Foel Fach Wind Farm Limited.

Foel Fach Wind Farm – Environmental Statement Volume III

Appendix 8.2: Geophysical Survey Report: Foel Fach Wind Farm

Project Reference: 664094

DECEMBER 2025

Energy for generations

Coriolis Energy

FWW24

FOEL FACH WIND FARM

GEOPHYSICAL SURVEY REPORT

on behalf of Foel Fach Wind Farm Limited

September 2025

HEADLAND ARCHAEOLOGY

REGISTERED ORGANISATION CIfA

FOEL FACH WIND FARM

GEOPHYSICAL SURVEY REPORT

on behalf of Foel Fach Wind Farm Limited

September 2025

This report adheres to the quality standard of ISO 9001:2015

PROJECT INFO:

HA Project Code **FWW24** / HA Report No **2025-118** / NGR **SH 92133 41090** / Parish **Bala Parish Council** / Local Authority **Gwynedd Council** / Fieldwork Date **15/01/2025**

PROJECT TEAM:

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REGISTERED ORGANISATION CIfA

PROJECT SUMMARY

Headland Archaeology (UK) Ltd was commissioned by Foel Fach Wind Farm Limited (the Applicant), to undertake a geophysical (magnetometer) survey on Pen y Bwlch Gwyn, east of Glan-Yr-Afon, North Wales where a wind farm is proposed. The survey covered part of the route of the track which will afford access to the proposed wind farm. This geophysical survey report will be submitted in support of any future planning application for the development. The results may also inform future archaeological strategy, if required.

The survey has primarily recorded anomalies of geological or natural origin, the likely result of changes in depth and composition of the mudstone and felsic geologies and overlying soils and the sloping nature of the Site. Anomalies of possible agricultural origin have also been recorded reflecting the possible previous arable cultivation of the flatter parts of the Site. Possible land drains in the east have also been identified. A single L-shaped anomaly has been interpreted as of uncertain origin. It's right-angled linear form and elevated magnetic strength suggest an anthropogenic origin is most likely, perhaps associated with the possible land drains recorded immediately to the west

No anomalies of likely archaeological origin have been recorded by the survey. The magnitude and resolution of the anomalies indicates that there was likely sufficient magnetic contrast for the detection of sub-surface archaeological features. The archaeological potential of the Site, based solely on the results of the geophysical survey, is therefore assessed as very low.

Cafodd Headland Archaeology (UK) Ltd ei gomisiynu gan Foal Fach Wind Farm Limited (y Cleient), i ymgyryd arolwg geoffisegol (magnetomedr) ar Pen y Bwlch Gwyn, i yr dwyrain of Glan-Yr-Afon, Gogledd Cymru lle mae fferm gwynt yn cael ei gynnig. Roedd yr arolwg yn cwpasu rhan o lwybr y trac a fydd yn rhoi mynediad i yr fferm wynt sydd yn cael ei gynnig. Bydd adroddiad arolwg geoffisegol hwn yn cael ei gyflwyno i gefnogi ynrhyw cais cynllyunio ar gyfer y datblygiad yn y dyfodol. Gall y caluniadau hyn hefyd cyfarwyddo strategaeth archeolegol yn y dwyfodol.

