STRATASCAN

Geophysical Survey Report

Buckley's Field, Middlewich
Cheshire

for

Gifford and Partners

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J2025

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LIST OF FIGURES

1 SUMMARY OF RESULTS

The magnetometry survey identified a number of anomalies of possible archaeological origin. A large positive linear anomaly has been identified in the north east of the site. This anomaly may represent a cut feature of archaeological origin and may be associated with a Roman road thought to exist in the area. A further positive linear anomaly has been identified in the centre of the survey area which may represent a cut feature of archaeological origin. A number of faint positive and negative linear anomalies have also been identified. These anomalies may be caused by archaeological, modern or agricultural activity.

The resistivity survey also identified a number of anomalies that could have archaeological origins. A number of bands of varying resistivity oriented in a generally north west – south east direction can be seen, which may relate to structural remains. A linear anomaly crosses the south eastern part of the survey area that may be related to a service trench.

Many potential archaeological features may be obscured due to the large areas of magnetic disturbance caused by modern features and obstructions.

2 INTRODUCTION

2.1 Background synopsis

Stratascan were commissioned by Gifford and Partners to undertake geophysical surveys of Buckley’s Field as part of The Roman Middlewich Archaeology Project. This survey forms part of stage 1 of The Roman Middlewich Archaeology Project that is designed to build upon previous Community projects and archaeological knowledge of the area.

2.2 Site location

The site is Buckley’s Field which is located southwest of King Street in Middlewich, Cheshire at OS ref. SJ 705 665.

2.3 Description of site

The survey area is approximately 0.7ha of grassy open ground which is divided into two approximately equal sized areas separated by a fairly well defined break in slope orientated in a north-south direction. The area to the north-east of this line is roughly level but the south western area slopes to towards the river Croco. Overgrown vegetation is present around the perimeter of the survey area, which also contained two obstructions in the centre, a large bushy tree and a collection of metal barrels. The survey was unable to extend to the northern field boundary due to the overgrown vegetation.


Looking southeast over survey area

2.4 Geology and Soils

The underlying geology is Triassic mudstone with overlying River Terrace Deposits and Alluvium (British Geological Survey South Sheet, Forth Edition Solid, 2001; First Edition Quaternary, 1977). Due to the sites urban environment the area has not been surveyed, although the overlying soils are likely to be Salop that are typical stagnogley soils. These consist of slowly permeable seasonally waterlogged reddish fine loamy over clayey soils (Soil Survey of England and Wales, Sheet 3 Midland and Western England).

2.5 Site history and archaeological potential

Archaeologists first noted the Roman site at Middlewich (Salinae) in the 18th century where initial interest focused on the location of the Roman fort in Harbutt's Field, situated northwest of the survey area. The construction of the railway through Middlewich revealed evidence of a Roman settlement, while more recent excavations and evaluations confirmed the extent of Roman settlement identified in the late Victorian period (L-P partnership 2004).

A Roman military base was established around 60AD at Middlewich. The fort was built on a defensive site above the River Dane and became a staging post on the main military road to the North. A geophysical survey carried out by Stratascan in August 1993 located the position and extents of the fort. The Romans established their salt works on land by the River Croco between the military fort and the site of the existing Celtic salt making settlement (Twigg 2002).

Middlewich grew into a flourishing industrial settlement, with evidence of metalworking, glass making and leather working. The salt works probably continued in use into the 4th century AD (Tindall 2001).

Excavations carried out by Bestwick in the 1970's of Buckley's Field revealed evidence of iron smithing. Evidence of briquettage and a brine hearth has been identified in the adjacent field west of the survey area. Hypocaust tiles were also discovered by Bestwick, suggesting the presence of at least one substantial roman building, but the precise location of this find is unknown.

Excavations carried out by L-P archaeology prior to the Fairclough Homes Development discovered a series of pits and trenches cut into the ground surface, some of which were aligned with wattles. Possible kilns, fire pits and briquettage provide further evidence of industrial production (L-P partnership 2004).

The Roman road King Street and a further possible Roman road are thought to run through Buckley's Field at an approximate north to south alignment (Garner 2004).

