HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

CASTLE GREG FORTLET

GEOPHYSICAL SURVEY REPORT

HES PROJECT NUMBER: CAGR2021
NGR: NT 05022 59256
DATE: December 2022
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EXECUTIVE SUMMARY

Historic Environment Scotland (HES), Archaeological Survey, undertook geophysical (gradiometer and electro-magnetic) survey at Castle Greg Roman fortlet, Camilty Plantation, West Lothian, Scotland. This project aimed to support investigation into effective methods of integrating multiple datasets for recording earthwork and sub-surface archaeological remains, using geophysical, spectral, and topographic datasets.

The following report contains the results of the geophysical survey element of these investigations.

The fieldwork was conducted on 21st and 22nd July 2022. In total 0.28ha were surveyed with a Sensys MXPDA gradiometer and 0.29ha were surveyed using a CMD Mini Explorer electro-magnetic device. The geophysical surveys produced good quality results which give a high level of confidence that the methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.

The survey produced the following results:

- Identification of possible buildings in the interior of the fortlet.
- Identification of a possible oven.
- The identification of the fortlet's ramparts.

In summary the survey has identified possible buildings within Castle Greg fortlet and the fortlet rampart base, along with a possible oven.

This survey has led to additional information for 1 entry in the National Record of the Historic Environment.

This document has been prepared in accordance with HES' Terrestrial Geophysical Survey Standard Operating Procedures v1.0			
Version:	CAGR2021-Report-v1.2		
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1.0 - INTRODUCTION

Historic Environment Scotland (HES), Survey and Recording, undertook geophysical (gradiometer and electro-magnetic) surveys at Castle Greg Roman fortlet, Camilty Plantation, West Lothian, Scotland. This project aimed to support investigation into effective methods of integrating multiple datasets for recording earthwork and sub-surface archaeological remains, using geophysical, spectral, and topographic datasets. Fieldwork was undertaken on 21st and 22nd July 2022.

The following report contains the results of the geophysical survey element of these investigations.

2.0 – PROJECT BACKGROUND & AIMS

The survey forms part of an ongoing programme of research into remote sensing methods for archaeological survey by the Archaeological Survey Team in the Heritage Directorate of Historic Environment Scotland. The geophysical survey project forms part of a five-year Historic Scotland Foundation funded project aimed at developing a geophysical survey capability at HES.

This methodological research aim is specific to the project and outside the ScARF recommendations (ScARF 2021: section 5.3) which do not address technical and methodological improvements of geophysical survey techniques. The proliferation of remote sensed survey is a challenge to effective integration of different datasets to support deeper understandings of archaeological remains. There is also a particular need for datasets that are directly comparable due to the circumstances in which they are gathered. Survey at Castle Greg Roman fortlet planned to address methodological research questions specifically relating to the integration of the results from multiple survey techniques. This is part of a long-term research collaboration between the University of Edinburgh and HES (Cowley *et al.* 2018; James *et al* 2020; Moriarty *et al* 2018).

Castle Greg provided an excellent opportunity to progress this research. It survives as an upstanding earthwork that may respond to different methodological approaches, and there is a wide range of existing material (including oblique imagery, geophysical and topographic data) relating to the site. The survey aimed to document the site using a range of sensors over the course of two days. The survey has the potential to enhance our knowledge of both the surviving earthworks and the apparently level interior, and it may help clarify the impact of documented 19th century excavations.

Geophysical survey of Castle Greg was intended to establish the relative effectiveness of gradiometry and electro-magnetic methodologies in identifying sub-surface archaeological features at the site. Beyond these general aims, the survey intended to address the following questions:

- How do the results obtained through the gradiometry and electro-magnetic techniques compare at Castle Greg?
- To what extent does the use of multiple methods enhance understanding of the site's archaeology?
- Can internal structures be identified?
- Can previously unknown features be identified?

The survey results could lead to the creation of new entries, or the amendment of existing entries in the National Record of the Historic Environment, and/or could inform future review of the designated area under the 1979 Ancient Monuments and Archaeological Areas Act.

3.0 – SITE LOCATION & DESCRIPTION

Castle Greg Roman fort is located in an area of rough grassland at Camilty Plantation, West Lothian, Scotland. The survey area (centred on NT 05022 59256) covers a total area of 1ha and lies 8.5km south of the centre of Livingston (Figure 1).

The survey area is located near the summit of Camilty Hill (290m OD), one of a series of relatively low hills that lie along the northwest flank and at a much lower level than the Pentland Hills. The site is now surrounded by coniferous plantation obscuring much of the landscape character, but it once had extensive views to the northeast, southwest and northwest. The survey area is closely bound by a plantation to the south and east but is open to the north and west.

The solid geology is recorded as Calders Member, Strathcylde Group, Sedimentary Rock Cycles. This is overlain with superficial deposits (Figure 3) of Devensian Till – Diamicton, which is surround by areas of Peat (BGS 2021). The site's soil is recorded as Peaty Gley (Scotland's Soils 2021).

The survey area comprises of a single land parcel (Figure 2), referred to hereafter as CG01, which contains the remains of Castle Greg Roman Fortlet. The land is owned by Forestry and Land Scotland and contains a scheduled monument. Forestry and Land Scotland granted permission to access the land. The survey area is not within a World Heritage Site. However CG01 is entirely contained within scheduled monument SM1933.

As the survey area contains part of a Scheduled Monument, as per The Scheduled Monument Consent Procedure (Scotland) Regulations 2015, a Metal and Mineral Detecting Consent was obtained from Historic Environment Scotland's Planning, Consents and Advice Team prior to survey being conducted.

The survey area does not include any land designated as either a Site of Special Scientific Interest or a Special Area of Conservation. It is not protected under the Ramsar Convention, does not lie within a National or Regional Park and it is not a nature reserve (NatureScot 2021). Reference to the National Biodiversity Network's Atlas (NBN 2021) for the survey area, and a 200m buffer surrounding it, showed no sightings of flora or fauna which required the granting of a licence for the survey to be conducted, therefore NatureScot were not consulted.

During the survey the weather conditions were extremely hot, dry and sunny with temperature exceeding 30° Celsius throughout the survey. The ground conditions were very dry underfoot.

A photographic record showing the survey area and ground conditions can be found in Section 12.0 – IMAGES.

4.0 – ARCHAEOLOGICAL BACKGROUND

Castle Greg is a Roman fortlet (Scheduled Monument: SM1933; NRHE ID: 48988). It is rectangular in plan, with rounded corners (Figures 4 & 5) measuring about 55m by 46m between the rampart crests. The rampart is well defined and is best preserved on the south where it measures around 8.5m (28ft) wide by 1.2m high, although it is denuded on the northwest. The rampart is surrounded by double ditches measuring around 2.4m wide by 0.8m deep. The only break in the defences is on the east where there is a 2.7m wide gap in the rampart. This is associated with a 6.7m wide causeway crossing the ditches. Towards the centre of the fortlet is a circular hollow measuring 3.6m in diameter, representing the location of a well.

A series of excavations during the 19th century (Macdonald 1818; Wilson 1855; M'Call 1984) clearly established that the site was Roman in date. However the exact location and physical impact of these excavations is not known. Geophysical surveys undertaken in 2012 and 2013 by Edinburgh Archaeological Field Society (Hawkins 2014: 188) identified internal features including features interpreted as possible ovens as well as a possible annexe. This annexe has since been discounted. It has long been suspected that a Roman road may have led to

the site from the northeast. A road or track visible on oblique aerial photographs (e.g. RCAHMSAP 1980, SC 1731257), extending from the entrance of the fortlet to the northeast may represent the survival of this road.

Some 230m to the northwest of the fort, and within the same clearing, there is a circular enclosure that measures about 12m in internal diameter. This stands within a much larger oval enclosure (RCAHMS 1929, No. 141; Scheduled Monument: SM1165; NRHE ID: 49002). Both features are clearly visible on oblique aerial photographs (RCAHMSAP 1980, SC 1731256 & SC 1731257), though the area of conifers has since been expanded to obscure the north part. Although interpreted in 1965 by R. Feachem as a possible hexagonal Roman Shrine, the smaller enclosure was interpreted by OS Investigators as a sheepfold (OS (MJF) 1979).

An area totalling 10.11ha (25 acres) of the land surround the fortlet was ploughed ahead of plantation in 1989. Following the ploughing, fieldwalking was conducted and a small collection of flint was retrieved (NRHE ID: 72639).

5.0 – SURVEY METHODOLOGY

The survey was conducted on 21st and 22nd July 2022. The survey was originally attempted on 15th March 2022, however difficulties experienced with the GNSS equipment produced extremely poor quality data so the survey was repeated.

All survey was carried out in accordance with the Chartered Institute for Archaeologists, *Standard and Guidance for archaeological geophysical survey* (CIfA 2020), the *EAC Guideline for the Use of Geophysics in Archaeology* (Schmidt *et al.* 2016), and the Historic Environment Scotland, *Geophysical Survey, Standard Operating Procedures* (HES 2020).

Survey methods were selected to best deliver the aims detailed in Section 2, in accordance with the recommendations outlined in the EAC guidelines, and in accordance with the manufacturer's guidelines (GF Instruments 2019; Sensys 2019). All sensors had valid in-date calibration certificates which are included in Appendix 2.

5.1 – GRADIOMETER SURVEY

The gradiometer survey was conducted using a Sensys MXPDA system mounted on a Sensys F-type non-magnetic frame. Due to the uneven ground conditions the frame was suspended from the system's battery harness and carried by the operator. This system utilised five Sensys FGM650/3 sensors operating at 100hz, mounted at a 0.25m sensor separation with bases carried 0.25m from the surface. The system was balanced prior to the commencement of the survey and the calibration position is shown in Figure 6.

The survey was conducted by walking parallel traverses in a zig-zag pattern, with traverses aligned northwest-southeast and positioned 1.25m apart. Navigation was provided by MONMX, the system's on-board software which displays position and the areas of previously collected data, ensuring that each traverse was evenly spaced. The position of the traverses is shown as a "breadcrumb" trail in Figure 6. Data points were recorded every 0.125m along each traverse, with positional accuracy provided by a Leica GS16 GNSS antenna mounted directly on the frame of the cart at a height of 1.5m. This provided a constant stream of data in NMEA format allowing each reading to be accurately georeferenced without the need for a pre-determined grid system.

Data was logged using the system's MONMX v.5.01-03/00 software package on a Panasonic FZ-G1 tablet computer in .prm format. Following the completion of the survey the data was then exported from the system in both .asc and .uxo formats. The .uxo file was processed and visualised using DW Consulting's Terrasurveyor

v3.0.36.10 and the .asc file retained for archiving purposes. Interpretations of this data were then generated using ESRI ArcGIS Pro v2.8.6.

Data quality was maintained by avoiding ferrous objects within the survey such as fences, gates and inspection covers where possible.

Gradiometer survey can be affected by the site's underlying geology. High levels of background magnetism are often experienced in locations with igneous or metamorphic geologies. This can mask the subtle changes in the magnetic field associated with archaeological remains, making them difficult to detect. The sedimentary bedrock formations recorded at the site were expected to exhibit low levels of background magnetism and therefore provide a good response to this methodology (EH 2008: 15).

A total of 0.28 hectares of data were collected employing this methodology.

5.2 – ELECTRO-MAGNETIC SURVEY

The electro-magnetic survey was conducted using a hand-held GF Instruments CMD Mini Explorer. This system employed a single transmitter coil and three receiver coils spaced at 0.32m, 0.71m and 1.18m from the transmitter. The system was set in High (Horizontal Coplanar) configuration, so provided an estimated effective depth penetration of 0.25m, 0.5m, and 0.9m respectively. The system was carried at approximately 0.1m from the surface to the right-hand side of the operator.

The survey was conducted by walking a series of parallel traverses, with traverses aligned northwest-southeast and positioned 0.5m apart. Navigation was provided by the system's on-board software which displays position and the areas of previously collected data, ensuring that each traverse was evenly spaced. The position of the traverses is shown as a "breadcrumb" trail in Figure 6. Data points were recorded every 0.2 seconds along each traverse, with positional accuracy provided by a Leica GS16 mounted on a survey backpack at an antenna height of 1.8m. This provided a constant stream of data in NMEA format allowing each reading to be accurately georeferenced without the need for a pre-determined grid system.

Both quadrature (conductivity) and in-phase (magnetic susceptibility) readings were measured and recorded on the system's integral datalogger. This resulted in six readings being recorded at each position. This data was later transferred from the system in .bin format. The files were then processed and visualised following the process described in Appendices 4, 5 and 6. Interpretations of this data were then generated using ESRI ArcGIS Pro v2.8.6.

A total of 0.29 hectares of data were collected, employing this methodology.

6.0 – SURVEY RESULTS & INTERPRETATION

The following section presents the results obtained using the data collection methodology detailed in Section 5 and the data processing methodologies in Appendices 5, 6, and 7. The results are presented separated by anomaly type and methodology.

The figures relating to these results and interpretations can be found in Section 12.

A total of 0.28ha of the planned 1ha for survey were surveyed (Figure 6). The 0.72ha discrepancy is accounted for by a combination of poor ground conditions rendering areas inaccessible, and the extremely hot weather experienced during the survey. This limited the amount of survey which could be safely carried out. Ground conditions also made it difficult to maintain straight and even traverses which is apparent in the GNSS breadcrumbs shown in Figure 6.

The gradiometer results for CG01 have been visualised as greyscale plots with minimally processed data plotted at -50/50nT (Figure 7) and fully processed data displayed at -5/5nT (Figure 8). XY trace plots have been produced (Figure 9), along with a graphical interpretation of the data (Figure 10). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

The electro-magnetic (magnetic susceptibility) results for CG01 have been visualised as greyscale plots displayed at -2/2mS/m for three depths, along with the graphical interpretation of the data (Figure 11). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

The electro-magnetic (conductivity) results for CG01 have been visualised as greyscale plots displayed at -1/1 ppt for three depths, along with the graphical interpretation of the data (Figure 12). Numbered anomalies are listed in Appendix 3 and described in Appendix 4.

In general, only anomalies of archaeological or possible archaeological origins have been assigned an anomaly number.

6.1 – AREA CG01 GRADIOMETER SURVEY – ARCHAEOLOGICAL FEATURES

In area CG01 one anomaly of probable archaeological origin has been identified in the gradiometer data.

This feature **CACR2021-0001** is formed of a series of negative responses along the perimeter of the survey area. It measures 8m wide along the north edge of the survey area and 4m wide along the east. There is a distinct break roughly mid-way along the eastern side, around 30m from the northern edge of the survey area. This corresponds with the entrance to the fort. The responses along the west and south of the survey area form a weak linear trend. This feature follows the course of the rampart (Figure 10) and has been interpreted as representing the rampart's rubble core. This feature has been added to NRHE 48988.

6.2 – AREA CG01 GRADIOMETER SURVEY – POSSIBLE ARCHAEOLOGICAL FEATURES

In area CG01 three anomalies of possible archaeological origin have been identified in the gradiometer data.

The first possible archaeological feature is **CAGR2021-0002**. This feature is formed of a series of negative anomalies located within the area defined by CAGR2021-0001. The anomalies form a near continuous band extending around the interior of the fort and running parallel to the fort's ramparts. There is a distinct break on the eastern side, positioned around 12m from the northern extent of CAGR2021-0002 and measuring about 12m across. This break lies opposite the entrance to the fortlet and aligns with CAGR2021-0001. It is therefore likely a further entrance feature. CAGR2021-0002 has been interpreted as evidence for a possible range of buildings within the fortlet and may represent the remains of barrack blocks. Structures of a similar size and shape were found during the excavation of the fortlet at Barburgh Mill, Dumfries and Galloway (NRHE: 65789, Symonds 2018 86 fig 27) and at Martinhoe fortlet, Devon (Symonds 2018: 43 fig 9E).This feature has been added to NRHE 48988.

The third possible archaeological feature is **CAGR2021-0003**, located to the south of CAGR2021CG-0002. This feature is formed of a weak negative response, defining a curved trend measuring 9m in diameter. This feature may be related to human activity within the fortlet.

To the east of CAGR2021-0002 on the western side of the survey area is **CAGR2021-0004**. This is an area of high magnetic response reminiscent of an area of burning. It measures 8m from north to south and 6m from east to west and has been interpreted a possible site of an oven or hearth. This feature and above has been added to the NRHE 48988.

6.3 – AREA CG01 GRADIOMETER SURVEY – HISTORICAL AGRICULTURE FEATURES

No anomalies of historical agricultural origins have been identified in the gradiometer data.

6.4 – AREA CG01 GRADIOMETER SURVEY – MODERN AGRICULTURAL FEATURES

No anomalies of modern agricultural origins have been identified in the gradiometer data.

6.5 – AREA CG01 GRADIOMETER SURVEY – GEOLOGICAL & FLUVIAL FEATURES

No anomalies of geological and fluvial origins have been identified in the gradiometer data.

6.6 – AREA CG01 GRADIOMETER SURVEY – MODERN FEATURES

No anomalies of modern features have been identified in the gradiometer data.

6.7 – AREA CG01 GRADIOMETER SURVEY – FEATURES OF UNCERTAIN ORIGINS

No anomalies of unknown or uncertain origins have been identified in the gradiometer data.

7.0 CG01 ELECTRO-MAGNETIC SURVEY

The results in Figures 11 and 12 shows the Magnetic Susceptibility and Conductivity data at three separate depth penetrations and the interpretation of this data.

The interpretation of the Conductivity data is based on a composite of all three depths. However, interpretation for the Magnetic Susceptibility data is based on a composite of depth 2 and 3 only. This is due to areas displaying as high magnetic susceptibility in depth 1, appearing as low Magnetic Susceptibility in depths 2 and 3. This phenomenon is caused by a polarity shift which occurs when using an electro-magnetic device in a horizontal co-planar configuration at depths greater than 1m (Bonsall *et al* 2013: 225).

7.1 – AREA CG01 ELECTRO-MAGNETIC SURVEY – MAGNETIC SUSCEPTIBILITY – HORIZONTAL CO- PLANAR

In the magnetic susceptibility data, there is one almost continuous feature and two features consisting of disconnected responses.

