GeoQuest ASSOCIATES

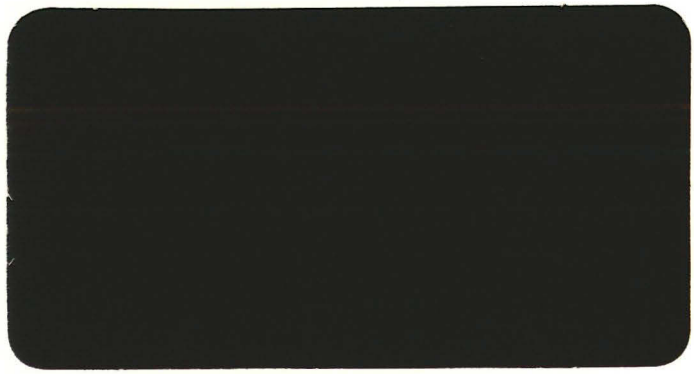
9716

GEOPHYSICAL SURVEY OF FIVE SITES ON THE ROUTE OF THE BLYBOROUGH (LINCS.) TO COTTAM (NOTTS.) GAS PIPELINE

Site Investigations

Lincolnshire County Council
Archaeology Section

12 Friars Lane
LINCOLN LN2 5AL
Tel: 01522 575292 Fax: 01522 530724



GEOPHYSICAL SURVEY OF FIVE SITES ON THE ROUTE OF THE BLYBOROUGH (LINCS.) TO COTTAM (NOTTS.) GAS PIPELINE

A programme of research carried out on behalf of

Wessex Archaeology

by

GeoQuest Associates

1 INTRODUCTION

1.1 This report presents the results of detailed geophysical surveys of five selected sites on the route of the proposed Blyborough (Lincs.) to Cottam (Notts.) gas pipeline. The aim of the study was to provide further information concerning subsoil archaeological features prior to the construction of the pipeline.

1.2 The research was carried out by GeoQuest Associates on behalf of the Trust for Wessex Archaeology Ltd, acting as archaeological consultants to Penspen Ltd. The geophysical field survey was carried out between 28th April and 7th May, 1997.

2 THE SURVEY AREAS

2.1 Four of the five sites investigated are situated within a N-S aligned corridor immediately east of the B1398 road between Hemswell and Blyborough. The fifth site surveyed is located about 0.7km north of Hemswell to the west of the B1398. These areas were selected for geophysical survey on the basis of a desk-based assessment that identified cropmark and landscape features, artifact scatters and isolated objects which highlighted the potential for archaeological features surviving in the subsoil.

2.2 *Site 5* (SK 940936), NE of Willhoughton Manor was positioned to investigate a rectangular enclosure with other curvilinear and linear features identified from aerial photographs.

2.3 *Site 9* (SK 942941) is situated east of the junction of Westbeck Lane and Middle Street and coincides with the site of potential Roman buildings identified from a surface spread of artefacts which include ceramic building material.

2.4 *Site 23* (SK 942944) East of Blyborough Hall, is the site of a small oval enclosure (possible long barrow) and other linear features identified from aerial photographs.

2.5 *Site 24* (SK 936919), SW of Patchett's Cliff. This site was located to investigate a series of rectilinear enclosures contiguous with a triple ditch system and other sub-circular features. In a second stage of investigation the survey of this site was extended north to meet the lane to Patchett's Cliff in order to trace the extension of archaeological features revealed by the initial geophysical survey.

2.6 *Site 26* (SK 929917), North of Hemswell. The survey area forms the southern part of a rectilinear enclosure and linear features of possible Iron Age and Romano-British date as suggested by finds of pottery in the immediate vicinity.

3 LANDUSE, TOPOGRAPHY AND GEOLOGY

3.1 The solid geology in each of the study areas comprises Jurrassic limestones which are obscured by deposits of drift and alluvium. There are no rock outcrops in any of the five areas examined. The sites are generally level or gently undulating.

3.2 The survey areas are situated on arable land which bore developing crops at the time of survey: cereal (Sites 5 and 26), beans (Site 9), potatoes (Site 23) and a root crop (Site 24).

3.3 Overhead high voltage power lines traversed the survey areas at Sites 5 and 9.

4 THE GEOPHYSICAL SURVEY

4.1 The geophysical survey was undertaken on behalf of Wessex Archaeology Ltd in accordance with a Brief prepared by Andrew J Lawson. The Project Brief specified geomagnetic survey of each of the five areas at a resolution of 1.0x0.25m, with subsequent interpolation of data onto a 0.25x0.25m grid.

4.2 The primary aim of the geophysical surveys was to record any subsoil features that might be of archaeological interest and to compare the findings with the results of the desk study.

4.3 Previous research has shown that in the majority of cases a significant magnetic susceptibility contrast exists between the undisturbed subsoil and the fill of cut features such as ditches and pits, as well as between the subsoil and stone features such as foundations and tracks. The main processes at work appear to be iron oxide production in the plough soil, due to repeated burning, with further enrichment after burial as a result of microbial activity fueled by organic material. Geomagnetic surveying should therefore be an appropriate and rapid technique for locating buried archaeological features in this instance.

4.4 The geophysical survey was carried out in gridded units of 20x20m which were located with respect to permanent landscape features using tapes and an optical square to an estimated accuracy of 0.5m. The geomagnetic survey was carried out by one team using a Geoscan FM36 fluxgate gradiometer fitted with an ST1 sample trigger and utilising the zig-zag traverse scheme described in Appendix A.

4.5 Data were downloaded on site into a portable graphics computer for storage, quality control and initial interpretation. These data were subsequently transferred to a laboratory computer for final processing and archiving.

5 DATA PROCESSING

5.1 The GeoQuest **InSite®** software program was used to process the geophysical data and produce continuous tone grey-scale images of the raw data in each area, at scales of 1:1000 and 1:2500. These results are shown in Figures 2 and 3 on plans derived from digital map files supplied by Wessex Archaeology. A convention is used that shows positive magnetic anomalies as dark grey and negative magnetic anomalies as light grey. Figure 2 includes keys which relates the grey scale intensities to anomaly values in nano Tesla per metre. These keys also apply to the images presented in Figure 3.

5.2 The following basic processing steps were applied to the data:

Removal of striping artifacts in the images caused by alternating changes in level between zig-zag traverses.

Removal of Random 'Spikes' present in the data due to small ferrous objects or fired stone on or near the ground surface. This process replaces spikes with the mean of near-neighbours.

Correction for apparent shear in strong geomagnetic anomalies surveyed by zig-zag traversing.

Correction for drift in magnetometer calibration with time.

Adjustment of grid mean values to achieve an optimum match along the lines of contact between data grids.

Interpolation of the data, using a bilinear function, to generate a regular mesh of values at 0.25 x 0.25m intervals.

5.3 The geophysical images were printed on a Hewlett Packard HP650C Designjet plotter with 256 grey shades and 600 dpi resolution. A sigmoid function was used to map the data to printed grey tones since this provides a measure of contrast equalisation. Appendix B provides more information about data processing and itemises the algorithms that were applied to produce the grey-scale images in Figures 2 and 3.

6 DISCUSSION OF RESULTS

6.1 Key to Figures

6.1.1 A number of significant anomalies have been detected in the data and these are presented on a 1:2000 geophysical interpretation plan using coded colours and patterns (Figure 4). The following types of anomaly have been distinguished:

Green Significant regions of anomalously high magnetic field gradient which might be associated with high susceptibility, soil-filled structures such as *pits* and *ditches*.

Blue Areas of anomalously low magnetic field gradient, corresponding to features of low magnetic susceptibility, such as concentrations of sedimentary rock *rubble* and *field drains*.

Red Strong *dipolar magnetic anomalies* (paired negative-positive) which may reflect recent *bonfires* or dumps of material with very high susceptibility. Smaller examples are almost certainly due to near-surface iron objects such as *horseshoes* and have been ignored in the subsequent archaeological interpretation.

6.1.2 A 1:2000 archaeological interpretation plan is presented in Figure 6.

6.2 Site 5

6.2.1 The geophysical terrain in this area was remarkably smooth with the major anomalies arising from deposits of ferrous debris near the western and eastern margins of the survey area.

6.2.2 Two very weak and diffuse positive magnetic lineations have been detected which are aligned parallel to the field boundary forming the northern limit of the survey area. These anomalies have been tentatively identified as the ditches **d1** and **d2** in Figure 5 but may reflect field drains.

6.2.3 No further geophysical anomalies of archaeological interest have been identified in this study area. In particular, no geophysical evidence has been found in support of the cropmark features seen in aerial photographs.

6.3 Site 9

6.3.1 This area is characterised by a dense pattern of E-W trending, positive and negative magnetic lineations which almost certainly reflect a set of field drains and/or a magnetic susceptibility texture created by ploughing in this direction.

6.3.2 A weak and intermittent, curvilinear positive magnetic lineation has been detected within the southern half of the survey area. The form of this anomaly is consistent with the remains of a poorly-preserved ditch (**d3**).

6.3.3 No further geophysical anomalies of archaeological interest have been identified in this study area.

6.4 Site 23

6.4.1 The major geophysical feature in this area comprises a zone of intense magnetisation in a position corresponding to the oval cropmark trace. The strength of the anomaly suggests the presence of surface ferrous debris although the existence of fired material at this position (of possible archaeological interest) cannot be ruled out.

6.4.2 The survey has detected a weak and fragmentary positive magnetic lineation, with E-W orientation, traversing the southern third of this survey area. This feature has been tentatively identified as ditch **d4** in Figure 5.

6.4.3 The geophysical survey has provided no evidence for additional features of archaeological interest in this study area.

6.5 Site 24

6.5.1 The major geophysical anomalies in this study area comprise compact clusters of intense magnetic dipoles which almost certainly represent dumps of ferrous debris or brick rubble.

