NAA

GEOPHYSICAL SURVEY

DUDLEY DRIVE

GOLDTHORPE

SOUTH YORKSHIRE

prepared for
St Pauls Developments plc

NAA 21/59
November 2021

Northern
Archaeological
Associates

01833 690800
info@naaheritage.com
www.naaheritage.com
Marwood House
Harmire Enterprise Park
Barnard Castle
Co. Durham
DL12 8BN

QUALITY ASSURANCE		
Project Number	2112	
Report Number	21-59	
Manager	Alice James	
Edit	Andy Crowson	
Authorised	Alice James	
Issue 1		02/11/2021

Author Alice James and Greg Speed
Illustrations Alice James and Dawn Knowles

Client St Pauls Developments plc
Location Dudley Drive, Goldthorpe, South Yorkshire, S63 9AU
District South Yorkshire

Grid Ref SE 45085 04013
Fieldwork 19th to 20th June and 9th October 2021
OASIS Number northern1-433641

DUDLEY DRIVE, GOLDTHORPE, SOUTH YORKSHIRE
GEOPHYSICAL SURVEY REPORT

TABLE OF CONTENTS

FIGURE LIST

Disclaimer

The results of geophysical survey may not reveal all potential archaeology and do not provide a comprehensive map of the sub-surface, but only responses relative to the environment. Geological, agricultural and modern responses may mask archaeological features. Short-lived features may not give strong responses. Only clear features have been interpreted and discussed in this report.

DUDLEY DRIVE, GOLDTHORPE, SOUTH YORKSHIRE
GEOPHYSICAL SURVEY REPORT

Summary

Northern Archaeological Associates (NAA) was commissioned by St Pauls Developments plc to undertake a geophysical (gradiometer) survey on land at Dudley Drive, Goldthorpe, South Yorkshire in advance of a solar farm development (NGR: SE 45085 04013).

The geophysical survey was carried out between the 19th and 20th June and on 9th October, and covered 4 fields totalling c. 7.15ha.

The proposed development area (PDA) lies in a landscape rich in prehistoric and Roman archaeology. The geophysical survey has confirmed the potential for buried deposits from these periods to be present within the PDA by mapping a series of rectilinear, linear and sub-circular anomlies that are likely to be caused by a droveway, field systems, enclosures and ring ditches. The relationship and exact origin of anomalies is complex and further investigation is required to fully characterise the archaeological features that the anomalies relate to.

It is likely that the site was part of agricultural lands during the medieval period with survey results showing clear evidence of ridge and furrow. A field boundary running on an east–west orientation was identified that is recorded on the First Edition 1854 Ordnance survey map.

In the south of the site there are several bands of magnetic disturbance likely to be caused by geological or pedological changes in the substrata; within these bands are regularly spaced linear anomalies that plausibly denote shallow mineral extraction associated with the Shafton Coal seam that runs to the west of the site. It is possible that magnetic disturbances in the north of the site are also in part of a geological origin, but it is not possible to ascertain if anomalies are caused by mining associated endeavours. The results also identified anomalies considered to be of a modern origin and caused by ferrous object within the topsoil or periphery of the site.

1.0 INTRODUCTION

1.1 Northern Archaeological Associates (NAA) was commissioned by St Pauls Developments plc to undertake a geophysical (gradiometer) survey on land at Dudley Drive, Goldthorpe, South Yorkshire in advance of a solar farm development (Fig 1; NGR: SE 45085 04013). The geophysical survey totalled c.7.15ha and was carried out in two visits between the 19th and 20th June and on the 9th October.

1.2 The report details the setting (location, topography, geology) and archaeological background of the scheme and sets out the methodology used for the geophysical survey. The interpretation of the geophysical survey is achieved through the analysis of identified anomalies and is aided by a rapid examination of supporting information. The results of the geophysical survey are discussed below, and the interpretations are supported by appropriate illustrations. Where feasible, a detailed synopsis of anomalies is provided and, if possible, the features that the anomalies are likely to relate to are suggested.

2.0 LOCATION, TOPOGRAPHY AND GEOLOGY

Location and land use

2.1 The proposed development area (PDA) comprises four fields to the west of Goldthorpe, South Yorkshire (Fig. 1). The site is bordered by Dudley Drive to the west, Barnsley Road to the north, residential areas to the east and commercial units to the south.

Topography

2.2 There is a general downward slope to the south of the PDA. The highest topographical point is in the north of the site and is recorded at 42m above Ordnance Datum (aOD); the lowest level is in the south of the site and is recorded at 29m aOD.

Geology

2.3 The south of the PDA contains Pennine Middle Coal Measures, and the north of the site contains sandstone of the Mexborough Rock Formation. No superficial deposits are recorded within the PDA (BGS 2021). The Shafton Coal Seam, which runs to the west of the site, was subjected to shallow unchartered mine workings and opencast operations in the mid-1990s. Two unchartered mineshafts lie to the west of the PDA, the nearest of which is suggested to have been located in the field directly west of Dudley Drive.

3.0 ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

Prehistoric and Roman

3.1 The PDA lies within a landscape rich in cropmarks of relict field systems and enclosures that are largely related to settlement and field systems of Iron Age to Roman date.

