ADDENDUM

TO A FLOOD RISK ASSESSMENT

(COVERING A FOUL SEWAGE AND SURFACE WATER ASSESSMENT)

DEVELOPMENT AT

SITE SOUTH OF HIGH STREET ASCOT, SL5 7JE

CLIENT: LONDON SQUARE & ASCOT CENTRAL CAR PARK LIMITED

JOB No: 21146

REPORT REF: 21146-REP03-FRA ADDENDUM 1

DATE: MAY 2023

REVISION: P4
Revisions in bold italics in text of report

AUTHOR: TB

BARNARD & ASSOCIATES Ltd.
Consulting Civil & Structural Engineers
18 Northfields Prospect
Northfields
London SW18 1PE
☎ 0208 874 9005
Fax No. 0208 870 7386
Email barnard@intonet.co.uk

Directors: T J Barnard BScHons CEng MIStructE M P Duckett IEng AMIStructE

Registered Address: 5 Underwood Street, London N1 7LY
Registered in England No. 3173850

Table of Contents

1.0 Introduction

A Flood Risk Assessment and Below Ground Drainage Assessment (21146-REP01-FRA dated May 2022) was prepared by Barnard & Associates Ltd and submitted to accompany Planning Application reference 22/01971/FULL, for a proposed development at the site south of High Street Ascot (National Grid Reference 492313, 168669).

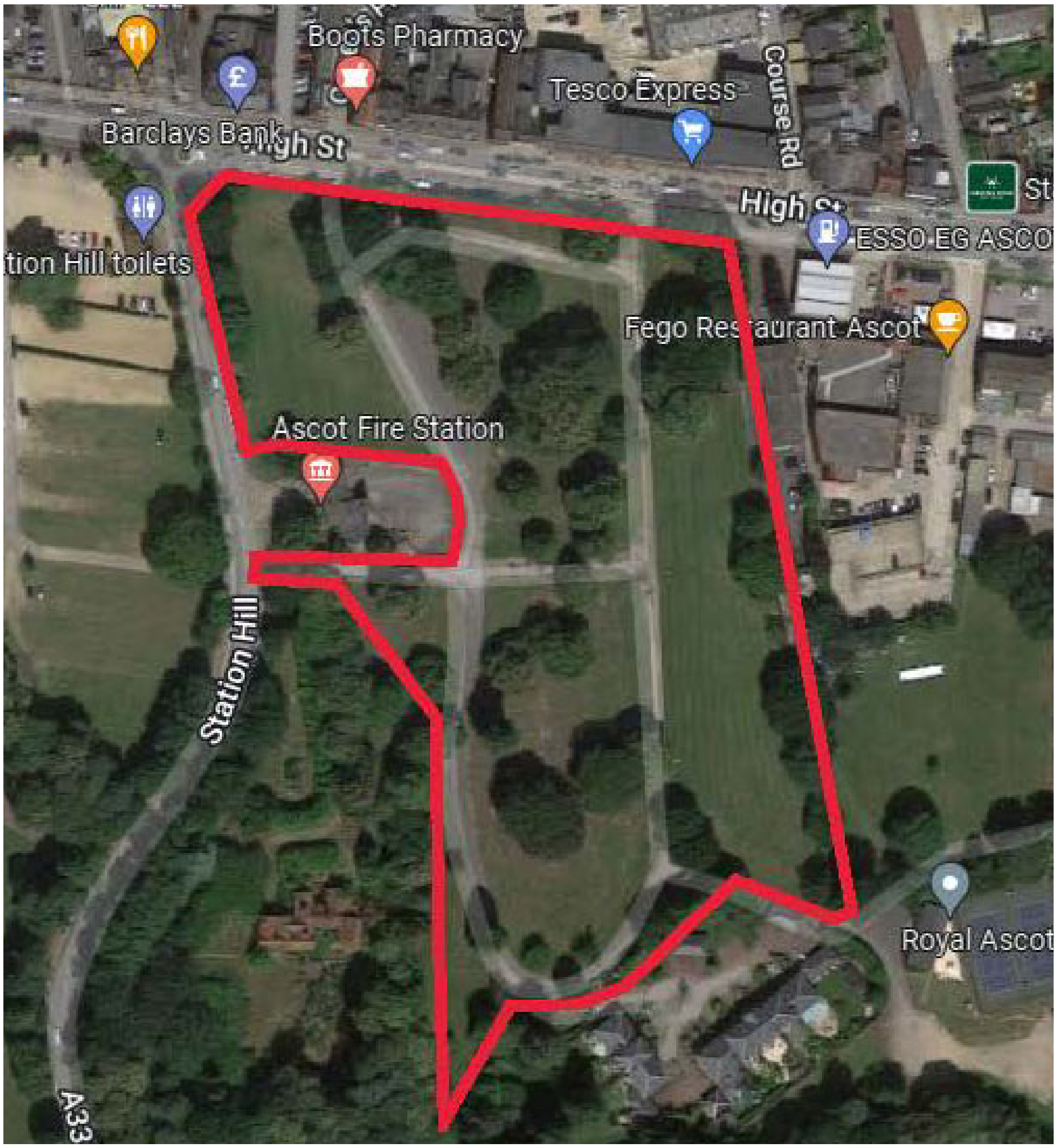


Figure 1; site location plan with approximate site boundary in red

1.01 Addendum Report

This Addendum report (FRA Addendum 1) has been prepared following the submission of the original FRA, to report on the following matters :-

- Amendments to the proposed development layout, see section 2.01.
- Additional BRE 365 Infiltration testing undertaken on site, see section 2.02.
- Additional deeper bore infiltration testing undertaken on site, see section 2.03.
- Comments received from the Planning Authority, see sections 2.05 and 4.00
- Amendments to the proposed surfacings, see section 3.01.
- Amendments to the proposed method of stormwater discharge, see section 3.03.

Revision P3 of the FRA Addendum incorporates all queries raised by the LLFA raised since its initial issue, and also all responses to the queries.

The LLFA have reviewed the responses to queries raised and have issued their final comments dated 12 May 2023, raising no further queries.

The final comments accept the proposals and make a recommendation to the LPA for the wording of a pre commencement condition regarding below ground stormwater drainage proposals.

Revision P4 of this FRA Addendum report has been produced following layout changes to the development proposals, brought about after further discussions with the planning authority.

The layout changes have resulted in amendments to the catchment area proposals and subsequent changes to the detailed design of the below ground drainage proposals for each catchment.

The design proposals contained in this revision P4 of the FRA Addendum follow all of the principles of the design proposals contained in revision P3, incorporating all queries raised by the LLFA since the initial issue of the FRA Addendum, and also all responses to the queries.

1.02 Existing Site Layout

The site occupies a total area of 2.76ha and is located in an urban area. It is an open site, generally soft landscaped, utilised as car parking on race days at Ascot Race Course located across Ascot High Street.

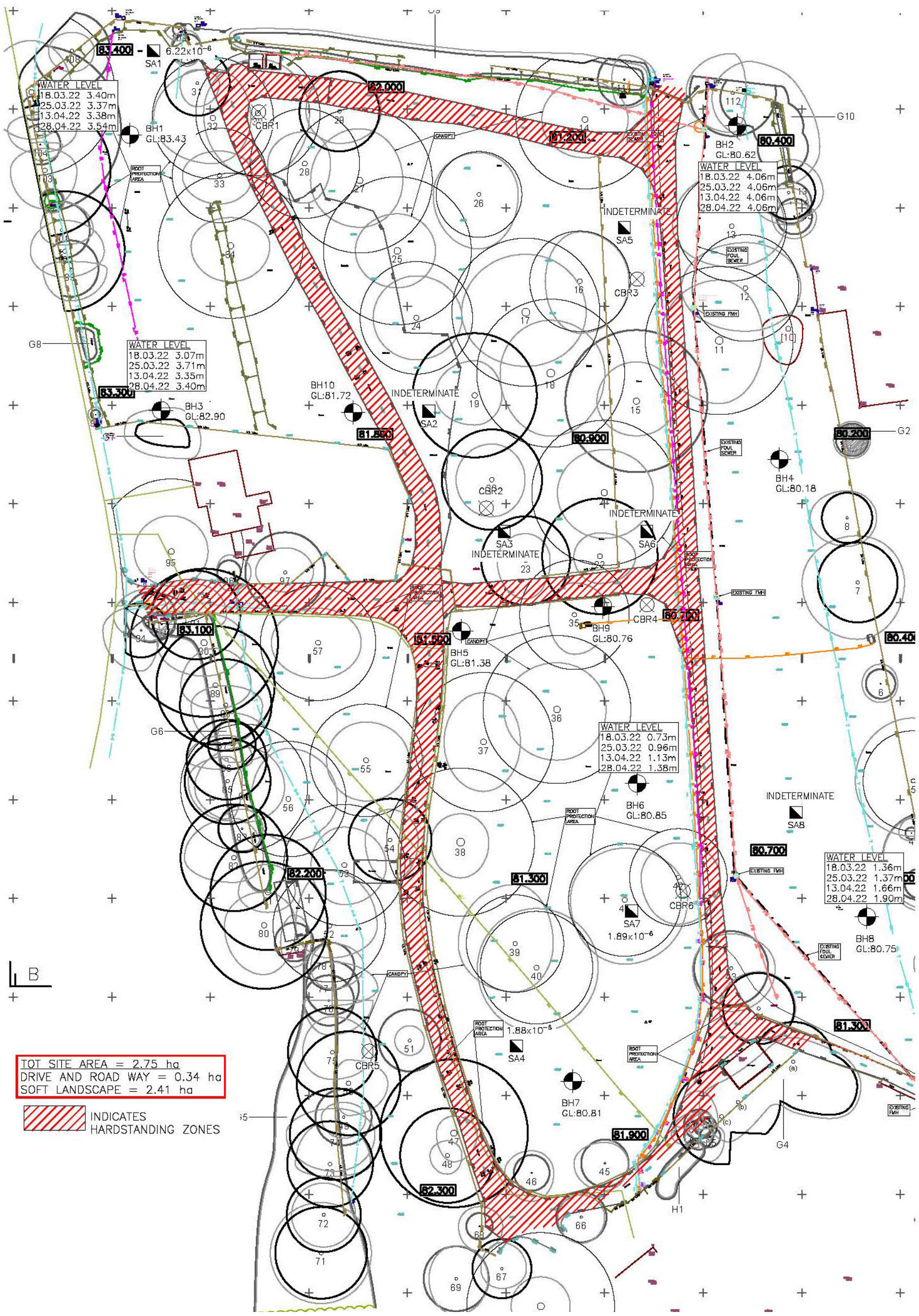


Figure 2; site plan as existing

The Environment Agency (EA) flood maps confirm that the site lies within Flood Zone 1 and is therefore not affected by fluvial or tidal flooding and is not in a flood plain.

An existing Foul sewer crosses the site, shown in figure 2 above.

There are no stormwater sewers in the vicinity of the site.

There are no ordinary watercourses or main rivers in the vicinity of the site.

There are no flood defences on or in the vicinity of the site

It is understood that the traditional means of discharge of stormwater in Ascot is via traditional Soakaways.

1.03 Matters Covered in 21146-REP01-FRA Dated May 2022, not repeated in this report

The following guidance was reviewed and acknowledged in 21146-REP01-FRA dated May 2022 :-

- National Planning Policy Guidance, March 2014 "Flood Risk and Coastal Change."
- Windsor and Maidenhead Council Strategic Flood Risk Assessment, with maps and figures
- Windsor and Maidenhead Council Environment and Climate Strategy 2020-2025
- Berkshire County Council Preliminary Flood Risk Assessment
- Environment Agency Advice Regarding Climate Change Allowances

Existing site conditions, topography, geology and hydrology, are all described in detail in 21146-REP01-FRA dated May 2022).

Existing Greenfield run off rates are estimated in 21146-REP01-FRA dated May 2022.

Unattenuated Flows without using Soakaways or Permeable Paving are estimated in 21146-REP01-FRA dated May 2022.

A Flood Risk Assessment is set out in 21146-REP01-FRA dated May 2022.

A foul drainage strategy is set out in 21146-REP01-FRA dated May 2022.

1.04 Existing Hard Standings on Site

It should be noted that areas of road, hardstanding and driveway in the existing site are counted as impermeable area in the table below. The hard standings and driveways have been surveyed and do not appear to have any positive drainage, with run-off from the driveway is discharging to adjacent soft landscaping.

Figure 3; view of site, typical driveway, hard impermeably surfaced

Figure 4; view of site, tarmac exit driveway, drains to verges

Table 1 below summarises the impermeable and permeable areas before the development.

Table 1 – Site Areas Existing (Phase 2 Area)

Existing Site	Total Area (ha)	Impermeable Area (ha)	Soft Landscape (ha)
	2.76	0.34	2.42

1.05 Initial BRE 365 Infiltration Testing and Groundwater Levels

Prior to the preparation of 21146-REP01-FRA dated May 2022, submitted with the original planning application, BRE365 infiltration testing was completed across the site. The results of the infiltration testing were reported in Appendix F of 21146-REP01-FRA dated May 2022.

The Geotechnical Site Investigation confirmed the underlying ground consists of topsoil or limited made ground to a depth of 0.45m or so, over grey sandy clay to 1.2m below ground, over a band of clayey sands, over pale grey fine sands to a depth of 4.8m below ground, over fine clayey sands over dense grey sands proved to a depth of in excess of 15m below ground.

Groundwater was noted in monitoring wells across the site at a depth generally of 0.7m to 3.3m below ground, with one borehole monitoring well not holding water.

The locations of the initial geotechnical investigation points are indicated on Figure 2 above.

The results of the testing indicated that the ground conditions exhibited poor infiltration characteristics.

Infiltration rates varied from 6.22×10^{-6} to indeterminate.

The testing was undertaken in March 2022.

The test results are attached to this report in Appendix A.

1.06 Development Proposals Initially Submitted

The development initially comprised of:

- Redevelopment of the existing site to provide 3,300m² commercial and community floorspace (mix of uses within Use Classes E, F1 and F2) and 137 dwellings with associated parking, access, open space, landscaping and other associated works

- Provision of new public open space with associated hard and soft landscape works, new pedestrian and cycle paths and children's play area.

2.0 Matters Arising Since Submission of Original Drainage Strategy

2.01 Amendments to the Proposed Development Layout

Since the original submission of Planning Application 22/01971/FULL, comments have been received from various Consultees which have resulted in amendments to the Development layout.

The amendments to the layout issued in the FRA addendum revision P3 are summarised as follows:-

- A tree has been removed so that the extent of the RPA on the development is reduced close to the access point from Ascot High Street.
- Change in location and size of the public piazza area adjacent to the community building creating 1050sqm of flexible external space.
- Block 3 re-designed to incorporate additional car parking, double height community space with folding glazed doors at ground level opening out into the community piazza.
- Removal of townhouses and two sets of linked flyover apartments within the western triangle of the site.

Further layout amendments have been agreed in principle with the planning authority and are included in this P4 revision to the FRA addendum, summarised as follows -

Following a detailed review of all responses by key stakeholders, members of the public, statutory consultees and the Council, a series of revisions have been made to the proposed development which include the following key changes:

- ***Reduced quantum of development***
  - ***Commercial floorspace reduced to 1,798.9sqm***
  - ***Community Floorspace reduced to 278.5sqm***
  - ***Number of residential dwellings reduced from 133 to 117***
- ***Detailed design and architectural changes to the elevations of Blocks 1, 2 and 3;***
- ***Reduction in scale of Block 2 down to three storeys across the whole building;***
- ***Replacement of previous apartment Block 6 with six new houses including a mix of three and four bedrooms.***
- ***Introduction of 17 three bedroom dwellings (mix of apartments and houses).***
- ***Detailed design and architectural changes to the mews buildings to create a more subservient form of development within the southern part of the site.***
- ***Minor revisions to car parking layout across the site.***

Figure 5 Development layout submitted in Appendix D of 21146-REP01-FRA dated May 2022

Figure 6 Amended development layout Revision P3

Figure 6A Amended development layout Revision P4

2.02 Additional BRE 365 Infiltration Testing Undertaken on Site

2022 was a particularly dry year with little rainfall in the winter, spring and summer months. The site continued to be utilised as an overflow car park for Ascot race course during the summer months, until the close of the racing season.

A second suite of infiltration testing was undertaken in October 2022 following the initial infiltration testing undertaken in March 2022.

The October 2022 shallow infiltration test results are attached in Appendix B of this report.

The results are summarised as follows :-

SA1 4.55 x 10^{-6} m/s, 4.29 x 10^{-6} m/s
SA2 3.88 x 10^{-6} m/s, 3.15 x 10^{-6} m/s
SA3 2.50 x 10^{-4} m/s, 1.34 x 10^{-4} m/s, 5.65 x 10^{-5} m/s
SA4 5.20 x 10^{-6} m/s, 3.46 x 10^{-6} m/s
SA5 2.06 x 10^{-6} m/s, indeterminate
SA6 4.24 x 10^{-6} m/s, indeterminate
SA7 2.05 x 10^{-5} m/s, 1.17 x 10^{-5} m/s, 1.32 x 10^{-5} m/s
SA8 9.76 x 10^{-6} m/s, 6.68 x 10^{-6} m/s, 2.65 x 10^{-6} m/s

The infiltration test result rates are all significantly higher than the original infiltration test results undertaken in March 2022.

It should be noted however that there had been lower than average rainfall in the months leading up to the additional testing in October 2022.

The initial design proposal submitted in report 21146-REP01-FRA dated May 2022 assumed an infiltration rate of 1.88 x 10^{-6} m/s. The majority of the additional infiltration test results are considerably above this rate.

2.03 Deep Infiltration Testing on Site

At the same time as undertaking further shallow infiltration testing, deeper infiltration testing was also undertaken on site in October 2022, at similar locations to the shallow infiltration testing locations.

The purpose of the additional testing was to investigate the possibility of utilising a deeper infiltration system as the primary means of stormwater discharge for the development. The proposed means of discharge being investigated was the ECO-90 system provided by Groundwater Dynamics.

Technical details of the ECO-90 system are attached to the report as Appendix C.

The ECO-90 system was introduced to the UK in 2012, and has been installed at Ascot Race Course to alleviate stormwater drainage ponding and surface water accumulation, (noting that Ascot Race Course is in close proximity to the development site with similar underlying ground conditions).

The ECO-90 system is normally a 6m to 12 m deep stormwater discharge system, with a cross section consisting of 5 open Chambers. It is a drainage extrusion made from standard HDPE (high density polyethylene). The system is installed in a predrilled hole, and has attenuation storage installed above it. Multiple bores, referred to as clusters, are constructed in sufficient number to meet the required drainage discharge rate.

The ECO-90 boreholes improve the soil strata through micro-fissures to allow infiltration throughout the full soil strata surrounding the device. It does not function like a traditional borehole soakaway. The system enables water to laterally infiltrate to depth where more permeable strata enable the system to drain down.

In deep bore soakaways, the water is conveyed via a chamber then a deep bore liner (unperforated) into the deeper ground strata, before being allowed to infiltrate via a slotted linter – this means the surface water "suddenly" appears in the deeper ground strata rather than naturally moving through the ground.

Deep bore soakaways can therefore lead to particulates in the deeper strata to suddenly be washed away, potentially creating stability issues for surrounding roads and structures.

As opposed to this, the ECO-90 system effectively improves the ground directly surrounding the porous subbase/infiltration trench so that the infiltrating water can travel down into the more porous strata more easily, hence reducing the half drain times of the infiltration features and increasing their effectiveness.

The performance characteristics of the system are tested by trial installations of the system on site. A suite of falling head tests is undertaken in a series of bores in which the ECO-90 has been installed.

The tests for the development site were undertaken on 17 October 2022, and the test results are attached in Appendix D to this report.

8 test locations were identified, in relatively close proximity to the locations of the shallow BRE365 infiltration testing also undertaken in October 2023 reported on in section 2.02 above.

A suite of bores was constructed at each of the 8 chosen locations, at varying depths between 12m and 1.5m, with falling head tests undertaken in each bore to inform the design of the ECO-90 system.

The falling head tests were all successfully completed in initially dry bores.

2.04 Groundwater Monitoring Results

Groundwater levels have continued to be monitored across the development site since the original monitoring undertaken in March 2022.

The results of the monitoring are attached to this report as Appendix E.

In summary the groundwater levels dropped in the summer months and have risen again in the winter months.

It is also noted that the underlying soils are not saturated.

In addition to the groundwater monitoring undertaken and reported on by A P Geotechnics, further testing was undertaken on site by Groundwater Dynamics, reported on in section 2.03 above.

Each of the test bores undertaken by Groundwater Dynamics was noted as dry, with falling head testing undertaken in the test bores confirming significant drops in water level within each bore under the falling head at each test location.

It is concluded therefore that the groundwater encountered on site is from perched water tables close to the surface.

2.05 Comments Received from the Lead Local Flood Authority

Comments on Original FRA

The original FRA was reviewed by the Planning Authority and comments were received on 10 August 2022 from the (LLFA)

Three comments were received from the LLFA.

Their response is attached to this Addendum FRA in Appendix F.

Briefly, the comments were as follows :-

1 Paragraph 3.7.3 of the Flood Risk Assessment states that groundwater is encountered between 0.7m to 3.3m below ground. It is required that there is at least 1m from the base of the infiltration device to the top of the groundwater level. Confirmation is required that this is achieved throughout the site.

2. Due to the ground conditions referenced in the Flood Risk Assessment, infiltration testing to BRE Digest 365 should be completed prior to this application being approved as it is unlikely that a sufficient infiltration rate will be achieved.

3. Should infiltration not be viable is there an alternative method of disposal of surface water?

The comments are addressed in Section 4.00 of this Addendum report.

Initial Comments on FRA Addendum

Further comments were subsequently received from the LLFA in relation to this FRA Addendum, as follows :-

LLFA comments dated 24 February 2023, which can be summarised as follows :-

1. Can the applicant demonstrate through use of The Simple Index approach as set out within The SuDS Manual CIRIA C753, how sufficient water quality treatment will be provided? It is anticipated that the proposals as set out in Section 5.01 of the FRA addendum will be sufficient, but we still require this to be confirmed via methodology outlined above. Clarity on proposed treatment for the catchments draining exclusively via permeable paving will also be required.

2. The body of the report states that a draft management and maintenance plan is included within Appendix H. However, Appendix H includes drawings of the existing site only.

3. Section 1.1 of Appendix G states that "EC49 has been appointed by Groundwater Dynamics (GWD) to undertake calculations to demonstrate the level of drainage that may be realised by sustainable means through the use of the GWD Energy-Passive Groundwater Recharge Pump (ECO-90) system for dispersing surface water into ground with low infiltration properties at the natural ground surface". Can the applicant clarify if this is a pumped system?

4. It is our understanding that the ECO-90 sizing and depths have been derived using the infiltration testing presented within Appendix B, of Appendix G. It appears that infiltration testing in these locations has only been undertaken once at each location. For the testing to be BRE Digest 365 compliant the boreholes would be required to be filled three times over the same or consecutive days.

5. Can the applicant clarify how the infiltration rate used in the MicroDrainage calculations, and the ECO-90 calculations been calculated?

6. We note that calculations for the ECO-90 for catchment J have been included in the FRA addendum. However, this area is proposed to drain via permeable paving. Can calculations for this please be provided?

7. How has the risk of groundwater impacting the ECO-90 system been mitigated?

8. Section 3.03.2 states that catchments C, D and E will have permeable paving as storage. However the MicroDrainage models make use of a porosity value of 0.95.

The comments are addressed in Section 4.00 of this Addendum report.

<u>Final Comments on FRA Addendum</u>

LLFA comments dated 12 May 2023, which can be summarised as follows :-

1. Noted that the proposed SuDS will provide sufficient treatment for the surface water discharge.

2. Noted the provision of the proposed maintenance activities.

3. Noted that the clarification on how the groundwater recharge pump will operate.

4. It is our understanding that the ECO-90 increases the rate of infiltration by increasing the fissures in the soil locally around the device, and as such the infiltration rate increases over time. As set out in the response to our previous comments the product makes use of its own test procedure devised for the system and is warranted by the providers/installers. As LLFA we are therefore satisfied by the hydraulic design of the system and consider it within the remit of building control to determine if bRE365 testing is required.

5. We acknowledge the clarification regarding the calculations of ECO-90 depth, and spacing and consider it has now been sufficiently demonstrated the proposed surface water drainage infrastructure has been sized so as to manage flood risk up to the 1 in 100 year plus climate change event.

6. We note the provision of revised MicroDrainage calculations for catchment J, utilising the correct porosity for permeable paving and indicating that flooding is not predicted by the model

7. It is noted that the impact of groundwater on the performance of the system has been accounted for.

8. We note the provision of revised MicroDrainage calculations for catchments C,D and E, utilising the correct porosity for permeable paving and indicating that flooding is not predicted by the model.

Recommendation for Planning Condition

We recommend that should the local planning authority be minded to grant planning permission for this application a suitably worded pre-commencement (excluding demolition) condition be imposed requiring submission of full details of the proposed surface water drainage system and its maintenance arrangements. We would suggest the following wording:

No development (excluding demolition) shall commence on the site until a surface water drainage scheme for the development, based on sustainable drainage principles has been submitted to and approved in writing by the Local Planning Authority.

Details shall include:

1. Full details of all components of the proposed surface water drainage system including dimensions, locations, gradients, invert levels, cover levels and relevant construction details.

2. Supporting calculations confirming compliance with the Non-Statutory Technical Standards for Sustainable Drainage Systems.

3. Details of the maintenance arrangements relating to the proposed surface water drainage system, confirming who will be responsible for its maintenance and the maintenance regime to be implemented. The surface water drainage system shall be implemented and maintained in accordance with the approved details thereafter.

Reason: To ensure compliance with National Planning Practice Guidance and the Non-Statutory Technical Standards for Sustainable Drainage Systems, and to ensure that the proposed development is safe from flooding and does not increase flood risk elsewhere.

3.0 Amendments to the Proposed Stormwater Discharge Strategy

3.01 Changes to The Proposed Areas Within the Development

Original Scheme Proposals 21146-REP01-FRA Dated May 2022

The developed Areas proposed in the original scheme proposals submitted with 22/01971/FULL are summarised in Table 2 below

Table 2 – Site Areas Proposed in original development Proposal

Proposed Site	Total Area (ha)	Impermeable Area (roof) (ha)	Permeable Area (Roads, paths, drives) (ha)	Soft Landscape (ha)
	2.76	0.67	0.91	1.18

Figure 7 below illustrates the original surfacing proposals.

Amended Scheme Proposals Submitted with This Addendum Report

The developed Areas proposed in the amended scheme proposals submitted with this Addendum report are summarised in Table 3 below, and are also illustrated in Figure 8 below.

Table 3 – Site Areas Proposed in amended development Proposal

Proposed Site	Total Area (ha)	Impermeable Area (road, roof)	Permeable Area (Roads, paths, drives) (ha)	Soft Landscape (ha)
	2.76	1.17	0.58	1.01

Significant Change in Areas

The most significant change in the areas is the reduction in area of permeable paving in the new layout proposals**. Refer to Figure 8A for the current layout proposal. Figure 8 shows the layout prior to the most recent layout amendments, for comparison purposes.**

In the original scheme proposal, the entirety of the access road and parking areas were designated as permeable paving with shallow attenuation storage beneath.

In the new scheme proposals, the roads and parking areas are in the main to be impermeable traditionally constructed surfaces, with piped networks discharging to discreet attenuation storage prior to discharge to ground, refer to section 3.03. Areas of access road over RPA zones will remain permeably surfaced but with limited attenuation storage below.

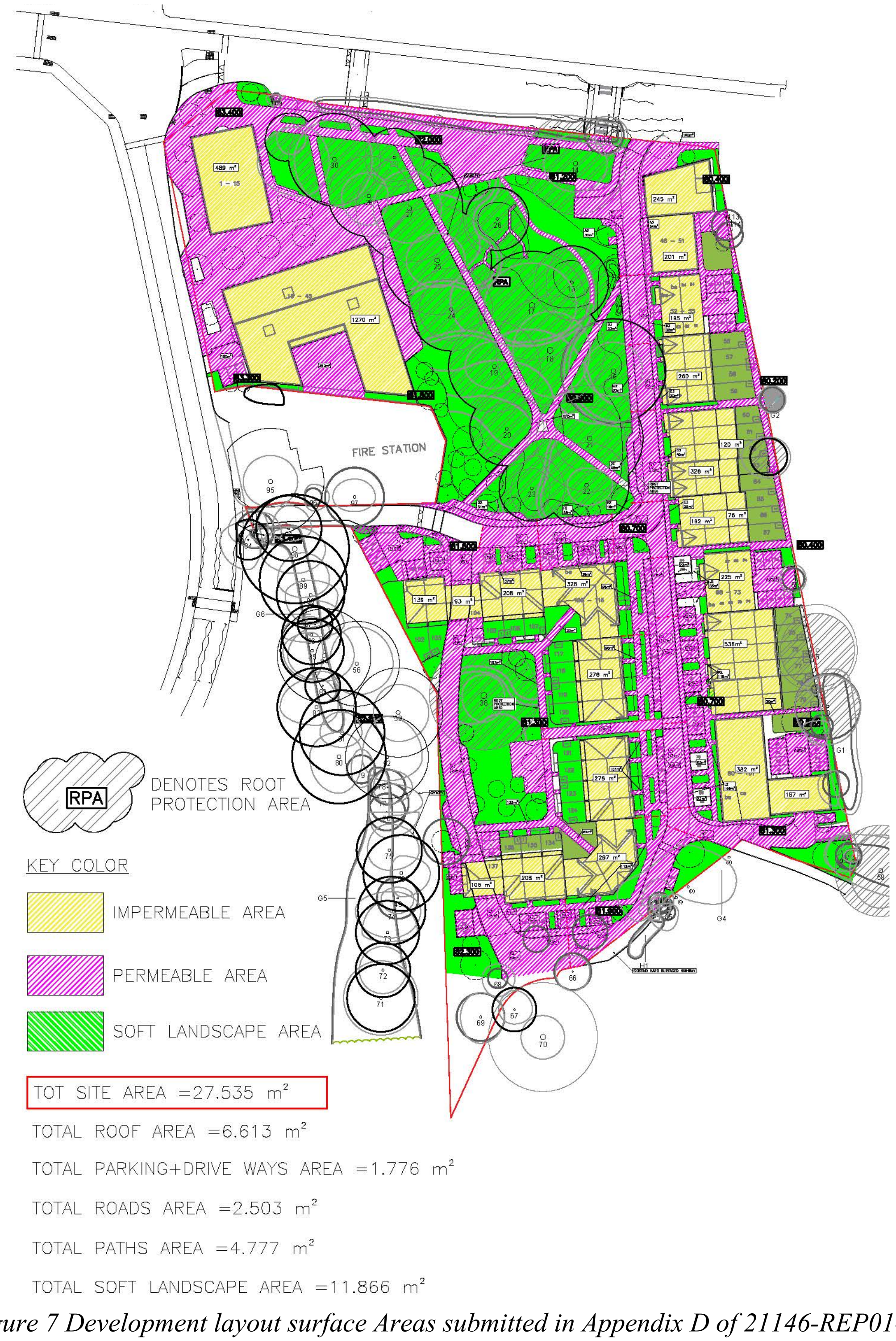


Figure 7 Development layout surface Areas submitted in Appendix D of 21146-REP01-FRA dated May 2022

Figure 8 Amended development layout Areas submitted in FRA Addendum revision P3

Figure 8A Amended development layout Areas Revision P4

3.02 Original Stormwater Discharge Strategy

The stormwater discharge strategy proposed in the initial submission was described on drawings 21146-31 P2, and drawings 34 P2, 35 P2, 36 P2 and 37 P2. in Appendix D of the original report 21146-REP01-FRA dated May 2022.

The methodology used in the original drainage design strategy is set out in section 3 of report 21146-REP01-FRA dated May 2022.

A design infiltration rate for the initial drainage design was assumed to be 1.88×10^{-6} m/s for the bulk of the site.

Further infiltration testing was recommended across the site, targeted to proposed infiltration locations for the final detailed design.

The drainage proposal can be summarised as follows and is illustrated in the following figures 9 to 13.

- Utilise permeable paving across the development for access road, parking courts and pathways, discharging to below.

- Incorporate large volumes of attenuation storage beneath the road surfaces, below the permeable paving, draining into the soils below the attenuation storage.

- The permeable paving, and attenuation storage below the access roads, parking and driveways, allow stormwater run off to be stored and to infiltrate into the underlying ground.

- It is noted that the infiltration rates across the test locations vary.

  The large plan area of the attenuation storage allows areas of underlying ground with differing infiltration rates to be linked together and average out to achieve the required design infiltration rate.

