

Clare Egan  
Barratt David Wilson Homes Southern Counties,  
BDW House,  
Walnut Tree Close,  
Surrey,  
GU14 SW

28<sup>th</sup> July 2017

Our ref. JB/17/LP1425

Dear Clare,

**Re: BRE 365 Borehole Soakage Testing – Courtwick Cottages**

## 1. Introduction

Leap Environmental Ltd (hereafter referred to as LEAP) has been appointed by Barratt Homes Southern Counties Ltd to undertake borehole soakage testing at a site referred to as Courtwick Park Cottages, Littlehampton, West Sussex. The instruction to carry out the works was given by Clare Egan of Barratt David Wilson Homes Southern Counties in an e-mail dated 12<sup>th</sup> July 2017.

The purpose of the investigation is to provide information on the soakage potential of the underlying soils and assess the suitability of conventional soakaways for the proposed development.

The site and surrounding areas have been the subject of previous investigations by LEAP and others. The following site investigation reports have been supplied by the Client and the reader is referred to these earlier reports which should be read in conjunction with this report.

- Preliminary Site Investigation Report at Courtwick, Littlehampton by Southern Testing dated 2<sup>nd</sup> July, 2010, Report Ref J10227
- Site Investigation and Risk Assessment Report at Courtwick, Littlehampton by Southern Testing dated 23<sup>rd</sup> March, 2012, Report Ref J10749
- BRE 365 Trial Pit Soakage Testing – Courtwick Cottages Letter Report by LEAP dated 10<sup>th</sup> April 2017, Report Ref JB/17/LP1364

The relevant findings from the previous LEAP investigation are summarised below:

Leap Environmental Ltd  
South Coast Regional Office  
Premier House, Victoria Road,  
Littlehampton, West Sussex, BN16 6AA

Issued On:

## 2. Courtwick Cottages Letter Report prepared by LEAP dated 10th April 2017, Report Ref JB/I7/LPI364

LEAP was appointed by Barratt Homes Southern Counties Ltd to undertake full scale BRE365<sup>1</sup> trial pit soakage testing at the subject site. The purpose of the investigation was to provide information on the soakage potential of the underlying shallow soils and assess the suitability of conventional soakaways for the development.

One trial pit (TPSI) was excavated 10m north east of the proposed soakaway chamber location on 4<sup>th</sup> April 2017. Ground conditions comprised topsoil/made ground to 0.35m over soft to firm silty clay to 2.4m overlying medium dense gravelly silty sand. Gravel was fine to coarse sub rounded to sub angular flint.

A full scale BRE365 soakage test was conducted on TPSI, on the sandy silty clays and silty to very silty sands encountered to 3.0mbgl. The results indicated a poor infiltration rate (0.08 l/m<sup>2</sup>/min). This was considered to be indicative of the very silty nature of the sands identified at depth. It was noted that due to time constraints the trial pit was only tested once, therefore additional testing was recommended.

## 3. Site Description

The proposed soakaway location was set out by the Client and is located in the rear garden of a 2-storey house. The house is located immediately to the south of Courtwick Lane, BN17 7PD, 1.2km north west of Littlehampton town centre. The site is part of the wider Courtwick Park redevelopment.

The geology of the site has been ascertained with reference to the British Geological Survey website and the BGS Sheet No. 317/332 solid and drift edition. The site is mapped as being underlain by Raised Beach Deposits, comprising silty sands and gravels over the Lewes Nodular Chalk Formation, which typically comprises very hard nodular chalks with interbedded soft to medium hard chalks and marls.

The Hydrogeology of the site has been assessed with reference to the Environment Agency web site. The site is not located within a source protection zone regarding potable water and the underlying superficial soils are classified as a Secondary A aquifer. The underlying chalk is classified as a principal aquifer.

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<sup>1</sup> Building Research Establishment Digest 365: 2007. Soakaway Design

#### 4. Intrusive Investigations

The current intrusive works comprised the drilling of one rotary CFA drilled borehole (BH1) to a depth of 8.95mbgl. The borehole is located at the site of the proposed soakaway, as specified by the Client.

