APPENDIX C – DEEP BOREHOLE SOAKAGE TEST INVESTIGATION

Report Title:

Deep Borehole Soakage Test Investigation

Project Name:

Hemel Hempstead Crematorium

Report Reference: **BRD3627-OR4-B**

Date: **June 2021**

BRD Environmental Ltd
Hawthorne Villa, 1 Old Parr Road,
Banbury, Oxfordshire, OX16 5HT
01295 272244 info@brduk.com
www.brduk.com

REPORT CONTROL SHEET

REPORT TITLE	**DEEP BOREHOLE SOAKAGE TEST INVESTIGATION**
PROJECT	**HEMEL HEMPSTEAD CREMATORIUM**
CLIENT	**WATFORD BOROUGH COUNCIL**

REPORT REFERENCE	ISSUE DETAIL	DATE	PREPARED BY	CHECKED BY
BRD3627-OR4-A	First Issue.	26/05/2021	R Marina	B Devonshire
BRD3627-OR4-B	Second Issue: Incorporation of minor amendments from Webb Yates.	11/06/2021	B Devonshire	N Kimber

BRD Environmental Limited

Geotechnical and Environmental Services

- Ground Investigation
- Japanese Knotweed Removal
- Soil, Water and Gas Testing
- Contamination Assessment
- Geotechnical Advice
- Remediation Solutions

Hawthorne Villa, 1 Old Parr Road, Banbury, Oxfordshire. OX16 5HT
T: 01295 272244 www.brduk.com info@brduk.com

REPORT LAYOUT

This report is divided into the following four sections: Summary Report, Technical Report, Supporting Information and Appendices.

SUMMARY REPORT

This expanded executive summary provides the main findings of the work undertaken in brief non-technical language. This section provides an overview of the key outcomes for the benefit of non-specialists and concludes with the main recommendations. This section should only be relied upon in the context of the whole report and the Technical Report should be referred to with respect to any design decisions.

TECHNICAL REPORT

The main report section is intended to provide the technical detail of the investigation and is intended to provide the level of information required by current guidance documents and practice. The Technical Report is written in a language that, in part, assumes knowledge of subject matter so that it can be written in as concise a form as possible. Its intended audience is peers, regulators and other professionals in related disciplines.

SUPPORTING INFORMATION

This section of the report provides background details of a generic nature together with specific technical approaches adopted by BRD and details of the guidance documents that are commonly referenced in the report. The section also includes explanations of technical terms to assist non-specialist readers in understanding the Technical Report. It should be noted that not all the information within this section is necessarily applicable to this specific report.

APPENDICES

The final section of the report presents the factual data collected and employed as part of the investigation.

SUMMARY REPORT - GENERAL INFORMATION

SUBJECT	COMMENTS
CURRENT SITE CONDITION	The site currently comprises an overgrown field including a standing/attenuation pond with an outfall to a borehole soakaway that is associated with the new cemetery development to the north.
PROPOSED DEVELOPMENT	It is proposed that the site will be developed with a new crematorium building together with additional car parking and landscaping with a separate drainage system.
DEEP BOREHOLE SOAKAGE TESTS	This investigation has confirmed that the use of deep borehole soakaways is viable at this site. The behaviour of the test and detailed logging of the chalk has identified a combined horizon of granular structureless chalk and fractured structured chalk that provides exceptionally fast infiltration.

SUMMARY REPORT – KEY RECOMMENDATIONS

RECOMMENDATIONS

The following recommendations are made for the design of the drainage system:

- In the interests of sustainability and as it has been constructed in manner such that it is suitable for use, the borehole well installed for this investigation should be considered for incorporation into the drainage design as a long term borehole soakaway.
- The design of the drainage system should be such that the water discharged into the deep borehole soakaway is as free of silt as is reasonably practicable to achieve. This will be critical in prolonging the use of the borehole soakaway.
- An appropriate factor of safety should be applied to the high infiltration rates recorded in this investigation so that there is some allowance for deterioration of performance over time as silting up occurs. With that in mind, BRD would suggest that design flow into the borehole soakaway should not exceed 2 l/s.
- Any additional deep borehole soakaways required should be designed to discharge between about 10m and 20m below ground level in the vicinity of the borehole undertaken for this investigation. The boreholes should be drilled a few metres deeper than this as that provides some capacity within the soakaway for silting up of the base without diminishing soakaway performance.
- During operation, the performance and build up of any silt within the borehole soakaways should be periodically monitored. The design of the boreholes should be such that the syphon head over the well can be easily and safely removed for such inspections. This monitoring should enable any deterioration in performance to be identified before the system is no longer operational so that remedial action can be taken if required (e.g. clearing out of the well).
- The use of deep borehole soakaways should be agreed with the Environment Agency.

1. INTRODUCTION TO TECHNICAL REPORT

1.1. CONTRACT DETAILS

CLIENT	Watford Borough Council.
SITE	Land situated at Bunkers Lane in the town of Hemel Hempstead.
CLIENT'S ADVISORS	BRD Environmental Limited (BRD) has been commissioned by Webb Yates Engineers (WYE) on behalf of the Client.
REPORT CONTEXT	It is understood that the Client intends to develop the site as a crematorium. The proposed crematorium facility consists of a single storey timber or reinforced concrete frame forming several buildings as well as surrounding open area.
REPORT TYPE	A ground investigation comprising a series of 3No. soakage tests within a deep borehole.
REPORT OBJECTIVES	The site has previously been the subject of a desk study and ground investigation referenced as follows: • 'Phase 1 Environmental Desk Study – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR1-A, dated February 2020. • 'Phase 2 Geo-Environmental Site Investigation – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR2-A, dated February 2020. • 'Soakage Test Investigation – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR3-A, dated October 2020. The purpose of the report is to investigate the use of a deep borehole soakaway.

1.2. SCOPE OF WORKS

The agreed scope of works was:

- Mobilisation to site and production of health and safety documentation.
- Setting out the accurate location and level of the exploratory point by topographical grade GPS unit.
- Undertake a Cable Avoidance Tool (CAT) scan at each exploratory point location.
- Drilling of 1No. borehole of 200mm diameter using cable percussive drilling techniques to 30m depth.
- Undertake in-situ Standard Penetration Testing (SPT) in general accordance with BS5930:2015 at 2m intervals from 10m depth to assist in producing engineering logs.
- Installation of a 30m depth soakage test well.

- Borehole will be logged in general accordance with BS5930:2015 and CIRIA C574 “Engineering in Chalk” by the supervising Senior Geo-Environmental Consultant.

- Undertake 3No. soakage tests within the investigation well to determine the infiltration rate.

- Provision of a combined factual and interpretative investigation report. Factual findings to include exploratory point record and test results. Interpretative reporting to include a summary of information from previous work at the site and commentary on deep borehole soakaway feasibility. Report to be supplied in an electronic Adobe pdf format.

1.3. REPORT LIMITATIONS

Any site boundary lines depicted on plans included within this report are approximate only and do not imply legal ownership of land. Any observations of tree species, asbestos containing materials within structures or invasive weeds, does not constitute a formal survey of such features. The identification of such features is therefore tentative only. In the case of Japanese Knotweed, BRD can undertake separate surveys for this plant undertaken by a Property Care Association qualified surveyor.

The report does not consider whether sensitive ecology or archaeology is present as these require consideration by professionals specialising in these matters. It should be recognised that the collection of desk study information may not be exhaustive and that other information pertinent to the site may be available.

The recommendations, interpretations and conclusions of this report are based solely on the ground conditions found at the exploratory holes. Due to the variability in the nature of ground, conditions between exploratory holes can only be interpreted and not defined. The description of the site and the ground conditions is accurate only for the dates of the field works. In particular, groundwater levels can vary due to seasonal and other effects.

At the time of writing, detailed information on the proposed structure, such as detailed layout, loadings and serviceability limits, was not available. Accordingly, where geotechnical design advice is provided it is on the prescriptive basis allowed for by Eurocode 7: employing conventional and conservative design rules. The scope of this investigation excludes a formal slope stability study and any observations made regarding slopes are for information only.

This report is restricted to the provision of advice in connection with drainage. For geotechnical advice and contamination assessment the previous investigation should be referred to.

2. SITE CHARACTERISTICS

2.1. SITE SETTING

SITE ADDRESS AND POST CODE	Land off Bedmond Road and Bunkers Lane, Hemel Hempstead, HP3 8LN.
NATIONAL GRID REFERENCE	508850E, 205910N

2.2. SITE DESCRIPTION

SUBJECT	COMMENTS
CURRENT SITE DESCRIPTION	The irregularly shaped, 5.8Ha site is currently an open field, previously of agricultural use. The site slopes gently in a southerly direction. A fenced off drainage pond has been constructed in the south of the site in association with the new cemetery development directly north of the site The site is bounded by a combination of wooden and metal fences with tree lines just offsite. The northern boundary is open to the newly constructed cemetery car park.
SURROUNDING LAND USE	Directly north of the site is a newly constructed car park and a single storey building. Further to the north of the site are agricultural fields, beyond which are residential houses on the outskirts of Hemel Hempstead. To the east of the site is Bedmond Road, beyond which are agricultural fields. To the south of the site is Bunkers Lane, beyond which are farms / residential properties with associated green land. To the west of the site is Bunker's Park Open Space.
PROPOSED DEVELOPMENT	It is proposed that the site will be developed as a crematorium with a single storey timber or reinforced concrete frame forming several buildings, associated parking and open space with a drainage pond.
HISTORICAL SUMMARY	The site has been used as agricultural throughout its history.
PUBLISHED GEOLOGY	The superficial deposits of Clay-with-Flints Formation is shown to be beneath the western half of the site. No superficial deposits are shown to be beneath the eastern half of the site. The Lambeth Group is shown to be the shallowest bedrock beneath the site. The Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated) is also found in the local area. Two previous investigations at the site would suggest that the ground conditions beneath the site comprise around 5m-6m of Clay-with-Flints directly overlying the Chalk.

