GEOLOGICAL
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DATA ACQUISITION
CONSULTANCY

Water Infiltration Test Report

LOCATION	St. Mary's University, Waldegrave Road, Twickenham, TW1 4SX
ISSUE DATE	8th July 2020
FOR	St. Mary's University
CLIENT REF.	PO 52621ES
OUR REF.	G20158

Prepared by

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1. Introduction

In accordance with your instruction Geoinvestigate Ltd. carried out water infiltration testing at the above location on 16th June 2020.

It is understood that development is planned in the form of two relatively small extensions to the existing buildings. The approximate footprints of the proposed extensions are shown on the site plan in Appendix 1. Geoinvestigate Ltd. were asked to investigate the permeability of soils to assist in decision making and design regarding the potential use of soakaways for water disposal and, if feasible, to assist in their design.

To this end, two means of investigation have been undertaken:

1. Water infiltration testing according to BS 5930 "falling head tests in boreholes" methodology in boreholes drilled to 2.00m below current ground levels. This was undertaken to determine the permeability of soils at appropriate depths for potential future soakaway installation. Two (2) boreholes were drilled to a depth of 2.00m for infiltration testing to be undertaken, and three repeat tests undertaken in each (6 tests total).

2. Two boreholes were attempted to be drilled to greater depth (target 4.00m below current ground levels) to inspect the makeup of deeper soils and check for shallow groundwater (perched or otherwise). One of these boreholes reached 3.00m before meeting refusal and confirmed the depth to groundwater, but the other met refusal at just 1.80m.

BGS mapping shows the site to be underlain by the Kempton Park Gravel Member (sand and gravel) with bedrock of the London Clay Formation (clay/mudstone). Alluvium is mapped to the east around and below the nearby River Thames.

A review of BGS borehole records was undertaken prior to the investigation: Records located approximately 200m-300m to the east and northeast along the route of Strawberry vale / Cross Deep (roads) show silty or sandy clay or occasionally clayey sand (which would not be expected to be permeable), with two records showing sandy gravel strata from circa 3.5m-4.0m to 8.0m which might normally offer good permeability but these were assumed to be already wet/saturated because water levels of 3.0m or 3.5m are recorded in those boreholes. A borehole record some 1000m to the west shows sand/sand and gravel to 2.05m and silty clay (London Clay) below. Again, a standing water level is shown corresponding with the potentially more permeable strata (at 1.26m), suggesting that these are probably already saturated with groundwater.

As such, prior to the investigation, it was expected that relatively impermeable clayey soils would be found, potentially underlain by saturated sands and gravels. It was therefore expected that soakaways would not be feasible for the site.

2. Scope of Investigation

Four (4) windowless sampling boreholes (ref. BH1-BH4) were sunk using a Dando Terrier mini drilling rig to depths of between 1.80m and 3.00m below the current ground levels to carry out infiltration testing or attempt to inspect deeper ground conditions at the locations also shown on the included site plan. Boreholes BH1 and BH2 were sunk to a depth of 2.00m for infiltration testing, and boreholes BH3 and BH4 were attempted to be sunk to a depth of 4.00m but both met refusal at 3.00m and 1.80m respectively.

Information on the ground conditions revealed by the excavations is presented on the borehole logs which are included in Appendix 1 of this report. Their locations are shown on the plan also included in Appendix 1.

Calculations of water infiltration rates are included in Appendix 2. Water infiltration tests 1, 2 and 3 were carried out in BH1 and Tests 4, 5 and 6 were carried out in BH2.

Two soakaway design calculations have been carried out for the site; one for each of the proposed building extensions. The footprints of the proposed extensions have been estimated and appropriate design dimensions for simple rectangular, gravel-filled soakaways have been determined. The calculation sheets are presented in Appendix 3.

3. Investigation Findings

3.1 Ground Conditions Encountered

Shallower boreholes (BH1, BH3 and BH5)

Boreholes BH1 and BH2 were sunk to a depth of 2.00m to carry out water infiltration testing.

All four of the boreholes encountered turf and topsoil comprising clayey gravelly sand to between 0.10m and 0.20m below ground level (BGL). This was underlain by made ground to 0.30m and 0.50m at BH1 and BH2 respectively. The made ground comprised sandy gravel fill, sometimes clayey.

"Loose"* and "loose to medium dense" gravelly sand natural subsoils were then encountered in both boreholes to completion at 2.00m, with some strata at BH1 described as clayey or slightly clayey.

*Quotation marks indicate an interpretation of strength by the attending engineer in granular strata where no SPT was possible/undertaken.

Both of these boreholes remained open and dry on completion of drilling but some collapse of the gravelly sand soils occurred when the boreholes were filled with water for the infiltration testing.

Deeper boreholes (BH3 and BH4)

Boreholes BH3 and BH4 were intended to be sunk to a depth of 4.00m but refusal on large cobbles or simply very dense soils prevented this from being achieved.

Unsurprisingly, similar ground conditions to those at BH1 and BH2 were encountered in these boreholes with gravelly and very gravelly sand encountered to their full depths, though noted to be clayey to 1.10m BGL at BH4. The natural soils were generally medium dense and dense (and occasionally loose at shallower depth), confirmed by Standard Penetration Tests (SPTs) undertaken at 1.00m intervals during drilling.

BH4 was relatively close to BH1 where clayey shallow strata were also encountered. As such more clayey soils might be expected in the south of the proposed development area, while the north (BH2/BH3 area) might be expected to generally contain a lower/negligible clay content, probably favouring permeability.

SPT N_{300} values of N=6, N=52 and N=34 were returned by the tests commencing from 1.00m, 2.00m and 3.00m BGL in BH3 respectively. An N_{300} value of N=26 was returned by the test commencing from 1.00m at BH4.

Both boreholes remained open on completion and standing water was recorded at a depth of 2.80m BGL in BH3. BH4 remained dry to its full 1.80m depth.

No water infiltration testing was carried out in BH3 or BH4

3.2 Water Infiltration Testing

Infiltration testing was carried out in boreholes BH1 and BH2 according to the BS 5930 "falling head tests in boreholes" method to ascertain the permeability of subsoils and assess the site's suitability for soakaways.

Three repeat tests were carried out in each of boreholes with 1.00m of borehole casing left in situ from ground level to 1.00m below ground level. The response zones for all of the tests comprised natural gravelly sand soils as described on the borehole logs below 1.00m. Infiltration tests 1, 2 and 3 were carried out in borehole BH1, and Infiltration tests 4, 5 and 6 were carried out in borehole BH2.

The water infiltration testing was carried out with an initial water level (following filling) at ground level and the rate of drop was measured against time. Each test was observed for up to 60 minutes or until complete drainage to the collapsed depth.

Both boreholes collapsed when being filled with water for the testing. The collapsed depths were used in the calculations of infiltration rates to reflect the smaller test volume/surface area.

However, given the gravelly nature of the soils it is thought relatively unlikely that total closure occurred below the depths of collapse, and more likely that directly adjacent soils collapsed inwards leaving some void space around the boreholes into which water would be displaced/draining. As such, the returned infiltration rates are expected to be slightly higher than the true permeability of the soils where significant collapse occurred. This is probably evidenced by the higher infiltration rates observed during Tests 5 and 6 in BH2 following more significant collapse after Test 4 (repeat tests will normally turn slower rates due to surcharge of surrounding soils with water). Therefore, as a conservative assumption, rather than taking a mean infiltration rate from the test results, the lowest result for each location has been used for subsequent soakaway dimension design calculations.

Full results of the tests and calculations of infiltration rates are presented in Appendix 2, and the results are summarised in Table 1 on the following page:

Table 1: Infiltration Rates

Location	Test	Infiltration Rate	Lowest Infiltration Rate
BH1	1	1.93×10^{-6} ms^{-1}	**1.75×10^{-6} ms^{-1}**
	2	1.89×10^{-6} ms^{-1}	
	3	1.75×10^{-6} ms^{-1}	
BH2	4	2.39×10^{-6} ms^{-1}	**2.39×10^{-6} ms^{-1}**
	5	5.46×10^{-5} ms^{-1}	
	6	9.49×10^{-5} ms^{-1}	

For soakaways to be a feasible option, test results ought to be in the 10^{-6} ms^{-1} range as a minimum, with results in the order of 10^{-5} ms^{-1} generally being required where space might be limited and large/long trench-type soakaways will not be feasible. As such, these results are in the moderate range (10^{-6} ms^{-1}); soakaways are probably a feasible option, but they may need to be relatively large/long features.

