magnitude surveys

Geophysical Survey Report

of

Hardwick Hill Cemetery Extension

For

Oxford Archaeology

On Behalf Of

Cemetery Development Services Ltd.

Magnitude Surveys Ref: MSSP522

August 2020

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 2.9ha area of land at Hardwick Hill, Banbury. A fluxgate gradiometer survey was successfully completed across the site. The geophysical results are characterised by the detection of a ridge and furrow ploughing regime across the whole survey area; a second smaller group of agricultural features have been identified only in the northwest corner of the survey area, and could be related to another phase of cultivation or could be drainage related. Possible archaeological activity has been identified in the form of linear anomalies forming incomplete enclosures and/or former field systems of uncertain date. Natural variations in the survey area's geology have also been identified. The impact of modern activity on the results is limited to the edges of the survey area.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Oxford Archaeology on behalf of Cemetery Development Services Ltd to undertake a geophysical survey on a c.2.9ha area of land near Hardwick Hill Cemetery, Banbury, Oxfordshire (SP 45455 43484).

1.2. The geophysical survey comprised hand-pulled cart-mounted fluxgate gradiometer survey.

1.3. The survey was conducted in line with the current best practice guidelines produced by Historic England (David et al., 2008), the Chartered Institute for Archaeologists (CIfA, 2014) and the European Archaeological Council (Schmidt et al., 2015).

1.4. It was conducted in line with a WSI produced by MS (Magnitude Surveys, 2019).

1.5. The survey commenced on 19/08/2019 and took one day to complete.

2. Quality Assurance

2.1. Magnitude Surveys is a Registered Organisation of the Chartered Institute for Archaeologists (CIfA), the chartered UK body for archaeologists, and a corporate member of ISAP (International Society of Archaeological Prospection).

2.2. Director Dr. Chrys Harris is a Member of CIfA, has a PhD in archaeological geophysics from the University of Bradford and is the Vice-Chair of ISAP. Director Finnegan Pope-Carter is a Fellow of the London Geological Society, the chartered UK body for geophysicists and geologists, as well as a member of GeoSIG, the CIfA Geophysics Special Interest Group. Reporting Analyst Dr. Kayt Armstrong has a PhD in archaeological geophysics from Bournemouth University, is the Vice Conference Secretary and Editor of ISAP News for ISAP, and is the UK Management Committee representative for the COST Action SAGA.

2.3. All MS managers have relevant degree qualifications to archaeology or geophysics. All MS field and office staff have relevant archaeology or geophysics degrees and/or field experience.

3. Objectives

3.1. The objective of this geophysical survey is to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The site is located c.9.3km north from Banbury (Figure 1). Survey was undertaken across two fields of grassland. The site is bounded by the M40 to the north-east, the A423 to the east, Banbury Crematorium and cemetery to the south and farmland to the west (Figure 2). A field totalling c.035ha was unable to be surveyed due to overgrown grassland.

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	Grassland field. Generally flat, with a slight slope down to the northwest in the northwest corner.	The survey area was bounded to the north by trees, hedges and a barbed wire fence, to the east by trees and hedges, to the south by wooden garden fence and trees, and to the west by trees and hedges.
2	Grassland field. Generally flat. Ridge and furrow could be seen running east to west. Data were collected in line with the ridge and furrow to reduce the impact of the extant ridge and furrow and improve the visualisation of any underlying features.	The survey area was bounded to the north by trees and a hedge, to the east by hedges and a wooden fence, with a wooden garden fence to the south, and trees and hedges to the west. A metal gate was present halfway along the eastern boundary.
3	Overgrown grassland.	Unsurveyable due to nettles and high vegetation.

4.3. The underlying geology consists of Dyrham formation interbedded siltstone and mudstone. Charmouth Mudstone Formation can be found to the immediate west of the site. No superficial deposits have been recorded across the survey area (British Geological Survey, 2019).

