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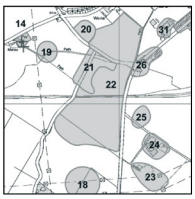





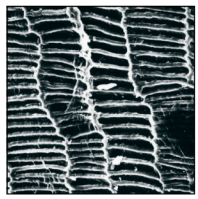


PENRITH TO MELKINTHORPE GAS PIPELINE, CUMBRIA

GEOPHYSICAL SURVEY

commissioned by Northern Gas Networks

July 2020

HEADLAND ARCHAEOLOGY

REGISTERED ORGANISATION CIfA

PENRITH TO MELKINTHORPE GAS PIPELINE, CUMBRIA

GEOPHYSICAL SURVEY

commissioned by Northern Gas Networks

July 2020

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PROJECT INFO:

HA Project Code **PTMP20** / NGR **NY 5274 2842 – NY 5755 2526** / Parish **Penrith** / Local Authority **Cumbria** / OASIS Ref. **headland5-398120**

PROJECT TEAM:

Project Manager **David Harrison** / Author **Matthew Berry** / Fieldwork **Olivier Vansassenbrouck, Peter Heykoop** / Graphics **Eleanor Winter, Ross Bishop, Sam Harrison**

Approved by **David Harrison** D Harrison.....

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HEADLAND ARCHAEOLOGY

part of the RSK Group

REGISTERED ORGANISATION CIfA

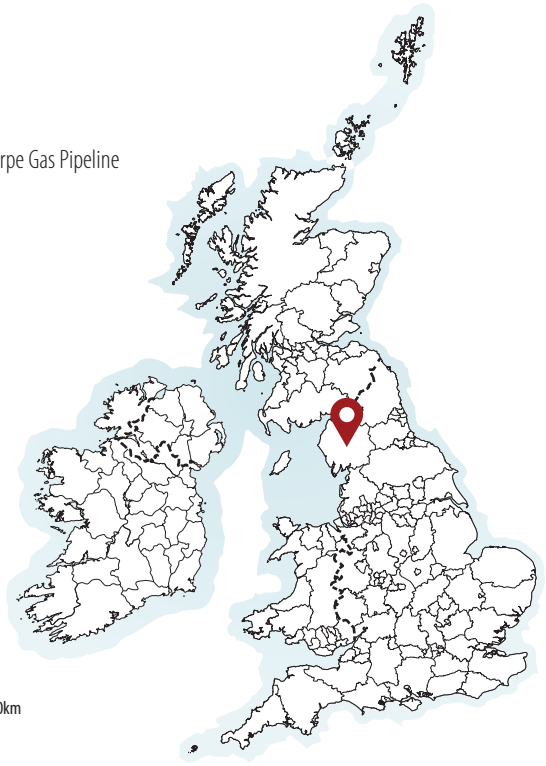
PROJECT SUMMARY

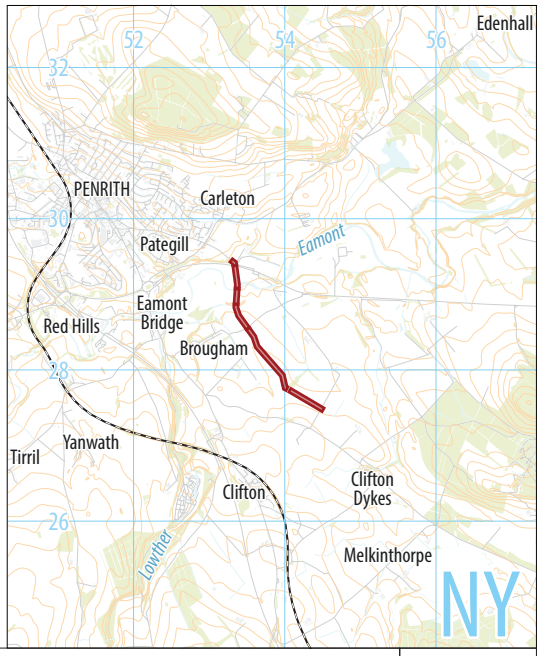
Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey over 5ha along a linear corridor between Penrith and Clifton Dykes, Cumbria, to inform proposals for the route of a gas pipe. The survey has not identified any anomalies of clear archaeological potential. Linear anomalies discovered adjacent to the River Eamont and River Lowther are likely land drains, whilst other linear anomalies and trends elsewhere on the route can be attributed to either modern service pipes or are likely natural in origin.

