Site Wide Sustainable Drainage Systems Strategy

J4053 Hemel Hempstead Crematorium

Ref: J4053-C-RP-0002

Revision: 09

Status: S4

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DOCUMENT CONTROL

Document number:	J4053-C-RP-0002		
Status:	S4	**Reason for issue:**	Technical Design
Date:	15/06/2021	**Revision:**	09

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Approver:	Andy Yates	**Signature**	Andy Yates Digitally signed by Andy Yates DN: DC=LOCAL, DC=WEBBYATES, OU=Employees, OU=LON, CN=Andy Yates, E=andy.yates@webbyates.com Reason: I am approving this document Date: 2021-06-15 16:52:46

REVISION HISTORY

Date	Status	Revision
01/04/2020	S3	00
29/04/2020	S3	01
18/05/2020	S3	02
21/05/2020	S3	03
17/07/2020	S3	04
24/08/2020	S3	05
27/08/2020	S3	06
11/12/2020	S4	07
03/03/2021	S4	08
15/06/201	S4	09

1. INTRODUCTION

Webb Yates Engineers (WYE) is part of a design team commissioned by Watford Borough Council to develop a Sustainable Drainage Strategy for the proposed development of a new Crematorium located south-east of Hemel Hempstead, Hertfordshire (hereafter referred to as the 'Proposed Development'). The purpose of this report is to outline the drainage strategy and design philosophy associated with the below ground drainage for the new proposed re-development.

The scope of works for this report covers the following items;

- Assessment of storage volume requirements and discharge rates.
- Assessment of various Sustainable Drainage Systems (SuDS) options and their suitability for the site.
- Concept drainage design including outfall connections to exiting sewers within and/or off the site.
- Requirements to achieve third party approvals: EA and LLFA

This document has been prepared with reference to:

- Ministry of Housing, Communities & Local Government: National Planning Policy Framework (NPPF), March 2018
- National Planning Practice Guidance (NPPG)
- Environment Agency Flood Maps (https://flood-map-for-planning.service.gov.uk/)
- Department for Communities: "Improving the flood performance of new buildings", May 2007
- The SuDS Manual (C753): 2015
- Hertfordshire Lead Local Flood Authority SuDS Policy Statement (Draft 2017)
- Webb Yates Flood Risk Assessment for the site (J4053-C-RP_00_S3)
- Code of Practice for Surface Water Management for Development Sites (BS 8582:2013)
- DEFRA Non-Statutory Technical Standards for Sustainable Drainage Systems
- BS EN 12056-2:2000 - Gravity Drainage Systems Inside Buildings
- BS EN 752:2017 - Drain and Sewer Systems Outside Buildings
- BS EN 1295-1:1998 - Structural Design of Buried Pipelines Under Various Loading Conditions
- Building Regulations 2015 - Part H: Drainage and Waste Disposal
- WRc - "Sewers for Adoption – A design and construction guide for developers", 7th Edition
- The Wallingford Procedure: Design and Analysis of Urban Storm Drainage

- Phase 1 Geo-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, BRD Environmental Ltd, report ref. BRD3627-OR3-A, dated October 2020.
- CIBSE Guide G, Public Health and Plumbing Engineering

2. BACKGROUND

2.1. PROJECT SITE

The site is located south-east of Hemel Hempstead in Hertfordshire (Figure 1). The OS grid reference is approximately TL 08792 05969. It is situated off Bedmond Road and Bunkers Lane. Adjacent properties consist predominantly of open ground, with Bunker's Park Open Space to the west, and some dwellings in the south-west corner. Access is provided by a small road off Bedmond Road. The site slopes to the south-west.

Figure 1: Site location

The current site is previously undeveloped, so existing below ground structures, services or contamination are not expected. This is supported by the ground investigation report.

The project is to provide a crematorium, associated external landscaping including car parking. Directly adjacent to the scope of the crematorium planning application is a new cemetery development. This cemetery development was subject to a separate planning application (ref.: 4/02553/17/MFA) and the works have been completed by others prior to the crematorium development proposals. The new crematorium development interfaces with some of the infrastructure of the cemetery development (e.g. access roads and parking) however, the crematorium development is proposed to have completely separate and independent drainage systems. As such the cemetery development is not considered further in this report.

A copy of the site-wide general arrangement is provided in Appendix A.

2.2. PROPOSED DEVELOPMENT

2.2.1. Structure

The structure of the proposed crematorium is to consist of a single storey building with a pitched roof. It is irregular in plan, consisting of numerous wings and extensions to the main chapel and crematory room and offices. A porte-cochère is formed with the roof spanning from the main building to an adjacent detached building. Along two faces the roof overhangs. The interior is to use as much natural light as possible, which is to be achieved via the use of large windows and rooflights with the necessary structural frames.

2.2.2. Roads and Paving

A new road is to be constructed, forming the hearse/cortège route from the site access to the crematorium. It will pass under the porte-cochère, to allow drop-off of mourners, before circling the crematorium and back exit from the site. Parking is provided for users of the crematorium which comprises new parking areas as well as some extension of the cemetery development parking area.

2.2.3. Drainage

The site is to be self-draining and independent of any public sewer systems. The foul drainage of the crematorium is to be sent to a dedicated package treatment plant. The treated effluent will then be discharged into the surface water system.

Surface water runoff, is drained, via a number of treatment stages into a new detention pond, to provide further treatment and attenuation, prior to being discharged to a deep borehole soakaway (refer to section 5.1 for more details, refer to Appendix C for the proposed development drainage drawings).

2.2.4. Flood Risk

The site is in Flood Zone 1 so has a low risk of surface water flooding. Please refer to the Webb Yates Flood Risk Assessment document J4053-C-RP-0001 for more information.

3. SITE CONTEXT

3.1. TOPOGRAPHY

A site survey was undertaken by Dowland Partnership in January 2020. The ground levels generally slope from 135 m above Ordnance Datum (AOD) in the north west corner to 131 m AOD at the southern edge of the site boundary. There is a detention basin located in the southern part of the site which is the low point of the site 129.60 m AOD. The figure below indicates the high area (blue) transition to the low area (red) across the site to indicate the fall to the south.

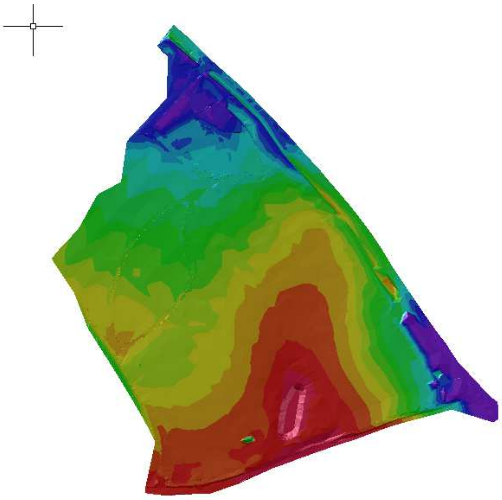


Figure 2: Topography associated with the site.

3.2. GEOLOGY

BRD Environmental Limited (BRD) was commissioned by Webb Yates Engineers (WYE) on behalf of the Client to complete a ground and site investigation. The following is a summary of the information contained in the reports below:

- Phase 1 Geo-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

3.2.1. Strata

The strata of the site is set out below in Table 1.

Table 1: Ground conditions of site

Strata	Typical Description	Depth Encountered (m)		
		From	**To**	**Strata thickness (m)**
Topsoil	Gravelly, sandy clay with gravel of fine to coarse flint	0.0	0.2 - 0.45	0.2-0.45
Superficial deposits of Clay-with-Flints Formation	Gravelly, silty clay or gravelly, sandy clay with gravel of fine to coarse flint. Occasionally, the Clay-with-Flints Formation was devoid of flint gravel, especially in borehole WS05 where flint gravel was rare	0.2 - 0.45	>5.45	
Bedrock	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 5 m- 6 m of Clay-with-Flints directly overlying the Chalk. The Lambeth Group was not encountered.	5.0 – 6.0	> 5.0- 0.6	>0.5

3.2.2. Hydrogeology and Hydrology

The site is located within the Thames river basin. The closest watercourse is the River Gade approximately 2.3 km south west of the site. Currently most of the surface water is likely to infiltrate directly into the underlying soils.

The site is situated upon superficial deposits designated as Unproductive Strata. The Lambeth Group is designated a Secondary A Aquifer. The Lewes Nodular Chalk Formation and Seaford Chalk Formation (undifferentiated) is designated as a Principal Aquifer. The site is located within a groundwater Source Protection Zone 3 (Total Catchment).

Shallow infiltration testing was undertaken (BRD Environmental Soakage Testing Report, October 2020 – see Appendix B). This testing demonstrated that the disposal of collected surface water to shallow soakaways will not be feasible at this site due to the cohesive nature and therefore low permeability of the underlying soils. However, the underlying bedrock is chalk and has a good rate of permeability.

Deep borehole infiltration testing was undertaken (BRD Environmental Depp Borehole Soakage Test Investigation, June 2021 – see Appendix C). This testing demonstrated that disposal of collected surface water to deep borehole soakaways within this underlying chalk was feasible and provided appropriate test data to enable the design of the drainage systems (as described in this document) to be completed.

4. DRAINAGE DESIGN OBJECTIVES

This section outlines the engineering principles and design criteria which have been followed in order to produce the proposed design. These include British & European standards, codes of best practice and guidance which were used by Webb Yates Engineers during the design process.

4.1. DESIGN RAINFALL

In accordance with the NPPF guidance, the effects of climate change should be included within the assessment of future flood risk. As the site area is less than 5 km^2, the site is classified as ‘small’ and therefore the climate change allowances in NPPF Technical Guidance Table 2 are appropriate. This table has been included below for reference.

Table 2: Table showing climate change allowances (Extract from NPPF Technical Guidance, Table 2)

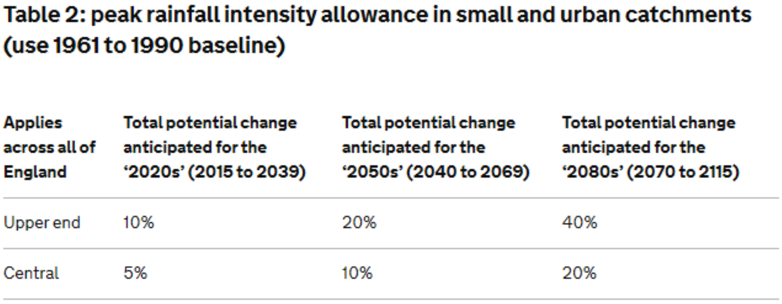


Table 2: peak rainfall intensity allowance in small and urban catchments (use 1961 to 1990 baseline)

Applies across all of England	Total potential change anticipated for the ‘2020s’ (2015 to 2039)	Total potential change anticipated for the ‘2050s’ (2040 to 2069)	Total potential change anticipated for the ‘2080s’ (2070 to 2115)
Upper end	10%	20%	40%
Central	5%	10%	20%

Based on these values the hydraulic drainage design for the proposed drainage network has been modelled for a range of rainfall intensities up to and including ones for a 1in 100 year event plus 40% allowance for climate change.

