A47/A11 Thickthorn Junction

Scheme Number: TR010037

Volume 6
6.3 Environmental Statement Appendices
Appendix 6.2 – Geophysical Survey

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

March 2021

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

The A47/A11 Thickthorn Junction Development Consent Order 202[x]

ENVIRONMENTAL STATEMENT APPENDICES
Appendix 6.2 – Geophysical Survey

Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010037
Application Document Reference	TR010037/APP/6.3
BIM Document Reference	HE551492-GTY-EHR-000-RP-LH-30007 HE551492-GTY-EHR-000-RP-LH-30008
Author:	A47/A11 Thickthorn Junction Project Team, Highways England

Version	Date	Status of Version
Rev 0	March 2021	Application Issue

WYAS Archaeological Services

A47/A11 Thickthorn Junction

Hethersett

Norfolk

ENF143424

Geophysical Survey

Report no. 3121
April 2018

Client: [redacted]

A47/A11 Thickthorn Junction
Hethersett
Norfolk
ENF143424

Geophysical Survey

Summary

A cart-based geophysical (magnetometer) survey, covering approximately 17.5 hectares was undertaken on land within the vicinity of the Thickthorn Junction on the A47, Hethersett, Norfolk. Anomalies of archaeological origin have been recorded, some of which correspond to cropmarks. Possible archaeological anomalies have also been recorded which may be associated with ring ditches. A former field boundary has also been detected in the eastern part of the site which corresponds well with recorded boundaries on Ordnance Survey mapping. Responses associated with a gravel pit in the eastern part of the site are present. The archaeological potential of the site would be characterised as high in the north and low elsewhere.

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Services

Report Information

Client:	[redacted]
Address:	[redacted]
Report Type:	Geophysical Survey
Location:	Hethersett
County:	Norfolk
Grid Reference:	TG 1829 0515
Period(s) of activity:	?Prehistoric
Report Number:	3121
Project Number:	8234
Site Code:	AIP18
Event Number:	ENF143424
OASIS ID:	archaeol11-316373
Date of fieldwork:	March 2018
Date of report:	April 2018
Project Management:	[redacted] BSc MCIfA
Fieldwork:	[redacted] BSc MSc MCIfA
	[redacted] BA
Report:	[redacted]
Illustrations:	[redacted]

Authorisation for distribution: ----------

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1 Introduction

Archaeological Services WYAS (ASWYAS) were commissioned by Mott MacDonald Sweco Joint Venture (the client), to undertake a geophysical (magnetometer) survey on land surrounding the Thickthorn Junction of the A47, near Hethersett, Norfolk. This is in advance of junction improvements as part of the A47 improvement programme. The survey was undertaken in line with current best practice (CIfA 2014; David *et al*. 2008) and also to the archaeological specification for geophysical survey prepared by the client on behalf of Highways England (MM 2018). There was a slight change in the survey areas from the original specification, due to the southern part of Thickthorn Park being recently planted with trees and design changes which meant that the areas around Cantley Stream were to be included. The survey was carried out between the 12th - 16th March 2018.

Site location, topography and land-use

The survey area is located at the Thickthorn Junction of the A47, Hethersett on the south western outskirts of Norwich (see Fig. 1). This section of the scheme comprises multiple small sites within the vicinity, bounded by Norwich Road (B1172) to the north, the A47 to the east and a railway line to the south. The survey area encompasses eight fields of varying ground conditions of arable and pastoral land. The areas total approximately 17.5 ha. The survey area is centred at TG 18296 05154. The height above Ordnance Datum (aOD) lies between 19m to 29m.

Soils and geology

The bedrock geology of the survey area predominantly belongs to the Lewes Nodular Chalk Formation. The sedimentary bedrock formed approximately 72 to 94 million years ago in the Cretaceous period. A variation of superficial deposits have been recorded over the survey area. The higher, north-eastern areas of the scheme are made up of the Lowestoft Formation, Diamicton. Whilst the southern portion of the survey area is overlain by the Sheringham Cliffs Formation comprising of sand and gravel deposits formed up to 3 million years ago (BGS 2018). The soils in the area are classified in the Burlingham association, characterised as stagnogleyic argillic brown soils, in addition to slightly acid loamy and clayey with impeded drainage (SSEW 1983).

2 Archaeological Background

Norfolk Historic Environment Record (NHER) data was provided by the client and has been marked on Figure 2. The following illustrates the wealth of archaeological monuments present both within and surrounding the proposed survey area.

To the west of the survey area, earthworks and cropmarks of an undated linear ditch and bank may suggest a possible post medieval drainage feature (NHER 54613).

A hollow way (NHER 11527) is visible as an earthwork and lies between survey areas. This is thought to be a former approach to Thickthorn Hall. Thickthorn Park (NHER 33732) lies within the survey area and is an early 19th-century landscaped park surrounding Thickthorn Hall. The park includes a medieval moat that was turned into an ornamental lake, a late 19th-century kitchen garden, early 19th-century lodges and concrete greenhouses from the 1930s.

To the south of 11527 lies NHER 18186 comprising cropmarks of linear ditches perhaps relating to the parish boundary, together with several possible fragmentary enclosures of an unknown date.

NHER number 54403 lies within the survey area consisting of cropmarks of possible field boundary ditches at right angles to each other as well as banks and a pit of unknown dates. NHER number 11820 also lies within the survey area and relates to a building of an unknown date. The building has internal divisions and is possibly a remnant of agricultural activity in the area.

A scheduled monument lies between the survey areas named as 'Two Tumuli in Big Wood', list entry 1003977. These consist of two Bronze Age round barrows (NHER 9463 and 9464) and both survive as earthworks.

Another possible large ring ditch (NHER 54618) lies to the southeast of the survey area and is visible on aerial photographs measuring approximately 28m in diameter.

To the north of the survey area lies a possible Bronze Age round barrow (NHER 9395) surviving as a low mound and visible as cropmarks. The mound measures approximately 24m in diameter with the ring ditch measuring 42m in external diameter. This ring ditch is situated within another HER monument (NHER 54404) which relates to cropmarks of possible prehistoric field boundaries, respecting the position of the round barrow.

To the immediate north of the survey area, surrounding the Thickthorn Junction lies NHER 9396 described as an undated enclosure or field system, prehistoric flint artefacts, Iron Age and Roman coins, medieval pottery sherds and a post-medieval seal.

South of the survey area NHER 54614 consists of cropmarks of a possible double ditched enclosure. It is possible that they represent medieval features and are perhaps associated with Cantley deserted medieval village, 100m to the south.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was to provide sufficient information to enable an assessment to be made of the impact of the development on potential sub-surface archaeological remains and for further evaluation or mitigation proposals, if appropriate, to

be recommended. To achieve this aim, a magnetometer survey covering all amenable parts of the PDA was undertaken (see Fig. 2).

The general objectives of the geophysical survey were:

- Locate and identify the nature and extent of previously unknown archaeological features along the proposed route option;
- Establish whether any features associated with known archaeological remains can be traced within the current survey areas;
- Establish whether any remains identified during previous geophysical surveys can be traced continuing into the current survey areas;
- Establish the condition of any archaeological deposits, particularly their level of preservation; and,
- Identify any areas of modern disturbance.

Magnetometer survey

The survey was undertaken using a Sensys Magneto®MXPDA cart-based magnetometer system. This system has five FGM650 fluxgate gradiometers mounted at 0.5m intervals with readings of between ±0.1nT and ±10,000nT recorded at 20Hz. The gradiometers are linked to a Trimble R6 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) allowing for the geo-referencing of all measurement points within ±1cm accuracy. The data is recorded by Sensys Magneto®MXPDA software on a Personal Data Assistant (PeDA) device and stored on a Secure Digital (SD) memory card within the PeDA. Terrasurveyor (DW Consulting) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the 1:50000 Ordnance Survey (OS) mapping, is shown in Figure 1. Figure 2 displays an overview of the processed magnetometer data at a scale of 1: 5000, with the overall interpretation, at the same scale in Figure 3. The minimally processed data, together with an interpretation of the survey results are presented in Figures 4 to 17 inclusive at a scale of 1:1250.

Technical information on the equipment used, data processing and survey methodologies are given in Appendix 1. Technical information on locating the survey area is provided in Appendix 2. Appendix 3 describes the composition and location of the archive. A copy of the completed OASIS form is included in Appendix 4. Repeat traverses of the data are included in Appendix 5.

The survey methodology, report and any recommendations comply with guidelines outlined by Historic England (David *et al.* 2008) and by the Chartered Institute for Archaeologists

(CIfA 2014). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The figures in this report have been produced following analysis of the data in processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

4 Results and Discussion (see Figures 4 to 17)

Modern anomalies

Ferrous anomalies, as individual 'spikes', or as large discrete areas are typically caused by ferrous (magnetic) material, either on the ground surface or in the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as modern ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. There is no obvious pattern or clustering to their distribution in this survey to suggest anything other than a random background scatter of ferrous debris in the plough-soil.

Areas of magnetic disturbance within Area 3 have been caused by metal fencing surrounding trees. A service pipe has been recorded in the west of Area 1 and also running along the western boundary of Area 6.

A large area of magnetic disturbance in the east of Area 8 appears to be a large area of dumping or made ground. Review of the 1995, 1:10,000 Ordnance Survey Map (OM 2018) shows this area to have been a gravel pit, likely to be associated with the construction of the A47.

Geological anomalies

The survey has detected a number of low magnitude anomalies in Areas 1 and 5 that have been interpreted as geological in origin. It is thought that the responses have been detected because of the variation in the composition and depth of the deposits of superficial material in which they derive and also topographical variations.

Agricultural anomalies

A former field boundary has been identified in Area 3 which appears on Ordnance Survey mapping dating from 1966 (OM 2018).

Magnetically strong linear responses in Area 6 correspond to small field divisions as marked on the digital mapping and seen in aerial images.

Parallel linear trends have been recorded in Areas 4 and 7 and are associated with modern cultivation, field drains can be seen in Areas 2 and 5.

Possible archaeological anomalies

A strong magnetic response (**P1**) has been identified in Area 4 (Figs 7-9) within the cluster of archaeological anomalies (**A1**, see below). A preferred interpretation for this is that it is the remains of a kiln, or an area of intense burning. It is also possible that it is a buried ferrous object of modern origin, therefore the interpretation must be viewed with caution.

Weak curvilinear trends have been detected within Area 7 (Figs 13-15) such as those at **P2**. It is possible that these represent ring ditches or possibly barrows given the nearby evidence of the known barrows to the south. These measure in diameter from 9m to 15m.

Archaeological anomalies

Archaeological anomalies can be seen in Area 4 (Figs 7-9) and consist of ditches, linear trends and pits. Cropmark evidence survives in this area which some of the anomalies correlate, as stated below.

Group of anomalies (**A1**) appear to form a rectilinear enclosure with a number of pit-like features located in and out of the enclosure. These features do not correspond to any cropmarks but are on the same alignment as the tentative building (NHER 11820) to the immediate north.

