GEOPHYSICAL SURVEY REPORT

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SUMO Survey Services
SUMO Group Member

Project name:
FABlink, Exeter, Devon

Client:
RPS Planning, Transport and Environment

Job ref:
J9818

April 2016

GEOPHYSICAL SURVEY REPORT

Project name: **FABlink, Exeter, Devon** Client: **RPS Planning, Transport and Environment**	Job ref: **J9818**
Survey date: **12th-13th April 2016**	Report date: **May 2016**
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1 SUMMARY OF RESULTS

A detailed gradiometry survey was carried out over approximately 7.5 hectares of arable land. No features of archaeological origin have been identified, however a number of remains related to WWII military sites have been detected. The identification of services and possible building remain corresponds with information from Devon & Dartmoor HER. Evidence of ploughing, former ponds and possible former field boundaries indicate that the site has a more recent agricultural past. Other modern features identified include magnetic disturbance from nearby ferrous objects and magnetic spikes.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned to undertake a geophysical survey of an area outlined as the preferred location for the converter station, as part of the FAB Link development. The FAB project aims to connect the French and British grids, and is routed via the island of Alderney. This survey forms part of an archaeological investigation being undertaken by RPS Planning, Transport and Environment.

2.2 Site Details

NGR / Postcode	SY 016 933 / EX5 2LL
Location	The site is located east of Exeter, Devon, and lies immediately east of Exeter Airport.
HER/SMR	Devon
District	East Devon
Parish	Rockbeare
Topography	Mostly flat
Current Land Use	Arable
Weather Conditions	Dry, clear
Soils	The overlying soils are known as Brockhurst 1, which are typical stagnogley soils. These consist of reddish, fine loamy over clayey soils (Soil Survey of England and Wales, Sheet 5 South West England).
Geology	The underlying geology comprises mudstone of Aylesbeare Mudstone Group. No drift geology is recorded (British Geological Survey website).

Archaeology	A search of Devon & Dartmoor HER (Devon County Council, 2016) within a 500m radius of the site identifies a number of WWII military remains. A number of dispersed military sites are recorded within the site and the surrounding area. Dispersed site 4 (MDV48847) is recorded in the south of the survey area and consisted of a row of at least seven huts, possible temporary brick buildings, lined along the southern hedge. Site 3 (MDV78397) is recorded in the north-west of the area and consisted of a range of structures, visible on aerial photographs from 1944 and demolished by 1966. Sites 2 and 5 are recorded the west and north-east of the survey area respectively (MDV48846 and MDV56271). A north-east – south-west aligned infilled service trench, visible on aerial photographs as a soil mark, connects the two sites and runs directly through the survey area. To the south of the site, possible bomb craters are visible as a series of earthwork pits and levelled pits (MDV112979). Given the high density of WWII remains within the site and surrounding area, it can be determined that there is a high potential for remains of this period to be detected, with limited potential for remains of all other periods.
Survey Methods	Detailed magnetic survey (gradiometry)
Study Area	c. 7.5ha

2.3 Aims and objectives

To locate and characterise any anomalies of possible archaeological interest within the study area.

3 METHODS, PROCESSING & PRESENTATION

3.1 Standards & Guidance

This report and all fieldwork have been conducted in accordance with the latest guidance documents issued by Historic England (2008) and the Chartered Institute for Archaeologists (2002 & 2014).

Stratascan Ltd are a Registered Organisation with the CIfA and are committed to upholding its policies and standards.

3.2 Survey methods

Due to the high potential for WWII military remains, detailed magnetic survey was used as an efficient and effective method of locating archaeological anomalies.

More information regarding this technique is included in Appendix A.

3.3 Processing

The following schedule shows the basic processing carried out on the data used in this report:

1. *Destripe*
2. *Destagger*

3.4 Presentation of results and interpretation

The presentation of the data for each site involves a plot of the minimally processed data as a greyscale plot and a colour plot showing extreme magnetic values. Magnetic anomalies have been identified and plotted onto the 'Interpretation of Anomalies' drawing.

When interpreting the results several factors are taken into consideration, including the nature of archaeological features being investigated and the local conditions at the site (geology, pedology, topography etc.). Anomalies are categorised by their potential origin. Where responses can be related to very specific known features documented in other sources, this is done (for example: Abbey Wall, Roman Road). For the generic categories levels of confidence are indicated, for example: probable, or possible archaeology. The former is used for a confident interpretation, based on anomaly definition and/or other corroborative data such as cropmarks. Poor anomaly definition, a lack of clear patterns to the responses and an absence of other supporting data reduces confidence, hence the classification "possible".

4 RESULTS

The detailed magnetic gradiometer survey conducted at Exeter has identified a number of anomalies that have been characterised as being of WWII origin. The following list of numbered anomalies refers to numerical labels on the interpretation plots.

4.1 Probable Archaeology

No probable archaeology has been identified within the survey area.

4.2 Possible Archaeology

No possible archaeology has been identified within the survey area.

4.3 Medieval/Post-Medieval Agriculture

A number of weak, positive linear anomalies **[1]** across the south of the site may be related to former field boundaries that are not present on available OS mapping, dating back to 1889. Discrete areas of strong magnetic debris **[2]** are related to former ponds that are visible on OS maps from 1889 to 1971. A further area of magnetic debris **[3]**, similar in response to Anomaly 2 may also be related to a former pond, but is not visible on available mapping. Evidence of modern ploughing **[4]** is visible across the site in the form of magnetically weak, closely spaced, parallel linear anomalies.

4.4 *WWII Anomalies*

An area of strong magnetic debris **[5]** near the centre of the site is likely to be related to a former military building, while areas of scattered magnetic debris **[6]** in the south of the site may be related to former huts recorded on the HER (MDV48847) forming part of dispersed military site 4.

