Geophysical Survey Report

Edgehill Park Phase 4, Whitehaven

For

CFA Archaeology

On Behalf Of

Story Homes Ltd

Magnitude Surveys Ref: MSNX1150A

HER Event Number: [TBC]

January 2022

magnitude surveys

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Abstract

Magnitude Surveys was commissioned to assess the subsurface archaeological potential of c. 5.8ha of land west of Gameriggs Road, Whitehaven, Cumbria. A fluxgate gradiometer survey was successfully completed across c. 3.1ha, with c. 2.7ha that were not surveyed due to waterlogged conditions and steep terrain. Anomalies related to modern agricultural land usage are evident across the survey area in the form of ploughing trends and drainage. There is also evidence of historic agricultural usage in the form of mapped and unmapped historic field boundaries. Some anomalies classified as 'Undetermined' were identified within the survey area and while archaeological interpretations for these cannot be excluded, no anomalies suggestive of significant archaeological activity have been identified. The impact of modern activity in the survey area was limited to surrounding structures and small isolated areas.

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1. Introduction

1.1. Magnitude Surveys Ltd (MS) was commissioned by CFA Archaeology on behalf of Story Homes Ltd to undertake a geophysical survey over a c. 5.8ha area of predominantly agricultural land west of Gameriggs Road. Whiteheaven, Cumbria in advance of the proposed Edgehill Phase 4 residential development (NX 97431 15764).

1.2. The geophysical survey comprised quad-towed, cart-mounted 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 (Roberts, 2021).

1.5. The survey commenced on 23rd December and took 2 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 Paul Johnson has a PhD in archaeology from the University of Southampton, is a Fellow of the Society of Antiquaries of London, 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 west of Gameriggs Road, Whitehaven (Figure 1). Gradiometer survey was undertaken across one field under grassland. The survey area was split into two sections, separated by the track leading from Gameriggs Road to High House (Figure 2). c. 2.7ha around the perimeter and to the south of the track was unable to be surveyed. This was due to steep terrain south of the track, and areas of flooding at the base of this slope, and in the north-west corner of the site.

4.2. Survey considerations:

Survey Area	Ground Conditions	Further Notes
1	The field consisted of grassland sloping to the south with a steep slope to the far south.	The area was bordered by intermittent hedges to the south and south east as well as an iron fence along the east boundary. A section of corrugated iron fencing surrounds a building site to the east. All other borders had no physical boundary. Large parts of the north, west and east were not surveyed. There was a road that was located to the south.

4.3. The underlying geology comprises of mudstone, siltstone and sandstone from the Pennine Middle Coal Measures, there are also faults and veins of coal that run through the survey area. Superficial deposits are also present in the form of Diamicton Till towards the south (British Geological Survey, 2022).

4.4. The grounds consist of freely draining, slightly acidic and loamy soils (Soilscapes, 2022).

5. Archaeological Background

5.1. The following is a summary of an Archaeological Baseline and Archaeological Report provided and produced by CFA Archaeology (Walker, 2021).

5.2. No features of archaeological origin are recorded within the survey area.

5.3. A review of Historic Environment Record data and historic mapping recorded evidence of industrial activity, including the presence of a former coal mine, 'Moss Pit' located in the southernmost extent of the survey area; a brickfield, recorded as Gameriggs Brickfield on the Ordnance Survey 1st Edition map (1865); as well as a former farmstead Far Prestonhaws, also recorded on historic Ordnance Survey mapping, to the west of this, towards Wilson Pit Road.

5.4. Within the wider landscape the presence of former industrial sites was recorded including a tilery, further coal pits, and chemical works.

5.5. Geophysical survey was undertaken across two areas, located at the very south of the survey area, and immediately to the west of its' north-western edge, covering the area recorded on 1st edition mapping as 'Gameriggs Brickfields'. The survey recorded anomalies of industrial origins, relating to the coalpit, and brickfield respectively. Evidence of possible ridge and furrow cultivation was also recorded.

5.6. The remaining area was subject to further geophysical survey further geophysical survey. The survey primarily recorded agricultural trends, including some ridge and furrow, as well as drainage. Several ditches were recorded as well as scattered ferrous anomalies which were thought to have been related to previous industrial activity or perhaps more recent evidence of burning.

5.7. Subsequent trial trenching in the area of 'Moss Pit' revealed anomalies previously identified by geophysical survey to be of modern origin. Trial trenching was also undertaken immediately adjacent to the south-east of the southern edge of the survey area. Three trenches were excavated, though no archaeological evidence was identified.