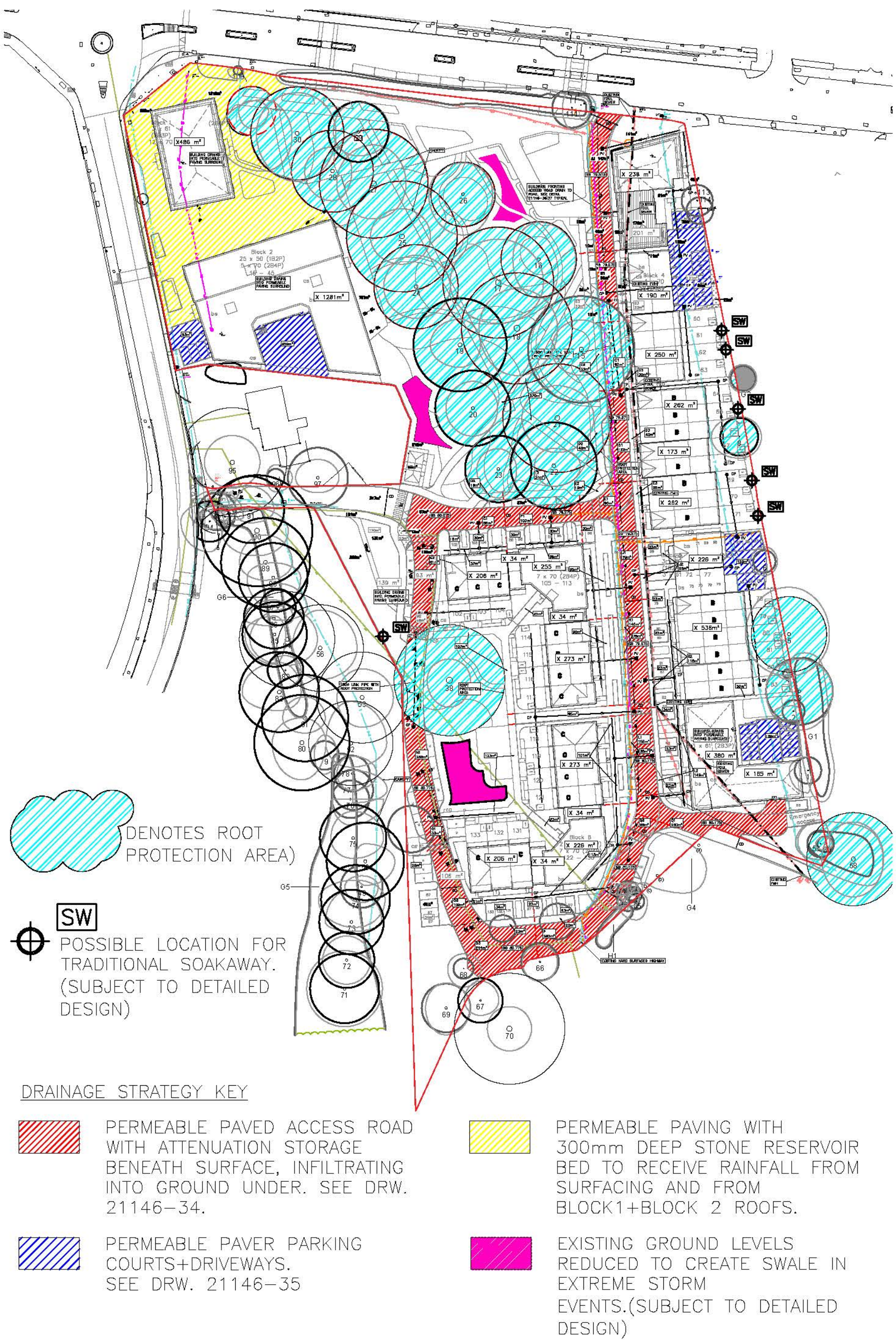


Figure 9 Original drainage strategy proposed

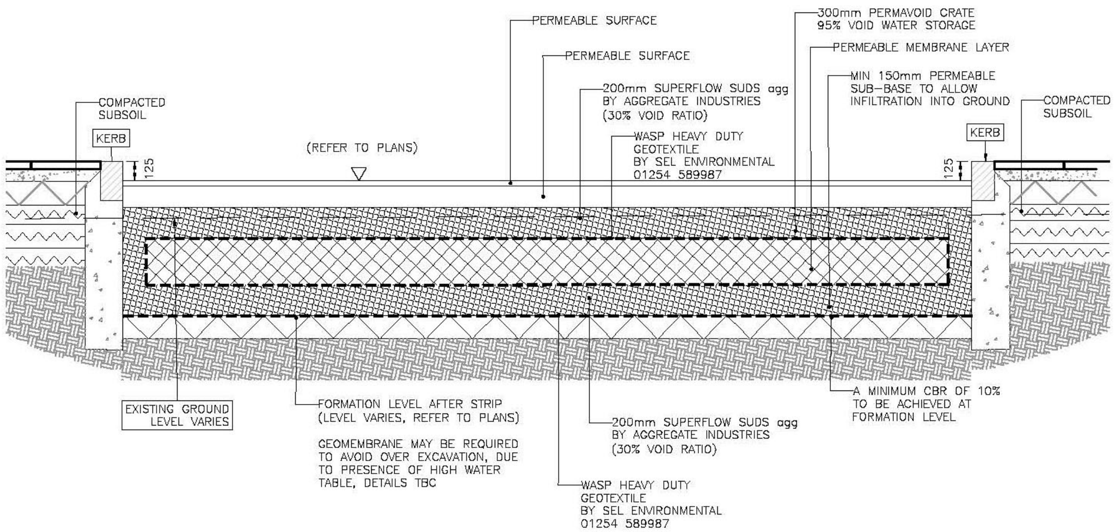


Figure 10 Original drainage strategy, section through road

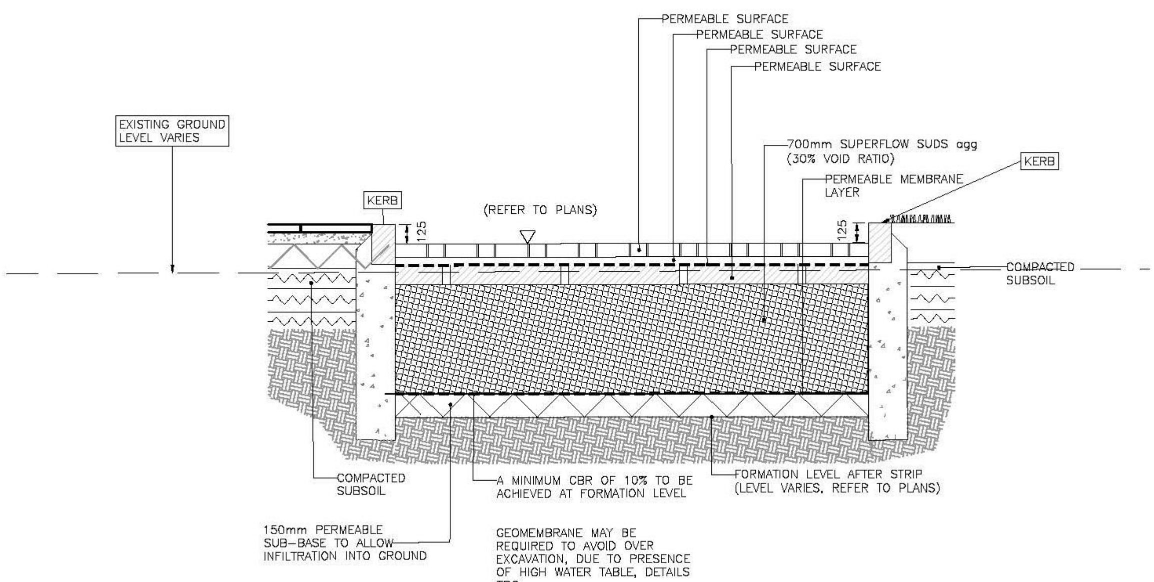


Figure 11 Original drainage strategy, section through parking courts

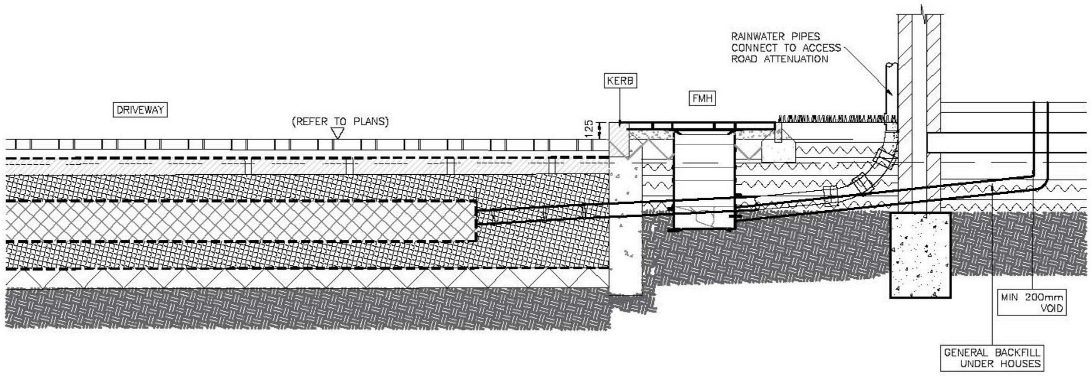


Figure 12 Original drainage strategy, section through rainwater discharge

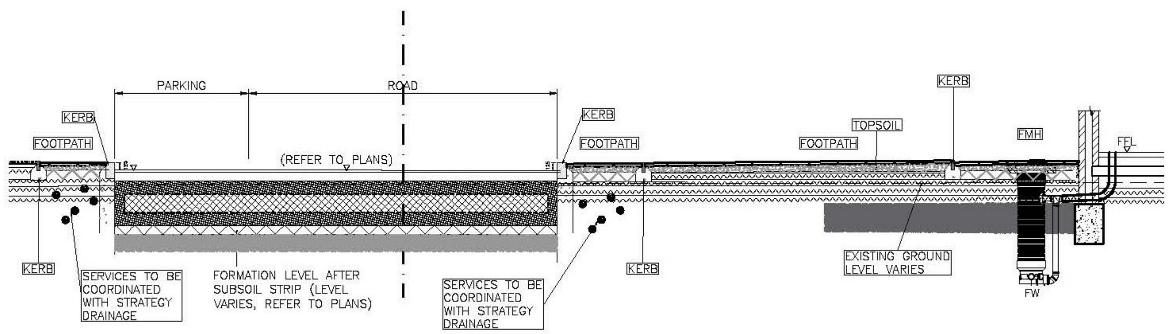


Figure 13 Original drainage strategy, cross section

3.03 Amended Stormwater Drainage Strategy

Further to the additional testing undertaken in October 2022, the stormwater drainage strategy has been re-considered.

It is intended to adopt the ECO-90 system, an augmented shallow infiltration system, as the principle means of discharge of stormwater for the development.

The original principle of shallow attenuation storage and shallow infiltration will be utilised only in isolated areas (see design proposals for catchments E and J).

The drainage proposal will discharge stormwater via attenuation storage crates, with the stormwater passing out of the base of the attenuation storage into ECO-90 system "clusters" of 12m deep bores. Refer to figure 14 below.

The principles of the drainage discharge proposal are described below :-

3.03.1 Catchment Zones

The development site is split into a series of 8 individual catchment zones.

The catchment zones match the test point locations for the 8 suites of deeper infiltration testing, and the shallow infiltration test locations from October 2022.

3.03.2 Drainage Discharge into Ground Within Catchment Zone

Each catchment zone will have its own local drainage system.

Discharge of stormwater into the ground will occur via ECO-90 clusters, located beneath attenuation storage, at discreet locations within each catchment zone, except catchment J, see below.

For this development, an ECO-90 Cluster is calculated per square meter. The number of clusters required for this development are calculated in the catchment specific discharge design calculations attached to this report as Appendix G.

For smaller catchment zones C and D, attenuation storage above the ECO-90 clusters will be created by using permeable paving and a stone base containing a minimum of 30 % voids, rather than attenuation cells.

For Catchment E, the layout has been significantly amended in this location. It is proposed to incorporate a cellular tank below ground beneath the rear gardens to plots 82 to 85, discharging into ECO-90 Clusters.

For larger catchments zones A, B, F, G and H, attenuation storage above the ECO-90 clusters will be provided by attenuation cells rather than permeable paving stone bases.

For catchment zone J, permeable paving will be utilised without ECO-90 clusters beneath, discharging into the ground at shallow depth.

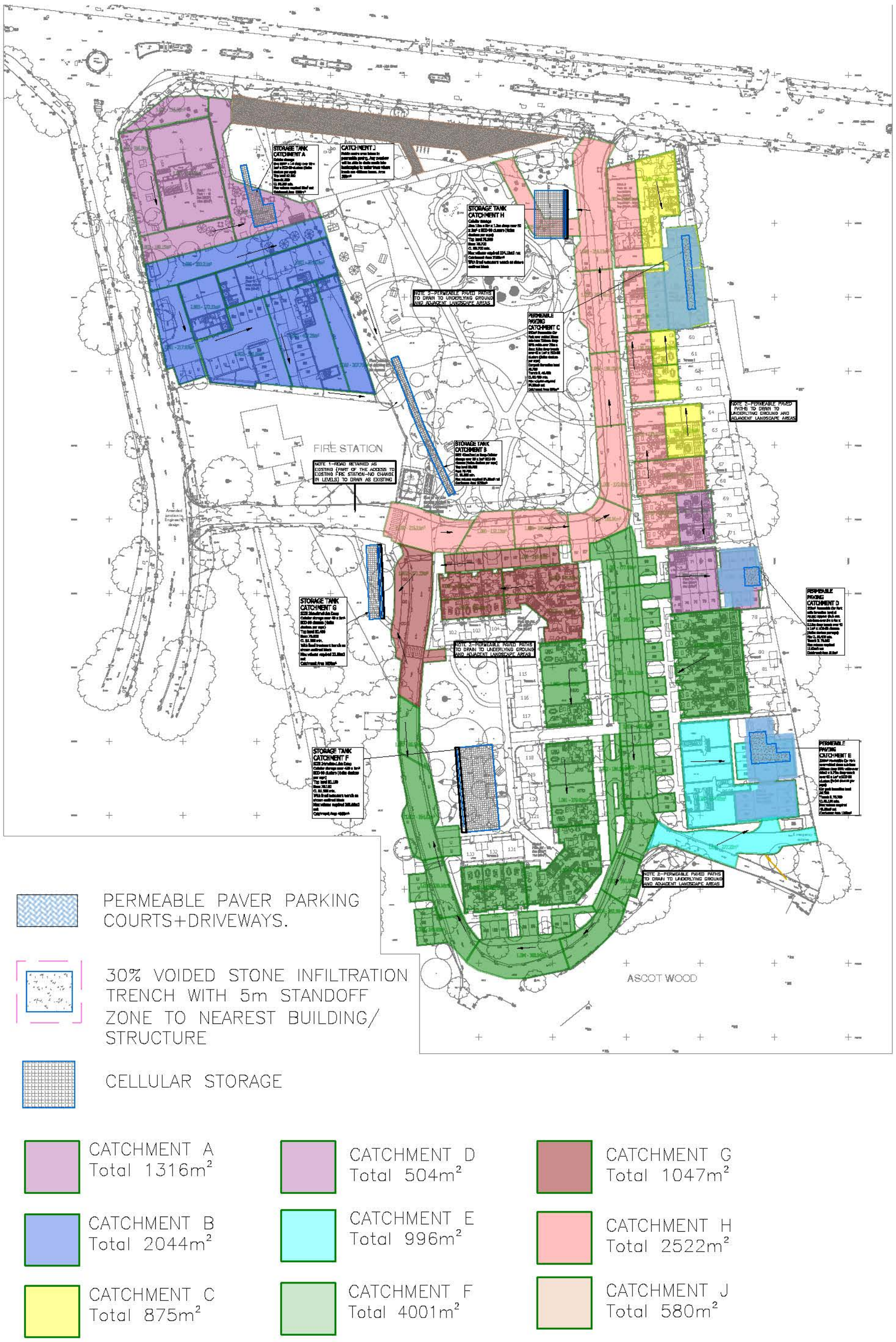


Figure 14 Drainage strategy, Catchment zones and discreet discharge via ECO-90 clusters as submitted in FRA Addendum Revision P3

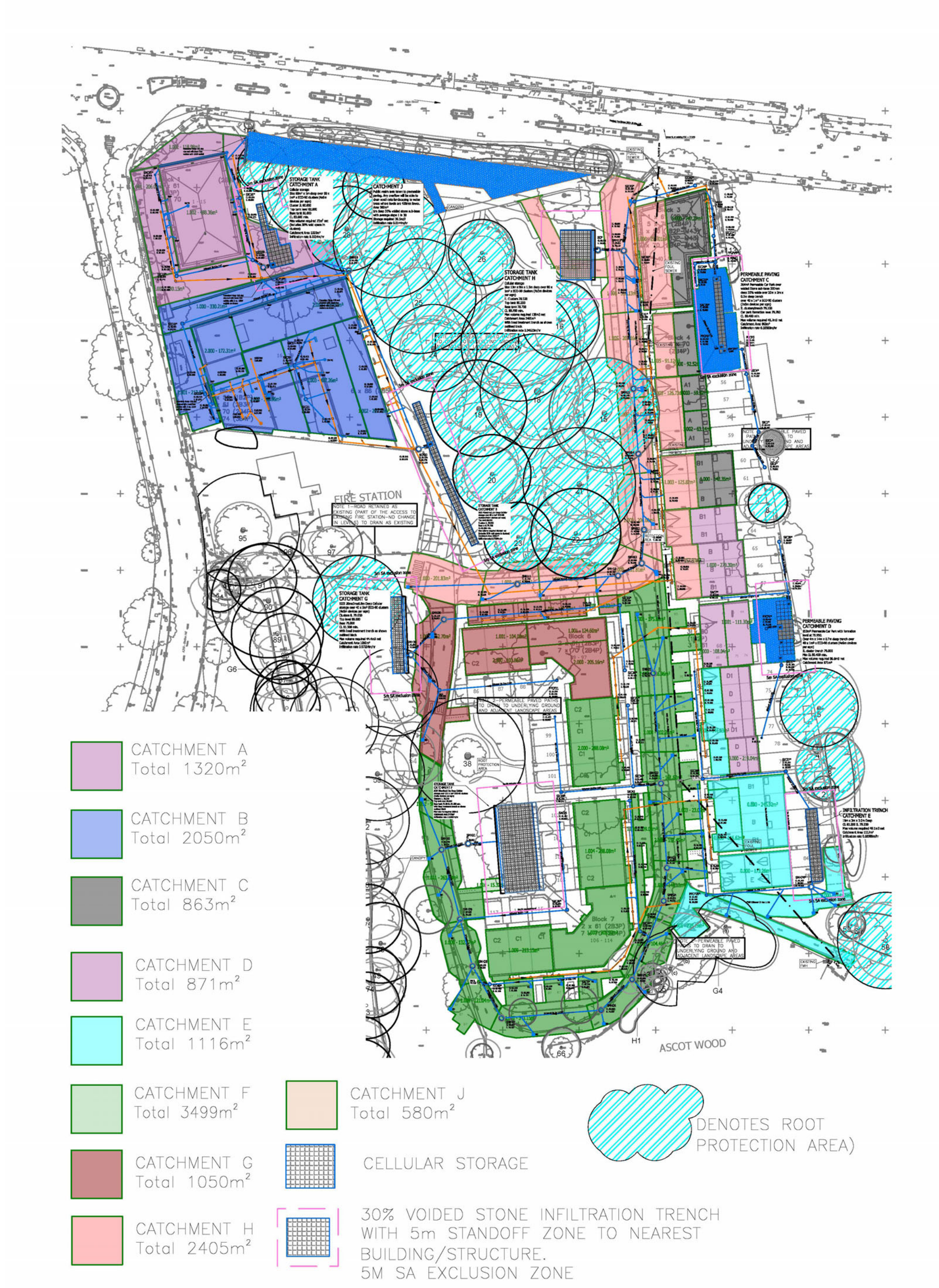


Figure 14A Drainage strategy, Catchment zones and discreet discharge via ECO-90 clusters as submitted in FRA Addendum Revision P3

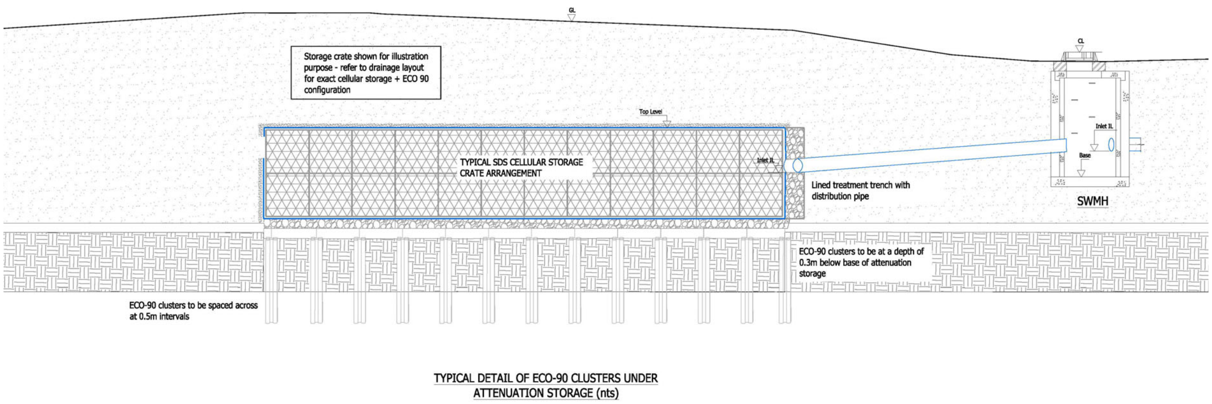


Figure 15 GWD Eco-90 Detail

3.03.3 Conveyance of Run Off

Traditional piped networks will be constructed to collect run off and discharge into each catchment attenuation tank within each zone.

Roofs

Roof areas remain similar to those originally proposed. Roof areas will discharge via traditional rainwater pipes into local below ground drainage collector pipes.

Impermeable Roads and Drives

The new access road through the development falls within 3 of the 8 catchment zones, F, G and H.

Run off will be collected via traditional deep trapped road gullies and will be conveyed via a traditional piped network to the attenuation tank in each individual catchment.

Within each attenuation tank F, G and H, a lined treatment trench is incorporated to deal with pollutants within the run off from impermeable roads and driveways, prior to passing into the attenuation tank and discharging into the underlying ground via the ECO-90 clusters.

Paths

Paths within open spaces and green spaces will be permeably paved and will discharge to the ground and to adjacent areas of soft landscaping.

3.03.4 Summary of Attenuation Volumes and ECO-90 Clusters

Catchment A ***(Catchment Area 1320m2)***

Net 73m3 net of cellular storage over ***62 No ECO-90*** clusters on a 1m x 1m grid (4 No 6m long ECO-90s per cluster).

Catchment B ***(Catchment Area 2050m2)***

Net 86.4m3 net of cellular storage over ***84 No ECO-90*** clusters on a 1m x 1m grid (4 No 6m long ECO-90s per cluster).

Catchment C ***(Catchment Area 863m2)***

Net 41.7m3 of stone base storage below permeable paving over ***44 No ECO-90 clusters*** on a 1m x 1m grid (2 No 6m long ECO-90s per cluster).

Catchment D ***(Catchment Area 871m2)***

Net 36.8m3 of stone base storage below permeable paving over ***56 No ECO-90 clusters*** on a 1m x 1m grid (4 No 6m long ECO-90s per cluster).

Catchment E ***(Catchment Area 1117m2)***

Net 56 of cellular storage over 95 No ECO-90 Clusters on a 1m x 1m grid (4No 6m long devices per cluster).

Catchment F ***(Catchment Area 3499m2)***

Net 270m3 of cellular storage over ***330 No ECO-90 clusters*** on a 1m x 1m grid (4 No 6m long ECO-90s per cluster).

Discharge to enter attenuation storage via lined treatment trench.

Catchment G ***(Catchment Area 1050m2)***

Net 44.4m3 of cellular storage over ***42 No ECO-90 clusters*** on a 1m x 1m grid (4 No 6m long ECO-90s per cluster).

Discharge to enter attenuation storage via lined treatment trench.

Catchment H ***(Catchment Area 2405m2)***

Net 138m3 of cellular storage over ***82 No ECO-90 clusters*** on a 1m x 1m grid (4 No 3m long ECO-90s per cluster).

Discharge to enter attenuation storage via lined treatment trench.

Catchment J (Catchment Area 580m2, public realm only, no roads or buildings)

Discharge via permeable paving to ground.

3.03.5 Calculations

The number of ECO-90 installations in each cluster, and the required attenuation storage volume, have been calculated on a catchment-by-catchment basis.

The calculations are attached to this report as Appendix G ***(revised calculations issued in rev P4 of this FRA Addendum).***

4.0 Addressing Comments from LLFA

Responses To Comments on Original FRA

The comments received from the LLFA relating to the original drainage strategy report 21146-REP01-FRA dated May 2022, are set out in section 2.05 above and responded to below.

- *Confirmation is required that there is at least 1m from the base of the infiltration device to the top of the groundwater level throughout the site*

Further in situ testing and monitoring has confirmed that the groundwater encountered on site is perched.

Deeper test bores to 12m undertaken in October 2022 recorded dry conditions to depth, with falling head infiltration testing successfully undertaken at all bore test points.

The amended stormwater discharge strategy will discharge to lower more free draining strata.

- *Further BRE 365 infiltration testing should be undertaken*

Further BRE 365 testing has been undertaken and is reported in section 2.02 above.

In addition, further deeper infiltration testing has also been undertaken on site and is reported in section 2.03 above.

- *Is there an alternative method of disposal of surface water ?*

It is intended to adopt the ECO-90 system, an augmented shallow infiltration system, as the principle means of discharge of stormwater for the development.

Responses To Comments Raised by LLFA Dated 24 February 2023

The comments raised in February 2023 were responded to as follows :

1 Can the applicant demonstrate through use of The Simple Index approach as set out within The SuDS Manual CIRIA C753, how sufficient water quality treatment will be provided?

The simple index approach is now included in section 5.01.1 of this addendum

2 The body of the report states that a draft management and maintenance plan is included within Appendix H. However, Appendix H includes drawings of the existing site only.

The draft management plan is attached as Appendix K

3 Section 1.1 of Appendix G states that "EC49 has been appointed by Groundwater Dynamics (GWD) to undertake calculations to demonstrate the level of drainage that may be realised by sustainable means through the use of the GWD Energy-Passive Groundwater Recharge Pump (ECO-90) system for dispersing surface water into ground with low infiltration properties at the natural ground surface". Can the applicant clarify if this is a pumped system?

The Energy Passive Groundwater Recharge Pump is the scientific name of the proprietary device as included in the patent documentation. The device requires no power supply, includes no hinges, pivots or other articulated joints. It comprises a HDPE extrusion that is installed vertically into a small diameter borehole in the ground. See explanation here: https://www.groundwaterdynamics.co.uk/how-the-eco-90-works-for-stormwater/ Groundwater dynamics would be happy to talk the LLFA through their system which have been installed on many sites across the UK and throughout the USA where it was invented.

4 It is our understanding that the ECO-90 sizing and depths have been derived using the infiltration testing presented within Appendix B, of Appendix G. It appears that infiltration testing in these locations has only been undertaken once at each location. For the testing to be BRE Digest 365 compliant the boreholes would be required to be filled three times over the same or consecutive days.

The calculations for the proprietary system are based upon BRE365 and the testing follows a similar procedure but is not a BRE365 test. Thorough BRE365 testing was carried out and found to be to variable across the site (refer to previous results as attached). These were insufficient in some areas to drain the site, hence the involvement of Groundwater Dynamics. The proprietary system uses a test procedure devised for the system, a calculation system devised for the system and is warranted by the system providers/installers.

5 Can the applicant clarify how the infiltration rate used in the MicroDrainage calculations, and the ECO-90 calculations been calculated?

The calculations provided are presented in a stepwise manner with units clearly identified. The calculations can be explained in further detail on a one-to-one basis with Groundwater dynamics subject to the signing of appropriate non-disclosure agreements. We can arrange this via a Teams meeting if required

6 We note that calculations for the ECO-90 for catchment J have been included in the FRA addendum. However, this area is proposed to drain via permeable paving. Can calculations for this please be provided?

Please see catchment J calculations attached within zip file. These are based on an infiltration rate of 0.0144m/hr (or 4x10-6m/s), which is the rate of shallow soakage test SA1 in the attached test results.

We have also updated the drainage layout to a more detailed design, and made some adjustments to the size and shape of the attenuation above the ECO-90 areas, but still using the rates as shown in the ECO-90 report. See attached detailed drainage layouts and full set of updated MD calcs.

7 How has the risk of groundwater impacting the ECO-90 system been mitigated?

The systems have been designed to be clear of recorded groundwater in the usual manner. In cases where limited amounts of groundwater are found, such as perched lenses, these will generally be drained to lower strata as part of the functioning of the system between the designed rainfall events. As long as the perched lenses are intercepted during the test drill exercise, the calculated rates for the system discharge will include inflow from the perched water.

8 Section 3.03.2 states that catchments C, D and E will have permeable paving as storage. However the MicroDrainage models make use of a porosity value of 0.95.

These have now been modelled as complex structures, with a 150mm deep infiltration trench sitting above the ECO-90 clusters with porous car park with porosity value of 0.3. See attached zip file.

<u>Further Query Raised by LLFA By Email (Project Centre To B&A Dated 14 April 2023)</u>

The following query was raised by the LLFA as noted above, and responded to as set out below :-

Within the responses to Points 6 and 8, the catchments referenced are to drain via permeable paving and as such we would expect the porosity value within the MicroDrainage calculations to be 0.3.

The responses appear to indicate that this has been addressed from Rev PA of the FRA Addendum but looking at the modelled results the porosity values are as per the below table.

I thought it would be useful to indicate where I'm looking to get these numbers, within a fairly large document. If I'm looking at the wrong section, can you please let me know where I should be looking.

Catchment	*Page*	*Issue*
Catchment C	*161*	*Porosity 0.95*
Catchment D	*165*	*Porosity modelled as 1*
Catchment E	*169*	*Porosity modelled as 1*
Catchment J	*185*	*Porosity modelled as 1*

The following response was forwarded by email 19 April 2023 (B&A to Project Centre).

Please find attached copies of the following information from GTA which we believe answer your queries.

GTA Civils below ground drainage general arrangement drawings 12112/1601 and 1602 indicating the proposed drainage layouts.

Catchment area MicroDrainage Calculations as follows :-

Catchment A dated 13 December 2022
Catchment B dated 13 December 2022
Catchment C dated 13 December 2022 Permeable Paving (porosity now modelled as 0.3).
Catchment D dated 13 December 2022 Permeable Paving (porosity now modelled as 0.3).
Catchment E dated 13 December 2022 Permeable Paving (porosity now modelled as 0.3).
Catchment F dated 14 December 2022
Catchment G dated 14 December 2022
Catchment H dated 13 December 2022
Catchment J dated 13 December 2022 (porosity now modelled as 0.3).

Whilst the calculation header sheets are dated December 2022, the calculations have been updated.

<u>Further Query Raised by LLFA By Email (Project Centre To B&A Dated 27 April 2023)</u>

I've been working my way through my comments, and I'm down to only 1. I think it would be worth going through the calculations set out in the attachment so I can bottom out my last issue and get this one resolved.

Would you have availability w/c 8th for an hour or so just so I can fully understand the calculations?

A Teams meeting was held between the design team and the LLFA on Tuesday 9 May 2023 to review the calculations submitted.

During the course of the meeting the LLFA requested written clarification on the following point originally raised in the comments dated 24 February 2023:-

5 Can the applicant clarify how the infiltration rate used in the MicroDrainage calculations, and the eco-90 calculations been calculated ?

For example;

The cluster calculation sets out infiltration test results achieved at various lengths of eco-90, 1.5m, 3m, 6m, 9m, 12m.

The calculated eco-90 infiltration rate- for example catchment area A states the infiltration rate as 0.22344m/hr.

How is this infiltration rate arrived at from the cluster calculation on the previous sheet and from the in situ testing undertaken by Groundwater Dynamics?

The comment was responded to as follows to the LLFA with the response provided by Engineering Consultancy 49, the designers of the ECO-90 system for the development :-

Without giving away the core of my business - although i am happy to explain the calculations over the phone to the LLFA's representative (and have done for several LLFA's and water companies in the past).

Calculations for the infiltration rates take the results of the test drilling exercise and apply a modified version of the BRE365 calculation (modified for shape of trial and volume of water) by following the BRE calculation alongside the calculations in the report - and taking notice of the units, the calculation procedure is clear.

The results of the test drilling exercise are treated on a BH-by-BH basis.

The reduction in water level (i.e. discharged volume) is divided over the wetted area to arrive at an infiltration rate in m/sec and converted to m/hr for compatibility with MicroDrainage. This process intrinsically underestimates the infiltration rate in a similar way to the BRE365 calculation.

The rate calculated in this way can then be multiplied by the surface area of the borehole to achieve a rate per borehole. By using additional boreholes (up to a maximum of 4 per sq. m) allows the system to gain the benefit of greater surface area over a traditional soakaway. 4 is the maximum used as any more than this and the boreholes simply transfer water into each other via the microfissures created by the ECO-90 array maturing and whilst the weight of the column of water acting under gravity "pushes" water into the low permeability soils faster than it would normally leave a traditional soakaway in the same soil, it does not allow the full benefits of the ECO-90 product to be realised.

Calculating the rate for 1sq.m cluster in this way allows the system to be readily scalable through the MD rainfall simulations to achieve figures for storage volume and half drain time etc.

It should be noted that in addition to the underestimation of the infiltration rate inherent in the BRE calculation, the calculations are not yet sophisticated enough to consider the maturation of the system in the soil type as this is a function of the composition, compaction , voids ratio and particle size distribution of the soils that the product is installed into.

Between the underestimation from the BRE365 calculation, ignoring the maturing of the system and the factor of safety of 2, we have only had - to the best of my knowledge - one instance of an installation not operating as intended in the last 8+ years and that turned out to be as a result of an offsite (upstream and man-made) issue and was resolved by moving the installation to another part of the site.

This is the slightly more technical version than given previously. As stated above, I would be happy to discuss with the LLFA if they require further information and would be willing to talk through the calculations on a step-by-step basis to achieve the required outcome.

Hopefully, the above is sufficient but let me know if you require further information.

Final Comments on FRA Addendum

The LLFA completed their review with no further queries.

The LLFA comments dated 12 May 2023, are set out below :-

1. Noted that the proposed SuDS will provide sufficient treatment for the surface water discharge.

2. Noted the provision of the proposed maintenance activities.

3. Noted that the clarification on how the groundwater recharge pump will operate.

4. It is our understanding that the ECO-90 increases the rate of infiltration by increasing the fissures in the soil locally around the device, and as such the infiltration rate increases over time. As set out in the response to our previous comments the product makes use of its own test procedure devised for the system and is warranted by the providers/installers. As LLFA we are therefore satisfied by the hydraulic design of the system and consider it within the remit of building control to determine if bRE365 testing is required.

5. We acknowledge the clarification regarding the calculations of ECO-90 depth, and spacing and consider it has now been sufficiently demonstrated the proposed surface water drainage infrastructure has been sized so as to manage flood risk up to the 1 in 100 year plus climate change event.

6. We note the provision of revised MicroDrainage calculations for catchment J, utilising the correct porosity for permeable paving and indicating that flooding is not predicted by the model

7. It is noted that the impact of groundwater on the performance of the system has been accounted for.

8. We note the provision of revised MicroDrainage calculations for catchments C,D and E, utilising the correct porosity for permeable paving and indicating that flooding is not predicted by the model.

5.0 Approvals and Adoption of SuDS

The ongoing management and maintenance of SuDS will fall under the responsibility of the site owner/operator.

A draft management and maintenance plan is attached as Appendix K.

5.01 Pollution Control

A pre-treatment trench is incorporated, wrapped in Inbitex, at the downstream end of the piped networks receiving run off from the highway carriageway and hard standings.

The pre-treatment trench will filter hydrocarbon pollutants prior to entering the attenuation storage.

The detailed sizing of the pre-treatment trench will follow at detailed design stage.

The ECO-90 system receives flow from above.

