ST MARY'S PLEASANCE, HADDINGTON, EAST LOTHIAN

ARCHAEOLOGICAL GEOPHYSICAL SURVEY REPORT

40980

28th November 2025

On Behalf of: *Haddington Historical Society*

National Grid Reference: *NT 51812 73708*

Author: *Robert Legg*

Illustration by: *Robert Legg*

Date of Fieldwork: *9th October 2025*

Document Review History

Rev	Date	Author	Approved by	Revision Stage
01	28.11.2025	Robert Legg, Project Manager	Susan Ovenden, Associate Director	First issue

Contents

List of Illustrations

Non-Technical Summary

AOC Archaeology was commissioned by Haddington Historical Society to carry out an archaeological geophysical survey using the magnetic gradiometry and earth resistance survey methods to investigate the extent of archaeological remains at St Mary's Pleasance, Haddington, East Lothian. A specific survey objective was to assess an earthwork identified in LiDAR data, postulated to reflect the location of the medieval royal residence.

The survey area consisted of a garden of 0.5 ha, located at NGR NT 51812 73708 of which approximately 0.35ha could be surveyed. No anomalies of a probable archaeological origin were interpreted from survey data. However, anomalies in both the earth resistance and the magnetic gradiometry data could relate to wall foundations.

Anomalies in both the earth resistance and the gradiometer data do coincide with the earthwork identified from LiDAR, though they appear more likely to reflect garden landscaping rather than any archaeological features. Other anomalies appear to reflect either garden landscaping or masonry, and a possible garden path or service trench.

1 Introduction

1.1. This report of a geophysical survey over the garden of St Mary's Pleasance, Haddington, East Lothian has been prepared by AOC Archaeology for Haddington Historical Society.

1.2. AOC Archaeology were commissioned to carry out a geophysical survey across the modern garden of St Mary's Pleasance, approximately 0.5 ha, using earth resistance and magnetic gradiometry. The survey took place on the 9th October 2025 as part of a research project.

1.3. Archaeological geophysical survey uses non-intrusive and non-destructive techniques to determine the presence or absence of anomalies likely to be caused by archaeological features, structures or deposits, as far as is reasonably possible (CIfA 2014, updated 2020). It is therefore a common component of the process of evaluating the impact of development on the historic environment. It is also a key tool in archaeological research as it is non-destructive and able to cover large areas, to allow below ground interventions to be appropriately targeted.

1.4. This survey was carried out to provide information on the presence, character and extent of potentially buried archaeological remains within the site. The significance of any such remains can only be determined with reference to further information and therefore this report may form part of an assessment of significance but cannot stand alone as such.

2 Parcel Location and Description

2.1. The survey area is located just on the south-eastern edge of Haddington, East Lothian (NGR NT 51812 73708). The survey was carried out over landscaped garden consisting primarily of a manicured lawn with tree plantings, with a meadow in the east beneath a ha-ha (see Figure 1).

2.2. The garden area totals approximately 0.5ha, of which approximately 0.35ha could be surveyed, The garden lies immediately east of Haddington House on Sledgate, and just north of St Mary's Church cemetery. The area is largely flat and sits at approximately 48m above Ordnance Datum (aOD).

2.3. The recorded solid geology underlying the survey area consists of sedimentary bedrock cycle of Aberlady Formation. This is overlain by superficial alluvial clay, silt, sand and gravel deposits (BGS 2025). No soils classification has been given to the soils of the survey area (Scotland's Soils 2025).

2.4. Magnetic Gradiometry typically provides a variable result over sedimentary geologies (overlain alluvium) (David et. al. 2008, 15). In this instance the survey area's setting at the edge of a town had a much stronger impact upon the survey data than the underlying geology.

3 Archaeological and Historical Background

3.1. The archaeological background below is summarised from a funding proposal provided by the client and supplemented by search of Historic Environment Scotland's, (HES) online resource, Trove.scot (HES 2025).

3.2. Haddington is one of the earliest royal burghs of Scotland, being established during the reign of David I (1124-1153). Of the fifteen royal burghs established by David I, Haddington is the only one without a royal residence. Documentary sources show that Alexander II, son of William of Lion, was born in Haddington suggesting there was a royal residence. Recently discovered charters suggest a royal presence in Sidegate from the mid-1100's, and St Mary's Pleasance is considered to be the most likely location for such a building. Other early royal residences of David I 's reign comprise a circular 'fosse' or ditch, enclosing a motte and bailey castle.

3.3. Haddington's royal site was burnt by the English at various times in the 13th century and appears to have been virtually abandoned by the royals by 1297. However, the structure itself may have remained largely undisturbed until Scotland's longest siege in 1548/49 when it is surmised that any upstanding remains would have been incorporated into the extensive earthen fortifications. Some landscaping aside, the area of the Pleasance has remained largely open with only minimal disturbance since the 16th century so there is a strong possibility that traces of sub-surface structures, such as a circular defensive ditch, might survive. This supposition is supported by recently produced LiDAR images, which appear to show a faint circular shadow, in the garden that could potentially be the remains of the 12th century motte.

3.4. The grounds of St Mary's Pleasance are a garden laid out in 1973-75, based upon 17th century principles of garden design. The site itself dates to the 17th and 18th century and was the orchard associated with Haddington House. The garden comprises a series of small gardens: a sunken garden on the east side of the Haddington House, a Cottage Garden leading into an orchard, and Meadow east of the orchard beneath a Ha-Ha feature. At the southern end of the Meadow is a conical shaped Mount for viewing the garden and townscape.

3.5. Immediately east of the site is 18th century Lady Kitty's walled garden with a dovecote in the northeast corner. Immediately south is the 14th-15th century St Mary's church and grounds.

4 Aims and Objectives

4.1. The primary aim of the archaeological geophysical survey is to identify and record potential geophysical anomalies indicative of archaeological remains through the production and interpretation of geophysical data which will aid in informing the development of subsequent phases of the archaeological evaluation strategy.

4.2. The results of the geophysical survey will be assessed and interpreted to gain a clear understanding of potential buried remains within the targeted area.

