Extension to Lowther Holiday Park
Lowther, Cumbria

Archaeological geophysical survey

Project No. ARC/2861/1067

October 2020

Extension to Lowther Holiday Park
Lowther, Cumbria

Archaeological geophysical survey

Project No. ARC/2861/1067

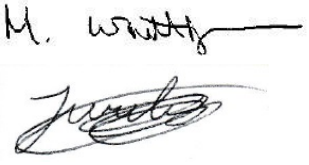
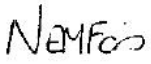
Report prepared by		Report checked by	
Name	Mark Whittingham BSc MA MCIfA Jelmer Wubs BA MA	Name	Nicola Fairs BSc MSc DIC CGeol FGS
Signature		Signature	
Date	02/10/20	Date	07/10/20

Table of Contents

1. SUMMARY

Phase Site Investigations Ltd was commissioned by Greenlane Archaeology Ltd to carry out a magnetic gradient survey at the site of a proposed extension to Lowther Holiday Park, Lowther, Cumbria. The aim of the survey was to help establish the presence / absence, extent, character, relationships and date (as far as circumstances and the inherent limitations of the technique permits) of archaeological features within the survey area.

The survey was undertaken using a Phase Site Investigations Ltd multi-sensor array cart system (MACS). The MACS comprised 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. The MACS data was collected on profiles spaced 0.5 m apart with readings taken at between 0.1 and 0.15 m intervals.

The survey has provided evidence for archaeological activity, in the form of two sub-circular anomalies, suggestive of prehistoric features such as barrows or round-houses, and several linear / curvi-linear responses indicative of infilled archaeological ditches. There are also a number of additional anomalies that could be related to archaeological features / activity.

The majority of the responses associated with probable and possible archaeological features are fragmented, weak or discontinuous. This suggests that some features may have been truncated but also that the magnetic susceptibility of the soils could vary across the site and be relatively low in places; possibly to the extent that some features may only produce weak or intermittent responses or may not produce measureable magnetic responses. It is likely that the full extent of the archaeological activity across the site has not been determined by the magnetic survey.

The survey has also identified anomalies that relate to modern material / objects (including a number of pipes, drains or cables), agricultural activity (including ridge and furrow) and geological / pedological variations.

There are a large number of weak responses that are of uncertain origin. Generally the weakness of the responses and their fragmented / discontinuous nature precludes a reliable interpretation. Some of them could be related to archaeological features / activity but others could be a product of natural features / variations, agricultural or other relatively modern activity.

2. INTRODUCTION

2.1 Overview

Phase Site Investigations Ltd was commissioned by Greenlane Archaeology Ltd to carry out an archaeological geophysical survey at the site of a proposed extension to Lowther Holiday Park, Lowther, Cumbria utilising magnetic gradiometers.

The aim of the survey was to help establish the presence / absence, extent, character, relationships and date (as far as circumstances and the inherent limitations of the technique permits) of archaeological features within the survey area.

The location of the site is shown in drawing ARC_2861_1067_01.

2.2 Site description

The site is situated on land to the west of Lowther Holiday Park (centred at NGR NY 522 261), approximately 8.1 km to the south of Penrith and covered an area of approximately 12.6 ha.

The site covered two areas located in parts of two adjacent fields. Each area has been given a number as shown in drawing ARC_2861_1067_02.

Area 1 covered the northern part of a pasture field and had a downwards slope from west to east. The geology in the north of this area consists of limestone of the Three Yard Limestone Member with mudstone, siltstone and sandstone of the Alston Formation in the south of the area with the east of the area overlain by glacial till (British Geological Survey, 2020).

Area 2 covered the majority of a field that was under grass or an immature crop and was relatively level, except for a depression in the south-east of the area. The geology in the north-east and south-west of this area consists of mudstone, siltstone and sandstone of the Alston Formation with limestone of the Three Yard Limestone Member present in the central, north-western and southern parts of the area. The entire area is overlain by glacial till (British Geological Survey, 2020).

The site was bounded by a mixture of hedges, post and wire fences and drystone walls to the north, west and east with no fixed boundary along the southern edge of the site. A dilapidated wall and area of soft / uneven ground separated Areas 1 and 2 and a metal cattle feeder was present in this area. Farm machinery was present in the north of the area

2.3 Archaeological background

A heritage impact assessment undertaken by Greenlane Archaeology Ltd (2020) highlighted that the area surrounding the site,

'*is filled with archaeological remains from the prehistoric period onwards, including some substantial monuments of Neolithic and Bronze Age date a short distance to the north, but with a number of settlements of medieval and earlier origin nearby and the important Lowther Castle and church to the south. More significant is a Romano-British settlement and associated earthworks immediately to the west of the proposed development area and a neighbouring barrow, both of which are Scheduled Monuments'*.

The assessment also notes that,

'*A consultation of the available maps shows that the site has been open fields since at least the 18th century, with some variation of the field pattern occurring since that time.*

Aerial photographs have also revealed a range of cropmarks within the main part of the site [Area 2], some of which perhaps relate to the Scheduled Romano-British settlement to the west. [...] the main field comprising the site has been extensively ploughed and improved and so any remains relating to the cropmarks [...] will have already been impacted upon but elements could still survive.'

The heritage impact assessment indicates that there are numerous air photographs of the local area with some,

'*showing various cropmarks, probably related to infilled ditches, buried walls and trackways, extending into the proposed development site'*

An Ordnance Survey map from 1863, shown within the heritage impact assessment, shows a field boundary within Area 2 on a rough south-west to north-east alignment. The assessment also indicated the presence of a post-medieval limekiln and quarry to the immediate north-west of the site.

2.4 Scope of work

The survey area was specified by the client.

The scheduled area surrounding the Roman-British settlement to the west extends up to the boundary of the site. This boundary was set out on site and the survey area was offset by several metres to the east to ensure that the scheduled area was not encroached upon. Areas adjacent to the field boundaries and metal surface obstructions were left unsurveyed which meant that the area accessible / suitable for survey was reduced to approximately 11.4 ha, the extents of which are shown in drawing ARC_2861_1067_02.

No other problems were encountered during the survey which was carried out between 8 and 10 September 2020.

3. SURVEY METHODOLOGY

3.1 Magnetic survey

The survey was undertaken using a Phase Site Investigations Ltd multi-sensor array cart system (MACS).

The MACS comprised 8 Foerster 4.032 Ferex CON 650 gradiometers with a control unit and data logger. The Foerster gradiometers do not require balancing as each sensor is automatically 'zeroed' using the control unit software.

The MACS utilises an RTK GNSS system which means that survey grids do not have to be established. Instead an area is surveyed over a series of continuous profiles and the position of each data point is recorded using an RTK GNSS system. The sensors have a separation of 0.5 m which means that data was collected on profiles spaced at 0.5 m apart. Readings were taken at between 0.1 m and 0.15 m intervals.

Data is collected on zig-zag profiles along the full length or width of a field, although fields can be sub-divided if they are particularly large. Marker canes are set-out along field boundaries at set intervals and these are used to align the profiles. The survey profiles are usually offset from field boundaries, buildings and other metallic features by several metres to reduce the detrimental effect that these surface magnetic features have on the data. The location of the MACS data is converted direct to Ordnance Survey co-ordinates using the UK OSTN 02 projection. As the survey is referenced direct to Ordnance Survey National Grid co-ordinates temporary survey stations are not established.

3.2 Data processing and presentation

The MACS data was stored direct to a laptop using in-house software which automatically corrects for instrument drift and calculates a mean value for each profile. A positional value is assigned to each data point based on the sensor number and recorded GNSS co-ordinates. The data is gridded using in-house software and parameters are set based on the sensor spacing and mean values. No additional processing is required. The gridded data is then displayed in Surfer 9 (Golden Software) and image files of the data are created.

The data was exported as greyscale raster images (PNG files). Data for the entire site is presented at a scale of 1:3000 and plots for individual fields / areas (or parts of fields / areas) with accompanying interpretations are shown at a scale of 1:1500. All greyscale plots were clipped at -2 nT to 3 nT. Greyscale plots have been 'smoothed' using a visual interpolation but the data itself has not been interpolated.

The data has been displayed relative to a digital Ordnance Survey base plan provided by the client as drawing *'1004 – Site Plan – Rev A.dwg'*. The base plan was in the Ordnance Survey National Grid co-ordinate system and as the survey grids / data were referenced directly to National Grid co-ordinates the data could be simply superimposed onto the base plan in the correct position.

X-Y trace plots were examined for all of the data and overlain onto the greyscale plot to assist in the interpretation, primarily to help identify dipolar and bipolar responses that will probably be associated with surface / near-surface iron objects. However, X-Y trace plots have not been presented here as they do not show any additional anomalies that are not visible in the greyscale data. A digital drawing showing the X-Y trace plot overlain on the greyscale plot is provided in the digital archive.

All isolated responses have been assessed using a combination of greyscale and X-Y trace plots. There are a large number of 'iron spike', isolated dipolar anomalies present in the data. These responses are highly likely to be caused by modern material but the potential for these to be associated with archaeological features is increased slightly by their proximity to other anomalies / features. As such the isolated responses have been shown on the interpretation.

Anomalies associated with agricultural and drainage regimes are present in the data but each individual anomaly has not been shown on the interpretation. Instead the general orientation of the regime is indicated.

The data was examined over several different ranges during the interpretation to ensure that the maximum information possible was obtained from the data.

The anomalies have been categorised based on the type of response that they exhibit and an interpretation as to the cause(s) or possible cause(s) of each anomaly type is also provided.

