Geophysical Survey Report

Flixton Quarry Extension, Buck Land

For

Cotswold Archaeology Suffolk

On Behalf Of

Breedon Group

Magnitude Surveys Ref: MSTM862

HER Event Number: FLN 122

Parish Code: FLN 112

OASIS ID: magnitud1-415084

February 2021

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Issue Date:

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Abstract

Magnitude Surveys Ltd was commissioned to assess the subsurface archaeological potential of a c. 17.9ha area of land near Flixton, Suffolk. A fluxgate gradiometer survey was successfully completed across the majority of the survey area. The geophysical survey has primarily detected anomalies relating to agricultural practices, including drainage, cultivation, and both mapped and unmapped field boundaries. Variations within the background of the survey area relate to the near surface geology, which have in turn complicated a more confident interpretation of features and possibly obscured their full extent. Sources of interference relate to boundary features along the perimeter of the survey area as well as a modern service.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by Cotswold Archaeology Suffolk on behalf of Breedon Group to undertake a geophysical survey over a c. 17.9ha area of land near Flixton, Suffolk (TM 31517 87641).

1.2. The geophysical survey comprised of a quad-towed and hand-carried GNSS-positioned fluxgate gradiometer survey. Magnetic survey is the standard primary geophysical method for archaeological applications in the UK due to 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 featured buildings (SFBs) 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, 2020) and the European Archaeological Council (Schmidt *et al.,* 2015).

1.4. It was conducted in line with a WSI produced by MS (Swinbank, L. 2021).

1.5. The survey commenced on 02/02/2021 and took two days 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 for Archaeological Prospection).

2.2. The directors of MS are involved in cutting edge 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, field and office staff have degree qualifications relevant to archaeology or geophysics 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 survey area was located c. 450m northeast of Flixton, Suffolk (Figure 1). Gradiometer survey was undertaken across three arable fields and a pasture field. The survey area was bounded by fields of pasture to the north and east. The B1062 to the south and housing to the west (Figure 2). An area of c. 0.4ha of land has not been surveyed due to waterlogged ground conditions and the presence of a pond and manure pile.

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	The area consisted of flat, wet, arable land containing maize stubble.	The northern edge of the survey area was bounded by a stream, a dirt track to the east, a fence, hedges, and trees to the south, and a fence to the west. The plough direction ran in a north to south orientation
2	The area consisted of flat, wet, arable land containing maize stubble.	The northern, eastern and southern edges were bounded by a fence, trees, and hedges. A dirt track provided the boundary to the west. The plough direction ran in an east to west orientation. A borehole was located towards the northeastern corner.
3	The area consisted of flat, wet, grassland - pasture.	The northern and eastern edges were bounded by a stream. Hedges and trees bounded the area to the south, and a stream and hedges provided the boundary to the west. Two areas of flooded ground, with variable depth, were located within the west of the area.
4	The area consisted of flat, wet, arable land containing barley with areas of grass to the north.	The area was mostly bounded by a grass verge to the north which partially continued beyond the survey area, a stream to the northeast, a fence to the east, a grass verge to the south, a fence to the southwest, and trees and hedges to the west. The plough direction ran in an east to west orientation. A pond was located to the north, a borehole to the east and to the west, a manure pile and rough, un-even track.

4.3. The underlying geology comprises of sand of the Crag Group. The superficial deposits mostly consist of River Terrace Deposits of sand and gravel. These deposits are present across the majority of Areas 1 and 4. A large band of Head clay, silt, sand, and gravel is present to the south and southeast of the survey area. Peat of the Braydon Formation is located to the northeast of Areas 1 and 3. Sand of the Happisburgh Glacigenic Formation is located in the southwest corner of Area 4 (British Geological Survey, 2021).

4.4. The soils mainly consist of lime-rich loamy and clayey soils with impeded drainage. A small area to the northeast consists of fen peat soils (Soilscapes, 2021).

5. Archaeological Background

5.1. Awaiting background information (DBA or other) from client.

6. Methodology

6.1. Data Collection

6.1.1. 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.

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

6.1.3. 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

6.1.4. The magnetic data were collected using MS' bespoke quad-towed and hand-carried GNSS-positioned system].

6.1.4.1. MS' [cart and hand-carried] 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.

6.1.4.2. 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.

6.1.4.3. 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.

6.2. Data Processing

6.2.1.1. Magnetic data were processed in bespoke in-house software produced by MS. Processing steps conform to the EAC and Historic England guidelines for 'minimally enhanced data' (see Section 3.8 in Schmidt *et al.*, 2015: 33 and Section IV.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, as well as the total field data from the lower sensors. 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 of the gradient and total field at different plotting ranges have been used for data interpretation. Greyscale images should be viewed alongside the XY trace plot (Figures 7 & 10). XY trace plots visualise the magnitude and form of the geophysical response, aiding 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, historical maps, LiDAR data, and soil and geology maps. Google Earth (2021) was also consulted, to compare the results with recent land use.

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 from further work, in order to constantly improve our knowledge and service.

7.2. Discussion

7.2.1. The geophysical results are presented in combination with satellite and historical maps (Figure 4).

7.2.2. The geophysical survey was successfully completed across the majority of the survey area, with waterlogging, manure heaps, and an extant pond precluding survey in certain areas. The survey has produced a varied magnetic background, largely resulting from changes in the near-surface natural stratification and saturation. These variations in material have, in places, created a speckled background to the data, complicating any interpretation of features identified. The wet ground conditions have also produced a data artefact, where a small section of survey was prevented, and the image has interpolated across the small gap. Modern interference is limited to ferrous anomalies along extant field boundaries and the road along the southern perimeter.