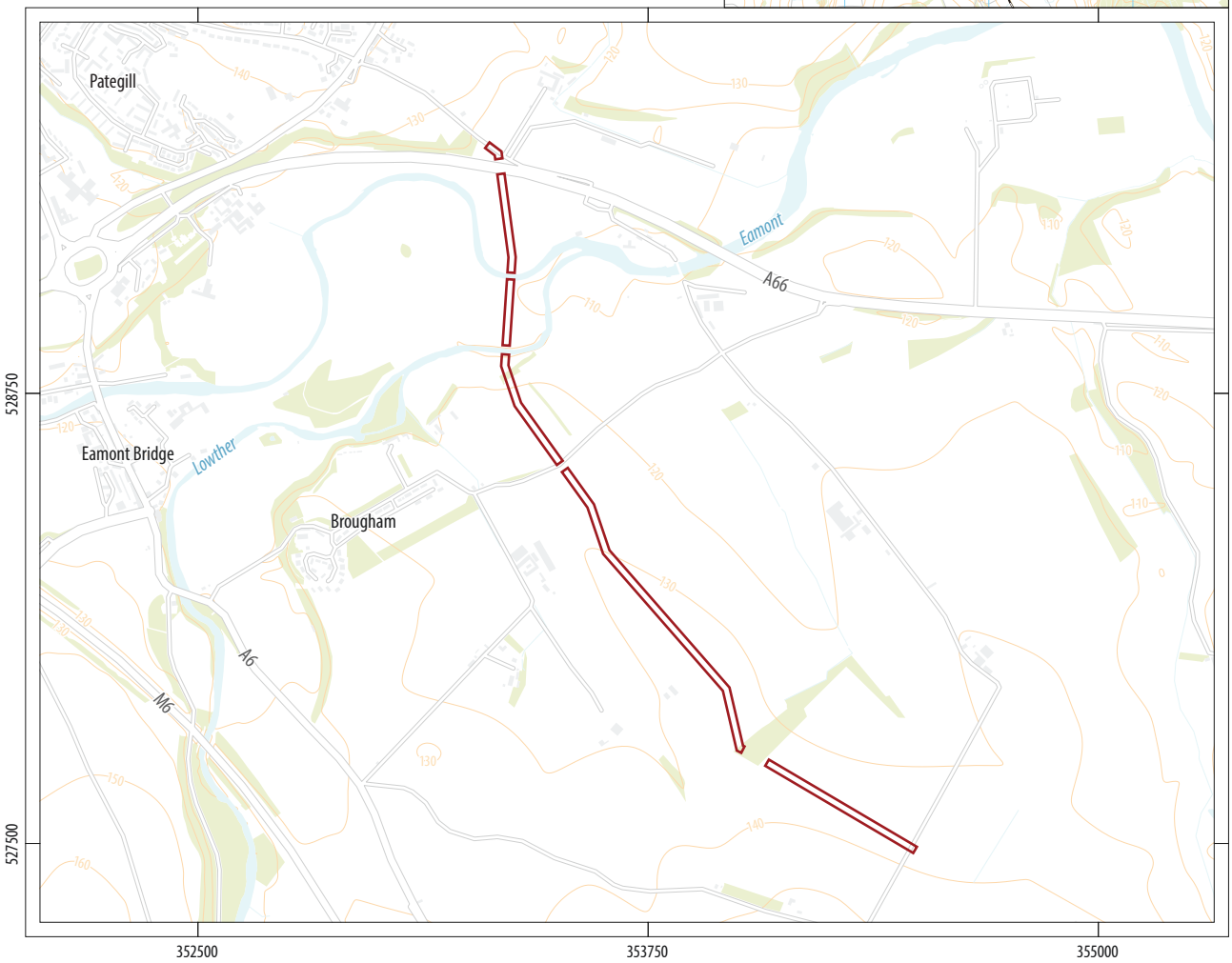
CONTENTS

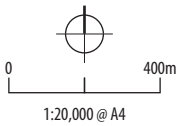
LIST OF ILLUSTRATIONS

Penrith to Melkinthorpe Gas Pipeline
Cumbria









geophysical survey area

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ILLUS 1 Site location

PENRITH TO MELKINTHORPE GAS PIPELINE, CUMBRIA

GEOPHYSICAL SURVEY

1 INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Northern Gas Networks (the Client), to undertake a linear geophysical (magnetometer) survey on a corridor of land between Penrith and Melkinthorpe to inform planning proposals for a future gas pipeline.

The survey was undertaken in order to determine the presence of any potential sub-surface archaeological remains along the proposed route and to inform future archaeological strategy. It was undertaken in accordance with guidance within the National Planning Policy Framework (MHCLG 2019) and in line with current best practice (Chartered Institute for Archaeologists 2014, Europae Archaeologia Consilium 2016).

1.1 SITE LOCATION, TOPOGRAPHY AND LAND-USE

The pipeline extends for 7km in a south-easterly direction from Penrith NY 5274 2842 to Melkinthorpe NY 5755 2526. The Geophysical Survey Area (GSA) is only concerned with those areas which pass through open farmland in the northern part of the route between Moor Lane (NY 5448 2748) in the south and the A66 in the north (NY 5329 2947) (Illus 1). This stretch of corridor, 20m in width, spans seven fields (GS1–GS7) to the north and south of the River Eamont and River Lowther. GS1 was overgrown and unsuitable for survey (Illus 2) and GS4 was unavailable for survey during the fieldwork. At the time of the survey, all fields were under pasture except for GS7 which was under a cereal crop (Illus 3–7).

The GSA is at 127m Above Ordnance Datum (AOD) where the route crosses the A66 increasing as the route moves south to 141m AOD at Moor Lane.

The survey was carried out on the 11th and 12th June 2020.

1.2 GEOLOGY AND SOILS

The bedrock geology comprises Penrith Sandstone Formation and is overlain in the south by till and in the north by alluvium where the route crosses both the River Eamont and River Lowther (NERC 2020).

The soils are classified in the Soilscape 10 and Soilscape 6 Associations, both of which are characterised as freely draining soils (Cranfield University 2020).

2 ARCHAEOLOGICAL BACKGROUND

The proposed development site does not contain any designated or recorded heritage assets.

