

2EE02 EEW - HS2 Phase 2a Early Environmental Works

# Site 082 - Geophysics Survey Report Heritage Non-intrusive Survey Reports Group 011

Document no: 2EE02-BAF-EV-REP-WS04-000011

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C01	Matt Berry	Sam Harrison	Alistair Webb	31/10/2022	1 <sup>st</sup> Issue

Methodology	Project Plan Site Code
Gradiometer (Magnetometer) Survey	2a20DPIRMG

Security classification: OFFICIAL

HS2 Ltd - Code 1 - Accepted

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# 1 Executive Summary

- 1.1.1 This document comprises a Final Report for a non-intrusive geophysical survey on the route of the proposed Phase 2a of High Speed Two (HS2) covering land proposed for development or likely to be impacted during the scheme as part of the Early Environmental Works (EEW) package. This report contains the results of a magnetometer survey undertaken on 2nd February 2022 at Site 82 within Group 011.
- 1.1.2 The aim of the survey is to establish the presence/absence, extent and character of detectable archaeological remains within the proposed route of HS2 Phase 2a. The scope of the surveys is dependent upon securing access to the land and for the areas to be suitable for survey.
- 1.1.3 EEW Group 011 is located to south of the town of Stone and west of the village of Aston-By-Stone, Staffordshire. Site 82 is located approximately 415m south of North Pirehill Farm and immediately adjacent to the Staffordshire Fire and Rescue Headquarters and encompasses c.6.8ha of which approximately 1.6ha was required for magnetometer survey over two separate parcels of land.
- 1.1.4 The HS2 Ltd Phase 2a GWSI: HERDS document indicates that the EEW Group area is not situated within a Recognised Archaeological zone (RAZ).
- 1.1.5 The survey has not identified any anomalies of definite archaeological origin. No distinguishable anomalies are evident in the westernmost parcel of the site.
- 1.1.6 Anomalies in the easternmost parcel all likely relate in some way to the topography which undulates and steeply slopes down to the north and west, towards a copse and pond which bound the survey area. Linear responses surrounding an area of magnetic disturbance which corresponds to a former extraction pit marked on historic mapping, suggest the presence of fields drains and likely indicates attempts to drain and level through the tipping/infilling of magnetic material in this part of the field to aid arable cultivation. It remains plausible that some of the linear anomalies here may relate to the former fish pond and associated weir at this location which are linked to Aston Farm to the north, though it remains more likely the anomalies detected reflect modern attempts to improve drainage in this location of the field.

## 2 Introduction

### 2.1 Project Background

- 2.1.1 HS2 is a new railway network proposed by the Government to provide a new link between London, the West Midlands, the East Midlands, South Yorkshire, Leeds and Manchester. HS2 Phase 2a comprises approximately 36 miles of railway starting at Fradley at its southern end and connects with the West Coast Main Line (WCML), south of Crewe, to allow HS2 services to join the existing network and call at Crewe Station.
- 2.1.2 The overall framework within which archaeological work will be undertaken is set out in the draft Environmental Minimum Requirements (EMR) for HS2 Phase 2a. Accordingly, the nominated undertaker or any contractors will be required to implement certain control measures in relation to archaeology before construction work begins.
- 2.1.3 The works have been undertaken in accordance with Written Scheme of Investigation (WSI, HS2 2019) and conform with current best practice and guidance for geophysical surveys as outlined in the Chartered Institute for Archaeologists' (CIfA) Standard and Guidance for archaeological geophysical survey (CIfA 2014) and European Archaeologiae Consilium Guidelines for the use of Geophysics in Archaeology (EAC 2016).
- 2.1.4 The selection of areas required for geophysical survey included as part of this Early Environmental Works (EEW) package are set out in location specific Written Scheme of Investigations (WSIs) based on Groups containing individual sites. HS2 Ltd has provided each EEW site along the Phase 2a route with a unique identifier Site Code.
- 2.1.5 Within EEW Group 011 (HS2 2021) the Site Code for geophysical survey is:
- Site 82: 2a20DPIRMG

### 2.2 Scope of Document

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

### 2.3 The Site

- 2.3.1 EEW Group 011 is located to south of the town of Stone and west of the village of Aston-By-Stone, Staffordshire. Site 82 is located approximately 415m south of North Pirehill Farm and immediately adjacent to the Staffordshire Fire and Rescue Headquarters and is centred at NGR 390023 330825. The Site encompasses c.6.8ha of which approximately 1.6ha was required for magnetometer survey over two separate sub-rectangular parcels of land (Figure 1).
- 2.3.2 The westernmost survey parcel was under pasture and the remaining area adjacent the Fire and

Rescue Headquarters contained a young cereal crop at the time of survey. Full coverage of the site was achieved except for a very small waterlogged area in the eastern parcel.

