Project Code: NCGP09
Date of report: January 2010
Client: Rhead Group

NEWHOUSES TO CALFHILL GAS PIPELINE

Geophysical Survey

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MA PIfA

HEADLAND ARCHAEOLOGY Ltd

PROJECT SUMMARY SHEET

Client	RHEAD GROUP
National Grid Reference	BETWEEN NT 513 448 AND NT 513 387
Address	N/A
Parish	LAUDER, MELROSE
Council	SCOTTISH BORDERS COUNCIL
Planning Application Ref No	N/A
NMRS No	N/A
Oasis No	HEADLAND1-70694
SMR No	N/A
HB/SAM No	N/A
Listing Category	N/A
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Specialists	N/A
Schedule	
Fieldwork	9 – 20 NOVEMBER 2009
Report	JANUARY 2010

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Date:.....

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Illus 1
Proposed Newhouses to Calfhill Gas Pipeline: Overall survey corridor

NEWHOUSES TO CALFHILL GAS PIPELINE

Geophysical Survey

by Scott Harrison

A magnetic gradiometer (magnetometer) survey was undertaken along 5.49km of the 6.5km proposed route of the Newhouses to Calfhill gas pipeline, that took place between the 9th and the 19th of November, covering a total survey area of 16.54 ha. This investigation was conducted under contract to Rhead Group (Ref: 09/2504/006), operating on behalf of Scotland Gas Networks, and was monitored by an archaeological consultant from Groundwork Archaeology Ltd. Some parts of the proposed route were deemed unsuitable for survey for reasons of land use, topography and drainage and were omitted from the survey.

The results of the survey suggest that, as currently, the predominant historic land use throughout the proposed corridor has been agricultural. The evidence for this was the common presence of anomalies that have been attributed to both ridge and furrow cultivation and more modern ploughing.

The results of the survey suggest one definite area of former settlement on the proposed route on the Threepwood Estate, where there is both cartographic (an estate map) and topographic evidence to support the presence of a post-medieval settlement. This site is assessed as being of High Archaeological Potential.

A further two possible sites have been identified solely by geophysical survey. These comprise anomalies to the north and south of Colmsliehill. Both of these are assessed as being of Medium Archaeological Potential.

1 STANDARDS

Headland Archaeology (UK) Ltd. conducts all geophysical surveys in accordance with the standards and professional guidelines codified in Geophysical Survey in Archaeological Field Evaluation, English Heritage and Professional Services Guideline No 1 (2nd ed). Headland Archaeology (UK) Ltd. is a Registered Organisation of the Institute for Archaeologists and abides by its Codes of Conduct and Guidance.

All data provided by Headland Archaeology (UK) Ltd., is treated in accordance with the guidelines laid out in Geophysical Data in Archaeology: A Guide to Good Practice (AHDS Guides to Good Practice) (Schmidt 2001). The report structure is explained diagrammatically in Illus 3.

1.1 Statement of Indemnity

Geophysical surveys rely on observations about the physical properties of the archaeological remains they attempt to locate. Through experience, it becomes possible for geophysicists to identify features with reasonable accuracy by the physical traces these features leave. It must be noted however, that interpretation of geophysical anomalies is subjective and no hypotheses offered should be treated as fact, until tested and proved by intrusive investigation.

For anyone unfamiliar with magnetic gradiometry, it may be pertinent to read Appendix 2, which will explain to some extent, the physics that underpin the application of magnetic gradiometry (magnetometry).

2 INTRODUCTION

This report details the results of a magnetic gradiometer survey of a 5.49km section of the 6.5km proposed route of the Newhouses to Calfhill Gas Pipeline that took place between the 9th November and the 19th of November 2009. The survey corridor was 30m wide and the total survey area was 16.47Ha.

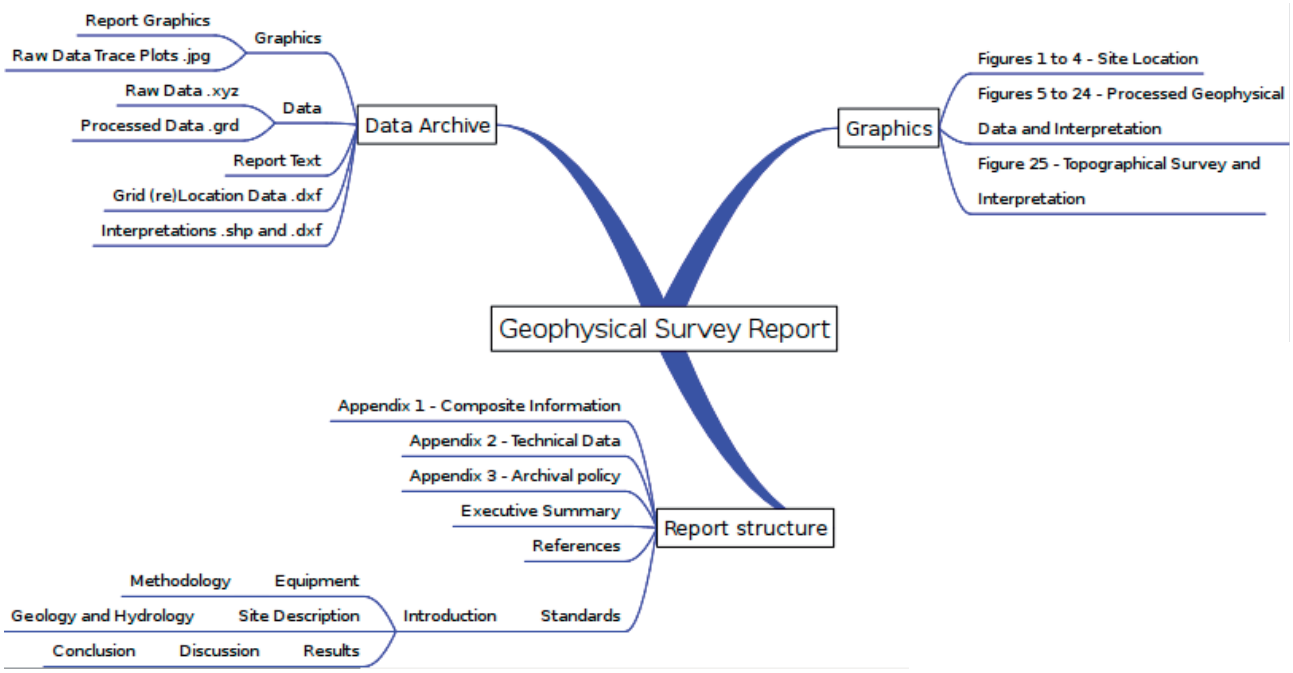
This investigation was undertaken for Rhead Group, operating on behalf of Scottish Gas Networks, and monitored by an archaeological consultant from Groundwork Archaeology Ltd.

Part of the proposed route was deemed unsuitable for survey for reasons of land use, topography and drainage and was excided from the survey. A WSI for the work was prepared by Groundwork Archaeology Ltd, which was approved by the Scottish Borders Council Archaeology Officer.

The proposed pipeline corridor is oriented approximately north / south between Ordnance Survey coordinates NT 513 448, 3 km south-west of Lauder and NT 513 387, 3km north-east of Galashiels, in the Scottish Borders.

The primary aim of the survey was to assess the development area for the presence or absence of anomalies that are of potential archaeological significance. These results will be used to inform the mitigation strategy for the proposed pipeline.

A Bartington Instruments Ltd. Grad601-2 magnetic gradiometer was used to conduct the survey and a sample rate of 1m x 0.25m was used across throughout.



Illus 2
Report structure

3 SITE DESCRIPTION (ILLUS 2 – 5)

The individual survey grids were combined into single composite grids for processing and display, each referred to hereafter as a stage. They were assigned numbers running from Stage 1 to Stage 23. Each stage is of a different length and is composed of similarly orientated grids aligned end to end along the route of the corridor. The ends of each stage are delineated by a blue line in Illus 6-25. The data was collected in a generally north/south direction and the stages are numbered from north to south. Appendix 1 consists of a table of all NGR coordinates for the origin point of each stage (generally, the north-east corner) and the direction of the first traverse, in addition to their size and total area. The survey results are also available as geo-referenced digital data included with the digital archive provided with the report.

3.1 Stages 1 – 12

Starting from the north, the survey corridor goes up the north-facing slope of a hill (296 mOD) and gently down the south-facing slope to Moss Burn. Much of the north-facing slope is typified by marginal sheep-grazing land with occasional patches of rushes. At higher elevations the land becomes increasingly free draining, the quality of the grazing land improves and the rushes become less frequent. The land immediately bordering Moss Burn is marginal land covered by rough scrub.

3.2 Stages 13 – 18

Continuing from Stage 13, the corridor passes through a flat patch of boggy grazing land and up the north face of Colmslie Hill (290 mOD). It then goes down a gentle south-facing slope before steeply descending toward the Allan Water. While the north-facing slope is a lot damper than the south-facing one, both are reasonable-quality sheep pasture. The area around the Allan Water is very boggy, marginal land.

