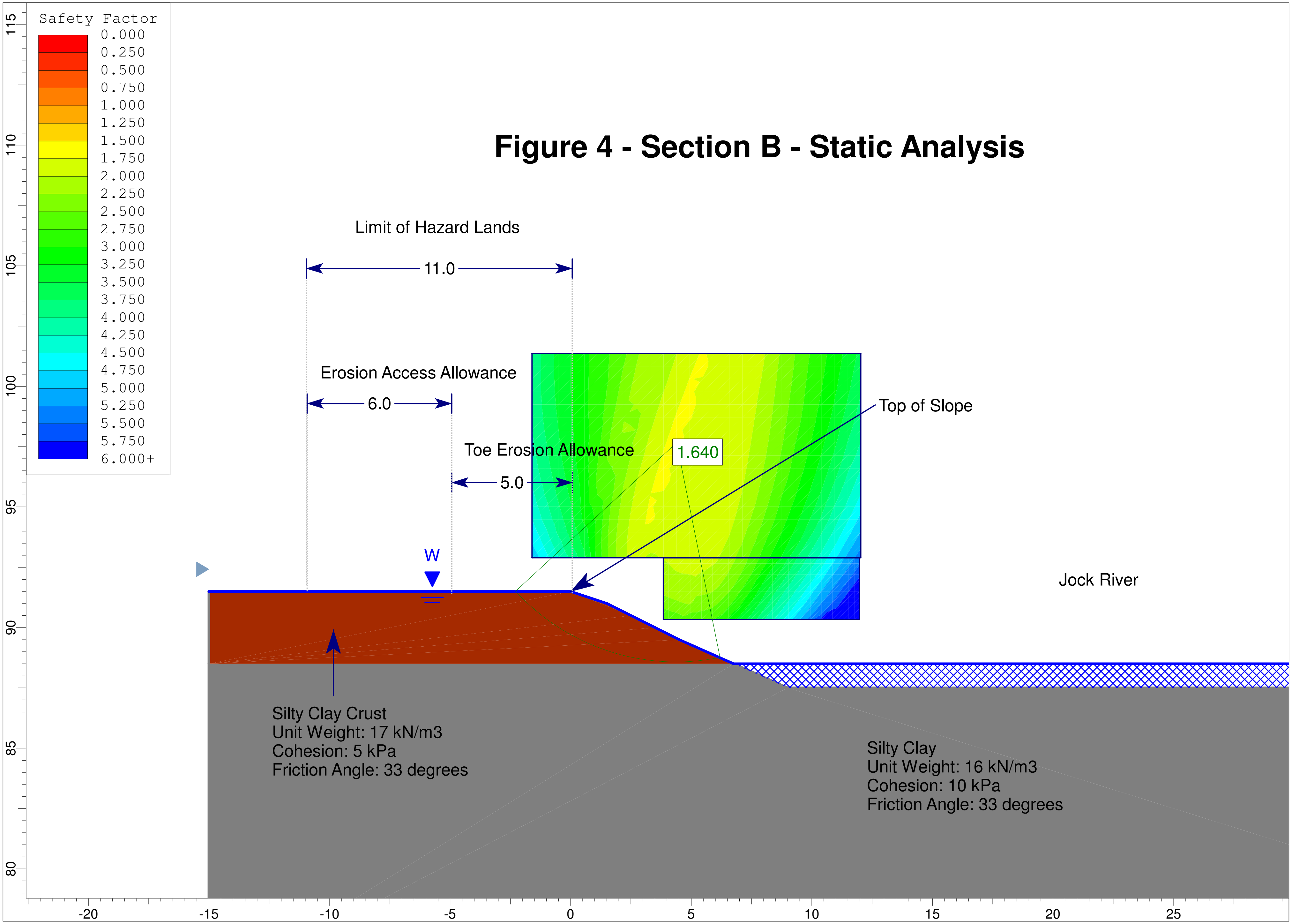
