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Geophysical Survey Part 9

The Yorkshire and Humber (CCS Cross Country Pipeline) Development Consent Order

Under Regulation 5(2)(a) of the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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June 2014

ARCHAEOLOGICAL SERVICES WYAS

Yorkshire and Humber Carbon Capture Scheme (CCS) Cross Country Pipeline Tollingham to Dalton

Geophysical Survey

Report no. 2600

April 2014

Client: AECOM

REGISTERED IA ORGANISATION

Yorkshire and Humber Carbon Capture Scheme (CCS) Cross Country Pipeline
Tollingham to Dalton

Geophysical Survey

Summary

A geophysical (magnetometer) survey, covering approximately 161 hectares, was carried out along the preferred route of the Tollingham to Dalton section of the Yorkshire and Humber Carbon Capture Scheme (CCS) Cross Country Pipeline. A proposed Block Valve site, close to Holme on the Wolds, was also surveyed. Five sites of definite and high archaeological potential have been identified along this section of the corridor including two adjacent to Roman roads and a third that locates an extensive probable Iron Age settlement site. In addition anomalies of archaeological potential have been located at several other locations which include anomalies which may locate Bronze Age barrows.

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Report Information

Client:	AECOM
Address:	5th Floor, 2 City Walk, Leeds, LS11 9AR
Report Type:	Geophysical Survey
Location:	Tollingham to Dalton
County:	East Yorkshire
Grid Reference:	SE 8222 3598 to SE 9529 4736
Period(s) of activity:	Romano-British
Report Number:	2600
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Site Code:	DVC12
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Planning Application No.:	
Date of fieldwork:	November 2012 – May 2013
Date of report:	July 2013
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1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by AECOM, on behalf of their client, National Grid, to undertake a programme of geophysical (magnetometer) survey along the proposed route of the Yorkshire and Humber Carbon Capture Scheme (CCS) Cross Country Pipeline and its associated infrastructure. The proposed route runs from Drax Power Station, in North Yorkshire, to the east coast near Barmston, in East Yorkshire (see Fig. 1), a distance of 74 kilometres. The route is divided into four sections – Camblesforth to Tollingham, Tollingham to Dalton, Dalton to Skerne and Skerne to Barmston.

This report relates to the Tollingham to Dalton section, which runs from an area near Holme-on-Spalding-Moor (at the western end of the section) in a north-easterly direction until it reaches the next section near Dalton and Holme on the Wolds. It includes the proposed site of a Block Valve at Dalton (see Fig. 2). During the course of the survey the route of the pipeline corridor and location and extent of infrastructure was revised. Waterlogging and access issues also restricted access in certain areas. The scheme boundary shown on all figures represents the current proposals; previous boundaries are not displayed. Any apparent 'gaps' in the survey or areas surveyed 'outside' the displayed corridor are due to the reasons outlined above. The scheme of work was undertaken in accordance with guidance contained with the National Planning Policy Framework (2012) and to a Written Scheme of Investigation (WSI), produced by AECOM and approved by Humber Archaeology Partnership. The geophysical survey was carried out between November 27th 2012 and May 21st 2013.

Site location, land-use and topography

The Tollingham to Dalton section starts west of Tollingham, at SE 8222 3598. It runs in a north-easterly direction, south of Market Weighton, through Weighton Wold and Holme Wold until it reaches the next section at Dalton, SE 9529 4736. The route incorporates the proposed site of a Block Valve at Dalton, near to Holme on the Wolds, centred at SE 9511 4719 (see Fig. 2). The pipeline corridor crosses mixed farmland with an undulating topography which gently rises from 6m above Ordnance Datum (aOD) at Tollingham to the edge of the Wolds at 130m aOD. The topography then drops towards Holme on the Wolds where a height of 40m aOD is recorded. Survey was not possible within some areas of the survey corridor due to waterlogging, excessive crop growth and refused access. These areas are depicted on Figures 2 to 104 inclusive.

