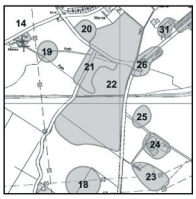
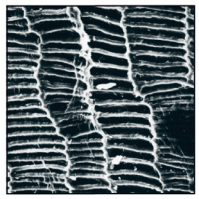
BRBE20










BRADWELL B, ESSEX

INTERIM GEOPHYSICAL SURVEY REPORT

commissioned by Wood Environment and Infrastructure Solutions Ltd
on behalf of Bradwell Power Generation Company Ltd

December 2020

HEADLAND ARCHAEOLOGY

REGISTERED ORGANISATION CIfA

BRADWELL B, ESSEX

INTERIM GEOPHYSICAL SURVEY REPORT

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December 2020

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

PROJECT INFO:

HA Project Code **BRBE20** / NGR **TM 01390 08747** / Parish **Bradwell** / Local Authority **Essex County Council** / OASIS Ref. **headland5-411058**

PROJECT TEAM:

Project Manager **Sam Harrison** / Author **Alistair Webb** / Fieldwork **Glyn Sheldrick, Michael Puntorno, Richard McGregor Edwards, Matt Berry** / Graphics **Beata Wieczorek-Oleksy, Ross Bishop**

Approved by **Sam Harrison**

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HEADLAND ARCHAEOLOGY

part of the RSK Group

REGISTERED ORGANISATION CIfA

PROJECT SUMMARY

Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey on agricultural land south and east of the current nuclear power station at Bradwell, Essex. The survey area (180 hectares) comprises approximately 40% of the land within a planning application red line boundary for a proposed new nuclear power station (Bradwell B) at the site. Access is still being sought for the remaining 292ha which, once surveyed, will be the subject of a separate, overall, report that incorporates all the information from this interim document.

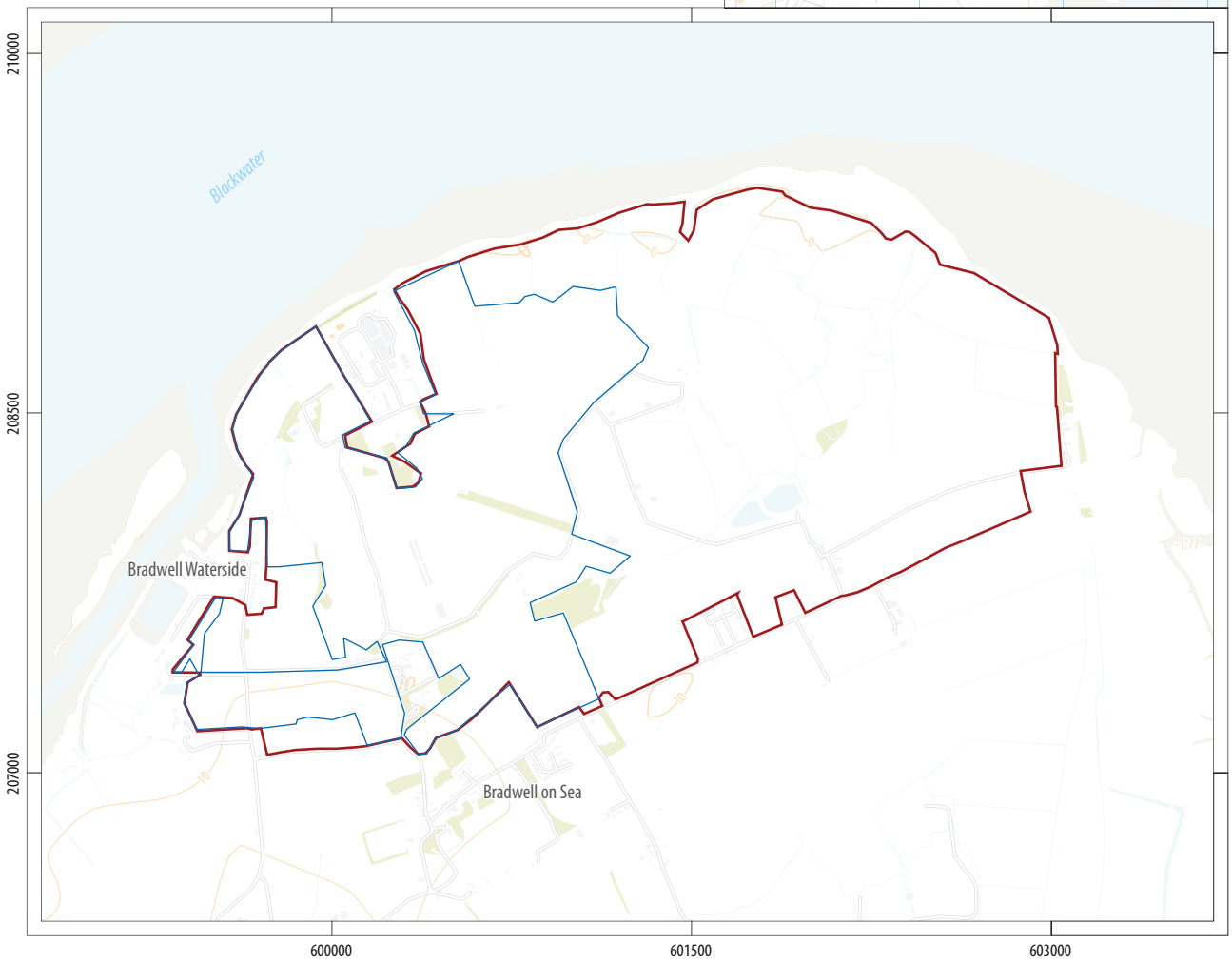
The survey has covered most of the western half of the application area, a large proportion of which was formerly part of Bradwell Bay Airfield which was operational during World War II but decommissioned in the early 1960s. Some of the runways still survive and serve to divide and provide access between the surrounding fields which are in agricultural production following remediation of the airfield. Nevertheless, anomalies indicative of airfield infrastructure and services are still prominent in the data. Other magnetically disturbed areas are caused by the construction of the current power station. Nearer the estuary anomalies characteristic of a former marshy intertidal, environment are identified. Other non-archaeological anomalies are caused by former field boundaries and land drains, pipes and services. Across much of the survey area linear anomalies forming fields/ enclosures are identified although these are of uncertain date and are not recorded on historic mapping. These features are interpreted as archaeological being particularly prevalent along the southern site boundary and towards the centre of the site. Two areas have been identified as of particular interest, possibly areas of settlement. Other linear anomalies throughout the survey area may also have an archaeological origin although no clear pattern can be seen; some of these anomalies correspond with cropmarks transcribed from air photographs. Tentative evidence of a salt production site has also been identified close to the coastline. Although the evidence for either settlement or salt production is far from clear cut the archaeological potential of the areas surveyed to date is assessed as moderate and high at specific locations.

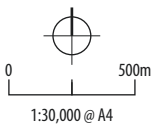
CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

Bradwell B
Essex





proposed development area
geophysical survey area

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ILLUS 1 Site location

BRADWELL B, ESSEX

INTERIM GEOPHYSICAL SURVEY REPORT

1 INTRODUCTION

Headland Archaeology (UK) Ltd was commissioned by Wood Environment & Infrastructure Solutions UK Ltd (The Consultant), on behalf of Bradwell Power Generation Company (The Client) to undertake a geophysical (magnetometer) survey on land east of Bradwell A Nuclear Power Station in advance of the submission of a planning application for a new nuclear facility to the east of the current plant which is being decommissioned. The planning application boundary encompasses 51 fields which cover approximately 482 hectares. This interim report details the results from most of the western half of the site within the planning application boundary, some 180 hectares. Access is currently being negotiated to the remainder of the proposed application area. A full report will be completed once the remainder of the application areas has been surveyed.

The results of the survey will inform future archaeological strategy at the site. The survey was undertaken to assess the impact of the proposed scheme on the historic environment. It was undertaken in accordance with an Archaeological Written Scheme of Investigation (WSI) (Headland, 2020), with guidance within the National Planning Policy Framework (MHCLG 2019) and in line with current best practice (Chartered Institute for Archaeologists 2014, Europae Archaeologia Consilium 2016).

Bradwell Power Generation Company Limited is proposing to build a new nuclear power station, Bradwell B, comprising two UK HPR1000 nuclear reactors, together with associated buildings, structures and components. Located to the south-east of the Bradwell A nuclear power station, which ceased electricity generation in 2002, the Bradwell B power station would have an expected electrical output capacity of approximately 2.2 Gigawatts (GW).

The Project is a Nationally Significant Infrastructure Project (NSIP) under Part 3 of the Planning Act 2008 and therefore the applicant intends to submit an application to the Planning Inspectorate (PINS) for a Development Consent Order (DCO). In addition to the nuclear power station, the application will seek consent for on-site and off-site associated development that is necessary for the construction and operation of the power station. The application will comprise details of all development proposals and will be accompanied by an Environmental Statement (ES) and other relevant documents.

The surveys were carried out between September 1st and September 17th 2020.

1.1 SITE LOCATION, TOPOGRAPHY AND LAND-USE

The site is located on the Dengie peninsula in the Maldon district of Essex, 1km north-west of Bradwell-on-Sea (Illus 1), in the Maldon District of Essex, centred at NGR 600634, 208219. The proposed development area (PDA) lies to the east and south of the current nuclear power station and is bounded to the north-east by the estuary of the Blackwater River and to the east by the North Sea. Arable farmland extends to the south and south-west.

The PDA is currently under agricultural arable production. Some fields were fallow having recently been harvested and the remainder had been drilled and re-seeded. The fields surround the remains of the former Bradwell Bay Airfield, including hardstanding associated with the former runways and taxiway.

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1.2 GEOLOGY AND SOILS

The solid geology underlying the PDA comprises Thames Group – Silty Clay. This is overlain by superficial deposits of Head (Diamicton), Intertidal Deposits (Clay and Silt) and River Terrace Deposits (Sand and Gravel) which cover most of the site (BGS 2020 – Illus 3).

The soils are classified in the Soilscape 22 Association characterised as loamy soils with naturally high groundwater (Cranfield University 2020).

2 ARCHAEOLOGICAL BACKGROUND

A full and extensive archaeological background is described in the Heritage Statement Report (Wood 2020), which included information on the PDA and a wider study area which extended 500m beyond the PDA. Below is a summary of the main findings of this report.

Several prehistoric small finds have been uncovered within the wider study area; a scatter of burnt flints and three struck flints (MEX1035604) were found during the Hullbridge Survey plus a flint arrowhead (MEX35292).

Mounds of industrial waste including coarse pottery vessels, ash and heat affected soil, produced during salt making activities, are recorded outside the survey area with one dating to the Iron Age (MEX37860). Within the wider study area there is further evidence for Iron Age activity, finds of pottery (MEX1035603) and a ditch/gully dating from the Iron Age to Roman period (MEX1035605) was found during the Hullbridge Survey. The remains of a structure comprising a group of 12 oak posts staked into an old land surface (MEX37815) is recorded to the north of the site boundary, as well as further finds of Iron Age pottery (MEX394) and a brooch (MEX1038442).

The fort at Othona (SM 1013834) to the south east of the site boundary is a Saxon Shore fort dating to the late 3rd century. There are 15 HER records relating to the Roman period within the 500m study area, with further records relating to a broader Iron Age to Roman date. Evidence for Roman activity comprises small finds including beads (MEX397), coins (MEX392, MEX7120) and pottery (MEX6916), in addition to building material (e.g. MEX1038441). In the wider study area there are 14 further HER records dating to the early medieval and medieval periods. There are ten HER records dating to the post medieval period within the 500m study area, largely reflecting the agricultural nature of the area at the time. Several cropmarks are also visible in and around the survey area.

More recently, the site was used as a World War II airfield (MEX41854), Bradwell Bay Airfield. The airfield had three runways, two of which were extended during the war and there were over 300 buildings and other structures at the site including blister hangars; the adjacent marshes were used as a bombing range. The airfield was closed in 1946 and part of it was redeveloped in the early 1960s becoming the site of Bradwell A nuclear power station.

A geophysical survey (SUMO, 2020) was carried out in the centre of the PDA in March 2020 where the load test area and compound is to be located. The report concluded that 'no magnetic responses that could be categorised as being of definite archaeological potential' had been identified. However, a complex of enclosures and a well-defined curvilinear ditch were recorded and were classed as 'possible archaeology'. A couple of pit-like anomalies were also identified as well as several responses likely to be associated with the former airfield.

3 AIMS, METHODOLOGY AND PRESENTATION

The general aim of the geophysical survey was to provide enough information to establish the presence/absence, character and extent of any archaeological remains within the PDA. This will therefore enable an assessment to be made of the impact of the proposed development on any sub-surface archaeological remains, if present.

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 PDA;
- to obtain information that will contribute to an evaluation of the significance of the scheme upon cultural heritage assets; and
- to prepare a report summarising the results of the survey.

3.1 MAGNETOMETER SURVEY

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.

The survey was undertaken using four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid carrying frame. The system was programmed to take readings at a frequency of 10Hz (allowing for a 10-15cm sample interval) on roaming traverses (swaths) 4m apart (Illus 2). These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R8s 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 V3.0.35.1 (DWConsulting) software was used to process and present the data.

3.2 REPORTING

Illus 1 shows the site in national, regional and local contexts. The GPS swaths and sector boundaries are shown on Illus 2 at a scale of 1;12,500. The superficial geological deposits are shown at the same scale in Illus 3. Plots showing survey data and interpretation comprise Illus 4 and Illus 5, both also at a scale of 1:12,500. Illus 6 to Illus 38 inclusive display the data in greyscale and X-Y trace plot format with accompanying interpretation diagrams in Sector order at a scale of 1:2,500.

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 2020), guidelines outlined by Europae Archaeologia Consilium (EAC 2016) and by the Chartered Institute for Archaeologists (ClfA 2014). All illustrations from Ordnance Survey (OS) mapping are reproduced with the permission of the controller of Her Majesty's Stationery Office (© Crown copyright).

The illustrations in this report have been produced following analysis of the data in 'raw' and processed formats and over a range of different display levels. All illustrations are presented to most suitably display and interpret the data from this site based on the experience and knowledge of management and reporting staff.

