Clandon Park, West Clandon, Guildford, Surrey

Detailed Gradiometer and
Ground Penetrating Radar Survey Report

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wessexarchaeology

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Contents

List of Figures

List of Tables

Summary

A detailed gradiometer and ground penetrating radar survey was conducted over land at Clandon Park, West Clandon, Guildford, Surrey (centred on NGR 504300 151250). The project was commissioned by Bristol and Bath Heritage Consultancy Ltd, on behalf of The National Trust, to establish the presence, or otherwise, and nature of detectable archaeological features.

The site comprises maintained grassland, covering an area of 3 ha. The geophysical survey was undertaken between 3 January and 9 February 2023. The survey has demonstrated the presence of past garden arrangements. A wide network of garden paths has been identified to the south and east of Clandon House, including the Entrance Avenue that extends from steps on the eastern side of the house. In addition, associated drainage channels have been identified running parallel to the paths. It is likely that several different phases of park development are evident within the results.

Several other anomalies have been identified that pertain to former garden features, mostly around the south and east of the house. The probable remains of the 'Gravel Garden', recorded on 1730 mapping, have been identified, as well as possible retaining or garden walls.

Circular features are thought to relate to former garden features. This interpretation is supported by the location of one along the route of the Entrance Avenue. However, it cannot be discounted that they relate to more modern activity such as landscaping or water management.

Numerous high-amplitude anomalies have been identified to the south of Clandon House. They are related to landscaping processes associated with the modern garden layout.

The remaining anomalies are thought to be modern or natural. The modern anomalies mostly relate to services and land drains.

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The fieldwork was undertaken by Pamela Warne, Jake Bishop, Callum Jervis and Rok Plesnicar. Rok Plesnicar processed and interpreted the geophysical data, wrote the report and prepared the illustrations. The geophysical work was quality controlled by Tom Richardson. The project was managed on behalf of Wessex Archaeology by Tom Richardson.

Clandon Park, West Clandon, Guildford, Surrey

Detailed Gradiometer and Ground Penetrating Radar Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology was commissioned by Bristol and Bath Heritage Consultancy Ltd, on behalf of The National Trust, to carry out a geophysical survey at Clandon Park, West Clandon, Guildford, Surrey (centred on NGR 504300 151250) (**Figure 1**). The survey forms part of an ongoing programme of archaeological works in support of the renovation of the Clandon House.

1.2 Scope of document

1.2.1 This report presents a brief description of the methodology followed by the detailed survey results and the archaeological interpretation of the geophysical data.

1.3 The site

1.3.1 The site is located at West Clandon, 5 km east of Guildford, in the county of Surrey

1.3.2 The survey comprises a total of 3 ha of land, divided into 6 areas currently utilised as a car park, road, and park area. The site is bounded by the Clandon Park Estate to the north and west, Clandon Wood Nature Reserve to the east, and agricultural land to the south.

1.3.3 The site is on an incline from 80 m above Ordnance Datum (aOD) at the northern edge to 104 m aOD at the southern edge.

1.3.4 The solid geology comprises Mudstone, Siltstone and Sandstone of the Pennine Lower Coal Measures Formation with overlying superficial geological deposits of diamicton till (BGS 2023).

1.3.5 The soils underlying the site are likely to consist of typical stagnogley soils of the 711h (Wickham 3) association (SSEW SE Sheet 5 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer and ground penetrating radar (GPR) surveys.

2 ARCHAEOLOGICAL BACKGROUND

2.1 Introduction

2.1.1 A brief for the geophysical survey was prepared by Bristol & Bath Heritage Consultancy (2022), which examined the potential for the survival of buried archaeological remains within the development area. The following background is not exhaustive, but is summarised from aspects of the document that are considered relevant to the interpretation of the geophysical survey data.

2.2 Summary of the archaeological resource

Historical Background

2.2.1 Clandon Park was developed out of two medieval manorial centres, at Merrow – known as Temple Court, and at West Clandon, where in the late 16th or early 17th century an existing house was enlarged to create an imposing mansion. In the 1690s, the gardens around the house were formalised on a grand scale.

2.2.2 The present mansion was built around 1730 – 33, on the site of the Jacobean house and fitted into the existing garden arrangement. The current boundary of the park was created in the late 18th century and the landscape was remodelled replacing canals and avenues of former gardens with lawns, clumps of trees, lakes, and a new drive from Merrow Gate.

2.2.3 The house was utilised as a military hospital during the First World War and as a storage place for documents from the Public Records Office during the Second World War.

2.2.4 On 29 April 2015, the Mansion was devasted by fire, with the loss of most of the interiors and their contents.

Archaeological Background

2.2.5 Previous archaeological investigations conducted in Clandon park have uncovered interesting features. In 2005 and 2017, excavations in the basement of the mansion revealed archaeological features such as a drainage channel formed of chalk blocks, brick and, sandstone slabs; a brick wall which was interpreted as either a foundation footing for the basement of the 1730s house or a foundation wall for its Tudor or Jacobean predecessor; a tile drain from the Tudor/Jacobean house; a drain and brick walls associated the 1730s house; and late 19th/early 20th century walls and drains.

2.2.6 Based on a geophysical survey of the south and east lawns which detected some anomalies relating to the late Tudor/Jacobean garden (Historic England 2015), an archaeological evaluation was conducted of the latter. This evaluation recorded a construction cut for a 17th century wall foundation, which had been demolished and a garden laid out over (AOC Archaeology 2016). A garden wall constructed of reused 16th century bricks was also found.

2.2.7 Historic England's 2016 dendrochronological analysis of salvaged structural timbers suggested a felling date of 1729 – 30.

2.2.8 In 2021 archaeological evaluations and watching brief were undertaken inside and outside the basement of the mansion, and in areas outside (MOLA 2022). At least two phases of stone foundations were found in two test pits in the basement which may represent the remains of the house that preceded the current mansion. The basement test pits also demonstrated that a building preceded the northern and southern sections of the manor. A test pit in an alcove at the southern end of the basement suggested the alcove was a later insertion to the southern external wall of the mansion.

2.2.9 Archaeological watching brief during the replacement of the site's temporary hoarding in the spring/summer of 2022 revealed buried remains of foundations of the southern wall of the forecourt to the south-west of the site, with possible evidence for a fine gravel surfacing of the forecourt north of the wall, and a more roughly-laid gravel path to the south (MOLA forthcoming).