Geology and soils

The underlying bedrock within the south-western part of the section comprises of Mercia Mudstone which is overlain by a mixture of Bielby Sands and glaciolacustrine deposits of sand and gravel. This extends from Tollingham to a geological boundary close to Cliffe Road which runs south from Market Weighton. Here, the underlying bedrock becomes Penarth Group mudstone which then becomes Scunthorpe Mudstone and Charmouth Mudstone Formations. These are overlain by superficial deposits of glaciolacustrine deposits of sand

and gravel. At the A1034 the topography steeply rises on to the Wolds, the bedrock geology here consists of six bands containing Marlstone Rock, Whitby Mudstone, Ravensthorpe Beds and Kirton Cementstone Beds, Cave Oolite, Hunstanton Formation chalk and Ferriby Chalk before changing to Welton Chalk formation on the Wolds. Towards the end of the corridor, the proposed route passes over Burnham Chalk and Welton Chalk formations, with superficial deposits of Head in valley bottoms (British Geological Survey 2013). The soils are described from west to east, as part of the Holme Moor, Everingham, Newport 1, Swaffham Prior and Hunstanton soil associations. These consist of sandy soils; deep stoneless permeable fine sands; deep, well-drained coarse loams and sands; well-drained calcareous coarse and fine loams; and deep well drained often reddish fine and coarse loams of the Hunstanton association respectively (Soil Survey of England and Wales 1983).

2 Archaeological Background

The following archaeological background is summarised from draft baseline information provided by the client. A more detailed and comprehensive assessment of the archaeological background will be contained within the Environmental Impact Assessment (EIA), currently in preparation. Preliminary data from the EIA (AECOM 2013) does, however, indicate more than 308 archaeological records within the Tollingham to Dalton search area (as entered on the Humber Archaeological Partnership Sites and Monuments Record, and the National Monuments Record). An additional 26 assets were identified during a review of aerial photographs, while 23 sites or find spots were recorded during an archaeological walkover survey undertaken by the client. More than a third of the records relate to post-medieval activity but with a significant number (102) relating to prehistoric activity and 62 assets have been recorded as being of Iron Age or Roman date. There are twenty scheduled monuments in close proximity of the proposed route that consist of nineteen round barrows on Weighton Wold and an oval barrow to the east of Kipling Cotes Station (see Figs 18, 19 and 20; and 24, 25 and 26).

Evidence for Neolithic activity within the Tollingham to Dalton section is limited to two barrows located near to the survey corridor (AECOM Archaeology Identifier Number TD103 and TD70 – see Figs 18, 19 and 20; and 24 and 25). Other burial monuments within this section are thought to relate to the Bronze Age and occur individually and as groups. These include the scheduled monuments that form part of the High Wold Bronze Age barrow cemetery near High Wold Farm (TD71-TD80 and TD294-TD296 – see Figs 18, 19 and 20). The Wolds Entrenchment is located with the Tollingham to Dalton section. This is a substantial earthwork and cropmark feature consisting of banks and ditches (TD184).

Assets dating to the pre-Iron Age period take the form of settlement sites, such as a ladder settlement identified by aerial photography at Springwell Field, near Market Weighton (TD83 – see Figs 21, 22 and 23) and hut circles at Skiff Farm (TD3 – see Figs 3, 4 and 5). Industrial activity has been recorded along the corridor that dates to the Iron Age and Roman periods, this includes metal working sites and pottery production sites (TD19 – see Figs 3, 4 and 5 and TD343 – see Figs 15, 16 and 17).

The Roman period along the Tollingham to Dalton section is represented by numerous pottery finds, and by settlement activity including enclosures and field systems. Two Roman roads (Margary 1973) pass through the section on a north-west/south-east alignment passing either side of Market Weighton (see Fig. 2). The westernmost Roman Road (Margary road number 2e) runs from Brough on Humber to York (TD64 – see Figs 12, 13 and 14) while the eastern road (Margary road number 29) runs from South Newbald to Malton (see Figs 15, 16 and 17).

Early medieval heritage assets are not common throughout the Tollingham to Dalton Section and whilst medieval assets are numerous, they are primarily located in current settlements and not in proximity to the pipeline corridor.

Several post-medieval heritage assets fall within or close to the pipeline corridor, the majority of which appear to be agricultural in origin. Other assets include listed buildings and are thought to be from the 18th or 19th centuries. Throughout this section a number of chalk or marl pits have been identified (TD311-TD312 – see Figs 21, 22 and 23), these are thought to have be in operation and then abandoned in the mid-19th century.

Therefore, on the basis of the current evidence base, the application area is considered to have a moderate archaeological potential with areas of high archaeological potential in the vicinity of the barrow cemetery at Weighton Wold and at the ladder settlement at Springwell Field.

3 Aims, Methodology and Presentation

The main aim of the geophysical survey was to provide sufficient information to enable an assessment to be made of the impact of the proposed development on any potential archaeological remains and for mitigation proposals, if appropriate, to be recommended. To achieve this aim a magnetometer survey covering the whole of the pipeline corridor was carried out, a total of 161 hectares.

