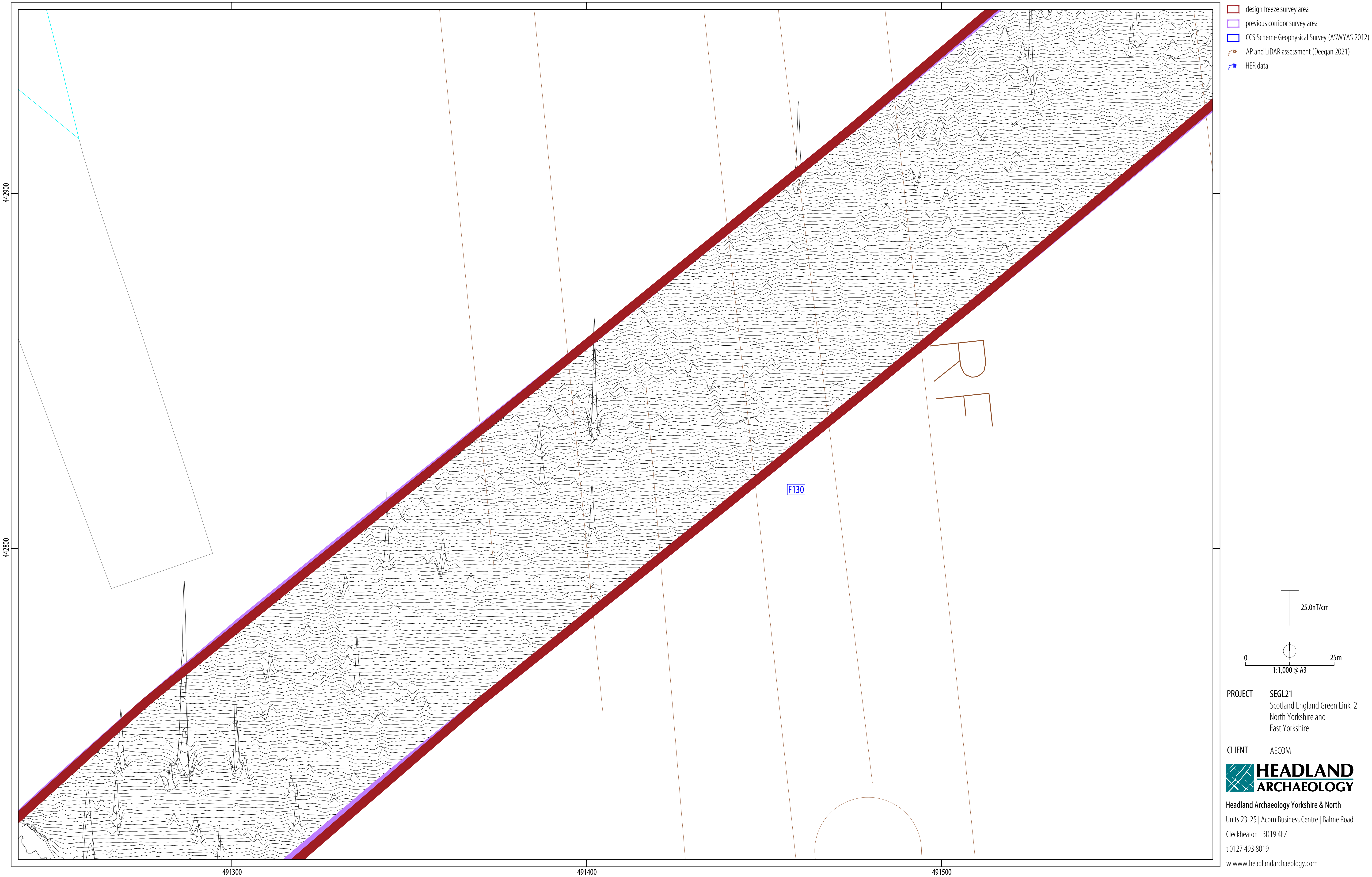

PROJECT SEGL21
Scotland England Green Link 2
North Yorkshire and
East Yorkshire

CLIENT AECOM

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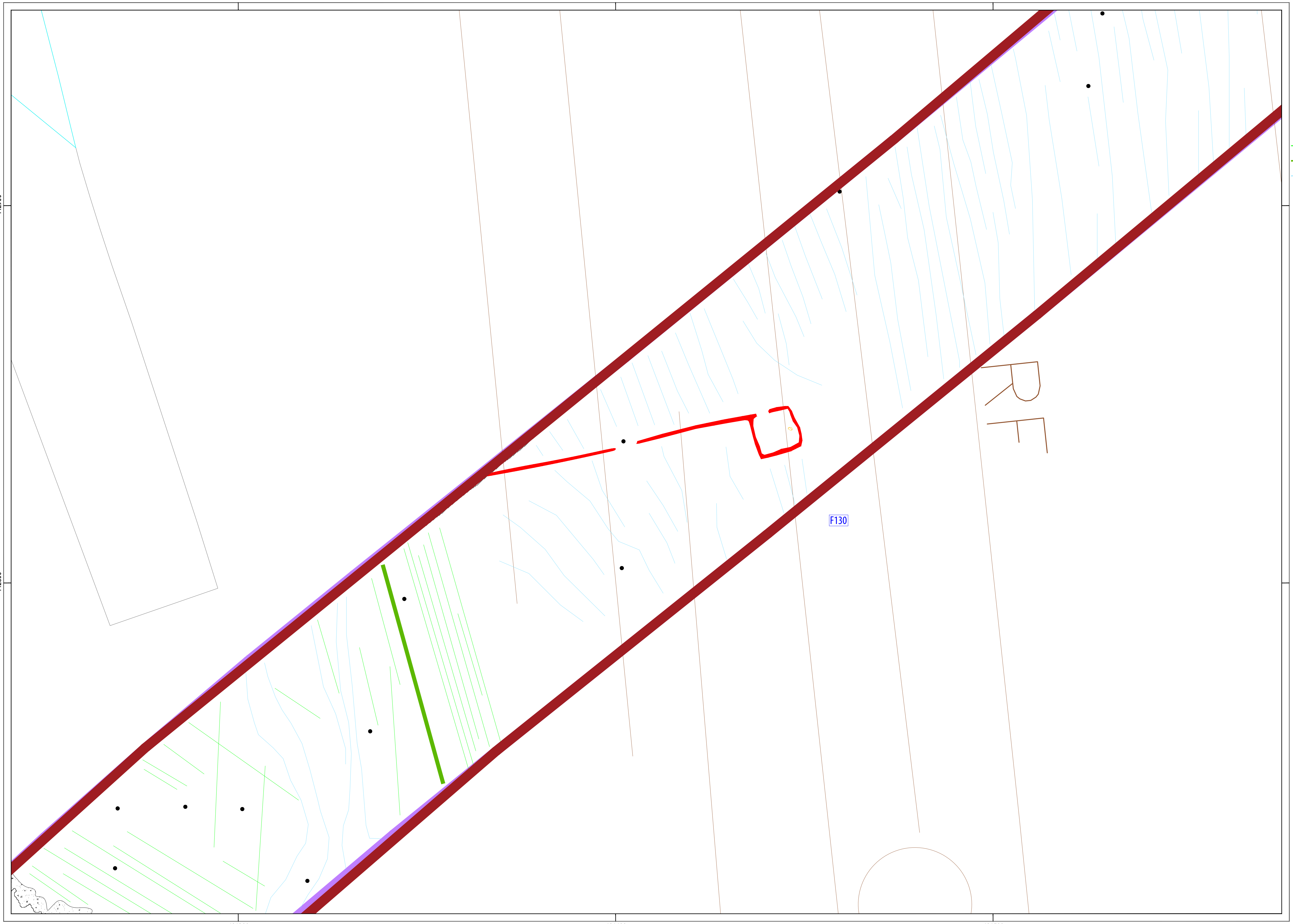
ILLUS 313 XY trace plot of minimally processed magnetometer data; AAA13



design freeze survey area
previous corridor survey area
CCS Scheme Geophysical Survey (ASWYAS 2012)
