ARCHAEOLOGICAL SURVEYS

GEOPHYSICAL SURVEY REPORT

Bristol Northern Relief Main Keynsham

Geophysical survey

for

Wessex Archaeology

David Sabin and Kerry Donaldson

December 2005

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Bristol Northern Relief Main
Keynsham

Geophysical survey

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Report and fieldwork by David Sabin and Kerry Donaldson

Survey date – **9th to 16th December 2005**
Ordnance Survey Grid Reference – **ST 638 695 to ST 650 697**

Archaeological Surveys
2, Westway Close, Castle Combe, Wiltshire, SN14 7QZ
Tel. 01249 782234   FAX 0871 661 8804
Email: info@archaeological-surveys.co.uk
Web: www.archaeological-surveys.co.uk

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SUMMARY

A geophysical survey was carried out over approximately 3.6 ha along two proposed routes of a water main near Keynsham, Bath and North East Somerset. From a trial survey using magnetometry and resisistivity, within the vicinity of the site of the Keynsham Roman Villa, magnetometry was selected as the most appropriate technique for locating geophysical anomalies. The magnetometry survey located a number of anomalies within Area 5 to the south of Keynsham villa which may relate to cut features such as ditches and pits. It is also possible that positive linear and discrete anomalies within Areas 6, 8 and 10 may also relate to cut features however the limited width of the survey corridor does not allow for accurate characterisation of the anomalies.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys was commissioned by Wessex Archaeology on behalf of Bristol Water to undertake a geophysical survey of two possible pipeline routes near Keynsham. This survey formed part of an assessment of any potential archaeology that may be affected by groundwork associated with pipeline construction on either route.

1.2 Survey objectives

1.2.1 The objective of the survey was to primarily use magnetometry and resistivity within a trial area to assess the efficacy of each technique to locate geophysical anomalies that may be archaeological in origin. Subsequent to this trial, magnetometry was selected as the most appropriate and efficient method of collecting data. The results of this survey will help in the assessment of potential archaeological features prior to intrusive activities.

1.3 Site location

1.3.1 The potential pipeline routes are located to the north and north west of Keynsham within the unitary local government authority of Bath and North East Somerset. Table 1, below, lists central Ordnance Survey Grid references for each survey area.

Area no.	**Ordnance Survey Grid Reference (central easting, northing)**	**Approximate size (hectares)**	**Approximate length (metres)**
1	363879, 169502	0.2	100
2	363996, 169511	-	Unsurveyable
3	364143, 169455	-	Unsurveyable
4	364312, 169350	0.36	180
5	364552, 169114	0.68	340
6	364752, 169203	1.08	540
7	364716, 169423	0.32	160
8	364824, 169279	0.4	200
9	365034, 169705	0.12	60

10	364973, 169593	0.36	180
11	365074, 169704	0.1	48

Table 1 Survey area referencing with approximate size and length

Plate 1 Survey Area 4 - looking east towards Keynsham and the Avon valley

1.4 Site description

1.4.1 The geophysical survey covers two pipeline route options that have been separated into a number of survey areas based on individual land packages including agricultural and sports fields. Areas 5, 6 and 8 have been split into smaller sections where the pipeline route changes direction, see Figure 02.

1.4.2 Table 2, below, lists individual survey areas along with their corresponding groundcover, soil type and underlying geology. Additional comments have been added where conditions are liable to impact on the quality of the data or the precise area surveyed.

Area no.	Groundcover	Soil	Geology	Comments
1	Rough pasture with spreading hedgerow along pipe centreline	Worcester association – typical argillic pelosols	Triassic Keuper Marl	Survey corridor shifted south, unsurveyable field margin due to vegetation
2	Cabbages/cauliflower	Worcester association	Triassic Keuper Marl	Area unsurveyable due to brassica crop
3	Cabbages/cauliflower	Worcester association	Triassic Keuper Marl	Area unsurveyable due to brassica crop

4	Ruined maize/sweetcorn (see Plate 1)	Worcester association – typical argillic pelosols	Triassic Keuper Marl	Land drops steeply towards the east – survey affected by standing crop and rough ground/hedge along field margin
5	Rough pasture	Worcester association – typical argillic pelosols	North western part on higher ground, Keuper Marl – River Alluvium on lower eastern part	North eastern side of corridor is variably affected by embankment associated with the A4175
6	Playing field – mown grass	Worcester association – typical argillic pelosols Fladbury 1 association – pelo-alluvial gley soils	Mainly River Alluvium	Metal fencing close to southern and eastern ends
7	Playing field – mown grass	Fladbury 1 association – pelo-alluvial gley soils	River Alluvium	Rough areas close to northern boundary – survey corridor shifted south due to mature trees and shrubs
8	Playing field	Fladbury 1 association – pelo-alluvial gley soils	River Alluvium	Rough areas close to western boundary
9	Short pasture	Fladbury 1 association – pelo-alluvial gley soils	River Alluvium	Occasional waterlogging – area separated from 10 by shallow open drain
10	Short pasture	Fladbury 1 association – pelo-alluvial gley soils	River Alluvium	Occasional waterlogging
11	Short pasture	Fladbury 1 association – pelo-alluvial gley soils	River Alluvium	Occasional waterlogging

Table 2 Description of groundcover, soils and geology for each survey area

1.5 Site history and archaeological potential

1.5.1 The proposed pipeline route runs adjacent to a large Roman complex at Durley Hill cemetery, OS grid reference 364500, 169250 and approximately 600m west of a second Roman site discovered at the Somerdale chocolate factory during its construction, OS ref. 365700, 169400. Roman structural remains have also been located in between the Somerdale site and the proposed pipeline (Browne, 1991).

1.5.2 The Durley Hill Roman complex contained evidence for a lavish suite of domestic rooms with elaborate architectural embellishments and fine mosaic flooring (Bulleid and Horne, 1926; Russell, 1994; Walters and Beeson, 1995). The site is known to have had three large wings at right angles to each other with a south western corner passing under the current A4175.

1.5.3 With important Romano-British finds located close to the proposed pipeline routes, the archaeological potential of the survey areas is high. The effects of modern disturbance from services, landscaping and build up of soil from alluviation cannot be predicted but may have significantly influenced the survival of archaeological remains.

1.6 Geology and soils

1.6.1 The underlying geology for each survey area is listed in Table 2 (BGS 2001). For magnetic survey it is of note that both soils derived from Keuper Marl and river alluvium can produce poorer results than other underlying geologies eg. Jurassic limestone.

1.6.2 The overlying soils for each survey area are listed in Table 2. Soils of the Worcester association are typical argillic pelosols (clayey) and often reddish in colour. Fladbury 1 soils are pelo-alluvial gley soils (clayey and affected by groundwater) that often form flat areas at risk of flooding (Soil Survey of England and Wales 1983).

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Detailed magnetometry records localised magnetic fields that can relate to former human activity. Alteration of iron minerals present within topsoil is related to activities such as burning and the break down of biological material. These minerals become weakly magnetic within the Earth's magnetic field and can accumulate in features such as ditches and pits that are cut into the underlying subsoil. Mapping this magnetic variation can provide evidence of former settlement and land use. Additional technical details can be found in Appendix A.

2.1.2 The electrical resistance or resistivity of the soil depends upon the moisture content and distribution within the soil. Buried features such as walls can affect the moisture distribution and are usually more moisture resistant than other features such as the infill of a ditch. A stone wall will generally give a high resistance response and the moisture retentive content of a ditch can give a low resistance response.

2.2 Equipment details and configuration

2.2.1 The detailed magnetic survey was carried out using a Bartington Grad601-2 gradiometer. This instrument effectively measures a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally. The instrument is extremely sensitive and is able to measure magnetic variation to 0.1 nanoTesla (nT). All readings are saved to an integral data logger for analysis and presentation.

2.2.2 Data was collected at 0.25m centres along traverses 1m apart. The survey area was separated into 20m by 20m grids giving 1600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 1995).

2.2.3 The proposed pipeline route was located in the field using a CSI Wireless dGPS (differential Global Positioning System) and the survey grids were set out using a Topcon GTS212 total station. The dGPS uses an error correction signal transmitted from ground-based beacons and is considered as having sub-metre accuracy. A number of parameters are constantly monitored in order to achieve best accuracy.

2.2.4 The resistivity survey was carried out using TR Systems Ltd Resistance Meter TRCIA 1.31 using a mobile Twin Probe array. Readings were taken at 1m intervals across the site giving 400 readings within a full 20m x 20m grid.

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger is analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display.

2.3.2 Only minimal processing is carried out in order to enhance the results of the survey for display. Raw data is always analysed and displayed in the report as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey. It should be noted that image processing does not change the values of the data and is used for visual enhancement; data processing will alter values through mathematical functions.

Magnetometry image processing

- Clipping of the raw data at ±10nT to improve greyscale resolution
- Clipping of processed data at either ±3nT or ±1 nT to enhance low magnitude anomalies
- Clipping of trace plots at ±100nT in order to minimise strong readings obscuring low magnitude responses
- Destagger may also be used to enhance linear anomalies

Magnetometry data processing

- Zero mean traverse is applied in order to balance readings along each traverse

2.3.3 Data logged by the resistance meter is downloaded and processed within ArcheoSurveyor software. Raw data is analysed and displayed within the report as well as processed data. The following processing has been carried out on data in this survey:

Resistivity image processing

- Raw resistivity data has been clipped between +17 and +13 ohms for Area 6a and between +24.8 and 13.1 ohms for Area 6c in order to improve greyscale resolution.
- Processed data has been clipped between + 2.5 and –1.4 ohms for Area 6a and between +2 and -2 ohms for Area 6c to enhance any possible archaeological anomalies. Negative values are a function of the mathematical operation carried out across the data during processing.

Resistivity data processing

- Data has been “despiked” in order to remove spurious high contact responses.
- Data is passed through a high pass filter in order to enhance archaeological features.

2.3.4 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. A brief summary of each anomaly with an appropriate reference number is set out in list form within the results, section 3, to allow a rapid assessment of features within each survey area. Where further interpretation is possible or where a number of possible origins should be considered, further more detailed discussion is set out in section 4.

3 RESULTS

3.1 Magnetometry

3.1.1 The detailed magnetic survey was carried out over a total of 9 survey areas covering an approximate area of 3.6ha. Geophysical anomalies located can be generally classified as positive linear and discrete positive responses of possible archaeological origin, positive and negative linear anomalies of an uncertain origin, positive areas of uncertain origin, areas of magnetic debris and disturbance and strong dipolar anomalies relating to ferrous objects and material in the topsoil. Where significant or complicated anomalies exist within a survey area, anomalies will be numbered with subsequent discussion in section 4 where appropriate.

3.1.2 The brief listing of anomalies below attempts to set out a number of separate categories that reflect the range and type of likely causative features:

Anomalies with a possible archaeological origin

(Positive anomalies abstracted are plotted in red)

The category is used where archaeological features are known to have been located in immediately adjacent areas, in this case Keynsham Roman Villa. Without this additional evidence the anomalies would fall within an uncertain category, see below.

Anomalies with an uncertain origin

(Positive anomalies abstracted are plotted in orange)

The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Within corridor surveys often the full extent and shape of an anomaly remains unknown due to the constraints of the survey area. Anomalies in this category may well be related to archaeologically significant features but equally relatively modern features, geological/ pedological anomalies and agricultural features should be considered.

Anomalies with an agricultural origin

(Anomalies abstracted are plotted in green)

Where confidence is high that anomalies have been caused by agricultural features this category is applied. The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to more modern ploughing.

Anomalies with a modern origin

(Anomalies abstracted are plotted in magenta)

The majority of magnetic anomalies fall within this category. The magnetic response is often strong and bipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables etc. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance – such disturbance can effectively obscure low magnitude anomalies if they are present. Magnetic debris often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material (occasionally magnetic debris may be associated with kilns, furnace structures or hearths and may therefore be archaeologically significant).

3.1.3 Area 1 (centred on 363879, 169502) (Figures 3-7)

Anomalies with a modern origin

- A strong dipolar linear anomaly crosses the survey area and is a response to a modern pipeline.

- Several strong discrete dipolar anomalies are responses to ferrous objects in the topsoil.

3.1.4 Area 2 – unsurveyable

3.1.5 Area 3 - unsurveyable

3.1.6 Area 4 (centred on 364312,169350) (Figures 8-12)

Anomalies with a modern origin

- An area of magnetic debris with a relatively high magnitude is located in the north-western part of the survey area and is likely to be a response to dumped thermoremnant material with a high ferrous content.

- In the centre of the survey area is an area of magnetic debris with a very low magnitude. It is probable that this is a response to thermoremnant material. Situated within this area of magnetic debris is a positive linear anomaly of uncertain origin.

3.1.7 Area 5 (centred on 364552, 169114) (Figures 13-17)

Anomalies with a possible archaeological origin

(1) – Extending approximately north-south across the centre of the survey area is a positive linear anomaly. It appears to be fragmented and it is possible that this is a response to the magnetically enhanced fill of a cut feature.

(2) – In the western part of the site is a positive linear anomaly which may relate to a cut feature and appears associated with negative linear anomaly (3).

(3) – Situated parallel to and approximately 1.5m south-east of anomaly (2) is a negative linear anomaly. It is possible that this is a response to an embankment or wall which is less enhanced than the surrounding soil.

(4) – Positive linear anomaly that may be associated with a cut feature. The feature is of low magnitude and obscured by magnetic disturbance associated with nearby fencing and debris.

(5) – Negative linear anomalies that may be associated with former structural remains.

(6) – A positive linear anomaly adjacent and parallel to anomalies (2) and (3) and may represent a cut feature.

Anomalies with an uncertain origin

(7) – Situated between anomalies (1) and (2 & 3) appear several positive area anomalies. Their form is such that they appear as broad irregular linears or discrete areas suggesting that they may be responses to cut features.

(8) – A low magnitude positive curvilinear anomaly, with an approximate diameter of 10m is situated between two positive area anomalies.

Anomalies with a modern origin

(9) – Situated along the north-eastern boundary of the survey area is a magnetic response from ferrous fencing material.

(10) – Several strong dipolar anomalies indicate the presence of ferrous objects in the topsoil.

Anomalies with an agricultural origin

(11) – A series of very low magnitude broad positive anomalies are probably a response to former ridge and furrow.

3.1.8 Area 6 (centred on 364752, 169203) (Figures18-24, abstraction Figure28)

Anomalies with an uncertain origin

(12) – In the south of the survey area two positive linear anomalies appear to converge to form an “L” shaped anomaly. It appears that the easterly extension of this anomaly extends towards a discrete positive anomaly (15).

(13 & 14) – To the north of anomaly (12) are two positive linear anomalies. It appears that anomaly (14) may be formed of several discrete positive anomalies.

(15) – Several discrete positive area anomalies can be seen in the southern part of the site. It is possible that they are associated with each other and with linear anomalies (12,13 & 14).

(16) – An area of magnetic debris is located close to anomalies (12-15) and it is possible that they are all associated. Although magnetic debris can indicate a spread of thermoremnant material, the magnitude of this anomaly is relatively high (30 to 50nT) which may suggest a ferrous content.

(17) – Towards the centre of the site is a discrete area of magnetic debris. The magnitude of this area is high (100 to 1000nT) indicating ferrous material is present.

(18) – In the north is another area of magnetic debris again with a relatively high magnitude (60 to 100nT). It is interesting to note that this anomaly corresponds directly to an area of high resistance located within the resistivity survey (see results below).

Anomalies with a modern origin

(19) – A series of parallel weakly dipolar linear anomalies can be seen across the majority of area 6. They are oriented approximately north-east to south-west and indicate the presence of possible ceramic land drains across the site.

(20) – Towards the southern part of the survey area is a strong dipolar linear anomaly and associated widespread magnetic disturbance. This is a response to a modern service or pipeline in this area.

(21) – In the south of the site is an area of magnetic disturbance from adjacent fencing.

(22) – Along the eastern edge of the survey area ferrous material (mainly fencing) has caused magnetic disturbance.

(23) – Several strong dipolar anomalies indicate the presence of ferrous objects in the topsoil.

3.1.9 Area 7 (centred on 364716, 169423) (Figures 30-33)

Anomalies with a modern origin

- Several strong discrete dipolar anomalies are responses to ferrous objects in the topsoil.

3.1.10 Area 8 (centred on 364824, 169279) (Figures 18, 26-28)

Anomalies with an uncertain origin

(24) – In the south of the survey area is a positive linear anomaly. It appears to extend beyond the limits of the survey area towards the north-east and may be a response to the fill of a cut feature.

(25) – Several discrete positive area anomalies can be seen in the centre and southern part of the site. At least two appear as broadly irregular linear anomalies while others are more discrete.

Anomalies with a modern origin

(26) – Along the north-western edge of the survey area is an area of magnetic debris. The magnitude of the anomaly is generally relatively low although there may be an indication of some ferrous material within the spread. It is possible that this material has been dumped in the vicinity.

(27) – Several strong dipolar anomalies indicate the presence of ferrous objects in the topsoil.

3.1.11 Area 9 (centred on 365034, 169705) (Figures 34-38)

Anomalies with a modern origin

- Several strong discrete dipolar anomalies are responses to ferrous objects in the topsoil.

3.1.12 Area 10 (centred on 364973, 169593) (Figures 34-38)

Anomalies with an uncertain origin

(28) – Two low magnitude positive linear anomalies appear to join to form an "L" shaped anomaly. It is possible that this anomaly is a response to a cut feature such as ditch and may indicate the location for a former land boundary.

(29) – It is possible to interpret this anomaly as a possible linear feature extending south from (28) and ending in a discrete positive area anomaly and another linear anomaly parallel to (28).

(30) – In the south of the site is a positive area anomaly which may be the response to the fill of a cut pit like feature although its origin is uncertain.

(31) – A pair of low magnitude positive linear anomalies flank a negative linear anomaly. These linear anomalies are parallel to the east-west extension of anomaly (28) and although it is difficult to be certain if they are associated, it is possible.

(32) – A positive linear anomaly and a parallel negative linear anomaly are located approximately 10m to the south of (31). They are oriented approximately north-east to south-west and it is not clear if they are associated with anomaly (31).

(33) – A negative linear anomaly can be seen extending from the north-eastern corner of the survey area towards an area of magnetic disturbance (31). It is difficult to be certain of the origin of this anomaly as although it is a response to material less enhanced than the topsoil, it is possible that this may relate to a modern service and may be associated with anomaly (34).

Anomalies with a modern origin

(34) – A strong dipolar linear anomaly and associated magnetic disturbance are a response to a modern service or pipeline.

(35) – Several strong dipolar anomalies indicate the presence of ferrous objects in the topsoil.

3.1.13 Area 11 (centred on 365074,169704) (Figures 34-38)

Anomalies with a modern origin

- An area of magnetic disturbance is a response to the existing water pipeline in this area.

- Several strong discrete dipolar anomalies are responses to ferrous objects in the topsoil.

3.2 Resistivity Area 6 (Figures 39-41)

3.2.1 A total of four 20 by 20m grids were surveyed using resistivity within Area 6. Three were situated in the south of the site within Area 6a and one in Area 6c.