The location of BH1 and the previous trial pit soakage test position are indicated on Figure I, Appendix B.

Ground conditions encountered during both phases of the works are detailed on the attached logs and summarised below:

**Table I: Summary of encountered soils**

| Depth (mbgl)        | Soil Description                                                                                                                                                                                               |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| GL – 0.25           | Grass over buff brown very silty, slightly sandy friable clay TOPSOIL with frequent rootlets throughout.<br><br>BH1 only.                                                                                      |
| GL – 0.35           | Grass over dark brown very silty gravelly clay topsoil MADE GROUND with frequent roots and rootlets. Gravel is fine to coarse flint with occasional brick and rare plastic fragments.<br><br>TPSI only.        |
| 0.25 – 0.60         | Brown and orange very silty, slightly gravelly fine sand SUBSOIL. Gravel is medium to coarse sub rounded to sub angular flint with rare rootlets.<br><br>BH1 only.                                             |
| 0.35/0.60 – 2.0/2.4 | Loose to medium dense / soft to firm orange buff brown slightly sandy silty CLAY with frequent rootlets, sand partings and occasional gravel of fine to coarse sub rounded to sub angular flint. TPSI and BH1. |
| 2.0/2.4 – 3.0*/4.4  | Medium dense light brown orange and yellow slightly silty fine to medium SAND with very rare gravel of fine sub angular to rounded flint TPSI and BH1.                                                         |

|          |                                                                                                                                                                                                           |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4.4-8.95 | Structureless white and cream CHALK recovered as matrix dominated chalk with pale yellow and light brown staining. Matrix is silty clay. Clasts are low density fine to medium chalk. Grade Dm. BH1 only. |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

\* Full extent of the investigation

Groundwater was struck at 8.3mbgl in BH1, with measured standing water levels of 7.8mbgl after 20 minutes. No groundwater was encountered in TPS1.

Saturated moisture content tests were proposed to provide density information for the chalk. However, due to the matrix dominated nature of the underlying chalk no samples were recovered which were suitable for testing.

### 5. Soakage Test Results

A single falling head soakage test was undertaken within BH1. Due to time constraints the borehole was only filled once.

As part of the previous investigations by LEAP detailed above, a full scale BRE365 soakage test was conducted on TPS1, on the sandy silty clays and silty to very sands encountered to 3.0mbgl.

The results of the soakage tests during both phases of the investigation are attached and a summary is indicated in the table below.

**Table 2: Summary of soakage tests**

| Test Location | Soakage Rate           |                         | Comments                                                                                   |
|---------------|------------------------|-------------------------|--------------------------------------------------------------------------------------------|
|               | (m/s)                  | (l/m <sup>2</sup> /min) |                                                                                            |
| TPS1          | $1.406 \times 10^{-6}$ | 0.08                    | Result not fully compliant with BRE365, as the drop in water level did not fall below 75%. |
| BH1           | $1.09 \times 10^{-6}$  | 0.065                   |                                                                                            |

The results indicate that a poor infiltration rate of 0.08 l/m<sup>2</sup>/min was achieved within the top 3.0m of the Raised Beach Deposits in TPS1, locally comprising silty sands and silty sandy clays. This is thought

to be indicative of the locally high fines content of these soils. The result did not comply with BRE365 guidelines as the water did not drop below 75% of the starting level.

The falling head test conducted in BHI indicates that a rate of 0.065 l/m<sup>2</sup>/min was achieved within the deeper raised beach deposits and chalk. Based on local experience and CIRIA C574, these results are comparable with matrix dominated chalk (Grade Dm), which typically behaves as a fine soil for engineering purposes.

The water level in TPSI dropped 0.23m over 3 hours, whilst BHI fell 2.1m over 2 hours indicating that some soakage potential is present although below the levels generally acceptable for soakaway design after BRE 365.

## 6. Conclusions

The trial holes indicated an infiltration rate in the range of 0.065-0.08 l/m<sup>2</sup>/min. However, the shallow test result should be used with caution due to the non-compliant nature of the test.

