Providing Ground Solutions

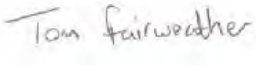
Chase New Homes Limited

The Barn Hotel, West End Road, Ruislip, HA4 6JB

Desk Study, Geotechnical and Geoenvironmental Interpretative Report

January, 2023

Card Geotechnics Limited
4 Godalming Business Centre
Woolsack Way, Godalming GU7 1XW
Telephone: 01483 310600
www.cgl-uk.com

Author	Andrew Bond, Engineer *PhD MSc BSc (Hons) FGS AFHEA*				
Checked	Tom Fairweather, Principal Engineer *MSc BSc DIC CGeol FGS RoGEP*				
Approved	Adam Cadman, Associate Director *MSc BSc (Hons) CGeol FGS*				
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1. INTRODUCTION

Card Geotechnics Limited (CGL) has been commissioned by Chase New Homes Limited to provide a combined desk study, geoenvironmental and geotechnical report for The Barn Hotel, West End Road, Ruislip, HA4 6JB herein referred to as "the site". The site comprises a hotel complex of several low-rise buildings as well as areas of soft landscaping.

The aim of this report is to evaluate potential human health, environmental and geotechnical risks and constraints associated with potential development of the site.

This report presents the following:

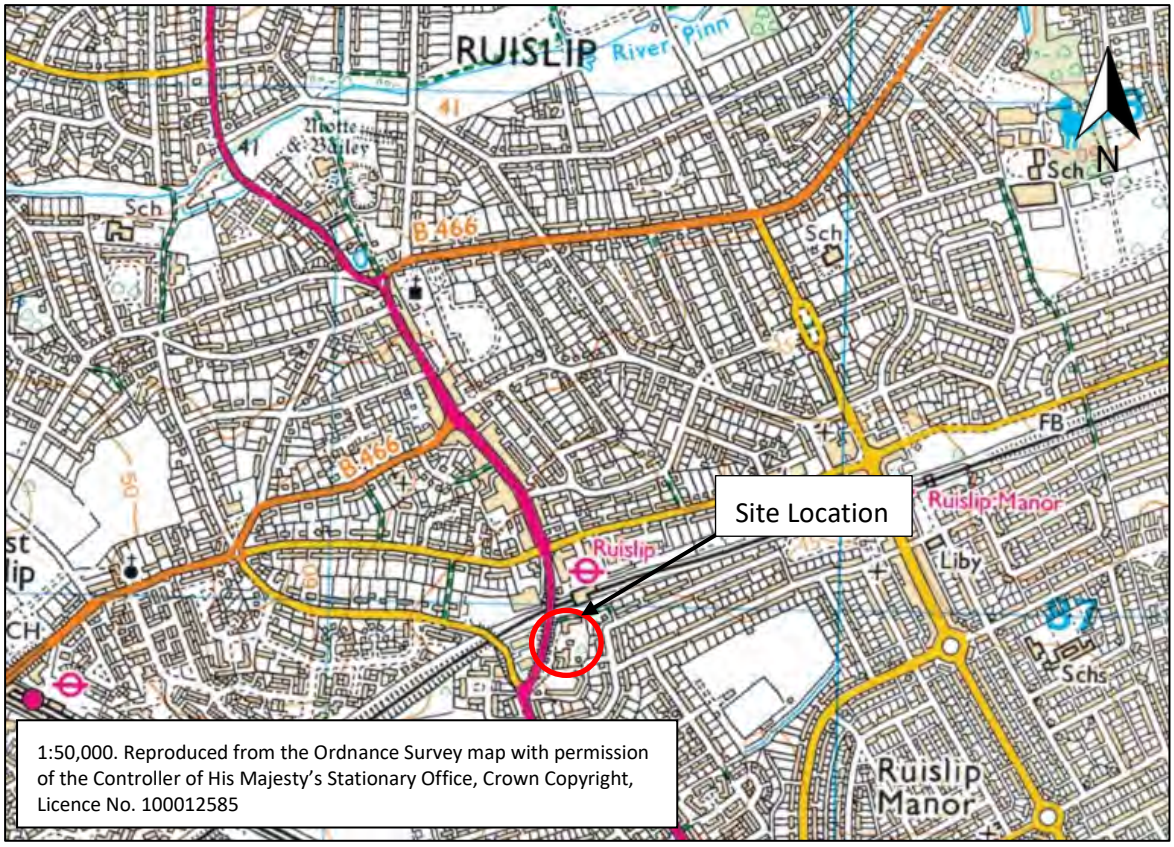
- Review published and unpublished records, to provide information on the historical, environmental, geological, hydrogeology and hydrological setting of the site and establish a preliminary Conceptual Site Model (CSM) and undertake a preliminary risk assessment;
- Provide details on the ground conditions encountered during the ground investigation and provide analysis and interpretation of chemical and geotechnical laboratory testing undertaken on representative soil/groundwater samples;
- Develop a revised Conceptual Site Model based on the findings of the desk study, ground investigation and laboratory testing;
- Present a generic quantitative risk assessment to assess potential risks to human health, controlled waters, buildings, structures, plants and vegetation and recommendations with respect to waste disposal;
- Provide an outline contamination remediation strategy for the site to address potentially unacceptable risks to identified receptors, as appropriate; and
- Provide recommendations for geotechnical design aspects of the proposed development, including foundations, road/pavements, excavations, groundwater control, drainage and buried concrete.

2. SITE LOCATION AND DESCRIPTION

2.1 Site Location

The site is located to the east of West End Road, Ruislip, HA4 6JB in the London Borough of Hillingdon (*Plate 1*). National Grid coordinates for the approximate centre of the site are 509472E 186917N. The site is approximately 1.91 hectares in area.

Plate 1: Site location plan



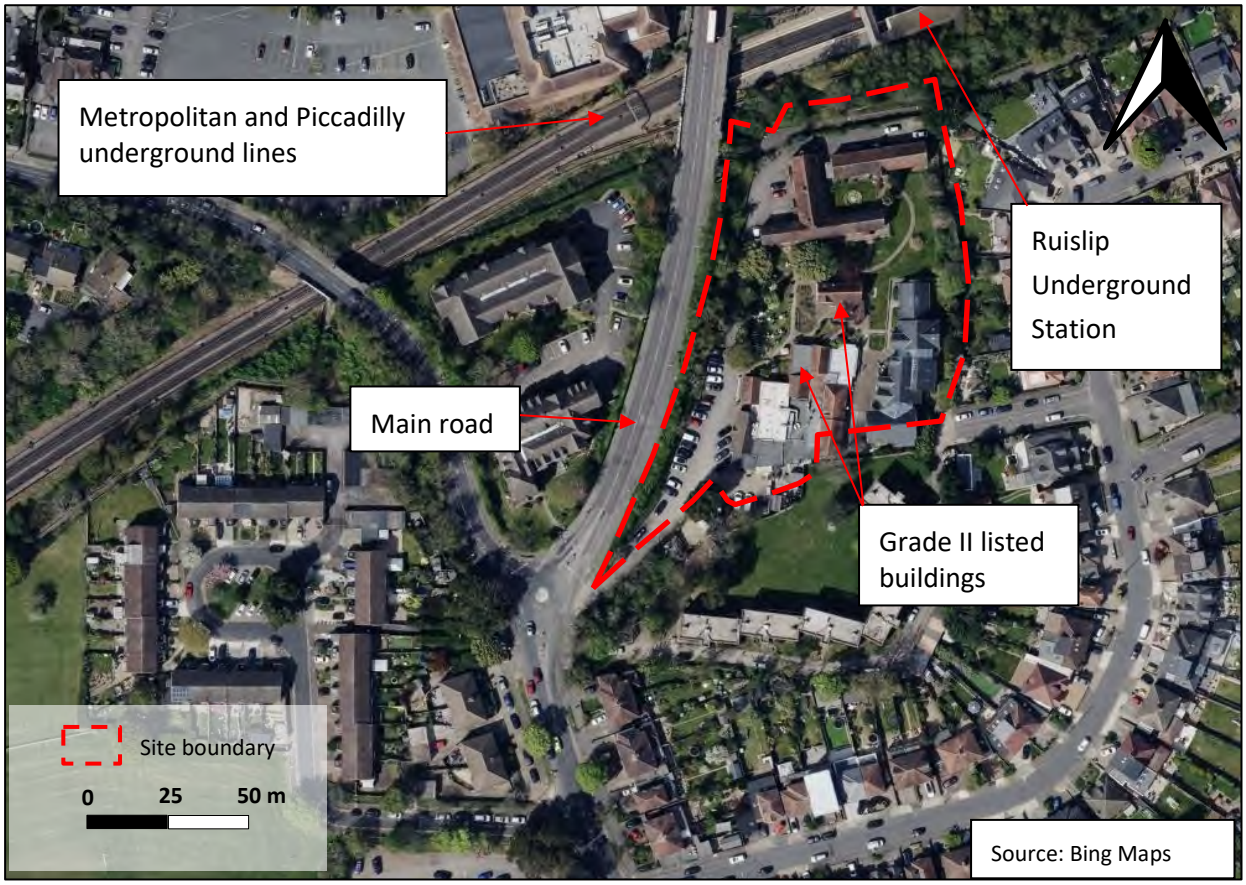
2.2 Site Description and Walkover

The site is broadly square in shape and comprises 'The Barn Hotel' complex which includes several single and two-storey structures (Plate 2). Attention is drawn to the three Grade II listed nineteenth century farm buildings generally located at the centre of the site. The largest standalone building currently provides hotel suites. The second and third buildings have been encapsulated by the hotel building. Of these, one is adjacent to the bar/lounge and will uncovered through careful demolition during the redevelopment of the wider site.

The centre of the site is also occupied by areas of soft landscaping (Plate 2). The site is located to the east of a main road (Plate 2) which is elevated above the height of the site, with a retaining wall present along the western boundary with various retained heights.

The site is bound to the north by a footpath beyond which lies the Metropolitan and Piccadilly overground lines and Ruislip Station and to the south and east by housing developments (Plate 2).

Plate 2: Site Layout



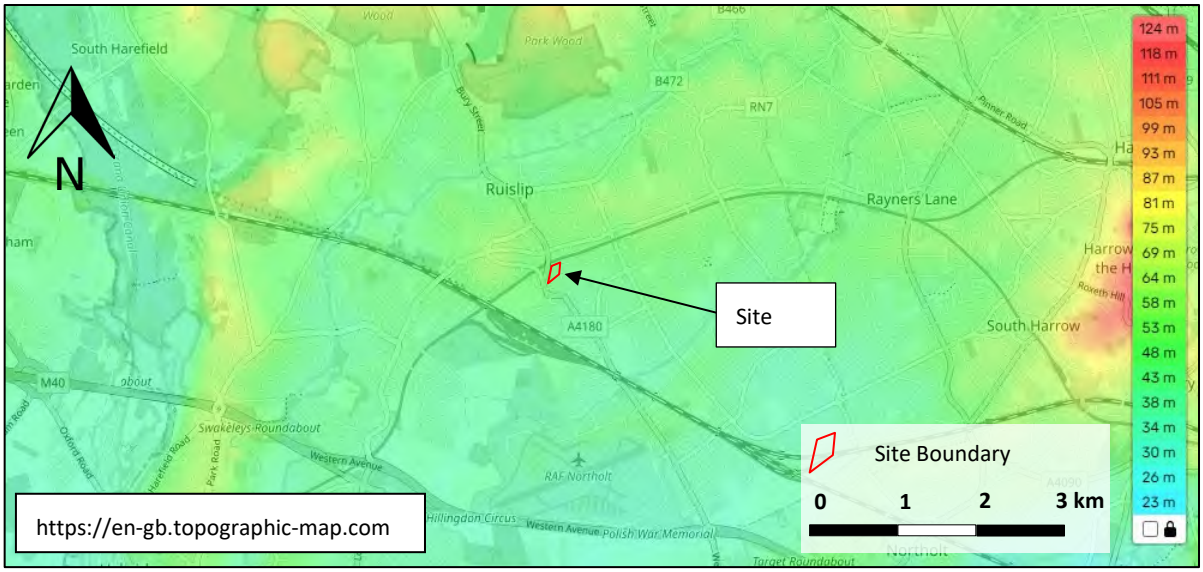
A site walkover was undertaken on the first day of site works on 15 November 2022. The site walkover noted the following key features:

- Relatively steep (approximately 30 degree) bank on the western boundary supported by crib wall. The bank forms the eastern edge of the A4180 which runs in embankment north to south, west of the site.
- A gentle gradient change from the north of the site down to the south of the site (approximately 1m to 2m difference). This level is incorporated in the site by terraced gardens and development platforms in the north and centre of the site.
- The buildings in the south of the site are modern and built after the original Sherly's Farm building was constructed.

- An underground wine cellar was understood to be present in the east of the site, immediately north of the newer hotel building.
- A number of mature trees were identified on site, between buildings and around the boundary.
- The south of the site is used for deliveries, lorry parking and contains the hotels store areas.

With reference to publicly available topographic data[1], the wider area 's elevation typically ranges between approximately 43m and 53mOD.

Plate 3: Topography surrounding the site (topographic scale in m OD).

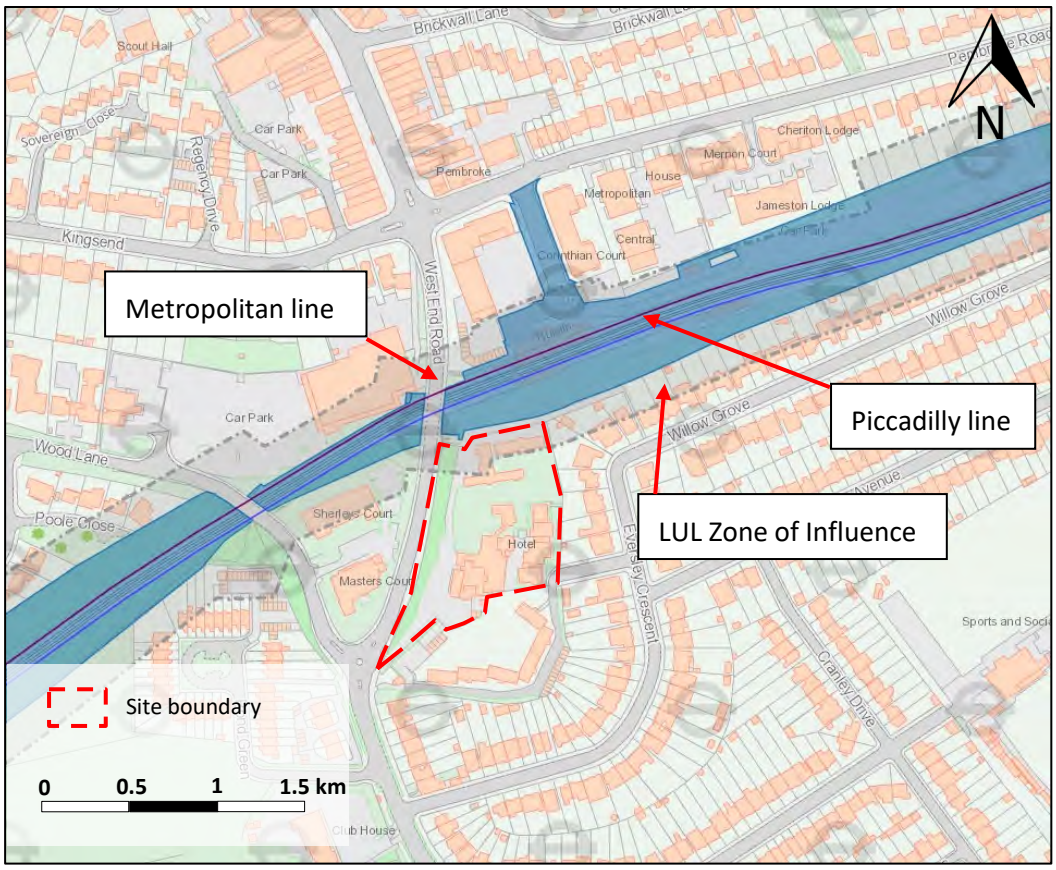


2.3 Infrastructure

With reference to the Transport for London (TfL) Property Asset Register[2], a number of assets and their associated zones of influence run near to the site's northern boundary or encroach on the site, respectively. These include the Metropolitan line and the Piccadilly line as well as their zones of influence (Plate 4).

[1] https://en-gb.topographic-map.com, [Accessed December 2022]
[2] https://tfl.maps.arcgis.com/apps/webappviewer/index.html?id=5129c766255941d3be16a6828faa8f18 [Accessed December 2022]

Plate 4 : Excerpt from the TfL Property Asset Register[2]



2.4 Proposed Development

The development will comprise the demolition of the majority of the existing structures on site with the notable exception of the listed structures. Two new apartment blocks will be constructed, one located in the north of the site (Building 1), and another located in the south of the site (Building 2). Building 1 is understood the be four storeys tall whilst Building 2 is understood the be three storeys tall. Low-rise two storey houses with private gardens are proposed in the east of the site. The remainder of the site will be covered by areas of soft landscaping as well as hardstanding for parking spaces. Proposed Development Plans have been included as Appendix A.

3. DESK STUDY

3.1 Sources of Information

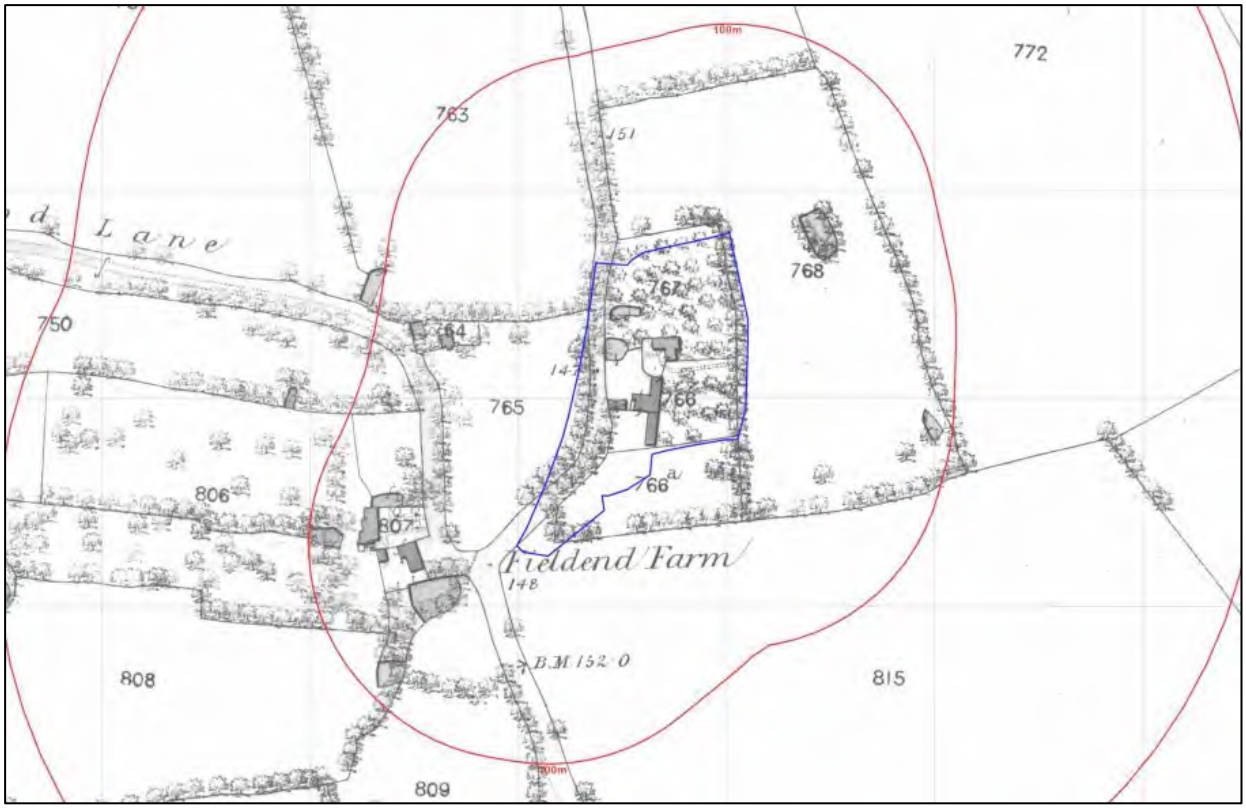
The historical development of the site has been traced from ordnance survey maps dating between 1864-1865 and 2022. These maps were produced on scales ranging from 1:2,500 to 1:10,560 and are presented in Appendix C.

3.2 Site History

Details of the site history and surrounding area are summarised below with approximate distances taken from the nearest boundary of the site.

With reference to the earliest Ordnance Survey map dated 1864-1865, the site was occupied by a farm which comprised of two farm buildings (corresponding to the existing listed buildings) towards the middle of the site and two ponds in the northwest corner of the site. Off-site were a number of ponds, including those 100m west of the site and 90m east of the site, as well *as Fieldend Farm* 75m southwest of the site. The site as it appeared in 1864-1865 is shown in an extract of an historical map in Plate 5.

