Springwell Solar Farm

Environmental Statement
Appendix 9.4: Geophysical Survey Report

Part 1

Volume 3

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Springwell Energyfarm Ltd

Document Parts

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1. Non-technical summary

1.1.1. Headland Archaeology (UK) Ltd was instructed by RSK on behalf of Springwell Energyfarm Ltd (the Applicant) to undertake two geophysical (magnetometer) surveys on a contiguous parcel of land measuring approximately 1559 hectares (ha) in size (the Geophysical Survey Area – GSA), located 15km south of Lincoln between the villages of Metheringham and Brauncewell, Lincolnshire, at the site of the proposed Springwell Solar Farm.

1.1.2. The results of both an initial geophysical survey covering the main areas which may form part of the solar farm proposals measuring approximately 1490ha and a subsequent survey across four fields being considered for cable route options measuring roughly 69ha were originally reported on separately but are both detailed herein. The later survey covering the cable route option is contained within the **Annex 1** of this report. This geophysical survey report, together with the **Environmental Statement (ES) Volume 3, Appendix 9.1: Archaeological Desk-Based Assessment [EN010149/APP/6.3]), ES Volume 3, Appendix 9.2: Geoarchaeological Deposit Modelling Report [EN010149/APP/6.3], ES Volume 3, Appendix 9.3: Aerial Investigation and Mapping Report [EN010149/APP/6.3]** and **ES Volume 3, Appendix 9.5: Archaeological Trial Trenching Report [EN010149/APP/6.3]** have informed the Environmental Impact Assessment (EIA) produced in support of a development consent order (DCO) application for the construction of the solar farm. The geophysical survey results will also inform future archaeological strategy.

1.1.3. The original larger survey evaluated an area of approximately 1490ha and not unexpectedly recorded a wide variety of archaeological and non-archaeological anomalies. The results of the survey largely corroborated, but also greatly expanded, the current understanding of the archaeological potential of the proposed site as contained within the Lincolnshire Historic Environment Record (LHER). It is evident from the survey results and information contained within the LHER that there were significant levels of prehistoric activity within different areas of the GSA from at least the Bronze Age, likely continuing through into the Iron Age before the two Roman roads that bisect the site were constructed.

1.1.4. The main findings of the original larger survey include several foci of archaeological activity ranging from ring ditches and likely round barrows, pit alignments and extended series and/or concentrations of ditches, enclosures and pit-like anomalies located at the southern extent of the GSA near Brauncewell Quarry, to the north and south of Hall Farm (Bloxholm), surrounding RAF Digby to the south, east and north-east, north of Ashby de la Launde and Scopwick and west of Brickyard Farm where the archaeological potential must be considered very high. The only

findings of note from the subsequent survey for the cable route option were two pit alignments, one located adjacent to the A15 and the other south-west of RAF Digby which marked a continuation of a much longer pit alignment recorded in the original survey.

1.1.5. Outside of these foci of activity, a regular gridded pattern of weakly magnetically enhanced, linear trend anomalies aligned north-west/south-east was identified in almost every field west of the B1191. An anthropogenic cause for these ditch-like anomalies, such as a relict field system, was considered most likely given the homogeneity and regularity of the responses over such a large area. Subsequent trial trenching found that these features represented variations and fracturing in the bedrock limestone geology.

1.1.6. Elsewhere, magnetic anomalies identifying; former ponds, buildings, pits and extraction sites, agricultural trends including ridge and furrow and modern cultivation patterns, former boundaries, field drains and buried services and those arising from natural/geological variations are widely recorded across the GSA.

1.1.7. Where the survey has identified more significant levels of archaeological activity not previously recorded in the LHER includes the land between Ashby de la Laund and RAF Digby, north-east of RAF Digby and south of Blankney. Whilst the survey data has shown dense areas of archaeological activity exist within and between locations identified in the LHER as containing archaeological assets, the results also identify large areas within the GSA where the archaeological potential is considered low, particularly across fields adjacent to the A15 (but further north of Brauncewell Quarry) and the easternmost fields of the site.

1.1.8. The level of detail and range of anomalies recorded across both surveys is argued to provide a high level of confidence in the findings and that they accurately reflect the archaeological potential of the GSA, notwithstanding the limitations of magnetometer survey to define particularly small, very weakly enhanced or anomalies masked by areas of disturbance and/or stronger magnetic anomalies.

1.1.9. The results from a contiguous survey of this size have contributed a wealth of information to the understanding of not only individual foci of archaeological activity within the GSA but the archaeological potential of the area and wider landscape. Further analysis of the archaeological significance of some of the features recorded by the survey beyond their spatial distribution and potential relationship with other features is perhaps merited, however lies beyond the scope of this survey report.

2. Introduction

2.1. Background and scope of survey

2.1.1. Headland Archaeology (UK) Ltd was instructed by RSK on behalf of Springwell Energyfarm Ltd (the Applicant) to undertake a geophysical (magnetometer) survey on a contiguous parcel of land measuring approximately 1490ha in size located 15km south of Lincoln between the villages of Metheringham and Brauncewell, Lincolnshire, at the site of the proposed Springwell Solar Farm (**Figure 1**).

2.1.2. The geophysical survey report, alongside **Environmental Statement (ES) Volume 3, Appendix 9.1: Archaeological Desk-Based Assessment [EN010149/APP/6.3]**), **ES Volume 3, Appendix 9.2: Geoarchaeological Deposit Modelling Report [EN010149/APP/6.3]**, **ES Volume 3, Appendix 9.3: Aerial Investigation and Mapping Report [EN010149/APP/6.3]** and **ES Volume 3, Appendix 9.5: Archaeological Trial Trenching Report [EN010149/APP/6.3]** has informed the Environmental Impact Assessment produced in support of a development consent order (DCO) application for the construction of the solar farm. The geophysics survey results will also inform future archaeological strategy, if required.

2.1.3. The survey was undertaken in accordance with a Written Scheme of Investigation for Geophysical Survey (WSI) (**Annex 2**), following guidance contained in the National Planning Policy Framework (NPPF) **[Ref. 1]** and was carried out in line with current best practice guidance prepared by Chartered Institute for Archaeologists (CIFA) **[Ref. 2]** and the Europae Archaeologia Consilium (EAC) **[Ref. 3].**

2.1.4. The significant majority of the survey was undertaken during an initial largely uninterrupted phase of work (except for Christmas and New Year) between October 17th, 2022 and March 9th, 2023. Revisions to the Geophysical Survey Area (GSA) boundary during the survey led to the inclusion of three additional fields (E1, W1 and W2) at the southern end of the site which were surveyed between March 15th and April 4th, 2023. Other fields were removed as design proposals evolved. Initially unsuitable fields under heavy plough at the time of the original survey were subsequently surveyed between May 9th and May 12th 2023.

2.1.5. Additional fields have since been added to the GSA to evaluate cable route options. The results of the survey of the cable route option areas are presented in Annex 1.

