

New House Farm, Luzlow, Stoke-on-Trent

Geophysical Survey Report for SLR Consulting

July 2024

Ecus Ltd

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1. Summary

- 1.1.1 Ecus Ltd were commissioned to carry out an archaeological geophysical survey for SLR Consulting Ltd at New House Farm, Luzlow, Stoke-on-Trent, in July 2024. A total of five linear areas within four agricultural fields were surveyed, measuring a combined area of c. 2 ha. The Site is situated on the west side of Luzlow Lane, 1.2 km north-northwest of Werrington and 2.2 km northeast of the periphery of Stoke-on-Trent.
- 1.1.2 The geophysical survey produced good data and highlighted several anomalies that are interpreted as modern in origin. A series of positive, interconnected linear anomalies have been identified traversing the survey area predominantly in the west. These are likely to be a network of land drains. Several smaller anomalies also interpreted as land drains are noted to the southeast.
- 1.1.3 Elsewhere, modern ferrous disturbance is noted throughout the survey area, including to the north surrounding a probable underground service such as a pipe or cable, as well as to the southeast under the overhead powerlines.

2. Introduction

2.1 Project Background

- 2.1.1 Ecus Ltd were commissioned by SLR Consulting to undertake a programme of archaeological geophysical survey ahead of a proposed development on land at New House Farm, Luzlow, Stoke-on-Trent (hereafter 'the Site'), centred on National Grid Reference (NGR) 393320 349080 (SJ 93320 49080) (Figure 1).

2.2 Location, Topography and Geology

- 2.2.1 The Site was located immediately to the west of Luzlow Lane, 1.2 km north-northwest of Werrington and 2.2 km northeast of the periphery of Stoke-on-Trent. The survey area was c. 2 ha in size and comprises five generally linear portions across four agricultural fields. The immediate field boundaries were demarcated by hedgerows, trees and ditches.
- 2.2.1 The survey area was on a west-facing slope, falling from approximately 251 m above Ordnance Datum (aOD) to the east of the linear corridor to the southeast, to approximately 241 m aOD at the western boundary.
- 2.2.2 The underlying geology is recorded as Mudstone, Siltstone and Sandstone of the Millstone Grit Group throughout the majority of the Site. An area of Rough Rock (Sandstone) is noted to the west and Chatsworth Grit (Sandstone) to the east. The superficial deposits are recorded as Till, Devensian – Diamicton (British Geological Survey, 2024).

3. Archaeological and Historical Background

3.1 Introduction

- 3.1.1 The following historical and archaeological background has been compiled using publicly available online resources within an approximate 2 km search radius. While not exhaustive, the below aims to present a summary of the known archaeological and historical resource considered relevant to the interpretation of the geophysical survey data.
- 3.1.2 No archaeological investigations have taken place within the survey area.

3.2 Summary of Archaeological and Historical Resource

Prehistoric

- 3.2.1 An axe head believed to be Neolithic or Bronze-Age in date, was discovered at Moore Hill Farm located c. 1.24 km northeast of the Site in 1964. A second axe head of similar date was also found at Bank Hill Farm located c. 1.48 km northwest of the Site.
- 3.2.2 A probable Neolithic end scrapper was found c. 220 m southwest from the Site. The scrapper was heavily abraded and retouched at the distil end.

Medieval

- 3.2.3 The nearby village of Bagnall located c. 1.84 km northeast of the Site and is believed to be an old medieval settlement. The local church is thought to be of medieval origin.
- 3.2.4 Evidence of medieval ridge and furrow cultivation is visible in aerial photography c. 1.56 km northeast of the Site. An earthwork bank in the shape of a crescent is also visible within the same area (Hunting Surveys Ltd. 1963).
- 3.2.5 Remnants of ridge and furrow are also evident c. 1.9 km North of the Site at Bagnall Golf Course. Though these have mostly degraded due to modern use of the course.