There is evidence the surrounding landscape was occupied during prehistory and in particular the Bronze Age. Non-designated heritage assets close to GS5 include prehistoric struck flint find spots (NHLE 45110 and 45111). More significant findings from this period may be of interest to the wider scheme.

There is recorded evidence of Roman activity in the form of settlement and infrastructure in the immediate vicinity of the GSA with three scheduled Roman monuments (HE List Entry 1007180, 1007186 and 1007187) listed immediately to the east (Illus 2).

Frenchfield Roman road (NHLE 1007180) and associated settlement enclosure cropmarks are recorded immediately east of GS1 north of the A66. Several archaeological excavations in this area have

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ILLUS 2 GS1, looking north-west **ILLUS 3** GS2, looking south **ILLUS 4** GS3, looking west

revealed Roman pottery with the area believed to have formed part of a Roman vicus.

Brougham Roman fort (Brocavum), civil settlement and Brougham Castle (NHLE 1007186) lay approximately 400m east of GS3. A further 400m north-east lies a Roman marching camp (NHLE 1007187).

Non-designated heritage assets close to the line of the pipeline corridor from the Roman period include a tombstone (NHLE 2848) approximately 150m east of the corridor in the northern part GS5 and a find spot for a vessel (NHLE 42305) immediately adjacent to the northern part of GS5.

There was an increase in activity during the medieval and post-medieval periods in the wider study area. The pipeline corridor crosses a non-designated heritage asset (NHLE 15420), a post-medieval earthwork in GS3, immediately north of the River Lowther.

South of the River Lowther the route passes close to multiple non-designated heritage assets including Brougham Deserted Medieval Village (NHLE 2846) immediately to the west. It is thought Brougham DMV may have originally stood on the road leading past Brougham Chapel towards Appleby and it is recorded that houses here were demolished c 1670.

3 AIMS, METHODOLOGY AND PRESENTATION

The general aim of the geophysical survey was to provide enough information to establish the presence/absence, character and extent of any archaeological remains within the GSA. This will therefore enable an assessment to be made of the impact of the proposed development on any sub-surface archaeological remains, if present.

The specific archaeological objectives of the geophysical survey were:

- to gather enough information to inform the extent, condition, character and date (as far as circumstances permit) of any archaeological features and deposits within the PDA;
- to obtain information that will contribute to an evaluation of the significance of the scheme upon cultural heritage assets; and
- to prepare a report summarising the results of the survey.

3.1 MAGNETOMETER SURVEY

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

ILLUS 5 GS5, looking north **ILLUS 6** GS7, looking south-east

on soil magnetism and the interpretation of magnetic anomalies is provided in Appendix 1.

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

MLGrad601 and MultiGrad601 (Geomar Software Inc) software was used to collect and export the data. Terrasurveyor V3.0.35.1 (DWConsulting) software was used to process and present the data.

3.2 REPORTING

A general site location plan is shown in Illus 1 at a scale of 1:10,000. Illus 2–6 are site condition photographs. Illus 7 and 8 are 1:7,500 site location maps with greyscale magnetometer data and overall interpretation information.

Large-scale, fully processed (greyscale) data, minimally processed data (XY trace plot) and interpretative plots are presented at a scale of 1:2,500 in Illus 9 to Illus 17 inclusive.

Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the site archive. Data processing details are presented in Appendix 4.

The survey methodology, report and any recommendations comply with guidelines outlined by Europae Archaeologia Consilium (EAC 2016) and by the Chartered Institute for Archaeologists (CIfA 2014). All illustrations from Ordnance Survey (OS) mapping are reproduced with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

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

4 RESULTS AND DISCUSSION

Ground conditions were very good throughout the GSA contributing to a high standard of data collection. The survey has detected a low level of background magnetic variation in GS2 and GS3, close to the River Eamont and River Lowther, which is a result of the homogenous properties of the alluvial deposits. Further south, in GS5–GS7, the magnetic background contains many more isolated, randomly scattered weakly magnetic anomalies which are likely due to the superficial till deposits in these locations. Against these backgrounds several anomalies have been identified and cross-referenced to specific examples on the interpretation illustrations, where appropriate.

4.1 FERROUS AND MODERN ANOMALIES

Ferrous anomalies, characterised as individual 'spikes', 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 is common on most sites, often being present as a result of manuring or tipping/infilling. There is no obvious clustering to these ferrous anomalies which might indicate an archaeological origin. Far more probable is that the 'spike' responses are likely caused by the random distribution of ferrous debris in the upper soil horizons.

Two dipolar linear anomalies, aligned north-east/south-west, in GS5 and GS6 locate modern service pipes (Illus 12–14).

Magnetic disturbance around the field edges is due to ferrous material within, or adjacent to the boundaries and is of no archaeological interest.

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4.2 AGRICULTURAL ANOMALIES

The most conspicuous findings of the survey are a series of positive linear anomalies on varying alignments across GS2. Given the proximity to the River Eamont and the magnetic signature of these responses it is likely they are due to a form of land drainage.

4.3 GEOLOGICAL ANOMALIES

Occasional and sporadic discrete low magnitude anomalies throughout the GSA are probably due to localised variation in the depth and composition of the topsoil and are not thought to be of any archaeological potential.

Sinuous and weakly magnetic linear trends in close proximity to the River Lowther are characteristic of palaeochannels – the anomaly being due to the magnetic contrast between the infilled channel and the surrounding soil.