5.8. Further trial trenching, immediately adjacent to the north-western edge of the survey area, revealed the remains of various brick-built structures and surfaces were identified, relating to Gameriggs brickfield.

5.9. Subsequently an archaeological strip, map and record was undertaken to investigate the remains of structures relating to Gameriggs brickfield. Two areas were excavated with the surviving remains of two buildings recorded. Evidence indicates that at least one of the buildings likely housed a brick kiln with areas of intense burning noted. The recovery of saggars and kiln rods from the site suggests that there may have been pottery production somewhere in the vicinity of the site, although there was no direct evidence of this within the two buildings within the excavation areas.

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 cart system.

6.1.4.1. 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.

6.1.4.2. 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. 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 (Figure 6). 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 (2022) 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 imagery and historical maps (Figure 7). The survey was carried out on an area of c. 5.8ha, located west of Gameriggs Road, Whitehaven, with c. 2.7ha not surveyed.

7.2.2. The fluxgate gradiometer survey has responded well to the environment of the survey area. The survey area has been impacted by magnetic interference from nearby buildings, structures and equipment as well as some field boundaries. The magnetic anomalies can possibly mask any weaker anomalies that may be present in the vicinity of the strong responses.

7.2.3. The survey has primarily detected evidence of modern and historic agricultural activities as well as natural features.

7.2.4. The geophysical survey has detected evidence for agricultural usage in the forms of drainage, plough trends as well as both mapped and unmapped historic boundaries. The modern agricultural practices are present throughout the survey area in the form of agricultural trends that align with recent ploughing regimes.

7.2.5. Some anomalies have been classified as undetermined across the survey area. These include a variety of magnetic anomalies that show different morphology, shapes and sizes. These are likely to be related to the geological context or agricultural usage of the area but cannot be further identified.

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

7.3.1.3. **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.

7.3.1.4. **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.

7.3.1.5. **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)** – A series of linear, positive anomalies have been detected (Figure 5). These correlate with historical OS mapping and, in some cases, boundaries visible on satellite imagery. Additionally, a discontinuous, linear anomaly has been detected which exhibits a negative magnetic signal that follows a field boundary recorded in 2nd Edition OS Maps (Figure 7). Another weak linear anomaly [**1a**] is identified but has not been previously mapped on historical maps.

7.3.2.2. **Agricultural Trends** – Across the survey area a series of parallel linear anomalies have been detected. These are very closely spaced and only a few indicative linear trends have been picked out to give an idea of direction and presence across the site. The orientation is well matched with modern cultivation visible in recent satellite imagery and are interpreted as agricultural trends caused by modern ploughing (Figure 5). There is also potential for these trends to be identified as drainage features.

7.3.2.3. **Drainage Features** – Across the site, few arrangements of drainage features have been identified. These linear anomalies are characterised by strong, positive signal that exhibit a ditch-like morphology.

7.3.2.4. **Undetermined (Strong/Weak) –** A series of amorphous, linear, and curvilinear anomalies have been identified in multiple areas. These anomalies have a generally weak magnetic signal and are mostly curvilinear, suggesting that they could be related either to human activities or to the natural features which are present in the survey area. The strong magnetic signal, in the south east of the greyscale, could be related to natural causes, however it could also represent

ferrous debris or drag-out from the nearby manmade structures. Thus, it's also classified as 'Undetermined'.

7.3.2.5. **Natural (Strong/Weak) –**A series of sinuous variations in the magnetic background have been identified in central part of the survey area on what is identified as a coal seam**.** These features are positive in magnetic signal and are explicit in both the greyscale and total field data.

8. Conclusions

8.1. A fluxgate gradiometer survey has successfully been undertaken across most of the survey area, with c. 2.7 ha that were not surveyed due to the ground being waterlogged or too steep to safely survey. The geophysical survey has detected a range of different types of anomalies of agricultural, natural and undetermined origins. Modern activity in the form of magnetic disturbance is generally limited to the borders of the survey area, however, some magnetic disturbance is noticeable within the survey area. This may have prevented any further identification of anomalies within the nearby vicinity.

8.2. Agricultural activity has been detected throughout the survey area as both mapped and unmapped former field boundaries, as well as, plough trends and drainage features.

8.3. Several undetermined anomalies have been detected throughout the survey area which may have represented further natural or agricultural variations; however, a more conclusive classification cannot be given due to the enhanced magnetic background and the limited context due to the proximity to nearby structures and limits of survey area.

