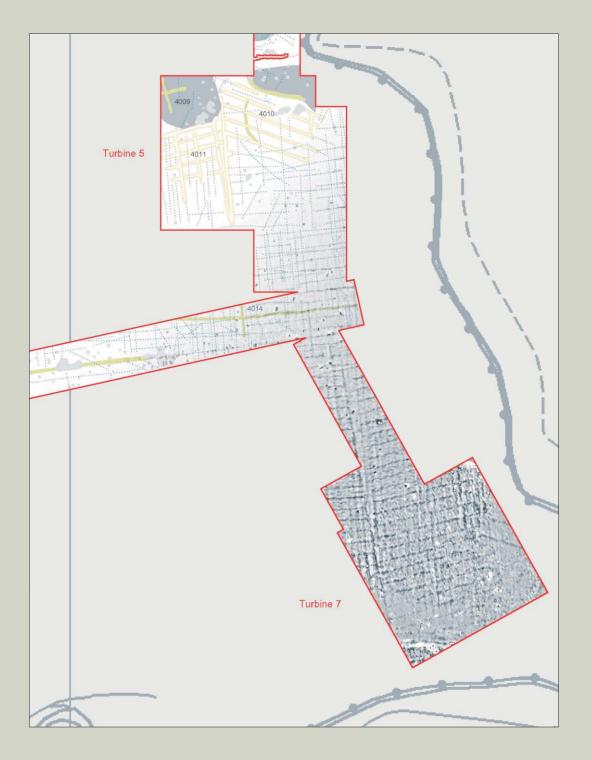
Wessex Archaeology

Proposed Wind Farm at Bishop Wood Selby, North Yorkshire

Detailed Gradiometer Survey Report



Ref: 71200.03

April 2009

SELBY

NORTH YORKSHIRE

Detailed Gradiometer Survey Report

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Summary

Wessex Archaeology was commissioned by Prowind GmbH, to undertake a geophysical survey at the Site of a proposed wind farm development near Selby, North Yorkshire, approximately centred upon OS NGR 456465 432040.

The Site covers a total area of approximately 90 hectares. Detailed gradiometer survey was conducted over the 18.7ha of the Site which lies directly within the footprint of the development.

A number of linear anomalies of possible archaeological interest were identified in the dataset, although it is likely that the majority of these represent former field boundaries or remnants of ploughing headlands.

Strong ploughing trends on varying alignments can be observed throughout the survey area, indicating current and former ploughing strategies. It is possible that some of these ploughing trends are indicative of ridge and furrow, although it is difficult to be conclusive about this interpretation without invasive testing.

Elsewhere, anomalies characteristic of alluvial deposits appear in the vicinity of extant drainage channels. It is possible that these responses indicate former channels, or upcast from the cutting of modern drainage.

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Acknowledgements

The detailed gradiometer survey was commissioned by Prowind GmbH. The assistance of Bernhard Baumann and Reimar von Wachholtz of Prowind and Nicola Smith of North Energy Associates is gratefully acknowledged in this respect.

The fieldwork was directed by Ben Urmston, and assisted by Nathan Thomas, Cristina Serra, Elina Brook, Ruth Panes, Duncan Wright and Kevin Stratford. Ben Urmston processed and interpreted the geophysical data and wrote this report, with assistance from Paul Baggaley. The geophysical work was managed and quality controlled by Paul Baggaley. Illustrations were prepared by Karen Nichols. The project was managed on behalf of Wessex Archaeology by Paul Baggaley with assistance from Paul White.

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Detailed Gradiometer Survey Report

1 INTRODUCTION

1.1 **Project background**

- 1.1.1 Wessex Archaeology was commissioned by Prowind GmbH to undertake a geophysical survey in advance of the proposed development of a wind farm at Bishop Wood, near Selby, North Yorkshire (**Figure 1**), hereafter referred to as 'the Site'. The Site, approximately centred upon OS NGR 456465 432040, lies some 2km northwest of the village of Thorpe Willoughby and covers some 90 hectares, although the physical impact of the development will be considerably smaller than this (FAS 2008).
- 1.1.2 The aim of the project was to conduct geophysical survey to establish the presence/absence, extent, character and date of detectable archaeological remains within the access tracks, compounds and turbine locations of the Site.
- 1.1.3 This report presents a brief description of the methodology followed, the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 Survey areas

- 1.2.1 A 30m wide corridor centred upon the proposed tracks, 100m x 100m areas around turbine centres and areas around ancillary compounds and other works were investigated through geophysical survey. A proportion of the Site was not suitable for gradiometer survey due to ground conditions, terrain and other obstructions; in particular, some parts of the access track closely follow existing drainage channels. A total area of approximately 18.7ha was found to be accessible for detailed gradiometer survey.
- 1.2.2 The Site comprises arable land in the form of large irregular fields, which are crossed by a number of sizeable drainage channels. The Site is bounded to the north by a golf course and caravan park, and to the south by a railway line.
- 1.2.3 The superficial geology underlying the Site is likely to comprise a mixture of alluvium and wind blown sands overlying Triassic sandstone. The soils are likely to be typical brown sands of the 551d association and the typical cambic gleys of the 831b association (SSEW 1983). Soils in such geological settings have been shown to produce magnetic contrasts suitable for detection of archaeological remains through survey with the Bartington Grad 601-2 gradiometer.

2 METHODOLOGY

2.1 Introduction

- 2.1.1 A geophysical specification was prepared by Wessex Archaeology to investigate the Site. The methodology consisted of detailed gradiometer survey conducted using Bartington Grad 601-2 dual gradiometer systems. The survey was conducted in general accordance with English Heritage guidelines *Geophysical Survey in Archaeological Field Evaluation* (2008).
- 2.1.2 The geophysical survey was conducted by Wessex Archaeology's in-house geophysics team from 2nd to 18th March and from 30th March to 1st April 2009. Survey grids were established at 30m x 30m and located using a Leica 1200 RTK GPS system, which is precise to within 0.05m and therefore exceeds English Heritage recommendations.
- 2.1.3 The detailed gradiometer survey was conducted using a Bartington Grad 601-2 Gradiometer system over 30m x 30m grids with a sample interval of 0.25m along transects spaced 1m apart.
- 2.1.4 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

3 **RESULTS AND INTERPRETATION**

3.1 Introduction

- 3.1.1 The geophysical survey identified a number of anomalies of anthropogenic origin and the results are presented as a series of greyscale and interpretation plots of the Site at a scale of 1:2000 (**Figures 2** to **11**).
- 3.1.2 The interpretation of the datasets highlights the presence of potential archaeological anomalies, trends, ferrous/burnt or fired objects, areas of general increased magnetic response, and anomalies of probable geological origin. Full definitions of the interpretation terms used in this report are provided in **Appendix 2**.
- 3.1.3 Numerous ferrous anomalies, modern drainage and the effect of existing tracks are visible throughout the detailed survey dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