The new surface water drainage systems for the site include SuDS and are designed to accommodate increases in peak rainfall intensity as given in NPPF and CIRIA Report C753: The SuDS Manual.

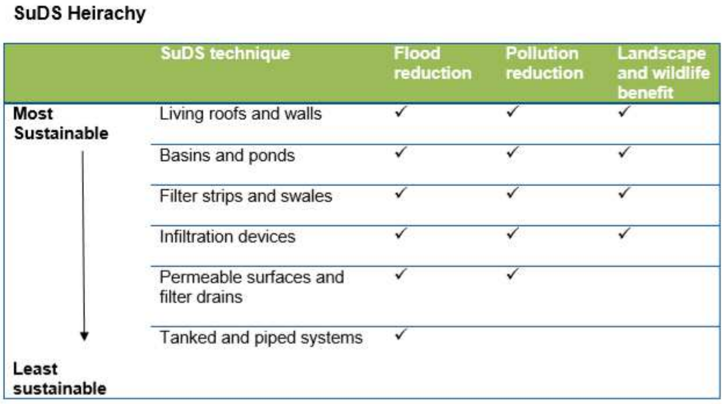
4.2. FLOOD RISK MANAGEMENT MEASURES

Please refer to the Webb Yates Flood Risk Assessment J4053-C-RP-0001_01_S9 for the proposed Flood Risk Management Measures.

4.3. HERTFORDSHIRE SUDS POLICY STATEMENT

The design shall comply with the LLFA SuDS Policy Statement (Draft 2017) key requirements identified in this document have been listed below:

- Proposals for SuDS must follow the discharge hierarchy as set out in the non-statutory technical standards for sustainable drainage systems. The SuDS hierarchy in the Hertfordshire LLFA Summary guidance for developers is below in Figure 3.



SuDS Heirachy

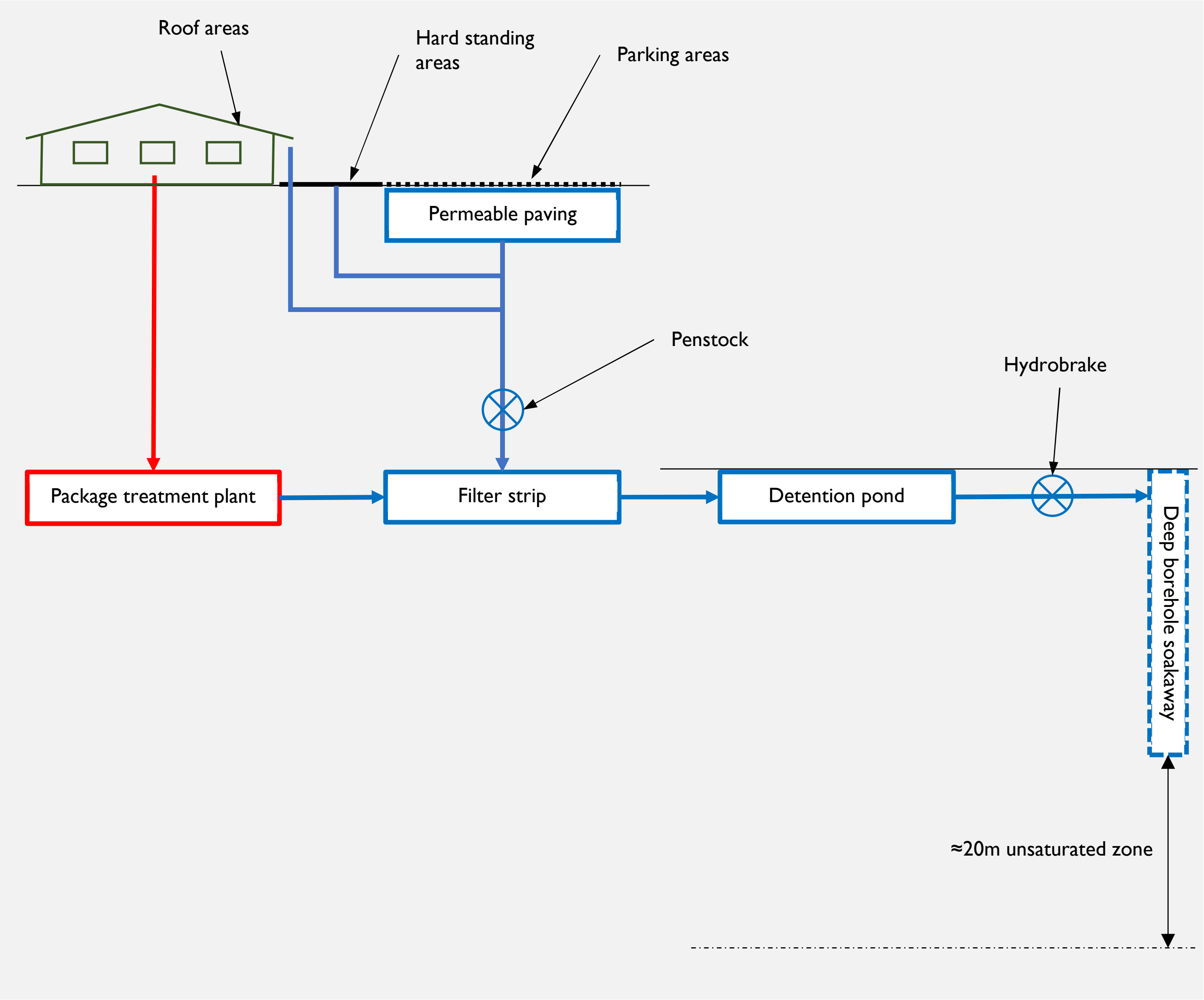
	SuDS technique	Flood reduction	Pollution reduction	Landscape and wildlife benefit
Most Sustainable	Living roofs and walls	✓	✓	✓
	Basins and ponds	✓	✓	✓
	Filter strips and swales	✓	✓	✓
	Infiltration devices	✓	✓	✓
	Permeable surfaces and filter drains	✓	✓	
Least sustainable	Tanked and piped systems	✓		

Figure 3: LLFA SuDS hierarchy (Hertfordshire LLFA Summary guidance for developers)

- For greenfield sites, the peak runoff rate from the development for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event must not exceed the peak greenfield runoff rate from the whole site for the same event.
- The runoff volume from the developed site in the 1 in 100 year, 6 hour rainfall event must not exceed the greenfield runoff volume for the same event.
- Flooding must not occur on any part of the site for a 1 in 30 year rainfall event except in areas that are designed to hold and convey water
- During a 1 in 100 year plus climate change rainfall event no flooding should occur in any part of a building (including a basement); utility plant susceptible to water (e.g. pumping station or electrical sub-station) or on neighbouring sites.
- If there is flooding during 1 in 100 year plus climate change rainfall event, this should be indicated on plan showing extent and depth. Flows that exceed design criteria must be managed in exceedance routes) that minimise risks to people and property both on and off the site.
- Proposals must demonstrate that the SuDS have been designed at or near the surface in line with the SuDS hierarchy. Underground attenuation features will only be acceptable where it can be proved that alternate surface based methods are not appropriate or feasible.
- The design of the drainage system must account for the likely impacts of climate change and changes in impermeable area over the design life of the development. Appropriate allowances should be applied in each case.

5. DRAINAGE STRATEGY

The proposed drainage strategy is shown in the drawings in Appendix D and diagrammatically as indicated below highlighting the key features of the system and treatment stages



5.1. SURFACE WATER STRATEGY

With the proposed development, the inclusion of SuDS is a key consideration and it is a legal requirement to have SuDS included which aim to reduce the amount of surface run-off which is occurring.

The design of the surface water system has been implemented following the drainage hierarchy and SuDS management train as suggested by the SuDS Manual 2015.

The Building Regulations Requirement H3 stipulates that rainwater from roofs and paved areas is carried away from the surface to discharge to one of the following (listed in order of priority):

- An adequate soakaway or some other adequate infiltration system,
- A watercourse, or where that is not practicable,
- A sewer.

The site shall be drained by a dedicated borehole soakaway and detention pond. This is in line with the highest SuDS hierarchy priority.

5.1.1. Greenfield Runoff

The total catchment area draining to the new detention basin location prior to development was 5.5 ha. This catchment includes all the proposed works and therefore the remaining catchment area of the site remains in the predevelopment condition.

The Greenfield runoff rate was calculated using UKSUDS.com tool, the output is included in Appendix D. The IH124 method was used and based on the strata of the site the soil class 4 was used. Soil class descriptions are included below in Table 3.

Table 3: Soil types and soil parameters

General soil description	Soil Class	Parameter	Runoff Potential
Well drained sandy, loamy or earthy peat soils. Less permeable loamy soils over clayey soils on plateau adjacent to very permeable soils in valleys.	S1	0.15	Very Low
Very permeable soils (e.g. gravel, sand) with shallow groundwater. Permeable soils over rocks. Moderately permeable soils some with slowly permeable subsoils.	S2	0.3	Low
Very fine sands, silts and sedimentary clays. Permeable soils (e.g. gravels, sand) with shallow groundwater in low lying areas. Mixed areas of permeable and impermeable soils in similar proportions.	S3	0.4	Moderate
Clayey or loamy soils.	S4	0.45	High
Soils of the wet uplands: bare rocks or cliffs. Shallow, permeable rocky soils on steep slopes. Peats with impermeable layers at shallow depth.	S5	0.50	Very High

The volume of runoff from the greenfield area has been conservatively based on a percentage impervious (PIMP) value of 30%, the Standard Percentage Runoff (SPR) value calculated from the IH124 greenfield calculation was 47% (Appendix E).

Therefore, the area of the site in the predevelopment condition that drained to the southern basin location was 5.5 x 0.3 = 1.64 ha.