A general discussion of the anomalies is provided for the entire site and then the results are discussed on an area by area basis. A discussion of the general categories of anomaly which have been identified by the survey is provided in Appendix 1.5.

The geophysical interpretation drawing must be used in conjunction with the relevant results section and appendices of this report.

4. RESULTS

4.1 General

The data quality across the majority of the survey area is very good allowing the data to be viewed at a narrow range of readings to better identify weak anomalies. There are several areas that have a more disturbed magnetic background and a number of strong responses but these are due to the presence of magnetic material / features in the topsoil or sub-surface, rather than low data quality.

Anomalies relating to archaeological features are present in the data but in places these are weak and / or fragmented and 'fade out'. It is also worth noting that a former field boundary, which is shown on historic maps to cross the survey area, is not visible in the data and responses relating to agricultural activity have varying responses across the site. These suggest that the magnetic susceptibility of the soils could vary across the site and be relatively low in places; possibly to the extent that some features may only produce weak or intermittent responses or may not produce measureable magnetic responses.

There are a large number of isolated responses across the site. The majority of these will relate to modern material or natural features / variations and some could be associated with natural features / variations. It is possible that a small number could be related to archaeological features / material but it is not possible to determine, which, if any, these may be other than possibly by proximity to archaeological features / activity. A selection of the stronger / larger isolated responses has been shown on the interpretation. The archaeological potential of these may be increased where they are located in proximity to archaeological or possible archaeological features / activity but it should be recognised that the majority of these responses will be caused by modern or natural material.

4.2 Area 1

Basic topography: Relatively steep downwards slope from the west to the east. Some undulations present.

Area description: Pasture field. The area was relatively soft underfoot, particularly along the eastern edge. The area was bounded by a mixture of hedges and post and wire fencing to the north-,north-west and east with no fixed boundary to the south or south-west. An unmetalled trackway ran along and adjacent to the southern edge of the survey area. A cattle feeder and remnants of a dilapidated wall were present in the east of the area and overhead cables were present within the north of the area.

Summary of anomalies: Numerous isolated dipolar and small bipolar responses are present, a large majority, if not all, of which will be associated with relatively modern material. Selected responses have been shown on the interpretation.

A linear bipolar anomaly associated with sub-surface utility apparatus (pipe or cable).

Very strong responses associated with strongly magnetic relatively modern features / material. These responses can extend for some distance beyond the feature and in some cases

the feature causing the strong response may be located beyond the survey area.

Positive linear responses associated with a probable regime of ridge and furrow.

Several trends of uncertain origin. Some trends may indicate continuations of archaeological features.

A number of isolated positive responses, the majority of which are probably related to modern deeper buried ferrous / fired material or geological / pedological variations but could also be caused by an infilled isolated feature.

Positive linear / curvi-linear responses and trends related to a trackway.

A positive linear response associated with an infilled archaeological feature.

Further discussion / additional information:

A relatively strong positive linear response (**Anomaly A**) runs through the area from west to east. The anomaly is slightly staggered / fragmented which could indicate that it has been truncated by a regime of ridge and furrow that cuts across it. The anomaly is indicative of an infilled ditch and has a similar alignment to features associated with the scheduled settlement to the west.

Anomalies B are made up of fragmented positive linear responses and weaker trends. It corresponds with the location of a trackway and is probably associated with this modern feature.

There are several weak trends adjacent to the eastern edge of the survey area (**Anomalies C**). The cause of these is not certain but they are not suggestive of archaeological features and are probably related to relatively modern agricultural activity.

4.3 Area 2

Basic topography: Relatively level. An area of lower ground is present towards the south of the field but the ground rises again in the south-east.

Area description: The field was under grass or an immature arable crop and was relatively firm underfoot. The area was bounded by a mixture of hedges, post and wire fencing a drystone wall with no fixed boundary to the south or south-west of the area. Farm machinery was present in the north of the field. Overhead cables were present within the north-east and south of the area.

Summary of anomalies: Numerous isolated dipolar and small bipolar responses are present, a large majority, if not all, of which will be associated with relatively modern material. Selected responses have been shown on the interpretation.

Areas of magnetic disturbance probably associated with relatively modern features / material although some responses could be related to natural features / variations.

A number of linear bipolar anomalies associated with sub-surface utility apparatus (pipes or cables).

Very strong responses associated with strongly magnetic relatively modern features / material. These responses can extend for some distance beyond the feature and in some cases the feature causing the strong response may be located beyond the survey area.

Relatively weak positive linear responses are present associated with modern ploughing regime(s).

Positive linear responses associated with probable field drains.

Broad areas of positive responses probably associated with natural features or variations

Two negative linear responses of uncertain origin.

Numerous trends of some of which will indicate continuations of archaeological features others are of uncertain origin.

Numerous isolated positive responses, the majority of which are probably related to modern deeper buried ferrous / fired material or geological / pedological variations but some could be caused by an isolated features.

Positive linear / curvi-linear responses of uncertain origin. Some responses may be related to infilled linear / curvi-linear archaeological features but others may be caused by agricultural or drainage activity.

Positive linear / curvi-linear responses associated with several archaeological infilled features.

Further discussion / additional information:

A number of bipolar linear anomalies are present in this area that will be related to pipes, drains or possibly cables.

There is evidence for archaeological features / activity in the south-east and south of field and a number of other possible archaeological features across the area.

There are two sub-circular anomalies in the south-east of the area. **Anomaly D** is indicative of a feature such as a barrow or round-house and is relatively strong, although it is weaker in its south-eastern edge. There are several isolated responses in this part of the anomaly and it is not certain if these are masking the response from the underlying feature or if there is a break in it. **Anomaly E** is weaker but the response appears to be unbroken. It is not certain if the variations in strength suggest a different function or composition for the two features, greater truncation or increasing depth of soil cover for Anomaly E or if it just reflects natural changes in the soils infilling the sub-circular ditches.

There are numerous other curving responses in the south of the area (**Anomalies F**), many of which are relatively weak and / or fragmented and have been shown as trends. Given that Anomaly E is relatively weak but is related to an archaeological feature it is possible that some of these other weak responses could also be related to the remnants of archaeological features. However, it is also possible that some of these anomalies could be related to natural

features / variations or are a product of agricultural activity. There are several general groupings of these weak curving responses but whether these reflect areas of archaeological activity or natural variations is not certain. One area may be defined by more linear responses (**Anomalies G**) which could suggest that it is an area of archaeological activity but it is also possible that some of Anomalies G are caused by natural features and / or agricultural activity. There are anomalies that are indicative of archaeological ditches (**Anomalies H**) which indicates that there is archaeological activity, other than the circular features, in the south of the area but these responses are fragmented and / or discontinuous and so the full extent of the archaeological features / activity cannot be determined.

Slightly further north there are other anomalies suggestive of an infilled archaeological ditch (**Anomalies I**) but again these are fragmented and discontinuous across the area. They are on the same alignment as **Anomalies J** in the west of the area, which in turn is probably caused by a continuation of the ditch in Area 1 which produced Anomaly A. It is not certain if the underlying feature continues across the full width of Area 2, but contains fill material that is less magnetic in the centre of the area or is more deeply buried or whether the underlying feature has been truncated to a greater extent where there are no visible anomalies.

In the south-west of the area there are several responses (**Anomalies K**) that could be related to the same, relatively modern feature that has produced Anomalies B in Area 1 but it is also possible that these are caused by an unrelated feature and so could be related to an archaeological feature / activity. Also in the south-west of the area there are weak linear responses on the same alignment (**Anomalies L**). The responses are fragmented and relatively straight and could be related to a modern feature, such as a field drain, but they could also be associated with an infilled feature and as such could possibly be archaeological in origin. There are several other weak trends in this part of the area that are suggestive of anthropogenic features / activity (**Anomalies M**) but these are too weak and fragmented to reliably interpret. They could possibly be related to infilled ditches, and as such may be archaeological in origin, but they could also be caused by drainage or other relatively modern features / activity.

Anomalies N are suggestive of an infilled feature and so could be related to an archaeological ditch but there are similar anomalies further north, some of which are more suggestive of natural features and so it cannot be determined with certainty if Anomalies N are related to archaeological or natural features. **Anomalies O** are indicative of an infilled feature and are suggestive of an archaeological ditch but could be related to a more modern feature. There are a number of other responses in this part of the area but some are relatively diffuse and others are weak so again a reliable interpretation is not possible. **Anomalies P** may be more suggestive of anthropogenic features and **Anomalies Q** natural features / variations but the exact cause of these is not certain.

There are numerous additional trends across the area but in many cases it is not possible to reliably determine if these are related to drainage or other modern features / activity, archaeological features or are a product of natural variations. **Anomalies R** stand out slightly as these are linear, slightly stronger or more coherent and are suggestive of being caused by anthropogenic features / activity but whether this is archaeological or more modern activity is not certain. If some of these anomalies are related to archaeological features then it is clear that the full extent of this activity cannot be determined from the magnetic data. The trends in the far south of the area (**Anomalies S**) are probably related to agricultural or other modern features but it is possible that some of them could have a different origin.

There are two negative linear anomalies in the south of the area (**Anomalies T**). The exact cause of these is uncertain but on this geology it is unlikely that these are related to infilled features and they are probably caused by non-metallic pipes or drains.

There are two broad, diffuse areas of positive and / or negative responses, one of which forms a curving shape (**Anomaly U**). These are indicative of natural features / variations with Anomaly U possibly being related to a palaeochannel (or other infilled natural feature).

