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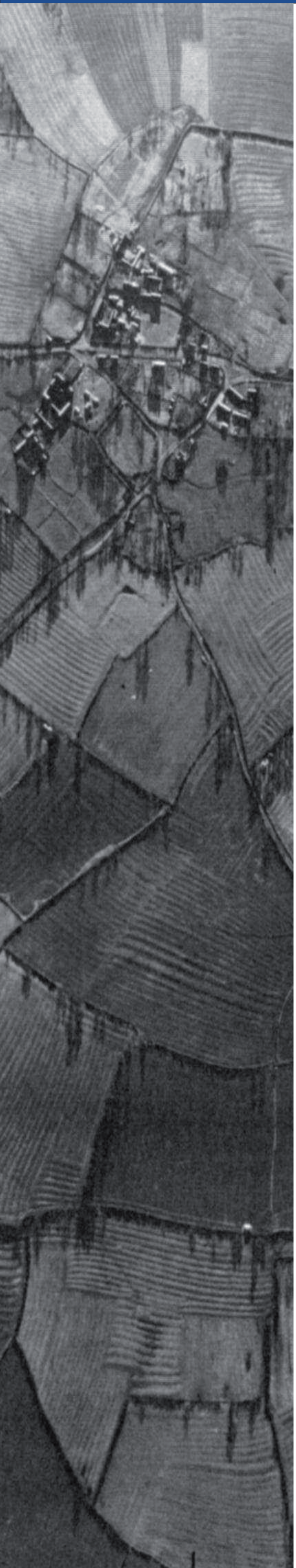

Five Islands School, St Mary's, Isles of Scilly

MAGNETOMETER AND EARTH RESISTANCE SURVEY REPORT

for

Kier Western

David Sabin and Kerry Donaldson

April 2010

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Five Islands School, St Mary's, Isles of Scilly

Magnetometer and Earth Resistance Survey

for

Kier Western

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Survey date - **23rd to 27th April 2010**
Ordnance Survey Grid Reference – **SV 91130 10290**

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SUMMARY

Archaeological Surveys Ltd was commissioned by Kier Western to undertake a magnetometry and resistivity survey of an area of land at Carn Gwaval School on the island of St Mary's, Isles of Scilly. The site has been outlined for the development of the new Five Islands School.

The results of the survey indicated the presence of a number of anomalies, although interpretation is limited as many are poorly defined and of low contrast. Anomalies have been caused by relatively recent land use and where extended periods of waterlogging occur across the eastern part of the site, magnetic susceptibility is suppressed and magnetic anomalies may not have formed.

Linear anomalies within the western part of the site may indicate early land division and field layout; however, it is possible that more modern agricultural cultivation or land division is responsible.

A ring-like high resistance anomaly, with a diameter of approximately 12m, was located in Area 4 which forms the eastern part of the site. The response may indicate the presence of structural remains and although the anomaly has been categorised as uncertain in origin, its archaeological potential should be considered. A round high resistance anomaly, with a diameter of approximately 6m, was also located in Area 4 and this appears to correlate with a low circular mound of unknown date.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Kier Western to undertake a magnetometry and resistivity survey of an area of land at Carn Gwaval School on the island of St Mary's, Isles of Scilly. The site has been outlined for the development of the new Five Islands School. The survey forms part of an archaeological assessment of the site.

1.1.2 The geophysical survey was carried out in accordance with a Written Scheme of Investigation (WSI) produced by Archaeological Surveys (2010). The WSI considers the requirements of a Brief for geophysical survey issued by the Local Planning Authority Archaeologist, Eleanor Breen (2010).

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry and earth resistance survey to locate geophysical anomalies that may be archaeological in origin, so that they may be assessed prior to development of the site.

1.2.2 Magnetometry is a highly effective and efficient means of archaeological prospection recommended for survey over large areas. Earth resistance survey is particularly effective at locating former structural remains. The survey and report generally follow the recommendations set out by: English Heritage, 2008, *Geophysical survey in archaeological field evaluation;* Institute for Archaeologists, 2002, *The use of Geophysical Techniques in Archaeological Evaluations*.

1.3 Site location, description and survey conditions

1.3.1 The site is located to the south east of Hugh Town on St Mary's in the Isles of Scilly. Ordnance Survey National Grid Reference (OS NGR) SV 91130 10290, see Figure 01. The geophysical survey covers an area of approximately 2.8ha within 4 separate areas, labelled Areas 1 – 4, see Figure 02.

1.3.2 Area 1 forms the north western part of the site and is located immediately south of Carn Gwaval Primary School, see Plate 1. The western part of the area slopes down to generally flat ground forming the eastern half of the area. Dilapidated agricultural buildings are located in the northern part of the survey area and there was evidence for the removal of vegetation associated with former field boundaries in the central-western part of the area. The western and north western boundaries are formed by stone walls, trees and shrubs. The flat ground forming the eastern half of Area 1 had been recently cleared of daffodils. The western half contained daffodils, areas of rough vegetation and a number of obstructions were caused by piles of recently cut vegetation.

1.3.3 Area 2 lies immediately south of Area 1 and is separated from it by a low granite wall and trees, see Plate 2. Similar to Area 1, the western half of the field slopes down to the east, with the eastern half generally flat. The northern part of the field contained daffodils, with open soil in the south.

1.3.4 Area 3 lies in the central part of the site to the east of Areas 1 and 2 and to the south east of the school, see Plate 3. The area is used as a playing field for the school and is also a recreational facility for the public. Within the eastern part of the playing field, a skate park is separated by wire fencing. The area is generally flat and low lying although a wide shallow depression crosses the central part of the area.