3.2 In 1992 preliminary works for the A635 Goldthorpe Bypass (Barnsley Road) were undertaken to the north and north-west of the PDA (Merrony 1993). These works comprised c.4.5ha of geophysical survey and 1ha of fieldwalking in an area of recorded cropmarks to the north of Barnsley Road, followed by the excavation of nine trial trenches. The geophysical survey results complemented cropmark interpretations and identified unknown archaeological features. The results of the survey mapped a series of enclosures and a double ditch representing a droveway or trackway, running north-west to south-east, with further trackways leading off to the north and south (towards the current PDA). The fieldwalking recovered a few sherds of medieval pottery and an assemblage of 19th and 20th-century material. The trial trenching confirmed the presence of the features recorded by the geophysical survey but did not recover any dating evidence. The trenches revealed that many of the ditches were sealed beneath up to 1m of buried subsoil, perhaps hillwash, and some of the ditches were only 0.4m deep. The trenching also failed to find any evidence for internal features within the enclosures, possibly due to the narrow (1.7m-2m) width of the trenches.

3.3 Further work was undertaken in 2014 adjacent to Barnsley Road, just to the east of the 1992 work and immediately north of the current PDA. This included a desk-based appraisal and geophysical survey (NAA 2014a) followed by monitoring of geotechnical trial-pitting (NAA 2014b). The geophysical survey confirmed the results of the 1992 survey and demonstrated that the probable Iron Age to Roman field system continued further to the east than had been previously surveyed. Due to their restricted scope, the geotechnical investigations produced largely negative results.

3.4 To the south-west of the PDA, excavations undertaken during 2012-3 in advance of the construction of a distribution centre for Aldi Stores at Goldthorpe Industrial Estate (NAA 2013) revealed a palimpsest of archaeological features. The earliest of these were three Early Bronze Age cremation burials. Two of these had been covered by a stone cairn or barrow. Other Bronze Age features included several pits and an oval gully, possibly the ditch around a smaller barrow.

3.5 The site lay within an extensive later Iron Age and Roman field system. The ditched boundaries appeared to have been laid out mainly in a single event, with one of the principal ditches diverting around the remains of the Bronze Age cairn. Several of the ditches extended beyond the limits of the excavated area, confirming that the site formed part of a much larger complex of conjoined fields. One enclosure within the field system housed some form of structure in its primary phase.

3.6 Some of the field boundaries had been maintained in some form of use into the immediate post-Roman period and were associated with two corn-drying kilns, radiocarbon dated to the 5th or 6th centuries. Kilns of this date are nationally very rare making these particularly significant discoveries (Ross *et al.* 2017).

3.7 Further excavation was carried out in 2016 in the area between the 2012-3 excavation and Commercial Road bordering the south-western corner of the current PDA (NAA 2016). This work recorded more of the Iron Age and Roman field system, which continued beyond the investigated are to the east, west and north (towards the current PDA). Other features included several pits, at least one of which dated from the Late Mesolithic period.

3.8 Within the current PDA, sample geophysical survey was undertaken across several areas in 1997 (Webb 1997). The survey recorded one of the double-ditched trackways, recorded to the north in 1993, continuing southwards across the western end of the PDA and with further fields and enclosures attached. There was also a 12m diameter circular feature interpreted as representing the ring-gully of a round house. This survey lay within the area of the recent geophysical survey which is the subject of the current report.

Medieval and post-medieval

3.9 Many of the nearby placenames were recorded in the Domesday Survey, indicating that the area was extensively settled by AD1066. The placename Goldthorpe was probably derived from Old Scandinavian for 'a subsidiary settlement belonging to Golda' (Ekwall 1960, 200) while the name Thurnscoe was also Old Scandinavian, and probably meant 'thorn-bush wood' (*op. cit.*, 472). Billingley had an Old English origin, meaning 'the clearing of the Billingas, Billi's people' (*op. cit.*, 43). The three names suggest relatively small settlements within the extensive woodland that once covered much of the county.

However, there is no evidence to suggest that these early settlements were in the same locations as their medieval counterparts.

3.10 Archaeological fieldwork suggests that, during the medieval period, much of the immediate area was under ridge and furrow cultivation, presumably part of the open fields of the settlement of Goldthorpe. Trial trenches excavated in 1993 found remains of medieval ridge and furrow truncating the probable Roman field system and enclosures (Merrony 1993). Ridge and furrow was also recorded at Goldthorpe Industrial Estate (NAA 2013 and 2016) and recorded by geophysical survey in the current PDA (Webb 1997).

3.11 The excavation at Goldthorpe Industrial Estate identified the remains of a 17th- or 18th-century limekiln, which appeared to post-date the open field cultivation. It is therefore possible that similar features could be present within the current PDA.

4.0 AIMS AND OBJECTIVES

4.1 The aim of the geophysical survey was to map and record potential buried features located within the PDA. Through analysis of the results of the geophysical survey, NAA aims to provide a detailed interpretation of the archaeological potential of the site that will inform subsequent archaeological mitigation strategies.