4.3. Specifically, the aims of the gradiometer survey are:

- To locate, record and characterise any potential surviving sub-surface archaeological remains within the survey area; and
- To produce a comprehensive site archive and report.

4.4. A specific survey objective is to assess the potential that the earthwork identified in LiDAR data could reflect the location of the medieval royal residence.

5 Methodology

5.1. The geophysical survey was undertaken on the 9th October 2025.

5.2. All geophysical survey work was carried out in accordance with current good practice specified in the EAC guidelines document (Schmidt *et al.* 2015), as recommended by Historic England, and in the Chartered Institute for Archaeologists' *Standard and Guidance for Archaeological Geophysical Survey* (2014, updated 2020).

5.3. Parameters and survey methods were selected that were suitable for the prospective aims of the survey and in accordance with recommended professional good practice (Schmidt *et al.* 2015).

5.4. The gradiometer survey was carried out using Bartington Grad601-2 fluxgate gradiometers (see Appendix 2). The survey was conducted within a grid system, across grids measuring 20m by 20m which were marked out using temporary markers at each grid node.

5.5. Grid nodes were set out and recorded using a Trimble R8 / R10 dGPS with an error no greater than +/- 0.05m. The GPS system uses the Trimble "VRS Now" service to provide instant access to real-time kinematic (RTK) corrections enabling an accuracy of < 2cm. It was connected via a SIM card run on the Vodafone network with good cellular signal in the survey areas, meaning a repeater was not required.

5.6. Data was collected in the field on a southeast-northwest alignment using zig-zag traverses, with a sample interval of 0.25m and a traverse interval of 1m. A total of 14 full or partial grids were surveyed within the specified area, totalling an area of approximately 0.35 ha.

5.7. Before each session of use, each gradiometer was balanced around a single set up point within the survey area specifically chosen for use by all instruments used in the survey. This point is magnetically quiet and balancing the machine around this point, produces a more uniform dataset throughout and allows all data to be plotted with ease within a standard range as appropriate to the survey environment. Striping of the data may occur due to instrument drift; it is decided in the field if this is within a sensible and acceptable limit; if it is not, the grids in question are re-collected.

5.8. Care was also taken to attempt to avoid metal obstacles present within the survey area, such as metal objects within and adjacent to the survey area as gradiometer survey is affected by 'above-ground ferrous disturbance' and avoiding these improves the overall data quality and results obtained.

5.9. The gradiometer data were downloaded using Bartington Grad601 PC Software v313 and processed using Geoscan Geoplot v4.0, the details of which can be found in Appendices 2 and 3. Data processing, storage and documentation were carried out in accordance with the good practice specifications detailed in the guidelines issued by the Archaeology Data Service (Schmidt and Ernenwein 2009).

5.10. The Earth Resistance survey was carried out using a Geoscan Research RM85 resistance meter (see Appendix 2). The survey was conducted within a system of grids measuring 20m by 20m each, which were marked out using temporary markers at each grid node.

5.11. Grid nodes were set out and recorded using a Trimble R8 / R10 dGPS with an error no greater than +/- 0.05m. The GPS system uses the Trimble "VRS Now" service to provide instant access to real-time kinematic (RTK) corrections enabling an accuracy of < 2cm. It was connected via a SIM card run on the Vodafone network with good cellular signal in the survey areas, meaning a repeater was not required.

5.12. Data was collected on a southeast-northwest alignment using zig-zag traverses, with a sample interval of 1m and a traverse interval of 0.5m. A total of 12 full or partial 20m by 20m grids were surveyed, totalling an area of approximately 0.4 ha.

5.13. The data were downloaded and processed using Geoscan Geoplot v4.0 and the details of these processes can be found in Appendices 2 and 3.

5.14. Interpretations of the data were created as shapefile layers in ArcGIS Pro.

6 Results and Interpretation

6.1 The gradiometer and earth resistance survey results have been visualised as side-by-side greyscale plots, with the processed gradiometer data plotted at -5 to 8nT, and processed earth resistance data plotted at 50 to 98 ohms as seen in Figure 3. Side by side interpretations of the data can be seen in Figure 4. Figure 5 shows minimally processed gradiometer data plotted as XY traces at 11nT/cm at A3.

6.2 Appendix 4 contains a guide to the interpretation categories employed and the logic used to assign anomalies to specific classes, as well as a short discussion of how past human activity results in these anomalies, however some important points are noted below.

6.3 The classes have three sub-types (generally); anomalies (typically indicated by a solid colour polygon), spreads (a stippled polygon) and trends (a line with a colour matching the polygon colour). Anomalies refer to distinct changes in the survey data which suggest an abrupt boundary between materials below ground, such as a cut feature with a magnetically contrasting fill. Spreads of enhanced material refer to diffuse areas of altered magnetic contrast which suggest a localised spread of material with a magnetic contrast within the topsoil or ploughzone. Linear trends are less distinct and are typically visible as linear patterning in the overall texture of the data. A common example of these is the striping effect caused by recent ploughing.

6.4 Anomalies placed in the 'uncertain' class may have an archaeological origin, but other explanations are equally likely. Where any particular interpretation is more likely than others, the anomaly is assigned to that class.

6.5 The definite 'Archaeology' class is only used for anomalies with no other possible explanation, either due to their diagnostic characteristics or because they are corroborated by other sources such as previous interventions within the Parcel. Anomalies with magnetic characteristics or morphologies that suggest an archaeological origin will generally be assigned to the 'Possible Archaeology' class.

6.6 The anomaly type 'ferrous spike' is assigned to strong dipolar anomalies which cover a small spatial area and have a characteristic appearance in the XY traces of the survey data. These are strongly likely to be of recent origin in the form of magnetic or ferrous debris within the topsoil; 'spikes' of other origin will be assigned to their appropriate classification.

6.7 A distinction is made between modern disturbance from strongly ferrous materials within or adjacent to the survey area, such as the strong dipolar 'halos' produced by services like gas mains, and spreads of material within the topsoil causing noise which is assumed to have a recent origin. Generally speaking, 'modern disturbance' occurs at a distance from magnetic source, whereas modern magnetic spreads/debris are related to material directly at that location.