5 CONCLUSION

The survey has not identified any anomalies of archaeological potential.

Clearly defined linear anomalies discovered over alluvial deposits next to the River Eamont and River Lowther are likely land drains, whilst other linear anomalies and trends elsewhere on the route can be attributed to either modern service pipes or are likely natural in origin.

It should be noted, however, that interpretation of magnetic data along narrow survey corridors can be challenging, particularly over superficial deposits of varying depth and composition. Whilst the geophysical survey suggests that the pipeline route is of low archaeological potential, the immediate landscape remains of high archaeological potential and it is possible that isolated and/or discrete archaeological features have not been detected by the survey.

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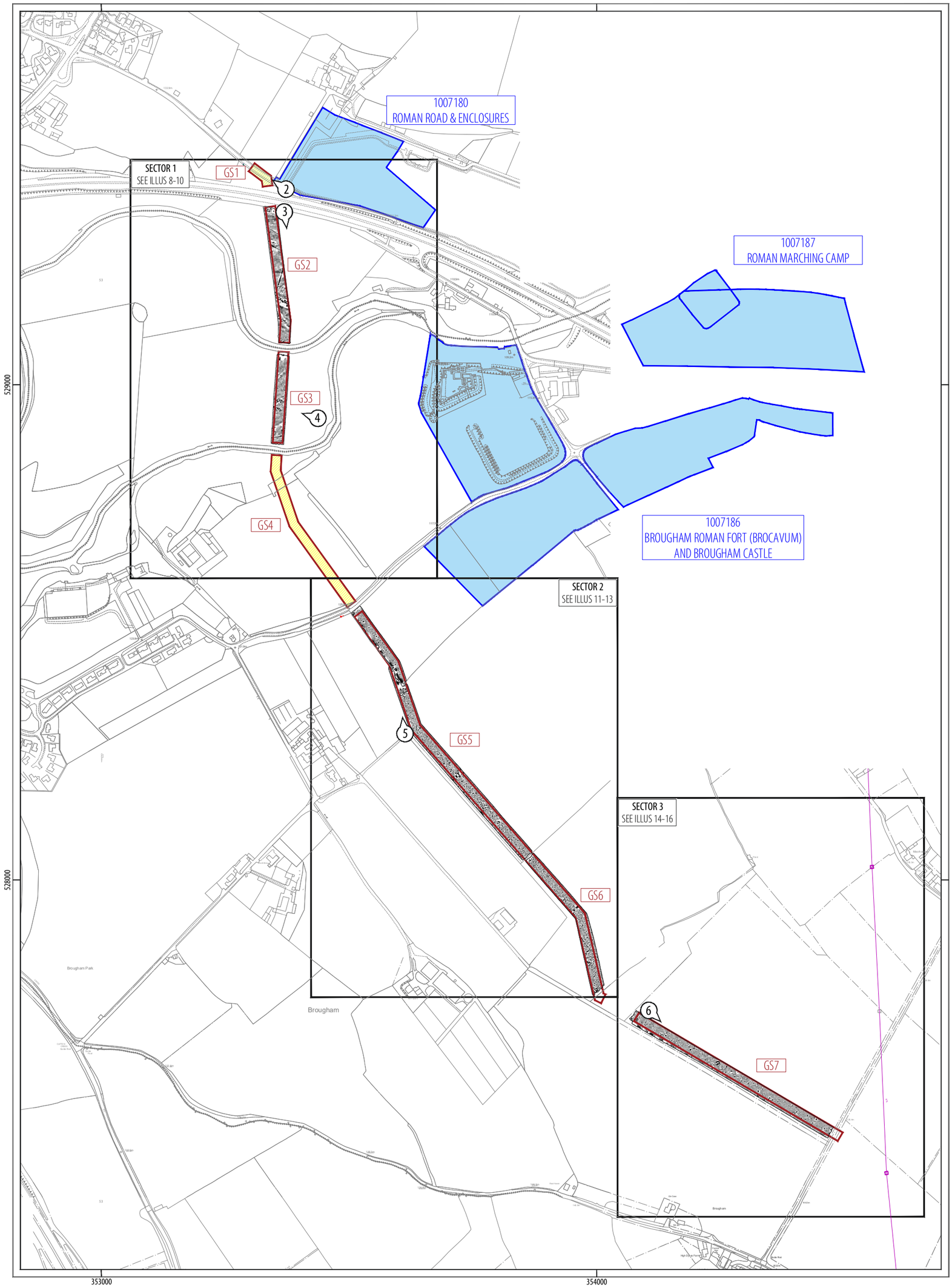

geophysical survey area
scheduled monument
unsuitable for survey
location and direction of ILLUS 2-6

0 200m
1:7,500 @ A3

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Penrith to Melkinthorpe Pipeline
Cumbria

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ILLUS 7 Survey location showing greyscale magnetometer data (1:7,500)

