

PMWF24



PEN MARCH WIND FARM, MERTHYR TYDFIL

GEOPHYSICAL SURVEY REPORT

PLANNING REF. pre-application

Headland Archaeology Yorkshire & North
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Commissioned by RWE Renewables Ltd.

18/11/2024

PROJECT INFORMATION:

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PLANNING REF.	pre-application
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CONSULTANT/AGENT	n/a
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PROJECT TEAM:

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PROJECT SUMMARY

Headland Archaeology (UK) Ltd was commissioned by RWE Renewables Ltd to undertake a geophysical (magnetometer) survey at the proposed site of Pen March Wind Farm, Merthyr Tydfil. The survey covered areas centred around the planned location of six wind turbines, and at two other locations which will encompass an electrical and control building compound with battery storage and a works compound, an overall area of 13.6 hectares. However, due to a combination of waterlogged, boggy, overgrown and steeply undulating ground survey was only completed, or part completed, at six out of the eight survey areas. The results of the geophysical survey will be submitted in support of the application for the proposed development and may also inform future archaeological strategy.

Against a homogeneous magnetic background, the survey has recorded four small clusters of discrete responses of uncertain origin in three of the survey areas. These anomalies do not form any coherent pattern although their extent is clearly defined and, on this basis, they are not considered likely to be of archaeological origin. They are interpreted as most likely of natural origin although the anomaly response, particularly from the stronger anomalies within these groupings, could indicate an anthropogenic cause. However, it is difficult to draw more confident conclusions given the relatively small size of the survey areas and the incomplete data sets. The only other anomalies are interpreted as of geological origin. No obvious above ground remains or earthworks were noted within the survey areas.

Where survey was possible the archaeological potential is assessed as low. In those areas where the survey could not be carried out the archaeological potential remains undetermined.

DRAFT

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PEN MARCH WIND FARM, MERTHYR TYDFIL

GEOPHYSICAL SURVEY REPORT

1. INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by RWE Renewables Ltd (the Client) to undertake a geophysical (magnetometer) survey on selected parcels of land for the proposed development site of Pen March Wind Farm, Merthyr Tydfil (Illus 1). The results of the geophysical survey will be submitted in support of the application for the development of the site and may also inform future archaeological strategy, if required.

The survey was undertaken in accordance with the requirements of Planning Policy Wales 2024 (Edition 12, Ch.6 The Historic Environment), and with the Written Scheme of Investigation for Geophysical Survey (WSI) (Headland Archaeology 2024).

The WSI was produced to the standards laid down in the European Archaeological Council's guideline publication, EAC Guidelines for the Use of Geophysics in Archaeology (Europae Archaeologia Consilium 2016) and the Chartered Institute for Archaeologists' (CIfA) Standard and Guidance for Archaeological Geophysical Survey (CIfA 2020). The survey was also carried out in line with the same best practice guidelines.

The survey was carried out between November 11th and November 14th, 2024.

1.1. SITE LOCATION, TOPOGRAPHY AND LAND-USE

The Geophysical Survey Areas (GSA's) comprised eight parcels covering approximately 13.6 hectares which are set within a wider scheme application boundary of 460 hectares. The GSA's comprised blocks covering the proposed location of six wind turbines, as well as areas for an electrical and control building with battery storage area and a works compound area, for the proposed Pen March Wind

Farm located on Pen March Mountain, north-east of Merthyr Tydfil.

The GSA's are sited on common land centred at NGR 308725, 210127 north-east of Merthyr Tydfil, north of the A465, south-east of Pontsticill and west of Rhymney. The land is open pasture on the lower slopes of Pen March Mountain with rougher grass in upland areas. Outcrops of bedrock are also evident in and around the GSA's (Illus 2 to Illus 9).

Topographically the land within the wider application area and between the individual parcels of the GSA is varied. The southern boundary of the site lies at around the 350m Above Ordnance Datum (AOD). The land then rises gradually over the eastern side of the site to around 530m AOD in the centre of the northern boundary. It is around 410m AOD along the western edge, with a gradual drop down to the southwestern corner of around 380m AOD. The localised topography of each individual survey parcel is also varied with steep undulations present in several parcels.

1.2. GEOLOGY AND SOILS

The underlying bedrock geology varies across the wider application boundary and comprises a mix of sedimentary limestone, sandstone, mudstone and siltstone formations. Four of the turbine bases (TB2, TB3, TB5 and TB6) and the electrical and control building compound are located on sandstone of the South Wales Lower Coal Measures Formation. The northernmost turbine (TB1) is located on mudstone of the Bishopston Mudstone Formation. The easternmost turbine base (TB4) is located on both sandstone and mudstone of the South Wales Lower Coal Measures Formation. The area designated for a works compound is located on mudstone, siltstone and sandstone of the South Wales Lower Coal Measures Formation.

Diamicton (till) superficial deposits overlay the location of TB6, the proposed works compound area and north-eastern fringe of TB4 (NERC 2024).

The soils covering the majority of the GSA's are described as slowly permeable wet very acid upland soils with a peaty surface, classified in Soilscape 19. The northernmost turbine base is located on soils classified as freely draining very acid sandy and loamy soils in the Soilscape 14 Association (Cranfield University 2024).

2. ARCHAEOLOGICAL BACKGROUND

The following background is abstracted from a Historic Environment Desk Based Assessment (HEDBA – HCUK Group 2024a) produced for the proposed scheme. This document alongside an Assessment of the Significance of Impact of Development on Historic Landscape of Historic Interest in Wales 2 (ASIDOHL2 – HCUK Group 2023b) should be consulted for a more detailed archaeological background covering the wider application area.

For the wider application area, the HEDBA stated that, 'a 2km radius study area was used for archaeological sites recorded on the Glamorgan Gwent and Clwyd Powys Archaeological Trusts Historic Environment Records and for sites held on the National Monuments Record. Assessment of the searches, in conjunction with analysis of historic cartographic sources, aerial photographs and LiDAR data led to the conclusions that the site has a moderate potential for prehistoric remains to be present within the proposed development areas, possibly associated with hitherto unrecorded cairns, buildings or field boundaries. There is a low potential for Roman and early medieval remains to be present. For the medieval period, the potential for remains to be present is low, although if so, they would likely be associated with land divisions, agricultural buildings and sheep shelters'.

'Remains are known to be present within the Application Boundary of post-medieval date, and although nothing is known within the areas of proposed development, there is quite a high likelihood for agricultural remains to be present, such as field boundaries or shelters. There is also a high potential for mineral extraction remains, such as further quarries, and a high potential for further remains associated with the Dowlais Free Drainage System. For the modern period the potential is moderate as further mineral

extraction remains and additions or repairs to the Dowlais Free Drainage System may be present'.

More specifically in terms of the GSA's no heritage assets are recorded within any of the survey areas.

A large irregular 'D' shaped drystone wall enclosure (GGAT04892m) that is in the process of becoming scheduled and two cairns (GGAT04893m and GGAT03139m) lie approximately 150m south of the proposed site of the electrical and control building compound with battery storage area.

A likely misidentified cairn (GGAT00781m) is recorded immediately east of TB2.

A former sheepfold (NPRN 243162) lies approximately 75m north of TB5.

There is also evidence of quarry scoops on top of outcropping bedrock (GGAT02418m and GGAT03200m) evident in LiDAR data immediately adjacent to the electrical and control building compound site. A shooting butt (GGAT03059m) is also recorded at this location.

3. AIMS, METHODOLOGY & PRESENTATION

3.1. AIMS AND OBJECTIVES

The principal objectives of the geophysical survey were to gather information to establish the presence/absence, character and extent of any archaeological remains within the GSA's, to inform a planning application and thereby any further investigation strategies.

The aims of the survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies,
- to therefore determine the likely presence/absence and extent of any buried archaeological features, and
- to prepare a comprehensive site archive and report.

3.2. METHODOLOGY

Magnetic survey methods rely on the ability of a variety of instruments to measure very small

magnetic fields associated with buried archaeological remains. A feature such as a ditch, pit or kiln can act like a small magnet, or series of magnets, that produce distortions (anomalies) in the earth's magnetic field. In mapping these slight variations detailed plans of sites can be obtained, as buried features often produce reasonably characteristic anomaly shapes and strengths (Gaffney & Gater 2003). Further information on soil magnetism and the interpretation of magnetic anomalies is provided in Appendix 1.

Magnetometry is the most widely used geophysical survey technique in archaeology as it can quickly evaluate large areas and, under favourable conditions, identify a wide range of archaeological features including infilled cut features such as large pits, gullies and ditches, hearths, and areas of burning, and kilns and brick structures. It is therefore good at locating settlements of all periods, prehistoric field systems and enclosures, and areas of industrial or modern activity, amongst others. It is less successful in identifying smaller features such as post-holes and small pits (except when using a non-standard sampling interval), unenclosed (prehistoric) settlement sites and graves and burial grounds. However, magnetometry is by far the single most useful technique and was assessed as the best non-intrusive methodology for this site.

The survey was undertaken using four Sensys FGM650/10 sensors mounted at 1m intervals (1m traverse interval) onto a rigid hand carried 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. Anomaly GeoSurvey v1.12.3 (Lichenstone Geoscience) and QGIS v.3.28.5 software was used to process and present the data respectively.

3.3. DATA PRESENTATION AND TECHNICAL DETAIL

A general site location plan showing the GSA's is shown in Illus 1 at a scale of 1:20,000. Illus 2 to Illus 9

inclusive are site condition photographs of each survey parcel. Illus 10 shows the location and direction of the site condition photographs and areas unsuitable for survey at 1:7,500. Illus 11 and Illus 12 are overall plans of the processed magnetometer data and interpretation respectively, also at a scale of 1:7,500. These overall plans also show the sequencing of the 1:1,000 illustrations. Fully processed (greyscale) data, minimally processed (XY trace plot) data and interpretative plans are presented by individual area, at 1:1,000, in Illus 13 to Illus 30 inclusive.

Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2 details the survey location information and Appendix 3 describes the composition and location of the site archive. Data processing details are presented in Appendix 4. A copy of the OASIS entry (Online Access to the Index of Archaeological Investigations) is reproduced in Appendix 5.

The survey methodology, report and any recommendations comply with the Written Scheme of Investigation (Headland Archaeology 2024), guidelines outlined by Europae Archaeologia Consilium (EAC 2016) and by the Chartered Institute for Archaeologists (CIfA 2020).

All illustrations using Ordnance Survey (OS) mapping are reproduced with the permission of the controller of His Majesty's Stationery Office (© Crown copyright).

The Illustrations in this report have been produced following analysis of the data in 'raw' (minimally processed) and processed formats and over a range of different display levels. All illustrations are presented to display and interpret the data to best effect. The interpretations are based on the experience and knowledge of Headland management and reporting staff.

4. RESULTS & DISCUSSION

4.1. SITE CONDITIONS

Magnetometer survey is generally recommended over any sedimentary bedrock but the average response over sandstone and mudstone geologies can be poor and often variable depending on the presence of any overlying superficial deposits (English Heritage 2008; Table 4). Nevertheless,

magnetometry was still the most appropriate non-intrusive geophysical technique for evaluating the GSA's, taking account of the limitations noted in Section 3.2 and given the difficult terrain and ground conditions.

Surface conditions were generally poor (Illus 2 to Illus 9 inclusive) with long, thick grass, boggy areas and steeply undulating ground widespread. No survey was possible within TB3 and the proposed works compound. Almost total coverage was possible in TB1 and TB2 and also the proposed site of the electrical and control building compound. Approximately half the area was suitable for survey at TB4 and TB5 but only 25% was surveyed in TB6.

Despite the challenging ground conditions data quality was generally good with only minimal post-processing required. The survey has recorded a generally homogenous magnetic background across the GSA's against which only four small clusters of discrete responses of uncertain origin are identified in TB2, TB5 and the battery storage site (Illus 11 and Illus 12).

The detection of a number of discrete responses in multiple survey parcels suggests that there was sufficient magnetic contrast for the detection of potentially archaeological features, if present, notwithstanding the limitations of magnetometer survey to identify the types, sizes, and period of archaeological features as described in Section 3.2 and keeping in mind the variability over sandstone and mudstone bedrock geologies.

The results of the survey are therefore determined to provide a reasonable indication of the archaeological potential of the GSA's, though it is acknowledged the limited size and incomplete coverage of the survey parcels restricts a more confident interpretation of the recorded anomalies.

The results from each survey parcel are presented below in Table 1.