4 RESULTS AND DISCUSSION

Ground conditions were very good throughout the PDA. The fields were mostly still stubble following the recent harvest or having recently been ploughed and re-drilled and therefore firm underfoot. This contributed to a high standard of data. A handful of fields had been deep-ploughed and were not suitable for survey.

4.1 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 soil by manuring or tipping/infilling. There is no obvious clustering to these ferrous anomalies (except where noted below) which might indicate an archaeological origin. Far more probable is that the 'spike' responses are likely caused by the random distribution of ferrous debris in the upper soil horizons.

Where there are clusters of 'spikes' areas of more general magnetic disturbance are identified. Two large areas of disturbance are recorded at the south-western corner of F26 and the north-west corner of F23. Analysis of air photographs taken during the construction of the power station suggest that this disturbance is likely due to material left over from the construction of the power station that has been incorporated into the topsoil.

Another area of disturbance in the south-western corner of F27 correlates with the former location of a small cluster of buildings shown on the 1925 6"/mile Ordnance Survey map. Again, the disturbance is due to the residual material from the buildings still left in the plough soil.

Several high magnitude linear anomalies are identified in F3. It is not clear whether these anomalies, which are due to sub-surface pipes are associated with the power station, or perhaps more likely, by airfield infrastructure; the two shorter runways ended at approximately this location.

4.2 AGRICULTURAL ANOMALIES

Numerous linear trend anomalies have been identified across the PDA which have been interpreted as being due to agricultural activity such as land drainage and boundary removal. Anomalies due to field drains are most clearly seen in F15 and F22 in the classic herring-bone pattern. Other anomalies locate former field boundaries which were removed to increase field size as farming became more mechanised and improve efficiency. At least six former boundaries have been identified after analysis of the historic mapping. Most distinct is the sinuous boundary in F27 which was almost certainly a small channel or creek that marked the former edge of cultivated land. As the coastal fringe was drained the creek either silted up or was partially infilled.

4.3 GEOLOGICAL ANOMALIES

Around the coastal fringes of F26 and F27 the data is characterised by an amorphous and irregular pattern of anomalies characteristic in former intertidal estuarine environments; these areas correlate with the intertidal clay and silt soils (Illus 3). The anomalies are due to the magnetic contrast between the former water filled (now infilled) channels and the surrounding drier patches of land.

4.4 PROBABLE AND POSSIBLE ARCHAEOLOGICAL ANOMALIES

Linear anomalies, sometimes isolated and more often part of a larger aggregation of conjoined anomalies are identified in most of the fields away from the coastal fringes. These anomalies are caused by infilled ditches forming field systems and enclosures of unknown date. For ease of description these anomalies have been grouped into three main areas described in the table below. It should be noted that it is very difficult in many cases to determine whether some of the isolated linear anomalies are due to archaeological ditches or are just more recent 'trends' in the data which are more likely due to recent agricultural activity.

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TABLE 1 Summary of findings

GEOPHYSICAL SURVEY SECTOR NO	SUMMARY OF FINDINGS
Sectors 3, 7 and 11 Illus 12–14, 24–26, 36–39	The largest single coherent pattern of enclosures. These extend from F10 (Sector 3) in the west to F17 (Sector 11) in the east, a distance of nearly 2km. Very few complete fields/enclosures are identified but the overall pattern appears more coherent in F16 and F17, to the east, although a single rectangular enclosure is clearly identified in F10 in the south-western corner of the PDA (Sector 3). Further descriptive detail will be supplied in the overall final report.
Sector 2, 5, 6 and 10 Illus 9–11, 18–23, 33–35	Again, the pattern of fields is fragmentary but with some more distinct fields/enclosures visible in the north-west of F15 (Sector 6). Two areas where the pattern is clear enough to be confident of a probable (red) rather than a possible archaeological interpretation are located in the north-east of Field 28, where much smaller and circular enclosures are identified. This area represents either a different style of enclosure and may be indicative of settlement activity although this interpretation should be viewed as tentative. A second area of probable archaeological activity is identified in F25. Here too a smaller arrangement of enclosures is identified with a small circular enclosure located in the south-western corner of a much larger rectangular.
Sector 1,2 Illus 6–11	In F4 a clearly defined but irregular pattern of field boundaries is identified. These fields are clearly larger and with a different morphology than those described above. There are also several broad, amorphous high magnitude discrete anomalies which might be due to variations in the intertidal superficial deposits but might also be indicative of salt production. Again, this interpretation is considered tentative.

5 CONCLUSION

The survey has successfully evaluated the geophysical survey areas to which access is currently available. Anomalies caused by the former airfield, power station construction, recent agricultural activity and variations within the soils and superficial deposits have all been recorded. In addition, anomalies have been identified which are indicative of field systems and enclosures, possibly with some evidence of settlement at two locations. Tentative evidence of a salt production site has also been identified. Although the evidence for either settlement or salt production is far from clear cut the archaeological potential of the areas surveyed to date is assessed as moderate and high at specific locations.

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 23 October 2020

Cranfield University 2019 ***Cranfield Soil and Agrifood Institute Soilscapes*** http://www.landis.org.uk/soilscapes/ accessed 23 October 2020

Europae Archaeologia Consillium (EAC) 2016 ***EAC Guidelines for the Use of Geophysics in Archaeology: Question to Ask and Points to Consider*** Namur, Belgium http://www.old.europeanarchaeological-council.org/files/eac_guidelines_2_final.pdf accessed 23 October 2020

Gaffney C & Gater J (2003) ***Revealing the Buried Past: Geophysics for Archaeologists*** Stroud

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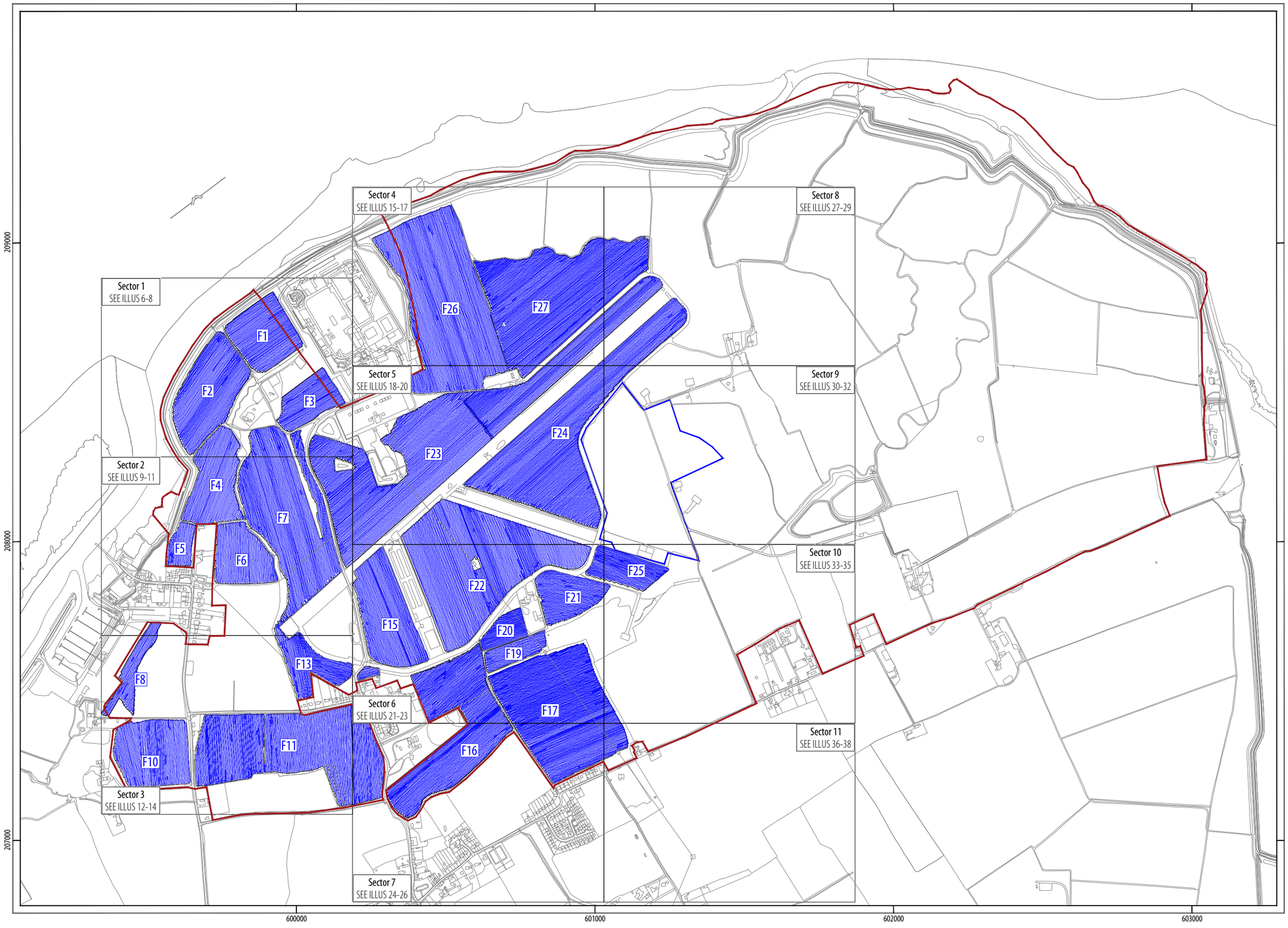
SUMO Survey 2020 ***Geophysical Survey Report Land East of Bradwell Power Station, Essex***

Wood Environment & Infrastructure Solutions UK Ltd 2020 ***Bradwell BGround Investigation - Heritage Statement Report***



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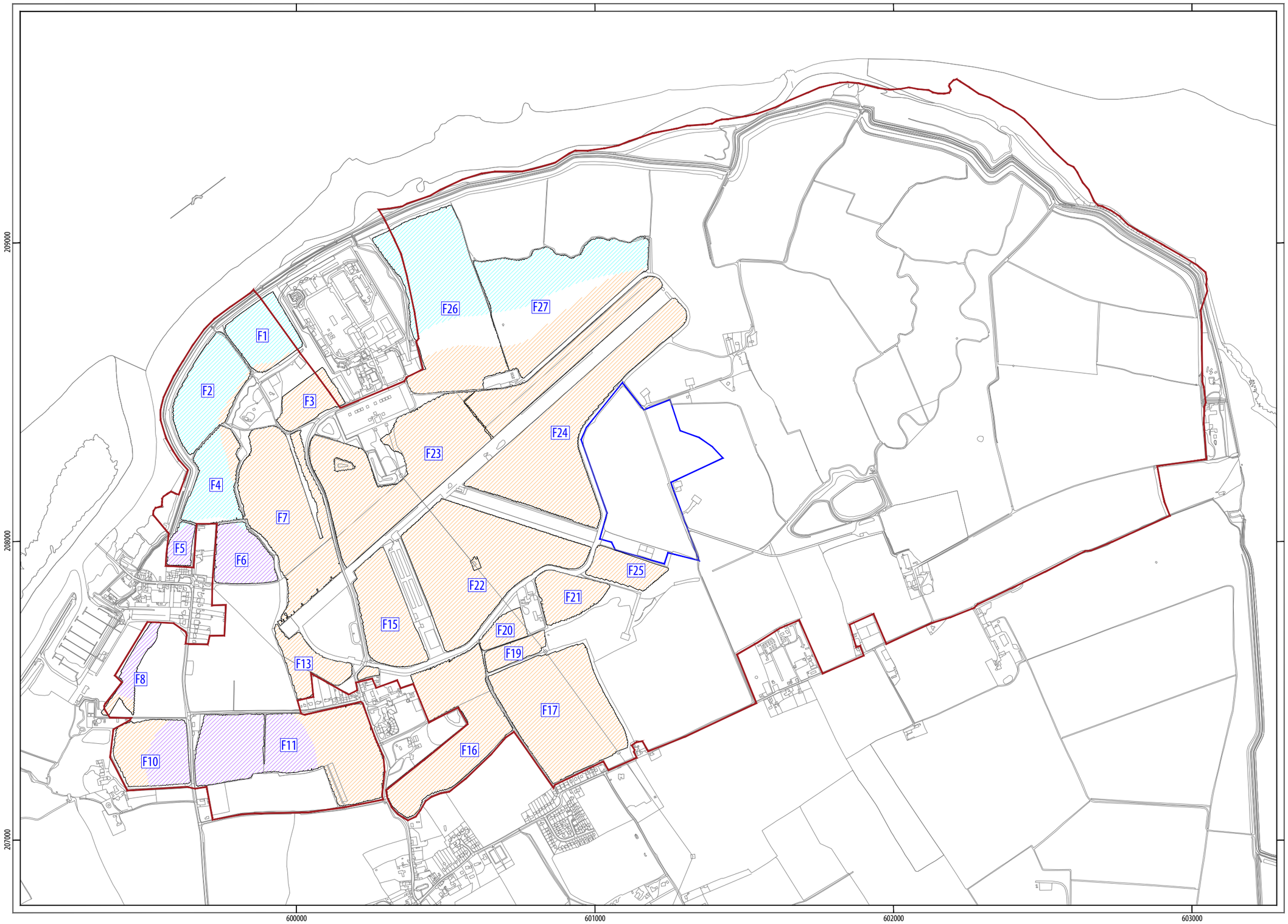
ILLUS 2 Survey location showing GPS swaths



geophysical survey area
area of previous survey
Head - Diamicton
Intertidal Deposits - Clay and Silt
River Terrace Deposits - Sand and Gravel