3.3 Soakaway Design

Soakaway design calculations have been carried out for each of the two proposed extensions separately, and a combined design serving both locations has also been produced. These calculations have been done in accordance with the method set out in BRE 365* for a simple rectangular, gravel-filled soakaway and have used the rainfall data provided in that document and the infiltration rates calculated in Appendix 2:

*2016 update, including allowance for M100 (1 in 100 year) rainfall events and the +30% volume estimate for climate change.

Space may not be available to install a soakaway at the location of BH2 (depending on the required size) because soakaways ought to be minimum 5m from any building foundations. However, the soils at BH3 are inferred to be comparable and ample space is available here.

Based on the apparent size of the proposed structures on the site plan provided to Geoinvestigate, drained areas of $105m^2$ (approx. 15m x 7m extension) and $30m^2$ (approx. 6m x 5m extension) have been assumed for the soakaways in the south and north of the study area respectively (the areas of BH1/BH4 and BH2/BH3 respectively).

- Soakaway Design Calculation 1 uses the test results for BH1 and assumes that the soakaway will be placed in the BH1/BH4 area (southern half of investigation area). This is designed to serve the southern proposed extension of assumed drained area $105m^2$.
- Soakaway Design Calculation 2 uses the test results for BH2 and assumes that the soakaway will be placed in the BH2/BH3 area (northern half of investigation area). This is designed to serve the smaller northern proposed extension of assumed drained area $30m^2$.
- Soakaway Design Calculation 3 uses the test results for BH2 and assumes that the soakaway will be placed in the BH2/BH3 area (northern half of investigation area). This is designed to serve the both proposed extensions of assumed combined drained area $135m^2$.
- Soakaway Design Calculation 4 is as Calculation 3 but uses the lower test results for BH1 and assumes that the soakaway will be placed in the BH1/BH4 area (southern half of investigation area).

Full calculation outputs are presented in Appendix 3 and are summarised on Table 2 on the following page.

Suitable soakaway dimensions for simple rectangular, gravel-filled soakaways as described above are presented in Table 2. These designs assume the top of the soakaway will be buried at a depth of 0.50m and the soakaway will extend to 2.00m below ground level (i.e. an active depth of 1.50m). The maximum depth of 2.00m BGL has been chosen in the assumption that groundwater levels (observed at 2.80m in BH3) will probably be shallower in winter months*.

*No monitoring of groundwater levels is being undertaken and so it is feasible that groundwater may become even shallower than 2.00m at times. Therefore, no absolute guarantee can be offered that these soakaway designs will be fully functional year-round but these are considered to be relatively conservative estimates regardless. Monitoring may be possible by the client (see conclusions section later).

These dimensions have been concluded to be the most suitable through iteration but are not absolute and can be recalculated to suit spatial requirements on site if requested. The calculations and resultant dimensions have been manipulated to produce dimensions which will hopefully strike a useful compromise between:

1. Minimising the volume of soil removal while maintaining functionality of the resultant soakaway(s).
2. Choosing simple dimensions ("round" numbers), making subsequent measuring and excavation simple to implement.

Table 2: Soakaway Design Parameters

Design Sheet	Extension & Assumed Location	Depth to top of Soakaway (m)	Depth of Soakaway (m)	Total Depth BGL (m)	Chosen Length (m)	Calculated Width (m)	Comments
1	South Extension, at BH1/BH4	0.50	1.50	2.00	17.20	1.00	Long trench-type, 34.4m^3 excavation
2	North Extension, at BH2/BH3				2.20	2.20	Square, 9.68m^3 excavation
3	BOTH Extensions Combined, at BH2/BH3				21.00	1.00	Long trench-type, 42m^3 excavation. Would need to be at BH3 location.
4	BOTH Extensions Combined, at BH1/BH4				22.00	1.00	Long trench-type, 44m^3 excavation. Would need to be at BH3 location.

4 Conclusions

The water infiltration testing undertaken in boreholes BH1 and BH2 suggests that soakaways will provide a feasible option for surface water disposal at the site. The tests suggest that the soils are permeable but not necessarily *highly* permeable. Representative infiltration rates are in the region of 1.5×10^{-6} to 2.5×10^{-6} ms^{-1}.

Example soakaway design dimensions have been calculated for both proposed extensions. The larger of the proposed extensions will require a relatively long (17m x 1m) trench-type soakaway while a smaller (2.2m) square soakaway will be suitable for the smaller extension.

These soakaway designs are of the simple rectangular gravel-filled type as described in BRE 365. Other design types are available such as concrete ring chamber-type soakaways, but a specialist drainage design consultant may be required if alternative configurations are to be explored.

Given the limited available space between the proposed extensions and the adjacent running track, it might be simpler to combine the two soakaways into one, situated in a more convenient location. Two designs for this eventuality have also been produced (see Table 2 earlier), and a trench-type soakaway of 21m or 22m x 1.0m would be suitable, depending on location. Where space for such features exists, more permeable soils are expected to be present in the greenspace to the north (at BH3) than perhaps below the playing fields to the south (close to BH4).

There also remains the potential to include other SUDS features in the development such as attenuation tanks/ponds to prevent high outflow during periods of high rainfall, and/or incorporating green roofs into the building designs but these are not necessarily required given soakaways are a feasible option.

NOTE ALSO:
Two features were noted within the study area during the initial sub-surface scanning that comprise either existing soakaways or attenuation chambers. On lifting of inspection covers these were revealed to be approximately 3m diameter concrete ring chambers whose base is approximately 3m below ground level. One of these was noted to contain standing water, assumed to be the natural surrounding groundwater level, approximately consistent with the level observed in BH3.

It was unclear which buildings or hardstanding these soakaways are serving, and it is obviously currently unknown whether they were designed based on ground testing, an assumed/estimated permeability, or neither. Their presence does however show that there is precedent for the use of soakaways at the site, assuming flooding does not occur due to their becoming overwhelmed. They might also allow water level monitoring to be carried out through the winter buy the client if required (assuming this is the surrounding groundwater level) to check whether groundwater levels rise above 2.0m BGL at any point (the depth of the recommended soakaway designs). Care should be taken not to install new soakaways close to existing soakaways as the performance of both would be affected by their proximity.

END OF REPORT

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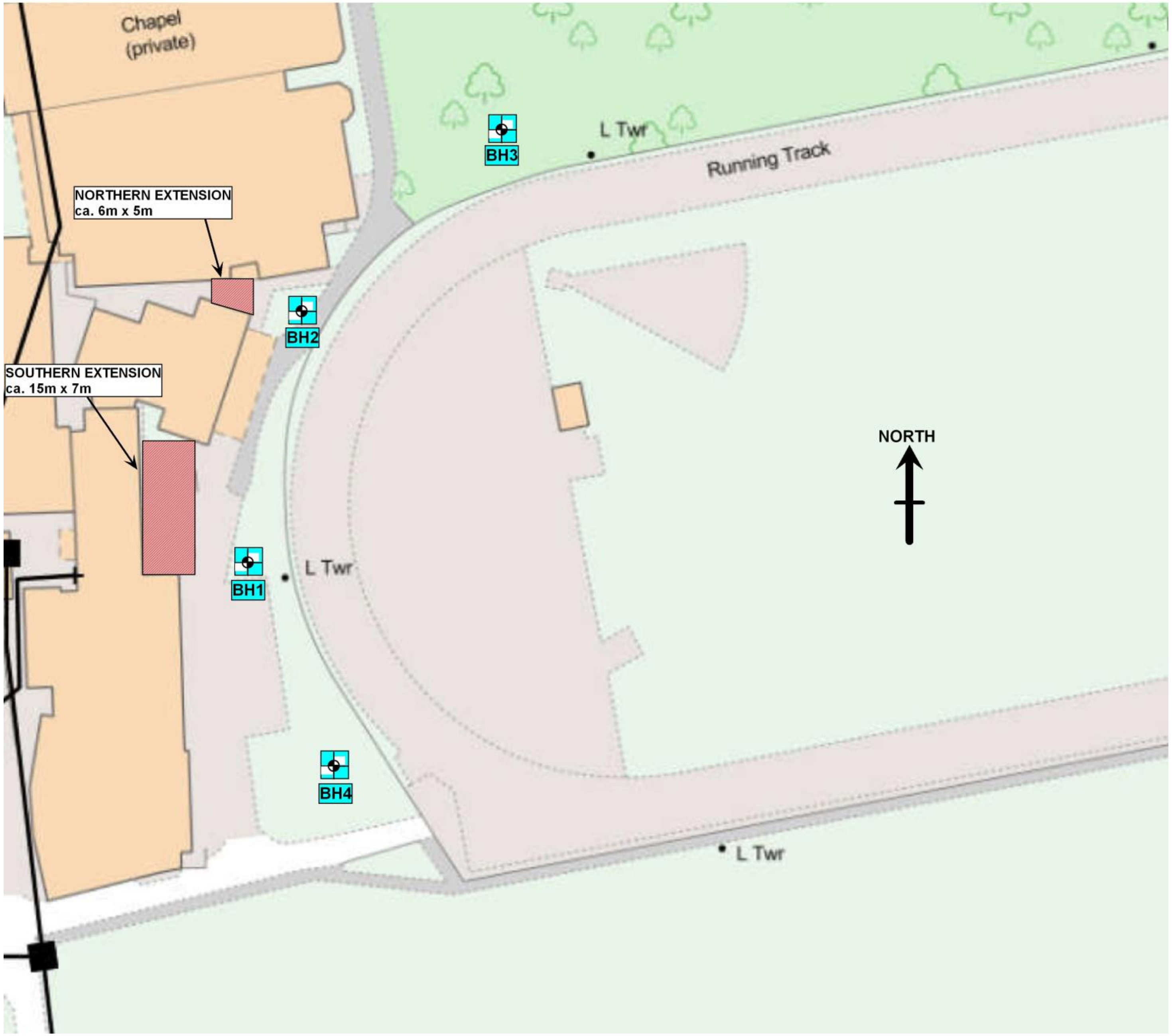
APPENDIX 1
Site plan
and
Borehole Logs