Where the subbase/attenuation crate system is in receipt of outflow from roads/car parking the system is lined with Inbitex, a bio geo-textile, which uses microbial populations to deal with hydrocarbon pollutants.

One metre square of Inbitex can deal with 400g of hydrocarbon each year – which negates the need for an interceptor.

The attenuation crate system in the soakaways is fully wrapped in Inbitex over a blinding layer of 10mm cleaned gravel.

5.01.1 The Simple Index Approach for Water Quality Management

Referring to The SuDS manual CIRIA 753 Chapter 26, the Simple Index Approach considers the level of pollution hazard appropriate for the development, and considers which SuDS measures are able to provide an adequate level of pollution Mitigation.

The Pollution Hazard Indices are assessed for the development proposals.

The mitigation indices for the SuDS features in the development are then assessed.

Provided that the SuDS mitigation indices are greater than or equal to the Pollution Hazard Indices, then it is concluded that the SuDS features provided are sufficient.

Determine the Pollution Hazard Index

Low traffic roads, parking areas, roofs and significant soft landscaping.

Hazard level deemed to be low.

The following Pollution Hazard Indices are appropriate to the development :-

Suspended solids	0.5
Metals	0.4
Hydrocarbons	0.4

Consider SuDS Measures Incorporated into the Development:-

The following SuDS measures are incorporated into the development :-

Permeable Paving

Permeable paving is proposed for all parking courts in the development and for public areas at the Ascot High Street (North end of the site).

Permeable paving provides a mitigation index of 0.7.

The permeable paving is proposed at the car parking courts and will therefore be located at the source of the pollution hazard.

Pre-Treatment Trenches

Pre-Treatment trenches are proposed for each catchment that receives run off from the low traffic residential roads in the development, prior to run off entering the cellular storage and ECO 90 discharge clusters.

Pre-Treatment trenches have a mitigation index of 0.4.

Deep Trap Road Gullies

The low traffic residential roads drain to deep trap road gullies that will act as initial receptors for silt and sediment and will assist with removal of suspended solids prior to run off entering the pre-treatment trenches.

Deep trap gullies do not have an index in the Simple index Approach but are a primary means of trapping suspended solids in the run off from the low traffic roads.

SuDS Mitigation Index for Development

The SuDS mitigation indices for the development proposals are equal to or greater than the pollution hazard indices.

The combination of deep trap road gullies and pre treatment trench provides an adequate mitigation index.

The permeable paving provides an adequate mitigation index.

5.02 Below Ground Services Coordination

The primary drainage system will be in the same shallow plane as the incoming statutory services that will service the development.

It will be necessary to pre-plan the coordination of below ground services, to run through dedicated service corridors to run parallel to areas of permeable paving to avoid issues associated with damage to the permeable paving and statutory provider requirements for laying services away from permeable areas.

Dedicated service corridors will need to be laid out and coordinated with the below ground drainage networks.

Crossing points for services to cross permeable paved roads and the like will need to be coordinated and designated and worked to as part of the overall coordination of works below ground for the development.

It should also be noted that there are significant trees on the site, some of which have root protection areas that are located in areas where new services are likely to be laid.

Detailed consideration will need to be given to the methods used for the installation of drain pipes and services so as to comply with the requirements of the arboricultural assessment for the site.

6.0 Conclusions

The key conclusions of this Flood Risk Assessment are as follows:

1. The proposed residential development falls wholly within Flood Zone 1 and fluvial floodwater will not enter the development site.

2. Consideration of residual risks within the development proposals indicate that the development proposal is acceptable.

3. The below ground drainage proposals contain and discharge stormwater run-off from the development site and will not increase flood risk elsewhere.

4. Permeable paving is considered appropriate for parking courts and parking areas.

5. Infiltration from attenuation storage vessels will be incorporated across the development site, discharging into the ground at low level.

6. The occupants of the development will not be vulnerable and can safely access and egress the development via a dry route surrounding the site.

7. Other possible sources of flooding have been considered and the development proposal has been shown not to be vulnerable to flooding from sheet flow or sewer surcharging and flooding.

APPENDIX A

AP Geotechnics
Original Infiltration Testing March 2022

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

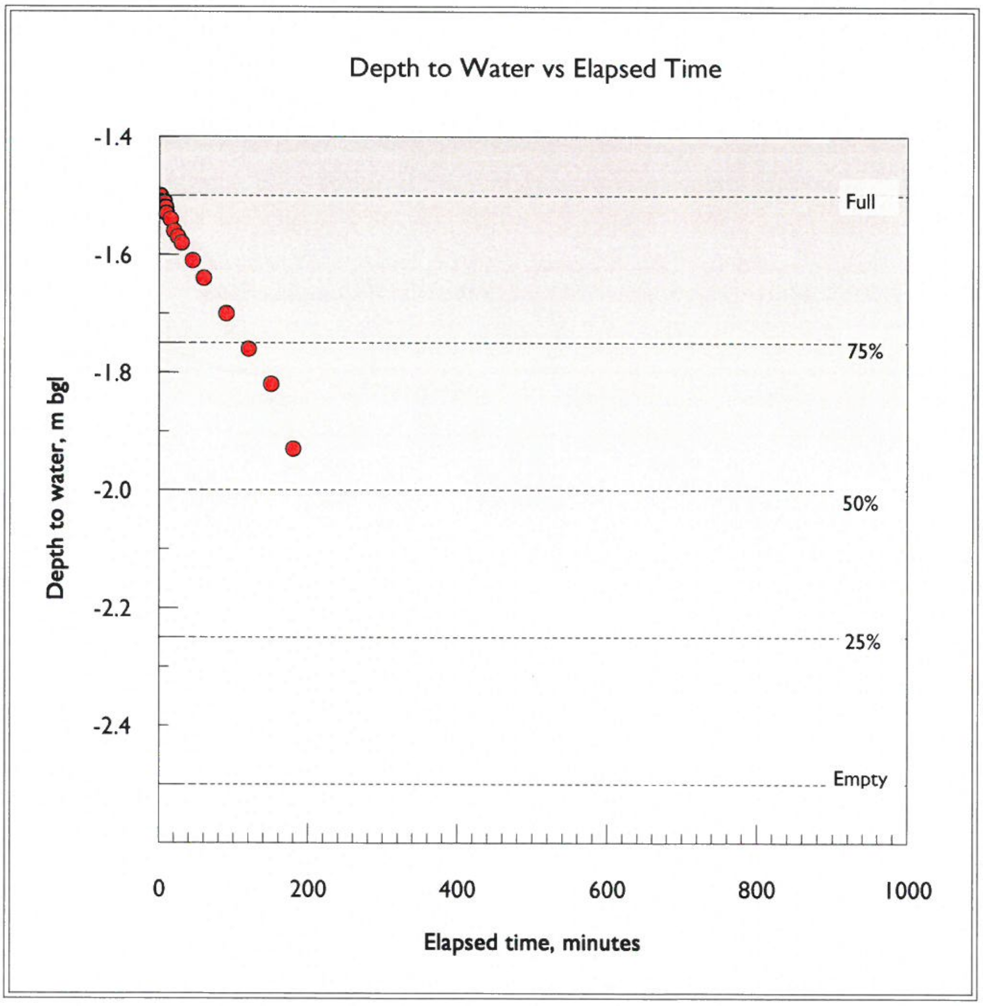
Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT — Project No: 5506
Client: London Square — Sheet No: 1/1

TP	1
Test No.	1
Depth, m	2.50
Length, m	1.60
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.500
1.0	1.500
2.0	1.500
3.0	1.510
4.0	1.510
5.0	1.510
6.0	1.510
7.0	1.510
8.0	1.520
9.0	1.520
10.0	1.530
15.0	1.540
20.0	1.560
25.0	1.570
30.0	1.580
45.0	1.610
60.0	1.640
90.0	1.700
120.0	1.760
150.0	1.820
180.0	1.930



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.48 m^3

A50 = 3.16 m^2

T75-T25 = 407 min (extrapolated)

f = <u>6.22E-006</u> m/s (extrapolated)

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

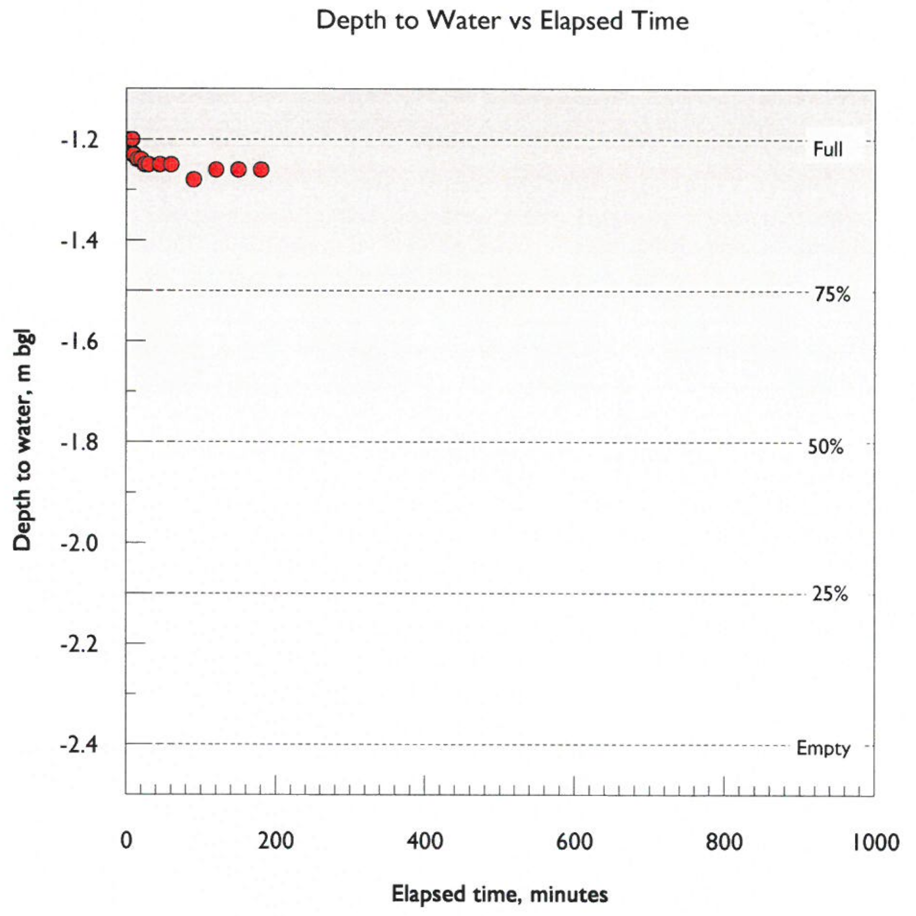
Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT — Project No: 5506
Client: London Square — Sheet No: 1/1

TP	2
Test No.	1
Depth, m	2.40
Length, m	1.60
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.200
1.0	1.200
2.0	1.200
3.0	1.200
4.0	1.200
5.0	1.200
6.0	1.200
7.0	1.200
8.0	1.200
9.0	1.230
10.0	1.230
15.0	1.240
20.0	1.240
25.0	1.250
30.0	1.250
45.0	1.250
60.0	1.250
90.0	1.280
120.0	1.260
150.0	1.260
180.0	1.260



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.58 m^3
A50 = 3.60 m^2
T75-T25 = indeterminate min

f = indeterminate m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

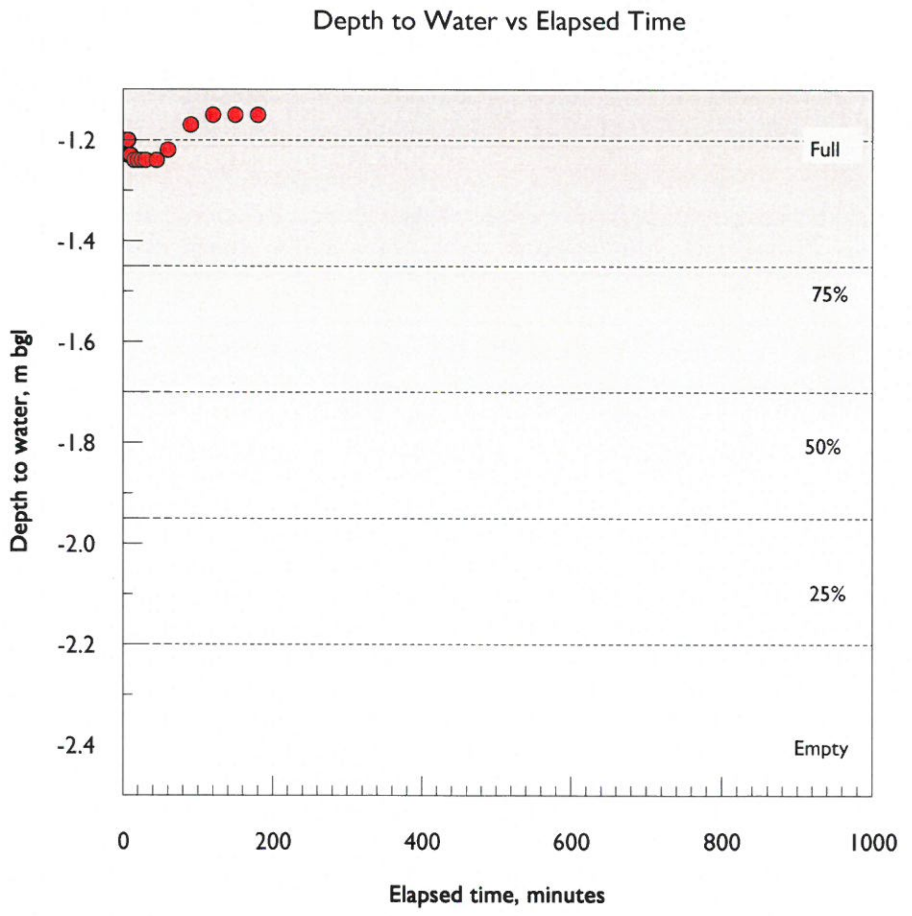
Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT — Project No: 5506
Client: London Square — Sheet No: 1/1

TP	3
Test No.	1
Depth, m	2.20
Length, m	1.70
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.200
1.0	1.200
2.0	1.200
3.0	1.200
4.0	1.200
5.0	1.200
6.0	1.200
7.0	1.200
8.0	1.230
9.0	1.230
10.0	1.230
15.0	1.240
20.0	1.240
25.0	1.240
30.0	1.240
45.0	1.240
60.0	1.220
90.0	1.170
120.0	1.150
150.0	1.150
180.0	1.150



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.51 m^3
A50 = 3.32 m^2
T75-T25 = indeterminate min

f = indeterminate m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

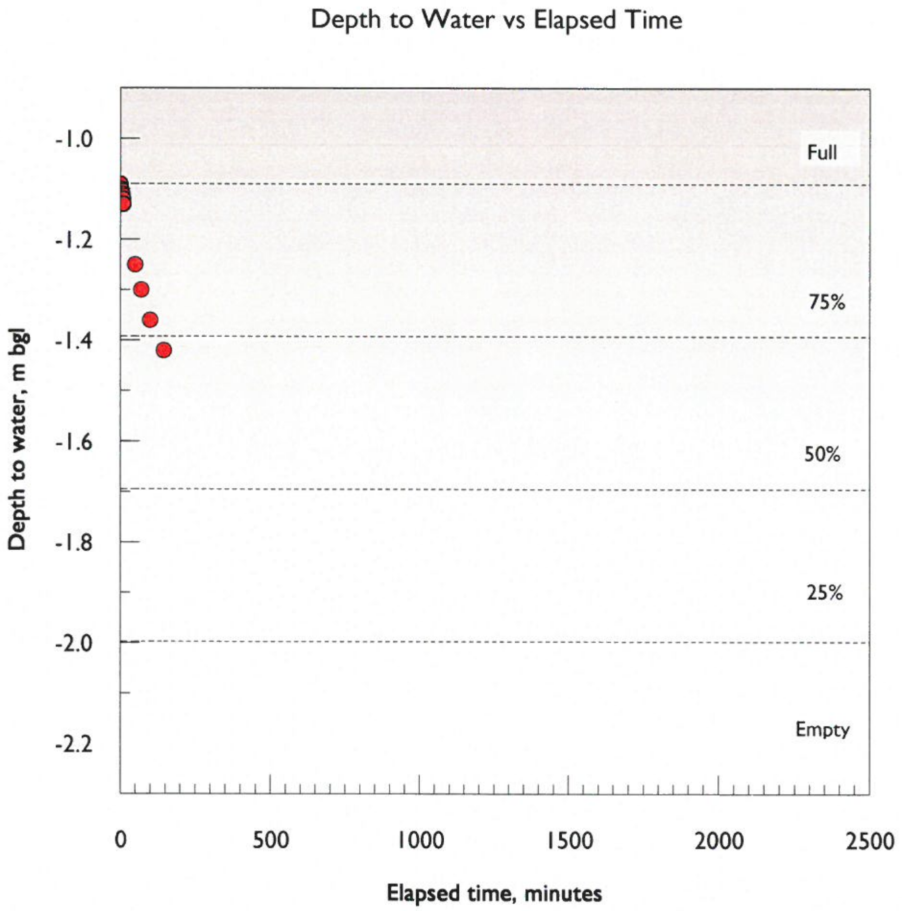
Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT — Project No: 5506
Client: London Square — Sheet No: 1/1

TP	4
Test No.	1
Depth, m	2.30
Length, m	1.75
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.090
1.0	1.090
2.0	1.100
3.0	1.100
4.0	1.110
5.0	1.110
6.0	1.110
7.0	1.110
8.0	1.120
9.0	1.120
10.0	1.130
50.0	1.250
70.0	1.300
100.0	1.360
145.0	1.420



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.64 m^3

A50 = 3.89 m^2

T75-T25 = 1450 min (extrapolated)

f = 1.88E-006 m/s (extrapolated)

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT
Client: London Square

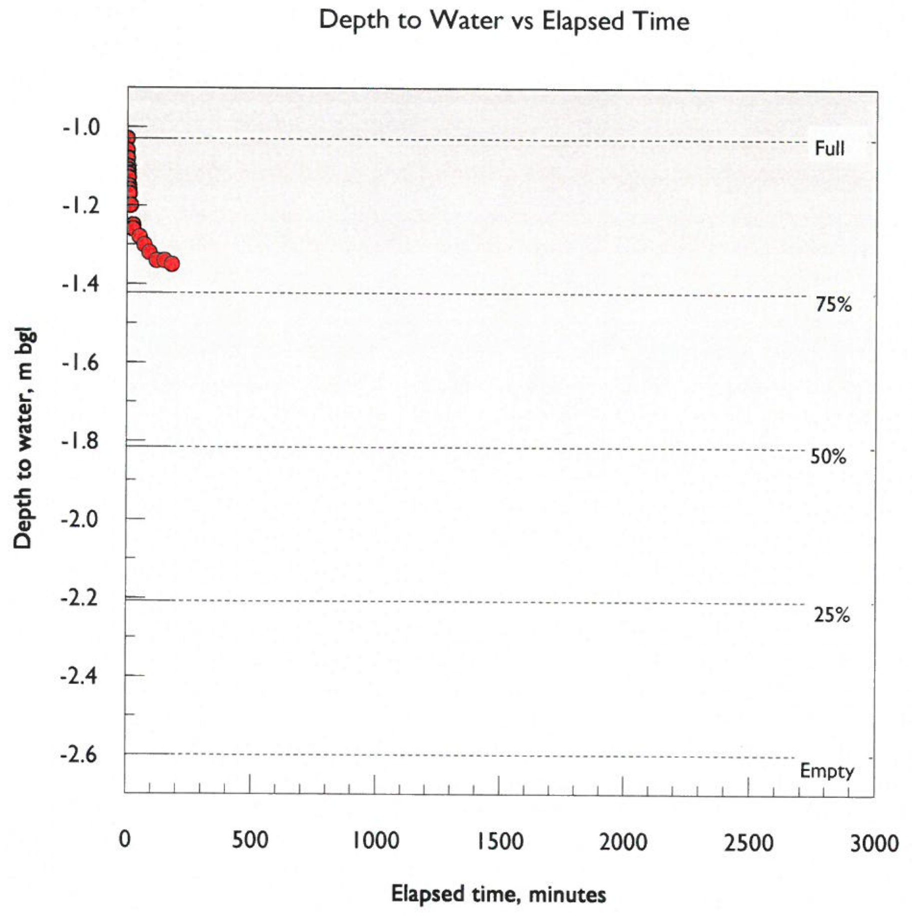
Project No: 5506
Sheet No: 1/1

TP	5
Test No.	1
Depth, m	2.60
Length, m	1.70
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.030
1.0	1.060
2.0	1.080
3.0	1.100
4.0	1.110
5.0	1.120
6.0	1.130
7.0	1.150
8.0	1.160
9.0	1.170
10.0	1.170
15.0	1.200
25.0	1.250
35.0	1.260
50.0	1.280
70.0	1.300
90.0	1.320
120.0	1.340
150.0	1.340
180.0	1.350



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.80 m^3

A50 = 4.63 m^2

T75-T25 = indeterminate min

f = indeterminate m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

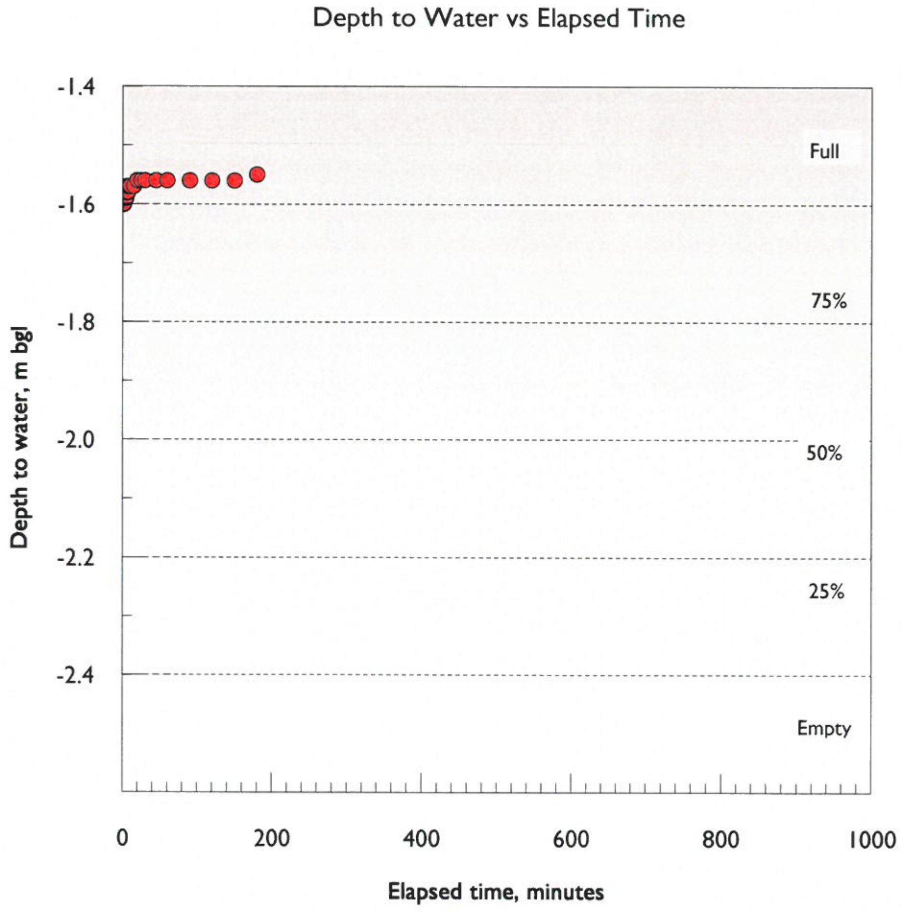
Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT — Project No: 5506
Client: London Square — Sheet No: 1/1

TP	6
Test No.	1
Depth, m	2.40
Length, m	1.70
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.600
1.0	1.600
2.0	1.600
3.0	1.590
4.0	1.590
5.0	1.590
6.0	1.580
7.0	1.580
8.0	1.570
9.0	1.570
10.0	1.570
15.0	1.570
20.0	1.560
25.0	1.560
30.0	1.560
45.0	1.560
60.0	1.560
90.0	1.560
120.0	1.560
150.0	1.560
180.0	1.550



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.41 m^3
A50 = 2.86 m^2
T75-T25 = indeterminate min

f = indeterminate m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT
Client: London Square

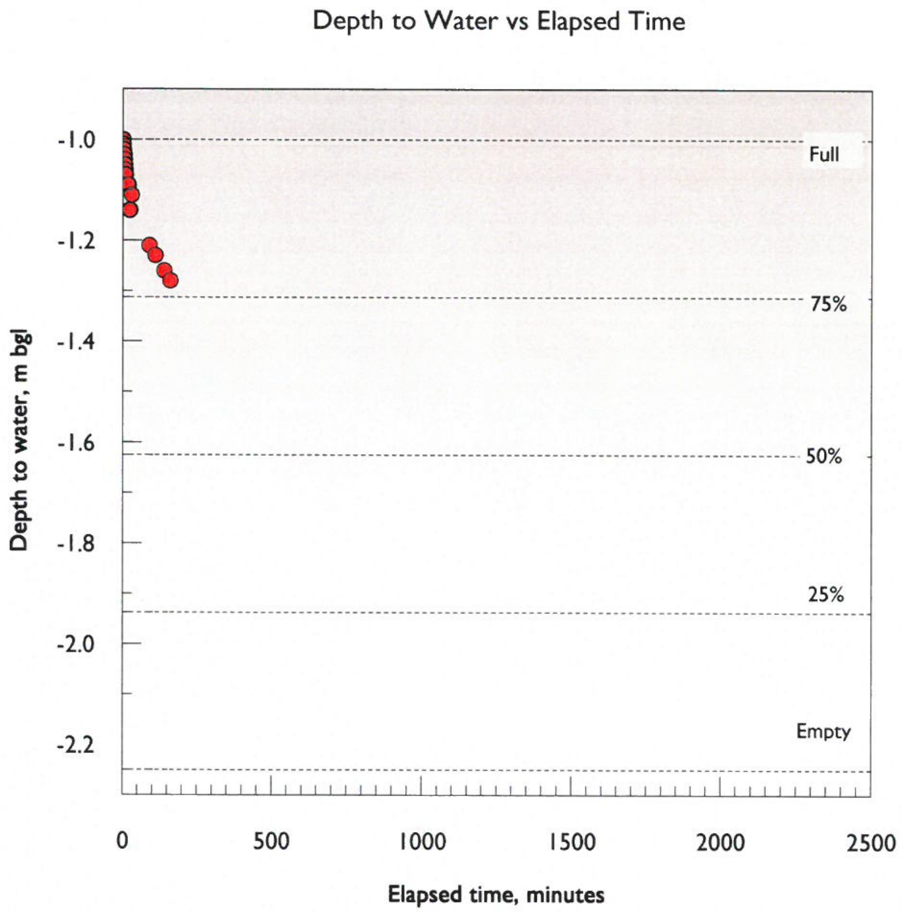
Project No: 5506
Sheet No: 1/1

TP	7
Test No.	1
Depth, m	2.25
Length, m	1.75
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.000
1.0	1.000
2.0	1.000
3.0	1.010
4.0	1.020
5.0	1.030
6.0	1.030
7.0	1.040
8.0	1.050
9.0	1.060
10.0	1.070
20.0	1.090
30.0	1.110
50.0	1.140
90.0	1.210
110.0	1.230
140.0	1.260
160.0	1.280



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.66 m^3

A50 = 3.99 m^2

T75-T25 = 1450 min (extrapolated)

f = 1.89E-006 m/s (extrapolated)

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

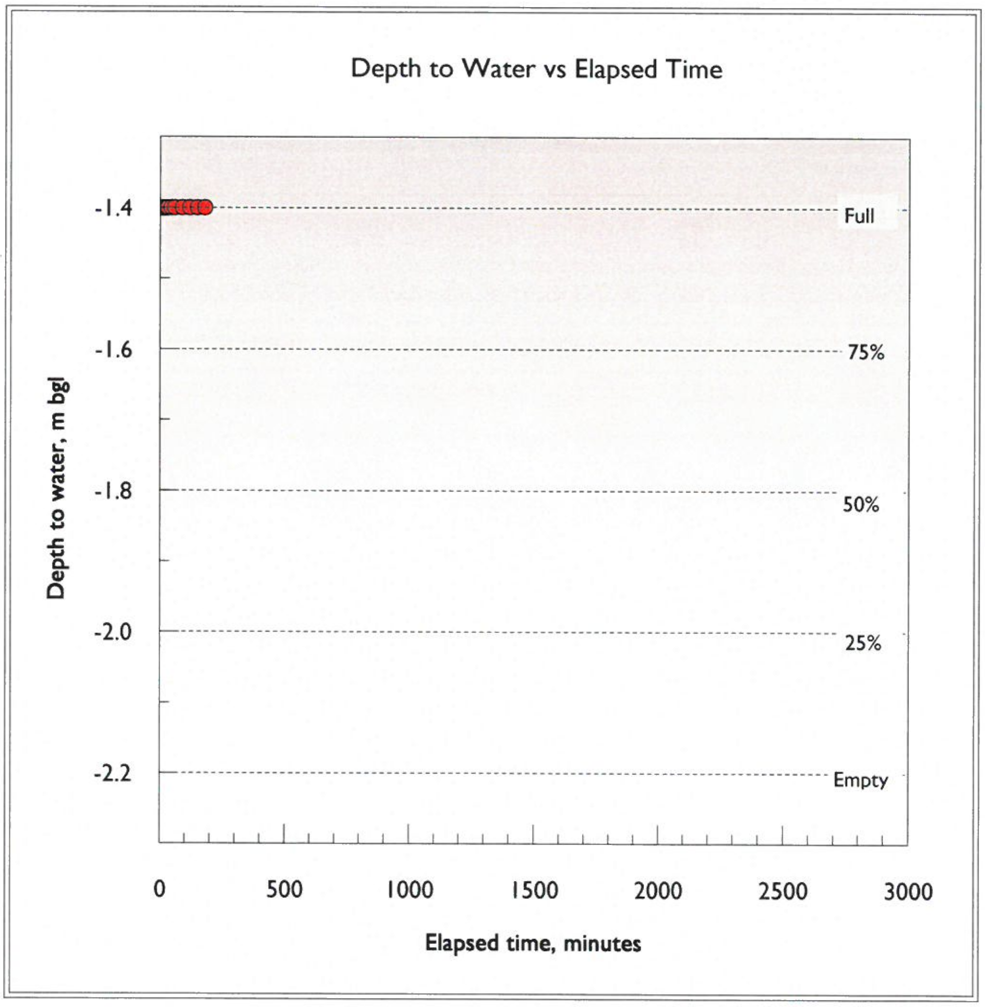
Project: LAND OFF STATION HILL AND ASCOT HIGH STREET, ASCOT — Project No: 5506
Client: London Square — Sheet No: 1/1

TP	8
Test No.	1
Depth, m	2.20
Length, m	1.70
Width, m	0.60

Description of stratum under test
Bagshot Formation

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	1.400
1.0	1.400
2.0	1.400
3.0	1.400
4.0	1.400
5.0	1.400
6.0	1.400
7.0	1.400
8.0	1.400
9.0	1.400
10.0	1.400
15.0	1.400
20.0	1.400
25.0	1.400
30.0	1.400
45.0	1.400
60.0	1.400
90.0	1.400
120.0	1.400
150.0	1.400
180.0	1.400



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.41 m^3

A50 = 2.86 m^2

T75-T25 = indeterminate min

f = <u>indeterminate</u> m/s

APPENDIX B

AP Geotechnics
Additional Infiltration Testing October 2022

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

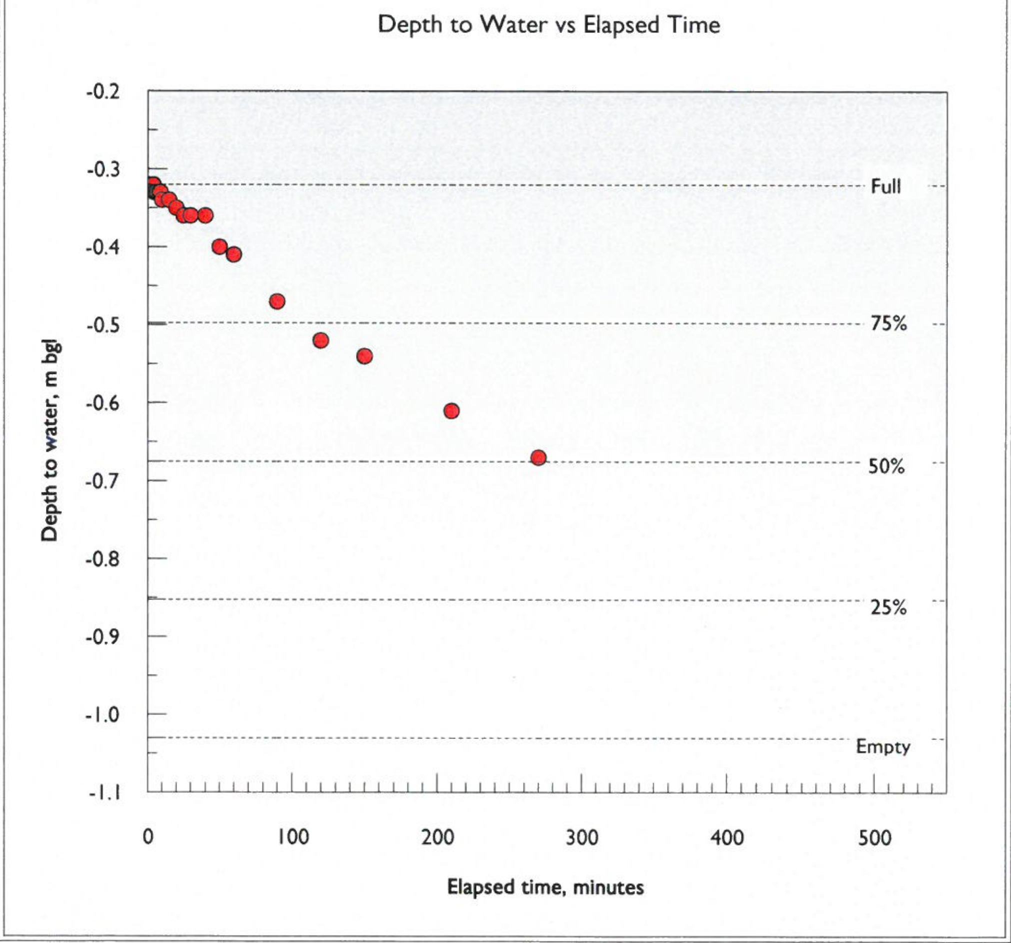
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 1/2