There are several areas of magnetic disturbance. Anomalies of this type are usually caused by concentrations of modern material and that could be the case here as the anomalies could be related to areas of infill material. However, the responses could be also caused by concentrations of naturally magnetic material, such as gravel deposits. There is evidence for industrial activity to the north of the site and it is possible that some of the areas of magnetic disturbance or larger isolated responses could be related to similar activity but there is no direct evidence to suggest that this is the cause of any responses within this site.

5. DISCUSSION AND CONCLUSIONS

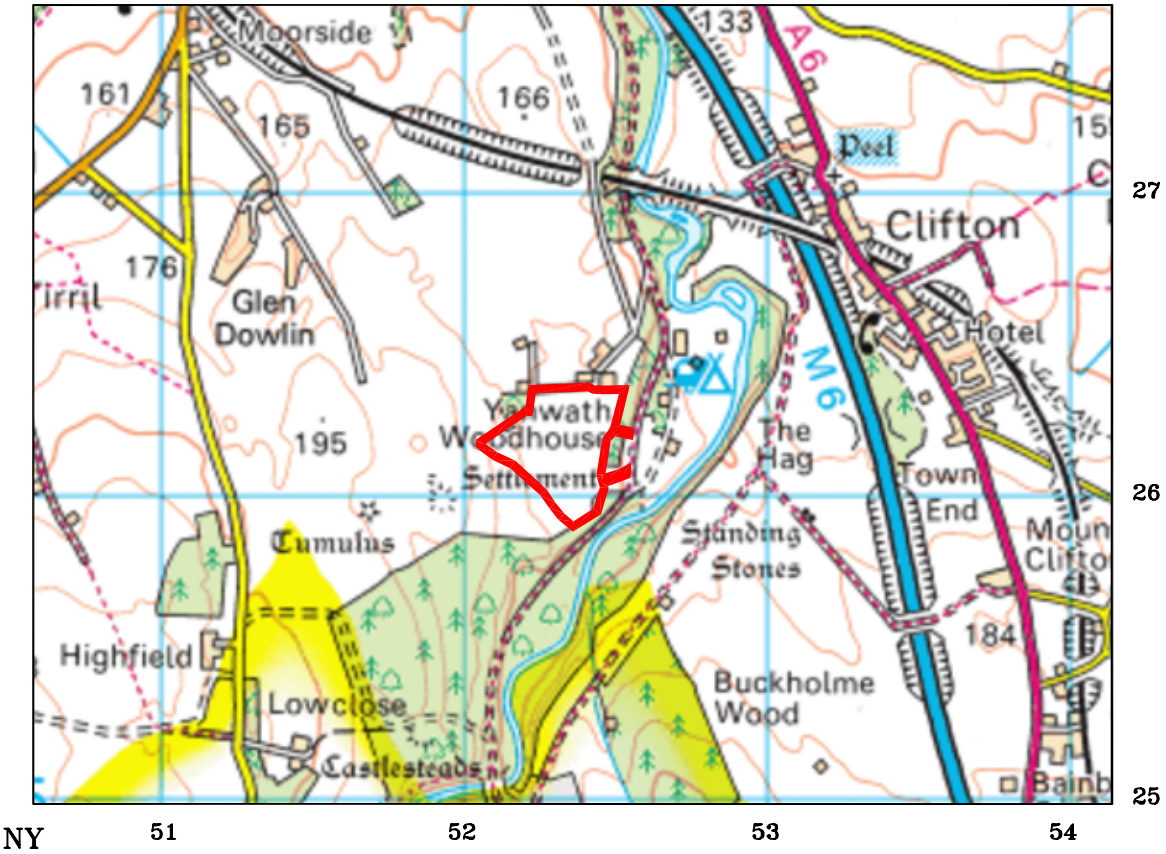
The survey has provided evidence for archaeological activity, in the form of two sub-circular anomalies, suggestive of prehistoric features such as barrows or round-houses, and several linear / curvi-linear responses indicative of infilled archaeological ditches. There are also a number of additional anomalies that could be related to archaeological features / activity.

The majority of the responses associated with probable and possible archaeological features are fragmented, weak or discontinuous. This suggests that some features may have been truncated but also that the magnetic susceptibility of the soils could vary across the site and be relatively low in places; possibly to the extent that some features may only produce weak or intermittent responses or may not produce measureable magnetic responses. It is likely that the full extent of the archaeological activity across the site has not been determined by the magnetic survey.

The survey has also identified anomalies that relate to modern material / objects (including a number of pipes, drains or cables), agricultural activity (including ridge and furrow) and geological / pedological variations.

There are a large number of weak responses that are of uncertain origin. Generally the weakness of the responses and their fragmented / discontinuous nature precludes a reliable interpretation. Some of them could be related to archaeological features / activity but others could be a product of natural features / variations, agricultural or other relatively modern activity.

It should be noted that a geophysical survey does not directly locate sub-surface features - it identifies variations or anomalies in the background response caused by features. The interpretation of geophysical anomalies is often subjective and it is rarely possible to identify the cause of all such anomalies. Not all features will produce a measurable anomaly and the effectiveness of a geophysical survey is also dependant on the site-specific conditions. The main factors that may limit whether a feature can be detected are the composition of a feature, its depth and size and the surrounding material. It is not possible to guarantee that a geophysical survey will identify all sub-surface features. Confirmation on the identification of anomalies and the presence or absence of sub-surface features can only be achieved by intrusive investigation.



SITE LOCATION

SCALE

0m 500m 1000m

NOTE

THIS DRAWING AND THE INFORMATION CONTAINED THEREIN IS ISSUED IN CONFIDENCE AND IS THE COPYRIGHT OF PHASE SITE INVESTIGATIONS LIMITED. DISCLOSURE OF THIS INFORMATION TO THIRD PARTIES AND UNAUTHORISED COPYING OR REPLICATION OF THIS DATA WITHOUT APPROVAL IS FORBIDDEN.

PHASE SITE INVESTIGATIONS

Phase Site Investigations Ltd, 703A Whinfield Drive, Aycliffe Business Park, Newton Aycliffe, County Durham, DL5 6AU

T: +44 [0] 01325 311 751
E: enquiries@PhaseSI.com
W: www.PhaseSI.com

Scale [A4 Sheet]	Drawing	Status
AS SHOWN	ARC_2861_1067_01	FINAL

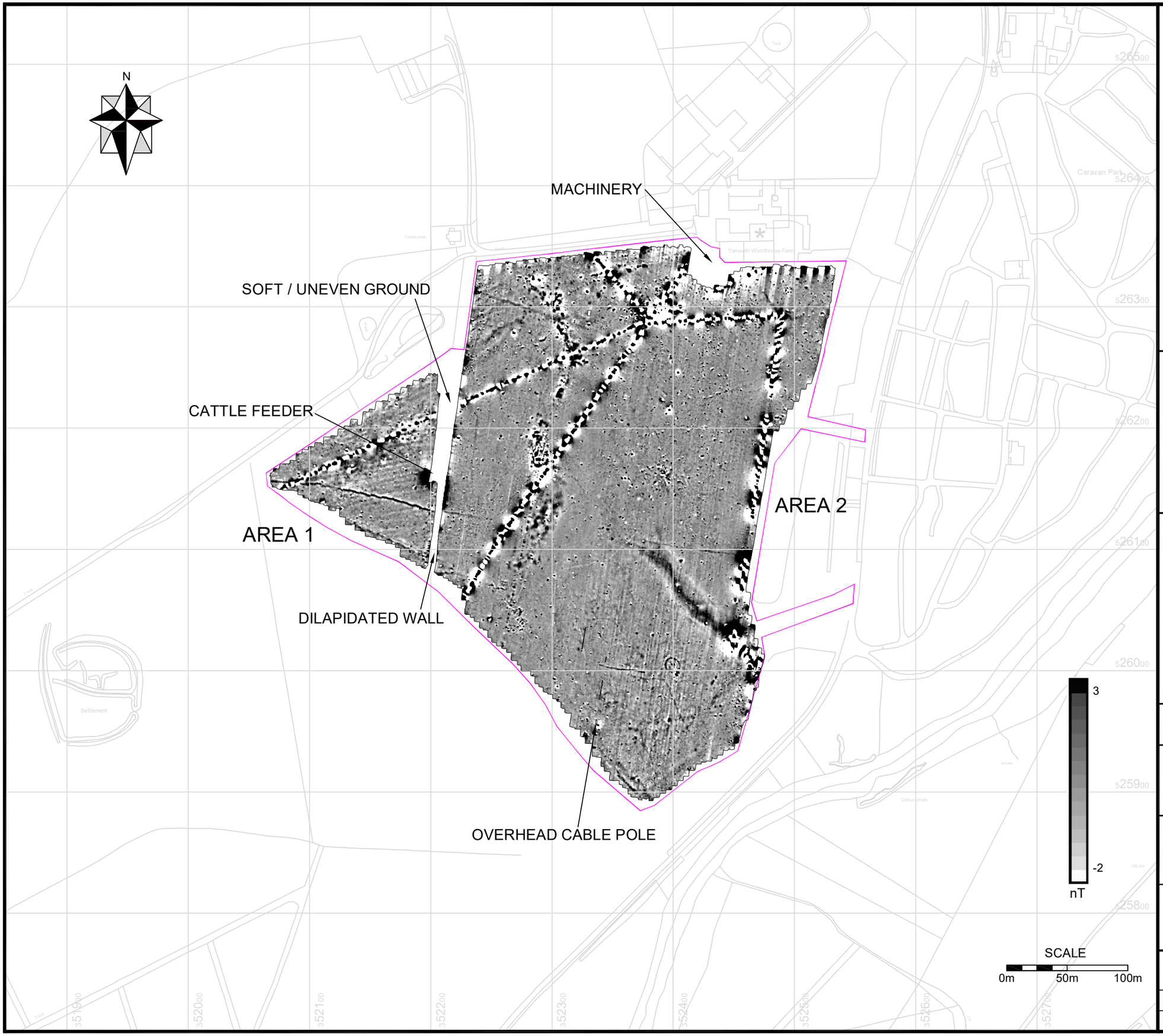
Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
EXTENSION TO LOWTHER HOLIDAY PARK
LOWTHER, CUMBRIA