6.8 Generally, only anomalies (or groups thereof) of a likely archaeological or historical origin have been assigned an anomaly number on the interpretation figures. However, anomalies interpreted as resulting from other processes that are integral to the discussion of the results have also been assigned anomaly numbers.

6.9 Magnetic survey data exhibits a strong magnetic enhancement largely resulting from strong magnetic disturbance associable with structures along the perimeter of the survey area, and the distribution of debris across the survey area, likely to result from the landscaping of the garden. Though some anomalies have been identified against this background, it is likely this magnetic noise has masked anomalies associated with buried features. Modern interference is not so readily identified in the earth resistance data with a strong contrast between high and low resistance anomalies, though much of the variation as discussed below is likely to result from landscaping of the garden.

Archaeology

6.10. No anomalies of probable archaeological origins have been interpreted from either the earth resistance or fluxgate gradiometer survey data. Anomalies of possible archaeological and unclear origins though have been identified from the data of each geophysical survey method.

Possible Archaeology

6.11. Located along the western edge of the survey area are two conjoining high resistance anomalies are identifiable in the earth resistance data [***r1***]. These anomalies could reflect the location of wall foundations, and a nearby negative in the gradiometer data [***m1***], is consistent with the presence of stone masonry. Both the earth resistance and the gradiometer anomalies are separate from the circular feature in the LiDAR data and seem more likely to reflect a structure associated with Haddington House, rather than a royal residence.

Unclear Anomalies

6.12. Several high resistance anomalies and an area of slightly lower resistance have been interpreted from the earth resistance data, which coincide with the circular feature identified in the LiDAR data [***r2***]. The high resistance anomalies could reflect the locations of masonry; however, they are more likely to reflect landscaping associated with the forming of the garden.

Two magnetic anomalies [***m2***] have also been identified within this area, though similarly they seem more likely to reflect landscaping associated with the garden.

6.13. Several other high resistance anomalies are scattered across the survey area [***r3***], which as above could reflect deposits of masonry but seem more likely to relate to landscaping associated with the garden and tree roots.

6.14. Transecting the survey area west to east is a linear low resistance anomaly in the earth resistance data and corresponding negative anomaly in the gradiometer data [***r4, m3***]. These anomalies do not relate to any known features, though they seem likely to relate to either a former garden path or service trench.

6.15. Located near the northern edge of the survey are ephemeral linear anomalies in both the earth resistance and the gradiometer data [***r5, m4***]. The origin of these is unclear but natural or modern origins are most likely.

Non archaeological anomalies

6.16. Along the edges of the survey area in the gradiometer data is strong magnetic disturbance associated with structures along the edge of the survey area. Across the survey area is also groupings of dipolar anomalies consistent with the presence of ferrous debris, which is likely to relate to the landscaping and use of the garden.

7 Conclusions

7.1 An earth resistance and magnetic gradiometer survey has been successfully carried out by AOC Archaeology. Strong magnetic noise associated with debris and structures around the perimeter of the survey has contributed to an enhanced magnetic background and is likely to have hindered the identification of magnetic anomalies. However, it has been possible to identify anomalies of possible archaeological and uncertain origins in both the magnetic gradiometer and earth resistance survey data.

7.2 No anomalies of probable archaeological origins were identified; however, anomalies of possible archaeological origins in both the earth resistance and gradiometer data may reflect the location of wall foundations of a structure possibly associated with Haddington House.

7.3 Several anomalies within both the gradiometer and earth resistance data appear to coincide with the location of a circular feature postulated, from LiDAR data, to be a possible location of a medieval royal residence. Though this interpretation cannot be discarded, the survey data is more consistent with garden landscaping.

7.4 Other high resistance anomalies could reflect the presence of masonry across the survey area but again these seem more likely to reflect landscaping associated with the garden. Another anomaly appears to reflect a former path or service trench.

7.5 In assessing the results of the geophysical survey against the specific aims set out in Section 4:

- The survey has succeeded in locating, recording and characterising surviving sub-surface remains within the Site, though more remains may be present that are not suitable for detection using magnetic gradiometry;

- The survey will help in determining the next stage of works as it has provided evidence that remains of archaeological, possible archaeological, historical and uncertain origin are most likely present on site, and has provided a number of targets for further investigation;
- The survey has resulted in a comprehensive report and archive.

8 Statement of Indemnity

8.1 The survey has resulted in a comprehensive report and archive. Although the results and interpretation detailed in this report have been produced as accurately as possible, it should be noted that the conclusions offered are a subjective assessment of collected data sets.

8.2 The success of a geophysical survey in identifying archaeological remains can be heavily influenced by several factors, including geology, seasonality, area conditions and the properties of the features being detected. Therefore, the geophysical interpretation may only reveal certain archaeological features and not produce a complete plan of all the archaeological remains within a survey area.

9 Archive Deposition

9.1 In accordance with professional standard practice an 'Online Access to the Index of Archaeological Investigations' ('OASIS') record will be completed for submission to the HER and Archaeological Data Service (ADS) (Appendix 1).

9.2 One digital and hard copy of the report and data will be submitted to the relevant Historic Environment Record (HER) at the Client's discretion.

9.3 A digital copy of the report and data will also be submitted to the ADS at the Client's discretion.

10 Bibliography

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Figures

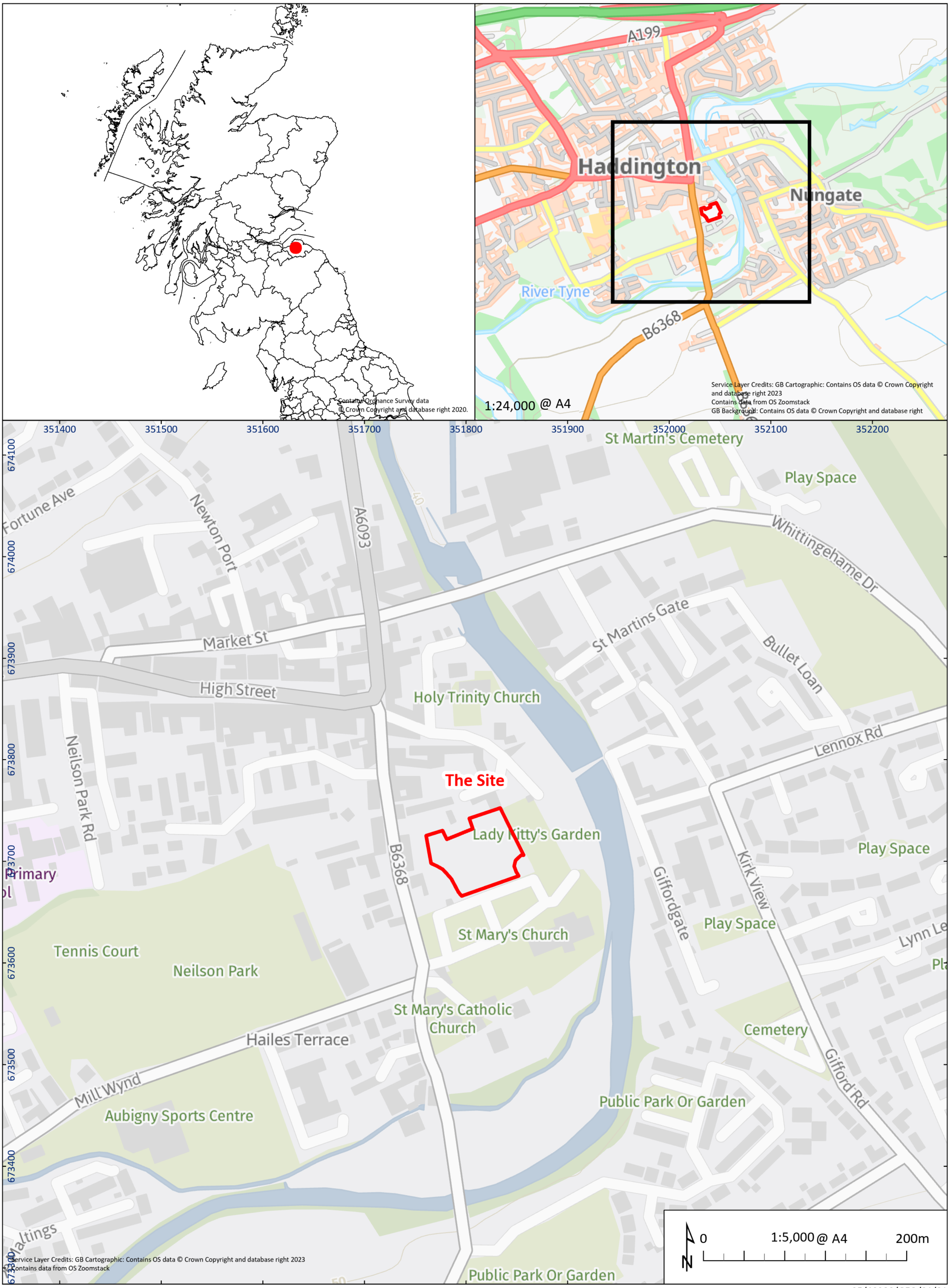

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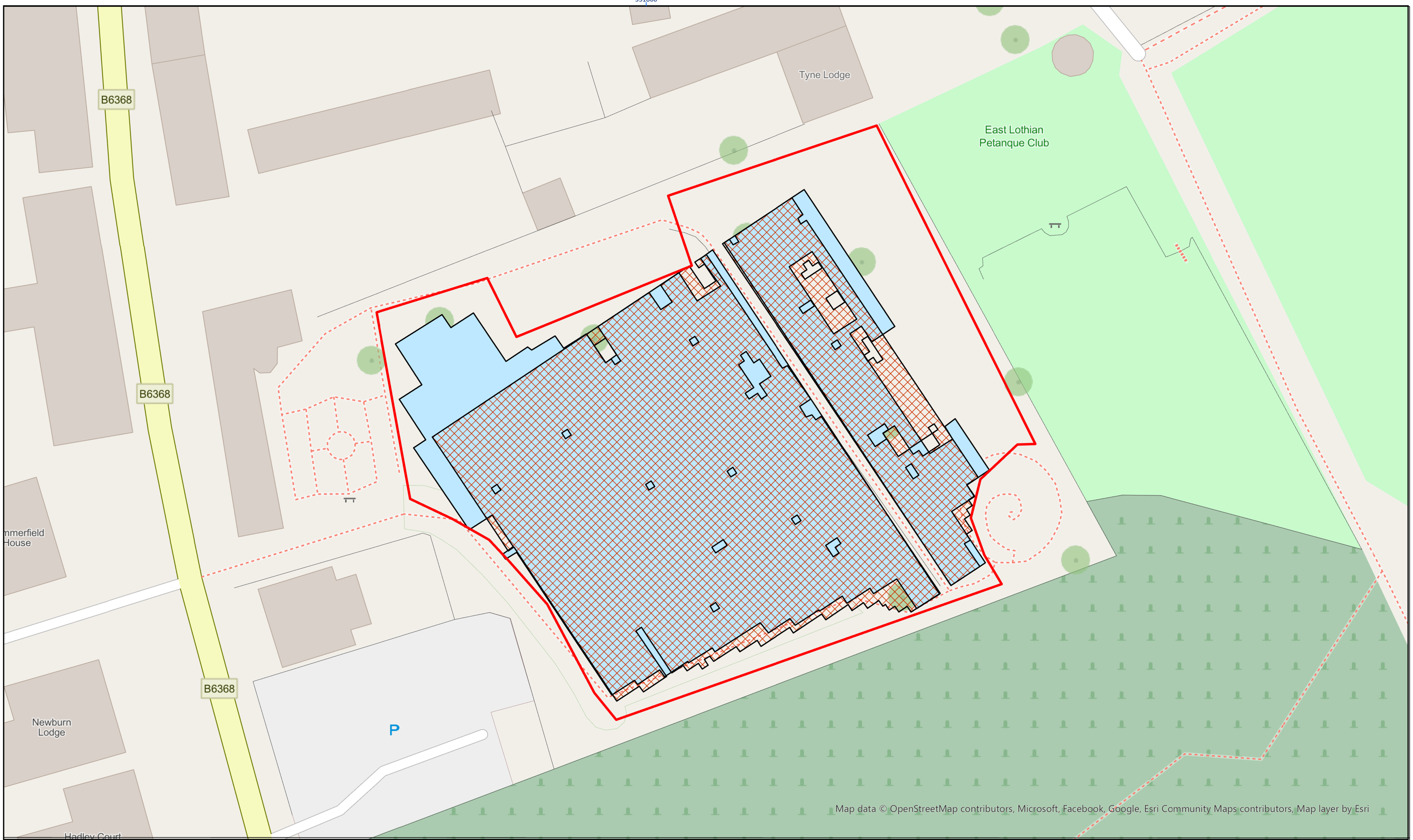
Figure 1: Site Location



