Soil Consultants
Ground Investigation
Geotechnical Analysis
Contamination Assessment

SITE INVESTIGATION REPORT

PROPOSED REDEVELOPMENT:

DENVILLE HALL, 62 DUCKS HILL ROAD, NORTHWOOD, HILLINGDON HA6 2SB

Client:	**DENVILLE HALL 2012 LTD** **62 Duck's Hill Road** **Hillingdon** **HA6 2SB**
Consulting Engineers:	**LONDON STRUCTURES LAB** **48a Union Street** **London SE1 1TD**
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This investigation has been undertaken within the constraints of the client's instruction/contract, together with those set out in the 'General information, limitations and exceptions' section at the end of this report. The SCL 'Standard Terms of Appointment' are also included at the end of this report and these identify the contractual arrangements for the investigation. Conclusions or recommendations made in this report are limited to those which can be reasonably based upon the research and/or intrusive investigation work carried out. Any comments which rely on third-party information which has been provided to us are made in good faith and on the assumption that such information is accurate. SCL have not carried out independent validation of any third-party information.

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- GroundSure historical maps (Ref SCL-8995153)
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1.0 INTRODUCTION

Consideration is being given to the redevelopment of parts of this site, including the demolition of a number of derelict buildings and the construction of several new two to three-storey buildings, one of which will incorporate a single level basement. In connection with the proposed works, Soil Consultants Ltd (SCL) were commissioned by Change Project Consulting Ltd, on behalf of the client, Denville Hall 2012 Ltd, to carry out a site investigation to include the following elements:

- Stage 1 Tier 1 Preliminary Risk Assessment (Desk Study) including initial Conceptual Site Model (CSM)
- Intrusive investigation to identify the ground sequence and groundwater conditions
- Geotechnical and geo-environmental sampling and laboratory testing
- Provision of advice on foundations, retaining walls, ground floor slabs and the feasibility of the use of soakaways
- Stage 1 Tier 2 generic quantitative risk assessment and refined Conceptual Site Model (CSM)

This report includes a summary of the findings and conclusions of the Desk Study research and Preliminary Risk Assessment. It then describes the intrusive investigation undertaken, gives a summary of the ground conditions encountered and discusses various foundation options. The Stage 1 Tier 2 generic environmental appraisal is then provided, including a revised CSM.

2.0 SITE DESCRIPTION

A summary description of the site and its general setting is as follows:

Site location and setting	↓ Located on the western side of Duck's Hill Road, within the London Borough of Hillingdon ↓ NGR 508140E 191350N
Site dimensions	↓ The site is irregular in shape, measuring approximately 125 (N-S) x 110m (E-W) across its centre
Site boundaries	↓ Duck's Hill Road to the east with woodland and residential properties beyond. Open fields to the west and residential properties/gardens to the north and south
Site description	↓ The site comprises the grounds of Denville Hall care home ↓ The southern part of the site is occupied by the main building/facilities (Photo 1), which comprises a 16th Century house (rebuilt c.1850) which has been subsequently extended/redeveloped including a substantial two-storey extension c.2004. Access is via an asphalt driveway, flanked by tended grass areas, which leads to two discrete parking areas to the north of the main building. A large, tended lawn is present to the north-east of the main building which is bordered by an asphalt pathway on all sides (Photo 6) ↓ The northern and eastern parts of the site are occupied two smaller, detached, derelict residential buildings, comprising a two-storey apartment block (Photo 7) and bungalow (Photo 2). Both buildings were set within grassed areas bordered by mature trees/vegetation ↓ A bin/waste storage area is present at the northern end of the car park (Photo 4) and a small detached refrigeration/food storage unit is present adjacent to the main residential block (Photo 5) ↓ A single-track drive connects the northern part of the site with Duck's Hill Road to the northeast
Topography and site levels	↓ Topographical drawing supplied (Milton Keynes Surveys, Ref: 41975_1, dated July 2022) indicates the wider site to slope down to the south/south-east, from a maximum elevation of about +74.20mOD within the northern extent to a minimum of about +68.00mOD adjacent to the site's junction with Duck's Hill Road, at an overall slope angle of about three degrees ↓ Ground floor level of the main building is between about +71.30m and +71.50mOD
Existing vegetation within site and adjacent properties	↓ Numerous mature broadleaf and coniferous tree species are present within the site and on its boundaries. A tree survey (GHS Trees Arboricultural and Planning Integration Report, Ref GHA/DS/122660:21) indicates the presence of high water demand trees including oak and cypress, and moderate water demand species including sycamore, ash, pine and wellingtonia

The current site features are shown on the Site Plan and Site Photographs which are included in Appendix A.

3.0 STAGE 1 TIER 1 PRELIMINARY RISK ASSESSMENT (DESK STUDY)

This assessment is generally based upon current UK guidance, primarily the Environment Agency's "Land contamination: risk management" 2020. The scope of the assessment is as follows:

- A review of historical and current land–use and potential contaminated land risks
- Development of an outline conceptual model, identifying potential sources, pathways and receptors
- Development of a strategy for intrusive investigation

3.1 Review of historical mapping

The following summary of the history of the site and surrounding area has been compiled from a series of historical maps (Groundsure Ref: SCL-8995153, 19/08/22) obtained from a commercially available database; these are included in Appendix B.

Historical development of site and surrounding area		
Map date	**The site**	**Significant development / features in surrounding area**
1864/1900	The site is occupied by a single, substantial, property identified as Northwood Hall, part of which comprises a glass/greenhouse. Further large glass/greenhouses are present to the west The remainder of the site comprises deciduous and broadleaf woodland	The immediate surrounding area generally comprises woodland to the west and a mixture of woodland and furze/pasture to the east A road/track is present along the south-eastern boundary Three buildings with nearby wells about 102m E Several ponds are present between 20m and 241m E/SE. Also present 131m NW Marsh land about 100m E which appears to have been landscaped
1911/1920	A rectangular area is present within the centre of the site, bordered by a break of slope, (which roughly corresponds with the location of the contemporary lawn) indicating possible re-grading of the area	Several detached properties between 60m and 173m NE A number of cuttings are shown within the area to the east formerly shown as woodland and furze/pasture

Historical development of site and surrounding area		
Map date	**The site**	**Significant development / features in surrounding area**
1932/1965	The site is identified as Denville Hall Home for Aged Actors and Actresses Glass/greenhouses formerly within the western part no longer no longer present Two large detached buildings, and several smaller ancillary buildings/structures, present within the northern and eastern parts of the site	Residential development immediately north and south of site, and fronting Duck's Hill Road Area labelled 'The Gravel Pits' 165m E
1974/2003	The main building has been significantly developed/extended to the west/north-west	Electricity substations 22m SE and 54m N
2010 to present	Redevelopment of the main building (c.2004 based on anecdotal evidence)	No significant changes apparent

3.2 Database information

The database report includes information of local activities encompassing a range of subjects related to land use, pollution, and geological/hydrological conditions. Our assessment of contaminative uses and other environmental issues relevant to the site and its surroundings is provided below. The full database report (Groundsure Ref: SCL-6753702, 01/05/20) is included as Appendix B and this should be read and understood fully in conjunction with this summary.

Past land use

- Historical industrial land uses: numerous unspecified pits/ground workings and gravel pits within 250m, the nearest being 90m E
- Historical tanks: nearest are unspecified tanks 44/49m S
- Historical energy features: nearest are electricity substations 12m SE and 52m N
- Historical petrol stations and garages: none within 500m

Waste and landfill

- Active and historical landfills: none within 500m
- Waste exemptions: 14m N (37-45 Ducks Hill Lane; using waste exemption)

Current industrial land use

- Recent industrial land uses: Electricity substations 25m SE and 56m N
- Current or recent petrol stations: none within 500m
- Licensed pollutant release (within 250m): 435m E (Par Four Service Station; unloading of petrol into storage)
- Licensed Discharges to controlled waters: 123m NE (Mallard Way; sewage discharges into Cannon Brooke)
- Pollution incidents: 87m NW (smoke and firefighting run-off; minor land impact, significant air impact)

Hydrogeology

- Superficial aquifer: 'Secondary A' Aquifer 416m NW
- Bedrock aquifer: 'Secondary A' Aquifer on site, 'Unproductive Aquifer' 14m W
- Groundwater vulnerability: Medium vulnerability on site. Leaching class 'Low'
- Groundwater abstractions: nearest is 484m SW (Northwood Pumping Station)
- Source Protection Zones: Type 2 Outer Catchment on site, Type 1 Inner Catchment 184m W

Hydrology

- Water Network (OS MasterMap): 11m SE (inland river), 217mE (lake or reservoir), 218m E (inland river)
- Surface water features/bodies: none within 250m
- WFD Surface water body catchments: River Pinn catchment on site

River and coastal flooding

- Risks of flooding (RoFRaS), historical flooding and flood defences: none identified within 250m
- No Zone 2 or 3 floodplains or flood defences within 50m