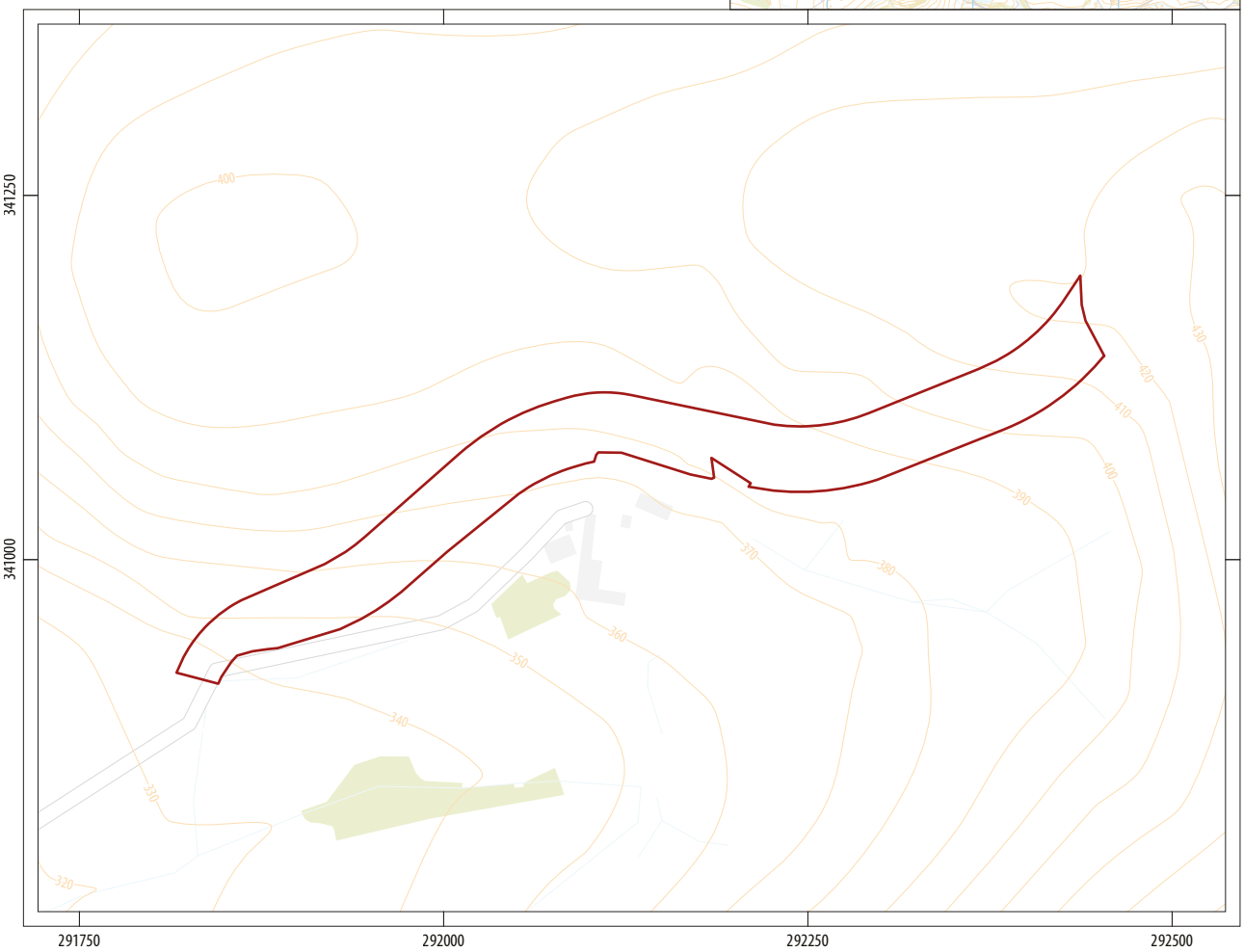
Yn bennaf, cofnododd yr arolwg anomaleddau o darddiad daearegol neu naturiol, calyniad tebygol newidadau i dyfnder a chyfnasoddiad y daearegau carreg laid a ffelsig ac yr dros briddoedd a lethr y safle. Cofnododd hefyd nomeleddau o darddiad amaethyddol posib sydd yn adlweyrchu yr amaethu âr posib dros rhannau y safle sydd yn fwy gwastad. Nododd draeniau tir posib i yr dwyrain. Dehoglwyd un anomaledd siâp-L o darddiad ansicr. Mae ei ffurf llinellol ongl sgwâr ac ei gryfder magnetig uchel yn awgrymu bod tarddiad anthropogenig yn fwyaf tebygol, efallai yn gysylltiedig â yr draeniau tir posib cofnododd ar unwaith i yr gorllewin.

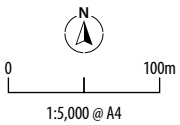
Ni chofnododd yr arolwg anomeleddau o darddiad archeolegol tebygol. Mae maint a chydraniad yr anomeleddau yn arddangos cyferbyniad magnetig digonol ar gyfer datgelu nodweddion archeolegol isarwyeb. Yn seiliedig ar canlyniadau yr arolwg geoffisegol yn unig asesir bod y potesial archeologel felly yn isel iawn.

CONTENTS

LIST OF ILLUSTRATIONS

Foel Fach Wind Farm
Glan-Yr-Afon





geophysical survey area

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ILLUS 1 Site location

FOEL FACH WIND FARM

GEOPHYSICAL SURVEY REPORT

1 INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Foel Fach Wind Farm Limited (the Applicant), to undertake a geophysical (magnetometer) survey on Pen y Bwlch Gwyn, east of Glan-Yr-Afon, North Wales in advance of a proposed wind farm development. The survey covered part of the route of the track that will afford access to the proposed wind farm (Illus 1). This geophysical survey report will be submitted in support of any future planning application for the development. The results may also inform future archaeological strategy, if required.