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

10.1. Copyright and 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

British Geological Survey, 2022. Geology of Britain. Whitehaven, Cumbria. [http://mapapps.bgs.ac.uk/geologyofbritain/home.html/]. Accessed 04/01/2022.

Chartered Institute for Archaeologists, 2020. Standards 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.

Google Earth, 2022. Google Earth Pro V 7.1.7.2606.

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.

Roberts, D., 2021. Written Scheme of Investigation for a Geophysical Survey of Edgehill Park Phase 4, Whitehaven, Cumbria. Magnitude Surveys.

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.

Soilscapes, 2022. Whitehaven, Cumbria. Cranfield University, National Soil Resources Institute. [http://landis.org.uk]. Accessed 05/01/2022.

Walker J., 2021. Wilson Pit Road, Whitehaven, Cumbria. Archaeological Strip, Map and Record, Phase 5. Report No. Y519/21.

12. Project Metadata

MS Job Code	MSNX1150A
Project Name	Edgehill Park Phase 4, Whitehaven
Client	CFA Archaeology
Grid Reference	NX 97431 15764
Survey Techniques	Magnetometry
Survey Size (ha)	5.8ha (Magnetometry)
Survey Dates	2021-10-23 to 2021-10-24
Project Lead	Daniel Roberts BSc (Hons) MSc MRes FGS
Project Officer	Dr. Anna Chmielowska PCIfA
HER Event No	TBC
OASIS No	TBC
S42 Licence No	N/A
Report Version	0.3

13. Document History

Version	Comments	Author	Checked By	Date
0.1	Initial draft for Project Lead to Review	CL	AC	06 January 2022
0.2	Corrections from Project Lead, draft after Director Approval	CL	FPC	07 January 2022
0.3	Corrections from Client	AC	FPC	25 January 2022

MSNX1150 - Edgehill Park Phase 4, Whitehaven
Figure 1 - Site Location
1:25,000 @ A4
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Survey Area

N

0 0.5 1 km

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297200
297400
297600
297800
515800
515600
Windermere Road
Valley View Road
Bowness Road
Greenbank Avenue
Other Sports Facility
Play Space
Greenbank
Playing Field
Gameriggs Road
Area 1
High House
B5345
N
0
50
100
150 m

MSNX1150 - Edgehill Park Phase 4, Whitehaven
Figure 2 - Location of Survey Area
1:2,000 @ A3
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Survey Area
Unsurveyable

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297200

297400

297600

515800

515800

Lowther Gardens

Fleswick Avenue

Windermere Road

Valley View Road

Bowness Road

Greenbank Avenue

Other Sports Facility

Play Space

Greenbank

Playing Field

B5345

Gameriggs Road

Area 1

High House

MSNX1150 - Edgehill Park Phase 4, Whitehaven
Figure 3 - Magnetic Total Field (Lower)
1:1,500 @ A3
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48997 nT 49005

N

0 50 100 150 m

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297200
297400
297600
515800
515800
Lowther Gardens
Fleswick Avenue
Windermere Road
Valley View Road
Bowness Road
Greenbank Avenue
Other Sports Facility
Play Space
Playing Field
Greenbank
B5345
Gameriggs Road
Area 1
High House

MSNX1150 - Edgehill Park Phase 4, Whitehaven
Figure 3 - Magnetic Gradient
1:1,500 @ A3
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-1 nT 2

N

0 50 100 150 m

magnitude surveys

297200
297400
297600
515800
515800
Lowther Gardens
Fleswick Avenue
Windermere Road
Valley View Road
Bowness Road
Greenbank Avenue
Other Sports Facility
Play Space
Playing Field
Greenbank
B5345
Gameriggs Road
Gameriggs Road
Greenbank Avenue
1a
Area 1
High House

