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LICHFIELDS ON BEHALF OF IAMP LLP

IAMP ONE PHASE 2 SITE EXTENSION

MAGNETIC GRADIOMETER SURVEY REPORT

NOVEMBER 2022

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MAGNETIC GRADIOMETER SURVEY REPORT

NOVEMBER 2022

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EXECUTIVE SUMMARY

Wardell Armstrong LLP (WA) was commissioned by Lichfields, on behalf of IAMP LLP, to undertake a magnetic gradiometer survey of land north of the A1290, Sunderland, National Grid Reference (NGR): NZ 32850 58950. The geophysical survey was undertaken to determine the presence, nature and extent of potential archaeological remains.

The survey was undertaken over twelve days during 15th to 23rd June and 7th to 11th November 2022, across *c.*36ha of arable land. The survey results were dominated by evidence of former ridge and furrow cultivation, in addition to a number of probable former field boundaries and two historic boundaries that correspond with historic Ordnance Survey maps of the Site. Other anomalies of possible archaeological origin included numerous discrete positive anomalies (12-14) which have the potential to be cut and infilled pits or pit clusters, and a group of positive anomalies that appeared to include a penannular form (**11**). The survey also detected two probable palaeochannels (**16**-**17**), likely former braided channels flowing into the watercourse on the northern boundary of the Site.

ACKNOWLEDGEMENTS

Wardell Armstrong LLP (WA) thanks the client, Lichfields, for commissioning the project on behalf of IAMP LLP, and for all their assistance throughout the work.

The geophysical survey was undertaken by Cat Peters, Caitlin Thompson, Katherine Bostock and Ronald Brown. The report and accompanying figures were produced by John Summers and reviewed by Cat Peters. The project was managed by Dave Jackson, who also provided final quality assurance approval of the report.

1 INTRODUCTION

1.1 Project Circumstances and Planning Background

1.1.1 During 15th to 23rd June and 7th to 11th November 2022, Wardell Armstrong LLP (WA) undertook a magnetic gradiometer survey over land north of the A1290, Sunderland (centred on National Grid Reference (NGR): NZ 32850 58950; Figure 1). The survey was commissioned by Lichfields, on behalf of IAMP LLP.

1.1.2 The geophysical survey was commissioned to determine the presence, nature and extent of potential archaeological remains within the proposed development site. The geophysical results will be used to inform any further requirements for archaeological mitigation at the site.

1.2 Aims of the Survey

1.2.1 The aims of the geophysical survey were to;

- determine the presence or absence of buried archaeological remains within the Site;
- determine the character, extent and distribution of any archaeological sub-surface features;
- disseminate the results of the fieldwork through an appropriate level of recording; and
- determine areas of high potential to inform any future archaeological mitigation requirements.

1.3 Project Documentation

1.3.1 The project conforms to archaeological advice provided by the Tyne and Wear Archaeology Officer, Sophie Laidler.

1.3.2 This report outlines the results of the geophysical survey undertaken, and the interpretation of the geophysical survey results, in light of the historical and archaeological background of the Site.

2 BACKGROUND

2.1 Location and Geological Context

2.1.1 The Site is located to the west of Downhill and north-west of Castletown, to the north-west of the centre of the city of Sunderland. It is situated to the north of the A1290 and industrial units that front the road. The River Wear is approximately 2km to the south-east of the Site. The Site covers an area of *c.*36ha and comprises multiple arable fields, associated with the disused North Moor Farmstead which is located within the northern part of the Site. A channelled watercourse marks the northern boundary of the Site, which flows into the River Don approximately 250m to the north-east, while further arable land surrounds the rest of its perimeter. The Site has a relatively level topography, rising from around 34m AOD in the north-east, to 38m AOD in the south.

2.1.2 The bedrock geology underlying the site is Cretaceous mudstone, siltstone and sandstone of the Penine Middle Coal Measures Formation, which is overlain by the Quaternary Pelaw Clay Member (BGS 2022). Soils over the Site are characterised as slowly permeable seasonally wet slightly acid but base-rich loams and clays (Soilscapes 2022).

2.2 Historical and Archaeological Background

2.2.1 The site is situated in an area identified as having archaeological potential, ranging from prehistoric activity to 20th century military defences. In the wider vicinity, an archaeological desk-based assessment for the IAMP Phase 1 development has been completed, in addition to a geophysical survey and archaeological trial trench evaluation of a triangular plot of land to the west of West Moor Farm by AD Archaeology in 2021.

2.2.2 A large programme of archaeological geophysics was undertaken to the north and east of the present site ahead of IAMP Phase 2 by Headland Archaeology in 2018 (Harrison and Harrison 2018). This survey, which partially overlaps in the north of the Site, is directly relevant to the present investigation and has been used to provide comparative data. The survey predominantly identified anomalies resulting from historic and modern agriculture, historic field boundaries, geomorphological variations and other modern sources. Only a single curving linear anomaly of potential archaeological origin was identified, located in the southern part of the study area.

3 METHODOLOGY

3.1 Standards and Guidance

3.1.1 The archaeological geophysical survey was undertaken following the Chartered Institute for Archaeologists' *Standard and Guidance for Archaeological Geophysical Survey* (CIfA 2020), EAC *Guidelines for the Use of Geophysics in Archaeology* (EAC 2015), Historic England (2008) guidelines for geophysical survey and the WA Geophysical Survey Manual (WA 2021).

3.2 The Geophysical Survey

3.2.1 Archaeological geophysics is defined as the '*examination of the Earth's physical properties using non-invasive ground survey techniques to reveal buried archaeological features, sites and landscapes*' (Gaffney & Gater 2003). Geomagnetic survey is offered as a standard level investigative method as it offers the quickest ground coverage of the various survey techniques available and responds to a variety of remains derived from archaeological activity (EAC 2015).

3.2.2 A Geomagnetic survey was selected as the most appropriate technique for this site due to the rapid data collection technique and the expected presence of possible archaeological features at depths of no more than 1.5m. A magnetometer survey identifies the presence of magnetised features within the ground, which can either be created by thermoremanence (heated remains such as kilns or hearths) or defined in terms of the magnetism inducted when it is placed in a magnetic field (Gaffney & Gater 2003).

3.2.3 The geomagnetic survey was carried out using a Bartington Grad 601-2 dual gradiometer system which utilises two sensors set 1m apart. The survey was undertaken within a system of 30m by 30m grids which were delineated across the site using temporary grid markers.

3.2.4 The survey was undertaken using a zig-zag traverse pattern, utilising a sample interval of 0.25m and a traverse interval of 1m, providing 3600 sample measurements per full survey grid. Measurements were recorded on the Bartington's on-board datalogger, which was downloaded at regular intervals and backed up appropriately.

3.2.5 The survey was carried out over cultivated land, under variable atmospheric conditions, which included periods of strong wind. A strip at the western extent of Area 8 amounting to *c.*0.4ha could not be surveyed due to the presence of a haul road and the construction of a new pylon, but otherwise there were no obstructions to the survey of the site area.

3.3 Data Processing

3.3.1 The geomagnetic survey data were downloaded using DW Consulting Terrasurveyor Lite onto a laptop computer and were backed up accordingly. The data were subsequently processed using DW Consulting Terrasurveyor Lite, which was used to produce ‘greyscale’ images of the processed data (Figures 4a-e). A palette bar shows the relationship between the grey shades and geomagnetic values in nano-tesla (nT) for each area. The raw data are displayed as greyscale and colour plot indicating the dynamic range of magnetic values recorded within the study area (Figures 3a-e).

3.3.2 Raw data were processed in order to further define and highlight the archaeological features detected. The following basic data processing functions were used:

- Destripe: to reduce the effect of striping in the gradiometer data, sometimes caused by the misalignment of the twin sensors (zero mean traverse was performed on all survey grids using a threshold of 1 standard deviation).
- Destagger: to reduce location inaccuracies in the gradiometer data, sometimes caused by irregular pacing.
- Interpolate: to match the resolution of the sample intervals in the x and y directions (increased in the Y direction).
- Clip: to clip the dynamic range of the data to specified maximum and minimum values, in order to limit the influence of large noise spikes in the geophysical data (clipped from -5nT to 5nT).

3.4 Interpretation

3.4.1 Five types of geophysical anomaly were detected in the gradiometer data:

- *Positive Magnetic*: Regions of anomalously high or positive magnetic data, which may be associated with the presence of high magnetic susceptibility soil filled features, such as pits or ditches.
- *Negative Magnetic*: Regions of anomalously low or negative magnetic data, which may be associated with features of low magnetic susceptibility, such as stone-built features, geological features, land-drains or sub-surface voids.

- *Dipolar Magnetic*: regions of paired positive and negative magnetic anomalies, which typically reflect ferrous or fired materials, including fired/ferrous debris in the topsoil, or fired structures such as kilns or hearths.
- *Bipolar Magnetic*: typically linear regions of alternate positive and negative magnetic anomalies, which typically reflect buried service pipes or drains.
- *Magnetic Disturbance*: areas of high amplitude magnetic disturbance or interference, which may be associated with the presence of modern structures, such as services, fences or buildings.

3.4.2 A colour-coded geophysical interpretation diagram (Figures 5a-e) was created using AutoCAD LT2023, showing the locations and extent of the magnetic anomalies in light of the archaeological and historical context of the site.

3.5 Site Archive

3.5.1 Wardell Armstrong LLP supports the **O**nline **A**cces**S** to the Index of Archaeological **I**nvestigation**S** (OASIS) project. This project aims to provide an on-line index and access to the extensive and expanding body of grey literature, created as a result of developer-funded archaeological work.

4 GEOPHYSICAL SURVEY RESULTS

4.1 Introduction

4.1.1 The results of the geophysical survey are depicted in Figures 4a-e and corresponding interpretation in Figures 5a-e, in which magnetic anomalies are labelled with a specific anomaly number and referred to in the discussion below.

4.2 Results

4.2.1 Anomalies of probable archaeological origin

4.2.2 Ubiquitous across the site were regular positive linear anomalies representing remnants of medieval/ post-medieval ridge and furrow cultivation (**1**-**3**; Figures 5a-e). In most areas these represent positive linear magnetic responses from the remaining furrows in fields subjected to modern cultivation. Area 5, in the east of the site, contains surviving earthworks of ridge and furrow, with the magnetic data being different in character (**2**; Figure 5c). These are characterised as broader diffuse positive anomalies (furrows), alternating with parallel negative linear anomalies (banks/ ridges). Numerous alignments of ridge and furrow are present in the survey data. The furrows in Area 8 were characteristically sinuous (**3**; Figure 5d), which implies a medieval date. In the south of the site, in Area 9, strong positive linear anomalies resulting from ridge and furrow cultivation are on the same alignment as modern ploughing, making them difficult to distinguish where their magnetic response was weaker.

