



**magnitude
surveys**

**Geophysical Survey Report
Station Road, Market Bosworth**

**For
RPS**

**On Behalf Of
Richborough Estates**

Magnitude Surveys Ref: MSSK719

HER Event Number: To be issued after submission of report to HER

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of a c. 4ha area of land at Station Road, Market Bosworth, Leicestershire. A fluxgate gradiometer survey was successfully completed across the survey area. The survey has identified ridge and furrow cultivation, which was not extant at the time of survey, and anomalies indicative of ceramic field drains. Anomalies of undetermined origin have also been detected; these are of uncertain date and origin. The impact of modern activity on the results includes magnetic disturbance from fencing at field edges, ferrous debris, and from buried services which have been identified across the site. No anomalies indicative of significant archaeological activity have been identified.

Contents

Abstract.....	2
List of Figures	4
1. Introduction	5
2. Quality Assurance	5
3. Objectives.....	5
4. Geographic Background.....	6
5. Archaeological Background.....	6
6. Methodology.....	7
6.1. Data Collection.....	7
6.2. Data Processing.....	8
6.3. Data Visualisation and Interpretation.....	8
7. Results.....	9
7.1. Qualification.....	9
7.2. Discussion.....	9
7.3. Interpretation.....	10
7.3.1. General Statements	10
7.3.2. Magnetic Results - Specific Anomalies.....	10
8. Conclusions	12
9. Archiving	12
10. Copyright.....	12
11. References	13
12. Project Metadata	14
13. Document History	14

List of Figures

Figure 1:	Site Location	1:25,000 @ A4
Figure 2:	Location of Survey Areas	1:2,000 @ A3
Figure 3:	Magnetic Gradient	1:1,000 @ A3
Figure 4:	Magnetic Interpretation	1:1,000 @ A3
Figure 5:	Magnetic Interpretation Over Satellite Imagery and Historic Maps	1:2,000 @ A3
Figure 6:	XY Trace Plot	1:1,000 @ A3



1. Introduction

- 1.1. Magnitude Surveys Ltd (MS) was commissioned by RPS on behalf of Richborough Estates to undertake a geophysical survey on a c. 4ha area of land off Station Road, Market Bosworth (SK 39584 03227).
- 1.2. The geophysical survey comprised hand-pulled, cart-mounted GNSS-positioned fluxgate gradiometer survey. Magnetic survey is the standard primary geophysical method for archaeological applications in the UK for its ability to detect a range of different features. The technique is particularly suited for detecting fired or magnetically enhanced features, such as ditches, pits, kilns, sunken earth houses, and industrial activity (David *et al.*, 2008).
- 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. The survey was conducted in line with a WSI produced by MS (2020).
- 1.5. The survey commenced on 30 July 2020 and was completed the following day.

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. The directors of MS are involved in the cutting edge of research and the development of guidance/policy. Specifically, Dr. Chrys Harris has a PhD in archaeological geophysics from the University of Bradford, is a Member of CIfA and is the Vice-Chair of the International Society for Archaeological Prospection (ISAP); Finnegan Pope-Carter has an MSc in archaeological geophysics and is a Fellow of the London Geological Society, as well as a member of GeoSIG (CIfA Geophysics Special Interest Group); Dr. Kayt Armstrong has a PhD in archaeological geophysics from Bournemouth University, is a Member of CIfA, the Editor of ISAP News, and is the UK Management Committee representative for the COST Action SAGA; Dr. Paul Johnson has a PhD in archaeology from the University of Southampton, has been a member of the ISAP Management Committee since 2015, and is currently the nominated representative for the EAA Archaeological Prospection Community to the board of the European Archaeological Association.
- 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 was to assess the subsurface archaeological potential of the survey area.

4. Geographic Background

4.1. The site is located c. 650m northwest of Market Bosworth (Figure 1). The survey area comprises three pasture fields. The survey area was bounded by Station Road to the south, further fields to the west, woodland to the east and the grounds of Kings Golf and Country club to the north, and the private road leading to the country club cut through the centre of the survey area aligned north-south (Figure 2).