Title
SITE LOCATION MAP

Job No
ARC_2861_1067

		Drawn	CW
Chk.	NF	Date	11/09/2020



NOTES

1. THIS DRAWING MUST BE USED IN CONJUNCTION WITH THE ACCOMPANYING REPORT (ARC_2861_1067_RPT.PDF) WHICH PROVIDES DETAILS OF THE TECHNIQUES EMPLOYED, THEIR INHERENT LIMITATIONS AND ANY SITE SPECIFIC ISSUES.
2. THIS DRAWING IS BASED UPON DRAWING '1004 - Site Plan - Rev A.dwg' PROVIDED BY THE CLIENT. THE ORDNANCE SURVEY CO-ORDINATES OBTAINED FOR THIS SURVEY WERE MEASURED USING THE UK OSTN02 PROJECTION. THIS PROJECTION SHOULD BE TAKEN INTO ACCOUNT IF THE SURVEY GRID IS RELOCATED.
3. PHASE SITE INVESTIGATIONS CANNOT ACCEPT RESPONSIBILITY FOR THE RELIABILITY OR ACCURACY OF ANY INFORMATION PROVIDED BY A THIRD PARTY.
4.

ALWAYS EXERCISE CAUTION WHEN EXCAVATING

KEY

SITE BOUNDARY

PHASE SITE INVESTIGATIONS

Phase Site Investigations Ltd, 703A Whinfield Drive, Aycliffe Business Park, Newton Aycliffe, County Durham, DL5 6AU

T: +44 [0] 01325 311 751
E: enquiries@PhaseSI.com
W: www.PhaseSI.com

Scale [A3 Sheet]	Drawing	Status
1:3000	ARC_2861_1067_02	FINAL

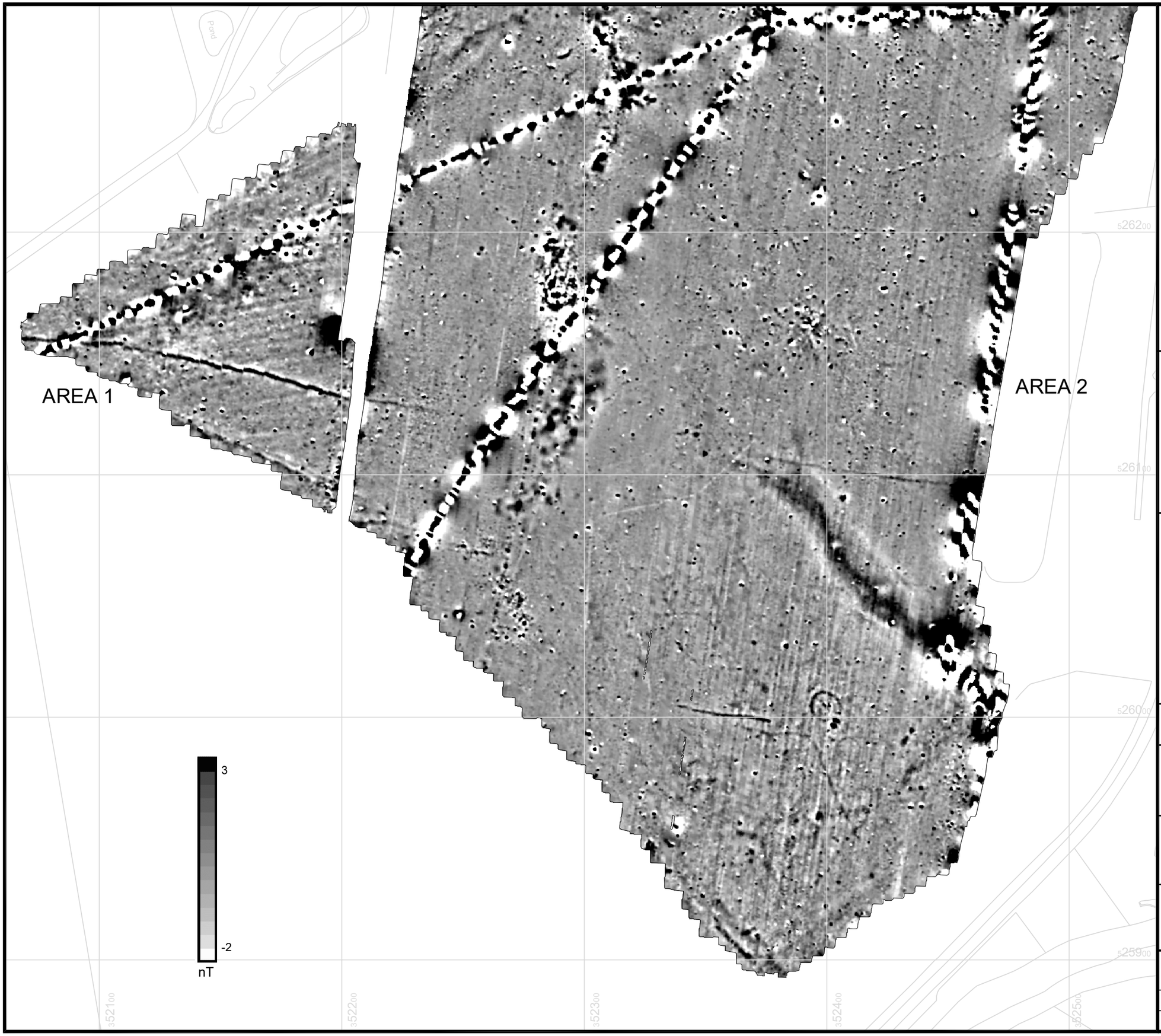
Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
EXTENSION TO LOWTHER HOLIDAY PARK
LOWTHER, CUMBRIA

Title
LOCATION OF SITE SHOWING MAGNETIC GRADIENT DATA

Job No
ARC_2861_1067

Surveyed	JW, PW	Drawn	JW, MW
Chk.	NF	Date	10/09/2020



NOTES

1. THIS DRAWING MUST BE USED IN CONJUNCTION WITH THE ACCOMPANYING REPORT (ARC_2861_1067_RPT.PDF) WHICH PROVIDES DETAILS OF THE TECHNIQUES EMPLOYED, THEIR INHERENT LIMITATIONS AND ANY SITE SPECIFIC ISSUES.
2. THIS DRAWING IS BASED UPON DRAWING '1004 - Site Plan - Rev A.dwg' PROVIDED BY THE CLIENT. THE ORDNANCE SURVEY CO-ORDINATES OBTAINED FOR THIS SURVEY WERE MEASURED USING THE UK OSTN02 PROJECTION. THIS PROJECTION SHOULD BE TAKEN INTO ACCOUNT IF THE SURVEY GRID IS RELOCATED.
3. PHASE SITE INVESTIGATIONS CANNOT ACCEPT RESPONSIBILITY FOR THE RELIABILITY OR ACCURACY OF ANY INFORMATION PROVIDED BY A THIRD PARTY.
4. THIS DRAWING AND THE INFORMATION CONTAINED THEREIN IS ISSUED IN CONFIDENCE AND IS THE COPYRIGHT OF PHASE SITE INVESTIGATIONS LIMITED. DISCLOSURE OF THIS INFORMATION TO THIRD PARTIES AND UNAUTHORISED COPYING OR REPLICATION OF THIS DATA WITHOUT APPROVAL IS FORBIDDEN.

ALWAYS EXERCISE CAUTION WHEN EXCAVATING

N

PHASE SITE INVESTIGATIONS

Phase Site Investigations Ltd, 703A Whinfield Drive, Aycliffe Business Park, Newton Aycliffe, County Durham, DL5 6AU