1.3.5 Area 4 forms the eastern part of the site and is currently used as agricultural pasture, see Plate 4. The field is low lying and poorly drained; wide ditches bisect the area into roughly equal size quadrants and assist in land drainage. Marshy and waterlogged ground is located to the north and south, with residential dwellings forming part of Old Town located immediately south east. The north western quadrant is further defined by a number of granite stones.

Plate 1: Area 1 looking towards the north west

Plate 2: Area 2 looking to the west

Plate 3: Area 3 looking towards the north east

Plate 4: Area 4 looking towards the south west

1.3.6 The ground conditions across the site were variable with a number of zones less than optimum for the collection of geophysical survey data. The western part of Area 1 and northern part of Area 2 contained daffodils, rough vegetation and very uneven ground surfaces that created difficult conditions for traversing. Very dry ground within Areas 1 – 3 resulted in difficult conditions for resistance survey. Weather conditions during the survey were generally fine and sunny.

1.4 Site history and archaeological potential

1.4.1 The western part of the site contains late 19th and early 20th century bulb strips, while the eastern part of the site is anciently enclosed land. Although there are no scheduled monuments within the development area, there are two nearby scheduled monuments that may have associated archaeological remains.

1.4.2 An Iron Age/Romano-British fogou (SM15550) lies approximately 60m to the west of the site. It is possible that it is evidence for later prehistoric or

Romano-British occupation within the environs.

1.4.3 The remains of the 13th /14th century Ennor Castle (SM 15469) lie some 100m to the east of the site. There is, therefore, potential for unrecorded medieval settlement and land use within the surrounding landscape.

1.5 Geology and soils

1.1.1 The underlying solid geology across the site is intrusive granite, syenite, granophyre and allied types (BGS, 2001) with overlying superficial deposits of alluvium (BGS, 1977). The overlying soil across the survey area is from the Laployd association, which is a typical humic gley. It consists of a permeable, gritty, coarse loamy soil with a wet humose or peaty surface horizon affected by groundwater (Soil Survey of England and Wales, 1983).

1.5.1 Magnetometry may produce variable results dependant upon localised ground conditions; areas affected by high water tables and long periods of waterlogging can be associated with very poor results. Earth resistance survey may be influenced by solid geology, where it occurs at shallow depths, and may also be influenced by drainage. However, an extended period of dry conditions prior to the survey is likely to provide optimum conditions for resistivity.

2 METHODOLOGY

2.1 Technical synopsis

2.1.1 Magnetometry survey records localised magnetic fields that can be associated with features formed by human activity. Magnetic susceptibility and magnetic thermoremnance are factors associated with the formation of localised fields. Additional details are set out below and within Appendix A.

2.1.2 Iron minerals within the soil may become altered by burning and the break down of biological material; effectively the magnetic susceptibility of the soil is increased, and the iron minerals become magnetic in the presence of the Earth's magnetic field. Accumulations of magnetically enhanced soils within features, such as pits and ditches, may produce magnetic anomalies that can be mapped by magnetic prospection.

2.1.3 Magnetic thermoremnance can occur when ferrous minerals have been heated to high temperatures such as in a kiln, hearth, oven etc. On cooling, a permanent magnetisation may be acquired due to the presence of the Earth's magnetic field. Certain natural processes associated with the formation of some igneous and metamorphic rock may also result in magnetic thermoremnance.

2.1.4 The localised variations in magnetism are measured as sub-units of the Tesla, which is a SI unit of magnetic flux density. These sub-units are nano Teslas (nT), which are equivalent to 10^{-9} Tesla (T).

2.1.5 The electrical resistance or resistivity of the soil depends upon the moisture content and distribution within the soil. Buried features such as walls can affect the moisture distribution and are usually more moisture resistant than other features such as the infill of a ditch. A stone wall will generally give a high resistance response and the moisture retentive content of a ditch can give a low resistance response. Localised variations in resistance are measured in ohms (Ω), which is the SI unit for electrical impedance or resistance.

2.1.6 The Twin Probe configuration used in this survey is favoured for archaeological prospection and can give a response to features up to 1m in depth with a mobile probe separation of 0.5m.

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using a Bartington Grad601-2 gradiometer. This instrument effectively measures a magnetic gradient between two fluxgate sensors mounted vertically 1m apart. Two sets of sensors are mounted on a single frame 1m apart horizontally.

2.2.2 The instrument is extremely sensitive and is able to measure magnetic variation to 0.01nanoTesla (nT), with an effective resolution of 0.03 nT. The data are limited to ±100nT when surveying with the highest sensitivity. All readings are saved to an integral data logger for analysis and presentation

2.2.3 The instrument is operated according to the manufacturer's instructions with consideration given to the local conditions. An adjustment procedure is required, prior to collection of data, in order to balance the sensors and remove the effects of the Earth's magnetic field; further adjustment is required during the survey due to instrument drift often associated with temperature change.

2.2.4 It may be very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that can be associated with large ferrous objects, geological/pedological features, 'magnetic' debris within the topsoil and natural temperature fluctuations. Imperfect balance results in a heading error often visible as striping within the data; this can be effectively removed by software processing and generally has little effect on the data unless extreme.

2.2.5 The Bartington gradiometer undergoes regular servicing and calibration by the manufacturer. A current assessment of the instrument is shown in Table 1 below.

Date of calibration/service	16th May 2009
Sensor type	Bartington Grad - 01 – 1000 Nos. 242 and 396
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instrument was considered to be in good working order prior to the survey with no known faults or defects.

2.2.6 Magnetic data were collected at 0.25m centres along traverses 1m apart. The survey area was separated into 30m by 30m grids (900m²) giving 3600 recorded measurements per grid. This sampling interval is very effective at locating archaeological features and is the recommended methodology for archaeological prospection (English Heritage, 2008).