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	Pasture field which sloped down from east to west.	Bounded to the north by a hedgerow and wire fencing, to the east by wire fencing and an access road beyond. Bounded to the south by wire fencing and trees, and to the west by wire fencing. The presence of trees on the east and south boundaries prevented small sections of survey A telegraph pole was located on the eastern boundary, with overhead cables running along the eastern boundary. A metal trough was located in the southwest corner of the area.
2	Pasture field which sloped down from east to west.	Bounded on all sides by wire fencing. A hedgerow was also present along the western half of the north boundary. A steep slope along the east and southeast boundaries prevented 0.04ha of survey. A metal trough was located in the southeast corner of the area.
3	Pasture field which sloped slightly down from east to west.	Bounded on all sides by wire fencing. Hedgerows and trees were present along the north, west and southwest boundaries. A pond was located central to the western boundary of the area. A wooden post located in centre-north of the area marked a manhole cover. A metal tank and trough were located in the northeast corner of the area next to the field entrance.

4.1. The underlying geology comprises mudstone of the Gunthorpe member. Superficial deposits recorded within the survey area are glaciofluvial deposits of sand and gravel in the east, and clay and silt of the Bosworth clay member in the west and centre (British Geological Survey, 2020).

4.2. The soils consist of slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils (Soilscapes, 2020).

5. Archaeological Background

5.1. The following summary is derived from a Leicestershire and Rutland HER data search within 1km of the centre of the survey area, provided by RPS:

- 5.2. The survey area is located c. 660m east of the late Anglo-Saxon to post-medieval settlement core of Market Bosworth (MLE2935). Findspots within Market Bosworth include a Viking spearhead (MLE8336), a medieval scabbard, and an undated mound earthwork (MLE8336). A previous assessment carried out on the western half of the survey area identified eroded ridge and furrow cultivation within the survey area itself, which was not extant at the time of survey, and in surrounding fields (ELE8722). North of the survey area, c. 135m, a possible medieval holloway (MLE9606) has been recorded associated with the ridge and furrow cultivation. The shrunken medieval village of Cotan (MLE2911) is located 710m south of the survey area, associated with this former village a further holloway, tofts, enclosures and a chapel have been identified.

6. Methodology

- 6.1. Magnetometer surveys are generally the most cost effective and suitable geophysical technique for the detection of archaeology in England. Therefore, a magnetometer survey should be the preferred geophysical technique unless its use is precluded by any specific survey objectives or the site environment. For this site, no factors precluded the recommendation of a standard magnetometer survey. Geophysical survey therefore comprised the magnetic method as described in the following section.

6.2. Data Collection

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

- 6.2.2. 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

- 6.2.3. The magnetic data were collected using MS' bespoke hand-pulled cart system.

- 6.2.3.1. 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.

- 6.2.3.2. 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.

- 6.2.3.3. 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.

6.3. Data Processing

6.3.1. 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.

6.4. Data Visualisation and Interpretation

6.4.1. 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. 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.

6.4.2. 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 (2020) was consulted as well, to compare the results with recent land usages.

6.4.3. 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 with satellite imagery and historic maps (Figure 6).

7.2.2. A fluxgate gradiometer survey was carried out over 4ha at Station Road, Market Bosworth, a small 0.04ha area could not be surveyed due to the steep slope between Areas 1 and 2. The survey has generally responded well to the environment of the survey area, although magnetic disturbance from modern activity is present at the edges of the survey areas, due to extant fencing, and along the route of services, including an extant manhole cover. The strong magnetic signals produced from the modern activity have caused several slight data artefacts along the line of data collection (see section 7.3.2.7). The presence of the modern activity has not impacted the identification of other, more weakly enhanced anomalies across the site, including those interpreted as agricultural and undetermined origin. Although two anomalies were ascribed an 'Undetermined origin', no anomalies indicative of significant archaeological activity were identified.

7.2.3. Agricultural activity has been identified in the form of ridge and furrow cultivation (Figure 4), expanding on the recorded ridge and furrow previously recorded within the west of the survey area (see section 5.2). Recent satellite images (Google Earth, 2020) show cropmark variations in-line with the agricultural anomalies identified by the survey, however, these ridge and furrow earthworks were not extant at the time of survey. Drains have been recorded across Areas 2 and 3, some of which occur within the ridge and furrow regime, suggesting the reutilisation of the cultivation furrows. This suggests an historic agricultural usage of the site, likely dating from the medieval settlement at Market Bosworth. Abutting the boundary between Areas 1 and 2, magnetic disturbance from the nearby service and fence-lines have made the interpretation of two linear anomalies difficult, it is possible these relate to the shifting position of the extant field boundary.

