WILLERBY PIG FARM, WILLERBY, NORTH YORKSHIRE.

REPORT ON A GEOPHYSICAL SURVEY.
OSA REPORT No: OSA12EV16 (Geophysics)

October 2012.

OSA

ON SITE ARCHÆOLOGY LTD

25A Milton Street • York • North Yorkshire • YO10 3EP
telephone • 01904 411673 • fax • 01904 414522 • mobile • 07767 385766
e-mail • onsitearchaeology@gmail.com

Report Summary.

PROJECT NO:	OSA11EV16 (Geophysics)
SITE NAME:	Willerby Pig Farm, Willerby, North Yorkshire
COUNTY:	NorthYorkshire
NATIONAL GRID REFERENCE:	TA 0010 7920
COMMISSIONED BY:	George F White 8 Front Street, Wolsingham, County Durham. DL13 3AA
GRAPHICS:	Ben Gourley
FIELDWORK:	Ben Gourley
REPORT:	Ben Gourley Dave Pinnock
TIMING:	Fieldwork September 2012 Report preparation September 2012
ENQUIRIES TO:	Nick Pearson On Site Archaeology Ltd 25A Milton Street York YO10 3EP
tel	(01904) 411673
fax	(01904) 414522
mobile	(07767) 385766
e-mail	onsitearchaeology@gmail.com
web	www.onsitearchaeology.co.uk

Table of Contents.

List of Figures.

1.0 Abstract.

A geophysical survey was carried out by On-Site Archaeology *in area of proposed wind turbine and access track at Willerby Pig Farm, Willerby, North Yorkshire. The site is in an area where there is evidence for early settlement, but since the archaeological implications of the proposals cannot be adequately assessed on the basis of currently available information, a scheme of archaeological field evaluation has been proposed. The geophysical survey, reported here, comprises the first stage in the proposed work.*

The survey initially comprised a 1ha square, centred upon the proposed location of the turbine, together with a 30m wide corridor following the proposed cable route to link the turbine to existing buildings. As the results of the initial survey indicated the likely presence of archaeological remains, a second phase of survey was added to the south and east of the original location to explore the extent of archaeological remains in that area. This may allow the re-siting of the proposed turbine to mitigate the impact on archaeology. The total area of the geophysics, including the second phase, was approximately 3ha.

The evaluation has revealed a number of responses probably associated with historic land division, possibly of Iron Age of Roman date. A series of rectilinear responses of slightly elevated magnetic character suggest the presence of ditches and other features cut into the underlying geology. These are particularly notable around the northern end proposed development area and in a linear feature that crosses the site on an east-west axis. The results are consistent with other similar archaeological work in the area and reinforce the significance of the area for the high level of survival of archaeological deposits of all periods. The significance of the archaeological features may range from local to regional

It is proposed that the turbine and associated infrastructure are carefully positioned to avoid impact on the remains indicated in the geophysical survey and an indicative layout is included. It is further proposed that the footprint of all the infrastructure be stripped of topsoil and subject to an appropriate level of recording in a 'strip and record' methodology.

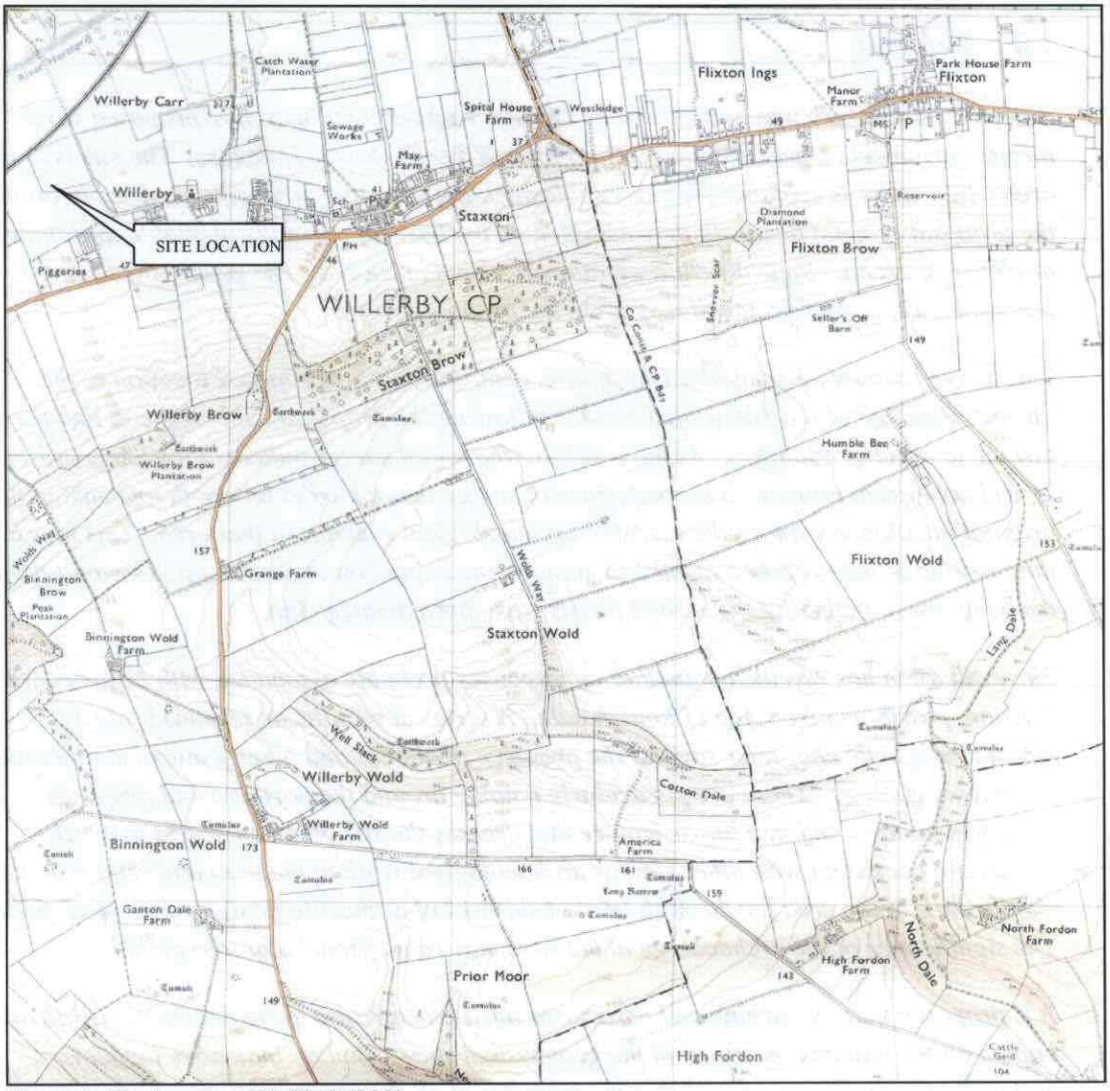

*Figure 1. Site Location (*TA 0010 7920*)*

2.0 Site Location, Geology, Topography and Land Use.

Willerby Pig Farm is located on gently sloping ground on the south side of the Vale of Pickering, just north of the A64, and directly to the west of the village of Willerby. The site is centred at National Grid Reference TA 0010 7920, with the sloping ground level at approximately 29m AOD just above the low ground of the Vale. The farm is bordered on the south by the A64, and on the north by the Malton to Scarborough train line.