5.1.2. Proposed Development

The proposed drainage design uses a combination of permeable pavement, gullies, and rainwater pipes to drain hardstanding surface water to below ground drainage network and then discharge the surface water runoff to the detention pond installed in Phase I, upstream of the soakaway, via a header wall.

Where the Phase II design includes landscaped mounds which grade towards the proposed development, filter drains are proposed to protect the building from overland flows and keep this runoff away from the buried drainage network.

The proposed carpark areas use permeable pavement under car park spaces and normal asphalt lanes between (which drain to the permeable paved areas). This permeable pavement shall provide attenuation and treatment of stormwater runoff, and the configuration is durable because the asphalt can tolerate turning forces more effectively. Soakaway testing to BRE Digest 365 was carried out in the locations of the permeable paving (refer to Appendix B for details). This determined that no shallow infiltration could be taken and hence the design has been developed assuming zero infiltration in the areas of permeable paving.

As per the LLFA requirements, the conveyance network is designed to prevent flooding in the 1 in 30 year event (plus 40% climate change as well as the 1 in 100 year plus 40% climate change. The storm water flow from the new development is to be attenuated within a new detention basin below the development for all events up to and including a 1 in 100 year return period plus 40% climate change.

This has been modelled in MicroDrainage and the results of the MicroDrainage model are shown outlined in the table below (full results are provided in Appendix F):

Table 4: Proposed surface water design performance

	1:30 year + 40% CC	**1:100 year + 40% CC**
Number of flooded manholes	0	0
Flooded volume (m^3)	0.00	0.00
Maximum water level in attenuation basin (m AOD)	131.21	131.54
Attenuation pond freeboard (m) **(Based on top of pond level 132.20 m AOD)**	0.99	0.66
Maximum required storage volume m^3	308.1	415.1
Maximum outflow rate from Hydrobrake (l/s)	1.9	2.1
Soakaway soakage flow rate (l/s) based deep borehole infiltration testing (average of 3 tests)	8.2	8.2
Soakaway safety factor	4.3	3.9

There will be some infiltration at the base of the permeable pavement, however due to the dense soil conditions this has conservatively been ignored from the MicroDrainage model. The MicroDrainage results are included in Appendix F.

Due to the restricted flowrate from the hydrobrake the 24 hour half drain from the pond cannot be met for the 1 in 100 year event. As a result, it is proposed that the pond is sized to accommodate the 1 in 100 year event (plus 40% CC) and the 1 in 30 year event (plus 40% CC) , i.e. the storage volume is at least 308.1 + 415.1 = 723 m^3. This means that the attenuation pond will accommodate the 1:100 year flows in addition to the 1:30 year flows.

5.1.3. Water Quality

As per the water quality SuDS tool the surface water runoff from the proposed buildings and adjacent hardstanding areas is a Low pollutant hazard. The requirement for treatment of this runoff shall be met by the combination of permeable paving, gully silt traps, gravel filtration trench and the attenuation basin connected in series.

The carpark area is assessed as Medium pollution hazard as the number of traffic movements per day is estimated to be greater than 300. The requirement for treatment of this runoff shall be met by the combination of permeable pavement, gravel filtration trench and the detention pond connected in series.

It is recognised that given the outfall is direct into the chalk over a Principal Aquifer the control of pollution of any water entering the soakaway must be a key priority (refer also to Section 6 for further assessment of the discharge to the borehole soakaway). Therefore, there are 3 forms of treatment for most of the site, and all areas of the site with medium pollutant hazard. Refer to Appendix G for water quality calculations.

This meets the drainage hierarchy in Building Regs part H as well as the SuDS manual and appropriate measures have been taken to ensure that pollutants such as hydrocarbons and silt do not enter the deep borehole soakaway.

5.2. FOUL WATER DESIGN

The closest public sewer is approximately 360m north west of the crematorium building and at a higher level than the building. To reach this public sewer would require a pumping main to be installed as well as passing through land not owned by our client. There would be considerable cost and complexity in providing a connection to this public sewer and hence it is proposed that the foul water flows are treated and managed within the site development as discussed below.

It is proposed to discharge the foul drainage to an on site Klargester BioFicient fluidised bed reactor, sewage treatment plant (or similar approved) prior to conveying the treated effluent to the surface water system. All foul water flows are domestic effluent, there are no trade effluent requirements from the operation of the facility.

The foul water system is based on the following factors and assumptions:

- The crematorium will operate 5 days per week.
- There will be up to 6 full-time staff working at the facility. Separate toilet and kitchen facilities are provided for the staff.
- The crematorium will hold up to 7 services per day, but is anticipated to average approximately 1200 services per year.
- It is anticipated that around 70 visitors on average will attend each service (although this may vary from very low numbers, 2-4, up to around 130, the maximum capacity of the chapel).
- A toilet block is provided in both the waiting area and at the exit from the floral tribute for the use of arriving and departing visitors. It has been assumed that 50% of the visitors use the toilet block per service (this is based on an average dwell time of 30 mins for visitors both prior to and following a service).

5.2.1. Package Treatment Plant

The sizing of the package treatment plant is based on the anticipated maximum number of visitors to the crematorium over a weekly period. This is as follows (and based on the factors and assumptions stated above):

- 6 full-time staff working at the crematorium for 5 days per week
- 7 services per day for 5 days of the week = 35 services per week
- An average of 70 visitors to each service = 2,450 visitors per week
- 50% of visitors will use the toilet blocks = 1,225 toilet block uses per week = 245 uses per day
- Loads for full-time staff are taken as 'Commercial/Industrial: full-time day staff' (as CIBSE Guide G, Public Health and Plumbing Engineering, Table 4.10)
- Loads for visitors are taken as 'Amenities: toilet blocks (per use)' (as CIBSE Guide G, Public Health and Plumbing Engineering, Table 4.10)

To determine the size of the package treatment plant, the loads were calculated as follows:

		Flow (litres)	BOD5 (grams)	Ammonia (N) (grams)
Staff (6 No.)	*Values per user per day*	*90*	*38*	*5*
	Subtotal	540	228	30
Visitors (245 uses)	*Values per use per day*	*10*	*12*	*2.5*
	Subtotal	2,450	2,940	613
	Total (per working day)	2,990	3,168	643
Convert to daily average (multiply by 5/7)				
	Total (average daily value)	**2,136**	**2,263**	**459**

Based on the above, a Klargester BioFicient 34H package treatment plant is proposed. The capacity of this as follows:

- Flow: 11,250 litres per day
- BOD5: 4500 grams per day
- Ammonia (N): 600 grams per day

5.2.2. Package Treatment Plant Outflow

The treated outflow from the package treatment plant discharges to the surface water system and then subsequently passes through secondary treatment (filter strip) and tertiary treatment (detention pond with planting) before discharging to the deep borehole soakaway.

To quantify the anticipated values through this treatment train, average weekly values for the usage of the crematorium facility are used as follows:

- 6 full-time staff working at the crematorium for 5 days per week
- 1200 services per year = 24 services per week
- An average of 70 visitors to each service = 1,680 visitors per week
- 50% of visitors will use the toilet blocks = 840 toilet block uses per week = 168 uses per day
- Loads for full-time staff are taken as 'Commercial/Industrial: full-time day staff' (as CIBSE Guide G, Public Health and Plumbing Engineering, Table 4.10)

- Loads for visitors are taken as ‘Amenities: toilet blocks (per use)’ (as CIBSE Guide G, Public Health and Plumbing Engineering, Table 4.10)
- The efficiency of the package treatment plant is taken from Klargester’s product certification (see Appendix H) as follows:
    - Chemical oxygen demand: 90.6% efficiency; 67 mg/l effluent
    - Biological oxygen demand: 94.4% efficiency; 20 mg/l effluent
    - Ammonia (N): 99% efficiency; 0.4 mg/l effluent
    - Suspended solids: 92.7%; 27 mg/l effluent

To determine the characteristics of the package treatment plant effluent, the loads and treatment were calculated as follows:

		Flow (litres)	BOD5 (grams)	Ammonia (N) (grams)
Staff (6 No.)	*Values per user per day*	*90*	*38*	*5*
	Subtotal	540	228	30
Visitors (168 uses)	*Values per use per day*	*10*	*12*	*2.5*
	Subtotal	1,680	2,016	420
	Total (per working day)	2,220	2,244	450
	Total (per week)	**11,100**	**2,263**	**459**
Treatment efficiency				
	Effluent per week	11,100	222	4.5
	Effluent per day (average)	**1,586**	**32**	**0.6**

From the above table it can be seen that the average daily outflow from the package treatment plant is:

- Flow: 1.6 m^3/day
- BOD5: 32 g/day
- Ammonia (N): 0.6 g/day

Infiltration testing (BRD Soakage Test Investigation – see Appendix B) has been carried out on the site to assess the viability of using a drainage field to discharge this treated effluent. The average percolation value (V_p) measured on site was 82 which as per BS 6297:2007 is within the acceptable range for a drainage field. However due to the large number of visitors per day using the facilities designing a drainage field as per the standard formula below is not practical as one would end up with a required floor area of 3,600m^2 for the drainage field;

$A_t = p \times V_p \times 0.25$

- A_t is the floor area
- p is the number of occupants in the home/building (taken as 174 users, see table above)
- V_p is the percolation value in secs/mm (i.e. the result from the percolation test)

This area is considered too high provide an adequate drainage field which would perform satisfactorily and as a result, it is proposed to discharge into the surface water system.

The treated effluent from the package treatment plant is therefore proposed to be discharged to the surface water system. This system incorporates further treatment stages which will improve the water quality prior to its final discharge into the deep borehole soakaway:

1. The flows firstly pass through a filter strip treatment stage.
2. The flows then pass through a detention pond system which includes a sediment forebay and planting to provide further ‘polishing’ of the flows.

Following these treatment stages, the flow passes into a deep borehole soakaway to discharge to the underlying Chalk. The borehole terminates around 20m above the saturated zone, i.e. there is around 20m depth of unsaturated zone below the base of the borehole soakaway.

6. DEEP BOREHOLE SOAKAWAY ASSESSMENT

As described above, it is proposed to discharge the surface water and foul effluent to a deep borehole soakaway. The Environment Agency position statement G9 – *Use of deep infiltration systems for surface water or sewage effluent disposal* states the following:

"The Environment Agency will only agree to the use of deep infiltration systems for surface water or sewage effluent disposal if the developer can show that all of the following apply:

- *the discharge to groundwater is indirect (with the exception of clean uncontaminated roof water to ground - see Position Statement G12)*
- *there are no other feasible disposal options such as shallow infiltration systems or drainage fields/mounds that can be operated in accordance with the appropriate current British Standard 6297:2007+A1:2008*
- *the system is no deeper than is required to obtain sufficient soakage*
- *acceptable pollution control measures are in place*
- *risk assessment demonstrates that no unacceptable discharge to groundwater will take place – in particular inputs of hazardous substances to groundwater will be prevented*
- *there are sufficient mitigating factors or measures to compensate for the increased risk arising from the use of deep structures*

For new effluent discharges that meet the above criteria, secondary treatment is required.