2.2.7 The earth resistance survey was carried out using TR Systems Ltd Resistance Meter TRCIA 1.31 using a mobile Twin Probe array. The standard mobile frame for the TRCIA instrument has a 0.5m electrode separation and readings were recorded at 1m intervals along 1m traverses across the site.

2.2.8 The survey grids were set out to the Ordnance Survey OSGB36 datum using a Penmap RTK GPS. The GPS is used in conjunction with Topcon's TopNET service where positional corrections are sent via a mobile telephone link. Positional accuracy of around 10 – 20mm is possible using the system. The instrument is regularly checked against the ETRS89 reference framework using Ordnance Survey ground marker C1ST7784 (Horton).

2.3 Data processing and presentation

2.3.1 Magnetometry data downloaded from the Grad 601-2 data logger are analysed and processed in specialist software known as ArcheoSurveyor. The software allows greyscale and trace plots to be produced for presentation and display. Survey grids are assembled to form an overall composite of data (composite file) creating a dataset of the complete survey area. Appendix C contains specific information concerning the survey and data attributes and is derived directly from ArcheoSurveyor; this should be used in conjunction with information provided by Figure 02.

2.3.2 Only minimal processing is carried out in order to enhance the results of the magnetometry. Raw data are always analysed as processing can modify anomalies. The following schedule sets out the data and image processing used in this survey:

- clipping of the raw data at ±30nT to improve greyscale resolution,
- clipping of processed data at ±3nT to enhance low magnitude anomalies,
- zero median/mean traverse is applied in order to balance readings along each traverse.

Reference should be made to Appendix B for further information on the specific processes carried out on the data. Appendix C metadata includes details on the processing sequence used for each survey area.

2.3.3 Data logged by the resistance meter is downloaded and processed within ArcheoSurveyor software. Raw data is analysed and displayed within the report as well as processed data. The following processing has been carried out on data in this survey:

- raw earth resistance data have been shown clipped to 2 SD (Standard Deviations),
- processed data have been clipped to 2SD after despiking and filtering (see below) to enhance any possible archaeological anomalies (negative values are a function of the mathematical operation carried out across the data during filtering),
- data have been “despiked” in order to remove spurious high contact responses,
- data are passed through a high pass filter in order to enhance anomalies.

2.3.4 An abstraction and interpretation is offered for all geophysical anomalies located by the survey. A brief summary of each anomaly, with an appropriate reference number, is set out in list form within the results (Section 3) to allow a rapid assessment of features within each survey area. Where further interpretation is possible, or where a number of possible origins should be considered, more detailed discussion is set out in Section 4.

2.3.5 The main form of data display used in this report is the greyscale plot. Both 'raw' and 'processed' data have been shown followed by an abstraction and interpretation plot. Anomalies are abstracted using colour coded points, lines and polygons. All plots are scaled to landscape A3 for paper printing.

2.3.6 Graphic raster images in bitmap format (.BMP) are initially prepared in ArcheoSurveyor. Regardless of survey orientation, data captured along each traverse are displayed and processed by ArcheoSurveyor from left to right. Prior to displaying against base mapping, raster graphics require a rotation to restore north to the top of the image. Greyscale images are rotated by AutoCAD.

2.3.7 The raster images are combined with base mapping using ProgeCAD Professional 2010 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. Quality can be compromised by rotation of graphics in order to allow the data to be orientated with respect to grid north; this is considered acceptable as the survey results are effectively georeferenced allowing relocation of features using GPS, resection method etc.. A digital archive, including raster images is produced with this report, allowing separate analysis if necessary, see Appendix D below.

3 RESULTS

3.1 General overview - magnetometry

3.1.1 The detailed magnetic survey was carried out over a total of 4 survey areas covering an area of approximately 2.8ha. Magnetic anomalies can be generally classified as positive and negative anomalies of an uncertain origin, anomalies of an agricultural origin, areas of magnetic debris and disturbance and strong discrete dipolar anomalies relating to ferrous objects. Anomalies located within each survey area have been numbered and will be outlined below with subsequent discussion in Section 4.

3.1.2 Useful magnetic data were collected across the survey areas although anomalies were very weak and of very low contrast in some areas. It is very likely that the combination of a high water table and extended periods of waterlogging have suppressed the formation of useful magnetic anomalies within Area 4. Daffodils within Areas 1 and 2 were associated with soil ridges that created difficult conditions for traversing. Minor distortion to the data is inevitable although unlikely to degrade the results significantly.

3.1.3 Measurements of mass specific magnetic susceptibility were carried out on a small number of topsoil and subsoil samples retrieved from geotechnical investigations that were being carried out during the survey. The samples were collected opportunistically within Area 1; however, an assessment of magnetic susceptibility did not form part of the geophysical requirement although was considered worthwhile in order to provide supplementary information on the magnetic state of the soils. Mean values for topsoil of 50 SI kg^{-1} 10^{-8} and for subsoil of 9 SI kg^{-1} 10^{-8} were recorded using a Bartington MS2 meter with MS2B sensor. The topsoil values are considered to be moderately high and indicate good contrast between topsoil and subsoil and are typical of many other UK soils where magnetometry is effective. The values may not be representative of conditions across the whole survey area and suppression of magnetic susceptibility within low lying parts of the site has already been suggested above.