Post medieval to modern

- 3.2.6 There are several Grade II listed buildings within the search radius of the Site. Specifically, within the nearby village of Bagnall. These are comprised of dwellings and farm buildings originating in the 18th to early 20th centuries.
- 3.2.7 In 1890, an infectious disease hospital was constructed c. 1.7 km northwest of the Site. Originally a timber structure, it was rebuilt in brick 1906. Bagnall Heights Retirement Home now sits on the original site.

- 3.2.8 In August 1944, an American P-47 Thunderbolt fighter-bomber crashed during a training exercise at Greenway Hall Golf Course c. 2.24 km northwest of the Site. The wreckage of the plane was excavated in the 1980's and is marked by a depression in the ground.

4. Geophysical Survey Methodology

- 4.1.1 All survey work was completed to appropriate standards, as outlined by existing guidance (ClfA 2020a; 2020b, 2022; Schmidt *et al.* 2015).
- 4.1.2 The gradiometer survey was completed using Sensys FGM650/3 dual magnetic gradiometer system with data logger mounted on a non-magnetic cart-system and towed behind an All-Terrain Vehicle at a suitable distance. Readings were recorded at a resolution of 0.01 nT and data collected with a traverse interval of 0.75 m and a sample interval of between 0.20–0.25 m (further details are available in Appendix A).
- 4.1.3 Data was collected by traversing the survey area in 4.5 m increments with the gradiometer systems mounted on a carbon fibre hand-pushed cart to achieve the best possible results. Real Time Kinematic (RTK) differential GPS equipment was used to accurately determine the position of the survey equipment and monitor data.
- 4.1.4 The processing of survey data was undertaken using TerraSurveyor64 software and consisted of standard processing procedures. The accompanying figures were created using QGIS software and support the findings of the survey as described in Section 6 and 7 below.
- 4.1.5 Interpretation of identified anomalies was achieved through analysis of anomaly patterning and increases in magnetic response and was aided by examining the available supporting information. The interpretations follow Ecus' colour coding and categorisations of anomalies and attempt, where possible, to suggest the nature of buried features (see Appendix A).

5. Mitigating Factors

- 5.1.1 At the time of the survey, Site conditions were dry with all survey areas comprised of harvested grassland. This did not have a negative effect on the quality of the survey data. However, haybales were present across the survey area which has resulted in small gaps in the survey data where obstacles were avoided.
- 5.1.2 Field boundaries comprised hedgerows and wire fencing. Where necessary, a 2 m-buffer was maintained along the wire fencing and other obstacles to minimise the effects of magnetic interference on the survey data and to help to reduce, as far as reasonably practicable, any non-detection of potential buried features.
- 5.1.3 The results of the geophysical survey may not reveal all potential archaeology within a survey area, and geological, agricultural and modern features may limit the detection of weaker archaeological responses.

6. Results of Interpretation

6.1.1 Anomalies found within the survey data are listed in Table 1 and shown on Figure 3.

Table 1: Survey Anomalies

Anomaly Number	Anomaly Type	Description	Interpretation
1.	Land Drains	Weak, interconnected positive linear anomalies on various alignments to the west of the survey area.	These anomalies represent a modern field drainage system.
2.	Modern Service	Strong, dipolar linear anomaly noted traversing the northeast linear portion of the survey area on a northwest to southeast alignment.	This anomaly indicates an underlying service such as a pipe or cable.
3.	Ferrous Disturbance	A series of irregular shaped, dipolar anomalies predominantly noted at the periphery of the survey area as well as surrounding anomaly (2), as well as to the southeast at (3)	These anomalies are likely caused by proximity to boundary fencing and as well as the underlying service to the northeast (2). Anomaly (3) is caused by an overhead powerline traversing this portion of the survey area.
N/A	Ferrous Spike	Circular dipolar anomalies located throughout the Site.	These anomalies most likely indicate sporadic agricultural waste or other ferrous materials as a result of modern agricultural practice.