3.2 Detailed survey results and interpretation

- 3.2.1 Turbine 1 lies at the southwestern extent of the Site (**Figures 2** and **3**). Linear anomaly **4000** perhaps represents a former field boundary, although it does not exhibit clear contrast with the magnetic background. Numerous linear and curvilinear trends are evident nearby; a slight WNW-ESE bias can be seen, perhaps indicating former field systems. Other linear and curvilinear trends are possibly chance alignments of anomalies.
- 3.2.2 Further to the southeast (**Figures 2** and **3**), ploughing trends emulate the nearby extant drainage ditch and boundaries. A pair of sub-linear anomalies **4001** may have some archaeological significance although this interpretation is hampered by the limits of the survey area. Anomalies **4002**, appearing nearby, are likely to be geological or pedological in origin due to their broad and continuous responses; it is conceivable that such anomalies are anthropogenic in origin, although the general magnetic background suggests otherwise, and it is likely that they indicate fluvial or alluvial deposits.
- 3.2.3 Continuing southeast (**Figures 2** to **5**), ploughing trends persist beyond a region of increased magnetic response. The latter marks the transition from the possible geological responses to a more typical magnetic background, culminating at linear anomalies **4003** (**Figures 4** and **5**), which are possibly former enclosures or boundaries. Numerous linear ploughing trends can be observed, along with a pair of isolated anomalies of possible archaeological significance.
- 3.2.4 Beyond the extant drainage channel, broad anomalies **4004** are typical of alluvial deposits (**Figures 4** and **5**). A series of linear responses, for example **4005** and **4006**, may indicate former field divisions or ridge and furrow ploughing; the survey extents limit the interpretation.
- 3.2.5 The modern track, oriented NNW-SSE, is evident in the data (**Figures 4** and **5**). Sub-annular anomaly **4007** may have an anthropogenic origin. Linear anomaly **4008** may be a former field boundary or enclosure ditch. Linear anomaly **4015**, in the region of Turbine 6, is likely to represent a former field boundary. **4015** is coincident with a region of increased magnetic response, which may indicate more magnetic deposits being ploughed to the surface; this may reflect an underlying pedological change, however. Elsewhere, ploughing trends on approximate NNW-SSE and ESE-WSW alignments are evident.
- 3.2.6 The southern portion of the buffer around Turbine 3 was not surveyable due to heavy ploughing; however, the northern portion was accessible (**Figures 4** and **5**). Three linear anomalies are evident in this area; **4016**, approximately 1.5m wide, is aligned approximately N-S and is likely to represent a former field boundary. **4017** and **4018** are parallel with each other and aligned approximately NNE-SSW; it is possible that they relate to former field systems or enclosures. Elsewhere, numerous discrete anomalies are similar in response to pits, although their distribution is not coherent. Strong trends aligned NW-SE indicate the current ploughing strategy, demonstrated by the current periphery between the drilled and heavily ploughed soil. Other curvilinear trends may have some archaeological significance, although their lack of contrast with the magnetic background makes this interpretation more tentative.

- 3.2.7 The area around Turbine 2 (**Figures 6** and **7**) is dominated by orthogonal ploughing trends oriented largely WNW-ESE and NNE-SSW. A pair of parallel linear anomalies **4012** can be seen on a NE-SW orientation. These anomalies do not correlate with current topographic features and it is assumed that they indicate former field boundaries, given the form and magnitude of their responses. The strong ploughing trends persist along the cable route to the east. Some trends to the north of **4012** show some curvilinearity and may have more archaeological significance than those clearly indicating ploughing.
- 3.2.8 Strong ferrous responses in the vicinity of the proposed contractor's compound and substation can be observed (**Figures 6** and **7**), which are due to an area of hardstanding and an abandoned mechanical excavator. Immediately south lies a National Grid pylon. Along the cable route to the south, the only anomalies of note are small and isolated; it is conceivable that they are of archaeological interest although the interpretation is hampered by the width of the corridor.
- 3.2.9 Ploughing trends, oriented NNW-SSE and E-W, dominate the area around Turbine 4 (**Figures 8** and **9**) and along the cable route towards the east. Rectilinear anomalies **4013** and **4014**, lying to the south and southwest of Turbine 5, may indicate former field divisions or enclosures and are perhaps of some archaeological interest.
- 3.2.10 Around Turbine 5 (**Figures 8** and **9**), two regions of increased magnetic response can be seen within the data set. It is likely that anomalies **4009** and **4010** are natural in origin, given the close proximity of other responses characteristic of geological sources. However, they exhibit somewhat different form, and it is conceivable that they are anthropogenic in origin. Numerous anomalies **4011** indicative of ceramic field drains appear in a 'herringbone' distribution, characteristic of post-medieval and later strategies. A profusion of ploughing trends on the same alignment can also be observed.
- 3.2.11 The region surrounding Turbine 7 exhibits further strong ploughing trends, again on approximately N-S and E-W alignments (**Figures 8** and **9**); it is possible that these trends represent the remains of ridge and furrow, or ceramic field drains. Other stronger anomalies can be observed, at the northern extent of the survey area around Turbine 7 for instance, which may be of some archaeological interest although their interpretation has been hampered by the strong ploughing. It is conceivable that some of these responses are the result of ceramic drainage, given the linearity of the anomalies, although this cannot be proven without invasive testing. A small region of increased magnetic response to the south of Turbine 7 is characteristic of a geological origin, and may reflect the close proximity of an extant drainage channel to the south.

- 3.2.12 The proposed track extends north then east from Turbine 5 towards Dam Lane to the east and closely follows existing drains and tracks (**Figures 10** and **11**). Immediately north of Turbine 5, a region of increased magnetic response is evident within the dataset and is perhaps the result of magnetic deposits being ploughed to the surface; it is possible that this enhancement has an archaeological origin. Two linear anomalies **4019** may represent former field boundaries or enclosures. A series of linear anomalies and trends **4020** may indicate the remnants of ridge and furrow; between **4019** and **4020**, strong disturbance associated with the nearby pylon is clearly visible in the data. Elsewhere, weak linear trends aligned approximately W-E indicate the current ploughing direction.
- 3.2.13 To the east of Dutchman's Dike (Figures 10 and 11), linear anomalies 4021 probably represent a single boundary or enclosure ditch. Linear anomaly 4022 is almost certainly a spur of this drainage ditch, extending out of the survey area to the northeast, and was probably backfilled in the relatively recent past; however, the presence of palaeoenvironmental deposits cannot be discounted. Immediately east of 4022, the magnetic background is noticeably quieter as far as the extant eastern boundary of this field, aside from a few isolated anomalies and linear ploughing trends.
- 3.2.14 To the east of the boundary (**Figures 10** and **11**), the route turns southeast until it meets the extant track, with numerous linear ploughing trends aligned approximately W-E appearing in this area. The response from the modern track dominates the central portion of the survey area as far as Dam Lane; it should be noted that the part of the extant N-S boundary has been removed and this appears in the data as ferrous disturbance to the north of the track. Linear trends are probably indicative of ploughing although they do not appear to have a prevailing orientation. A number of isolated anomalies may be anthropogenic in origin, although their distribution is somewhat erratic. At the eastern extent of the survey area, numerous linear and curvilinear trends are apparent, with a region of increased magnetic response bordering Dam Lane. Modern service **4023** extends towards the northwest from the boundary, the strong ferrous response indicating a steel pipe.

4 CONCLUSION

4.1 Introduction

- 4.1.1 The detailed gradiometer survey has been successful in detecting anomalies of possible archaeological potential throughout the Site, although no anomalies of definite archaeological origin were identified.
- 4.1.2 The strong magnetic response of the existing tracks across the Site did not prohibit the survey of land adjacent to these tracks. Numerous linear anomalies and trends were identified across the Site which are due to either ploughing or ceramic drainage systems. Where anomalies could definitely be identified as being related to modern drainage systems they have been marked as such, for example in the area around Turbine 5.