2.3. PREVIOUS INVESTIGATIONS

BRD is aware of a couple of previous reports relating to the site associated with the new cemetery to the north of the site and BRD have also undertaken investigations for the crematorium itself. These are discussed briefly below.

2.3.1. T2 Audit Report

Cemetery Development Services carried out a desktop soil and water survey on a larger area of which the site belongs.

- 'A report to Dacorum Borough Council on the site conditions for a proposed cemetery development as part of an Environment Agency T2 Audit', Cemetery Development Services, CDSL/1084, dated March 2014

The audit report was conducted over a larger area than just the site and included both desk based research and site investigation. The site investigation included 9No. trial pits of which 6No. are located within the site.

The trial pits recorded a layer of topsoil overlying the Clay-with-Flints Formation throughout the site. The Clay-with-Flints Formation was proved to a maximum depth of 3.60m bgl where the trial pits were terminated. Cemetery Development Services estimated that the groundwater level beneath the site was likely to be in excess of 50m.

2.3.2. Borehole Soakaway Report

A single borehole was drilled in the south of the site to a depth of 20m bgl as the soakaway for the disposal of the surface water from the new attenuation/stilling pond.

The borehole was logged by the drillers who recorded a superficial orange brown silty gravelly clay to 5.70m bgl, presumed to be the Clay-with-Flints, underlain by an off white Chalk with occasional bands of flint to the base of the borehole.

The borehole was found to be dry on completion of the works, indicating any groundwater beneath the site is at least below 20m bgl. A pre-installation soakage test was undertaken in the borehole and recorded an infiltration rate in the region of 500l/min. A monitoring well was then installed with plain pipe to 11m bgl and slotted to 20m bgl. A post-installation soakage test was then undertaken which recorded 400l/min. The details of the borehole soakaway are provided within:

- 'Borehole Soakaway Installation at Land off Bedmond Road, Hemel Hempstead, HP3 8LN', Southern Testing Laboratories Limited, DK/MS/J13317, dated October 2017.

2.3.3. BRD Environmental Ltd

The site was the subject of a previous desk study referenced as follows:

- 'Phase 1 Environmental Desk Study – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR1-A, dated February 2020.

The desk study revealed the expected agricultural history of the site. The site was then subject to a ground investigation as detailed in the report referenced:

- 'Phase 2 Geo-Environmental Site Investigation – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR2-A, dated February 2020.

The ground investigation comprised a series of narrow diameter boreholes focused on the proposed area for the new crematorium building. Below a layer of Topsoil, the Clay-with-Flints Formation was encountered throughout the site whilst no Lambeth Group or Chalk soils were found.

As part of the investigation of the drainage to the proposed development a further phase of ground investigation was undertaken as documented within:

- ‘Soakage Test Investigation – Hemel Hempstead Crematorium’, BRD Environmental Ltd, report ref. BRD3627-OR3-A, dated October 2020.

The ground investigation comprised a two shallow BRE Digest 365 soakage test which failed to empty at the required rate and two drainage percolation test undertaken to BS 6297 in the proposed foul drainage field which recorded different results, one test passing the 3 required fillings and the second one failing but a continuous steady drop of water was recorded.

3. GROUND INVESTIGATION

3.1. INVESTIGATION DESIGN

METHODOLOGY	It was intended to drill a deep borehole and undertake 3No. soakage tests within the investigation well to determine infiltration rate for a deep borehole soakaway. Clean water to undertake the soakage tests was provided by a tractor towed 12,000 litres ($12m^3$) bowser. This was the maximum size of tanker that could be accommodated on site without the construction of a dedicated roadway across the field.
DATES OF SITE WORKS	The drilling works were undertaken on 11th and 12th May 2021. The soakage tests were undertaken on 14th and 15th May 2021.
CONSTRAINTS TO EXPLORATORY HOLE LAYOUT	No constraints were found.
EXPLORATORY HOLE SPACING	The exploratory borehole was undertaken at the co-ordinates specified by the Client's engineers Webb Yates.

3.2. BRD FIELDWORK

CABLE PERCUSSIVE BOREHOLE	
REFERENCES	BH01
DEPTH	30.30m
RIG TYPE	Dando 2000.
BACKFILL	Borehole BH01 had a monitoring well installed as shown on the log and detailed below. Note that the borehole was drilled at 200mm diameter.

The investigation well was constructed as follows:

- Raised head cover with padlock set in concrete. The head work will be surrounded by three wooden posts with orange plastic barrier fencing to make visible to follow on contractor.
- The well comprised a 110mm nominal diameter standpipe fitted with top and bottom screw-in ends.
- Plain pipe to a depth of 9m below existing ground level (begl).
- Perforated pipe with 85 micron pore size geotextile wrap to base of borehole at 30.3m begl.
- Bentonite pellet seal from surface to 7.5m begl. Pellets hydrated as backfill placed.
- Granular 2 to 4mm diameter filter medium annulus surround from 7.5m begl (i.e. >1m above top of perforated pipe section to allow for settlement as per guidance) to the base of the borehole. Filter medium sized to suit 1mm slots of perforated pipe. Filter medium at depth installed by tremie pipe.

4. GROUND CONDITIONS

4.1. OVERVIEW

Below a thin cover of topsoil, superficial deposits of the Clay-with-Flints Formation were recorded to 7.0m bgl. Beneath the bedrock of the Lewes Nodular Chalk Formation was encountered, first as structureless chalk to 11.0m bgl with structured chalk found beneath through to the maximum depth of investigation.

Details of the various stratigraphic units are given in the following sections.

4.2. ARTIFICIAL GROUND

No artificial ground was encountered during the investigation.

4.3. TOPSOIL

A thin layer of topsoil was recorded from ground level up to 0.25m bgl comprising 'dark brown, slightly gravelly clay. Gravel of fine to coarse, subangular to subrounded flint'.

4.4. SUPERFICIAL DEPOSITS

4.4.1. Clay with Flint Formation

Superficial soils of the Clay-with-Flints Formation were recorded beneath the topsoil up to 7.0m bgl, described as 'firm becoming stiff, light brown becoming orange brown, slightly silty, slightly sandy, gravel clay with occasional cobbles. Gravel of fine to coarse, subrounded to angular flint'.

4.5. BEDROCK

4.5.1. Lewes Nodular Chalk Formation

It should be noted that cable percussive drilling is destructive to the weak rock of the chalk. Standard Penetration Tests (SPT) were undertaken within the chalk as the sample retrieved from the split spoon sampler is less disturbed and the SPT N-value can also assist in understanding the structure of the chalk. A Consultant experienced in drilling within the chalk supervised and logged the boring. However, the divisions and grades within the chalk should still be viewed as tentative only.

The bedrock geology of the Lewes Nodular Chalk Formation was encountered beneath the superficial deposits comprising:

- Structureless Chalk from 7.0m to 11.0m bgl, described as 'structureless chalk recovered as white with occasional brown staining, soft, gravelly clay. Gravel is weak, low density chalk with occasional fine to coarse gravel and cobbles of subrounded flint nodules. (CIRIA Grade Dm)' from 7.0m to 9.0m bgl and as 'Structureless chalk recovered as white with occasional brown staining, clayey gravel with brown veining. Gravel is weak, low density chalk with occasional flint to coarse gravel and cobbles of subrounded flint nodules. (CIRIA Grade Dc)' from 9.0m to 11.0m bgl.

- Strucutured Chalk from 11.0m to 30.30m bgl, described as 'weak, medium density, white with occasional black specks and rare brown staining chalk. Occasional fine to coarse, subrounded flint nodules. No evidence of any discontinuities. (CIRIA Grade C2)' from 11.0m to 14.0m bgl, as 'weak, medium density, white with occasional black specks and rare brown staining chalk. Occasional fine to coarse, subrounded flint nodules. (CIRIA Grade B2)' from 14.0m to 24.0m

bgl and as ‘weak, medium density, white with fine black specs chalk with occasional flint nodules. Fractures not infilled. (CIRIA Grade A1)’ from 24.0m to 30.30m bgl.

4.6. GROUNDWATER BEHAVIOUR

Given the elevated position of the site and with reference to hydrogeological maps, it is anticipated that the groundwater within the chalk aquifer will be considerable depth (likely greater than 70m below ground level).

As expected, groundwater was not encountered whilst forwarding the borehole and the borehole was dry before the infiltration testing was conducted.

5. SOAKAGE ASSESSMENT

5.1. BACKGROUND

Due to the presence of the negligibly permeable Clay-with-Flints deposits near surface, it is understood that the only viable drainage option is for infiltration into the chalk present at depth.

The drainage system to the recently constructed cemetery comprised an attenuation basin that discharges to a deep borehole soakaway. This borehole soakaway was commissioned in September 2017. However, towards the end of 2020 this original borehole soakaway's performance had diminished and a replacement borehole soakaway was drilled alongside the original. Both boreholes reported initial soakage rates of over 500 litres per minute (l/min).

It is anticipated that the original cemetery borehole soakaway failed due to it silting up. As the new replacement borehole soakaway was drilled immediately adjacent to the original and fast infiltration rates were again recorded, it would appear that silting up was mainly within the borehole well itself rather than the fissures in the surrounding chalk rock becoming blocked.