4.5 *Other Anomalies*

Underground services are visible as strong bipolar linear anomalies in the south **[7]** and running northeast-southwest **[7a]** across the site. Anomaly 7a corresponds with a service trench connecting two dispersed military sites, recorded on Devon & Dartmoor HER (MDV48846). Two small positive linear anomalies **[8]**, in the centre of the area, are of uncertain origin, and are possibly associated with the former military sites. Areas of magnetic disturbance **[9]** are the result of nearby ferrous metal objects, such as fences and underground services. These effects can mask weaker archaeological anomalies. Smaller ferrous objects, or 'magnetic spikes' **[10]** indicate ferrous metal objects and are likely to be modern rubbish.

5 DATA APPRAISAL & CONFIDENCE ASSESSMENT

Mudstone geologies, such as Aylesbeare Mudstone, can provide variable results for gradiometer survey. The data across the site does not show a high contrast between anomalies and the background magnetic response, with evidence of ploughing and possible former field boundaries visible only as weak features. The remains of the WWII military sites are all high amplitude, and as such the underlying geology does not affect their responses. Given the limited potential for remains other than WWII military features, it can be determined that the survey is likely to have been effective.

6 CONCLUSION

The survey at Exeter has not identified any features of archaeological origin, however a number of anomalies likely related to former WWII military sites have been detected, corroborating with information from Devon & Dartmoor HER. The remains are related to services and the possible remains of former buildings. Possible former field boundaries, former ponds and evidence of modern ploughing indicate that the site has a more recent agricultural past. The remaining features are modern and include magnetic disturbance from nearby ferrous objects and magnetic spikes, which are likely to be modern rubbish.

7 REFERENCES

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Appendix A - Technical Information: Magnetometer Survey Method

Grid Positioning

For hand held gradiometers the location of the survey grids has been plotted together with the referencing information. Grids were set out using a Trimble R8 Real Time Kinematic (RTK) VRS Now GNSS GPS system.

An RTK GPS (Real-time Kinematic Global Positioning System) can locate a point on the ground to a far greater accuracy than a standard GPS unit. A standard GPS suffers from errors created by satellite orbit errors, clock errors and atmospheric interference, resulting in an accuracy of 5m-10m. An RTK system uses a single base station receiver and a number of mobile units. The base station re-broadcasts the phase of the carrier it measured, and the mobile units compare their own phase measurements with those they received from the base station. This results in an accuracy of around 0.01m.

Technique	Instrument	Traverse Interval	Sample Interval
Magnetometer	Bartington Grad 601-2	1m	0.25m

Instrumentation: Bartington *Grad*601-2

Bartington instruments operate in a gradiometer configuration which comprises fluxgate sensors mounted vertically, set 1.0m apart. The fluxgate gradiometer suppresses any diurnal or regional effects. The instruments are carried, or cart mounted, with the bottom sensor approximately 0.1-0.3m from the ground surface. At each survey station, the difference in the magnetic field between the two fluxgates is measured in nanoTesla (nT). The sensitivity of the instrument can be adjusted; for most archaeological surveys the most sensitive range (0.1nT) is used. Generally, features up to 1m deep may be detected by this method, though strongly magnetic objects may be visible at greater depths. The Bartington instrument can collect two lines of data per traverse with gradiometer units mounted laterally with a separation of 1.0m.

The readings are logged consecutively into the data logger which in turn is daily down- loaded into a portable computer whilst on site. At the end of each site survey, data is transferred to the office for processing and presentation.

Data Processing

Zero Mean Traverse	This process sets the background mean of each traverse within each grid to zero. The operation removes striping effects and edge discontinuities over the whole of the data set.
Step Correction (Destagger)	When gradiometer data are collected in 'zig-zag' fashion, stepping errors can sometimes arise. These occur because of a slight difference in the speed of walking on the forward and reverse traverses. The result is a staggered effect in the data, which is particularly noticeable on linear anomalies. This process corrects these errors.

Display

Greyscale/ Colourscale Plot	This format divides a given range of readings into a set number of classes. Each class is represented by a specific shade of grey, the intensity increasing with value. All values above the given range are allocated the same shade (maximum intensity); similarly all values below the given range are represented by the minimum intensity shade. Similar plots can be produced in colour, either using a wide range of colours or by selecting two or three colours to represent positive and negative values. The assigned range (plotting levels) can be adjusted to emphasise different anomalies in the data-set.

Interpretation Categories

In certain circumstances (usually when there is corroborative evidence from desk based or excavation data) very specific interpretations can be assigned to magnetic anomalies (for example, *Roman Road, Wall,* etc.) and where appropriate, such interpretations will be applied. The list below outlines the generic categories commonly used in the interpretation of the results.