7.2.3. The geophysical survey has identified numerous mapped and un-mapped field boundaries (Figure 4). The removal of boundaries across mapping sources is suggestive of multiple phases of field layout and agricultural practice. Given the location of the survey area adjacent to mapped watercourses, it is possible some of these boundaries were formerly canalised ditches and have since been backfilled with a more enhanced material. Ploughing trends and a network of drains have also been identified within the survey area. Superficial deposits of natural material have formed both, bands and more diffuse zones of background enhancement across the survey area, possibly relating to localised, seasonal flooding within the site (see section 4.3). Undetermined anomalies are considered to be anthropogenic, given their form and general orientation within the landscape; however, given their similarities with other nearby natural variations, and location within an area of Peat (see section 4.3) a geological origin is also possible.

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. **Data Artefact** – Data artefacts usually occur in conjunction with anomalies with strong magnetic signals due to the way in which the sensors respond to very strong point sources. They are usually visible as minor 'streaking' following the line of data collection. While these artefacts can be reduced in post-processing through data filtering, this would risk removing 'real' anomalies. These artefacts are therefore indicated as necessary in order to preserve the data as 'minimally processed'.

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

7.3.1.4. **Ferrous/Debris (Spread)** – A ferrous/debris spread refers to a concentration of multiple discrete, dipolar anomalies usually resulting from highly magnetic material such as rubble containing ceramic building materials and ferrous rubbish.

7.3.1.5. **Magnetic Disturbance** – The strong anomalies produced by extant metallic structures, typically including fencing, pylons, vehicles and service pipes, have been classified as 'Magnetic Disturbance'. These magnetic 'haloes' will obscure weaker anomalies relating to nearby features, should they be present, often over a greater footprint than the structure causing them.

7.3.1.6. **Undetermined** – Anomalies are classified as Undetermined when the origin of the geophysical anomaly is ambiguous and there is no supporting contextual evidence to justify 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 distinct from those caused by ferrous sources.

7.3.2. Magnetic Results - Specific Anomalies

7.3.2.1. **Agricultural (Strong, Weak and Zone)** - In the middle of Area 3 and in the centre-east of Area 4, anomalies that correspond to mapped historical field boundaries have been detected. The anomaly in Area 3 [**3b**] has a stronger magnetic signal than [**4a**] indicating that [**3b**] may have been in-filled with relatively more-enhanced material, contrasting the magnetic background (Figure 8). Other linear anomalies displaying a much weaker magnetic signal have been identified as running east-west within Area 1. These anomalies are most likely unmapped field boundaries that are at least older than the 2nd edition OS Maps Series. The anomaly [**4b**] is located in the centre of Area 4, orientated north-south and has a weak dipolar magnetic signal. The anomaly corresponds to a strip of land seen on 2nd edition OS Maps and other historic maps until the 1950's at the earliest (Figure 4).

Then between 1957 and 1970 the strip of land becomes a part of the larger field, forming a shape similar to the existing field system.

7.3.2.2. **Drains** – Within Areas 1, 3, & 4, several linear anomalies display magnetic characteristics, similar to that of field drains. Variations in the magnetic signatures between areas are likely to be a result of the changes in near surface geologies and saturation, which provide a contrasting background within each area. Drains noted in the east of the survey area appear much more positively enhanced than others noted further west. Given the nature of the superficial material in this area, the drains may be silted up (producing the enhancement). This interpretation is supported by the ground conditions noted at the time of survey, which identified this area to be waterlogged.

7.3.2.3. **Undetermined (Strong)** – In the west of Area 3 several, discrete positively enhanced anomalies have been detected (Figure 8). These anomalies are most probably anthropogenic in origin and potential interpretations include mineral extraction, or pits. However, a confident interpretation is difficult as there is insufficient contextual information to determine if they are related to archaeological activity, or more-recent agricultural practices.

8. Conclusions

8.1. A fluxgate gradiometer survey was successfully completed across the majority of the survey area. An area of c. 0.4ha of land has not been surveyed due to waterlogged ground conditions and the obstruction of a pond and a manure pile. The geophysical survey has detected anomalies of an agricultural and natural origin that reflect a change across time in the land management of the area. The underlying geology of clay, silt, sand, gravel and peat has produced a varied magnetic background which has impeded a more-confident interpretation of some anomalies. Magnetic disturbance related to modern activity is mostly located along the borders of the survey area and are a result of extant fences and a service.

8.2. Anomalies that correspond to mapped historic field boundaries have been detected across the survey area, along with some possible unmapped boundaries.

8.3. Bands of natural are present within the survey area along with more diffuse zones of natural as a result of the superficial deposits.

8.4. Anomalies of undetermined origins have been detected. These are most likely anthropogenic in origin however a confident classification cannot be made as it is impossible to ascertain if the anomalies are related to archaeological or agricultural practices.

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 any dictated time embargoes.