SA	1
Test No.	1
Depth, m	1.03
Length, m	1.10
Width, m	0.60

Description of stratum under test
Red brown, orange brown and grey mottled sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.320
1.0	0.320
2.0	0.320
3.0	0.320
4.0	0.320
5.0	0.330
6.0	0.330
7.0	0.330
8.0	0.330
9.0	0.330
10.0	0.340
15.0	0.340
20.0	0.350
25.0	0.360
30.0	0.360
40.0	0.360
50.0	0.400
60.0	0.410
90.0	0.470
120.0	0.520
150.0	0.540
210.0	0.610
270.0	0.670



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.23 m^3

A50 = 1.87 m^2

T75-T25 = 460 min extrapolated

f = **4.55E-006 m/s** extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

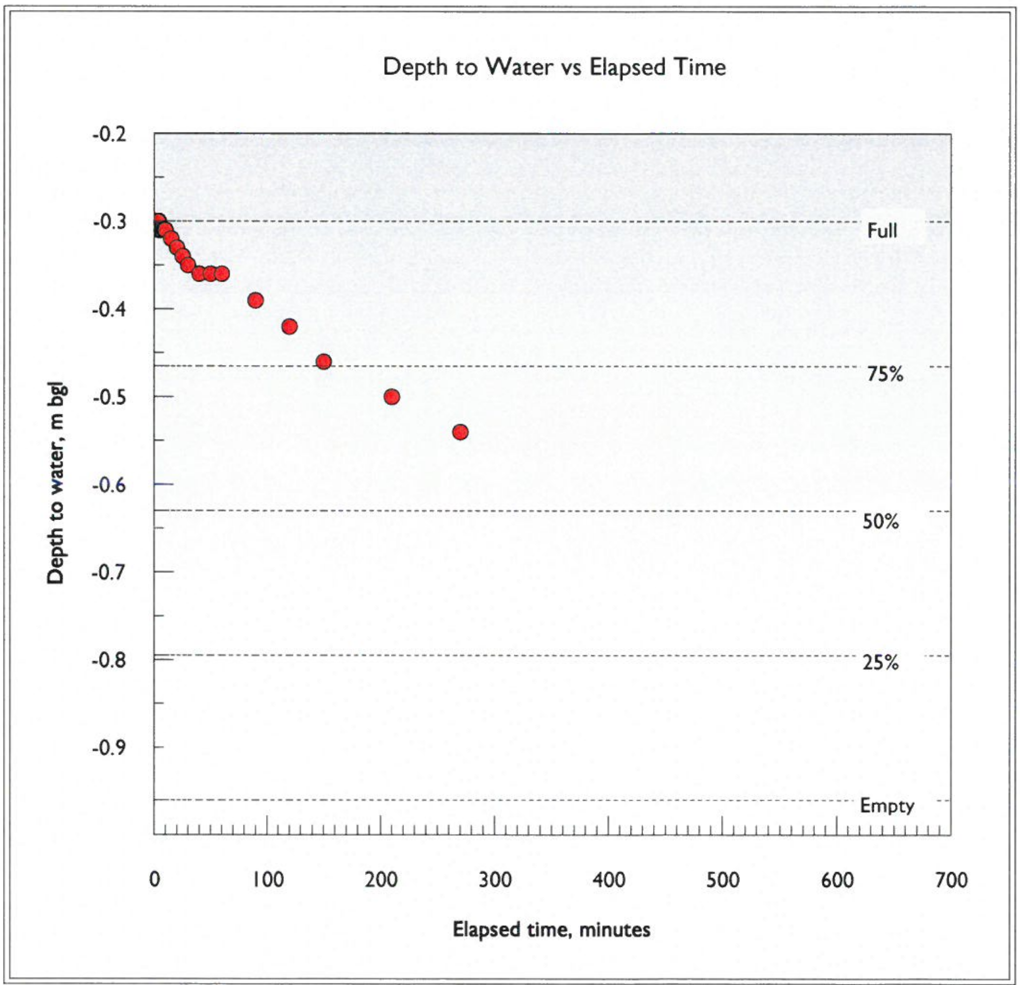
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 2/2

SA	1
Test No.	2
Depth, m	0.96
Length, m	1.10
Width, m	0.60

Description of stratum under test
Red brown, orange brown and grey mottled sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.300
1.0	0.300
2.0	0.300
3.0	0.300
4.0	0.300
5.0	0.310
6.0	0.310
7.0	0.310
8.0	0.310
9.0	0.310
10.0	0.310
15.0	0.320
20.0	0.330
25.0	0.340
30.0	0.350
40.0	0.360
50.0	0.360
60.0	0.360
90.0	0.390
120.0	0.420
150.0	0.460
210.0	0.500
270.0	0.540



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.22 m^3

A50 = 1.78 m^2

T75-T25 = 475 min extrapolated

f = 4.29E-006 m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

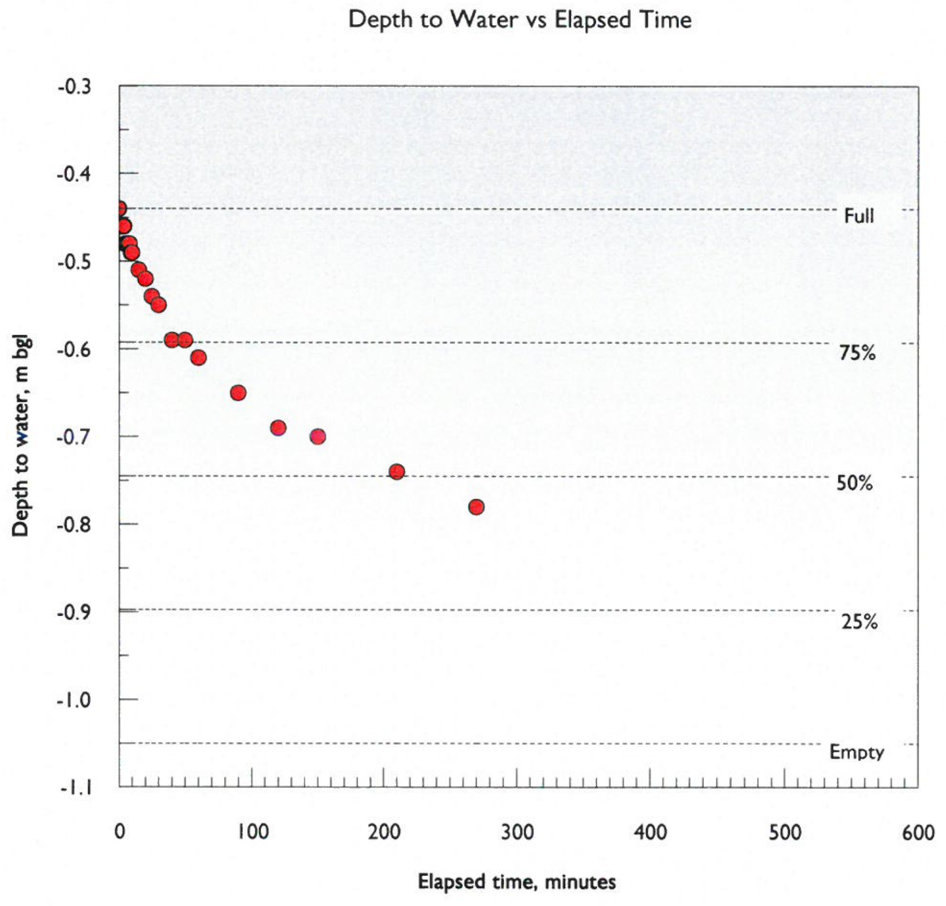
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 1/2

SA	2
Test No.	1
Depth, m	1.05
Length, m	1.50
Width, m	0.60

Description of stratum under test
Red brown, orange brown and grey mottled sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.440
1.0	0.460
2.0	0.460
3.0	0.460
4.0	0.460
5.0	0.480
6.0	0.480
7.0	0.480
8.0	0.480
9.0	0.490
10.0	0.490
15.0	0.510
20.0	0.520
25.0	0.540
30.0	0.550
40.0	0.590
50.0	0.590
60.0	0.610
90.0	0.650
120.0	0.690
150.0	0.700
210.0	0.740
270.0	0.780



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.27 m^3

A50 = 2.18 m^2

T75-T25 = 540 min extrapolated

f = 3.88E-006 m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

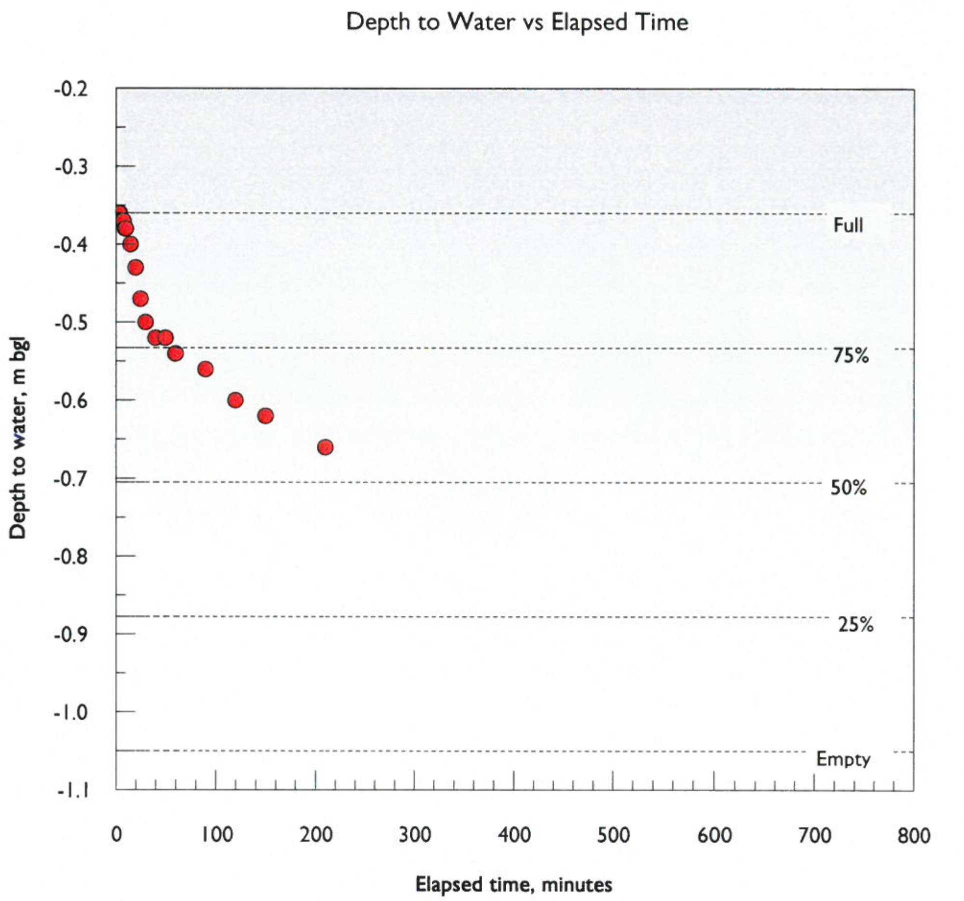
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 2/2

SA	2
Test No.	2
Depth, m	1.05
Length, m	1.50
Width, m	0.60

Description of stratum under test
Red brown, orange brown and grey mottled sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.360
1.0	0.360
2.0	0.360
3.0	0.360
4.0	0.360
5.0	0.370
6.0	0.370
7.0	0.370
8.0	0.370
9.0	0.380
10.0	0.380
15.0	0.400
20.0	0.430
25.0	0.470
30.0	0.500
40.0	0.520
50.0	0.520
60.0	0.540
90.0	0.560
120.0	0.600
150.0	0.620
210.0	0.660



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.31 m^3

A50 = 2.35 m^2

T75-T25 = 700 min extrapolated

f = 3.15E-006 m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT
Client: London Square

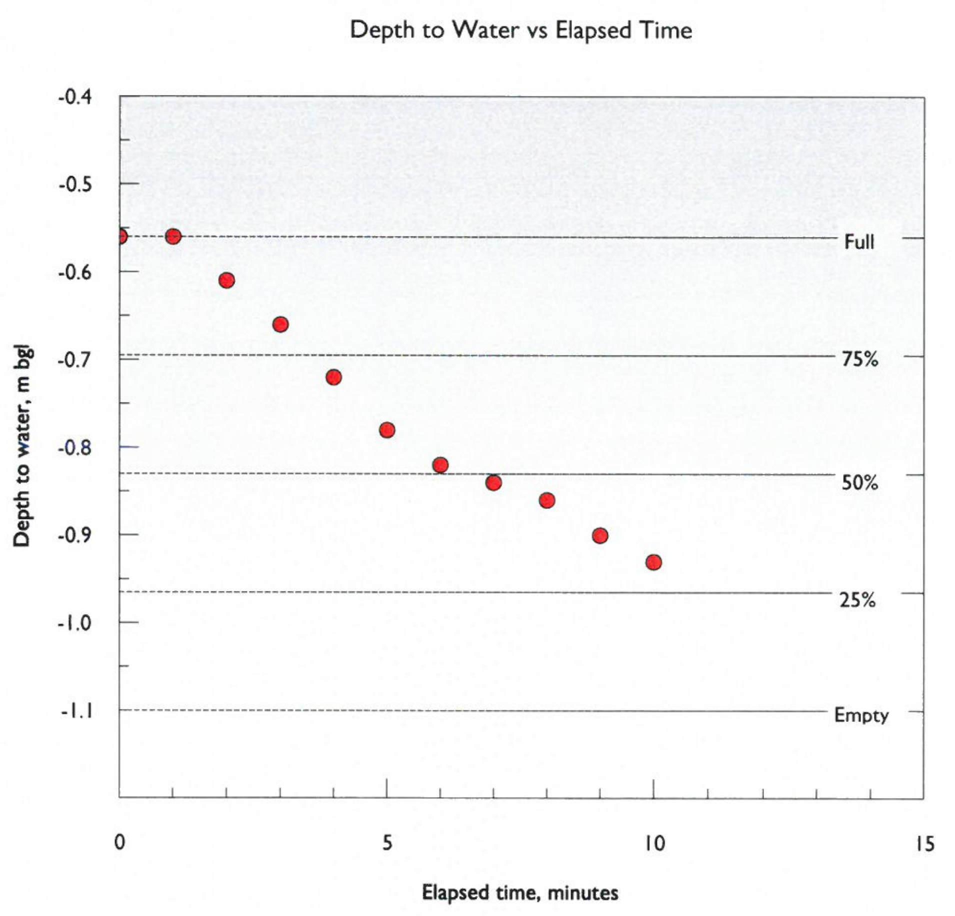
Project No: 5590
Sheet No: 1/3

SA	3
Test No.	1
Depth, m	1.10
Length, m	1.30
Width, m	0.65

Description of stratum under test
MADE GROUND: Dark brown clayey sand with glass, pottery, glass bottles, slate and pottery

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.560
1.0	0.560
2.0	0.610
3.0	0.660
4.0	0.720
5.0	0.780
6.0	0.820
7.0	0.840
8.0	0.860
9.0	0.900
10.0	0.930



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.23 m^3
A50 = 1.90 m^2
T75-T25 = 8 min

f = <u>2.50E-004</u> m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

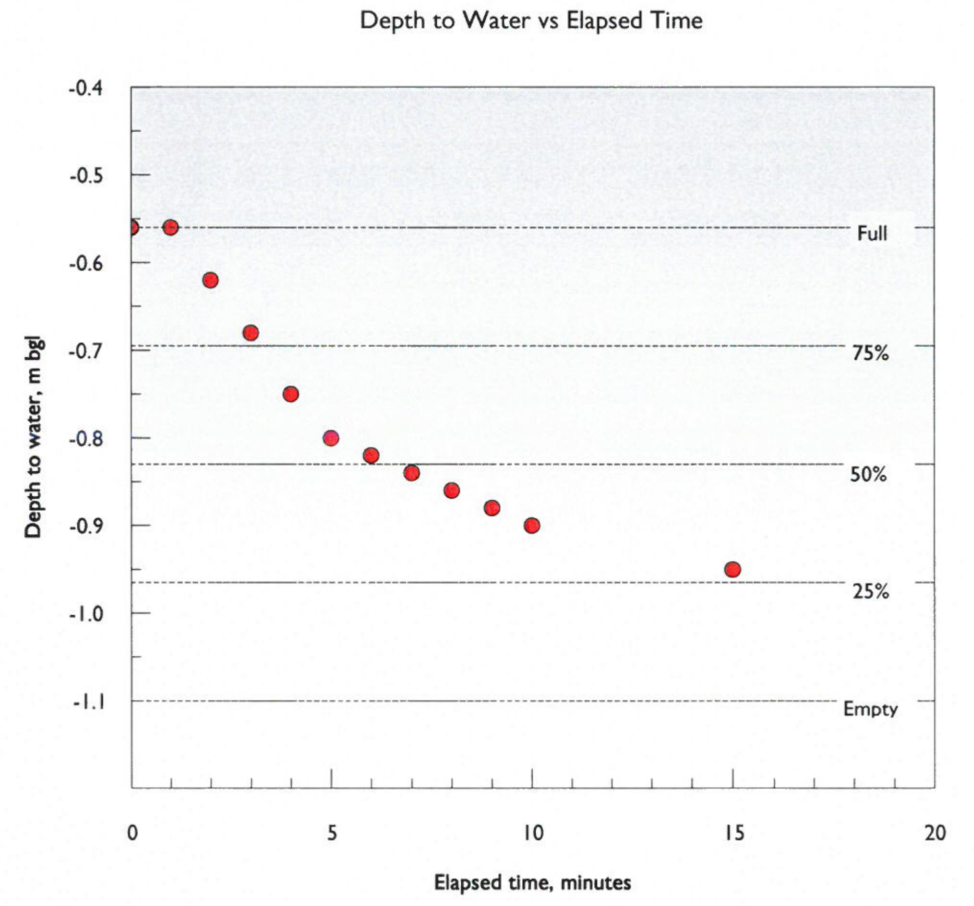
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 2/3

SA	3
Test No.	2
Depth, m	1.10
Length, m	1.30
Width, m	0.65

Description of stratum under test
MADE GROUND: Dark brown clayey sand with glass, pottery, glass bottles, slate and pottery

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.560
1.0	0.560
2.0	0.620
3.0	0.680
4.0	0.750
5.0	0.800
6.0	0.820
7.0	0.840
8.0	0.860
9.0	0.880
10.0	0.900
15.0	0.950



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.23 m^3

A50 = 1.90 m^2

T75-T25 = 15 min

f = 1.34E-004 m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

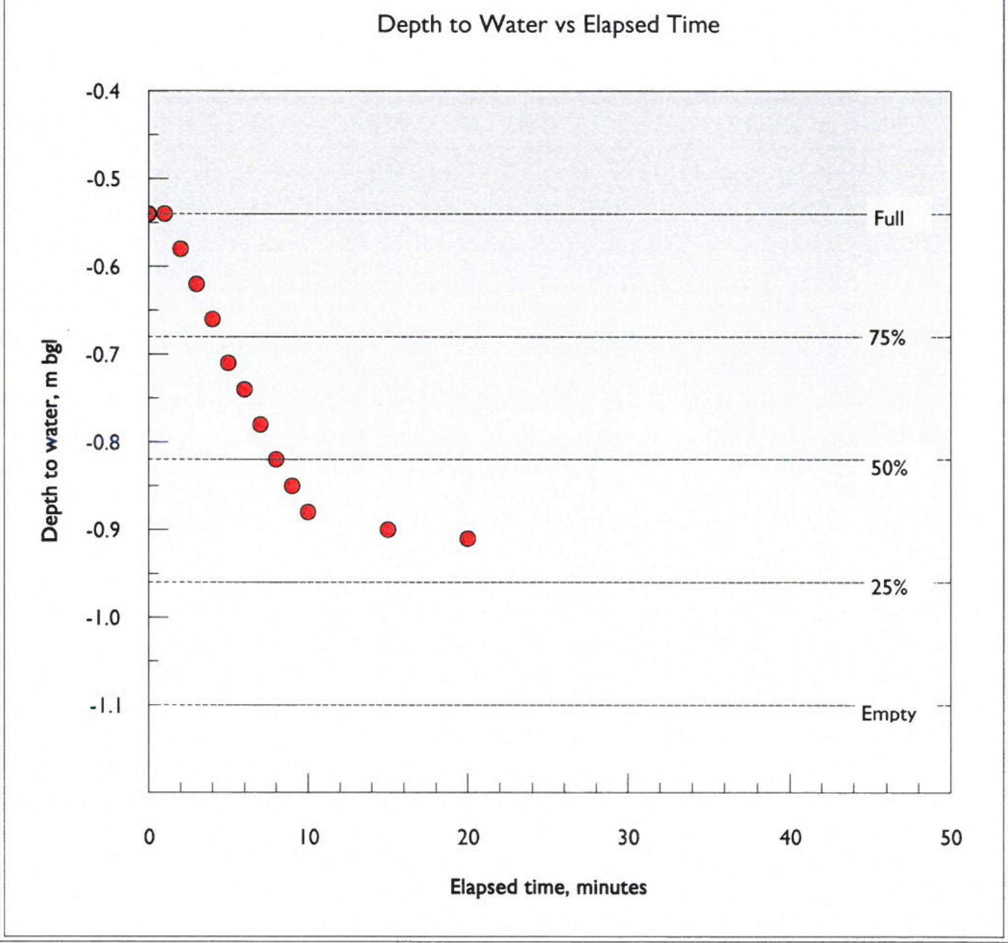
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT, SL5 7JE — Project No: 5590
Client: London Square — Sheet No: 3/3

SA	3
Test No.	3
Depth, m	1.10
Length, m	1.30
Width, m	0.65

Description of stratum under test
MADE GROUND: Dark brown clayey sand with glass, pottery, glass bottles, slate and pottery

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.540
1.0	0.540
2.0	0.580
3.0	0.620
4.0	0.660
5.0	0.710
6.0	0.740
7.0	0.780
8.0	0.820
9.0	0.850
10.0	0.880
15.0	0.900
20.0	0.910



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.24 m^3
A50 = 1.94 m^2
T75-T25 = 36 min extrapolated

f = **5.65E-005** m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

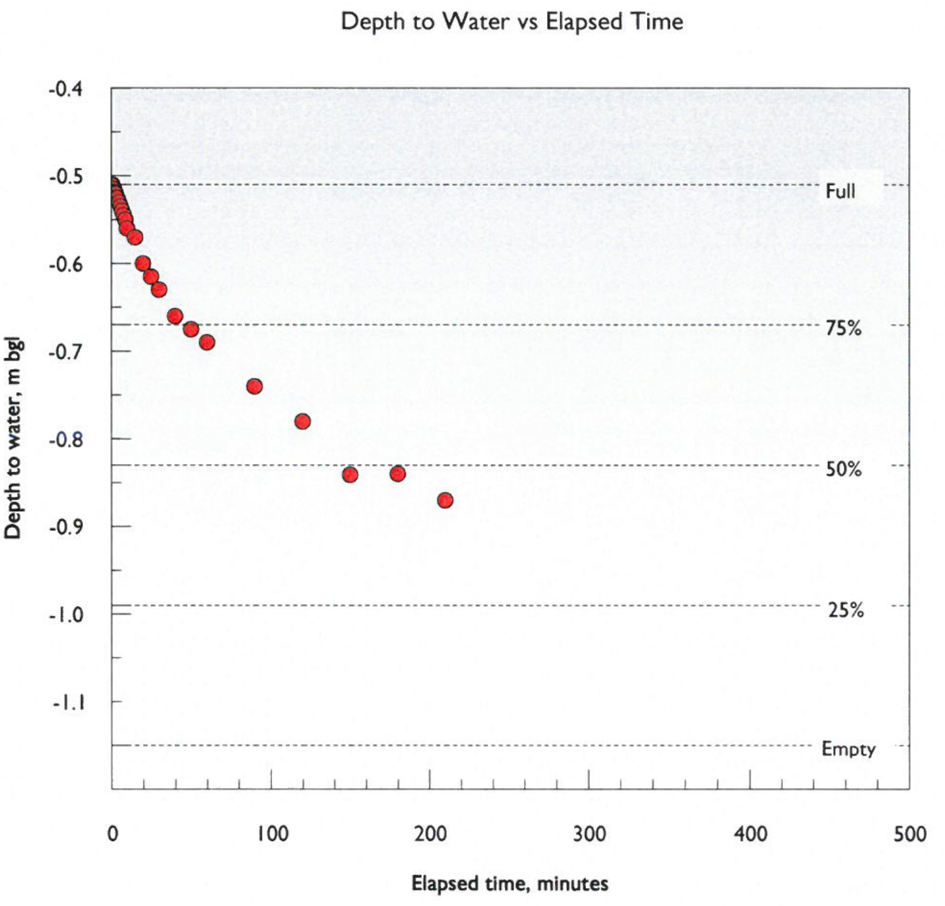
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 1/2

SA	4
Test No.	1
Depth, m	1.15
Length, m	1.10
Width, m	0.65

Description of stratum under test
Orange brown, brown and grey mottled slightly sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.510
1.0	0.510
2.0	0.515
3.0	0.520
4.0	0.525
5.0	0.530
6.0	0.535
7.0	0.540
8.0	0.545
9.0	0.550
10.0	0.560
15.0	0.570
20.0	0.600
25.0	0.615
30.0	0.630
40.0	0.660
50.0	0.675
60.0	0.690
90.0	0.740
120.0	0.780
150.0	0.841
180.0	0.840
210.0	0.870



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.23 m^3

A50 = 1.84 m^2

T75-T25 = 400 min extrapolated

f = **5.20E-006** m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT
Client: London Square

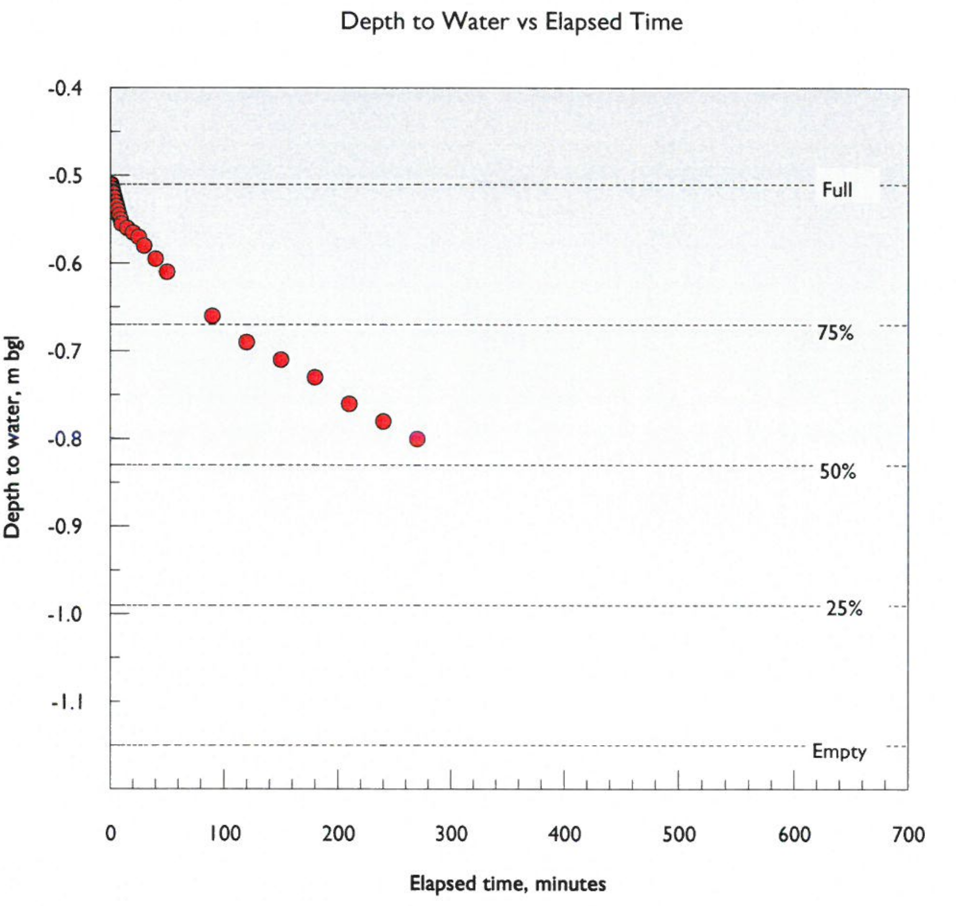
Project No: 5590
Sheet No: 2/2

SA	4
Test No.	2
Depth, m	1.15
Length, m	1.10
Width, m	0.65

Description of stratum under test
Orange brown, brown and grey mottled slightly sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.510
1.0	0.510
2.0	0.515
3.0	0.520
4.0	0.525
5.0	0.530
6.0	0.535
7.0	0.540
8.0	0.545
9.0	0.550
10.0	0.555
15.0	0.560
20.0	0.565
25.0	0.570
30.0	0.580
40.0	0.595
50.0	0.610
60.0	0.325
90.0	0.660
120.0	0.690
150.0	0.710
180.0	0.730
210.0	0.760
240.0	0.780
270.0	0.800
300.0	0.810



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.23 m³
A50 = 1.84 m²
T75-T25 = 600 min extrapolated

f = **3.46E-006** m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

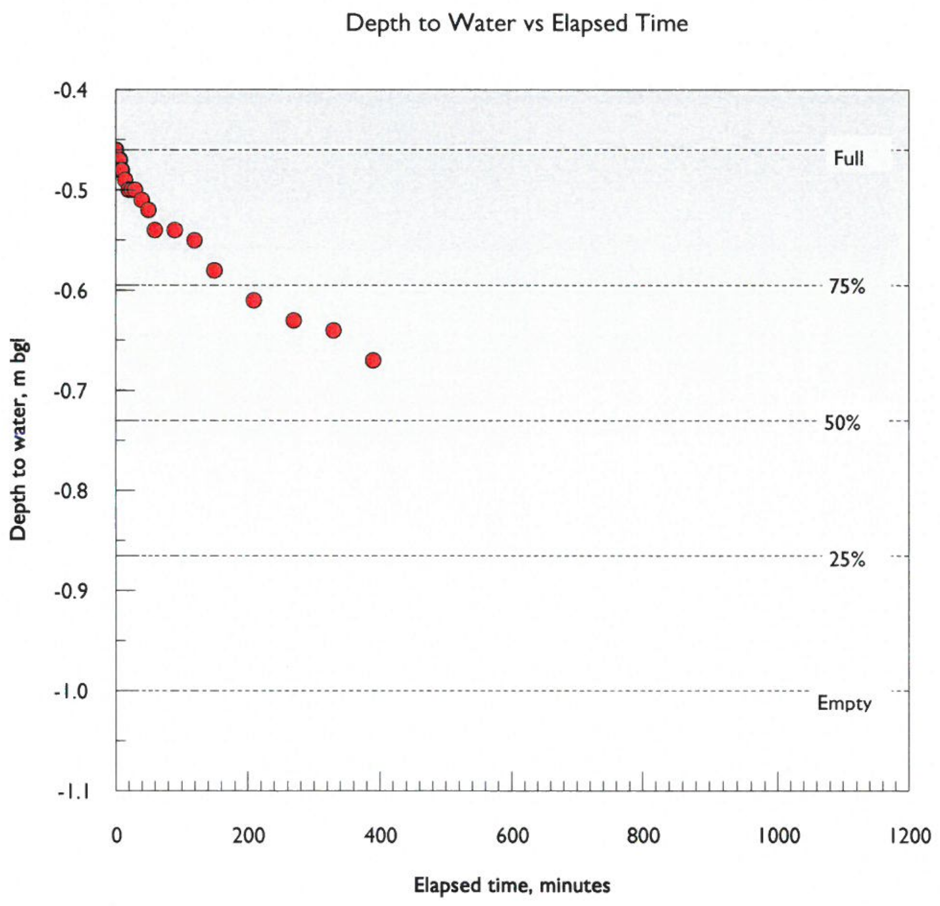
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT, SL5 7JE — Project No: 5590
Client: London Square — Sheet No: 1/2

SA	5
Test No.	1
Depth, m	1.00
Length, m	1.50
Width, m	0.60

Description of stratum under test
Orange brown, brown and grey mottled sandy CLAY with gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.460
1.0	0.460
2.0	0.470
3.0	0.470
4.0	0.470
5.0	0.470
6.0	0.470
7.0	0.470
8.0	0.480
9.0	0.480
10.0	0.480
15.0	0.490
20.0	0.500
25.0	0.500
30.0	0.500
40.0	0.510
50.0	0.520
60.0	0.540
90.0	0.540
120.0	0.550
150.0	0.580
210.0	0.610
270.0	0.630
330.0	0.640
390.0	0.670



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.24 m^3

A50 = 2.03 m^2

T75-T25 = 920 min extrapolated

f = **2.16E-006 m/s** extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

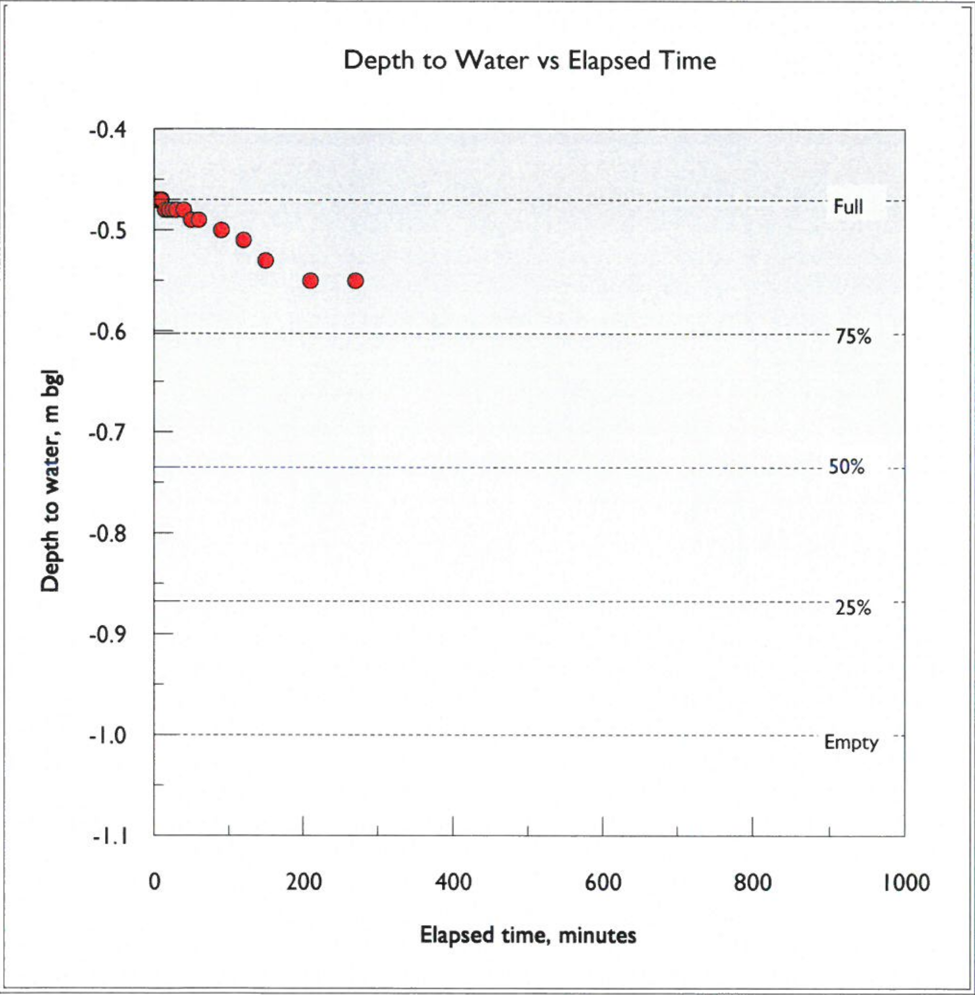
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 2/2