4.4. The soils consist of freely draining slightly acid but base-rich soils. The soil to the immediate west of the site is slowly permissible, seasonally wet and slightly acidic but also base-rich loamy and clayey (Soilscapes, 2019).

5. Archaeological Background

5.1. The information regarding the archaeological and historical background derives from previously undertaken archaeological investigations in the area (Cotswold Archaeology 1992, 2001; Oxford Archaeology 2003, 2011). The following summary provide a context for the proposed works.

5.2. The site is situated on the crest of a hill formation overlooking River Cherwell and Oxford Canal that runs c. 1.2km further east. The grade II listed Hardwick House (also known as Hardwick Farm) with associated earthworks of medieval decent are situated c. 750m south-west of the site and Banbury, a medieval market town, lies c. 2.7km south of the site.

5.3. Extensive archaeological works undertaken in advance of the Banbury Flood Alleviation Scheme c. 1.12km south-east of the site identified a multi-period landscape ranging from the Mesolithic to the Middle Ages. 35 Neolithic pits containing early and middle Neolithic flint and

Peterborough and Grooved ware pottery, and late Iron Age to Roman circular enclosure were among the remains that were uncovered.

5.4. Evidence for Roman occupation was uncovered during investigations at Hardwick House and a multi-phase field system of national importance has been investigated at Little Boughton to the north of the site.

5.5. Evidence for Saxon/early medieval activity comes from the excavation undertaken at Hardwick Farm c. 750m south-west of the survey area, the site of a shrunken medieval village with widespread preserved ridge and furrow systems. Archaeological investigations in the immediate vicinity identified features associated with medieval land management and the presence of a hollow way running NNE-SSW between the main medieval settlement and the field systems.

6. Methodology

6.1.Data Collection

6.1.1. Geophysical prospection comprised the magnetic method as described in the following table.

6.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments Grad-13 Digital Three-Axis Gradiometer	1m	200Hz reprojected to 0.125m

6.1.3. The magnetic data were collected using MS' bespoke hand-pulled cart system. MS' cart system was comprised of Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing was through a multi-channel, multi-constellation GNSS Smart Antenna RTK GPS outputting in NMEA mode to ensure high positional accuracy of collected measurements. The RTK GPS is accurate to 0.008m + 1ppm in the horizontal and 0.015m + 1ppm in the vertical.

6.1.3.1. Magnetic and GPS data were stored on an SD card within MS' bespoke datalogger. The datalogger was continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allowed for data collection, processing and visualisation to be monitored in real-time as fieldwork was ongoing.

6.1.3.2. A navigation system was integrated with the RTK GPS, which was used to guide the surveyor. Data were collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

6.2.Data Processing

6.2.1. Magnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to Historic England's standards for "raw or minimally processed data" (see sect 4.2 in David et al., 2008: 11).

Sensor Calibration – The sensors were calibrated using a bespoke in-house algorithm, which conforms to Olsen et al. (2003).

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping effects caused by small variations in sensor electronics.

Projection to a Regular Grid – Data collected using RTK GPS positioning requires a uniform grid projection to visualise data. Data are rotated to best fit an orthogonal grid projection and are resampled onto the grid using an inverse distance-weighting algorithm.

Interpolation to Square Pixels – Data are interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

6.3.Data Visualisation and Interpretation

6.3.1. This report presents the gradient of the sensors' total field data as greyscale images. The gradient of the sensors minimises external interferences and reduces the blown-out responses from ferrous and other high contrast material. However, the contrast of weak or ephemeral anomalies can be reduced through the process of calculating the gradient. Consequently, some features can be clearer in the respective gradient or total field datasets. Multiple greyscale images at different plotting ranges have been used for data interpretation. Greyscale images should be viewed alongside the XY trace plot (Figure 7). XY trace plots visualise the magnitude and form of the geophysical response, aiding in anomaly interpretation.