10. Copyright

11. References

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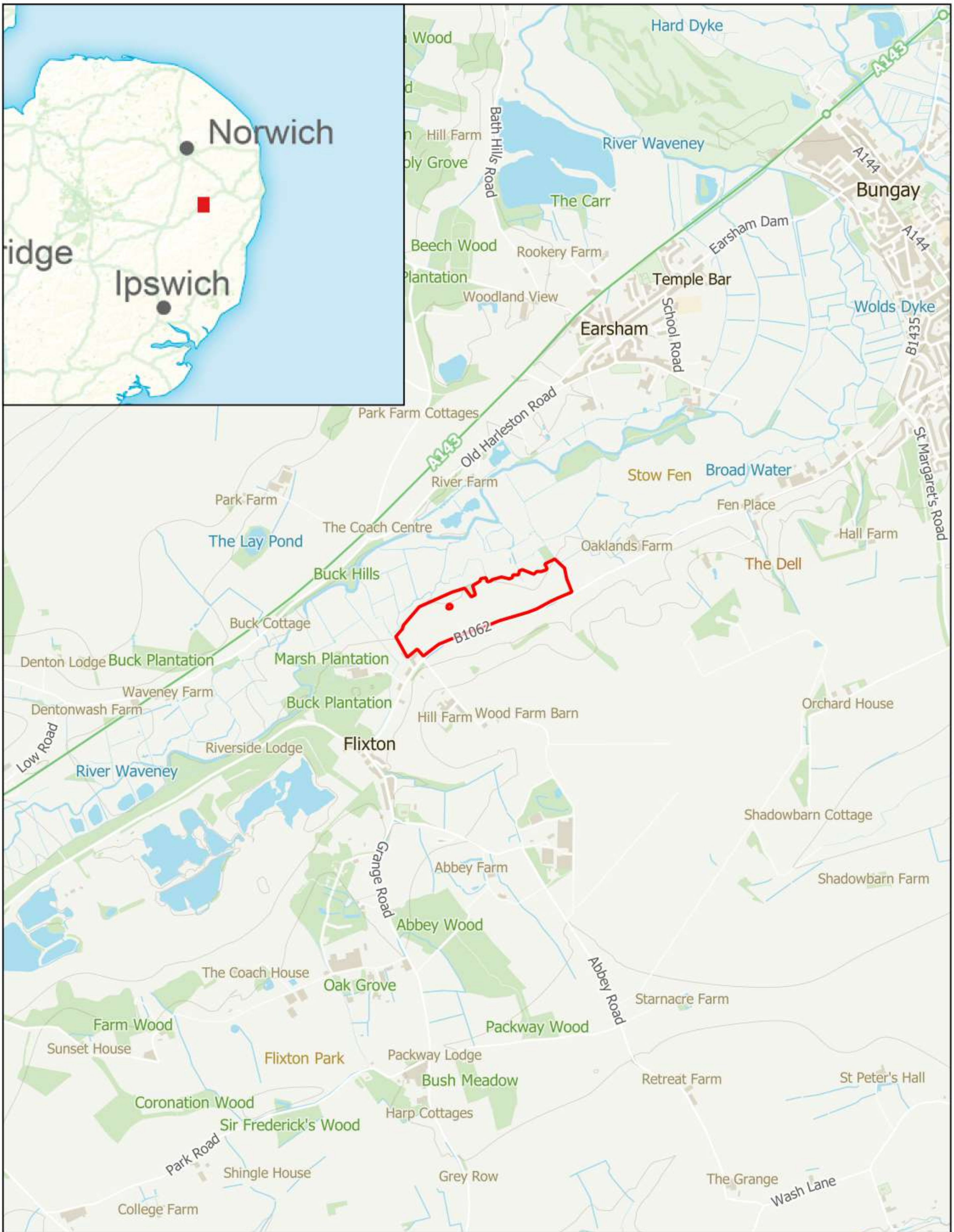
12. Project Metadata

MS Job Code	MSTM862
Project Name	Flixton Quarry Extension; Buck Land
Client	Cotswold Archaeology
Grid Reference	TM 3151 8764
Survey Techniques	Magnetometry
Survey Size (ha)	17.19ha (Magnetometry)
Survey Dates	2021-10-05 to 2021-10-15
Project Lead	Leanne Swinbank, BA ACIfA
Project Officer	Leanne Swinbank, BA ACIfA
HER Event No	FLN 112
OASIS No	magnitud1-415084
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	DW, CM	FS	05 February 2021
0.2	Draft following Project lead corrections.	DW, CM, FC	PSJ	08 February 2021
1.0	No client corrections. Adding WSI & OASIS summary as appendices. Issued as Final.	N/A	LS	10 February 2021



MSTM862 - Flixton Quarry Extension, Buckland
Figure 1 - Site Location
1:25,000 @ A4

N

0 0.5 1 km

Site Boundary

magnitude surveys

MSTM862 - Flixton Quarry Extension, Buckland
Figure 2 - Location of Survey Area's
1:5,000 @ A3

Survey Extent
Unsurveyable

N

0 100 200 300 m

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MSTM862 - Flixton Quarry Extension, Buckland
Figure 3 - Magnetic Total Field (Lower Sensor)
1:3,000 @ A3

magnitude surveys

MSTM862 - Flixton Quarry Extension, Buckland
Figure 4 - Magnetic Interpretation Over Satellite Imagery and Historical Maps (Overview)
1:3,000 @ A3

Agricultural (Strong)
Agricultural (Weak)
Agricultural (Spread)
Natural (Strong)
Natural (Weak)
Natural (Zone)
Magnetic Disturbance
Ferrous/Debris (Spread)
Undetermined (Strong)
Agricultural (Trend)
Ferrous (Trend)
Service
Drainage Feature

