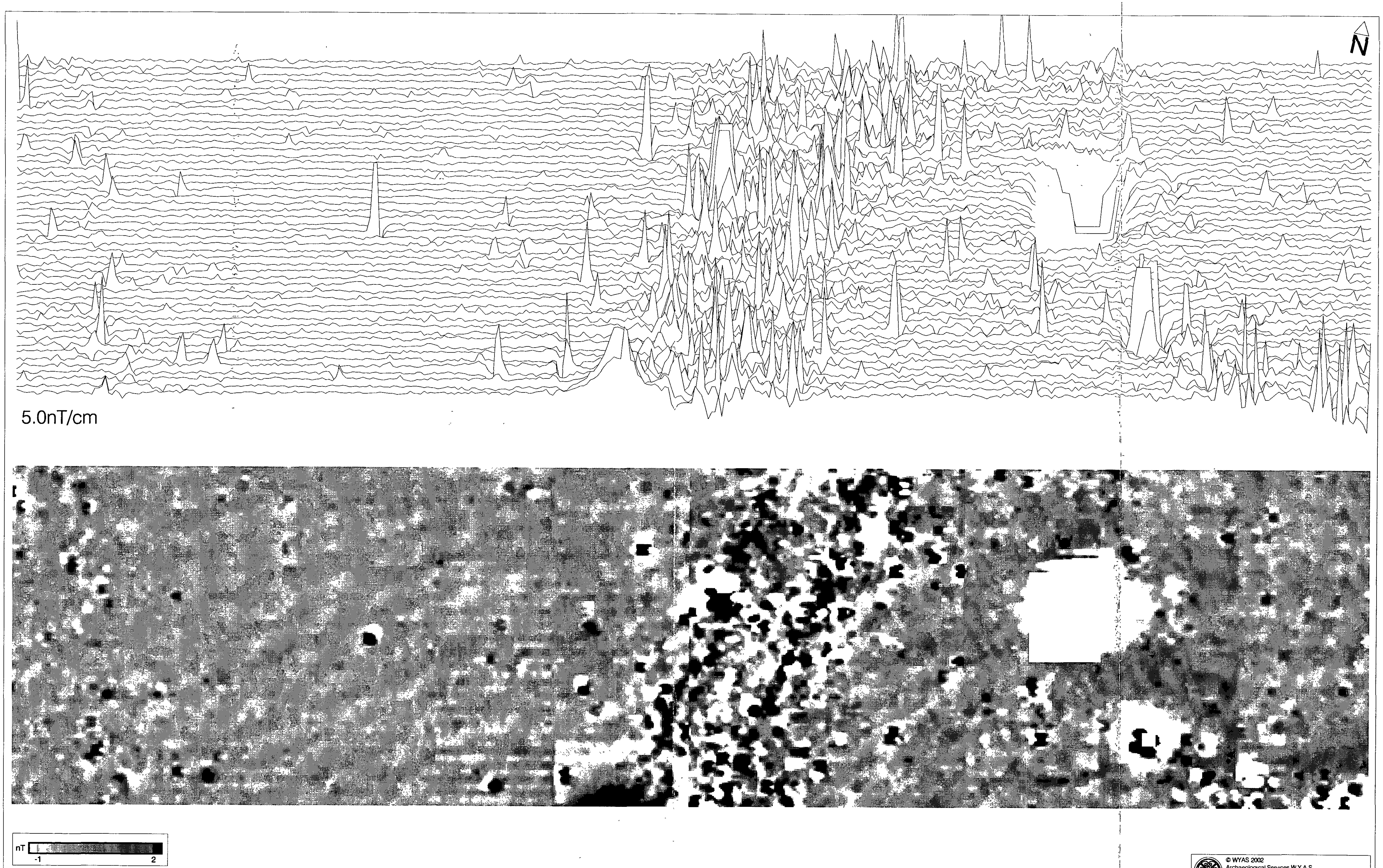
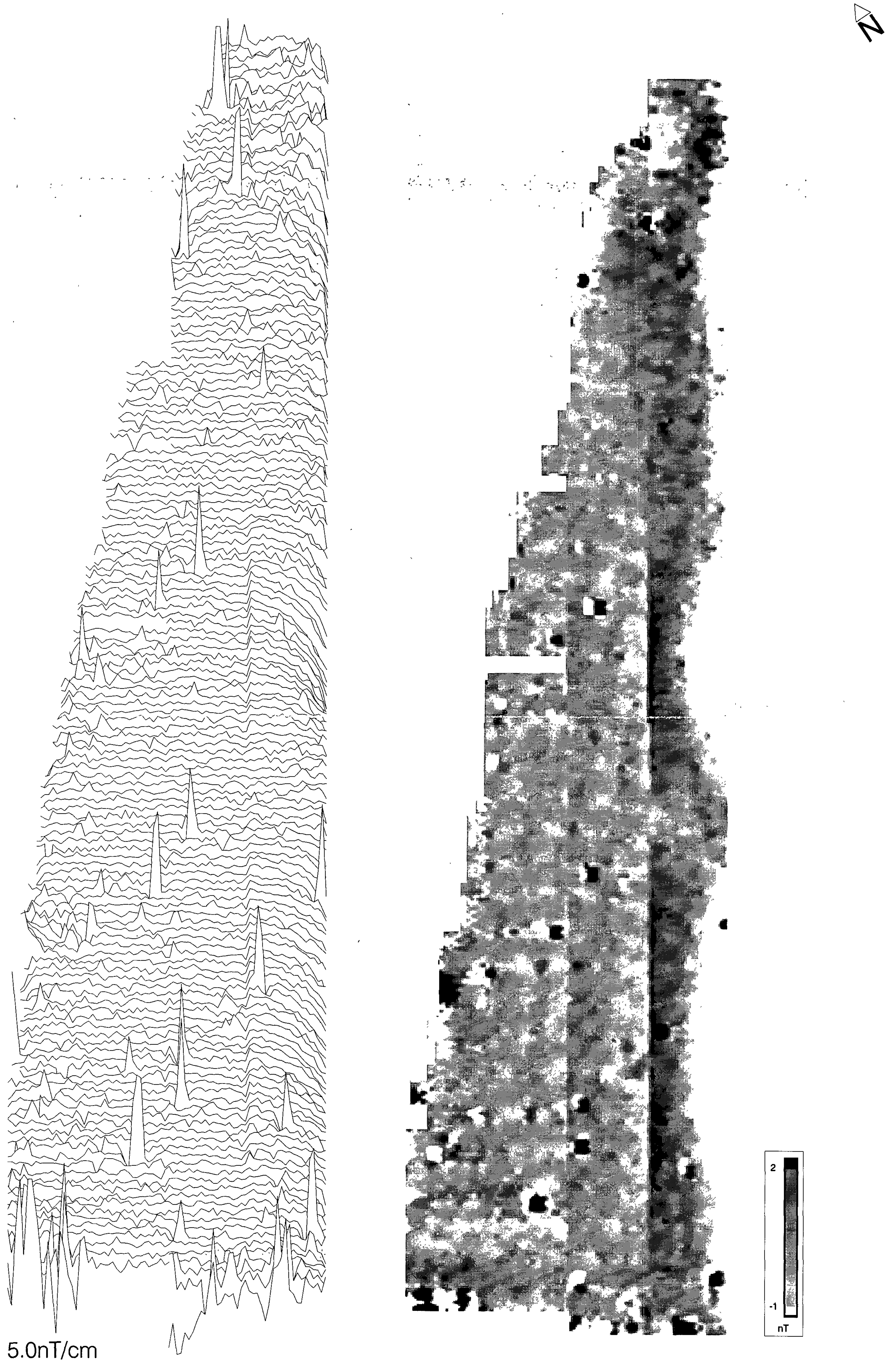


Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel 0113 383 7515 Fax 0113 383 7501

Fig. 41. Greyscale and X-Y trace plot of gradiometer data; Block N



Archaeological Services W Y A S
PO Box 30, Nepshaw Lane South, Morley, LS27 0UG
Tel 0113 383 7515 Fax 0113 383 7501

Fig. 42. Greyscale and X-Y trace plot of gradiometer data; Block O

Appendix 1

Magnetic Survey Technical Information

1 Magnetic Susceptibility and Soil Magnetism

1 1 Iron makes up about 6% of the Earth s crust and is mostly present in soils and rocks as minerals such as maghaemite and haemetite These minerals have a weak measurable magnetic property termed ***magnetic susceptibility*** Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility If the enhanced material subsequently comes to fill features such as ditches or pits localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer)

1 2 In general it is the contrast between the magnetic susceptibility of deposits filling cut features such as ditches or pits and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut which causes the most recognisable responses This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil thereby making it more magnetic than the subsoil or the bedrock Linear features cut into the subsoil or geology such as ditches that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels Discrete feature such as pits can also be detected Less magnetic material such as masonry or plastic service pipes that intrude into the topsoil may give a negative magnetic response relative to the background level

1 3 The magnetic susceptibility of the soil can also be enhanced significantly by heating This can lead to the detection of features such as hearths, kilns or burnt areas

2 Types of Magnetic Anomaly

2 1 In the majority of instances anomalies are termed ***'positive'*** This means that they have a positive magnetic value relative to the magnetic background on any given site However some features can manifest themselves as ***'negative'*** anomalies which, conversely means that the response is negative relative to the mean magnetic background Such negative anomalies are often very faint and are commonly caused by modern non ferrous features such as plastic water pipes Infilled natural features may also appear as negative anomalies on some geologies

2 2 Where it is not possible to give a probable cause of an observed anomaly a ? is appended

2 3 It should be noted that anomalies that are interpreted as modern in origin may be caused by features that are present in the topsoil or upper layers of the subsoil Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly

2 4 The types of response mentioned above can be divided into five main categories which are used in the graphical interpretation of the magnetic data

Isolated dipolar anomalies (iron spikes)

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

Areas of magnetic disturbance

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

Linear trend

This is usually a weak or broad linear anomaly of unknown cause or date An agricultural origin either ploughing or land drains is a common cause