- 2.3.3 The easternmost parcel slopes down to the west and north towards an extant pond and copse from c.106m above Ordnance Datum (aOD) at the boundary with the Fire and Rescue Headquarters to 96m aOD in the location of the pond. The westernmost parcel was flat at approximately 105m aOD.
- 2.3.4 The solid geology across both parcels within the Site is recorded as mudstone of the Mercia Mudstone Group. No superficial deposits are recorded across the westernmost parcel but the survey area adjacent the Fire and Rescue Headquarters is overlain by till, diamicton (BGS 2021).
- 2.3.5 The soils covering the eastern parcel of the Site area classified in Soilscape 8 Association described as slightly acid loamy and clayey soils with impeded drainage. The soils covering the western parcel of the Site area classified in Soilscape 18 Association described as slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils (Cranfield University 2020).
- 2.3.6 Average responses of magnetometer surveys over mudstones are generally poor but results can be very variable depending on the nature and depth of overlying deposits if present (English Heritage 2008; Table 4). It remains that magnetometry was the most appropriate geophysical technique for evaluating the Site taking account of the limitations noted in Section 4.3 below.

## 3 Archaeological Background

### 3.1 Summary of the archaeological resource

- 3.1.1 The following archaeological background summarises details from the Location Specific Written Scheme of Investigation (LSWSI, HS2 2021) together with information from publicly available online resources and other in-house resources.
- 3.1.2 The assessment and determination of the significance of archaeological assets is defined by Chapter 10 of the HS2 Ltd EIA Scope and Methodology Report (HS2 2017a).
- 3.1.3 The Recognised Archaeological Zones (RAZ) represent a high-level indication of likely concentrations of archaeological remains across the Phase 2a route. The location and spatial extent of RAZs has been determined using HS2 Environmental Statement (ES) Cultural Heritage information and subsequent survey data.
- 3.1.4 The HS2 Ltd Phase 2a GWSI: HERDS document indicates that the EEW Group area is not situated within a RAZ.
- 3.1.5 The HS2 Environmental Statement (ES; HS2 2017b) and Staffordshire Historic Environment Record (HER) has identified two archaeological assets within or immediately adjacent to Site 82:
- A collection of post-medieval water management features adjacent to the north-east boundary of Site 82 which consist of an extant mill pond, leat and fishpond by Aston Farm (HER MST14524, MST2031 / STS076). These features were visible in the Ordnance Survey 25": mile map of 1878. If post-medieval water management features, associated with these assets, are extant within the site area they would be of low significance.
  - Pire Hill, possibly meaning 'look-out hill' or possibly associated with the use of the area as the site of an early medieval beacon or other activity involving fire, is situated 280m west of the site boundary (HER MST3623). Pire Hill was the meeting place of one of the Staffordshire hundreds. If evidence of early medieval activity is encountered within the site area these remains may be considered of moderate to high significance depending on the state of preservation and type of remains.
- 3.1.6 The CA 3: Fradley to Colton: Cultural heritage survey report (HS2 2017c) noted that geophysical survey work has been undertaken within the immediate vicinity of the EEW Group area. The survey work was undertaken in survey area CA3-1997, adjacent to and

partially within the south-west most part of Site 82, and CA3-2008, overlapping with the western and central area of Site 82. The features recorded within these areas comprise:

- 3-1997-001: An area of dipolar concentration, located within the southern site area, which is likely an archaeological feature. Specially, the anomaly represents a possible 'old marl pit' identified in the Ordnance Survey 25": mile map of 1924 which indicates evidence of post-medieval extraction. This evidence is corroborated by a circular depression identified during remote sensing surveys, LiDAR ID 2330. If extant, these remains would be of low significance.
- 3-2008-002: A linear anomaly, located north of the extant pond feature, thought to be a former field boundary which may be of post-medieval or modern date, aligned north-west to south-east. This feature is of negligible to low significance.