The general objectives of the geophysical survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified;
- to therefore determine the presence/absence and extent of any buried archaeological features; and
- to prepare a report summarising the results of the survey.

Magnetometer survey

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). Bartington Grad601 magnetic gradiometers were used during the survey taking readings at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m grids so that 3600 readings were recorded in each grid. These readings were stored in the memory of the instrument and later downloaded to computer for processing and interpretation. Geoplot 3 (Geoscan Research) software was used to process and present the data. Further details are given in Appendix 1.

Reporting

A general site location plan, incorporating the Ordnance Survey map and showing the four overall sections, is shown in Figure 1 at a scale of 1:250000. Figure 2 is a large scale (1:50000) overview of the Tollingham to Dalton section showing the extent of the pipeline corridor and its associated infrastructure. At this scale the corridor has been divided into ten blocks. Figures 3 to 32 inclusive show the processed greyscale magnetometer data, the first edition Ordnance Survey mapping (1855) and the overview interpretation of the data along the route at a scale of 1:5000. Detailed data plots ('raw' and processed) and full interpretative figures are presented at a scale of 1:2000 in Figures 33 to 104 inclusive with the route split into seventeen sectors. The survey area numbers which are depicted on Figures 3 to 104 inclusive were assigned prior to the fieldwork to aid communications with the client. Archaeological identifier numbers, depicted on the same figures correspond to those in the draft baseline information provided by the client.

Further technical information on the equipment used, data processing and survey methodologies are given in Appendix 1 and Appendix 2. Appendix 3 describes the composition and location of the site archive.

Archaeological Services WYAS is registered with the Online Access to the Index of archaeological investigations project (OASIS). The OASIS ID for this project is archaeol11-177996.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David *et al.* 2008) and by the Institute for Archaeologists (IfA 2013). All figures reproduced from Ordnance Survey mapping are with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The figures in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All figures are presented to most suitably display and interpret the data from this site based on the experience and knowledge of Archaeological Services staff.

4 Results and Discussion (see Figs 3 to 104 inclusive)

Magnetometer Survey

The anomalies identified by the survey fall into a number of different types and categories according to their origin and these are discussed below and cross-referenced to specific examples and locations along the proposed pipeline route.

Ferrous Anomalies

Ferrous responses, manifesting either as individual ‘spike’ anomalies or more extensive areas of magnetic disturbance, are typically caused by modern ferrous (magnetic) debris, either on the ground surface or in the plough-soil, or are due to the proximity of magnetic material in field boundaries, buildings or other above ground features. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation. Ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling. Throughout the route iron ‘spike’ anomalies are common and there is no obvious pattern or clustering to their distribution to suggest anything other than a random background scatter of ferrous debris in the plough-soil.

Clusters of ferrous anomalies coalescing into larger areas of magnetic disturbance have been identified at a number of locations, predominantly adjacent to roads, trackways, pylons, buildings or drains. Examples include the drain in Area 152 (see Figs 33, 34 and 35) and the drain and trackway in Area 121, manifesting in the data as magnetic disturbance (see Figs 60, 61 and 62). These clusters are not considered to be of archaeological significance.

High-magnitude dipolar linear anomalies have been identified traversing Area 154 (see Figs 33, 34 and 35), Area 115 under the current trackway (see Figs 68, 69 and 70), Area 107 (see Figs 75, 76 and 77) and Area 94 (see Figs 93, 94 and 95). These anomalies delineate the routes of service pipes.

The data within Area 141 (see Figs 42, 43 and 44), Area 134 (see Figs 51, 52 and 53) and Area 118 (see Figs 63-68) is characterised by a mass of individual ‘iron spike’ anomalies which results in the data having a dense ‘speckled’ appearance. These anomalies are caused by the effects of organic waste which had been spread across these fields. The anomalies are either due to ferrous material incorporated within the organic waste or possibly to the concentration of magnetic minerals caused by bacteria during the decomposition process. It can be difficult to identify any anomalies of archaeological origin, if present, against this magnetic background, although within Area 141 and Area 118 other higher magnitude anomalies are visible through the speckled background (see below).