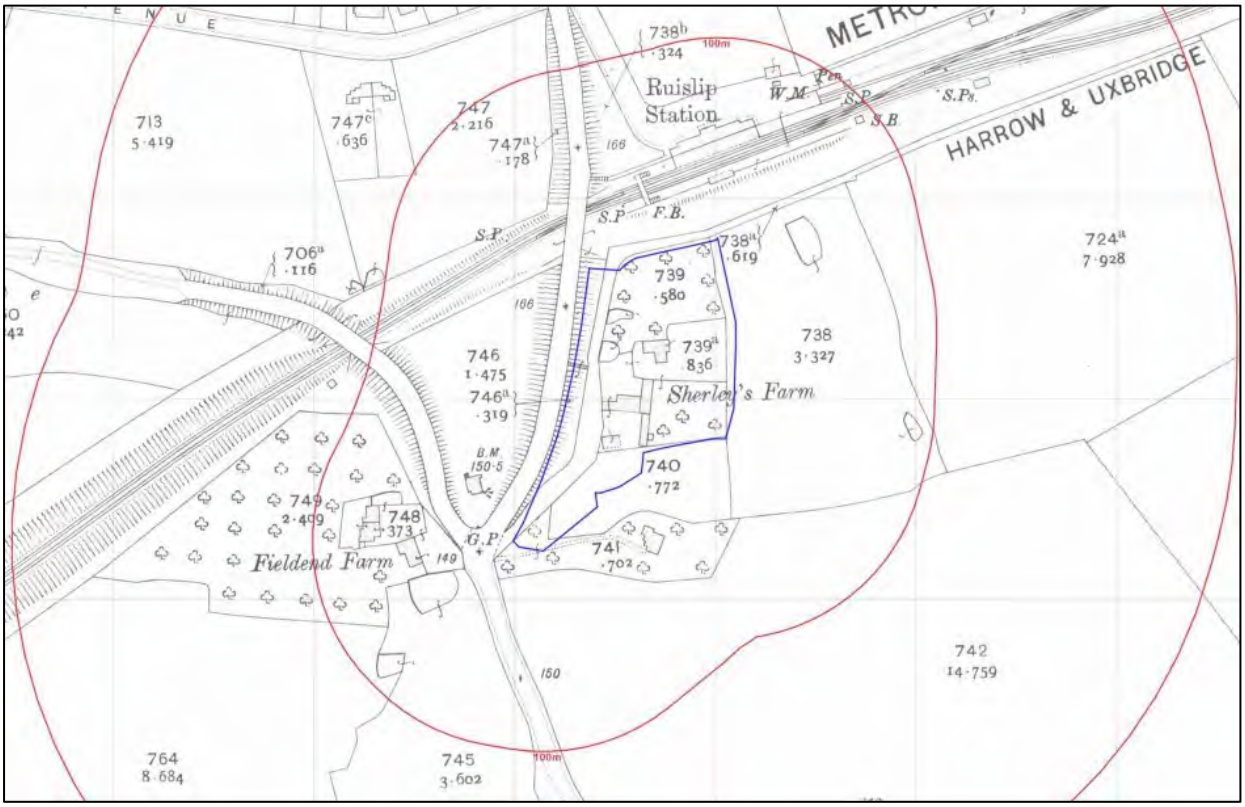
Plate 5: An excerpt from a 1:2,500 map from 1864-1865



From c. 1896 the site is named on historical maps as *Sherley's Farm*, however, the site has not undergone further development, nor are any significant changes noted in the immediate vicinity with the exception of a collection of terrace houses 270m southeast of the site.

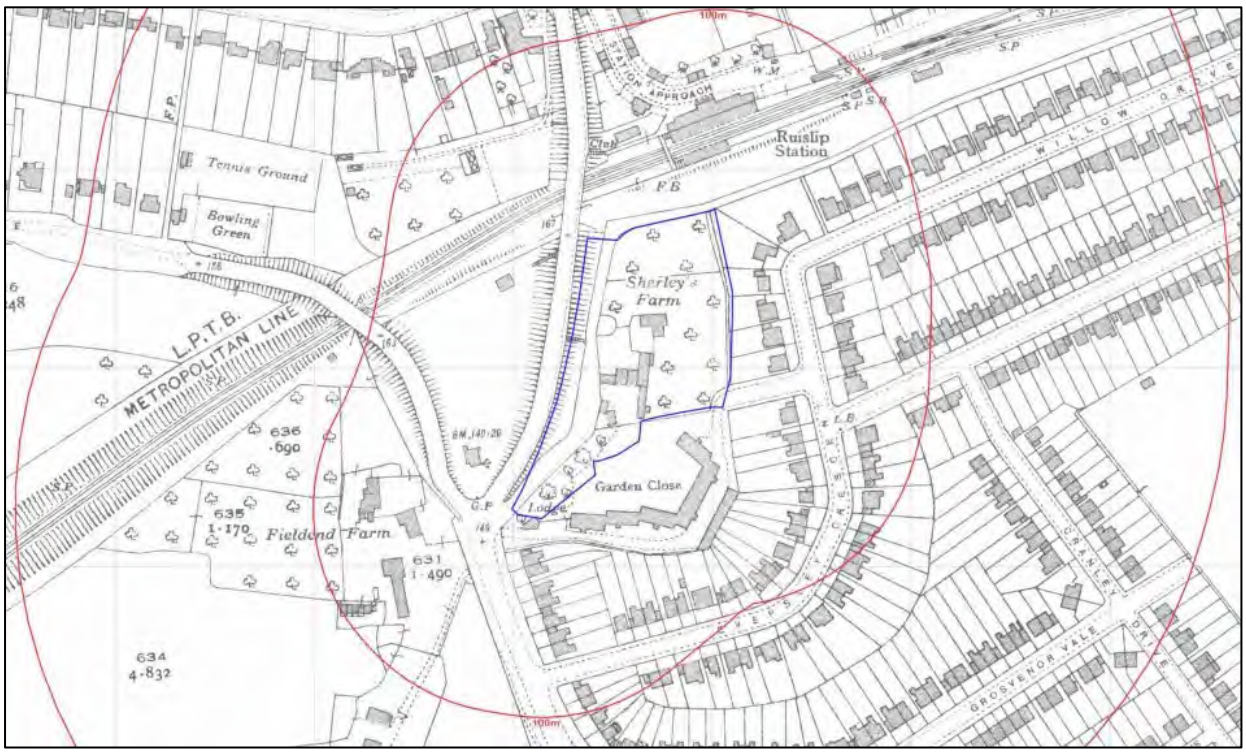
From c. 1914 the *Metropolitan Railway* was constructed a short distance north of the site including the construction of *Ruislip Station* and West End Road was constructed on an embankment adjacent to the western site boundary. The land 150m north of the site became increasingly developed in the form of new houses and roads. The site and the surround area as it would have appeared in 1914 is shown in an extract of an historical map in Plate 6.

Plate 6: An excerpt from a 1:2,500 map from 1914



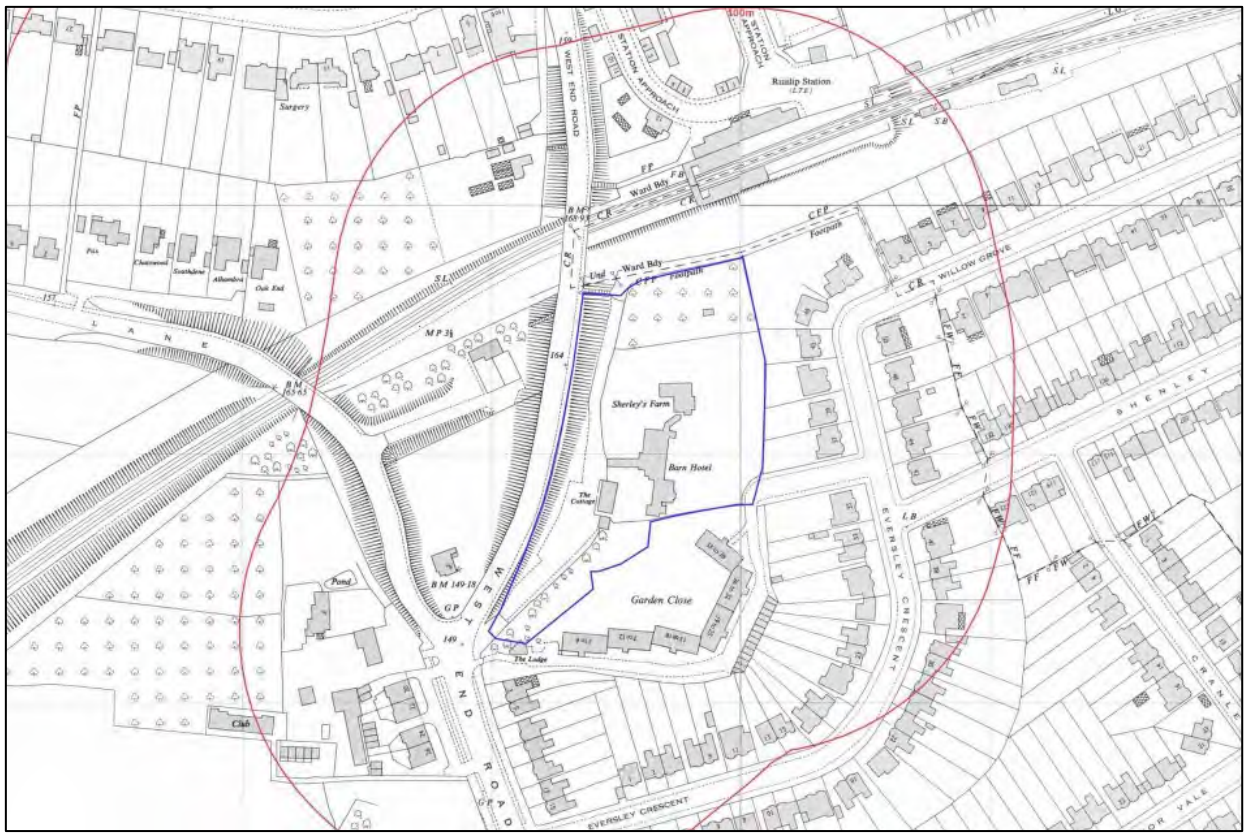
From 1935 the land surrounding the site had become more developed including the construction of numerous housing estates in the form of *Eversley Crescent* (50m E), *Grosvenor Vale* (200m SE*), Cranley Drive* (150m E) and *Pembroke Road* (150m N). Development of the land surrounding the site continued through to 1938 in the form of the housing estate *Willow Grove* (30m E), the *Garden Close* apartments directly south of the site and a school 250m southwest of the site. The more northerly of the two ponds on the site was infilled by 1935. Some of this development is shown in an extract of the 1938 historical map in Plate 7.

Plate 7: An excerpt from a 1:2,500 map from 1938



From c. 1960-1961 the site was developed through the construction of *Barn Hotel* in the centre of the site. The construction of the hotel also coincided with the infilling of the second pond on site. *Fieldend Farm* was developed from 1960-1961 into a housing development. This is shown in an extract of the 1960-1961 historical map in Plate 8.

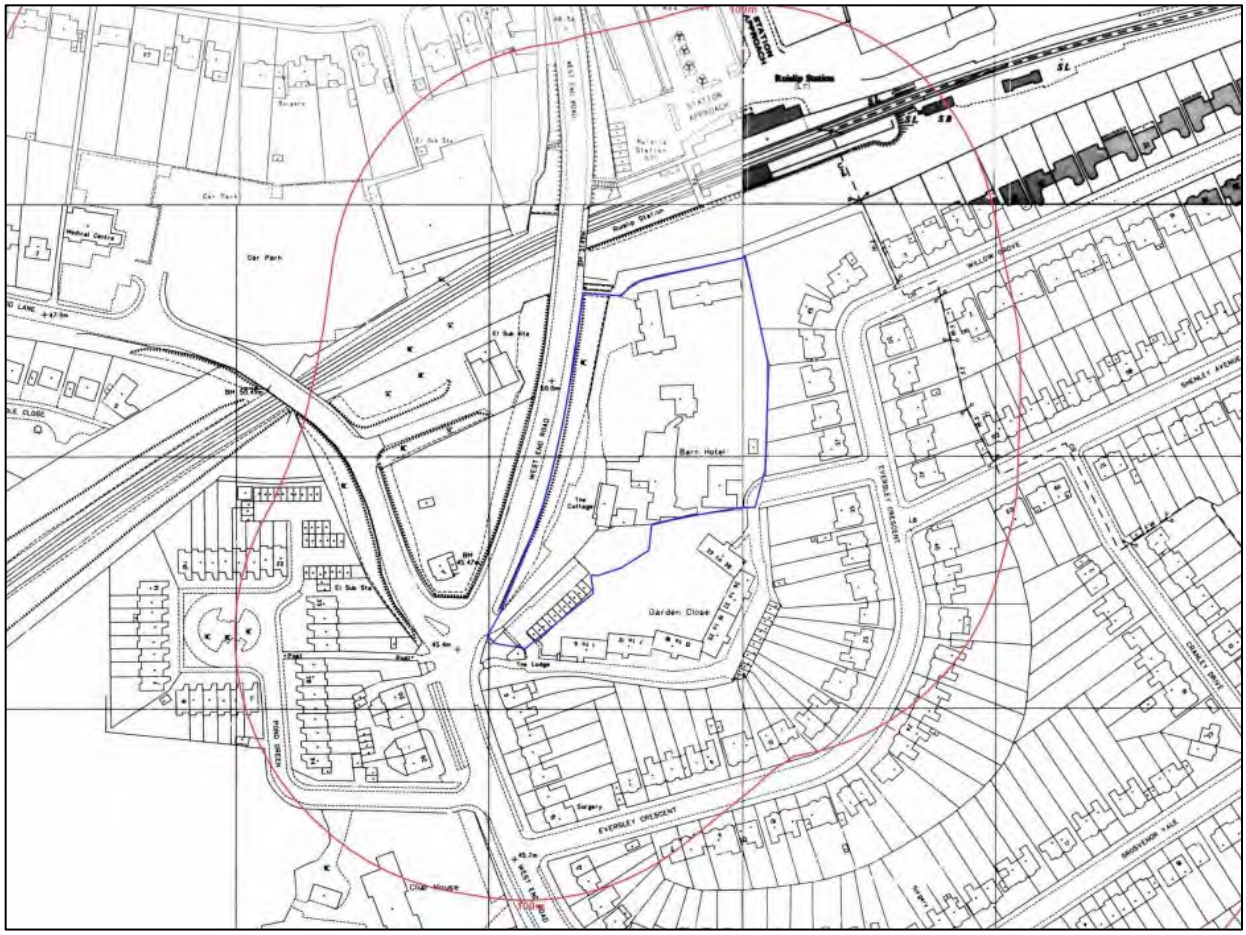
Plate 8: An excerpt from a 1:2,500 map from 1960-1961



Fieldend Farm was also developed further from c. 1972-1974 in the form of the *Pond Green* housing development. These developments are shown in an extract of a 1988-1992 historical map in Plate 9.

No further significant changes were recorded in the 1988-1992, 1992-1995 and 2003 large scale maps.

Plate 9: Excerpt from a 1:1,250 map from 1988-1992



3.2.1 Planning History

A search of the Hillingdon Council planning portal has been undertaken for the site which returned numerous records[3]. These relate to amendments and alterations to the hotel footprint and access points with notable approved applications including:

- An application to develop the listed structures on site in November and December 1986;
- The erection of a 2-storey extension to provide 10 double bedrooms in the October of 1987;
- The erection of a single storey extension to the detached bedroom accommodation and administration block in the February and March of 1998;
- The erection of a two-storey accommodation block containing 10 bedrooms and 3 suites in the March of 2004;
- The construction of an underground wine cellar in the May of 2005; and,

[3] https://planning.hillingdon.gov.uk/OcellaWeb/planningSearch

- More recently, the demolition of 3 garages and an existing lodge in connection with a new entrance way and parking layout scheme.

3.2.2 Unexploded Ordnance (UXO)

A Preliminary Unexploded Ordnance (UXO) Risk Assessment has been procured for the site from 1st Line Defence and is included in Appendix D. The report notes that during the Second World War the site was situated with the Urban District of Ruislip and Northwood which sustained an overall low-moderate density of bombing. However, given that a bombing incident was recorded on the site's eastern border as well as approximately 50m to the south of the site and with the majority of the site being occupied by open land these areas are unlikely to have been frequently accessed. 1st Line Defence conclude that further research is recommended in the form of a Detailed UXO Risk Assessment in accordance with CIRIA guidelines and that prior to this or in lieu of this, appropriate UXO Risk Mitigation Measures be provided for intrusive works.

3.3 Geology

3.3.1 Published Geology

With reference to the British Geological Survey (BGS) GeoIndex[4] and the Groundsure Enviro+Geo Insight Report (included in Appendix E) the site is anticipated to be underlain by the Lambeth Group which is potentially overlain by the London Clay Formation in the southern area of the site. No surficial deposits are anticipated to be encountered.

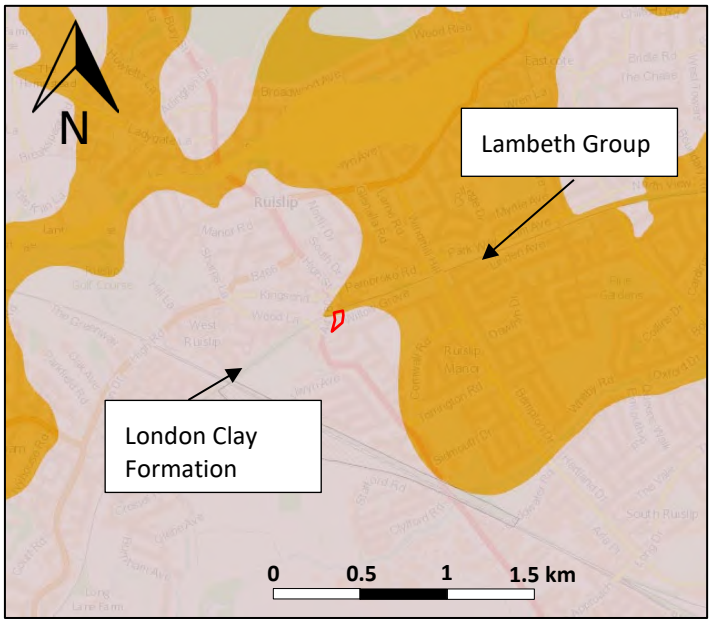
No artificial deposits are mapped on or within the vicinity of the site, however, Made Ground is anticipated associated with: previous development of the site; the embankment on the western site boundary; and the infilled ponds noted on the historical maps.

With reference to the BGS Geology of London geological memoir [5], the BGS Open Report on the Lambeth Group[6], and the BGS 1:50,000 maps which cover the site and the surrounding area[7] [8] the London Clay Formation is anticipated to be either absent or up to 2m thick in the area of the site and the Lambeth Group is anticipated to be between 15m and 20m thick. The Lambeth Group in this area is anticipated to comprise of the Undivided Reading Formation (approx. 14m to 17m thick) and the Upnor

[4] https://mapapps2.bgs.ac.uk/geoindex/home.html? [Accessed December 2022]
[5] Ellison, R A, Woods, M A, Allen, D J, Forster, A, Pharoah, T C, And King, C. 2004. *Geology of London. Memoir of the British Geological Survey, Sheets 256 (North London), 257 (Romford), 270 (South London) and 271 (Dartford) (England and Wales).*
[6] Entwisle, D C, Hobbs, P R N, Northmore, K J, Skipper, J, Raines, M R, Self, S R, Ellison, R A, and Jones, L D. 2013. Engineering Geology of British Rocks and Soils- Lambeth Group. British Geological Survey Open Report, OR/13/006. 316pp.
[7] British Geological Survey, 2006. North London. England and Wales Sheet 256. Bedrock and Superficial Deposits. 1:50 000. (Keyworth, Nottingham: British Geological Survey.
[8] British Geological Survey, 2005. Beaconsfield. England and Wales Sheet 255. Solid and Drift Geology. 1:50 000 (Keyworth, Nottingham. British Geological Survey).

Formation (approx. 3m to 6m thick). The Thanet Sand Formation is anticipated to be absent with the Lambeth Group directly overlying the Chalk at depth.

Plate 10: Bedrock geology surrounding the site



The following geological descriptions for the above strata are provided based on the BGS Lexicon:

- London Clay Formation: greyish brown, stiff to very stiff clayey silt to silty clay, occasionally with pyrite nodules, selenite crystals, bioturbation and partings of silt and sand;
- Lambeth Group (exc. Upnor Formation): multicoloured, laterally and vertically variable sequences of clay with layers of sand, shells and limestones;
- Upnor Formation: Typically, glauconitic rich fine to coarse sand with variable clay and silt content. Beds of gravel to base and minor thin clay layers. When fresh sands are dark grey to dark green and weather to pale grey brown and yellow brown.
- Upper Chalk: white chalk with beds of flint, nodular chalks, hardground and marl seams.