OUR REF: G20158	YOUR REF: PO 52621ES	SITE PLAN (NOT TO SCALE)
DATE: 16/06/20	LOCATION: St. Mary's University, Waldegrave Road, Twickenham, TW1 4SX	



GEOINVESTIGATE Ltd.

Your Ref. **Our Ref.** G20158 **BH No.1** **Sheet No. 1 of 1**
Location: St. Mary's University, Waldegrave Road, Twickenham TW1 4SX **DATE**: 16/06/20

Depth (m)	Description of Strata	Thick -ness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.10	TURF / TOPSOIL. Loose brown clayey	100				Cv kN/m^2			
0.20	gravelly sand. Gravel is fine to coarse of	100	(1)						0.25
0.30	sandstone, brick and asphalt.	100	(2)						
	(1) MADE GROUND. "Medium dense" pale brown and grey slightly clayey sandy gravel. Gravel is fine to coarse of sandstone, brick and asphalt.								0.50
	(2) MADE GROUND. "Medium dense" black sandy gravel. Gravel is fine to								0.75
1.00	coarse of asphalt, brick and sandstone.	700							1.00
	"Loose to Medium dense" brown and yellow clayey gravelly SAND. Gravel is fine to coarse of flint.								1.25
	"loose" pale brown and yellow very slightly clayey gravelly SAND. Gravel is fine to coarse of flint.	800							1.50
1.80									1.75
2.00	"Loose" yellow gravelly SAND. Gravel is fine to coarse of flint.	200							2.00
	Borehole terminated at 2.00m Water infiltration test carried out in borehole on competion of drilling. Test carried out according to BS 5930 "Falling head test in boreholes" method with 1.00m of borehole casing left in situ, testing soils below 1.00m. See results of Infiltration Tests 1, 2 and 3 for details. Borehole partially collapsed on filling with water for Tests 1 and 2, collapsing below 1.70m for Test 1 and below 1.55m for Test 2. Remained open to 1.55m for Test 3 (i.e. no further collapse).								

Remarks:
Casing to 1.00m
Dynamic windowless sampling by Terrier Rig to 2.00m
Borehole remained open and dry on completion

Key:
Slotted Pipe
Plain Pipe
Bentonite
Gravel Filter

O Disturbed sample
Cv Shear vane
W Water sample
S Standard Penetration Test using solid cone

BH1

GEOINVESTIGATE Ltd.

Your Ref. **Our Ref.** G20158 **BH No.2** **Sheet No. 1 of 1**
Location: St. Mary's University, Waldegrave Road, Twickenham TW1 4SX **DATE**: 16/06/20

Depth (m)	Description of Strata	Thick-ness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.20	TURF / TOPSOIL. "Loose" brown clayey gravelly sand. Gravel is fine to coarse of sandstone and brick.	200				Cv kN/m^2			0.25
0.50	MADE GROUND. "Loose" brown and dark brown slightly clayey gravelly sand. Gravel is fine to coarse of flint, sandstone and brick.	500							0.50
1.10	"Loose to medium dense" pale brown and yellow slightly gravelly SAND. Gravel is fine to coarse of flint.	600							0.75 1.00
1.40	"Loose to medium dense" brown and orange very gravelly SAND. Gravel is fine to coarse of flint.	300							1.25
1.90	"Loose" pale brown and yellow slightly gravelly SAND. Gravel is fine to coarse of flint.	500							1.50 1.75
2.00	"Loose" yellow slightly gravelly SAND. Gravel is fine to coarse of flint. Moist.	100							2.00
	Borehole terminated at 2.00m Water infiltration test carried out in borehole on competion of drilling. Test carried out according to BS 5930 "Falling head test in boreholes" method with 1.00m of borehole casing left in situ, testing soils below 1.00m. See results of Infiltration Tests 4, 5 and 6 for details. Borehole partially collapsed on filling with water for all tests, collapsing below 1.75m for Test 1, below 1.30m for Test 2, and below 1.20m for Test 3.								

Remarks:
Casing to 1.00m
Dynamic windowless sampling by Terrier Rig to 2.00m
Borehole remained open and dry on completion

Key:
Slotted Pipe
Plain Pipe
Bentonite
Gravel Filter

O Disturbed sample
Cv Shear vane
W Water sample
S Standard Penetration Test using solid cone

BH2

GEOINVESTIGATE Ltd.

Your Ref. **Our Ref.** G20158 **BH No.3** **Sheet No. 1 of 1**
Location: St. Mary's University, Waldegrave Road, Twickenham TW1 4SX **DATE**: 16/06/20

Depth (m)	Description of Strata	Thick -ness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.20	TURF / TOPSOIL. Loose brown clayey gravelly sand. Gravel is fine to coarse of sandstone and flint.	200				Cv kN/m^2			
1.90	Loose pale brown and yellow gravelly SAND. Gravel is fine to coarse of flint. Becoming Medium dense below 1.20m. Becoming dense below 1.70m.	1700					1,2,1,2,1,2 N=6 1.00m-1.45m 2.00m-2.45m 11,11,12, 14,12,14 N=52		0.25 0.50 0.75 1.00 1.25 1.50 1.75
3.00	Dense yellow and orange very gravelly SAND. Gravel is fine to coarse of flint. Becoming moist below 2.30m. Becoming medium dense below 2.60m.	1100					3.00m-3.45m 1,4,7,9,9,9 N=34	SWL at 2.80m	2.00 2.25 2.50 2.75 3.00
	Borehole terminated at 3.00m due to refusal								

Remarks:
Casing to 1.00m
Dynamic windowless sampling by Terrier Rig to 3.00m
Borehole remained open on completion
Standing water level at 2.80m

Key:
Slotted Pipe
Plain Pipe
Bentonite
Gravel Filter

O Disturbed sample
Cv Shear vane
W Water sample
S Standard Penetration Test using solid cone

BH3

GEOINVESTIGATE Ltd.

Your Ref. **Our Ref**. G20158 **BH No.4** **Sheet No. 1 of 1**
Location: St. Mary's University, Waldegrave Road, Twickenham TW1 4SX **DATE**: 16/06/20

Depth (m)	Description of Strata	Thick -ness	Legend	Gas Well	Sample	Test Type Result	SPT N Value (Depth)	Depth to Water	Depth (m)
0.20	TURF/ TOPSOIL. Loose brown clayey gravelly sand. Gravel fine to coarse of sandstone and flint.	200				Cv kN/m^2			0.25
1.10	Medium dense dark grey and orange clayey gravelly SAND. Gravel is fine to coarse of flint.	900					1.00m-1.45m 2,3,4,6,8,8 N=26		0.50 0.75 1.00
1.50	Medium dense orange and brown gravelly SAND. Gravel is fine to coarse of flint.	400							1.25 1.50
1.80	Dense orange and brown very gravelly SAND. Gravel is fine to coarse of flint.	300							1.80
	Borehole termianted at 1.80m due to refusal, possibly on a large cobble								

Remarks:
Casing to 1.00m
Dynamic windowless sampling by Terrier Rig to 1.80m
Borehole remained open and dry on completion

Key:
Slotted Pipe
Plain Pipe
Bentonite
Gravel Filter

O Disturbed sample
Cv Shear vane
W Water sample
S Standard Penetration Test using solid cone

BH4

APPENDIX 2
Water Infiltration Test Results

Infiltration Test Result

G20158
St Mary's University,
Waldegrave Road, Twickenham, TW1 4SX
16 June 2020

Infiltration test 1

(BH1)