It is noted that topsoil made ground was encountered to 0.35m in TPSI and soakaways are not recommended to discharge to made ground. However, given the encountered ground conditions it is not expected that made ground extends to below 1.0m at this stage.

At present, we have assumed from field observations that the underlying chalk is structureless with low density chalk gravel. Based on CIRIA C574 soakaways in low density chalk should be located a minimum of 10m from any foundations. If the site is at high risk of solution features, then the distance should be increased to 20m.

A standing groundwater level of 7.8m below ground level was encountered within the chalk in the location of the proposed soakaway, resulting in an unsaturated zone of 3.4m within the chalk. It should be noted that the borehole was drilled after a prolonged bout of dry weather and therefore groundwater levels are anticipated to be higher during the wet winter months, reducing the existing unsaturated zone.

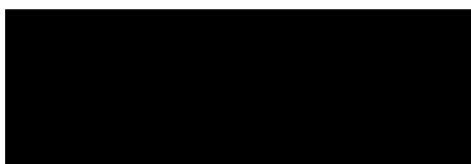
The site is not situated in a groundwater source protection zone (SPZ) but the chalk is classified as a Principal Aquifer. Soakage directly into groundwater is unlikely to be acceptable to the Environment Agency (EA) except in exceptional cases due to the potential risk of contamination. If the proposed soakaway is only designed to drain surface water runoff from roof drains then it may be possible to discharge into the chalk. In any case, the EA should be consulted and may require the depth of the base of soakaways to be several metres above the groundwater table and if the soakaway is designed to service any pavement, road or hardstanding areas, alternative solutions should be considered.

Based on the above, conventional soakaways in the Raised Beach Deposits may be suitable if complemented with additional attenuation ponds to account for storm events given the relatively poor soakage achieved. Any such solution should be designed and approved by a drainage engineer.

Alternatively, consideration should be given to adding other shallow sustainable urban drainage systems (SUDS), such as swales, permeable paving or attenuation ponds to the current site drainage plan.

Please do not hesitate to contact us if you need any clarification on the above.

Yours sincerely,



Joao Brissos

*This letter report has been prepared by Leap Environmental Ltd on the basis of information received from a variety of sources which Leap Environmental Ltd believes to be accurate. Nevertheless, Leap Environmental Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.*

*Leap Environmental Ltd has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed.*

*This report is generally consistent with the Eurocode requirements for a Ground Investigation Report, noting the limitations on brief to provision of pile design information only. However, the laboratory testing has been carried out on samples which do not comply with the Eurocode classifications as identified in tables 2 and 3 of EN ISO 22475-1. This report should not be deemed as a Geotechnical Design Report, and where any calculations have been made, these are not Eurocode compliant and are for indicative purposes only.*

*The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted, and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.*

*This report is confidential to the Client, and Leap Environmental Ltd accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental Ltd beforehand. Any such party relies upon the report at their own risk.*

## APPENDIX A – FIGURES

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Figures

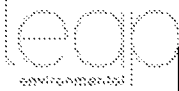


|                                                                                      |           |                                   |        |                          |             |         |
|--------------------------------------------------------------------------------------|-----------|-----------------------------------|--------|--------------------------|-------------|---------|
|  | Client :  | Barratt Homes                     | Date:  | 04/04/2017               | Project ID: | LP01425 |
|                                                                                      | Project : | Courtwick Cottages, Littlehampton | Title: | Trial hole location plan | Fig. No.    | I       |

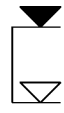
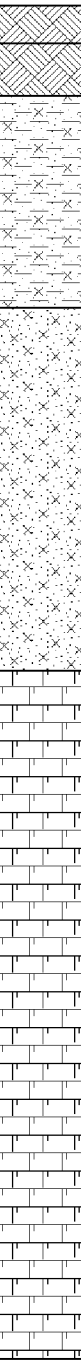
## APPENDIX B – TRIAL HOLE LOGS