4.2 Conclusions

- 4.2.1 The gradiometer survey has located twenty-nine linear anomalies of possible archaeological potential across the Site. These anomalies exhibit stronger magnetic responses than the many linear trends, which are thought to relate to former ploughing. The anomalies of possible archaeological potential are thought to predominantly be former field boundaries although in places they may be caused by ploughing and are producing a stronger response than others in close proximity.
- 4.2.2 The most complex groups of linear anomalies are **4009**, **4010**, and **4013** to **4021**; all of these are thought to represent former field boundaries or enclosures. No known archaeological features were identified in the desk-based assessment (FAS, 2008) within the boundaries of the Site. However, the Site covers an area of large irregular fields and it may be that some field boundaries have been removed relatively recently and would produce similar linear anomalies. Linear anomaly **4022** is thought to represent a backfilled spur of Dutchman's Dike.
- 4.2.3 It is possible that a number of the linear ploughing trends and anomalies of possible archaeological interest are indicative of surviving ridge and furrow. Instances of such ploughing are noted in the surrounding area, and it is possible that some unidentified ridge and furrow exists within the boundaries of the Site. Perhaps the best candidates are anomalies at **4020**.
- 4.2.4 The character of the magnetic responses was consistent across the majority of the Site, with the notable exception of anomalies **4004** and **4005**, which are thought to represent a localised change in geology or pedology.

5 **REFERENCES**

English Heritage, 2008. *Geophysical Survey in Archaeological Field Evaluation*. Research and Professional Service Guideline No 1, 2nd edition.

Soil Survey of England and Wales, 1983. *Soils of Northern England: Sheet 1*. Ordnance Survey, Southampton.

FAS, 2008. Bishop Wood and Wood Lane, Selby, North Yorkshire: Archaeological Desk-Based Assessment. FAS report FAS2008 414 BBW365.

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APPENDIX 1: SURVEY EQUIPMENT AND DATA PROCESSING

Survey Methods and Equipment

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have a resolution of 0.1nT over a $\pm 3000nT$ range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica 1200 RTK GPS system and then extended using tapes. The Leica 1200 RTK GPS system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined to an accuracy of 1-2cm in real-time and therefore exceed the level of accuracy recommended by English Heritage (2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detail surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (English Heritage, 2008).

Post-Processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger Shifting each traverse forward or backward by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike Filtering any data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings caused by modern, small ferrous objects at the surface

Typical displays of the data used during processing and analysis:

- XY Plot Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This image can include a hidden line algorithm to remove certain lines and enhance the image. This type of image is useful as it shows the full range and shape of individual anomalies.
- Greyscale Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

APPENDIX 2: GEOPHYSICAL INTERPRETATION

The interpretation methodology used by Wessex Archaeology separates the anomalies into two main categories: archaeological and unidentified responses.

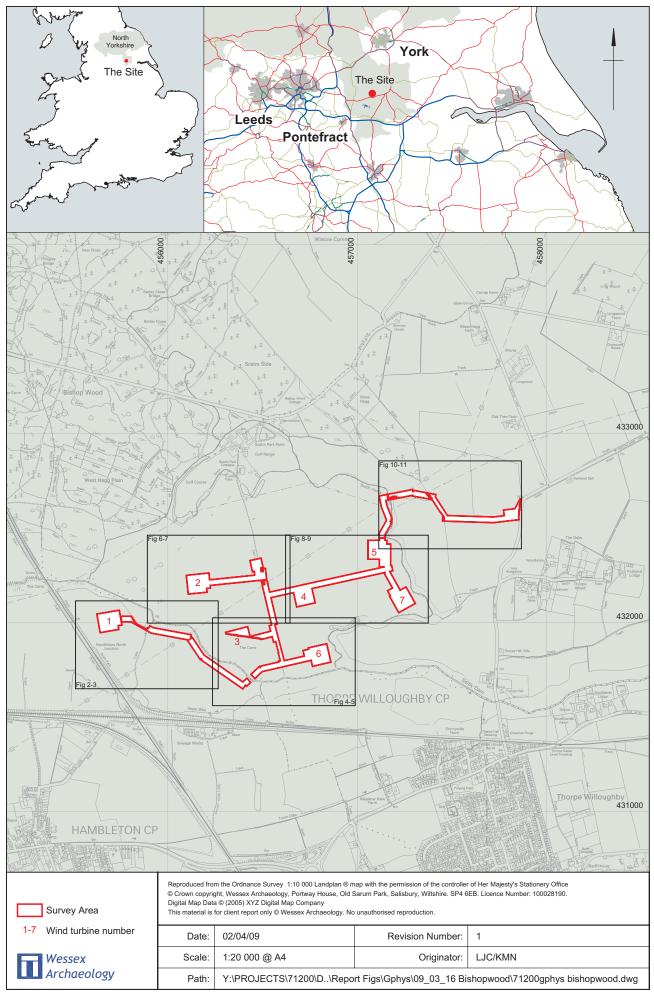
The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

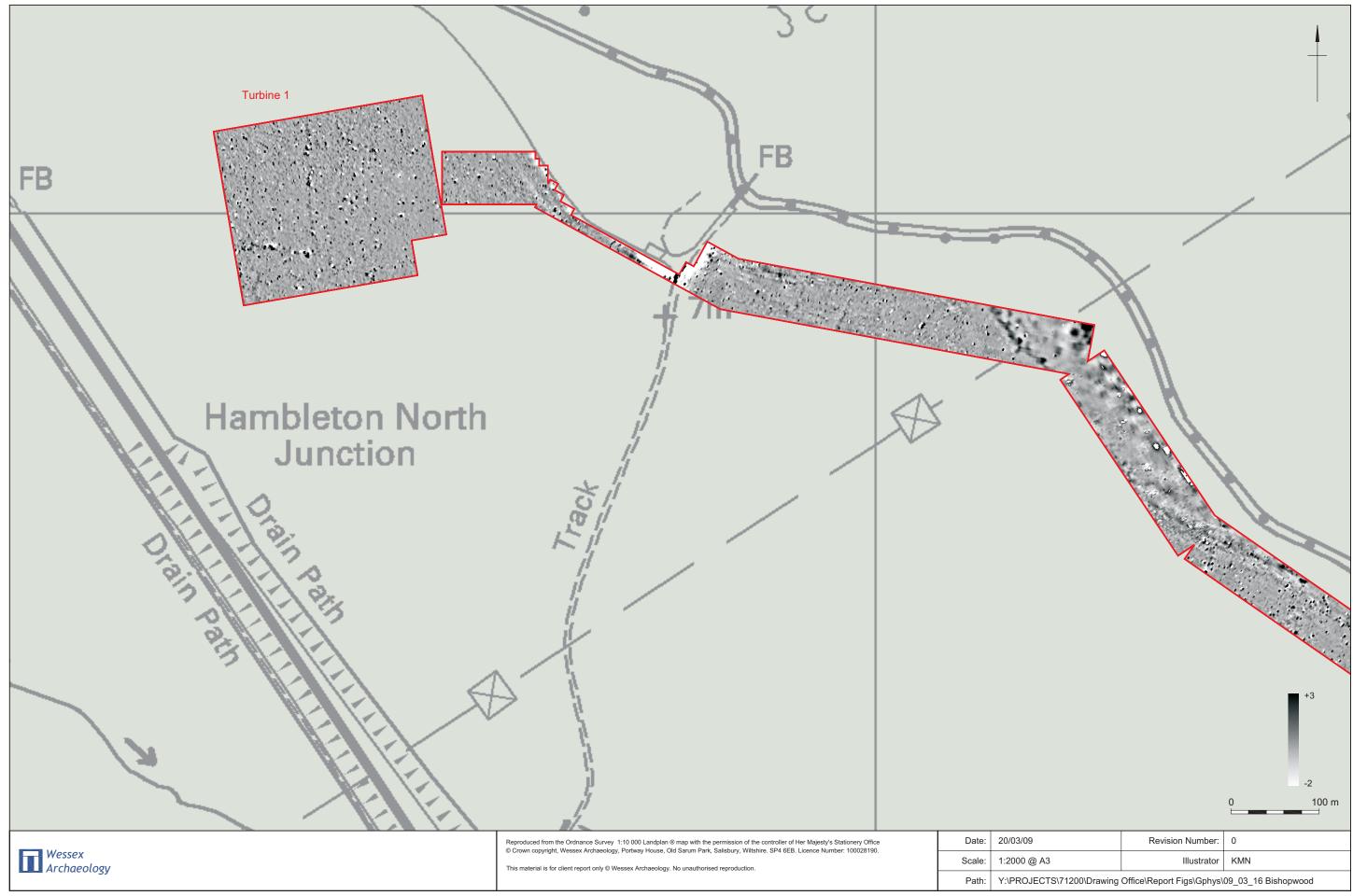
- Archaeology used when there is a clear geophysical response and anthropogenic pattern.
- Probable archaeology used for features which give a clear response but which form incomplete patterns.
- Possible archaeology used for features which give a response but which form no discernable pattern or trend.