3.3 Stages 19 – 20

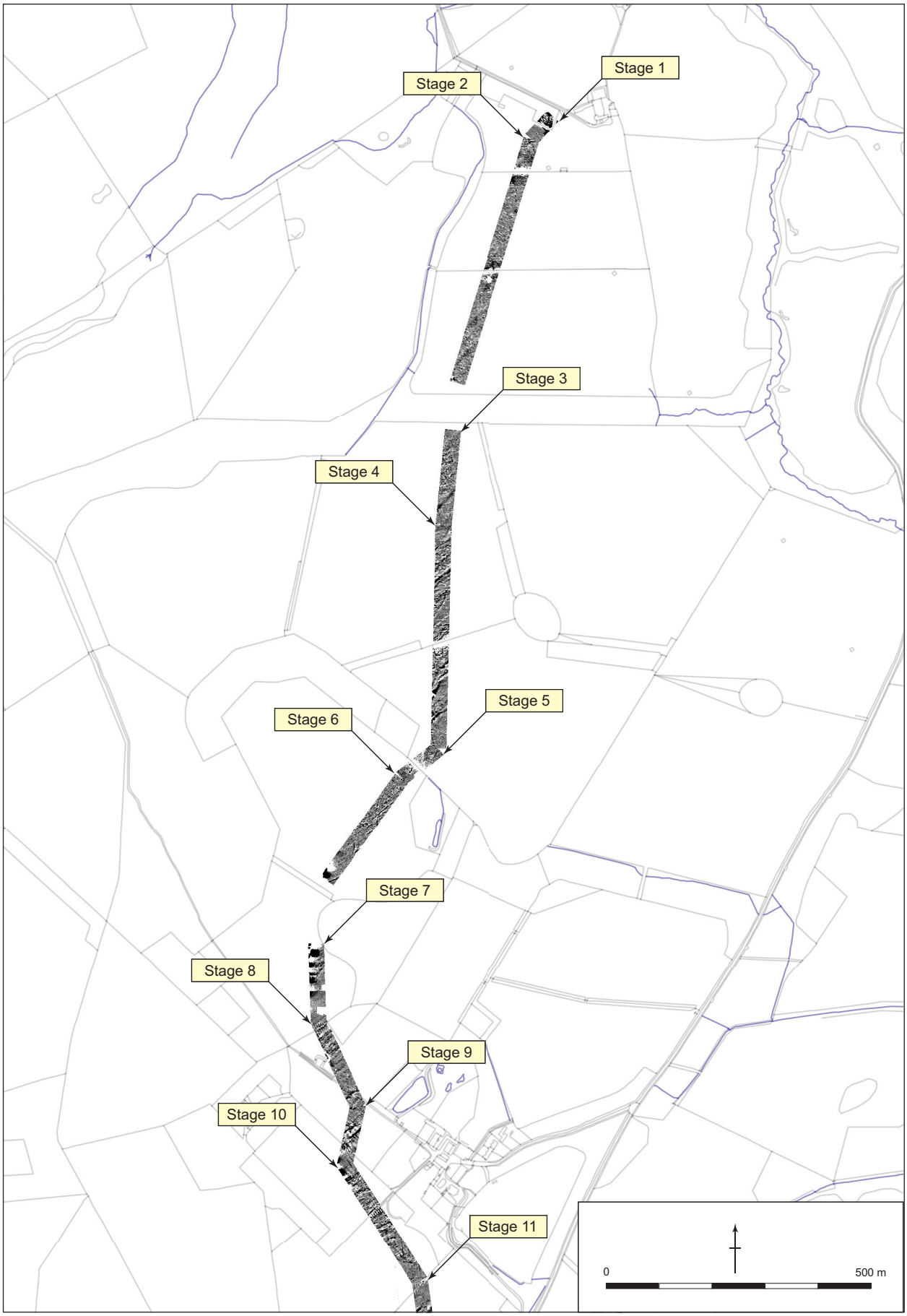
From Stage 19, the pipeline corridor travels up the north-facing slope of a small hill and then follows the line of a south-facing hill to a flat-bottomed valley, containing two streams. This section of the corridor is reasonably free draining, although in the valley bottom, the route becomes quite waterlogged and evidence of ridge and furrow cultivation is visible. Cattle are grazed along this stretch of the route.

3.4 Stages 21 – 23

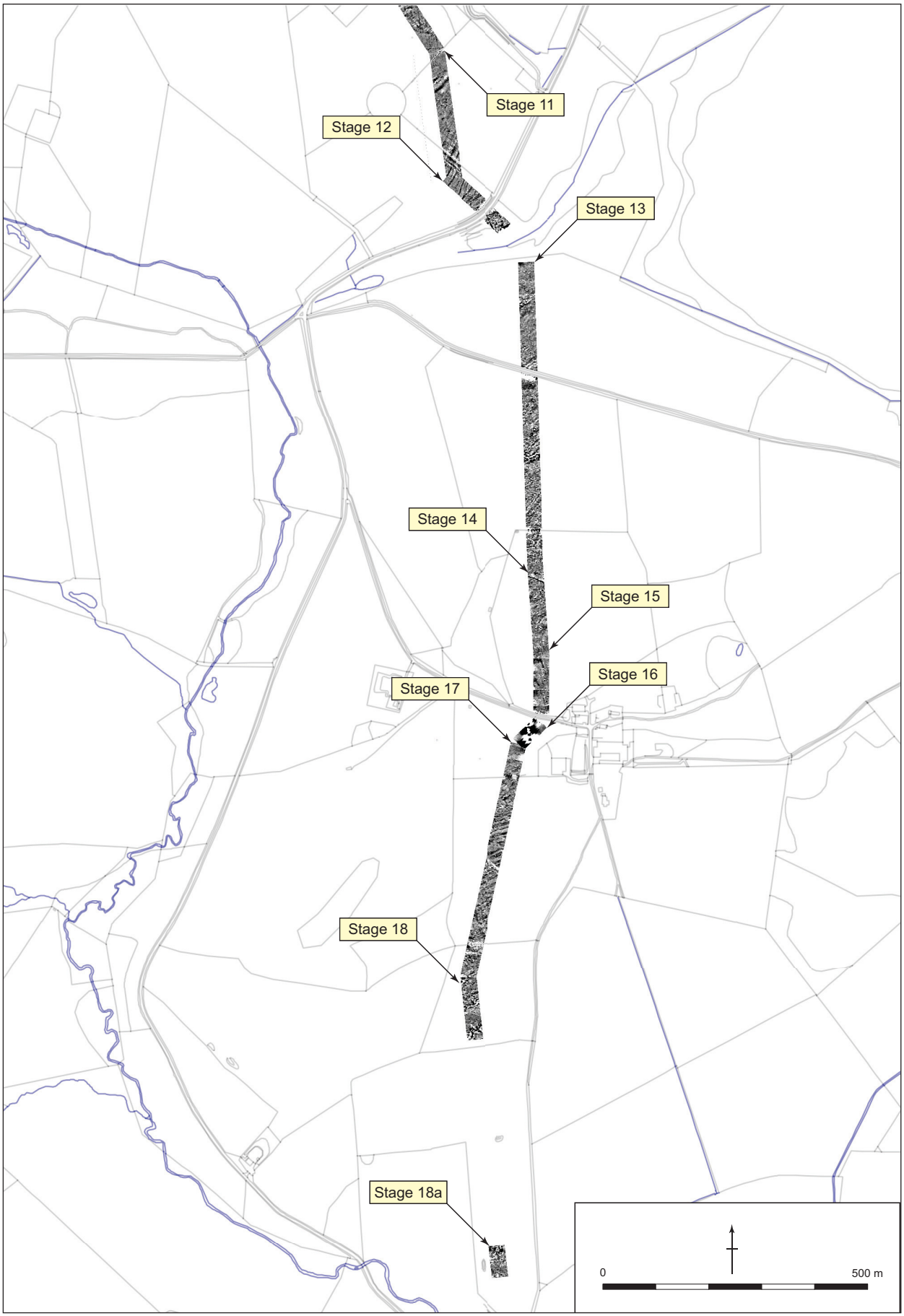
From Stage 21, the corridor traverses a very steep north-facing slope of Calfhill (253 mOD), which becomes more gentle toward the end of the corridor near the peak of Calfhill. The north-facing slope of this leg is typified by visible ridge and furrow cultivation.

4 GEOLOGY AND HYDROLOGY

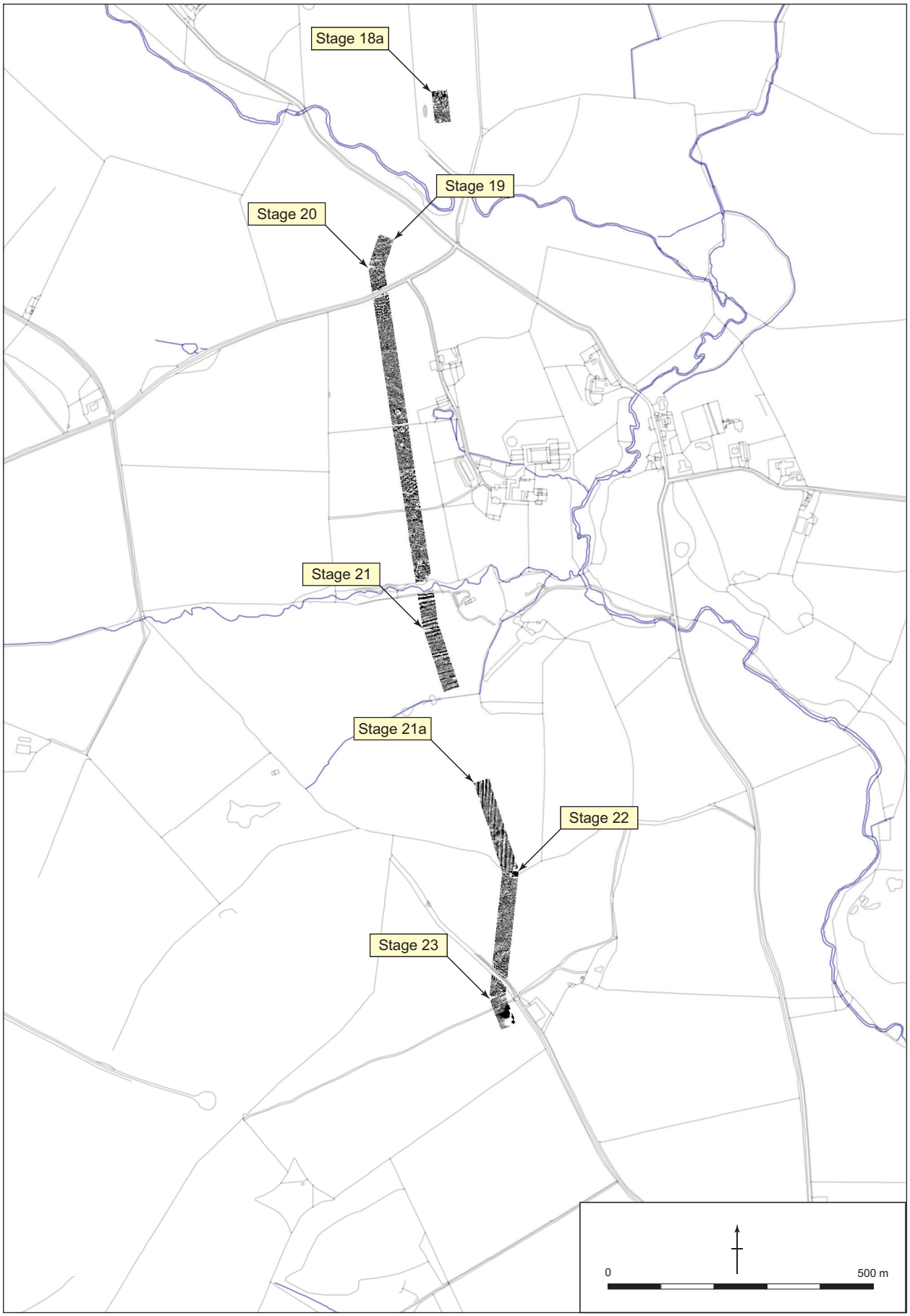
The solid geology of the corridor comprises sedimentary rocks of the Gala Group, which derive from the Llandovery epoch of the Silurian period - that is they were deposited between 443 and 428 million years ago. The Gala Group rocks comprise Buckholm Grits:



Illus 3
Site layout (north)



Illus 4
Site layout (centre)



Illus 5
Site layout (south)

massive grits with greywacke and shales, and Abbotsford Flags: purple and grey flaggy sandstones. These rocks were folded during the Caledonian Orogeny - which occurred between 490 and 390 million years ago - and now exhibit a north-easterly dip of between 40 and 75 degrees (Cater 2009).