AP and LiDAR assessment (Deegan 2021)
HER data

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	agricultural
linear	former field boundary
linear trend	geological variation
magnetic enhancement	archaeology?
magnetic enhancement	archaeology

0 25m
1:1,000 @ A3

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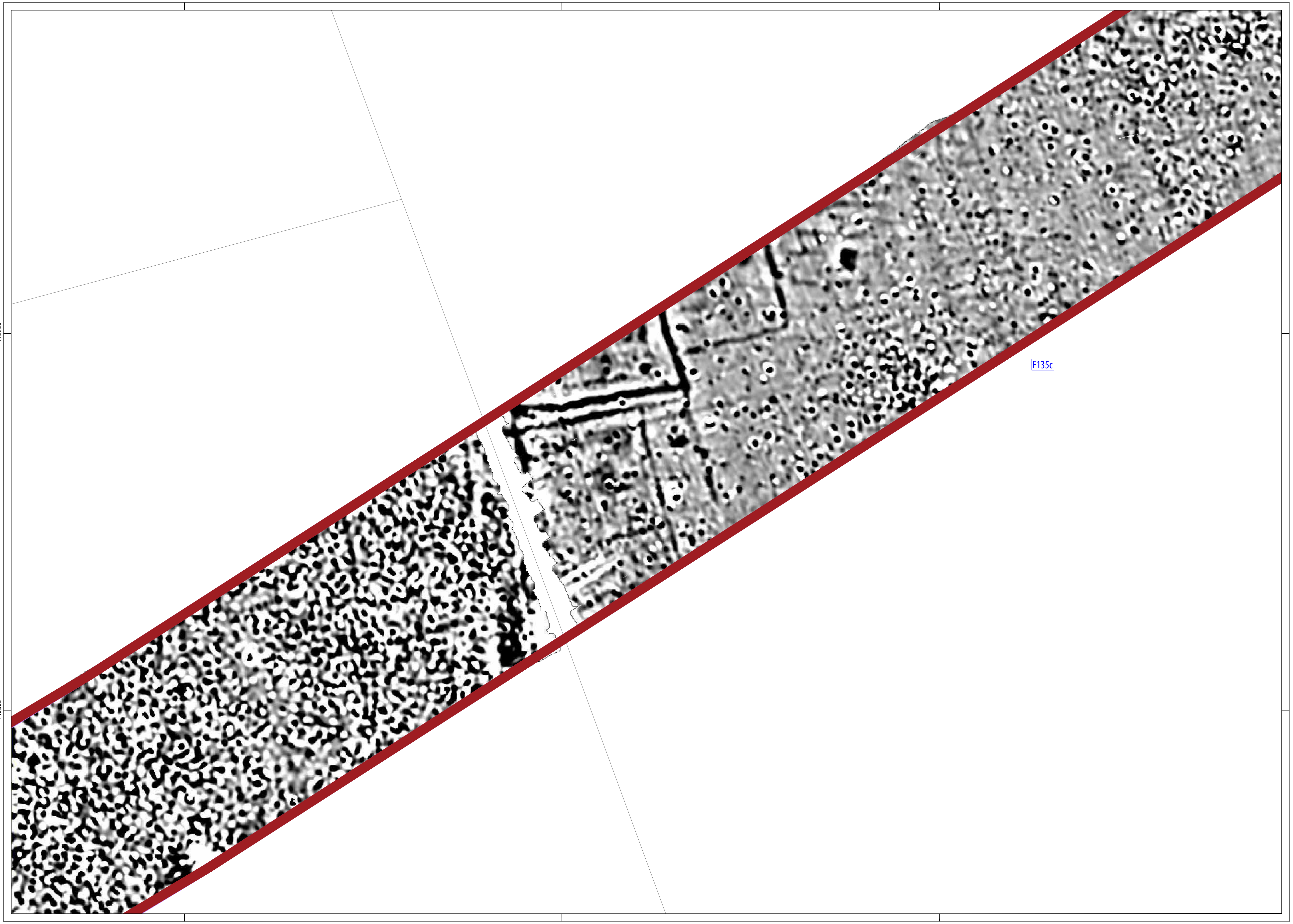
ILLUS 314 Interpretation of magnetometer data; AAA13



