WYAS Archaeological Services

# Land at Gazebo Farm

# Rackheath

# Norfolk

## Geophysical Survey

Report no. 2832
December 2015

**Client:** Mott MacDonald

# Land at Gazebo Farm
# Rackheath
# Norfolk

## Geophysical Survey

*Summary*

*An additional phase of geophysical (magnetometer) survey, covering approximately 0.8 hectares, was carried out on land north of Gazebo Farm, the route of the Norwich Northern Distributor Road, previously surveyed by Archaeological Services WYAS. The survey aimed to determine the location of a crashed World War II fighter aircraft (P-51 Mustang). The survey results were unable to conclusively confirm the suggested location of the crash site, but there were a number of ferrous anomalies which could be considered consistent with the remains of a crashed aircraft. As a result, the archaeological potential of this site is considered to be medium.*

WYAS
Archaeological Services

## Report Information

| | |
|---|---|
| Client: | Mott MacDonald |
| Address: | Mott MacDonald House, 8-10 Sydenham Road, Croydon, CR20 2EE |
| Report Type: | Geophysical Survey |
| Location: | Rackheath, Norwich |
| County: | Norfolk |
| Grid Reference: | TG 2772 1367 |
| Period(s) of activity: | Post-medieval |
| Report Number: | 2832 |
| Project Number: | 6276 |
| Site Code: | NDR15 |
| OASIS ID: | archaeol11-233644 |
| Planning Application No.: | Unknown |
| Museum Accession No.: | n/a |
| Date of fieldwork: | December 2015 |
| Date of report: | December 2015 |
| Project Management: | Christopher Sykes BA MSc |
| Fieldwork: | Becky Goulding BSc MSc Dip (Arch) |
| | Ashely Green BS |
| Report: | Ashely Green |
| Illustrations: | Becky Goulding |
| Photography: | Becky Goulding |

Authorisation for distribution: ----------


Nepshaw Lane South, Morley, Leeds LS27 7JQ
Telephone: 0113 383 7500.
Email: admin@aswyas.com

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# 1 Introduction

Archaeological Services WYAS (ASWYAS) was commissioned by Mott MacDonald to carry out a programme of non-intrusive geophysical (magnetometer) survey on a parcel of land along a section of the proposed Norwich Northern Distributor Road (NNDR) (see Fig. 1). All work was undertaken in accordance with guidance contained within the National Planning Policy Framework (DCLG 2012), in line with current best practice and in compliance with a Project Design (Goulding 2015). The survey was carried out in a single day, December 3rd 2015.

### Site location, land-use, and topography

The route of the proposed NNDR originates north-west of Norwich at the A1067/Fakenham Road (TG 1466 1540) and runs eastwards 7km towards Norwich Airport continues east for an additional 8km to the A1151/Wroxham Road (TG 2726 1384) before continuing south for 5km and terminating south of Smee Lane (TG 2900 00924).

This element of the wider survey was conducted at land north of Gazebo Farm, Rackheath (centred at TG 2772 1367), approximately 6km north-east of Norwich and 2km south of the village of Rackheath.

The survey area comprised of a portion of a single field of overgrown grassland, with areas of bracken and nettles at its southern end. The survey area was marked on the ground by newt fencing which had been put in place by the developer. The field sloped gently from north to south, averaging 32m above Ordnance Datum.

### Geology and soils

The underlying bedrock geology along the corridor comprises elements of the Crag Group formation, which consists of sands and gravels formed in areas previously dominated by shallow seas. The overlying superficial deposits are of the Sheringham Cliffs formation – sands and gravel formed in areas previously under ice age conditions (British Geological Survey 2015).

The soil within the survey area is of the Wick 2 association. This association is described as deep, stoneless, well-drained coarse loams (Soil Survey of England and Wales 1983).

# 2 Archaeological Background

The proposed route passes near to numerous heritage assets which are recorded in the Norfolk Historic Environment Record (NHER). These are mainly cropmark sites that are thought to be Iron Age and Roman in origin.

