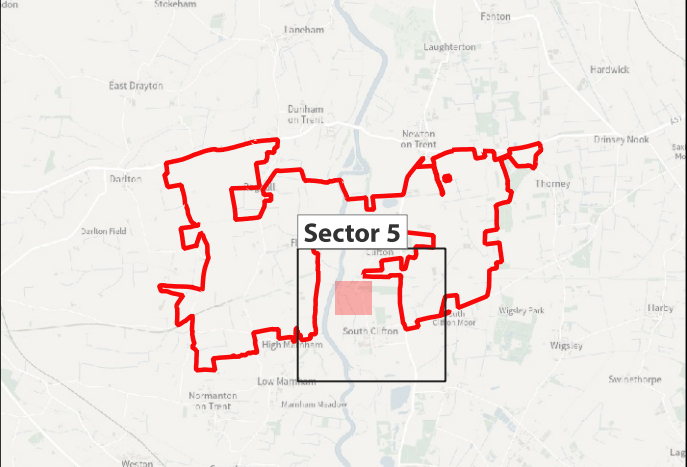








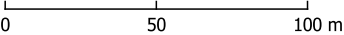
**HEADLAND**  
ARCHAEOLOGY

part of the **RSK** Group



**Key**

-  Survey Extent
-  Ferrous Objects
-  Agriculture
-  Field Drain
-  Magnetic Disturbance
-  Natural



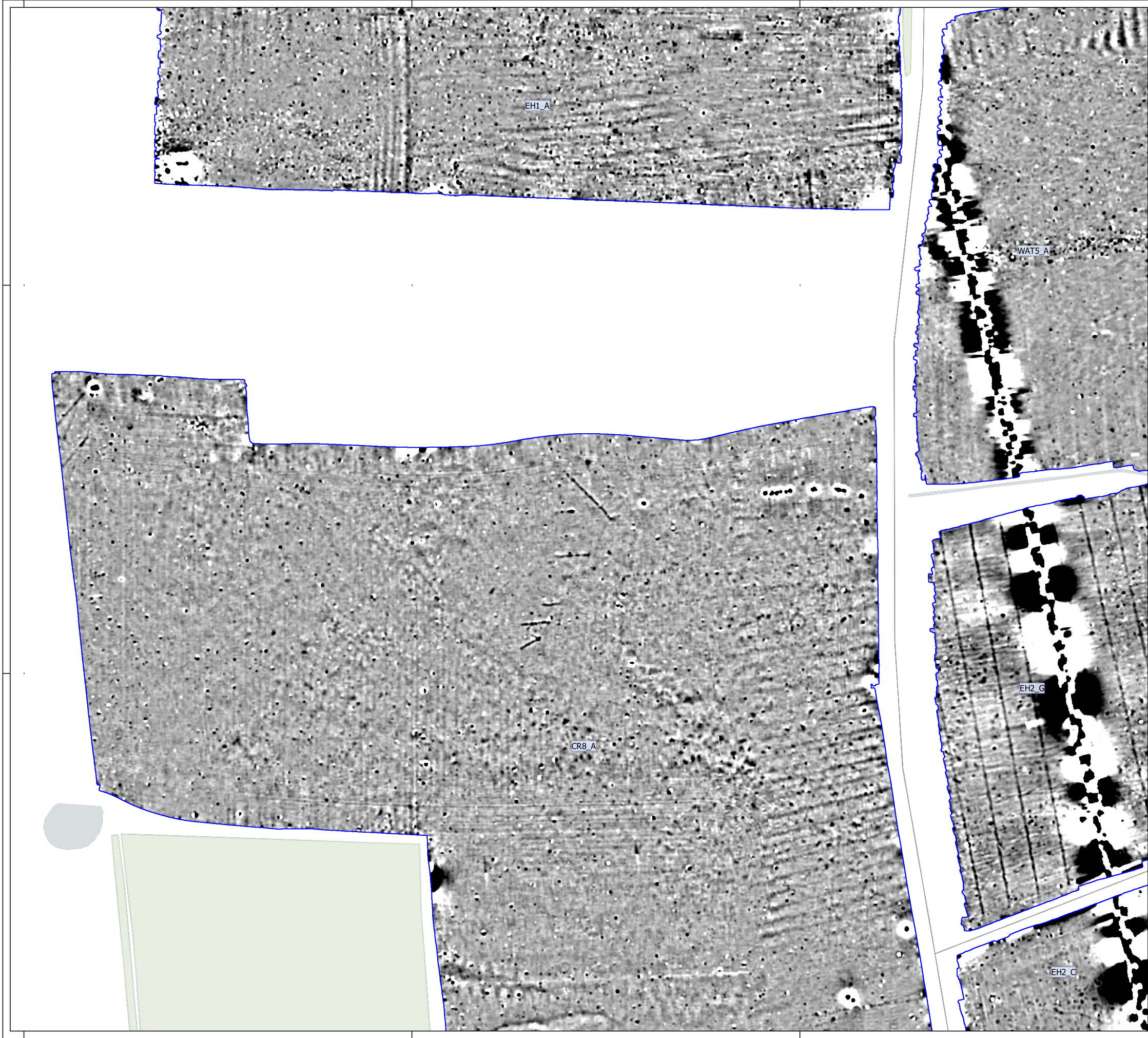
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Illus - 18 Interpretation of magnetometer data





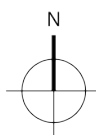
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371000

482250

482500

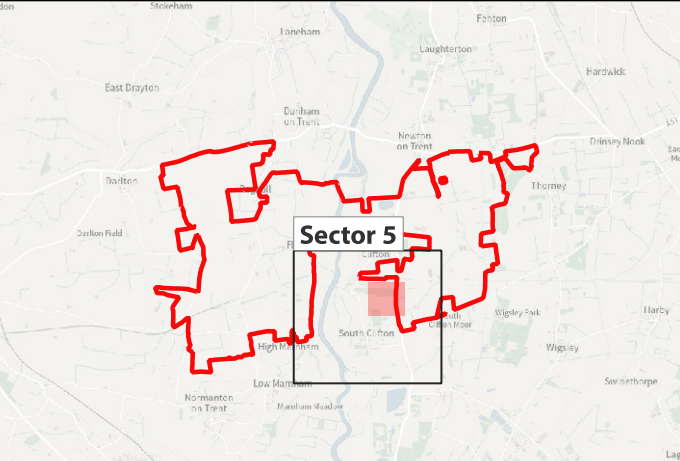
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**HEADLAND**  
ARCHAEOLOGY

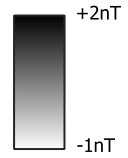
part of the **RSK** Group



**Sector 5**

**Key**

 Survey Extent



+2nT

-1nT

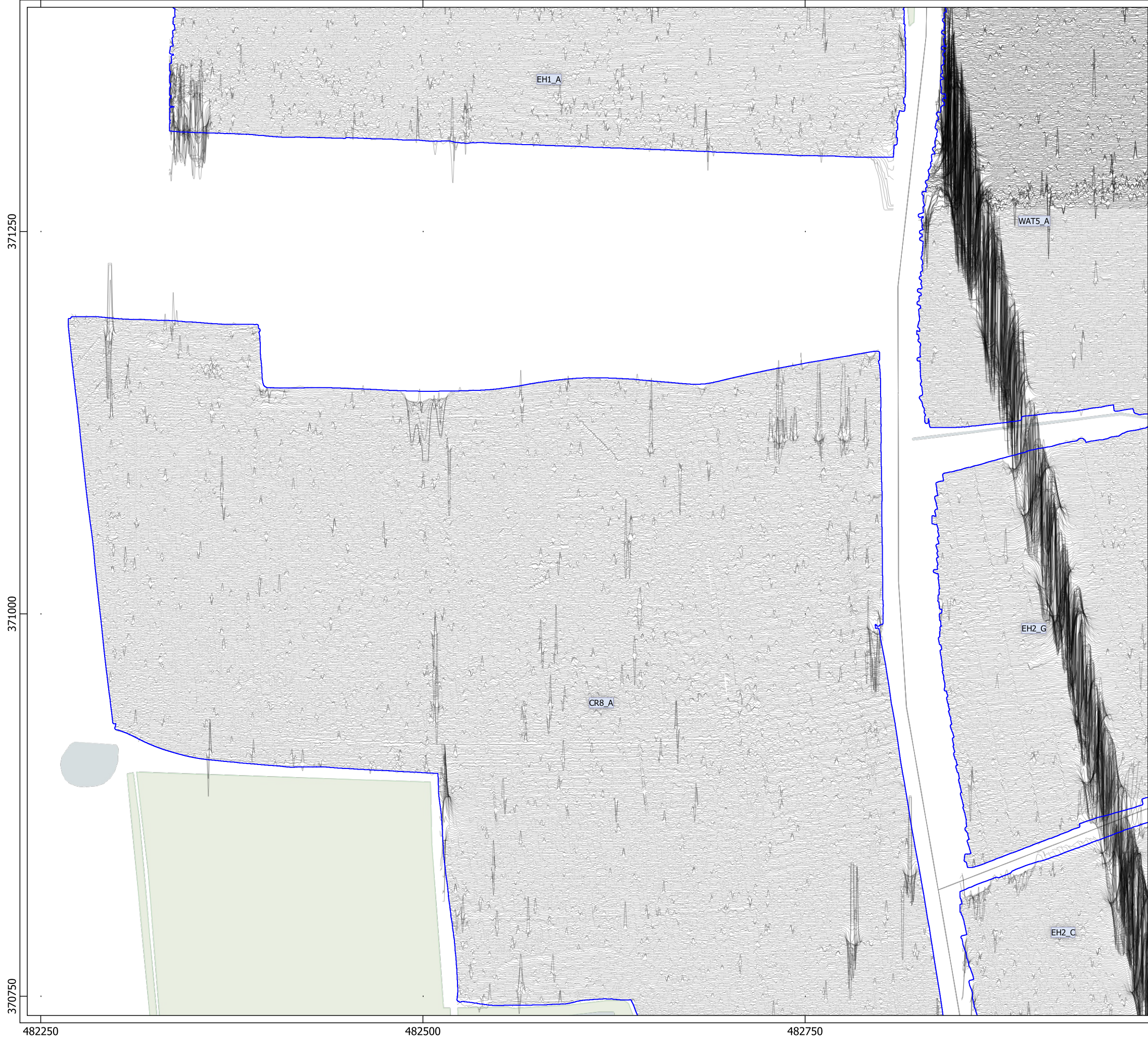
0 50 100 m

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371250

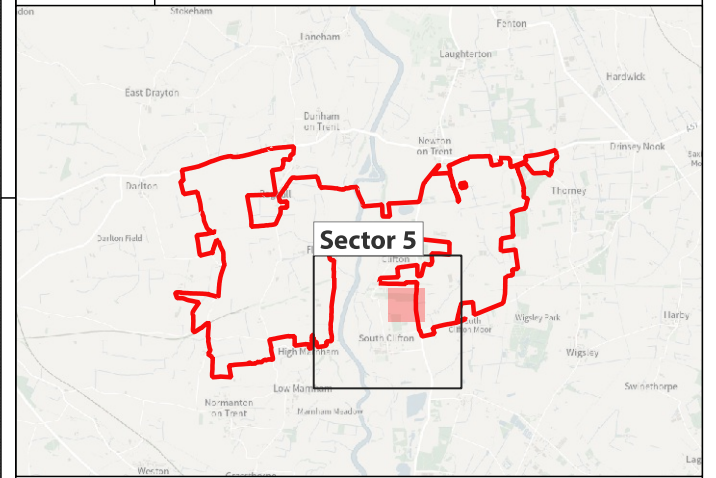
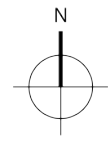
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370750

482250

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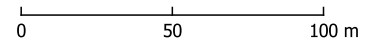
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**Key**

Survey Extent

XY Trace (25nT/cm)

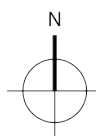



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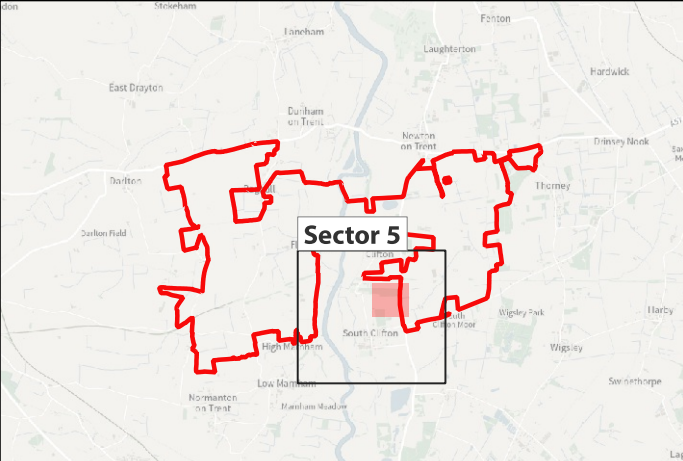






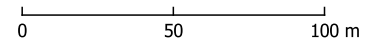
**HEADLAND**  
ARCHAEOLOGY

part of the **RSK** Group



**Key**

- Survey Extent
- Ferrous Objects
- Agriculture
- Field Boundary
- Field Drain
- Natural
- Pipe
- Uncertain
- Ridge and Furrow
- Former Field Boundary
- Archaeology
- Magnetic Disturbance
- Natural
- Possible Archaeology
- Uncertain