Ditches (**A2**) to the southeast of **A1** are part of the complex of possible field boundaries, some of which are visible as cropmarks on aerial photographs (NHER 54403). The geophysical survey has detected further anomalies to add to the known archaeology within the area.

5 Conclusions

The magnetic survey has detected anomalies of archaeological and possible archaeological origin, some of which correspond to cropmark evidence. These anomalies consist of enclosures, ditches, pits and possible ring ditches.

A former field boundary has been identified which corresponds to former mapping. A handful of field drains and services pipes have also been located. A large area of magnetic disturbance relates to a gravel pit, likely to be associated with the construction of the A47.

The survey has worked well on this geology and land-use and has detected anomalies of interest. Based upon the results of the survey, the archaeological potential of the site is considered to be high in the northern half and low elsewhere.

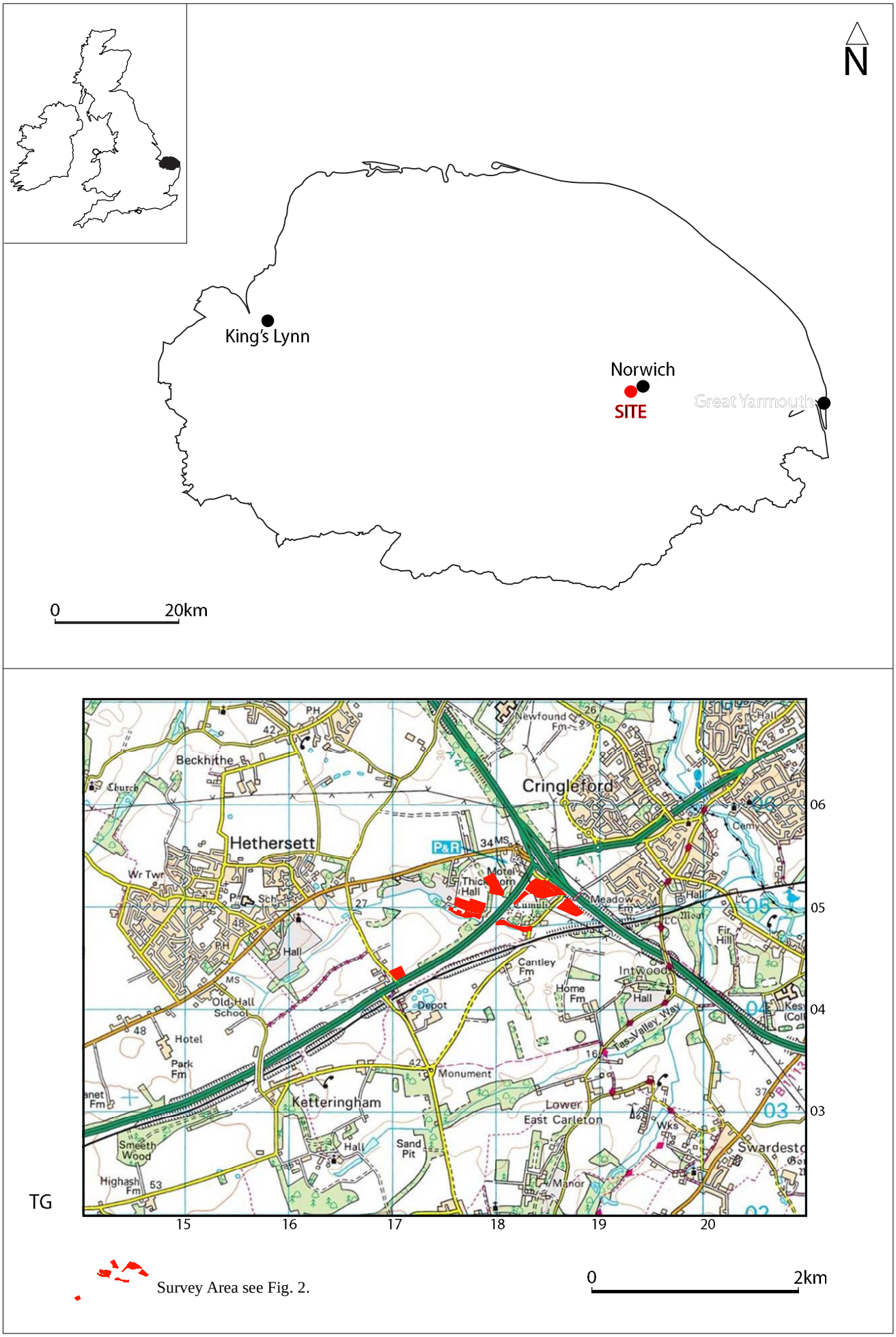

Fig. 1. Site location

PROJECT ID: 8234_AIP18: THICKTHORN

SURVEY AREA

LOCATION AND DIRECTION OF PLATES

LOCATION OF REPEAT TRAVERSE

AREA 1
SEE FIGS 4-5

AREAS 2 & 3
SEE FIGS 6-7

AREA 4
SEE FIGS 8-9

AREA 5
SEE FIGS 10-11

AREA 6
SEE FIGS 12-13

AREA 7
SEE FIGS 14-15

AREA 8
SEE FIGS 16-17

N

2.0

-1.0

nT

305000

617000

618000

0 200m

Fig. 2. Site location showing greyscale magnetometer data @ 1:5000

PROJECT ID: 8234_AIP18: THICKTHORN	
	SURVEY AREA
	CROPMARK DATA

AREA 4
SEE FIGS 8-9

AREA 7
SEE FIGS 14-15

AREA 8
SEE FIGS 16-17

AREAS 2 & 3
SEE FIGS 6-7

AREA 6
SEE FIGS 12-13

AREA 5
SEE FIGS 10-11

AREA 1
SEE FIGS 4-5

11820

54403

54613

9463

9464

11527

18186

54614

54618

N

3050 00

6170 00

6180 00

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	FIELD DRAIN
	LINEAR TREND	FORMER FIELD BOUNDARY
	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	FORMER GRAVEL QUARRY
	MAGNETIC ENHANCEMENT	GEOLOGY
	MAGNETIC ENHANCEMENT	ARCHAEOLOGY?
	LINEAR TREND	ARCHAEOLOGY?
	MAGNETIC ENHANCEMENT	ARCHAEOLOGY

Archaeological Services W Y A S
Nepshaw Lane South, Morley, LS27 7JQ
Tel: 0113 535 0163

Fig. 3. Overall interpretation of magnetometer data, including client supplied cropmark data @ 1:5000

0 200m

Fig. 4. Processed greyscale magnetometer data: Area 1 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN

N

TYPE OF ANOMALY		INTERPRETATION
•	DIPOLAR ISOLATED	FERROUS MATERIAL
——	DIPOLAR LINEAR	SERVICE PIPE
	MAGNETIC ENHANCEMENT	GEOLOGY

ard

Pond

ond

Station

4 Square

1to2

3

6 Station House

33.2m

A 11

5162 00

6170 00

6172 00

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Nepshaw Lane South, Morley, LS27 7JQ
Tel: 0113 535 0163

0 50m

Fig. 5. Interpretation of magnetometer data: Area 1 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN

N

Pond

Pond

FB

2.0

-1.0

nT

305000

6176 00

6178 00

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Tel: 0113 535 0163

0 50m

Fig. 6. Processed greyscale magnetometer data: Areas 2 and 3 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN

N

3050 00

Pond

Pond

FB

TYPE OF ANOMALY		INTERPRETATION
	DIPOLAR ISOLATED	FERROUS MATERIAL
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	FIELD DRAIN
	LINEAR TREND	FORMER FIELD BOUNDARY
	MAGNETIC ENHANCEMENT	GEOLOGY

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6176 00

6178 00

0 50m

Fig. 7. Interpretation of magnetometer data: Areas 2 and 3 (1:1000 @ A3)

Fig. 8. Processed greyscale magnetometer data: Area 4 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN

Ward's Wood

N

TYPE OF ANOMALY		INTERPRETATION
	DIPOLAR ISOLATED	FERROUS MATERIAL
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	ARCHAEOLOGY?
	MAGNETIC ENHANCEMENT	ARCHAEOLOGY

A1

P1

A2

3052 00

6178 00

6180 00

Archaeological Services W Y A S
Nepshaw Lane South, Morley, LS27 7JQ
Tel: 0113 535 0163

0 50m

Fig. 9. Interpretation of magnetometer data: Area 4 (1:1000 @ A3)