2.3 Recent investigations in the area

Geophysical survey

2.3.1 In 2021 a GPR Survey was undertaken in areas immediately to the east and south of the mansion (SUMO 2021). Results show the northern end of the east lawn contained reflections consistent with phases of building/demolition activity but no clear evidence of a coherent distribution of structures, layers suggestive of intact building foundations, or garden landscaping layouts. The southern end of the east lawn showed evidence of layers/surfaces consistent with its known use within garden parterre-type layout since the 18th century. An area of existing parterre garden to the south of the house was surveyed, the eastern part of this area contained four distinctive zones of deep disturbed fill suggestive of either pits of demolished basement structures. A watching brief in the area suggested the natural chalk is very close to the surface. Although the top of a possible infilled deep feature corresponding with the SUMO GPR survey was tentatively identified, along with a number of garden path surfaces (MOLA 2022b). A number of large areas of disturbed fill in the west of the south parterre area detected by the SUMO GPR survey were of uncertain origin.

3 METHODOLOGY

3.1 Introduction

3.1.1 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team between 3 and 13 January 2023 and on 9 February 2023. Field conditions at the time of the survey were wet, which may have limited the penetration of the GPR. An overall coverage of 1.4 ha with GPR and 1.7 ha with the gradiometer survey was achieved.

3.1.2 The methods and standards employed throughout the geophysical survey conform to that set out as current best practice, and guidance outlined by the Chartered Institute for Archaeologists' (CIfA 2014) and European Archaeologiae Consilium (Schmidt *et al.* 2015).

3.2 Aims and objectives

3.2.1 The aims of the survey comprise the following:

- To determine, as far as is reasonably possible, the nature of the detectable archaeological resource within a specified area using appropriate methods and practices; and
- A magnetometer survey will be employed to provide a rapid overview, identifying areas of disturbance, cut features such as infilled ditches and pits, brick rubble etc.
- GPR surveys will be used to detect any buried surfaces or wall footings
- Verification of the results obtained through the 2015 and 2021 surveys.
- Production of a single coherent dataset acquired ad processed using a consistent methodology.
- Certainty that geophysical survey coverage has been obtained for all necessary areas

3.2.2 In order to achieve the above aims, the objectives of the geophysical survey are:

- To conduct a geophysical survey covering as much of the specified area as possible, allowing for on-site obstructions;
- To clarify the presence/absence of anomalies of archaeological potential; and

- Where possible, to determine the general nature of any anomalies of archaeological potential.

3.2.3 Survey Area 1

- Geophysical survey in this area will principally be directed at the identification of features which may survive below ground relating to the designed landscapes of the 18th -19th century

3.2.4 Survey Area 2

- Geophysical survey in this area will principally be directed at the identification of features which may survive below ground relating to the designed landscapes of the 18th - 19th century

3.2.5 Survey Area 3

- Geophysical survey in this area will principally be directed at the identification of features which may survive below ground relating to the designed landscapes of the 18th - 19th century

3.2.6 Survey Area 4

- Geophysical surveys in this area will in particular focus on the identification of the early 18th ' century formal gardens, as well as clarifying the survival of structural remains relating to buildings which preceded the current Mansion or were part of its original design (particularly adjacent to the south elevation of the House) and developing an understanding of the extent of landscaping works during the late 18th century.

3.2.7 Survey Area 5

- Geophysical survey in this area will principally be directed at the identification of features which may survive below ground relating to the designed landscape of the early 18th century, in particular different iterations of the forecourt layout and the garden panels shown on Knyff's 1708 depiction.

3.2.8 Survey Area 6

- Geophysical survey in this area will principally be directed at the identification of features which may survive below ground relating to predecessors of the current House and the Jacobean stable block which occupied this approximate location.

3.3 Fieldwork methodology

Gradiometer

3.3.1 The cart-based gradiometer system used a Leica Captivate RTK GNSS instrument, which receives corrections from a network of reference stations operated by the Ordnance Survey (OS) and Leica Geosystems. Such instruments allow positions to be determined with a precision of 0.02 m in real-time and therefore exceeds European Archaeologiae Consilium recommendations (Schmidt *et al.* 2015).

3.3.2 The detailed gradiometer survey was undertaken using four SenSys FGM650/3 magnetic gradiometers spaced at 1 m intervals and mounted on a non-magnetic cart. Data were collected with an effective sensitivity of ±8 µT over ±1000 nT range at a rate of 100 Hz, producing intervals of 0.02 m along transects spaced 4 m apart.

Ground Penetrating Radar (GPR)

3.3.3 The GPR survey was conducted using an Impulse Radar Raptor 45, 8 channel antenna, with a central frequency of 450 MHz. The multi-channel GPR system uses a separate shielded transmitter and receiver antennae, towed by a motorised vehicle. The data were recorded every 4 cm, with a horizontal profile spacing of 8.5 cm, and a time window of 100 ns. The majority of the data was collected in the zigzag method, however site boundary and coverage dictated single direction survey method on occasion.

3.3.4 The vehicle based GPR system provides real-time positioning, enabling full site coverage without the need to set up individual grid nodes. However, to ensure survey accuracy, the boundaries of the survey extent were established using a real-time kinematic (RTK) Global Navigation Satellite System (GNSS) instrument. This system allowed positions to be determined with sub-decimetre, accuracy and therefore exceeds EAC recommendations (Schmidt et. al. 2015).

3.3.5 The survey within the Māori shelter was conducted using an Impulse Radar Crossover 4080 system with a dual frequency antenna. The Crossover 4080 antenna was mounted on a rough terrain cart which is fitted with an odometer to measure horizontal distance along the ground surface. This was deployed across the GPR area, with data collected along traverses spaced 0.25 m apart. The 400 MHz antenna was determined to provide the best quality data in this case. The data was collected in a regular grid, which was later georeferenced using GPS.

3.4 Data processing

Gradiometer

3.4.1 Data from the survey were subjected to minimal correction processes. These comprise a background removal median function with an effective window of 50 m, applied to correct for any variation between the sensors, a discard overlaps function where transects have been collected too close together and an interpolation used to grid the data.

