MTE Consultants
123 St. George St., London, ON N6A 3A1

July 3, 2020

MTE File No.: 45013-300

Mr. Guy Riopeele
10919 Longwoods Road Inc.
10919 Longwoods Road
Middlesex Centre, Ontario

Dear Mr. Riopeele:

RE: Results of In-situ Infiltration Testing, Proposed Industrial Subdivision, 10919 Longwoods Road, Middlesex Centre, ON

This letter presents the results of in-situ infiltration testing carried out to support the design of at-source stormwater infiltration facilities for a proposed industrial subdivision to be located at 10919 Longwoods Road in the Municipality of Middlesex Centre, Ontario (herein referred to as the "Site"). The approximate location of the Site is shown on **Figure 1**.

Field Methodology

On April 15 and 16, 2020 in-situ infiltration testing of the native surficial soils was carried out using a constant head well permeameter (Guelph Permeameter Model 2800K1) supplied by Hoskins Scientific. Test methods followed the manufacturer's operating instructions[1]. Infiltration tests were carried out at three locations identified as corresponding to the proposed footprint of the at-source stormwater infiltration facilities. The approximate test locations are shown on **Figure 2.**

At each test location, two infiltration tests were performed, each in a unique auger hole that was manually advanced to a depth of 0.5 meters below the existing ground surface. It is our understanding that the grade will be raised for this development and that the tested elevations correspond to the approximate base of the proposed infiltration facilities.

Each of the auger holes extended through the topsoil, which was noted to range in thickness from 0.3 to 0.4 meters, into the underlying native sand and silt deposits. A description of the shallow soils encountered in the auger holes at the test depth is provided in **Table 1**.

Based on a review of nearby borehole logs prepared as part of the geotechnical investigation[2], the stratigraphy is relatively consistent beneath the tested depth. As a result, additional tests were not completed to assess infiltration of the soils underlying the infiltration facility. Copies of the borehole logs are attached.

---

[1] Soilmoisture Equipment Corp. December 2012. *Operating Instructions, Guelph Permeameter, Model 2800.*

[2] MTE Consultants, March 2019. *Geotechnical Investigation, 10919 Longwoods Road, Proposed Industrial Subdivision.* MTE File No.: 45013-300.

Table 1: Summary of Infiltration Test Locations

Test ID	Location	UTMs (Zone 17T)	Ground Elevation (m AMSL)^2	Test Elevation (m AMSL)^2	Soil Description for Test Elevation
IT-1	Lot #7	467573m E, 4750768m N	235.65	235.15	Sand, some silt to sandy silt with trace clay
IT-2	SWM Block	467536m E, 4750857m N	235.37	234.87	Sand, some silt to sandy silt
IT-3	Lot #12	467426m E, 4750717m N	236.29	235.79	Silty sand to silt, some sand with trace to some clay

NOTES:

1. All values approximate.
2. "m AMSL" refers to meters above mean sea level.

Analysis and Results

Field saturated hydraulic conductivity (K_{fs}) was estimated following the single-head method described by Reynolds and Elrick (1986)[3] and a calculation spreadsheet available online from Soilmoisture Equipment Corp.[4] Copies of the calculation sheets for each of the six tests are attached.

The results of the infiltration tests on native soils are summarized in **Table 2**. The recommended design infiltration rate is based on guidance provided by the Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC)[5] and the approximate relationship between hydraulic conductivity and infiltration rate. It is noted that hydraulic conductivity and infiltration rate are different concepts and unit conversion does not apply. A factor of safety of 3 was applied to the recommended design infiltration rates.

Table 2: Results of Infiltration Testing

Test ID	Location	K_{fs} (m/sec)	Geometric Mean, K_{fs} (m/sec)	Recommended Design Infiltration Rate (mm/hr)
IT-1	Lot #7	9.5E-06	1.0E-05	29
		1.1E-05		
IT-2		1.6E-06	1.7E-06	18

---

[3] Reynolds, W.D. and Elrick, D.E. 1986. *A Method for Simultaneous In-Situ Measurement in the Vadose Zone of Field Saturated Hydraulic Conductivity, Sorptivity and the Conductivity-Pressure Head Relationship.* Ground Water Monitoring Review Vol 6, No. 4.

[4] https://www.soilmoisture.com/Calculators/Guelph-Permeameter-Ksat-Calculator-ver-3.xls

[5] TRCA and CVC. 2011. *Low Impact Development Stormwater Management Planning Design Guide*. Appendix C, Version 1.0.

Test ID	Location	K_{fs} (m/sec)	Geometric Mean, K_{fs} (m/sec)	Recommended Design Infiltration Rate (mm/hr)
	SWM Block	1.9E-06		
IT-3	Lot #12	5.3E-08	2.9E-08	6
		1.5E-08		

NOTES:

1. All values are approximate.

Recommendations

The following recommendations are provided:

- If the footprint or proposed depth of the at-source infiltration facilities is altered from the tested locations, additional in-situ infiltration testing should be carried out at new locations and/or depths;
- A groundwater monitoring program should be implemented to establish the seasonal high groundwater elevation and confirm that there is sufficient separation from the base of the infiltration facility to the seasonal high groundwater table; and
- Following determination of the seasonal high groundwater level, if there is less than 2 m of separation between the proposed based of the infiltration facility and the seasonal high groundwater level, a groundwater mounding analysis should be completed as part of the detailed design.

Limitations

This letter was prepared for 10919 Longwoods Road Inc. Any use which a third party makes of this document, or any reliance on or decisions to be made based on it, are the sole responsibility of such third parties.

Our findings are based on limited data and information collected during the identified field testing and are based solely on-site conditions encountered at the time of investigation. The site conditions were inferred based on observations and tests at a limited number of locations and the conditions may vary between and beyond these locations.

Services performed by MTE were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the Environmental Engineering and Consulting profession. No other warranty is expressed or implied.

Closure

We trust that this letter provides sufficient information for your current needs. Should you require additional information or have any questions regarding the information provided, please contact the undersigned.

Yours Truly,

MTE Consultants Inc.

PROFESSIONAL GEOSCIENTIST
JOHN D. McNEIL
PRACTISING MEMBER
2014
ONTARIO

John McNeil, M.Sc., P.Geo.
Senior Hydrogeologist
519-204-6510 ext. 2228
jmcneil@mte85.com

Attachments:

- Figures 1 and 2
- Borehole Logs
- K_{fs} Calculations

MBC/JDM/jdm

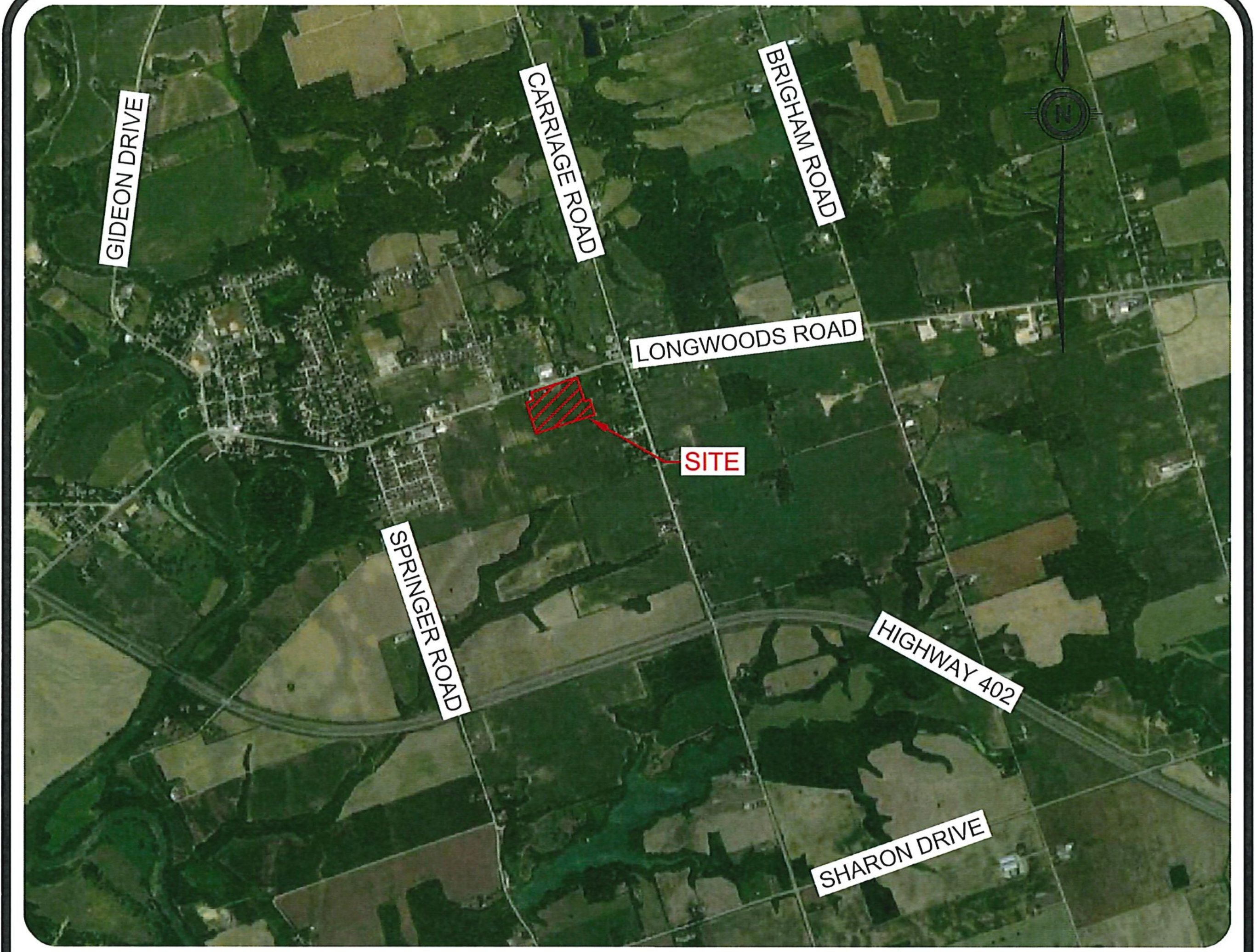
M:\45013\300\Deliverables\Infiltration Testing\Final\45013-300L02 20200703 Infiltration Results.docx

Attachment A

Figures

Project: 45013-300 CAD: P:\P\45013\300\BH FIGURES\45013-300 BH FIGURES.DWG

FIGURE 1 – LOCATION PLAN



REFERENCES:

- AERIAL IMAGE FROM GOOGLE EARTH PRO.

MTE
Engineers |Scientists |Surveyors

LOCATION PLAN

Project Name 10919 LONGWOODS ROAD PROPOSED INDUSTRIAL SUBDIVISION	
Site 10919 LONGWOODS ROAD, MUNICIPALITY OF MIDDLESEX, ON	Client 10919 LONGWOODS ROAD INC.

Scale. (8.5x11)	MTE Project No.	Date	Figure No.
N.T.S.	45013-300	MARCH 27, 2019	1

March 27, 2019 — 11:39 a.m. — Plotted By: awilliams FIGURE 2 — SITE PLAN Project: 45013-300 CAD: P:\P\45013\300\BH FIGURES\45013-300 BH FIGURES_3.DWG

LEGEND

⊕ BH107–19 MTE BOREHOLE

◈ MW101–19 MTE MONITORING WELL

▼ IT–1 MTE INFILTRATION TEST LOCATION

REFERENCES:

- AERIAL IMAGE FROM GOOGLE EARTH PRO.
- BOREHOLE ELEVATIONS SURVEYED BY MTE.

MTE
Engineers, Scientists, Surveyors

SITE PLAN

Project Name 10919 LONGWOODS ROAD PROPOSED INDUSTRIAL SUBDIVISION			
Site 10919 LONGWOODS ROAD, MUNICIPALITY OF MIDDLESEX, ON		Client 10919 LONGWOODS ROAD INC.	
Scale (11x17) 1:2000	MTE Project No. 45013-300	Date MARCH 27, 2019	Figure No. 2

Attachment B

Borehole Logs

The following are abbreviations and symbols commonly used on borehole logs, figures and reports.

Sample Types

AS	Auger Sample
CS	Chunk Sample
BS	Bulk Sample
GS	Grab Sample
WS	Wash Sample
SS	Split Spoon
RC	Rock Core
SC	Soil Core
TW	Thinwall, Open
TP	Thinwall, Piston

Soil Tests

PP	Pocket Penetrometer
FV	Field Vane
SPT	Standard Penetration Test
CPT	Cone Penetration Test
WC	Water Content
WL	Water Level

Penetration Resistance

Standard Penetration Test, N (ASTM D1586)	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.) open spilt spoon sampler for a distance of 300 mm (12 in.).
Dynamic Cone Penetration Resistance	The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive an uncased 50 mm (2 in.) diameter, 60o cone attached to “A” size drill rods for a distance of 300 mm (12 in.).

Soil Description

Cohesive Soils	Undrained Shear Strength (Cu)	
Consistency	kPa	psf
Very Soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very Stiff	100 to 200	2,000 to 4,000
Hard	Above 200	Above 4,000

Cohesionless Soils	
Relative Density	SPT N Value
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Above 50

WH	Sampler advanced by static weight of hammer
WR	Sampler advanced by static weight of drilling rods
PH	Sampler advanced by hydraulic force
PM	Sampler advanced by manual force

DTPL	Drier than Plastic Limit
APL	About Plastic Limit
WTPL	Wetter than Plastic Limit
mbgs	Metres below Ground Surface

ID Number: MW101-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

Soil Description	Elevation (masl) Depth (m)	Sample Number	Sample Type	Standard Penetration	Water Content (%)
Ground Surface	235.0 0.0				
TOPSOIL dark brown/black sandy silt, some organics, wet	234.7 0.3	1	SS	4	24
SAND AND SILT loose light brown sandy silt, saturated	234.2 0.8				
compact light brown silty sand, saturated		2	SS	15	21
		3	SS	12	21
		4	SS	11	21
grey	231.8 3.2	5	SS	18	19
dense	230.4 4.6	6	SS	32	18
		7	SS	38	22
Drilling Terminated	228.4 6.6				

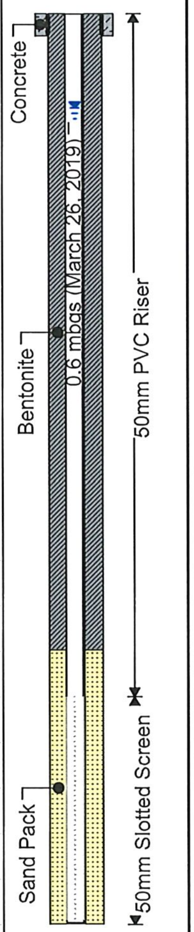
Depth scale: 0–24 ft; 0–6 m

Dynamic Cone ×; Standard Penetration ● (20 40 60 80)

Shear Strength (PP) ▲ kPa; Shear Strength (FV) ■ kPa (50 100 150 200)

Water Content ● % (10 20 30)