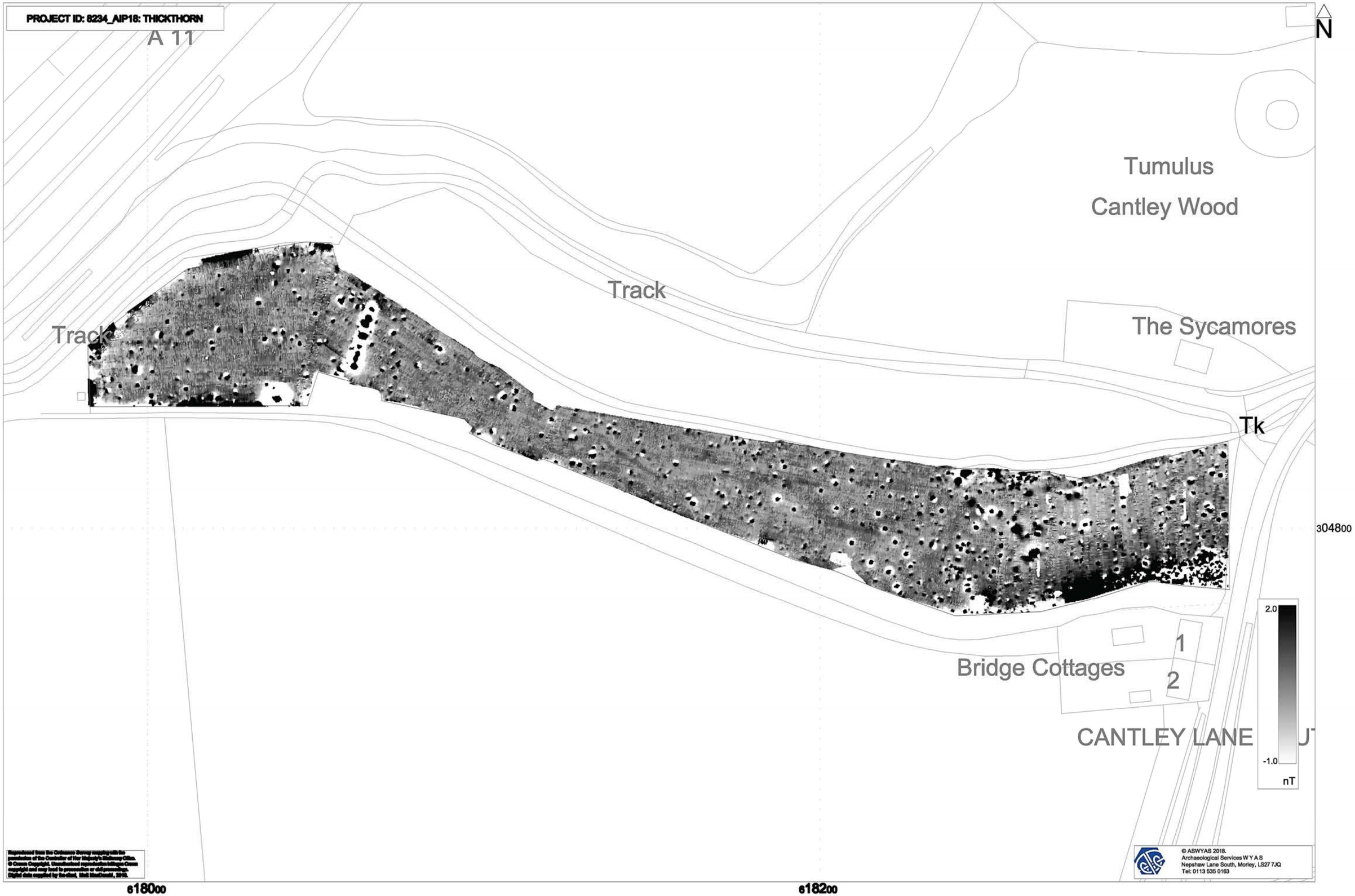
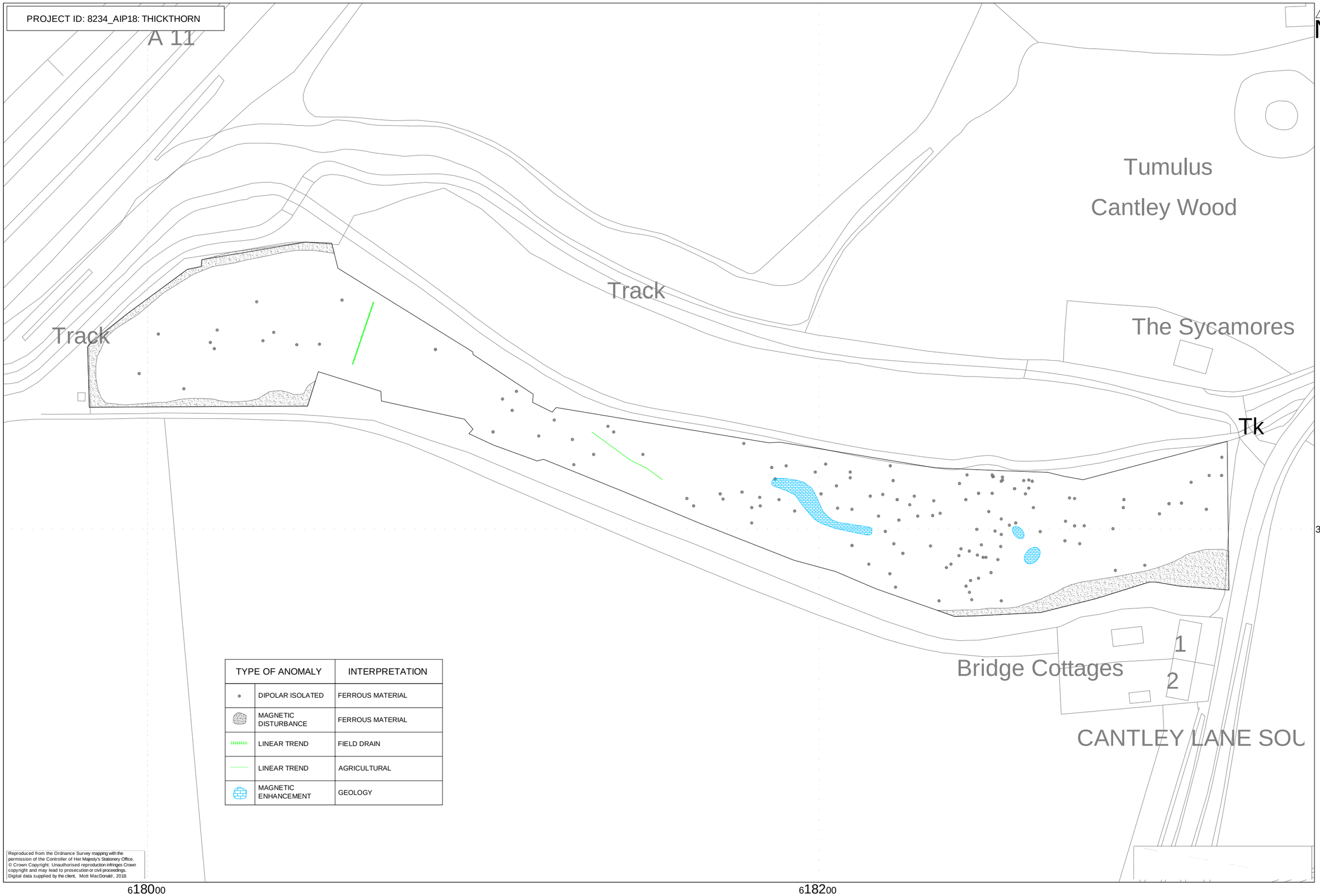


Fig. 10. Processed greyscale magnetometer data: Area 5 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN



TYPE OF ANOMALY		INTERPRETATION
	DIPOLAR ISOLATED	FERROUS MATERIAL
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	FIELD DRAIN
	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	GEOLOGY

Fig. 11. Interpretation of magnetometer data: Area 5 (1:1000 @ A3)

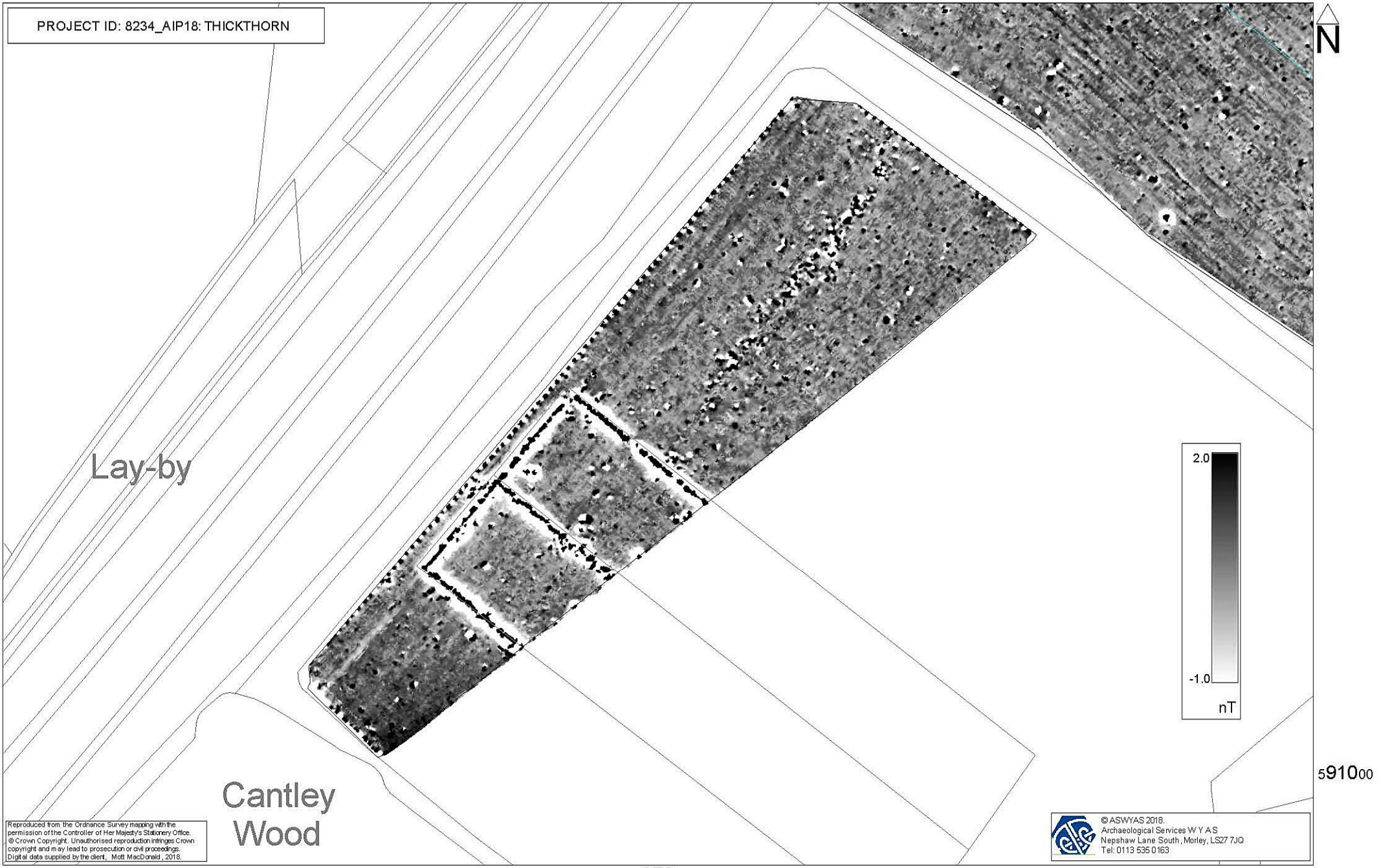


Fig. 12. Processed greyscale magnetometer data; Area 6 (1:1000 @ A4)