7.2.4. Anomalies classified as 'Undetermined' have been identified, none of which share an alignment with the known holloway (see section 5.2) that runs to the north of the survey area. The undetermined anomalies have no corroborative evidence to suggest a modern or historic origin and may be earlier or natural in origin.

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. **Agricultural** – Two closely spaced, linear anomalies have been identified located abutting the boundary between Areas 1 and 2, [2a] (Figure 4). The presence of wire fencing and a buried service close to these anomalies have produced high levels of magnetic disturbance surrounding them. Due to this magnetic disturbance the interpretation of these anomalies is tentative; however, it is possible the anomalies may indicate the boundary between Areas 1 and 2 once extended further south and has since shifted to its current location to the east.
- 7.3.2.2. **Ridge and Furrow (Trend)** – A series of curvilinear anomalies have been identified across the survey area but are particularly enhanced within Area 1 (Figure 3). The curvilinear form of these anomalies and the relatively wide spacing, between 5m-8m in separation, is typical of ridge and furrow cultivation (Figure 4), which has been previously identified within Area 3 (see section 5.2). Areas 2 and 3 contain similar but less magnetically enhanced linear anomalies, with spacing between 6m-14m. The ridge and furrow in Areas 2 and 3 may have been subjected to more intensive subsequent ploughing being situated on a gentler section of slope, which could explain the differences in the magnetic between the anomalies in these areas. Localised variations in the magnetic properties of the soil and geology could also explain the varying magnetic signature of ridge and furrow cultivation across the site.

- 7.3.2.3. **Drainage Feature** – A series of weakly dipolar, linear anomalies have been identified within Area 2 and 3 (Figure 3). This type of magnetic signal is typical of ceramic field drains. Within Area 3 at least three field drains have been identified following the alignment of ridge and furrow cultivation furrows which suggests reuse and adaption of these agricultural features. A drainage feature has been identified leading to the pond in the west of Area 3, this is visible as a cropmark on satellite imagery from the year 2000 (Google Earth, 2020).
- 7.3.2.4. **Service** – Linear anomalies with dipolar magnetic signals which cast a broad magnetic halo have been detected in all three survey areas (Figure 3). These anomalies are typical of buried service features. A linear anomaly identified within Area 3, [3a], has a strong positively enhanced magnetic signal to the south and a significantly weaker magnetic signature to the north (Figure 3). [3a] leads directly to the location of a manhole cover which was noted at the time of survey (see section 4.2). The presence of a manhole cover at [3a] suggests this is a pipe with an inspection chamber, and the change in magnetic signal is likely due a change in material of the pipe.
- 7.3.2.5. **Undetermined** – Anomalies classified as “Undetermined” within Areas 1 have weak, positive magnetic signals [1a] (Figure 4). there is no corroborative evidence to suggest an agricultural or archaeological origin for either feature: as they do not correspond with any mapped features on available historic maps (Figure 5), nor form identifiable archaeological shapes or patterns. [1a] is not parallel with any modern or historically mapped features which could suggest an earlier origin.
- 7.3.2.6. **Ferrous/Debris (Spread)** – Areas containing high concentrations of dipolar anomalies have been detected central to the north and south boundaries of Area 2 (Figure 4). These areas correspond with the locations of former gateways visible on satellite imagery dating from 1999-2000 (Google Earth, 2020). It is likely that material was added in order to strengthen the ground in these former gateways.
- 7.3.2.7. **Data Artefact** – Several data artefacts are visible within the dataset as minor “streaking” following the line of data collection. Data artefacts usually occur in conjunction with anomalies with strong magnetic signals due to how the sensors respond to very strong point sources. While these artefacts can be reduced in post-processing, this would risk removing real features. Therefore, these artefacts have been left in but indicated where appropriate.