SA	5
Test No.	2
Depth, m	1.00
Length, m	1.50
Width, m	0.60

Description of stratum under test
Orange brown, brown and grey mottled sandy CLAY with gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.470
1.0	0.470
2.0	0.470
3.0	0.470
4.0	0.470
5.0	0.470
6.0	0.470
7.0	0.470
8.0	0.470
9.0	0.470
10.0	0.470
15.0	0.480
20.0	0.480
25.0	0.480
30.0	0.480
40.0	0.480
50.0	0.490
60.0	0.490
90.0	0.500
120.0	0.510
150.0	0.530
210.0	0.550
270.0	0.550



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.24 m³

A50 = 2.01 m²

T75-T25 = indeterminate min

f = <u>indeterminate</u> m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

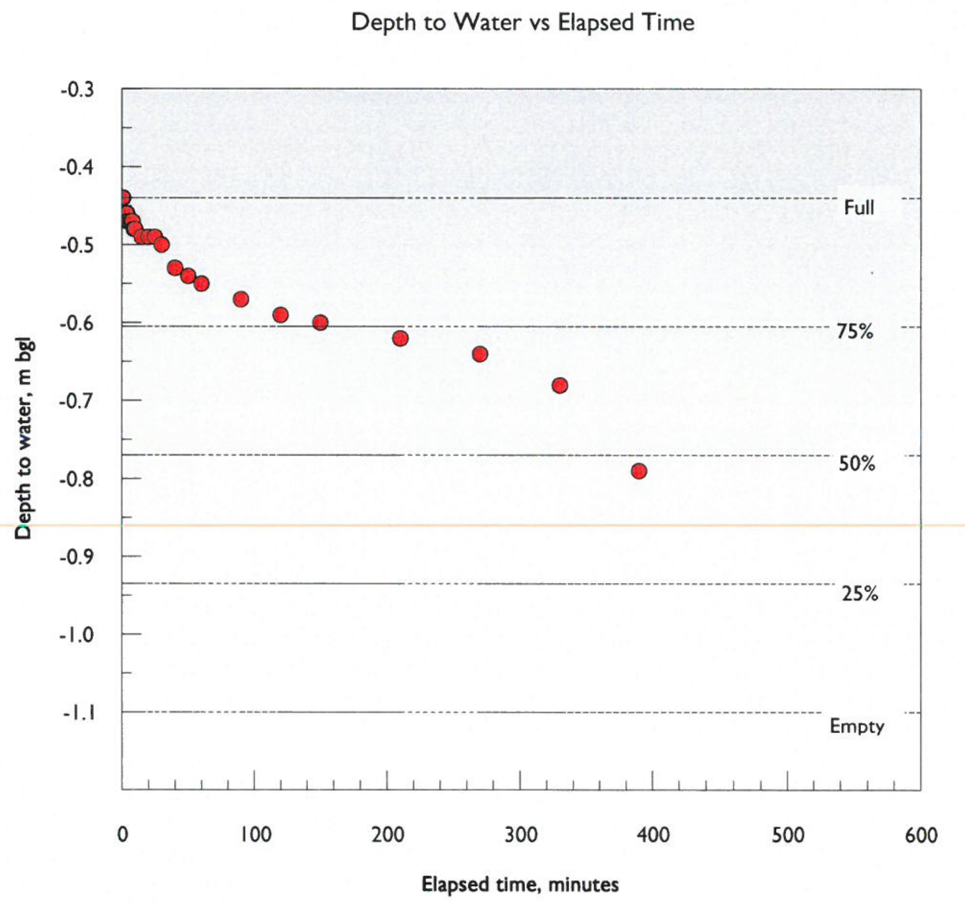
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 1/2

SA	6
Test No.	1
Depth, m	1.10
Length, m	1.20
Width, m	0.60

Description of stratum under test
Red brown, orange brown and light grey slightly sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.440
1.0	0.440
2.0	0.460
3.0	0.460
4.0	0.460
5.0	0.470
6.0	0.470
7.0	0.470
8.0	0.470
9.0	0.480
10.0	0.480
15.0	0.490
20.0	0.490
25.0	0.490
30.0	0.500
40.0	0.530
50.0	0.540
60.0	0.550
90.0	0.570
120.0	0.590
150.0	0.600
210.0	0.620
270.0	0.640
330.0	0.680
390.0	0.790



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.24 m^3

A50 = 1.91 m^2

T75-T25 = 490 min extrapolated

f = **4.24E-006** m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT
Client: London Square

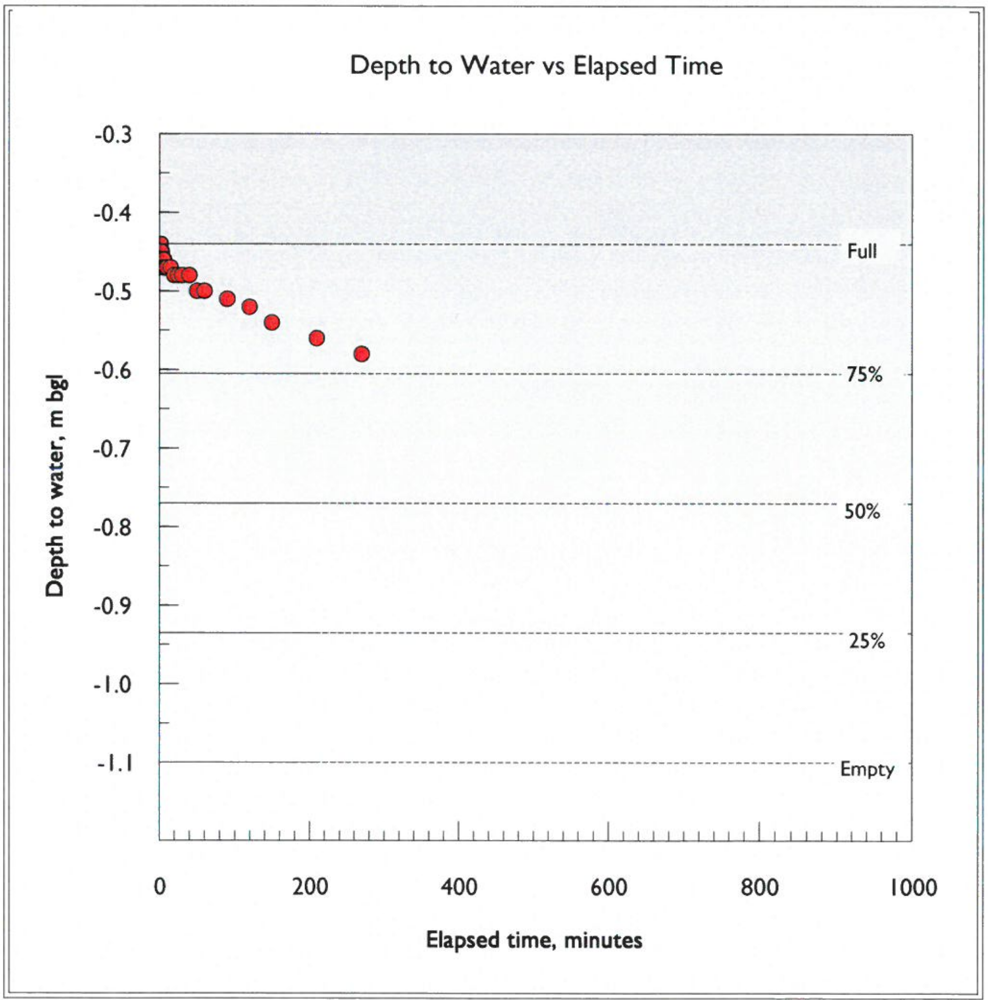
Project No: 5590
Sheet No: 2/2

SA	6
Test No.	2
Depth, m	1.10
Length, m	1.20
Width, m	0.60

Description of stratum under test
Red brown, orange brown and light grey slightly sandy CLAY

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.440
1.0	0.440
2.0	0.440
3.0	0.450
4.0	0.460
5.0	0.460
6.0	0.460
7.0	0.470
8.0	0.470
9.0	0.470
10.0	0.470
15.0	0.470
20.0	0.480
25.0	0.480
30.0	0.480
40.0	0.480
50.0	0.500
60.0	0.500
90.0	0.510
120.0	0.520
150.0	0.540
210.0	0.560
270.0	0.580



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.24 m^3
A50 = 1.91 m^2
T75-T25 = indeterminate min

f = <u>indeterminate</u> m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

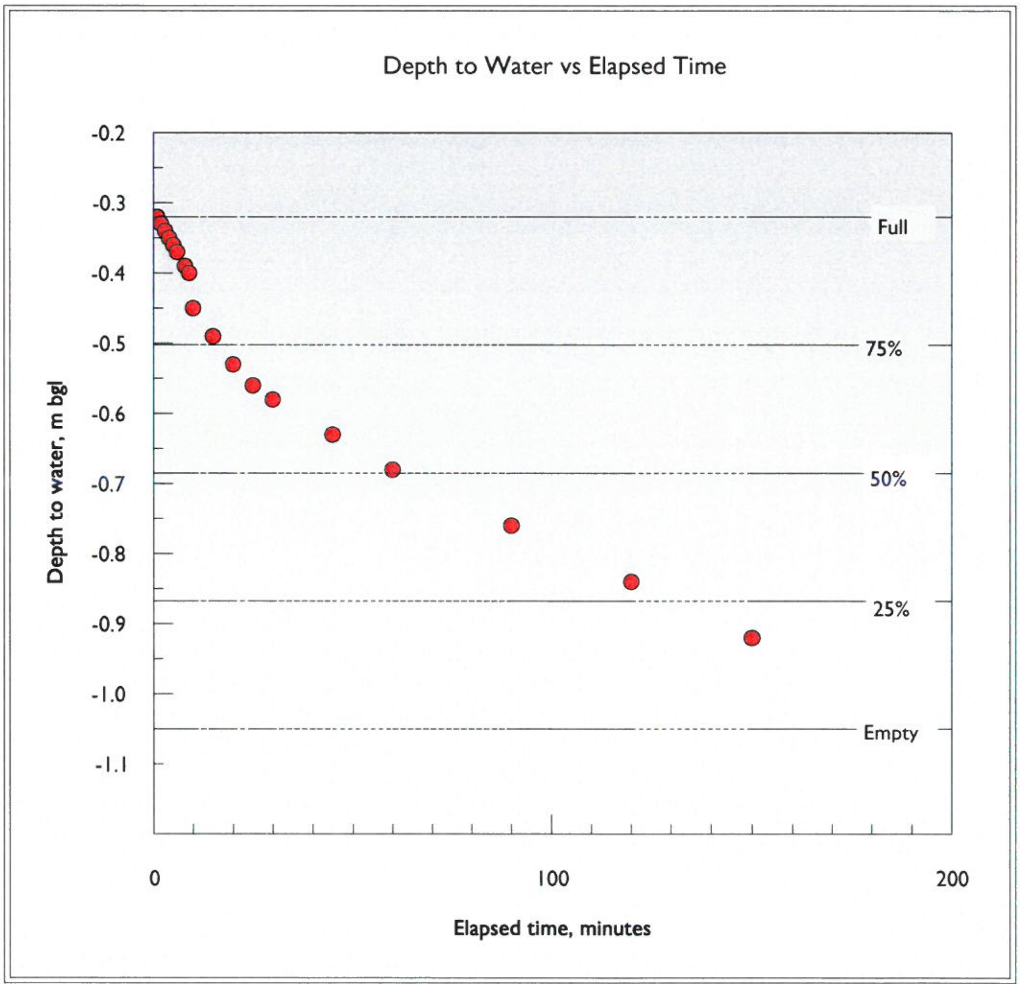
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 1/3

SA	7
Test No.	1
Depth, m	1.05
Length, m	1.20
Width, m	0.65

Description of stratum under test
Orange brown and brown slightly clayey SAND with occasional gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.320
1.0	0.320
2.0	0.330
3.0	0.340
4.0	0.350
5.0	0.360
6.0	0.370
7.0	0.038
8.0	0.390
9.0	0.400
10.0	0.450
15.0	0.490
20.0	0.530
25.0	0.560
30.0	0.580
45.0	0.630
60.0	0.680
90.0	0.760
120.0	0.840
150.0	0.920



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.28 m^3

A50 = 2.13 m^2

T75-T25 = 110 min

f = **2.02E-005** m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

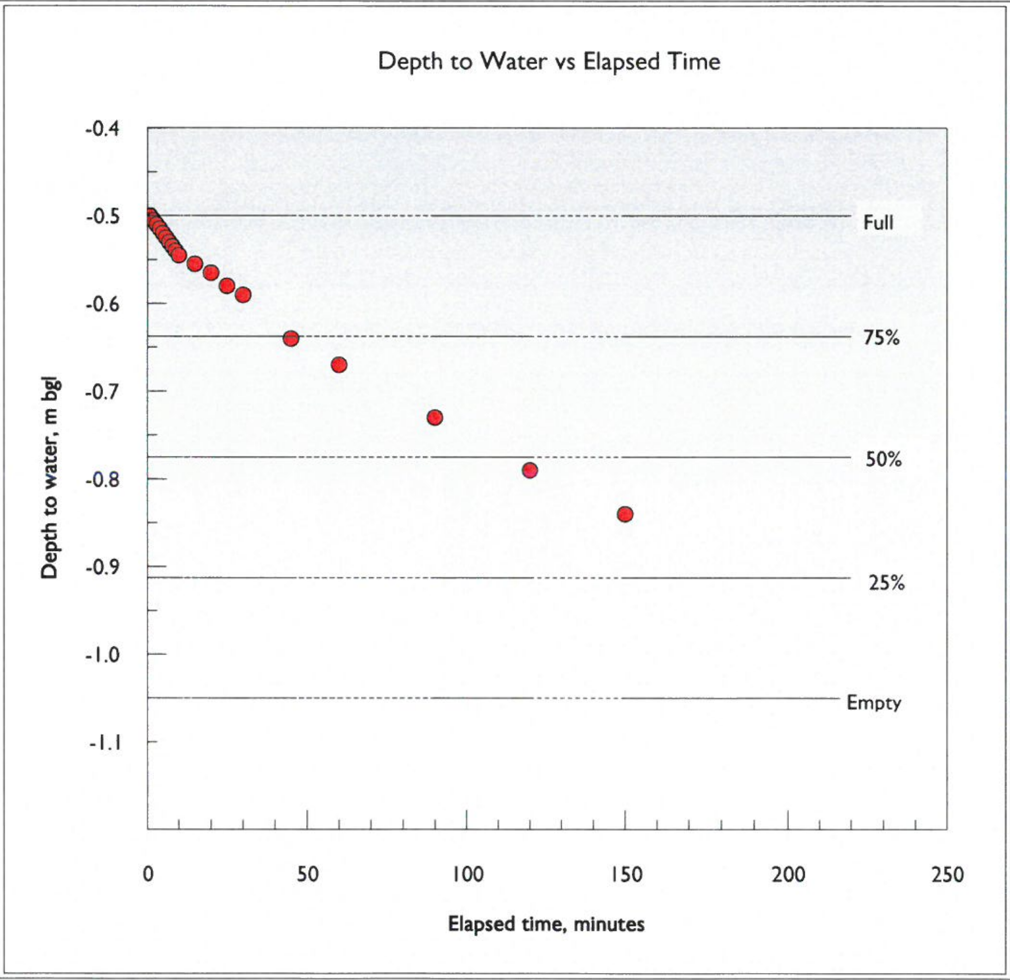
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 2/3

SA	7
Test No.	2
Depth, m	1.05
Length, m	1.20
Width, m	0.65

Description of stratum under test
Orange brown and brown slightly clayey SAND with occasional gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.500
1.0	0.500
2.0	0.505
3.0	0.510
4.0	0.515
5.0	0.520
6.0	0.525
7.0	0.530
8.0	0.535
9.0	0.540
10.0	0.545
15.0	0.555
20.0	0.565
25.0	0.580
30.0	0.590
45.0	0.640
60.0	0.670
90.0	0.730
120.0	0.790
150.0	0.840
180.0	0.890



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.21 m³

A50 = 1.80 m²

T75-T25 = 170 min extrapolated

f = 1.17E-005 m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT
Client: London Square

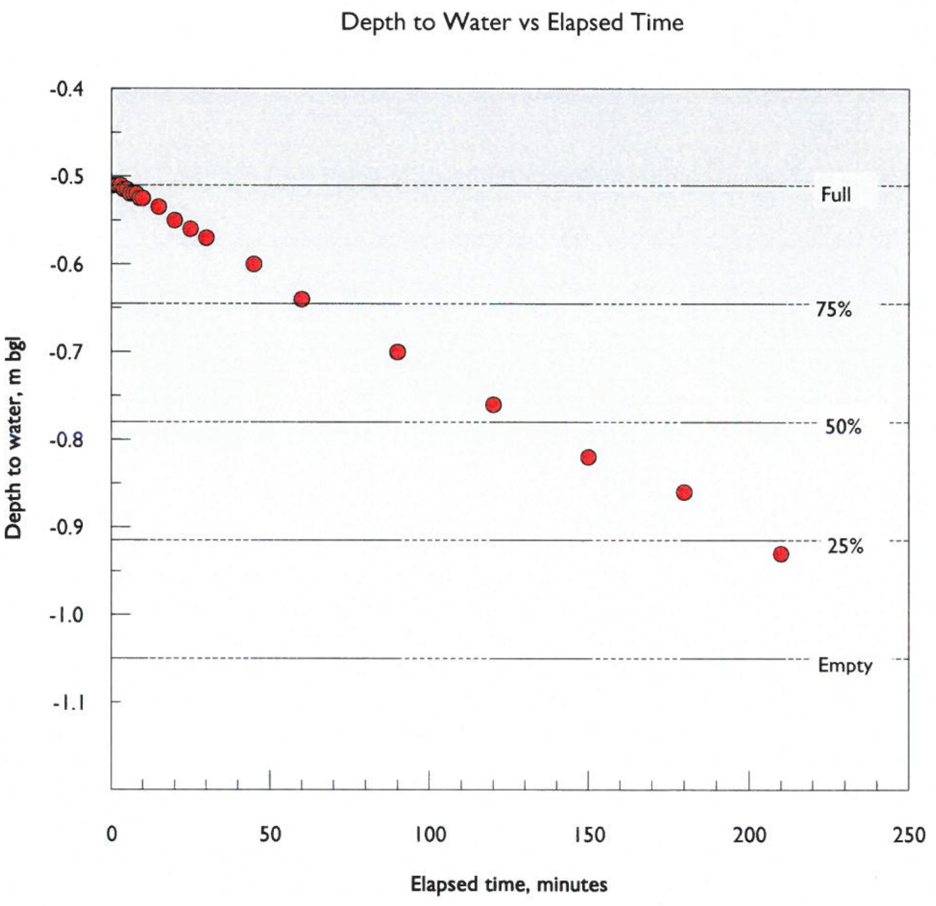
Project No: 5590
Sheet No: 3/3

SA	7
Test No.	3
Depth, m	1.05
Length, m	1.20
Width, m	0.65

Description of stratum under test
Orange brown and brown slightly clayey SAND with occasional gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.510
1.0	0.510
2.0	0.510
3.0	0.510
4.0	0.515
5.0	0.515
6.0	0.520
7.0	0.520
8.0	0.520
9.0	0.525
10.0	0.525
15.0	0.535
20.0	0.550
25.0	0.560
30.0	0.570
45.0	0.600
60.0	0.640
90.0	0.700
120.0	0.760
150.0	0.820
180.0	0.860
210.0	0.930
240.0	1.000



f = (V75-V25)/A50(T75-T25)
V75-V25 = 0.21 m^3
A50 = 1.78 m^2
T75-T25 = 150 min

f = **1.32E-005** m/s

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT
Client: London Square

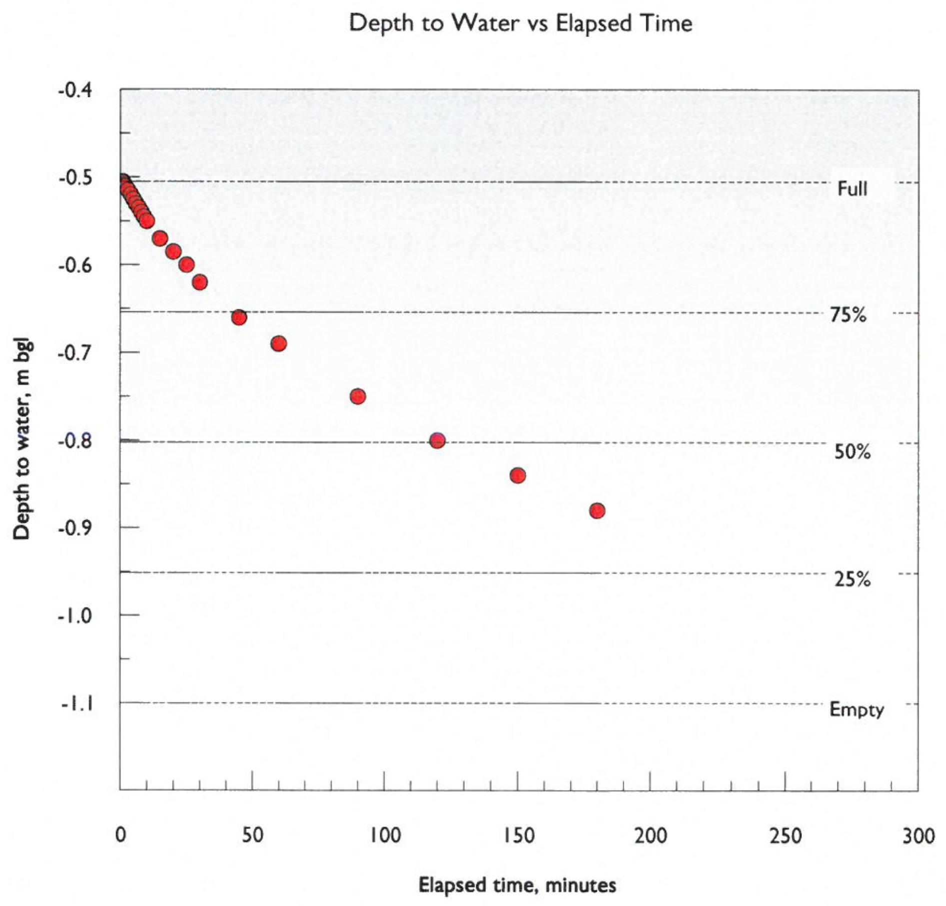
Project No: 5590
Sheet No: 1/3

SA	8
Test No.	1
Depth, m	1.10
Length, m	1.30
Width, m	0.65

Description of stratum under test
Orange brown slightly clayey SAND with some gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.505
1.0	0.505
2.0	0.510
3.0	0.515
4.0	0.520
5.0	0.525
6.0	0.530
7.0	0.535
8.0	0.540
9.0	0.545
10.0	0.550
15.0	0.570
20.0	0.585
25.0	0.600
30.0	0.620
45.0	0.660
60.0	0.690
90.0	0.750
120.0	0.800
150.0	0.840
180.0	0.880



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.25 m³

A50 = 2.01 m²

T75-T25 = 214 min extrapolated

f = **9.76E-006** m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590

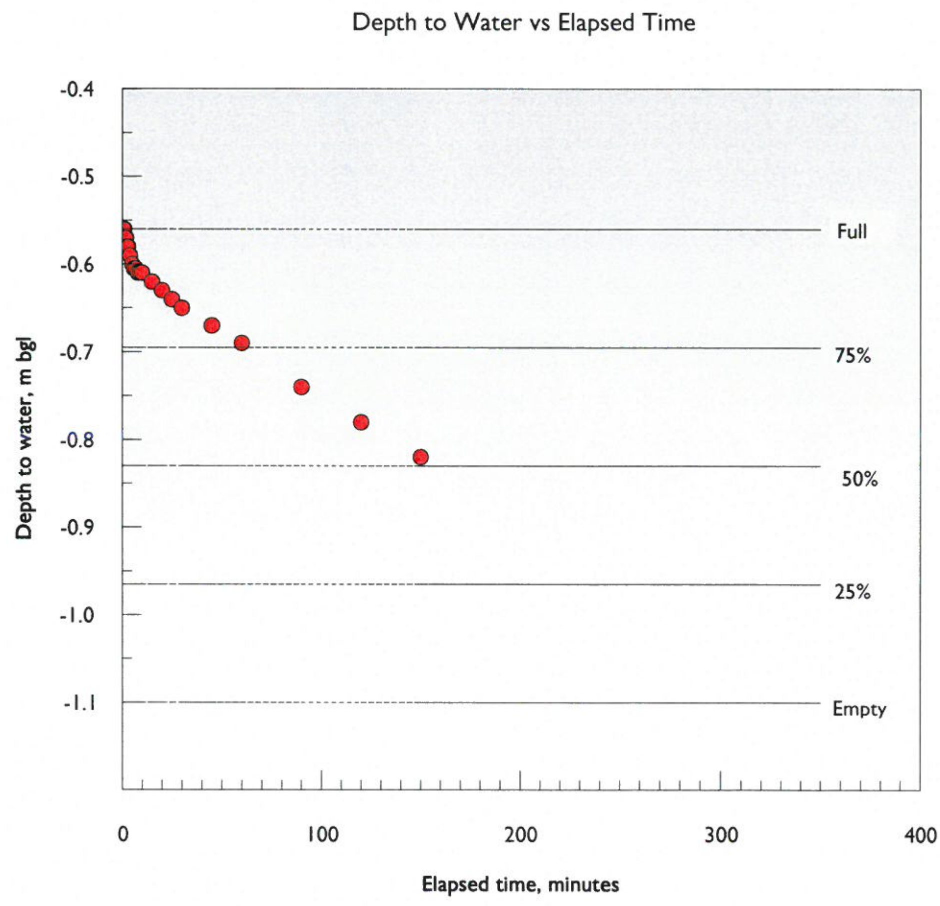
Client: London Square — Sheet No: 2/3

SA	8
Test No.	2
Depth, m	1.10
Length, m	1.30
Width, m	0.65

Description of stratum under test
Orange brown slightly clayey SAND with some gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.560
1.0	0.560
2.0	0.570
3.0	0.580
4.0	0.590
5.0	0.600
6.0	0.605
7.0	0.605
8.0	0.610
9.0	0.610
10.0	0.610
15.0	0.620
20.0	0.630
25.0	0.640
30.0	0.650
45.0	0.670
60.0	0.690
90.0	0.740
120.0	0.780
150.0	0.820



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.23 m^3

A50 = 1.90 m^2

T75-T25 = 300 min extrapolated

f = 6.68E-006 m/s extrapolated

SOAKAWAY TEST RESULTS

BRE DIGEST 365 - SOIL INFILTRATION RATE

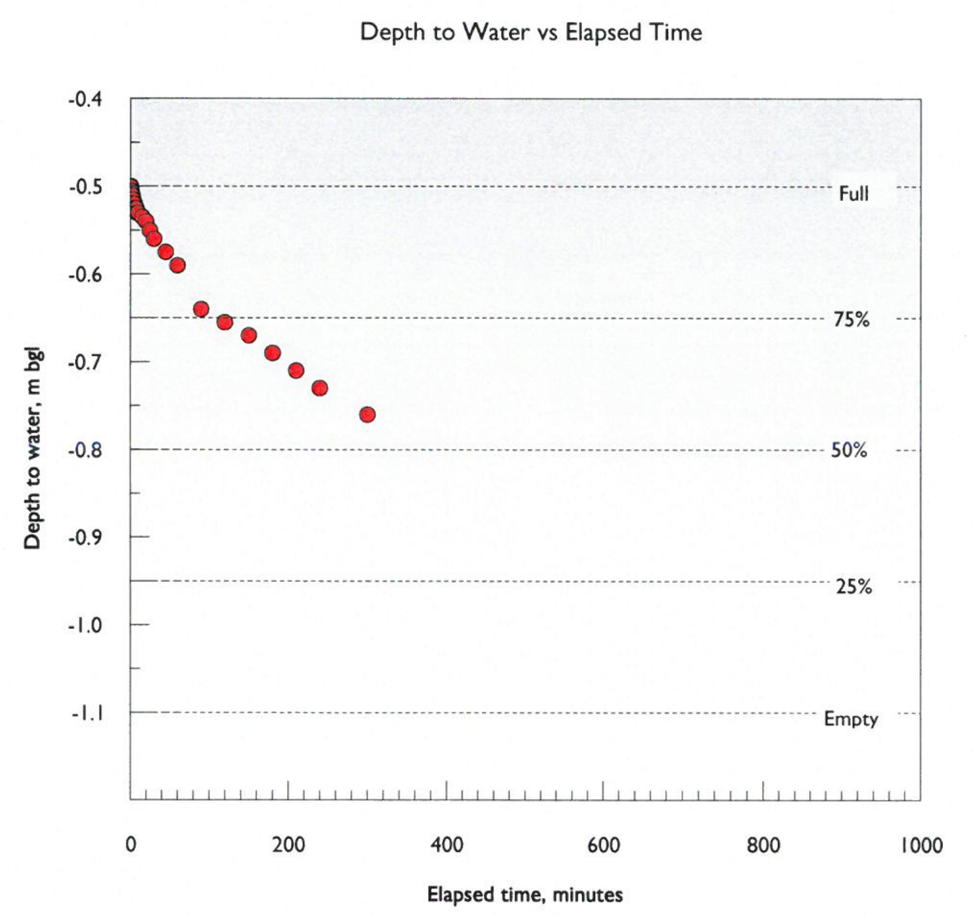
Project: LAND OFF STATION HILL AND THE HIGH STREET, ASCOT — Project No: 5590
Client: London Square — Sheet No: 3/3

SA	8
Test No.	3
Depth, m	1.10
Length, m	1.30
Width, m	0.65

Description of stratum under test
Orange brown slightly clayey SAND with some gravel

Depth to water prior to test, m below g.l.
pit dry

Elapsed Time min	Depth to Water m
0.0	0.500
1.0	0.500
2.0	0.505
3.0	0.510
4.0	0.515
5.0	0.520
6.0	0.520
7.0	0.525
8.0	0.525
9.0	0.530
10.0	0.530
15.0	0.535
20.0	0.540
25.0	0.550
30.0	0.560
45.0	0.575
60.0	0.590
90.0	0.640
120.0	0.655
150.0	0.670
180.0	0.690
210.0	0.710
240.0	0.730
300.0	0.760



f = (V75-V25)/A50(T75-T25)

V75-V25 = 0.25 m^3

A50 = 2.02 m^2

T75-T25 = 790 min extrapolated

f = **2.65E-006** m/s extrapolated

APPENDIX C

ECO-90
A Guide to the Eco-90 Drainage System

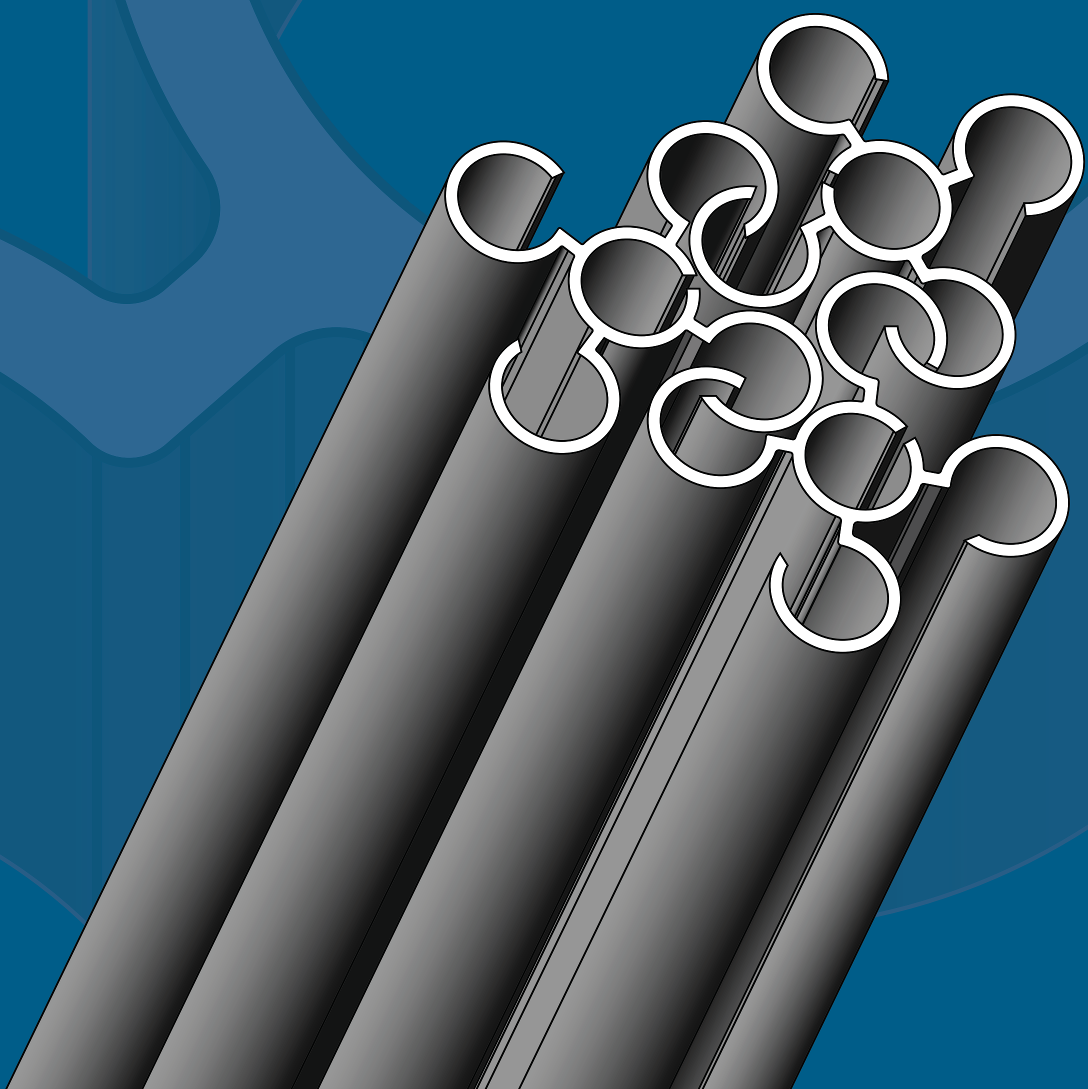
ECO-90™

GROUND WATER DYNAMICS

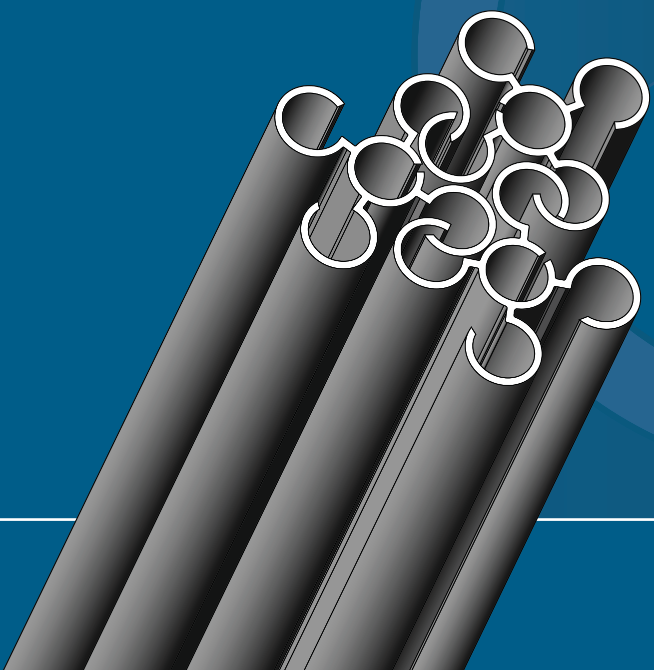
A GUIDE TO THE ECO-90™ DRAINAGE SYSTEM

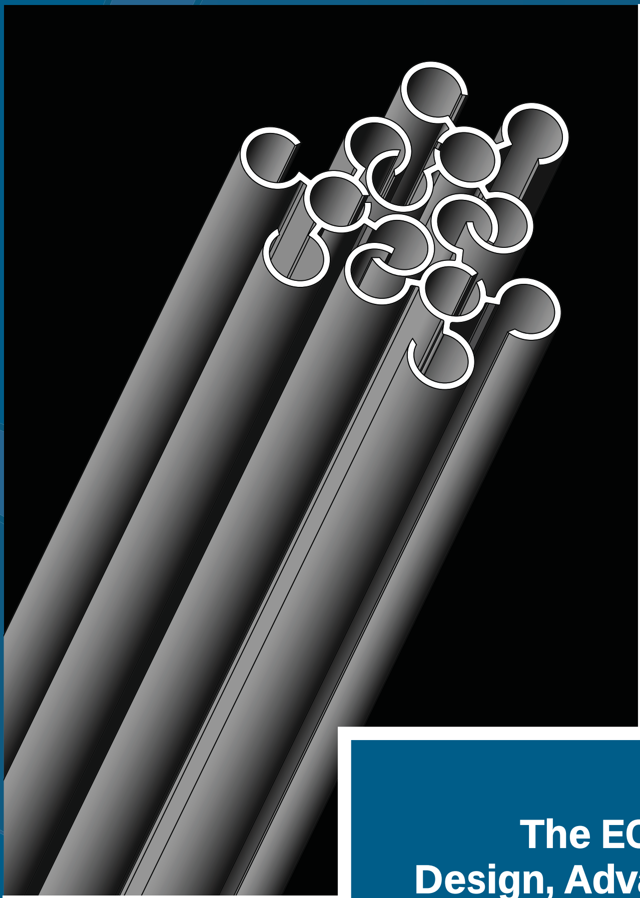
DESIGN, INSTALLATION & OPERATION. ECOLOGICAL & ENVIRONMENTAL STANDING.