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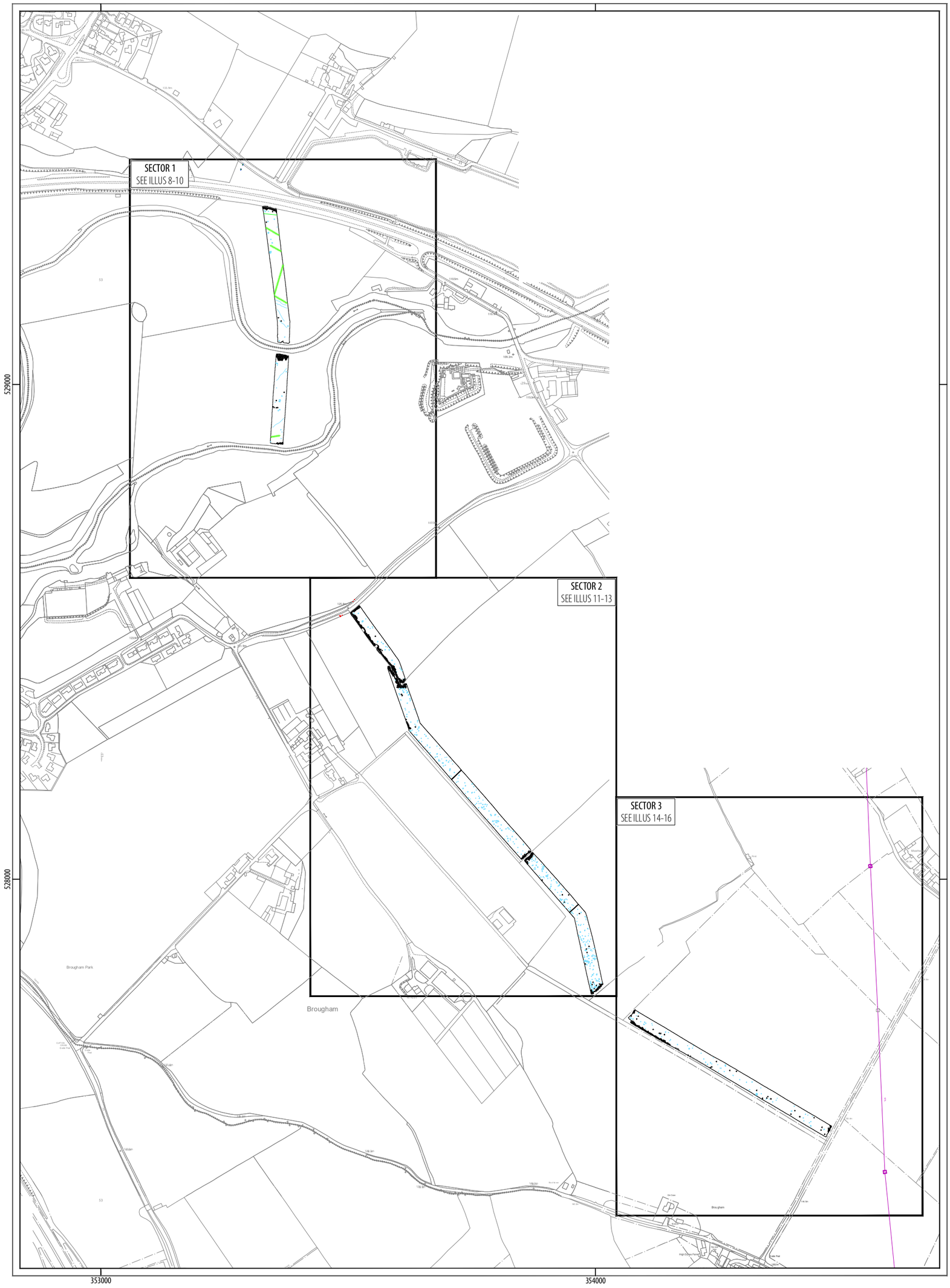

TYPE OF ANOMALY	INTERPRETATION	TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material	linear trend	geological variation
magnetic disturbance	ferrous material		
dipolar linear	service pipe		
linear trend	field drain		
linear trend	agricultural		
magnetic enhancement	geology		

0 200m
1:7,500 @ A3

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ILLUS 8 Overall interpretation of magnetometer data (1:7,500)

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nT
-1.0 2.0

0 50m
1:2,500 @ A3

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ILLUS 9 Processed greyscale magnetometer data, Sector 1 (1:2,500)

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25.0nT/cm

0 50m

1:2,500 @ A3

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ILLUS 10 XY trace plot of minimally processed magnetometer data, Sector 1 (1:2,500)

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TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	field drain
linear trend	agricultural
magnetic enhancement	geology
linear trend	geological variation

0 50m
1:2,500 @ A3

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ILLUS 11 Interpretation of magnetometer data, Sector 1 (1:2,500)

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nT
-1.0 2.0

0 50m
1:2,500 @ A3

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ILLUS 12 Processed greyscale magnetometer data, Sector 2 (1:2,500)

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25.0nT/cm

0 50m

1:2,500 @ A3

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ILLUS 13 XY trace plot of minimally processed magnetometer data, Sector 2 (1:2,500)