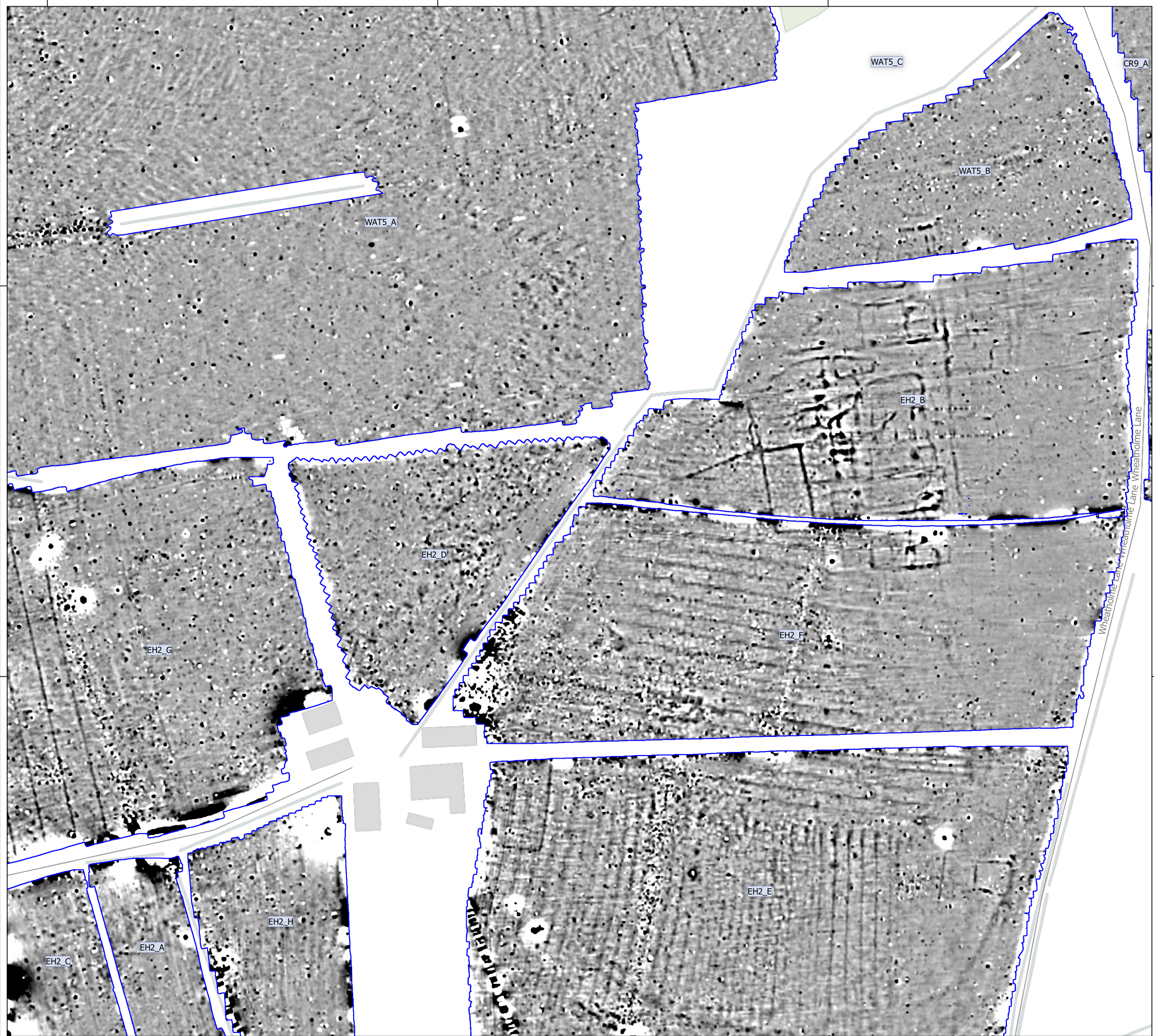


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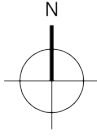
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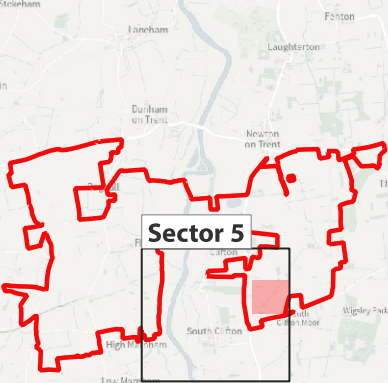
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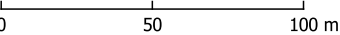
**Sector 5**

**Key**

 Survey Extent



+2nT  
-1nT



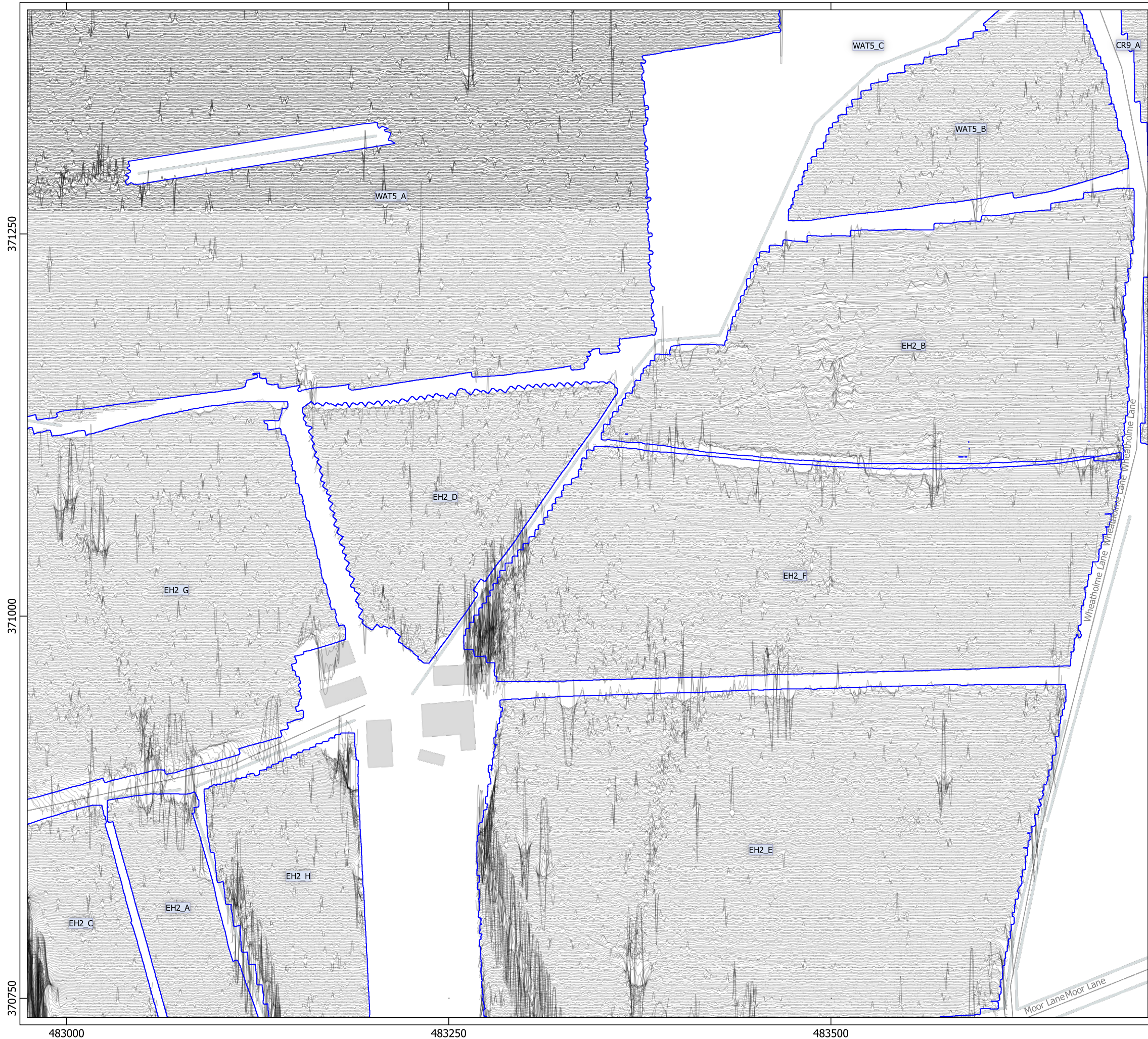
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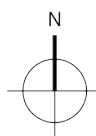
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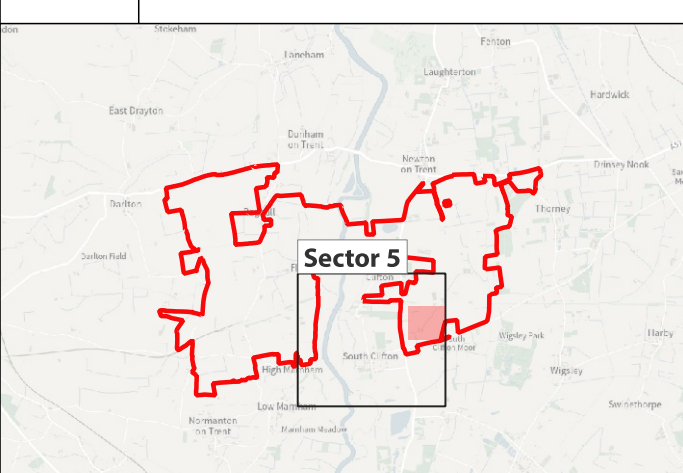


N



**HEADLAND**  
ARCHAEOLOGY

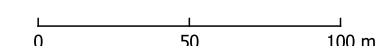
part of the **RSK** Group



Sector 5

**Key**

- Survey Extent
- XY Trace (25nT/cm)



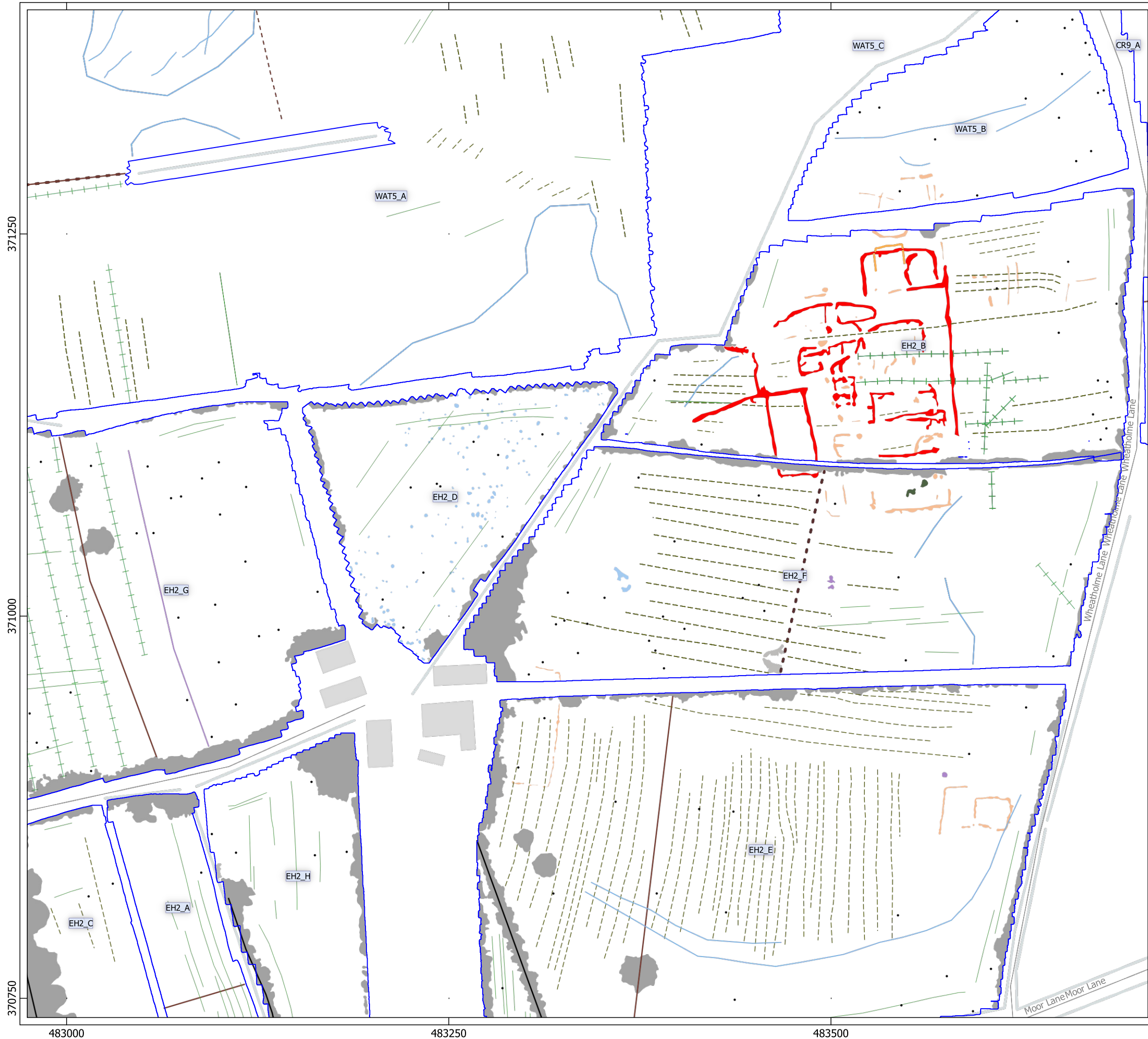
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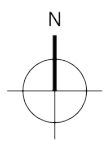
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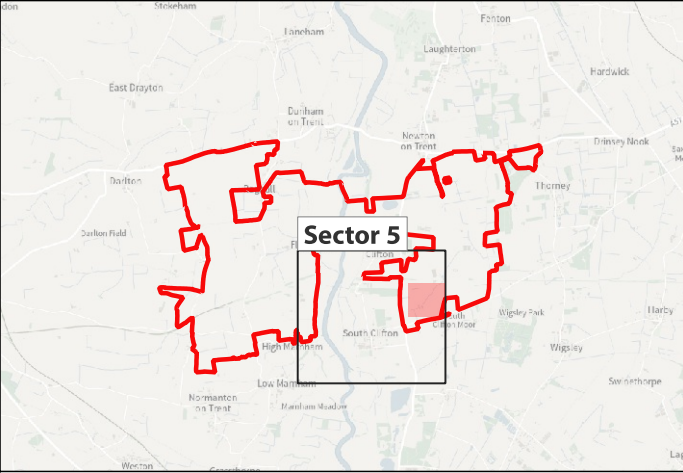






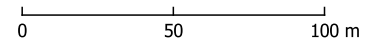


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**Key**

- Survey Extent
- Ferrous Objects
- Agriculture
- Field Boundary
- Possible Field Boundary
- Field Drain
- Natural
- Pipe
- Uncertain
- Ridge and Furrow
- Former Field Boundary
- Possible Archaeology
- Archaeology
- Magnetic Disturbance
- Natural
- Possible Archaeology
- Uncertain
- Burning?
- Magnetic Disturbance Modern?



