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surveys**

**Wynard Main Reinforcement Scheme
Northern Route: Embleton – Dalton Piercy
Geophysical Survey Report MSNZ05B**

**For
Trent and Peak Archaeology
On Behalf Of
Anglian Water**

Magnitude Surveys Ref: MSNZ05B

November 2015



magnitude surveys

Unit 17, Commerce Court

Challenge Way

Bradford

BD4 8NW

+44 (0)1274 926020

info@magnitudesurveys.co.uk

Report Written by:

Graeme Attwood MSc

Figures Produced by:

Finnegan Pope-Carter BSc MSc FGS

Report Checked by:

Chrys Harris BA MSc

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Abstract

Magnitude Surveys was commissioned to assess the nature of the archaeological landscape across a ~4ha corridor of land between Embleton and Dalton Piercy, near Hartlepool, Tees Valley—using geophysical survey. The corridor's entire length was successfully surveyed using the magnetic method. An anomaly of probable archaeological origin has been detected and takes the form of a circular ditch-like feature, possibly pre-historic in origin. The magnetic survey has also detected many anomalies of undetermined origin, which are likely caused by agricultural or geological processes.

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1. Introduction

- 1.1. Magnitude Surveys Ltd (MS) was commissioned by Trent and Peak Archaeology (TPA) on behalf of Anglian Water (AW) to undertake a geophysical survey across a corridor of land from Amerston Hall, east of Embleton (NZ 427 303), toward Dalton Piercy (NZ 462 314), near Hartlepool, Tees Valley.
- 1.2. The geophysical survey comprised:
 - 1.2.1. Hand pulled, cart-mounted fluxgate gradiometer survey.
- 1.3. The survey was conducted in line with the current best practice guidelines produced by Historic England and the Chartered Institute of Field Archaeologists (CIfA 2014, *David et al.* 2008).
- 1.4. This survey was undertaken between the 9 November and the 11 November 2015.

2. Quality Assurance

- 2.1. Project management, survey work, data processing and report production have been carried out by qualified and professional geophysicists to standards exceeding the current best practice (CIfA 2014, *David et al.* 2008).
- 2.2. Magnitude Surveys is a corporate member of ISAP (International Society of Archaeological Prospection).
- 2.3. Finnegan Pope-Carter is a Fellow of the London Geological Society, the Chartered UK body for geophysicists and geologists.

3. Objectives

- 3.1. The geophysical survey aimed to assess the nature of the archaeological landscape of the survey area.
- 3.2. The survey forms part of the archaeological mitigation required by the planning archaeologist and shall be used to inform the location of any trenches, should they be required.

4. Geographic Background

- 4.1. The underlying geology comprises Roxby formation (mudstone) and Ford formation (dolostone) with superficial deposits of Devensian till (BGS 2015). Historic England guidelines state mudstone geology can produce average magnetic responses, with variable responses over till, depending on depth (*David et al.* 2008).
- 4.2. The soils are primarily slowly permeable, seasonally wet slightly acid but base-rich loamy and clayey soils (Soilscape 2015).
- 4.3. The survey corridor was predominately flat at the western end, rising towards a summit on Amerston Hill, where the land levelled before dropping steeply into a stream. From the stream the land rose to a high point of 85m OD north of the Red Lion farm, before gently dropping to the A19. East of the A19, the land rose steadily to Dalton Piercy. The land use was a mixture of pasture and arable. The arable land had recently been sown, causing no hindrance to survey. A 50m length at the western end of Area 2 could not be surveyed due to recent ploughing, which created a terrain unsuitable for survey work.

5. Archaeological Background

- 5.1. The survey area has not been the subject of any previous archaeological geophysical surveys or other archaeological work.
- 5.2. The archaeological brief for the project states that:

...the general area was highly populated from at least the later Iron Age onwards (e.g. ring ditches at Red Gap Moor – HER 8076), with major multi-period sites at Stob House (HER 0609) and east of Brierton (HER 8263).

During the medieval period the area included nucleated settlements at Dalton Piercy (HER 0682) and Brierton (HER 0772) with a complex of dispersed farmsteads such as Amerston Hall (HER 8142) Close Farm (HER 0638), Red Gap (HER 0600) and High Stotfold (HER 8238). (Rowe P, 2015).

- 5.3. Along the line of the proposed pipeline route there have been a number of artefacts recorded including prehistoric flint (HER 1670 & 1699) prehistoric animal remains (HER 825) and Romano British pottery (HER 1756 & 1758). A First World War army barracks (HER 8400) is recorded approximately 200m south of the Pipeline at the eastern end north of Dalton Piercy (Tees Archaeology 2015).

6. Methodology:

6.1. Data Collection:

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

- 6.1.2. Table of survey strategies:

Method	Instrument	Traverse Interval	Sample Interval
Magnetic	Bartington Instruments 1000L fluxgate gradiometer	1m	10Hz reprojected to 0.125m

- 6.1.3. Magnetic data were collected using a bespoke hand-pulled cart system.

- 6.1.4. The cart system supports the magnetic and GPS instruments with a bespoke datalogger. The magnetic instruments comprise two Bartington Instruments 1000L fluxgate gradiometers operating in NMEA mode. Positional referencing is through a Hemisphere S320 RTK GPS outputting in NMEA mode. Corrections were made through Topcon TopNet. Data from both instruments were logged in a bespoke datalogger. Data were transferred to a laptop computer for processing.

- 6.1.5. A series of temporary sight markers were established in each survey area to guide the surveyor and ensure full coverage with the cart. Data were collected by traversing the survey area along the longest possible lines, to ensure that the data was efficiently collected and processed.

6.2. Data Processing

6.2.1. Data were processed in bespoke in-house software produced by MS.

6.2.2. Magnetic processing steps were limited to:

Zero Median Traverse – The median of each sensor traverse is calculated within a specified range and subtracted from the collected data. This removes striping affects caused by small variations in sensor electronics. Care is taken to ensure this filter does not remove linear trends running parallel to the survey direction.

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

6.3.1. Greyscales should be viewed alongside the accompanying XY trace plots; these plots visualise the magnitude and form of the geophysical response, aiding in anomaly interpretation.

7. Survey Considerations

Refer to Figure 2 for survey area locations.

Survey Area	No. Survey Blocks	Surveyed Y/N	Ground Conditions	Further notes
1	1	Y	Short pasture	
2	1	Y	Stubble / Plough	A small area could not be surveyed due to ploughing in the field's western end.
3	1	Y	Stubble	
4	1	Y	Seedlings	
5	1	Y	Seedlings	
6	2	Y	Seedlings	
7	3	Y	Stubble	A narrow area could not be surveyed due to a strip of crop that had not been harvested.
8	1	Y	Seedlings	
9	1	Y	Seedlings	
10	1	Y	Young Crop	
11	1	Y	Young Crop	
12	1	Y	Stubble	
13	1	Y	Stubble	
14	1	Y	Stubble	

8. Results

8.1. Qualification

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

8.1.2. The corridor width has been set at 20m based on an agreement between Peter Rowe, Planning Archaeologist for Tees Valley and Anglian Water. Magnitude Surveys advises the minimum corridor width for such a linear survey should be 30m, as recommended by Historic England's 2008 "Geophysical Survey for Archaeological Field Evaluations" guidelines. The narrow swath of a 20m corridor can make interpreting the origin of magnetic anomalies more difficult, which can lead to a greater number of anomalies classified with a non-defined origin. Furthermore, wider survey coverage could assist the development process by providing potential alternative routes, in the event archaeological remains are discovered (David *et al.* 2008: 17).

8.2. Discussion

8.2.1. Anomalies have been categorised across the site through the interpretation of greyscale images and XY traces in conjunction with historic mapping and satellite imagery.

8.2.2. Magnetic survey has responded well to the survey area's geological and pedological environment, detecting modern soil disturbance and anomalies associated with archaeological and agricultural processes. A number of anomalies have been detected and classified as Undetermined; these anomalies exhibit characteristics of anomalies with possible archaeological origin, but could potentially be of agricultural, geological or pedological in origin. A number of buried utilities cross the survey area; the strong responses from these utilities may mask weaker features. In Area 6 an anomaly of likely archaeological origin has been detected, further discussed in section 8.3.6.