T: +44 [0] 01325 311 751
E: enquiries@PhaseSI.com
W: www.PhaseSI.com

Scale [A3 Sheet]	Drawing	Status
1:1500	ARC_2861_1067_03	FINAL

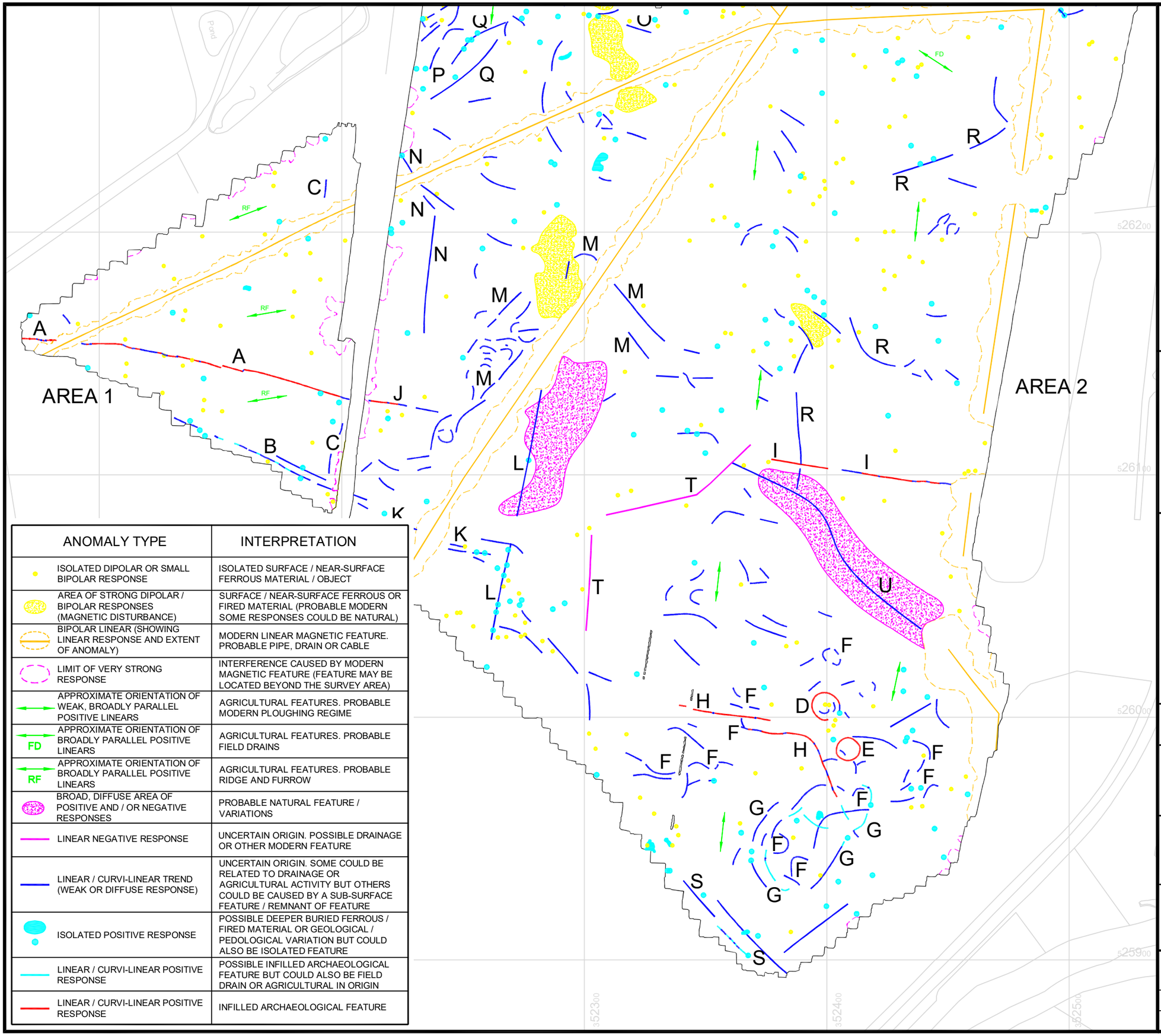
Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
EXTENSION TO LOWTHER HOLIDAY PARK
LOWTHER, CUMBRIA

Title GREYSCALE PLOTS OF MAGNETIC GRADIENT DATA: AREA 1 AND CENTRE AND SOUTH OF AREA 2

Job No
ARC_2861_1067

Surveyed	JW, PW	Drawn	MW
Chk.	NF	Date	10/09/2020



ANOMALY TYPE	INTERPRETATION
ISOLATED DIPOLAR OR SMALL BIPOLAR RESPONSE	ISOLATED SURFACE / NEAR-SURFACE FERROUS MATERIAL / OBJECT
AREA OF STRONG DIPOLAR / BIPOLAR RESPONSES (MAGNETIC DISTURBANCE)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN SOME RESPONSES COULD BE NATURAL)
BIPOLAR LINEAR (SHOWING LINEAR RESPONSE AND EXTENT OF ANOMALY)	MODERN LINEAR MAGNETIC FEATURE. PROBABLE PIPE, DRAIN OR CABLE
LIMIT OF VERY STRONG RESPONSE	INTERFERENCE CAUSED BY MODERN MAGNETIC FEATURE (FEATURE MAY BE LOCATED BEYOND THE SURVEY AREA)
APPROXIMATE ORIENTATION OF WEAK, BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE MODERN PLOUGHING REGIME
APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS (FD)	AGRICULTURAL FEATURES. PROBABLE FIELD DRAINS
APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS (RF)	AGRICULTURAL FEATURES. PROBABLE RIDGE AND FURROW
BROAD, DIFFUSE AREA OF POSITIVE AND / OR NEGATIVE RESPONSES	PROBABLE NATURAL FEATURE / VARIATIONS
LINEAR NEGATIVE RESPONSE	UNCERTAIN ORIGIN. POSSIBLE DRAINAGE OR OTHER MODERN FEATURE
LINEAR / CURVI-LINEAR TREND (WEAK OR DIFFUSE RESPONSE)	UNCERTAIN ORIGIN. SOME COULD BE RELATED TO DRAINAGE OR AGRICULTURAL ACTIVITY BUT OTHERS COULD BE CAUSED BY A SUB-SURFACE FEATURE / REMNANT OF FEATURE
ISOLATED POSITIVE RESPONSE	POSSIBLE DEEPER BURIED FERROUS / FIRED MATERIAL OR GEOLOGICAL / PEDOLOGICAL VARIATION BUT COULD ALSO BE ISOLATED FEATURE
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	POSSIBLE INFILLED ARCHAEOLOGICAL FEATURE BUT COULD ALSO BE FIELD DRAIN OR AGRICULTURAL IN ORIGIN
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	INFILLED ARCHAEOLOGICAL FEATURE

NOTES

1. THIS DRAWING MUST BE USED IN CONJUNCTION WITH THE ACCOMPANYING REPORT (ARC_2861_1067_RPT.PDF) WHICH PROVIDES DETAILS OF THE TECHNIQUES EMPLOYED, THEIR INHERENT LIMITATIONS AND ANY SITE SPECIFIC ISSUES.
2. THIS DRAWING IS BASED UPON DRAWING '1004 - Site Plan - Rev A.dwg' PROVIDED BY THE CLIENT. THE ORDNANCE SURVEY CO-ORDINATES OBTAINED FOR THIS SURVEY WERE MEASURED USING THE UK OSTN02 PROJECTION. THIS PROJECTION SHOULD BE TAKEN INTO ACCOUNT IF THE SURVEY GRID IS RELOCATED.
3. PHASE SITE INVESTIGATIONS CANNOT ACCEPT RESPONSIBILITY FOR THE RELIABILITY OR ACCURACY OF ANY INFORMATION PROVIDED BY A THIRD PARTY.
4. THIS DRAWING AND THE INFORMATION CONTAINED THEREIN IS ISSUED IN CONFIDENCE AND IS THE COPYRIGHT OF PHASE SITE INVESTIGATIONS LIMITED. DISCLOSURE OF THIS INFORMATION TO THIRD PARTIES AND UNAUTHORISED COPYING OR REPLICATION OF THIS DATA WITHOUT APPROVAL IS FORBIDDEN.

ALWAYS EXERCISE CAUTION WHEN EXCAVATING

N

PHASE SITE INVESTIGATIONS

Phase Site Investigations Ltd, 703A Whinfield Drive, Aycliffe Business Park, Newton Aycliffe, County Durham, DL5 6AU

T: +44 [0] 01325 311 751
E: enquiries@PhaseSI.com
W: www.PhaseSI.com

Scale [A3 Sheet]	Drawing	Status
1:1500	ARC_2861_1067_04	FINAL

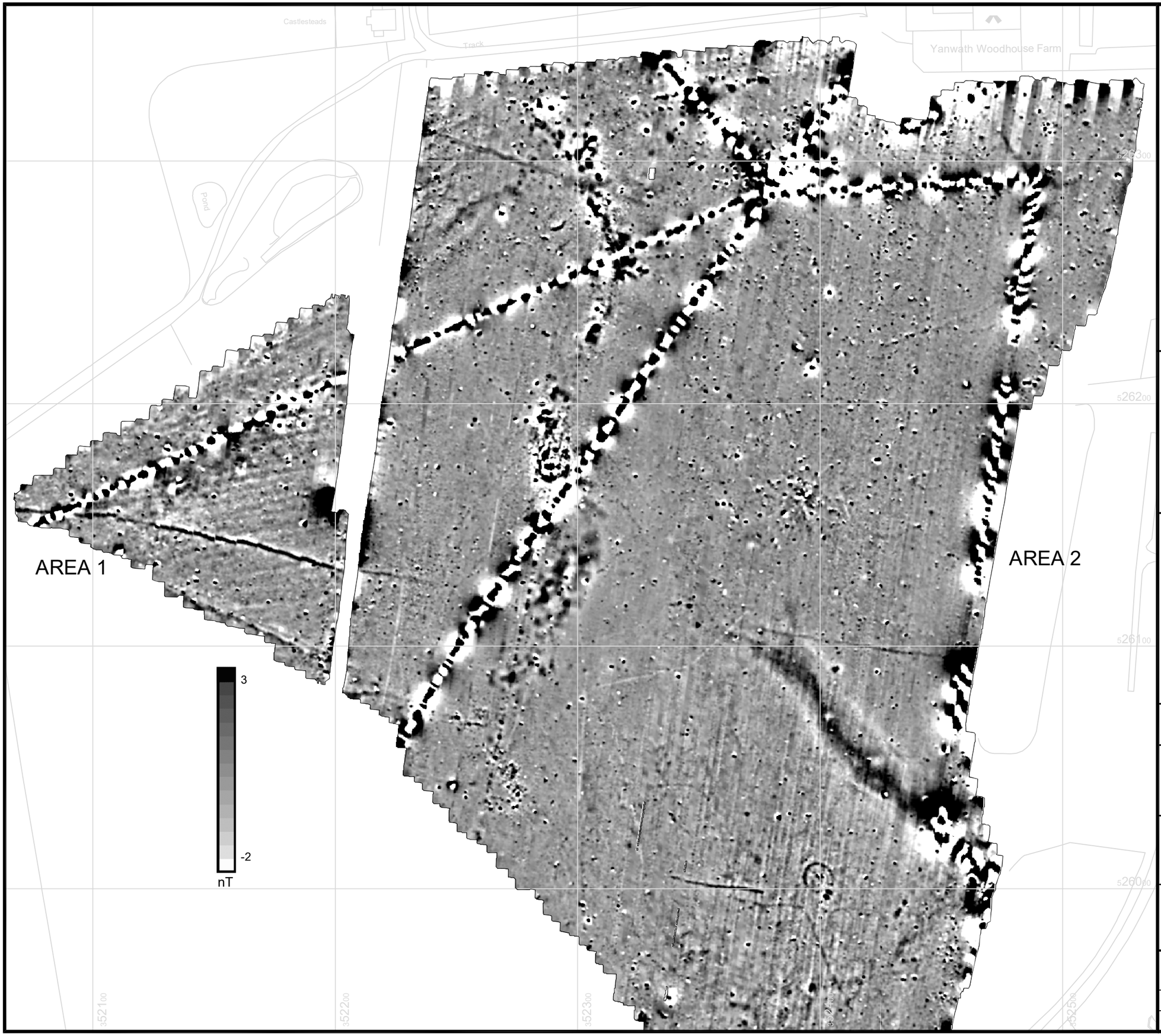
Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
EXTENSION TO LOWTHER HOLIDAY PARK
LOWTHER, CUMBRIA