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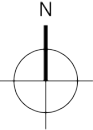
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Illus - 19 Interpretation of magnetometer data



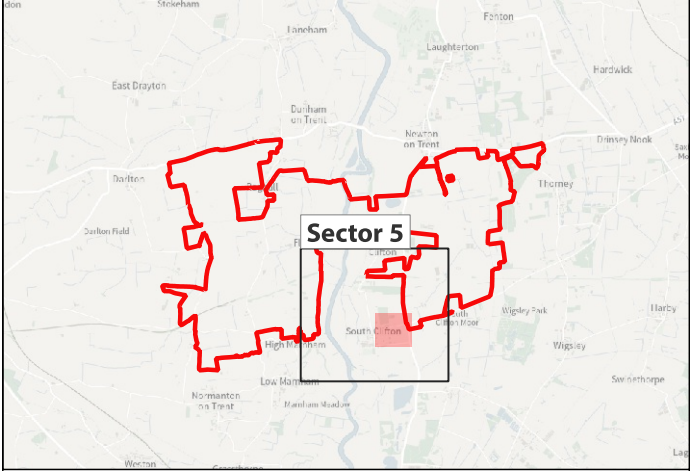







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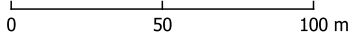
part of the **RSK** Group



**Sector 5**

**Key**

 Survey Extent

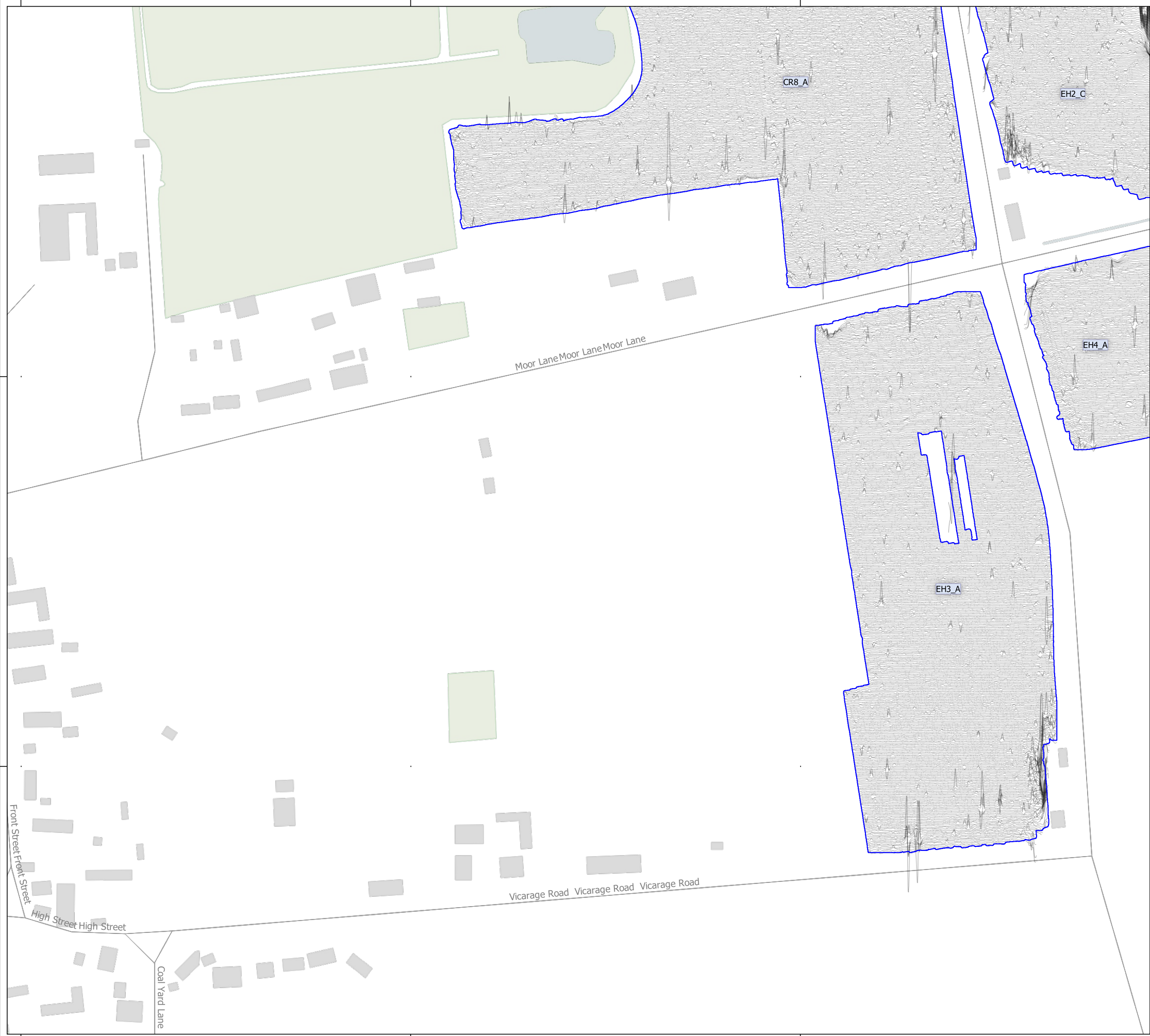


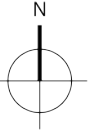
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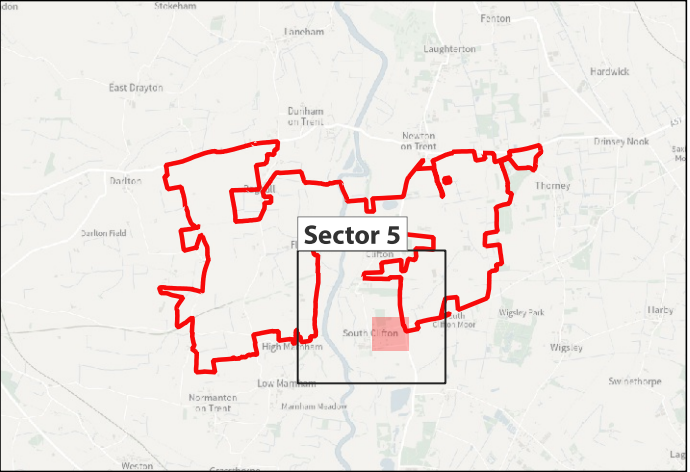






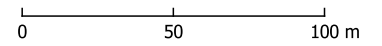


**HEADLAND**  
ARCHAEOLOGY

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**Key**  
 Survey Extent  
 XY Trace (25nT/cm)



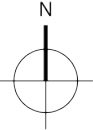
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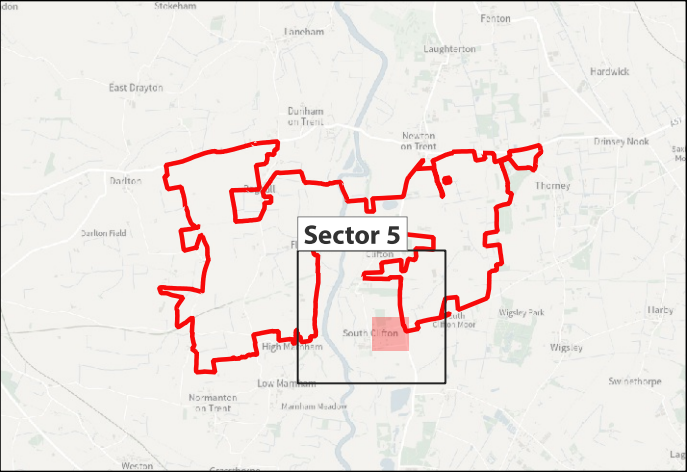

















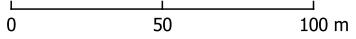
**HEADLAND**  
ARCHAEOLOGY

part of the **RSK** Group



**Key**

-  Survey Extent
-  Ferrous Objects
-  Agriculture
-  Field Boundary
-  Field Drain
-  Natural
-  Uncertain
-  Ridge and Furrow
-  Magnetic Disturbance
-  Uncertain
-  Magnetic Disturbance Modern?

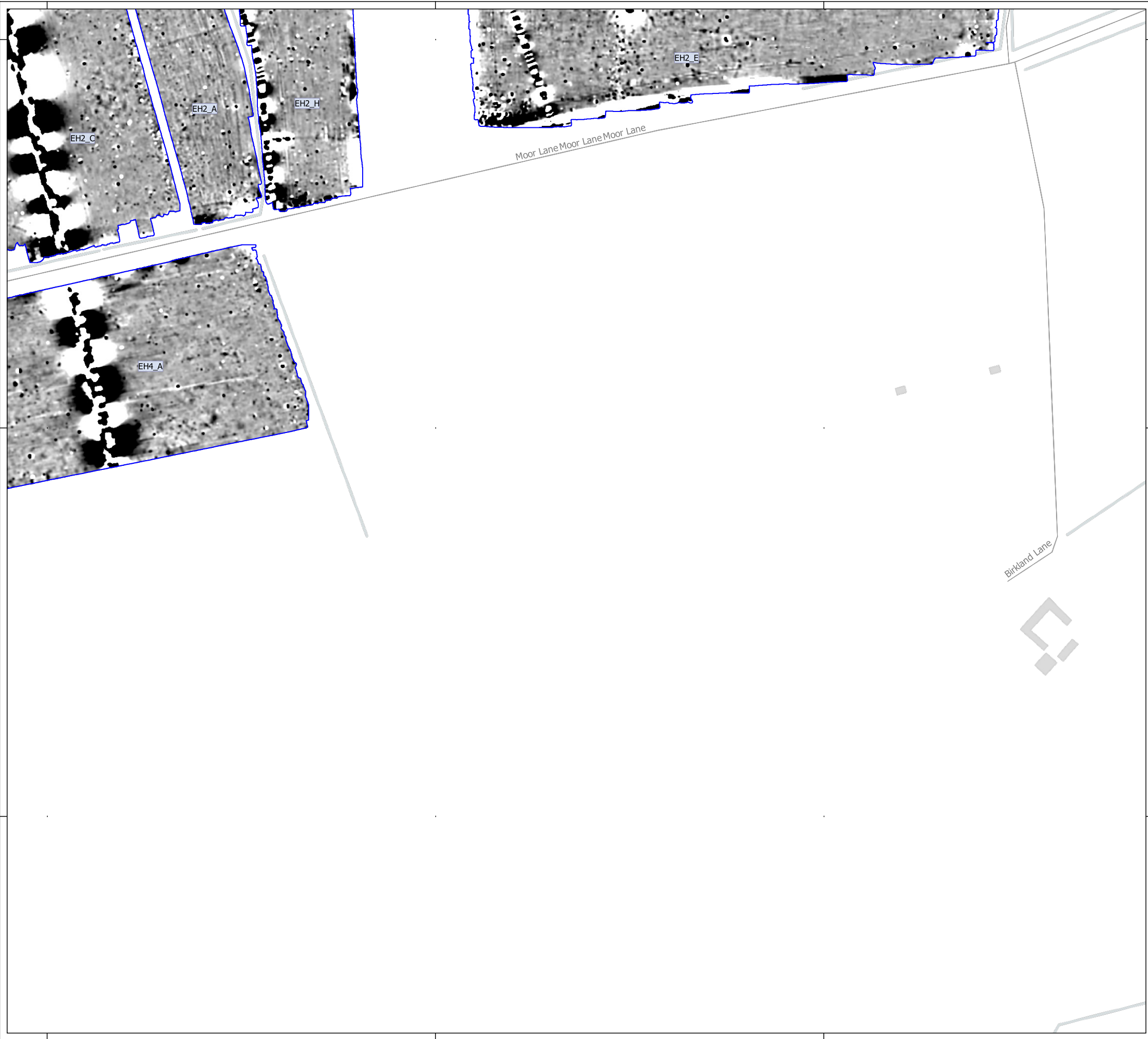


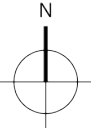
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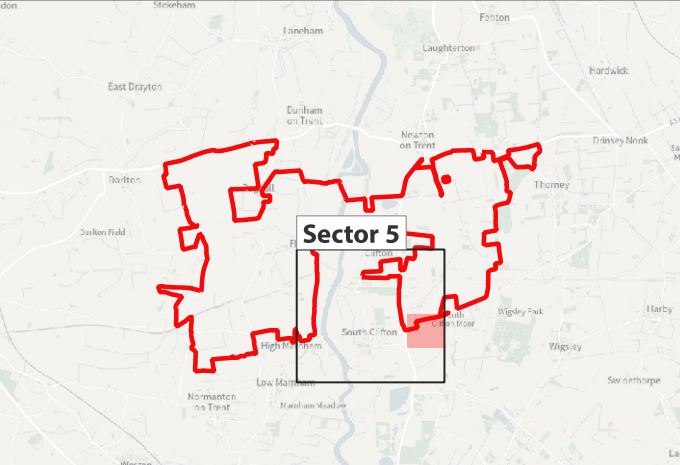