7. Discussion

- 7.1.1 The geophysical survey produced good data and highlighted several anomalies that are interpreted as modern in origin. A series of positive, interconnected linear anomalies have been identified traversing the survey area predominantly in the west. These are likely to be a network of land drains.
- 7.1.2 Elsewhere, modern ferrous disturbance is noted throughout the survey area, including to the north surrounding a likely underground service such as a pipe or cable, as well as to the south under the overhead powerlines.
- 7.1.3 While anomalies associated with recent agricultural land use are prevalent in the survey data, these are not likely to be of medieval or earlier origin, such as those identified in the surrounding landscape. No further anomalies indicating archaeological features have been identified.

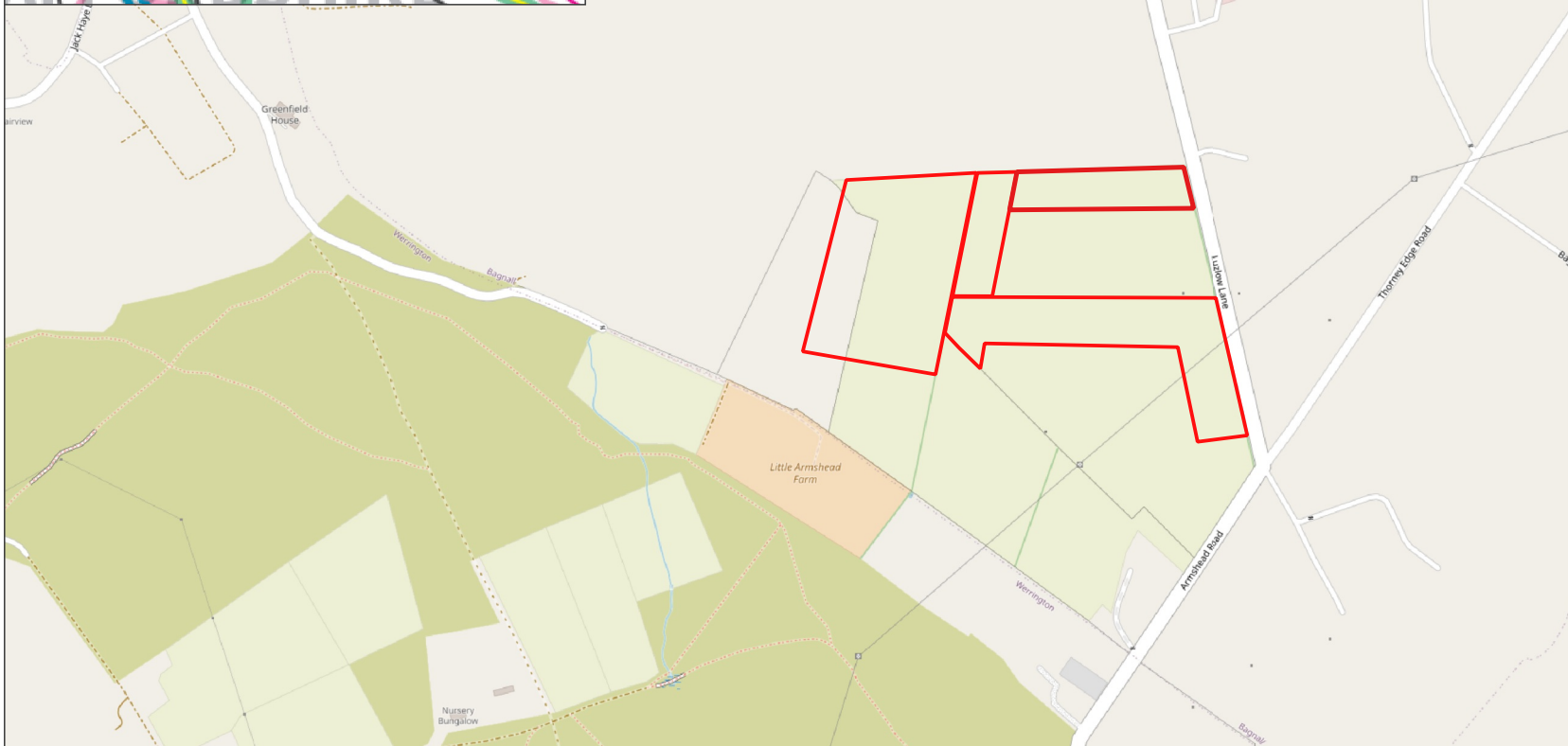
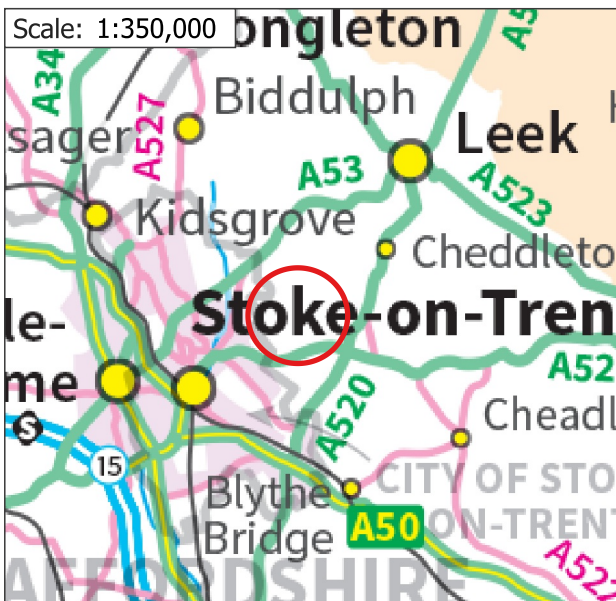
8. Storage and Curation