Surface water and groundwater flooding

- Surface water flooding: the highest risk on site (and within 50m) is 1 in 30 year – 0.3m-1.0m
- Groundwater flooding: the highest risk on site (and within 50m) is 'low'

Environmental designations

- SSSI: nearest is Ruislip Woods 720m S
- National Nature Reserves: nearest is Ruislip Woods 938m S
- Local Nature Reserves: nearest is Batchwood Heath 925m NW
- Designated Ancient Woodland: nearest is Top Wood/French Grove 723m W
- Green Belt: London area Green Belt on site
- Nitrate Vulnerable Zones: none within 2km

Visual and cultural designations

- Listed Buildings: 6m NE (The Cottage, Northwood)

Agricultural designations

- Agricultural Land Classification: Grade 3 agricultural land on site

Habitat designations

- Priority Habitat Inventory: numerous records of deciduous
- Habitat networks: Network Enhancement Zone 2 220n N

Geology

- Superficial geology: none recorded on site
- Bedrock geology: Lambeth Group (very low to moderate permeability clay, silt and sand) recorded on site. London Clay 14m W
- BGS boreholes: none identified within 250m
- Natural ground subsidence: moderate risk of shrink-swell clays; very low to negligible risks for all categories where identified

Mining, ground workings and natural cavities:

- Natural cavities: none identified within 500m
- Britpits: nearest is Northwood Pits (Type A surface mineral working) 208m E
- Surface ground workings: unspecified pit 32m SE and 90m E, unspecified ground workings 143m E, 160m E, 175m NE and 205m E. Numerous records of ponds within 250m, the nearest being 111m N
- Non-coal mining: small scale underground chalk mining may have occurred on site. Potential for localised difficult ground conditions are at a level where they should be considered
- Mining cavities: nearest is 667m N (chalk)

Radon

- Less than 1% of properties affected, Radon protection measures not required

Soil chemistry

- BGS estimated urban soil chemistry, extract as follows:

Location	Arsenic (mg/kg)	Bioaccessible Arsenic (mg/kg)	Lead (mg/kg)	Bioaccessible Lead (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Nickel (mg/kg)	Tin (mg/kg)
On site	11	1.9	89	61	0.8	56	29	17	8
On site	12	2.1	99	68	0.7	62	31	18	8
On site	12	2.1	72	49	0.7	55	24	17	7
On site	12	2.1	106	73	0.7	58	33	18	8
On site	12	2.1	117	80	0.7	63	38	19	8
On site	12	2.1	79	54	0.7	62	24	17	6

Railway infrastructure and projects

- No historical, current or proposed railways or tunnels within 250m

3.3 Other information

A contaminated land enquiry was lodged with Hillingdon Council. No response had been received at the time of compiling this report.

3.4 Walk-over survey

A site walk-over survey was undertaken on 22nd August 2022. A description of the general features of the site and the topography is provided in Section 2.0 above. From inspection of visible and accessible areas, a summary of specific features relevant to the land quality assessment is as follows:

Feature	Commentary
Electricity substations and transformers	None identified on site. Nearest is located about 20m S of site (Photo 10).
Fuel storage tanks	None present based on conversations with site management and on-site observations
Fuel interceptors	None observed
General chemical storage/waste	None observed
Invasive species	None observed
Evidence of gas	None observed

Feature	Commentary
protection	
Surface water contamination	↓ No surface/pooled water observed on site
Waste storage	↓ Bin storage area and waste skip present within northern part of the site (Photo 4)
ACMs	↓ None observed. Pre-2000 buildings may contain ACM's

3.5 Potential pollution linkages and Initial Conceptual Site Model

The information in the preceding sections has been used to undertake the Preliminary Risk Assessment and to compile the Initial Site Conceptual Model below. The assessment follows as risk-based approach, with the potential risks determined qualitatively using the 'source-pathway-receptor' linkage concept; a risk of harm may only exist where a plausible linkage is present. The assessment has been formulated based on the following table:

		Consequences			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High likelihood**	Very high risk	High risk	Moderate risk	Moderate/low risk
	Likely	High risk	Moderate risk	Moderate/low risk	Low risk
	Low likelihood	Moderate risk	Moderate/low risk	Low risk	Very low risk
	Unlikely	Moderate/low risk	Low risk	Very low risk	Very low risk

Definitions of the risks are summarised as follows:

- **Very high:** high probability that severe harm could occur, or there is evidence that it is currently occurring. If realised, the risk could result in substantial liability. Urgent investigation/remediation
- **High:** harm is likely to occur, realisation is likely to present substantial liability. Urgent investigation required. Remedial works may be required in short-term, will be in long-term
- **Moderate:** possible that harm could arise, but unlikely to be severe. Investigation normally required to clarify risk and liability. Remedial works may be necessary in long-term
- **Low:** possible that harm could occur, but this would at worst be mild
- **Very low:** low possibility of harm, unlikely to be severe

The assessment has been carried out by identifying and evaluating the potential sources of contamination, the potential receptors and the plausible pathways for contamination migration are summarised as follows:

Potential sources of contamination

A summary of potential sources identified by our review of the above information is as follows:

- **Made ground:** historical maps indicate potential re-grading of the site c.1911; therefore, made ground may be present
- **Electricity substations:** 12m SE (1974-92), 52m N (1974-1984), 25m SE and 56m N (both current)
- **Potentially infilled land**: Unspecified pits 32m SE and 90m E. Several ponds between 111m N and 132m N and between 21m and 131m E/SE. Former gravel pits 208m E

It should be noted that any developed, non-greenfield land is likely to contain made ground. This will probably be of uncertain or unknown origin and may contain contaminants that have not been specifically identified.

The assessed risks from these potential sources are summarised in the Initial Conceptual Site Model below.

Potential receptors

In the context of the proposed development, the following potential receptors have been identified:

- Human health: inhabitants/users of building, construction workers, adjacent site users
- Controlled waters: Secondary 'A' bedrock aquifer beneath site which may be in hydraulic conductivity with the underlying chalk aquifer. The site is within a Type 2 Source Protection Zone (outer catchment) and the nearest surface water feature is 11m SE. The site is assessed as being of **medium environmental sensitivity**
- Building fabric and services: buried foundations, basement wall, potable water pipes

Plausible pathways

- Ingestion of soil, dust or water
- Inhalation of dust, gas or vapours
- Direct physical contact with contaminated soil/water
- Vertical and lateral migration of contamination including leaching
- Chemical attack of building infrastructure, including water supply pipes
- Migration of ground gas/vapour through permeable soils or open pathways

The Initial Conceptual Site Model and an estimate of the risk associated with each potential linkage is shown in the following table:

Source	Pathway	Receptor	Assessed risk and commentary/justification
On-site: contaminated soil and groundwater	Ingestion, contact, inhalation	End user, construction workers and infrastructure	**Low / moderate risk:** the PRA has identified made ground, associated with historical re-grading of the site, as the main potential contamination source. Pre-2000 buildings present on site which may contain asbestos
	Leaching from contaminated soils and migration in groundwater	Aquifer and surface water	**Low risk:** there is a Secondary 'A' bedrock Aquifer beneath the site, which may be in hydraulic conductivity with the underlying chalk aquifer. No significant onsite contamination sources were identified and therefore the risk to the aquifer is expected to be low. The site lies within a Type 2 Outer catchment SPZ and there are no nearby abstraction points; the nearest surface water feature is 11m distant
Off-site: contaminated soil	Lateral migration of contaminants to site in groundwater	End user	**Low risk:** main potential sources are the nearby electricity substations. These are considered to be of low/limited risk due to low mobility of PCBs in groundwater
On-site and off-site: ground gas and vapours	Lateral and vertical migration of gas/vapour	End-user and buildings	**Low risk:** low/limited risk of ground gas/vapours associated with made ground on site and nearby potentially infilled land. The site is not in a radon affected area

The overall risk rating for the site is assessed as being **Low**.

3.6 Recommendations for intrusive investigation

The Initial Conceptual Site Model identified potential pollution linkages resulting in the overall assessed risk rating of moderate. The following programme of intrusive investigation is recommended:

- Suitable intrusive investigation to confirm the ground sequence, allow soil/water sampling and the installation of monitoring pipes
- Made ground was identified by the PRA as the main potential contamination source, and therefore the investigation should provide general coverage of the site. Electricity substations present off-site are considered low risk
- Soil and groundwater samples should be recovered where relevant and be analysed for a range of general contaminants to include metals/semi-metals, petroleum hydrocarbons, asbestos screening and specifically PCBs
- Groundwater and gas monitoring

The Initial Conceptual Site Model should then be revised to include complete pollution linkages and outline mitigation/remedial measures should be identified, together with any requirements for additional investigation.

4.0 EXPLORATORY WORK AND LABORATORY TESTING

The ground investigation was carried out in August 2022 and is described below.

4.1 Constraints of investigation

The investigation was carried out in accordance with the scope produced by London Structures Lab (dated 24.05.2022). This document determined the scope of the investigation and the locations of the exploratory points.