3.3.2 Unpublished Geology

With reference to the BGS GeoIndex[4] numerous borehole records are located within 500m of the site. Information from the ten closest borehole records is summarised in Table 1. Levels have been provided where available. Borehole records and a borehole location plan are included in Appendix E.

Table 1. Summary of BGS borehole records

BGS reference	Grid reference	Direction	Base of borehole (mbgl) [mOD]	Date	Water level (mbgl) [mOD]	Depth to top of stratum (mbgl) [mOD]			
						Made Ground/ Topsoil	London Clay Formation	Harwich Formation	Lambeth Group
TQ08NE214	509395 186895	40m W	6.50 [NR]	1991	NR	0.0 [NR]	NR	NR	0.30*
TQ08NE213	509375 186870	60m W	6.50 [NR]	1991	3.10 [NR]	0.0 [NR]	NR	NR	0.35*
TQ08NE212	509370 186885	70m W	6.50 [NR]	1991	2.30 [NR]	0.0 [NR]	NR	NR	0.30*
TQ08NE79	509310 186900	130m W	5.80 [43.55]	1986	DRY	0.45 [48.60]	NR	NR	2.50 [46.55]**
TQ08NE80	509300 186920	140m W	8.20 [42.24]	1986	DRY	0.40 [50.04]	NR	NR	3.70 [46.74]
TQ08NE83	509290 186930	150m W	6.50 [43.81]	1986	DRY	0.50 [49.81]	NR	NR	4.20 [46.11]**
TQ08NE322	509277 186882	160m W	8.00 [NR]	2009	NR	0.0 [NR]	0.15 [NR]	3.85 [NR]	5.90 [NR]
TQ08NE321	509273 186888	170m W	5.00 [NR]	2009	NR	0.0 [NR]	0.10 [NR]	1.70 [NR]	3.60 [NR]
TQ08NE84	509280 186940	170m W	4.70 [44.92]	NR	DRY	0.7 [48.92]	NR	NR	1.80 [47.82]**
TQ08NE85	509270 186940	180m W	4.50 [45.12]	NR	DRY	0.80 [48.82]	2.10 [47.52]**	NR	NR

*Recorded as London Clay in BGS records however identified as Lambeth Group by CGL.
**Lithology not assigned to stratigraphic unit in BGS records. Assignment by CGL.
NR- not recorded

Based on CGL's interpretation of the nearest historical boreholes the London Clay Formation is anticipated to be absent from the site, although it is mapped as present on site by the geological society. The descriptions of the Lambeth Group recorded in the historical boreholes suggests that the Mottled Beds are encountered near surface. The descriptions of the Lambeth Group did not match those expected of the Shelly Beds.

3.3.3 Mining

The Groundsure report notes the potential presence of small scale underground mining on site and approximately 490m east of the site. However, given the depth to the chalk and presence of sub artesian groundwater within the basal Lambeth Group, which overlies the chalk, it is considered that the risk from chalk mining on site is negligible.

3.4 Hydrogeology and Hydrology

The Environment Agency (EA)[9] has produced an aquifer designation system consistent with the requirements of the Water Framework Directive. The designations have been set for superficial and bedrock geologies and are based on the importance of aquifers for potable water supply and their role in supporting surface water bodies and wetland ecosystems.

The site is not within a Source Protection Zone (SPZ) with the closest SPZ being located 472m to the north. The underlying London Clay Formation is designated Unproductive stratum whilst the underlying Lambeth Group is designated as a Secondary A aquifer. The Upper Chalk at depth is a Principal Aquifer. The Upnor Formation and granular layers of the Lambeth Group may be in continuity with the Principal Aquifer.

There are no surface water features within 250m of the site. The nearest surface water body is 1.2km southeast of the site in the form of Yeading Brook. The site is not within Flood Zone 2 or Flood Zone 3. The site is at low risk of groundwater flooding, negligible risk of surface water flooding and very low risk of flooding from rivers or the sea.

3.5 Ground Hazards

The risks associated with potential geological hazards have been assessed using the Enviro+Geo Insight report (see Appendix D) and are summarised in Table 2.

Table 2. Geological hazards

Hazard	*Risk*
Shrink-swell clays	Low to Moderate
Landslides	Very low
Ground dissolution	Negligible
Compressible deposits	Negligible
Collapsible deposits	Very low
Running sands	Very low

[9] https://magic.defra.gov.uk/MagicMap.aspx [Accessed December 2022]

3.6 Environmental Setting

The Groundsure Enviro+Geo Insight report (see Appendix D) has been obtained to provide information on the environmental setting of the site and assist in identifying possible sources of ground contamination. A summary of the pertinent points is set out below:

- There are no historical or active (licensed) waste sites or waste exemptions with 500m of the site nor historical or active landfills.
- There are 15 records of industrial land use within 250m of the site including Ruislip Station 50m to the north.
- There are 5 records of licensed pollutant release within 500m of the site largely pertaining to dry cleaning.
- There have been no pollution incidents or pollutant release within 500m of the site.
- There are no records of surface or groundwater abstraction within 2km of the site.
- The site is part of the Water Framework Directive surface water body catchment area "Crane Rivers and Lakes".
- The site is part of a Site of Specific Scientific Interest (SSSI) Impact risk zone and there are 2 records of SSSIs within 2000m of the site.
- There are no active petrol stations within 500m of the site.

3.7 Radon

The Groundsure Enviro+Geo Insight report identifies that the site is in an area where less than 1% of properties are above the Radon Action Level. This indicates no radon protective measures are required for new properties.

3.8 Regulatory Enquiries

Hillingdon Borough Council was contacted[10] for information regarding potentially contaminated land across the site and in the surrounding area. To date, a response is awaited from the Council. Any pertinent information received will be forwarded as an addendum to this report.

[10] https://www.hillingdon.gov.uk/contaminated-land-enquiry-form

4. PRELIMINARY RISK ASSESSMENT

Historical contamination of land may present harm to human health and the environment. Current UK legislation stipulates that the risk associated with potential land contamination is assessed and remediated, if necessary. Under the Town and Country Planning Act 1990 (as amended), potential land contamination is a "material planning consideration" together with the National Planning Policy Framework[11] (revised in July 2021, to replace the 2012 version further revised in 2018 and 2019), which means that a planning authority must consider contamination when they prepare development plans or consider individual applications for planning permission. It is the responsibility of the developer to carry out the remediation where it is required and satisfy the Local Authority that the remediation has been carried out as agreed.

Additionally, Part 2A of the Environmental Protection Act 1990 requires that a significant source-pathway-receptor linkage exists to determine a site as contaminated land. This means that there has to be a contaminant present, a receptor that could be harmed by this contaminant, and a pathway linking the two. Part 2A deals with the contamination risk from a site in its current use, however, the planning system requires that the proposed use is considered. Where remediation is carried out under the planning system, it should be ensured that the site is in such a condition that it would still not meet the definition of contaminated land under Part 2A.

4.1 Preliminary Conceptual Site Model

A preliminary conceptual model has been compiled for the site with respect to the proposed development to identify the potential sources of contamination and the associated potential contaminant linkages. This model also informs the potential need for further investigation at the site.

4.2 Preliminary Qualitative Risk Assessment

4.2.1 Potential Sources

Potential contamination sources can include both current and historical activities on site and in the surrounding area. The following potential sources have been identified at the site.

- On-site sources: Made Ground associated with the redevelopment of the site including delivery areas/ car parking could be a source of total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), heavy metals and potentially asbestos containing material.

[11] Ministry of Housing, Communities and Local Government (2021). National Planning Policy Framework.

Historical infilling of the former ponds may also provide a potential source of contaminations similar to the above listed suite of contaminants:

- Off-site sources – historical off-site activities close to the site include the construction of *Ruislip Station*. This could be source of similar contaminants to the above. The electrical substation 20m northwest of the site could be a potential source of polychlorinated biphenyls (PCBs);
- Ground gas/vapours – Made Ground (including the infilled ponds) can be a source of ground gas where an appreciable organic content is present. Hydrocarbon can also product organic vapours and ground gases; and
- Groundwater – Perched water in the Made Ground may be a source of contamination resulting from impacts from the current and previous on and off-site sources. Potential contaminants in perched water would be similar to those present in the soils, as discussed above.

4.2.2 Potential Pathways

The potential migration pathways that may be present at the site include:

- Ingestion and inhalation – contamination within the Made Ground can result in the ingestion or inhalation of contaminated soils (and asbestos fibres if present);
- Direct/dermal contact – direct/dermal contact with contaminated soils or shallow groundwater can results in the uptake of contaminants through the skin or permeation of contamination through structures;
- Root uptake – uptake of phytotoxic contamination by plants/vegetation within areas of proposed soft landscaping;
- Lateral and vertical migration – leaching from potential contamination in the soils may impact the groundwater. However, the underlying soils are expected to be cohesive of very low permeability which will prevent migration to sensitive receptors (aquifers at depth and the closest surface water feature located over 1.2km from the site);
- Ground gas/vapour migration – lateral migration of ground gases and/or vapours through the soil matrix could lead to accumulation within buildings and other enclosed spaces such as service and drainage runs, posing a risk of asphyxiation;
- Drainage and services – could provide a preferential pathway for dissolved phase contamination migration and/or ground gases/vapour transport; and

- Foundation works – potential creation of contaminant pathway to deeper aquifers via piling as part of foundation works.

4.2.3 Potential Receptors

Based on the proposed end use of the site for residential purposes, the main receptors at the site are considered to be:

- Future site occupants/users – future site users are primarily at risk from direct contact, inhalation or ingestion if soil is exposed within soft landscaping and from ground gas/vapour accumulation within buildings, arising from contaminated soils and inhalation of asbestos fibres.

- Construction workers – primarily at risk from direct contact, inhalation or ingestion of contaminants and inhalation of asbestos fibres for the duration of the works. Workers will be subject to site-specific health and safety assessments.

- Off-site results – potential contamination risks are likely to be low assuming appropriate practises during construction.

- Controlled waters: the deep aquifers Lambeth Group (Secondary A) and Upper Chalk are unlikely to be impacted by contamination in the shallow soils/perched water unless piling works create a preferential pathway for contamination migration. Surface water receptors have been discounted as a receptor based on the absence of potential receptors within 1km of the site;

- Buildings and infrastructure – buried concrete and services, such as plastic water supply pipes, can be at risk from chemically aggressive ground and permeation of organic contaminants into water supply pipes. Ground gases and vapour may also accumulate in buildings; structures and services/service corridors presenting an explosive risk.

- Plants and vegetation – Plants and vegetation within areas of proposed soft landscaping will primarily be at risk from phytotoxic contaminants such as copper, boron, nickel and zinc.

4.3 Preliminary Qualitative Risk Assessment

A preliminary qualitative risk assessment has been undertaken based on the findings of the conceptual site model and the potential contaminant linkages that may exist at the site in accordance with the October 2020 Land Contamination Risk Management Guidance (LCRM)[12] (replacing Contaminated Land

[12] Environment Agency (2020). *Land Contamination Risk Management (LCRM)*.

Report (CLR) 11[13]). Using criteria broadly based on those presented in CIRIA Report C552[14], the magnitude of the risk associated with potential contaminant linkages has then been assessed and is summarised below in Table 3 below. The risk assessment methodology is presented in Appendix F.

Table 3. Preliminary Risk Assessment

Potential Source/Medium	*Potential Exposure Route*	*Potential Receptor*	*Severity*	*Probability*	*Risk Rating*	*Comments*
Explosive/ asphyxiating gases/vapours from underlying soils (Made Ground if present) and potential on and off-site sources	Migration of gases and vapours through the surface via permeable soils and drainage & services	Internal building spaces & future occupiers	Medium	Low likelihood	Moderate/ Low	Made Ground may be present on site associated with the previous development of the site and the infilling of the ponds.
Organic/ inorganic contaminants such as hydrocarbons, PAH, metals and asbestos within underlying soils (based on historical on-site and off-site sources)	Direct/indirect ingestion of soil and dust, inhalation of particle vapours and asbestos fibres and dermal contact	Construction workers	Minor	Likely	Low	There is potential for shallow soils to be impacted by asbestos and/or contaminants. Chemical analysis and assessment of shallow soils required to assess risk.
		Future site users	Medium	Unlikely	Low / moderate	The site is anticipated to be partly covered with buildings and hardstanding. However, a significant part of the site is to be covered with soft landscaping, including private gardens.
	Direct contact with underground structures and services	Buildings and structures	Mild	Likely	Moderate/ Low	Sulfate concentrations in the natural soils beneath the site may present a risk to buried concrete. There is potential for contamination within Made Ground if new buried water supply pipes will be laid. Chemical assessment of soils required to assess risk.
	Root uptake	Plants and vegetation	Minor	Likely	Low	Soft landscaping is to cover much of the site.
Organic/inorganic contaminants within perched water within the Made Ground	Direct contact and ingestion of contaminated groundwater	Future site users	Medium	Unlikely	Low	Construction workers may come into contact with shallow groundwater during excavation works. Hardstanding will limit contact for future site users. Assessment of groundwater contamination is required to assess risks.
		Construction workers	Minor	Likely	Low	
		Off-site residents	Medium	Unlikely	Low	
	Inhalation of vapours	Future site users	Medium	Low likelihood	Moderate/ Low	

[13] Environment Agency (2004). *Model Procedures for the Management of Land Contamination (CLR11).*
[14] CIRIA (2001) Contaminated Land Risk Assessment. A guide to good practice. C552.

Potential Source/Medium	*Potential Exposure Route*	*Potential Receptor*	*Severity*	*Probability*	*Risk Rating*	*Comments*
	Vertical migration	Secondary A aquifer (Lambeth Group) and Principal Aquifer (Upper Chalk)	Medium	Unlikely	Low	If piling is proposed where the pile toe penetrates into the granular portion of the Lambeth Group this is a possible pathway to the deep aquifers of the Upnor Formation (Lambeth Group) and Upper Chalk.
	Direct contact with underground structures and services	Buildings and structures	Mild	Likely	Moderate/ Low	Buried concrete to be designed as appropriate for ground conditions. Chemical assessment of groundwater required to assess risk.

5. FIELDWORK

The CGL Investigation was undertaken between 15 and 22 November 2022 and comprised six machine excavated trial pits (TP101 to TP106), two cable percussion boreholes (BH101 and BH102) and four windowless sampler boreholes (WS101 to WS104). The trial pits were excavated to a maximum depth of 2.2mbgl, windowless sampler boreholes were drilled to maximum of 5.0mbgl, cable percussion boreholes were excavated to a maximum depth of 25.2mbgl. Both cable percussion boreholes and two windowless sampler boreholes (WS101 and WS103) were installed with ground gas and ground water monitoring wells. A summary of the excavation from the ground investigation is summarised in Table 4.

Table 4. Summary of exploratory holes

Location ID	*Easting (m)*	*Northing (m)*	*Ground Level (mOD)*	*Hole Type*	*Final Depth (m bgl)*	*Termination Reason*
TP101	509499.503	186945.490	44.397	TP	2.0	Achieved Target Depth
TP102	509487.328	186919.651	44.197	TP	1.90	Achieved Target Depth
TP103	509456.976	186927.127	44.780	TP	2.20	Achieved Target Depth
TP104	509481.834	186955.076	45.411	TP	2.10	Achieved Target Depth
TP105	509505.678	186924.316	43.856	TP	2.00	Achieved Target Depth
TP106	509454.932	186913.843	44.176	TP	2.20	Achieved Target Depth
WS101	509496.876	186959.638	44.853	WS	5.00	Achieved Target Depth
WS102	509499.427	186938.539	44.289	WS	5.00	Achieved Target Depth
WS103	509472.921	186933.482	45.117	WS	5.00	Achieved Target Depth
WS104	509506.508	186894.986	43.949	WS	5.00	Achieved Target Depth
BH101	509455.855	186950.720	45.601	CP	20.2	Refusal
BH102	509445.927	186862.001	44.447	CP	25.0	Achieved Target Depth

CP denotes Cable Percussion boreholes, WS denoted Windowless Sample holes, TP denotes trial pits

The boreholes and trial pits were positioned to provide coverage across the site to inform the ground and groundwater model, windowless samplers were positioned to provide coverage and inform the ground gas and groundwater model.

Prior to commencing ground penetrating works, a buried services survey was undertaken by a subcontracted specialist surveyor (Midland Survey Ltd). The investigation was undertaken in general accordance with the requirements of BS 5930:2015+A1:2020[15] and BS 10175:2011+A2:2017[16]. The exploratory holes were logged by an Engineer from CGL, and representative soil samples were retrieved and sent for laboratory analysis.

[15] British Standards Institution. (2020). *Code of practice for site investigations*. BS 5930:2015+A1:2020
[16] British Standards Institution. (2017*). Investigation of potentially contaminated sites – Code of practice*. BS 10175:2011+A2:2017

All intrusive investigation locations were carried out under supervision of a UXO specialist who provided down hole clearance to the boreholes and windowless sample locations and a watching brief during the trial pitting works.

An exploratory hole plan for the CGL ground investigation is included as Figure 2 and the exploratory hole records are included as Appendix G.

5.1 Monitoring

A total of four monitoring wells were installed within the exploratory holes including single installations within the two boreholes (BH101 and BH102) and two of the windowless sampler borehole locations (WS101 and WS103). One initial round of ground gas (shallow installations only) and groundwater level monitoring has been undertaken at the site on 7/12/2022.

Table 5. Monitoring Well Installation Details

Location ID	*Instrument*	*Installed*	*Response Top (mbgl)*	*Response Base (mbgl)*	*Cover*	*Response Zone Strata*
BH101	Standpipe	17/11/2022	17.0	20.0	Flush	Upnor Formation
BH102	Standpipe	22/11/2022	9.0	13.0	Flush	Lambeth Group - Undivided Reading Formation
WS101	Standpipe	16/11/2022	1.0	4.0	Flush	Head/ Lambeth Group -Undivided Reading Formation
WS103	Standpipe	16/11/2022	0.6	2.6	Flush	Head/ Lambeth Group -Undivided Reading Formation

5.2 Laboratory Testing

5.2.1 Chemical

Representative soil samples were submitted to Nicholls Colton Limited and i2 Analytical Limited (UKAS and MCERTS accredited laboratories) for chemical testing. The contaminant testing included the following determinants:

- Heavy metals / metalloids including antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc;
- PAH and total petroleum hydrocarbons (TPH by Criteria Working Group banding);
- Total monohydric phenols;
- BTEX compounds (benzene, toluene, ethylbenzene, xylenes);

- Total cyanide;
- Soil Organic Matter (SOM);
- Asbestos screen and identification.

In addition, three groundwater samples were analysed for a similar testing suite to the soil suites, which included additional testing for calcium and hardness, but did not include the asbestos testing. The results of the chemical laboratory testing are included in Appendix I.

5.2.1 Geotechnical

Representative soil samples were taken for geotechnical testing and samples for pH and sulfate testing in line with the Building Research Establishment (BRE) concrete in aggressive ground conditions guidance[17] were sent to i2 Analytical Limited (a UKAS accredited laboratory).

The following tests were scheduled at the geotechnical laboratory:

- Natural moisture content;
- Particle Size Distribution;
- Atterberg Limits;
- pH, sulfate and water soluble sulfate; and
- Quick Undrained Triaxial

The results of the geotechnical laboratory testing are included in Appendix J.

[17] Building Research Establishment (2005). *Special Digest 1. Concrete in Aggressive Ground*. Third Revision. June 2005.

6. GROUND AND GROUNDWATER CONDITIONS

6.1 Summary

The ground conditions encountered within the CGL ground investigation are summarised in Table 6 and were generally consistent with the anticipated geology.

