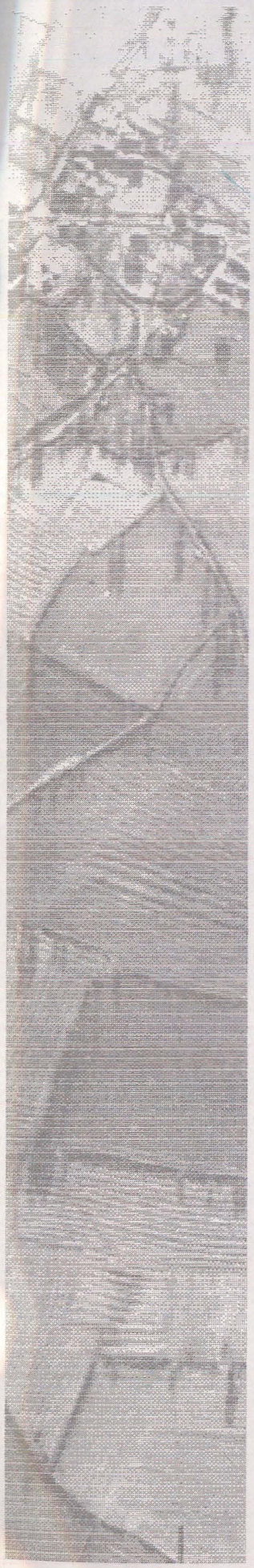

ARCHAEOLOGICAL SURVEYS

GEOPHYSICAL SURVEY REPORT

Churchill Avenue, Skegness

Magnetic Susceptibility and
Magnetometer Survey

for

Manorcrest Homes Ltd.

David Sabin and Kerry Donaldson

March 2006

Ref no. J139

ARCHAEOLOGICAL SURVEYS

Churchill Avenue, Skegness

Magnetic Susceptibility and Magnetometer Survey

for

Manorcrest Homes Ltd.

Report and fieldwork by David Sabin and Kerry Donaldson

Survey date – **from March 31st to 1st April**

Ordnance Survey Grid Reference – **TF 560 650**

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CONTENTS

LIST OF FIGURES

LIST OF HISTOGRAMS

LIST OF PLATES

SUMMARY

Magnetic susceptibility reconnaissance survey followed by targeted detailed magnetometry was carried out on land off Churchill Avenue towards the northern side of Skegness. The reconnaissance survey revealed generally low levels of soil susceptibility with small pockets of moderate enhancement towards the northern end of the survey area. Detailed magnetometry targeted the most enhanced areas and also 'tested' areas of low enhancement in order to produce a more even distribution of target areas. Almost all of the target areas revealed characteristic patterns associated with former salt marsh, creeks etc. and few anomalies could be confidently characterised and interpreted. A number of linear anomalies with a possible anthropogenic origin were located and may represent former cut features such as ditches although it is not possible to infer a period of use or construction from the results.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys were commissioned by Manocrest Homes Ltd. to undertake a geophysical survey of an area of land at Skegness in Lincolnshire that has been outlined for a proposed residential development. This survey formed part of an assessment of any potential archaeology that may be affected by the development.

1.2 Survey objectives

1.2.1 The objective of the survey was to carry out magnetic susceptibility reconnaissance at a coarse resolution in order to identify zones of magnetic enhancement that may indicate areas of human occupation/modification. Subsequent targeting of enhanced areas, using detailed magnetometry in order to locate geophysical anomalies that may be archaeological in origin, was conducted to allow a more detailed assessment of the archaeological potential of the site.

1.3 Site location

1.3.1 The site is located to the north of Skegness in Lincolnshire at OS grid reference TF 560 650.

1.4 Site description

1.4.1 The geophysical survey covers an area of approximately 15ha of flat agricultural land. At the time of surveying a short arable crop was emerging across much of the survey area and the soil was reasonably dry and aerated.

1.4.2 The site is bounded to the south by new residential dwellings and compounds used for holding construction materials. The area is split into two fields separated by an open ditch and having a general orientation north northeast to

south southwest. Open ditches form boundaries to the west and east whilst the northern boundary is formed by a curving hedgerow.

Plate 1 Looking northeast from the southern end of the survey area

1.5 Site history and archaeological potential

1.5.1 No specific details relating to the site were available to archaeological surveys. No observations of earthworks or other features of archaeological potential were made within the survey area, surface finds consisted of very occasional post medieval pottery sherds.

1.6 Geology and soils

1.6.1 The underlying solid geology consists of chalk but this is overlain by alluvial deposits (BGS 2001, 1977).

1.6.2 The soils across much of the site are from the Wallasea 2 association and form over marine alluvium, groundwater is often controlled by ditches and pumps in these areas.(Soil Survey of England and Wales 1983).

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Iron minerals within the soil can be altered through biological decay and burning which can enhance the magnetic susceptibility of the soil. Field equipment can be used to measure the magnetic susceptibility of the soil allowing zones to be mapped which may indicate areas of potential

archaeological activity. This also allows subsequent targeting of higher resolution survey techniques such as magnetometry or resistivity in order to obtain more detail.

2.1.2 Magnetic susceptibility is only measurable in the presence of a magnetic field and is defined as a ratio between the intensity of the induced field to that of the magnetising field. As the two fields are measured in the same units the ratio can effectively be defined using no units although it is common practice to add SI to distinguish measurements from an older system.

2.1.3 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.

2.1.4 The localised variations in magnetism are measured as sub-units of the tesla which is a SI unit of magnetic flux density. These sub-units are nanoteslas (nT) which are equivalent to 10^{-9} tesla (T).

2.2 Equipment details and configuration

2.2.1 The magnetic susceptibility survey was conducted using an MS2 meter with MS2D field coil manufactured by Bartington Instruments Ltd. The instrument was used in conjunction with a CSI Wireless Differential Global Positioning System (dGPS) receiver used to navigate to measuring positions.

2.2.2 Magnetic susceptibility data was collected every 20m. Each position was recorded 3 to 5 times to ensure a representative value free from erratic or spurious readings created by ferrous debris or poor soil contact. The values were entered into PocketGIS software as a point attribute attached to the coordinates of each recording station.

2.2.3 The detailed magnetic survey (magnetometry 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.

2.2.4 Data was collected at 0.25m centres along traverses 1m apart. The survey was targeted over 6 separate areas which were split into 30m by 30m grids giving 3600 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). The survey areas and grids were set out to the Ordnance Survey National Grid

(OSGB36) using a Topcon GTS212 total station in conjunction with a CSI Wireless dGPS.