4.2 Rotary auger boreholes

Two boreholes (BH01 and BH02) were completed using a specialist solid stem rotary auger drilling rig to a depth of 18.0m below ground level (bgl). In-situ testing (SPT) was carried out at regular intervals and the hammer Energy Ratio (E_r) for the equipment used was 83%; the relevant certificate is appended. Disturbed/undisturbed samples were taken for geotechnical and geo-environmental testing, and PID headspace testing was carried out on shallow made ground and natural soil samples. A 50mm internal diameter combined water/gas monitoring pipe was installed in both boreholes to a depth of 5.0mbgl.

An additional shallow borehole (BH03) was constructed in order to facilitate basic falling head soakage testing. However, a significant thickness of made ground was identified at this locality and groundwater was encountered at 1.50m depth. In agreement with the structural engineers, soakage testing was undertaken within a dynamic sampler borehole (WS03).

4.3 Dynamic sampler boreholes

Three dynamic (windowless) sampler boreholes (WS01 to WS03) were completed using a tracked drilling rig to depths of between 4.0m and 5.0mbgl. Standard Penetration Tests (SPT) were undertaken at regular intervals and representative samples taken for geotechnical and environmental testing. The appended calibration certificate for the SPT equipment used indicates the Energy Ratio, Er, of 81%. Basic falling head soakage testing was undertaken in WS03 to assess the feasibility of full-scale soakage testing. 35mm internal diameter combined water/gas monitoring pipes were installed in WS01 and WS02 to depths of 4.0m and 5.0mbgl respectively. both boreholes to a depth of 5.0mbgl.

4.4 Hand excavated trial pits

Three trial pits (TP01 to TP03) were excavated using hand tools against the existing buildings to expose, and record details of, the existing foundations.

4.5 Shallow soil sampling

Five shallow soil samples (S01 to S05) for contamination testing were obtained from within the proposed garden area using hand tools.

4.6 Groundwater and gas monitoring

A single groundwater/gas monitoring was carried following completion of the site works on 30th September 2022.

4.7 Geotechnical laboratory testing

The following geotechnical laboratory testing was completed:

- Index properties tests (Atterberg Limits)
- Particle size distribution tests
- Unconsolidated, undrained triaxial tests

4.8 Chemical and contamination testing

Selected soil samples were delivered to a specialist laboratory (DETS Ltd) and the following testing was carried out:

General soil suite	-	8no samples
Asbestos screening	-	8no samples
PCBs	-	1no sample
Waste Acceptance Criteria (WAC)	-	2no samples
Soluble sulphate/sulphur/pH analyses	-	10no samples

The engineering borehole records, trial pit logs and the laboratory testing results are included in Appendix A.

5.0 GROUND CONDITIONS

Published BGS information (1:50,000 and 1:10,000 scale maps) indicates that the site is underlain by the Lambeth Group which rests upon the Seaford and Newhaven Chalk Formations. This sequence was confirmed beneath a variable thickness of made ground, and is summarised as follows:

Stratum	Depth to base	Level at base	Thickness
Topsoil and made ground	Varies between 0.60m and 2.75m	Varies between +71.30mOD and +68.20mOD	Up to 2.90m
Geologically Re-worked Lambeth Group (Light greyish/orangish/bluish brown slightly gravelly silty CLAY)	Varies between 2.75m and 3.0m where proven; locally absent	Varies between +71.30mOD and +66.45mOD	Between 1.75m and 2.20m where proven
Lambeth Group clay (Bluish/orangish/reddish brown silty CLAY)	Varies between 3.0m and 4.75m where proven; locally absent	Varies between +68.90mOD and +64.45mOD	Between 0.90m and 3.30m where proven
Lambeth Group sand (Light greyish brown/greyish green silty SAND to sandy GRAVEL)	Between 9.00m and 10.50m where proven	Between +61.00mOD and +60.20mOD	Between 7.75m and 9.00m where proven
Seaford and Newhaven Chalk	Base not proven, extended to maximum borehole depth at 18.0m	Below +51.20mOD	Not proven

Detailed descriptions are presented on the exploratory hole records and the ground sequence is represented on the geological cross sections; this information is appended.

5.1 Made ground

Made ground was encountered beneath a nominal layer of dark brown topsoil and was present to depths of between about 0.60m and 2.90mbgl. These non-engineered soils typically comprised brown/dark brown clay with variable gravel of brick, flint, tile, chalk and charcoal, locally grading to brown/black ashy gravelly sand. A significant thickness of made ground within the central and northern part extents (WS02, BH02 and BH03) may indicate historical re-grading of the site. Indeed, some potential re-grading is shown on the historical maps c.1913-1914.

Standard Penetration Tests (SPT) 'N' values of between 4 and 9 were measured indicate low to high strength clay soils/loose to medium dense granular soils.

5.2 Lambeth Group clay

Natural clay soils that we consider represent the Lambeth Group were encountered beneath the made ground and, where the base was proven, extended to depths of between 3.0m and 4.75mbgl, attaining a

maximum thickness of 3.75m in BH01. These clay soils appeared to be absent in BH03 and may have been removed/replaced, as evidenced by a significant thickness of made ground at this locality. The soils generally comprised light brown/reddish brown/orangish brown/bluish grey mottled silty clay with a variable flint gravel content and occasional calcrete pockets.

SPT 'N' values of between 6 and 23, and hand shear vane values of between 40kN/m^2 and >120kN/m^2 were recorded in the clay soils. However, we consider that some of the higher bound values (such as shear vanes values >120kN/m^2 in WS02 and WS03 and a triaxial result of 304kN/m^2 in BH01) probably reflect elevated soil strengths due to the presence of desiccation. On this basis, we consider the characteristic strength values are indicative of generally medium to high, locally low strength clay. Atterberg limit testing indicates the clay soils to be of generally intermediate plasticity (BS classification) and medium volume change potential (NHBC classification).

5.3 Lambeth Group sand

Granular soils of the Lambeth Group were encountered clay at depths of between 2.90m and 4.75mbgl and, where the base was proven, extended to depths of between 9.0m and 10.50mbgl, attaining a maximum thickness of 7.50m in BH02. These soils generally comprised light brownish and greenish grey silty gravelly sand grading into silty sandy flint gravel.

SPT 'N' values of between 24 and >50 (refusal), are indicative of a generally medium dense to dense, becoming very dense, state of compaction. Particle size distribution (PSD) analysis indicates a sand content of between 35% and 95%, with gravel varying between 6% and 51% and fines between 5% and 27%.

5.4 Seaford and Newhaven Chalk

Chalk was encountered below the granular soils of the Lambeth Group at depths of between 9.0m and 10.50mbgl, and was present to the maximum depth investigated (18.0mbgl).

The boreholes were constructed using the solid stem auger method, which provides SPT profiling but does not allow for determination of CIRIA chalk grades. Visual observations and logging indicated the disturbed samples to generally comprise off white to cream, comminuted chalk silt with variable intact chalk gravel content and rare flint nodules.

In-situ SPT 'N' values of between 13 and >50 (refusal) were recorded within the chalk, generally showing an increasing 'N' value with depth, which we consider indicates reasonably competent chalk.

5.5 Groundwater

Groundwater inflow was not observed during drilling with the boreholes remaining dry. However, groundwater was present in BH03 struck/standing at a depth of 1.50mbgl; we consider this probably represents a localised perched groundwater within a deep area of made ground at this location. The monitoring pipes were dry during post-fieldwork measurements undertaken on 29th September 2022. Of course, groundwater levels can vary seasonally and may be higher following periods of wet weather. It is recommended that the borehole installations are monitored periodically prior to construction.

5.6 Desiccation

A number of densely planted mature trees are present in close proximity to, and within, the proposed development areas. The tree survey information provided indicates species present to include high water demand oak, cypress and hawthorn, and moderate water demand ash, pine, sycamore, birch, beech and wellingtonia.

The site is assessed by the BGS to be in an area of 'moderate' hazard with regards to shrinking and swelling ground stability. Our investigation revealed the presence of generally medium volume change potential clay soils at shallow depth across the majority of the site, and therefore we consider this assessment should be upgraded to 'high' risk. In assessing desiccation, we have considered the measured soil strengths, moisture contents, the presence of roots and our visual observations. Based on the above the following observations are of note:

- Live roots observed within all boreholes (with the exception of BH02) to depths of between 2.00m and 3.00mbgl.
- Elevated shear strengths (hand shear vanes values of >120kN/m^2 and hand penetrometer results of >6kg/cm^2) to depths of 3.0m and 2.0mbgl in WS01 and WS02 respectively. Triaxial test result of 304kN/m^2 in BH01.
- Reduced moisture contents (generally <15%) to depths of between 2.50m and 3.50mbgl in WS01 and WS03. Negative liquidity index values measured within the vast majority of clay samples tested.

On this basis, we consider that the shallow clay soils are desiccated, or at least partially desiccated, to depths of between about 2.00m and 3.50mbgl due to the presence of existing trees/vegetation. Our investigation has provided only limited coverage of the site, and it is self-evident that zones of desiccation may extend to greater depths in areas not covered by our investigation, and in particular close to the areas of closely spaced mature trees.