8.3. Interpretation

8.3.1. General Comments

- 8.3.1.1. Refer to Figure 2 for survey area locations.
- 8.3.1.2. Geophysical anomalies will be discussed broadly as classification types across the entire survey area. Only anomalies that are distinctive or unusual will be discussed individually in their respective areas sections.
- 8.3.1.3. **Undetermined** – Anomalies are classified as Undetermined when the anomaly origin is ambiguous through the geophysical results and there is no supporting or correlative evidence to warrant a more certain classification. These anomalies are likely to be the result of archaeological, geological or pedological processes and are generally not ferrous in nature.
- 8.3.1.4. **Ferrous** – A number of discrete ferrous-like anomalies have been mapped across the entire survey area. These responses are likely to be the result of modern metallic disturbance on or near the ground surface. Broad ferrous responses from modern metallic features, such as fences, gates, feeders and pipes may mask any weaker underlying archaeological anomalies.

8.3.2. Area 1

- 8.3.2.1. Refer to Figure 3 for the area's greyscale and Figure 14 for the area's interpretation.
- 8.3.2.2. **Ferrous** – An existing water main has been detected at the western end of the survey area. To the south of this is an additional ferrous anomaly, which is generated by a series of inspection covers located at the field's edge.

8.3.3. Area 3

- 8.3.3.1. Refer to Figure 4 for the area's greyscale and Figure 15 for the area's interpretation.
- 8.3.3.2. **Agricultural** - Ploughing trends oriented in a sub north-south alignment have been detected throughout this survey area. From the limited segments of ploughing visible in the greyscales, it is not possible to determine modern or historic ploughing origins.

8.3.4. Area 4

- 8.3.4.1. Refer to Figures 4 and 5 for the area's greyscales and Figures 15 and 16 for the area's interpretation.
- 8.3.4.2. **Agricultural** – The ploughing trends noted in Area 3 have also been detected in Area 4 along the same alignment.
- 8.3.4.3. **Ferrous** – A large ferrous anomaly was detected within the centre of the survey area. The cause of this anomaly has not been determined.

8.3.5. Area 6

- 8.3.5.1. Refer to Figure 6 for the area's greyscale and Figure 17 for the area's interpretation.
- 8.3.5.2. **Probable Archaeology** – A positive magnetic ring approximately 10m in diameter has been identified on the summit of the survey area. This ring is partially obscured by ridge and furrow (see below para. 8.3.6.2). Two small, pit-like anomalies have also been detected within this ring. With such a limited survey area, it is not possible to provide a context regarding this anomaly. However, the anomalies are almost certainly archaeological in origin: likely prehistoric, possibly a barrow ditch or roundhouse gully.
- 8.3.5.3. **Agricultural** – Very strong, positive magnetic linear anomalies have been detected at the western end of this survey area. Due to the form and magnitude of these responses, they likely result from a ridge and furrow ploughing system.
- 8.3.5.4. **Undetermined** – An amorphous negative response has been resolved in the centre of Area 6. When interpreted in conjunction with satellite imagery (Infoterra Ltd & Bluesky 2006 and 2008 Google Earth), the anomaly occurs in the same location as successive crop failures. However, the origin of the response remains undetermined.
- 8.3.5.5. Further faint linear anomalies in the vicinity of the probable archaeology ring feature have been categorised as Undetermined. Given their position near the ring anomaly, these anomalies have the potential to be archaeological in origin. However, due to the limited context of the survey area, an agricultural or natural origin cannot be ruled out.

8.3.6. Area 7

- 8.3.6.1. Refer to Figure 7 for the area's greyscale and Figure 18 for the area's interpretation.
- 8.3.6.2. A small band of crop remained around the edge of the field at the time of survey. Due to the thickness and height of the crop, survey was not possible up to the field boundary.
- 8.3.6.3. **Agricultural** – Positive magnetic anomalies on a north - south linear alignment bisect the data set. These are likely caused by ploughing.

8.3.7. Area 8

- 8.3.7.1. Refer to Figure 8 for the area's greyscale and Figure 19 for the area's interpretation.
- 8.3.7.2. **Ferrous** – A large ferrous anomaly has been detected in the centre of the survey area. No ground or supporting evidence provides evidence for this anomaly's origin.

8.3.7.3. **Agricultural** – Positive magnetic anomalies on a sub north - south linear alignment bisect the data set. These are likely caused by ploughing.

8.3.8. Area 9

8.3.8.1. Refer to Figures 9 and 10 for the area's greyscales and Figures 19 and 20 for the area's interpretation.

8.3.8.2. **Undetermined** – A group of linear and pit-like anomalies have been detected throughout the survey area. The 1856 six inch ordnance survey map of the area denotes a field boundary on a similar alignment to the survey traverses. It is therefore possible that one or more of these linear anomalies depict changes in the field divisions. However, due to the limited context of the survey area, the origin of these anomalies cannot be confidently classified.

8.3.8.3. **Agricultural** – Linear anomalies on a similar alignment to Area 8 have been detected and are likely ploughing trends.

8.3.9. Area 10

8.3.9.1. Refer to Figures 9 and 10 for the area's greyscales and Figures 20 and 21 for the area's interpretation.

8.3.9.2. **Agricultural** – Linear anomalies on a number of alignments have been detected. These anomalies likely reflect earlier sub-divisions of the field and the slightly different ploughing orientations of each field.

8.3.10. Area 12

8.3.10.1. Refer to Figures 11 and 12 for the area's greyscale and Figures 22 and 23 for the area's interpretation.

8.3.10.2. **Agricultural** – Various orientations and groupings of ploughing trends have been detected throughout this survey area.

8.3.11. Area 13

8.3.11.1. Refer to Figures 12 and 13 for the area's greyscales and Figures 23 and 24 for the area's interpretation.

8.3.11.2. **Agricultural** – Broad, positive magnetic anomalies orientated sub east-west have been detected in the survey area. These are likely caused by ridge and furrow cultivation.

8.3.12. Area 14

8.3.12.1. Refer to Figure 13 for the area's greyscale and Figure 24 for the area's interpretation.

8.3.12.2. **Undetermined** – A number of sinuous positive magnetic anomalies have been detected within the survey area. These are likely to be agricultural in origin but an geological or pedological origin cannot be ruled out.

9. Conclusions:

- 9.1. The limited context due to the narrow survey corridor makes classification of the anomalous responses more difficult. Some anomalies have been classified as Undetermined due to this constraint; however, the majority of these anomalies are likely to be agricultural or geological in origin.
- 9.2. A positive magnetic ring anomaly has been detected in Area 6, this is likely to be archaeological in origin; possibly representing a barrow or roundhouse feature. A number of pit-like anomalies have been detected within the ring and could also represent archaeological deposits. Sinuous linear anomalies surrounding the ring-ditch could be archaeological in origin; however, due to the limited survey context, an agricultural or natural origin cannot be ruled out for these anomalies, resulting in an Undetermined classification.
- 9.3. Agricultural ploughing regimes, both modern and historic, have been identified throughout the survey area.

10. Archiving

- 10.1. Magnitude Surveys Ltd maintains an in-house digital archive, which is based on (Schmidt and Ernenwein 2013).
- 10.2. Magnitude Surveys Ltd contributes all reports to the ADS Grey Literature Library subject to any time embargo dictated by the client.
- 10.3. Whenever possible, Magnitude Surveys has a policy of making data available to view in easy to use forms on its website. This can benefit the client by making all of their reports available in a single repository, while also being a useful resource for research. Should a client wish to impose a time embargo on the availability of data this can be achieved in discussion with MS.