The scheme of work was undertaken in accordance with the requirements of the Planning Policy Wales 2024 (Edition 12, Ch.6 The Historic Environment) and with the Written Scheme of Investigation for Geophysical Survey (WSI) (Headland Archaeology 2025).

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' (ClfA) Standard and Guidance for Archaeological Geophysical Survey (ClfA 2020). The survey was carried out in line with the same best practice guidelines.

The survey was carried out on January 15, 2025.

1.1 SITE LOCATION, TOPOGRAPHY AND LAND-USE

The geophysical survey area (GSA - Site) covers the route for a track that will allow access to the proposed Foel Fach Wind Farm, which will be located east of Glan-Yr-Afon. The GSA is centred at NGR SH 92133 41090, east of Glan-Yr-Afon, north-east of Frongonch, south-east of Cwmtirmynach and west of Foel Fach and covers approximately 2.8 hectares (ha) within the wider scheme application boundary which covers approximately 92.4ha. The GSA comprises permanent pasture (Illus 2 to Illus 5 inclusive)

The Site slopes down from the north-eastern end of the GSA at 420m Above Ordnance Datum (AOD) to the south-western end at 340m AOD. It also slopes from north to south across the GSA rendering the steeper parts of the route unsuitable for survey (Illus 6).

1.2 GEOLOGY AND SOILS

The solid bedrock geology across the south-western half of the GSA is mudstone of the Ceiwsyn Formation formed between 457.5 and 452.75 million years ago during the Ordovician period. In the north-eastern half of the GSA an igneous intrusion of tuff of the Frondderw Tuff Member formed between 455.25 and 454 million years ago also during the Ordovician period.

There are no recorded overlying superficial deposits within the GSA (NERC 2025).

The soils covering the west of the GSA are classified in Soilscape 13 being described as freely draining, acidic, loamy soils over rock. The soils covering the east of the GSA are classified in Soilscape 16 and are described as very acidic and loamy upland soils with a wet peaty surface (Cranfield University 2025).

2 ARCHAEOLOGICAL BACKGROUND

The following is abstracted from an Archaeological Desk-Based and Stage 1 Setting Assessment Statement (Headland Archaeology 2025).

ILLUS 2 F1, looking south-west

The DBA established that there are no designated historic assets within the GSA but that there are 44 non-designated historic assets 43 of which are recorded on the Heneb/Trust for Welsh Archaeology (WAT) HER. These assets are predominantly of post-medieval date or of an unknown origin (see below).

The assets are mostly agricultural in character and include farms, outbuildings or outfarms, sheepfolds and shelters, and enclosures. Features including a pond, a sluice, peat cuttings, mines and quarries and gravel pits are indicative of small-scale industrial and extraction activity. Small features such as boundary markers, trackways, and a dam are also recorded as assets.

Two non-designated historic assets date to the prehistoric period. These comprise a grass covered cairn on the summit of Garnedd Fawr, and a hut circle: the latter has been suggested to possibly be a medieval or post-medieval livestock shelter. The remaining two non-designated historic assets are from the medieval period and are associated with the former township of Llaethgwm, and a possible former hermitage.

The DBA concluded that 'a review of HER data ….. demonstrates that the remains of Bronze Age activity and medieval to post-medieval are possibly preserved within the Site' and that 'the potential for hitherto unknown archaeological remains of low to medium importance to be preserved within the Site is assessed as medium'.

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, and thereby support any forthcoming planning application and inform any further investigation strategies.

The aims of the survey were:

- to provide information about the nature and possible interpretation of any magnetic anomalies identified,
- to therefore determine the likely presence/absence and extent of any buried archaeological features, or other geophysical anomalies, and provide an interpretation, and
- to produce 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

ILLUS 3 F3, looking east

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 or burial grounds. However, magnetometry is by far the single most useful technique and was assessed as the best non-intrusive evaluation methodology for this Site.

The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz on roaming traverses (swaths) 1m 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. Anomaly GeoSurvey v1.12.3 (Lichenstone Geoscience) and QGIS v.3.34.6 software was used to process and present the data respectively.