4.2.3 To the north of Area 6, in Area 3, parallel NE-SW strong positive linear anomalies (**4** and **5**; Figure 5c) appear to define the limit of the extant ridge and furrow in this part of the survey area. These are partially visible as earthworks and are likely part of a former trackway or boundary. An additional positive linear anomaly (**6**; Figure 5c) on the same alignment close to the south-eastern boundary of Area 4 also appears to be part of the same enclosure/ boundary system.

4.2.4 Bisecting Area 4 on an ENE-WSW alignment was a relatively weak positive linear anomaly (**7**; Figure 5c). This linear anomaly does not respect the remnant ridge and furrow in Area 4 and is most likely not contemporary.

4.2.5 Further linear positive anomalies, probably representing cut and infilled ditch features, were present in the south of Area 5 (**8**; Figure 5c) and Area 2 (**9**; Figure 5c) and in Area 9 (**10**; Figure 5e). These broadly correspond with the alignment of extant field boundaries but are not depicted on Ordnance Survey mapping of the area from the first edition onwards (NLS 2022) and most likely represent earlier field boundaries.

4.2.6 In the northern part of Area 9 was a collection of relatively high amplitude positive anomalies (**11**; Figure 5e) which could be of archaeological origin, including a possible penannular form within the group. However, the irregular nature of a number of the anomalies makes it difficult to attribute a meaningful interpretation.

4.2.7 Across the survey area were 54 discrete positive anomalies (**12**-**14**; Figures 5b-5e) ranging in size between 2m and 6.5m, which are consistent with cut and infilled pit features or pit clusters. hese were concentrated predominantly in Areas 5,7, 9 and the north-west of Area 8, and could represent remnants of past human activity in these areas of the site. The cluster of anomalies in the north-west of Area 8 (**13**; Figure 5d) appears to form two sub-circular arrangements and there appears to be a linear arrangement of anomalies across Area 9 (**14**; Figure 5e) but these forms could be coincidental. The discrete positive anomalies (**12**-**14**; Figures 5b-5e) were differentiated from other point anomalies across the survey area by having values of between 5nT and 20nT but could have a range of origins, including natural or modern activity.

4.2.8 Two parallel positive linear anomalies on a NNW-SSE alignment in Area 8 (**15**; Figure 5d) could represent former boundaries but their relationship with land drains in this area suggests that they are more likely associated with drainage.

4.2.9 **Anomalies of geomorphological origin**

4.2.10 Running broadly N-S through Areas 8, 4 and 2 were two sinuous, diffuse, intermittent positive trending anomalies (**16**-**17**; Figures 5c and 5d). These are consistent with natural features, such as infilled channels. They are likely to represent former braided channels feeding into the watercourse on the northern boundary of the Site, running as they do from the higher ground of the south and centre of the Site to lower elevations in the north and north-east.

4.2.11 **Anomalies of historical and modern origin**

4.2.12 A positive linear anomaly aligned NNW-SSE through the centre of Area 8 (**18**; Figure 5d) and an ENE-WSW anomaly in the north of Area 1 (**19**; Figure 5b) correspond with boundaries depicted on the first edition 6” Ordnance Survey map (NLS 2022)

4.2.13 Across most of the survey area, regular closely spaced linear anomalies are visible which align with the direction of modern ploughing, as identified with reference to historic satellite imagery (Google Earth 2022). These effects are widespread and have not been digitised to avoid over-complication of the interpretative plot.

4.2.14 At the western edge of Area 8, a NNW-SSE negative linear anomaly (**20**; Figure 5d) corresponds with the extent of cultivation and is caused by the accumulation of soil on the ploughing headland.

4.2.15 Positive linear anomalies (**21**; Figure 5d) on three separate alignments and with regular 7m-8m spacing in Area 8 are likely to derive from land drains. The anomalies appear to respect a pair of NNW-SSE anomalies (**15**), which may also be part of the drainage system (above).

4.2.16 Modern services are represented by a high amplitude bipolar anomaly in Area 6 (**22;** Figure 5a), indicating the location of a buried service, and magnetic interference from electricity pylons (**23**; Figures 5b-5e) in Areas 1, 5, 8 and 9.

4.2.17 Magnetic interference (**24**; Figures 5c and 5d) associated with the site boundary was relatively limited, being most pronounced in proximity to the haul road in the west of Area 8 and in the areas around North Moor Farm. The intrusion of magnetic interference on the survey data was limited and unlikely to have had a significant impact on the visibility of weaker anomalies of potential archaeological origin.

4.2.18 Numerous positive dipolar responses were present across the survey area. The majority of these are probably not archaeologically significant and represent modern ferrous material within the near subsurface.

5 CONCLUSIONS

5.1 Interpretation

5.1.1 The magnetic gradiometer survey of the Site identified a number of anomalies of possible archaeological origin. Most prominent were extensive remains of former ridge and furrow cultivation (**1**-**3**), present throughout most of the survey area, along with probable associated boundaries (**4**-**6**). This is comparable with the survey of adjacent areas by Headland Archaeology, which also identified widespread evidence of ridge and furrow (Harrison and Harrison 2018). In Area 5, ridge and furrow remains visible as earthworks. Combined with land drains and disturbance from modern cultivation, the identification of anomalies of archaeological origin was challenging in some areas of the survey.

5.1.2 Three positive linear anomalies (**8**-**10**) are likely to represent former field boundaries, although they do not correspond with historic mapping of the Site. In addition, two historic field boundaries (**18** and **19**) depicted on the first edition Ordnance Survey map were detected.

5.1.3 A further linear anomaly (**7**) in the north of the site did not appear to be associated with either historic land divisions or earlier ridge and furrow cultivation. A group of relatively high amplitude positive anomalies (**11**) towards the south of the survey in Area 9 may be of archaeological origin and included an apparent penannular form. In addition to these were numerous discrete positive anomalies (**12**-**14**), which have the potential to represent pits or pit clusters of archaeological origin.

5.1.4 The remaining anomalies were of geomorphological origin (probable palaeochannels (**16**-**17**) flowing to the north of the Site), or modern origin (land drains (**21**), a buried service in Area 6 (**22**), pylons (**23**) and areas of magnetic interference (**24**) associated with boundaries and modern features in close proximity to the survey area).

5.1.5 The greyscale plot of processed gradiometer data from the site (Figures 4a-e) shows a good degree of contrast between the recorded magnetic anomalies and background values, with a range of anomalies visible. This indicates that the method was successful in characterising sub-surface features present within the survey area.

5.1.6 In general, the results are comparable with those from the earlier survey of adjacent land (Harrison and Harrison 2018), which identified predominantly features associated with agriculture, including ridge and furrow and field boundaries, with relatively limited evidence of well-defined features of probable archaeological origin.