Groundwater Observations and Standpipe Details



Initial water level at 0.3mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

ID Number: MW102-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

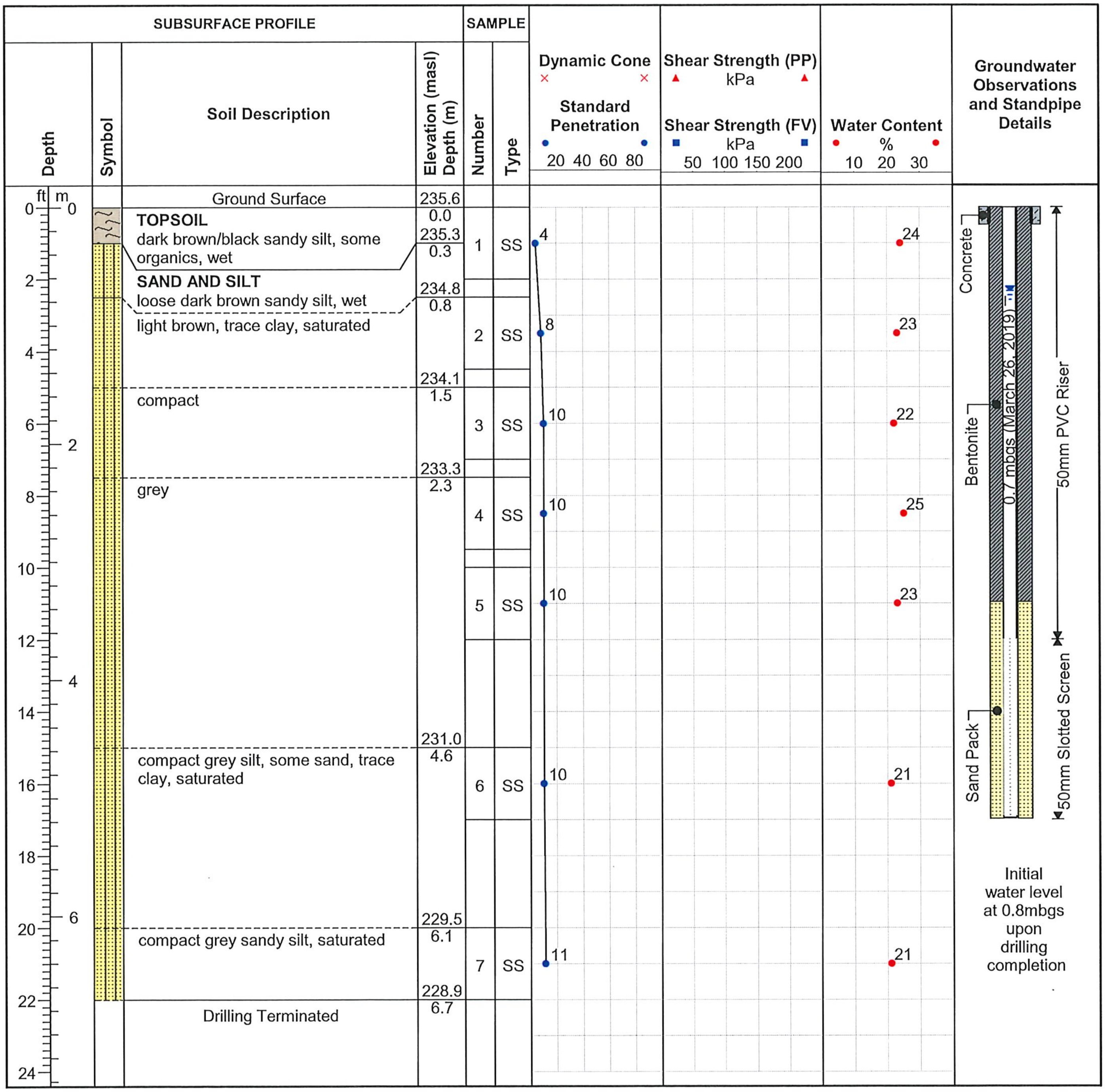
Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing



Elevation (masl) Depth (m)	Soil Description	Number	Type	Standard Penetration	Water Content %
235.6	Ground Surface				
0.0	**TOPSOIL** dark brown/black sandy silt, some organics, wet	1	SS	4	24
235.3 0.3	**SAND AND SILT** loose dark brown sandy silt, wet				
234.8 0.8	light brown, trace clay, saturated	2	SS	8	23
234.1 1.5	compact	3	SS	10	22
233.3 2.3	grey	4	SS	10	25
		5	SS	10	23
231.0 4.6	compact grey silt, some sand, trace clay, saturated	6	SS	10	21
229.5 6.1	compact grey sandy silt, saturated	7	SS	11	21
228.9 6.7	Drilling Terminated				

Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

MTE

Sheet: 1 of 1

ID Number: MW103-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

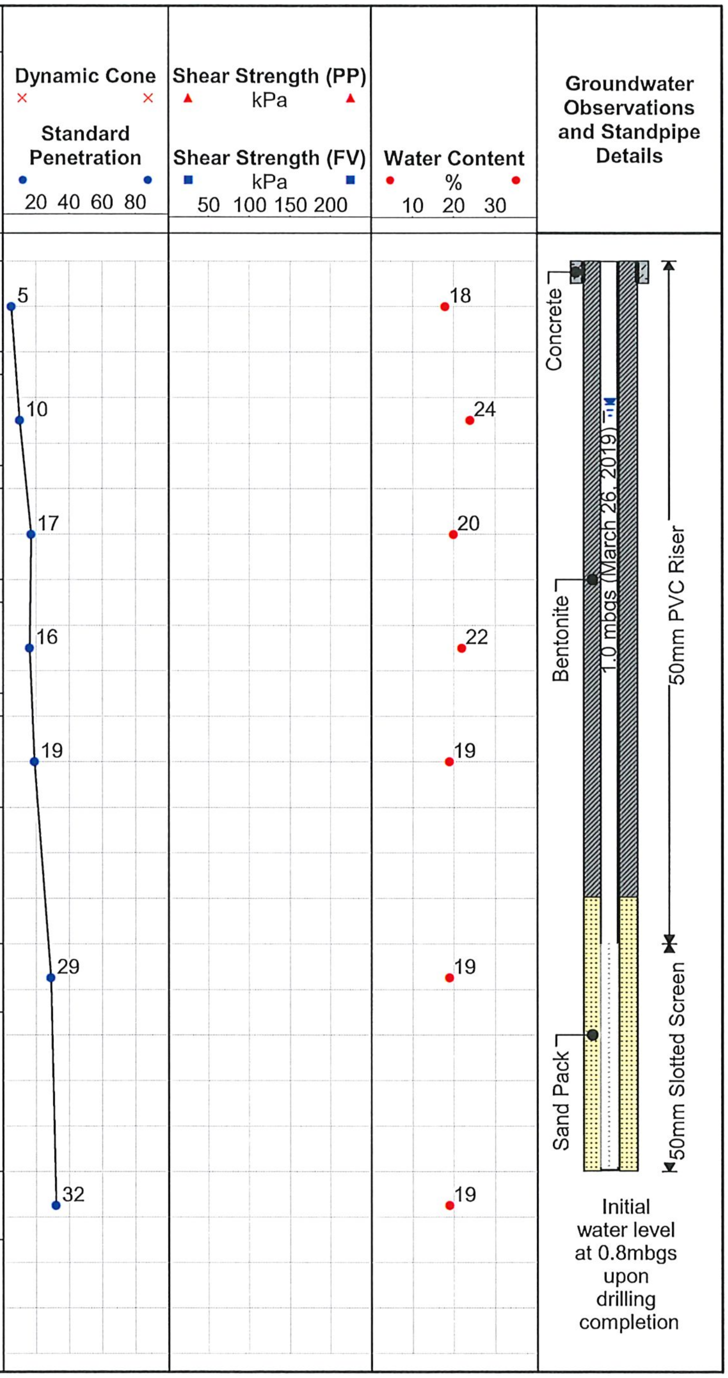
Protective Cover: Monument Casing

SUBSURFACE PROFILE

Soil Description	Elevation (masl) Depth (m)
Ground Surface	235.3
TOPSOIL dark brown/black sandy silt, some organics, wet	0.0
SAND AND SILT loose dark brown sandy silt, wet	234.5 0.8
compact, saturated	
compact light brown silty sand, saturated	233.8 1.5
compact grey sandy silt, trace clay, saturated	230.7 4.6
dense	229.2 6.1
Drilling Terminated	228.7 6.6

SAMPLE

Number	Type	Standard Penetration	Water Content %
1	SS	5	18
2	SS	10	24
3	SS	17	20
4	SS	16	22
5	SS	19	19
6	SS	29	19
7	SS	32	19



Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

ID Number: MW104-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

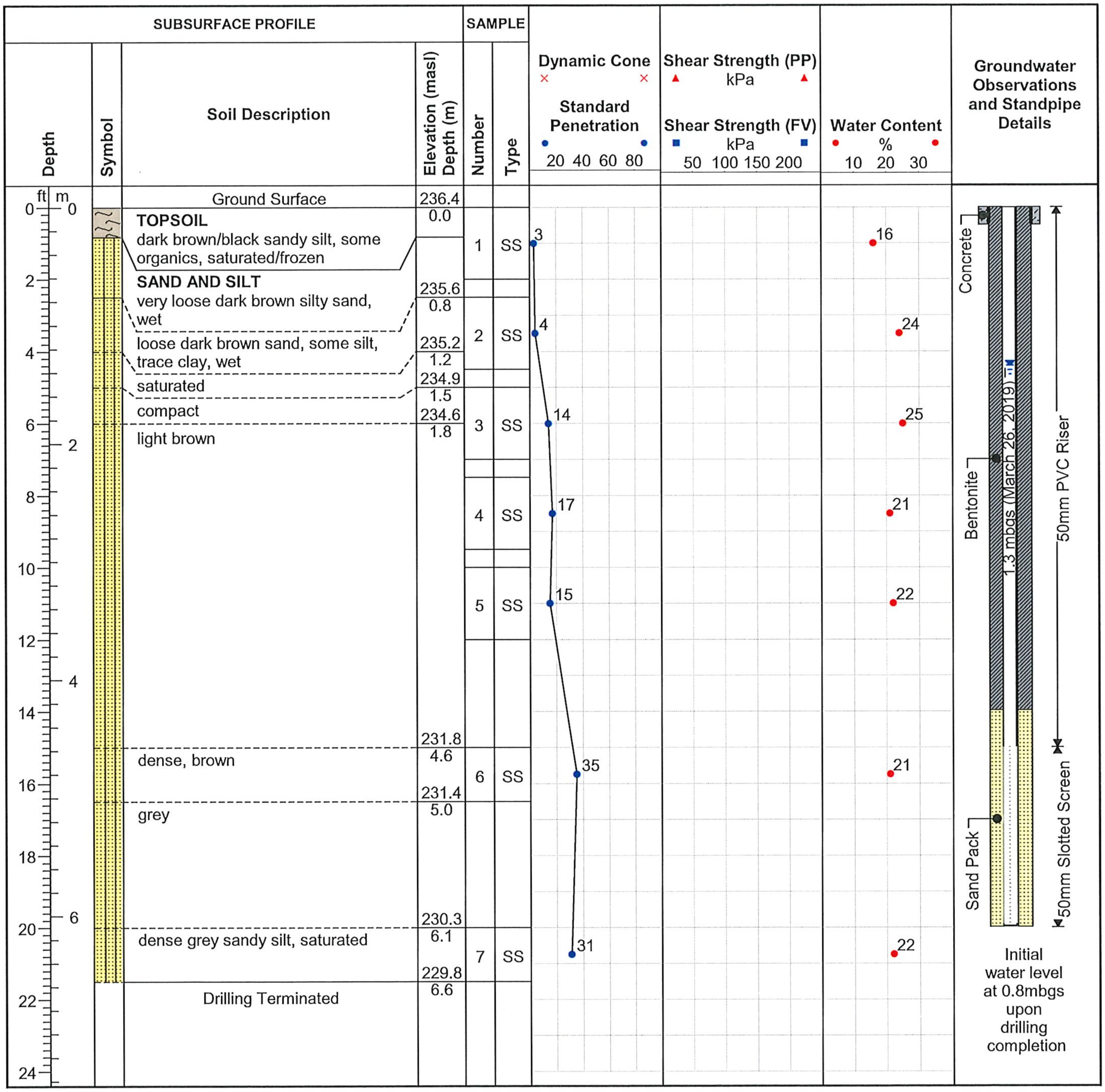
Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing



Soil Description	Elevation (masl) Depth (m)
Ground Surface	236.4 0.0
TOPSOIL dark brown/black sandy silt, some organics, saturated/frozen	
SAND AND SILT very loose dark brown silty sand, wet	235.6 0.8
loose dark brown sand, some silt, trace clay, wet	235.2 1.2
saturated	234.9 1.5
compact	234.6 1.8
light brown	
dense, brown	231.8 4.6
grey	231.4 5.0
dense grey sandy silt, saturated	230.3 6.1
Drilling Terminated	229.8 6.6

Number	Type	Standard Penetration	Water Content %
1	SS	3	16
2	SS	4	24
3	SS	14	25
4	SS	17	21
5	SS	15	22
6	SS	35	21
7	SS	31	22

Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

ID Number: MW105-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

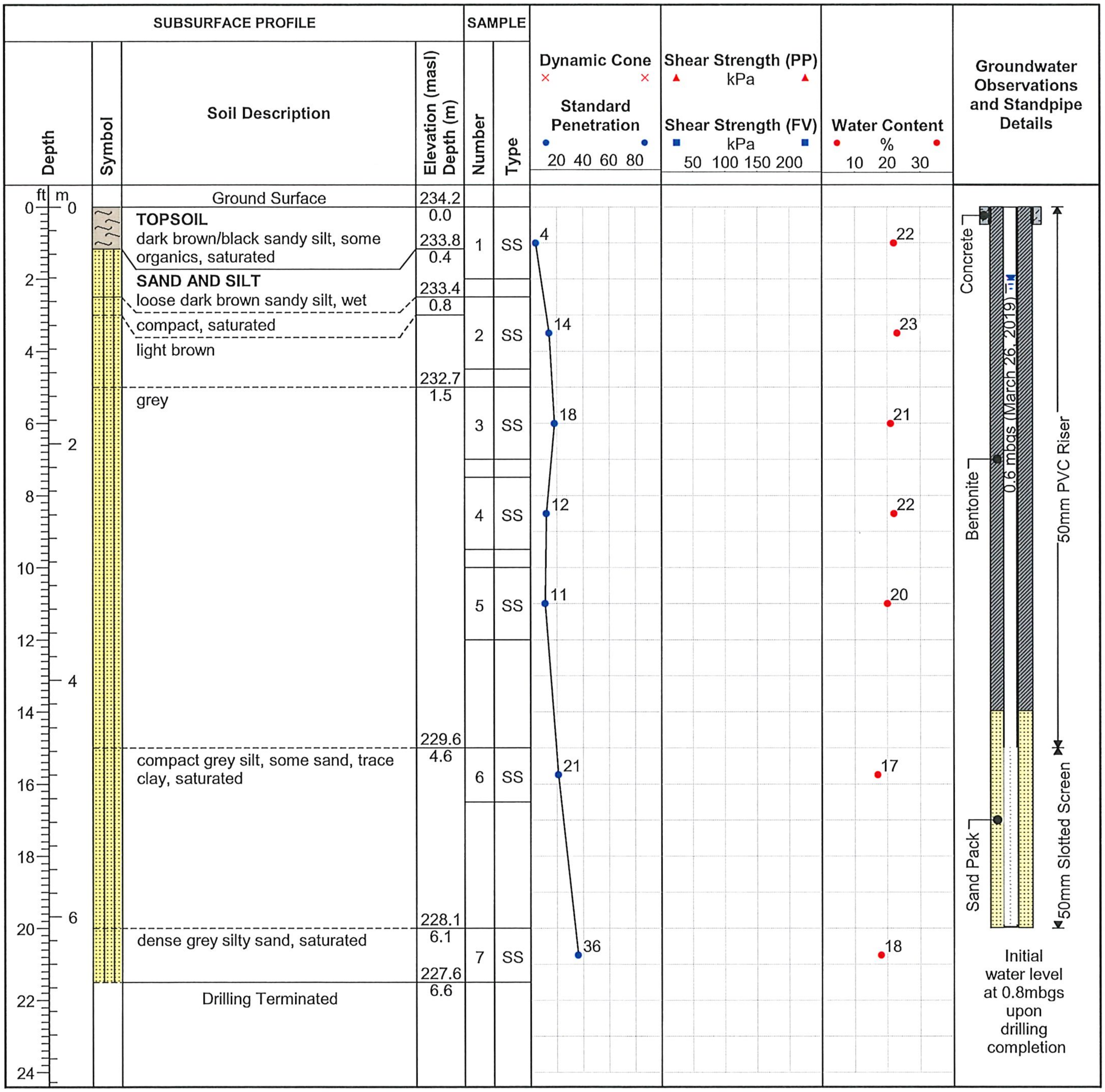
Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing



Soil Description	Elevation (masl) Depth (m)
Ground Surface	234.2
TOPSOIL dark brown/black sandy silt, some organics, saturated	0.0
SAND AND SILT loose dark brown sandy silt, wet	233.8 0.4
compact, saturated	233.4 0.8
light brown	
grey	232.7 1.5
compact grey silt, some sand, trace clay, saturated	229.6 4.6
dense grey silty sand, saturated	228.1 6.1
Drilling Terminated	227.6 6.6

Number	Type	Standard Penetration	Water Content %
1	SS	4	22
2	SS	14	23
3	SS	18	21
4	SS	12	22
5	SS	11	20
6	SS	21	17
7	SS	36	18

Initial water level at 0.8mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

ID Number: MW106-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

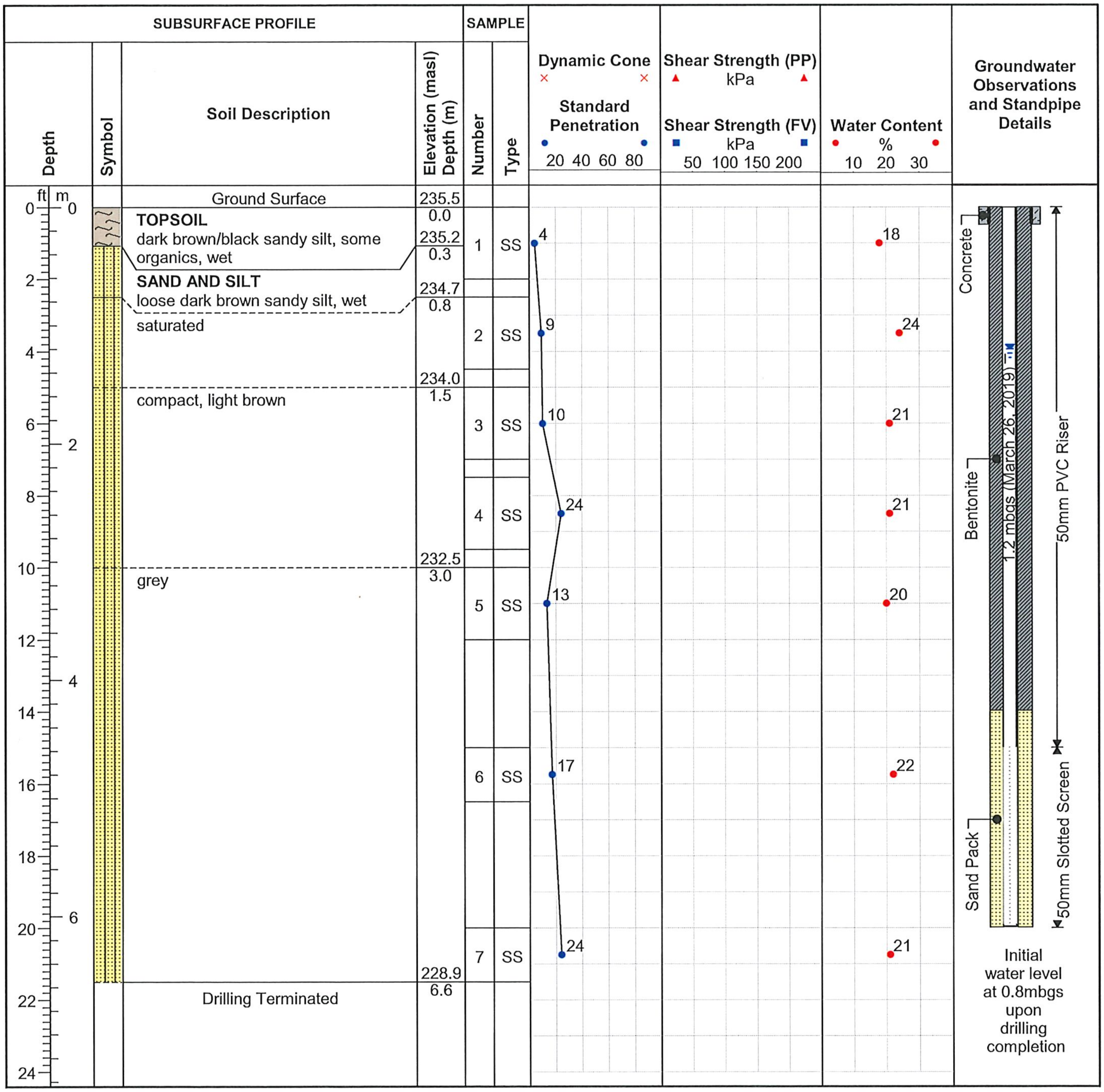
Drill Date: 3/20/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing



Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

ID Number: BH107-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

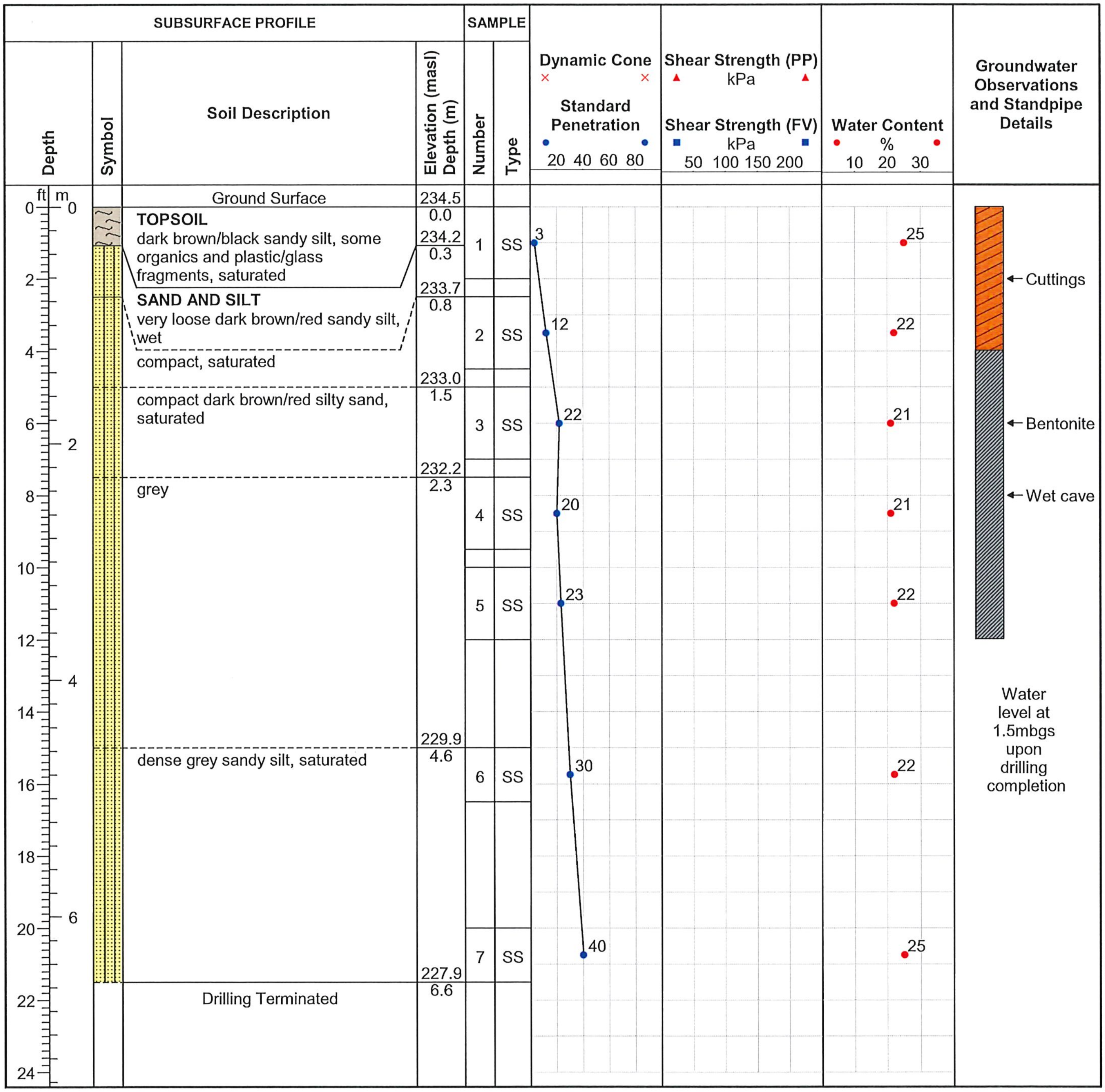
Drill Date: 3/21/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing



Soil Description	Elevation (masl) Depth (m)
Ground Surface	234.5 0.0
TOPSOIL dark brown/black sandy silt, some organics and plastic/glass fragments, saturated	234.2 0.3
SAND AND SILT very loose dark brown/red sandy silt, wet	233.7 0.8
compact, saturated	
compact dark brown/red silty sand, saturated	233.0 1.5
grey	232.2 2.3
dense grey sandy silt, saturated	229.9 4.6
Drilling Terminated	227.9 6.6

Number	Type	Standard Penetration	Water Content (%)
1	SS	3	25
2	SS	12	22
3	SS	22	21
4	SS	20	21
5	SS	23	22
6	SS	30	22
7	SS	40	25

Water level at 1.5mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

Notes:
Bentonite forced into wet cave at 2.4mbgs

ID Number: BH108-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

Drill Date: 3/21/2019

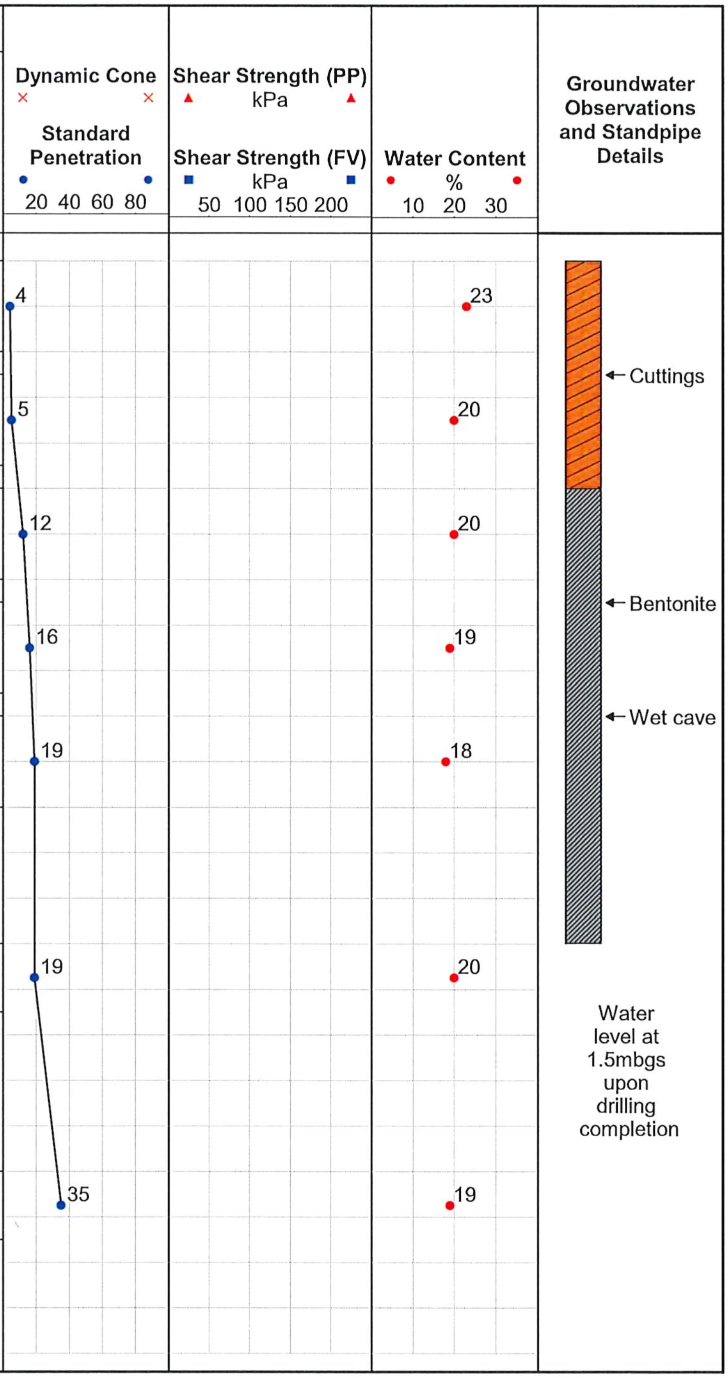
Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing

SUBSURFACE PROFILE			SAMPLE	
Symbol	Soil Description	Elevation (masl) Depth (m)	Number	Type
	Ground Surface	235.1		
	TOPSOIL dark brown/black sandy silt, some organics, saturated	0.0	1	SS
	SAND AND SILT loose dark brown sandy silt, wet	234.7 0.4		
	trace clay, saturated	234.3 0.8	2	SS
	compact, light brown	233.6 1.5	3	SS
	compact grey silty sand, saturated	232.8 2.3	4	SS
			5	SS
	compact grey sandy silt, saturated	230.5 4.6	6	SS
	dense	229.0 6.1	7	SS
	Drilling Terminated	228.5 6.6		



Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Notes:
Bentonite forced into wet cave at 3.1mbgs

Sheet: 1 of 1

ID Number: BH109-19

Project: 10919 Longwoods Road Proposed Industrial Subdivision

Project No: 45013-300

Client: 10919 Longwoods Road Inc.