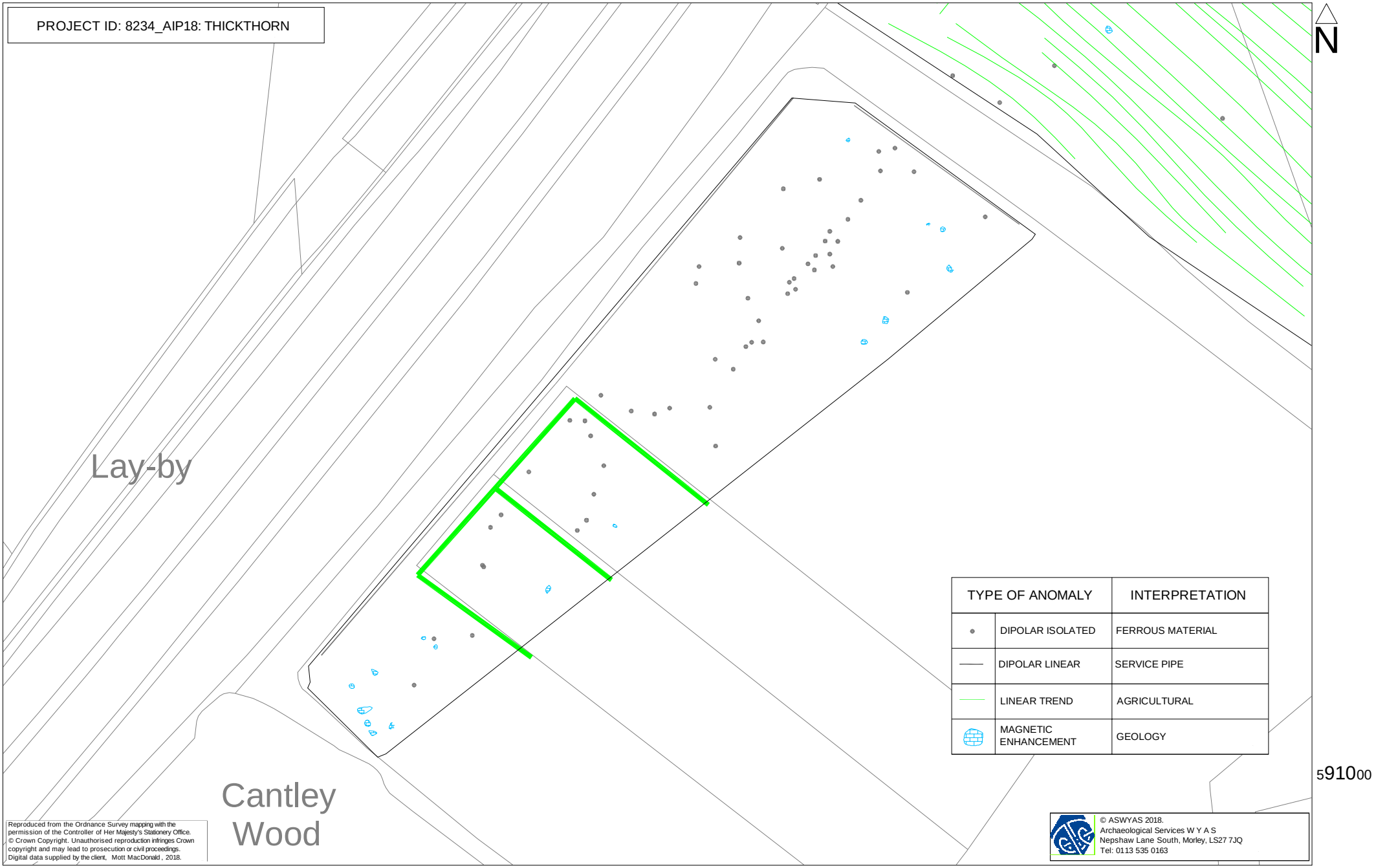


Fig. 13. Interpretation of magnetometer data; Area 6 (1:1000 @ A4)

PROJECT ID: 8234_AIP18: THICKTHORN

N

Path (um)

ED & Ward Bdy

d Bdy

305200

2.0

-1.0

nT

102

112

SOUTH CANTLEY LANE

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Nepshaw Lane South, Morley, LS27 7JQ
Tel: 0113 535 0163

618400

618600

0 50m

Fig. 14. Processed greyscale magnetometer data: Area 7 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN

TYPE OF ANOMALY		INTERPRETATION
	DIPOLAR ISOLATED	FERROUS MATERIAL
	MAGNETIC DISTURBANCE	FERROUS MATERIAL
	LINEAR TREND	AGRICULTURAL
	MAGNETIC ENHANCEMENT	GEOLOGY
	LINEAR TREND	ARCHAEOLOGY?

N

Track

ED & Ward Bdy

d Bdy

P2

102

112

SOUTH CANTLEY LANE

3052 00

6184 00

6186 00

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0 50m

Fig. 15. Interpretation of magnetometer data: Area 7 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN

N

112 SOUTH CANTLEY LANE

FB

124

Tre

305000

2.0

-1.0

nT

20.1m

ack

ETL

Track

Fishing Lake

FB

Pond

Archaeological Services WYAS
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618600

618800

0 50m

Fig. 16. Processed greyscale magnetometer data: Area 8 (1:1000 @ A3)

PROJECT ID: 8234_AIP18: THICKTHORN

TYPE OF ANOMALY		INTERPRETATION
	DIPOLAR ISOLATED	FERROUS MATERIAL
	MAGNETIC ENHANCEMENT	GEOLOGY
	MAGNETIC ENHANCEMENT	FORMER GRAVEL QUARRY

N

112

SOUTH CANTLEY LANE

FB

124

Track

3050 00

20.1m

ack

ETL

Track

Fishing Lake

FB

Pond

Archaeological Services W Y A S
Nepshaw Lane South, Morley, LS27 7JQ
Tel: 0113 535 0163

6186 00

6188 00

0 50m

Fig. 17. Interpretation of magnetometer data: Area 8 (1:1000 @ A3)

Plate 1. General view of Area 1, looking east

Plate 2. General view of Area 2, looking west

Plate 3. General view of Area 3, looking west

Plate 4. General view of Area 4, looking northeast

Plate 5. General view of Area 5, looking east

Plate 6. General view of Area 6, looking northeast

Plate 7. General view of Area 7, looking southeast

Appendix 1: Magnetic survey - technical information

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 haemetite. 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. Areas of human occupation or settlement can then be identified by measuring the magnetic susceptibility of the topsoil because 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 topsoils, subsoils and rocks 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 and the fermentation and bacterial effects associated with rubbish decomposition. The area of enhancement is usually quite large, mainly due to the tendency of discard areas to extend beyond the limit of the occupation site itself, and spreading by the plough.

Types of Magnetic Anomaly

In the majority of instances 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 present as a consequence of 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.

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 on two or three successive traverses. 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.

Methodology: Gradiometer Survey

The magnetometer survey was undertaken using a Sensys Magneto MXPDA cart-based instrument. The instrument has 5 fluxgate gradiometers spaced 0.5m apart with readings recorded at 20Hz. The gradiometers have a range of recording between 0.1nT and 10,000nT. They are linked to a Trimble R6 RTK dGPS system with data recorded by Sensys Magneto MXPDA software on a rugged PDA device. The data was stored on an SD memory card

within the PDA and later downloaded to a computer for processing and interpretation. MAGNETO (Sensys Gmbh) software was used to process and present the data

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in processed greyscale format. The data in the greyscale images has been interpolated and selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

MAGNETO was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits

Appendix 2: Survey location information

An initial survey station was established using a Trimble VRS differential Global Positioning System (Trimble R6 model). The data was geo-referenced using the geo-referenced survey station with a Trimble RTK differential Global Positioning System (Trimble R6 model). The accuracy of this equipment is better than 0.01m. The survey grids were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator CS6 and AutoCAD 2008) files; and
- a full copy of the report.

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS). Brief details may also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i.e. available for consultation in the Norfolk Historic Environment Record).

Appendix 4: Oasis form

OASIS DATA COLLECTION FORM: England

OASIS ID: archaeol11-316373

Project details

Project name	A47/A11 Thickthorn Junction
Short description of the project	A cart-based geophysical (magnetometer) survey, covering approximately 17.5 hectares was undertaken on land within the vicinity of the Thickthorn Junction on the A47, Hethersett, Norfolk. Anomalies of archaeological origin have been recorded, some of which correspond to cropmarks. Possible archaeological anomalies have also been recorded which may be associated with ring ditches. A former field boundary has also been detected in the eastern part of the site which corresponds well with recorded boundaries on Ordnance Survey mapping. Responses associated with a gravel pit in the eastern part of the site are present. The archaeological potential of the site would be characterised as high in the north and low elsewhere.
Project dates	Start: 12-03-2018 End: 16-03-2018
Previous/future work	No / Not known
Any associated project reference codes	8234 - Sitecode
Any associated project reference codes	54403 - Related HER No.
Any associated project reference codes	11820 - Related HER No.
Any associated project reference codes	ENF143424 - HER event no.
Type of project	Field evaluation
Monument type	RING DITCH Bronze Age
Monument type	HOLLOW WAY Medieval
Monument type	FIELD BOUNDARIES Late Prehistoric
Significant Finds	?RING DITCHES Uncertain
Significant Finds	DITCHES Uncertain
Methods & techniques	"Geophysical Survey"
Development type	Road scheme (new and widening)

Prompt	National Planning Policy Framework - NPPF
Position in the planning process	Not known / Not recorded
Solid geology	CHALK (INCLUDING RED CHALK)
Drift geology	SAND AND GRAVEL OF UNCERTAIN AGE OR ORIGIN
Techniques	Magnetometry

Project location

Country	England
Site location	NORFOLK SOUTH NORFOLK HETHERSETT A47/A11 Thickthorn Junction
Study area	17.5 Hectares
Site coordinates	TG 1829 0515 52.599726227778 1.223741812966 52 35 59 N 001 13 25 E Point
Height OD / Depth	Min: 19m Max: 29m

Project creators

Name of Organisation	Archaeological Services WYAS
Project brief originator	[redacted]
Project design originator	[redacted]
Project director/manager	[redacted]
Project supervisor	[redacted]