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APPENDIX 1: FIGURES

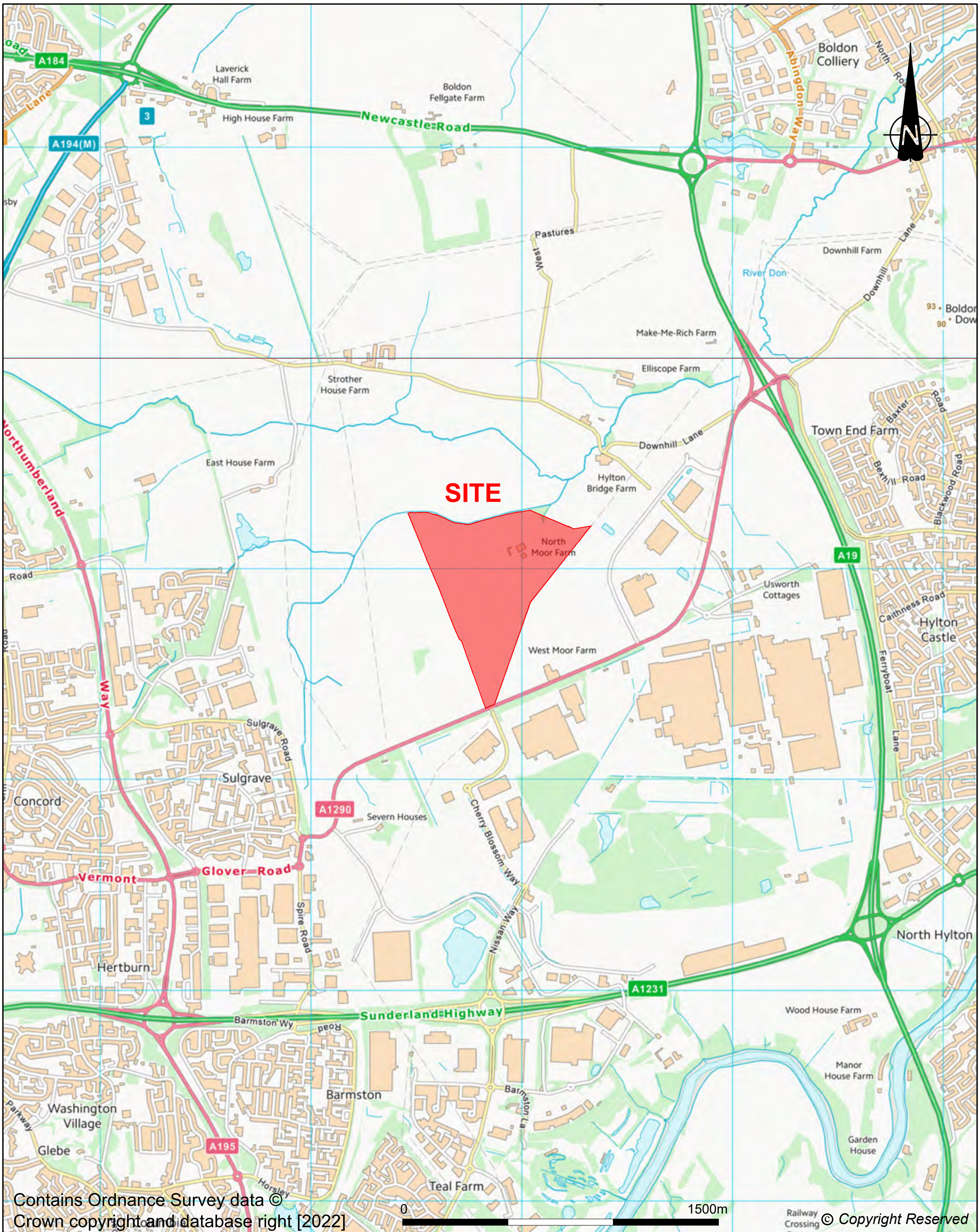

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Figure 1
Site location plan

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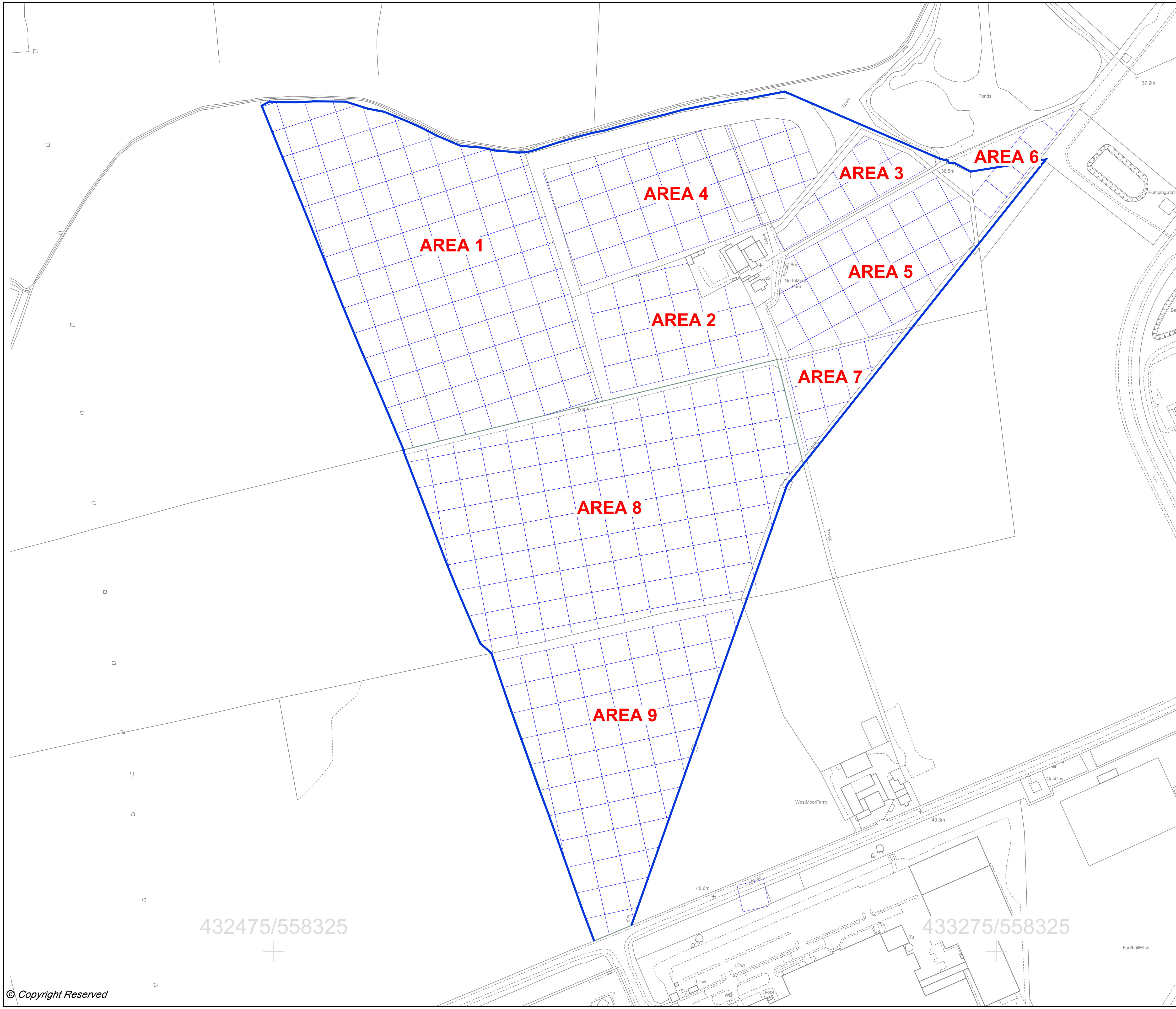

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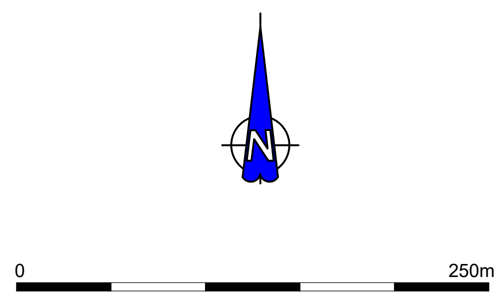

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Figure 2
Survey grid

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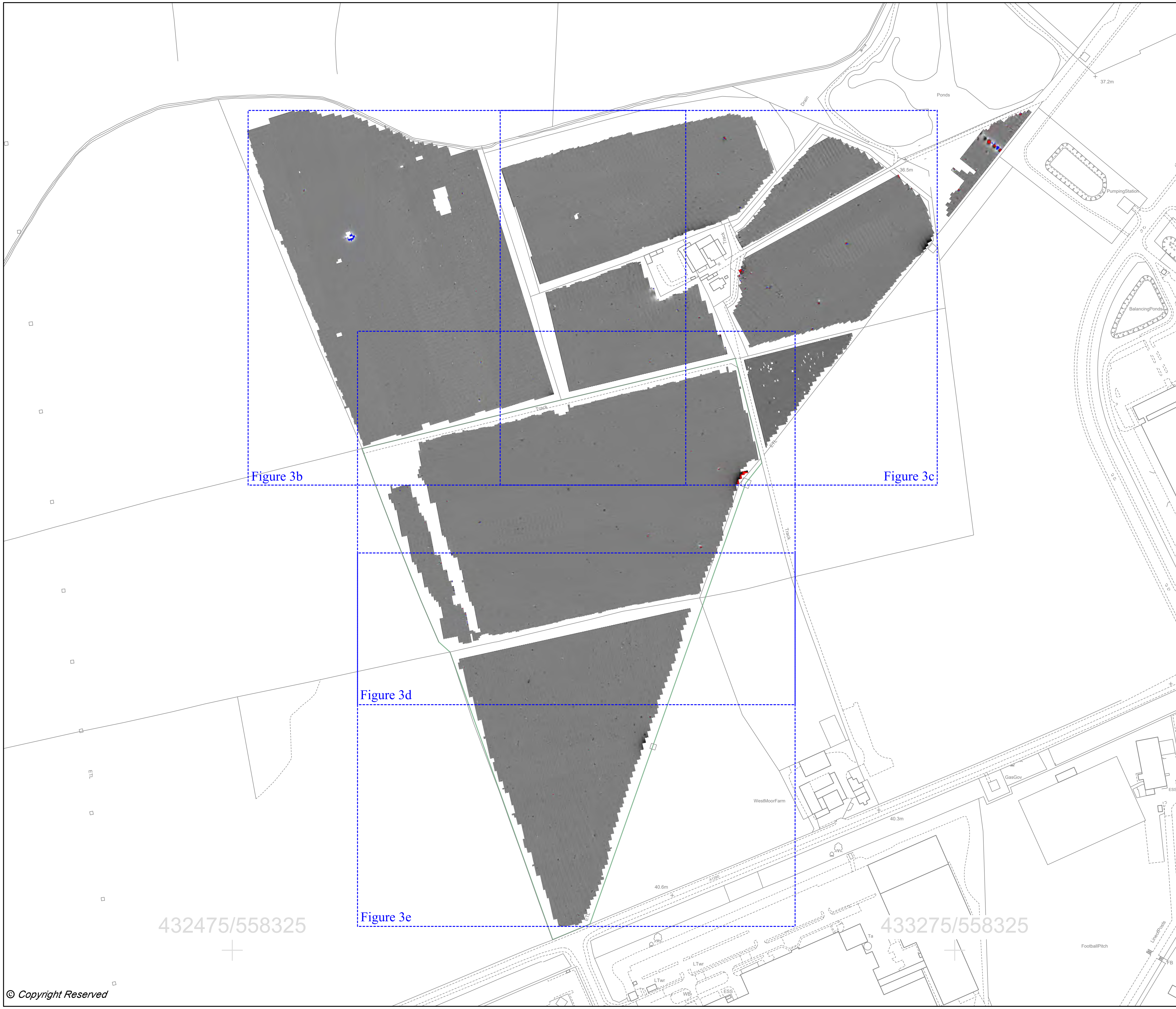

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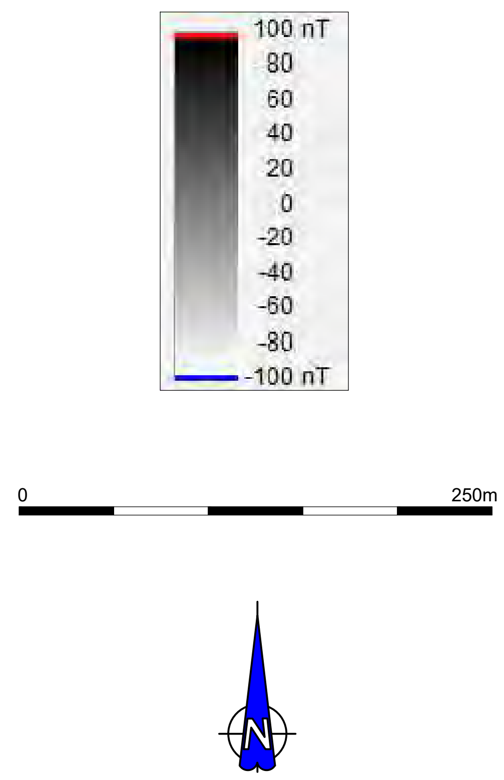

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Figure 3a
Greyscale and colour plot of unprocessed gradiometer data