3.1.7 LiDAR/ Remote sensing survey data (HS2 2017c) identified two features within or adjacent to Site 82 which comprise:

- Aerial photography ID 131: An area of possible vestigial ridge and furrow, overlapping with the central area of Site 82, aligned north-west to south-east. These may be post-medieval; however, the features may be the product of modern ploughing. If extant and of post-medieval, these remains would be of low significance.
- LiDAR ID 2330: A sub-rectangular depression, located in the southern area of Site 82, measuring approximately 85m × 50m and aligned east to west. The feature appeared to have been truncated down the central axis from north to south and is visible in the 1870s County Series mapping. It is thought to be an infilled post-medieval extraction pit, possibly the same 'Old Marl Pit' identified in Ordnance Survey mapping and geophysical anomaly 3-1997-001, or a former pond feature. If extant, this asset would be of low significance.

3.1.8 Heritage Asset data supplied from the HS2 APS database identifies one feature within EEW group 011 which comprises:

- Asset ID 131: a large area of indicative medieval and/or post-medieval ridge and furrow identified through a series of aerial photographs taken between 1945-1955. These ridge and furrow features are thought to have been mostly levelled in the 21st century through modern ploughing. If extant, this asset would be of negligible to low value.

## 4 Methodology

### 4.1 Magnetometry

Magnetic survey methods rely on the ability of a variety of instruments to measure very small magnetic fields associated with buried archaeological remains. A feature such as a ditch, pit or kiln can act like a small magnet, or series of magnets, that produce distortions (anomalies) in the earth's magnetic field. In mapping these slight variations, detailed plans of sites can be obtained as buried features often produce reasonably characteristic anomaly shapes and strengths (Gaffney and Gater 2003). Further information on soil magnetism and the interpretation of magnetic anomalies is provided in Annex 1 and Annex 2 respectively.

### 4.2 Aims and Objectives

4.2.1 The aims of the survey comprise the following:

- To determine, as far as is reasonably possible, the nature of the detectable archaeological resource within a specified area using appropriate methods and practices; and
- To inform either the scope and nature of any further archaeological work that may be required; or the formation of a mitigation strategy (to offset the impact of the development on the archaeological resource); or a management strategy.

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

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

### 4.3 Assumptions and limitations

Magnetometry is the most widely used geophysical survey technique in archaeology as it can quickly evaluate large areas and, under favourable conditions, identify a wide range of archaeological features including infilled cut features such as large pits, gullies and ditches, hearths, and areas of burning and kilns and brick structures. It is therefore good at locating

settlements of all periods, prehistoric field systems and enclosures and areas of industrial or modern activity, amongst others. It is less successful in identifying smaller features such as post-holes and small pits (except when using a non-standard sampling interval), unenclosed (prehistoric) settlement sites and graves/burial grounds. Magnetometry has the potential to rapidly confirm the presence/absence of a wide range of potential archaeological remains within the site and was thus chosen as the most appropriate technique in this instance.

## 4.4 Fieldwork Methodology

4.4.1 The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 4m apart (Figure 1). These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point, in accordance with EAC guidelines (EAC 2016).

4.4.2 Unenclosed areas were surveyed using the co-ordinates of the pre-determined Site boundary visible as an outline on the MLGrad601 software during data collection.

4.4.3 MLGrad601 (Geomar Software Inc.) software was used to collect the data.

## 4.5 Data processing

4.5.1 Data collected using RTK GPS-based methods cannot be produced without minimal processing of the data. The minimally processed data has been interpolated to project the data onto a regular grid and de-striped to correct for slight variations in instrument calibration drift and any other artificial data.

4.5.2 A high pass filter has been applied to the greyscale plots to remove low frequency anomalies (relating to survey tracks and modern agricultural features) to maximise the clarity and interpretability of the archaeological anomalies.