5.7 Existing foundations

Three trial pits (TP01 to TP03) were excavated to provide details of the foundations of the neighbouring building and boundary wall. The findings from the trial pits are included in the Appendix as briefly summarised below:

Trial pit	Location	Foundation base depth	Projection from face of adjacent wall	Bearing stratum
TP01	Derelict bungalow	0.70m	0.15/0.30m	Light orangish brown/grey mottled slightly gravelly clay – possible natural soils
TP02	Accommodation block	Not proven	>0.60m	Not proven
TP03	Derelict apartment building	1.20m	0.28/>0.5m	Light brown/grey mottled silty CLAY with occasional flint gravel

5.8 Environmental observations

No obvious olfactory or visual signs of soil or groundwater contamination were encountered in the boreholes. PID headspace testing (for VOC concentrations) was undertaken on samples of made ground and natural soils during the borehole exercise and during subsequent monitoring - no elevated levels were noted.

6.0 GEOTECHNICAL ASSESSMENT

The proposed works at this site include the re-development of the wider site, including the demolition of several existing, derelict, buildings, and the construction three new buildings (linked via a glass covered walkways), landscaped areas and outdoor amenities. Based on the information provided, details of the proposed new buildings are as follows:

- Building A: a detached two-storey building replacing an existing bungalow within the southern part of the site.
- Building B: a detached three-storey building incorporating a partial single level basement beneath, replacing an existing two storey building within the northern part of the site.
- Building C: a large single storey side extension to the existing main accommodation block, connected to both Building 'A' and Building 'B' via a glass covered walkway.

A plan showing the latest development proposals is presented in Appendix A. Foundation loads were not available at the time of compiling this report.

The investigation has revealed that beneath a variable thickness of topsoil and made ground (up to 2.90m in our boreholes) the natural Lambeth Group is present to depths of between 9.0m and 10.50mbgl, resting upon the Seaford and Newhaven Chalk which extends to at least 18.0m depth. The shallow Lambeth Group generally comprise an upper layer of geologically re-worked clay soils overlying 'in-situ' clay soils, both of which are at least partially desiccated; granular Lambeth group soils are present at depths of between 2.75m and 4.75m.

We understand that, due to protection orders on a number of the existing trees, the requirement for foundation excavations must be minimised within the designated Root Protection Areas (RPA). Therefore, where the proposed buildings are within the RPAs, traditional spread foundations are unlikely to be feasible. Whilst traditional spread foundations could theoretically be adopted if final design proposals indicate buildings are outside the RPA, our investigation has revealed the shallow clay soils to be desiccated to variable depths, and without a more comprehensive investigation we consider there is a significant risk of deep desiccation and associated shrink/swell movement. Therefore, we consider pile foundations would present the most practical solution. Notwithstanding this, where basements are proposed, spread foundations could be adopted, if formation level is below the zone of assessed desiccation or lies within granular non-shrinkable soils.

As with any site underlain by chalk, consideration will need to be given to the potential presence of solution features, and this is discussed further below.

6.1 Ground stability and chalk dissolution

Dissolution features within the chalk occur due to erosional processes during the last periglacial period/environment. The independent report commissioned from Groundsure (Ref: 8995154) collates information on historical mining and natural cavities recorded in the vicinity of the site and is included in Appendix B. The report indicates that there are no recorded natural cavities within 500m of site and it assesses the risk of potential for ground dissolution stability hazards as being 'negligible'. In addition to the Groundsure report we have undertaken a natural cavities risk assessment using Edmonds procedure (Engineering Geology Special Publications No.18, 2001); this assessment indicates that subsidence hazards are 'Very Low'.

With regards to mining and quarrying, the report indicates the nearest BGS 'BritPits' mineral site to be 208m east of the site (chalk pit); the nearest historical ground working is recorded 32m south-east. The potential for localised small-scale non-coal historical mining on site is considered to be at a level where the risk of localised 'difficult' ground conditions should be considered.

Our investigation has revealed chalk 'rockhead' at a depth of about 9.00m and 10.50mbgl. Whilst a detailed solution feature risk assessment was not within the scope of our investigation, we consider SPT 'N' values of between 13 and >50 (refusal) recorded to be indicative or relatively competent chalk.

Notwithstanding the above, it should be noted that the presence of solution features cannot be totally ruled out without a much more comprehensive investigation. Therefore, a careful watching brief should be kept during construction, and if anomalous ground conditions are encountered then specialist advice should be sought from geotechnical contractors experienced in providing options for further investigation and potentially additional remedial measures. Dynamic probing of the proposed pile locations/foundation lines would reduce the risk of unexpected ground conditions being encountered at a late stage during construction.

6.2 Buildings A and C

Proposed buildings A and C comprise new a detached two-storey apartment building and single storey café/dining extension to the main accommodation building respectively. Whilst structural loads are unavailable, we anticipate these structures would generate relatively low to modest loads. Pile foundations are considered the most appropriate foundation for these buildings due to the presence of RPAs and desiccation of the shallow clay soils.

Piled foundations

For the ground conditions encountered, we consider that CFA piles, bearing within the competent chalk, will present the optimum type although helical screw piles and / or driven piles could be considered subject to potential desiccation effects being overcome. The following table of coefficients may be used for the preliminary determination of pile resistance.

Shaft friction/adhesion

Stratum	Depth	Ultimate unit shaft friction, 'q_s' (kN/m²)
All soils to 3.50m depth	Up to 3.5m	Ignore
Lambeth Group (assume sand)	Between about 3.5m and 9.0m	25
Chalk	Below 9.0m depth	0.8 x σv'

Notes:

a) Shaft friction in the chalk is calculated as qs = σv' x β, where β = 0.45 for CFA piles with part of the shaft in weak soils (N<20). For well-constructed rotary bored piles a β value of 0.8 may be used in the chalk and the above shaft friction values in the chalk may be increased by about 80%

b) Sequence based on BH01 ground conditions

Base resistance

Stratum	Depth	Ultimate base resistance, 'q_b'
Chalk	12m to 18m	'q_b' = 1600kN/m² Note that CIRIA C574 also recommends that the allowable base resistance (q_{all}) should not exceed 1000-1800kN/m² for SPT 'N' >25. We recommend that q_{all} = 1600kN/m² is adopted for preliminary design

Notes:

a) The base resistance assumes SPT 'N' > 25

Under EC7 (BS EN 1997-1:2004 and UK National Annex) the limit states GEO and STR must be verified using Design Approach 1, which checks reliability with two different combinations of partial factors. The following partial factors are applicable to bored and CFA piles, to be used in conjunction with a Model Factor of 1.4:

Parameter			Combination 1			Combination 2			
			A1	M1	R1	A2	M1	R4	R4+
Permanent actions (G)	Unfavourable	γ_G	1.35			1.0			
	Favourable	$\gamma_{G,fav}$	1.0			1.0			
Variable actions (Q)	Unfavourable	γ_Q	1.5			1.3			
	Favourable	$\gamma_{Q,fav}$	0			0			
Material properties (X)		γ_M		1.0			1.0		

Parameter		Combination 1			Combination 2			
		A1	M1	R1	A2	M1	R4	R4+
Base resistance (R_b)	γ_b			1.0			2.0	1.7
Shaft resistance (R_s)	γ_s			1.0			1.6	1.4
Total resistance (R_t)	γ_t			1.0			2.0	1.7
Tensile resistance ($R_{s,t}$)	$\gamma_{s,t}$			1.0			2.0	1.7

For guidance purposes, indicative pile resistances for CFA/bored piles are as follows, calculated using the above preliminary parameters and partial factors where relevant:

Pile diameter (mm)	Pile toe level (mOD)	Pile toe depth (m)	Compressive Resistance (kN) Combination 1	Combination 2
300	+57.2	12	290	195
	+54.2	14	540	325
	+51.2	18	795	485
450	+57.2	12	465	325
	+54.2	14	870	520
	+51.2	18	1250	760

Notes:

a) Concrete stress should be considered in the final design

b) Pile toe depth is relative to existing ground level (approximately +69.2mOD)

c) Pile resistances are given as a guide and do not constitute design recommendations

The design engineer must ensure that the correct comparisons are made between the properly factored Design Actions and Design Resistances. The above pile resistances have incorporated the required partial factors for ULS design but do not incorporate explicit checks on serviceability. The presence of shrinkable soils and trees close to the footprint of the proposed structures means heave precautions will be required, in accordance with NHBC Standards Sitework clause S4(c). In the above parameters table, we have recommended that all soils to 3.5m depth are ignored due to potential desiccation. The pile designer will need to assess potential tensile forces and specify appropriate reinforcement.

Whilst we do not consider chalk dissolution to be a significant risk at this site and no loose soils or voids associated with the presence of solution features have been identified in the boreholes, consideration must be given to the possibility of their presence and an appropriate contingency should be in place during piling should anomalous ground conditions be encountered. The piling contractor should assess the risk and prepare appropriate mitigation measures. It is also noted that a significant thickness of made ground is present in some areas and thus the possible presence of obstructions should also be taken into consideration.