Archaeology/Probable Archaeology	This term is used when the form, nature and pattern of the response are clearly or very probably archaeological and /or if corroborative evidence is available. These anomalies, whilst considered anthropogenic, could be of any age.
Possible Archaeology	These anomalies exhibit either weak signal strength and / or poor definition, or form incomplete archaeological patterns, thereby reducing the level of confidence in the interpretation. Although the archaeological interpretation is favoured, they may be the result of variable soil depth, plough damage or even aliasing as a result of data collection orientation.
Industrial / Burnt-Fired	Strong magnetic anomalies that, due to their shape and form or the context in which they are found, suggest the presence of kilns, ovens, corn dryers, metal- working areas or hearths. It should be noted that in many instances modern ferrous material can produce similar magnetic anomalies.
Former Field Boundary (probable & possible)	Anomalies that correspond to former boundaries indicated on historic mapping, or which are clearly a continuation of existing land divisions. Possible denotes less confidence where the anomaly may not be shown on historic mapping but nevertheless the anomaly displays all the characteristics of a field boundary.
Ridge & Furrow	Parallel linear anomalies whose broad spacing suggests ridge and furrow cultivation. In some cases the response may be the result of more recent agricultural activity.
Agriculture (ploughing)	Parallel linear anomalies or trends with a narrower spacing, sometimes aligned with existing boundaries, indicating more recent cultivation regimes.
Land Drain	Weakly magnetic linear anomalies, quite often appearing in series forming parallel and herringbone patterns. Smaller drains will often lead and empty into larger diameter pipes and which in turn usually lead to local streams and ponds. These are indicative of clay fired land drains.
Natural	These responses form clear patterns in geographical zones where natural variations are known to produce significant magnetic distortions.
Magnetic Disturbance	Broad zones of strong dipolar anomalies, commonly found in places where modern ferrous or fired materials (e.g. brick rubble) are present. They are presumed to be modern.
Service	Magnetically strong anomalies usually forming linear features indicative of ferrous pipes/cables. Sometimes other materials (e.g. pvc) cause weaker magnetic responses and can be identified from their uniform linearity crossing large expanses.
Ferrous	This type of response is associated with ferrous material and may result from small items in the topsoil, larger buried objects such as pipes, or above ground features such as fence lines or pylons. Ferrous responses are usually regarded as modern. Individual burnt stones, fired bricks or igneous rocks can produce responses similar to ferrous material.
Uncertain Origin	Anomalies which stand out from the background magnetic variation, yet whose form and lack of patterning gives little clue as to their origin. Often the characteristics and distribution of the responses straddle the categories of *Possible Archaeology* and *Possible Natural* or (in the case of linear responses) *Possible Archaeology* and *Possible Agriculture*; occasionally they are simply of an unusual form.

Where appropriate some anomalies will be further classified according to their form (positive or negative) and relative strength and coherence (trend: weak and poorly defined).

Appendix B - Technical Information: Magnetic Theory

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock. Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTeslas (nT) in an overall field strength of 48,000nT, can be accurately detected.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremanent* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

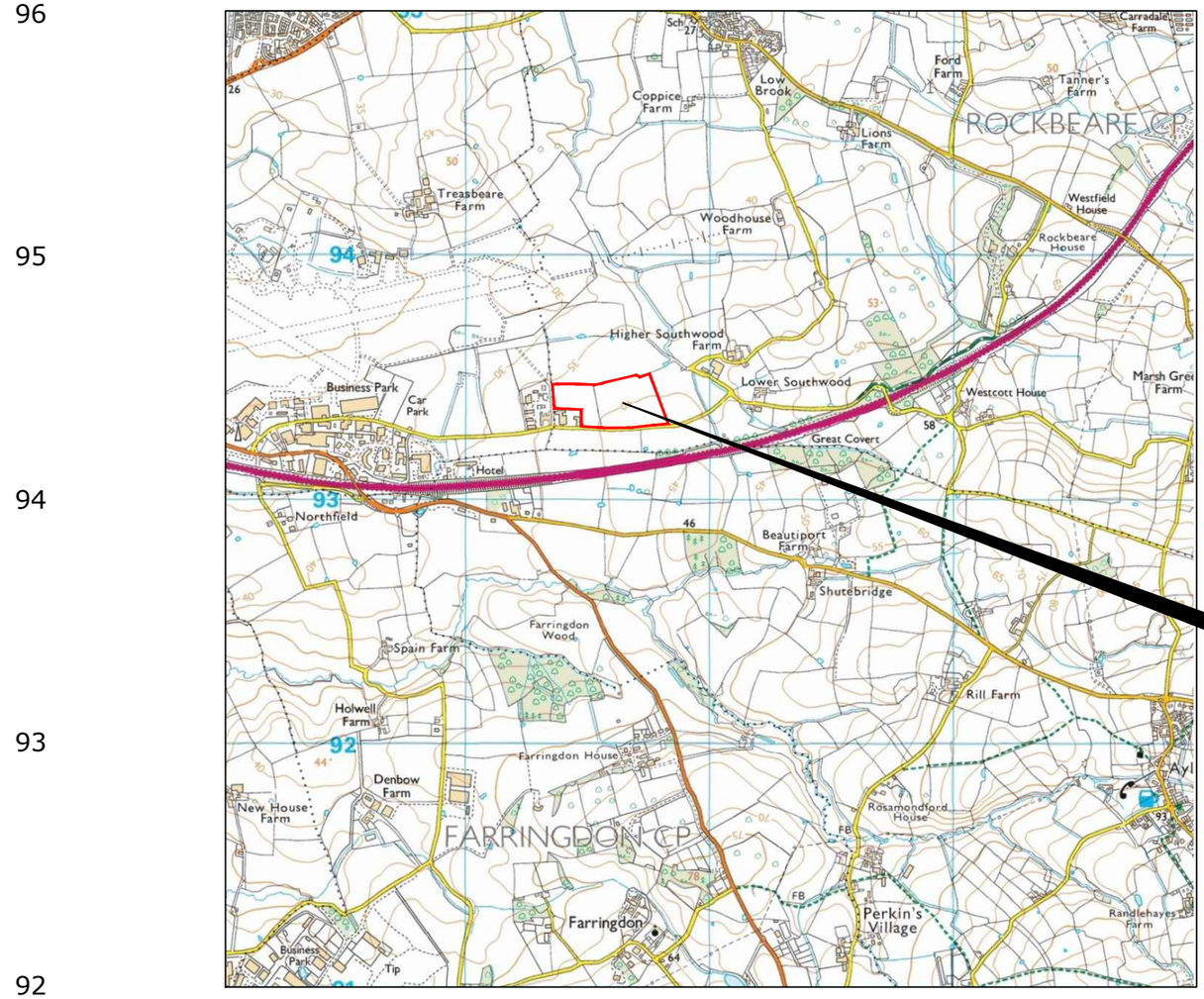
Thermoremanence is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremanent archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity, disturbance from modern services etc.