- 8.1.1 The archive will be prepared in accordance with national guidelines (ClfA 2020b). The integrity of the primary field record will be preserved. Security copies will be maintained where appropriate. Digital records of the geophysical survey will be held by Ecus.
- 8.1.2 An OASIS form has been created on the results of the works under the reference number (ecusltd1-526677). Following approval, a pdf version of the final version of this report will be submitted within three months to the Archaeology Data Service via the OASIS form.

References

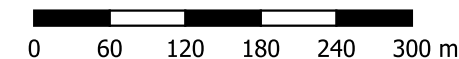
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Scale: 1:350,000



Key

Site Boundary



SLR Consulting
New House Farm, Luzlow,
Stoke-on-Trent

Figure 1
Site Location

A	17.06.24	PFP	-
Rev	Date	Drawn by	Checked by
Site centred on:		SJ 93363 49110	



Key

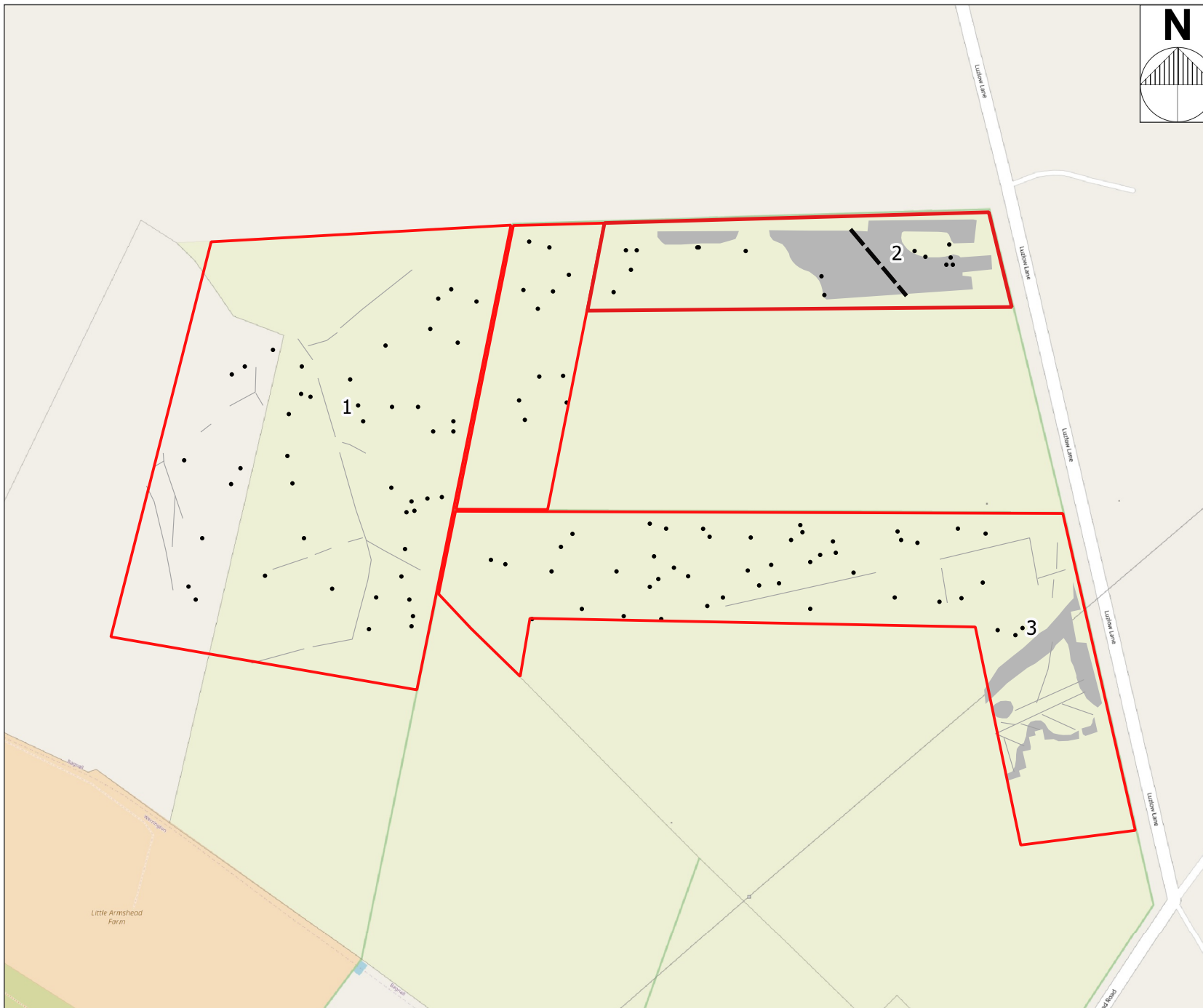
Site Boundary

0 20 40 60 80 100 m

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Figure 2
Greyscale Plot

A	18.06.24	PFP	-
Rev	Date	Drawn by	Checked by
Site centred on:		SJ 93363 49110	



Key

- Site Boundary
- Drainage
- Service
- Ferrous spike
- Ferrous Disturbance



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Figure 3
Interpretation Plot

A	18.06.24	PFP	-
Rev	Date	Drawn by	Checked by
Site centred on:		SJ 93363 49110	

Appendix 1: Technical Information

Gradiometer Survey

Magnetic surveys measure distortions in the earth's magnetic field caused by small magnetic fields associated with buried features (Gaffney and Gater 2003, 36) that have either remnant or induced magnetic properties (Aspinal *et al.* 2008, 21–26). Human activity and inhabitation often alter the magnetic properties of materials (Aspinal *et al.* 2008, 21) resulting in the ability for numerous archaeological features to be detected through magnetic surveys. Intensive burning or heating can result in materials attaining a thermoremanent magnetisation; examples of which include kilns, ovens, hearths, and brick structures (Aspinal *et al.* 2008, 27; Gaffney and Gater, 2003, 37). When topsoil-rich with iron oxides, fills a man-made depression in the subsoil, it creates an infilled feature, such as a pit or ditch, with a higher magnetic susceptibility compared to the surrounding soil (Aspinal *et al.* 2008, 37–41; Gaffney and Gater 2003, 22–26). Magnetic surveys can also detect features with a lower magnetic susceptibility than the surrounding soil, an example of which is a stone wall.