The survey was focussed in a wheat field to the northwest of the main complex of farm buildings where a proposed wind turbine near the centre of the field is planned. The groundcover was freshly harvested wheat and predominantly clear ground.

Figure 2 shows the exact location of the geophysical work. The survey covers the area of the proposed turbine and includes the area radiating approximately 50m out from this central location. It also covers a 30m wide corridor from the turbine location back to the main complex of farm buildings to the south. The second phase of the survey area measured approximately 120m x 90m. The total area of the survey, including the second phase, was three hectares.

A large new barn structure has been built on the southern extent of this corridor within the last two years and its location is indicated by red hatching on Figure 2.

The site lies above bedrock geology comprising Speeton Clay Formation Mudstone, overlain by superficial sand and gravels (British Geological Survey *OpenGeoscience*).

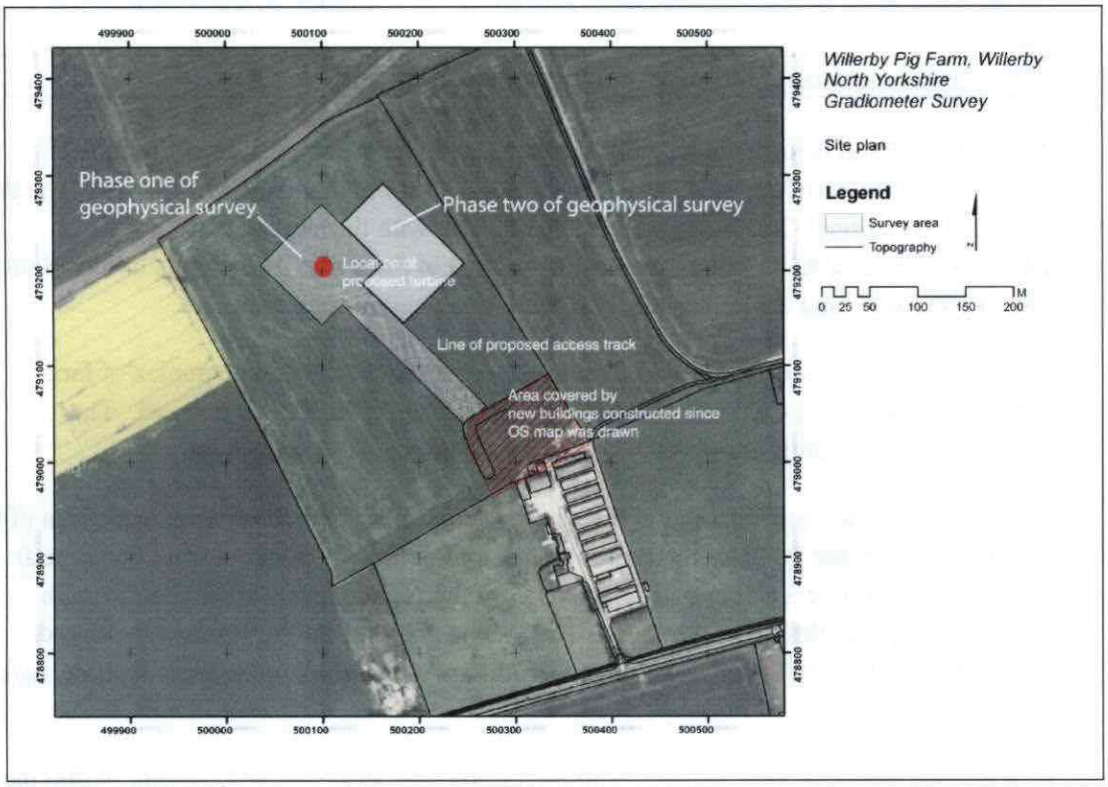

Figure 2. Location of survey

3.0 Archaeological Background.

The proposed development site lies within an area of high archaeological potential including archaeological features known through cropmark evidence.

The turbine location as currently proposed sits within an area of ladder settlement. The full extent of the ladder settlement is not known. It is likely to extend beyond the limits as portrayed by the cropmark evidence and probably continues to the south, through the development site and beyond. To the southwest of the site, lies a further settlement area, including several enclosures and ring ditches, which appears to meet with the ladder settlement. A metal detecting rally also recovered finds of Romano-British date of 3rd-4th centuries. Within prehistoric settlement sites, human remains are likely to be present. (The above section is drawn from information provided by North Yorkshire County Council Heritage Environment Team.)

4.0 Methodology.

4.1 General.

The surveys and reporting were conducted in accordance with the current professional guidelines "Geophysical Survey in Archaeological Field Evaluation" (English Heritage 2008) and "Draft Standard and Guidance for Archaeological Geophysical Survey" (Institute for Archaeologists 2010).

Geophysical surveying enables the relatively rapid and non-invasive identification of potential archaeological features within landscapes and can involve a variety of complementary techniques such as magnetometry, electrical resistivity, ground-penetrating radar and electromagnetic survey. Some techniques are more suitable than others in particular situations, depending on a variety of site-specific factors including the nature and depth of likely targets; ground conditions; proximity of buildings, fences or services and the local geology and drift.

In this instance, based on existing knowledge of sites in the vicinity, it was considered likely that cut features, such as ditches and pits, may be present on the site, and that other types of feature such as trackways, and possibly fired (such as kilns and hearths) might also be present (see Stoertz 1997, Ancient Landscapes of the Yorkshire Wolds).

Magnetic survey is generally well suited to the detection of features of this type in a range of conditions, and it is usually an effective and rapid means of assessment especially for features that have subsequently silted up or been filled in. Geological conditions do play a significant role in the successful identification of archaeological deposits with this technique, and the near- surface chalks in the area are generally responsive to this method, showing good contrast between natural background geology and archaeological or geological anomalies.

It should be noted however, that whilst useful for the remote identification of archaeological anomalies, magentometry is also significantly affected by changes in the localised magnetic field caused by ferrous material in the soil and in the immediate area. Modern conduits, metal fences/ buildings, and any other ferrous objects in the topsoil all produce elevated magnetic responses that can confuse interpretation of results. None the less, the survey area at Willerby Farm was almost entirety free of such magnetic pollutants, and the resulting data represents a very clear and clean picture of the magnetic character of the near surface geology and topsoil.

4.2 Fieldwork methodology.

For archaeological survey the most frequently used magnetic technique in Britain is Gradiometry (using hand held Fluxgate Gradiometers) which detect and record minor variations in the vertical component of the local magnetic field of near surface soils and subsoils. These variations are caused by changes in a soil's magnetic susceptibility or permanent thermo-remnant magnetisation that in many cases can reflect archaeological

activity and the form and extent of discrete features. Data is collected at regular intervals over a gridded area producing a continuous coverage over the site.