Including a synopsis of an independent scientific analysis paper covering the efficacy of the ECO-90™ system.



Contents





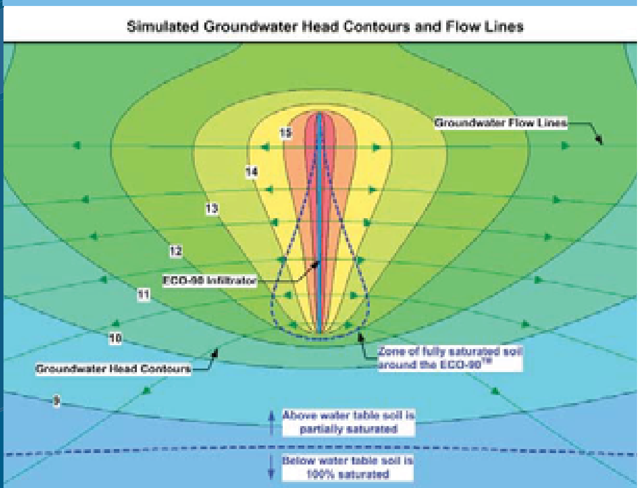
£500,000

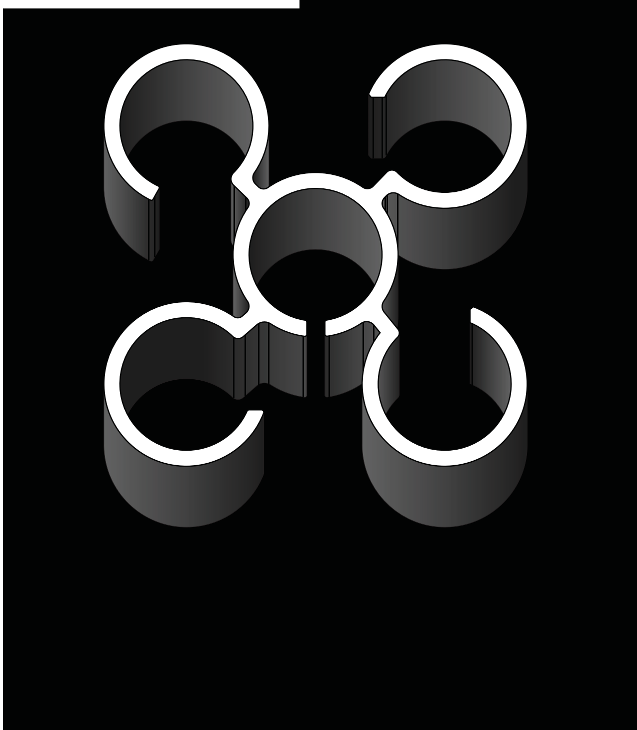
PROFESSIONAL INDEMNITY COVER

Where we supply and install an ECO-90™ engineered drainage solution we offer an insured warranty, covered by up to £500,000 Professional Indemnity cover. Higher cover is available as required.

In some instances, such as natural turf where we offer our own ECO-90™ drainage design solution and install, we offer a two year defect warranty. This means we will return to site to remedy any problems at our expense.

The ECO-90™ Design, Advantages over Traditional Drainage & Sector Applications





Background

Extreme rainfall events have created growing problems for natural turf reliant businesses and organisations, from golf courses to school playing fields and multiple other examples.

Increased property development has resulted in a larger proportion of land with impermeable surfaces which, when combined with prolonged periods of rainfall, can give rise to nuisance groundwater and flooding.

For new builds there is now fast-growing resistance from planning authorities and water boards to developments that cannot deal with storm water and even effluent discharge at source (on site).

In addition, if a development collects storm water and then moves it into a storm drain that takes it to wherever, the land that the development stands on has lost water it used to have. This negatively impacts the ecology and environment of the catchment area and can also undermine the aquifer and the drought resistance of ditches, streams and rivers. Public opinion, particularly amongst the demographic of house buyers, is shifting to growing intolerance of property developers who show little concern for the ecology and environment in which they have developed housing.

Whilst traditional piped drainage systems require an outflow to storm drains, the ECO-90™ system deals with rainfall at source, cost effectively, environmentally and with minimal disruption. For sites with poor infiltration rates, soakaways will struggle but the ECO-90™ system, as a deep drainage system, in most cases will work.

THE ECO-90™
A unique approach to drainage design

Deals with storm water at source, a game changer in below the ground SuDS (Sustainable Drainage Systems)

Solves surface saturation, standing water and localised flooding for municipal and recreational facilities

Moves storm water into multiple soil stratas to a depth of 12 metres, bringing into play major additional volume of soil for drainage

For new build sites no connection needed to storm drains or combined sewers

For residential new build where ECO-90™ is preferred to soakaways, the reduced drainage footprint can create space for more houses and a higher GDV

Resolves basement and ground floor flooding

No moving parts, no external power source required, a self-cleaning sealed system

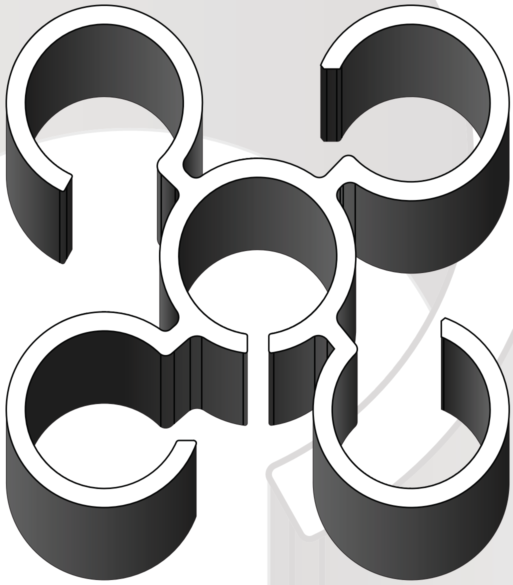
A CARBON NEGATIVE drainage system

£500,000 professional indemnity cover for all installations

Over 300 successful UK installations since 2012.

“ The future of 'at source' drainage - a cluster of ECO-90s™

E info@groundwaterdynamics.co.uk



The ECO-90™

The ECO-90™ is a worldwide patented technology, that enhances and accelerates multiple soil stratas ability to absorb water. We introduced it into the UK in 2012, the system was originally used to deal with natural turf drainage issues: flood; saturated ground; and standing water. High profile customers included Edgbaston Cricket Club, Gleneagles Golf Course, Royal Ascot and Silverstone F1.

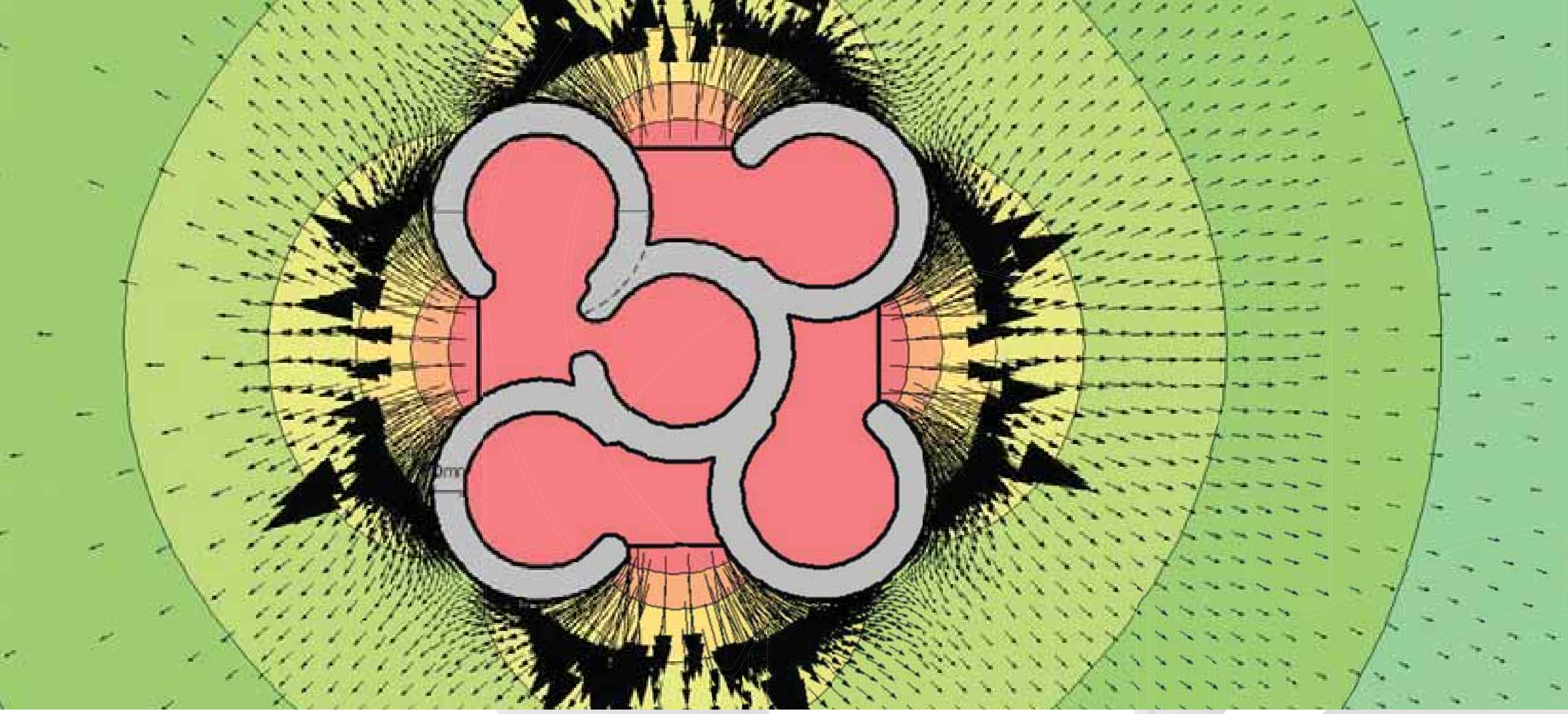
These installations attracted the attention of Architects and Drainage Engineers who were interested in using the system to satisfy Sustainable Drainage System (SuDS) requirements in planning. Increasingly the system is being used as a SuDS solution in new build schemes, particularly given an escalating planning and water board requirement to deal with storm water at source, allied to growing focus on the ecological and environmental impact of such developments.

The ECO-90™ design

The ECO-90™ is a cut length, with a cross section consisting of five open chambers (see above). It is a drainage extrusion made from standard HDPE (High-density Polyethylene), a thermoplastic. With a high strength-to-density ratio, HDPE material is often used for corrosion-resistant piping and is deemed more eco-friendly than other materials used within the industry as it does not deteriorate in the soil. HDPE is commonly re-cycled, it has a Class 2 resin identification.

It is important to understand that the ECO-90™ is not a pipe, the open chambers are a key reason why it works. The ECO-90™ has no moving parts, requires no external energy source and is self-cleaning, requiring no ongoing maintenance.

> “ The ECO-90™ is a Tier 1 below ground SuDS system, designed to engineered industry standards using WinDes micro-drainage positive outflow that half-drains down within 24 hours.



How the ECO-90™ works

The ECO-90™ come in lengths of up to 12 metres.

It is installed vertically into a pre-drilled hole:

(i) that for natural turf installations (such as golf courses, sports pitches etc.) is 30cm deeper than the ECO-90™ length and, therefore the ECO-90™ stands 30cm below the surface. This prevents surface water entering the ECO-90™. Once installed the ECO-90™ is also capped, preventing any pollutants from directly entering the chambers

(ii) that for construction drainage purposes, in conjunction with an infiltration trench, the pre-drilled hole is at the base of the trench and the trench has a geotextile lining to deal with pollutants (hydrocarbons – oil).

Given (i) and (ii) above, the ECO-90™ drainage system is therefore not a borehole drain.

Water held in the soil surrounding the open chambers moves into them and then descends, its natural propensity. Soil around the ECO-90s™ becomes saturated and this creates two key results:

(iii) as the water enters the ECO-90™ chambers and moves to the bottom of the ECO-90™ to a depth of 12 metres, the head of water in the chambers is now exerting significant pressure throughout the length (depth) of the ECO-90™, creating a differential hydraulic head. This head forces water out of the chambers into surrounding unsaturated soil stratas (see Discharge Velocity Modelling above)

(iv) in addition, unsaturated soils start drawing water out of the saturated soils, that now surround the ECO-90s™. This can happen laterally and even upwards. In certain soil structures this discharge can be far greater laterally than vertically, particularly in laminated (layered) soils and is another key advantage of the open chamber design of the ECO-90™ system.

As water is forced out of the chambers due to (iii) and (iv) above, the soil surrounding the ECO-90™ starts to reduce saturation, enabling more surface or trench water to now enter the chambers. The result is a virtuous cycle of nuisance surface or storm water being drawn into the chambers and then being discharged into deeper unsaturated soil stratas. Essentially the ECO-90™ system has created a deep drain, utilizing soil stratas between 2 metres to 12 metres below ground level.

By technical definition, a designed and installed array of ECO-90s™ form a Passive Groundwater Recharge Based Drainage System.

E info@groundwaterdynamics.co.uk

ECO-90™ replacing traditional drainage

An ECO-90™ system is a multiple install of ECO-90s™ and is a clear design option against traditional drainage systems. As previously stated, by technical definition it is a Passive Groundwater Recharge Based Drainage System.

It scores above these traditional systems over six scales:

- At the scale of the full drainage field the ECO-90™ system, as a deep drainage system increases the surface area to volume ratio, making more soil available for drainage as well as increasing the likelihood of intercepting more permeable soils. This has the benefit of reducing risk of drainage failure, with multiple ECO-90™ forming the system and increasing the likelihood of discharging into soil stratas to a depth of over 12 metres
- Against soakaways an ECO-90™ system can also have the effect of reducing drainage allocation footprint to any new build site, driving GDV higher. This can be further enhanced by using ECO-90™ clusters beneath permeable paving, reducing the volume of water to the point where large scale attenuation is not required
- At the scale of the individual wells the ECO-90™ system improves the drainage and storage potential of soils, allowing them to develop through use
- At the micro or mineralogical scale, soil moisture transfer (shrink-swell) is promoted in otherwise low permeability soils, such as clays and silts
- At the carbon scale, the ECO-90™ creates healthier soils that were formerly saturated; and surface soil suffering drought to be rehydrated from water held in hydrated soils below. By creating more balanced hydration of soils across the seasons, shrub and tree growth are accelerated and are also more drought resistant. This results in removing or securing the removal of carbon from the atmosphere faster and thereby making the system operationally CARBON NEGATIVE
- At the ecological and environmental scale, the ECO-90™ system design can allow storm water to infiltrate naturally across a construction development site, replicating as best as possible the former operation of the catchment area that the site is now building on. This increases the probability of recharging aquifers, ditches, streams and rivers and reducing drought risk with attendant CARBON NEGATIVE benefits.

> “Through my understanding of the ground and the principles of groundwater movement, the technical basis of the ECO-90™ system was easily understood.
>
> At its simplest, it is a catalyst that optimises the drainage potential of the ground.
>
> **Russell Bowman**
> Geo & Hydrogeologist, Soils & Structures

Applications of the ECO-90™ system across specific sectors

Councils/Devolved Aministrations/UK Gov

ECO-90™ Solution to Existing Flooding, Standing Water & New Planning Applications

- Carbon neutral strategies on existing estate
- Car Parks
- Cemeteries
- DOT Major Roads/Motorways (incl. landslip)
- DOT Rail Network (incl. landslip)
- Bridges
- Local non-DOT Roads
- New Commercial/ Public Buildings / Residential
- Parks & Recreational Areas
- Planning - refused sewer connection for storm water
- Public Buildings
- Social Housing
- Sports Pitches

ECO-90™ Solution to Existing Problem Flooding, Standing Water & New Planning Applications

- Basement Flooding
- Ground Floor Flooding
- Car Parks
- New Build (SuDS)
- Saturated Landscapes
- Nuisance Standing Water
- Refused Connection - storm water/effluent

ECO-90™ Solution to Flooding & Standing Water

- Bowling Greens
- Cricket Grounds
- Golf & Horse Racing Courses
- Racing Circuits
- Pitches – Football, Hockey, Lawn Tennis, Polo, Rugby et al.

ECO-90™ Solution to Existing Problem Flooding, Standing Water & New Planning Applications

- Basement flooding
- Flood alleviation
- New Build with greater GDV
- Saturated Landscape/Gardens
- Refused connection -storm water/effluent

ECO-90™ Solution to Flooding & Standing Water

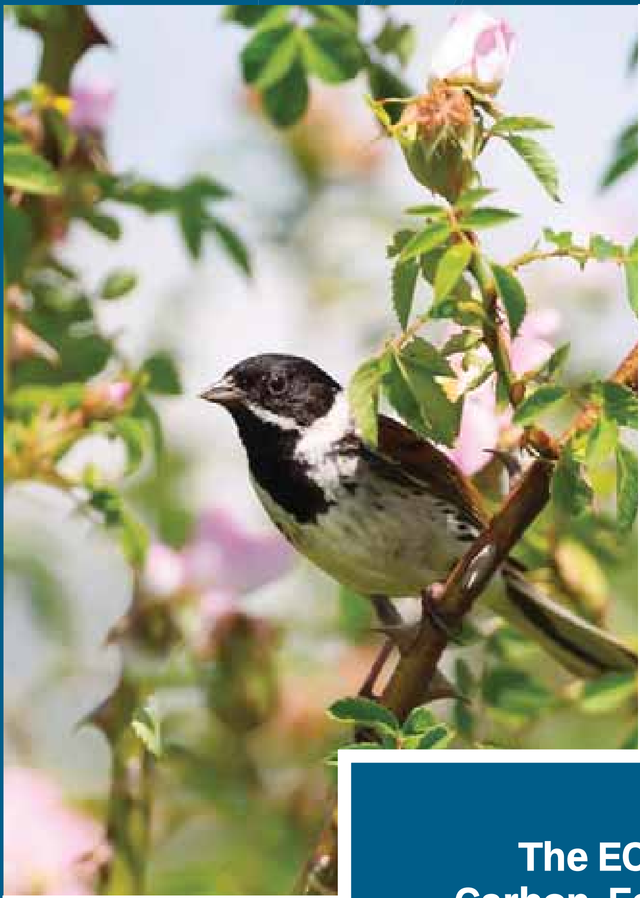
- Airport Runways
- Construction Phase (Temporary) Drainage
- Infrastructure Permanent Drainage
- Railways
- Roads
- Brownfield Urban Regeneration

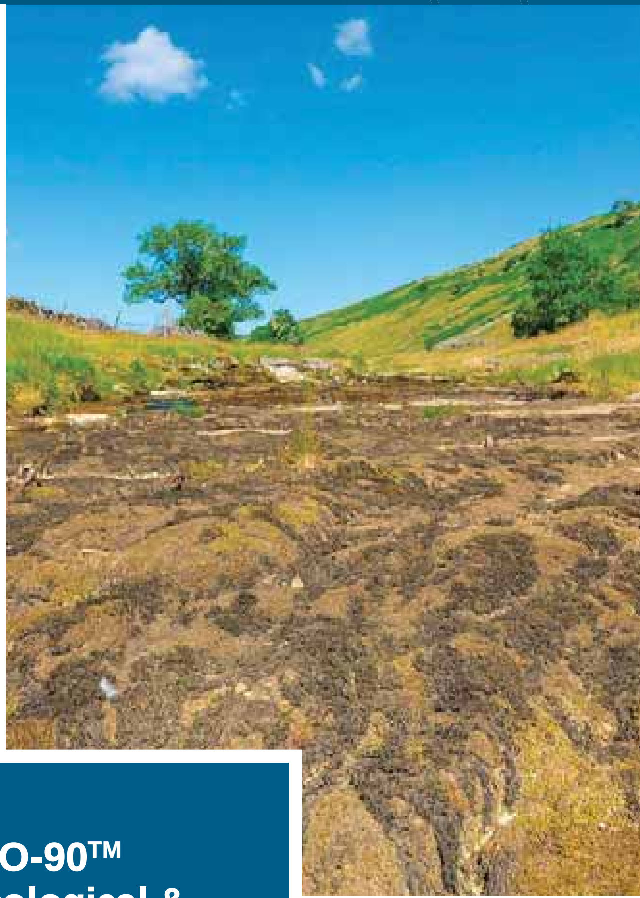
£500,000

PROFESSIONAL INDEMNITY COVER

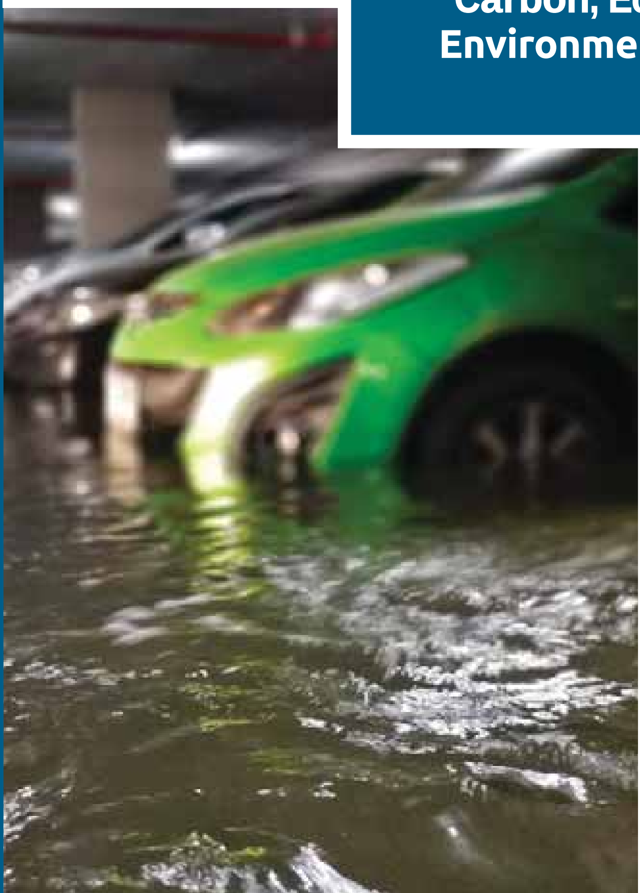
Where we supply and install an ECO-90™ engineered drainage solution we offer an insured warranty, covered by up to £500,000 Professional Indemnity cover. Higher cover is available as required.

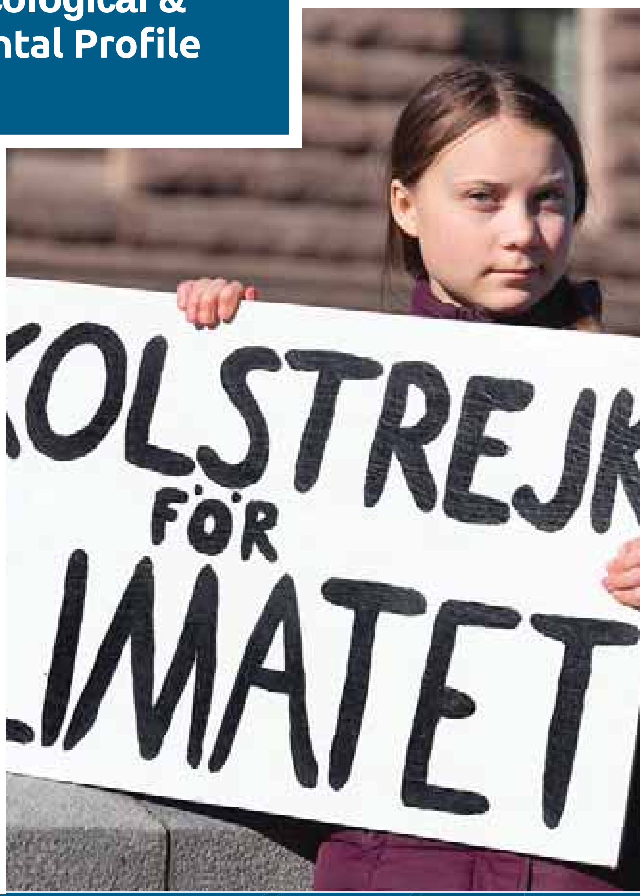
In some instances, such as natural turf where we offer our own ECO-90™ drainage design solution and install, we offer a two year defect warranty. This means we will return to site to remedy any problems at our expense.





The ECO-90™ Carbon, Ecological & Environmental Profile





Introduction

The ECO-90™ system deals with storm water at source, allowing catchment storm water to infiltrate the soil on either a construction or natural turf site, helping water to move below ground much as it did prior to the land being developed. This is at the heart of the ECO-90™ ecological and environmental profile and is best seen through how it impacts two key issues: drought and flood.

For instance, because the ECO-90™ system does not follow traditional drainage design that moves large amounts of storm water from A to B in conventional horizontal pipes creating problems down the line, it does not contribute, as they do, to the flooding of water treatment facilities that then discharge into critical stream, river and marine ecosystems.

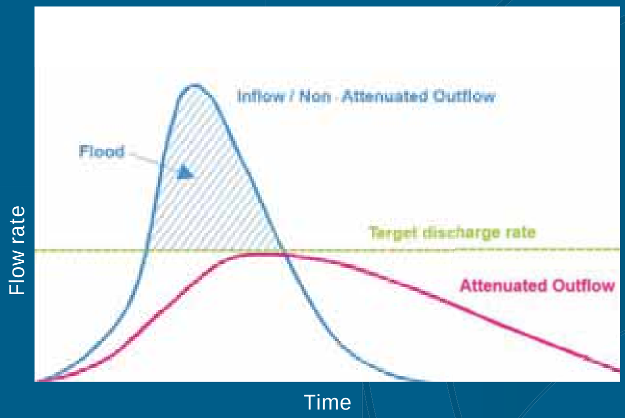
Furthermore, on larger construction sites, 'clusters' of ECO-90™ can be installed strategically around the site, allowing for a decentralised approach to drainage and assisting highly localised storm water infiltration. This has the dual benefit of reducing the amount of attenuation (trench(es)) required and more fully replicating pre-development catchment storm water infiltration.

On the issue of carbon, the ECO-90™ system is operationally CARBON NEGATIVE, a real plus point for any land-owner or developer in their pursuit of ever lower carbon footprints.

> The closer any site gets to letting rainfall infiltrate and percolate as it always has, the better the ecological and environmental result.

How ECO-90™ reduces flood risk

Although the most preferable SuDS is a passive infiltration system where storm water is first attenuated using volumetric storage facilities, followed by the slow release of the stored water back into the ground, in many locations it is often the case that the ground is not considered suitable for surface infiltration systems due to the clay/silt ground being insufficiently permeable. This means that the storm water either has to be discharged to a sewer or a local watercourse, which can lead to flooding.



However, if the design of an attenuation trench, comprising large storage, is enhanced with a large number of drilled ECO-90™ infiltrators installed from the base of the trench, the pressure head of collected stormwater provides the pressure to force the water into the ground via the ECO-90™ array. Furthermore, by installing these highly permeable ECO-90s™ to depth, more permeable ground strata are encountered, particularly highly anisotropic ground where the horizontal permeability is much higher than the vertical permeability. By enabling infiltration at depth into silt or sand lenses within clay soils, the ECO-90™ system helps to prevent local surface water flooding.

For construction sites an ECO-90™ system helps to mitigate the peak water levels in local rivers following storm events, as shown by the hydrograph opposite. This is because surface water takes time to move through the ECO-90™ system, so providing for more gradual increase in river levels during heavy rainfall and slower reduction in river levels once the rain has passed.

> “
>
> For construction sites an ECO-90™ system helps to mitigate the peak water levels in local rivers following storm events, reducing flood risk.

E info@groundwaterdynamics.co.uk

How ECO-90™ reduces drought risk

Whilst a lot is made of the impact of new build developments on flooding, little is made of the ecological and environmental damage from drought that these developments can cause. Connecting to storm drains might be the easy way out for developers but in most cases such connections take storm water off to wherever, resulting in the land that the development stands on losing water it used to have. This negatively impacts the catchment area and can also undermine the aquifer and the drought resistance of ditches, streams and rivers.

The ECO-90™ system deals with storm water at source, allowing catchment storm water to infiltrate the soil on either a construction or natural turf site, helping water to move below ground much as it did prior to the land being developed. This provides significant ongoing support for the local ecology.

Former fruit trees killed by drought.

> "It is most likely that with climate change causing extreme weather events, drought will become more frequent and potent. This will be exacerbated by water from any new development being routed elsewhere.

ECO-90™ carbon credentials

As the ECO-90™ system uses no external energy source, it is operationally carbon neutral, with zero carbon run costs and no ongoing maintenance. It can improve the drainage carbon footprint of any site by wiping out external energy requirements to deal with storm water, with no need for pumps moving water or the energy requirements of treatment works. The system simply becomes part of the soil structure, facilitating the movement of water through multiple soil stratas.

In addition, the ECO-90™ system is positive for bush, plant and tree growth. It can deal with saturated soils, resulting in a root system no longer rotting in the ground, enabling it to perform its vital role in providing water and nutrients to its above ground host. This was the case at Royal Ascot (see picture opposite) where the Parade Ring is encircled by a bush hedge. The bushes were failing because of saturated ground but once an ECO-90™ system was installed the nuisance water was infiltrated into deeper unsaturated ground and the bushes returned to health.

Equally, the ECO-90™ system is a conduit to transfer surface water to the water table, thereby recharging aquifers and other natural water courses, such as streams and rivers. This helps provide greater drought resistance, enabling plant life to see out spells of drought and thrive again. Where plant life dies, carbon is released into the atmosphere.

By supporting plant growth and survival, the ECO-90™ system helps remove carbon dioxide from the atmosphere and any system or device that facilitates this, combined with zero external energy demand to operate, is described as carbon negative, the highest accolade available in the global drive for a carbon neutral world.