Modern Anomalies

Three anomalies have been identified which correspond to agricultural features depicted on early Ordnance Survey mapping. For this reason, these anomalies have been ascribed a modern interpretation, and whilst they may be of local historical interest, they are not thought to be of any archaeological significance. Two areas of magnetic disturbance have been identified to the north of the A1079 (see Figs 69-74). The southernmost area, **A**, is located immediately north of the road and is marked on the first edition Ordnance Survey mapping as an old chalk pit (see Fig. 19) subsequently backfilled. The northernmost area, **B**, is identified as TD333 (see Figs 72, 73 and 74), which is also depicted on the first edition Ordnance Survey mapping (see Fig. 19) and is thought to be a backfilled dew pond. A similar feature, **C**, has also been identified towards the end of the section in Area 91 (see Figs 96-101) which is also depicted as a dew pond on the first edition Ordnance Survey mapping (see Fig. 31).

Agricultural Anomalies

Faint parallel linear trend anomalies have been identified in most sections of the survey corridor. The most numerous trend anomalies are caused by ploughing. The close spacing between these anomalies is typical of modern ploughing. One area containing broader and slightly curving trend anomalies has been identified in Area 89 and Area 88 (see Figs 99 to 104 inclusive), and are interpreted as being due to the medieval and post-medieval practice of ridge and furrow ploughing. The anomalies are caused by the magnetic contrast between the infilled furrows and former ridges.

Over the last 150 years the size of the fields has been increased by the removal of many of the boundaries shown on the first edition Ordnance Survey map; these boundaries are indicated on the 1:5000 overview figures (see Figs 4, 7, 10, 13, 16, 19, 22, 25, 28 and 31). Of the 35 former field boundaries within the pipeline corridor, 20 have been identified in the geophysical survey, generally as weakly magnetised linear trends. Such trends are exemplified by the north/south aligned linear trend within Area 150 (see Figs 4, 5 and 6) and the faint linear trend, orientated north-west/south-east in Area 157 (see Figs 75, 76 and 77). The exact reasons why some of the former field boundaries have not been detected by the geophysical survey are uncertain. Some may have been removed by later agricultural activity. However, it is likely, given the superficial deposits of sands and gravels, that there exists a low magnetic contrast between cut features, such as the soil-filled former boundary ditches, and the surrounding soils. Therefore, it is possible that low magnitude, discrete archaeological anomalies, may remain undetected.

In Area 141 (see Figs 42, 43 and 44), within a field where organic waste has been spread (see above), a former field boundary has been identified, **D**. This anomaly has a stronger magnetic response than the organic waste and is thought to be caused by a drain located in the ditch of the former boundary. Within Area 136 (see Figs 48-53), Area 123 (see Figs 57, 58 and 59), Area 108 (see Figs 72, 73 and 74), Area 102a (see Figs 81-86) and Area 96 (see Figs 90, 91 and 92), linear trend anomalies have been identified that are suggestive of former field boundaries yet do not appear on any previous mapping. These are thought to be field boundaries that were removed before the first edition Ordnance Survey mapping was produced in 1855.

A number of field drain anomalies have been identified in Area 148, Area 145, Area 144, Area 142 to Area 139, Area 123, Area 121 and Area 119 (see Figs 33 to 65 inclusive). Almost all these anomalies occur on mudstone geology and their frequency would tend to suggest that the land is susceptible to seasonal waterlogging and/or poor drainage. It is considered possible that there may be other, undetected, drains at other locations on the mudstone geology.

Within Area 92 and Area 91, on the chalk geology, four trend anomalies have been interpreted as field drains. The trends are mainly linear in appearance and appear to respect the topography which rises to the north and the south from the lowest point where the trends intersect. The north-west/south-east aligned trend clearly runs towards a former dew pond, anomaly **C** (see Figs 96 to 101 inclusive) within the south-east corner of the field, and reinforcing the field drain interpretation. However, a linear cropmark, TD332, is recorded within the field to the immediate east of these anomalies and therefore an archaeological interpretation cannot be completely dismissed.

Geological Anomalies

Variations in the magnetic background across the Tollingham to Dalton section corresponds to variations in the underlying bedrock and superficial geology (British Geological Survey 2013). Broadly speaking discrete anomalies identified as areas of magnetic enhancement which are interpreted as geological in origin throughout the west of the section (Area 153 to Area 119) are thought to indicate localised variations in the soils resulting from episodes of seasonal waterlogging. These areas occur on the Mercia Mudstone formation geology and are not as frequent on the more freely draining chalks of the Wolds. The identification of several field drains along this part of the corridor corroborates this interpretation (see above). In contrast, the background response throughout the eastern part of the section (Area 118 to Area 85) is characterised by a myriad of faint, sinuous linear trend anomalies often radiating from high points in the landscape. These anomalies are thought to be caused by an accumulation of magnetically enhanced material within fissures in the chalk bedrock and by localised areas of soil creep within the undulating landscape.