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Trial hole logs

|                                                                                                                                                                |  |                                                   |  |                                |                                            |                 |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------------------------------|--|--------------------------------|--------------------------------------------|-----------------|
|  Leap Environmental Ltd<br>The Atrium, Curtis Road<br>Dorking, Surrey RH4 1XA |  | <h1 style="text-align: center;">Borehole Log</h1> |  |                                | Borehole No.<br><b>BH1</b><br>Sheet 1 of 1 |                 |
| Project Name: Courtwick Cottages                                                                                                                               |  | Project No. LP1425                                |  | Co-ords: -                     |                                            | Hole Type<br>BH |
| Location: Littlehampton, West Sussex, BN17 7EU                                                                                                                 |  |                                                   |  | Level:                         |                                            | Scale<br>1:50   |
| Client: Barratt Homes Southern Counties                                                                                                                        |  |                                                   |  | Dates: 21/07/2017 - 21/07/2017 |                                            | Logged By<br>JB |

| Well                                                                                | Water Strikes | Samples and In Situ Testing |      |                   | Depth (m)                                  | Level (m)                                                                          | Legend                                                                                                                                                                 | Stratum Description                                                                  |  |
|-------------------------------------------------------------------------------------|---------------|-----------------------------|------|-------------------|--------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--|
|                                                                                     |               | Depth (m)                   | Type | Results           |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|  |               | 0.15                        | D    | N=8 (1,2/2,2,2,2) | 0.25                                       |  | Grass over buff brown very silty, slightly sandy friable clay TOPSOIL with frequent rootlets throughout                                                                |  |  |
|                                                                                     |               | 0.50                        | D    |                   | 0.60                                       |                                                                                    | Glass fragment encountered at 0.1m                                                                                                                                     |                                                                                      |  |
|                                                                                     | 1.00          |                             |      |                   |                                            |                                                                                    | Brown orange very silty slightly gravelly fine sand SUBSOIL. Gravel is medium to coarse sub rounded to sub angular flint with rare rootlets                            |                                                                                      |  |
|                                                                                     | 1.00 - 1.45   | SPTL S                      |      |                   | Black organic staining encountered at 0.4m |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               | 2.00                        | D    | 2.00              | Brick fragment encountered at 0.5m         |                                                                                    | Orange brown slightly sandy silty CLAY with occasional sandy partings and rare black organic staining. Becoming clayey fine SAND below 1.5m and less clayey with depth |                                                                                      |  |
|                                                                                     |               | 2.50                        |      |                   |                                            |                                                                                    | Light brown orange and yellow slightly silty fine to medium SAND with very rare gravel of fine sub angular to rounded flint.                                           |                                                                                      |  |
|                                                                                     | 2.50 - 2.95   | SPTL S                      |      |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               | 3.50                        | D    |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               | 4.00                        |      |                   |                                            |                                                                                    | Becoming dark brown and more clayey below 4.0m                                                                                                                         |                                                                                      |  |
|                                                                                     | 4.00 - 4.45   | SPTL S                      |      |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               | 5.00                        | D    | 4.40              |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               | 5.50                        |      |                   |                                            |                                                                                    | White cream CHALK recovered as matrix dominated chalk with pale yellow and light brown staining. Matrix is silty clay. Clasts are low density fine to medium chalk     |                                                                                      |  |
|                                                                                     | 5.50 - 5.95   | SPTL S                      |      |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               | 6.50                        | D    |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               | 7.00                        |      |                   |                                            |                                                                                    | Partings of dark brown clay noted between 4.4m and 5.0m                                                                                                                |                                                                                      |  |
| 7.00 - 7.45                                                                         | SPTL S        |                             |      |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     | 8.00          | D                           |      |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     | 8.50          |                             |      |                   | Wet between 5.5-5.6m                       |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
| 8.50 - 8.95                                                                         | SPTL S        |                             |      |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               |                             |      |                   |                                            |                                                                                    |                                                                                                                                                                        |                                                                                      |  |
|                                                                                     |               |                             |      |                   | 8.95                                       |                                                                                    | End of borehole at 8.95 m                                                                                                                                              |                                                                                      |  |