4.2 The objectives of the project were to:

- carry out a geophysical survey across areas deemed suitable for data collection within the PDA;
- attempt to identify, record and where possible characterise any subsurface remains within the survey boundary;
- assess the archaeological potential of identified anomalies; and
- identify possible concentrations of past activity in order to inform the requirement for any further archaeological investigation at the site.

5.0 METHODOLOGY

5.1 All survey work was completed to appropriate standards set out in current guidelines (CIfA 2014; Schmidt *et al*. 2015). The gradiometer survey used Bartington Grad601-2 dual magnetic gradiometer systems with data loggers. Readings were recorded at a resolution of 0.01nT and data was collected with a traverse interval of 1m and a sample interval of 0.25m. The survey data was collected with reference to a site survey grid

comprised of individual 30m x 30m squares. The grid was established using Real Time Kinematic (RTK) differential GPS equipment, and was marked out using non-metallic survey markers. All grid nodes were set out with a positional accuracy of at least 0.1m and could be relocated on the ground by a third party. The base lines used to create the survey grids are shown on Figure 2 and further details are available in Appendix A.

5.2 The processing was carried out using Geoplot 3.0 software and consisted of standard processing procedures. Details of processing steps applied to collected data are provided in Appendix B.

5.3 On the greyscale plots, positive readings are shown as increasingly darker areas and negative readings are shown as increasingly lighter areas (Figs 3 and 4).

5.4 Interpretation of identified anomalies is generally achieved through analysis of anomaly patterning and increases in magnetic response and is often aided by examining supporting information. The interpreted data uses colour coding to highlight specific readings in the survey area (Fig. 5). Appendix C details the terminology and characterisation of anomalies used for interpreting data.

Surface conditions and other mitigating factors

5.5 Field boundaries comprised hedgerows and metal fencing; there were occasional areas of high vegetation along field edges.

5.6 Areas A and C contained overgrown grass and Area D contained low-lying pasture and all three areas were surveyed on the 19th and 20th June 2021. Area B comprised arable land and was surveyed on the 9th October 2021.

5.7 Attempts were made to avoid areas affected by above-ground features that were likely to have a high magnetic susceptibility, such as metal fencing, to minimise the potential for their magnetic responses to impinge on the survey results and mask potential buried features.

6.0 RESULTS

6.1 The following section provides a detailed interpretation of the areas surveyed, then discusses anomalies identified generally across the site.

General anomalies across the whole site (Figs 4 and 5)

6.2 A series of linear anomalies (**A**) run on a north–south orientation along the western edge of Area A that denote the continuation of a droveway or trackway that has been recorded in fields to the north of Barnsley Road.

6.3 A series of linear anomlies (**B** and **C**) has been mapped across the PDA that are likely to denote a field system. Their similarity in alignment with **A** could be used to postulate that they belong to features of similar dates. Anomalies comprising **B** have a more coherent patterning and increase in magnetic value than **C**, which potentially reflects topographic and geological changes within the site.

6.4 Rectilinear anomalies (**D**) appear in the north-west of Area A that relate to an enclosure that was first recorded during the geophysical survey in 1997. Its relationship with nearby anomalies relating to a track (**A**) and field system (**B**) is difficult to ascertain. The geophysical survey in 1997 suggested that a track (**A**) led up to an entrance in the south-west of enclosure (**D**) and anomalies within the enclosure related to ditches creating internal sub-divisions. The 1997 survey postulated that the alignment of ditches outside the enclosure could be used to infer that there were several different phases of activity. The present survey area was curtailed by heavy vegetation including hedgerows along the western edge of Area A and so it was not possible to cover the same ground as the 1997 survey. Consequently, it is not possible to confirm the presence of an entrance in the south-west of the enclosure (**D**). Several linear anomalies, trends and amorphous anomalies occur in the centre of the enclosure; it is possible that linear anomalies and trends relate to ditches used to subdivide the enclosure and amorphous anomalies denote pits. It should be noted that the linear anomalies within the enclosure appear on the same alignment as the track (**A**) and it could be postulated that the anomaly running north–south (**E**) denotes part of the droveway and the anomaly running east–west (**F**) belongs to the field system **B**. Several trends were identified in the north-east of the enclosure but are of an unknown origin. It is plausible that they denote ditches, although they appear on the same alignment as anomalies associated with ridge and furrow and in an area containing magnetic disturbance caused by geological and pedological changes in the substrata, and so a very tentative interpretation applies.

6.5 Two subcircular anomalies were identified in the north of Area B (**G** and **H**). Although **G** appeared well-defined in the 1997 survey, anomalies in the current survey were composed of weak increases in magnetic value and fragmented patterning . Although

tentative—given the field's current use—it is plausible that this feature has been partially destroyed by ploughing. A second subcircular anomaly (**H**) with strong increase in magnetic value was identified to the north-east of **G** but was not identified during the 1997 survey. Both anomalies are considered archaeological and relate to ring ditch features such as round houses or barrows.

6.6 A field boundary was identified (**I**) that is on the 1854 Ordnance Survey (OS) map.

6.7 There are numerous weak isolated anomalies with an amorphous form across the survey area. Those with a coherent patterning or broader form have been identified in the interpretation. A tentative interpretation applies: those located nearby to anomalies suggested to have an archaeological origin have a greater potential to also relate to buried archaeological deposits, and potentially denote pits.