3.3 DATA PRESENTATION AND TECHNICAL DETAIL

A general site location plan is shown in Illus 1 at a scale of 1:5,000. Illus 2 to Illus 5 inclusive are site condition photographs. Illus 6 shows the survey location, photograph locations and areas unsuitable for survey at a scale of 1:2,500. Illus 7 to 9 show the fully processed (greyscale) data, minimally processed (XY trace plot) data and interpretative plan, also all at a scale of 1:2,500.

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

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

ILLUS 4 F1, unsuitable for survey looking west

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 Archaeology management and reporting staff.

4 RESULTS & DISCUSSION

4.1 SITE CONDITIONS

Magnetometer survey is generally recommended over any sedimentary geology, but results can be variable over mudstone bedrock geologies. Thermoremanent effects can preclude survey over some igneous rock types (basalts), but other types of igneous rock may not have such an adverse effect (English Heritage 2008; Table 4).

Surface conditions were generally good (Illus 2 and Illus 3) and data quality was also good with only minimal post-processing required. However, the steep gradient and uneven surface restricted survey in places (Illus 4 and Illus 5).

The magnetic background is quite variable throughout the GSA due to a combination of factors including variation in and between the two types of bedrock geologies and the degree of slope and therefore depth of topsoil.

Against this magnetic background, anomalies of predominantly agricultural, modern and geological/natural origin have been recorded. A single anomaly of uncertain origin has also been identified.

The magnitude and resolution of the anomalies overlying the bedrock indicates that there was likely sufficient magnetic contrast, for the detection of sub-surface 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. The effects, if any, of the igneous intrusion are minimal and it is therefore considered that the results of the survey provide a good indication of the archaeological potential of the Site.

The anomalies recorded by the survey are discussed below according to their interpreted origin.

4.2 ANOMALIES OF FERROUS AND MODERN ORIGIN

Ferrous anomalies, characterised as individual 'spikes', are typically caused by ferrous (magnetic) material, either on the ground surface or in the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an

ILLUS 5 F2, unsuitable for survey looking south-east

archaeological interpretation, as modern ferrous debris is common on most sites, often being introduced into the topsoil during manuring or tipping/infilling. There is no obvious clustering of the 'spike' responses, so these anomalies are likely to be indicative of a random distribution of modern ferrous debris in the plough-soil.

Bands or small areas of magnetic disturbance recorded along the boundaries of the GSA are likely to be due to the accumulation of ferrous debris around field margins, or due to ferrous material in the boundary itself.

4.3 ANOMALIES OF AGRICULTURAL ORIGIN

Several faint linear trends have been recorded. In F3 the anomalies are 'negative' and are aligned from north to south, at right angles to the slope. The most likely cause are land drains although this seems counter-intuitive given the direction of slope. In F1 and F2, which are the less sloping parts of the GSA, the anomalies may also be caused by land drains or perhaps reflect the direction of ploughing from a period when the land was cultivated. Another possibility is that these trends in F1 and F2 are caused by the accumulation of soil along breaks of slope as can be seen in F1 (see Illus 4).

4.4 ANOMALIES OF GEOLOGICAL ORIGIN

The magnetic background is quite variable throughout the GSA, comprised of both discrete and larger, more amorphous anomalies reflecting changes in the mudstone bedrock. The more magnetically elevated of these identified within F2 correlate with an intrusion of tuff of the Frondderw Tuff group, an igneous rock. Elsewhere, more sinuous, linear anomalies largely correlate to topographical changes, likely as a result of colluvial deposits that have accumulated at these locations.

4.5 ANOMALIES OF POSSIBLE OR PROBABLE ARCHAEOLOGICAL ORIGIN

No anomalies of possible or probable archaeological origin are recorded by the survey.

4.6 ANOMALIES OF UNCERTAIN ORIGIN

A single right-angled L-shaped linear anomaly, recorded in the east of F3 (Illus 8 - U1), clearly stands out due to its slightly elevated magnetic signal compared with other anomalies in the proximity. This anomaly has been interpreted as of uncertain origin as it cannot be confidently interpreted in any other category. However, the possible field drain anomalies to the west of U1 do seem to terminate at, or along, an edge possibly defined by the northern 'side' of U1. On balance this anomaly is considered most likely to be of agricultural origin, possibly also part of the postulated field drains.

5 CONCLUSION

The survey has primarily recorded anomalies of geological or natural origin, the likely result of changes in depth and composition of the mudstone and felsic geologies and overlying soils and the sloping nature of the Site.