8. Conclusions

- 8.1. A fluxgate gradiometer survey has been undertaken across the majority of the survey area, with small gaps in the data being due to the presence of a particularly steep slope between Areas 1 and 2. The survey has generally responded well to the environment of the site despite the presence of strong magnetic anomalies causing several small data artefacts throughout the dataset, which have been highlighted in the interpretation plots. These strong magnetic anomalies relate to the modern activity present on the site in the form of service lines and magnetic disturbance from fencing at field edges. Areas containing ferrous debris are present in the location of former gateways which is suggestive of ground reinforcement.
- 8.2. The level of modern activity on the site has not prevented the detection of a range of other anthropogenic activity, including historic and more recent agricultural activity. In addition, anomalies of undetermined origin have been interpreted where a specific origin or date is uncertain. The anomalies ascribed an 'Undetermined' classification lack any distinctive archaeological shape or pattern; as such, no anomalies indicative of significant archaeological activity have been identified.
- 8.3. Evidence of ridge and furrow cultivation across the site and the adaption of some of these into more recent drainage features indicates the prolonged agricultural use of the site. It is likely the site formed part of the agricultural hinterland of the medieval town of Market Bosworth.

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.

11. References

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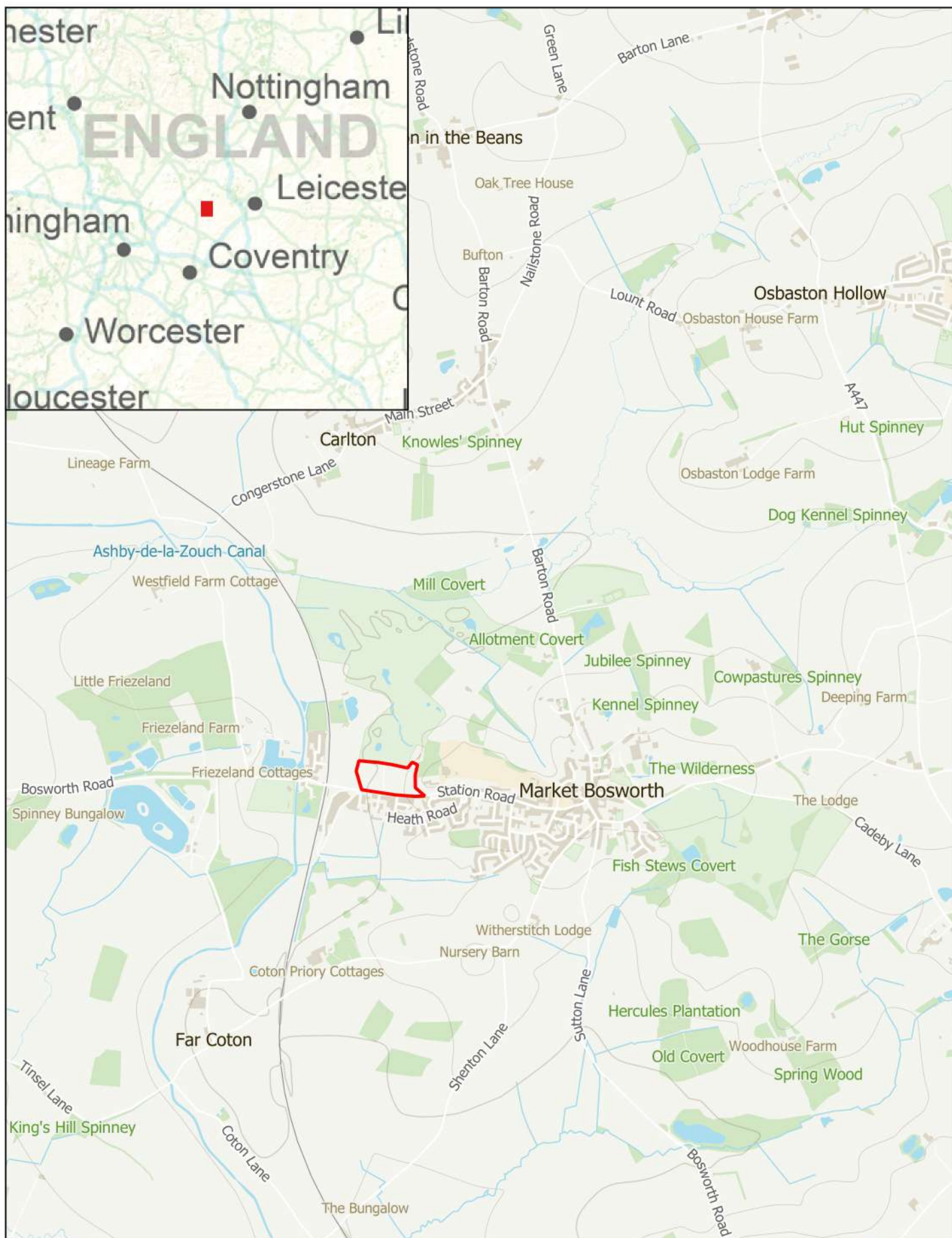
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12. Project Metadata