3.2.2 Within Area 6a in the south of the site, four broad linear low resistance anomalies can be seen. These anomalies are of a relatively lower resistance than the rest of the site (between 0.5 and 1ohms lower) and are approximately 5m wide. Their form is similar to responses to the in-filled furrows associated with ridge and furrow agricultural systems however, it is possible that they may have been caused by former earth moving or landscaping in the area.

3.2.3 Area 6c contains a relatively high resistance area, which although may be interpreted as a response to structural remains, this type of anomaly may also be a response to dumped material.

3.2.4 Two high resistance linear anomalies relate to land drains likely to be of a relatively modern origin. One high resistance anomaly appears to extend southwards from the high resistance area anomaly, however it is difficult to accurately determine its origin or if it is associated with the area anomaly.

4 DISCUSSION

4.1 Magnetometry

4.1.1 Area 5 contains several positive linear anomalies that may associated with the magnetically enhanced fill of cut features such as ditches. It is possible that a negative linear anomaly is a response to less magnetically enhanced material used in construction of a land boundary or wall. There are also several fragmented positive linear anomalies and discrete area anomalies that may also relate to cut features, however due to the small scale of the survey it is difficult to accurately interpret the origin of these features. Romano-British remains have been recorded within this area that probably link to the Keynsham villa site to the north (Bulleid and Horne, 1926; Russell, 1994) and it would seem likely that the magnetic anomalies located are associated with these remains.

4.1.2 In the southern part of Area 6 several positive linear and discrete anomalies may relate to cut features. Although it appears as if two linears join to form an “L” shaped anomaly, due to the limited area of the survey, their form and any possible relationship to other anomalies cannot be determined, however an archaeological origin could be considered.

4.1.3 Towards the northern part of Area 6 (6c) an area of magnetic debris corresponds directly to a high resistance area anomaly located in the resistance survey. Although it is possible that this is a response to material spread from a demolished structure it is also possible that this material has been dumped in the area. Several other spreads of magnetic debris can be seen in Area 6 with a relatively high magnitude which may suggest a ferrous content to the material.

4.1.4 Area 8 contains a positive linear and several discrete positive area anomalies. Although they may relate to cut features such as ditches and pits this is not possible to determine within the constraints of the survey.

4.1.5 Area 10 contains several low magnitude positive linear and discrete responses It is possible that these relate to cut features such as ditches and former land boundaries, however the site contains several linear depressions which relate to drainage channels. It is therefore not possible to determine if the anomalies are archaeological in origin or have been created in modern times.

4.2 Resistivity

4.2.1 The resistance survey was carried out as a trial within Area 6, only four 20m by 20m grids were surveyed due to problems from electrical ground currents possibly associated with nearby services. Although anomalies have been located with this technique it is not possible to determine if they relate to archaeological features. Broadly linear low resistance responses in the south of the site have a similar form to furrows associated with a ridge and furrow system, however these do not appear to extend northwards and may be associated with landscaping.

4.2.2 A high resistance area anomaly is a response to material such as building remains, however it is not possible to determine whether the material was derived in situ or has been dumped here in the past.

5 CONCLUSION

5.1.1 A trial survey using magnetometry and resistivity was carried out within Area 6. Both techniques located a number of geophysical anomalies, however magnetometry was selected for continued survey along the remainder of the pipeline corridor. Prior to the commencement of the survey, analysis of the underlying geology revealed less than optimum conditions for magnetometry. With a number of magnetic anomalies located during the trial, it was considered that the characteristics of the soils and underlying geology were in fact more conducive to magnetometry than initially feared and although anomalies were located by resistance survey, the greater efficiency of magnetometry was a clear advantage; progress using resistivity was hindered by the need to filter stray earth currents that are often associated with nearby services.

5.1.2 Several positive linear and discrete anomalies were located in Area 5, situated to the south of the cemetery and A4175, which may relate to features such as ditches, walls and pits which may be archaeological in origin. Excavation carried out during the 1920s (Bulleid and Horne, 1926) and further work carried out in the 1990s (Russell, 1994), gives good evidence for Romano-British structural remains within this area probably linked to the main Keynsham villa site located in the cemetery to the north.

5.1.3 It is possible that cut features have also been located in Areas 6, 8 and 10, however the limited extent of the survey area does not allow for accurate characterisation of these features.

6 REFERENCES

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field on cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with the surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength of magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

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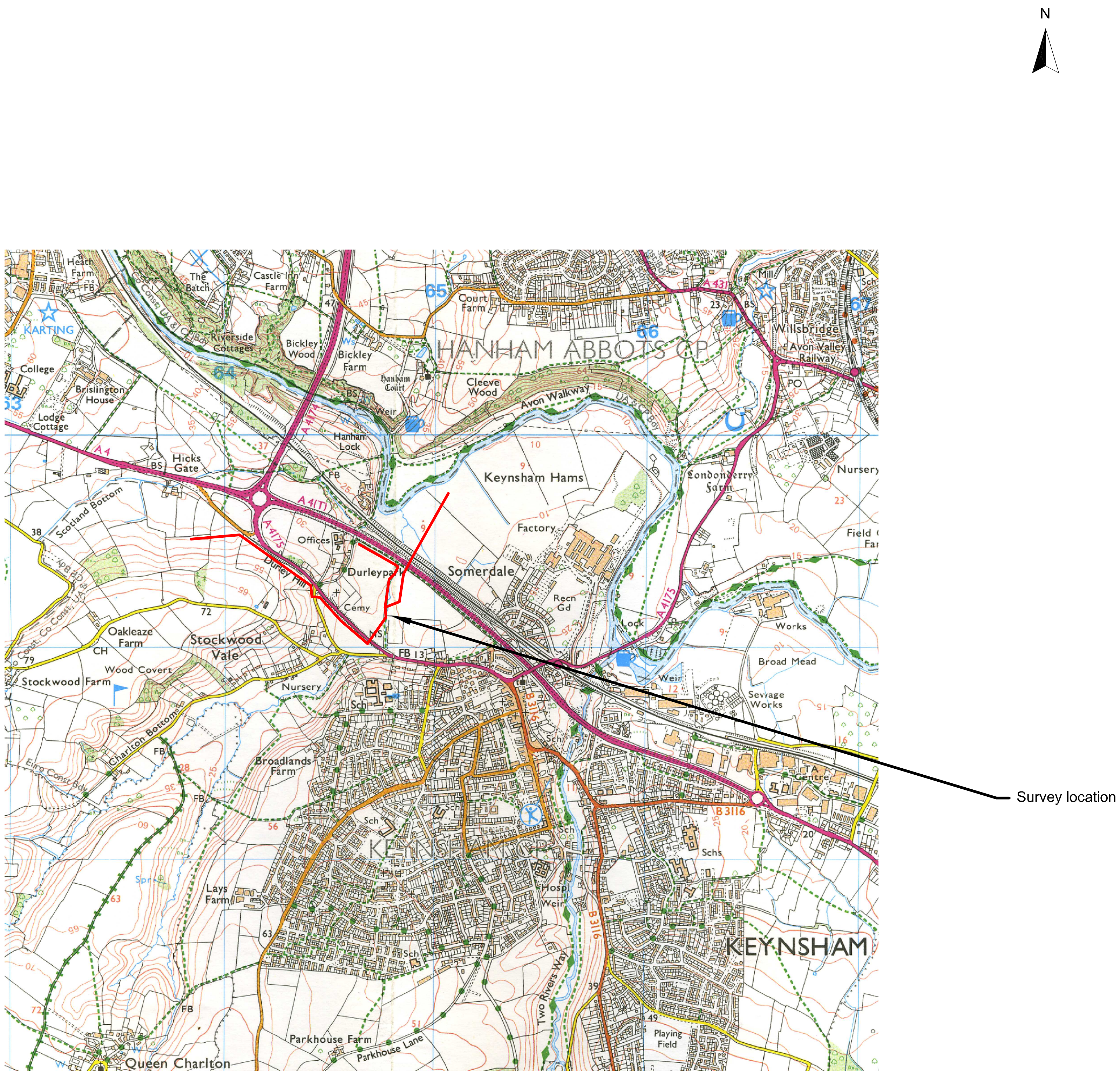


Map of survey area

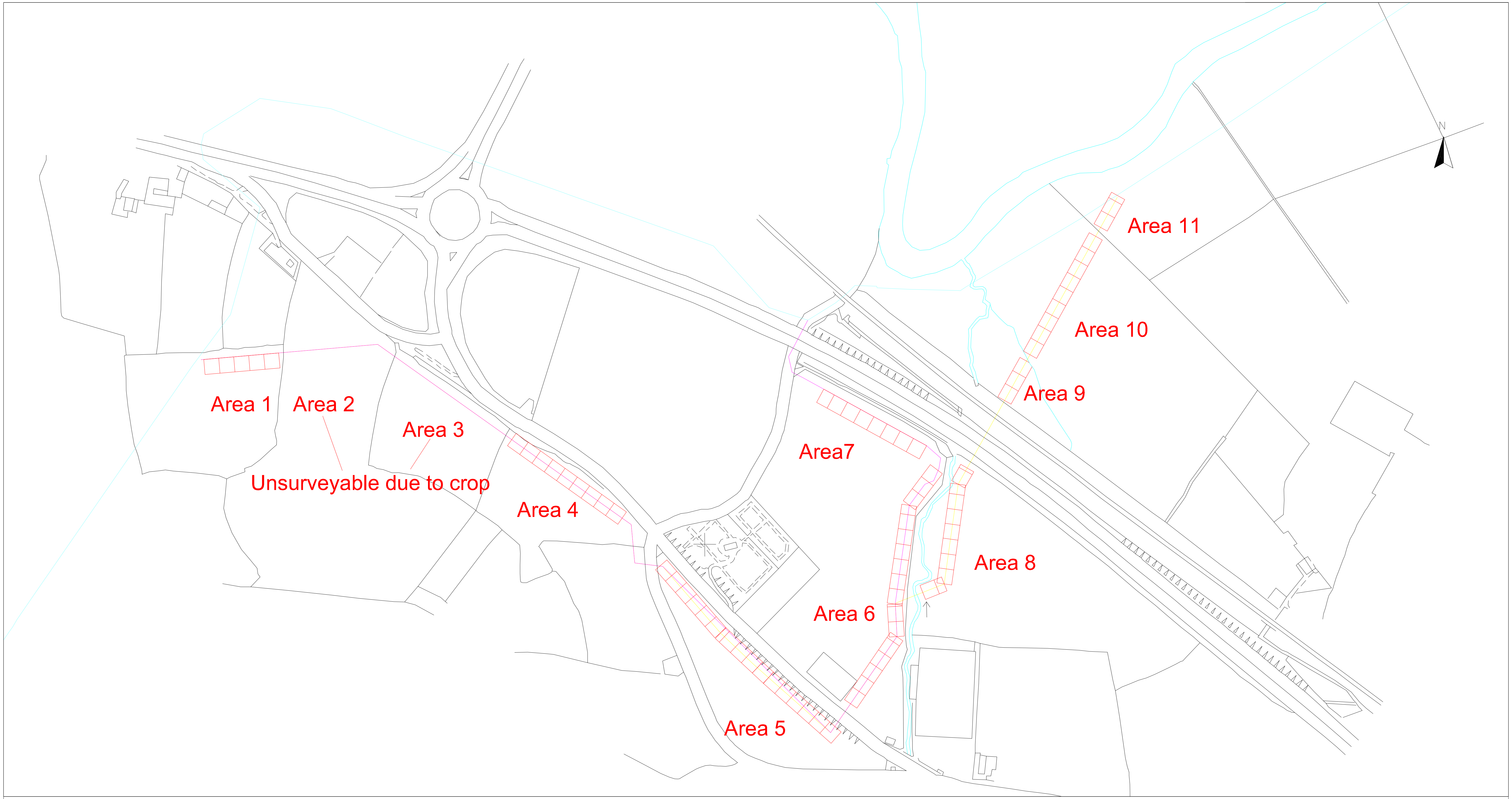
● Survey location

Site centred on OS NGR
ST 646 690

SCALE 1:25 000

0km 500m 1km

FIG 01



Location of survey grids

SCALE 1:5000

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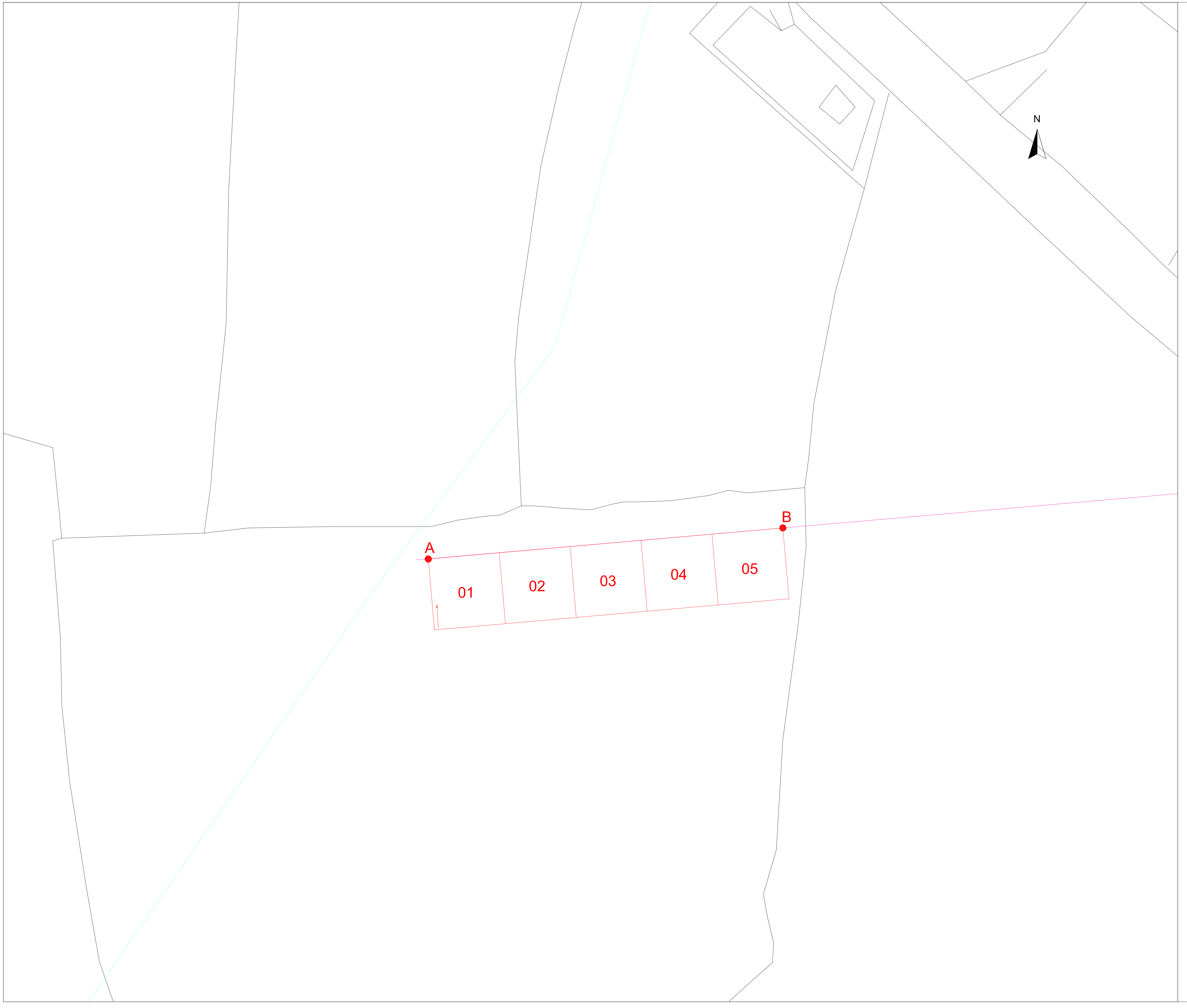
FIG 02



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Referencing information

Based on OS grid coordinates (OSGB36)

A 363831.26, 169508.83

B 363930.88, 169517.56

A - B Baseline

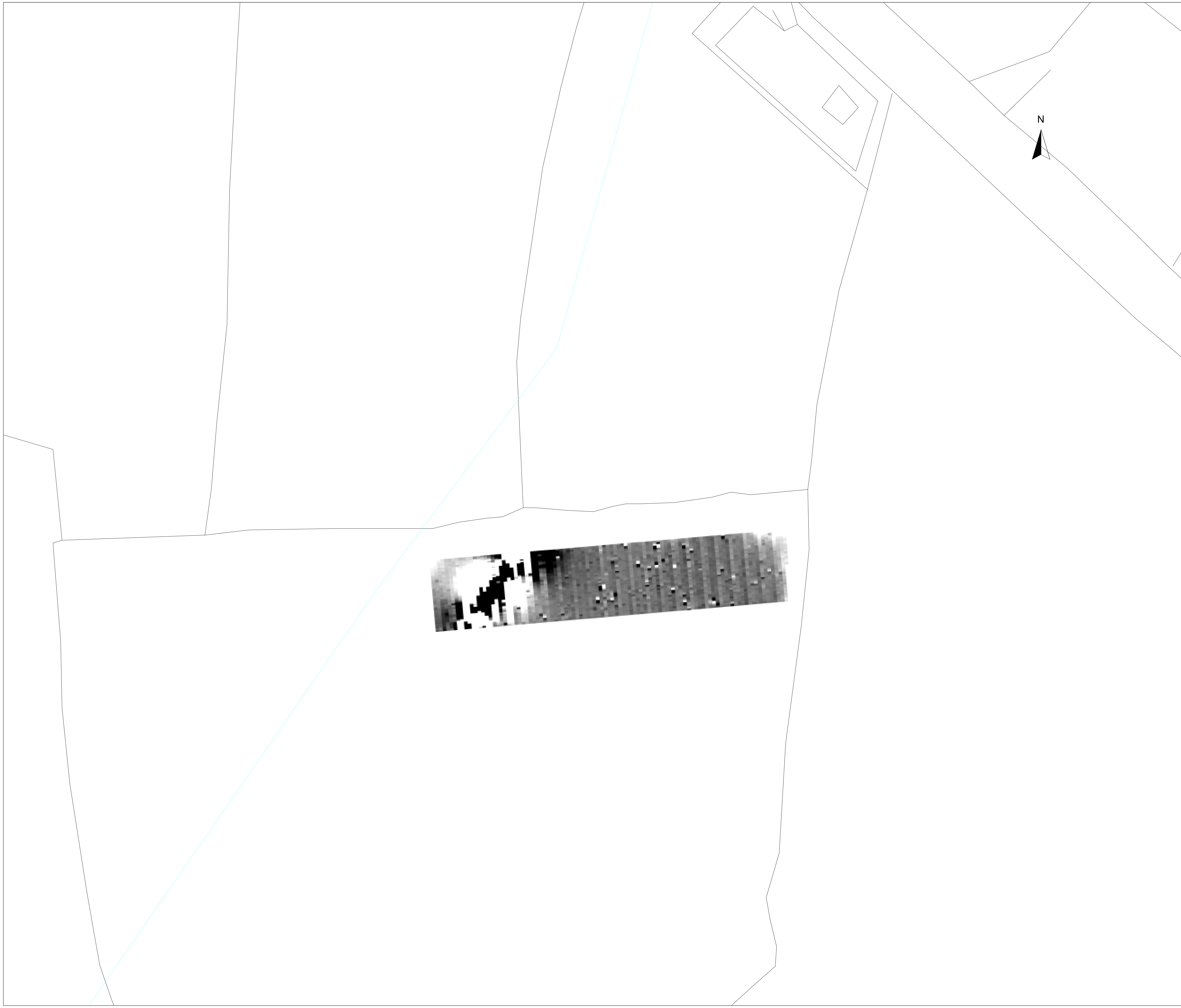
Proposed pipeline route

Survey start and traverse direction

SCALE 1:1000

0m 10 20 30 40 50m

FIG 03



Archaeological Surveys

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Bristol Northern Relief Main
Keynsham