4.2. TABLE 1

Area Illus No.	Percentage completed. Archaeological Anomalies	Interpretation
TB1 Illus 13-15	95% No	Findings are limited to a single discrete higher magnitude response of uncertain origin. The form of the anomaly is indicative of a possible lightning strike.
TB 2 Illus 16-18	95% No?	A well-defined cluster of discrete anomalies of varying magnetic strengths, distinct from the generally homogenous magnetic background, are recorded in the southern half of the parcel. There is little coherence or apparent pattern to the distribution of the anomalies that would indicate an archaeological origin, although the stronger discrete responses to the south and at the south-eastern edge of the parcel have a magnetic signature that could indicate an anthropogenic cause. Nevertheless, on balance it is considered more likely that the responses are natural in origin though an anthropogenic and possible archaeological cause cannot be definitively ruled out.
TB 3	0% N/A	This parcel was unsuitable for survey due to ground conditions consisting of tall tussocks of coarse grass and deep ravines.
TB 4 Illus 19-21	50% No	Where survey was possible no anomalies of note have been recorded against a homogenous magnetic background. About half of the parcel was unsuitable due to the presence of bog grass, tall tussocks and deep ravines.
TB 5 Illus 22-24	40% No?	A cluster of discrete magnetically enhanced responses of uncertain origin are recorded at the eastern and western extents of this parcel. The responses are similar in nature to those recorded across parts of TB2 and as such there is little to suggest an archaeological origin. Consequently, and despite a vaguely circular arrangement of anomalies at the northern corner of the parcel, these anomalies are also on balance considered to be natural in origin. Unsuitable areas within this parcel consisted of bog grass, tall tussocks and uneven ground.
TB 6 Illus 25-27	25% No	No anomalies of note are recorded against a homogenous magnetic background in the 25% which was suitable for survey.
Electrical and control building compound with battery storage Illus 28-30	90% No	Two short curvilinear spreads of magnetically enhanced discrete anomalies are recorded against an otherwise homogenous magnetic background. The anomalies are of uncertain origin though appear to correspond to modern trackways and/or natural gullies visible on satellite imagery. They are therefore assessed as having low archaeological potential.
Works compound	0% N/A	This parcel was unsuitable for survey due to ground conditions consisting of long snaggy grass, areas of bog, tall tussocks and very uneven ground.

5. CONCLUSION

Survey was attempted across all eight parcels. However, full survey coverage was not attainable due to a combination of boggy, overgrown and steep and uneven ground conditions. No survey was

possible at TB3 or at the proposed site of the works compound.

The survey has recorded a generally homogenous magnetic background across the GSA's against which only four small clusters of discrete responses of uncertain origin are identified in TB2, TB5 and the

control building compound site. Generally, these anomalies do not exhibit any coherent pattern or distribution that might indicate an anthropogenic origin and are considered most likely natural in origin. The small cluster of responses within the building compound parcel appear to correspond to modern tracks and natural gullies evident on satellite imagery.

The anomalies do not correspond to any mapped superficial deposits though this remains a plausible interpretation with pockets of till, head and peat deposits all recorded in the surrounding landscape. The anomaly response particularly from the stronger anomalies within these groupings could, however, indicate an anthropogenic cause and therefore a possible archaeological origin cannot be entirely dismissed. It remains difficult to draw more confident conclusions given the relatively small size of the survey areas and incomplete data sets.

The detection of a number of discrete responses in some GSA's suggests that there was sufficient magnetic contrast for the detection of potentially archaeological features, if present, notwithstanding the limitations of magnetometer survey to identify the types, sizes, and period of archaeological features as detailed herein.

No obvious above ground remains or earthworks were noted within the GSA's.

Therefore, based on the results of the survey the archaeological potential of the GSA's is assessed as low. The exceptions are in those parcels where survey was partial or not possible at all. Here, the archaeological potential remains undetermined.

6. REFERENCES

Chartered Institute for Archaeologists (CIfA) 2020 Standard and guidance for archaeological geophysical survey (Reading) https://www.archaeologists.net/sites/default/files/CIfA%26Geophysics_3.pdf accessed 14th November 2024

Cranfield University 2024 Cranfield Soil and Agrifood Institute Soilscales <http://www.landis.org.uk/soilscales/> accessed 14th November 2024

English Heritage 2008 Geophysical Survey in Archaeological Field Evaluation

Europae Archaeologia Consilium (EAC) 2016 EAC Guidelines for the Use of Geophysics in Archaeology: Question to Ask and Points to Consider (Namur, Belgium) <https://www.europae-archaeologiae-consilium.org/eac-guidelines> accessed 14th November 2024

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HCUK Group 2023a Historic Environment Desk Based Assessment Pen March Wind Farm, Merthyr Tydfil [Client ref: 06151A-DBA]

HCUK Group 2023b Historic Landscape of Historic Interest in Wales 2 Pen March Wind Farm (ASIDOHL2) [Client ref: 06151A]

Headland Archaeology 2024 Pen March Wind Farm, Merthyr Tydfil, Written Scheme of Investigation for Geophysical Survey [Unpublished Client Document Ref. PMWF24]

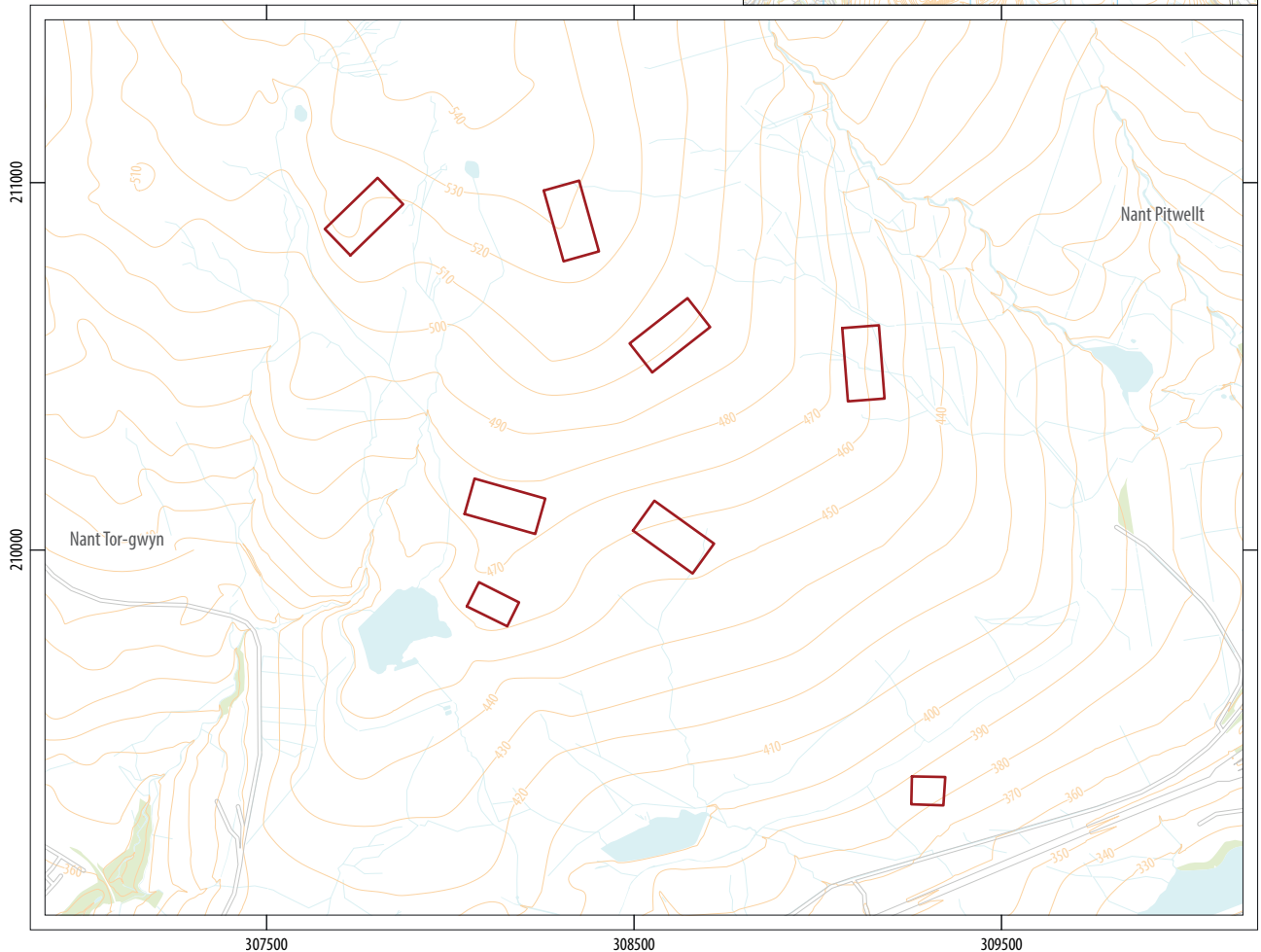
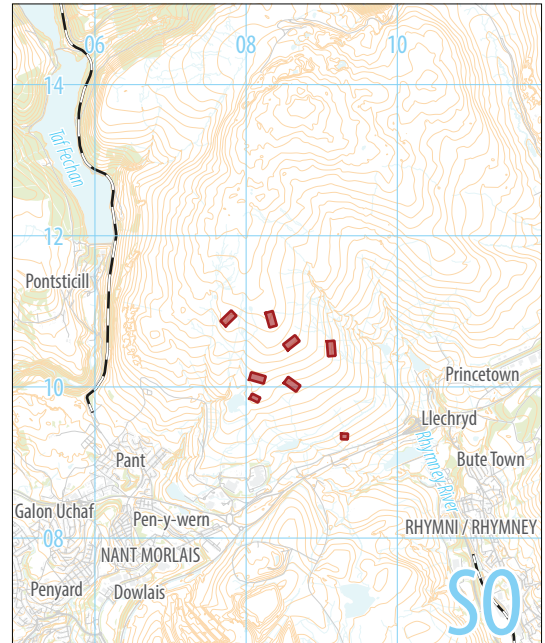
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Pen March Wind Farm
Merthyr Tydfil

0 200km
1:12,500,000 @ A4



0 400m
1:20,000 @ A4

 geophysical survey area

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Illus 2 Turbine Base 1, looking north-east



Illus 3 Turbine Base 2, looking north



Illus 4 Turbine Base 3, looking north-west



Illus 5 Turbine Base 4, looking north



Illus 6 Turbine Base 5, looking west



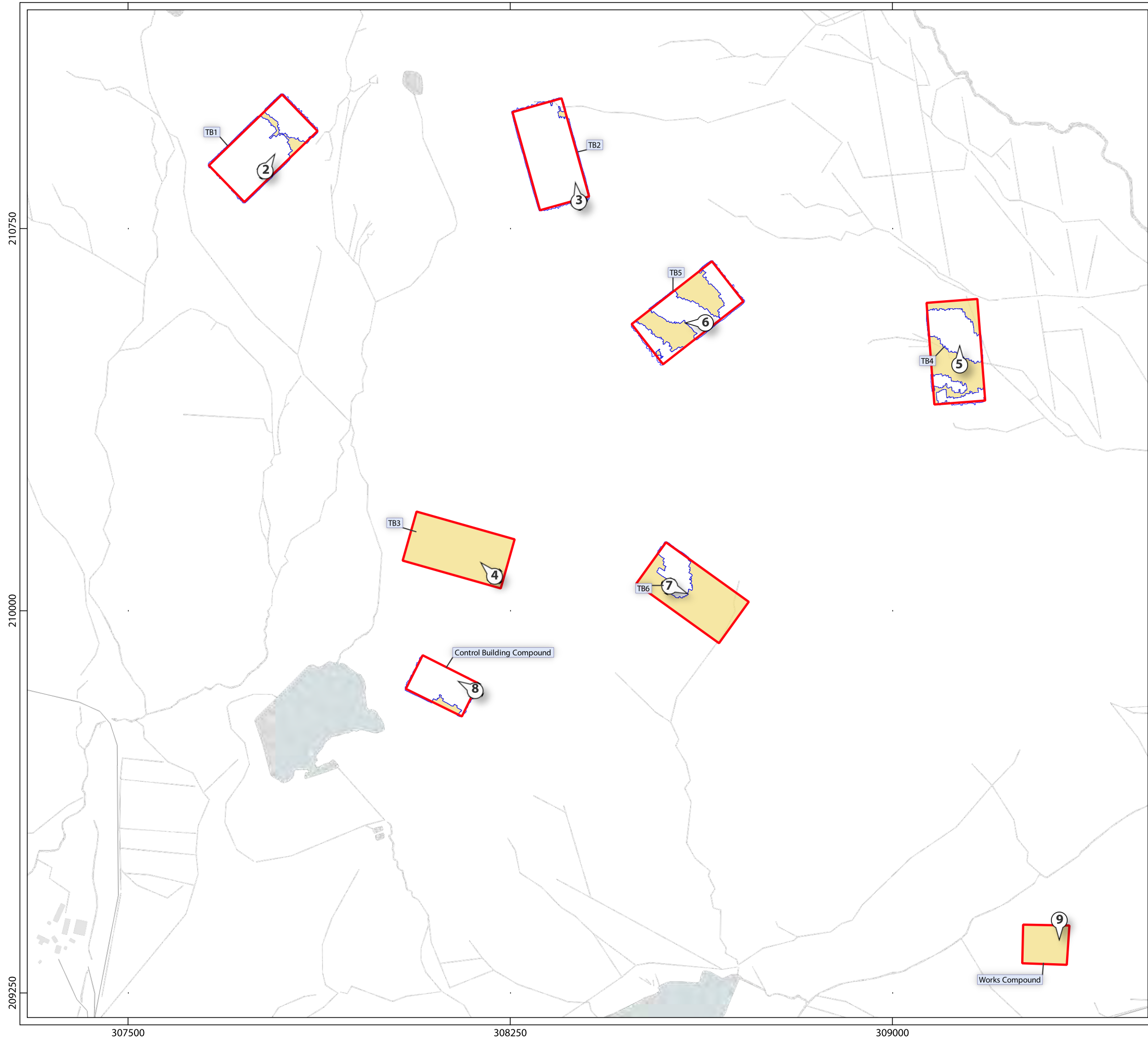
Illus 7 Turbine Base 6, looking south-east



