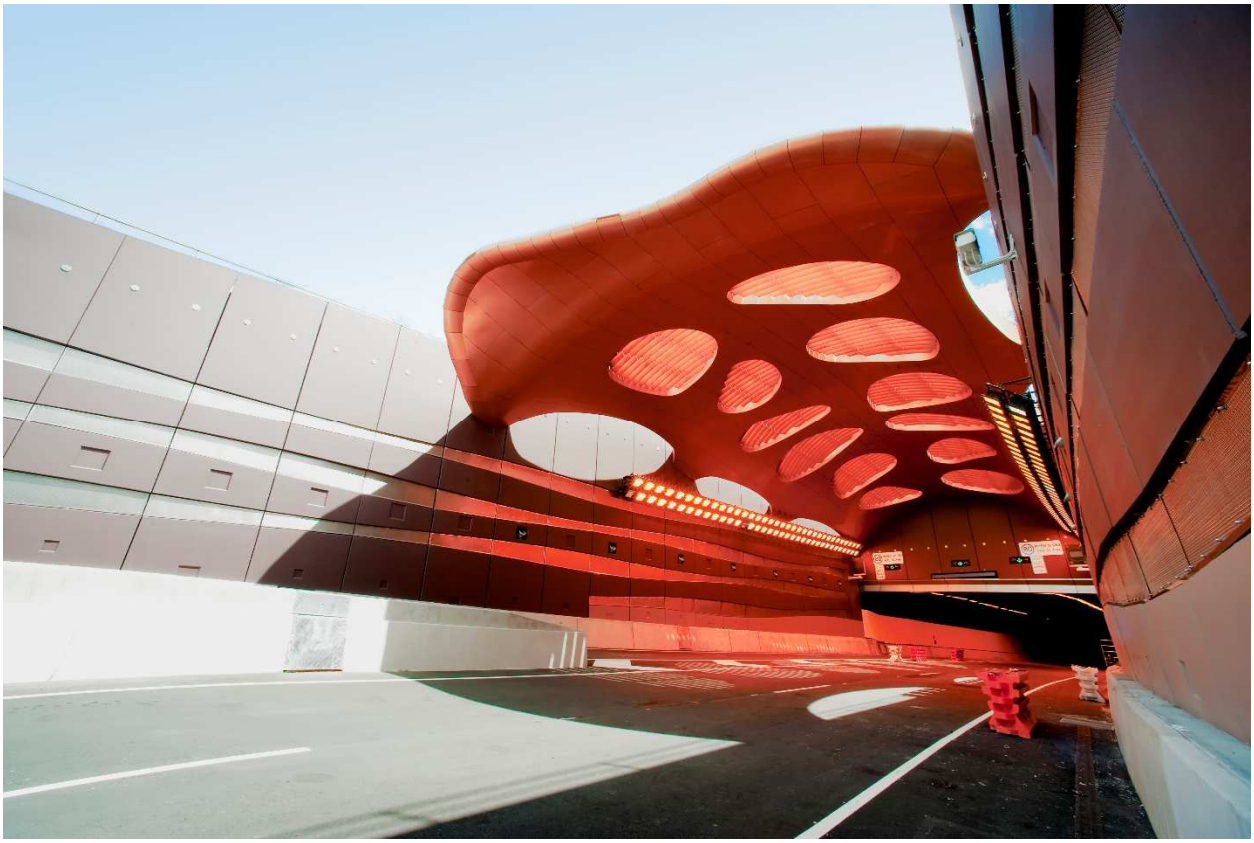
DELTINI COMMERCIAL DEVELOPMENTS

636040 PRINCE OF WALES RD., W. PRIMROSE, ON

INFILTRATION STUDY

OCTOBER 29, 2018



636040 PRINCE OF WALES RD., W. PRIMROSE, ON

INFILTRATION STUDY

DELTINI COMMERCIAL DEVELOPMENTS

PROJECT NO.: 181-01582-01
DATE: OCTOBER 29, 2018

WSP
UNIT 1
14 RONELL CRESCENT
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October 29, 2018

DELTINI COMMERCIAL DEVELOPMENTS
1350 Shawson Drive
Mississauga, ON
L4W 1C5

Attention: Ms. Marika Zigon

Dear Ms. Zigon,

Subject: Infiltration Study - 637040 Prince of Wales Rd., W. Primrose, ON

WSP Canada Inc. (WSP) was retained by Deltini Commercial Developments/1461125 Ontario Limited to complete an infiltration study of current site conditions for select locations at 636040 Prince of Wales Rd West in Primrose, Ontario. Figure 1 shows the site location. The work was completed to determine the infiltration potential of the varying soil conditions at the property for consideration of Low Impact Development (LID) techniques. The testing, methodology, calculations and data assessment are in accordance with the Low Impact Development Stormwater Management Planning and Design Guide issued by the Toronto Region Conservation Authority and Credit Valley Conservation (TRCA and CVC). The results of the testing are compared to the requirements established in the Stormwater Management Planning and Design Manual (MOE, March 2003).

Yours sincerely,

Nicole Collins
Environmental Technician

Gord Jarvis
Team Lead - Environment

GJ/ham

WSP ref.: 181-01582-01

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1 INTRODUCTION

The Site is located on the west side of Prince of Wales Road West and north of Highway 89 in a mixed-use area in the Town of Primrose, Ontario. The Site is currently agricultural with a total area of approximately 382,800 m^2 (94.6 acres).

The objectives of this investigation include:

- Evaluate the potential infiltration rate of native soils above the water table using in-situ infiltration testing; and,
- Collection of soil samples at the same depths as the tests to be submitted for grain-size analyses.

2 IN-SITU TESTING

WSP conducted the in-situ infiltration testing (IT) on September 24 & 25, 2018. A small excavator was required to dig to the target depths to perform the testing. The testing was conducted with a double-ring infiltrometer in the test-pits excavated to depths ranging between 0.5 to 1.6 m below ground surface (BGS). The in-situ infiltration testing was completed at seven locations (test pits) at the site, with eight (8) tests completed (IT1 to IT8) to determine the infiltration rate of the soils. The location of the infiltration tests is shown on ***Figure 1*** and the results are summarized in **Table 1** below, and in ***Appendix A***.

Infiltration testing was completed by saturating the native soils and measuring the rate of water infiltration (mm/hr) at each location.

The testing was completed in the various soil conditions encountered at the site and have been compared to each other in the following categories; clayey silt and silt; and, silty sand, sand and gravelly sand.

The measured infiltration rates in the clayey silt and silt materials encountered at the site ranged from 5 to 28 mm/hr, with a geometric mean of 16 mm/hr, and permeability rates ranged from $2.5x10^{-8}$ to $1.5x10^{-5}$ cm/s. As per the LID guideline, a safety correction factor of 2.5 should be applied to the measured infiltration rates to calculate the design infiltration rate. The safety factor is required to account for site heterogeneity, potential reduction in soil permeability during construction and gradual accumulation of fine sediments over time. As such, the recommended design infiltration rate for the clayey silt and silt soils encountered at the site is 6 mm/hr.

