geotechnical and environmental consultants

ground&water

Ground Investigation Report/Basement Impact Assessment

34 Nassau Road SW13 9QE

On behalf of Tom Richards

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V1.02			
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EXECUTIVE SUMMARY	
PROPOSED DEVELOPMENT	At the time of reporting, March 2024, the proposed development was understood to comprise the construction of a basement under the existing house and a small extension to the rear, to a maximum depth of 3.80m bgl, along with a small lightwell to the front. A pool, pool house and patio are also proposed in the rear garden. The levels on-site were considered to remain the same.
GEOLOGY	The BGS Solid and Drift Geological Map for the area revealed that the site was underlain by the superficial Kempton Park Gravel Member, underlain by the bedrock of the London Clay Formation. Alluvium was noted to be ~148m north-west of the site. An area of artificial ground was noted ~190m south-east of the site.
HYDROGEOLOGY	The DEFRA online maps indicated that the site was located on Secondary A Aquifer associated with the superficial Kempton Park Gravel Member, underlain by Unproductive Strata associated with the London Clay Formation. From analysis of hydrogeological and topographical maps the groundwater table was anticipated to be encountered at shallow to moderate depth within the Kempton Park Gravel Member, capping the impermeable London Clay Formation. Perched water was also likely to be found within the Made Ground, especially after periods of intense or prolonged rainfall. It was considered that the groundwater was flowing westwards, towards the River Thames and in alignment with local topography.
VOLUME CHANGE POTENTIAL	Shallow Kempton Park Gravel member (cohesive): Medium – High Depper Kempton Park Gravel Member (granular): No
FOUNDATION DESIGN	The design and construction of the basement and associated structural elements would need to take into account the volume change potential of the respective soils. The basement is expected to be constructed within the deeper, granular KPGM deposits, while the cohesive shallow zone of high VCP, should be considered as a main factor for the pool house. Any shallow foundations (eg pool house) should take into account seasonal heave and special precautions may be required (void, compressible material for foundations, etc). For the pool house, a suspended slab is recommended, as a result of the Made Ground thickness recorded and the shallow cohesive zone of high VCP.
SUB-SURFACE CONCRETE	According to BRE Special Digest 1, 2005, 'Concrete in Aggressive Ground' a Sulphate Design Class of DS-1 could be used for sub-surface concrete in contact with the Kempton Park Gravel Member. Table C1 of the Digest indicated an ACEC (Aggressive Chemical Environment for Concrete) classification of AC-1.
CONTAMINATION	Elevated levels of Lead, Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(a,h)anthracene were found within the Made Ground sample WS01/1.20m bgl, therefore, a Full Contamination Assessment is recommended, which was not within the scope of this report.

1.0 INTRODUCTION

1.1 General

Ground and Water Limited were instructed by Tom Richards on 04/03/2024 to conduct a Ground Investigation Report on the site referred to as 34 Nassau Road SW13 9QE. The scope of the investigation was detailed within the Ground and Water Limited fee proposal (reference: QU-0154REV2).

1.2 Aims of the Investigation

The aim of the investigation was understood to be to supply the client and their designers with information regarding the ground conditions underlying the site to assist them in preparing an appropriate scheme for development.

The investigation was to be undertaken to provide parameters for the design of foundations by means of in-situ and laboratory geotechnical testing undertaken on soil samples recovered from trial holes.

The proposed development includes a basement. A Basement Impact Assessment, including screening and detailed comment on surface water flooding/management or combined flooding (sourced from SFRA or similar sources) was part of the remit of the report.

The requirements of the following reports were reviewed with respect to this project:

- The London Borough of Richmond Upon Thames, Planning Advice Note: Good Practice Guide on Basement Developments (May 2015);
- The London Borough of Richmond Upon Thames: Further Groundwater Investigations (March 2021);
- The London Borough of Richmond Upon Thames: Strategic Flood Risk Assessment Level 1 (March 2021); and
- The London Borough of Richmond Upon Thames: Basement Assessment User Guide (March 2021).

In addition, a Ground Movement Assessment for the impact of the proposed development on surrounding properties and assets was not in the remit of the report.

A full scale Environmental Desk Study and Contamination Assessment including a gas risk assessment were not part of the remit of this report; however Included within the fee proposal was an allowance to undertake chemical laboratory testing on soil samples recovered from the site to enable recommendations for the safe redevelopment of the site and the protection of site workers, end-users and the public from any potential contamination identified.

The techniques adopted for the investigation were chosen considering the requirements of the client, anticipated ground conditions, and bearing in mind the nature of the site, limitations to site access and other logistical limitations.

1.3 Conditions and Limitations

This report has been prepared based on the terms, conditions and limitations outlined within

Appendix A.

1.4 Technical Glossary

Generic technical terms can be viewed within the glossary provided within Appendix B.

2.0 SITE SETTING

2.1 Site Location

The site comprised a 800m^2 rectangular shaped plot of land, with a north-east to south-west orientation, located along the south side of Nassau Road. The site was located within Barns, a mainly residential area within The London Borough of Richmond Upon Thames. A Site Location Plan is provided within Figure 1 and a plan showing the site development area is given within Figure 2.

2.2 Site Description

A Site Walkover was undertaken on 19/03/2024. A description of the site, as noted during the Site Walkover, is tabulated below. An aerial view of the site, showing an approximate site boundary, is given within Figure 3.

Site Description Sheet	
Variable	**Description**
Use of site	The site was made up of a semi-detached residential building, with a back garden with a small building within.
Area topography	The area was relatively flat.
Structures on-site	The main house was in the north-eastern portion of the site, with a small outbuilding in the centre of the site.
Structures off-site	Semi-detached and detached houses along Nassau Road.
Use of surrounding ground	A residential area.
Boundary features	North-East: Nassau Road. South-East: Wooden Fence. South-West: Wooden Fence. North-West: Wooden Fence.
Site covering	The site is mainly soft landscape, with hardstanding under the buildings on-site, along with a small area of decking to the south of the main house.
Contamination sources on-site	None noted.
Contamination sources off-site	None noted.
Vegetation on-site	Semi-mature to mature trees, as well as bushes and shrubs.
Vegetation off-site	Large, mature trees in close proximity to the site.
Services	General housing services noted such as drains and electrics/arial.

2.3 Site Topography

The site was noted to be relatively flat and level with no major slopes. The site did not contain a basement/lower ground floor. The area in which the site was located was noted to be generally sloping downwards in a north-western direction from Sidmouth Wood towards the River Thames. A contour map has been provided within Figure 3.

2.4 Historical Map Review

The site formed part of a larger undeveloped area, with a development of residential housing located ~200m south-west, this was shown in the earliest historical maps available (1868). The River Thames was noted ~200m west of the site. The 1896 maps showed that a very small portion of the south of the site was taken up by a Pavilion. The sites environs also included a cricket ground~15m north, as well as a gravel pit ~115m north-west.

The next available map is the 1913 map, which showed residential development within the sites environs and the site itself. The site contained a semi-detached house in the northern portion, with a small building in the centre of the site. Almost the entire of the site's close environs (within 100m) have been developed with semi-detached or detached residential houses, with a small open space ~80m north-west of the site. The gravel pit had been filled in by that time.

The 1933 maps showed that major residential development has extended to the site's northern environs up to 250m from the site. A new factory was located ~90m south of the site, however this had been demolished and a new building has been built in its place by the 1950 maps. No other significant changes were noted up to the most recent historical mapping in 2024.

Historical maps, obtained from GroundSure, can be viewed within Appendix C.

2.5 Nearby Assets and Subterranean Developments

No railway cuttings were noted within a 250m radius of the site. No London Underground tunnels were noted within a 250m radius of the site. The site is not in close proximity to any National Rail lines. The site was considered to be not sufficiently close to underground transport services, in order for these to affect the property and there are no approved proposals for any TfL services in the vicinity that would affect the development.

The properties along Nassau Road, were mainly 2-to-3 storey, semi-detached and detached residential properties. No lower ground floors were noted in close proximity to the site.

5No. Listed buildings were noted ~144m south-east; ~165m south-east; ~173m south; ~210m south-east and ~235m south.

2.6 Proposed Development

At the time of reporting, March 2024, the proposed development was understood to comprise the construction of a basement under the existing house and a small extension to the rear, to a maximum depth of 3.80m bgl, along with a small lightwell to the front.

A pool, pool house and patio are also proposed in the rear garden.

The levels on-site were considered to remain the same.

The proposed development fell within Geotechnical Design Category 2 in accordance with Eurocode 7. A cross-section of the proposed development is provided within Figure 5.

2.7 Geology

The BGS Solid and Drift Geological Map for the area revealed that the site was underlain by the superficial Kempton Park Gravel Member, underlain by the bedrock of the London Clay Formation. Alluvium was noted to be ~148m north-west of the site. An area of artificial ground was noted ~190m south-east of the site. No other superficial deposits, outcrops of other bedrock deposits or areas of Made/Worked Ground were noted within a 250m radius of the site.

2.8 Hydrogeology and Hydrology

The DEFRA online maps indicated that the site was located on Secondary A Aquifer associated with the superficial Kempton Park Gravel Member, underlain by Unproductive Strata associated with the London Clay Formation.

From analysis of hydrogeological and topographical maps the groundwater table was anticipated to be encountered at shallow to moderate depth within the Kempton Park Gravel Member, capping the impermeable London Clay Formation. Perched water was also likely to be found within the Made Ground, especially after periods of intense or prolonged rainfall. It was considered that the groundwater was flowing westwards, towards the River Thames and in alignment with local topography.

The nearest surface water feature was observed to be the river Thames, approximately 200m west of the site.

2.9 BGS Borehole Records

A BGS borehole record in similar geology ~250m west of the site (ref.: TQ27NW879) noted Topsoil to 0.40m bgl, overlying gravelly clay to 4.30m bgl, this is underlain by a sandy gravel to 6.00m ngl, with a silty clay for the remaining depth of the borehole (9.50m bgl). A groundwater strike was noted at 4.30m bgl.

Another BGS borehole record in similar geology ~417m south-east of the site (ref.: TQ27NW426), noted the London Clay Formation to 44.00m bgl.

2.10 Flooding

A summary of the risk of various flooding types has been summarised in the following table.

Summary of Flood Risk			
Type of Flooding	**Figure Reference**	**On-site Flood Risk**	**Maximum Nearby Flood Risk**
Rivers and Seas	Figure 6	Flood Zone 3	On-site
Flood Defences	Figure 7	Yes	On-site
Reservoir	Figure 8	Yes, when rivers flood	Within 50m
Surface Water Flooding	Figure 9	Low	Within 50m
Groundwater and Throughflow Flooding	Figure 13, 14 and 15	Groundwater – yes between 50 – 74.9% Site **not** in a throughflow catchment area	Similar to on-site
Sewer Flooding	Figure 16	SW13	Records of sewer flooding: 10No. indoor incidents and 7No. outdoor incidents within the Post Code District.
Critical Drainage Areas	Figure 17	No	N/A

2.11 Radon

A review of the freely available UK Health Security Agency radon database, UK Radon, indicated that the site was located within a 1km grid square, where the maximum radon potential of <1% was recorded. Basic radon protection measures are required in areas where more than 3% of houses are at or above the Action Level.

The proposed construction included a basement, this is a vulnerable structure when it comes to radon, therefore waterproofing should be upgraded to include radon protection.

2.12 Unexploded Ordnance Review

A review of the data available on www.zeticauxo.com/ revealed the site was located within the London high-risk area associated with unexploded ordnance (UXO). The London area is further separated into 25No. categories based on bombing densities, where green is indicated for areas having <10 bombs dropped per km^2 and red is indicated for areas having >150 bombs dropped per km^2. The site is situated within the orange area, ~halfway through the spectrum. 1No. known Luftwaffe Bombing Target site was located ~1.00km north-east of the site.

3.0 BASEMENT IMPACT ASSESSMENT

A scoping and screening assessment was undertaken for the proposed development based on the supplementary planning document (SPD) for the London Borough of Richmond Upon Thames. This stage should identify any areas of concern and therefore focus efforts on further investigation.

3.1 Stage 1: Screening

The screening questions/fields for three distinct topics (surface water/flooding, groundwater, and stability) have been summarised within this section of the report.

3.1.1 Subterranean Screening Flowchart

Questions relating to groundwater, as well as discussion and conclusions, can be viewed tabulated below.

Subterranean Characteristics Screening Flowchart		
Question	**Discussion**	**Conclusion**
Does the recorded water table extend above the base of the proposed subsurface structure?	**Potentially:** The DEFRA online maps, online SFRA mapping tool and nearby BGS geological boreholes indicated that the site was underlain by a Secondary (A) Aquifer of the Kempton Park Gravel Member and then Unproductive strata of the London Clay Formation. A BGS borehole record in similar geology ~250m south-west of the site (ref: TQ27NW879) noted a groundwater strike at 4.30m bgl. Some amounts of perched water was likely to be found within localised Made Ground and within the sandy gravelly, especially after periods of intense or prolonged rainfall.	**Take forward to scoping**
Is the proposed subsurface development structure within 100m of a watercourse or spring line?	**No:** Reference to OS mapping, the River Thames was noted ~200m west of the site.	No further action required
Are infiltration methods proposed as part of the site's drainage strategy?	It is understood that infiltration methods will be applied to drain the site and prevent surface water flooding; therefore, no unsuitable risk of surface water flooding was to be anticipated once the proposed development is operational.	No further action required
Does the proposed excavation during the construction phase extend below the local water table level or spring line (if applicable)?	**Maybe:** Based on nearby BGS record, groundwater levels were expected to be near the depth of the basement level with a groundwater strike recorded at 4.30m bgl. The SFRA highlighted the site was located within an area of permeable superficial deposits with the potential for elevated groundwater levels.	**Take forward to scoping**
Is the shallowest geological strata at the site London Clay?	**No:** The BGS Solid and Drift Geological Map for the Richmond Area highlighted the site was underlain by the superficial deposits of the Kempton Park Gravel Member.	**Take forward to scoping**
Is the site underlain by an aquifer and/or permeable geology?	**Yes:** The BGS Solid and Drift Geological Map for the Richmond Area highlighted the site was underlain by the superficial deposits of the Kempton Park Gravel Member and then the bedrock deposits of the London Clay Formation. The DEFRA online maps and online SFRA map tool indicated the site was underlain by a Secondary (A) Aquifer of the Kempton Park Gravel Member and then an Unproductive Aquifer of the London Clay Formation.	**Take forward to scoping**

3.1.2 Land Stability

Questions relating to land stability, as well as discussion and conclusions, can be viewed tabulated below.

Land Stability Screening Flowchart		
Question	**Discussion**	**Conclusion**
Does the site, or neighbouring area, topography include slopes that are greater than 7˚?	**No:** The site was noted to have no major slopes and/or undulations. No significant slopes, natural or man-made, were noted within close proximity to the site. No deep failures were expected due to the geology and the depth of the basement.	No further action required
Will changes to the site's topography result in slopes that are greater than 7˚?	**No:** The gradients on-site were considered to remain similar to the existing.	No further action required
Will the proposed subsurface structure extend significantly deeper underground compared to the foundations of the neighbouring properties?	**Maybe/Yes:** The proposed development was understood to comprise the excavation of a new basement beneath the existing property to a maximum depth of ~3.80m bgl, with a small extension to the rear and lightwell to the front. The site walkover did not highlight basements / lower ground floors within the neighbouring structures.	**Take forward to scoping**
Will the implementation of the proposed subsurface structure require any trees to be felled or uprooted?	**Yes:** The Arboricultural Report undertaken highlighted that trees were to be removed.	**Take forward to scoping**
Has the ground at the site been previously worked?	**No:** With reference to the BGS Solid and Drift Geological Map for the area, an area of artificial ground was noted ~190m south-east of the site.	No further action required
Is the site within the vicinity of any tunnels or railway lines?	**No:** No railway (above ground and/or underground) infrastructure was noted within a 250m radius of the site.	No further action required

3.1.3 Flood Risk and Drainage

Questions relating to Flood Risk and Drainage as well as discussion and conclusions, can be viewed tabulated below and below.

Flood Risk and Drainage Screening Flowchart		
Question	**Discussion**	**Conclusion**
Will the proposed subsurface development result in a change in impermeable area coverage on the site?	The amount of hardstanding anticipated to increase, which in turn could create a larger risk of surface water flooding; however, the change is expected to be small and site drainage is to be implemented which will reduce this risk to an acceptable level.	**Take forward to scoping**
Will the proposed subsurface development impact the flow profile of throughflow, surface water or groundwater to downstream areas?	The proposed development would comprise excavation of a small basement to the relatively shallow depth of ~3.80m bgl, therefore surface flow patterns are not expected to be altered. The site was not located within an Throughflow Catchment and/or potential throughflow catchment area. The above should be supported by the results of a ground investigation and the depth to impermeable strata.	**Take forward to scoping**
Will the proposed subsurface development increase throughflow or groundwater flood risk to neighbouring properties?	Given the relatively small size of the structure, it was unlikely to form a significant barrier to cause an increased risk to flooding of neighbouring properties. The basement is expected to be formed within the superficial more permeable soils of the KPGM and therefore groundwater can flow below and at the sides of	No further action required

Flood Risk and Drainage Screening Flowchart		
Question	Discussion	Conclusion
	the structure. The surrounding structures were not expected to have basements; therefore, flow is expected to be less restricted. The above should be supported by the results of a ground investigation. The site was **not** within a throughflow catchment area.	