The Environment Agency will apply position statement G1 to any deep infiltration systems potentially involving the discharge of non-hazardous pollutants. The Environment Agency will encourage operators of existing deep infiltration systems to alter their facilities so that direct inputs of pollutants are avoided, particularly where there is potential for hazardous substances to enter groundwater."

This section provides supporting information to demonstrate that the above criteria have been met.

6.1.1. Site Context and Conceptual Hydrogeological Model

Figure 4 below provides a representation of the site context with regards to the potential for pollution to enter the groundwater.

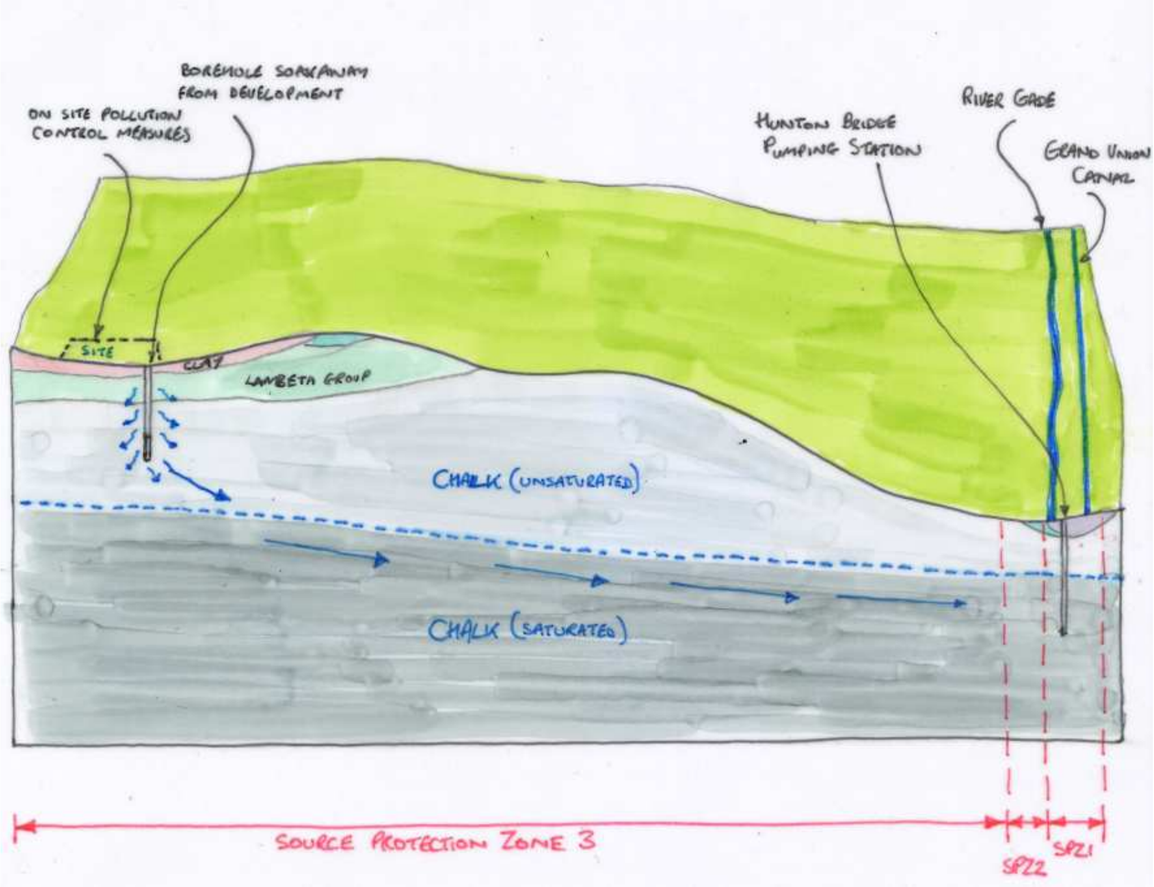


Figure 4: Groundwater site context

Key aspects of the site context are as follows:

- The site level is around 135 – 130m AOD.
- It is proposed that on site pollution controls are provided (as discussed within this document)
- Surface water is discharged to a deep borehole soakaway on the site. This borehole is proposed to be 30m deep (from approximately 130m AOD to 100m AOD).
- The site is underlain by the Chalk with a groundwater level approximately 50 – 60m below ground level (70m AOD – 80m AOD) thus providing around 20-30m of unsaturated zone.
- The groundwater flow is in an approximately southward direction.
- The site is located within a Source Protection Zone 3.
- In the direction of groundwater flow, it is approximately 5km to Source Protection Zone 1 which includes the Hunton Bridge Pumping Station (groundwater abstraction), the River Gade and the Grand Union Canal.

Sources of potential pollution to the groundwater are as follows:

- Oils and hydrocarbons from vehicles accessing and parking on the site (e.g. mineral oil and petroleum oil – hazardous substances)
- Metals from vehicles accessing and parking on the site (e.g. zinc, cadmium, copper – non hazardous pollutants)

- Sediments from surface run-off (non hazardous pollutant)
- Chemicals from cleaning and washing of the building (e.g. sodium hypochlorite – non hazardous pollutant)
- Biological matter from foul water effluent (e.g. faecal coliforms – non hazardous pollutant)
- Ammonia from foul water effluent (non hazardous pollutant)

Please note, it has been confirmed with the cremator supplier that the operation of the cremators does not create the discharge of any chemicals to the drainage systems.

The potential pathway for pollutants to enter the groundwater is via effective rainfall being discharged to the deep borehole soakaway, then percolating through the unsaturated zone, prior to recharging the saturated zone at depth in the aquifer.

The main receptors for the potential pollutants are as follows:

- The groundwater of the aquifer
- Abstraction for drinking water and industrial usage
- Base flow to rivers and watercourses

6.1.2. Groundwater Quality Risk Assessment

A groundwater quality risk assessment has been undertaken in accordance with Design Manual for Roads and Bridges, LA 113: *Road drainage and the water environment* (Annex C) as follows:

		Weighting factor	**Score**	**Result**
Source	Traffic flow	10	Low = 1	10
	Rainfall depth (annual averages)	10	Low = 1	10
	Drainage area ratio	10	Low = 1	10
Pathway	Infiltration method	15	High = 3	45
	Unsaturated zone	20	Low = 1	20
	Flow type	20	Low = 1	20
	Unsaturated zone clay content	5	Medium = 2	10
	Organic carbon	5	High = 3	15
	Unsaturated zone soil pH	5	Medium = 2	10
	Overall Risk Score			**150**

This overall risk score represents an overall risk score of 150 which is classified as 'Medium Risk' albeit at the bottom of this category (medium risk = 150 – 250).

Based on this assessment additional pollution treatment and control measures are proposed to improve the quality of the water prior to discharge to the borehole soakaway.

6.1.3. Groundwater Risk Assessment

Based on the potential sources of pollution to the groundwater, four pollutants are used as indicators of the potential of pollution to affect the groundwater; sediment, petroleum oil, metals and ammonia. Additional treatment stages are proposed (as described in Section 5 above) including permeable paving (no infiltration) to the parking areas, a filter strip treatment stage, and a detention pond with planting and sediment forebay prior to the flows being discharged to the borehole soakaway.

The average annual rainfall for the site is 700 mm and the drained area is 6000m^2. This leads to an average annual rainfall of 4200m^3 which is to be collected and, following onsite treatment, passed to the borehole soakaway.

The compliance point for the assessment below is taken as the base of the borehole soakaway and therefore, conservatively, no dilution or attenuation within the unsaturated zone has been included.

Sediment can be washed into the drainage system from rainfall events, particularly from the hard landscaping areas of the site. CIRIA Report C753 provides (Table 26.8) reported a mean value of total suspended solids for urban open areas of 126.3 mg/l. The majority of the parking and hard landscaped surfaces are provided with permeable paving (no infiltration). Permeable paving systems have been reported to provide over 80% removal of suspended solids (CIRIA Report C582). Conservatively, using a 70% reduction would reduce the suspended solids to 38 mg/l. Further treatment stages of a filter strip treatment stage could be expected to provide a further 40% removal of suspended solids, i.e. down to around 23 mg/l. Further treatment of a detention pond, with a sediment forebay, provides a final treatment stage (with a similar removal efficiency as permeable paving = 70%) will further reduce the quantity of suspended solids to around 7 mg/l. This is below the level reported as causing observable biological effects of 25 mg/l (CIRIA Report C753, Table 26.8) and is therefore considered acceptable.

Petroleum oil will potentially be discharged as unburnt hydrocarbons from vehicles accessing and using the site. The site is predominantly used by passenger cars (staff and visitors) with only a small number of other vehicles occasionally accessing the site (e.g. deliveries, maintenance vehicles). The average number of services per year is 1200 and (based on traffic surveys at West Herts Crematorium) the average number of vehicles attending a service is 31. Conservatively assuming 50 vehicles per service equates to 60,000 vehicles per year. To ascertain a conservative value for the potential source of hydrocarbons, the Euro emissions standards give maximum values for vehicle emissions. For the Euro 3 emissions standards (for all vehicles produced from 1/1/2001) the allowable total hydrocarbon emission for petrol passenger cars was 0.20 g/km. Conservatively assuming a 1 km journey around the site means a value for total hydrocarbon emissions of 12 kg per year.

Permeable paving systems can provide a very high level of treatment for hydrocarbons. Permeable paving systems have been reported to provide over 80% removal of polyaromatic hydrocarbons (CIRIA Report C582). Conservatively, using a 70% reduction would reduce the hydrocarbons to 3.6 kg per year. Further treatment stages of a filter strip treatment stage could be expected to provide a further 50% removal, i.e. down to around 1.8 kg per year. Further treatment from a detention pond, with planting, provides a final treatment stage (with a similar removal efficiency as a filter strip = 50%) will further reduce the quantity of hydrocarbons to around 0.9 kg per year. Based on the annual average rainfall, this equates around 0.2 mg/l.