The 1:50000 British Geological Survey Map (Scotland Sheet 25W) indicates that most of the proposed development is underlain by Pleistocene boulder clay. The vicinities of Stages 6, 7 and 8 to the north-west of Threepwood, Stage 18 running down from Colmsliehill to the Allan Water and Stages 22 and 23 on Calfhill are recorded as having bedrock at surface, indicating that there is very thin or no superficial geology under these Stages. Alluvium underlies the proposed pipeline corridor where it crosses the Allan Water, while peat underlies the corridor in the vicinity of Moss Burn. Dense vegetation and wet ground prevented survey in these areas.

5 EQUIPMENT

The instrument used to conduct the survey was a Grad601-2 magnetic gradiometer from Bartington Instruments Ltd. The Grad601-2 is composed of two horizontally aligned sensor arrays, separated by 1m. Each sensor array is composed of two vertically aligned magnetometers, also separated by 1m. The unit comprises an automatic data logger to allow the automatic collection of data at predefined sample intervals.

A Trimble R6 Differential Global Positioning System (DGPS) with VRS-Now technology was used to accurately locate the survey grids along the corridor. This comprised a mobile GPS receiver utilising VRS-Now technology, which effectively acts as a base station. A hand-held computer unit was connected to the mobile GPS receiver and this was used to view and collect data.

6 METHODOLOGY

Prior to commencing the geophysical survey, a series of 30m x 30m grids was plotted along the route of the proposed pipeline, using AutoCAD. The grids were orientated along the length of the corridor, ensuring that the proposed pipeline was directly in the centre of each series of grids. This data was then uploaded to the DGPS data logger. The archive contains a CAD-compatible file documenting the grid system used, allowing for the accurate relocation of the grid system if necessary.

The 30m x 30m grids were set-out on site to an accuracy of ±0.05m using the DGPS, and the traverses within the grids were walked in an alternating direction, with the starting point usually in the north-eastern corner of each series of grids. The data were then downloaded from the unit using a laptop PC for processing and visualising. This process was repeated at the end of each day.

The sample rate employed was 0.25m x 1m, that is readings were taken every 0.25m along traverses spaced 1m apart. This is commonly used "for evaluation surveys, where the goal is to establish the presence or absence of archaeological features" (English Heritage 2008).

Allowances were made to ensure that Landowner 4 was surveyed last, due to a positive test for bovine tuberculosis, as outlined in the project brief; however, this is not reflected in the stage numbering. When leaving the site at the end of each day and when traversing from one landowner to another, the members of the survey team sprayed their boots and vehicle wheels with an approved disinfectant, to prevent any possible spread of bovine TB from one landowner to another.

A small area of topographic survey was also undertaken as part of the works, as an extension to the contract. The results are included as Illus 25 and briefly discussed below.

7 RESULTS

The results are classified according to four categories. The categories serve as a visual guide and an aid to the discussion of the results. They are subjective and site dependant.

High Archaeological Potential – Identifiable, known archaeological feature types that are of high archaeological significance. Often (but not always), additional evidence exists, to support any identification of *High Archaeological Potential* anomalies.

Medium Archaeological Potential – Possible archaeological feature types that may be of high archaeological significance.

Low Archaeological Potential – Known or possible archaeological feature types that are or are likely to be of low archaeological significance.

Agricultural – This category mainly includes plough furrows that are interpreted as modern and does not normally contain drainage ditches and field boundaries, which are usually classed as being of *Low Archaeological Potential*. This category is included to differentiate visible, but insignificant anomalies from the significant anomalies described above.

Throughout the survey, there were some areas where the ground conditions, either because of dense vegetation, or steep glacial valley slopes, meant that they were not suitable for surveying. Between, Stages 2 and 3, Stages 6 and 7 and Stages 12 and 13, there were several small areas that were omitted due to the presence of shelter belts, or other dense vegetation. These areas measured approximately 300m in total and are visible on the appropriate Illus.

In the south of the survey area, three sections of the route were omitted because the steep, glacially-derived slopes were unsuitable for the application of magnetic gradiometry. These were located between Stages 18 and 18-a, Stages 18-a and 19 and Stages 21 and 21-a. These areas measured 390m, 240m and 180m, respectively.

The total surveyed area was 5490m and the total unsurveyable area was 1110m.

7.1 Stages 1 – 2 (Illus 6 – 7)

The results in the north of Stage 1 were obscured by numerous bipolar ferrous anomalies contained within a small, modern enclosure. South of this there was very little variation and no patterns could be discerned.

There is one anomaly of *Low Archaeological Potential*, located immediately south of the northernmost field boundary in Stage 2. It is a curvilinear, positively magnetic anomaly that is potentially a ditch, although its shape does not suggest any obvious purpose and it may be natural in origin. Immediately south of this there is a negatively magnetic anomaly (light in colour), that is probably the remains of a field wall footing. There is a further diffuse anomaly in the south of Stage 1; again, this may be natural in origin.

7.2 Stages 3 – 5 (Illus 8 – 9)

In Stages 3 and 4, there are numerous anomalies of *Low Archaeological Potential*. Most of these are orientated south-west/north-east and it is possible that some of these are field boundaries or drainage ditches. However, the quantity of anomalies suggests that most of them are likely to be the remains of cultivation furrows. They are relatively large anomalies, not typical of modern ploughing, and their magnetic response is similar to that left by ridge and furrow cultivation.

A very clear example of the magnetic response from ridge and furrow can be seen in the results from Stage 21 and 21a (Illus 22 - 25). While the magnetic responses left by the putative ridge and furrow remains in Stages 3 & 4 were more diffuse, this would be expected if they had been eroded more by modern ploughing.

In the centre of Stage 4, north of the fence that divides the area, there is a subtle, narrow south-west/north-east-orientated, negative magnetic anomaly. While it is on the same alignment as the possible ridge and furrow cultivation anomalies, it is not usual for ridge and furrow anomalies to possess negative magnetism without a corresponding anomaly of positive (dark in colour) magnetism. This anomaly is probably caused by a boundary wall or other typically negatively magnetic feature and is marked as being of *Low Archaeological Potential*.

To the south of the fence that divides the area, there are a number of linear features that are interpreted as remains of ridge and furrow cultivation as well. There is also a small irregular, curvilinear anomaly on a similar alignment to the probable cultivation features and its appearance suggests that it may be a ditch. These are all assessed as being of *Low Archaeological Potential*.

The large, linear, positive anomalies that characterised Stage 4 were not present within Stage 5 but there were several clusters of bipolar ferrous anomalies. It is likely that these are modern in origin because it is common to have ferrous anomalies in close proximity to modern field boundaries. However, the largest of these was identified as being of *Low Archaeological Potential* because of its clear, well-defined appearance.

7.3 Stages 6 – 8 (Illus 10 – 11)

Approximately 90 m of the proposed pipeline corridor was omitted from the survey in between Stages 6 and 7. This was due to the presence of a shelter belt visible on the Illus.

In Stage 6, there were several anomalies that are suggestive of Agricultural activity and, as they are thin, regularly-arranged anomalies, these are possibly more modern than the ridge and furrow described for Stage 4.

In the far south of Stage 6, there is a strong positively magnetic linear anomaly that enters the survey area from the south and exits to the west. The form of this anomaly suggests that it is probably a drainage feature.

The ferrous signature of the existing pipeline obscured much of the north-west and west of Stage 7 and a section in the south-east could not be surveyed because of the presence of dense rushes. There are two small, diffuse south-west/north-east-orientated anomalies in Stage 7. There are no defining characteristics and an interpretation cannot be ascertained.

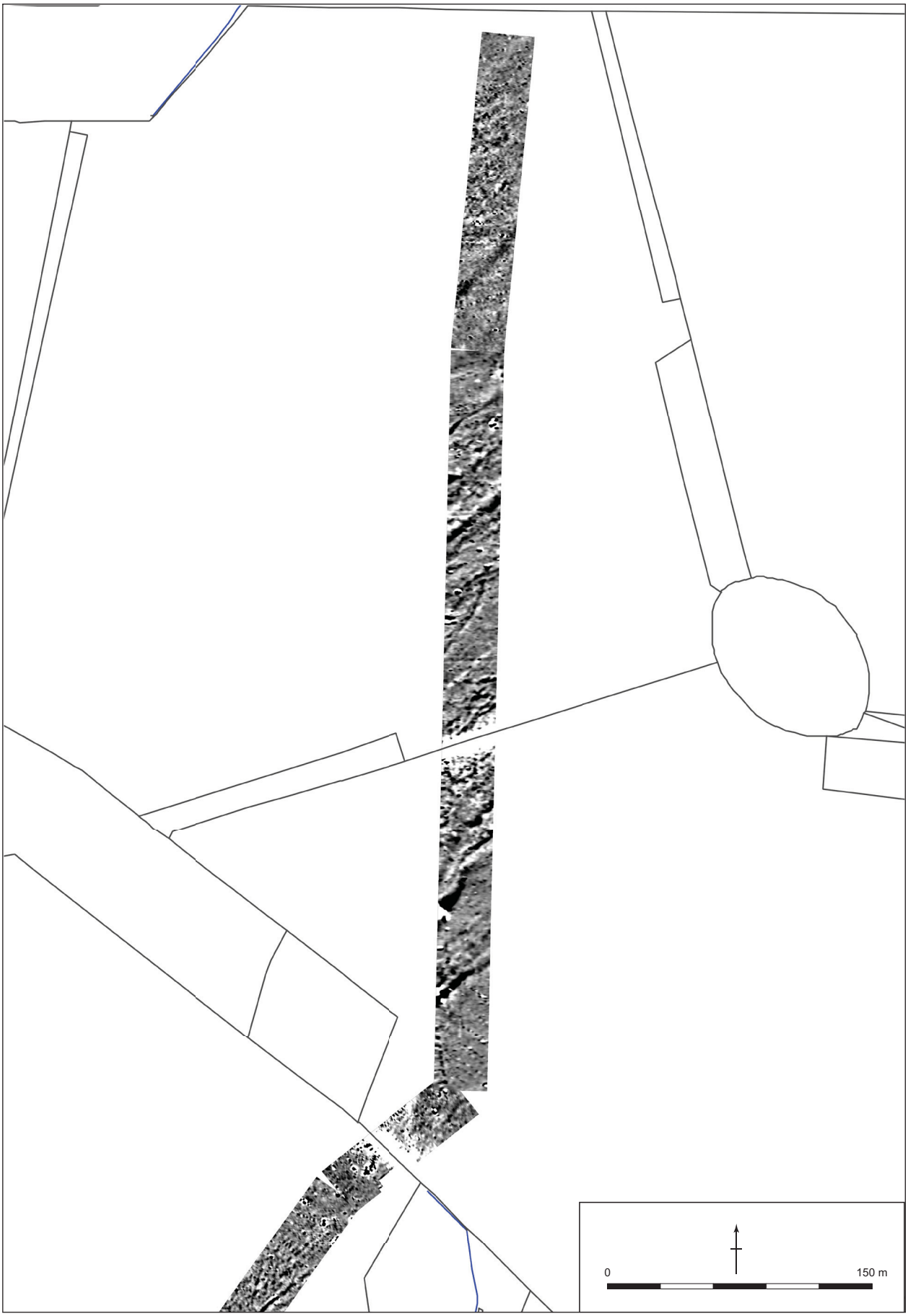
Stage 8 contains a positively magnetic, linear anomaly that is assessed as being of *Low Archaeological Potential*. It is located in the north of the stage and was orientated south-west/north-east. There are two additional anomalies of *Low Archaeological Potential* within the stage, which are of uncertain derivation.