6.5.2 A set of distinct, positive magnetic lineations have been located in the southern block of survey and almost certainly correspond to silted ditches that survive in the subsoil. These have been labelled **d10**, **d11** and **d12** in Figure 5. From an examination of the present survey extent these ditches do not appear to form a coherent pattern such as a field system or enclosure. Ditch **d11** may correlate with a linear cropmark feature.

6.5.3 Of particular archaeological interest is the discovery of strong linear and curvilinear positive anomalies in the northern block of survey which provide good evidence for a set of ditches (**d5** to **d9**; Figure 5). Ditch **d5** appears to form part of an enclosure with minimum dimensions of 100x30m that extends north and east beyond the survey area.

6.5.4 An E-W oriented texture and set of lineations in the northern survey block almost certainly reflects a set of land drains and subsoil disturbance due to ploughing.

6.6 Site 26

6.6.1 A compact zone of dipolar magnetic anomalies in the central part of this area probably represents a dump of ferrous debris or brick rubble.

6.6.2 A weak and diffuse positive magnetic anomaly in the western central part of this area may correspond to the ditch indentified from aerial photographs. The geophysical data suggest that this feature is poorly preserved in the subsoil.

6.6.3 The geophysical survey has provided no evidence for additional features of archaeological interest in this study area.

7 CONFIDENCE LIMITS

d1 as ditch	20%	**d4** as ditch	30%
d1 as land drain	20%	**d5** as ditch	90%
d2 as ditch	20%	**d6** as ditch	75%
d2 as land drain	20%	**d7-d12** as ditches	60%
d3 as ditch	40%	**d7-d12** as drains	20%
d3 as geological	15%		

8 CREDITS

Survey: D.N. Hale, R. Still, R. Carter and N. Till
Graphics and Report: M.J. Noel
Date: 29th May 1997