4.5.3 The data has also been clipped to remove extreme values and to improve data contrast.

4.5.4 MultiGrad601 (Geomar Software Inc.) software was used to export the survey data files.

4.5.5 Terrasurveyor V3.0.37.0 (DWConsulting) software was used to process and export graphical plots the data.

# 5 Geophysical Survey Results and Interpretation

## 5.1 Gradiometer survey results and interpretation

- 5.1.1 The magnetometer survey was carried out on the 2nd February 2022 and covered an area of 1.6ha.
- 5.1.2 Fully processed (greyscale) data, minimally processed data (XY trace plot) and interpretative plans are presented at a scale of 1:2,500 in Figures 2 – 4 inclusive.
- 5.1.3 The magnetic background is homogenous across the Site likely a result of the underlying mudstone geology.
- 5.1.4 Both survey areas were once part of Black Plantation visible on early 20th century OS mapping. Findings from the westernmost parcel are limited to a continuous stretch of magnetic disturbance at the field boundary caused by a metal fence. Occasional sporadic low magnitude and dipolar 'spike' anomalies are likely natural and modern in origin and of no archaeological consequence.
- 5.1.5 Anomalies in the easternmost parcel all likely relate in some way to the topography which undulates and steeply slopes down to the north and west towards the copse and pond which bound the survey area on the northern limit. A large concentration of high magnitude responses (82-001) positioned between two linear anomalies towards the centre of the parcel corresponds to a circular depression recorded on historic mapping and possibly identifies a former quarry pit. The magnetic response in the data suggests the infilling or dumping of magnetic material in this location.
- 5.1.6 A clear pattern of field drains (82-002) is visible in the western half of this parcel oriented north-northwest/south-southeast. Linear anomalies marked uncertain (82-003 and 82-004) likely identify services and/or field drains though the magnetic response does not indicate an obvious ferrous component to some of these features. The westernmost of these linear anomalies located at the edge of the copse (82-005) is perhaps the most likely to identify a former boundary or possible ditch given the consistently magnetically weak nature of the anomaly.
- 5.1.7 Occasional sporadic low magnitude and dipolar 'spike' anomalies are likely natural and modern in origin respectively. Areas of magnetic disturbance recorded at the field boundaries is caused by fencing or an accumulation of magnetic debris in the boundary itself and of no archaeological consequence.

## 6 Discussion

- 6.1.1 The survey has not identified any anomalies of definite archaeological origin. No distinguishable anomalies are evident in the westernmost parcel of the site.
- 6.1.2 Anomalies in the easternmost parcel all likely relate in some way to the topography which undulates and steeply slopes down to the north and west, towards the copse and pond which bound the survey area on the northern limit. Linear responses surrounding an area of magnetic disturbance which corresponds to a former extraction pit marked on historic mapping, suggest the presence of fields drains and likely indicates attempts to drain and level through the tipping/infilling of magnetic material in this part of the field to aid arable cultivation.
- 6.1.3 It remains plausible that some of the linear anomalies here may relate to the former fish pond and associated weir linked to Aston Farm to the north, though it remains more likely the anomalies detected reflect modern attempts to improve drainage in this location of the field.

# References

## Bibliography

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Cranfield University 2020 Cranfield Soil and Agrifood Institute Soilscales  
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2019 HS2 Phase 2a Written Scheme of Investigation for EI-711 Surveys Package 1: Magnetometry (HS2-HS2-EV-MST-A000001)

HS2, 2021, Phase 2a LS-WSI: EEW Group 011, EEW Site 82 (HS2 Document no: 2EE01-BAF-EV-PRO-A000-000028, Revision: 04)

# Annex 1: Magnetometer survey

## Magnetic susceptibility and soil magnetism

Iron makes up about 6% of the earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haematite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of the topsoil, subsoil and rock, into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected.

The magnetic susceptibility of a soil can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns, or areas of burning.

## Annex 2: Geophysical Interpretation

Most anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However, some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended. It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

### **Isolated dipolar anomalies (iron spikes)**

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being introduced into the soil during manuring.

### **Areas of magnetic disturbance**

These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

### **Lightning-induced remnant magnetisation (LIRM)**

LIRM anomalies are thought to be caused in the near surface soil horizons by the flow of an electrical current associated with lightning strikes. These observed anomalies have a strong bipolar signal which decreases with distance from the spike point and often appear as linear or radial in shape.