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**Sector 5**

**Key**

 Survey Extent



+2nT

-1nT

0 50 100 m

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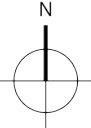
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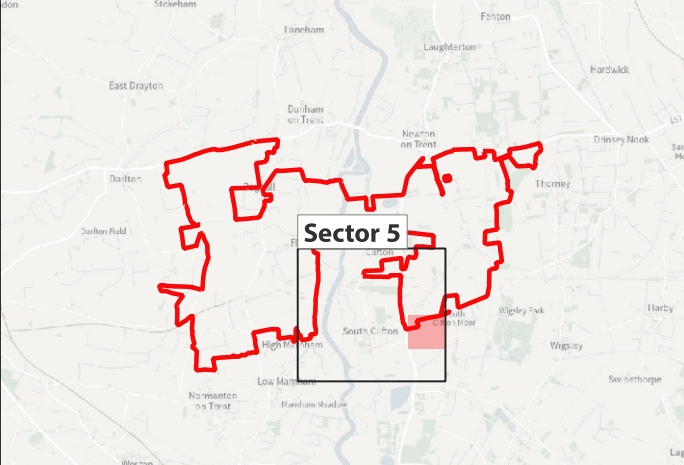
















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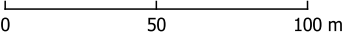
part of the **RSK** Group



**Sector 5**

**Key**

-  Survey Extent
-  Ferrous Objects
-  Agriculture
-  Field Boundary
-  Field Drain
-  Natural
-  Pipe
-  Uncertain
-  Ridge and Furrow
-  Magnetic Disturbance

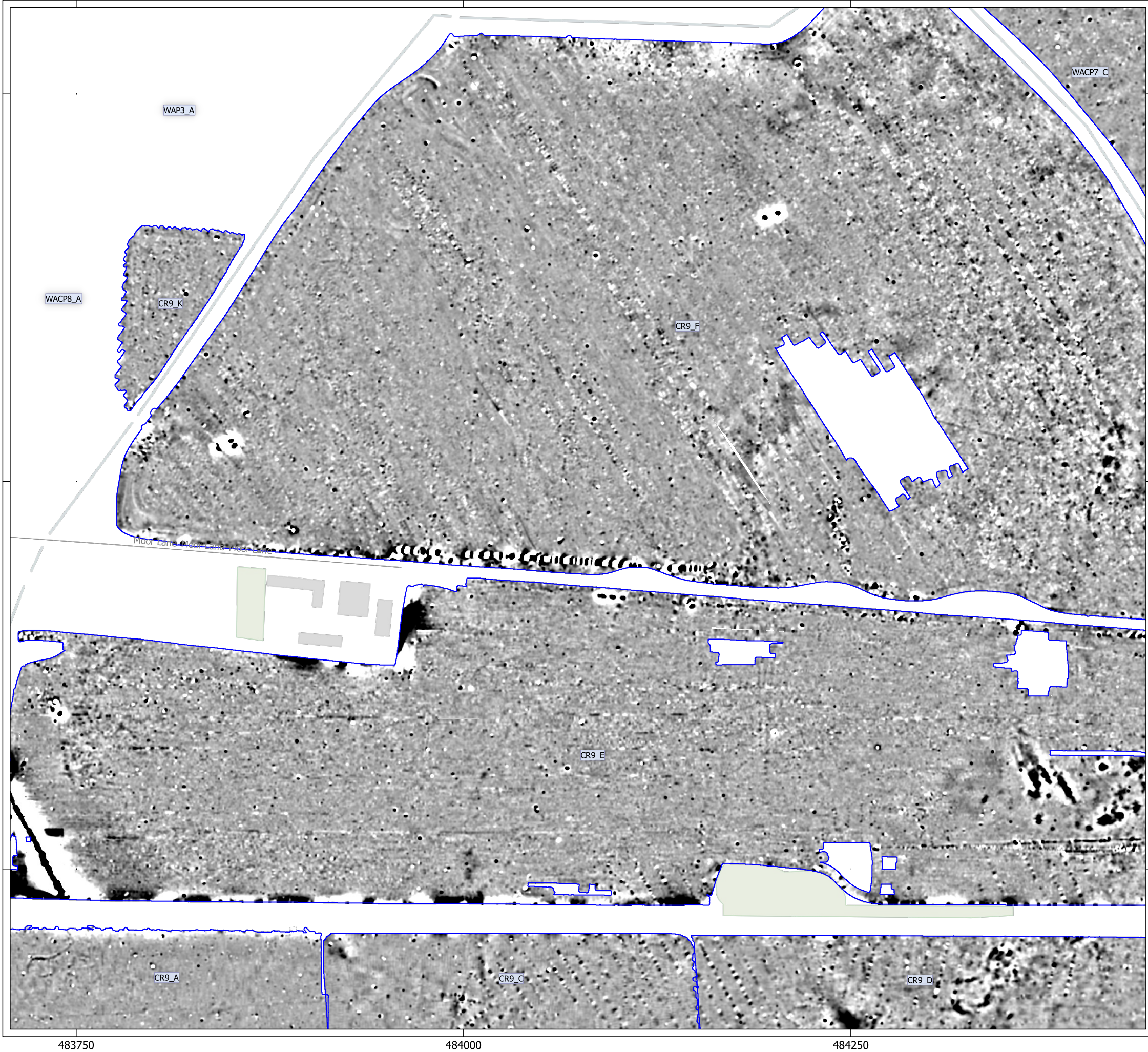


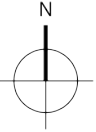
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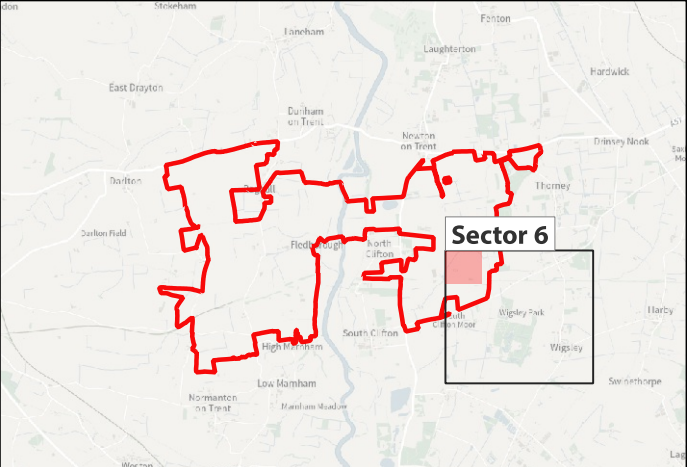







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**Sector 6**

**Key**

 Survey Extent



+2nT

-1nT

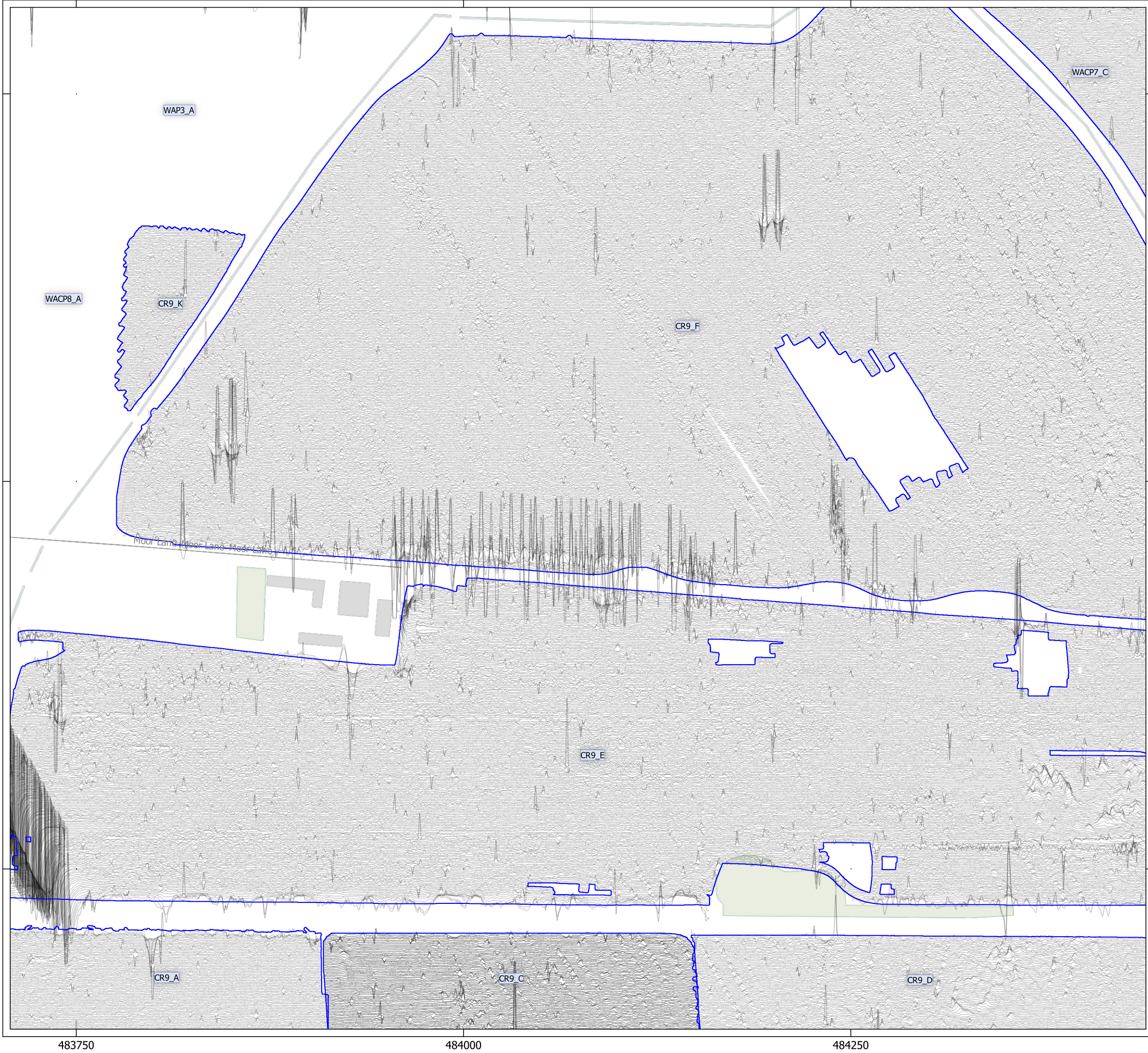
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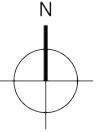
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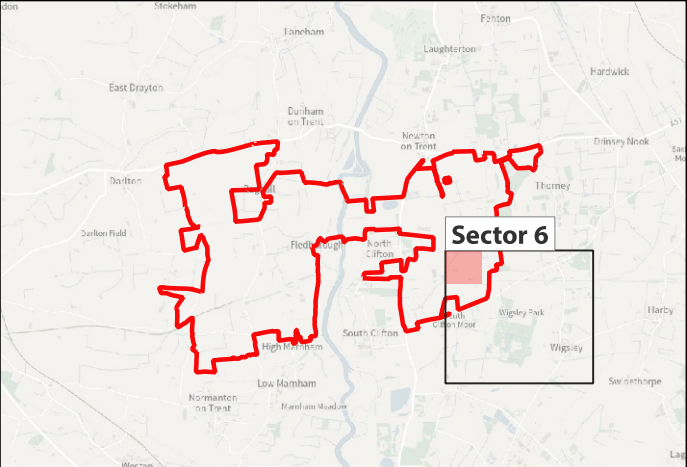








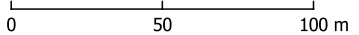
**HEADLAND**  
ARCHAEOLOGY

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**Sector 6**

**Key**  
 Survey Extent  
 XY Trace (25nT/cm)



050100 m

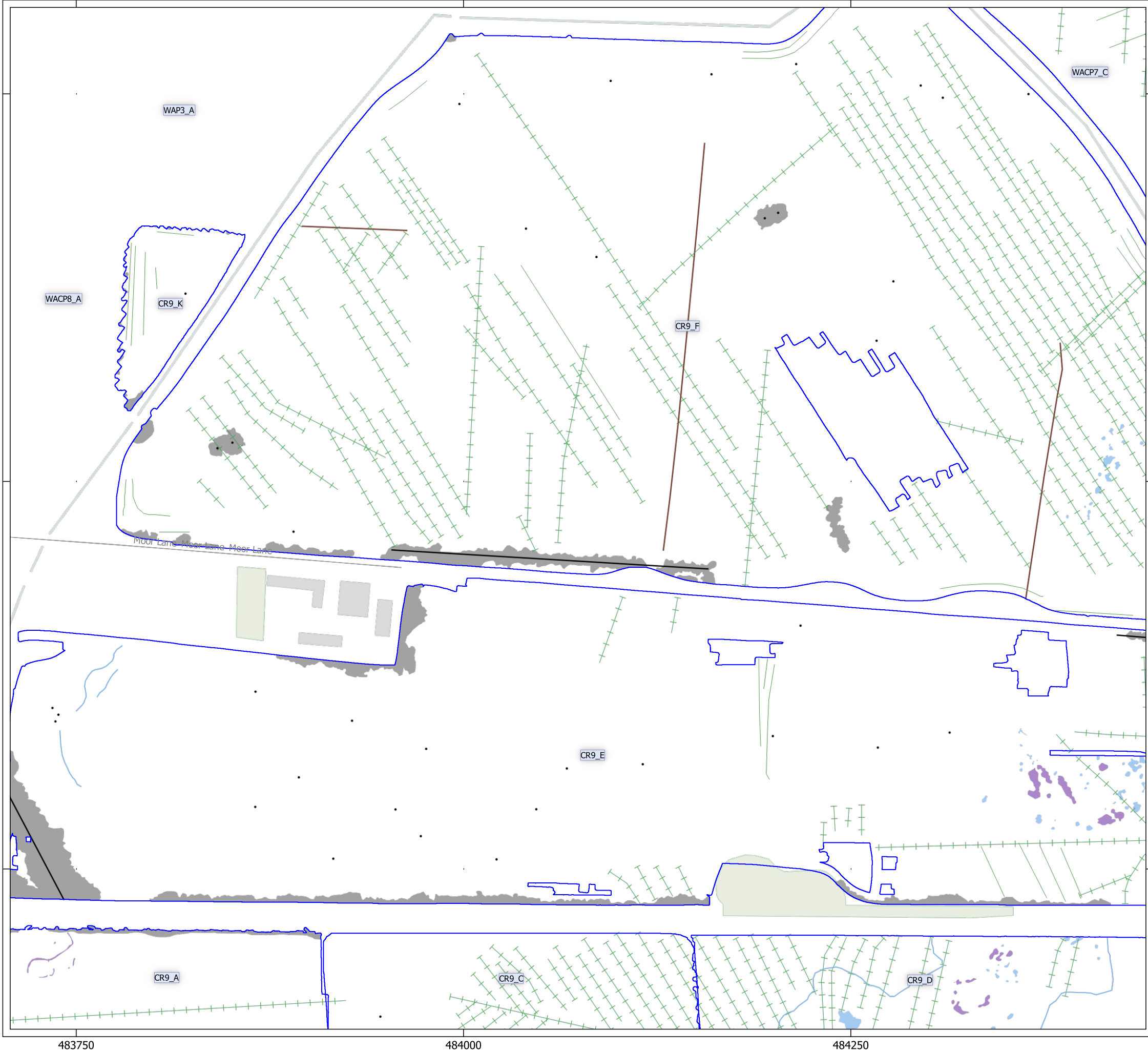
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Illus - 20 XY trace plot of minimally processed magnetometer data