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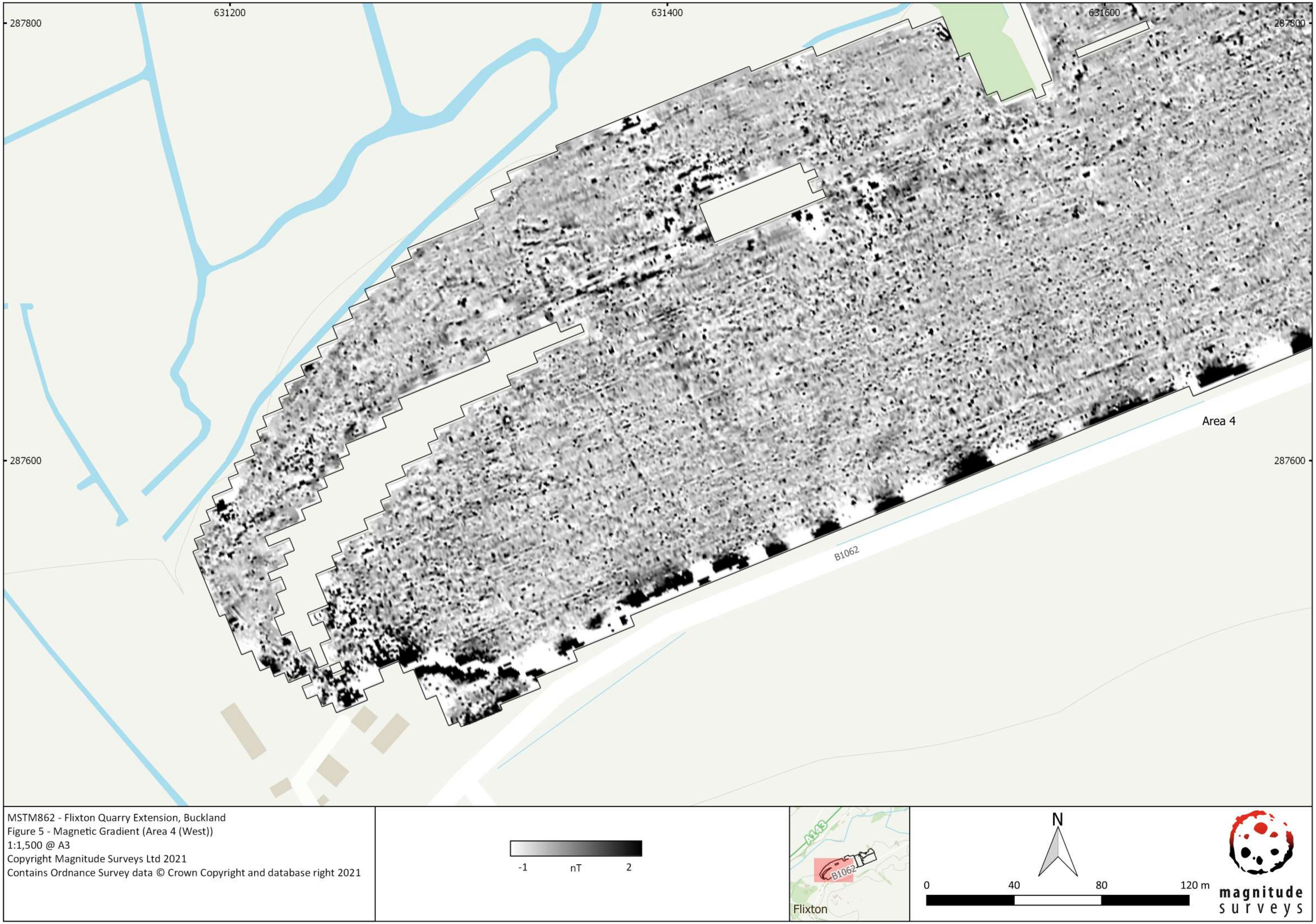
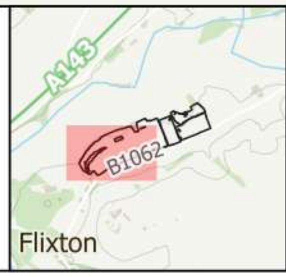


MSTM862 - Flixton Quarry Extension, Buckland
Figure 5 - Magnetic Gradient (Area 4 (West))
1:1,500 @ A3

MSTM862 - Flixton Quarry Extension, Buckland
Figure 6 - Magnetic Interpretation (Area 4 (West))
1:1,500 @ A3

Agricultural (Strong)
Agricultural (Weak)
Agricultural (Spread)
Natural (Strong)
Natural (Weak)
Natural (Zone)
Magnetic Disturbance
Ferrous/Debris (Spread)
Agricultural (Trend)
Data Artefact
Service
Drainage Feature
Ferrous (Spike)