As a result of difficulties with the existing cemetery drainage system, it is understood that the proposed crematorium is to have a separate drainage system discharging to its own borehole soakaway.

5.2. DISCUSSION OF METHODOLOGY

A key reference in drainage design is 'The SuDS Manual' that in turn references 'BRE Digest 365' for shallow infiltration testing. However, the SuDS Manual recognises that where it is not possible to undertake the infiltration tests in trial pits due to depth then tests can be carried out in boreholes. The SuDS Manual references BS EN ISO 22282-2:2012 'Geotechnical investigation and testing. Geohydraulic testing. Water permeability tests in a borehole using open systems' for such borehole falling head tests.

Standard BS EN ISO 22282-2:2012 provides for three test methods:

a. Constant flow.

b. Variable head i.e. the falling head tests referred to in the SuDS Manual.

c. Constant head test.

However, tests (a) and (b) are for where groundwater is present in the test borehole (i.e. in saturated ground conditions). Soakaways need to avoid direct discharge of water to groundwater and so the SuDS Manual is erroneous in referring to this test calculation method.

Whilst test method (c) allows for the test to be undertaken in unsaturated is only suitable for permeability coefficients between 10^{-4} and 10^{-7} m/s. The previous borehole soakaway tests suggest far higher permeability is present within the chalk and indeed this was mirrored by BRD's test. The test method also requires stationery flow conditions to be achieved that would require an enormous volume of water given this high permeability.

It is therefore concluded that permeability calculations to BS EN ISO 22282-2:2012 are not appropriate to conditions at the site.

The SuDS Manual makes reference to emulating the BRE Digest 365 test by repeating the filling the test borehole three times. This was achieved in the borehole for this investigation.

The SuDS Manual expresses concern that a smaller volume of water is used in the borehole test compared to those in a trial pit test. In this case, twelve cubic metres was discharged into the

borehole that is far greater volume than the typical one to two cubic metres of water employed in conventional trial pit soakage test. Accordingly, this not a concern with the testing completed as part of this investigation.

In summary, the tests were completed with the broad requirement of three fills of a sufficient volume of water with the fall in water levels recorded over time. As the fall of water was so rapid, detailed analysis is not possible as the behaviour is outside the scope of the mathematical procedures provided in the guidance and would therefore be misleading.

5.3. TEST RESULTS

5.3.1. Filling Borehole with Water

The tractor towed bowser tanker discharged water into the borehole at the following rates:

	Test 1	Test 2	Test 3
Tanker capacity (litres)	12,000	12,000	12,000
Discharge Time (seconds)	1,564	1,328	1,329
Discharge into well rate (l/s)	7.67	9.04	9.03

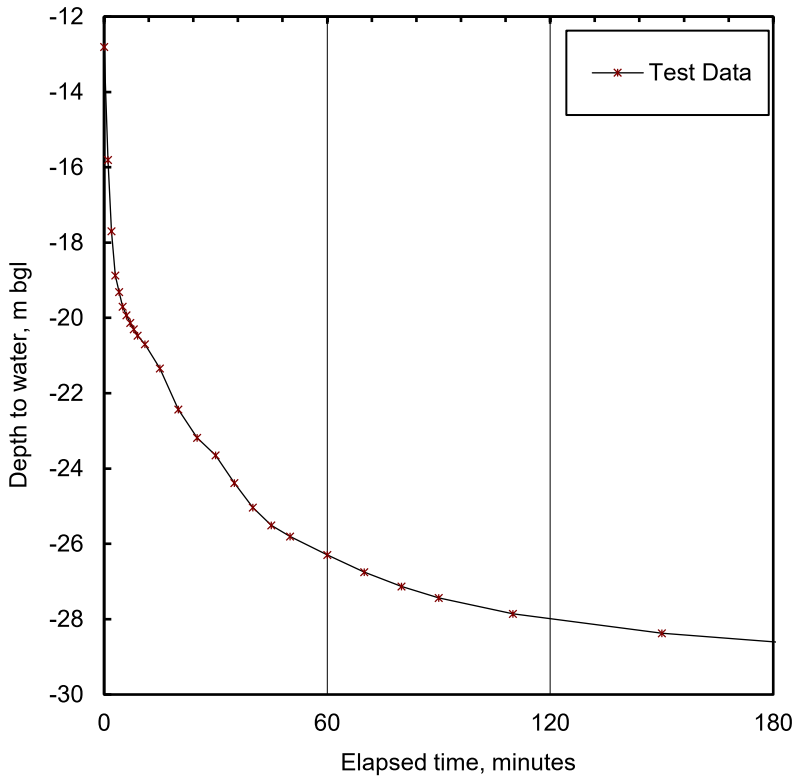
The discharge was by gravity using a 75mm hose.

The discharge rate for the first filling for Test 1 was slower as a result of poor positioning of the tanker and the use of two rather than one length of discharge hose.

Overall, nearly 36m^3 of water were added and drained away in less than the twenty four hour period that the majority of the tests were completed within.

5.3.2. Observed Behaviour

In all three tests, the water level was noted to fall very rapidly until about 22m bgl. Thereafter the water level continuously fell but at a much slower rate. This test behaviour is best illustrated in the third test as depicted in the graph below:



Whilst there would be expected to be a slowing down of the rate over time due to the reduction in the head of water within the test well, this contrast in rates is too high for it to be the explanation for the observed behaviour.

Within the constraints of logging, this test behaviour matches well with the change of the chalk from medium spaced discontinuities to no discontinuities/fractures (i.e. from Grade B2 to A1) observed around 24m bgl. It should be remembered that whilst definitive lines are drawn across on the engineering log, these abrupt divisions are artificial as in reality the change in the chalk grading is usually gradual.

It is therefore clear that the infiltration rate in the chalk varies with depth:

- The upper completed weathered structureless chalk (Grade Dm) will have a low permeability as it will be in a clay like state. This is why the perforated well section was started at the base of this layer.

- The middle band of clast dominated structureless chalk (Grade Dc) and chalk with discontinuities (Grade B2) found exceptionally rapid infiltration. The rate of infiltration was greater than the speed at which the tanker could be discharged and so the infiltration rates presented below are still conservative.

- The lower band of chalk (Grade A1) does not have observable discontinuities. As a result the infiltration rate was far slower.

This observed behaviour is in keeping with expectations for the different grades of chalk and the groundwater behaviour within the chalk. The Chalk is a dual porosity aquifer with flow occurring

primarily in the fracture network and the bulk of groundwater being stored in the secondary low flow porous matrix. In the middle band of chalk at the site it is the fracture flow that is dominant that offer the best conditions for infiltration. Whereas the lower band is where the secondary flow mechanism is dominant and so the infiltration rates will be far lower.

As a consequence of this behaviour, the bulk of the data collected is for the secondary flow mechanism and so is not applicable to the design of soakaways that should be targeted in the more permeable chalk horizon.

5.3.3. Infiltration Rate

As a consequence of the test behaviour, the only way to capture the rapid infiltration rate is to relate it to the rate water was placed in the borehole well.

To make the calculation as accurate as possible, the volume of water in the well at the point the first reading was taken (less than ten seconds after tanker discharge was stopped) has been subtracted from the total volume discharged by the tanker.

	Water level first reading (m bgl)	Volume discharged less the column of water left in the well (litres)	Discharge time (seconds)	Infiltration Rate	
				(l/s)	(l/min)
Test 1	18.82	11,642	1,564	7.4	447
Test 2	16.02	11,554	1,328	8.7	522
Test 3	12.95	11,458	1,329	8.6	517

Notes:

- It should be remembered that these values should really be expressed as “greater than” as the limiting factor was the tanker discharge rate rather than the ground infiltration rate. The rate for the first tests is only lower as a result of the slower discharge from the tanker on that occasion.
- The rates are also only applicable to the band of chalk between about 9m and 22m depth.
- It is worth noting that these rates are in keeping with the tests conducted by Southern Testing in the nearby existing cemetery borehole soakaway.

5.4. RECOMMENDATIONS

This investigation has confirmed that the use of deep borehole soakaways is viable at this site.

The following recommendations are made for the design of the drainage system:

- In the interests of sustainability and as it has been constructed in manner such that it is suitable for use, the borehole well installed for this investigation should be considered for incorporation into the drainage design as a long term borehole soakaway.

- The design of the drainage system should be such that the water discharged into the deep borehole soakaway is as free of silt as is reasonably practicable to achieve. This will be critical in prolonging the use of the borehole soakaway.

- An appropriate factor of safety should be applied to the high infiltration rates recorded in this investigation so that there is some allowance for deterioration of performance over time as silting up occurs. With that in mind, BRD would suggest that design flow into the borehole soakaway should not exceed 2 l/s.

- Any additional deep borehole soakaways required should be designed to discharge between about 10m and 20m below ground level in the vicinity of the borehole undertaken for this investigation. The boreholes should be drilled a few metres deeper than this as that provides some capacity within the soakaway for silting up of the base without diminishing soakaway performance.

- During operation, the performance and build up of any silt within the borehole soakaways should be periodically monitored. The design of the boreholes should be such that the syphon head over the well can be easily and safely removed for such inspections. This monitoring should enable any deterioration in performance to be identified before the system is no longer operational so that remedial action can be taken if required (e.g. clearing out of the well).

- The use of deep borehole soakaways should be agreed with the Environment Agency.