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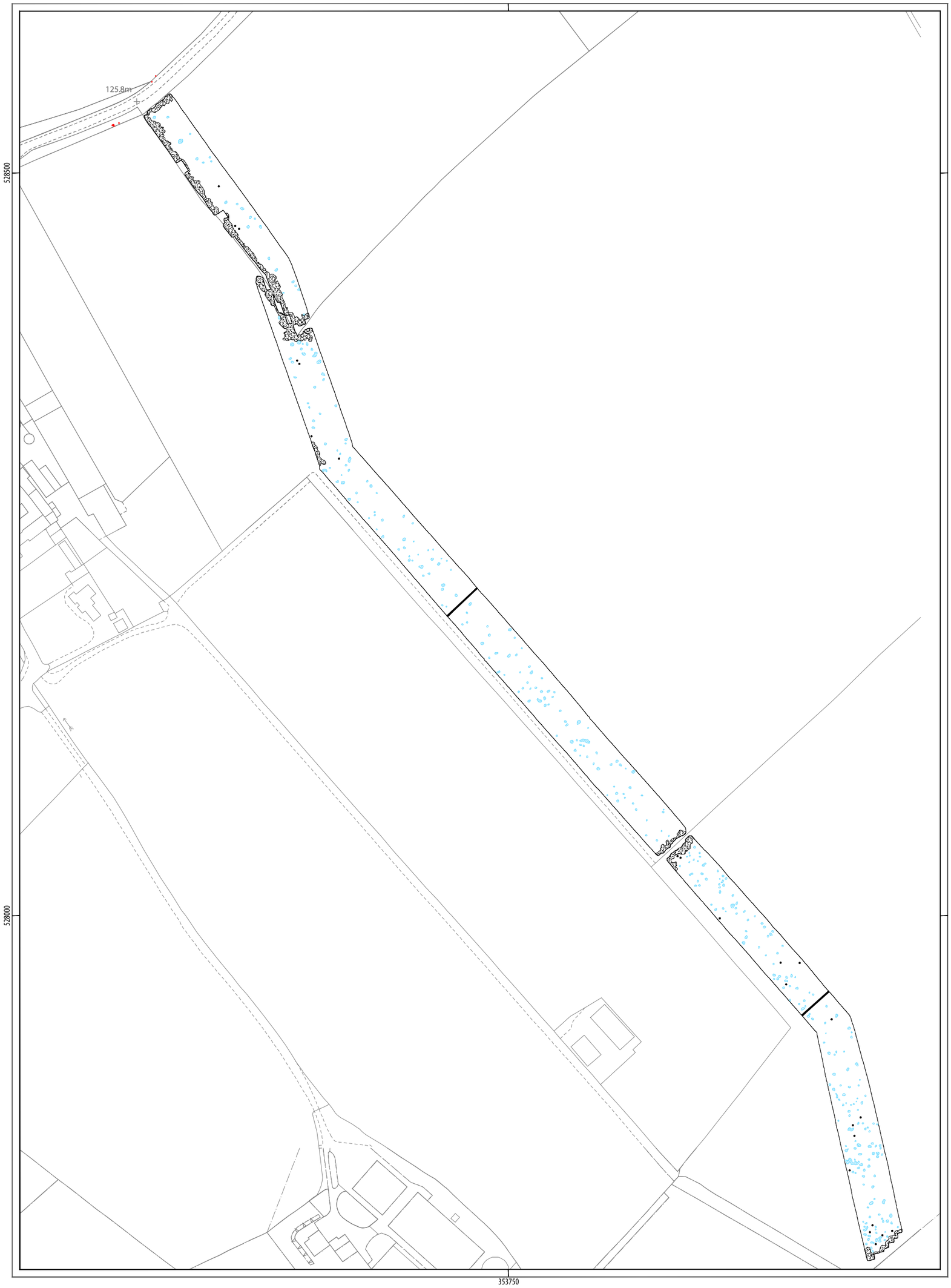

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
magnetic enhancement	geology

0 50m
1:2,500 @ A3

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ILLUS 14 Interpretation of magnetometer data, Sector 2 (1:2,500)