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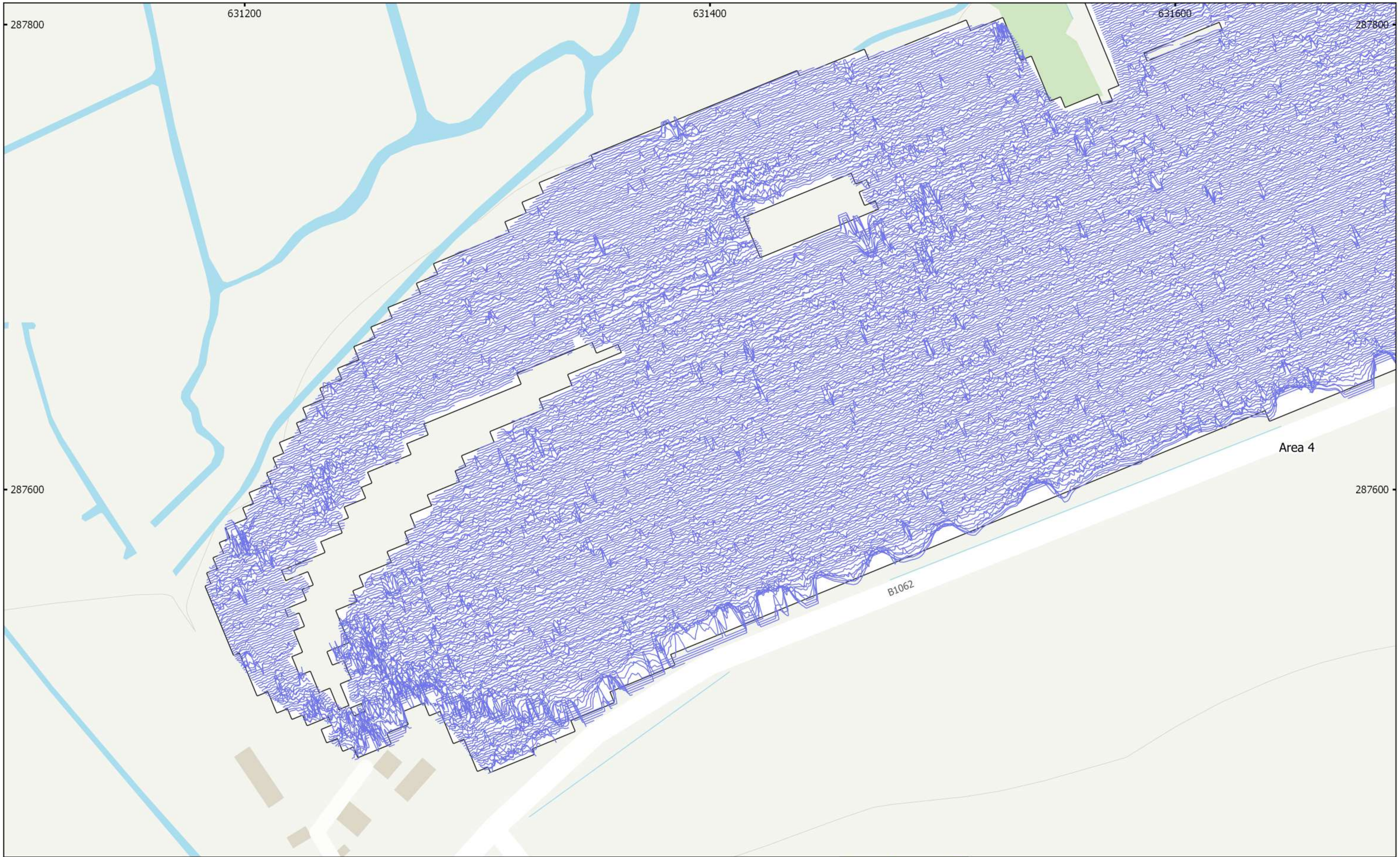
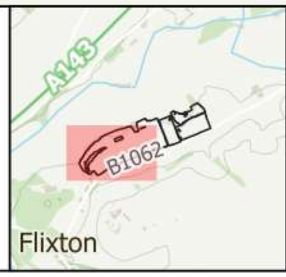
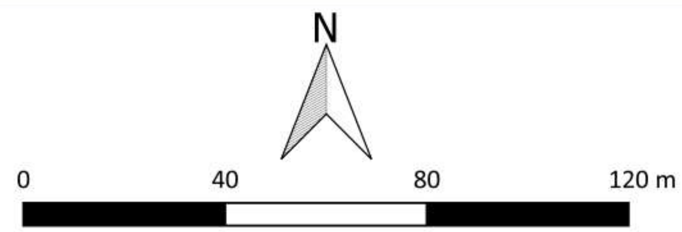
magnitude surveys



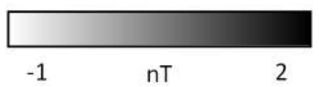


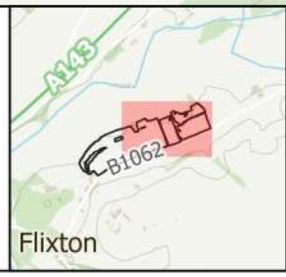


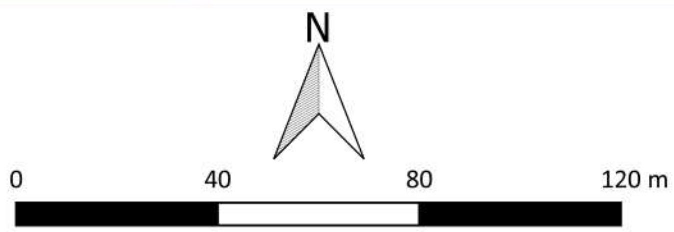
MSTM862 - Flixton Quarry Extension, Buckland
Figure 7 - XY Trace Plot (Area 4 (West))
30nT/cm at 1:1,500 @ A3

magnitude surveys

MSTM862 - Flixton Quarry Extension, Buckland
Figure 8 - Magnetic Gradient (Areas 1, 2, 3 & 4 (East))
1:1,500 @ A3