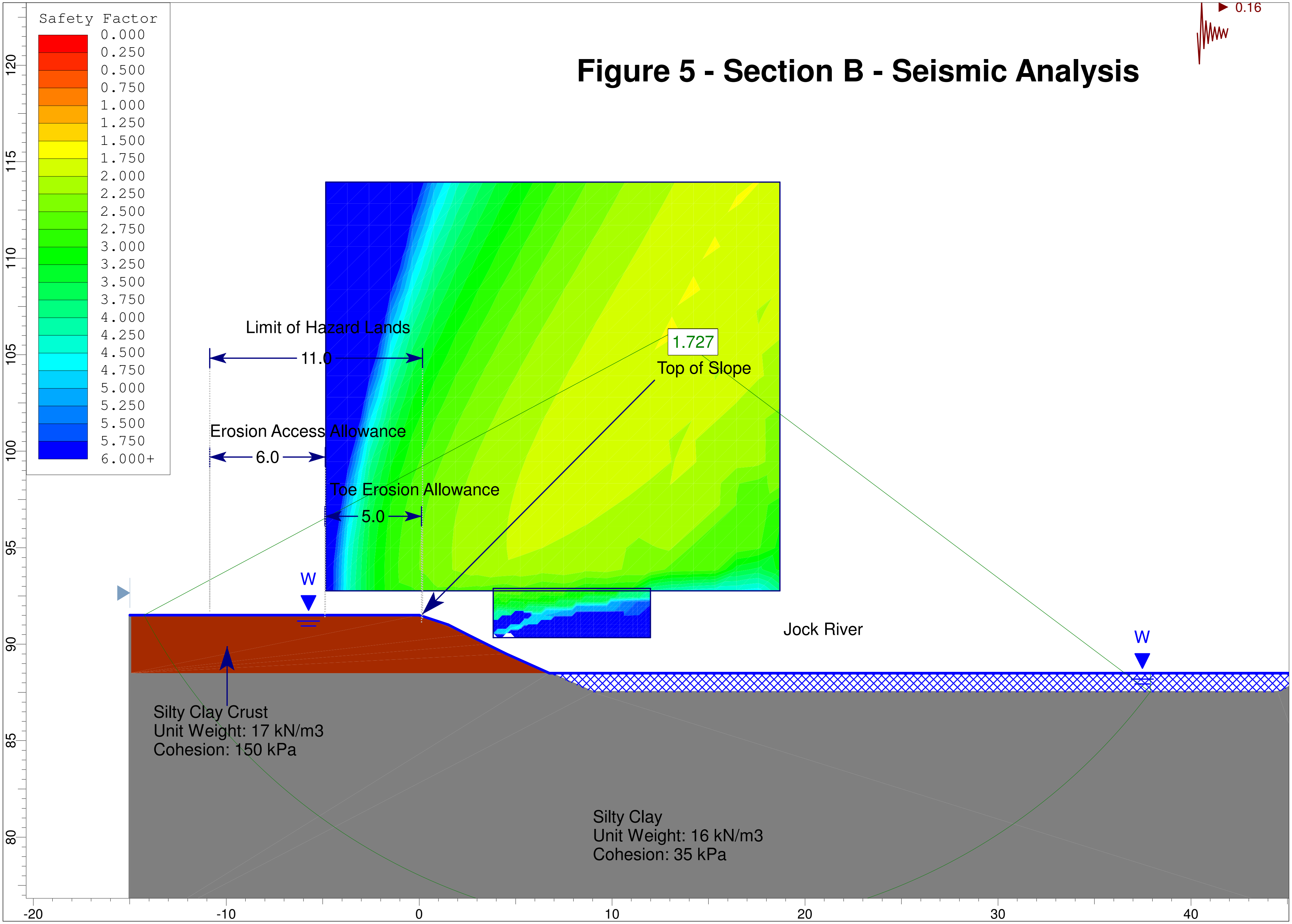