COTTAM GAS PIPELINE

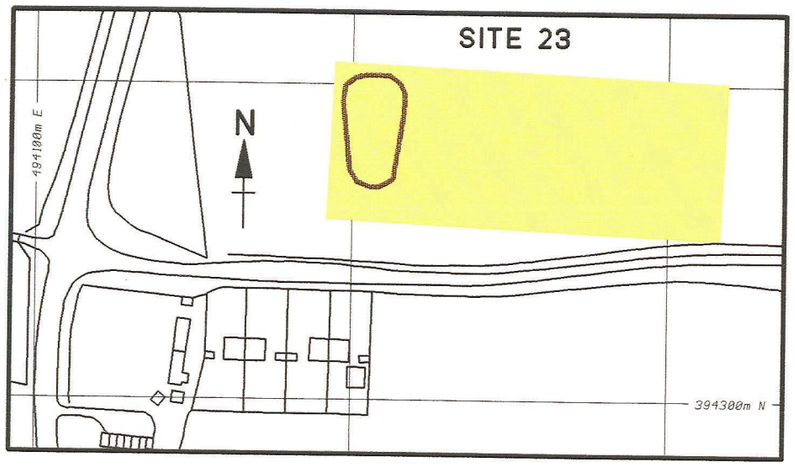
LOCATION OF GEOPHYSICAL SURVEYS

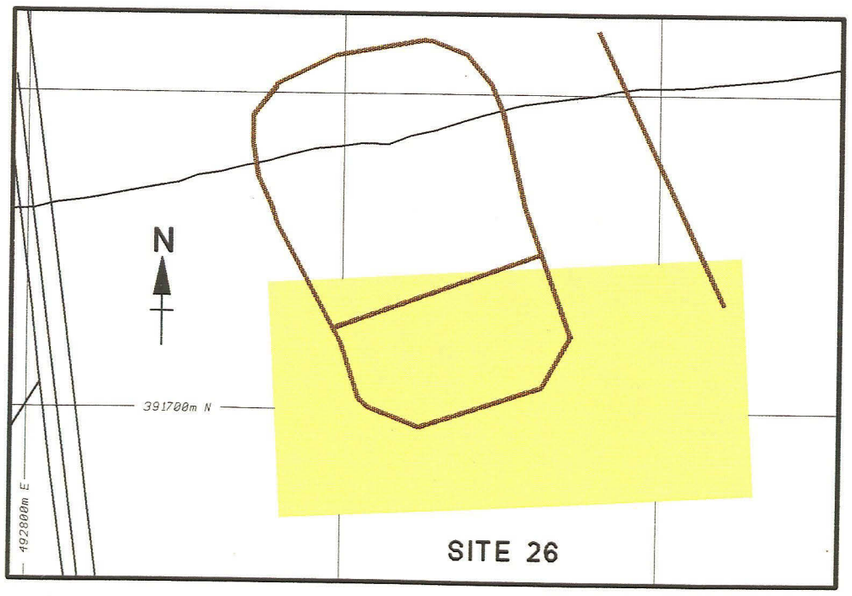
SURVEY BY GeoQuest Associates

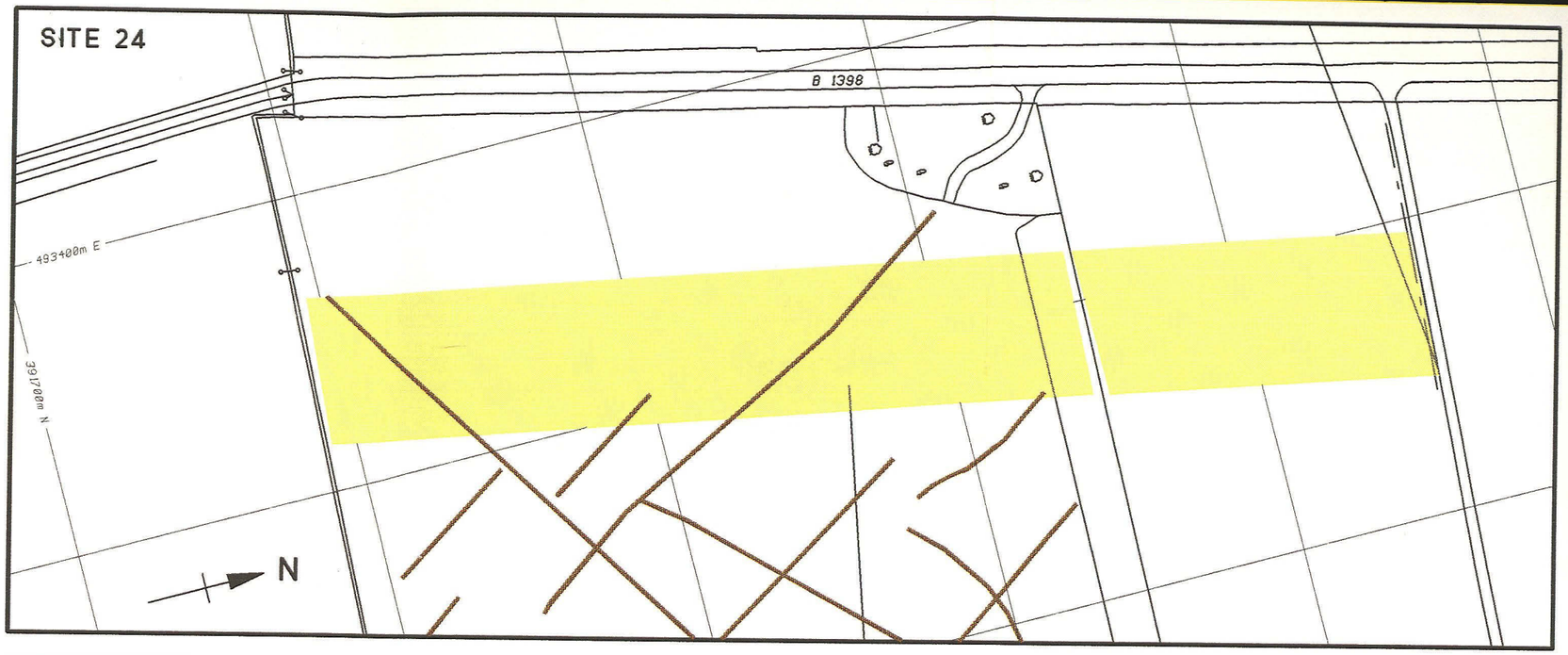
FOR Wessex Archaeology

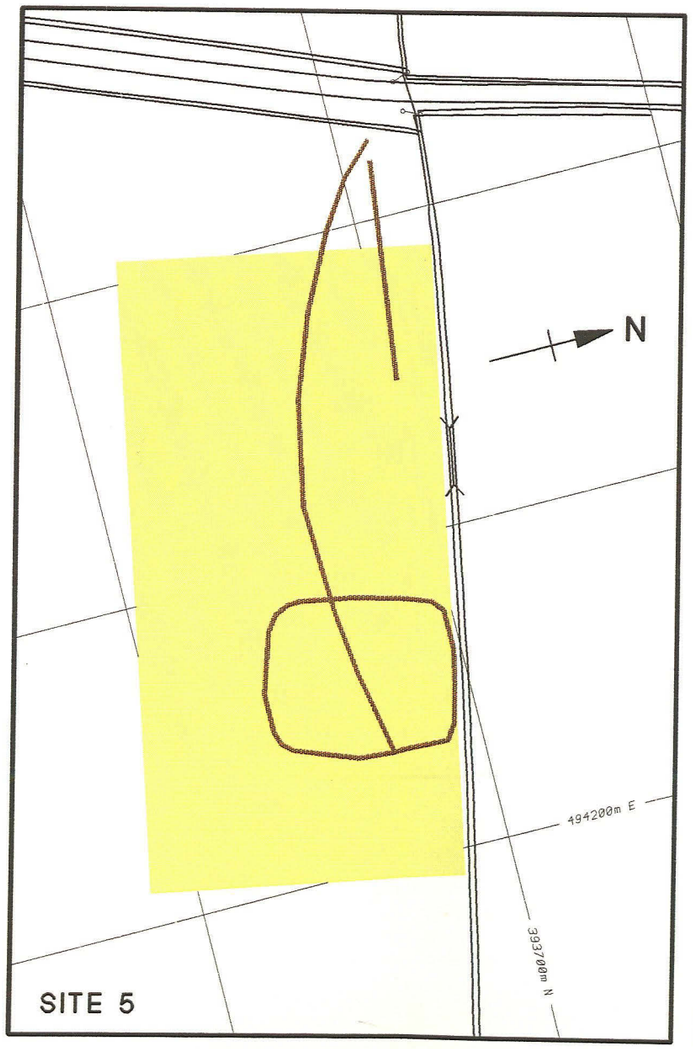
0 50 100 1:2000 200

SURVEY AREA | CROPMARK | ARTEFACT SCATTER









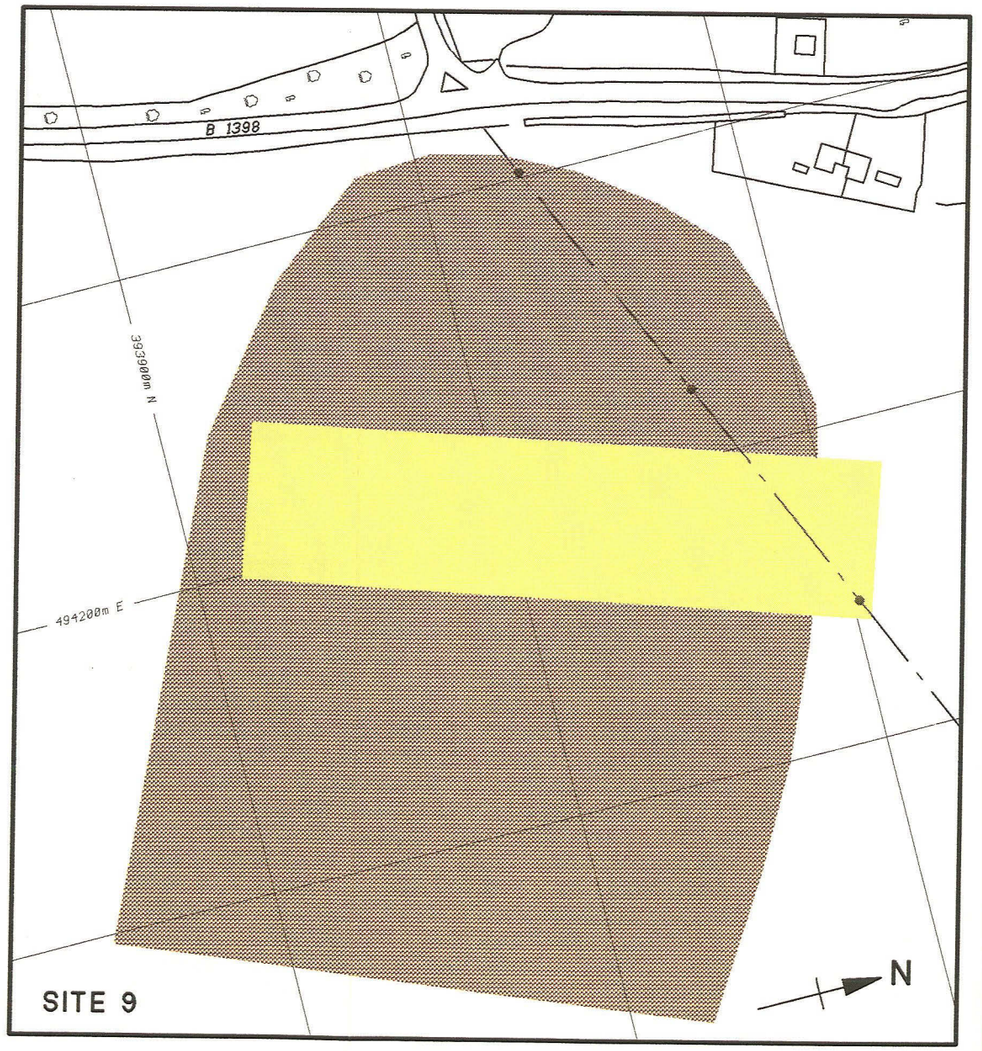


FIGURE 1

COTTAM GAS PIPELINE

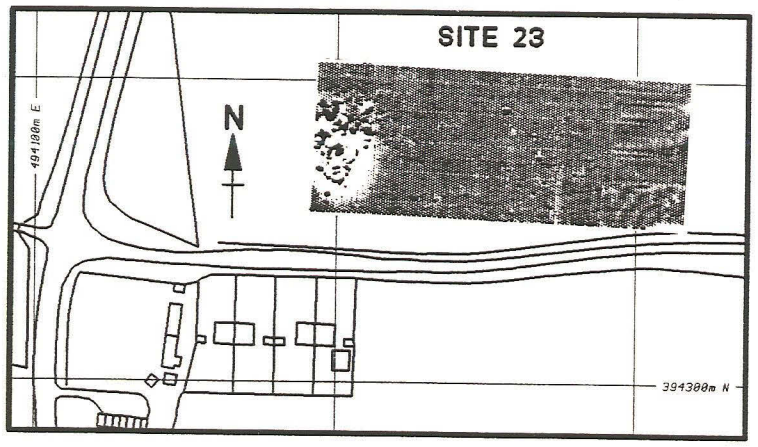
RESULTS OF GEOPHYSICAL SURVEYS

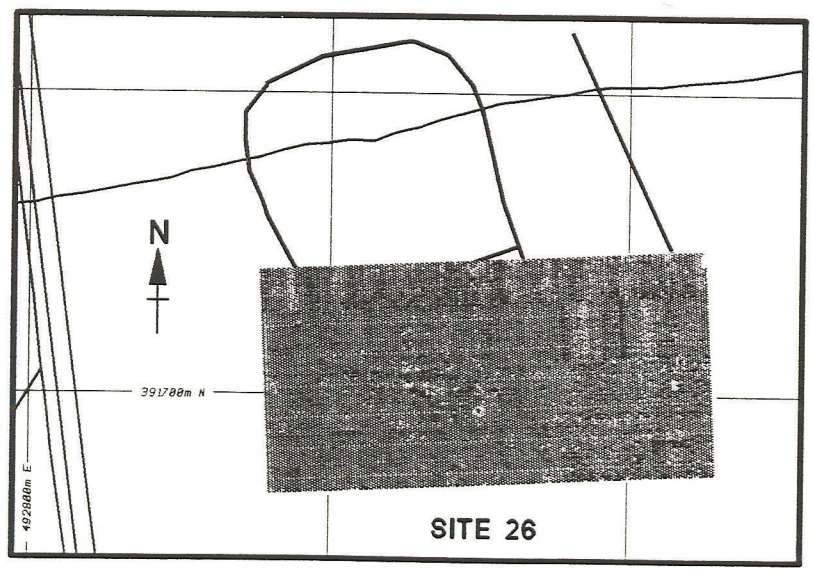