OS 100km square = SY



Amendments

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Site centred on NGR: SY 016 933

Client: RPS

Project Title: GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

Job No. 9818

Subject: LOCATION PLAN OF SURVEY AREA

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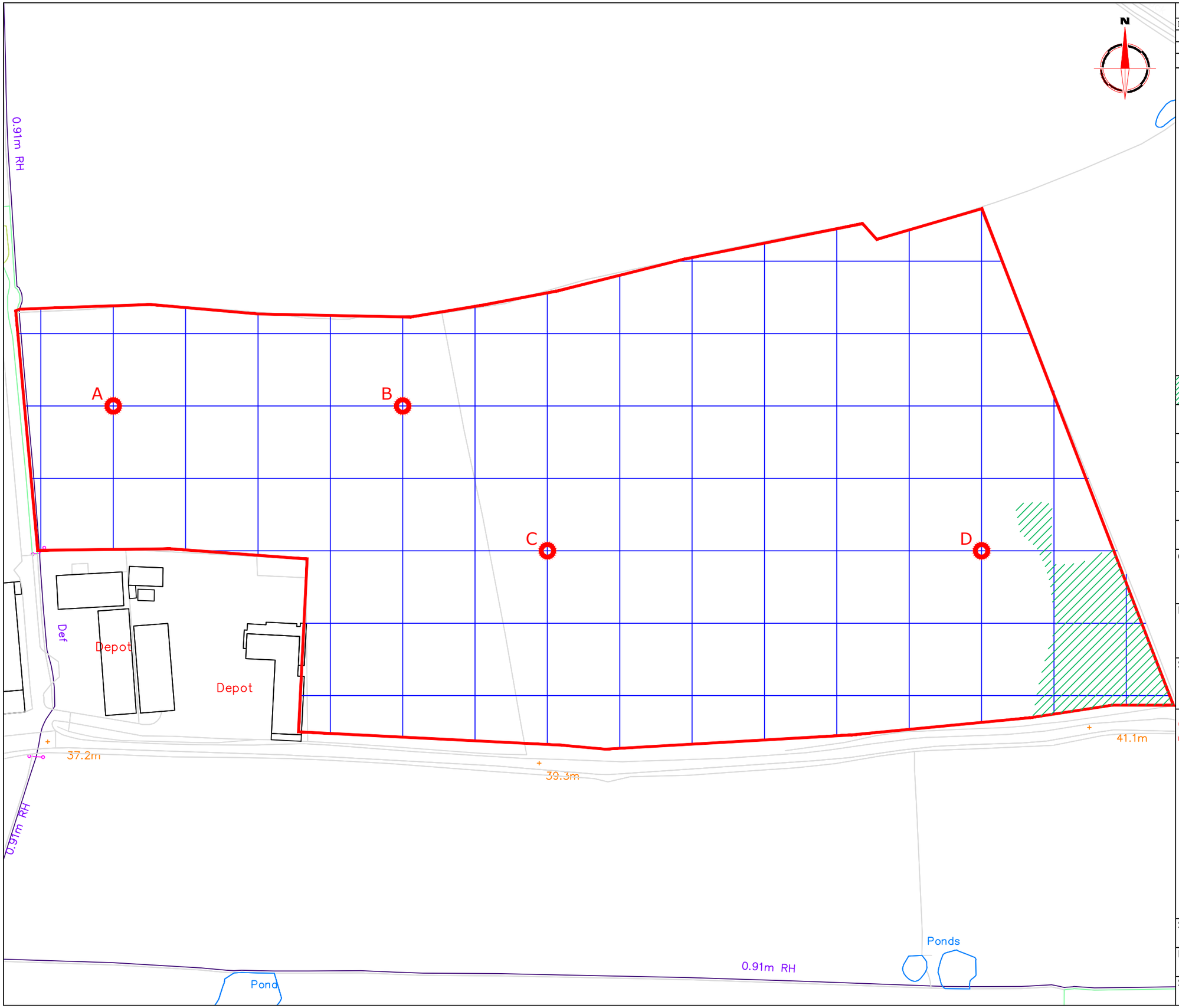

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Unsurveyable - large piles of manure

OS GRID REFERENCES

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D	301746.53, 093373.90

Client
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Project Title
GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