2.1.6. All the accessible parcels within the GSA were surveyed with the total area surveyed amounting to approximately 1490ha. For such a large area there were generally very few areas within the GSA that were unsuitable

for survey with only a few examples of overgrown or waterlogged patches and strips of bird cover at the field margins.

2.2. Location, topography and landuse

2.2.1. The GSA comprises an irregular shape parcel of land broadly aligned north-east to south-west located approximately 15km south of Lincoln, spread across conjoining fields situated between the villages of Metheringham and Brauncewell, Lincolnshire. The GSA can broadly be sub-divided into three parcels spanning Sectors 1-4 (**Figures 2** and **3**) extending from NGR 503498, 351995 adjacent to Brauncewell quarry in the south, to the northernmost field bound by Blankney Moor Lane at NGR 507969, 360600.

2.2.2. The western and southern parts of the GSA covered by Sectors 1 and 2 lie immediately adjacent to the A15 to the east and west between Brauncewell Quarry and south of RAF Digby. Sector 3 spans the central section of the GSA surrounding RAF Digby to the south, east and north-east heading towards the village of Scopwick. The northernmost block of land within the GSA covered by Sector 4 lies north-east of Scopwick and is bound by the Peterborough to Lincoln railway to the east.

2.2.3. At the landscape scale the topography of the GSA gradually slopes down from a height of approximately 54m above Ordnance Datum (AOD) west of the A15 at the north-west corner of Sector 1, down to roughly 7m AOD at the north-east corner of the GSA where it is bound by the railway and approximately 36m AOD at the southernmost boundary of the GSA. Generally, there is more topographic variation in the western half of the GSA, markedly in the location of sinuous variations in the underlying limestone bedrock geology as highlighted by LiDAR and geology data respectively (**Figure 4**). There is little topographic variation within the fields of the eastern half of the site.

2.2.4. The fields within the GSA are predominantly agricultural in nature containing a mix of arable crops and pasture. Ground conditions were generally very good across the GSA with many fields surveyed post-harvest and between crop rotations. Multiple wooded areas and coppices are scattered in and around the site and are not included in the GSA. There is one watercourse that runs roughly east/west through the GSA in Sector 3 to the water treatment plant east of RAF Digby, the Site also contains drainage ditches along field boundaries.

2.3. Geology and soils

2.3.1. The solid bedrock geology beneath most of the GSA consists of different formations of sedimentary Jurassic period limestone that belongs to the Southern Lincolnshire Edge, a north/south linear scarp of limestone running the length of Greater Lincolnshire. However, the geology is considerably more complex east of the B1191 compared to the west

(**Figure 4** inset). To the west limestone of the Upper Lincolnshire Limestone Member underlies nearly all the GSA covered by Sectors 1 and 2. The exception is a narrow band of Lower Lincolnshire Limestone Member limestone that runs from the B1191 in the east, on a broadly south-west/northeast alignment, to the western edge of the GSA on Temple Road, crossing fields TB3, TB4, Bcd114 and Bcd115. Just east of the A15 this band bi-furcates with a second band running in a north-westerly direction up to the western edge of the GSA in field BCD102. The sinuous spread of this band of Lower Lincolnshire limestone coincides with the topographic variations in this part of the GSA seen in LiDAR data (**Figure 4**) with dry valleys evident in the fields it crosses.

2.3.2. The only other variation in bedrock geology in these sectors underlies Bcd11 and Bcd120 where limestone of the Blisworth Limestone Formation is recorded surrounding a thin band of Argillaceous rocks with subordinate sandstone and limestone of the Rutland Formation.

2.3.3. The change in bedrock geology across Sector 3 largely respects the route of the B1191 through RAF Digby to the north and south where limestone of the Blisworth Formation lies to the east and Lincolnshire and Upper Lincolnshire Formations lay to the northwest and south-west respectively. Two small patches of mudstone of the Blisworth Clay formation lie within fields Rw02 and the north-eastern corner of RW10.

2.3.4. The bedrock geology underlying Sector 4 appears as four bands loosely aligned north to south the westernmost of which is recorded as Blisworth Limestone Formation limestone. To the east are two thin sinuous bands of mudstone and limestone of the Cornbrash Formation followed by a larger band of sandstone, siltstone and mudstone of the Kellaways Formation.

2.3.5. No superficial deposits are recorded over a significant majority of the GSA. Two sinuous bands of sedimentary sand and gravel deposits follow the course of dry valleys and natural depressions in the limestone bedrock aligned roughly east/west in the southern part of the GSA spanning the northern parts of fields Bcd108, Bcd109, Bcd110 and Bcd111 and across the southernmost field in the GSA, W2. A small spread of clay, silt, sand and gravel Head deposit is also recorded alongside the sand and gravel deposits in W2. A spread of clay and silt tidal flat deposits encroaches from the north into parts of By02 and By03 and are the only other superficial deposits recorded across the GSA **[Ref. 4].**

2.3.6. The overlying soils of the GSA are less varied than the underlying geology with three broad areas identified. To the south and west of RAF Digby (Sectors 1 and 2) the overlying soils are classified in the Soilscape 3 Association, characterised as shallow lime-rich loamy soils over chalk or limestone. To the east and north-east of RAF Digby (Sectors 3 and 4) the soils are classified in the Soilscape 5 Association described as freely draining lime-rich loamy soils. The easternmost fields of the GSA (Sector 4) around Acre Lane are classified in the Soilscape 22 Association,

characterised as loamy soils with naturally high groundwater **[Ref. 5]** (**[Ref. 5]**).

2.3.7. Guidance published by English Heritage **[Ref. 6] (Table 4)** indicates that magnetometer survey can be recommended over any sedimentary geology and average responses to magnetometer survey over Jurassic limestone are good, although a wide range of magnetic susceptibilities in the parent rock can result in very variable background responses to magnetometer survey. Also, any Quaternary deposits overlying the solid geology are a primary consideration as they often show a high degree of local variation, and the magnetic response is usually dependent on the magnetic mineralogy of the parent solid geology.

2.3.8. The combination of underlying limestone bedrock and widespread absence of superficial deposits means the prevailing geological and pedological conditions for much of the GSA are entirely appropriate for the application of magnetometer survey for the detection of archaeological features. Previous small scale magnetometer surveys bordering the GSA in advance of the expansion of the Brauncewell Quarry site **[Ref. 8], [Ref. 9], [Ref. 10], [Ref. 11]** also yielded positive results highlighting the suitability of the technique in this location.

3. Archaeological background

3.1.1. The following archaeological background is adapted from information detailed within a comprehensive archaeological desk-based assessment (**ES Volume 3, Appendix 9.1: Archaeological Desk-Based Assessment [EN010149/APP/6.3]**) and aerial investigation report (**ES Volume 3, Appendix 9.3: Aerial Investigation and Mapping Report [EN010149/APP/6.3]**).