A search of the Pastscape (2015) database revealed a number of heritage assets surrounding the survey area. A Holy Trinity church and settlement (Monument 1348355) is located

0.25km east of the survey area along Green Lane West. The medieval settlement was deserted by 1540 and is currently the site of industrial buildings.

The specific purpose of this geophysical survey is to investigate claims by local aircraft enthusiasts that the field is the location of an aircraft crash during World War II. Rackheath Airfield, once located approximately 1km northeast of the survey area and currently the site of an industrial estate, was in use from 1943 to 1945. The airfield housed three runways (only one of which is extant), hangers, bomb store, ammunition dump, and barracks. During WWII the airfield was used by the United States Army 8th Air Force 467th Bomb Group (Pastscape 2015). On the 22nd April 1945 a P-51 Mustang from the 479th Fighter Group based at Wattisham and piloted by 1/Lt. Robert C Young crashed on the site in question not far from the former gymnasium building. Robert Young was unfortunately killed in the accident and subsequently buried at Cambridge American Cemetery (K Hamilton *pers* comm).

Previous phases of geophysical survey have been undertaken along the route of the NNDR by Archaeological Surveys (AS) and North Pennine Archaeology (NPA) between 2006 and 2009 and by ASWYAS between 2012 and 2014.

## 3 Aims, Methodology and Presentation

The primary 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. To achieve this aim, a magnetometer survey covering a total of 0.8 hectares was carried out.

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 plan showing the full extent of the route of the NDR, incorporating the Ordnance Survey raster district mapping, is shown in Figure 1 at a scale of 1:50000. Figure 2 is a large scale (1:2000) overview of the survey area and wider survey location. Figures 3 to 5 show the processed greyscale magnetometer data, minimally processed XY trace plot, and the overview interpretation of the data, respectively, at a scale of 1:1000.

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. The completed OASIS form is available in Appendix 4.

The geophysical survey methodology, report and any recommendations comply with guidelines outlined by English Heritage (David et al. 2008) and by the Chartered Institute for Archaeologists (CIfA 2014). 

***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 - 5 inclusive)

### Ferrous/modern anomalies

Ferrous anomalies, as individual 'spikes', or as large discrete areas are typically caused by ferrous (magnetic) material, either on the ground surface or in the plough-soil, or the proximity of the survey area to magnetic material in boundary fences, buildings, or other above ground features. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as modern ferrous debris or material is common on rural sites, often being present as a consequence of manuring or tipping/infilling.

However, on this site there is an increase in the number and density of ferrous anomalies towards an area in the south-east of the survey (**A**), approximately at the proposed location of the crash site. Although the anomalies are in an increased concentration in this area, they do not form a clear pattern. The larger of these ferrous anomalies are of a substantial size, measuring 2-4m wide, and combined with their high magnitude, are likely to represent large pieces of ferrous material.

Along the southern boundary, below this concentration of anomalies, there are two discrete areas of ferrous disturbance (**B**). These relate to an area of hard standing, now partially overgrown, that was once associated with the extant building to the south of the survey area.

### Geological anomalies

Throughout the site several small discrete anomalies are recorded. Anomalies in this category are primarily categorised as discrete areas of enhanced magnetic response that are caused by variation in the composition of the upper soil horizons and superficial deposits.

## 5 Conclusions

Geophysical survey of the site was unable to conclusively confirm or exclude the possibility of the presence of an aircraft crash on this site.

The presence of a high concentration of large scale ferrous anomalies could be suggestive of the presence of the remnants of an aircraft. After the majority of the wreckage had been salvaged, only the smaller elements would remain producing a pattern of debris scatter similar to the distribution of the anomalies. The photograph of the crash site, provided by the client, however, shows the plane to be burnt out and there is no evidence of any intense or large-scale burning on the site – which would be visible as large areas of ferrous disturbance.