|                                                                                                         |                                                                                       |
|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Remarks<br>Water strike at 8.3m. Rising to 7.8m after 20 minutes. Location of falling head soakage test |  |
|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|

|                                                                                                                                                                                                                                                                    |  |  |  |                                           |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                            |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|-------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------|--|
| <div style="display: flex; flex-direction: column; justify-content: space-between;"> <div> Leap Environmental Ltd<br/> The Atrium, Curtis Road<br/> Dorking, Surrey RH4 1XA </div> <div style="background-color: black; width: 150px; height: 20px;"></div> </div> |  |  |  | <h1 style="margin: 0;">Trial Pit Log</h1> |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  | Trialpit No<br><b>TPS1</b><br>Sheet 1 of 1 |  |
| Project Name: Courtwick Cottages                                                                                                                                                                                                                                   |  |  |  | Project No.<br>LP1364                     |  | Co-ords: -<br>Level: 8.30                                                                                                                                                                                                                                                                                                                                                                                                                                     |  | Date<br>04/04/2017                         |  |
| Location: Courtwick Park, Courtwick Lane, Littlehampton, BN17 7PD                                                                                                                                                                                                  |  |  |  |                                           |  | Dimensions (m):<br><div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: right; margin-right: 10px;">Depth<br/>3.00</div> <div style="border: 1px solid black; width: 100px; height: 40px; display: flex; align-items: center; justify-content: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: 0.8em;">0.8</div> <div style="margin-left: 10px;">2.4</div> </div> </div> |  | Scale<br>1:25<br>Logged<br>JB              |  |
| Client: Barratt Homes                                                                                                                                                                                                                                              |  |  |  |                                           |  |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                            |  |

| Water Strike | Samples and In Situ Testing |      |         | Depth (m) | Level (m) | Legend | Stratum Description                                                                                                                                                                     |   |
|--------------|-----------------------------|------|---------|-----------|-----------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
|              | Depth                       | Type | Results |           |           |        |                                                                                                                                                                                         |   |
|              | 0.10                        | ES   |         | 0.35      | 7.95      |        | Grass over dark brown very silty gravelly clay topsoil<br>MADE GROUND with frequent roots and rootlets. Gravel is fine to coarse flint with occasional brick and rare plastic fragments | 1 |
|              |                             |      |         |           |           |        | Soft to firm buff brown very silty CLAY with frequent rootlets.<br><i>Black staining noted between 0.35-0.45m</i>                                                                       |   |
|              | 1.50                        | D    |         | 2.40      | 5.90      |        | Becoming gravelly and slightly sandy at 2.0m. Gravel is fine to coarse sub rounded to sub angular flint                                                                                 | 2 |
|              |                             |      |         |           |           |        |                                                                                                                                                                                         |   |
|              | 3.00                        | D    |         | 3.00      | 5.30      |        | Medium dense pale brown yellow and mottled orange gravelly very silty medium SAND. Gravel is fine to medium angular to sub rounded flint                                                | 3 |
|              |                             |      |         |           |           |        | End of pit at 3.00 m                                                                                                                                                                    |   |
|              |                             |      |         |           |           |        |                                                                                                                                                                                         | 4 |
|              |                             |      |         |           |           |        |                                                                                                                                                                                         | 5 |

|                                                     |  |  |
|-----------------------------------------------------|--|--|
| Remarks: Location of full scale BRE365 Soakage Test |  |  |
| Stability: Stable                                   |  |  |