3.2 Stage 2: Scoping

There are areas of concerns that the Screening process have highlighted.

- **Perched Water and Groundwater:** It was anticipated that groundwater was to be found within the Secondary (A) Aquifer of the Kempton Park Gravel Member. Given the proposed basement depth, it was likely that the basement may encounter the groundwater level during construction. **This is to be taken forward for further assessment through a ground investigation and the installation of a monitoring well.**

- **Seasonal Soil Moisture and Volume Change Potential:** Anticipated geology considered the presence of granular superficial soils of the Kempton Park Gravel Member underlain by cohesive soils of the London Clay Formation. Localised cohesive bands may also be found within the superficial soils and the bedrock soils are likely to be subject to subsidence due to shrinkage-swelling. **The depth and volume change potential of the underlying soils should be investigated.**

- **Pressure Induced Settlement and Heave:** Given the overburden pressure release following excavation of soil, as well as the loading of retaining wall foundations, the pressure across the basement is likely to cause differential settlement and heave. **Regarding the bulk basement construction, care will need to be taken to ensure that the slab is protected through accommodating heave (primarily) and any seasonal if applicable.**

- **Retaining Wall Design:** Given the design of basements, retaining walls should be appropriately designed to withstand the horizontal pressure of adjacent strata. **Retaining walls should be appropriately designed**.

- **Instability During Excavation:** Stability issues may arise during the excavation through natural soils and Made Ground. **Indicative measures that can be undertaken throughout excavation and construction will be discussed within this report, and more specific measures within the construction method statement.**

- **Ground Movement and Nearby Assets:** Various buildings and structures were noted in close proximity to the site, with the site itself having a proposed lower ground floor, and neighbouring properties not; therefore, differential foundation depths would cause potential damage to the walls of nearby buildings, due to soil displacement following the excavation/installation of the basement. This may also cause damage to nearby roads, pavements and utilities. **A Ground Movement Assessment (GMA) is recommended to assess the soil displacement and damage to nearby buildings, roads, pavements and utilities.**

- **Sub-Surface Concrete in Aggressive Ground Conditions:** Concrete may corrode if unsuitable concrete is used. A suitable concrete class should be used for all sub-surface concrete used for all foundations, based on the levels of sulphates and the pH within the ground it is being constructed on/through. **Testing in accordance with BRE Special Digest is required to be undertaken and a concrete specification is to be provided.**

- **Surface Water Flooding and Site Drainage:** Data from the Environment Agency website indicated that the site, and the majority of the surrounding area, was at a low risk of surface water flooding. The amount of hardstanding was expected to increase following the construction of the proposed development. It is understood that infiltration methods will be applied to drain the site and prevent surface water flooding.

  The effect the proposed development will have on surface water flooding and the requirements to prevent surface water flooding and site drainage are to be discussed further within this report.

- **Groundwater Flooding and Flow:** As the site was underlain by a Secondary (A) Aquifer, underlain by Unproductive Strata, there was considered to be a risk of groundwater flooding. **A groundwater monitoring well should be installed as part of the site investigation, as well as groundwater dip measurements following the site works, to investigate groundwater levels. Throughflow issues were discussed within the screening section, however they will also be discussed within the end of the report, after the ground investigation results and having all data together.**

- **Sewer Flooding:** Given their subterranean position, basements can be susceptible to flooding from sewers. 10No. indoor incidents and 7No. outdoor incidents within the postcode area. **The effect the basement will have on the risk of sewer flooding and the requirements to prevent sewer flooding is to be discussed further within this report.**

- It is understood that some trees will be removed and/or planted. Any potential geotechnical/structural impact of that activity should be discussed and addressed.

A site-specific ground investigation has been undertaken to inform design, including provision of information on the existing foundations. The results of this investigation and subsequent engineering considerations are provided within this report.

The submission of a drainage scheme will likely be required. It is understood this will form part of the overall Structural Scheme and will be included in the Structural Engineers report.

4.0 SITE WORKS

4.1 Scope of Works

Site works were undertaken on 08/03/2024 and comprised the drilling of the 2no. Modular Window Sample Boreholes to 3.00m and 6.00m bgl with Standard Penetration Tests at 1.00m intervals. Boreholes were terminated early due to density of strata. Boreholes were terminated early due to density of strata. Super Heavy Dynamic Probes (DP1) were undertaken through the base of WS1 to final depths of 7.00m bgl.

Combined Ground-gas and Groundwater Monitoring Well Construction						
Trial Hole	**Type of Installation**	**Depth of Installation (m bgl)**	**Thickness of slotted piping with gravel filter pack (m)**	**Depth of plain piping with bentonite seal (m bgl)**	**Response Zone (m bgl)**	**Piping internal diameter (mm)**
WS01	Standpipe	3.00	2.00	1.00	1.00 – 3.00	50
WS02	Standpipe	3.00	2.00	1.00	1.00 – 3.00	50

The approximate location of the trial hole locations can be seen within Figure 18.

Prior to commencing the ground investigation, a walkover survey was carried out to identify the presence of underground services and drainage. Where underground services/drainage were suspected and/or positively identified, the exploratory position was relocated away from these areas.

As a further precautionary measure, the borehole was hand excavated to 1.00m below the local ground level (bgl) and scanned with a Cable Avoidance Tool (CAT scanner) to minimise the risk to services.

Upon completion of the drilling works, the trial holes were backfilled and made good, in relation to the surrounding area.

4.2 Sampling Procedures

Small disturbed samples were recovered from the trial holes at the depths shown on the trial hole records. Soil samples were generally retrieved from each change of strata and/or at specific areas of concern. Samples were also taken at approximately 0.5m intervals during broad homogenous soil horizons.

A selection of samples were despatched for geotechnical testing purposes. A programme of chemical laboratory testing, scheduled by Ground and Water Limited and carried out by an accredited chemical testing laboratory, was undertaken on soils samples recovered from the boreholes.

5.0 ENCOUNTERED GROUND CONDITIONS

5.1 Soil Conditions

The trial holes were logged by a Ground and Water Limited representative, generally in accordance with BS EN 14688 'Geotechnical Investigation and Testing – Identification and Classification of Soil'.

The ground conditions encountered within the trial holes constructed on the site did generally conform to that anticipated from examination of the geology map. A capping of Made Ground was noted to overlie the superficial Kempton Park Gravel Member.

The succession of conditions and description of soils encountered in the trial holes in descending order is tabulated below.

Summary of Strata Encountered (WS01 – WS02)			
Strata	**Top Depth (m bgl)**	**Base Depth (m bgl)**	**Thickness (m)**
MADE GROUND: Dark brown sandy gravelly CLAY. Sand is fine. gravel is fine to coarse, angular to sub-rounded of flint (80%), brick (15%) and chalk (5%).	GL	1.20	1.20
KEMPTON PARK GRAVEL MEMBER: Orange, brown very sandy CLAY. Sand is fine.	1.20	1.80 – 2.20	0.60 – 1.00
KEMPTON PARK GRAVEL MEMBER: Light brown very sandy GRAVEL. Sand is fine to coarse. Gravel is fine to coarse, angular to subrounded of flint.	1.80 – 2.20	>3.00 - >4.00	>1.20 - >1.80

For details of the composition of the soils encountered at particular points, reference must be made to the individual trial hole logs within Appendix D of this report.

5.2 Roots Encountered

Roots were noted to a maximum depth of 1.50m bgl. A summary of the depth of root penetration can be viewed below.

Root Depth	
Trial Hole	**Fresh Root Penetration (m bgl)**
WS01	1.20
WS02	1.50

It must be noted that the chance of determining actual depth of root penetration through a narrow diameter borehole is low. Roots may be found to greater depths at other locations on the site, particularly close to trees and/or trees that have been removed both within the site and its close environs.

5.3 Groundwater Conditions

A summary of the groundwater observations during site works has been provided below.

Groundwater Strikes during Drilling		
Trial Hole	**Groundwater reading (m bgl)**	**Depth after 20 minutes (m bgl)**
WS01	2.80	2.70
WS02	2.90	2.80

Changes in groundwater level occur for a number of reasons including seasonal effects and variations in drainage. The investigation was undertaken in March 2024 when groundwater levels are likely to be at their annual maximum (highest elevation). Exact groundwater levels may only be determined through long term measurements from monitoring wells installed on-site.

Groundwater monitoring was undertaken on two occasions to date. The results can be seen tabulated below.

Groundwater Observations			
Date	**Trial Hole**	**Water Level (m bgl)**	**Final Well Depth (m bgl)**
19/03/2024	WS01	Dry	2.45
	WS02	3.10	3.19
02/04/2024	WS01	Dry	2.30
	WS02	2.90	3.00

5.4 Obstructions

No SPT could be undertaken at 4.00m bgl due to the sands filling up the casing.

No other artificial or natural sub-surface obstructions were noted during construction of the trial holes.

6.0 IN-SITU AND LABORATORY TESTING

6.1 In-Situ Strength Testing

Standard Penetration Tests (SPTs) and Super Heavy Dynamic Probes (SHDPs) were undertaken as part of the site investigation. The results of the SPT's have not been amended to consider hammer efficiency, rod lengths and overburden pressure in accordance with Eurocode 7. The test results are presented on the borehole logs within Appendix D. An interpretation of the in-situ geotechnical testing results is given in the table below.

Interpretation of In-situ Geotechnical Testing Results					
Strata	**SPT "N" Blow Counts/Equivalent SPT "N Value from DP**	**Equivalent Undrained Shear Strength (Cu) (kPa)**	**Soil Type**		**Trial Hole/s**
			Granular (Density)	**Cohesive (Cu)**	
Shallow Kempton Park Gravel Member (Cohesive)	21 – 28	105 – 140	-	High	WS01/1.20m bgl WS02/1.20m bgl
Deeper Kempton Park Gravel Member (Granular)	>27 – 52	-	Dense – Very Dense	-	BH1/2.75 – 3.80m bgl WS1/1.00 – 2.50m bgl
Assumed Kempton Park Gravel Member (Granular)	*14 – 39*	-	*Medium – Dense*	-	*DP2/4.00 – 6.00m bgl*
Assumed London Clay Formation (Cohesive)	*12 – 13*	*60 – 65*	-	*Medium*	*DP2/6.00 – 7.00m bgl*

It must be noted that field measurements of undrained shear strength (Cu) are dependent on a number of variables including disturbance of sample, method of investigation and also the size of specimen or test zone.

6.2 Geotechnical Laboratory Testing

A programme of geotechnical laboratory testing, scheduled by Ground and Water Limited and carried out by an accredited geotechnical testing laboratory was undertaken on samples recovered. Details of the specific tests used in each case are given below.

Standard Methodology for Laboratory Geotechnical Testing		
Test	**Standard**	**Number of Tests**
Atterberg Limit Tests	BS1377:2016:Part 2:Clauses 3.2, 4.3 & 5	2
Moisture Content Determinations	BS1377:2016:Part 2:Clause 3.2	2
Particle Size Distribution Tests	BS1377:2016:Part 2:Clause 9	3
Water Soluble Sulphate and pH Test	BS1377:2018:Part 3:Clause 5	1
BRE Special Digest 1 Tests	BRE Special Digest 1 "Concrete in Aggressive Ground (BRE, 2005).	2

6.2.1 Atterberg Limit Testing

A précis of Atterberg limit testing undertaken can be seen tabulated below. The test results are presented within Appendix E.

Atterberg Limit Tests Results Summary							
Stratum	Moisture Content (%)	Passing 425 µm sieve (%)	Modified PI (%)	Soil Class	Consistency Index (Ic)	Volume Change Potential	
						BRE	NHBC
Kempton Park Gravel Member (cohesive)	21 – 29	36 – 54	26.64 – 41.04	CL	Very Soft	Medium – High	Medium – High

- **NP – Non-plastic**
- **BRE Volume Change Potential refers to BRE Digest 240 (based on Atterberg results)**
- **Soil Classification based on British Soil Classification System.**
- **Consistency Index (Ic) based on BS EN IS0 14688-2:2018.**

6.2.2 Moisture Deficit Assessment

The results of the Atterberg Limit tests were analysed to determine the Liquidity Index of the samples, to give an indication as to whether the samples recovered showed a moisture deficit as well assessing their degree of consolidation. Liquid Limit analyses was undertaken to assess whether there were any potentially significant moisture deficits within the samples tested.

A potential moisture deficit, caused by lithology, was noted within WS2 at 2.00m bgl.

6.2.3 Particle Size Distribution Testing

The results of particle size distribution (PSD) testing undertaken show that the deeper granular Kempton Park Gravel Member does not have volume change potential in accordance with BRE240 and NHBC Standards Chapter 4.2. The results of the PSD testing can be viewed within Appendix E.

Particle Size Distribution Tests Results Summary			
Stratum	Range Passing 63µm Sieve (%)	Volume Change Potential	
		BRE	NHBC
Kempton Park Gravel Member (granular)	2 – 4	No	No

- **Volume Change Potential refers to BRE Digest 240 (based on Grading test results).**
- **Shrinkability refers to NHBC Standards Chapter 4.2 (based on Grading test results).**
- **BRE 240 states that a soil has a volume change potential when the clay fraction exceeds 15%. Only the silt and clay combined fraction are determined by sieving therefore the volume change potential is estimated from the percentage passing the 63µm sieve.**
- **NHBC Standards Chapter 4.2 states that a soil is shrinkable if the percentage of silt and clay passing the 63µm sieve is greater than 35% and the Plasticity Index is greater than 10%.**

6.3 Chemical Laboratory Testing

An un-targeted set of samples (2No. Made Ground and 3No. Kempton Park Gravel Member) were submitted to the accredited chemical laboratory for analysis. The results can be viewed in Appendix F.

Based on the proposed development, the results of the chemical laboratory testing were compared to the Generic Assessment Criteria (GAC) for a 'Residential with homegrown produce' land-use scenario, as this was considered the most appropriate land-use scenario.

Elevated levels of Lead, Benzo(a)pyrene, Benzo(b)fluoranthene and Dibenz(a,h)anthracene were found within the Made Ground sample WS01/1.20m bgl, therefore, a Full Contamination Assessment is recommended, which was not within the scope of this report.

7.0 ENGINEERING CONSIDERATIONS

7.1 Soil Characteristics and Foundation Considerations

A summary of the soil characteristics following the intrusive site investigation and laboratory testing and the relevant foundation considerations has been provided below. The following information from the ground investigation was considered pertinent to the design of foundations.

- Foundations should be taken through any Made Ground and either into, or onto a suitable underlying natural stratum of adequate bearing characteristics.
- The design and construction of the basement and associated structural elements would need to take into account the volume change potential of the respective soils. The basement is expected to be constructed within the deeper, granular KPGM deposits, while the cohesive shallow zone of high VCP, should be considered as a main factor for the pool house.
- The loads of proposed foundations should not exceed the allowable bearing capacity of the soils they are founding upon.
- Foundations must not be placed within fresh root penetrated and/or desiccated soils with volume change potential. It is recommended that foundations are taken at least 300mm into non-fresh root penetrated strata if the soils have volume change potential, or into soils of no volume change potential.
- The influence of trees on or surrounding the site will need to be taken into account in final design (NHBC Standards Chapter 4. 2) (tree rings).
- Any shallow foundations (eg pool house) should take into account seasonal heave and special precautions may be required (void, compressible material for foundations, etc).
- For the pool house, a suspended slab is recommended, as a result of the Made Ground thickness recorded and the shallow cohesive zone of high VCP.
- Any water ingress must be prevented from entering foundation trenches and excavations must be kept dry and either concreted or blinded as soon after excavation as possible. If water were allowed to accumulate within the excavation for even a short period of time, an increase in heave may occur. The shear strength will also be reduced, resulting in lower bearing capacities, resulting in increased settlements. Instability issues may arise within the foundation trenches, in case of perched water being present.
- Final designs for the foundations should be carried out by a suitably qualified Engineer based on the findings of this investigation and with reference to the anticipated loadings, serviceability requirements for the structure and the developments proximity to former, present, and proposed trees.

7.2 Geotechnical Analysis

This section of the report states suitable geotechnical parameters for the soils encountered as well as comments on the bearing capacity of the soils. A settlement/heave analysis was undertaken following the construction of the proposed development using Pdisp from Oasys.