SURVEY BY GeoQuest Associates

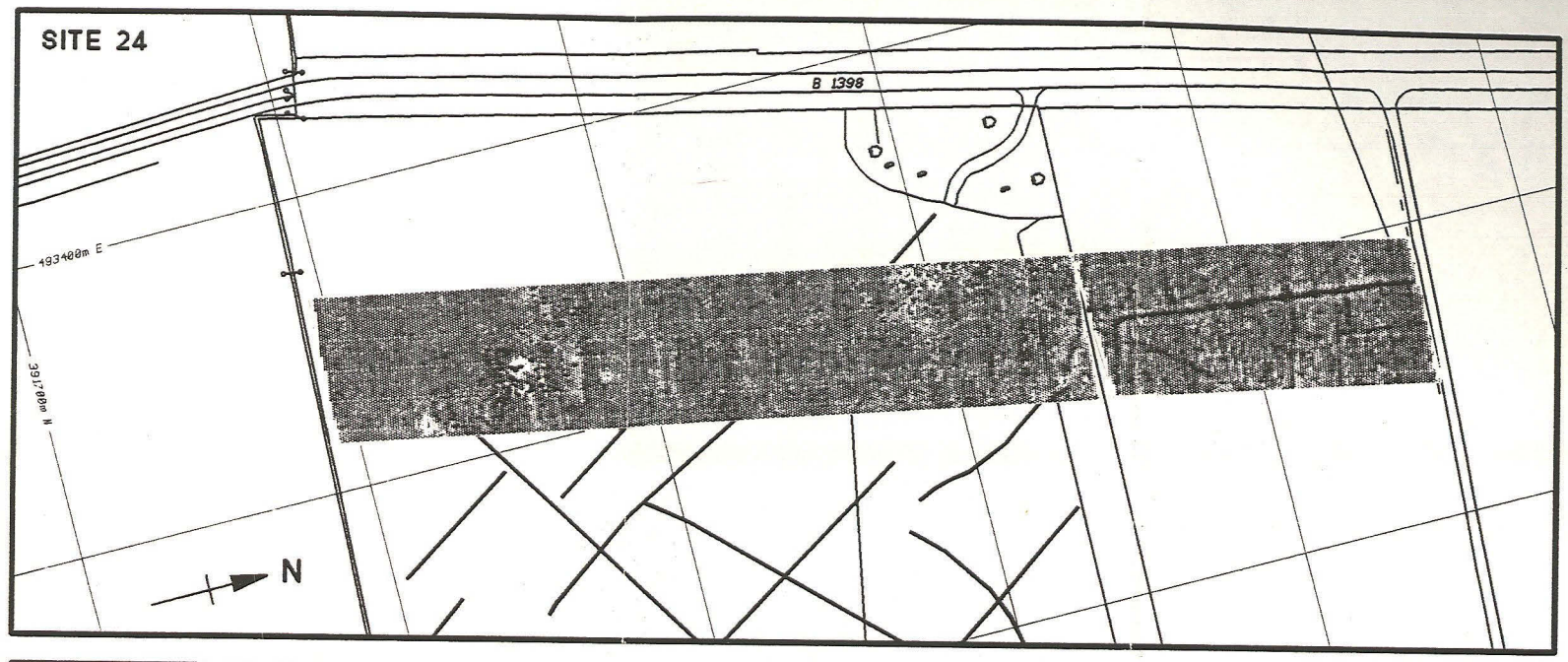
FOR Wessex Archaeology

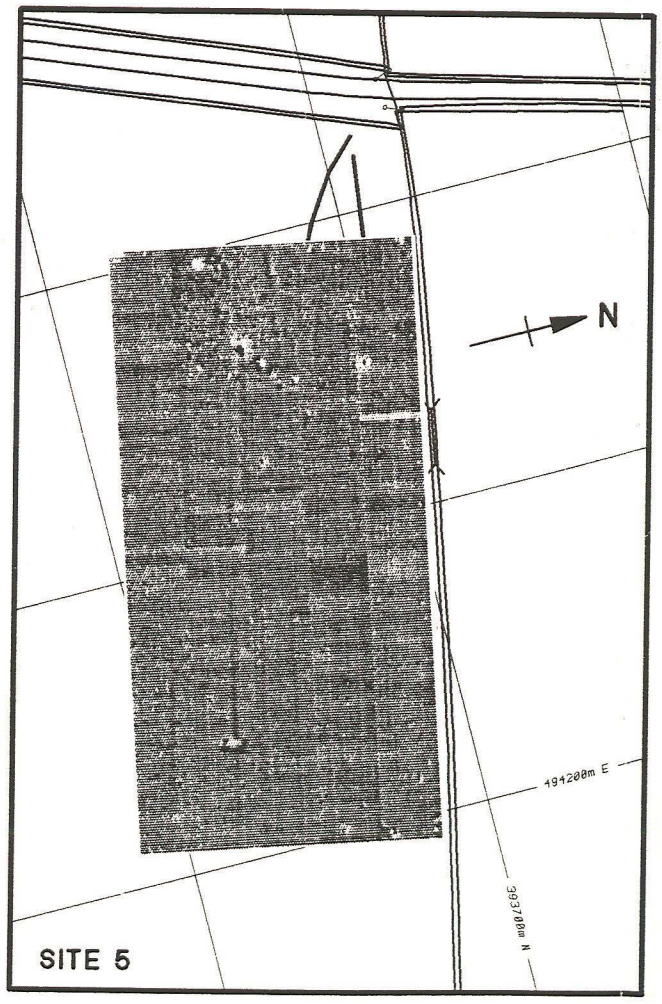
0 50 100 1:2500 200

For anomaly magnitudes refer to keys in Figure 2









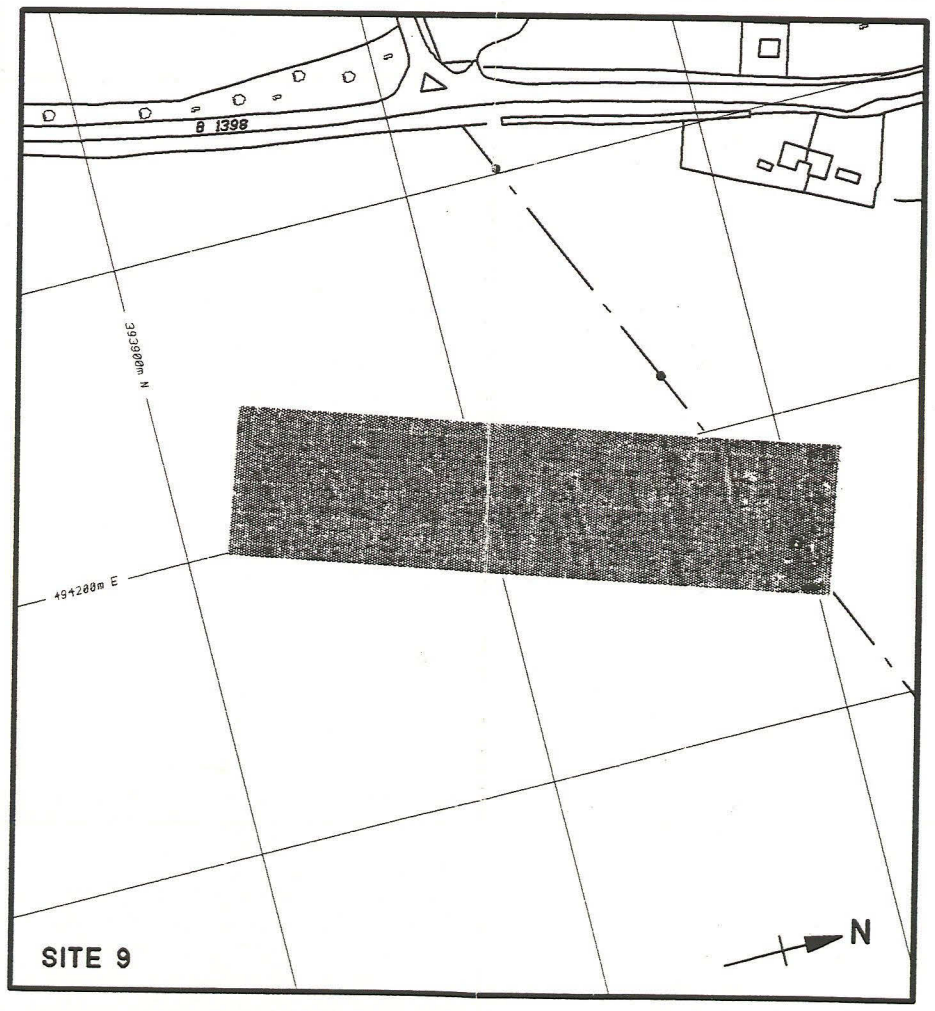


FIGURE 3

COTTAM GAS PIPELINE

GEOPHYSICAL INTERPRETATION

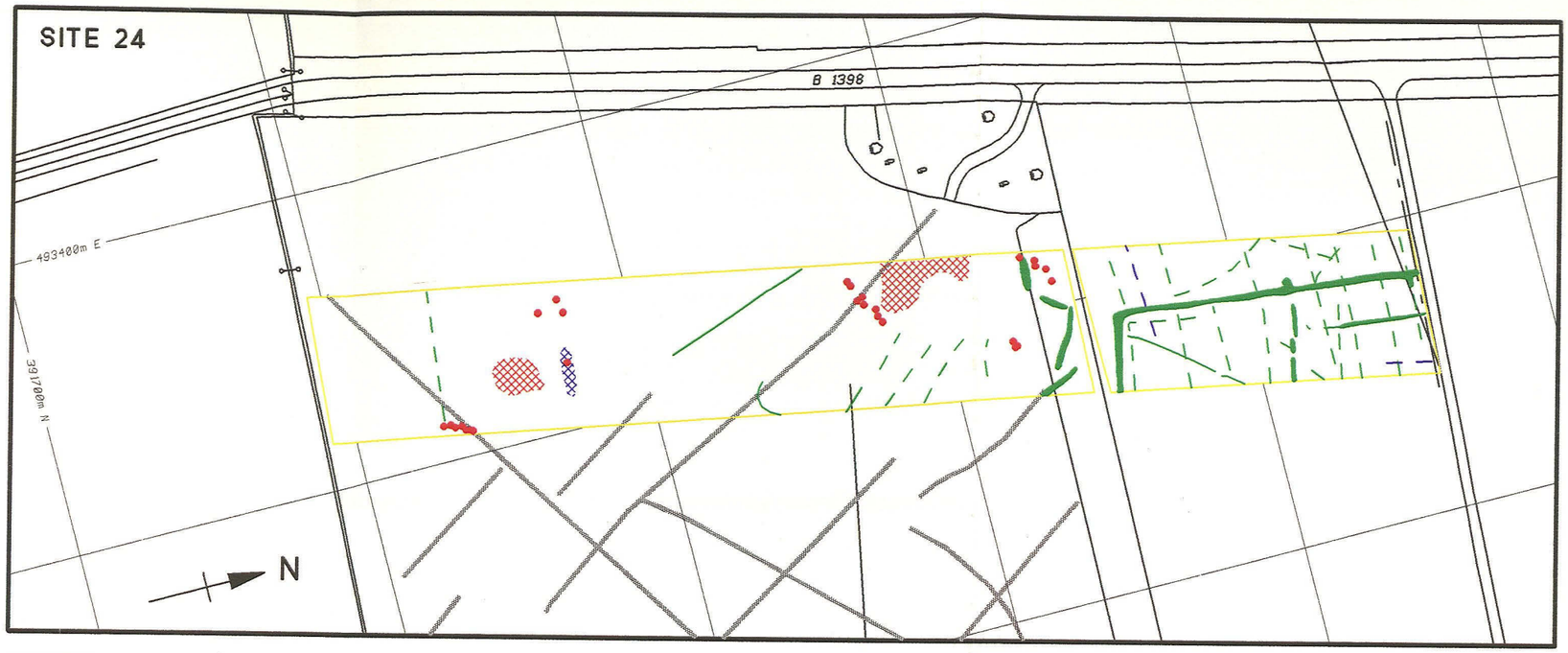
SURVEY BY GeoQuest Associates

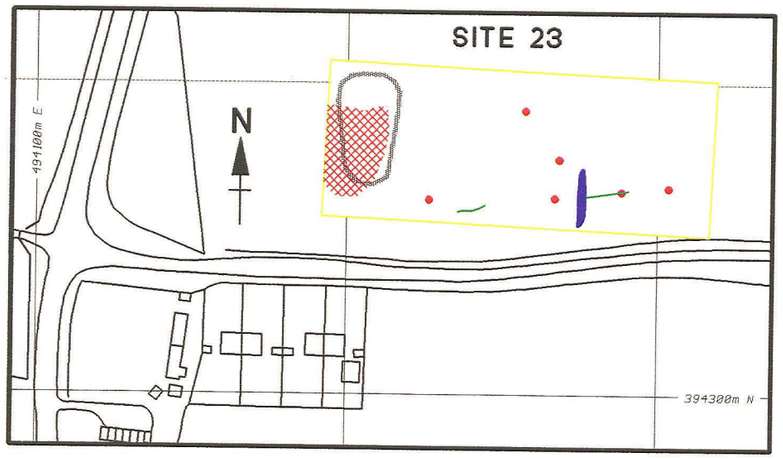
FOR Wessex Archaeology

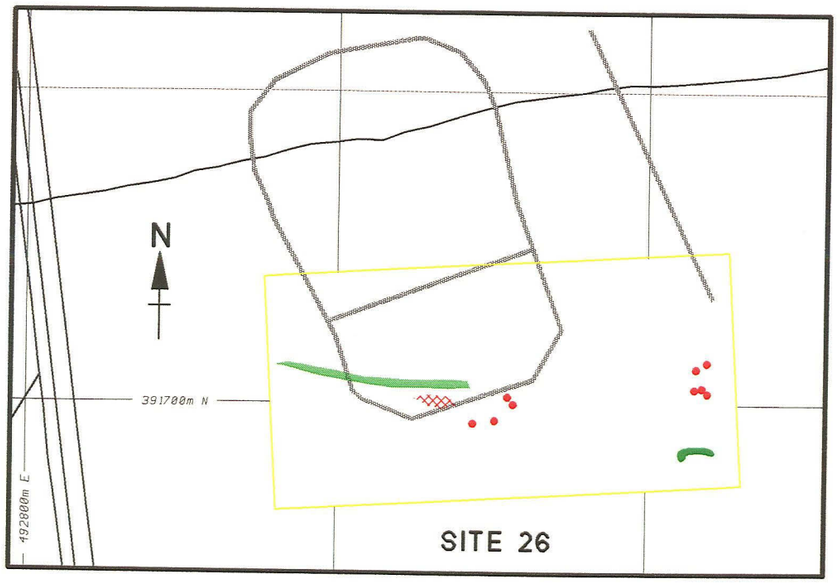