2.6 Survey objectives

The objective of the survey was to locate any features of possible archaeological significance, in particular any features relating to the Roman settlement of Middlewich. The survey forms part of stage 1 of The Roman Middlewich Archaeology Project.

2.7 Survey methods

An initial detailed magnetic survey (gradiometry) was used as an efficient and effective method of locating archaeological anomalies, in particular to identify possible areas of metalworking (identified from the investigations carried out by Bestwick in the 1970's). At a later date a resistivity survey, a technique that had been successfully used to identify the nearby Roman fort (see appendix B), was carried out to identify possible structures or other features of archaeological origin. More information regarding these techniques is included in the Methodology section below.

3 METHODOLOGY

3.1 Date of fieldwork

The magnetometry survey was executed on the 23rd June 2005 when the weather conditions were hot and dry. The resistivity survey was completed on the 20th of July in similar weather conditions.

3.2 Grid locations

The location of the survey grids has been plotted in Figures 2 and 8 together with the referencing information. Grids were set out using a Leica 705auto Total Station and referenced to suitable topographic features around the perimeter of the site.

3.3 Description of techniques and equipment configurations

The magnetic survey was carried out using a dual sensor Grad601-2 Magnetic Gradiometer manufactured by Bartington Instruments Ltd. The Grad601-2 consists of two high stability fluxgate gradiometers suspended on a single frame. Each sensor has a 1m separation between the sensing elements increasing the sensitivity to small changes in the Earths magnetic field.

The resistance survey used an RM15 system manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger, which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

3.3.1 Magnetometer

Although the changes in the magnetic field resulting from differing features in the soil are usually weak, changes as small as 0.2 nanoTesla (nT) in an overall field strength of 48,000nT, can be accurately detected using an appropriate instrument.

The mapping of the anomaly in a systematic manner will allow an estimate of the type of material present beneath the surface. Strong magnetic anomalies will be generated by buried iron-based objects or by kilns or hearths. More subtle anomalies such as pits and ditches can be seen if they contain more humic material which is normally rich in magnetic iron oxides when compared with the subsoil.

To illustrate this point, the cutting and subsequent silting or backfilling of a ditch may result in a larger volume of weakly magnetic material being accumulated in the trench compared to the undisturbed subsoil. A weak magnetic anomaly should therefore appear in plan along the line of the ditch.

3.3.2 Resistance Meter

This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current, which is passed through them. As resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high resistivity response, while features such as a ditch which retains moisture give a relatively low response.

Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used through-out.

3.4 Sampling interval, depth of scan, resolution and data capture

3.4.1 Sampling interval

Magnetometer
Readings were taken at 0.25m centres along traverses 1m apart. This equates to 3600 sampling points in a full 30m x 30m grid.

Resistivity
Readings for resistivity grids 1 to 7 were taken at 1.0m centres along traverses 1.0m apart. This equates to 900 sampling points in a full 30m x 30m grid. Grid 11 measured 20m x20m and was located in the same orientation as grids 1 to 7. It was surveyed by taking readings at 0.5m intervals along traverses 0.5m apart resulting in the capture of 1600 data points. In both cases all traverses were surveyed in a "zigzag" mode.

3.4.2 Depth of scan and resolution

Magnetometer
The Grad601-2 has a typical depth of penetration of 0.5m to 1.0m. This would be increased if strongly magnetic objects have been buried in the site. The collection of data at 0.25m centres provides an appropriate methodology balancing cost and time with resolution.

Resistivity
The 0.5m probe spacing of a twin probe array has a typical depth of penetration of 0.5m to 1.0m. The collection of data at 1m centres with 0.5m probe spacing provides an appropriate methodology balancing cost and time with resolution. Collection of data at 0.5m centres increases the resolution of anomalies but increases the duration of the survey.

3.4.3 Data capture

The readings for both techniques used are logged consecutively into the data logger which is downloaded on a daily basis into a portable computer whilst on site. At the end of each job, data is transferred to the office for processing and presentation.