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**Key**

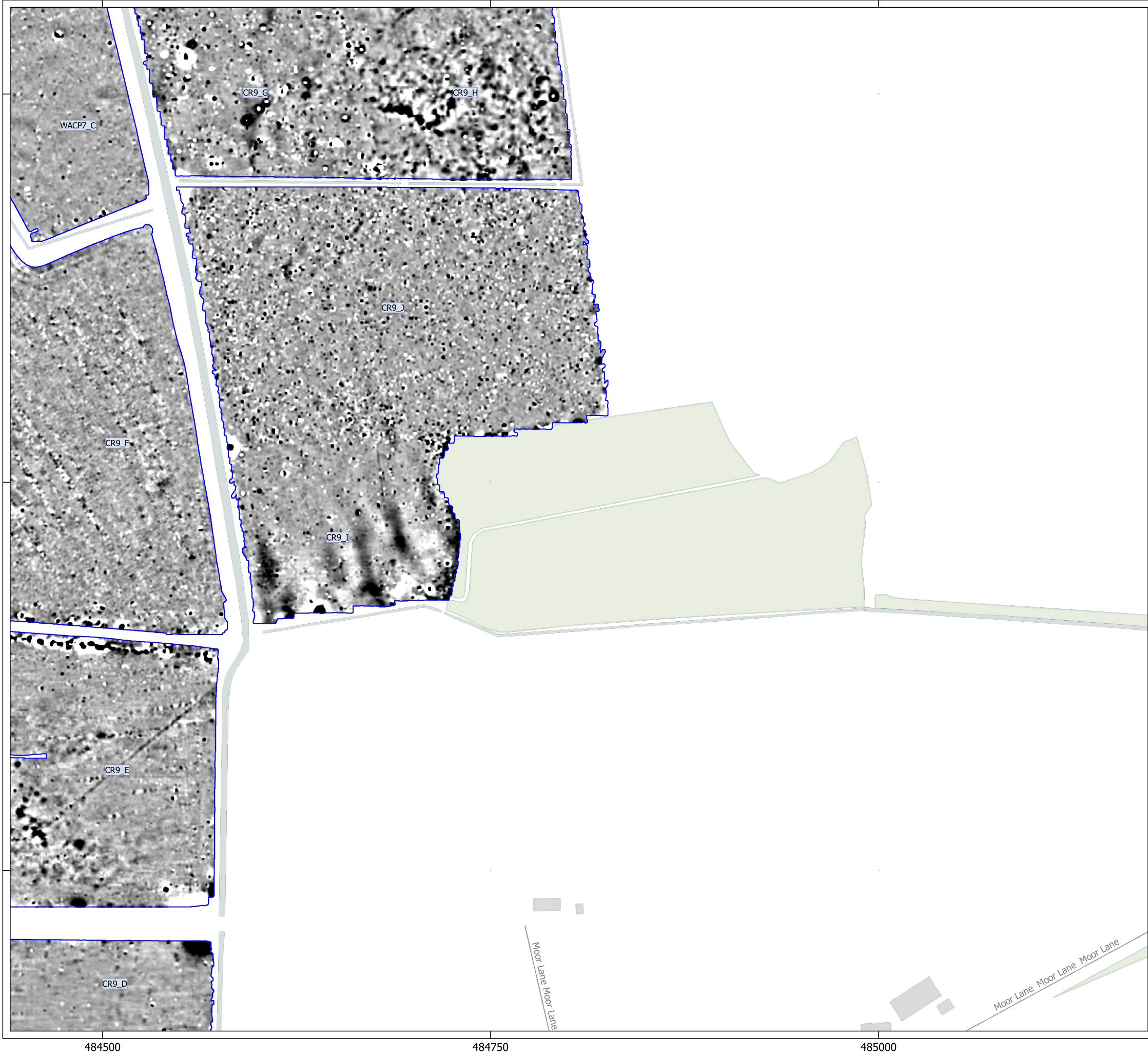
- Survey Extent
- Ferrous Objects
- Agriculture
- Field Boundary
- Field Drain
- Natural
- Pipe
- Magnetic Disturbance
- Natural
- Uncertain

0 50 100 m

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372000

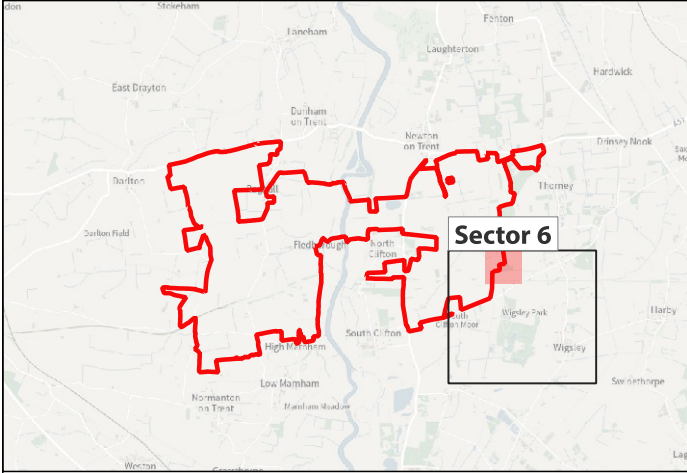
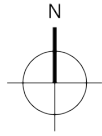
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371500

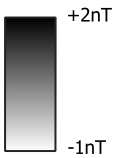
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484750

485000



Key  
Survey Extent

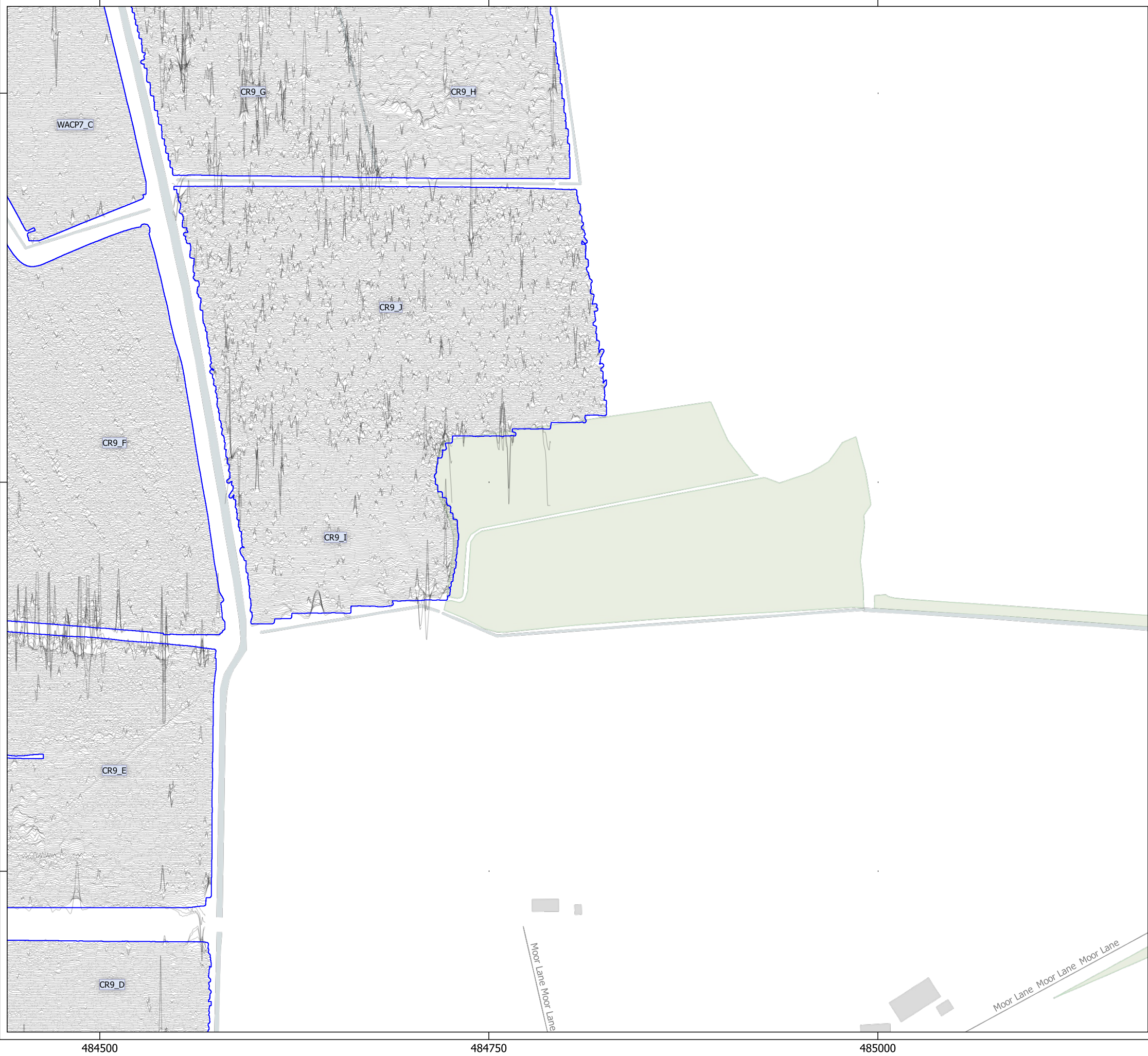


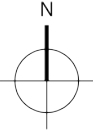
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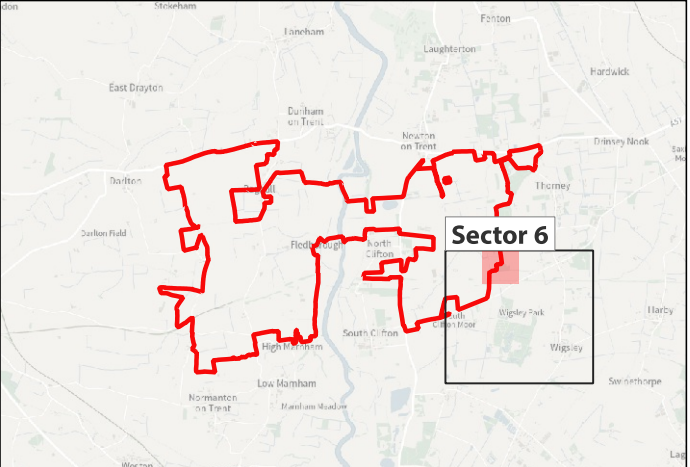