Table 6. Summary of Ground Conditions

Stratum	*Top of Stratum (mbgl) [mOD]*	*Thickness (m)*
Grass over soft dark brown / mottled grey and orange clayey SILT / silty CLAY with occasional, subangular, fine to coarse gravel of flint. *(Only present in positions WS101, TP101, TP103)* **[TOPSOIL]**	0.00 [+44.85 to +44.40]	0.3 to 0.4
Variable, comprising both granular and cohesive deposits. Cohesive deposits: Soft to firm dark brown / black / grey mottled brown clay / silty clay / silty sandy clay / clayey silt with frequent, rounded to angular, fine to coarse gravel of flint, brick, concrete, nails, slate, rusted metal, electrical wiring, plastic tubing, rope, bin bag fragments, glass and porcelain. Frequent rootlets and occasional wood fragments. Rare partially decomposed organic matter and cobbles of terracotta roof tile, brick and concrete. Granular deposits: Grey brown / dark brown / black clayey sandy gravel. Gravel is angular to subrounded, fine to coarse of brick, flint and concrete. Occasional subangular brick and concrete cobbles. Rare partially decomposed organic matter. Rare asphalt cobbles and bituminous odour. *(Not present in positions WS101 and TP101)* **[MADE GROUND]**	0.0 to 0.30 [+45.60 to +43.86]	0.25 to 1.30
Predominately soft to firm grey mottled brown CLAY with orange and red veining, infrequent large rootlets and frequent dark organic matter. Rare, rounded, fine to medium flint gravel. **[HEAD DEPOSITS]**	0.2 to 1.3 [+44.60 to +43.15]	1.0 to 1.5
Predominantly firm to stiff becoming very stiff mottled CLAY with occasional calcareous concretions subordinate beds of medium dense to very dens yellow brown mottled grey slightly clayey SAND. **[UNDIVIDED READING FORMATION - LAMBETH GROUP]**	1.9 to 2.0 [+43.60 to +41.95]	10.0 to 12.0
Predominantly very dense orangey brown silty SAND with infrequent specs of glauconite with subordinate beds of very stiff SILT and CLAY with gravel bands. *(Only encountered in BH101 and BH102, remaining exploratory holes were terminated in the overlying deposits at shallower depth)* **[UPNOR FORMATION - LAMBETH GROUP]**	12.00 to 14.00 [+33.60 to +30.45]	6.20 to 7.50
Recovered as chalk silt and gravel with flints. Clasts are weak low density white to light grey chalk. *(Only present in BH101, BH102 was terminated in the overlying Upnor Formation)* **[CHALK GROUP]**	19.50 [26.10]	Proven to 25.00m

Plots of the Standard Penetration Test (SPT) N60 values and undrained shear strength (c_u) plotted against depth are included as Figures 3 and 4, respectively.

A summary of the in-situ and geotechnical laboratory data is provided in Table 7.

Table 7. Summary of CGL Geotechnical Test Data

SPT 'N' Data						
Strata			***Range of SPT N values***		***Range of SPT N60 values***	
Head Deposits			4 to 7		4.7 to 7.7	
Undivided Reading Formation - Lambeth Group			11 to 50		13.7 to 62.5	
Upnor Formation - Lambeth Group			27 to 50		33.7 to 62.5	
Chalk Group			50		62.5	
Atterberg Limits						
Strata	***Moisture Content (%)***	***Liquid Limit (%)***	***Plastic Limit (%)***	***Plasticity Index (%)***	***% material <425µm***	***Modified Plasticity Index [I'_p] (%)***
Head Deposits	19 to 42	46 to 86	18 to 38	23 to 45	70 to 100	16.1 to 52
Undivided Reading Formation - Lambeth Group	5.7[a] to 32	37 to 68	16 to 33	19 to 43	99 to 100	23 to 43
Particle Size Distribution						
Strata	***Very Coarse %***	***Gravel %***	***Sand %***	***Silt %***	***Clay %***	***Fines (Clay and Silt Total) %***
Upnor Formation	0	0	6	53	41	94

a. Low value observed in the upper Reading Formation. No evidence of desiccation visually noted or significant amounts of granular material.

Details of each stratum are provided separately in the following sections of this report.

6.2 Topsoil

Topsoil was encountered in three of the exploratory hole positions (WS101, TP101, TP103) located within the areas of existing soft landscaping and ranged in thickness from 0.3m to 0.4m. The Topsoil typically comprised grass over soft, dark brown or mottled grey and orange, clayey silt or silty clay with occasional, subangular, fine to coarse gravel of flint.

6.3 Made Ground

Made Ground was encountered in all but two of the exploratory hole positions (WS102, WS103, WS104, TP102, TP103, TP104, TP105, TP106, BH101, BH102) ranging in thickness between 0.25m and 1.3m. The maximum thickness of Made Ground was encountered in TP104 on a raised embankment within the Barn Hotel gardens. The composition of the Made Ground was found to comprise both cohesive and granular layers.

The cohesive deposits comprised soft to firm dark brown / black / grey mottled brown clay / silty clay / silty sandy clay / clayey silt. The sand is fine to coarse. Frequent, rounded to angular, fine to coarse gravel of flint, brick, concrete with gravel sized fragments of nails, slate, rusted metal, electrical wiring,

plastic tubing, rope, bin bag fragments, glass and porcelain noted. It is noted that the fragments of man made materials noted were not identified in one area. Instead spread predominately across TP104, TP105 and TP106. It is noted that no one locations included all of the man made materials presented in the summary description above. Frequent rootlets and occasional wood fragments were also noted alongside rare, decomposed rootlets and cobbles of terracotta roof tile, brick and concrete.

The granular deposits comprised grey brown / dark brown / black clayey sandy gravel. The gravel is angular to subrounded, fine to coarse of brick, flint and concrete. The sand is logged fine to coarse, with occasional subangular brick and concrete cobbles noted. Rare roots, asphalt cobbles and bituminous odour noted were noted.

No in-situ testing was undertaken within the Made Ground due to it being relatively thin and predominately encountered within the hand dug pits.

6.4 Head Deposits

Head Deposits were encountered below the Made Ground at BH102, WS101, WS102, WS103 and WS104 and typically measures between 1.2m and 1.6m in thickness. The material was predominately cohesive with rare gravels of flint and limestone and infrequent partially decomposed rootlets. Soft and powdery, calcareous concretions were noted to the base of the Head Deposits/ boundary of the Lambeth Group.

A total of four SPTs were undertaken within the Head Deposits with values ranging between 4 and 7 blows. Correlated N60 values have been calculated between 4.7 and 7.7 blows. Assuming an f1 value of 4.5[18] correlated undrained shear strengths for this material ranged between 21kPa and 34kPa. Insitu hand shear vane tests were carried out during the windowless sampling boreholes which recorded undrained shear strengths ranging between 35kPa and 88kPa. A single laboratory shear strength test recorded a value of 70kPa.

The classification testing of the cohesive soils recorded the following ranges:

- Moisture Content: 19% to 42%
- Liquid Limit: 46% to 86%
- Plastic Limit: 18% to 38%; and

[18] Stroud, M A & Butler, F G. 1975 – The standard penetration test and the engineering properties of glacial materials. In: Proceedings of the Symposium of glacial materials, University of Birmingham, April 1975.

- Modified plasticity indices: 16.1% to 52%

6.5 Undivided Reading Formation - Lambeth Group

The Undivided Reading Formation of the Lambeth Group was encountered in each exploratory hole location. Within the two cable percussive boreholes the thickness of the Undivided Reading Formation was noted to range between 10m to 12m. The strata comprised of predominantly cohesive lithologies with more frequent minor granular deposits towards the base of the formation.

The cohesive deposits comprised of soft to very stiff mottled clay / silty clay / sandy clay. The mottling included a range of colours including brown, grey, orange, red, yellow, purple and blue-grey. The sand is fine to medium. Lenses of orange fine sand, and inclusions of brown, white and grey silt was noted within the upper 2m to 4m of the stratum. Occasional red and orange veining, rounded fine to medium gravel of flint and chert, and soft and powdery, calcareous concretions were noted throughout.

The granular deposits comprised medium dense to very dense yellow brown mottled grey slightly clayey fine to medium sand. The granular beds were encountered between 9.7mbgl and 11mbgl (34.6mOD and 35.90mOD) in BH101 and 10.5mbgl and 12.5mbgl (31.95mOD and 33.95mOD) in BH102.

A total of 25 SPTs were undertaken in the Undivided Reading Formation (23 in cohesive soils and two in granular soils). N values within the cohesive soils ranged from 11 to 43. The N values were used to calculate N60 values throughout the strata with cohesive N60 values ranging between 13.7 and 53.7. N60 values for the cohesive deposits of the Undivided Mottled Beds were subsequently used to calculate undrained shear strength (c_u), when multiplied by a f1 value of 4.5[19]. The correlated N60 derived undrained shear strengths ranged between approximately 61kPa and approximately 240kPa. Insitu hand shear vane tests were carried out during the windowless sampling boreholes which recorded undrained shear strengths ranging between 107kPa and 150kPa. Laboratory shear strength tests recorded values between 152kPa and 604kPa.

SPT values within the granular Undivided Mottled Beds recorded values of between 43 and 50. The N values were used to calculate N60 values throughout the strata with the granular deposits recording an N60 of between 53.7 and 62.5. The N60 value for the granular deposits therefore correlates with 'very dense'.

The classification testing of the cohesive soils recorded the following ranges:

[19] Stroud, M A & Butler, F G. 1975 – The standard penetration test and the engineering properties of glacial materials. In: Proceedings of the Symposium of glacial materials, University of Birmingham, April 1975.

- Moisture Content: 5.7% to 32%
- Liquid Limit: 37% to 68%
- Plastic Limit: 16% to 33%; and
- Modified plasticity indices: 23% to 43%

A large range of moisture content and plasticity index was recorded in a sample of the Lambeth Group at 3m in BH101. Limited granular material and no visual signs of desiccation were identified within this material. It is unknown why the lower values were recorded in this specific sample.

The modified plasticity index (I'p) indicates that the clays of the Mottled Beds have a low to high potential for volume change[20] with an average I'p of 34%, 'medium volume change potential'. The All samples of the Mottled Beds plot above the 'A Line' as a clay soil.

6.6 Upnor Formation - Lambeth Group

The Upnor Formation of the Lambeth Group was encountered in both of the deep cable percussive boreholes (BH101 and BH102) and was between 6.2m and 7.5m thick. The stratum was predominantly very dense, orangey brown, silty, fine to medium sand with subordinate beds of very stiff, brown, slightly sandy, clayey silt with grey and brown sandy patches. A basal pebble band was noted in both boreholes at levels of 26.8mOD (BH101) and 25.45mOD (BH102).

A total of seven SPTs were undertaken in the granular Upnor Formation with 'N' values ranging from 27 to 50, and N60 values of 34 to 63, corresponding to a relative density of dense to very dense.

A single PSD test undertaken from a cohesive dominated layer of the Upnor Formation at 16.5mbgl in BH102, which recorded the following particle distribution:

- Sand 6%
- Silt 53%; and
- Clay 41%

The results of the testing indicate that the Upnor Formation (excluding the basal pebble band) with BH101 typically comprises slightly sandy clayey Silt.

[20] NHBC (2007) Part 4 Foundation Chapter 4.2 Building near trees

6.7 Chalk Group

The Chalk Group was encountered only in cable borehole BH101 at 19.5mbgl and was proven to a maximum depth of 25mbgl. BH102 was terminated at 20.2mbgl in the pebble bed in the overlying Upnor Formation, which was also encountered at the chalk interface in BH101. The chalk was recovered as a white to light grey gravel and silt due to the percussive nature of the drilling. The chalk clasts were weak of low density. The flint gravel was angular to subrounded, fine to coarse, with rare flint cobbles from 21.7mbgl.

A total of four in situ SPTs were undertaken in the Chalk Group and recorded 'N' values of greater than 50 for penetration between 72mm and 292mm – these values indicate structured chalk, however, it is not possible to determine the chalk grade due to sample disturbance. No chalk clasts of sufficient size for laboratory saturation moisture content / maximum dry density were recovered during the drilling.

6.8 Ground Gas

Ground gas monitoring was undertaken on 7 December 2022 for boreholes BH102, WS101 and WS102, with borehole BH101 monitored on 12 December 2022 as the monitoring installations was found to be blocked during the first visit. The visits were undertaken during atmospheric pressure ranging between 1005mb to 1016mb in stable and falling pressure systems. The results of the ground gas monitoring are summarised in Table 8.

Table 8. Summary of Ground Gas Monitoring

Borehole	*Response Zone Strata*	*Response Zone (mbgl) [mOD]*	*Date*	*Steady Flow Rate (l/hr)*	*Minimum O_2 (% vol in air)*	*Steady CO_2 (% vol in air)*	*Maximum CH_4 (% vol in air)*	*Maximum PID (ppm)*	*Groundwater depth*
BH101[a]	Upnor Fm. & Upper Chalk	17 to 20 [+28.6 to +25.6]	12/12/2022	NA[b]	NA	NA	NA	NA	NA
BH102[a]	Undivided Reading Formation - Lambeth Group	9 to 13 [+35.45 to +31.45]	07/12/22	NA	NA	NA	NA	NA	NA
WS101[a]	Head Deposits and Undivided Reading Formation - Lambeth Group	1 to 4 +[43.85 to +40.85]	07/12/22	<0.1	17.4	4.2	<0.1	<0.1	1.00
WS103	Head Deposits and Undivided Reading Formation - Lambeth Group	0.6 to 2.6 [+44.52 to +42.52]	07/12/22	<0.1	18.2	0.3	<0.1	<0.1	0.80

Notes: PID – Photoionisation Detector, PPM – parts per million.
a – installations flooded during gas monitoring
b – installations not monitored for gas as these targeted deep groundwaters only

Given the limited thickness of the Made Ground in the boreholes (max 1.0m thick, although slightly thicker Made Ground was encountered in the trial pits), no monitoring installations were installed in this material.

The response zones of the monitoring installations in BH101 and BH102 are at depth within the Upnor Formation / Chalk and Reading Formation, respectively, for the purpose of groundwater monitoring. The response zones are also saturated with groundwater levels recorded at 6.1mbgl and 7.02mbgl.

The response zones of the monitoring installations in WS101 and WS103 are within the Head Deposits and shallow Undivided Reading Formation where organic material was identified. The response zone in WS101 was saturated with groundwater at 1.0mbgl, with WS102 partially saturated (groundwater at 0.8mbgl and top of response zone at 0.6mbgl).

The monitoring results reflect the saturated nature of the response zones, with no flow and measurable carbon dioxide (CO_2) in WS101 although this is not representative of a soil source. The results in WS102, which includes a small length of unsaturated response zone, recorded a maximum CO_2 concentration of 0.3% and no measurable methane (CH_4).

6.9 Groundwater

Groundwater strikes were recorded during the drilling of BH101 at 18m (rising to 13.6m within 20 minutes, and 9.2m within 24 hours) and BH102 at 18.6m (rising to 6.2m within 20 minutes). Groundwater seepage was also recorded at the base on the hand pits (1.2m) in WS101, WS102 and WS103 as well as within TP102 (1.4m) and TP104 (2.1m). No groundwater was encountered in the remaining windowless sampler or trial pit positions on site.

One round of groundwater monitoring has been completed to date on 7 December 2022 (BH102, WS101 and WS103) and 12 December 2022 (BH101). A summary of the results in outlined in Table 9.

An historical borehole was noted near to BH101, this was dipped during the monitoring round however, its installation details/ targeted response zone is unknown.

Table 9. Summary of Groundwater Monitoring

Borehole	*Response Zone Strata*	*Response Zone (mbgl) [mOD]*	*Date*	*Depth (mbgl) [mOD]*
BH101 (Deep)	Upnor Formation and Upper Chalk	17 to 20 [+28.6 to +25.6]	12/12/2022	7.02 [+38.58]
BH102 (Deep)	Reading Formation - Lambeth Group	9 to 13 [+35.45 to +31.45]	07/12/2022	6.14 [+38.31]
WS101 (Shallow)	Head Deposits and Reading Formation - Lambeth Group	1 to 4 [+43.85 to +40.85]	07/12/2022	1.00 [+43.85]
WS103 (Shallow)	Head Deposits and Reading Formation - Lambeth Group	0.6 to 2.6 [+44.52 to +42.52]	07/12/2022	0.80 [+44.32]

Borehole	*Response Zone Strata*	*Response Zone (mbgl) [mOD]*	*Date*	*Depth (mbgl) [mOD]*
BH101 (Deep)	Upnor Formation and Upper Chalk	17 to 20 [+28.6 to +25.6]	12/12/2022	7.02 [+38.58]
Additional Borehole	Unknown	Unknown (base of 1.63mbgl)	12/12/2022	Damp at 1.63 [+43.97]*

*Ground level based on BH101

Groundwater was recorded at depths of 6.14mbgl (BH102) and 7.02mbgl (BH101) in the deep monitoring installations, indicating sub-artesian water pressures in the Upnor Formation / Chalk aquifers and in the granular beds of the Reading Formation – the groundwater appears to be in hydraulic continuity based on the relatively consistence resting water levels (38.31mOD and 38.58mOD).

The groundwater in WS101 and WS103 is considered to be perched water in the shallow head deposits, which seeped into the borehole during drilling with the cohesive soils of the Reading Formation acting as a sump.

6.10 Sulphate and pH Conditions

A total of 11 soil samples from across the site have been tested in accordance with BRE SD1 for pH and sulfate conditions. The results of the testing are summarised in Table 10.

Table 10. Sulfate and pH Conditions

Strata	pH	Total Sulphate as SO_4 (mg/kg)	Water Soluble SO_4 16hr extraction (2:1 Leachate Equivalent) (g/l)	Total Sulphur (mg/kg)
Made Ground	7.1 to 10.2	-	53 to 200	-
Undivided Reading Formation – Lambeth Group	8.3 to 8.9	77 to 6400	14 to 2300	58 to 3300
Upnor Formation – Lambeth Group	8.2 to 8.7	100 to 250	21 to 110	<50 to 1000

6.11 Desiccation Assessment

A desiccation assessment has been undertaken as shown in Table 1 of Appendix L. The desiccation assessment is based on three locations with TP102 acting as a control (away from mature vegetation) and WS103 and WS101 being positioned closed to mature vegetation. The results of the desiccation assessment indicate that potentially desiccated soils were located at 2.5mbgl in WS101 and WS103, both associated with samples of the Lambeth Group. Additional areas of potentially desiccated soils were also encountered in BH101 between 3.0 and 4.5mbgl, associated with the Lambeth Group.

7. CONTAMINATION ASSESSMENT

7.1 Introduction

This section of the report evaluates risks to potential receptors at the site from identified chemical contamination. Potential receptors have been identified with reference to the Part 2A regime and associated Defra guidance[21]. As part of the Part 2A regime, under the planning regime all receptors (humans, controlled waters, vegetation and buildings) have been considered if there is the potential for them to be adversely affected by exposure to contamination. CGL's approach and rationale to assessment criteria adoption for this site is presented in Table 1 of Appendix K.

7.2 Risks to Human Health

Soil samples were submitted for chemical analysis as part of the ground investigation, comprising 10 samples of the Made Ground and two samples of the Reading Formation of the Lambeth Group. The risks to human health have been assessed on a *residential with homegrown produce consumption* end use (assuming 6% SOM for Made Ground and 2.5% SOM for Reading Formation) and the assessment results are summarised in Table 2 and Table 3 of Appendix K.

7.2.1 Risks from Soil Contaminants

7.2.1.1 Made Ground

Of the 10 samples of Made Ground assessed, four (TP104, WS104 and two from BH101) were noted to contain elevated concentrations of lead above the GAC. Following further statistical assessment (US_{95} approach) the results recorded a US_{95} value of 928.5mg/kg against the GAC of 200mg/kg. It is therefore considered that a risk from lead is present across the site's Made Ground material.

Furthermore, exceedances of a number of PAH's were observed within TP106 associated with Benzo (a) Anthracene, Chrysene, Benzo (b) fluoranthene, Benzo (a) Pyrene, Indeno (1,2,3,-cd) pyrene and Dibenzo (a,h) anthracene. Following further statistical assessment (US_{95} approach) the results demonstrated exceedances of the respective GACs. It is therefore considered that a risk from PAHs is present across the site's Made Ground material.

7.2.1.2 Natural Soils

Two samples were tested from the natural soils. No exceedances were identified indicating that that the natural soils do not present an unacceptable risk to human health.

[21] DEFRA. (2012). *Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance*. Department for Environment, Food and Rural Affairs.

7.2.2 Risks from Vapours

With reference to Table 4 of Appendix K there is an overall low risk to human health from groundwater derived vapours on account of volatile organic concentration measurements falling within the threshold for "Residential land use"[22].

7.3 Risks to Controlled Waters

As identified within the preliminary risk assessment, no surface water receptors have been identified and the potential risks to the deep aquifers of the Upnor Formation and Chalk from contamination in the shallow soils and perched water will be largely mitigate by the predominantly low permeability Reading Formation, although piling may result in preferential pathways (depending on piling methodology adopted). No free product / gross contamination was identified during the investigation in the shallow soils and perched water and on this basis, the risks to controlled waters are considered to be low.

Notwithstanding this, a total of three groundwater samples were scheduled for laboratory analysis with all samples originating from the deeper aquifer within the base of the Lambeth Group / Upnor Formation. This testing is undertaken to inform the design of buried concrete (sulfate and pH) and for general water quality should disposal be required during construction. The results have been screened against Freshwater Environmental Quality Standard (EQS) and Drinking Water Values (DWV) to assess the general quality of the samples and the results are presented in Table 5 of Appendix K – this is a conservative assessment in the absence of receptors / viable pathways.

The results of the groundwater testing indicate that contaminant concentrations are generally below the EQS or DWV, with some minor exceedences for metals (selenium and zinc) and sulfate, however, these are considered to be naturally occurring within the strata and are not considered to represent an unacceptable risk to controlled waters or human health receptors.