Project archives

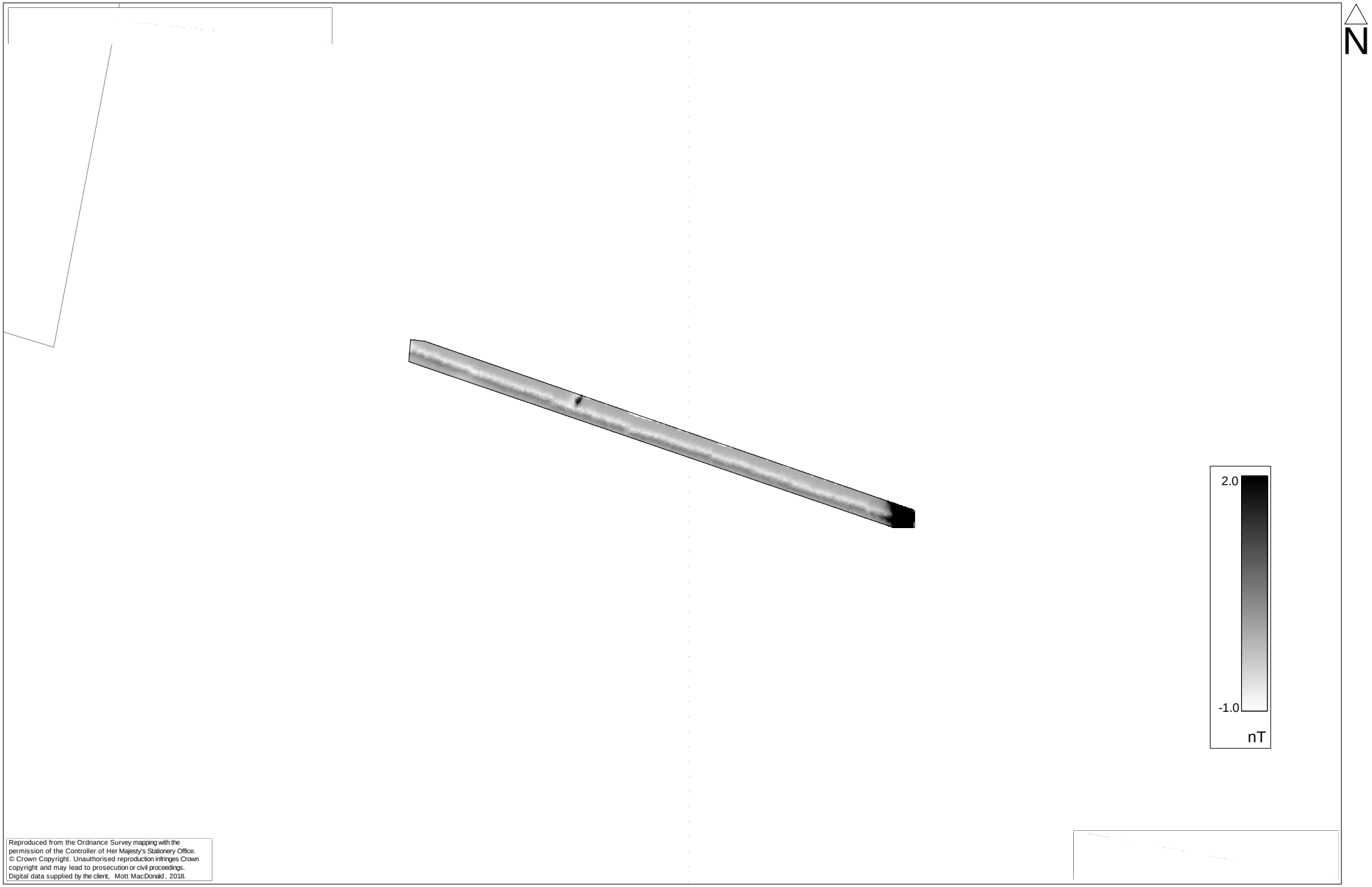
Physical Archive Exists?	No
Digital Archive recipient	[redacted]
Digital Contents	"Survey"
Digital Media available	"Geophysics","Images raster / digital photography","Survey","Text"
Paper Archive Exists?	No

Project bibliography 1

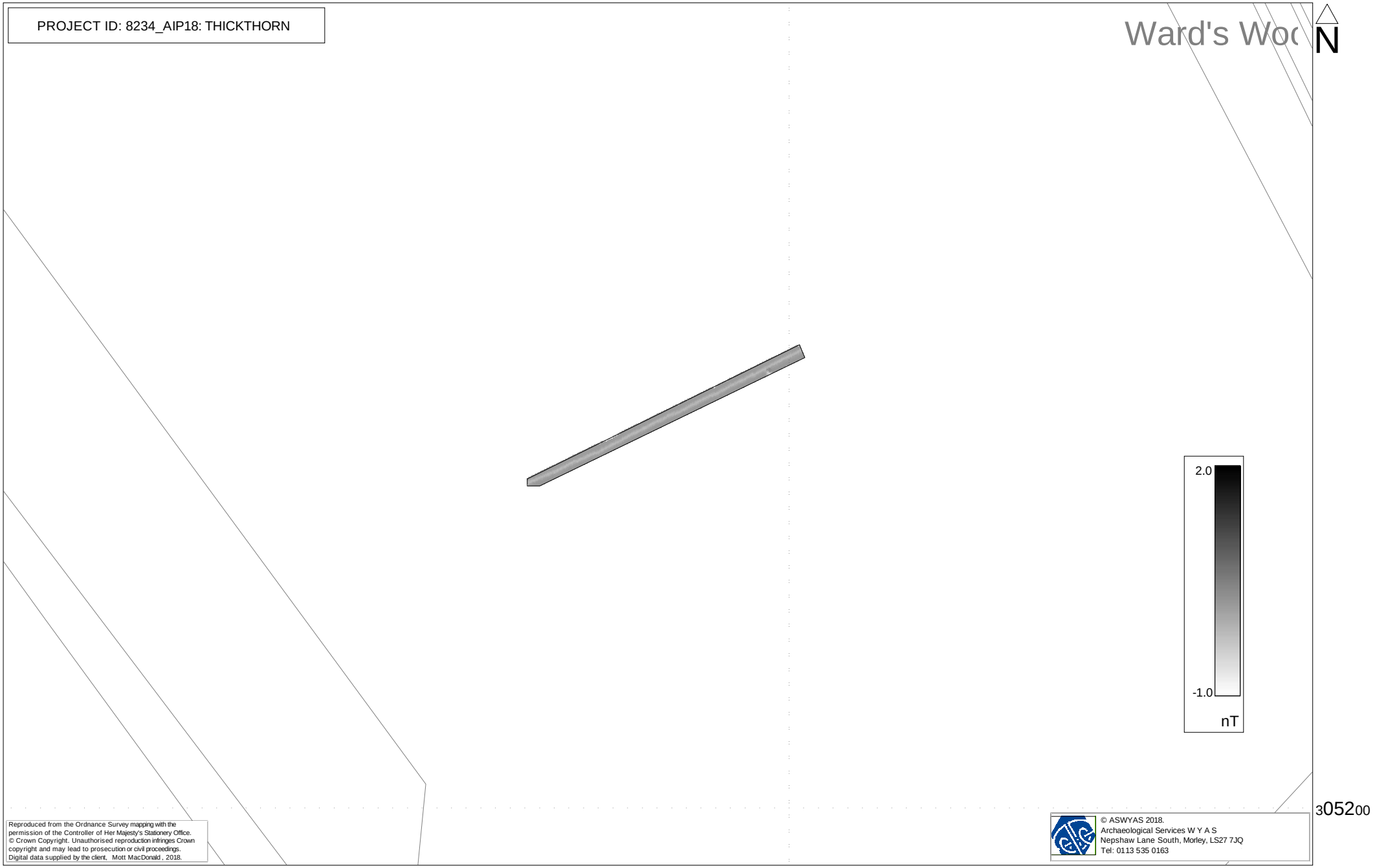
Publication type	Grey literature (unpublished document/manuscript)
Title	A47/A11 Thickthorn Junction, Hethersett
Author(s)/Editor(s)	[redacted]
Date	2018
Issuer or publisher	ASWYAS
Place of issue or publication	Leeds

Appendix 5: Repeat tracks

Appendix 5. Repeat track; Area 1 (1:1000 @ A4)

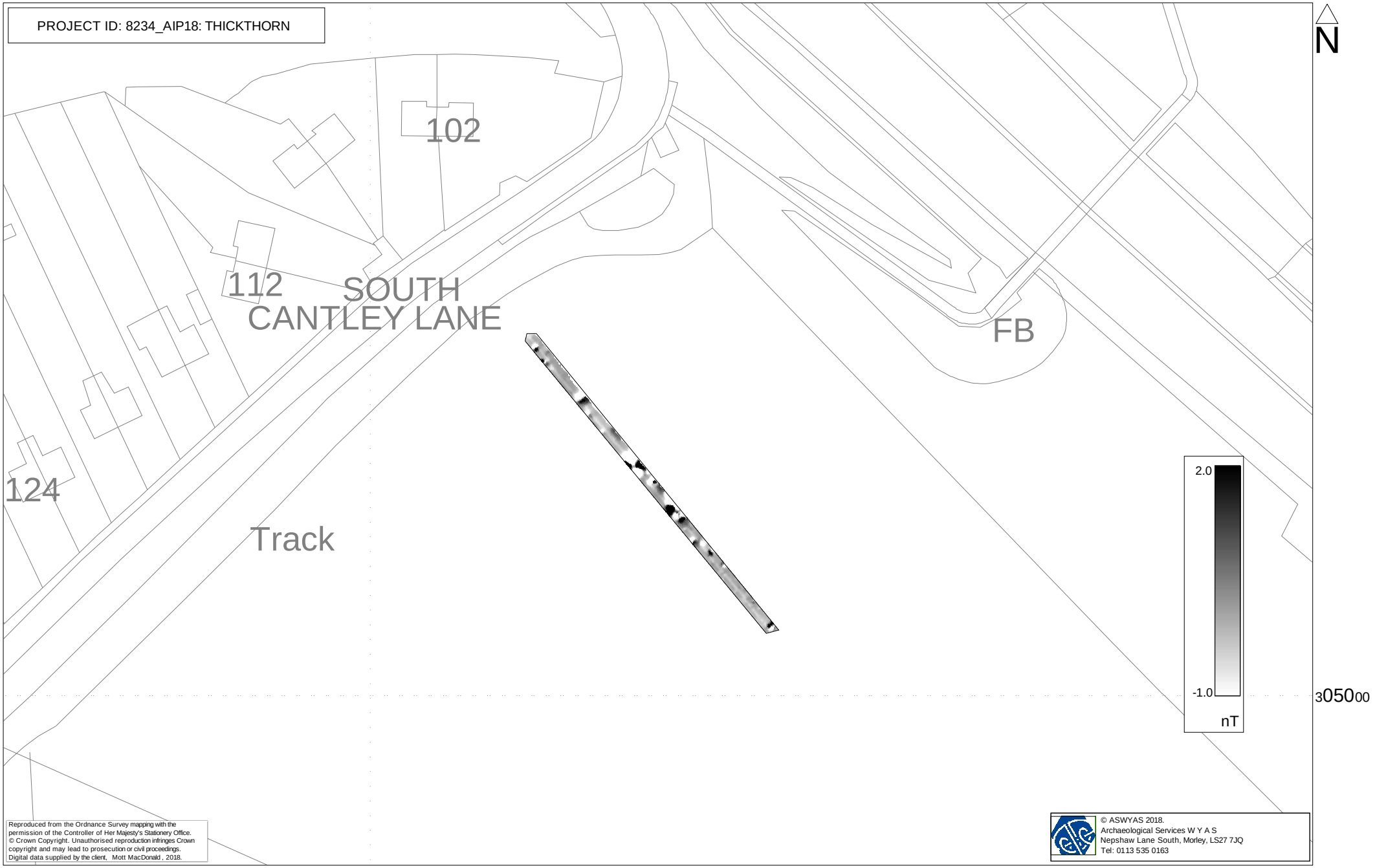


Appendix 5. Repeat track; Area 3 (1:500 @ A4)



Appendix 5. Repeat track; Area 4 (1:1000 @ A4)

Appendix 5. Repeat track; Area 7 (1:1000 @ A4)



Appendix 5. Repeat track; Area 8 (1:1000 @ A4)

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Geophysical Survey Report

A47-A11 Thickthorn Junction

Hethersett, Norfolk

For

[redacted]

On Behalf Of

[redacted]

Magnitude Surveys Ref: MSTG812

HER Event Number: ENF150634

OASIS ID: magnitud1-413625

December 2020

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Issue Date:

27 January 2021

Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 11.8ha area of land at Thickthorn Interchange, Norwich, Norfolk. A fluxgate gradiometer survey was successfully completed across the survey area, with the exception of 1.83ha land that was overgrown. The survey has detected anomalies of possible archaeological origin, which take the form of weak linear and curvilinear anomalies that may indicate fragmentary remains of enclosures or trackways. A small number of discrete anomalies may indicate cut features such as pits. These anomalies are located immediately north of known geophysical/cropmark evidence previously identified as having probable archaeological origins, however, due to the weak magnetic signal and fragmented state of the detected anomalies a more confident interpretation was not possible. Anomalies indicative of modern ploughing and drainage, as well as natural geological variations have also been identified across the survey area. The impact of modern activity on the results is generally limited to the ferrous material in field edges and small zones of ferrous debris; however, significant strong anomalies thought to be caused by subsurface features relating to recent (but no longer extant) livestock husbandry have potentially obscured any weaker anomalies present in one field.