design freeze survey area
previous corridor survey area
CCS Scheme Geophysical Survey (ASWYAS 2012)
AP and LiDAR assessment (Deegan 2021)
HER data

nT
-1.0 2.0
0 25m
1:1,000 @ A3

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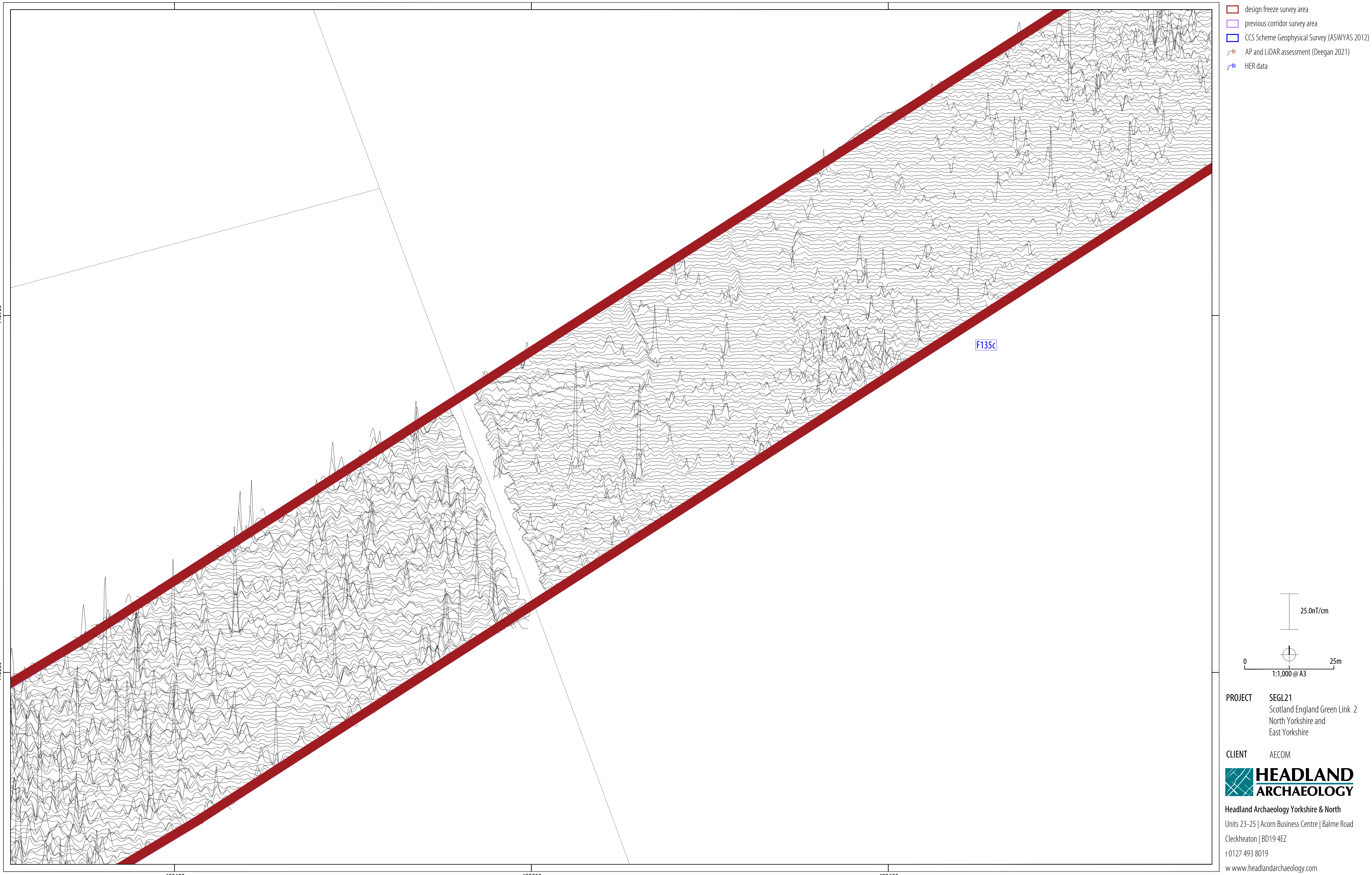
ILLUS 315 Processed greyscale magnetometer data; AAA14