Illus 8 Electrical and control building compound with battery storage area, looking west-northwest



Illus 9 Construction compound area, looking south



N

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Key

- Geophysical Survey Area
- Survey Extent
- ? Location and Direction for Illus 02 to 09
- Unsuitable Survey Area

0

100

200 m

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Site:	PMWF24
Created by:	LD
Checked by:	SH
Version:	v2.1
Date:	19/11/2024
Scale:	1:7,500 @ A3

Illus 10 - Survey location showing photograph locations



N

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Key

Geophysical Survey Area

Survey Extent

Area for Illus 13 to 30

+2nT

-1nT

0

100

200 m

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Illus 11 - Overall greyscale plot of processed magnetometer data



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Key

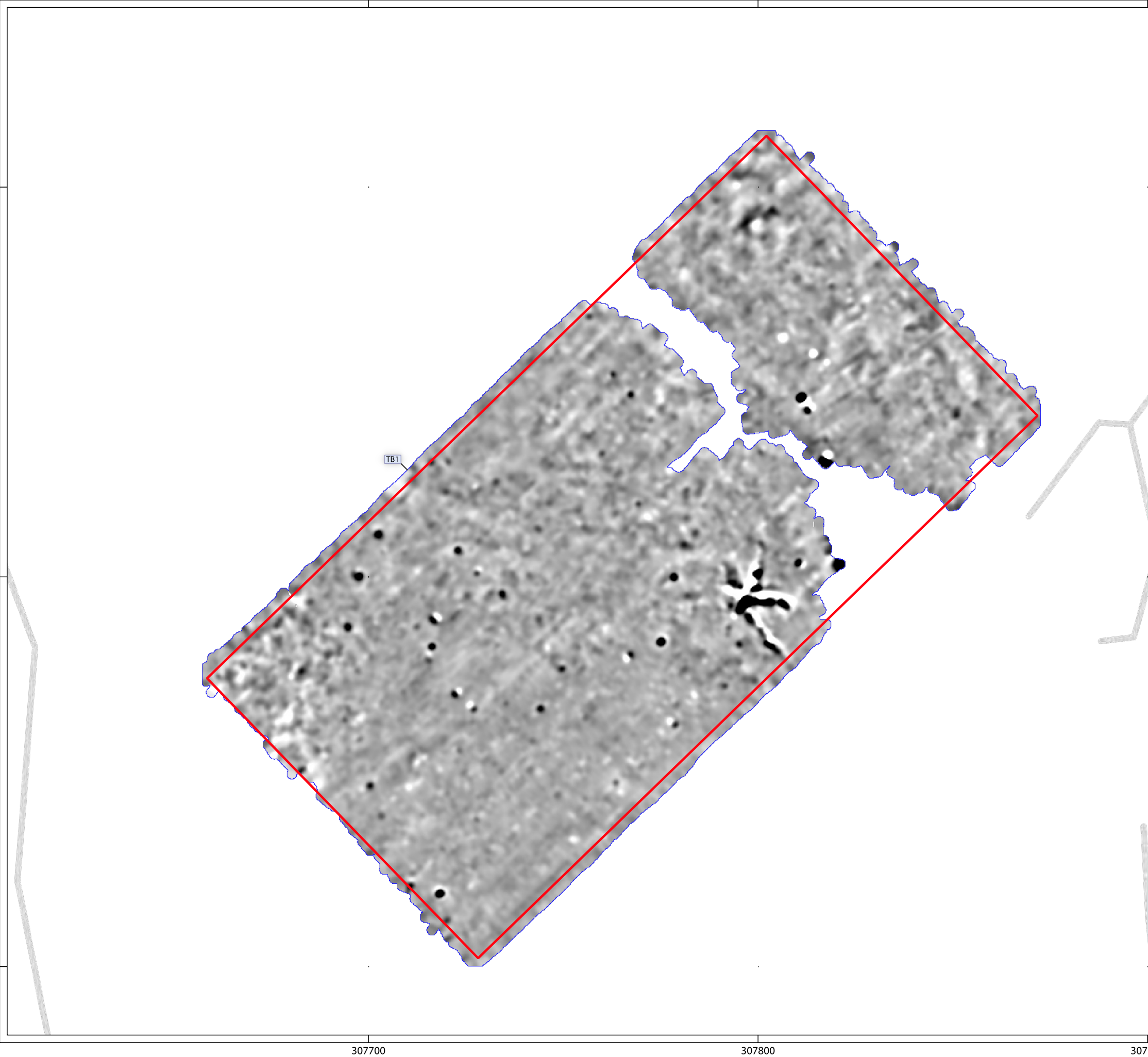
- Geophysical Survey Area
- Survey Extent
- Area for Illus 13 to 30
 - Ferrous Objects
 - Natural
 - Magnetic Disturbance (Above Ground)
 - Magnetic Disturbance (Below Ground)
 - Natural
 - Uncertain

0100200m

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Illus 12 - Overall interpretation of magnetometer data



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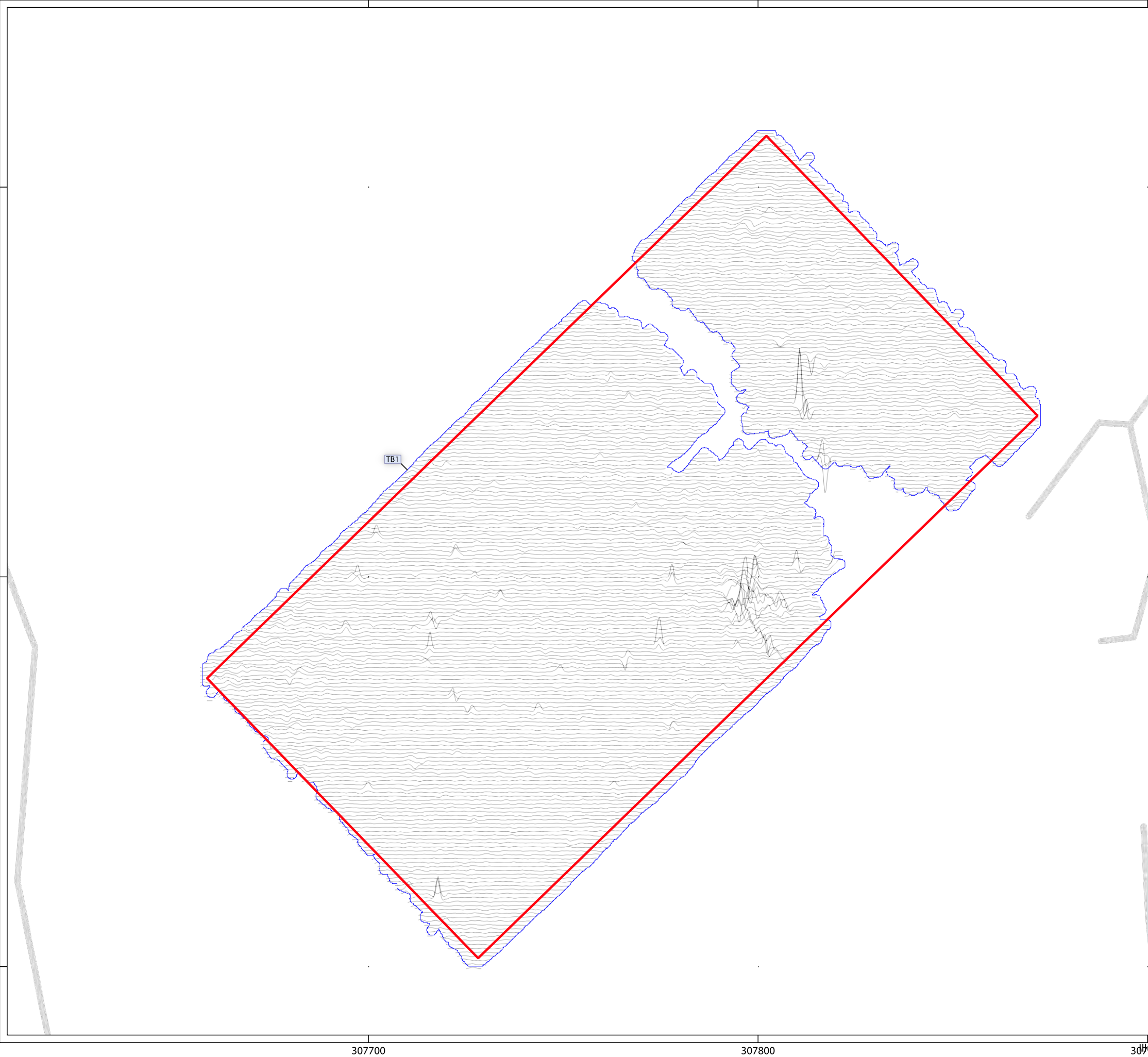
Key

- Geophysical Survey Area
- Survey Extent

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Date:	15/11/2024
Scale:	1:1,000 @ A3



N

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Key

Geophysical Survey Area

Survey Extent

XY Trace (25nT/cm)

0

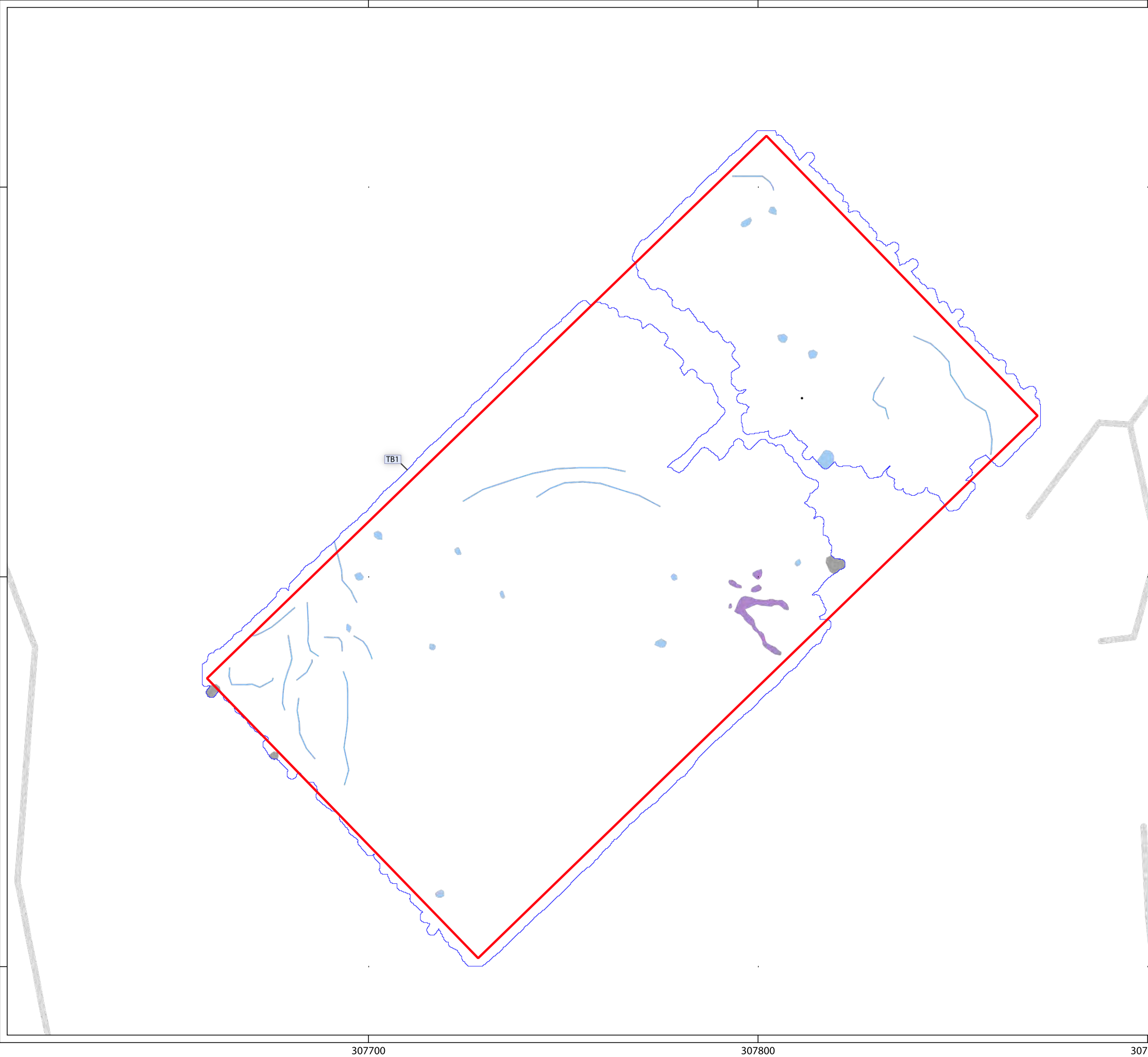
20

40 m

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Checked by:	SH
Version:	v1.0
Date:	15/11/2024
Scale:	1:1,000 @ A3



N

HEADLAND

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Key

Geophysical Survey Area

Survey Extent

Ferrous Objects

Natural

Magnetic Disturbance (Above Ground)

Natural

Uncertain

0

20

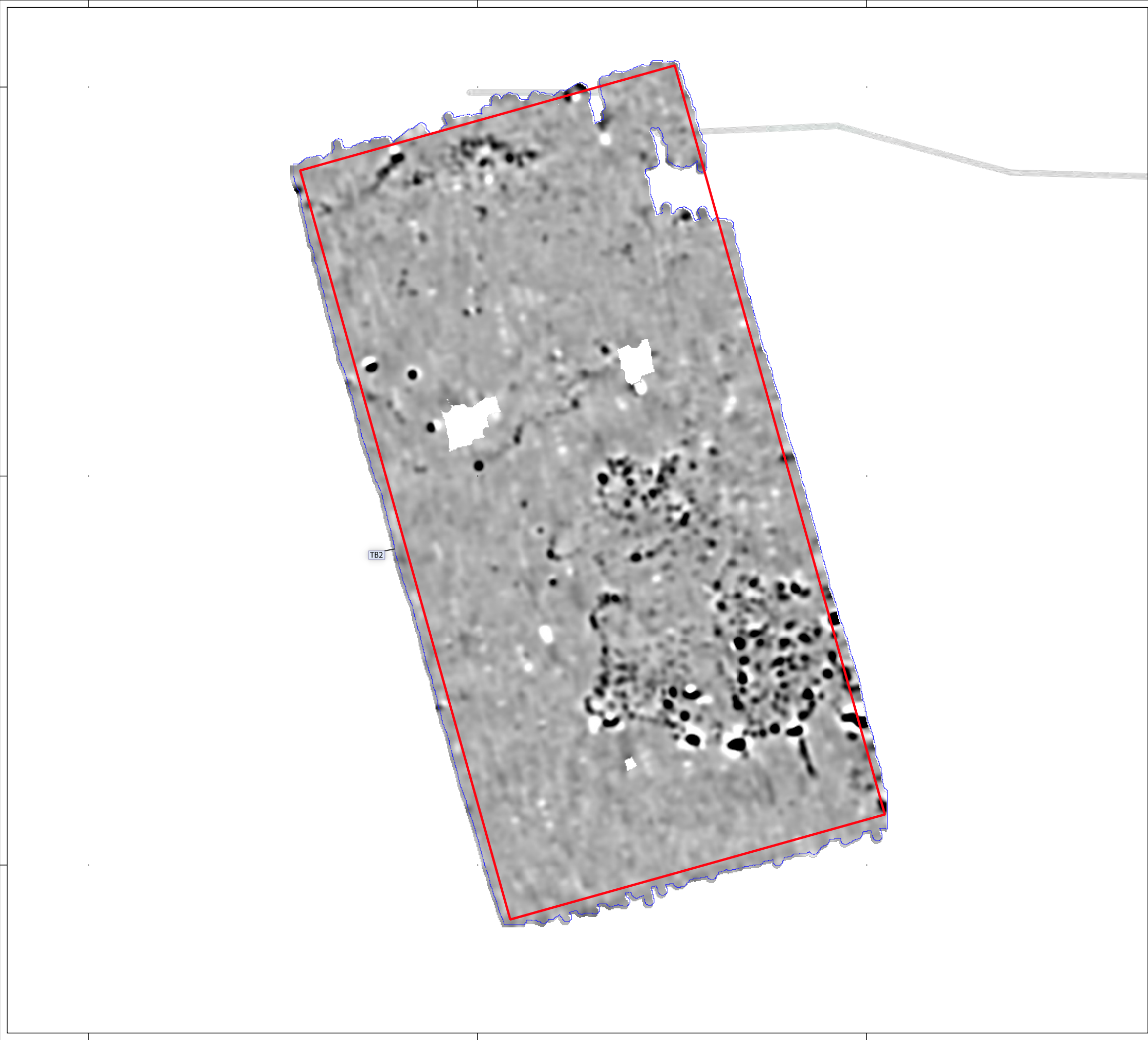
40 m

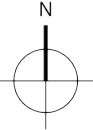
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Site:	PMWF24
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Checked by:	SH
Version:	v1.0
Date:	15/11/2024
Scale:	1:1,000 @ A3

Illus - 15 Interpretation of magnetometer data; Turbine Base 1

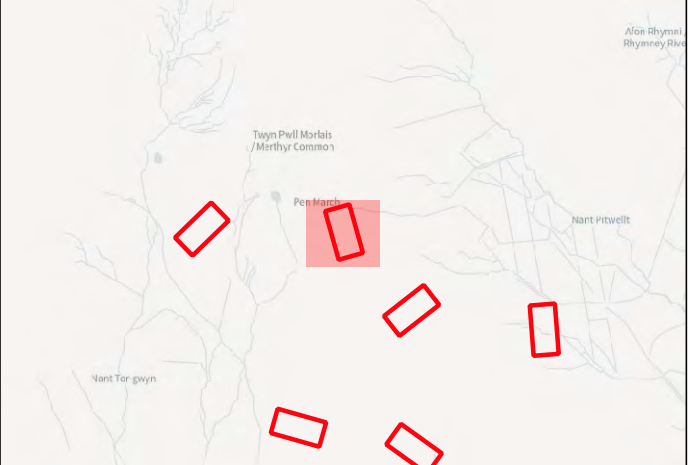






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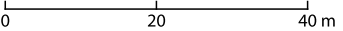


Key

-  Geophysical Survey Area
-  Survey Extent



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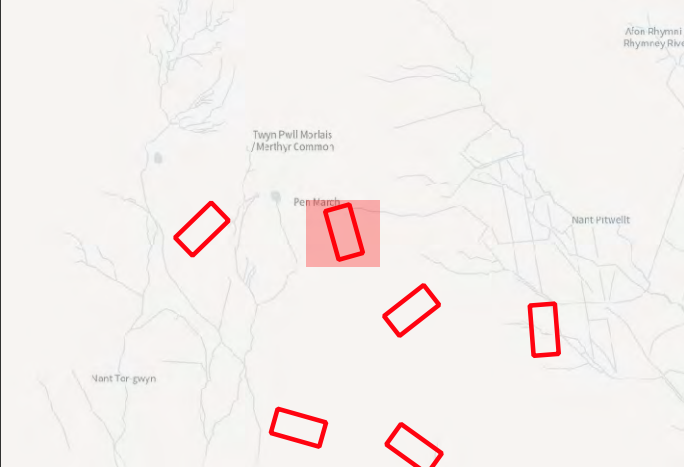
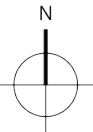


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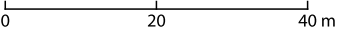
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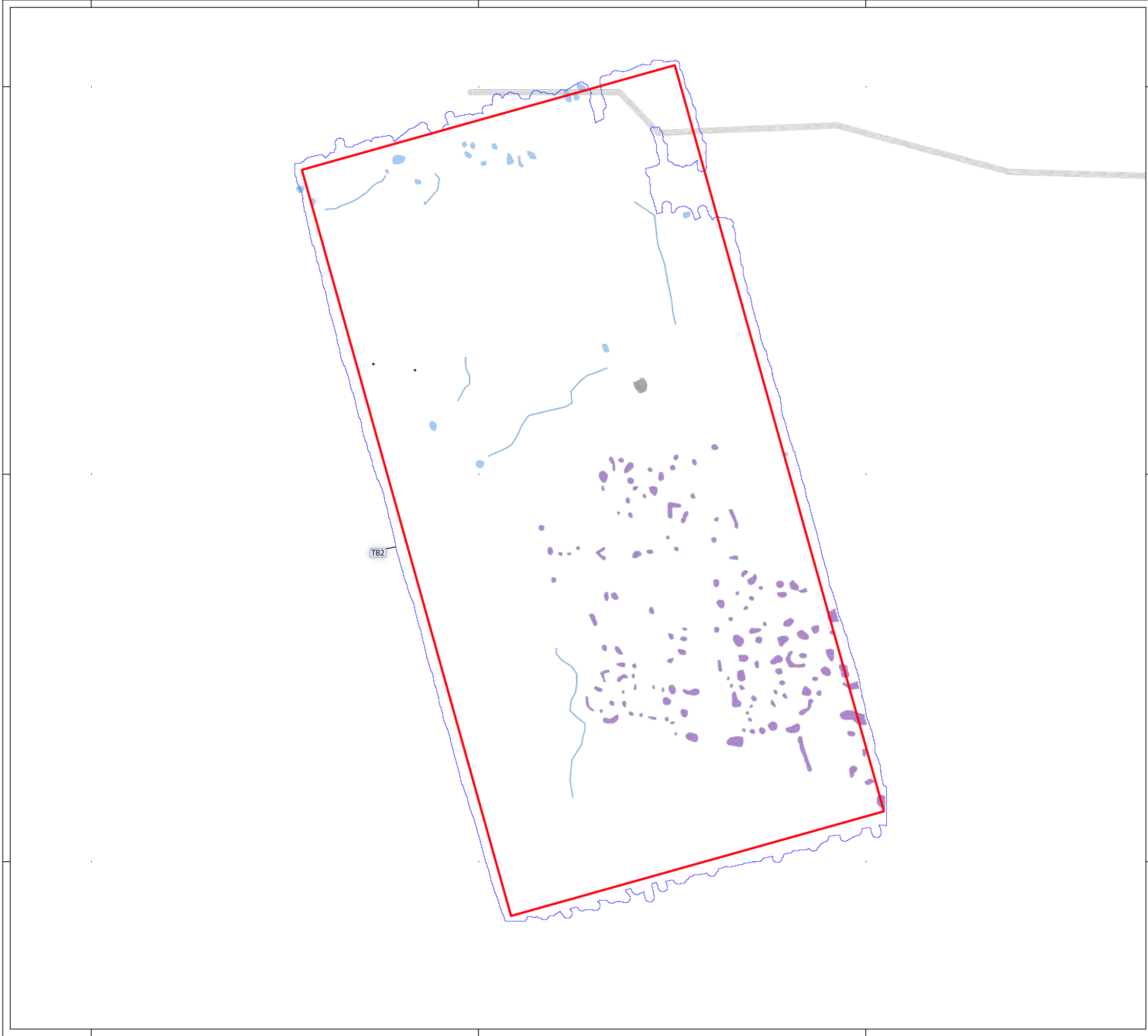


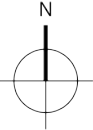
- Key**
- Geophysical Survey Area
 - Survey Extent
 - XY Trace (25nT/cm)



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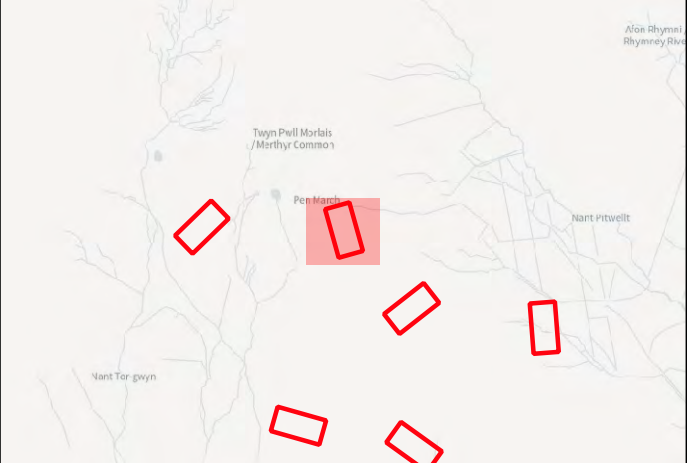






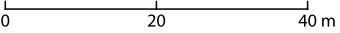
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Key

-  Geophysical Survey Area
-  Survey Extent
-  Ferrous Objects
-  Natural
-  Magnetic Disturbance (Above Ground)
-  Natural
-  Uncertain