Title
INTERPRETATION OF MAGNETIC GRADIENT DATA: AREA 1 AND CENTRE AND SOUTH OF AREA 2

Job No
ARC_2861_1067

Surveyed	JW, PW	Drawn	JW, MW
Chk.	NF	Date	10/09/2020



NOTES

1. THIS DRAWING MUST BE USED IN CONJUNCTION WITH THE ACCOMPANYING REPORT (ARC_2861_1067_RPT.PDF) WHICH PROVIDES DETAILS OF THE TECHNIQUES EMPLOYED, THEIR INHERENT LIMITATIONS AND ANY SITE SPECIFIC ISSUES.
2. THIS DRAWING IS BASED UPON DRAWING '1004 - Site Plan - Rev A.dwg' PROVIDED BY THE CLIENT. THE ORDNANCE SURVEY CO-ORDINATES OBTAINED FOR THIS SURVEY WERE MEASURED USING THE UK OSTN02 PROJECTION. THIS PROJECTION SHOULD BE TAKEN INTO ACCOUNT IF THE SURVEY GRID IS RELOCATED.
3. PHASE SITE INVESTIGATIONS CANNOT ACCEPT RESPONSIBILITY FOR THE RELIABILITY OR ACCURACY OF ANY INFORMATION PROVIDED BY A THIRD PARTY.
4. THIS DRAWING AND THE INFORMATION CONTAINED THEREIN IS ISSUED IN CONFIDENCE AND IS THE COPYRIGHT OF PHASE SITE INVESTIGATIONS LIMITED. DISCLOSURE OF THIS INFORMATION TO THIRD PARTIES AND UNAUTHORISED COPYING OR REPLICATION OF THIS DATA WITHOUT APPROVAL IS FORBIDDEN.

ALWAYS EXERCISE CAUTION WHEN EXCAVATING

N

PHASE SITE INVESTIGATIONS

Phase Site Investigations Ltd, 703A Whinfield Drive, Aycliffe Business Park, Newton Aycliffe, County Durham, DL5 6AU

T: +44 [0] 01325 311 751
E: enquiries@PhaseSI.com
W: www.PhaseSI.com

Scale [A3 Sheet]	Drawing	Status
1:1500	ARC_2861_1067_05	FINAL

Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

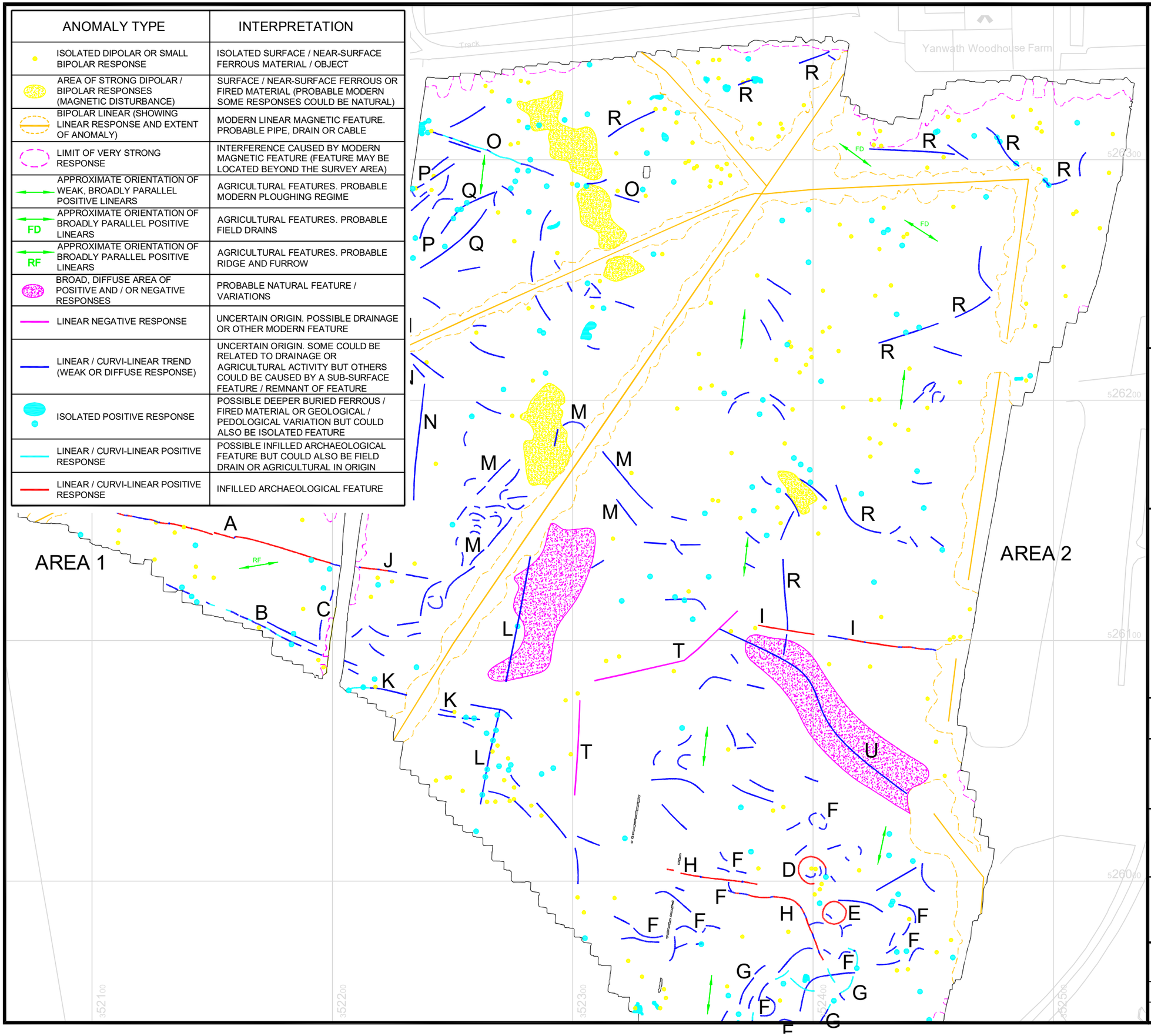
Site
EXTENSION TO LOWTHER HOLIDAY PARK
LOWTHER, CUMBRIA

Title GREYSCALE PLOTS OF MAGNETIC GRADIENT DATA: NORTH AND CENTRE OF AREA 2 AND AREA 1

Job No
ARC_2861_1067

Surveyed	JW, PW	Drawn	MW
Chk.	NF	Date	10/09/2020

ANOMALY TYPE	INTERPRETATION
ISOLATED DIPOLAR OR SMALL BIPOLAR RESPONSE	ISOLATED SURFACE / NEAR-SURFACE FERROUS MATERIAL / OBJECT
AREA OF STRONG DIPOLAR / BIPOLAR RESPONSES (MAGNETIC DISTURBANCE)	SURFACE / NEAR-SURFACE FERROUS OR FIRED MATERIAL (PROBABLE MODERN SOME RESPONSES COULD BE NATURAL)
BIPOLAR LINEAR (SHOWING LINEAR RESPONSE AND EXTENT OF ANOMALY)	MODERN LINEAR MAGNETIC FEATURE. PROBABLE PIPE, DRAIN OR CABLE
LIMIT OF VERY STRONG RESPONSE	INTERFERENCE CAUSED BY MODERN MAGNETIC FEATURE (FEATURE MAY BE LOCATED BEYOND THE SURVEY AREA)
APPROXIMATE ORIENTATION OF WEAK, BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE MODERN PLOUGHING REGIME
FD APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE FIELD DRAINS
RF APPROXIMATE ORIENTATION OF BROADLY PARALLEL POSITIVE LINEARS	AGRICULTURAL FEATURES. PROBABLE RIDGE AND FURROW
BROAD, DIFFUSE AREA OF POSITIVE AND / OR NEGATIVE RESPONSES	PROBABLE NATURAL FEATURE / VARIATIONS
LINEAR NEGATIVE RESPONSE	UNCERTAIN ORIGIN. POSSIBLE DRAINAGE OR OTHER MODERN FEATURE
LINEAR / CURVI-LINEAR TREND (WEAK OR DIFFUSE RESPONSE)	UNCERTAIN ORIGIN. SOME COULD BE RELATED TO DRAINAGE OR AGRICULTURAL ACTIVITY BUT OTHERS COULD BE CAUSED BY A SUB-SURFACE FEATURE / REMNANT OF FEATURE
ISOLATED POSITIVE RESPONSE	POSSIBLE DEEPER BURIED FERROUS / FIRED MATERIAL OR GEOLOGICAL / PEDOLOGICAL VARIATION BUT COULD ALSO BE ISOLATED FEATURE
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	POSSIBLE INFILLED ARCHAEOLOGICAL FEATURE BUT COULD ALSO BE FIELD DRAIN OR AGRICULTURAL IN origin
LINEAR / CURVI-LINEAR POSITIVE RESPONSE	INFILLED ARCHAEOLOGICAL FEATURE