7.2.1 Geotechnical Parameters for Modelling

Following a literature review from well documents publications, the short-term and long-term Young's Modulus (E short term and E') has been produced. The parameters, shown below, were used when undertaking the settlement/heave analysis within Pdisp.

Summary of Geotechnical Parameters							
Geological Strata	Depth (m bgl)		Short-term Young's Modulus (Eu short term) (kPa)		Long-term, Young's Modulus (E' long term) (kPa)		Poisson's Ratio
	Top	Base	Top	Base	Top	Base	
Made Ground	0.00	1.20	10,000.00	10,000.00	10,000.00	10,000.00	0.45
Kempton Park Gravel Member (Cohesive)	1.20	2.20	24,150.00	24,150.00	18,112.50	18,112.50	0.45
Kempton Park Gravel Member (Granular)	2.20	4.00	100,000.00	100,000.00	100,000.00	100,000.00	0.30
Assumed Kempton Park Gravel Member (granular)	4.00	6.00	78,000.00	32,000.00	78,000.00	32,000.00	0.30
Assumed London Clay Formation (cohesive)	6.00	7.00	22,500.00	45,000.00	16,875.00	33,750.00	0.45
	7.00	44.00	45,000.00	265,500.00	33,750.00	199,125.00	0.45

Made Ground

Made Ground was modelled between ground level and 0.70m bgl. A short-term and long-term Young Modulus (Eu and E') of 10MPa was suitable and on the conservative side, regarding Made Ground encountered on site. A Poisson's Ratio of 0.45 was considered suitable for these soils, given their variable nature.

Kempton Park Gravel Member (Cohesive)

Cohesive Kempton Park Gravel Member (Cohesive) were modelled between 1.20m – 2.20m bgl. A relationship of 1.15*N for the Eu value (in MPa) was considered suitable for the shallow Kempton Park Gravel Member (Cohesive), based on published literature (CIRIA 1995 / Butler 1975). (Eu/N = 1.0 – 1.2 for cohesive soils). A Poisson's Ratio of 0.45 was considered suitable for these soils, given their cohesive nature.

Kempton Park Gravel Member (Granular)

Granular Kempton Park Gravel Member were modelled between 2.20m – 6.00m bgl. Given the granular soils are permeable, no significant long-term draining of the soil was anticipated to occur and therefore the short and long-term modulus was considered sensible to remain the same. The widely accepted relationship between recorded SPTs within granular soils and E values of 2000* SPT "N" values was used for this consideration. The value was cross-referenced with representative published data (Obrzud & Truty 2012), showing a range of between 50 – 320MPa for the Young Modulus for dense sands and gravels. This also aligns with the drained modulus (30 – 160MPa) for River Terrace Gravels included in *"Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension CIRIA Special Publication 200".* A Poisson's Ratio of 0.30 was considered suitable for the granular soils.

London Clay Formation

Cohesive soils of the assumed London Clay Formation were encountered from 6.00m to the base of the dynamic probe, a depth of 7.00m bgl. Based on the nearby BGS boreholes the London Clay formation was understood to extend to a depth >44.00m bgl.

Where SPT "N" Values were undertaken, the Cu could be calculated by multiplying by 5, as stated by Stroud (1974). Where the London Clay Formation was inferred, a design line was taken from "*Burland*

JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension CIRIA Special Publication 200". The equation was undrained shear strength = (depth into the LCF x 8) + 50.

The relationship between Eu and Cu is generally dependent on strain levels. For small strains, a ratio of 750 can be adopted based on well documented publications. This is also reflected for the London Clay Formation, after extensive research, within graphs depicting strains and Eu/Cu ratios included in *"Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension CIRIA Special Publication 200".* A Poisson's Ratio of 0.45 was considered suitable for these soils, given their cohesive nature.

Long-Term Conditions
A ratio of E' to Eu of ~0.75 was considered a sensible approach for this stage in the design, for cohesive soils. For Made Ground, it was considered suitable for E' and Eu to be equal, given that these soils are more permeable and to limit the level of anticipated Young Modulus at a representative value.

7.2.2 Bearing Capacity

The following allowable bearing capacities were anticipated for the basement depth at 3.80m bgl. Based on the soil profiles within WS01 and WS02.

Allowable Bearing Capacities	
Foundation Depth (m bgl)	**Allowable Bearing Capacity (kN/m^2)**
3.80 (basement)	250 - 270
1.00/1.20 – 2.00 (Shallow cohesive zone)	200

7.2.3 Settlement/Heave Analysis

Analysis of vertical ground movements, using the Mindlin analysis method within Pdisp software, was undertaken to assess the potential movements resulting from changes of vertical pressure. Geotechnical parameters noted in the previous section of this report were used for the model. A rigid boundary at depth was considered at 44.00m bgl, for calculation purposes. The inputs and outputs of this analysis can be viewed within Appendix H.

Five representative stages of construction, in terms of the net change in vertical pressure, have been modelled. These were considered to adequately approximate the movements rising from the basement construction.

- **Stage 1:** Excavation of the retaining wall voids, with short-term conditions;
- **Stage 2:** Representative net loads associated with the construction of the retaining walls, with short-term conditions;
- **Stage 3:** Stage 2 loads as well as loads associated with the mass excavation of the basement footprint, with short-term conditions;
- **Stage 4:** Mass excavation load, as well as loads associated with the construction of the basement slab, with short term conditions and full net pressure at retaining wall locations. The basement is fully constructed from this stage onwards;
- **Stage 5:** Stage 4 arrangement but for long-term conditions.

A load of 30kN/m^2 was anticipated during construction and the mass excavation. The final loads were based on calculations by the structural engineers and they were selected to be representative of the site, this was 93kN/m^2.

Given the overall rectangular shape of the basement, the excavation was based on a rectangle using the maximum length and width of the basement. This was considered conservative and will ensure accurate results.

The overburden pressure release following the excavation and removal of soils was based on a specific weight of soil of 19kN/m. Based on a proposed basement depth of 3.80m bgl, an overburden pressure release of 72.2kN/m^2. The overburden pressure release was modelled at 3.80m bgl.

Retaining wall loads were modelled as extending 1.00m towards the centre of the basement and as having a representative uniform load of 30kN/m^2 in the short term, and 93kN/m^2 in the long term once fully loaded. This was selected in order not to underestimate the heave and overestimate any settlement. The load of the basement slab was unknown at the time of reporting and was assumed to be 10kN/m^2. All loads were modelled at 3.80m bgl.

A tabulated summary of all applied loads, at each stage/model, can be viewed below.

Summary of Net Bearing Pressure Changes for PDisp Analysis				
Description	**Applied Load (+ive)/ Load Removal (-ive) (kN/m^2)**			
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4 and 5**
Excavation of Retaining Wall Voids	-72.2			
Construction of Retaining Walls		30	30	93
Mass Excavation Void			-72.2	-72.2
Construction of Basement Slabs				10.00

The method stated above was considered to comprise a comprehensive and reasonably conservative approach, in order to estimate the maximum potential heave and settlements.

A tabulated summary concluding the amount of soil displacement shown at the basement depth within the contour plots can be viewed below. It should be noted that the soil displacement between models are not cumulative values; therefore, the amount of soil displacement between models should not be added together as each model shows each construction stage individually.

Settlement/Heave Analysis	
Model	**Soil Displacement**
Model 1	0.74 – 2.98mm heave. No settlement
Model 2	0.31 – 1.24mm settlement. No heave
Model 3	0.72 – 9.23mm heave. No settlement
Model 4	1.70mm (settlement) – 7.16mm heave.
Model 5	1.85mm (settlement) – 8.98mm heave.
Diagrammatic representation can be viewed within Appendix H. Please note that the above figures should not be added together (or be superimposed) and that they represent anticipated movements at different accumulated stages of construction, in order to approach and test all expected combinations of loading regimes (models).	

A maximum amount of heave of 9.23mm was noted following the mass excavation of the basement void (Model 3), and was noted to be the maximum amount of heave during the construction phases. Once constructed, the maximum amount of heave increased from 7.16mm for short term conditions (Model 4), to 8.98mm for long term conditions (Model 5); therefore, the highest risk of movement will likely occur during the construction of the basement and later through long-term heave of the constructed basement.

7.2.4 Additional Comments

Regarding the bulk basement construction, care will need to be taken to ensure that the slab is protected through accommodating heave. Heave protection measures will need to be incorporated.

Final designs for the foundations should be carried out by a suitably qualified Engineer based on the findings of this investigation and with reference to the anticipated loadings, serviceability requirements for the foundations. A Structural Engineer will also need to review the anticipated ground movements and assess their potential impact on the existing structure and neighbouring properties. It must be noted that finalised construction will aid the structural stability of the neighbouring party walls, reducing the risk of the seasonal movements noted during the structural works.

The location of the proposed tree removals will not have an affect on the proposed basement, due to the distance. However, the pool house may be affected, geotechnical conditions regarding this are outlined within the report.

7.3 Retaining Walls, Excavations and Stability

Shallow excavations in the Made Ground are likely to be marginally stable at best. Long, deep excavations, through these strata and into the underlying KPGM are likely to become unstable.

Appropriate propping and support should be incorporated during construction of the basement.

The excavation of the basement must not affect the integrity of the adjacent structures beyond the boundaries. The excavation must be supported by suitably designed retaining walls. It is considered unlikely that battering the sides of the excavation, casting the retaining walls and then backfilling to the rear of the walls would be suitable given the close proximity of the party walls.

The retaining walls for the basement will need to be constructed based on the soils encountered with an appropriate angle of shear resistance (Φ’) and effective cohesion (C’) for the ground conditions encountered, regarding long-term considerations, as well using an appropriate undrained shear strength Cu for short-term considerations.

The overlying Made Ground needs to be considered in the design of the basement. A conservative value of Cu will need to be considered.

Based on the ground conditions encountered within the boreholes the following parameters tabulated below could be used in the design of retaining walls, for a long-term consideration. These have been designed based on the in-situ strength testing profile recorded, results of geotechnical classification tests and reference to literature.

Retaining Wall/Basement Design Parameters					
Strata	**Unit Volume Weight (kN/m³)**	**Cohesion Intercept (c')** (kPa)	**Angle of Shearing Resistance (°)**	**Ka (Rankine)**	**Kp (Rankine)**
Made Ground	~19	0	12	0.66	1.52
Kempton Park Gravel Member (Cohesive)	~20 – 22	0	24 – 28	0.36 – 0.42	2.37 – 2.77
Kempton Park Gravel Member (Granular)	~20 – 22	0	32 – 40	0.22 – 0.31	3.25 – 4.60

It should be noted that the Ka and Kp values presented in the table, are shown for guidance and they are derived from the Rankine theory for soil pressures. The values for angles of internal friction provided are considered to be characteristic values of the soils encountered.

According to C760, a design method (e.g. EC7) should be adopted and followed through the whole design process. In addition, the following considerations should be considered during the design process:

- Appropriate consideration of groundwater levels.
- Surcharge pressure equivalent to the pressures of any adjacent buildings.
- Surcharge pressures from potential piling work platforms and heavy plant traffic.

Unsupported earth faces formed during excavation may be liable to collapse without warning and suitable safety precautions should therefore be taken to ensure that such earth faces are adequately supported before excavations are entered by personnel.

Ground Instability Recommendations

Specific measures should be included in a competent Construction Method Statement for the works on this site by the structural engineer and the contractor. If instability is noted, the following could be applied for good workmanship and mitigation of any risk. It should be noted that these are indicative.

- Where soft/loose spots are encountered, trench sheets should be left in. Alternatively, a back prop with precast lintels or sacrificial boards should be installed. If the soil support to the ends of the lintels is insufficient, brace the ends of the PC lintels with 150x150 C24 timbers and prop with Acrows diagonally back to the ground.
- Where voids are present, trench sheeting with 75mm diameter holes should be installed, to allow the concrete to flow behind the trench sheeting thereby filling any voids encountered in soils behind.
- Prior to casting, a layer of DPM should be installed between trench sheeting (or PC lintels) and new concrete. The lintels should be cut into the soil by 150mm either side of the pin. A site stock of a minimum of 10 lintels should be present to prevent delays due to ordering.

7.4 Sub-Surface Concrete Design

Concrete to be placed in contact with soil or groundwater must be designed in accordance with the recommendations of Building Research Establishment Special Digest 1, 2005, *'Concrete in Aggressive Ground'* considering the pH of the soils. For the classification given below, the "mobile" and "natural" case was adopted given the geology encountered and the residential use of the site.

Made Ground

Made Ground was noted to have water soluble sulphates between 10 – 13.6 mg/l and pH of 7.7 – 8.0.

Kempton Park Gravel Member

According to Box C6 of BRE Special Digest 1, 2005, 'Concrete in Aggressive Ground' the Kempton Park Gravel Member did not fall within a list of UK geological formations known to contain pyrite. Consequently, it was not required to consider the levels of total potential sulphate in the classification process.

The water soluble sulphate concentration ranged between 8.44 – 23mg/l, with a pH range of 8.0 – 8.4.

London Clay Formation

The soils of the London Clay Formation are expected at ~6.00m bgl. Therefore, no construction is expected to be taking place at that depth.

7.5 Hydrogeological Effects, Flooding and Surface Water Disposal

Basements have potential to greatly impact hydrological and hydrogeological regimes. Numerous comments and considerations reflecting on the relationship between the basement and groundwater/surface water have been discussed below.

7.5.1 Basement Construction

If the construction works take place during the winter months, when the groundwater level is expected to be at its higher elevation, water could accumulate thus dewatering could be required to facilitate the construction and prevent the base of the excavation blowing before the slab was cast. **The lower ground floors must be suitably tanked to prevent ingress of groundwater and also surface water run-off. A dewatering or permitting grout contingency plan should be included within the Construction Method Statement and considered in the final design. As there will be potential for groundwater to collect behind the retaining walls, the basement should be waterproofed and designed to withstand hydrostatic pressures in accordance with BS8102:2009: Code of Practice for the Protection of Below Ground Structures against Water from the Ground.**

Should groundwater/perched water be encountered across the site, dewatering from sumps introduced into the floor of the excavation may be required. Consideration could be given to creating a coffer dam using contiguous piled or sheet piled walls to aid construction below the perched water table if groundwater becomes a significant issue. **The advice of a reputable dewatering company should be sought.**

7.5.2 Site Drainage

The majority of new developments are encouraged to use Sustainable Urban Drainage Systems (SUDS) to manage surface water drainage. This ensures that any volumes and peak flow rates of surface water leaving a developed site are no greater than the rates prior to the proposed development unless specific off-site arrangements are made and result in the same effect.

The principles of SUDS and the requirements of the London Plan Policy 5.13 Sustainable Drainage should be applied to reduce the risk of flooding from surface water ponding and collection associated with the construction of the basement.

In accordance with the London Plan Policy 5.13 Sustainable Drainage the surface water run-off should be managed as close to its source as possible in line with the following drainage hierarchy.

- Rainwater use as a resource (for example rainwater harvesting, blue roofs for irrigation)
- Rainwater infiltration to ground at or close to source
- Rainwater attenuation in green infrastructure features for gradual release (for example green roofs, rain gardens)
- Rainwater discharge direct to a watercourse (unless not appropriate)
- Controlled rainwater discharge to a surface water sewer or drain
- Controlled rainwater discharge to a combined sewer.

Drainage should be designed and implemented in ways that deliver other policy objectives of this Plan, including water use efficiency and quality, biodiversity, amenity and recreation.

Soakage testing in accordance with BRE365 was beyond the scope of this investigation.

Any soakaways should be located sufficiently away from buildings and infrastructure, in order to prevent undermining of foundations. Additional drainage may be considered should significant amounts of water be encountered.

The submission of a Sustainable Urban Drainage Scheme (SUDS) is likely to be required for this site due to the proposed development increasing the amounts of hardstanding.

It is understood that measures will be implemented, like green roofs, garden, to account for surface water management and infiltration.

Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources, abstractions and surface water features/watercourses.

7.5.3 Additional Comments, Groundwater, Throughflow

The site itself has the potential to flood from groundwater, due to a Secondary Aquifer underlain by Unproductive Strata. Perched water may be encountered within the Made Ground and the underlying geological formations, especially after periods of prolonged or intense rainfall. **This should be considered in final design.**

Groundwater was recorded at 2.80 – 3.10m bgl.

Groundwater is expected to flow through the more permeable Kempton Park Gravel Member. The proposed basement does not extend into the cohesive London Clay Formation (expected at ~6.00m bgl), so when groundwater is elevated to above basement level, it can flow beneath the basement as well as around; therefore, groundwater flow direction will not be affected. In addition, the site is not within a throughflow catchment area.

Given their subterranean position, lower ground floors can be susceptible to flooding from sewers. In order to minimise the risk of sewer flooding to the development, all subterranean development must be connected to the sewerage network, installed with a positively pumped non-return valve device.