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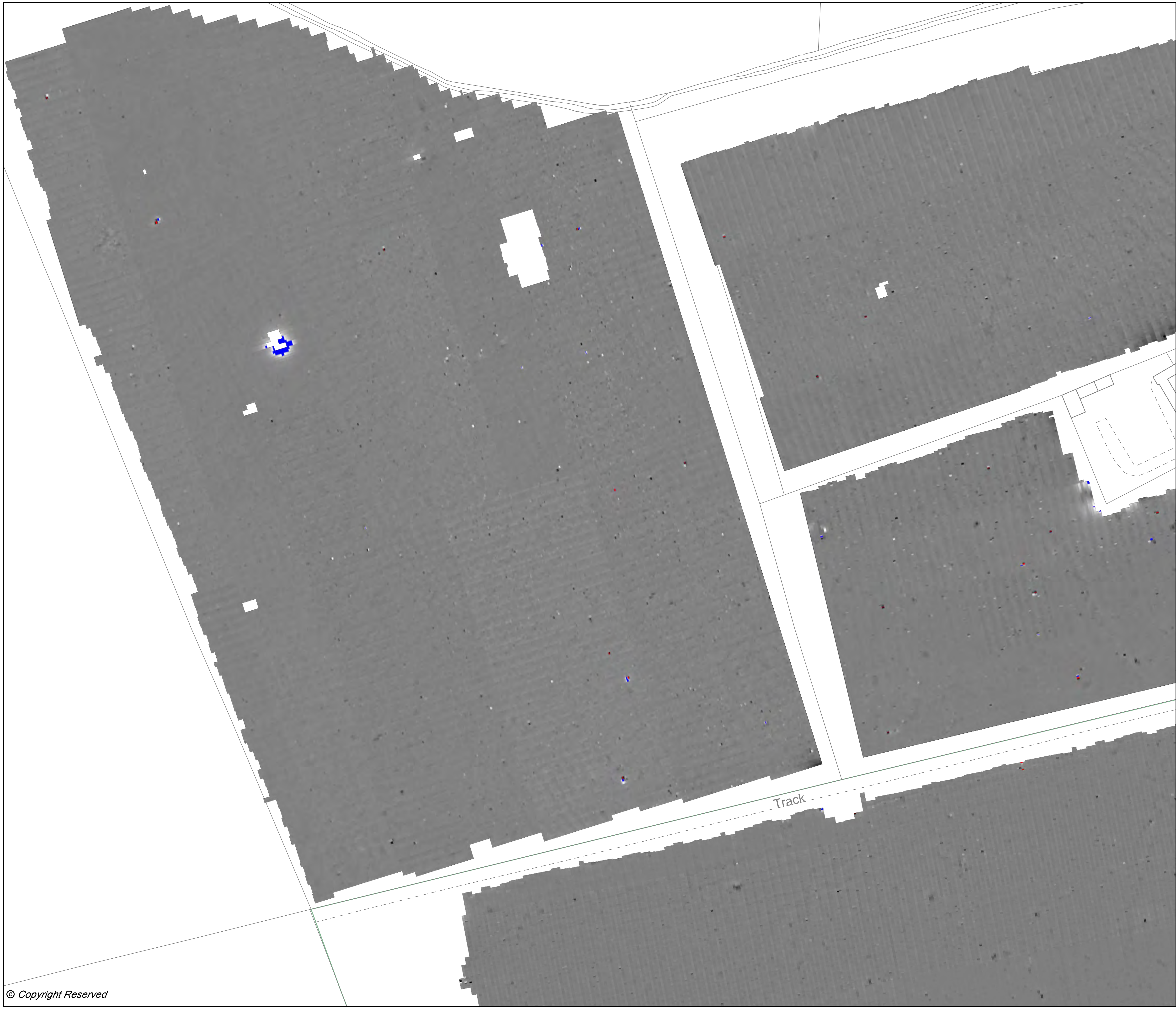

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Figure 3b
Greyscale and colour plot of unprocessed gradiometer data

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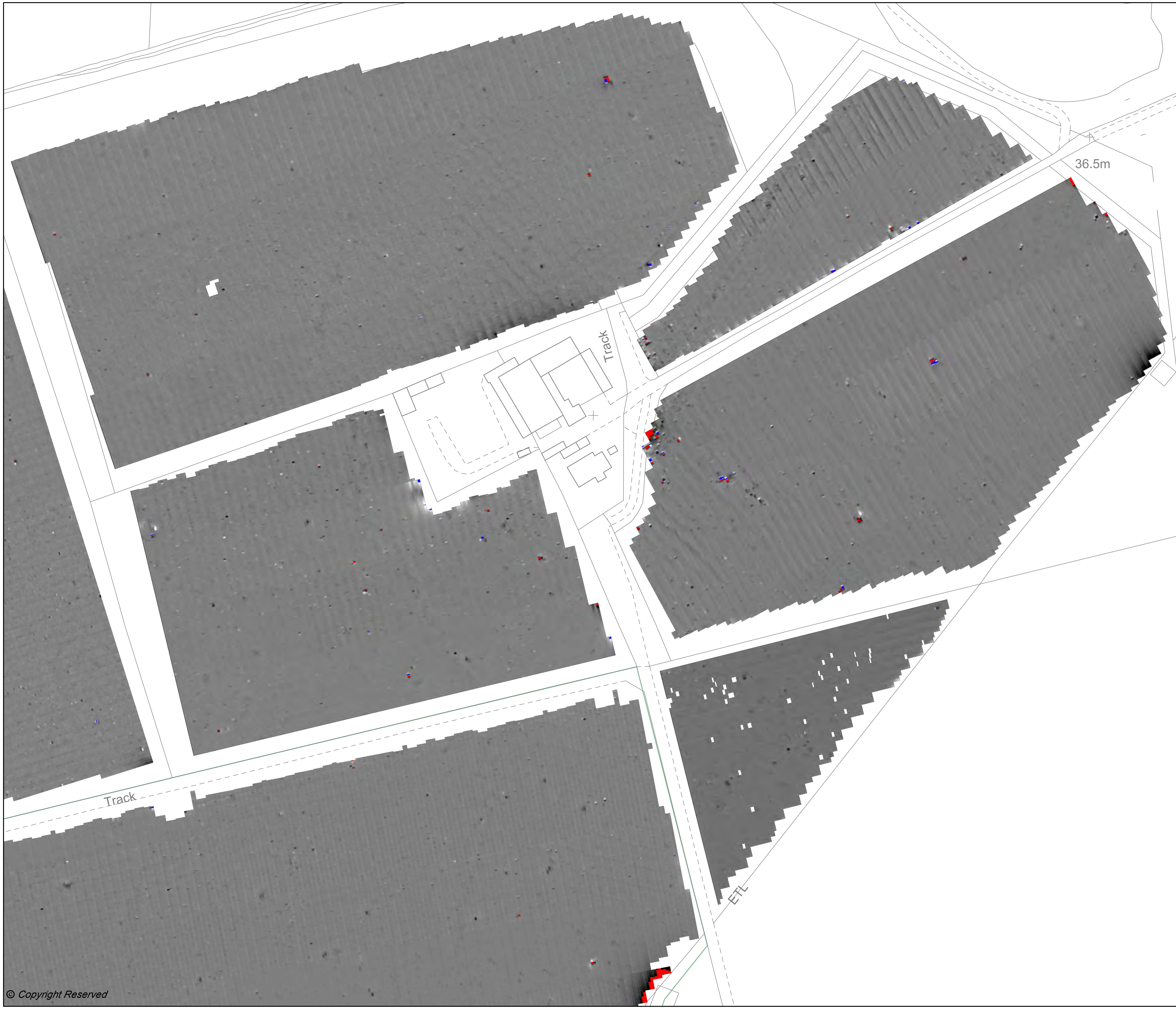

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Figure 3c
Greyscale and colour plot of
unprocessed gradiometer data

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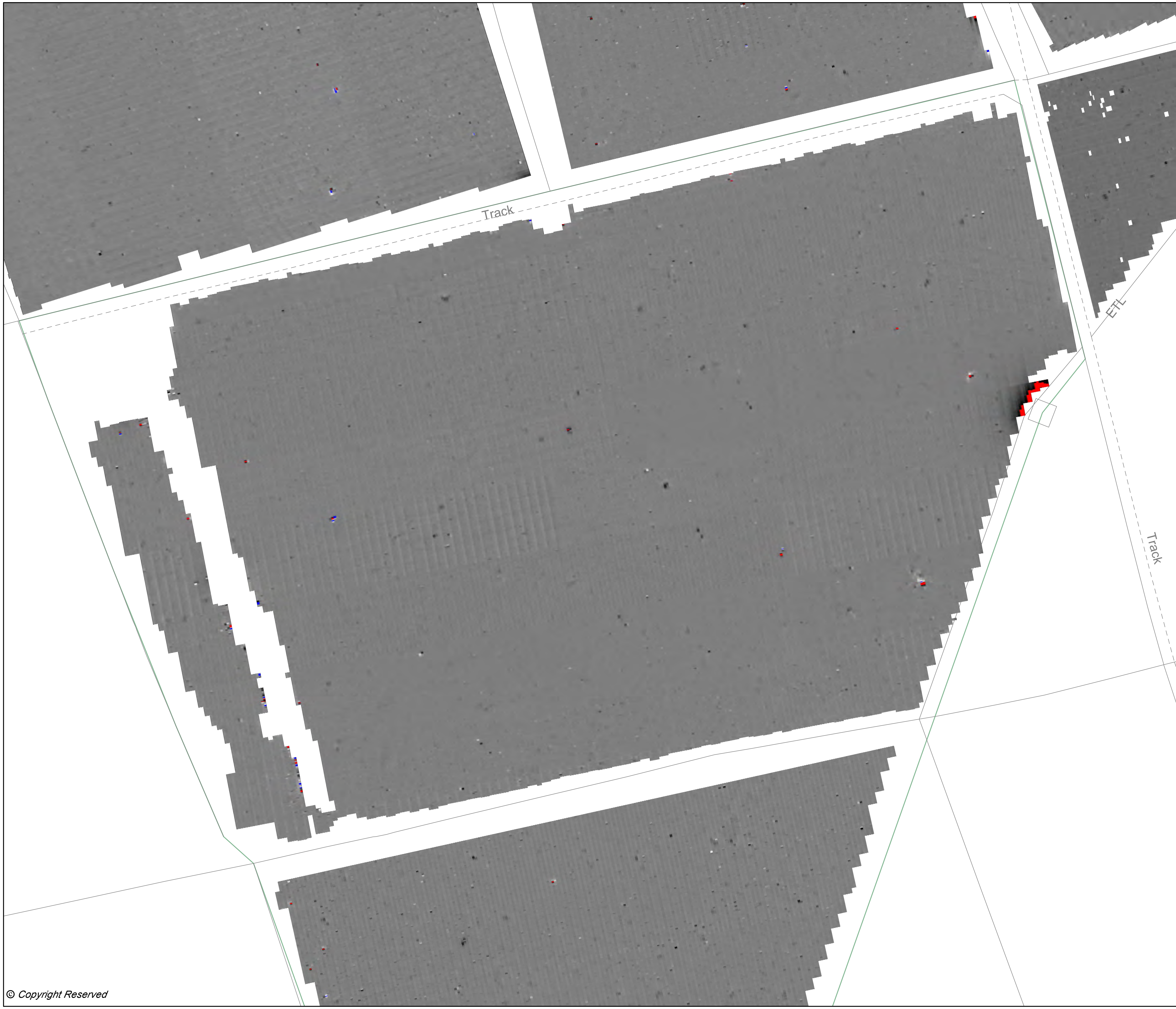

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Figure 3d
Greyscale and colour plot of unprocessed gradiometer data