Limitations

Poor results can be due to several factors including short lived archaeological occupation/use or sites with minimal cut or built features. Results can also be limited in areas with soils naturally deficient in iron compounds or in areas with soils overlying naturally magnetic geology, which will produce strong responses masking archaeological features.

Overlying layers, such as demolition rubble or layers of made ground, can hide any earlier archaeological features. The presence of above ground structures and underground services containing ferrous material can distort or mask nearby features.

Particularly uneven or steep ground can increase the processing required or distort results beyond the capabilities of processing. It is also possible in areas containing dramatic topographical changes that natural weathering, such as hill wash, often in combination with intensive modern ploughing, will reduce the topsoil on slopes and towards the peaks of hills and possibly destroy or truncate potential archaeological features. Conversely features at the bottom of slopes may be covered by a greater layer of topsoil and so if buried features are present, they appear faint within the results, if at all.

Over-processing of data can also obscure or remove features, especially if there are on the same orientation as the direction of data collection. Consequently, where possible, attempts are made to ensure data is not collected on the same orientation as known potential features and that data quality is sufficient to minimise the required data processing.

Instrumentation

The data was collected using Bartington Grad 601-2 fluxgate gradiometers, either in a cart configuration with four sensors arranged at one metre intervals or as handheld pairs of sensors. The Bartington 601-2 is a single axis, vertical component fluxgate gradiometer comprising a data logger battery cassette and two sensors. The sensors are Grad-01-1000L cylindrical gradiometer sensors mounted on a rigid carrying frame; each sensor contains two fluxgate magnetometers with 1 m vertical separation.

The difference in the magnetic field between the two fluxgates in each sensor is measured in nano Tesla (nT). The gradiometer data is recorded with a range of $\pm 100\text{nT}$, which equates to a resolution of 0.01nT . It should be noted that the actual resolution is limited to 0.03nT because of internal instrumental noise (Bartington Instruments Ltd, n.d., 23). The gradiometers are calibrated at the start of every day and recalibrated whenever necessary.

The data was collected using SENSYS FGM650/3 magnetometer in a cart configuration with five sensors arranged at 1 m intervals. This gradiometer data is recorded with a range of $\pm 1000\text{nT}$, which equates to a resolution of 0.01nT . It should be noted that the actual resolution is limited to 0.03nT because of internal instrumental noise.

The gradiometer records five lines of data on each traverse, with traverses walked in a zig-zag pattern until all the survey is covered.

Appendix 2: Data Visualisation Information

The data was used to produce a series of images to demonstrate the results of surveys, detailed below:

Greyscale/colour scale plot – This visualised the results as a shaded drawing with highest readings showing as black, running through different shades to lowest showing as white.

Interpreted plot – Through detailed analysis, anomalies have been interpreted and possible features identified. Interpretation drawings are used to show potential features and to reinforce and clarify the written interpretation of the data. Anomalies have been characterised using the terminology detailed in the following section and have been assigned colour coding, which is outlined in keys on figures associated with this report.

Magnetic Anomalies and Terminology

Table 2: Lexicon of Terminology

Terminology	Detail
Anomaly	Any outstanding high or low readings forming a particular shape or covering a specific area with the survey results.
Feature	A man-made or naturally created object or material that has been detected through investigation works and has sufficient characteristics or supporting evidence for positive identification.
Magnetic susceptibility	The ability of a buried feature to be magnetically induced when a magnetic field is applied.
Magnetic response	The strength of the changes in magnetic values caused by a buried feature with either a greater or lesser ability to be magnetised compared with the soil around it. Anomalies are considered to either have strong/weak or positive/negative responses. The strength of magnetic response (along with patterning) can be essential in determining the nature of an anomaly, but it should be noted that the size or strength of the magnetic response does not correlate with the size of the buried feature.

Patterning of an anomaly	The shape or form of an individual anomaly.
Thermoremanence	The affect caused when a material has been magnetically altered through a process of heating. Thermoremanent magnetisation occurs when an object or material is heated passed the Curie Point and acquires a permanent magnetisation that is associated with the magnetic field that they cooled within (Gaffney and Gater 2003, 37).