Occasional isolated exceptions to this explanation have been noted, and are generally thought to arise from differing forms of water erosion. Within Areas 102 and 101 (see Figs 84, 85 and 86) a number of winding linear bands of magnetic enhancement are visible. Generally, these bands respect the gentle north-facing slope and the undulating topography, and are thought to be due to a build-up of colluvium at the base of slopes.

Two further geological areas of note occur across Area 100 and Area 99 (see Figs 84 to 89 inclusive) and Area 89 (see Figs 99, 100 and 101). Here, interlinking linear and rectilinear anomalies are visible over extensive elevated locations. Interpretation of these anomalies is tentative. In places, their linear and rectilinear morphology is suggestive of archaeological anomalies caused by infilled features such as ditches. However, the anomalies are fragmentary and sometimes weak and no clear archaeological pattern is discernible. On balance, therefore, a geological interpretation is assigned, the anomalies being thought to be due to the erosion of the bedrock by water and/or ice.

Possible Archaeological Anomalies

Unless otherwise stated, anomalies of possible archaeological origin are thought to be caused by infilled cut features such as ditches, often forming part of a system of land division and settlement, and by discrete features such as pits.

Across the corridor in the Tollingham to Dalton section a number of anomalies have been ascribed a possible archaeological interpretation. Whilst these anomalies do not manifest in any coherent archaeological pattern, they are generally high in magnitude and are located near to areas of known archaeology, and have therefore been interpreted as being potentially archaeological. For example, within Area 150 a cluster of anomalies is located 100m west of TD13, the site of a possible Romano-British settlement (see Figs 36, 37 and 38). Within Area 145, several short linear anomalies can be seen close to TD51, possible Iron Age enclosures (see Figs 39, 40 and 41), and within Area 148 a cluster of anomalies can be seen 100m north-east of TD18, possible enclosures identified as cropmarks (see Figs 36, 37 and 38).

A broad and amorphous anomaly has been identified within Area 141, south of Sand Lane, near Holme-on-Spalding-Moor (see Figs 42, 43 and 44). The anomaly is located within a field swamped by magnetic disturbance due to the spreading of organic waste (see above). No clear archaeological pattern is discernable within the broad magnetic background and it is thought possible that this anomaly may be geological or modern in origin. However, the anomaly corresponds to AECOM archaeology identifier TD54 which is recorded as an enclosure and, therefore a possible archaeological interpretation is assigned.

North-west/south-east aligned discrete linear and curvilinear anomalies within Area 120 (see Figs 60 to 65 inclusive) may indicate an oval-shaped enclosure. The anomalies are faint and extend beyond the southern extent of the survey area making a confident archaeological interpretation tentative. It is possible that the anomalies indicate variations in the soil due to episodes of seasonal waterlogging. Nevertheless, the anomalies lie within close proximity of several surface finds including metal-working waste and pottery sherds (TD353 to TD356) and therefore a possible archaeological origin is assigned.

To the south of Wold Cottages, in Area 115 and Area 116 (see Figs 66, 67 and 68) a rectilinear anomaly, **E**, with a clear dog-leg has been identified aligned north-west/south-east. No obvious archaeological pattern is visible, and the anomaly may be agricultural in origin, but it is also possible that it indicates a ditch pre-dating the publication of the first edition Ordnance Survey map. Surface finds to the immediate east of the anomaly include metal working waste and pottery sherds (TD347, TD348 and TD349).

At High Wold Farm two faint parallel linear trends, **TR1**, have been identified aligned north-east/south-west in contrast to the surrounding geological trends (Area 113 - see Figs 69, 70 and 71). The site of Weighton Wold lies a short distance to the east and it is thought possible that these anomalies indicate ditches delineating the route of a trackway. However, the anomalies are very faint and it is possible that they indicate an unmapped former field boundary. Due north of the possible trackway, and on the opposite side of Weighton Hill road, two potential barrows, **B1** and **B2**, have been identified manifesting as very faint sub-circular trend anomalies, 8m in diameter (Area 112 – see Figs 69 to 74 inclusive). The anomalies are located 94m south-west of a round barrow (TD710) protected as a scheduled monument and part of High Wold Farm Barrow Cemetery (see Figs 18, 19 and 20) and therefore, an archaeological interpretation must be considered.

An L-shaped linear anomaly, **F**, has been recorded in Area 108 (see Figs 75, 76 and 77) possibly caused by a soil-filled ditch. A possible enclosure, trackway and ditches (TD82) are recorded 206m to the southeast (see Fig. 23) and it is possible that this anomaly indicates a continuation of these features. Approximately 30m to the east, a faint square anomaly, **B3,** has been identified measuring 7m in diameter and, a short distance away, a faint circular anomaly **B4**, measuring 5m in diameter. Given the local archaeological context and the close proximity of the barrow cemetery, it is possible that these anomalies indicate a square barrow and a round barrow respectively. This interpretation is further reinforced by the presence of three further possible square barrows, **SB1**, **SB2** and **SB3**, 90m to the north-east. These manifest more clearly in the data as small square anomalies each measuring between 7m and 9m in diameter. However, due to their low magnitude, none of the possible barrows are of definite archaeological origin and a geological interpretation for all is also plausible.

Anomalies indicting a significant settlement site (**Site 3** - see below) have been identified at Springwell Field, approximately 4km east of Market Weighton. Three linear anomalies, **G**, **H** and **I**, have been identified to the east and west of this site which are thought to indicate ditches, possible indicating former field systems. The westernmost anomaly, **G**, can be seen in the south-west of Area 107 (see Figs 75, 76 and 77). East of **Site 3**, in Area 104 and Area 103, two intersecting linear anomalies have been recorded, **H** and **I** (see Figs 78 to 83 inclusive). A single archaeological identifier at this location (TD337) records a small find spot of flint and pottery.

To the north of **Site 4**, at Common Wold, Area 100 and Area 99 (see Figs 84 to 89 inclusive), several anomalies of possible archaeological interest have been identified in the vicinity of heritage assets including a possible barrow, TD106, identified as a cropmark on aerial photographs and, to the west of the corridor, a possible double-ditched trackway, TD113. Linear and rectilinear anomalies have been identified on a regular north-south alignment. It is possible that these anomalies indicate soil-filled ditches forming part of a field system. To the north of these anomalies, a faint and fragmentary circular anomaly, **B5**, is visible corresponding to the site of the possible barrow, TD106. The anomaly measures 19m in diameter. Despite the possible archaeological nature of these anomalies interpretation is tentative given the variable nature of the geology. A geological interpretation is feasible, and the anomalies may be due to cracking in the chalk bedrock. To the immediate south of **B5** a broad rectangular anomaly, **P4**, corresponds to TD314, a large rectilinear cropmark (see Figs 24, 25 and 26) and a deep depression on the ground noted during the survey. This anomaly is thought to be caused by a chalk extraction pit. Another rectangular anomaly, **P3**, has been identified within Area 100 (see Figs 87, 88 and 89). This is also thought to be caused by an infilled chalk pit and is located 150m due east of TD335, a possible former mine/quarry.

To the north of Common Wold, at South Dalton Wold, two linear anomalies, **J** and **K**, have been identified at approximate right angles (Area 95 - see Figs 90 to 95 inclusive). These are likely to indicate soil-filled ditches. The anomalies do not correspond to the existing field layout, nor that depicted on the first edition Ordnance Survey map (see Fig. 28) and an archaeological interpretation must therefore be considered. A settlement complex, TD93, is recorded 500m to the south-west, due west of Kiplingcotes Farm, and GoogleEarth images indicate that anomalies **J** and **K** appear on the same north-east/south-west alignment. It is possible, therefore, that these anomalies indicate ditches associated with an outlying field system.

A cluster of broad high magnitude anomalies has been identified towards the southern end of the corridor. Possible pit anomalies, **P5 – P12**, have been identified within Area 90 and Area 89 (see Figs 99, 100 and 101). These are thought to indicate pits and, given the frequency of known chalk pits in the immediate landscape, it is possible that these are further extraction pits. However, no clear pattern is visible within the data and origin of these anomalies is uncertain.

Archaeological Anomalies

The following sites have been assigned an archaeological interpretation based upon their clarity and morphology and their proximity to one or more known heritage assets.

Site 1 (see Figs 54, 55 and 56)

Fragmented linear anomalies have been identified south of High Common Farm corresponding to TD64, a Roman Road (Margary 1973, Road No. 2e) which runs from Brough on Humber to York. The anomalies, **M**, identified are thought to be due to flanking roadside ditches (Area 126 - see Fig. 14 and Figs 54, 55, 56). The anomalies are magnetically weak, suggesting that the magnetic contrast between the road and the surrounding soil is poor or that the feature may have been partially plough damaged. A linear anomaly, **N**, which is identified 33m to the west is orientated parallel to the road and may be associated with the road. Given the clear archaeological potential adjacent to the Roman road, several discrete anomalies and areas of magnetic enhancement, have also been ascribed a possible archaeological origin, although a localised pedological origin is also a plausible.