NOTES

1. THIS DRAWING MUST BE USED IN CONJUNCTION WITH THE ACCOMPANYING REPORT (ARC_2861_1067_RPT.PDF) WHICH PROVIDES DETAILS OF THE TECHNIQUES EMPLOYED, THEIR INHERENT LIMITATIONS AND ANY SITE SPECIFIC ISSUES.
2. THIS DRAWING IS BASED UPON DRAWING '1004 - Site Plan - Rev A.dwg' PROVIDED BY THE CLIENT. THE ORDNANCE SURVEY CO-ORDINATES OBTAINED FOR THIS SURVEY WERE MEASURED USING THE UK OSTN02 PROJECTION. THIS PROJECTION SHOULD BE TAKEN INTO ACCOUNT IF THE SURVEY GRID IS RELOCATED.
3. PHASE SITE INVESTIGATIONS CANNOT ACCEPT RESPONSIBILITY FOR THE RELIABILITY OR ACCURACY OF ANY INFORMATION PROVIDED BY A THIRD PARTY.
4.

ALWAYS EXERCISE CAUTION WHEN EXCAVATING

N

PHASE SITE INVESTIGATIONS

Phase Site Investigations Ltd, 703A Whinfield Drive, Aycliffe Business Park, Newton Aycliffe, County Durham, DL5 6AU

T: +44 [0] 01325 311 751
E: enquiries@PhaseSI.com
W: www.PhaseSI.com

Scale [A3 Sheet]	Drawing	Status
1:1500	ARC_2861_1067_06	FINAL

Client
GREENLANE ARCHAEOLOGY LTD
ULVERSTON

Site
EXTENSION TO LOWTHER HOLIDAY PARK
LOWTHER, CUMBRIA

Title
INTERPRETATION OF MAGNETIC GRADIENT DATA: NORTH AND CENTRE OF AREA 2 AND SOUTH OF AREA 1

Job No
ARC_2861_1067

Surveyed	JW, PW	Drawn	JW, MW
Chk.	NF	Date	10/09/2020

BIBLIOGRAPHY AND REFERENCES

Greenlane Archaeology Ltd, 2020, Extension to Lowther Holiday Park, Lowther, Cumbria: Heritage Impact Assessment

British Geological Survey, 2020, online resource - www.bgs.ac.uk

APPENDIX 1

Magnetic survey: technical information

1.1 Theoretical background

1.1.1 Magnetic instruments measure the value of the Earth's magnetic field; the units of which are nanoTeslas (nT). The presence of surface and sub-surface features can cause variations or anomalies in this magnetic field. The strength of the anomaly is dependent on the magnetic properties of a feature and the material that surrounds it. The two magnetic properties that are of most interest are magnetic susceptibility and thermoremnant magnetism.

1.1.2 Magnetic susceptibility indicates the amount of ferrous (iron) minerals that are present. These can be redistributed or changed (enhanced) by human activity. If enhanced material subsequently fills in features such as pits or ditches then these can produce localised increases in magnetic responses (anomalies) which can be detected by a magnetic gradiometer even when the features are buried under additional soil cover.

1.1.3 In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of topsoils, subsoils and rocks into which these features have been cut which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected. Less magnetic material such as masonry or plastic service pipes which intrude into the topsoil may give a negative magnetic response relative to the background level. The strength of magnetic responses that a feature will produce will depend on the background magnetic susceptibility, how rapidly the feature has been infilled, the level and type of human activity in the area and the size and depth of a feature. Not all infilled features can be detected and natural variations can also produce localised positive and negative anomalies.

1.1.4 Thermoremnant magnetism indicates the amount of magnetism inherent in an object as a result of heating. Material that has been heated to a high temperature (fired), such as brick, can acquire strong magnetic properties and so although they may not appear to have a high iron content they can produce strong magnetic anomalies

1.1.5 The magnetic survey method is highly sensitive to interference from surface and near-surface magnetic 'contaminants'. Surface features such as metallic fencing, reinforced concrete, buildings or walls all have very strong magnetic signatures that can dominate readings collected adjacent to them. Identification of anomalies caused by sub-surface features is therefore more difficult, or even impossible, in the vicinity of surface magnetic features. The presence of made ground also has a detrimental effect on the magnetic data quality as this usually contains magnetic material in the form of metallic scrap and brick. Identification of features beneath made ground is still possible if the target feature is reasonably large and has a strong magnetic response but smaller features or magnetically weak features are unlikely to be identified.

1.1.6 The interpretation of magnetic anomalies is often subjective and it is rarely possible to identify the cause of all magnetic anomalies. Not all features will produce a measurable magnetic response and the effectiveness of a magnetic survey is also dependant on the site-specific conditions. The main factors that may limit whether a feature can be detected are the

composition of a feature, its depth and size and the surrounding material. It is not possible to guarantee that a magnetic survey will identify all sub-surface features.

1.1.7 Most high resolution, near surface magnetic surveys utilise a magnetic gradiometer. A gradiometer is a hand-held instrument that consists of two magnetic sensors, one positioned directly above the other, which allows measurement of the magnetic gradient component of the magnetic field. A gradiometer configuration eliminates the need for applying corrections due to natural variations in the overall field strength that occur during the course of a day but it only measures relative variations in the local magnetic field and so comparison of absolute values between sites is not possible.

1.1.8 Features that are commonly located using magnetic surveys include archaeological ditches and pits, buried structures or foundations, mineshafts, unexploded ordnance, metallic pipes and cables, buried piles and pile caps. The technique can also be used for geological mapping; particularly the location of igneous intrusions.

1.2 Instrumentation

1.2.1 A multi-sensor array cart system (MACS) utilising 8 Foerster 4.032 Ferex CON 650 gradiometers, spaced at 0.5 m intervals, with a control unit and data logger was used for the magnetic survey.

1.3 Survey methodology

1.3.1 The MACS utilises an RTK GNSS system which means that survey grids do not have to be established. Instead an area is surveyed over a series of continuous profiles and the position of each data point is recorded using an RTK GNSS system. The sensors have a separation of 0.5 m which means that data was collected on profiles spaced at 0.5 m apart. Readings were taken at between 0.1 m and 0.15 m intervals.

1.3.2 Data is collected on zig-zag profiles along the full length or width of a field, although fields can be sub-divided if they are particularly large. Marker canes are set-out along field boundaries at set intervals and these are used to align the profiles. The survey profiles are usually offset from field boundaries, buildings and other metallic features by several metres to reduce the detrimental effect that these surface magnetic features have on the data. The location of the MACS data is converted direct to Ordnance Survey co-ordinates using the UK OSTN 02 projection. As the data is related direct to Ordnance Survey National Grid co-ordinates temporary survey stations are not established.

1.3.3 The Foerster gradiometers have a resolution of 0.2 nT but the stability of the cart system significantly reduces noise caused by instrument tilt and movement when compared with a traditional hand-held gradiometer system and the increased data intervals provide a higher resolution data set. The sensors have a range of ± 10,000nT and readings are taken at 0.1 nT resolution.

1.4 Data processing and presentation

1.4.1 The MACS data is stored direct to a laptop using in-house software which automatically corrects for instrument drift and calculates a mean value for each profile. A positional value is assigned to each data point based on the sensor number and recorded GNSS co-ordinates. The data is gridded using in-house software and parameters are set based on the sensor spacing and mean values. No additional processing is required. The gridded data is then displayed in Surfer 9 (Golden Software) and image files of the data are created.

1.4.2 The data was exported as greyscale raster images (PNG files). Data for the entire site is presented at a scale of 1:3000 and plots for individual fields / areas (or parts of fields / areas) with accompanying interpretations are shown at a scale of 1:1500. All greyscale plots were clipped at -2 nT to 3 nT. Greyscale plots have been 'smoothed' using a visual interpolation but the data itself has not been interpolated.

1.4.3 The data has been displayed relative to a digital Ordnance Survey base plan provided by the client as drawing *'1004 - Site Plan - Rev A.dwg'*. The base plan was in the Ordnance Survey National Grid co-ordinate system and as the survey grids were set-out directly to National Grid co-ordinates the data could be simply superimposed onto the base plan in the correct position.

1.5 Interpretation

1.5.1 The anomalies have been categorised based on the type of response that they have and an interpretation as to the cause(s) or possible cause(s) of each anomaly type is also provided. The following anomaly types may be present within the data:

Dipolar, bipolar and strong responses

Dipolar and bipolar responses are those that have a sharp variation between strongly positive and negative components.

In the majority of cases these responses are usually caused by modern ferrous features / objects, although fired material (such as brick), some ferrous or industrial archaeological features and strongly magnetic gravel could also produce dipolar and bipolar responses.