Anomalies of possible agricultural origin have also been recorded reflecting the possible previous arable cultivation of the flatter parts of the Site. Possible land drains in the east have also been identified. A single L-shaped anomaly has been interpreted as of uncertain origin. It's right-angled linear form and elevated magnetic strength suggest an anthropogenic origin is most likely, perhaps associated with the possible land drains recorded immediately to the west

No anomalies of likely archaeological origin have been recorded by the survey. The magnitude and resolution of the anomalies indicates that there was likely sufficient magnetic contrast for the detection of sub-surface archaeological features, if present. The archaeological potential of the Site, based solely on the results of the geophysical survey, is therefore assessed as very low.

6 REFERENCES

Chartered Institute for Archaeologists (ClfA) 2020 ***Standard and guidance for archaeological geophysical survey*** (Reading) https://www.archaeologists.net/sites/default/files/ClfAS%26GGeophysics_3.pdf accessed 17th January 2025

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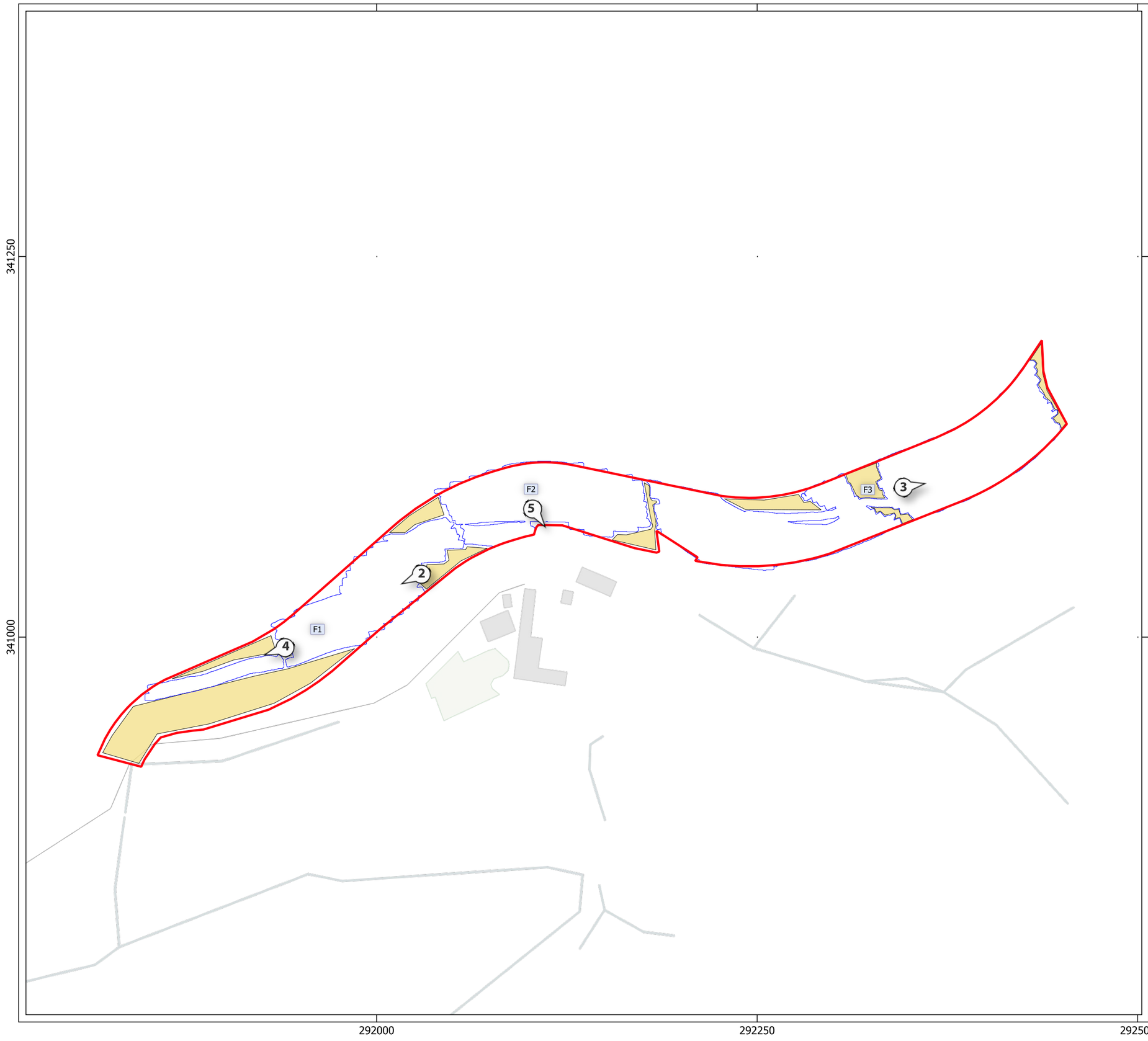