Different anomalies can represent different features created by human occupation, agricultural or modern activity, or natural pedological or geological changes in the substrata. Anomalies interpreted as 'greater' are considered more likely to be of the interpreted characterisation; whereas a 'lesser' categorisation represents a more tentative interpretation applied to those anomalies with weaker increases in magnetic response or if the anomaly has incomplete patterning or irregular form. The strength and size of anomalies can vary depending on the magnetic properties of the feature, the magnetic susceptibility of the soil, the depth at which the feature is buried, and the state of preservation.

Table 3: Characterisation of anomalies

Characterisation	Detail
Archaeology and probable archaeology	Linear anomalies with a positive or negative magnetic responses and composed of a patterning or shape that is suggestive of a buried archaeological feature. These are often indicative of structural remains or infilled features such as ditches. The strength of anomaly signal can be suggestive of the properties of the feature. Negative linear anomalies represent upstanding or infilled features that are less magnetically susceptible than background readings, for example structures or ditches composed of a non-igneous stone material. Bipolar linear anomalies considered to be of an archaeological nature are indicative of material with a high magnetic susceptibility, such as a brick wall. Isolated anomalies or anomalies with a more amorphous form possibly represent infilled features or thermomagnetic features such as areas of heating/burning of an archaeological origin. Unless

	associated with conclusively identified archaeological remains, such as linear anomalies, absolute identification of positive responses can be problematic as it is often not possible to decipher if they are of an archaeological, modern, or agricultural origin. Consequently, isolated positive responses are not shown within the interpretation unless composed of a broad form or belonging to a series of isolated positive responses. Bipolar responses considered likely to be of an archaeological origin are also interpreted as isolated anomaly (archaeology). These are considered to relate to material with a very strong magnetic susceptibility or thermoremanent magnetisation.
Possible archaeology	Weak and diffuse anomalies with an uncertain origin are denoted by trends. It is possible that these belong to archaeological features but given their weak signatures or incomplete patterning it is equally plausible that they relate to agricultural features or natural soil formations.
Historic Feature	Linear anomalies, sub/irregular-rectilinear either with positive or negative magnetic responses, that correspond with the location of field boundaries, ponds or buildings recorded on historic maps, Aerial photos or LiDAR coverage of the site.
Ridge and furrow	Broadly spaced linear anomalies that are likely to be indicative of earlier forms of agriculture, such as ridge and furrow. These often correspond with the location of earthworks visible on the ground or identified on aerial photos or LiDAR survey coverage.
Masking anomalies	
Strongly magnetic bipolar or dipolar.	Positive anomalies with associated negative 'halo' (bipolar) denote features with a strong magnetic response are likely to be of a modern origin.
Service	Isolated bipolar responses of a modern nature are likely to relate to buried ferrous material or objects, such as

	metallic agricultural debris. If a trend is noted in the alignment or spacing of isolated bipolar responses, it is possible that they are indicative of ferrous fittings or connectors used on buried non-magnetic buried utilities.
Increased magnetic response / ferrous disturbance	Areas of magnetic disturbance, often along the edges of survey areas are caused by standing metal structures such as fencing and buildings. Also, areas of increased magnetic response denote areas of disturbance containing a high concentration of dipolar or bipolar responses. These are generally considered to be caused by modern debris in the topsoil, although it is possible that the disturbance is in part also caused by isolated archaeological material or geological or pedological changes in the substrata.
Modern Agriculture	
Ploughing trend, land drain	Ploughing trend tends to be regularly spaced linear anomalies, often with a narrower spacing, that conform with ploughing regime at the time of survey, or a recent regime recorded on aerial photos of the site. The response and distribution of land drains varies depending on the composition of the land drain and associated ditch or channel. Consequently, land drains can be composed of weak / strong positive / negative magnetic responses and are identified as a product of either their variance in magnetic values or positioning compared with regularly spaced linear anomalies considered to relate to modern ploughing. Land drains can be located within former agricultural regimes, such as ridge and furrow.