6.3.2. Geophysical results have been interpreted using greyscale images and XY traces in a layered environment, overlaid against open street maps, satellite imagery, historic maps, LiDAR data, and soil and geology maps. Google Earth (2019) was consulted as well, to compare the results with recent land usages.

6.3.3. Geodetic position of results - All vector and raster data have been projected into OSGB36 (ESPG27700) and can be provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively. Figures are provided with raster and vector data projected against OS Open Data.

7. Results

7.1.Qualification

7.1.1. Geophysical results are not a map of the ground and are instead a direct measurement of subsurface properties. Detecting and mapping features requires that said features have properties that can be measured by the chosen technique(s) and that these properties have sufficient contrast with the background to be identifiable. The interpretation of any identified anomalies is inherently subjective. While the scrutiny of the results is undertaken by qualified, experienced individuals and rigorously checked for quality and consistency, it is often not possible to classify all anomaly sources. Where possible an anomaly source will be identified along with the certainty of the interpretation. The only way to improve the interpretation of results is through a process of comparing excavated results with the geophysical reports. MS actively seek feedback on their reports as well as reports of further work in order to constantly improve our knowledge and service.

7.2.Discussion

7.2.1. The geophysical results are presented in consideration historic maps (Figure 6).

7.2.2. The fluxgate gradiometer survey has responded well to the environment of the survey area with both strong and weak anomalies being detected. The geophysical data is characterised by multi-phase landscape management of the survey area, with a combination of former ploughing regimes as well as possible archaeological unrecorded field systems. Modern interference is limited to the edges of the survey area, particularly around Hardwick Hill House. Natural variations have also been identified across the survey area.

7.2.3. Agricultural activity has been identified in the numerous linear anomalies classified as ridge and furrows running east to west across the whole of the survey area (Figure 5). These exhibit the characteristic curvature of medieval ploughing regimes, and a generally strong magnetic enhancement, even when viewed in the wider plotting range gradient (Figure 3), as well as being extant in the survey area. Strong levels of magnetic enhancement is usually produced by long-used features and/or the location of these features being places where natural soils are magnetically stronger. A second group of agricultural features has been identified on the same alignment and with a similar magnetic signature to the main ridge and furrow, but much weaker and located between the ridge and furrow; hence a similar origin of a different phase of ridge and furrow has been considered likely. Fainter linear anomalies can also be detected running parallel between the stronger ridge and furrow anomalies indicating further historic cultivation of the land. A smaller group of agricultural features have been identified in the northwest corner and could either be related to another phase of cultivation or drainage related.

7.2.4. Archaeological activity has been identified in the form of a possible former field system and/or enclosure (Figure 5). These types of anthropogenic features are in line with other landscape management features recorded within the wider environs of the survey area (see 5. Archaeological Background) and could potentially be part of a former field

system. Particularly with the features recorded within the Hardwick Hill House site (Roman occupation, the Medieval shrunken village and associated field system, settlement and holloway), it is feasible some of the anomalies identified in the magnetic data might be continuations of features recorded during the Hardwick Hill investigations.

7.2.5. Further linear anomalies have been recorded throughout the survey area, not sharing the alignment of the possible archaeological anomalies and generally exhibiting a weak, ephemeral magnetic signal. These are likely to be the result of some sort of landscape organisation (field systems, enclosures) of an uncertain date; but a more detailed assessment cannot be made from the magnetic data. These have been categorised as 'undetermined'.

7.3.Interpretation

7.3.1. General Statements

7.3.1.1. Geophysical anomalies will be discussed broadly as classification types across the survey area. Only anomalies that are distinctive or unusual will be discussed individually.

7.3.1.2. **Magnetic Disturbance** – The strong anomalies produced by extant metallic structures along the edges of the field have been classified as 'Magnetic Disturbance'. These magnetic 'haloes' will obscure the response of any weaker underlying features, should they be present, often over a greater footprint than the structure they are being caused by.