0 250m
1:12,500 @ A3

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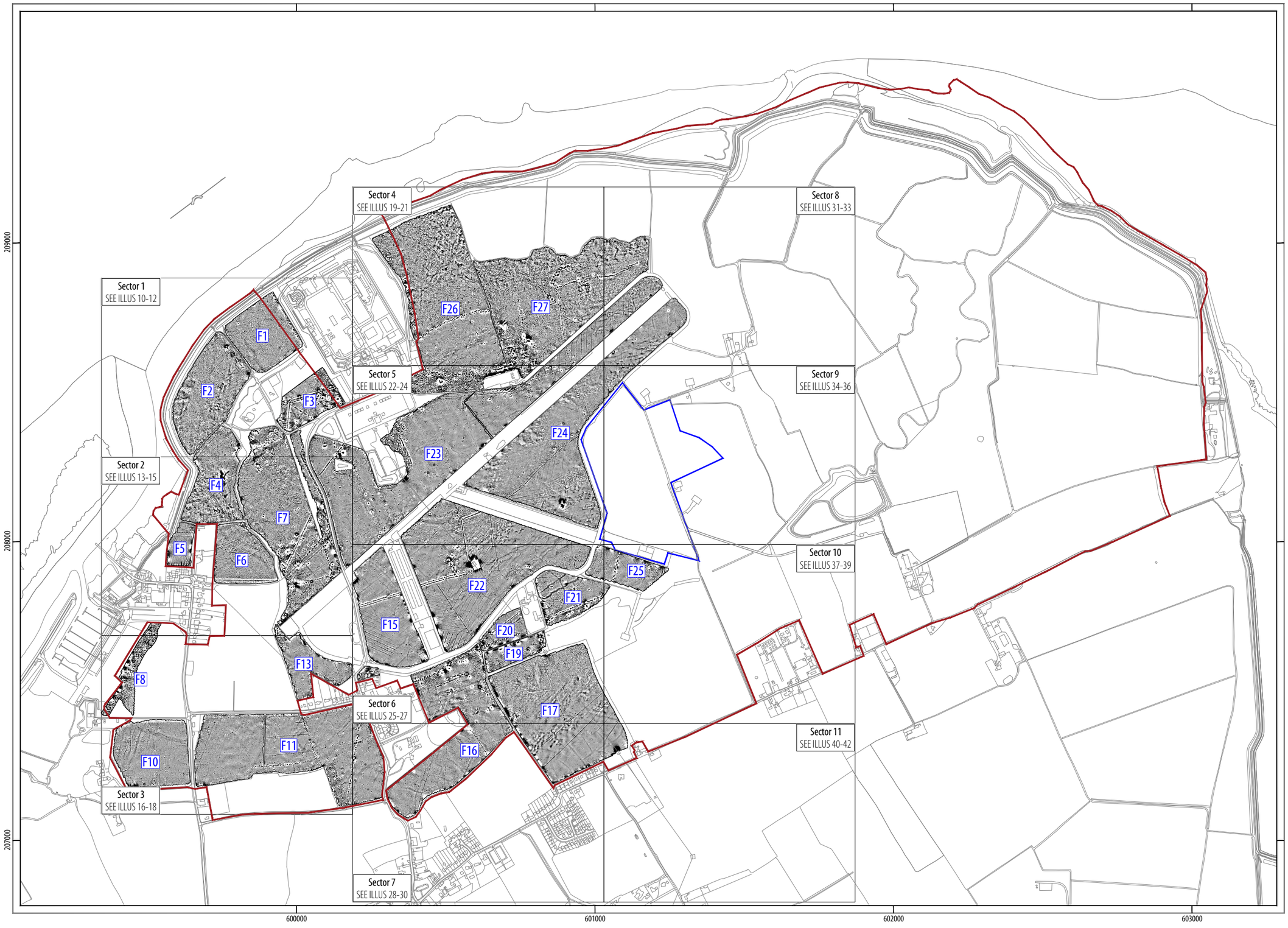
ILLUS 3 Overview showing superficial geologies



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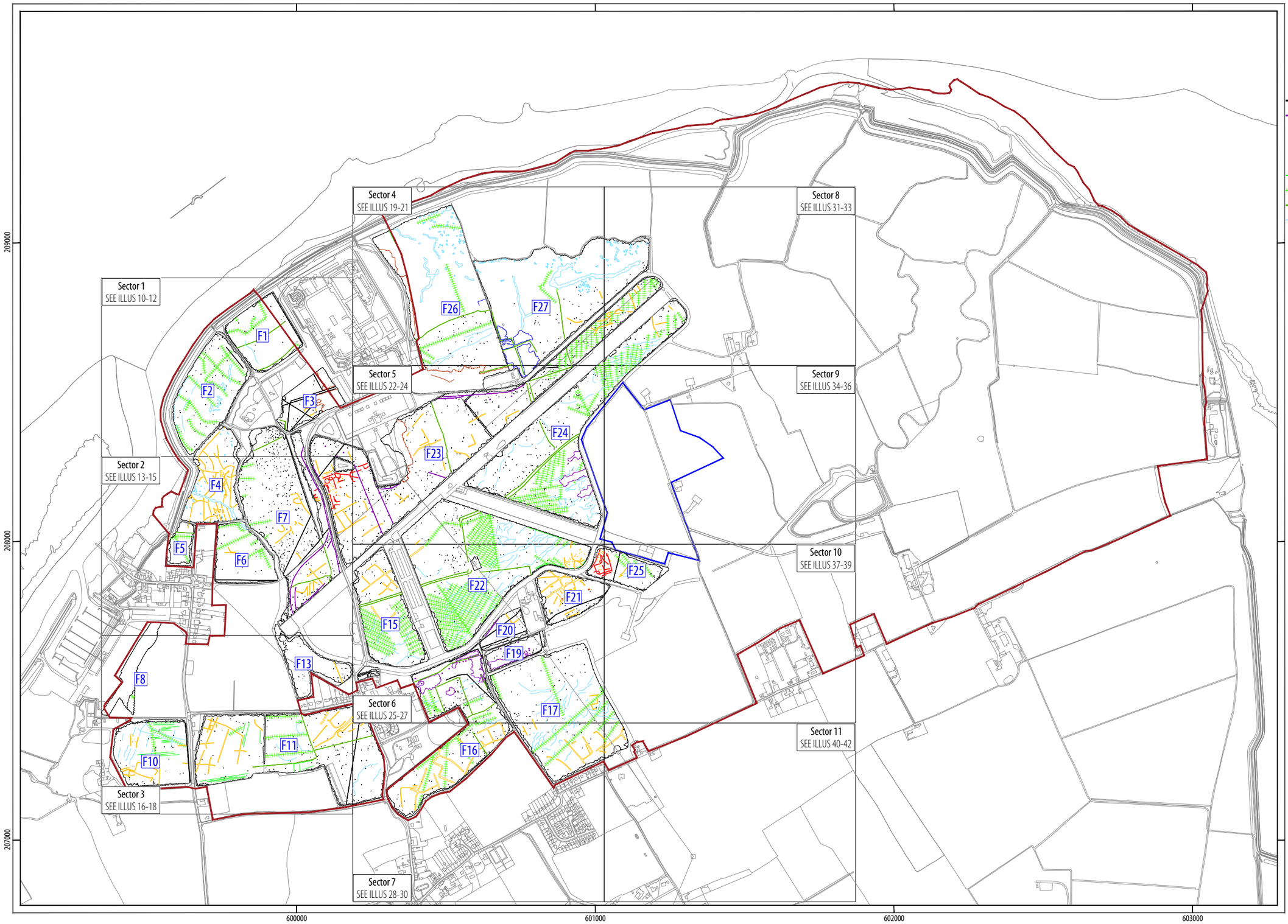
ILLUS 4 Greyscale magnetometer data



geophysical survey area
area of previous survey

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear	former airfield
magnetic disturbance	former airfield
magnetic disturbance	modern
magnetic disturbance	former power station
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	kiln/burning
magnetic enhancement	archaeology

0 250m
1:12,500 @ A3

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ILLUS 5 Interpretation of magnetometer data

nT
-1.0 2.0

0 50m
1:2,500 @ A3

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ILLUS 6 Processed greyscale magnetometer data; Sector 1

208750

208500

599500

599750

600000

F1

F2

F3

F4

F7

F23

25.0nT/cm

0 50m

1:2,500 @ A3

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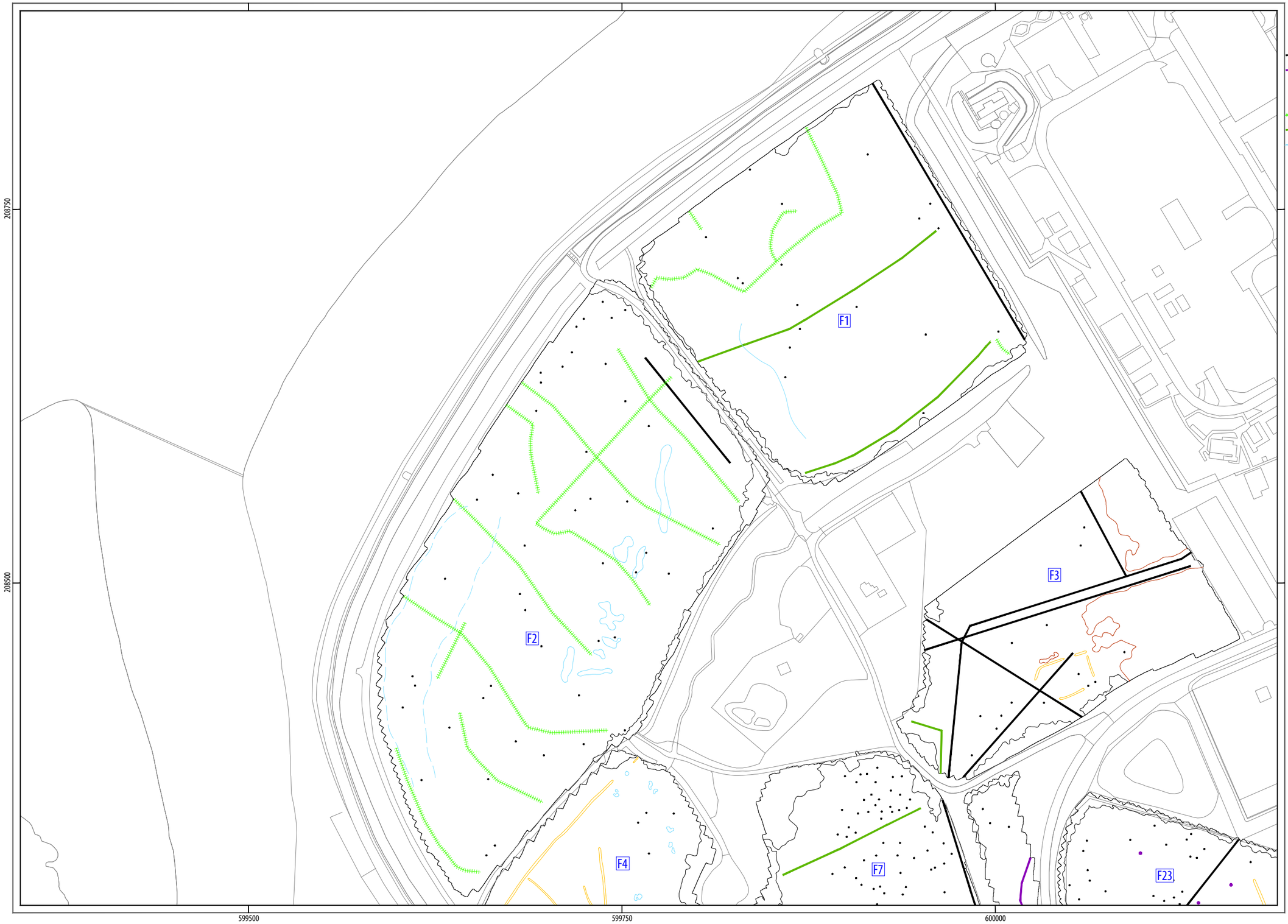
ILLUS 7 XY trace plot of minimally processed magnetometer data; Sector 1



TYPE OF ANOMALY	INTERPRETATION
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magnetic disturbance	ferrous material
dipolar linear	service pipe
linear	former airfield
magnetic disturbance	former airfield
magnetic disturbance	former power station
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?

0 50m
1:2,500 @ A3

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ILLUS 8 Interpretation of magnetometer data; Sector 1

nT
-1.0
2.0

0
50m
1:2,500 @ A3

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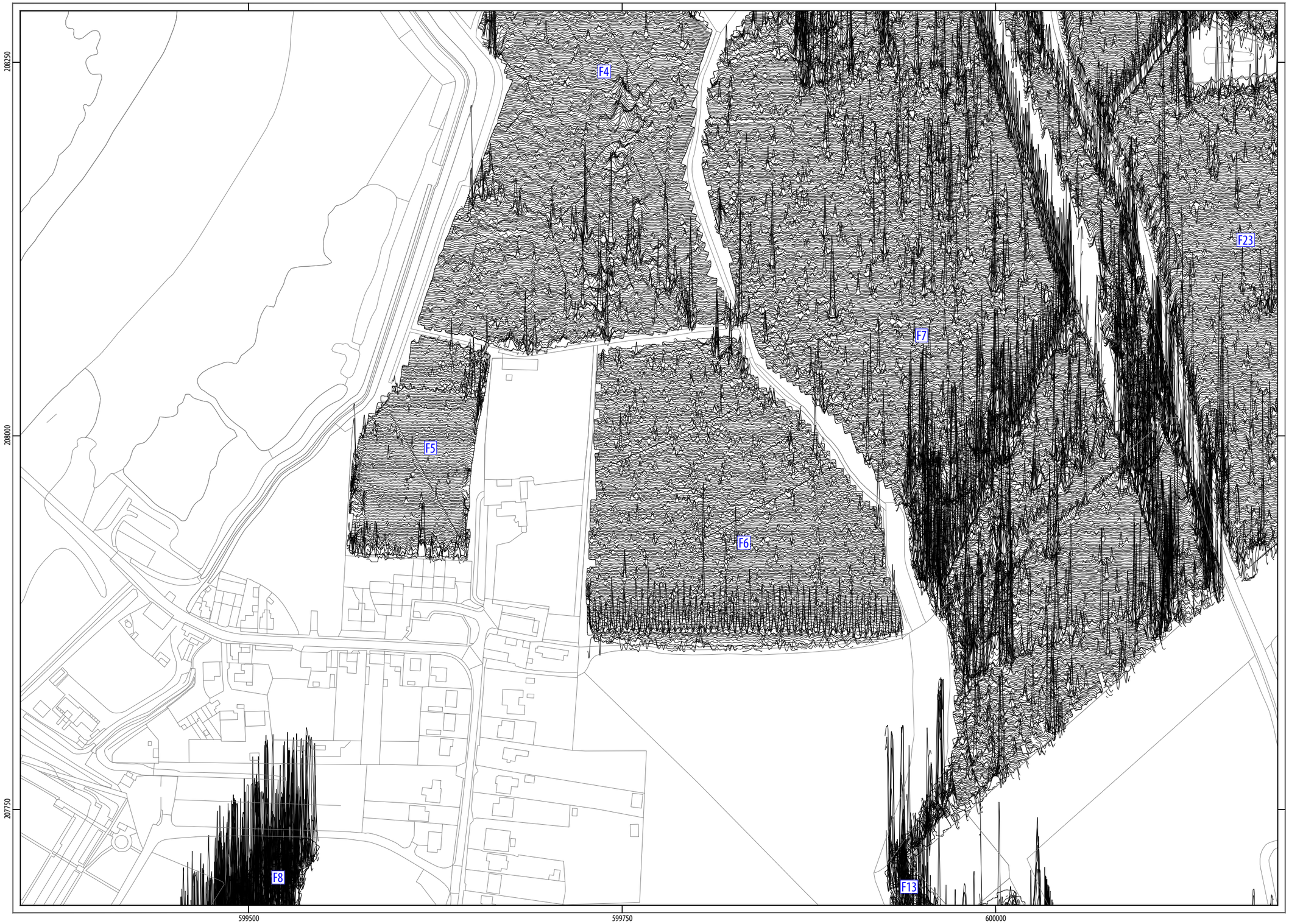
ILLUS 9 Processed greyscale magnetometer data; Sector 2