A piling specialist must be consulted at an early stage to advise on the most appropriate pile type and to ultimately provide the final pile design. If pile testing is undertaken, it will be possible to apply lower partial factors.

6.3 Buidling B

Building B comprises a three-storey apartment block with a single level basement beneath. No structural loads are available, but we anticipate this structure would generate moderate to high loads. Either traditional spread foundations or a raft, bearing within the natural Lambeth Group at basement level, are considered appropriate to support this structure.

Basement excavation and retaining walls

Based on the information provided an excavation depth of about 3.60m will be required to form the basement, which we assume will comprise an RC box with the new basement walls and floor slabs providing long term support. The excavation is expected to encounter a variable thickness of made ground, possibly up to about 3.0m thick locally, overlying the Lambeth Group; based on our boreholes (BH03 and WS03), both granular and cohesive Lambeth group soil may be exposed at formation level. If space permits, it should be possible to construct the basement in an open battered excavation. Alternatively, sheet piles or contiguous bored piles would provide an alternative option for an embedded retaining wall, subject to any issues with noise/vibration being addressed.

Whilst groundwater was encountered at a depth of about 1.50m in BH03, we consider this probably represents a pocket of perched groundwater within the localised thick made ground, as water was not observed within the remaining boreholes constructed in close proximity (BH02 and WS03). A trial excavation is recommended to the full basement depth to confirm groundwater levels/flow volumes and excavation stability; this will assist in determining support requirements and any need for further control measures, such as sump pumping.
Careful selection of the appropriate design parameters will be needed, incorporating allowances for factors such as the presence of groundwater.

The following table of coefficients may be used for the preliminary design of the basement retaining wall:

Stratum	Bulk density (Mg/m^3)	Effective cohesion, c′ (kN/m^2)	Effective friction angle, ϕ' (degrees)
Made ground	1.80	0	22
Lambeth Group (clay)	2.00	0	21
Lambeth Group (sand)	2.00	0	35

Eurocode 7 stipulates that partial material factors must be applied to the best estimates of geotechnical soil properties during the design stage. The design engineer must ensure that the correct comparisons are

made between Design Actions and Design Resistances after the application of appropriate partial factors. The determination of appropriate earth pressure coefficients and the pattern of earth pressure distribution should be carried out by the geotechnical designer; these will depend upon the type/geometry of the wall and the overall design approach. Of course, where the retaining wall is constructed against a battered slope, the active earth pressures will also be determined by the type of backfill placed. The final wall design and working sequence/procedure should be undertaken by suitably qualified professionals.

Clay desiccation should be considered in areas close to existing vegetation, particularly along the northern elevation where there are trees present close to the proposed footprint, including a mature oak tree and line of conifers. Although the basement excavation is expected to extend beyond the zone of root influence from existing vegetation and will remove any seasonally-affected soils, the wall designer should address the possible risk of there being desiccated clays behind the wall and incorporate appropriate measures. Where an open excavation is used, any significantly desiccated/root-infested clay soils should not be used to infill behind the wall unless appropriate conditioning is undertaken to prevent any potential clay swelling and associated heave. Alternatively, a compressible material could be installed behind the wall as a safeguarding to reduce potential future swelling pressures which could occur.

Basement raft

We consider the natural Lambeth Group soils would offer a suitable bearing stratum upon which to construct a raft. At the time of compilation of our report, design pressures for the raft were not available; however, for this form of construction, we do not envisage that the UDL of the raft would exceed about 50kN/m^2. For a 3.6m dig, there would be a net unload of about 70kN/m^2 and hence it is unlikely that the new building load would generate a net increase in stress on the natural soils. If a UDL is not achievable and structural loads are concentrated as line or point loads these could be carried by thickenings within the basement slab subject to spread foundation design recommendations below.

Based on the borehole records there may be a very limited thickness of clay remaining above the granular soils across part of the footprint. Whilst in theory, there would be an element of heave and heave pressure from this clay, for the thickness involved, this is expected to be negligible for design purposes. The underlying granular soils would not exhibit the same heave characteristics. We do not anticipate that desiccation effects would require special precautions at basement level.

It will be necessary to consider uplift of the slab due to potential hydrostatic pressures and in this respect the guidelines incorporated in BS8102:2009 should be followed. The slab design will need to take account of potential seasonal fluctuations and/or accidental and flood conditions. Although the water levels are currently well below basement level (dry conditions to the base of all boreholes and within the installation from the investigation) the basement will be wholly within the clay stratum and thus accidental flood conditions could exist; indeed, there is potential for water to be present within the made ground which is currently standing at about 1.50m below ground level. We consider that a design water level at 1m below ground level would be appropriate which would result in a hydrostatic uplift pressure of about 25kN/m^2. This figure would need to be agreed with the local building control.

Basement spread foundations

The structural loads could be carried by discrete pad or strip foundations at basement level. At Formation level, both granular and cohesive Lambeth Group soils are expected to be exposed and therefore, where clay soils are present, foundation excavations should be deepened to bear within the underlying granular soils. Any effects of root growth and desiccation are not expected to adversely affect the design of foundations at basement level; however, foundation excavations should of course be inspected to ensure a suitable formation level has been achieved.

For preliminary assessment of the feasibility and sizing of foundations placed within the natural granular soils, an allowable bearing resistance of 150kN/m^2 would be appropriate; this would be applicable to moderate sized strip or pad foundations, say up to 2.5m width. As required by EC7, the design engineer must ensure that the correct comparisons are made between Design Actions and Design Resistances after the application of appropriate partial factors and using the final base geometry. For ULS design the bearing resistance should be determined, using undrained and/or drained analysis as appropriate, to calculate the degree of utilisation of the foundation (limit state GEO). SLS checks should be carried out using appropriate methods in accordance with current practice.

6.4 Ground floor slabs (Buildings A & C)

Our investigation has revealed up to 2.75m of non-engineered made ground generally overlying shrinkable clay soils. Therefore, suspended floor slabs should be adopted for new buildings where basements are not proposed, supported by the main foundations, and incorporating a suitable void beneath based on medium volume change susceptible soils.

6.5 Soakaways

A falling head infiltration test was undertaken within borehole WS03 at a depth of 4.0mbgl. The testing resulted in no measurable fall in the level of water over a period of about 2 hours, indicating the soils to be practically impermeable. On this basis, we consider that traditional soakaways, constructed within the shallow clay soils, are unlikely to provide a suitable method of disposing of surface run-off. The deeper, granular, layers of the Lambeth Group may provide higher infiltration rates; however, these may prove impractical to construct due to the depth of the granular soils. If shallow soakaways within the granular layers of the Lambeth Group are to be adopted, infiltration rates should be confirmed following full-scale testing in accordance with the BRE DG365 procedure. We consider a deep borehole soakaway, constructed within the underlying chalk, may provide a practical alternative, subject to guidance contained within CIRIA C574.

As the site lies above chalk the use of soakaways should be approved by the Environment Agency. As established above, this site is assessed as being low risk with respect to solution features. The guidance contained within CIRIA C574 should be followed and therefore soakaways must be placed a minimum distance of 10m from any existing or proposed structure.

6.6 Foundation concrete

Low concentrations of water-soluble sulphates (2:1 water/soil extract) were measured in selected made ground and natural soil and samples, with near neutral to slightly alkaline pH values. The results fall into Site Design Class DS-1 of Table C2 given in BRE Special Digest 1 (2005). We assess the site as having 'static' groundwater and this would result in an ACEC Site Class of AC-1s.

7.0 STAGE 1 TIER 2 ENVIRONMENTAL ASSESSMENT

This appraisal is generally based on the Environment Agency's 'Land contamination: risk management', 2020, adopting current UK practice which uses the Source-Pathway-Receptor methodology to assess contamination risks. For a site to be designated as contaminated a plausible linkage between any identified sources and receptors must be identified, ie whether significant pollution linkages (SPLs) are present. In considering the potential for contamination to cause a significant effect, the extent and nature of the potential source are assessed and pathways/receptors identified; without an SPL there is theoretically no risk to the receptors from contamination. The assessed risks to the various potential receptors are summarised in the tabulated Conceptual Site Model which forms Section 7.6 of this report.

7.1 Environmental setting and context

The site is underlain by a Secondary 'A' bedrock aquifer beneath site which may be in hydraulic conductivity with the underlying chalk (which is a principal aquifer). The site lies within a Source Protection Zone II and the nearest surface water feature is 11m from site

The site is assessed as being of **Medium** environmental sensitivity.

7.2 Contamination sources and testing

The Preliminary Risk Assessment is presented in Section 3.6 and this identifies significant potential sources of contamination and the associated risks. The testing comprised analysis of eight soil samples for a range of contaminants which were considered to reflect the potential historical/current site usages and the potential sources. Specifically, analysis for PCBs was included to reflect the presence of an electricity substation 20m from the southern boundary.