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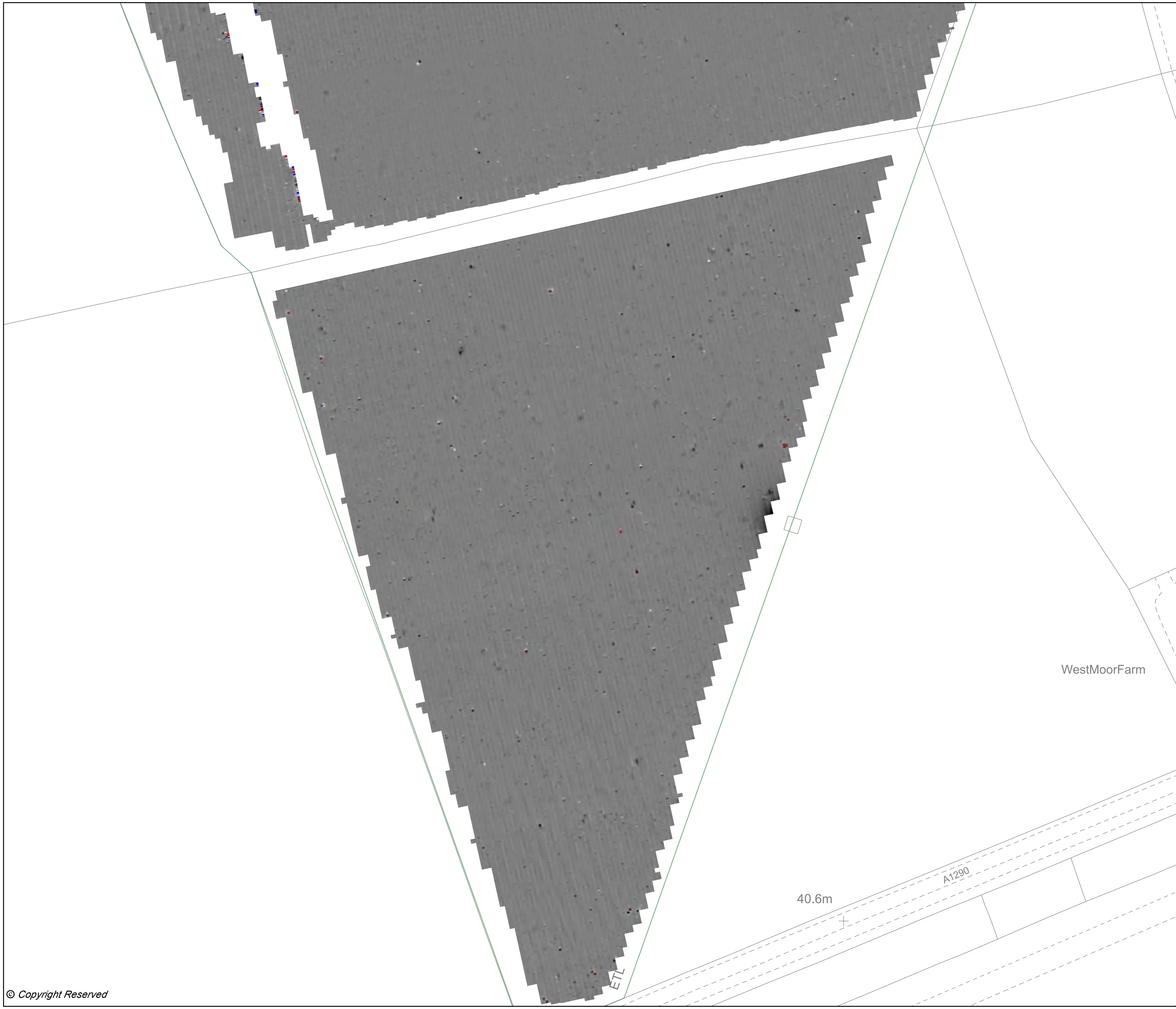

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DRAWING TITLE
Figure 3e
Greyscale and colour plot of unprocessed gradiometer data

DRG No.	REV
NT15821-303	A

DRG SIZE	SCALE	DATE
A3	1:1,500	17/11/2022

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DRAWING TITLE
Figure 4
Greyscale plot of processed gradiometer data

DRG No. NT15821-504		REV A
DRG SIZE A3	SCALE 1:4,000	DATE 16/11/2022
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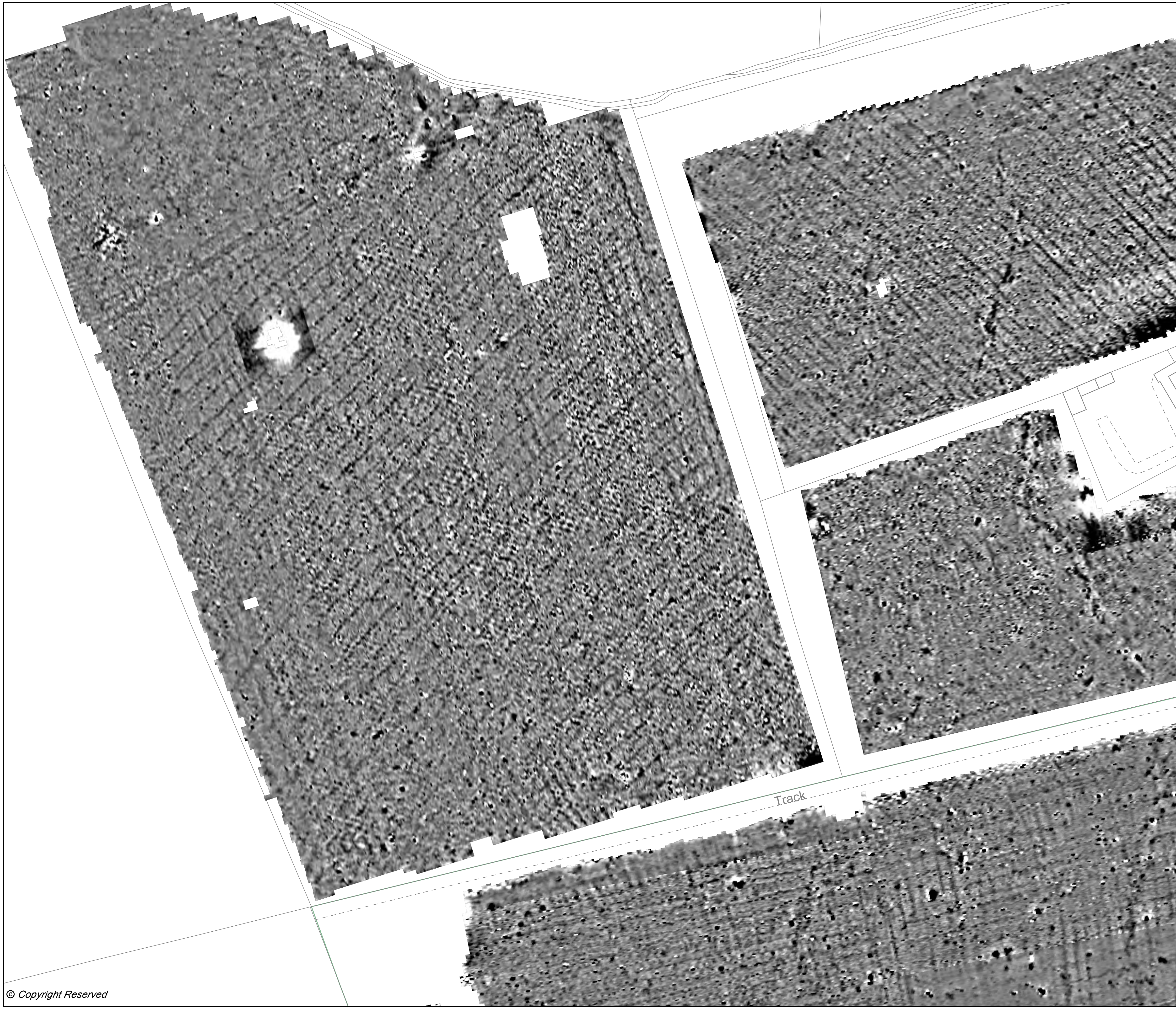

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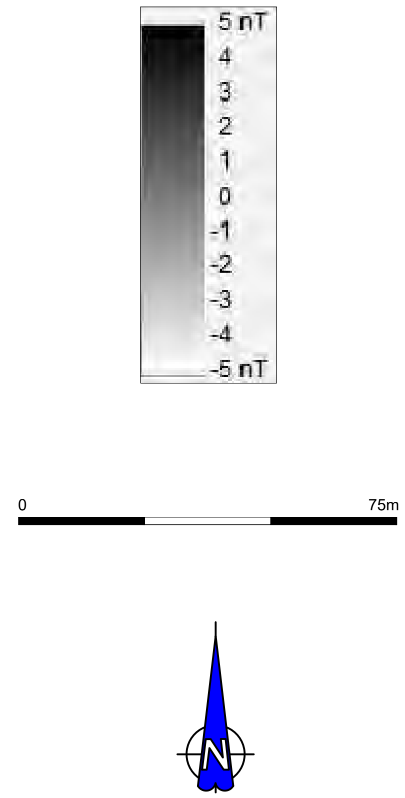

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DRAWING TITLE

Figure 4b
Greyscale plot of processed gradiometer data

DRG No.		REV
NT15821-504		A
DRG SIZE A3	SCALE 1:1,500	DATE 16/11/2022
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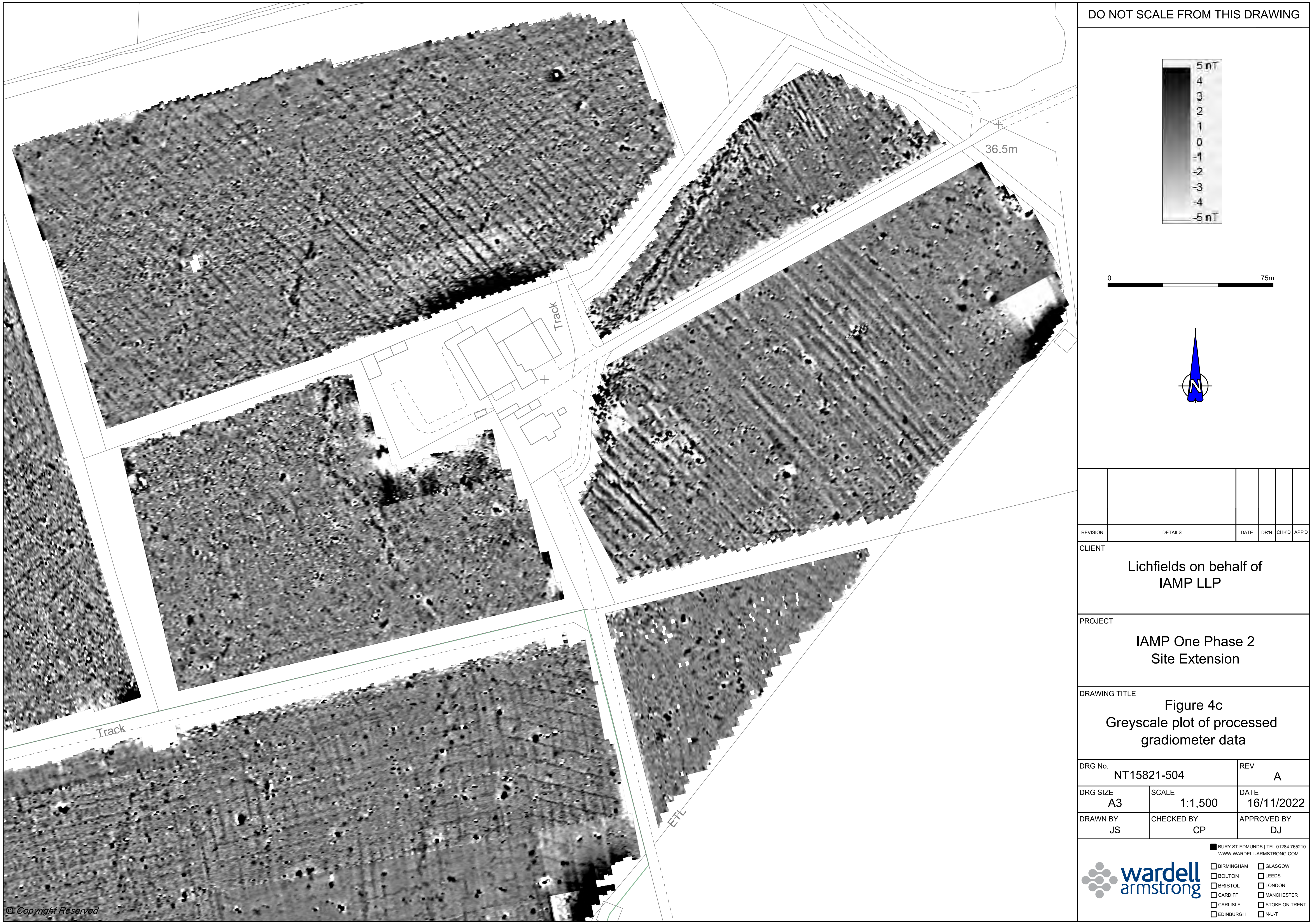