Job No. 9818

Subject
LOCATION OF SURVEY GRIDS AND REFERENCING

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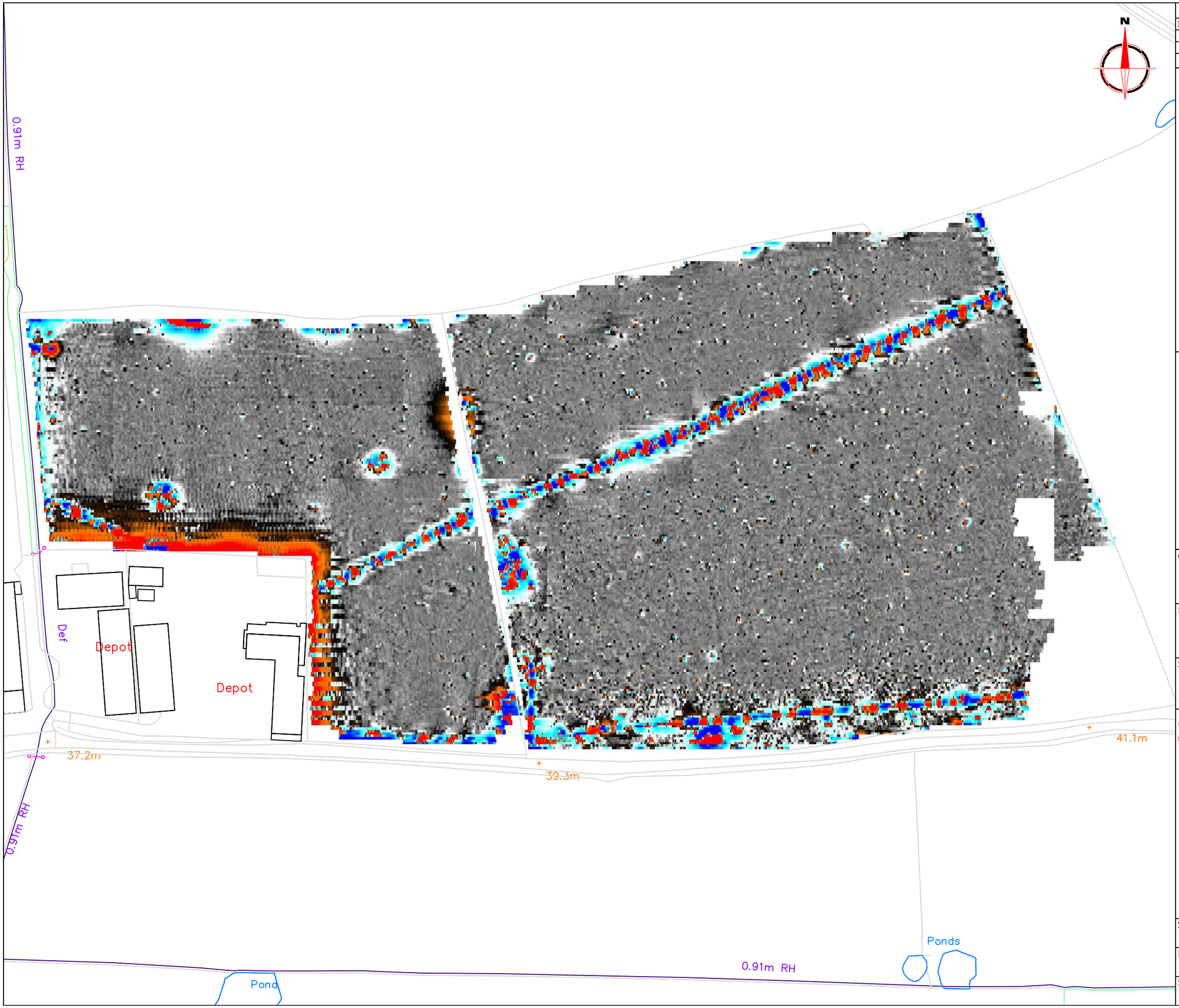

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Subject
COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES - OVERVIEW

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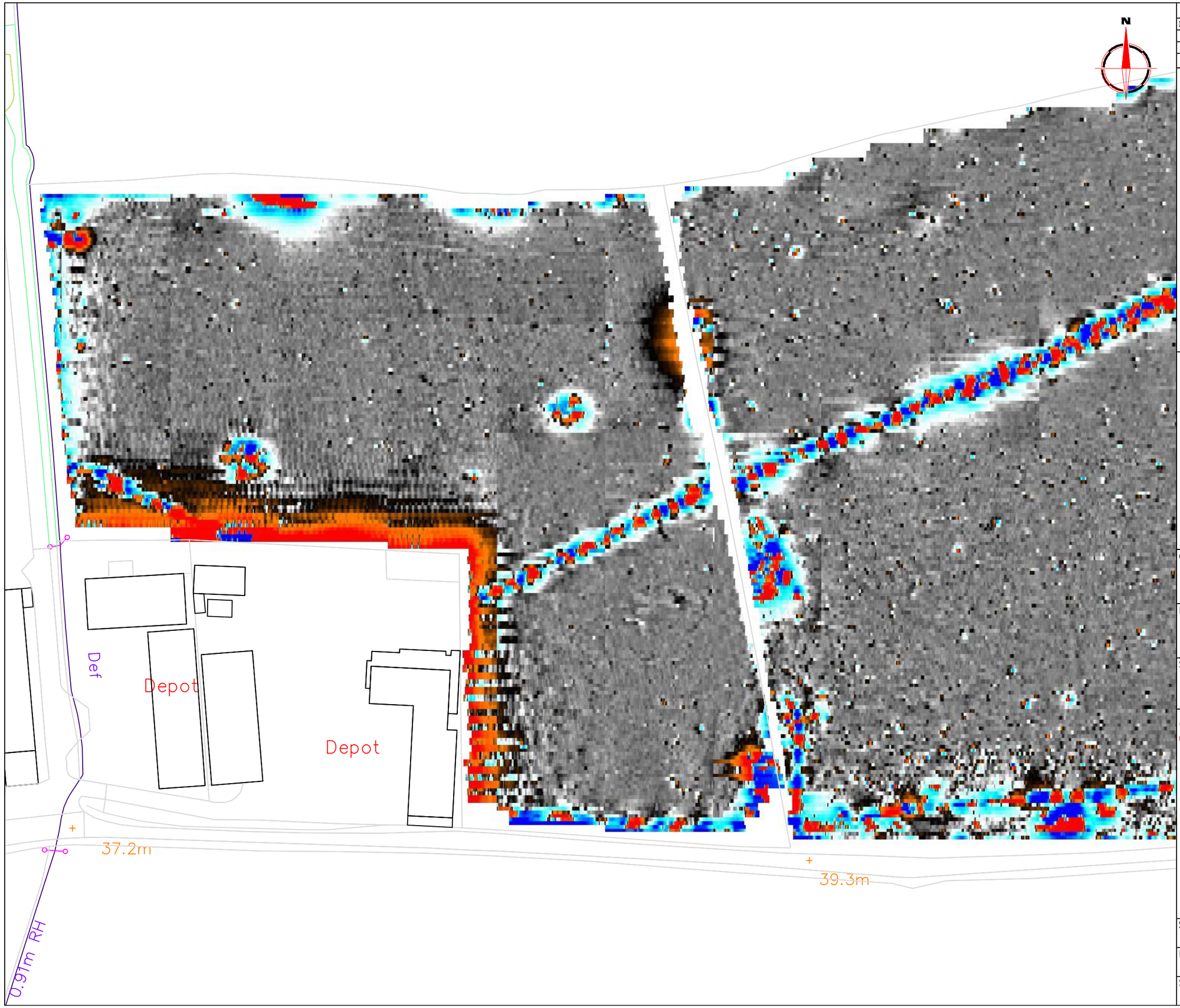