6.8 There are several weak and diffuse linear trends. Generally, these fail to produce the necessary patterning or increases in magnetic response in order to be interpreted fully, and consequently their origin is unknown.

6.9 Ridge and furrow runs on a north–-south orientation throughout the PDA. Several isolated linear anomalies with weak increases in magnetic strength were also identified that are likely to be agricultural in origin, but their exact cause is unknown.

6.10 Several bipolar responses have been identified. Isolated bipolar anomalies are considered to be modern and caused by material with a high magnetic susceptibility, such as ferrous objects. It should be noted that the strength and size of the anomaly associated with the buried utility reflect the highly magnetic responses of the ferrous material of the buried pipe rather than actual feature dimensions.

6.11 Dipolar anomalies often relate to ferrous or modern objects buried in the topsoil. Consequently, these anomalies are generally considered to be of a modern nature and have not been depicted on interpretation plots.

6.12 Concentrations of dipolar anomalies have been identified that are likely to be caused by modern magnetic debris in the topsoil or near the surface; concentrations of bipolar anomalies—predominantly located along the edges of the survey area—relate to above-ground features external to the survey area, such as metal fencing, gates and electricity poles.

6.13 There are several broad responses that are considered likely to be caused by geological or pedological changes in the substrata. There are several bands of magnetic disturbance in the south of the site that appear on the same orientation as the Shafton Coal seam. Within these areas of magnetic disturbance are several regularly spaced linear anomalies with a south-west to north-east alignment that is plausibly suggestive of shallowing mining. There are also areas of magnetic disturbance in the north of the site that are also considered to be of a geological origin, however it is less clear whether the disturbance can also in part be surmised as being caused by mineral extraction.

7.0 CONCLUSIONS

7.1 The results of the survey have identified a clear potential for archaeological remains within the PDA. Several linear anomalies have been identified running along the north-west edge of the site that relate to the continuation of a droveway or track recorded by archaeological investigations to the north of Barnsley Road. Running perpendicular to the east of the droveway is a series of anomalies that are likely to denote a field system. A rectangular enclosure (dimensions of 38m by 46m) is also located in the north-west of the site. The relationship between the droveway, field system and enclosure are difficult to determine, and it is not possible to ascertain whether they relate to the same or different phases of activity. Several subcircular anomalies are in the centre of the PDA that denote ring ditches. Further investigation is required to understand the exact archaeological feature that these anomlies relate to.

7.2 One field boundary was identified that is first recorded on the 1854 OS map. Regularly spaced anomalies running on a north–south alignment are caused by ridge and furrow.

7.3 In the south of the site there is a high level of magentic disturbance that is likely to be caused by geological or pedological changes in the substrata and shallow mining associated with the Shafton Coal seam. It is plausible that magnetic disturbance in the north of the site is also caused by geological activity, but it is uncertain if anomalies are also in part caused by mining activity.

7.4 The results have also identified isolated bipolar anomalies, and areas of modern disturbance.

8.0 STORAGE AND CURATION

8.1 The records of the geophysical survey are currently held by NAA. All material will be appropriately packaged for long-term storage in accordance with national guidelines (CIfA 2014; Schmidt *et al*. 2015). An OASIS form will be completed on the results of the works within three months of the completion of the project. This will include submission of a PDF version of the final report to the Archaeology Data Service via the OASIS form.

REFERENCES

Aspinal, A., Gaffney., C. and Schmidt, A. (2008) *Magnetometry for Archaeologists*. Plymouth: Altamira Press.

Bartington Instruments (n.d.) *Grad601 Single Axis Magnetic Field Gradiometer system.* Oxford: Bartington Instruments.

British Geological Survey (2021) *Geology of Britain viewer*. [Online] Available at: https://www.bgs.ac.uk/discoveringGeology/geologyOfBritain/viewer.html (accessed on 30/10/2021).

Chartered Institute for Archaeologists (CIfA) (2014) *Standard and guidance for archaeological geophysical survey*. Reading: Chartered Institute for Archaeologists.

Ekwall, E. (1960) *The Concise Oxford Dictionary of English Place Names (4th Edition)*. Oxford University Press.

Gaffney, C. and Gater, J. (2003) *Revealing the Buried Past*. Stroud: Tempus Publishing.

Merrony, C. J. N. (1993) *An Archaeological Evaluation in Advance of the Dearne Towns Link Road Stage 4 (Goldthorpe Bypass) at Goldthorpe, South Yorkshire*. Unpublished South Yorkshire Archaeology Service report.

NAA (2013) *Goldthorpe Industrial Estate, Goldthorpe, South Yorkshire: Excavation Report*. Unpublished Northern Archaeological Associates Ltd Report 13-131.

NAA (2014a) *Land off Barnsley Road, Goldthorpe, South Yorkshire: Cultural Heritage Appraisal*. Unpublished Northern Archaeological Associates Ltd Report 14-92.

NAA (2014b) *Geotechnical Investigation, Barnsley Road, Goldthorpe, South Yorkshire: Archaeological Monitoring*. Unpublished Northern Archaeological Associates Ltd Report 14-104.

