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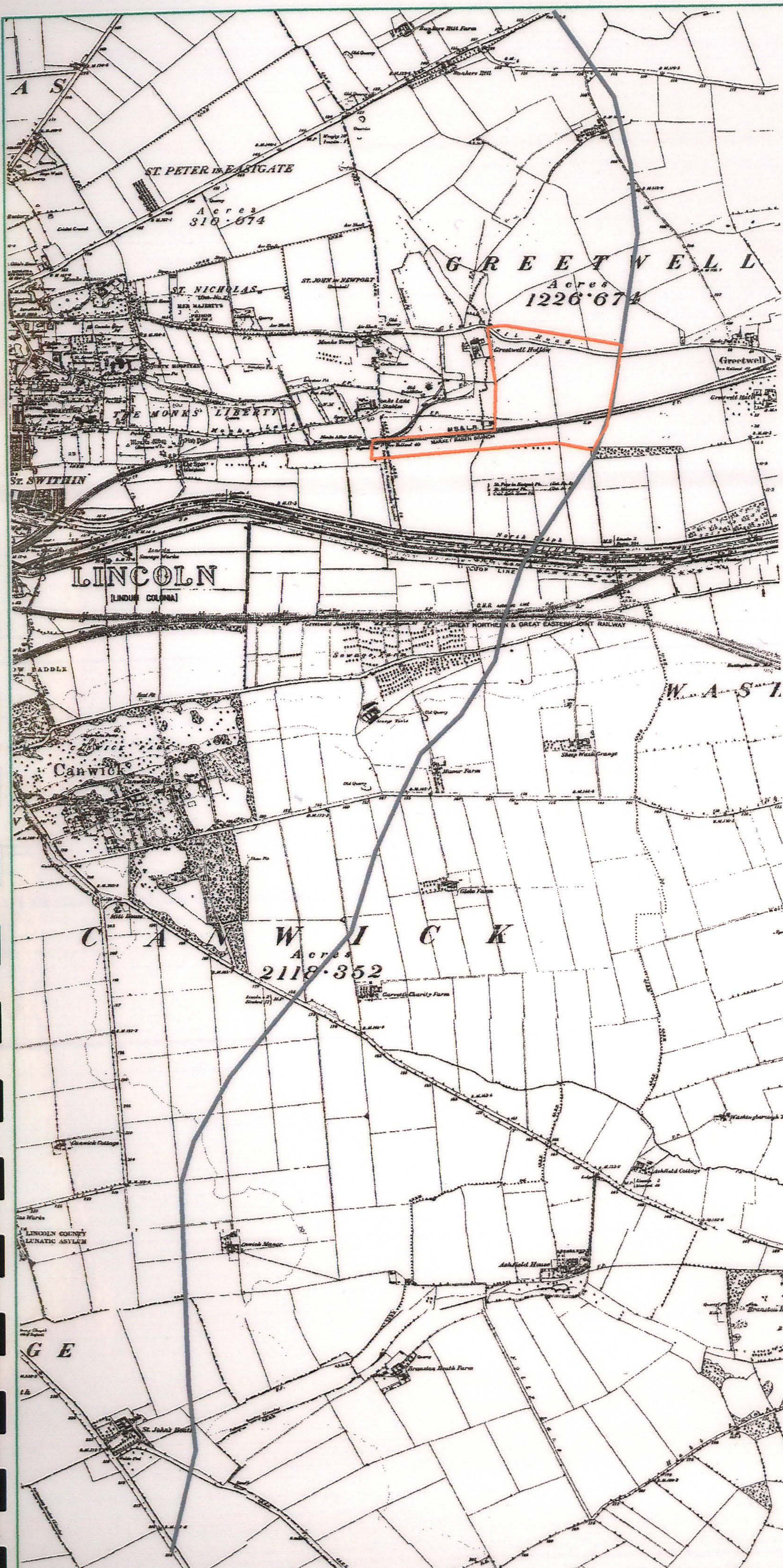

LINCOLN EASTERN BYPASS NORTHEAST DEVELOPMENT QUADRANT ACCESS

GEOPHYSICAL SURVEY

VOLUME I (OF II)

PRE-CONSTRUCT GEOPHYSICS

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VOLUME 1: REPORT TEXT

Report prepared for Babtie Group
By David Bunn

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PRE-CONSTRUCT GEOPHYSICS

Unit G
William Street Business Park
Saxilby
Lincoln
LN1 2LP

Summary

- *Fluxgate gradiometer and earth resistance surveys were undertaken on land within the proposed Lincoln Eastern Bypass Northeast Development Quadrant Access*