Climate Change

A seismic shift in public opinion and buying behaviour

Climate Change has become a catch-all term for our concern about our impact on nature. The realisation about the effect that humans have on the natural environment is most obvious when looked at through the lense of carbon emissions. This is, however, part of a wider public concern about what we are doing to ecosystems through: relentless building development; plastics; drought; flood; and the extinction of countless species.

Public opinion, particularly amongst the demographic of house buyers, is shifting to growing concerns about property developments that show little care for the ecology and environment and are 'green washing'. Such house buyers are wary of any implied association to 'green washing' and associated 'profit at all costs' motives. Moving forward, developers who put profit ahead of the natural environment will find increasing reputational issues with house buyers and sites will struggle to sell down.

Children are influencing parents' opinions

Much of adult concerns regarding climate change relates to the climate and nature legacy they will leave for our children. What children think therefore does matter.

In March 2020 BBC Newsround worked with Savanata-ComRes, a specialist survey company who asked 2,000 eight to sixteen year olds to answer a series of questions about climate change.

- Four out of five of children (80%) said the problem of climate change was important to them, with over a third saying it was very important
- Just three out of every 100 said that the environment wasn't important to them
- Nearly three quarters (73%) said they are worried about the state of the planet right now - including 22% who say they are very worried
- When asked about their futures, almost three in five (58%) children said they're worried about the impact that climate change will have on their lives
- More than half (59%) of them don't think their voices are being heard on climate change
- Nearly two thirds (64%) don't believe people in power are listening to them enough when they do talk about it
- But when asked about the action being taken by grown-ups to tackle the problem, more than two in five (41%) said they don't trust adults to tackle the challenges that climate change presents.

Sustainable Drainage Systems (SuDS) will become far more dominant in planning decisions

Water features in Climate Change as a threat due to drought or flood, but is not necessarily appreciated as a highly precious commodity in our daily lives. The UK currently has a water surplus of 12% but population growth will see that become a water deficit of between 8% – 22% within the next 30 years (DEFRA, March 2017). This makes the case for SuDS enforcement all the more important because developments discharging storm water into sewers, including water courses, that in the end lose the water to the sea is irrational and unsustainable.

The ECO-90™ drainage system stands up to robust ecological and environmental interrogation and whilst most house buyers don't stop to think about climate change and drainage systems, it is only a matter of telling them before they understand what's on site and where it fits into SuDS.

Wild water swimming, pollution and SuDS

With many people forced to stay close to home due to COVID lockdown there was a surge in river swimming. This resulted in many swimmers confronting river pollution and a barrage of questions aimed at water companies followed. Storm drains taking storm water to combined treatment works have become overrun in major rainfall events and either the sewage is discharged into a watercourse or sent back up into homeowners toilets, so the watercourse gets it. As of February 2021 a private members bill is now looking to address this matter and the result is most likely that water companies will either refuse new connections to their storm drains or to allow it at a restricted rate. Again, SuDS will be seen as an answer and ECO-90™ as a 'go-to' system within the Tier 1 hierachy of SuDS solutions.

> "Water will increasingly be understood as a precious resource. Run out of it and watch the mayhem.

The ECO-90™ Drainage Systems for the Construction Sector

Installations for commercial, municipal and residential developments

Flood prevention to existing buildings, including basements and groundfloor

Retrofitting drainage systems

Designing an Engineered ECO-90™ system

It is vital to investigate any site where an ECO-90™ system is being considered. The system requires an understanding of soil stratas of any site to a depth of 12 metres and to know the height of the water table.

We follow a three-stage approach to designing an ECO-90™ system:

Stage 1 We produce a desk based geo and hydrogeological report, using British Geological Survey records. This is a good indication of what soils and rock stratas are likely to be encountered on site and also the probable height of the water table.

Stage 2 Provided the Stage 1 report is positive for an ECO-90™ system, we move to test-drilling to a depth of 12 metres or to the ground water level if higher. We conduct a minimum of four clusters of four drilled holes across a site. The clusters are drilled holes to a range of depths: 1.5m, 3m, 6m and 12m. For this we use a geo-hydraulics falling head test to a range of depths from which we extract infiltration rates.

Stage 3 The test-drilling results are then provided to a Consulting Drainage Engineer who uses micro-drainage software to perform calculations regarding required storage capacity (attenuation), ECO-90™ outflow rate and half drain-down time. From this the Engineer produces a Drainage Design Statement (summarised in the example table below) showing the required size of:

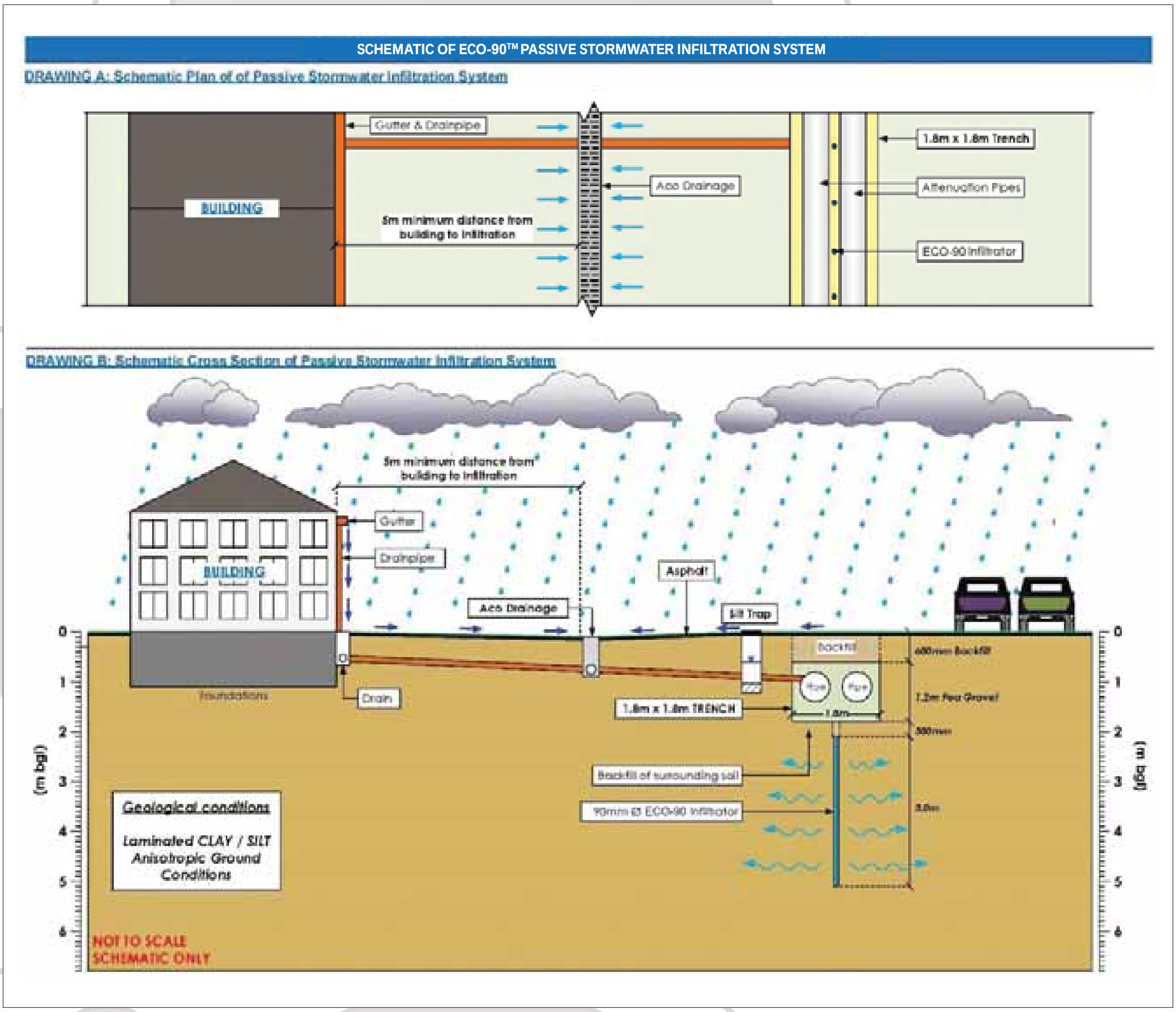
- the infiltration trench (soakaway) – this is needed to buffer storm water from major rainfall events
- the ECO-90™ array(s) – these are located at the base of the infiltration trench.

To err on the side of caution, the Engineer applies a safety factor against infiltration rates and also assumes no lateral infiltration as this takes time to establish and cannot be recorded at test-drilling stage. The maximum storage volume is based on required parameters, typically a 1 in 100 year event plus 40% climate change allowance.

Max. Storage Vol m^3	Infiltration Trench Dimensions			No. of clusters	Length of boreholes	Length of ECO-90™	Storage in Boreholes m^3	Storage in Trench m^3
	Length	Width	Depth					
79	80m	3m	0.91m	240	2,450m	2,190m	13.7	65.3

E info@groundwaterdynamics.co.uk

Installing ECO-90s™ to form a complete drainage system



When ECO-90s™ are installed as an array beneath an infiltration trench they form an unrivalled natural storm water drain up to 12 metres deep, dealing with storm water at source.

For construction projects, including satisfying a Drainage Design Statement and Sustainable Drainage System (SuDS) regulations, the system design will incorporate an infiltration (storm water) trench to deal with any required sudden storm water storage, with the ECO-90s™ then draining down the trench to unsaturated soil stratas (as shown in the above illustration). To deal with silt and pollutants the storm water moves through a silt trap and then enters the trench. The trench has a geotextile filter, Inbitex that encourages the formation of microbes that in turn degrade hydrocarbons (oils).

The Drainage Design Statements, including the size and location of the infiltration trench are completed by an independent firm of Consulting Drainage Engineers as a turn-key solution. However, they can also act in a consulting capacity to Architects and other Consulting Engineers, with no need to engage with their client.

ECO-90™ Construction at Scale

Newcastle High School

Construction: Drainage system for Astro Pitch

Impermeable area: 11,000 m^2

Storm water storage requirement: 512 m^3

Edinburgh University

Construction: Drainage system for New Build, Avian research Centre

Impermeable area: 10,000 m^2

Storm water storage requirement: 360 m^3

Motor Point

Construction: Drainage system for New Showroom and Forecourt

Impermeable area: 5,811 m^2

Storm water storage requirement: 155 m^3

"As a drainage designer I used to dread looking at sites that needed drainage but without access to an outflow. The ECO-90™ changed that and for the last six years I have enjoyed working with GWD and seeing how many water and drainage issues can be solved by an ECO-90™ system."

Steve Bowles, Consulting Drainage Engineer, EC49

The ECO-90™ Drainage Systems for Natural Turf Installations


Storm water troubles growing

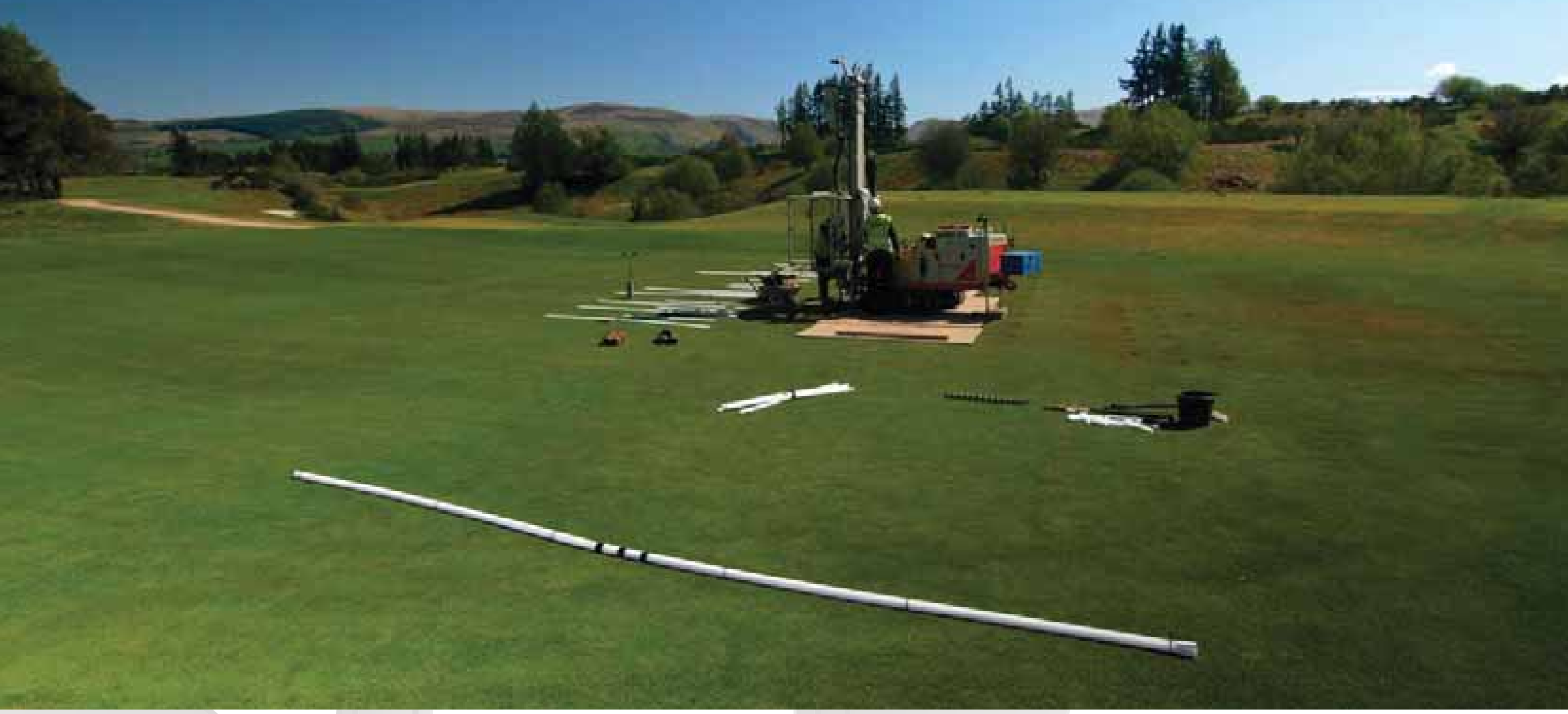
Major rainfall events, many associated with climate change can play havoc with recreational facilities and many businesses or organisations that rely on a good dry surface for its facilities to successfully operate can be severely affected.

From cemeteries, golf courses, horse racing, parks and pitches, nuisance water is a growing problem.

The very inception of the introduction of the ECO-90™ system in 2012 was aimed at dealing with the debilitating effect of localised flooding, saturated ground and standing surface water on recreational facilities. From Edgbaston Cricket Ground, Gleneagles Golf Course, Royal Ascot Parade Ring, Silverstone F1 we quickly established our Hall of Fame. Times move on and from Stanton Cemetery to Wandsworth Common and countless other installations, we have proved the efficacy of the ECO-90™ drainage system to solve these problems.

In addition, we have helped secure planning permission for new facilities that were blocked by a water company's refusal to take storm water into their sewers. We know how to deal with storm water at source (on site), an increasingly key condition in planning based on the growing enforcement of Sustainable Drainage System (SuDS) regulations that focus on dealing with storm water at source as a condition for planning permission.

FACILITY	PROBLEM
Cemetery	Loved ones cannot access graves; burials
Golf Courses	Closure of holes; falling membership and declining associated spend
Horse Racing	Cancellation of meetings
Parks and Children Play Areas	Council tax levies for unusable facilities
Pitches	Unusable facilities affecting both private and public sector



Natural Turf Installations

An ECO-90™ system is designed to irradicate surface saturation and ponding enabling natural turf surfaces to drain efficiently. When installing into natural turf an ECO-90™ system causes limited site disruption and as a sealed system, requires no direct maintenance over time.

Designing an ECO-90™ system

It is vital to investigate any site where an ECO-90™ deep drainage system is being considered. The system requires an understanding of soil stratas of any site to a depth of 12 metres and to know the height of the water table.

In addition, many natural turf facilities have been subject to significant compaction from day to day use by customers and by maintenance works. Technically this results in the need to analyse the health of the turf itself, the 'profile', because compaction can create an impossible infiltration scenario for the surface water to infiltrate to below ground soils.

We follow a three-stage approach to designing an ECO-90™ system for natural turf:

Stage 1 We take samples of the 'Profile' and send this for laboratory analysis. This looks at compaction levels and the permeability level. Some Profiles have almost no permeability. This means no matter what we do to increase infiltration below the surface it will be in vain because water cannot even infiltrate through the turf surface. In such cases, remedial action will be advised and we will recommend turf specialists to be engaged to resolve the infiltration quality of the Profile.

Stage 2 We produce a desk-based geo and hydrogeological report, using the British Geological Survey and any recorded trial borehole records. This is a good indication of what soils and rock stratas are likely to be encountered on site and also the probable height of the water table.

Stage 3 Provided the Stage 2 report is positive for an ECO-90™ system, we move to test-drilling to a depth of 12 metres or to the ground water level if higher. We conduct clusters of four drilled holes across a site or problem area. The clusters are drilled holes to a range of depths: 1.5m, 3m, 6m and 12m. For this we use a geo-hydraulics falling head test to a range of depths from which we extract infiltration rates.

The results of Stage 3 provide us with the data we need to create a Drainage Design for the site or problem area. Using our experience of over 300 successful ECO-90™ installs we then set out the ECO-90™ array required to deal with storm water at source (rainfall on site).

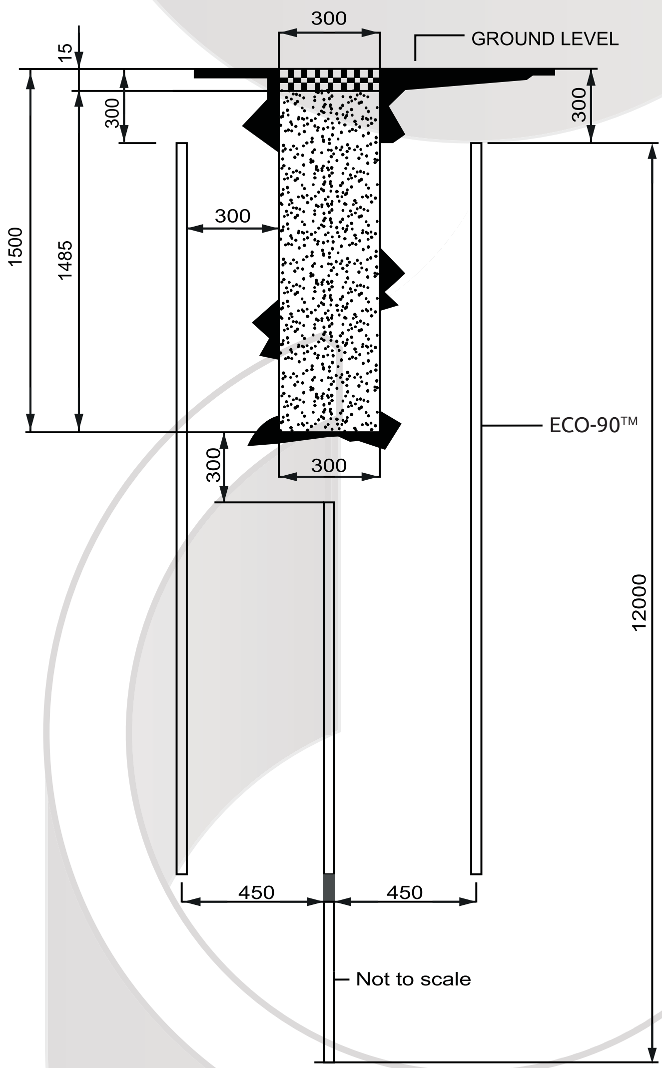
The ECO-90™ supported infiltration trench

For some turf installations, such as pitches and cemeteries, we often install an infiltration storm trench to act as a buffer to deal with heavy rainfall. The trench sometimes has a geotextile filter, Inbitex that encourages the formation of microbes that in turn degrade hydrocarbons (oils). We install ECO-90s™ below the trench to carry the filtered water down from the trench into deeper soil stratas.

The small storm water infiltration trench shown below forms part of a sports field drainage project. Installed in the base of the trench are 6 metre ECO-90s™ at 2 metre spacing and the side walls of the trench respectively have 3 metre ECO-90s™ at 1 metre centres. The cross-sectional sketch shows the positioning of the ECO-90s™ in relation to the trench and ground level. The top of the trench was finally dressed with a RT/Free draining root zone in order to ensure high levels of infiltration during storm events.

An ECO-90™ supported trench design creates a drainage asset capable of significant storm water storage before the ECO-90s™ empty the trench (half drain-down within 24 hours), which in turn creates capacity for the next rainfall event.

In some cases we will incorporate lateral (horizontal) infiltration drainage that takes storm water to a holding trench, with ECO-90™ infiltrators beneath that take the storm water into multiple soil stratas and from there the water will find its natural way to water courses or an aquifer. We have used this approach for cemeteries and grass pitches but it is intrusive to install and in most cases not appropriate for golf courses.

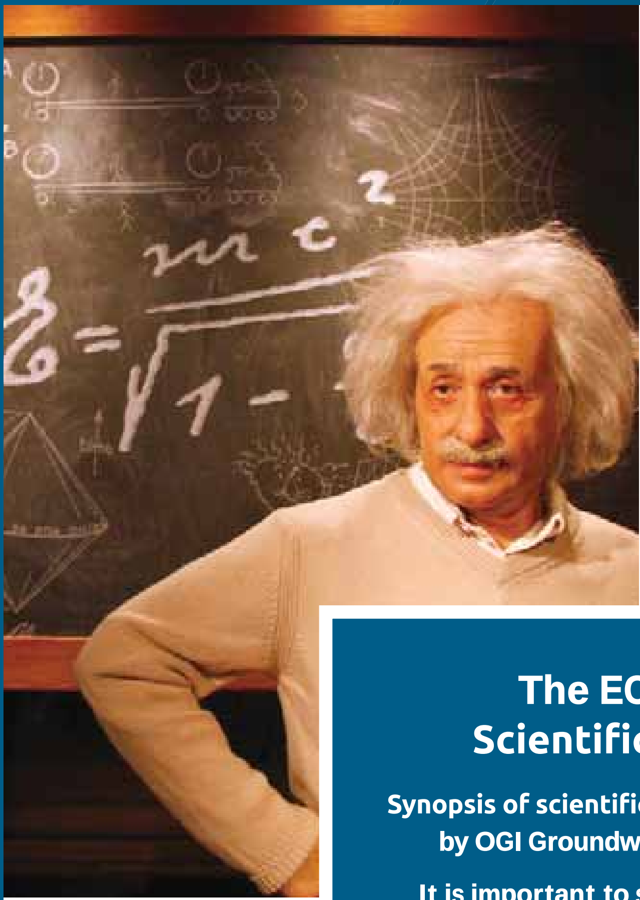


E info@groundwaterdynamics.co.uk

A gentle touch to installation

We take great care when installing an ECO-90™ system. Where a new facility is being constructed, installing an ECO-90™ system is straightforward, we can operate on site along with other ground work firms without concerning ourselves about 'spoiling' the landscape – it is the finished works that matter. However, for an existing recreational facility we are very mindful to ensure that the installation does not damage the facility itself.

The best example of this was the work we did at Gleneagles golf course, as shown in the pictures below. We used track mats for the drill rig to ensure we did not leave traction tracks from the drill rig moving across the fairways and the green. We used green hole cutters prior to drilling the ECO-90™ installation holes and we then set aside these cut turfs, ready for reinserting them once the ECO-90™ is installed. The installation took five days and the hole was closed during this period. However, once we had completed the installation the hole was again playable and was re-opened immediately. It was hard to see we had ever set foot on the Course.



The ECO-90™ Scientific Analysis

Synopsis of scientific analysis undertaken by OGI Groundwater Consultants.

It is important to stress that Newton did not create gravity, he explained it. Einstein did not create energy, he explained it. Likewise OGI did not create the ECO-90™ but has provided a valuable explanation of the underlying science that deals with the 'how' and the 'why'. The science supports over 300 successful installations across the UK, achieved since launch in 2012 – that is the most compelling evidence of all.

GROUND WATER DYNAMICS

OGI
GROUNDWATER SPECIALISTS

EXECUTIVE SUMMARY

Groundwater Dynamics Ltd has developed the ECO-90 Passive Stormwater Attenuation and Infiltration System to provide an efficient method to collect, attenuate and infiltrate stored water into soils of variable permeability at depth.

The ECO-90 system has been designed to infiltrate water at greater depths (typically in the range of 3 to 12m deep) than conventional soakaway systems (which are typically installed in the upper two metres of ground).

This technical report presents unsaturated groundwater flow computer modelling undertaken by OGI Groundwater Specialists Ltd to demonstrate scientifically how the Groundwater Dynamics ECO-90 infiltration system works in practice.

From prior observations of the ECO-90 infiltrator, Groundwater Dynamics engineers have observed that the unique cross-sectional geometry comprising circular chambers leads to the development of micro-fissures in the surrounding ground that over time radiate outwards from the edge of the ECO-90. OGI's modelling of the ground surrounding the ECO-90 suggests that these micro-fissures may have been created by the large groundwater flow exit velocities that form around the curved edges of the ECO-90 chambers as water flows out of it and into the surrounding soil. This effect, combined with the continuously changing water content of the surrounding soil due to changing rainfall conditions, is likely to be the phenomenon that drives the development of micro-fissures over time.

When the presence of micro-fissures around the ECO-90 are modelled, the infiltration capacity of the ECO-90 is greatly increased. This means that the ECO-90 with micro-fissures behaves like a circular well with a diameter significantly greater than the effective diameter of the ECO-90 itself. The presence of micro-fissures around the ECO-90 increases the available surface area of the surrounding soil that is available for water to infiltrate, therefore increasing the amount of water infiltration capacity.

The ECO-90 is always installed within the unsaturated zone of the soil, typically a few metres above the natural water table. This means the soil around the ECO-90 is partially saturated, and as such the pore-water pressure in the soil is negative. This negative water pressure is called suction because it wants to "suck" more water into the soil to neutralise the negative pressure. When water travels down the ECO-90, the suction in the surrounding soil acts to "pull" the water out of the ECO-90 and into the ground. The cross-sectional modelling of the ECO-90 demonstrated that over time, if there is a continuous stream of water entering the ECO-90, a zone of fully saturated soil forms around the ECO-90. In addition to the suction acting to pull water into the ground, the weight of the water in the ECO-90 from the above infiltration trench acts to "push" the water into the ground. It is these combined forces that are driving water through the infiltration system from the surface and into the ground at depth, so producing an efficient and enhanced Sustainable Drainage System (SuDS) that considerably outperforms a normal crate style soakaway system.

4.3 Model 3: Comparison between a Normal Soakaway and the ECO-90 System.

A third model has been set up in SEEP/W to compare the effectiveness of a normal crate type soakaway system to the ECO-90 infiltration system.

This model is a development of the model presented in Section 4.2. For this model, a layer of lower permeability soil at the ground surface is simulated. It is common within the UK to find low permeability soils within the top two metres of the ground surface, and then soils with higher permeability beneath it.

Often this is due to the presence of horizontal sand and silt lenses within clay soils. This results in a soil of anisotropy, which means the horizontal permeability of the soil is greater than the vertical permeability. It is these layers at depth that the ECO-90 infiltrator targets, and which makes it highly effective. Often soakaway crates are located within the top two metres of the soil, which can hamper the infiltration potential. To simulate this effect, the first 2.0m of the soil is modelled as a silty clay with a horizontal and vertical permeability of 1.0×10^{-7} m/s. Beneath this the soil is simulated with a horizontal permeability of 1.0×10^{-6} m/s and a vertical permeability of 1.0×10^{-7} m/s.

The soakaway crate is simulated as being 1.0m in diameter and 1.0m in height. It is located between 18.8m OD and 19.8m OD. The conceptual model is shown in Figure 11 (a). A fixed head of 19.0m OD is specified in the soakaway crate to simulate a similar scenario to the modelling presented in Section 4.2. For the comparison, the ECO-90 conceptual model is presented in Figure 11 (b).

E info@groundwaterdynamics.co.uk

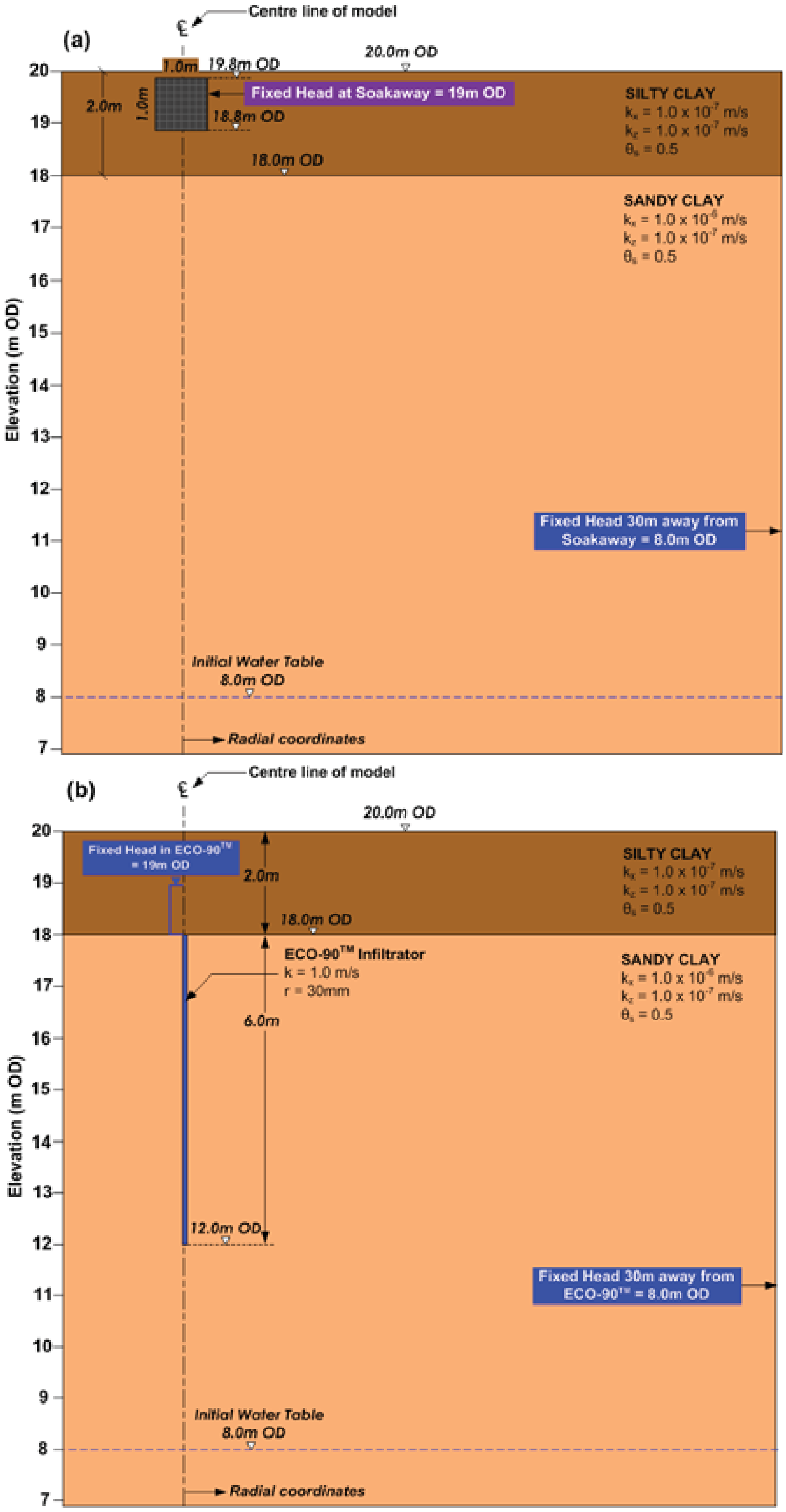


Figure 11: Radial conceptual model drawing for:
(a) the scenario with the soakaway crate in the top 2.0m of soil
(b) the scenario with the ECO-90 installed from 2.0m bgl to 6.0m bgl.

The simulated groundwater head contours and flow lines for this model are shown in Figure 12 (a) for the soakaway crate and (b) for the ECO-90 infiltrator.

As can be seen by the pattern of the groundwater head contours, the normal soakaway system only impacts groundwater conditions within the top 2.0m of soil, which significantly reduces the infiltration capacity of the system.

The ECO-90 system on the other hand has a large impact between 2.0m bgl and 6.0m bgl, with water flowing out horizontally from the ECO-90 over this entire depth range.

From the SEEP/W model output, OGI has calculated the infiltration rate for both the soakaway system and the ECO-90 probe. The results are:

- Soakaway system: Simulated infiltration rate = 0.0013 lit/s (0.08 lit/min)
- ECO-90 infiltrator: Simulated infiltration rate = 0.06 lit/s (3.6 lit/min)

As you can see from the simulated infiltration rates, the ECO-90 is considerably more effective at infiltrating into the ground than the soakaway crate system near the surface.

This is due to the ECO-90 being able to infiltrate water into more permeable horizontal layers such as sand and silt lenses which are found at greater depths below the ground surface.

It must be noted however that the flow rates given here are based on just one set of modelled ground conditions.

Further analysis is required for different arrangements of ECO-90 infiltrators to develop a deeper understanding of the difference in potential infiltration rates between normal soakaway systems and the ECO-90 system as it is installed in practice.

For a copy in full of the OGI scientific analysis please contact us.