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Client
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Project Title
GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

Job No. 9818

Subject
COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES - WEST

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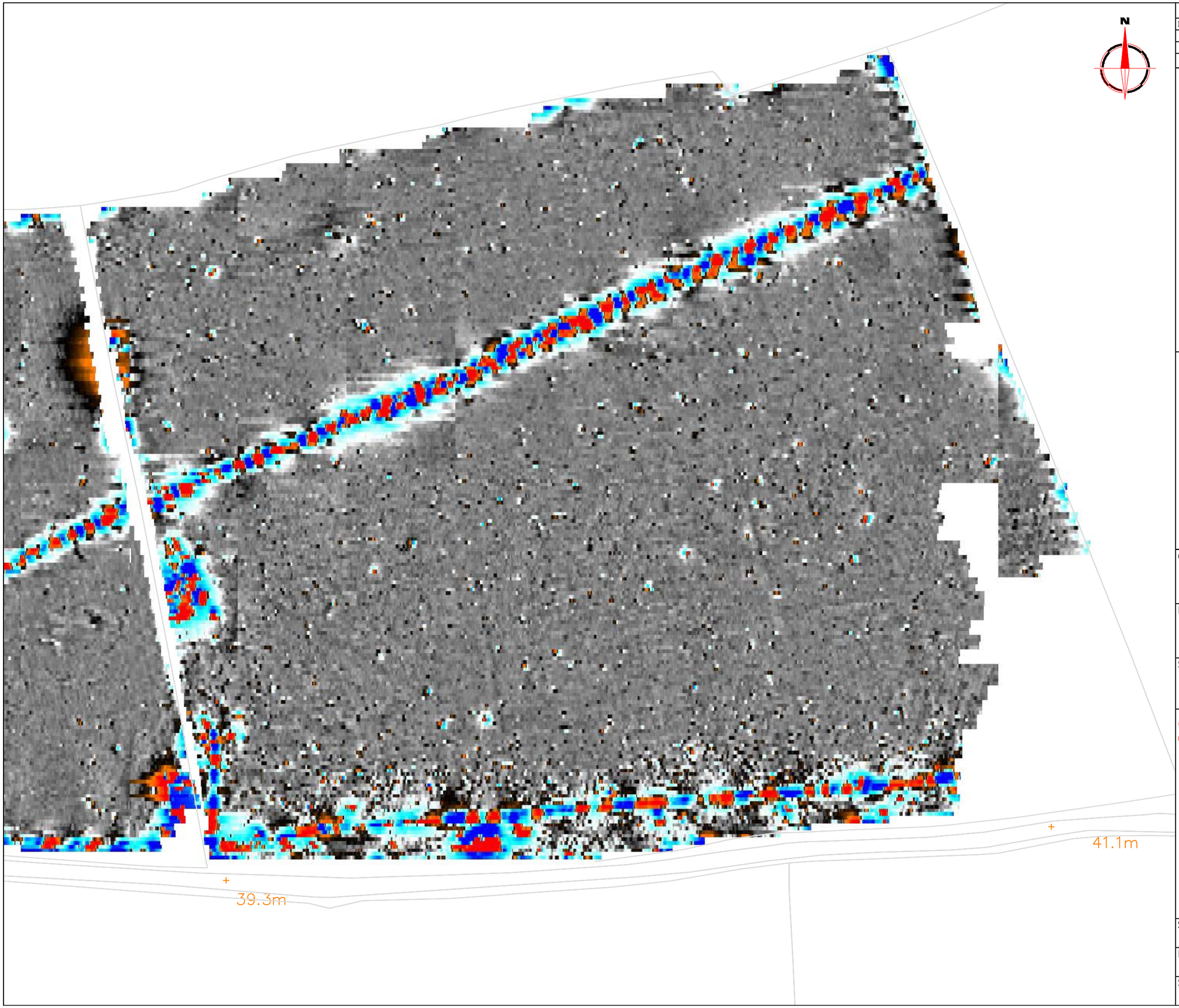

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-100nT

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COLOUR PLOT OF GRADIOMETER DATA SHOWING EXTREME VALUES - EAST

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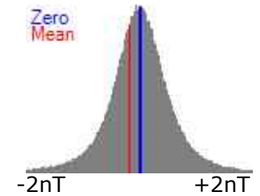

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PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA - OVERVIEW

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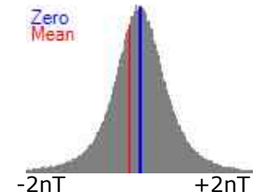

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GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