- *In the southern part of the site, the gradiometer survey recorded a number of linear anomalies and zones of magnetic variation that may indicate buried ditches and possible structural remains. Elements of the latter were targeted for resistance survey, the results of which appear to provide supportive evidence of walls and rubble spreads of at least one structure*

- *For the most part, magnetic variation in the northern part of the site almost certainly reflects former quarry activity, traces of which survive as earthworks*

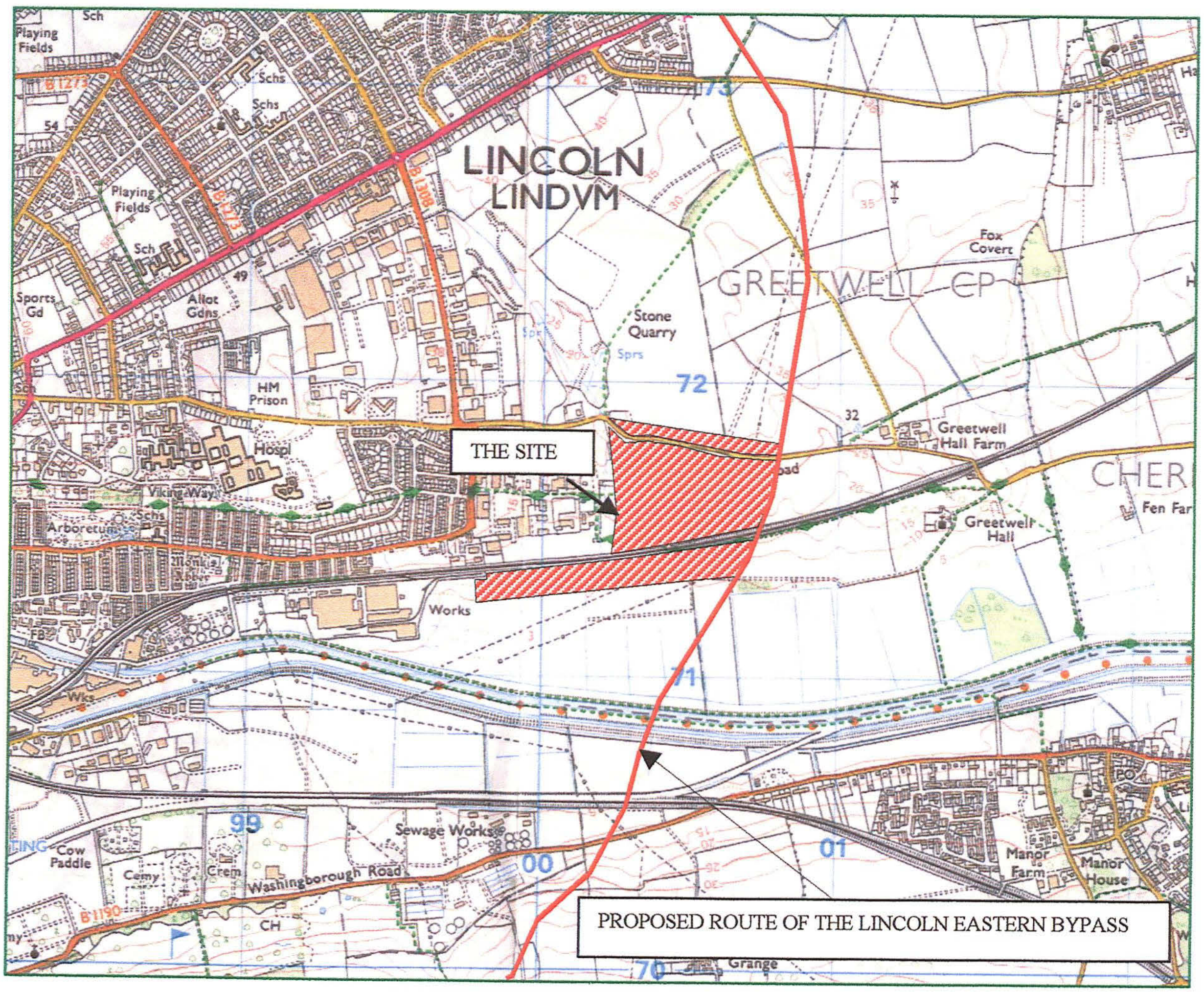

Fig.1: Location of site Scale 1:25000

1.0 Introduction

Babtie Group, acting on behalf of Lincolnshire County Council, commissioned Pre-Construct Geophysics to undertake fluxgate gradiometer and resistance surveys of land within the proposed Lincoln Eastern Bypass Northeast Development Quadrant Access.