The unidentified category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend used for low amplitude or indistinct linear anomalies.
- Ferrous used for responses caused by ferrous material. These anomalies are likely to be of modern origin.

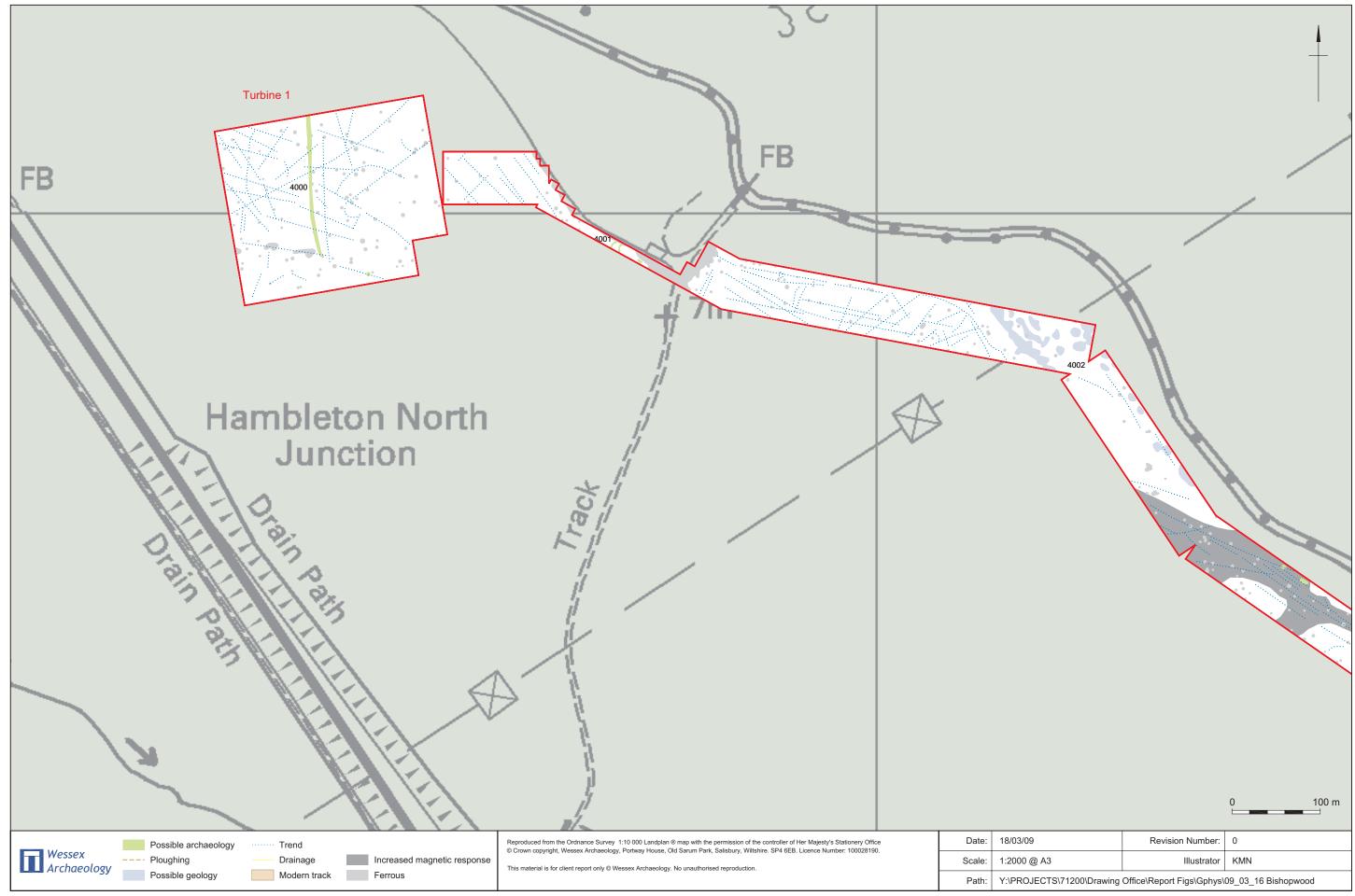
Finally, services such as water pipes are marked where they have been identified.