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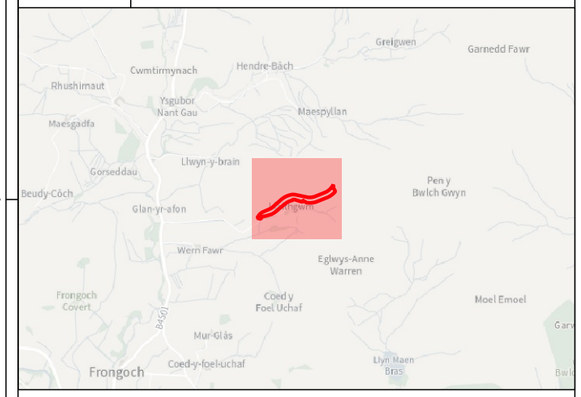

Key

- Geophysical Survey Area
- Survey Extent
- Location and Direction for Illus 02 to 05
- Unsuitable Survey Area

0 50 100 m

Site:	FFWW24
Created by:	KSS
Checked by:	RB
Version:	v1.0
Date:	04/02/2025
Scale:	1:2,500 @ A3

Illus 06 - Survey location showing photograph locations and areas unsuitable for survey

N

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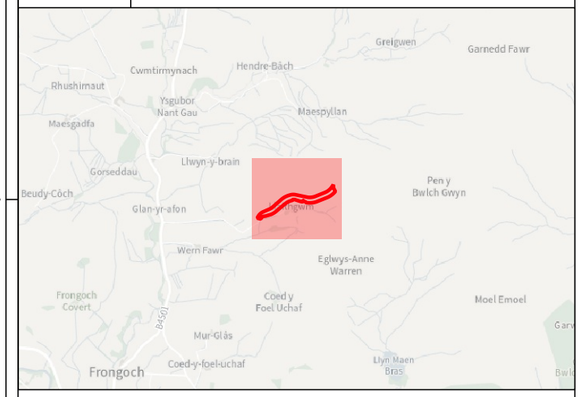

Key

Survey Extent

+2nT

-1nT

0 50 100 m

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Date:	04/02/2025
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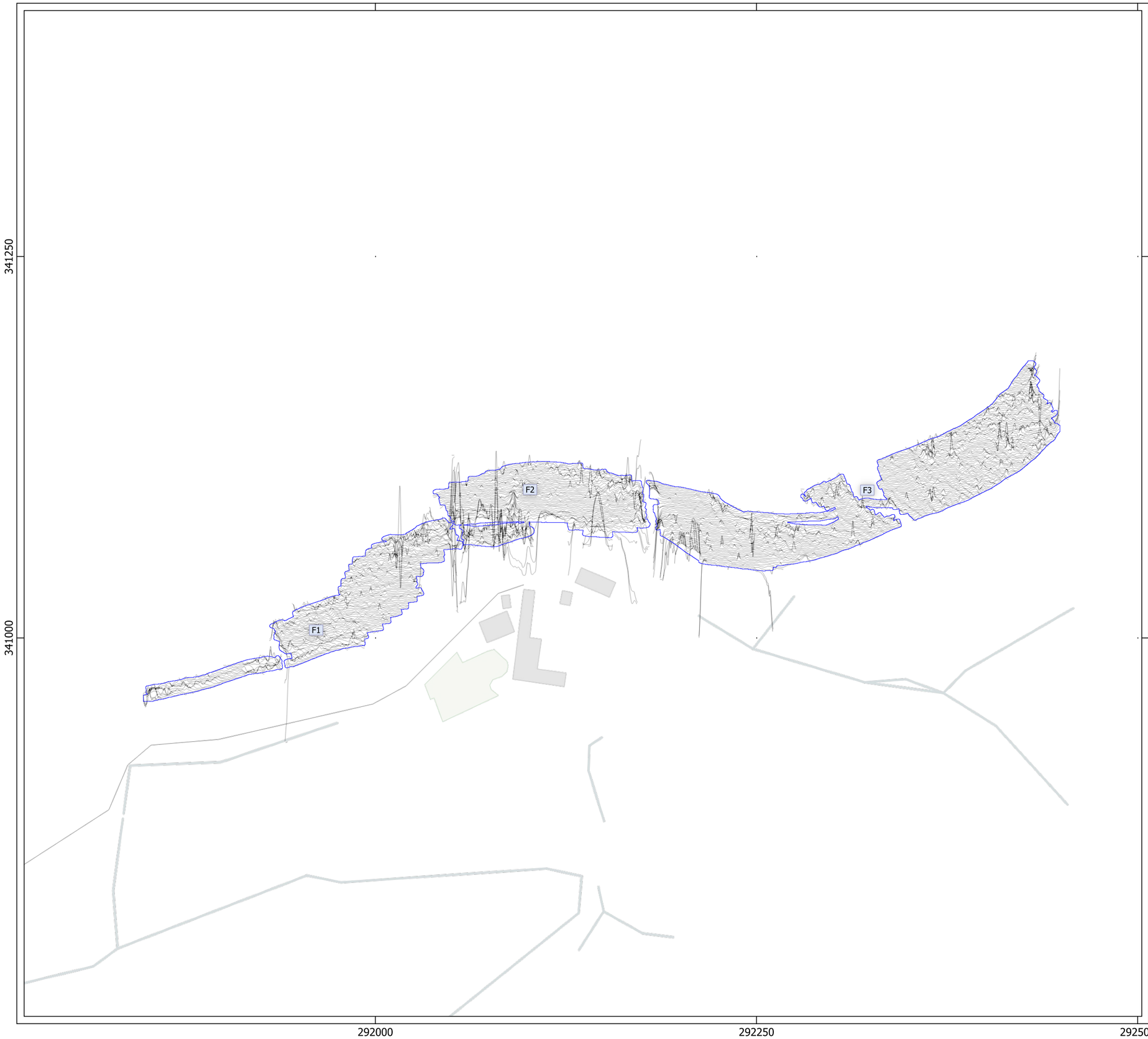
Illus - 07 Processed greyscale magnetometer data



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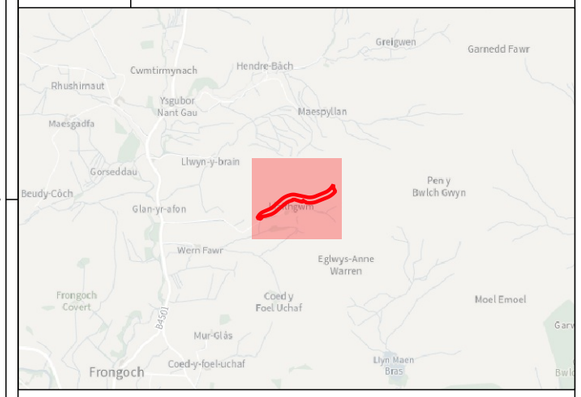

Key

Survey Extent

XY Trace (25nT/cm)

0 50 100 m

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Created by:	KSS
Checked by:	RB
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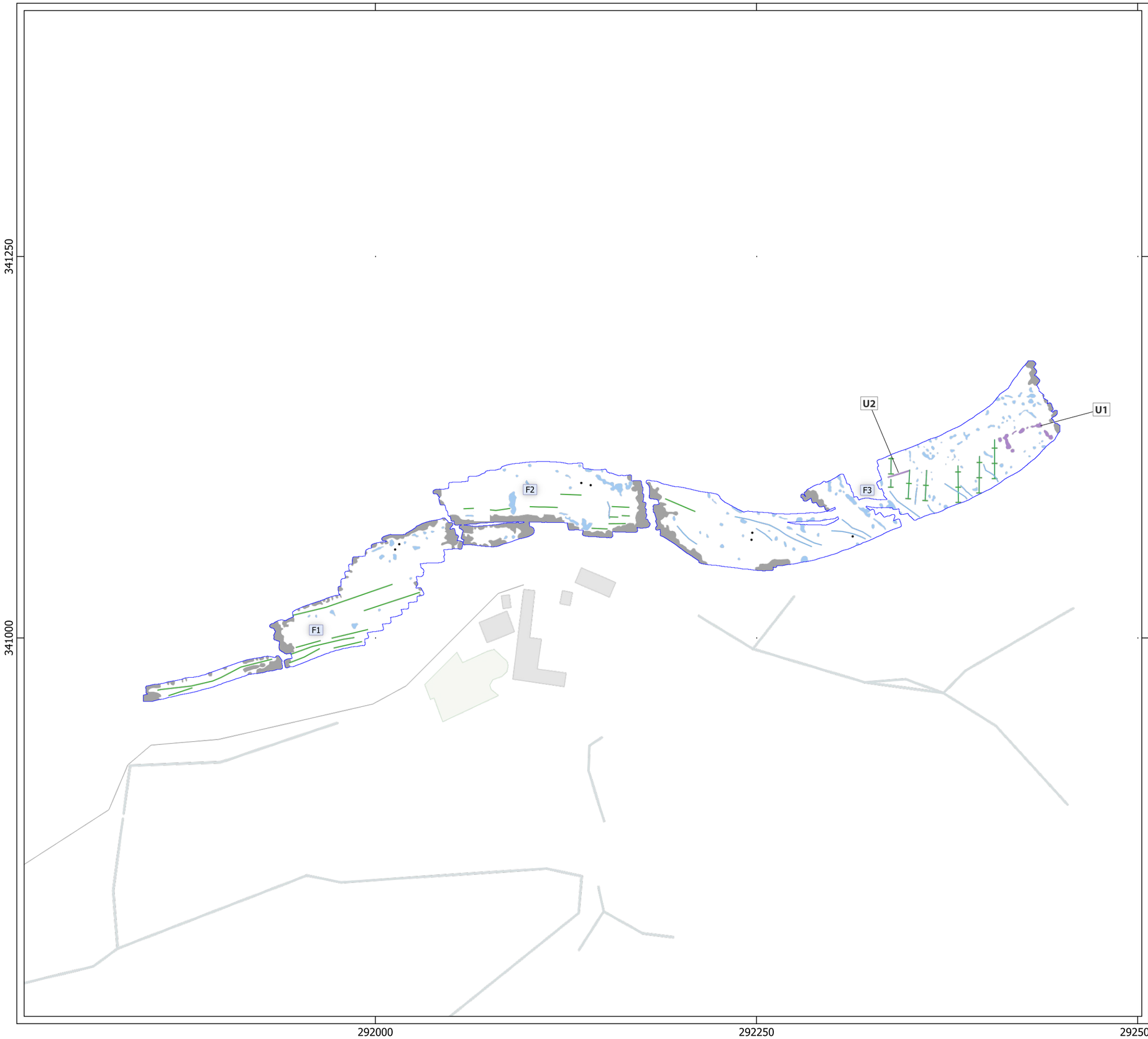
Illus - 08 XY trace plot of minimally processed magnetometer data



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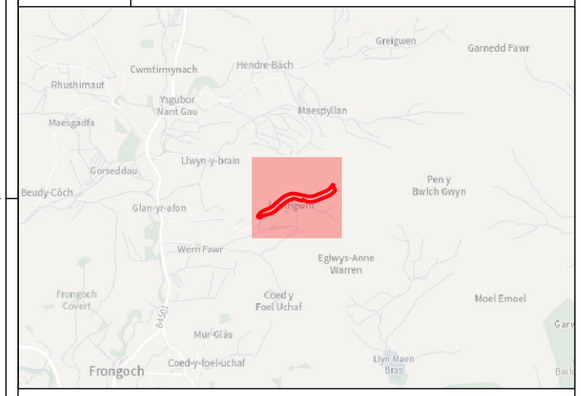

Key

- Survey Extent
- Ferrous Objects
- Agriculture
- Field Drain
- Natural
- Magnetic Disturbance (Above Ground)
- Natural
- Uncertain

	Abbreviation
U	Uncertain

0 50 100 m

Site:	FFWW24
Created by:	KSS
Checked by:	RB
Version:	v1.0
Date:	04/02/2025
Scale:	1:2,500 @ A3

Illus - 09 Interpretation of magnetometer data

7 ANNEXES

ANNEX 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.

ANNEX 2 SURVEY LOCATION INFORMATION

The magnetometer data was collected and is geo-located based on survey grade Real Time Kinetic (RTK) differential Global Positioning System (dGPS) used on both hand-carried and towed systems. The accuracy of this dGPS equipment is better than 0.01m. The GPS systems output in NMEA mode in real time, with a visual guide of survey tracks and any survey area boundaries displayed on a tablet device in view of the survey operator to ensure full coverage. Any survey area boundaries are uploaded as a string of co-ordinates or shapefile to the tablet prior to the commencement of survey.

ANNEX 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 associate 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.

ANNEX 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, heading errors and any other artificial data.

The XY data has been clipped to remove extreme values and to improve the interpretability of the data.

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