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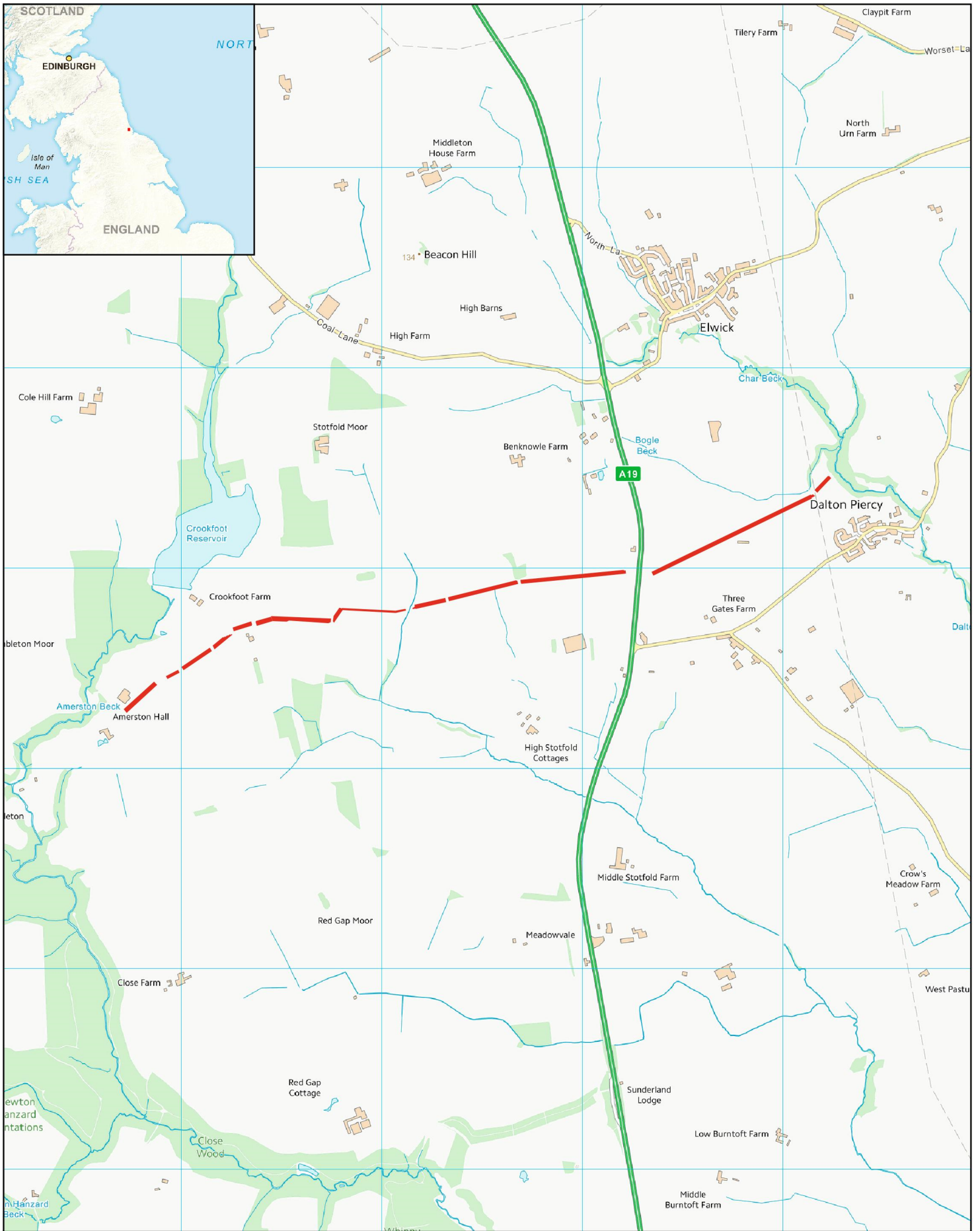
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 Survey Area

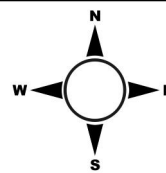
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Figure 1 - Site Location

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0 250 500 750 m



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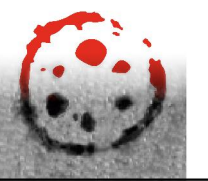
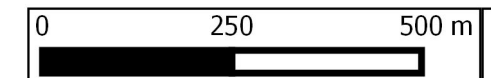
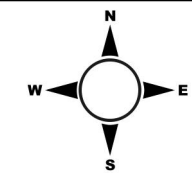


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 Figure 2 - Location of Survey Areas
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Legend

- WAT - DIRECTIONAL DRILLING_5000
- WAT - OPEN CUT_5000



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Area 1

Area 2

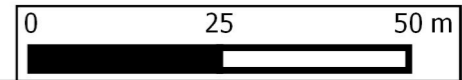
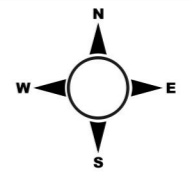
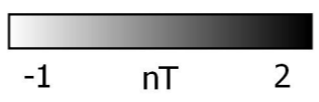
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Figure 3 - Magnetic Greyscale

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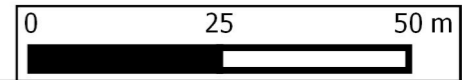
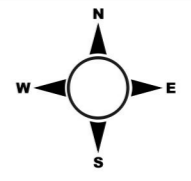
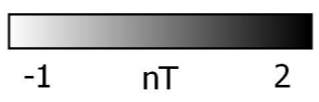
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Figure 4 - Magnetic Greyscale
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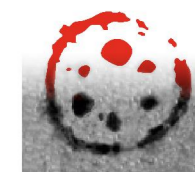
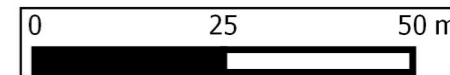
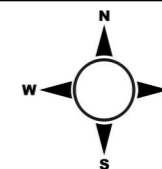
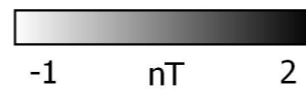


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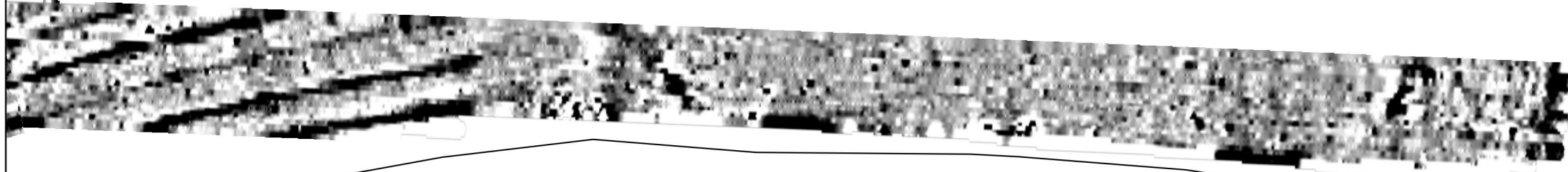
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Figure 5 - Magnetic Greyscale
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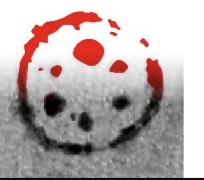
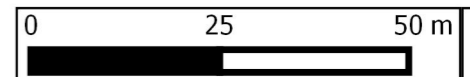
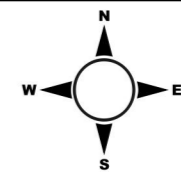
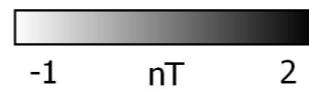
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Area 6

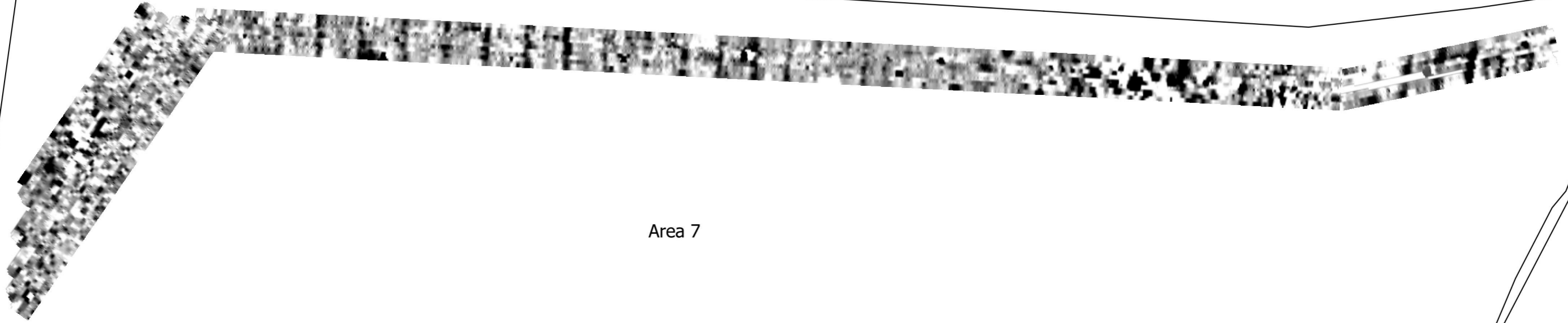


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Figure 6 - Magnetic Greyscale
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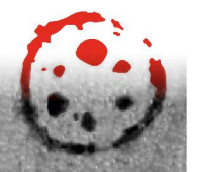
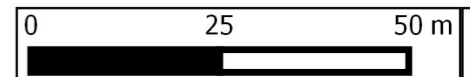
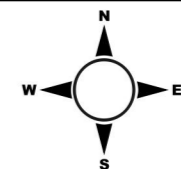
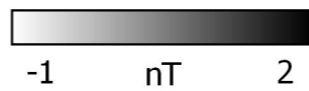
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Area 7

MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
Figure 7 - Magnetic Greyscale
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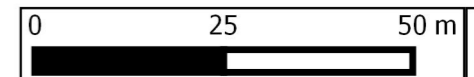
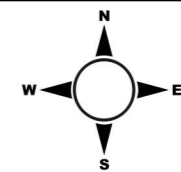
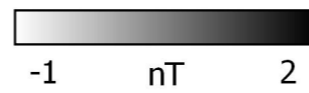


Area 8

Area 9

MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
Figure 8 - Magnetic Greyscale
1 : 1000 @ A3

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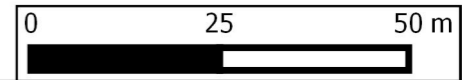
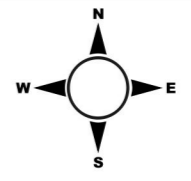
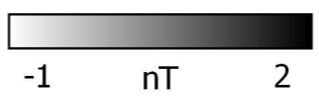


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surveys

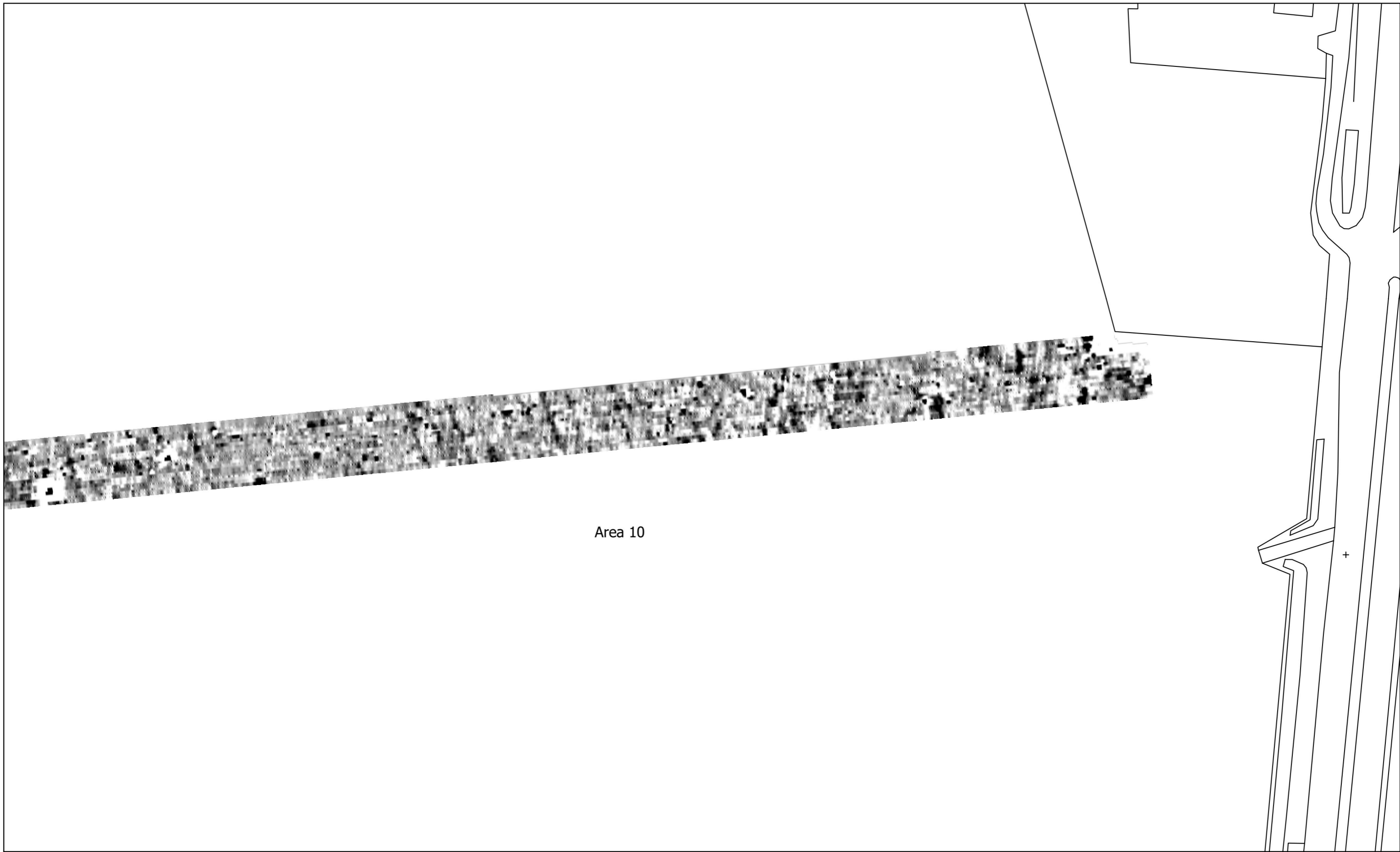


MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
Figure 9 - Magnetic Greyscale
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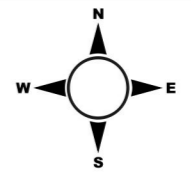
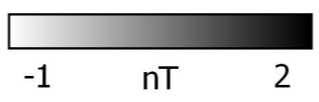
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Area 10

MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
Figure 10 - Magnetic Greyscale
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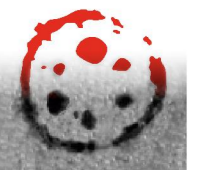
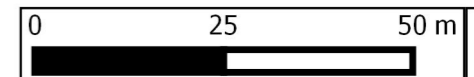
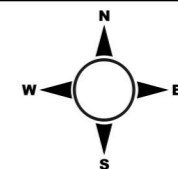
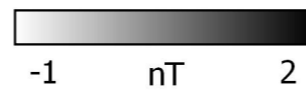


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Figure 11 - Magnetic Greyscale
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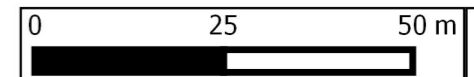
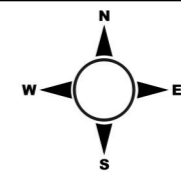
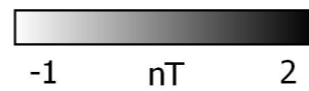