Metals (cadmium, copper, zinc) can be released from vehicles using the facility. CIRIA Report C753 provides (Table 26.8) reported mean total cadmium, copper and zinc of 2.2, 27.9 and 203 μm/l respectively (urban open areas). The majority of the parking and hard landscaped surfaces are provided with permeable paving (no infiltration). Permeable paving systems have been reported to provide over 90% removal of metals (CIRIA Report C582). Conservatively, using a 70% reduction for the permeable paving, 40% reduction for the subsequent filter strip, and a 70% reduction for the detention pond would reduce the quantity of cadmium, copper and zinc to around 0.1, 1.5 and 11 μg/l. For cadmium, this is the same as the minimum reporting value (0.1 μm/l) and is therefore considered acceptable. For copper and zinc, the level is lower than the 97.7th percentile values given for the unconfined and confined aquifer in BGS Baseline Report: 6. The Chalk of the Colne and Lee River Catchments (Cu: 21.5 μm/l unconfined, 27.7 μm/l confined; Zn: 109 μm/l unconfined, 180 μm/l confined) and are therefore considered acceptable.

Ammonia is present in the foul water flows and, although it is treated via the foul package treatment plant, a remaining amount passes to the surface water system. As described in section 5 above, the calculated quantity of ammonia discharged from the treatment plant is 0.6 grams per day. Taken over an annual period, this equates to 219 g per year. Ignoring any of the secondary treatment stages, the ammonia will be diluted by the rainwater prior to discharging to the borehole. Based on the average annual rainfall for the site, this reduces the ammonia concentration to 0.05 mg/l. The ammonia will be further diluted and attenuated within the unsaturated zone. The BGS Baseline Report: 6. The Chalk of the Colne and Lee River Catchments gives a 97.7th percentile value for NH_4-N of 0.060 mg/l for the unconfined aquifer, and 1.370 mg/l for the confined aquifer. As such, the concentrations of the ammonia are considered to be the same or lower than the natural background level in the groundwater and therefore acceptable.

There is also the potential for an accidental spillage of pollutants which could be discharged into the drainage systems. To provide mitigation for this it is proposed to install a penstock on the surface water systems such that in the event of an accidental spillage, the system to be isolated from the discharge to the borehole.

6.1.4. Summary of Groundwater Assessment

With regards to the criteria stated by the Environment Agency in their position statement G9, below is a summary of the responses to the specific criteria.

- The discharge to groundwater is indirect:
  - Confirmed: the discharge is indirect with approximately 20-30m of unsaturated bedrock below the base of the borehole.
- There are no other feasible disposal options such as shallow infiltration systems or drainage fields/mounds that can be operated in accordance with the appropriate current British Standard 6297:2007+A1:2008

  - Confirmed: the upper ground strata are impermeable to facilitate shallow infiltration systems or facilitate a suitable drainage field.
- The system is no deeper than is required to obtain sufficient soakage.
  - Confirmed: the borehole is to be 30m depth to reach suitable strata for infiltration whilst also maximising the unsaturated zone.
- Acceptable pollution control measures are in place
  - Confirmed: on site treatment measures of permeable paving (no filtration), filter strip and detention pond (with sediment forebay and planting) provide pollution control measures. A penstock is also provided to the surface water system in case of accidental spillages.
- Risk assessment demonstrates that no unacceptable discharge to groundwater will take place – in particular inputs of hazardous substances to groundwater will be prevented
  - Confirmed: the proposed treatment and mitigation measures demonstrate no unacceptable discharge to the groundwater.
- There are sufficient mitigating factors or measures to compensate for the increased risk arising from the use of deep structures
  - Confirmed: sufficient treatment measures and control measures are provided.

7. MAINTENANCE SCHEDULE

The drainage system will be designed to minimise maintenance requirements; however, a full maintenance scheme will be established for those elements not being offered for adoption. The surface and foul drains, will be maintained by the Freeholder to the manufacturer's recommendations as part of their property maintenance program.

7.1.1. Below Ground Drainage Piped Systems

The below ground piped system (based on assessed flood risk) should be inspected every 10 years as a minimum and repaired and cleansed where necessary.

7.1.2. Gullies, Filter Drains and Channel Drains

Gullies, Filter drains and channel drains should be cleaned out very six months or when required.

7.1.3. Sewage Treatment Plant

This will be maintained as per the manufacturer's requirements.

7.1.4. Permeable Pavement

The pervious pavement should be inspected annually, particularly for silt accumulation, to establish brushing frequencies. During the first 6 months after installation the pavement should be inspected, for evidence of poor operation, within 48 hours of each major storm. Additional maintenance shall be as per the manufacturer's requirements.

7.1.5. Pond Header Wall

Should be inspected after every major rainfall event and cleaned out when required

7.1.6. Pond and Deep Borehole Soakaways

These will be maintained as per the existing maintenance schedule in place for the Phase 1 works.

8. CONCLUSION

The site wide drainage strategy outlined above meets the requirements set out by Building Regulations Part H and the CIRIA SuDS manual.

The proposed surface water strategy is to attenuate the surface water on site into the existing detention basin at the southern end of the site. This detention basin shall continue to outfall at a restricted rate, controlled by an existing hydro-brake, into a borehole soakaway.

Surface water from the proposed impervious areas shall be conveyed to the detention basin via either the positive drainage network or overland flow paths as the topography of the site shall direct any overland flow from the development to the basin.

The detention basin and the conveyance network shall be designed to accommodate surface water runoff, generated by the proposed development, for all rainfall events up to the 1 in 100-year return period rainfall event plus 40% climate change.

It is proposed to connect the foul drainage into a stand alone sewage treatment plant on the site.

Sufficient treatment measures are provided to prevent the discharge of pollutants to the groundwater.

As mentioned in Section 7 the site drainage scheme would be managed and maintained by the freeholder after completion as part of their upkeep works for the site.

APPENDIX A – SITE WIDE GENERAL ARRANGEMENT

GENERAL NOTES:

1. DO NOT SCALE FROM THIS DRAWING. DIMENSIONS GOVERN
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE
3. ALL DIMENSIONS SHALL BE VERIFIED ON SITE BEFORE PROCEEDING WITH THE WORK
4. PLINCKE SHALL BE NOTIFIED IN WRITING OF ANY DISCREPANCIES
5. PLINCKE ACCEPT NO LIABILITY FOR ANY EXPENSE LOSS OR DAMAGE OF WHATSOEVER NATURE AND HOWEVER ARISING FROM ANY VARIATION MADE TO THIS DRAWING OR IN THE EXECUTION OF THE WORK TO WHICH IT RELATES WHICH HAS NOT BEEN REFERRED TO THEM AND PRIOR APPROVAL OBTAINED

A0 Original Sheet Size

0mm 50mm

KEY PLAN

CDM:

IN ADDITION TO THE HAZARDS / RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, NOTE THE FOLLOWING:

ITEM NO.	RISK REGISTER DETAILS

KEY:

N

P02	TENDER ISSUE	31.07.20	GW	CB
P01	TENDER ISSUE	30.07.20	GW	CB
REV	REVISION	DATE	DWN	CHK

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Project:
HEMEL HEMPSTEAD CREMATORIUM

Drawing:
LANDSCAPE GENERAL ARRANGEMENT PLAN

Date: 30.07.20

Scale: 1:500

Status: STAGE 4 - TENDER

Drn: GW

App'd: CB

Drawing No: 0569-PLI-XX-ZZ-DR-L-0010

Rev: P02

APPENDIX B – SOAKAGE TEST INVESTIGATION

Report Title:

Soakage Test Investigation

Project Name:

Hemel Hempstead Crematorium

Report Reference: **BRD3627-OR3-A**

Date: **October 2020**

BRD Environmental Ltd
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REPORT CONTROL SHEET

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

REPORT REFERENCE	**ISSUE DETAIL**	**DATE**	**PREPARED BY**	**CHECKED BY**
BRD3627-OR3-A	First Issue	19/10/2020	B Devonshire	N Kimber

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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.

APPENDIX 1 SITE PLANS & PHOTOGRAPHS

Site Location Plan	Ref. BRD3627-OP1-B
Site Photographs	Ref. BRD3627-OP7-A
Exploratory Hole Location Plan	Ref. BRD3627-OD2-A

APPENDIX 2 EXPLORATORY HOLE RECORDS

Logs of trial pits.	Ref. TP01-TP04
Photographic records of trial pits.	Ref. BRD3627-OP6-A
BRE365 soakage test records.	2 x A4 pages
BS6297 percolation test.	2 x A4 pages

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.
SHALLOW SOAKAGE TESTS	The two shallow BRE Digest 365 soakage tests failed to empty at the required rate and this confirms that surface water disposal to shallow infiltration devices is not appropriate.
DRAINAGE FIELD PERCOLATION TEST	The two soakage tests undertaken to BS 6297 in the proposed foul drainage field recorded different results despite their relatively close proximity. The one test passed as it soaked away within the required six hours on all three fillings. The second test position failed, but it is worth noting that there was a continuous steady drop in water levels throughout the testing. Whilst the test results are not ideal, with some added precautions as detailed within the report, an appropriately designed drainage field will be feasible.
EXISTING SOAKAWAY BOREHOLE TEST	Whilst there had been a storm event the weekend previous to the site works, given the reported soakage rate, the attenuation/stilling pond should have been near empty. Instead the attenuation pond was found to be full almost covering the inlet pipe (i.e. backed up within the drainage pipe system). The outlet chamber containing the flow control device was full of water to the same level as the pond and the borehole soakaway chamber was also overwhelmed by water to almost the same level. Whilst testing the existing borehole was not possible, the following conclusions could be drawn: • The flow control device that regulates flow into the borehole soakaway has been set too open. Had the flow been controlled to that which the borehole is soaking at, the borehole chamber would not have been full of water and the operating rate could have been assessed. • It is clear from observation that the borehole soakaway is not operating at the reported rate and that the current system can only just about cope with the existing drainage. The additional flows from the proposed development will need to be managed by providing additional borehole soakaways to supplement the existing. Alternatively, the crematorium should have its own attenuation pond and borehole soakaway.

SUMMARY REPORT – KEY RECOMMENDATIONS

RECOMMENDATIONS
If finding out the existing soakage rate remains important, then there will need to be a sustained dry period, checks would need to be made in advance of the works that the pond is empty and obviously additional fees for remobilisation of the equipment required to complete the test. It may be some months before the test could be completed.

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 soakage tests.
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. The purpose of the report is to undertake a series of different types of soakage tests to confirm design criteria for the surface and foul water management at the site.