MS Job Code	MSSK719
Project Name	Station Road, Market Bosworth
Client	RPS
Grid Reference	SK 39584 03227
Survey Techniques	Magnetometry
Survey Size (ha)	4ha
Survey Dates	2020-07-30 to 2020-07-31
Project Lead	Leanne Swinbank BA ACIfA
Project Officer	N/A
HER Event No	To be issued on submission of report to HER
OASIS No	N/A
S42 Licence No	N/A
Report Version	1.0

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Lead to Review	LS	JC	06 August 2020
0.2	Draft following corrections. Sent for director approval.	LS	CH	06 August 2020
0.3	Draft following director corrections.	LS	CH	10 August 2020
1.0	Final version following client corrections. Approved by director.	LS	CH	13 August 2020



MSSK719 - Station Road, Market Bosworth

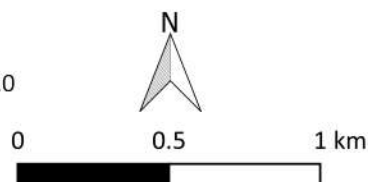
Figure 1 - Site Location

1:25,000 @ A4

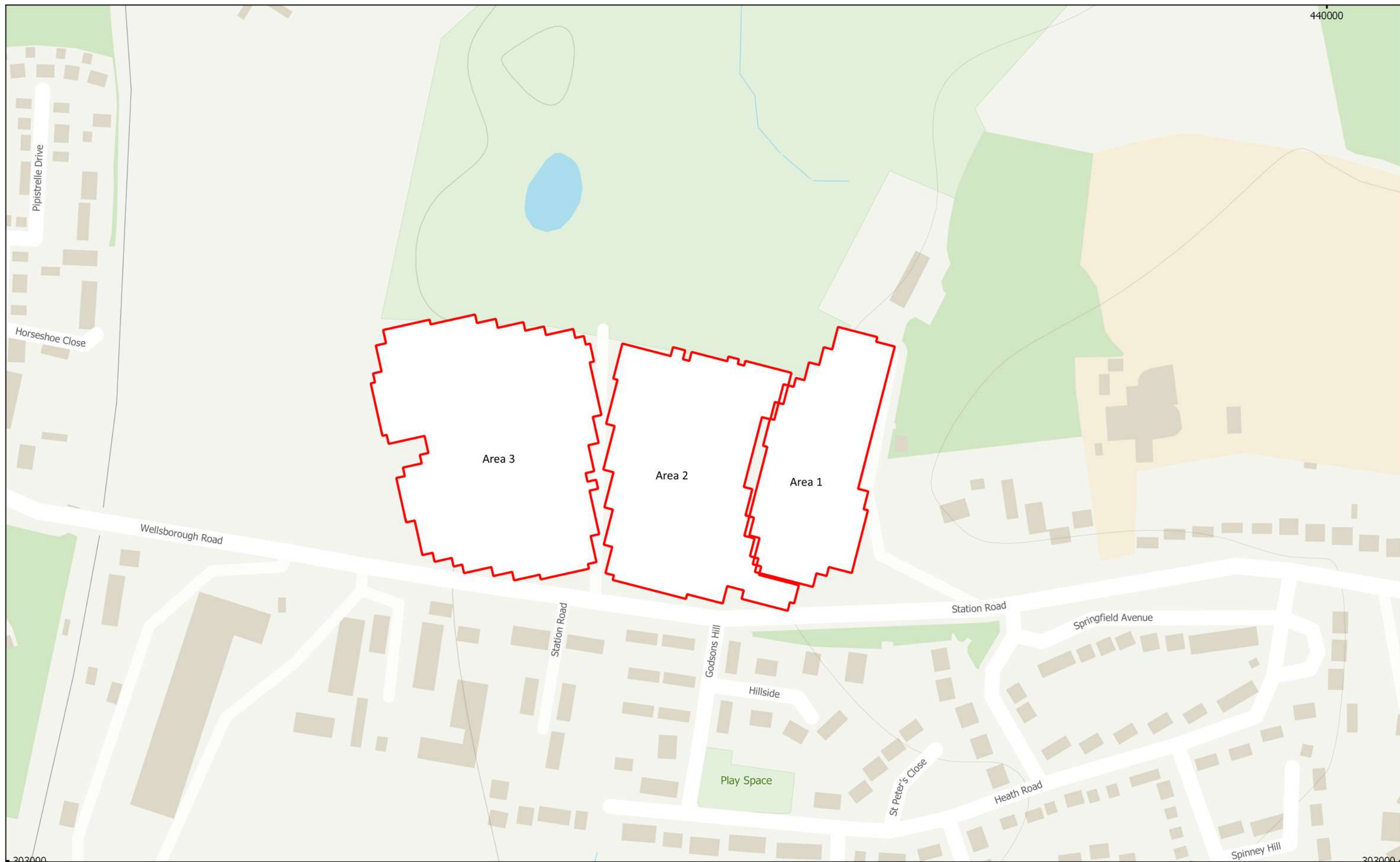
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 Site Location