NAA (2016) *Aldi Regional Distribution Centre Carpark, Goldthorpe, South Yorkshire: Archaeological Excavation Report*. Unpublished Northern Archaeological Associates Ltd Report 16-67.

Ross, C., Gardiner, L. F., Brogan, G. and Russ, H. (2017) 'Post-Roman crop production and processing: Archaeological evidence from Goldthorpe, South Yorkshire'. *Environmental Archaeology: The Journal of Human Palaeoecology* **22(3)**, 233-246.

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. and Fassbinder, J. (2015) *EAC Guidelines for the Use of Geophysics in Archaeology.* EAC Guidelines 2. Belgium: Europae Archaeologiae Consilium.

Webb, A (1997) *Bolton House Farm, Goldthorpe, Barnsley: Geophysical Survey*. Unpublished Archaeological Services WYAS report.

Online sources

National Library of Scotland http://maps.nls.uk/

Historic England National Heritage List for England https://historicengland.org.uk/advice/hpg/heritage-assets/nhle/

Old Maps www.old-maps.co.uk

Google Earth http://earth.google.co.uk

Magic (DEFRA) http://magic.defra.gov.uk/MagicMap.aspx

NPPF Planning Practice Guidance https://www.gov.uk/government/collections/planning-practice-guidance

British Geological Survey GeoIndex https://www.bgs.ac.uk/

Domesday Book www.opendomesday.org

APPENDIX A:
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 remanent or induced magnetic properties (Aspinal *et al*. 2008, 21–26). Human activity and inhabitation often alters 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, heaths and brick structures (Gaffney and Gater 2003, 37; Aspinal *et al*. 2008, 27). 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 (Gaffney and Gater 2003, 22–26; Aspinal *et al*. 2008, 37–41). Magnetic surveys can also detect features with a lower magnetically 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 hillwash, often in combination with intensive modern ploughing, will reduced 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 handheld Bartington Grad 601-2 fluxgate gradiometers. 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 1m vertical separation.

The difference in the magnetic field between the two fluxgates in each sensor is measured in nanoTesla (nT). NAA gradiometer data is recorded with a range of ±100nT, which equates to a resolution of 0.01nT. It should be noted that the actual resolution is limited to 0.03nT as a consequence of internal instrumental noise (Bartington Instruments n.d., 23).

The gradiometer records two lines of data on each traverse, the grids are walked in a zig-zag pattern amounting to 15 traverses. The gradiometers are calibrated at the start of every day and recalibrated whenever necessary.

SURVEY DETAILS

Table A1: survey summary.

	Survey
Grid size	30m x 30m
Traverse interval	1m
Reading interval	0.25m
Direction of 1st traverse	N
Number of Grids	117
Area covered	7.15ha

Table A2: baseline co-ordinates (baseline is shown on Fig. 2)

Grid point (gp) A	Grid point (gp) B
NGR: 445190.04 404026.91	NGR: 445190.05 403966.92

Grid point (gp) C	Grid point (gp) D
NGR: 444952.90 404140.83	NGR: 444961.90 404081.51

Table A3: Site information and conditions

Item	Detail
Geology	Pennine Middle Coal Measures and Mexborough Rock Formation
Topography	29m to 42m aOD
Land use	Arable and Pasture
Weather/conditions prior to and during survey	Overcast

APPENDIX B:

DATA PROCESSING INFORMATION

Gradiometer survey data is downloaded using the Bartington Grad 601 software and the processing was undertaken using Geoplot 3.0 software.

Table B1: commonly applied techniques.

Process	Effect
Zero mean traverse	Removes stripping which can occur as a consequence of using multi sensor arrays or a zig-zag data collection method by setting the mean reading for each traverse to zero.
Destagger	Removes stagger in the data introduced through inconsistence data collection pace and often exacerbated through the zig-zag methodology.
Clip	Clips data above or below a set value to potentially enhance potential weaker anomalies.
Despike	Removes random spikes or high readings to reduce the appearance of dominant readings, often created by modern ferrous objects that can distort the results.
Low pass filter	Removes low frequency waves or broad anomalies such as those caused by strong or large gradual variations in the soil's magnetic susceptibility often caused by geological or natural changes in the substrata.
Interpolation	Used to smooth or reduce the blocky appearance of data by improving the spatial density and balance the quantity of data points in the X and Y directions.

Table B2: processing steps.

Minimal processing	Increased processing
• Zero mean traverse +5/-5 • Destagger:	• Low Pass Filter • Interpolate Y, Expand – Linear

APPENDIX C:
DATA VISUALISATION INFORMATION

FIGURES

The data from the surveys were used to produce a series of images to represent the results. The terminology is detailed below:

- Greyscale/Colourscale Plot: this visualised the results as a shaded drawing with highest readings showing as black, running through to lowest shade showing as white.

- XY-trace Plot: this creates a line drawing showing the peaks and troughs of the readings as vertical offset from a centreline.

- Interpreted Plot: through detailed analysis, anomalies have been interpreted and possible features identified. Interpretation drawings are used to show potential features and, in particular, 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 outlined in keys found on the relevant figures associated with this report.

MAGNETIC ANOMALIES AND TERMINOLOGY

Table C1: 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.