1.2. SCOPE OF WORKS

The agreed scope of works was:

- Mobilisation to site and production of health and safety documentation.

- Undertake a Cable Avoidance Tool (CAT) scan at each exploratory point location. Provision of safety fencing to create a secure working area around each investigation point.

- Undertake a soakage test in 3No. 750mm deep trial pits in general accordance with BRE Digest 365. Water will be supplied by tanker. It is anticipated that these tests will fail the required infiltration rate to comply with BRE Digest 365 and so repeat tests are not anticipated.

- Excavate two test pits at the location of the proposed foul water drainage field and undertake percolation tests to BS 6297:2007+A1:2008 'Code of practice for the design and installation of drainage fields for use in wastewater treatment'.

- All exploratory points will be logged and sampled in general accordance with BS5930:2015 by supervising Geo-Environmental Consultant.

- Provide a temporary dam across head wall exit of the attenuation pond. Undertake a falling head infiltration test within the existing borehole soakaway using 2,000 litres of water. Employ a pump as well as the gravity supply for rapid supply of water from the bowser to the borehole soakaway.

- Determination of the relative topographic level and location of each exploratory point.
- Provision of a combined factual and interpretative soakage test investigation report. Factual findings to include all exploratory point record and test results. Interpretative reporting to include calculation of drainage rates for each test type. 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. The Lambeth Group was not encountered.

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.

3. GROUND INVESTIGATION

3.1. INVESTIGATION DESIGN

METHODOLOGY	It was intended to undertake a soakage test in three shallow trial pits in general accordance with BRE Digest 'DG 365: Soakaway design' to confirm whether or not permeable pavements would work. Two test pits at the location of the proposed foul water drainage field were excavated to undertake percolation tests to BS 6297:2007+A1:2008 'Code of practice for the design and installation of drainage fields for use in wastewater treatment'. The existing borehole soakaway was to be subject to a falling head infiltration test to prove its operational performance.
DATES OF SITE WORKS	The main field works were undertaken on 8th and 9th October 2020.
CONSTRAINTS TO EXPLORATORY HOLE LAYOUT	One of the proposed shallow BRE365 soakage tests was located within an existing area of permeable pavement car parking and so was not attempted. The existing borehole soakaway was flooded at the time of the site works and so the falling head test could not be undertaken.
EXPLORATORY HOLE SPACING	The exploratory holes were undertaken at the points specified by Webb Yates Engineers.

3.2. BRD FIELDWORK

TRIAL PITS	
REFERENCES	TP01 to TP04.
DEPTH RANGE	From 0.75m to 0.8m.
EXCAVATOR	JCB 3CX style wheeled backactor. Trial pits TP03 and TP04 were extended by hand excavation for the percolation tests.
BACKFILL	All the trial pits were backfilled with arisings upon completion.

4. GROUND CONDITIONS

4.1. OVERVIEW

With the benefit of trial pits, the closer inspection of the near surface soils allowed these to be tentatively identified as possible Head Deposits derived from the expected Clay-with-Flints Formation.

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

TOPSOIL: Dark brown, slightly gravelly clay. Gravel of fine to coarse, subangular flint.

4.4. SUPERFICIAL DEPOSITS

4.4.1. Head Deposits

Soils superficially similar to the Clay-with-Flints were uncovered by the trial pits and were typically decribed as ‘Stiff, orange brown, gravelly, silty CLAY. Gravel of fine to coarse, subangular flint with some subrounded quartzite’.

4.5. BEDROCK

As expected, the bedrock geology was not encountered in any of the exploratory holes.

4.6. GROUNDWATER BEHAVIOUR

Groundwater was not encountered whilst forwarding the exploratory holes. However, due to previous rainfall, seepage into the trial pits from the topsoil layer was noted.

5. GEOTECHNICAL ASSESSMENT

5.1. SOAKAWAYS

5.1.1. Soil Infiltration Rate

The records of the soakage tests are presented in the Appendices that includes the calculation of the soil infiltration rate. A summary of results are presented in the table below:

TRIAL PIT	SOIL INFILTRATION RATE		STRATUM TESTED
TP03	Test 1	Permeability too low to calculate soil infiltration rate.	Stiff, orange brown, gravelly, silty CLAY. Gravel of fine to coarse, subangular flint with some subrounded quartzite.
TP04	Test 1	Permeability too low to calculate soil infiltration rate.	Stiff, orange brown, gravelly CLAY. Gravel of fine to coarse, subangular flint with some subrounded quartzite.

5.1.2. Soakaway Design Advice

The shallow soakage test pits would not have reached half empty within 24 hours and have therefore failed. This confirms that disposal of collected surface water to shallow soakaways will not be feasible at this site due to the cohesive nature of near surface soils and their proven low permeability.

5.2. PERCOLATION TESTS

At the base of trial pits TP03 and TP04, hand dug percolation test pits were formed. Percolation tests to BS 6297:2007+A1:2008 'Code of practice for the design and installation of drainage fields for use in wastewater treatment' were then undertaken. The full test details are provided in the Appendices and the results summarised below:

TRIAL PIT	TIME TO DROP 150mm (sec)		Vp	AVERAGE Vp
TP03	Test 1	Greater than 6 hrs		
	Test 2	Greater than 6 hrs		
	Test 3	Greater than 6 hrs		
TP04	Test 1	9000	60	82
	Test 2	Dry overnight		
	Test 3	15500	103	

Vp: Percolation Value.
Average Vp: Average Percolation Value.

The test in TP03 failed to drain completely within the required six hours and therefore the rate of percolation into the soil was too slow. However, it is worth noting that a continuous drop in water level was recorded in the tests in this test pit, albeit very slowly.

Based on the BS 6297:2007: '*a drainage field for disposal should only be used when percolation tests indicate average values of Vp between 15 and 100*'. Tests results for TP01 have recorded an average percolation value that is within the acceptable range for a drainage field.

The test results have confirmed that the ground conditions at the site are not ideal for a drainage field. However, it is considered that treated effluent from the pocket treatment plant could be discharged to a drainage field that incorporated the following additional precautions:

- The drainage field should be oversized to account for the variability in the percolation rate.
- The trenches should be made wider so that more gravel is incorporated around the percolation pipes. This will provided additional attenuation storage capacity within the system as well as increasing the surface area for infiltration to occur.
- The site is gently sloping. Up gradient of the drainage field, the finished landscape surface should be graded so that any surface water run off is diverted from entering the drainage field area. Likewise the slopes should fall away from the drainage field. These steps are so that soil infiltration due to precipitation is minimised.

Alternatively and as allowed for by BS 6297:2007, the treated effluent could be pumped in to an infiltration mound.

5.3. FALLING HEAD BOREHOLE TEST

Whilst there had been a storm event the weekend previous to the site works, given the reported soakage rate, the attenuation/stilling pond should have been near empty. Instead the attenuation pond was found to be full almost covering the inlet pipe (i.e. backed up within the drainage pipe system). The outlet chamber containing the hydrobrake flow control device was full of water to the same level as the pond and the borehole soakaway chamber was also overwhelmed by water to almost the same level.

During the works the water level in the pond was recorded by topographic grade GPS survey equipment. In ~22 hours the water level of the pond dropped 188mm from 131.341m Above Ordnance Datum (AOD) on Thursday 8th October to 131.153m AOD on Friday 9th October.

Whilst testing the existing borehole was not possible, the following conclusions could be drawn:

- The flow control device that regulates flow into the borehole soakaway has been set too open. Had the flow been controlled to that which the borehole is actually soaking at, the borehole chamber would not have been full of water and the operating infiltration rate could have been assessed.
- It is clear from observation that the borehole soakaway is not operating at the reported rate and that the current system can only just about cope with the existing drainage. The additional flows from the proposed development will need to be managed by providing additional borehole soakaways to supplement the existing. Alternatively, the crematorium should have its own attenuation pond and borehole soakaway.

5.4. RECOMMENDATIONS FOR FURTHER GEOTECHNICAL WORK

If finding out the existing soakage rate remains important, then there will need to be a sustained dry period, checks would need to be made in advance of the works that the pond is empty and obviously additional fees for remobilisation of the equipment required to complete the test. It may be some months before the test could be completed.

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.

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.

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

01295 272244
info@brduk.com

Photographs from Soakage Investigation

Plate 1: Borehole soakaway on 29th September 2020.

Plate 2: Borehole soakaway on 8th October 2020.

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP7-A
Date Issued:	October 2020

BRD
01295 272244
info@brduk.com

Photographs from Soakage Investigation

Plate 3: Hydrobrake (flow throttle valve) chamber on 29th September 2020.

Plate 4: Hydrobrake chamber on 8th October 2020.

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP7-A
Date Issued:	October 2020

BRD
01295 272244
info@brduk.com

Photographs from Soakage Investigation

Plate 5: Existing area of permeable car parking.

Plate 6: Attenuation pond on 8th October 2020.

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP7-A
Date Issued:	October 2020