The first feature in the magnetic susceptibility data is **CAGR2021-0005**. This feature is positioned in the northwest corner of the survey area and consists of several disconnected high magnetism responses. This feature may represent the location of an oven set into the rampart.

The second feature **CAGR2021-0006** is located in the north of the survey area and consists of multiple disconnected low magmatism anomalies. This feature is formed of an irregular magnetic susceptibility response measuring approximately 11m from east to west and 3.5m from north to south. This feature corresponds with the location of CAGR2021-0002 in the gradiometer data and could therefore possibly represents the floor of a building.

Feature **CAGR2021-0007** is located in the south of the survey area and is an area of low magmatic susceptibility, measuring 30m long and 5m wide and forms an irregular rectangular shape. This feature corresponds with the southern extent of CAGR2021-0002, and therefore also is interpreted as a possible building within the fortlet.

CAGR2021-0008 is located on the southern extent of the survey area and consists of multiple disconnected anomalies displaying high magnetic susceptibility. This feature consists of irregular anomalies, the largest of which measure between 5m wide and 10m long and the smallest around 1m by 1m. As they are positioned on the rampart, they are likely to represent the core of this rampart. This feature also corresponds with the location of CAGR2021-00012.

7.2 – AREA CG01 ELECTRO-MAGNETIC SURVEY – CONDUCTIVITY– HORIZONTAL CO- PLANAR

There are four features of interest within the conductivity data.

The first, an area of very low conductivity, is located at the north of the survey area, **CAGR2021-0009**. This feature extends along the northern rampart of the fort and corresponds with CAGR2021-0001. As such, it has been interpreted as representing the rampart core.

To the south of CAGR2021-0009, is feature **CAGR2021-0010**. This area of low conductivity forms an irregular rectangular shape measuring 40m from east to west and 10m from north to south. As this location corresponds with a section of CAGR2021CG-0002 and CAGR2021CG-0006, this feature possibly represents the compacted floor of a building forming part of a barrack block.

Within the south of the survey area is an area of high conductivity, **CAGR2021-0011.** This mirrors the size and location of CARG2021CG-0007 and a section of CAGR2021-0002. It is therefore likely to represent the compacted floor of a building, possibly forming part of a barrack block.

Extending along the rampart in the south of the survey area is a linear area of low conductivity, **CAGR2021CG-0012**. This feature measures 5m wide and 40m long and is likely to represent the rampart core.

Details of all electro-magnetic features have been added to NHRE 48988.

7.3 – EXTERNAL DATASET – GROUND RESISTANCE

In March 2012 Forestry and Land Scotland and the Edinburgh Archaeological Field Society carried out a ground resistance survey over the fortlet's platform and defences (Hawkins 2014; NRHE: 993452). The interpretation of the results stated, "The survey clearly recorded the lines of the rampart, double ditches and upcast and revealed some internal anomalies, including internal roadways and high resistance 'blobs' which may be ovens built into the inner part of the rampart.". Figure 14 shows a georeferenced greyscale plot of the results of the 2012 survey and Figure 15 displays a HES reinterpretation of this data.

Figure 16 shows the greyscale result from the gradiometer, magnetic susceptibility, conductivity, and earth resistance surveys and Figure 17 a comparison of their interpretations.

The newly obtained datasets correlate well with earth resistance survey. As stated in the initial interpretation the lines of the ditches (**CAGR2021-0013**) display clearly in the data, showing as low resistance due to their moisture retention. The Berm between the double ditch system (**CAGR2021-0014**) displays as high or very high resistance for most of its course and the upcast mound (**CAGR2021-0015**) present as a high resistance anomaly for most of its circuit.

The fortlet's rampart (**CAGR2021-0016**) appears as a fragmentary high resistance anomaly with a clearer response towards the north of the site.

Immediately within the rampart is a 4m wide band of low resistance (**CAGR2021-0017**). This runs almost continually along the southern and western rampart but is more fragmentary towards the north and east. A second anomaly of a similar width is located 13m north of and parallel with the southern rampart. When compared with the location of CAGR2021-0002 in the gradiometer data, it is apparent that the earth

resistance anomalies surround the gradiometer feature interpreted as a range of buildings. The resistance anomalies therefore possibly represent the location of areas of hardstanding surrounding the buildings.

A band of low resistance anomalies (**CAGR2021-0018**) extends in an easterly direction from the fortlet's east gate. This likely represents the spur linking the fortlet with the Roman road believed to be located to the east (NRHE: 72222).

Close to the centre of the fortlet is a broadly circular anomaly (**CAGR2021-0019**) displaying high resistance at its centre and low resistance at its perimeter. This may mark the location of the fortlet's well, identified during the 19th century excavations (Macdonald 1818; Wilson 1855; M'Call 1984).

The initial report interpreted a series of high resistance 'blobs' as the possible locations of ovens set into the interior of the rampart. However, when the location of these anomalies are compared with the gradiometer and magnetic susceptibility it is apparent they do not correspond with areas which appear to have been subjected to burning. Therefore, it is unlikely that they are ovens and may possibly represent tumble from the rampart.

8.0 – CONCLUSIONS

The geophysical survey has produced good quality gradiometer and electro-magnetic results which have successfully contributed to the aims detailed in Section 2. There is a high level of confidence that the chosen methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.

Despite only being able to survey 0.29ha of the proposed survey area, the results have shown some interesting anomalies. The survey has identified the possible location of a range of buildings within the fortlet along with a potential oven. The survey did not identify the location of the well identified during the 19th century excavations or find any anomalies that could be associated with it.

The resistivity data has added a further layer of understanding to Castle Greg. The results of the resistivity data correspond well with that of the gradiometer and electromagnetic data and further confirm the features identified. In addition, the resistivity survey may have located a well within the centre of the survey area. This was not detected by the other survey methods. Having access to the results from a fourth survey method further highlights how well these geophysical techniques complement each other, building up a more comprehensive picture of the area surveyed.

Although originally planned, a UAV survey was not carried out due to operation reasons. Therefore, it is not possible to add any additional datasets to the comparison.

In assessing these results against the specific aims listed in Section 2.

- *How do the results obtained through the gradiometry and electro-magnetic techniques compare at Castle Greg?* The gradiometer and electro-magnetic techniques have good correspondence between the datasets for most of the features within the fort.
- *Can internal structures be identified?* Yes, internal structures interpreted as possibly represent barracks blocks have been identified.
- *Can previously unknown features be identified?* Two potential buildings and an area of burning which may represent an oven have been identified.

In summary the survey has identified possible buildings within Castle Greg fortlet and the fortlet rampart base, along with a possible oven.

9.0 – CAVEATS

Geophysical survey relies upon the detection of anomalous values and patterns in the physical properties of the ground and uses these as a proxy for anthropogenic activity; it does not directly detect archaeological features. Therefore, the results from this method of survey will not be a direct indicator of the absence or presence of archaeological features.

The ability of geophysical survey to identify the potential for archaeological remains is impacted by several interconnecting factors, including geological and fluvial processes, weather conditions, ground conditions, and the taphonomic processes involved in the archaeological site's formation. Therefore, the survey results may not provide a complete plan of the site's archaeology.

Nonetheless Historic Environment Scotland have endeavoured to produce interpretations of the data as accurately as possible. However, it should be noted that these interpretations and the conclusions contained within this report are a subjective assessment of the data.

10.0 – ARCHIVE DEPOSITION

A digital copy of this report has been supplied to both Historic Environment Scotland and the local Historic Environment Record for archive purposes. An event record has been generated for the National Record of the Historic Environment (NRHE) summarising the methodology and results of the project. The site record for NRHE ID 48988 has been amended.

In accordance with standard industry practice an Online Access to the Index of Archaeological Investigations (OASIS) record has been generated and submitted to the Historic Environment Record (HER) and the Archaeological Data Service (ADS).

As the survey was conducted in Scotland an entry has been generated for inclusion in "Discovery and Excavation in Scotland". This text can be found in Appendix 8.

The digital elements of the project have been supplied to the NRHE for archive in the following formats.

- Unprocessed survey data supplied as .txt files.
- Processed survey data supplied as .tif files.
- A .zip containing the following .shp files.
    - Polygons showing the survey area extents and containing the survey's metadata.
    - Interpretation polygons.
    - Interpretation polylines.
    - Interpretation points.

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12.0 – IMAGES

Image 1 – Looking southeast across the fortlet (DP394472)

Image 2 – Looking east across the interior of the fortlet (DP394474)

Image 3 – Looking east over the northern Rampart (DP394473)

Image 4 – Looking south across the fortlets western ditches (DP394475)

13.0 – FIGURES

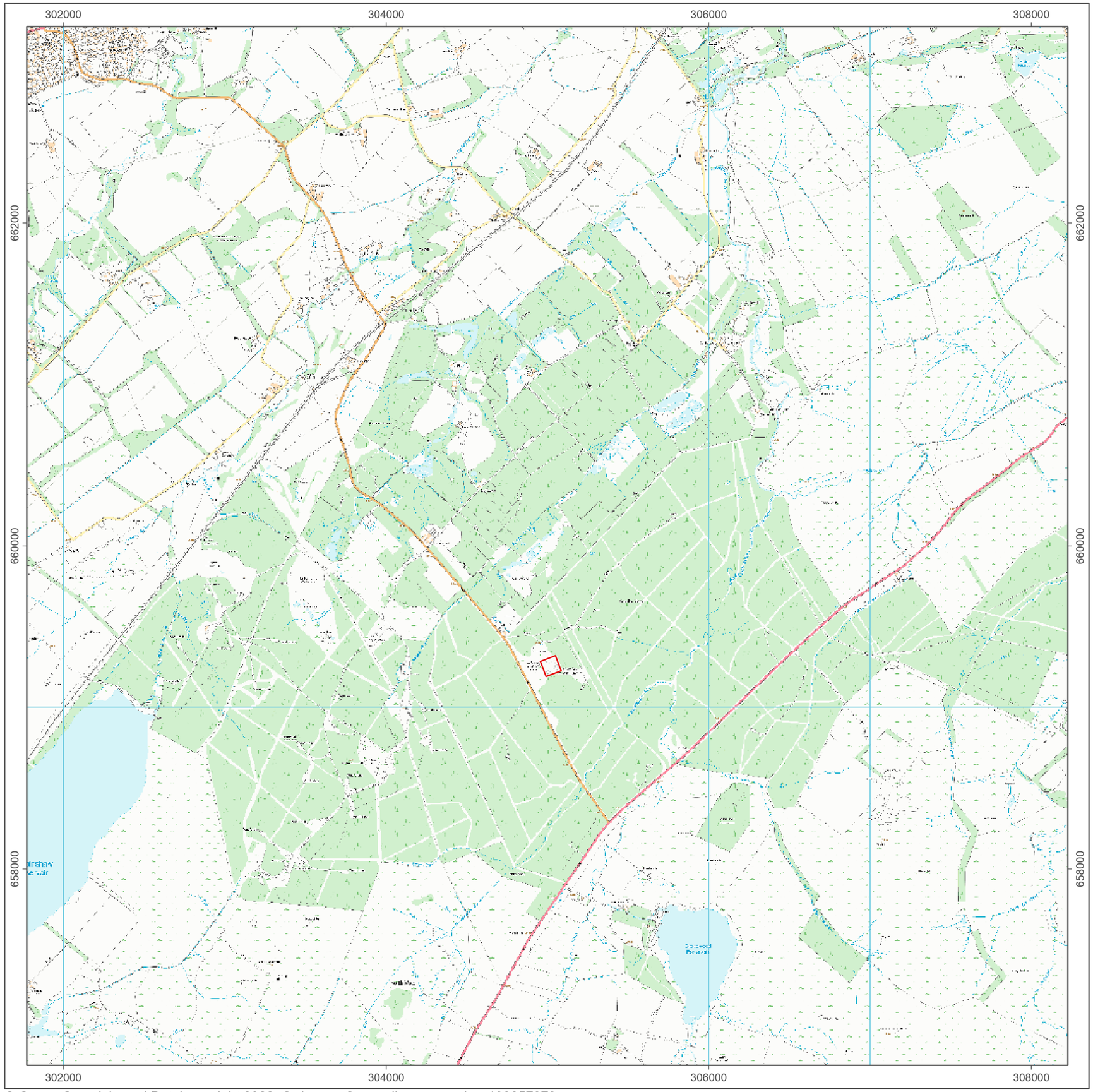
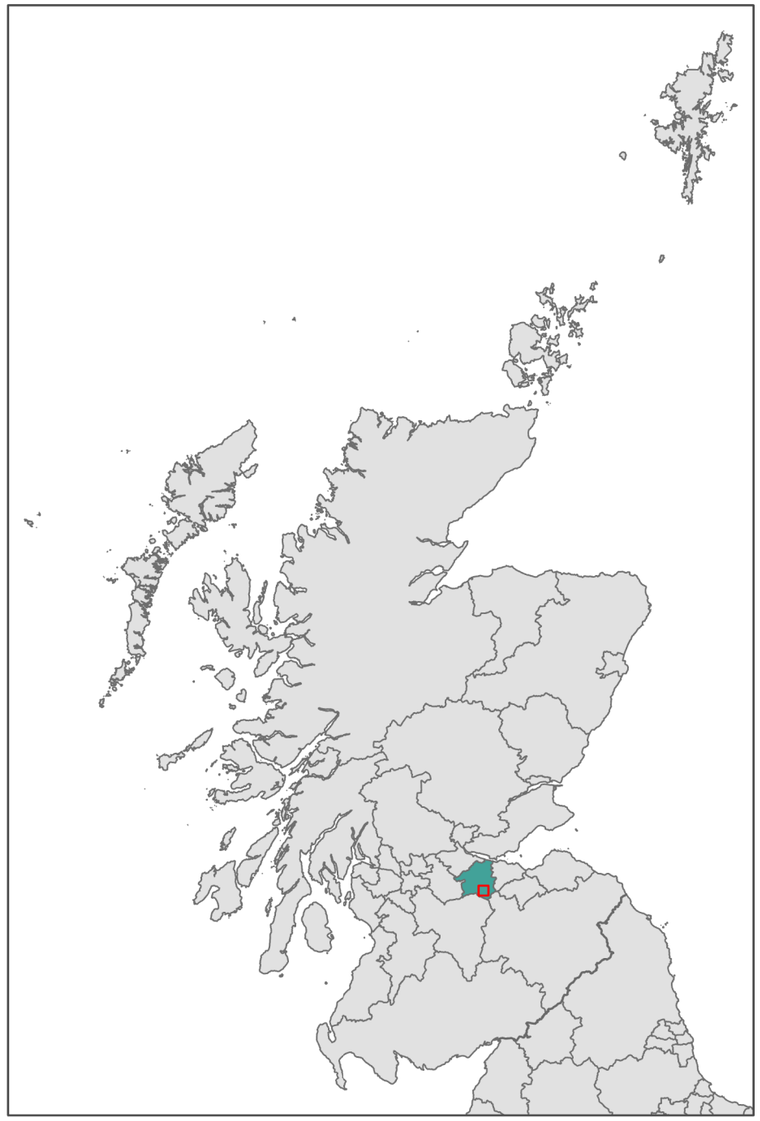


Figure 01	Survey Location	
Project Name	Castle Greg	HISTORIC ENVIRONMENT SCOTLAND / ÀRAINNEACHD EACHDRAIDHEIL ALBA
Project Code	CAGR2021	
Prepared By	Hazel Blake	
Prepared On	18/10/2022	

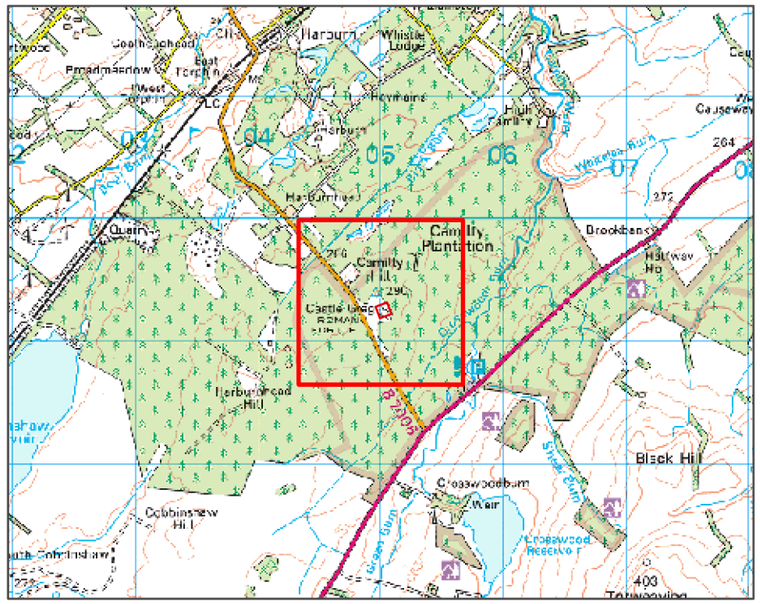


West Lothian

North	Scale: 1:24,000 @ A3	Datum: OSGB 1936
	Meters 0 490 980 1,470 1,960	

Figure 02	Survey Area
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/10/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



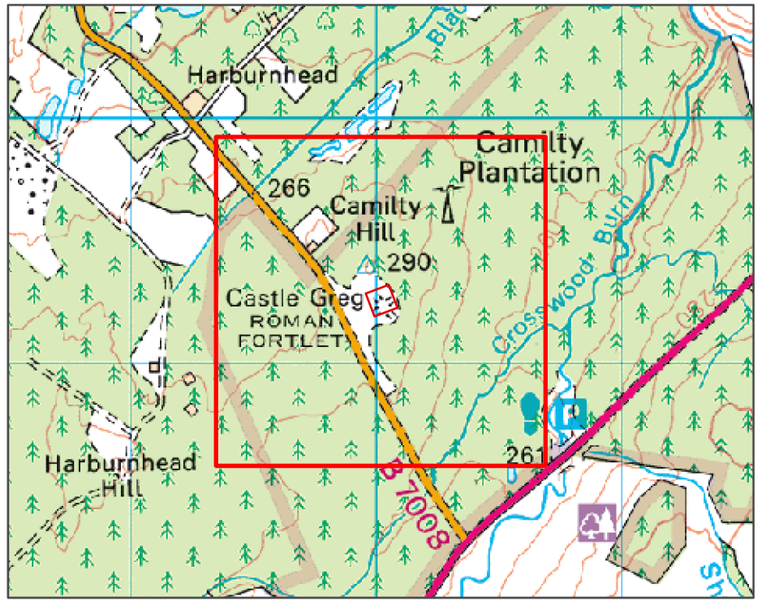
Survey Area

North	Scale: 1:5,000 @ A3	Datum: OSGB 1936

Metres
0 100 200 300 400

Figure 03	Geology Drift (BGS 2021)
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/10/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