***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.***

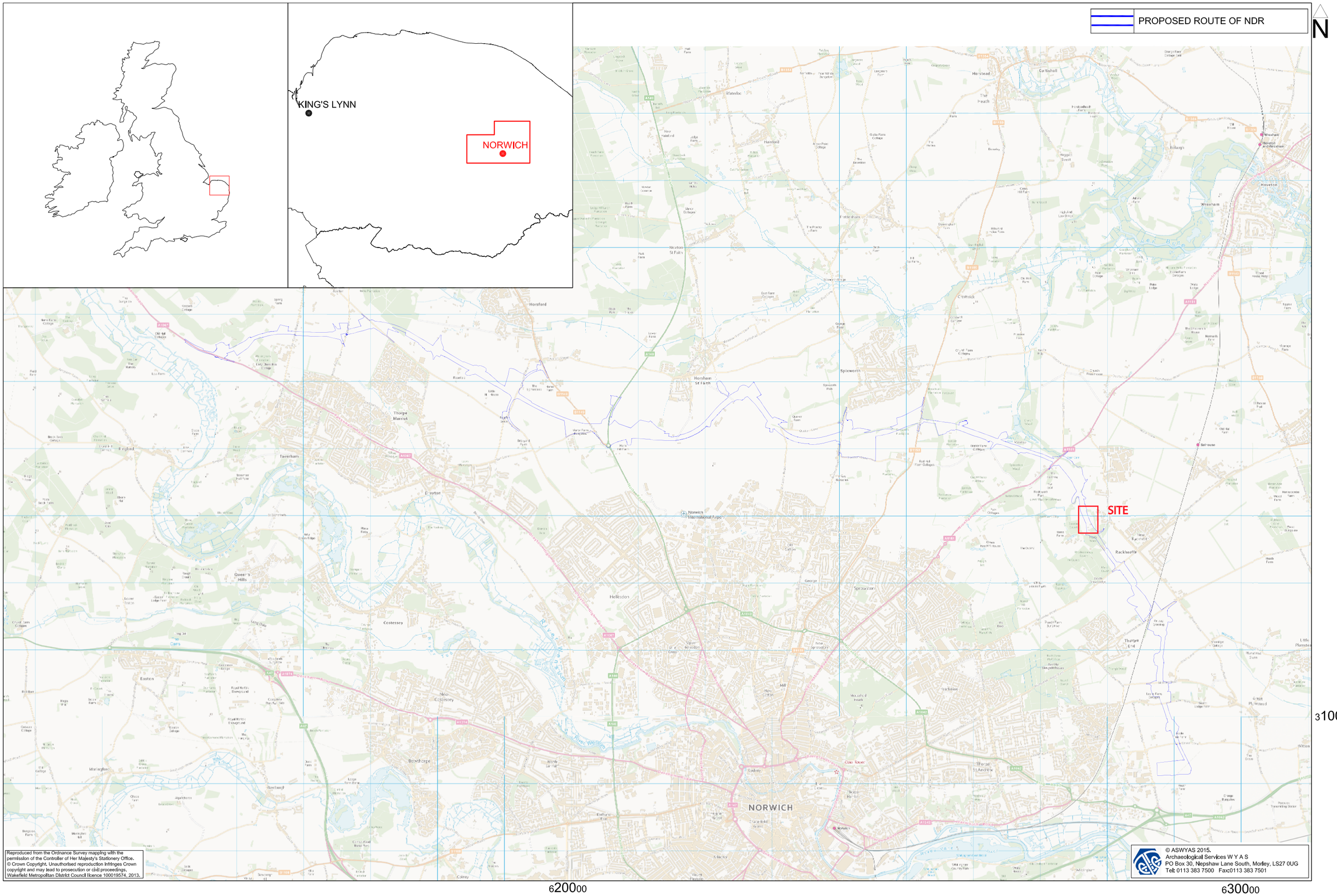


*Fig. 1. Proposed route of Northern Distributor Road showing geophysical survey area (1:50000 @ A3)*

SURVEY BOUNDARY

UNSURVEYABLE

1 LOCATION AND DIRECTION OF PLATES

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GREEN LANE WEST

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6280 00

0 100m




Archaeological Services W Y A S
Nepshaw Lane South, Morley, LS27 7JQ
Tel: 0113 383 7500 Fax:0113 383 7501

