GROUND INVESTIGATION REPORT 4 THE GROVE, HIGHGATE, LONDON N6 6JU

TE1723-TE-00-XX-RP-GE-001-V02

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Prepared for:

SODA Studio

Prepared by: Andrew Harrison/ Stuart Milne

Tier Environmental Ltd

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EXECUTIVE SUMMARY

Introduction	Tier Environmental were commissioned by SODA Studio to undertake Ground Investigation works for a property located at 4 The Grove, Highgate, London N6 6JU. The investigation purpose was to characterise the underlying ground conditions with respect to their geotechnical properties in order to aid with foundation and basement design, to support a basement impact assessment.
Proposed land use	The proposed development will include extending an existing basement beneath the front garden area and replacing an existing greenhouse with a summerhouse and swimming pool in the rear garden.
Site location and surrounding land uses	The site is located at 4 The Grove, Highgate, London N6 6JU. Roughly rectangular in plan, the site comprises an existing multi storey property, dominating the eastern periphery and terraced rear gardens. Generally flat, the front garden area is paved with bricks and the rear garden comprises a brick paved patio, adjacent to the house, and grassed lawns with flower beds and bushes/trees around the perimeter. Red brick walls and iron rail fencing delineate the site on all sides. Residential properties and private gardens surround the property to the north, south and west. To the east is a gravel parking area, The Grove, main roads, and residential properties.
Site history	The existing property and gardens were constructed around 1688 and have remained relatively unchanged since this time.
Mining and Mineral Extraction	The Site Is not located within an area that has been subjected to historical mining or mineral extraction.
Previous investigations	Tier is not aware of any previous investigation works at the Site. However, a previous intrusive investigation has been undertaken for the adjacent property (No. 5), by third parties, which was made available at the start of these works. The investigation findings were summarized in a ground investigation report that should be read in conjunction with this report and is referenced as: • Geotechnical & Environmental Associates Limited – '5 The Grove, London N6 6JU, Ground Investigation and Basement Impact Assessment Report' (Report reference: J21179, dated 26 August 2021).
Fieldwork	6 No. windowless sample boreholes (WS1010 to WS106) to between 2.15m and 6.00m depth and a single hand dug pit (HDP01) to 1.20m depth.
Laboratory testing	Selected Made Ground samples were submitted for chemical analysis (heavy metals, non-metallic compounds, hydrocarbons, pH and asbestos) to confirm whether contaminated soils were present on-site. Natural soil samples were subjected to geotechnical testing. All testing was undertaken at accredited laboratories.
Ground conditions	The encountered ground conditions included a granular and clay rich Made Ground cover (to between 1.50m and 2.70m depth) overlying predominantly clay rich soils with granular pockets / horizons belonging to the Bagshot Formation, which were recorded to the full investigation depth at 6.45m. Perched groundwater was recorded within borehole WS101 at around 5.00m depth (114.55m AOD), during the investigation works and at 4.70m depth (114.85m AOD), during follow-on monitoring. A groundwater seepage was also recorded in WS102 at 3.70m depth (117.04m AOD). Where encountered, perched groundwater was associated with granular soils within the Bagshot Formation.
Ground stability	No ground stability issues have been recorded for the site.
Foundations and floor slabs	Foundations for the proposed summer house should be taken through the Made Ground to found on competent clay rich/granular Bagshot soils at 2.00m depth. Alternatively, a raft foundation solution could be adopted. The basement and swimming pool will be founded within the clay rich/granular Bagshot Formation soils. Consideration should be given to larger than anticipated settlements occurring beneath the proposed swimming pool due to potentially high compressibility soils. Mesh reinforcement should be considered where foundations cross different soil types, i.e. clay rich to granular.
Sulphate class	A Design Sulphate and Aggressive Chemical Environment for Concrete (ACEC) Class of DS-1 / AC-1 is considered appropriate for all on-site soils.
Contamination – Human Health	Elevated lead concentrations (269mg/kg and 486mg/kg) have been recorded within the Made Ground above the Generic Screening Criteria for human health and a residential land use with plant up take of 200mg/kg. Construction workers handling the Made Ground are the most likely human receptors at risk from elevated lead concentrations. The risk level can be reduced through employing good hygiene practice such as wearing gloves and appropriate PPE.
Radon Requirements	Basic radon protection measures are not currently required for the proposed development on this Site.

1. INTRODUCTION

Tier Environmental were commissioned by SODA Studio to undertake intrusive ground investigation works for a property located at 4 The Grove, Highgate, London N6 6JU. (Hereinafter referred to as "Site").

1.1. Proposed Development

Under current proposals the development will include extending the existing basement under the front garden and replacing a greenhouse, in the lower rear garden, with a summerhouse and swimming pool. The proposed summerhouse will likely be a lightweight timber structure clad in wood and glass. Due to the natural fall of the ground, the proposed swimming pool will be an above ground structure with a potential depth of around 2.00m.

The proposed site layouts for the front and rear gardens are included as drawings TE1723-TE-00-XX-DR-003-V01 and TE1723-TE-00-XX-DR-004-V01, in Appendix A.

1.2. Previous Reports

No previous reports pertaining to the Site itself have been made available. However, ground investigation works were undertaken by Geotechnical & Environmental Associates Limited (GEA) for the adjacent property (No. 5, The Grove) in June 2021. The findings were summarised in a ground investigation and basement impact assessment report that was made available at the start of these works and should be read in conjunction with this report, referenced as:

- Geotechnical & Environmental Associates Limited – '5 The Grove, London N6 6JU, Ground Investigation and Basement Impact Assessment Report' (Report reference: J21179, dated 26 August 2021).

Pertinent information from this report and applicable to the site has been referred to in this report.

1.3. Objectives

Taking into account the proposed development of the Site, the objectives of this appraisal were:

- To determine the historical and current land use.
- To establish the environmental setting of the Site.
- To evaluate whether past mining or other extractive industries could have an influence on the Site.
- To determine current ground and groundwater conditions.
- To determine the potential risks to human health within a proposed growing area.
- To provide a preliminary waste soils classification.
- To provide preliminary geotechnical parameters to inform basement and foundation recommendations.
- To assess soil permeability to aid with drainage design.

1.4. Assumptions

The following assumptions are made in this report:

- It is assumed that ground levels will not change significantly from those described in this report or a shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The ground investigation has been designed with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.
- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- The use of the terms ‘shallow’ and ‘deep’ within this report (from a geotechnical perspective) assume *typically* between ground level to circa 3.00m below ground level (bgl) for ‘shallow’ and greater than 3.00m bgl regarded as ‘deep’;
- The comments and opinions presented in this report are based on the findings of the desk study research, reviewed third-party information and ground conditions encountered during intrusive investigation works performed by Tier Environmental and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the Site which have not been revealed by this investigation and which have not been taken into account by this report.
- Responsibility cannot be accepted for any conditions not revealed by this investigation. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

This report has been prepared for the sole use of SODA Studio. No other third party may rely upon or reproduce the contents of this report without the written approval of Tier Environmental. If any unauthorised third party comes into possession of this report, they rely on it entirely at their own risk and the authors do not owe them any Duty of Care or Skill.

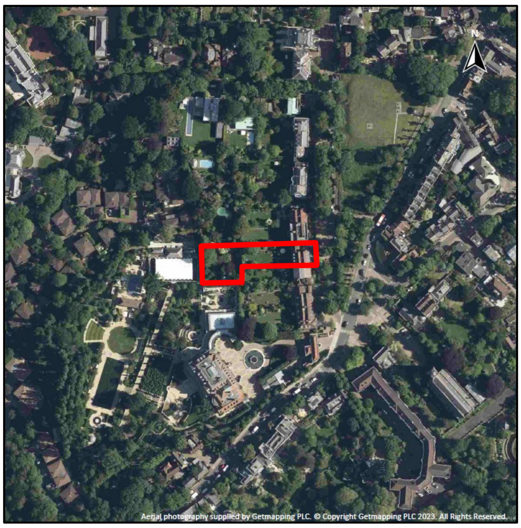
2. SITE DETAILS AND DESCRIPTION

Table 2.1 Current Site Overview.

Site name	4 The Grove
Site address	4 The Grove, Highgate, London, N6 6JU. A site location plan is included as Drawing No. TE1723-TE-00-XX-DR-001-V01 within Appendix A.
National Grid Reference (NGR)	528130 187270
Approximate Site area	0.17 ha
Site shape	The site is roughly rectangular in plan.
Current land use on the Site	The site is located within Highgate village in the London Borough of Camden. It includes a three-storey red brick Grade II* listed semi-detached property, with a basement, that dominates the eastern quarter of the site. The front garden, to the east, is flat and brick paved. Steps lead from the front garden along the property's northern edge to the rear garden, which comprises a paved patio leading to grass covered lawns that have been formed into two terraces. A red brick retaining wall separates the lower terraced rear garden from the upper part. A greenhouse is situated on the southern boundary to the lower terraced rear garden, which contains raised flower beds in the northwest corner and is also partly tree covered. Borders line the northern and southern boundaries to the upper terraced part of the rear garden. The site is accessed via a gate from the Grove on the eastern boundary and the front garden is delineated with red brick wall, metal rail fencing and trees. Delineating the rear garden are a vegetated red brick wall, hedging and trees. The existing site layout is shown on drawing TE1723-TE-00-XX-DR-002-V01 included in Appendix A.
Surrounding land uses	Private terraced gardens bound the site to the north and south and the grounds to Witanhurst Mansion bound it to the west. The Grove and trees bound the site to the east, beyond which are Highgate West Hill and private residences.
General topography and ground levels	The site is situated on elevated ground, above 125m Above Ordnance Datum (m AOD) forming Highgate Hill. Ground elevations sloping towards the southwest to around 70m AOD at Highgate Ponds (located at roughly 600m to the southwest). Ground surface elevations at the front (eastern side) of the house are at approximately 128.6m AOD and fall to around 126.7m AOD on the patio area to rear (western side) of the house. The rear garden generally falls from the patio area towards the west with the lower terraced rear garden sloping from around 122.7m AOD (in the east) to 119.1m AOD (in the west).

An aerial photograph (from the Groundsure report) of the Site and site boundary is shown below.

Figure 2-1 Recent Aerial Photograph from Groundsure



3. SITE HISTORY

3.1. Site Historical Review

The site history has been taken from historical Ordnance Survey (OS) plans obtained as part of a Groundsure Report for the site, Ref: 2429_TE1723, which is presented in Appendix B.

The earliest maps, dating from 1870, show the existing property as semi-detached with the existing gardens as per their current layout. The existing greenhouse within the lower terraced garden was shown on maps dating from 1896. The property forming one of several such semi-detached (existing) properties along the Grove to the north and south. The existing road layout and properties were shown to the east with a 'Waterworks' (covered), or reservoir on later maps located approximately 90m to the northeast. A large residential property, identified as Parkfield, was shown approximately 90m to the south. To the west was open parkland belonging to Fitzroy Park with two large pools approximately 50m from the western site boundary. Several glass houses were shown immediately adjacent to and approximately 30m to the north and west.

Maps dated from around 1938 onwards show the existing house and neighbouring properties had been joined to form a single terrace. Parkfield had been replaced with a much larger building, identified as the existing Witanhurst Mansion, the grounds to which were shown bounding the site to the west. The pools and glasshouses to the north and west were no longer shown on maps dating from this time.

Anecdotal evidence from the client indicates that the property (No. 4 The Grove), is a Grade II listed terraced house that was built around 1688.

Google Earth imagery dated between December 1945 and September 2021, show the site and surrounding area as they currently appear.

3.2. Preliminary Unexploded Ordnance Risk Assessment

A Preliminary UXO Risk Assessment was completed for the ground investigation works at No. 5 The Grove which identified a minimal risk of encountering unexploded ordnance at the site. The reasons given for this were as follows:

"The site was located within the Metropolitan Borough of St Pancras during the Second World War which was subject to high bombing density. The site itself remained unchanged between pre and post war mapping, and no records of bomb drops or bomb damage are recorded within the site vicinity. The closest record is 90m south of the site".

In line with CIRIA C681: Unexploded ordnance (UXO) A guide for the construction industry, a preliminary UXO risk assessment has been completed for the site.

Table 3.1 Preliminary UXO Risk Assessment.

	Yes/no	Comments
Is the Site indicated to have been directly bombed?	No	There are no records for direct bomb drops associated with the site.
Is the site within an area recorded to have been bombed?	Yes	The borough was subject to high density bombing.
Could the site have been a high-risk target?	No	The site is within a residential area that has remained unchanged since before the Second World War.
Any development cycles since 1945?	No	No change is shown from pre to post war historical OS maps.
Mitigating Factors	Yes	No recorded bomb damage in site vicinity.
Preliminary assessment of UXO Risk	Low	The site is considered to be at relatively low risk.
Further works?	No	None required.

4. ENVIRONMENTAL SETTING

4.1. Geology

The site is situated on elevated ground that falls towards the southwest.

The published British Geological Survey (BGS) map Sheet 256, "North London", dated 2006 and information contained within the Groundsure report (Appendix C), indicate the site to be devoid of superficial deposits. The underlying bedrock is shown to be the Bagshot Formation, which is Eocene in age and formed under alternating fluvial and shallow marine conditions. The BGS Geo-Index website (www.webapps.bgs.ac.uk), generally describes this stratum as 'pale yellow-brown to pale grey or white, locally orange or crimson, fine- to coarse-grained sand that is frequently micaceous and locally clayey, with sparse glauconite and sparse seams of gravel'. Underlying this stratum is clay strata belonging to the Claygate Member (part of the London Clay Formation). The Claygate Member is generally described as 'dark grey clays with sand laminae, passing up into thin alternations of clays, silts and fine-grained sand, with beds of bioturbated silt'.

Historical BGS borehole records located approximately 32m northwest (TQ28NE446) and 155m southwest (TQ28NE447) both recorded Made Ground to 1.00m depth. London Clay (between 126m thick in TQ28NE447 and 128m thick in TQ28NE446), was recorded beneath the Made Ground, to between 127m (TQ28NE447) and 129m (TQ28NE446) depth. In turn, the London Clay was underlain by Thanet Sands (between 17m thick in TQ28NE447 and 18m thick in TQ28NE446), to between 144m (TQ28NE447) and 147m (TQ28NE446) depth. Chalk with Flints (57m in TQ28NE446 and 62m TQ28NE447) was recorded to the full borehole depths at 204m (TQ28NE446) and 206m (TQ28NE447), underlying the Thanet Sands. No groundwater observations were given.

No records for faults or other major geological structures are shown either on-site or within 250m of the site.

4.2. Mining and Mineral Extraction

The site is not located within in an area likely to be affected by coal mining. A single mineral extraction entry is recorded within 250m of the site and located roughly 50m to the southwest and identified as unspecified ground workings.

4.3. Ground Stability

The potential risk for the site to be impacted by hazards associated with compressible deposits, ground dissolution or shrinking and swelling clays is given as negligible. For running sands, the potential risk is given as low and for collapsible deposits and landslides as very low.

4.4. Hydrogeology

The site is situated on elevated ground at between roughly 127m AOD and 122m AOD, with ground elevations sloping towards the southwest. Topographic and geological information indicate that groundwater is likely to occur at depth and within the Thanet Sands that underlie the London Clay Formation. Perched groundwater is anticipated to be present within granular pockets and horizons associated with the Bagshot Formation.

Both the Bagshot Formation and Claygate Members have been designated by the Environment Agency as Secondary A Aquifers.

There are no groundwater source protection zones (SPZs) located either on-site or within 250m of the site.

4.5. Hydrology

The site is situated on elevated ground with ground surfaces sloping very gently towards the west and covered in brick paving/ an existing property over the eastern end and grassy lawns over the western half. Therefore, surface water is anticipated to occur as overground flow to on-site drainage networks over hard surfaces, within the front garden area, and to percolate directly into the ground within the rear gardens.

There are no surface water courses within 250m of the site. The covered, below ground reservoir, is the nearest surface water feature to the site, located approximately 90m to the northeast. Various minor water courses and the 'Highgate Ponds' are located downslope and over 300m to the southwest, which are anticipated to be features sat on top of the underlying clay strata belonging to the Claygate Member.

The site is situated within a Flood Zone 1 and not at risk from flooding due to fluvial sources. The potential risk of flooding from groundwater and surface water sources is considered to be low.

4.6. Soil Chemistry

The Groundsure report indicates that the site is within an area where the BGS estimated urban soil chemistry for elevated metal concentrations are 22 mg/kg (Arsenic), 368 mg/kg (Lead), 0.5 mg/kg (Cadmium), 86 mg/kg (Chromium), 46 mg/kg (Copper), 22 mg/kg (Nickel) and 16 mg/kg (Tin). BGS Measured Urban Soil Chemistry concentrations are recorded as 22.4 mg/kg (Arsenic), 382.2 mg/kg (Lead), 0.5 mg/kg (Cadmium), 84.5 mg/kg (Chromium), 45.9 mg/kg (Copper), 21.9 mg/kg (Nickel) and 15.4 mg/kg (Tin).

4.7. Radon Risk

The site is located within a low probability radon area where less than 1% of properties above the Action Level. Therefore, no radon protection measures are required within new properties or extensions.

4.8. Previous Investigations

No previous reports pertaining to the Site itself have been made available. However, a previous ground investigation has been undertaken by third parties, Geotechnical & Environmental Associates Limited (GEA), for the adjacent property (No. 5, The Grove) and the findings summarised in the following report, which should be read in conjunction with this report, referenced as:

- Geotechnical & Environmental Associates Limited – '5 The Grove, London N6 6JU, Ground Investigation and Basement Impact Assessment Report' (Report reference: J21179, dated 26 August 2021).

The intrusive works included 8 No. shallow hand dug foundation inspection pits and 3No deep demountable cable percussion boreholes (BH1 to BH3) that included measurement of in-situ soil strengths using standard penetration test (SPT) equipment. During the investigation works, soil samples were collected for logging purposes and laboratory chemical analysis and geotechnical testing. Upon completion, boreholes BH1 to BH3 where installed with groundwater monitoring standpipes to between 10.00m and 6.00m depth. The foundation inspection pits were backfilled with arisings on completion.

The encountered ground conditions included a Made Ground cover overlying predominantly clay rich and granular soils belonging to the Bagshot Formation and clay soil interpreted as the Claygate Member. The Made Ground, encountered to between 0.80m and 2.00m depth, generally included brick paving and sands and cement (BH1) over dark brown clayey gravelly sand that included brick ash and glass fragments. The underlying Bagshot

Formation was encountered to a maximum investigation depth, at 15.00m (BH1), and the clay rich soils were generally described as firm to stiff orange brown and/mottled grey sandy and sandy gravelly clay with bands and lenses of clayey sand. Clay soils interpreted as the Claygate Member were recorded to the full investigation depth, at 20.45m (BH1), and were generally described firm grey sandy clay with lenses of fine sand. The Granular soils were generally described as medium dense to dense orange brown and brown silty clayey sand and gravelly sand. During drilling, groundwater (probably Perched) was recorded at between 6.00m and 14.00m depth and associated with the granular Bagshot Sand horizons. The report indicates that no follow-on groundwater monitoring was undertaken.