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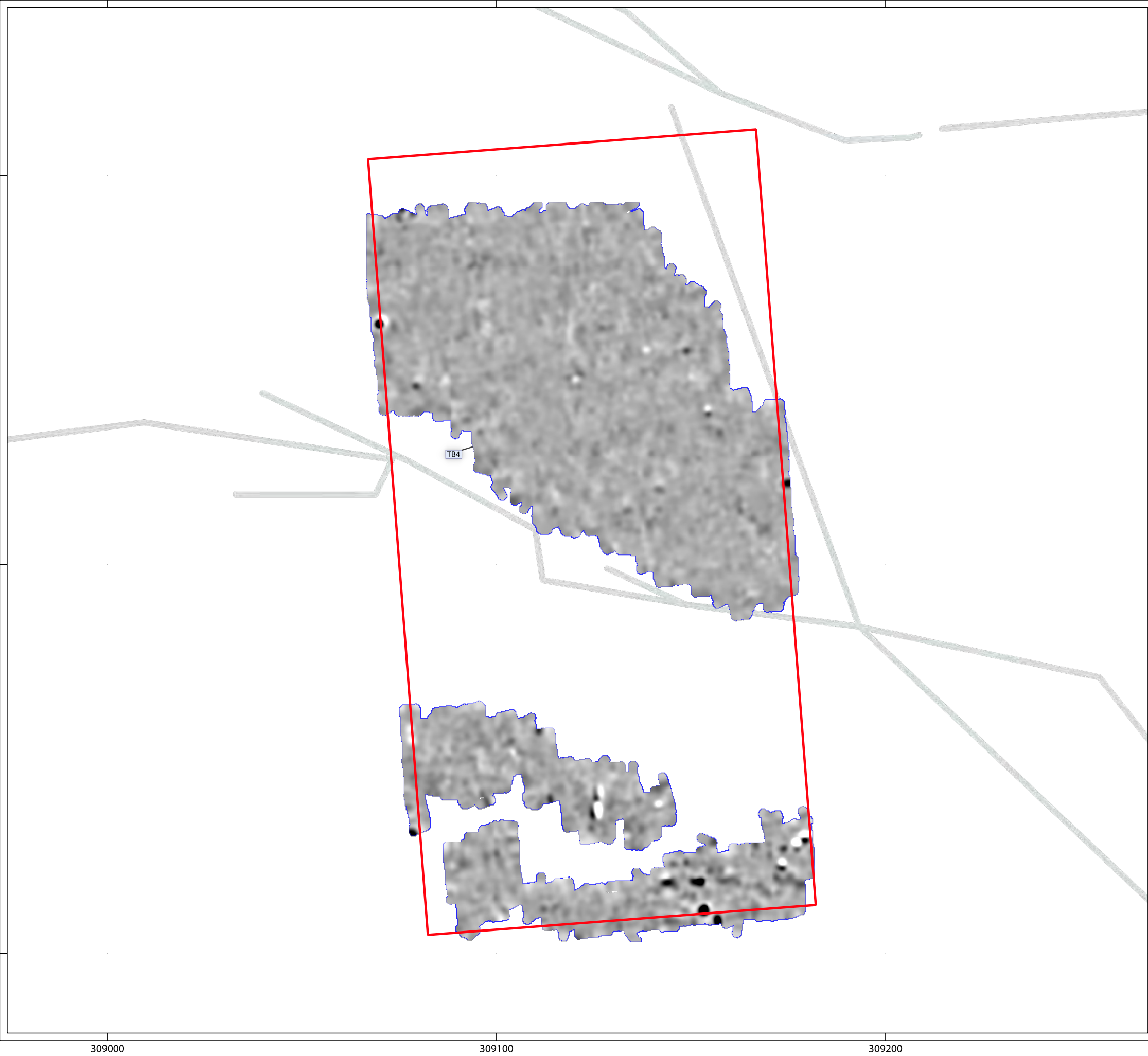
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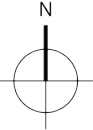
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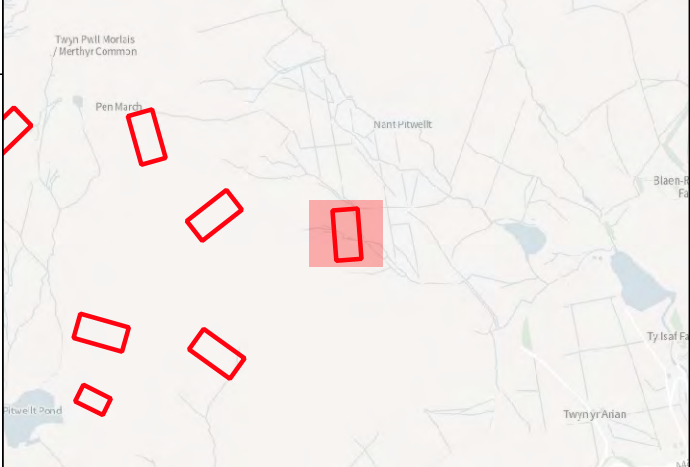






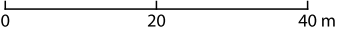
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Key

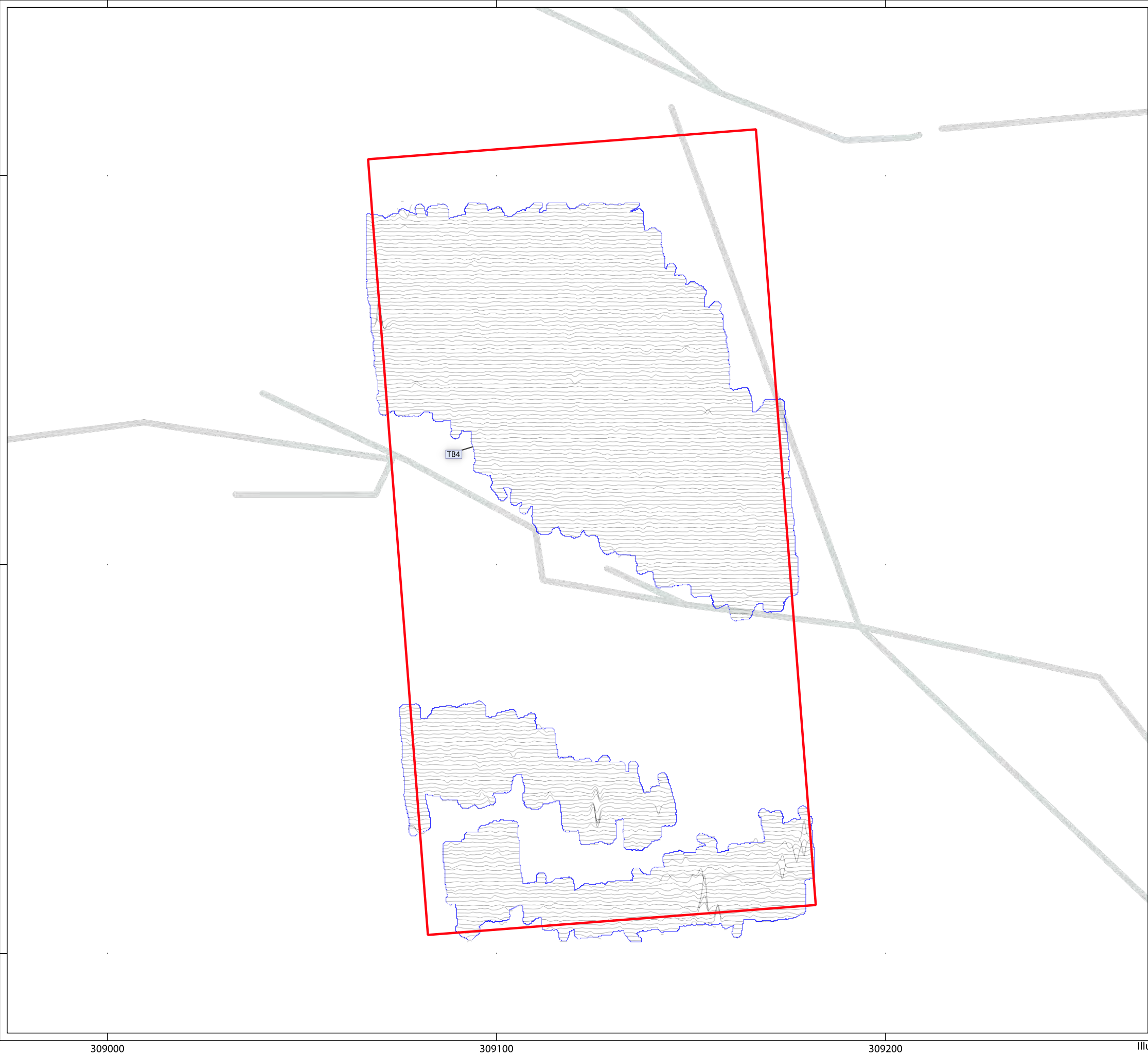
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-  Survey Extent



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Key

Geophysical Survey Area

Survey Extent

XY Trace (25nT/cm)

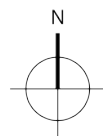
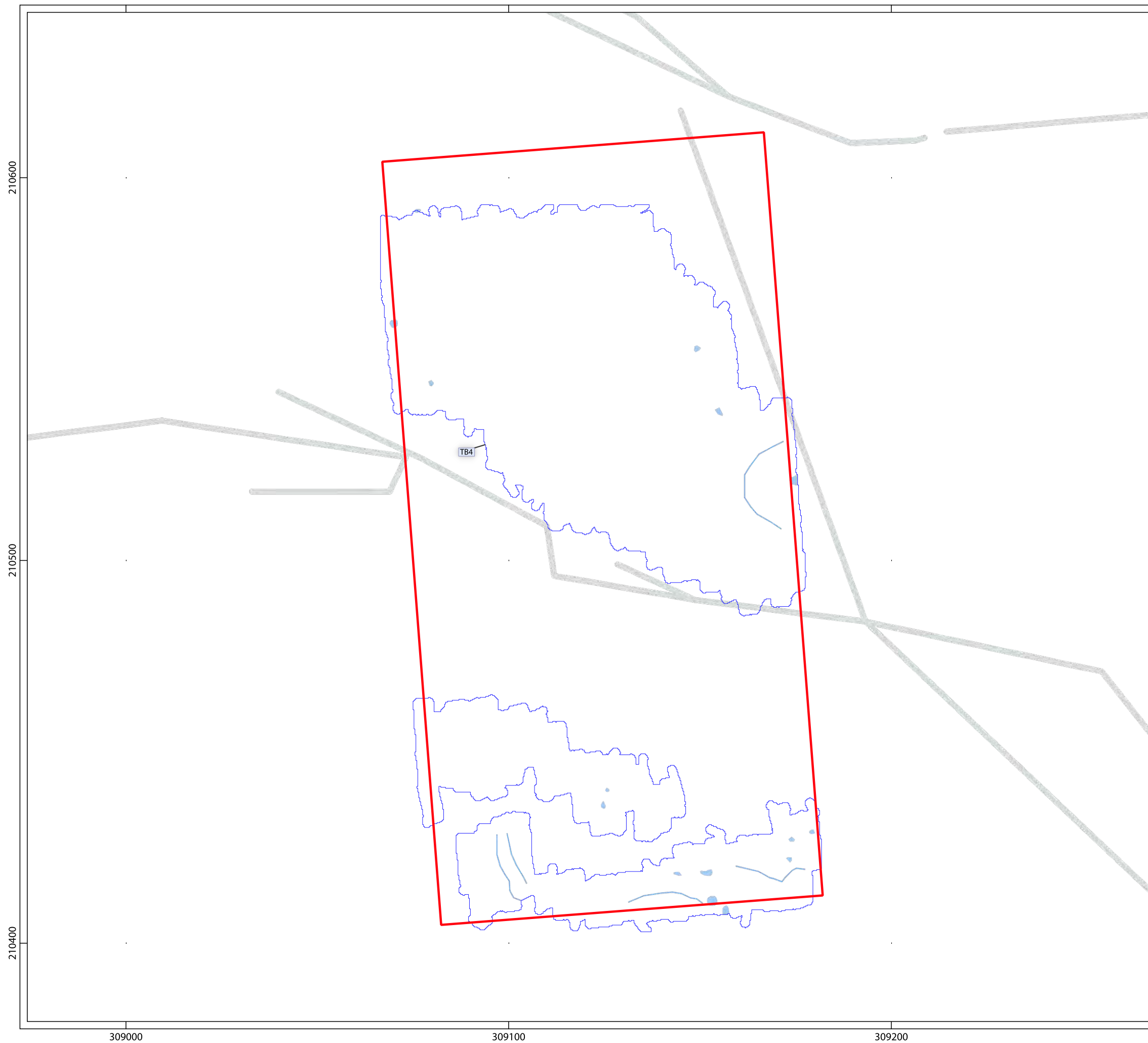
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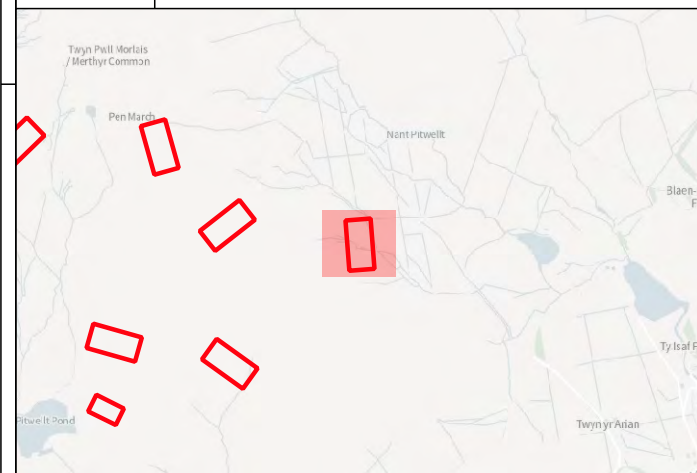
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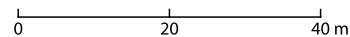