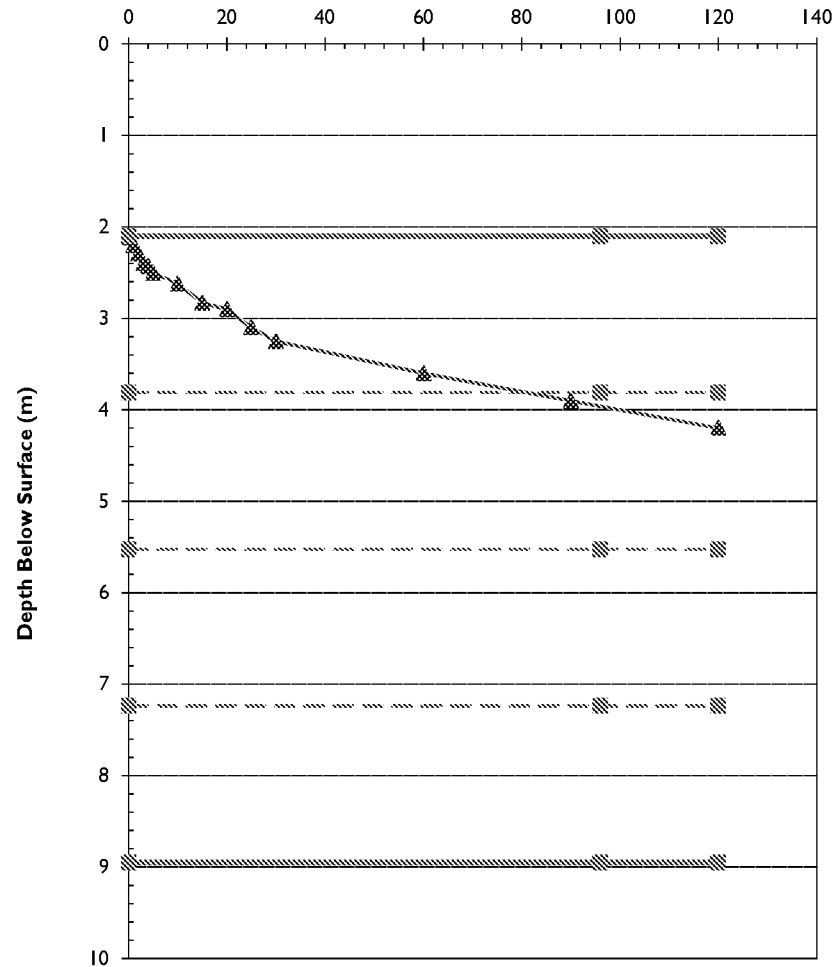
## APPENDIX C – SOAKAGE TEST RESULTS

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Soakage Test Results

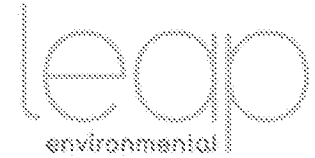
## BRE Digest 365 - Soakage Test

Filling to Max Water Depth (min)



initial)

Test Hole No: BHI  
Test No: Test No 1



|                                     |           |
|-------------------------------------|-----------|
| Diameter of Borehole (m)            | 0.127     |
| Depth to End of Borehole Casing (m) | 0         |
| Depth to Borehole Base (m)          | 8.95      |
| Depth to Top of Permeable Soils (m) |           |
| Depth to Groundwater Surface (m)    | 7.8       |
| Depth to Top of Granular Fill (m)   |           |
| Voids Assumed within Borehole (%)   |           |
| Depth of Water at Start of Test (m) | 2.1       |
| Max Water Dropdown during Test (m)  | 2.1       |
| Total Soakage Test Time (min)       | 120       |
| Mean Internal Discharge Area (m2)   | 2.04249   |
| Discharge Rate (litre/min)          | 0.12872   |
| Soakage Rate (litre/m2/min)         | 0.0630211 |
| BRE Soil Infiltration Rate (m/sec)  | 1.05E-06  |