Contents

List of Figures

1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Cotswold Archaeology on behalf Galliford Try to undertake a geophysical survey over a c. 11.8ha area of land near to the Thickthorn Interchange, Norwich, Norfolk (TG 1742 0484).

1.2. The geophysical survey comprised hand-carried GNSS-positioned fluxgate gradiometer survey. Magnetic survey is the standard primary geophysical method for archaeological applications in the UK due to its ability to detect a range of different features. The technique is particularly suited for detecting fired or magnetically enhanced features, such as ditches, pits, kilns, sunken featured buildings (SFBs) and industrial activity (David *et al*., 2008).

1.3. The survey was conducted in line with the current best practice guidelines produced by Historic England (David *et al*., 2008), the Chartered Institute for Archaeologists (CIfA, 2014) and the European Archaeological Council (Schmidt *et al.,* 2015).

1.4. It was conducted in line with a WSI produced by MS (Cantarano, 2020).

1.5. The survey commenced on 30th November 2020 and took four days to complete.

2. Quality Assurance

2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).

2.2. The directors of MS are involved in cutting edge research and the development of guidance/policy. Specifically, [redacted] has a PhD in archaeological geophysics from the University of Bradford, is a Member of CIfA and is the [redacted] of the International Society for Archaeological Prospection (ISAP); [redacted] has an MSc in archaeological geophysics and is a Fellow of the London Geological Society, as well as a member of GeoSIG (CIfA Geophysics Special Interest Group); [redacted] has a PhD in archaeological geophysics from Bournemouth University, is a Member of CIfA, the [redacted] of ISAP News, and is the [redacted] for the COST Action SAGA; [redacted] has a PhD in archaeology from the University of Southampton, has been a member of the ISAP Management Committee since 2015, and is currently the [redacted] for the EAA Archaeological Prospection Community to the board of the European Archaeological Association.

2.3. All MS managers have degree qualifications relevant to archaeology or geophysics. All MS field and office staff have relevant archaeology or geophysics degrees and/or field experience.

3. Objectives

3.1. The objective of this geophysical survey was to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The survey area was located c. 1.5km west of Cringleford (Figure 1). Gradiometer survey was undertaken across seven fields under arable cultivation. The survey area was bounded by the B1172 to the north, the A47 to the east, the Norwich Rail Line to the south, and further agricultural land to the west; it was bisected by the A11 (Figure 2). A total of c. 1.83ha could not be surveyed due to overgrown vegetation.

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
9	The area consisted of a ploughed/rolled arable field. The terrain sloped gently down from north to south.	The survey area was bounded by hedges to the north and east, and by a row of trees and the A11 to the south; there was no physical boundary to the west.
10	The area consisted of a ploughed/rolled arable field under fallow conditions. The terrain was flat.	The survey area was bounded by trees to the north, west, and east. There was no physical boundary to the south. Several large trees were located within the survey area.
11	The area consisted of an overgrown grassland field. The terrain was flat in the north, but sloped down towards the south in the southern third of the area.	The survey area was bounded by trees on all sides. A wire fence ran east-west across the centre of the survey area. Significant areas of the field were unsurveyable due to overgrown vegetation.
12	The area consisted of grassland field with overgrown vegetation in places. The terrain sloped gently down from north to south. Numerous animal burrows were present across the northern half of the field.	The survey area was bounded to the south and east by a wire fence. There was no physical boundary to the northwest. A pylon was located in the eastern corner. An area of the south-western part of the field was unsurveyable due to overgrown vegetation, and a pile of debris was located in the centre of the field.
13	The area consisted of a pasture field with large areas of overgrown vegetation. The terrain was level.	The survey area was bounded by hedges and wire fencing to the north, and by the Cantley Stream to the south. The majority of the area could not be surveyed due to overgrown vegetation.
14	The area consisted of pasture. The terrain sloped down from west to east.	The survey area was bounded to the north by an electric fence (deactivated at the time of survey) and by trees and Cantley Lane South to the east. There was no physical boundary to the south. The western end of the area was partly divided by a field boundary hedge and track.

15	The area consisted of an overgrown pasture field, containing several bramble thickets. The terrain was level.	The survey area was bounded to the south by a tree line. There was no physical boundary on the other sides. A metal shed was located in the north-western corner.

4.3. The underlying geology comprises undifferentiated chalk of the Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation. Superficial deposits comprise sand and gravel of the Sheringham Cliffs Formation across the majority of the survey area, with surrounding lobes of the Lowestoft Formation (diamicton) extending across Area 10 and parts of Areas 9, 11 and 12. A strip of alluvium (comprising clay, silt, sand and gravel) associated with the Cantley Stream runs through the survey area (Areas 14 and 15) (British Geological Survey, 2021).

4.4. The soils consist of slightly acid loamy and clayey soils with impeded drainage (Soilscapes, 2021).

5. Archaeological Background

5.1. The following is a summary of information provided in a Geophysical Survey Scope produced by [redacted] and provided by [redacted].

5.2. A previous geophysical survey identified two main areas of possible archaeological activity. In the southern half of the field containing Area 10, an area of intense burning within a rectilinear enclosure was identified as well as indications of probable former field boundaries corresponding to cropmarks. A series of possible ring ditches were detected in the field north east of our Survey Area 12.

5.3. Survey Area 12 is adjacent to a scheduled monument encompassing two Bronze Age round barrows, located in the wood directly to the south.

5.4. Several prehistoric finds have been recorded around the survey area including prehistoric flints. Past field walking in the eastern part of survey area has revealed three bronze age socketed axes, flint tools and small quantities of Neolithic, Bronze Age, and Iron Age pottery.

5.5. The survey area is located c.100m north of the deserted medieval village (DMV) of Cantley. A double ditched enclosure located north of the DMV and c.100m west of Area 14 suggests that possible remains may be present beyond the area identified as the DMV. A medieval moat is now incorporated into a local pond at the former country estate Thickthorne Park c.550m west of Area 11.

5.6. Through the post-medieval period, the survey area was widely agricultural, however, some industrial clay extraction was located c.800m north of survey area. The Norfolk Railway, opened in 1844, runs through the survey area in an approximately northeast to southwest direction.

6. Methodology

6.1. Magnetometer surveys are generally the most cost effective and suitable geophysical technique for the detection of archaeology in England. Therefore, a magnetometer survey should be the

preferred geophysical technique unless its use is precluded by any specific survey objectives or the survey area environment. For this survey area, no factors precluded the recommendation of a standard magnetometer survey. Geophysical survey therefore comprised the magnetic method as described in the following section.

6.2. Data Collection

6.2.1. Geophysical prospection comprised the magnetic method as described in the following table.

6.2.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments Grad-13 Digital Three-Axis Gradiometer	1m	200Hz reprojected to 0.125m

6.2.3. The magnetic data were collected using MS' bespoke hand-carried GNSS-positioned system.

6.2.3.1. MS' hand-carried system was comprised of Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing was through a multi-channel, multi-constellation GNSS Smart Antenna RTK GPS outputting in NMEA mode to ensure high positional accuracy of collected measurements. The RTK GPS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

6.2.3.2. Magnetic and GPS data were stored on an SD card within MS' bespoke datalogger. The datalogger was continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allowed for data collection, processing and visualisation to be monitored in real-time as fieldwork was ongoing.

6.2.3.3. A navigation system was integrated with the RTK GPS, which was used to guide the surveyor. Data were collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

6.3. Data Processing

6.3.1. Magnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to Historic England's standards for "raw or minimally processed data" (see Section 4.2 in David *et al.,* 2008: 11).

Sensor Calibration – The sensors were calibrated using a bespoke in-house algorithm, which conforms to Olsen *et al.* (2003).

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics.

Projection to a Regular Grid – Data collected using RTK GPS positioning requires a uniform grid projection to visualise data. Data are rotated to best fit an orthogonal grid

projection and are resampled onto the grid using an inverse distance-weighting algorithm.

Interpolation to Square Pixels – Data are interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

6.4. Data Visualisation and Interpretation

6.4.1. This report presents the gradient of the sensors' total field data as greyscale images, as well as the total field data from the lower sensors. The gradient of the sensors minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the contrast of weak or ephemeral anomalies can be reduced through the process of calculating the gradient. Consequently, some features can be clearer in the respective gradient or total field datasets. Multiple greyscale images of the gradient and total field at different plotting ranges have been used for data interpretation. Greyscale images should be viewed alongside the XY trace plot (Figure 9, 12, 15, 18). XY trace plots visualise the magnitude and form of the geophysical response, aiding anomaly interpretation.

6.4.2. Geophysical results have been interpreted using greyscale images and XY traces in a layered environment, overlaid against open street maps, satellite imagery, historical maps, LiDAR data, and soil and geology maps. Google Earth (2021) was also consulted, to compare the results with recent land use.

6.4.3. Geodetic position of results – All vector and raster data have been projected into OSGB36 (ESPG27700) and can be provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively. Figures are provided with raster and vector data projected against OS Open Data.

7. Results

7.1. Qualification

7.1.1. Geophysical results are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen technique(s) and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible, an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports, as well as reports from further work, in order to constantly improve our knowledge and service.

7.2. Discussion

7.2.1. The geophysical results are presented in combination with historical maps (Figure 6).

7.2.2. The fluxgate gradiometer survey has generally responded well to the environment of the survey area. The impact of modern activity on the data is generally limited to the perimeters of fields (see Section 4.2). This has allowed the identification of weaker anomalies that may relate to archaeological features, agricultural activity and natural geological variation. However, a significant proportion of the dataset from Area 12 is dominated by strong anomalies that appear to relate to recent use of the area for livestock rearing, as noted from satellite imagery (Google Earth, 2020). Similar large magnetic haloes occur in Areas 15 and 11, where they correspond with the locations of a metal shed and a wire fence noted at the time of survey. In Area 9, a buried service has been detected.