The survey methodology was based upon guidelines set out in the English Heritage document *'Geophysical Survey in Archaeological Field Evaluation'* (David, 1995).

2.0 Location and description

The proposed development area lies to the east of the city on land sandwiched between Greetwell Quarry and the River Witham floodplain. For the most part, the site lies on the southeastern slope of the Lincoln Edge that falls from a height of approximately 30m OD to 3m OD. This reflects the geology of the area, which is comprised of limestone deposits of the Jurassic period, interspersed with patches of Blisworth Clay. Alluvial deposits cover the floodplain of the River Witham (British Geological Survey, 1973).

Areas within 7 fields (designated as fields A-G) were surveyed.

Survey Areas (Figs. 1-18)

Survey areas A-D (Figs. 1-8)

These areas comprise a c.100m wide block of land (c. 9.5ha) that lies to the immediate south of the railway and extends eastwards from Lincoln to the proposed bypass. Two small areas in Field E were targeted for resistance survey. Area A is uncultivated shrub, Areas B and C are pasture, and Area D is arable. With the exception of Field D (stubble), land use is pasture. A small pond and water-filled ditch lie at the eastern end of Area B.

The ground is low lying and level in Areas A-B. The ground level gradually rises across Areas C and D.

Survey areas E-F (Figs. 1, 2, 9-16)

These areas are situated between Greetwell Road and the northern edge of the railway. A southeast-facing slope that falls from c.30m OD- c.5m OD defines the topography. Area E, an irregularly shaped block of land of c. 6ha, forms the western part of a large field. Quarry earthworks in the northwest corner of the field were not surveyed. Current land use is arable (oilseed rape).

Area F comprises a c.8.5ha field that lies to the immediate east of the city boundary.

Survey area G (Figs. 1, 2, 17-18)

This area comprises a c.2ha strip of land that lies between Greetwell Road and Greetwell Quarry. Current land use is arable (oilseed rape).

3.0 Archaeological and historical background

The proposed development area lies within a rich archaeological landscape, with evidence of occupation dating from the Neolithic period onwards. Aerial photography had previously identified likely sites of barrows to the north and south of the Witham; it is believed that they occur only within the flood plain, below the 5m contour.

In 2003, geophysical and walkover surveys were undertaken along the route of the proposed Lincoln Eastern Bypass (Bunn & Palmer-Brown, 2003, Clay 2003). This work substantiated existing evidence of a number of suspected sites, in addition to identifying formerly unrecorded archaeological remains. A programme of trial excavation has identified traces of significant occupation activity of the area, dating from the prehistoric period (Rylatt, 2004). Traces of a probable Iron Age settlement were recorded to the northeast of the current site, as well as Bronze Age barrows, Roman and medieval buildings on land to the south of the River Witham. This work also revealed traces of a Mesolithic to early Bronze Age land surface (containing flints and features of unspecific date) to the south of the development area. To the immediate south of Area C, along the northern edge of the Floodplain, traces of a possible building were recorded.

To the immediate east of the current site, the excavations produced only limited evidence of significant remains.

4.0 Methodology

Magnetic variation that is detectable within soils can often determine the nature and extent of past human activity. At British latitudes, the earth's magnetic field is approximately 50,000 nanoteslas (The nanotesla is the SI unit of magnetic flux, used in gradiometry to measure magnetic variation in relation to the Earth's magnetic field). Against this background, most archaeological features produce an enhancement of around 5-30 nanoteslas (nT). The strength of this magnetic variation depends largely on the composition of the geology. For example, limestone and chalk exhibits low magnetic susceptibility, and contrasts well against soils: conversely, strongly magnetic igneous rocks can mask subtle anomalies completely.

For the most part, soils tend to be more responsive to magnetic remote sensing than the geologies over which they lie. Ferrous oxides occur naturally in many drift deposits, particularly those derived from, or containing elements of, igneous rocks. Organic decomposition within topsoils can supplement the level of ferrous compounds, a process amplified by agricultural activities.

The fills of ditches and pits tend to increase soil depths, and hence magnetic strengths, relative to surrounding soils. The converse also applies.