25.0nT/cm

0 50m

1:2,500 @ A3

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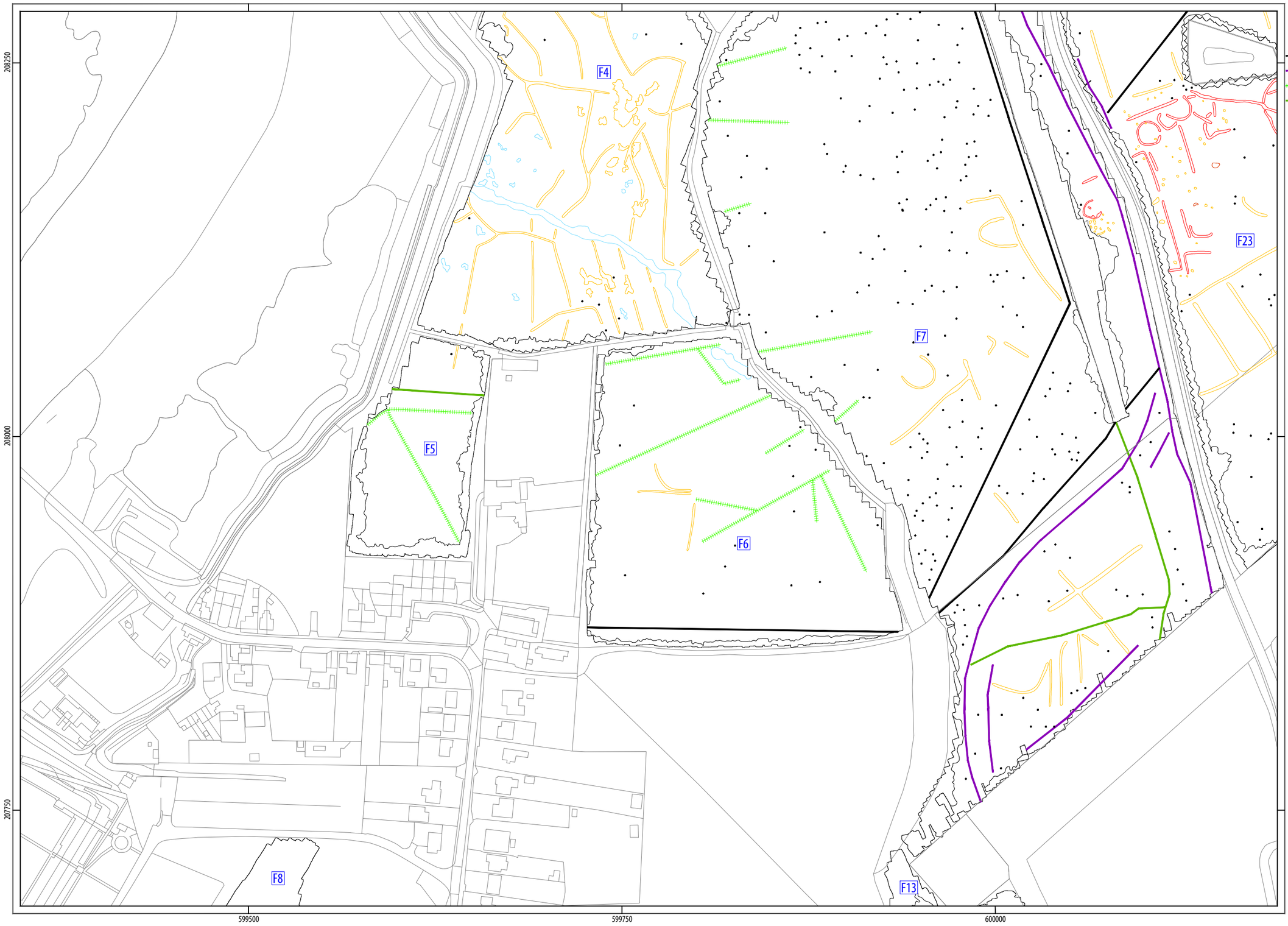
ILLUS 10 XY trace plot of minimally processed magnetometer data; Sector 2



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear	former airfield
linear trend	field drain
linear	former field boundary
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	kiln/burning
magnetic enhancement	archaeology

0 50m
1:2,500 @ A3

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ILLUS 11 Interpretation of magnetometer data; Sector 2

F8

F13

F10

F11

207500

207250

599500

599750

600000

-1.0 nT 2.0

0 50m

1:2,500 @ A3

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ILLUS 12 Processed greyscale magnetometer data; Sector 3

F8

F13

F10

F11

207500

207250

599500

599750

600000

25.0nT/cm

0 50m

1:2,500 @ A3

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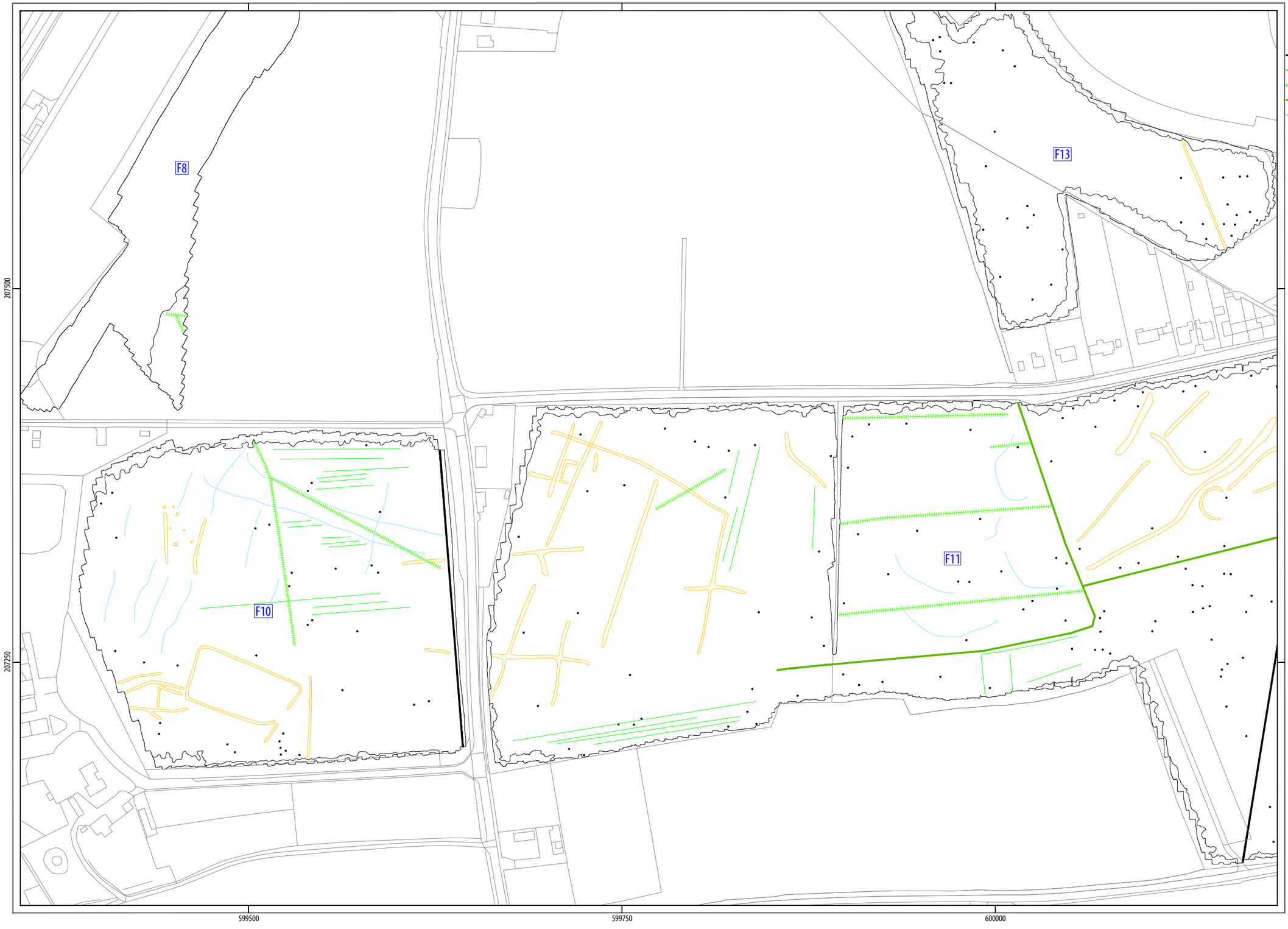
ILLUS 13 XY trace plot of minimally processed magnetometer data; Sector 3



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?

0 50m
1:2,500 @ A3

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ILLUS 14 Interpretation of magnetometer data; Sector 3

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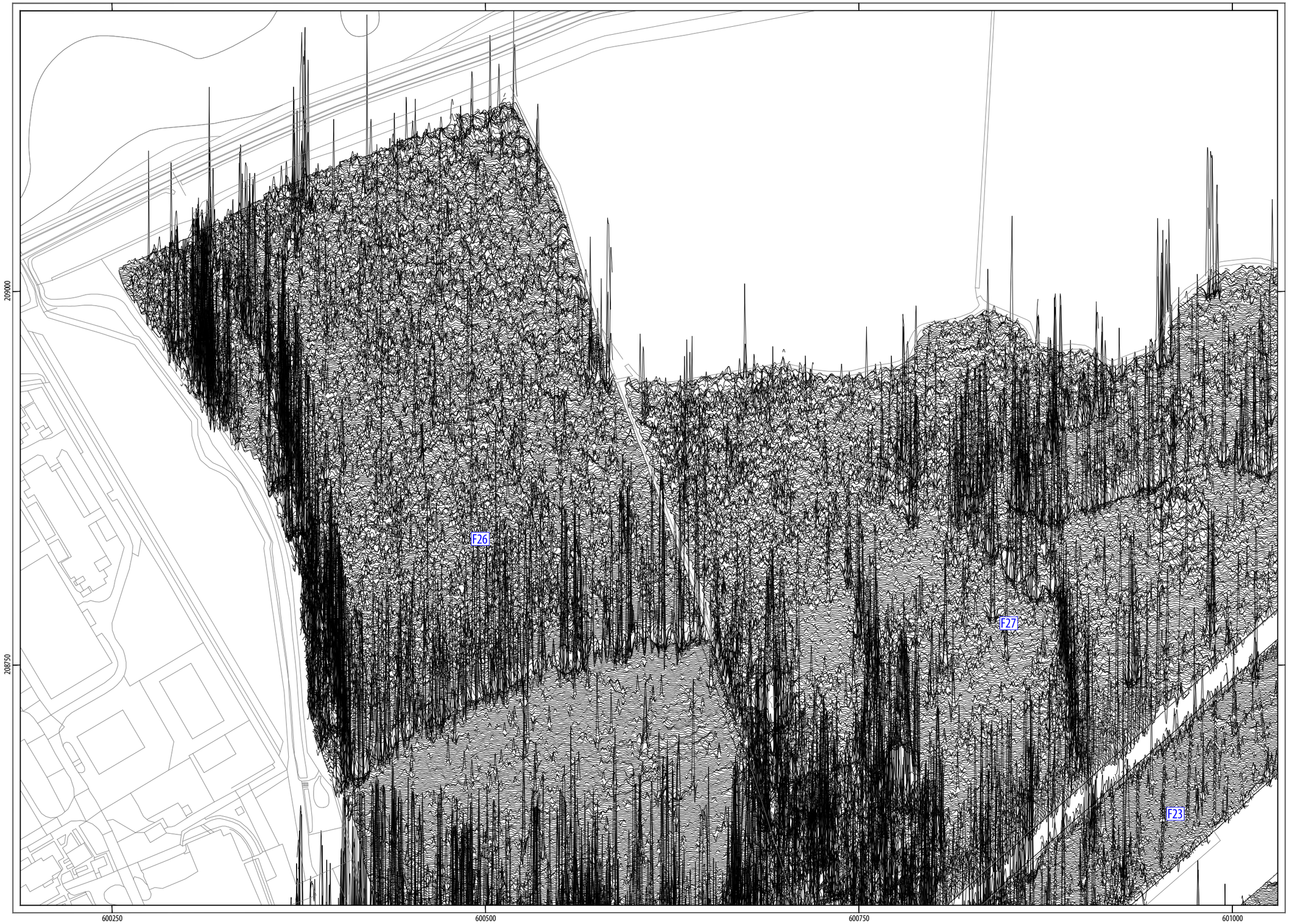
ILLUS 15 Processed greyscale magnetometer data; Sector 4