7.2.3. Across the south of Area 10, a number of linear anomalies have been classified as Possible Archaeology (Figure 11). They have been identified as relating to subsurface anthropogenic features on the grounds of their morphology, strength and signal form. It is also noted that their shape and configuration is similar to that of cropmarks and geophysical anomalies, interpreted as having archaeological origins, that are located within the same field (to the south of the MS survey area; see Section 5.2), and the anomalies may indicate an extension of this complex. Although they do not form a complete or distinctive layout, the right-angle return and parallel arrangement of the anomalies are consistent with features such as enclosure boundaries and trackways. However, it is possible that they may also be related to modern drainage or perhaps to the upkeep of parkland in the 19th century (Figure 6). A curvilinear anomaly has also been identified as Possible Archaeology in Area 12. It has a similar magnetic signal than the anomalies identified across Area 10 and its morphology suggest an anthropogenic origin. However, its weak magnetic signal and lack of further context has prevented a more confident interpretation.

7.2.4. Parallel linear anomalies characteristic of those caused by modern ploughing have been identified across the survey area. This interpretation is supported by their correlation with the direction of ploughing regimes visible in satellite imagery. It is likely that some of these linear anomalies (particularly in Areas 10 and 12) relate to modern land drainage practices and ploughed out drains; however, the similarity of the magnetic responses makes it difficult to distinguish confidently between the two and an Agricultural Trend classification has been used to include both.

7.2.5. Across the survey area, bands of natural subsurface variation have been identified, which present as more magnetically enhanced zones or discrete anomalies (Figures 3-5). These are typical of the magnetic background detected over deposits of superficial deposits of till, sand and gravel, and alluvium, while curvilinear variations in Area 14 are likely to relate to channel migration of the Cantley Stream.

7.2.6. Parallel curvilinear anomalies running on a northeast-southwest orientation across Area 12 have been classified as Undetermined. They are considered likely to relate to modern trackways or similar, given recent land use in this field; however, they do not correspond with any specific features identifiable on satellite imagery, LiDAR or historical maps. The uncertainty reflected in their classification stems from the possibility that they may have a natural geological origin.

7.3. Interpretation

7.3.1. General Statements

7.3.1.1. Geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually.

7.3.1.2. **Data Artefact** – Data artefacts usually occur in conjunction with anomalies with strong magnetic signals due to the way in which the sensors respond to very strong point sources. They are usually visible as minor 'streaking' following the line of data collection. While these artefacts can be reduced in post-processing through data filtering, this would risk removing 'real' anomalies. These artefacts are therefore indicated as necessary in order to preserve the data as 'minimally processed'.

7.3.1.3. **Ferrous (Spike)** – Discrete dipolar anomalies are likely to be the result of isolated pieces of modern ferrous debris on or near the ground surface.

7.3.1.4. **Ferrous/Debris (Spread)** – A ferrous/debris spread refers to a concentration of multiple discrete, dipolar anomalies usually resulting from highly magnetic material such as rubble containing ceramic building materials and ferrous rubbish.

7.3.1.5. **Magnetic Disturbance** – The strong anomalies produced by extant metallic structures, typically including fencing, pylons, vehicles and service pipes, have been classified as 'Magnetic Disturbance'. These magnetic 'haloes' will obscure

weaker anomalies relating to nearby features, should they be present, often over a greater footprint than the structure causing them.

7.3.1.6. **Undetermined** – Anomalies are classified as Undetermined when the origin of the geophysical anomaly is ambiguous and there is no supporting contextual evidence to justify a more certain classification. These anomalies are likely to be the result of geological, pedological or agricultural processes, although an archaeological origin cannot be entirely ruled out. Undetermined anomalies are generally distinct from those caused by ferrous sources.

7.3.2. Magnetic Results - Specific Anomalies

7.3.2.1. **Possible Archaeology (Weak)** – In the south of Area 10, an L-shaped anomaly has been identified [**10a**] (Figures 10-12), which may indicate part of a rectilinear enclosure. It consists of two narrow, weak positive anomalies separated by a central weak negative anomaly, which may indicate the feature was originally formed with two narrow ditches flanking an earthen bank. Further negative curvilinear anomalies [**10b**] have been identified to the northwest of [**10a**], and while they are close by, it is not possible to ascertain if the features they relate to are associated with those at [**10a**]. A further weak negative linear anomaly was identified c. 26m to the east of, and running parallel to, the anomaly at [**10a**]. They are of a similar shape and layout to geophysical anomalies and cropmarks previously identified to the immediate south of Area 10 (see Section 5.2) and may have similar origins. A negative curvilinear anomaly has been identified in Area 12 [**12a**]. It has a similar magnetic signal to [**10a-c**] and its morphology suggests an anthropogenic origin. It is however, possible that the linear negative anomalies indicate land drains, or other agricultural activity, hence they have been categorised as Possible Archaeology to reflect a degree of uncertainty in the interpretation.

7.3.2.2. **Possible Archaeology (Strong/Weak)** – Adjacent to the linear anomalies at [**10b**], two small discrete anomalies have been identified that may indicate cut features, such as pits, that contain magnetically enhanced fill. A similar, though weaker, anomaly is located c. 30m to the south. Three weakly enhanced linear anomalies also indicating cut features, such as ditches, that contain magnetically have been identified c.55m northeast of [**10a**]. Although they are more pronounced than the general 'background' anomalies resulting from the superficial deposits, a natural origin cannot be ruled out.

7.3.2.3. **Services** – Across the centre and west of Area 12, a series of strong positive linear anomalies have been identified [**12b**] (Figures 14-16). These align to form a rectilinear grid measuring c. 39m by c. 22m (and probably extending northwest beyond the survey area). These anomalies collocate with probable animal pens identified on recent satellite imagery (Google Earth, 2020) and are likely to be caused by water pipes or foundations relating to the pens. A further strong positive linear anomaly was identified running northeast-southwest immediately south of these anomalies (classified as Magnetic Disturbance) and is likely to relate to the same use of the field.

7.3.2.4. **Undetermined (Weak)** – Within Area 12, weak parallel curvilinear anomalies [**12c**] were detected close to the eastern boundary (Figures 13-15). It is possible that these anomalies are related to the use of the field for livestock as satellite imagery indicates several trackways and parch marks on a similar alignment. However, given their scale, morphology, strength and diffuse edges, it is not possible to rule out a natural geological origin for these anomalies.

7.3.2.5. **Natural (Strong, Weak and Zones)** – Across the south of Area 9, bands of weakly positive natural variations have been identified, with stronger enhanced anomalies within the bands (Figures 7-9). These bands appear to correlate with the topographical slope identified within the survey area (Section 4.2) and may be related to slope processes. Further weak positive natural variations have been identified in the south of Area 14 (Figures 16-18), where they are likely to be caused by sediments deposited by the Cantley Stream (present c. 40m northeast of Area 14). A further zone of mildly enhanced material is present across the centre of Area 10 (Figures 10-12) and is typical of mineralogical variation in these types of superficial deposits.

7.3.2.6. **Agricultural (Trend)** – Across Areas 9, 10, 12 and parts of 14, weak parallel linear anomalies have been identified on multiple alignments (Figures 4-5). These indicate modern ploughing regimes and many correlate with the orientation of ploughing visible on satellite imagery, LiDAR and on the ground at the time of survey. A representative sample have been indicated on the interpretation figures. It is likely that some of the more pronounced linear anomalies may be caused by (ploughed out) land drains, although these have been included in the Agricultural category as it is not possible to fully distinguish the two with confidence.

8. Conclusions

8.1. A fluxgate gradiometer survey has been successfully undertaken across the survey area, with the exception of c. 1.83ha that could not be surveyed due to overgrown vegetation. The geophysical survey has detected a range of anomalies of anthropogenic and natural origin. The natural variation caused by superficial deposits/soils has resulted in several bands of anomalies relating to the magnetic enhancement, although they were not sufficiently strong to prevent the identification of other anomalies within these zones. The impact of modern activity is generally limited to interference from perimeter fencing, with a buried service detected, and some small zones of ferrous debris recorded across the survey area. Strong magnetic anomalies have, however, been detected over a significant portion of a field in the east of the survey area, which appear to relate to recent livestock pens and associated infrastructure.

8.2. Possible archaeological activity has been identified as a series of weak linear and curvilinear anomalies interpreted as possible enclosures or trackways in the north of the survey area. These anomalies may represent a continuation of possible features recorded from previous geophysical/aerial photography data in the south of the field, although it is difficult to be certain due to the weak magnetic signal of these anomalies.

8.3. Agricultural activity has been identified as a series of weak parallel linear anomalies across much of the survey area. These are likely to be evidence of modern ploughing and drainage regimes.

8.4. The origin of two parallel linear anomalies cannot be confidently identified from the magnetometer data alone, and they have thus been classified as Undetermined. It is likely that they are associated with former livestock farming in this field, however, geological or archaeological origins cannot be excluded.

9. Archiving

9.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.

9.2. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to any dictated time embargoes.

10. Copyright

10.1. Copyright and intellectual property pertaining to all reports, figures and datasets produced by Magnitude Services Ltd is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