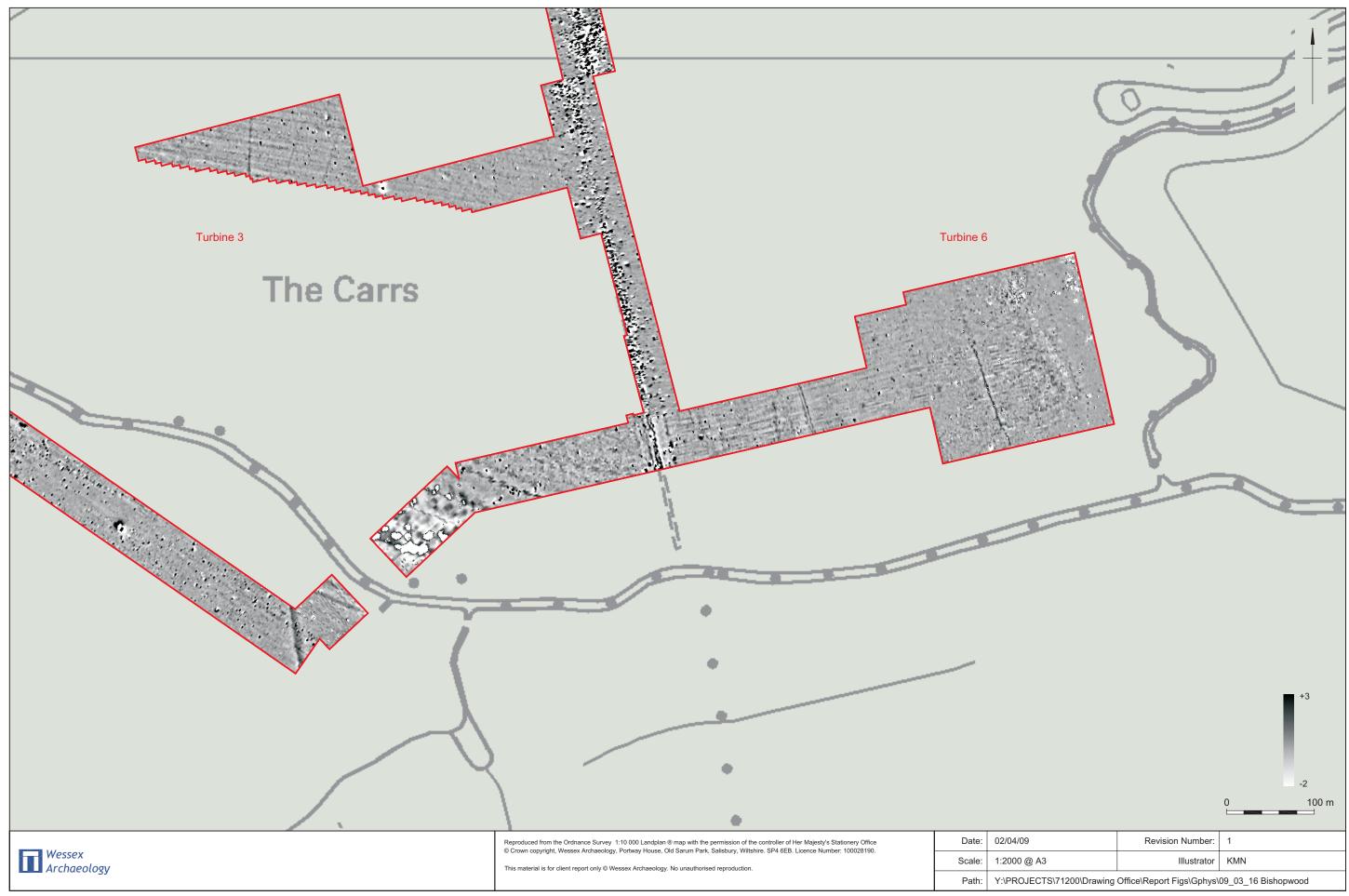
Greyscale plot of turbine 1

Figure 2



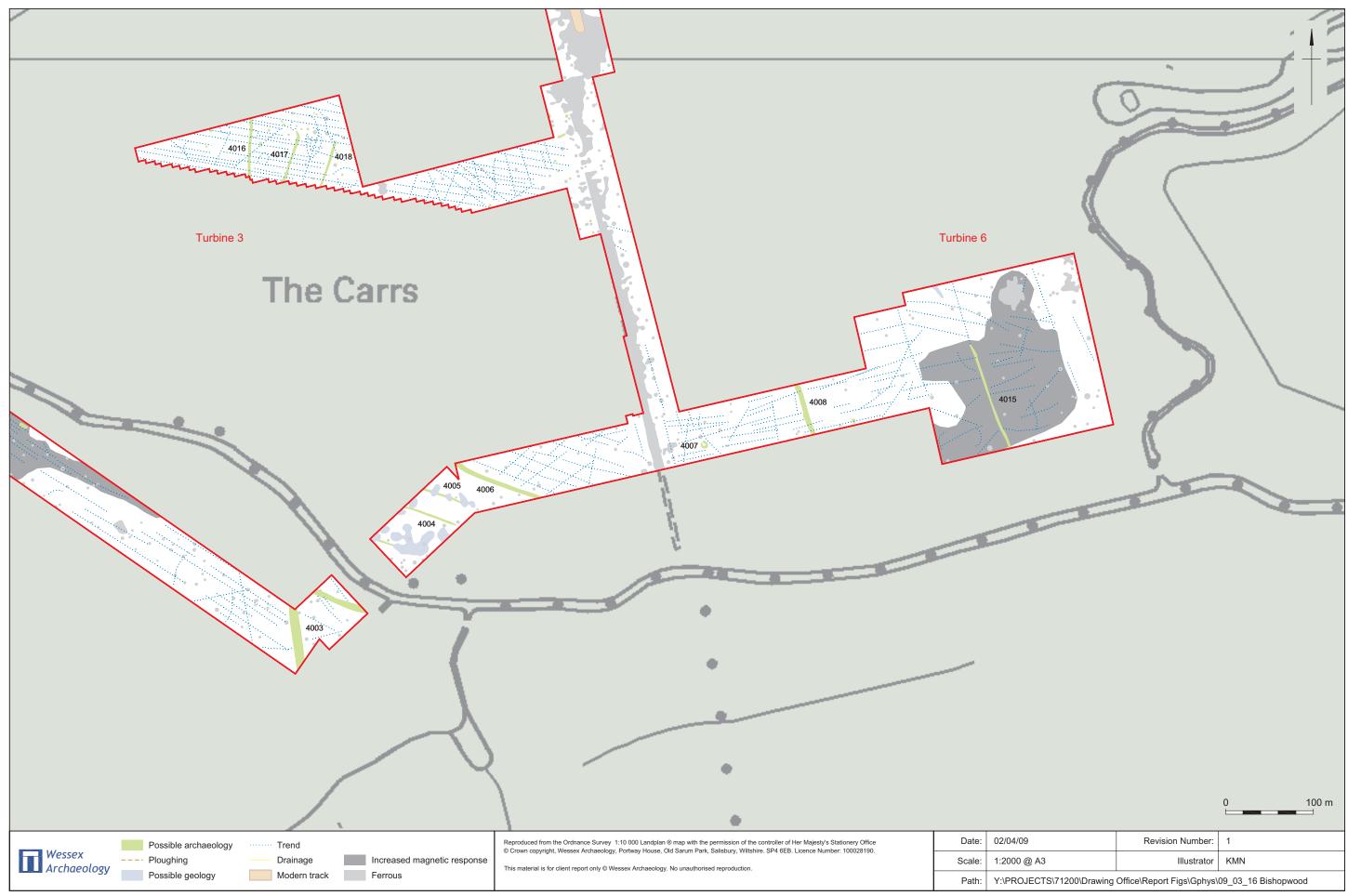
Interpretation plot of turbine 1

Figure 3



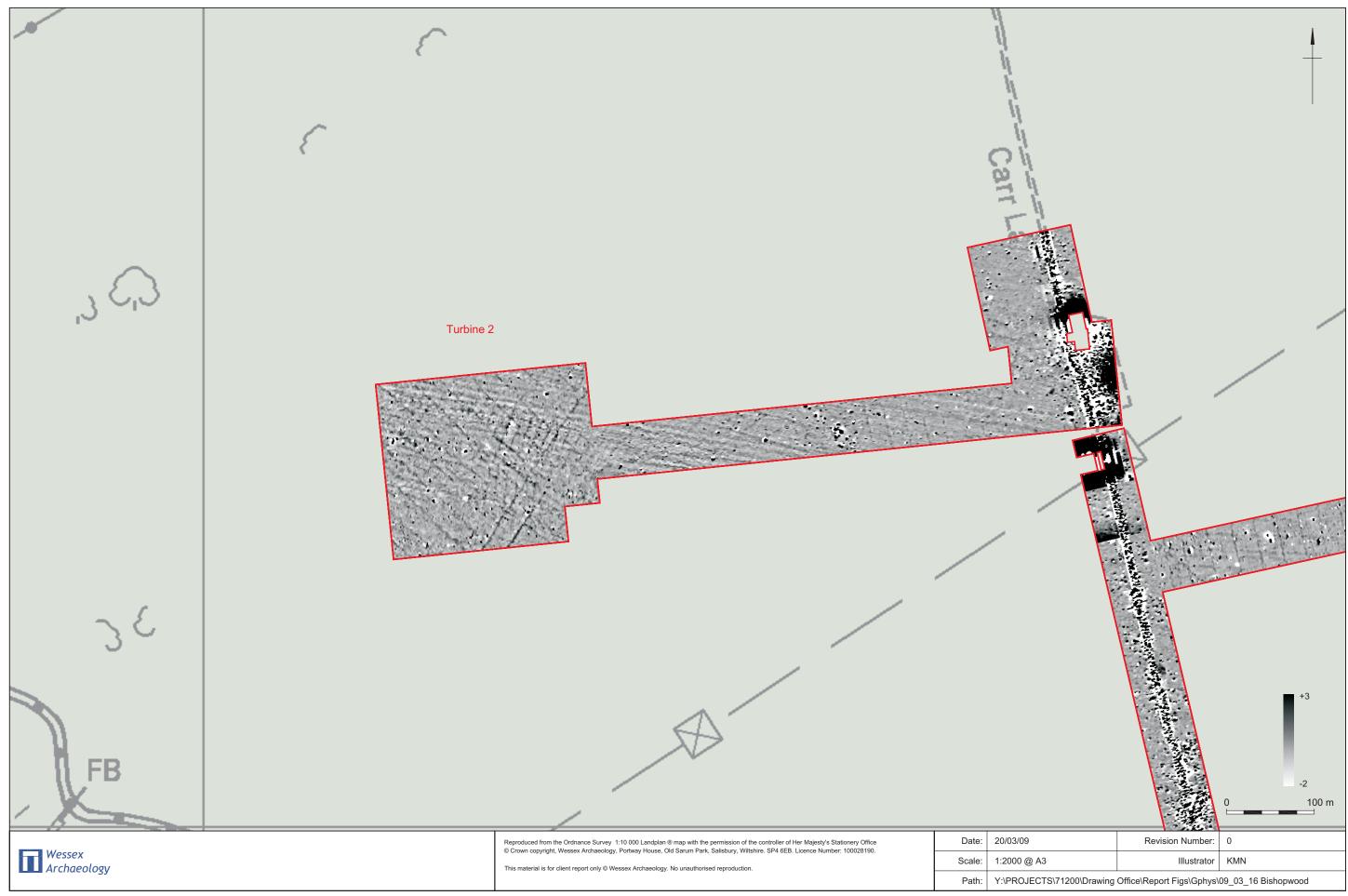