Time/s	Depth to water/m	Head/m (above base of borehole)
0	0.000	1.700
30	0.235	1.465
60	0.265	1.435
120	0.303	1.397
180	0.385	1.315
240	0.439	1.261
300	0.475	1.225
600	0.605	1.095
900	0.691	1.009
1200	0.783	0.917
1800	0.855	0.845
2700	0.985	0.715
3600	1.091	0.609

Borehole dimensions:

Depth of Casing, D =	1.00	m
Diameter of Casing, D =	0.125	m
Cross-sectional area, A =	0.012277	m^2
Depth below Casing, L =	0.70	m
Ground Water Level =	N/A	m

Intake factor, F, using:

$$F = \frac{2\pi L}{\log_e[(L/D) + \sqrt{1 + (L/D)^2}]}$$

Source: BS 5930

Intake factor, F = 1.815 m

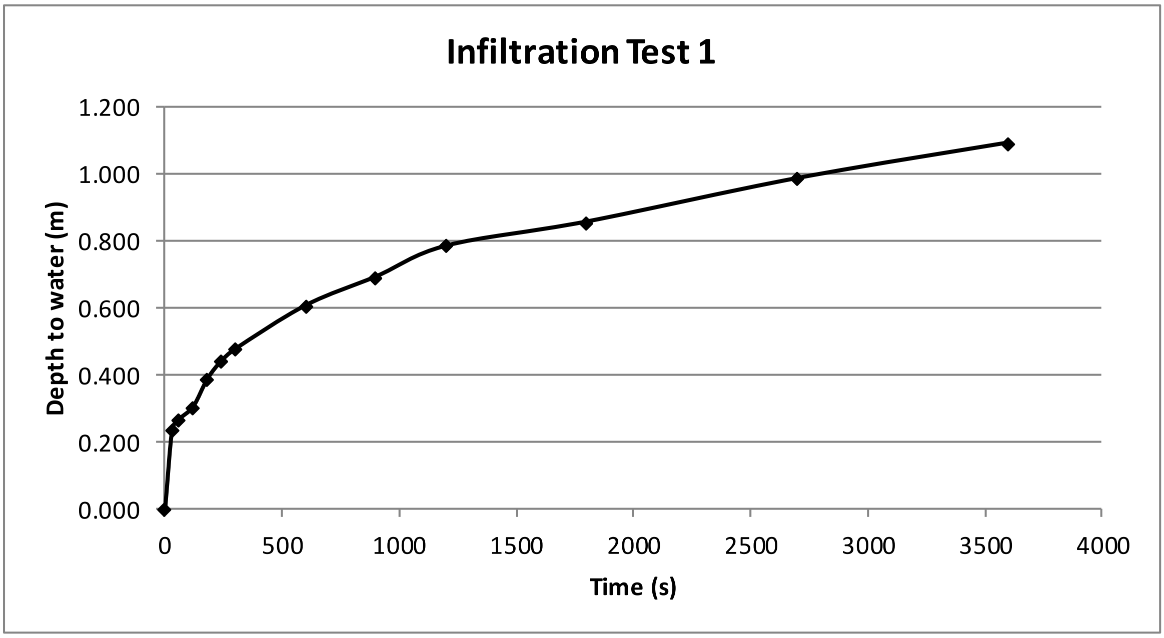
Choose start time t_1 to be: t_1 =	0	s
Choose end time t_2 to be: t_2 =	3600	s
Head at time t_1, H_1 =	1.700	m
Head at time t_2, H_2 =	0.609	m

Permeability, k, using:

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

Source: BS 5930

Permeability, k = 1.93E-06 ms^{-1}



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Infiltration Test Result
G20158
St Mary's University,
Waldegrave Road, Twickenham, TW1 4SX
16 June 2020

Infiltration test 2

(BH1)

Time/s	Depth to water/m	Head/m (above base of borehole)
0	0.000	1.550
30	0.035	1.515
60	0.055	1.495
120	0.087	1.463
180	0.109	1.441
240	0.144	1.406
300	0.171	1.379
600	0.275	1.275
900	0.369	1.181
1200	0.466	1.084
1800	0.617	0.933
2700	0.784	0.766
3600	0.905	0.645

Borehole dimensions:

Depth of Casing, D =	1.00	m
Diameter of Casing, D =	0.125	m
Cross-sectional area, A =	0.012277	m^2
Depth below Casing, L =	0.55	m
Ground Water Level =	N/A	m

Intake factor, F, using:

$$F = \frac{2\pi L}{\log_e[(L/D) + \sqrt{1 + (L/D)^2}]}$$

Source: BS 5930

Intake factor, F = 1.580 m

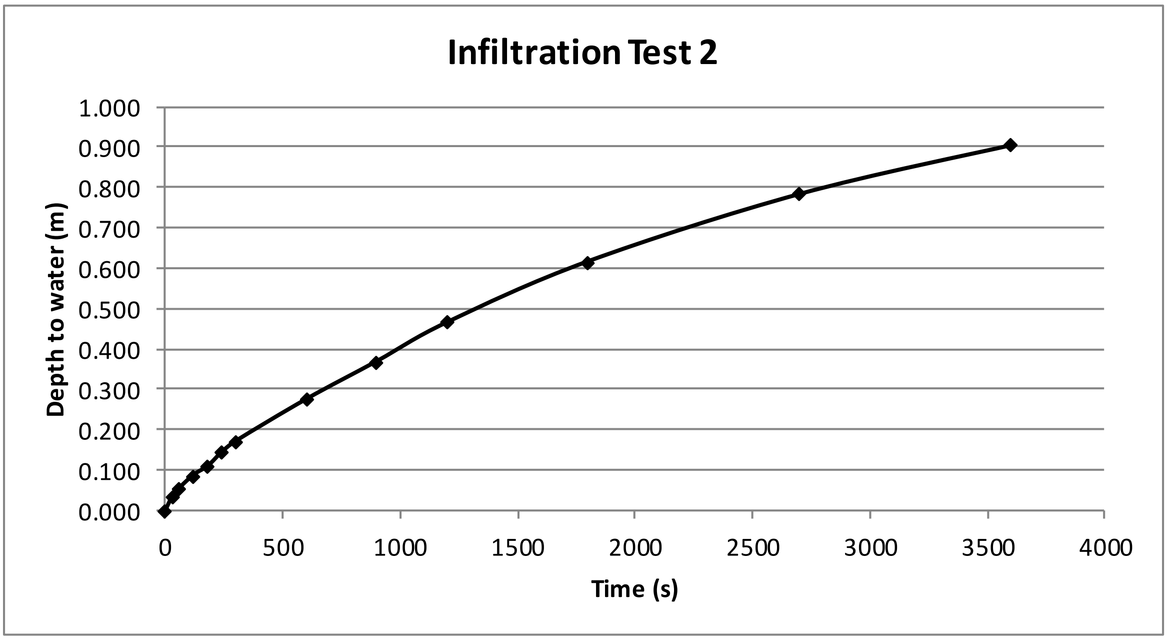
Choose start time t_1 to be: t_1 =	0	s
Choose end time t_2 to be: t_2 =	3600	s
Head at time t_1, H_1 =	1.550	m
Head at time t_2, H_2 =	0.645	m

Permeability, k, using:

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

Source: BS 5930

Permeability, k = 1.89E-06 ms^{-1}



Infiltration Test Result
G20158
St Mary's University,
Waldegrave Road, Twickenham, TW1 4SX
16 June 2020

Infiltration test 3

(BH1)

Time/s	Depth to water/m	Head/m (above base of borehole)
0	0.000	1.550
30	0.021	1.529
60	0.028	1.522
120	0.055	1.495
180	0.089	1.461
240	0.118	1.432
300	0.140	1.410
600	0.260	1.290
900	0.365	1.185
1200	0.453	1.097
1800	0.612	0.938
2700	0.779	0.771
3600	0.860	0.690

Borehole dimensions:

Depth of Casing, D = 1.00 m
Diameter of Casing, D = 0.125 m
Cross-sectional area, A = 0.012277 m^2
Depth below Casing, L = 0.55 m
Ground Water Level = N/A m