Survey Areas

Figure 2

- Red Line Boundary
- Resistance Survey
- Gradiometer Survey

N
0 10m
Scale: 1:500 @ A3

Drawing Number: 05/40980/GEO/2/01	
Created by: RL	Date: 02/12/2025
Checked by: SO	Date: 02/12/2025
Approved by: CS	Date: 02/12/2025

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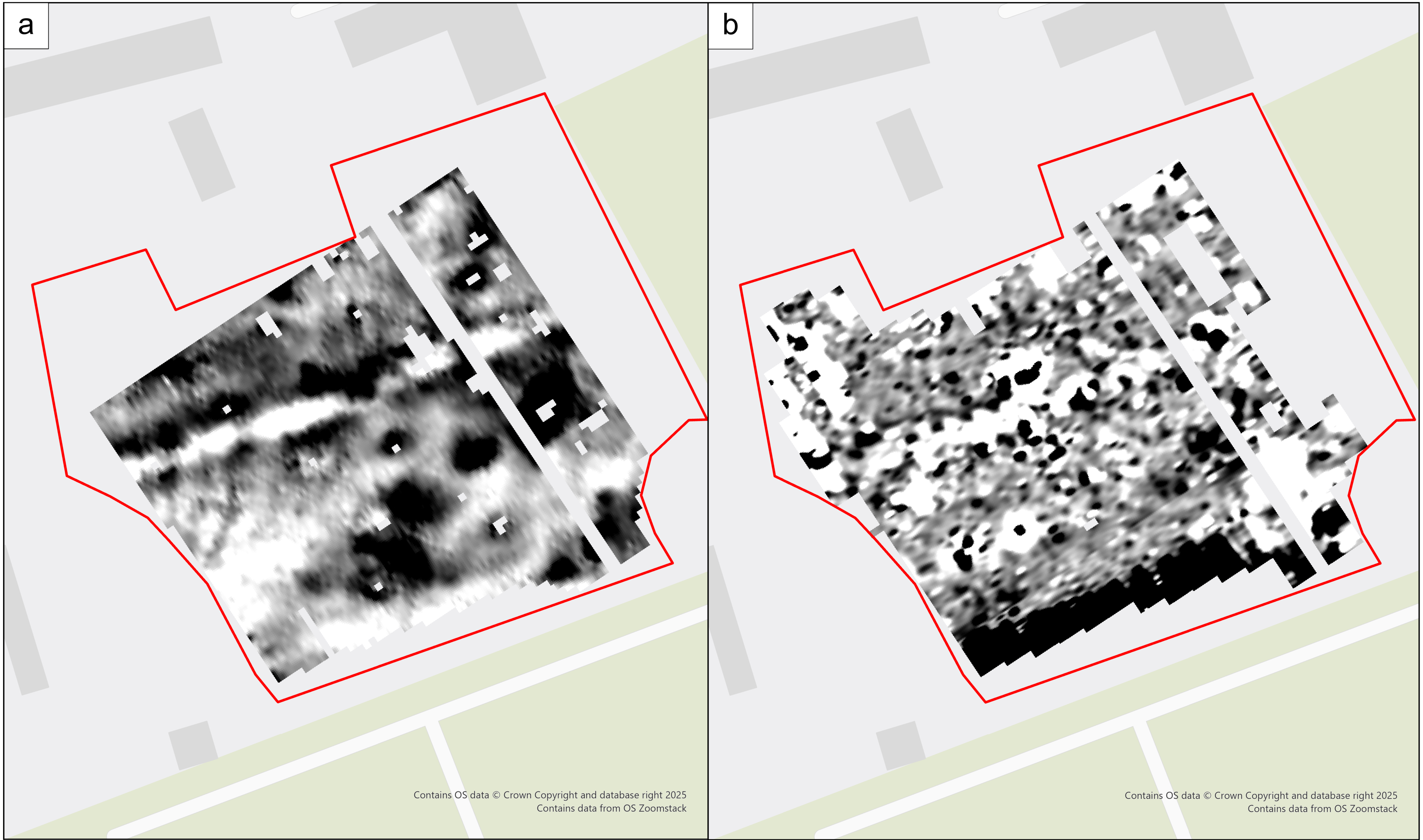
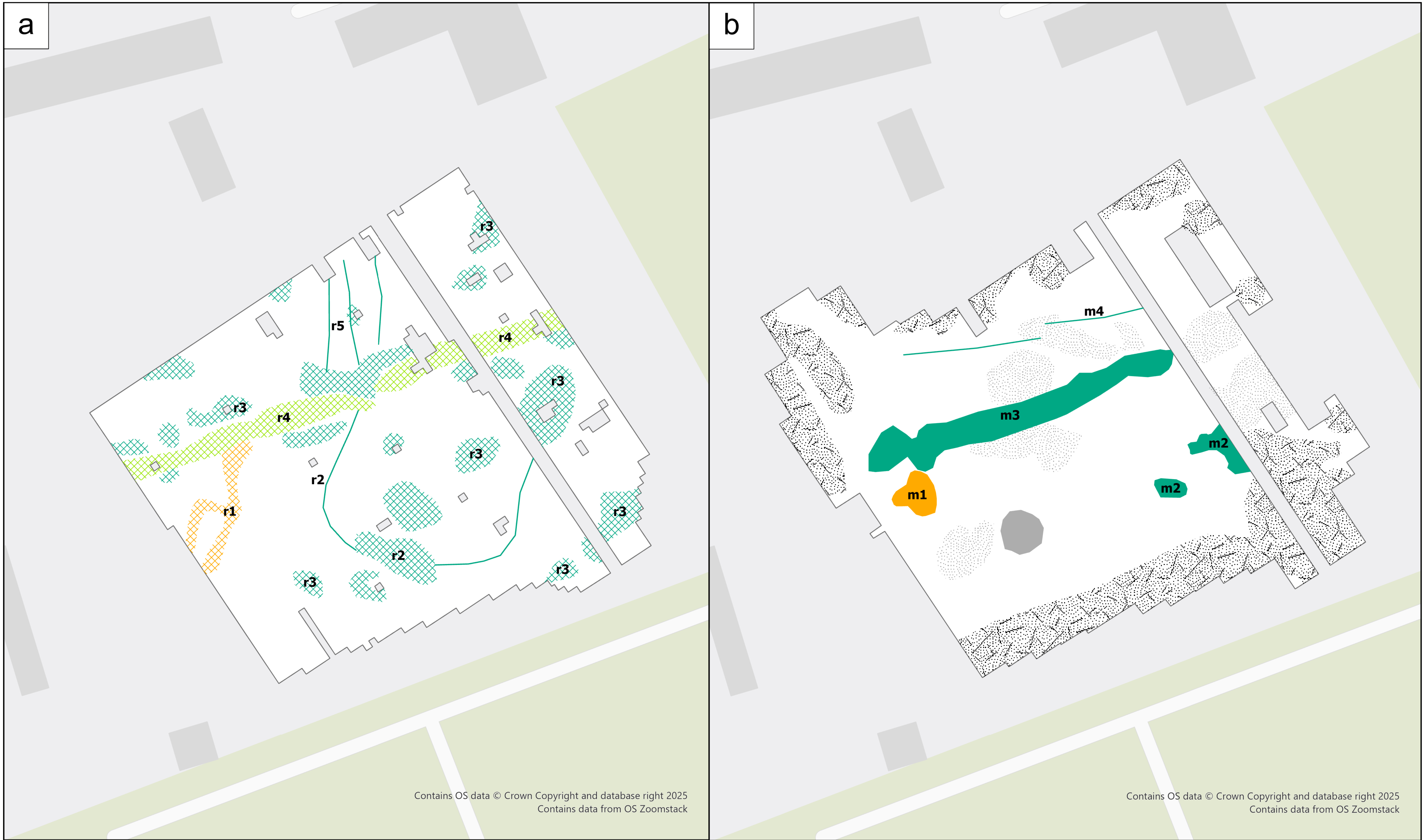