3.4.2 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

Ground Penetrating Radar (GPR)

3.4.3 Data from the survey were subjected to common radar signal correction processes. These comprise wobble correction, bandpass gain and filtering to remove frequency noise, background removal, Kirchhoff migration, and a Hilbert transformation. These steps are standard processing procedures and produce the highest quality resolution data for interpretation and presentation.

3.4.4 The approximate depth conversion for the 450 MHz antenna has been calculated on the assumption that the GPR pulses travel through the ground with an average speed of 0.1 m/ns. To determine this velocity, radargrams were analysed for suitable hyperbolic reflections of the GPR pulse through the subsurface deposits. It is possible to determine the average velocity of the GPR pulse through the ground more precisely if excavated features at a known depth can be identified and cross-referenced in the data.

3.4.5 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

Table 1 Relative velocity to depth conversion based on a dielectric constant of 9 for the 450 MHz antenna

Time Slice	Time (ns)	Depth (cm)
1	0.0 - 1.95	0.-0 - 0.1
2	2.07 - 4.02	0.1 - 0.2
3	4.13 - 6.08	0.21 - 0.3
4	6.2 - 8.15	0.31 - 0.41
5	8.26 - 10.21	0.41 - 0.51
6	10.33 - 12.28	0.52 - 0.61
7	12.39 - 14.35	0.62 - 0.72
8	14.46 - 16.41	0.72 - 0.82
9	16.52 - 18.48	0.83 - 0.92
10	18.59 - 20.54	0.93 - 1.03
11	20.65 - 22.61	1.03 - 1.13
12	22.72 - 24.67	1.14 - 1.23
13	24.79 - 26.74	1.24 - 1.34
14	26.85 - 28.8	1.34 - 1.44
15	28.92 - 30.87	1.45 - 1.54
16	30.98 - 32.93	1.55 - 1.65
17	33.05 - 35.	1.65 - 1.75
18	35.11 - 37.07	1.76 - 1.85
19	37.18 - 39.13	1.86 - 1.96
20	39.24 - 41.2	1.96 - 2.06

4 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

4.1 Introduction

4.1.1 This survey adopted a multi-method approach incorporating gradiometer and GPR. As each of these techniques have varying benefits and limitations for the detection of different types of deposits and materials, the use of these complementary methods maximises the potential for characterisation of archaeological remains.

Gradiometer survey

4.1.2 Results are presented as a series of greyscale plots, and archaeological interpretations at a scale of 1:1,250 (**Figures 2** and **3**). The data are displayed at -2 nT (white) to +3 nT (black) for the greyscale.

4.1.3 All features are described in terms of their geophysical character. The interpretation of the datasets highlights the presence of potential archaeological anomalies, but also includes ferrous responses, burnt, or fired objects, and magnetic trends (**Figure 3**). Numerous anomalies (visible throughout the dataset, which are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation. Full definitions of the interpretation terms used in this report are provided in **Appendix 3**.

GPR Survey

4.1.4 Results are presented as a series of greyscale timeslice plots and archaeological interpretations at a scale of 1:1,250 (**Figures 4** – **13**).

4.1.5 The 450 MHz antenna used in this survey has the potential of detecting features to a depth of 4 m in optimal conditions, however, the total depth reached varies depending on the specific conditions of each area.

4.1.6 All features are described in terms of their geophysical character. It is important to stipulate that all the depths referred to in this report are approximate levels below the current ground surface.

4.1.7 It should be noted that small, waterlogged or low contrast features may produce responses that are below the detection threshold of the geophysical instruments. Excessive disturbance can also impede the ability of geophysical techniques to detect archaeology. It may therefore be the case that more archaeological features may be present than have been identified through these methods.

4.1.8 The geophysical survey techniques may also not detect all services present on site. This report and accompanying illustrations should not be used as the sole source for service locations and appropriate equipment (e.g. CAT and Genny) should be used to confirm the location of buried services before any trenches are opened on site.

4.2 Gradiometer survey results and interpretation

4.2.1 A broad, weakly positive anomaly is located in the centre of Area 3 at **4000** (**Figure 3**). This anomaly is 14.5 m long and up to 2.5 m wide on a north-east to south-west orientation. It likely indicates an area of compacted material. Another positive linear anomaly at **4001** is located 3 m to the south of it. This is 7 m long by 0.8 m wide and indicates a linear ditch-like feature on the same north-east to south-west alignment. Clandon park was known to be on the same orientation and these features likely indicate a former garden path with a drainage ditch.

4.2.2 In the southern part of Area 4 is a linear area of increased magnetic response at **4002** that is on a north-east to south-west orientation. It is 13 m long by 1 m wide with a T-shaped ending at its western side. It likely indicates clay drains. A similar anomaly is present at the eastern side of Clandon House at **4003**. It has the same orientation as **4002** and is 33 m long by 2 m wide. It corresponds with a path visible on a 1945 aerial photograph from Google Earth, leading to the Hinemihi - the Maori meeting house.

4.2.3 A large amorphous area of increased magnetic response is present in front of Clandon House at **4004** in Area 4. Anomalies of this kind are indicative of made ground, with the presence of burned bricks. When compared to the 1730 garden plan (circa 1730 garden plan attributed to James Leoni; National Trust collection ref 1441243), this area corresponds with the location of the gravel gardens. It is likely that bricks material from the walls of the gravel garden was spread across the surface when they were removed.

4.2.4 A similar area of increased magnetic response to the north-east at **4005** is present between Areas 3 and 4. It traverses the site on NNE to SSW orientation and is up to 10 m wide. It indicates an infilled ha-ha that is visible on 2014 aerial photos.

4.2.5 Several areas of strong magnetic response have been identified in the northern side of Area 3 (**4006**, **4007**) and in Area 2 (**4008**). These anomalies are considered to be made ground, likely to be of modern due to stronger magnetic properties.

4.2.6 Several strong dipolar linear anomalies have been identified traversing the site (**4009** – **4014**). These are indicative of modern services, such as cables or pipes.