The soil test results have been assessed where relevant against the DEFRA Soil Guideline Values (SGV) and Category 4 Screening Levels (C4SLs), together with the LQM/CIEH Suitable 4 Use Level (S4UL) for Human Health Risk Assessment in which Generic Assessment Criteria (GACs) have been derived from the CLEA Model (2nd Edition, 2009). The contamination testing was carried out specifically for the purpose of providing a general guidance evaluation for the proposed development. Reference should be made to the foreword to the appended contamination test results in order to fully understand the context in which this discussion should be viewed.

The redevelopment will a combination of buildings/hardstanding and landscaped areas with its primary use as a care home facility. We have used, where relevant, the trigger levels for **Public Open Space (Residential)** to assess the results of the contamination testing.

Using the relevant the trigger levels, all of the results fell below the threshold values, with the following exceptions.

- **Benzo(a)pyrene:** a slightly elevated concentration of 6.53mg/kg was measured in one sample of made ground (S1 @ 0.2m depth), when compared to the C4SL threshold level of 5.7mg/kg.

The results of the testing suggest that there is no discernible contamination present at the sampling positions, a localised elevated Benzo(a)pyrene concentration was present in one sample. It should be noted that there may of course be pockets of undetected contamination between exploratory points.

Although Asbestos-Containing Materials (ACM) were neither observed on site nor identified in the samples examined, we note that buildings (especially those constructed before 2000) are a potential source of ACM. Furthermore, any made ground, construction or demolition materials on site may also contain ACM. These matters should be addressed in the Pe-construction H&S plan prior to any demolition or earthworks.

The implications of these results are addressed in the revised Conceptual Site Model below.

7.3 Ground gas/vapour monitoring

The PRA identified a potential gas risk from potentially infilled land associated with historical ground workings/pits, the nearest being recorded about 30m south-east of site. Gas monitoring was undertaken on one occasion following completion of the fieldwork, as agreed with the client. A maximum carbon dioxide concentration of 5.0% was recorded in BH01, while no elevated concentrations of methane, hydrogen sulphide and carbon dioxide were measured. PID readings in the borehole installations were generally <1ppm, with one measurement of 5.0ppm in WS02. The maximum measured flow rate was 0.2 l/hr in WS01. On the basis of the initial gas monitoring results, we consider that Characteristic Situation 2 (low risk) is appropriate at this stage (as described in CIRIA C665 "Assessing risks posed by hazardous ground gases to buildings", 2007) and gas protection measures will need to be incorporated accordingly. However, it may be possible to adopt a 'building by building' approach to gas protection measures, in which case a CS1 (very low risk) classification could be adopted for buildings B and C. We recommended additional monitoring is undertaken to allow a full assessment of the ground gas regime over an extended period, and this may allow the less onerous classification to be adopted for all the buildings, subject to the results; a further five visits is considered appropriate. This approach should be confirmed with the local authority building control/EA.

7.4 Disposal of excavated soils

A rigorous hazard assessment of the results was not within the scope of our investigation, but our preliminary conclusion from the contamination and WAC testing (where total polyaromatic hydrocarbons were elevated in one sample) is that the made ground will probably classify as 'stable non-reactive hazardous waste in no-hazardous landfill' with an 'inert' classification for the natural soils. Early consultations should be made with appropriate waste facilities or regulators to confirm the off-site disposal requirements.

7.5 Refined Conceptual Site Model

Taking into account the above discussion, the assessed risks to potential receptors identified in the PRA are summarised in the refined Conceptual Site Model (CSM) below. This includes recommendations for appropriate mitigation measures to render any SPLs inactive and reduce the risks to receptors to acceptable levels:

Source	Pathway	Receptor	Assessed risk, justification and measures to mitigate the risk to acceptable levels
On site: contaminated soil/water	Ingestion & direct contact	End user	**Low:** - The PRA identified made ground as the main potential contamination source. No visual or olfactory evidence of gross contamination was identified in any of the soil samples. - All measured concentrations were below the relevant threshold values in the samples tested (including made ground) except for slightly elevated Benzo(a)pyrene in one sample. - The proposed development will result in the removal of some of the made ground (ie the main identified potential contamination source) and development areas of the site will be covered by new floor slabs and areas of hardstanding, which will provide an effective barrier to end users. Therefore, the SPL to human health will be inactive in these areas. - The SPL to human health will be active in proposed landscaped areas, where elevated Benzo(a)pyrene was measured locally. Risk to end users should be mitigated by the removal of all made ground in this area replacing with certified clean topsoil. Alternatively, close-centred sampling/testing of the shallow soils in this area may potentially permit the re-use of the soils on site if the elevated concentration is shown to be a 'hotspot' and removed
	Ingestion, contact & inhalation	Construction workers and third parties	**Low:** - The SPL to human health created by the presence of slightly elevated Benzo(a)pyrene will be active during construction. The risks to these receptors will be managed through health & safety procedures and CDM regulations - A careful watching brief should be kept during construction and if obvious or suspected contamination is encountered this should be dealt with prescriptively
	Leaching from contaminated soils and migration in groundwater	Aquifer and surface water	**Low:** - The site is assessed as being of 'medium' environmental sensitivity - A proportion of the made ground will be removed during construction and the new development will reduce the amount of water infiltration into the ground - A thick sequence of low permeability clay is present across much of the site which will reduce migration into the underlying aquifer
	Direct contact with soil/water	Building fabric and infrastructure	- The effects of soluble sulphates and alkali/acidic ground are discussed in Section 6.4 of this report - Detailed assessment of soil/groundwater contamination with respect to water supply pipes is outside the scope of this report. See the relevant water authority requirements and UKWIR 'Guidance for the selection of water supply pipes to be used in brownfield sites', 2010.

Source	Pathway	Receptor	Assessed risk, justification and measures to mitigate the risk to acceptable levels
Off site: contaminated soil/water	Lateral migration of contaminants in groundwater	End-user and buildings	**Low:** • No significant off-site sources identified by the PRA with the exception of the nearby electricity substation. No significant visual or olfactory evidence of contamination was noted in the samples recovered and the vast majority of measured concentrations were below relevant threshold values, including PCBs
On-site and off-site: ground gas & vapour	Lateral migration through strata, service runs and cracks in buildings	End-user and buildings	**Low / Moderate:** • The PRA identified a low risk of ground gas/vapours from nearby potentially infilled land. Made ground is a potential source of ground gas. Initial gas monitoring suggests that CIRIA 665 CS2 applies based on worst case scenario, and additional monitoring is recommended with final gas characteristic situation being agreed with the local regulatory authority. • The site is not within a radon affected area

In conclusion, based upon the information reviewed and the results of the investigation, our assessment is that with the localised removal of made ground within the area of slightly elevated benzo(a)pyrene and replacement with certified clean topsoil it should be possible to reduce the risks to acceptable levels. Alternatively, close centred sampling/testing of this area may permit the re-use of soil on site, if the localised contamination is shown to be a 'hotspot' and removed.

The investigation has provided general coverage of the site and it is self-evident that there may be zones of contamination within the site which were not encountered.

A careful watching brief should be kept during construction to ensure that any potentially contaminated soil encountered is disposed of in a safe and controlled manner. Site workers should observe normal hygiene precautions when handling soils and if material suspected of being contaminated is identified during construction, this should be set aside under protective cover and further tests undertaken to verify the nature and levels of contamination present. If contamination is present, a full site re-assessment may be required and a contingency should be in place in this regard.

Additional gas monitoring is recommended and a total of six readings should be undertaken in accordance with good practice.

GENERAL INFORMATION, LIMITATIONS AND EXCEPTIONS

Unless otherwise stated, our Report should be construed as being a Ground Investigation Report (GIR) as defined in BS EN1997-2. Our Report is not intended to be and should not be viewed or treated as a Geotechnical Design Report (GDR) as defined in EN1997-2. Any 'design' recommendations which are provided are for guidance only and are intended to allow the designer to assess the results and implications of our investigation/testing and to permit preliminary design of relevant elements of the proposed scheme.

The methods of investigation used have been chosen taking into account the constraints of the site including but not limited to access and space limitations. Where it has not been possible to reasonably use an EC7 compliant investigation technique we have adopted a practical technique to obtain indicative soil parameters and any interpretation is based upon our engineering experience and relevant published information.

The Report is issued on the condition that Soil Consultants Ltd will under no circumstances be liable for any loss arising directly or indirectly from ground conditions between the exploratory points which differ from those identified during our investigation. In addition, Soil Consultants Ltd will not be liable for any loss arising directly or indirectly from any opinion given on the possible configuration of strata between the exploratory points, below the maximum depth of the investigation or where site conditions have changed since the exploratory work; such opinions, where given, are for guidance only and no liability can be accepted as to their accuracy. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in using this Report.

Comments made relating to groundwater or ground-gas are based upon observations made during our investigation unless otherwise stated. Groundwater and ground-gas conditions may vary with time from those reported due to factors such as seasonal effects, atmospheric effects and and/or tidal conditions. We recommend that if monitoring installations have been included as part of our investigation, continued monitoring should be carried out to maximise the information gained.