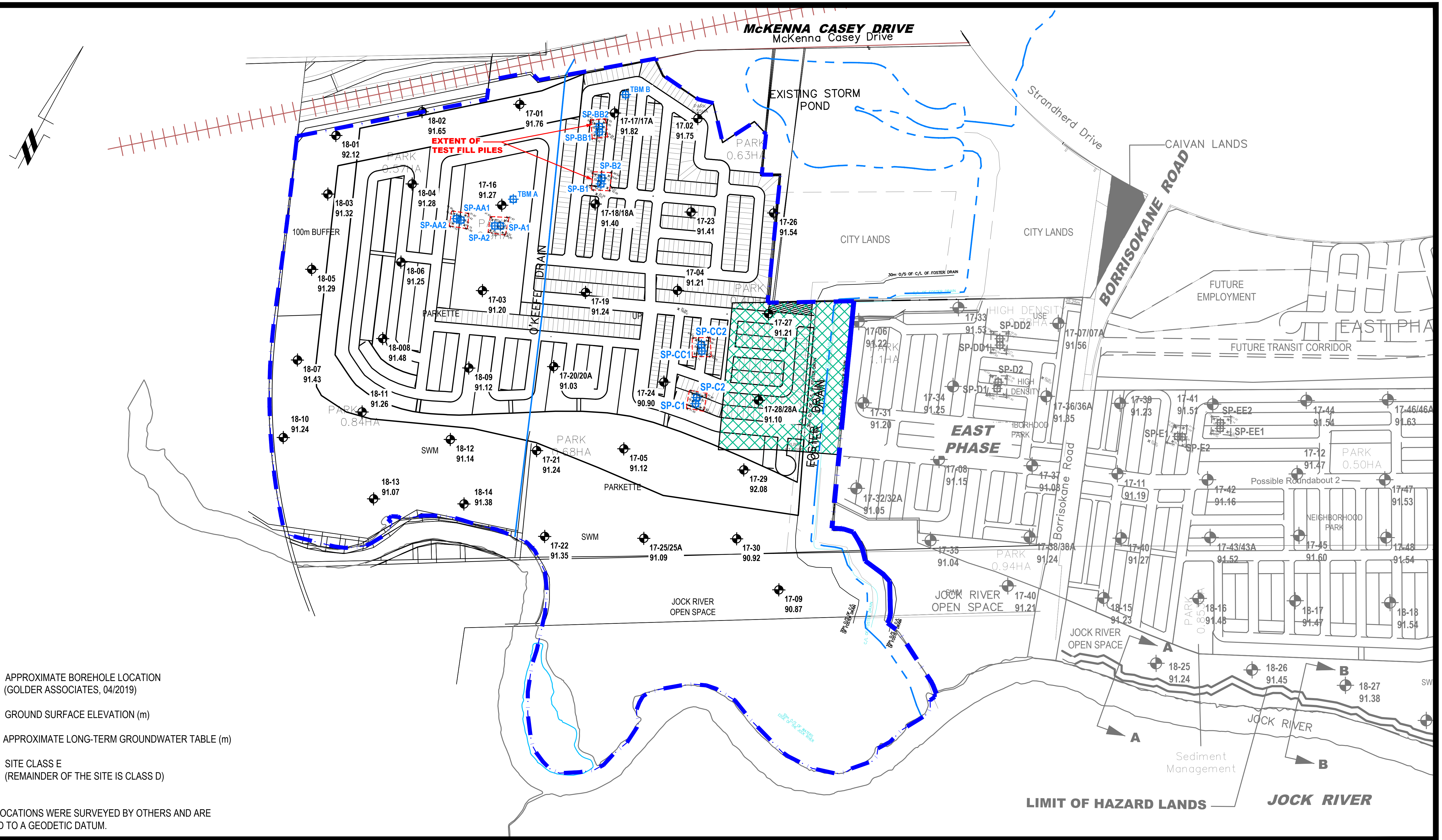