Ferromagnetic substances such as iron induce a very high response to magnetic surveys, and are thus easier to identify. Perhaps of more significance to the archaeological prospector are the weaker ferrous oxides; the randomly orientated magnetic fields of these materials produce minimal magnetic variation in their natural state. Geology and soil type can determine this variance (see above). Specifically, clay soils are ferrous oxide rich, hence their characteristic red colouration. Clay has literally been a fundamental building block in human social development: firing increases its versatility, but also enhances the magnetic properties of its ferrous content. For kilns, this may be in the order of 1000-5000 nT. Similar processes occur during the formation of igneous rocks.

Invariably, most surveys detect discrete anomalies, either in groups, or randomly scattered across a site. In the absence of intrusive investigation, the nature and origin of these anomalies is often difficult to establish. Strongly magnetic dipolar anomalies usually reflect ferrous objects, such as ploughshares and horseshoes. Weaker examples may indicate ceramic materials such as brick and tile, often introduced onto the site during manure spreading. The strength of the magnetic variation derives from permutations of the size and depth of the feature/object and the magnetic susceptibility of the surrounding soil. Pit-like anomalies, usually positive, can be identical to naturally occurring depressions, and the potential of these can only be estimated when they are examined in context with other factors, such as the proximity of definite, or suspected archaeological remains.

The use of magnetic surveys to locate sub-surface ceramic materials and areas of burning, as well as magnetically weaker features, is well established, particularly on large green field sites. The detection of magnetic anomalies requires the use of highly sensitive instruments, in this instance the Bartington 601 Dual Fluxgate Gradiometer. This must be accurately calibrated to the mean magnetic value of each survey area. Two sensors, mounted vertically and separated by 1m, measure slight localised distortions of the earth's magnetic field. Cumulative readings can be stored, processed and displayed as graphic images.

The gradiometer survey data has been processed using zero mean functions to correct the unevenness of the plots in order to give a smoother graphical appearance. The data was also processed using algorithm to remove magnetic spikes, thereby reducing extreme readings sometimes caused by stray iron fragments and spurious effects due to the inherent magnetism of soils.

Resistance survey measures the electrical resistance of the earth's soil moisture content. A twin probe configuration is normally used, which involves the pairing of electrodes (one current and one potential), with one pair remaining in a fixed position (remote probes), whilst the mobile probes measure resistivity variations across the survey grids. Resistance is measured in ohms, and this method generally detects to a depth of 1m.

Features such as wall foundations are usually identified as high resistance anomalies, as well as rubble spreads, made surfaces (ie yards and paths) and metalled roads and trackways. In contrast, low resistance values are normally associated with water-retentive features such as large pits, ditches, drains and gulleys.

Data from the survey was analysed using Geoplot v.3.0 (Geoscan 2000). The data has been processed using high and low pass filters in order to reduce anomalies caused by variation in geology and depth of topsoil. This also gives the plots and smoother graphical appearance. The plots are shown as raw and enhanced data.

The survey was undertaken by, Peter Heykoop, Peter Masters and David Bunn during November 2003 and January 200

Survey parameters

INSTRUMENT	TRAVERSE INTERVAL	SAMPLE INTERVAL
BARTINGTON 601 DUAL GRADIOMETER	1M ZIGZAG	4 READINGS/M
GEOSCAN RM 15 RESISTIVITY METER	1M ZIGZAG	1 READING/M

Area surveyed

AREA	GRADIOMETRY HECTARES	RESISTANCE HECTARES
A	0.72	-
B	3.42	-
C	4.0	0.44
D	1.62	-
E	6.2	-
F	8.50	-
G	2.0	-
TOTAL	26.46	0.44

5.0 Results

Area A (Figs. 1-4)

Strong magnetic variation along the northern edge of the survey relates to a metal fence, and there are probably buried ferrous materials in this area such as iron objects and rubble (boxed/circled in purple). Discrete examples of the latter may account for pockets of disturbance in other parts of the site.

Weak linear anomalies in the southern and eastern parts of the site may indicate ditches. At least two appear to extend into Area B (see below). Their archaeological significance is unclear, but it is possible that one may be the remains of a former ditch that collected outfall from land drains (possible examples of drains were detected in Area B). It also respects the current boundary that separates the survey areas. The other could potentially be of greater archaeological significance.

The results also show extremely ephemeral circular anomalies (more discernable on digital image). These may have been introduced during processing and, as such, would be illusory.

Area B (Figs. 1-4)

Potential ditch-like anomalies were detected in the south-western corner of the survey (shown as red lines). These anomalies appear to relate to features in Area A. They are crossed by two parallel, fragmented linears that possibly represent land drains (blue). The westernmost example appears to extend to the north of the survey and possibly across the area occupied by the railway. It also extends toward, and possibly terminates at, a broad ditch-like linear anomaly at the corner of the plot. If so, the latter may be a relatively recent drain (see above). However, this scenario is not clearly defined in the results, and it is possible that the short anomaly reflects traces of an earlier ditch.