3.1.4 The listing of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the magnetometry survey. A basic explanation of the characteristics of the magnetic anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. Sub-headings are then used to group anomalies with similar characteristics for each survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST MAG POS LINEAR UNCERTAIN AS-ABST MAG NEG LINEAR UNCERTAIN AS-ABST MAG POS DISCRETE UNCERTAIN AS-ABST MAG POS AREA UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. Positive anomalies are indicative of magnetically enhanced soils that may form the fill of 'cut' features or may be produced by accumulation within layers or 'earthwork' features; soils subject to burning may also produce positive anomalies. Negative anomalies are produced by material of comparatively low magnetic susceptibility such as stone and subsoil.
Anomalies with an agricultural origin AS-ABST MAG AGRICULTURAL AS-ABST MAG LAND DRAIN	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing. Land drains often form characteristic patterns.
Anomalies associated with magnetic debris AS-ABST MAG DEBRIS AS-ABST MAG STRONG DIPOLAR	Magnetic debris often appears as areas containing many small dipolar anomalies that may range from weak to very strong in magnitude. It often occurs where there has been dumping or ground make-up and is related to magnetically thermoremnant materials such as brick or tile or other small fragments of ferrous material. This type of response is occasionally associated with kilns, furnace structures, or hearths and may therefore be archaeologically significant. It is also possible that the response may be caused by natural material such as certain gravels and fragments of igneous or metamorphic rock. Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies with a modern origin AS-ABST MAG DISTURBANCE	The magnetic response is often strong and dipolar indicative of ferrous material and may be associated with extant above surface features such as wire fencing, cables, pylons etc.. Often a significant area around such features has a strong magnetic flux which may create magnetic disturbance; such disturbance can effectively obscure low magnitude anomalies if they are present. Fluxgate sensors may respond erratically and with hysteresis adjacent to strong magnetic sources. Buried services may produce characteristic multiple dipolar anomalies dependant upon their construction.

Table 2: List and description of magnetometry interpretation categories

3.2 General overview – earth resistance survey

3.2.1 The earth resistance survey was carried out over a total of 4 survey areas covering approximately 2.8ha. Geophysical anomalies located can be generally classified as high and low resistance anomalies of uncertain origin, areas of high resistance associated with daffodil cultivation, areas of high and low resistance linear anomalies associated with agricultural activity. Anomalies located within each survey area have been numbered and will be outlined below with subsequent discussion in Section 4.

3.2.2 Data quality generally appears good. High contact resistance due to dry and compacted surfaces was encountered in Areas 1, 2 and 3; however, this appears unlikely to have significantly degraded the data or obscured other anomalies.

3.2.3 The listing of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the earth resistance survey. A basic explanation of the characteristics of the anomalies is set out for each category in order to justify interpretation, a basic key is indicated to allow cross reference to the abstraction and interpretation plot. Sub-headings are then used to group anomalies with similar characteristics for each survey area.

Report sub-heading CAD layer names and plot colour	Description and origin of anomalies
Anomalies with an uncertain origin AS-ABST RES HIGH LINEAR UNCERTAIN AS-ABST RES LOW LINEAR UNCERTAIN AS-ABST RES HIGH DISCRETE UNCERTAIN AS-ABST RES LOW DISCRETE UNCERTAIN AS-ABST RES HIGH AREA UNCERTAIN AS-ABST RES LOW AREA UNCERTAIN AS-ABST RES VARIABLE AREA UNCERTAIN	The category applies to a range of anomalies where there is not enough evidence to confidently suggest an origin. Anomalies in this category may well be related to archaeologically significant features, but equally relatively modern features, geological/pedological features and agricultural features should be considered. High resistance anomalies are indicative of comparatively low moisture and may indicate stone, compacted soil, changes in drainage, etc. Low resistance anomalies are indicative of comparatively high moisture and may relate to the fill of cut features, organic material within the soil, damp areas etc..
Anomalies with an agricultural origin AS-ABST RES AGRICULTURAL AS-ABST RES LAND DRAIN	The anomalies are often linear and form a series of parallel responses or are parallel to extant land boundaries. Where the response is broad, former ridge and furrow is likely; narrow response is often related to modern ploughing. Anomalies associated with land drainage often form distinctive patterns.

Table 3: List and description of resistivity interpretation categories

3.3 List of anomalies – magnetometry

3.3.1 Area 1 centred on OS NGR 091045 010282, see Figures 03, 04 and 07.

Anomalies with an uncertain origin

(1) – Very weak (<1nT), negative linear anomalies that may form rectilinear features within the field. It is possible that the anomalies have been caused by subsoil or stone with low magnetic susceptibility compared with the topsoil. The anomalies are probably related to either former land division or cultivation practices.

(2) – A positive linear anomaly close to the southern edge of the survey area may indicate a ditch-like feature or accumulation of topsoil. The anomaly may relate to the nearby land boundary.

(3) – Several areas of weak positive response may indicate discrete patches of magnetically enhanced soil. The origin of the anomalies cannot be determined.

Anomalies with an agricultural origin

(4) – Parallel linear anomalies caused by modern cultivation.

Anomalies associated with magnetic debris

(5) – A zone of magnetic debris within the central part of the survey area has been caused by modern ferrous material.

Anomalies with a modern origin

(6) – Magnetic disturbance caused by nearby buildings or services.

3.3.2 Area 2 centred on OS NGR 091068 010228, see Figures 03, 04 and 07.

Anomalies with an uncertain origin

(7) – A broad positive linear anomaly (<5nT) within the western half of the field. The positive response appears to be associated with a weaker negative anomaly. It is possible that the positive anomaly has been caused by an infilled ditch-like feature; the associated negative response may indicate the presence of subsoil within the topsoil.

(8) – Several negative and positive linear anomalies cross the area (similar to Area 1) and may indicate former land boundaries or cultivation practices.

(9) – A positive zone at the southern end of the survey area may indicate magnetically enhanced soil but is of uncertain origin.

Anomalies with an agricultural origin

(10) – Parallel linear anomalies caused by modern cultivation.