3.5 Processing, presentation of results and interpretation

3.5.1 Processing

Magnetometer
Processing is performed using specialist software known as *Geoplot 3*. This can emphasise various aspects contained within the data but which are often not easily seen in the raw data. Basic processing of the magnetic data involves 'flattening' the background levels with respect to adjacent traverses and adjacent grids. 'Despiking' is also performed to remove the anomalies resulting from small iron objects often found on agricultural land. Once the basic processing has flattened the background it is then possible to carry out further processing which may include low pass filtering to reduce 'noise' in the data and hence emphasise the archaeological or man-made anomalies.

The following schedule shows the basic processing carried out on all processed gradiometer data used in this report:

Zero mean grid	(sets the background mean of each grid to zero and is useful for removing grid edge discontinuities) *Threshold = 0.25 std. dev.*
Zero mean traverse	(sets the background mean of each traverse within a grid to zero and is useful for removing striping effects) *Last mean square fit = off*
Despike	(useful for display and allows further processing functions to be carried out more effectively by removing extreme data values) *X radius = 1 Y radius = 1* *Threshold = 3 std. dev.* *Spike replacement = mean*

In addition the following processing extreme high and low readings caused by modern disturbance have been removed in an attempt to enhance and reveal faint magnetic anomalies.

Resistivity
The processing was also carried out using *Geoplot 3* and involved the 'despiking' of high contact resistance readings and the passing of the data though a high pass filter. This has the effect of removing the larger variations in the data often associated with geological features. The nett effect is aimed at enhancing the archaeological or man-made anomalies contained in the data.

The following schedule shows the processing carried out on the processed resistance plots.

Despike	*X radius = 1*
	Y radius = 1
	Spike replacement
High pass filter	*X radius = 10*
	Y radius = 10
	Weighting = Gaussian

3.5.2 Presentation of results and interpretation

Magnetometer

The presentation of the data for each site involves a print-out of the raw data both as greyscale (Figure 3) and trace plots (Figure 4 and 5), together with a greyscale plot of the processed data (Figure 6). Magnetic anomalies have been identified and plotted onto the 'Abstraction and Interpretation of Anomalies' drawing for the site (Figure 7).

Resistivity

The presentation of the data for the site involves a print-out of the raw data as a grey scale plot (Figures 9 and 12), together with a grey scale plot of the processed data (Figures 10 and 13). The 'Abstraction and Interpretation of Anomalies' drawings (Figures 11 and 14) shows a plot of the resistivity anomalies identified.

4 RESULTS

Magnetometer
The anomalies identified within the survey area can be separated into the following categories:

- Positive anomalies with associated negative responses – near surface ferrous objects
- Magnetic disturbances associated with services
- Positive linear anomalies – possible cut features of archaeological origin
- Faint negative linear anomalies – possible structural remains of archaeological origin
- Faint positive area response possibly relating to a cut feature of archaeological origin
- Areas of magnetic disturbance associated with modern activity

Positive anomalies with associated negative response
These positive anomalies with negative responses are likely to represent near surface ferrous objects and can be identified in three clusters within the north of the survey area (**E**, **F** and **G**). These responses may be archaeological in origin as the site history revealed evidence of iron smithing in the area, although due to the sites urban location these anomalies may also be of modern origin.

Magnetic disturbances associated with services
Two services have been identified within the survey area and have contributed to the areas of magnetic disturbance. One service runs parallel with the south-western field boundary. The other runs in a northeast to southwest orientation across the eastern side of the survey area.

Positive linear anomalies – possible cut features of archaeological origin
A large positive linear anomaly has been identified in an approximate north to south orientation across the north-eastern corner of the survey area (**A**). This anomaly may represent a cut feature of archaeological origin, such as a ditch, and may be associated with a Roman road believed to run across the site.

A smaller positive linear anomaly has been identified across the centre of the survey area in an approximate northeast to southwest alignment. The anomaly is roughly 15m long (**B**). This anomaly may represent a cut feature of archaeological origin.

A number of faint positive linear anomalies situated to the west of anomaly **E** and southeast of **B** may represent cut features of archaeological origin. Due to the large areas of magnetic disturbances surrounding the perimeter of the survey, it is difficult to abstract a coherent alignment of anomalies that would indicate possible archaeological structures or features. These anomalies may therefore be of archaeological or modern origin.