3.2. Pre-historic

3.2.1. There are 34 records held by the Lincolnshire Historic Environment Record (LHER) relating to prehistoric activity located in part or fully within the GSA. Most of this evidence has been recorded from air photographs during the National Mapping Programme (NMP). Fields within Sectors 1 and 2 show evidence for prehistoric settlement and funerary activity. On the eastern boundary of the GSA in Sector 2 (field Bcd111) a potential prehistoric settlement has been recorded from cropmarks (MLI84458); settlement is also recorded within the northern parts of Sector 3 (fields Bcd066 and Bcd148; MLI87414). Surrounding these areas of settlement is evidence for prehistoric barrow burials. Immediately north of the settlement evidence in Sector 3 is a potential barrow cemetery (MLI87416) and south of RAF Digby (Bcd079) three possible round barrows are recorded close to each other (MLI90994; MLI90995; MLI 90998). Other isolated round barrows are recorded in the wider GSA, further away from settlement evidence in fields Bcd120 (MLI84453) and Bcd148 (MLI90982). A Bronze Age cremation (MLI82506) has also been recorded just outside the GSA, 200m north of field By20 in Sector 4 east of Brickyard Farm but inside the railway bounding the GSA. The relative commonality of round barrows within the GSA and the presence of a Bronze Age burial is indicative of Bronze Age occupation within the GSA.

3.2.2. There is also evidence within the GSA that this area was used during prehistory for agricultural exploitation. More broadly all areas contain cropmark evidence for linear ditches and enclosures. Notably areas east of the A15 in Sectors 1 and 2 which contain two pit alignments (MLI84452; MLI88357) and Sector 3 where two trackways with enclosures nearby are recorded (MLI86753; MLI87413). It is clear that the GSA was occupied during the prehistoric period, the reliance on aerial imagery to identify sites has created a generalisation in time period. However, the considerable presence of round barrows is indicative of a Late Neolithic to Bronze Age presence.

3.2.3. There is assessed to be high potential for prehistoric remains to be present across the GSA due to the considerable evidence recorded here by the NMP. However, it is possible that the continuous ploughing of the area through at least the postmedieval and modern periods has caused damage to below ground archaeological remains.

3.3. Romano-British

3.3.1. The LHER records eight assets of Romano-British date within the GSA, the most significant evidence of which is the Roman road running through Sector 3 crossing fields Rw01, Rw07, Rw08, Rw12 and Bk02 (MLI60813). There is another recorded Roman road following the same alignment as the present A15 (MLI86228). Both roads, described as continuations of Mareham Lane, run from the Roman settlement at Sleaford to the fort at Lincoln. Evidence of Romano-British activity within the GSA is solely made up of artefactual finds which is indicative of this area being frequented by travellers heading between Sleaford and Lincoln.

3.3.2. There is assessed to be low to medium potential for archaeological remains of Romano-British date to survive within the GSA. It is most likely that any remains would most likely be found in Sector 3, probably associated with the Roman road recorded here. Any other remains would likely be artefactual. However, it is possible that the continuous ploughing of the area through at least the postmedieval and modern periods has caused damage to below ground archaeological remains.

3.4. Medieval

3.4.1. The medieval period is poorly represented within the GSA with cropmarks seen in Sector 2 (Bcd111; MLI84457), a parish boundary recorded in Sector 3 (MLI89155) and a brass jetton find recorded immediately north of C6 but outside the GSA (MLI82650). During this period the nearby settlements of Ashby-de-la-Launde (MLI89166), Scopwick (MLI86774), Brauncewell (NHLE1018397) and Temple Bruer (MLI84449) started to develop and just outside Sectors 2, 3 and 4 medieval ridge and furrow is recorded (MLI60568; MLI87033; MLI87419; MLI87446). It is most likely that this area was used for agricultural exploitation during the medieval period.

3.4.2. There is assessed to be medium potential for archaeological remains of this date to survive within the GSA. There is good evidence that this area was farmed during the medieval period, so any remains are likely to be agricultural in nature, for example ridge and furrow ploughing. Such remains were unlikely detected by the NMP and are not visible on air photographs due to the post-medieval and modern ploughing here.

3.5. Post-medieval to modern

3.5.1. The agricultural use of the GSA continued into the post-medieval period. The field boundaries present today can largely all be traced back to tithe maps (Kirkby Green 1840 and Roulston 1843) and first edition Ordnance Survey mapping. The only other evidence recorded for the post-medieval period relates to highly localised, small-scale extraction dotted around the GSA.

3.5.2. The GSA has continued to be used for agriculture into the modern period and there is little evidence to suggest any other use of this area other than for agriculture. The LHER holds two records dating to the modern period: a World War 2 (WW2) aircraft crash site relating to two aircraft (a Lancaster and a Hurricane) in Sector 4 (field By22; MLI125416) and RAF Digby in the north of Sector 3 (MLI60621). There is medium to high potential that remains of a post-medieval to modern date survive within the GSA, but these would most likely be agricultural in nature. However, there is potential that remnants of localised post-medieval extraction could survive as well as evidence of the aircraft crash site in field By22.

3.5.3. There are 247 previous archaeological events within a 2km study area recorded by the Lincolnshire HER. Twenty-five of these are within the GSA. One of these archaeological events is an antiquarian investigation immediately outside the GSA east of Brickyard Farm in the location of a Bronze Age cremation (ELI2712). Another is a research-led investigation of a WW2 pillbox on the northern boundary of Bcd079 (ELI12971) and the remaining events are chance discoveries.

3.5.4. The GSA has been intensively ploughed since the post-medieval period which has caused extensive disturbance across the site. Many of the cropmarks are no longer visible on LiDAR or recent air photographs, likely due to modern agricultural activity.

4. Aims, Methodology and Presentation

4.1.1. The general aim of the geophysical survey was to provide enough information to corroborate, identify and characterise sub-surface anomalies that may have an archaeological origin, including defining the spatial limits of already known or suspected heritage assets, within the defined survey areas. This information will form part of a much larger body of evidence from a variety of sources that, taken as a whole, will enable an assessment to be made of the impact of the proposed development on any subsurface archaeological remains, where present and therefore help determine an appropriate mitigation strategy.

4.1.2. The specific archaeological objectives of the geophysical survey were:

- To gather enough information to inform the extent, condition, character and date (as far as circumstances permit) of any archaeological features and deposits within the GSA;
- To obtain information that will contribute to an evaluation of the significance of the proposed solar development upon cultural heritage assets; and
- To prepare a fully illustrated report on the results of the survey that is compliant with all relevant standards, guidance and good practice.

4.2. Magnetometer survey

4.2.1. It is acknowledged that magnetometry has limitations and that certain types of sub-surface remains may, under certain circumstances, be more likely to be identified by other survey techniques such as earth resistance, ground penetrating radar (GPR) or electro-magnetic methods which measure different geophysical properties. However, to achieve the immediate project aims over such a large area constituting the GSA, magnetometry was selected as the best general-purpose methodology for assessing the site given the sub-surface remains most likely to be encountered, the results of earlier surveys and the project considerations.