Greyscale plot of raw magnetometer data - Area 1

+10nT

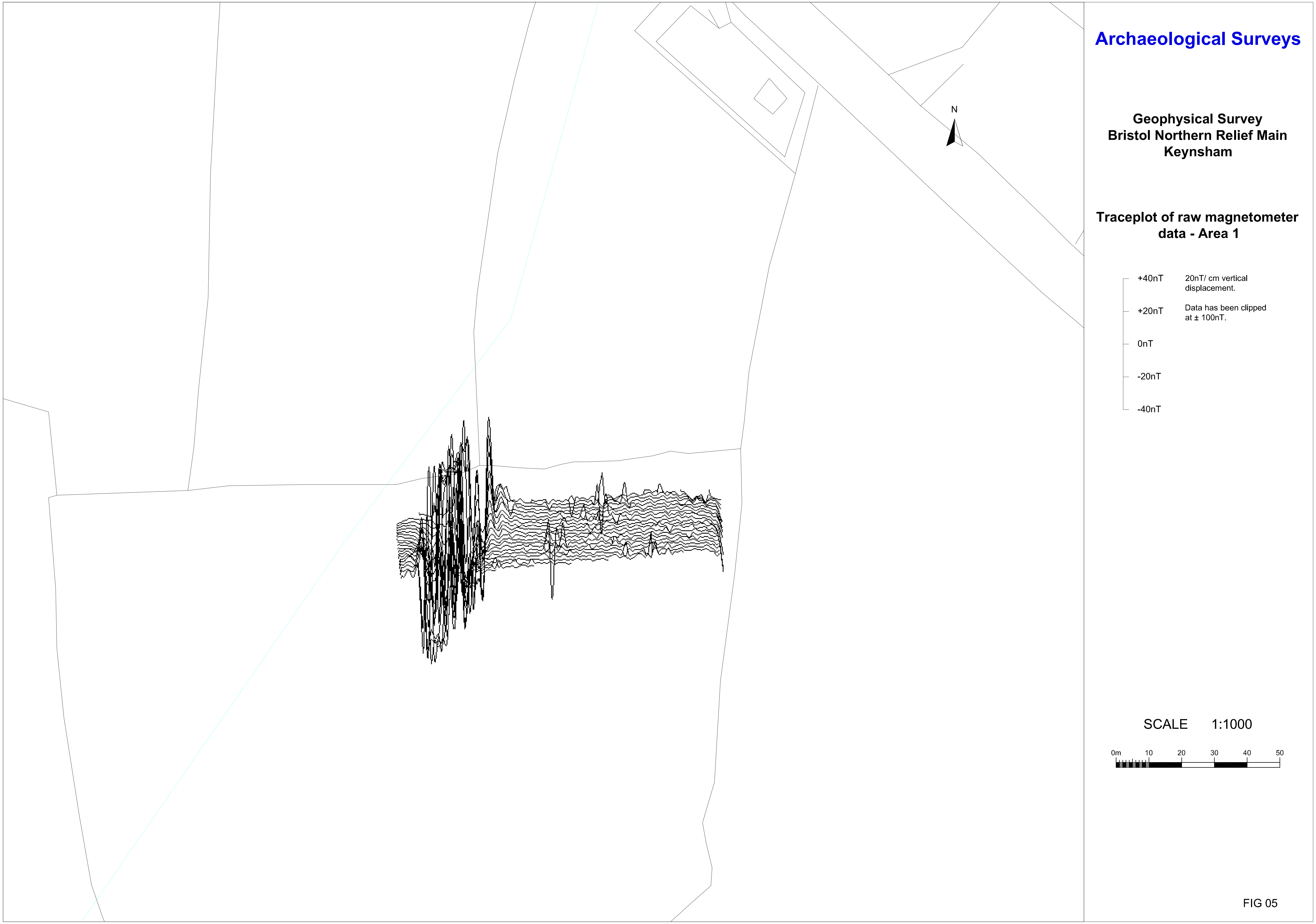
-10nT

-3SD +3SD

SCALE 1:1000

0m 10 20 30 40 50

FIG 04



Archaeological Surveys

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Bristol Northern Relief Main
Keynsham

Traceplot of raw magnetometer data - Area 1

FIG 05

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Bristol Northern Relief Main
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Greyscale plot of processed magnetometer data - Area 1

SCALE 1:1000

FIG 06

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Keynsham

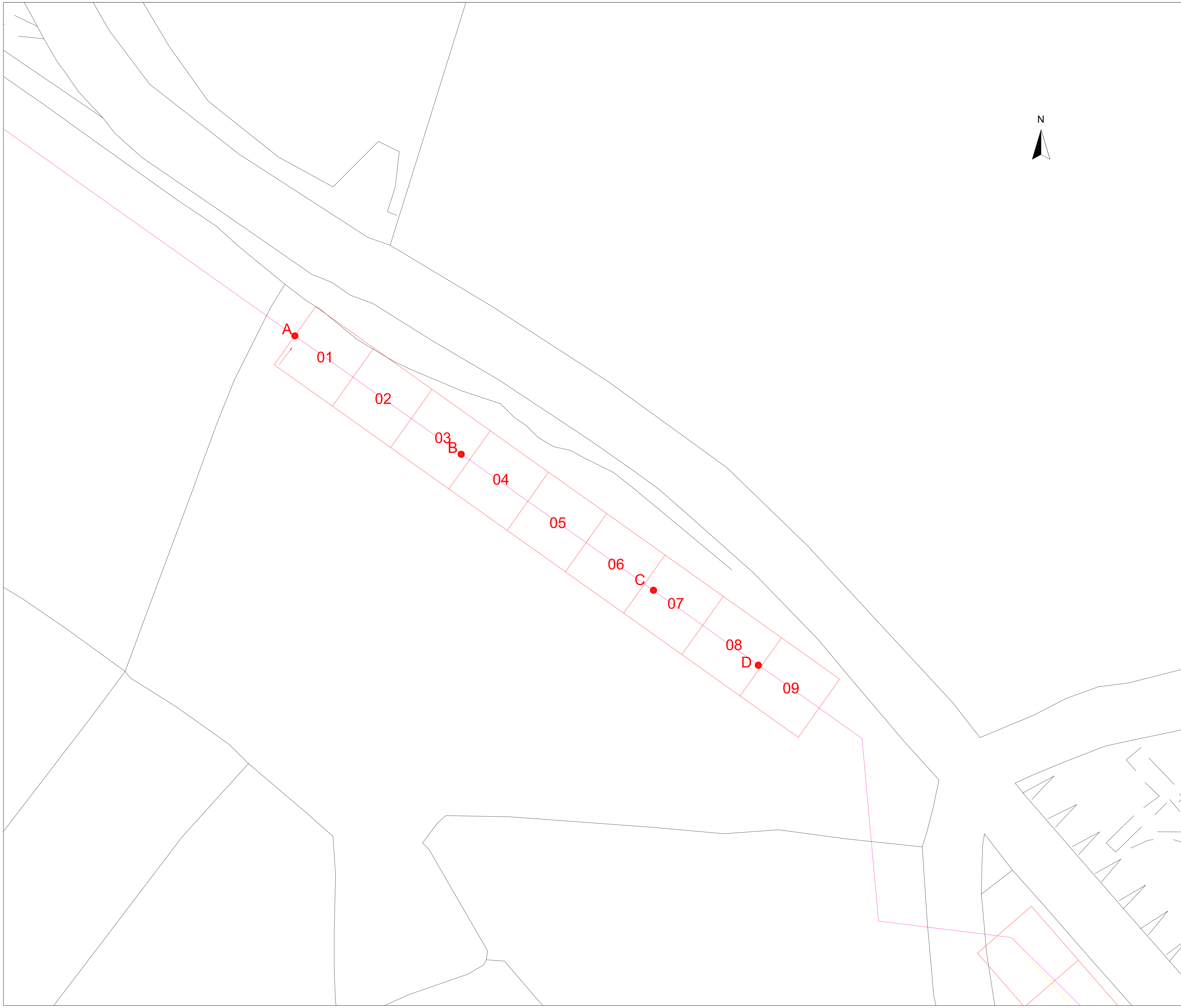
Abstraction and interpretation of magnetometer anomalies - Area 1

Strong dipolar linear anomaly - pipeline / service

Strong dipolar anomaly - ferrous object in topsoil

SCALE 1:1000

FIG 07



Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
Keynsham

Referencing information - Area 4

Based on OS grid coordinates (OSGB36)

A 364240.61, 169402.42

B 364287.17, 169369.25

C 364341.00, 169331.17

D 364370.35, 169310.17

A - D Baseline (grids start at point A)

B Inter-sight point due to curving surface

C Inter-sight point due to curving surface

D End of baseline

Proposed pipeline route

Survey start and traverse direction

SCALE 1:1000

0m 10 20 30 40 50m

FIG 08

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Greyscale plot of raw magnetometer data - Area 4

SCALE 1:1000

FIG 09

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Traceplot of raw magnetometer data - Area 4

+40nT
+20nT
0nT
-20nT
-40nT

20nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

0m 10 20 30 40 50m

FIG 10

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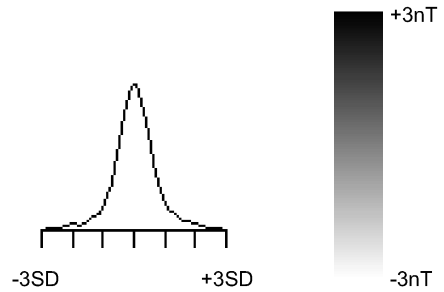
Greyscale plot of processed magnetometer data - Area 4



SCALE 1:1000

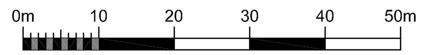
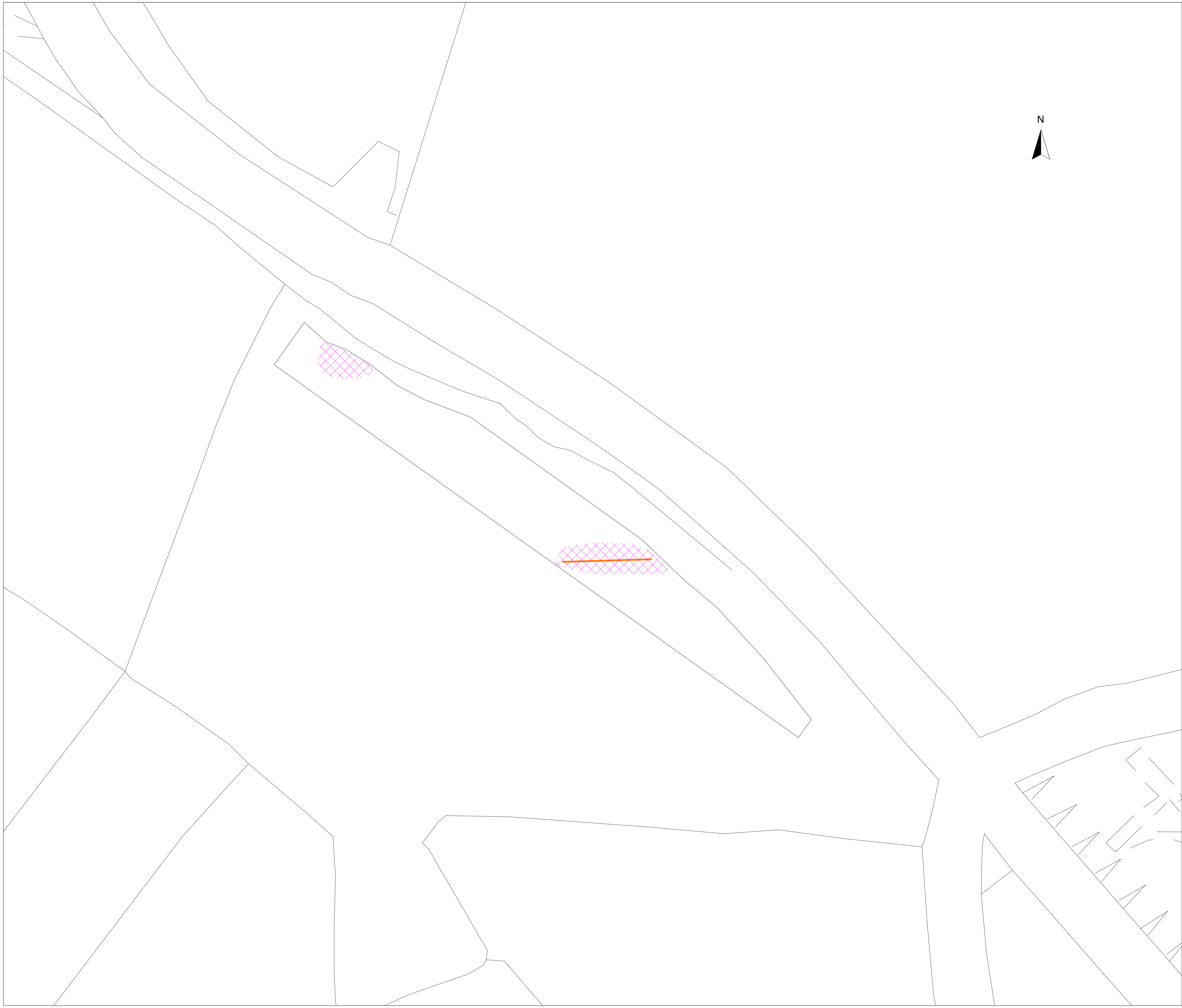


FIG 11



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Bristol Northern Relief Main
Keynsham

Abstraction and interpretation of magnetometer anomalies - Area 4

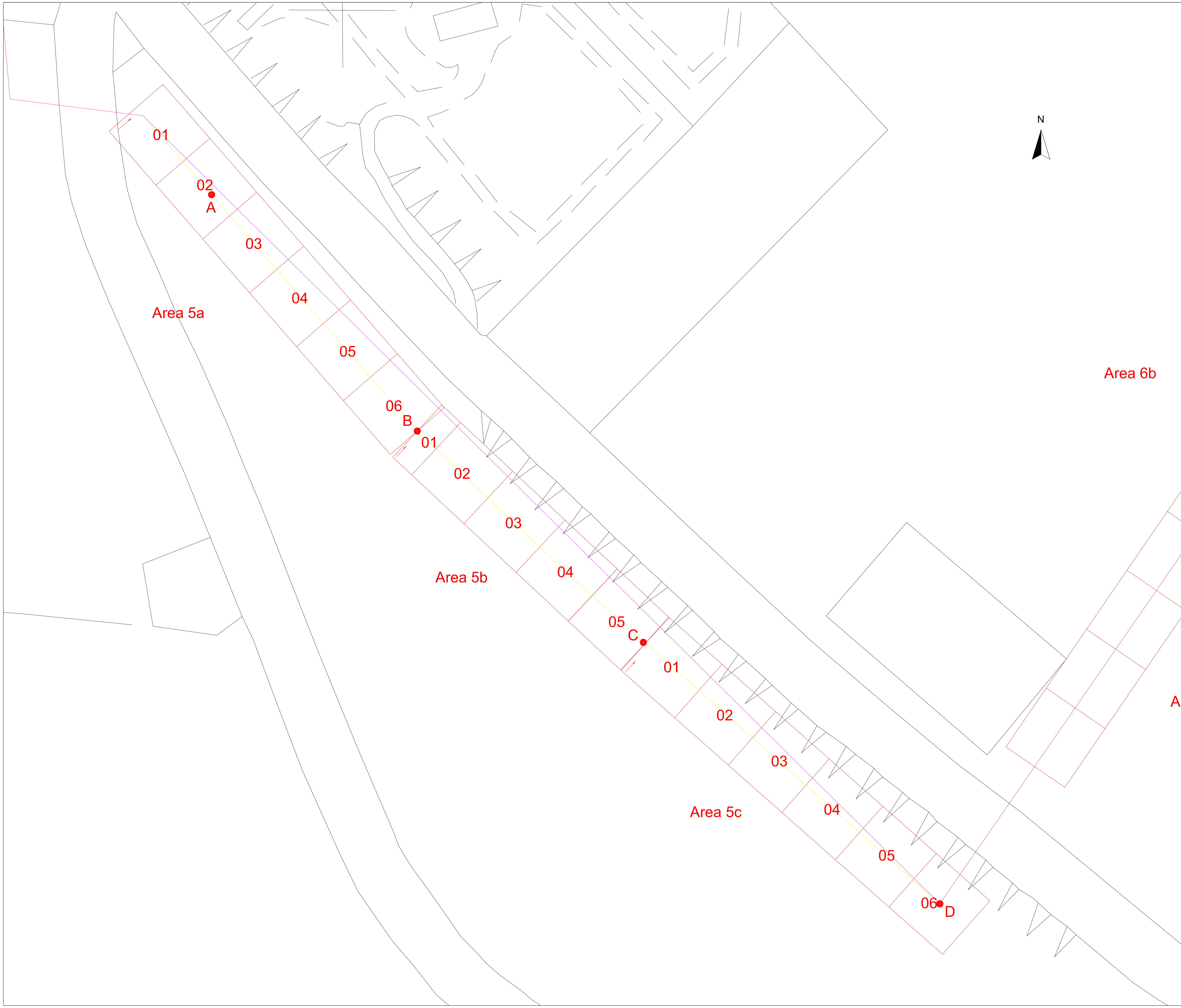
Magnetic debris - spread of thermoremnant material

Positive linear anomaly - of uncertain origin

SCALE 1:1000

0m 10 20 30 40 50m

FIG 12



Archaeological Surveys

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Keynsham

Referencing information - Area 5

Based on OS grid co-ordinates (OSGB36)

A	364460.40, 169211.76
B	364517.95, 169145.50
C	364581.26, 169086.37
D	364664.24, 169013.14
A - B	Baseline
B - C	Baseline
C - D	Baseline
A	Centreline point
B	End point for Area 5a
C	Centreline point
D	Centreline point (10m from grid end)
	Proposed pipeline routes
	Survey start and traverse direction