The measured infiltration rates for the silty sand, sand and gravelly sand materials encountered at the site ranged from 61 to 212 mm/hr, with a geometric mean of 148 mm/hr, and permeability rates ranged from $2.8x10^{-4}$ to $3.0x10^{-2}$ cm/s. As per the LID guideline, a safety correction factor of 2.5 should be applied to the measured infiltration rates to calculate the design infiltration rate. The safety factor is required to account for site heterogeneity, potential reduction in soil permeability during construction and gradual accumulation of fine sediments over time. As such, the recommended design infiltration rate for the silty sand, sand and gravelly sand soils encountered at the site is 59 mm/hr.

In addition to the field testing for infiltration, grain size analyses of soil samples were completed. The grain size distribution chart is presented in ***Appendix B***, along with the infiltration testing results. The results show that the clayey silt and silt soils consist of 0 to 5% gravel, 4 to 15% sand and 80 to 96% fines. The results show that the silty sand, sand and gravelly sand soils consist of 0 to 33% gravel, 54 to 90% sand and 6 to 30% fines. The hydraulic conductivity value (K) was estimated from particle size analyses using the Hazen method, which is an empirical relationship where:

$$K = C * d_{10}^2$$

Where:

C = constant, average value of 1.0, when D is in mm and K is in cm/s;

d_{10}=diameter of the 10^{th} percentile grain size (mm).

Table 2-1 Summary of Infiltration Test Results

TEST #	TEST LOCATION	SOIL TYPE AT TEST DEPTH	INFILTRATION TEST - DOUBLE-RING INFILTROMETER			ESTIMATED PERMEABILITY (K) (CM/S) CALCULATED FROM INFILTRATION RATE	ESTIMATED PERMEABILITY (K) (CM/S) CALCULATED FROM GRAIN SIZE ANALYSIS
			Test Pit Depth (m)	Measured Infiltration Rate (mm/hr)	Calculated Percolation Time (T) (min/cm)		
IT1	TP1	Clayey Silt	1.0	5	120	$2.5x10^{-8}$	$<1.0x10^{-6}$
IT2	TP2	Silty Sand	1.6	61	10	$2.8x10^{-4}$	$2.7x10^{-3}$
IT3	TP3	Clayey Silt	1.0	28	21	$1.5x10^{-5}$	$<1.0x10^{-6}$
IT4	TP4	Sand	1.0	195	3	$2.2\ x10^{-2}$	$7.5x10^{-2}$
IT5	TP5	Silt	1.2	19	32	$3.6x10^{-6}$	$1.8x10^{-3}$
IT6	TP5	Silty Sand	0.5	212	3	$3.0x10^{-2}$	$2.2x10^{-2}$
IT7	TP6	Gravelly Sand	1.0	189	3	$1.9x10^{-2}$	$1.4x10^{-1}$
IT8	TP7	Silt	1.4	23	26	$7.3x10^{-6}$	$3.5x10^{-3}$

3 GEOTECHNICAL INVESTIGATION

WSP also completed a geotechnical investigation drilling program at the site in February and March 2018. As part of this drilling program, groundwater monitoring wells were installed in seven borehole locations as shown on ***Figure 1***. The borehole logs are included in ***Appendix* C**. The observations made of the groundwater conditions in some monitoring wells are summarized in **Table 2-2** below:

Table 3-1 Groundwater Levels Observed in Monitoring Wells

WELL ID	DATE OF WATER LEVEL MEASUREMENT	WELL DEPTH (M BGS)	DEPTH TO WATER (M BGS)
BH18-02	March 6, 2018	4.68	3.94
BH18-03	March 6, 2018	4.74	1.52
BH18-04	March 6, 2018	7.60	6.76
BH18-05	March 6, 2018	5.63	2.12
BH18-07	March 6, 2018	4.65	2.30
BH18-08	March 6, 2018	7.04	5.20
BH18-10	March 6, 2018	4.40	1.64
BH18-11	March 6, 2018	5.25	3.48

Groundwater was encountered in TP6 at a depth of 0.7 m BGS. Groundwater was not encountered in any of the other test pit locations. Based on the March 2018 water level measurements (see **Table 2-2**), the depth to groundwater can be expected to range from 1.52 to 6.76 m BGS. In order to confirm seasonal high groundwater in the area of the storm water management facilities, continuous groundwater level monitoring is recommended.

Bedrock was not encountered in the boreholes drilled as part of the geotechnical assessment completed at the site in which the drilled depths ranging from 2.1 to 8.2 m BGS.
For the consideration and design of LID stormwater management techniques, Table 4.1 of the MOE Storm Water Management Planning and Design Manual should be adhered to; infiltration rate ≥ 15 mm/hr, > 1 m to groundwater table and > 1 m to bedrock.

We trust this report satisfies your needs. If there are questions or if more information is required, please do not hesitate to contact our office.

Prepared by:

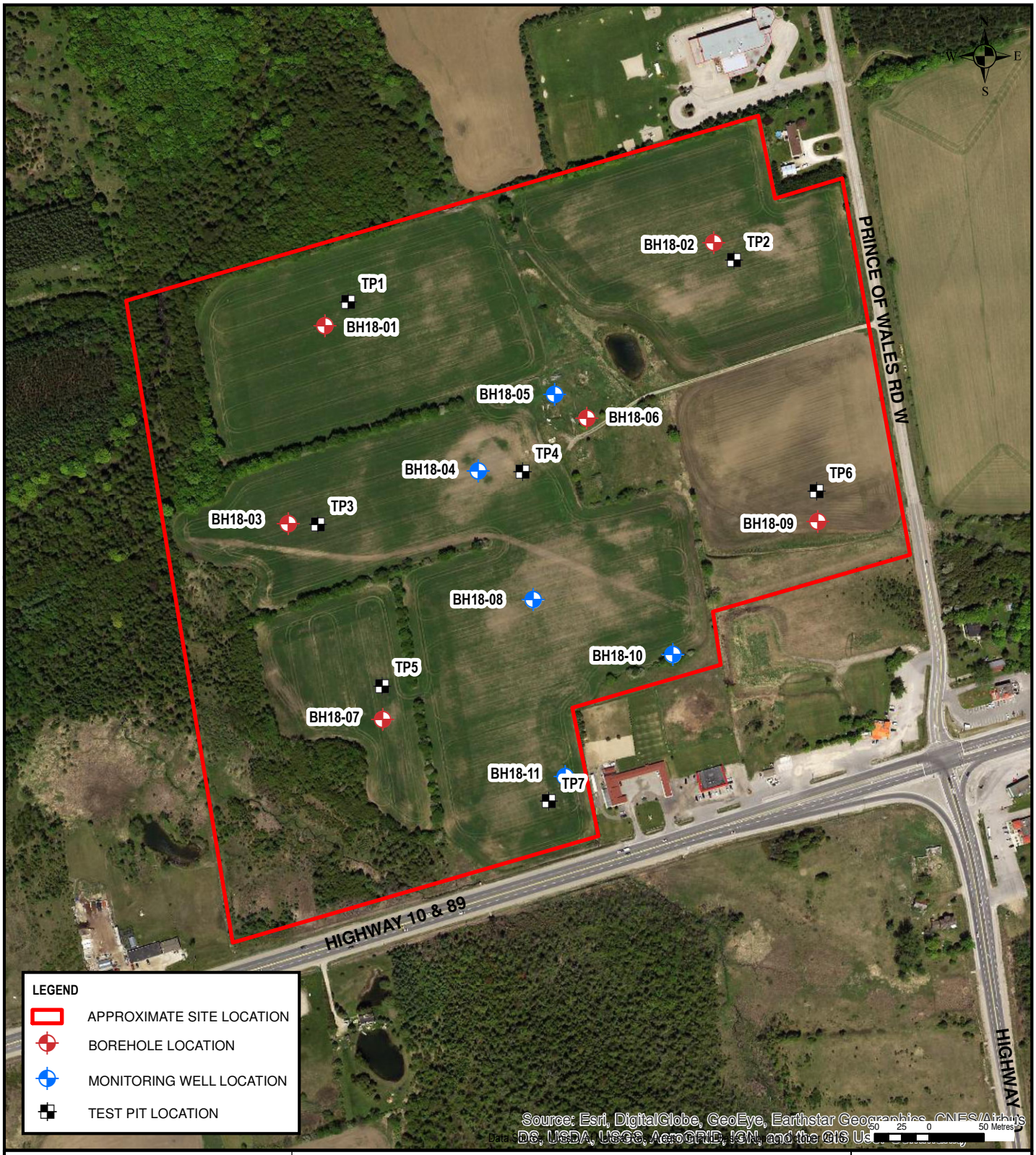
Nicole Collins
Environmental Technician

Reviewed by:

Gord Jarvis
Team Lead - Environment

APPENDIX

DRAWINGS



14 RONELL CRESCENT, UNIT 1
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PROJECT:
INFILTRATION TESTING
636040 PRINCE OF WALES ROAD WEST
PRIMROSE, TOWNSHIP OF MULMUR, ONTARIO

TITLE:
TEST PIT LOCATION MAP

CLIENT:
DELTINI COMMERCIAL DEVELOPMENTS

SCALE:	1:5,000
DRAWN BY:	TP
CHECKED BY:	-
PROJECT NO:	181-01582-01
DATE:	OCTOBER 2018
FIGURE NO:	1
REV.:	-

Document Path: T:\181-01582-00\MXD\400\181-01582-01 Figure 1 Test Pit Location.mxd

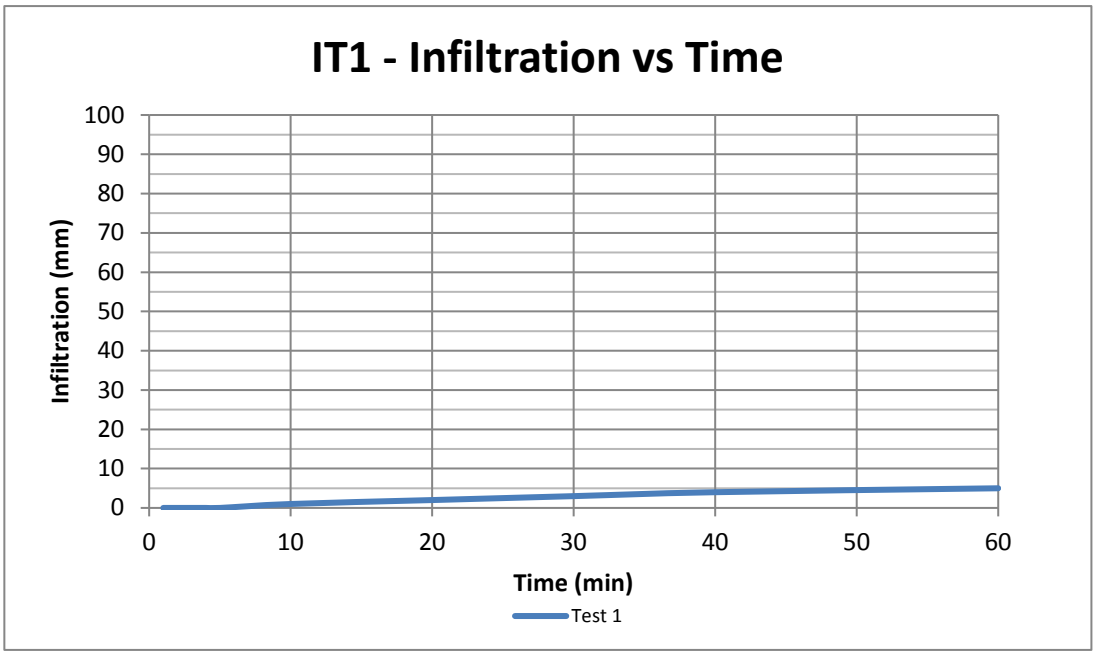
APPENDIX

A INFILTRATION TEST DATA

Location - TP1

Test 1

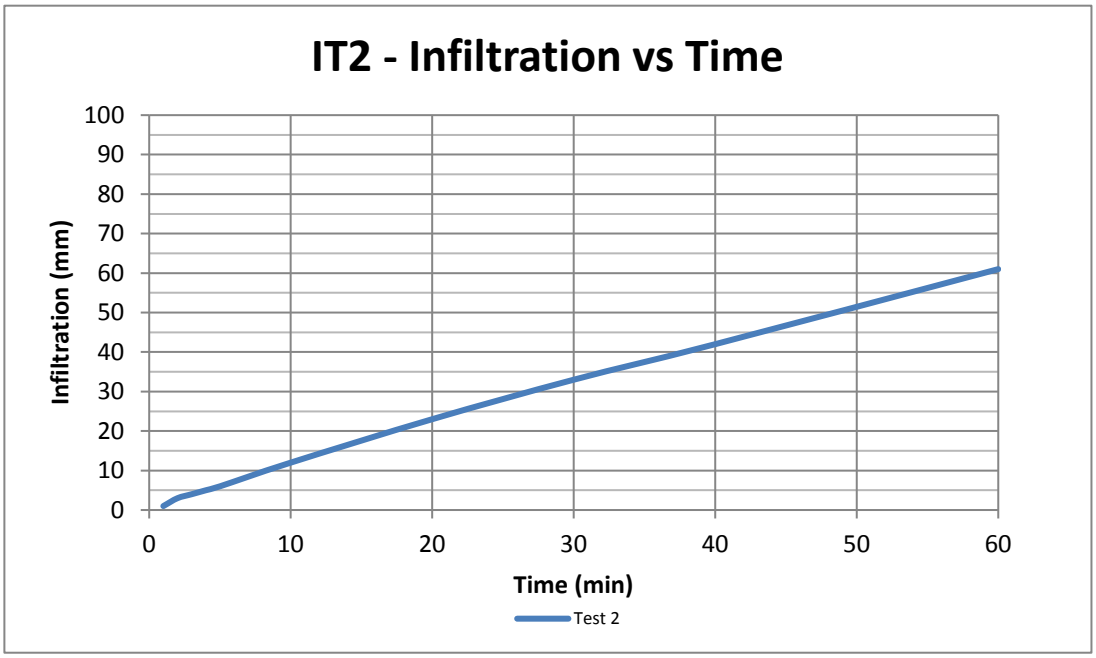
Time (min)	Infiltration (mm)
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0
10	1.0
20	2.0
30	3.0
40	4.0
60	5.0