Area 12

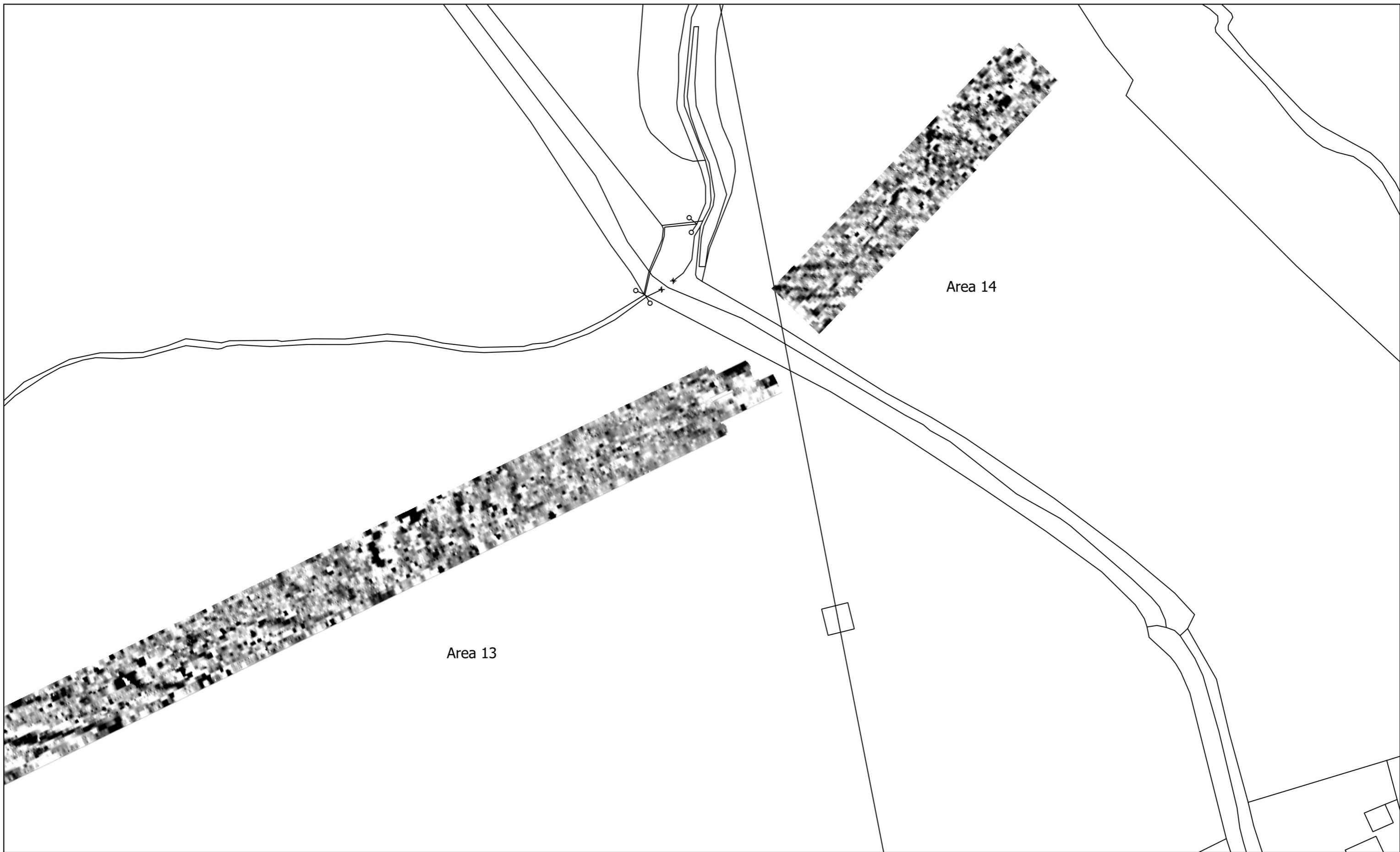
Area 13

MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
Figure 12 - Magnetic Greyscale
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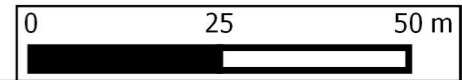
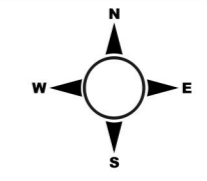
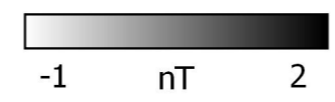


Area 14

Area 13

MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
Figure 13 - Magnetic Greyscale
1 : 1000 @ A3

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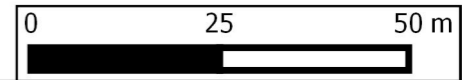
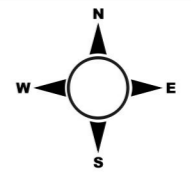
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Figure 14 - Magnetic Interpretation

1 : 1000 @ A3

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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |



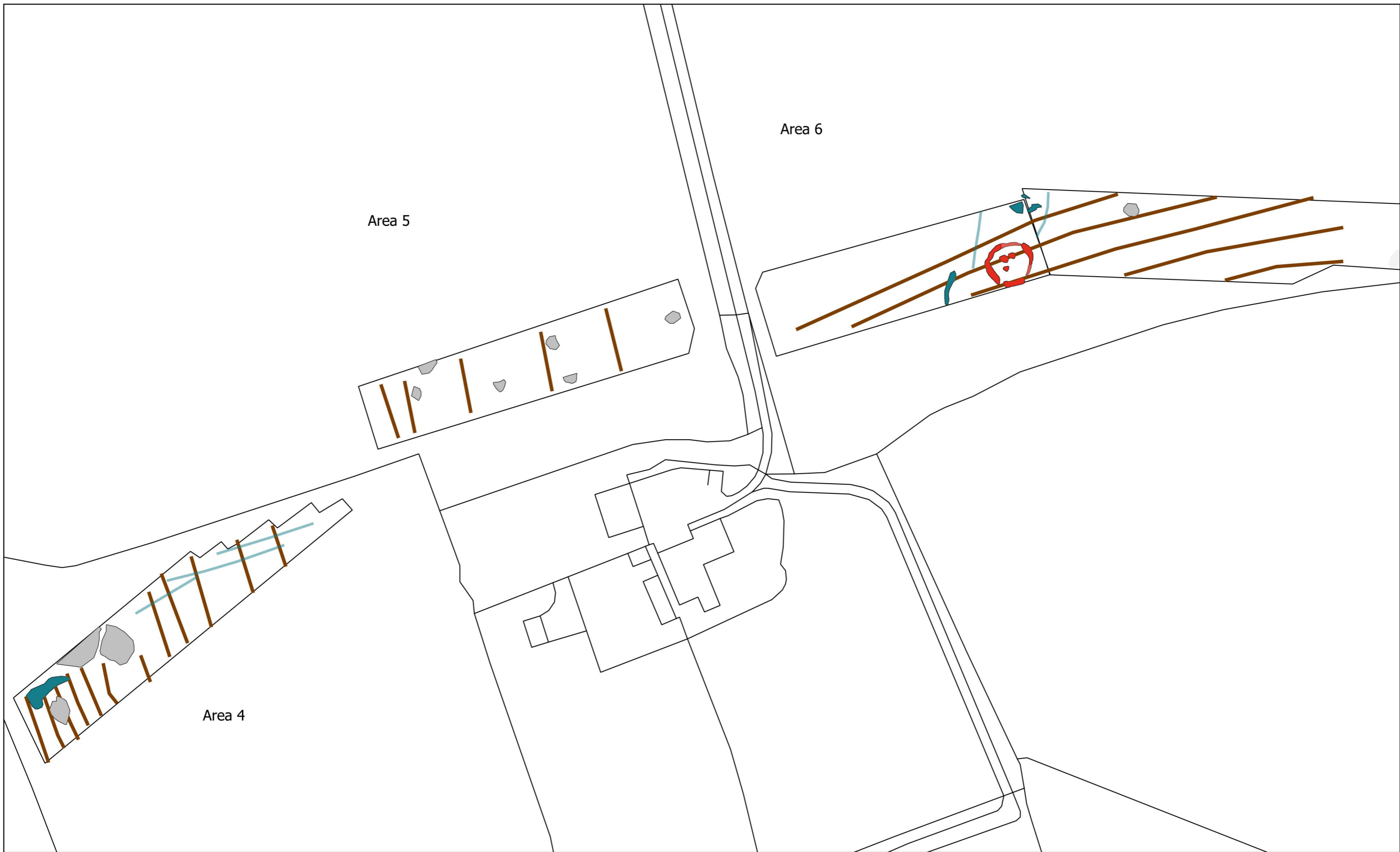
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MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
 Figure 15 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |

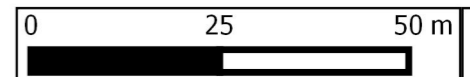
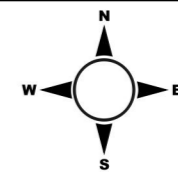
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MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
 Figure 16 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |



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Area 6

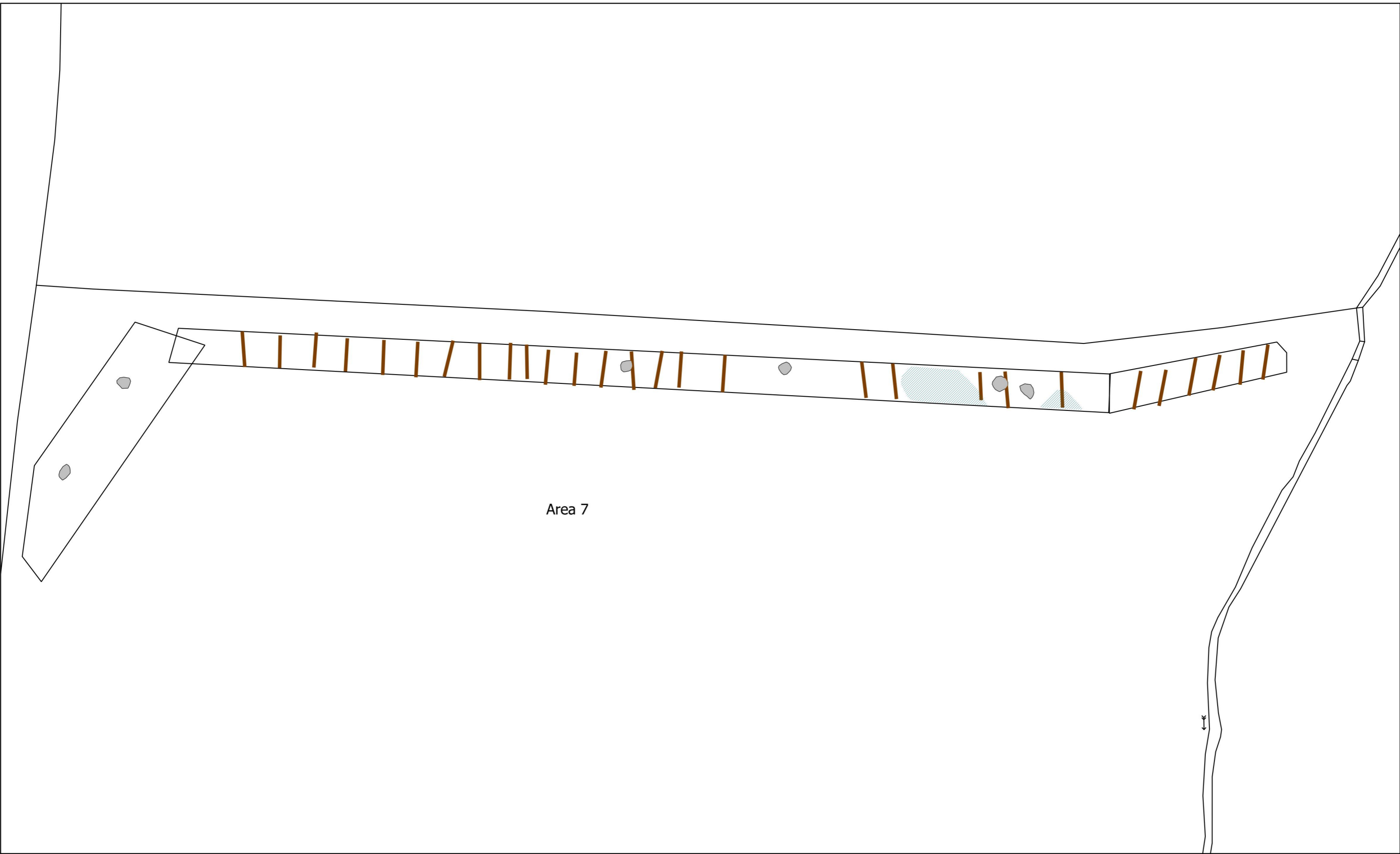


MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
Figure 17 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |

0 25 50 m

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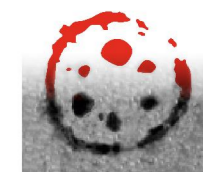
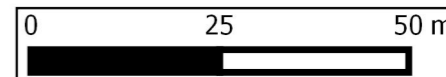
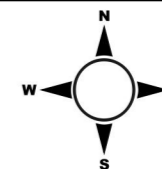


Area 7

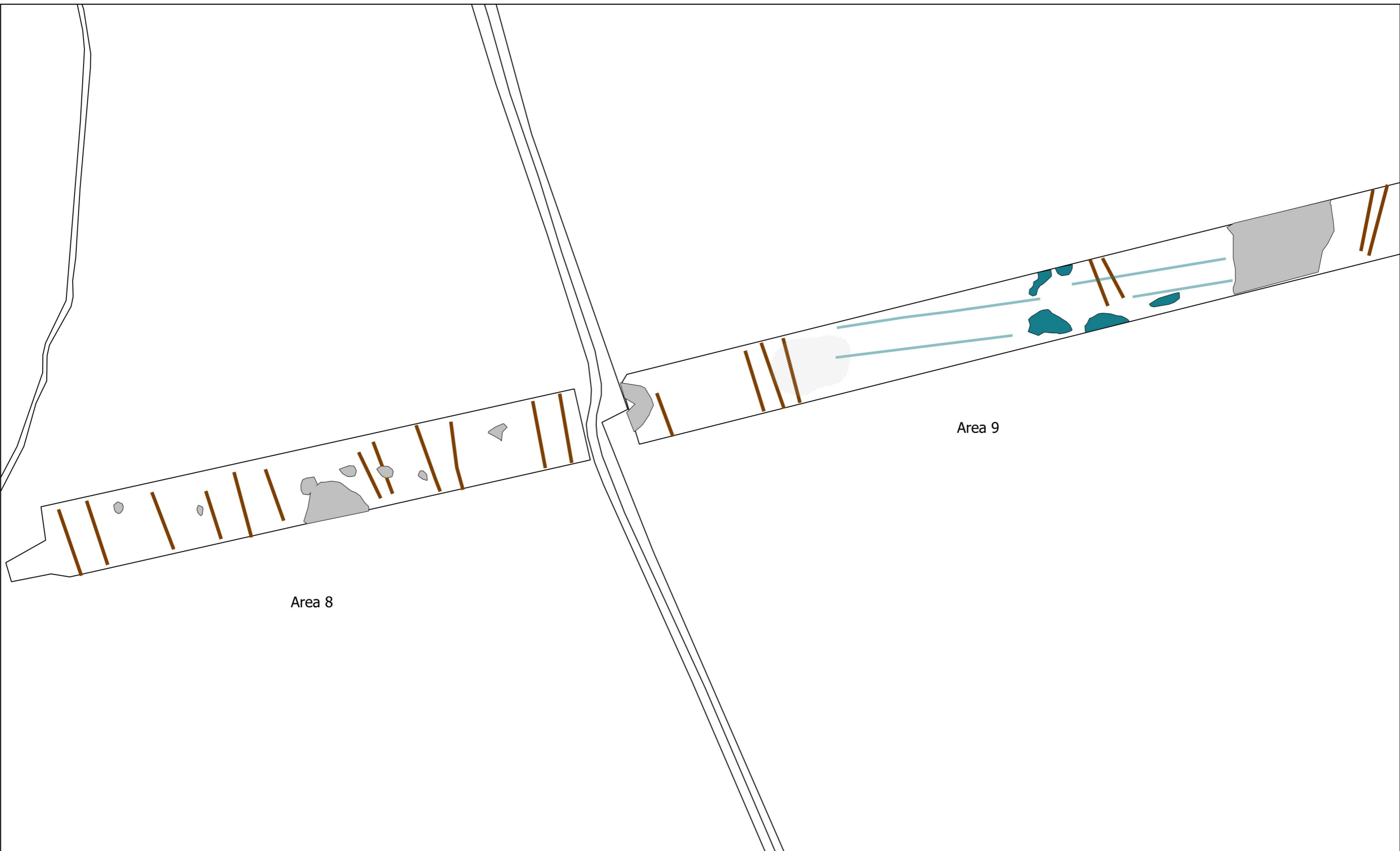
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 Figure 18 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |



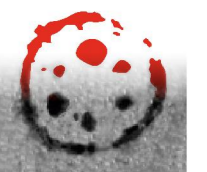
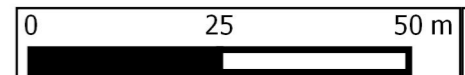
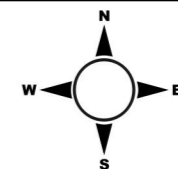
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 Figure 19 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |



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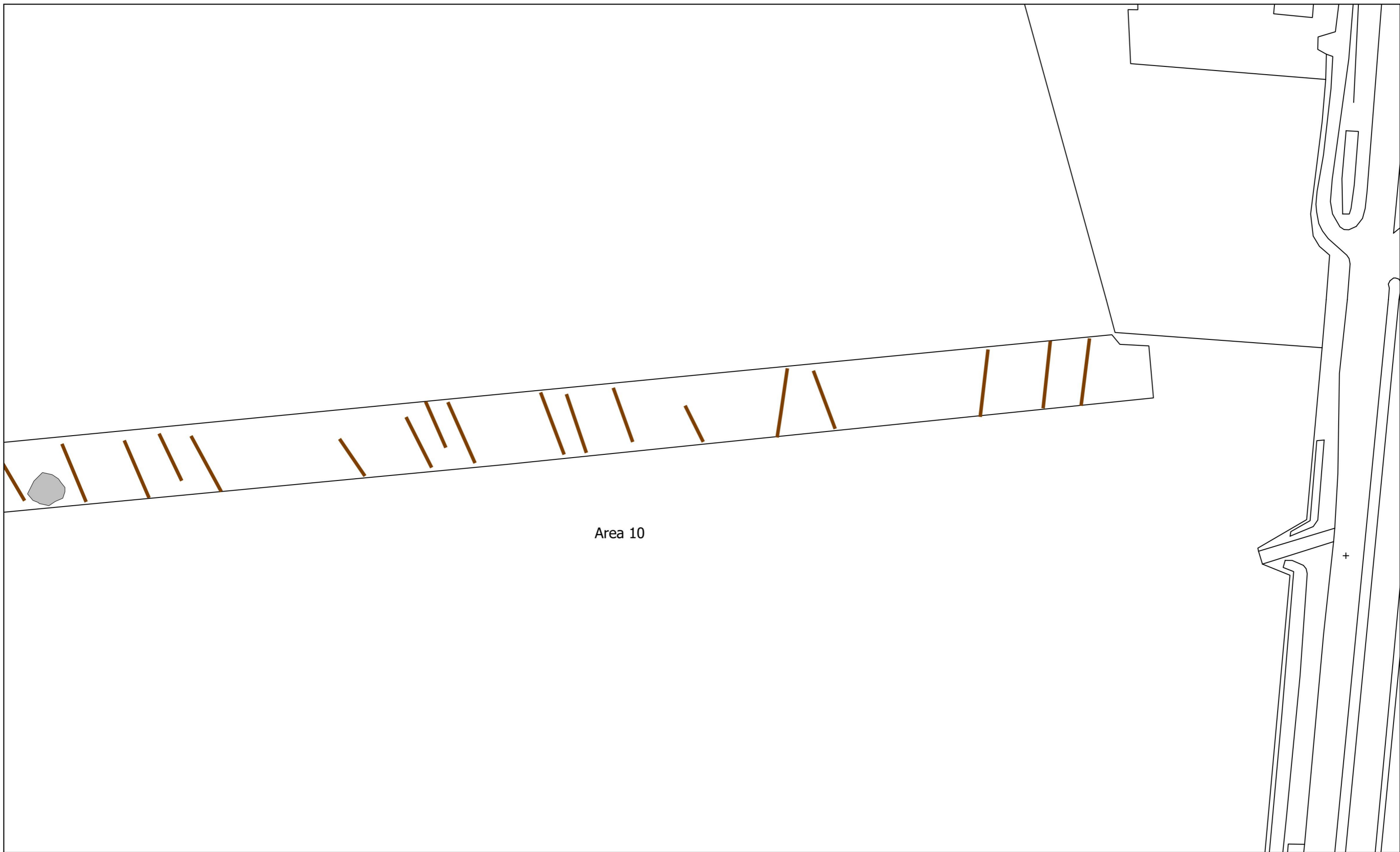
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 Figure 20 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |

0 25 50 m

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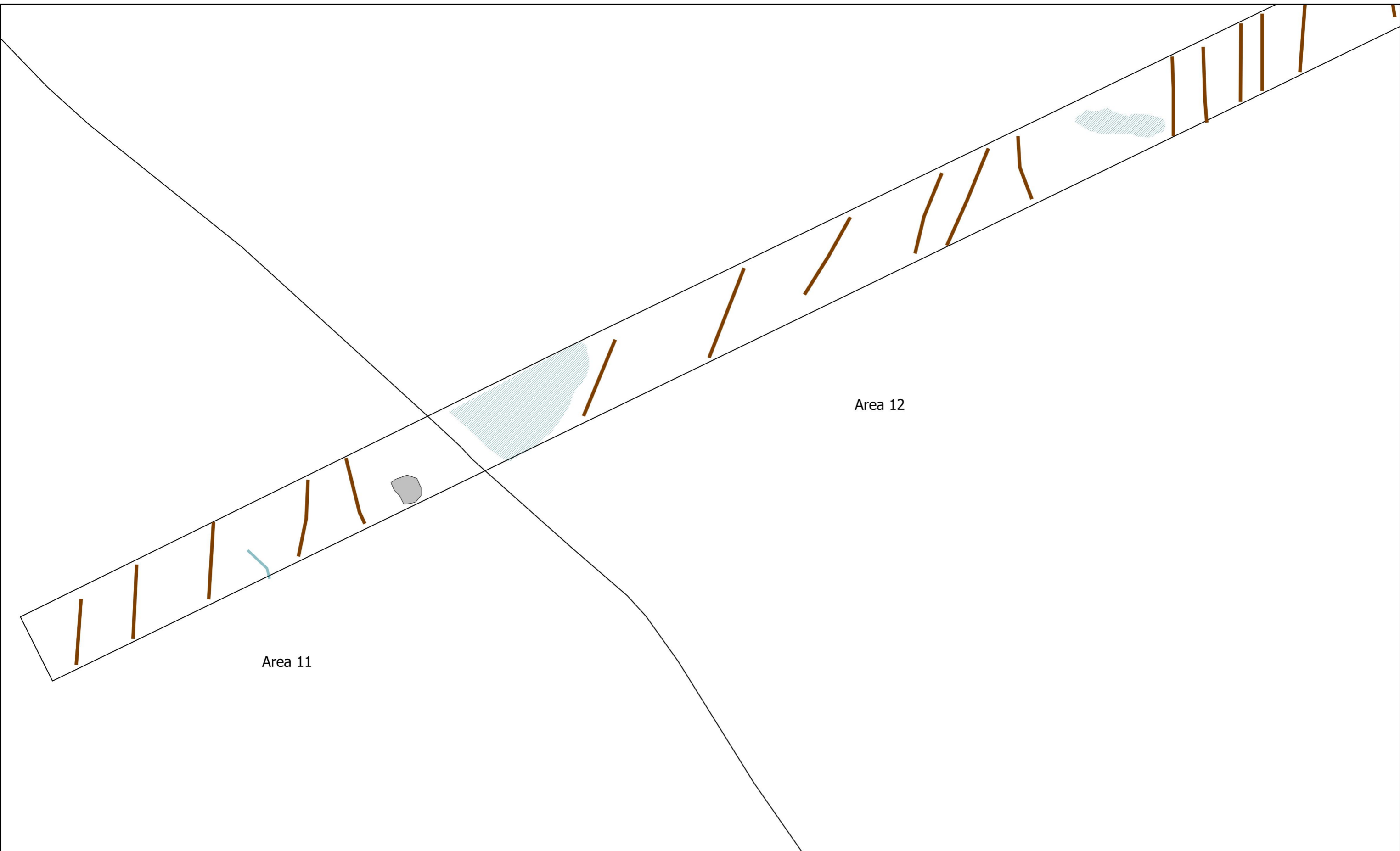
Area 10

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 Figure 21 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |

0 25 50 m

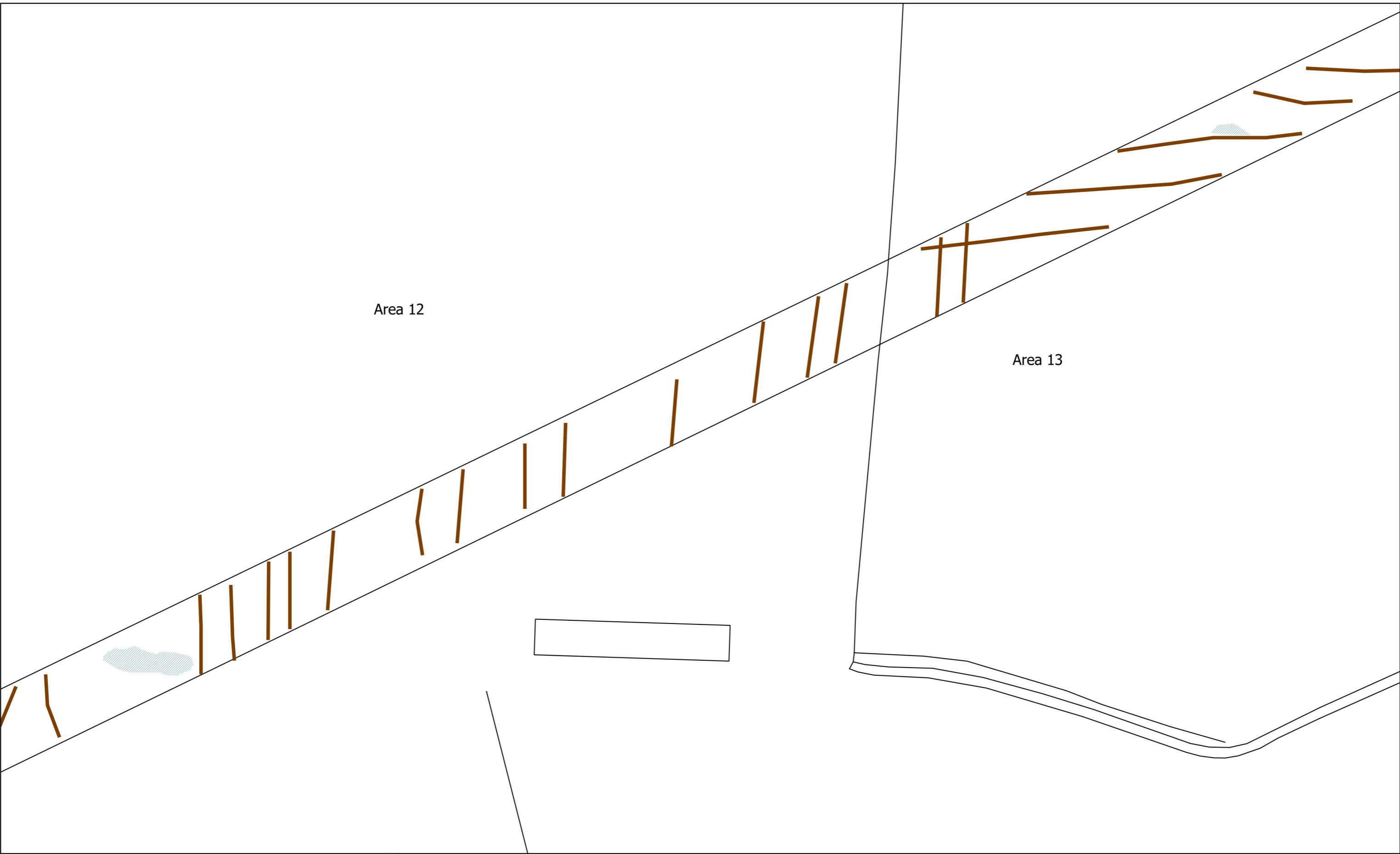
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 Figure 22 - Magnetic Interpretation
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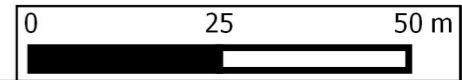
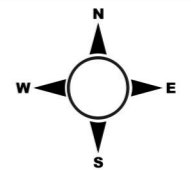
- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |

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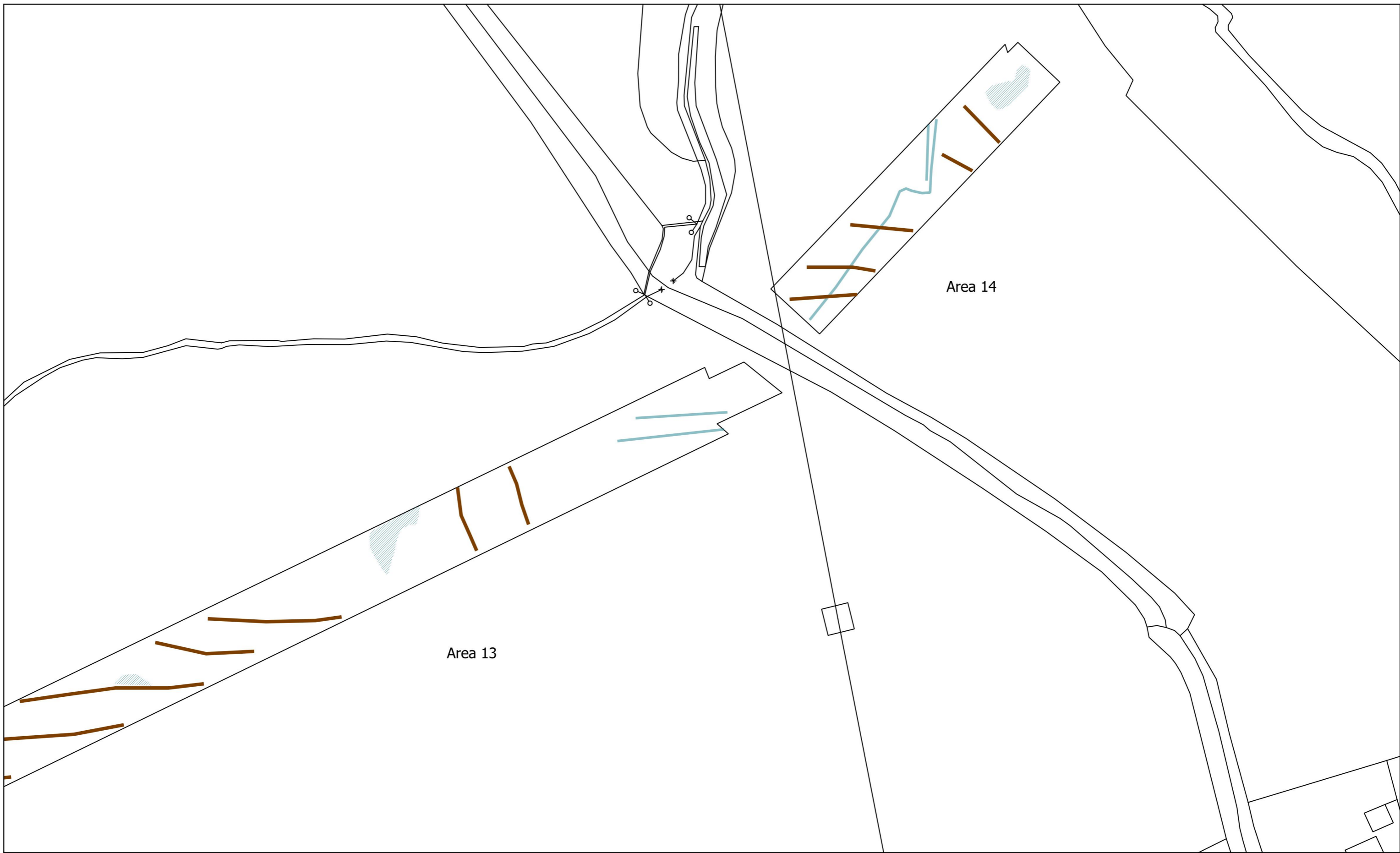


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 Figure 23 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |



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MSNZ05B - Wynyard Main Reinforcement Scheme, Northern Route
 Figure 24 - Magnetic Interpretation
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- | | | |
|-------------------------------|-----------------------------|---------------------|
| Archaeology Probable - Strong | Archaeology Possible - Weak | Agricultural Plough |
| Archaeology Probably - Weak | Undetermined - Strong | Ferrous |
| Archaeology Possible - Strong | Undetermined - Weak | Ferrous - Zone |
| | Undetermined - Zone | |

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