REPORT SPECIFIC REFERENCES

- 'Phase 1 Environmental Desk Study – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR1-A, dated February 2020.
- 'Phase 2 Geo-Environmental Site Investigation – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR2-A, dated February 2020.
- 'Soakage Test Investigation – Hemel Hempstead Crematorium', BRD Environmental Ltd, report ref. BRD3627-OR3-A, dated October 2020.
- 'Digest DG 365: Soakaway design' BRE, Revised 2016.
- 'Borehole Soakaway Installation at Land off Bedmond Road, Hemel Hempstead, HP3 8LN', Southern Testing Laboratories Limited, DK/MS/J13317, dated October 2017.
- 'CIRIA C753: The SuDS Manual', CIRIA, 2015.
- BS EN ISO 22282-2:2012 'Geotechnical investigation and testing. Geohydraulic testing. Water permeability tests in a borehole using open systems'

SUPPORTING INFORMATION

SITE CHARACTERISTICS

The site characteristics are collated from various information sources, including but not limited to Ordnance Survey, British Geological Survey (BGS), Environment Agency (EA) and local authorities.

BRD generally commission the Landmark Information Group to produce an Envirocheck Report for study sites and where employed this is included in the Appendices. It should be noted that some of the data provided in the Envirocheck report is not considered within BRD's interpretation for the site characteristics as part of a geotechnical assessment.

HISTORY

Mapped History

The site history summarises the changes in use or layout of the site over time and is largely developed from a study of available Ordnance Survey maps. It should be noted that changes to the site may have occurred between the editions of the maps employed to assess the history of the site. Historical information of relevance within the 250m surrounding the site is also discussed in a separate section. The historical plans referred to in the text are generally included in an Appendix.

Aerial photography

As a minimum, current and historical aerial images of the site and surrounding areas are studied from the Google Earth program. Where additional historic aerial photographs have been purchased then these are referenced within the technical report.

Internet Searches

A simple search of the internet for relevant material relating to the use or history of the site is made. Information obtained from internet searches has been accepted as fact without validation by BRD except for ensuring the source is reputable. It should be recognised that due to programme and budgetary constraints the search conducted may not have revealed all the information available.

GEOLOGY

The geology of the site is assessed by reference to the relevant British Geological Survey (BGS) 1:50,000 scale sheet in Bedrock and Superficial (historically Solid and Drift) edition. Many of these geological maps are relatively old with superseded terminology and descriptions. BRD therefore employ the BGS Open Geoscience website to determine current nomenclature of strata and to assist in determining geological boundaries against current topographic features. BRD also employ BGS Regional Geology Guides to assist in understanding the geological context of the site.

Ground Stability Hazards

Ground stability hazards caused by mining, ground dissolution, landslide potential, collapsible ground and natural cavities are identified by the Envirocheck database search of records held by The Coal Authority, British Geological Survey and studies completed by Ove Arup and Peter Brett Associates.

The Envirocheck database ground stability hazard entries for compressible ground, running sands and shrinking or swelling clays are not discussed directly. This is because these hazards are very common and are considered within the preliminary geotechnical assessment where necessary.

Radon

Radon is a naturally occurring colourless and odourless gas that is radioactive. It is formed by the radioactive decay of radium which in turn is derived from the radioactive decay of uranium, both of which are minerals that can be found in many soil types. Whilst it is recognised that the air inside every house contains radon, some houses built in certain defined areas of the country might have unacceptably high concentrations and require special precautions to be taken during construction to reduce this risk.

Radon can move through cracks and fissures in the soil into the atmosphere or into buildings via basements and/or underfloor voids. If radon enters the living space of buildings its concentration can potentially increase and provide a risk to human health as the inhalation of the radioactive decay products of radon gas can increase the risk of developing lung cancer.

The maps contained within 'Radon: Guidance on protective measures for new buildings' (2015) identify areas where no radon protection measures are necessary or where higher concentrations are present that either basic or full radon protection measures are required to be fitted to all new buildings together with supplementary advice concerning extensions, conversions and refurbishments. However, some local authorities have local bylaws, that BRD may not be aware of, that insist on radon protection to all new dwellings within their area regardless of the recommendations of the 'Radon: Guidance on protective measures for new buildings' (2015) report.

Basic radon protection measures comprise incorporation of a continuous gas resistant membrane sealed at joints and around service entries into the floor construction and extended across the cavity tray.

Full radon protection measures comprise incorporating a continuous gas resistant membrane into the floor construction together with a ventilated sub-floor void through either the use of suspended floor construction or a 'radon sump'. The membrane is sealed at joints and around service entries into the floor and extended across the cavity tray.

'Radon: Guidance on protective measures for new buildings' (2015) should be referred to for detail on the construction of the protective measures.

GROUND INVESTIGATION

Exploratory holes are logged by an experienced Geo-Environmental Consultant in general accordance with 'Code of practice for site investigations' BS5930:2015, British Standards Institution, 2015. Soil samples for chemical and geotechnical analysis are taken from the exploratory holes at intervals dictated by the nature of the soils and the objectives of the investigation.

Where stated on the logs of inspection pits, trial pits or boreholes (where insitu testing has not been undertaken), the relative density of coarse (sand and gravel) soils is tentative only. Such assessments of density are on the basis of visual inspection only taking into consideration such factors as drilling rates, stability of pit side walls, appearance and behaviour under excavation.

Where Chalk strata is encountered it is logged and graded in general accordance with CIRIA guidance 'C574 - Engineering in Chalk'. It should be recognised that where percussive drilling methods are employed, the structure of the Chalk is destroyed and therefore the grading stated on such logs is either tentative or absent where it is not possible to assess the grade.

Hand Dug Inspection Pits

Hand tools are used to forward shallow inspection pits as a cost effective method of describing and sampling near surface soils. The technique is also used where exposure of existing footings is required. The depth reached by such techniques is a function of the nature of the ground and generally does not exceed 1.5m

Trial Pits

Mechanically excavated trial pits allow detailed inspection of near surface ground due to the large volume of soil exposed. A wheeled backhoe loader is the usual machine for digging trial pits that are typically 3 to 4.5m deep, 0.5m wide and 3m long.

Windowless Sampling Boreholes

This type of borehole is formed by a small tracked dynamic percussion drilling rig with samples retrieved in thin plastic liners within the narrow diameter steel sampling tubes. Borehole depths of up to 5m are typical, but in exceptional circumstances up to 15m depth can be achieved. This is the smallest type of rig that is capable of undertaking Standard Penetration Tests (SPTs).

Hand Held Window Sampling

Hand held window sampling is a useful method of drilling narrow diameter boreholes particularly where access is difficult. Hand held mechanical percussive hammers are used to drive the sampling tube into the ground. The soil samples are collected within the hollow metal sampling tubes and inspected via the open window along one side. Window sampling boreholes can be forwarded to depths of 3m to 6m depending upon ground conditions.

Cable Percussive Boreholes

This form of drilling involves repetitive dropping of a tube into the soil under its own weight from a tripod support. The sample is obtained from the clay cutter head in fine soils or a bailer for wet granular soils. As the borehole progresses SPTs can be undertaken and relatively undisturbed samples can be obtained. Typically these boreholes are 15 to 25m deep, but depths of double that can be achieved in soils, but only thin weak rock layers can be penetrated.

Rotary Boreholes

Where competent rock is required to be drilled then rotary drilling techniques are required. The drilling rigs can vary in size from small tracked units to larger units mounted on four wheel drive trucks. Rotary open hole drilling techniques break the rock into small fragments and so recovery of any samples is limited. In contrast, rotary coring retrieves excellent samples. Some rigs also allow windowless sampling to be undertaken through soil layers. There are no practical limits to the depths that this drilling method can achieve.

Dynamic Probing

Dynamic probing comprises a sectional rod with a sacrificial cone at the base of slightly larger diameter than the rod. The rod is driven into the ground by a constant mass falling through a set distance. The number of blows required to forward the rod per 100mm is then recorded and presented in a graph of N_{10} values. The standard applicable to dynamic probing is "BS EN ISO 22476-2:2005 Incorporating corrigendum no. 1, Geotechnical investigation and testing — Field testing — Part 2: Dynamic probing" BSi, February 2007.

Static Cone Penetration Tests

Cone Penetration Tests (CPT) consist of pushing a conical 60° cone into the ground at a constant rate and recording the force required to do this. Sensors in the cone record other information and this data can be correlated to a number of different geotechnical parameters.

Dynamic Penetrometer

The Transport Research Laboratory Dynamic Cone Penetrometer (TRL DCP) uses an 8 kg hammer dropping through a height of 575mm to drive a 60° cone of 20mm maximum diameter into the ground. The depth driven either per blow or per several blows is recorded. The strength of each of the soil layer encountered is then calculated by converting the penetration rate (mm per blow) into an approximate California Bearing Ratio (CBR) value employing the correlation proposed by TRL.

Gas Monitoring

Gas monitoring is undertaken with a portable gas monitor for oxygen, Methane, Carbon Dioxide, Hydrogen Sulphide and Carbon Monoxide together with recording of atmospheric pressure and any flow rate.

Vapour Monitoring

Headspace tests and monitoring for Volatile Organic Compounds (VOC) or Semi Volatile Organic Compounds (SVOC) is undertaken using a Photo Ionisation Detector (PID). The MiniRAE models used have a 10.6 eV lamp calibrated for isobutylene. The PID is useful tool to indicate the presence of a wide range of volatile compounds, but only provides semi-quantitative data as different compounds provide a different response and thus the reading is not a true reflection of the actual concentration present.

Low PID readings can be recorded in natural uncontaminated organic soils or even as a result of atmospheric pollution. It is generally accepted by consultants and regulators that recorded values in excess 50 parts per million (ppm) represents the presence of organic compound pollutants and in excess of 100 ppm such contamination may be significant.