4.3 Ground penetrating radar survey results and interpretation

4.3.1 The GPR survey has identified a series of responses that likely represent the former landscape organisation in Areas 3 and 4. They are predominately represented by broad planar reflectors, organised on a south-west to north-east orthogonal arrangement. A series of broad linear reflectors (**4100** – **4102**) have been identified running from the steps on the north-eastern side of the house towards the sunken 'Dutch garden'. They are up to 6.5 m wide and have a combined length of 155 m. They are split into three segments and are visible on Timeslices 3 – 14 (0.2 m – 1.44 m below ground surface) (**Figures 5, 7, 9, 11, 13**), however, the reflections from the lower levels are likely a consequence of the accumulation of water and as such, they create a 'ringing' effect. The feature is present in the north-eastern part of the garden in Timeslices 3 – 7 (0.2 m – 0.72 m below ground surface) which could be the consequence of the sloping topography. The reflections indicate a surface feature, likely a gravel path, which corresponds with the Entrance Avenue marked on the 1730 garden plan and later portraits of the estate and has likely been truncated further from the house by landscape remodelling of the gardens in the late 19th century.

4.3.2 In addition to the Entrance Avenue, an orthogonal grid of similar responses has been identified to the south and east of Clandon House. The responses at **4103** – **4108** are on a north-east to south-west orientation, while those at **4109** – **4113** are on south-east to north-west orientation (**Figures 5, 7, 9, 11, 13**). They are up to 5 m wide and appear on Timeslices 3 – 14 (0.2 m – 1.44 m below ground surface). These anomalies indicate features of compacted material, such as gravel, likely associated with former paths.

4.3.3 Perhaps the most different feature is located at **4105** which is only visible on Timeslices 4 – 5 (0.31 m – 0.51 m below ground surface) (**Figure 7**). This anomaly corresponds with a park path depicted on the 1730 garden plan. When compared with the stronger response, located 9 m to the south at **4106**, it suggests poorer preservation at **4105** and potentially indicates separate phases of the garden layout.

4.3.4 A feature is noted as a weak planar reflector at **4113**, is 6 m wide and has been located 110 m to the east of **4113** in the area to the south of the 'Dutch garden' (**Figure 9**). It appears in Timeslices 7 – 9 (0.62 m – 0.93 m below ground surface) and corresponds with a path noted on the 1730s map of the estate. The feature response is weak, which would suggest that it was truncated by later changes.

4.3.5 Some of the identified paths are accompanied by linear features (**4105 (Figure 7**)**, 4107** (**Figures 5**, **7**), **4108** (**Figures 5**, **7**, **9**), **4109** (**Figure 5**), **4111** (**Figures 7**, **9**, **11**), **4112** (**Figure 5**)). They have been interpreted as drains or channels and could be associated with paths. As such they are possibly a part of the garden arrangement.

4.3.6 A horizontal linear reflector **4114** was identified near the Clandon house, to the north of Entrance Avenue (**Figures 5, 7, 9, 11**). It is 8.3 m long and 0.7 m wide, visible in Timeslices 2 – 10 (0.1 m - 1.13 m below ground surface). It likely indicates a small wall that has been truncated. The same area was surveyed by SUMO in 2021 and did identify a possible structure at this location. This feature was identified in 2016 AOC trenching (Trench 2, 2003) as a wall constructed from reused bricks.

4.3.7 An area of weaker broad planar responses (**4115**, **4116**) is located between **4100** and **4104** (**Figures 7, 9, 11, 13**). It covers an area of 23 m by 11 m and indicates a more compacted material visible in Timeslices 5 – 14 (0.41 m – 1.44 m below ground surface). It respects the orthogonal arrangement of the park and likely relates to the remains of the Gravel garden identified on the 1730 plan of the park, however, it could as well be just a continuation of the made ground from later landscaping of the area.

4.3.8 A broad high amplitude area of responses is located to the north-east of **4111** at **4117** (**Figures 7, 9, 11, 13**). It occupies an area of 35 m by 23 m and is visible on Timeslices 4 – 17 (0.31 m – 1.75 m below ground surface). It indicates deposition of ununiform compacted material like rubble containing building material, possibly as a result of landscaping, however, the complex nature of responses does not allow for a more accurate interpretation. It likely relates to an area of disturbed ground as a result of the 19th century remodelling of the gardens. A GPR investigation conducted by Historic England has identified similar anomalies within this area. The trial trench (Trench 4) from AOC in 2016 has revealed a made ground of layers of soil that was rich in chalk with pieces of bricks, which was likely the result of landscaping. This confirms the weaker response that usually indicates layers that can retain more moisture and confirms the interpretation as the made ground.

4.3.9 Further to the east of **4117** is an area of high amplitude planar responses **4118** (**Figures 7, 9, 11, 13**). It is 4 m wide and 17,5 m long and extends beyond the northern border of Area 4. It indicates disturbed ground, or potentially an area of compacted material which is visible in Timeslices 7 – 17 (0.62 m – 1.75 m below ground surface) and has the same orientation as garden features. This likely relates to the remains of a small retaining wall perpendicular to the slope of the garden.

4.3.10 To the east of **4118** is an oval low amplitude area **4119** that occupies a 6.5 m by 4.3 m area (**Figures 9, 11, 13**). A strong annular reflector is located immediately below the area of low amplitude with a diameter of 5 m and a further centrally positioned response. It is located immediately south of the Entrance Avenue and its shape suggests a garden feature such as a fountain. The bird's eye view of the mansion from 1708 by Leonard Knyff indicates a circular feature in a similar position which is not visible on the Estate plan from the 1730s. The exact position could not be established due to the nature of the painting, however, it does indicate similar features present. This could suggest that the low-amplitude response indicates the footprint of where the garden feature used to be and the circular stronger reflectors are the remanets of the wall foundation. However, this could as well be a more recent water management feature.

4.3.11 A strong planar response **4120** is located 15 m to the east from **4119**, is up to 6 m wide and traverses the site on NNW- SSE orientation (**Figures 5, 7, 9, 11**). It was recognised in Timeslices 2 – 11(0.1 m – 1.13m below ground surface). It corresponds with the magnetic anomaly **4004** and it is indicative of a modern ha-ha that was built by National Trust in the 1970s and demolished and infilled in 2015.

4.3.12 To the south of Clandon House is a weak rectilinear planar response located at **4121** (**Figures 5, 7**). It is up to 5 m wide, occupies an area of 17.5 m by 12 m, and is visible on Timeslices 3 – 5 (0.21 m – 0.51 m below ground surface). It is arranged on the same orthogonal orientation as the garden and indicates further garden paths. To the east of **4121**, on the same orientation is a similar type of planar response at **4122** that is 4.4 m wide by 23 m long, which is likely a part of the same feature within the wider garden arrangement visible on the Timeslices 3 – 4 (0.21 – 0.41 below ground surface). These responses can point to additional garden paths that lead to the southern entrance of the house. This interpretation is less reliable however, due to the number of high amplitude features in the vicinity and below.

4.3.13 A broad planar reflector at **4123** is located in the south-east of Area 4. It occupies an area of 12 m by 7 m and is visible in Timeslices 3 – 6 (0.21 m – 0.61 m below ground surface) (**Figures 5, 7**). It indicates a layer of compacted material and is likely part of the garden network of paths. About 10 m to the north of it is another small high amplitude planar

reflector at **4124**, which is visible in Timeslices 5 – 10 (0.41 m – 1.03 m below ground surface) (**Figures 7, 9, 11**). It is 9.5 m long by 2 m wide and has the same orientation as the garden features. It indicates an accumulation of compacted material, likely a further garden arrangement.

4.3.14 A linear anomaly formed of high amplitude planar reflectors is located in the south-west of Area 4 at **4125** (**Figures 5, 7, 9, 11, 13**). It is 1 m wide and 35 m long, visible on Timeslices 5 – 9 (0.41 m – 0.92 m below ground surface). It is indicative of a small wall that runs parallel to the house, possibly part of the former gardens. The responses are weak which suggests that it was truncated by later interventions in the area.

4.3.15 Two linear strong reflectors are located in the south of Area 4 at **4126** (**Figure 5**). These responses are on the same orientation as garden features noted in the rest of the survey and appear in Timeslices 2 – 3 (0.1 m – 0.3 m below ground surface). They are 0.75 m wide and occupy a space of 6 m by 4 m. The linear nature of the features suggests a small wall or a layer of compacted material that is likely related to the garden arrangement.

4.3.16 A circular area of high amplitude response at **4127** is truncating the linear feature at **4125** in the south-west of Area 4. It has a diameter of 7.3 m in Timeslice 5 (0.41 m below ground surface) and 4.5 m in Timeslice 11 (1.13 m below ground surface) (**Figures 5, 7, 9, 11, 13**). The feature appears as a set of complex planar responses at the top and a planar circular response at the bottom, which suggests that the original feature was likely removed. It could relate to a garden feature as it is located in the vicinity of a similarly shaped feature on the estate plan from the 1730s.

4.3.17 A curvilinear planar reflector is located at the south-east of Area 4 at **4128** (**Figures 5, 7, 9, 11**). It is 50 m long and up to 5.5 m wide, located along the slope at the top of the sloped lawn. This broad feature is visible between Timeslices 3 – 11 (0.21 m – 1.13 m below ground surface) and it follows the top edge of the sloped lawn. It indicates a compacted layer of material likely the natural result of the topographic features on site.

4.3.18 An area of low amplitude response **4129** is located to the north of **4127** (**Figures 9, 11, 13**) in area 4. It has a rectangular shape, 6.5 m long and 3 .5 m wide visible between Timeslices 6 – 20 (0.62 m – 2.06 m below ground). It relates to a modern feature, such as a soakaway.

4.3.19 To the west of **4129** is a similar area of low amplitude responses **4130** (**Figures 7, 9, 11, 13**). It is round with a diameter of 5 m and visible between Timeslices 6 – 16 (0.52 m – 1.65 m below ground). This feature as well relates to a modern feature likely related to water management.

4.3.20 The remaining high amplitude responses throughout the site indicate complex planar reflectors, which are generally considered to be the result of several phases of landscaping and adapting the garden into today's form. A more in-depth interpretation could not be discerned from the current data.

4.3.21 Numerous point reflectors have been identified throughout the site. The responses **4131** – **4135** indicate the water main pipeline, indicated on the utility plans. The remaining features correspond with land drains and unidentified modern services, such as pipes, cables or drains.

4.3.22 No reflectors that would indicate the presence of potential archaeological features were identified in Areas 1, 5, and 6. The features in these areas are all identified as modern in provenience, likely a result of landscaping or modern services.

5 DISCUSSION

5.1.1 The geophysical survey at Clandon park has demonstrated the presence of past garden arrangements in Areas 3 and 4. A wide network of garden paths has been identified to the south and east of Clandon House. These paths include the Entrance Avenue which extends from steps on the eastern side of the house. In addition, linear features that likely indicate associated drainage channels have been identified running parallel to the paths. It is likely that several different phases of park development are evident within the results. Some garden paths were identified by Historic England in 2015 and correspond with garden paths identified in this survey.

5.1.2 A wall was identified near the Clandon house, to the north of Entrance Avenue and confirmed with the 2016 AOC trenching. It was defined as a brick wall, constructed from reused bricks. This, however, was not identified in the results of the GPR survey by SUMO 2021.

5.1.3 Several other anomalies have been identified that pertain to former garden features, mostly around the south and east of the house. The probable remains of the 'Gravel Garden', recorded on 1730 mapping, have been identified, as well as possible retaining or garden walls. The survey by Historic England in 2015 detected similar anomalies within this area. The later trenching from AOC reveals layers of silty clays mixed with bricks and charcoal which suggests a situation after the 'Gravel Garden', and possibly not much of the 'Gravel Garden' remains.

5.1.4 Circular features are thought to relate to former garden features, possible fountains or plant beds. This interpretation is supported by the location of one along the route of the Entrance Avenue, although their exact function is unclear and it cannot be discounted that they relate to more modern activity such as landscaping or water management.

5.1.5 Remains of a modern ha-ha that was constructed in the 1970s and demolished in 2015 was identified in magnetic and GPR data.

5.1.6 Numerous high-amplitude anomalies have been identified to the south of Clandon House. They are related to landscaping processes associated with the modern garden layout.

5.1.7 The remaining anomalies are thought to be modern or natural. The modern anomalies mostly relate to services and land drains.

5.1.8 No indication of archaeological features was identified in Area 1. The GPR survey in Area 1 has identified numerous modern services, manholes, and made ground.

5.1.9 No indication of archaeological features was identified in Area 2. A high amplitude anomaly indicates an accumulation of building material which suggests made ground.

5.1.10 Numerous high amplitude responses identified in Area 5 are attributed to the more recent use of space as a car park in front of Clandon House. Additionally, several modern services are identified traversing the area.

5.1.11 No indication of archaeological features was identified in Area 6. There is no evidence for the buildings visible in the 1708 birds eye view depiction of the old mansion by Leonard Knyff.

5.1.12 Overall this phase of geophysical surveys corroborates the results of the previous Historic England (2015) and SUMO (2021) surveys, with the results further supported by the ground truthing of areas by the AOC (2016) evaluation. All three sets of surveys have identified walls to the east of the house, which are confirmed by the AOC evaluation. The garden features identified by this phase are broadly consistent with those in the Historic England surveys, with the Entrance Avenue and Gravel Garden seen clearly in both datasets, as well as numerous weaker anomalies likely associated with other former garden features. Combined with historical mapping and documentary evidence, this presents a good overview of the former garden layout with the number of sources providing a high level of confidence in interpretation.

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Map references

James Leoni, circa 1730 garden plan; *National Trust collection ref 1441243*

APPENDICES

APPENDICES

Appendix 1 Survey equipment and data processing

Survey methods and equipment

The magnetic data for this project were acquired using a non-magnetic cart fitted with four SenSys FGM650/3 magnetic gradiometers. The instrument has four sensor assemblies fixed horizontally 1 m apart allowing four traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 0.6 m separation and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of ±8 µT over ±1000 nT range. All of the data are then relayed to a CS35 tablet, running the MONMX program, which is used to record the survey data from the array of FMG650/3 probes at a rate of 20 Hz. The program also receives measurements from a GPS system, which is fixed to the cart at a measured distance from the sensors, providing real time locational data for each data point.

The cart-based system relies upon accurate GPS location data which is collected using a Leica Captivate system with rover and base station. This receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by European Archaeologiae Consilium recommendations (Schmidt et al. 2015) for geophysical surveys.

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.01 m intervals along traverses spaced up to 0.25m apart.

Post-processing

The magnetic data collected during the survey is downloaded from the system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

Typical data and image processing steps may include:

- GPS DeStripe – Determines the median of each transect and then subtracts that value from each datapoint in the transect within the defined window. May be used to remove the striping effect seen within a survey caused by directional effects, drift, etc.
- Discard Overlaps - Intended to eliminate a track(s) that have been collected too close to one another. Without this, the results of the interpolation process can be distorted as it tries to accommodate very close points with potentially differing values.
- GPS Base Interpolation – Sets the X & Y interval of the interpolated data and the track radius (area around each datapoint that is included in the interpolated result).

Typical displays of the data used during processing and analysis:

- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

Appendix 2: Ground Penetrating Radar Survey Equipment and Data Processing

Survey Methods and Equipment

The ground penetrating radar (GPR) data were collected using a cart mounted shielded antennae with central frequencies suitable for the types of target being investigated. Lower frequency antennae are able to acquire data from deeper below the surface, whereas higher frequencies allow high resolution imaging of near-surface targets at the expense of deep penetration. The exact make and model of equipment varies.

The depth of penetration of GPR systems is determined by the central frequency of the antenna and the relative dielectric permittivity (RDP) of the material through which the GPR signal passes. In general, soils in floodplain settings may have a wide range of RDPs, although around 8 may be considered average, resulting in a maximum depth of penetration c. 2.5m with the GPR signal having a velocity of approximately 0.1m/ns.

The GPR beam is conical in shape, however, and whilst most of the energy is concentrated in the centre of the cone, the GPR signal illuminates a horizontal footprint, which becomes wider with increasing depth. At the maximum depth of the antenna, it becomes impossible to resolve any feature smaller than the horizontal footprint for the corresponding depth. The size of the footprint is dependent upon central frequency, and its size increases as the central frequency decreases.

The vertical resolution is similarly dependent upon the central frequency; for the 300MHz antenna, features of the order of 0.05m may be resolved vertically. Antennae with lower frequencies can therefore penetrate more deeply but are less resolute in both horizontal and vertical directions. Choice of antenna frequency is guided largely by the anticipated depth to the target and the required resolution.

GPR data for detailed surveys are collected along traverses of varying length separated by 0.5m with cross lines collected running perpendicular to these traverses at wider separations. The data sampling resolution is governed by the data logger and a minimum separation of 0.05m between traces is collected for all surveys.

Post-Processing

The radar data collected during the detail survey are downloaded from the GPR system for processing and analysis using commercial software (GPR Slice). This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

Typical data and image processing steps may include:

- Gain – Amplifies GPR data based upon its position in the profile, which boosts the contrast between anomalies and background. A wobble correction is also applied during this step;
- Background Filter - is used to remove banding noises that are seen across the radargrams
- Bandpass – Removes GPR data lying outside a specified range, which removes high- and low-frequency noise.

Typical displays of the data used during processing and analysis:

- Timeslice – Presents the data as a series of successive plan views of the variation of reflector energy from the surface to the deepest recorded response. The variation in amplitude is represented using a greyscale with black indicating high amplitude and white indicating low amplitude responses.

- Radargram – Presents each radar profile in a vertical view with distance along the profile expressed along the x axis and depth along the y axis. The amplitude variation is expressed using a greyscale.

Appendix 3: Geophysical Interpretation

The interpretation methodology used by Wessex Archaeology separates the anomalies into four main categories: archaeological, modern, agricultural, and uncertain origin/geological.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.

- Possible archaeology – used for features which give a response, but which form no discernible pattern or trend.

The modern category is used for anomalies that are presumed to be relatively modern in date:

- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.

- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

The agricultural category is used for the following:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping.

- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow.

- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries.

- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses.

The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.

- High/low resistance – used for responses indeterminate areas of high and low resistance of uncertain origin.

- High/low amplitude – used for indeterminate areas of high and low amplitude of uncertain origin.

- Trend – used for low amplitude or indistinct linear anomalies.

- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of positive, negative, or broad bipolar (positive and negative) anomalies.