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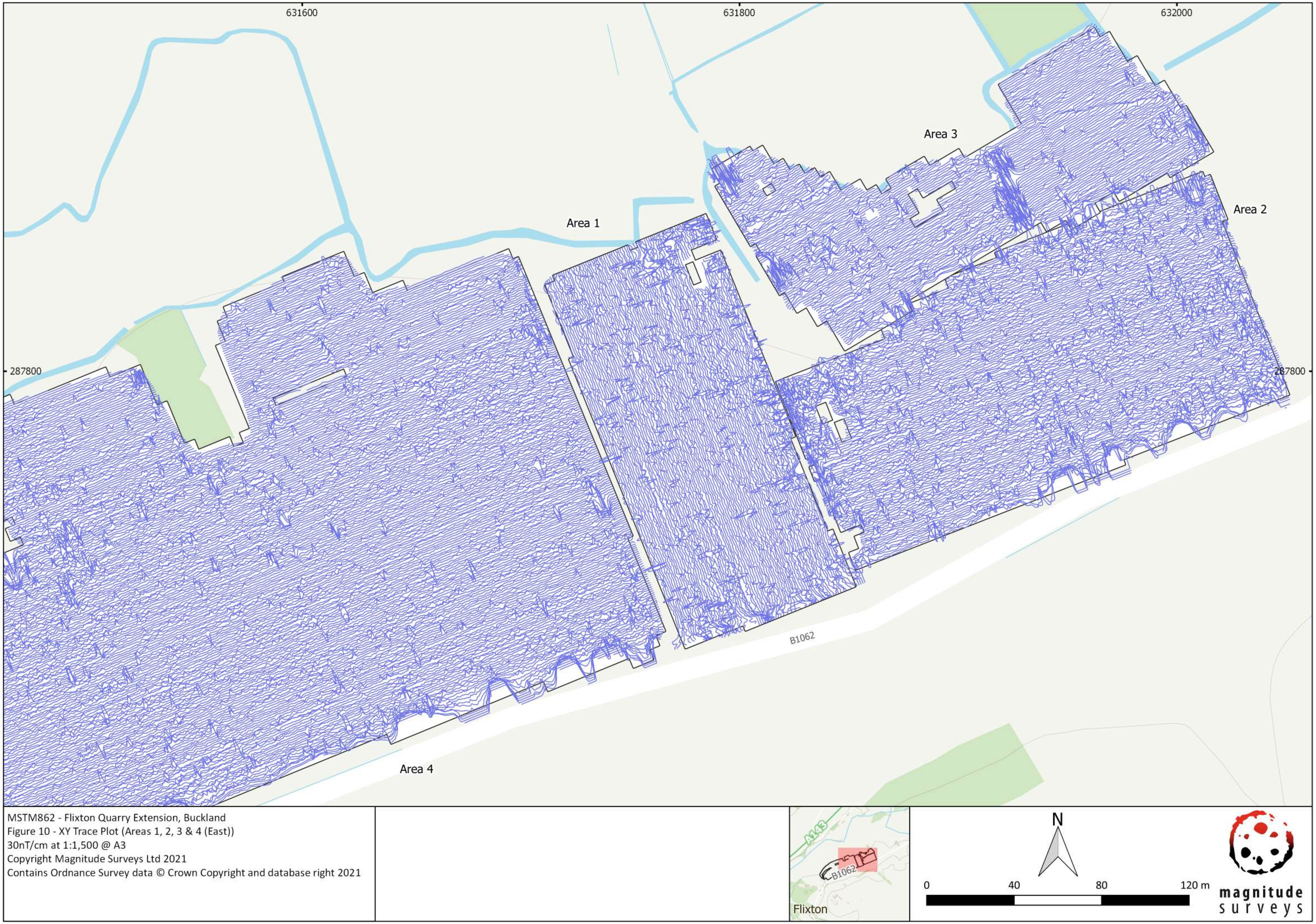
MSTM862 - Flixton Quarry Extension, Buckland

Figure 9 - Magnetic Interpretation (Areas 1, 2, 3 & 4 (East))

1:1,500 @ A3

magnitude surveys



MSTM862 - Flixton Quarry Extension, Buckland
Figure 10 - XY Trace Plot (Areas 1, 2, 3 & 4 (East))
30nT/cm at 1:1,500 @ A3

magnitude surveys

Written Scheme of Investigation

For a Geophysical Survey

of

Flixton Quarry, Suffolk

For

Cotswold Archaeology

Magnitude Surveys Ref: MSTM862

Parish Code: FLN 112

January 2021

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Version	Purpose/Revision	Author	Figures	Approved By	Date Issued
1.0	WSI to client	Leanne Swinbank BA ACIfA	Leanne Swinbank BA ACIfA	Leanne Swinbank BA ACIfA	14 January 2021
2.0	Additions as requested by SCCAS	Leanne Swinbank BA ACIfA	N/A	Leanne Swinbank BA ACIfA	19 January 2021

Print Name:	Signature:	Role:	Date:

Contents

1. Introduction

1.1. This document details a Written Scheme of Investigation for a geophysical survey by Magnitude Surveys Ltd (MS) for Cotswold Archaeology. The survey comprises a c. 17.19ha area of land at Flixton Quarry, Suffolk (TM 31517 87641).

1.2. The geophysical survey will comprise hand-pulled/quad-towed, cart-mounted or hand-carried 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 to detecting fired or magnetically enhanced features, such as ditches, pits, kilns, sunken featured buildings (SFBs) and industrial activity (David *et al*., 2008).

1.3. The survey will be conducted in line with the current best practice guidelines produced by Historic England (David *et al*., 2008), the Chartered Institute for Archaeologists (CIfA, 2014), the European Archaeological Council (Schmidt *et al*., 2015) and the SCCAS geophysical survey standard requirements document (SCCAS, 2020).

2. Objective

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

3. Quality Assurance

3.1. Project management, survey work, data processing and report production will be carried out by qualified and professional geophysicists to standards exceeding the current best practice (CIfA, 2014; David *et al*., 2008; Schmidt *et al*., 2015). All MS managers, field and office staff have degree qualifications relevant to archaeology or geophysics and/or field experience.

3.2. 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 for Archaeological Prospection).