Consultation with the Environment Agency must be sought regarding any use that may have an impact on groundwater resources, abstractions and surface water features/watercourses.

7.6 Discovery Strategy

A full contamination assessment was beyond the scope of this investigation, where targeted sampling was not undertaken. There may be areas of contamination that have not been identified during the course of the intrusive investigation (e.g. underground storage tanks). Such occurrences may be discovered during the construction phases for the redevelopment of the site.

Groundworkers should be instructed to report to the Site Manager any evidence for such contamination; this may comprise visual indicators, such as fibrous materials within the soil, discolouration, or odours and emission. Upon discovery advice must be taken from a suitably qualified person and then the Local Authority will need to be informed.

7.7 Waste Disposal

The excavation of foundations and soils is likely to produce waste which will require classification and then recycling or removal from site.

Under the Landfill (England and Wales) Regulations 2002 (as amended), prior to disposal all waste must be classified as;

- Inert;
- Non-hazardous, or;
- Hazardous.

The Environment Agency's Hazardous Waste Technical Guidance (WM3) document outlines the methodology for classifying wastes. Once classified the waste can be removed to the appropriately licensed facilities, with some waste requiring pre-treatments prior to disposal.

Following the investigation, 2No. samples of Made Ground were submitted to the analytical laboratory to undergo a suite of testing for contamination testing, as discussed in the previous sections. Sampling depths were chosen to reflect the receptor of concern, human health, and typically comprised a surface or near surface sample and periodically to 1.00m bgl. Any horizon where olfactory or visual evidence of contamination was present was also sampled.

Based on a risk phase analysis of the chemical laboratory test results, in accordance with EC Hazardous Waste Directive and undertaken by Ground and Water Limited, all soil samples of Made Ground encountered on-site were NON-HAZARDOUS. The results of the assessment are given within Appendix I.

It is important to note that whilst we consider our in-house assessment tool to be an accurate interpretation of the requirements of WM3, therefore producing an initial classification in accordance with the guidance, this method classifies soils as either non-hazardous or hazardous and landfill operators have their own assessment tools and can often come to different conclusions. As a result, some landfill operators could refuse to take apparently suitable waste. It is recommended that the receiving landfill views the results of this assessment and the chemical laboratory results to determine their own classification.

In addition to the samples described above, 1No. sample was scheduled to undergo Waste Acceptance Criteria (WAC) testing with single batch leachate from a singular sample. This sample was labelled as inert waste.

Where contaminated soils are to be removed, they should be placed on an impermeable membrane (visqueen or similar) to ensure that no cross-contamination of soils occurs.

7.8 Duty of Care

Groundworkers must maintain a good standard of personal hygiene including the wearing of overalls, boots, gloves and eye protectors and the use of dust masks during periods of dry weather.

To prevent exposure to airborne dust by both the general public and construction personnel the site should be kept damp during dry weather and at other times when dust would be generated as a result of construction activities.

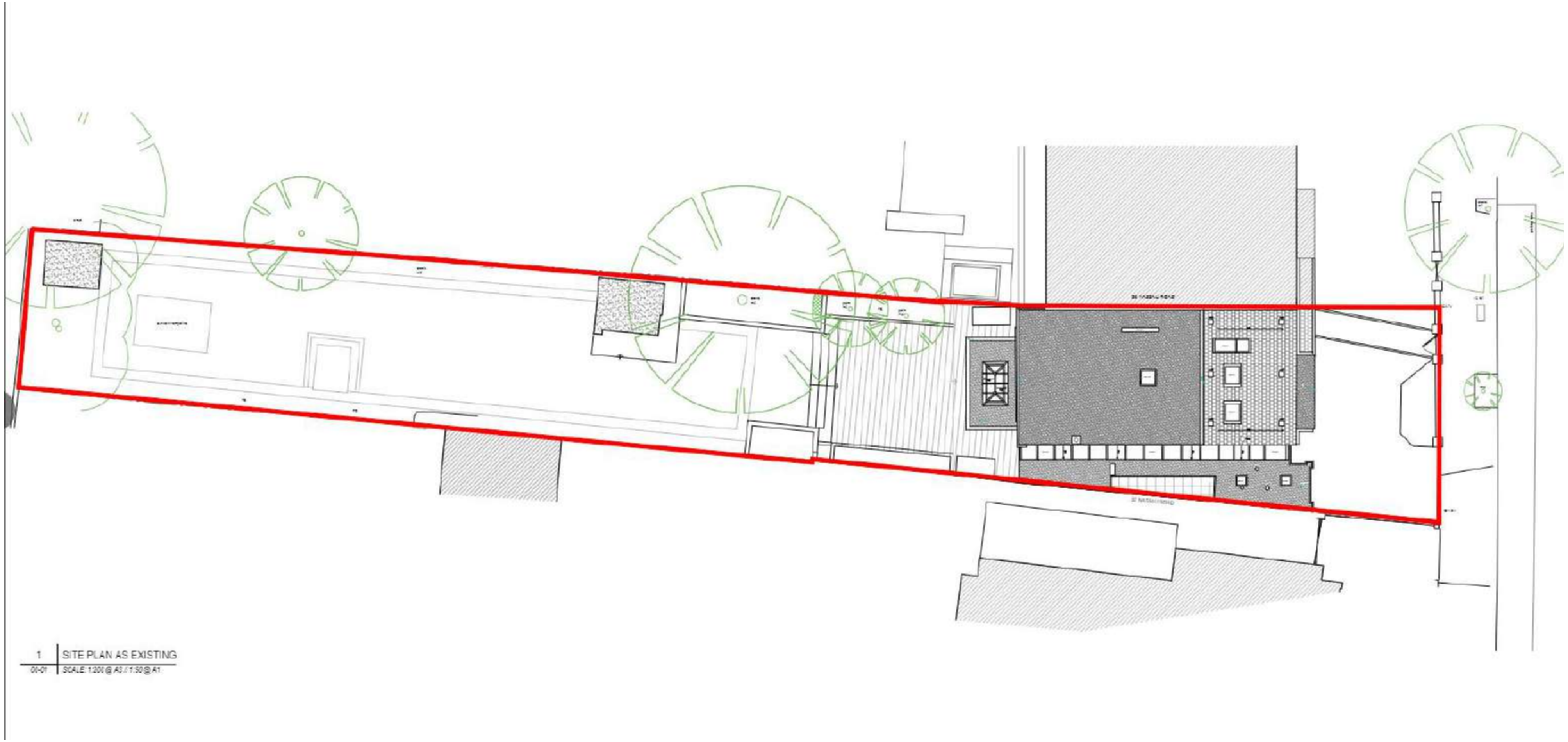
The site should be securely fenced at all times to prevent unauthorised access. Washing facilities should be provided and eating restricted to mess huts.

FIGURES

Site boundary

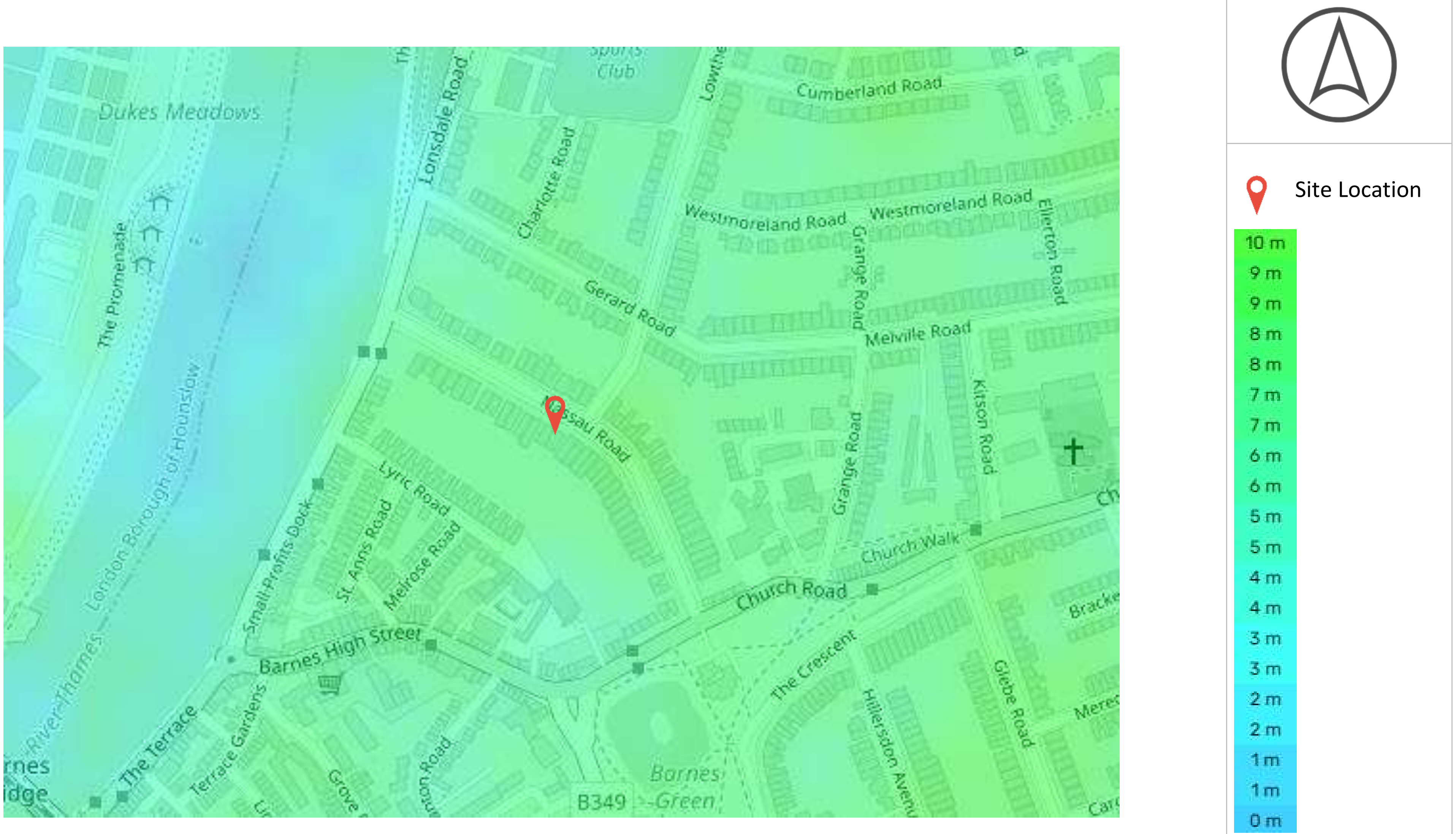
34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 1 – Site Location Plan	**GWPR5909**

ground&water



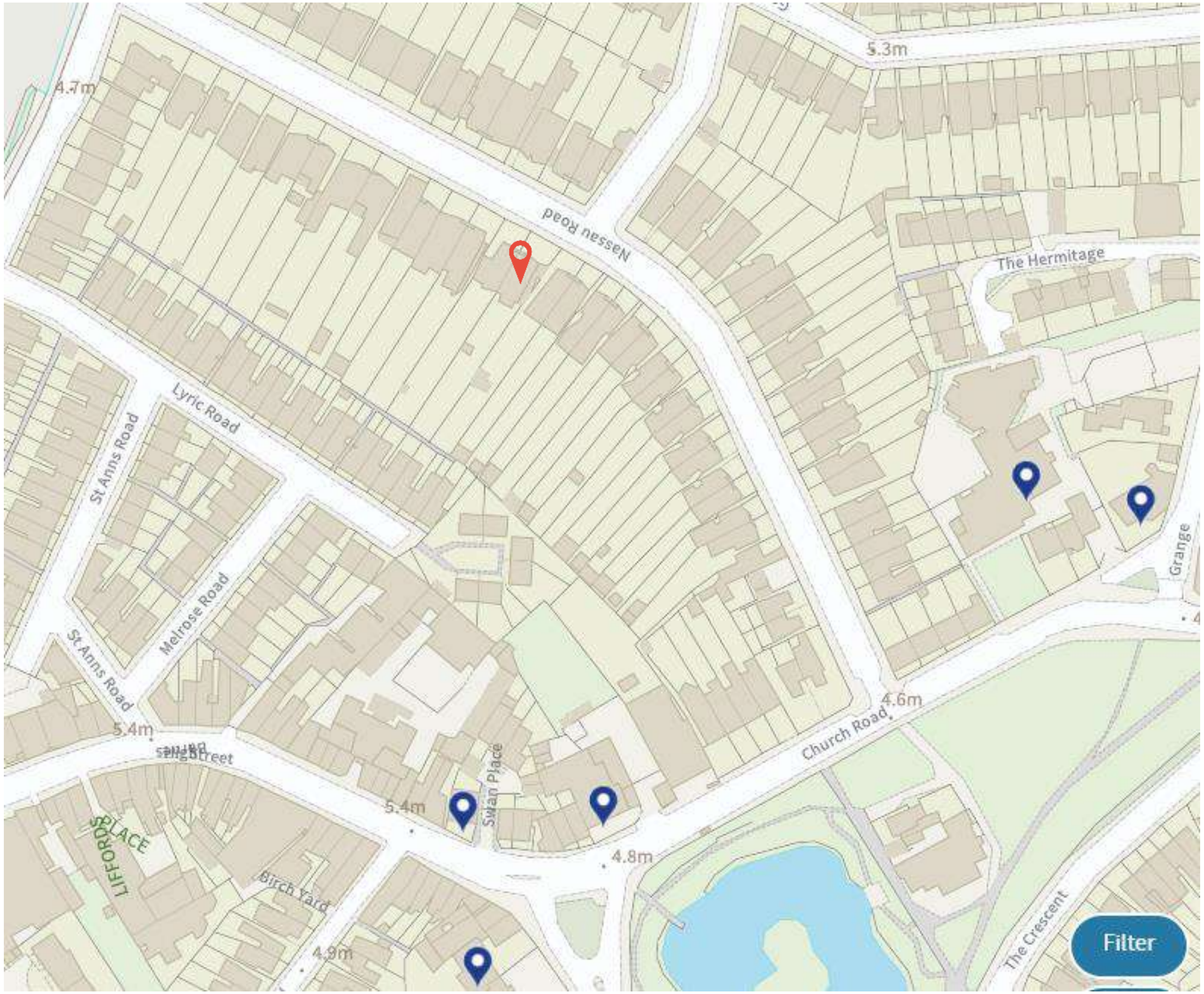
34 Nassau Road SW13 9QE	
Tom Richards	April 2024
Figure 2 – Existing Plan	GWPR5909

ground&water



34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 3 – Topographical Contour Map	**GWPR5909**

ground&water



Site Location

34 Nassau Road SW13 9QE

Tom Richards	**April 2024**
Figure 4 – Nearby Listed Buildings	**GWPR5909**

34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 5 – Proposed Development Section	**GWPR5909**

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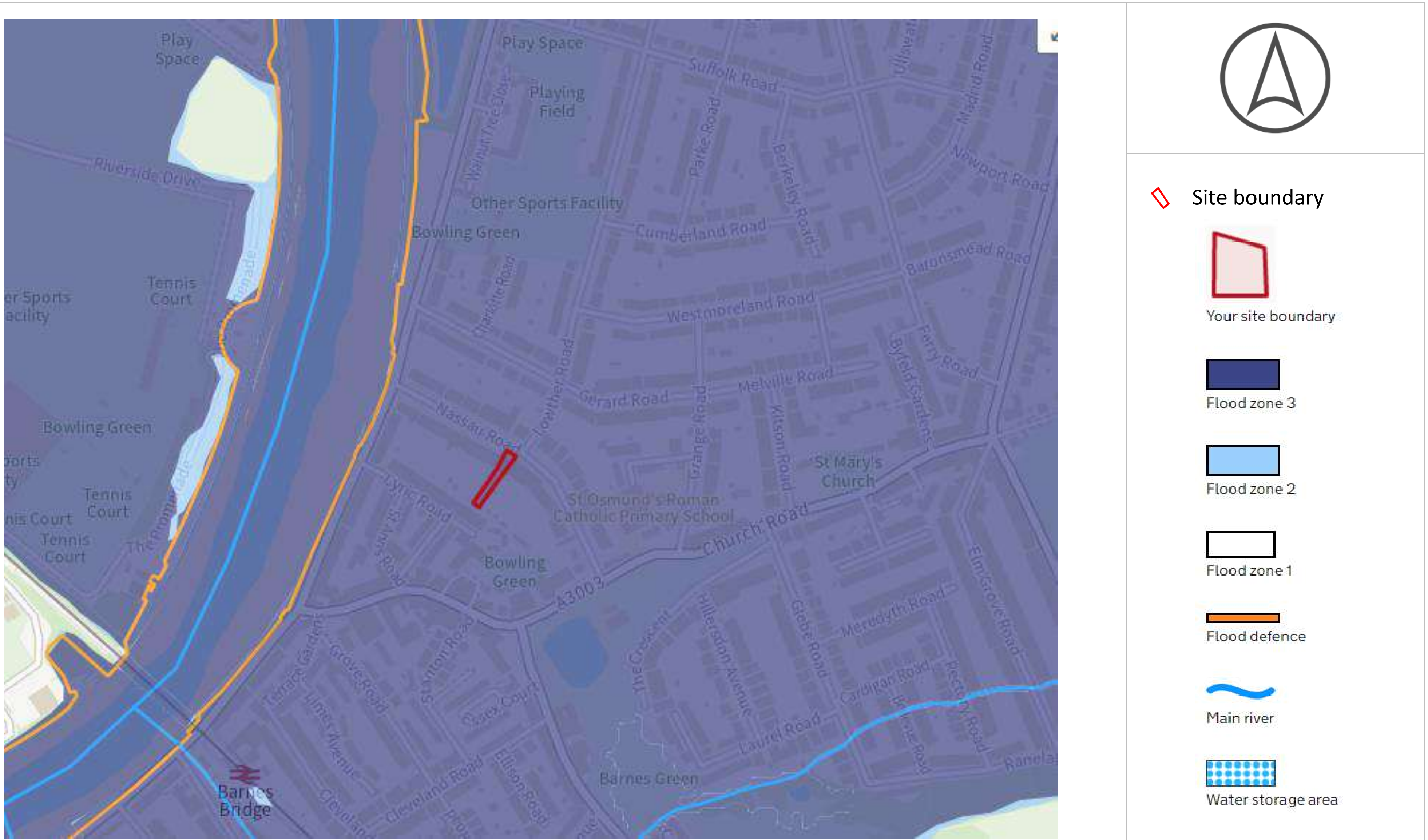

34 Nassau Road SW13 9QE	
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Figure 6 – EA Flooding From Rivers and Seas	GWPR5909

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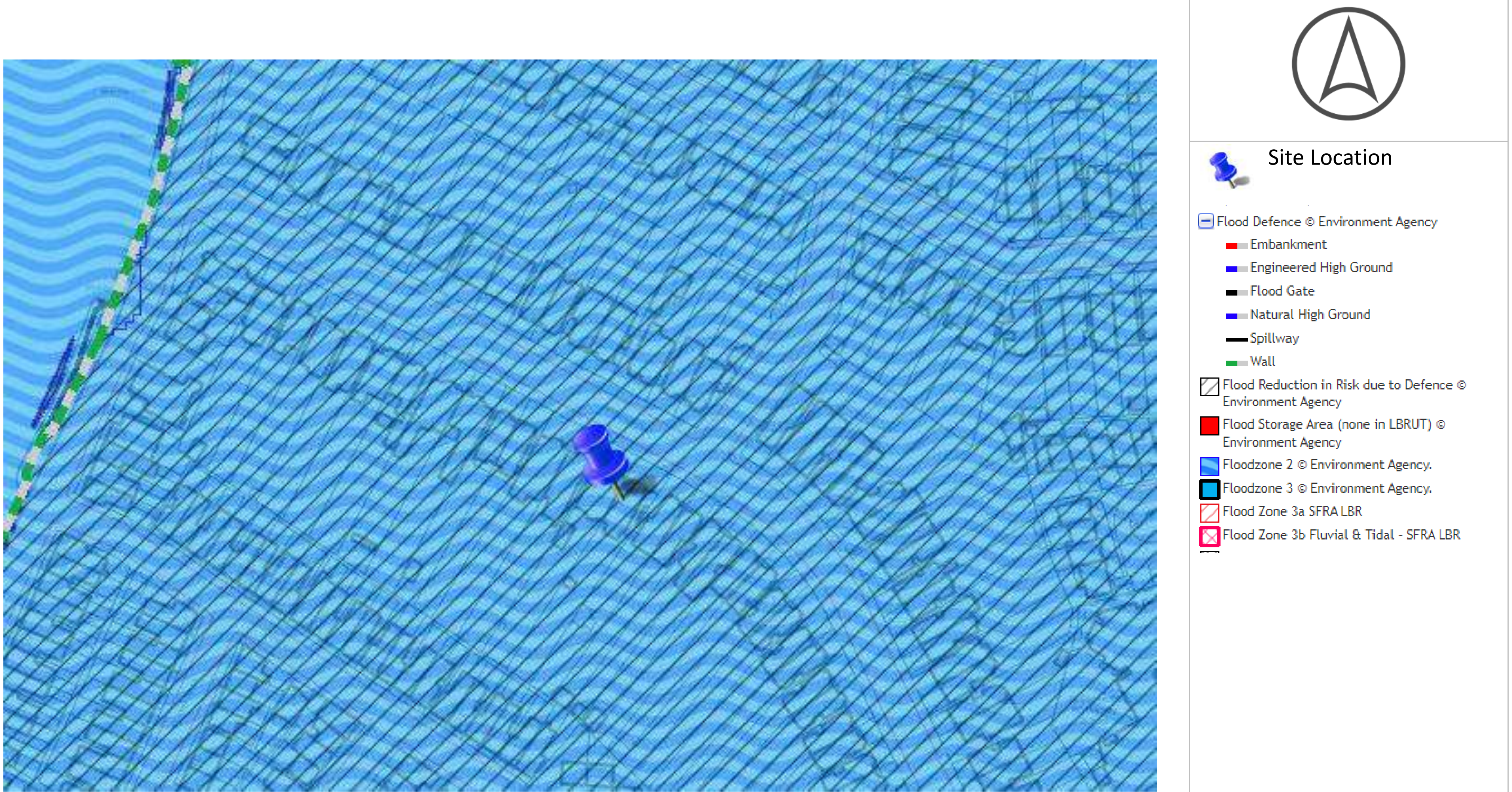

34 Nassau Road SW13 9QE	
Tom Richards	April 2024
Figure 7 – SFRA Flood Zones/Defences	GWPR5909

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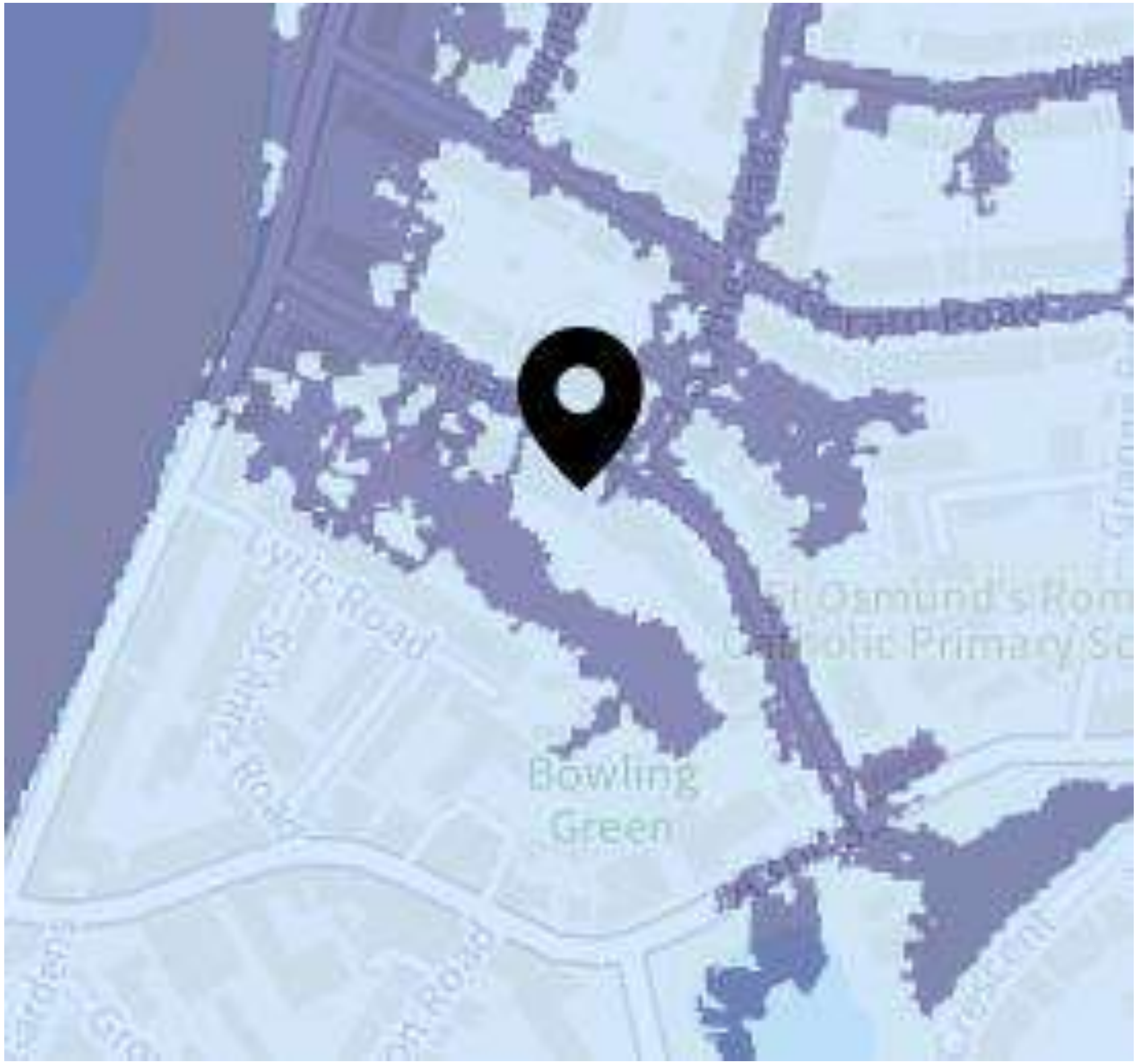

Site Location

When river levels are normal

When there is also flooding from rivers

34 Nassau Road SW13 9QE	
Tom Richards	April 2024
Figure 8 – EA Reservoir Flooding	GWPR5909

ground&water

Site Location

Risk of Flooding from Surface Water Extent 1 in 30 Chance © Environment Agency

Risk of Flooding from Surface Water Extent 1 in 100 Chance (ie 1 in 100 year Surface Water Extent) © Environment Agency

Risk of Flooding from Surface Water Extent 1 in 1000 Chance © Environment Agency

34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 9 – SFRA Surface Water Flooding	**GWPR5909**

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34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 10 – Depth of Surface Water Flooding (1 in 1000 Chance Event)	**GWPR5909**

ground&water

Site Location

Risk of Flooding from Surface Water Depth 1 in 100 chance © Environment Agency

- 0.00 - 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- 0.90 - 1.20m
- > 1.20m

34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 11 – Depth of Surface Water Flooding (1 in 100 Chance Event)	**GWPR5909**

ground&water

Site Location

Risk of Flooding from Surface Water depth 1 in 30 chance © Environment Agency

- 0.00 - 0.15m
- 0.15 - 0.30m
- 0.30 - 0.60m
- 0.60 - 0.90m
- 0.90 - 1.20m
- > 1.20m

34 Nassau Road SW13 9QE	
Tom Richards	April 2024
Figure 12 – Depth of Surface Water Flooding (1 in 30 Chance Event)	GWPR5909

ground&water

Site Location

Area Susceptible To Groundwater Flood © Environment Agency

- less than 25%
- between 25% and 49.9%
- between 50% and 74.9%
- 75% or more

34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 13 – EA Area Susceptible to Groundwater Flooding	**GWPR5909**

ground&water

Site Location

Increased Potential for Elevated Groundwater - GLA Drain London

- Consolidated
- Consolidated & Permeable Superficial
- Permeable Superficial

34 Nassau Road SW13 9QE		ground&water
Tom Richards	**April 2024**	
Figure 14 – SFRA Increased Potential For Elevated Groundwater	**GWPR5909**	

Site Location

Throughflow Catchment Area (Throughflow and Groundwater Policy Zone)

Potential Throughflow Catchment Area

34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 15 – Throughflow Catchment Area	**GWPR5909**

ground&water

Site Location

Incident - Thames Water

- 0 to 10 incidents reported
- 10 to 20 incidents reported
- 20 to 30 incidents reported
- 30 to 40 incidents reported

34 Nassau Road SW13 9QE	
Tom Richards	**April 2024**
Figure 16 – Sewer Flooding Incidents	**GWPR5909**

Site Location

Critical Drainage Area

34 Nassau Road SW13 9QE	
Tom Richards	April 2024
Figure 17 – Critical Drainage Area	GWPR5909

ground&water

Site boundary

Windowless Sampler Borehole

NTS

34 Nassau Road SW13 9QE	
Tom Richards	April 2024
Figure 18 – Trial Hole Location Plan	GWPR5909

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APPENDIX A: Conditions and Limitations

2 The Long Barn, Norton Farm, Selborne Road, Alton, Hampshire GU34 3NB
0333 600 1221 enquiries@groundandwater.co.uk **groundandwater.co.uk**

The ground is a product of continuing natural and artificial processes. As a result, the ground will exhibit a variety of characteristics that vary from place to place across a site, and also with time. Whilst a ground investigation will mitigate to a greater or lesser degree against the resulting risk from variation, the risks cannot be eliminated.

The report has been prepared on the basis of information, data and materials which were available at the time of writing. Accordingly, any conclusions, opinions or judgements made in the report should not be regarded as definitive or relied upon to the exclusion of other information, opinions and judgements.

The investigation, interpretations, and recommendations given in this report were prepared for the sole benefit of the client in accordance with their brief; as such these do not necessarily address all aspects of ground behaviour at the site. No liability is accepted for any reliance placed on it by others unless specifically agreed in writing.

Any decisions made by you, or by any organisation, agency or person who has read, received or been provided with information contained in the report ("you" or "the Recipient") are decisions of the Recipient and we will not make, or be deemed to make, any decisions on behalf of any Recipient. We will not be liable for the consequences of any such decisions.

Current regulations and good practice were used in the preparation of this report. An appropriately qualified person must review the recommendations given in this report at the time of preparation of the scheme design to ensure that any recommendations given remain valid in light of changes in regulation and practice, or additional information obtained regarding the site.

Any Recipient must take into account any other factors apart from the Report of which they and their experts and advisers are or should be aware. The information, data, conclusions, opinions and judgements set out in the report may relate to certain contexts and may not be suitable in other contexts. It is your responsibility to ensure that you do not use the information we provide in the wrong context.

This report is based on readily available geological records, the recorded physical investigation, the strata observed in the works, together with the results of completed site and laboratory tests. Whilst skill and care has been taken to interpret these conditions likely between or below investigation points, the possibility of other characteristics not revealed cannot be discounted, for which no liability can be accepted. The impact of our assessment on other aspects of the development required evaluation by other involved parties.

The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous in ground activities. The ground conditions have been sampled or monitored in recorded locations and tests for some of the more common chemicals generally expected. Other concentrations of types of chemicals may exist. It was not part of the scope of this report to comment on environment/contaminated land considerations.

The conclusions and recommendations relate to 34 Nassau Road SW13 9QE.

Trial hole is a generic term used to describe a method of direct investigation. The term trial pit, borehole or window sampler borehole implies the specific technique used to produce a trial hole.

The depth to roots and/or of desiccation may vary from that found during the investigation. The client is responsible for establishing the depth to roots and/or of desiccation on a plot-by-plot basis prior to the construction of foundations. Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping.

Ownership of copyright of all printed material including reports, laboratory test results, trial pit and borehole log sheets, including drillers log sheets, remain with Ground and Water Limited. Licence is for the sole use of the client and may not be assigned, transferred or given to a third party.

Only our client may rely on this report and should this report or any information contained in it be provided to any third party we accept no responsibility to the third party for the contents of this report save to the extent expressly outlined by us in writing in a reliance letter addressed from us to the third party.

Recipients are not permitted to publish this report outside of their organisation without our express written consent.

APPENDIX B: Technical Glossary

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TECHNICAL GLOSSARY

The list of possible definitions within the report may be seen below. Please note that some definitions may not be relevant to this report.

HYDROGEOLOGY:

A **Principal Aquifer** is a layer of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Secondary (A) Aquifers consist of deposits with permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as Minor Aquifers.

Secondary (B) Aquifers consist of deposits with predominantly lower permeability layers with may stoke and yield limited amounts of groundwater due to localised features such as fissures, think permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

Secondary Aquifers (Undifferentiated) are assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both a minor aquifer and non-aquifer in different locations due to the variable characteristics of the rock type.

Unproductive Strata are rock layers with low permeability that have negligible significance for water supply or river base flow. These were formerly classified as non-aquifers.

FLOOD ZONES:

Environment Agency Flood Zone 2, defined as; land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.

Environment Agency Flood Zone 3 shows the extent of a river flood with a 1 in 100 (1%0 or greater chance of occurring in any year or a sea flood with a 1 in 200 (0.5%) or greater chance of occurring in any year.