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Key

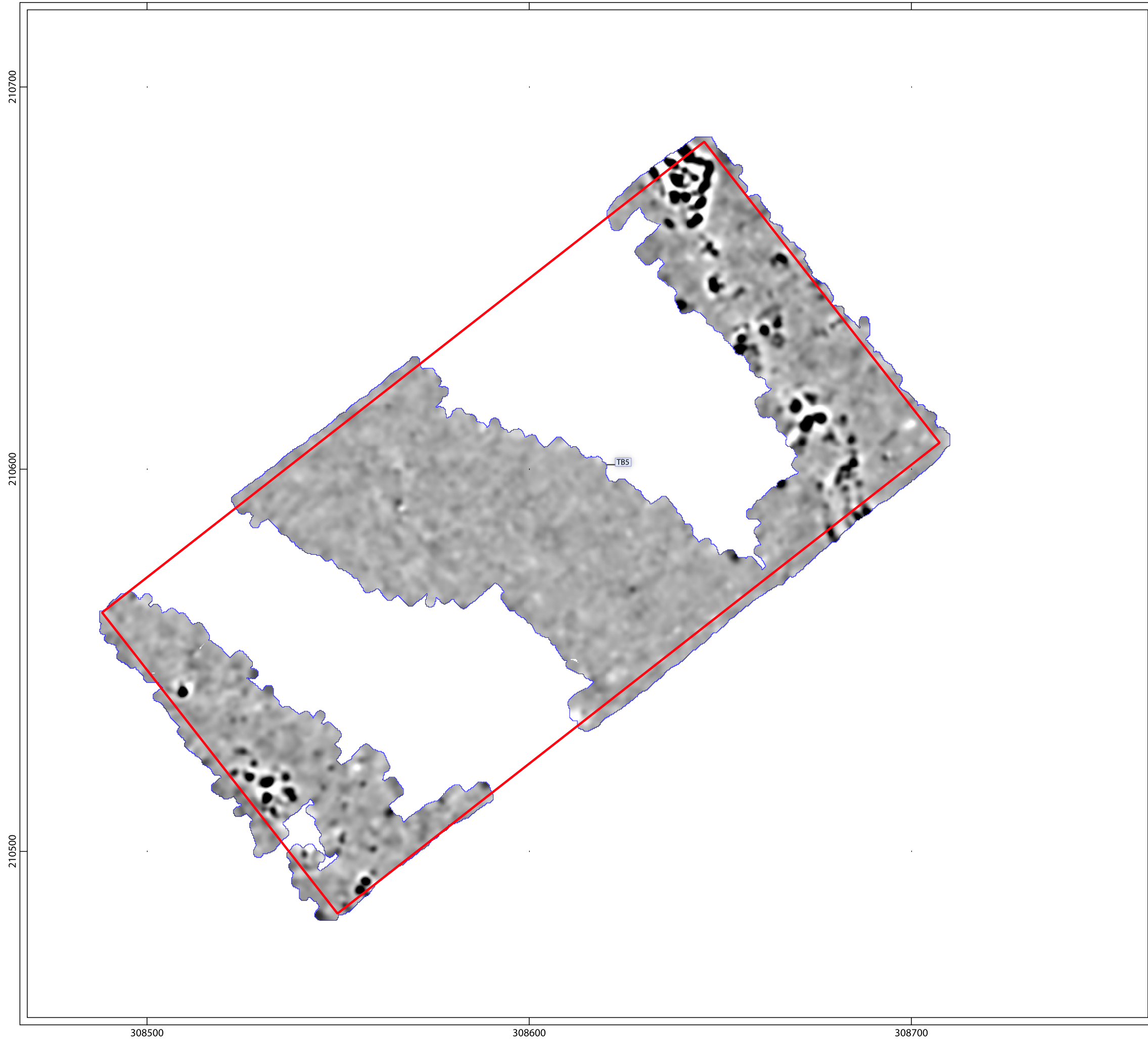
-  Geophysical Survey Area
 Survey Extent
 Natural
 Natural

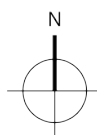


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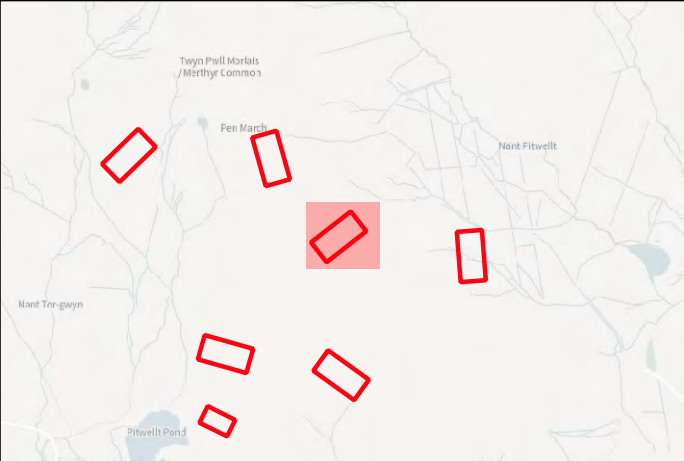






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Key
 Geophysical Survey Area
 Survey Extent



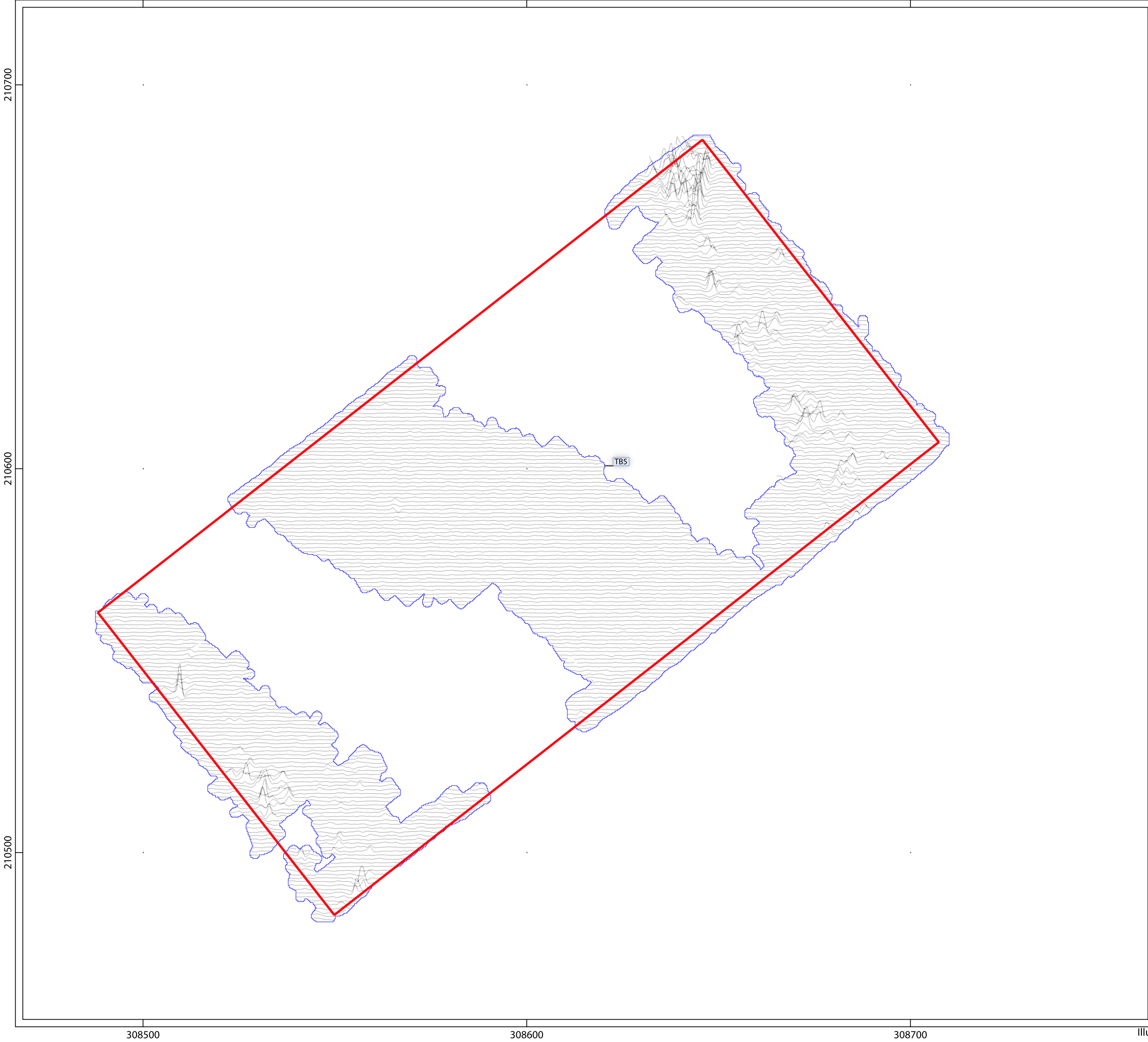
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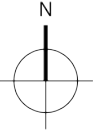
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Illus - 22 Processed greyscale magnetometer data; Turbine Base 5

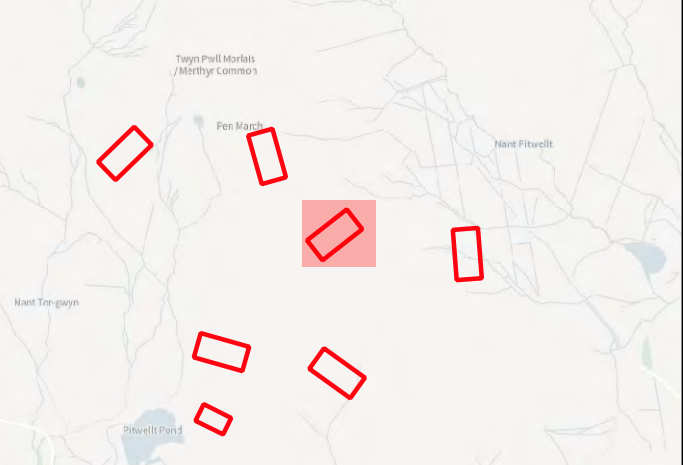






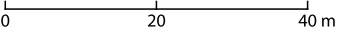
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Key

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

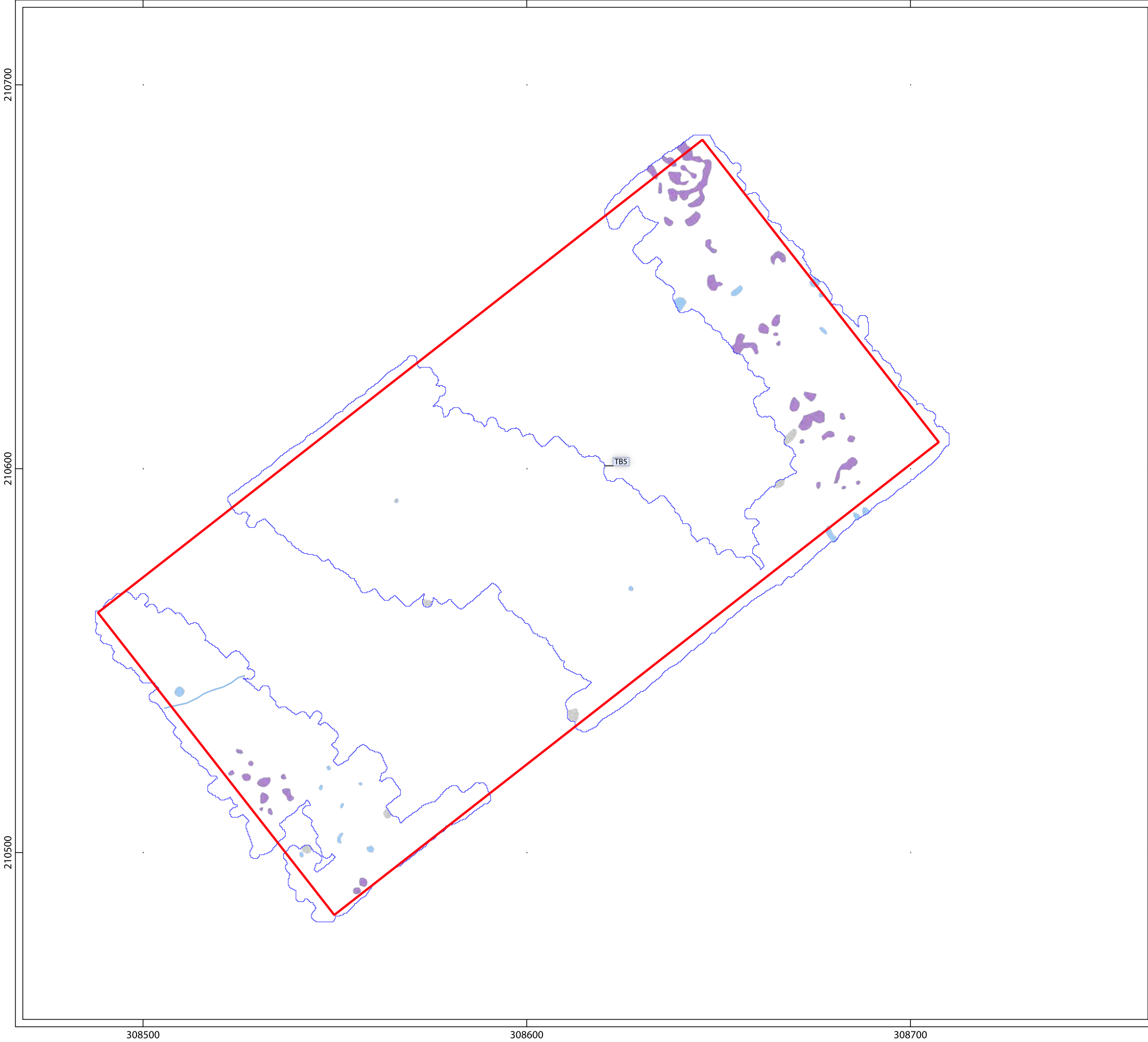


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Illus - 23 XY trace plot of minimally processed magnetometer data; Turbine Base 5