3.3. The directors of MS are involved in cutting edge 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.

3.4. MS has developed a bespoke geophysical system whereby data is live-streamed from the field back to the office while fieldwork is ongoing. This allows for data to be regularly monitored not only in the field, but by managers in a controlled office environment. Coverage gaps or small errors within the data can be quickly identified and rectified, improving quality control of field survey. The live data streaming allows MS to provide processed data to the client at regular intervals, allowing all parties to be informed of the field survey's progress. Should it become apparent that the survey is being compromised by local conditions, such as the spreading of green waste, this will be reported back to the client and a mitigation strategy can be devised if necessary.

4. Risk Assessment

4.1. MS has a Risk Assessment and Method Statement (RAMS) for survey that can be produced on request, and will be updated to reflect any site conditions we are pre-notified of. Before geophysical survey will commence, a brief walkover will be undertaken to identify any additional hazards of an unusual or site-specific nature. If any additional hazards are identified, an additional site-specific risk assessment will be updated to include these hazards and all surveyors will be informed of the risk. If appropriate mitigation factors cannot be put in place, then the field or part thereof will not be surveyed.

4.2. Field staff will attend a site induction if required. Necessary PPE will be supplied and worn. Wet and cold/hot weather protection is also supplied.

4.3. All surveyors have been issued company mobile phones. Survey teams are expected to make regular contact with the office to keep all parties updated with survey progress. Any change in conditions that may affect the health and safety of the survey team must be reported immediately.

4.4. The survey van contains suitable welfare facilities. Antiseptic hand gel is provided, as is bottled drinking water. A first aid kit is stored in the cab of the van, with a second kit near personnel within the survey area.

4.5. The nearest NHS urgent care centre is at Norfolk and Norwich University Hospital, Colney Lane, Norwich, NR4 7UY. Should toilets be unavailable on site, the nearest public accessible toilet is located at East of England Supermarket Car Park, Bullock Fair Close, Harleston, IP20 9AT.

5. Methodology

5.1. Data Collection

5.1.1. 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.

5.1.2. For this reason, geophysical survey will comprise the magnetic method as described in the following table.

5.1.3. Table of survey strategies:

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

5.1.4. MS employs a modular cart system, which can easily be configured to be towed by quad, pulled by hand, or carried depending on what is most suitable for the site configuration and conditions. The system can be hand-carried so that survey can be undertaken should conditions preclude survey with the wheels. The hand carried system retains all of the advantages of a cart system because it is still GNSS positioned and the sensors are maintained at a consistent height.

5.1.5. Magnetic data will be collected using MS' bespoke, hand-pulled/quad-towed cart system or hand-carried GNSS-positioned system. MS' cart or hand-carried system will be comprised of Bartington Instruments Grad 13 Digital Three-Axis Gradiometers. Positional referencing will be 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.

5.1.6. Magnetic and GPS data will be stored on an SD card within MS' bespoke datalogger. The datalogger is continuously synced, via an in-field Wi-Fi unit, to servers within MS' offices. This allows data collection, processing and visualisation to be monitored in real-time as fieldwork is ongoing (see Section 3.4).

5.1.7. A navigation system integrated with the RTK GPS will be used to guide the surveyor, whether the system is being quad towed, hand pulled or carried. Where possible, allowing for terrain, crops and obstacles, data will be collected by traversing the survey area along the longest possible lines, ensuring efficient collection and processing.

5.2. Data Processing

5.2.1. Magnetic data will be processed in bespoke in-house software produced by MS. Processing steps conform to the EAC and Historic England guidelines for 'minimally enhanced data' (see Section 3.8 in Schmidt *et al.*, 2015: 33 and Section IV.2 in David *et al.*, 2008: 11). Data plots contained within the report also conform to these guidelines.

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

Zero Median Traverse – The median of each sensor traverse will be 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 will be 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 will be interpolated using a bicubic algorithm to increase the pixel density between sensor traverses. This produces images with square pixels for ease of visualisation.

5.3. Data Visualisation and Interpretation

5.3.1. The report will present the gradient of the sensors' total field data as greyscale images, as well as the total field data from the upper and/or lower sensors, where appropriate. 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 will be used for data interpretation.

5.3.2. Geophysical results will be interpreted using greyscale images and XY traces in a layered environment, overlaid against OS Open Data, satellite imagery, historical maps, LiDAR data, and soil and geology maps. Google Earth (2021) will also be consulted, to compare the results with recent land use.

5.3.3. Geodetic position of results – All vector and raster data will be projected into OSGB36 (ESPG27700) and provided upon request in ESRI Shapefile (.SHP) and Geotiff (.TIF) respectively. Figures will be provided with raster and vector data projected against OS Master Mapping.

6. Reporting

6.1. A detailed report of the survey will be produced after data collection is completed. The Planning Archaeologist will be provided with a draft report for approval, and the approved report will be submitted along with digital, geo-referenced copies of the geophysical survey plans for inclusion in the Suffolk to the HER. The final report will include as standard:

- Abstract
- Introduction – Details site location and client details.
- Quality Assurance – Details the expertise of Magnitude Surveys and Magnitude Surveys employees undertaking the work.
- Objectives – Details survey objectives.
- Geographic Background – Details the soils and geology of the survey area, as well as providing a general summary of site conditions at time of survey.
- Survey Considerations – Details specific points of note for each survey area, including topography, upstanding obstructions or neighbouring objects.
- Archaeological Background – Details a brief summary of the archaeological and historical background of the survey area and its immediate environs. While this will not be an exhaustive assessment, it will draw on elements relevant to the results obtained during survey.
- Methodology – Details survey strategy employed, instruments used, data collection strategy, data processing and visualisation methods.
- Results – Details the results and interpretation of the geophysical survey, both in a general context and in terms of specific anomalies of archaeological interest. Geophysical results will be discussed in combination with satellite imagery, historical mapping and LiDAR data - if freely available - as supporting interpretative evidence.
- Conclusions
- Archiving
- Copyright
- References
- Figures – The site location and individual survey areas will be presented. Georeferenced greyscale images of the minimally enhanced data, XY traces and corresponding interpretations will be displayed at appropriate scales. Interpretations will also be displayed over satellite imagery, historical mapping and LiDAR - as applicable - to provide further context for the interpretations. All figures will include a detailed scale bar, north arrow and key.