Isolated dipolar responses are those that have a single positive and negative element. They are usually caused by isolated, ferrous or fired material on or near to the surface. The objects that cause dipolar responses are usually relatively small, such as spent shotgun cartridges, iron nails and horseshoes (hence they are often referred to as 'iron spikes') or pieces of modern brick or pot. Some types of archaeological artefacts can also produce this type of response but unless there is strong supporting evidence to the contrary they are assumed not to be of archaeological significance.

Bipolar anomalies have strong positive and negative components but are not technically magnetic dipoles. The majority of **isolated bipolar responses** are caused by ferrous or fired material on or near to the surface. These responses tend to be produced from larger objects, compared to dipolar anomalies, or a concentration of smaller objects. Some archaeological features/ activity, including areas of burning or industrial activity can also produce this type of response but unless there is strong supporting evidence to the contrary they are assumed not to be of archaeological significance.

A large majority, if not all, of the dipolar and bipolar responses at this site will be non-archaeological in origin but there may be greater potential for them to be related to archaeological features / activity where they are located in proximity to probable or possible archaeological features.

Bipolar linear anomalies are usually produced by buried pipes / cables that are usually metallic, although in some instances ceramic pipes can also produce popular anomalies. In some instances the anomaly can extend for a significant distance beyond the feature that produces the anomaly. Bipolar anomalies are often very strong and can potentially mask responses from other sub-surface features in the vicinity of the pipe or cable.

Areas containing numerous **strong dipolar / bipolar responses (magnetic disturbance)** are usually caused by greater concentrations of ferrous or fired material and are often found adjacent to field boundaries where such material tends to accumulate. Above ground metallic or strongly magnetic features, such as fences, gates, pylons and buildings can also produce very strong bipolar responses. If an area of magnetic disturbance is located away from existing field boundaries then it could indicate a former field boundary, several large isolated objects in close proximity, an area where modern material has been tipped or an infilled cut feature, such as a quarry pit. Areas of dipolar / bipolar response can occasionally be caused by features / material associated with archaeological industrial activity or natural deposits that have varying magnetic properties but they are usually caused by modern activity. Responses in areas of magnetic disturbance can sometimes be so strong that archaeological features located beneath them may not be detected.

Very strong responses, notably bipolar anomalies, from modern features can dominate the data for a significant distance beyond the feature. The extent of these areas is usually shown either as part of the bipolar anomaly or as a **limit of very strong response.** It should be noted that this effect extends beyond the feature and so the limit of the response does not correspond to the actual size or location of the feature within it. In many cases where these strong responses are present at the edge of survey area the feature causing the anomaly be actually be located beyond the survey area. It should be recognised that other sub-surface features located within these areas may not be detected.

Negative linear anomalies

Negative linear anomalies occur when a feature has lower magnetic readings than the surrounding material and can often be associated with ploughing regimes or plastic / concrete pipes or natural features.

They can also indicate the presence of a feature that cuts into magnetic soils or bedrock and which is infilled with less magnetic material and in certain geologies can be associated with archaeological features.

Linear / curvi-linear anomalies (probable agricultural)

In many geological / pedological conditions agricultural features / regimes can produce magnetic anomalies due to the accumulation / alignment of magnetic topsoil. In most cases these are exhibited as a series of **broadly parallel positive linear** anomalies. The majority of these responses are associated with modern ploughing regimes but in some instances, where the responses are broader and more widely spaced, they can indicate the presence of the remnants of ridge and furrow.

Field drain systems can also produce linear anomalies, usually where the drains are made from fired ceramic or infilled with magnetic gravels.

Where a series of parallel anomalies are present then the approximate orientation of the anomalies are shown on the interpretation drawing to indicate the direction of the agricultural regime but for the sake of clarity individual anomalies have not been shown.

Individual anomalies may be shown if the response is not part of a regime.

Broad area of positive / negative responses

Broad areas of positive / negative responses can have a variety of causes. If the areas are generally quite large and irregular in shape then they are usually suggestive of natural features, such as lenses of sand and gravel deposits, palaeochannels or other natural

features / variations where the natural material differs from the surrounding sub-surface. In some instances anomalies of this type can be associated with anthropogenic (usually modern) activity.

Linear / curvi-linear trends

An anomaly is categorised as a **trend** if it is not certain that the response is associated with an extant sub-surface feature. Trends are usually weak, irregular, diffuse or discontinuous and it is usually not certain what their cause is, if they represent significant sub-surface features or even if they are associated with definite features.

It is possible that some of the trends are associated with geological / pedological variations. Others may be produced by artificial constructs within the data, either caused by processing or in some instances by intersecting anomalies (usually different agricultural regimes) that give the appearance of curving or regular shapes. Many trends are a product of weak, naturally occurring responses that happen to form a regular pattern but which are not associated with a sub-surface feature.

In some instances former features that have been severely truncated can still produce broad, diffuse or weak responses even if the underlying feature has been removed. This is due to the presence of magnetic soils associated with the former feature still being present along its route. In other instances the magnetic properties of the soils filling a feature may vary and so the magnetic signature of the feature can change, even if the sub-surface feature itself remains uniform. If a response from a feature becomes significantly weak or diffuse then part of the anomaly may be shown as a trend as it is uncertain if the feature is still present or has been severely truncated or removed.

Isolated positive responses

Isolated positive responses can occur if the magnetism of a feature, area or material has been enhanced or if a feature is naturally more magnetic than the surrounding material. It is often difficult to determine which of these factors causes any given responses and so the origin of this type of anomaly can be difficult to determine. They can have a variety of causes including geological variations, infilled archaeological features, areas of burning (including hearths), industrial archaeological features, such as kilns, or deeper buried ferrous material and modern fired material.

Larger or stronger areas of positive response have been shown on the interpretation as have those isolated responses located in close proximity to possible or probable archaeological features. These anomalies could also be associated with geological / pedological variations but their size or proximity to other anomalies increases their archaeological potential.

Positive linear / curvi-linear anomalies

Positive magnetic anomalies indicate an increase in magnetism and if the resulting anomaly is linear or curvi-linear then this can indicate the presence of a man-made feature. **Positive or enhanced linear / curvi-linear** anomalies can be associated with agricultural activity, drainage features but they can also be caused by ditches that are infilled with magnetically enhanced material and as such can indicate the presence of archaeological features. Some natural infilled features can also produce positive anomalies.

1.5.2 Several different ranges of data were used in the interpretation to ensure that the maximum information possible is obtained from the data.

1.5.3 X-Y trace plots were examined for all of the data and overlain onto the greyscale plot to assist in the interpretation, primarily to help identify dipolar / bipolar responses that will probably be associated with surface / near-surface iron objects. X-Y trace plots have not been used in the report as they do not show any additional anomalies that are not visible in the greyscale

data. A digital drawing showing the X-Y trace plot overlain on the greyscale plot has been provided in the digital archive.

1.5.4 All isolated responses have been assessed using a combination of greyscale and X-Y trace plots.

1.5.5 Anomalies associated with agricultural regimes are present in the data. The general orientation of these regimes has been shown on the interpretation but, for the sake of clarity, each individual anomaly has not been shown.

1.5.6 The greyscale plots and the accompanying interpretations of the anomalies identified in the magnetic data are presented as 2D AutoCAD drawings. The interpretation is made based on the type, size, strength and morphology of the anomalies, coupled with the available information on the site conditions. Each type of anomaly is displayed in separate, easily identifiable layers annotated as appropriate.

1.6 Limitations of magnetic surveys

1.6.1 The magnetic survey method requires the operator to walk over the site at a constant walking pace whilst holding the instrument. The presence of an uneven ground surface, dense, high or mature vegetation or surface obstructions may mean that some areas cannot be surveyed.

1.6.2 The depth at which features can be detected will vary depending on their composition, size, the surrounding material and the type of magnetometer used for the survey. In good conditions large, magnetic targets, such as buried drums or tanks can be located at depths of more than 4 m. Smaller targets, such as buried foundations or archaeological features can be located at depths of between 1 m and 2 m.

1.6.3 A magnetic survey is highly sensitive to interference from surface and near-surface magnetic 'contaminants'. Surface features such as metallic fencing, reinforced concrete, buildings or walls all have very strong magnetic signatures that can dominate readings collected adjacent to them. Identification of anomalies caused by sub-surface features is therefore more difficult or even not possible in the vicinity of surface and near-surface magnetic features.

1.6.4 The presence of made ground also has a detrimental effect on the magnetic data quality as this usually contains magnetic material in the form of metallic scrap and brick. Identification of features beneath made ground is still possible if the target feature is reasonably large and has a strong magnetic response but smaller features or magnetically weak features are unlikely to be identified.

1.6.5 It should be noted that anomalies that are interpreted as modern in origin may be caused by features that are present in the topsoil or upper layers of the subsoil. Removal of soil to an archaeological or natural layer can therefore remove the feature causing the anomaly.

1.6.6 A magnetic survey does not directly locate sub-surface features - it identifies variations or anomalies in the local magnetic field caused by features. It can be possible to interpret the cause of anomalies based on the size, shape and strength of response but it should be recognised that a magnetic survey produces a plan of magnetic variations and not a plan of all sub-surface features. Interpretation of the anomalies is often subjective and it is rarely possible to identify the cause of all magnetic anomalies. Geological or pedological (soil) variations or features can produce responses similar to those caused by man-made (anthropogenic) features.

1.6.7 Anomalies identified by a magnetic survey are located in plan. It is not usually possible to obtain reliable depth information on the features that cause the anomalies.

1.6.8 Not all features will produce a measurable magnetic response and the effectiveness of a magnetic survey is also dependant on the site-specific conditions. It is not possible to guarantee that a magnetic survey will identify all sub-surface features. A magnetic survey is often most-effective at identifying sub-surface features when used in conjunction with other complementary geophysical techniques.