2.3 Data processing and presentation

2.3.1 Magnetic susceptibility readings recorded in the field using PocketGIS were downloaded into MapInfo GIS software with Vertical Mapper and displayed as an interpolated colour plot using a fifth order polynomial solution, see Figure 02. No processing is required for this data.

2.3.2 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.

2.3.3 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:

Processing

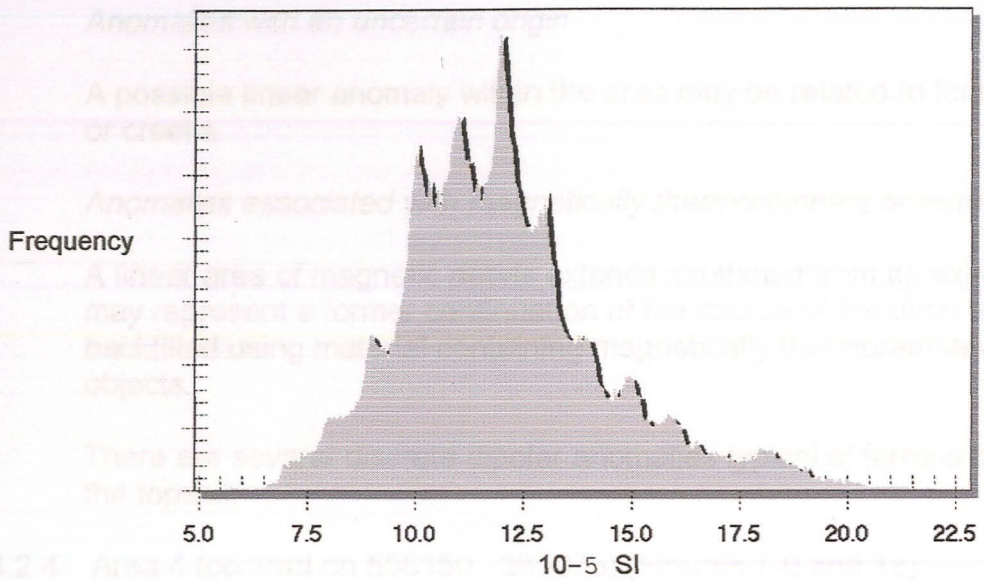
- Clipping of the raw data at ±10nT to improve greyscale resolution
- Clipping of processed data at either ±3nT to enhance low magnitude anomalies
- Clipping of trace plots at ±100nT in order to minimise strong readings obscuring low magnitude responses
- Destagger may also be used to enhance linear anomalies
- Zero mean traverse is applied in order to balance readings along each traverse

3 RESULTS

3.1 Magnetic susceptibility

3.1.1 The magnetic susceptibility survey shows that levels of enhancement were confined to a relatively narrow range from 5 to 22 10^{-5} SI. Pockets of relative enhancement were located in the north and north eastern parts of the survey area. Detailed magnetic survey was targeted over six separate areas, four of which were relatively enhanced zones, with two areas chosen to test low enhancement and produce a more even distribution of detailed magnetometry across the site.

3.1.2 Histogram 1 is used to demonstrate the frequency and range of data across the site, further discussion is offered in Section 4 below.



Histogram 1 Frequency of magnetic susceptibility values derived from Vertical Mapper

3.2 Detailed magnetometry

The detailed magnetic survey was carried out over a total of six survey areas (Figure 03) covering a total area of approximately 1.5ha. Four areas were targeted over zones of high magnetic enhancement (Areas 2, 3, 4 and 5), as revealed by the magnetic susceptibility reconnaissance survey, with two areas used as a control for zones of low magnetic susceptibility and to improve the distribution of magnetometry across the site(Areas 1 and 6). Most survey areas produced characteristic patterns associated with former salt marsh and tidal creeks and these have not been abstracted for the purpose of clarity.

3.2.1 Area 1 (centred on 556030, 364875) (Figures 4-6 and 13)

Anomalies with an uncertain origin

A number of possible linear anomalies may be related to a natural response associated with former salt marsh and creeks.

Anomalies associated with magnetically thermoremnant or ferrous material

There are several discrete dipolar anomalies typical of ferrous objects within the topsoil.

3.2.2 Area 2 (centred on 556070, 365035) (Figures 4-6 and 13)

Anomalies associated with magnetically thermoremnant or ferrous material

There are several discrete dipolar anomalies typical of ferrous objects within the topsoil.

3.2.3 Area 3 (centred on 556090, 365150) (Figures 7-9 and 13)

Anomalies with an uncertain origin

A possible linear anomaly within the area may be related to former salt marsh or creeks.

Anomalies associated with magnetically thermoremnant or ferrous material

A linear area of magnetic debris extends southeast from an existing ditch and may represent a former continuation of the course of the ditch which has been backfilled using material containing magnetically thermoremnant or ferrous objects.

There are several discrete dipolar anomalies typical of ferrous objects within the topsoil.

3.2.4 Area 4 (centred on 556150, 365075) (Figures 7-9 and 13)

Anomalies with an uncertain origin

A linear anomaly with a northeast to southwest orientation extends across the eastern half of the survey area. The origin of the feature is uncertain but drainage should be considered.

Anomalies associated with magnetically thermoremnant or ferrous material

There are several discrete dipolar anomalies typical of ferrous objects within the topsoil.

3.2.5 Area 5 (centred on 556010, 365315) (Figures 7-9 and 13)

Anomalies with an uncertain origin

A single faint linear anomaly is of uncertain origin.

Anomalies with an agricultural origin

A series of parallel linear anomalies have a similar orientation to nearby ditches and probably represent agricultural marks created by ploughing or drainage.

Anomalies associated with magnetically thermoremnant or ferrous material

There are several discrete dipolar anomalies typical of ferrous objects within the topsoil.

3.2.6 Area 6 (centred on 555890, 364870) (Figures 10-13)

Anomalies with an uncertain origin

Two parallel linear anomalies cross the survey area with a northwest to southeast orientation. These anomalies are not parallel or perpendicular to current land boundaries and may represent cut features.

A faint linear anomaly with an east west orientation is also of uncertain origin.

Anomalies associated with magnetically thermoremnant or ferrous material

There are several discrete dipolar anomalies typical of ferrous objects within the topsoil.

4 DISCUSSION

4.1 Magnetic susceptibility survey

4.1.1 Magnetic susceptibility across the site varies little although there are pockets of enhancement towards the north eastern and northern parts of the survey area. However, the peak values recorded during the survey are certainly unremarkable which may be a function of the local soil conditions; for example it is known that gley soils with periods of waterlogging can have suppressed susceptibilities even where anthropogenic activity is high.

4.1.2 Considering Histogram 1, see 3.1.2 above, it can be seen that the curve is approximately 'bell-shaped' with little extension on the upper end of the curve. This type of distribution tends to support any interpretation for a lack of anthropogenic modification to the soil though again this should be treated cautiously as the particular soil conditions may be unsuitable for enhancement. Even if soil conditions are unsuitable there is certainly little evidence for 'industrial period' dumping which tends to act independently of soil conditions and relates to the incorporation of clinker etc. in the topsoil.

4.1.3 Of the areas of enhanced magnetic susceptibility that were located, only Area 3 offers some evidence for the origin of the enhancement from the targeted detailed magnetometry. An area of magnetic debris located in Area 3 tends to suggest the line of a former ditch possibly backfilled with material that has a magnetically thermoremnant element such as brick. Areas of enhancement away from Area 3 may therefore only relate to variations within the topsoil susceptibility as no solid relationship with cut features could be established. It is possible that the variations within the topsoil susceptibility may relate to the incorporation of naturally enhanced material from deeper in the soil profile, this material may be associated with the former salt marsh that has been clearly located by the detailed magnetometry.

4.2 Detailed magnetometry

4.2.1 Very few features were located by the targeted detailed magnetometry that could be confidently interpreted. Anomalies classed as uncertain may represent former cut features although there were no characteristics

associated with these anomalies that could allow confident interpretation. Area 6 has the most notable uncertain anomalies which appear as a pair of parallel linear responses possibly representing former cut features. These anomalies do not appear to respect the current layout of land packages which may infer that they are earlier features.

4.2.2 Almost all survey areas show characteristic magnetic variation and patterns associated with former salt marsh and creeks. These anomalies can obscure and confuse detailed magnetometry and in such environments it is difficult to distinguish natural from man-made features. The response is not common in the UK and is generally limited to a small zone along the east coast of England although its occurrence is not easy to predict; in the Netherlands it is more common and has been better researched (Kattenberg, 2004).

5 CONCLUSION

5.1.1 A number of uncertain magnetic anomalies were located across the site and there is little evidence for the presence of significant archaeological anomalies. Area 6 appears to contain parallel linear anomalies that do not respect the current land layout and may therefore be tentatively interpreted as earlier features.

5.1.2 Suppressed topsoil magnetic susceptibilities, possibly related to periods of waterlogging, contrast strongly with natural anomalies related to enhanced susceptibilities at depth. These natural anomalies are formed by deposits related to former salt marsh and creeks and may be over 2m below the current land surface.

6 REFERENCES

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British Geological Society, 2001, *Solid Geology Map, UK South Sheet, 1:625 000 scale, 4th edition.*

English Heritage, 1995, *Geophysical survey in archaeological field evaluation. Research and Professional Service Guideline No 1.*

Kattenberg, A.E., Aalbersberg, G., 2004, *Archaeological Prospection of Dutch Perimarine Landscape by Means of Magnetic Methods.* Archaeological Prospection **11** pp227-235. John Wiley and Sons.

Kattenberg, A.E., 2004, *Magnetic Prospection on Potential Acid Sulphate Soils in the Netherlands and UK.* Paper delivered at the Environmental and Industrial Geophysics Group conference 15 December 2004.

Soil Survey of England and Wales, 1983, *Soils of England and Wales, Sheet 4 Eastern England.*

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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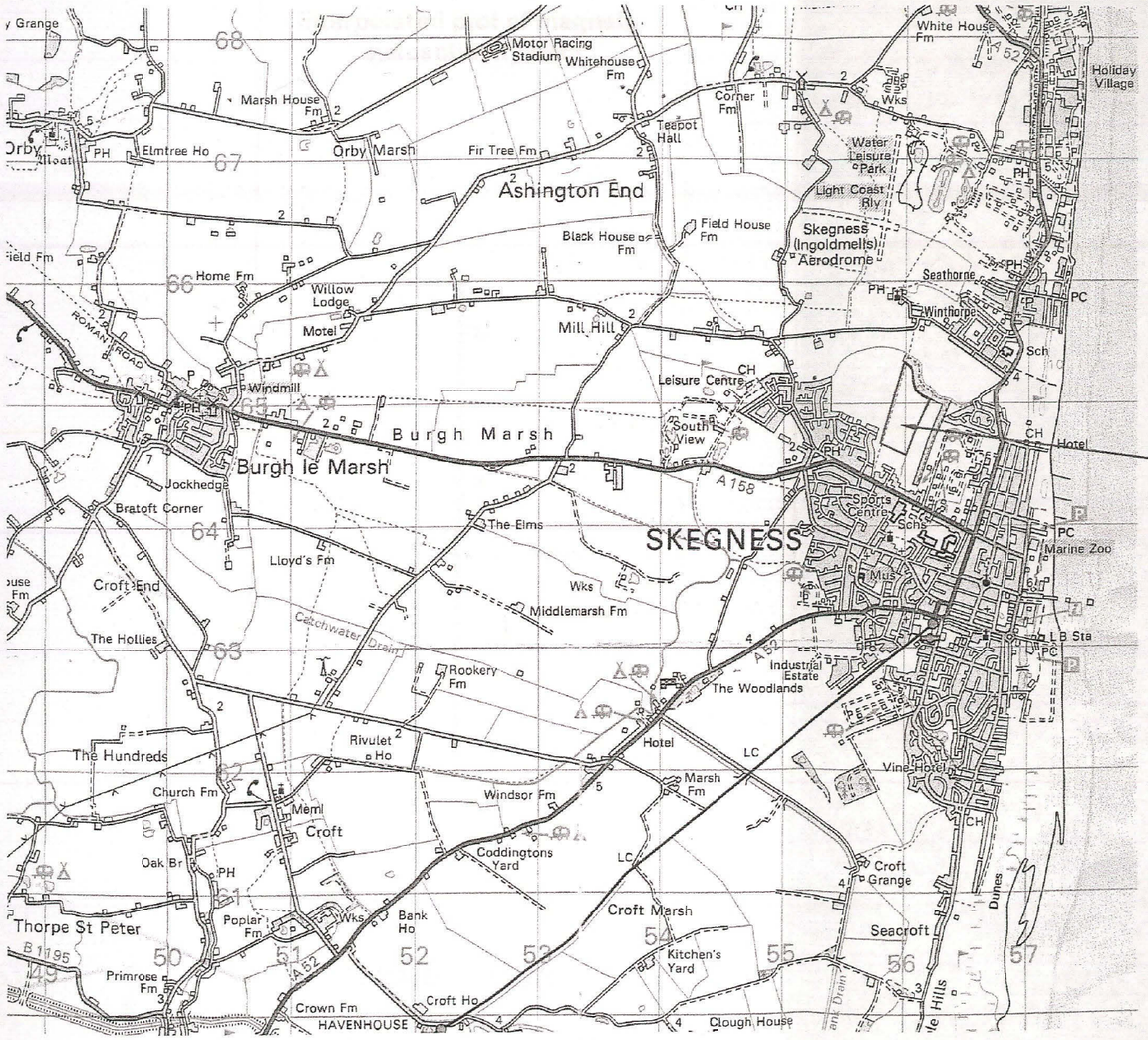
Map of survey area



Survey location

Site centred on OS NGR
TF 560 650

SCALE 1:50 000

0km 1 2km

FIG 01

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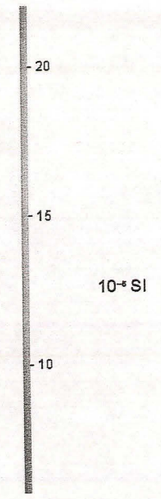
Interpolated plot of magnetic susceptibility data



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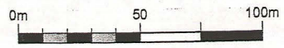
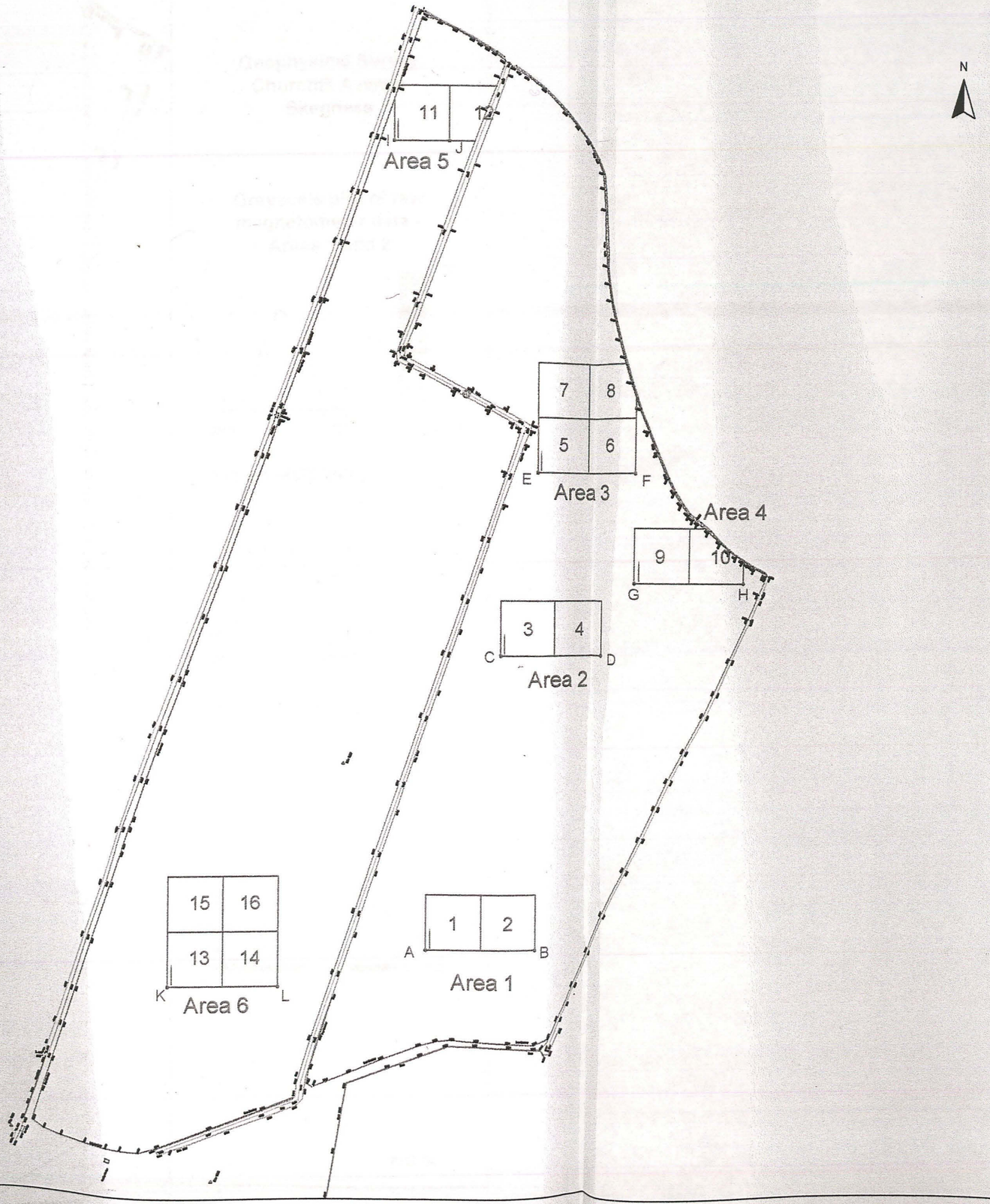


FIG 02



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Churchill Avenue
Skegness

Referencing information

Based on OS coordinates (OSGB36)

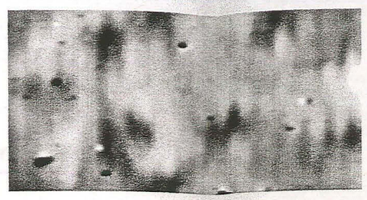
A	556000,	364860
B	556060,	364860
C	556040,	365020
D	556100,	365020
E	556060,	365120
F	556120,	365120
G	556120,	365060
H	556180,	365060
I	555980,	365300
J	556010,	365300
K	555860,	364840
L	555920,	364840

Survey start and traverse direction

SCALE 1:2500

0m 50 100m

FIG 03



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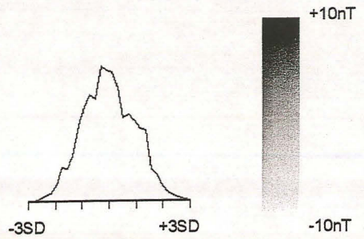
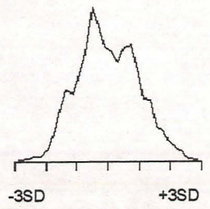
Greyscale plot of raw magnetometer data - Areas 1 and 2



Area 1 histogram



Area 2 histogram

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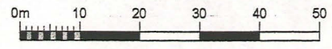
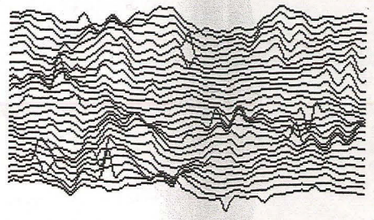
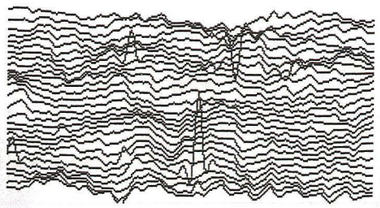


FIG 04





N

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Skegness

Traceplot of raw magnetometer data - Areas 1 and 2

+40nT — approx. 20nT/ cm vertical displacement.

+20nT

Data has been clipped at ± 100nT.

0nT

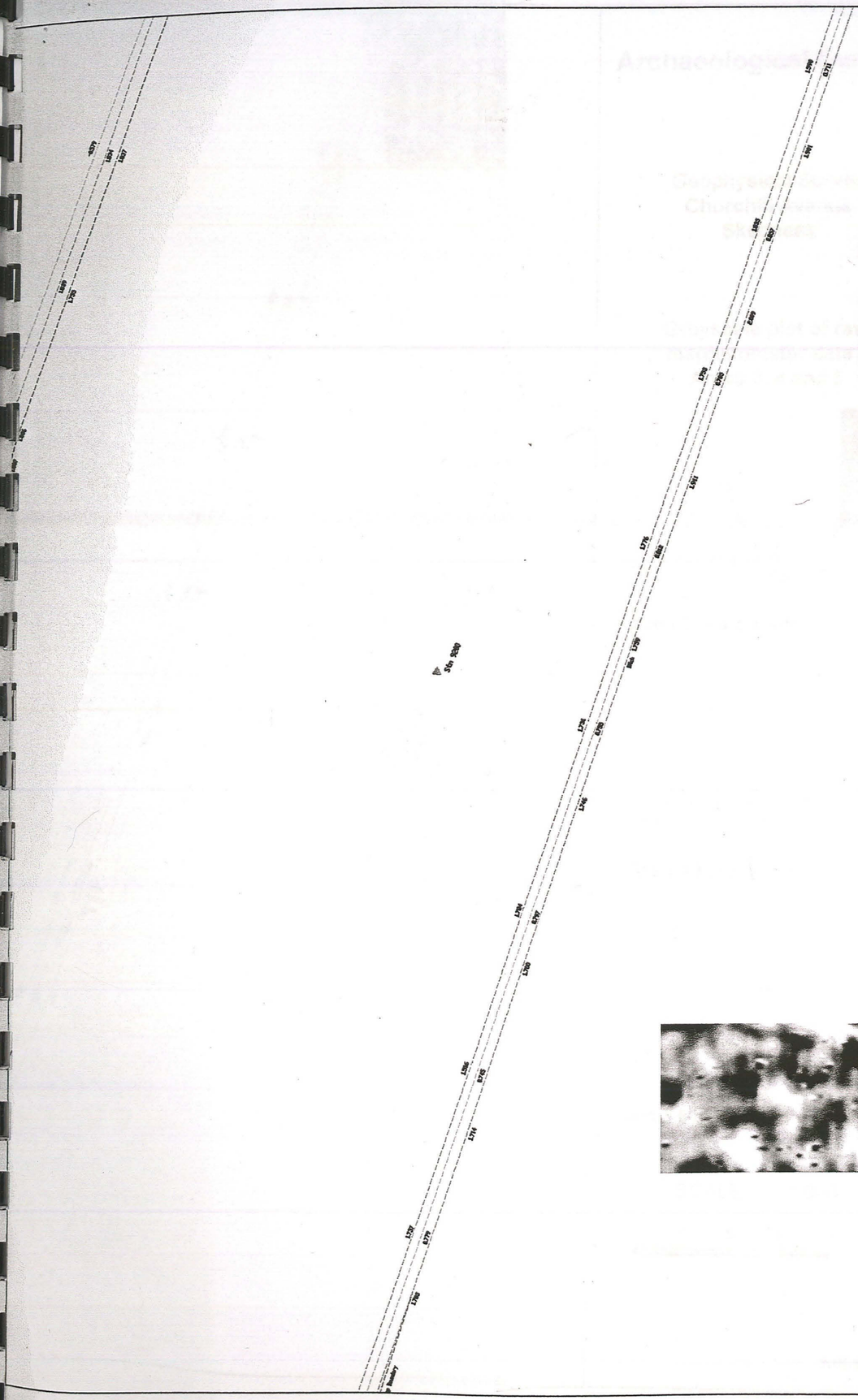
-20nT

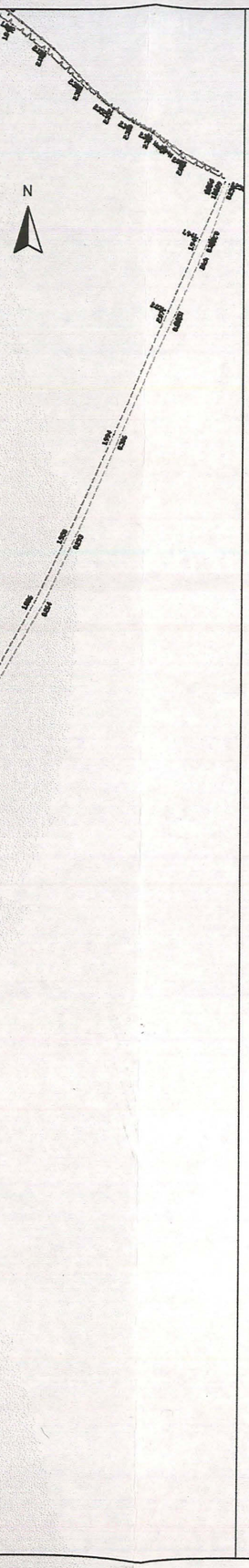
-40nT

SCALE 1:1000

0m 10 20 30 40 50m

FIG 05





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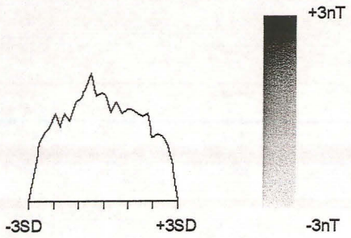
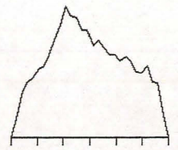
Skegness

Greyscale plot of processed magnetometer data - Areas 1 and 2



Area 1 histogram



Area 2 histogram

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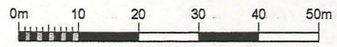
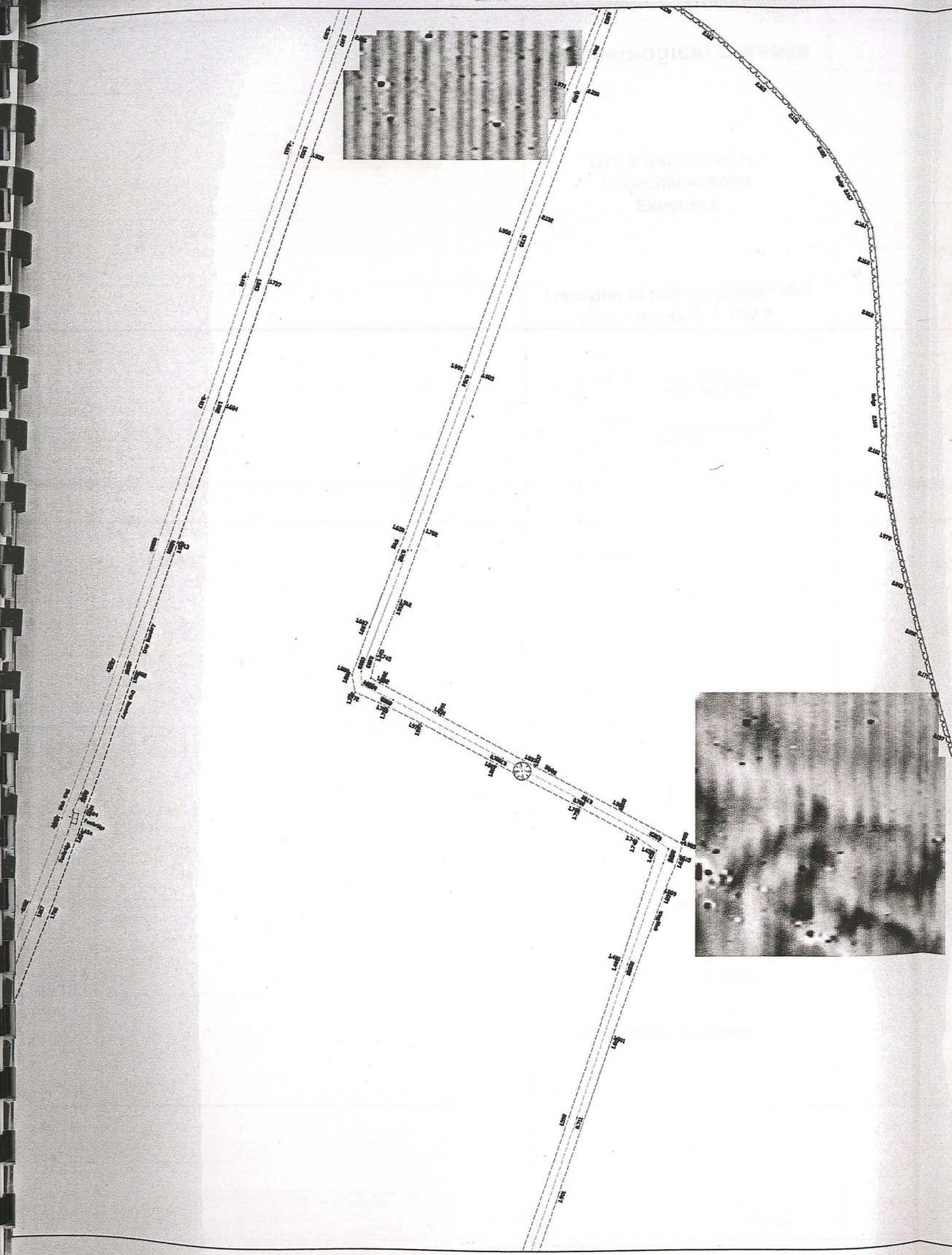


FIG 06



N

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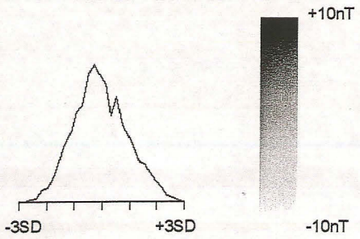
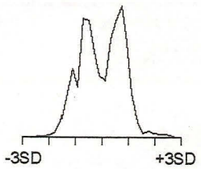
Greyscale plot of raw magnetometer data - Areas 3, 4 and 5



Area 3 histogram

Area 4 histogram



Area 5 histogram

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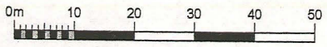
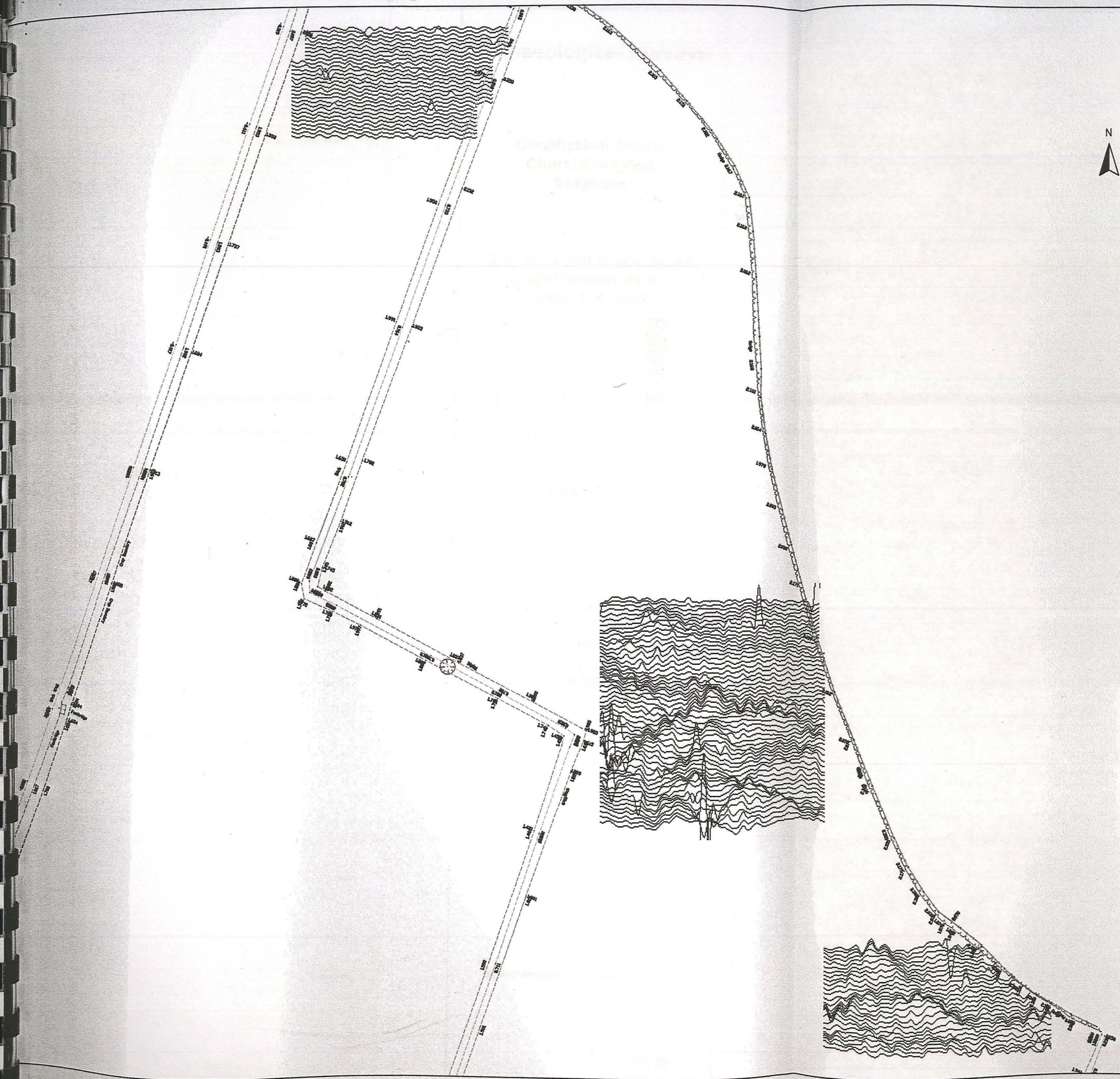


FIG 07



N

Archaeological Surveys

Geophysical Survey
Churchill Avenue
Skegness

Traceplot of raw magnetometer data - Areas 3, 4 and 5

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

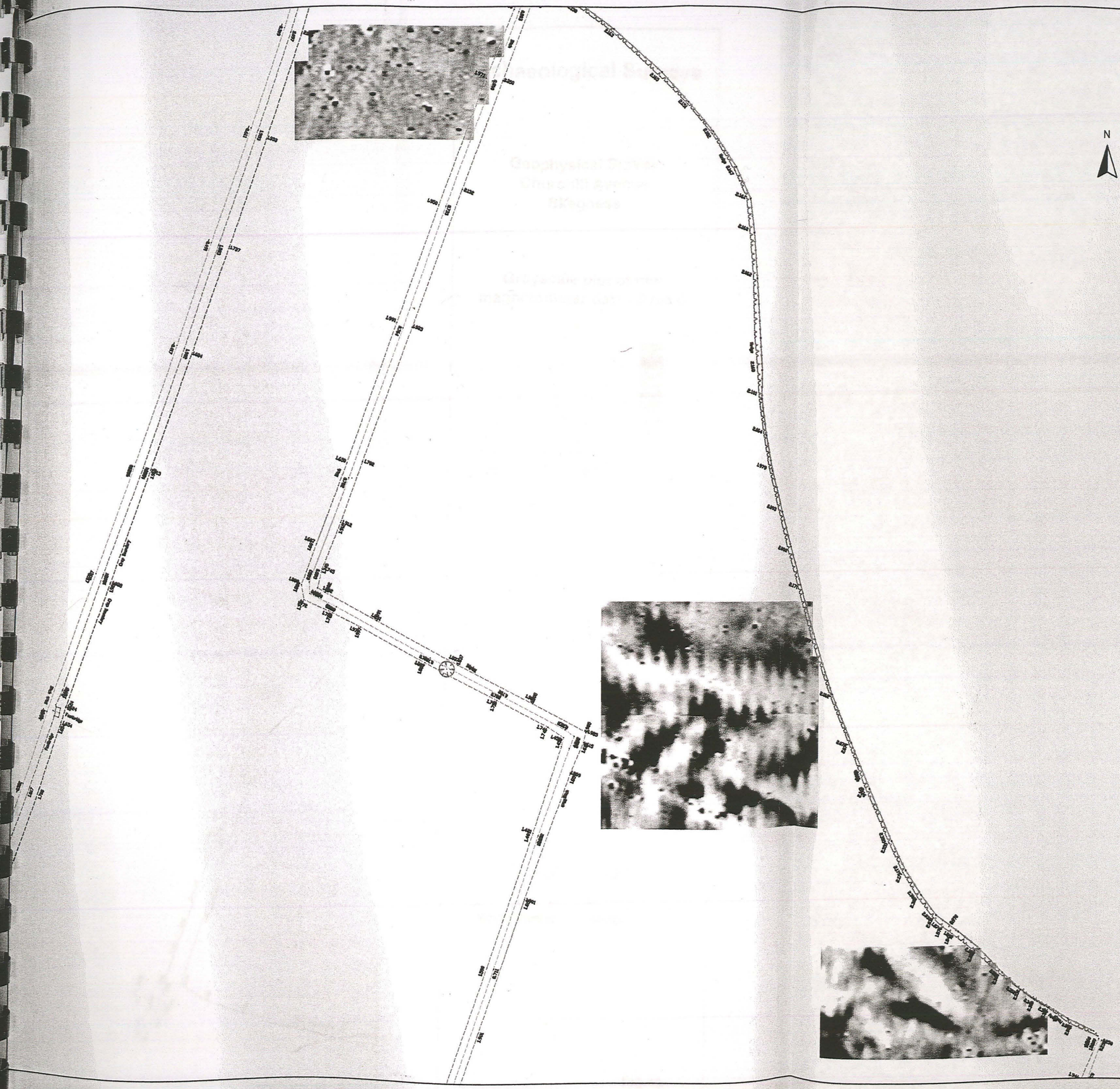
approx 20nT/ cm vertical displacement.

Data has been clipped at ± 100nT.

SCALE 1:1000

0m 10 20 30 40 50m

FIG 08



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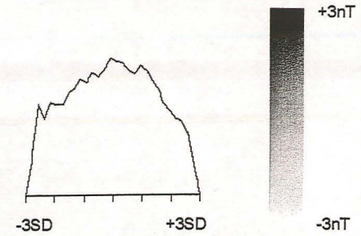
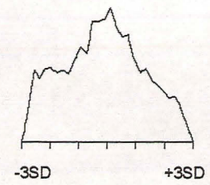
Archaeological Surveys

Geophysical Survey
Churchill Avenue
Skegness

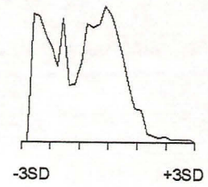
Greyscale plot of processed magnetometer data - Areas 3, 4 and 5



Area 3 histogram



Area 4 histogram



Area 5 histogram

SCALE 1:1000

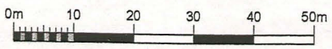
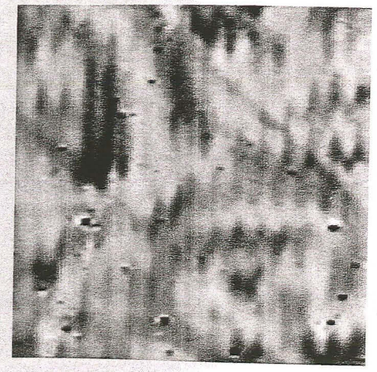


FIG 09



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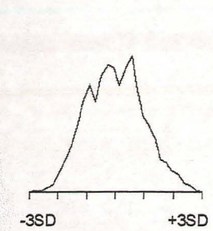
Greyscale plot of raw magnetometer data - Area 6



SCALE 1:1000

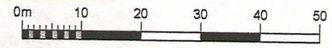
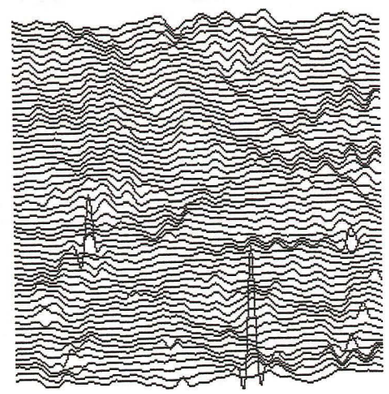


FIG 10



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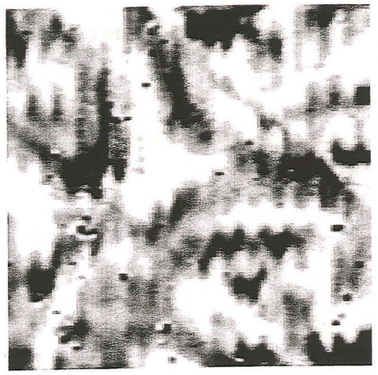
Traceplot of raw magnetometer data - Area 6

+40nT	approx 20nT/ cm vertical displacement.
+20nT	Data has been clipped at ± 100nT.
0nT	
-20nT	
-40nT	

SCALE 1:1000

0m 10 20 30 40 50m

FIG 11



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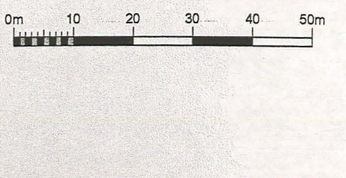
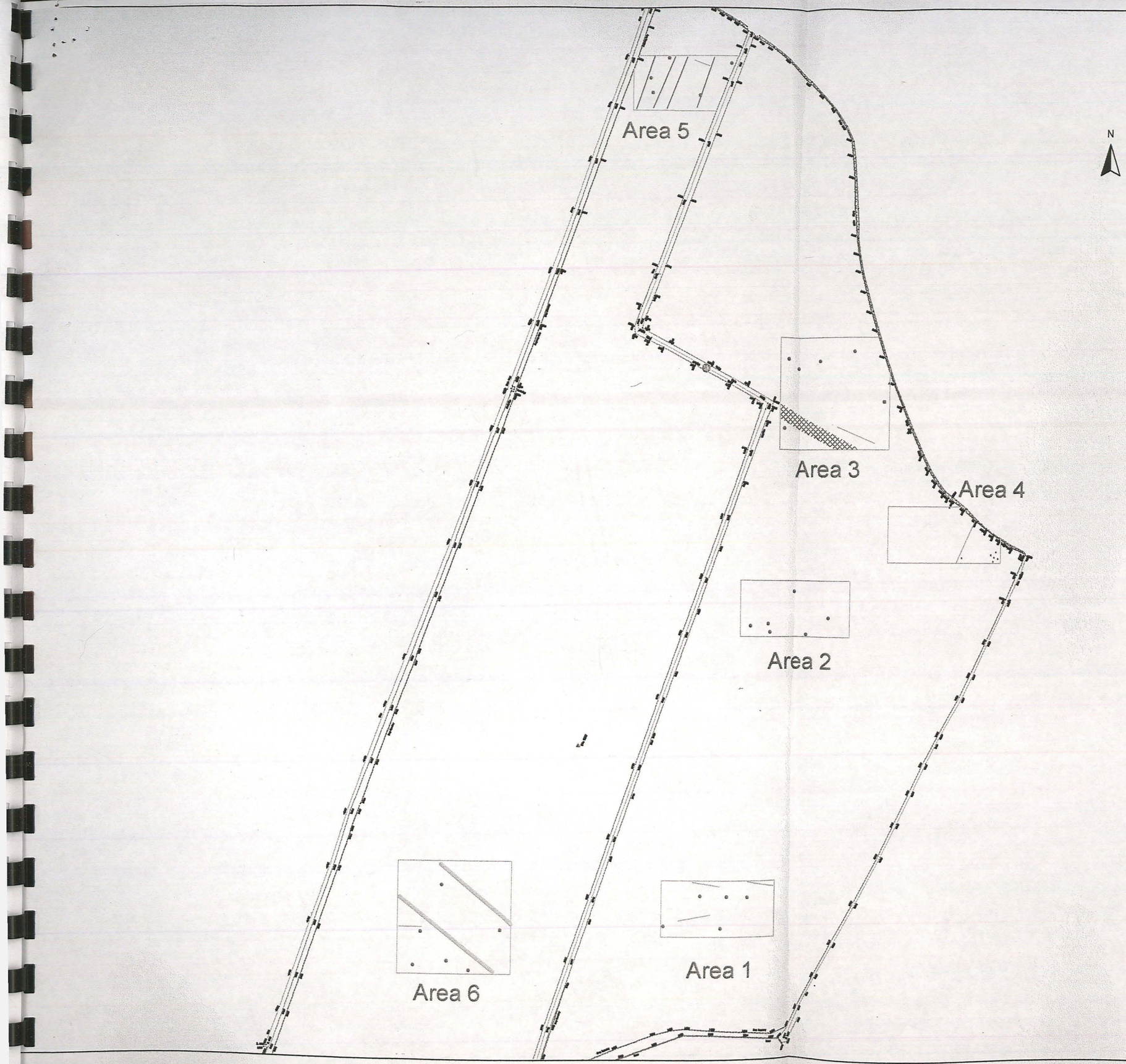
Greyscale plot of processed magnetometer data - Area 6



SCALE 1:1000

FIG 12



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Abstraction and interpretation of magnetometer anomalies

- Positive linear anomaly - uncertain origin
- Linear anomaly - of agricultural origin
- Magnetic debris - spread of thermoremnant material
- Strong dipolar anomaly - ferrous object in topsoil

SCALE 1:2000

0m 20 40 60 80 100m

FIG 13