E info@groundwaterdynamics.co.uk

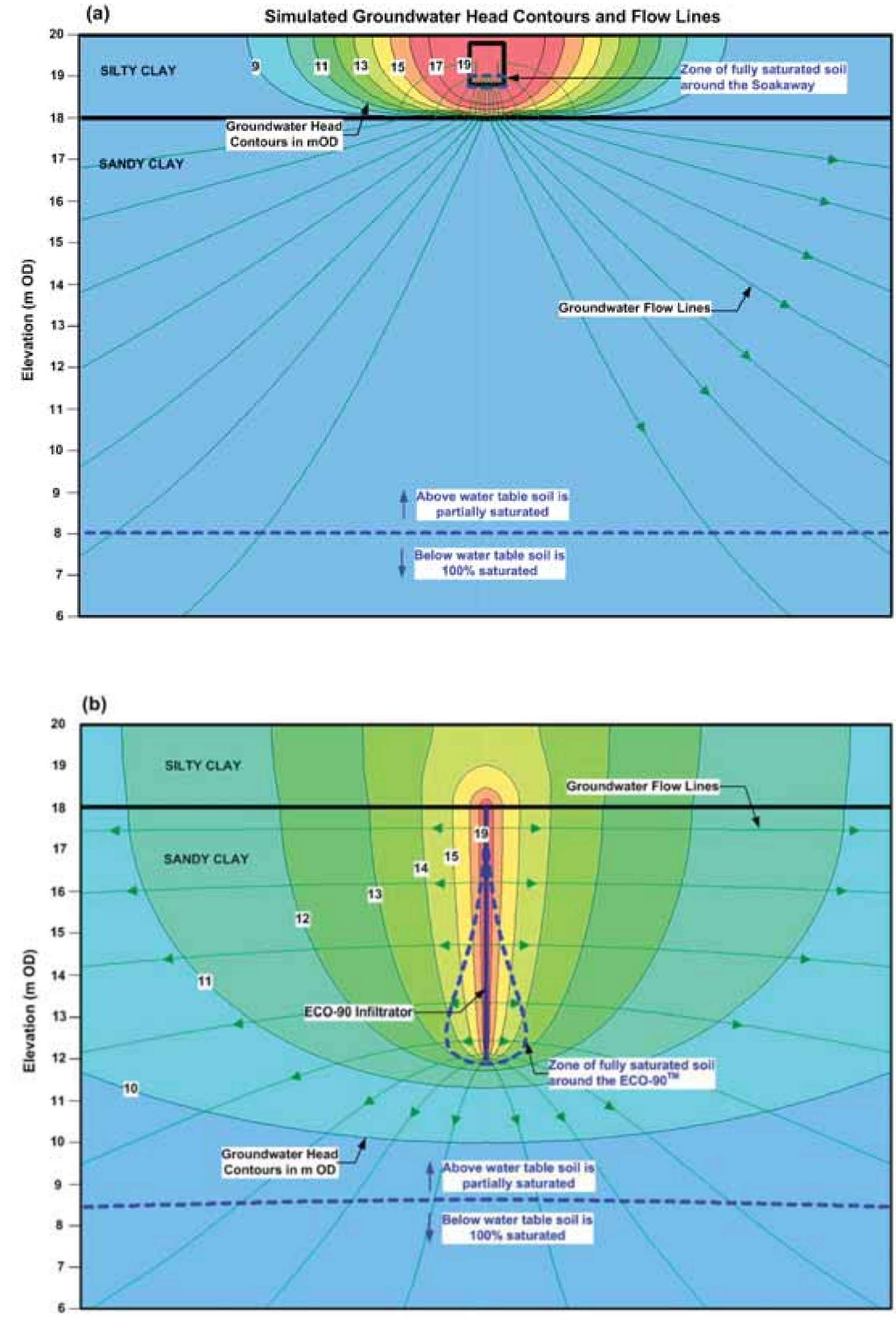


Figure 12: Simulated groundwater head contours and groundwater flow paths for (a) normal soakaway system and (b) a single ECO-90 infiltrator.

Annexe 1: Drilling rig

The Comacchio GEO 205 mini-drill rig

We use the Comacchio GEO 205 mini drill-rig. It can carry out a variety of drilling techniques that makes it a formidable, yet compact, soil investigation rig.

Rig Specification

Tracking width:	1.1 m
Tracking length:	4.5 m
Working width:	2.0 m
Stored height:	2.1 m
Working height:	4.5 m
Weight:	2.0 tonnes

Annexe 2: Drilled hole dimensions & ECO-90™ lengths

Vertical holes are drilled with a diameter of between 63.5mm and 88.9mm using displacement augers to depths up to 14 metres below ground level. Once drilled the ECO-90s™ are capped and then vertically installed, coming to rest 300mm below ground level. If installed in natural turf, such as a golf course, the drilled holes are then dressed with a mixture of native soil and a root zone mix before the original turf core is replaced.

ECO-90s™ are manufactured and stored in 6 metre lengths. Before each installation begins, and with reference to the ECO-90™ system design for the site, some of these lengths are cut into 1.5 and 3 metre lengths and will be installed into the 63.5mm diameter boreholes. For 6 and 12 metre lengths, 3 ECO-90™ devices are interlinked together, before being vertically inserted into the larger 88.9mm diameter boreholes.

The 6 and 12 metre lengths are called 'Primaries'. The 1.5 and 3 metre lengths are called 'Secondaries'. Wherever possible an ECO-90™ system design will comprise an array of Primaries, interspersed with Secondaries that draw water down and find deeper drainage by connecting to a Primary.

Annexe 3: ECO-90™ system maintenance

The ECO-90™ system has no requirement for maintenance.

If it is used below a traditional infiltration trench there will be a need for the trench and silt traps to be maintained.

Your Notes

Your Notes

E info@groundwaterdynamics.co.uk

Your Notes

Tel: 01926 833146
www.groundwaterdynamics.co.uk
info@groundwaterdynamics.co.uk

Furzen Hill Farm, Coventry Road
Cubbington, Leamington Spa, CV32 7UJ

APPENDIX D

Extract from Engineering Consultancy 49 Drainage Design Statement Borehole Log and Infiltration Testing Datasheet

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD/ RB
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	1	**Drill diameter**	89 mm	**Ground**	Damp

date: 17/10/22

Borehole Reference

	BH1	BH2	BH3	BH4	-	-	-

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	12000	6000	3000	1500	-	-	-
Final drill depth (mm)	12300	6000	3000	1350			
Time to drill (mins)	60	30	7	3			

Soil / Drilling Conditions

Description

Log supplied by Soil & Structures ltd - samples sent to lab

BH1 - 10m well screen used (No Silt Sock) - 5 minutes of pumping at 85L a minute (approx 400 litres) BH filled to 3100mm bgl

BH1 - Damp spoil on last retracted auger - No GW in BH

BH1 - BH blocked/ collapsed @ 8300mm (40 mins into test)

BH2 - BH filled to 1700mm bgl

BH2 - BH blocked/ collapsed @ 4440mm (40 mins into test)

BH3 - BH blocked/ collapsed @ 1540mm (40 mins into test) // BH4 - BH blocked/ collapsed @ 1140mm (40 mins into test)

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)	10500/12000 approx						
Water level after 0 mins (mm)	dry	dry	dry	dry			
Water level after 20 mins (mm)	dry	dry	dry	dry			

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	12300	6000	3000	1500			
Water level pre-test (mm)							
Pipework or open cavity?	P	O	O	O			

Test Results

Mins	*Secs*	*Mins*	*Secs*	*Depth to water (mm bgl)*						
1	60									
2	120			4550	3650	580	250			
3	180									
4	240			5080	4000	650	270			
5	300									
6	360			5400	4240	720	320			
7	420									
8	480			5750	4350	800	400			
9	540									
10	600			6050	4400	840	430			
15	900			6840		940	520			
20	1200			7200		980	550			
25	1500			7400		1000	600			
30	1800			7910		1050	660			
40	2400			8070		1100	680			
50	3000			8170		1130	730			
60	3600			8220		1140	730			

Notes

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD/ RB
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	2	**Drill diameter**	89 mm	**Ground**	Damp

date: 18/10/22

Borehole Reference

	BH1	BH2	BH3	BH4	-	-	-

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	12000	6000	3000	1500	-	-	-
Final drill depth (mm)	12000	6650	3000	1400			
Time to drill (mins)	60	30	7	3			

Soil / Drilling Conditions

Description

drilled on 17/10/2022 - tested 18/10/2022

BH1 - 5m slotted pipe/ 6m unslotted pipe (silt sock used on 5m of slotted pipe)

BH1 - Hole collapsed at 10800mm prior to installing pipework - potentially collapse at GW ingress?

BH2 - 4m slotted pipe/ 3m unslotted pipe (silt sock used on 3m of slotted pipe)

BH3 - 2m slotted pipe/ 1m unslotted pipe (silt sock used on 2m of slotted pipe)

BH1 - tested by RB

No silt ingress when silt sock used (lab results sent off to estabish size of silt particles for silt sock micron size required)

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)	10500/12000 approx						
Water level after 0 mins (mm)		dry	dry	dry			
Water level after 20 mins (mm)		dry	dry	dry			

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	10800	6000	3000	1500			
Water level pre-test (mm)	10780						
Pipework or open cavity?	p	p	p	O			

Test Results

Mins	*Secs*	***Mins***	*Secs*	*Depth to water (mm bgl)* BH1	BH2	BH3	BH4	-	-	-
1	60				3390	1020	710			
2	120									
3	180				3730	1150	930			
4	240									
5	300				3970	1250	1020			
6	360									
7	420				4260	1470	1070			
8	480									
9	540				4400	1600	1100			
10	600									
15	900				4970	2000	1160			
20	1200				5470	2170	1200			
25	1500				5660	2550	1220			
30	1800				5780	2740	1230			
40	2400				5960	2850	1260			
50	3000				6080	2870	1270			
60	3600				6190	2870	1280			

Notes

BH1	BH2	BH3	BH4	-	-	-

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD/ RB
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	3	**Drill diameter**	89 mm	**Ground**	Damp

date: 18/10/22

Borehole Reference

	BH1	**BH2**	**BH3**	**BH4**	**-**	**-**	**-**

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	12000	6000	3000	1500	-	-	-
Final drill depth (mm)	11600	6000	3000	1500			
Time to drill (mins)	45	15	6	3			

Soil / Drilling Conditions

Description

BH1 blocked @ 10420 after drilling - pushed well screen through to 11600 - gw dropped to 10670 before test

BH1 (8 slotted pipe/ 4 unslotted pipe) no silt sock used

BH2 (3 slotted pipe/ 3 unslotted pipe) no silt sock used

BH3 collapse @2500mm 40 mins into test

BH1 test recorded by RB

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)							
Water level after 0 mins (mm)	10420	dry	dry	dry			
Water level after 20 mins (mm)	10670	dry	dry	dry			

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	11600						
Water level pre-test (mm)	10670	dry	dry	dry			
Pipework or open cavity?	P	P	O	O			

Test Results

Mins	*Secs*	***Mins***	*Secs*	*Depth to water (mm bgl)*						
1	60				1950	660	60			
2	120				2480	940	70			
3	180				2860	1220	100			
4	240				3260	1440	150			
5	300				3470	1630	150			
6	360				3580	1680	190			
7	420				3680	1790	220			
8	480				3820	1890	240			
9	540				3900	1960	260			
10	600				3960	2000	280			
15	900				4910	2130	360			
20	1200				5070	2240	400			
25	1500				5270	2300	430			
30	1800				5430	2370	480			
40	2400				5740	2430	540			
50	3000				5760	2480	580			
60	3600				5790		630			

Notes

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	4	**Drill diameter**	89 mm	**Ground**	Damp

date: 18/10/22

Borehole Reference

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	12000	9000	6000	3000	-	-	-
Final drill depth (mm)	12300	9000	6500	3000			
Time to drill (mins)	35	25	15	5			

Soil / Drilling Conditions

Description

BH1 (6 slotted pipe/ 7 unslotted pipe) no silt sock used

BH2 (6 slotted pipe/ 3 unslotted pipe) no silt sock used

BH1 (4 slotted pipe/ 1 unslotted pipe) no silt sock used

Unable to fill bh1 + bh2 initially

Same ground as areas 1-3 (more gravel struck between 1.5 - 3m)

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)							
Water level after 0 mins (mm)	dry	dry	dry	dry			
Water level after 20 mins (mm)	dry	dry	dry	dry			

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)							
Water level pre-test (mm)							
Pipework or open cavity?	P	P	P	O			

Test Results

Mins	*Secs*	*Mins*	*Secs*	*Depth to water (mm bgl)*						
1	60				4100	2700	300			
2	120									
3	180			2650	6090	3550	670			
4	240									
5	300			4900	6440	3950	820			
6	360				6660	4120	900			
7	420			5880	6830	4270	1000			
8	480			6500	6960	4410	1070			
9	540			7540	7050	4570	1150			
10	600			7320	7150	4730	1250			
15	900			9100	7450	5000	1440			
20	1200			10070	7710	5210	1640			
25	1500			10530	7830	5300	1740			
30	1800			10570	7900	5400	1830			
40	2400			10970	8050	5570	2020			
50	3000			11150	8150		2200			
60	3600			11270	8270		2400			

Notes

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	5	**Drill diameter**	89 mm	**Ground**	Damp

date: 19/10/22

Borehole Reference

	BH1	BH2	BH3	BH4	-	-	-

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	12000	6000	9000	3000	-	-	-
Final drill depth (mm)	12000	6300	9000	3000			
Time to drill (mins)	40	15	30	5			

Soil / Drilling Conditions

Description

BH1 (10 slotted pipe/ 2 unslotted pipe) no silt sock used

BH2 (3 slotted pipe/ 3 unslotted pipe) no silt sock used

BH3 (5 slotted pipe/ 4 unslotted pipe) 5m silt sock used

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)	11500						
Water level after 0 mins (mm)		dry	dry	dry			
Water level after 20 mins (mm)		dry	dry	dry			

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	11700	6180	8840	3000			
Water level pre-test (mm)	11670	dry	dry	dry			
Pipework or open cavity?	P	P	P	O			

Test Results

Mins	*Secs*	***Mins***	*Secs*	*Depth to water (mm bgl)*						
1	60			4000	3100	5100	590			
2	120			4600	3240	5960	840			
3	180			5300	3550	6450	1020			
4	240			5660	3800	6750	1200			
5	300			5940	4670	7000	1230			
6	360			6240	4380	7220	1340			
7	420			6710	4550	7420	1470			
8	480			7770	4700	7550	1520			
9	540			8300	4800	7660	1600			
10	600			8700	4900	7760	1700			
15	900			9670	5100	8120	1960			
20	1200			10150	5270	8420	2150			
25	1500			10260	5320	8540	2300			
30	1800			10460	5370	8570	2400			
40	2400			10650	5440	8620	2600			
50	3000			10730	5480	8670	2670			
60	3600			10800	5510	8700	2740			

Notes

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	Drill method	Rotary auger	Logger	JOD
Client	GTA civils	Drill rig	Comachio 205	Weather	Dry throughout
Test drill area	6	Drill diameter	89 mm	Ground	Damp

date: 19/10/22

Borehole Reference

	BH1	BH2	BH3	BH4	-	-	-

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	9000	6000	3000		-	-	-
Final drill depth (mm)	9400	6000	3000				
Time to drill (mins)	25	15	5				

Soil / Drilling Conditions

Description

BH1 (5 slotted pipe/ 3 unslotted pipe) no silt sock used

BH2 (3 slotted pipe/ 3 unslotted pipe) no silt sock used

casings suspended from the bottom as ground collapsing around pipework

Same ground as all areas

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)							
Water level after 0 mins (mm)	dry	dry	dry				
Water level after 20 mins (mm)	dry	dry	dry				

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	9400	6000	3000				
Water level pre-test (mm)	dry	dry	dry				
Pipework or open cavity?	P	P	O				

Test Results

Mins	*Secs*	*Mins*	*Secs*	*Depth to water (mm bgl)*						
1	60			3450	1420	280				
2	120			4250	1670	340				
3	180			4760	2000	400				
4	240			5070	2250	460				
5	300			5260	2500	500				
6	360			5480	2680	550				
7	420			5720	2830	600				
8	480			5860	3000	610				
9	540			6070	3110	640				
10	600			6740	3240	670				
15	900			7180	3700	820				
20	1200			7550	3990	880				
25	1500				4200	920				
30	1800				4350	960				
40	2400				4540	1000				
50	3000				4670	1050				
60	3600				4770	1100				

Notes

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	7	**Drill diameter**	89 mm	**Ground**	Damp

date: 19/10/22

Borehole Reference

	BH1	BH2	BH3	BH4	-	-	-

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	9000	6000	3000		-	-	-
Final drill depth (mm)	9000	6000	3000				
Time to drill (mins)	30	20	5				

Soil / Drilling Conditions

Description

BH1 (6 slotted pipe/ 2 unslotted pipe) no silt sock used

BH2 (3 slotted pipe/ 2 unslotted pipe) no silt sock used

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)		**6000**					
Water level after 0 mins (mm)	dry	dry	dry				
Water level after 20 mins (mm)	dry	dry	dry				

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	9000	6000	3000				
Water level pre-test (mm)	dry	dry	dry				
Pipework or open cavity?	P	P	O				

Test Results

Mins	*Secs*	***Mins***	*Secs*	*Depth to water (mm bgl)*						
1	60			1090	500	960				
2	120			1700	680	1250				
3	180			2070	780	1360				
4	240			2300	860	1490				
5	300			2530	940	1600				
6	360			2730	1030	1650				
7	420			2920	1080	1700				
8	480			3100	1100	1760				
9	540			320	1180	1800				
10	600			3370	1240	1880				
15	900			3850	1450	2100				
20	1200			4130	1630	2230				
25	1500			4420	1710	2350				
30	1800			4660	1860	2400				
40	2400			4950	2120	2540				
50	3000			5280	2290	2600				
60	3600			5540	2440	2660				

Notes

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	8	**Drill diameter**	89 mm	**Ground**	Damp

date: 19/10/22

	Borehole Reference						
	BH1	**BH2**	**BH3**	**BH4**	-	-	-

Drilling Details

	BH1	BH2	BH3	BH4	-	-	-
Target drill depth (mm)	9000	6000	3000		-	-	-
Final drill depth (mm)	9000	6000	3000				
Time to drill (mins)	35	25	5				

Soil / Drilling Conditions

Description

Ground saturated in area 8 - affecting stability of BH's

BH's collapsing at various points throughout testing - unable to clear using drain rods

Pipework not used as unable to retract

Strata as per other areas

Groundwater Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth to damp rods (mm)							
Water level after 0 mins (mm)							
Water level after 20 mins (mm)							

Test Conditions

	BH1	BH2	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	7700	3000					
Water level pre-test (mm)		3000	dry				
Pipework or open cavity?	O	O	O				

Test Results

Mins	*Secs*	***Mins***	*Secs*	*Depth to water (mm bgl)*						
1	60			960	0	50				
2	120			1300	10	70				
3	180			1580	30	90				
4	240			1800	50	100				
5	300			1860	70	100				
6	360			1930	100	110				
7	420			2000	110	110				
8	480			2020	130	120				
9	540			2080	150	40				
10	600			2100	170	170				
15	900			2410	270	210				
20	1200			2620	340	250				
25	1500			2980	400	300				
30	1800			3280	480	330				
40	2400			3600	550	380				
50	3000			3840	630	440				
60	3600			4090	700	570				

Notes

1 All depths below ground level (bgl) unless stated

2

Eco90 Field Trial - Borehole Log and Infiltration Testing Datasheet

GROUND WATER DYNAMICS

Project Name	High st, Ascot	**Drill method**	Rotary auger	**Logger**	JOD
Client	GTA civils	**Drill rig**	Comachio 205	**Weather**	Dry throughout
Test drill area	retest	**Drill diameter**	89 mm	**Ground**	Damp

date: 20/10/2022

Borehole Reference

Drilling Details

	BH1 (A1 12m)	BH2 (A5 9m)	BH3	BH4	-	-	-
Target drill depth (mm)	12000	9000			-	-	-
Final drill depth (mm)	12000	9000					
Time to drill (mins)							

Soil / Drilling Conditions

Description

Area 1 12m BH retest - BH collapsed at 7820mm bgl after 3 days of pipework being in the ground - Pipes had to be retracted using JCB 3cx

Area 5 9m BH retest - BH collapsed at 8700mm - 40mm higher than previous day (pipes were suspended so its not silt ingress through silt sock) - Pipes clean internally when

Groundwater Conditions

	BH1 (A1 12m)	BH2 (A5 9m)	BH3	BH4	-	-	-
Depth to damp rods (mm)							
Water level after 0 mins (mm)							
Water level after 20 mins (mm)							

Test Conditions

	BH1 (A1 12m)	BH2 (A5 9m)	BH3	BH4	-	-	-
Depth of hole pre-test (mm)	7820	8700					
Water level pre-test (mm)	dry	dry					
Pipework or open cavity?	P	P					

Test Results

Mins	*Secs*	*Mins*	*Secs*	*Depth to water (mm bgl)*						
1	60			1420	2670					
2	120			2060	3510					
3	180			2090	3980					
4	240			3210	4450					
5	300			3360	4770					
6	360			3460	5130					
7	420			3550	5280					
8	480			3750	5400					
9	540			3940	5510					
10	600			4030	5600					
15	900			4260	6070					
20	1200			4500	6410					
25	1500			4680	6640					
30	1800			4800	6820					
40	2400									
50	3000									
60	3600									

Notes

1 *All depths below ground level (bgl) unless stated*

2

APPENDIX E

AP Geotechnics Standpipe Records
August 2022 – January 2023

STANDPIPE RECORDS

GAS EMISSIONS AND WATER LEVELS

Project: ASCOT HIGH STREET, ASCOT
Client: London Square — Project No: 5590
Agent: Barnard & Associates — Sheet No: 1/3

Date		Measurement	Units	Location							
16/08/2022				BH1		BH2		BH3		BH6	
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	26	Flow rate	l/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atmos. mb	1000	Methane	%	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Carbon dioxide	%	1.0	1.6	0.2	0.3	1.1	1.6	0.5	0.5
Cloud	90 %	Carbon monoxide	ppm	0	0	0	0	0	0	0	0
Sun	10 %	Hydrogen sulphide	ppm	0	0	0	0	0	0	0	0
Rainfall	nil	Oxygen	%	20.1	19.6	20.8	20.0	20.1	19.4	20.8	20.5
		PID reading	ppm	0	0	0	0	0	0	0	0
		Water level	m bgl	Dry @ 3.72		Dry @ 4.04		Dry @ 4.02		2.12	

Date		Measurement	Units	Location							
16/08/2022				BH8							
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	26	Flow rate	l/hr	0.0	0.0						
Atmos. mb	1000	Methane	%	0.0	0.0						
		Carbon dioxide	%	0.2	0.1						
Cloud	90 %	Carbon monoxide	ppm	0	0						
Sun	10 %	Hydrogen sulphide	ppm	0	0						
Rainfall	nil	Oxygen	%	20.5	20.7						
		PID reading	ppm	0	0						
		Water level	m bgl	Dry @ 3.98							

Date		Measurement	Units	Location							
12/09/2022				BH1		BH2		BH3		BH6	
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	23	Flow rate	l/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Atmos. mb	1004	Methane	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Carbon dioxide	%	4.7	5.5	2.4	3.5	4.0	4.3	0.3	2.1
Cloud	80 %	Carbon monoxide	ppm	0	0	0	0	0	0	0	0
Sun	20 %	Hydrogen sulphide	ppm	0	0	0	0	0	0	0	0
Rainfall	nil	Oxygen	%	15.5	14.8	18.6	18.1	16.9	16.7	19.1	17.7
		PID reading	ppm	0	0	0	0	0	0	0	0
		Water level	m bgl	Dry @ 3.72		Dry @ 4.04		Dry @ 4.02		1.86	

Date		Measurement	Units	Location							
12/09/2022				BH8							
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	23	Flow rate	l/hr	0.0	0.0						
Atmos. mb	1004	Methane	%	0.0	0.0						
		Carbon dioxide	%	0.0	0.0						
Cloud	80 %	Carbon monoxide	ppm	0	0						
Sun	20 %	Hydrogen sulphide	ppm	0	0						
Rainfall	nil	Oxygen	%	20.7	20.8						
		PID reading	ppm	0	0						
		Water level	m bgl	Dry @ 3.98							

Readings taken with GFM435 manufactured by Gas Data Ltd.

STANDPIPE RECORDS

GAS EMISSIONS AND WATER LEVELS

Project: ASCOT HIGH STREET, ASCOT
Client: London Square — Project No: 5590
Agent: Barnard & Associates — Sheet No: 2/2

Date		Measurement	Units	Location							
17/10/2022				BH1		BH2		BH3		BH6	
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	20	Flow rate	l/hr	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Atmos. mb	1011	Methane	%	65.1	0.0	0.0	0.0	0.0	0.0	46.6	0.0
		Carbon dioxide	%	0.2	0.1	0.0	0.0	0.9	1.4	0.6	1.1
Cloud	50 %	Carbon monoxide	ppm	0	0	0	0	0	0	0	0
Sun	50 %	Hydrogen sulphide	ppm	0	0	0	0	0	0	0	0
Rainfall	nil	Oxygen	%	20.6	20.6	21.2	20.9	25.0	19.7	20.9	19.6
		PID reading	ppm	0	0	0	0	0	0	0	0
		Water level	m bgl	Dry @ 3.72		Dry @ 4.04		Dry @ 4.02		2.32	

Date		Measurement	Units	Location							
17/10/2022				BH8							
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	20	Flow rate	l/hr	0.0	0.0						
Atmos. mb	1011	Methane	%	0.0	0.0						
		Carbon dioxide	%	0.0	0.0						
Cloud	50 %	Carbon monoxide	ppm	0	0						
Sun	50 %	Hydrogen sulphide	ppm	0	0						
Rainfall	nil	Oxygen	%	20.7	20.8						
		PID reading	ppm	0	0						
		Water level	m bgl	Dry @ 3.98							

Date		Measurement	Units	Location							
16/11/2022				BH1		BH2		BH3		BH6	
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	11	Flow rate	l/hr	0.3	0.0	-0.6	0.0	0.3	0.0	76.2	0.0
Atmos. mb	984	Methane	%	4.1	0.0	3.9	0.0	2.2	0.0	2.2	0.0
		Carbon dioxide	%	3.4	2.2	4.2	5.1	5.1	6.2	1.5	1.9
Cloud	90 %	Carbon monoxide	ppm	0	0	0	0	0	0	0	0
Sun	nil	Hydrogen sulphide	ppm	0	0	0	0	0	0	0	0
Rainfall	light	Oxygen	%	17.8	18.1	17.5	15.8	17.1	15.7	17.1	15.1
		PID reading	ppm	0	0	0	0	0	0	0	0
		Water level	m bgl	Dry @ 3.72		Dry @ 4.04		Dry @ 4.02		0.66	

Date		Measurement	Units	Location							
16/11/2022				BH8							
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	11	Flow rate	l/hr	0.1	0.0						
Atmos. mb	984	Methane	%	4.5	0.0						
		Carbon dioxide	%	3.9	1.6						
Cloud	90 %	Carbon monoxide	ppm	0	0						
Sun	nil	Hydrogen sulphide	ppm	0	0						
Rainfall	light	Oxygen	%	16.8	18.4						
		PID reading	ppm	0	0						
		Water level	m bgl	2.15							

Readings taken with GFM435 manufactured by Gas Data Ltd.

STANDPIPE RECORDS

GAS EMISSIONS AND WATER LEVELS

Project: ASCOT HIGH STREET, ASCOT
Client: London Square — Project No: 5590
Agent: Barnard & Associates — Sheet No: 3/3

Date		Measurement	Units	Location							
04/01/2023				BH1		BH2		BH3		BH6	
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	15	Flow rate	l/hr	0.0	0.0	-3.6	-6.0	0.0	0.0	0.0	0.0
Atmos. mb	1007	Methane	%	0.0	0.0	2.3	0.0	6.2	0.0	0.0	0.0
		Carbon dioxide	%	0.2	4.5	1.5	3.5	2.8	3.2	2.0	0.0
Cloud	100 %	Carbon monoxide	ppm	0	0	0	0	0	0	0	0
Sun	nil	Hydrogen sulphide	ppm	0	0	0	0	0	0	0	0
Rainfall	nil	Oxygen	%	19.5	16.0	18.5	15.8	20.9	14.9	18.7	20.0
		PID reading	ppm	0	0	0	0	0	0	0	0
		Water level	m bgl	3.22		Dry @ 4.04		2.15		0.34	

Date		Measurement	Units	Location							
04/01/2023				BH8							
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C	15	Flow rate	l/hr	0.0	0.0						
Atmos. mb	1007	Methane	%	9.6	0.0						
		Carbon dioxide	%	1.4	0.9						
Cloud	100 %	Carbon monoxide	ppm	0	0						
Sun	nil	Hydrogen sulphide	ppm	0	0						
Rainfall	nil	Oxygen	%	16.4	18.2						
		PID reading	ppm	0	0						
		Water level	m bgl	1.04							

Date		Measurement	Units	Location							
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C		Flow rate	l/hr								
Atmos. mb		Methane	%								
		Carbon dioxide	%								
Cloud		Carbon monoxide	ppm								
Sun		Hydrogen sulphide	ppm								
Rainfall		Oxygen	%								
		PID reading	ppm								
		Water level	m bgl								

Date		Measurement	Units	Location							
Weather conditions				Initial	Steady	Initial	Steady	Initial	Steady	Initial	Steady
Temp. °C		Flow rate	l/hr								
Atmos. mb		Methane	%								
		Carbon dioxide	%								
Cloud		Carbon monoxide	ppm								
Sun		Hydrogen sulphide	ppm								
Rainfall		Oxygen	%								
		PID reading	ppm								
		Water level	m bgl								

Readings taken with GFM435 manufactured by Gas Data Ltd.

APPENDIX F

LLFA Comments dated 10th August 2022
LLFA Comments dated 24th February 2023
Project Centre Email to B&A Dated 14th April 2023
Project Centre Email to B&A Dated 27th April 2023
LLFA Comments dated 12th May 2023

Comments on behalf of the Lead Local Flood Authority relating to sustainable drainage

www.rbwm.gov.uk

Royal Borough of Windsor & Maidenhead

Application number: 22/01971/FULL
Site: Land Bounded By Ascot Fire Station Station Hill And West of Hermitage Parade And South of High Street Ascot
Description: Redevelopment of the site to provide 3,261sqm commercial and community floorspace (mix of uses within Use Classes E, F1 and F2) and x137 dwellings with associated parking, access, open space, landscaping and other associated works. Provision of new public open space with associated hard and soft landscape works, new pedestrian and cycle paths and children's play area.
Date: 10th August 2022
Prepared by: Patricia Machado (RBWM.sudsDC@projectcentre.co.uk)

1.1 Documents reviewed

As part of responding to the above planning application, we have reviewed the following documents:

- Flood Risk Assessment

1.2 Comments

Based on the review of the above-mentioned documents, we have the following comments:

1. Paragraph 3.7.3 of the Flood Risk Assessment states that groundwater is encountered between 0.7m to 3.3m below ground. It is required that there is at least 1m from the base of the infiltration device to the top of the groundwater level. Confirmation is required that this is achieved throughout the site.
2. Due to the ground conditions referenced in the Flood Risk Assessment, infiltration testing to BRE Digest 365 should be completed prior to this application being approved as it is unlikely that a sufficient infiltration rate will be achieved.

3. Should infiltration not be viable is there an alternative method of disposal of surface water?

1.3 Recommendation

Unless the applicant is given the opportunity to respond to the above comments, we recommend that application 22/01971/FULL is not approved at present.

1.4 Contact Information

If you have any queries, please forward it to planning@RBWM.gov.uk

Document Control

Project Centre shall not be liable for the use of any information contained herein for any purpose other than the sole and specific use for which it was prepared.

Job Number	Issue	Description	Originator	Approver
22/01971	1	FULL	Patricia Machado 10.08.22	Thomas Hawes 10.08.22

G:\Project Centre\Project-BST\1000007252 - RBWM Lot 3 2021-22\2 Project Delivery\6 SUDS DC support\22-23\22-01971 Land Bounded by Ascot Fire Station

Comments on behalf of the Lead Local Flood Authority relating to sustainable drainage

www.rbwm.gov.uk

Royal Borough of Windsor & Maidenhead

Application number: 22/01971/FULL	
Site: Land Bounded By Ascot Fire Station Station Hill And West of Hermitage Parade And South of High Street Ascot	
Description: Redevelopment of the site to provide 3,261sqm commercial and community floorspace (mix of uses within Use Classes E, F1 and F2) and x137 dwellings with associated parking, access, open space, landscaping and other associated works. Provision of new public open space with associated hard and soft landscape works, new pedestrian and cycle paths and children's play area.	
Date: 24th February 2023	
Prepared by: Tom Hawes (RBWM.sudsDC@projectcentre.co.uk)	

1.1 Documents reviewed

As part of responding to the above planning application, we have reviewed the following documents:

- Flood Risk Assessment
- Planning Statement Addendum
- Cover Letter
- FRA Addendum Revision P01 including Appendices A-J

1.2 Comments

Based on the review of the above-mentioned documents, we have the following comments:

1. Can the applicant demonstrate through use of The Simple Index approach as set out within The SuDS Manual CIRIA C753, how sufficient water quality treatment will be provided? It is anticipated that the proposals as set out in Section 5.01 of the FRA addendum will be sufficient, but we still require this to be confirmed via methodology outlined above. Clarity on proposed

treatment for the catchments draining exclusively via permeable paving will also be required.

2. The body of the report states that a draft management and maintenance plan is included within Appendix H. However, Appendix H includes drawings of the existing site only.
3. Section 1.1 of Appendix G states that "EC49 has been appointed by Groundwater Dynamics (GWD) to undertake calculations to demonstrate the level of drainage that may be realised by sustainable means through the use of the GWD Energy-Passive Groundwater Recharge Pump (ECO-90) system for dispersing surface water into ground with low infiltration properties at the natural ground surface". Can the applicant clarify if this is a pumped system?
4. It is our understanding that the ECO-90 sizing and depths have been derived using the infiltration testing presented within Appendix B, of Appendix G. It appears that infiltration testing in these locations has only been undertaken once at each location. For the testing to be BRE Digest 365 compliant the boreholes would be required to be filled three times over the same or consecutive days.
5. Can the applicant clarify how the infiltration rate used in the MicroDrainage calculations, and the ECO-90 calculations been calculated?
6. We note that calculations for the ECO-90 for catchment J have been included in the FRA addendum. However, this area is proposed to drain via permeable paving. Can calculations for this please be provided?
7. How has the risk of groundwater impacting the ECO-90 system been mitigated?
8. Section 3.03.2 states that catchments C, D and E will have permeable paving as storage. However the MicroDrainage models make use of a porosity value of 0.95.

1.3 Recommendation

Unless the applicant is given the opportunity to respond to the above comments, we recommend that application 22/01971/FULL is not approved at present.

1.4 Contact Information

If you have any queries, please forward it to planning@RBWM.gov.uk

Document Control

Project Centre shall not be liable for the use of any information contained herein for any purpose other than the sole and specific use for which it was prepared.

Job Number	Issue	Description	Originator	Approver
22/01971	1	FULL	Patricia Machado 10.08.22	Thomas Hawes 10.08.22
22/01971	2	FULL	Thomas Hawes 03.01.23	Joe Hitchman 03.01.23
22/01971	3	FULL	Thomas Hawes 24.02.23	Joe Hitchman 24.02.23

G:\Project Centre\Project-BST\1000007252 - RBWM Lot 3 2021-22\2 Project Delivery\6 SUDS DC support\22-23\22-01971 Land Bounded by Ascot Fire Station