*Fig. 2. Survey location showing greyscale magnetometer data (1:2000 @ A3)*


*Fig. 3. Processed greyscale magnetometer data (1:1000 @ A4)*


*Fig. 4. XY trace plot of minimally processed magnetometer data (1:1000 @ A4)*


*Fig. 5. Interpretation of processed greyscale magnetometer data (1:1000 @ A4)*

*Plate 1. General view of survey area, looking north-west*

*Plate 2. General view of survey area, looking north-east*

# 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.

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

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 have been presented in this report in XY trace and greyscale formats. In the former format the data shown are ‘raw’ with no processing other than grid biasing having been done. The data in the greyscale images have 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 have 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 have 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 or for the removal of any of the survey reference points.***

## Appendix 3: Geophysical archive

The geophysical archive comprises:-

- an archive disk containing compressed (WinZip 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 Norfolk Historic Environment Record).

## Appendix 4: OASIS form

# OASIS DATA COLLECTION FORM: England



## Printable version

## OASIS ID: archaeol11-233644

### Project details

| | |
|---|---|
| Project name | Land at Gazebo Farm, Rackheath |
| Short description of the project | An additional phase of geophysical (magnetometer) survey, covering approximately 0.8 hectares, was carried out on land north of Gazebo Farm, the route of the Norwich Northern Distributor Road, previously surveyed by Archaeological Services WYAS. The survey aimed to determine the location of a crashed World War II fighter aircraft (P-51 Mustang). The survey results were unable to conclusively confirm the suggested location of the crash site, but there were a number of ferrous anomalies which could be considered consistent with the remains of a crashed aircraft. As a result, the archaeological potential of this site is considered to be medium. |
| Project dates | Start: 03-12-2015 End: 03-12-2015 |
| Previous/future work | Yes / Not known |
| Any associated project reference codes | archaeol11-206008 - OASIS form ID |
| Type of project | Field evaluation |
| Current Land use | Grassland Heathland 2 - Undisturbed Grassland |
| Monument type | AIRCRAFT CRASH SITE Modern |
| Significant Finds | ?AIRCRAFT Modern |
| Methods & techniques | "Geophysical Survey" |
| Development type | Road scheme (new and widening) |
| Prompt | National Planning Policy Framework - NPPF |
| Position in the planning process | Not known / Not recorded |
| Solid geology | NORWICH CRAG, RED CRAG AND CHILLESFORD CLAY |
| Drift geology | GLACIAL SAND AND GRAVEL |
| Techniques | Magnetometry |

### Project location

| | |
|---|---|
| Country | England |

| | |
|---|---|
| Site location | NORFOLK NORWICH NORWICH Land at Gazebo Farm, Rackheath |
| Study area | 0.8 Hectares |
| Site coordinates | TG 277 136 52.671680893765 1.368281442765 52 40 18 N 001 22 05 E Point |

## Project creators

| | |
|---|---|
| Name of Organisation | Archaeological Services WYAS |
| Project brief originator | Mott MacDonald |
| Project design originator | Mott MacDonald |
| Project director/manager | C. Sykes |
| Project supervisor | B Goulding |

## Project archives

| | |
|---|---|
| Physical Archive Exists? | No |
| Digital Archive recipient | Mott MacDonald |
| Digital Contents | "Survey" |
| Digital Media available | "Geophysics","Images raster / digital photography","Text" |
| Paper Archive recipient | ASWYAS |
| Paper Contents | "Survey" |
| Paper Media available | "Survey ","Unpublished Text" |

## Project bibliography 1

| | |
|---|---|
| Publication type | Grey literature (unpublished document/manuscript) |
| Title | Land at Gazebo Farm, Rackheath, Norwich |
| Author(s)/Editor(s) | Green, A |
| Date | 2015 |
| Issuer or publisher | ASWYAS |
| Place of issue or publication | Leeds |
| Description | A4 report with A4 and A3 figures |

| | |
|---|---|
| Entered by | Emma Brunning (Emma.Brunning@aswyas.com) |
| Entered on | 9 December 2015 |

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