In the centre, orientated north-west/south-east there is a cluster of anomalies orientated very close to the alignments of the modern field boundary to the south-west and they may relate to relatively recent ploughing.

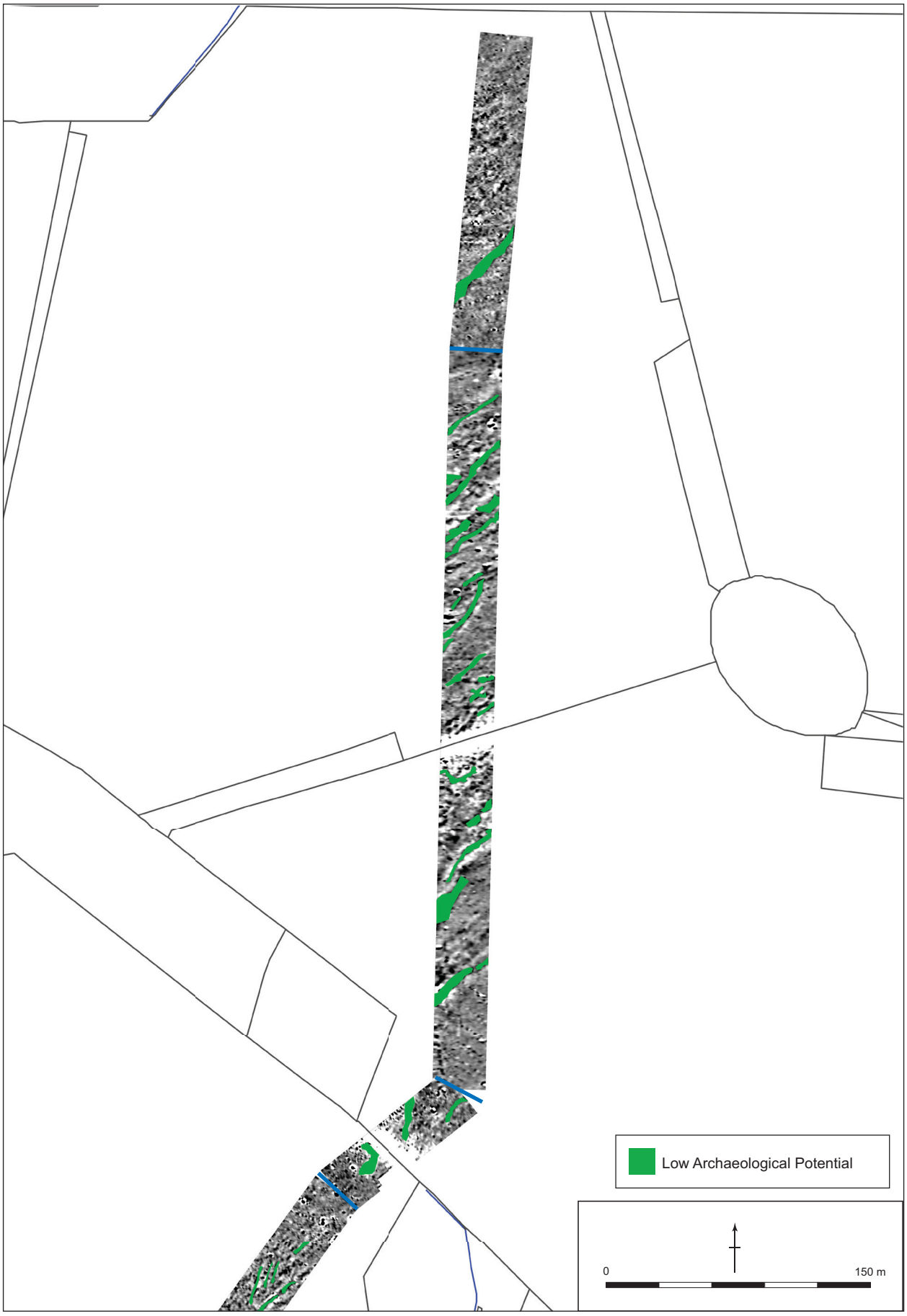
In the south of this stage, there is a curvilinear, positively magnetic anomaly. The signature is similar in appearance to that of a ditch, but because it is irregular and broken, this interpretation is tenuous, but it is assessed as being of *Low Archaeological Potential*.

Illus 6
Stages 1 and 2 - Processed data

Illus 7
Processed data with interpretation overlaid



Illus 8
Stages 3 to 5 - Processed data



Illus 9
Processed data with interpretation overlaid

Illus 10
Stages 6 to 8 - Processed data

Illus 11
Processed data with interpretation overlaid

7.4 Stages 9 – 12 (Illus 12 – 13)

In the centre of Stage 9, there are two large, irregular, positive linear anomalies. There is a very similar anomaly visible in Stage 11. Both anomalies are south-west/north-east orientated and follow the broad orientation of surrounding field boundaries. They are assessed as being of *Low Archaeological Potential*

In much of the north of Stage 10, the results were variable and no patterns can be discerned. However, immediately north of the east/west-orientated field boundary that crosses the survey area in the north, there are several thin, linear anomalies that respect the field boundary. These are regular in appearance and regularly spaced, indicating that they are likely to have been caused by relatively recent ploughing.

In the south of Stage 10, there is a series of thin linear anomalies which, because of their appearance and spacing were probably mostly caused by ploughing; some may relate to drainage features, however. Their appearance indicates that they may be evidence of relatively recent ploughing, but they may be related to the adjacent series of linear anomalies and, therefore, may be of *Low Archaeological Potential*, rather than Agricultural.

Within this area there is a series of possibly related, linear anomalies. It is possible that they may represent a derelict field system or some other land division; however, such an interpretation is tenuous. They have been interpreted as being of *Low Archaeological Potential*.

In the north of Stage 11, there are several anomalies on the same alignment as the anomalies in the south of Stage 10. These again probably derive from relatively modern ploughing. Significantly, these anomalies straddle the modern field boundary, indicating that they do not respect it and therefore predate it.

South of this, there are two large, irregular, positive linear anomalies on a south-west/north-east orientation. They are very similar in appearance to the anomaly described in Stage 9 and, as noted above, they follow the broad orientation of surrounding field boundaries and are assessed as being of *Low Archaeological Potential*.

In the south of Stage 11, there are several south-west/north-east-orientated linear anomalies that run parallel to the road in the south of the area. As they are slightly variable in orientation and have the appearance of wide, slightly diffuse, positive anomalies, they are likely to be related to archaeological traces of ridge and furrow cultivation, possibly associated with the settlement to the south of the road in Stage 12. These anomalies are marked as Agricultural features.

In the north of Stage 12, there are several linear anomalies that are orientated south-west/north-east. They are similarly orientated to the anomalies in the south of Stage 11 and are likely to be an extension of the ridge and furrow cultivation system described in the south of Stage 11.

A 1774 map of the Threepwood Estate was consulted by the survey team and suggests that there was a collection of buildings to the south of the road. It is possible that one of the north-west/south-east linear anomalies in the north of Stage 12 may be related to the field boundary defining the northern extent of the farmstead (to the north of the road) represented on the Threepwood estate map (see Illus 26, inset) and that the modern boundary, adjacent to the anomaly, is a modern representation of the same boundary. However, this is tenuous, because the survey accuracy of the 1774 map is difficult to ascertain. There are no additional anomalies that appear related to any of the other boundaries or buildings to the north of the road shown on the 1774 map.

Immediately south of the road, the geophysical survey indicated a large number of bipolar ferrous signatures. A topographic survey of the settlement was undertaken as an extension to the works and is shown as Illus 26. When the results of a topographical survey are overlaid, the anomalies appear to cluster in the vicinity of a topographic feature interpreted as a structure and marked 'Building B'. To the immediate north-west a similar cluster of bipolar anomalies is visible and corresponds with a rise in the topographical survey. It is possible that this represents a building immediately to the north-west of Building B on the estate plan. These areas are marked as being of *High Archaeological Potential*.