Selected Made Ground samples from 5 No. exploratory holes (BH2, BH3, TP1, TP2 and TP11), were sent to the laboratory for chemical analysis that included heavy metals, total cyanide, total phenols, total Polycyclic Aromatic Hydrocarbons (PAH), sulphide, benzo(a)pyrene, naphthalene, Total Petroleum Hydrocarbons (TPH), total organic carbon, pH and asbestos. The results were compared to C4SL and S4UL guideline values for a residential end-use with plant uptake. With the exception of lead, no contaminants analysed for were recorded above their Generic Screening Criteria for the proposed end-use. However, for lead, elevated concentrations between 82 and 800 mg/kg were recorded with 4 No. samples (between 330mg/kg and 800mg/kg) exceeding the GAC of 200mg/kg for a residential end-use with plant uptake.

The lead source was unknown and put down to possibly being lead based paint or coal within the Made Ground. It was noted from their Envirocheck report that the site lies within an area known to have elevated background lead concentrations, between 300mg/kg and 600mg/kg. Unverified, anecdotal information to the north of the site indicated that background lead concentrations could potentially be as high as 900mg/kg. The background concentrations recorded generally agreeing with what was found with the Groundsure report (Section 4.6). In the GEA report, it was argued that the proposed development would not result in an increase in soft landscaping at the site. Therefore, the exposure to lead in Made Ground would remain the same as it had historically. It was concluded that remediation measures for end-users were not envisaged; however, protection measures would be required for construction workers, i.e. good hygienic working practices when handling contaminated soils, in association with published guidance.

Borehole and laboratory report extracts from the GEA investigation are included in Appendix D.

6. FIELDWORK

The information contained in this report is limited to areas of land accessible during the ground investigation within the Site boundary, as indicated on the Site plan (TE1723-TE-00-XX-DR-001-V01), included in Appendix A.

Tier Environmental scoped the intrusive ground investigation using guidance presented in:

- BS 5930:2015+A1:2020;
- BS EN 1997:2004 and 2007.

Tier Environmental's standard strata description criteria are compliant with the above guidance.

6.1. Scope of Ground Investigation

The ground investigation works were conducted between 13th and 14th February 2023 and supervised by a suitably qualified Tier Geo-Environmental engineer. Table 6.1 and Table 6.2 below provide a summary of the exploratory holes completed, their rationale and installations. Exploratory hole locations are presented on Drawing No. TE1723-TE-00-XX-DR-005-V01 in Appendix A.

Table 6.1 Scope of Ground Investigation and Rationale

Exploratory Hole Type	Exploratory Hole Reference	Exploratory Hole Depths (m bgl)	Rationale
Window sample boreholes with demountable rig. (Rear Garden Area).	WS101 to WS103	6.00m to 6.45m	To confirm the shallow ground conditions across the Site, conduct *in situ* soil strength tests using Standard Penetration Test (SPT) apparatus, facilitate collecting soil samples for logging purposes and laboratory geotechnical testing and chemical analysis. Boreholes also facilitated installing standpipes for groundwater monitoring and falling head tests.
Window sample boreholes with standard rig. (Front Garden Area).	WS014 to WS106B	2.00m to 6.45m	
Hand dug pit.	HDP1	1.20m	To collect soil a sample for logging purposes and laboratory chemical analysis.

Table 6.2 Scope of Monitoring Installations

Exploratory Hole Location	Strata Targeted	Slotted Response Zone (m bgl)	Rationale
WS101	Bagshot Formation	1.00-6.00m	Targeting potential perched groundwater within granular horizons/lenses.
WS104		1.00-5.00m	
WS106B		1.00-5.00m	

The investigation works also included in-situ falling head permeability tests within the installed boreholes. Tests were undertaken in borehole WS101 only on 14th February, during the investigation works, and in boreholes WS101, WS104 and WS106B during a follow-on groundwater monitoring visit on 6th March 2023.

No constraints were encountered during the ground investigation.

Depths and accurate descriptions of strata and groundwater observations made during investigation works, together with details of the samples recovered, are presented on the Engineer's exploratory hole records in Appendix E. The falling head permeability test results are included in Appendix F .

6.2. Geotechnical Testing

Laboratory geotechnical testing was scheduled by Tier Environmental on selected samples as presented in Table 6.3. The testing was performed by K4 Laboratories, at their Watford laboratories, a UKAS (No. 2519) accredited (where appropriate) laboratory. Test certificates including details of the testing undertaken are presented in Appendix G and the testing undertaken detailed in Table 7.4 below:

Table 6.3 Geotechnical Laboratory Testing Schedule.

Test	Stratum type	Number of tests	Rationale
Natural Moisture Content determinations	Bagshot Formation	6	Soil classification.
Atterberg Limits	Bagshot Formation	4	Soil classification (Liquid Limit, Plastic Limit and Plasticity Index).
Particle size distribution (wet sieve method)	Bagshot Formation	2	Soil classification.
Unconsolidated quick undrained triaxial compression tests	Bagshot Formation	2	Determine the laboratory undrained shear strength for clay rich soils.
One-dimensional consolidation	Bagshot Formation	2	Determine the long-term consolidation behaviour of clay rich soils.
BRE SD1 Suite	Made Ground	4	Determine the potential for aggressive ground condition classification towards buried concrete.
	Bagshot Formation	2	

6.3. Chemical Analysis

In order to better determine whether chemical contamination was present on-site, selected Made Ground samples from boreholes WS104 (0.70m depth), WS105 (1.30m depth) and HDP1 (0.60m depth) were sent for chemical analysis. Made Ground samples were selected as these soils occur at shallow depth and represent potentially contaminated soils that end-users and construction workers are most likely to come into contact with. The selected samples were analysed for a suite of chemicals most likely to be associated with Made Ground.

Samples for chemical analysis were sent to Element Materials Technology, at their Deeside laboratory, a UKAS (No. 4225) and MCerts (where appropriate for soils analysis) accredited laboratory. A full list of determinants analysed along with the UKAS accreditation for each individual testing method are shown on the laboratory test certificates included in Appendix H and are presented in Table 6.4 below:

Table 6.4 Schedule of Chemical Testing for Human Health Risk Assessment and Preliminary Waste Soils Assessment.

Laboratory analysis	Made Ground 1	Made Ground 2
Tier Environmental soil suite (pH, metals, total and water soluble sulphate, total monohydric phenol, speciated PAH and total organic carbon). *	1	2
Asbestos in soils screen	1	2

*For definition of Tier Environmental analytical suites, please see Appendix N. NA - not applicable.

Sampling and QA/QC protocols are presented in Appendix I.

7. GROUND CONDITIONS

The following section provides a summary of the ground conditions encountered during the intrusive investigation works. The encountered ground conditions generally agree with those from published geological information and the previous intrusive investigation works undertaken at the adjacent property (No. 5). The ground conditions recorded generally included a Made Ground cover overlying clay rich and granular soils belonging to the Bagshot Formation.

Exploratory hole logs showing the various strata depths, groundwater strikes, installations and evidence for potential contamination are included in Appendix E.

7.1. Strata Descriptions

Artificial Ground

Brick paving was encountered at surface within the front garden area only (boreholes WS104 to WS106A), to 0.10m depth.

Borehole WS106A was terminated at 2.30m depth upon encountering a red brick structure at 1.90m depth within the front garden area. No other services or buried structures were encountered during the investigation works.

Made Ground – MG1

Locations encountered	WS101, WS102, WS103, WS106B, HDP1
Depths encountered from top of stratum (range)	Ground level
Depths encountered to base of stratum (range)	0.25m to 0.35m bgl
Thickness (range)	0.25m to 0.35m bgl
Spatial location on site	Encountered within the rear garden area and borders within the front garden area.
General description	Made Ground/Topsoil recorded as dark brown sandy silt with rootlets.

Made Ground – MG2

Locations encountered	WS101, WS102, WS103, WS104, WS106B
Depths encountered from top of stratum (range)	0.30m to 1.40m bgl
Depths encountered to base of stratum (range)	0.20m to 2.20m bgl
Thickness (range)	0.25m to 1.45m
Spatial location on site	Recorded predominantly in the rear garden area and on the north and south peripheries within in the front garden.
General description	Dark brown to brown silty, slightly gravelly, fine to medium sand including brick, pottery, and flint.

Made Ground – MG3

Locations encountered	WS101, WS103, WS104, WS105, WS106A, WS106B
Depths encountered from top of stratum (range)	0.10m to 1.10m bgl

Depths encountered to base of stratum (range)	1.20m to 1.95m bgl
Thickness (range)	0.55m to 1.85m
Spatial location on site	Widespread across site.
General description	Typically, soft, brown to orange variably gravelly sandy clay including flint and brick.

Superficial Deposits

No superficial Deposits were encountered during the intrusive investigation works.

Bedrock – Clay Rich Bagshot Formation

Bagshot Formation - Clay Rich Soils	
Locations encountered	WS101, WS102, WS103, WS104, WS105, WS106B
Depths encountered from top of stratum (range)	1.50m to 6.10m bgl
Depths encountered to base of stratum (range)	3.50m to 6.45m bgl
Thickness (range)	1.34m to 4.80m
Spatial location on site	Widespread across site
General description	Soft to firm orangish brown mottled brown and grey gravelly sandy/silty clay. Occasional thin sand laminations.

Bedrock – Granular Bagshot Formation

Bagshot Formation - Granular Soils	
Locations encountered	WS101, WS102, WS103, WS104, WS105, WS106B
Depths encountered from top of stratum (range)	2.70m to 5.50m bgl
Depths encountered to base of stratum (range)	4.45m to 6.45m bgl
Thickness (range)	0.90m to 2.10m
Spatial location on site	Widespread across site
General description	Loose to medium dense dark brown and orangish brown mottled grey laminated sand.

7.2. Groundwater Observations During Fieldwork and Follow-on Monitoring

During the investigation works, groundwater was encountered in boreholes WS101, at 5.00m depth, and WS102 (as a seepage at 3.70m depth), located within the rear garden area, associated with the granular Bagshot Formation soils. All other boreholes undertaken within the rear and front garden areas were dry.

A single follow-on groundwater monitoring visit, undertaken on 6th March 2023, recorded groundwater in borehole WS101 only, which is located within the rear garden area, at 4.20m depth. It is anticipated that the recorded groundwater level is associated with perched groundwater within the confined granular Bagshot Formation layer encountered at between 5.00m and 5.30m depth within this borehole. The wells in boreholes WS104 and WS106B, located within the front garden area were dry during the monitoring visit.

8. GEOTECHNICAL SOIL PARAMETERS

8.1. Soil Classification – Fine Soils

Natural Moisture Content

Natural Moisture Content determinations were undertaken on 7 No. clay rich samples from the Bagshot Formation at between 2.00m and 4.00m depth. The recorded Natural Moisture Content was between 15% and 24%.

Atterberg Limits Tests

Atterberg Limit Tests for Liquid Limit, Plastic Limit and Plasticity Index measurements were undertaken on 4 No. of the clay rich Bagshot Formation soil samples (WS101, WS103 – in the rear garden area and WS104 and WS106B in the front garden area), between 2.50m and 3.80m depth.

The results indicated that for the clay rich Bagshot Formation soils within the rear garden area, between 2.50m and 3.80m depth, the Liquid Limit ranged from 28% to 31%, Plastic Limit from 15% to 16% and the Plasticity Index from 13% to 15%. Oversized particles were recorded for these samples indicating that the Modified Plasticity Index is between 6% and 11%, which according to NHBC standards corresponds to a clay rich soil with a very low to low volume change potential.

For the clay rich Bagshot Formation soils within the front garden area, at 3.00m depth, the Liquid Limit ranged from 42% to 45%, Plastic Limit from 21% to 23% and the Plasticity Index from 21% to 22%. Oversized particles were recorded on one sample, and none were recorded for the other indicating that the Modified Plasticity Index is equivalent to the Plasticity Index. Therefore, the Modified Plasticity Index for these soils is between 20% and 21%, which according to NHBC standards corresponds to a clay rich soil with medium volume change potential.

8.2. Soil Classification – Granular Soils

Natural Moisture Content

Natural Moisture Content determinations were undertaken on 2 No. granular soil samples from the Bagshot Formation at 3.50m and 5.00m depth. The returned Natural Moisture Content for these soils was 24%.

In-situ Soil Permeability

In-situ falling head permeability tests were undertaken during the intrusive investigation works, in borehole WS101 during the site works and in boreholes WS101, WS104 and WS106B during the follow-on monitoring visit on 6th March 2023. The tests aimed at targeting the granular Bagshot Formation soils and the results retuned ranged from 1.06 x 10^{-5}m/s to 9.01 x 10^{-8}m/s, indicating that these soils have relatively low permeability and are likely to exhibit relatively poor infiltration rates. This is anticipated, given the predominantly clay rich nature of this stratum and the clayey nature of the granular soils.

The results from the in-situ falling head permeability tests are summarised in Table 8.1, below. The falling head permeability test results are included in Appendix F.

Table 8.1 In-situ Falling Head Permeability Test Summary

Well ID	Date	Test No	Coefficient of Permeability (k)	Target Soils
WS101	14/02/2023	Test 1	9.01 x 10^{-8}m/s	Bagshot Formation – gravelly sandy CLAY / silty sandy CLAY and clayey thinly laminated SAND.
	06/03/2023	Test 1	8.47 x 10^{-7}m/s	
		Test 2	1.17 x 10^{-6}m/s	
		Test 3	1.06 x 10^{-6}m/s	
WS104	06/03/2023	Test 1	1.27 x 10^{-6}m/s	Bagshot Formation – silty sandy CLAY.
		Test 2	1.06 x 10^{-5}m/s	
		Test 3	8.85 x 10^{-6}m/s	
WS106B	06/03/2023	Test 1	9.89 x 10^{-7}m/s	Bagshot Formation - silty very sandy CLAY and very clayey SAND.
		Test 2	5.28 x 10^{-6}m/s	
		Test 3	2.59 x 10^{-6}m/s	

Particle Size Distribution

Particle size distribution (PSD) determinations were undertaken on 2 No. Bagshot Formation soil samples, identified as being granular, at 3.50m (WS102 – rear garden area) and 5.00m (WS106B – front garden area) depth.

The results returned for the sample taken from WS102 at 3.50m depth showed it to comprise 32.7% fines (clay plus silt) and 67.3% sand, which indicates that it can be classed as a uniformly or evenly graded very clayey or very silty sand.

For the sample taken from WS106B, at 5.00m depth, the results show that this soil comprises 41.1% fines (clay plus silt), 58.3% sand and 0.6% gravel indicating that it can be classed as a uniformly or evenly graded sandy slightly gravelly clay or silt. In hand specimen, as shown on the borehole log, the layer from which this sample came from, between 4.10m and 6.45m depth, is described as a very clayey sand. The PSD results indicate that it may be more consistent either with a silt or a very clayey sand.

8.3. Soil Shear Strength

Standard Penetration Tests

Standard Penetration Tests (SPTs) were undertaken in all windowless sample boreholes at roughly 1m intervals between 1.20m and 6.00m depth within the Made Ground and Bagshot Formation bedrock.

For the Made Ground, returned SPT N values ranged from 3 to 25, in the rear garden area (WS101 to WS103) and typically between 2 and 6, in the front garden area (WS104 to WS106B) with a single N value exceeding 50 recorded in WS106A at 2.00m depth. The results show no particular trend with depth and that the Made Ground is either a variable very soft to stiff clay rich soil and/or granular soil with a relative density between very loose and medium dense. The N value exceeding 50, recorded in borehole WS106A, corresponds with the red brick structure encountered in this borehole.

Within the clay rich Bagshot Formation soils returned N values ranged between 5 and 15, in the rear garden area, and from 6 to 9 in the front garden area. The results show no particular trend with depth and indicate these soils to have a soft becoming firm to stiff clay soil consistency, which generally agrees with what was found in hand specimen.

Returned N values within the granular Bagshot Formation soils ranged from 6 to 11 in the rear garden area and between 12 and 24 within the front garden area. The results show a slight increase in strength with depth and indicating these soils to have an increasing relative density from loose to medium dense.

For overconsolidated clay rich Bagshot Formation soils an equivalent undrained shear strength to a 100mm diameter triaxial compression test can be determined using industry standard's, such as Stroud's method. The equivalent undrained shear strength (Cu) can be calculated using the average Plasticity Index, to determine a conversion factor (f1), SPT N values and the following formula:

$$Cu = f1N \text{ (Tomlinson 2001)}$$

The average plasticity index for the clay rich Bagshot Formation soils is 18% and the corresponding f1 value is 5.76.

Therefore, the equivalent estimated undrained shear strengths for the clay rich Bagshot Formation soils range from 29kPa to 86kPa indicating a low to high strength beneath the rear garden area. Beneath the front garden area, the equivalent estimated undrained shear strengths for the clay rich soils is 35kPa and 52kPa, indicating a low to medium soil strength.

Laboratory Undrained Shear Strength

Direct undrained shear strength tests using triaxial compression were undertaken on 2 No. clay rich Bagshot Formation samples from borehole WS101, at 2.00m depth (rear garden area), and WS104, at 4.00m depth (front garden area), without porewater pressure measurements. The recorded undrained shear strengths were 57kPa (WS101) and 38kPa (WS104), which generally agree with the results recorded from in-situ tests. The results indicating a clay soil with medium strength in the rear garden area and low strength in the front garden area.

One-Dimensional Consolidation

One dimensional consolidation tests were undertaken on 2 No. clay rich Bagshot Formation samples from borehole WS101, at 2.00m depth (rear garden area), and WS104, at 4.00m depth (front garden area). The test results show this soil to be an over consolidated clay. No swelling pressure was recorded before the start of consolidation for either test.

For the sample taken from WS101 (rear garden area), the measured Coefficient of compressibility (mv) on loading was between 0.22m^2/MN and 0.89m^2/MN indicating an initially high compressibility becoming medium as consolidation progressed. The measured mv value on unloading was 0.06m^2/MN indicating a low swelling potential.

Measured mv values on loading for the sample taken from WS104 (front garden area), were between 0.15m^2/MN and 0.29m^2/MN indicating a medium compressibility. The measured mv value on unloading was 0.026m^2/MN indicating a very low swelling potential.

8.4. Determination of Characteristic pH and Water-Soluble Sulphate

Representative samples of the soils encountered during the Tier Environmental ground investigations, were tested to determine their pH and water-soluble sulphate (SO_4^{2-}) concentrations.

Recorded water soluble sulphate values for 5 No. Made Ground samples, from the rear and front garden areas, ranged between 6mg/l and 66mg/l with pH values between 7.43 and 8.58. Giving a characteristic sulphate value of 100 mg/l, based on the mean of the highest two results rounded to nearest 100mg/l. The corresponding characteristic pH value is 7.43, based on the mean of the lowest 20% results, in accordance with BRE SD1 (2005).

For 4 No. Bagshot Formation bedrock from both garden areas, water soluble sulphate values ranged between 11mg/l and 71mg/l and pH values between 5.56 and 8.13. Giving a characteristic sulphate value of 100 mg/l, based on the highest measured concentration rounded to the nearest 100mg/l. The corresponding characteristic pH value is 5.56, based on the lowest measured value, in accordance with BRE SD1 (2005).

Whilst no evidence of gross hydrocarbon contamination has been observed at the Site, it is a concrete specialist should review the TPH results and ground conditions summary within this report to ensure appropriate concrete design against retardation / degradation due to hydrocarbons.

9. GEOTECHNICAL ASSESSMENT

9.1. Introduction

The following advice and recommendations are based on constructing a basement extension in the front garden of 4 The Grove, and new above ground swimming pool and summerhouse in the rear garden. Proposed development layout plans are included in Appendix A. From assessment of the nature of the ground conditions and the type of proposed structures, it is considered that the situation falls within EC7 Geotechnical Category 2.

Should the nature of the development be changed then the results of this investigation would need to be reviewed and reassessed.

9.2. Excavations

It is anticipated that excavations encountering Made Ground and granular Bagshot Formation soils, particularly where perched groundwater is present, will be prone to sidewall collapse and will require temporary support to remain open.

All excavations requiring man entry should be either battered back to a safe angle, supported using an appropriate proprietary trench support system or adequately shored to provide safe working conditions. Shoring to all excavations requiring man entry must be designed by a suitably qualified and experienced engineer. All support systems will require regular inspection as detailed in published guidelines to ensure the excavation support is adequate and appropriate for the ground conditions present.

It should be possible to progress excavations with conventional equipment.

Perched groundwater was recorded in two boreholes within the rear garden area during the investigation works, associated with granular pockets and horizons within the Bagshot Formation. Whilst it is considered that specific groundwater control is unlikely to be required at this site, limited pumping from sumps or bailing out may be required to deal with slight seepages and/or surface water ingress during inclement weather periods.

9.3. Slope Stability

The site is relatively flat and terraced with no significant changes in level as part of the development being anticipated. It is therefore considered that slope stability is unlikely to be a concern at this site.

9.4. Concrete Design

The results for pH and sulphate testing indicate that aggressive ground conditions are not present at this site it being classed as brownfield. Therefore, a Design Sulphate Class of DS-1 and Aggressive Chemical Environment for Concrete (ACEC) Class of AC-1 is considered appropriate for all on-site soils. The groundwater regime is anticipated to be mobile.

9.5. Drainage Design

Undertaking soakaways to calculate soil infiltration rates for surface water disposal was beyond the scope of these investigation works. However, given the predominantly clay rich nature of the soils encountered, and the low permeability results recorded from in-situ falling head tests, it is considered that the use of soakaways will not be feasible at this site.

9.6. Pavement Construction

Considering the encountered shallow Made Ground across the site, it is recommended that a preliminary design California Bearing Ratio (CBR) of less than 2% is assumed at this stage.

9.7. Basements

Excavation / Temporary Works

The proposed development includes extending the existing basement eastwards and beneath the front garden area to the property, which sits at an elevation of around 128.6m AOD. The basement extension depth, including concrete slab and formation is approximately 4.00m and will be founded at roughly 124.6m AOD.

The recorded ground conditions underlying the front garden area (boreholes WS104, WS105 and WS106A/WS106B), generally included soft clay rich and granular Made Ground to between 1.50m and 2.70m depth overlying clay rich and granular Bagshot Formation bedrock to the full investigation depth at 6.45m. No groundwater seepages were recorded within these wells during the intrusive investigation works or from the follow-on monitoring visit.

It is anticipated that (perched) groundwater will not be encountered during the basement excavation works. However, the basement excavation will expose greater soil volumes than has been investigated by the boreholes and therefore, the potential for encountering larger pockets and/or interconnected layers containing perched groundwater cannot be totally ruled out. Therefore, it is recommended that the existing monitoring wells are maintained and that monitoring groundwater levels continues up to the construction phase.

There is insufficient room to construct the proposed basement within an open excavation and therefore temporary retaining wall support to the excavation will be required in the form of a piled wall.

Permanent sheet piled retaining walls may provide a suitable retaining structure. The problems of noise and vibrations associated with dynamically-driven sheet piling could be eliminated by adopting a statically-driven (pneumatic) system. Alternatively, a secant pile wall solution may be acceptable. These methods are likely to be able to produce a relatively watertight seal. The disadvantage of secant pile wall systems over the use of permanent sheet piling is the plant and material requirements, and relative time of completion.

The extent of the ground movements that result from the basement excavation will depend on the method of excavation and support together with the overall stiffness of the basement structure in the temporary condition. Both temporary works and the finished structure should, therefore, incorporate appropriate structural support to ensure the necessary rigidity. The timing of the provision of support to the wall for the temporary works will be especially important.

Basement Retaining Walls

Based on the results of this investigation, published guidance and previous experience in comparable ground, the following moderately conservative unfactored effective stress parameters for the design of retaining walls are presented in Table 9.1 below:

Table 9.1 Basement Retaining Walls Design Parameter Summary

Stratum	Bulk Density γB (kN/m³)	Undrained Shear Strength Su (kPa)	Angle of Shearing Resistance ϕ'peak/ϕ'crit (°)	Apparent Cohesion c' (kPa)
Made Ground – Clay Rich	17	20	0	0
Made Ground - Granular	17	0	20	0
Bagshot Formation – Clay Rich Soils	20	26	0	0
Bagshot Formation – Granular Soils	20	0	31	0

Basement Heave and Floor Slab

Excavation for a 4.00m deep basement will result in the removal of approximately 80kPa of overburden pressure. The proposed excavation is likely to cause some heave. This will likely comprise both an "immediate" elastic component that may be expected to occur within the construction period and long-term swelling that would, theoretically, occur over a period of many years. These movements are likely to be largely mitigated by the basement slab and the weight of the structure, but it would be prudent to conduct a detailed analysis of the likely movements once the basement design has been finalised.

Following the basement extension excavation, it should be possible to adopt a ground bearing reinforced floor slab. The base of the excavations should be inspected and subject to proof-rolling. Any soft spots should be excavated and replaced with lean-mix concrete or suitably compacted coarse-grained fill.

No groundwater was recorded during the investigation works or from follow-on monitoring. Therefore, it is anticipated that whilst perched groundwater may be present, the potential risk from 'flotation' of the proposed basement is relatively low.

Waterproofing

Waterproofing or "tanking" the walls and floor of the basement will help to prevent ingresses from perched groundwater, should it occur, through the walls and base. Whichever form of water proofing is employed it is emphasised that manufacturer's recommendations for installation of any proprietary products must be followed. Consideration should be given to providing combined protection. It is also prudent to include an internal sump and pump as a backup to the water proofing of the basement.

9.8. Preliminary Foundation Recommendations

In the rear garden area, it is proposed to remove the existing greenhouse and to replace it with a lightweight timber frame summerhouse clad with glass and timber and a swimming pool to around 2.00m depth.

Encountered ground conditions beneath the proposed swimming pool and summerhouse location within the rear garden area (WS01 to WS103) also encountered a Made Ground cover overlying clay rich and granular Bagshot Formation bedrock. Made Ground, encountered to between 1.55m and 2.15m depth, comprised soft dark brown and orange brown gravelly silt and clay and loose to medium dense dark brown and brown gravelly sand. The Made Ground also included brick, ash, pottery, roots and rootlets. The underlying Bagshot Formation included soft to firm orangish brown and brown sandy clay and loose to medium dense brown and grey clayey sand. During the investigation works, groundwater (perched) was recorded at 5.00m depth, (WS101) and a seepage was observed at 3.70m depth (WS102). The groundwater level in WS101 had risen to 4.20m depth when the borehole was monitored and WS102 and WS103 were dry.

Due to its variable nature, Made Ground is not considered to represent a suitable bearing stratum and foundations should be taken through this to found upon the underlying Bagshot Formation, which was found to include firm and locally soft clay soils and loose to medium dense granular soils. It is considered that potentially over deepened footings to 2.00m depth would be feasible for the proposed summerhouse, which should be founded on either clay soils with a minimum firm consistency or medium dense granular soils. Potentially the formation depth for the swimming pool will be 2.00m. Consideration should be given to reinforcing concrete using steel mesh reinforcement where foundations/the swimming pool base pass over changes in soil type from clay rich to granular. Removing the existing greenhouse will potentially lead to the ground beneath the proposed structures being disturbed; therefore, requiring foundations to be taken deeper.

Floor Slabs

The investigation findings indicate that Made Ground/ clay rich Bagshot Formation soils underlie the proposed summerhouse location. Therefore, a fully suspended floor slab designed and constructed in accordance with NHBC Standards is recommended for this structure.

With reference to Section 4.7, the floor construction will not have to incorporate radon/gas protection measures.

Traditional Footings

Proposed Summerhouse

With regards to the proposed summerhouse, it should be possible to adopt traditional over deepened footings down to 2.00m depth taken through the Made Ground to found upon firm clay rich Bagshot Formation soils and/or medium dense granular soils. Mesh reinforcement to strengthen foundations should be considered where changes from clay rich to granular soils are encountered.

A presumed bearing value of 60kPa is considered appropriate for foundations up to 1m wide bearing upon the clay rich Bagshot Formation soils. Immediate and long-term settlement should be within tolerable limits and take place over several years. Consideration should be given to the potentially high compressibility for these soils, recorded from testing in borehole WS101, which may lead to larger than expected settlements.

The clay rich Bagshot Formation, within the rear garden area, has been shown to have a low volume change potential when assessed against NHBC standards and therefore the minimum foundation depth required is 0.75m. This should be taken to 1.00m where required to allow for restricted new tree planting. Under the NHBC Standards, foundation depths have to be increased if they are within the influence zone of felled trees, existing trees or proposed tree planting. It should be noted that where trees are in groups the resulting competition for resources can lead to deeper root systems than allowed for in the NHBC Standards. In any event, foundations should be taken below any roots encountered in foundation trench excavation. Where the required foundation depth varies around a structure, this can be accommodated by forming steps in the foundation as per NHBC Standards.

Where foundation depths exceed 1.50m in clay soils and are within the zone of influence of existing or felled trees or where foundations cut through tree roots, a compressible void former will be required against the internal faces of new foundations in order to accommodate potential long term soil heave. Such precautions against heave should be designed and constructed in accordance with NHBC Standards.

Where footings are taken to more than 2.00m depth, the excavator must be set up with care and operated correctly to ensure trench walls are vertical and base horizontal as any slight inclination will result in eccentric loading on such deep trench fill footings.

A number of trees and tree stumps are located within the rear garden area where the summerhouse location is proposed. It will be necessary to remove all unwanted trees, stumps and root structures prior to commencing with construction. Any resultant void should be backfilled accordingly with respect to the preferred foundation design.

The proposed development shall include removing the existing greenhouse, which will make it difficult to predict potential footing depths as the demolition works and foundation removal are likely to disturb the underlying soils. Therefore, locally over deepened footings should be anticipated in areas where former structures are to be removed.

During foundation construction, all soft spots found at formation level should be excavated and replaced with lean mix concrete. Foundation excavations should be kept dry and left open for the minimum amount of time possible. Where foundations cannot be completed immediately, a blinding layer of concrete should be placed.

Proposed Swimming Pool

Ideally the proposed, above ground, swimming pool should be founded on firm to stiff clay soils or medium dense granular soils belonging to the Bagshot Formation, which is expected to provide adequate bearing. Exploratory holes WS101 and WS102, positioned where the proposed swimming pool is located, encountered such soils at between 1.65m and 2.15m depth. Anticipated loadings from the swimming pool when filled with water are around 30kPa. Consideration should be given to the potentially high compressibility for the clay rich Bagshot Formation soils, recorded from testing in borehole WS101, which may lead to larger than expected settlements.

An initial excavation for the proposed swimming pool should be taken through the Made Ground and down to the competent Bagshot Formation soils. Due to the Made Ground and granular soils, the excavation sidewalls are anticipated to suffer from sidewall collapse without adequate support to keep them open, particularly during inclement wet weather periods. Therefore, consideration should be given to providing suitable and adequate sidewall support during the pool construction. Perched groundwater was recorded at between 3.70m and 5.00m depth, associated with granular soils, and is not anticipated to pose a problem for the swimming pool construction. However, limited groundwater control employing pumping from sumps or bailing may be required to deal with seepages or surface water ingress during wet weather periods.

Once the excavation is completed, consideration should be given to placing a raft or compacted granular layer/fill in the base to build up the levels to the required design base level for the swimming pool. The removed overburden pressure is anticipated to be relatively low and will depend on the excavation depth. Once the overburden pressure has been removed, heave within the excavation sidewalls and base is likely to be relatively low and occur during the construction period. The weight of the infilled excavation and swimming pool structure will help to mitigate any long-term swelling and heave resulting from the removed overburden pressure.

Given that the swimming pool will be above ground hydrostatic pressures behind the swimming pool sidewalls will not be an issue.

Consideration should be given to 'tanking' or lining the swimming pool sides and base, to seal it, and prevent the contents from leaking into the surrounding soils and rock, therefore, posing a potential contamination risk.

Raft Foundations

Alternatively, for the summerhouse, a raft foundation could be considered taken through the Made Ground to found within the underlying Bagshot Formation soils. Preliminary works will include removing the existing greenhouse base which could be crushed and used along with compacted granular Made Ground as fill to build up the formation level, on to which the raft could sit. Alternatively, a raft founded on screw-piles taken down to the Bagshot Formation would be possible.

10.HUMAN HEALTH RISK ASSESSMENT

Chemical analysis was conducted on representative 3 No. Made Ground samples to show that no significant contamination was present in soils on site. The selected samples were subjected to analysis for heavy metals, non-metallic compounds, PAHs, TPH CWG plus BTEX & MTBE and asbestos.

The chemical analysis results are presented in Appendix H.

10.1. Data Interpretation Approach

The analytical data obtained were reviewed for completeness and consistency. The data for each sample type was then compiled, screened against the Generic Assessment Criteria (GACs) for a residential with homegrown produce land use and those potential contaminants of concern which were found to exceed the GACs were then subjected to detailed analysis as described below.

Previously, it was possible for results from soil (and leachate) samples to be subject to statistical assessment in accordance with a 2008 guidance document (CL:AIRE / CIEH Guidance on Comparing Soil Contamination Data with a Critical Concentration). This guidance has now been withdrawn and replaced with the following document:

- Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration (CL:AIRE 2020)

The purpose behind statistical assessment is ultimately to determine whether concentrations of contaminants are at levels that present potential risk to the future site users (and the wider environment if the statistical assessment is conducted on leachate test results).

The new guidance places even greater emphasis and reliance on the desk study being carried out first, appropriately detailed sampling strategies, collection and testing of samples for contamination and use of appropriate screening criteria.

The guidance requires an increased number of criteria to be met before a robust statistical assessment can be conducted and introduces the principle of the Central Limit Theorem (CLT); a key tool of statistics that is used in the comparison of confidence intervals with the critical concentration. A common ‘rule of thumb’ is that the CLT will apply provided your sample size is between 20 and 50.

On this basis, Tier Environmental considers that statistical assessment in accordance with the CL:AIRE 2020 guidance may not be applied in this instance given that the number of samples obtained is below 20 No. for any given identified soil population.

Due consideration of the ground conditions, distinct identifiable populations of soil and proposed development layout has been undertaken and, where appropriate, laboratory results associated with discrete populations or ‘hotspots’ have been assessed separately.

10.2. Selection of Generic Assessment Criteria (GAC)

In short, for the majority of the contaminants of concern, LQM/CIEH Suitable 4 Use Levels (S4ULs) published in 2015 have been adopted as GACs for a residential with homegrown produce land use; however, further details on the hierarchal approach for the selection of the GACs used as screening criteria for this assessment is provided in Appendix J.

These values are considered as appropriate screening criteria as they incorporate updated assumption exposures derived for the production of C4SLs but within the context of deriving screening criteria above which assessment of the risks or remedial action may be needed (i.e. within the context of the planning regime rather than Part 2A context for which C4SLs were derived).

For those potential contaminants of concern where the selected GAC is dependent on Soil Organic Matter content (SOM), an assumed SOM of 1% has been selected based on the reported Total Organic Carbon (TOC) concentrations (which have been converted to SOM by dividing by a conversion factor of 0.58). It should be noted; however, that for any soil samples where the TOC may be artificially driven by the presence of petroleum hydrocarbons, that these TOC results have been removed from the data set when determining an appropriate characteristic SOM. For this purpose, Tier Environmental have notionally considered that any TOC results from soil samples where the measured total TPH concentration exceeds 500mg/kg should be removed.

10.3. Human Health Risk Assessment

Measured concentrations of contaminants of concern reported in excess of the respective GACs are summarised in Table 10.1 below:

Table 10.1 Summary of Contaminants of Concern Exceeding their Respective GACs:

Contaminant of Concern	Exploratory Hole Location	Depth (m bgl)	Soil Population	Units	Measured Concentration	GAC
Metals						
Lead	WS104	0.70	MG2	mg/kg	269	200
	HDP01	0.60	MG1		486	

Measured widespread concentrations of lead have been reported in excess of the GAC protective of human health for a residential with homegrown produce land use.

Testing completed for the adjacent property by GEA (2021) recorded 4 No. of 5 No. samples tested contained an elevated concentration of lead, in excess of the relevant GACs, ranging between 330-800mg/kg. GEA concluded that the site lies within an area known to have a background concentration of lead of between 300 mg and 600 mg. Additionally, a localised area nearby to the north is known to have a background lead concentration of between 600 mg and 900 mg. They determined that given the development of No 5 The Grove did not include any expansion of the soft landscaping areas, exposure would remain as it has been throughout the history of the site, and ultimately no remedial measures were recommended.

Tier Environmental would consider the recorded lead concentrations of 269mg/kg to 486mg/kg to fall within the acceptable range of background levels for the wider site area based on an assessment of the BGS 'London Earth - Lead in Topsoil Geochemical Map'. Furthermore, the proposed development is similar is scope to the adjacent property where exposure to soft landscaping is not increasing, and therefore remedial measures are not likely required.

Asbestos

Asbestos can be present in soil as fragments of bulk Asbestos Containing Materials (ACMs) (e.g. asbestos cement sheeting) and also as discrete asbestos fibres within the soil matrix. This investigation has carried out assessments to determine whether both bulk fragments and / or fibres are present in the soil at the site. The asbestos assessment commenced on site with inspection of the Made Ground by our suitably qualified supervising engineer for the presence of bulk ACMs.

During the fieldwork no suspected ACMs were identified and for the 3 No. Made Ground samples analysed, none were reported to contain asbestos.

Groundwater

Limited perched groundwater was recorded in a single borehole during and following the investigation works at around 5.00m depth and associated with a confined granular horizon. The soils associated with the Bagshot Formation are predominantly clay rich and the likelihood of water percolating through these soils from the surface is considered very low. Therefore, it is considered that the potential for contaminant in groundwater pose very little risk to human health.

Utilities

It is recommended that the results of the chemical testing and details of the proposed remedial works are provided to the appropriate utility companies to determine the necessity for service protection.

Construction and Maintenance Workers

Contamination may pose a short-term (acute) or long-term (chronic) risk to workers during construction and maintenance. The potential risks must be specifically assessed as part of the health and safety evaluation for the works to be performed in accordance with prevailing legislation. Site practices must conform to the specific legislative requirements and follow appropriate guidance (e.g., HSE, 1991; CIRIA, 1996).

On the basis of the results obtained, the following potential exposure risks to construction and maintenance workers have been highlighted:

- Lead in Made Ground

Asbestos **has not** been reported during the ground investigation works; however, in the event that previously unidentified asbestos is identified during future earthworks / construction works at concentrations above 0.001% w/w (i.e. above 'trace' levels), the Control of Asbestos Regulations 2012 should be adhered to. A summary of complying with CAR: risk assessments, licensing and training is provided in Appendix K for reference.

Undiscovered Contamination

Should any hitherto undiscovered contamination be encountered during construction works the Geo-Environmental Engineer should be informed immediately so that appropriate measures can be taken. The potential for the presence of significant undiscovered contamination at this site is considered to be low.

10.4. Controlled Waters Risk Assessment

Assessing contamination risks to controlled waters is beyond the scope of this assessment.

10.5. Ground Gas Risk Assessment

An assessment of potential ground gas risks pertaining to the site is beyond the scope of this assessment.

11.PRELIMINARY WASTE SOILS CLASSIFICATION

11.1. Waste Classification

If the Site is to be redeveloped and materials are disposed off Site, the material exported from the Site to Landfill should be hauled by a register waste carrier in accordance with Duty of Care Regulations 1991 and the Hazardous Waste Regulations 2005.

It will be necessary to register the Site in advance of the intended reclamation works with the Environment Agency before disposal to landfill can take place. There will be requirement for the waste producer to provide appropriate Waste Acceptance Criteria (WAC) testing of the Soils for disposal to ensure that the soils are appropriately classified and that the landfill is licensed to receive such soils. A consignment note shall be completed, signed and retained by all parties involved. The consignment note shall state the volume of waste, a physical description of the material and statement of its chemical composition. The waste consignment notes shall be kept by the contractor for a period of at least two years.

Tier Environmental have assessed the chemical results in terms of basic characterisation of soils for waste. This provides a preliminary assessment of whether a material is potentially inert/non-hazardous or hazardous waste, with the final outcome being determined by WAC testing.

Basic waste characterisation has demonstrated that all 3 No. of the samples of the material tested have been classified as non-hazardous waste:

- WS04 at 0.70m bgl (Made Ground)
- WS105 at 1.30m bgl (Made Ground)
- HDP01 at 0.60m bgl (Made Ground)

No Waste Acceptance Criteria testing was completed as part of this investigation.

Natural soils are likely to be suitable for disposal to an inert waste landfill.

11.2. Materials Re-Use

Subject to volumetric fill requirements and a future assessment of suitability of re-use (both chemically and geotechnically), some materials may be considered for potential re-use in line with an appropriate end-of-waste protocol such as WRAP Quality Protocol for Aggregates from Inert Waste, U1 Exemption or a Materials Management Plan in accordance with the CL:AIRE Definition of Waste Code of Practice (DoWCoP). Please note that any previously landfilled or mining waste materials may not be appropriately subject to consideration under DoWCoP and may not be re-used under DoWCoP unless sufficient lines of evidence and agreement with the local Environment Agency Waste Team can be sought beforehand.

Re-Use of Excavated and Stockpiled Clean Naturally Occurring Soils on Other Sites

In addition, Tier Environmental are aware that CL:AIRE is classing stockpiled clean, naturally occurring soils as waste, unless their final destination is identified in a Materials Management Plan, before they are excavated. However, Tier Environmental consider that any clean naturally occurring soils arising from enabling works, earthworks or construction activities would be regarded as an asset and the default assumption for this Site (prior to excavation and stockpiling) is not the intention to discard these materials where they may be reasonably re-used on this, or another, development site. Stockpiling is a recognised, recommended means of safely storing soils. Whilst there may be advantages to leaving soils in-situ, stripping topsoil and subsoil prior to earthworks is a routine construction activity. Tier Environmental consider that it is not unreasonable to state that in the event that the developer owns another site where the construction phase is ongoing, soils can be transferred between their sites as an owned product and never become waste.

The above paragraph above is therefore considered a clear intention to reuse any clean, naturally occurring soils derived from excavations at this Site (which may also include temporary stockpiling these materials). It is considered; however, that in addition to this the following must be adhered to:

- Reuse does need to occur within a 'reasonable' timeframe (12 No. months); and,
- If soils are transferred to a third party (another developer), there needs to be some contractual agreement in place, as in this situation it is important to have something in place confirming that surplus soils are required by the third party.

Re-Use of Excavated and Stockpiled Clean Naturally Occurring Soils Within The Site They Are Excavated From

Further to the above, where soils are naturally occurring, uncontaminated and re-used on the site they are excavated from, they fall outside of the Waste Framework Directive (WFD) i.e. they will not be classified as a waste Currently the CL:AIRE Definition of Waste Code of Practice states the following which appears to support this position: *"If the material is waste an Environmental Permit will be required to lawfully deposit or re-use it unless the material is "uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated", which is excluded from waste regulation by the Waste Framework Directive (2008)."*

12.CONCLUSIONS AND RECOMMENDATIONS

12.1. Conclusions

- Historically the site has remained relatively unchanged since the existing residential property was constructed around 1688.
- The site is situated on elevated ground and terraced with the house dominating the eastern end, at roughly 127.8m AOD, with a brick paved front garden and rear gardens dominating the western two thirds with the lower terrace at roughly 122.7m AOD to 119.1m AOD.
- The proposed development will include extending the existing basement beneath the front garden area and replacing an existing greenhouse in the rear garden with a swimming pool and light weight, timber frame summerhouse.
- Encountered ground conditions include a granular and clay rich Made Ground cover overlying predominantly clay rich Bagshot Formation with granular pockets and horizons.
- Perched groundwater was recorded in a single borehole (WS101), in the rear garden area, at roughly 5.00m depth during the investigation works and follow-on monitoring. A perched groundwater seepage was observed in borehole WS102, at 3.70m depth, during the investigation works, however, this well was dry during the follow-on monitoring visit.
- Due to the Made Ground and granular soils, excavations will require appropriate support to remain open and require limited groundwater control such as pumping from sumps of bailing during inclement weather.
- Slope stability is no considered to be an issue at the site.
- A Design Sulphate and Aggressive Chemical Environment for Concrete (ACEC) Class of DS-1 / AC-1 is considered appropriate for all on-site soils.
- A sheet pile retaining structure will be required for the basement construction to avoid destabilising adjacent ground/properties and support excavation sidewalls. Groundwater is not anticipated to be a problem, however, it would be prudent to install waterproofing and drainage measures to avoid issue with unforeseen perched groundwater.
- All foundations should be taken through the Made Ground to found upon the underlying clay rich and granular Bagshot Formation soils. Over deepened footings to around 2.00m depth will be suitable for the summerhouse, or alternatively a raft could be employed.
- Sidewall support will be required for the swimming pool foundation excavation, which will be founded within the clay rich/granular Bagshot Formation soils.
- Elevated lead concentrations were recorded in Made Ground samples that are consistent with previous investigation works at the next-door property and naturally elevated background concentrations.
- Elevated lead concentrations are most likely to impact construction workers who will handle Made Ground. The risk to construction workers can be reduced through good hygiene practices and procedures, such as wearing protect gloves and appropriate PPE.
- Made Ground fort off-site disposal would be classed as non-hazardous waste and natural soils as inert waste.

12.2. Recommendations

It would be prudent to continue monitoring existing wells on-site up to the basement construction to better understand whether perched groundwater is likely to pose an issue.

13.REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigation. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisations for their comment and approval prior to undertaking any works on site.

It is recommended that conditions placed on any planning permission are discharged prior to commencement of site works.

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15.GLOSSARY OF TERMS

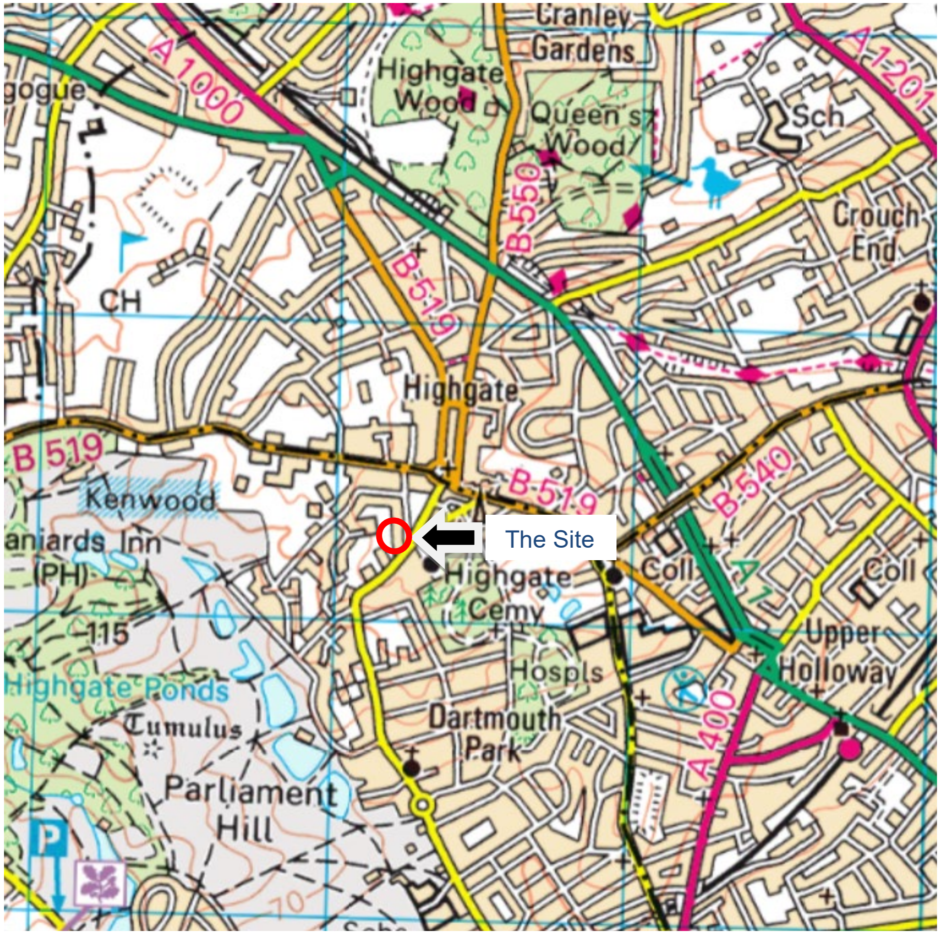
ACEC	Aggressive Chemical Environment for Concrete (classification)
aOD	Above Ordnance Datum
bgl	Below ground level
BGS	British Geological Survey
BRE	Building Research Establishment
CBR	California Bearing Ratio (test)
COMAH	Control of Major Accident Hazards (regulations)
Designated location	Site (and the ecosystem on that site) protected under national of international legislation. A potential ecological receptor to be considered as part of the assessment of land contamination. Example designated locations include SSSIs (q.v.), SACs (q.v.), national nature reserves, Ramsar sites and bird special protection areas.
DQA	Data Quality Assessment
DQO	Data Quality Objective
DQRA	Detailed Quantitative Risk Assessment
DWS	Drinking Water Standard
EQS	Environmental Quality Standard
GAC	Generic Assessment Criterion
GQA	General Quality Assessment (Environment Agency)
GSV	Gas Screening Value
HCV	Health Criteria Value
IPPC	Integrated Pollution Prevention and Control (regulations)
K_{OW}	Octanol-water partition coefficient
LEL	Lower Explosive Limit
LL	Liquid Limit
LoD	Limit of Detection (analytical)
LoQ	Limit of Quantification (analytical)
Mean Value Test	Statistical test (described in the CIEH Guidance) to estimate the mean value of a normally distributed population of data at a given level of confidence. Normally for contaminated land assessment, the 95th percentile (referred to as the 95%UCL or US95) is applied as a reasonable but conservative estimate of the mean concentration for comparison with the relevant assessment criteria.
Maximum Value Test	Statistical test (described in the CIEH Guidance) to identify whether an elevated concentration within a normally distributed data set forms part of the underlying population from which it has been sampled or whether it is an outlier (such as a localised area of contamination) that merits further consideration.
MC	Moisture Content
NGR	National Grid Reference
NIHHS	Notification of Installations Handling Hazardous Substances (regulations)
OS	Ordnance Survey
PI	Plasticity Index
PID	Photoionisation Detector
PL	Plastic Limit
ppm	Parts per million
ppmv	Parts per million by volume
QA	Quality Assurance
QC	Quality Control
SAC	Special Area of Conservation
SOM	Soil Organic Matter

SPT	Standard Penetration Test
SPZ	Source Protection Zone (see Appendix L)
SSAC	Site-Specific Assessment Criterion
SSSI	Site of Special Scientific Interest
SVOC	Semi-Volatile Organic Compound
TEF	Toxicity Equivalent Factor
TPH	Total Petroleum Hydrocarbons
TWA	Time Weighted Average
US95	95^{th} percentile estimate of the true mean value of a data population (also known as 95%UCL).
VOC	Volatile Organic Compound

APPENDIX A - DRAWINGS

Site Location Plan

Contract Number:	TE1723
Contract:	4 The Grove, Highgate, London N6 6JU.
Client:	SODA Studio



0 km 2

Approximate Scale

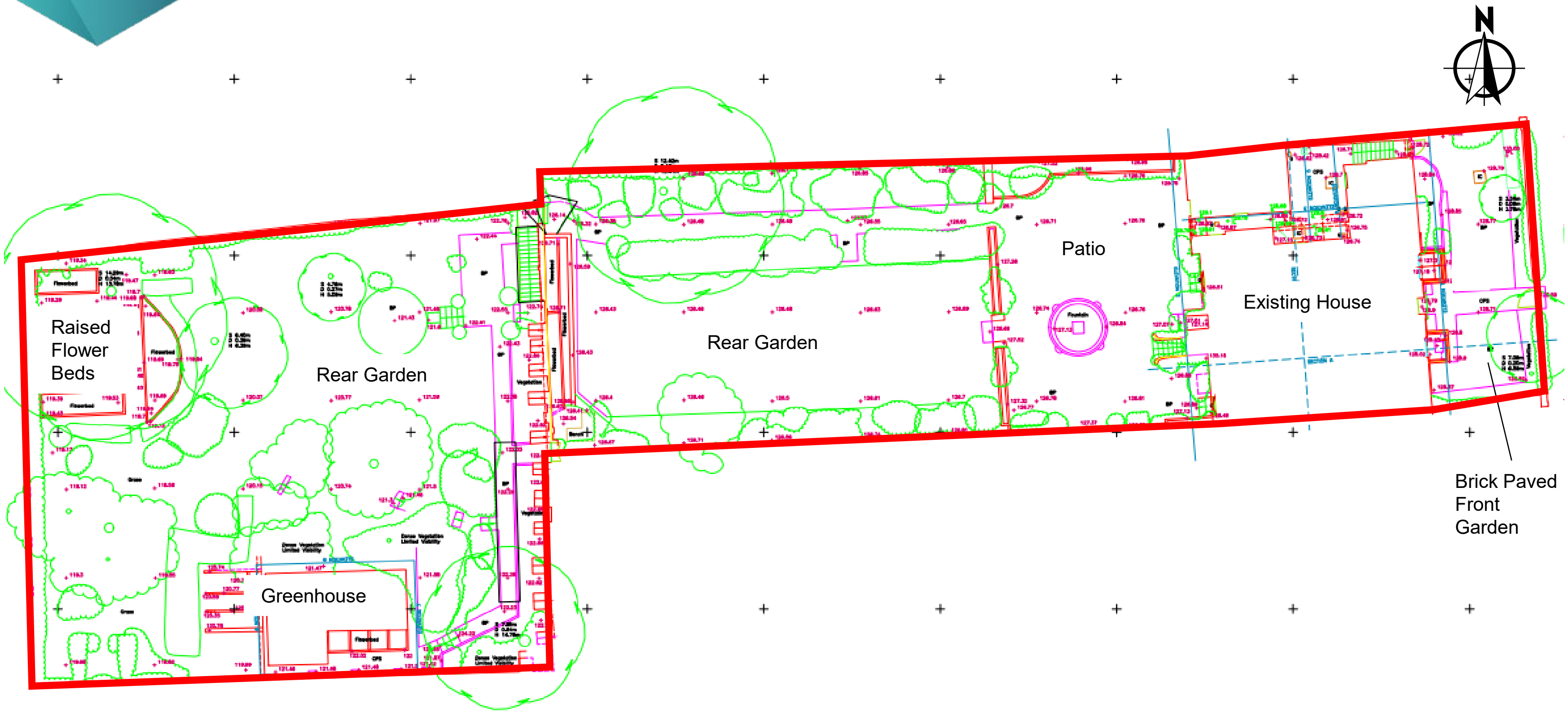
www.bingmaps.co.uk

Scale	-
Drawn by AH	**Approved** JF
Drawing Number	TE1723-TE-00-XX-DR-GE-001-V01

TIER CONSULT

Existing Site Layout Plan

Contract Number:	TE1707
Contract:	4 The Grove, Highgate, London N6 6JU.
Client:	SODA Studio



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Approximate Scale

KEY:

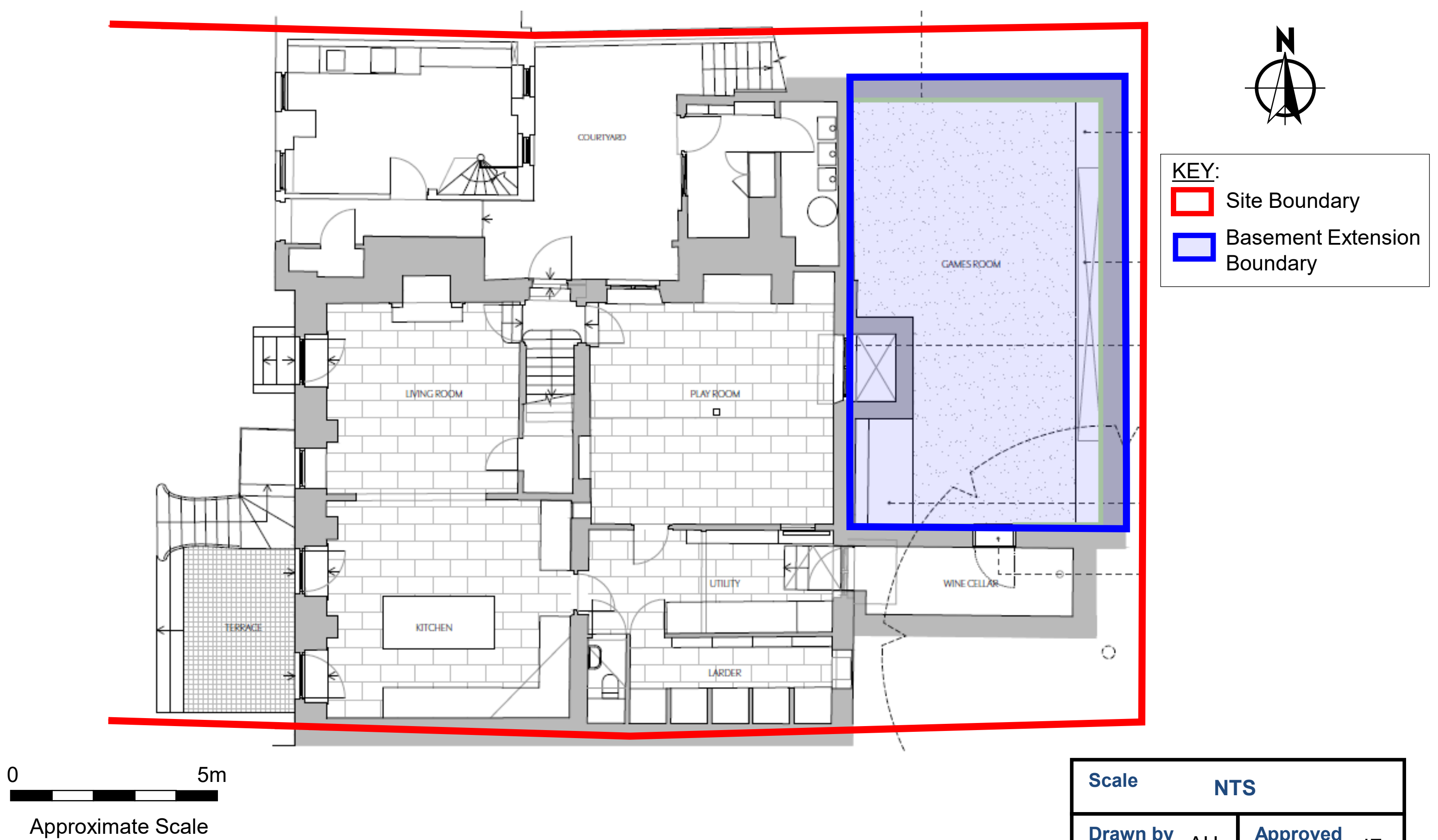
Site Boundary

Scale	NTS		
Drawn by	AH	**Approved**	JF
Drawing Number	TE1723-TE-00-XX-DR-GE-002-V01		

Extract taken from MSA Surveys Drawing, 5764-T S1 P01, dated 07/10/2022.

Proposed Layout Drawing – Basement Extension

Contract Number:	TE1707
Contract:	4 The Grove, Highgate, London N6 6JU.
Client:	SODA Studio



Scale	**NTS**		
Drawn by	AH	**Approved**	JF
Drawing Number	TE1723-TE-00-XX-DR-GE-003-V01		

Extract taken from SODA Architect Pre-Application Document, dated 22/09/2022.

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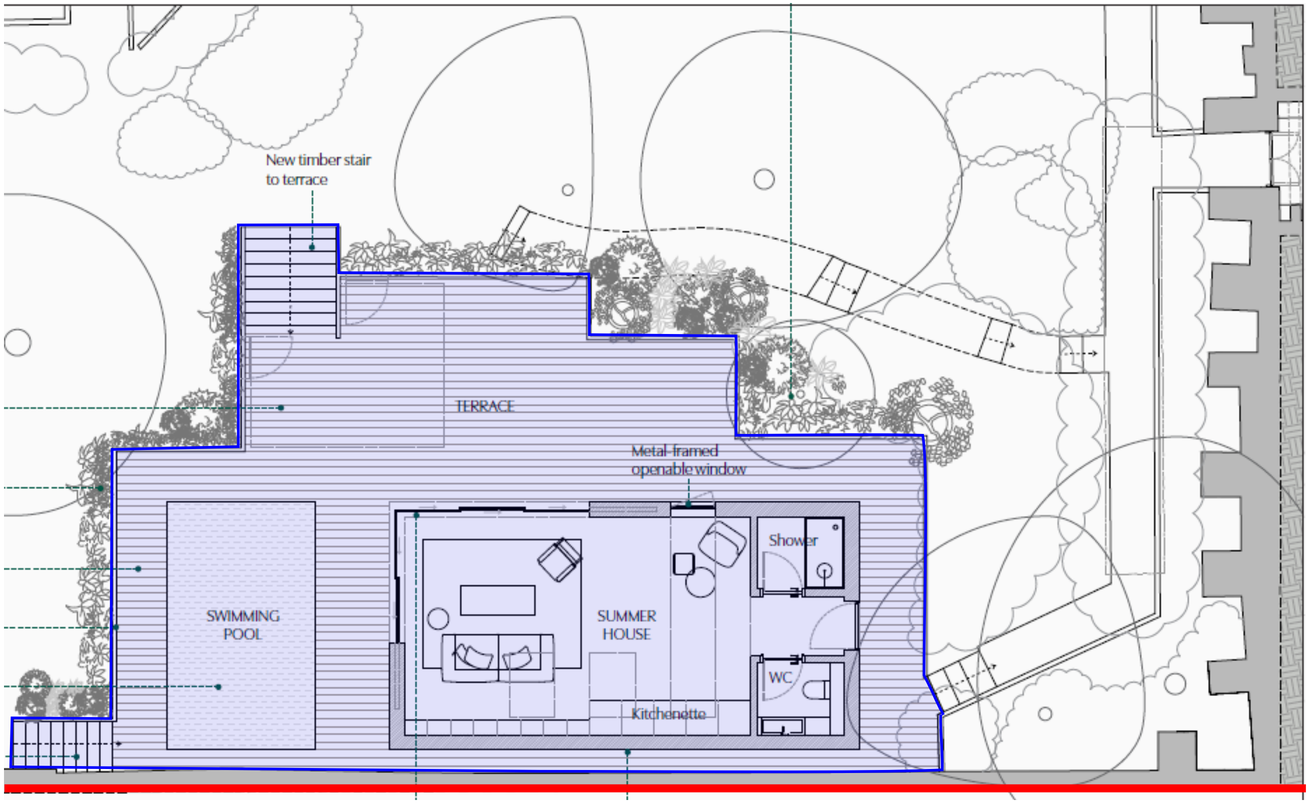
Proposed Layout Drawing – Summerhouse and Swimming Pool

Contract Number:	TE1707
Contract:	4 The Grove, Highgate, London N6 6JU.
Client:	SODA Studio



KEY:
Site Boundary.
Summerhouse/Swimming Pool Boundary.

0 5m
Approximate Scale

Scale	NTS		
Drawn by	AH	**Approved**	JF
Drawing Number	TE1723-TE-00-XX-DR-GE-004-V01		

Extract taken from SODA Architect Pre-Application Document, dated 22/09/2022.

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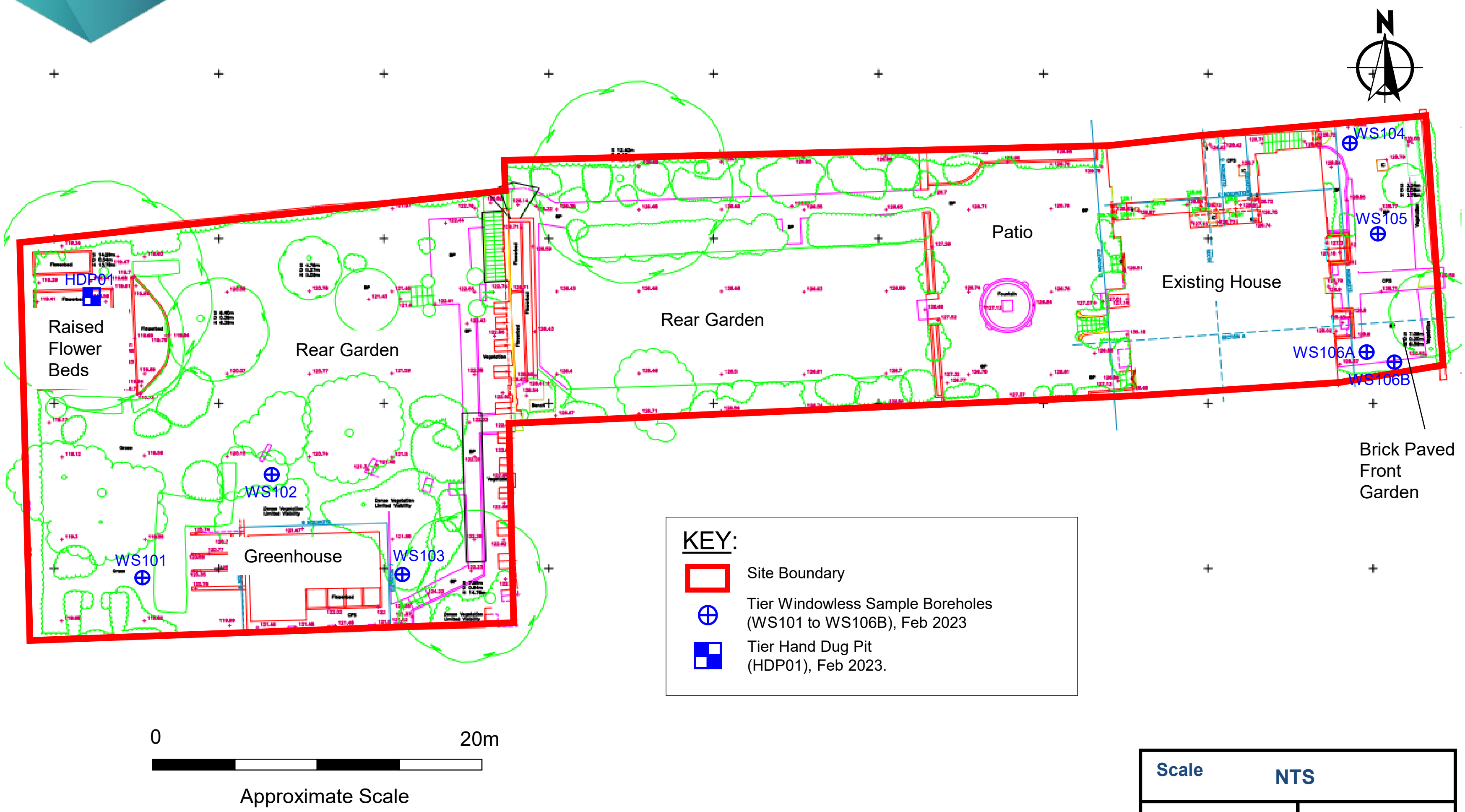
Exploratory Hole Location Plan

Contract Number:	TE1707
Contract:	4 The Grove, Highgate, London N6 6JU.
Client:	SODA Studio



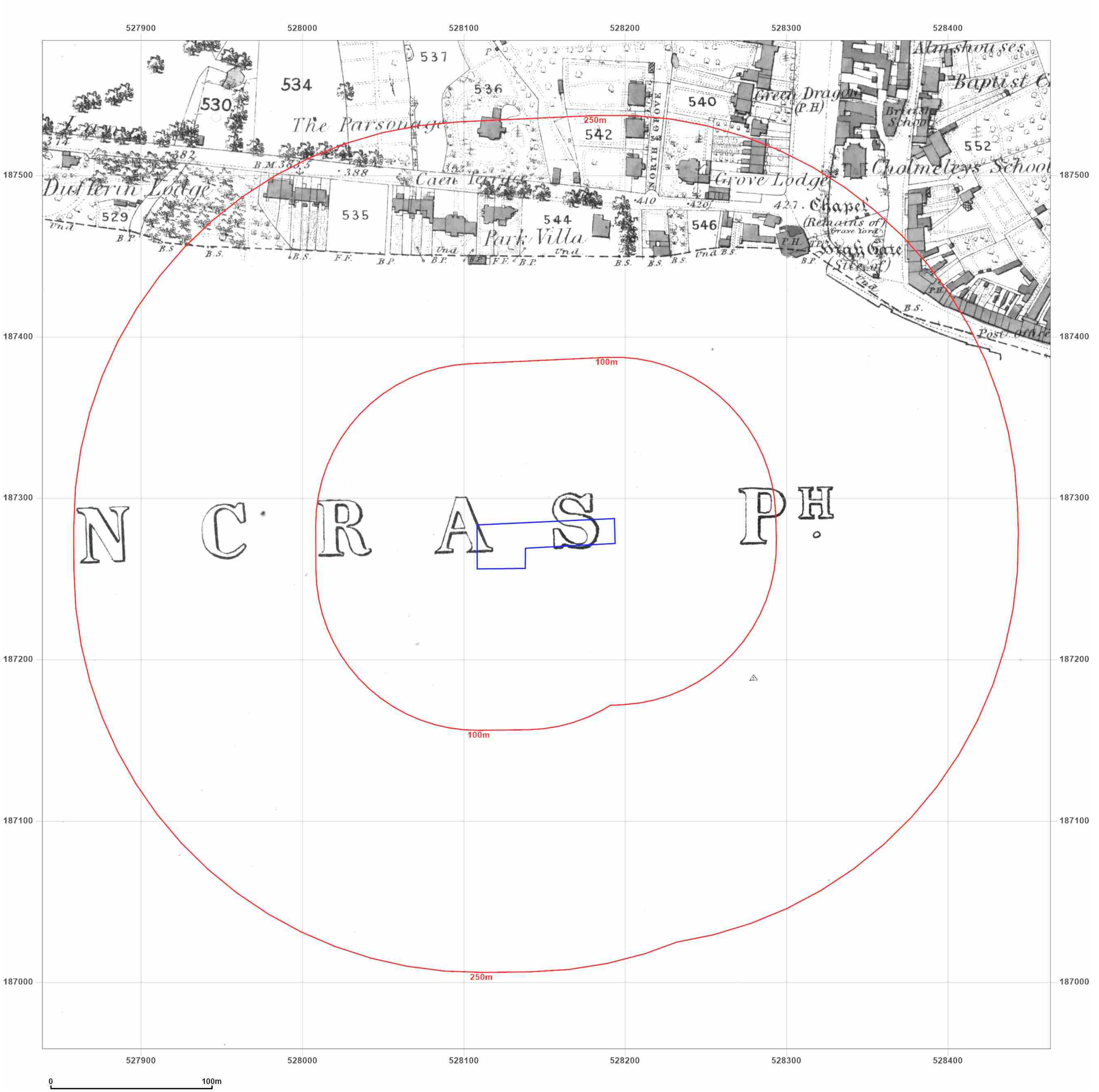
KEY:

- Site Boundary
- Tier Windowless Sample Boreholes (WS101 to WS106B), Feb 2023
- Tier Hand Dug Pit (HDP01), Feb 2023.

Extract taken from MSA Surveys Drawing, 5764-T S1 P01, dated 07/10/2022.

Scale	NTS		
Drawn by	AH	**Approved**	JF
Drawing Number	TE1723-TE-00-XX-DR-GE-005-V01		

APPENDIX B – GROUNDSURE REPORT – HISTORICAL OS MAPS



Groundsure INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: County Series

Map date: **1864**

Scale: 1:2,500

Printed at: 1:2,500

N
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Surveyed 1864
Revised 1864
Edition N/A
Copyright N/A
Levelled N/A

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Map legend available at:
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4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: County Series

Map date: **1870**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1869
Revised N/A
Edition 1870
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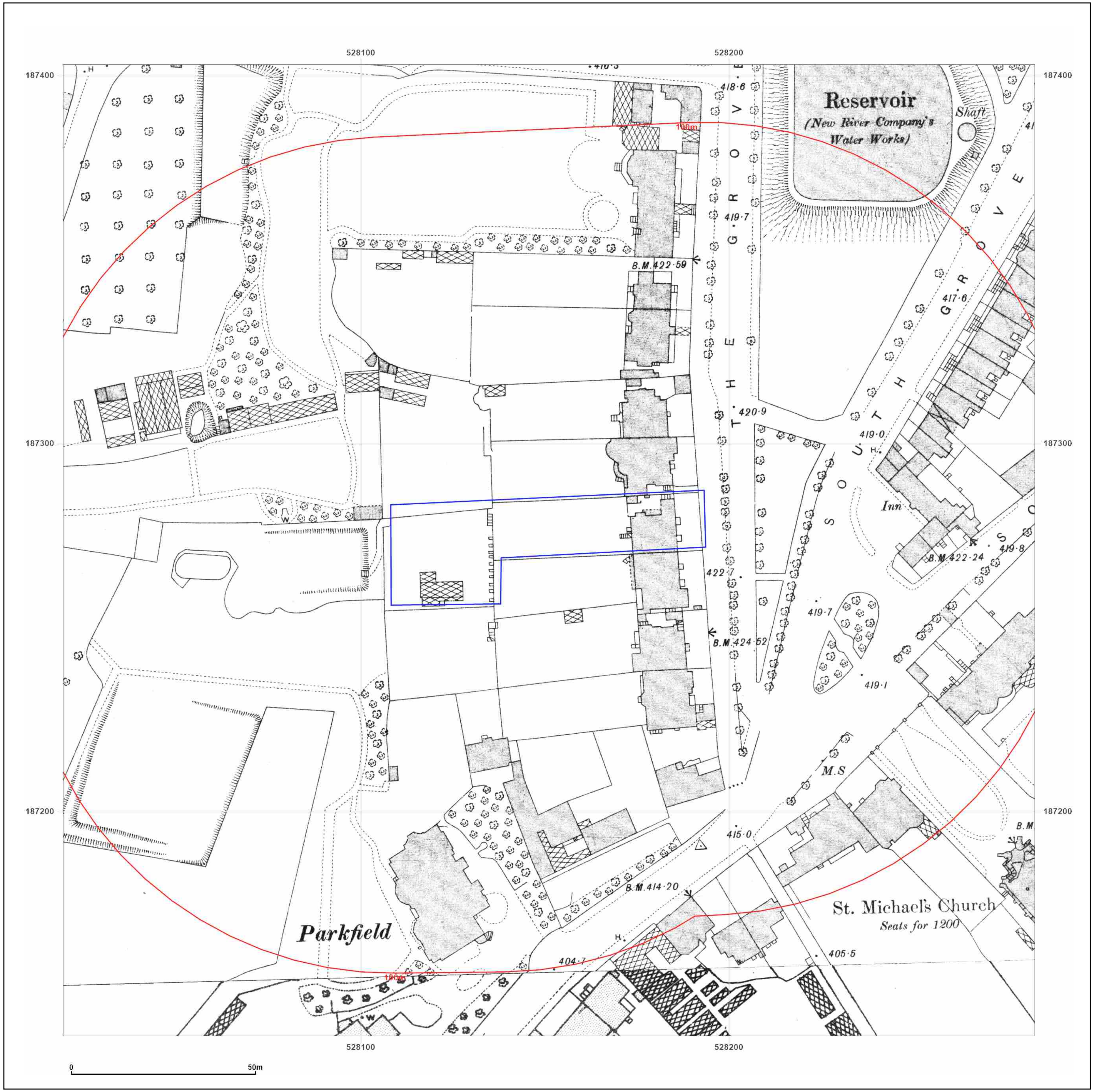

Groundsure INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: 1056 Scale Town Plan

Map date: **1896**

Scale: 1:1,056

Printed at: 1:1,056

N W E S

Surveyed 1894
Revised N/A
Edition 1896
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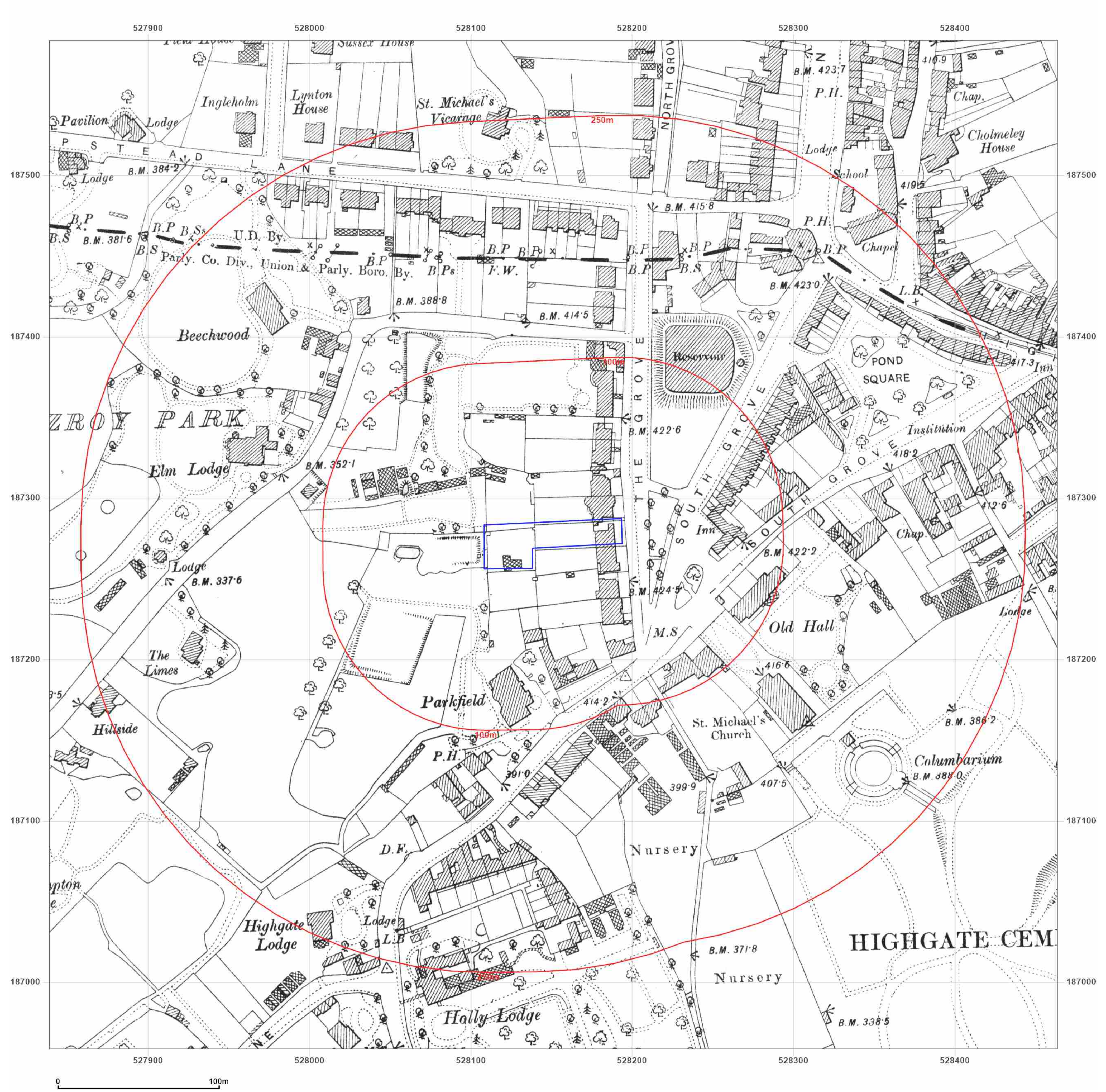

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Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: County Series

Map date: 1896

Scale: 1:2,500

Printed at: 1:2,500

Surveyed 1896
Revised 1896
Edition N/A
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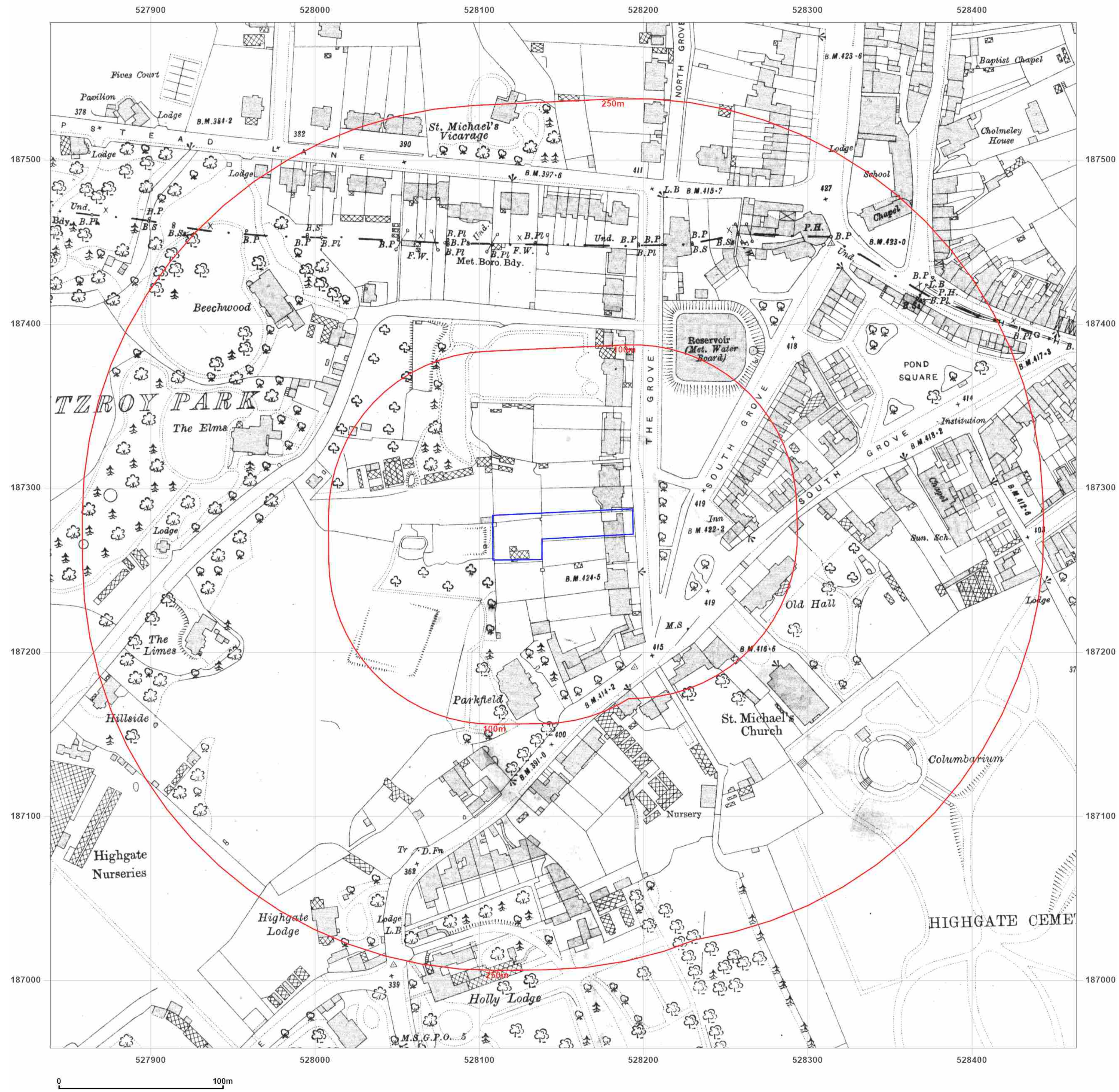

Surveyed 1914
Revised 1914
Edition N/A
Copyright N/A
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Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: County Series

Map date: **1914**

Scale: 1:2,500

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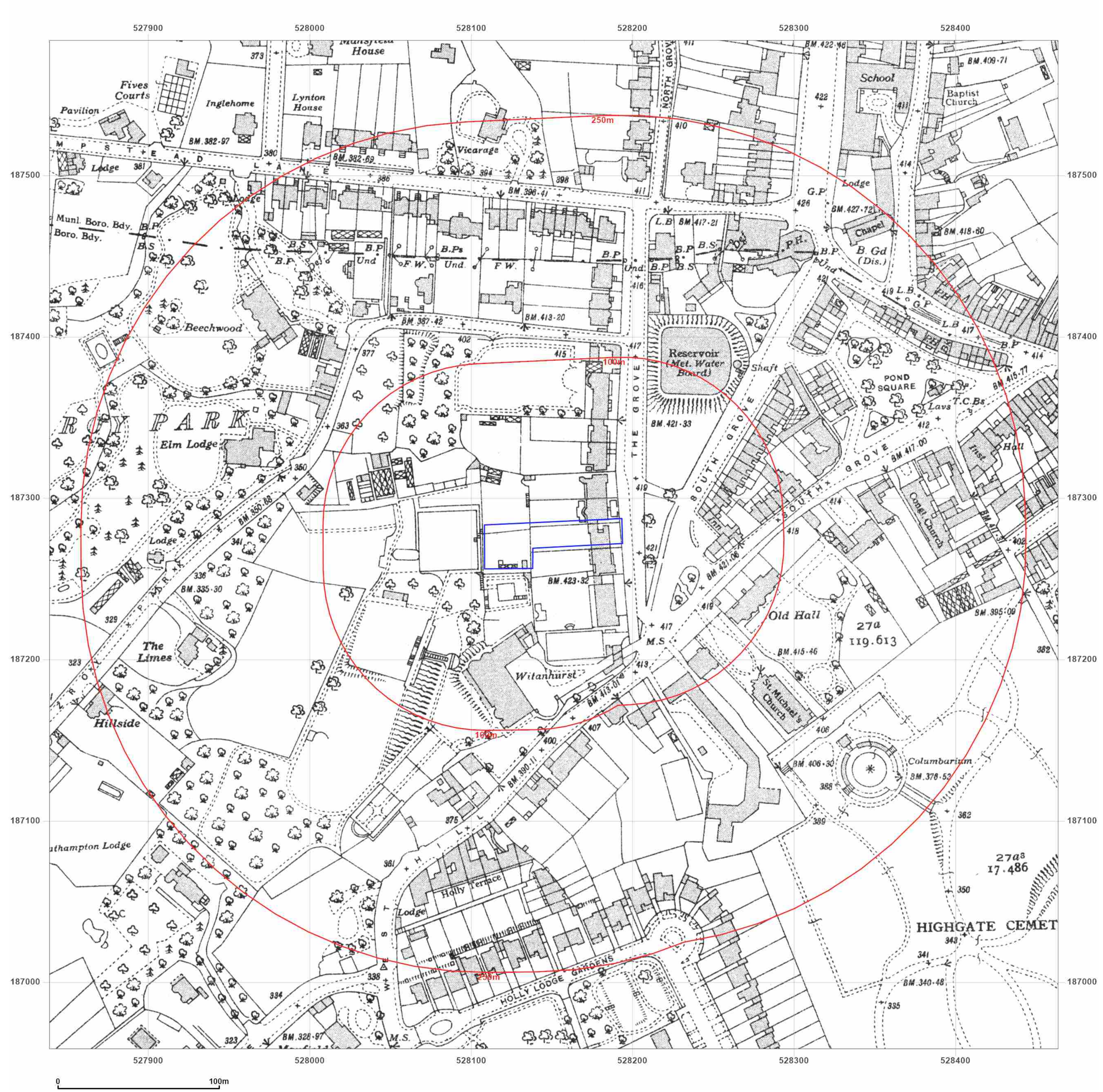

Groundsure INSIGHTS

Site Details:

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Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: County Series

Map date: **1935**

Scale: 1:2,500

Printed at: 1:2,500

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Revised 1935
Edition N/A
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Levelled N/A

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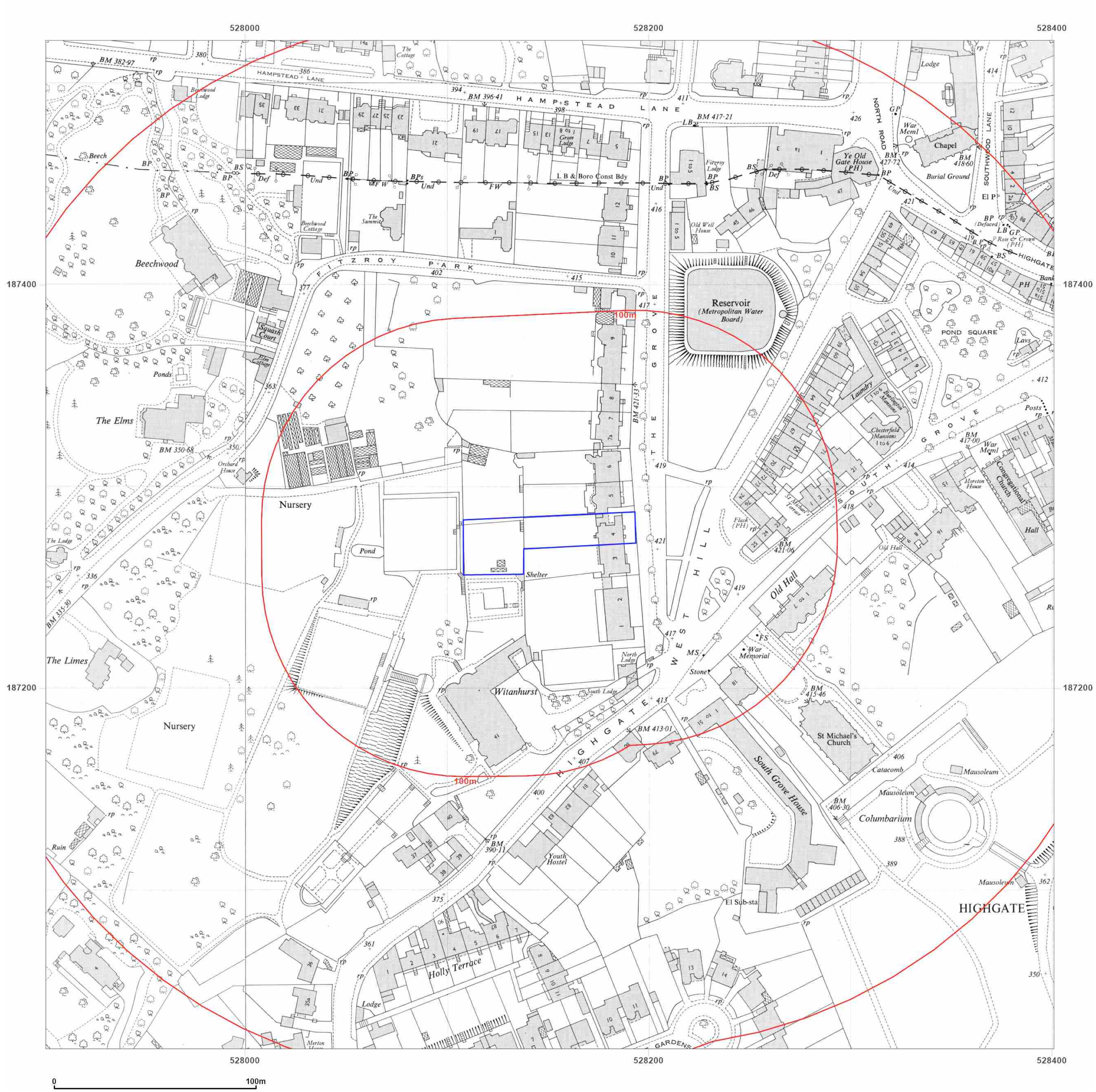

Site Details:

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Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: **1950-1951**

Scale: 1:1,250

Printed at: 1:2,000

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Surveyed 1950 Revised 1950 Edition N/A Copyright N/A Levelled 1934	Surveyed 1950 Revised 1950 Edition N/A Copyright N/A Levelled N/A
Surveyed 1950 Revised 1950 Edition N/A Copyright N/A Levelled 1934	Surveyed 1951 Revised 1951 Edition N/A Copyright N/A Levelled 1933

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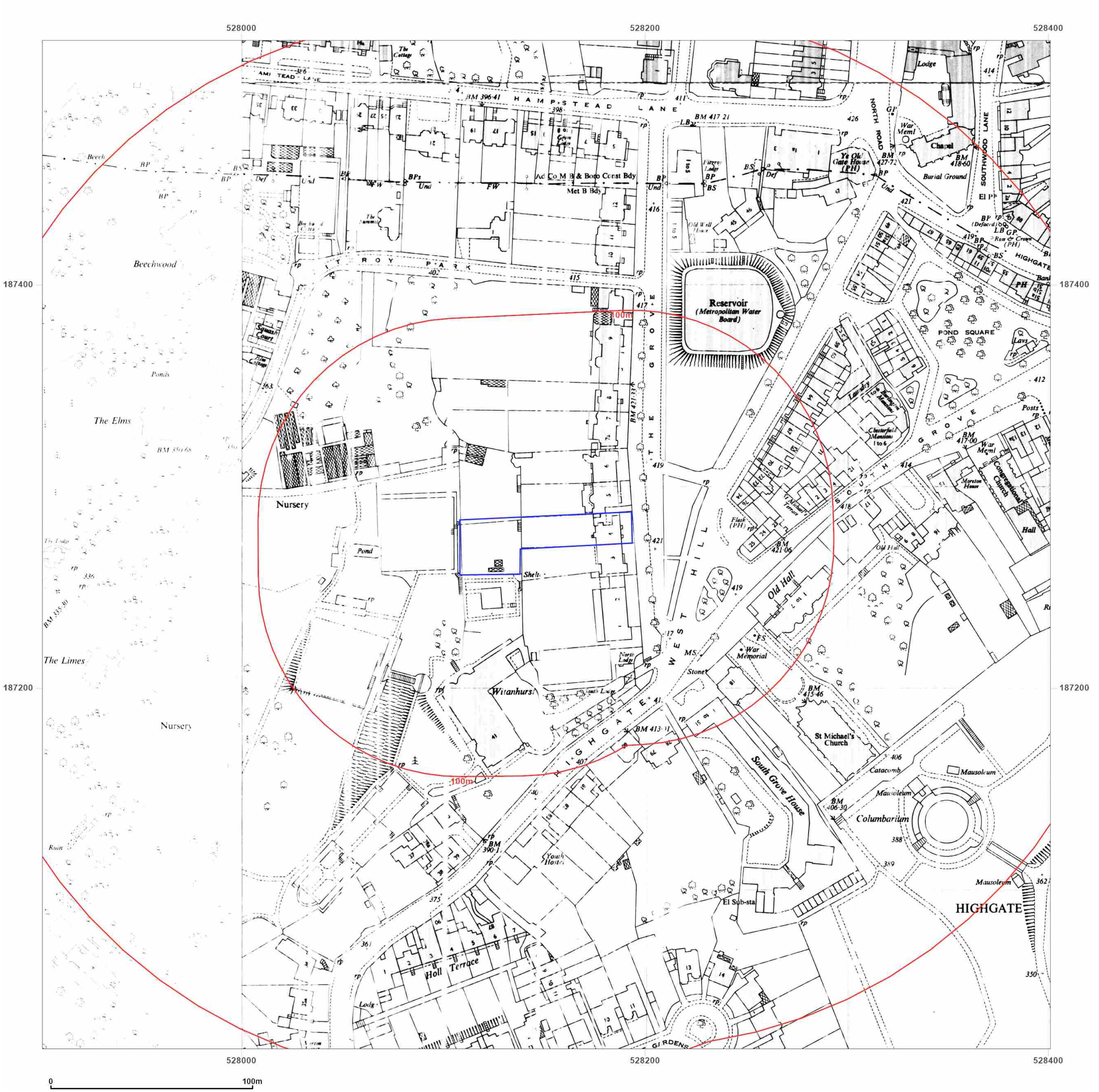

Groundsure INSIGHTS

Site Details:

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Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: 1952

Scale: 1:1,250

Printed at: 1:2,000

N W E S

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

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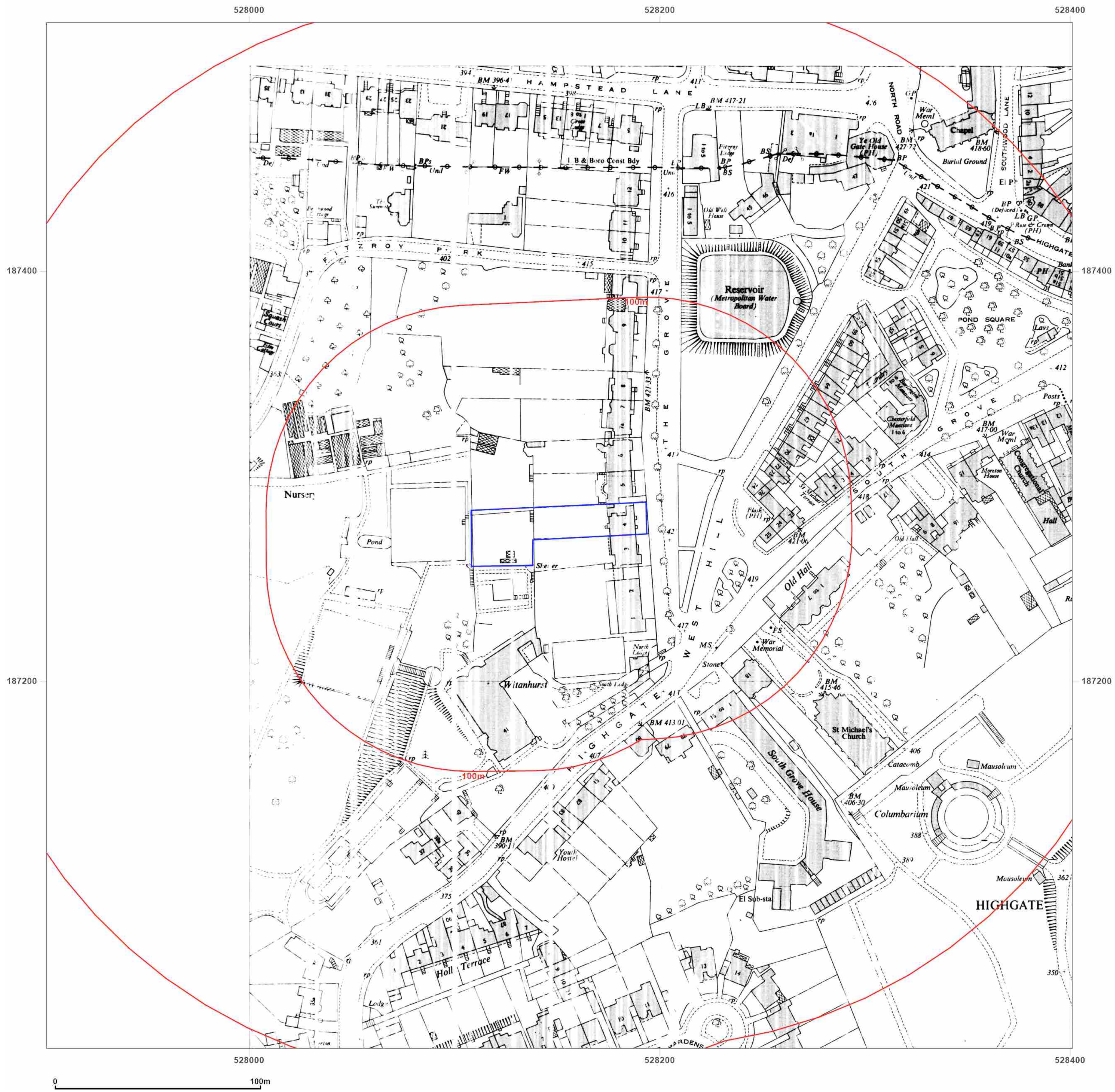

Groundsure INSIGHTS

Site Details:

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Client Ref: 2429_TE1723
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Map Name: National Grid

Map date: 1952

Scale: 1:1,250

Printed at: 1:2,000

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

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Production date: 10 February 2023

Map legend available at:
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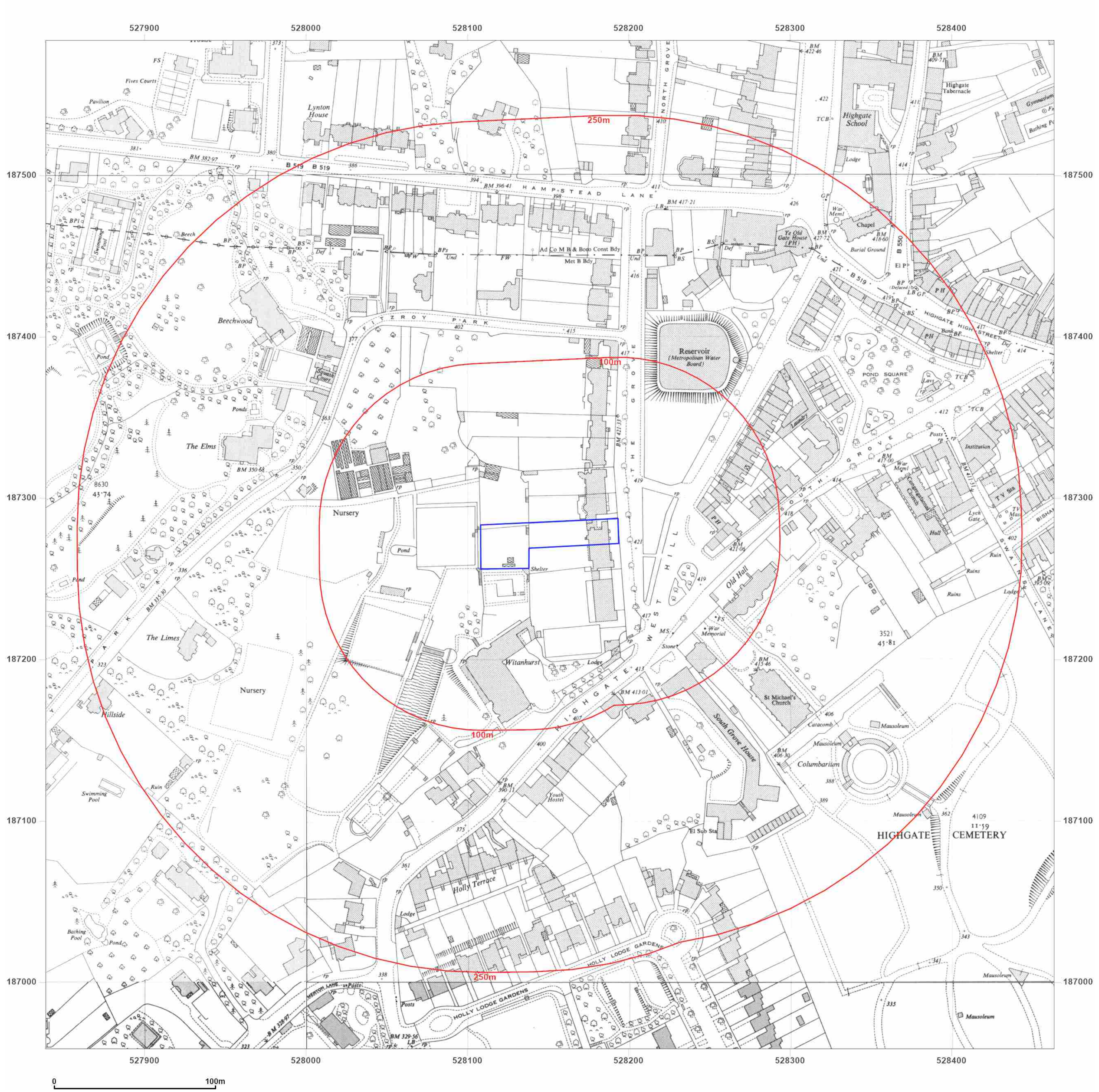

Groundsure INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: **1950-1952**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1952 Revised 1952 Edition N/A Copyright N/A Levelled N/A	Surveyed 1952 Revised 1952 Edition N/A Copyright N/A Levelled N/A

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Production date: 10 February 2023

Map legend available at:
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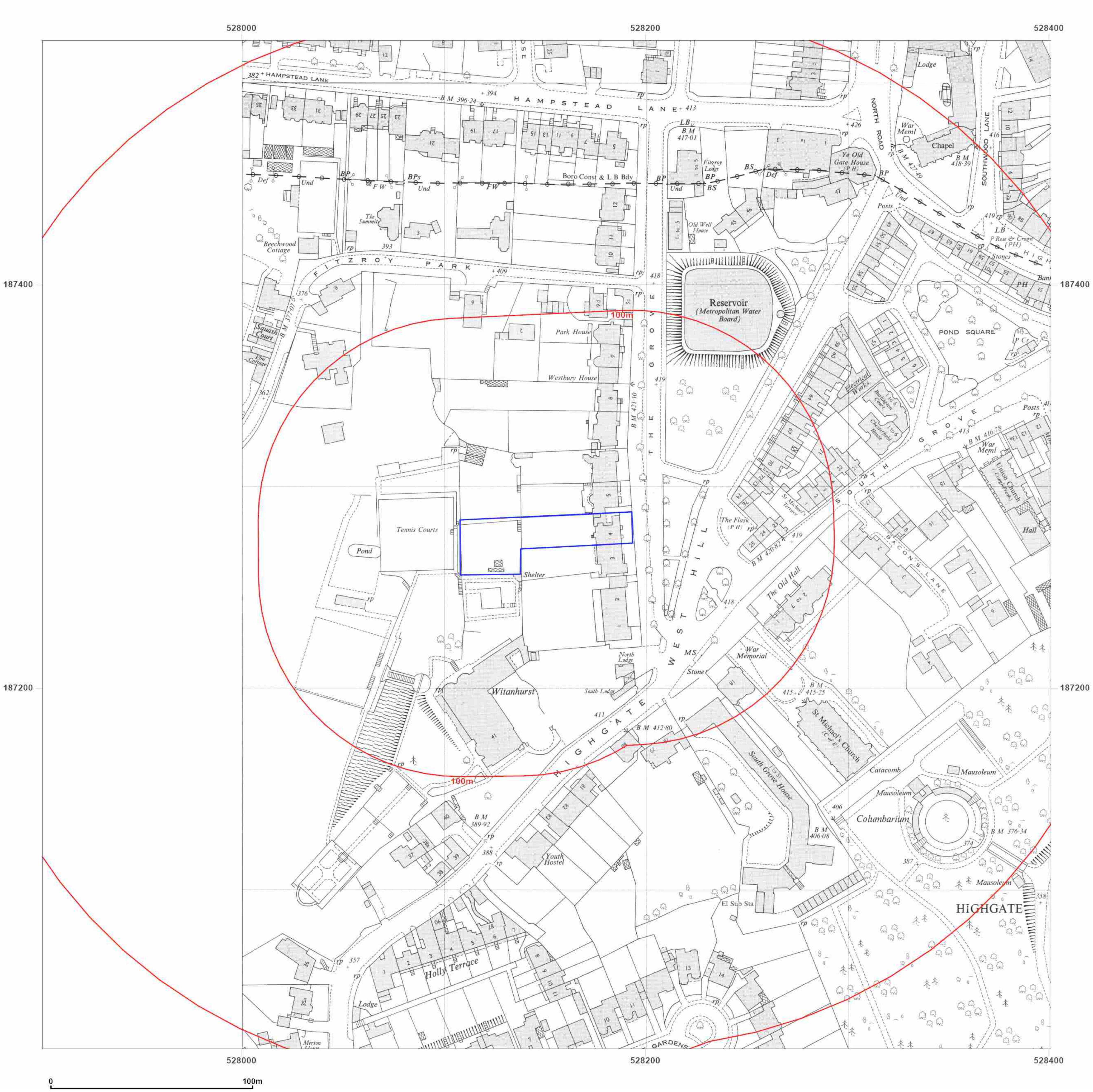

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INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: **1968**

Scale: 1:1,250

Printed at: 1:2,000

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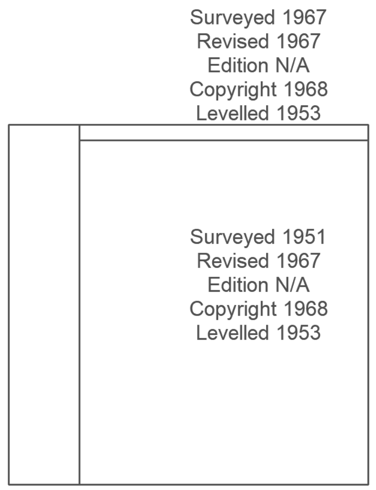

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Production date: 10 February 2023

Map legend available at:
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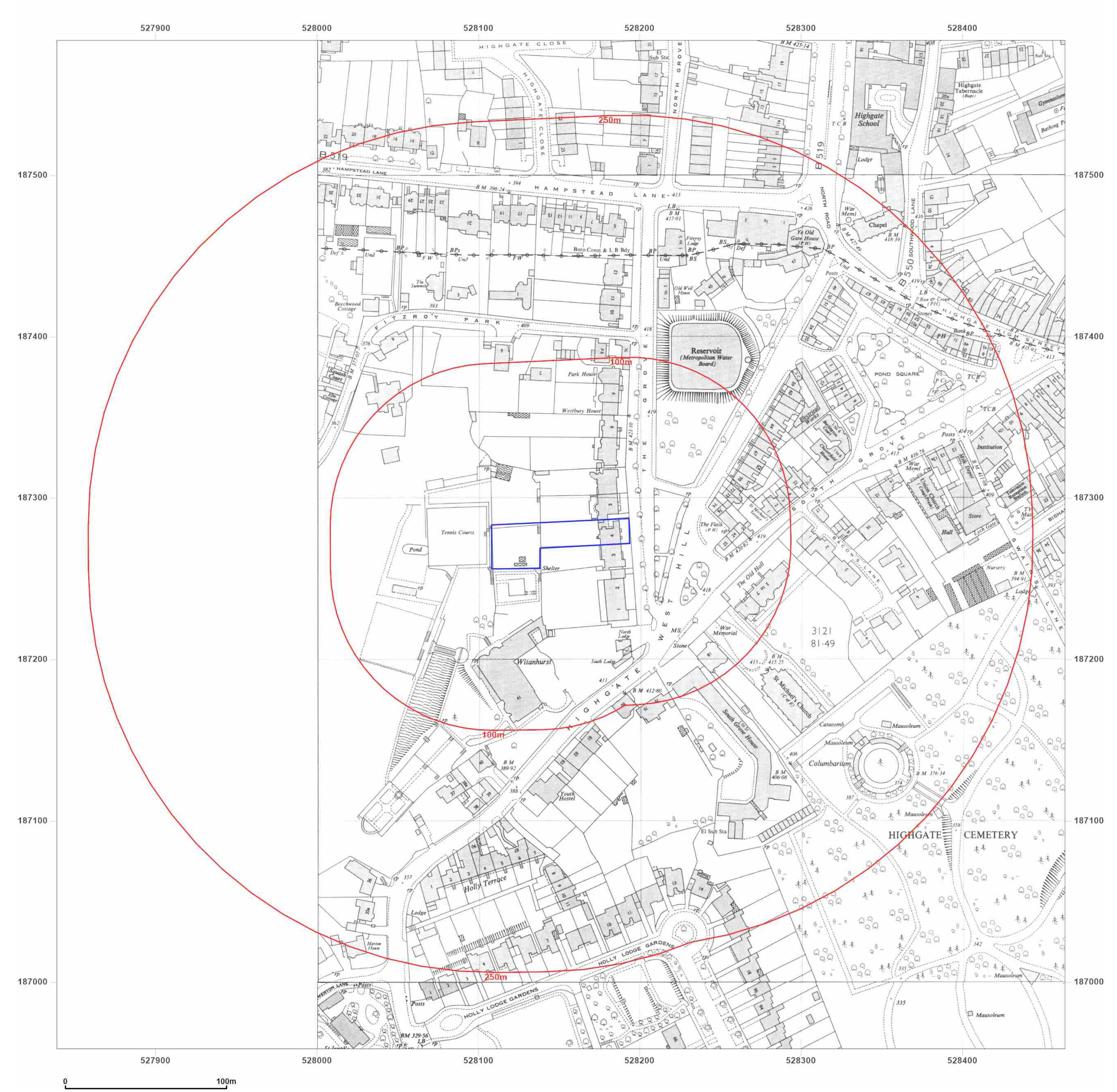

Groundsure INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: 1970

Scale: 1:2,500

Printed at: 1:2,500

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Levelled 1954

Surveyed 1968
Revised 1968
Edition N/A
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Levelled 1954

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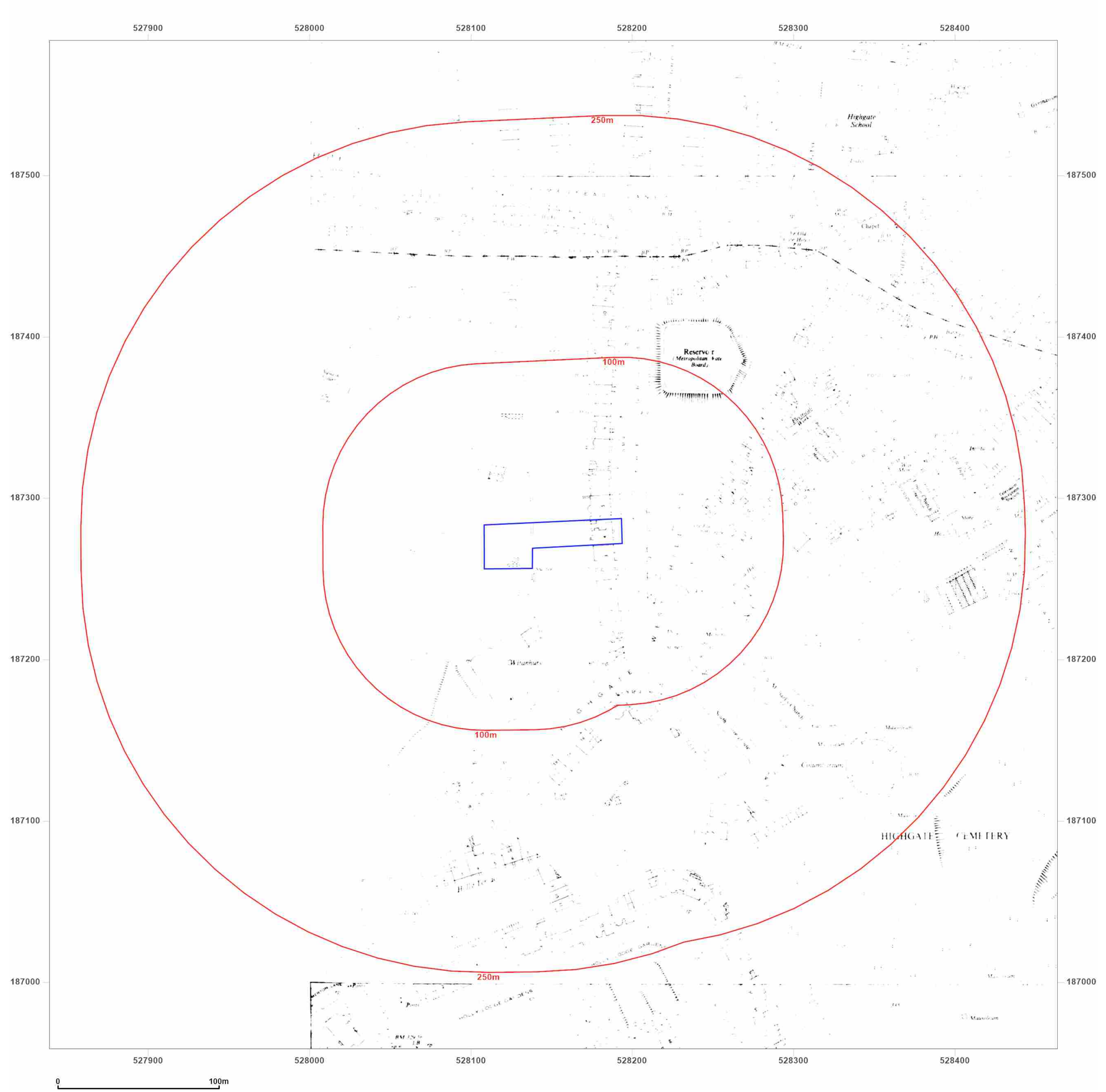


Site Details:

4, THE GROVE, LONDON, N6 6JU

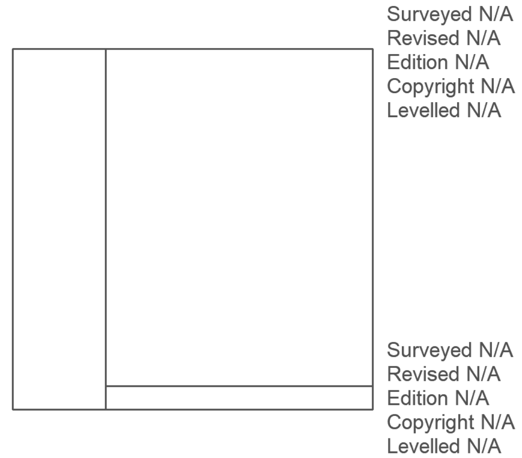
Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: **1970**

Scale: 1:2,500

Printed at: 1:2,500



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Map legend available at:
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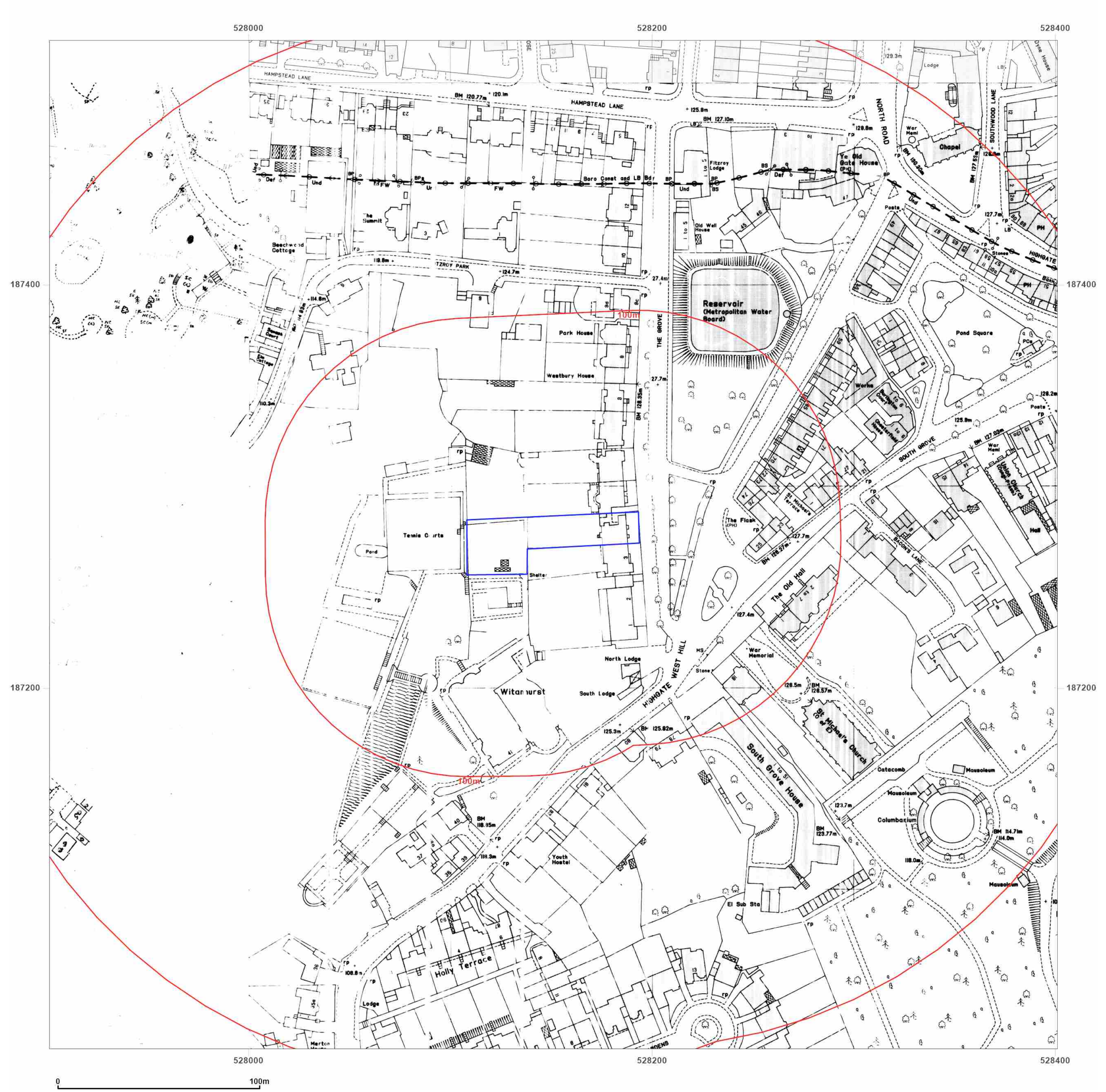

Groundsure INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: **1974-1978**

Scale: 1:1,250

Printed at: 1:2,000

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

Surveyed N/A
Revised 1978
Edition N/A
Copyright 1968
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Map legend available at:
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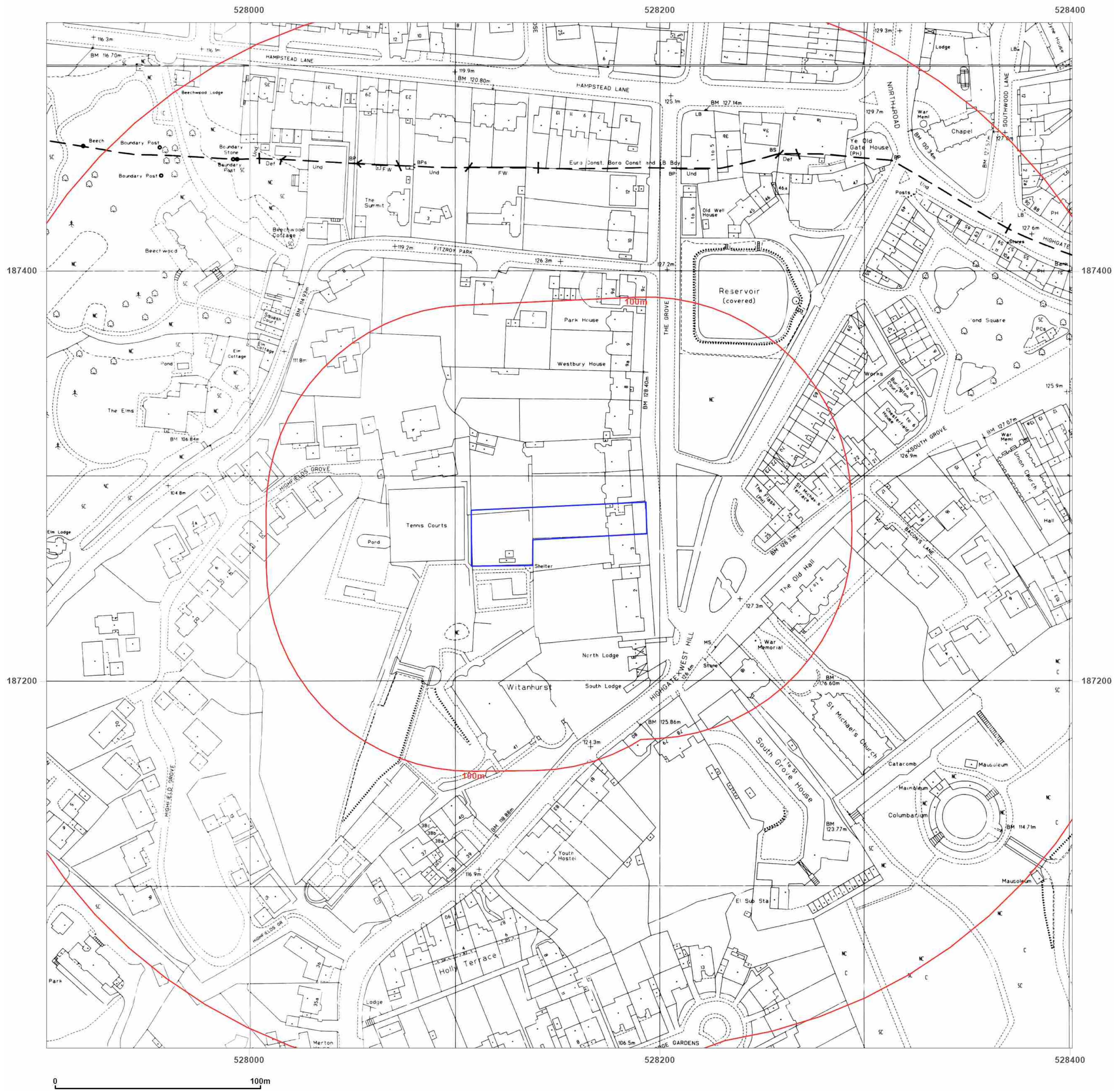

Groundsure INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref: 2429_TE1723
Report Ref: GS-9349302
Grid Ref: 528151, 187271

Map Name: National Grid

Map date: 1991

Scale: 1:1,250

Printed at: 1:2,000

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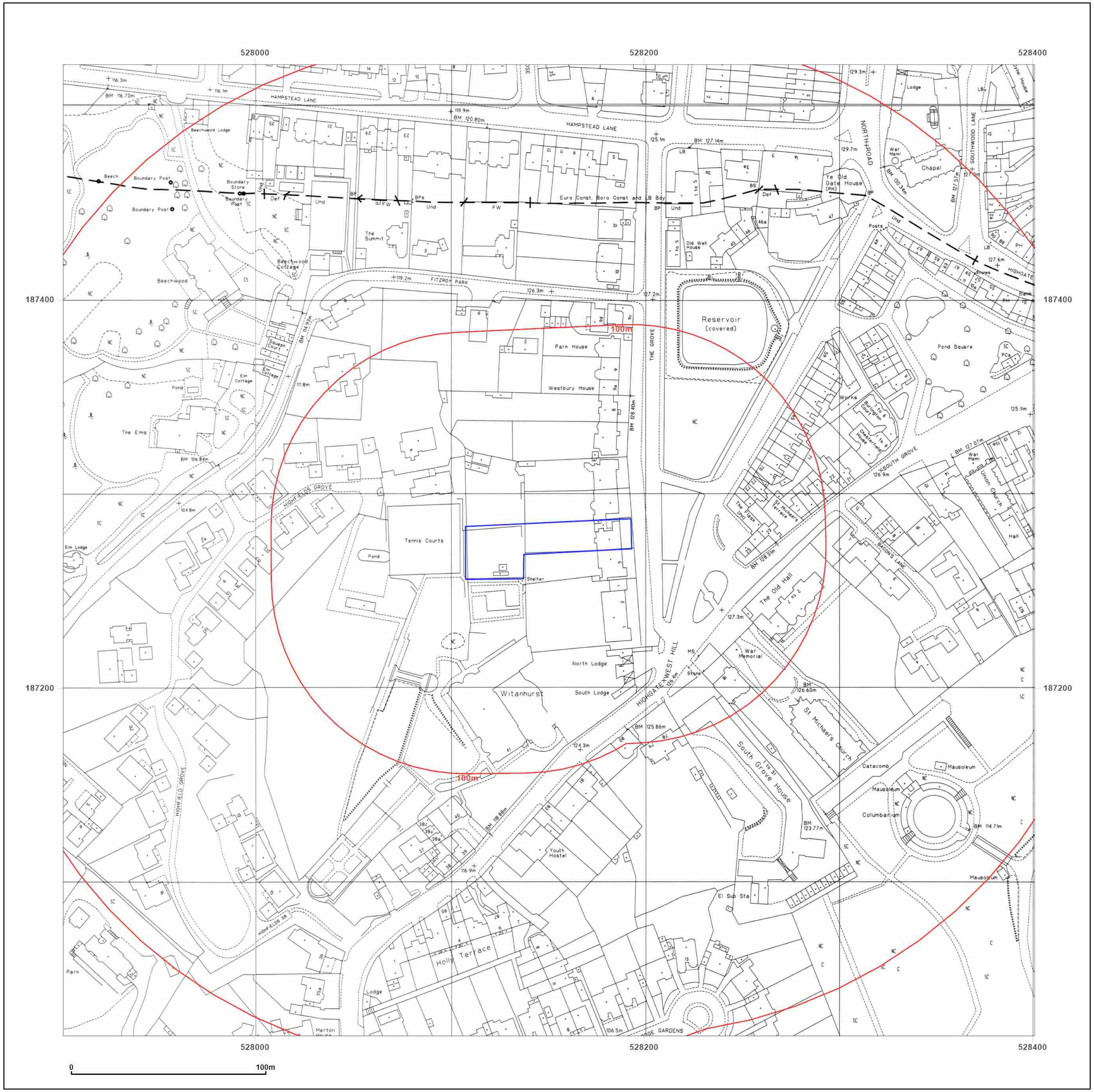

Groundsure INSIGHTS

Site Details:

4, THE GROVE, LONDON, N6 6JU

Client Ref:	2429_TE1723
Report Ref:	GS-9349302
Grid Ref:	528151, 187271

Map Name:	National Grid
Map date:	**1991**
Scale:	1:1,250
Printed at:	1:2,000

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