Location - TP2

Test 2

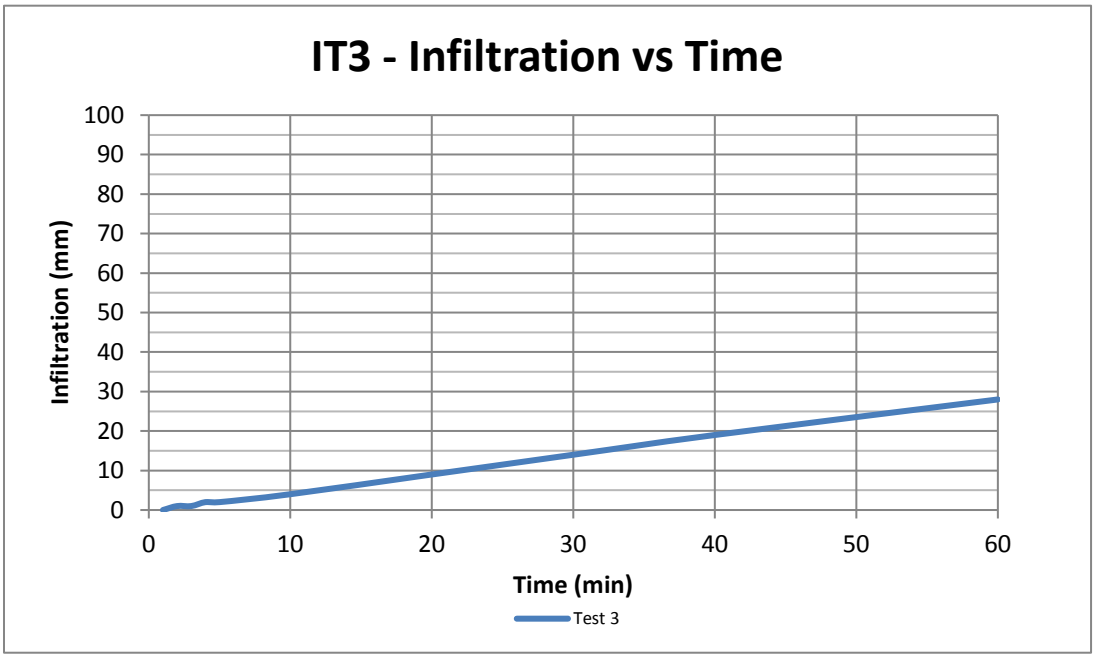
Time (min)	Infiltration (mm)
1	1.0
2	3.0
3	4.0
4	5.0
5	6.0
10	12.0
20	23.0
30	33.0
40	42.0
60	61.0



Location - TP3

Test 3

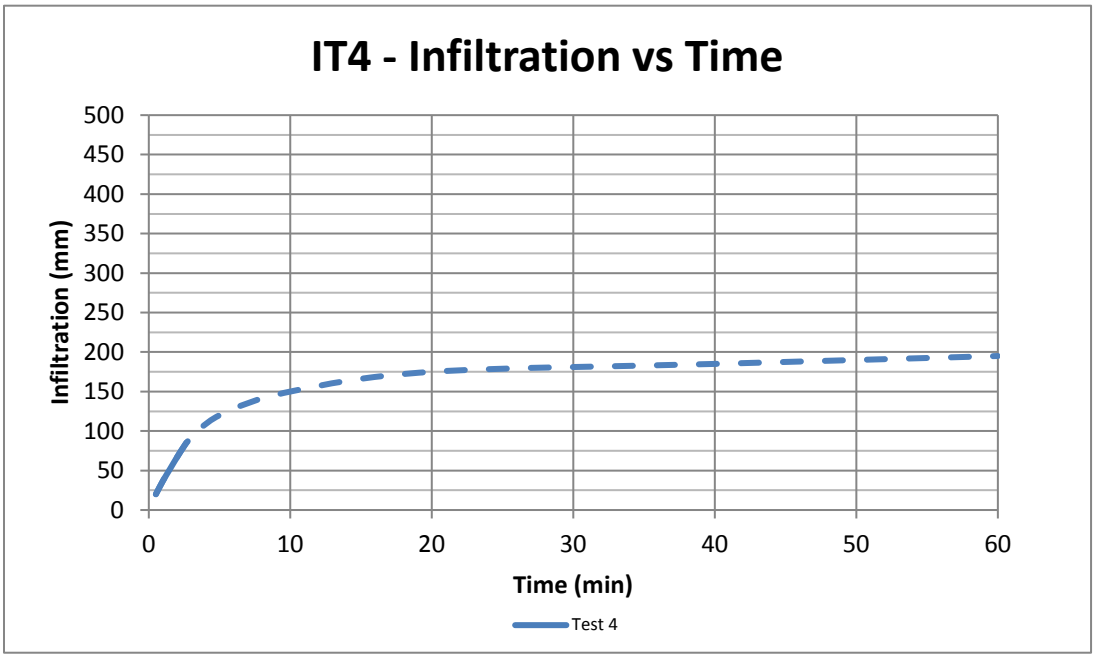
Time (min)	Infiltration (mm)
1	0.0
2	1.0
3	1.0
4	2.0
5	2.0
10	4.0
20	9.0
30	14.0
40	19.0
60	28.0



Location - TP4

Test 4

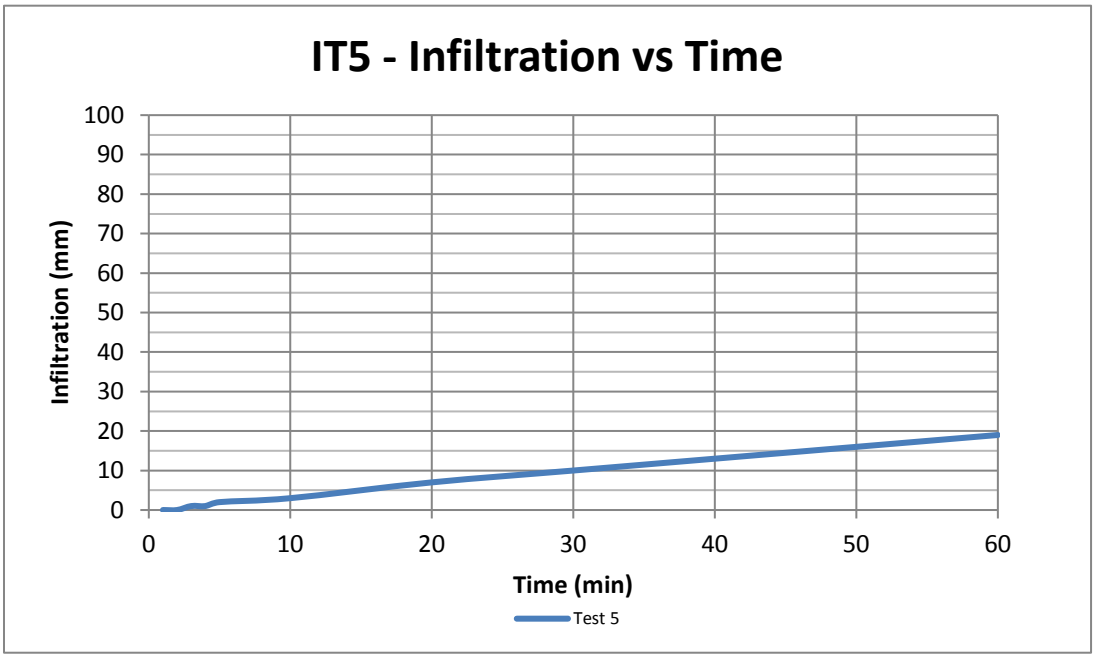
Time (min)	Infiltration (mm)
0.5	20.0
1	37.0
1.5	52.0
2	67.0
2.5	81.0
2.75	87.0