N

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Key

Geophysical Survey Area

Survey Extent

Natural

Magnetic Disturbance (Below Ground)

Natural

Uncertain

0

20

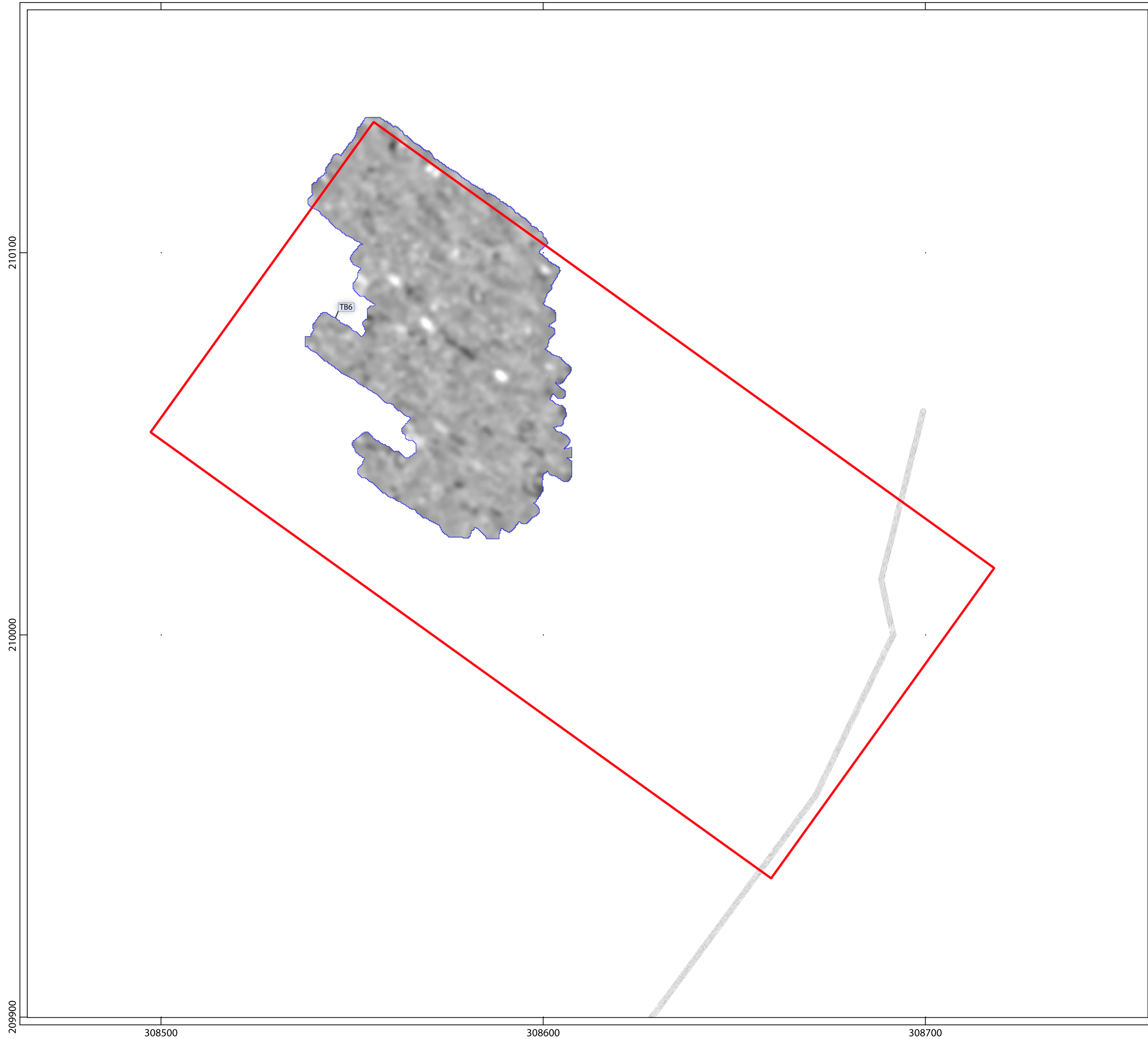
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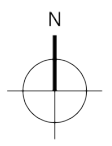
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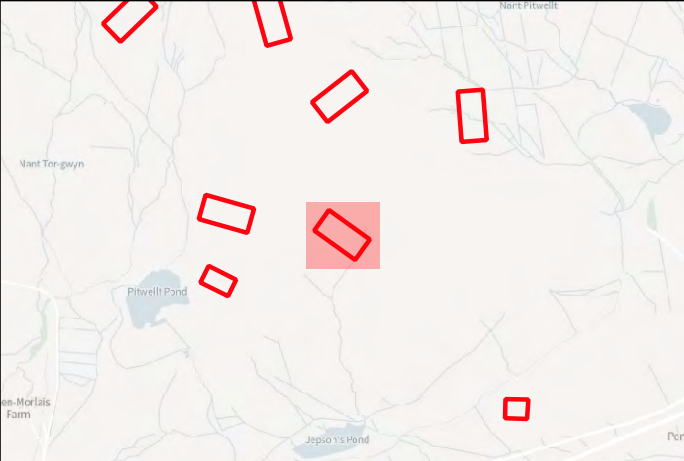
Illus - 24 Interpretation of magnetometer data; Turbine Base 5





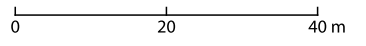
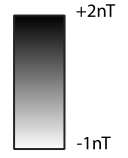


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Key

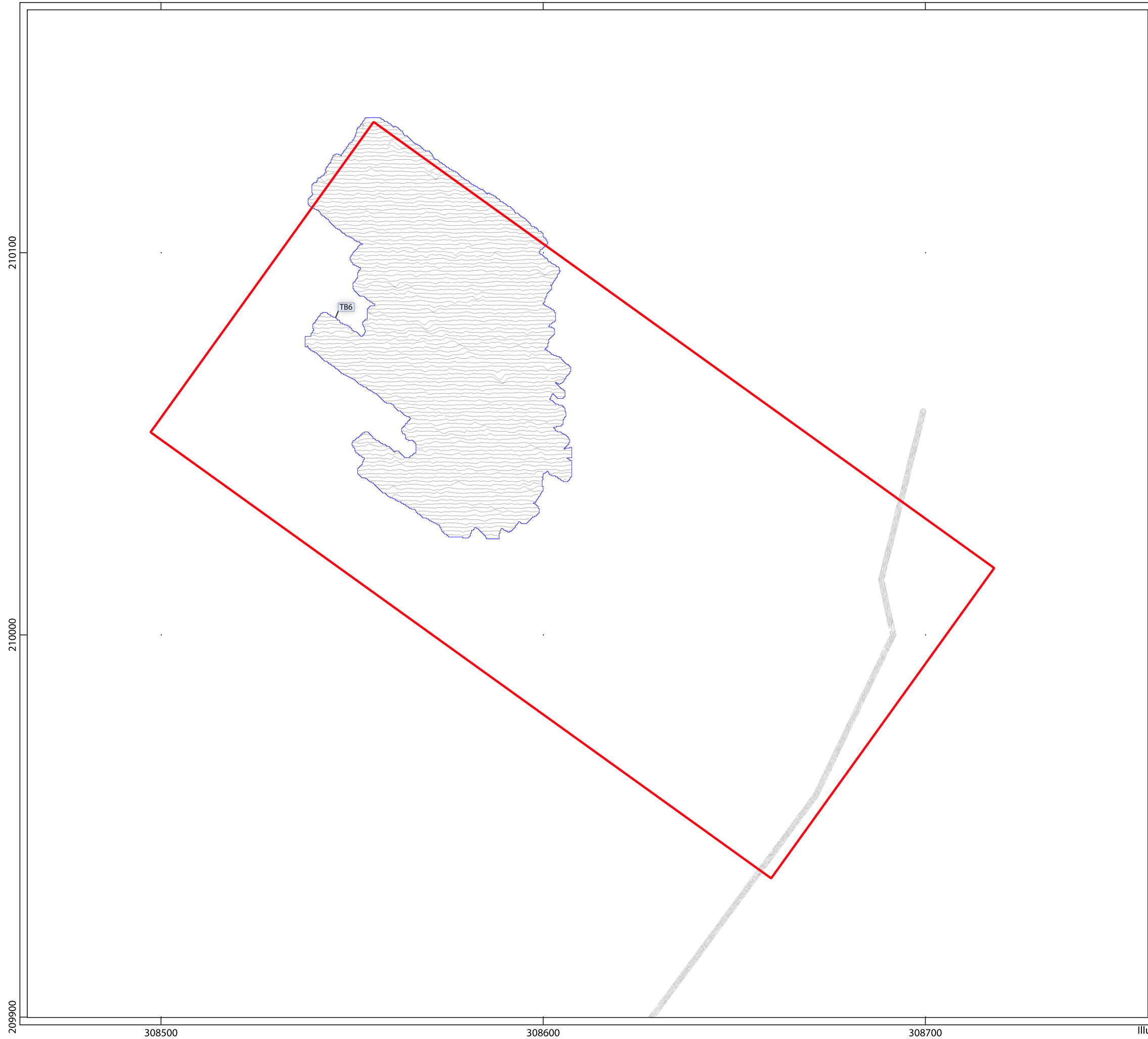
-  Geophysical Survey Area
-  Survey Extent



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Key

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

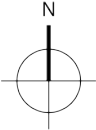
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Illus - 26 XY trace plot of minimally processed magnetometer data; Turbine Base 6

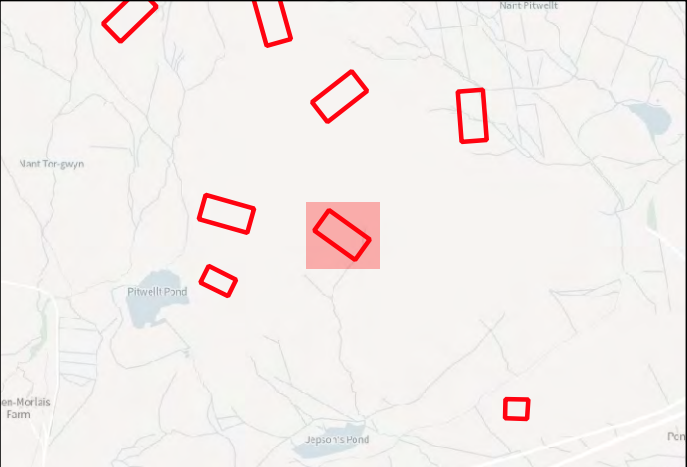






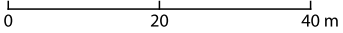
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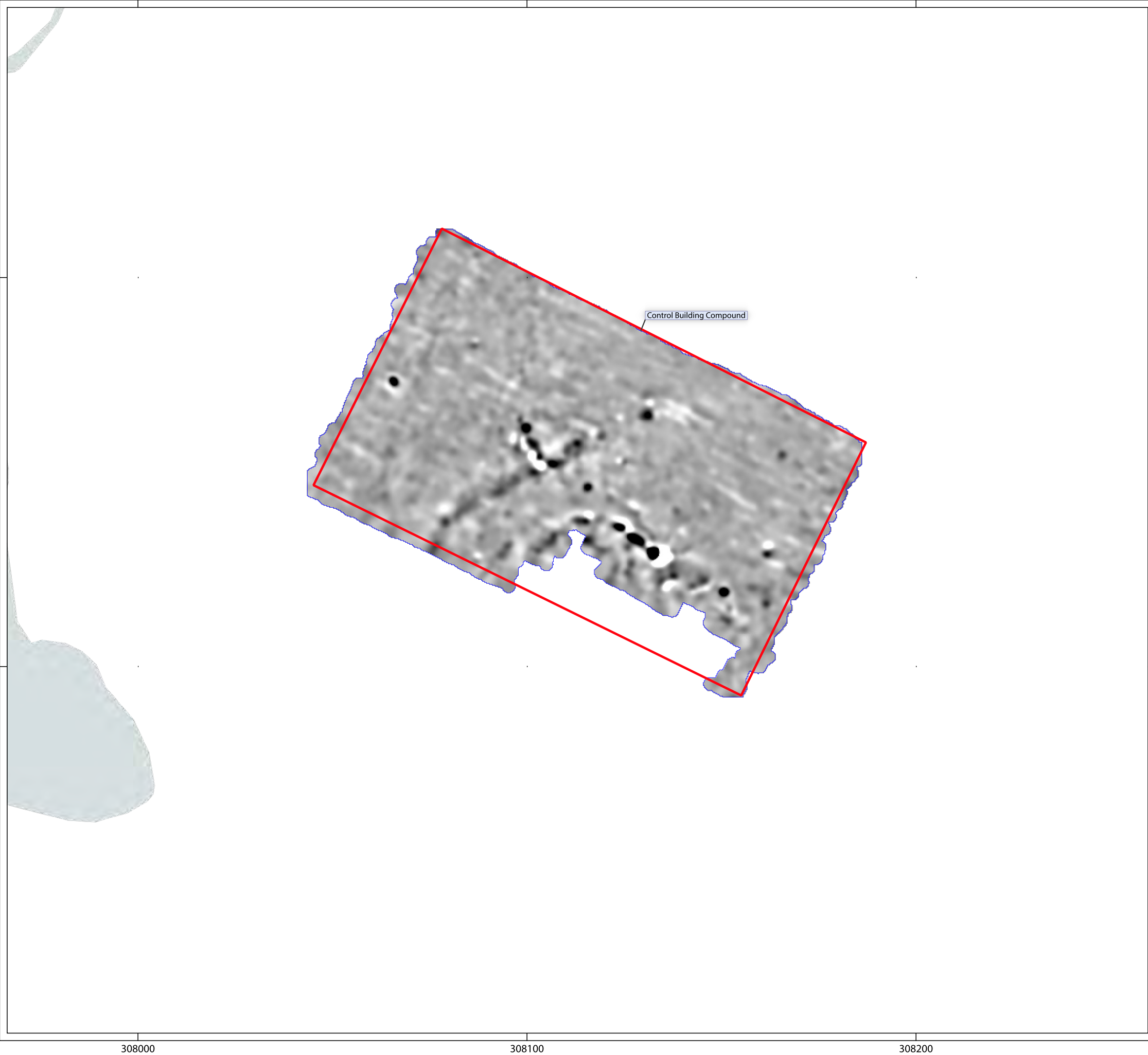
-  Geophysical Survey Area
-  Survey Extent
-  Natural
-  Natural