The survey area at Willerby Farm comprises approximately 3 hectares. The site was divided into twenty five 30x30m grids and tied-in to known Ordnance Survey points using a Leica GPS900. The GPS900 is an RTK GPS unit providing survey quality location information accurate to around 10mm.

Data collection was carried out using two Bartington Grad 601 fluxgate gradiometers with automatic data logging facilities. Samples were recorded using an interval of 0.25 x 1 m in accordance with current archaeological guidelines (English Heritage 2008), yielding 3600 measurements per 30m square. The instrument sensitivity was set to 0.03nT within a +/- 100nT range ensuring the accurate recording of small variation in the local magnetic gradient.

4.3 Processing and data treatment.

Following initial field survey, data was prepared and processed using a series of software tools to eliminate data defects resulting from local conditions or collection problems. Once defects have been identified, images are prepared using a greyscale representation of the relative strength of magnetic response in the survey areas. The greyscale plots provide a graphic' 2D image' of subsurface magnetic conditions and form the basis of the interpretation diagram in Figures 8 and 9. (Additional 'X/Y trace' plots are also included as an alternative graphic representation of results for comparison with greyscale plots).

For processing, Geoscan *Geoplot 3.0* software was used for initial data processing and Golden Software's *Surfer* used for the production of both raw and processed data plots.

The following processing and image enhancement functions have been applied to the data (see Appendix 1 for details):

Clip – Clips or limits data to specified maximum or minimum values; to eliminate the effects of very strong magnetic responses often caused by modern features; Clipping such responses makes statistical calculations more realistic for the determination of potential archaeological anomalies (which generally display weaker magnetic variation than those for large ferrous features). In this instance data was clipped from a maximum range of +/-100nT to +/-20nT to eliminate the responses from an are of very high readings at the centre of the site probably caused by a sizable buried metal object.

Despike – Used to locate and reduce the effects of random ferrous responses in the survey area that most commonly result from iron objects near to the surface. NB. Some features cannot be successfully eliminated using 'despike' (especially if they are caused by larger iron objects in top-soils) without compromising the nearby data, and in these cases they are left in the dataset and marked accordingly.

Only limited despiking was needed in this instance as the topsoil was mostly clear. The parameters used for the despike process were: radius of X4 x Y1 readings for local averaging

with a threshold of 3.0. A 'mean spike replacement method' was applied using the despike filter in Geoplot 3.0 software.

Zero Mean Traverse – For removing striping effects in the data caused by the orientation of the instrument sensors; also removes traverse striping caused by abnormally strong responses caused by ferrous pollution. For settings see Appendix 2 below.

Interpolation – Increases the number of data points in a survey on one or both axes. In this instance survey data was collected using a 0.25 x 1m sampling interval, and for final graphic preparation clipped and processed data was interpolated on the Y-axis resulting in a smoothed greyscale plot. Geoplot's *sin x/x* interpolation method was used for this process.

5.0 Results.

The data is presented here using greyscale and X/Y plots with minimal processing to give an impression of the full range data statistics (Figure 3 and 4). Darker greys and blacks represent elevated magnetic readings, and lighter values lower readings, while middle grey indicates the 'survey average' response of the underlying geological conditions.

Magnetic values are measured here in Nanotesla *(nT)* and the Bartington is configured at a sensitivity of 0.3 *nT* and records data within a range of -100nT/ +100nT. Within this range most archaeological and geological features occupy relatively low magnitude with respect to the survey zero (typically between -20 and +20 nT).

Responses of very high magnitude in the top and bottom end of this scale usually result from isolated metallic objects in the topsoil, or from major features with a high iron content nearby, or in the survey area. Apart from some minor responses from ferrous objects in the topsoil, and a couple of discrete areas the survey was mostly free from such high magnitude responses.

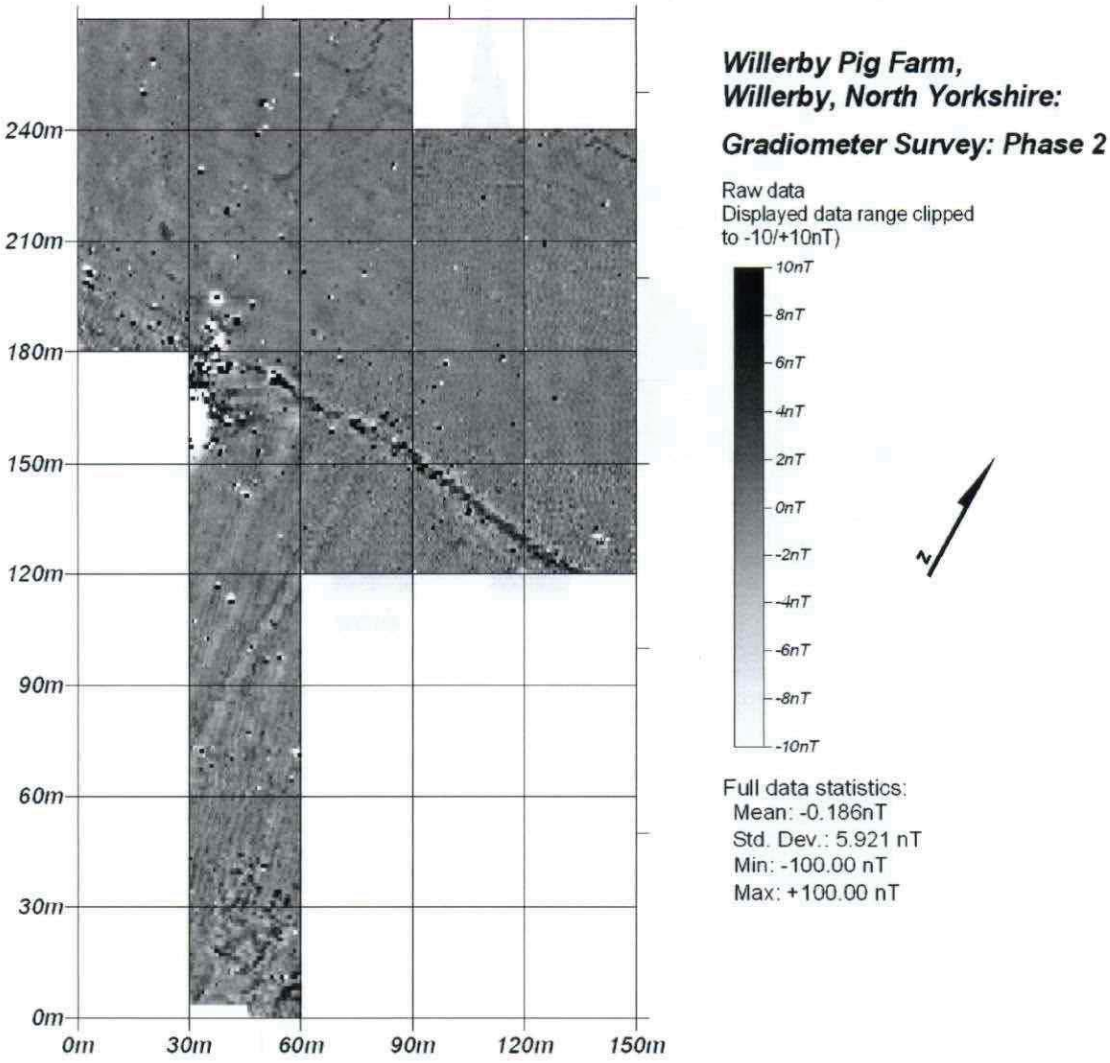

Figure 3. Greyscale plot of raw results including Phase 2 results)