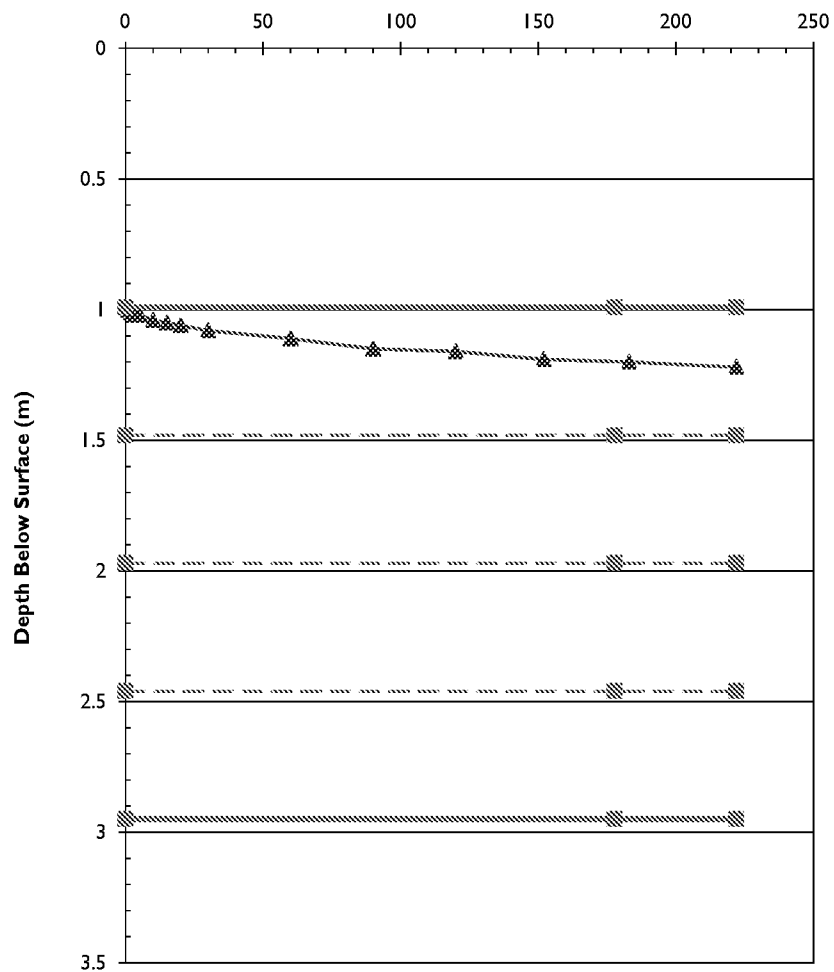
### Comments:

Water level fell to 75% -- 50% max water depth, calculations were based on actual fall of water level achieved.  
Result not compliant with BRE365 requirement since water did not fall to 25% max water depth.

Client: Barratt Homes  
Site: Courtwick Cottages  
Tested By: JB  
Test Date: 24/07/17

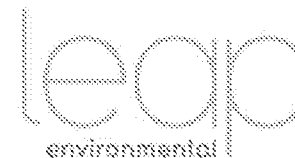
## BRE Digest 365 - Soakage Test

Filling to Max Water Depth (min)



initial)

Test Hole No: TPS1  
Test No: Test No 1



|                                     |           |
|-------------------------------------|-----------|
| Pit Length (m)                      | 2.4       |
| Pit Width (m)                       | 0.8       |
| Depth to Pit Base (m)               | 2.95      |
| Depth to Top of Permeable Soils (m) |           |
| Depth to Groundwater Surface (m)    |           |
| Depth to Top of Granular Fill (m)   |           |
| Voids Assumed for Granular Fill (%) |           |
| Depth of Water at Start of Test (m) | 0.99      |
| Max Water Dropdown during Test (m)  | 0.23      |
| Total Soakage Test Time (min)       | 222       |
| Mean Internal Discharge Area (m2)   | 13.176    |
| Discharge Rate (litre/min)          | 1.1114094 |
| Soakage Rate (litre/m2/min)         | 0.084351  |
| BRE Soil Infiltration Rate (m/sec)  | 1.406E-06 |

### Comments:

Water level did not fall to 75% max water depth, calculations were based on actual fall of water level achieved.  
Result not compliant with BRE365 requirement since water did not fall to 25% max water depth.

Client: Barratt Homes  
Site: Courtwick Cottages  
Tested By: JB  
Test Date: 07/04/17