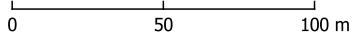
**HEADLAND**  
ARCHAEOLOGY

part of the **RSK** Group



**Sector 6**

**Key**  
 Survey Extent  
 XY Trace (25nT/cm)



050100 m

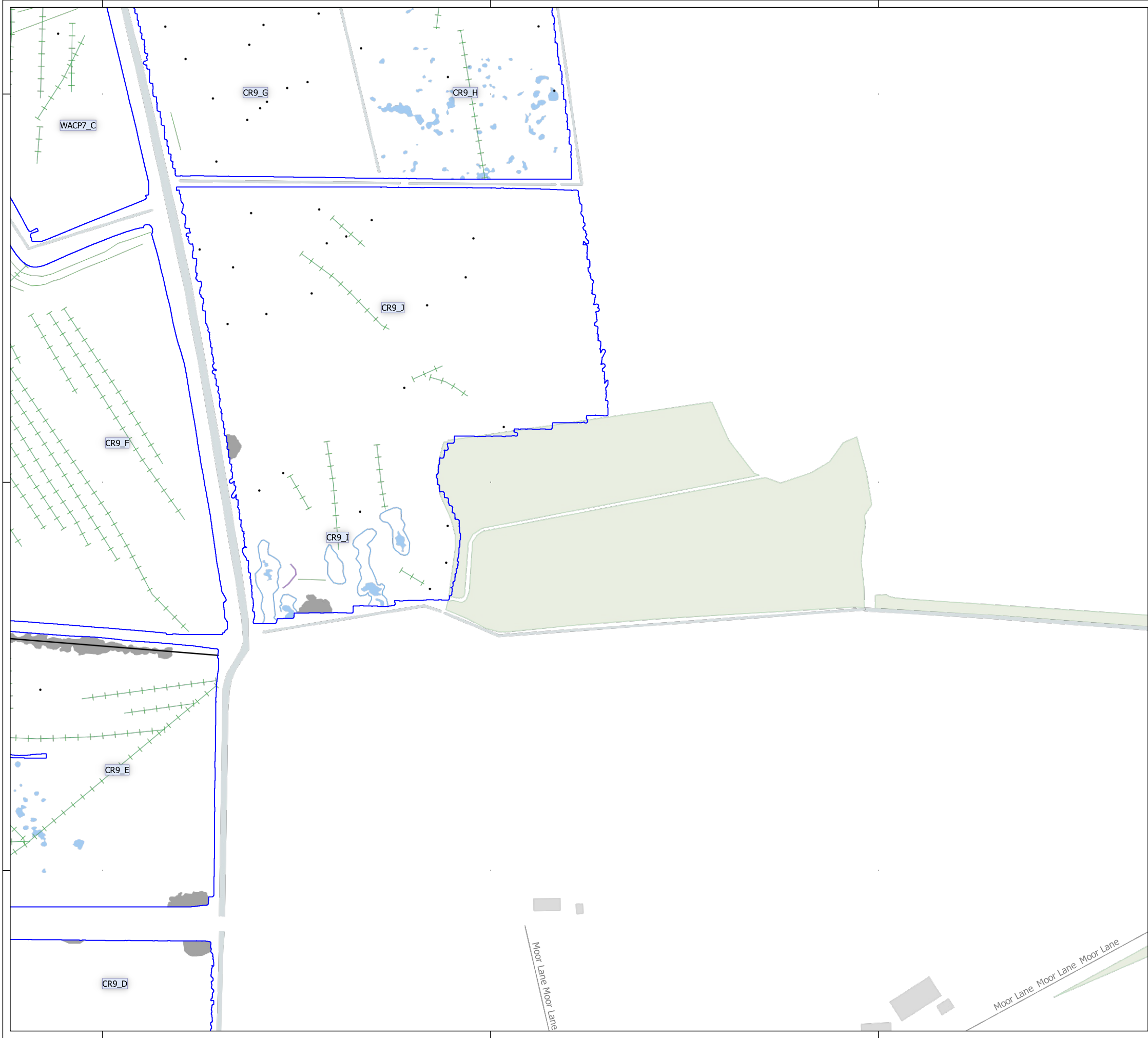
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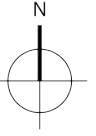
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Scale:	1:2,500 @ A3

Illus - 20 XY trace plot of minimally processed magnetometer data



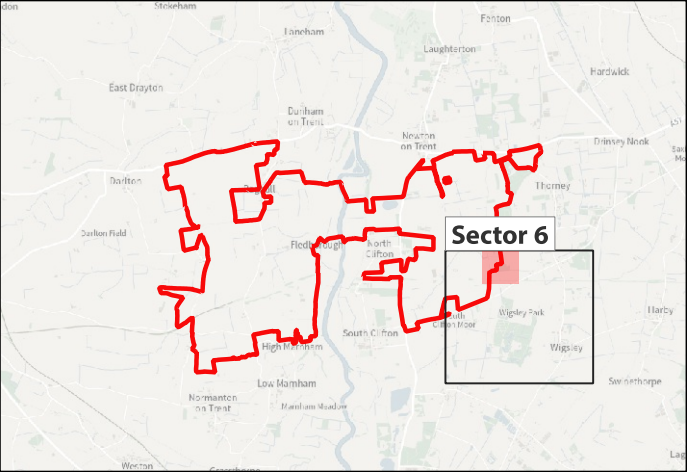






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**Sector 6**

**Key**

- Survey Extent
- Ferrous Objects
- Agriculture
- Field Drain
- Natural
- Pipe
- Uncertain
- Magnetic Disturbance
- Natural

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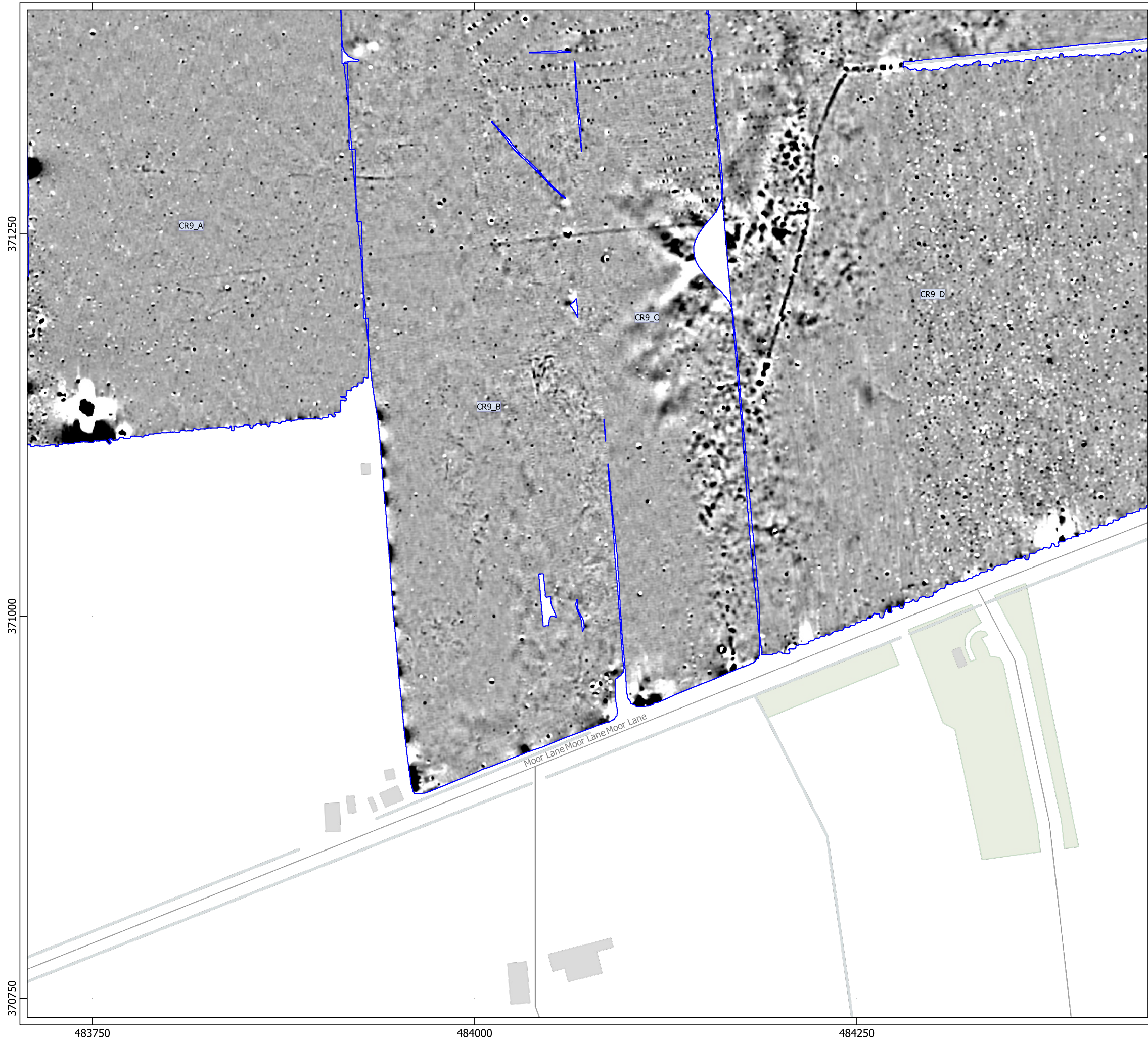
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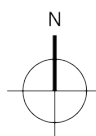
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Illus - 20 Interpretation of magnetometer data



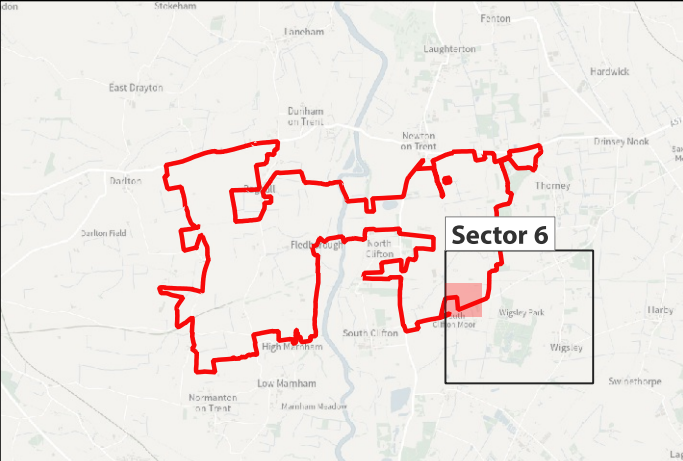







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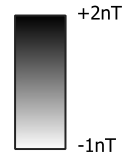
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**Sector 6**

**Key**

 Survey Extent



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-1nT

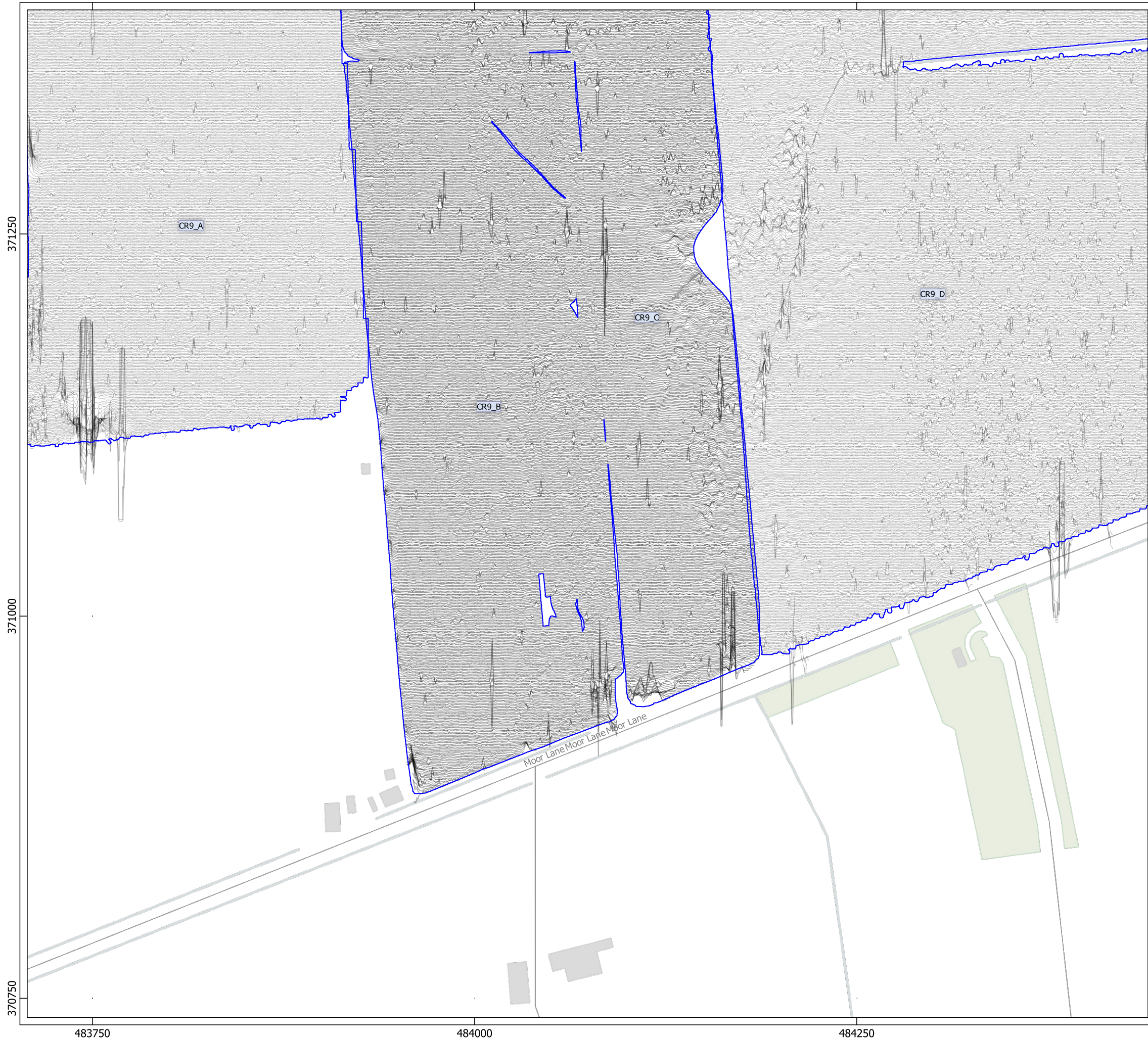
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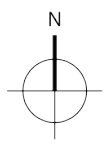
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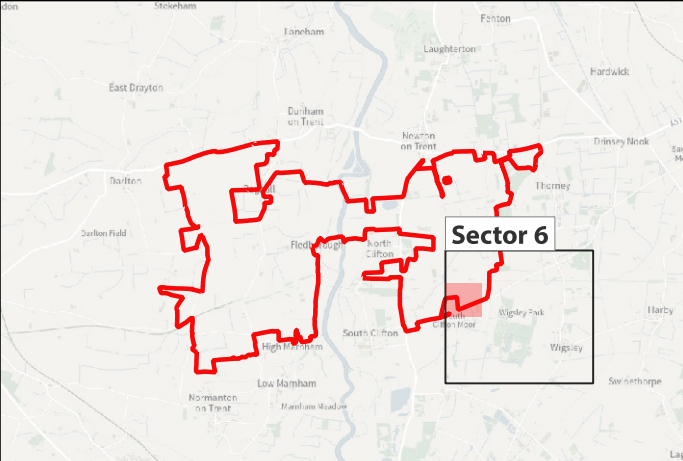







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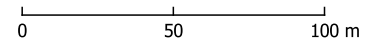


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**Key**

 Survey Extent

 XY Trace (25nT/cm)