Selenium concentrations exceeded the DWV concentration of 10µg/l with a value of 28µg/l in BH101 at 7.0mbgl. Bioavailable zinc concentrations exceeded the EQS concentration of 10.9µg/l in BH101 at 7.0mbgl with a value of 46.82µg/l. Sulphate concentrations exceeded the DWV concentration of 250mg/l with a range from 437mg/l to 687mg/l in boreholes BH102 at 6.5mbgl and WS101 at 1.0mbgl.

7.4 Ground Gas Risk

The ground investigation has identified a relatively thin cover of Topsoil/Made Ground across the site, typically no more than 1m, including in the area of the former ponds which are assumed to have be

[22] Society of Brownfield Risk Assessment, Development of Generic Assessment Criteria for Assessing Vapour Risks to Humna Health from Volatile Contaminants in Groundwater, Version 1.0, February 2017.

infilled (including BH101, TP103 and TP106). Whilst the organic content is typically >2.5%, no putrescible material was encountered. Based on these observations and the limited thickness of Made Ground, generation of ground gases from the Made Ground is likely to be very slow and not at a volume that would generate significant flow. On this basis, the Made Ground is not considered to be a viable source of significant ground gases.

Ground gas monitoring undertaken in installations within the natural soils has not identified sustained flow, no measurable methane and low concentrations of carbon dioxide.

On this basis, and given the saturated nature of three of the four monitoring installations, calculation of Ground Gas Screening Value (GSV) in general accordance with CIRIA C665[23] and BS 8485[24] is not considered to be necessary or appropriate.

Based on the above, it is considered that the potential risks from ground gas at the site is very low (i.e. Characteristic Situation 1) and no specific gas protection measures are required.

7.5 Risks to Vegetation and Plants

Plant growth can be affected by phytotoxic contaminants, such as copper, boron, nickel and zinc. As indicated within Table 6 within Appendix K. The concentration of (water soluble) boron (US_{95}) was 6.27mg/kg which marginally exceeded the boron assessment criteria for vegetation and plants of 5mg/kg. The concentration of zinc (US_{95}) was 376.50mg/kg which also exceeded the zinc assessment criteria of 200mg/kg. Therefore, the risk to vegetation and plants is considered to be moderate for the proposed development. The exceedances in zinc and boron were associated with elevated concentrations of these elements observed within Made Ground. This may be refined with further investigation, laboratory analysis and assessment.

7.6 Risks to Buried Water Supply Pipes

With reference to Table 7 within Appendix K, the risks to buried water supply pipes are considered to be low. Standard polyethylene (PE) pipes and metal pipes (but not copper due to elevated pH concentrations) are considered appropriate for use for drinking water supplies and it is recommended that the water supply company is contacted to confirm their requirements for water supply pipes.

[23] CIRIA, (2007). *Assessing Risks Posed by Hazardous Ground Gases to Buildings*. CIRIA Report C665.
[24] BSI Standards Publication, BS 8585:2015+A1:2019. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.

7.7 Quantitative Risk Assessment

The qualitative risk assessment has been updated based on the findings of the ground investigation and the potential pollutant linkages in accordance with LCRM[12] and is presented within Table 11 below. A pictorial conceptual site model is included as Figure 5.

Table 11. Quantitative Risk Assessment

Potential Source/Medium	*Potential Exposure Route*	*Potential Receptor*	*Severity*	*Probability*	*Risk Rating*	*Comments*
Explosive/ asphyxiating gases/vapours from underlying soils (Made Ground if present) and potential on and off-site sources	Migration of gases and vapours through the surface via permeable soils and drainage & services	Internal building spaces & future occupiers	Medium	Unlikely	Low	Made Ground represents a limited source of ground gases which would not be generated at a rate to produce volumes sufficient to result in flow into proposed buildings.
Organic/ inorganic contaminants such as hydrocarbons, PAH, metals and asbestos within underlying soils (based on historical on-site and off-site sources)	Direct/indirect ingestion of soil and dust, inhalation of particle vapours and asbestos fibres and dermal contact	Construction workers	Minor	Likely	Low	Construction workers may come into contact with contamination within shallow soils impacted by lead and TPH. However, the exposure will be short term and risk mitigated by adoption of good/ safe working practise, appropriate health and safety mitigation measures and PPE.
		Future site users	Medium	Low likelihood	Moderate / Low	The site is anticipated to be mostly covered with buildings and hardstanding, however where the Made Ground is exposed at finished level in gardens and areas of soft landscaping there is a potential risks to future site occupiers and mitigation will be necessary (removal of Made Ground or placement of soil capping layers).
	Direct contact with underground structures and services	Buildings and structures	Mild	Likely	Moderate/ Low	Sulfate content in soils will require consideration in the design of buried concrete. The risks to new water supply pipes are considered to be low.
	Root uptake	Plants and vegetation	Minor	Likely	Low	Existing topsoil / Made Ground represents a potential risk to plants and vegetation and a growth medium may be required.
Organic/inorganic contaminants within groundwater (perched water within the Made	Direct contact and ingestion of contaminated groundwater	Future site users	Medium	Unlikely	Low	Construction workers may come into contact with shallow groundwater during excavation works, however, contaminant concentrations are generally low.
		Construction workers	Minor	Likely	Low	

Ground and groundwater within the Lambeth Group/ Thanet Formation – if present)		Off-site residents	Medium	Unlikely	Low	Hardstanding will limit contact for future site users.
	Inhalation of vapours	Future site users	Medium	Unlikely	Low	No source identified during ground investigation.
	Vertical migration	Secondary A aquifer (Lambeth Group) and Principal Aquifer (Upper Chalk)	Medium	Unlikely	Low	The predominantly cohesive nature of the Reading Formation will prevent vertical migration to groundwater aquifers at depth. Whilst piling may create a preferential pathway (depending on methodology) between the Made Ground and deep aquifers of the Upnor Formation and Upper Chalk, no free product or gross contamination has been identified in the shallow soils.
	Direct contact with underground structures and services	Buildings and structures	Mild	Likely	Moderate/ Low	Buried concrete to be designed as appropriate for ground conditions.

8. GEOENVIRONMENTAL RECOMMENDATIONS

The site investigation has identified generally low risks to identified receptors associated with contaminant concentrations in the shallow soils and perched water. Notwithstanding this, elevated concentrations of lead and PAHs have been identified in the Made Ground which present a potential risks to future site occupiers where this material is exposed at finished level, and concentrations of zinc and boron present a potential risk to plants/vegetation.

No unacceptable risks have been identified to controlled water receptors in the absence of viable pathways / sources of contamination.

The risks associated with ground gases are considered to be low and no further monitoring / assessment or specific mitigation measures are considered to be required in this regard.

Whilst the existing buildings have limited coverage for ground investigation, based on the former and current land uses, it is considered that the potential for unencountered contamination may be suitably address with a watching brief and discovery strategy during ground works.

8.1 Outline Remediation Strategy

Based on the investigation and assessment undertaken, the following outline remediation strategy is recommended for the proposed development:

1. Contamination watching brief and discovery strategy during demolition and ground works, including site inspections by a suitably qualified geoenvironmental engineer

2. Removal of the Made Ground or placement of clean soil capping layers in areas of proposed soft landscaping and gardens where Made Ground is present at formation level

3. Standard polyethylene (PE) pipes and metal pipes (but not copper due to elevated pH concentrations) are considered appropriate for use for drinking water supplies. It is recommended that the water supply company is contacted to confirm their requirements for water supply pipes.

8.2 Watching Brief and Discovery Strategy

A watching brief will be put in place during the enabling works, earthworks and construction works by the Contractor. Should areas of unexpected contamination, including asbestos containing materials, be encountered or suspected, a qualified geoenvironmental engineer should be informed and the risk associated with the contamination assessed.

Where necessary, an appropriate remediation strategy should be devised and implemented, and the regulators should be informed of additional areas of contamination so identified. The regulators should be provided with the risk assessment and proposed remediation methodology for agreement before undertaking such works. Appropriate verification works to be completed if remedial measures are required will also be identified and agreed.

The following nominal discovery strategy, in the event of unexpected contamination, is to be implemented:

1. Work to cease in that area.

2. Notify geoenvironmental engineer to attend site and sample material. Notify Land Quality Officer at the Local Authority, as appropriate.

3. Geoenvironmental engineer to supervise the excavation of contaminated material, which will be placed in a bunded area and covered to prevent rainwater infiltration.

4. Soil samples will be obtained by the geoenvironmental engineer from both the excavated material and the soils in the sides and base of the excavation to demonstrate that the full area of contamination has been excavated. If appropriate, in-situ testing will be undertaken on the sides and base of the excavation to assess the presence of residual contamination in the soils.

5. On receipt of chemical test results, the soils will be appropriately classified for treatment or disposal and dealt with accordingly.

6. Detailed records, including photographs and duty of care records, of the excavations, stockpile sizes, source and location will be kept and regularly updated to allow materials to be easily tracked from excavation until disposal off site.

7. Backfilling to be undertaken with material certificated as suitable for the proposed end land use.

8.3 Material Management

The Contractor will be responsible for the material management and waste classification at the site. The “waste hierarchy” should be used to rank waste management options from most to least sustainable. Top priority should be given to preventing waste in the first place, for example, during the pre-construction and planning stages of a new development. However, if waste is created, priority should be given to preparing it for re-use, then recycling, then recovery, and last of all, disposal.

8.3.1 Re-use, Recycling and Recovery

In order to minimise the volume of soils being disposed to landfill facilities, it is prudent to consider material management options prior to waste disposal. Screening of uncontaminated natural arisings may permit recycling/re-use of the material on site or for other sites under the WRAP protocol[25] (uncontaminated granular soils only) or the CL:AIRE protocol[26] and would lead to a reduction in disposal requirements.

It is considered that the majority of the natural soils excavated within the site can be re-used within the site boundary under the CL:AIRE protocol. Clean natural arisings could be re-used on another site or imported from another site under the WRAP or CL:AIRE protocols.

If materials are re-used within the site, a Materials Management Plan (MMP) will be required to include details of where materials will arise and how they will be used within the limits of the Code of Practice; there is no requirement to seek an environmental permit to re-use materials. However, the process would require sign off by a Qualified Person and a final validation report and is not applicable to soils that pose harm to human health or the environment. If materials are re-used on another site, that recipient site will also require an MMP and signed declaration by a Qualified Person.

8.3.2 Waste Characterisation

A waste characterisation assessment has been carried out on the Made Ground chemical soil data obtained during the CGL ground investigation. The results of the assessment indicate that the majority of CGL soil samples analysed would likely be characterised as “not hazardous” with respect to waste disposal. However, the sample obtained Made Ground material encountered at TP106, which contained bituminous materials and odours was classified as “hazardous” due to elevated TPH within the sample.

Where the soils have been characterised as “not hazardous”, the material could be acceptable for disposal to a licensed inert waste facility (subject to Waste Acceptability Criteria (WAC) testing) or to a licensed non-hazardous waste facility. Samples of Made Ground and Head Deposits from TP104 and BH102, respectively, were submitted were submitted for WAC testing, the results indicate that the Made Ground at TP104 could be disposed at an inert waste facility. The Head Deposits contained marginally elevated levels of antimony and can be disposed of to a non-hazardous waste facility that accepts non-hazardous waste.

[25] WRAP. (n.d.) *The Quality Protocol.*
[26] CL:AIRE.(2011). *The Definition of Waste: Development Industry Code of Practice.* Version 2.

The Made Ground from the vicinity of TP106 should be disposed of to a hazardous waste facility.

Uncontaminated natural soils would be acceptable to an inert landfill without the need for WAC testing in accordance with current legislation. Excavated soil should be appropriately stored with preventative measures as outlined in Section 10.2.

In May/June 2012 HMR&C issued Briefs 15/12 and 18/12 clarifying how construction spoil and excess soils will be assessed for landfill tax purposes. Detailed accurate descriptions of waste are required for all wastes to support the landfill tax assessment. Uncontaminated naturally occurring soils will remain inert by default and eligible for the lower rate of landfill tax. Similarly, 'reworked soils' and demolition 'stone' comprising ONLY materials listed in the Schedule of the Landfill Tax (Qualifying Material) Order 2011 (SI 2011/1017) will also be eligible for the lower rate of landfill tax.

However, Made Ground containing soil and foreign objects such as timber, plastic, rubber, metal, paper, plasterboard, asbestos, etc., regardless of the results of chemical analysis for waste classification purposes, will be eligible for the standard (higher) rate of landfill tax. Therefore, to maximise eligibility for lower rate landfill tax on waste construction spoil/ reworked ground, careful waste segregation and controls are necessary.

8.3.3 Waste Handling

All material intended for off-site disposal should be transported and disposed in accordance with the Environmental Protection (Duty of Care) Regulations, 1991 and the Landfill (England and Wales) Regulations, 2002 (as amended). Waste legislation stipulates that *hazardous* and *not hazardous* waste should be pre-treated prior to disposal. Pre-treatment can be undertaken either at the site of origin or may be carried out at a licensed off-site facility and can include selective segregation of soils conducted on site.

8.4 Health and Safety

Precautions should be taken to minimise exposure of workers and the general public to potentially harmful substances during earthworks. The risks to contractors can be controlled through the implementation of site safety procedures and the use of suitable personal protective equipment (PPE). Attention should also be paid to restricting possible off-site nuisance such as dust and odour emissions. All site works should be undertaken in accordance with the guidelines prepared by the Health and

Safety Executive (HSE, 1991)[27] and CIRIA Reports 132[28] and C650[29] and all work should also be carried out in accordance with the Contractor's Construction Health and Safety Plan.

Precautions should include, but not be limited to:

- Personal hygiene, washing and changing procedures;
- Adequate PPE including disposable overalls, gloves and particulate filter masks/vapour respirators, where required;
- Dust and vapour suppression methods, including dampening down, minimising the working face exposed and covering stockpiles, where required;
- Regular cleaning of all site roads, access roads and the public highway;
- Safe storage of fuel and other potentially polluting liquids and the provision of spill control and clean up facilities; and
- Positive collection and disposal of on-site run-off including prevention of run-off migrating to pumped drainage in basement.

Excavations should be planned and inspected regularly by a competent person and no operatives should be permitted to enter unshored or otherwise protected excavations identified as unstable by a competent person, however shallow they are. The stockpiled material and excavations should be dampened during earthworks excavation and earth moving activities and vehicles should be washed before leaving site, with washings contained on site and suitably disposed.

Environmental monitoring for dust, odour, noise and vibration should be undertaken during the works and controls implemented to minimise potential for contaminated water to migrate off-site. This may require the use of holding ponds and settlement areas in wet weather conditions.

8.5 Made Ground Removal / Soil Capping Layers

Where the Made Ground remains at formation level in areas of soft landscaping or gardens, mitigation measures will be required.

Where Made Ground is to be removed to expose the underlying natural soils the formation should be inspected by a suitably qualified geoenvironmental engineer. A growth medium will be required to

[27] HSE (1991). Protection of Workers and the General Public during the development of contaminated land. Guidance Note HS(G)66, Health and Safety Executive, HMSO, 1991.
[28] CIRIA (1996). A guide for safe working on contaminated sites. Steeds JE, Shepherd E & Barry DL. CIRIA Report 132.
[29] CIRIA (2005) Environmental good practice – Site guide, 2nd Edition. CIRIA Report C650.

achieve finished levels and should comprise clean imported soil, including a minimum of 150mm of topsoil or 100mm of topsoil and 50mm of turf/sod.

Where the Made Ground is not removed, soil capping layers are required and should comprise:

- Communal soft landscaping: excavation of existing soils to a minimum depth of 450mm below proposed final level and placement of a minimum of 300mm of clean imported subsoil and a minimum of 150mm of topsoil or 100mm of topsoil and 50mm of turf/sod, with a geotextile separator layer at the base;

- Private gardens: excavation of existing soils to a minimum depth of 600mm below proposed final level and placement of a minimum of 450mm of clean imported subsoil and a minimum of 150mm of topsoil or 100mm of topsoil and 50mm of turf/sod, with a geotextile separator layer at the base.

The imported subsoil/topsoil should be from a known and reputable source and pre-import chemical laboratory analysis should be provided prior to importation for review by a suitably qualified geoenvironmental engineer. Following importation, the capping soils should be sampled and analysed for a suite contaminants consistent with those within the chemical assessment (Appendix K) at a frequency of 1 sample per 250m^3 of material for areas of communal soft landscaping and one sample / plot for private gardens.

The capping layer construction (presence of geotextile separator layer and soil thickness) should be verified following placement at a frequency of 1 pit per 150m^2 in areas of communal soft landscaping and one sample / plot for private gardens.

8.6 Water Supply Pipes

Findings of the ground investigation indicate that PE or metal pipes (not copper due to pH levels) could be adopted. These findings should be agreed with the local water company.

9. GEOTECHNICAL RECOMMENDATIONS

9.1 General

The following sections of this report provide preliminary recommendations regarding the geotechnical aspects of the development based on the information obtained during the ground investigations and the laboratory results.

9.2 Geotechnical Design Parameters

Geotechnical design parameters are based on the in situ SPT data, soil descriptions, results of the laboratory testing and published data. Based on the findings of the ground investigation, design parameters are provided within Table 12. These values are considered to be characteristic and are unfactored (Serviceability Limit State) parameters. Based on the groundwater monitoring records a moderately conservative groundwater level of 44.5mOD has been adopted. This level represents a perched water table at the base of the Made Ground. A deeper confined groundwater body is present within the granular Lambeth Group/ Upnor Formation with a design level of 33.5mOD, rising to level of 39mOD.

Table 12. Summary of Geotechnical Parameters

Stratum	Approx. Level to Top of Stratum (mOD)	Bulk Unit Weight γ_b (kN/m³)	Undrained Cohesion c_u (kPa) [c']	Friction Angle ϕ' (°)	Young's Modulus E_u (MPa) [E']
Made Ground	45	17	20 [0]	21	8[a] [6.4][b]
Head Deposits	44	18	35	21[d]	14[a] [11.2][b]
Reading Formation - Lambeth Group	42	20	100 + 14.8z[c] [2]	24[d]	60 + 8.88z[e] [48 + 7.1z][b]
Upnor Formation - Lambeth Group	32	19	-	38[f]	[85][g]
Upper Chalk Group	26	20	-	39[h]	-

a. Eu = 0.4*c_u from Padfield C J and Sharrock M J, 1983. Settlement of structures on clay soils.
b. *Based on 0.8E_u - Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.*
c. Z = depth below top of stratum
d. BSI Standards Publication, BS 8002: 2015, Code of practice for earth retaining structures.
e. *Based on 600 c_u - Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.*
f. *Peck, R.B., Hanson, W.E., and Thornburn, T.H., Foundation Engineering, 2nd Edn, John Wiley, New York, 1967, p.310.*
g. *Burland, Standing J.R., and Jardine F.M. (eds) (2001), Building response to tunnelling, case studies from construction of the Jubilee Line Extension London, CIRIA Special Publication 200.*
h. CIRIA C574 Engineering in Chalk

9.3 Foundations

9.3.1 Shallow Foundations

Lightly loaded structures including ancillary buildings and site cabins, and low rise housing may be constructed on shallow foundations bearing onto the Lambeth Group. It is recommended that shallow foundations are founded within the Lambeth Group, which is typically encountered on site at a depth of 2mbgl. The shallower Head Deposits material is not recommended for founding shallow foundations as this material demonstrates lower shear strengths. An allowable bearing capacity of 100kPa could be adopted for shallow foundations founded within the Lambeth Group. This value may be revised on review of detailed foundations design. It is recommended that insitu shear strength testing be undertaken at formation to confirm the lack of soft spots/ weak areas. Soft spots/ weak zones are areas which demonstrate a shear strength value <100kPa.

A raft foundation may also be appropriate for the proposed development subject to the proposed structural loads and settlement requirements. It is recommended that a raft settlement analysis be undertaken should this foundation solution be adopted.

In accordance with NHBC guidance[20] shallow foundations should be designed to account for the presence of potentially desiccated and medium volume change potential soils.

9.3.2 Piled Foundations

A preliminary pile design has been undertaken based on the findings of the site investigation. It is assumed that CFA piles will be used and that the existing site levels will remain and as such the pile platform levels have been assumed as +45.0mOD. It should be noted that disparate limestone bands and calcareous concretions may be encountered within the Lambeth Group. Additionally, flint gravels are present to the base of the Lambeth Group in the Upnor Formation. These hard bands should be considered when adopting appropriate piling methods. It is recommended that a piling contactor be approach with appropriate experience with piles in the Lambeth Group. Lastly, the presence of sub artesian groundwater within the Lambeth Group may pose a risk to pile formation. The preliminary pile designs are presented in Figure 6.