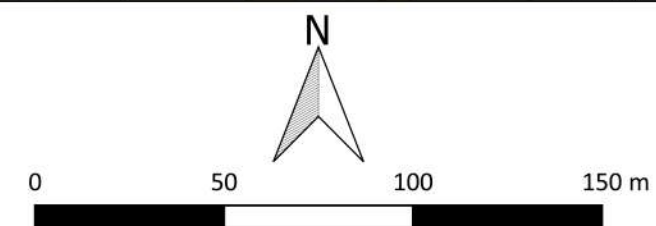


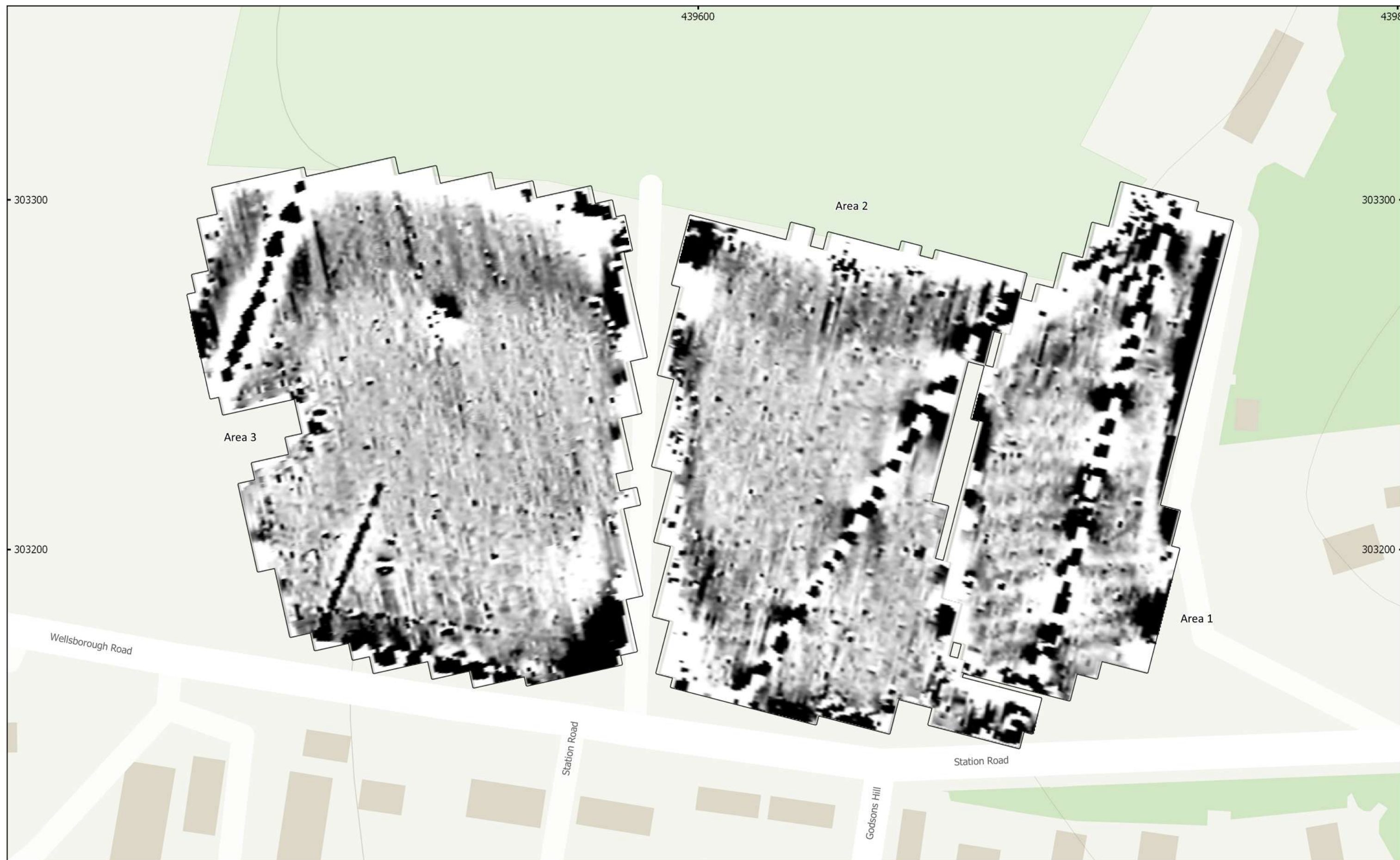
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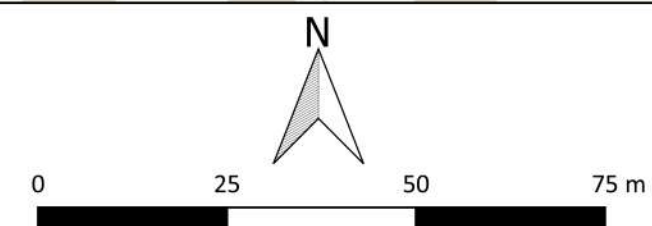
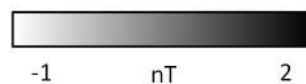
MSSK719 - Station Road, Market Bosworth
Figure 2 - Location of Survey Areas
1:2,000 @ A3
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 Survey Extents