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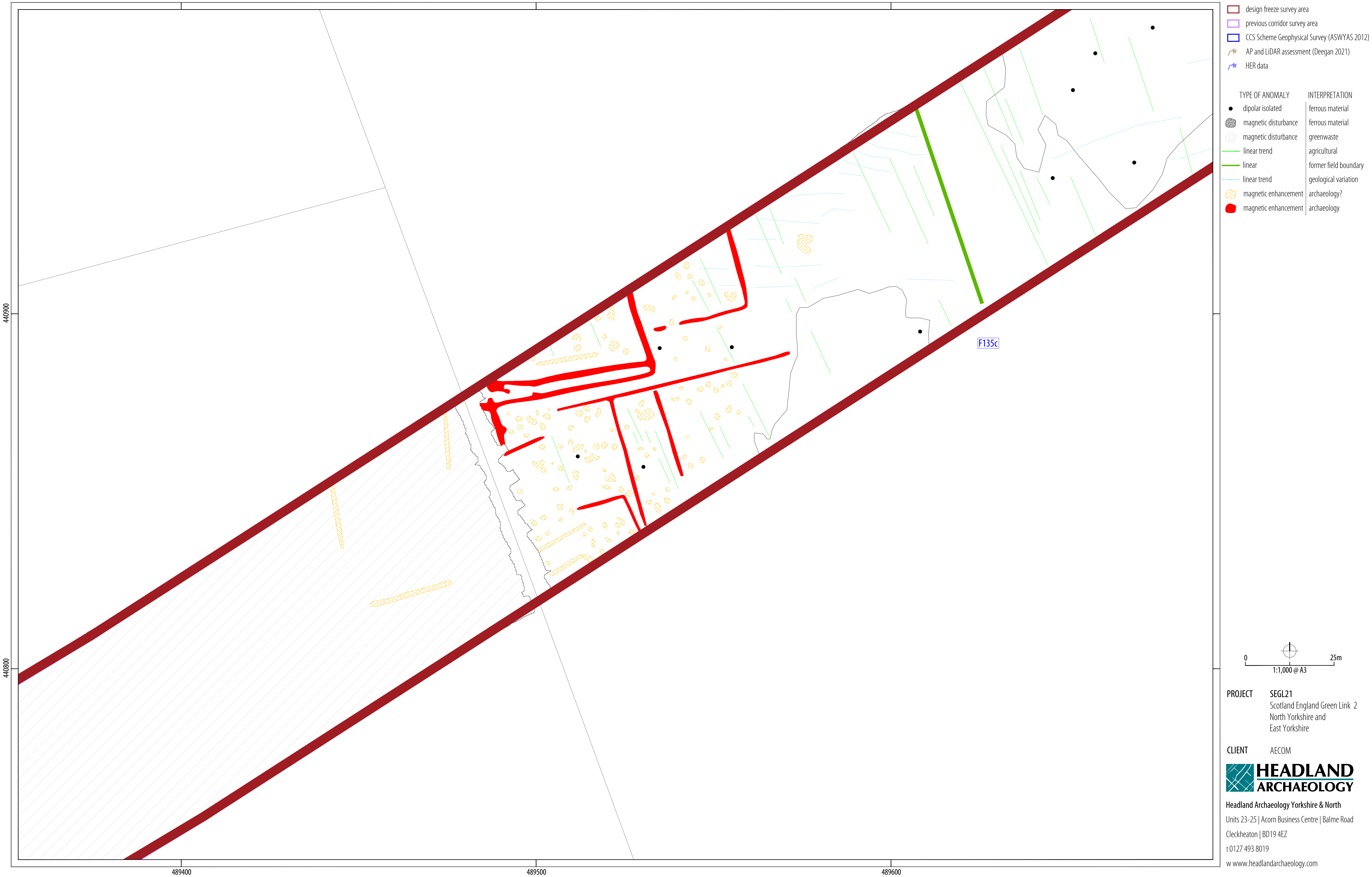
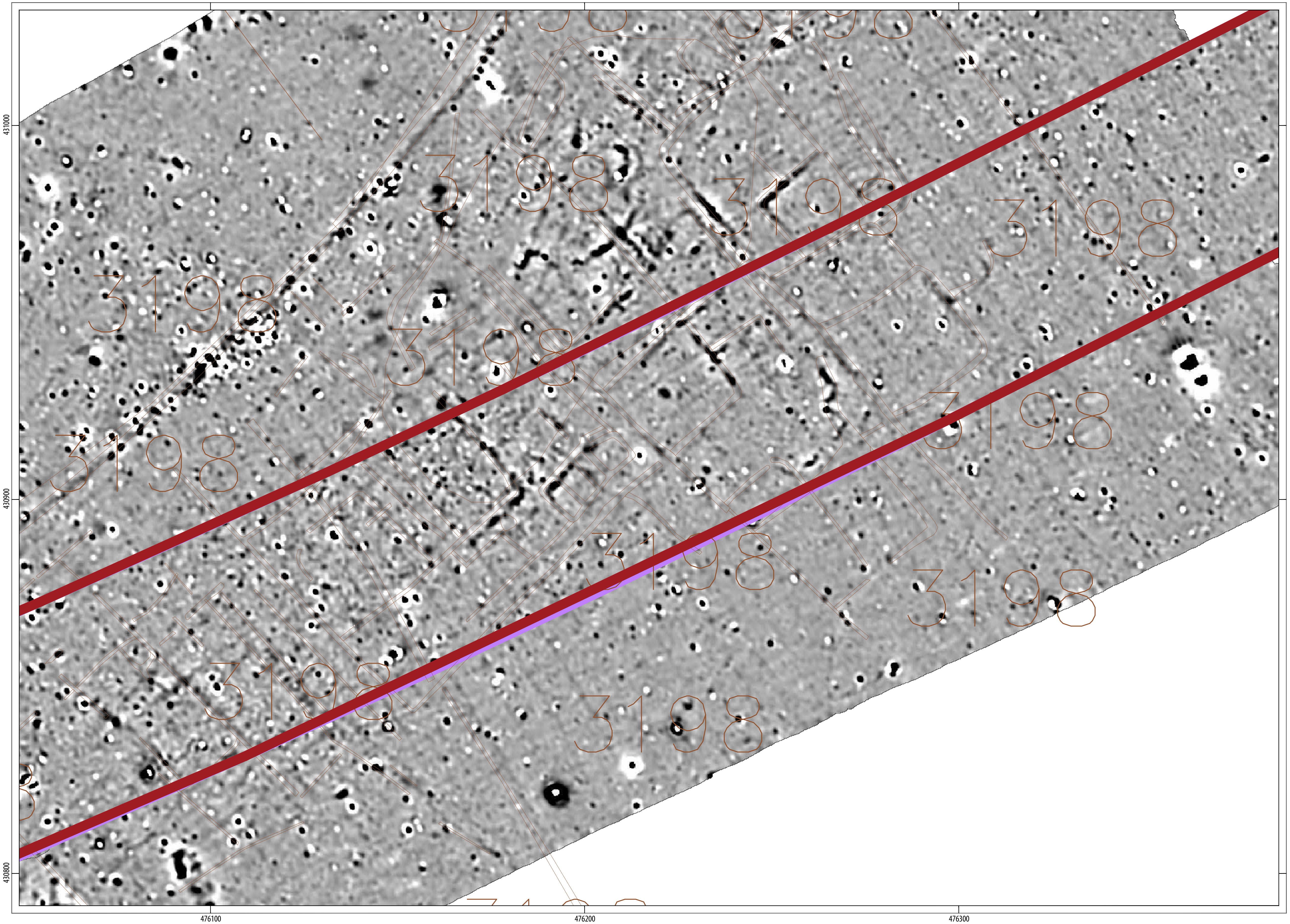
ILLUS 316 XY trace plot of minimally processed magnetometer data; AAA14