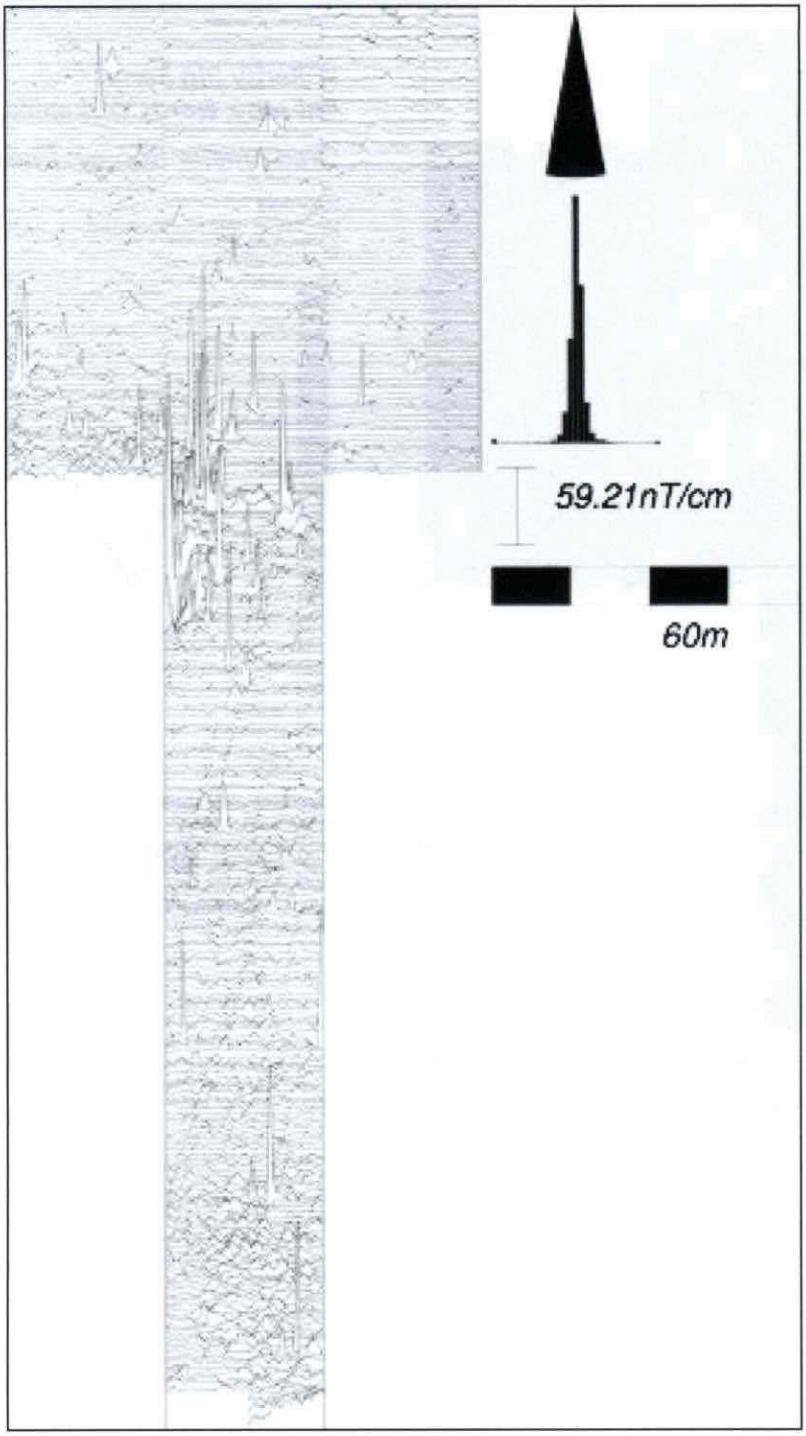

Figure 4. X/Y plot of raw results not includingPhase 2 area

Processed Data

Processing was undertaken to eliminate data anomalies. As above these include, *Clip, Despike, ZMT, and Interpolate*. The results are displayed in Figures 5 and 6.