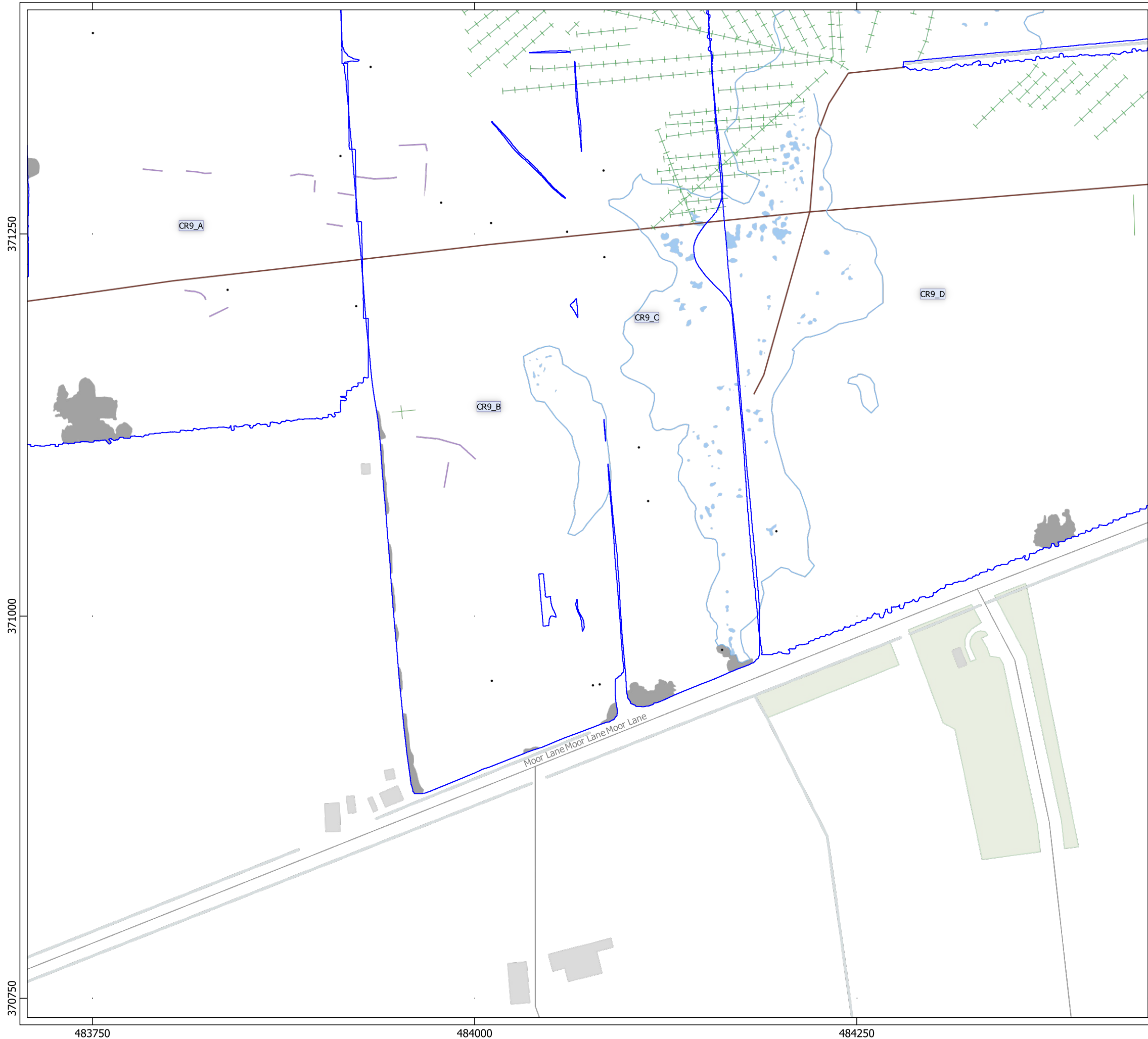
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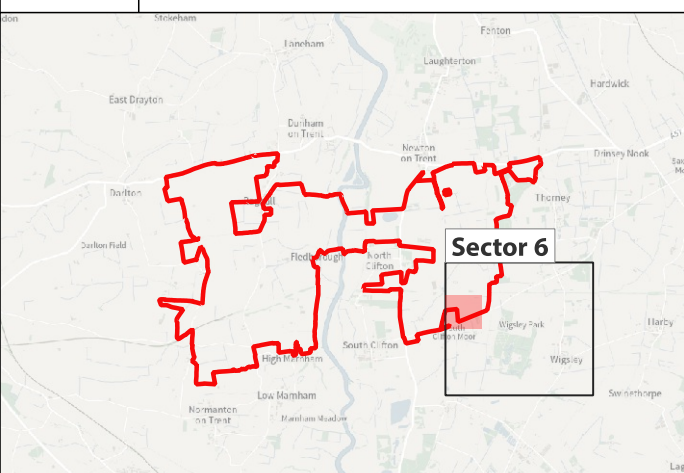






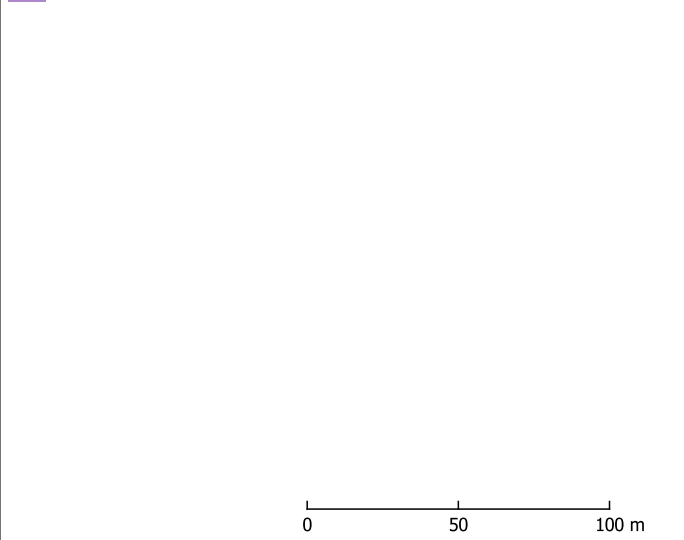


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**Key**

- Survey Extent
- Ferrous Objects
- Agriculture
- Field Boundary
- Field Drain
- Natural
- Uncertain
- Magnetic Disturbance
- Natural
- Uncertain

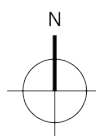



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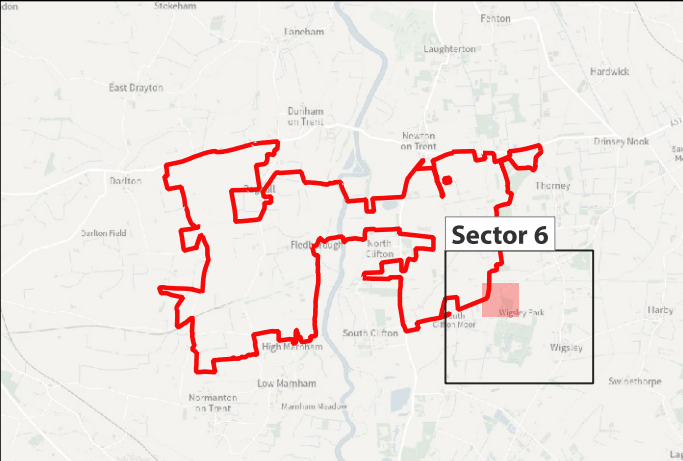





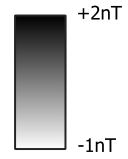


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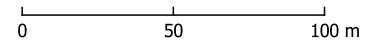
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**Key**  
 Survey Extent



+2nT  
-1nT



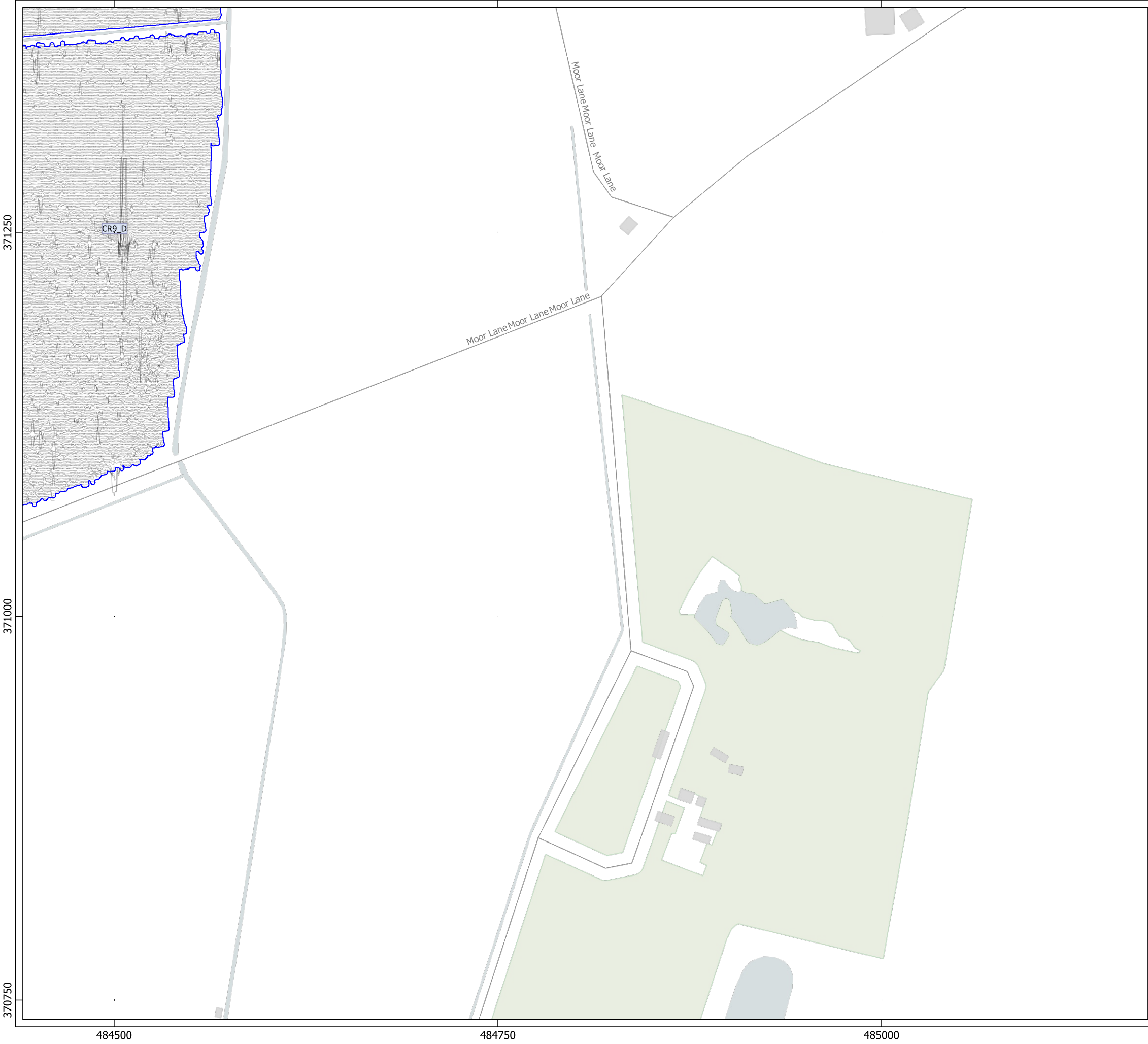
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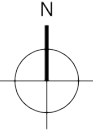
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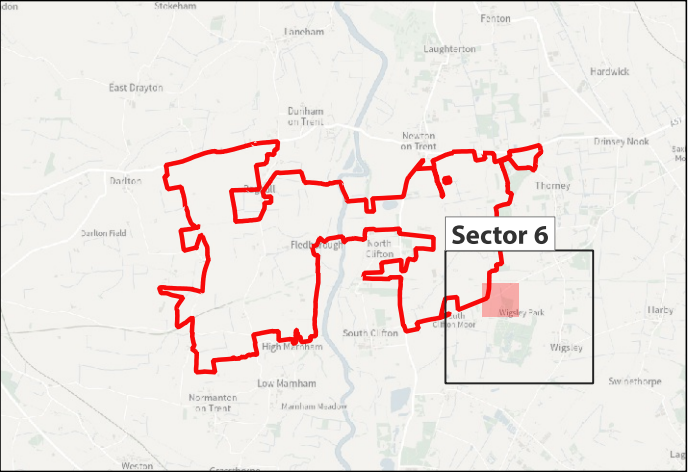







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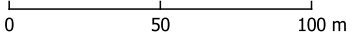


**Sector 6**

**Key**

 Survey Extent

 XY Trace (25nT/cm)