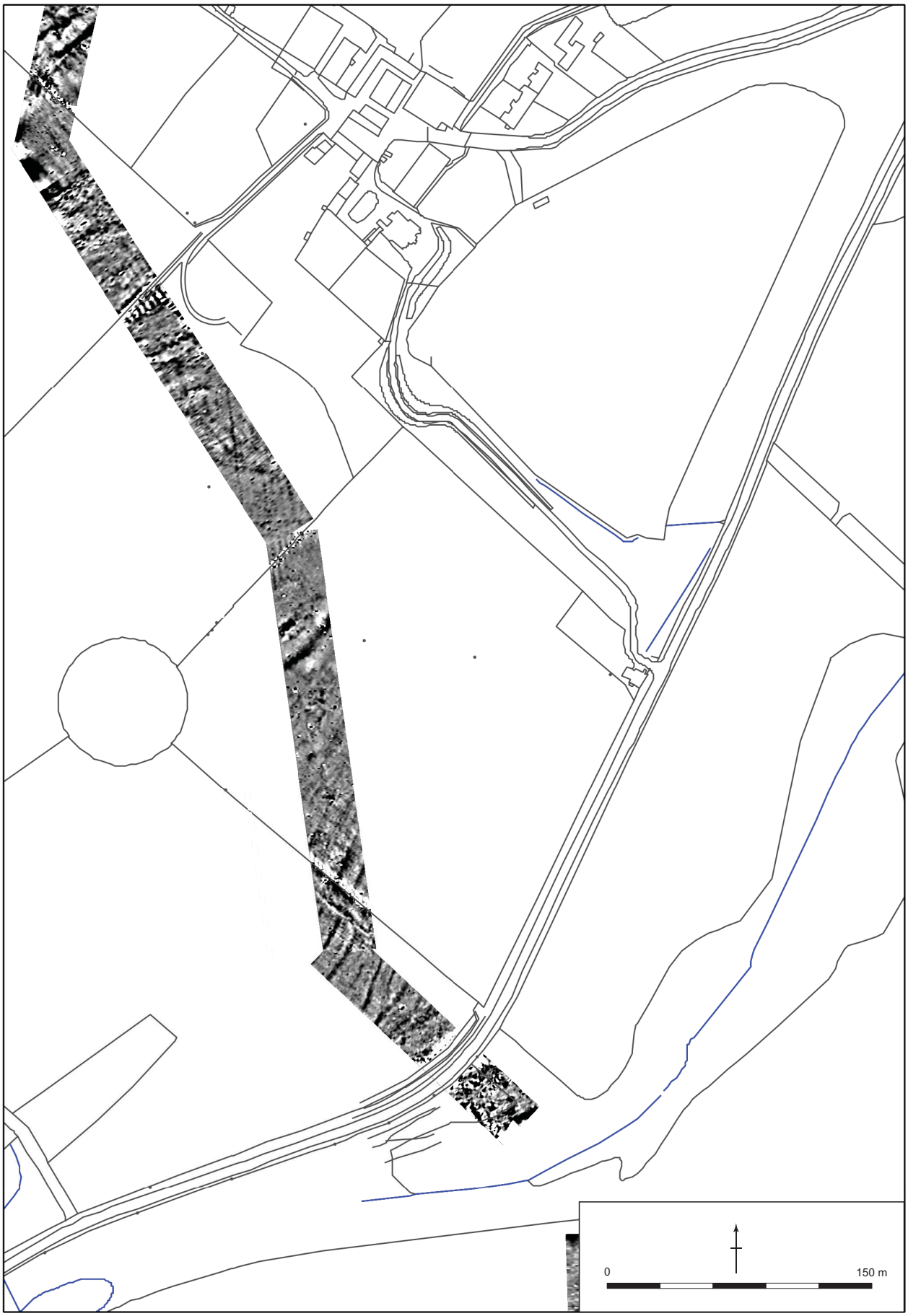
Within 'Field A', as marked on the topographic map (Illus 26), there is a negatively magnetic anomaly that is rectilinear in shape. It is common for features such as wall foundations to have a negative magnetism and, while the map does not provide any evidence for a structure in this area, it is possible that this anomaly represents the foundations an unrecorded structure. This area is marked as being of *Medium Archaeological Potential*.

7.5 Stage 13 (Illus 14 – 15)

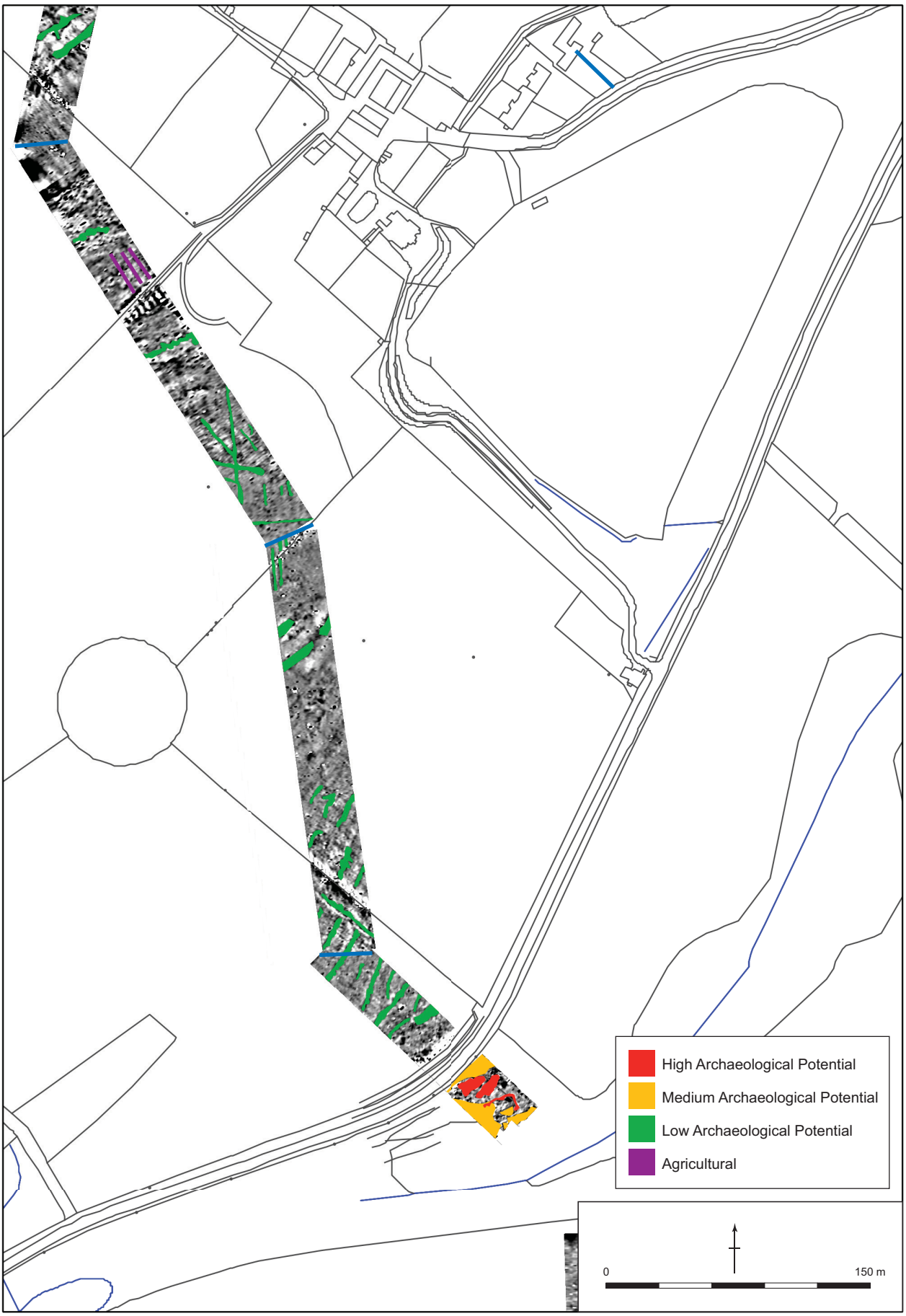
The results from the northern section of Stage 13, along the bottom of the valley, were "quiet" i.e. not variable. In the north of the stage, there is a diffuse anomaly or cluster of anomalies visible in the results. There is no obvious interpretation for these and it is possible that they are natural in origin; they are marked as being of *Low Archaeological Potential*.

The southern part of Stage 13, to the south of a road that bisects the stage, is more variable, with bipolar anomalies evenly spread throughout. These may relate to glacial erratics in the subsoil. Near the centre of the field on the south side of the road, there is a similar cluster of anomalies to that described in the north of Stage 13. Again, it may be natural in origin and is marked as being of *Low Archaeological Potential*.

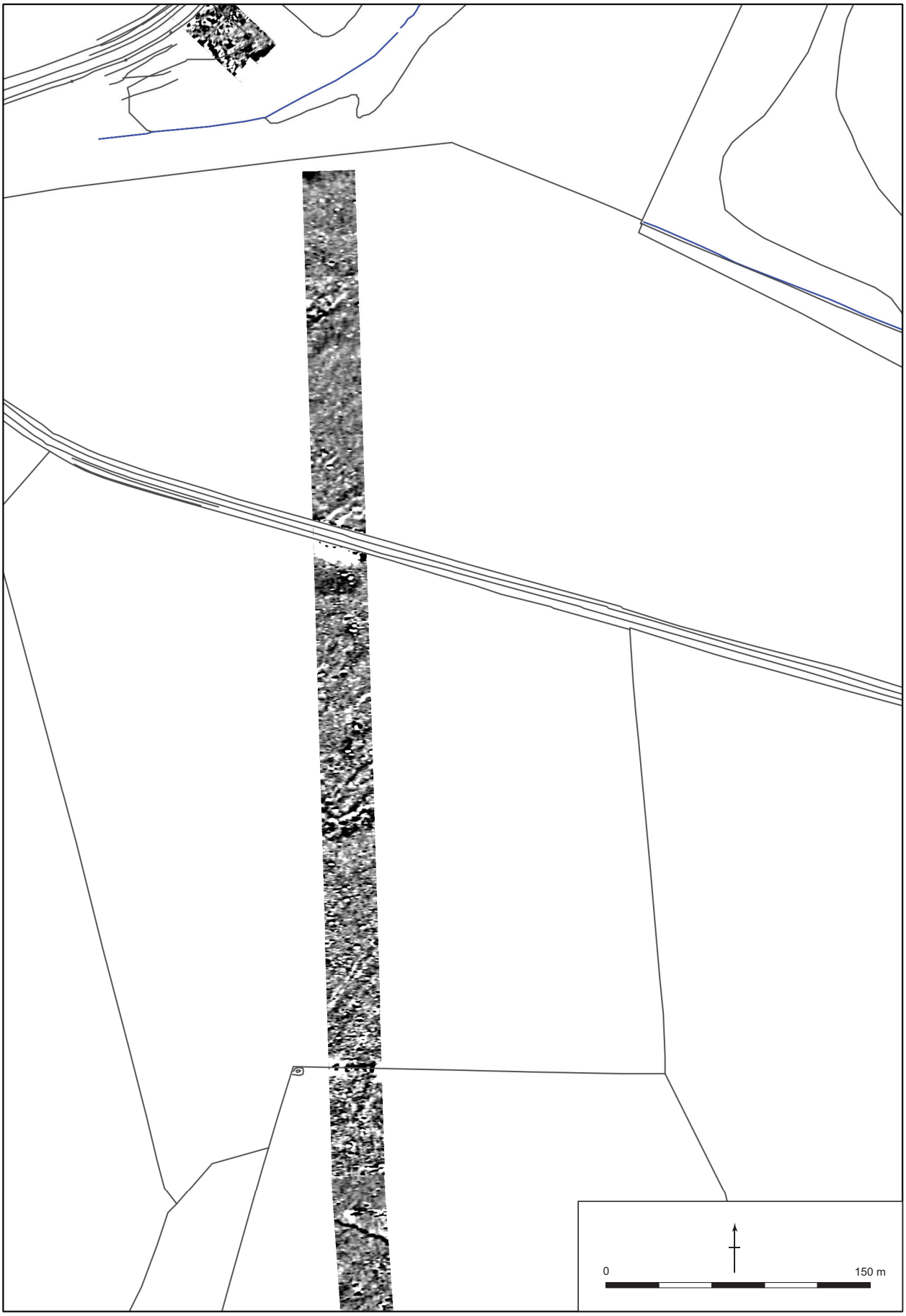
At the southern end of the stage, there are several thin positive anomalies. They may be the remnants of modern ploughing. They are marked as being of Agricultural origin.