Greyscale plot of turbines 3 and 6

Figure 4



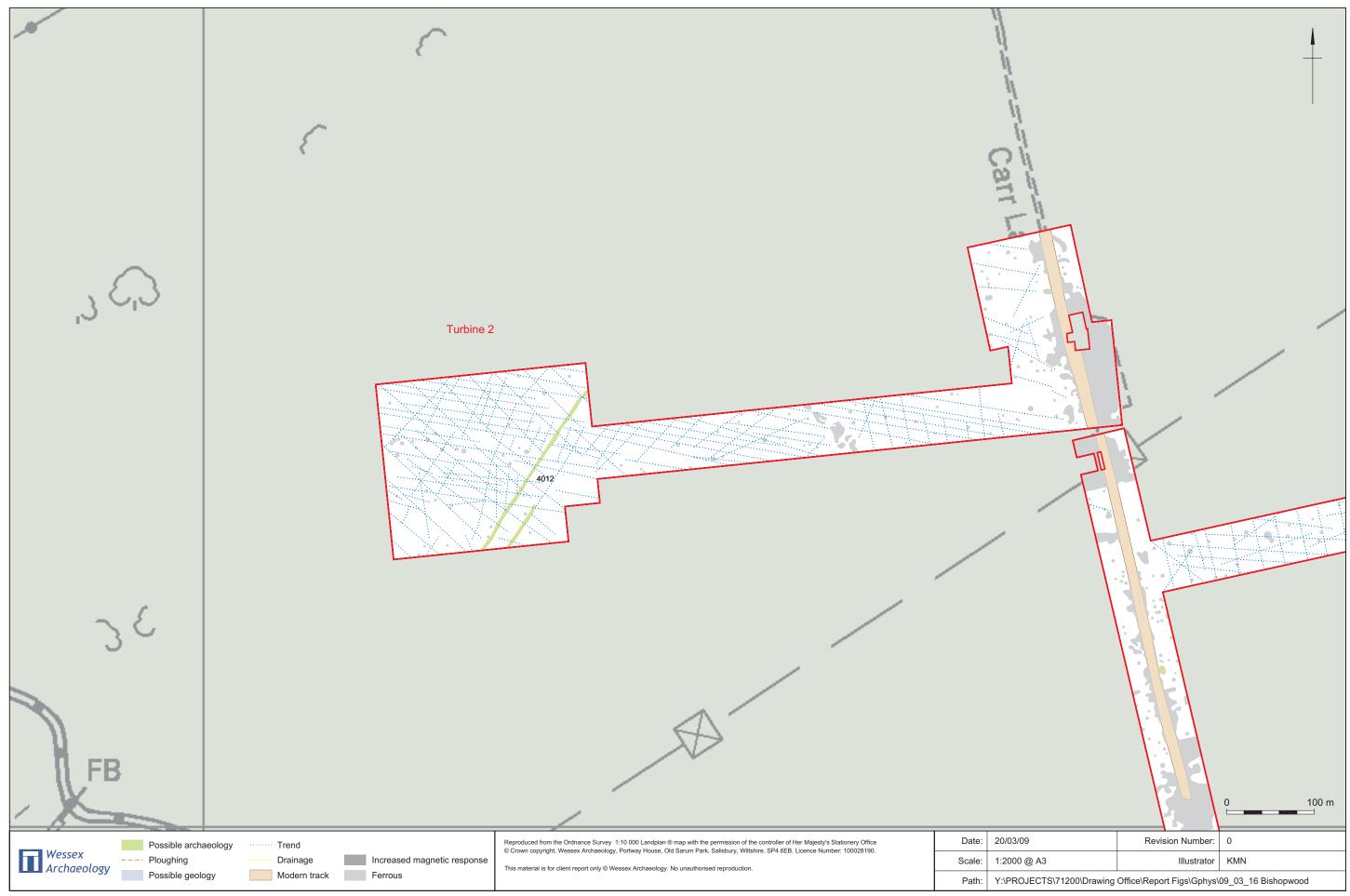
Interpretation plot of turbines 3 and 6

Figure 5



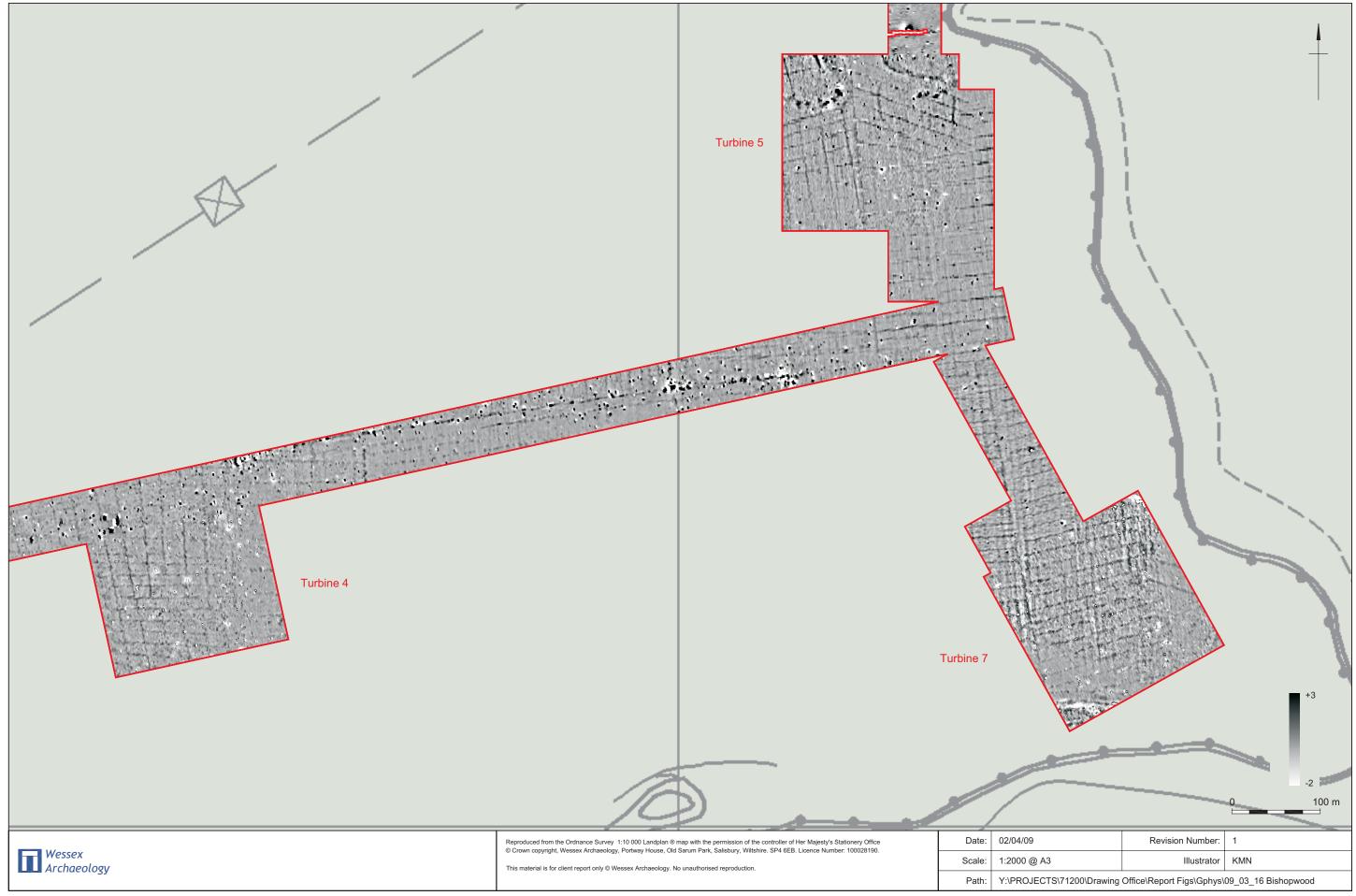
Greyscale plot of turbine 2