For the most part, discrete variation resolves as dipolar anomalies(examples circled in pink). These probably represent iron and magnetically enhanced materials, such as brick and tile. A cluster of this anomaly type was recorded in the mid-eastern part of the site (boxed pink). Slight differences in ground cover in this area provides further evidence of an underlying rubble deposit, possibly filling a former pond. A similar zone of variation was recorded close to the north-eastern corner of the survey. Nothing was noted on the surface in this area, although this may also represent a concentrated deposit of miscellaneous rubble.

A tight group of weak, predominately positive, anomalies were detected in the mid-western part of the plot (boxed red). These provide the clearest geophysical evidence for features such as pits.

Area C (Figs. 1-2, 5-6)

The results of the initial survey indicated that this area contained potentially significant anomalies. Consultation with the clients prompted a decision to extend the survey by 30m to the south of the original area. Two areas were also targeted for resistance survey.

The survey identified a series of parallel ditch-like anomalies in the mid-northern part of the field. The survey in Area F recorded traces of similarly aligned features to the north of the railway (see Area F). A number of east to west aligned examples may signify traces of cultivation (shown as brown). Others appear to be ditch-like, and possibly constitute elements of enclosures (shown as red). Some extend across a zone of apparent random magnetic variation (Area 1, boxed in red) that could indicate ceramic rubble and pits/burning (examples circled red). Other pit-like anomalies were detected elsewhere, some in close proximity to possible ditches.

Deep cultivation has unearthed possible structural remains within Area 1, consisting of large fragments of limestone rubble (*pers. comm.* Mr. Ward, landowner). The gradiometer survey also recorded a possible rubble spread in the south-east corner of the survey, where a low mound provided additional evidence of archaeological activity (Area 2). Resistance surveys were undertaken across both of these areas (boxed in blue). The results support the case for former buildings, particularly in Area 1. A regular arrangement of high resistance linear anomalies appears to indicate the footprint of a structure(s) (Fig. 6: resistance survey, orange lines). Some of the variation may represent robber trenches (red lines). Interestingly, most of the resistance anomalies lie to the southwest of the zone of magnetic variation and on a slightly different alignment to most magnetic linear anomalies. This suggests that structural remains may extend across a relatively wide area and that the bulk of the resistance anomalies reflect stone structural remains. The magnetic anomalies could represent related elements with greater magnetic susceptibility; for example, tile. The other resistance survey (Area 2) was less clear, although the topographical and geophysical evidence is indicative of some form of activity (at least one high resistance anomaly could signify a wall).

A number of short linear and curvilinear anomalies were recorded in the northeast corner of the survey area (3, boxed red). This variation may represent a further zone of concentrated activity.

A diffuse curvilinear anomaly extends across zone 2 and possibly continues into Area D (green broken line), where it appears to align with a possible former track (see below). A natural origin is also a possibility, as glacial fissures within near-surface calcareous deposits can resolve magnetically as ditch-like features. Alternatively, it could mark the position of a paleochannel or the northern edge of the River Witham floodplain.

Almost all of the strong magnetic variation can be reconciled to modern features, such as electricity poles and boundaries (boxed purple). Disturbance along and close to the northern edge of the survey toward the eastern end of the field corresponds to the location of a public right of access across the railway. Strong variation in the western part of the survey is unresolved, although it almost certainly reflects buried ferrous materials (purple shaded area). Possibilities include the remains of a former electricity pole. Similar anomalies were recorded in Areas D and E; those in Area E lie at intervals along the alignment of a former overhead electricity supply (as shown on a digital map provided by the client).

Area D (Figs. 1-2, 7-8)

The survey recorded zones of wide magnetic variation. 1 and 2 relate to an electricity pole and pylon, respectively. Anomaly 3 may indicate the former position of a similar feature (see above). Strong magnetic variation was induced by a fence that extends along the northern edge of the site (boxed purple)

A linear anomaly at the southern edge of the plot probably represents an existing farm track (purple line). A magnetically weaker curvilinear anomaly runs parallel to, and c. 5 m to the north of the track (4, red line). It also corresponds to a strip of grass that may be visual evidence of an earlier and/or broader alignment of the track; shallow subsurface remains of this feature may be preventing cultivation.