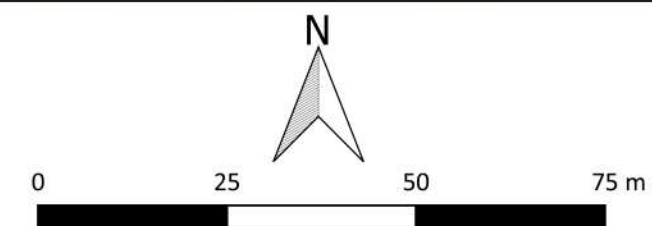
MSSK719 - Station Road, Market Bosworth
Figure 3 - Magnetic Gradient
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MSSK719 - Station Road, Market Bosworth
 Figure 4 - Magnetic Interpretation
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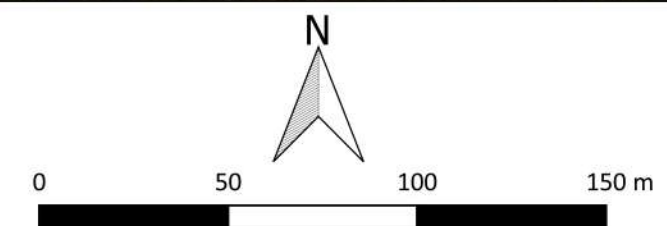
- | | | |
|-------------------------|----------------------|--------------------------|
| Agricultural (Strong) | Undetermined (Weak) | Ridge and Furrow (Trend) |
| Agricultural (Weak) | Undetermined (Trend) | Drainage Feature |
| Magnetic Disturbance | Data Artefact | Ferrous (Spike) |
| Ferrous/Debris (Spread) | Service | |





MSSK719 - Station Road, Market Bosworth
 Figure 5 - Magnetic Interpretation Over Satellite Imagery and Historic Maps
 1:2,000 @ A3
 Copyright Magnitude Surveys Ltd 2020
 Contains historic maps: Ordnance Survey, 6" 2nd Edition c. 1882-1913 ©
 National Library of Scotland
 Contains Satellite Imagery © Bing 2020

- | | | |
|-------------------------|----------------------|--------------------------|
| Agricultural (Strong) | Undetermined (Weak) | Ridge and Furrow (Trend) |
| Agricultural (Weak) | Undetermined (Trend) | Drainage Feature |
| Magnetic Disturbance | Data Artefact | Ferrous (Spike) |
| Ferrous/Debris (Spread) | Service | |





MSSK719 - Station Road, Market Bosworth
Figure 6 - XY Trace Plot
20nT at 1:1,000 @ A3
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