Subject
PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA - WEST

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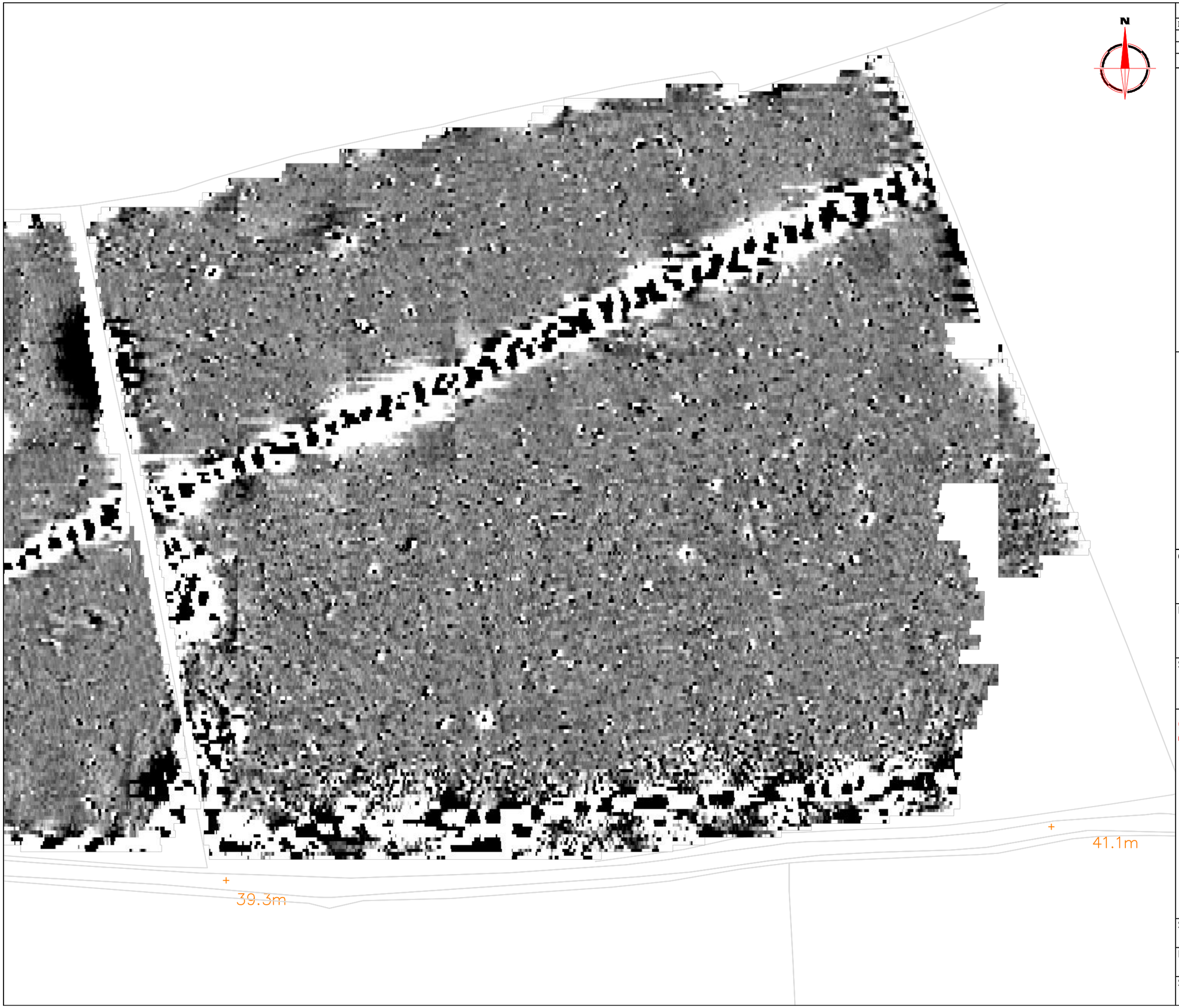

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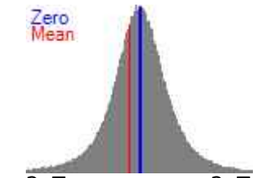

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GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

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PLOT OF MINIMALLY PROCESSED GRADIOMETER DATA - EAST

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Scale 1:1000 (0m 10 20 30 40 50)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
APR 16	RD	08

Amendments

Issue No.	Date	Description
-	-	-
-	-	-

MEDIEVAL/POST-MEDIEVAL AGRICULTURE

- Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
- Linear anomaly - probably related to a former field boundary not present on available mapping
- Strong magnetic debris - related to former pond visible on available mapping
- Strong magnetic debris - possibly related to former pond not visible on available mapping

WWII MILITARY ANOMALIES

- Magnetic disturbance - likely associated with former structures, or other feature, of military site
- Scattered magnetic debris - likely related to former military site

OTHER ANOMALIES

- Linear anomaly - probably related to pipe, cable or other modern service
- Positive anomaly - uncertain origin, possibly associated with WWII military site
- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Scattered magnetic debris
- Magnetic spike - probable ferrous object