A positive linear response can be seen through the magnetic disturbance in the north corner of the survey area (**H**). This anomaly may represent a cut feature of archaeological origin.

Faint negative linear anomalies – possible structural remains of archaeological origin
A number of faint negative linear responses have been identified in the north-western part of the survey area, mainly in a northeast to southwest alignment (**D**). These faint anomalies may represent structural remains of archaeological origin or possibly be associated with modern or agricultural activity.

Faint positive area response possibly relating to a cut feature of archaeological origin
In the approximate centre of the survey area is a faint positive area response (**C**). This anomaly may represent a cut feature of archaeological origin and may indicate a continuation of linear anomaly **B**.

Areas of magnetic disturbance associated with modern activity
The survey data is dominated by large areas of magnetic disturbance caused by the nearby field boundaries, identified services and the tree and barrel situated in the northeast of the survey area. These areas of magnetic disturbance may have obscured the presence of faint linear anomalies of possible archaeological origin.

It is also difficult to separate potential magnetic disturbances of possible archaeological origin associated with metal working from modern activities. It may be possible that some of the magnetic disturbances could be caused by archaeological activity, such as smithing. Anomalies of archaeological origin may also be masked by the magnetic disturbance. This is represented by two possible strong positive anomalies, one situated in the north corner near anomaly **H** and the other situated in the west corner of the survey area (see Figures 3 and 6). These anomalies may be of archaeological origin but masked by modern disturbances.

Resistivity

4.1 <u>Data collected at 1.0m intervals (Grids 1-7)</u>

The anomalies identified within the survey area can be separated into the following categories:

- Faint linear medium value resistivity feature
- Moderately high resistance Areas
- High resistance areas of possible possibly associated with modern activity
- Areas having moderate and low resistance values

The resistivity survey results showed few anomalies that can be confidently associated with archaeological activity.

Faint linear medium value resistivity feature
At the south eastern end of the field a thin (1m wide) linear feature of moderately low resistance extends from the north eastern to the southern boundaries of the survey area in an approximately north-south direction **(a)**. This is likely to be associated with the service also found within the magnetometry survey.

Moderately high resistance areas
The areas marked as **(b)** have moderately high resistance values and appear to be associated with the thin linear feature **(a)** described above. Due to the pattern of these areas and their close proximity to the faint linear feature it is possible that they are due to changes of drainage patterns connected with the service trench.

The areas of elevated resistance marked as **(d)** do not form any discernable pattern and are consequently thought to be the result of geological or pedological processes. Area **(e)** appears to coincide with a surface scatter of modern building material.

High resistance areas possibly associated with modern activity
An irregularly shaped discontinuous band of high resistance **(f)** is evident across the site. It is oriented in a north-west south east direction and varies in width from approximately 5m at its narrowest to nearly 20m at its widest. This area appears to correspond with the break of slope and may be caused by landscaping undertaken to extend the level area seen in the north-eastern portion of the site. In the southern corner of the survey area this band **(f)** of high resistance is cut by the faint linear feature **(a)** and the associated area of medium resistance **(b)** which may indicate that the landscaping predates the excavation of the service trench. Within band of high resistance there are areas **(g)** that exhibit resistance values that are significantly higher than those surrounding them. It is possible that these areas have structural origins; however, it is also possible that they may be related to landscaping.

Two areas **(c)** near to the bushes in the centre of the survey show raised resistance levels possibly due to the reduction of soil moisture content by nearby tree roots.

Areas having moderate and low resistance values
The south-western and south-eastern areas that slope towards the river Croco generally have lower soil resistance values than the rest of the site and would appear to reflect pedological processes. Within this general vicinity there are areas with lower resistances **(h** and **j)** these anomalies may possibly indicate cut features such as pits, ditches, quarrying or dumped material with heightened porosity of archaeological origin.