25.0nT/cm

0 50m

1:2,500 @ A3

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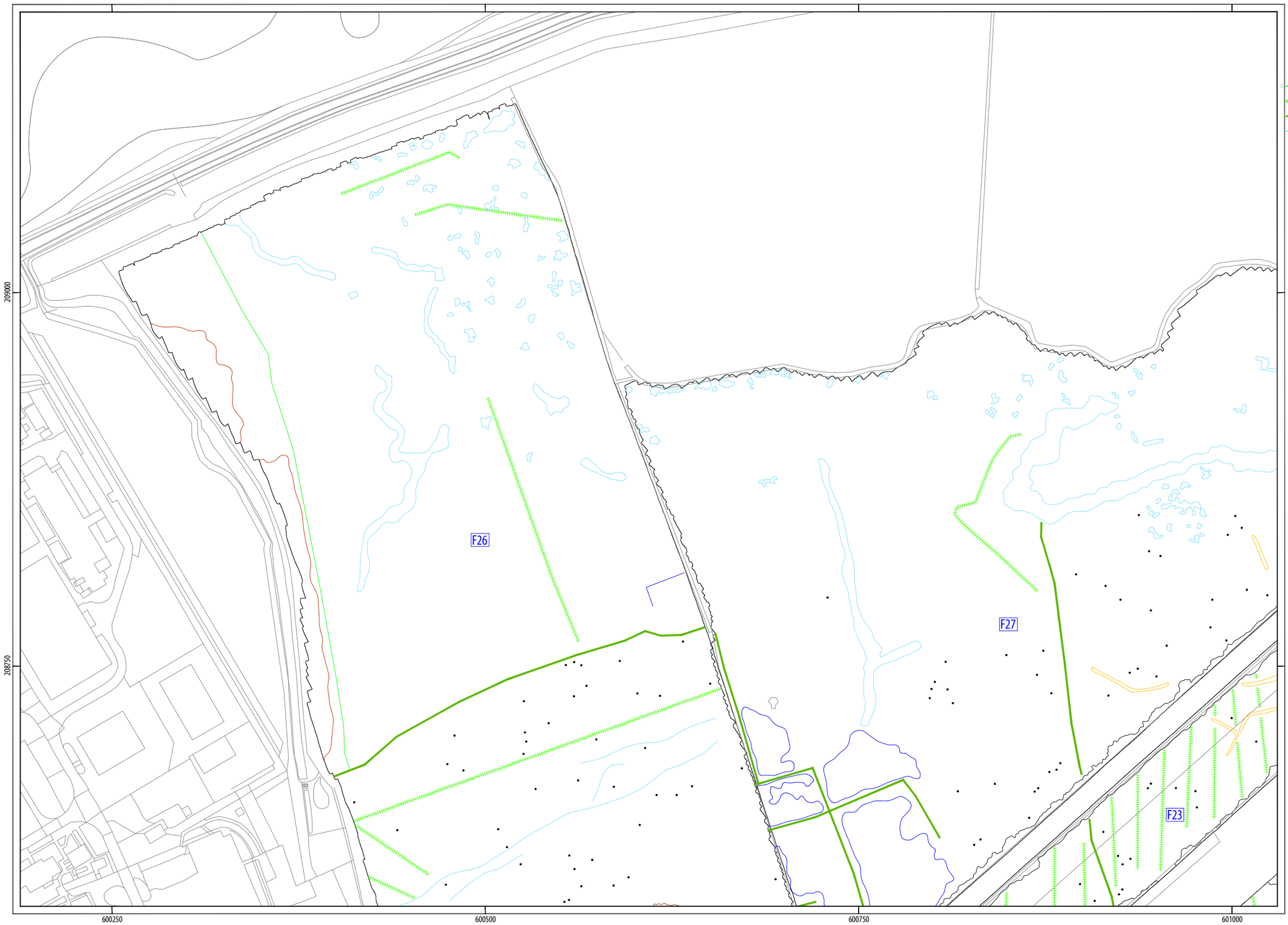
ILLUS 16 XY trace plot of minimally processed magnetometer data; Sector 4



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
magnetic disturbance	modern
magnetic disturbance	former power station
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?

0 50m
1:2,500 @ A3

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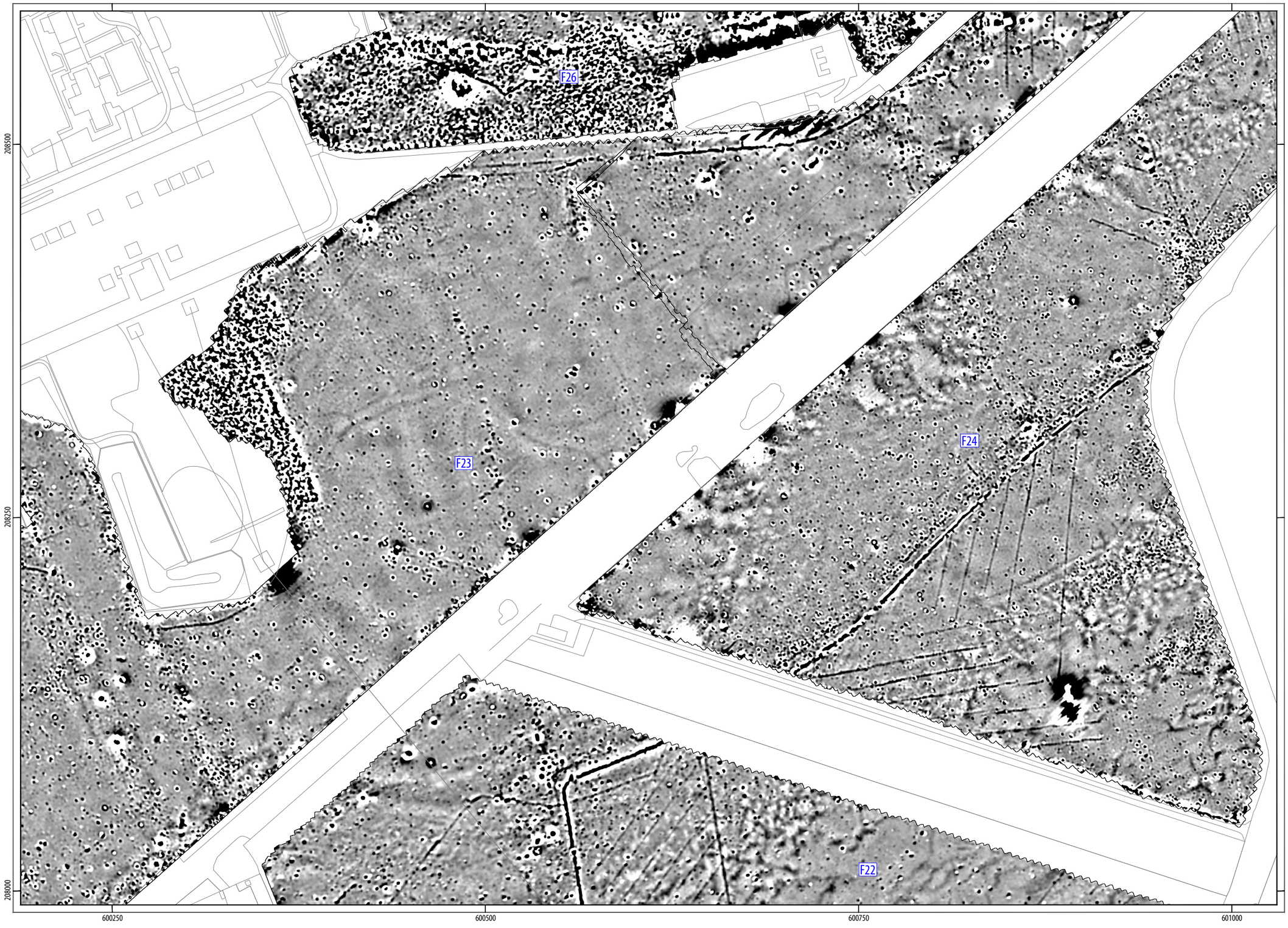
ILLUS 17 Interpretation of magnetometer data; Sector 4



-1.0 nT 2.0

0 50m
1:2,500 @ A3

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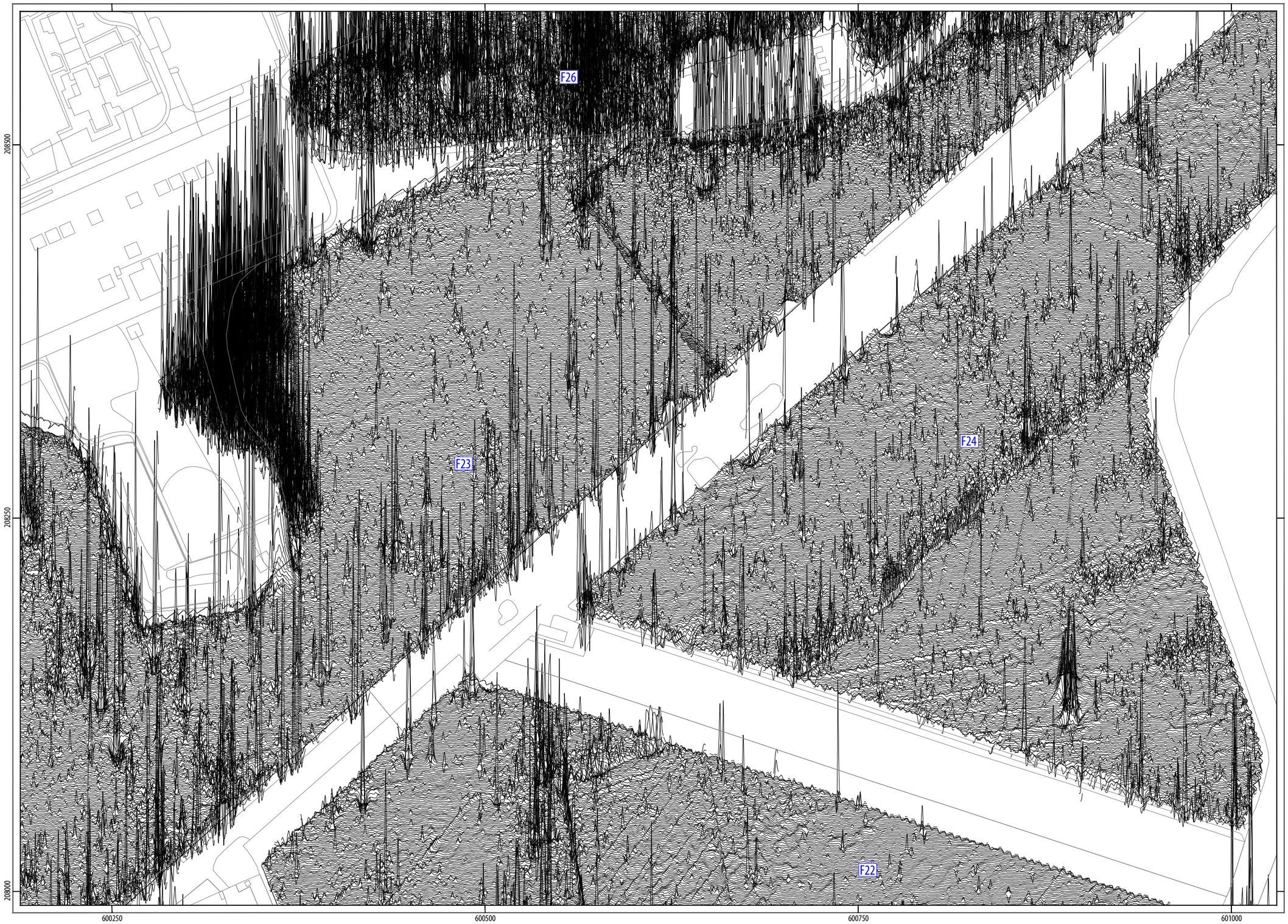
ILLUS 18 Processed greyscale magnetometer data; Sector 5



25.0nT/cm

0 50m

1:2,500 @ A3

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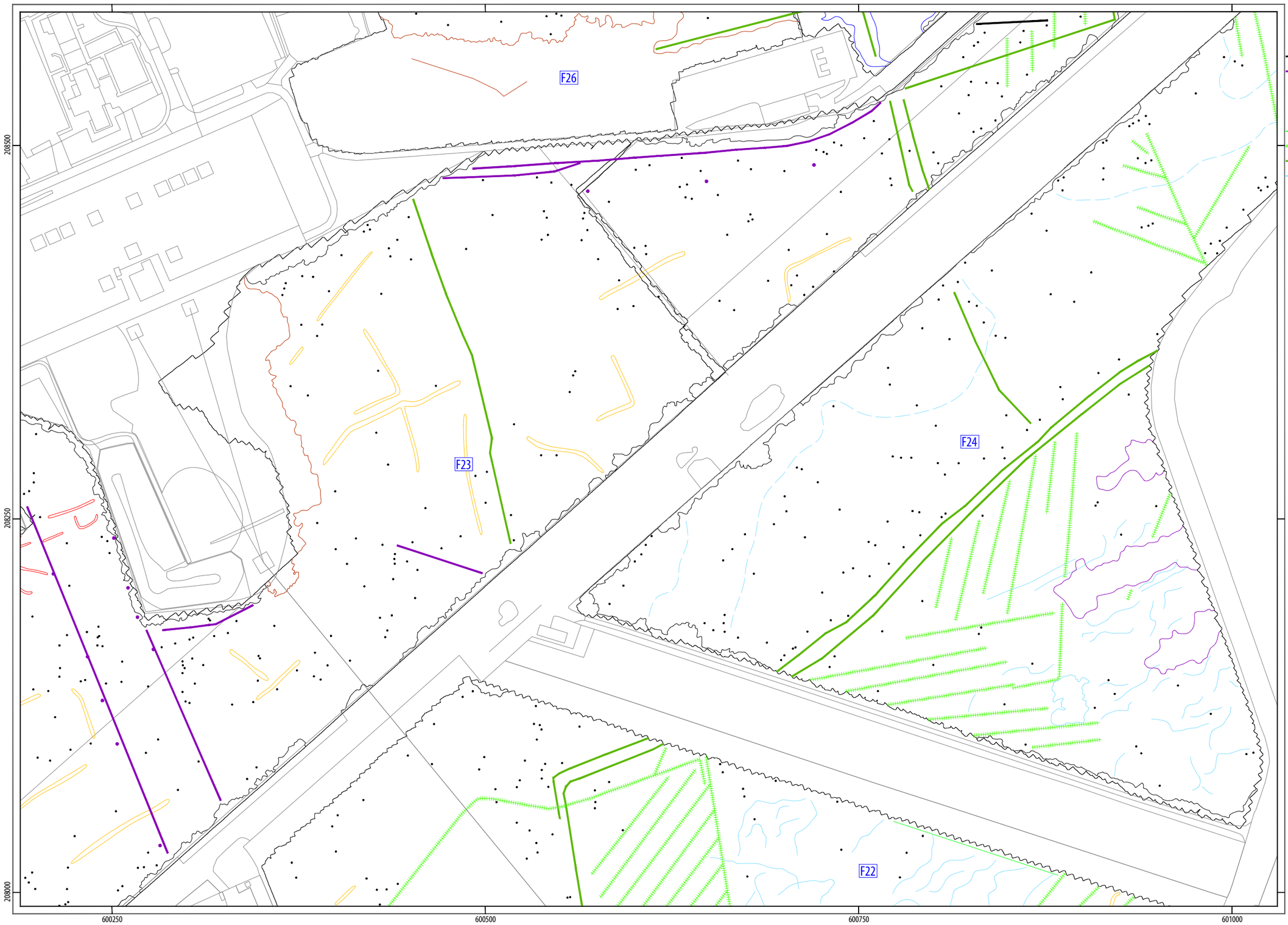
ILLUS 19 XY trace plot of minimally processed magnetometer data; Sector 5