Different anomalies can represent different features created by human, agricultural or modern activity, or natural pedological or geological changes in the substrata.

Anomalies interpreted with a 'greater' categorisation are considered more likely to be of the interpreted characterisation; whereas a more tentative interpretation is applied to those with a

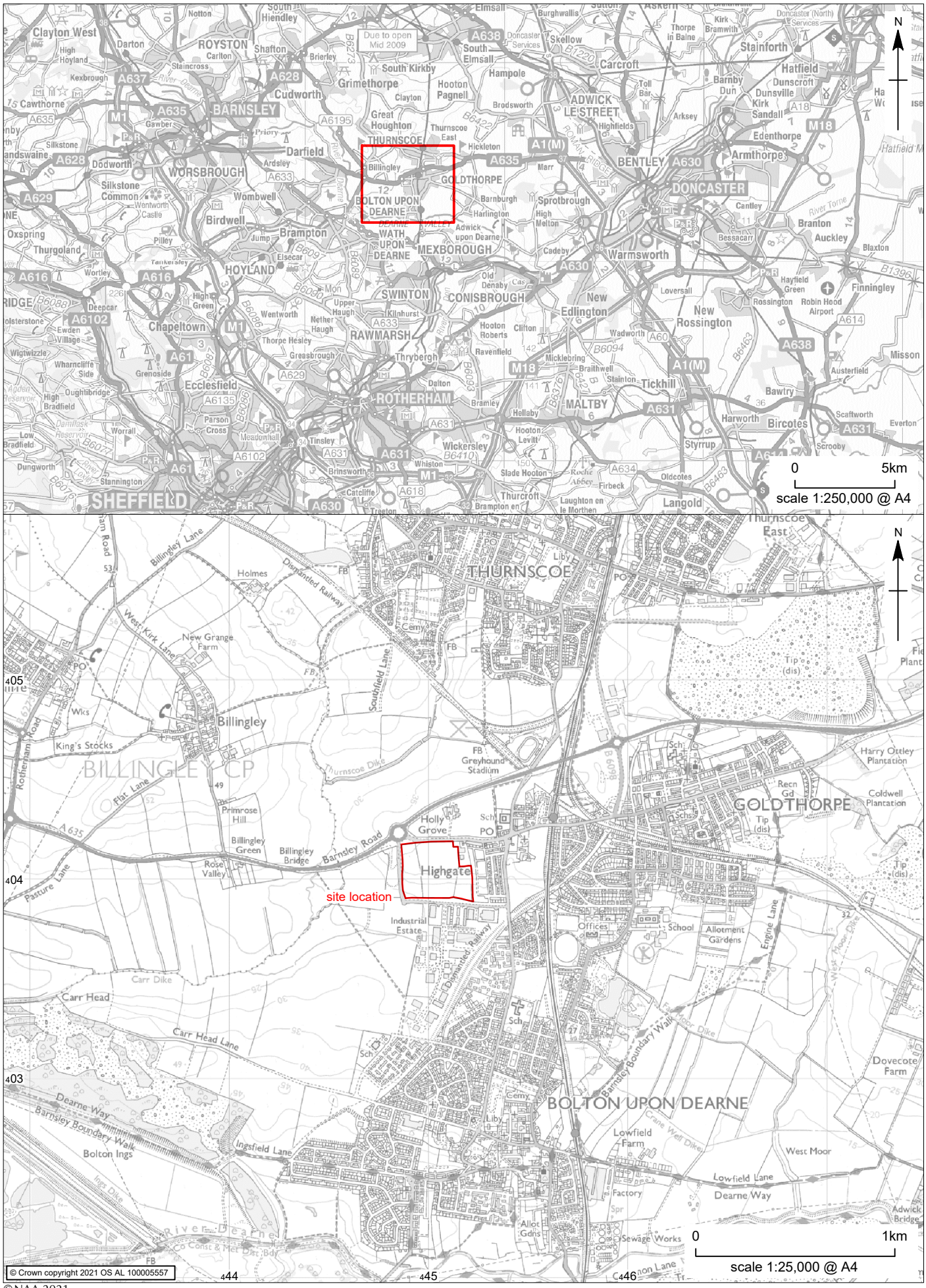
'lesser' categorisation as a consequence of weaker increases in magnetic response or the anomalies incomplete patterning or irregular form.

The strength and size of anomalies can vary depending on the magnetic properties of the feature, the magnetic susceptibility of the soil, the depth to which the feature is buried, and the state of preservation.

Table C2: characterisation of anomalies.

Characterisation	Detail
Archaeology	
Linear anomaly (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.
Amorphous anomaly (archaeology)	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 are also interpreted as isolated anomaly (archaeology). These are considered to relate to material with a very strong magnetic susceptibility or thermoremanent magnetisation.
Trends	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.
Agriculture	
Field boundary	Isolated linear anomalies that are likely to be indicative of former land divisions. A more conclusive interpretation is given to linear anomalies that correspond with the location of field boundaries 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.