SCALE 1:1000

0m 10 20 30 40 50m

FIG 13

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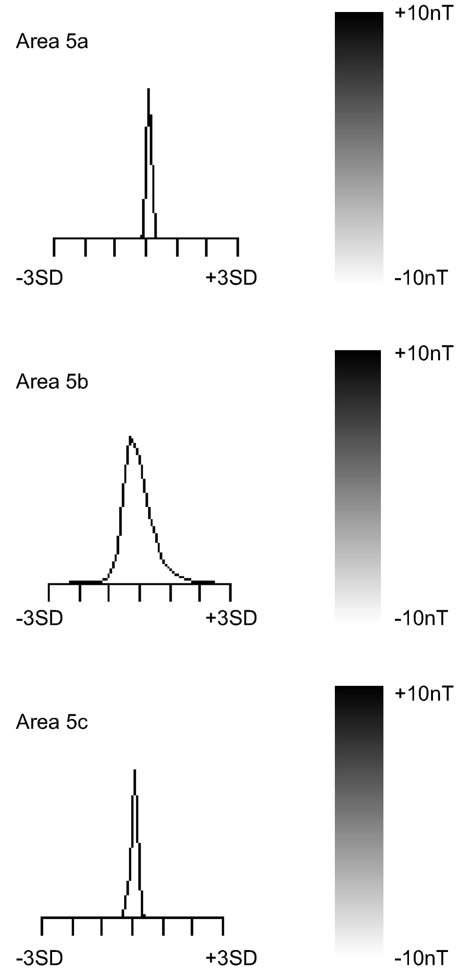
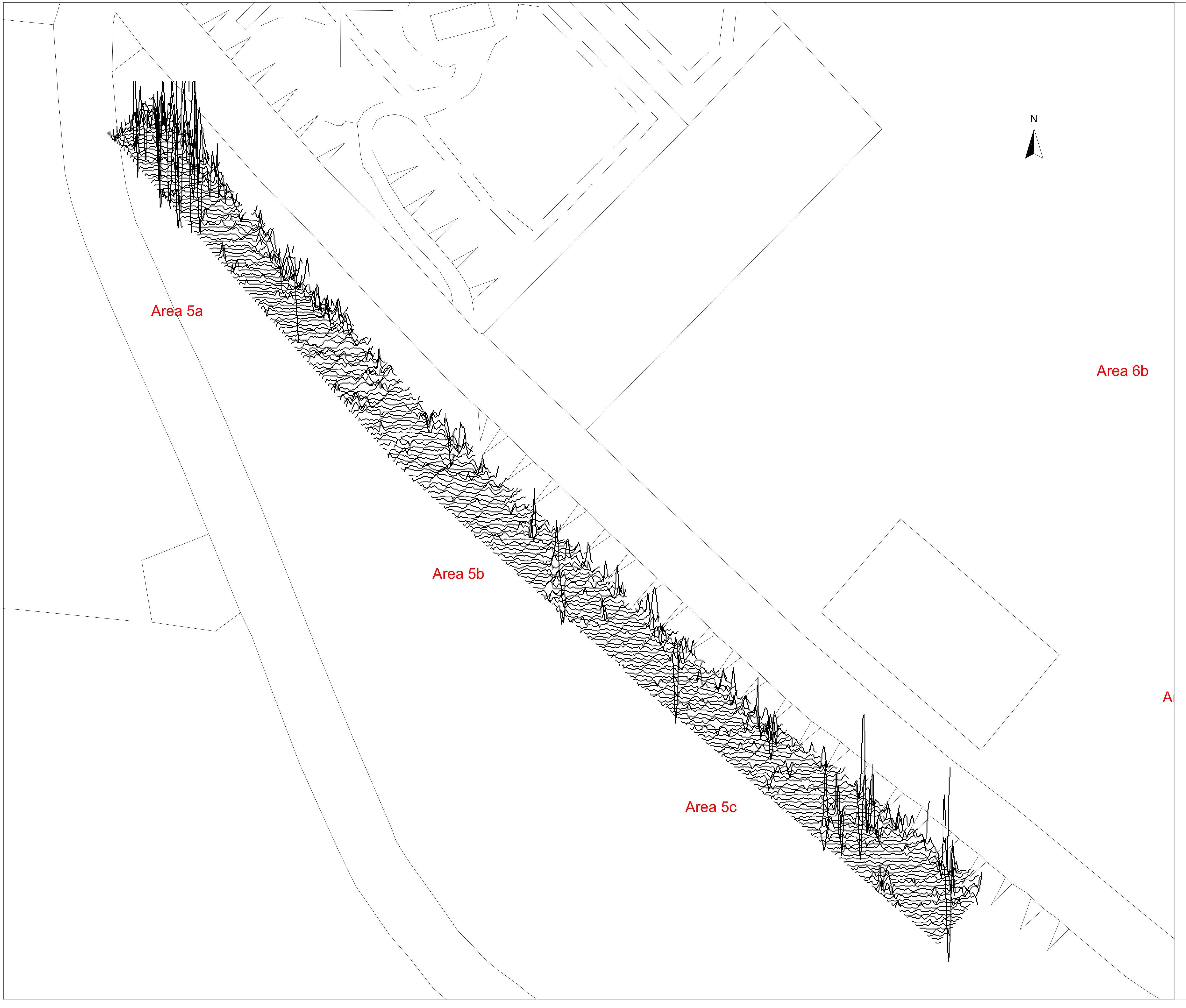
Greyscale plot of raw magnetometer data - Area 5



SCALE 1:1000

0m 10 20 30 40 50m

FIG 14



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Traceplot of raw magnetometer data - Area 5

+40nT
+20nT
0nT
-20nT
-40nT

20nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

0m 10 20 30 40 50m

FIG 15

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Greyscale plot of processed magnetometer data - Area 5

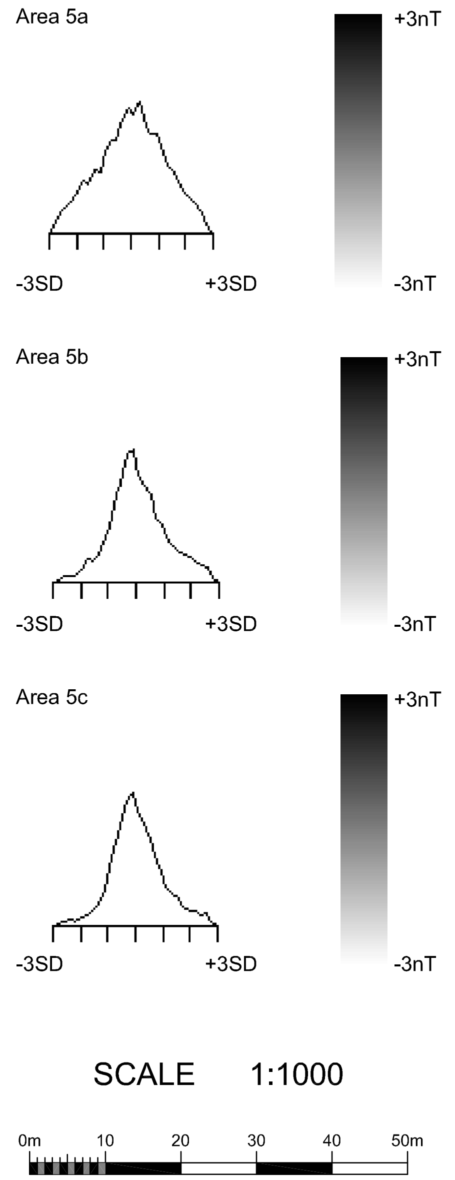
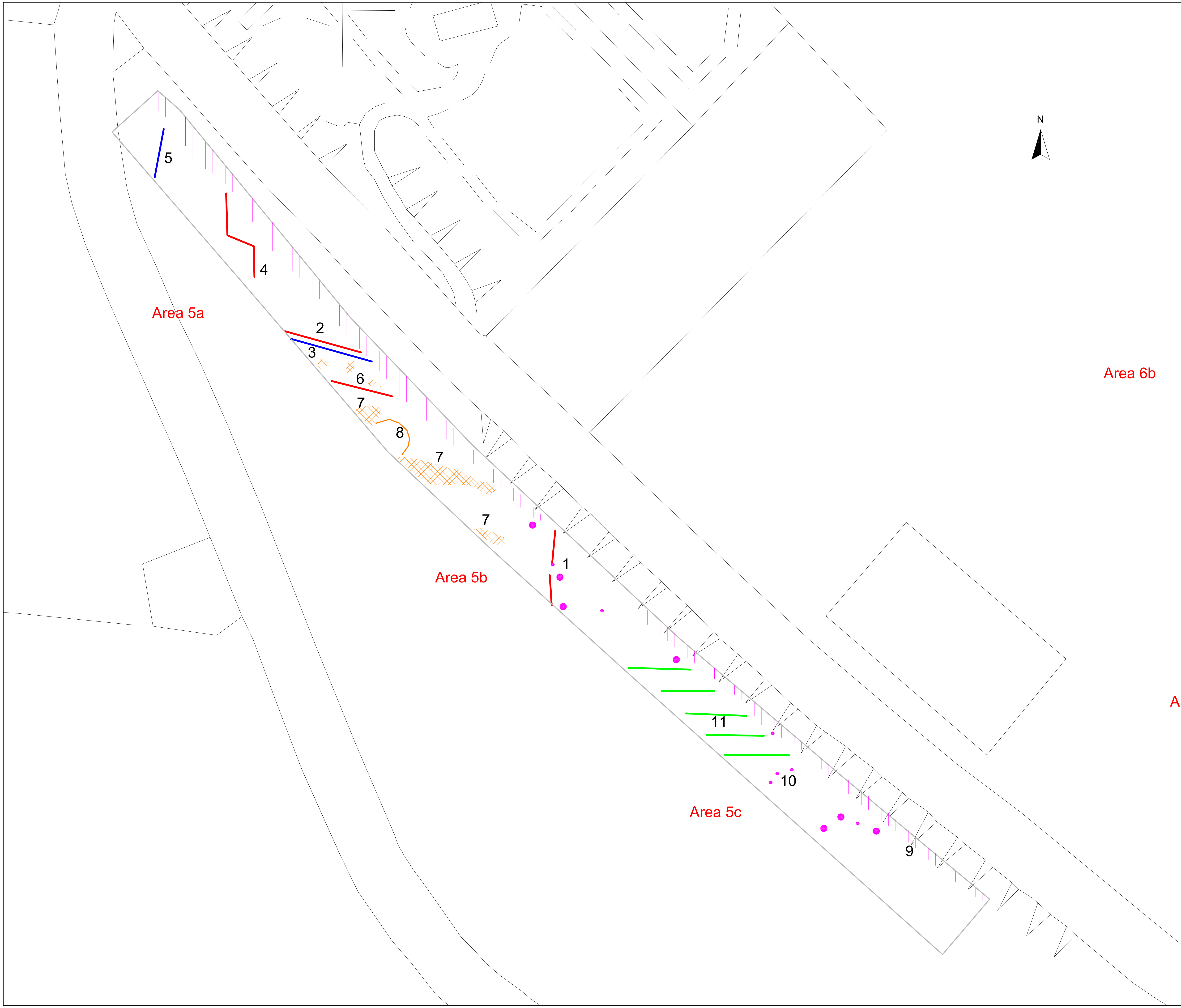


FIG 16



Archaeological Surveys

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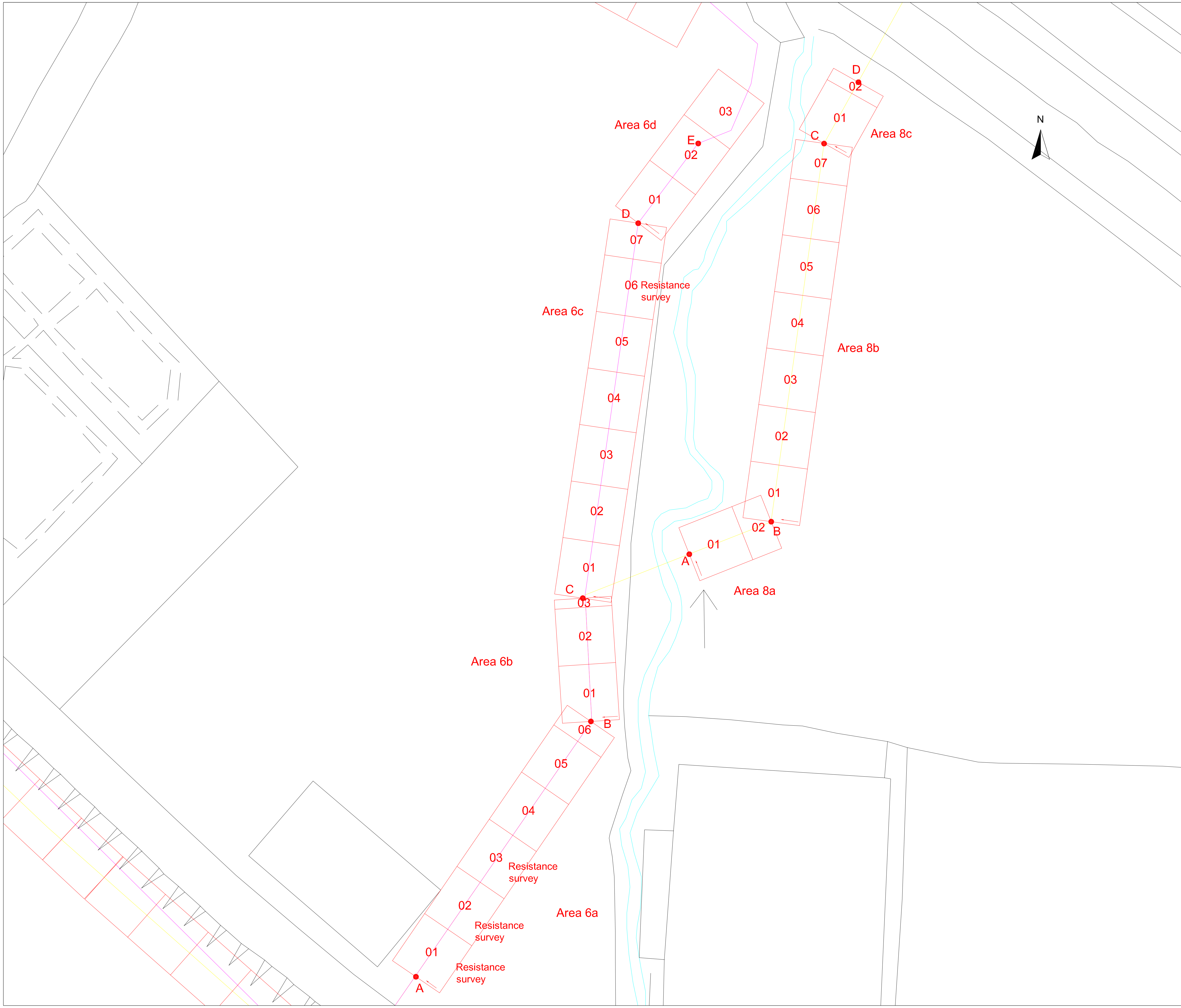
Abstraction and interpretation of magnetometer anomalies - Area 5

- Positive linear anomaly - cut feature of possible archaeological origin
- Positive linear anomaly - ?cut feature of uncertain origin
- Negative linear anomaly - ?possible structural remains
- Positive linear anomaly - possible former ridge and furrow
- Positive area anomaly - of uncertain origin
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object in topsoil

SCALE 1:1000

0m 10 20 30 40 50m

FIG 17



Archaeological Surveys

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Referencing information - Areas 6 & 8

Based on OS grid coordinates (OSGB36)

6A	364691.00, 169051.41
6B	364752.24, 169140.79
6C	364749.40, 169183.94
6D	364768.80, 169315.23
6E	364789.80, 169343.12
8A	364786.68, 169199.33
8B	364875.36, 169210.72
8C	364833.92, 169343.09
8D	364845.88, 169364.56