Intake factor, F, using:

$$F = \frac{2\pi L}{\log_e[(L/D) + \sqrt{(1 + (L/D)^2)}]}$$

Source: BS 5930

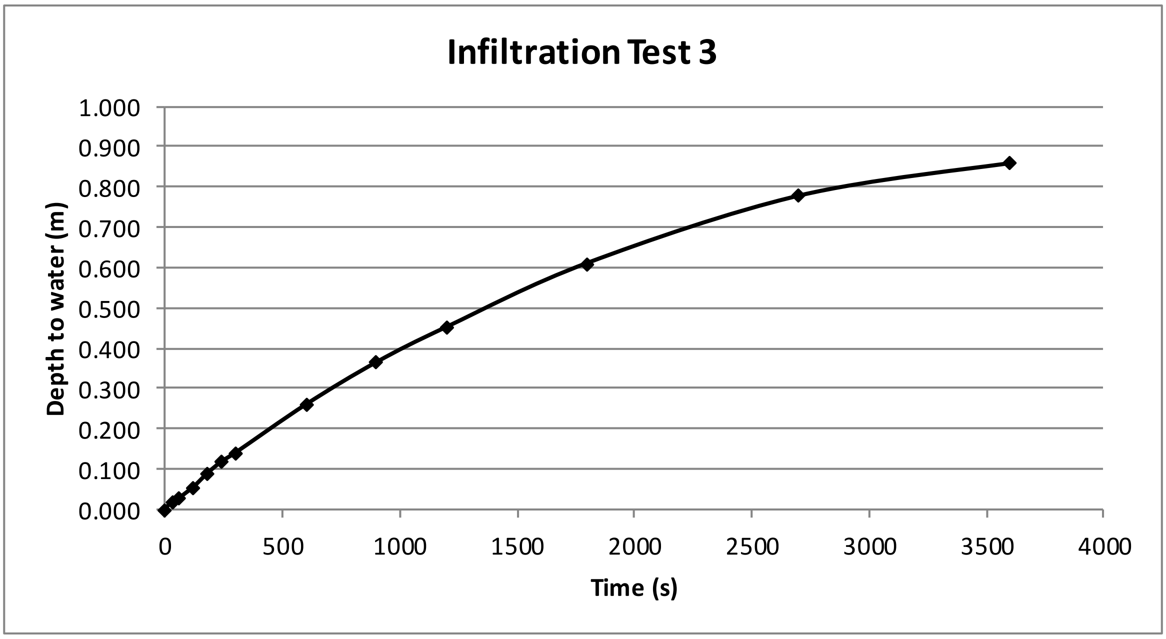
Intake factor, F = 1.580 m

Choose start time t_1 to be: t_1 = 0 s
Choose end time t_2 to be: t_2 = 3600 s
Head at time t_1, H_1 = 1.550 m
Head at time t_2, H_2 = 0.690 m

Permeability, k, using: $k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2}$ (general approach)

Source: BS 5930

Permeability, k = 1.75E-06 ms^{-1}



Infiltration Test Result
G20158
St Mary's University,
Waldegrave Road, Twickenham, TW1 4SX
16 June 2020

Infiltration test 4

(BH2)

Time/s	Depth to water/m	Head/m (above base of borehole)
0	0.000	1.750
10	0.190	1.560
20	0.295	1.455
30	0.369	1.381
60	0.500	1.250
90	0.595	1.155
120	0.670	1.080
150	0.725	1.025
180	0.775	0.975
240	0.850	0.900
300	0.920	0.830
420	0.990	0.760
600	1.090	0.660
900	1.150	0.600
1200	1.200	0.550
1800	1.230	0.520
2700	1.270	0.480
3600	1.285	0.465

Borehole dimensions:

Depth of Casing, D =	1.00	m
Diameter of Casing, D =	0.125	m
Cross-sectional area, A =	0.012277	m^2
Depth below Casing, L =	0.75	m
Ground Water Level =	N/A	m

Intake factor, F, using:

$$F = \frac{2\pi L}{\log_e[(L/D) + \sqrt{(1 + (L/D)^2)}]}$$

Source: BS 5930

Intake factor, F = 1.892 m

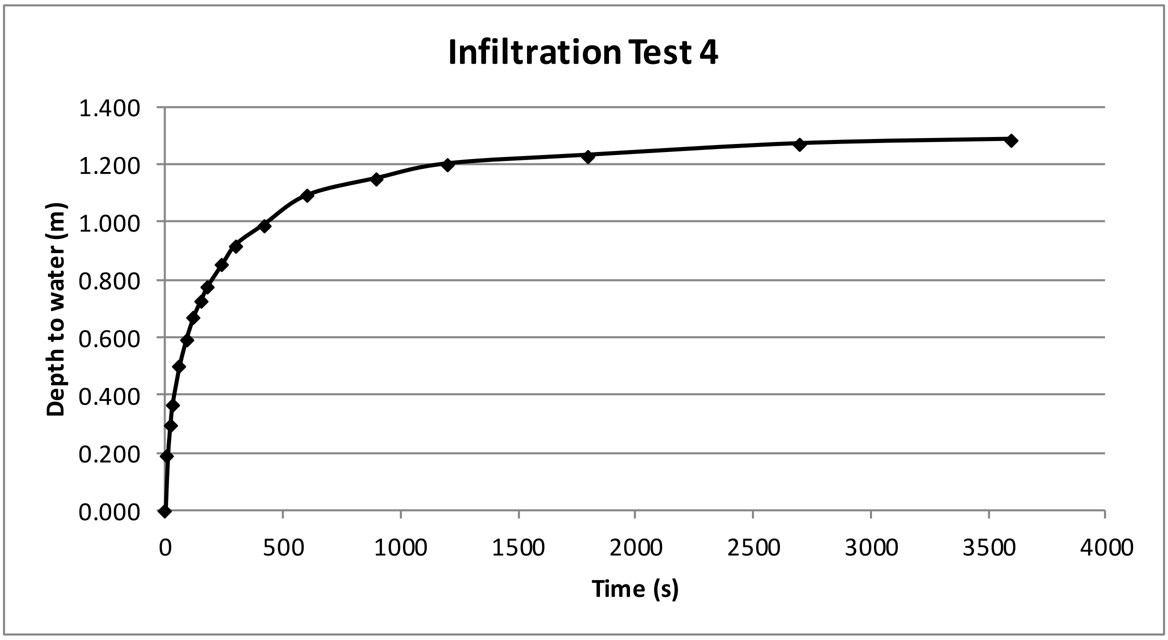
Choose start time t_1 to be: t_1 =	0	s
Choose end time t_2 to be: t_2 =	3600	s
Head at time t_1, H_1 =	1.750	m
Head at time t_2, H_2 =	0.465	m

Permeability, k, using:

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

Source: BS 5930

Permeability, k = 2.39E-06 ms^{-1}



Infiltration Test Result
G20158
St Mary's University,
Waldegrave Road, Twickenham, TW1 4SX
16 June 2020

Infiltration test 5

(BH2)

Time/s	Depth to water/m	Head/m (above base of borehole)
0	0.000	1.300
10	0.070	1.230
20	0.114	1.186
30	0.142	1.158
60	0.230	1.070
90	0.304	0.996
120	0.360	0.940
180	0.460	0.840
240	0.540	0.760
300	0.610	0.690
420	0.725	0.575
600	0.855	0.445
900	1.015	0.285
1200	1.140	0.160
1800	1.220	0.080
2700	1.300	0.000
Test complete after 45 minutes (complete drainage)		

Borehole dimensions:

Depth of Casing, D =	1.00	m
Diameter of Casing, D =	0.125	m
Cross-sectional area, A =	0.012277	m^2
Depth below Casing, L =	0.30	m
Ground Water Level =	N/A	m

Intake factor, F, using:

$$F = \frac{2\pi L}{\log_e[(L/D) + \sqrt{1 + (L/D)^2}]}$$

Source: BS 5930

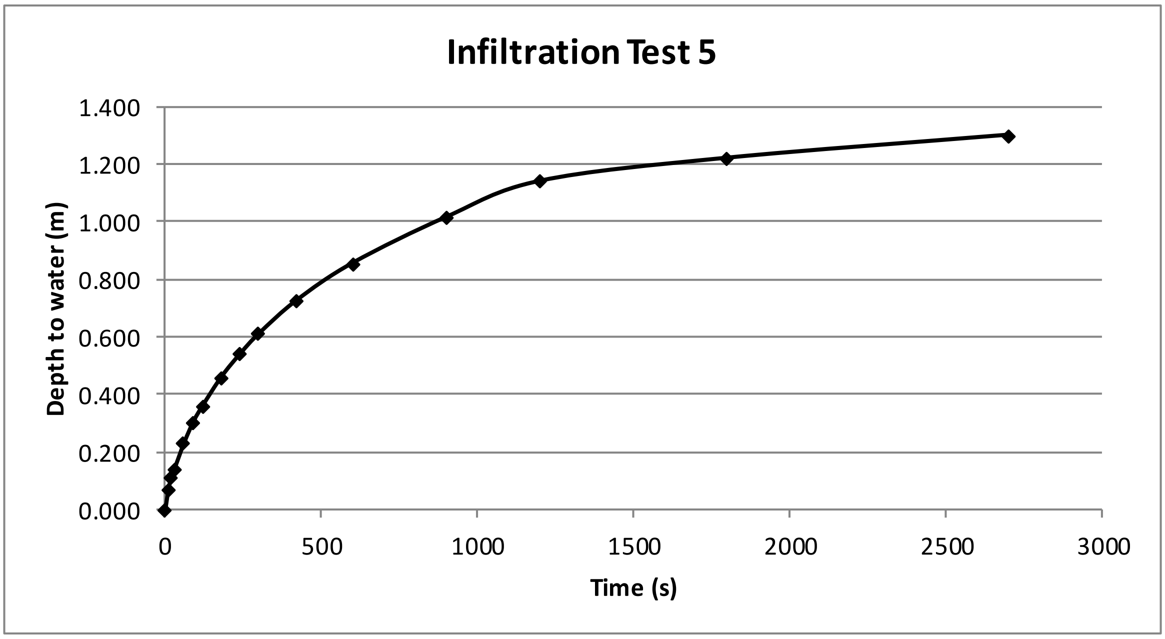
Intake factor, F =	1.172	m
Choose start time t_1 to be: t_1 =	0	s
Choose end time t_2 to be: t_2 =	2700	s
Head at time t_1, H_1 =	1.300	m
Head at time t_2, H_2 =	0.000	m

Permeability, k, using:

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

Source: BS 5930

Permeability, k = 5.46E-05 ms^{-1}



Infiltration Test Result
G20158
St Mary's University,
Waldegrave Road, Twickenham, TW1 4SX
16 June 2020

Infiltration test 6

(BH2)

Time/s	Depth to water/m	Head/m (above base of borehole)
0	0.000	1.200
10	0.113	1.087
20	0.186	1.014
30	0.243	0.957
60	0.360	0.840
90	0.470	0.730
120	0.550	0.650
180	0.675	0.525
240	0.780	0.420
300	0.870	0.330
420	1.005	0.195
600	1.105	0.095
900	1.135	0.065
1200	1.150	0.050
1800	1.200	0.000
Test complete after 30 minutes (complete drainage)		

Borehole dimensions:

Depth of Casing, D =	1.00	m
Diameter of Casing, D =	0.125	m
Cross-sectional area, A =	0.012277	m^2
Depth below Casing, L =	0.20	m
Ground Water Level =	N/A	m

Intake factor, F, using:

$$F = \frac{2\pi L}{\log_e[(L/D) + \sqrt{1 + (L/D)^2}]}$$

Source: BS 5930

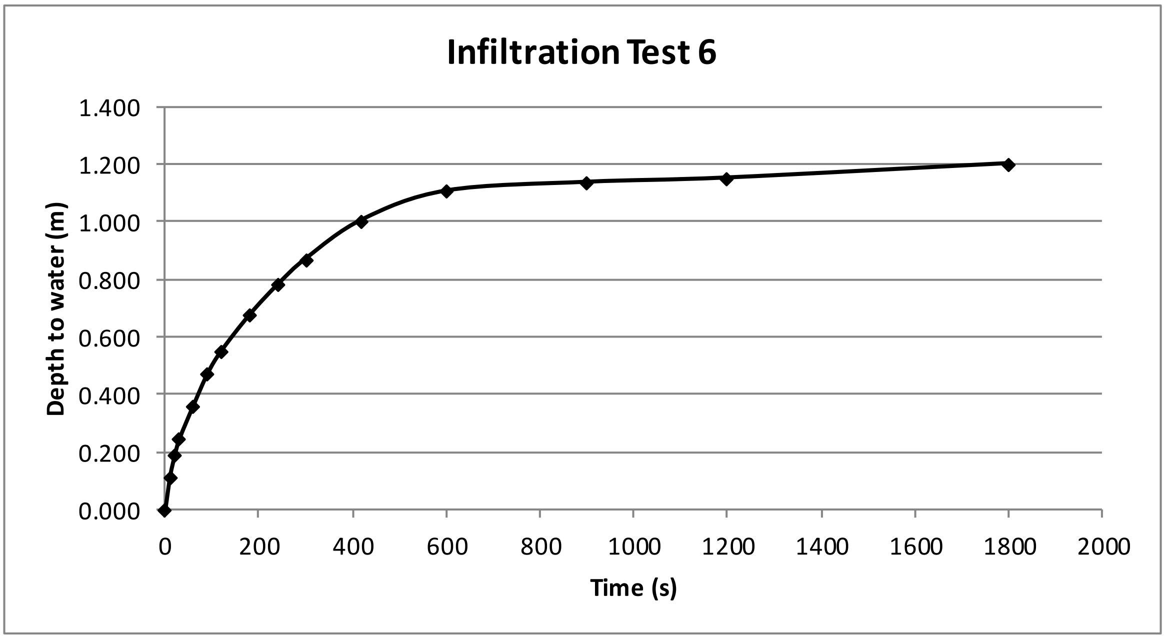
Intake factor, F =	1.007	m
Choose start time t_1 to be: t_1 =	0	s
Choose end time t_2 to be: t_2 =	1800	s
Head at time t_1, H_1 =	1.200	m
Head at time t_2, H_2 =	0.000	m

Permeability, k, using:

$$k = \frac{A}{F(t_2 - t_1)} \log_e \frac{H_1}{H_2} \text{ (general approach)}$$

Source: BS 5930

Permeability, k = 9.49E-05 ms^{-1}



APPENDIX 3
Soakaway Design Calculations

Soakaway Design Calculation 1

G20158

St. Mary's University,
Twickenham, TW1 4SX
10/03/16

SOAKAWAY DESIGN FOR SIMPLE RECTANGULAR GRAVEL FILLED PIT

Using method described in BRE Digest 365 (2016 revision)

$$I - O = S$$
$$I = A \times R$$
$$O = a_{s50} \times f \times D$$

Inflow - outflow = required storage volume (all in m^3)

Inflow = Drained area of site (m^2) x Rainfall in a ten year rainfall event of specified length (m)

Outflow = half surface area (excluding base) (m^2) x Infiltration rate (ms^{-1}) x Specified storm duration (s)

M100 RAINFALL EVENT

Plus 30% allowance for Climate Change

Input data:

r x 100 (from BRE 365map)	42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period multiplied by 100)
r	0.42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period)
Drained area of site, **A** (m^2)	105	Site area soakaway must service
Infiltration rate **f** (ms^{-1})	1.75E-06	Calculated from water infiltration testing, see report
Choose soakaway lenth (m)	17.2	Arbitrarily chosen to suit site needs
Choose soakaway depth (m)	1.5	Estimated appropriate depth
half depth (m)	0.75	Depth to 50% full
S = 30% of storage volume (pore space in granular fill)	7.74	x width (Width calculated below)
a_{s50} (m^2)	25.8	+ 2(width x half depth) (Width calculated below)

a_{s50} is 50% of the internal surface area of the soakaway excluding the base (= 2(length x ½ depth) + 2(width x ½ depth))

Therefore: **I = S + O** (both expressible in terms of width)

I can be calculated from Z1 and Z2 for each rainfall duration

S = length (chosen) x depth (chosen) x width x 0.30 (30% pore space in gravel)
i.e. **S** = a known number x **w**

O = a_{s50} (m^2) x **f** (ms^{-1}) x each rainfall duration (seconds)
O = (half depth x [2(length) + 2(width)]) x **f** (known) x **D** (I (=f.D.2Length.½depth + f.D.2W.½depth)

Rearrange to calculate width:

I = S + O (both expressible in terms of width)

w = [**I** - (length x depth x **f** x **D**)] / [(0.30 x length x depth) + (depth x **f** x **D**)]