Site Location: 10919 Longwoods Road, Middlesex Centre, ON

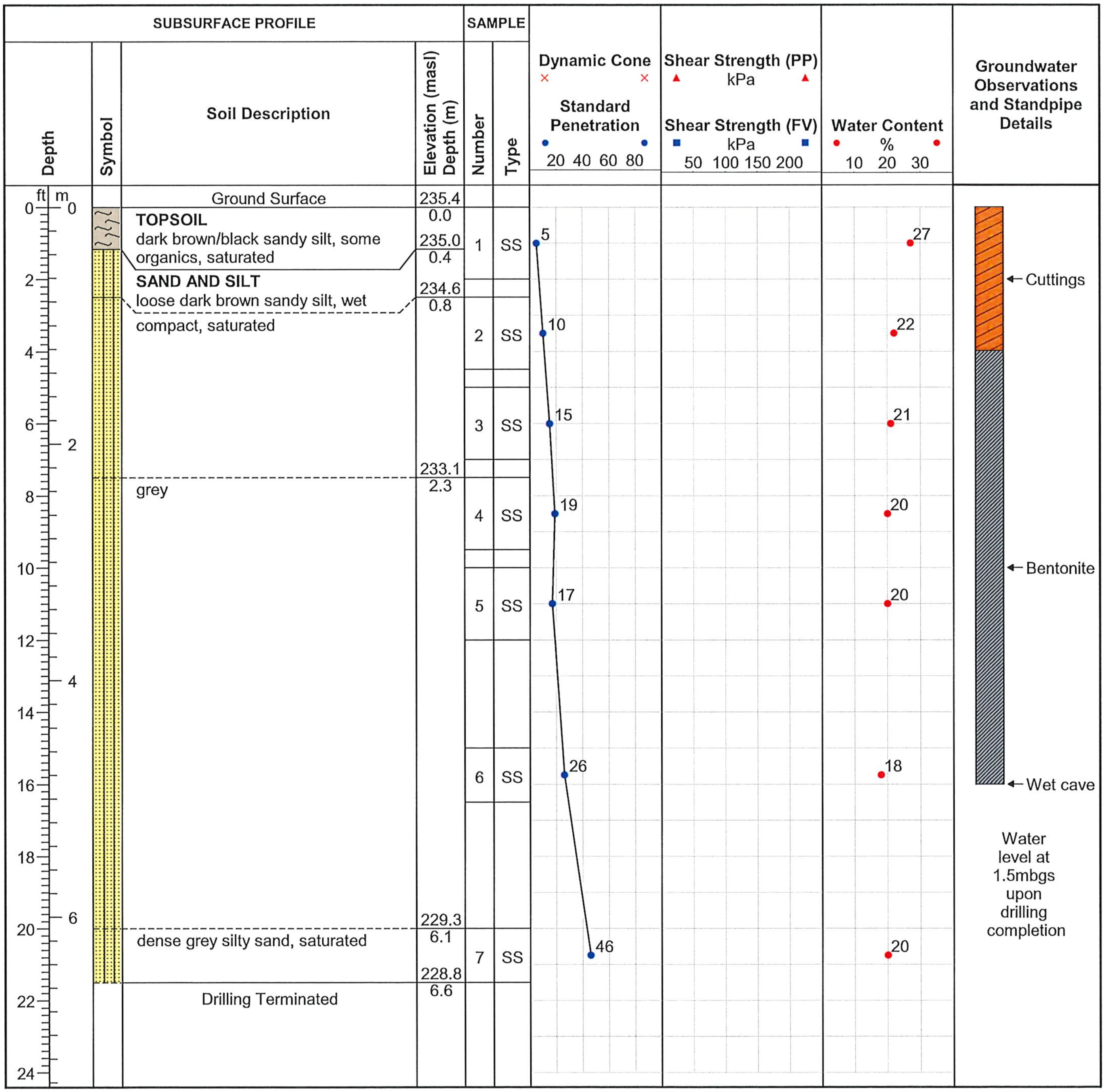
Drill Date: 3/21/2019

Drilling Contractor: London Soil Test Ltd.

Drill Rig: D50T Track

Drill Method: Hollow Stem Auger

Protective Cover: Monument Casing



Soil Description	Elevation (masl) Depth (m)	Number	Type	Standard Penetration	Water Content %
Ground Surface	235.4 0.0				
TOPSOIL dark brown/black sandy silt, some organics, saturated	235.0 0.4	1	SS	5	27
SAND AND SILT loose dark brown sandy silt, wet	234.6 0.8				
compact, saturated		2	SS	10	22
		3	SS	15	21
grey	233.1 2.3	4	SS	19	20
		5	SS	17	20
		6	SS	26	18
dense grey silty sand, saturated	229.3 6.1	7	SS	46	20
Drilling Terminated	228.8 6.6				

Water level at 1.5mbgs upon drilling completion

Field Technician: M. Dalgliesh

Drafted by: B. Heinbuch

Reviewed by: D. Gonser

Sheet: 1 of 1

Attachment C

K_{fs} Calculations

SOILMOISTURE® Guelph Permeameter Calculations

🟩 Input
🟨 Result

Single Head Method (1)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 1.5000

Res Type 35.22
H 10
a 3
H/a 3.333
a* 0.12
C0.01 1.218
C0.04 1.29
C0.12 1.288
C0.36 1.288
C 1.288
R 1.500
Q 0.881
pi 3.142

α*= 0.12 cm $^{-1}$

C = 1.287543
Q = 0.8805

K$_{fs}$ = 9.54E-04 cm/sec
5.72E-02 cm/min
9.54E-06 m/sec
2.25E-02 inch/min
3.76E-04 inch/sec

Φ$_m$ = 7.95E-03 cm ^{2} /min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 1.5000

Res Type 35.22
H 10
a 3
H/a 3.33333
a* 0.12
C0.01 1.21841
C0.04 1.29023
C0.12 1.28754
C0.36 1.28754
C 1.28754
R 1.500
Q 0.8805
pi 3.1415

α*= 0.12 cm $^{-1}$

C = 1.287543
Q = 0.8805

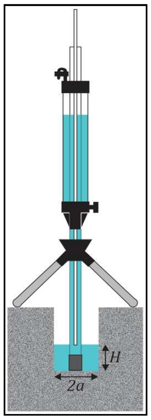
K$_{fs}$ = 9.54E-04 cm/sec
5.72E-02 cm/min
9.54E-06 m/ses
2.25E-02 inch/min
3.76E-04 inch/sec

Φ$_m$ = 7.95E-03 cm ^{2} /min

Average

K$_{fs}$ = 9.54E-04 cm/sec
5.72E-02 cm/min
9.54E-06 m/s
2.25E-02 inch/min
3.76E-04 inch/sec

Φ$_m$ = 7.95E-03 cm ^{2} /min



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	α^*(cm^{-1})	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121\left(H_2/a\right)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091\left(H_1/a\right)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091\left(H_2/a\right)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi\left(2H_1 H_2 (H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_2 = \frac{H_1 C_2}{\pi\left(2H_1 H_2 (H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi\left(2H_1 H_2 (H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi\left(2H_1 H_2 (H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

SOILMOISTURE®

Guelph Permeameter Calculations

🟩 Input

🟨 Result

Single Head Method (1)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 1.7000

Res Type	35.22
H	10
a	3
H/a	3.333
a*	0.12
C0.01	1.218
C0.04	1.29
C0.12	1.288
C0.36	1.288
C	1.288
R	1.700
Q	0.998
pi	3.142

α*= 0.12 cm^{-1}

C = 1.287543
Q = 0.9979

K_{fs} =	1.08E-03	cm/sec
	6.49E-02	cm/min
	1.08E-05	m/sec
	2.55E-02	inch/min
	4.26E-04	inch/sec

Φ_m = 9.01E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 1.7000

Res Type	35.22
H	10
a	3
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	1.700
Q	0.9979
pi	3.1415

α*= 0.12 cm^{-1}

C = 1.287543
Q = 0.9979

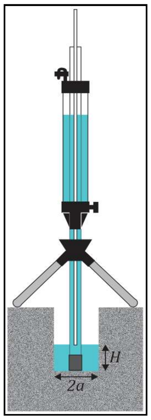
K_{fs} =	1.08E-03	cm/sec
	6.49E-02	cm/min
	1.08E-05	m/ses
	2.55E-02	inch/min
	4.26E-04	inch/sec

Φ_m = 9.01E-03 cm^2/min

Average

K_{fs} =	1.08E-03	cm/sec
	6.49E-02	cm/min
	1.08E-05	m/s
	2.55E-02	inch/min
	4.26E-04	inch/sec

Φ_m = 9.01E-03 cm^2/min



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121\left(H_2/a\right)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091\left(H_1/a\right)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091\left(H_2/a\right)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_2 = \frac{H_1 C_2}{\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

SOILMOISTURE Guelph Permeameter Calculations

🟩 Input

🟨 Result

Single Head Method (1)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2500

Res Type	35.22
H	10
a	3
H/a	3.333
a*	0.12
C0.01	1.218
C0.04	1.29
C0.12	1.288
C0.36	1.288
C	1.288
R	0.250
Q	0.147
pi	3.142

α*= 0.12 cm^{-1}

C = 1.287543
Q = 0.14675

K_{fs} = 1.59E-04 cm/sec
9.54E-03 cm/min
1.59E-06 m/sec
3.76E-03 inch/min
6.26E-05 inch/sec