Site 2 (see Figs 63 to 68 inclusive)

Linear and rectilinear anomalies, **E1** and **O**, suggestive of possible ditched enclosures have been identified within Area 119, at Gaufer Hill (see Figs 63, 64 and 65) and Area 117 (see Figs 66, 67 and 68). The anomalies are located within close proximity of the Roman Road (Margary road number 29) which runs from South Newbold to Malton (see Fig. 17). The course of the road itself has not been identified by the survey due to the spreading of organic waste throughout Area 118 (see above), but it is thought possible that these enclosures represent roadside activity. The route of a possible trackway, **TR3**, has tentatively been identified to the immediate west of Gaufer Hill. The restricted survey area at this location makes a confident interpretation difficult.

Site 3 (see Figs 75 to 80 inclusive)

A probable Iron Age ladder settlement has been recorded within Area 107, Area 106 and Area 105. A trackway, **TR4**, is flanked on the southern side by two large enclosures, **E2** and **E3**, which are subsequently sub-divided by eight further enclosures, **E4-E11**. To the north of the trackway are four further enclosures, **E12-E15**. To the north-west of the surveyed area the trackway, **TR4**, is flanked by two partial enclosures, **E16** and **E17**. Discrete areas of magnetic enhancement within and in close proximity to the enclosures are thought to be archaeological in origin being caused by features and activity associated with the settlement. In enclosure **E10** a possible chalk pit**, P6**, is visible, which corresponds to identifier TD311. A probable archaeology interpretation has been assigned to this anomaly as it appears to respect the alignment of the enclosure. The origin of this anomaly is thought likely to be of 19th century date although a prehistoric origin cannot be discounted.

Site 4 (see Figs 84, 85 and 86)

Three possible trackways, **TR5**, **TR6** and **TR7** are visible in the data within Area 102. Two of the possible features, **TR5** and **TR6** appear to intersect. In the same field as these probable trackways are numerous fragmented linear anomalies. The anomalies do not appear to have any coherent pattern. Within Area 102 (see Figs 81 to 86 inclusive) two rectangular pit-like anomalies, **P1** and **P2**, have been recorded. These are indicative of chalk pits that are known to be located throughout the Wolds and are clearly visible on GoogleEarth images of the area. A possible archaeological interpretation has been given as the exact nature of these anomalies is unknown and they are in close proximity to known barrows (TD103 and TD 105). In the same area there are a number of linear anomalies that are extremely fragmentary and do not form any coherent pattern. These are in a different orientation to the trackways (see below) that have been identified. On this basis a possible archaeological interpretation has been assigned.

Within the north of Area 101 parallel curvilinear anomalies, **Q**, have been recorded on an east/west alignment at the base of a north-facing slope. Upstanding earthworks to the east of this site are thought to be due to the Wolds Entrenchment which runs on the same alignment, and it is likely that these anomalies are caused by soil-filled ditches relating to his feature.

Site 5 (see Figs 99, 100 and 101)

To the east of Area 89 (see Figs 99, 100 and 101) a series of linear anomalies, **L**, of possible archaeological potential have been identified. The magnetic anomalies appear to be form part of a rectilinear enclosure on an east-west alignment and containing a number of internal sub-divisions. The full extent of the enclosure is unknown as the anomalies extend beyond the survey corridor to the south. To the immediate east of anomaly **L**, a possible trackway, **TR2**, can be seen as a sinuous, fragmented, double ditched linear anomaly. To the west of the enclosure, and corresponding to a prominent rise in topography, several linear and rectilinear anomalies are thought to indicate soil-filled ditches. No clear archaeological pattern is visible but the anomalies may form part of a former field system.

5 Conclusions

The geophysical survey has identified five sites of clear archaeological potential along the Tollingham to Dalton Section of the pipeline corridor as well as numerous discrete areas of magnetic enhancement and individual linear anomalies that are also suggestive of activity at several other locations. Here the lack of a definite archaeological interpretation is either because the anomalies are weak or fragmentary, there are complicating geological factors or there is little or no supporting archaeological information in the form of cropmarks or find spots. These other anomalies of potential include possible round and square barrows and several enigmatic rectangular pit-type anomalies which are supposed to be chalk pits of unknown, presumed 19th century origin.