Rainfall Duration (D, min)	Z1 (from Table 1)	Z1 x 20mm	Z2 (from Table 2)	R (mm)	R (m)	R_{CC} (+30%)	Inflow (I, m^3)	Duration D in seconds	Inf. Rate x D (s)	O (m^3)	Required Width (m)	W (m)
10	0.53	10.6	1.910	20.246	0.020246	0.026320	2.763579	600	1.05E-03	2.71E-02 + (1.58E-03 W)	3.53E-01	0.35
15	0.64	12.8	1.930	24.704	0.024704	0.032115	3.372096	900	1.58E-03	0.040635 + (2.36E-03 W)	4.30E-01	0.43
30	0.81	16.2	1.960	31.752	0.031752	0.041278	4.334148	1800	3.15E-03	0.08127 + (4.73E-03 W)	5.49E-01	0.55
60	1.00	20.0	2.000	40.000	0.040000	0.052000	5.460000	3600	6.30E-03	0.16254 + (9.45E-03 W)	6.84E-01	0.68
120	1.20	24.0	2.025	48.600	0.048600	0.063180	6.633900	7200	1.26E-02	0.32508 + (1.89E-02 W)	8.13E-01	0.81
240	1.42	28.4	2.015	57.226	0.057226	0.074394	7.811349	14400	2.52E-02	0.65016 + (3.78E-02 W)	9.21E-01	0.92
360	1.57	31.4	2.000	62.800	0.062800	0.081640	8.572200	21600	3.78E-02	0.97524 + (5.67E-02 W)	9.74E-01	0.97
600	1.74	34.8	1.990	69.252	0.069252	0.090028	9.452898	36000	6.30E-02	1.6254 + (9.45E-02 W)	9.99E-01	1.00
1440	2.16	43.2	1.960	84.672	0.084672	0.110074	11.557728	86400	1.51E-01	3.90096 + (2.27E-01 W)	9.61E-01	0.96

Chosen based on **r** from BRE 365, Table 1

Chosen based on Z1 X 20mm from BRE 365, Table 2

R plus 30% to account for climate change

Correct Soakaway Dimensions:

Critical Storm duration (100 year event):	600 mins
Associated soakaway width:	**1.00 m**
Previously chosen length:	**17.20 m**
Previously chosen Depth:	**1.50 m**
Storage Volume, **S**, when filled with gravel:	7.7 m^3

Suitability check:
Soakaway must be able to discharge 50% of its storage volume in 24 hours to function adequately.

a_{s50} (m^2):	27.30 m^2
Time to discharge half volume (**t_{s50}**, seconds):	80936 seconds
Time to discharge half volume (**t_{s50}**, hours):	22.48 hours

$$t_{s50} = \frac{S \times 0.5}{a_{s50} \times f}$$

Will soakaway discharge 50% volume in 24hrs? **Yes**

Conclusion: **Soakaway design OK**

Soakaway Design Calculation 2

G20158

St. Mary's University,
Twickenham, TW1 4SX
10/03/16

SOAKAWAY DESIGN FOR SIMPLE RECTANGULAR GRAVEL FILLED PIT

Using method described in BRE Digest 365 (2016 revision)

$$I - O = S$$
$$I = A \times R$$
$$O = a_{s50} \times f \times D$$

Inflow - outflow = required storage volume (all in m^3)

Inflow = Drained area of site (m^2) x Rainfall in a ten year rainfall event of specified length (m)

Outflow = half surface area (excluding base) (m^2) x Infiltration rate (ms^{-1}) x Specified storm duration (s)

M100 RAINFALL EVENT

Plus 30% allowance for Climate Change

Therefore: **I = S + O** (both expressible in terms of width)

Input data:

r x 100 (from BRE 365map)	42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period multiplied by 100)
r	0.42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period)
Drained area of site, **A** (m^2)	30	Site area soakaway must service
Infiltration rate **f** (ms^{-1})	2.39E-06	Calculated from water infiltration testing, see report
Choose soakaway lenth (m)	2.2	Arbitrarily chosen to suit site needs
Choose soakaway depth (m)	1.5	Estimated appropriate depth
half depth (m)	0.75	Depth to 50% full
S = 30% of storage volume (pore space in granular fill)	0.99	x width (Width calculated below)
a_{s50} (m^2)	3.3	+ 2(width x half depth) (Width calculated below)

a_{s50} is 50% of the internal surface area of the soakaway excluding the base (= 2(length x ½ depth) + 2(width x ½ depth))

I can be calculated from Z1 and Z2 for each rainfall duration

S = length (chosen) x depth (chosen) x width x 0.30 (30% pore space in gravel)
i.e. **S** = a known number x **w**

O = a_{s50} (m^2) x **f** (ms^{-1}) x each rainfall duration (seconds)
O = (half depth x [2(length) + 2(width)]) x **f** (known) x **D** ((=f.D.2Length.½depth + f.D.2W.½dep

Rearrange to calculate width:

I = S + O (both expressible in terms of width)

w = [**I** - (length x depth x **f** x **D**)] / [(0.30 x length x depth) + (depth x **f** x **D**)]

Rainfall Duration (D, min)	Z1 (from Table 1)	Z1 x 20mm	Z2 (from Table 2)	R (mm)	R (m)	R_{CC} (+30%)	Inflow (I, m^3)	Duration D in seconds	Inf. Rate x D (s)	O (m^3)	Required Width (m)	W (m)
10	0.53	10.6	1.910	20.246	0.020246	0.026320	0.789594	600	1.43E-03	4.73E-03 + (2.15E-03 W)	7.91E-01	0.79
15	0.64	12.8	1.930	24.704	0.024704	0.032115	0.963456	900	2.15E-03	0.0070983 + (3.23E-03 W)	9.63E-01	0.96
30	0.81	16.2	1.960	31.752	0.031752	0.041278	1.238328	1800	4.30E-03	0.0141966 + (6.45E-03 W)	1.23E+00	1.23
60	1.00	20.0	2.000	40.000	0.040000	0.052000	1.560000	3600	8.60E-03	0.0283932 + (1.29E-02 W)	1.53E+00	1.53
120	1.20	24.0	2.025	48.600	0.048600	0.063180	1.895400	7200	1.72E-02	0.0567864 + (2.58E-02 W)	1.81E+00	1.81
240	1.42	28.4	2.015	57.226	0.057226	0.074394	2.231814	14400	3.44E-02	0.1135728 + (5.16E-02 W)	2.03E+00	2.03
360	1.57	31.4	2.000	62.800	0.062800	0.081640	2.449200	21600	5.16E-02	0.1703592 + (7.74E-02 W)	2.13E+00	2.13
600	1.74	34.8	1.990	69.252	0.069252	0.090028	2.700828	36000	8.60E-02	0.283932 + (1.29E-01 W)	2.16E+00	2.16
1440	2.16	43.2	1.960	84.672	0.084672	0.110074	3.302208	86400	2.06E-01	0.6814368 + (3.10E-01 W)	2.02E+00	2.02

Z1: Chosen based on **r** from BRE 365, Table 1

Z2: Chosen based on Z1 X 20mm from BRE 365, Table 2

R_{CC}: R plus 30% to account for climate change

Correct Soakaway Dimensions:

Critical Storm duration (100 year event):	600 mins
Associated soakaway width:	**2.16** m
Previously chosen length:	**2.20** m
Previously chosen Depth:	**1.50** m
Storage Volume, **S**, when filled with gravel:	2.1 m^3

Suitability check:
Soakaway must be able to discharge 50% of its storage volume in 24 hours to function adequately.

a_{s50} (m^2):	6.54 m^2
Time to discharge half volume (**t_{s50}**, seconds):	68400 seconds
Time to discharge half volume (**t_{s50}**, hours):	19.00 hours

$$t_{s50} = \frac{S \times 0.5}{a_{s50} \times f}$$

Will soakaway discharge 50% volume in 24hrs? **Yes**

Conclusion: **Soakaway design OK**

GEO INVESTIGATE
GEOLOGICAL GEOTECHNICAL GEOENVIRONMENTAL

Soakaway Design Calculation 3
G20158
St. Mary's University,
Twickenham, TW1 4SX
10/03/16

SOAKAWAY DESIGN FOR SIMPLE RECTANGULAR GRAVEL FILLED PIT
Using method described in BRE Digest 365 (2016 revision)

$$I - O = S$$
$$I = A \times R$$
$$O = a_{s50} \times f \times D$$

Inflow - outflow = required storage volume (all in m^3)
Inflow = Drained area of site (m^2) x Rainfall in a ten year rainfall event of specified length (m)
Outflow = half surface area (excluding base) (m^2) x Infiltration rate (ms^{-1}) x Specified storm duration (s)

M100 RAINFALL EVENT

Plus 30% allowance for Climate Change

Therefore: **I = S + O** (both expressible in terms of width)

I can be calculated from Z1 and Z2 for each rainfall duration

S = length (chosen) x depth (chosen) x width x 0.30 (30% pore space in gravel)
i.e. **S** = a known number x **w**

O = a_{s50} (m^2) x **f** (ms^{-1}) x each rainfall duration (seconds)
O = (half depth x [2(length) + 2(width)]) x **f** (known) x **D** ((=f.D.2Length.½depth + f.D.2W.½dep

Rearrange to calculate width:

I = S + O (both expressible in terms of width)

w = [**I** - (length x depth x **f** x **D**)] / [(0.30 x length x depth) + (depth x **f** x **D**)]