0 50 100 1:2000 200

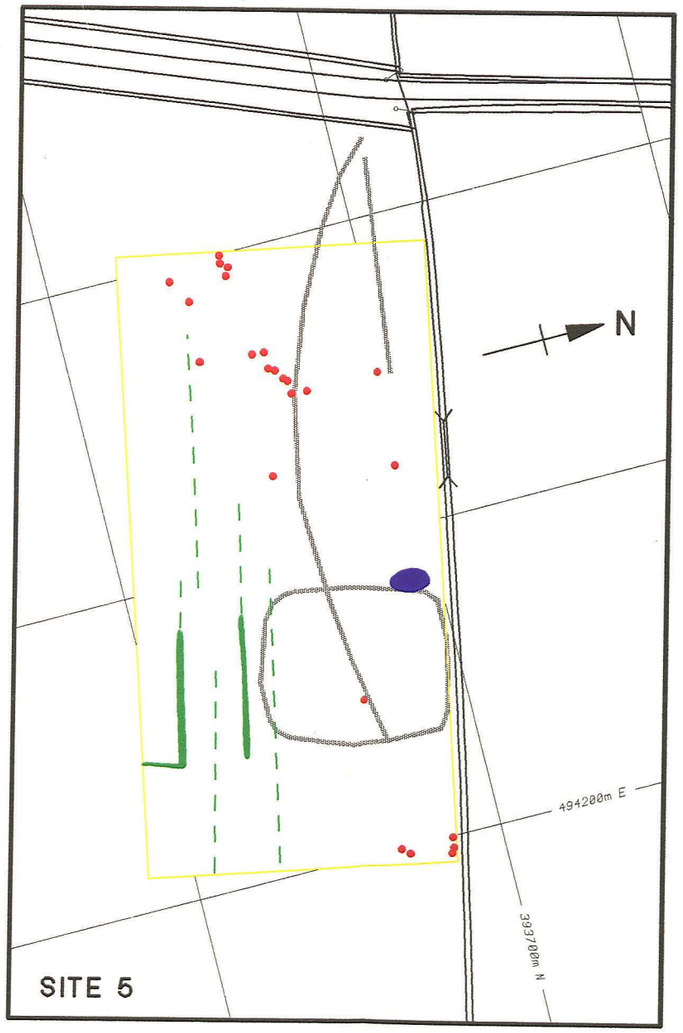
KEY

POSITIVE NEGATIVE DIPOLE CROPMARK









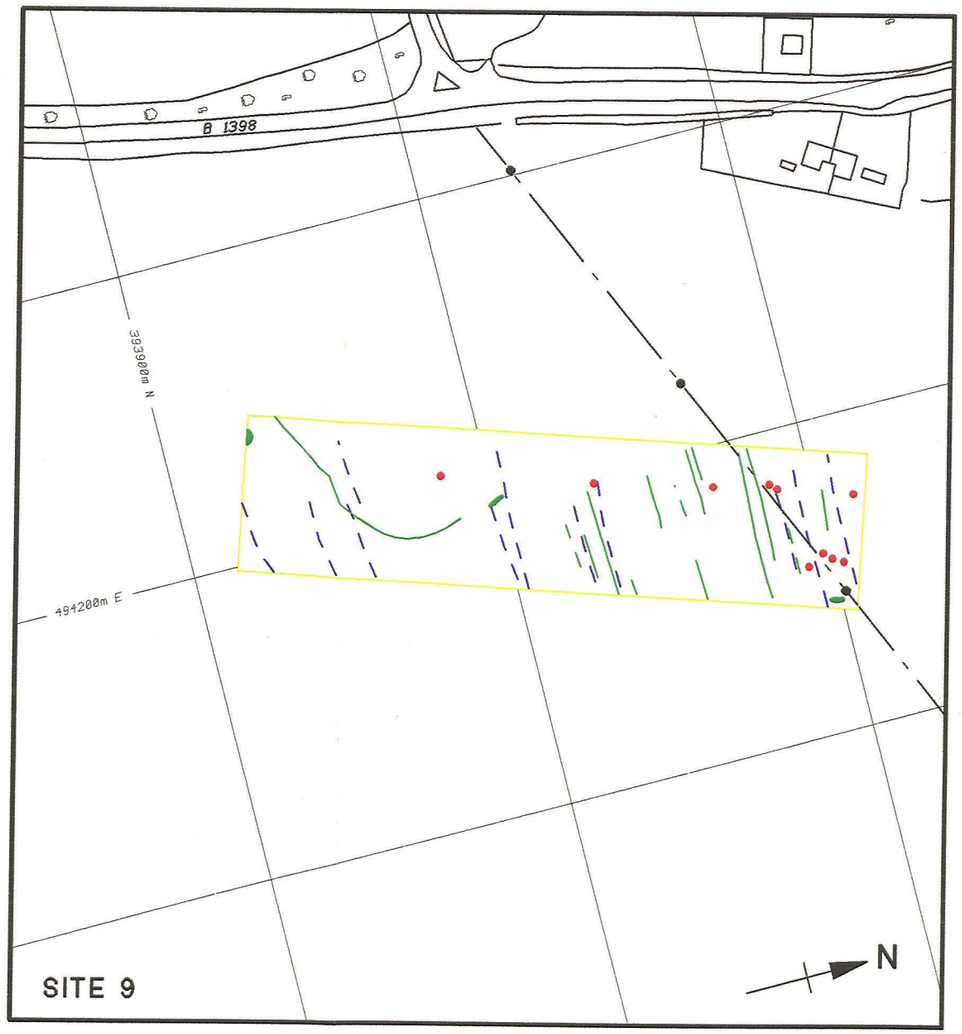


FIGURE 4

COTTAM GAS PIPELINE

ARCHAEOLOGICAL INTERPRETATION

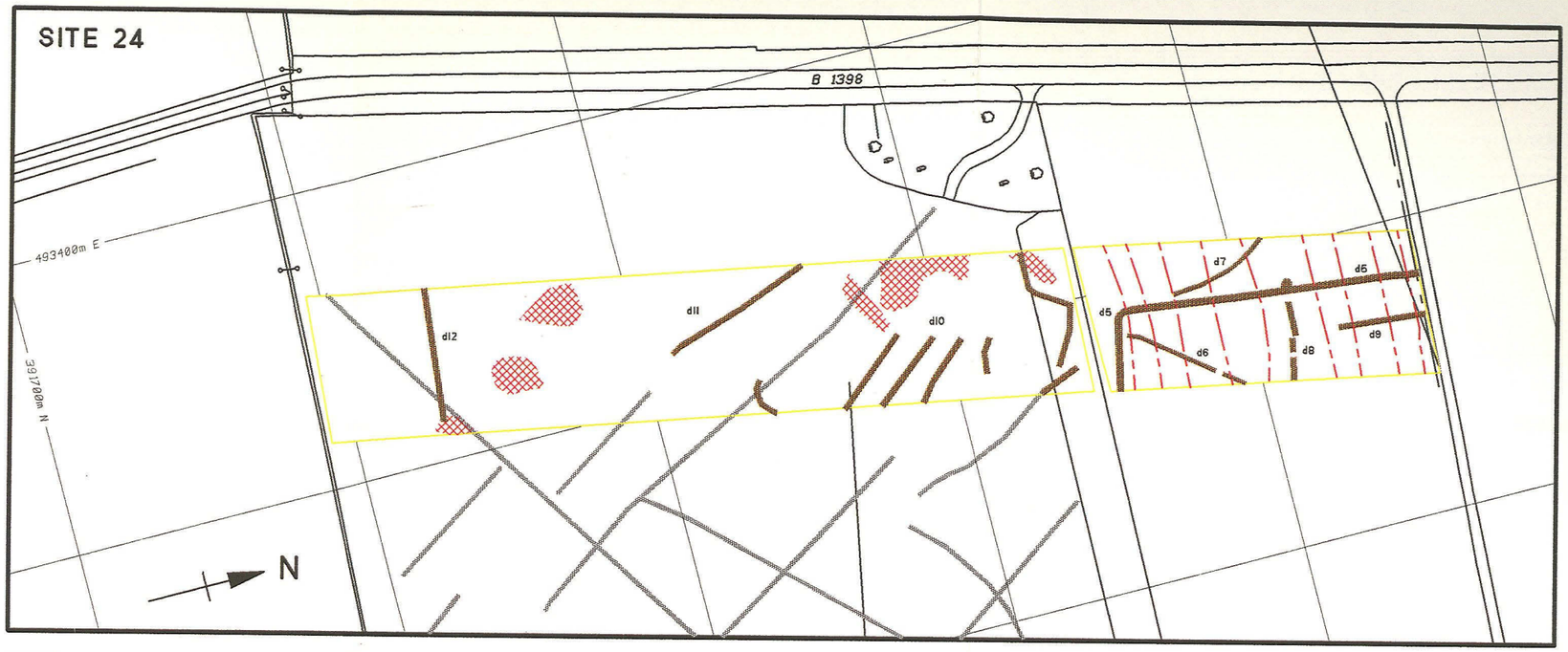
SURVEY BY GeoQuest Associates

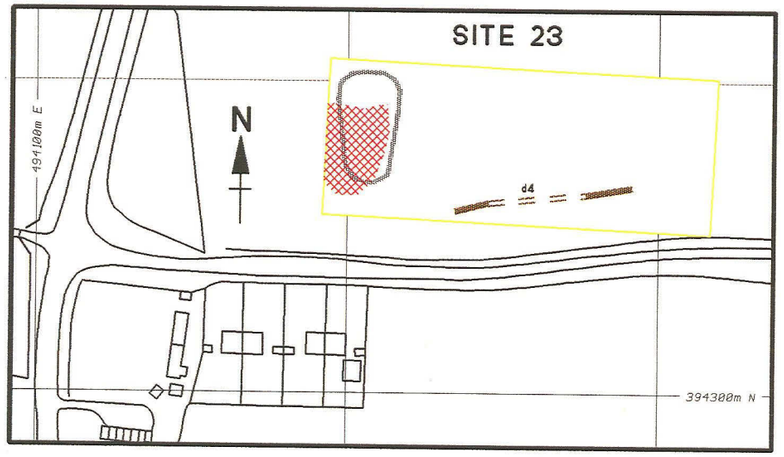
FOR Wessex Archaeology

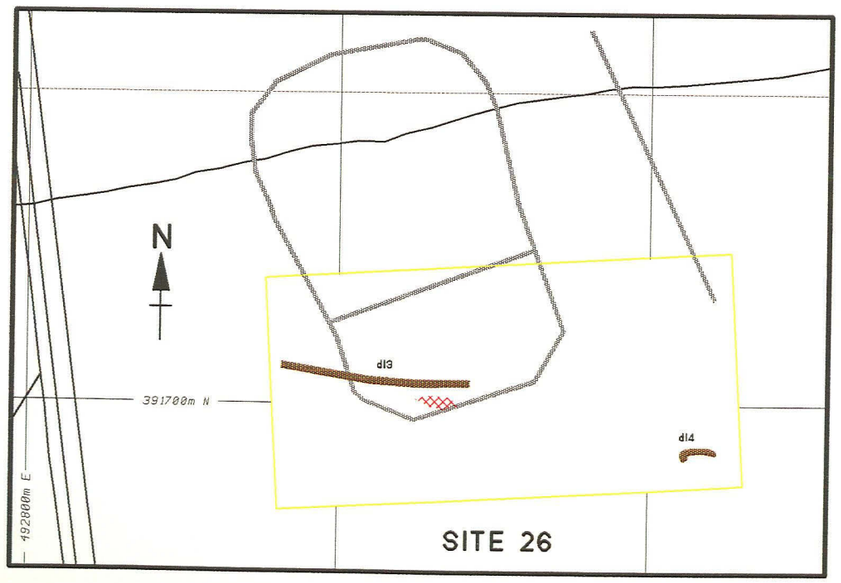
0 50 100 1:2000 200

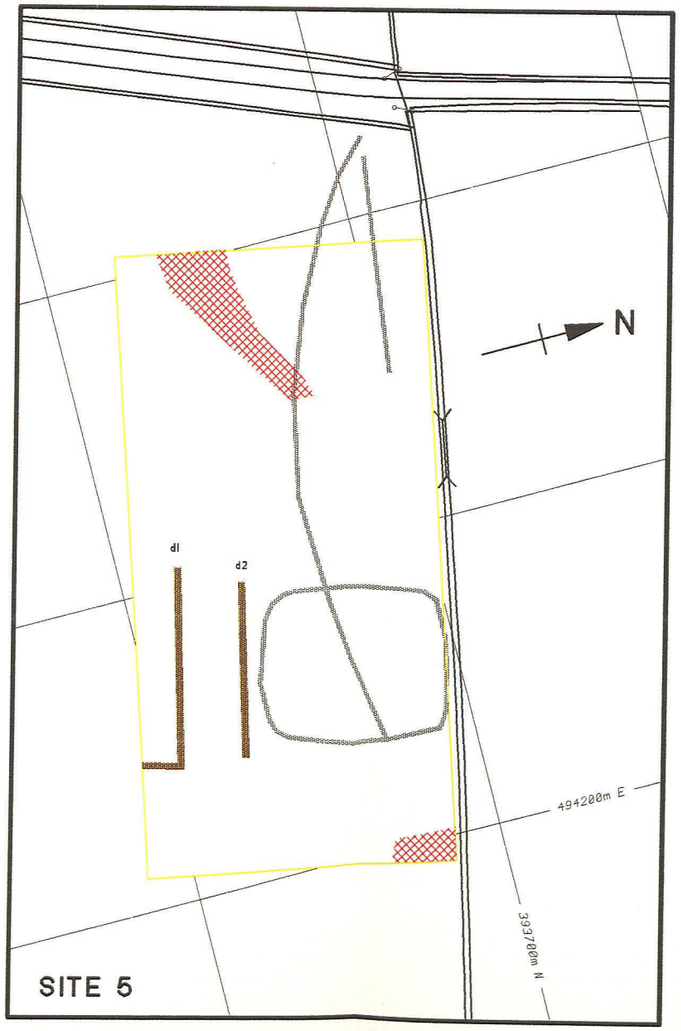
KEY

PITS/DITCHES FERROUS LITTER DRAINS CROPMARK