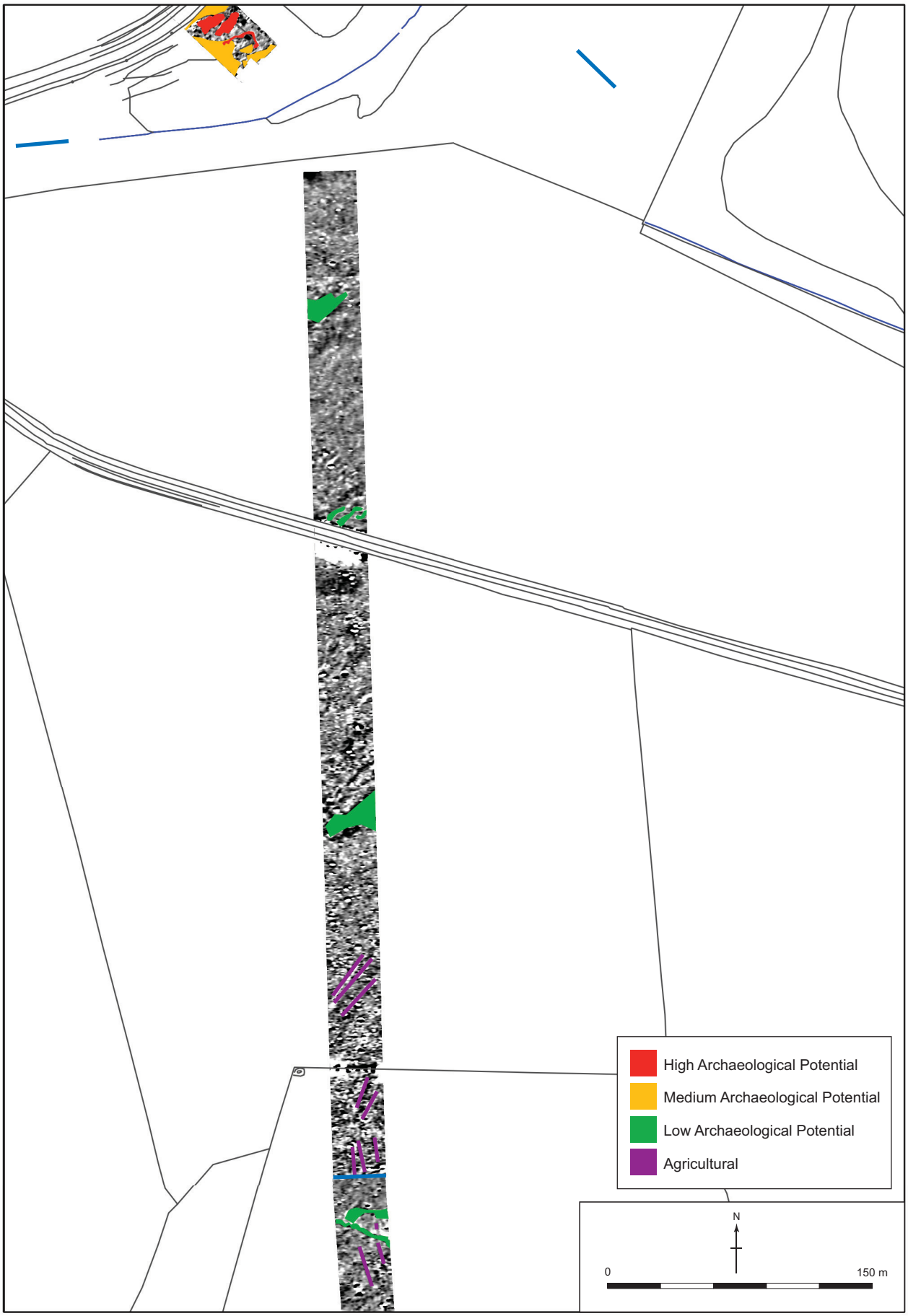
Illus 12
Stages 9 to 12 - Processed data



Illus 13
Stages 9 to 12 - Processed data with interpretation overlaid



Illus 14
Stage 13 - Processed data



Illus 15
Stage 13 - Processed data with interpretation overlaid

7.6 Stages 14 – 17 (Illus 16 – 17)

Throughout Stages 14 and 15, there are weak, regularly spaced, south-south-east/north-north-west-orientated linear Agricultural anomalies that are probably evidence of modern ploughing and have been marked as Agricultural on the Illus.

In the far north of Stage 14, there are two anomalies and one is marked as being of *Low Archaeological Potential*. One of the anomalies is a north-west/south-east orientated positive linear anomaly and it is highly likely to be a drainage ditch. Immediately north of this, is a variable ferrous anomaly of uncertain derivation. The anomaly is very strong, in the region of -80 nT - +20 nT, and it is marked as being of *Low Archaeological Potential*.

Toward the south of the stage, there is a curvilinear anomaly of *Medium Archaeological Potential* that is clearly discernable against the background variation. It potentially relates to a larger feature that may be present to the east of the surveyed corridor. To the north-west, there are two further anomalies that seem to mirror the orientation of the larger anomaly. The significance of this group of anomalies is unclear but it is possible that they relate to significant sub-surface archaeological features.

In the north of Stage 15 there is one large, diffuse, positively magnetic anomaly. It is unclear what this represents; it may relate to a large pit, although it may be geological in origin. It is marked as being of *Low Archaeological Potential*.

No anomalies are visible within the results for Stage 16. The survey area crosses the existing gas pipeline and the strong ferrous signature from this masks any anomalies that may be present.

Throughout Stage 17, there are several positive *Low Archaeological Potential* anomalies that are all orientated south-west/north-east. They are not regularly spaced like modern ploughing anomalies and they may be the remnants of ridge and furrow cultivation.

Near the centre of Stage 17, there is an anomaly assessed as being of *Medium Archaeological Potential*. It is a negatively magnetic linear anomaly. The clearest section runs from the south-east to the north-west and appears to return to the north-east. There is some suggestion that this return may itself turn to the south-east, at the boundary of the corridor. It is possible that this anomaly represents the stone foundations of a rectilinear building, although it may also relate to former field boundaries, or potentially an animal pen.

7.7 Stages 18 and 18a (Illus 18 – 19)

Within Stage 18, there are two irregular, positively magnetic anomalies of *Low Archaeological Potential*. Given their appearance, a geological origin is considered most likely, although an archaeological origin cannot be excluded.

In Stage 18a, there are two irregular positive anomalies. These are marked as being of *Low Archaeological Potential* and may reflect either natural variability or isolated features.

7.8 Stages 19 and 20 (north) (Illus 20 – 21)

In Stage 19, there are three faint south-west/north-east orientated linear anomalies. It is likely that they are Agricultural and a result of recent ploughing.

There are many areas of high variability in the results from Stage 20. These and they are not likely to be archaeological in origin.

On the northern side of a field boundary in the centre of Stage 20, there are two north-west/south-east-orientated, wide, diffuse, negatively magnetic anomalies. There is no obvious interpretation for these anomalies; however, they are similar in form to the anomalies identified in Stages 9 and 11 and therefore, they may be geological in origin. They are marked as being of *Low Archaeological Potential*.

7.9 Stages 20 (south) and 21 (Illus 22 – 23)

Near the middle of the field in the centre of Stage 20, there is an area of high variability and, within this, there are several south-west/north east and north-west/south-east anomalies that seem to form a criss-cross pattern. It is possible that they represent Agricultural features. However, their presence within an isolated area of high variability may mean that they may be more significant. Nevertheless, they are marked as being of *Low Archaeological Potential*.

To the south of these there is an isolated area of very high positive magnetism. It is possible that this area represents an area of burning. The area is a very large area of burning and is likely to have been a bonfire, rather than a small hearth. There is nothing to suggest that this event happened in antiquity and could just have easily been a bonfire associated with the existing farmhouse; however, it is conceivable that it is related to the other anomalies identified in the area, and that they are more significant.

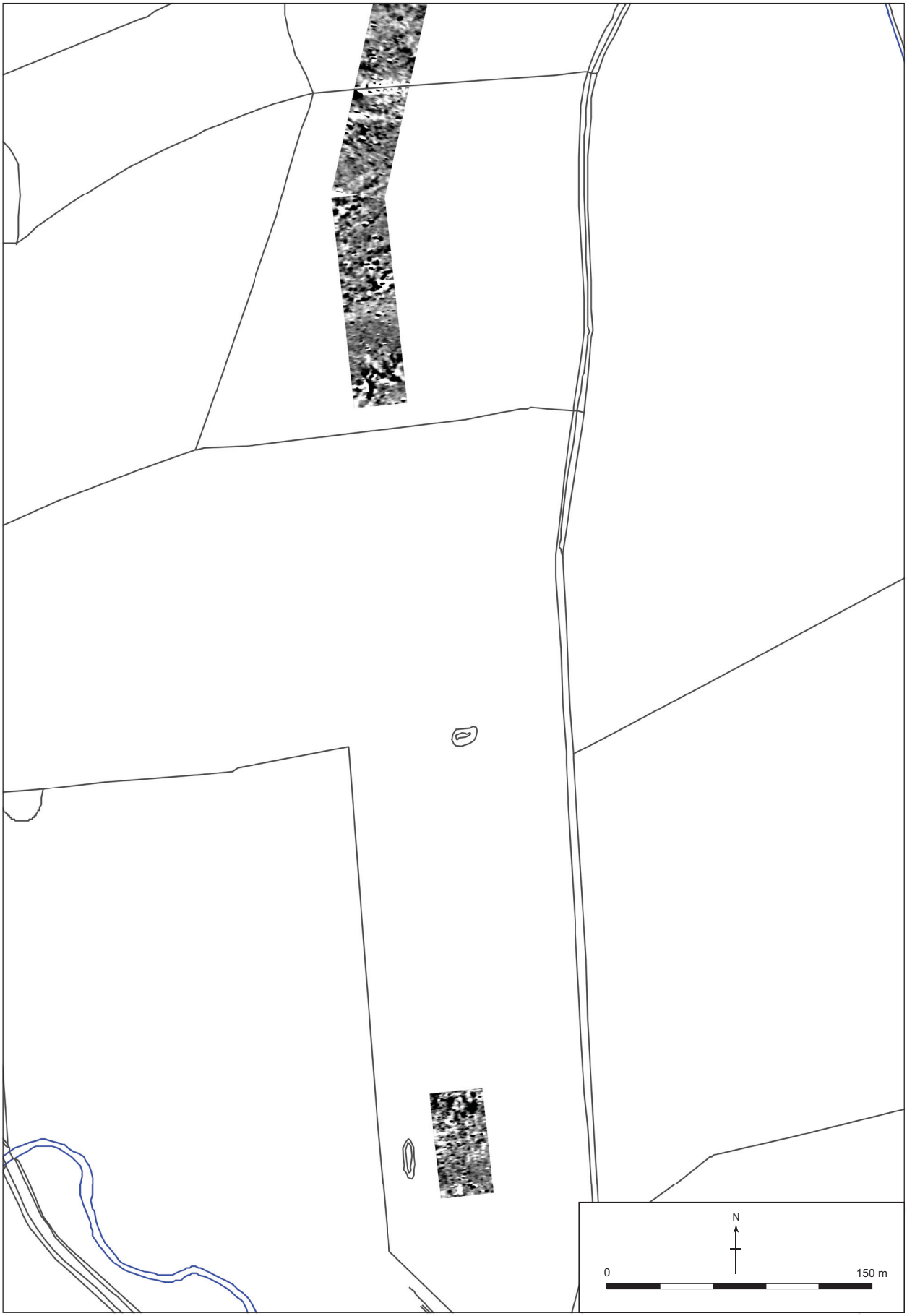
This variability is caused by a large number of bipolar ferrous anomalies, and while this in itself may be significant, there is very little extraneous evidence to suggest that they warrant individual identification.