Characterisation	Detail
Agriculture?	Weak, irregularly spaced or isolated linear anomalies that possibly relate to agricultural activity. Given the tentative interpretation, the agricultural process they are caused by is also likely to unknown.
Modern	
Bipolar response (modern)	Positive anomalies with associated negative 'halo' (bipolar) denote features with a strong magnetic response are likely to be of a modern origin. 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. Linear bipolar anomalies are likely to be indicative of modern services.
Dipolar anomaly	Dipolar anomalies relate to individual spike within the data and tend to be caused by ferrous objects. These responses have only been shown when located near to archaeological features. When the site is located in a mining landscape it is possible that identified dipolar anomalies relate to mining activity and are indicative of further pits or mine shafts.
Magnetic disturbance (modern)	Areas of increased magnetic response denote areas of disturbance containing a high concentration of dipolar and / 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. Areas of magnetic disturbance, often along the edges of survey areas are caused by standing metal structures such as fencing and buildings.
Natural	
Magnetic disturbance (geology/mining?)	Broad isolated responses that have an irregular patterning that may be indicative of geological or pedological changes in the substrata. Regularly spaced broad linear anomalies plausibly denote shallow mineral extraction following coal seams. It should be notes that ground water can naturally dissolve or erode porous or permeable bedrock, such as limestone, and create fissures and cracks. Depending on the magnetic susceptibility of the soil it is possible for these fissures to appear as a series of contiguous rectilinear anomalies, often having a similar appearance to archaeological enclosures.



Dudley Drive, Goldthorpe: site location

Figure 1

NAA
HERITAGE & ARCHAEOLOGY

KEY
geophysical survey baseline
geophysical survey grid
geophysical survey area
proposed development area

N

0 100 m

scale 1:2500 @ A4

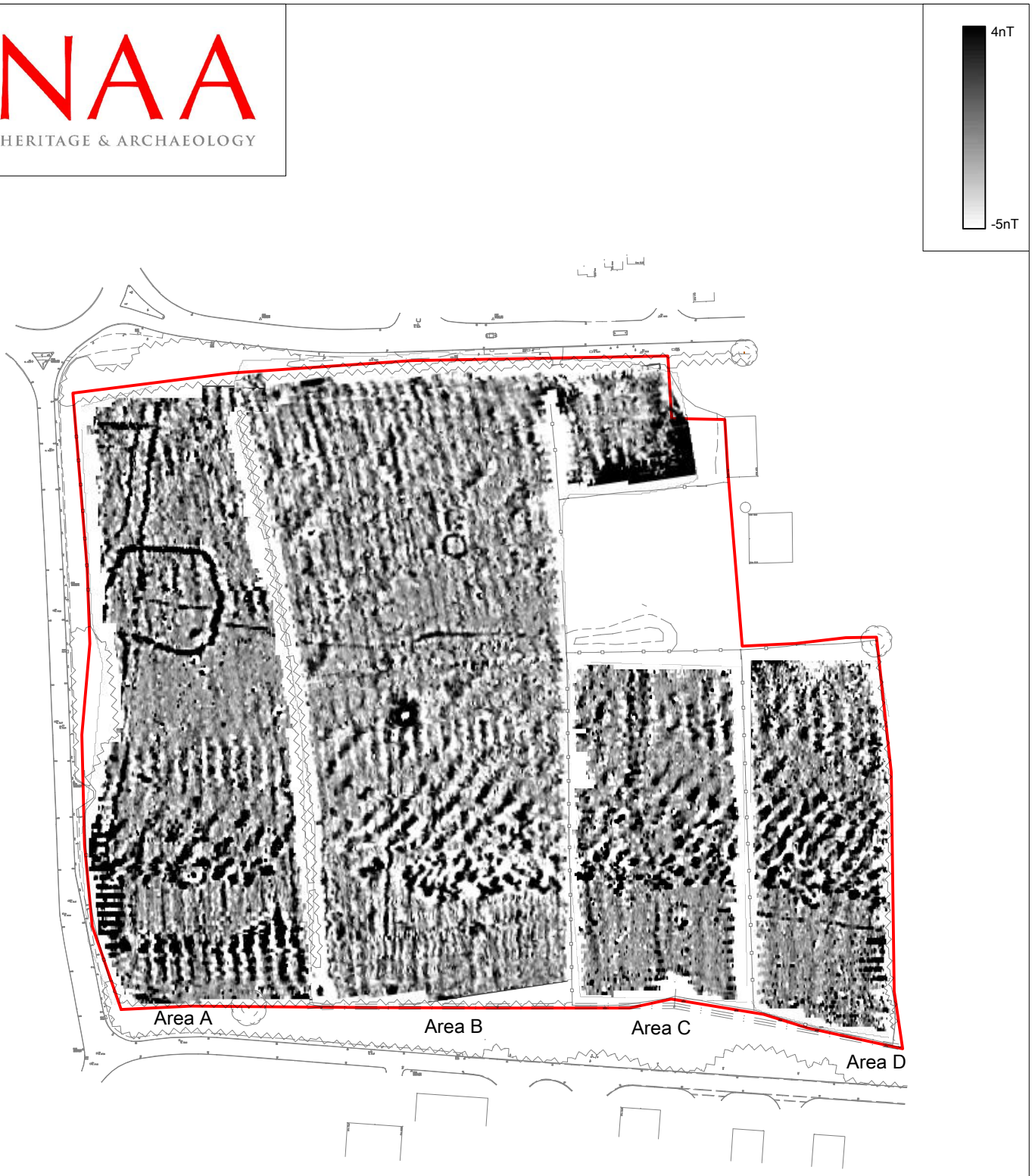
Dudley Drive, Goldthorpe: geophysical survey area