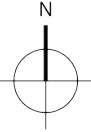


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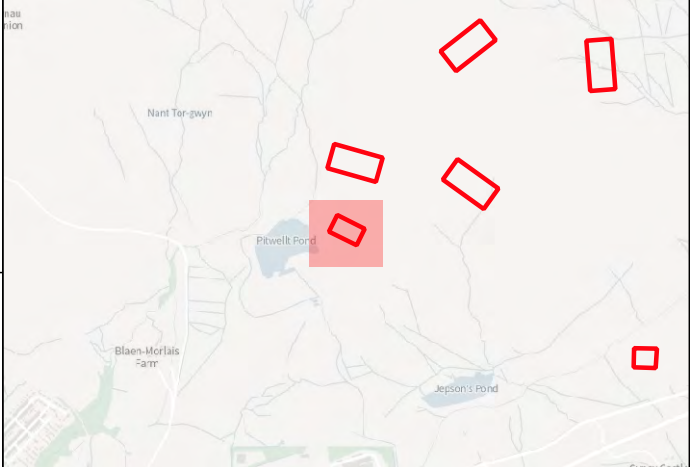






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Key

-  Geophysical Survey Area
-  Survey Extent

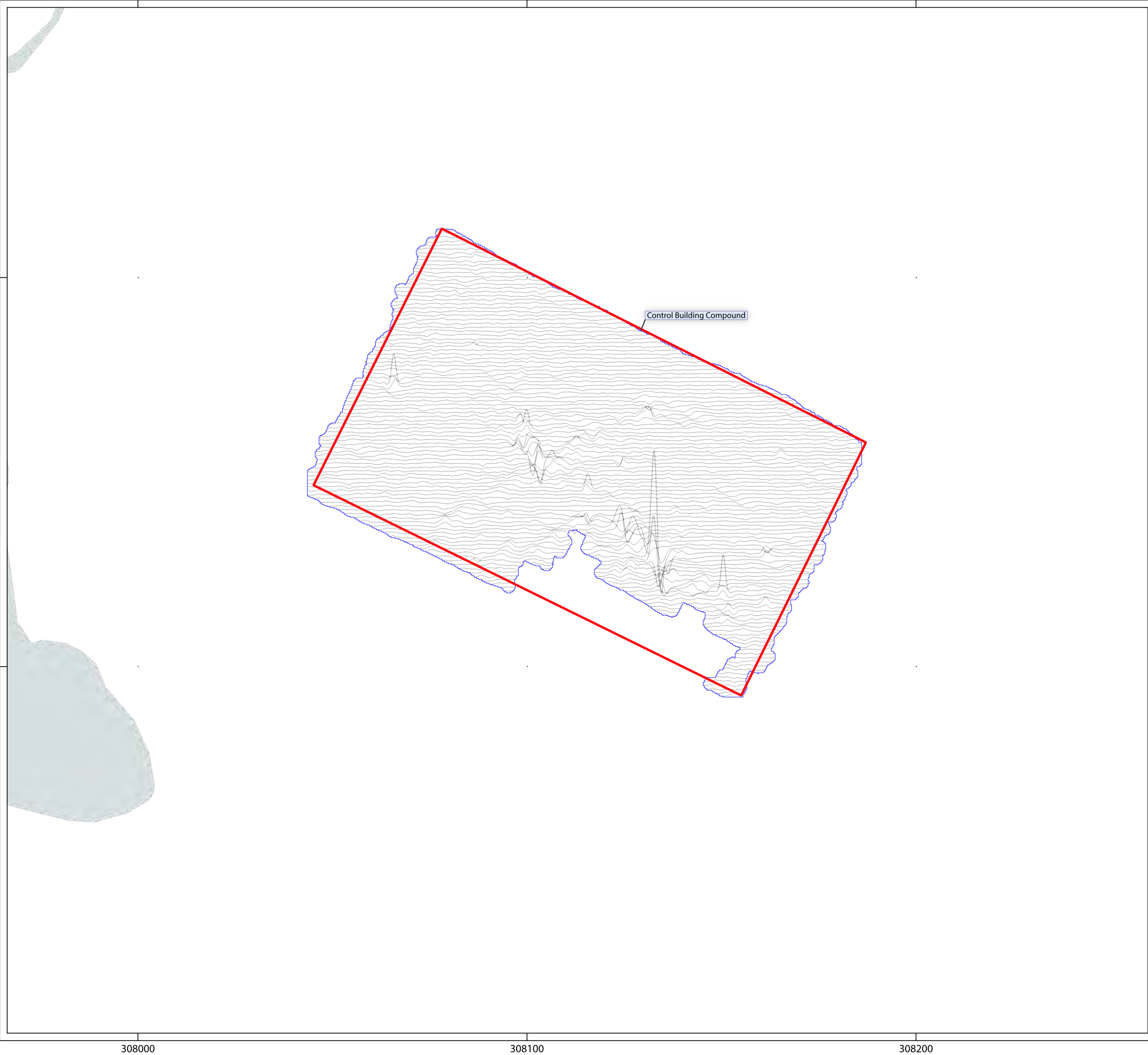


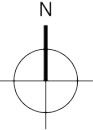
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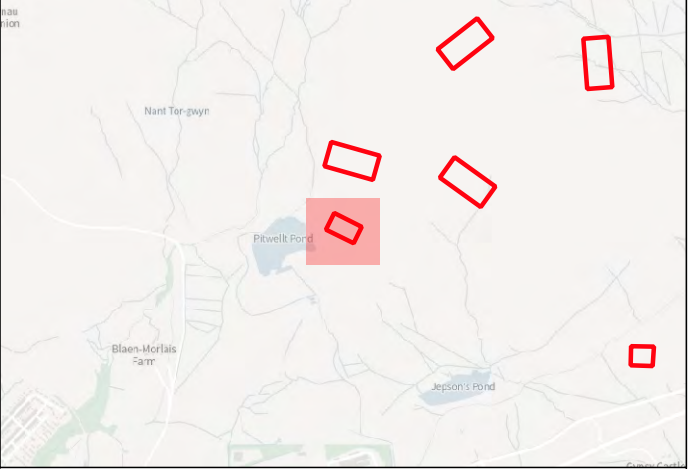






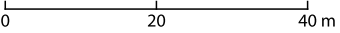
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Key

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

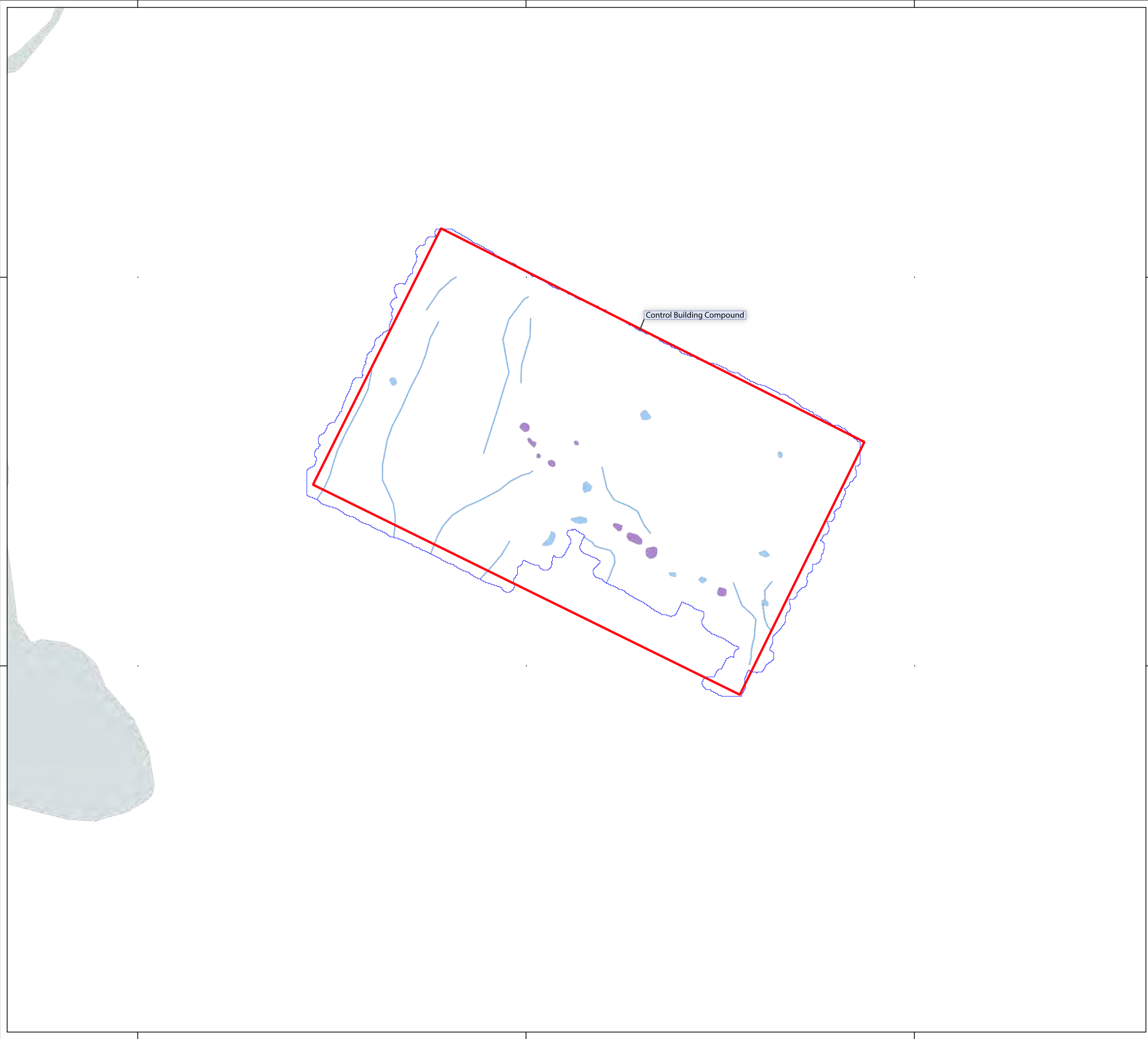


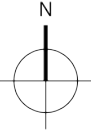
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Illus - 29 XY trace plot of minimally processed magnetometer data; Compound

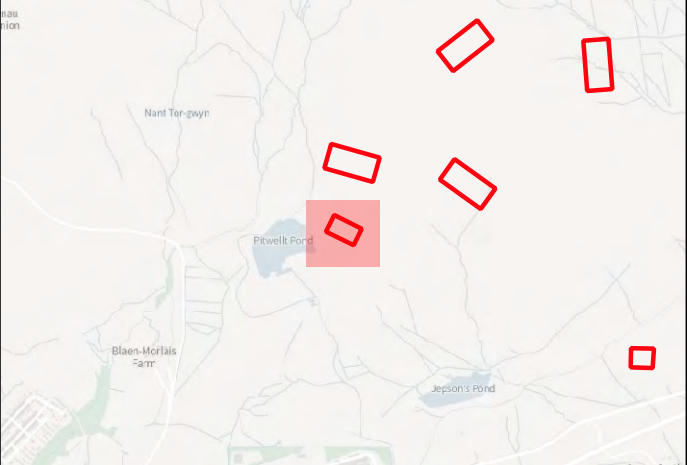






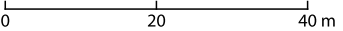
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Key

-  Geophysical Survey Area
-  Survey Extent
-  Natural
-  Natural
-  Uncertain



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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 can also be enhanced by the application of heat. This effect can lead to the detection of features such as hearths, kilns, or areas of burning.

Types of magnetic anomaly

In most instances 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 topsoil 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 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

The magnetometer data was georeferenced using a Trimble RTK differential Global Positioning System (Trimble R12 model). 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). The data will be stored in an indexed archive and migrated to new formats when necessary.

APPENDIX 4 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 ARCHIVE