Figure 6



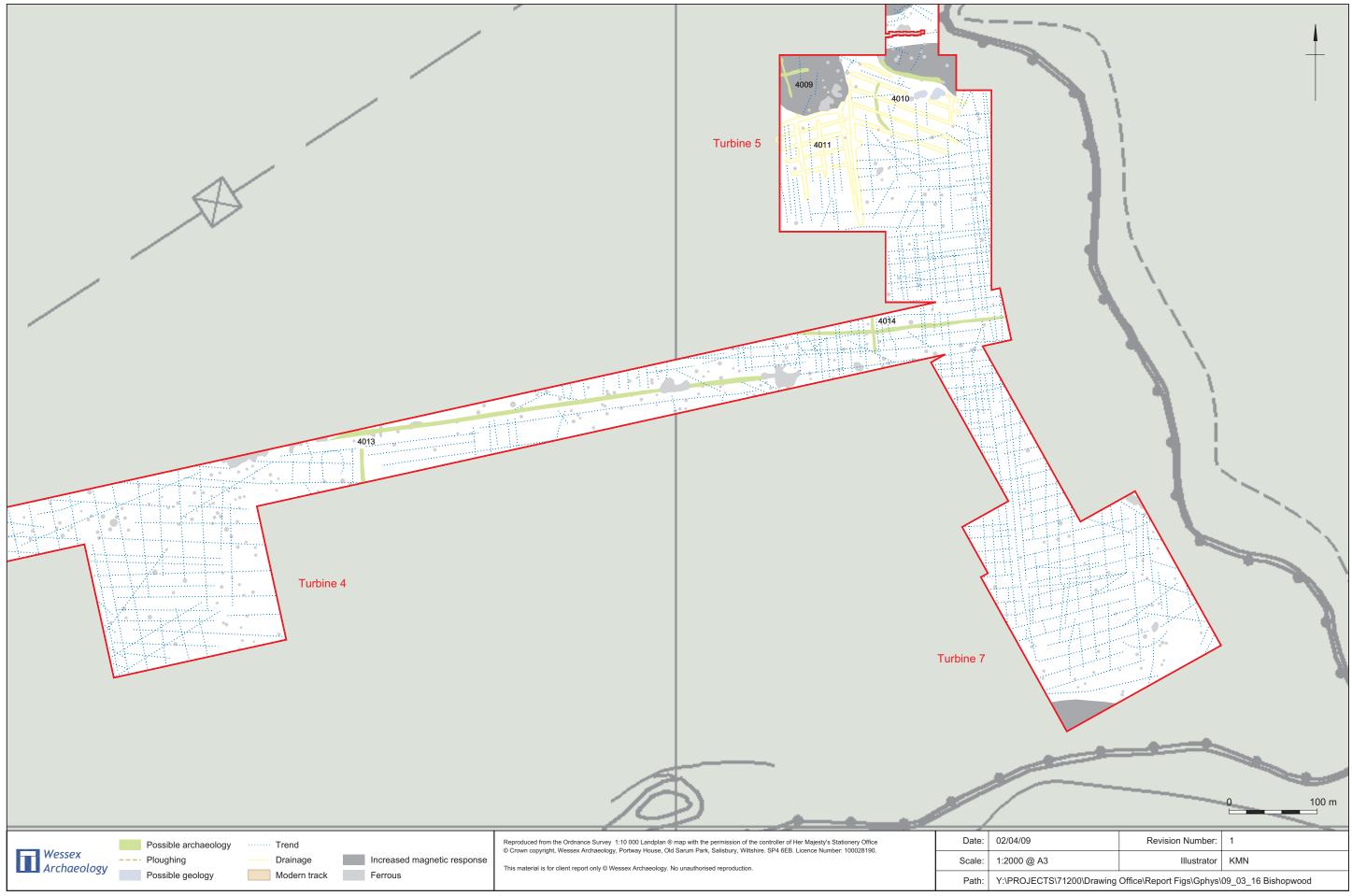
Interpretation plot of turbine 2

Figure 7



Greyscale plot of turbines 4, 5 and 7

Figure 8



Interpretation of turbines 4, 5 and 7

Figure 9