Location - TP5

Test 5

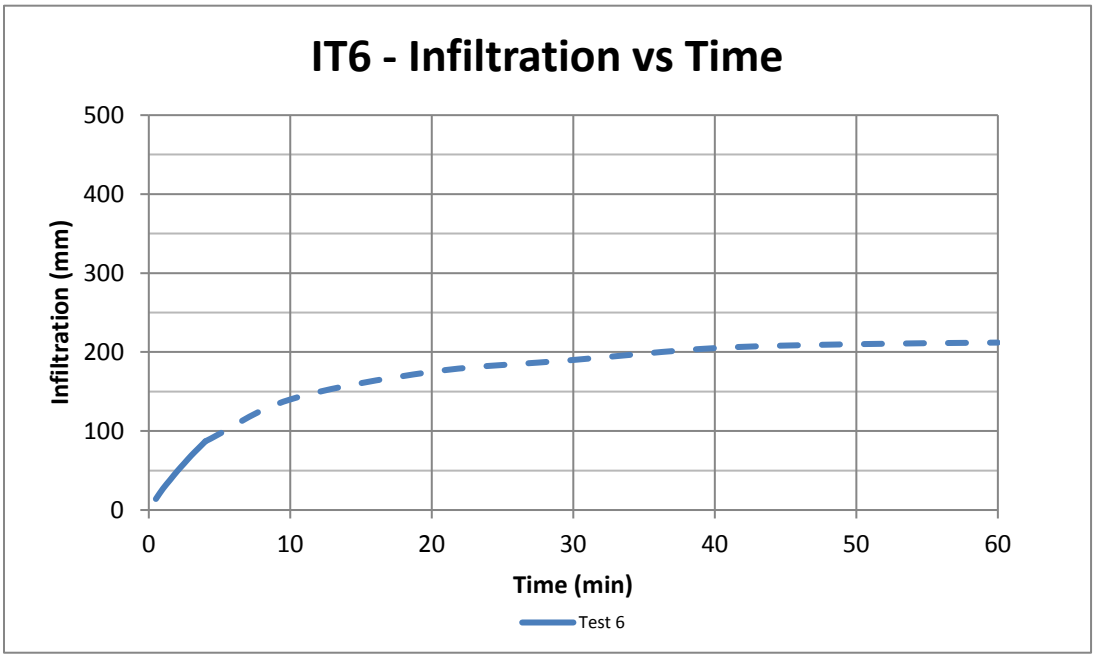
Time (min)	Infiltration (mm)
1	0.0
2	0.0
3	1.0
4	1.0
5	2.0
10	3.0
20	7.0
30	10.0
40	13.0
60	19.0



Location - TP5

Test 6

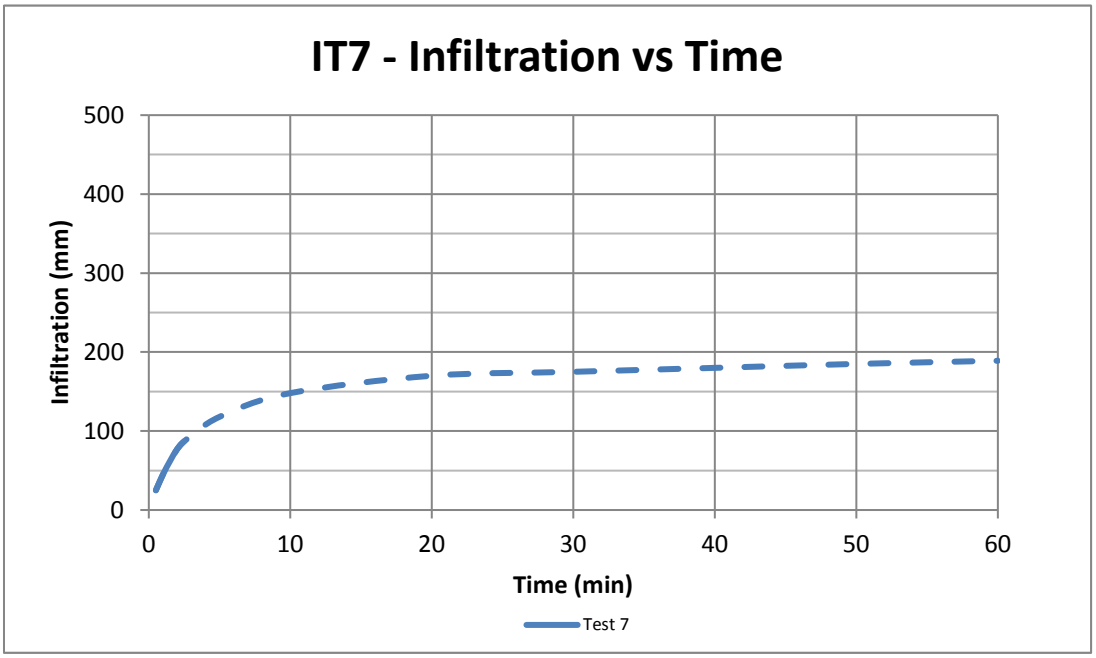
Time (min)	Infiltration (mm)
0.5	14.0
1	27.0
1.5	38.0
2	49.0
2.5	59.0
3	69.0
3.5	78.0
4	87.0