Specific geotechnical features/hazards such as (but not limited to) areas of root-related desiccation and dissolution features in chalk/soluble rock can exist in discrete localised areas - there can be no certainty that any or all of such features/hazards have been located, sampled or identified. Where a risk is identified the designer should provide appropriate contingencies to mitigate the risk through additional exploratory work and/or an engineered solution.

Where a specific risk of ground dissolution features has been identified in our Report (anything above a 'low' risk rating), reference should be made to the local building control to establish whether there are any specific local requirements for foundation design and appropriate allowances should be incorporated into the design. If such a risk assessment was not within the scope of our investigation and where it is deemed that the ground sequence may give rise to such a risk (for example near-surface chalk strata) it is recommended that an appropriate assessment should be undertaken prior to design of foundations.

Where spread foundations are used, we recommend that all excavations are inspected and approved by suitably experienced personnel; appropriate inspection records should be kept. This should also apply to any structures which are in direct contact with the soil where the soil could have a detrimental effect on performance or integrity of the structure.

Ground contamination often exists in small discrete areas - there can be no certainty that any or all such areas have been located, sampled or identified.

The findings and opinions conveyed in this Report may be based on information from a variety of sources such as previous desk studies, investigations or chemical analyses. Soil Consultants Limited cannot and does not provide any guarantee as to the authenticity, accuracy or reliability of such information from third parties; such information has not been independently verified unless stated in our Report. No liability will be accepted for changes to the ground and groundwater conditions which occur post investigation.

Our Report is written in the context of an agreed scope of work between Soil Consultants Ltd and the Client and should not be used in any different context. In light of additional information becoming available, improved practices and changes in legislation, amendment or re-interpretation of the assessment or the Report in part or in whole may be necessary after its original publication.

Unless otherwise stated our investigation does not include an arboricultural survey, asbestos survey, ecological survey or flood risk assessment and these should be deemed to be outside the scope of our investigation.

We will identify tree and plant species if possible, but a suitably qualified arboriculturalist/botanist should be consulted to provide definitive identification.

Where reference to 'topsoil' is made, this should be construed as any turf (if present) plus any obvious organic-rich/humic layer of soil beneath, which may or may not contain roots/rootlets. Unless otherwise requested, we do not provide a detailed description, undertake sampling/testing for classification purposes or provide a specific classification. The thickness of the 'topsoil' identified on our exploratory hole records is indicative only and should not be used for detailed volume or site strip calculations.

STANDARD TERMS OF APPOINTMENT OF SOIL CONSULTANTS LTD FOR GEOTECHNICAL SERVICES

1 Unless previously withdrawn, our offer remains valid for a period of sixty days from date of offer. If an instruction is given after the sixty days we reserve the right to reasonably adjust any cost associated with the project to reflect any variance on the original offer. In placing an instruction to proceed with exploratory work, whether directly from the Client or Client's representative, the Client is deemed to have accepted our Terms of Appointment.

2 Our offer is on the basis that free, unhindered access and working conditions are available and that the investigation can be completed in one visit, if applicable. Delays beyond our control will incur additional charges. If additional works outside our offer are required to facilitate the investigation these will be advised and any costs will be passed on to the Client.

3 In our quotation we will provide an estimate of any mobilisation period following an instruction to proceed. This estimate will be accurate at the time of quotation, but it should be noted that the mobilisation period may vary at a later date due to factors such as sub-contractor availability and workload.

4 In commissioning this work, the Client has a responsibility for the health, safety and welfare of operatives invited to undertake work on their site. The Client shall indemnify us in respect of any failure to fulfil their obligations in connection with all relevant and current Health and Safety Regulations.

5 The methods of investigation used have been chosen taking into account the constraints of the site including but not limited to access, space and budgetary limitations. Where it has not been possible to reasonably use an EC7 compliant investigation technique, or where a non-compliant technique has been specified, we will adopt practical and appropriate techniques to obtain indicative soil parameters.

6 Unless otherwise stated, our Report should be construed as being a Ground Investigation Report (GIR) as defined in BS EN1997-2. Our Report is not intended to be and should not be viewed or treated as a Geotechnical Design Report (GDR) as defined in BS EN1997-2. Any interpretation which is provided is for guidance only and must not be regarded as design or design recommendation.

7 Where excavation is required as part of the exploratory work, the Client shall provide drawings or plans showing accurate and complete locations of all underground services and structures. In performing our service, we shall take reasonable precautions to avoid damage to underground services or structures. We will not be responsible for any damage caused to underground services or structures and will not be liable for any claims for damage, expenses arising or losses unless the location of all underground services or structures are accurately shown on drawings and those plans have been provided to us in good time prior to commencement of the exploratory work. Risk to the Client can be further reduced by undertaking a scan of the site using a specialist underground scanning service which would be intended to identify traceable services at shallow depth.

8 With some sites, especially those in certain areas of London and other large towns and cities, there may be a risk of unexploded ordnance (UXO) being present. Unless otherwise stated our offer is on the basis that the Client or their representative provides a preliminary UXO risk assessment for the site. It should be noted that if the site is deemed to be in an area of risk then further measures will be required. These would normally comprise either a more detailed risk assessment and/or specialist site attendance by an EOD engineer. These measures can be commissioned either by the Client or Soil Consultants Ltd. If the Client requires, we would be pleased to obtain a preliminary risk assessment at cost+10%.

9 The Client will supply a site plan (to a rational scale), an indication of the scope and type of the proposed development and an indication of any relevant structural loading information.

10 Should the Client terminate the contract after instruction, we reserve the right to recover costs associated to work carried out between the time of instruction and the point of termination. Cancellation fees, and material costs shall be charged at cost plus 20% (+VAT). Engineer/technician time shall be charged at £95+VAT per hour and principal consultant/director time shall be charged at £125+VAT per hour.

11 The Report is issued on the condition that Soil Consultants Ltd will under no circumstances be liable for any loss arising directly or indirectly from ground conditions between the exploratory points which differ from those identified during the investigation. In addition Soil Consultants Ltd will not be liable for any loss arising directly or indirectly from any opinion given on the possible configuration of strata both between the exploratory points and/or below the maximum depth of the investigation; such opinions, where given, are for guidance only and no liability can be accepted as to their accuracy. The results of any measurements taken may vary spatially or with time and further confirmatory measurements should be made after any significant delay in using this Report.

12 If and when instructed, an agreed number of contamination tests will be carried out to give an outline assessment of potential contaminants. In some circumstances it may be necessary to recommend further monitoring, contamination testing and assessment and the scope of this work would be agreed with the Client. Notwithstanding this additional scope, local regulatory authorities may have specific requirements which need to be addressed. Unless otherwise agreed or stated our reporting will constitute neither a Quantitative Risk Assessment nor a Remediation Statement or Strategy.

13 Our reports are counter-checked by one of our suitably qualified and experienced engineers/geologists.

14 Notwithstanding anything to the contrary contained in these terms, our liability under or in connection with these terms whether in contract or in tort, in negligence, for breach of statutory duty or otherwise (other than in respect of personal injury or death) shall not exceed the sum equivalent to ten times our contract fee or £100,000 whichever is less in the aggregate for geotechnical and environmental matters unless otherwise agreed.

15 Without prejudice to any other exclusion or limitation of liability, damages, loss, expense or costs our liability for any claim or claims under this agreement be further limited to such sum as it would be just and equitable for us to pay having regard to the extent of our responsibility for the loss or damage giving rise to such claim or claims ("the loss and damage") and on the assumptions that:

(a) All other consultants, contractors, sub-contractors, project managers or advisers engaged in connection with the Project have provided contractual undertakings to the Client on terms no less onerous than those set out in the original contracts in respect of the carrying out of their obligations in connection with the Project; and

(b) There are no exclusions of or limitations of liability nor joint insurance or co-insurance provisions between the Client and any other party referred to in this clause and any such other party who is responsible to any extent for the loss and damage is contractually liable to the Client for the loss and damage; and

(c) All such other consultants, contractors, sub-contractors, project managers or advisers have paid to the Client such proportion of the loss or damage which it would be just and equitable for them to pay having regard to the extent of their responsibility for the loss and damage.

16 Further and notwithstanding anything to the contrary contained in this agreement and without prejudice to any provision in this agreement whereby liability is excluded or limited to a lesser amount, our liability under or in connection with this agreement whether in contract or in tort, in negligence, for breach of statutory duty or otherwise for any claim shall not exceed the amount, if any, recoverable by us by way of indemnity against the claim in question under professional indemnity insurance taken out by us and in force at the time that the claims or (if earlier) circumstances that may give rise to the claim is or are reported to the insurers in question. The limitation shall not apply if no such amount is recoverable due to us having been in breach of our obligations or the terms of any insurance maintained in accordance therewith or having failed to report any such claim or circumstances to the Insurers in question timeously.