Environment Agency Flood Zone 3 area that benefits from flood defences, defined as; land and property in this flood zone would have a high probability of flooding without the local flood defences. These protect the area against a river flood with a 1% chance of happening each year, or a flood from the sea with a 0.5% chance of happening each year.

GROUNDWATER SOURCE PROTECTION ZONES (SPZS):

Inner Zone (SPZ1): This zone is 50 day travel time of pollutant to source with a 50 metres default minimum radius.

Outer Zone (SPZ2): This zone is 400 day travel time of pollutant to source. This has a 250 or 500 metres minimum radius around the source depending on the amount of water taken.

Total Catchment (SPZ3): This is the area around a supply source within which all the groundwater ends up at the abstraction point. This is the point from where the water is taken. This could extend some distance from the source point.

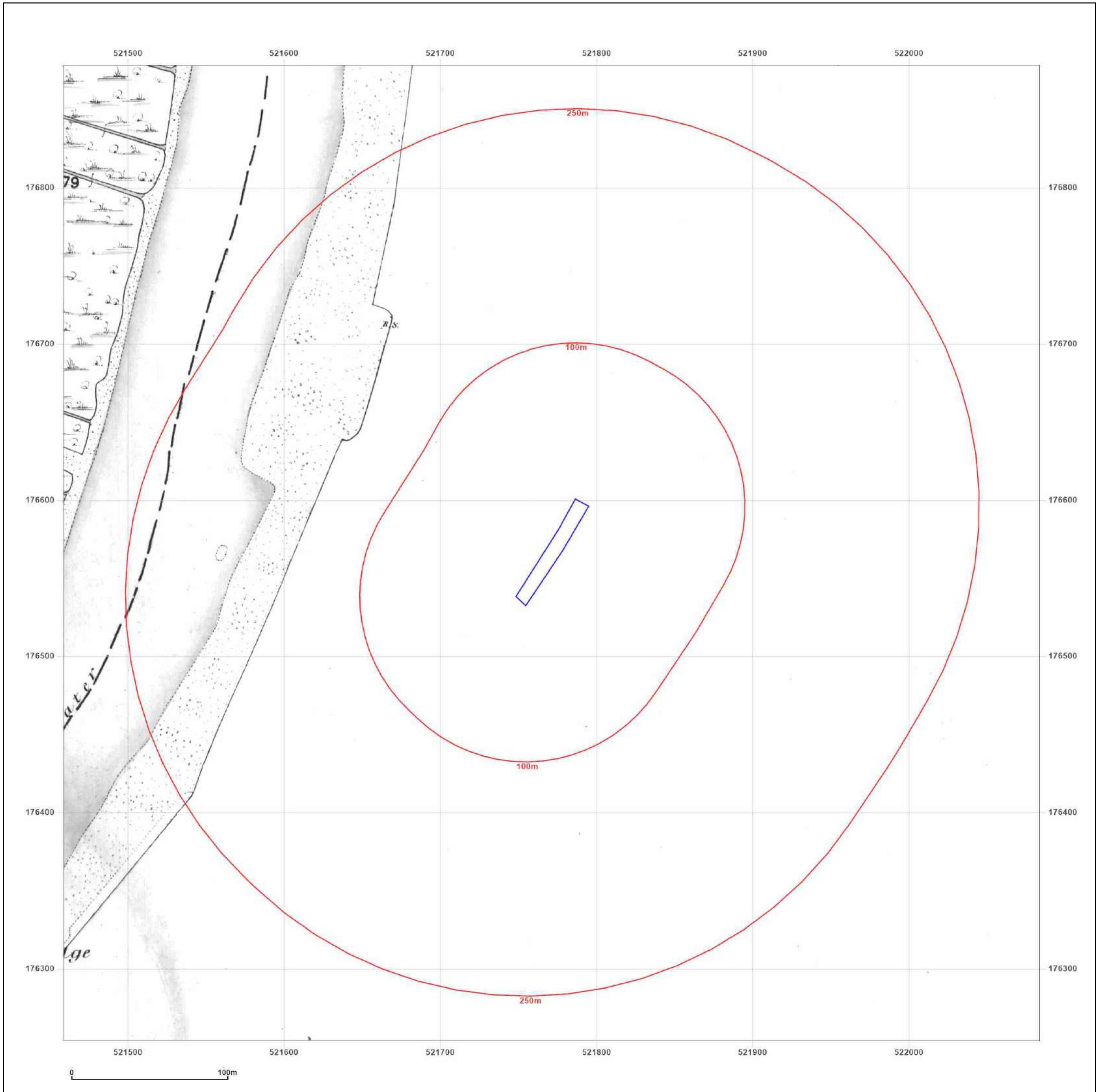
Zone of Special Interest (SPZ4): This zone is where local conditions require additional protection.

IN-SITU STRENGTH GEOTECHNICAL TESTING:

Windowless Sample and/or Cable Percussion and/or Rotary Boreholes provide samples of the ground for assessment but they do not give any engineering data. The standard penetration test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil. The test uses a thick-walled sample tube, with an outside diameter of 50mm and an inside diameter of 35mm, and a length of around 650mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5kg falling through a distance of 760mm. The sample tube is driven 150mm into the ground and then the number of blows needed for the tube to penetrate each 75mm up to a depth of 450mm is recorded. The sum of the number of blows is termed the "standard penetration resistance" or the "N-value".

Dynamic Probing involves the driving of a metal cone into the ground via a series of steel rods. These rods are driven from the surface by a hammer system that lifts and drops a 63.5kg (SHDP) hammer onto the top of the rods through a set height, thus ensuring a consistent energy input. The number of hammer blows that are required to drive the cone down by each 100mm increment are recorded. These blow counts then provide a comparative assessment from which correlations have been published, based on dynamic energy, which permits engineering parameters to be generated. (The Dynamic Probe 'Super Heavy' (SHDP) Tests were conducted in accordance with BS 1377; 1990; Part 9, Clause 3.2).

APPENDIX C: GroundSure Historical Mapping



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Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: County Series

Map date: **1867**

Scale: 1:2,500

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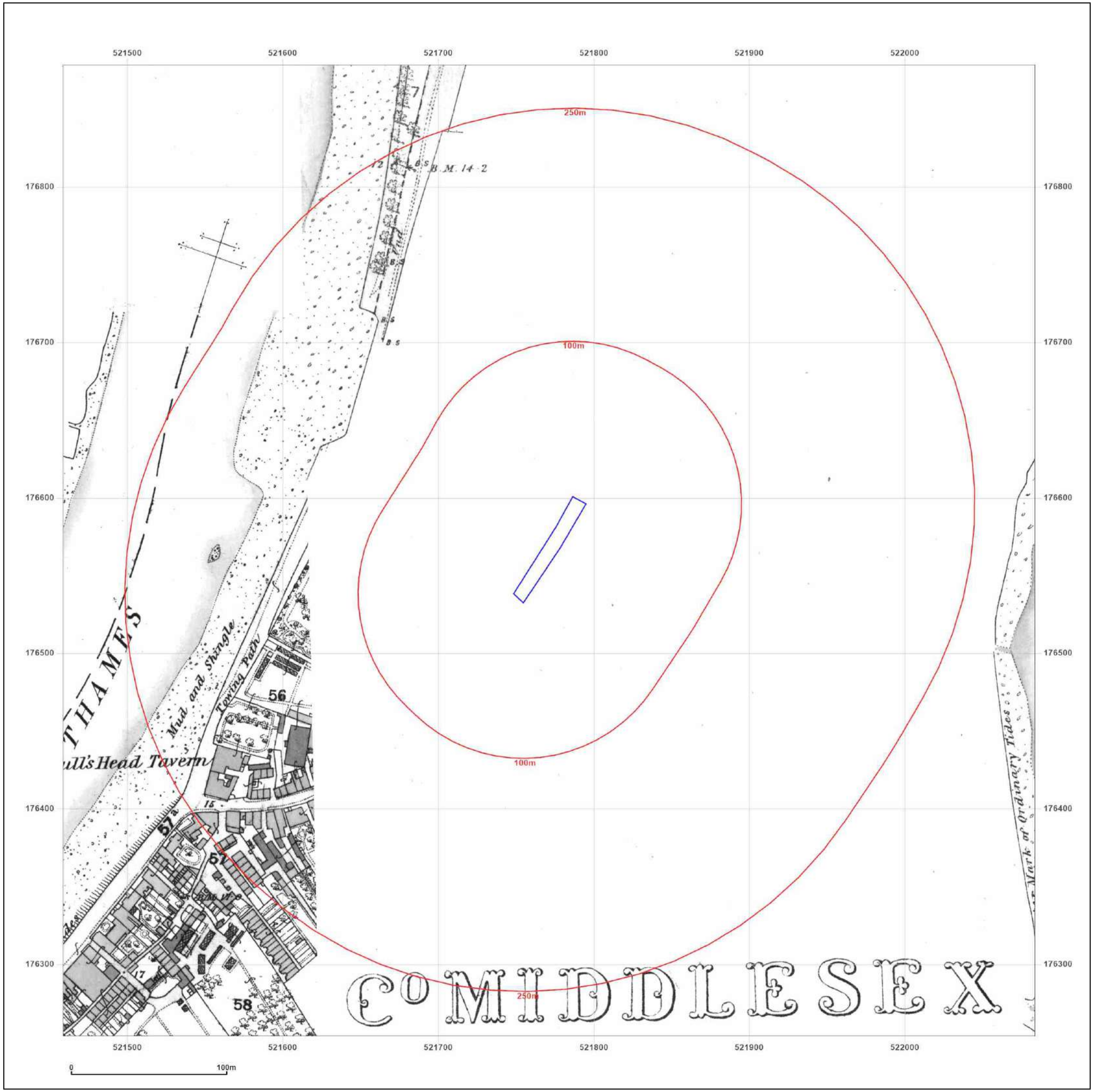

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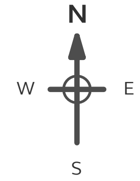

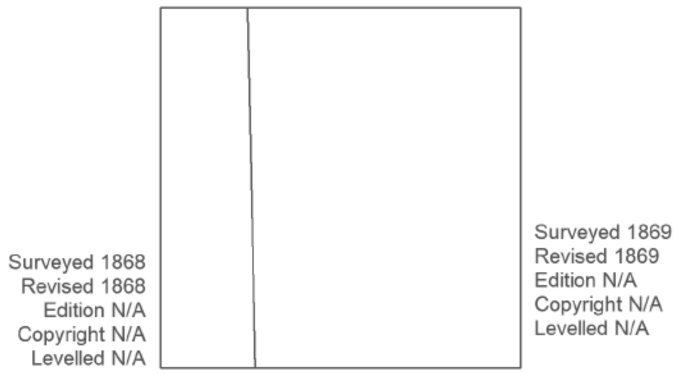

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Map Name: County Series

Map date: 1868-1869

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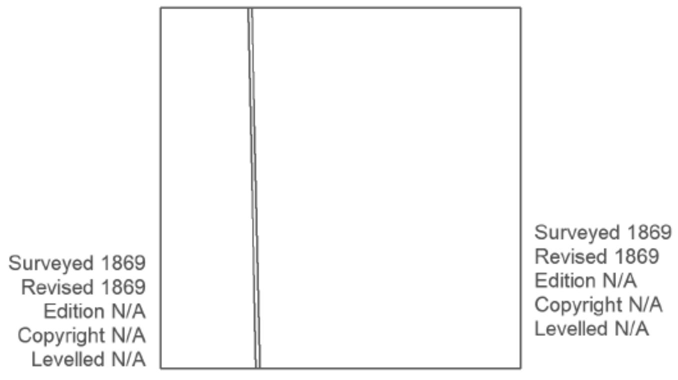

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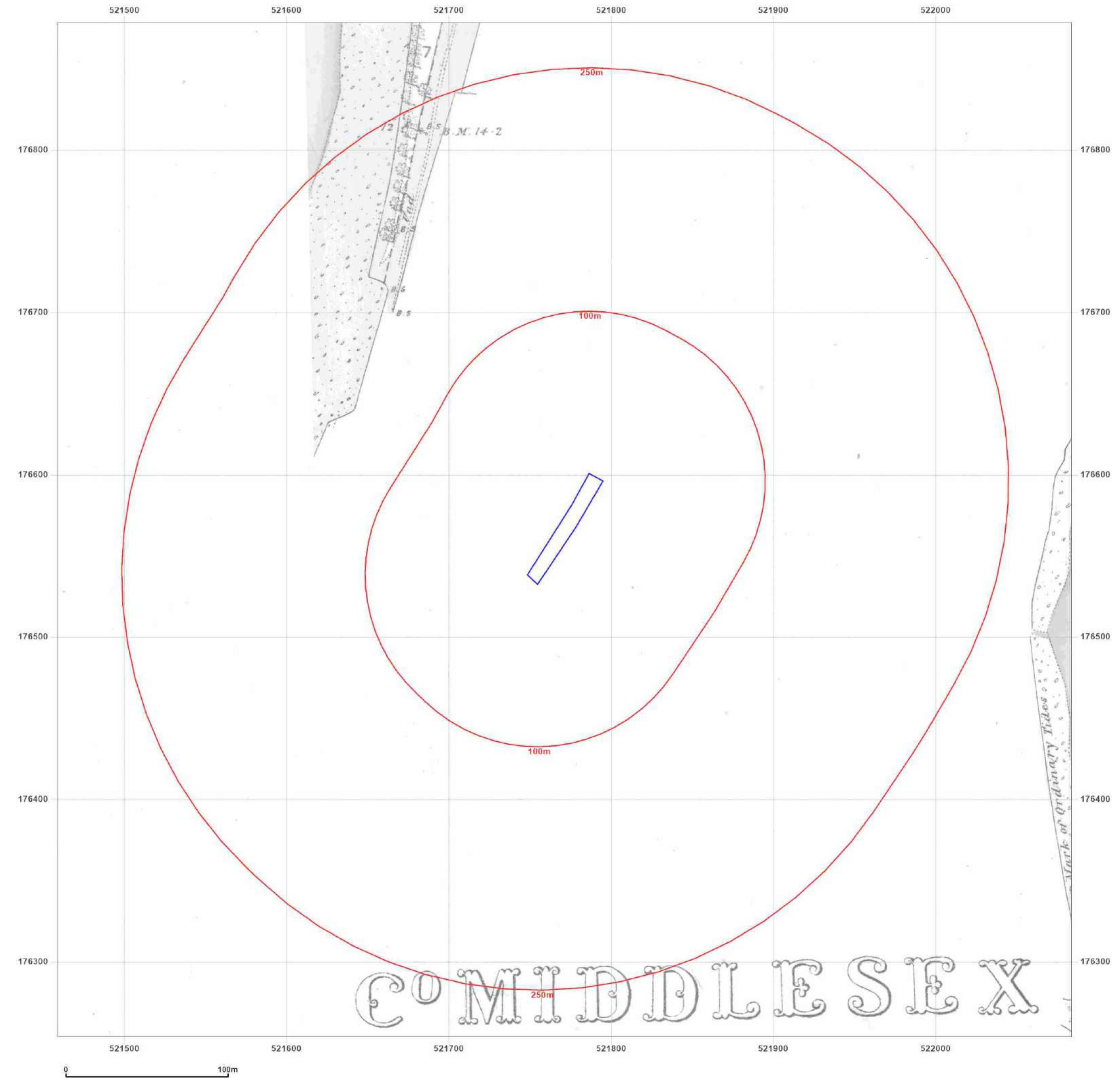

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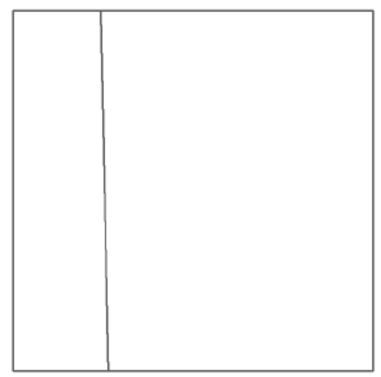