ILLUS 317 Interpretation of magnetometer data; AAA14



design freeze survey area
previous corridor survey area
CCS Scheme Geophysical Survey (ASWYAS 2012)
AP and LiDAR assessment (Deegan 2021)
HER data

nT
-1.0 2.0

0 25m
1:1,000 @ A3

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ILLUS 318 Processed greyscale magnetometer data; AAA15

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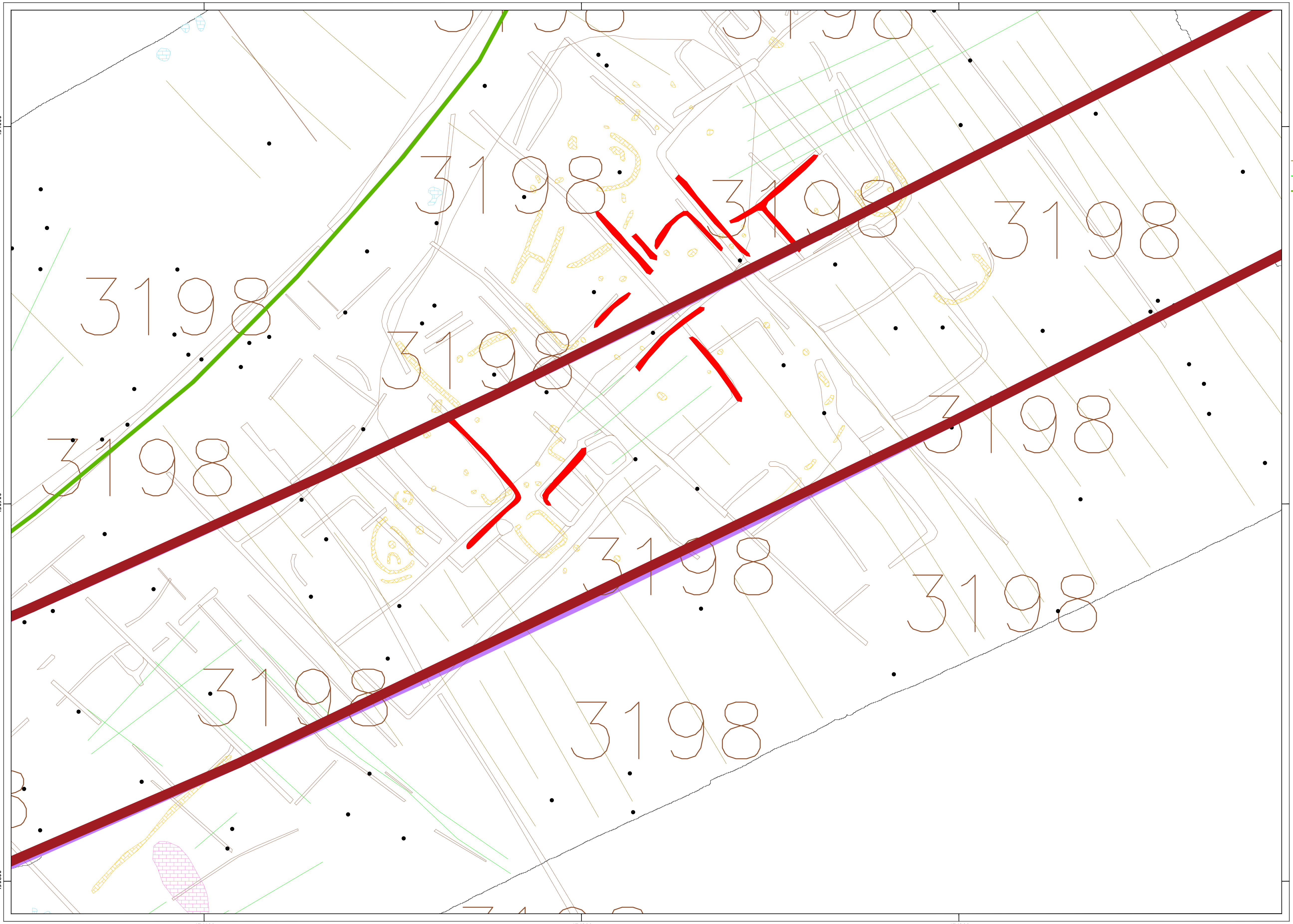
ILLUS 319 XY trace plot of minimally processed magnetometer data; AAA15