The larger anomalies with visible "halos" surrounding them, just outside this area of high variability, are distorted. They are also bipolar anomalies, but a low pass filter used to slightly reduce the variability in the data set and improve the clarity of the data can produce this halo effect.

At the southern edge of Stage 20 and through all of Stage 21, on the floor of the flat valley, are numerous east/west orientated anomalies caused by ridge and furrow cultivation. In some places, the ridges were visible on the ground as mounds up to 6m wide and 30cm or more in height.

Illus 16
Stages 14 to 17 - Processed data

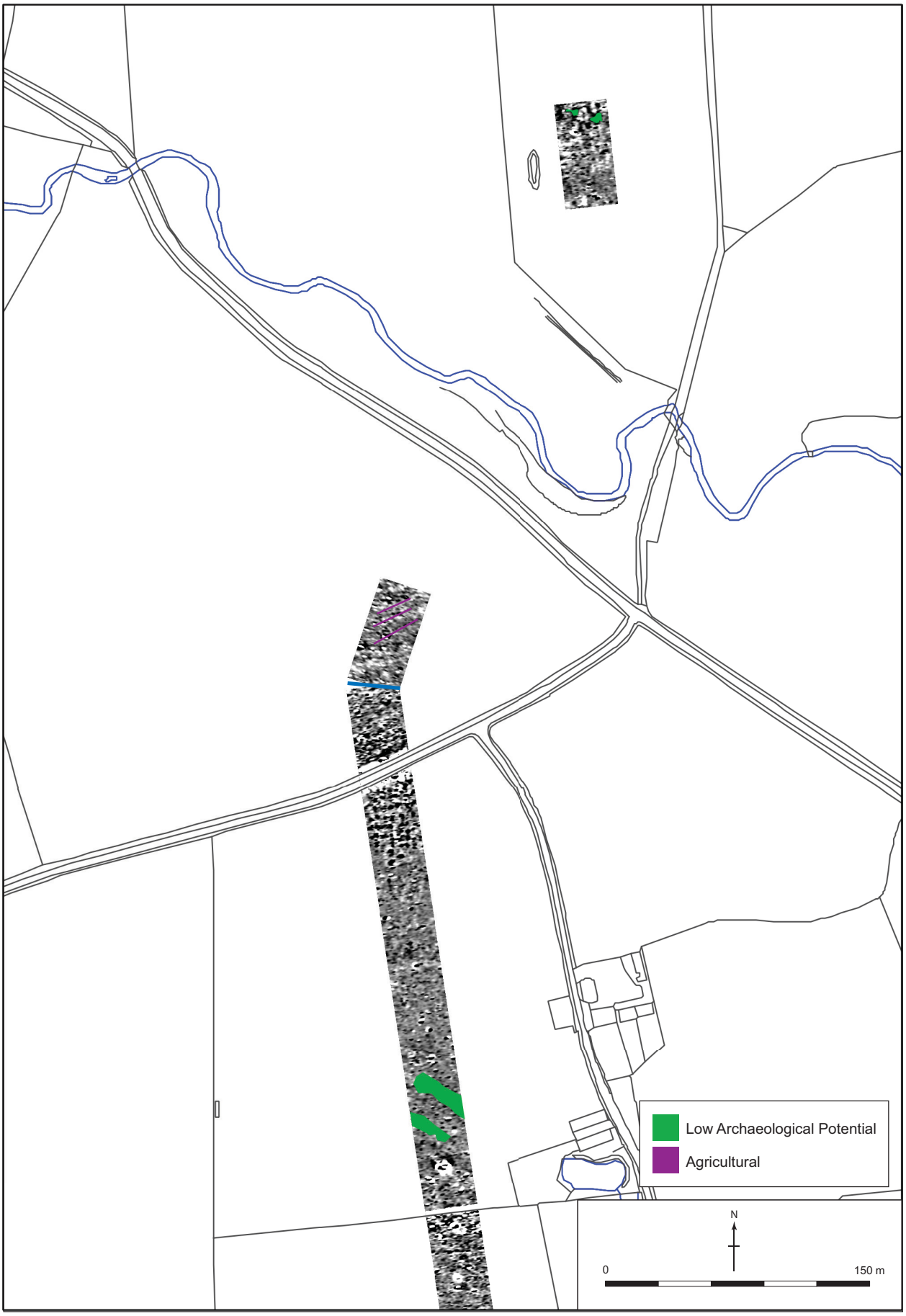
Illus 17
Stages 14 to 17 - Processed data with interpretation overlaid



Illus 18
Stages 18 and 18a - Processed data

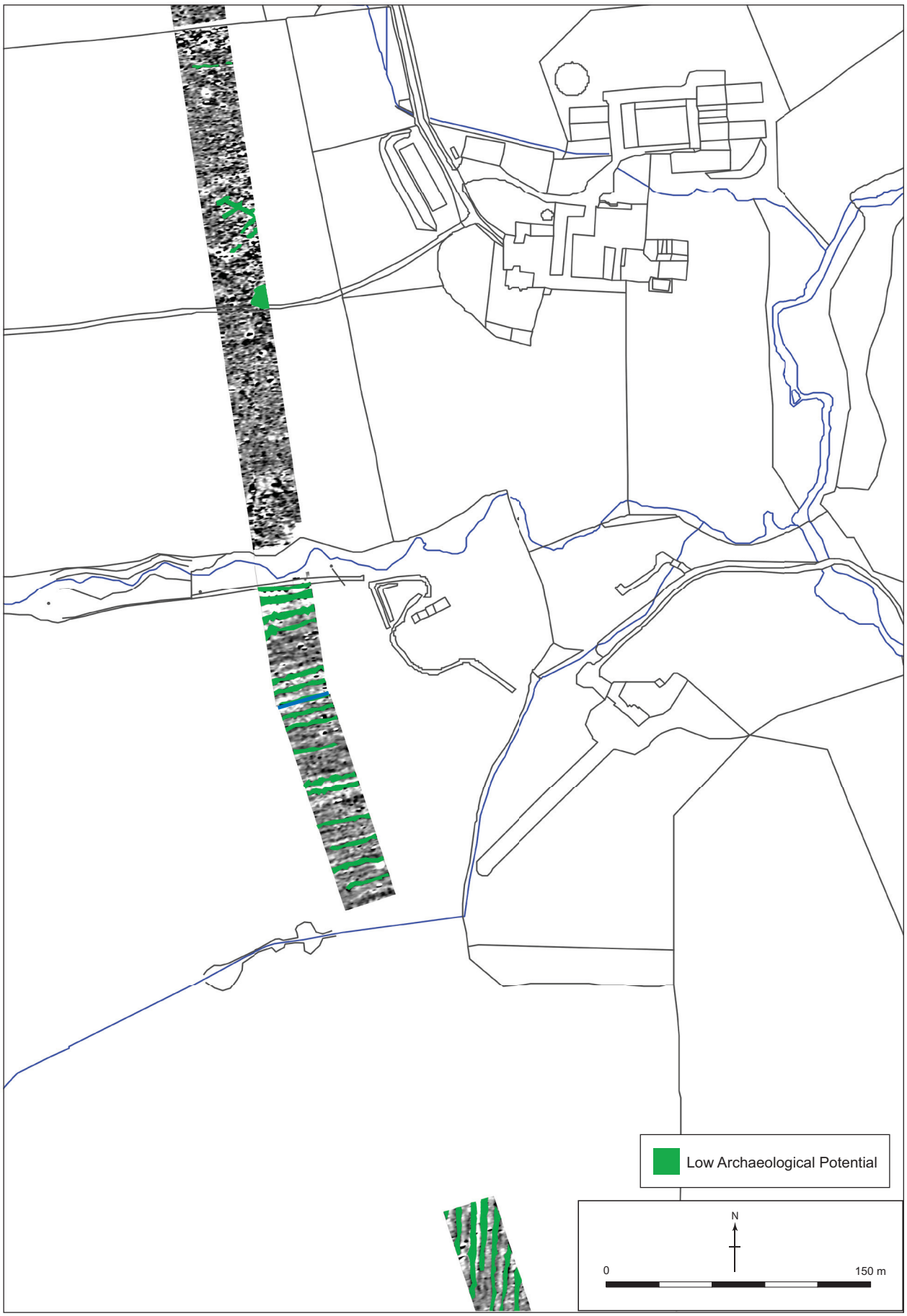
Illus 19
Stages 18 and 18a - Processed data with interpretation overlaid

Illus 20
Stages 19 and 20 (north) - Processed data



Illus 21
Stages 19 and 20 (north) - Processed data with interpretation overlaid

Illus 22
Stages 20 (south) and 21 - Processed data



Illus 23
Stages 20 (south) and 21 - Processed data with interpretation overlaid

Illus 24
Stages 21a to 23 - Processed data

Illus 25
Stages 21a to 23 - Processed data with interpretation overlaid

7.10 Stages 21a – 23 (Illus 24 – 25)

A similar pattern of ridge and furrow cultivation was clearly visible on the ground in Stage 21a, as north/south-orientated, linear, positively magnetic anomalies. These anomalies are so strong and numerous that there are very few additional anomalies, archaeological or otherwise, visible in the results.

Within Stage 22, there are numerous, diffuse, positively magnetic anomalies, as well as many isolated ferrous anomalies. None of these are interpreted as being of archaeological potential.

There are two anomalies of *Low Archaeological Potential* present within Stage 22. An anomaly in the north is orientated north-east/south-west and is visible as a series of bipolar anomalies. The north-eastern end of the anomaly meets the apex of the field to the north and it is most likely that this anomaly was caused not by a field boundary but by the ferrous debris that tends to collect along field boundaries.