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear	former airfield
magnetic disturbance	former airfield
magnetic disturbance	modern
magnetic disturbance	former power station
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?
magnetic enhancement	archaeology

0 50m
1:2,500 @ A3

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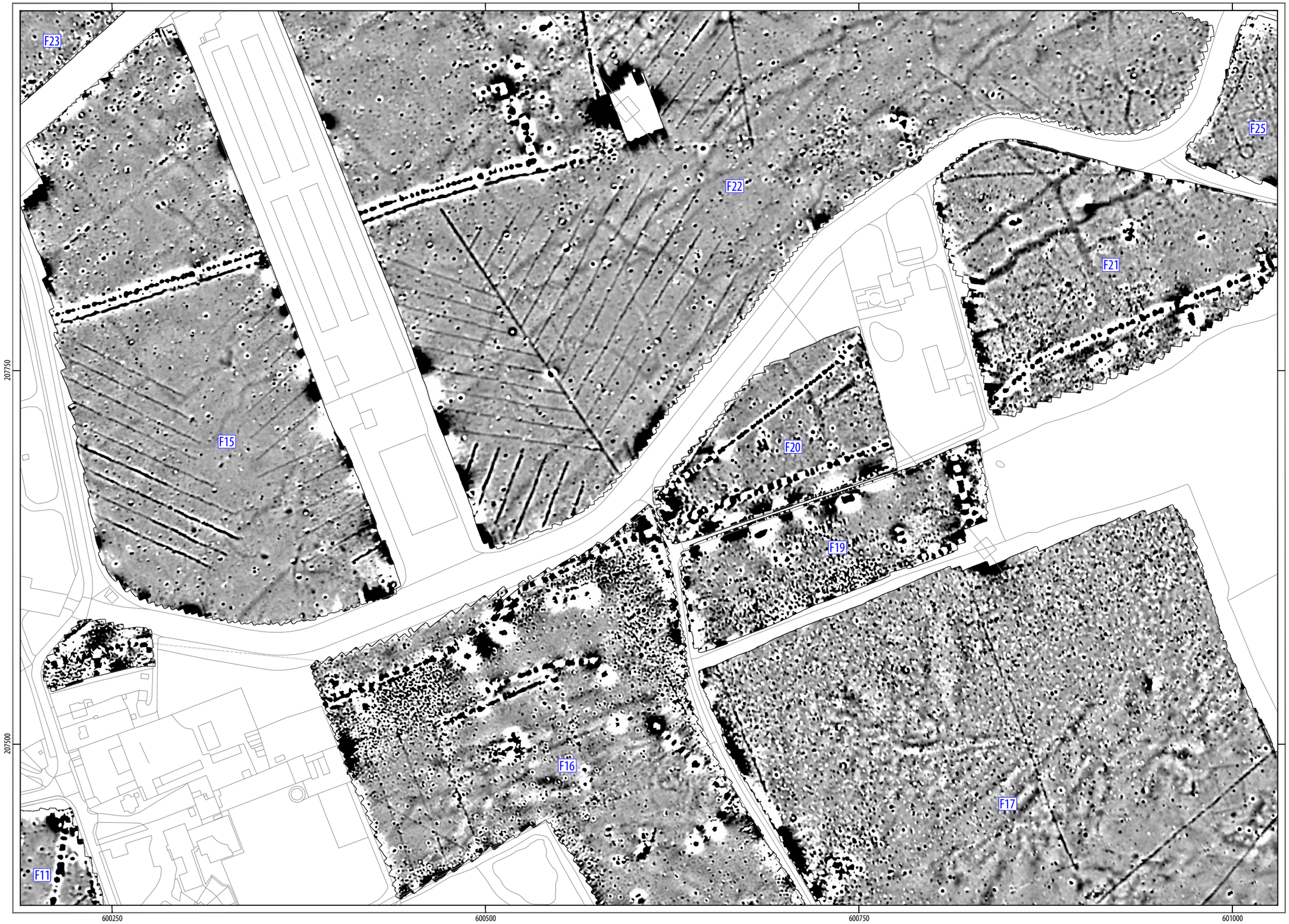
ILLUS 20 Interpretation of magnetometer data; Sector 5



-1.0 nT 2.0

0 50m
1:2,500 @ A3

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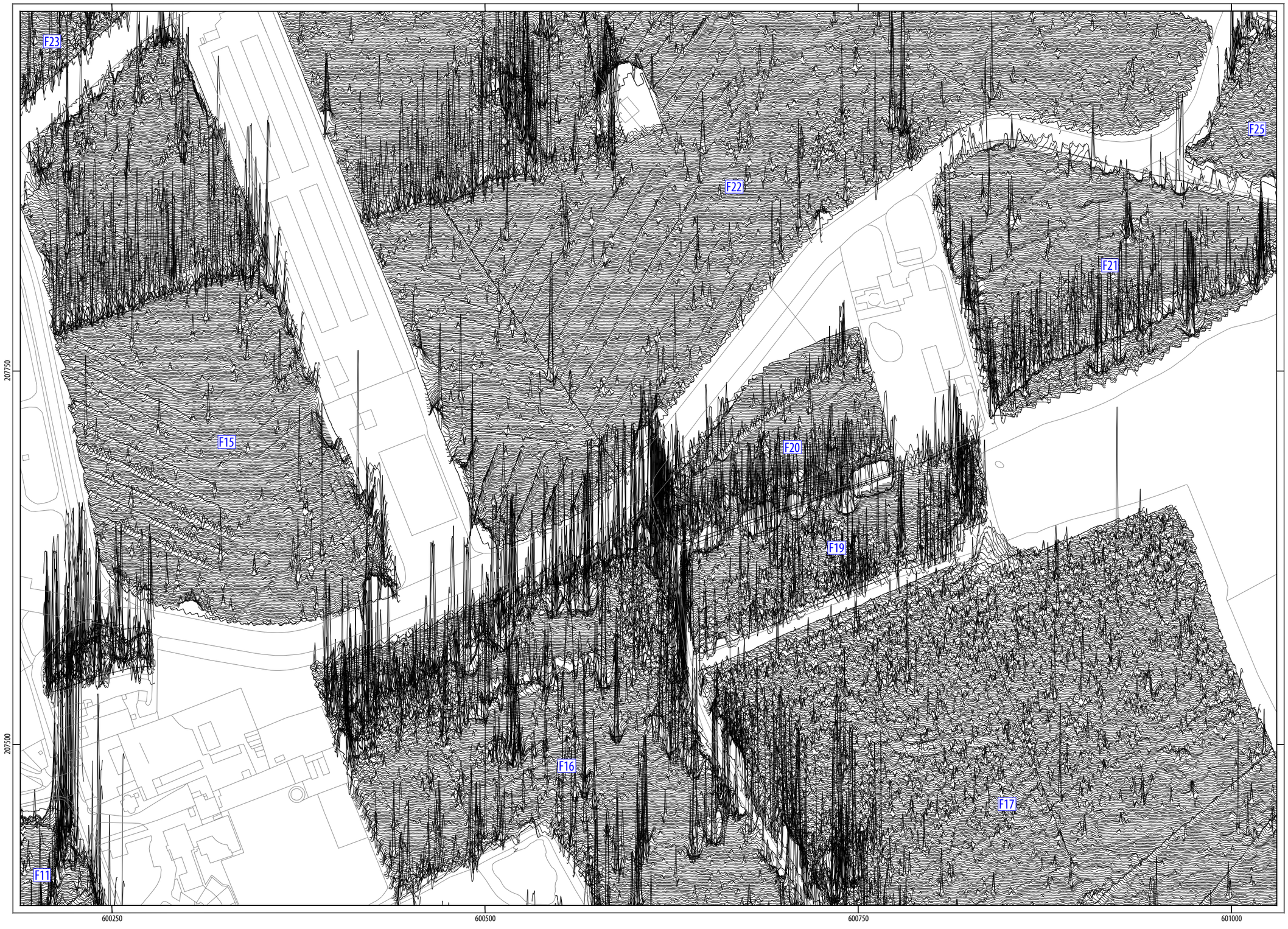
ILLUS 21 Processed greyscale magnetometer data; Sector 6



25.0nT/cm

0 50m

1:2,500 @ A3

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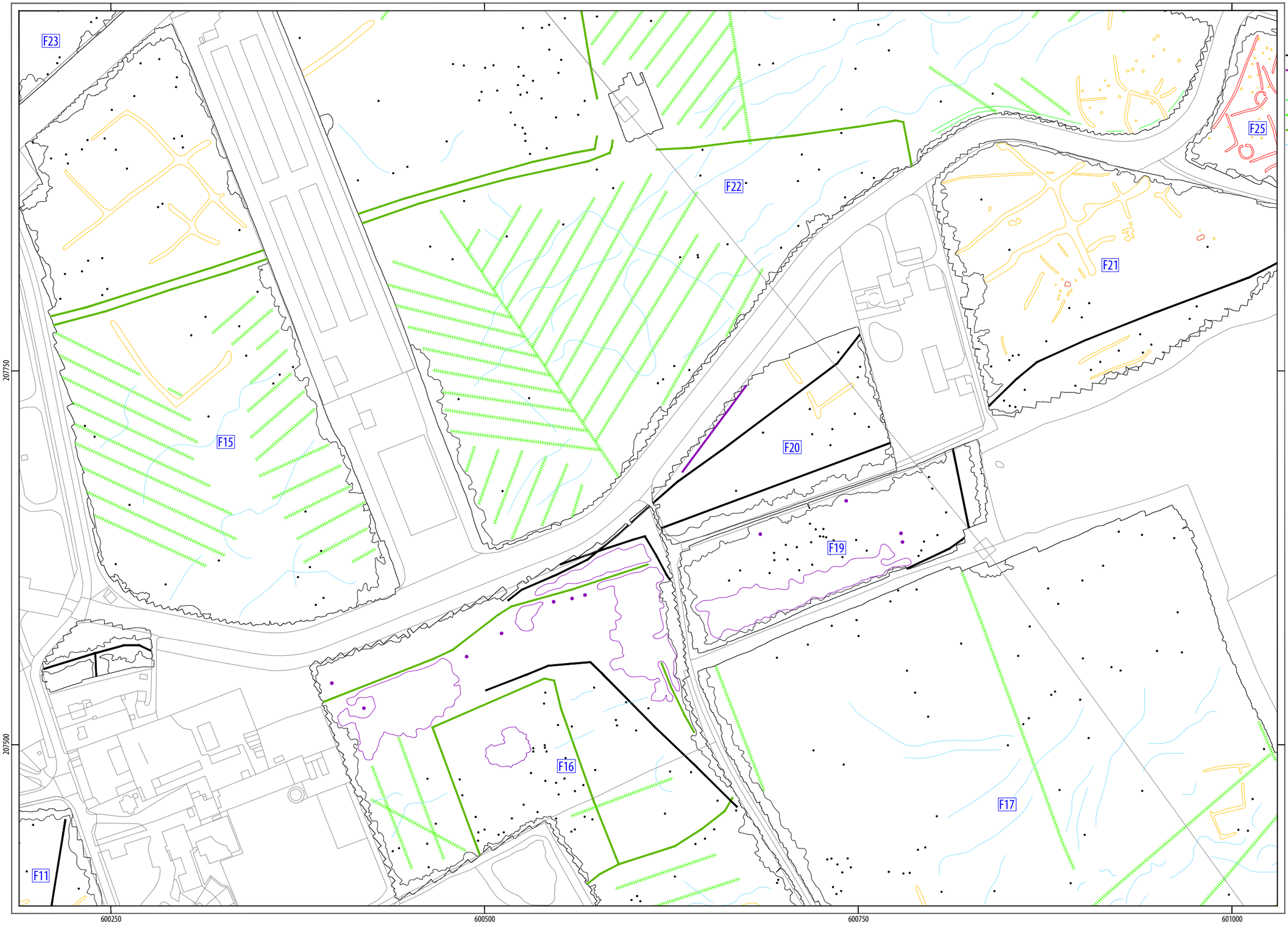
ILLUS 22 XY trace plot of minimally processed magnetometer data; Sector 6



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear	former airfield
magnetic disturbance	former airfield
linear trend	agricultural
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	archaeology?
magnetic enhancement	kiln/burning
magnetic enhancement	archaeology

0 50m
1:2,500 @ A3

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ILLUS 23 Interpretation of magnetometer data; Sector 6

-1.0 nT 2.0

0 50m
1:2,500 @ A3

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ILLUS 24 Processed greyscale magnetometer data; Sector 7