MSNX1150 - Edgehill Park Phase 4, Whitehaven
Figure 5 - Magnetic Interpretation
1:1,500 @ A3
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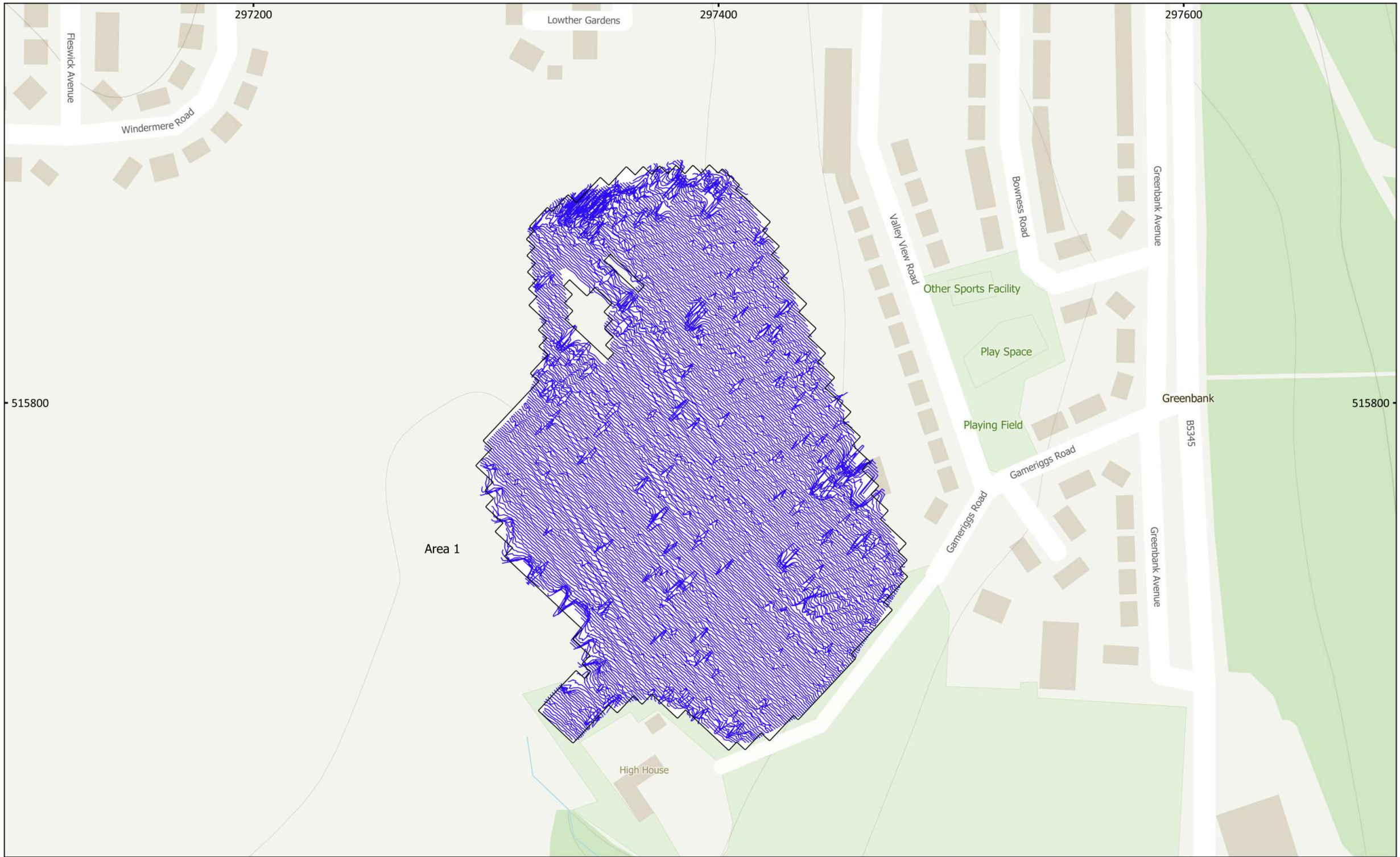
Agricultural (Strong)
Agricultural (Weak)
Magnetic Disturbance
Ferrous/Debris (Spread)
Natural (Strong)
Natural (Weak)
Undetermined (Strong)
Undetermined (Weak)
Agricultural (Trend)
Drainage Feature
Ferrous (Spike)

N

0 50 100 150 m

magnitude surveys



MSNX1150 - Edgehill Park Phase 4, Whitehaven
Figure 6 - XY Trace Plot
90nT/cm at 1:1,500 @ A3
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N

0 50 100 150 m

magnitude surveys

297000
297200
297400
297600
297800
516000
515800
515600
Prestonhows
Acres
3156.112
Gameriggs
Brickfield
300
Area 1
High House
Banks Hall
Far Prestonhows
100
308.7
301

MSNX1150 - Edgehill Park Phase 4, Whitehaven
Figure 7 - Magnetic Interpretation Over Historical Maps and Satellite Imagery
1:2,500 @ A3
Copyright Magnitude Surveys Ltd 2022
Contains historical mapping © CLS Data 2022: Ordnance Survey, 6" 2nd edition c. 1882-1913
Contains satellite imagery © Bing Satellite 2022

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

N

0 50 100 150 m

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