Processed Data: a) Earth Resistance Survey & b) Gradiometer Survey.

Figure 3	a 98Ω 50Ω	b 8nT -5nT	Red Line Boundary	N 0 10m Scale: 1:500 @ A3	Drawing Number: 05/40980/GEO/3/01 Created by: RL Date: 02/12/2025 Checked by: SO Date: 02/12/2025 Approved by: CS Date: 02/12/2025	AOC Archaeology Group



Interpretation: a) Earth Resistance Data & b) Gradiometer Data.

Figure 4

a
- High Resistance (Possible Archaeology)
- High Resistance (Unclear origin)
- Low Resistance (Unclear origin)
- Linear Trend (Unclear Origin)

b
- Anomaly (Possible Archaeology)
- Anomaly (Unclear Origin)
- Spread (Magnetic Disturbance)
- Anomaly (Ferrous/Iron Spike)
- Spread (Ferrous/Iron Spike)
- Linear Trend (Unclear Origin)

N

0 10m

Scale: 1:500 @ A3

Drawing Number: 05/40980/GEO/4/01	
Created by: RL	Date: 02/12/2025
Checked by: SO	Date: 02/12/2025
Approved by: CS	Date: 02/12/2025

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XY Trace Plot of Minimally Processed Gradiometer data

Figure 5

50nT
-50nT

N
0 10m
Scale: 1:500 @ A3

Drawing Number: 05/40980/GEO/5/01

Created by: RL	Date: 02/12/2025
Checked by: SO	Date: 02/12/2025
Approved by: CS	Date: 02/12/2025

AOC Archaeology Group

Appendix 1. Survey Metadata

Appendix 1 Table 1 – Survey Metadata

Area	Description
Surveying Company	AOC Archaeology Group
Data collection staff	Susan Ovenden
Client	Haddington Historical Society
Site name	St Mary's Pleasance, Haddington
County	East Lothian
NGR	NT 51812 73708
Land use/ Area condition	Public Garden
Duration	9th October 2025
Weather	Sunny and Overcast
Survey type	Gradiometer Survey / Resistance
Instrumentation	Grad 601-2 / RM85
Area covered	0.35 ha
Download software	Geoplot
Processing software	Geoplot
Visualisation software	ArcGIS Pro
Geology	Bedrock: Sedimentary Aberlady Formation Superficial: Alluvial clay, silt, sand and gravel deposits
Soils	Not recorded (Scotland's soils, 2025)
Scheduled Ancient Monument	n/a
Known archaeology on site	No
Historical documentation/ mapping on site	Yes (NLS 2024)
Report title	St Mary's Pleasance, Haddington, East Lothian. Archaeological geophysical report
Project number	40980
Report Authors	Robert Legg
Quality Checked by	Susan Ovenden

Appendix 2. Archaeological Prospection Techniques, Instrumentation and Software Utilised

Gradiometer Survey

Gradiometer surveys measure small changes in the earth's magnetic Area. Archaeological materials and activity can be detected by identifying changes to the magnetic values caused by the presence of weakly magnetised iron oxides in the soil (Aspinall et al., 2008, 23; Sharma, 1997, 105). Human habitation often causes alterations to the magnetic properties of the soils and sediments present in the area (Aspinall et al, 2008, 21). There are two physical transformations that produce a significant contrast between the magnetic properties of archaeological features and the surrounding soil: the enhancement of magnetic susceptibility and thermoremnant magnetization (Aspinall et al., 2008, 21; Heron and Gaffney 1987, 72).