Survey Area

GEOLOGY - DRIFT

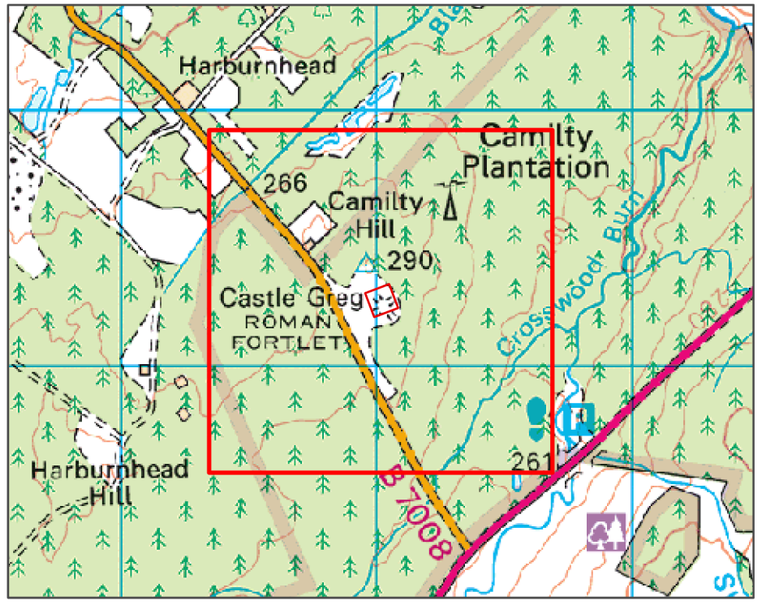
- Peat
- Hummocky Glacial Deposits - Diamicton, Sand & Gravel
- Till, Devensian - Diamicton

North	Scale: 1:5,000 @ A3	Datum: OSGB 1936

Metres: 0 100 200 300 400

Figure 04	Historic Environment
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/10/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



Survey Area

HISTORIC ENVIRONMENT

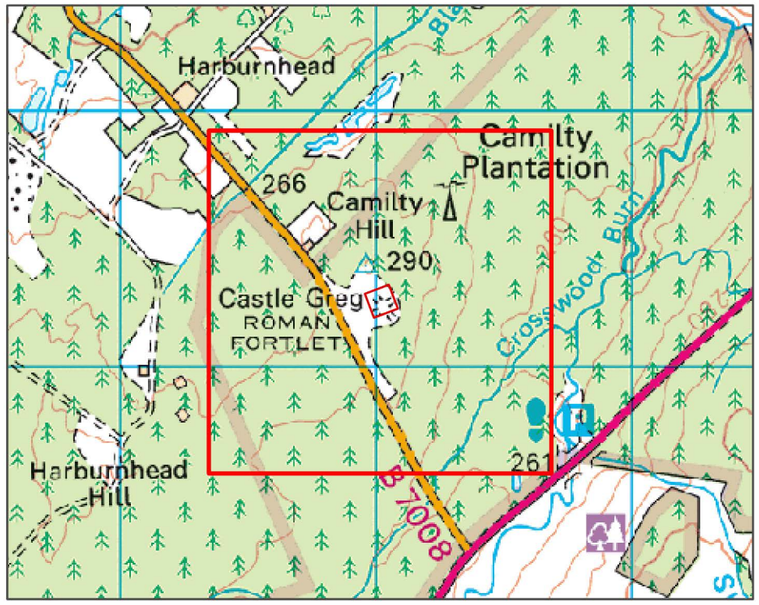
- NRHE Entry
- Scheduled Monument

North	Scale: 1:5,000 @ A3	Datum: OSGB 1936

Metres: 0 100 200 300 400

Figure 05	Environment Agency LiDAR Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/10/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



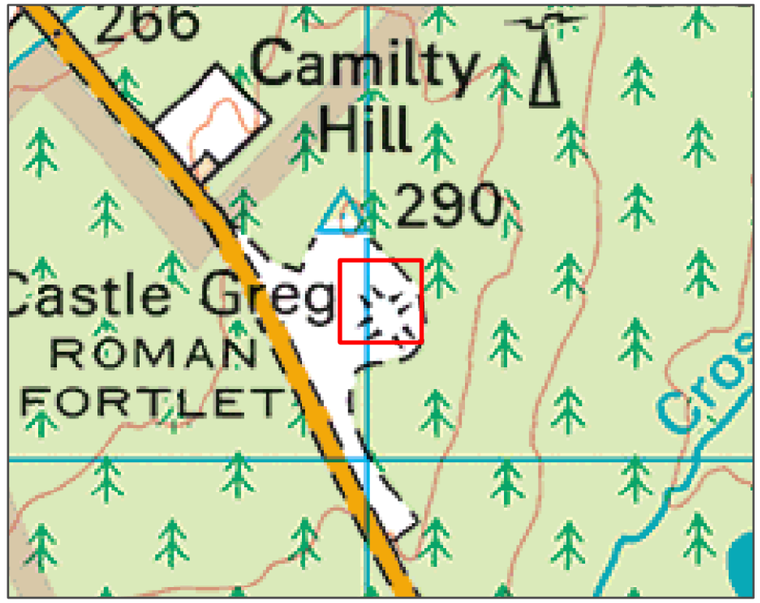
Resolution (metres)	0.50
Visualisation	Multi Direction Hillshade
Directions	16
Altitude (degrees)	35
Azimuth (degrees)	315
Stretch	Standard Deviation
Standard Deviations	1
Gamma	1
Z-Factor	1

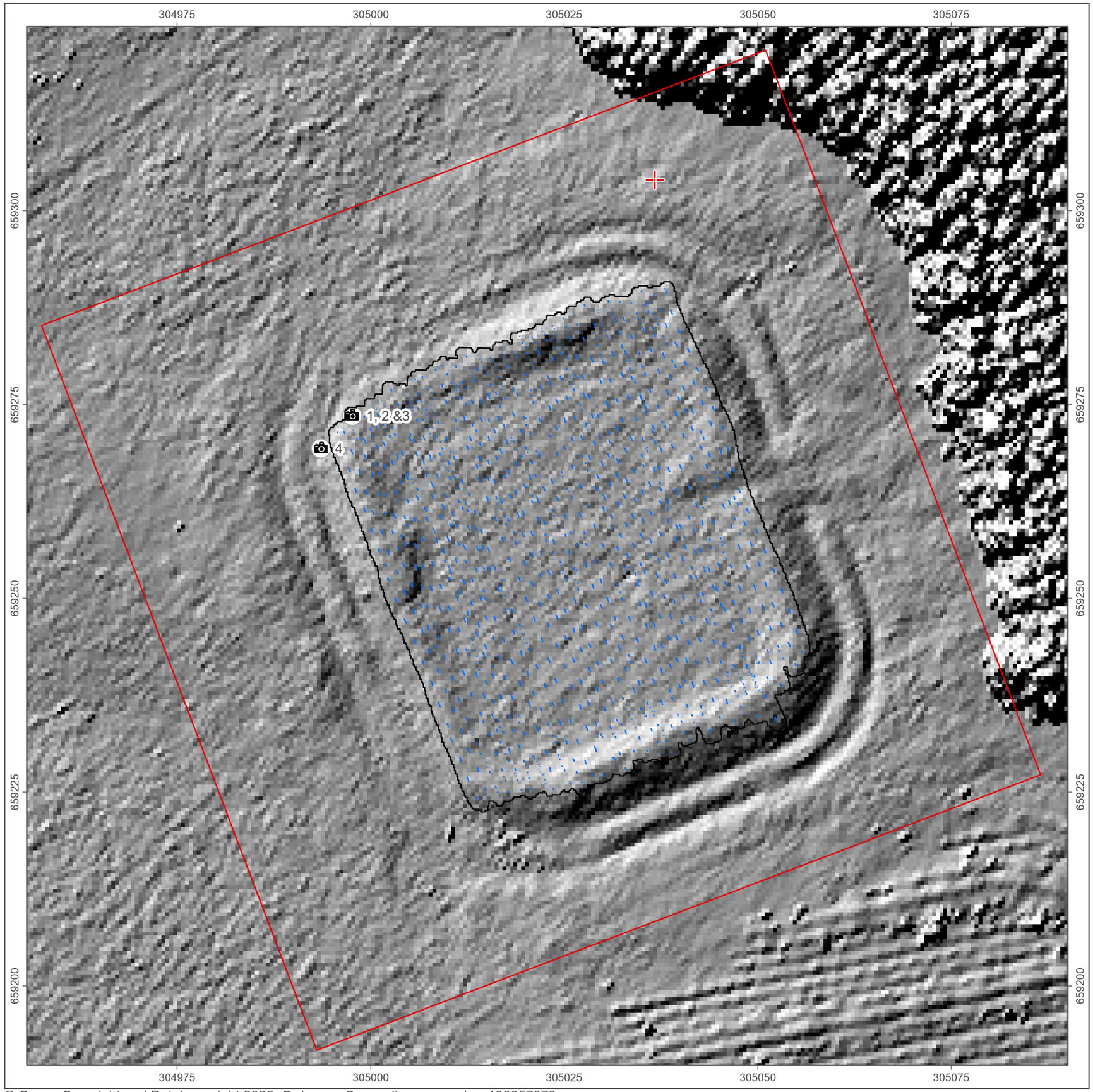
North	Scale: 1:5,000 @ A3	Datum: OSGB 1936

Metres
0 100 200 300 400

Figure 06	Gradiometer Survey GNSS Swaths & Calibration Position
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	20/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





Survey Area

- Survey Area
- Survey Area Outline

Survey Metadata

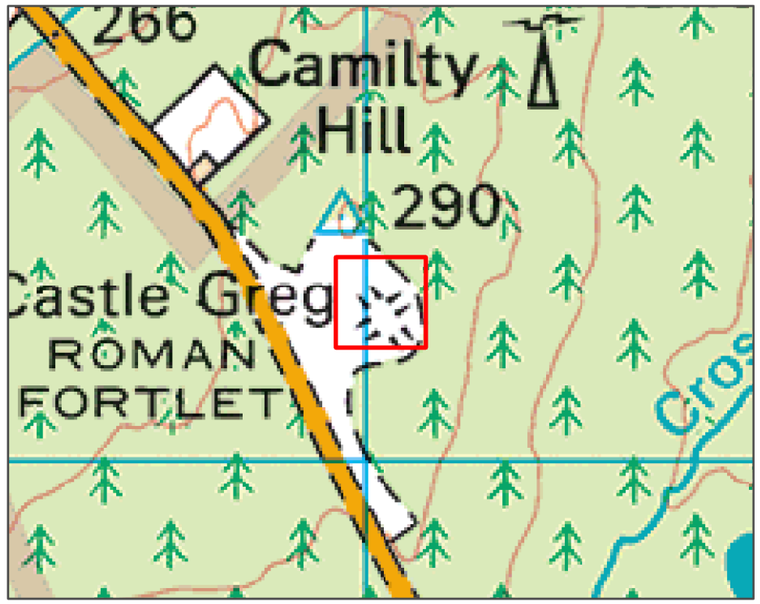
- Calibration Position
- GNSS Breadcrumbs
- Photograph Position

North	Scale: 1:500 @ A3	Datum: OSGB 1936

Metres: 0 10 20 30 40

Figure 07	Minimally Processed Gradiometer Data - Greyscale Plot
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	14/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

50nT

-50nT

Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1
Gamma	1

North

Scale: 1:550 @ A3

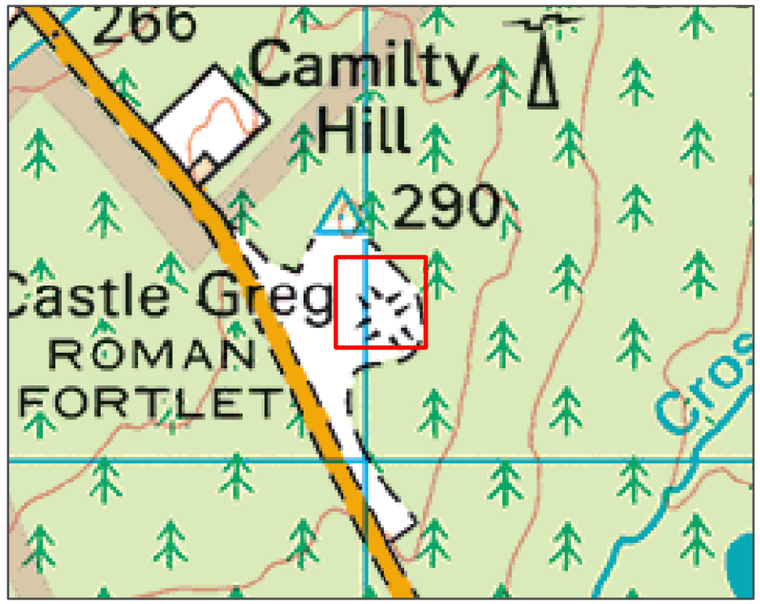
Datum: OSGB 1936

Metres 0 10 20 30 40

Figure 08	Processed Gradiometer Data - Greyscale Plot
Project Name	Castle Greg
Project Code	2021
Prepared By	Hazel Blake
Prepared On	22/11/2022

CAGR

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GREYSCALE PLOT

Value

5

-5

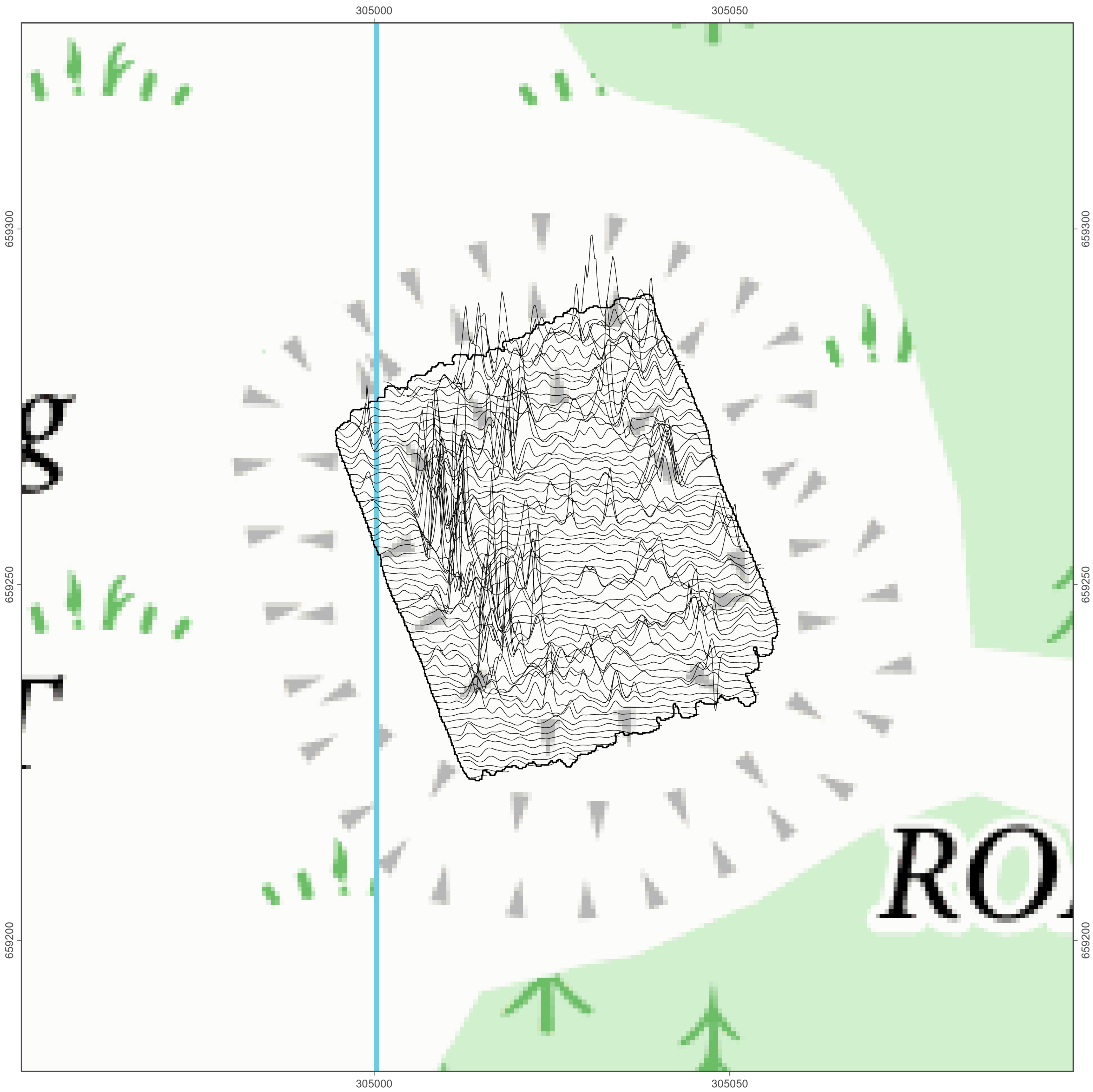
Cell size (m)	0.12
Stretch	Standard Deviation
Standard Deviations	1
Gamma	1