A - B Baseline
B - C Baseline
C - D Baseline
D - E Baseline

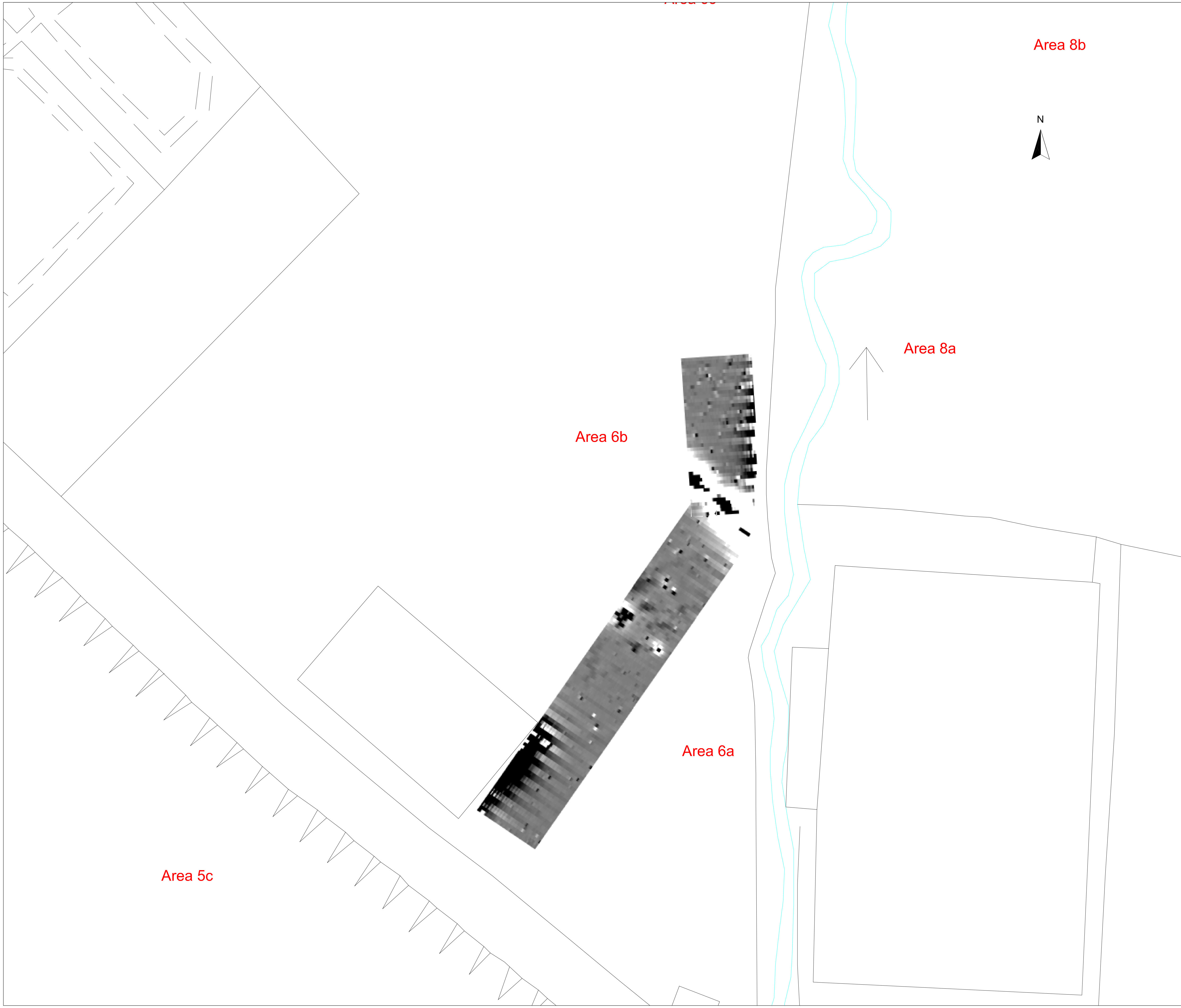
Proposed pipeline routes

Survey start and traverse direction

SCALE 1:1250

0m 10 20 30 40 50m

FIG 18



Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
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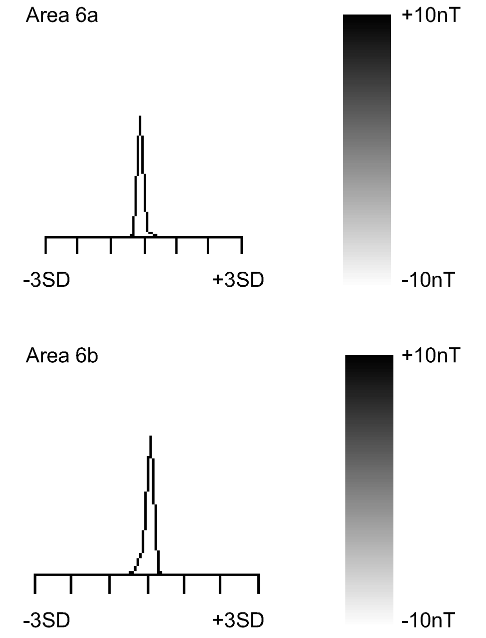
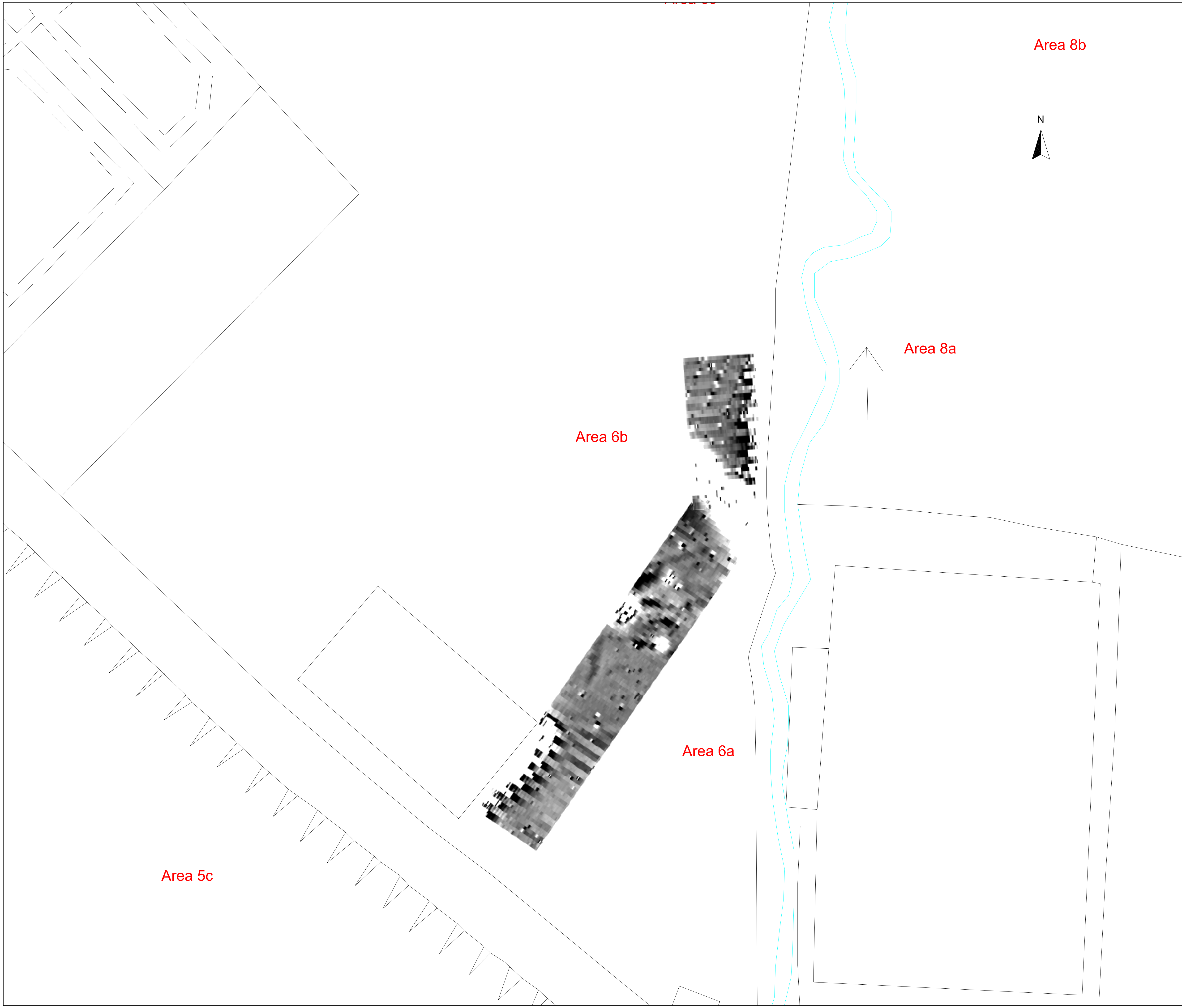
Greyscale plot of raw magnetometer data - Area 6a & 6b



SCALE 1:1000

0m 10 20 30 40 50m

FIG 19



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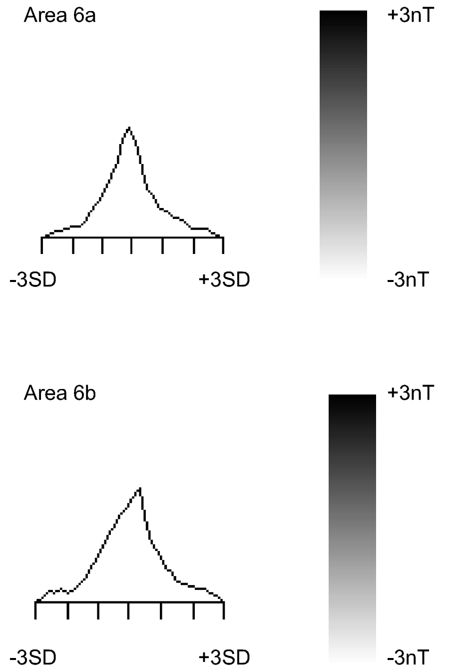
Greyscale plot of processed magnetometer data - Area 6a & 6b



SCALE 1:1000

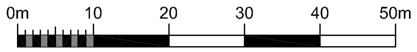
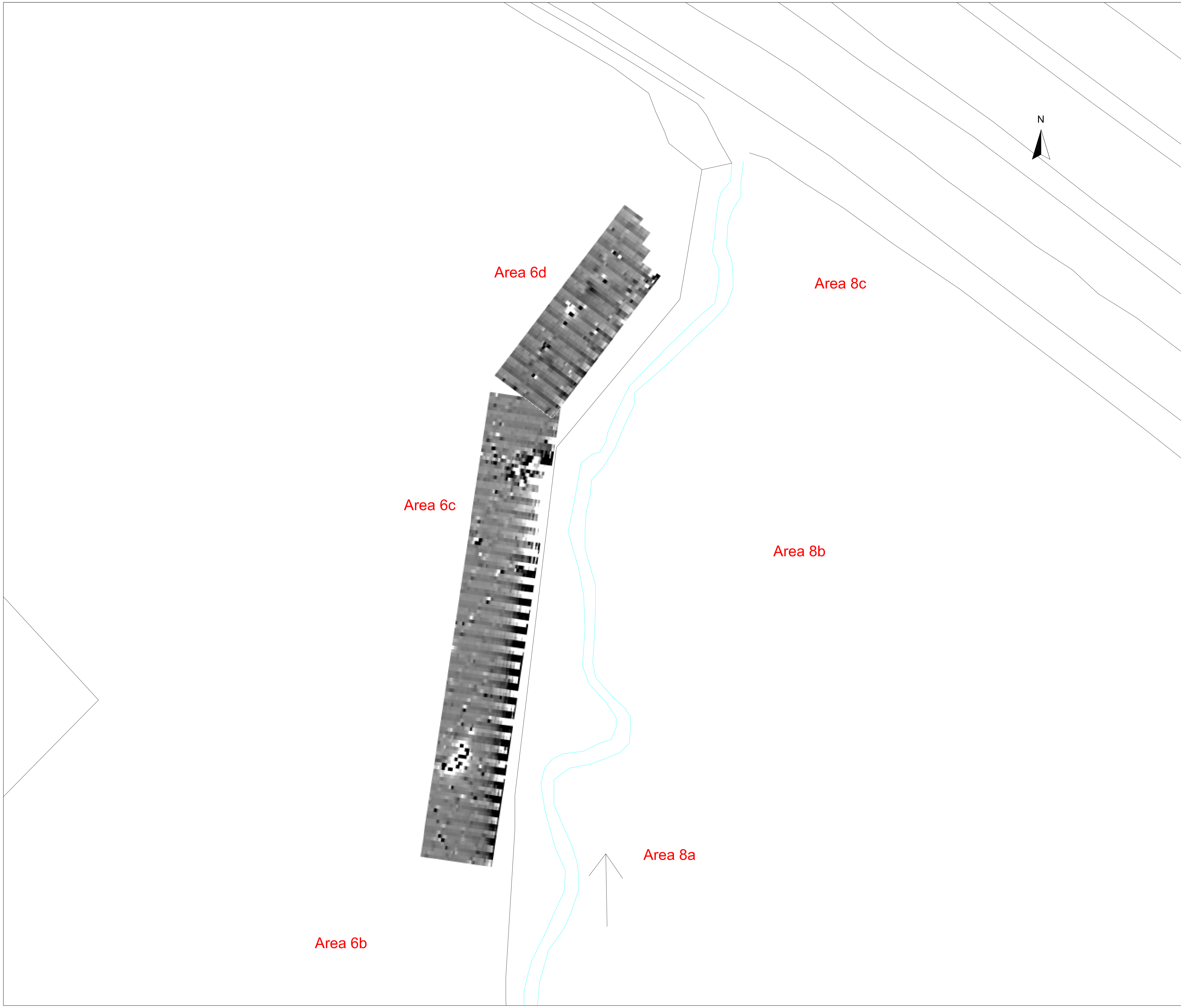


FIG 21



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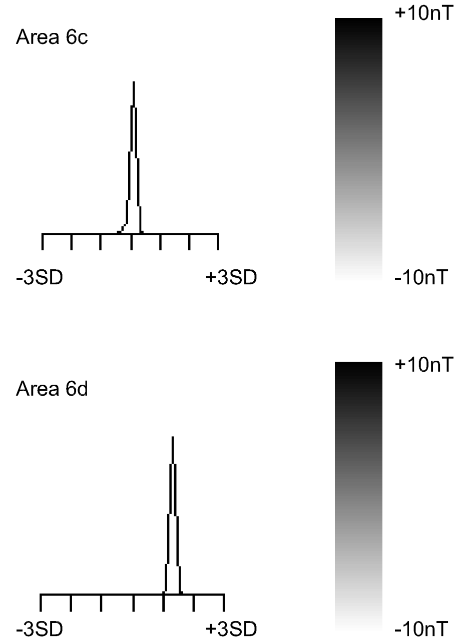
Greyscale plot of raw magnetometer data - Areas 6c & 6d



SCALE 1:1000

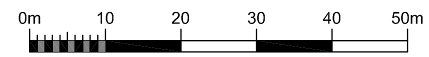
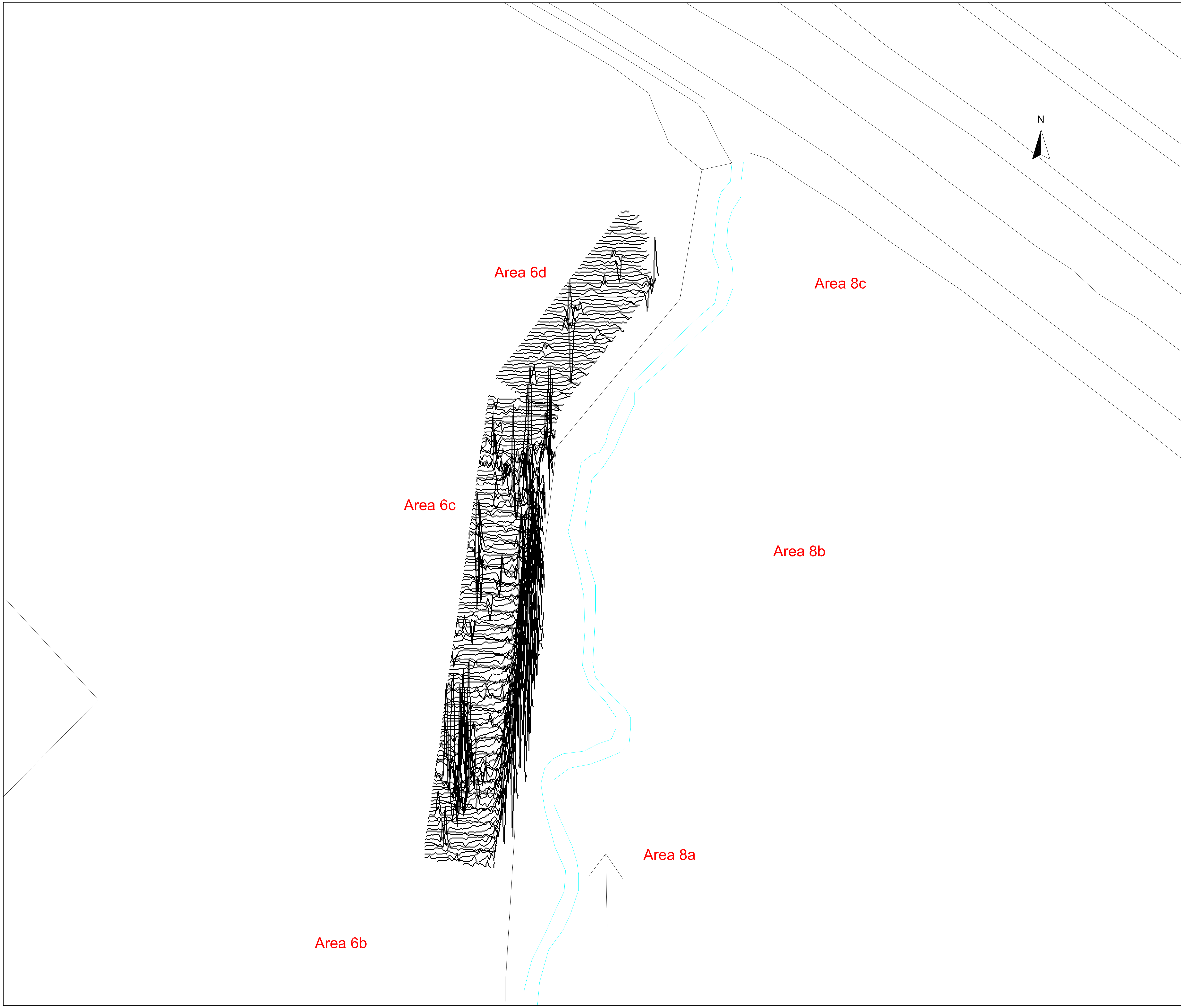


FIG 22



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Traceplot of raw magnetometer data - Area 6c & 6d

SCALE 1:1000

FIG 23

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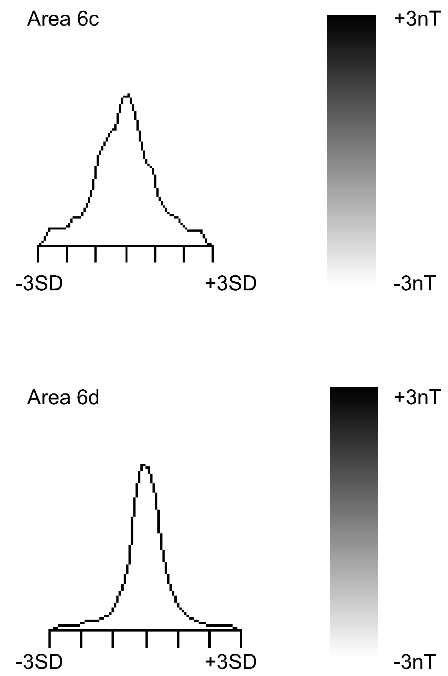
Greyscale plot of processed magnetometer data - Area 6c & 6d