Ditches and pits can be easily detected through gradiometer survey as the topsoil within and around settlements generally has a greater magnetisation than the subsoil; caused by human activity. This enhanced material accumulates in cut features such as ditches and pits. Areas of burning or materials which have been subjected to heat commonly also have high magnetic signatures, such as hearths, kilns, fired clay and mudbricks (Clark 1996, 65; Lowe and Fogel 2010, 24).

It should be noted that negative anomalies can also be useful for characterising archaeological features. If the buried remains are composed of a material with a lower magnetisation compared to the surrounding soil, the feature in question displaying a negative signature. For example, stone- built structures that are composed of sedimentary rocks are frequently non-magnetic and so will appear as negative features within the dataset if the local soils and sediments are at all magnetised.

Ferrous objects – i.e. iron and its alloys - are strongly magnetic and are typically detected as high-value peaks in gradiometer survey data; small (in spatial terms) spikes are generally assumed to derive from ferrous material of recent origin (e.g. stray bits of farm equipment) in the topsoil, though archaeological sources cannot be ruled out. Broader dipolar anomalies and those with diagnostic characteristics of form will be assigned to other classifications based on their character, which might include archaeology, burning, modern ferrous or uncertain.

Although gradiometer surveys have been successfully carried out in all areas of the United Kingdom, the effectiveness of the technique is lessened in areas with complex geology, particularly where igneous and metamorphic bedrock is present or there are layers of alluvium or till between the surface and the layers of interest. All magnetic geophysical surveys must therefore take the effects of background geological and geomorphological conditions into account.

Gradiometer Survey Instrumentation and Software

AOC Archaeology's gradiometer surveys are carried out using Bartington Grad601-2 magnetic gradiometers. The Grad601-2 is a high-stability fluxgate magnetic gradient sensor, which uses a 1m sensor separation. The detection resolution is from 0.03 nT/m to 0.1nT/m, depending on the sensor parameters selected, making the Grad601-2 an ideal instrument for prospective survey of large areas as well as detailed surveys of known archaeology. The instrument stores the data collected on an on-board data-logger, which is then downloaded as a series of survey grids for processing.

Following the survey, gradiometer data is downloaded from the instrument using Grad601 PC Software v313. Survey grids are then assembled into composites and enhanced using a range of processing techniques using Geoscan Geoplot v3.0 / v4.0 (see Appendix 3 for a summary of the processes used in Geoplot to create final data plots).

Earth Resistance Survey

Earth resistance surveys measure the flow of an electrical current that has been inserted into the ground through electrode pairs. The apparent resistivity is recorded over a grid of measurements, allowing high and low resistance readings to be used identify archaeological features buried within the ground. High resistance anomalies include walls and structures, rubble, made surfaces, roads, coffins and cists and low resistance anomalies include ditches and pits, gullies, drains, graves and metal pipes (Gaffney, 2003, 26). The surveys identify features such as ditches and pits because they retain more / less moisture than the surrounding soil (David 2008, 24). Changes in resistance will also occur where there are variations in topography, vegetation and agricultural practice as well as modern man-made features (Gaffney 2003, 112), so care must be taken during data processing and interpretation to account for these factors,

Earth resistance survey is also affected by the season, however, and in saturated conditions it can be difficult to distinguish resistance anomalies from the background geology. In waterlogged conditions, water can also pool against impermeable surfaces such as walls or floors and give a false impression of a low resistance anomaly (Gaffney 2003, 27). It is prudent to take into consideration the ground conditions and soil moisture content when interpreting earth resistance datasets.

Earth resistance less subject to interference from adjacent buildings than gradiometer, and so can be a valuable alternative in more built-up survey areas. The two methods complement each other, especially where targeted earth resistance is undertaken over possible archaeological remains, as they rely on different physical properties and can therefore cover categories of archaeological remains that the other method is less likely to detect.

Earth Resistance Survey Instrumentation and Software

AOC Archaeology's Earth Resistance Surveys are conducted using a Geoscan Research RM15 resistance meter, with a set number of probes and remote probes depending on the chosen survey methodology. Typically, either two or four probes are used, in conjunction with an

MPX15 multiplexor attachment if required, to allow more than one measurement to be collected at each measurement point. This might be to allow a greater density of measurements, or to allow measurements using different mobile probe separations, which in theory allows a greater depth of investigation.

Data is typically collected on an east-west alignment using zig-zag traverses, with a set sample interval depending on the degree of resolution required. The gain is set appropriate to ground conditions and the local geology, and the same background readings are maintained when moving the location of the remote probes to ensure consistency between the grids of collected data.

Following completion of the survey, the earth resistance data is downloaded directly from the instrument using Geoscan Geoplot v4.0. The survey grids are then assembled into composites and enhanced using a range of processing techniques using Geoscan Geoplot v4.0 (see Appendix 3 for a summary of the processes used in Geoplot to create final data plots).

Appendix 3. Summary of Data Processing

Fluxgate Gradiometer Survey	
Process	**Effect**
Clip	Limits data values to within a specified range
Interpolate	Increases the resolution of a survey by interpolating new values between surveyed data points, creating a smoother overall effect.
Low Pass filter	Uses a Gaussian filter to remove high-frequency, small spatial scale variance, typically for smoothing the data.
Periodic Filter	Used to either remove or reduce the appearance of constant and reoccurring features that distort other anomalies, such as recent plough lines.
Remove Turns (TerraSurveyor)	Uses analysis of the direction of travel derived from the GNSS data to break continuous streams of data into individual traverses.
Zero Mean Traverse	Resets the mean value of each traverse to zero, in order to address the effect of striping in the data and counteract edge effects.