Φ_m = 1.33E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2500

Res Type	35.22
H	10
a	3
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	0.250
Q	0.14675
pi	3.1415

α*= 0.12 cm^{-1}

C = 1.287543
Q = 0.14675

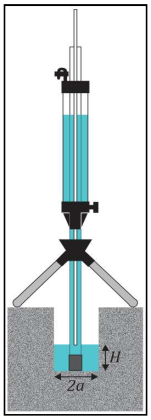
K_{fs} = 1.59E-04 cm/sec
9.54E-03 cm/min
1.59E-06 m/ses
3.76E-03 inch/min
6.26E-05 inch/sec

Φ_m = 1.33E-03 cm^2/min

Average

K_{fs} = 1.59E-04 cm/sec
9.54E-03 cm/min
1.59E-06 m/s
3.76E-03 inch/min
6.26E-05 inch/sec

Φ_m = 1.33E-03 cm^2/min



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm²/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1))}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

SOILMOISTURE Guelph Permeameter Calculations

🟩 Input

🟨 Result

Single Head Method (1)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22

Enter water Head Height ("H" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.3000

Res Type	35.22
H	10
a	3
H/a	3.333
a*	0.12
C0.01	1.218
C0.04	1.29
C0.12	1.288
C0.36	1.288
C	1.288
R	0.300
Q	0.176
pi	3.142

α*= 0.12 cm $^{-1}$

C = 1.287543

Q = 0.1761

K_{fs} = 1.91E-04 cm/sec
1.14E-02 cm/min
1.91E-06 m/sec
4.51E-03 inch/min
7.51E-05 inch/sec

Φ_m = 1.59E-03 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir): 35.22

Enter water Head Height ("H" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.3000

Res Type	35.22
H	10
a	3
H/a	3.33333
a*	0.12
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.28754
R	0.300
Q	0.1761
pi	3.1415

α*= 0.12 cm $^{-1}$

C = 1.287543

Q = 0.1761

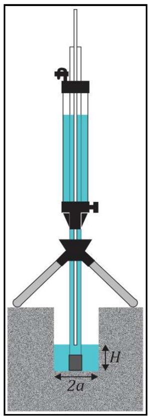
K_{fs} = 1.91E-04 cm/sec
1.14E-02 cm/min
1.91E-06 m/ses
4.51E-03 inch/min
7.51E-05 inch/sec

Φ_m = 1.59E-03 cm^2/min

Average

K_{fs} = 1.91E-04 cm/sec
1.14E-02 cm/min
1.91E-06 m/s
4.51E-03 inch/min
7.51E-05 inch/sec

Φ_m = 1.59E-03 cm^2/min



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(\mathrm{cm}^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121\left(H_2/a\right)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091\left(H_1/a\right)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091\left(H_2/a\right)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_2 = \frac{H_1 C_2}{\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi\left(2H_1 H_2(H_2 - H_1) + a^2(H_1 C_2 - H_2 C_1)\right)}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Permeameter Calculations

🟩 Input

🟨 Result

Single Head Method (1)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir):	2.16
Enter water Head Height ("H" in cm):	25
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.3500

Res Type	2.16
H	25
a	3
H/a	8.333
a*	0.12
C0.01	1.948
C0.04	2.132
C0.12	2.246
C0.36	2.246
C	2.246
R	0.350
Q	0.013
pi	3.142

α^*= 0.12 cm^{-1}

C = 2.246256

Q = 0.0126

K_{fs} =	5.34E-06	cm/sec
	3.20E-04	cm/min
	5.34E-08	m/sec
	1.26E-04	inch/min
	2.10E-06	inch/sec

Φ_m = 4.45E-05 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2

(enter "35.22" for Combined and "2.16" for Inner reservoir):	2.16
Enter water Head Height ("H" in cm):	25
Enter the Borehole Radius ("a" in cm):	3
Enter the soil texture-structure category (enter one of the below numbers):	3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.3500

Res Type	2.16
H	25
a	3
H/a	8.33333
a*	0.12
C0.01	1.94805
C0.04	2.13216
C0.12	2.24626
C0.36	2.24626
C	2.24626
R	0.350
Q	0.0126
pi	3.1415

α^*= 0.12 cm^{-1}

C = 2.246256

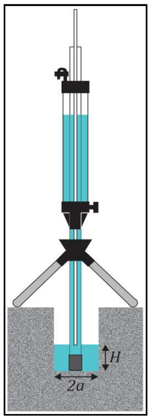
Q = 0.0126

K_{fs} =	5.34E-06	cm/sec
	3.20E-04	cm/min
	5.34E-08	m/ses
	1.26E-04	inch/min
	2.10E-06	inch/sec

Φ_m = 4.45E-05 cm^2/min

Average

K_{fs} =	5.34E-06	cm/sec
	3.20E-04	cm/min
	5.34E-08	m/s
	1.26E-04	inch/min
	2.10E-06	inch/sec
Φ_m =	4.45E-05	cm^2/min



Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121\left(H_2/a\right)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091\left(H_1/a\right)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091\left(H_2/a\right)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093\left(H_1/a\right)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093\left(H_2/a\right)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi\left(2H_1 H_2 (H_2 - H_1) + a^2 (H_1 C_2 - H_2 C_1)\right)}$ $G_2 = \frac{H_1 C_2}{\pi\left(2H_1 H_2 (H_2 - H_1) + a^2 (H_1 C_2 - H_2 C_1)\right)}$ $K_{fs} = G_2 Q_2 - G_1 Q_1$ $G_3 = \frac{(2H_2^2 + a^2 C_2)C_1}{2\pi\left(2H_1 H_2 (H_2 - H_1) + a^2 (H_1 C_2 - H_2 C_1)\right)}$ $G_4 = \frac{(2H_1^2 + a^2 C_1)C_2}{2\pi\left(2H_1 H_2 (H_2 - H_1) + a^2 (H_1 C_2 - H_2 C_1)\right)}$ $\Phi_m = G_3 Q_1 - G_4 Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Guelph Permeameter Calculations

🟩 Input

🟨 Result

Single Head Method (1)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 25
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.1000

Res Type	2.16
H	25
a	3
H/a	8.333
a*	0.12
C0.01	1.948
C0.04	2.132
C0.12	2.246
C0.36	2.246
C	2.246
R	0.100
Q	0.004
pi	3.142

α*= 0.12 cm^{-1}

C = 2.246256
Q = 0.0036

K_{fs} = 1.53E-06 cm/sec
9.16E-05 cm/min
1.53E-08 m/sec
3.60E-05 inch/min
6.01E-07 inch/sec

$Φ_m$ = 1.27E-05 cm^2/min

Single Head Method (2)

Reservoir Cross-sectional area in cm^2
(enter "35.22" for Combined and "2.16" for Inner reservoir): 2.16
Enter water Head Height ("H" in cm): 25
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.1000

Res Type	2.16
H	25
a	3
H/a	8.33333
a*	0.12
C0.01	1.94805
C0.04	2.13216
C0.12	2.24626
C0.36	2.24626
C	2.24626
R	0.100
Q	0.0036
pi	3.1415

α*= 0.12 cm^{-1}

C = 2.246256
Q = 0.0036

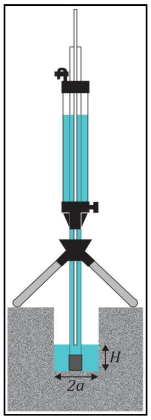
K_{fs} = 1.53E-06 cm/sec
9.16E-05 cm/min
1.53E-08 m/ses
3.60E-05 inch/min
6.01E-07 inch/sec

$Φ_m$ = 1.27E-05 cm^2/min

Average

K_{fs} = 1.53E-06 cm/sec
9.16E-05 cm/min
1.53E-08 m/s
3.60E-05 inch/min
6.01E-07 inch/sec

$Φ_m$ = 1.27E-05 cm^2/min



Calculation formulas related to shape factor (*C*). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_2/a}{2.081 + 0.121(H_2/a)}\right)^{0.672}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	