25.0nT/cm

0 50m

1:2,500 @ A3

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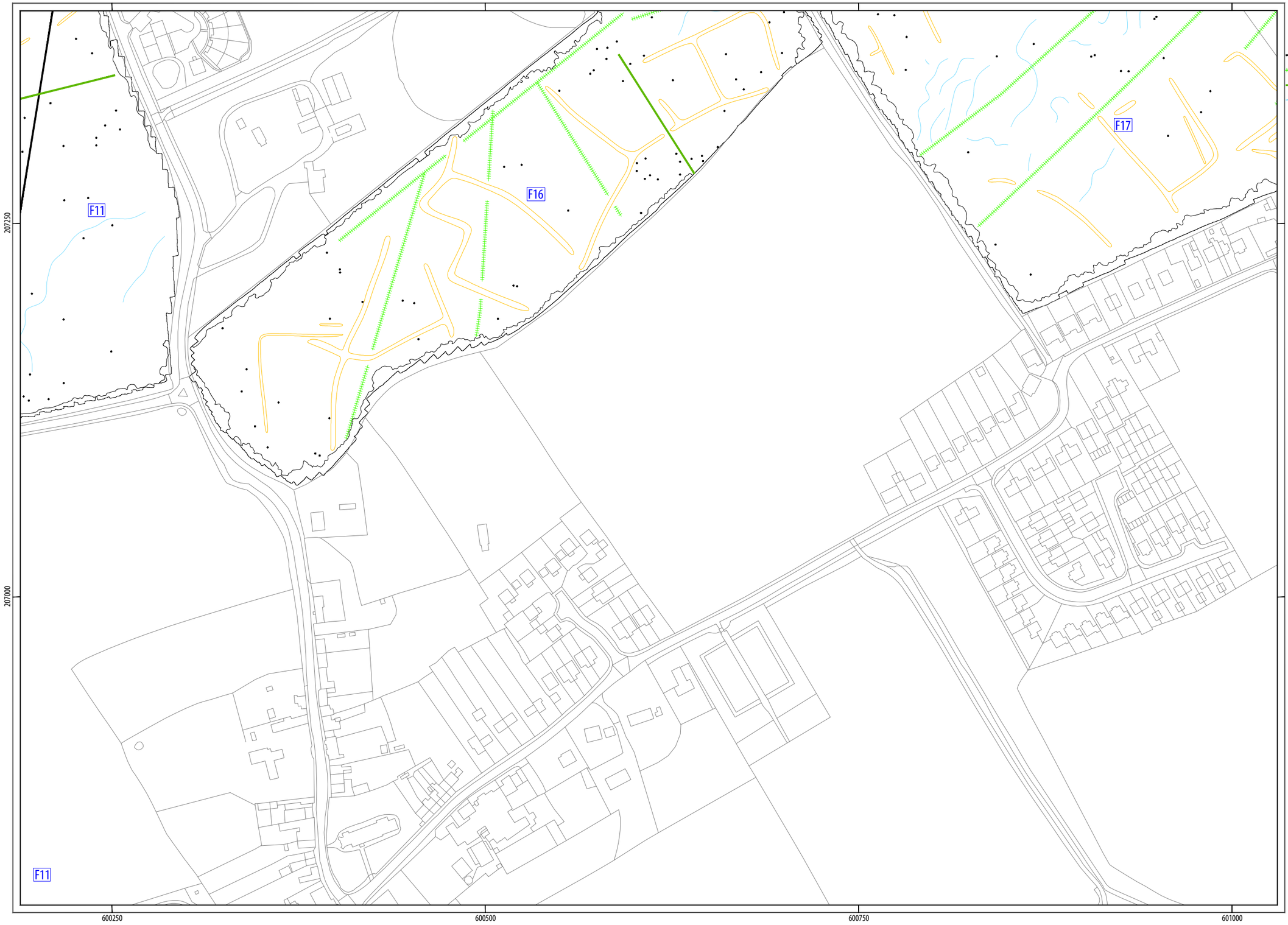
ILLUS 25 XY trace plot of minimally processed magnetometer data; Sector 7



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	field drain
linear	former field boundary
linear trend	geological variation
magnetic enhancement	archaeology?

0 50m
1:2,500 @ A3

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ILLUS 26 Interpretation of magnetometer data; Sector 7

-1.0 nT 2.0

0 50m
1:2,500 @ A3

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ILLUS 27 Processed greyscale magnetometer data; Sector 8

25.0nT/cm

0 50m

1:2,500 @ A3

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ILLUS 28 XY trace plot of minimally processed magnetometer data; Sector 8

TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	field drain
linear trend	geological variation
magnetic enhancement	geology
magnetic enhancement	archaeology?

0 50m
1:2,500 @ A3

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ILLUS 29 Interpretation of magnetometer data; Sector 8

-1.0 nT 2.0

0 50m
1:2,500 @ A3

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ILLUS 30 Processed greyscale magnetometer data; Sector 9

25.0nT/cm

0 50m

1:2,500 @ A3

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ILLUS 31 XY traceplot of minimally processed magnetometer data; Sector 9

TYPE OF ANOMALY
- dipolar isolated
- linear trend
- linear trend

INTERPRETATION
- ferrous material
- field drain
- geological variation

0 50m
1:2,500 @ A3

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ILLUS 31 Interpretation of magnetometer data; Sector 9

-1.0 nT 2.0

0 50m
1:2,500 @ A3

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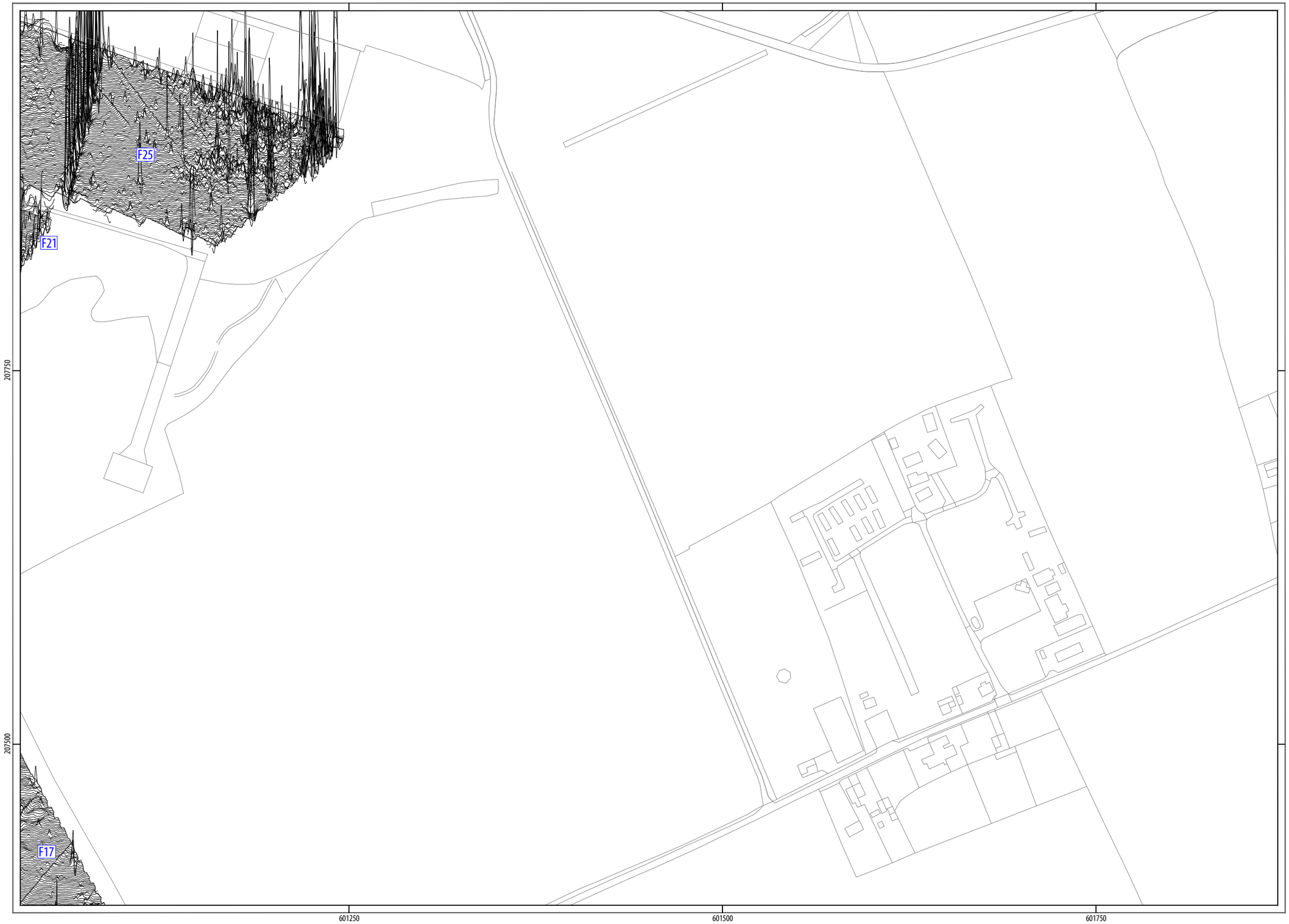
ILLUS 33 Processed greyscale magnetometer data; Sector 10



25.0nT/cm

0 50m

1:2,500 @ A3

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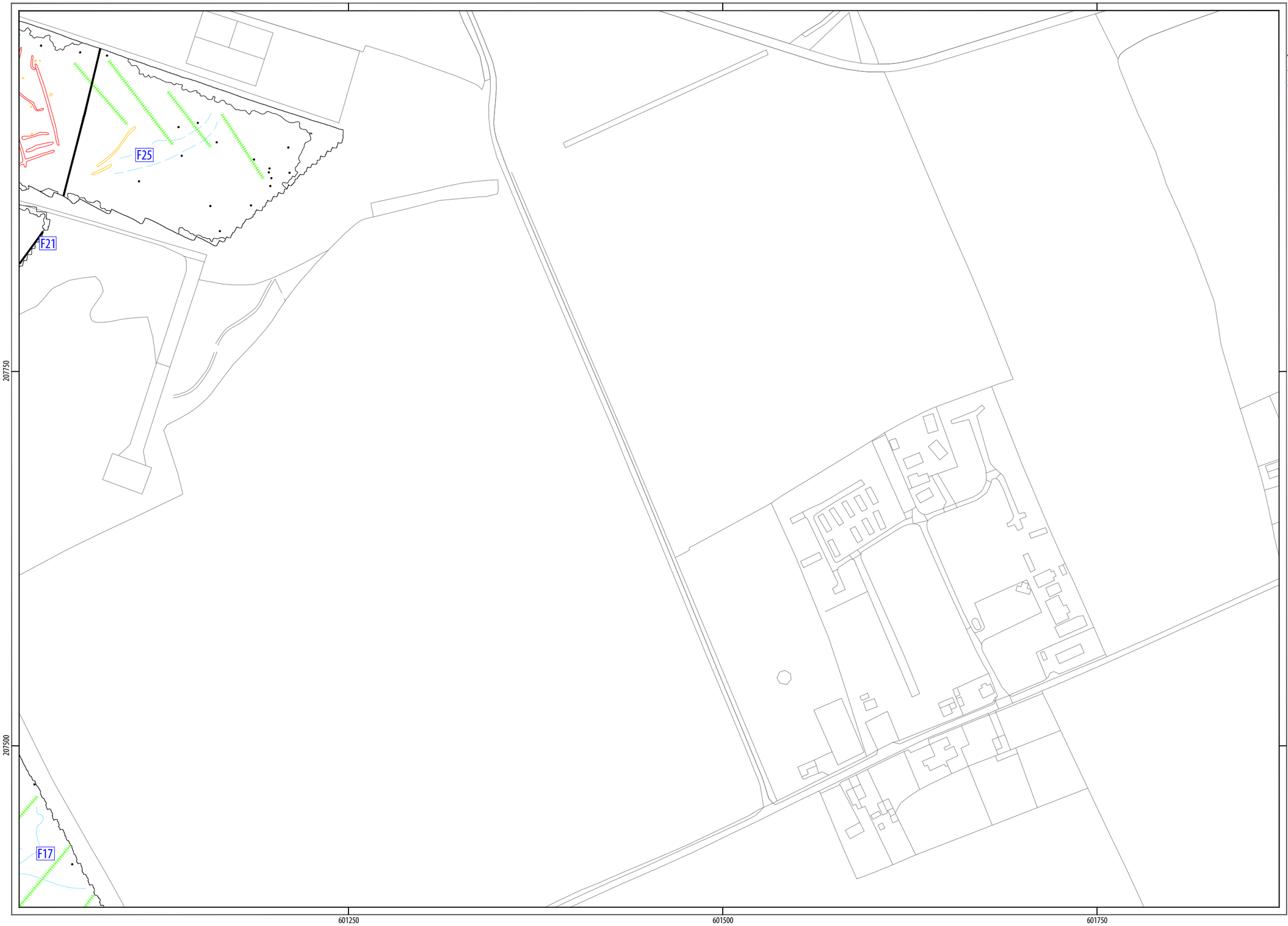
ILLUS 34 XY trace plot of minimally processed magnetometer data; Sector 10



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
dipolar linear	service pipe
linear trend	field drain
linear trend	geological variation
magnetic enhancement	archaeology?
magnetic enhancement	archaeology