The definite archaeological activity is identified adjacent to two Roman roads at Site 1 and Site 2 whilst Site 3 locates an extensive, presumed Iron Age, settlement site. Site 4 locates several probable trackways with fragmentary anomalies to suggest a surrounding field system. Site 5 locates a possible series of enclosures with an adjacent trackway and possibly part of the Wolds Entrenchment.

The effects of changes in geology along this section of the corridor are reflected by the type and frequency of anomaly recorded during the magnetometer survey. The results on the mudstone indicate evidence of seasonal waterlogging as areas of magnetic enhancement and with linear trend anomalies indicative of field drains. On the chalk magnetic anomalies are recorded that are consistent with possible soil-filled fissures or of soil creep on the more undulating Wolds landscape.

The detrimental effects of the spreading of organic mulch is also clearly visible in the data and has severely hampered detection and interpretation at locations where archaeology is considered highly likely to be present, most notably adjacent to the Roman road.

Based on the geophysical survey the archaeological potential along the corridor is high at the five designated sites and moderate in the areas immediately surrounding those other anomalies attributed a possible potential.

Disclaimer

The results and subsequent interpretation of data from geophysical surveys should not be treated as an absolute representation of the underlying archaeological and non-archaeological remains. Confirmation of the presence or absence of archaeological remains can only be achieved by direct investigation of sub-surface deposits.

Appendix 1: Magnetic survey - technical information

Magnetic Susceptibility and Soil Magnetism

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).

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. The magnetic susceptibility of a soil can also be enhanced by the application of heat and the fermentation and bacterial effects associated with rubbish decomposition. The area of enhancement is usually quite large, mainly due to the tendency of discard areas to extend beyond the limit of the occupation site itself, and spreading by the plough. An advantage of magnetic susceptibility over magnetometry is that a certain amount of occupational activity will cause the same proportional change in susceptibility, however weakly magnetic is the soil, and so does not depend on the magnetic contrast between the topsoil and deeper layers. Susceptibility survey is therefore able to detect areas of occupation even in the absence of cut features. On the other hand susceptibility survey is more vulnerable to the masking effects of layers of colluvium and alluvium as the technique, using the Bartington system, can generally only measure variation in the first 0.15m of ploughsoil.

Types of Magnetic Anomaly

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 that, conversely, means that the response is negative relative to the mean magnetic background.

It should be noted that anomalies interpreted as modern in origin might 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.

The types of response mentioned above can be divided into five main categories that 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. These anomalies are often caused by agricultural activity, either ploughing or land drains being 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 XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (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.

Methodology: Magnetic Susceptibility Survey

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. For field surveys a Bartington MS2 meter with MS2D field loop is used due to its speed and simplicity. 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.

Methodology: Gradiometer Survey

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.

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 a ‘negative’ scanning result should be validated by sample detailed magnetic survey (see below).

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 0.25m 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.

During this survey a Bartington Grad601 magnetic gradiometer was used taking readings on the 0.1nT range, at 0.25m intervals on zig-zag traverses 1m apart within 30m by 30m square grids. The instrument was checked for electronic and mechanical drift at a common point and calibrated as necessary. The drift from zero was not logged.

Data Processing and Presentation

The detailed gradiometer data has been presented in this report in XY trace and greyscale formats. In the former format the data shown is ‘raw’ with no processing other than grid biasing having been done. The data in the greyscale images has been interpolated and selectively filtered to remove the effects of drift in instrument calibration and other artificial data constructs and to maximise the clarity and interpretability of the archaeological anomalies.

An XY 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. 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’. Geoplot 3 software was used to create the XY trace plots.

Geoplot 3 software was used to interpolate the data so that 3600 readings were obtained for each 30m by 30m grid. The same program was used to produce the greyscale images. All greyscale plots are displayed using a linear incremental scale.

Appendix 2: Survey location information

The site grid was laid out using a Trimble VRS differential Global Positioning System (Trimble 5800 model). The accuracy of this equipment is better then 0.01m. The survey grids were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if co-ordinates are measured off hard copies of the mapping rather than using the digital co-ordinates.

Archaeological Services WYAS cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party

Appendix 3: Geophysical Archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 8) files of the raw data, report text (Microsoft Word 2000), and graphics files (Adobe Illustrator CS2 and AutoCAD 2008) files; and

- 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 may 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 East Yorkshire Historic Environment Record).

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