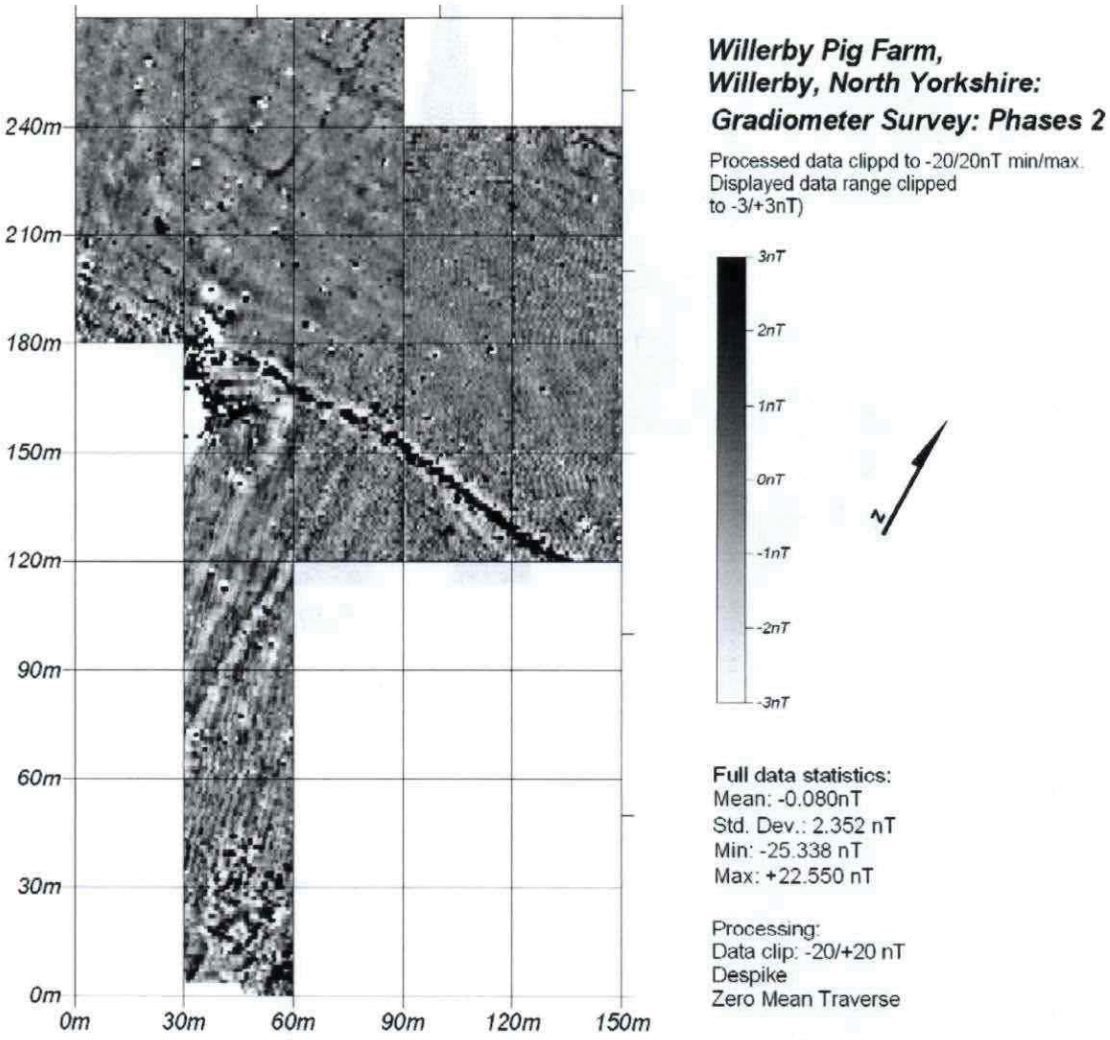

Figure 5. Greyscale plot of processed results (including Phase 2 area)

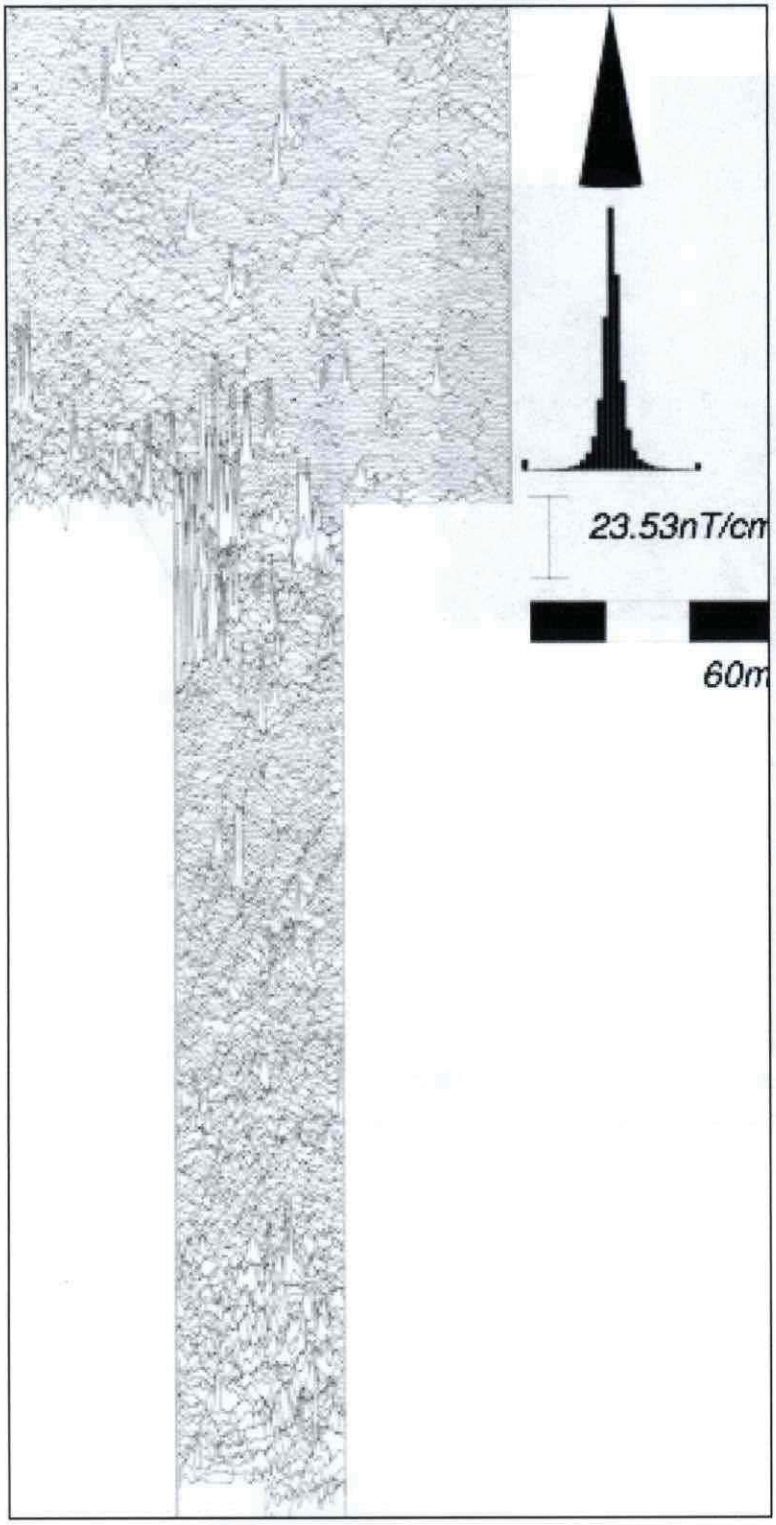

Figure 6. X/Y trace plot of processed results (not including Phase 2 area)