### **Linear trend**

This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

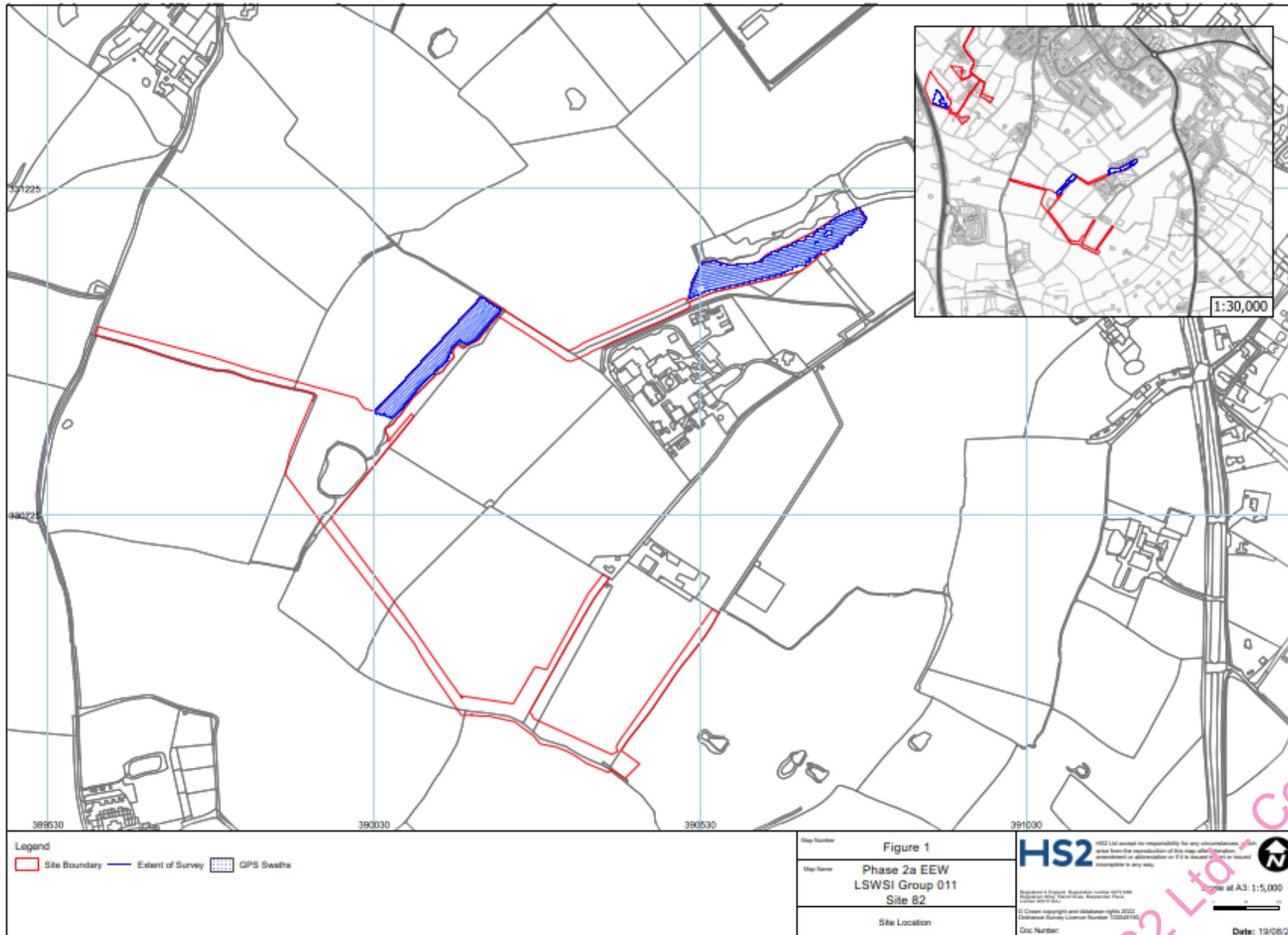
### **Areas of magnetic enhancement/positive isolated anomalies**