The headspace test procedure involves the collection of a sample of suspected contaminated soils and placing within a sample bag. A tight seal to the bag is formed with a similar volume of air trapped to that of the soil and the sample is left for fifteen minutes to allow volatilisation of any contaminants. The bag is then pierced by, and sealed around, the sample probe of the PID and a reading taken.

Borehole well monitoring is undertaken by connecting the PID directly to the gas tap on the monitoring well installation.

Groundwater Level Monitoring

Groundwater levels are recorded with an electronic dip meter that has a detector end that is lowered into the borehole well. An audible signal is made when water is reached and the depth recorded from the graduated tape used to lower the detector. Where there is potential for a separate Light Non Aqueous Phase Liquid (LNAPL) to be present floating on the groundwater an oil/water interface meter is used in preference to a conventional dip meter so that any such floating product can be detected.

Geotechnical Sampling

BRD schedule a range of geotechnical testing as appropriate to the identified ground conditions, available budget and the proposed development. Different types of soil samples are obtained as appropriate to the ground conditions and planned testing.

SAMPLE TYPE	SYMBOL USED ON LOGS	DESCRIPTION
Disturbed	D	Small disturbed soil samples of about 1 to 2 kg are collected in plastic bags.
Bulk	B	Large disturbed bulk samples up to about 20 to 30 kg are collected in plastic bags
Undisturbed	U	'Undisturbed' samples generally collected in plastic or metal tubes within cable percussive boreholes of 100mm diameter for samples of fine soils of firm to stiff consistency. Can also be representative of samples taken by cutting plastic sample liners from windowless sampling drilling methods. It is recognised that such samples do not generally meet Eurocode sample quality requirements for the tests commonly employed. However, given the wealth of experience with these sampling methods this continues to be common in United Kingdom practice particularly for less sensitive developments where more expensive sampling techniques are not economically justifiable.
Undisturbed	UT	A thin walled steel sampler developed by Archway Engineering called a UT100 in an attempt to gain better quality samples of soft to firm fine soils when using cable percussive drilling methods.

Contamination Sampling

BRD schedule contamination testing as appropriate to the ground conditions, available budget, potential contaminants and the proposed development. Samples are collected in single use laboratory supplied containers.

Soil samples are retrieved in plastic containers and/or amber glass jars with a lined plastic cap. Contamination samples are indicated by a 'J' on exploratory hole logs.

Water samples are collected in plastic bottles and/or amber glass jars with a lined plastic cap then placed in cool boxes together with freezer packs. Water samples are indicated by a 'W' on exploratory hole records, but generally such samples are not tested as testing from dedicated monitoring wells is preferred for sample quality reasons.

Samples retrieved from the exploratory holes are dispatched to the laboratory by overnight courier. Where samples cannot be transported directly from site they are temporarily stored in the BRD dedicated sample storage facility which includes refrigeration where necessary. The individual accreditation of the test methods is detailed in the laboratory test report.

GEOTECHNICAL ASSESSMENT

Under Eurocode 7 (EC7) the following risk ranking is applied to geotechnical projects:

GEOTECHNICAL CATEGORY	***DESCRIPTION***
1	*Small and relatively simple structures for which it is possible to ensure that the fundamental requirements will be satisfied on the basis of experience and qualitative geotechnical investigations with negligible risk. For example, straightforward ground conditions, local experience, no excavation below the water table unless this will be straight forward.*
2	*Conventional types of structures and foundations. No difficult soil or loading conditions. Quantitative geotechnical data and laboratory testing. Routine procedures for field and laboratory testing. Conventional structures and no exceptional geotechnical risk. For example, spread, raft and piled foundations, retaining walls, bridge piers and abutments, embankments, ground anchors, tunnels and excavations.*
3	*Those structures not in Categories 1 and 2 such as very large or unusual structures, structures involving abnormal risks, or unusual or exceptionally difficult ground or loading conditions. Structures in highly seismic areas. Structures in areas of probable site instability or persistent ground movements that require separate investigation or special measures.*

GEOTECHNICAL PARAMETERS

Soakage Tests

Soakage tests comprise the filling of a test pit with water and recording the time taken for the water to drain away. The tests are undertaken in general accordance with 'Digest DG 365: Soakaway design' BRE, Revised 2016. The test pits are usually gravel filled for safety with a slotted vertical pipe through which water observations are made. Water is generally supplied by a tanker to allow fast filling of the pits with water. Compliant tests are filled and allowed to drain near empty three times.

Standard Penetration Tests

The standard penetration test (SPT) determines the resistance of soils at the base of a borehole to the dynamic penetration of a split barrel sampler and the recovering of disturbed samples for identification purposes. In gravelly soils and some soft rocks a solid cone is used in preference to the sampler.

The basis of the test consists in driving a sampler by dropping a hammer of 63.5 kg mass on from a height of 760 mm. The number of blows (N value) necessary to achieve a penetration of the sampler of 300 mm is recorded. The test is described in 'Geotechnical investigation and testing — Field testing — Part 3: Standard penetration test - BS EN ISO 22476-3:2005 Incorporating corrigendum no. 1', BSi, 2007.

The uncorrected N values of the SPT tests are recorded upon the borehole logs together with a record of blows for each 75mm test portion including the seating blows. Where the full test depth cannot be achieved due to refusal on hard stratum, the number of blows and the distance achieved is recorded and the N value given as >50. The abbreviation SPT(c) is used upon the logs indicates that the test was performed with a solid cone rather than a split spoon sampler.

It is necessary to apply a correction to the N values to account for the effects of energy delivery using the equation: $N_{60} = \frac{E_r}{60} N$ *where* E_r *is the energy ratio of the specific test equipment.*

In the case of tests in sand, for the effects of overburden and rod length the equation is modified to $N_{60} = \frac{E_r}{60} \; x \; \lambda \; x \; C_N \; x \; N$ *where* λ *is the correction factor for energy losses due to the rod length and* C_N *is the correction factor for vertical stress due to overburden of the soil.*

Sulphate

In order to compare the laboratory soil test results with 'Concrete in aggressive ground. BRE Special Digest 1: 2005' (BRE, 2005) laboratory results are converted to SO_4 *mg/l. Laboratory results expressed as* SO_3 *g/l and are multiplied by a factor of 1200 to express the results as* SO_4 *mg/l.*

Index Property Tests

In accordance with National House Building Council (NHBC) Standards Chapter 4.2 – Building near trees, the laboratory plasticity indexes are assessed against their volume change potential. The Modified Plasticity Index is defined as the Plasticity Index of the soil multiplied by the percentage of particles with a nominal diameter of less than 425µm. Whilst the NHBC Standards were developed for residential buildings, the advice is equally applicable to a large number of other types of low rise structures.

Hand Shear Vane

The undrained shear strength of the fine (i.e. clay) soils at the site can be established using hand shear vane apparatus. Usually three readings are taken at every depth tested and the uncorrected results recorded on the exploratory point log. Shear vane readings from depths below 1.2m depth in trial pits are from tests performed on excavated soil. In accordance with Eurocode 7 — Geotechnical design — Part 2: Ground investigation and testing EN 1997-2:2007 the results should be corrected. BRD employ only simple correction methods as the more complex correction methodologies imply undue accuracy to a test that has distinct disadvantages and limitations.