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DRAWING TITLE

Figure 4c
Greyscale plot of processed gradiometer data

DRG No.		REV
NT15821-504		A
DRG SIZE A3	SCALE 1:1,500	DATE 16/11/2022
DRAWN BY JS	CHECKED BY CP	APPROVED BY DJ

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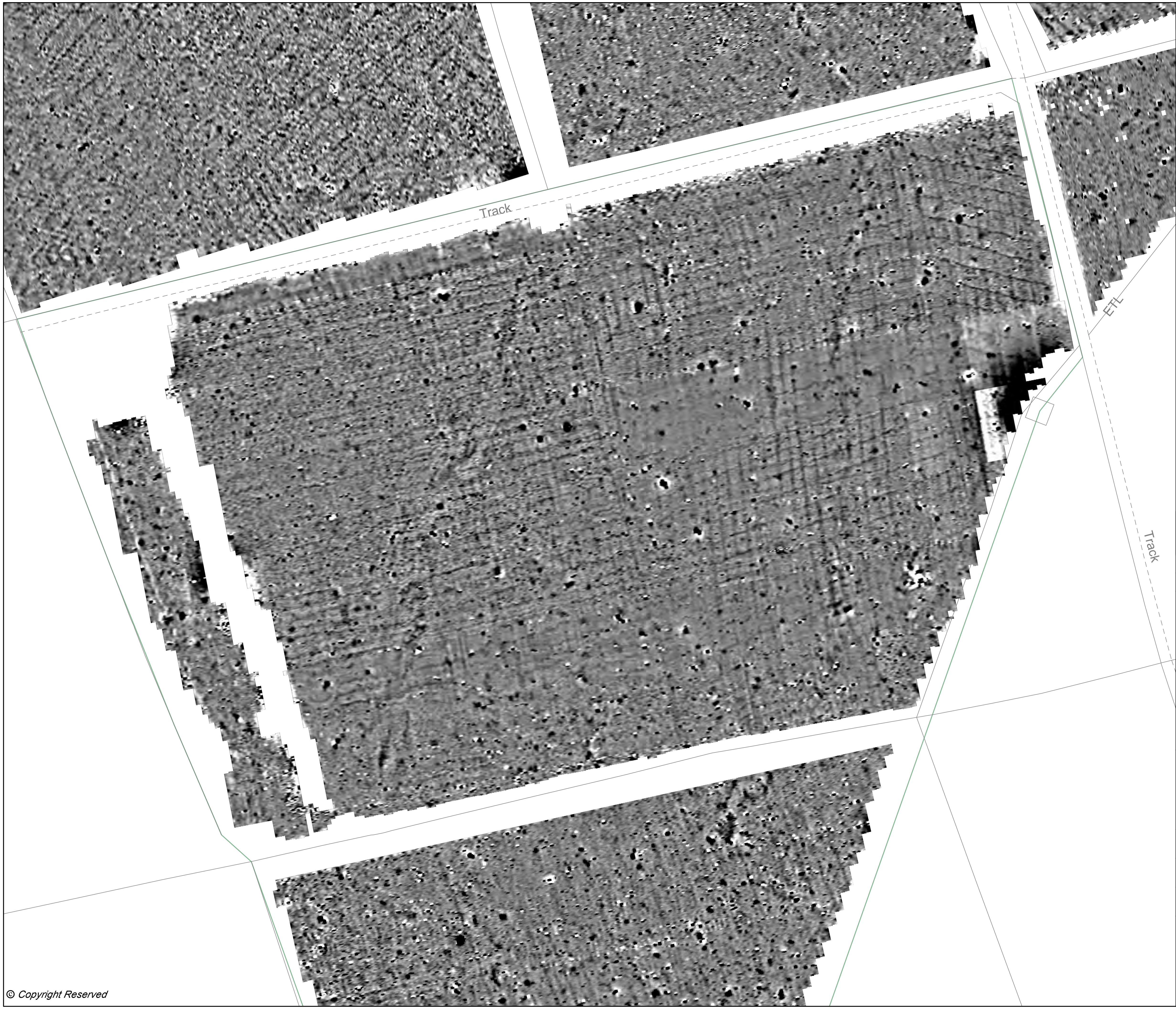

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DRAWING TITLE

Figure 4d
Greyscale plot of processed gradiometer data

DRG No.		REV
NT15821-504		A
DRG SIZE: A3	SCALE: 1:1,500	DATE: 16/11/2022
DRAWN BY: JS	CHECKED BY: CP	APPROVED BY: DJ

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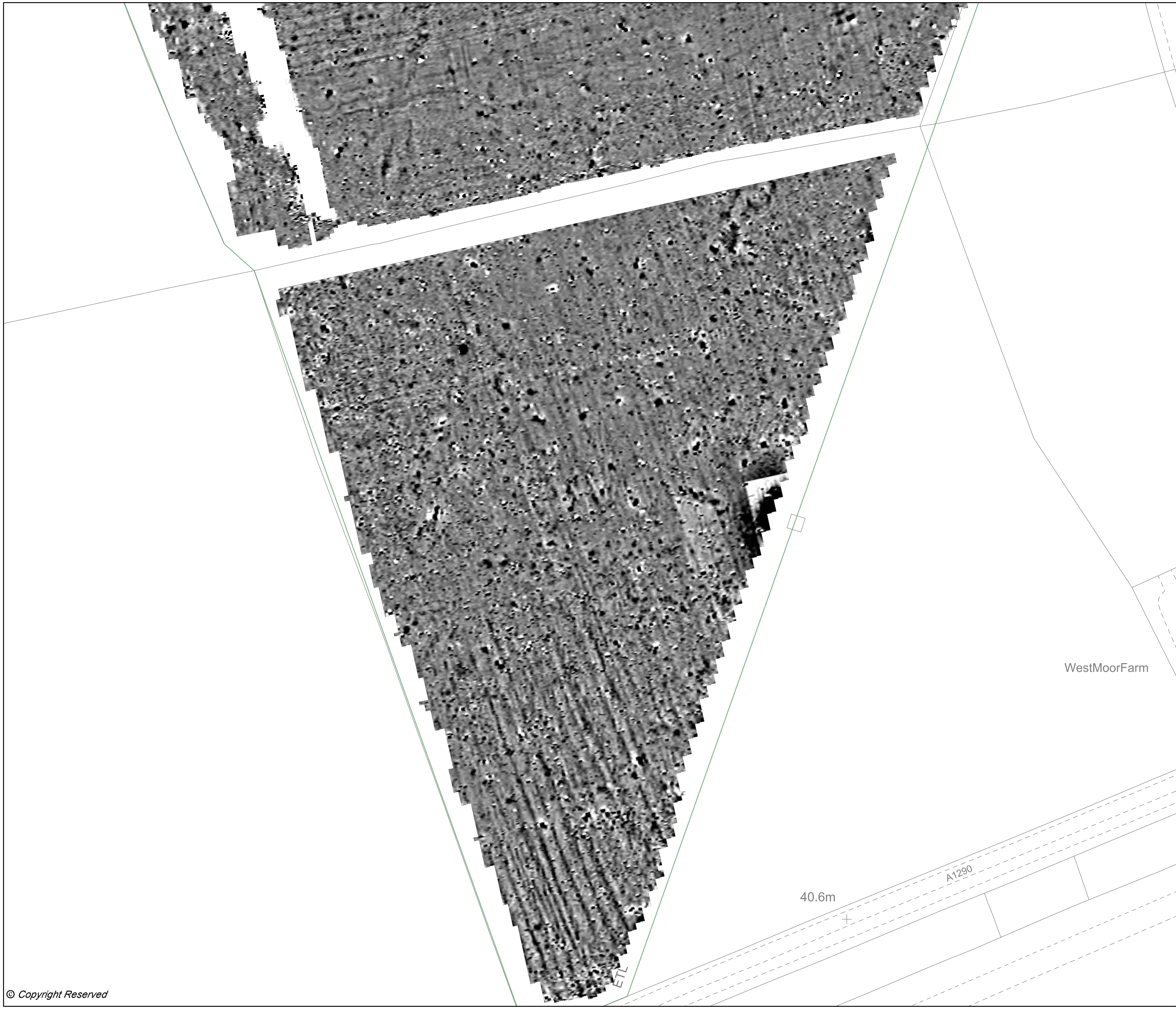

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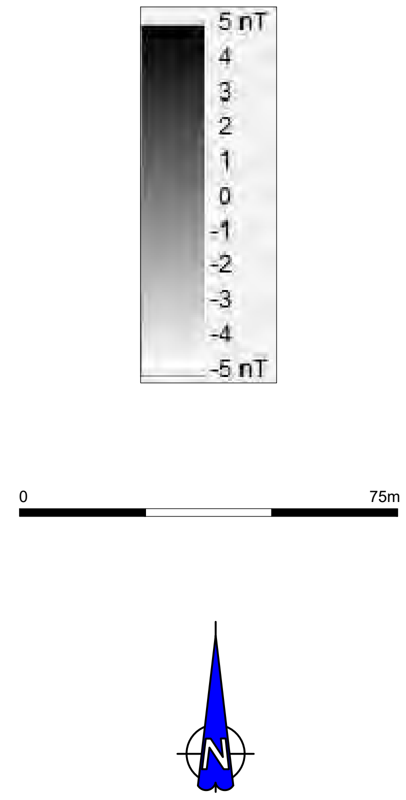

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Figure 4e
Greyscale plot of processed gradiometer data