4.2.2. 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 **[Ref. 7].** Further information on soil magnetism and the interpretation of magnetic anomalies is provided in **Annex 2.** The surveys were undertaken using two adaptations of four Bartington Grad601 sensors mounted at 1m intervals (1m traverse interval) onto a rigid frame. For most of the survey the frame was carried manually by the surveyors. When ground conditions were suitable the

frame was towed on a wheeled array behind a quadbike. In both configurations 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. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R12 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point.

4.2.3. MLGrad601 and MultiGrad601 (Geomar Software Inc.) software was used to collect and export the data. A combination of Terrasurveyor v3.0.35.1 (DWConsulting) and Anomaly GeoSurvey v1.11.11 (© 2018 Robbie Austrums) software packages were used to process and export the data plots. Subsequent data interpretation work was undertaken using Autodesk AutoCAD and Figures were produced in QGIS v3.22.12.

4.2.4. An overall location plan of the GSA is presented at a scale of 1:100,000 in **Figure 1.** Overall processed greyscale and interpretation plans are shown in **Figure 2** and **Figure 3** respectively at a scale of 1:40,000. LiDAR data with the GSA outline superimposed is displayed in **Figure 4** at a scale of 1:34,000. Bedrock geology data with GSA outline is displayed as the inset to **Figure 4.**

4.2.5. Due to the size and geographic spread of the GSA, twelve overview Figures (three per Sector 1 through 4) detailing the location of the 1:2,500 Figures, processed greyscale data and magnetometer interpretation with field names and LHER monument and event data, are shown at a scale of 1:12,500 in **Figure 5** through **Figure 16.** Individual fields are referred to by names provided to Headland Archaeology at the commencement of the project. The survey data is shown in fully processed greyscale format, minimally processed XY trace plot format with accompanying interpretation plots at 1:2,500 in **Figures 17** to **208** inclusive.

4.2.6. The survey report for the cable option route is included in **Annex 2** and Figures **209** to **216** inclusive**.** Technical information on the equipment used, data processing and magnetometer survey methodology is given in **Annex 3.** Details of the survey location information are in **Annex 4.** A note on the format of the geophysical data archive is present in **Annex 5.** Data processing details for the magnetometer survey are also presented in **Annex 5.** An OASIS Archive entry will be produced.

4.2.7. The survey methodology, report and any recommendations comply with guidelines outlined by the EAC **[Ref. 3]** and by CIfA **[Ref. 2].** All Figures including Ordnance Survey (OS) mapping are reproduced with the permission of the controller of His Majesty's Stationery Office (© Crown copyright).

4.2.8. The Figures in this report have been produced following analysis of the data in 'raw' (minimally processed) and processed formats (see above)

and over a range of different display levels. All Figures are presented to display and interpret the data from this site to best effect based on the experience and knowledge of management and reporting staff.

5. Results

5.1.1. The results are described by Sector in **Table 1** below. Within each Sector, fields have been grouped based on their geographic proximity and/or similar types of geophysical responses identified within. Many of the broader geological anomalies and some foci of archaeological activity extend beyond the modern field boundary limits and therefore grouping of fields was required to best describe and define the characteristics of these features. The list of associated archaeological LHER assets and events included in the results table is not exhaustive and only includes those assets relevant to the anomalies identified in the survey lying within or immediately adjacent to those fields being discussed as part of the GSA.

Table 1 Section 1 Figure 5 to 7 and 17 to 49

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
Tb1 (Figures 17 to 22 and 26 to 28)	No?	None	No anomalies of clear archaeological potential are identified in this field. A series of faint, regular parallel and perpendicular linear trend anomalies forming a grid like pattern cross the southern part of the field in a general north-west/south-east direction. These anomalies are tentatively interpreted as possibly forming part of a very large field system extending across many of the fields contained within Sectors 1 and 2. The more consistent nature of these linear anomalies lies in contrast to the irregular background mottling effects likely derived from natural periglacial processes or surface cracks in the limestone. The northern extent of these ditch-like features appears to respect a dry valley evident in the LiDAR data (**Figure 4**), possibly identifying another depression in the limestone bedrock as seen elsewhere in the GSA, crossing the northern part of Tb1 and Tb2. However, the absence of response here may be a result of the more homogenous deposits present within the depression and does not necessarily indicate an absence of features. Contained within the southern half of the field and located predominantly towards the peripheries of the present field

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
			boundaries are several discrete magnetically enhanced anomalies of uncertain origin but which are thought to possibly identify former extraction pits. Faint trends, tentatively interpreted as possible ridge and furrow based on their more regular appearance, are identified north of the southernmost pylon. However, these curving anomalies could equally be modern and/or natural in origin. Sinuous and discrete magnetically enhanced anomalies likely identifying a wide shallow depression in the limestone bedrock splitting in two directions at the location of the northernmost pylon, dominate the magnetic responses in the northern half of the field. Two service pipes and two pylon bases are also located within the field.
Tb2 (Figures17 to 28 and 32 to 34)	Yes	MLI86694 MLI86228 MLI86690 ELI5330	Except for a short 45m linear section of discrete anomalies identifying a pit alignment in the northeast corner of the field (**Figures 23-25**), no other anomalies of clear archaeological potential are recorded. A range of overlapping magnetic anomalies of natural and anthropogenic origin are recorded in the southern half of the field but their cause, extent and any possible associations remain uncertain. No clear anomalies of likely archaeological origin are recorded in the location of a findspot for a Middle Bronze Age socketed spearhead

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
			(MLI86690) east of the centre of the field. It should be noted that the superimposition of anomalies makes interpretation of individual features difficult at this location. The pit alignment, not previously recorded in the LHER, is oriented north-east/south-west and lies adjacent to a former quarry site (MLI86694) off the A15 and former Roman road (MLI86228) at NGR 502311, 356494. The alignment possibly extends to the west as more of a continuous curving ditch-like feature, but the response becomes difficult to differentiate from sinuous geological responses derived from a wide shallow dry valley, possibly identifying a depression in the limestone bedrock as seen elsewhere in the GSA to the south, extending in a similar direction across the field. The pit alignment is recorded to the east on the eastern side of the A15 extending into field Bcd044(Part) subsequently surveyed in a separate phase of works relating to cable route options (**Annex 1**). The same pattern of regular parallel and perpendicular linear trend anomalies forming a grid like design, present in many other fields within Sectors 1 and 2, are evident in all parts of the field not dominated by responses from the topographic depression crossing the field. The pattern of anomalies again does not appear to respect present or former field boundaries

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
			and may identify a former system of land division. The superimposition of various types of anomalies, particularly in the southern half of this field restricts a more confident interpretation of the nature, extent and any interrelationship (if present) between any of the underlying features. It remains unclear whether more regular patterns of anomalies in this area are a result of coincidental arrangements of geological effects or may have possible anthropogenic causes potentially associated with the hypothesized field system. Any anomalies that appear distinct from the magnetic background either due to their shape and/or magnetic signature are interpreted as of uncertain origin. Also recorded in this part of the field are a series of parallel linear trends, oriented east/west, identifying a pattern of ridge and furrow, a linear anomaly recording a former boundary and two magnetically enhanced discrete anomalies likely locating former localised extraction. Similar to the southern half of Tb1 and most fields adjacent to the A15, several discrete, widely spaced, magnetically enhanced anomalies of uncertain origin are recorded predominantly at the periphery of the field. These anomalies possibly identify former extraction pits.