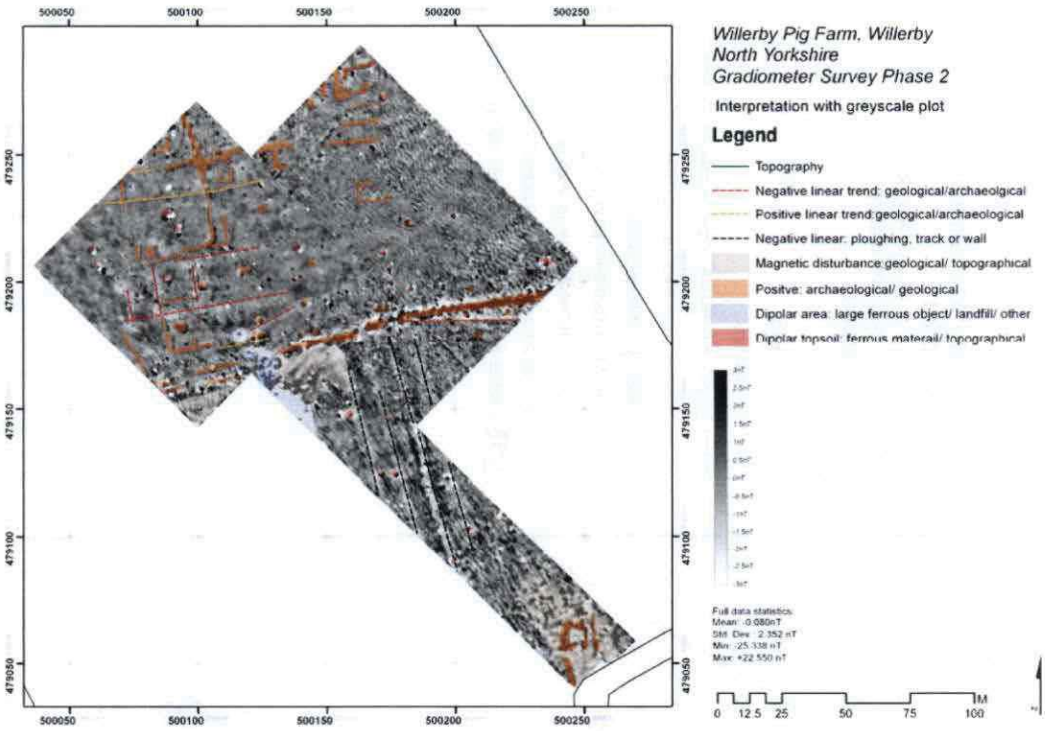

Figure 7. Greyscale plot with colour coded interpretation

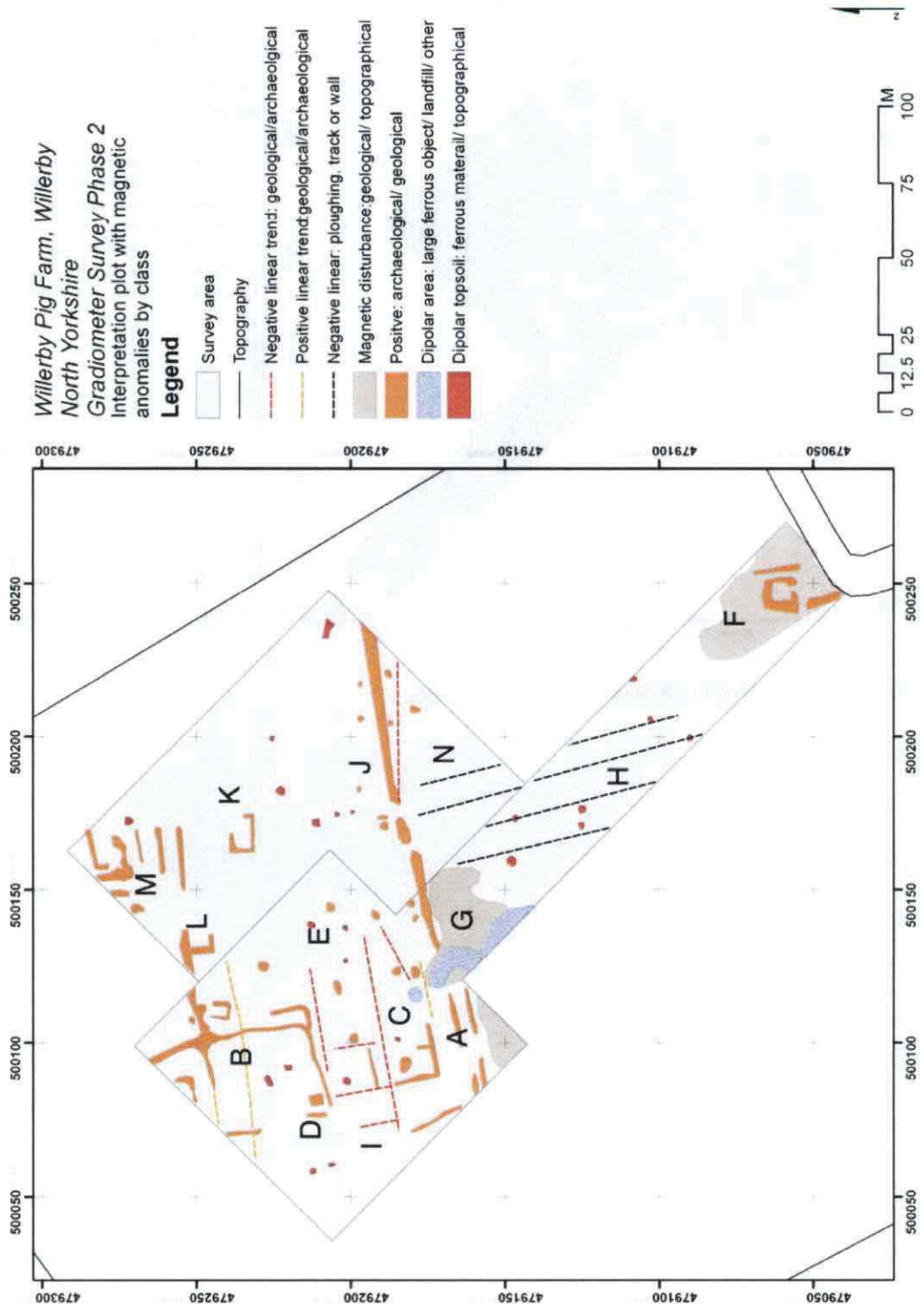

Figure 8. Interpretation with significant anomalies labelled.

6.0 Interpretation.

Figures 7 and 8 illustrate interpretation of anomalies within the survey area. For discussion see below.

Terminology: In magnetic survey, responses are described by *Nano Tesla* values in relation to the survey '*zero*' or *mean*. Therefore, '*positive*' refers to elevated or enhanced magnetic values, '*negative*' refers to lower values, and '*dipolar*' refers to responses that consist of an elevated peak and a negative trough. Depending on their origin and structure, each of these can constitute linear features, localised features, or features covering and area.

A combination of factors including: subsurface/ surface conditions, the depth of anomaly, and material composition all affect the form of magnetic responses. The categories of anomalies present at Willerby Pig Farm are varied and include magnetic responses to modern ferrous objects, topographical and geological features, as well as what appear to be extensive archaeological deposits.

Of the latter, the physical form and shape of the anomaly together with the character of magnetic responses gives the best indication of the presence of archaeological deposits, as opposed to geology for example. Anomalies at Willerby Pig Farm are mostly of a linear character but there are some discrete localised anomalies also. They are typical of archaeological 'cut' features commonly found on archaeological sites of all periods in this area, but particularly sites of Iron Age and Romano-British date (see Landscape Research Centre (www.lanscaperesearchcentre.org) and Stoertz 1997)

The ditches are mostly rectilinear in from, in some cases comprising fully enclosed areas, and have slightly elevated magnetic values (in contrast to the magnetic character of the background geology). Magnetic NT values range from +1.0 nT to +20.0 nT and suggest the presence of slightly magnetically enhanced soils which result from prolonged human activity at a site. Such soils tend to accumulate as silted deposits in ditch systems as well as localised cuts (pits etc) into the chalk limestone and sand geology.