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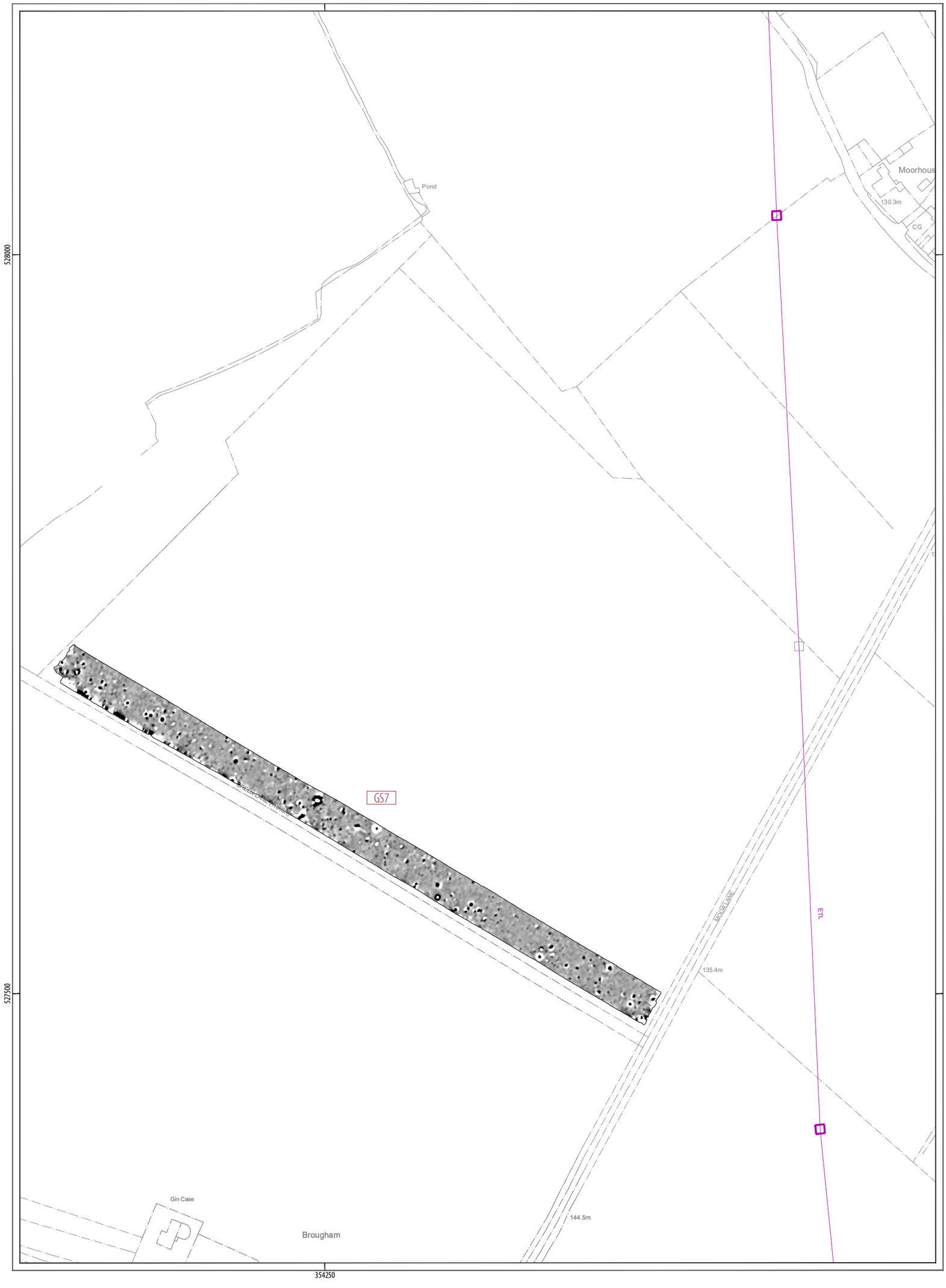

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ILLUS 15 Processed greyscale magnetometer data, Sector 3 (1:2,500)

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528000

527500

354250

Pond

Moorhous

130.3m

CG

GS7

ETL

135.4m

144.5m

Gin Case

Brougham

25.0nT/cm

0 50m

1:2,500 @ A3

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ILLUS 16 XY trace plot of minimally processed magnetometer data, Sector 3 (1:2,500)

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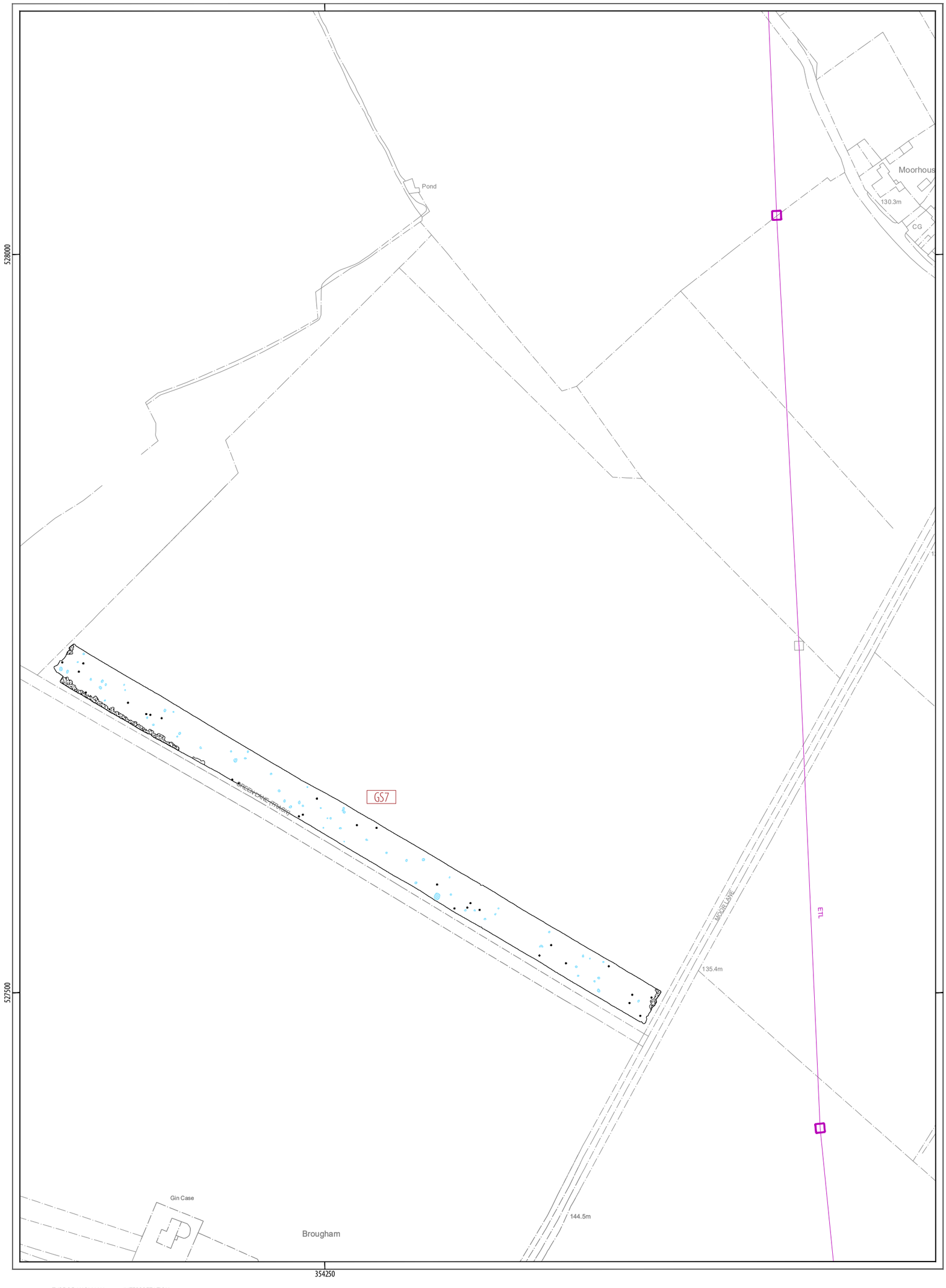