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
Bcd082 Bcd094 Bcd098 (Figures 26 to 31 and 35 to 40)	No	MLI89517 MLI86228 MLI60759 ELI7075	No anomalies of clear archaeological potential are recorded across these three fields adjacent to and west of the A15. Findings from these fields are limited to a small area of magnetic enhancement recording extraction adjacent to a former stone quarry pit (MLI89157) next to the A15, a continuation of the north-west/south-east aligned grid system of ditch-like anomalies and periodic magnetically enhanced discrete anomalies around the periphery of the field that are possibly due to modern extraction. Linear trends identifying field drains and/or modern cultivation patterns parallel to the modern-day field boundaries and irregular patterns of sinuous anomalies resulting from natural periglacial effects and/or surface cracks in the limestone are also identified.
Bcd084 Bcd086 Bcd093 Bcd096 Bcd097	Yes	MLI88357 MLI89203 MLI84520 ELI7068 MLI88323	A pit alignment (MLI88357), oriented predominantly north/south spanning nine adjoining fields, extends uninterrupted for 2.1km southwards from the GSA limits to the north in Bcd084 at NGR 503463, 356058, towards the centre of field Bcd115 at NGR 503243, 354000 (discussed further below in Sector 2). In this sector the pit alignment crosses fields Bcd084, Bcd093, Bcd096, Bcd100, Bcd104 and Bcd105 but does not appear to be associated with any other anomalies/features recorded by the

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
Bcd099 Bcd100 Bcd104 Bcd105 (Figures 35 to 40 and 44 to 49)		MLI20943 MLI89194 ELI6372 MLI86228	survey. The survey data adds detail to the LHER record showing that the two previously recorded pit alignments identified from cropmarks MLI84452 and MLI88357 are in fact a unified feature. The same arrangement of regular parallel and perpendicular linear trend anomalies forming a grid like pattern aligned north-west/south-east, present in many other fields within Sectors 1 and 2, are evident to varying degrees within all these fields. No definitive interpretation of these anomalies presents itself, but they could represent an extensive field system or form of land division predating the modern field arrangements which are identified from tithe maps from the mid-19th century (Headland Archaeology 2023a; Table 5 and Table 6). It remains unclear whether three faint partial circular anomalies identified adjacent/within the grid like anomalies in fields Bcd096 (NGR 503263, 355392), Bcd100 (NGR 503455, 355186) and Bcd104 (NGR 503292, 355499, very tentatively interpreted as of possible archaeological origin) are associated with these 'fields' or even if they have an anthropogenic cause (**Figures 47-49**). Two parallel ditch-like anomalies of uncertain origin, aligned roughly east/west, are recorded extending across fields Bcd096 and Bcd097 (**Figures 47-49 and 113-115**). No relationship is

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
			established with other features with which these anomalies appear to intersect including a wide, sinuous natural feature possibly identifying a depression in the limestone bedrock, pit alignment (MLI88357) and the regular gridded arrangement of linear trend anomalies. These parallel anomalies could potentially define a trackway heading in the direction of Ashby de la Launde approximately 800m to the east. Two further ditch-like anomalies, also aligned roughly east/west and of uncertain origin, are identified at the boundary between fields Bcd084 and Bcd093. These remain difficult to interpret as they are parallel in part to modern agricultural trends close to the current field boundary. A former extraction pit (MLI89203) recorded on historic mapping presents as a concentration of magnetic disturbance in the south-eastern corner of Bcd093 (**Figures 44-46**). South of this, at the eastern end of Bcd105, another area of likely extraction not identified on historic mapping is recorded as a cluster of magnetically enhanced amorphous responses. These anomalies lie immediately adjacent to LHER assets recording an unnamed farmstead (MLI20943) and Gamekeepers Cottage and pheasantry (MLI89194) located within a wood inside the GSA (**Figures 47-49**). No relationship between the previously

Field No. (Figure)	Archaeological Anomalies	Associated Archaeological LHER assets and events within GSA limits	Survey Interpretation
			recorded heritage assets and the magnetic anomalies can be established from the data and therefore these anomalies are interpreted as of uncertain origin. A small area of magnetic disturbance is also recorded in the location of a former windpump depicted on historic mapping due east of Ashby Lodge along the northern boundary of Bcd100 (**Figures 47-49**). The strong magnetic signature along the shared boundary between Bcd096 and Bcd100 in the direction of the former windpump suggests a service is buried within the boundary. As in most fields adjacent to the A15, several discrete, widely spaced, magnetically enhanced anomalies of uncertain origin, but possibly identifying former extraction pits, are recorded in field Bcd099. A broad sinuous feature of varied magnetic response identifying a geological trend, possibly a depression in the limestone bedrock, crosses fields Bcd096 and Bcd097 in an east/west direction.

6. Discussion and Conclusion

6.1.1. The survey has successfully evaluated all the suitable areas contained within the GSA and has recorded a wide variety of archaeological and non-archaeological features. The level of detail and range of anomalies recorded across the survey is argued to provide a high level of confidence in the findings and that they accurately reflect the archaeological potential of the GSA having likely recorded the extent of any significant archaeological remains, notwithstanding the limitations of magnetometer survey to define particularly small, very weakly enhanced or anomalies masked by areas of disturbance and/or stronger magnetic anomalies.

6.1.2. The results from a contiguous survey of this size have contributed a wealth of information to the understanding of not only individual foci of archaeological activity within the GSA but the archaeological potential of the area and wider landscape. The results of the survey largely corroborate but also greatly expand the current understanding of the archaeological potential of the GSA as contained within the Lincolnshire HER and detailed in the **ES Volume 3, Appendix 9.1: Archaeological Desk-Based Assessment [EN010149/APP/6.3]**.

6.1.3. The most significant concentrations of archaeological activity, containing examples of ring ditches and likely round barrows, pit alignments and extended series and/or concentrations of ditches, enclosures and pit-like anomalies are identified at the southern extent of the GSA near Brauncewell Quarry, to the north and south of Hall Farm (Bloxholm), surrounding RAF Digby to the south, east and north-east, north of Ashby de la Launde and Scopwick and west of Brickyard Farm, were broadly recorded in areas identified in the LHER as having at least some archaeological potential, which can now be confirmed as very high.