The anomaly in the south is located immediately north of the trackway that divides the area. It is on the same orientation as the track way and it is likely that they are related.

There are no archaeological anomalies present within Stage 23 and all that is visible is the modern trackway, marked by a linear arrangement of bipolar anomalies, and the large ferrous anomaly caused by the current gas pipeline.

8 DISCUSSION

The survey evidence suggests that historically, as today, much of the route of the proposed pipeline has been primarily in agricultural use; presumably from at least the late-medieval period. The evidence for this is the presence of remains relating to ridge and furrow cultivation and more modern, regularly-spaced plough marks. The fact that some of the ridges were not ploughed out in the modern period is unsurprising because much of the land is heavily sloping and up to 300m above sea level.

There are a few areas along the proposed route of the pipeline that would have been suitable for habitation, namely the sheltered valley floors, particularly the Allan Water and the unnamed tributaries to the south. However, the limiting factor then, as now, is that these areas were likely to have been too wet to support sustained and prolonged settlement, except for possible isolated settlements on marginal land. This became particularly apparent by the end of the survey when, after sustained heavy rain, the Allen Water burst its banks.

In the flat-bottomed valley south of the Allan Water, this is compounded by the poor quality of the land and apparent lack of improvement. It appears that the land is so poor that no attempt was made to plough the fields in recent times, using modern machinery, and remains of ridge and furrow cultivation survive well. This was probably because the valley floor was so wet, and the raised ridges offered some additional drainage. There is one small enclosed dwelling visible about 60m east of the pipeline and located on a slightly raised terrace. This terrace is probably glacially or immediately post-glacially derived and provides a dry island in this part of the valley. It is still likely however, that this represents as marginal, subsistence dwelling and is unlikely to be the general settlement pattern in the area for the reasons detailed above.

One exception to this general picture is a settlement on the Threepwood Estate that would be directly impacted upon by the current revision of the proposed pipeline route. That settlement is located only 200m from the southern end of a post-medieval track called the Girthgate, which was recorded on the 1st edition Ordnance Survey six-inch map as running north, in discontinuous lengths, through north Roxburghshire and south Berwickshire, and which is likely to have facilitated the movement of goods – including cattle – to the Edinburgh market in the post-medieval period. The geophysical survey possibly identified some of the structures associated with this settlement but much of the detail is obscured by many bipolar ferrous anomalies. Presumably the latter derive from waste associated with this settlement. This anomaly is assessed as being of *High Archaeological Potential*.

In Stage 17, there is an additional anomaly that may potentially be related to earlier settlement. It is a rectilinear, positively magnetic anomaly, located approximately 300m south-west of the existing Colmsliehill farmhouse. This may reflect the presence of a buried stone structure, possibly a former field boundary, sheepfold or other enclosing feature, but there is some suggestion of a return and there may be building foundations here. This anomaly is assessed as being of *Medium Archaeological Potential*.

Finally, there was a curvilinear anomaly in the east of Stage 14. The survey evidence suggests that the bulk of this feature exists to the east of the survey area and only a small part is within. While its cause is unknown, it is significant because its shape does not seem consistent with other anomalies within this stage. It may relate to buried archaeological features, for example an enclosure ditch, and it is assessed as being of *Medium Archaeological Potential*.

9 CONCLUSION

Overall, the survey was successful as it identified a wide variety of archaeological features, including areas of both known and possible settlement, areas of intensive agriculture and in some areas, field systems that predate the current field system.

It is apparent that the geophysical survey across the route did reveal some new information regarding the archaeology of the area, as well as confirm the existence of archaeology in areas such as Threepwood. It is also apparent that this information could not have been accessed through other means without a considerable outlay of both time and money in the form of extensive test trenching across the extent of the pipeline corridor.

It is significant that there is some evidence of archaeological features across the length of the survey corridor and this indicates that in areas where there are no anomalies visible, we can be confident that that is because there are no archaeological features within this area.

Furthermore, the notion that in Scotland, due partly to its glacially derived sub-soils, geophysics is at best unhelpful and at worst misleading may be proved untrue when the results from this survey can be tested by intrusive investigation. This has positive implications for linear surveys, such as roads and pipeline corridors.

10 REFERENCES

Cater, D 2009 *Written Scheme of Investigation for Geophysical Survey (Magnetometry): Borders Reinforcement Phase 2 – Proposed Newhouses to Calfhill Gas Pipeline.* Unpublished.

English Heritage 2008 *Geophysical Survey in Archaeological Field Evaluation. English Heritage Research and Professional Services Guideline No. 1 (2nd ed).* p22.

Schmidt, A 2001 *Geophysical Data in Archaeology: A Guide to Good Practice (AHDS Guides to Good Practice).* Oxbow Books: Oxford.

APPENDICES

Appendix 1 – Composite Information

Composite Name	Easting (NW Corner)	Northing (NW Corner)	Direction of 1st Traverse (°)	Size (m)	Area (m^2)
Stage 1	351295.6088	644832.5528	222.8653	60 x 30	1800
Stage 2	351258.1396	644794.3847	197.0376	480 x 30	1440
Stage 3	351109.3334	644248.4831	185.5397	180 x 30	5400
Stage 4	351092.0232	644070.4255	181.3231	420 x 30	12600
Stage 5	351077.8221	643637.6468	231.5970	90 x 30	2700
Stage 6	351010.1283	643584.7023	215.8811	240 x 30	7200
Stage 7	350851.3247	643281.4228	177.9501	150 x 30	4500
Stage 8	350854.5116	643141.5835	155.1578	180 x 30	5400
Stage 9	350930.7280	642973.9288	192.5012	120 x 30	3600
Stage 10	350899.4013	642878.8970	147.2153	270 x 30	8100
Stage 11	351047.8477	642645.8541	172.0692	240 x 30	7200
Stage 12	351064.2745	642421.4383	133.1355	150 x 30	4500
Stage 13	351218.1061	642247.4370	178.3409	570 x 30	17100
Stage 14	351234.5802	641678.2660	176.0739	180 x 30	5400
Stage 15	351246.9399	641497.6331	179.8920	120 x 30	3600
Stage 16	351242.3699	641366.6265	226.0009	60 x 30	1800
Stage 17	351203.4397	641332.5191	192.3913	450 x 30	13500
Stage 18	351062.1417	640109.8978	173.7829	120 x 30	3600
Stage 18a	351162.3675	640390.8442	173.7829	60 x 30	1800
Stage 19	351071.5451	640138.3860	198.2671	60 x 30	1800
Stage 20	351043.9223	640059.8653	171.4038	690 x 30	20700
Stage 21	351147.9515	639380.5049	161.9322	120 x 30	3600
Stage 21a	351240.9943	639095.2979	161.9322	180 x 30	5400
Stage 22	351297.4216	638917.9574	185.9332	240 x 30	7200
Stage 23	351271.6946	638686.1761	158.9713	60 x 30	1800

Appendix 2 – Technical Data

Geophysical Science

The aim of geophysical science in an archaeological context is to examine an area for potential sub-surface archaeological remains, without utilising invasive methods such as test trenching or excavation. This is done by examining the physical properties of the soil, specifically the contrast between the physical properties of potential archaeological features and those of the surrounding soil. These contrasts, known as anomalies, are visible in the results of the survey. The method(s) used to examine sites of archaeological potential are entirely dependent on the types of archaeological features anticipated.

Magnetic Gradiometry

Magnetic gradiometry is a means of measuring minute shifts in the earth's magnetic field caused by magnetised, iron-rich minerals present in the soil. At surface level, the charges of these particles create localised variations in the recorded magnetic field of the earth. The magnetic field strength of the earth is measured in Nanoteslas (nT).

The bedrock geology and the superficial geology that underlie a survey area are key components in determining how successful a magnetic gradiometry survey will be. As the bedrock plays a pivotal role in soil formation processes, both the quantity of iron present within the bedrock and its chemical composition can have a profound impact on the results of the survey. Because of this, surveys conducted on some sites are more successful, or "clearer", than those conducted on others. However, to some degree, all sites are amenable to magnetic gradiometer survey.

In oxidising or reducing environments, i.e. in the presence or absence of oxygen, the iron-rich minerals present in the soil can be "enhanced" through natural and anthropogenic forces. These compounds have undergone chemical and physical changes that affect their magnetic properties.

When iron is heated above a certain temperature, known as the Curie point (676 °C for haematite and 565 °C for magnetite), it becomes demagnetised. As it cools, it is remagnetised, acquiring a new magnetic field that is in alignment with the ambient magnetic field of the earth at that moment. This form of magnetism is called Thermo-Remnant Magnetism or TRM. As the earth's magnetic field regularly fluctuates by tens of nT (or even hundreds in times of increased solar activity), this can give rise to anomalies that can have a magnitude tens of times greater than that of the baseline.

Through different, more subtle processes, chemical and physical changes can also occur through the oxidising and reducing actions of bacterial microbes that are prevalent in soils. Organic matter, soil oxygen and soil moisture are all factors that influence this process. Anthropogenic actions, such as ploughing and the addition of organic matter to improve the structure of the soil, play a role in facilitating these reactions. These processes cause an increase in enhanced induced magnetic susceptibility, or MS, and this generally equates to a small increase in magnetism (several nT) against the background level.

These areas of TRM or MS are concentrated in areas of human activity but, more than that, these magnetised particles tend to spread far from the initial point of origin and find their way into the fills of ditches and pits. The anthropogenic spread of these minerals causes widespread magnetic enhancement across areas of human habitation and this enhancement facilitates the use of magnetic gradiometry in archaeological prospection.

Appendix 3 – Archival Policy

At Headland Archaeology (UK) Ltd., we take our responsibility to archive geophysical data in a professional manner very seriously. As interpretive theories and computational processes improve, it is imperative that a suitable archive exists to allow others to access the data and to reinterpret it in the light of improved theories and computational processes.

All data provided by Headland Archaeology (UK) Ltd., will be treated in accordance with the guidelines laid out in Geophysical Data in Archaeology: A Guide to Good Practice (AHDS Guides to Good Practice) (Schmidt 2001).

In general, recipients of the data produced during a geophysical survey include the contractor, the client and the appropriate national heritage body. All recipients will receive the following as a minimum standard:

- grid (re)location data in (CAD- and GIS-compatible)
- raw composite files (CAD- and GIS-compatible)
- processed composite files (CAD- and GIS-compatible)
- geophysical anomaly interpretations (CAD- and CAD-compatible)
- full report text and accompanying illustrations
- trace data plots

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Illus 26 - Newhouse to Calfhill Gas Pipeline: Topographic survey of Threepwood settlement with geophysics overlaid.