0 50m
1:2,500 @ A3

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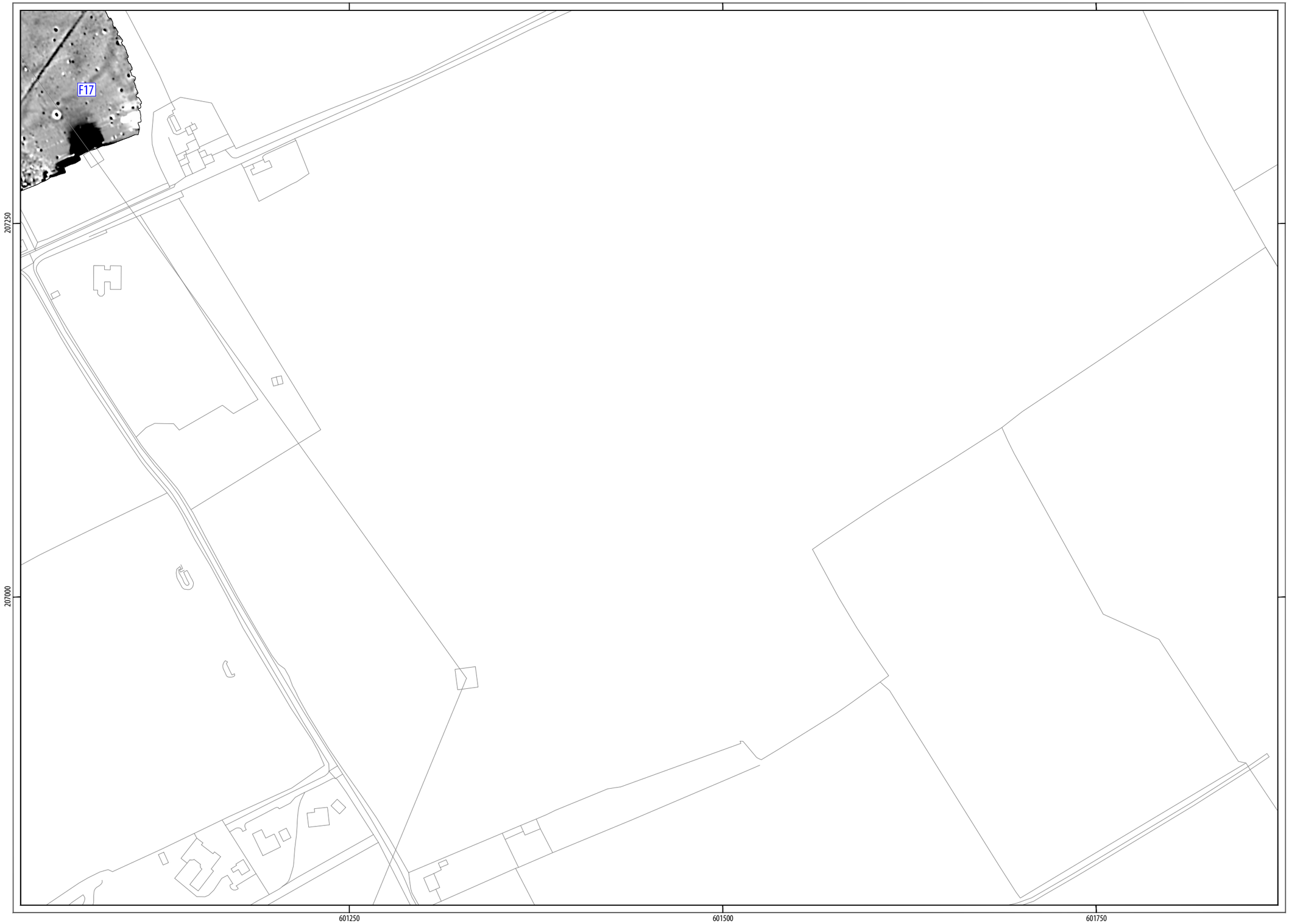
ILLUS 35 Interpretation of magnetometer data; Sector 10



-1.0 nT 2.0

0 50m
1:2,500 @ A3

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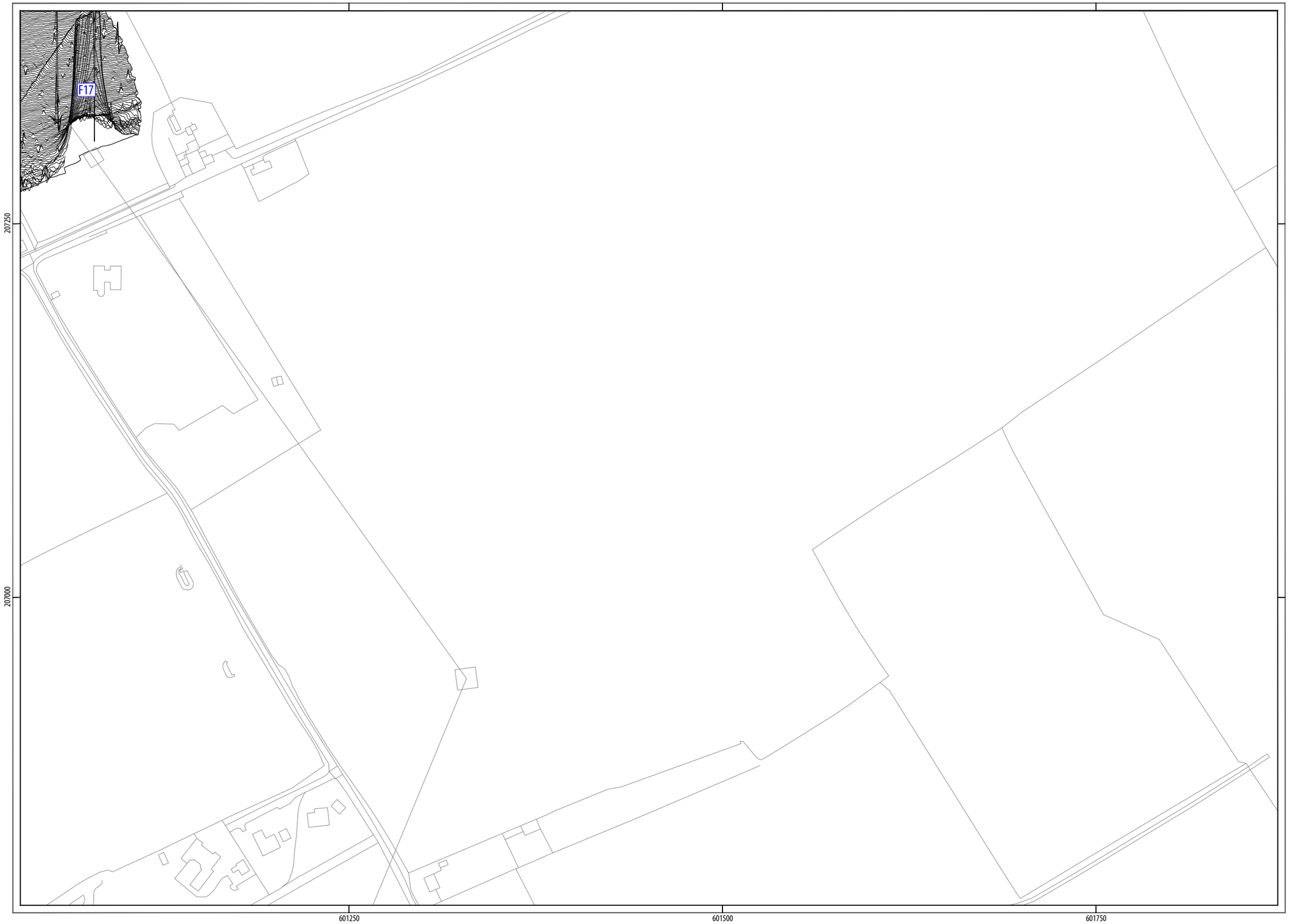
ILLUS 36 Processed greyscale magnetometer data; Sector 11



25.0nT/cm

0 50m

1:2,500 @ A3

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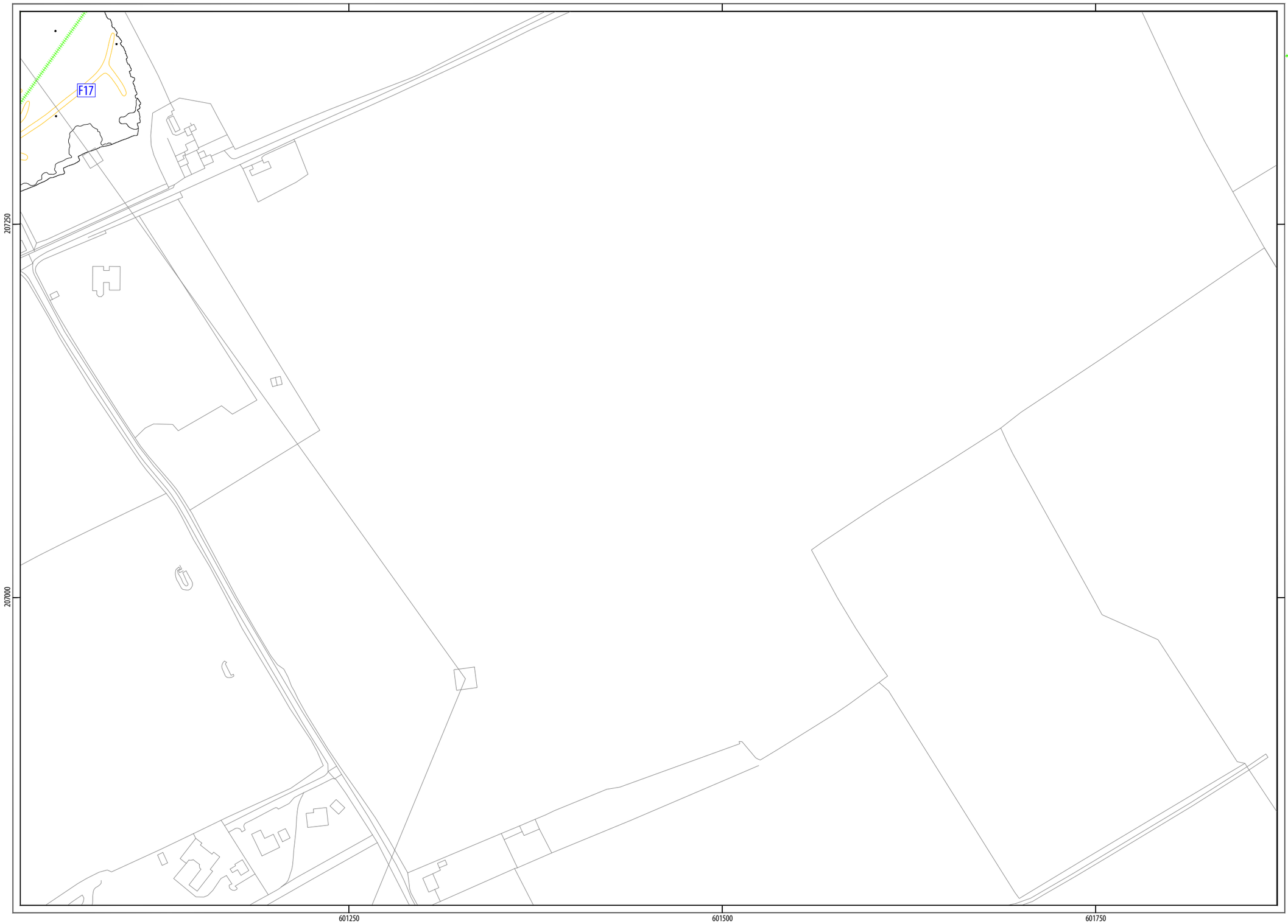
ILLUS 37 XY trace plot of minimally processed magnetometer data; Sector 11



TYPE OF ANOMALY	INTERPRETATION
dipolar isolated	ferrous material
magnetic disturbance	ferrous material
linear trend	field drain
magnetic enhancement	archaeology?

0 50m

1:2,500 @ A3

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ILLUS 38 Interpretation of magnetometer data; Sector 11

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 topsoils, subsoils and rocks 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 the majority of 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 present as a consequence of manuring.

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

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

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

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

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

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APPENDIX 2 SURVEY LOCATION INFORMATION

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

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

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

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

APPENDIX 3 GEOPHYSICAL SURVEY ARCHIVE

The geophysical archive comprises an archive disk containing the raw data in XYZ format, a raster image of each greyscale plot with 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.

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) in order to maximise the clarity and interpretability of the archaeological anomalies.

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

APPENDIX 5 OASIS DATA COLLECTION FORM: ENGLAND

OASIS ID: headland5-411058

PROJECT DETAILS	
Project name	Bradwell B
Short description of the project	Headland Archaeology (UK) Ltd undertook a geophysical (magnetometer) survey on agricultural land south and east of the current nuclear power station at Bradwell, Essex. The survey area (180 hectares) comprises approximately 40% of the land within a planning application red line boundary for a proposed new nuclear power station (Bradwell B) at the site. Access is still being sought for the remaining 292ha which, once surveyed, will be the subject of a separate, overall, report that incorporates all the information from this interim document. The survey has covered most of the western half of the application area, a large proportion of which was formerly part of Bradwell Bay Airfield which was operational during World War II but decommissioned in the early 1960s. Some of the runways still survive and serve to divide and provide access between the surrounding fields which are in agricultural production following remediation of the airfield.
Project dates	Start: 01-09-2020 End: 17-09-2020
Previous/future work	Not known / Not known
Any associated project reference codes	BRBE20 - Sitecode
Type of project	Field evaluation
Site status	None
Current Land use	Cultivated Land 4 - Character Undetermined
Monument type	N/A None
Monument type	N/A None
Significant Finds	N/A None
Significant Finds	N/A None
Methods & techniques	"Geophysical Survey"
Development type	Nuclear Power Station
Prompt	National Planning Policy Framework - NPPF
Position in the planning process	Pre-application
Solid geology (other)	Thames Group – Silty Clay
Drift geology (other)	of Head (Diamicton), Intertidal Deposits (Clay and Silt) and River Terrace Deposits (Sand and Gravel)
Techniques	Magnetometry
PROJECT LOCATION	
Country	England
Site location	ESSEX MALDON BRADWELL ON SEA Bradwell B
Study area	180 hectares
Site coordinates	TM 00634 08219 51.736169207986 0.906067145003 51 44 10 N 000 54 21 E Point
PROJECT CREATORS	
Name of Organisation	Headland Archaeology
Project brief originator	Wood
Project design originator	Headland Archaeology
Project director/manager	Harrison, S
Project supervisor	Berry, M.
Type of sponsor/funding body	Developer

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PROJECT ARCHIVES	
Physical Archive Exists?	No
Digital Archive recipient	Headland Archaeology
Digital Contents	''other''
Digital Media available	''Geophysics'','Images raster / digital photography'','Images vector''
Paper Archive Exists?	No

PROJECT BIBLIOGRAPHY 1	
Publication type	Grey literature (unpublished document/manuscript)
Title	Bradwell B, Essex: Geophysical Survey
Author(s)/Editor(s)	Webb, A.
Other bibliographic details	BRBE20
Date	2020
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