DRG No.		REV
NT15821-504		A
DRG SIZE A3	SCALE 1:1,500	DATE 16/11/2022
DRAWN BY JS	CHECKED BY CP	APPROVED BY DJ

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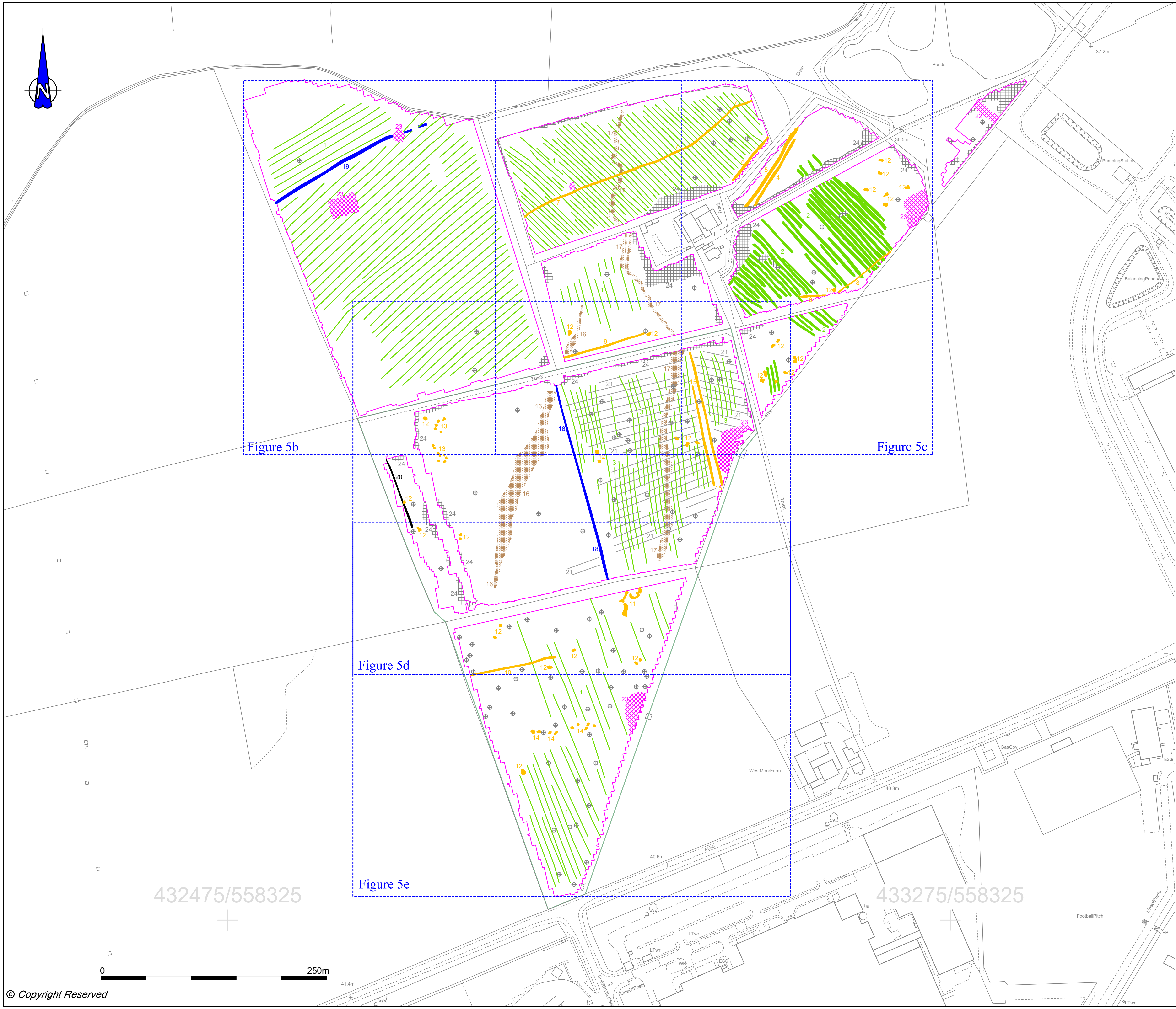

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KEY

- Positive anomaly - probable cut feature of archaeological origin
- Positive anomaly - Historic field boundary
- Negative anomaly - probable cultivation headland
- Cultivation furrows
- Land drains
- Geomorphological features
- Services (buried services and pylons)
- Magnetic interference/ disturbance
- Dipolar anomaly - modern ferrous object
- Extent of survey

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IAMP One Phase 2 Site Extension

DRAWING TITLE

Figure 5a Interpretation plot

DRG No.	REV
NT15821-505	A

DRG SIZE	SCALE	DATE
A3	1:4,000	17/11/2022

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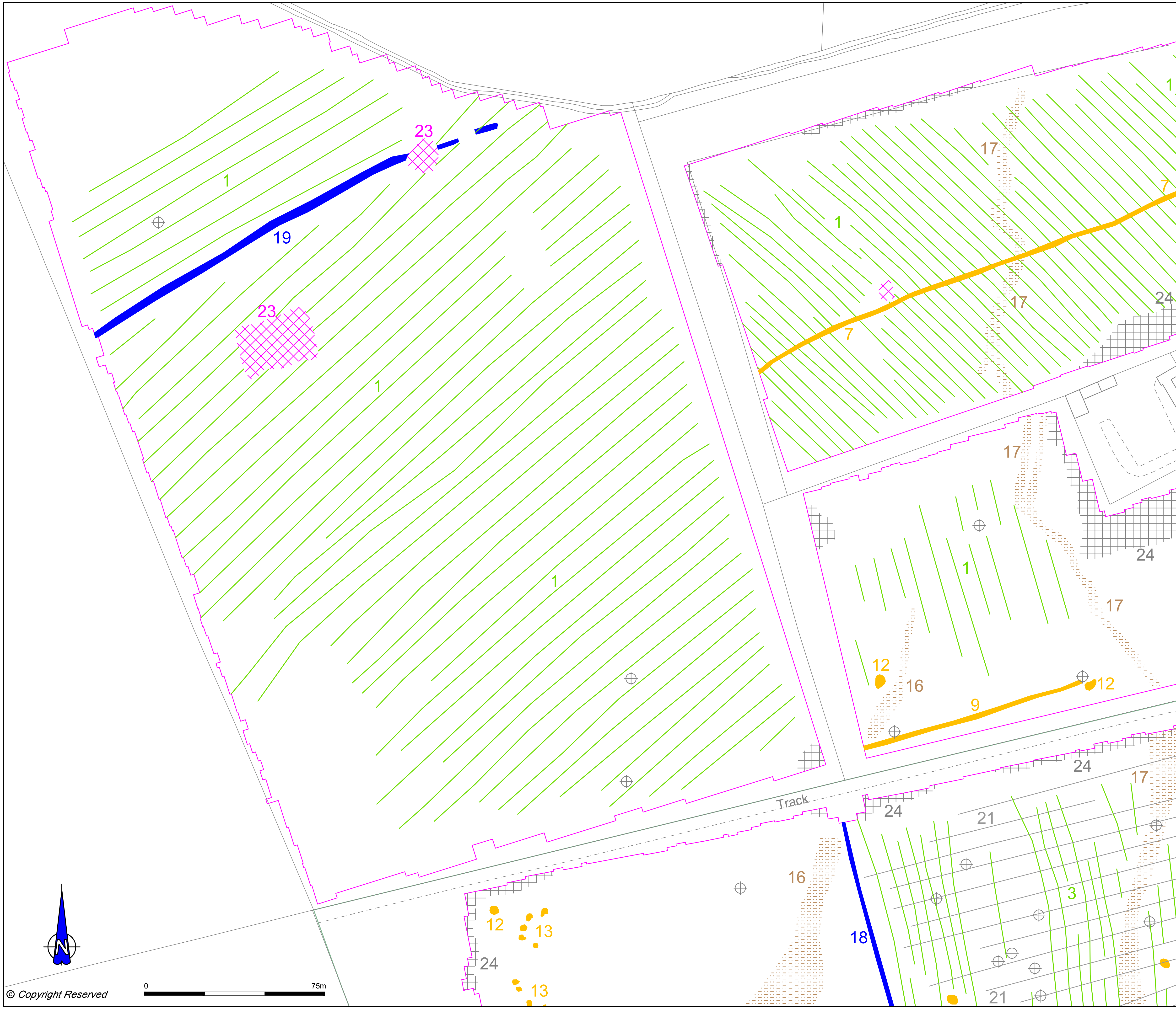

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KEY

- Positive anomaly - probable cut feature of archaeological origin
- Positive anomaly - Historic field boundary
- Negative anomaly - probable cultivation headland
- Cultivation furrows
- Land drains
- Geomorphological features
- Services (buried services and pylons)
- Magnetic interference/ disturbance
- Dipolar anomaly - modern ferrous object
- Extent of survey

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DRAWING TITLE
Figure 5b Interpretation plot

DRG No. NT15821-505		REV A
DRG SIZE A3	SCALE 1:1,500	DATE 17/11/2022
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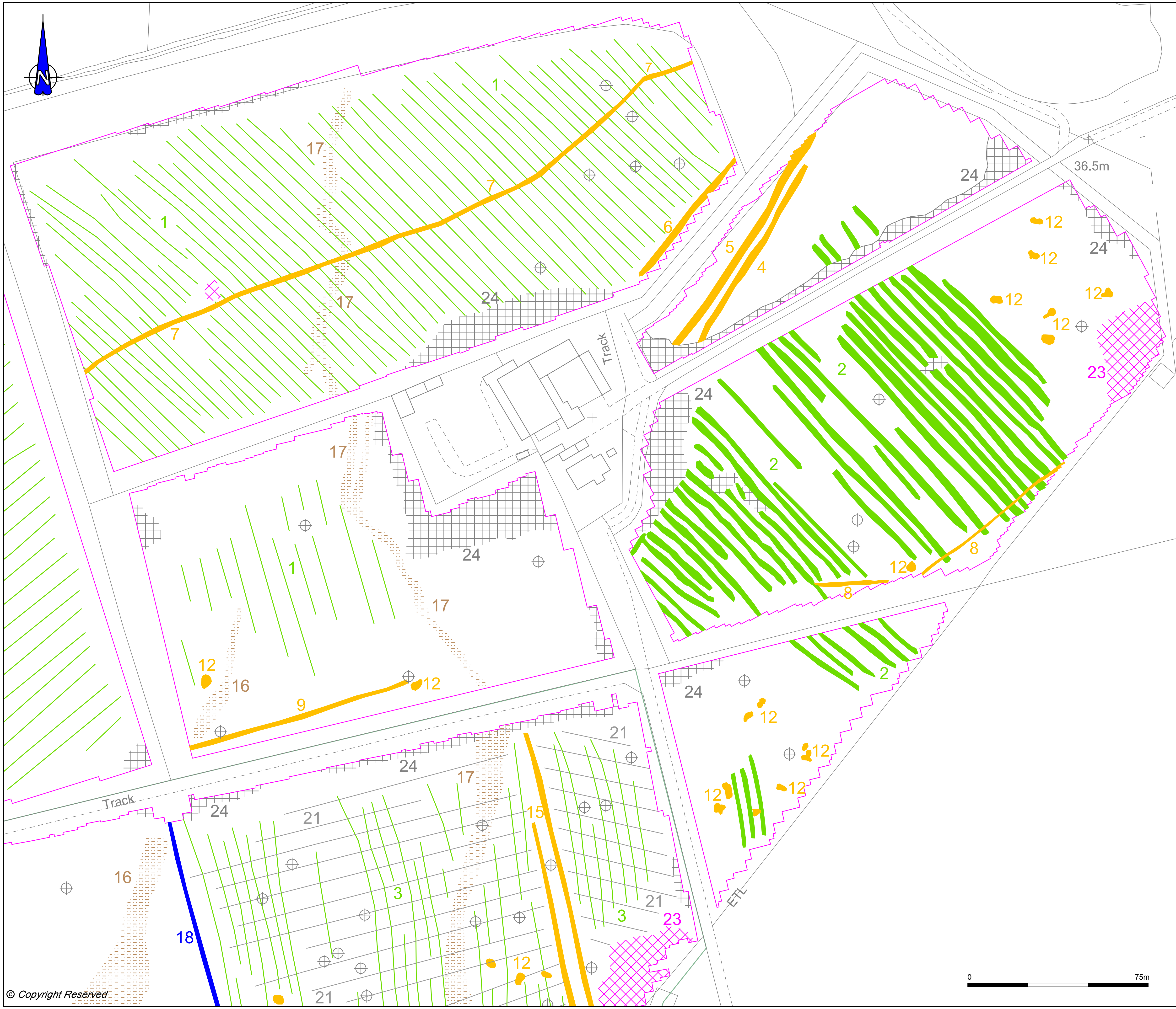