Client
RPS

Project Title
GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

Job No. 9818

Subject
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - OVERVIEW

STRATASCAN™
GEOPHYSICS FOR ARCHAEOLOGY AND ENGINEERING
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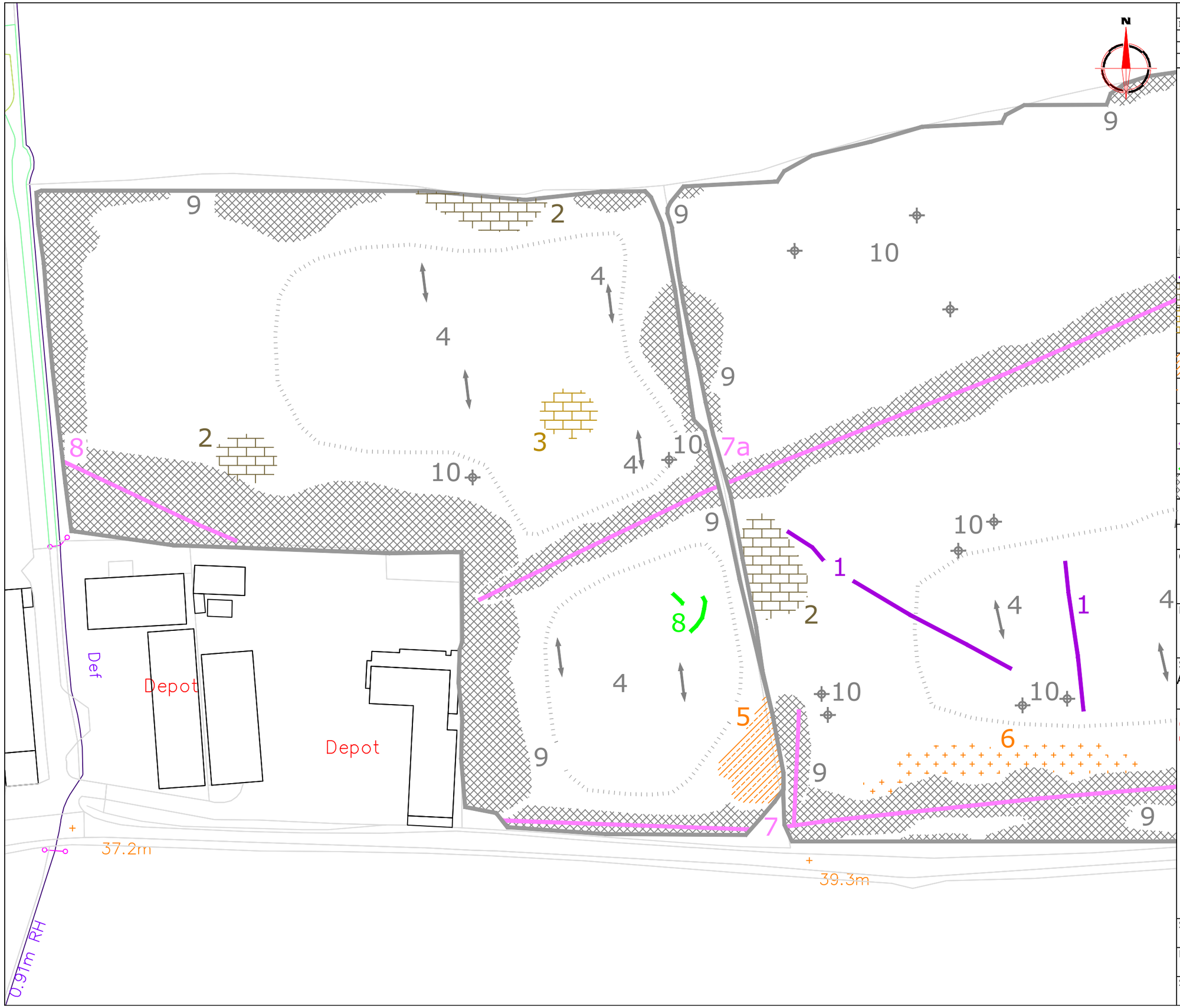
SUMO GROUP MEMBER

Scale 1:1500 (0m 10 20 30 40 50m)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
APR 16	RD	09



Amendments

Issue No.	Date	Description
-	-	-
-	-	-

MEDIEVAL/POST-MEDIEVAL AGRICULTURE

- Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
- Linear anomaly - probably related to a former field boundary not present on available mapping
- Strong magnetic debris - related to former pond visible on available mapping
- Strong magnetic debris - possibly related to former pond not visible on available mapping

WWII MILITARY ANOMALIES

- Magnetic disturbance - likely associated with former structures, or other feature, of military site
- Scattered magnetic debris - likely related to former military site

OTHER ANOMALIES

- Linear anomaly - probably related to pipe, cable or other modern service
- Positive anomaly - uncertain origin, possibly associated with WWII military site
- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Scattered magnetic debris
- Magnetic spike - probable ferrous object

Client: RPS

Project Title: GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

Job No. 9818

Subject: ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - WEST

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Scale 1:1000 (0m 10 20 30 40 50)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
APR 16	RD	10

Amendments

Issue No.	Date	Description
-	-	-
-	-	-

MEDIEVAL/POST-MEDIEVAL AGRICULTURE

- Closely spaced parallel linear anomalies - probably related to agricultural activity such as ploughing
- Linear anomaly - probably related to a former field boundary not present on available mapping
- Strong magnetic debris - related to former pond visible on available mapping
- Strong magnetic debris - possibly related to former pond not visible on available mapping

WWII MILITARY ANOMALIES

- Magnetic disturbance - likely associated with former structures, or other feature, of military site
- Scattered magnetic debris - likely related to former military site

OTHER ANOMALIES

- Linear anomaly - probably related to pipe, cable or other modern service
- Positive anomaly - uncertain origin, possibly associated with WWII military site
- Magnetic disturbance associated with nearby metal object such as service or field boundary
- Scattered magnetic debris
- Magnetic spike - probable ferrous object

Client
RPS

Project Title
GEOPHYSICAL SURVEY - FABLINK, EXETER, DEVON

Job No. 9818

Subject
ABSTRACTION AND INTERPRETATION OF GRADIOMETER ANOMALIES - EAST

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EUROPEAN GPR ASSOCIATION

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ISO 14001 certified

Scale 1:1000 (0m 10 20 30 40 50)

Plot	Checked by	Issue No.
A3	DGE	01
Survey date	Drawn by	Figure No.
APR 16	RD	11

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