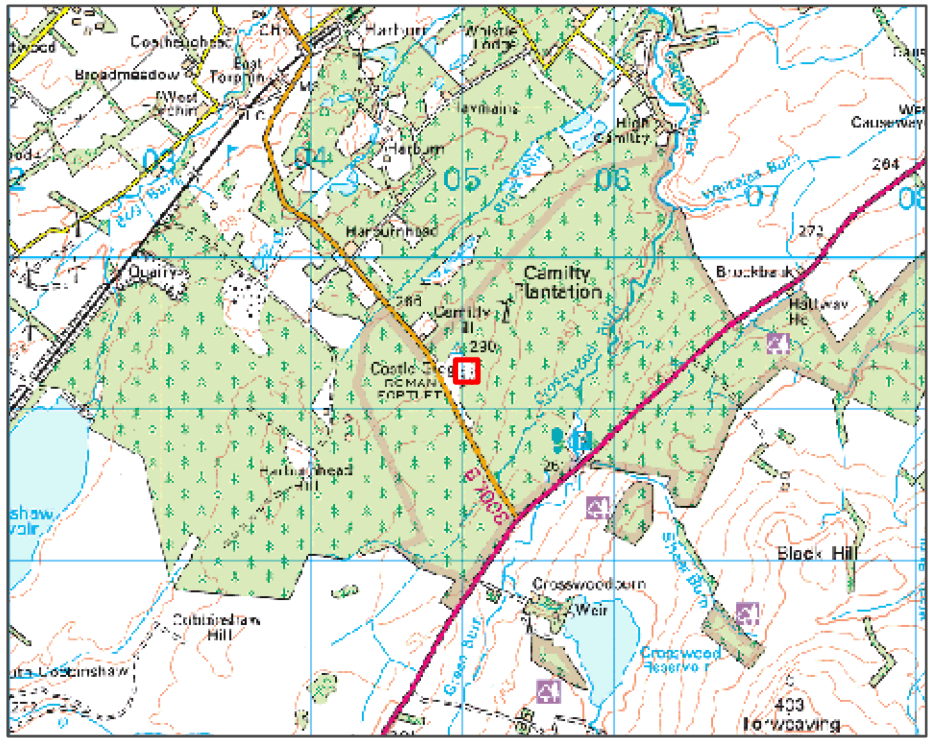
North	Scale: 1:550 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Figure 09	XY Trace Plot of Gradiometer Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	25/01/2023

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





GEOPHYSICAL SURVEY

XY Trace Plot

100 nT

50 nT

0 nT

North

Scale: 1:550 @ A3

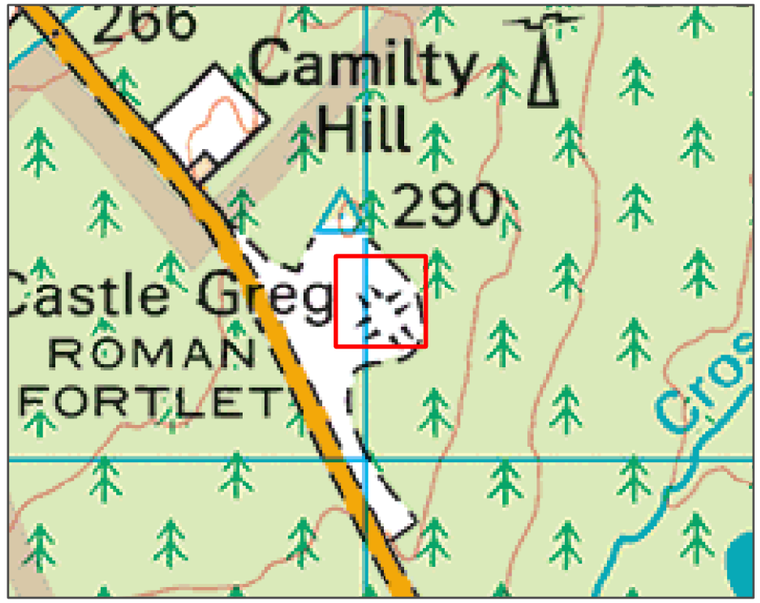
Datum: OSGB 1936

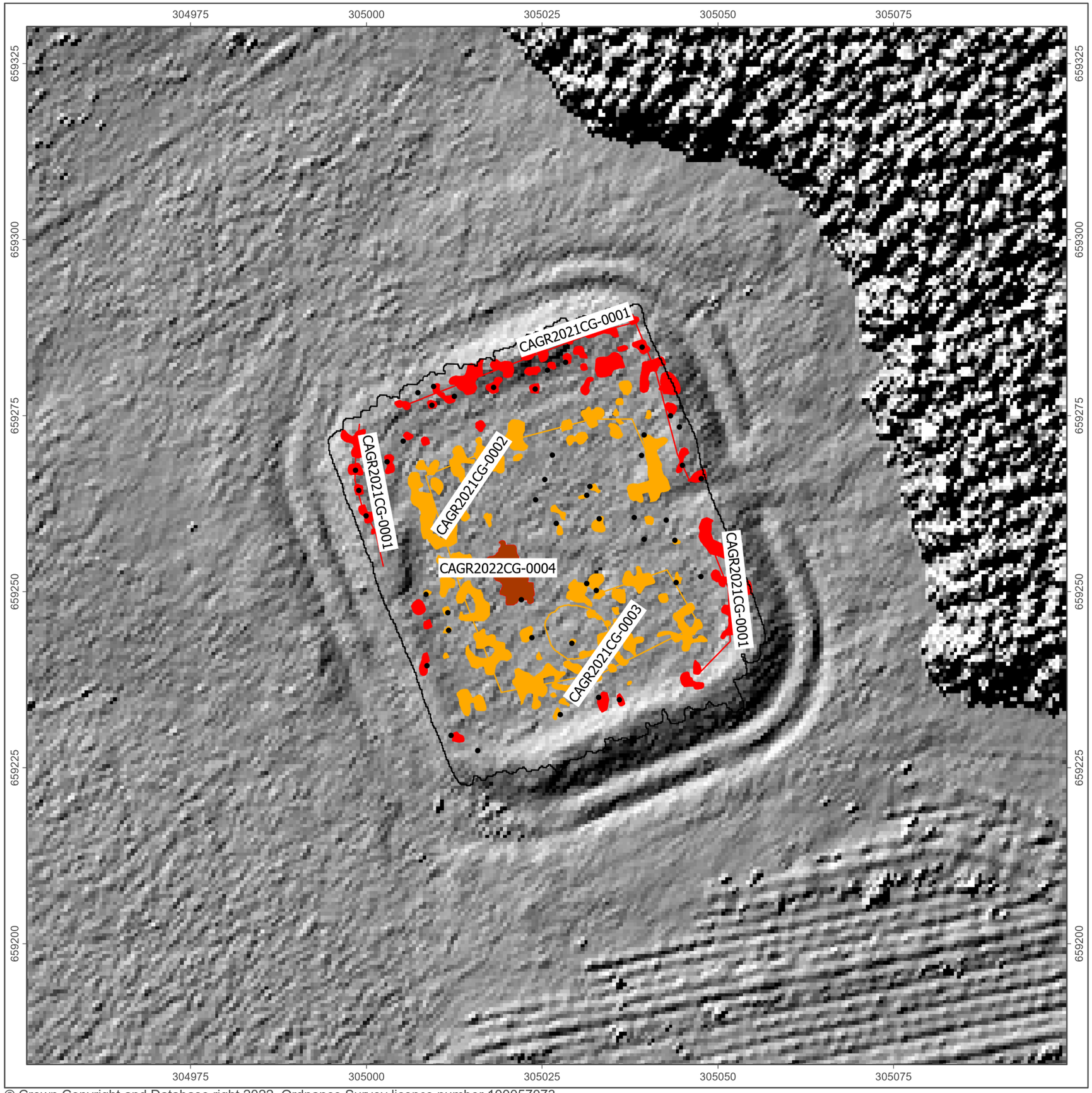
Metres

0 10 20 30 40

Figure 09	Interpretation of Gradiometer Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	14/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





Gradiometer Polyline

- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)

Gradiometer Polygon

- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

Gradiometer Point

Anomaly_Type

- Ferrous Spike

North

Scale: 1:550 @ A3

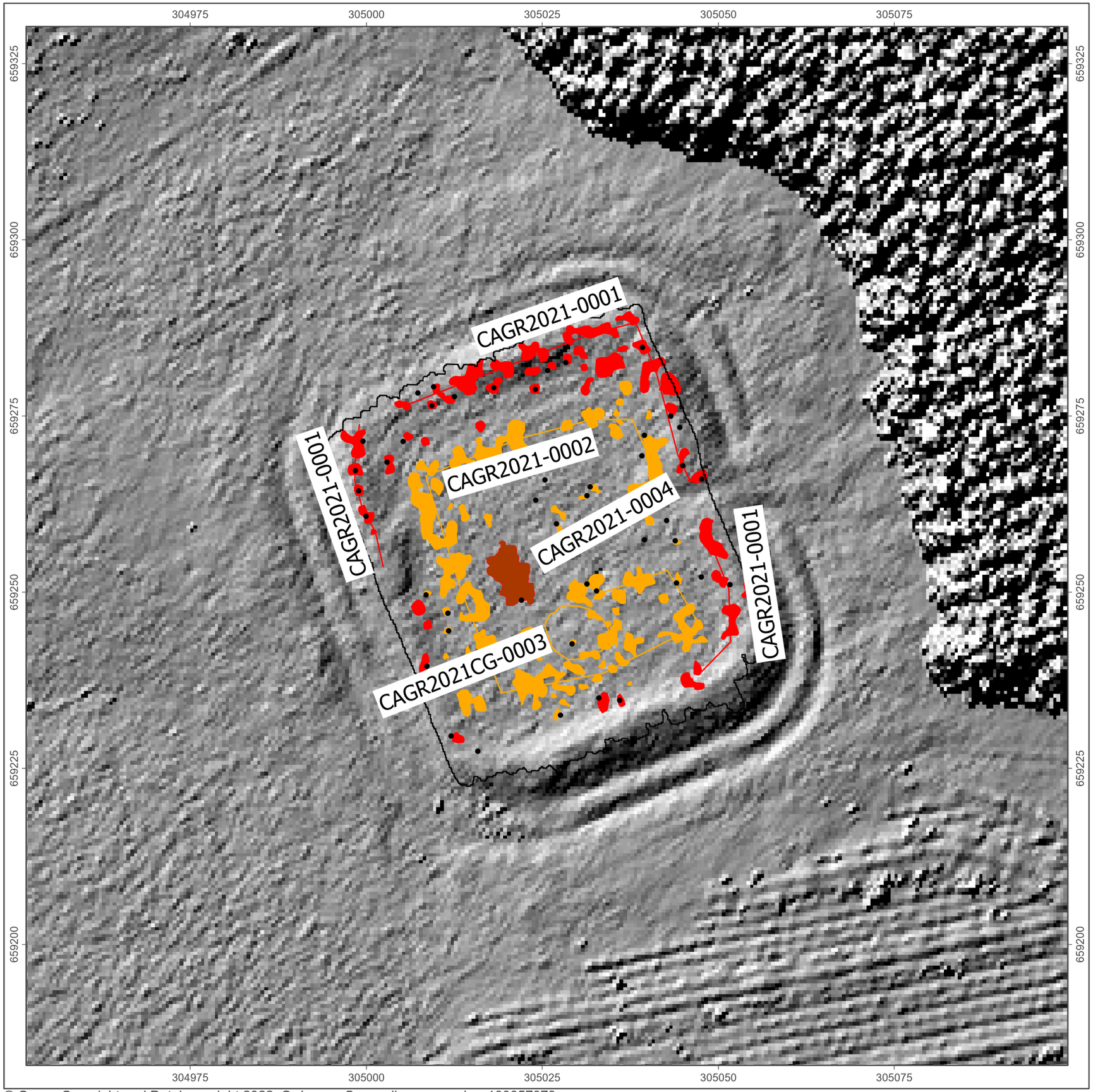
Datum: OSGB 1936

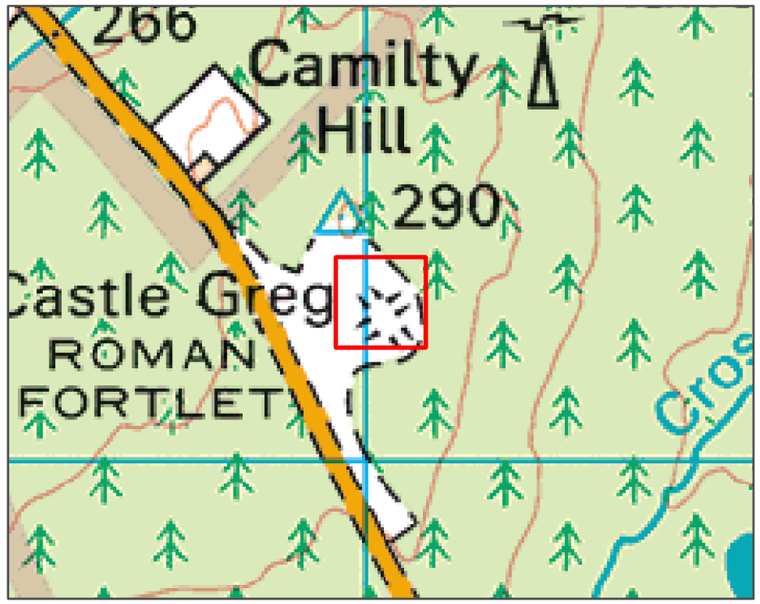
Metres

0 10 20 30 40

Figure 09	Interpretation of Gradiometer Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	23/01/2023

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





Gradiometer Polyline

- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)

Gradiometer Polygon

- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

Gradiometer

Anomaly_Type

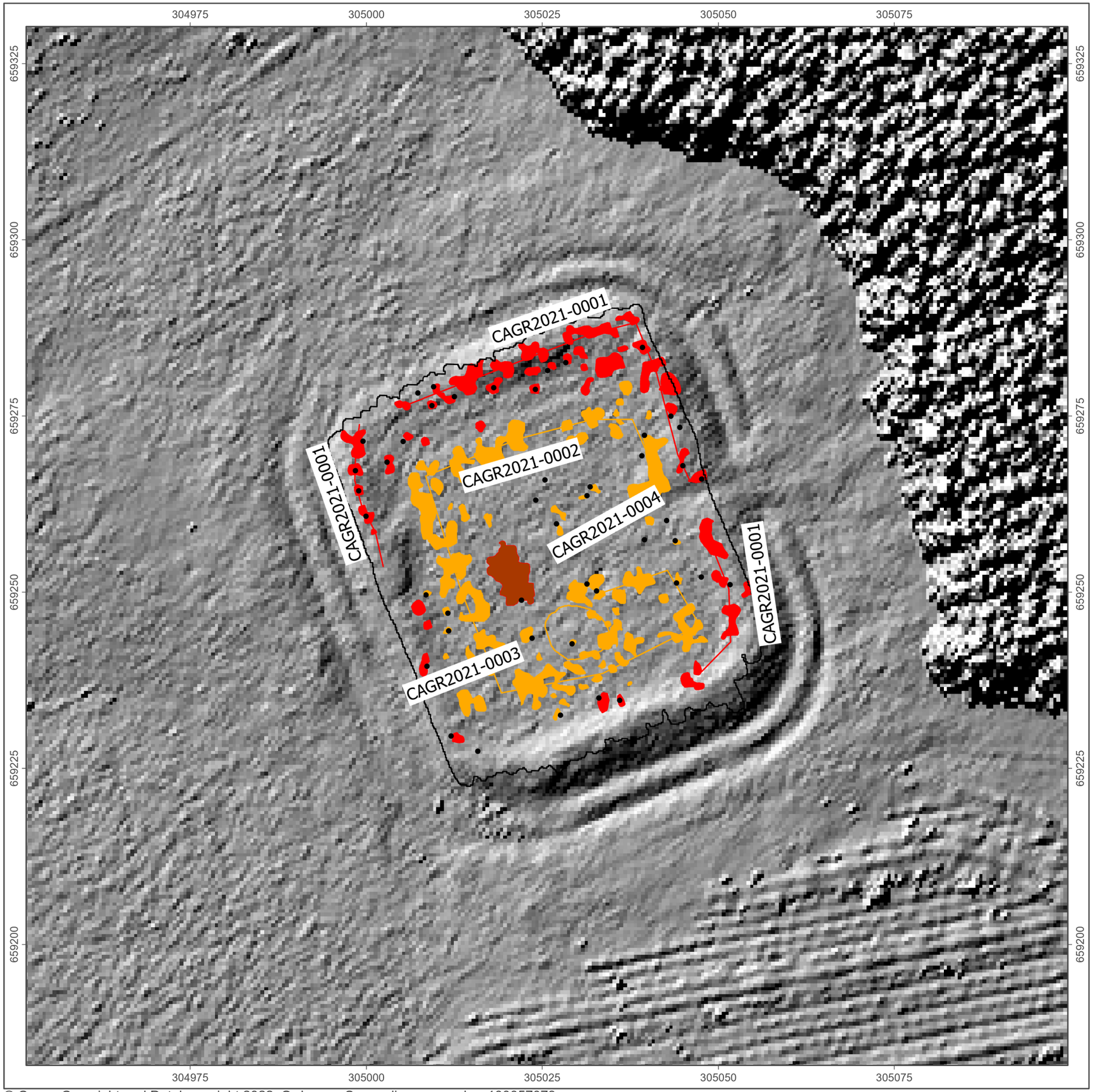
- Ferrous Spike

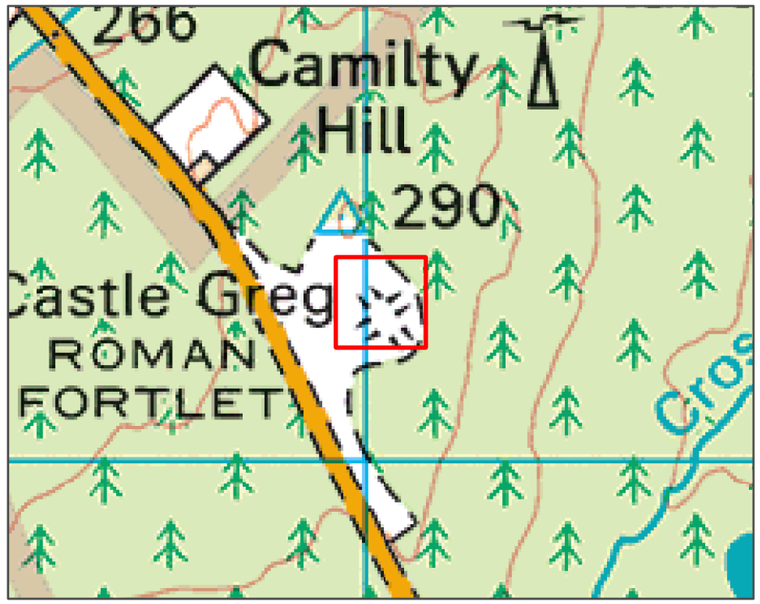
North	Scale: 1:550 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