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KEY

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- Positive anomaly - Historic field boundary
- Negative anomaly - probable cultivation headland
- Cultivation furrows
- Land drains
- Geomorphological features
- Services (buried services and pylons)
- Magnetic interference/ disturbance
- Dipolar anomaly - modern ferrous object
- Extent of survey

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DRAWING TITLE

Figure 5c
Interpretation plot

DRG No.		REV
NT15821-505		A
DRG SIZE A3	SCALE 1:1,500	DATE 17/11/2022
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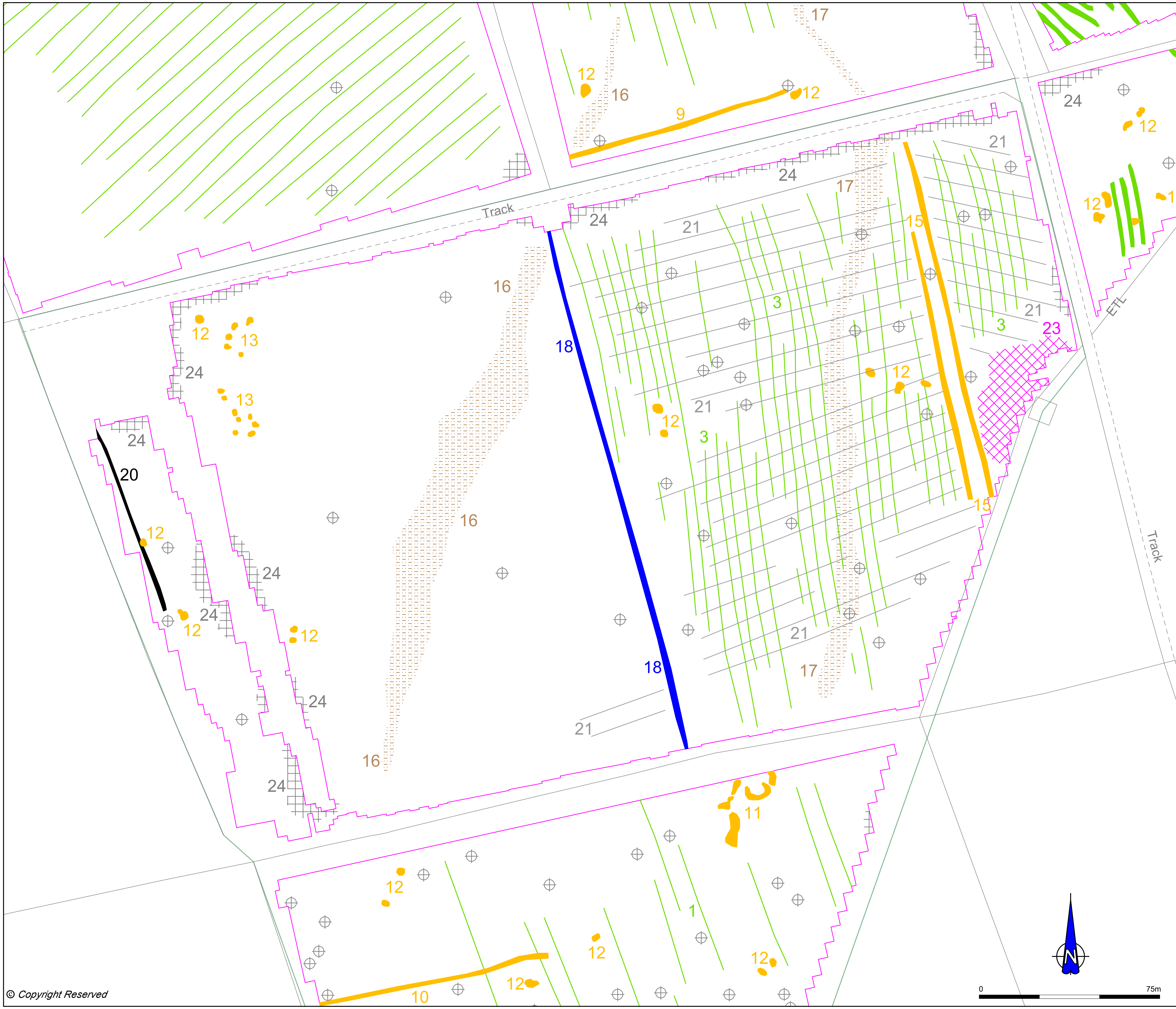

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KEY

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- Positive anomaly - Historic field boundary
- Negative anomaly - probable cultivation headland
- Cultivation furrows
- Land drains
- Geomorphological features
- Services (buried services and pylons)
- Magnetic interference/ disturbance
- Dipolar anomaly - modern ferrous object
- Extent of survey

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DRAWING TITLE

Figure 5d
Interpretation plot

DRG No.		REV
NT15821-505		A
DRG SIZE: A3	SCALE: 1:1,500	DATE: 17/11/2022
DRAWN BY: JS	CHECKED BY: CP	APPROVED BY: DJ

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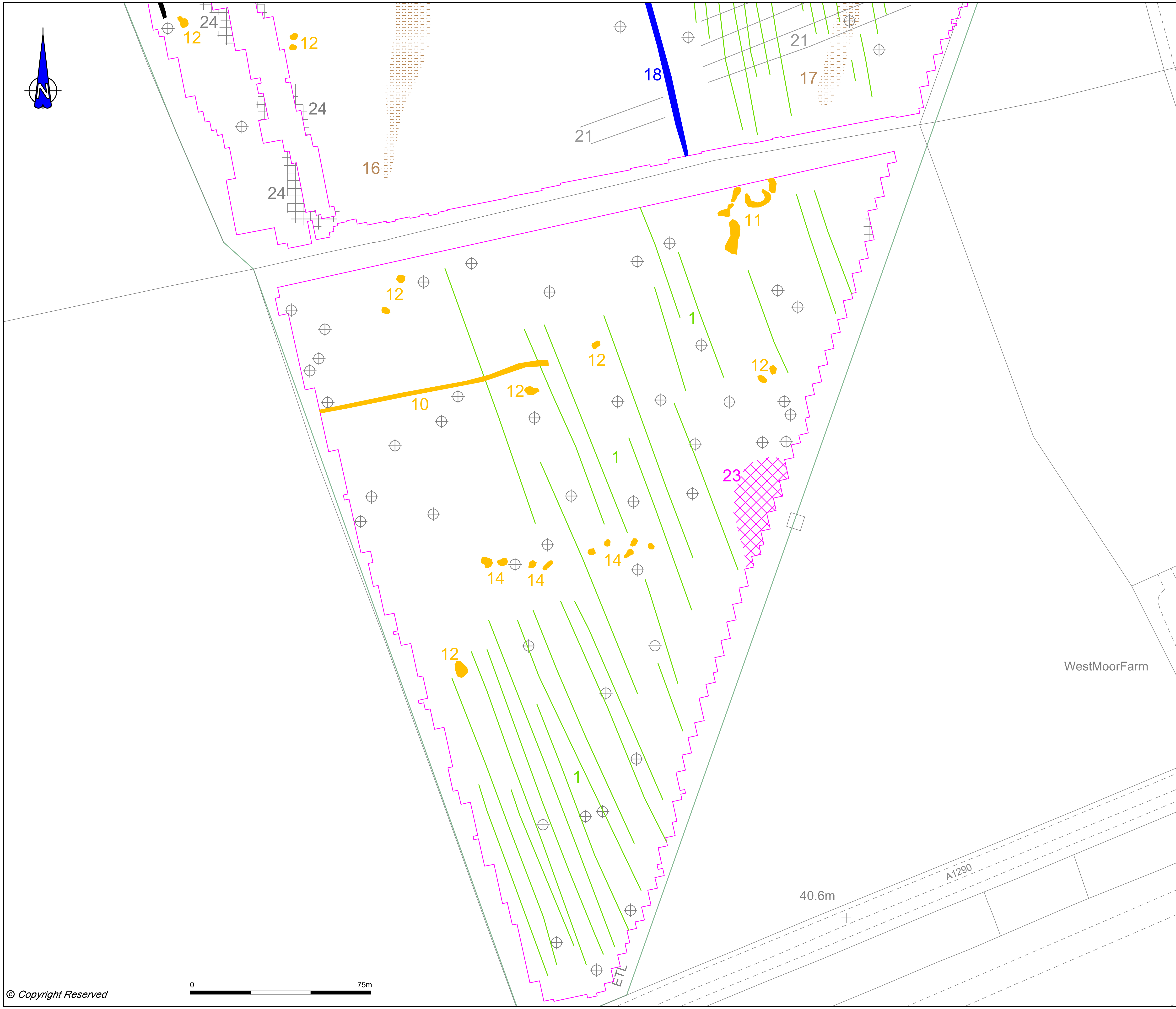

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KEY

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- Positive anomaly - Historic field boundary
- Negative anomaly - probable cultivation headland
- Cultivation furrows
- Land drains
- Geomorphological features
- Services (buried services and pylons)
- Magnetic interference/ disturbance
- Dipolar anomaly - modern ferrous object
- Extent of survey

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Figure 5e Interpretation plot

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DRG SIZE A3	SCALE 1:1,500	DATE 17/11/2022
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