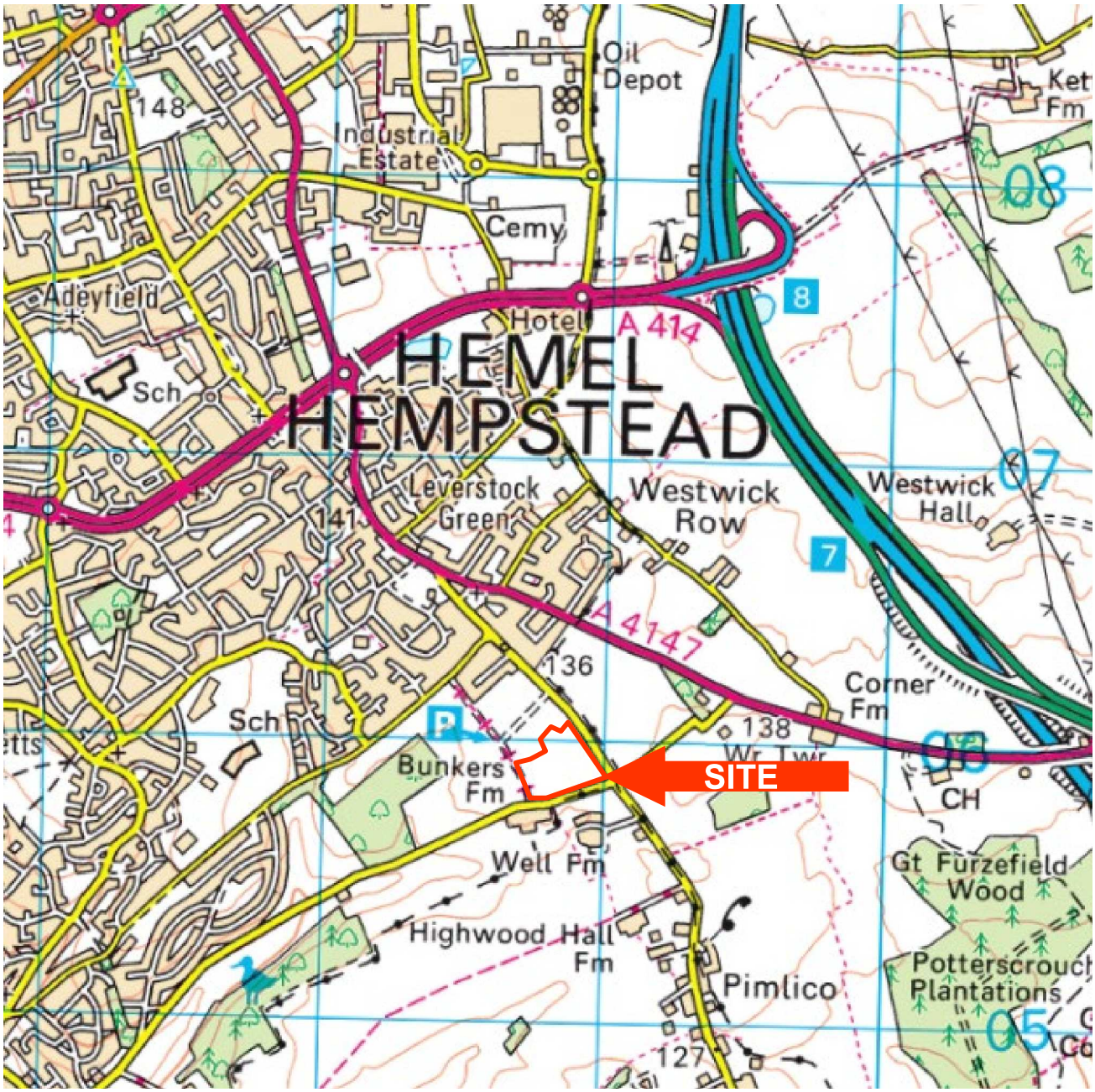
Pocket Penetrometers

The Pocket Penetrometer is a lightweight instrument for use by field personnel to check visual classification of soils. It is a simple test and there is inherent uncertainty related to the small volume of soil being tested and so the results should be used with appropriate caution. Pocket penetrometers are calibrated in terms of unconfined compressive strength and once converted to undrained shear strength (divide by two) the results are further reduced by a factor of 1.5 - 2.0 as the device tends to overestimate strengths.

Instrument Reading (uncompressive strength in kg/cm^2)	*Indicative Undrained Shear Strength (kN/m^2)*	*Indicative Consistency*	*Indicative strength*
1.0	*25 – 33*	*Soft*	*Low*
1.5	*38 – 50*	*Soft to firm*	*Low to medium*
2.0	*50 - 67*	*Firm*	*Medium*
2.5	*63 – 83*	*Firm to stiff*	*Medium to high*
3.5	*88 – 116*	*Stiff*	*High*
4.5	*113 – 150*	*Stiff to very stiff*	*High to very high*

APPENDIX 1

Site Location Plan



Not to scale.

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP1-B
Date Issued:	October 2020

BRD
01295 272244
info@brduk.com

Photographs from Deep Borehole Investigation

Plate 1: The 22.0m bgl SPT chalk sample with medium spaced discontinuities infilled with brown silt.

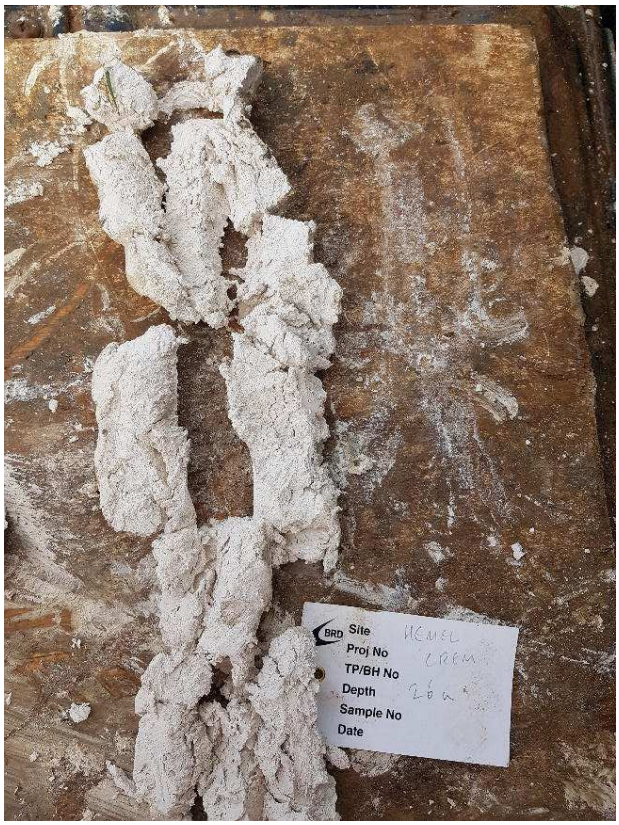


Plate 2: The 26.0m bgl SPT chalk sample not showing evident discontinuities.

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP8-A
Date Issued:	May 2021

BRD
01295 272244
info@brduk.com

Photographs from Deep Borehole Investigation

Plate 3: Perforated pipe with 85 micron pore size geotextile wrap with screw in base cap.

Plate 4: Backfilling materials consisting of granular 2 to 4mm diameter medium (gravel) and bentonite pellets.

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP8-A
Date Issued:	May 2021

BRD
01295 272244
info@brduk.com

Photographs from Deep Borehole Investigation

Plate 5: Completed borehole surrounded by orange fencing.

Plate 6: Cemetery attenuation pond on 11th May 2021.

BRD
01295 272244
info@brduk.com

Key:

- BRD Drainage Borehole
- Previous BRD Soakage Pit
- Previous BRD Windowless Sample Borehole
- Previous BRD Hand Dug Pit
- Site Boundary

Notes:

Drawing reproduced from Survey prepared by: The Downland Partnership Ltd; Title: Topographic Survey (Pages 1-11); Dated: Jan 2020

The location of all exploratory points were positioned by topographical survey.

All boundaries are approximate.

Revision	Date	Description	Drawn	Approved

Drawing title: BOREHOLE EXPLORATOTY POINT PLAN

Project title: HEMEL HEMPSTEAD CREMATORIUM

Client: WATFORD BOROUGH COUNCIL

Scale	Original drg. size/colour	Date
1:1000	A3 / C	17/05/2021

Drawn	Checked	Approved
RM	MM	BD

Drawing Number	Rev
BRD3627-OD4	A

BRD Environmental Ltd
01295 272244
info@brduk.com
www.brduk.com

APPENDIX 2

BOREHOLE RECORD

Client: Watford Borough Council
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627
Logged By: M Morgan
Date Commenced: 10/05/2021
Date Completed: 11/05/2021
Method Used: Cable Percussive Drilling Rig

Borehole No.

BH01

Sheet 1 of 4

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
				TOPSOIL: Dark brown, slightly gravelly clay. Gravel of fine to coarse, angular to subrounded flint.	0.25 (132.10)		TS	
				Firm becoming stiff, light brown becoming orange brown, slightly silty, slightly sandy, gravel CLAY with occasional cobbles. Gravel of fine to coarse, subrounded to angular flint.	1 2 3 4 5 6		CLAY-WITH-FLINTS FORMATION	
				Structureless CHALK recovered as white with occasional brown staining, soft, gravelly clay. Gravel is weak, low density chalk with occasional fine to coarse gravel and cobbles of subrounded nodular flint. (CIRIA Grade Dm).	7 7.00 (125.35) 8 8.00		CHALK	

Drilling Progress						Chiselling		
Date	Hole Depth	Casing Depth	Casing Dia (mm)	Water Depth	Water depth after 20mins / Type of test	From	To	Hours

General Remarks:

Borehole is 200mm in diameter.
Installed with 110mm standpipe with top and bottom screw-in end cap finished with raised metal cover.
Filter medium is 2-4mm gravel from 7.50m to 30.30m.
Bentonite seal from ground level to 7.50m.

Surface Elevation Level:
132.346 mAOD

All dimensions in metres
Log Scale 1:50

BRD
Telephone: 01295 272244
Email: info@brduk.com

BOREHOLE RECORD

Client: Watford Borough Council
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627
Logged By: M Morgan
Date Commenced: 10/05/2021
Date Completed: 11/05/2021
Method Used: Cable Percussive Drilling Rig

Borehole No.

BH01

Sheet 2 of 4

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
				Continued from 7m:Structureless CHALK recovered as white with occasional brown staining, soft, gravelly clay. Gravel is weak, low density chalk with occasional fine to coarse gravel and cobbles of subrounded nodular flint. (CIRIA Grade Dm).	(124.35) 9 9.00		LEWES NODULAR CHALK FORMATION + SEAFORD CHALK FORMATION (UNDIFFERENTIATED)	
				Structureless CHALK recovered as white with occasional brown staining, clayey gravel. Gravel is weak, low density chalk with occasional flint to coarse gravel and cobbles of subrounded flint nodules. (CIRIA Grade Dc). Some brown veining noted in chalk gravel.	(123.35) 10			
10.00	SPT	13 N		10.00 m: SPT: 3 for 150mm/3,5,3,2	11 11.00			
				Weak, medium density, white with occasional black specks and rare brown staining CHALK.Occasional fine to coarse, subrounded flint nodules. No evidence of any discontinuities. (CIRIA Grade C2).	(121.35) 12			
12.00	SPT	21 N		12.00 m: SPT: 13 for 150mm/6,4,5,6	13			
14.00	SPT	33 N		Weak, medium density, white with occasional black specks and rare brown staining CHALK with medium spaced discontinuities infilled (<3mm) with brown silt. . Occasional fine to coarse, subrounded flint nodules. (CIRIA Grade B2). 14.00 m: SPT: 13 for 150mm/11,8,7,7	14 14.00 (118.35) 15			
					16 16.00			

Drilling Progress

Date	Hole Depth	Casing Depth	Casing Dia (mm)	Water Depth	Water depth after 20mins / Type of test
10-05-21	10.00	3.00	200	Dry	SPT
10-05-21	12.00	3.00	200	Dry	SPT
10-05-21	14.00	3.00	200	Dry	SPT
10-05-21	16.00	3.00	200	Dry	SPT

Chiselling

From	To	Hours

General Remarks:

Borehole is 200mm in diameter.
Installed with 110mm standpipe with top and bottom screw-in end cap finished with raised metal cover.
Filter medium is 2-4mm gravel from 7.50m to 30.30m.
Bentonite seal from ground level to 7.50m.