3.3.3 Area 3 centred on OS NGR 091145 010285, see Figures 03, 04 and 07.

Anomalies with an uncertain origin

(11) – Short positive and negative linear anomalies at the northern end of the survey area are of uncertain origin, but may be associated with ground disturbance.

(12) – The area contains several poorly defined positive linear anomalies of uncertain origin. It is possible that they relate to land drainage although some may indicate land division.

(13) – A broad positive linear anomaly at the southern end of the survey area is uncertain in origin and may have been caused by nearby fencing and/or services. It

is possible that it is associated with a former boundary ditch.

Anomalies associated with magnetic debris

(14) – Zones of magnetic debris indicate the presence of ferrous objects within the topsoil and may relate to former land use or ground make-up.

Anomalies with a modern origin

(15) – Magnetic disturbance caused by fencing along the eastern side of the survey area.

3.3.4 Area 4 centred on OS NGR 091235 010334, see Figures 03, 04 and 07.

Anomalies with an uncertain origin

(16) – The survey area contains a number of weak positive linear anomalies of uncertain origin. The magnetic response may indicate former ditch-like features.

(17) – A negative linear anomaly close to the southern boundary appears to bound a zone of magnetic debris. It is possible that the response represents material of low magnetic susceptibility associated with ground make-up or land drainage.

Anomalies with an agricultural origin

(18) – A very weakly negative linear anomaly correlates with a ditch crossing the field from south west to north east. The ditch is associated with land drainage within a water meadow.

Anomalies associated with magnetic debris

(19) – A linear zone of magnetic debris crosses the survey area from north to south. The anomalies correlate with a drainage ditch and probably indicate dumped ferrous material.

(20) – Zones of magnetic debris probably associated with ground consolidation and make-up using magnetically thermoremnant material.

Anomalies with a modern origin

(21) – Zones of magnetic disturbance caused by ferrous objects beyond the limit of the survey area.

3.4 List of anomalies – earth resistance survey

3.4.1 Area 1 centred on OS NGR 091045 010282, see Figures 05, 06 and 08.

Anomalies with an uncertain origin

(22) – Low resistance linear anomalies cross the survey area and tend to correlate with several negative linear anomalies (see, anomalies 1). The low resistance may indicate former ditches that were associated with land division.

(23) – A high resistance linear anomaly located along the eastern side of the survey area may indicate ground compression through agricultural activity.

Anomalies with an agricultural origin

(24) – A zone of high resistance correlates with a daffodil crop present within the field during the survey. The high resistance has been caused by improved drainage and increased water uptake by plants.

(25) – Parallel linear anomalies caused by modern cultivation.

3.4.2 Area 2 centred on OS NGR 091068 010228, see Figures 05, 06 and 08.

Anomalies with an uncertain origin

(26) – Low resistance linear anomalies that may indicate former land divisions.

(27) – High resistance anomalies adjacent to the southern field boundary may be associated with soil compaction.

(28) – Poorly defined high resistance linear anomalies at the western end of the survey area are of uncertain origin.

(29) – A high resistance linear anomaly that appears to correlate with magnetic anomaly (7). The high resistance response may indicate disturbed ground or the presence of stone.

Anomalies with an agricultural origin

(30) - A zone of high resistance correlates with a daffodil crop present within the field during the survey. The high resistance has been caused by improved drainage and increased water uptake by plants.

3.4.3 Area 3 centred on OS NGR 091145 010285, see Figures 05, 06 and 08.

Anomalies with an uncertain origin

(31) – A low resistance linear anomaly crosses the southern part of the survey area and may indicate a former ditch-like feature.

(32) – A short, high resistance linear anomaly of uncertain origin.

(33) – A high resistance zone within the northern part of the survey area may indicate ground make-up or soil compaction. The area is regularly used for sports and surface compaction was evident.

(34) – A zone of high resistance at the southern end of the survey area may indicate ground make-up or compaction.

3.4.4 Area 4 centred on OS NGR 091235 010334, see Figures 05, 06 and 08.

Anomalies with an uncertain origin

(35) – A high resistance ring-like or sub rounded feature was located within the south western part of the field. The feature has a diameter of up to approximately 12m and may be associated with other high resistance anomalies nearby. High resistance response may indicate the presence of stone.

(36) – A high resistance round anomaly located in the north eastern part of the survey area. The anomaly appears to correlate with a very low circular earthwork approximately 6-7m in diameter. It is uncertain as to whether this represents soil dumping or whether it is a feature of archaeological potential.

(37) – High resistance linear anomalies within the south eastern part of the site are of uncertain origin but may indicate stone features.

(38) – The survey area contains a number of high and low resistance linear anomalies that may relate to agricultural activity, land drainage or former boundary features.

(39) – A zone of high and low resistance response at the eastern end of the survey area may indicate ground make-up.

(40) – A discrete high resistance anomaly is located within the central part of low resistance linear anomalies caused by drainage ditches (anomalies 41). The high resistance may indicate the presence of stone or other dumped material.

Anomalies with an agricultural origin

(41) – Low resistance linear anomalies that have been caused by damp soil within land drainage ditches.

(42) – Parallel linear anomalies of agricultural origin that may be associated with land drainage or cultivation.

4 DISCUSSION

4.1.1 Magnetometry and earth resistance survey have located a number of anomalies within all of the survey areas. Interpretation is limited as many anomalies are weak and of poor contrast. Relatively modern agricultural practices are likely to have formed a number of anomalies of uncertain origin although there is evidence of land division, within the western part of the site, that may indicate an early field pattern.