Location - TP6

Test 7

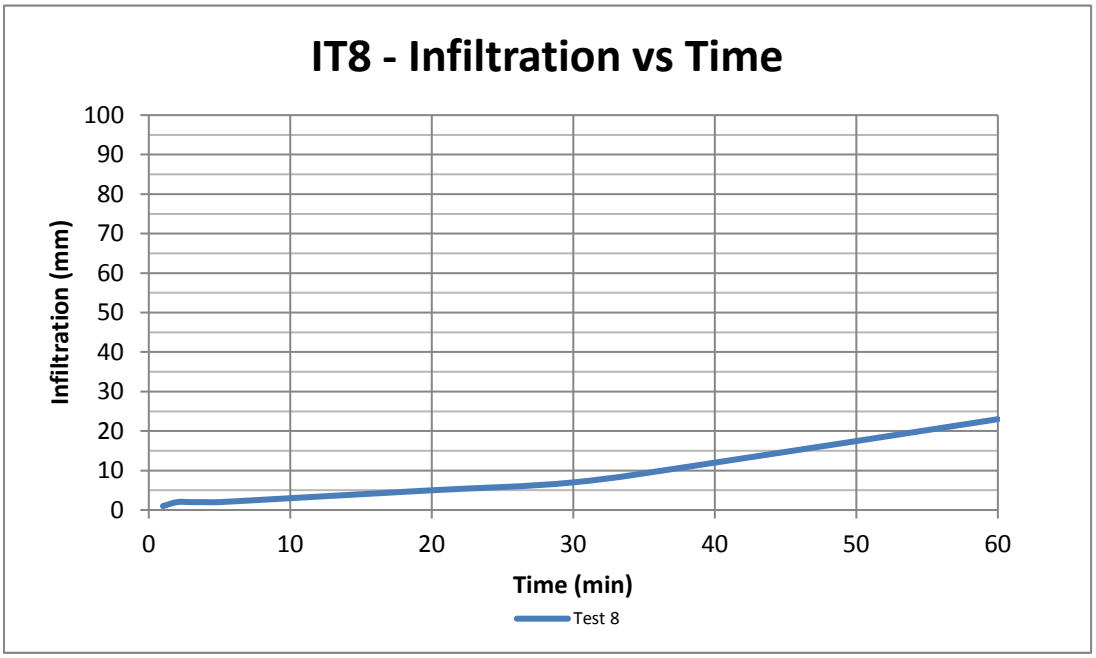
Time (min)	Infiltration (mm)
0.5	25.0
1	45.0
1.5	62.0
2	77.0
2.5	87.0



Location - TP7

Test 8

Time (min)	Infiltration (mm)
1	1.0
2	2.0
3	2.0
4	2.0
5	2.0
10	3.0
20	5.0
30	7.0
40	12.0
60	23.0

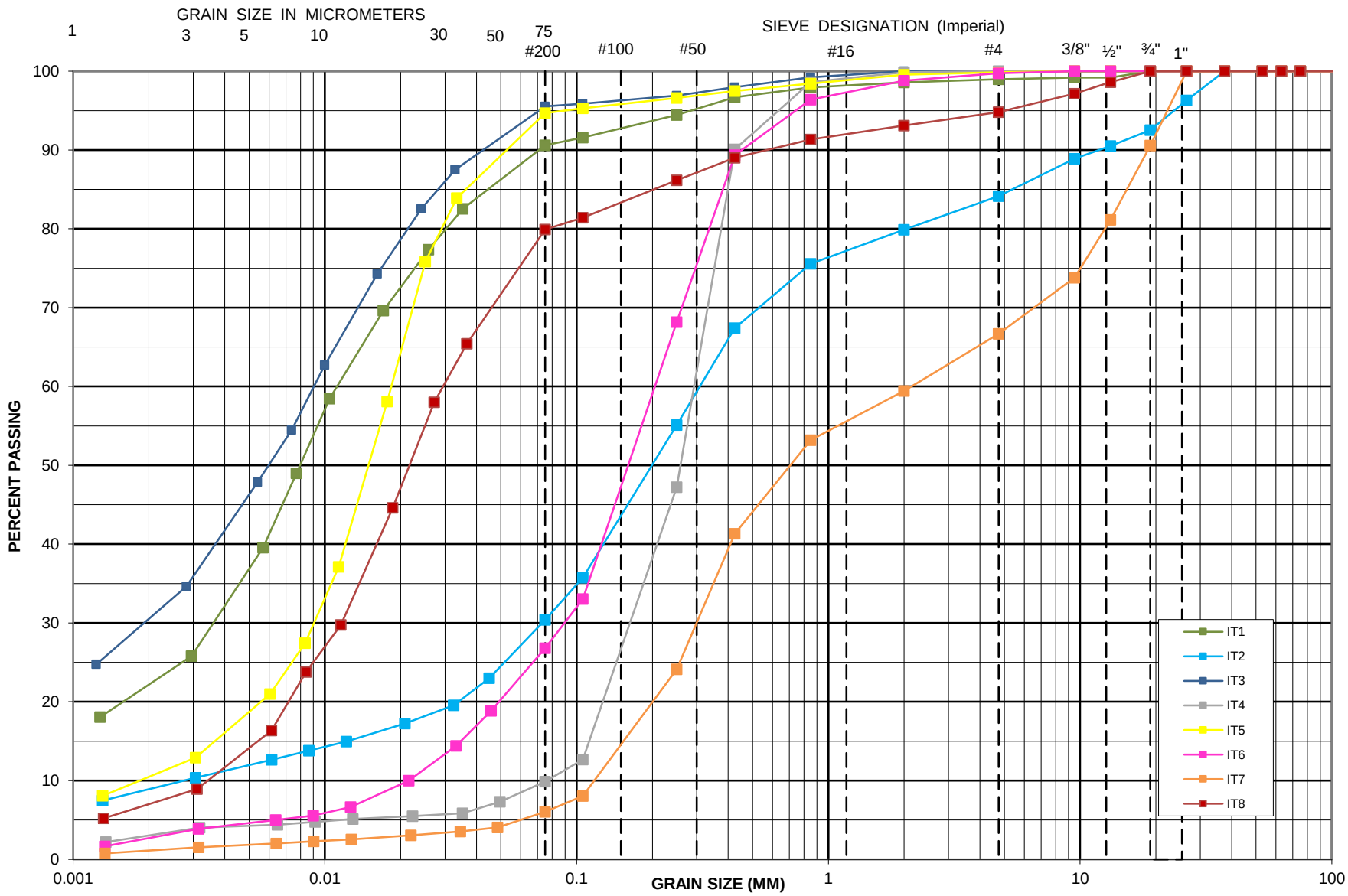


APPENDIX

B GRAIN SIZE DISTRIBUTION

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY AND SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

636040 Prince of Wales Rd, Primrose, Ontario

Figure No:	C
Project No.	181-01582-01
Date :	October, 2018

APPENDIX

C BOREHOLE LOGS

LOG OF BOREHOLE BH18-01

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00

CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 1

PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm

DATUM: Relative
Date: Feb/28/2018

BH LOCATION: See Figure 1

ELEV DEPTH (m)	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS/0.3 m	SPT N (plotted)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface					
0.0	**TOPSOIL:** 24cm					All samples read 0ppm on PID meter
0.2	**CLAYEY SANDY SILT (Reworked):** trace gravel, brown, moist, very loose	1	SS	2	2	
0.8	**SILTY CLAY TILL:** trace gravel, trace sand, brown, moist, firm	2	SS	8	8	
1.5	**GRAVELLY SILTY SAND TILL:** trace clay, occasional cobble, brown, wet, compact	3	SS	11	11	32 34 26 8
2.3	**SAND AND GRAVEL:** some silt, some cobble/boulder pieces, grey. dry, dense to very dense	4	SS	42	42	
		5	SS	50/ 50mm	50/ 50mm	
3.2	**AUGER REFUSAL:** Notes: 1) Auger refusal on boulders. 2) Redrilled second hole 1 m North of original borehole and had auger refusal at 1.4mbg. 2) Redrilled third hole 2m South of original borehole and had auger refusal at 3.2mbg. 3) Borehole was dry and open upon completion.					