Surface Elevation Level:
132.346 mAOD

All dimensions in metres
Log Scale 1:50

BRD
Telephone: 01295 272244
Email: info@brduk.com

BOREHOLE RECORD

Client: Watford Borough Council
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627
Logged By: M Morgan
Date Commenced: 10/05/2021
Date Completed: 11/05/2021
Method Used: Cable Percussive Drilling Rig

Borehole No.

BH01

Sheet 3 of 4

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
16.00	SPT	17 N		Continued from 14m: Weak, medium density, white with occasional black specks and rare brown staining CHALK with medium spaced discontinuities infilled (<3mm) with brown silt. . Occasional fine to coarse, subrounded flint nodules. (CIRIA Grade B2). 16.00 m: SPT: 10 for 150mm/4,5,4,4	(116.35) 17		LEWES NODULAR CHALK FORMATION + SEAFORD CHALK FORMATION (UNDIFFERENTIATED)	
18.00	SPT	22 N		18.00 m: SPT: 8 for 150mm/5,6,5,6	18 19			
20.00	SPT	24 N		20.00 m: SPT: 10 for 150mm/7,5,5,7	20 21			
22.00	SPT	23 N		22.00 m: SPT: 11 for 150mm/7,6,5,5 23.00 - 26.00 m: Increased flint content.	22 23 24 24.00			

Drilling Progress

Date	Hole Depth	Casing Depth	Casing Dia (mm)	Water Depth	Water depth after 20mins / Type of test
10-05-21	18.00	3.00	200	Dry	SPT
10-05-21	20.00	3.00	200	Dry	SPT
10-05-21	22.00	3.00	200	Dry	SPT
10-05-21	24.00	3.00	200	Dry	SPT

Chiselling

From	To	Hours

General Remarks:

Borehole is 200mm in diameter.
Installed with 110mm standpipe with top and bottom screw-in end cap finished with raised metal cover.
Filter medium is 2-4mm gravel from 7.50m to 30.30m.
Bentonite seal from ground level to 7.50m.

Surface Elevation Level:
132.346 mAOD

All dimensions in metres
Log Scale 1:50

BRD
Telephone: 01295 272244
Email: info@brduk.com

BOREHOLE RECORD

Client: Watford Borough Council
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627
Logged By: M Morgan
Date Commenced: 10/05/2021
Date Completed: 11/05/2021
Method Used: Cable Percussive Drilling Rig

Borehole No.

BH01

Sheet 4 of 4

Samples & Tests			Water	Description of Strata	Depth / (Level)	Legend	Geology	Installation /Backfill
Depth	Type & No	Value						
24.00	SPT	32 N		Weak, medium density, white with fine black specs CHALK with occasional flint nodules. . No evidence of any discontinuities. Presumed to be closed. (CIRIA Grade A1) 24.00 m: SPT: 5 for 150mm/9,9,7,7	(108.35)		LEWES NODULAR CHALK FORMATION + SEAFORD CHALK FORMATION (UNDIFF)	
26.00	SPT	28 N		26.00 m: SPT: 5 for 150mm/4,5,5,14	25 26 27			
28.00	SPT	29 N		28.00 m: SPT: 6 for 150mm/5,6,8,10	28 29 30			
					30.30 (102.05)			
					31 32			

Drilling Progress

Date	Hole Depth	Casing Depth	Casing Dia (mm)	Water Depth	Water depth after 20mins / Type of test
10-05-21	26.00	3.00	200	Dry	SPT
10-05-21	28.00	3.00	200	Dry	SPT
10-05-21	30.30	3.00	200	Dry	SPT
10-05-21	30.30	-	-	Dry	SPT

Chiselling

From	To	Hours

General Remarks:

Borehole is 200mm in diameter.
Installed with 110mm standpipe with top and bottom screw-in end cap finished with raised metal cover.
Filter medium is 2-4mm gravel from 7.50m to 30.30m.
Bentonite seal from ground level to 7.50m.

Surface Elevation Level:
132.346 mAOD

All dimensions in metres
Log Scale 1:50

BRD
Telephone: 01295 272244
Email: info@brduk.com

Deephole soakage test data

BH01					
Test 1		Test 2		Test 3	
13/05/2021		13/05/2021		14/05/2021	
WL @ Start	Dry	WL @ Start	Dry	WL @ Start	Dry
Time	Depth	Time	Depth	Time	Depth
08:24:30	18.82	11:18:00	16.02	08:00:00	12.95
08:25:00	19.59	11:18:30	17.20	08:00:30	14.93
08:25:30	20.38	11:19:00	18.40	08:01:00	15.95
08:26:00	20.50	11:19:30	18.92	08:01:30	16.91
08:26:30	20.90	11:20:00	19.26	08:02:00	17.85
08:27:00	21.07	11:20:30	19.48	08:02:30	18.81
08:27:30	21.33	11:21:00	19.72	08:03:00	19.02
08:28:00	21.58	11:21:30	19.90	08:03:30	19.22
08:28:30	21.80	11:22:00	20.20	08:04:00	19.46
08:29:00	21.90	11:22:30	20.46	08:04:30	19.68
08:29:30	22.13	11:23:00	20.50	08:05:00	19.85
08:30:00	22.39	11:23:30	20.66	08:05:30	19.97
08:30:30	22.60	11:24:00	20.81	08:06:00	20.08
08:31:00	22.85	11:24:30	20.93	08:06:30	20.20
08:31:30	23.07	11:25:00	21.04	08:07:00	20.28
08:32:00	23.22	11:25:30	21.12	08:07:30	20.35
08:32:30	23.36	11:26:00	21.23	08:08:00	20.45
08:33:00	23.50	11:26:30	21.33	08:08:30	20.54
08:33:30	23.61	11:27:00	21.43	08:09:00	20.62
08:34:00	23.72	11:27:30	21.53	08:09:30	20.68
08:34:30	23.81	11:28:00	21.65	08:10	20.74
08:35:00	23.90	11:28:30	21.76	08:11	20.85
08:35:30	24.02	11:29:00	21.87	08:12	20.96
08:36:00	24.13	11:29:30	21.99	08:13	21.11
08:36:30	24.25	11:30	22.20	08:14	21.28
08:37:00	24.38	11:31	22.41	08:15	21.49
08:37:30	24.53	11:32	22.68	08:16	21.60
08:38:00	24.61	11:33	22.73	08:17	21.87
08:38:30	24.74	11:34	22.98	08:18	22.08
08:39:00	24.83	11:35	23.14	08:19	22.34
08:40	25.09	11:36	23.32	08:20	22.58
08:41	25.26	11:37	23.42	08:21	22.78
08:42	25.40	11:38	23.55	08:22	22.94
08:43	25.56	11:39	23.65	08:23	23.07
08:44	25.72	11:40	23.81	08:24	23.20
08:45	25.87	11:41	24.00	08:25	23.33
08:46	25.97	11:42	24.19	08:26	23.45
08:47	26.05	11:43	24.36	08:27	23.55
08:48	26.14	11:44	24.52	08:28	23.64
08:49	26.21	11:45	24.65	08:29	23.72
08:50	26.28	11:46	24.76	08:30	23.80
08:51	26.34	11:47	24.88	08:31	23.89
08:52	26.40	11:48	24.98	08:32	24.04
08:53	26.47	11:49	25.07	08:33	24.21
08:54	26.54	11:50	25.16	08:34	24.37
08:55	26.61	11:51	25.25	08:35	24.53

Client: Watford Borough Council
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627

The table provides the observations during the soakage test. The bulk of the data mainly relates to the deeper chalk with slower infiltration rate. The infiltration rate between about 9m (if the water even got that high) and 22m bgl was faster than the discharge rate from the tanker and too fast to record the fall accurately with only the intial reading of each tests relating to that part of the borehole.