- design freeze survey area
- previous corridor survey area
- CCS Scheme Geophysical Survey (ASWYAS 2012)
- AP and LiDAR assessment (Deegan 2021)
- HER data

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
magnetic disturbance	quarrying
linear trend	ridge and furrow
linear trend	agricultural
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	archaeology

0 25m
1:1,000 @ A3

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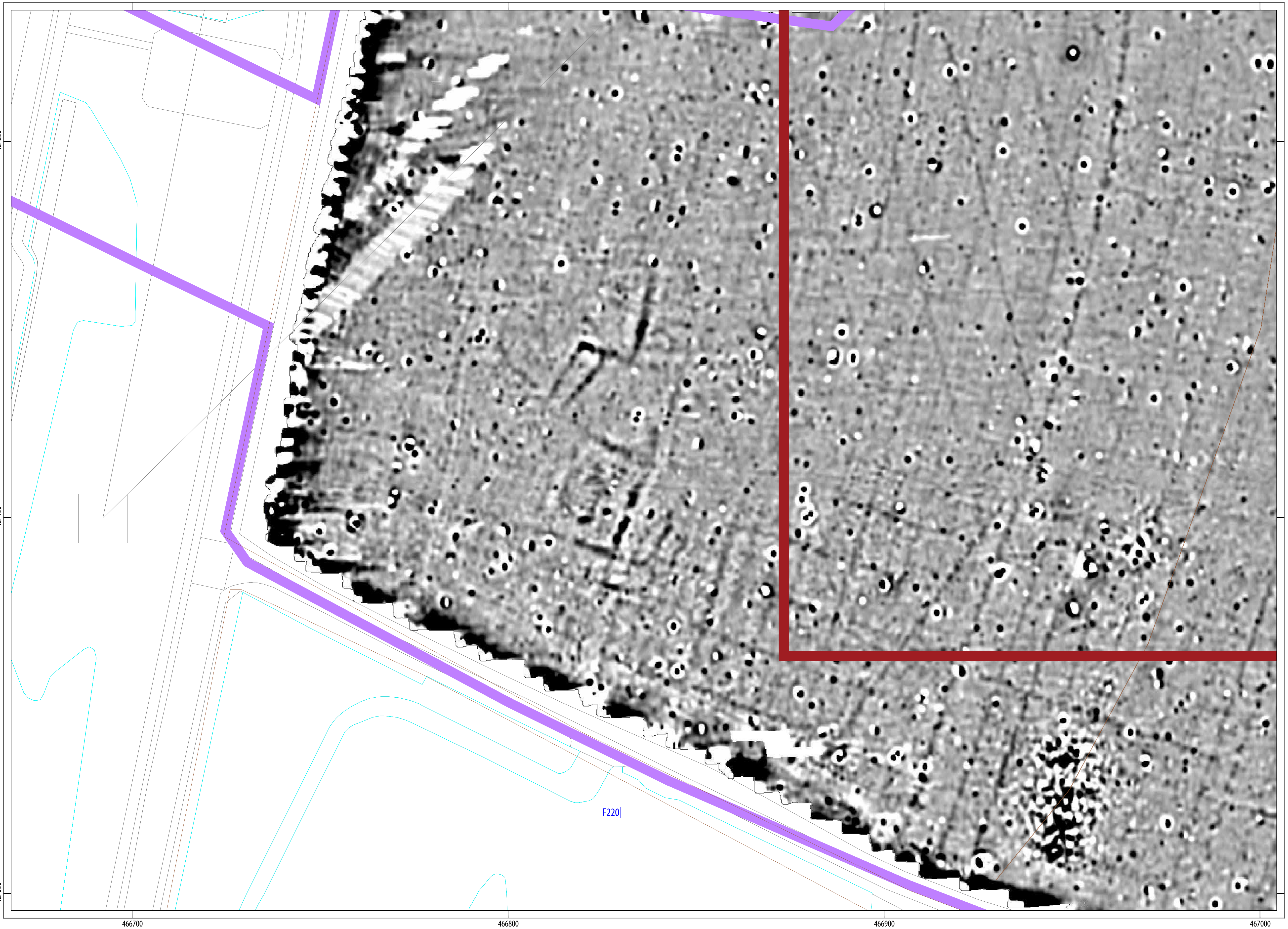
ILLUS 320 Interpretation of magnetometer data; AAA15