4.1.2 The resistance survey within Area 4, forming the eastern part of the site, has located several anomalies where, considering their morphology, features of archaeological potential should be considered. A high resistance ring-like or sub rounded feature was located within the south western part of the field and this may indicate structural remains. A high resistance circular feature was located in the north eastern part of Area 4 and this appears to correlate with a very low mound, approximately 6-7m in diameter, possibly surrounded by a shallow ditch. It is impossible to determine whether the mound is relatively recent in origin or of archaeological potential.

4.1.3 Current ground conditions within Area 4 indicate a very wet environment unsuitable for settlement and the field is used as a water meadow. However, the site may have formerly been drier, as a result of lower sea levels or the use of effective land drainage, and it may have been a very favourable spot located adjacent to a sheltered bay.

5 CONCLUSION

5.1.1 Magnetometry and resistivity survey located a number of anomalies across the site, although many are weak and of poor contrast. Confident abstraction and interpretation is, therefore, not possible for many of the anomalies.

5.1.2 Several linear anomalies that may indicate former land divisions were located by both magnetometry and resistivity in the western part of the site (Areas 1 and 2). It is possible that an early field layout is represented, although it is impossible to determine whether the anomalies have been caused by more recent agricultural practices.

5.1.3 Within the eastern part of the site (Area 4), resistivity located a ring-like high resistance feature, approximately 12m in diameter, and a high resistance circular anomaly, approximately 6m in diameter, that correlates with a low circular mound. Although the anomalies have been categorised as uncertain in origin, their archaeological potential should be considered.

6 REFERENCES

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Appendix A – basic principles of magnetic survey

Iron minerals are always present to some degree within the topsoil and enhancement associated with human activity is related to increases in the level of magnetic susceptibility and thermoremnant material.

Magnetic susceptibility is an induced magnetism within a material when it is in the presence of a magnetic field. This can be thought of as effectively permanent due to the presence of the Earth's magnetic field.

Thermoremnant magnetism occurs when ferrous material is heated beyond a specific temperature known as the Curie Point. Demagnetisation occurs at this temperature with re-magnetisation by the Earth's magnetic field upon cooling.

Enhancement of magnetic susceptibility can occur in areas subject to burning and complex fermentation processes on biological material; these are frequently associated with human settlement. Thermoremnant features include ovens, hearths, and kilns. In addition thermoremnant material such as tile and brick may also be associated with human activity and settlement.

Silting and deliberate infilling of ditches and pits with magnetically enhanced soil can create an area of enhancement compared with surrounding soils and subsoils into which the feature is cut. Mapping enhanced areas will produce linear and discrete anomalies allowing an assessment and characterisation of hidden subsurface features.

It should be noted that areas of negative enhancement can be produced from material having lower magnetic properties compared to the topsoil. This is common for many sedimentary bedrocks and subsoils which were often used in the construction of banks and walls etc. Mapping these 'negative' anomalies may also reveal archaeological features.

Magnetic survey or magnetometry can be carried out using a fluxgate gradiometer and may be referred to as gradiometry. The gradiometer is a passive instrument consisting of two fluxgate sensors mounted vertically 1m apart. The instrument is carried about 30cm above the ground surface and the upper sensor measures the Earth's magnetic field as does the lower sensor but this is influenced to a greater degree by any localised buried field. The difference between the two sensors will relate to the strength the magnetic field created by the buried feature. If no enhanced feature is present the field measured by both sensors will be similar and the difference close to zero.

There are a number of factors that may affect the magnetic survey and these include soil type, local geology and previous human activity. Situations arise where magnetic disturbance associated with modern services, metal fencing, dumped waste material etc., obscures low magnitude fields associated with archaeological features.

Appendix B – data processing notes

Clipping

Minimum and maximum values are set and replace data outside of the range with those values. Extreme values are removed improving colour or greyscale contrast associated with data values that may be archaeologically significant. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero Median/Mean Traverse (magnetometry only)

The median (or mean) of each traverse is calculated ignoring data outside a threshold value, the median (or mean) is then subtracted from the traverse. The process is used to equalise slight differences between the set-up and stability of gradiometer sensors and can remove striping. The process can remove archaeological features that run along a traverse so data analysis is also carried out prior its application.

De-stagger (magnetometry only)

Compensates for small positional errors within data collection by shifting the position of the readings along each traverse by a specified amount. Data lost at the end of each traverse are extrapolated from adjacent value in the same row.

Deslope (magnetometry only)

Corrects for striping and distortion caused by metal objects/services etc.. The process calculates a curve based on a polynomial best fit mathematical function for each traverse. This curve is then subtracted from the actual data.

High Pass Filter

Removes low frequency anomalies within the data that are not considered to be archaeologically significant and may be natural in origin. A window passes over the data, the mean of all the data within the window is subtracted from the centre value. The size of the window is adjusted as is the weighting which may be uniform or Gaussian.

Appendix C – survey and data information

Area 1 raw magnetometry

Filename: J319-Area1-mag-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 24/04/2010
Assembled by: on 24/04/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 360 x 120
Survey Size (meters): 90 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 3.54
Mean: 0.45
Median: 0.66
Composite Area: 1.08 ha
Surveyed Area: 0.68065 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 12
1 Col:0 Row:0 01.xgd
2 Col:0 Row:1 02.xgd
3 Col:0 Row:2 03.xgd
4 Col:0 Row:3 04.xgd
5 Col:1 Row:0 05.xgd
6 Col:1 Row:1 06.xgd
7 Col:1 Row:2 07.xgd
8 Col:1 Row:3 08.xgd
9 Col:2 Row:0 11.xgd
10 Col:2 Row:1 12.xgd
11 Col:2 Row:2 09.xgd
12 Col:2 Row:3 10.xgd

Area 1 processed magnetometry

Filename: J319-Area1-mag-proc.xcp

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Mean Traverse: Grids: All Threshold: 1 SDs
4 Clip from -3.00 to 3.00 nT