Column headings: SOIL PROFILE; STRATA PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION; STANDARD PENETRATION TEST RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE & Sensitivity, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30); POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3); REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

WSP-SOIL-ROCK-MAY-29-2017.GLB
WSP SOIL LOG-2016-SPT PLOT-120 181-01582-00 BH LOGS.GPJ 10/30/18

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity; ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE BH18-02

PROJECT: Geotechnical Investigation & Phase Two ESA

REF. NO.: 181-01582-00

CLIENT: Deltini Commercial Developments

ENCL NO.: 2

Method: Hollow Stem Auger

PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose

Diameter: 200mm

DATUM: Relative

Date: Feb/28/2018

BH LOCATION: See Figure 1

ELEV DEPTH (m)	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS/0.3 m	SPT "N" (plot)	NATURAL MOISTURE CONTENT	REMARKS AND GRAIN SIZE DISTRIBUTION (%)
	Ground Surface						
0.0	**TOPSOIL:** 38cm	1	SS	4	4	o	All samples read 0ppm on PID meter
0.4	**SILT AND SAND (Reworked):** trace clay, trace gravel, trace organics, brown, moist, very loose to loose						
0.8	**SANDY SILT (Reworked):** some clay, some gravel, trace organics, brown, wet, loose	2	SS	8	8	o	
1.5	**GRAVELLY SILTY SAND TILL:** trace clay, some cobbles and boulders, brown, wet, loose	3	SS	9	9	o	
	dense	4	SS	36	36	o	
		5	SS	39	39	o	
4.3	**GRAVEL:** some sand, some silt, some cobble/boulder pieces, grey, dry, dense	6	SS	44	44		
4.9	**END OF BOREHOLE:** Notes: 1) Borehole was dry and open upon completion. 2) 30mm piezometer was installed upon completion.						

W. L. 3.9 mBGL Mar 06, 2018

Column headings: STRATA PLOT; GROUND WATER CONDITIONS; ELEVATION; STANDARD PENETRATION TEST RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa): O UNCONFINED, + FIELD VANE & Sensitivity, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3); GR SA SI CL

GROUNDWATER ELEVATIONS

Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; O ^{8}=3% Strain at Failure

LOG OF BOREHOLE BH18-03

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 3
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm
DATUM: Relative
Date: Feb/28/2018
BH LOCATION: See Figure 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface							
0.0	**TOPSOIL:** 32cm		1	SS	8			All samples read 0ppm on PID meter
0.3	**CLAYEY SILT (Reworked):** some sand, trace organics, brown, wet, firm/stiff							
0.8	**SILT:** some clay, some sand, brown, wet, loose		2	SS	8			
1.5	**CLAYEY SILT TO SILT AND CLAY:** some sand, trace gravel, brown, moist, firm to very stiff		3	SS	5	W. L. 1.5 mBGL Mar 06, 2018		
	trace sand, occasional gravel		4	SS	7			
3.4	**SAND AND GRAVEL:** some silt, brown, wet, compact		5	SS	21			
4.6	**SAND:** some gravel, some silt, brown, saturated, very dense		6	SS	60			
5.0	**END OF BOREHOLE:** Notes: 1) Borehole was wet at 3.1 mbg and was open upon completion. 2) 30mm piezometer was installed upon completion.							

STANDARD PENETRATION TEST RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH (kPa)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ε=3% Strain at Failure

LOG OF BOREHOLE BH18-04

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 4
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm
DATUM: Relative
Date: Feb/27/2018
BH LOCATION: See Figure 1

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface						
0.0	**TOPSOIL:** 36cm	1	SS	22			All samples read 0ppm on PID meter
0.4	**SILTY SAND:** brown, moist, compact	2	SS	24			
		3	SS	27			
		4	SS	23			
	compact to dense	5	SS	30			
3.8	**SAND:** trace gravel, trace silt, brown, dry, dense	6	SS	38			
4.2	**SILTY SAND:** trace gravel, brown, moist, dense	7	SS	35			
	moist to wet, compact	8	SS	26	W. L. 6.8 mBGL Mar 06, 2018		
7.6	**CLAYEY SANDY SILT:** brown, wet, compact	9	SS	16			
8.2	**END OF BOREHOLE:** Notes: 1) Borehole was wet at 7.4 mbg and was open upon completion. 2) 50mm groundwater monitoring well was installed upon completion.						

STANDARD PENETRATION TEST RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ε=3% Strain at Failure

LOG OF BOREHOLE BH18-05

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 5
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm
DATUM: Relative
Date: Feb/27/2018
BH LOCATION: See Figure 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	STANDARD PENETRATION TEST RESISTANCE PLOT / SHEAR STRENGTH (kPa) / WATER CONTENT (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface										
0.0	**TOPSOIL:** 26cm										All samples read 0ppm on PID meter
0.3	**FILL:** gravelly silty sand, trace organics, brown, wet, loose		1	SS	6						
	gravelly sand, some silt, compact		2	SS	22						
			3	SS	20						
2.3	**GRAVELLY SAND TILL:** some silt, trace clay, cobble pieces, brown, wet, compact		4	SS	29		W. L. 2.1 mBGL Mar 06, 2018				
			5	SS	16						
4.6	**GRAVELLY SILT AND SAND TILL:** some clay, cobble pieces, brown, moist, very dense		6	SS	82						
5.5	**GRAVELLY SANDY SILT TILL:** some clay, cobble pieces, grey, moist, dense		7	SS	44						
6.1	**END OF BOREHOLE:** Notes: 1) Borehole was open and dry upon completion. 2) 50mm groundwater monitoring well was installed upon completion.										

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

LOG OF BOREHOLE BH18-06

PROJECT: Geotechnical Investigation & Phase Two ESA | REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments | Method: Hollow Stem Auger | ENCL NO.: 6
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose | Diameter: 200mm
DATUM: Relative | Date: Feb/26/2018
BH LOCATION: See Figure 1

ELEV DEPTH (m)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION	STANDARD PENETRATION TEST RESISTANCE PLOT (N)	WATER CONTENT (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface										
0.0	**TOPSOIL:** 43cm	1	SS	4			4	86			All samples read 0ppm on PID meter
0.4	**FILL:** sandy silt, trace gravel, trace clay, trace organics, brown, moist, very loose to loose gravelly sandy silt, some clay, trace organics, occasional cobble pieces, compact	2	SS	14			14				
1.5	**SAND AND GRAVEL:** some silt, cobble pieces, brown, wet, compact	3	SS	28			28				
2.1	**END OF BOREHOLE:** Notes: 1) Borehole was open and dry upon completion.										

SHEAR STRENGTH (kPa): ○ UNCONFINED; ● QUICK TRIAXIAL; + FIELD VANE & Sensitivity; × LAB VANE

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE BH18-07

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 7
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm
DATUM: Relative
Date: Mar/01/2018
BH LOCATION: See Figure 1

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface						
0.0	**TOPSOIL:** 30cm						
0.3	**SILTY SAND (Reworked):** trace organics, brown, moist, very loose to loose	1	SS	3			PID:0.6ppm
1		2	SS	6			PID:0.7ppm
1.1	**SAND:** some gravel, brown, wet, loose						
	cobble pieces, compact	3	SS	20			PID:10ppm
2							
2.3	**CLAYEY SILT:** brown, moist, firm/stiff	4	SS	8	W. L. 2.3 mBGL Mar 06, 2018		4 49 37 10 PID:2.3ppm
2.6	**SILT AND SAND TILL:** trace gravel, some clay, brown, very moist to wet, loose to compact						
3		5	SS	15			PID:2.6ppm
3.4	**SAND:** trace silt, trace gravel, brown, wet, compact						
4							
	cobble pieces	6	SS	13			PID:0.9ppm
5							
5.2	**END OF BOREHOLE:** Notes: 1) Borehole was wet at 2.3 mbg and was open upon completion. 2) 30mm piezometer was installed upon completion.						