Appendix 3 OASIS form

Summary for wessexar1-513646

OASIS ID (UID)	wessexar1-513646
Project Name	Geophysical Survey at Clandon Park, West Clandon, Guildford, Surrey
Sitename	Clandon Park, West Clandon, Guildford, Surrey
Activity type	Geophysical Survey, GROUND PENETRATING RADAR SURVEY, MAGNETOMETRY SURVEY
Project Identifier(s)	Clandon Park, West Clandon, Guildford, Surrey
Planning Id	
Reason For Investigation	Heritage management
Organisation Responsible for work	Wessex Archaeology
Project Dates	03-Jan-2023 - 09-Feb-2023
Location	Clandon Park, West Clandon, Guildford, Surrey NGR : TQ 04300 51250 LL : 51.2508915595494, -0.506917559710656 12 Fig : 504300,151250
Administrative Areas	Country : England County : Surrey District : Guildford Parish : West Clandon
Project Methodology	The cart-based gradiometer system used a Leica Captivate RTK GNSS instrument, which receives corrections from a network of reference stations operated by the Ordnance Survey (OS) and Leica Geosystems. Such instruments allow positions to be determined with a precision of 0.02 m in real-time and therefore exceeds European Archaeologiae Consilium recommendations The detailed gradiometer survey was undertaken using four SenSys FGM650/3 magnetic gradiometers spaced at 1 m intervals and mounted on a non-magnetic cart. Data were collected with an effective sensitivity of ±8 µT over ±1000 nT range at a rate of 100 Hz, producing intervals of 0.02 m along transects spaced 4 m apart. The GPR survey was conducted using an Impulse Radar Raptor 45, 8 channel antenna, with a central frequency of 450 MHz. The multi-channel GPR system uses a separate shielded transmitter and receiver antennae, towed by a motorised vehicle. The data were recorded every 4 cm, with a horizontal profile spacing of 8.5 cm, and a time window of 100 ns. The majority of the data was collected in the zigzag method, however site boundary and coverage dictated single direction survey method on occasion. The vehicle based GPR system provides real-time positioning, enabling full site coverage without the need to set up individual grid nodes. However, to ensure survey accuracy, the boundaries of the survey extent were established using a real-time kinematic (RTK) Global Navigation Satellite System (GNSS) instrument. This system allowed positions to be determined with sub-decimetre, accuracy and therefore exceeds EAC recommendations (Schmidt et. al. 2015). The survey within the Maori shelter was conducted using an Impulse Radar Crossover 4080 system with a dual frequency antenna. The Crossover 4080 antenna was mounted on a rough terrain cart which is fitted with an odometer to measure horizontal distance along the ground surface. This was deployed across the GPR area, with data collected along traverses spaced 0.25 m apart. The 400 MHz antenna was determined to provide the best quality data in this case. The data was collected in a regular grid, which was later georeferenced using GPS.

Project Results	A wide network of garden paths has been identified to the south and east of Clandon House, including the Entrance Avenue that extends from steps on the eastern side of the house. In addition, associated drainage channels have been identified running parallel to the paths. It is likely that several different phases of park development are evident within the results. Several other anomalies have been identified that pertain to former garden features, mostly around the south and east of the house. The probable remains of the 'Gravel Garden', recorded on 1730 mapping, have been identified, as well as possible retaining or garden walls. Circular features are thought to relate to former garden features. This interpretation is supported by the location of one along the route of the Entrance Avenue. However, it cannot be discounted that they relate to more modern activity such as landscaping or water management. Numerous high-amplitude anomalies have been identified to the south of Clandon House. They are related to landscaping processes associated with the modern garden layout. The remaining anomalies are thought to be modern or natural. The modern anomalies mostly relate to services and land drains.
Keywords	
Funder	
HER	National Trust HBSMR - unRev - STANDARD
Person Responsible for work	
HER Identifiers	
Archives	

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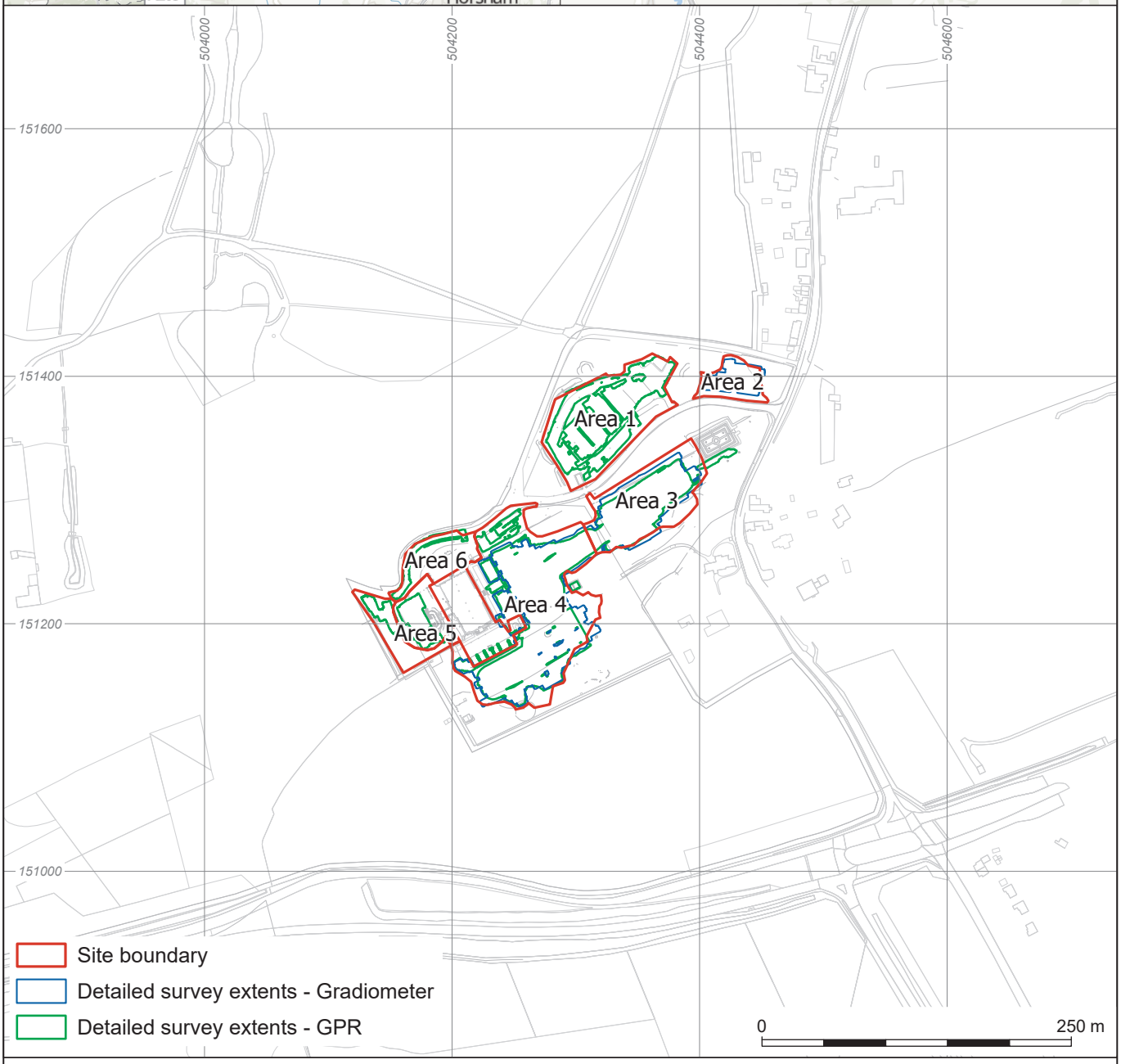