4.2 Data collected at 0.5m centres (Grid 11)

After discussion with the on-site archaeologist it was agreed that the 20m by 20m grid numbered 11 (See Figure 8) would be located in the area that was to be excavated as part of the community project. The results show more detail but it is still difficult to interpret the data. The initial survey at 1m centres indicated a 10m wide band of generally medium resistance values orientated roughly north south with moderately low resistivity values to the east and west of it. The detailed survey confirms this general impression but within the medium resistance band **(n)** there are patches of higher resistance values **(q)**. It is possible that these areas represent structures of archaeological origin but they are more likely to indicate variations in the underlying geology or be caused by landscaping. The discrete low resistance area **(r)** could be caused by a 3m diameter pit or could have a geological origin. The remaining areas of low resistance **(k, p** and **s)** appear to have the same range of values as the general background of the site, although it is possible that the area which also appears faintly in the larger resistivity survey could be a cut feature of archaeological origin **(k)**.

5 CONCLUSION

Despite the presence of large areas of magnetic disturbance which may have obscured potential archaeological features, a substantial number of positive and negative linear anomalies have been identified that may be of archaeological origin.

A large positive linear anomaly identified in the northeast of the survey may represent a ditch possibly associated with a Roman road. A positive linear anomaly present in the centre of the survey area may also be a cut feature of archaeological origin.

Faint positive and negative linear anomalies present within the centre of the survey area may suggest a general area of archaeological activity. The presence of near surface ferrous objects may indicate metal working areas, as first identified by Bestwick in the 1970's. However it should be noted that due to the sites urban environment, these anomalies might also be caused by modern activity.

The resistivity survey confirmed the general impression gained from the earlier magnetometry survey that the site has been disturbed in recent times. Much of this disturbance appears to be caused by landscaping of the site. A number of anomalies identified within the detailed resistivity survey may be of archaeological origin.

APPENDIX A – Basic principles of magnetic and resistivity surveys

Magnetic Survey

Detailed magnetic survey can be used to effectively define areas of past human activity by mapping spatial variation and contrast in the magnetic properties of soil, subsoil and bedrock.

Weakly magnetic iron minerals are always present within the soil and areas of enhancement relate to increases in *magnetic susceptibility* and permanently magnetised *thermoremnant* material.

Magnetic susceptibility relates to the induced magnetism of a material when in the presence of a magnetic field. This magnetism can be considered as effectively permanent as it exists within the Earth's magnetic field. Magnetic susceptibility can become enhanced due to burning and complex biological or fermentation processes.

Thermoremnance is a permanent magnetism acquired by iron minerals that, after heating to a specific temperature known as the Curie Point, are effectively demagnetised followed by re-magnetisation by the Earth's magnetic field on cooling. Thermoremnant archaeological features can include hearths and kilns and material such as brick and tile may be magnetised through the same process.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil creates a relative contrast against the much lower levels of magnetism within the subsoil into which the feature is cut. Systematic mapping of magnetic anomalies will produce linear and discrete areas of enhancement allowing assessment and characterisation of subsurface features. Material such as subsoil and non-magnetic bedrock used to create former earthworks and walls may be mapped as areas of lower enhancement compared to surrounding soils.

Magnetic survey is carried out using a fluxgate gradiometer which is a passive instrument consisting of two sensors mounted vertically either 0.5 or 1m apart. The instrument is carried about 30cm above the ground surface and the top sensor measures the Earth's magnetic field whilst the lower sensor measures the same field but is also more affected by any localised buried field. The difference between the two sensors will relate to the strength of a magnetic field created by a buried feature, if no field is present the difference will be close to zero as the magnetic field measured by both sensors will be the same.

Factors affecting the magnetic survey may include soil type, local geology, previous human activity, disturbance from modern services etc.

Resistivity Survey

This method relies on the relative inability of soils (and objects within the soil) to conduct an electrical current which is passed through them. As resistivity is linked to moisture content, and therefore porosity, hard dense features such as rock will give a relatively high resistivity response, while features such as a ditch which retains moisture give a relatively low response.

The resistance meter used was an RM15 manufactured by Geoscan Research incorporating a mobile Twin Probe Array. The Twin Probes are separated by 0.5m and the associated remote probes were positioned approximately 15m outside the grid. The instrument uses an automatic data logger which permits the data to be recorded as the survey progresses for later downloading to a computer for processing and presentation.

Though the values being logged are actually resistances in ohms they are directly proportional to resistivity (ohm-metres) as the same probe configuration was used through-out.