Area 2 raw magnetometry

Filename: J319-Area2-mag-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 24/04/2010
Assembled by: on 24/04/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 240 x 120
Survey Size (meters): 60 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -23.85
Std Dev: 1.79
Mean: 0.69
Median: 0.59
Composite Area: 0.72 ha
Surveyed Area: 0.38615 ha

Processes: 2
1 Base Layer
2 Clip from -23.85 to 30.00 nT

Source Grids: 8
1 Col:0 Row:0 05.xgd
2 Col:0 Row:1 06.xgd
3 Col:0 Row:2 07.xgd
4 Col:0 Row:3 08.xgd
5 Col:1 Row:0 01.xgd
6 Col:1 Row:1 02.xgd
7 Col:1 Row:2 03.xgd
8 Col:1 Row:3 04.xgd

Area 2 processed magnetometry

Filename: J319-Area2-mag-proc.xcp

Processes: 4
1 Base Layer
2 Clip from -23.85 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -3.00 to 3.00 nT

Area 3 raw magnetometry

Filename: J319-Area3-mag-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 25/04/2010
Assembled by: on 25/04/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 240 x 120
Survey Size (meters): 60 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 7.87
Mean: -0.40
Median: 0.34
Composite Area: 0.72 ha
Surveyed Area: 0.4191 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 8
1 Col:0 Row:0 01.xgd
2 Col:0 Row:1 02.xgd
3 Col:0 Row:2 03.xgd
4 Col:0 Row:3 04.xgd
5 Col:1 Row:0 05.xgd
6 Col:1 Row:1 06.xgd
7 Col:1 Row:2 07.xgd
8 Col:1 Row:3 08.xgd

Area 3 processed magnetometry

Filename: J319-Area3-mag-proc.xcp

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Mean Traverse: Grids: All Threshold: 1 SDs
4 Clip from -3.00 to 3.00 nT

Area 4 raw magnetometry

Filename: J319-Area4-mag-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 26/04/2010
Assembled by: on 26/04/2010
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 360 x 150
Survey Size (meters): 90 m x 150 m
Grid Size: 30 m x 30 m
X Interval: 0.25 m
Y Interval: 1 m

Stats
Max: 30.00
Min: -30.00
Std Dev: 4.49
Mean: -0.76

Median: -0.41
Composite Area: 1.35 ha
Surveyed Area: 0.99805 ha

Processes: 2
1 Base Layer
2 Clip from -30.00 to 30.00 nT

Source Grids: 14
1 Col:0 Row:0 01.xgd
2 Col:0 Row:1 11.xgd
3 Col:0 Row:2 12.xgd
4 Col:0 Row:3 13.xgd
5 Col:0 Row:4 14.xgd
6 Col:1 Row:0 02.xgd
7 Col:1 Row:1 07.xgd
8 Col:1 Row:2 08.xgd
9 Col:1 Row:3 09.xgd
10 Col:1 Row:4 10.xgd
11 Col:2 Row:1 03.xgd
12 Col:2 Row:2 04.xgd
13 Col:2 Row:3 05.xgd
14 Col:2 Row:4 06.xgd

Area 4 processed magnetometry

Filename: J319-Area4-mag-proc.xcp

Processes: 8
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: 01.xgd 11.xgd 12.xgd 13.xgd 14.xgd
4 DeStripe Median Traverse: Grids: 08.xgd 09.xgd 10.xgd 04.xgd 05.xgd 06.xgd
5 DeStripe Median Sensors: 02.xgd
6 DeStripe Mean Traverse: Grids: 07.xgd 03.xgd Threshold: 1.5 SDs
7 Clip from -3.00 to 3.00 nT
8 DeSlope (Area: Top 30, Left 120, Bottom 59, Right 239) using Horz Polynomial

Area 1 raw resistance

Filename: J319-Area1-res-raw.xcp
Instrument Type: TRCIA (Resistance)
Units: Ohm
Surveyed by: on 24/04/2010
Assembled by: on 24/04/2010
Collection Method: ZigZag
Sensors: 0 @ 0.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 90 x 120
Survey Size (meters): 90 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m

Stats
Max: 197.54
Min: 29.15
Std Dev: 39.06
Mean: 96.96
Median: 80.06
Composite Area: 1.08 ha
Surveyed Area: 0.7101 ha

Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Source Grids: 12
1 Col:0 Row:0 06.xgd
2 Col:0 Row:1 07.xgd
3 Col:0 Row:2 08.xgd
4 Col:0 Row:3 09.xgd
5 Col:1 Row:0 04.xgd
6 Col:1 Row:1 05.xgd
7 Col:1 Row:2 10.xgd
8 Col:1 Row:3 11.xgd
9 Col:2 Row:0 01.xgd
10 Col:2 Row:1 02.xgd
11 Col:2 Row:2 03+12.xgd
12 Col:2 Row:3 13.xgd

Area 1 processed resistance

Filename: J319-Area1-res-proc.xcp

Processes: 5
1 Base Layer
2 Clip at 2.00 SD
3 Despike Threshold: 3 Window size: 5x5
4 High pass Gaussian filter: Window: 21 x 21
5 Clip at 2.00 SD

Area 2 raw resistance

Filename: J319-Area2-res-raw.xcp
Instrument Type: TRCIA (Resistance)
Units: Ohm
Surveyed by: on 24/04/2010
Assembled by: on 24/04/2010
Collection Method: ZigZag
Sensors: 0 @ 0.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 60 x 120
Survey Size (meters): 60 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m

Stats
Max: 133.33
Min: 49.29
Std Dev: 18.09
Mean: 83.60
Median: 77.04
Composite Area: 0.72 ha
Surveyed Area: 0.3958 ha

Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Source Grids: 8
1 Col:0 Row:0 05.xgd
2 Col:0 Row:1 06.xgd
3 Col:0 Row:2 07.xgd
4 Col:0 Row:3 08.xgd
5 Col:1 Row:0 01.xgd
6 Col:1 Row:1 02.xgd
7 Col:1 Row:2 03.xgd
8 Col:1 Row:3 04.xgd

Area 2 processed resistance

Filename: J319-Area2-res-proc.xcp

Processes: 5
1 Base Layer
2 Clip at 2.00 SD
3 Despike Threshold: 3 Window size: 5x5
4 High pass Gaussian filter: Window: 21 x 21
5 Clip at 2.00 SD

Area 3 raw resistance

Filename: J319-Area3-res-raw.xcp
Instrument Type: TRCIA (Resistance)
Units: Ohm
Surveyed by: on 25/04/2010
Assembled by: on 25/04/2010
Collection Method: ZigZag
Sensors: 0 @ 0.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 60 x 120
Survey Size (meters): 60 m x 120 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m

Stats
Max: 98.52
Min: 30.60
Std Dev: 16.82
Mean: 61.93
Median: 58.11
Composite Area: 0.72 ha
Surveyed Area: 0.4465 ha

Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Source Grids: 8
1 Col:0 Row:0 01.xgd
2 Col:0 Row:1 02.xgd
3 Col:0 Row:2 03.xgd
4 Col:0 Row:3 04.xgd
5 Col:1 Row:0 05.xgd
6 Col:1 Row:1 06.xgd
7 Col:1 Row:2 07.xgd
8 Col:1 Row:3 08.xgd

Area 3 processed resistance

Filename: J319-Area3-res-proc.xcp

Processes: 5
1 Base Layer
2 Clip at 2.00 SD
3 Despike Threshold: 3 Window size: 5x5
4 High pass Gaussian filter: Window: 21 x 21
5 Clip at 2.00 SD

Area 4 raw resistance

Filename: J319-Area4-res-raw.xcp
Instrument Type: TRCIA (Resistance)
Units: Ohm
Surveyed by: on 26/04/2010
Assembled by: on 26/04/2010
Collection Method: ZigZag
Sensors: 0 @ 0.00 m spacing.
Dummy Value: 32702
Origin: Zero

Dimensions
Composite Size (readings): 90 x 150
Survey Size (meters): 90 m x 150 m
Grid Size: 30 m x 30 m
X Interval: 1 m
Y Interval: 1 m

Stats
Max: 50.02
Min: 11.87
Std Dev: 9.21
Mean: 30.83
Median: 31.10
Composite Area: 1.35 ha
Surveyed Area: 1.0295 ha

Processes: 2
1 Base Layer
2 Clip at 2.00 SD

Source Grids: 14
1 Col:0 Row:0 13.xgd
2 Col:0 Row:1 07.xgd
3 Col:0 Row:2 08.xgd
4 Col:0 Row:3 09.xgd
5 Col:0 Row:4 10.xgd
6 Col:1 Row:0 14.xgd
7 Col:1 Row:1 05.xgd
8 Col:1 Row:2 11.xgd
9 Col:1 Row:3 12.xgd
10 Col:1 Row:4 06.xgd
11 Col:2 Row:1 01.xgd
12 Col:2 Row:2 02.xgd
13 Col:2 Row:3 03.xgd
14 Col:2 Row:4 04.xgd

Area 4 processed resistance

Filename: J319-Area4-res-proc.xcp

Processes: 5
1 Base Layer
2 Clip at 2.00 SD
3 Despike Threshold: 3 Window size: 5x5
4 High pass Gaussian filter: Window: 21 x 21
5 Clip at 2.00 SD

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at Castle Combe, Wiltshire (see inside cover for address). Digital data are also supplied to the client on CD ROM, see below.

Surveys are reported on in hardcopy (recycled paper) using A4 for text and A3 for plots (all plots are scaled for A3).

This report has been prepared using the following software on a Windows XP platform:

- ArcheoSurveyor version 2.5.2.1 (geophysical data analysis),
- ProgeCAD Professional 2009 (report graphics),
- AutoCAD LT 2007 (report figures),
- OpenOffice.org 3.0.1 Writer (document text),
- PDF Creator version 0.9 (PDF archive).

Digital data are supplied on CD ROM which includes the following files:

- ArcheoSurveyor grid and composite files for all geophysical data,
- CSV files for raw and processed composites,
- geophysical composite file graphics as Bitmap images,
- AutoCAD DWG files in 2000 and 2007 versions,
- report text as OpenOffice.org ODT file,
- report text as Word 2000 doc file,
- report text as rich text format (RTF),
- report text as PDF,
- PDFs of all figures,
- photographic record in JPEG format.

The CD ROM structure is formed from a tree of directories under the title J319 FIS Scilly – CD. Directory titles include Data, Documentation, CAD, PDFs and Photos. Multiple directories exist under Data and hold Grid, Composite and Graphic files with CSV composite data held in Export.

The CAD file contains externally referenced graphics that are rotated with separate A3 size layouts for each figure. Layouts are fixed using frozen layers and named views allowing straightforward plotting or analysis on screen. (Note – CAD files are prepared using AutoCAD's e Transmit function to produce a directory containing the digital drawing along with any externally referenced graphics which may need reloading).

Copies of the report will be sent to the Cornwall and Scilly Historic Records Office, The Isles of Scilly Museum, Council for the Isles of Scilly Planning Department and the National Monuments Records office in Swindon. A pdf copy of the report will also be made available to the English Heritage/ads online access to the index of archaeological investigations (OASIS).