SCALE 1:1000

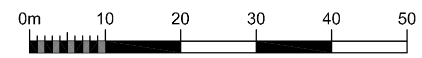


FIG 24

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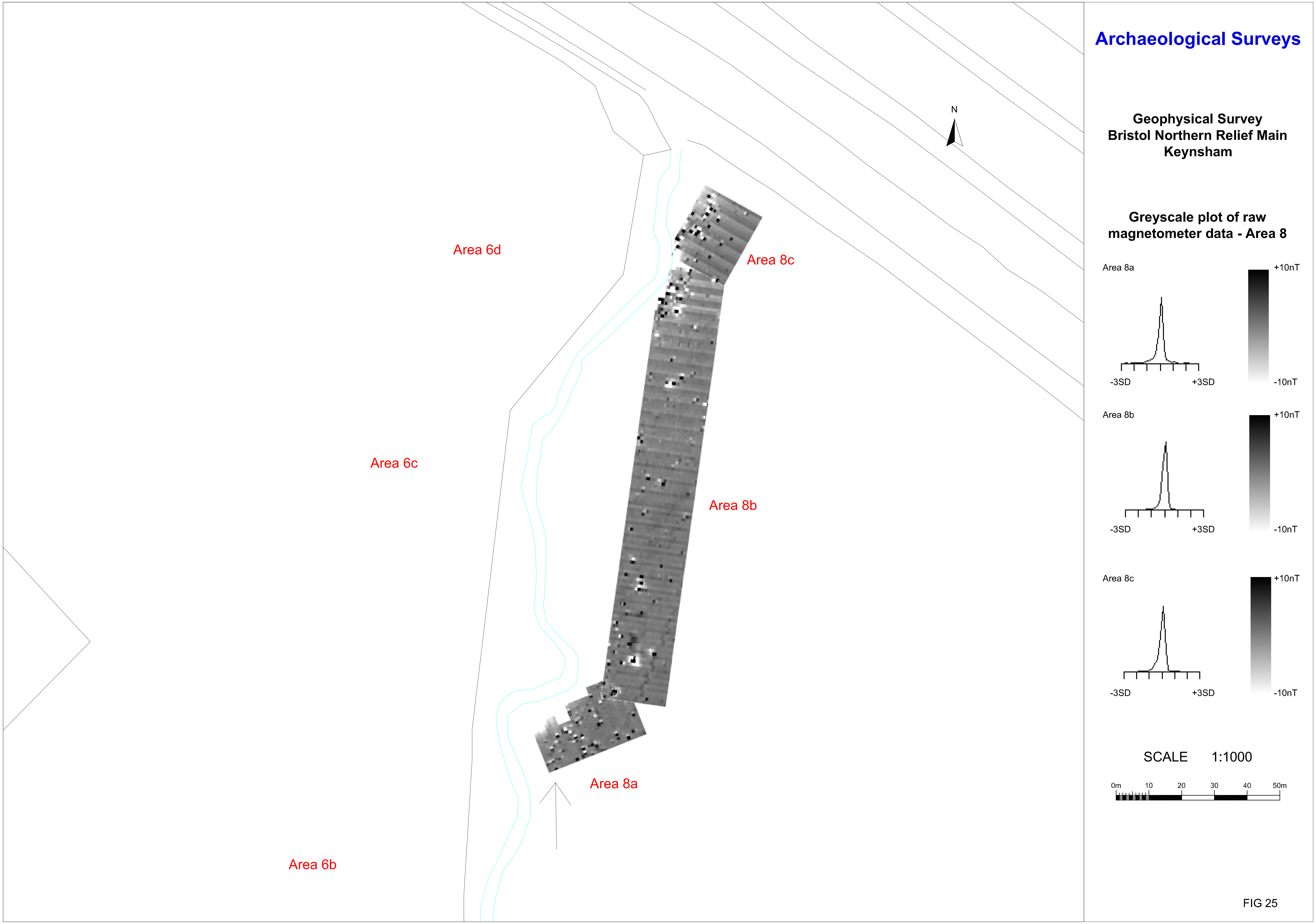
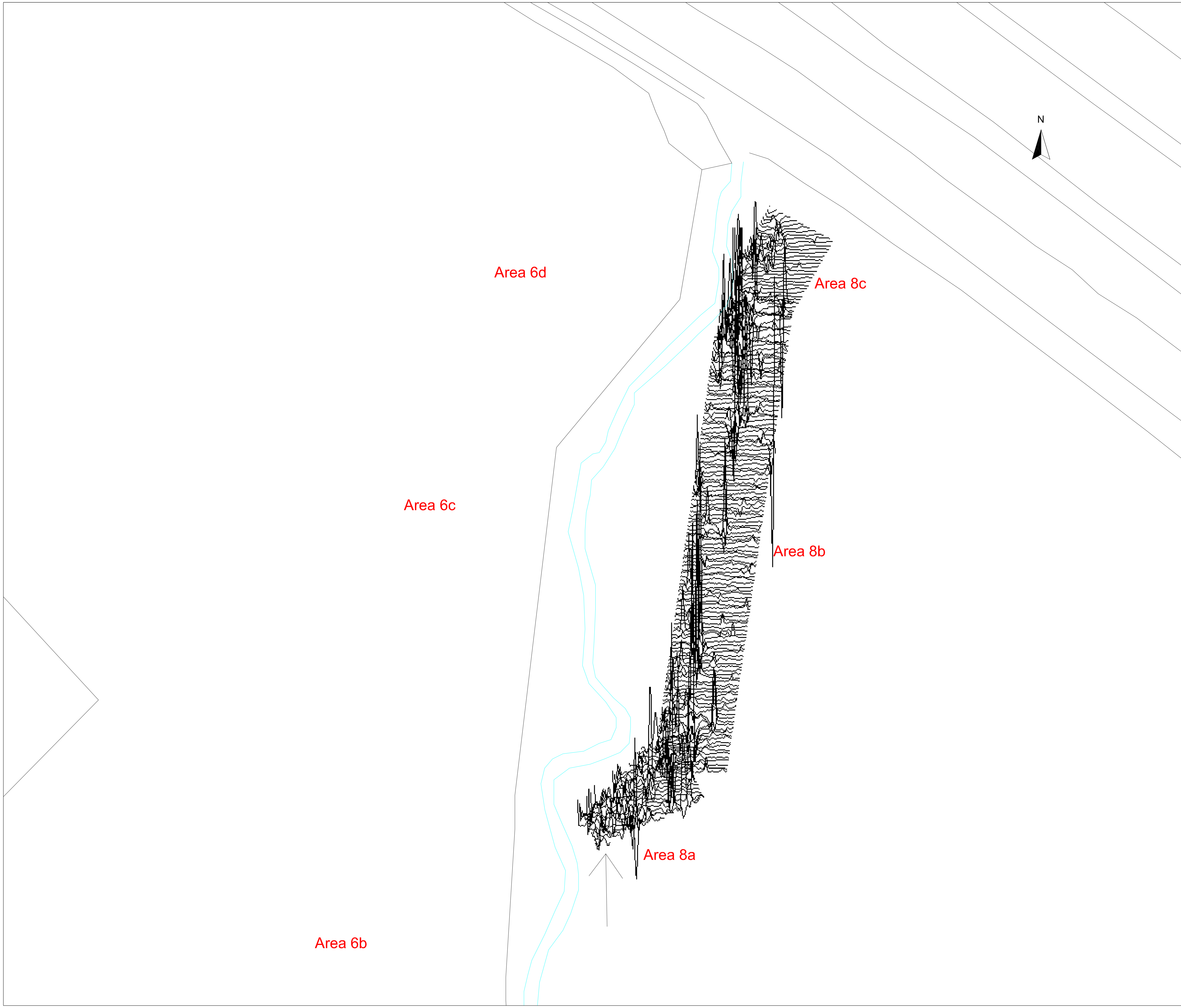


Greyscale plot of raw magnetometer data - Area 8

FIG 25



Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
Keynsham

Traceplot of raw magnetometer data - Area 8

+40nT
+20nT
0nT
-20nT
-40nT

20nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

0m 10 20 30 40 50m

FIG 26

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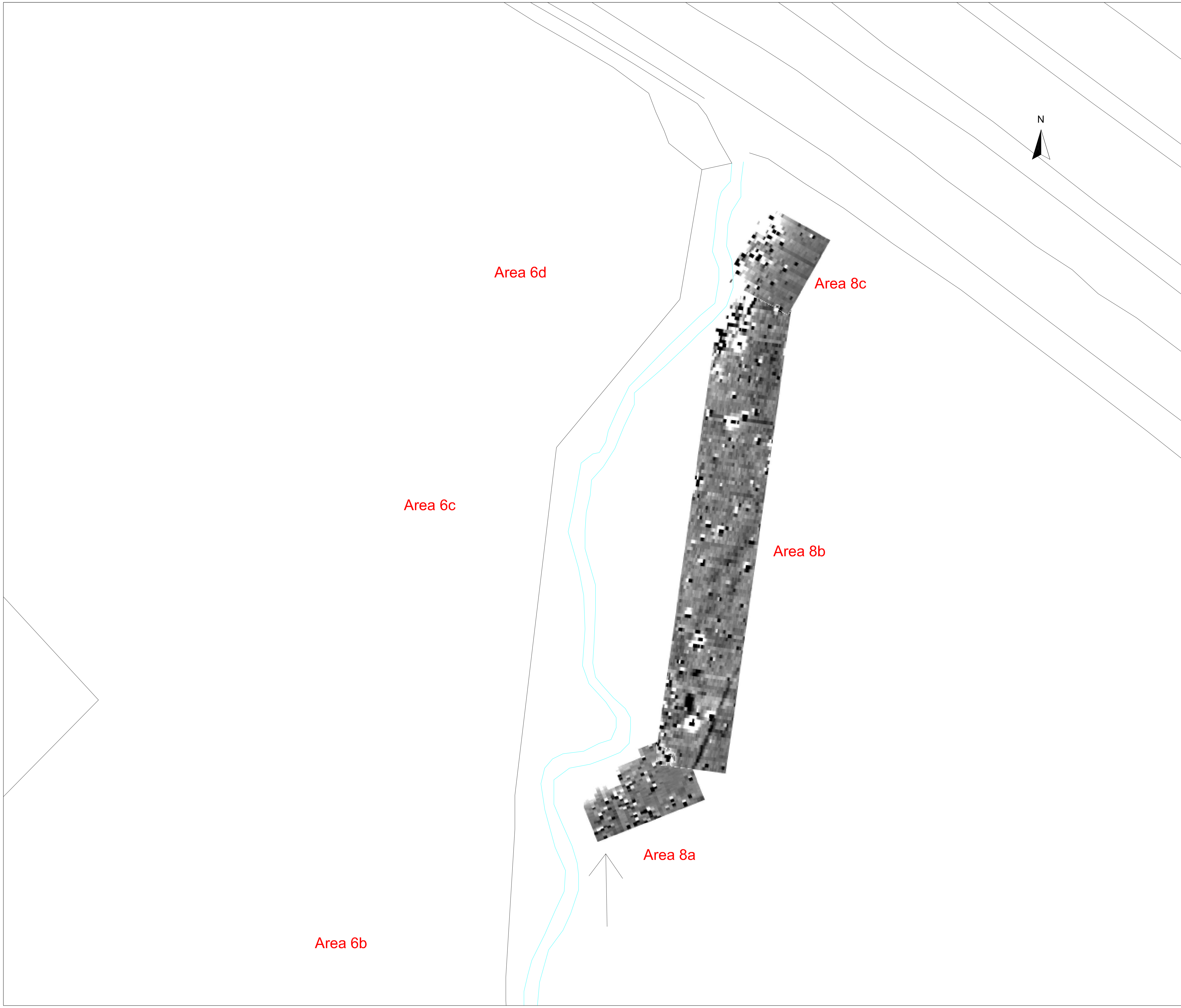
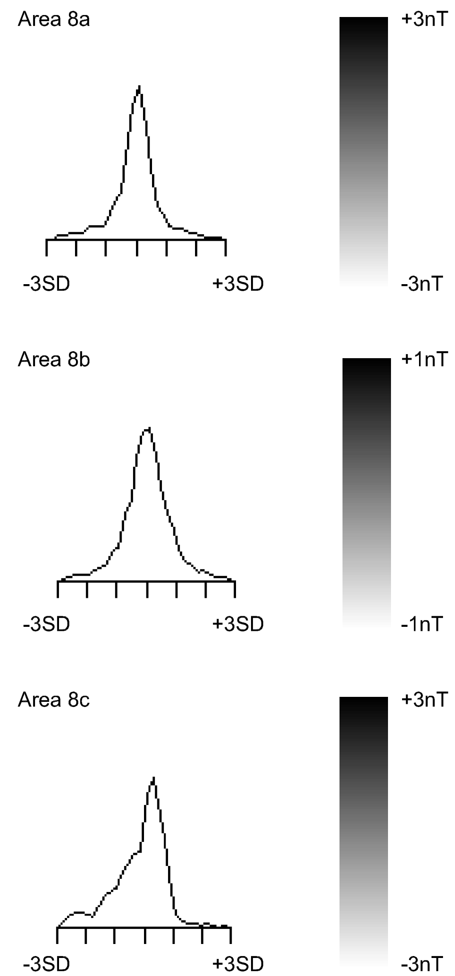
Greyscale plot of processed magnetometer data - Area 8





SCALE 1:1000

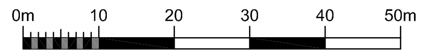


FIG 27

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Keynsham

Referencing information - Area 7

Based on OS coordinates (OS GB36)

A 364669.30, 169461.77

B 364791.95, 169394.28

A - B 140m baseline

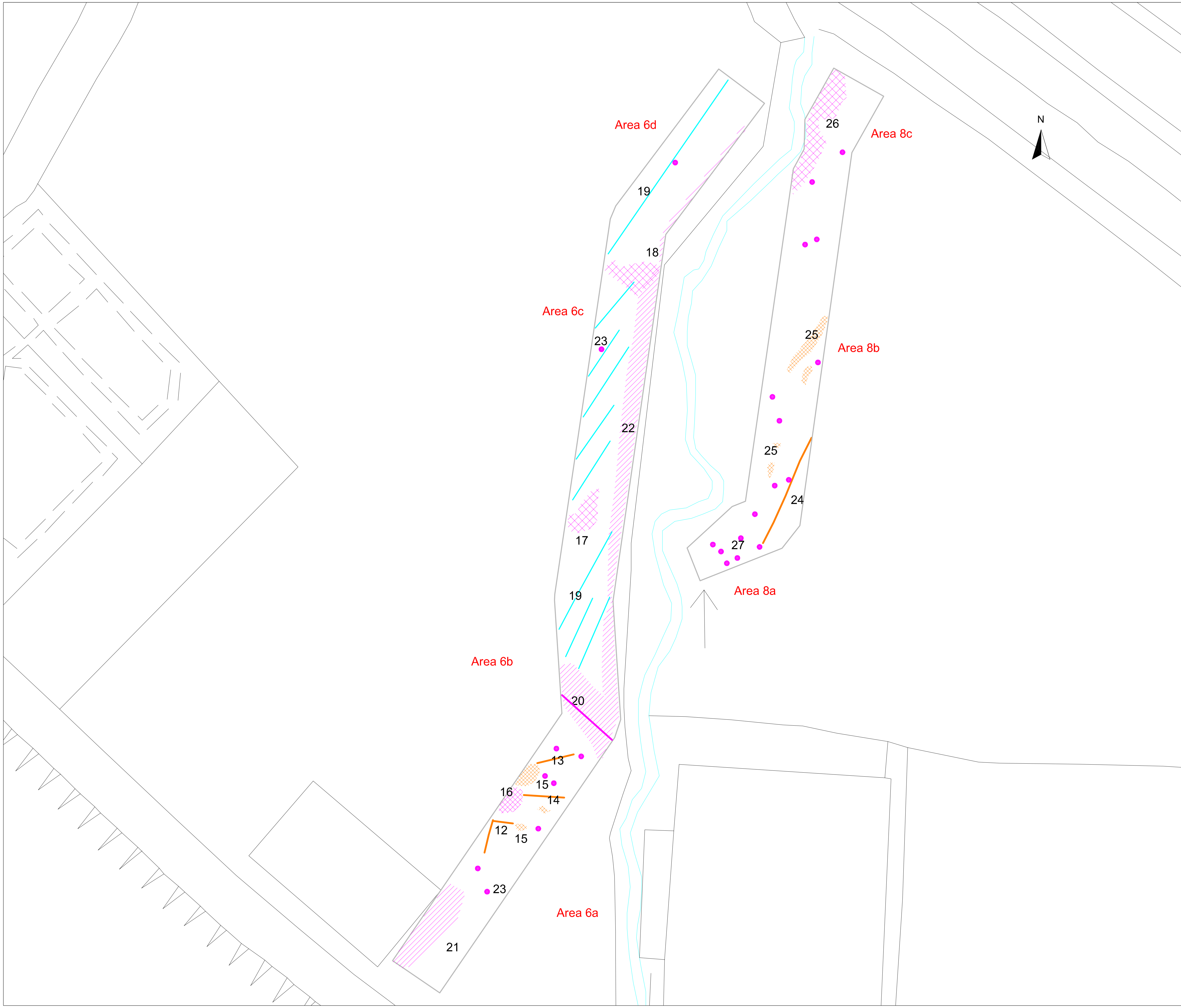
Proposed pipeline routes

Survey start and traverse direction

SCALE 1:1000

0m 10 20 30 40 50m

FIG 29



Archaeological Surveys

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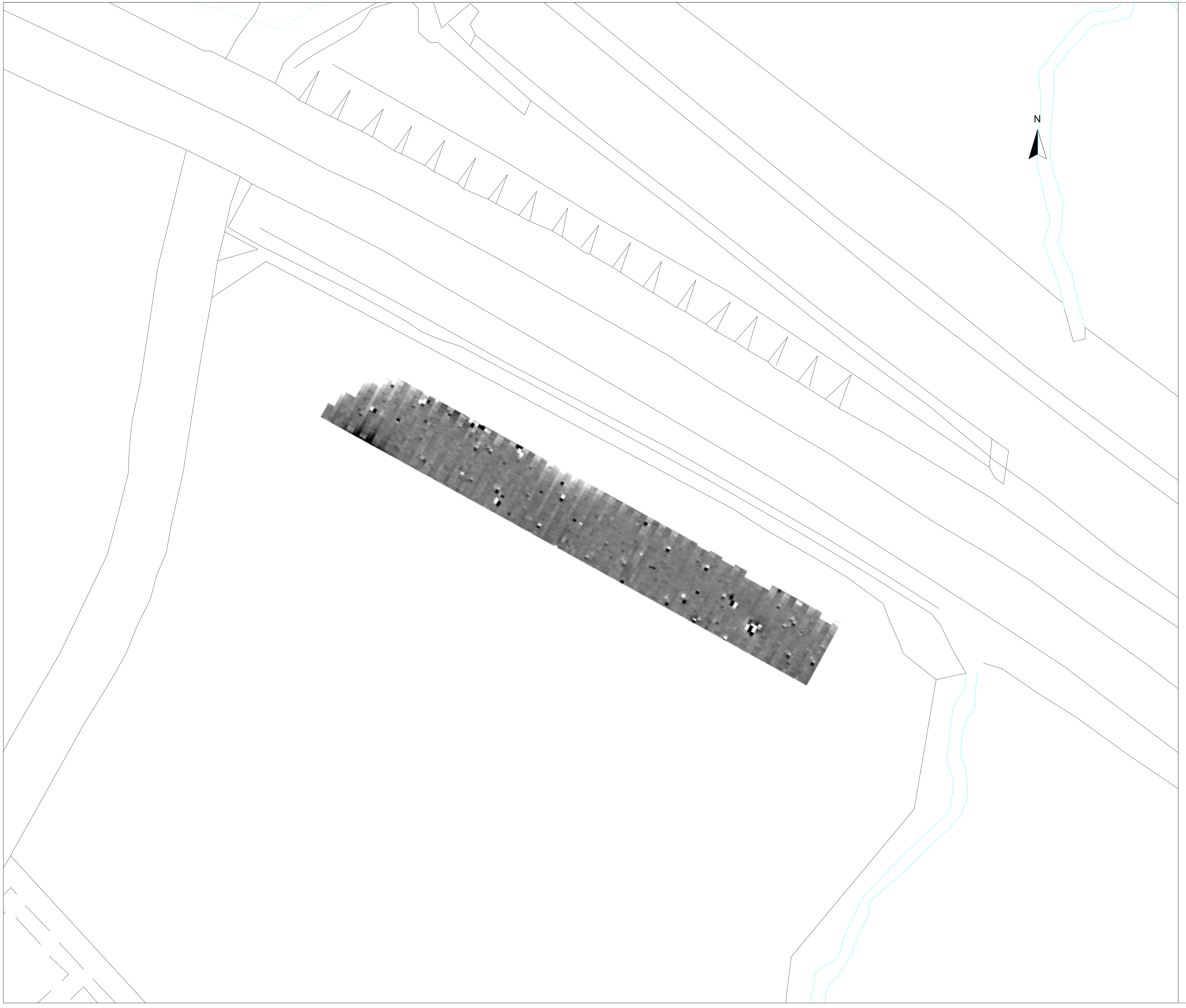
Abstraction and interpretation of magnetometer anomalies - Areas 6 & 8

- Positive linear anomaly - ?cut feature of uncertain origin
- Positive linear anomaly - possible land drain
- Positive area anomaly - ?cut feature of uncertain origin
- Magnetic debris - possible spread of thermoremnant material
- Magnetic disturbance from ferrous material
- Strong dipolar anomaly - ferrous object in topsoil

SCALE 1:1250

0m 10 20 30 40 50m

FIG 28



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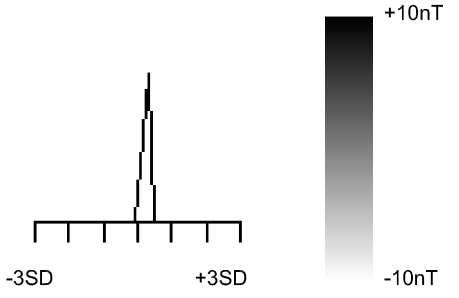
Greyscale plot of raw magnetometer data - Area 7