7.3.1.3. **Ferrous (Spike)** – Discrete ferrous-like, dipolar anomalies are likely to be the result of isolated modern metallic debris on or near the ground surface.

7.3.1.4. **Ferrous/Debris (Spread)** – A ferrous/debris spread refers to a concentrated deposition of discrete, dipolar ferrous anomalies and other highly magnetic material.

7.3.1.5. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of geological, pedological or agricultural processes, although an archaeological origin cannot be entirely ruled out. Undetermined anomalies are generally not ferrous in nature.

7.3.2. Magnetic Results - Specific Anomalies

7.3.2.1. **Archaeology Possible** – A series of linear anomalies have been recorded throughout Area 1 [**1a**] and Area 2 [**2a**]. Anomalies [**1a**] and [**2a**] exhibit a generally weak magnetic signal (Figure 4), with sections of the linear anomalies being recorded with a higher magnetic strength. These linear anomalies present a layout similar to that of a former field system; however, anomalies at [**1a**] could also be interpreted as an enclosure measuring c.22m by c.20m in size, with internal features being identified. The intermittence of the stronger

magnetic signal is likely to be a by-product of posterior ridge and furrow ploughing regimes, suggesting that the field system and possible enclosure may pre-date the medieval agricultural landscape revealed as the ridge-and-furrow palimpsest.

7.3.2.2. **Archaeology Possible** – Numerous small pit-like anomalies have been recorded through the survey area, particularly across the centre of Area 1. The exhibit a positive strong magnetic signal, particularly noticeable when viewed in the wide plotting range (Figure 3). These pit-like anomalies appear to hold greater significance due to their elongated linear alignment, specially the grouping of anomalies [**1b**]. Pits that form anomaly [**1b**] measure between c.1m to 2m in diameter, are positive in magnetic signal and are most noticeable when viewed in a wider gradient (Figure 4). These appear to be intersected by the ridge and furrow but are visible as distinct anomalies in the XY traces (Figure 7).

7.3.2.3. **Agricultural (Strong)** – In the north-west corner of Area 1, a series of parallel linear anomalies [**1c**] have been identified. These exhibit a strong magnetic signal, even when viewed in the wider plotting range (Figure 3) and XY traces (Figure 7). Anomalies [**1c**] run at an angle, cross cutting the ridge and furrow recorded in the survey area. The anomalies are a different phase to the broad ridge and furrow on the site as they cut across the ridge and furrow. Their placement at the bottom of the slope of the field suggests they may be drainage related, an origin of a different phase of ridge and furrow cultivation cannot be ruled out.

8. Conclusions

8.1. A fluxgate gradiometer survey has successfully been undertaken across the site. The geophysical survey has detected a range of different types of anomalies of archaeological, and agricultural origin. Modern interference is limited to the edges of the survey area, particularly close to Hardwick Hill House.

8.2. The natural variations within the sites geology have contributed to the enhancement of anthropogenic ditch-type features recorded in the magnetic data, and to the variability of that enhancement. Spreads of natural highly variable texture in the data have been identified as natural 'spreads' of varying topsoil composition, along with broader bands of changes in the magnetic enhancement that a result of the underlying geology, recorded as 'natural' across the survey area.

8.3. Archaeological activity has been detected across the survey area, in the form of a former field system and/or enclosure of uncertain date) with internal anomalies. It is feasible some of the archaeological features recorded in the magnetic data are a continuation of Romano to Medieval features similar to the former field systems previously recorded within Hardwick Hill House grounds. Pit-like anomalies of possible archaeological origin have been recorded throughout.

8.4. Agricultural activity has been detected as a single broad phase of ridge and furrow ploughing regime, running across the whole of the survey area. There are possible earlier instances of a ridge and furrow system on the same alignment visible in places between the ridge and furrow anomalies. A second smaller group of agricultural features could be related to another phase of cultivation and/or drainage features.