Deephole soakage test data

BH01					
Test 1		Test 2		Test 3	
13/05/2021		13/05/2021		14/05/2021	
WL @ Start	Dry	WL @ Start	Dry	WL @ Start	Dry
Time	Depth	Time	Depth	Time	Depth
08:56	26.67	11:52	25.34	08:36	24.70
08:57	26.74	11:53	25.43	08:37	24.84
08:58	26.80	11:54	25.52	08:38	24.99
08:59	26.85	11:55	25.62	08:39	25.08
09:00	26.91	11:56	25.68	08:40	25.18
09:01	26.97	11:57	25.74	08:41	25.28
09:02	27.03	11:58	25.80	08:42	25.38
09:03	27.09	11:59	25.86	08:43	25.48
09:04	27.14	12:00	25.92	08:44	25.57
09:05	27.19	12:02	26.03	08:45	25.66
09:06	27.24	12:04	26.12	08:46	25.74
09:07	27.29	12:06	26.23	08:47	25.79
09:08	27.35	12:08	26.33	08:48	25.85
09:09	27.40	12:10	26.42	08:49	25.91
09:10	27.45	12:12	26.51	08:50	25.95
09:12	27.53	12:14	26.60	08:51	26.00
09:14	27.62	12:16	26.71	08:52	26.05
09:16	27.71	12:18	26.80	08:53	26.11
09:18	27.79	12:20	26.89	08:54	26.16
09:20	27.88	12:22	26.97	08:55	26.21
09:22	27.96	12:24	27.05	08:56	26.27
09:24	28.02	12:26	27.14	08:57	26.31
09:26	28.09	12:28	27.21	08:58	26.35
09:28	28.15	12:30	27.26	08:59	26.40
09:30	28.20	12:32	27.32	09:00	26.44
09:32	28.25	12:34	27.37	09:02	26.54
09:34	28.29	12:36	27.43	09:04	26.64
09:36	28.33	12:38	27.49	09:06	26.73
09:38	28.37	12:40	27.55	09:08	26.81
09:40	28.41	12:42	27.60	09:10	26.90
09:42	28.45	12:44	27.65	09:12	26.98
09:44	28.49	12:46	27.70	09:14	27.06
09:46	28.53	12:48	27.75	09:16	27.14
09:48	28.57	12:50	27.80	09:18	27.21
09:50	28.60	12:52	27.85	09:20	27.28
09:52	28.64	12:54	27.90	09:22	27.34
09:54	28.68	12:56	27.94	09:24	27.40
09:56	28.71	12:58	27.98	09:26	27.47
09:58	28.74	13:00	28.02	09:28	27.53
10:00	28.77	13:05	28.12	09:30	27.58
10:02	28.80	13:10	28.20	09:32	27.63
10:04	28.83	13:15	28.27	09:34	27.68
10:06	28.86	13:20	28.34	09:36	27.72
10:08	28.89	13:25	28.41	09:38	27.77
10:10	28.91	13:30	28.47	09:40	27.81
10:12	28.93	13:35	28.52	09:42	27.85

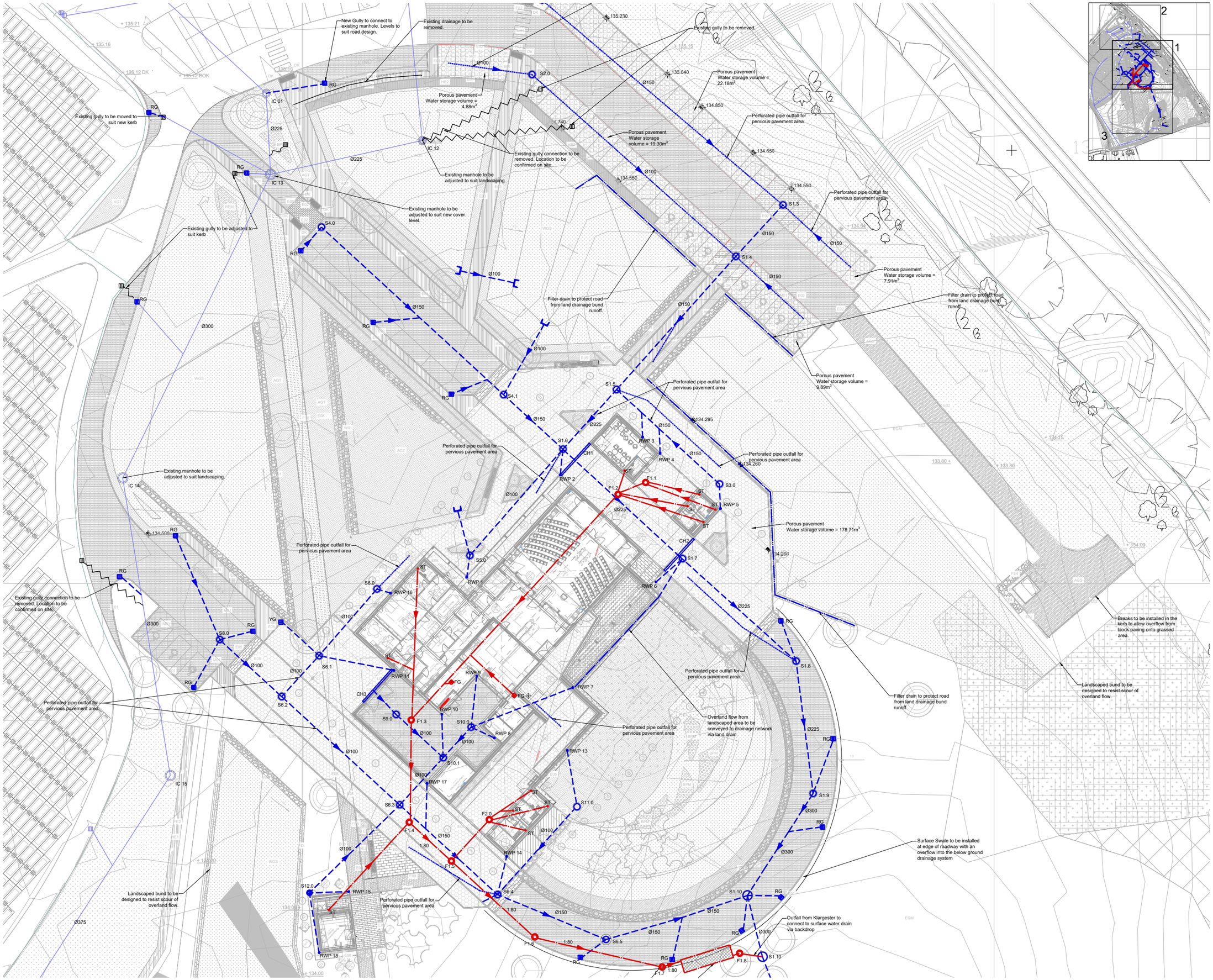
Client: Watford Borough Council
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627

Deephole soakage test data

BH01					
Test 1		Test 2		Test 3	
13/05/2021		13/05/2021		14/05/2021	
WL @ Start	Dry	WL @ Start	Dry	WL @ Start	Dry
Time	Depth	Time	Depth	Time	Depth
10:14	28.95	13:40	28.57	09:44	27.89
10:16	28.97	13:45	28.63	09:46	27.93
10:18	28.99	13:50	28.69	09:48	27.97
10:20	29.01	13:55	28.73	09:50	28.01
10:25	29.05	14:00	28.77	09:52	28.04
10:30	29.10	14:05	28.81	09:54	28.07
10:35	29.12	14:10	28.84	09:56	28.10
10:40	29.15	14:15	28.88	09:58	28.13
10:45	29.19	14:20	28.91	10:00	28.16
10:50	29.20	14:25	28.94	10:05	28.23
End of test		14:30	28.97	10:10	28.29
		14:35	29.00	10:15	29.30
		14:40	29.02	10:20	28.40
		14:45	29.05	10:25	28.46
		14:50	29.07	10:30	28.52
		14:55	29.09	10:35	28.56
		15:00	29.11	10:40	28.60
		15:10	29.14	10:45	28.65
		15:20	29.18	10:50	28.77
		15:30	29.21	10:55	28.74
		End of test		11:00	28.78
				11:05	28.80
				11:10	28.82
				11:15	28.86
				11:20	28.90
				11:25	28.93
				11:30	28.95
				11:40	28.99
				11:50	29.03
				12:00	29.07
				12:10	29.10
				12:20	29.13
				12:30	29.15
				12:40	29.18
				12:50	29.20
				13:00	29.22
				End of test	

Client: Watford Borough Council
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627

APPENDIX D – PROPOSED DRAINAGE DRAWINGS



Notes

1. For general notes and manhole schedule refer to drawing J4053-C-DR-0102 For below ground drainage details refer to drawing series J4053-C-DE-0401 to J4053-C-DE-0403.
2. Do not scale the drawing.
3. This drawing to be read in conjunction with all other Architects and Engineers drawings and specifications including outline structural specification.
4. All dimensions are in millimetres unless noted otherwise.
5. Any discrepancies between structural and architectural setting out dimensions must be brought to the attention of the Architect and Engineers.

DRAINAGE KEY

- Proposed Surface Water Drain
- Proposed Perforated Surface Water Drain
- Proposed Foul Drain
- Existing Surface Water Drain
- Existing Drain to be Removed
- S#.# / F#.# — Proposed Manhole Surface Water / Foul
- CH# — Proposed Drainage Channel
- TG# — Proposed Trapped Gully
- RWP# — Proposed Rainwater Pipe (With Roddable access)
- FG# — Proposed Foul Gully
- FD# — Proposed Filter Drain
- RG# — Proposed Road Gully
- YG# — Proposed Yard Gully
- ST# — Proposed Foul Stack (Generic)
- Porous Paved Areas

Rev	Date	Description	Drn	App
05	15.06.21	Stage 4 Update	JPD	AY
04	03.03.21	Stage 4 Update	GPD	AY
03	11.12.20	Stage 4 Update	GPD	AY
02	27.08.20	Stage 4 Update	GB	GPD
01	24.08.20	Stage 4 Update	GB	GPD
00	21.07.20	Stage 4 Issue	GB	GPD

WEBB YATES ENGINEERS
48-50 Scrutton Street
London EC2A 4HH
020 3696 1550
www.webbyates.co.uk
info@webbyates.co.uk

Project
Hemel Hempstead Crematorium

Drawing Title
Drainage Layout Part Plan 1 of 3

Drawing Status
Technical Design

Drawn by	Checked by	Sheet size	Scale	Rev status
GB	GPD	A1	1:250	S4

Drawing Number
J4053-C-DR-1001

Revision
05