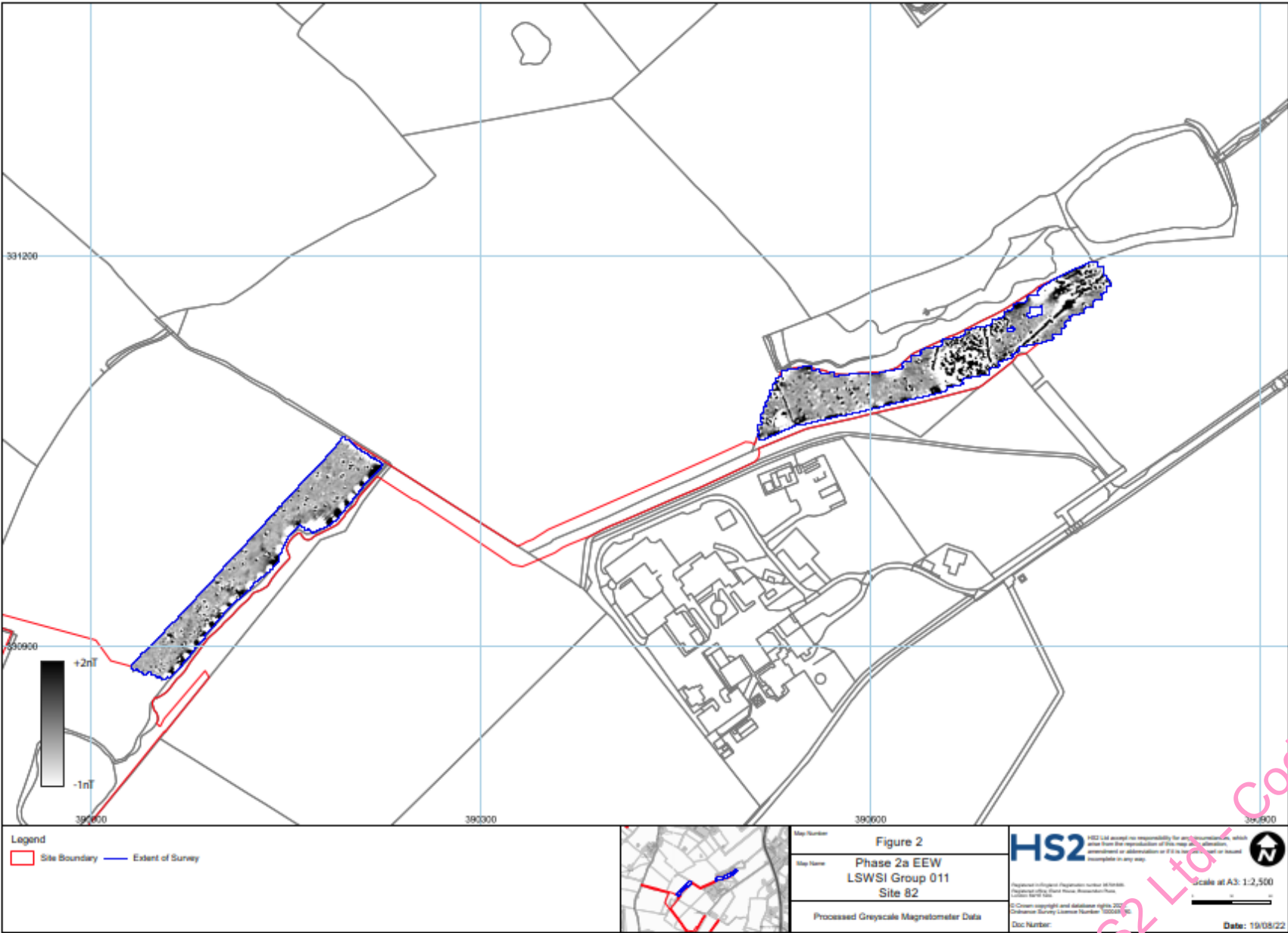
Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traces. In neither instance is there the intense dipolar response

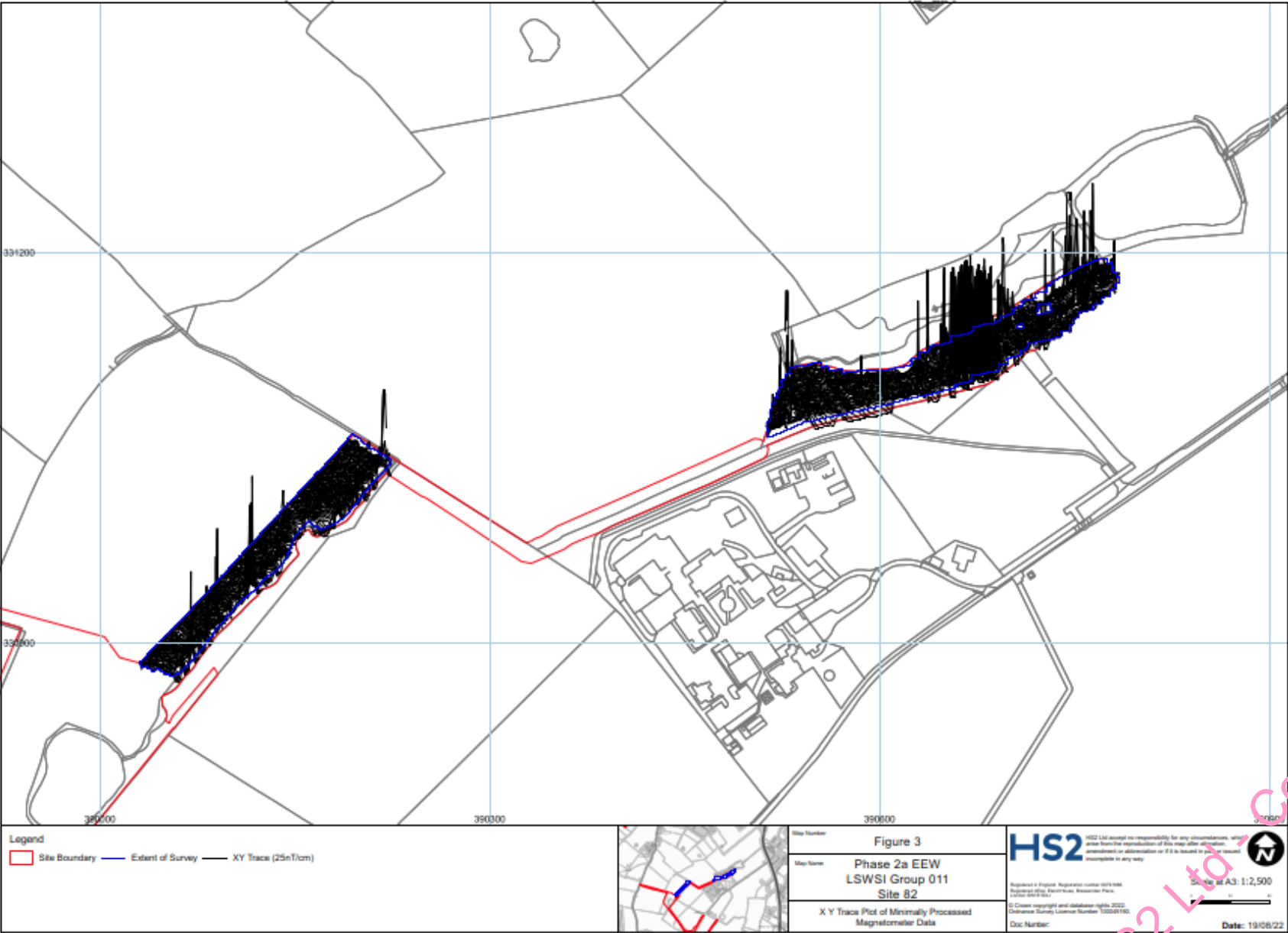
characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