Figure 10	Interpretation of Gradiometer Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	24/01/2023

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





Gradiometer Polyline

- Linear Trend (Archaeology
- Linear Trend (Possible Archaeology)

Gradiometer Polygon

- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

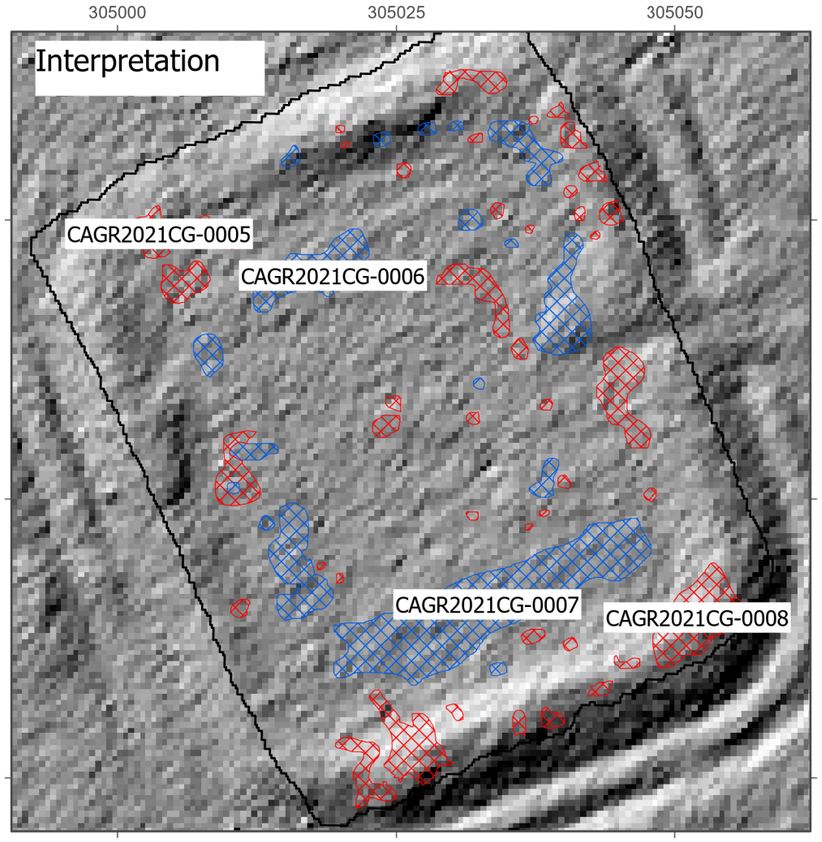
Gradiometer

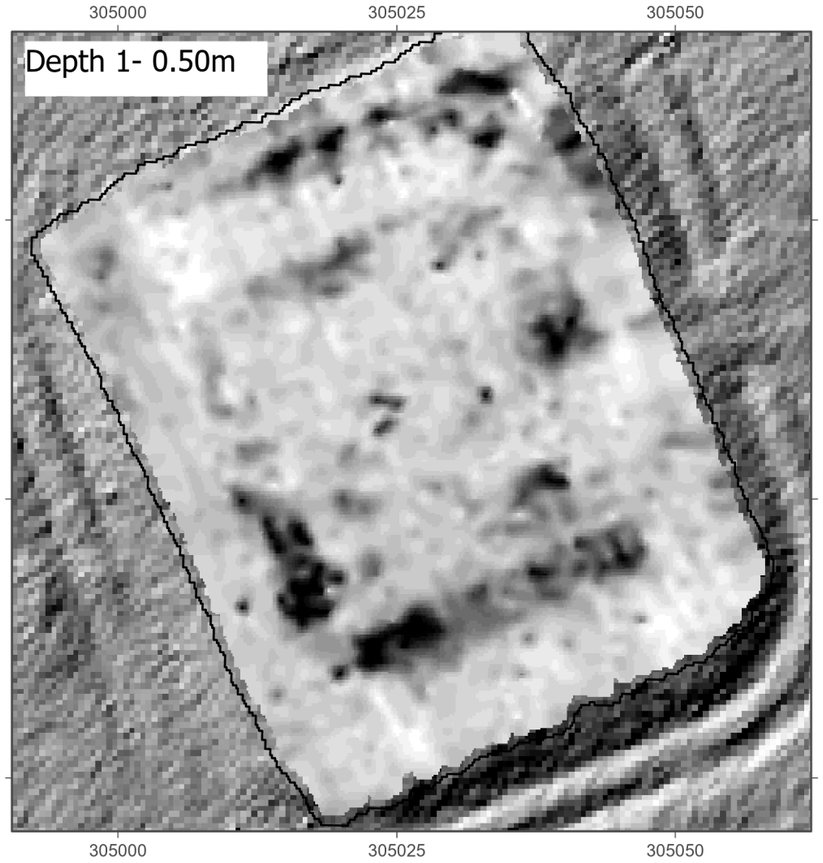
Anomaly_Type

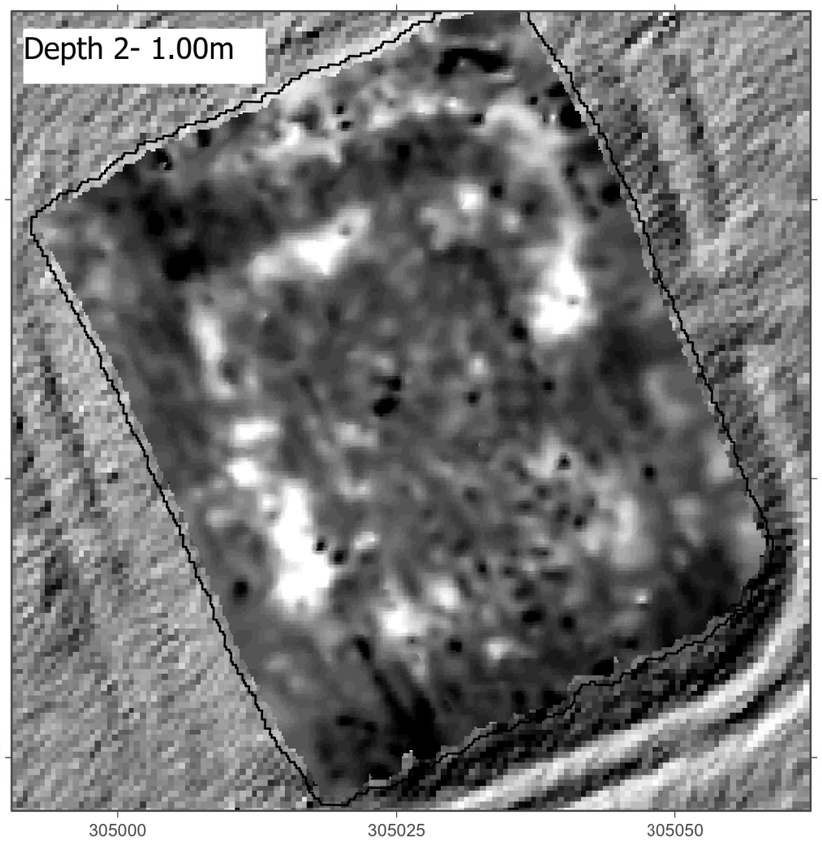
- Ferrous Spike

North	Scale: 1:550 @ A3	Datum: OSGB 1936

Metres: 0 10 20 30 40







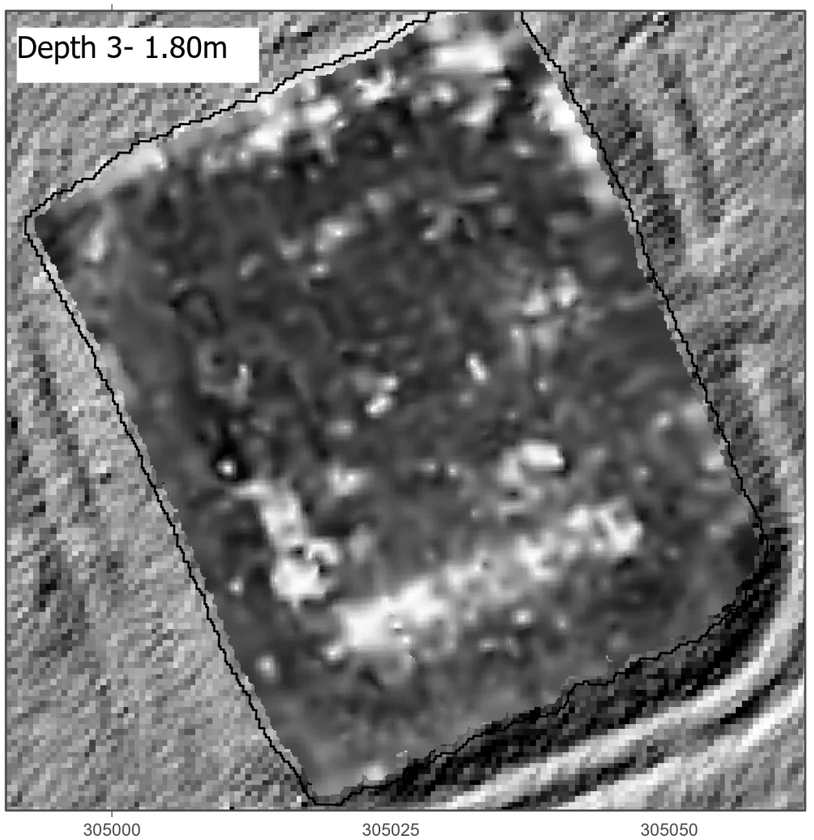


Figure 11	Processes Electro-magnetic Data and Interpretation Horizontal Co-planar Magnetic Susceptibility
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	14/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

Mag Susceptibility Polygon- Horizontal Co-planar (High)

In Phase

High Magnetism

Low Magnetism

GREYSCALE PLOT

ppt

0.06

-0.21

Survey Area Outline

North

Scale: 1:550 @ A3

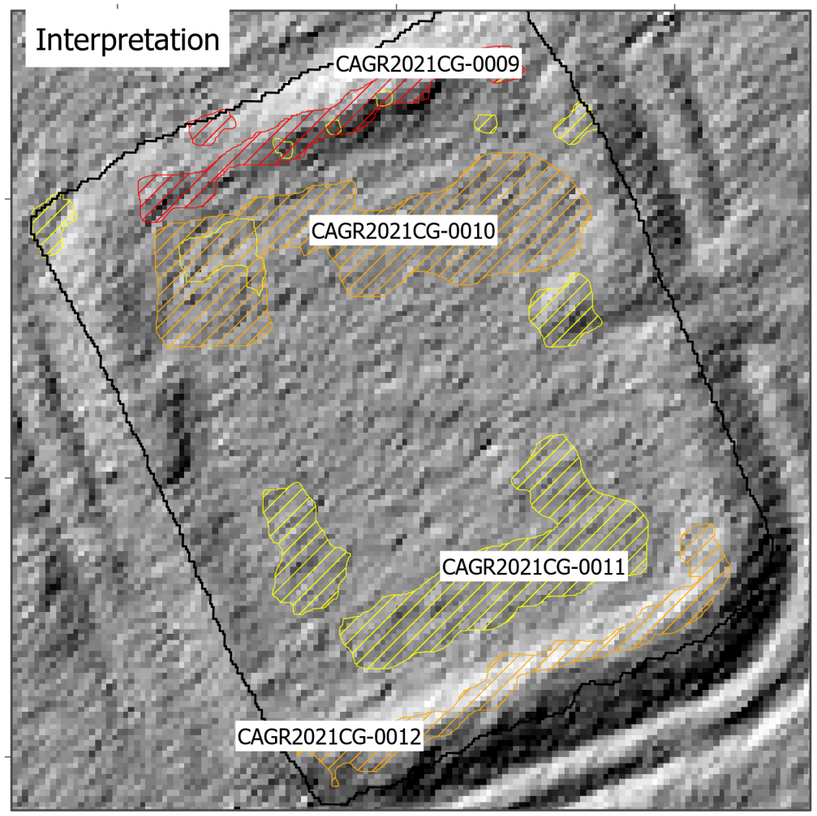
Datum: OSGB 1936

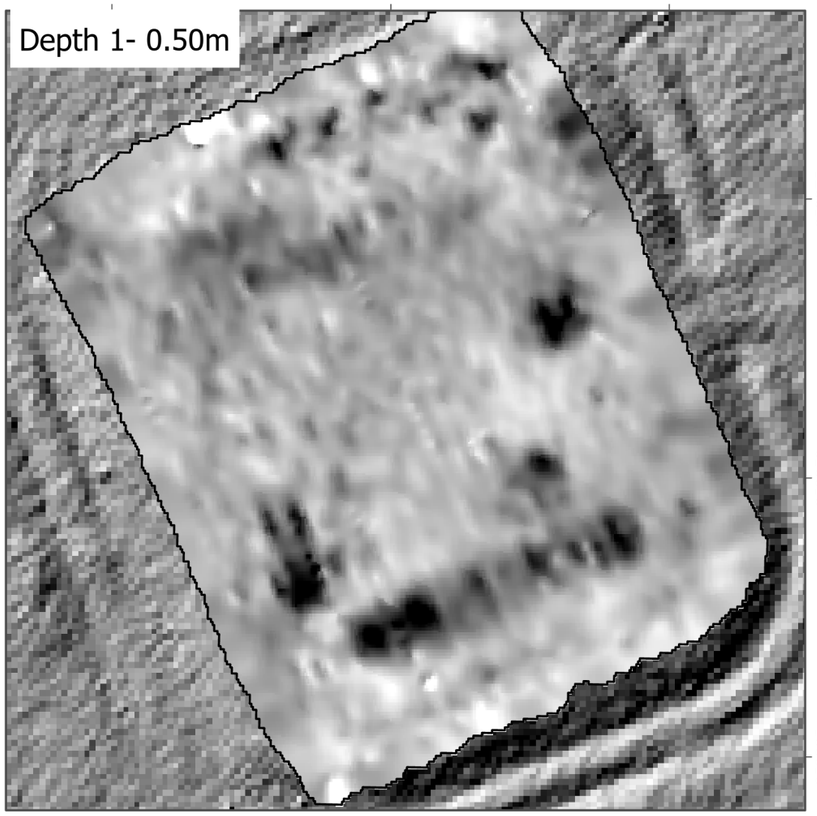
Metres

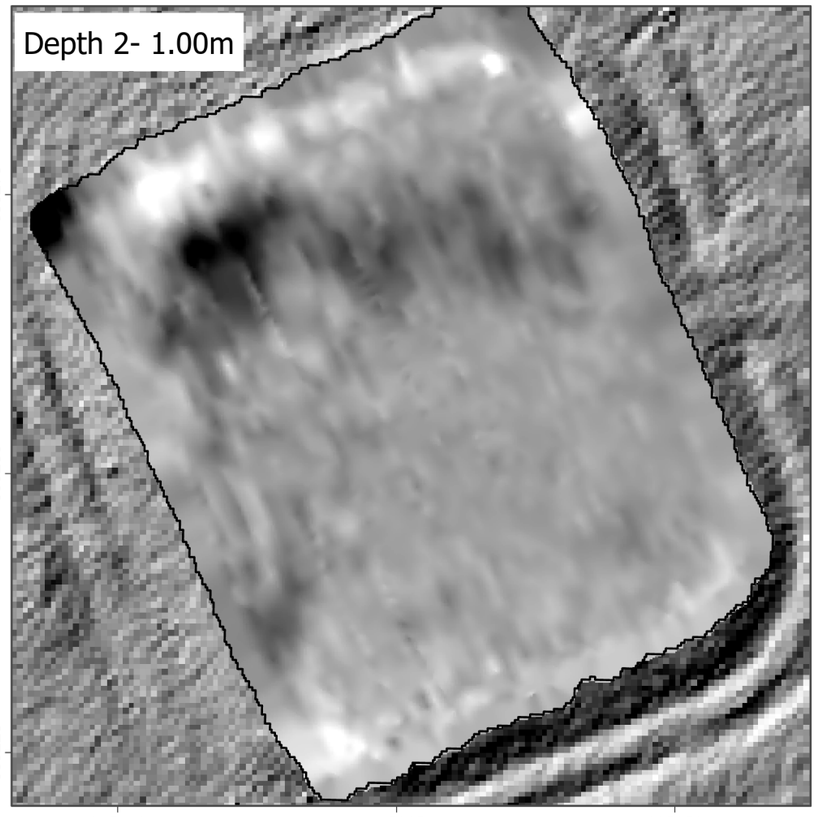
0 10 20 30 40

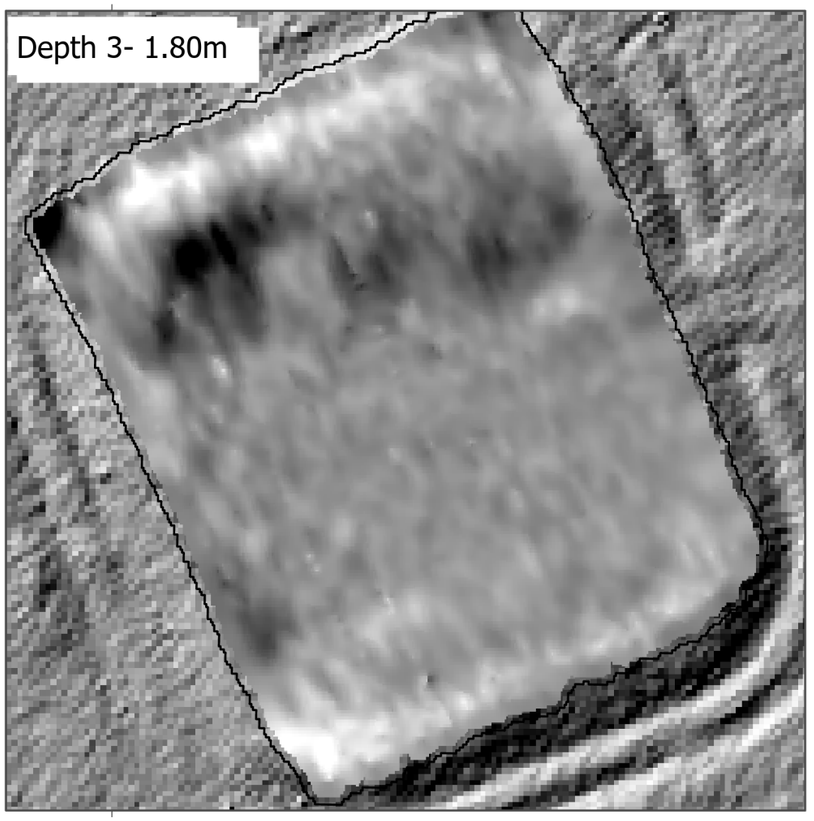
Figure 12	Processes Electro-magnetic Data and Interpretation Horizontal Co-planar Conductivity
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	14/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA









Conductivity Polygon- Horizontal Co-planar (High)

Quadrature

- High Conductivity
- Low Conductivity
- Very Low Conductivity

GREYSCALE PLOT

mS/m

2.48

-1.23

Survey Area Outline

North	Scale: 1:550 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

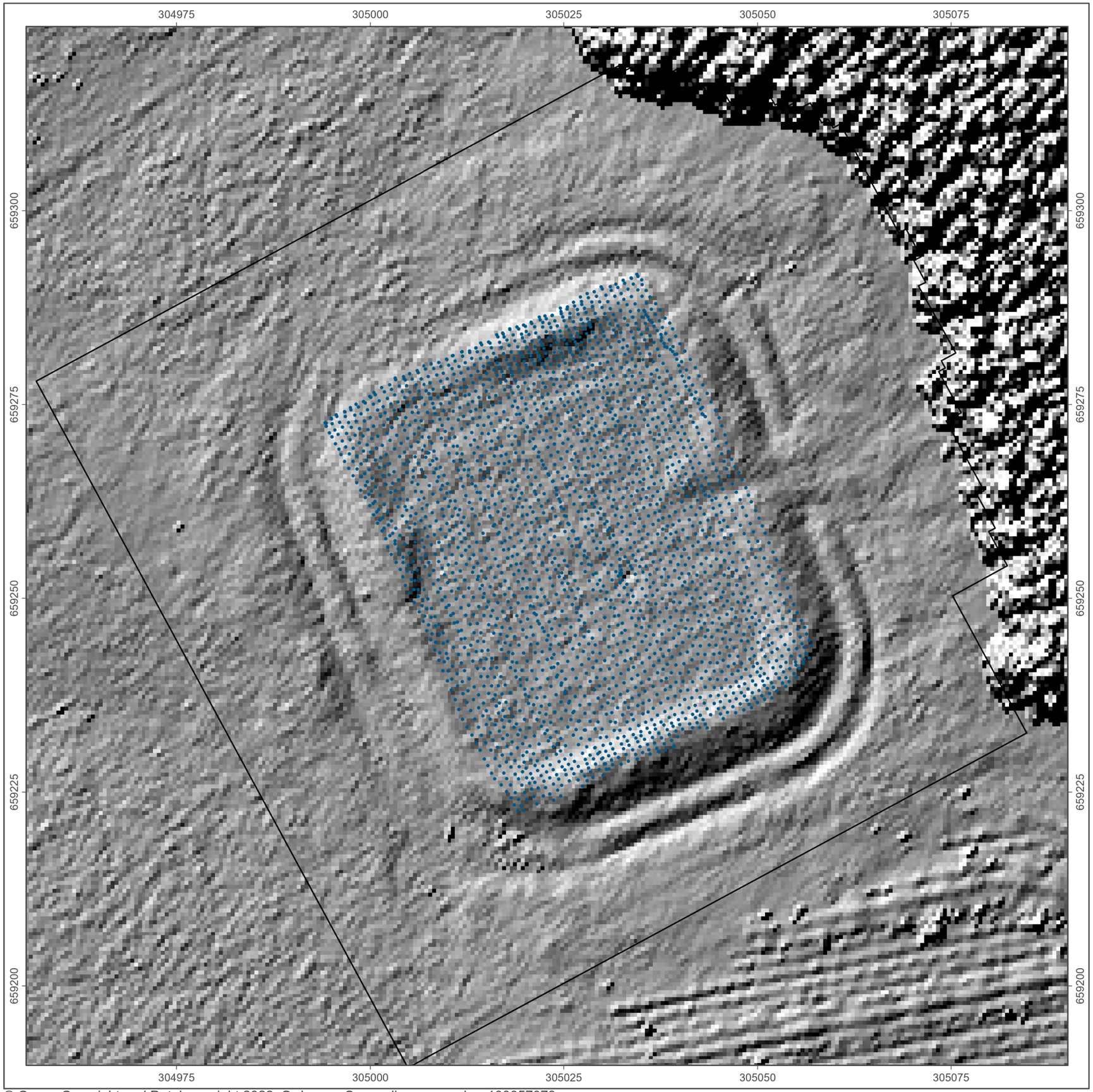
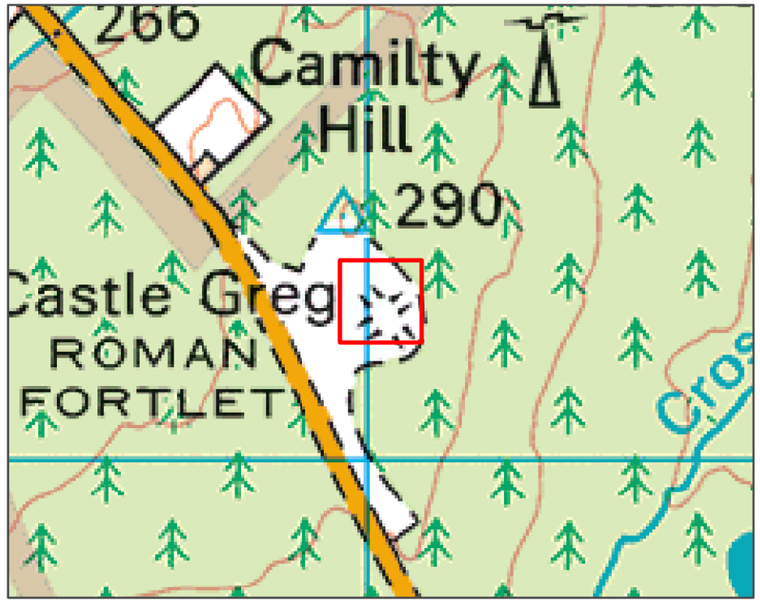


Figure 13	Electro-Magnetic Survey GNSS Swaths
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA



GEOPHYSICAL SURVEY

- GNSS Breadcrumbs

North	Scale: 1:500 @ A3	Datum: OSGB 1936

Metres
0 10 20 30 40

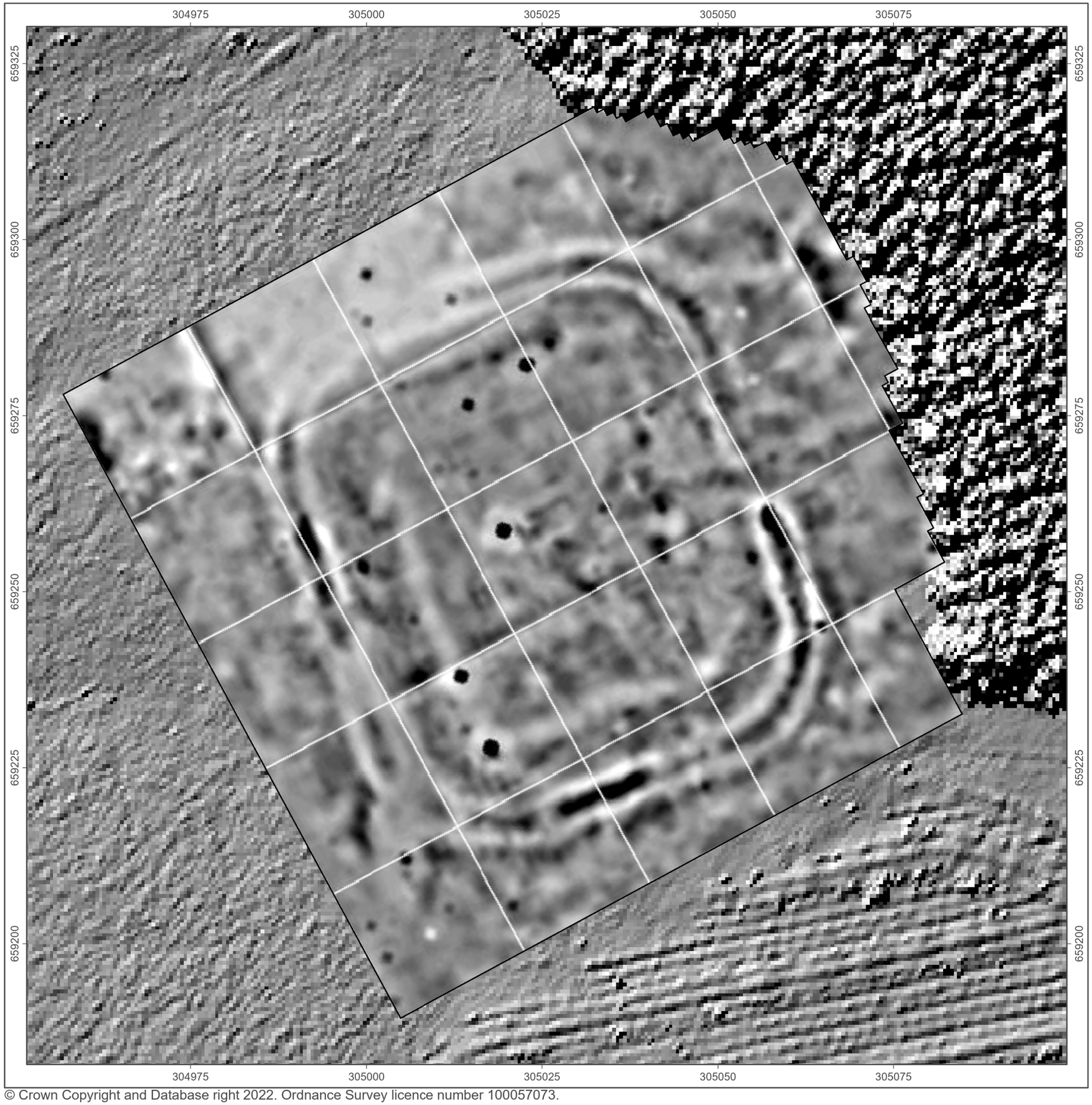
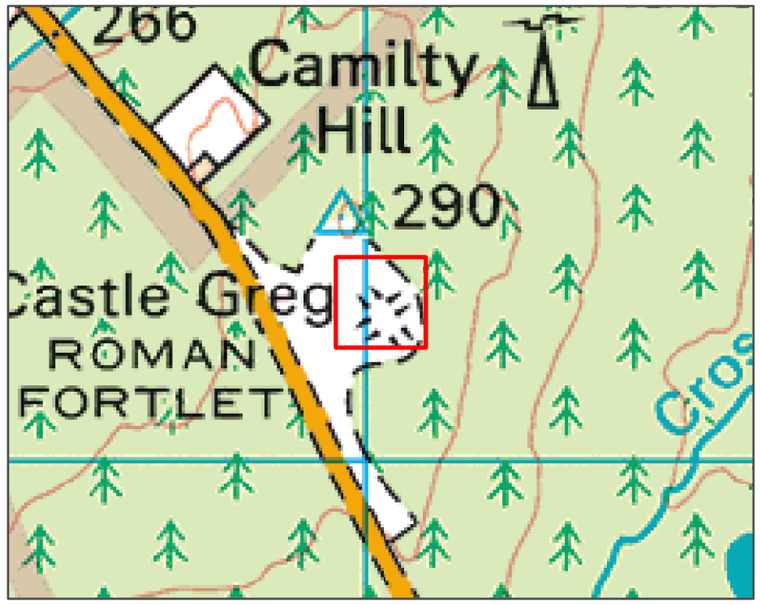


Figure 14	Greyscale of Resistivity Data	
Project Name	Castle Greg	HISTORIC ENVIRONMENT SCOTLAND / ÀRAINNEACHD EACHDRAIDHEIL ALBA
Project Code	CAGR2021	
Prepared By	Hazel Blake	
Prepared On	19/12/2022	

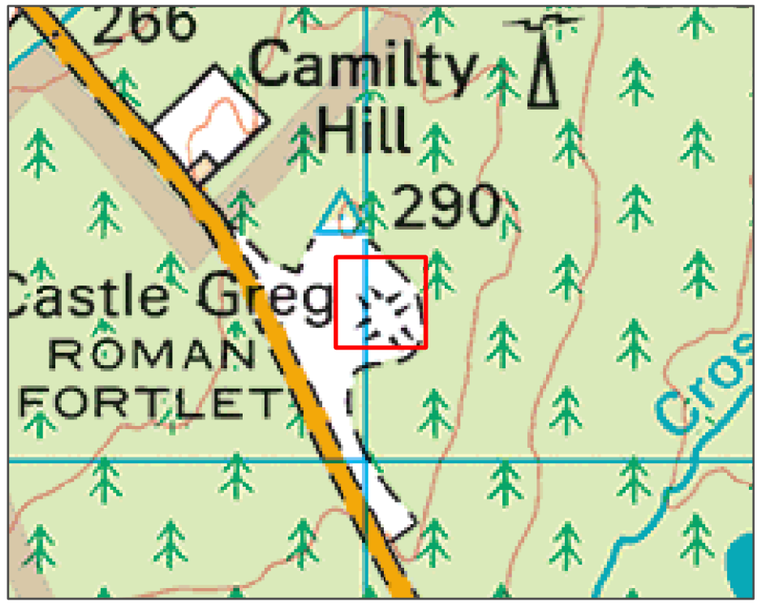


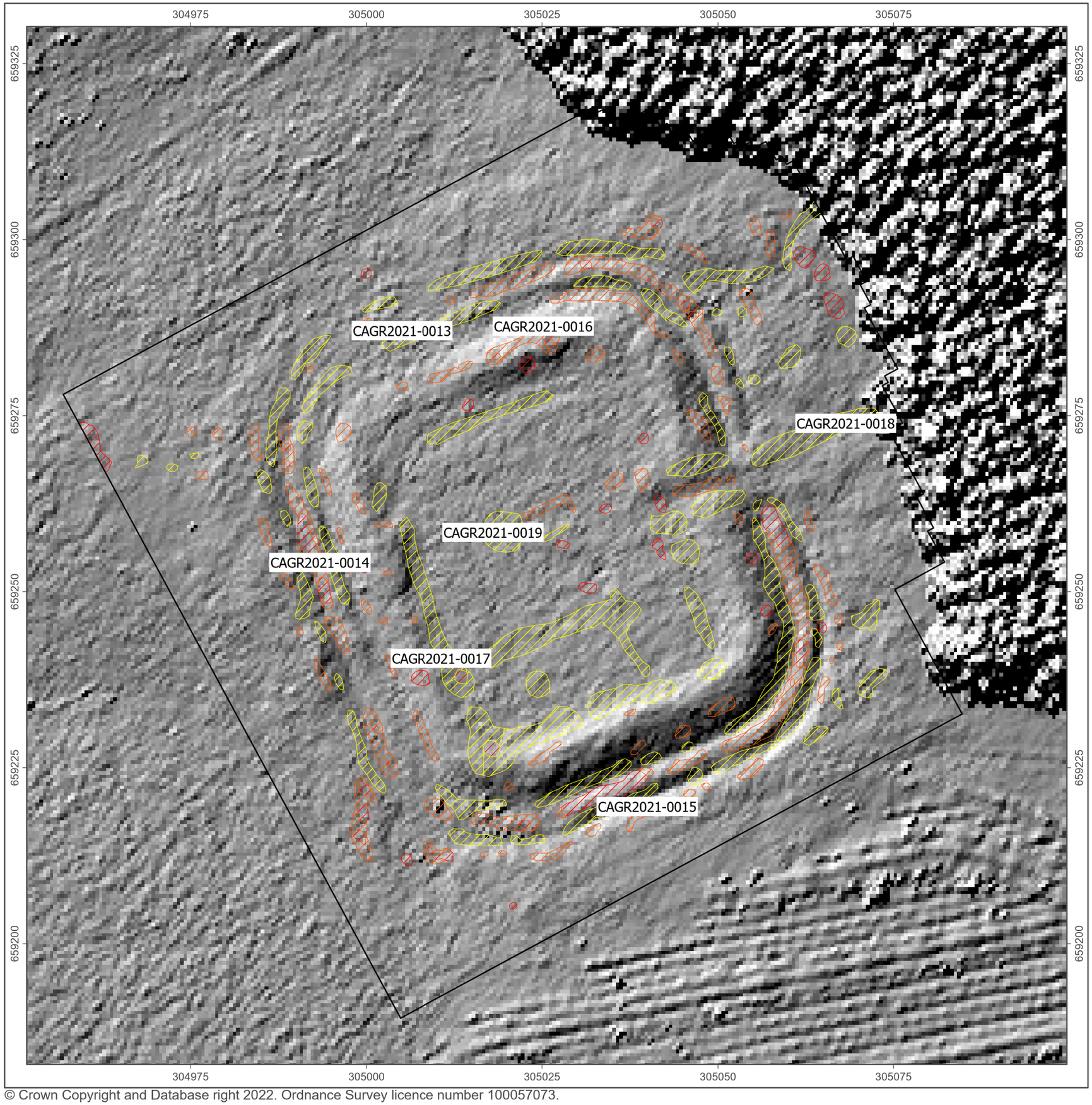
Survey Area Outline

North	Scale: 1:550 @ A3	Datum: OSGB 1936
	Metres 0 10 20 30 40	

Figure 15	Interpretation of Resistivity Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA





Resistivity Polygon

- Very High Resistance
- High Resistance
- Low Resistance
- Survey Area Outline

North

Scale: 1:550 @ A3

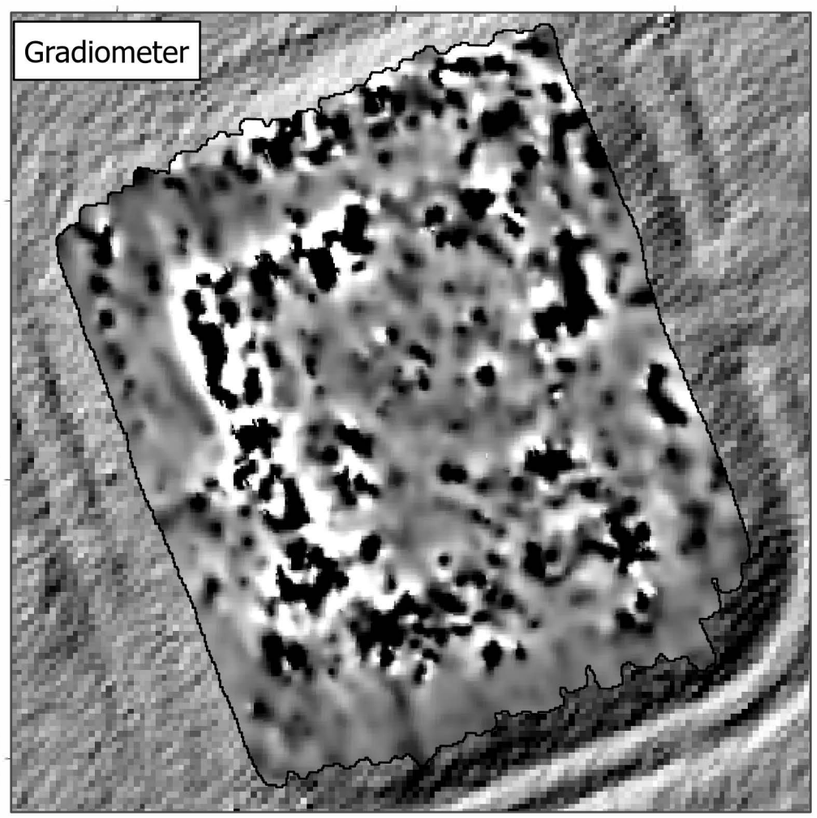
Datum: OSGB 1936

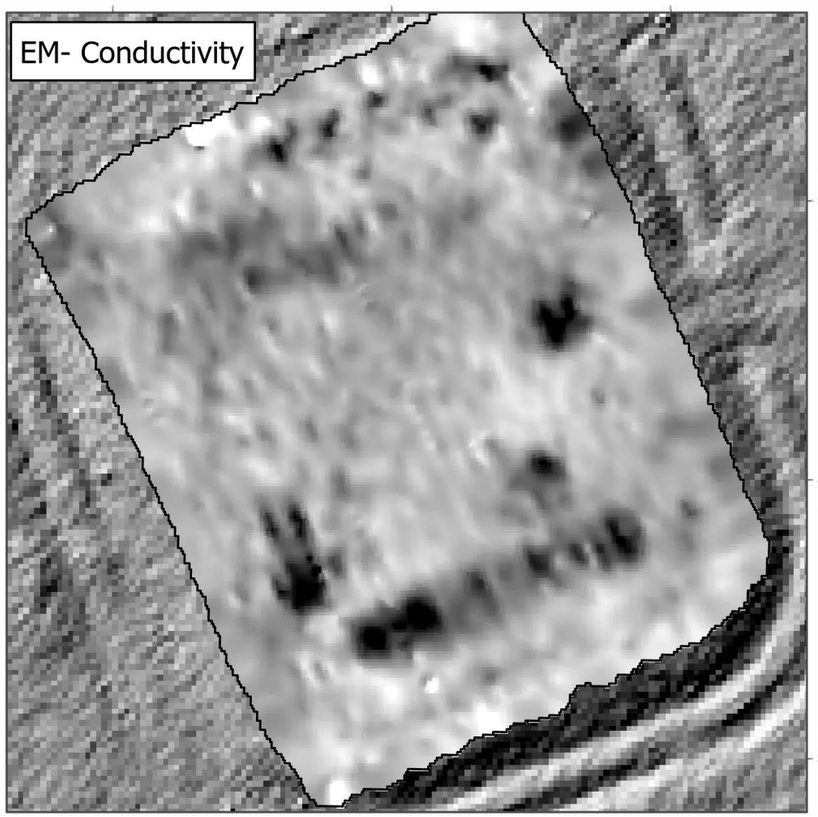
Metres

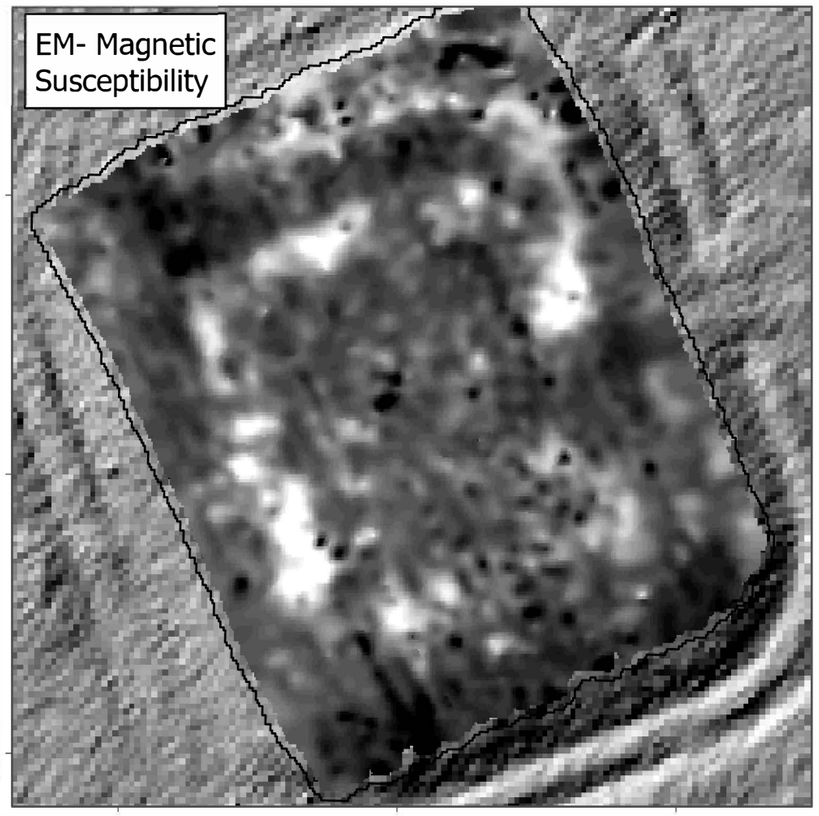
0 10 20 30 40

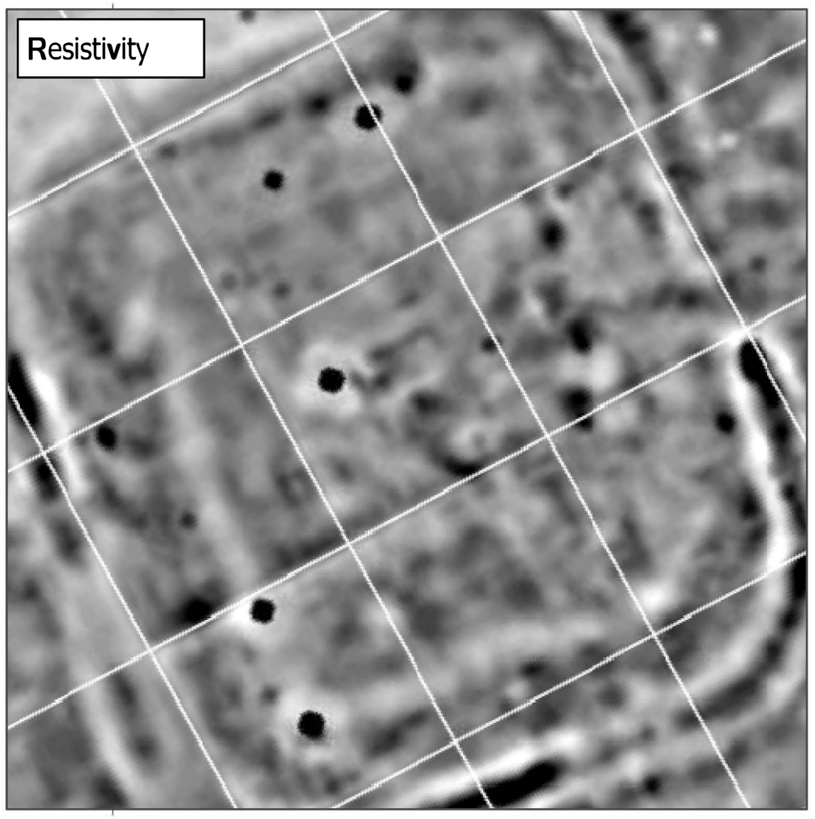
Figure 16	Processes Gradiometer, Electro-magnetic- Conductivity and Magnetic Susceptibility, and Resistivity Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA









Gradiometer

nT

5

-5

Conductivity

mS/m

2.48

-1.23

Magenetic Susceptibility

ppt

0.1

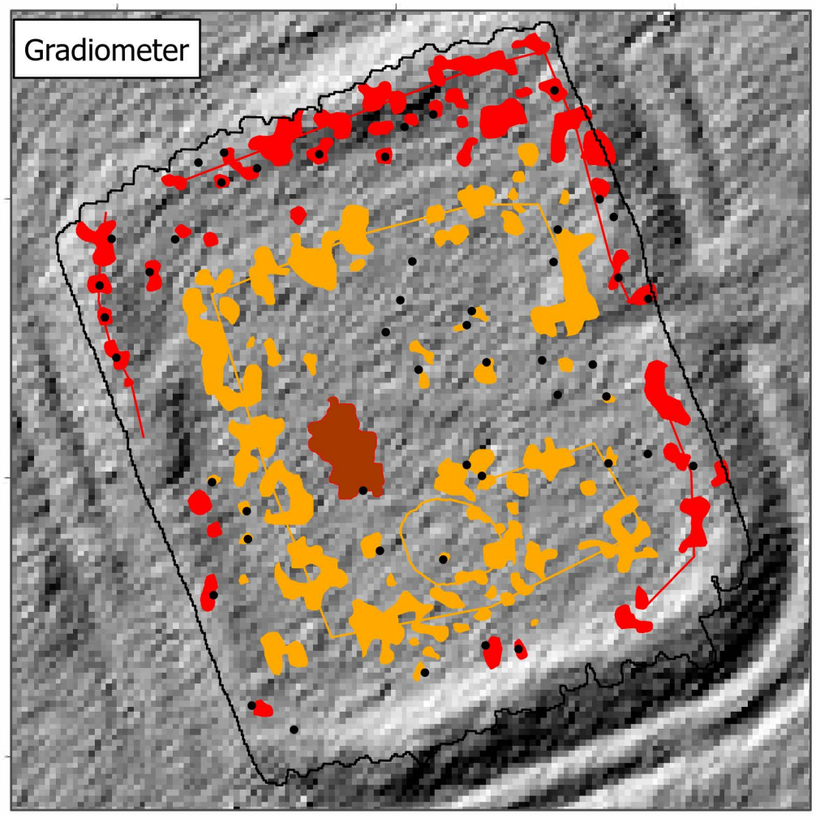
-0.20

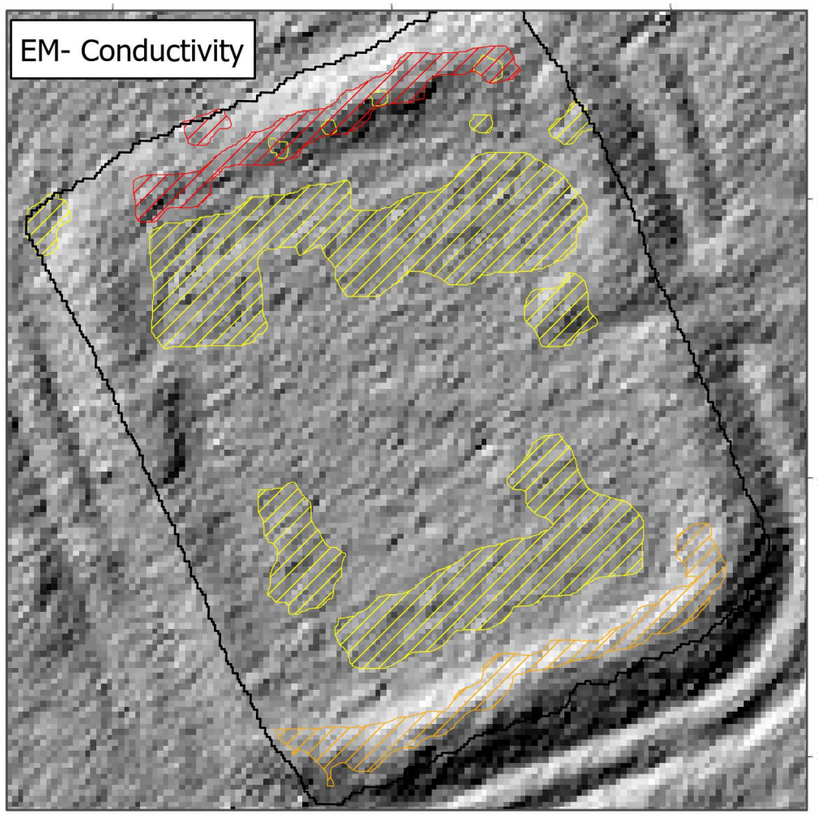
North	Scale: 1:550 @ A3	Datum: OSGB 1936

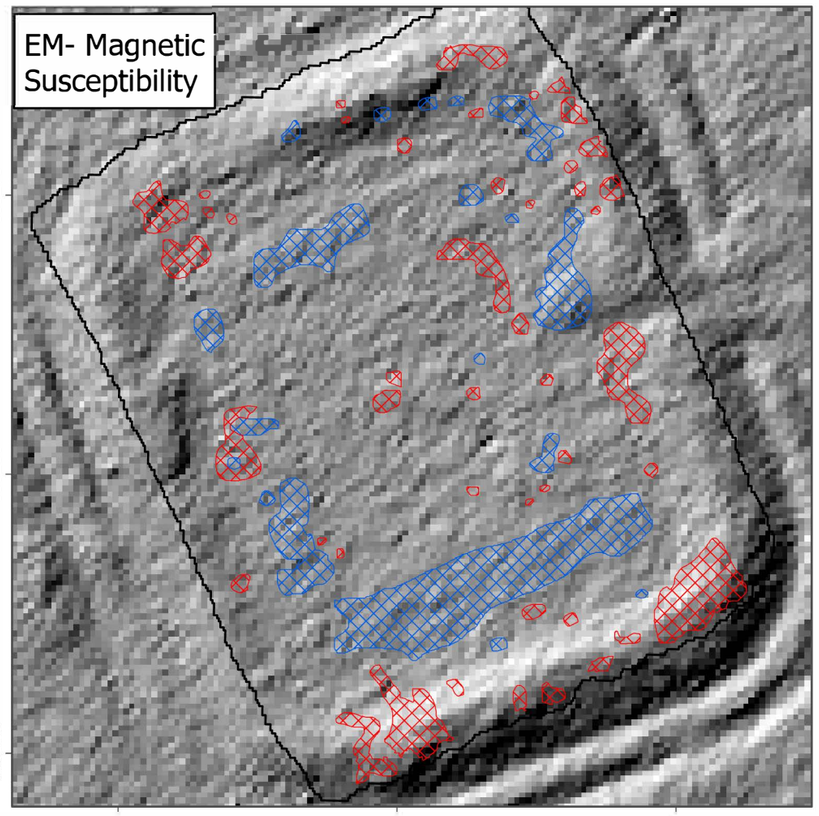
Metres 0 10 20 30 40

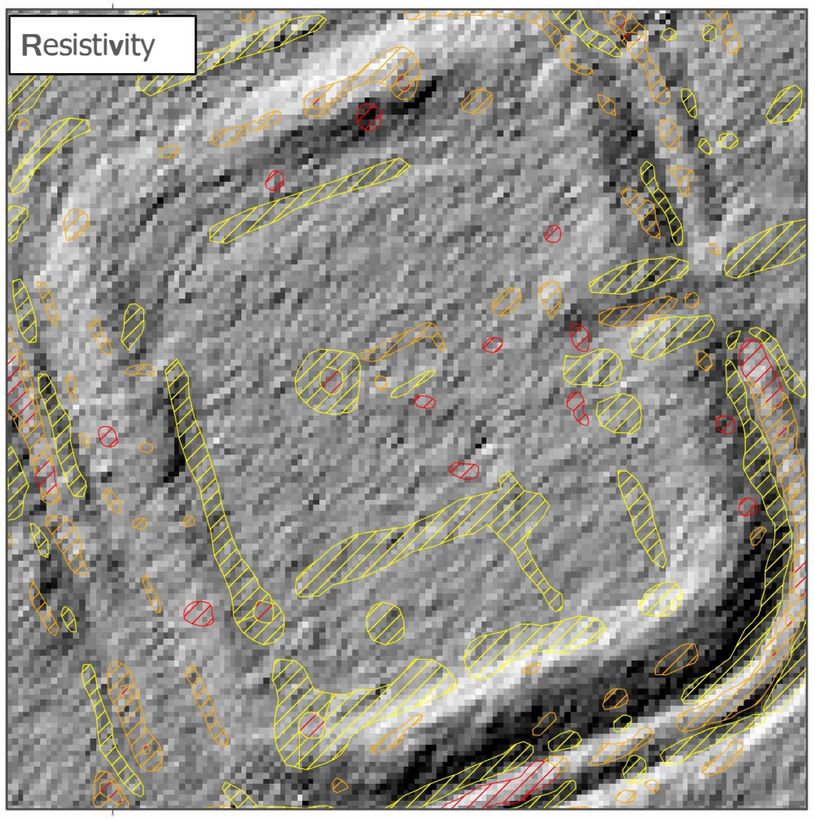
Figure 17	Interpretation Gradiometer, Electro-magnetic- Conductivity and Magnetic Susceptibility, and Resistivity Data
Project Name	Castle Greg
Project Code	CAGR2021
Prepared By	Hazel Blake
Prepared On	19/12/2022

HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA









Gradiometer

- Ferrous Spike
- Linear Trend (Archaeology)
- Linear Trend (Possible Archaeology)
- Enhanced Magnetism (Archaeology)
- Enhanced Magnetism (Possible Archaeology)
- Enhanced Magnetism (Area of Burning)

Conductivity

- High Conductivity
- Low Conductivity
- Very Low Conductivity

Magnetic Sususceptibility

- High Magnetism
- Low Magnetism

Resistivity

- Very High Resistance
- High Resistance
- Low Resistance

North	Scale: 1:550 @ A3	Datum: OSGB 1936

Metres 0 10 20 30 40

APPENDIX 1 – SURVEY METADATA

The following table details the survey's metadata.