design freeze survey area
previous corridor survey area
CCS Scheme Geophysical Survey (ASWYAS 2012)
AP and LiDAR assessment (Deegan 2021)
HER data

nT
-1.0
2.0

0
25m
1:1,000 @ A3

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ILLUS 321 Processed greyscale magnetometer data; AAA16

design freeze survey area
previous corridor survey area
CCS Scheme Geophysical Survey (ASWYAS 2012)
AP and LiDAR assessment (Deegan 2021)
HER data

25.0nT/cm

0 25m
1:1,000 @ A3

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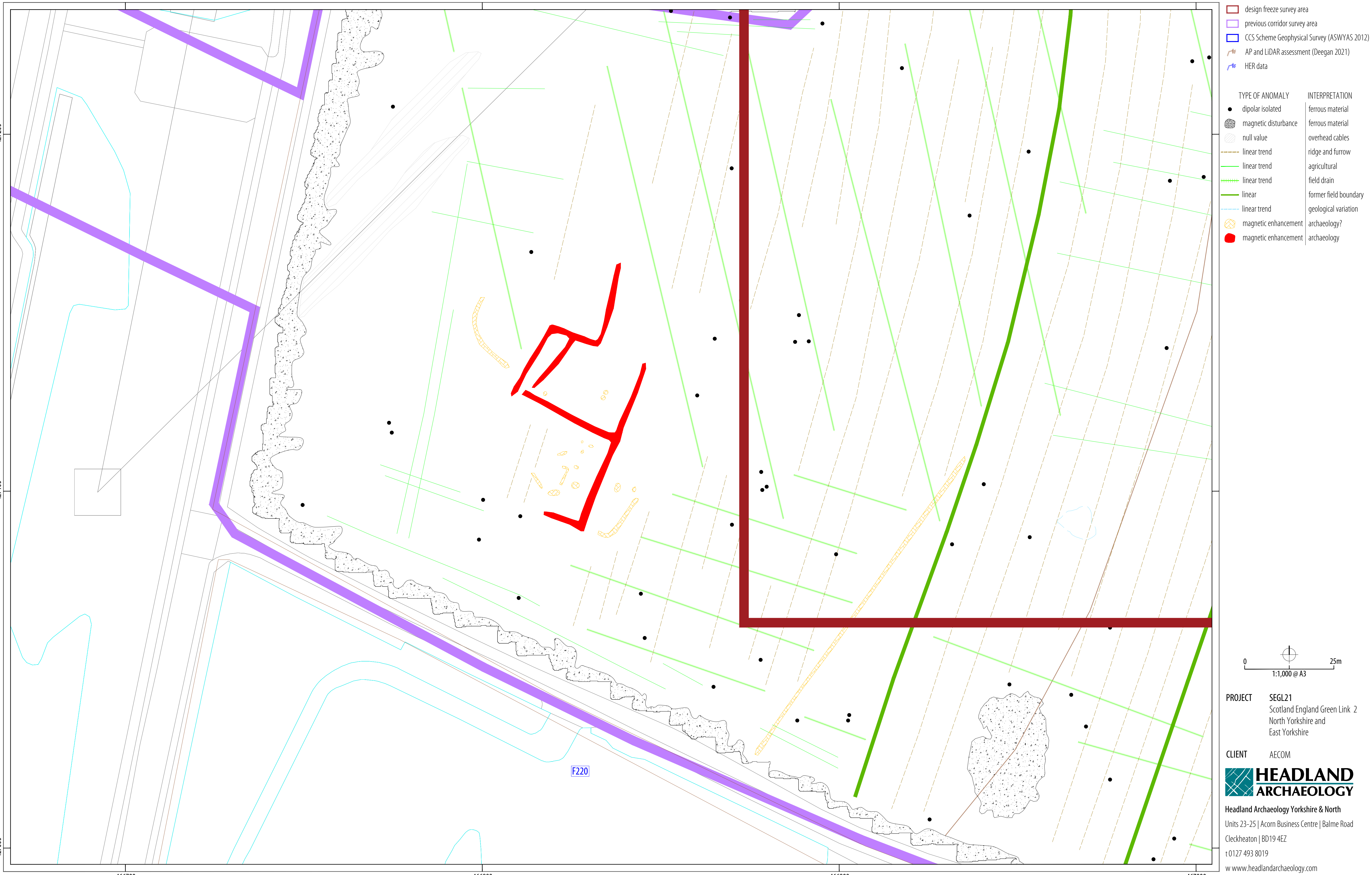
ILLUS 322 XY trace plot of minimally processed magnetometer data; AAA16