8.5. Anomalies of an undetermined origin have been identified across the survey area. The origin of these is difficult to determine as they are very ephemeral and exist among the strong anomalies caused by the ridge and furrow system.

9. Archiving

9.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report.

9.2. MS contributes reports to the ADS Grey Literature Library upon permission from the client, subject to the any dictated time embargoes.

10. Copyright

10.1. Copyright and the intellectual property pertaining to all reports, figures, and datasets produced by Magnitude Services Ltd. is retained by MS. The client is given full licence to use such material for their own purposes. Permission must be sought by any third party wishing to use or reproduce any IP owned by MS.

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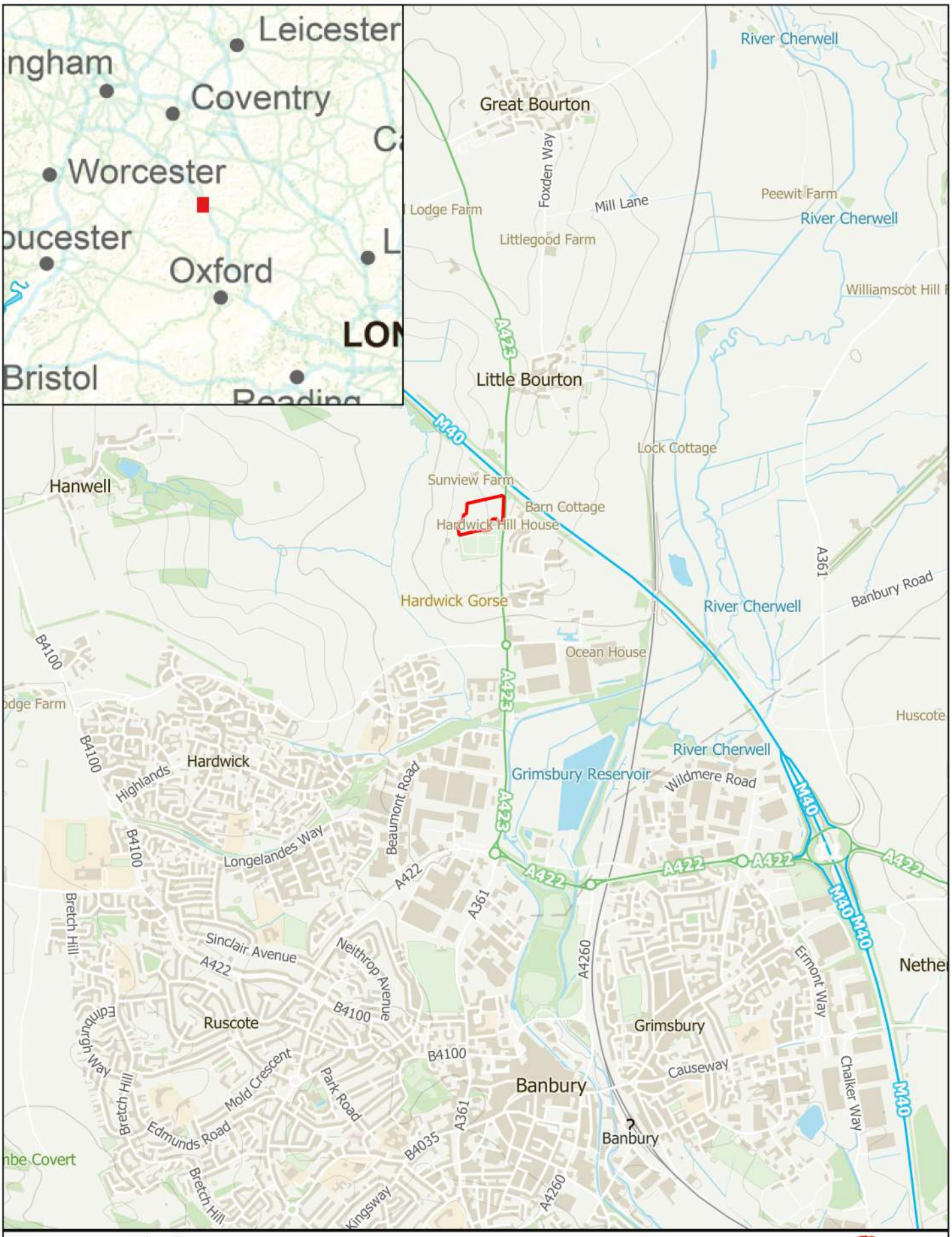