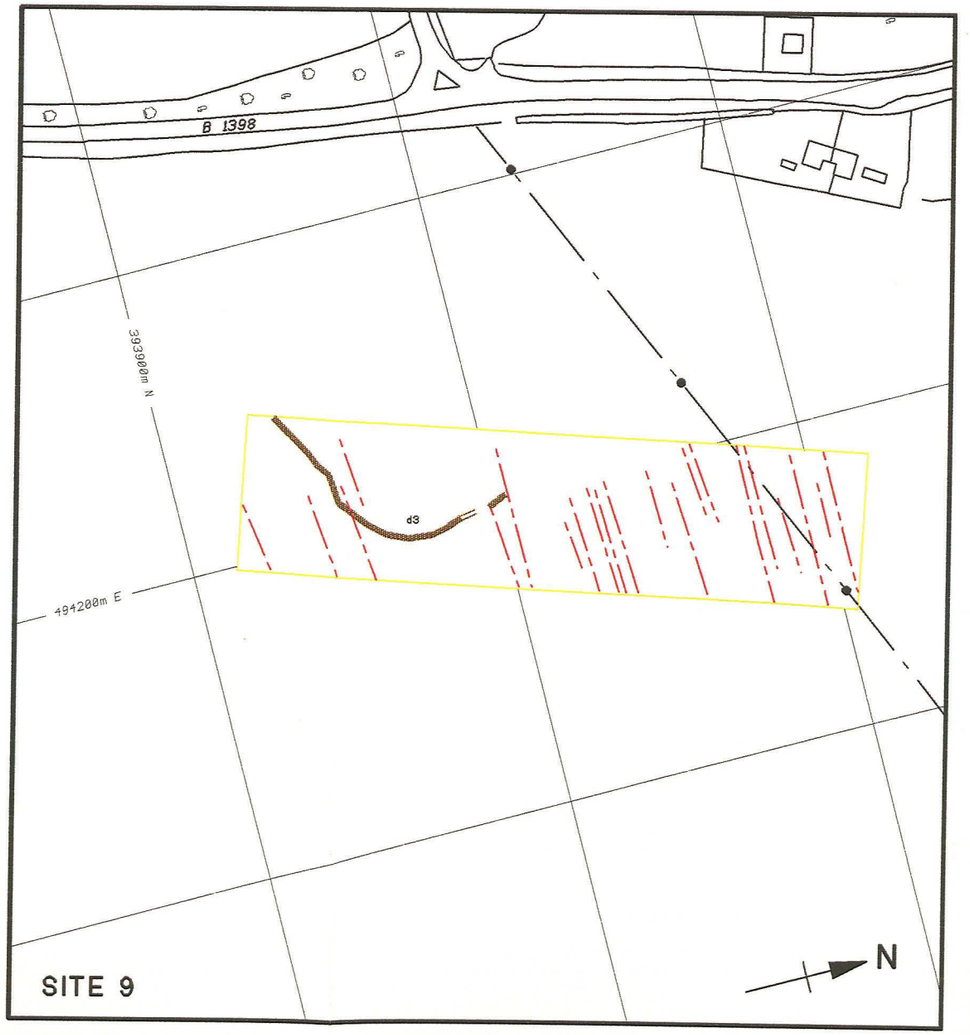


FIGURE 5

APPENDIX A
Principles of Geomagnetic Surveying

Geomagnetic prospecting detects subsurface features in terms of the perturbations or 'anomalies' that they induce in the Earth's magnetic field. In contrast to resistivity, seismic or electromagnetic surveying, no energy is injected into the subsoil and hence this is one of a class of *passive* geophysical techniques that includes gravity and thermal surveying. Two types of magnetic anomalies can be distinguished:

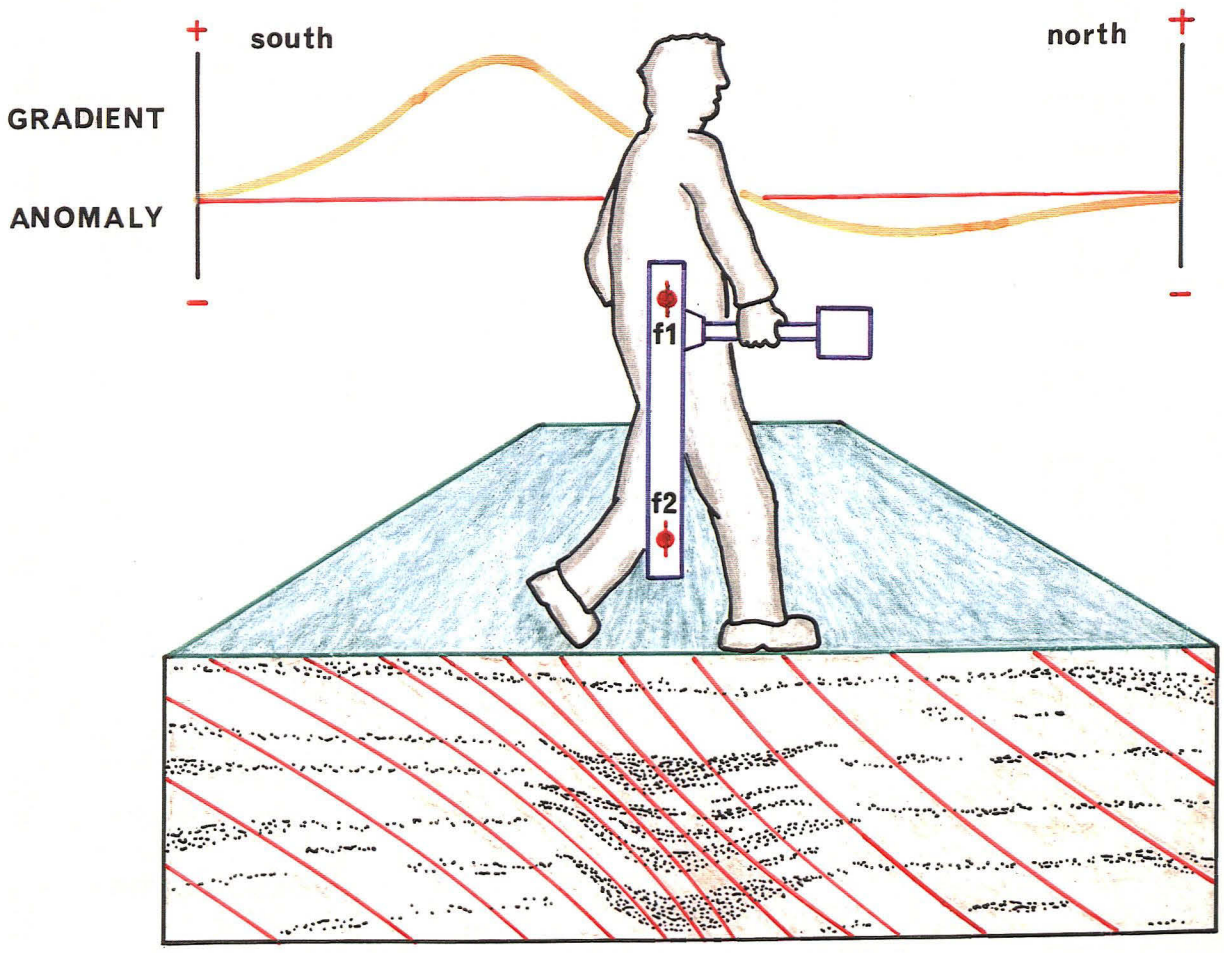
1 Anomalies arising from variations in *magnetic susceptibility* which will modulate the component of magnetisation *induced* in the subsurface by the Earth's magnetic field. For most archaeological sites, this is the dominant factor giving rise to geomagnetic anomalies. In general, susceptibility is relatively weak in sediments, such as sandstones and enhanced in igneous rocks and soils, especially those which have been burnt or stratified with organic material.

2 Anomalies due to large, *permanently magnetised* structures. Such permanent magnetisation or 'remanence' arises when earth materials are heated to above ~600°C and cooled in the geomagnetic field. Thus kilns and hearths are often detected as strong permanent magnets causing highly localised anomalies that dominate effects due to background susceptibility variations. Remanence can result from other physical and chemical processes but these give rise to anomalies that are usually unimportant for geophysical prospecting.

There are several approaches towards the practical measurement of geomagnetic anomalies. In this study measurements were made using a Geoscan FM36 fluxgate gradiometer which records the change with height in the vertical component of the Earth's magnetic field, as shown overleaf. This method has the advantage of being insensitive to diurnal variations while the Geoscan instrument also benefits from an integrated data logger. Note that in mid northern latitudes the magnetic anomaly will be asymmetric with the main peak displaced to the south of the archaeological feature. Thus, a ditch filled with a soil of enhanced susceptibility, for example, will generate a positive anomaly to the south, mirrored by a weak negative anomaly north of the feature. When portrayed as an area map of grey tones this gives rise to a 'shadowing' or pseudo relief effect which must be borne in mind when making an archaeological interpretation.

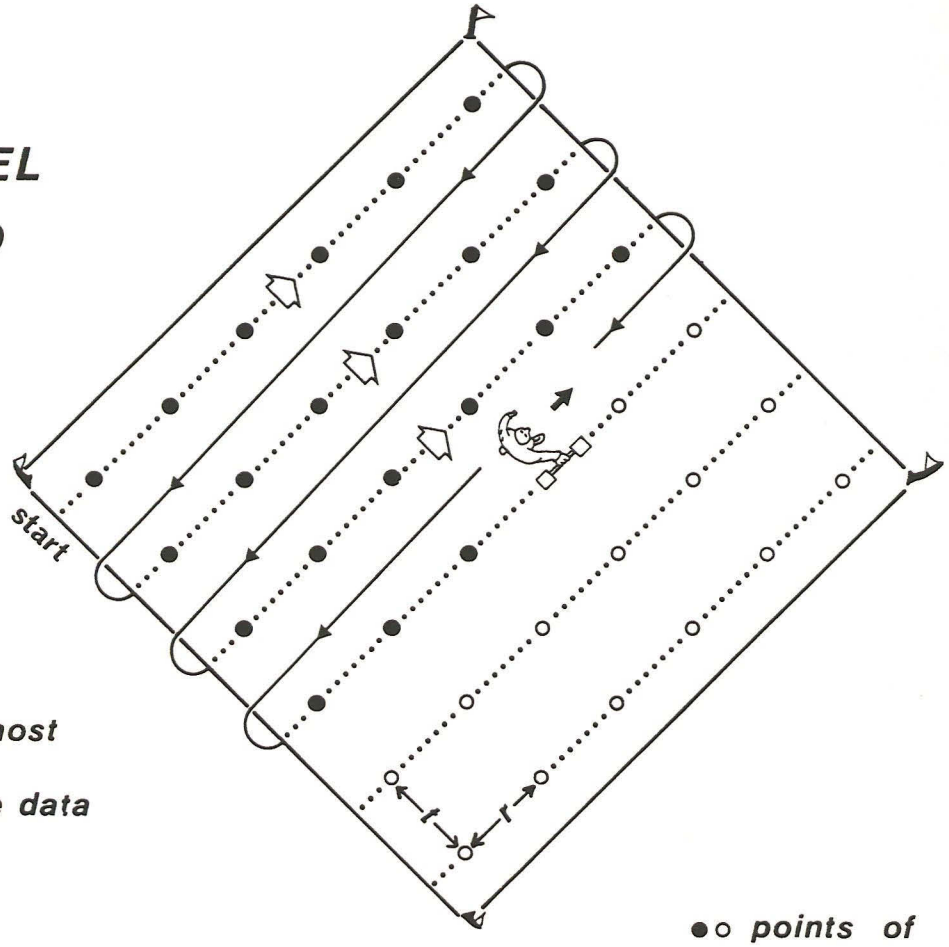
Two techniques can be used to survey gridded areas using the fluxgate magnetometer. In the parallel method the instrument is used to scan the area along traverses which are always in the same direction. This method minimises 'heading errors' due to operator and instrument magnetisation but is time consuming. The alternative zigzag method is significantly faster and suitable for areas where anomalies are large compared to these and other sources of error.