Areas of magnetic enhancement/positive isolated anomalies

Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an X–Y trace plot) on two or three successive traverses In neither instance is there the intense dipolar response characteristic of an area of magnetic disturbance or of an iron spike (see above) These anomalies can be caused by infilled discrete archaeological features such as pits or post holes or by kilns They can also be caused by pedological variations or by natural infilled features on certain geologies Ferrous material in the subsoil can also give a similar response It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information

Linear and curvilinear anomalies

Such anomalies have a variety of origins They may be caused by agricultural practice (recent ploughing trends earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches

3 *Methodology*

3 1 Magnetic Susceptibility Survey

3 1 1 There are two methods of measuring the magnetic susceptibility of a soil sample The first involves the measurement of a given volume of soil which will include any air and moisture that lies within the sample and is termed volume specific susceptibility This method results in a bulk value that it not necessarily fully representative of the constituent components of the sample The second technique overcomes this potential problem by taking into account both the volume and mass of a sample and is termed mass specific susceptibility However, mass specific readings cannot be taken in the field where the bulk properties of a soil are usually unknown and so volume specific readings must be taken Whilst these values are not fully representative they do allow general comparisons across a site and give a

broad indication of susceptibility changes This is usually enough to assess the susceptibility of a site and evaluate whether enhancement has occurred

3 2 Gradiometer Survey

3 2 1 There are two main methods of using the fluxgate gradiometer for commercial evaluations The first of these is referred to as ***magnetic scanning*** and requires the operator to visually identify anomalous responses on the instrument display panel whilst covering the site in widely spaced traverses typically 10m apart The instrument logger is not used and there is therefore no data collection Once anomalous responses are identified they are marked in the field with bamboo canes and approximately located on a base plan This method is usually employed as a means of selecting areas for detailed survey when only a percentage sample of the whole site is to be subject to detailed survey In favourable circumstances scanning may be used to map out the full extent of features located during a detailed survey

3 2 2 The disadvantages of magnetic scanning are that features that produce weak anomalies (less than 2nT) are unlikely to stand out from the magnetic background and so will be difficult to detect The coarse sampling interval means that discrete features or linear features that are parallel or broadly oblique to the direction of traverse may not be detected If linear features are suspected in a site then the traverse direction should be perpendicular (or as close as is possible within the physical constraints of the site) to the orientation of the suspected features The possible drawbacks mentioned above mean that negative results from magnetic scanning should always be checked with at least a sample detailed magnetic survey (see below)

3 2 3 The second method is referred to as ***detailed survey*** and employs the use of a sample trigger to automatically take readings at predetermined points typically at 0 5m intervals on zig zag traverses 1m apart These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning

3 2 4 The Geoscan FM36 fluxgate gradiometer and ST1 sample trigger were used for the detailed gradiometer survey Readings were taken on the 0 1nT range at 0 5m intervals on zig-zag traverses 1m apart within 20m by 20m square grids The instrument was checked for electronic and mechanical drift at a common point after every three grids and calibrated as necessary The drift from zero was not logged

3 3 Data Processing and Presentation

3 3 1 The detailed gradiometer data has been presented in this report in X-Y trace and greyscale formats In both formats the data shown is raw with no processing other than grid biasing having been done

3 3 2 An X Y plot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y axis to produce a stacked plot A hidden line algorithm has been employed to block out lines behind major spikes and the data has been clipped at 10nT The main advantage of this display option is that the full range of data can be viewed dependent on the clip so that the shape of individual anomalies can be discerned and potentially archaeological anomalies differentiated from iron spikes In house software (XY3) was used to create the X-Y trace plots

3 3 3 In-house software (Geocon 9) was used to interpolate the data so that 1600 readings were obtained for each 20m by 20m grid Contors software was used to produce the greyscale images All greyscale plots are displayed in the range –InT to 2nT unless otherwise stated, using a linear incremental scale

Appendix 2

Survey Location Information

Individual grids were set out using a Geotronics Geodimeter 600s total station theodolite for each of the survey blocks These were tied into Yorkshire Water marker pegs and to permanent landscape features such as fence lines, field boundaries drains and temporary reference points The survey grids were then superimposed onto a digital map base provided by the client There was a good correlation between this geophysical survey data and the digital map base and it is estimated that the average best fit error is better than ±1 0m Despite this good correlation it is recommended that if any of the survey grids need to be re established accurately then the Ordnance Survey co ordinates for the Yorkshire Water marker pegs be used If other points are used then the potential errors mentioned above must be considered

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party or for the removal of any of the survey reference points

Appendix 3

Geophysical Archive

The geophysical archive comprises -

- an archive disk containing compressed (WinZip 6) files of the raw data report text (Word 97) and graphics files (CorelDraw6 and AutoCAD 2000) files
- a full copy of the report

At present the archive is held by Archaeological Services WYAS although it is anticipated that it may eventually be lodged with the Archaeology Data Service (ADS) Brief details will also be forwarded for inclusion on the English Heritage Geophysical Survey Database after the contents of the report are deemed to be in the public domain (i e available for consultation in the relevant Sites and Monument Record Office)