17 Whilst our investigation may include asbestos screening/quantification on selected samples, this must not be deemed to constitute a full asbestos survey or be taken as sufficient to definitively identify the presence or quantity of asbestos within or on the ground. We will not accept responsibility if asbestos is encountered during any subsequent construction or development works and in placing a contract with us the Client accepts this condition. Where the fabric of a building is to be disturbed, the Client shall provide an appropriate asbestos survey to us prior

to exploratory work and make adequate provision to allow the implementation of sufficient and appropriate protective/remedial measures for the work to progress safely.

18 Where our report refers to 'topsoil', this should be construed as any turf (if present) plus any obvious organic rich/humic layer of soil beneath, which may or may not contain roots/rootlets. Unless otherwise requested, we do not provide a detailed description, undertake sampling/testing for classification purposes or provide a specific classification. The thickness of the 'topsoil' identified on our exploratory hole records is indicative only and should not be used for detailed volume or site strip calculations; if this type of classification is required, this should be identified to us at an early stage and the method of sampling, testing and classification agreed.

19 The Client agrees that they shall not bring any claim personally against any director/employee of Soil Consultants Ltd or consultant to us in respect of loss or damage suffered by the Client arising out of this contract.

20 Our appointment shall be under simple agreement and our liability under this contract or in tort shall be for a period of six years from date of appointment.

21 Our reports are non-assignable and are prepared for the benefit of the Client. No reliance can be assumed by others without written agreement from Soil Consultants Ltd. We will provide a letter of reliance at our discretion and this will be subject to payment of our fee, which will be 10% of contract value, subject to a minimum fee of £1,250 plus VAT. The terms of our letter of reliance are non-negotiable and the beneficiary should be aware that the information shall only apply to the scheme for which the report was originally produced and the original rights and benefits will apply.

22 A VAT invoice (at current rate) will be presented in respect of the work undertaken. Payment of our account is to be made within twenty-eight days of issue of our invoice unless otherwise agreed. On no account shall payment be on a 'pay-when-paid' basis. The information contained within our report remains the property of Soil Consultants Ltd and no reliance may be assumed by any party with an interest in the project until payment has been received in full. After one calendar month interest shall be chargeable at 10% above the Bank of England Rate and compensation claimed in accordance with 'Late Payments of Commercial Debts (Interest) Act 1998 and subsequent revisions. If the debt is referred to a debt collection agency then we have the right to recover associated fees under the terms of our contract.

APPENDIX A

Fieldwork, in-situ testing and monitoring

- Foreword
- Rotary auger borehole records
- Dynamic sampler borehole records
- Standard Penetration Test results
- SPT hammer calibration certificates
- Trial pit records
- Shallow sample summary
- Groundwater and gas monitoring results

Laboratory testing

- Index property testing
- Plasticity chart
- Unconsolidated undrained triaxial test results (QUT)
- Particle size distribution tests

Ground profiles

- Plot of SPT 'N' value and undrained cohesion versus level
- Cross section through boreholes

Contamination and chemical testing

- Foreword
- General soil suite
- PCB congeners suite
- WAC test results
- Sulphate/pH suite

Plans, drawings & photographs

- Site photographs
- Site survey drawing
- Tree Constraints Plan (GHA Trees Arboricultural Consultancy drawing Rev A, dated June 2021)
- Proposed development plans and sections
- Site Plan
- Location Plan

FOREWORD FOR ROTARY AUGER DRILLING - GUIDANCE NOTES

GENERAL

The borehole records are compiled from the driller's description of the strata encountered, an examination of the samples by our geotechnical engineer and the results of in-situ and laboratory tests. Based on these data, the report presents an opinion on the configuration of strata within the site. However, such reasonable assumptions are given for guidance only and no liability can be accepted for changes in conditions not revealed by the boreholes.

BORING METHODS

The rotary auger technique uses a solid-stems auger of 125mm diameter. The auger comprises 1m segments which are drilled into the ground and withdrawn in 1m increments for sampling. Casing can be utilised as required. The technique allows the ground conditions to be reasonably well established although disturbance of the ground is inevitable, particularly some "softening" of the upper zone of clay immediately beneath a granular soil. The presence of thin layers of different soils within a stratum may not always be detected.

GROUND WATER

The depth at which ground water was struck is entered on the borehole records. However, this observation may not indicate the true water level at that time. Due to the speed of boring and the relatively small diameter of the borehole, natural ground water may be present at a depth higher than the water strike. Moreover, ground water levels are subject to variations caused by changes in the local drainage conditions and by seasonal effects. When a moderate inflow of water does take place, boring is suspended for at least 10 minutes to enable a more accurate short-term water level to be achieved. An estimate of the rate of inflow is also given. This is a relative term and serves only as a guide to the probable flow of water into an excavation. Further observations of the water level made during the progress of the borehole are shown including end of shift and overnight readings and the depth at which water was sealed off by the borehole casing, if applicable.

SAMPLES

Undisturbed samples of predominantly cohesive soils are obtained using a 100mm diameter open-drive sampler. In granular soils, disturbed bulk samples are taken and placed in polythene bags. Small jar samples are taken at frequent intervals in all soils for subsequent visual examination. Where ground water is encountered in sufficient quantity, a sample of the ground water can also be taken.

IN-SITU STANDARD PENETRATION TESTS (SPT)

This test is performed in accordance with the procedure given in BS EN ISO 22476-3:2005. The individual blow count record for each test is given on a separate table. The 'N' value is normally the number of blows to achieve a penetration of 0.3m following a seating distance of 0.15m and is quoted at the mid-depth of the test zone. However if a change of stratum occurs within the test zone then a revised 'N' value can be calculated to assess one layer in particular. In hard strata full penetration may not be obtained. The presence of groundwater and particularly Where groundwater can affect the test and the measured values may not represent the true in-situ density of the soil.

Site & Location:	**Denville Hall,** **62 Duck's Hill Road, Northwood, Hillingdon HA6 2SB**	Borehole No:	**BH01**
Client:	**Denville Hall 2012 Ltd**	Coordinates: 508145E, 191330N	Sheet 1 of 2
Engineer:	**London Structures Lab**	Ground Level: +69.20mOD	Report No: 10767/JW

Progress & Observations	Samples & Tests: Type	Samples & Tests: Depth (m)	Field Test Results	Strata: Depth (m)	Strata: Level (m)	Legend	Strata Descriptions	Backfill / Installation
BH commenced: 23 August 2022 BH dia: 125mm	D	0.25		0.20	69.00		Grass over dark brown TOPSOIL	
	PID	0.25	0.0				MADE GROUND: brown/orangish brown slightly clayey sandy gravel of flint and rare brick fragments	
	D	0.50						
	PID	0.50	0.0					
	D	0.75						
	PID	0.75	0.0					
	D	1.00		1.00	68.20		Soft, becoming firm to very stiff, light brown/reddish brown/ greyish brown mottled slightly sandy slightly gravelly silty CLAY with occasional fine roots. Gravel is subangular to subrounded fine to medium flint gravel	
Hand excavated inspection pit to 1.20m	PID	1.00	0.0					
	D	1.20						
	SPT/S	1.20	N=6					
	PID	1.20	0.0					
	D	1.85					*at 1.85m; occasional fine roots. Possibly desiccated to about 2.75m*	
Triaxial result = 304kPa	U	2.00						
	D	2.75		2.75	66.45		Stiff brown, mottled grey, slightly sandy silty CLAY with frequent pockets of extremely weak calcrete	
	D	3.00						
	SPT/S	3.00	N=15					
	D	3.75		3.75	65.45		Stiff dark reddish brown, mottled greyish blue, silty CLAY	
	D	4.00						
	SPT/S	4.00	N=23					
	D	4.75		4.75	64.45		Dense light grey clayey silty fine to medium SAND	
	D	5.00						
	SPT/S	5.00	N=35					
	D	6.00		6.00	63.20		Very dense greyish green slightly silty very sandy GRAVEL. Gravel is rounded fine to coarse flint	
	D	6.50						
	SPT/S	6.50	N>50*					
	D	7.50						
	D	8.00						
	SPT/C	8.00	N>50*					
	D	9.00		9.00	60.20		CHALK - recovered as off white weak chalk gravel in a matrix of silt sized communited material. Rare gravel sized flint fragments	
	D	9.50						
	SPT/S	9.50	N=13					
				10.00	59.20		Continued on next sheet	

Key: U = Undisturbed B = Bulk D = Small disturbed W = Water ES = glass jar & plastic tub E = glass jar SPT/S = split spoon SPT/C = solid cone PP = Pocket Penetrometer [kg/cm²] HV = Hand Vane [kPa] PID = Photo Ionisation Detector [ppm - Isobutylene Equivalent, PhoCheck Tiger, 10.6eV lamp] * = full SPT penetration not achieved - see summary sheet

Borehole type: Rotary Auger

Remarks: a) approximate ground level from Midland Survey Ltd Utility and CCTV Drainage Survey (Ref: 41975_1, dated July 2022) and coordinates from online mapping data
b) 50mm ID standpipe installed to 5.0m

Borehole No: **BH01**