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
magnetic enhancement	geology

0 50m
1:2,500 @ A3

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ILLUS 17 Interpretation of magnetometer data, Sector 3 (1:2,500)

7 APPENDICES

APPENDIX 1 MAGNETOMETER SURVEY

Appendix 1.1 Magnetic susceptibility and soil magnetism

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

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of 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. This effect can lead to the detection of features such as hearths, kilns or areas of burning.

Appendix 1.2 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.

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

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

Areas of magnetic enhancement/positive isolated anomalies Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive 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.

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APPENDIX 2 SURVEY LOCATION INFORMATION

An initial survey base station was established using a Trimble VRS differential Global Positioning System (dGPS). The magnetometer data was georeferenced using a Trimble RTK differential Global Positioning System (Trimble R8s model).

Temporary sight markers were laid out using a Trimble VRS differential Global Positioning System (Trimble R8s model) to guide the operator and ensure full coverage. The accuracy of this dGPS equipment is better than 0.01m.

The survey data 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 coordinates are measured off hard copies of the mapping rather than using the digital coordinates.

Headland Archaeology cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.

APPENDIX 3 GEOPHYSICAL SURVEY ARCHIVE

The geophysical archive comprises an archive disk containing the raw data in XYZ format, a raster image of each greyscale plot with associate world file, and a PDF of the report.

The project will be archived in-house in accordance with recent good practice guidelines (http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics_3). The data will be stored in an indexed archive and migrated to new formats when necessary.

APPENDIX 4 DATA PROCESSING

The gradiometer data has been presented in this report in processed greyscale and minimally processed XY trace plot format.

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

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

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

APPENDIX 5 OASIS DATA COLLECTION FORM: ENGLAND

OASIS ID: headland5-398120

PROJECT DETAILS	
Project name	Penrith to Melkinthorpe Gas Pipeline, Cumbria
Short description of the project	Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey over 5ha along a linear corridor between Penrith and Clifton Dykes, Cumbria, to inform proposals for the route of a gas pipe. The survey has not identified any anomalies of clear archaeological potential. Linear anomalies discovered adjacent to the River Eamont and River Lowther are likely land drains, whilst other linear anomalies and trends elsewhere on the route can be attributed to either modern service pipes or are likely natural in origin.
Project dates	Start: 11-06-2020 End: 12-06-2020
Previous/future work	No / Yes
Any associated project reference codes	PTMP20 – Contracting Unit No.
Type of project	Field evaluation
Site status	None
Current Land use	Grassland Heathland 5 - Character undetermined
Monument type	N/A
Monument type	N/A
Significant Finds	N/A
Significant Finds	N/A
Methods & techniques	"Geophysical Survey"
Development type	Pipelines/cables (eg gas, electric, telephone, TV cable, water, sewage, drainage etc)
Prompt	National Planning Policy Framework – NPPF
Position in the planning process	After full determination (eg as a condition)
Solid geology (other)	Penrith Sandstone Formation
Drift geology	Alluvium
Drift geology	Boulder clay and morainic drift
Techniques	Magnetometry
PROJECT LOCATION	
Country	England
Site location	Cumbria, Eden, Penrith, Penrith To Melkinthorpe Gas Pipeline, Cumbria
Study area	5 Hectares
Site coordinates	NY 5448 2478 54.616000229505 -2.7049580418O1 54 36 57 N 002 42 17 W Line
Site coordinates	NY 5329 2947 54.658040727207 -2.724134277451 54 39 28 N 002 43 26 W Line
PROJECT CREATORS	
Name of Organisation	Headland Archaeology
Project brief originator	Headland Archaeology
Project design originator	Headland Archaeology
Project director/manager	David Harrison
Project supervisor	Olivier Vansassenbrouck
Type of sponsor/funding body	Developer

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PROJECT ARCHIVES	
Physical Archive Exists?	No
Digital Archive recipient	In house
Digital Contents	"other"
Digital Media available	"Geophysics", "Text"
Paper Archive Exists?	No

PROJECT BIBLIOGRAPHY 1	
Publication type	Grey literature (unpublished document/manuscript)
Title	Penrith to Melkinthorpe Gas Pipeline; Geophysical Survey
Author(s)/Editor(s)	Matthew Berry
Date	2020
Issuer or publisher	Headland Archaeology
Place of issue or publication	Leeds
Description	PDF[A]
Entered by	David Harrison (david.harrison@headlandarchaeology.com)
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