The following design assumptions should be considered by the piling contractor and are assumed for the preliminary pile design:

- The contribution to pile capacity from the Made Ground is discounted.
- Pile cut off level of +45.0mOD;

- Skin friction on the piles in the Lambeth and Upnor have been restricted to 140kPa, shaft friction is ignored in the Made Ground, no allowance is made for negative skin friction, or pile testing; and

- Factors of Safety (FoS) = EC7 'Combination 2' factoring: γ sf (skin friction) of 1.6, γ bf (base capacity) of 2.0 and Model Factor of 1.4. The limiting base stress of the Upnor Formation has been restricted to 10MPa[30].

- In the structured Upper Chalk Formation, an adhesion value of 0.80 has been taken, in accordance with CIRIA C574, Project Report 86[31].

- A limiting skin friction for structured chalk has been taken as 100kPa, based on CIRIA C574.

- An ultimate base stress of 10MPa has been adopted for the Chalk. Calculated based on multiplying the design SPT values by 200, following CIRIA C574 guidance.

Final detailed pile design and installation method will be undertaken and specified by the specialist piling contractor awarded the work. The piling contractor may show different pile toe levels and greater load capacity based on their design approach, interpretation of the ground model and design parameters, and also their experience with piling in similar ground conditions.

9.4 Excavations and Stability

Based on the findings of the investigation, excavations within the Made Ground and Topsoil are unlikely to be stable and will require temporary support or battering back to a safe angle during excavation and construction to prevent instability issues. Temporary excavations into the Head Deposits and Lambeth Group are expected to remain stable. Perched water was identified at the base of the Made Ground and may introduce instability into the side walls of the excavation. Control of the perched groundwater may be achieved by localised sump pumping during the excavation. Temporary batters should be constructed at an angle no greater than 1:3.

No operatives should enter un-shored or otherwise unprotected excavations identified as unstable by a competent person, however shallow they are, in accordance with the guidelines presented within CIRIA Report 97[32].

[30] CIRIA (2004) Engineering in the Lambeth Group C583
[31] CIRIA, (2003). *Shaft friction of CFA piles in chalk.* Project Report 86.
[32] CIRIA. (1992). *Trenching Practice (Second Edition)*. Construction Industry Research and Information Report 97.

9.5 Floor Slabs

Floor slabs should be constructed should be constructed above a void or void former layer to account for heave/shrink of the cohesive Lambeth Group deposits.

9.6 Pavements

It is recommended that the Topsoil is stripped from site and roadways/pavements are constructed onto Made Ground/ Head Deposits or Lambeth Group soils. A CBR value of <2.5% should be adopted for the Made Ground whilst a CBR value of 2.5% may be adopted for the Head and Upnor Formation and should be verified through in situ testing prior to construction.

9.7 Buried Concrete

The Design Sulfate (DS) and Aggressive Chemical Environmental for Concrete (ACEC) classes for each stratum are presented in Table 13 below based on the available geotechnical and chemical analysis data.

Table 13. Summary of DS and ACEC Classes

Stratum	DS Class	ACEC Class	TPS[a] DS Class	TPS ACEC Class
Made Ground	DS-1	AC-1s	-	-
Head Deposits and Undivided Reading Formation – Lambeth Group	DS-2	AC-2	DS-2	AC-2
Upnor Formation – Lambeth Group	DS-1	AC-1	DS-2	AC-2

a. TPS = Total Potential Sulfate

Based on the above results, DS-2 would be applicable to the Made Ground, Lambeth and Upnor Formation. Oxidisable sulfate percentages within the Lambeth Group suggests the potential for the state to be pyritic, therefore a Total Potential Sulfate class may be applicable. The Total Potential Sulfate (TPS) class of DS-2 for the Lambeth Group would be applicable at the site as open excavations e.g. pile cap and shallow foundation excavations are anticipated to extend into the stratum.

FIGURES

KEY

Locations

- TP Locations
- WS Locations
- CP Locations

LUL Zone of Influence

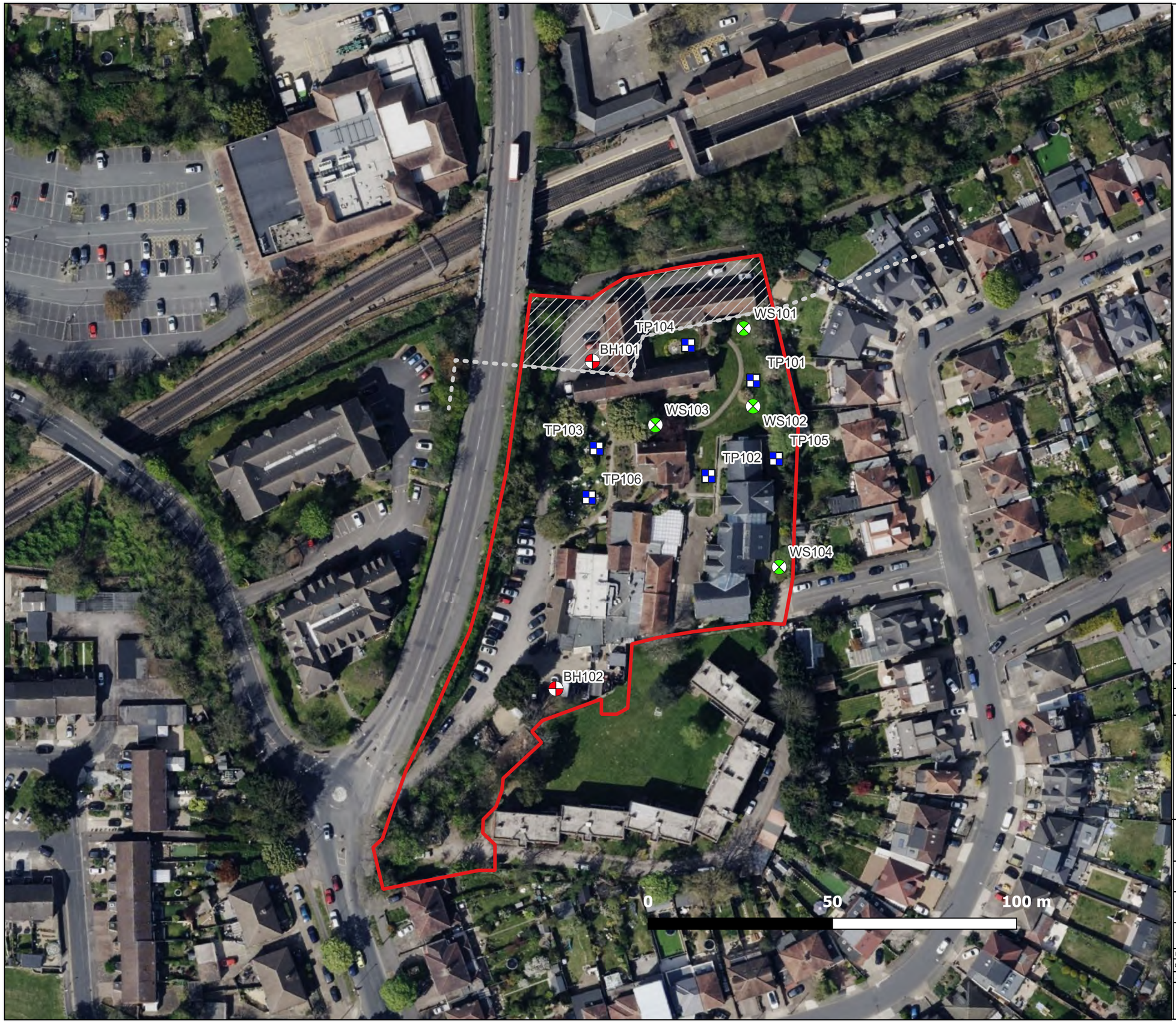
- LUL ZOI LINE
- LUL ZOI POLY

Rev	Date	Comments

Card Geotehnics Ltd
4 Godalming Business Centre
Wolsack way
Godalming
Surrey
GU7 1XW
T: 01483310600

Project	The Barn Hotel, West End Road, Ruislip HA4 6JB
Client	Chase New Homes Limited
Drawing title	Proposed Exploratory Hole Location Plan
Scale(s)	Job no. CG/39435

Drawn	DTM	09/11/2022	Dwg No. SR-01	Rev. 0
Checked	draft			
Approved	draft			



KEY

Site Boundary

Site Boundary

LUL ZOI Drawn

LUL ZOI LINE

LUL ZOI POLY

Exploratory holes

Cable Percussion Borehole

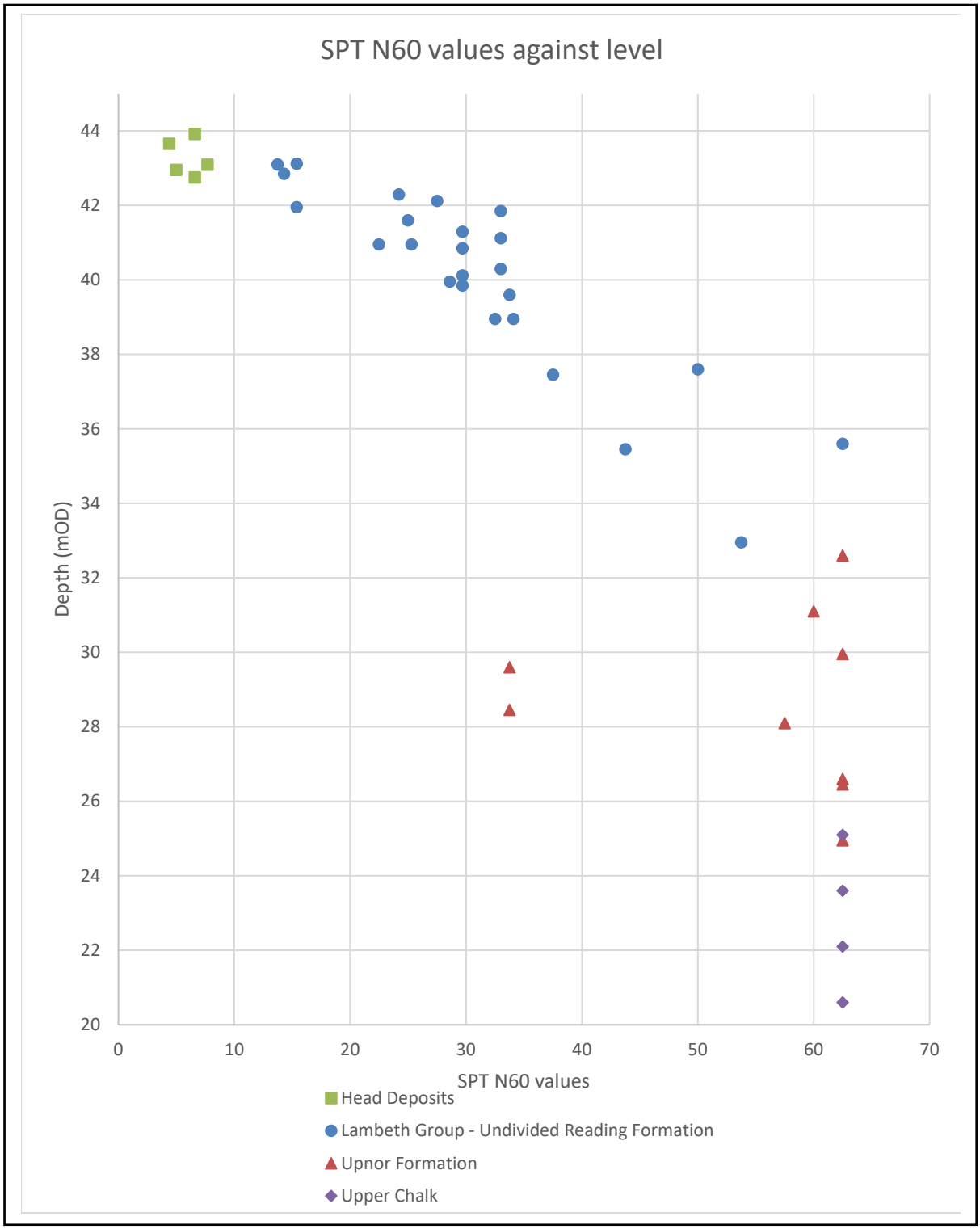
Trial Pit

Window Sample

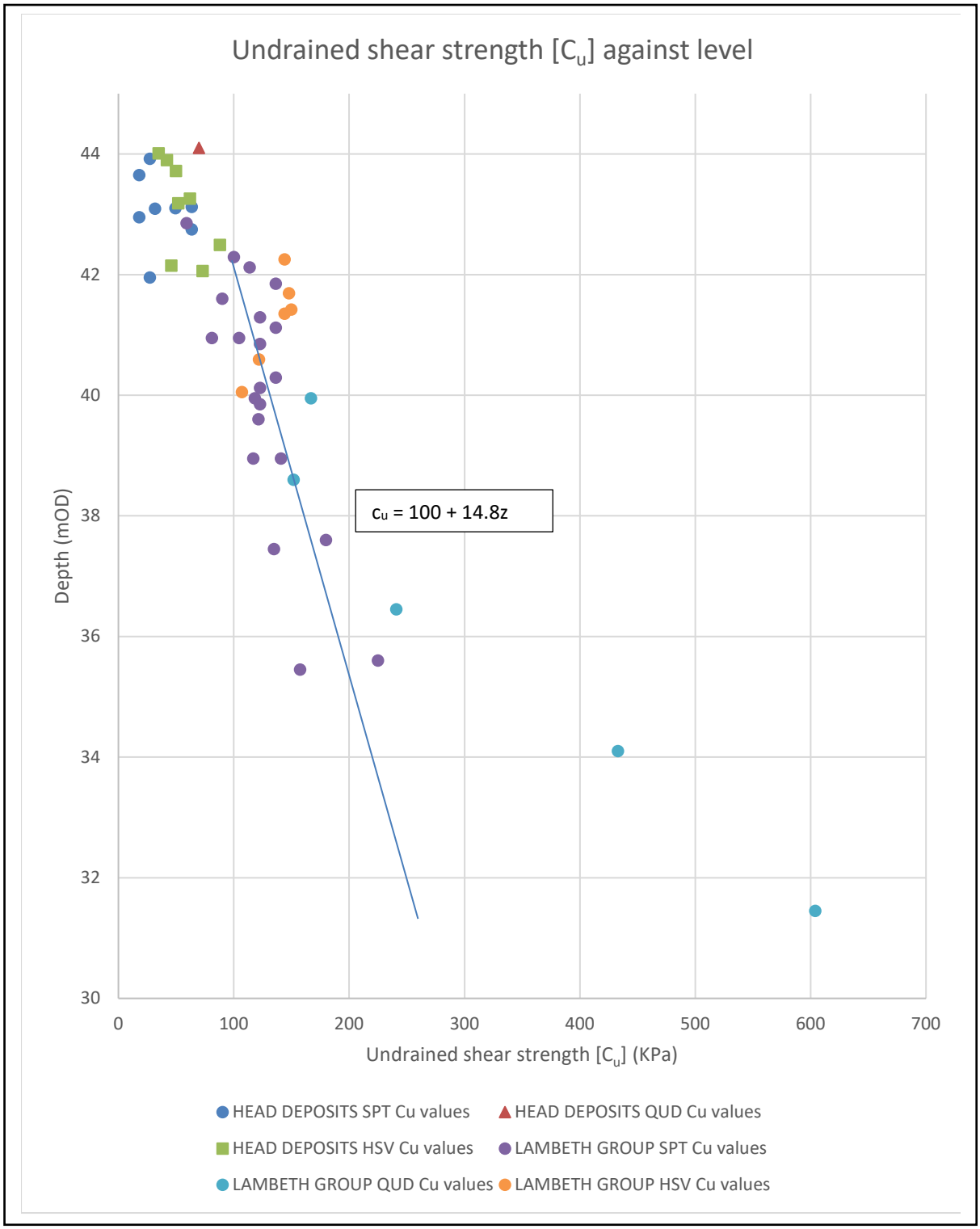
Rev	Date	Comments

Card Geotehnics Ltd
4 Godalming Business Centre
Wolsack way
Godalming
Surrey
GU7 1XW
T: 01483310600

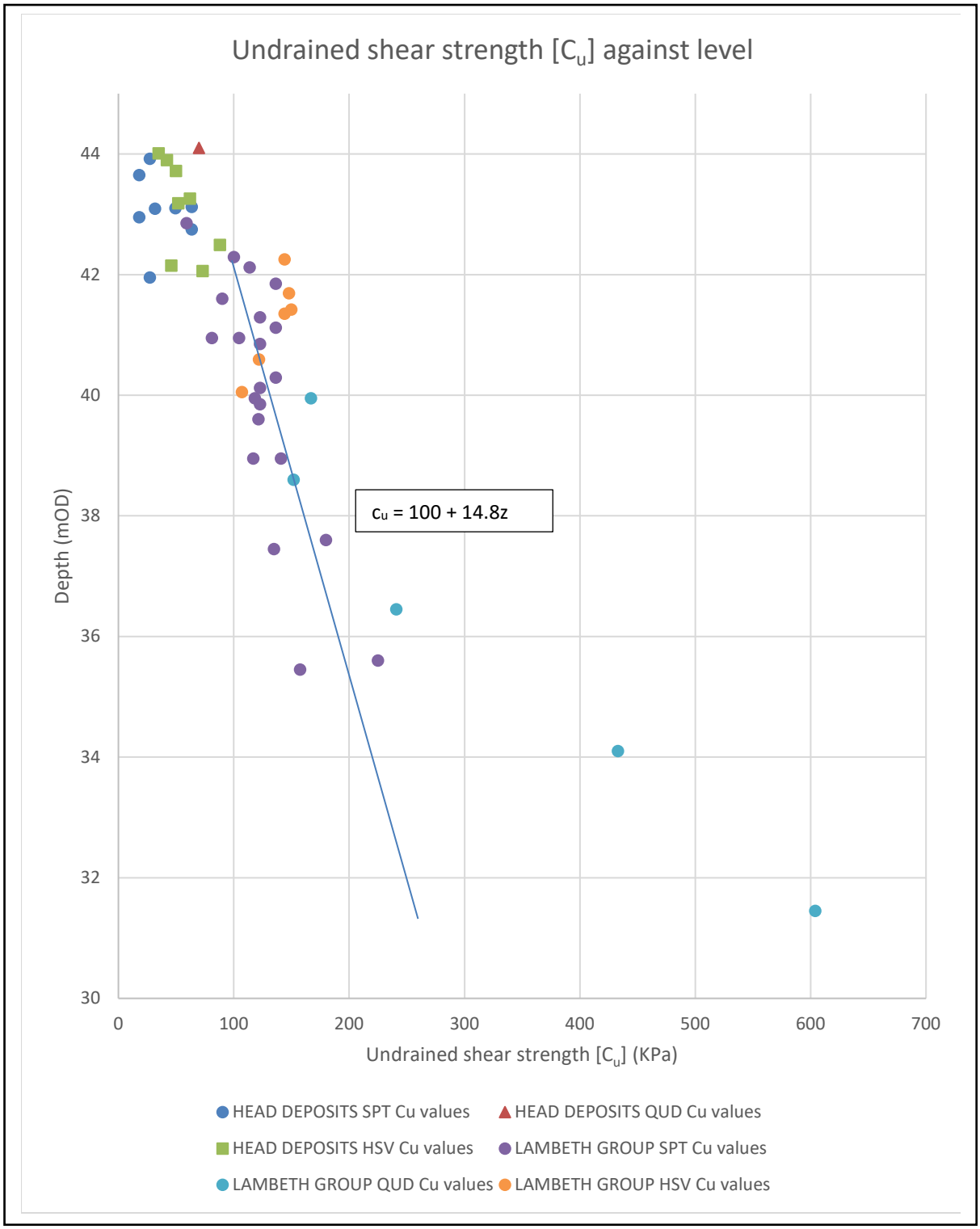
Project	The Barn Hotel, West End Road, Ruislip HA4 6JB
Client	Chase New Homes Limited
Drawing title	Figure 2 - Finalised Exploratory Hole Location Plan
Scale(s)	Job no. CG/39435
Drawn TSB 10/01/2023	Dwg No. CG/39435-001 Rev. 0
Checked	
Approved	



Client	Project	Job No
Chase New Homes Limited	**The Barn Hotel, West End Road, Ruislip, HA4 6JB**	**CG/39435**
CGL	Title **SPT N60 against level**	**Figure 3**



Client	Project	Job No
Chase New Homes Limited	**The Barn Hotel, West End Road, Ruislip, HA4 6JB**	**CG/39435**
CGL	Title **Undrained Shear Strength against Level**	**Figure 4**