6.1.4. Where the survey has proved invaluable is being able to accurately map the layout and extent of these extended areas of archaeological activity at a truly landscape level, features such as the multiple pit alignments spread across western and central areas of the GSA. One drawback however of the geology being so receptive to magnetometer survey has been in select locations where the superimposition of various types of anomalies of natural and/or anthropogenic origin has restricted a more confident interpretation of the nature, extent and any interrelationship (if present) between features recorded. Although the survey has detailed landscape scale archaeological features, further discussion of their archaeological significance beyond their spatial distribution as recorded by the survey however lies beyond the scope of this survey report.

6.1.5. Where the survey has identified more significant levels of archaeological activity not previously recorded in the LHER includes the land between

Ashby de la Laund and RAF Digby, north-east of RAF Digby and south of Blankney.

6.1.6. Perhaps the most enigmatic feature recorded by the survey is the extensive gridded pattern of weakly magnetically enhanced linear trend anomalies, aligned north-west/south-east that are identified in almost every field west of the B1191 constituting the western third of the GSA. An anthropogenic cause for these ditch-like anomalies, such as a relict field system, was considered likely given the homogeneity and regularity of the responses over such a large area. Their relationship (if any) with the other landscape scale features recorded by the survey remains uncertain. However, it is noteworthy these anomalies are not detected in the location of broad, sinuous geological variations crossing the western part of the GSA. The **ES Volume 3, Appendix 9.5: Archaeological Trial Trenching Report [EN010149/APP/6.3]** targeted some of these anomalies and found them to be the result of fractures in the underlying Upper Lincolnshire Limestone Member bedrock geology.

6.1.7. Other broad trends discernible from the results includes the propensity of archaeological activity to be predominantly sited on the higher ground underlain by the limestone geology of the Blisworth Limestone Formation and eastern fringes of the limestone of the Upper Lincolnshire Limestone Member towards the west and centre of the GSA.

6.1.8. The identification of some anomalies of archaeological potential away from these areas suggests a preference for these conditions and is not necessarily a bias due to a lack of magnetic contrast on the other geologies. It is evident from the survey results and information contained within the LHER that there were significant levels of prehistoric activity within different areas of the GSA from at least the Bronze Age, likely continuing through into the Iron Age before the two Roman roads that bisect the site were constructed. The vast majority of the archaeological anomalies identified by the survey appear prehistoric in character and generally fit the narrative of later medieval settlement being more focused towards the modern-day villages of Ashby de Launde, Brauncewell, Scopwick, Thorpe Tilney and Temple Bruer located outside the GSA. It is important to highlight the anomalies at the southern end of GSA lie within an archaeological prehistoric landscape with excavations at Brauncwell Quarry some of the largest and most concentrated investigations of prehistoric multiple boundaries in Lincolnshire and the East Midlands as a whole. The results of the survey which have accurately mapped the extent and layout of these enigmatic landscape features across large areas will further contribute to the understanding of these features and the archaeological record of the region.

7. References

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- **Ref. 2:** Chartered Institute for Archaeologists (CIfA) 2014 Standard and guidance for archaeological geophysical survey (Reading) Available online: [redacted].
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- **Ref. 10:** Lindsey Archaeological Services 1994 Archaeological Excavations at Brauncewell Limestone Quarry.
- **Ref. 11:** Lindsey Archaeological Services 2004 Brauncewell Limestone Quarry Extension Excavations and Watching Brief 2001-2.

Annex 1 – Grid Connection Route Geophysical Survey

Application Document Ref: EN010149/APP/6.3
Planning Inspectorate Scheme Ref: EN010149

Annex 1 Grid Connection Route Geophysical Survey

Summary

Headland Archaeology (UK) Ltd was instructed by RSK Environment on behalf of Springwell Energyfarm Ltd (the Applicant) to undertake a geophysical (magnetometer) survey to assess the archaeological potential of two possible route options for the cable that will connect the proposed Springwell Solar Farm, located 15km south of Lincoln, with a new electricity sub-station.

This survey is separate from, and additional to, that which covered the main solar farm proposal area (Headland Archaeology 2023a). Both reports, together with the archaeological desk-based assessment (DBA, Headland Archaeology 2023b) and Aerial Investigation Report (Headland Archaeology 2023c) have informed the Environmental Impact Assessment (EIA) produced in support of a development consent order (DCO) application for the construction of the solar farm and associated infrastructure. The survey results will be used to select the preferred cable route option and inform future archaeological strategy.

The main findings from the original solar farm survey were the identification of several foci of archaeological activity including features such as ring ditches and likely round barrows, pit alignments and extended series and/or concentrations of ditches, enclosures, and pit-like anomalies. However, most of this activity was nearly 1km from the current survey area on higher ground east of the A15.

No anomalies of definite archaeological potential have been identified by the survey. Part of a possible enclosure is recorded in the north-east of the survey area although a modern agricultural origin is considered equally plausible. Several discrete anomalies of uncertain origin are also recorded. However, with no evidence to support an archaeological interpretation these anomalies are considered more likely to be due to variation in the soils or geology or to recent agricultural activity. Anomalies correlating with the mapped location of a site of former mineral extraction are also recorded as well as those due to recent agricultural cultivation and drainage.

As with the previous (2023) survey, it is assessed that the level of detail, range of anomalies recorded, and receptivity of the underlying bedrock is such that a high level of confidence can be placed on the results providing an accurate assessment of the archaeological potential of the survey area. This is notwithstanding the limitations of magnetometer survey to define particularly small, very weakly enhanced or anomalies masked by areas of disturbance and/or stronger magnetic anomalies. The archaeological potential of the cable route option areas is therefore assessed as low throughout, with the possible exception of in the north-eastern corner around the possible ‘enclosure’, where it is assessed as uncertain.

Introduction

Headland Archaeology (UK) Ltd was instructed by RSK Environment on behalf of Springwell Energyfarm Ltd (the Applicant) to undertake a geophysical (magnetometer) survey to assess the archaeological potential of land, amounting to approximately 80ha, covering two possible cable route options (**Figure1**) to connect the proposed Springwell Solar Farm, to be located 15km south of Lincoln, between the villages of Metheringham and Brauncewell, with a new electricity sub-station to the north.

The survey was undertaken in accordance with the original Written Scheme of Investigation for Geophysical Survey (WSI) (**Annex 2**), following guidance contained in the National Planning Policy Framework (NPPF) **[Ref. 1]** prior to its revision in September 2023, and was carried out in line with current best practice guidance published by CIfA **[Ref. 2]** and Europae Archaeologia Consilium **[Ref. 3].**

The survey was carried out between March 11th and March 20th 2024.

Location, topography and land-use

The geophysical survey area (GSA) comprised an irregular shaped block of land made up of two 200m wide north to south aligned corridors connecting at their northern end to a larger rectangular area. The GSA therefore covers the two route options being considered for the grid connection corridors through which the export cables from the solar farm will connect to the proposed new substation.

The GSA is located immediately north-west of, and bordering, the previous survey limits for the proposed Springwell Solar Farm development and is approximately 2km east of Navenby and 13km south of Lincoln. It borders the A15 to the east being centred at NGR 501607, 357952. The spatial relationship between the current and earlier survey area is indicated on **Figure 2 to Figure 7** inclusive.