## **Linear and curvilinear anomalies**

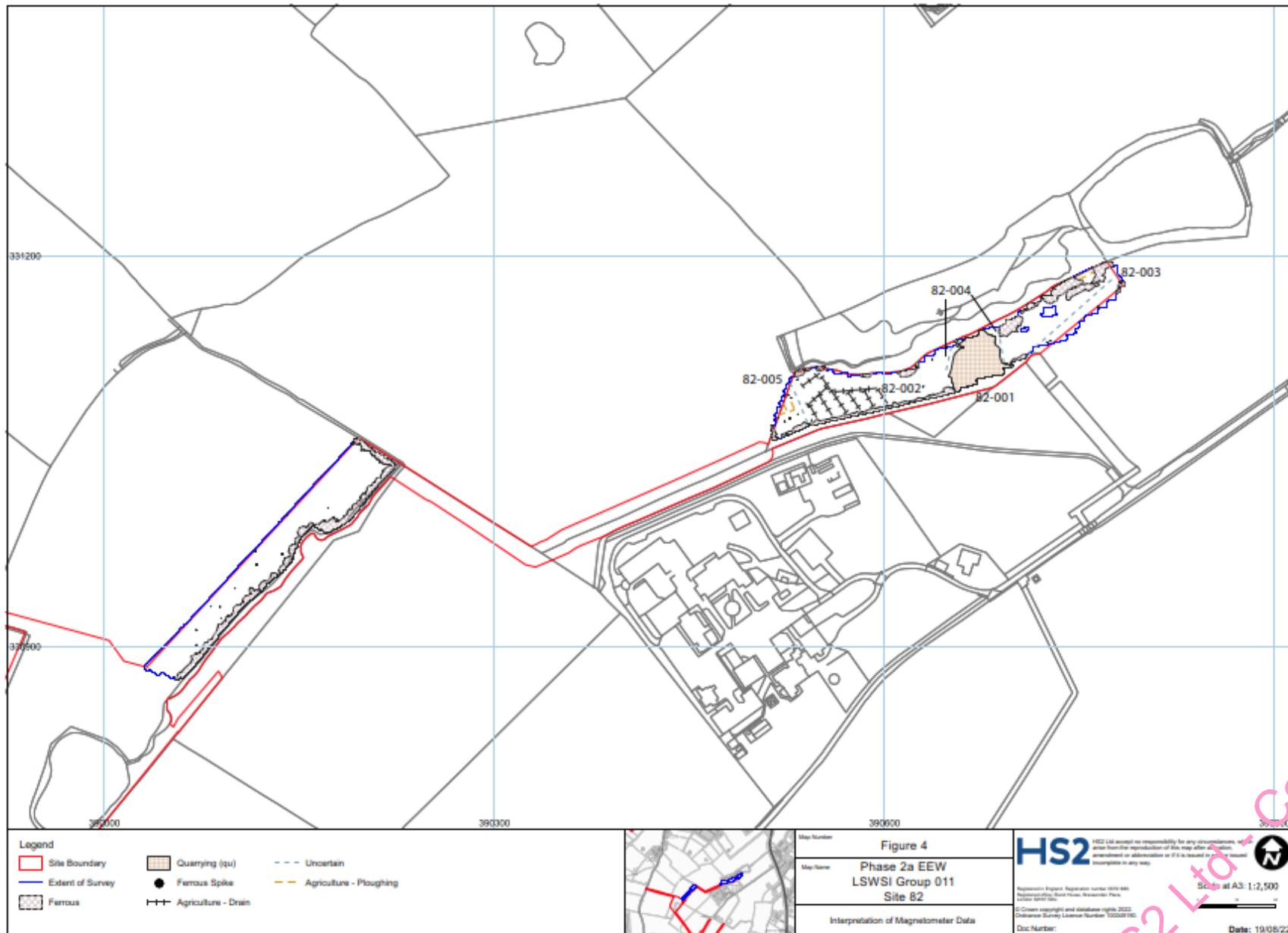
Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.