MSSP522 - Hardwick Hill Cemetery Extension
Figure 1 - Site Location
1:25,000 @ A4

Site Boundary

N

0 0.5 1 km

magnitude surveys

445250
445500
445750
243500
243250
Sunview Farm
Area 3
Area 2
Area 1
A423
M40
Bourton Road
Hornton Drive
Hardwick Hill House
Bourton Road
Horley Drive
Cemetery
Wardington Road
Edgcote Way

MSSP522 - Hardwick Hill Cemetery Extension
Figure 2 - Location of Survey Areas
1:2,000 @ A3

Survey Extent
Unsurveyable

N
0 50 100 150 m

magnitude surveys

445300
445400
445500
445600
243500
243400
Area 1
Area 2
A423
Bourton Road
Hardwick Hill House
Bourton Road

MSSP522 - Hardwick Hill Cemetery Extension
Figure 3 - Magnetic Gradient (Wide plotting range)
1:1,000 @ A3

-3 nT 5

N

0 25 50 75 m

magnitude surveys

445300
445400
445500
445600
243500
243400
Area 1
Area 2
A423
Bourton Road
Hardwick Hill House
Bourton Road

MSSP522 - Hardwick Hill Cemetery Extension
Figure 4 - Magnetic Gradient
1:1,000 @ A3

-1 nT 2

N

0 25 50 75 m

magnitude surveys

445300
445400
445500
445600
243500
243400

Area 1
Area 2
1a
1b
1c
2a
A423
Bourton Road
Hardwick Hill House

MSSP522 - Hardwick Hill Cemetery Extension
Figure 5 - Magnetic Interpretation
1:1,000 @ A3

- Archaeology Possible (Strong)
- Archaeology Possible (Weak)
- Agricultural (Strong)
- Natural (Weak)
- Natural (Spread)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Strong)
- Undetermined (Weak)
- Agricultural (Trend)
- Ridge and Furrow (Trend)
- Drainage Feature
- Ferrous (Spike)

N

0 25 50 75 m

magnitude surveys

445100 445200 445300 445400 445500 445600 445700 445800

243700 243600 243500 243400 243300

Area 1

Area 2

Hardwickhill House

M.S

Banbury 2

B. M. 395·3

B. P

390

MSSP522 - Hardwick Hill Cemetery Extension
Figure 6 - Magnetic Interpretation Over Historic Maps
1:2,000 @ A3

Contains historic maps: Ordnance Survey, 6" 2nd edition c. 1882-1913 © National Library of Scotland

- Archaeology Possible (Strong)
- Archaeology Possible (Weak)
- Agricultural (Strong)
- Natural (Weak)
- Natural (Spread)
- Magnetic Disturbance
- Ferrous/Debris (Spread)
- Undetermined (Strong)
- Undetermined (Weak)
- Agricultural (Trend)
- Ridge and Furrow (Trend)
- Drainage Feature
- Ferrous (Spike)

N

0 50 100 150 m

magnitude surveys

445300
445400
445500
445600
243500
243400
Area 1
Area 2
A423
Bourton Road
Hardwick Hill House
Bourton Road

MSSP522 - Hardwick Hill Cemetery Extension
Figure 7 - XY Trace Plot
1:1,000 @ A3

N
0
25
50
75 m

magnitude surveys