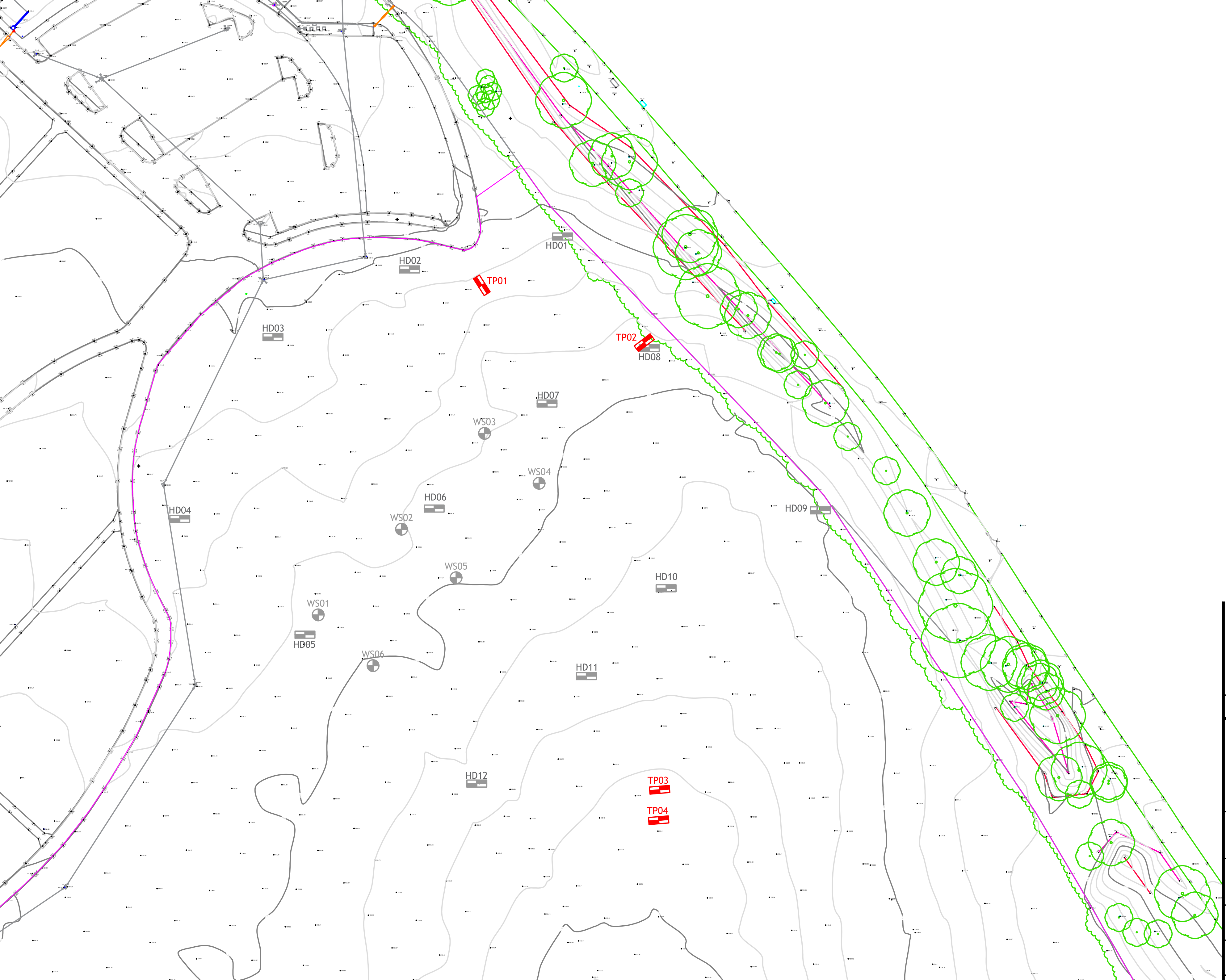
BRD
01295 272244
info@brduk.com

Photographs from Soakage Investigation

Plate 7: Photo taken in the morning of the 9th October 2020.

Plate 8: Slight drop in water observed 6 hours after Plate 7 was taken. There was no rain in these 6 hours.

| BRD Reference: | BRD3627-OP7-A |



Key:

🟥	BRD Soakage Pit
◑	Previous BRD Wir
▭	Previous BRD Har
—	Site Boundary

Notes:

Drawing reproduced fro
The Downland Partners
Topographic Survey (Pa
Dated: Jan 2020

The location of all expl
positioned by topograph

All boundaries are appr

Revision	Date	Description

Drawing title

SOAKAGE EXP

Project title

HEMEL HEMPS

Client

WATFORD BO

Scale
1:1000

Original

Drawn
RM

Checke

APPENDIX 2

TRIAL PIT RECORD

Client: Watford Borough Council
Project Title: Hemel Hempstead Cermatorium
Project No: BRD3627
Logged By: N Kimber
Date Completed: 08/10/2020
Method Used: 180° Backhoe excavator (JCB 3CX type)

Trial Pit No.

TP01

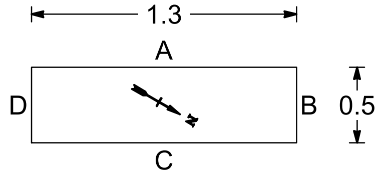
Sheet 1 of 1

Samples & Tests			Description of Strata	Depth / (Level)	Geology	Legend
Depth	Type & No	Value				
			TOPSOIL: Dark brown, gravelly sandy clay. Gravel of fine to coarse, subangular flint and subrounded quartzite.	0.50 (134.19)	TS	
			Stiff, orange brown, gravelly, silty CLAY. Gravel of fine to coarse, subangular flint with some subrounded quartzite.	0.75 (133.94)	H	

Pit Stability: Generally stable throughout
Groundwater: Not encountered

Surface Elevation Level:
134.693 mAOD

Plan of Trial Pit:



General Remarks:
Trial pit terminated at 0.75m bgl to undertake soakage testing.

All dimensions in metres
Log Scale 1:25

Telephone: 01295 272244
Email: info@brduk.com

TRIAL PIT RECORD

Client: Watford Borough Council
Project Title: Hemel Hempstead Cermatorium
Project No: BRD3627
Logged By: N Kimber
Date Completed: 08/10/2020
Method Used: 180° Backhoe excavator (JCB 3CX type)

Trial Pit No.

TP02

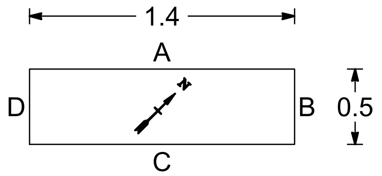
Sheet 1 of 1

Samples & Tests			Description of Strata	Depth / (Level)	Geology	Legend
Depth	Type & No	Value				
			TOPSOIL: Dark brown, slightly gravelly clay. Gravel of fine to coarse, subangular flint. Some desiccation of soils noted.	0.25 (133.90)	TS	
			Stiff, orange brown, gravelly CLAY. Gravel of fine to coarse, subangular flint with some subrounded quartzite. Some desiccation of soils noted.	0.75 (133.40)	HEAD	

Pit Stability: Generally stable throughout
Groundwater: Not encountered

Surface Elevation Level:
134.148 mAOD

Plan of Trial Pit:



General Remarks:
Trial pit terminated at 0.75m bgl to undertake soakage testing.

All dimensions in metres
Log Scale 1:25

Telephone: 01295 272244
Email: info@brduk.com

TRIAL PIT RECORD

Client:	Watford Borough Council	Trial Pit No.
Project Title:	Hemel Hempstead Cermatorium	**TP03**
Project No:	BRD3627	
Logged By:	N Kimber	
Date Completed:	08/10/2020	
Method Used:	See General Remarks	**Sheet 1 of 1**

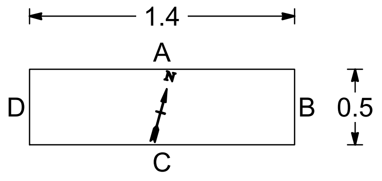
Samples & Tests			Description of Strata	Depth / (Level)	Geology	Legend
Depth	Type & No	Value				
			TOPSOIL: Dark brown, slightly gravelly clay. Gravel of fine to coarse, subangular flint.	0.25 (132.92)	TS	
			Stiff, orange brown, slightly gravelly CLAY. Gravel of fine to coarse, subangular flint with some subrounded quartzite.	0.80 (132.37)	HEAD	

1
2
3
4

Pit Stability: Generally stable throughout
Groundwater: Not encountered

Surface Elevation Level:
133.168 mAOD

Plan of Trial Pit:



General Remarks:
Trial pit terminated at 0.80m bgl to undertake soakage testing.
Trial pit was excavated down to 0.50m bgl with a 180° Backhoe Excavator, then hand dug down to 0.80m bgl. The hand dug pit size was 0.30m - 0.30m squared.

All dimensions in metres
Log Scale 1:25

Telephone: 01295 272244
Email: info@brduk.com

TRIAL PIT RECORD

Client: Watford Borough Council
Project Title: Hemel Hempstead Cermatorium
Project No: BRD3627
Logged By: N Kimber
Date Completed: 08/10/2020
Method Used: See General Remarks

Trial Pit No.

TP04

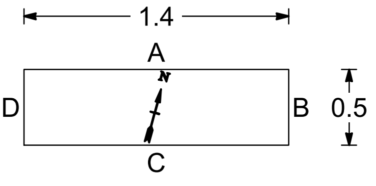
Sheet 1 of 1

Samples & Tests			Description of Strata	Depth / (Level)	Geology	Legend
Depth	Type & No	Value				
			TOPSOIL: Dark brown, slightly gravelly clay. Gravel of fine to coarse, subangular flint.	0.35 (132.76)	TS	
			Stiff, orange brown, slightly gravelly CLAY. Gravel of fine to coarse, subangular flint with some subrounded quartzite.	0.80 (132.31)	HEAD	

Pit Stability: Generally stable throughout
Groundwater: Not encountered

Surface Elevation Level:
133.106 mAOD

Plan of Trial Pit:



General Remarks:
Trial pit terminated at 0.80m bgl to undertake soakage testing.
Trial pit was excavated down to 0.50m bgl with a 180° Backhoe Excavator, then hand dug down to 0.80m bgl. The hand dug pit size was 0.30m - 0.30m squared.

All dimensions in metres
Log Scale 1:25

Telephone: 01295 272244
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Trial Pit Photographs

TP01

Project Title: Hemel Hempstead Crematorium
Client: Watford Borough Council
BRD Reference: BRD3627-OP6-A
Date Issued: October 2020

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info@brduk.com

Trial Pit Photographs

TP02

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP6-A
Date Issued:	October 2020

Trial Pit Photographs

TP03

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP6-A
Date Issued:	October 2020

BRD

01295 272244
info@brduk.com

Trial Pit Photographs

TP04

Project Title:	Hemel Hempstead Crematorium
Client:	Watford Borough Council
BRD Reference:	BRD3627-OP6-A
Date Issued:	October 2020