The GSA was under a mix of pasture and arable cultivation at the time of survey and lies at approximately 45m above Ordnance Datum (AOD) in the centre, south and east, sloping up to approximately 68m AOD in the west.

Geology and soils

The bedrock predominantly comprises Upper Lincolnshire Limestone Member, ooidal limestone, a sedimentary bedrock formed between 170.3 and 168.3 million years ago during the Jurassic period, although there is a narrow band of limestone (Upper

Lincolnshire Limestone Member), also a sedimentary bedrock formed between 170.3 and 168.3 million years ago during the Jurassic period, along the southern edge of Bcd43. There is no information available on any superficial deposits **[Ref. 4].**

The overlaying soils are classified in the Soilscape 3 Association, shallow lime-rich soils over chalk or limestone **[Ref. 5].**

Guidance (**[Ref. 6]**; **Table 4**) indicates that magnetometer survey can be recommended over any sedimentary geology and average responses to magnetometer survey over Jurassic limestone are good, although a wide range of magnetic susceptibilities in the parent rock can result in very variable background responses to magnetometer survey.

The combination of underlying limestone bedrock and absence of superficial deposits means the prevailing geological and pedological conditions are appropriate for the use of magnetometer survey for the detection of archaeological features. The suitability of magnetometry in these conditions is demonstrated by the results of the previous survey in fields bordering and adjacent to the GSA.

Archaeological background

A detailed archaeological background, adapted from information compiled within a comprehensive archaeological desk-based assessment (**ES Volume 3, Appendix 9.1: Archaeological Desk-Based Assessment [EN010149/APP/6.3]**) and aerial investigation report (**ES Volume 3, Appendix 9.3: Aerial Investigation and Mapping Report [EN010149/APP/6.3]**) gathered in support of an Environmental Impact Assessment (EIA) for the wider solar development (including the fields covered by this survey), was included in the report on the geophysical survey covering the wider development. Only information pertaining to the current GSA is included here.

No designated or non-designated heritage assets are identified within the GSA boundary. Non-designated assets located adjacent or close to the GSA are limited to the former Roman road, now the A15 (MLI86228) which runs along the eastern boundary of the GSA, and a possible medieval grange at Temple High Grange farm approximately 260m east of the GSA (**Figure 5** - MLI60381).

The results of the 2023 survey largely corroborated, but also greatly expanded, the current understanding of the archaeological potential of the wider solar farm site as contained within the Lincolnshire Historic Environment Record (LHER). The main findings of the earlier (2023) survey were the identification of several foci of archaeological activity with features including ring ditches and likely round barrows, pit alignments and extended series and/or concentrations of ditches, enclosures, and pit-like features being recorded. However, these anomalies/features are all located at least 850m from the nearest part of the current survey areas.

Aims, methodology and presentation

Aims and Objectives

The general aim of the geophysical survey was to provide enough information to corroborate, identify and characterise anomalies that may have an archaeological origin within the two cable route option survey areas. This information will help determine the preferred route option. On a wider project scale the survey will form part of the much larger body of evidence from a variety of sources, including the previous magnetometer survey, that taken as a whole, will enable an assessment to

be made of the impact of the proposed solar farm development and associated infrastructure on any sub-surface archaeological remains, where present, and therefore help determine an appropriate mitigation strategy.

The specific archaeological objectives of the geophysical survey were:

- To gather enough information to inform the extent, condition, character, and date (as far as circumstances permit) of any archaeological features and deposits within the GSA;
- To obtain information that will contribute to an evaluation of the significance of the proposed development upon cultural heritage assets; and
- To prepare a fully illustrated report on the results of the survey that is compliant with all relevant standards, guidance, and good practice.

Magnetometer survey

It is acknowledged that magnetometry has limitations and that certain types of sub-surface remains may, under certain circumstances, be more likely to be identified by other survey techniques, such as earth resistance, ground penetrating radar (GPR) or electro-magnetic (EM) methods, which measure different geophysical properties. However, given the success of the preceding surveys, magnetometry was selected as the best methodology for assessing the grid connection route areas.

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 (**[Ref. 7]**). Further information on soil magnetism and the interpretation of magnetic anomalies is provided in **Annex 2.**

The surveys were 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. These readings were stored on an external weatherproof laptop and later downloaded for processing and interpretation. The system was linked to a Trimble R12 Real Time Kinetic (RTK) differential Global Positioning System (dGPS) outputting in NMEA mode to ensure a high positional accuracy for each data point.

MLGrad601 and MultiGrad601 (Geomar Software Inc.) software was used to collect and export the data. Anomaly GeoSurvey v1.12.3 (Lichenstone Geoscience) and QGIS v.3.28.5 software was used to process and present the data respectively.

An overall location plan of the GSA shown in relation to the original survey for the solar farm is presented at a**Figure 1,**. **Figures 209 and 210** show the GPS swaths, ,

as well as the nearest heritage assets. **Figure 211 and Figure 212** show overviews of the processed magnetometer data and interpretation respectively. Fully processed (greyscale) data, minimally processed (XY trace plot) data and interpretative plans are presented by Sector, at 1:2,500, in **Figure 213 to Figure 226** inclusive.

Individual fields are referred to using nomenclature provided to Headland Archaeology at the commencement of the project.

Technical information on the equipment used, data processing and magnetometer survey methodology is given in **Annex 2.** Details of the survey location information are included in **Annex 3.** A note on the format of the geophysical data archive is present in **Annex 4.** Data processing details for the magnetometer survey are presented in **Annex 5.**

The survey methodology, report and any recommendations comply with guidelines outlined by Europae Archaeologia Consilium (**[Ref. 3]**) and by the Chartered Institute for Archaeologists (CIfA) **[Ref. 2]**)).

All illustrations from Ordnance Survey (OS) mapping are reproduced with the permission of the controller of His Majesty's Stationery Office (© Crown Copyright).

The illustrations in this report have been produced following analysis of the data in 'raw' (minimally processed) and processed formats (see above) and over a range of different display levels. All illustrations are presented to display and interpret the data from this site to best effect based on the experience and knowledge of Headland management and reporting staff.

Results and discussion

Site Conditions

Magnetometer survey is generally recommended over any sedimentary bedrock and the 'average response' on Jurassic Limestones is generally good (**[Ref. 6];** Table 4). Magnetometry was therefore the most appropriate non-intrusive geophysical technique for evaluating the GSA, taking account of the limitations noted in above.

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

The magnetic background is generally uniform within the GSA, similar to that identified in the previous survey.

Against this magnetic background, anomalies of various origin have been recorded (**Figure 7**), although some of the responses are low magnitude and not easy to discern. The fact that anomalies were recorded confirms that there was sufficient magnetic contrast, for the detection of potentially archaeological features, notwithstanding the limitations of magnetometer survey to identify the types, sizes, and period of archaeological features as described in Section 1.5 and keeping in mind the variable but generally good response to magnetometer survey on Jurassic

Limestones, the prevailing geology. The results of the survey therefore likely provide a good indication of the extent of sub-surface archaeological features within the GSA.