APPENDIX B - Plots of previous survey work by Stratascan

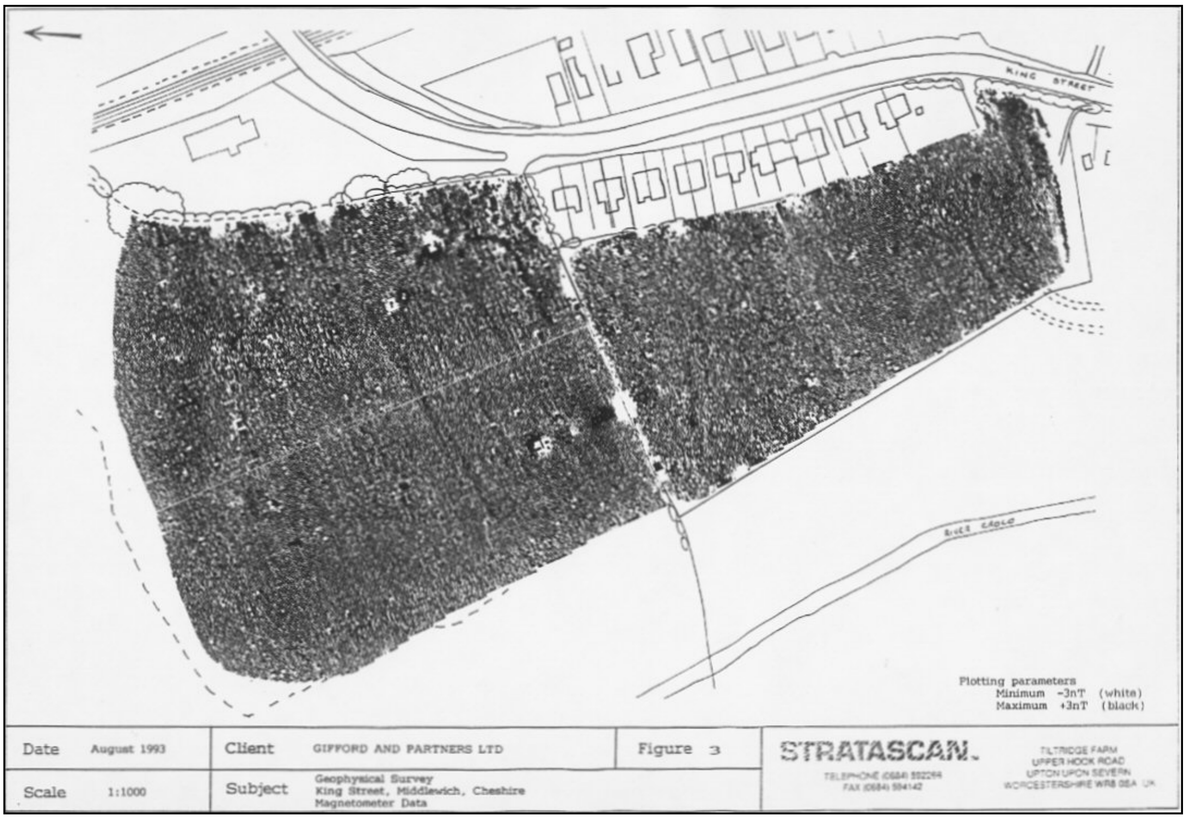

Plate 1: Magnetometry data at Middlewich Roman fort collected by Stratascan in 1993

Plate 2: Processed resistivity data at Middlewich Roman fort collected by Stratascan in 1993

BIBLIOGRAPHY

Garner. 2004**.** Brine in Britannia: Recent Archaeological Work on the Roman Salt Industry in Cheshire**.** *Archaeology North West* vol. 7 (Issue 17, for 2004-5)

L-P Partnership. July 2004. www.lparchaeology.com/projects/project2.php accessed 29/06/05

Tindall, A. Spring 2001. *Cheshire Archaeology News*. Issue 8 Spring 2001. Cheshire County Council

Twigg, G. D. November 2002. www.saltinfo.com/salt%20history2.htm accessed 29/06/05