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## Annex 3: OASIS Form

**Project Details:**

<b>Project name</b>	Geophysical Survey at Group 011 Site 82
<b>Type of project</b>	Geophysical Survey, MAGNETOMETRY SURVEY
<b>Project description</b>	<p>The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 4m apart. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point, in accordance with EAC guidelines (EAC 2016).</p> <p>The survey has not identified any anomalies of definite archaeological origin. No distinguishable anomalies are evident in the westernmost parcel of the site. Anomalies in the easternmost parcel all likely relate in some way to the topography which undulates and steeply slopes down to the north and west, towards a copse and pond which bound the survey area. Linear responses surrounding an area of magnetic disturbance which corresponds to a former extraction pit marked on historic mapping, suggest the presence of fields drains and likely indicates attempts to drain and level through the tipping/infilling of magnetic material in this part of the field to aid arable cultivation. It remains plausible that some of the linear anomalies here may relate to the former fish pond and associated weir at this location which are linked to Aston Farm to the north, though it remains more likely the anomalies detected reflect modern attempts to improve drainage in this location of the field.</p>

<b>Project dates</b>		<b>Start:</b> 02-Feb-2022	<b>End:</b> 02-Feb-2022		
<b>Previous work</b>		N/A			
<b>Future work</b>		N/A			
<b>Project Code:</b>	Group 011 Site 82	<b>HER event no.</b>			

		<b>NMR no.</b>		<b>OASIS form ID:</b>	hs2headl1-509454
		<b>SM no.</b>			
<b>Planning Application Ref.</b>					
<b>Site Status</b>		None			
<b>Land use</b>		Arable and Pasture			
<b>Monument type</b>		N/A	<b>Period</b>	N/A	

**Project Location:**

<b>Site Address</b>	located approximately 415m south of North Pirehill Farm and immediately adjacent to the Staffordshire Fire and Rescue Headquarters			<b>Postcode</b>	
<b>County</b>	Staffordshire	<b>District</b>	Stafford	<b>Parish</b>	Stone Rural
<b>Study Area</b>	1.6ha	<b>Height OD</b>	Between 96 and 105m Above Ordnance Datum	<b>NGR</b>	SJ 90645 31118 SJ 90130 30965

**Project Creators:**

<b>Name of Organisation</b>	HS2 Headland Archaeology (UK) Ltd				
<b>Project brief originator</b>	HS2	<b>Project design originator</b>	HS2		
<b>Project Manager</b>	Alistair Webb	<b>Project Supervisor</b>	Matt Berry		
<b>Sponsor or funding body</b>	Balfour Beatty	<b>Type of Sponsor</b>	Client		

**Project Archive and Bibliography:**

<b>Physical archive</b>	N/A	<b>Digital Archive</b>	Geophysical survey and report	<b>Paper Archive</b>	N/A
<b>Report title</b>	Phase 2a Heritage Non-intrusive Surveys Report: Group 011 Site 82 Geophysics survey report			<b>Date</b>	31/10/2022
<b>Author</b>	Headland Archaeology	<b>Description</b>	PDF/A	<b>Report ref.</b>	