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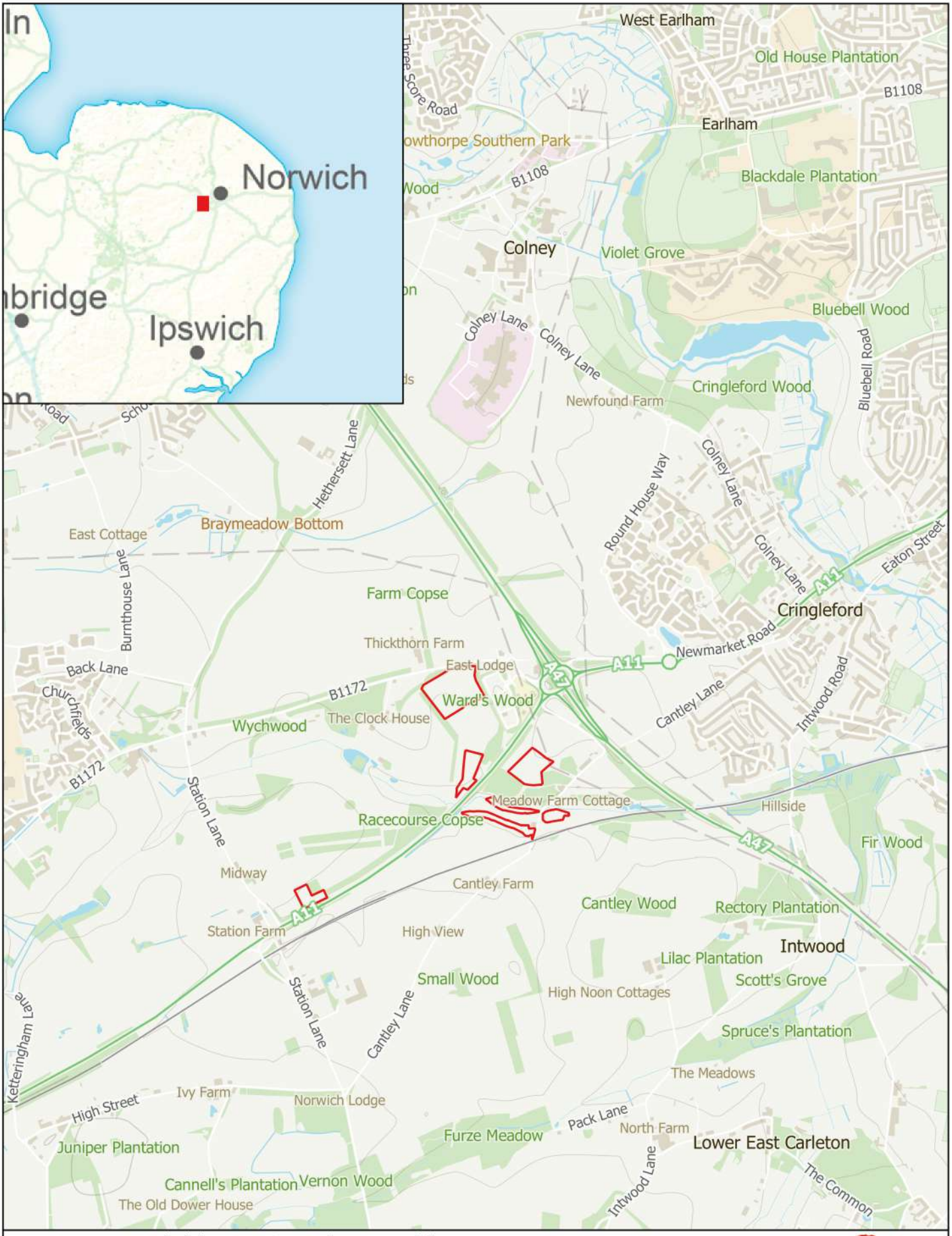
[redacted] A47/A11 Thickthorn Junction Geophysical Survey Scope. [redacted]

12. Project Metadata

MS Job Code	MSTG812
Project Name	A47-A11 Thickthorn Junction, Hethersett, Norfolk
Client	[redacted]
Grid Reference	TG 1742 0484
Survey Techniques	Magnetometry
Survey Size (ha)	11.8ha
Survey Dates	2020-11-30 to 2020-12-03
Project Lead	[redacted]
Project Officer	[redacted]
HER Event No	ENF150634
OASIS No	magnitud1-413625
S42 Licence No	N/A
Report Version	1.1

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Lead to Review	[redacted]	[redacted]	11 December 2020
0.2	Draft for Director Approval	[redacted]	[redacted]	14 December 2020
1.0	Issued as Final	[redacted]	[redacted]	16 December 2020
1.1	OASIS Number added to Front Page and Project Metadata	[redacted]	[redacted]	27 January 2021



MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 1 - Site Location
1:25,000 @ A4

Site Boundary

N

0 0.5 1 km

magnitude surveys

617250
618250
305500
305000
304500
B1172
A11
A47
Area 10
Area 11
Area 12
Area 13
Area 14
Area 15
Area 9
Thickthorn Wood
Wychwood
Wychwood House
The Clock House
Ward's Wood
Thickthorn Services
Cantley Wood
Cantley Lane South
Meadow Farm Cottage
Racecourse Copse
Midway
Station Lane
Cantley Farm

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 2 - Location of Survey Areas
1:5,000 @ A3

Survey Extents

N

0 100 200 300 m

magnitude surveys

617250
618250
305500
305000
304500
B1172
A11
A47
Thickthorn Wood
Wychwood
Wychwood House
The Clock House
Ward's Wood
Thickthorn Services
Area 10
Area 11
Area 12
Area 13
Area 14
Area 15
Area 9
Cantley Wood
Cantley Lane South
Meadow Farm Cottage
Racecourse Copse
Midway
Station Lane
Cantley Farm

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 3 - Magnetic Total Field (Lower Sensor) (Overview)
1:5,000 @ A3

48,997 nT 49,005

N

0 100 200 300 m

magnitude surveys

617250
618250
305500
305000
304500
B1172
A11
A47
Thickthorn Wood
Wychwood
Wychwood House
The Clock House
Ward's Wood
Thickthorn Services
Area 10
Area 11
Area 12
Area 13
Area 14
Area 15
Area 9
Cantley Wood
Cantley Lane South
Meadow Farm Cottage
Racecourse Copse
Midway
Station Lane
Cantley Farm

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 4 - Magnetic Gradient (Overview)
1:5,000 @ A3

-1 nT 2

N

0 100 200 300 m

magnitude surveys

617250
618250
305500
305000
304500
B1172
A11
A47
Thickthorn Wood
Wychwood
Wychwood House
The Clock House
Ward's Wood
Thickthorn Services
Area 10
Area 11
Area 12
Area 13
Area 14
Area 15
Area 9
Cantley Wood
Cantley Lane South
Meadow Farm Cottage
Racecourse Copse
Midway
Station Lane
Cantley Farm

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 5 - Magnetic Interpretation (Overview)
1:5,000 @ A3

- Archaeology Possible (Strong)
- Archaeology Possible (Weak)
- Natural (Strong)
- Natural (Weak)
- Natural (Zone)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Strong)
- Undetermined (Weak)
- Data Artefact
- Agricultural (Trend)
- Service
- Ferrous (Spike)

N
0 100 200 300 m

magnitude surveys

617250
618250
305500
305000
304500
Lodge
Thickthorn House
F.B.
Weir
Hydraulic Ram
F.P.
Area 9
Area 10
Area 11
Area 12
Area 13
Area 14
Area 15
Big Wood
Ford
B.M. 57.7
All Saints' Church & Burial Ground
(Site of)
B.M. 96.1
Cantley Farm
Cantley
M.P.
B.M. 95
T
L a n e

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 6 - Magnetic Interpretation Over Historical Maps
1:5,000 @ A3

Contains historical maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 © National Library of Scotland

- Archaeology Possible (Strong)
- Archaeology Possible (Weak)
- Natural (Strong)
- Natural (Weak)
- Natural (Zone)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Strong)
- Undetermined (Weak)
- Open
- Agricultural (Trend)
- Service
- Ferrous (Spike)

N

0 100 200 300 m

magnitude surveys

617000

617200

617400

304500

304500

Area 9

A11

Station Lane

304300

304300

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 7 - Magnetic Gradient (Area 9)
1:1,500 @ A3

-1 nT 2

N

0 40 80 120 m

magnitude surveys

617000

617200

617400

304500

304500

Area 9

A11

Station Lane

304300

304300

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 8 - Magnetic Interpretation (Area 9)
1:1,500 @ A3

Natural (Strong)
Natural (Weak)
Magnetic Disturbance
Undetermined (Strong)
Agricultural (Trend)
Service
Ferrous (Spike)

N

0 40 80 120 m

magnitude surveys

617000
617200
617400
304500
304500
304300
304300
Area 9
A11
Station Lane

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 9 - XY Trace Plot (Area 9)
30nT/cm at 1:1,500 @ A3

N
0
40
80
120 m

magnitude surveys

617800
618000
618200
305500
305300
B1172
East Lodge
Ward's Wood
Area 10

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 10 - Magnetic Gradient (Area 10)
1:1,500 @ A3

-1 nT 2

0 40 80 120 m

N

magnitude surveys

617800
618000
618200
305500
305300
B1172
East Lodge
10b
10a
10c
Area 10
Ward's Wood

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 11 - Magnetic Interpretation (Area 10)
1:1,500 @ A3

- Archaeology Possible (Strong)
- Archaeology Possible (Weak)
- Natural (Zone)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Data Artefact
- Agricultural (Trend)
- Ferrous (Spike)

N

0 40 80 120 m

magnitude surveys

617800
618000
618200
B1172
East Lodge
B1172
305500
305500
B1172
Ward's Wood
Area 10
305300
305300

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 12 - XY Trace Plot (Area 10)
30nT/cm at 1:1,500 @ A3

N
0
40
80
120 m
magnitude surveys

618000
618200
618400
305100
305100
A11
Area 11
Area 12
Cantley Wood
304900
304900
Cantley Lane South

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 13 - Magnetic Gradient (Areas 11 & 12)
1:1,500 @ A3

-1 nT 2

B1172
A47
A11

N

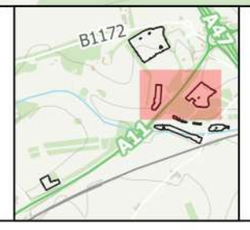
0 40 80 120 m

magnitude surveys

618000
618200
618400
305100
304900
A11
Area 11
12b
12a
12c
Area 12
Cantley Wood
Cantley Lane South

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 14 - Magnetic Interpretation (Areas 11 & 12)
1:1,500 @ A3

Archaeology Possible (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Weak)
Agricultural (Trend)
Service
Ferrous (Spike)

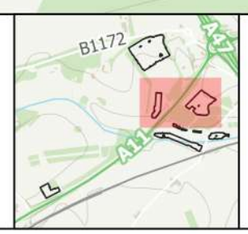


N
0
40
80
120 m

magnitude surveys

618000
618200
618400
305100
305100
A11
Area 11
Area 12
Cantley Wood
304900
304900
Cantley Lane South

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 15 - XY Trace Plot (Areas 11 & 12)
30nT/cm at 1:1,500 @ A3



N
0
40
80
120 m

magnitude surveys

618000
618200
618400
304900
304700
A11
Area 11
Area 12
Cantley Wood
Area 13
Area 14
Area 15
Meadow Farm Cottage
Cantley Lane South

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 16 - Magnetic Gradient (Areas 13 - 15)
1:1,500 @ A3

-1 nT 2

B1172
A47
A11

N

0 40 80 120 m

magnitude surveys

618000
618200
618400
304900
304700
Area 11
Area 12
12c
Area 13
Area 14
Area 15
Cantley Wood
Meadow Farm Cottage
Cantley Lane South
A11

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 17 - Magnetic Interpretation (Areas 13 - 15)
1:1,500 @ A3

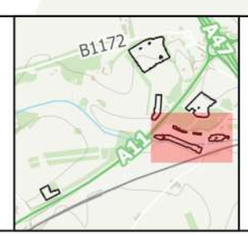
Natural (Weak)
Natural (Zone)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Weak)
Data Artefact
Agricultural (Trend)
Ferrous (Spike)

N
0
40
80
120 m

magnitude surveys

618000
618200
618400
Area 11
Area 12
Cantley Wood
A11
304900
304900
Meadow Farm Cottage
Area 13
Cantley Lane South
Area 14
Area 15
304700
304700

MSTG812 - A47-A11 Thickthorn Junction, Hethersett, Norfolk
Figure 18 - XY Trace Plot (Areas 13 - 15)
30nT/cm at 1:1,500 @ A3



N
0
40
80
120 m
magnitude surveys