It is not clear from the results that anomaly 4 continues beyond the western boundary into Area C (see above), although weak magnetic variation at the eastern edge of the latter may be evidence of this.

A north to south-aligned weak linear anomaly was recorded at the western edge of the survey 5). It possibly relates to linear 4, although a natural origin (e.g. paleochannel) should not be discounted. The survey identified a short 'L-shaped' anomaly (6) that appears to abut 5. This is more convincing as a potentially significant feature.

Two linear features at the northeast corner of the survey represent a continuation of a ditched track that had been identified during an earlier survey and excavation of the proposed bypass route (Bunn and Palmer Brown, 2003, J. Rylatt pers. comm.).

Short linear anomalies and discrete pit-like anomalies were recorded in the mid-southern part of the plot. These may be of natural origin (e.g. glacial).

Anomalies circled in orange represent survey errors (close proximity to ferrous materials).

Area E (Figs. 1-2, 9-12)

There is earthwork and/ cropmark evidence of quarrying in the fields to the north of the railway. Due to the limited archaeological potential of the earthworks, the northwestern corner of Area E was excluded from the survey. Over the remaining area, random and distinct magnetic variation indicates the extent of quarrying that was detectable by gradiometry (boxed green).

Linear anomalies 1-3 (blue) probably signify land drains or possible former land divisions. The survey also recorded numerous east-west or (to a lesser extent) north-south aligned closely spaced linear anomalies that extend across most of the survey (examples shown as brown lines). These appear to reflect cultivation scores of recent origin.

A diffuse curvilinear and magnetically negative anomaly close to the northern boundary probably indicates a buried plough furrow. Weak linear variation to the south of this almost certainly indicates traces of a paleochannel. Excavation to the east of the survey has established a natural origin (Rylatt, 2004).

Strong variation along the southern boundary of the field reflects the close proximity of a metal fence.

In the central part of survey area, an area containing a pylon was not surveyed (boxed purple). To the west of this, three isolated zones of strong disturbance (broken purple line) lie along the alignment of a former overhead electricity supply. These anomalies probably indicate the locations of poles. Anomalies circled in pink probably indicate similar remains (see Areas C and D, above).

Area F (Figs. 1-2, 13-16)

Traces of quarrying were recorded in Area F (boxed yellow): for the most part, the arrangement of linear anomalies within this zone probably relates to quarrying activities, although at least one (that continues into area G, shown as red line) could reflect a former land division.

In the southernmost quarry zone, some linear anomalies appear to indicate cultivation scores. These, and others, are parallel and magnetically similar to linear anomalies detected in Area C, which lies to the immediate south of the railway. A number of other linear anomalies (shown as red) also appear to relate to similar features in Area C. Some could be cultivation scores, although an alternative origin, such as ditches, should be considered. Their potential is enhanced by the close proximity of probable archaeological remains to the south of the railway.

The survey recorded magnetic traces of an existing track that extends along the western edge of the field (pink line). Strong variation along the southern edge relates to a metal fence.

A small hollow (?quarry pit, boxed pink), which was overgrown with shrub, was not surveyed. Strong magnetic variation at its western edge reflects an electricity pole and (possibly) two buried power lines that extend toward the western edge of the field (pink lines). Other strong anomalies probably indicate modern ferrous materials, deposited along the perimeter of the hollow.

Strong anomalies in the northwest corner of the survey relate to an electricity pole.

Area G (Figs. 1-2, 17-18)

Probable traces of former quarry activities were detected in the mid-part of the survey. Some of this variation resolves in linear fashion. The data was not destriped, due to the corresponding alignments of the survey traverse and the most extensive linear anomaly. The latter extends along the northern edge of Greetwell Road; this implies that they are contemporaneous.

Ditch-like linear anomalies in the western and eastern parts of the survey could indicate traces of former field boundaries (shown as red).

Zones of strong variation probably reflect ferrous materials deposited along the field boundaries (pink).

6.0 Conclusions

The majority of potentially significant features were detected to the south of the railway, particularly in area C where anomalies appear to indicate ditches and traces of walls; the latter being more clearly depicted in the resistance data.

In Area D, two closely-spaced linear anomalies almost certainly represent a former track that extended between Lincoln and Greetwell.

To the north of the railway, the survey identified probable traces of ironstone quarrying in all areas, although a number of linear anomalies in the southern half of Area F may relate to features identified in Area C.

7.0 Acknowledgements

Pre-Construct Geophysics would like to thank Babtie Group and Lincolnshire County Council for this commission.

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