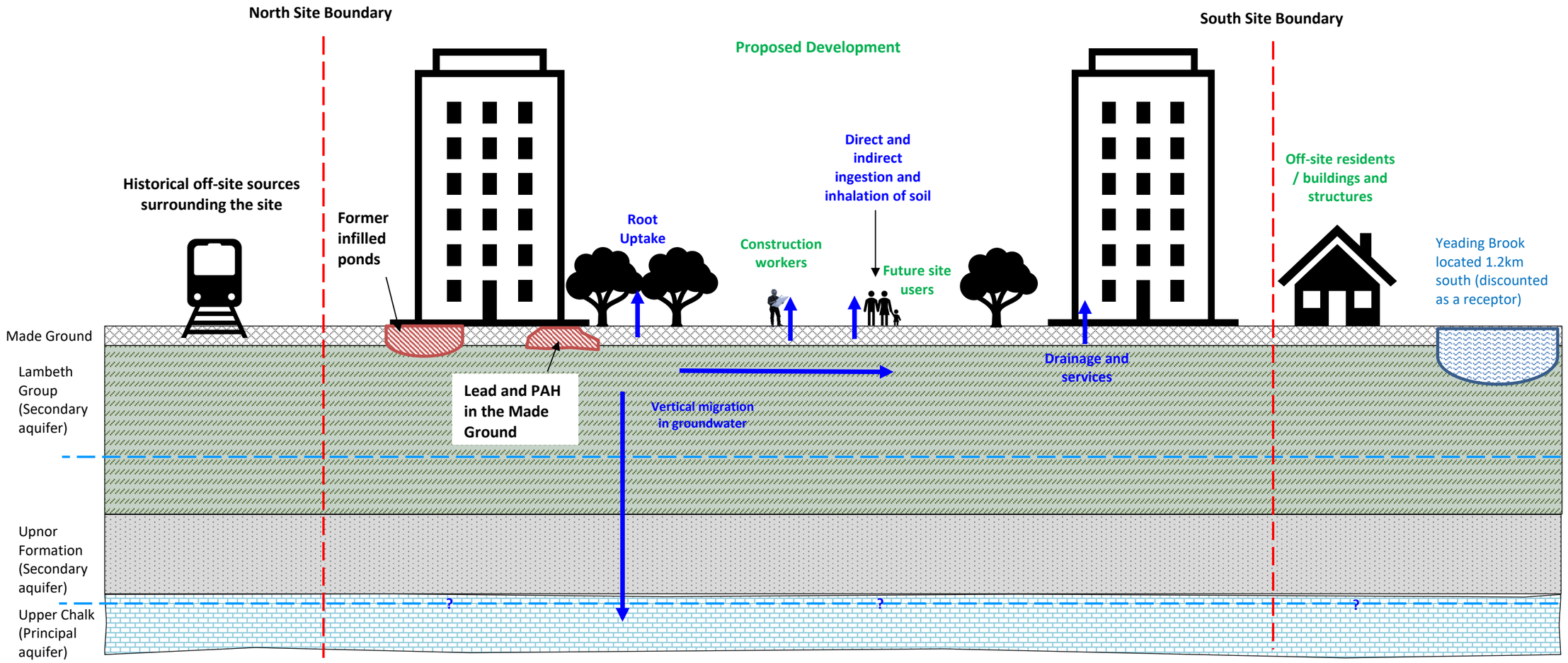


Client	Project	Job No
Chase New Homes Limited	**The Barn Hotel, West End Road, Ruislip, HA4 6JB**	**CG/39435**
CGL	Title **Undrained Shear Strength against Level**	**Figure 4**

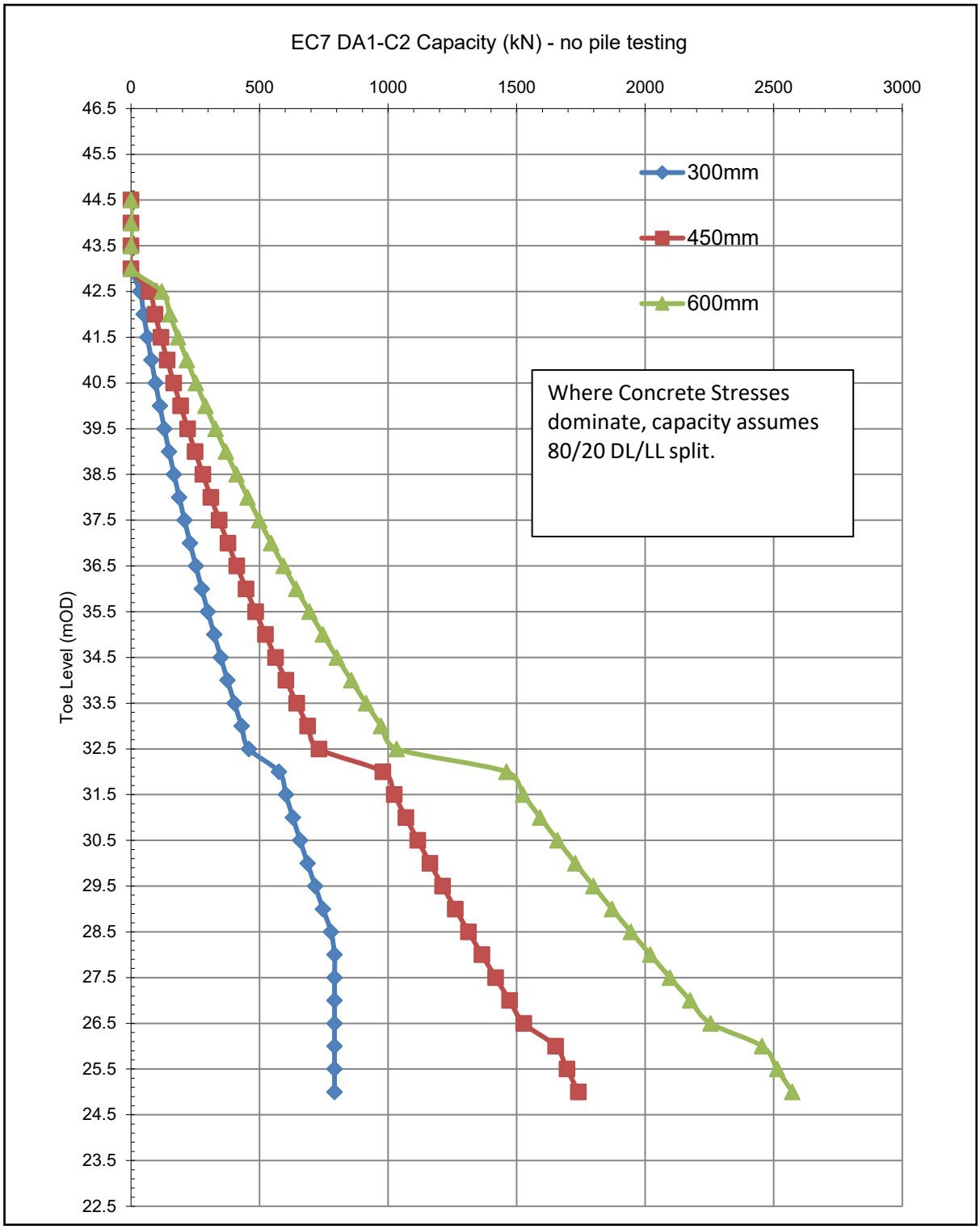
N

Contamination Pathways:

1. Direct contact with contaminated soils by future site users → Moderate/ Low → Elevated concentrations of lead and PAH recorded in the Made Ground. Capping layers will be required in areas of soft landscaping where Made Ground remains at formation level.
2. Direct contact with contaminated soils by construction workers → Low → Use of appropriate PPE and good hygiene should mitigate against contamination in the shallow soils.
3. Root uptake by vegetation → Moderate/ Low → Elevated concentrations of phytotoxic metals boron and zinc have been recorded in the Made Ground. Capping layers will be required in areas of soft landscaping where Made Ground remains at formation level.
4. Direct contact with underground services and structures → Moderate/Low → Standard polyethylene (PE) pipes and metal pipes (not copper) may be used, however the water supply company should be contacted to confirm their requirements for water supply pipes
5. Explosive/ asphyxiating gases/vapours from underlying soils (Made Ground) → Low → From the monitoring undertaken to date, the site confirms to CS1 where gas protection measures are not required.



Client	Project	Job No
Chase New Homes Ltd	**The Barn Hotel, West End Road, Ruislip, HA4 6JB**	**CG/39435**
CGL	Title: **Conceptual Site Model**	**Figure 5**



Client	Project	Job No
Chase New Homes Limited	**The Barn Hotel, West End Road, Ruislip, HA4 6JB**	**CG/39435**
CGL	Title: **Preliminary Pile Capacities**	**Figure 6**

APPENDIX A

Proposed Development Plan

CHASE
NEW HOMES
The Excitement is Building

Chase New Homes
Jasmine House
8 Parkway
Welwyn Garden City
AL8 6HG

Tel: 01707 660 660

NOTES

25 no. 1 bed flats approx 50 sq.m.
25 no. 2 bed flats approx 61 sq.m.
17 no. 2 bed flats approx 70 sq.m.
7 no. 3 bed houses approx 106.9 sq.m.

77 parking spaces

North

0 10 20 30 40 50 m

REV	AMENDMENTS	DATE
C	scheme including houses	20/04/22
B	revised access and parking	19/04/22
A	revised red line	08/04/22

DRAWN BY Author	DATE 02/24/22
SCALE (@ A1) 1 : 500	PROJECT NUMBER Project Number
CHECKED BY Checker	APPROVED

TITLE

Proposed site layout plan

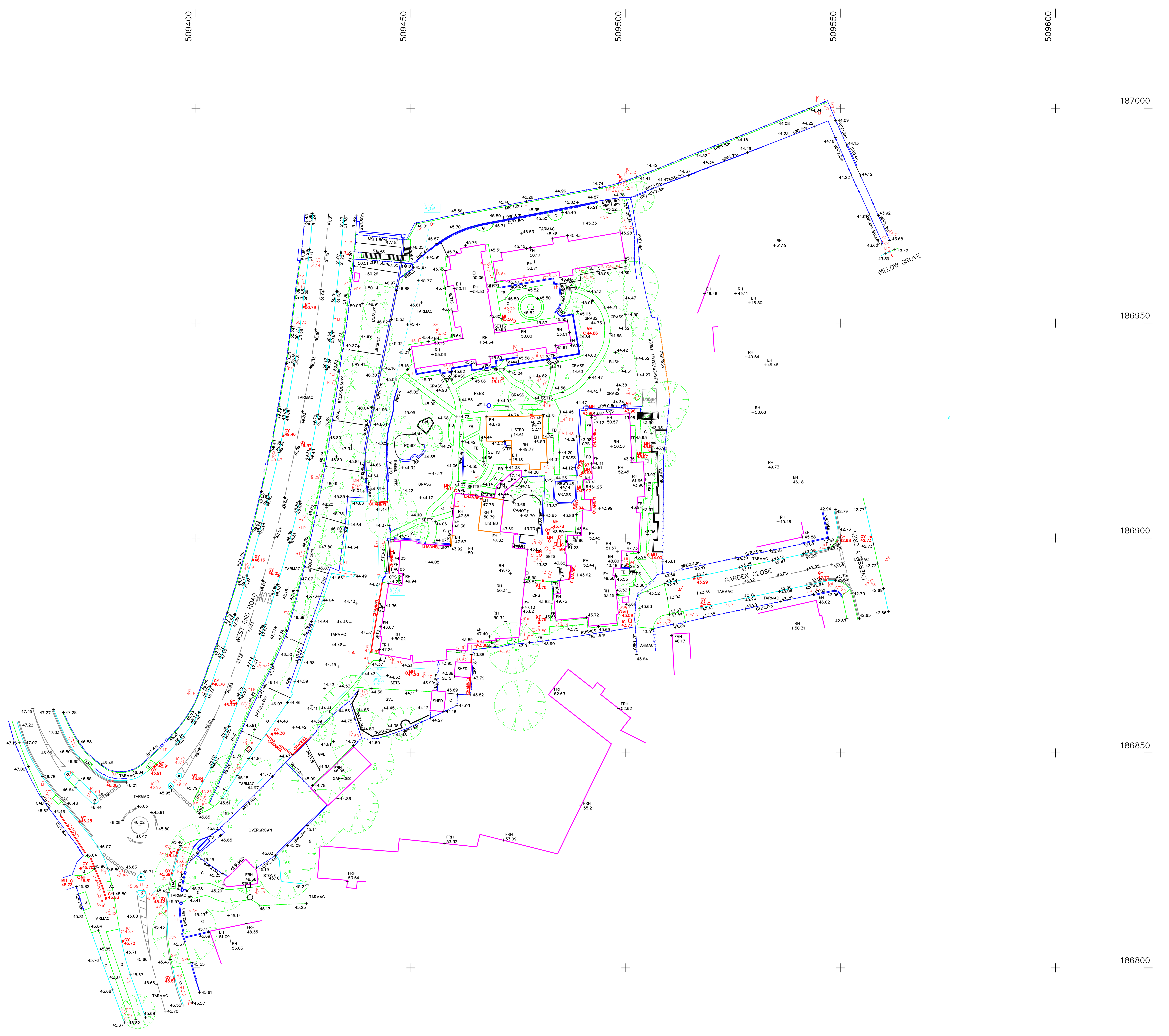
PROJECT

THE BARN HOTEL, WEST END ROAD, RUISLIP, HA4 6JB

DRAWING NUMBER

22 0063-1C

04/05/2022 11:29:09



TREE SCHEDULE				
NO.	GIRTH (DIA)	SPREAD	HEIGHT	TYPE
1	0.40	8.00	10.00	?
2	0.50MB	14.00	12.00	ASH
3	0.85	8.0	11.00	FIR
4	0.30	6.00	11.00	FIR
5	0.30	6.00	11.00	FIR
6	0.40	8.00	11.00	FIR
7	0.50	8.00	11.00	FIR
8	0.40	12.00	12.00	ASH
9	0.30	8.00	10.00.	ASH
10	0.35TB	8.00	12.00	ASH
11	0.20	6.00	8.00	ASH
12	0.20	6.00	8.00	ASH
13	0.45	11.00	12.00	ASH
14	0.30	8.0	9.00	S/BIRCH
15	0.40	7.00	9.00	S/BIRCH
16	0.35	0.00	0.00	STUMP
17	0.20	4.00	6.00	SYCAMORE
18	0.40	9.00	15.00	EUCALYPTUS
19	0.50	9.00	15.00	EUCALYPTUS
20	0.30	7.00	10.00	ASH
21	0.55	9.00	11.00	ASH
22	0.40	12.00	8.00	CHERRY
23	0.30	8.00	8.00	ASH
24	0.40	5.00	6.00	?
25	0.30TB	6.00	8.00	?
26	0.15	4.00	7.00	?
27	0.60	10.00	10.00	?
28	0.30	10.00	10.00	S/BIRCH
29	0.40	10.00	10.00	S/BIRCH
30	0.30	10.00	10.00	S/BIRCH
31	0.35	10.00	10.00	S/BIRCH
32	0.20	6.00	6.00	CHERRY
33	0.45	7.00	9.00	FIR
34	0.25	0.00	0.00	STUMP
35	0.30	6.00	6.00	?
36	0.25	0.00	0.00	STUMP
37	0.25	0.00	0.00	STUMP
38	0.30	0.00	0.00	STUMP
39	0.60	12.00	16.00	PALM
40	0.25	3.50	5.00	PALM
41	0.30	6.00	8.00	FIR
42	0.50	7.50	5.00	FIR
43	0.40TB	5.00	7.00	?
44	0.30	4.00	7.00	PALM
45	0.35TB	12.00	9.00	ASH
46	0.30	7.00	8.00	?
47	0.30	6.00	5.00	BAY
48	0.35	10.00	7.00	?
49	0.45	10.00	7.00	?
50	0.20	3.00	6.00	FIR
51	0.25	4.00	9.	?
52	0.40	8.00	10.00	C/BEACH
53	0.35	0.00	0.00	STUMP
54	0.45	3.00	4.00	PALM
55	0.35TB	4.00	4.00	FIR
56	0.30	6.00	8.00	?
57	0.40TB	12.00	15.00	ASH
58	0.65	15.00	16.00	?
59	1.60MB	15.0	15.00	?
60	0.45	8.00	10.00	SYCAMORE
61	0.60	14.00	15.00	SYCAMORE
62	0.40	10.00	13.00	?
63	0.50MB	16.00	16.00	?
64	0.30	8.00	12.00	?
65	0.30	8.00	12.00	?
66	0.30	8.0	10.00	SYCAMORE
67	0.50TB	15.00	15.00	SYCAMORE
68	0.40TB	12.00	12.00	SYCAMORE
69	0.40TB	12.00	12.00	SYCAMORE
70	0.20	8.00	10.00	SYCAMORE
71	0.20	8.00	10.00	SYCAMORE
72	0.50MB	12.00	15.00	SYCAMORE
73	0.30	12.00	15.00	SYCAMORE
74	0.30	12.00	15.00	SYCAMORE
75	0.30	12.00	15.00	SYCAMORE
76	0.30	12.00	15.00	SYCAMORE

ABBREVIATIONS

ABH	Arched Beam Height	KO	Kerb Outlet
B	Brick	L	Light
BAL	Balcony	LP	Lamp Post
BB	Belisha Beacon	MH	Manhole
BD	Bollard	MKR	Marker
BH	Beam Height	MSF	Metal Security Fence
BL	Bed Level	N/A	No Access
BP	Brick Pier	OHC	Overhead Cables
BRW	Brick Retaining Wall	P	Post
BS	Bus Stop	PALF	Palisade Fence
BT	British Telecom	PF	Picket Fence
BW	Brick Wall	PIT	Trial Pit
BWF	Barbed Wire Fence	PL	Pavement Light
C	Concrete	PM	Parking Meter
CAB	Cabinet	PRF	Post & Rail Fence
CBF	Close Boarded Fence	PWF	Post & Wire Fence
CBW	Concrete Block Wall	R	Render
CIF	Corrugated Iron Fence	RAD	Radiator
CL	Cover Level	RE	Rodding Eye
CLF	Chain Link Fence	RH	Ridge Height
COL	Column	RS	Road Sign
CPF	Concrete Panel Fence	RWP	Rain Water Pipe
CPS	Concrete Paving Slabs	S	Stone
CRW	Concrete Retaining Wall	SV	Stop Valve
CSU	Ceiling Slopes Up	SL	Skylight
CTV	Cable Television	SP	Soil Pipe
CW	Concrete Wall	SPS	Stone Paving Slabs
CZY	Crazy Paving	SRW	Stone Retaining Wall
D	Door	SW	Stone Wall
DH	Door Height	SWS	Surface Water Sewer
EC	Electricity Cover	TJ	Top of Joist
ESG	Electrical Switch Gear	T	TILE
EH	Eave Height	TI	Timber
EP	Electricity Pole	TRW	Timber Retaining Wall
FB	Flower Bed	UJ	Underside of Joist
FC	False Ceiling	UR	Underside of Ridge Board
F/E	Fire Escape	UWP	Underside of Wall Plate
FH	Fire Hydrant	V	Vent
FL	Floor Level	VP	Vent Pipe
GY	Gully	W	Window
GV	Gas Valve	WL	Water Level
HA	Hatch	WM	Water Meter
IC	Inspection Cover	WMF	Wire Mesh Fence
IL	Invert Level	WPF	Wooden Panel Fence
IRF	Iron Railing Fence	WCL	Window Cill Height
IWF	Interwoven Fence	WHL	Window Head Height
		WRW	Wooden Retaining Wall

Top / Banks / Bottom
Fences
Change in Surface
Edge of Vegetation
OS Data
3.28 Floor to Ceiling Height
Gate
Survey Station
+10.60 Floor Level
Tree

STATION CO-ORDINATE TABLE

Ref.	East	North	Elevation
1	509436.598	186873.332	44.453
2	509387.799	186817.886	45.800
3	509435.348	186966.123	51.238
4	509500.639	186981.226	44.636
5	509547.561	186998.113	44.146
6	509561.328	186966.642	43.575
7	509512.496	186887.962	43.462
8	509560.652	186894.904	42.899

NOTES

1. ALL LEVELS SHOWN ARE RELATED TO ORDNANCE SURVEY GPS DATUM.
2. TREE TYPES SHOWN ON THIS DRAWING CANNOT BE GUARANTEED AND IF CRITICAL SHOULD BE VERIFIED BY A TREE SPECIALIST. TREE SPREADS ARE AVERAGES UNLESS OTHERWISE INDICATED. TREE HEIGHTS ARE APPROXIMATE.
3. ALTHOUGH CARE HAS BEEN TAKEN, DUE TO ACCESS LIMITATIONS ALL HIGH LEVEL DETAIL HAS BEEN SURVEYED REMOTELY AND NOT CHECKED BY PHYSICAL MEASUREMENTS.
4. ALL CRITICAL MEASUREMENTS MUST BE CHECKED / VERIFIED.
5. ALL CO-ORDINATES AND LEVELS SHOWN RELATE TO AN ORDNANCE SURVEY DERIVED GRID.
6. ALL DRAINAGE INFORMATION SHOWN SHOULD BE VALIDATED IF CRITICAL. PIPE SIZES SHOWN ARE APPROXIMATE. CONNECTIONS BETWEEN MANHOLES HAVE BEEN DETERMINED BY SOUNDING METHODS ONLY AND CONSEQUENTLY SHOULD NOT BE RELIED UPON.