The anomalies are discussed below according to their interpreted origin.

Ferrous and Modern Anomalies

Ferrous anomalies, characterised as individual ‘spikes’, are typically caused by ferrous (magnetic) material, either on the ground surface or in the plough-soil. Little importance is normally given to such anomalies, unless there is any supporting evidence for an archaeological interpretation, as modern ferrous debris is common on most sites, often being introduced into the topsoil during manuring or tipping/infilling.

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

A large cluster of magnetically enhanced responses, in the south-east of the GSA in Bcd043 (**Figure 25** – Q1), locates an area of former mineral extraction and correlates with a quarry mapped on the 1888-1915 six-inch OS map. Several other broad clusters of magnetically enhanced anomalies may share a similar origin. However, these anomalies are much less extensive than Q1, do not correspond with any mapped quarries and may be caused by variations in the limestone geology.

Agricultural Anomalies

Throughout the GSA, weakly magnetic, closely spaced linear trend anomalies, parallel and perpendicular to current field extents, indicate the orientation of recent agricultural regimes.

A few broadly spaced linear trend anomalies, aligned north-northwest to south-southeast, at right angles to the current field layout, such as those recorded in Bcd 027 (**Figure 7**) are interpreted as field drains.

Anomalies of Geological Origin

The geological background across the GSA is generally fairly homogenous but with spreads of discrete anomalies, irregular patterns of sinuous and ‘crazy paving’ anomalies which are all interpreted as being due to pitting and fissuring in the limestone bedrock. These anomalies are more prevalent in Bcd027, in the north of the GSA, and in the south in Bcd043, in the latter instance continuing the pattern recorded in the fields immediately to the south surveyed in 2023.

Anomalies of Uncertain Origin

Several discrete anomalies have been interpreted as of uncertain origin (**Figure 7** – U1 to U9) on the basis that they cannot be confidently interpreted in any other category. The responses are similar to those recorded by the previous survey in fields adjacent to the A15 and possibly locate former extraction pits as seen in the wider landscape or possibly just be natural.

In Bcd031, a cluster of anomalies individual pit-like responses with magnetic signatures above the general magnetic background are also interpreted as of uncertain origin (**Figure 13** – MD1). Analysis of recent satellite imagery clearly identifies on 2022 images a square patch of ground, distinct from the rest of the field, that correlates with the location of MD1. Whilst the image resolution does not allow for a definite explanation it is considered likely that the anomalous responses are associated with very recent agricultural/modern activity.

Anomalies of Possible or Probable Archaeological Origin

Two clear but discontinuous parallel ditch-type anomalies, possibly forming one corner of a double-ditched enclosure, are recorded in Bcd027 (**Figure 13** – E1). The very regular 15m spacing between the two possible ditches and very straight nature of the anomalies could suggest a modern (agricultural). However, the orientation of E?1 is offset very slightly from the agricultural trend anomalies in this field and

this, allied with the proximity to the Roman road (MLI86228), now the A15, approximately 250m to the east, means an archaeological interpretation cannot be discounted.

Conclusion

No anomalies of definite archaeological potential have been identified by the survey.

Part of a possible enclosure is recorded in the north-east of the survey area although a modern agricultural origin is considered equally plausible.

Several discrete anomalies of uncertain origin are also recorded. However, with no evidence to support an archaeological interpretation these anomalies are also considered more likely to be due to variation in the soils or geology or to recent agricultural activity.

Anomalies correlating with the mapped location of a site of former mineral extraction are also recorded as well as those due to recent agricultural cultivation and drainage.

As with the previous (2023) survey, it is assessed that the level of detail, range of anomalies recorded and receptivity of the underlying bedrock is such that a high level of confidence can be placed on the results providing an accurate assessment of the archaeological potential of the survey area notwithstanding the limitations of magnetometer survey to define particularly small, very weakly enhanced or anomalies masked by areas of disturbance and/or stronger magnetic anomalies. The

archaeological potential of the survey area is therefore assessed as low throughout, with the possible exception of in the north-eastern corner of the site around the possible ‘enclosure’, where it is assessed as uncertain.

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Annex 2 – Magnometer Survey

Application Document Ref: EN010149/APP/6.3
Planning Inspectorate Scheme Ref: EN010149

Annex 2 Magnetometer Survey

Magnetic susceptibility and soil magnetism

Iron makes up about 6% of the earth's crust and is mostly present in soils and rocks as minerals such as maghaemite and haematite. These minerals have a weak, measurable magnetic property termed magnetic susceptibility. Human activities can redistribute these minerals and change (enhance) others into more magnetic forms so that by measuring the magnetic susceptibility of the topsoil, areas where human occupation or settlement has occurred can be identified by virtue of the attendant increase (enhancement) in magnetic susceptibility. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

In general, it is the contrast between the magnetic susceptibility of deposits filling cut features, such as ditches or pits, and the magnetic susceptibility of the topsoil, subsoil and rock into which these features have been cut, which causes the most recognisable responses. This is primarily because there is a tendency for magnetic ferrous compounds to become concentrated in the topsoil, thereby making it more magnetic than the subsoil or the bedrock. Linear features cut into the subsoil or geology, such as ditches, that have been silted up or have been backfilled with topsoil will therefore usually produce a positive magnetic response relative to the background soil levels. Discrete feature, such as pits, can also be detected.

The magnetic susceptibility of a soil (clay) can also be enhanced by the application of heat. This effect can lead to the detection of heat affected features such as hearths, kilns or areas of burning.

Types of magnetic anomaly

In most cases 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) [h5]

These responses are typically caused by ferrous material either on the surface or in the topsoil. They cause a rapid variation in the magnetic response giving a characteristic 'spiky' trace. Although ferrous archaeological artefacts could produce this type of response, unless there is supporting evidence for an archaeological interpretation, little emphasis is normally given to such anomalies, as modern ferrous objects are common on rural sites, often being introduced into the soil during manuring.

Areas of magnetic disturbance [h5]

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 [h5]

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 [h5]

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 [h5]

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

Annex 3 – Survey Location Information

Application Document Ref: EN010149/APP/6.3
Planning Inspectorate Scheme Ref: EN010149

Annex 3 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 Applicant 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.

Annex 4 – Geophysical Survey Archive

Application Document Ref: EN010149/APP/6.3
Planning Inspectorate Scheme Ref: EN010149

Annex 4 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 [redacted]). The data will be stored in an indexed archive and migrated to new formats when necessary.

Annex 5 – Magnometer Data Processing

Application Document Ref: EN010149/APP/6.3
Planning Inspectorate Scheme Ref: EN010149

Annex 5 Magnetometer 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) 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.

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Application Document Ref: EN010149/APP/6.3
Planning Inspectorate Scheme Ref: EN010149