SCALE 1:1000

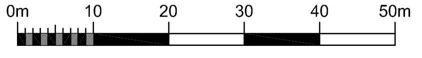
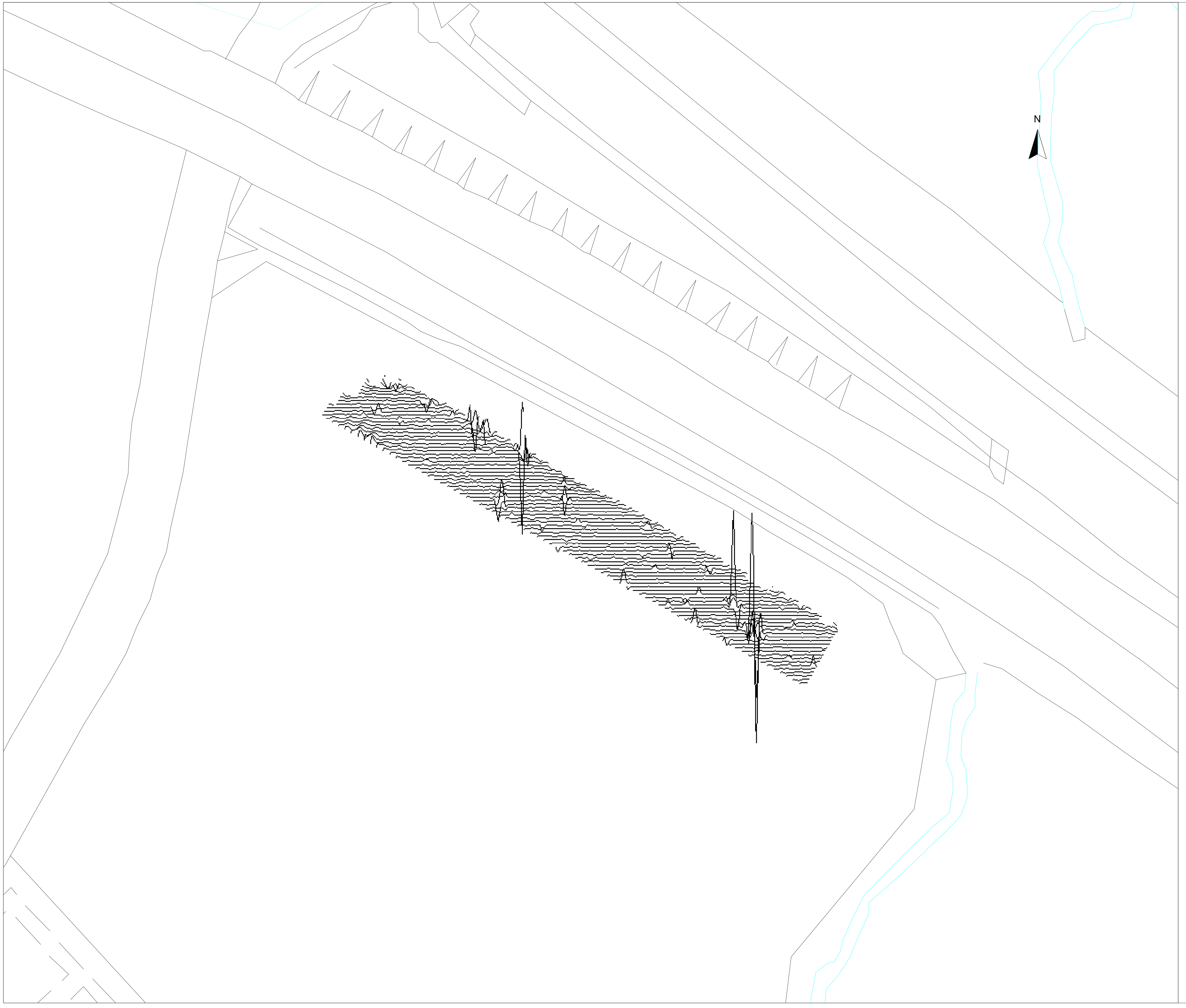


FIG 30



Archaeological Surveys

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Keynsham

Traceplot of raw magnetometer data - Area 7

+40nT
+20nT
0nT
-20nT
-40nT

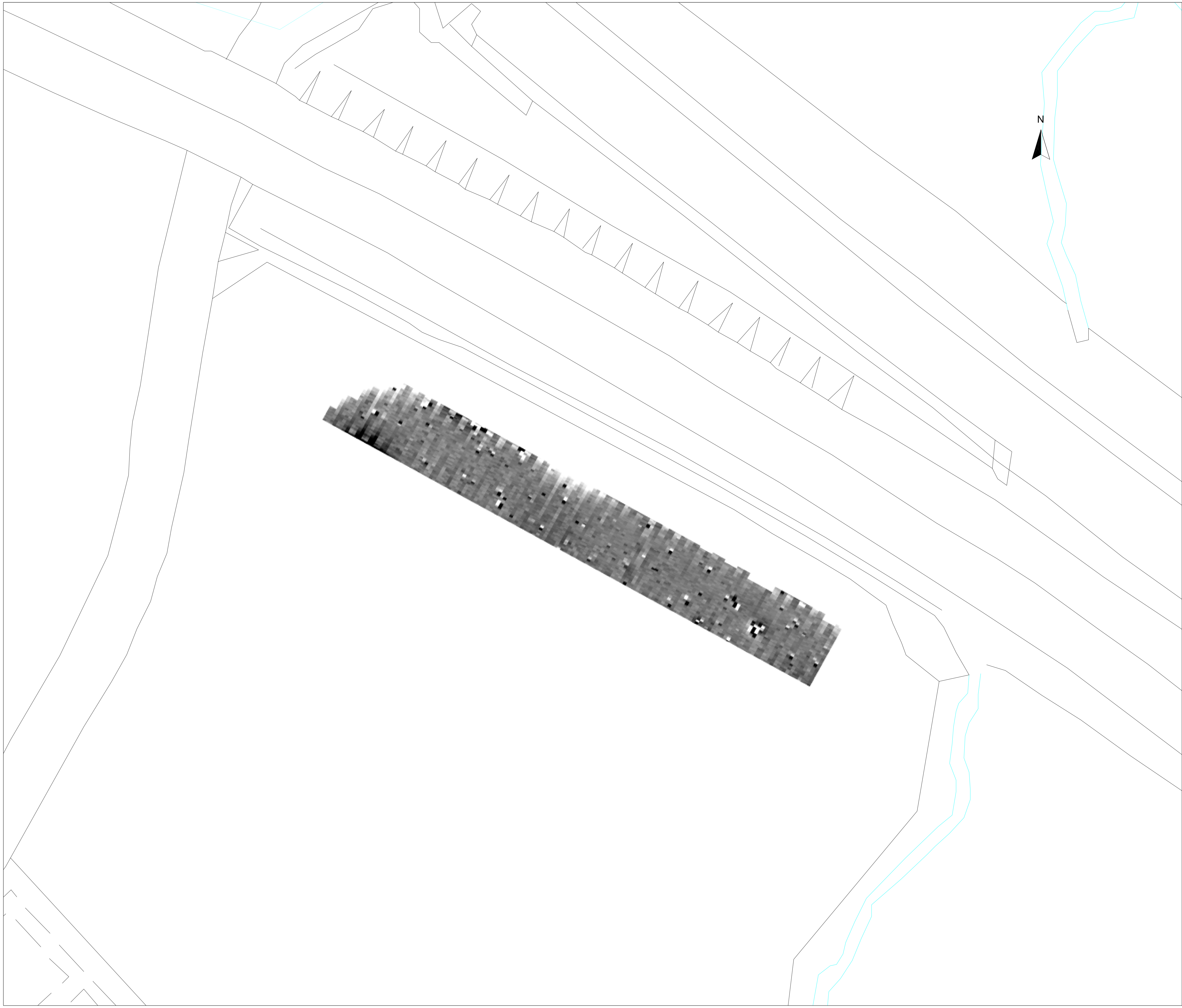
20nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

0m 10 20 30 40 50m

FIG 31



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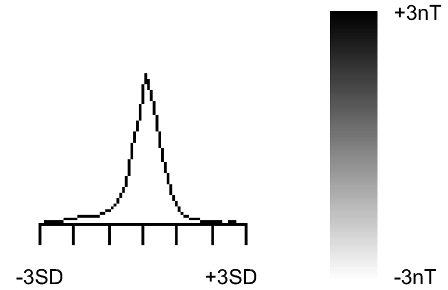
Greyscale plot of processed magnetometer data - Area 7



SCALE 1:1000

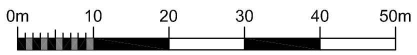
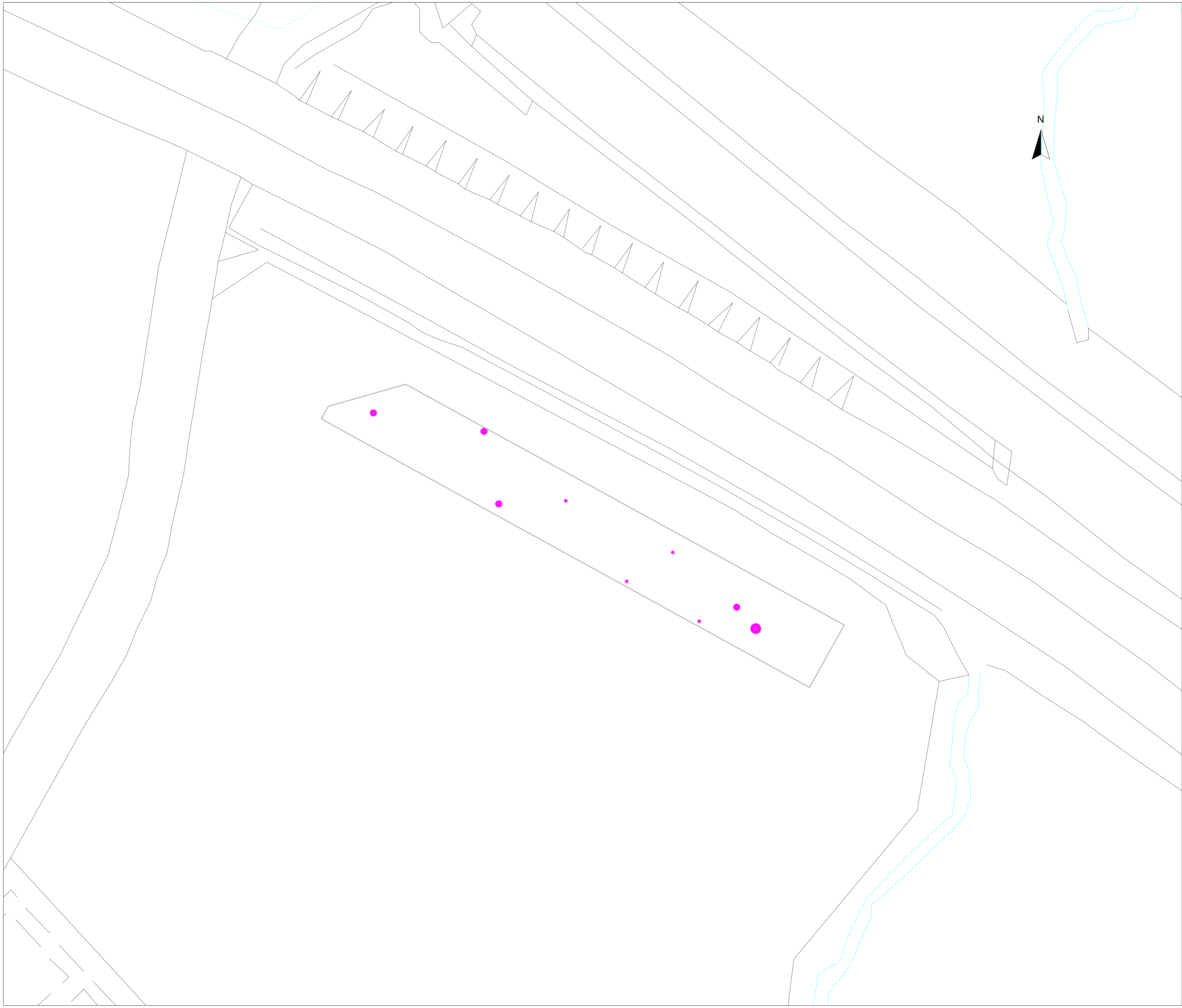


FIG 32



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Bristol Northern Relief Main
Keynsham

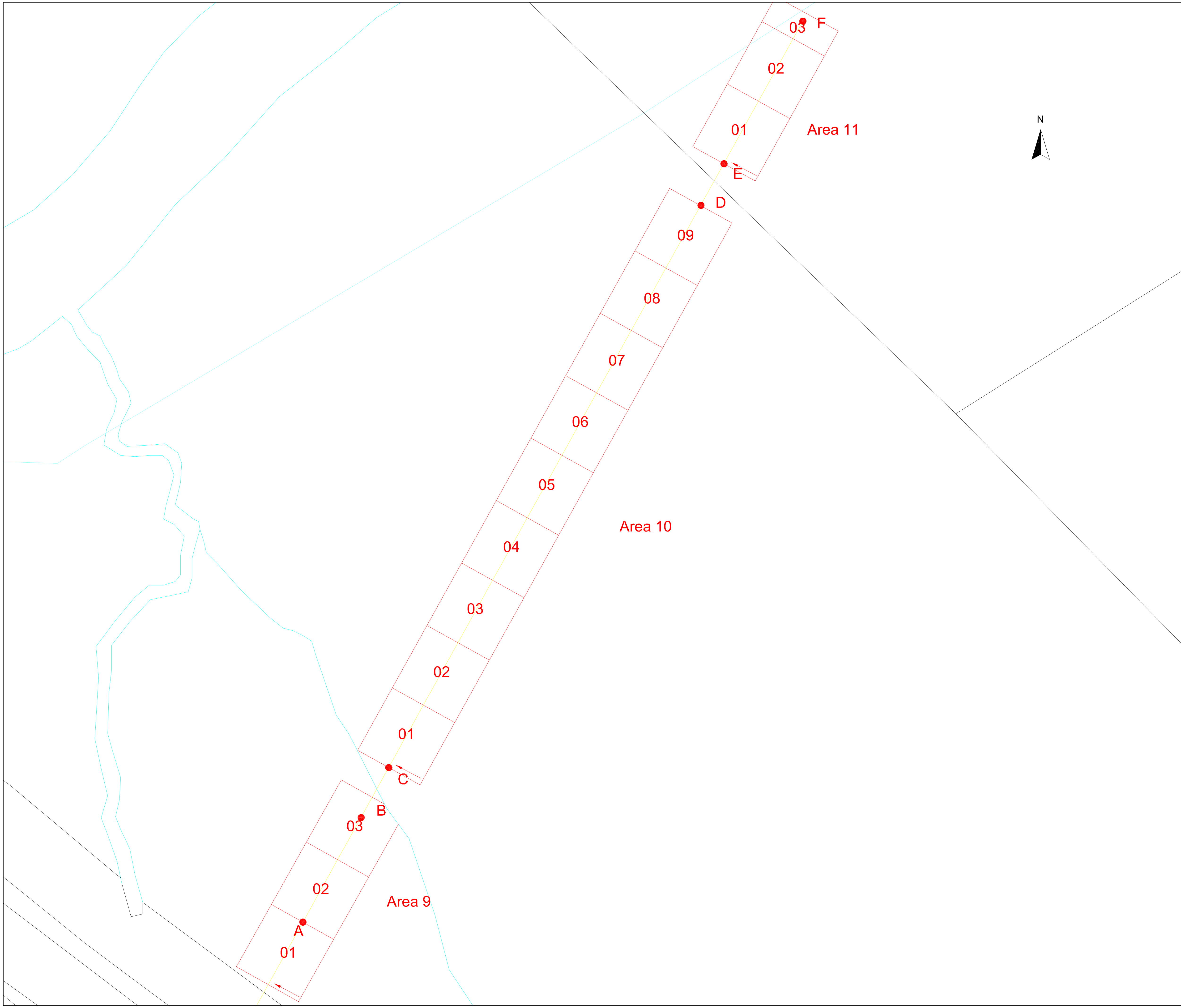
Abstraction and interpretation of magnetometer anomalies - Area 7

Strong dipolar anomaly - ferrous object in topsoil

SCALE 1:1000

0m 10 20 30 40 50m

FIG 33



Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
Keynsham

Referencing information - Areas 9, 10 and 11

Based on OS coordinates (OS GB36)

A 364905.16, 169471.87

B 364921.59, 169501.08

C 364929.33, 169515.10

D 365016.75, 169672.55

E 365023.20, 169684.20

F 365045.30, 169724.14

A - B Baseline

C - D Baseline

E - F Baseline

Proposed pipeline Option 2

Existing pipeline

Survey start and traverse direction

SCALE 1:1000

0m 10 20 30 40 50m

FIG 34

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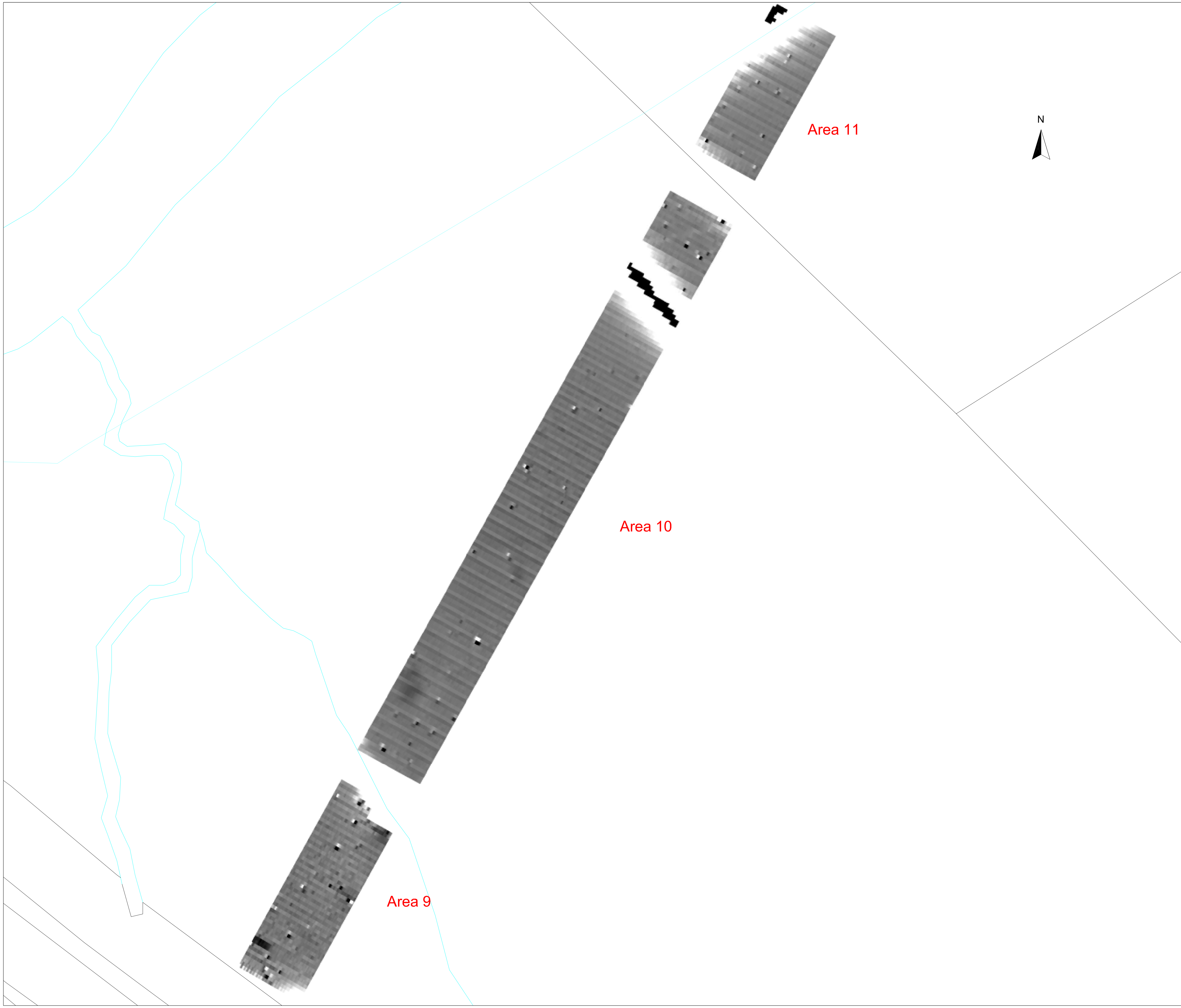
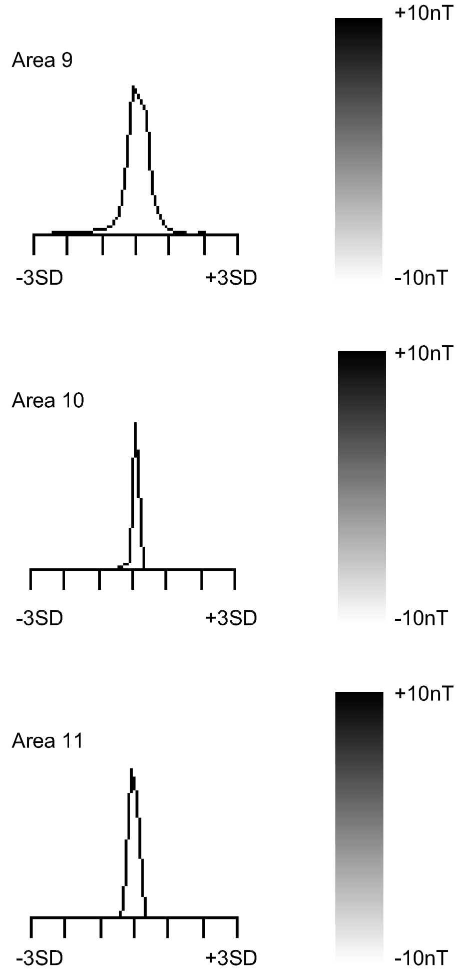
Greyscale plot of raw magnetometer data - Areas 9, 10 & 11

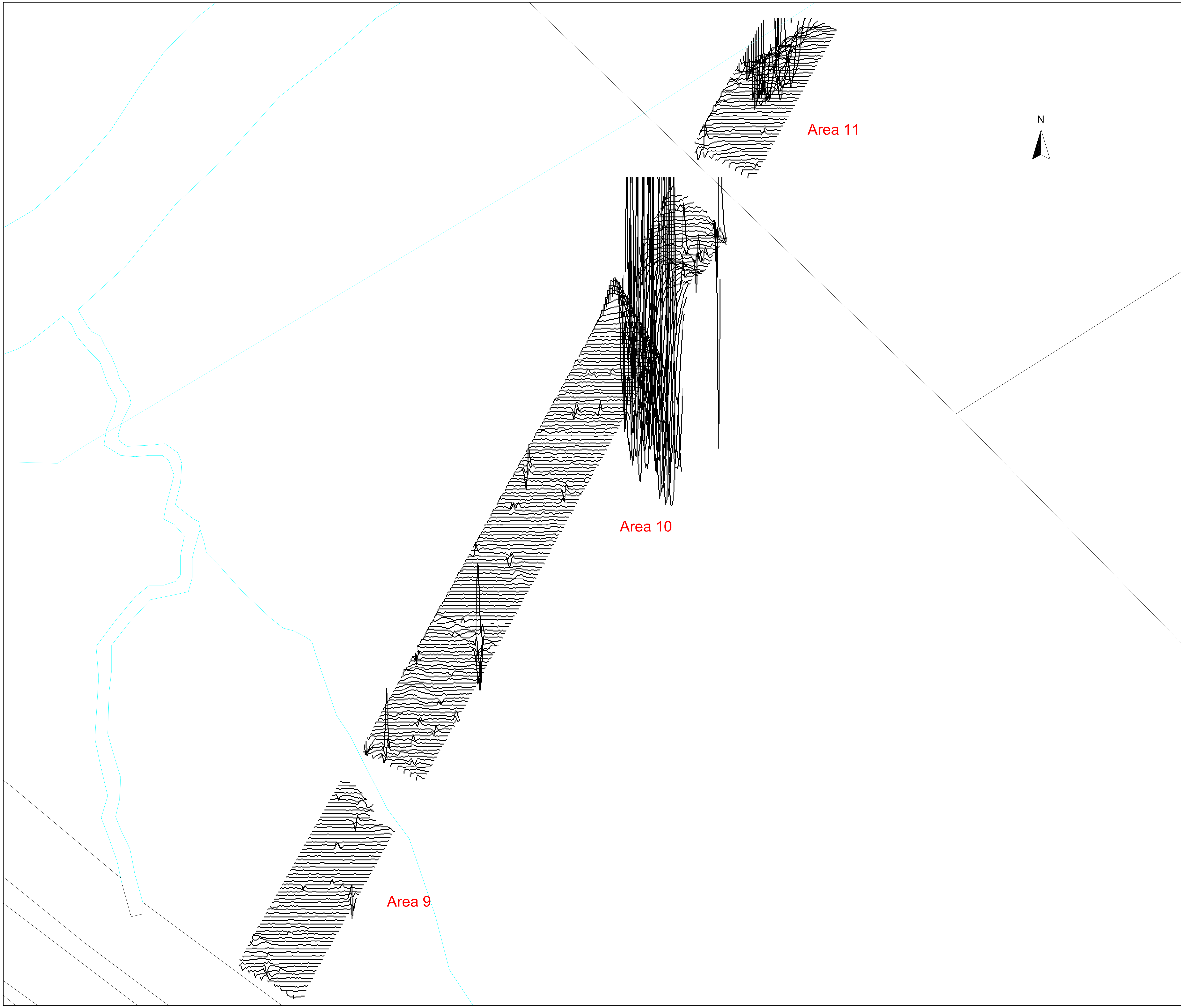




SCALE 1:1000

0m 10 20 30 40 50m

FIG 35



Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
Keynsham

Traceplot of raw magnetometer data - Areas 9, 10 & 11

+40nT
+20nT
0nT
-20nT
-40nT

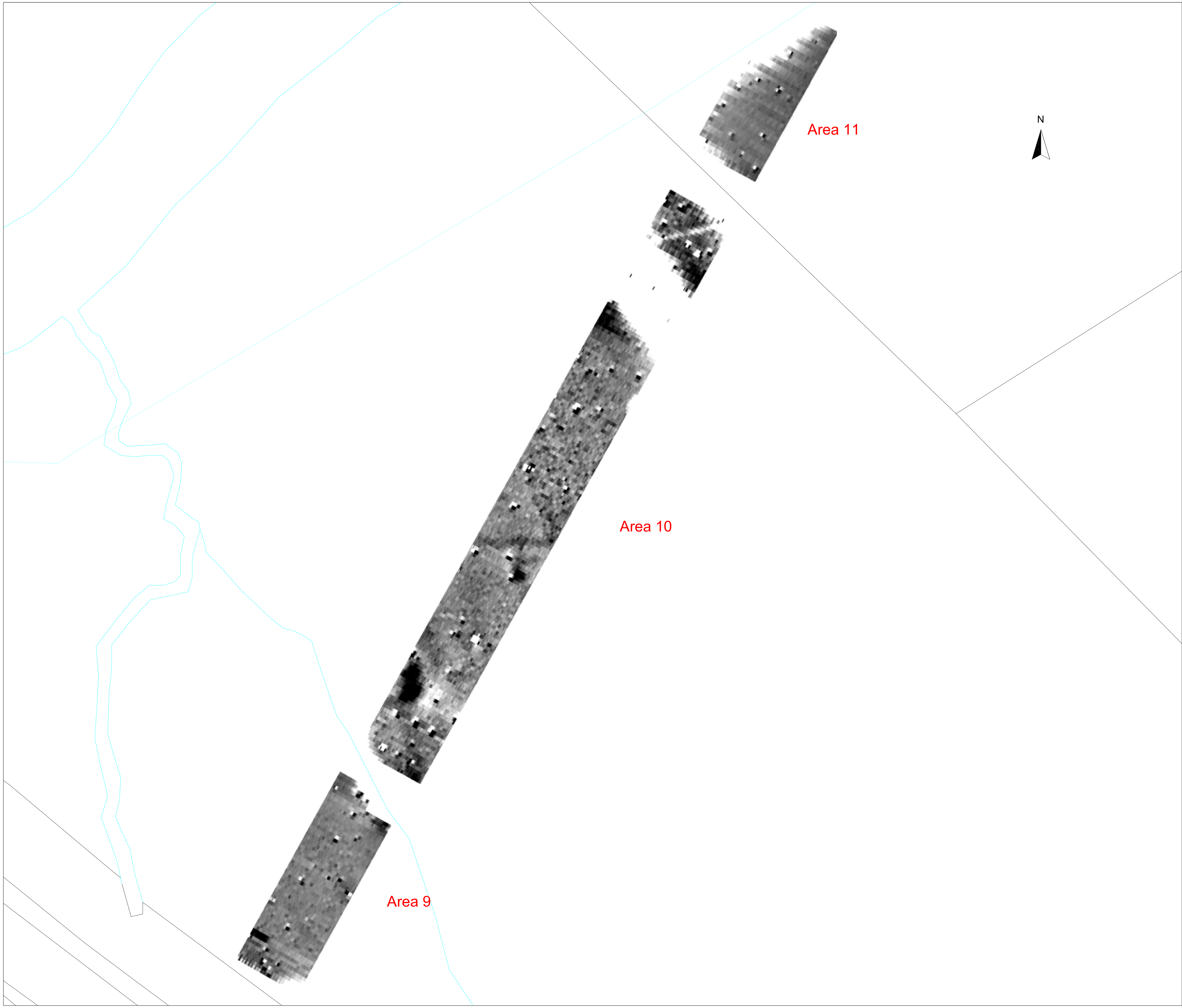
20nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

0m 10 20 30 40 50m

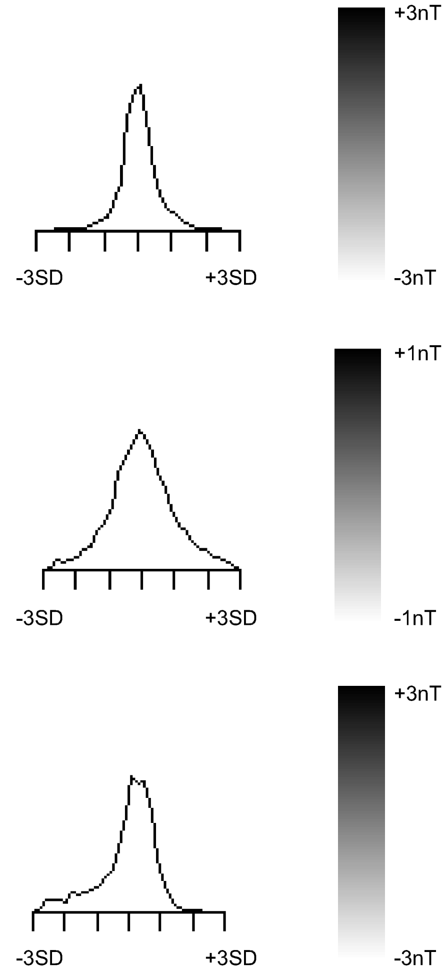
FIG 36



Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
Keynsham

Greyscale plot of processed magnetometer data - Areas 9, 10 & 11



SCALE 1:1000

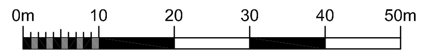
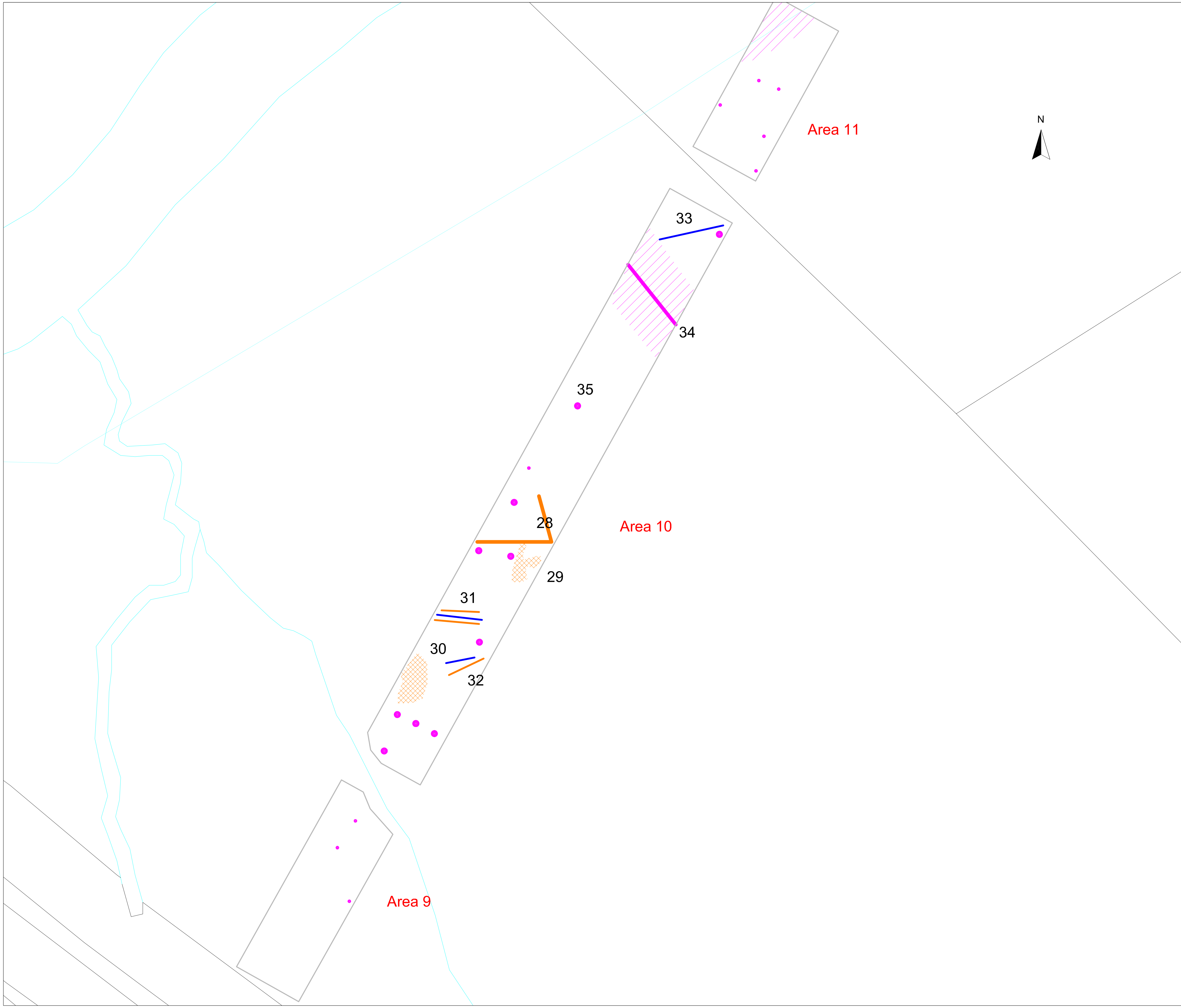


FIG 37



Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
Keynsham

Abstraction and interpretation of magnetometer anomalies - Areas 9, 10 & 11

- Positive linear anomaly - cut feature of uncertain origin
- Negative linear anomaly - of uncertain origin
- Postive area anomaly - ? cut feature of uncertain origin
- Magnetic disturbance from ferrous material
- Strong dipolar linear anomaly - pipeline / cable / service
- Strong dipolar anomaly - ferrous object in topsoil

SCALE 1:1000

0m 10 20 30 40 50m

FIG 38

Archaeological Surveys

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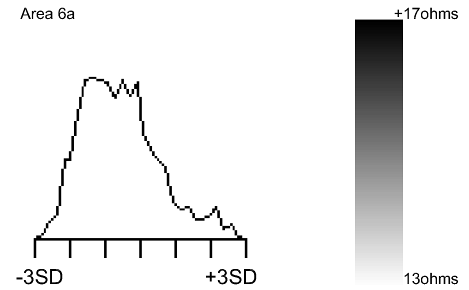
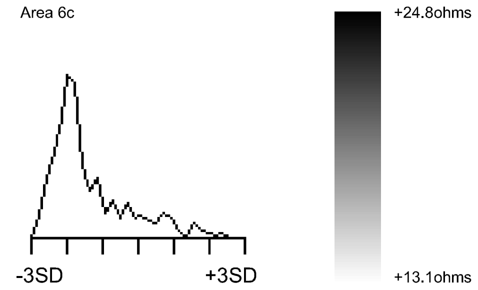
Bristol Northern Relief Main
Keynsham

Greyscale plot of raw resistance data - Area 6





SCALE 1:1000

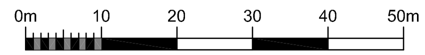
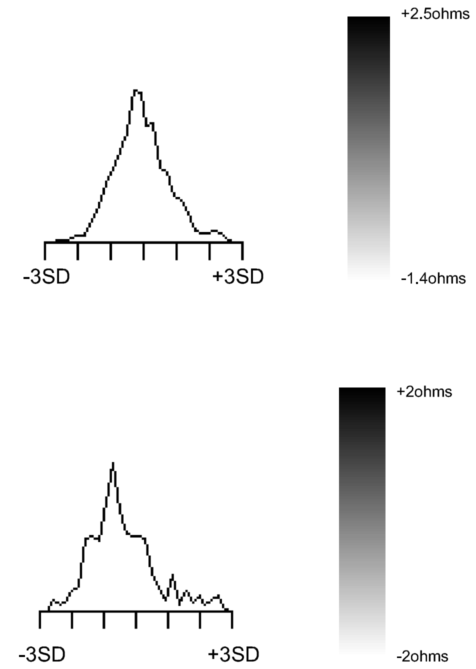


FIG 39

Archaeological Surveys

**Geophysical Survey
Bristol Northern Relief Main
Keynsham**

Greyscale plot of processed resistance data - Area 6



SCALE 1:1000

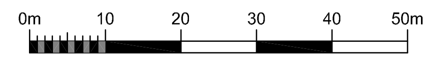


FIG 40

Archaeological Surveys

Geophysical Survey
Bristol Northern Relief Main
Keynsham

Abstraction and interpretation of resistance anomalies - Area 6

- High resistance linear anomaly - of uncertain origin
- High resistance linear anomaly - response to land drain
- Area of high resistance - possible structural remains? spread of dumped material
- Area of low resistance - possible soil variation/ ridge and furrow?

SCALE 1:1000

0m 10 20 30 40 50m

FIG 41