Figure 4 - Section B - Static Analysis

Figure 5 - Section B - Seismic Analysis





LEGEND:

⊕	APPROXIMATE BOREHOLE LOCATION (GOLDER ASSOCIATES, 04/2019)
91.56	GROUND SURFACE ELEVATION (m)
(88.81)	APPROXIMATE LONG-TERM GROUNDWATER TABLE (m)
▨	SITE CLASS E (REMAINDER OF THE SITE IS CLASS D)

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

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL
1	UPDATED TO LATEST CONCEPTUAL PLAN	19/10/2021	OC

CAIVAN COMMUNITIES

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

Title:

TEST HOLE LOCATION PLAN

Scale: 1:6000
Date: 02/2021
Drawn by: MPG
Report No.: PG5036-2
Checked by: SD
Dwg. No.: PG5036-4
Approved by: SD
Revision No.:

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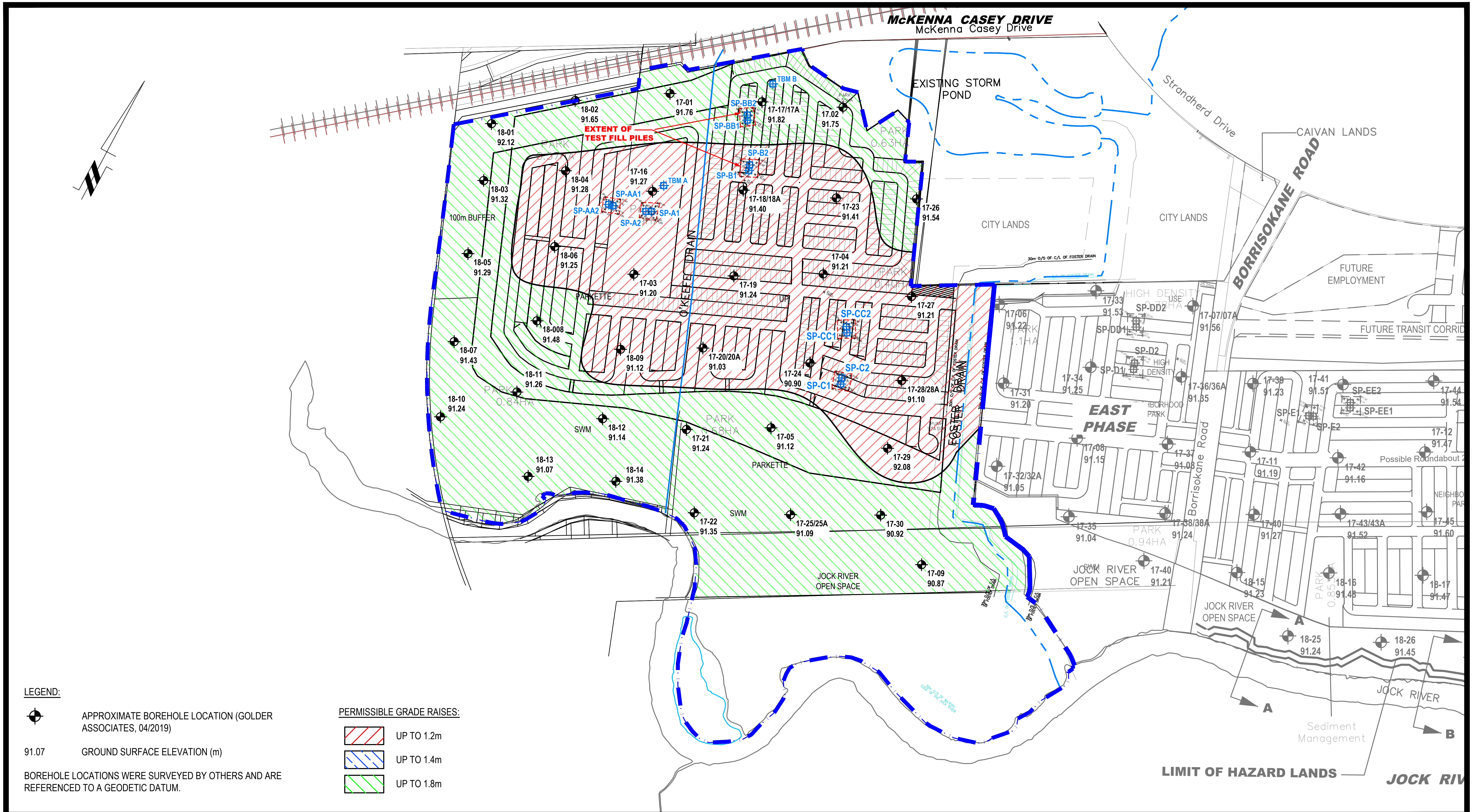

LEGEND:

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

91.07 GROUND SURFACE ELEVATION (m)

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

PERMISSIBLE GRADE RAISES:

- 🟥 UP TO 1.2m
- ▨ UP TO 1.4m
- 🟩 UP TO 1.8m

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consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL
1	UPDATED TO LATEST CONCEPTUAL PLAN	19/10/2021	OC

CAIVAN COMMUNITIES
GEOTECHNICAL INVESTIGATION
PROP. RESIDENTIAL DEVELOPMENT - CONSERVANCY LANDS WEST
OTTAWA, ONTARIO

Title:
PERMISSIBLE GRADE RAISE PLAN

Scale: 1:5000
Date: 09/2019
Drawn by: MPG
Report No.: PG5036-2
Checked by: SD
Approved by: SD
PG5036-5
Revision No.:

11x17

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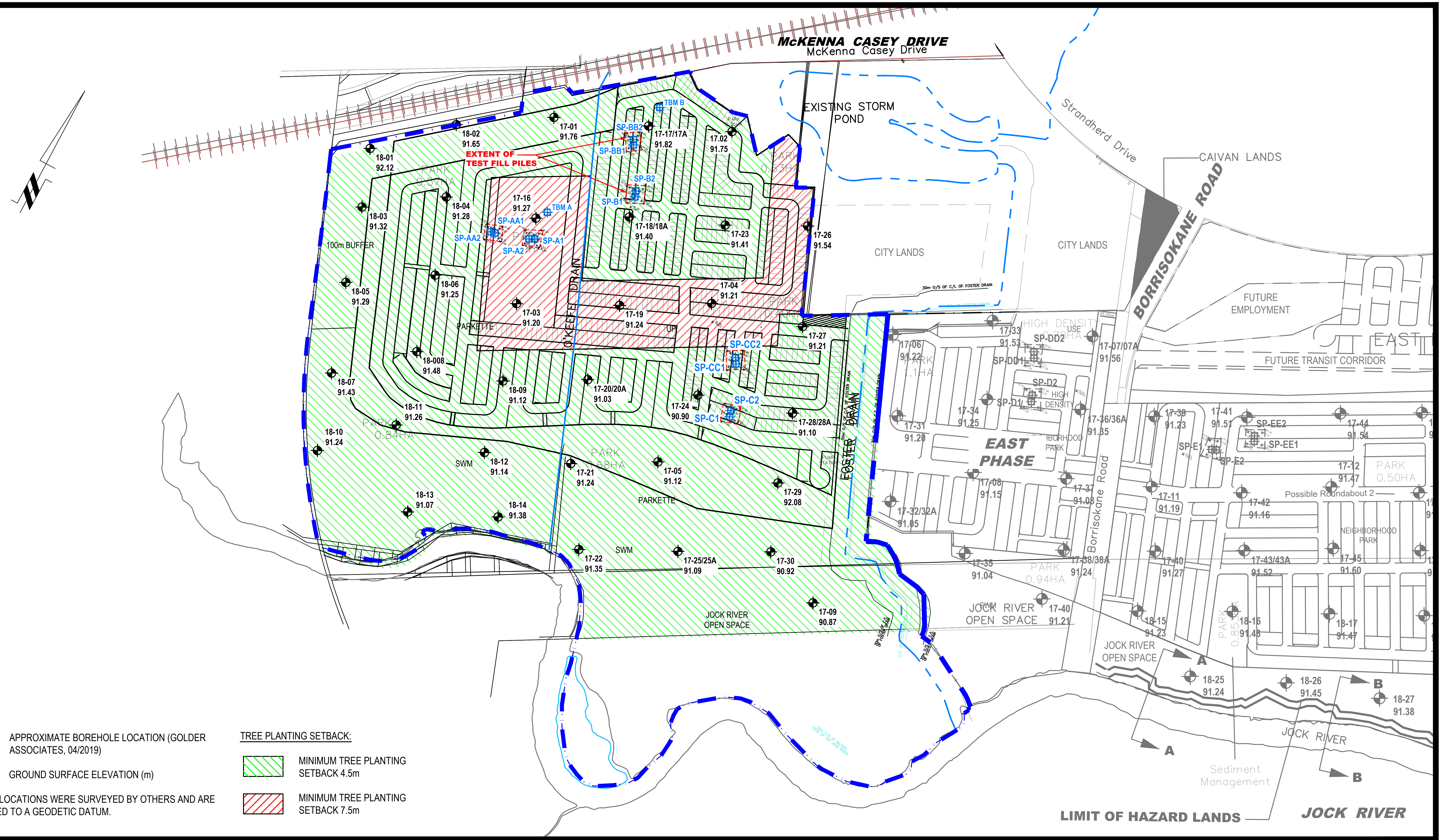

LEGEND:

⌖	APPROXIMATE BOREHOLE LOCATION (GOLDER ASSOCIATES, 04/2019)
91.07	GROUND SURFACE ELEVATION (m)

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

TREE PLANTING SETBACK:

🟩	MINIMUM TREE PLANTING SETBACK 4.5m
🟥	MINIMUM TREE PLANTING SETBACK 7.5m

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NO.	REVISIONS	DATE	INITIAL
1	UPDATED TO LATEST CONCEPTUAL PLAN	19/10/2021	OC

CAIVAN COMMUNITIES

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

Title:

TREE PLANTING SETBACK PLAN

Scale:	1:6000
Date:	09/2019
Drawn by:	MPG
Report No.:	PG5036-2
Checked by:	SD
Approved by:	SD
	PG5036-6
Revision No.:	

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