Figure 2

NAA
HERITAGE & ARCHAEOLOGY

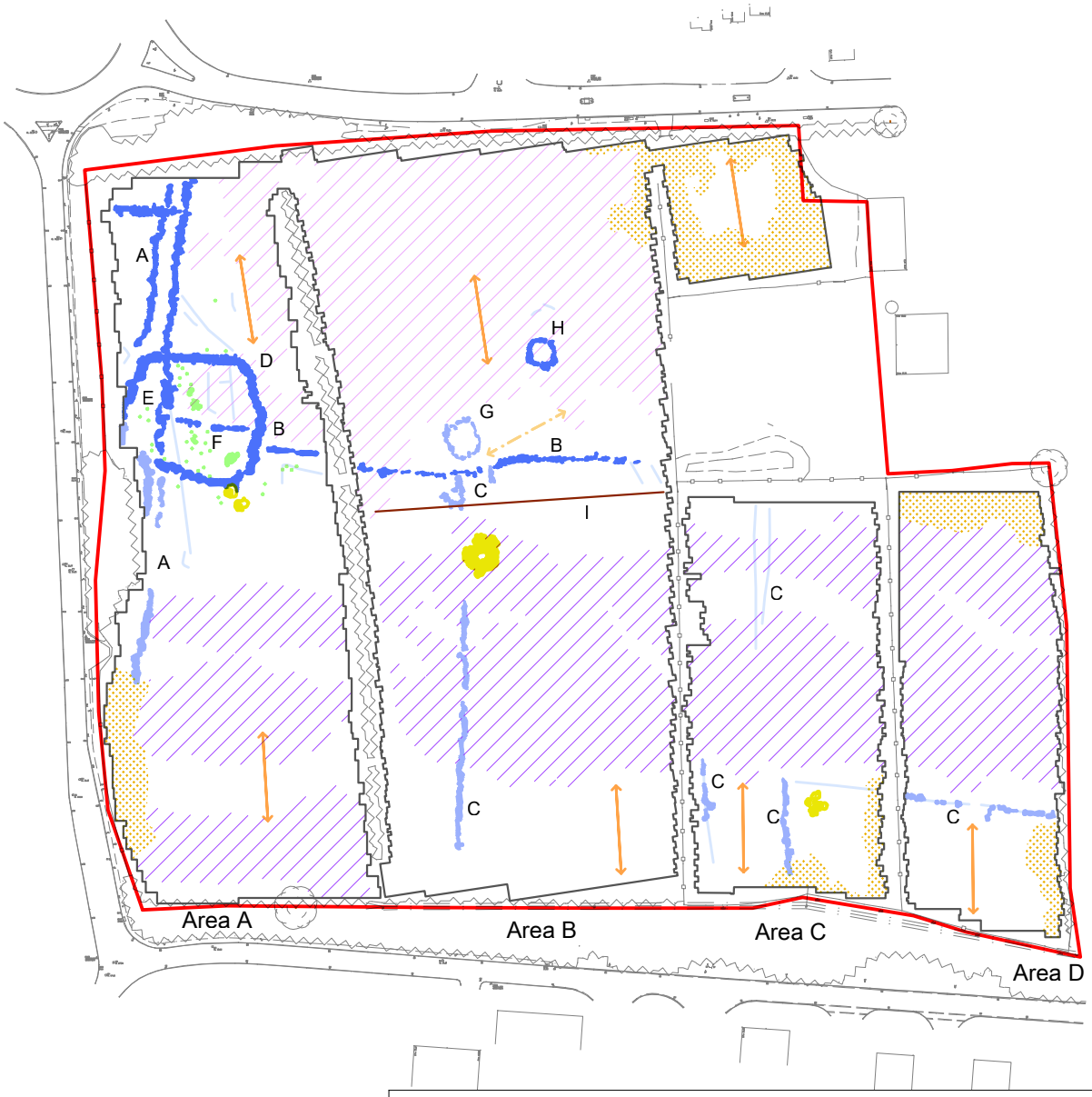
Dudley Drive, Goldthorpe: unprocessed greyscale plots of gradiometer survey results Figure 3

NAA
HERITAGE & ARCHAEOLOGY



Dudley Drive, Goldthorpe: processed greyscale plots of gradiometer survey results Figure 4

NAA
HERITAGE & ARCHAEOLOGY



KEY

- linear anomaly (archaeology) (greater / lesser)
- amorphous anomaly (archaeology?)
- field boundary
- trends
- ridge and furrow
- agriculture (unknown)
- bipolar anomaly (modern)
- magnetic disturbance (modern)
- magnetic disturbance (geology/mining?) (greater / lesser)
- edge of geophysical survey
- proposed development area

N

0 100 m

scale 1:2500 @ A3

Dudley Drive, Goldthorpe: interpretation of gradiometer survey results

Figure 5