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Figure 1: Site location and survey extent

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504100
504200
504300
504400
151400
151300
151200

Site boundary
Detailed survey extents

-2 nT
3 nT

0
50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 2; Detailed gradiometer survey results: greyscale plot

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504100 504200 504300 504400

151400 151300 151200

4008
4014
4007
4006
4000
4001
4005
4012
4013
4004
4011
4003
4010
4009
4002

Site boundary
Detailed survey extents
Possible archaeology
Increased magnetic response
Superficial geology
Trend
Ferrous
Modern service

0 50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 3; Detailed gradiometer survey results: interpretation

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504100
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151300
151200

Site boundary
Detailed survey extents

Low amplitude
High amplitude

0
50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 4: Ground penetrating radar survey results: greyscale plot Timeslice 3 (0.21 m - 0.3 m)

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504100 504200 504300 504400

151400 151300 151200

4135 4133 4102 4103 4101 4104 4132 4134 4100 4114 4109 4106 4107 4123 4126 4122 4112 4121 4108 4131

Site boundary
Detailed survey extents
Archaeology
Possible archaeology
High ampliture anomaly
Low amplitude anomaly
Superficial geology
Drain or channel
Land Drain
Water Main
Unidentified modern services

0 50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 5: Ground penetrating radar survey results: interpretation Timeslice 3 (0.21 m - 0.3 m)

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504100
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151400
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151200

Site boundary
Detailed survey extents

Low amplitude
High amplitude

0
50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 6: Ground penetrating radar survey results: greyscale plot Timeslice 5 (0.41 m - 0.51 m)

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504100 504200 504300 504400

151400 151300 151200

4135 4133 4102 4103 4101 4120 4132 4134 4117 4115 4100 4111 4114 4105 4110 4106 4124 4123 4107 4128 4121 4108 4127 4131 4125

Site boundary
Detailed survey extents
Archaeology
Possible archaeology
High amplitude anomaly
Low amplitude anomaly
Superficial geology
Drain or channel
Land Drain
Water Main
Unknown modern services

0 50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 7: Ground penetrating radar survey results: interpretation Timeslice 5 (0.41 m - 0.51 m)

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504100
504200
504300
504400
151400
151300
151200

Site boundary
Detailed survey extents

Low amplitude
High amplitude

0
50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 8: Ground penetrating radar survey results: greyscale plot Timeslice 7 (0.62 m - 0.72 m)

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504100 504200 504300 504400

151400 151300 151200

4135 4133 4113 4102 4103 4104 4119 4120 4132 4134 4118 4116 4117 4115 4114 4100 4111 4110 4124 4109 4106 4128 4129 4130 4126 4108 4131 4125

Site boundary
Detailed survey extents
Archaeology
Possible archaeology
High ampliture anomaly
Low amplitude anomaly
Superficial geology
Drain or channel
Land Drain
Water Main
Unknown modern services

0 50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 9: Ground penetrating radar survey results: interpretation Timeslice 7 (0.62 m - 0.72 m)

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504100
504200
504300
504400
151400
151300
151200

Site boundary
Detailed survey extents

Low amplitude
High amplitude

0
50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 10: Ground penetrating radar survey results: greyscale plot Timeslice 10 (0.93 m - 1.03 m)

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504100 504200 504300 504400

151400 151300 151200

4135 4133 4102 4103 4104 4117 4119 4120 4132 4134 4116 4115 4118 4114 4100 4111 4124 4106 4108 4127 4131

Site boundary
Detailed survey extents
Archaeology
Possible archaeology
High amplitude anomaly
Low amplitude anomaly
Superficial geology
Drain or channel
Land Drain
Water Main
Unknown modern services

0 50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 11: Ground penetrating radar survey results: greyscale plot Timeslice 10 (0.93 m - 1.03 m)

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504100
504200
504300
504400
151400
151300
151200

Site boundary
Detailed survey extents

Low amplitude
High amplitude

0
50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 12: Ground penetrating radar survey results: greyscale plot Timeslice 13 (1.24 m - 1.34 m)

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504100 504200 504300 504400

151400 151300 151200

4135 4133 4104 4117 4119 4132 4134 4115 4118 4100 4106 4131

Site boundary
Detailed survey extents
Archaeology
Possible archaeology
High amplitude anomaly
Low amplitude anomaly
Drain or channel
Land Drain
Water Main
Unknown modern services

0 50 m

Coordinate system: OSGB 1936 British National Grid

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Scale: 1: 1,250 | Revision: 0

Figure 13: Ground penetrating radar survey results: greyscale plot Timeslice 13 (1.24 m - 1.34 m)

X:\Projects\272030\GIS_ArcPro\272030_Clandon Park\272030_Clandon Park.aprx

504100
504200
504300
504400
151400
151300
151200

Area 1
Area 2
Area 3
Area 4
Area 5
Area 5a
Area 6

Site boundary
Detailed survey extents
Wall
Possible features
Path
Possible path
Path to Maori hut
Gravel Garden
Park arangement

0 50 m

Coordinate system: OSGB 1936 British National Grid

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Figure 14: Geophysical survey results: Interpretation combined

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