STANDARD PENETRATION TEST RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH (kPa)
○ UNCONFINED + FIELD VANE & Sensitivity
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+ 3, × 3: Numbers refer to Sensitivity
○ 8=3% Strain at Failure

LOG OF BOREHOLE BH18-08

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 8
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm
DATUM: Relative
Date: Mar/01/2018
BH LOCATION: See Figure 1

ELEV DEPTH (m)	DESCRIPTION	NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	REMARKS
	Ground Surface					
0.0	**TOPSOIL:** 25cm					
0.3	**SILTY SAND (Reworked):** brown, moist, compact	1	SS	18		PID:0.6ppm
0.8	**SILTY SAND TO SAND:** trace gravel, brown, damp to moist, compact	2	SS	19		PID:0.9ppm
1.5	**SAND:** some silt, trace gravel, brown, damp to moist, compact	3	SS	25		PID:0.7ppm
		4	SS	29		PID:0.9ppm
	10mm clayey silt layer, dense	5	SS	43		PID:0.5ppm
	cobble pieces					
	wet	6	SS	32		PID:0.4ppm
					W. L. 5.2 mBGL Mar 06, 2018	
	some silt to silty, compact	7	SS	18		PID:1.4ppm
7.0	**END OF BOREHOLE:** Notes: 1) Borehole was wet at 5.2 mbg and was open upon completion. 2) 50mm groundwater monitoring well was installed upon completion.					

Chart column headings: STANDARD PENETRATION TEST RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE & Sensitivity, ● QUICK TRIAXIAL, × LAB VANE (20, 40, 60, 80, 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10, 20, 30); POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3); REMARKS AND GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity; ○ ^{8}=3% Strain at Failure

LOG OF BOREHOLE BH18-09

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 9
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm
DATUM: Relative
Date: Feb/28/2018
BH LOCATION: See Figure 1

ELEV / DEPTH (m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS "N" 0.3 m	GROUND WATER CONDITIONS	ELEVATION	STANDARD PENETRATION TEST RESISTANCE PLOT / SHEAR STRENGTH (kPa) / WATER CONTENT (%)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface										
0.0	**TOPSOIL:** 38cm		1	SS	2						All samples read 0ppm on PID meter
0.4	**SILT AND SAND TILL:** some clay, trace gravel, trace organics, brown, wet, very loose										
0.8	**SAND AND GRAVEL:** trace to some silt, brown, wet, compact		2	SS	25						
1	grey, saturated		3	SS	22						33 58 (9)
2											
2.3	**SANDY SILT TILL:** some clay, some gravel, brown, wet, compact		4	SS	20						
3											
3.1	**GRAVELLY SILT AND SAND TILL:** some clay, grey, saturated, compact		5	SS	12						
4											
4.6	**SILTY SAND TILL:** some gravel, trace clay, cobble pieces, grey, saturated, dense		6	SS	32						
5											
5.0	**END OF BOREHOLE:** Notes: 1) Borehole was wet at 0.7 mbg and caved to 1.2 mbg upon completion.										

STANDARD PENETRATION TEST RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%): 10 20 30

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH18-10

PROJECT: Geotechnical Investigation & Phase Two ESA
REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments
Method: Hollow Stem Auger
ENCL NO.: 10
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose
Diameter: 200mm
DATUM: Relative
Date: Feb/26/2018
BH LOCATION: See Figure 1

(m) ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface						
0.0	**TOPSOIL:** 50cm	1	SS	3			All samples read 0ppm on PID meter
0.5	**SANDY SILT (Reworked):** some clay, trace gravel, trace organics, brown, wet, very loose						
0.8	**CLAYEY SANDY SILT TILL:** trace gravel, brown, moist, loose	2	SS	6			
1.5	**CLAYEY SILT TILL:** some sand, trace gravel, brown, moist, stiff	3	SS	11	W. L. 1.6 mBGL Mar 06, 20		
2.3	**SILT AND CLAY TILL:** trace sand, trace gravel, cobble pieces, brown, moist, stiff	4	SS	12			
3.1	**CLAYEY SILT TILL:** some sand, trace gravel, brown, moist, stiff to very stiff	5	SS	15			
3.4	**SAND:** some gravel, some silt, cobble pieces, silt seams, brown, saturated, compact to dense	6	SS	39			
5.2	**END OF BOREHOLE:** Notes: 1) Borehole was wet at 3.2 mbg and caved to 3.8 mbg upon completion. 2) 50mm groundwater monitoring well was installed upon completion.						

STANDARD PENETRATION TEST RESISTANCE PLOT
20 40 60 80 100
SHEAR STRENGTH (kPa)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES
+3, ×3: Numbers refer to Sensitivity
○ε=3% Strain at Failure

LOG OF BOREHOLE BH18-11

PROJECT: Geotechnical Investigation & Phase Two ESA — REF. NO.: 181-01582-00
CLIENT: Deltini Commercial Developments — Method: Hollow Stem Auger — ENCL NO.: 11
PROJECT LOCATION: 636040 Prince of Wales Rd W, Primrose — Diameter: 200mm
DATUM: Relative — Date: Feb/26/2018
BH LOCATION: See Figure 1

ELEV DEPTH (m)	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS/0.3 m	SPT "N" (plot)	Natural Moisture Content (%)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Ground Surface						
0.0	**TOPSOIL:** 42cm	1	SS	4	4	~20	All samples read 0ppm on PID meter
0.4	**SILT AND SAND (Reworked):** some clay, trace gravel, brown, wet, very loose to loose						
0.8	**SANDY SILT TILL:** some clay, trace gravel, brown, moist, loose	2	SS	6	6	~19	4 22 58 16
1.5	**CLAYEY SILT TILL:** some sand, trace gravel, brown, moist, firm	3	SS	4	4	~23	
2.3	**SAND:** some gravel, some silt, brown, moist, compact	4	SS	24	24	~10	
	trace gravel, wet	5	SS	28	28	~14	
4.6	**GRAVELLY SILTY SAND:** brown, saturated, loose to compact	6	SS	10	10	~13	
5.3	**END OF BOREHOLE:** Notes: 1) Borehole was wet at 4.3 mbg and caved to 4.4 mbg upon completion. 2) 50mm groundwater monitoring well was installed upon completion.						

Groundwater conditions: W. L. 3.5 mBGL Mar 06, 2018

Column headings: STANDARD PENETRATION TEST RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa): ○ UNCONFINED, + FIELD VANE & Sensitivity, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30); POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3); STRATA PLOT; GROUND WATER CONDITIONS; ELEVATION

GROUNDWATER ELEVATIONS
Measurement 1st 2nd 3rd 4th

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity; ○ ^{8}=3% Strain at Failure