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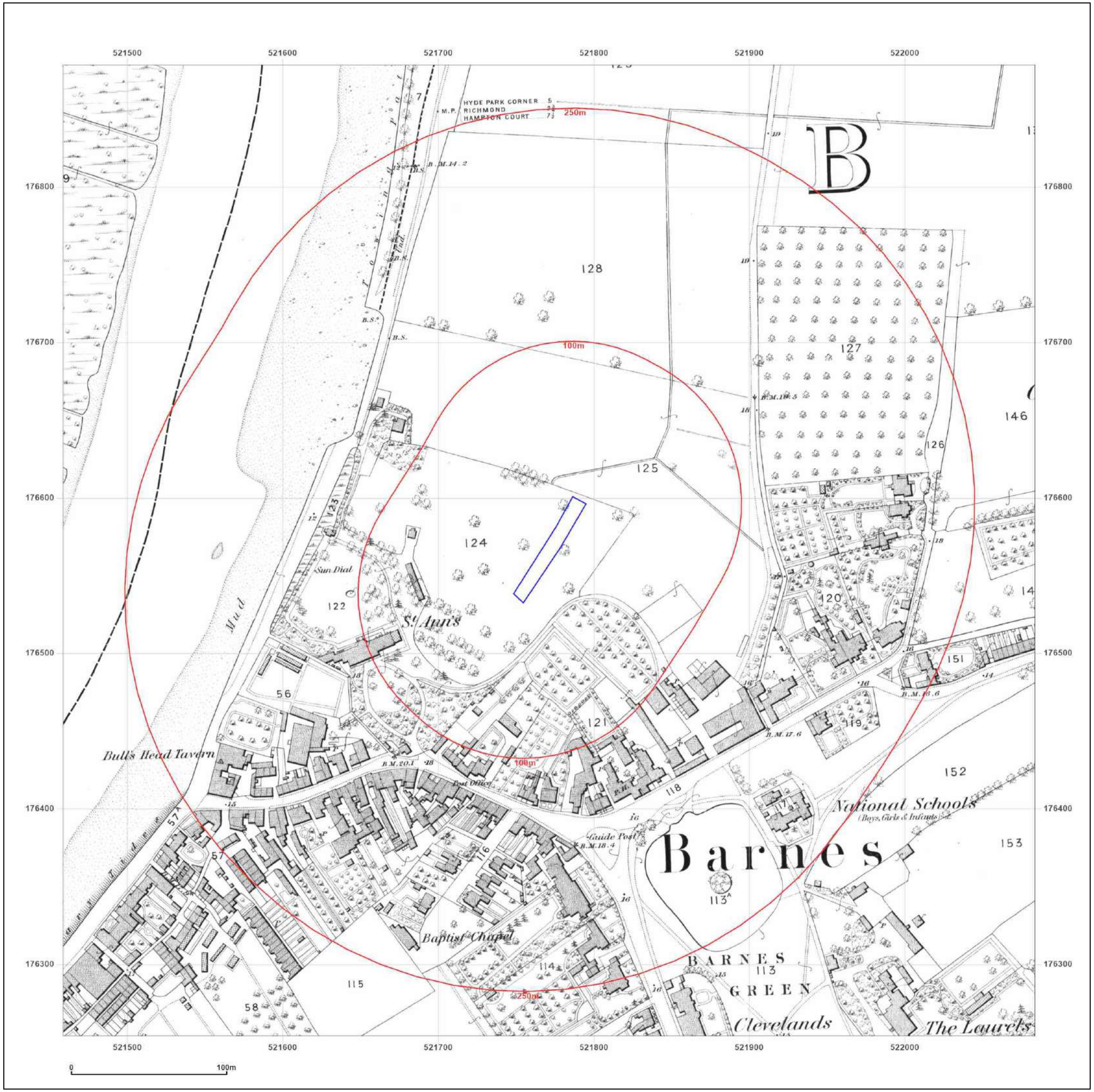

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Map Name: County Series

Map date: **1870**

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Grid Ref: 521771, 176566

Map Name: 1056 Scale Town Plan

Map date: **1896**

Scale: 1:1,056

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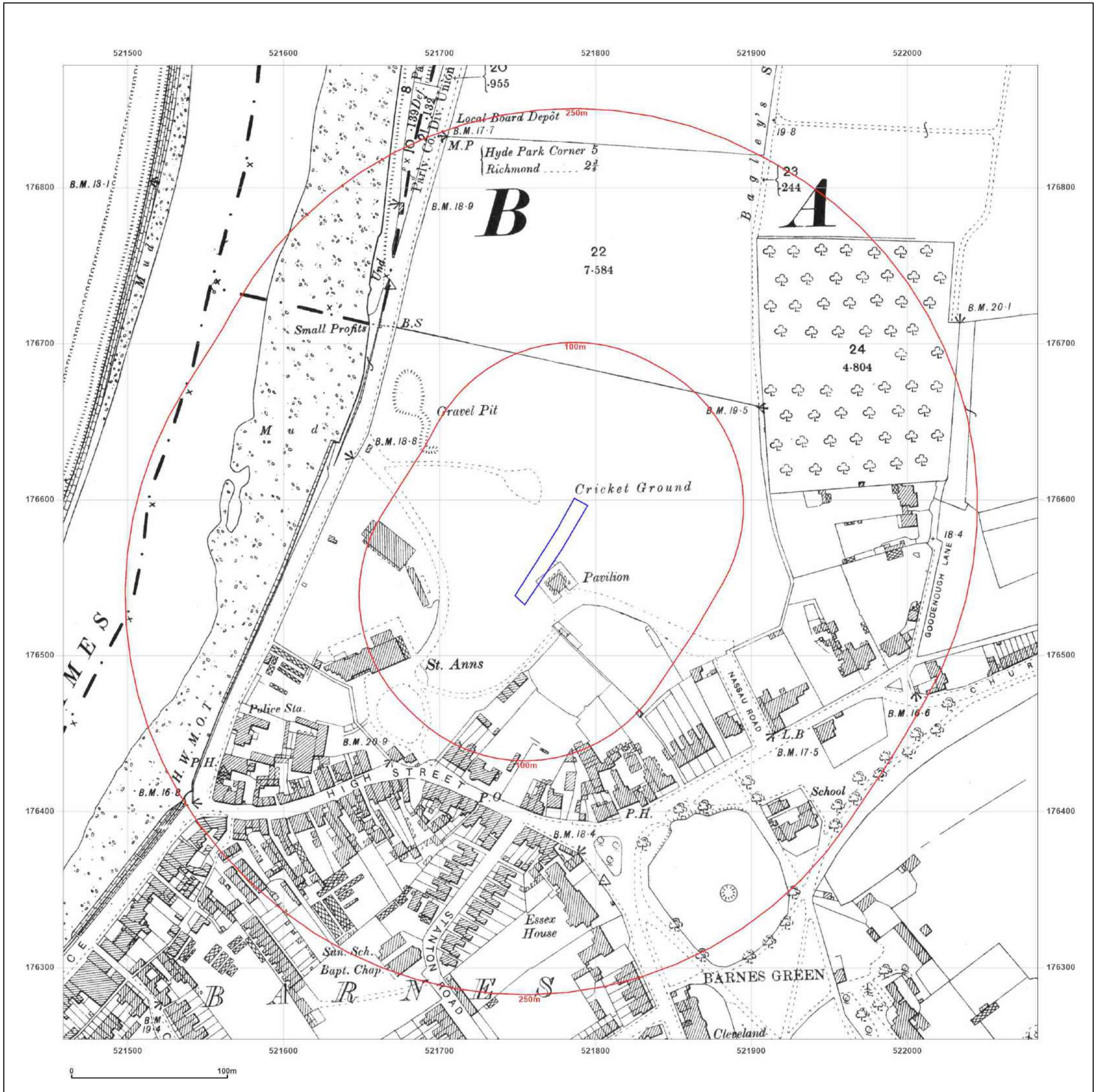

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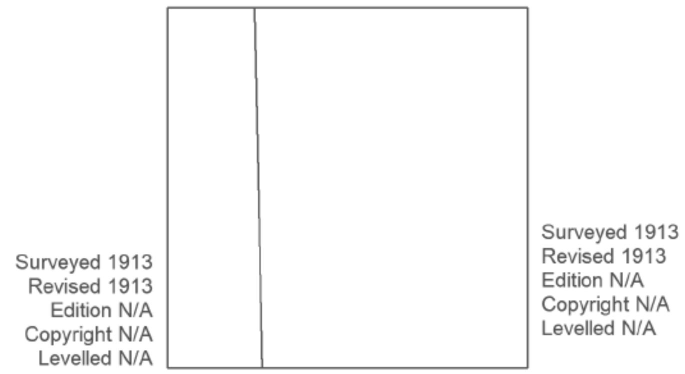

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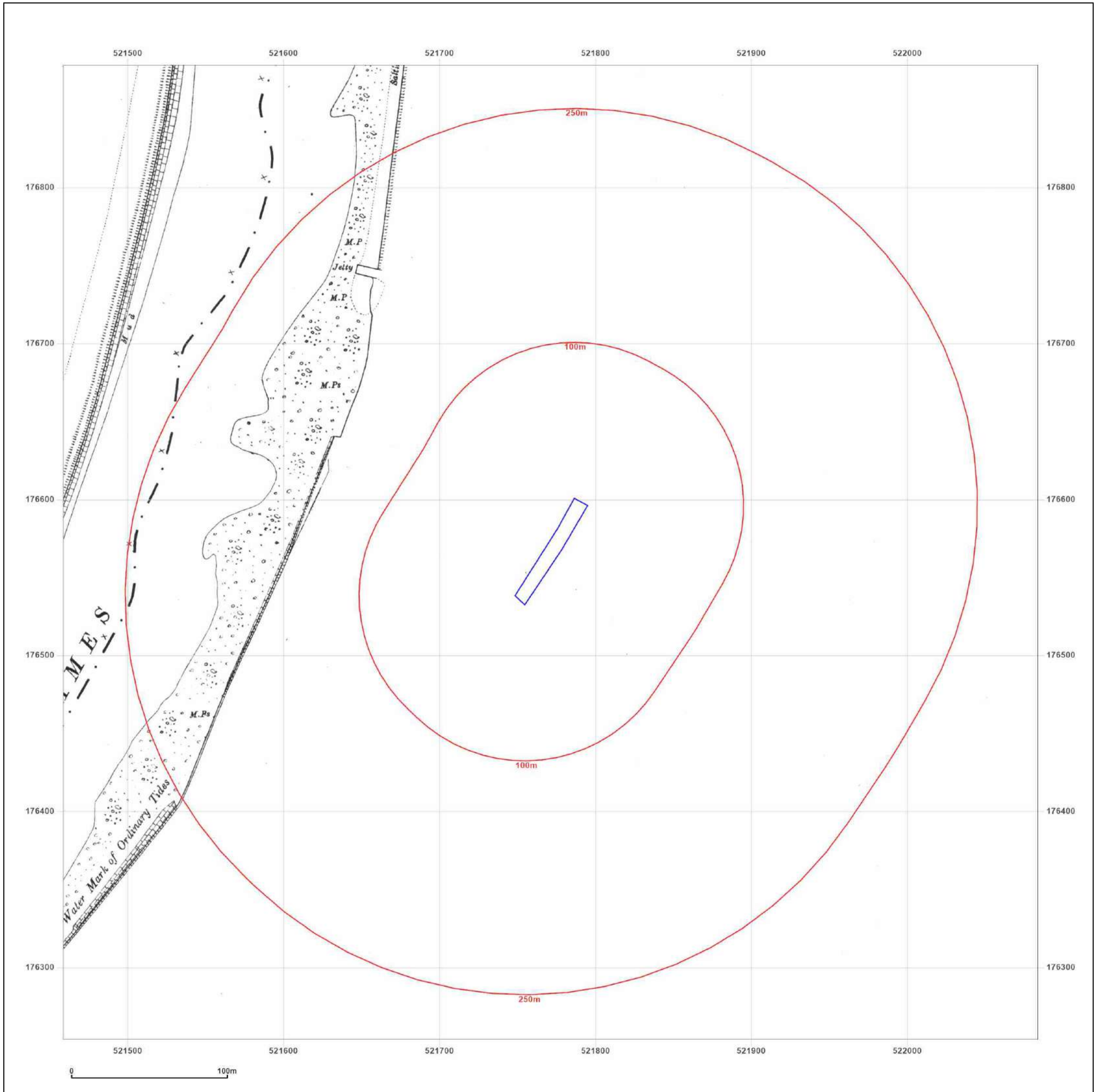

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Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: County Series

Map date: **1914**

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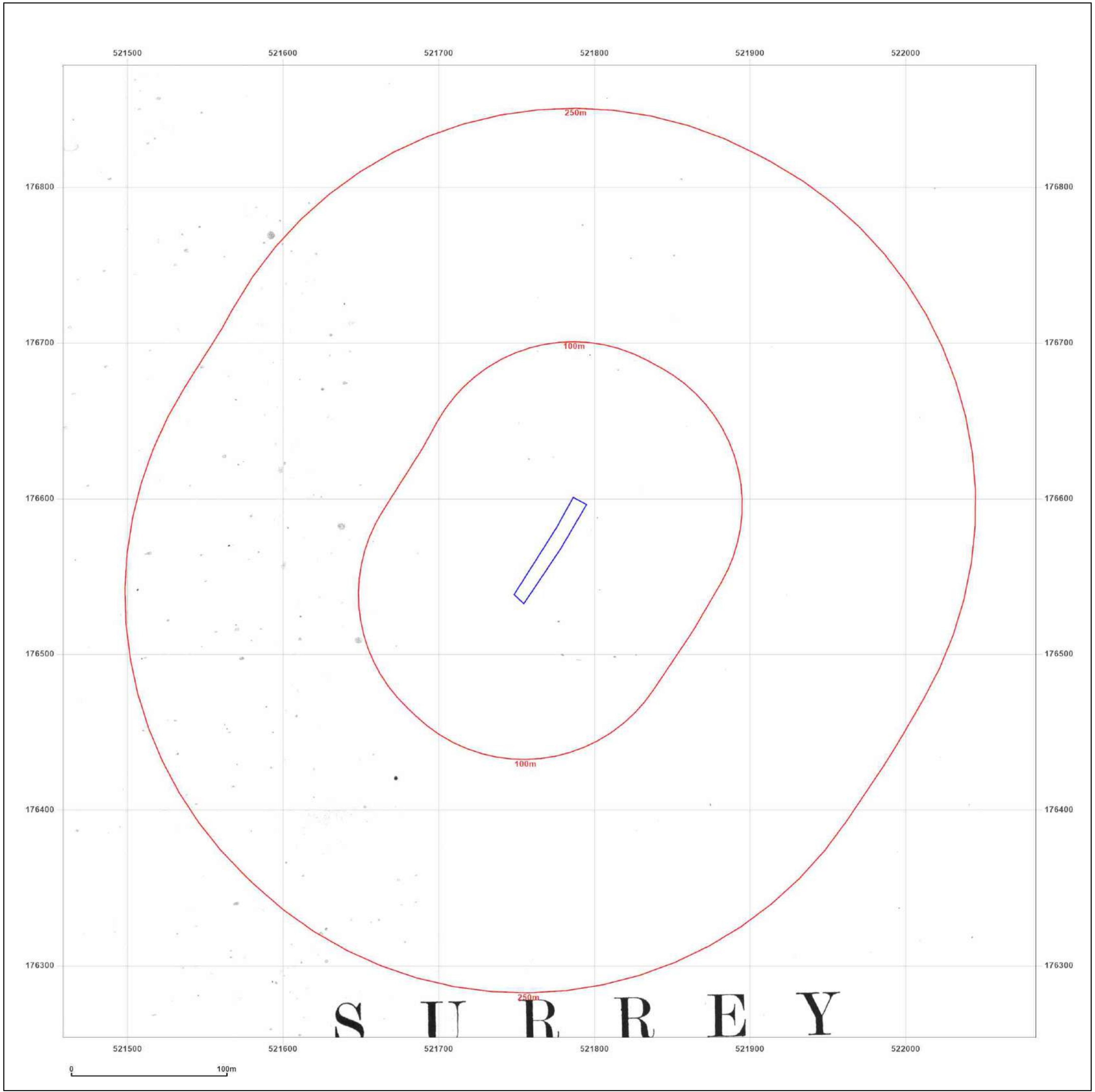