MAGNETIC SURVEYING



SURVEY SCHEMES

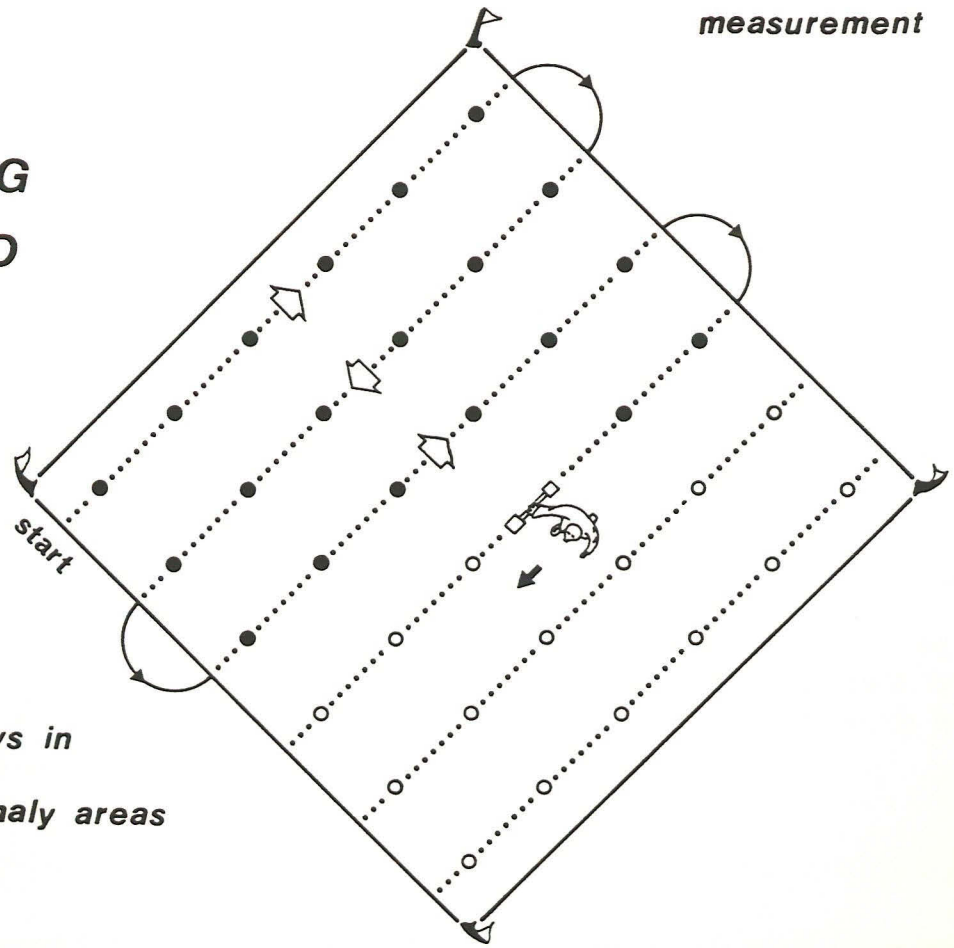
PARALLEL METHOD



slower but minimises most errors in the data

●○ *points of measurement*

ZIG-ZAG METHOD



suitable for rapid surveys in strong anomaly areas

APPENDIX B
Data Processing

PROCESSING THE SURVEY DATA

The geophysical images contained in this report were prepared within Microsoft Windows® using the InSite® program published by GeoQuest Associates. Geophysical images were then placed onto a map which was digitised from the Ordnance Survey, edited and then plotted using a computer aided drafting (CAD) system and colour inkjet printer.

Data were downloaded from the meter to a portable computer in the field for storage, visualisation and quality control (QC) assessment. These data were then transferred to a laboratory computer for final processing, printing and archiving.

A number of process steps have been applied to the geophysical data obtained during the survey and those which have been used are linked to the main flow path by arrows. Steps were applied in the order shown and are designed to reduce artifacts in the data and enhance geophysical features of archaeological interest. The following sections describe each step in more detail.

REMOVE STRIPING

Reduces a data artifact comprising alternating changes in level in readings logged along zig-zag traverses. This artifact is common in fluxgate magnetometer data. InSite uses a proprietary algorithm to reduce this error.

INFILL SMALL BLANK AREAS

Fills isolated blank data cells with the mean of near-neighbours or a suitable approximation entered manually. Small blank areas will have been logged if it was not possible to obtain a geophysical reading over, for example, a manhole cover in the case of a resistivity survey.

REMOVE SPIKES

Replaces isolated, anomalously high or low values with the mean of near neighbours or a suitable approximation entered manually. 'Spike' readings are commonly associated with ferrous litter or poor electrical contact in the case of geomagnetic and resistivity data, respectively.

REDUCE WALK HARMONICS

Reduces a regular oscillation in traverse data caused by walking movements of the operator during a geomagnetic survey. InSite employs a fast Fourier transform to determine the optimum amplitude and phase of the walk-induced harmonic which is then subtracted from each traverse.

REDUCE SHEAR ARTIFACTS

Corrects for apparent shear in geomagnetic anomalies surveyed by zig-zag traversing in a geomagnetic survey. The shearing effect arises from the interaction of the operator + magnetometer with the geomagnetic field and also from the lag in the instrument response to changes in the field. InSite uses a proprietary algorithm to reduce this error.

CORRECT FOR METER DRIFT

Corrects for a linear drift in the meter calibration with time. Such drift is a common problem with fluxgate magnetometers, particularly during periods of rapid air temperature change. InSite uses least-squares regression on the mean of data along each traverse to estimate the change in calibration level across each grid. This gradient is then removed from the data.

ADJUST GRID MEAN LEVELS

Adjusts for differences in the mean level in data grids due to changes in instrument calibration (fluxgate magnetometer survey) or alteration in remote electrode spacing (resistivity survey).

INTERPOLATE AND COMBINE

Combines grids to form an array of regularly-spaced data on a square mesh. InSite uses bilinear interpolation to accomplish this.

LOW PASS FILTER

If this process task is indicated then a 3x3 or 5x5 boxcar filter has been used to smooth the data and reduce noise or 'speckle' seen in the original image.

HIGH PASS FILTER

If this process task is indicated then a 3x3 or 5x5 filter, with appropriate coefficients, has been used to pass short-wavelength information into the resulting image.

EDGE DETECT FILTER

Signifies that a Sobel, Laplace or other specialised filter has been applied to enhance significant lateral transitions in the geophysical image.

DIRECTIONAL FILTER

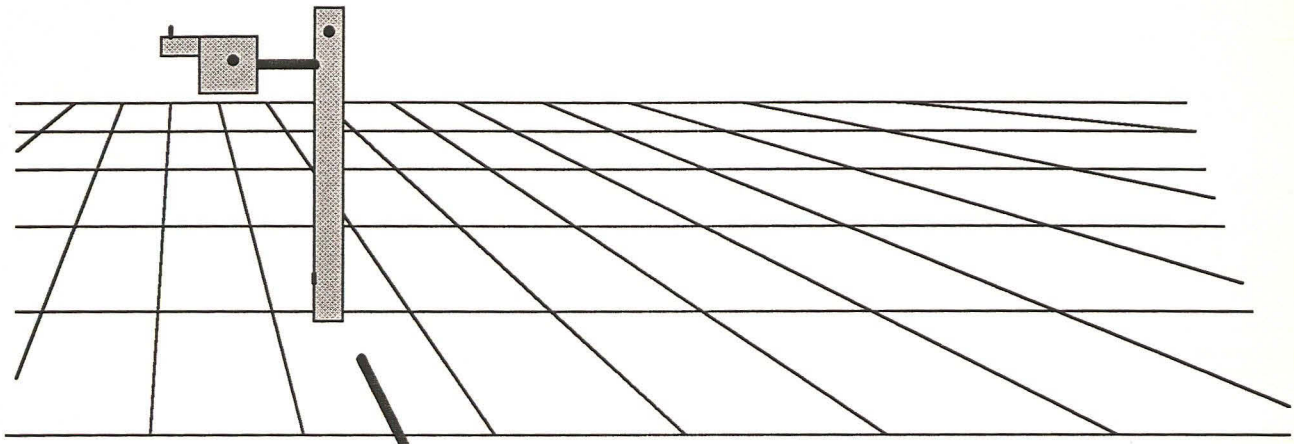
This filter is equivalent to illuminating the data from one direction to produce a pseudo-relief image. Directional filtering is usually employed to aid the identification of subtle anomalies in resistivity data. This filter highlights features trending at right angles to the direction of illumination.

NOTE

GeoQuest Associates can supply the geophysical images presented in this report in a variety of digital formats for visualisation on microcomputers running Microsoft Windows. These formats include the TIFF, BMP and PCX standards.

APPENDIX B
DATA PROCESSING

InSite



FIELD PC

LAB PC

QC

DATA ARCHIVE

IMAGE RAW GRID DATA

REMOVE STRIPING

INFILL SMALL BLANK AREAS

REMOVE SPIKES

REDUCE WALK HARMONICS

REPORT FIGUREs 3 & 4

INTERPOLATE AND COMBINE

ADJUST GRID MEAN LEVELS

CORRECT FOR METER DRIFT

REDUCE SHEAR ARTIFACTS

PROJECT: Blyborough - Cottam Pipeline

SITE: Sites 5, 9, 23, 24 and 26

NOTES

GeoQuest Associates
The Old Vicarage
Castleside
Co. Durham
DH8 9AP
Tel 01207 583576, Fax 01207 583577, Mobile 0850 782368
Email post@geofizz.demon.co.uk

SUPPLEMENTARY ORDER & COMMENT CARD

FOR REPORT COTTAM PIPELINE

PLEASE SUPPLY (tick or number the boxes, as required):

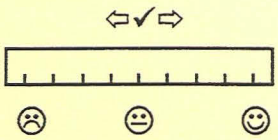
☐ **Additional reports at £** 15 **each. Total = £** ☐ **incl. post & packing**

☐ **Copies of Figures** ..... **(no charge for total of 4 or less)**

Geophysical image on disk in ☐ **TIFF or** ☐ **PCX file format (no charge)**

Please spend a moment to complete the sections below. Your comments will help us improve the quality and range of services which GeoQuest provides.

YOUR SATISFACTION WITH THIS REPORT?



GENERAL COMMENTS AND SUGGESTIONS FOR ENHANCEMENT AND OTHER SERVICES

HOW DID YOU HEAR OF US?

NAME ☐ **ORGANISATION** ☐

YOUR ROLE IN THIS PROJECT ☐

FIX
STAMP

GEOQUEST ASSOCIATES
THE OLD VICARAGE
CASTLESIDE
Co. DURHAM DH8 9AP
UK