REVISIONS | DATE

N INDICATIVE ONLY

SCALE: 1:500@A1
DATE: JUNE 2022
DRAWN: SDC

TITLE: SITE SURVEY

JOB: THE BARN HOTEL, W END Rd. RUISLIP, HA4 6JB

CLIENT: CHASE GREEN HOMES

DWG. No: LUG / 9.0

LAND UTILITY GROUP LTD.

MIDLANDS OFFICE
UNIT 10
STRENSHAM BUSINESS PARK
TWYNING ROAD
WORCESTER
WR8 9JZ
T: 0845 602 3966
M: 07979 367282

LONDON OFFICE
BRICKFIELD HOUSE
HIGH ROAD
THORNWOOD
EPPING
ESSEX
CM16 6TH
T: 01992 566698
M: 07977 112286
M: 07977 111935

APPENDIX B

Historical Maps

Groundsure INSIGHTS

Site Details:

THE BARN HOTEL, THE BARN HOTEL, WEST END ROAD, RUISLIP, HA4 6JB

Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: County Series
Map date: **1865**
Scale: 1:2,500
Printed at: 1:2,500

N
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Surveyed 1865
Revised 1865
Edition N/A
Copyright N/A
Levelled N/A

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Production date: 14 November 2022

Map legend available at:
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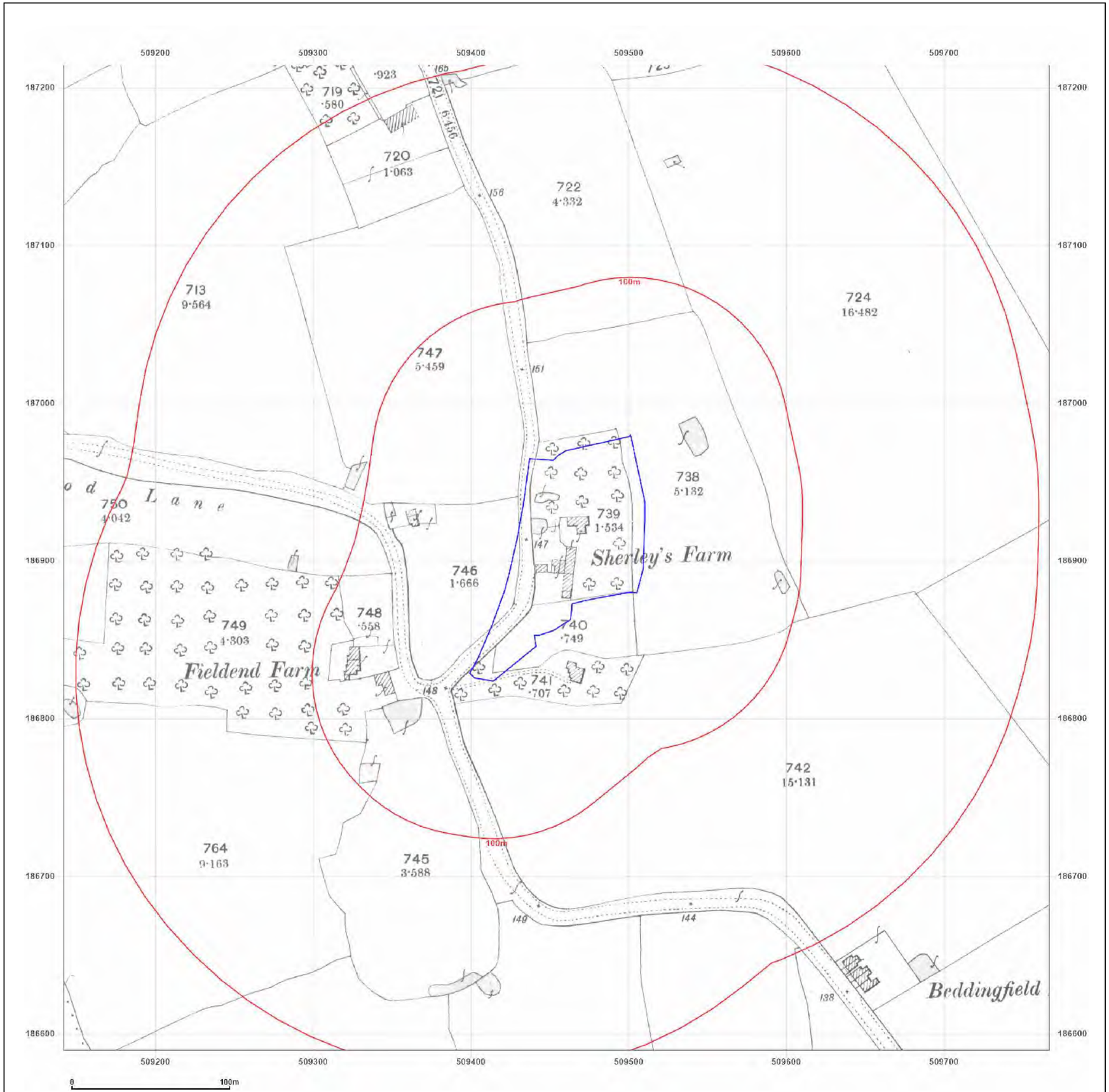

Groundsure INSIGHTS

Site Details:

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Grid Ref: 509454, 186902

Map Name: County Series
Map date: **1896**
Scale: 1:2,500
Printed at: 1:2,500

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Surveyed 1896
Revised 1896
Edition N/A
Copyright N/A
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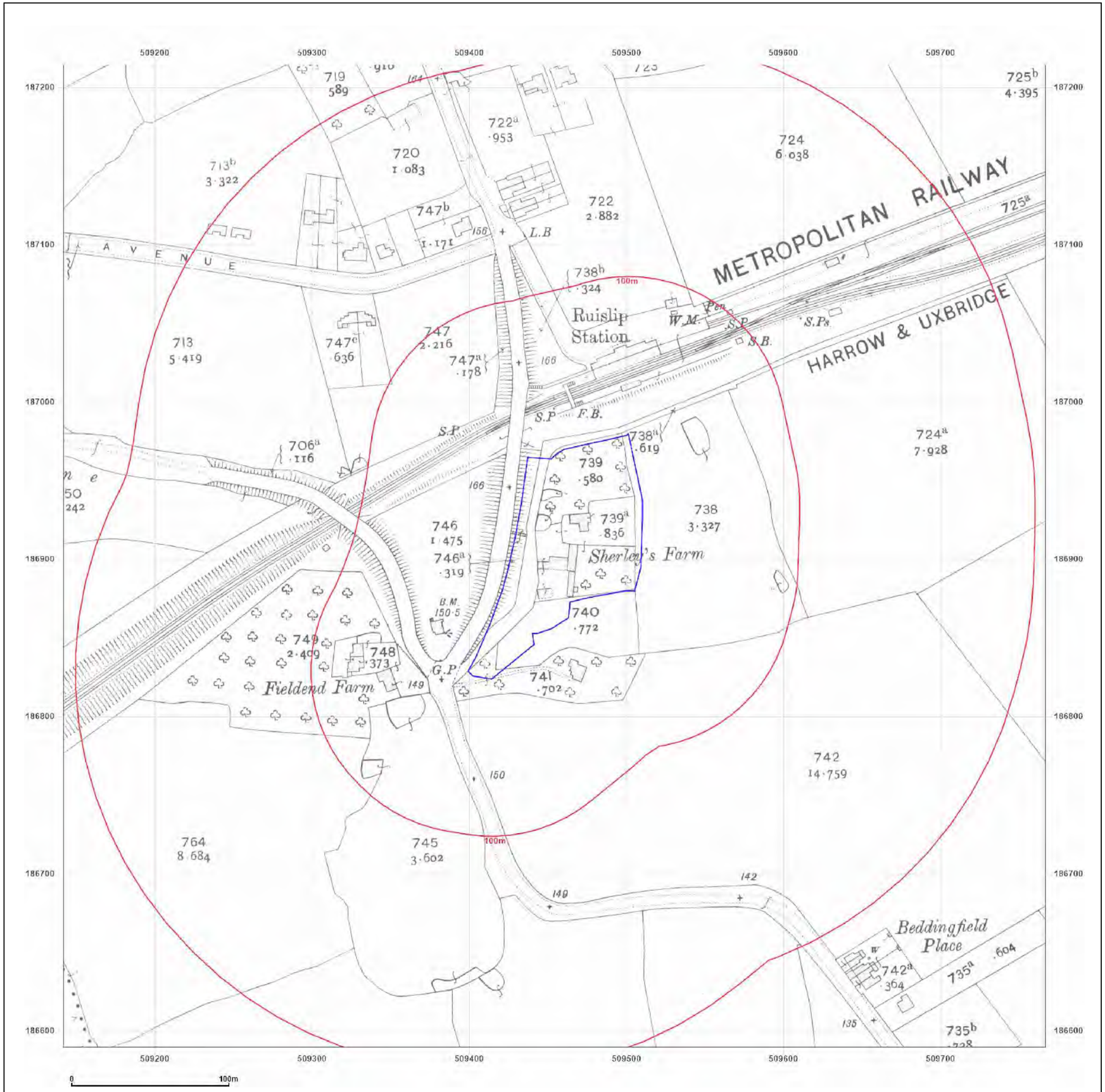

Groundsure INSIGHTS

Site Details:

THE BARN HOTEL, THE BARN HOTEL, WEST END ROAD, RUISLIP, HA4 6JB

Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: County Series

Map date: **1914**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1914
Revised 1914
Edition N/A
Copyright N/A
Levelled N/A

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Site Details:

THE BARN HOTEL, THE BARN HOTEL, WEST END ROAD, RUISLIP, HA4 6JB

Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: County Series
Map date: **1935**
Scale: 1:2,500
Printed at: 1:2,500

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Surveyed 1935
Revised 1935
Edition N/A
Copyright N/A
Levelled N/A

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Site Details:

THE BARN HOTEL, THE BARN HOTEL, WEST END ROAD, RUISLIP, HA4 6JB

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Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: County Series

Map date: **1938**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1938
Revised 1938
Edition N/A
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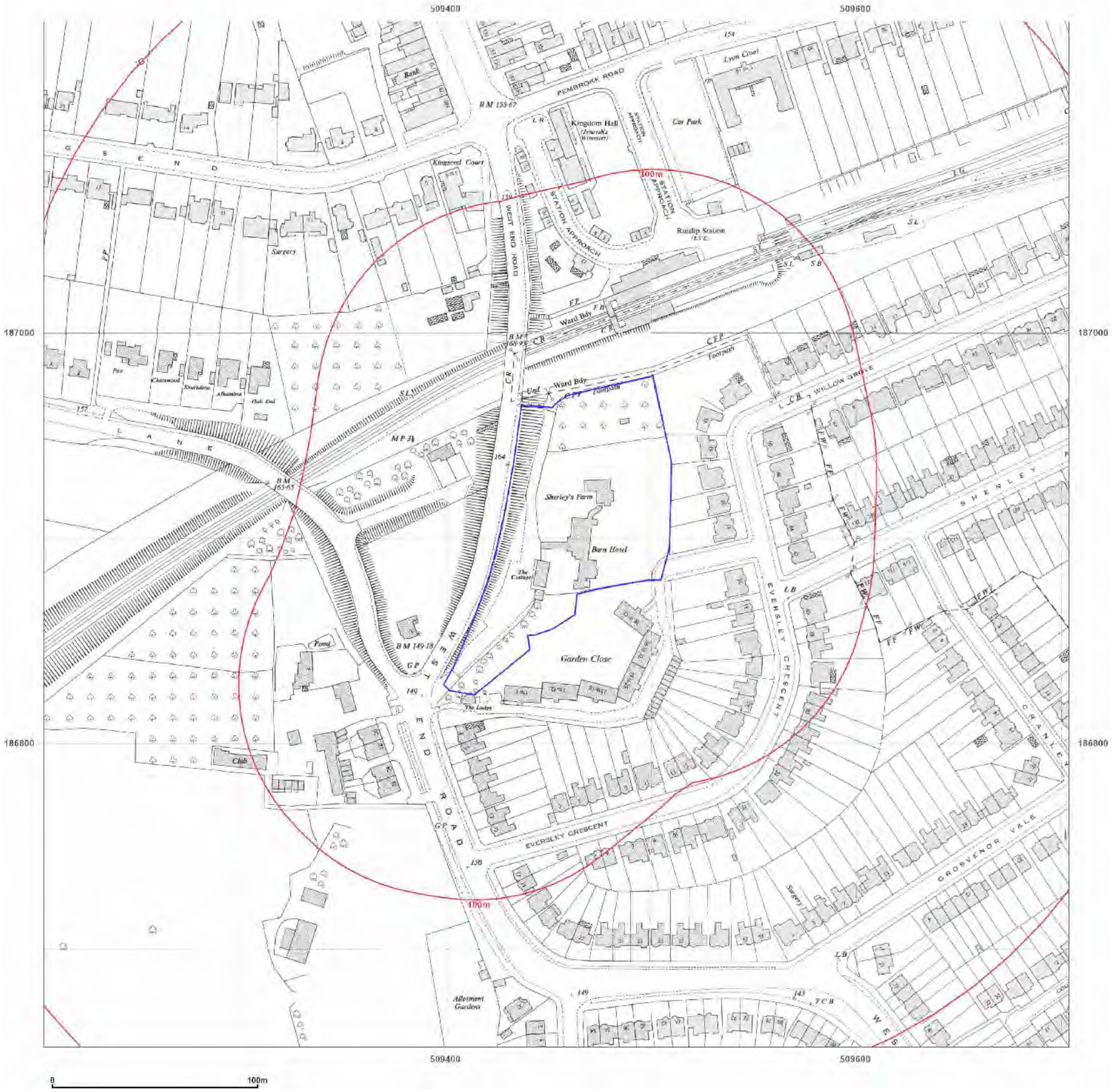

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Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid

Map date: **1960-1961**

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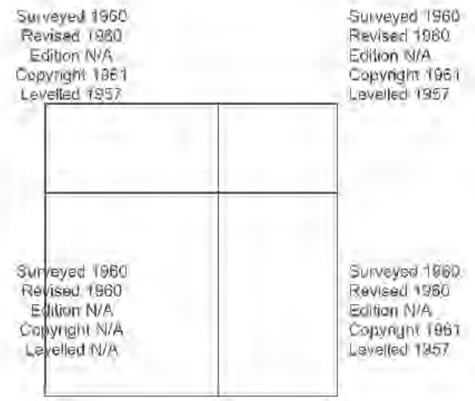

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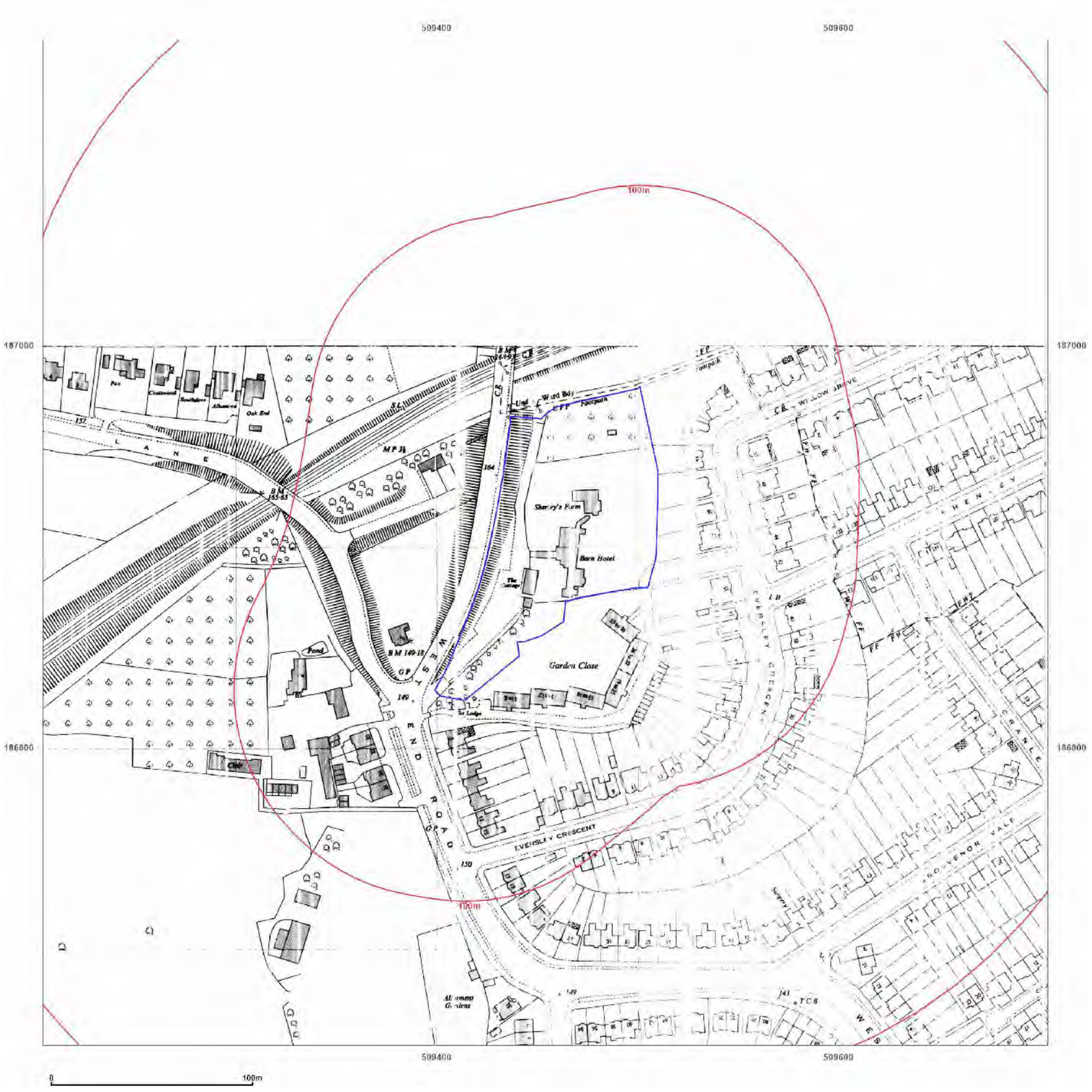

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Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid
Map date: **1961**
Scale: 1:1,250
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Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid

Map date: **1962**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1960
Revised 1960
Edition 1962
Copyright 1962
Levelled 1957

Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

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Site Details:

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Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid

Map date: **1962**

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Printed at: 1:2,500

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Surveyed N/A
Revised N/A
Edition N/A
Copyright N/A
Levelled N/A

Surveyed 1960
Revised 1960
Edition 1962
Copyright 1962
Levelled 1957

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Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid

Map date: **1961-1966**

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Printed at: 1:2,000

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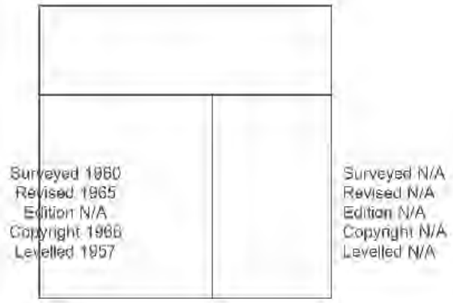

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Site Details:

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Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid
Map date: **1972-1974**
Scale: 1:1,250
Printed at: 1:2,000

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Surveyed 1960
Revised 1972
Edition N/A
Copyright 1972
Levelled 1957

Surveyed 1960
Revised 1973
Edition N/A
Copyright 1974
Levelled 1957

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Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid

Map date: **1982**

Scale: 1:1,250

Printed at: 1:2,000

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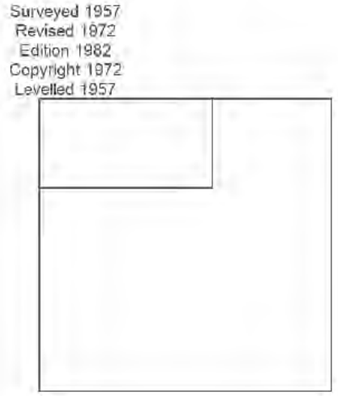

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Production date: 14 November 2022

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Site Details:

THE BARN HOTEL, THE BARN HOTEL, WEST END ROAD, RUISLIP, HA4 6JB

Client Ref: PO_011842
Report Ref: GS-9196486
Grid Ref: 509454, 186902

Map Name: National Grid

Map date: **1988-1992**

Scale: 1:1,250

Printed at: 1:2,000

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Surveyed 1991
Revised 1991
Edition N/A
Copyright 1991
Levelled N/A

Surveyed 1957
Revised 1988
Edition N/A
Copyright 1988
Levelled 1957

Surveyed N/A
Revised N/A
Edition N/A
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Revised N/A
Edition N/A
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