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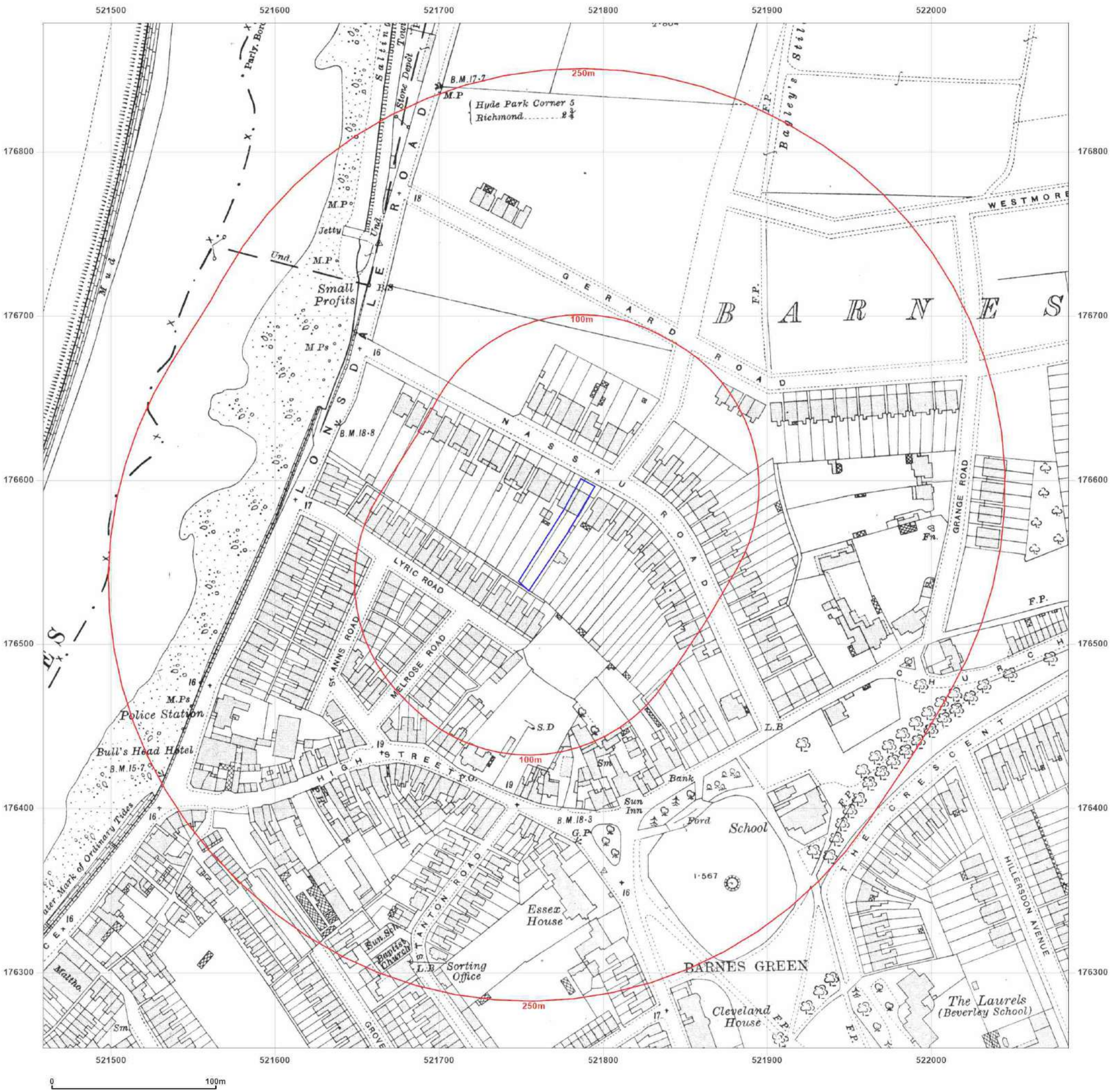

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Report Ref: GS-R7I-VE4-EA3-BPT
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Map Name: County Series

Map date: 1919

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Grid Ref: 521771, 176566

Map Name: County Series

Map date: 1933

Scale: 1:2,500

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Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: County Series

Map date: 1934

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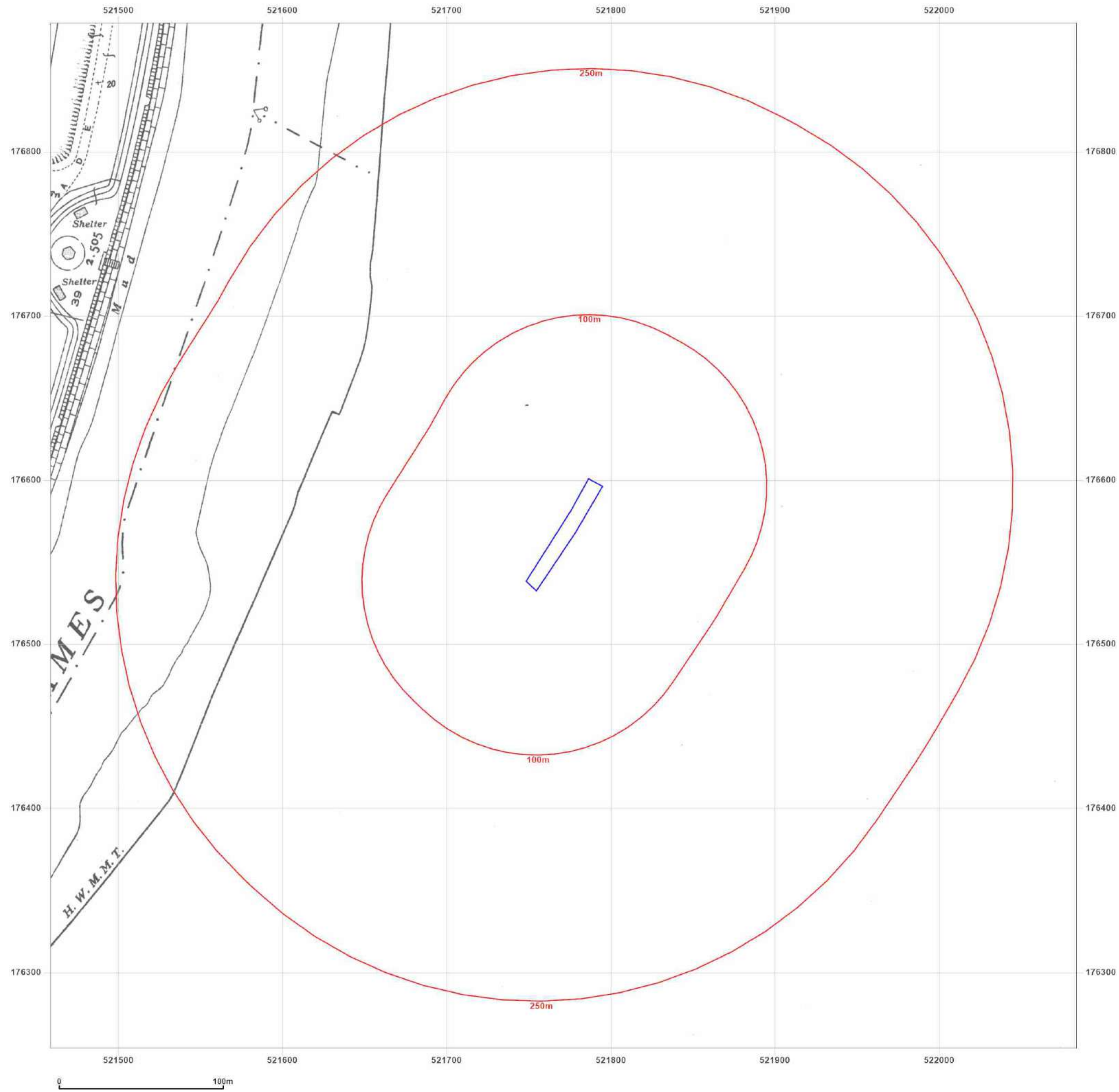

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Grid Ref: 521771, 176566

Map Name: County Series

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LONDON, RICHMOND UPON
THAMES, SW13 9QE

Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: County Series

Map date: **1940**

Scale: 1:2,500

Printed at: 1:2,500

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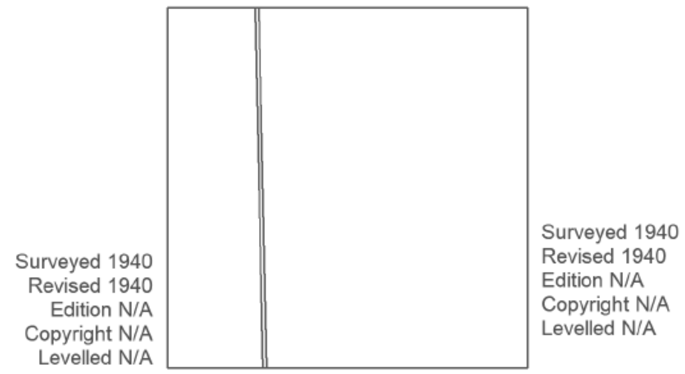

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Site Details:

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: **1950-1951**

Scale: 1:1,250

Printed at: 1:2,000

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Surveyed 1951 Revised 1951 Edition N/A Copyright N/A Levelled 1932	Surveyed N/A Revised N/A Edition N/A Copyright N/A Levelled N/A

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Site Details:

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Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: 1951

Scale: 1:2,500

Printed at: 1:2,500

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Site Details:

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Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: **1951**

Scale: 1:2,500

Printed at: 1:2,500

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Surveyed 1951
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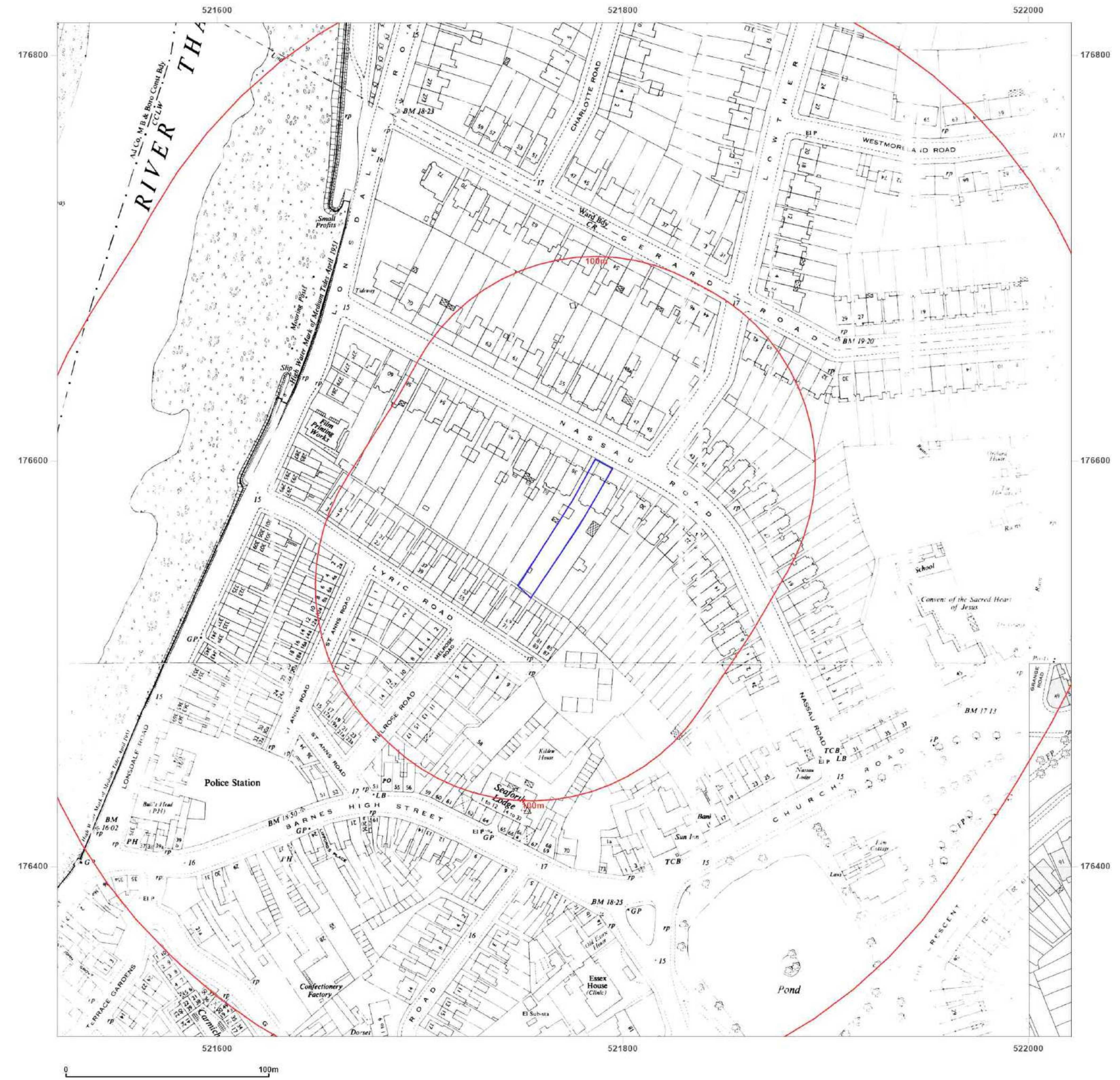

Groundsure INSIGHTS

Site Details:

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: **1951-1952**

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

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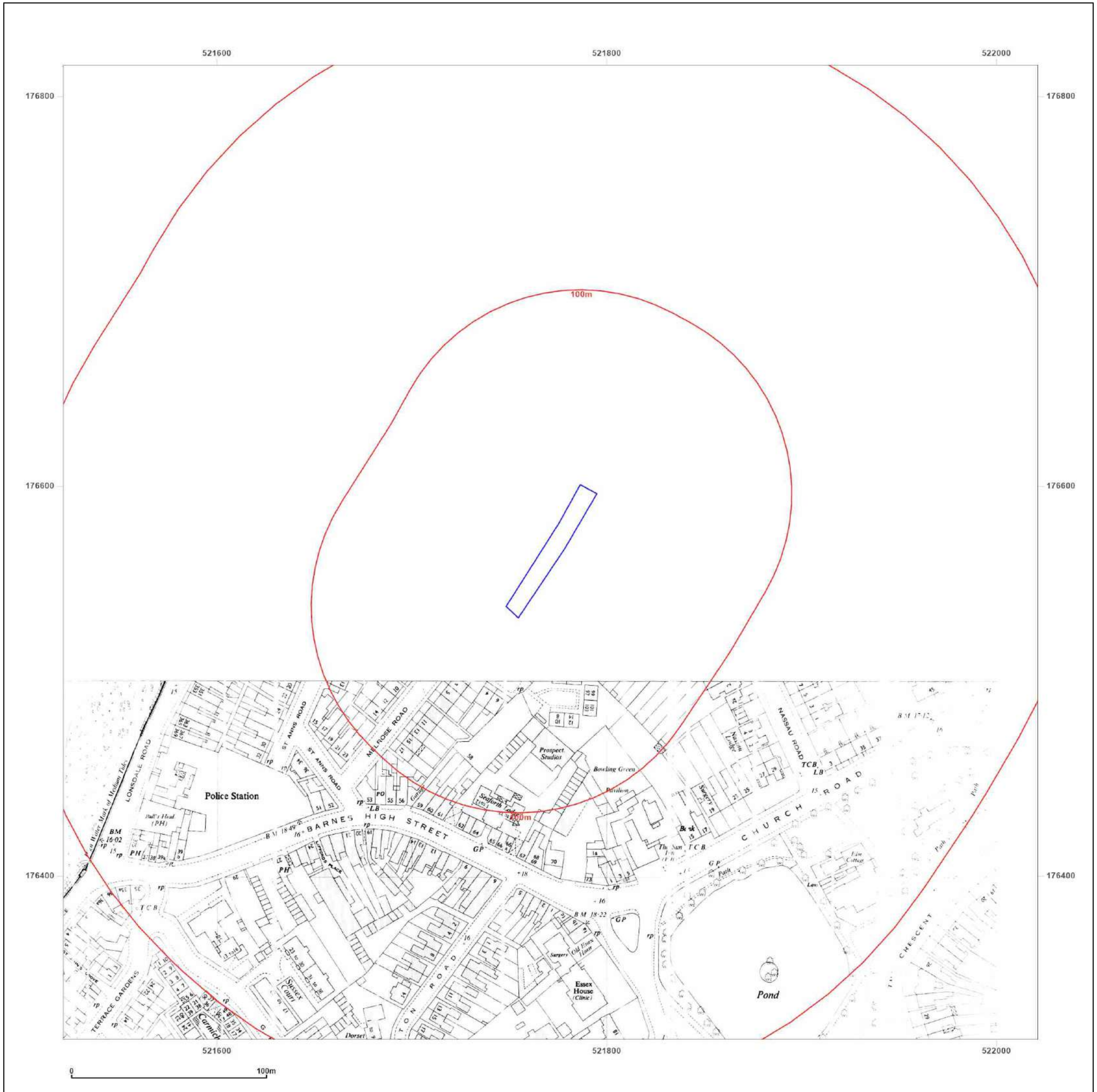

Site Details:

34, NASSAU ROAD, BARNES, LONDON, RICHMOND UPON THAMES, SW13 9QE

Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: 1964

Scale: 1:1,250

Printed at: 1:2,000

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

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Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: **1966**

Scale: 1:2,500

Printed at: 1:2,500

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Revised 1967
Edition N/A
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Site Details:

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Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: **1963-1967**

Scale: 1:1,250

Printed at: 1:2,000

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Revised 1966
Edition N/A
Copyright 1967
Levelled 1954

Surveyed 1963
Revised 1963
Edition N/A
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Levelled N/A

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Site Details:

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Client Ref: GWPR5909
Report Ref: GS-R7I-VE4-EA3-BPT
Grid Ref: 521771, 176566

Map Name: National Grid

Map date: **1968**

Scale: 1:2,500

Printed at: 1:2,500

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