Input data:

r x 100 (from BRE 365map)	42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period multiplied by 100)
r	0.42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period)
Drained area of site, **A** (m^2)	135	Site area soakaway must service
Infiltration rate **f** (ms^{-1})	2.39E-06	Calculated from water infiltration testing, see report
Choose soakaway lenth (m)	21	Arbitrarily chosen to suit site needs
Choose soakaway depth (m)	1.5	Estimated appropriate depth
half depth (m)	0.75	Depth to 50% full
S = 30% of storage volume (pore space in granular fill)	9.45	x width (Width calculated below)
a_{s50} (m^2)	31.5	+ 2(width x half depth) (Width calculated below)

a_{s50} is 50% of the internal surface area of the soakaway excluding the base (= 2(length x ½ depth) + 2(width x ½ depth))

Rainfall Duration (D, min)	Z1 (from Table 1)	Z1 x 20mm	Z2 (from Table 2)	R (mm)	R (m)	R_{CC} (+30%)	Inflow (I, m^3)	Duration D in seconds	Inf. Rate x D (s)	O (m^3)	Required Width (m)	W (m)
10	0.53	10.6	1.910	20.246	0.020246	0.026320	3.553173	600	1.43E-03	4.52E-02 + (2.15E-03 W)	3.71E-01	0.37
15	0.64	12.8	1.930	24.704	0.024704	0.032115	4.335552	900	2.15E-03	0.0677565 + (3.23E-03 W)	4.51E-01	0.45
30	0.81	16.2	1.960	31.752	0.031752	0.041278	5.572476	1800	4.30E-03	0.135513 + (6.45E-03 W)	5.75E-01	0.57
60	1.00	20.0	2.000	40.000	0.040000	0.052000	7.020000	3600	8.60E-03	0.271026 + (1.29E-02 W)	7.13E-01	0.71
120	1.20	24.0	2.025	48.600	0.048600	0.063180	8.529300	7200	1.72E-02	0.542052 + (2.58E-02 W)	8.43E-01	0.84
240	1.42	28.4	2.015	57.226	0.057226	0.074394	10.043163	14400	3.44E-02	1.084104 + (5.16E-02 W)	9.43E-01	0.94
360	1.57	31.4	2.000	62.800	0.062800	0.081640	11.021400	21600	5.16E-02	1.626156 + (7.74E-02 W)	9.86E-01	0.99
600	1.74	34.8	1.990	69.252	0.069252	0.090028	12.153726	36000	8.60E-02	2.71026 + (1.29E-01 W)	9.86E-01	0.99
1440	2.16	43.2	1.960	84.672	0.084672	0.110074	14.859936	86400	2.06E-01	6.504624 + (3.10E-01 W)	8.56E-01	0.86

Chosen based on **r** from BRE 365, Table 1

Chosen based on Z1 X 20mm from BRE 365, Table 2

R plus 30% to account for climate change

Correct Soakaway Dimensions:

Critical Storm duration (100 year event):	360 mins
Associated soakaway width:	**0.99** m
Previously chosen length:	**21.00** m
Previously chosen Depth:	**1.50** m
Storage Volume, **S**, when filled with gravel:	9.3 m^3

Suitability check:
Soakaway must be able to discharge 50% of its storage volume in 24 hours to function adequately.

$$t_{s50} = \frac{S \times 0.5}{a_{s50} \times f}$$

a_{s50} (m^2):	32.98 m^2
Time to discharge half volume (**t_{s50}**, seconds):	59115 seconds
Time to discharge half volume (**t_{s50}**, hours):	16.42 hours
Will soakaway discharge 50% volume in 24hrs?	**Yes**
Conclusion:	**Soakaway design OK**

Soakaway Design Calculation 4
G20158
St. Mary's University,
Twickenham, TW1 4SX
10/03/16

SOAKAWAY DESIGN FOR SIMPLE RECTANGULAR GRAVEL FILLED PIT

Using method described in BRE Digest 365 (2016 revision)

$$I - O = S$$
$$I = A \times R$$
$$O = a_{s50} \times f \times D$$

Inflow - outflow = required storage volume (all in m^3)

Inflow = Drained area of site (m^2) x Rainfall in a ten year rainfall event of specified length (m)

Outflow = half surface area (excluding base) (m^2) x Infiltration rate (ms^{-1}) x Specified storm duration (s)

M100 RAINFALL EVENT

Plus 30% allowance for Climate Change

Input data:

r x 100 (from BRE 365map)	42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period multiplied by 100)
r	0.42	(Ratio of 60 minute to 2 day rainfalls of 5 year return period)
Drained area of site, **A** (m^2)	135	Site area soakaway must service
Infiltration rate **f** (ms^{-1})	1.75E-06	Calculated from water infiltration testing, see report
Choose soakaway lenth (m)	22	Arbitrarily chosen to suit site needs
Choose soakaway depth (m)	1.5	Estimated appropriate depth
half depth (m)	0.75	Depth to 50% full
S = 30% of storage volume (pore space in granular fill)	9.9	x width (Width calculated below)
a_{s50} (m^2)	33	+ 2(width x half depth) (Width calculated below)

a_{s50} is 50% of the internal surface area of the soakaway excluding the base (= 2(length x ½ depth) + 2(width x ½ depth))

Therefore: **I = S + O** (both expressible in terms of width)

I can be calculated from Z1 and Z2 for each rainfall duration

S = length (chosen) x depth (chosen) x width x 0.30 (30% pore space in gravel)
i.e. **S** = a known number x **w**

O = a_{s50} (m^2) x **f** (ms^{-1}) x each rainfall duration (seconds)
O = (half depth x [2(length) + 2(width)]) x **f** (known) x **D** (I (=f.D.2Length.½depth + f.D.2W.½dep

Rearrange to calculate width:

I = S + O (both expressible in terms of width)

w = [**I** - (length x depth x **f** x **D**)] / [(0.30 x length x depth) + (depth x **f** x **D**)]

Rainfall Duration (D, min)	Z1 (from Table 1)	Z1 x 20mm	Z2 (from Table 2)	R (mm)	R (m)	R_{CC} (+30%)	Inflow (I, m^3)	Duration D in seconds	Inf. Rate x D (s)	O (m^3)			Required Width (m)	W (m)
10	0.53	10.6	1.910	20.246	0.020246	0.026320	3.553173	600	1.05E-03	3.47E-02	+ (	1.58E-03 W)	3.55E-01	0.36
15	0.64	12.8	1.930	24.704	0.024704	0.032115	4.335552	900	1.58E-03	0.051975	+ (	2.36E-03 W)	4.33E-01	0.43
30	0.81	16.2	1.960	31.752	0.031752	0.041278	5.572476	1800	3.15E-03	0.10395	+ (	4.73E-03 W)	5.52E-01	0.55
60	1.00	20.0	2.000	40.000	0.040000	0.052000	7.020000	3600	6.30E-03	0.2079	+ (	9.45E-03 W)	6.87E-01	0.69
120	1.20	24.0	2.025	48.600	0.048600	0.063180	8.529300	7200	1.26E-02	0.4158	+ (	1.89E-02 W)	8.18E-01	0.82
240	1.42	28.4	2.015	57.226	0.057226	0.074394	10.043163	14400	2.52E-02	0.8316	+ (	3.78E-02 W)	9.27E-01	0.93
360	1.57	31.4	2.000	62.800	0.062800	0.081640	11.021400	21600	3.78E-02	1.2474	+ (	5.67E-02 W)	9.82E-01	0.98
600	1.74	34.8	1.990	69.252	0.069252	0.090028	12.153726	36000	6.30E-02	2.079	+ (	9.45E-02 W)	1.01E+00	1.01
1440	2.16	43.2	1.960	84.672	0.084672	0.110074	14.859936	86400	1.51E-01	4.9896	+ (	2.27E-01 W)	9.75E-01	0.97

Chosen based on **r** from BRE 365, Table 1

Chosen based on Z1 X 20mm from BRE 365, Table 2

R plus 30% to account for climate change

Correct Soakaway Dimensions:

Critical Storm duration (100 year event):	600 mins
Associated soakaway width:	**1.01** m
Previously chosen length:	**22.00** m
Previously chosen Depth:	**1.50** m
Storage Volume, **S**, when filled with gravel:	10.0 m^3

Suitability check:
Soakaway must be able to discharge 50% of its storage volume in 24 hours to function adequately.

$$t_{s50} = \frac{S \times 0.5}{a_{s50} \times f}$$

a_{s50} (m^2):	34.51 m^2
Time to discharge half volume (**t_{s50}**, seconds):	82617 seconds
Time to discharge half volume (**t_{s50}**, hours):	22.95 hours
Will soakaway discharge 50% volume in 24hrs?	**Yes**
Conclusion:	**Soakaway design OK**