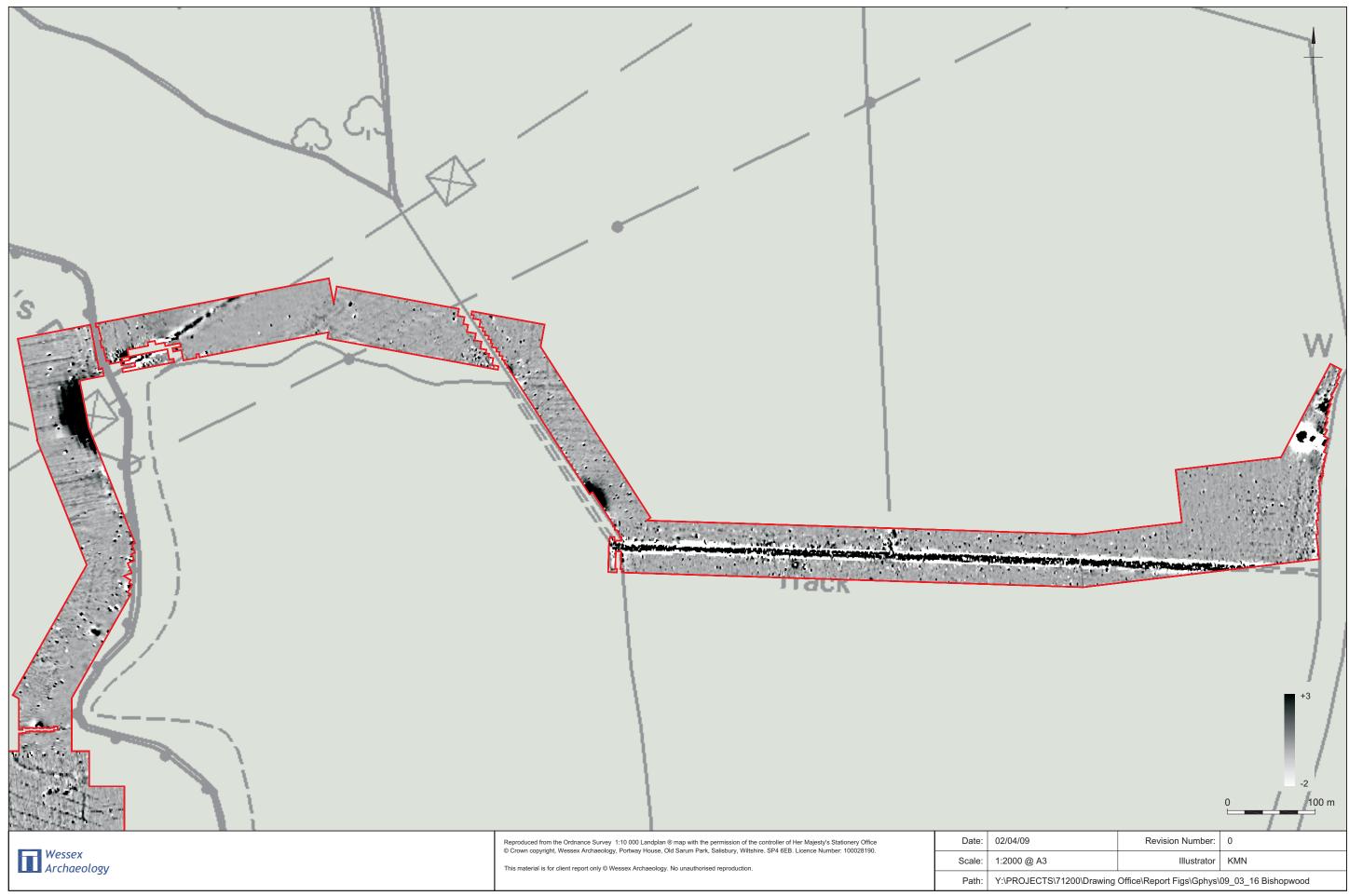
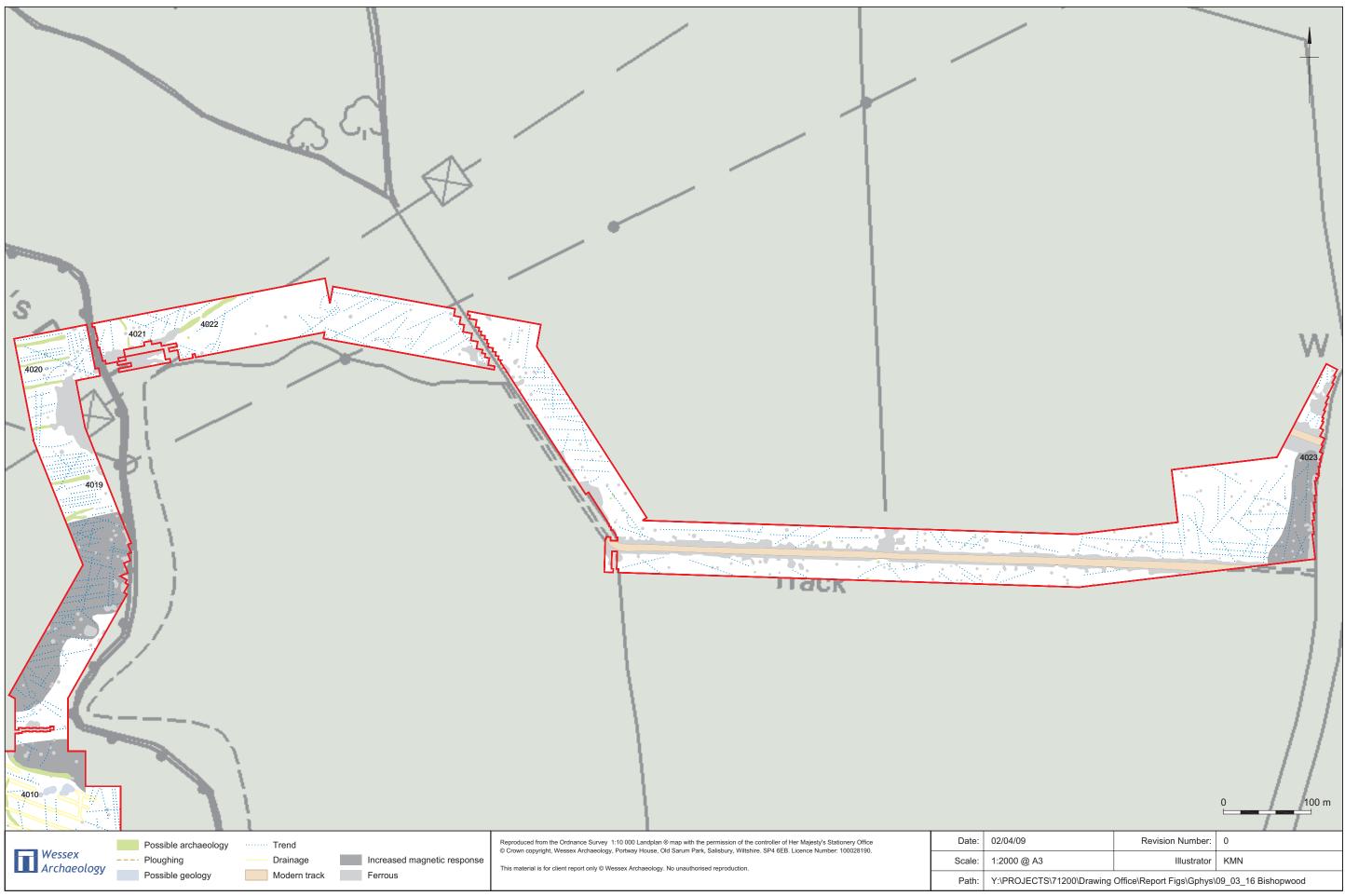


Figure 10



Interpretation of Link to Dam Lane

Figure 11





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