There are also a series of less distinct linear anomalies they are more ambiguous in their origin. Some can be positively attributed to modern faming activity and reflect mechanised ploughing patterns or tracks, but in the northern half of the survey area less clearly interpreted (marked on the interpretation plot as "negative linear trend). It is likely that these simply represent variation in the underlying chalk geology, but it is possible that they might be associated with ploughed out largely structural remains.

Figures 8 and 9 show a detailed breakdown and an interpretation of anomaly types with various categories identified in the associated legend. Categories are as follows with specific anomalies labelled alphabetically where relevant:

6.1 Initial survey.

Positive: archaeological/ geological

(A) The survey area is bisected by a raised topographic linear mound which runs on an east to west axis about half way across the field. This feature is associative with a significant linear ditch system which together with the raised linear mound is suggestive of a major track way

running with the contour between the higher ground to the south and low ground to the north. This may also be associated with other track systems identified to west in the work carried out by the Landscape Research Centre.

(B) To the north of this the main survey area is covered by a series of intersecting rectilinear responses indicative of ditches cut into the limestone and sand geology on the low ground to the north of the linear mound. Widths vary between 1 and 3 m suggesting that there is a system of agricultural division with varying levels of preservation of the deposits. In form and arrangement these are consistent with patterns of Romano- British or Iron Age land division areas are enclosed by ditch features.

(C) Between the larger ditch system to the north and the linear ditch/track described in **A** lies a strongly rectilinear positive anomaly. It is roughly square in plan at approximately 20m on each side and seems to have a dividing ditch running on a north south axis about half way across its length. The distinct rectilinear form of this features suggests it might represent the footprint of structural remains and its alignment with respect to **B** and a suggests that it will be roughly contemporary in date and use. Also associated with this anomaly is a large localised positive response (roughly 5m in diameter) that my represent a pit or a sunken feature.

(D) To the southeast extent of the enclosure described in **A** a localised rectangular anomaly of very slightly elevated magnetic readings may also reflect structural the presence of deposits to be associated with structural remains

(E) A series of localised cut features (possibly pits) not immediately associated with nearby features, but likely of similar character and date to **D**.

(F) At the very southern extent of the survey on the line of the proposed access track a roughly rectilinear response was detected. It is roughly square in shape and appears as a small rectangular ditch feature of positive magnetic values. It is possible that this represents intact archaeological deposits, but its proximity to the embankment and working yard area of a newly constructed barn make such a determination difficult. It is certainly connected with a wider spread of magnetically 'noisy' data at this end of the site.

Dipolar area: large ferrous object/ magnetic disturbance

(G) A dipolar response covering a roughly 20 m area most likely caused by a large ferrous object buried in the soil to the south the raised linear feature. Magnetic values from this feature mask any lower magnitude

Linear anomalies

(H) Linear responses from modern ploughing

(I) Negative, roughly linear responses associated with A, B and C. These responses almost certainly reflect underlying geological conditions on this lower areas of ground, but given

their association with the ditch systems described above they have been noted as possibly reflecting archaeological deposits

6.2 Phase 2 area.

Phase 2 revealed a similar range of anomalies to those identified in **Phase 1**; notably the continuation to the east of several linear features identified in the initial survey. However, on balance the extent and distribution of responses resulting from probable archaeological deposits were considerably less in the second phase of work. There are two exceptions to this – the continuation of the major linear **anomaly 'A'**, and a concentrated area of rectilinear responses on the north edge of the survey labelled here as **anomaly L** - are discussed in detail below.

Positive: archaeological/geological

(J) The topographic linear mound which runs on an east to west axis identified as **anomaly A** in Phase 1 continues across the survey area in Phase 2 as does the associated magnetic response which would appear to indicate a major linear ditch or track way. Indeed its presence is even more defined in Phase 2 and it appears to be flanked by a number of discrete positive magnetic responses which may indicate intact cut features (pits etc). It is notable that whereas **anomaly A** appeared to comprise two parallel ditches, that **anomaly J** is characterised by a single linear feature ranging from 3- 7 m in width along its length.

(K) A very faint rectilinear response some 40 m to the north of **anomaly J**. Although hardly perceptible in contrast to background geology, the outline of a rectangular response approximately 10 m across can be detected. Its alignment is worth considering in the context of **anomalies C and B.**

(L) Continuation of one of the linear responses associated with **anomly B** and similar in character and form. Although the magnetic response appears to diminish in this area, this features association with **B** strongly suggests the presence of intact archaeological deposits.

(M) A series of rectilinear responses suggesting the presence of deposits associated with former structural remains. The alignment and definition of these responses in association with the presence of features **C**, **B** and **L** suggests that this also belongs to a coherent system of land division and possibly settlement activity of similar date. The interpretation of these anomalies as belonging to structural remains is based on the concentrated distribution of these features and the plan form of responses with a strong rectilinear character over a small area not typical of features such as agricultural land division.

Linear anomalies

(N) A continuation of linear responses from modern ploughing to the south of **anomaly J**

7.0 Discussion and Conclusions.

7.1 Assessment of significance of the geophysical survey results.

The evaluation has revealed a number of responses probably associated with historic land division, possibly of Iron Age of Roman date. A series of rectilinear responses of slightly elevated magnetic character suggest the presence of ditches and other features cut into the limestone geology. These are particularly notable around the northern end proposed development area and in the linear feature (labelled A above) that crosses the site on an east west axis. The results are consistent with other similar archaeological work in the area and reinforce the significance of the area for the high level of survival of archaeological deposits of all periods.

Most of the responses in this survey seem to be associated mainly with past agricultural land use/division, although some might also be associated with settlement and possibly structure. The latter may be the case with features B and D, both of which might be connected with buildings directly to the north of the linear ditch system A.

The second phase of geophysical work, to the east and south of the original survey, has identified the presence of several magnetic anomalies similar to those in the original survey. However, these responses are more localised and not distributed across the whole of the survey area as in the earlier survey. There are several possible reasons for this including a genuine decrease in historic activity in this area representing the 'periphery' of archaeological activity identified in Phase 1. However, it should be noted that this apparent reduction could equally result from an increased depth of topsoil over archaeological deposits, or in an opposite scenario, that archaeological deposits have largely been ploughed out by historic agricultural activity, except for those of more substantial construction (such as anomaly J and M).

The indications of the geophysical survey are that remains of probable Iron Age/Romano-British date are likely to survive on this site. The degree of preservation is not possible to ascertain by the use of geophysical survey, beyond the obvious fact that the level of survival is sufficient to allow their presence to be detected. The significance of the remains is dependent to a certain degree on their level of preservation, but is likely to range from local to regional significance. There is nothing in the present evaluation results to suggest the presence of non-designated heritage assets of archaeological interest that are demonstrably of equivalent significance to scheduled monuments (as per paragraph 139 of the National Planning Policy Framework).