Earth Resistance survey	
Process	**Extent**
Despike	X=1 Y=1 Thr = 3 Repl = Mean
Interpolate	X, Expand – sin x/x Y, Expand – sin x/x
Palette Scale	Grey08 Min= 50 ohma Max= 98 ohma

Appendix 4. Technical Terminology

Type of Anomaly	Description of Type/Class and rationale for interpretation
Anomaly	Usually linear / curvilinear / rectilinear / discrete anomalies characterised by a sharp-edged increase or decrease in values compared to the magnetic background. Some interpretation classes may have more gradual transitions in magnetic character- this is used as part of the classification process.
Spread	Spreads of enhanced material refer to diffuse areas of altered magnetic character, which suggest a localised spread of material with a magnetic contrast within the topsoil or ploughzone or a generalised enhancement of the magnetic properties over a specific area. These anomalies do not have the high dipolar response characteristic of ferrous material anomaly unless specifically classified as a spread of ferrous debris.
Linear Trend	Linear trends are less distinct and are typically visible as linear patterning in the overall texture of the data. A common example of these is the striping effect caused by recent ploughing.

Class of Anomaly	Description
Probable Archaeology	Interpretation is supported by the presence of known archaeological remains or by other forms of evidence such as HER records, LiDAR data or cropmarks identified through aerial photography. OR the data contains diagnostic anomalies in terms of character or morphology which allow a secure interpretation. Anomalies typically have well defined edges with abrupt transitions indicative of cut features with magnetically enhanced fills, such as ditches. Discrete anomalies will be checked on XY traces for their magnetic character; discrete anomalies in this class likely to be cut features such as pits; anomalies indicating high temperature processes will alternatively be classified as 'burned area' - see below. Ferrous material creates distinct 'spikes' and is classified as such.
Possible Archaeology	Anomalies are interpreted as likely to have an archaeological origin, though other explanations are also possible, but less likely. Anomalies typically have well defined edges with abrupt transitions indicative of cut features with magnetically enhanced fills, such as ditches. Discrete anomalies checked on XY traces; discrete anomalies in this class likely to be cut features such as pits; anomalies indicating high temperature processes classified as 'burned area' - see below.
Burned Area	An anomaly with a form on the XY trace plot that is characteristic of high temperature activity such as a kiln or hearth. Should be considered as possible archaeology and should be assigned an anomaly number if a more specific interpretation is possible based on the anomaly characteristics (for example, a clear kiln) so that this can be discussed in text.
Historical Features	Features observed on historical mapping that correspond with anomalies in the data. Linear anomalies caused by removed Area boundaries often exhibit distinct characteristics related to the removal process. Areas of enhanced magnetism in this class could relate to former buildings, trackways, quarries or ponds and their nature should be clarified with the use of anomaly numbers and discussion in the results section.
Unclear Origin	These anomalies are (often) magnetically weak and discontinuous or isolated making their context difficult to ascertain. OR they are indistinct for other reasons such as magnetic disturbance in their vicinity. Anomalies in this category have no more likely explanation than another, so whilst an archaeological origin is possible, an agricultural, geological, or modern origin is also equally likely.
Agricultural	Anomalies associated with agricultural activity, either historical (unless shown on a map, then classed as a historical feature) or modern. Usually, this interpretation is arrived at due to on the ground observations of (for example) ploughing, access tracks and the like, or from observation of recent aerial images of the Parcel. Recent ploughing is shown as a dashed line and Ridge and Furrow ploughing is shown as a solid line.
Ridge and Furrow / Rig and Furrow	A series of regular linear or slightly curvilinear anomalies which are broad and usually have diffuse edges, either composed of an increased or decreased magnetic response compared to background values. Wide regular spacing between the anomalies is consistent with that of a ridge and furrow / rig and furrow ploughing regime, and the regime may also have a degree of sinuosity characteristic of certain types of ridge and furrow cultivation. Often, multiple directions will be present, with distinct headlands in between. The pattern might follow the general landscape organisation, or it may radically differ from it, depending on the local sequence of inclosure. The anomalies often present as a positive 'ridge' anomaly adjacent to a negative 'furrow' anomaly.
Ploughing Trends	A series of regular linear anomalies or changes in the texture of the survey data, either composed of an increased or decreased magnetic response compared to background values. Anomalies seen parallel to Area edges are representative of headlands caused by ploughing.
Drains	A series of magnetic linear anomalies (often with a characteristic alternating positive-negative pattern, which indicates a ceramic drain) of an indeterminate date, usually with a regular dendritic or herringbone patterning which reflects the topography of the Parcel.
Geology / Natural	An area of enhanced magnetism that is composed of irregular (usually) weak increases or decreases in magnetic values, frequently with gradual transitions in character, compared with background readings. These are likely to indicate natural variations in soil composition or reflect variations in the bedrock or superficial geology. In areas

	where former water courses were present, paleochannels may present as distinct curving and banded or braided linear anomalies.
Service	Strong linear anomalies often composed of contrasting high positive and negative dipolar values, with a halo of magnetic disturbance extending from the causative body. Such anomalies are characteristic of below-ground services.
Magnetic Disturbance	A zone of strong magnetic response (usually alternating between positive and negative with abrupt transitions) that has been caused by modern infrastructure or ferrous material within or adjacent to the Parcel, such as metallic boundary fencing, gateways. The magnetic haloes around services and changes in the background texture of the data resulting from overhead power lines also fall into this class. These haloes are strong enough to obscure other anomalies (including those of possible archaeological interest) in the area they affect.
Ferrous Anomalies / Ferrous (iron spikes) and ferrous or debris spreads	A response caused by ferrous materials on the ground surface or within the subsoil, which causes a strong but localised dipolar response in the data. These generally represent modern material often re-deposited during manuring, rubbish at Area edges and spreads of debris or building material used to surface tracks or left behind following demolition. Distinct from magnetic disturbance, these anomalies relate to material at their spatial location, rather than an effect occurring at a distance from the material responsible.
Free Category for custom use	A category which may be employed to denote specifically identified anomalies related to known past activity within the area, for example those definitely associated with a former Area, or mapped former mineral extraction.

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