7. Archiving

7.1. MS maintains an in-house digital archive, which is based on Schmidt and Ernenwein (2013). This archive stores the collected measurements, minimally processed data, georeferenced and un-georeferenced images, XY traces and a copy of the final report. A copy of this archive will be included on a disk with a final printed report.

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

7.3. An OASIS form will be filled in on completion of the survey, and a copy of the summary sheet will be added as an appendix to the final report.

8. Copyright

8.1. 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.

9. References

Chartered Institute for Archaeologists, 2014. Standard and guidance for archaeological geophysical survey. CIfA.

David, A., Linford, N., Linford, P. and Martin, L., 2008. Geophysical survey in archaeological field evaluation: research and professional services guidelines (2nd edition). Historic England.

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Olsen, N., Toffner-Clausen, L., Sabaka, T.J., Brauer, P., Merayo, J.M.G., Jorgensen, J.L., Leger, J.M., Nielsen, O.V., Primdahl, F., and Risbo, T., 2003. Calibration of the Orsted vector magnetometer. *Earth Planets Space* 55: 11-18.

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Schmidt, A. and Ernenwein, E., 2013. Guide to good practice: geophysical data in archaeology. (2nd edition). Oxbow Books: Oxford.

Schmidt, A., Linford, P., Linford, N., David, A., Gaffney, C., Sarris, A. and Fassbinder, J., 2015. Guidelines for the use of geophysics in archaeology: questions to ask and points to consider. EAC Guidelines 2. European Archaeological Council: Belgium.

MSTM862 - Flixton Quarry, Suffolk
Figure 1 - Site Location
1:25,000 @ A4

N

0 0.5 1 km

Site Boundary

magnitude surveys

MSTM862 - Flixton Quarry, Suffolk
Figure 2 - Location of Survey Area
1:5,000 @ A3

magnitude surveys

OASIS DATA COLLECTION FORM: England

List of Projects | Manage Projects | Search Projects | New project | Change your details | HER coverage | Change country | Log out

Printable version

OASIS ID: magnitud1-415084

Project details

Project name	Flixton Quarry Extension, Buck Land
Short description of the project	Magnitude Surveys Ltd was commissioned to assess the subsurface archaeological potential of a c. 17.9ha area of land near Flixton, Suffolk. A fluxgate gradiometer survey was successfully completed across the majority of the survey area. The geophysical survey has primarily detected anomalies relating to agricultural practices, including drainage, cultivation, and both mapped and unmapped field boundaries. Variations within the background of the survey area relate to the near surface geology, which have in turn complicated a more confident interpretation of features and possibly obscured their full extent. Sources of interference relate to boundary features along the perimeter of the survey area as well as a modern service.
Project dates	Start: 02-02-2021 End: 09-02-2021
Previous/future work	Not known / Not known
Any associated project reference codes	MSTM862 - Contracting Unit No.
Any associated project reference codes	FLN 122 - HER event no.
Type of project	Field evaluation
Site status	None
Current Land use	Cultivated Land 4 - Character Undetermined
Current Land use	Grassland Heathland 5 - Character undetermined
Monument type	DRAINAGE SYSTEM Uncertain
Monument type	FIELD BOUNDARY Uncertain
Significant Finds	NONE None
Significant Finds	NONE None
Methods & techniques	"Geophysical Survey"
Development type	Not recorded
Prompt	Unknown
Position in the planning process	Not known / Not recorded
Solid geology (other)	Crag Group Sand
Drift geology	RIVER TERRACE DEPOSITS
Drift geology	PEAT

Drift geology	LACUSTRINE CLAYS, SILTS AND SANDS
Techniques	Magnetometry

Project location

Country	England
Site location	SUFFOLK WAVENEY FLIXTON (NEAR BUNGAY) Flixton Quarry Extension, Buck Land
Postcode	NR35 1NZ
Study area	17.9 Hectares
Site coordinates	TM 3139 8769 52.437777777778 1.404722222222 52°26′16″N 001°24′17 Point
Lat/Long Datum	Unknown
Height OD / Depth	Min: 0m Max: 0m

Project creators

Name of Organisation	Magnitude Surveys Ltd
Project brief originator	Suffolk County Council Archaeological Service
Project design originator	Magnitude Surveys Ltd
Project director/manager	Paul S. Johnson
Project supervisor	Leanne Swinbank
Type of sponsor/funding body	Developer

Project archives

Physical Archive Exists?	No
Digital Archive recipient	Suffolk HER
Digital Archive ID	MSTM862
Digital Contents	"Survey"
Digital Media available	"GIS","Geophysics","Text"
Paper Archive Exists?	No

Project bibliography 1

Publication type	Grey literature (unpublished document/manuscript)
Title	Flixton Quarry Extension, Buck Land
Author(s)/Editor(s)	Wilkinson, D.
Author(s)/Editor(s)	Clements, M.
Other bibliographic details	MSTM862
Date	2021
Issuer or	Megnitude Surveys Ltd

publisher	
Place of issue or publication	Bradford
Description	Digital Report in PDF format
Entered by	Leanne Swinbank (info@magnitudesurveys.co.uk)
Entered on	10 February 2021

OASIS: