FLFD23

LEAFORD SOLAR FARM, STOKE-ON-TRENT

GEOPHYSICAL SURVEY

on behalf of Mabbett & Associates Ltd

December 2023

HEADLAND ARCHAEOLOGY

REGISTERED CIfA ORGANISATION

LEAFORD SOLAR FARM, STOKE-ON-TRENT

GEOPHYSICAL SURVEY

on behalf of Mabbett & Associates Ltd

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

PROJECT INFO:

HA Project Code **FLFD23** / HA Project No **2023-68** / NGR **SJ 95646 39251** / Parish **Fulford** / Local Authority **Staffordshire County Council** / Fieldwork Date **16.05.2023 – 19.05.2023** / OASIS Ref. **headland1-517225**

PROJECT TEAM:

Project Manager **Christian Adams** / Author **Ross Bishop** / Fieldwork **Abigail Calvert, Eloise Turner, Findlay Young, Thomas Jenkins** / Graphics **Marc Zubia-Pons, Ross Bishop, Tom Watson**

Approved by **Christian Adams** ........C.H. Adams........

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HEADLAND ARCHAEOLOGY

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REGISTERED CIfA ORGANISATION

PROJECT SUMMARY

Headland Archaeology (UK) Ltd was commissioned by Mabbett & Associates Ltd (the Client) to undertake a geophysical (magnetometer) survey on land at the proposed Leaford Solar Farm, Fulford, Stoke-on-Trent covering approximately 83 hectares, where a solar farm is being proposed. This geophysical survey report will be submitted as part of the planning application for the proposed development. The results may also inform future archaeological strategy, if required.

By far the most common anomalies identified within the dataset are due to geological, agricultural or modern causes. Anomalies locating twelve former field boundaries have been identified as well as field drains and service pipes. A single anomaly of uncertain origin has been recorded. No anomalies of archaeological potential have been recorded.

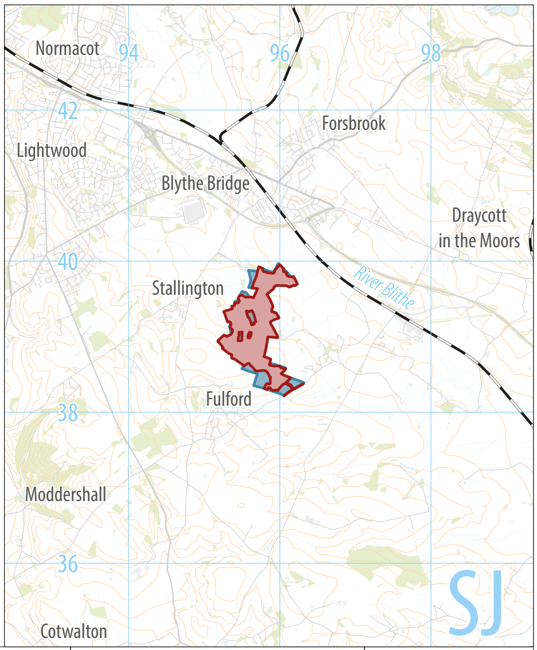
Overall, it is determined that the survey results provide a reliable indication of the archaeological potential of the geophysical survey area (GSA). The archaeological potential is consequently assessed as very low.

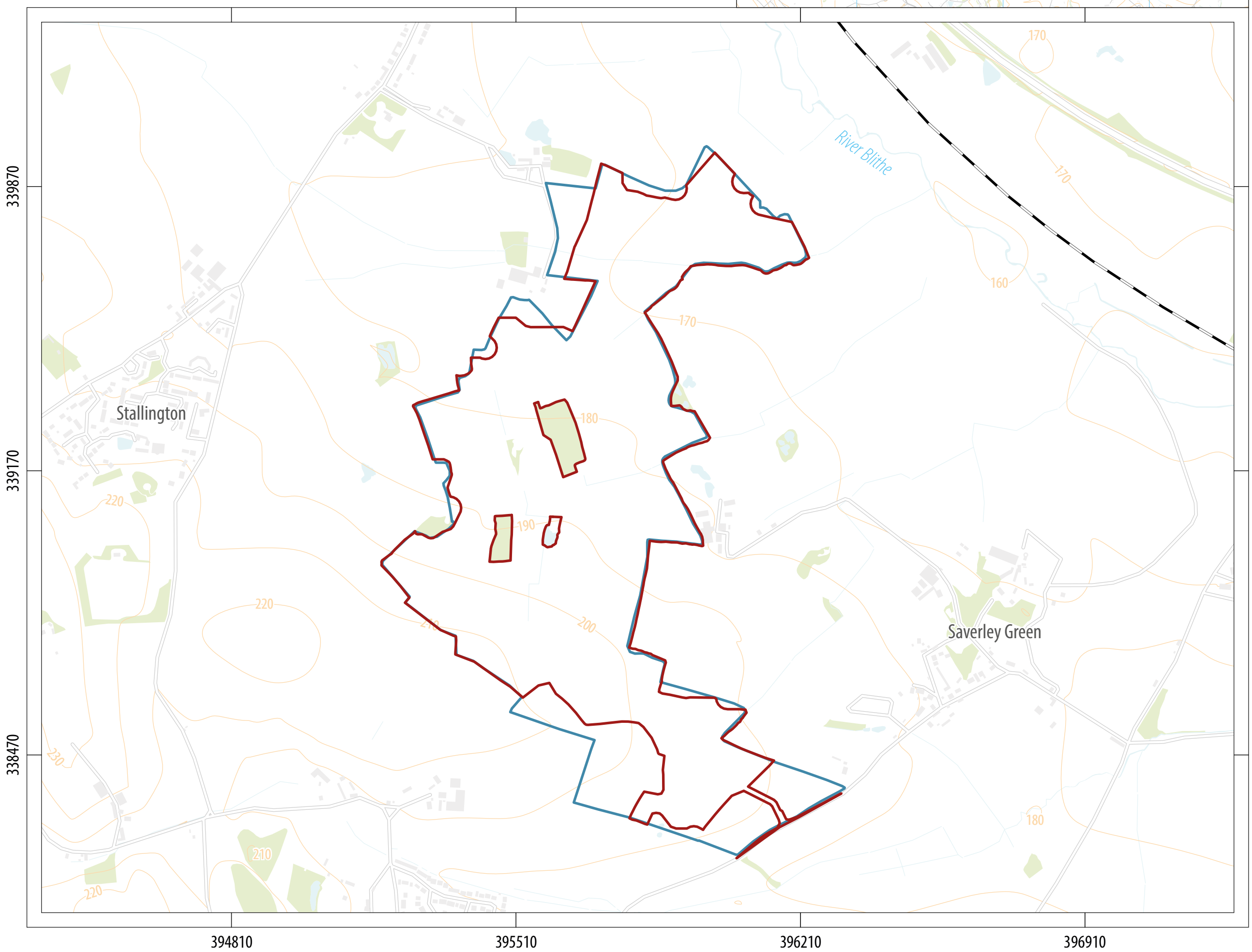
CONTENTS

LIST OF ILLUSTRATIONS

Leaford Solar Farm
Fulford
Staffordshire

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





0 150m
1:18,000 @ A4

geophysical survey area
proposed development area

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ILLUS 1 Site location

LEAFORD SOLAR FARM, STOKE-ON-TRENT

GEOPHYSICAL SURVEY

1 INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Mabbett & Associates Ltd (the Client) to undertake a geophysical (magnetometer) survey on land at the proposed Leaford Solar Farm, Fulford, Stoke-on-Trent covering approximately 83 hectares (Illus 1), where a new solar farm is being proposed.

This geophysical survey report will be submitted as part of the planning application for the proposed development and the results may also inform future archaeological strategy, if required. The scheme of work was undertaken in accordance with the then requirements of the National Planning Policy Framework (MHCLG 2021) and since (DLUHC 2023), with the Written Scheme of Investigation for Geophysical Survey (WSI - Headland Archaeology 2023).

The survey was undertaken in accordance with a Written Scheme of Investigation for Geophysical Survey (WSI - Headland Archaeology 2023) and was carried out in line with current best practice (Chartered Institute for Archaeologists CIfA 2014b, Europae Archaeologia Consilium 2016). The WSI was approved by Shane Kelleher County Archaeologist for Staffordshire County Council on May 12th 2023.

An initial survey covering 65 hectares was carried out between May 16th and May 19th, 2023. A further five adjoining areas located immediately to the south (F14, F17, F20, F22 and F23), totalling 18 hectares, were subsequently surveyed on September 7th and September 8th 2023.

1.1 SITE LOCATION, TOPOGRAPHY AND LAND-USE

The geophysical survey area (GSA) consists of an irregularly shaped parcel of land covering approximately 83 hectares and consists of 24 agricultural fields, centred at SJ 95646 39251. The GSA is located to the immediate north of Fulford and approximately 9km south-east of Stoke-on-Trent. The GSA is bounded by Saverley Green Road to the south-east, a farm track and buildings to the north-west and further agricultural fields in all other directions. Several areas of woodland and ponds are present within and surrounding the GSA. The proposed development area (PDA) is located entirely within the boundary of the GSA and measures approximately 69ha (Illus 1).

At the time of survey, all fields were under grass, either for silage (Illus 2 and Illus 3) or permanent pasture (Illus 4 and Illus 5) (pages 12-13).

Topographically the land within the GSA slopes gently upwards from the north at approximately 170m Above Ordnance Datum (AOD) to a maximum hight of approximately 206m AOD in the south-west, before gently falling to 188m AOD at the southern point of the GSA.

1.2 GEOLOGY AND SOILS

The GSA primarily lies on a bedrock of siltstone, mudstone and sandstone of the Tarporley Siltstone Formation, a sedimentary bedrock formed between 250 and 241.5 million years ago during the Triassic period. Mudstone of the Mercia Mudstone Group, a sedimentary bedrock formed between 252.2 and 201.3 million years ago during the Triassic period is present to the south.

The bedrock is overlain across most of the GSA by superficial deposits of Diamicton, sedimentary superficial deposits formed between 116 and

ILLUS 2 F2, looking north-west

11.8 thousand years ago during the Quaternary period. Cutting into the north of the GSA, covering all or part of F4, F6 and F15, two bands of River Terrace Deposits (sand and gravel) are also present. These are sedimentary superficial deposits formed between 2.588 million years ago and the present. Two small areas with no superficial deposits are present in the east and north of the GSA covering parts of F1, F2 and F15 (UKRI 2023).

The soils covering most of the GSA are described as slowly permeable seasonally wet slightly acid but base-rich loams and clays, as classified in the Soilscape 18 Association, except for in the north of the GSA, where loamy soils with naturally high groundwater are recorded, as classified in the Soilscape 22 Association (Cranfield University 2023).

2 ARCHAEOLOGICAL BACKGROUND

Examination of the Staffordshire Historic Environment Records (SHER), viewed on Heritage Gateway, identified very limited evidence of archaeological activity within or surrounding the GSA. A single heritage asset within the GSA is recorded comprising an area of ridge and furrow cultivation identified on air photographs within F13 (Monument ID:MST5690, HER ref:20420). The only other assets close to the GSA are post-medieval farmsteads and the 19th century Fulford Church of St Nicholas located to the south of the GSA.

3 AIMS, METHODOLOGY & PRESENTATION

3.1 AIMS & OBJECTIVES

The principal aim of the programme of geophysical survey was to gather information to establish the presence/absence, character, and extent of any archaeological remains within the GSA limits. This will enable an assessment to be made of the impact of any proposed development on any sub-surface archaeological remains.

The overall objective was to inform the application and thereby inform any further investigation strategies, as appropriate.

The specific archaeological objectives of the geophysical survey were:

- to gather enough information to inform the extent, condition, character, and date (as far as circumstances permit) of any archaeological features and deposits within the GSA limits;
- to obtain information that will contribute to an evaluation of the significance of the possible scheme upon cultural heritage assets; and
- to prepare a report summarising the results of the survey.

ILLUS 3 F15, looking west

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/burial grounds. However, magnetometry is by far the single most useful technique and was assessed as the best non-intrusive evaluation tool for this site although it is acknowledged that certain types and sizes of features may be difficult to identify in the prevailing soils and geology.

The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid 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 (Illus 6). These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R10 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. Terrasurveyor V3.0.37.0 (DWConsulting) software was used to process and present the data.

3.3 DATA PRESENTATION & TECHNICAL DETAIL

A general site location plan is shown in Illus 1 at a scale of 1:18,000. Illus 2 to Illus 5 are site condition photographs. Illus 6 shows the GPS swaths and photograph locations at 1:10,00. Overall greyscale magnetometer data and interpretation are also displayed at 1:10,000 in Illus 5 and Illus 6 respectively. Fully processed (greyscale) data, minimally processed (XY trace plot) data and interpretative plots are presented, by Sector, at a scale of 1:2,500, in Illus 9 to Illus 23 inclusive.

Technical information on the equipment used, data processing and magnetic survey methodology is given in Appendix 1. Appendix 2

ILLUS 4 F2, looking west

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 2023), guidelines outlined by Europae Archaeologia Consilium (EAC 2016) and by the Chartered Institute for Archaeologists (CIfA 2014b). All illustrations from 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 AND DISCUSSION

4.1 SITE CONDITIONS

Magnetometer survey can generally be recommended over any sedimentary bedrock, (English Heritage 2008; Table 4), although results can be variable over mudstone geologies and depending on the extent of any overlying superficial deposits, which are present on this site. Nevertheless, magnetometry was determined as the most appropriate geophysical technique for evaluating the GSA, taking account of the limitations noted above and in Section 3.2.

The magnetic background across the GSA is variable with numerous discrete low magnitude anomalies, reflecting variation within the superficial diamicton deposits and the soils that derive from them. There is a greater density of these discrete anomalies in the south of the GSA, roughly coinciding with the mapped change in bedrock geologies from Tarporley Siltstone Formation to Mercia Mudstone Group.

Broad, sinuous anomalies are recorded throughout the GSA, but more commonly and more extensively in the centre and south. In most instances these anomalies coincide with changes in the topography.

Whilst anomalies of geological/natural origin are apparent throughout the data, numerous other anomalies of agricultural, modern, and uncertain derivation are also recorded, and these are described below according to their interpreted origin.

ILLUS 5 F12, looking north

Surface conditions across the GSA were very good throughout and subsequently data quality was also good with only minimal post-processing required. No problems were encountered during the fieldwork.

4.2 FERROUS AND MODERN ANOMALIES

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 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 to recorded ferrous anomalies anywhere within the GSA that might suggest an archaeological origin. It is far more probable that the 'spike' responses are caused by the random distribution of ferrous debris in the upper soil horizons.

Two high magnitude linear dipolar anomalies in F1, F2, and F4 (Illus 8 and Illus 11 – SP1 and SP2), locate buried services/pipes.

Linear bands or small areas of magnetic disturbance recorded along or adjacent to some of the field boundaries are likely due to the accumulation of ferrous debris around the field margins and/or ferrous fencing forming part of the boundary itself.

4.3 GEOLOGICAL/NATURAL ANOMALIES

The magnetic background across much of the GSA is dominated by regular discrete low magnitude anomalies consistent with the variations in depth and composition of the superficial deposits which cover much of the GSA. In the south of the GSA, where these anomalies broadly align to the mapped geological boundary between the Tarporley Siltstone Formation and the Mercia Mudstone Group, there is a greater density of such discrete low magnitude anomalies.

Vague, weakly magnetic, sinuous anomalies identified throughout the GSA are more frequently recorded in the south and west of the GSA where the topography is steeper, specifically in F13, F16, F18, F20 and F24. These anomalies may be due to colluvial processes (accumulations of topsoil around breaks in slope or the base of slope) or to variations in the superficial geology.

4.4 AGRICULTURAL ANOMALIES

Twelve low magnitude linear anomalies (Illus 8 – FB1 to FB12) locate boundaries, recorded on the 1888-1913 six-inch first edition OS mapping, which have been removed over the last 130 years.

Parallel widely spaced dipolar or magnetically enhanced linear anomalies, identified in all fields except for F1, F2, F14, F17 and F23 and present on varying alignments and patterns, are caused by field drains.

Closely spaced, parallel linear low magnitude anomalies recorded across all fields are the result of modern cultivation regimes.

No anomalies indicative of the ridge and furrow cultivation recorded on the WSHER in F13 is evident in the data however one possible example is recorded in F23. This ridge and furrow is not visible as extant earthworks and will therefore have been reduced by later ploughing. These anomalies result from the magnetic contrast between the infilled furrows and the former ridges.

4.5 ANOMALIES OF UNCERTAIN ORIGIN

Two separate, isolated, magnetically enhanced discrete anomalies in F1 and F17 (Illus 9-11(pages 17-19) and Illus 21-23 (pages 29-31)– ME1 and ME2) are ascribed an uncertain origin. Both have distinct magnetic signatures compared to the natural magnetic background and/or other agricultural/geological anomalies that are possibly indicative of an anthropogenic cause. On the basis the anomalies cannot be confidently interpreted in any other category an uncertain origin has been attributed. An archaeological cause therefore cannot be ruled out. However, given the complete lack of archaeological potential across the GSA an agricultural origin or geological origin for these anomalies is still considered most likely.

4.6 ANOMALIES OF ARCHAEOLOGICAL ORIGIN

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

5 CONCLUSION

By far the most common anomalies identified within the dataset are due to geological, agricultural, or modern causes. Anomalies locating twelve former field boundaries have been identified as well as field drains and service pipes. Two separate isolated magnetically enhanced anomalies of uncertain origin have been recorded though no anomalies of archaeological potential are identified.

Overall, it is determined that the survey results provide a reliable indication of the archaeological potential of the geophysical survey area (GSA). The archaeological potential of the GSA is consequently assessed as very low.

6 REFERENCES

Chartered Institute for Archaeologists (CIfA) 2014 ***Standard and guidance for archaeological geophysical survey*** (Reading) https://www.archaeologists.net/sites/default/files/CIfAS%26GGeophysics_3.pdf accessed 21 June 2023

Cranfield University (2020) ***Cranfield Soil and Agrifood Institute Soilscapes*** http://www.landis.org.uk/soilscapes/ accessed 21 June 2023

English Heritage (2008) ***Geophysical Survey in Archaeological Field Evaluation***

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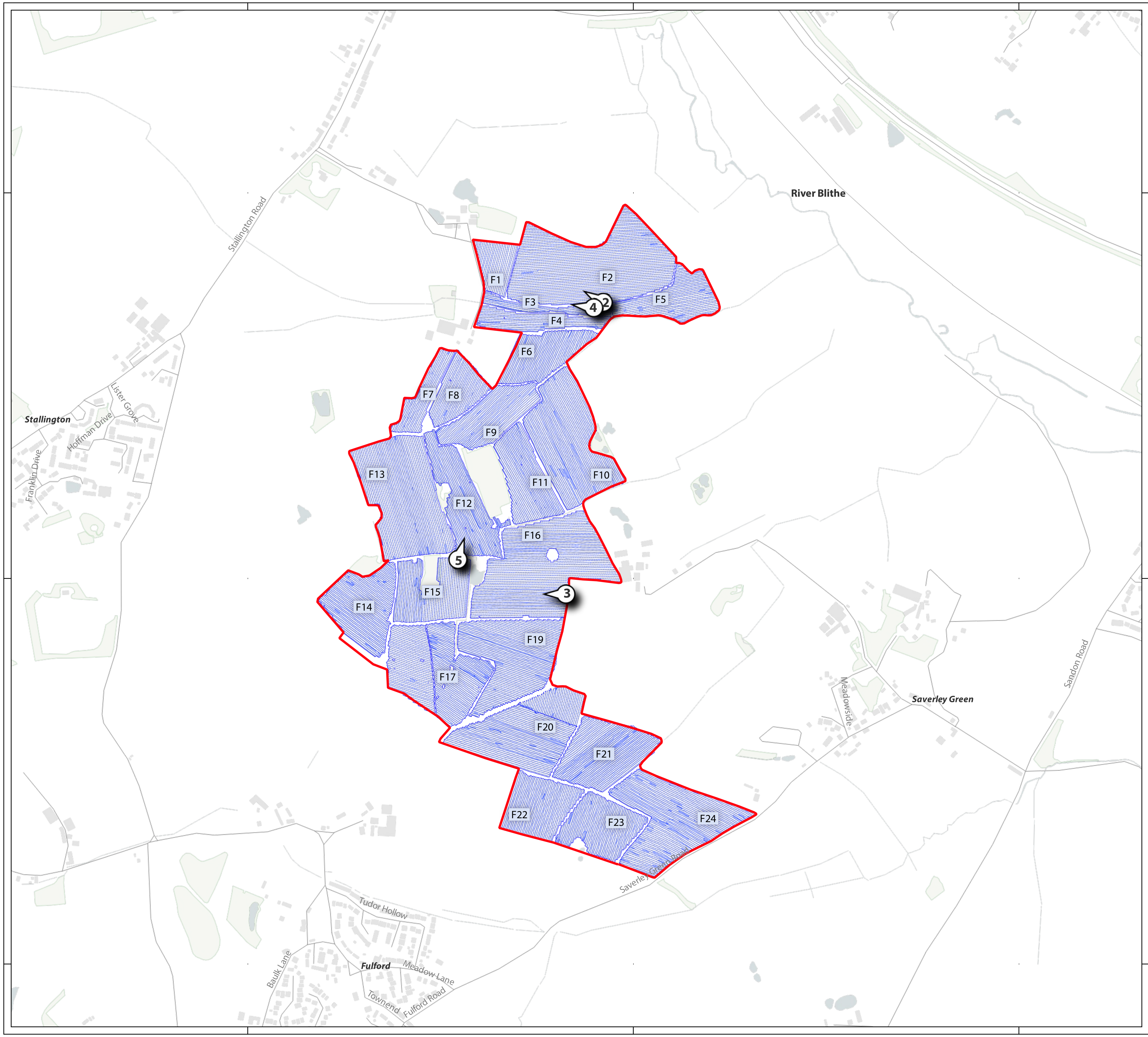
United Kingdom Research and Innovation (UKRI) 2023 ***British Geological Survey (BGS) Geology Viewer*** http://www.bgs.ac.uk/ accessed 21 June 2023



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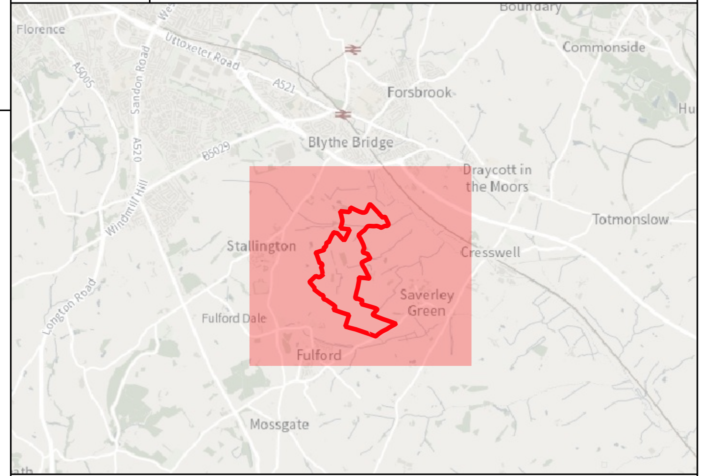


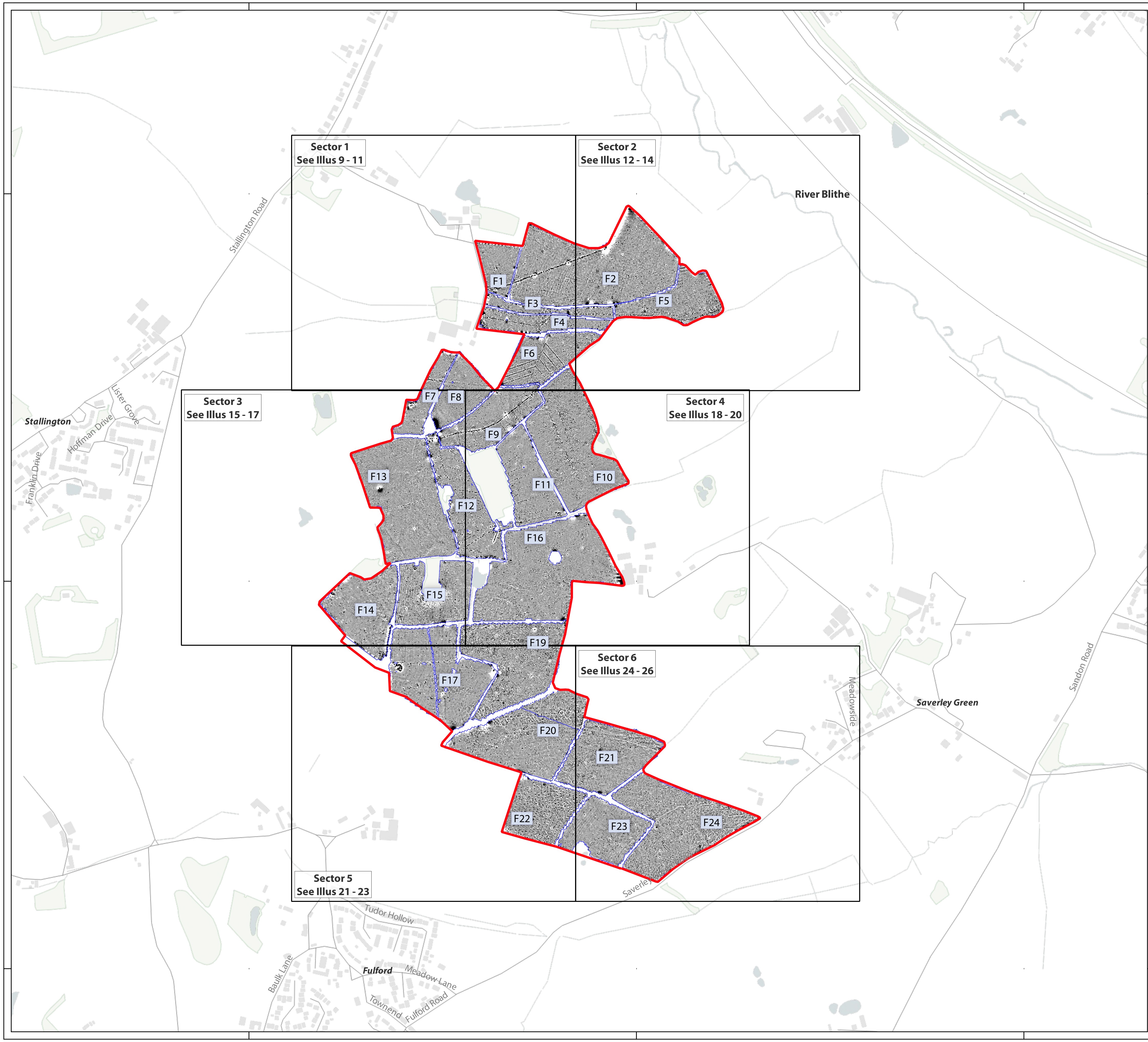
Key

- Geophysical Survey Area
- Survey Extent
- Location and Direction of Illus 02-05
- GPS Swaths

0 200 400 m

Site:	FLFD23
Created by:	LD
Checked by:	CA
Version:	v2.0
Date:	05/10/2023
Scale:	1:10,000 @ A3

Illus 06 - Survey location showing GPS swaths and photograph locations



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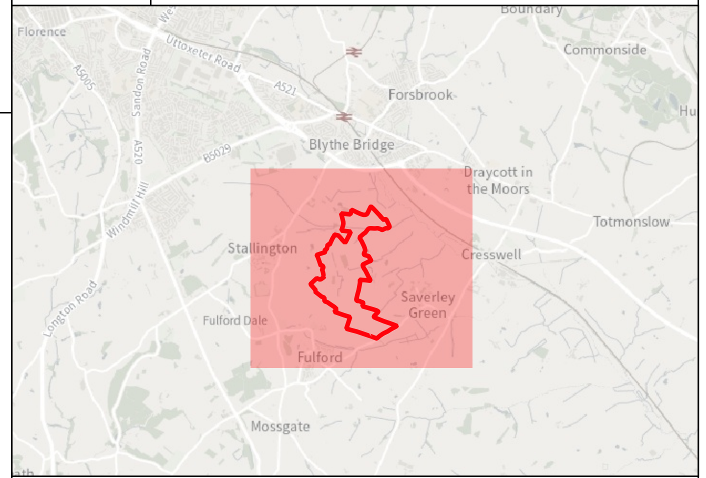

Key

- Geophysical Survey Area
- Survey Extent
- Areas for Illus 09 - 26

+2nT
-1nT

0 200 400 m

Site:	FLFD23
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Checked by:	CA
Version:	v2.0
Date:	05/10/2023
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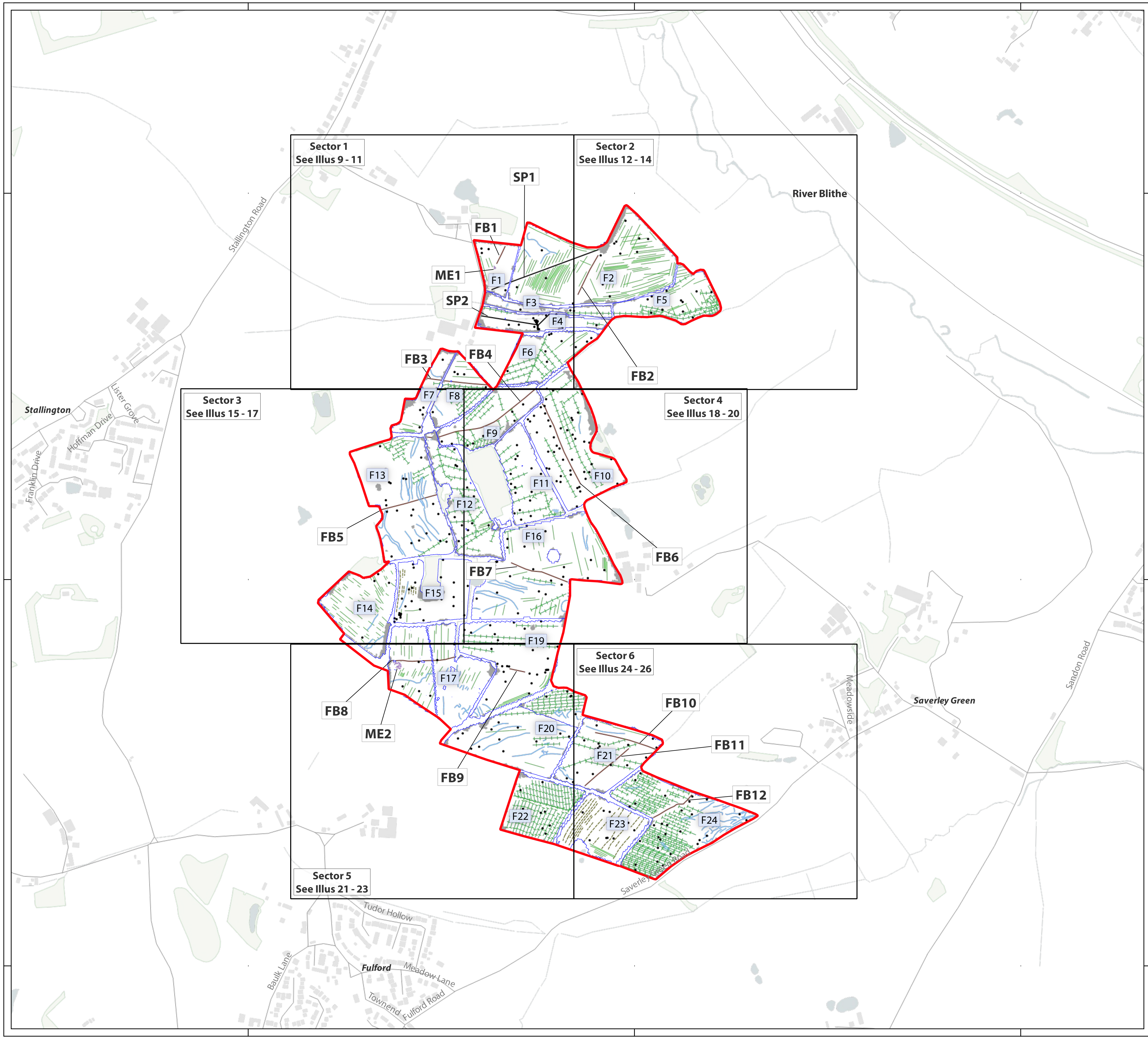
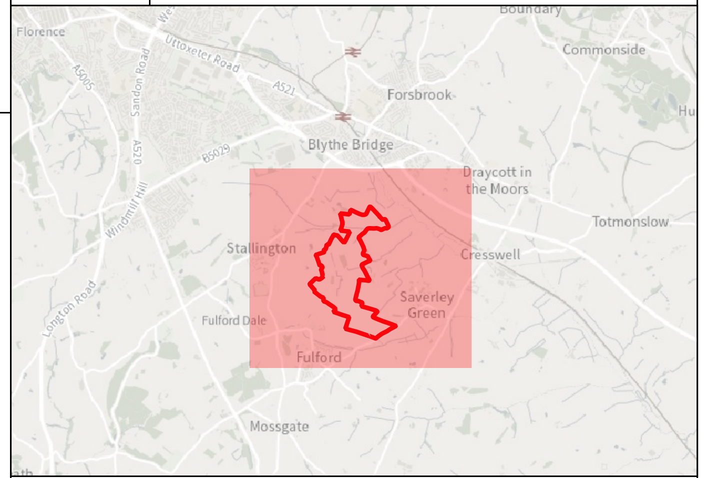
Illus 07 - Overall greyscale plot of processed magnetometer data





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Key

- Geophysical Survey Area
- Survey Extent
- Areas for Illus 09 - 26
- Ferrous Objects
- Agriculture
- Field Boundary
- Field Drain
- Natural
- Pipe
- Ridge and Furrow
- Magnetic Disturbance
- Natural
- Overhead
- Uncertain

Abbreviations

FB	Former Boundary
ME	Magnetic Enhancement
SP	Service Pipe

0 200 400 m

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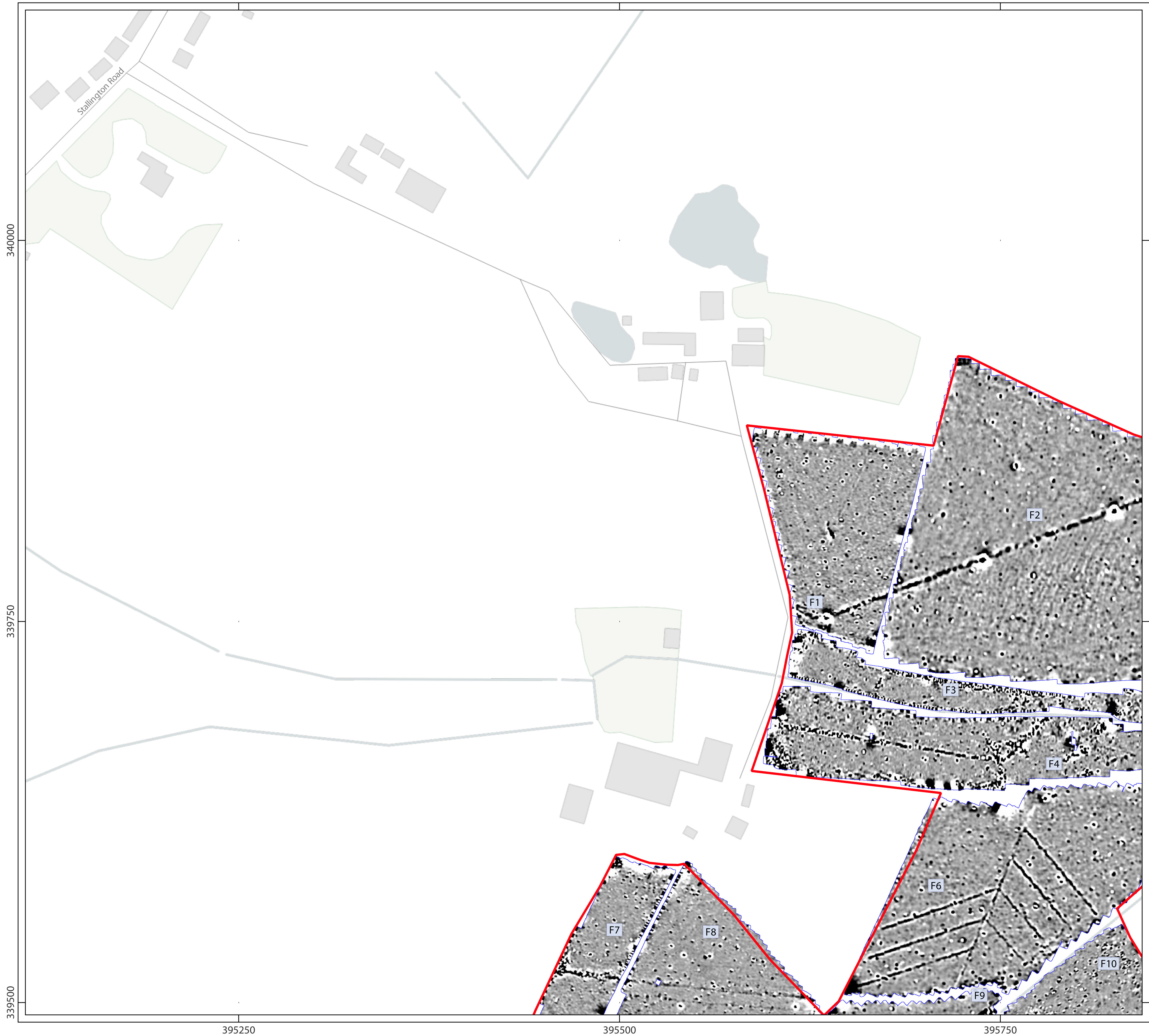
Illus 08 - Overall interpretation of magnetometer data



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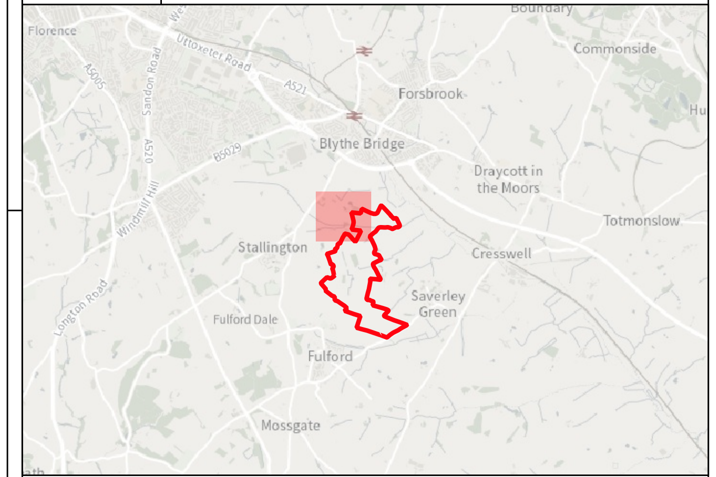

Key

Geophysical Survey Area

Survey Extent

+2nT

-1nT

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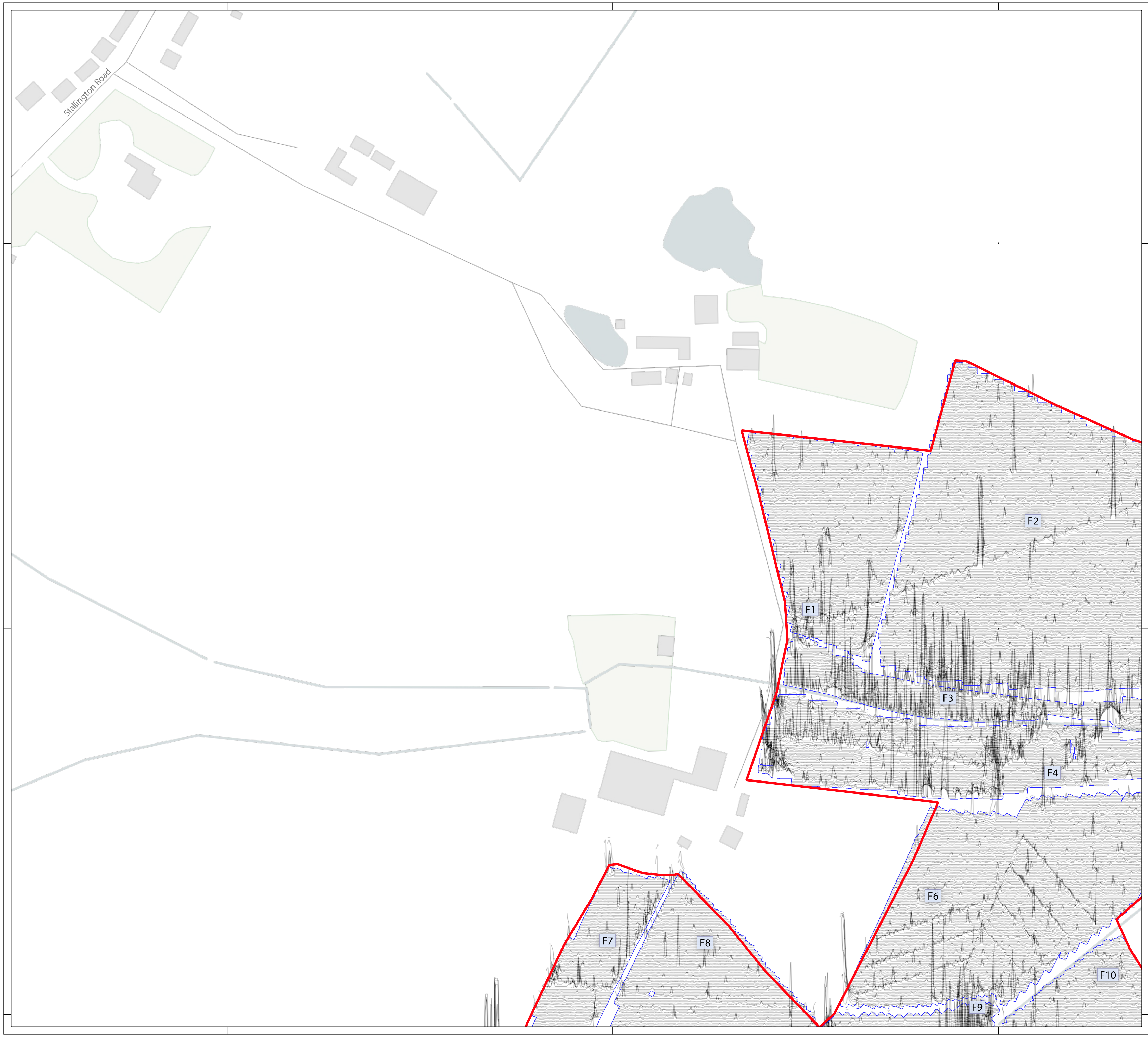
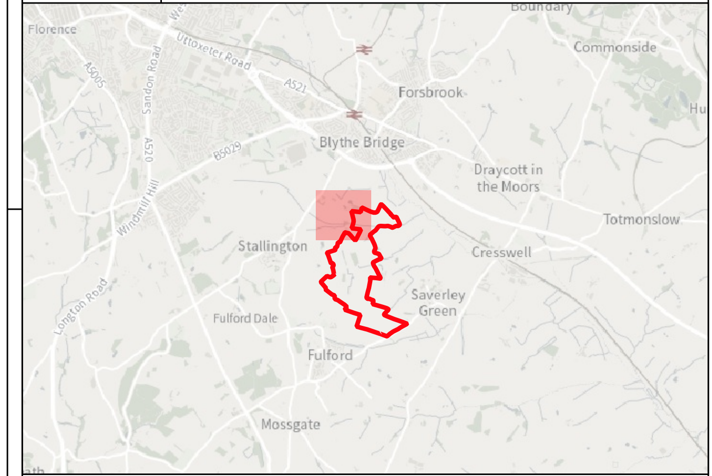
Illus - 09 Processed greyscale magnetometer data; Sector 1





Key

Geophysical Survey Area

Survey Extent

XY Trace (25nT/cm)

0 60 120 m

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Created by:	LD
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Date:	05/10/2023
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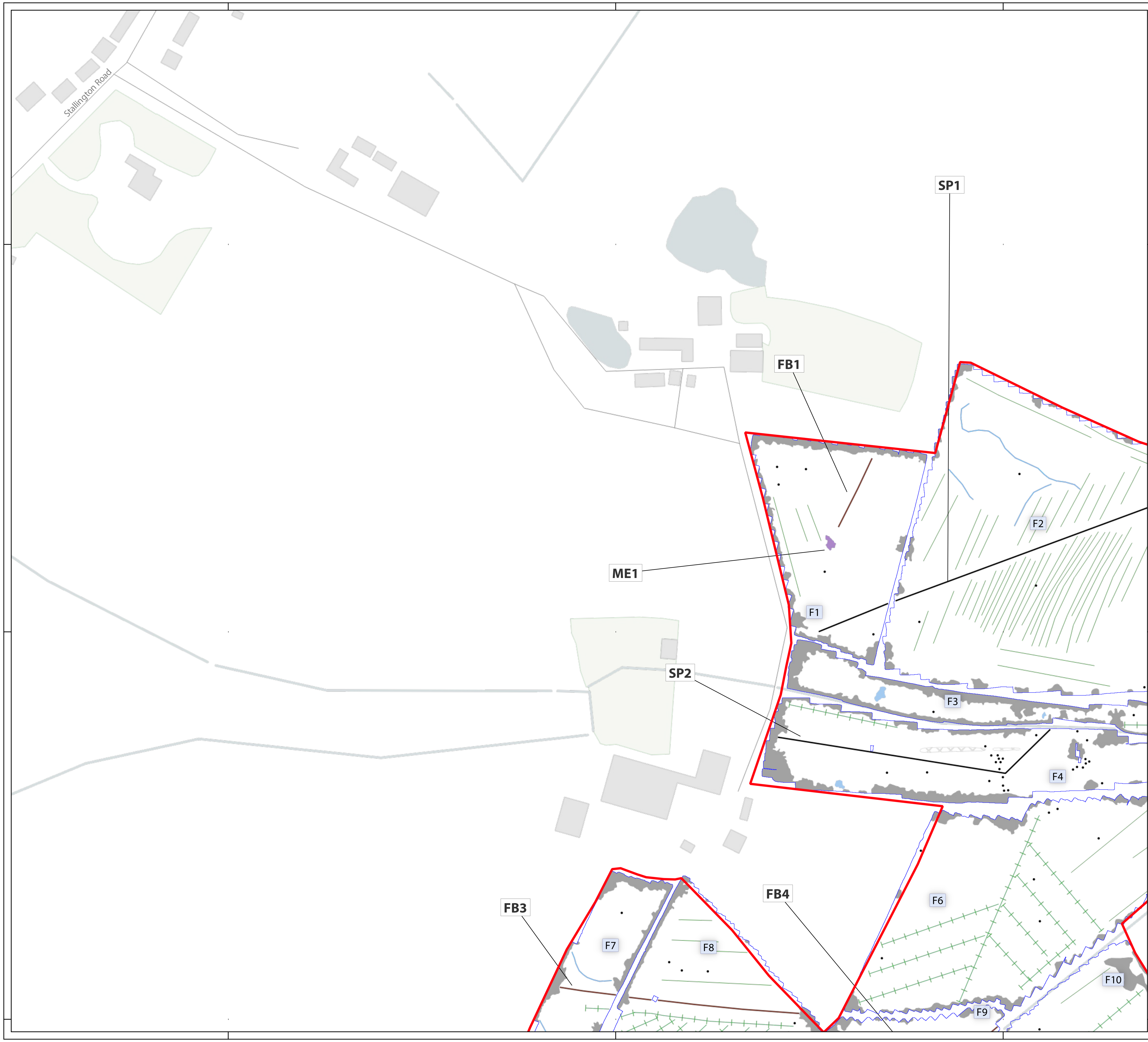
Illus - 10 XY trace plot of minimally processed magnetometer data; Sector 1



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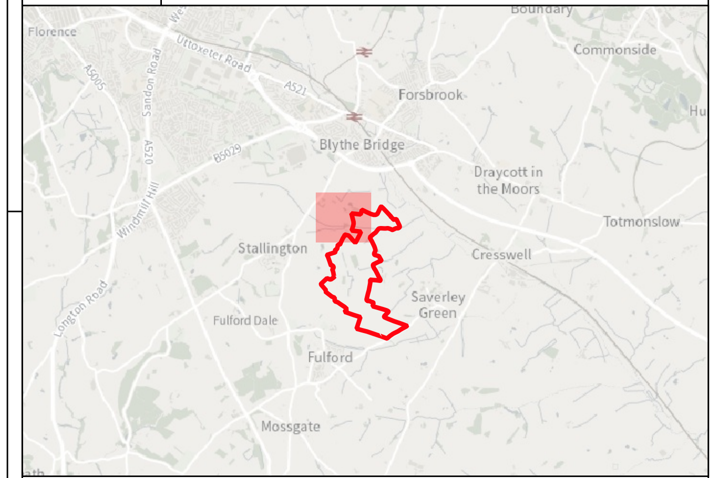

Key

- Geophysical Survey Area
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Abbreviations

FB	Former Boundary
ME	Magnetic Enhancement
SP	Service Pipe

0 60 120 m

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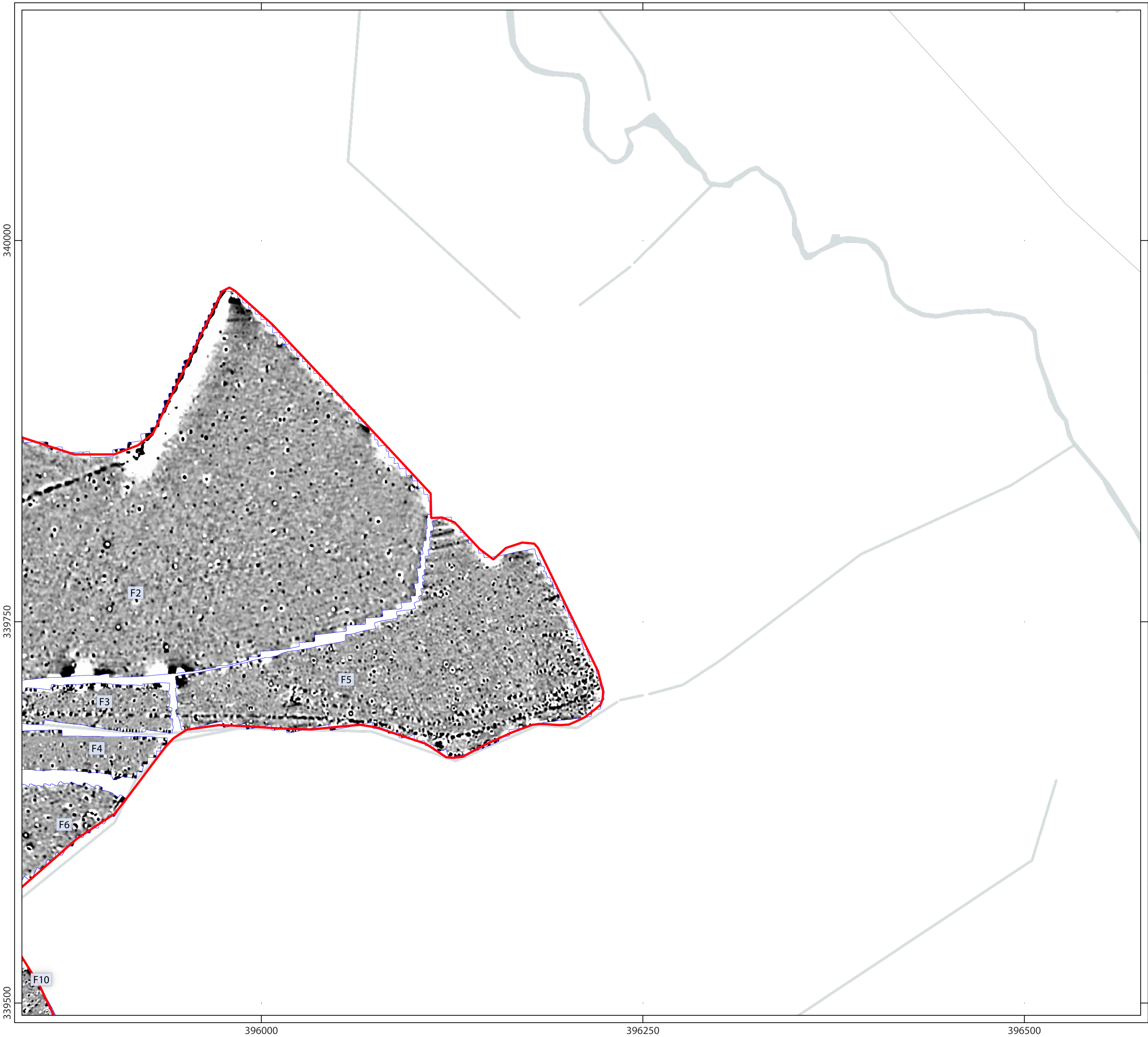
Illus - 11 Interpretation of magnetometer data; Sector 1



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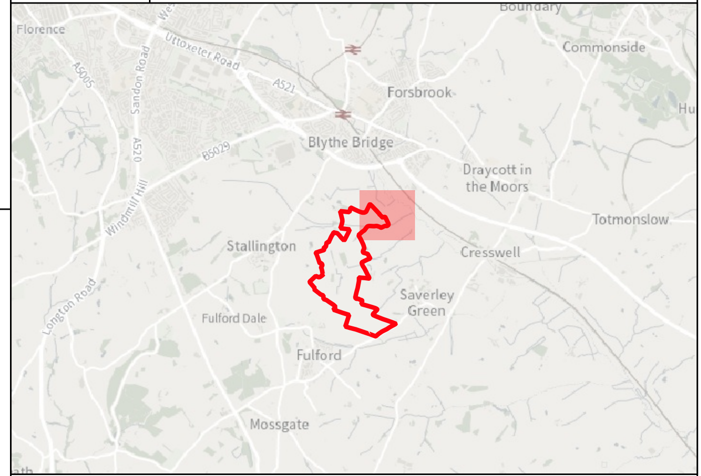

Key

Geophysical Survey Area

Survey Extent

+2nT

-1nT

0 60 120 m

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Created by:	LD
Checked by:	CA
Version:	v2.0
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Illus - 12 Processed greyscale magnetometer data; Sector 2

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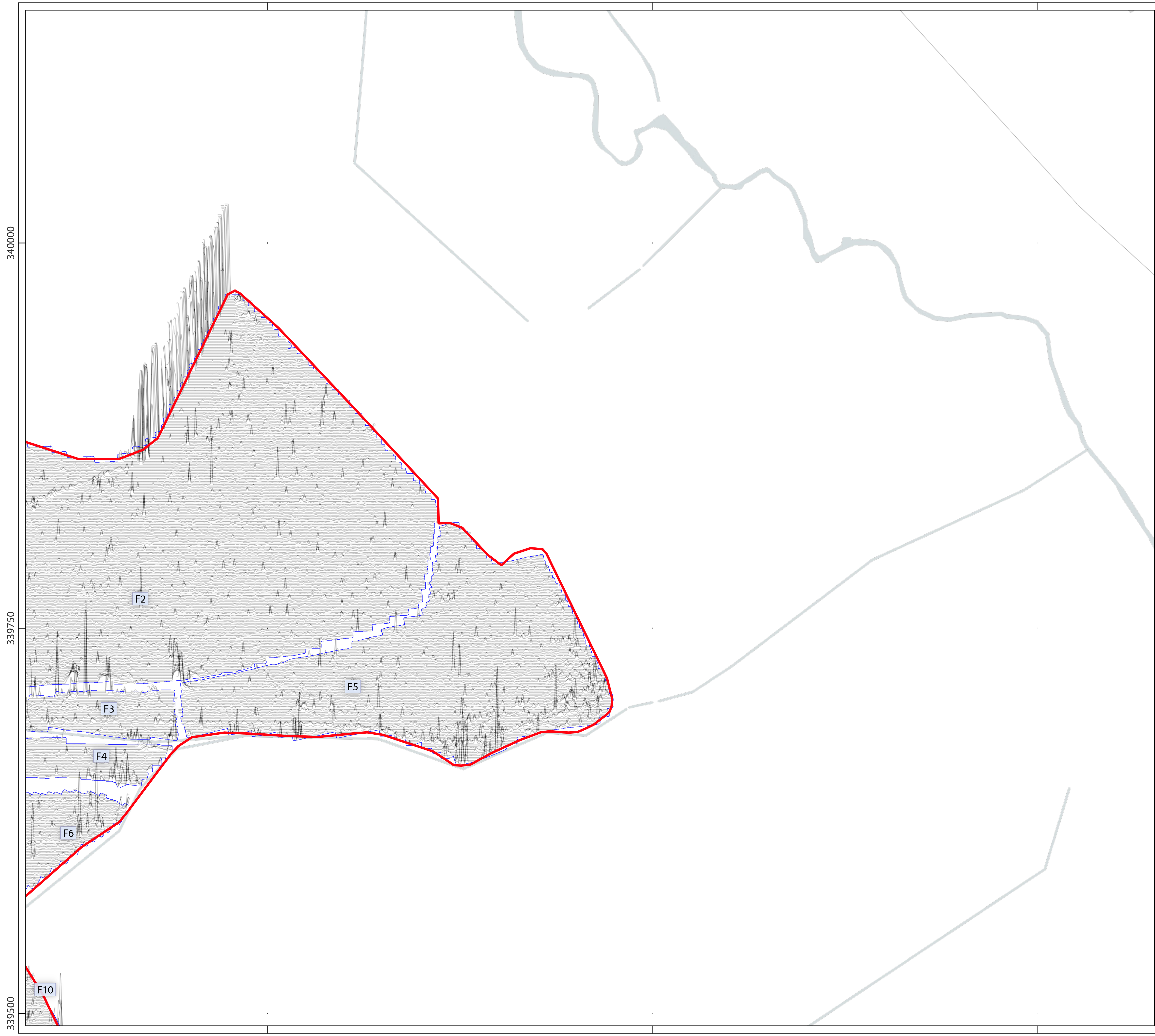

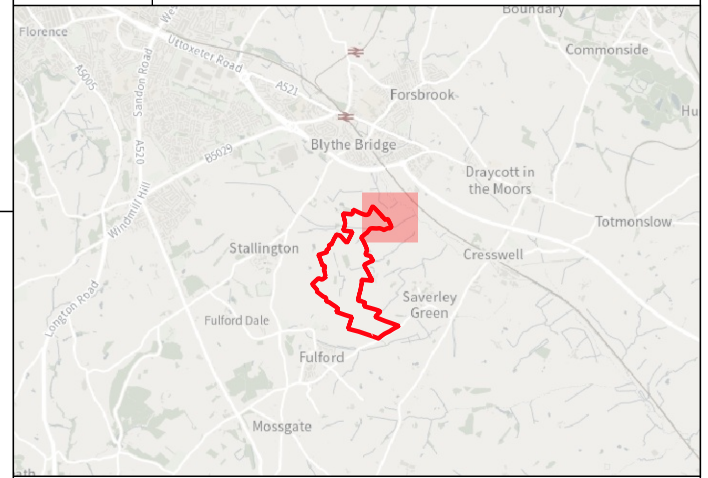

Key

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

0 60 120 m

Site:	FLFD23
Created by:	LD
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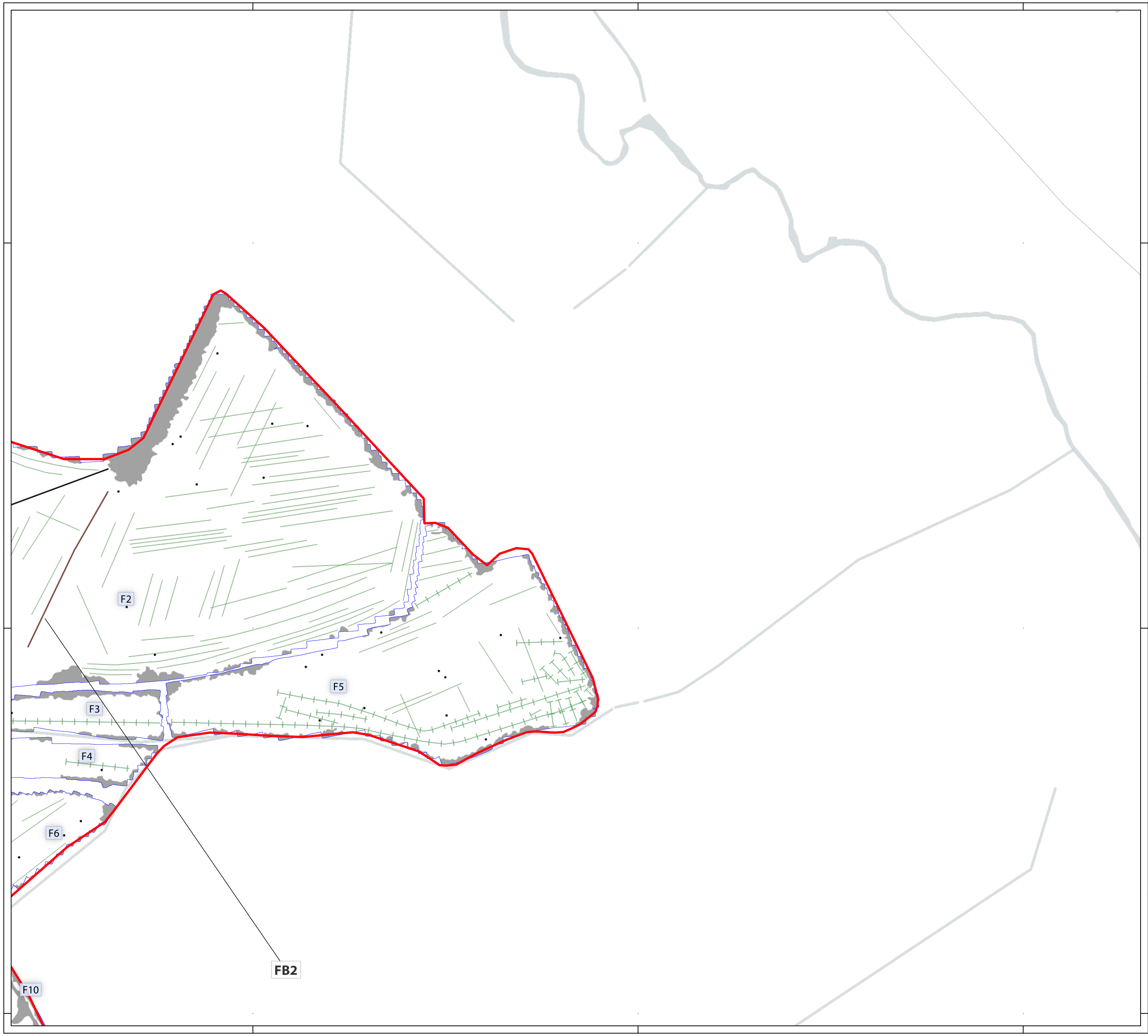
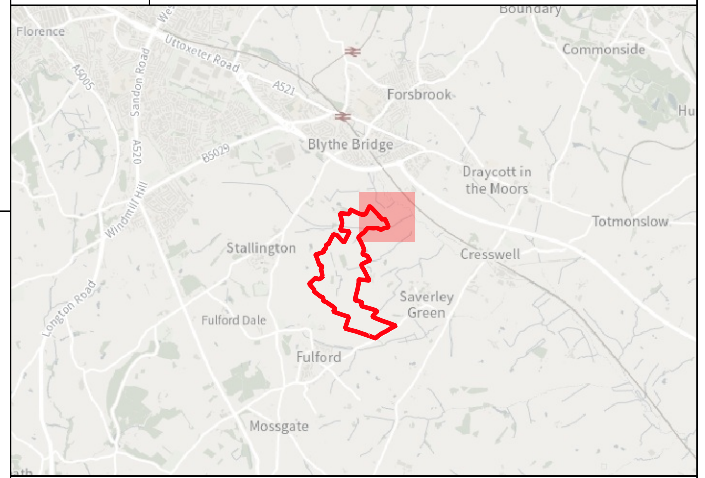
Illus - 13 XY trace plot of minimally processed magnetometer data; Sector 2





Key

- Geophysical Survey Area
- Survey Extent
- Ferrous Objects
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- Field Boundary
- Field Drain
- Pipe
- Magnetic Disturbance

Abbreviations

FB Former Boundary

0 60 120 m

Site:	FLFD23
Created by:	LD
Checked by:	CA
Version:	v2.0
Date:	05/10/2023
Scale:	1:2,500 @ A3

Illus - 14 Interpretation of magnetometer data; Sector 2