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ILLUS 323 Interpretation of magnetometer data; AAA16

8. APPENDICES

APPENDIX 1 MAGNETOMETER SURVEY

Magnetic susceptibility and soil magnetism

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

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

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

Types of magnetic anomaly

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

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

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

Isolated dipolar anomalies (iron spikes)

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

Areas of magnetic disturbance

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

Lightning-induced remnant magnetisation (LIRM)

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

Linear trend

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

Areas of magnetic enhancement/positive isolated anomalies

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

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 MAGNETOMETER 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) 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 ARCHIVE

Summary for headland1-506840

OASIS ID (UID) headland1-506840

Project Name Metal Detection, Geophysical Survey, Magnetometry Survey at Scotland England Green Link 2, Scotland England Green Link 2

Sitename

Activity type Geophysical Survey, Magnetometry Survey, Metal Detecting Survey, MAGNETOMETRY SURVEY

Project Identifier(s) P21-254

Planning Id

Reason For Investigation Planning: Pre application

Organisation Responsible for work Headland Archaeology (UK) Ltd

Project Dates 04-Oct-2021 - 04-Feb-2022

Location Scotland England Green Link 2 NGR : SE 93132 43639

LL : 53.8805942935428, -0.584746199950184

12 Fig : 493132,443639

Scotland England Green Link 2 NGR : SE 66667 27219

LL : 53.7371054908776, -0.990802791847055

12 Fig : 466667,427219

Administrative Areas Country : England

County : East Riding of Yorkshire District : East Riding of Yorkshire Parish : Etton

County : North Yorkshire District : Selby

Parish : Long Drax

Project Methodology The surveys were undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid 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 V3.0.37.0 (DWConsulting) software was used to process and present the data. The works comprised metal detecting surveys at targeted locations within the Scheme. All targeted archaeological metal detecting survey work was carried out in accordance with the survey specific WSI (Headland 2021) and in accordance with

Chartered Institute for Archaeologists (CIfA) Code of Conduct (2019) and CIfA Standards for the collection and documentation of archaeological materials (CIfA 2014).

A survey grade GPS tied to the Ordnance Survey (OS) National Grid was used to plot each transect within each field targeted for survey. Transects were spaced at 5m intervals (starting 2.5m from the southern boundary of the corridor) and plotted on the ground to an accuracy of +/- 10cm (as a minimum). Wooden canes with hazard tape attached were used to mark out each transect. All location information was fully geo- referenced.

The location of all artefacts was plotted using GPS, were bagged individually, and had a unique identifying number assigned to them. Where the date and function of an object was assumed modern or when the number of objects identified was so numerous that the recording of individual find spots was impractical, field notes were taken and the artefacts retained in bulk, with unique identifying numbers assigned during finds assessment. Items clearly of no archaeological significance, such as pieces of modern farm machinery, were discarded.

Details of each field where metal detecting was undertaken were recorded on pro-forma recording sheets. In addition, details of field conditions, equipment used, discriminator level, operator and comments about any discarded material were also recorded.

A concentration of pottery was observed on the ground surface within Field 179 and a sample of this material was retained and is included in the Finds Assessment below. The pottery was individually bagged, numbered, and plotted using GPS.

The recovery of archaeological objects located by metal detector was restricted to the depth of the plough-soil.

A notable absence of metal artefacts was apparent across several of the fields surveyed suggesting that some fields may have been metal detected previously.

No concentrations of artefacts were recorded sufficient to trigger increased sample coverage.

Project Results Most of the geophysical anomalies recorded are due to recent or post- medieval agricultural activity; modern ploughing, ridge and furrow cultivation (which was particularly prevalent over the Yorkshire Wolds), and field drainage which was very common across the lower lying sections of the Scheme across the Holderness Plain, the Vale of York and across the land either side of the River Ouse. A lot of anomalies were also recorded that are due to natural geological variation within the superficial deposits or to natural processes, such as the deposition of alluvium adjacent to watercourses.

In addition, anomalies of probable archaeological origin have been recorded at sixteen locations termed Areas of Archaeological Activity (AAA's). These AAA's are mostly (but not universally) located on the higher better draining upland areas of the Wolds but are also present on the Holderness Plain. They predominantly comprise parts of enclosures, trackways and field boundaries forming parts of wider clusters of enclosure, and possibly settlement, some of which were previously known, others identified for the first time during the recent AP and LiDAR assessment undertaken for SEGL2. A few anomalies/features have only been recorded by the magnetic survey including a probable round barrow and a possible square barrow. At most locations the magnetic survey has provided greater resolution and more detail, especially of smaller or ephemeral features, than was indicated by the cropmarks. In a few locations the cropmarks perhaps provide a more detailed picture.

Overall, it is concluded that the surveys are likely giving a good indication of the below ground archaeological resource where survey has been carried out, subject to the limitations of the technique. It is hoped that other survey techniques, such as metal detector survey, will help answer specific archaeological questions and potentially identify archaeological remains not usually identified by magnetometer survey, such as areas of early medieval settlement or unenclosed prehistoric activity. Together all surveys will add further information on the archaeological resource and, together with the other information submitted in support of the TCPA application,