Field	Description
Data Collection Organisation	Historic Environment Scotland
Site Name	Castle Greg Fortlet
Project ID	CAGR2021
OASIS ID	historic14-412624
Report Title	Castle Greg Fortlet, Archaeological Geophysical Survey Report
Report Author	Hazel Blake
Report QC	Dr Kirsty Millican/Dr Nick Hannon
National Grid Reference (centre)	NT 05022 59256
Coordinate System	OSGB1936
Transformation	OSTN15
Geoid	OSGM15
County	West Lothian
Scheduled Ancient Monument/s	SM1933
Known Archaeology on site	48988, 49002, & 72639
Survey Personnel	Dr Nick Hannon & Hazel Blake
Survey Dates	21st and 22nd July 2022
Weather Conditions	Dry, hot and sunny
Land Use	Rough Grass
Ground Conditions	Dry
Solid Geology	Calders Member, Strathclyde Group, Sedimentary (BGS 2021)
Drift Geology	Till, Devensian – Diamicton (BGS 2021)
Soil	Peaty Gley (Scotland's Soils 2021)
Survey Type	Gradiometer
Gradiometer Equipment	Sensys MXPDA
Sensors Type	FGM650/3
Sample Rate (hz)	100
Number of Sensors	5
Sensor Serial Numbers	1519/1520/1521/1522/1523
Sensor Separation (m)	0.25
Reading Interval (m)	0.125
Data Collection Software	MONMX v5.01-03/00
Data Processing Software	TerraSurveyor v3.0.36.10
Data Visualisation Software	ArcGIS Pro v2.8.6
Area Covered (ha)	0.28
Positional Accuracy	Leica GS16 GNSS +/- 0.02m
Survey Type	Electro-magnetic
EMI Equipment	CMD Mini Explorer
Sensor Separation/s (m)	0.2/0.5/0.7
Sensor Configuration	Low (Vertical Coplanar)
Traverse Separation (m)	0.5
Reading Interval (sec)	0.2
Data Collection Software	On-board hardware
Data Processing Software	TerraSurveyor v3.0.36.10
Data Visualisation Software	ArcGIS Pro v2.8.6
Area Covered (ha)	0.29
Positional Accuracy	Leica GS16 GNSS +/- 0.02m

APPENDIX 2 – CALIBRATION CERTIFICATES

SENSYS®
Magnetometers & Survey Solutions

SENSYS Sensorik & Systemtechnologie GmbH · Rabenfelde 5 · 15526 Bad Saarow

Technologiezentrum Rabenfelde

Inspection and Calibration Certificate

We hereby confirm that the device below:

MAGNETO® MXPDA 5channel system

(S/N: 000144)

with sensor probes FGM650/3

(S/N: 1519, 1520, 1521, 1522, 1523)

has been inspected and calibrated on **17.09.2020** by SENSYS - Sensorik und Systemtechnologie GmbH according to manufacturer's instructions and according to in-house inspection requirements. All inspections and maintenance procedures are carried out according to the quality management systems ISO 9001:2015 of SENSYS GmbH. No technical defects have been detected on the device. Thus the device can be used without any restrictions.

The next inspection is due in **September 2021** if no other damages or malfunction occurs in the meantime.

Bad Saarow, 17.09.2020

Gerd Rückschloss
Head of Customer Service

SENSYS Sensorik & Systemtechnologie GmbH
Rabenfelde 5
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Amtsgericht Frankfurt (Oder) · HRB 5419

Bankverbindung Sparkasse Oder-Spree
BLZ 170 550 50 · Kto.-Nr. 3000003060
BIC: WELADED1LOS
IBAN: DE 24 1705 5050 3000 0030 60

APPENDIX 3 – IDENTIFIED ANOMALIES

The following table lists each named anomaly identified in the survey.

Anomaly ID	Location	Classification	Interpretation
CAGR2021-0001	CG01	Enhanced Magnetism (Archaeology)	Rampart
CAGR2021-0002	CG01	Enhanced Magnetism (Possible Archaeology)	Building
CAGR2021-0003	CG01	Enhanced Magnetism (Possible Archaeology)	Settlement Activity
CAGR2021-0004	CG01	Enhanced Magnetism (Area of Burning)	Area of Burning
CAGR2021-0005	CG01	High Magnetic susceptibility	Possible oven
CAGR2021-0006	CG01	Low Magnetic susceptibility	Building
CAGR2021-0007	CG01	Low Magnetic susceptibility	Building
CAGR2021-0008	CG01	High Magnetic susceptibility	Rampart
CAGR2021-0009	CG01	Very Low Conductivity	Rampart
CAGR2021-0010	CG01	Low Conductivity	Building
CAGR2021-0011	CG01	Low Conductivity	Building
CAGR2021-0012	CG01	Low Conductivity	Rampart
CAGR2021-0013	CG01	Low Resistance	Ditches
CAGR2021-0014	CG01	High/Very High Resistance	Berm
CAGR2021-0015	CG01	High Resistance	Upcast mound
CAGR2021-0016	CG01	High Resistance	Ramparts
CAGR2021-0017	CG01	Low Resistance	Building
CAGR2021-0018	CG01	Low Resistance	Road
CAGR2020-0019	CG01	High Resistance	Well

APPENDIX 4 – GLOSSARY OF ANOMALY TYPES

The following table contains a glossary of the technical terminology used for gradiometer survey anomalies within this report.

	Anomaly Type	Description
Area	Area of Disturbance (Modern)	An area of magnetic disturbance caused by modern activity such as metallic fences, gates, inspection covers, green waste, or modern refuse.
	Enhanced Magnetism (Area of Burning)	An anomaly with a distinct pattern in the XY trace plot which indicates burning has taken place, suggesting the location of a hearth or kiln.
	Enhanced Magnetism (Historic Agriculture)	An anomaly caused by historic agricultural activity such as rig & furrow, or a headland.
	Enhanced Magnetism (Archaeology)	An anomaly of probable archaeological origin; this interpretation will either be based on other supporting evidence or on the form of the anomaly.
	Enhanced Magnetism (Historic Feature)	An anomaly caused by an historic feature. This will appear on a documentary record such as an old map but the feature is no longer extant on the surface, such as a demolished building, or a former field boundary.
	Enhanced Magnetism (Possible Archaeology)	An anomaly of possible archaeological origin; this interpretation will have no other supporting evidence.
	Enhanced Magnetism (Unclear Origin)	An anomaly for which it is not possible to assign an interpretation.
	Enhanced Magnetism (Utility)	An area of magnetic disturbance caused by the magnetic field of a utility, such as the halo around a gas pipe.
	Geology/Natural	An anomaly interpreted as caused by geological or fluvial processes, such as variations in underlying bedrock, or palaeo-channels.
Trend	Linear Trend (Archaeology)	A linear anomaly of probable archaeological origin; this interpretation will either be based on other supporting evidence or on the form of the anomaly.
	Linear Trend (Drainage)	A linear anomaly caused by modern drainage such as a field drain.
	Linear Trend (Historic Agriculture)	A linear anomaly caused by historic agricultural activity such as rig & furrow, or a headland.
	Linear Trend (Historic Feature)	A linear anomaly caused by a historic feature. This will appear on a documentary record such as an old map but the feature is no longer visible on the ground, such as an old pathway.
	Linear Trend (Modern Agriculture)	A linear anomaly caused by modern agricultural activity such as ploughing.
	Linear Trend (Possible Archaeology)	A linear anomaly of possible archaeological origin; this interpretation will have no other supporting evidence.
	Linear Trend (Unclear Origin)	A linear anomaly for which it is not possible to assign an interpretation.
	Linear Trend (Utility)	A linear anomaly caused by the presence of a modern utility, such as a gas pipe.
	Geology/Natural	A linear anomaly interpreted as caused by geological or fluvial processes, such as variations in underlying bedrock, or palaeo-channels.
Point	Ferrous Spike	An anomaly caused by a ferrous object in the topsoil which causes a spike in the XY trace plot of the data.

The following table contains a glossary of the technical terminology used for anomalies for electro-magnetic (Magnetic Susceptibility) survey within this report.

	Anomaly Type	Description
Area	High Magnetism	An area displaying particularly high magnetic properties, possibly of anthropogenic origins.
	Low Magnetism	An area displaying particularly low magnetic properties, possibly of anthropogenic origins.

The following table contains a glossary of the technical terminology used for anomalies for electro-magnetic (Conductivity) survey within this report.

	Anomaly Type	Description
Area	Very Low Conductivity	An area displaying very low conductivity, possibly of anthropogenic origins.
	Low Conductivity	An area displaying low conductivity, possibly of anthropogenic origins.
	High Conductivity	An area displaying low high conductivity, possibly of anthropogenic origins.

The following table contains a glossary of the technical terminology used for anomalies for earth resistance survey within this report.

	Anomaly Type	**Description**
Area	Very High Resistance	An area displaying very high resistance, possibly of anthropogenic origins.
	High Resistance	An area displaying high resistance, possibly of anthropogenic origins.
	Low Resistance	An area displaying low high resistance, possibly of anthropogenic origins.

APPENDIX 5 – DATA PROCESSING METHODOLOGY

The following section details the data processing methodology used for this survey; the specific process parameters used for each datafile are detailed in Appendix 6.

GRADIOMETER DATA PROCESSING

Following the collection of data using the methodology detailed in section 5.1, all datafiles were exported from the Sensys system's MONMX in .asc, and .uxo formats. These files were then transferred to the processing computer.

Data processing was conducted using TerraSurveyor v3.0.36.10 (DW Consulting: 2019). The GPS Geoid was set to "WGS-84" and the coordinate system set to "UTM Zone 30" prior to data import, to match the GNSS used during data collection. The .uxo files were imported using the pre-defined TerraSurveyor import template appropriate for the Sensys system and converted into .xcp format composites. The .asc format file was retained for archiving.

The .xcp file was opened and a .grd exported to allow visualisation of the minimally processed data. The data was destriped and clipped. The data was interpolated to values appropriate to the display requirements for the processed results. These processed results were exported in .grd format. An image boarder was generated and exported as a .dxf. The minimally processed data was clipped to -10/100 nT and an XY trace plot generated and exported as a .dxf.

The .grd and .dxf files were imported to the project's ArcGIS Pro geodatabase and converted into the British National Grid coordinate system using the "Project" and "Project Raster" tools, with the input coordinate system set as "ETRS_1989_UTM_Zone_30N", the output coordinate system as "British National Grid", using the "OSGB_1936_To_ETRS_1989_1" geographic transformation, resampled as "Nearest neighbour".

Once the reprojection was complete the data was manually interpreted.

ELECTRO-MAGNETIC DATA PROCESSING

Following the collection of data following the methodology detailed in section 5.2, all datafiles were exported from the CMD Mini Explorer's datalogger via a USB memory stick in .bin format. These files were then transferred to the processing computer and opened with the CMD Data Transfer application. Each file was then exported as an interpolated .dat file. Each data file was opened in Microsoft Excel and the trailing "W" and "N" removed from the data in columns A and B. Column B also had the leading "-" removed. The data was saved in .csv format.

Data processing was conducted using Terrasurveyor (DW Consulting: 2019). The GPS Geoid was set to "WGS-84" and the coordinate system set to "UTM Zone 30" prior to data import to match the GNSS used during data collection. The .csv files were imported using the pre-defined TerraSurveyor import template appropriate for the CMD Mini Explorer system, and converted into .xcp format composite. This process was repeated six times, each time changing the "Val posn" value on the "Source Settings" screen to produce a composite for each of the six sets of readings taken during survey.

The .xcp files were opened and a .grd exported to allow visualisation of the minimally processed data. The data was despiked, destriped and had a high-pass filter applied. The data was interpolated to values appropriate for the display requirements for the processed results. These processed results were exported in .grd format. An image boarder was generated and exported as a .dxf. The data was clipped and an XY trace plot generated and exported as a .dxf.

The .grd's were imported to the project's ArcGIS Pro geodatabase and converted into the British National Grid coordinate system using the "Project Raster" tool, with the input coordinate system set as "ETRS_1989_UTM_Zone_30N", the output coordinate system as "British National Grid", using the "OSGB_1936_To_ETRS_1989_1" geographic transformation, resampled as "Nearest neighbour".

Once the reprojection was complete the data was manually interpreted.

APPENDIX 6 – DATA PROCESSING STEPS

The following table details the processing steps each data file has undergone and the order these processes were applied before the data was transferred to the data visualisation software.

Filename	Process	Values
CAGR2021-MAG.xcp	Destripe	Mean / SD 1.5
	Clip	-100/100 nT
	Base Settings	Interval 0.121m, Track Radius 0.45m
	Remove Turns	Threshold Angle 45, Cut Length 5m
CAGR2021-SUSS1.xcp		0.181/1.15
	Destripe	Median, 1.5 SD
	Clip	-0.20-0.05
CAGR2021-SUSD2.xcp		0.177/1.15
	Destripe	Median, 1.5 SD
	High Pass Filter	Median, 201
	Clip	-0.15-0.15
CAGR2021-SUSD3.xcp		0.181/1.15
	Destripe	Median, 1.5 SD
	High Pass Filter	Median, 201
	Clip	-0.20-0.5
CAGR2021-COND1.xcp		
	High Pass Filter	Median, 30
	Destripe	Median, 1.5
CAGR2021-COND2.xcp	High Pass Filter	Median, 30
	Destripe	Median, 1.5
CAGR2021-COND3.xcp	High Pass Filter	Median, 30
	Destripe	Median, 1.5

APPENDIX 7 – GLOSSARY OF DATA PROCESSING TERMS

The following table contains a glossary of the technical terminology used during sections 4 and 5 of this report.

Process	Definition
Break on Jump	This process calculates the distance between each data point along a traverse and if this distance exceeds the set threshold the traverse will be split into individual traverses. This process is used when there is a large gap in the collected data points caused by GNSS signal drop-out.
Clip	This process removes values outside of the defined upper and lower limits and replaces them with the upper and lower limits. It can be applied as absolute values, or as a standard deviation. The process is used to remove the skewing effect of areas of unusually high or low values in the data.
De-spike	This process identifies data points which are unusually high or low compared with those around it and replaces the values with an average value based on the surrounding points. This process is used to remove the skewing effect of spikes in the data due to ferrous objects in the topsoil.
De-stagger	This process corrects mechanical errors which occur during data collection when a traverse is started too early or too late. It shifts the traverse backwards or forwards to compensate for the error. This process is used when data is collected on steep terrain when it is difficult to keep the cart parallel with the surface.
De-stripe	This process calculates the average (Mean, Mode or Median) of each individual traverse and then deducts this value from the readings along that traverse. This transforms the values into the difference from the average instead of an absolute value. This process is used to remove the striping effect caused by neighbouring traverses being surveyed in opposite directions (heading errors). This process is sometimes referred to as a 'Zero Mean Traverse'.
Discard Overlap	This process is used to remove data points when they have been collected too close to other data points. This process is used to remove the distorting effect caused by traverses overlapping due to operator error.
High Pass Filter	This process uses either a Gaussian or uniformly weighted window to remove low-frequency noise from the data to highlight the high-frequency trends.
Interval	This process sets the size of the cells in the greyscale image of the data and thus the level of interpolation applied to the data
Low Pass Filter	This process uses either a Gaussian or uniformly weighted window to remove high-frequency trends from the data resulting in a smoothing effect.
Reduce Points	This process uses an algorithm to reduce the number of data points passed to subsequent processing step. This process is used to reduce processing time for large data sets.
Remove Turns	This process is used to separate a track of data into individual traverses when data collection was not manually stopped by the surveyor at the end of each traverse. A turn is detected by a change in direction of travel and set in degrees. This is commonly used when data is collected using a mechanical towing device.
Straighten	This process corrects sudden changes in direction along a traverse. This process is used to correct errors caused by the GNSS changing between satellite constellations which cause a slight jump in position.
Track Radius	This process sets the size of area around each data point which is included in the interpolated calculation.

APPENDIX 8 – DISCOVERY AND EXCAVATION IN SCOTLAND TEXT

The text below was submitted for inclusion in the next Discovery and Excavation in Scotland.

The HES Archaeological Survey team undertook a geophysical survey (gradiometer and electro-magnetic) at Castle Greg. The field work was conducted on 21st and 22nd July 2022. In total 0.28ha was surveyed using a *Sensys MXPDA gradiometer and 0.29hs covered using a hand-held GF Instruments CMD Mini Explorer covering the Roman Fortlet. The geophysical survey has produced good quality gradiometer results, which have successfully contributed to the aims of the survey. There is a high level of confidence that the chosen methodology and survey strategy was appropriate to assess the archaeological potential of the survey area.*

The geophysical survey identified possible building and a possible oven within the ramparts.

(Project ID: CAGR2021)

APPENDIX 9 – NATIONAL RECORD OF THE HISTORIC ENVIRONMENT SITE RECORD CREATION OR AMENDMENT

The following table details the National Record of the Historic Environment entries which have been amended or created as a result of this survey.

NRHE ID	Anomaly ID	Change	Notes
48988	WORM2021-0001, WORM2021-0002, WORM2021-0003, WORM2021-0004, WORM2021-0005, WORM2021-0006, WORM2021-0007, WORM2021-0008, WORM2021-0009, WORM2021-0010, WORM2021-0011, WORM2021-0012, WORM2021-0013, WORM2021-0014, WORM2021-0015, WORM2021-0016, WORM2021-0017, WORM2021-0018, WORM2021-0019	Addition	

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