7.2 Impact of the proposed turbine, cable trench and other infrastructure.

The impact of the turbine will be limited to an area approx 13m x 13m forming the turbine base and a trench containing the electricity cable that will run south to the existing piggery buildings. Both the turbine base and the cable trench will be excavated to a depth that will directly impact on any buried archaeological remains.

In addition, an area of approximately 35mx20m to the south of the proposed turbine base will be topsoil stripped and stoned to form a base for the crane required for the erection of the turbine. The crane will also require an access track (along the same alignment as the cable trench). Neither the crane base nor the access track will be excavated below the topsoil and ought to have a minimal impact on any buried archaeological remains.

7.3 Proposed mitigation.

The primary method of mitigation will be the careful siting of the turbine and cable trench. The results of the second phase of geophysical investigation show an apparently less archaeologically rich area of the site located north of linear anomaly A/J and south of the rectilinear feature K and extending to the edge of the survey area to the east and as far west as the possible pits at E. For ecological reasons it is preferable for the turbine to be placed away from field boundaries and the presence of a railway line on the northern edge of the field also limits its siting due to public safety. Figure 9 shows an indicative layout of the various site components. The cable trench/access track is orientated in such a way as to avoid the rectilinear feature (F).

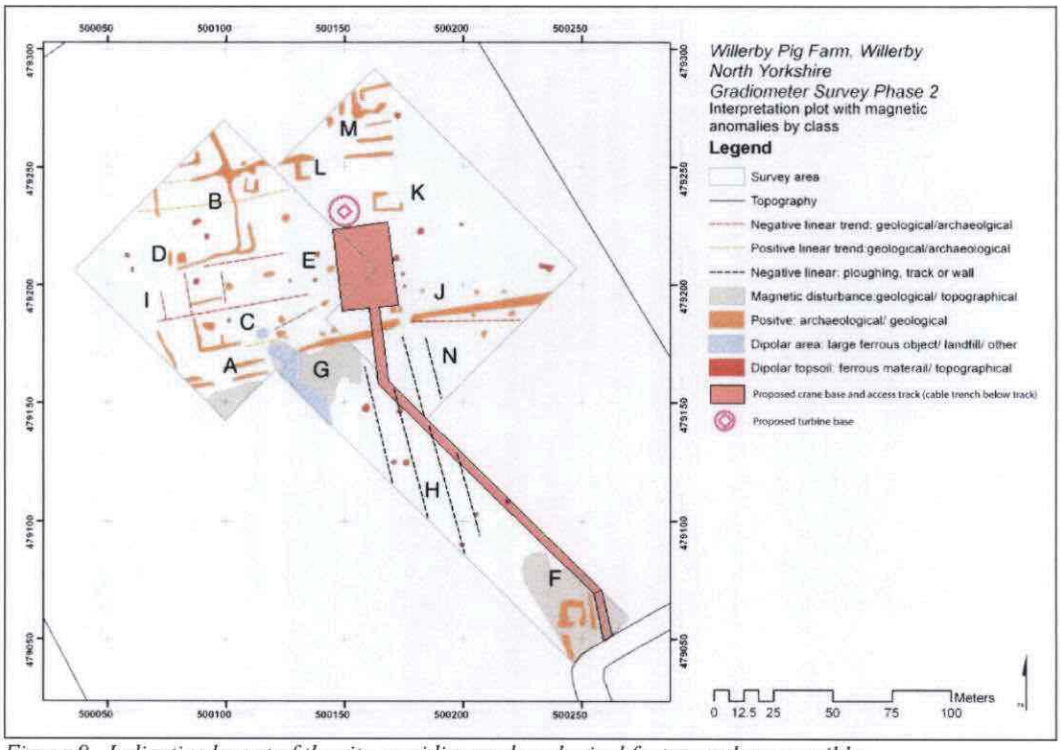

Figure 9. Indicative layout of the site, avoiding archaeological features where possible

Even with careful siting, the proposed turbine base and cable trench may impact on any archaeology that may not have been picked up by the geophysical survey. Therefore a second part of the mitigation will be a 'strip and record' exercise, which will involve stripping topsoil and any subsoil in all the areas of groundworks under archaeological control, including both the crane base and access track. Any archaeological features revealed will be planned and photographed. Where the features will be impacted upon by the development, i.e. within the

turbine base and the cable run, it will be necessary to excavate and record the features affected.

8.0 Appendix 1: Methodology.

Survey area	Willerby Pig Farm, Willerby	
Crop types	Harvested wheat	
Geology	Chalk and sand	
Instrumentation	Bartington Grad 601-2 Leica GPS900	
Software	Geoplot 3.00, ArcGIS 9.3, AutoCAD 2004, ArcGIS 9.3 Surfer	
Survey	Resolution: Sample Interval: Traverse interval: Grid Size: Cell size: Traverse method Survey Date	0.03nT/m used in 100nT range 0.25m 1m 30x30m 1x0.25m Zig-Zag May 2012
Processing	Using Geoplot 3.0 software: Clip, Despike, Zero Mean Grid, Zero Mean Traverse, Interpolation	
Coordinate system	GB Ordnance Survey	
Staff	Ben Gourley	

9.0 Appendix 2: Processing Methodology.

All processing and image preparation was done using Geoplot 3.00 software

Data Statistics: min/ max/mean and std. dev:

Mean: -0.186 nT

Std. Dev.: 5.921 nT

Min: -100.00

Max: 100.00

Processing procedures:

Despike: Search radius X=4 Y=1, Threshold: 3, Replacement method: Mean

Zero mean traverse: using Threshold Standard Deviation= 0.25

Zero mean traverse: using Geoplot Presets Grid=All, LMS=On. Pos.Threshold = +5, Neg.Threshold = -5.

Interpolate Using Geoplot Sin X/X on y-axis.

10.0 Appendix 3: Equipment used.

Bartington Grad 601- 2 dual fluxgate gradiometer. Data is stored in a non-volatile memory.

Full technical specification is available via http://www.bartington.com/templates/asset-relay.cfm?frmAssetFileID=102

Geoscan Geoplot 3.0 software http://www.geoscan-research.co.uk/page9.html

Leica GPS900 RTK dual frequency GPS. The GPS900 is a dual-frequency, geodetic, real-time RTK receiver with a potential accuracy of Kinematic (phase) Horizontal: 10mm + 1ppm and moving mode after initialisation Vertical: 20mm + 1ppm.

Full technical data and specification for the GPS900 may be obtained from http://www.leica-geosystems.com/en/downloads-downloads-search_74590.htm?search=true&product=GPS900

11.0 Appendix 4: Bibliography.

British Geological Survey *OpenGeoscience* http://maps.bgs.ac.uk/geologyviewer_google/googleviewer.html

English Heritage 2008 *Geophysical Survey in Archaeological Field Evaluation.* English Heritage 2008.

Institute for Archaeologists 2010 *Draft Standard and Guidance for Archaeological Geophysical Survey.* Institute for Archaeologists 2010.