SOIL INFILTRATION RATE

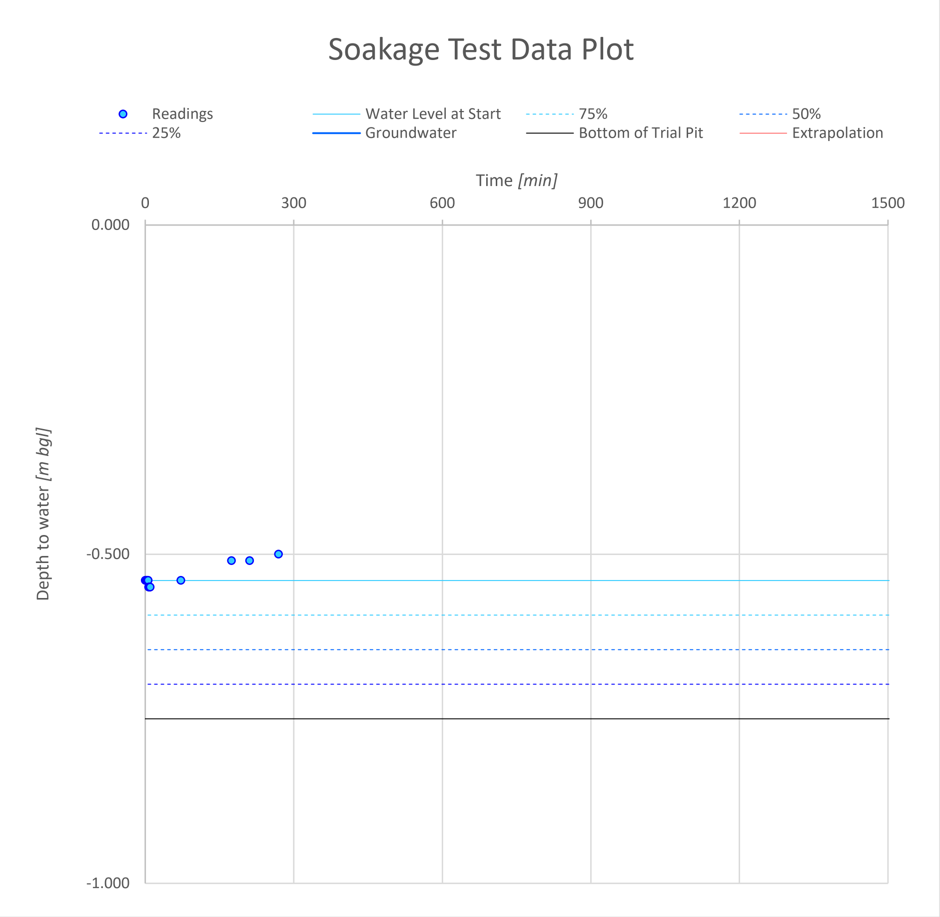
In accordance with BRE Digest 365:2016 - Soakaway Design

Client:	Haverstock
Project Title:	Hemel Hempstead Crematorium
Project No:	BRD3627

Trial Pit No:	TP01	**Length *[m]* :**	1.30
Test No:	1	**Depth *[m]* :**	0.75
Date:	08/10/2020	**Width *[m]* :**	0.45
Logged by:	NK	**Groundwater *[m bgl]* :**	Dry

	from - to *[m bgl]*		**Description**
Ground Conditions	0.00	0.50	TOPSOIL: Dark brown, gravelly, sandy clay. Gravel of fine to coarse, subangular flint and subrounded quartzite.
	0.50	0.75	Stiff, orange brown, gravelly, silty CLAY. Gravel of fine to coarse, subangular flint and some subrounded quartzite.

Time	**Water Depth**
[min]	***[m bgl]***
0	0.540
1	0.540
2	0.540
3	0.540
4	0.540
5	0.540
6	0.540
7	0.550
8	0.550
9	0.550
10	0.550
72	0.540
174	0.510
211	0.510
269	0.500



Soil Infiltration Rate [m/s]: $f = \dfrac{V_{p75\_25}}{a_{s50} \times tp_{75-25}}$

with:

V_{p75_25}	as Effective Storage Volume of water between 75% and 25% effective storage depth ***[m ³]***	**0.06**
a_{s50}	as Internal Surface Area of the soakage trial pit up to 50% storage depth including the base area ***[m ²]***	**0.95**
t_{p75_25}	as Time for the water level to fall from 75% to 25% effective storage depth ***[s]***	**n/a**

Soil Infiltration Rate *[m/s]* : **n/a**

Remarks: Result could not be calculated. Soakage test failed.
Partial collapse of sides and seepage from topsoil caused water level to rise.

SOIL INFILTRATION RATE

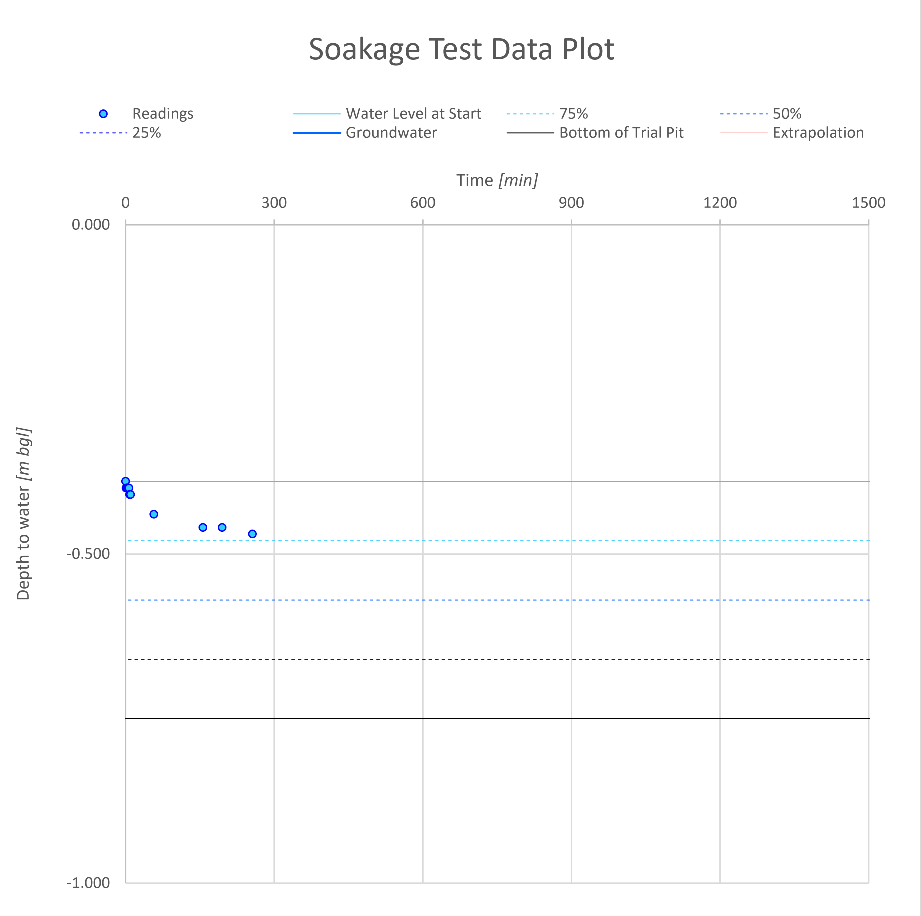
In accordance with BRE Digest 365:2016 - Soakaway Design

Client: Haverstock
Project Title: Hemel Hempstead Crematorium
Project No: BRD3627

Trial Pit No:	TP02	**Length *[m]* :**	1.40
Test No:	1	**Depth *[m]* :**	0.75
Date:	08/10/2020	**Width *[m]* :**	0.45
Logged by:	NK	**Groundwater *[m bgl]* :**	Dry

Ground Conditions	**from - to *[m bgl]***		**Description**
	0.00	0.25	TOPSOIL: Dark brown, gravelly, sandy clay. Gravel of fine to coarse, subangular flint. Some desiccation.
	0.25	0.75	Stiff, orange brown, gravelly, silty CLAY. Gravel of fine to coarse, subangular flint and some subrounded quartzite. Some desiccation.

Time	**Water Depth**
[min]	***[m bgl]***
0	0.390
1	0.400
2	0.400
3	0.400
4	0.400
5	0.400
6	0.400
7	0.400
8	0.410
9	0.410
10	0.410
57	0.440
156	0.460
195	0.460
256	0.470



Soil Infiltration Rate [m/s]:

$$f = \frac{V_{p75\_25}}{a_{s50} \times tp_{75-25}}$$

with:

V_{p75_25}	as Effective Storage Volume of water between 75% and 25% effective storage depth ***[m ³]***	**0.11**
a_{s50}	as Internal Surface Area of the soakage trial pit up to 50% storage depth including the base area ***[m ²]***	**1.30**
t_{p75_25}	as Time for the water level to fall from 75% to 25% effective storage depth ***[s]***	**n/a**

Soil Infiltration Rate *[m/s]* : **n/a**

Remarks: Result could not be calculated as would not reach half empty in 24 hours. Soakage test failed.

BS6297 PERCOLATION TEST

Client Name:	**Watford Borough Council**	**Test No:**
Project Name:	**Hemel Hemstead Crematorium**	**TP03**
Project No:	**BRD3627**	
Tested By:	**N Kimber & B Devonshire**	
Date:	**8th & 9th October**	

Overall depth of trial pit hole dug:

Mechanically excavated to 0.5m.
Test pit excavated to 0.8m (i.e. 300mm deep)

Test Results:

Test 1		**Test 2**		**Test 3**	
Time (seconds)	Depth (mm)	Time (seconds)	Depth (mm)	Time (seconds)	Depth (mm)
0	500	0	490	0	490
60	510	61440	730	1320	500
120	510	Did not empty within 6 hours		10080	520
180	510	Test failed		13320	530
240	510			18000	540
300	510			Will not empty in 6 hours	
360	510			Test failed	
420	510				
480	510				
540	510				
600	510				
1620	520				
7320	540				
9900	550				
13800	560				
Will not empty in 6 hours					
Test failed					

Percolation Calculation:

Test No.	**Time in seconds**		**Vp**	**Average Vp**
Test 1		÷ 150		
Test 2		÷ 150		
Test 3		÷ 150		

Notes: The required pre-soaking was not completed as the soils were sufficiently damp from previous storm event. Whilst tests failed, there was a continuous fall in water levels, albeit very slowly.

BS6297 PERCOLATION TEST

Client Name:	**Watford Borough Council**	**Test No:**
Project Name:	**Hemel Hemstead Crematorium**	**TP04**
Project No:	**BRD3627**	
Tested By:	**N Kimber & B Devonshire**	
Date:	**8th & 9th October**	

Overall depth of trial pit hole dug:

Mechanically excavated to 0.5m.
Test pit excavated to 0.8m (i.e. 300mm deep)

Test Results:

Test 1		Test 2		Test 3	
Time (seconds)	Depth (mm)	Time (seconds)	Depth (mm)	Time (seconds)	Depth (mm)
0	520	0	550	0	550
60	520	61200	Dry	1320	580
120	530			10080	720
180	530			13320	740
240	530			18000	760
300	530			20520	780
360	530				
420	530				
480	540				
540	540				
600	540				
6240	690				
8940	730				
13020	790				

Percolation Calculation:

Test No.	Time in seconds		Vp	Average Vp
Test 1	**9000**	÷ 150	**60**	**82**
Test 2	**Dry overnight**	÷ 150		
Test 3	**15500**	÷ 150	**103**	

Notes: The required pre-soaking was not completed as the soils were sufficiently damp from previous storm event.