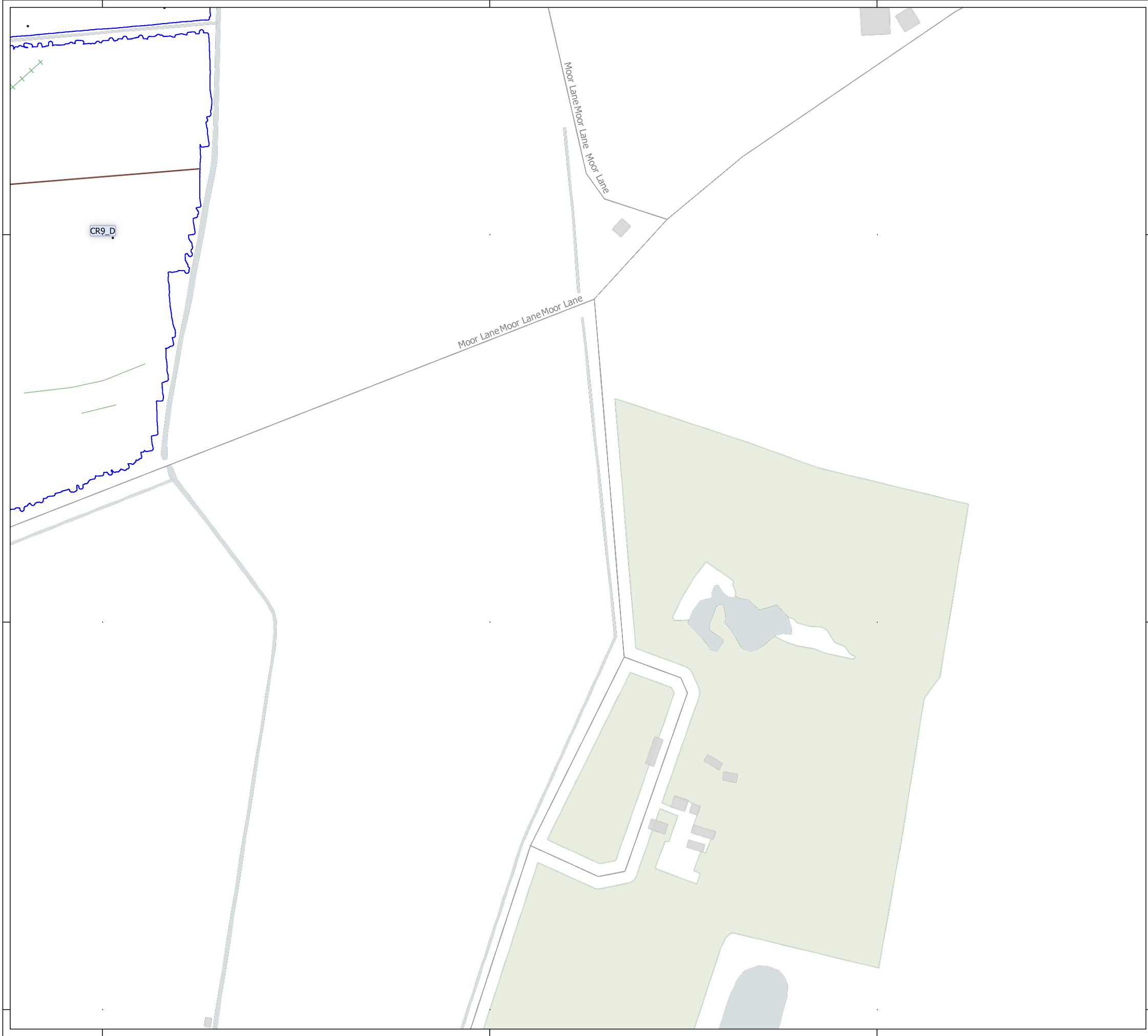


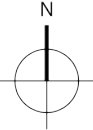
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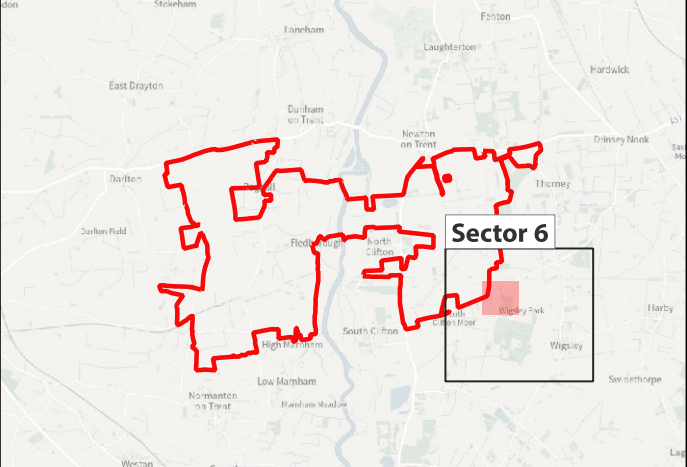











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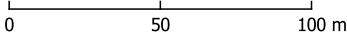
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**Sector 6**

**Key**

-  Survey Extent
-  Ferrous Objects
-  Agriculture
-  Field Boundary
-  Field Drain



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## 7 APPENDICES

### APPENDIX 1 MAGNETOMETER SURVEY

#### *Magnetic susceptibility and soil magnetism*

Iron makes up about 6% of the earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haematite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

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 the topsoil, subsoil, and rock 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.

The magnetic susceptibility of a soil (clay) can also be enhanced by the application of heat. This effect can lead to the detection of heat affected features such as hearths, kilns, or areas of burning.

#### *Types of magnetic anomaly*

In most cases anomalies are termed 'positive'. This means that they have a positive magnetic value relative to the magnetic background on any given site. However, some features can manifest themselves as 'negative' anomalies that, conversely, means that the response is negative relative to the mean magnetic background.

Where it is not possible to give a probable cause of an observed anomaly a '?' is appended.

It should be noted that anomalies interpreted as modern in origin might 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.

The types of response mentioned above can be divided into five main categories that are used in the graphical interpretation of the magnetic data:

**Isolated dipolar anomalies (iron spikes)** These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being introduced into the soil during manuring.

**Areas of magnetic disturbance** These responses can have several causes often being associated with burnt material, such as slag waste or brick rubble or other strongly magnetised/fired material. Ferrous structures such as pylons, mesh or barbed wire fencing and buried pipes can also cause the same disturbed response. A modern origin is usually assumed unless there is other supporting information.

**Lightning-induced remnant magnetisation (LIRM)** LIRM anomalies are thought to be caused in the near surface soil horizons by the flow of an electrical current associated with lightning strikes. These observed anomalies have a strong bipolar signal which decreases with distance from the spike point and often appear as linear or radial in shape.

**Linear trend** This is usually a weak or broad linear anomaly of unknown cause or date. These anomalies are often caused by agricultural activity, either ploughing or land drains being a common cause.

**Areas of magnetic enhancement/positive isolated anomalies** Areas of enhanced response are characterised by a general increase in the magnetic background over a localised area whilst discrete anomalies are manifest by an increased response (sometimes only visible on an XY trace plot) on two or three successive traverses. In neither instance is there the intense dipolar response characteristic exhibited by an area of magnetic disturbance or of an 'iron spike' anomaly (see above). These anomalies can be caused by infilled discrete archaeological features such as pits or post-holes or by kilns. They can also be caused by pedological variations or by natural infilled features on certain geologies. Ferrous material in the subsoil can also give a similar response. It can often therefore be very difficult to establish an anthropogenic origin without intrusive investigation or other supporting information.

**Linear and curvilinear anomalies** Such anomalies have a variety of origins. They may be caused by agricultural practice (recent ploughing trends, earlier ridge and furrow regimes or land drains), natural geomorphological features such as palaeochannels or by infilled archaeological ditches.



## APPENDIX 2 SURVEY LOCATION INFORMATION

An initial survey base station was established using a Trimble VRS differential Global Positioning System (dGPS). The magnetometer data was georeferenced using a Trimble RTK differential Global Positioning System (Trimble R8s model).

Temporary sight markers were laid out using a Trimble VRS differential Global Positioning System (Trimble R8s model) to guide the operator and ensure full coverage. The accuracy of this dGPS equipment is better than 0.01m.

The survey data were then super-imposed onto a base map provided by the client to produce the displayed block locations. However, it should be noted that Ordnance Survey positional accuracy for digital map data has an error of 0.5m for urban and floodplain areas, 1.0m for rural areas and 2.5m for mountain and moorland areas. This potential error must be considered if coordinates are measured off hard copies of the mapping rather than using the digital coordinates.

*Headland Archaeology cannot accept responsibility for errors of fact or opinion resulting from data supplied by a third party.*

## APPENDIX 3 GEOPHYSICAL SURVEY ARCHIVE

The geophysical archive comprises an archive disk containing the raw data in XYZ format, a raster image of each greyscale plot with associated world file, and a PDF of the report.

The project will be archived in-house in accordance with recent good practice guidelines ([http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics\\_3](http://guides.archaeologydataservice.ac.uk/g2gp/Geophysics_3)). The data will be stored in an indexed archive and migrated to new formats when necessary.

## APPENDIX 4 MAGNETOMETER DATA PROCESSING

The gradiometer data has been presented in this report in processed greyscale and minimally processed XY trace plot format.

Data collected using RTK GPS-based methods cannot be produced without minimal processing of the data. The minimally processed data has been interpolated to project the data onto a regular grid and de-striped to correct for slight variations in instrument calibration drift and any other artificial data.

A high pass filter has been applied to the greyscale plots to remove low frequency anomalies (relating to survey tracks and modern agricultural features) to maximise the clarity and interpretability of the archaeological anomalies.

The data has also been clipped to remove extreme values and to improve data contrast.



## APPENDIX 5 OASIS DATA COLLECTION FORM: ENGLAND

OASIS ID (UID): *headland1-531446*

Project Name:	Geophysical Magnetometry Survey at One Earth Solar Farm
Activity Type	Geophysical Survey, Magnetometry Survey,
Sitecode	OESF23
Project Identifier(s):	P23-175
Planning Id:	[no data]
Reason for Investigation:	Planning requirement
Organisation Responsible for work:	Headland Archaeology (UK) Ltd
Project Dates:	17-Jan-2024 - 28-Nov-2024
HER	Lincolnshire HER, Nottinghamshire HER
HER Identifiers	[no data]
Project Methodology:	<p>The surveys were undertaken using three types of fluxgate gradiometer sensors in both hand carried and ATV towed configurations. Hand carried survey was predominantly undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 4m apart. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R12 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point. MLGrad601 and MultiGrad601 (Geomar Software Inc.) software was used to collect and export the data. Hand carried and cart-based ATV towed survey was undertaken using four and five sensor arrays deploying Sensys FGM650/10 sensors mounted at 1m intervals (1m traverse interval) onto a rigid frame. The system was programmed to take readings at a frequency of 100Hz (allowing for a 1-2cm sample interval) on roaming traverses (swaths) 4m apart. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Leica GS18 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point. MonMX (Sensys Ltd) software was used to collect and export the data. ATV towed survey was also undertaken using five Foerster Ferex 4.035 sensors mounted at 1m intervals (1m traverse interval) on a wheeled non-magnetic cart. The system was programmed to take readings at a frequency of 300Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 5m apart. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R12 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point. DATAMONITOR 4 (Institut Dr. Foerster GmbH &amp; Co. KG) software was used to collect and export the data. Anomaly GeoSurvey v1.12.8 software package (© 2018 Robbie Austrums) was used to process and export all of the data plots from each survey system. Subsequent data interpretation and illustration work was all undertaken using QGIS v 3.34.6-Prizren.</p>
Project Results:	<p>The survey has successfully evaluated all suitable areas within the latest proposed site boundary, and some areas now scoped out of the project but still presented herein, with the total area surveyed amounting to approximately 1260 hectares. The results of the survey generally corroborate but also greatly expand the current understanding of the archaeological potential of the site as contained within the Lincolnshire and Nottinghamshire Historic Environment Records. Not unsurprisingly, given the size of the site, a large number and varied range of magnetic anomalies, including of agricultural, natural/geological, modern but also archaeological origin have been recorded by the survey. These are all identified against a relatively homogenous magnetic background ubiquitous across the site, (with the notable exception for fields in close proximity to the River Trent), that is likely derived from a relatively unresponsive underlying mudstone geology and overlying superficial deposits. The main findings of the survey include as many as nineteen separate locations within the current site boundary where foci of activity and/or individual archaeological features are clearly identified and where the archaeological potential is considered locally high. The majority of these areas include patterns of enclosure with associated ditches and trackways. The largest concentrations of these that are indicative of settlement activity and that correlate well with the entries on the local historic environment record (HER) are recorded between Ragnall and the River Trent, where three or four foci of activity could possibly identify one large extended area of activity, on the geological escarpment north of North Clifton, adjacent to Southmoor Lane and north of Moor Lane. Less dense areas of enclosure are evident in four separate locations adjacent to Feldborough Beck, south-east of Whimpton Moor medieval village, east of Crabtree Lane, adjacent to Northfield Lane and east of Roadwood Lane. In at least twelve locations the survey has mapped archaeological features, not previously known. Conversely, the survey has not identified any anomalies of possible archaeological potential in several locations east of the River Trent, where heritage assets comprising cropmarks and findspots are recorded on the local HER. All these areas coincide with spreads of overlying superficial sand and gravel deposits. It is uncertain whether there is a visibility bias in the detection of archaeological features across these deposits, as the survey has clearly mapped archaeological features across the same recorded geological and pedological conditions west of the River Trent. Consequently, the archaeological potential of those areas containing multiple HER assets relating to cropmarks east of the River Trent, in particular east of the A1133 remains unclear, though are not considered likely to contain significant areas of archaeological settlement activity. Outside of the areas of archaeological potential by far the most prevalent anomalies recorded by the survey are agricultural in origin, identifying systematic patterns of field drains, cultivation trends (both historic ridge and furrow and modern ploughing), and former field boundaries which typify the agricultural landscape within which the site is located. Sinuous channels and amorphous spreads of low magnitude discrete responses identifying natural/geological features caused by alluvial flood deposits are widespread within the fields adjacent to the River Trent and to a lesser extent Fledborough Beck. The results from a contiguous survey of this size have furthered the understanding of the extent and archaeological potential of the site and wider landscape and thereby added to the current understanding of the archaeological resource as identified on the Nottinghamshire and Lincolnshire HER's. Based on the results of the survey the archaeological potential of those areas containing clearly mapped extended and more isolated archaeological activity are considered locally high. In several locations where the magnetic survey responses are too vague and/or ephemeral to offer a more confident interpretation but are indicative of possible archaeological activity, the archaeological potential is considered moderate. Outside of these areas however the archaeological potential of the site is assessed as low.</p>



Keywords:	[no data]
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Archive:	[no data]
Report in OASIS:	Berry M (2025): Geophysical Magnetometry Survey at One Earth Solar Farm Cleckheaton: Headland Archaeology (UK) Ltd









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