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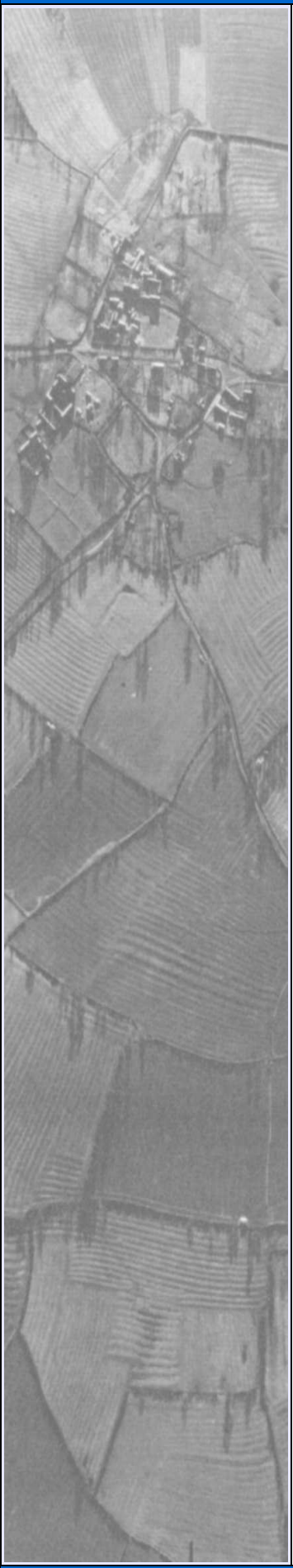

Treswarrow Farm
St Endellion
Cornwall

MAGNETOMETER SURVEY REPORT

for

Peter Wonnacott Planning

David Sabin and Kerry Donaldson

March 2011

Ref. no. 358

ARCHAEOLOGICAL SURVEYS LTD

Treswarrow Farm, St Endellion, Cornwall

Magnetometer Survey

for

Peter Wonnacott Planning

Fieldwork by David Sabin and Jack Cousins
Report by David Sabin BSc (Hons) MIFA and Kerry Donaldson BSc (Hons)

Survey date - **from 10th to 18th March 2011**
Ordnance Survey Grid Reference – **SW 984 777**

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SUMMARY

A detailed magnetometer survey was commissioned by Peter Wonnacott Planning ahead of a planning application for the installation of photovoltaic solar arrays as part of an archaeological assessment of the site. The survey was undertaken over 15.7ha within four pasture fields and located a number of geophysical anomalies that relate to archaeological features. In the northern part of the site, several positive linear and rectilinear anomalies appear to form at least two series of land division. A third phase is shown by the remains of removed Cornish Hedges. A cluster of positive curvilinear anomalies in the northern part of the site relate to a group of ring-ditches which may indicate a prehistoric settlement. In the southern part of the site, a sub-rectangular feature, indicating small enclosure has a subsequent, and latterly removed, Cornish Hedge constructed over the top of the feature.

1 INTRODUCTION

1.1 Survey background

1.1.1 Archaeological Surveys Ltd was commissioned by Peter Wonnacott Planning to undertake a magnetometer survey of an area of land at Treswarrow Farm, St Endellion, near Port Issac in Cornwall. The survey aims to provide information on the archaeological potential of land prior to a planning application for the installation of photovoltaic solar arrays. 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 (2011), and approved by Phil Copleston, Historic Environment Planning Advice Officer for Cornwall Council.

1.2 Survey objectives and techniques

1.2.1 The objective of the survey was to use magnetometry 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 The aim of the survey would be to inform decision-making as to further archaeological evaluation work and/or archaeological mitigation as part of the planning permission process, in line with the requirements of Planning Policy Statement (PPS) 5 policy HE6.1.

1.2.3 The methodology is considered an efficient and effective approach to archaeological prospection. The survey and report generally follow the recommendations set out by: English Heritage, 2008, *Geophysical survey in archaeological field evaluation; and* 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 at Treswarrow Farm in the parish of St Endellion and lies less than 3km to the south west of Port Issac in Cornwall, see Fig1. The central OS Grid Reference is SW 984 777.

1.3.2 The geophysical survey covers approximately 15.7ha within four pasture fields separated by Cornish Hedges. The site is south facing and the ground slopes down to the south with a variable gradient.

1.3.3 The ground conditions across the site were generally considered to be favourable for the collection of magnetometry data, although some areas of long grass and boggy ground were encountered. Weather conditions during the survey were fine and sunny.

1.4 Site history and archaeological potential

1.4.1 The Cornwall and Scilly Historic Environment Record lists a number of archaeological sites in the vicinity of the survey area. These include Treswarrow Medieval settlement 150m to the north west, Tolraggott prehistoric field system immediately to the east, Trevathan Iron Age/Romano British road, enclosure and field system some 500m east of the site and Trevathan Medieval/Post Medieval field system, 550m to the south east.

1.4.2 Given the proximity of the prehistoric field system immediately to the east, and the further archaeological sites within the surrounding vicinity, there is some potential to locate geophysical anomalies that may relate to archaeological features.

1.5 Geology and soils

1.5.1 The underlying solid geology across the site is from the Polzeath Slate Formation, mudstone, siltstone and sandstone (BGS 2011).

1.5.2 The overlying soil across the survey area is from the Powys association, which is a brown ranker. This consists of shallow, well drained, loamy soils over rock (Soil Survey of England and Wales, 1983).

1.5.3 The geological and pedological conditions are considered suitable for magnetometry, although the potential for natural anomalies, caused by shallow rock formations, is considered to be high.

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).

2.2 Equipment configuration, data collection and survey detail

2.2.1 The detailed magnetic survey was carried out using Bartington Grad601-2 gradiometers. The instruments effectively measure 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 instruments are extremely sensitive and are able to measure magnetic variation to 0.01nanoTesla (nT), with an effective resolution of 0.03nT. 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 instruments are 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 can be very difficult to obtain optimum balance for the sensors due to localised magnetic vectors that may 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 gradiometers undergo regular servicing and calibration by the manufacturer. A current assessment of the instruments is shown in Table 1 below.

Sensor type and serial numbers	Bartington Grad - 01 – 1000 Nos. 084, 085, 242 and 396
Date of certified calibration/service	Sensors 084 and 085 - 6th August 2010 (due Aug 2012) Sensors 242 and 396 - 3rd December 2009 (due Dec 2011)
Bandwidth	12Hz (100nT range) both sensors
Noise	<100pT peak to peak
Adjustable errors	<2nT

Table 1: Bartington fluxgate gradiometer sensor calibration results

The instruments were considered to be in good working order prior to the survey, with no known faults or defects.

2.2.6 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 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 survey for display. 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 ±5nT to enhance low magnitude anomalies,
- de-stagger is used to enhance linear 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 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 and objective assessment of features within each survey area. Where further interpretation is possible, or where a number of possible origins should be considered, more subjective discussion is set out in Section 4.

2.3.4 The main form of data display prepared for 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.

2.3.5 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; this corresponds to a direction of south to north in the field.

2.3.6 The raster images are combined with base mapping using ProgeCAD Professional 2009 and AutoCAD LT 2007, creating DWG file formats. All images are externally referenced to the CAD drawing in order to maintain good graphical quality. 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

3.1.1 The detailed magnetic survey was carried out over a total of four survey areas covering approximately 15.7ha. Geophysical anomalies located can be generally classified as positive linear and discrete positive responses of archaeological potential, positive and negative anomalies of an uncertain origin, anomalies relating to land management, anomalies with a natural origin and strong discrete dipolar anomalies relating to buried ferrous objects. Anomalies located within each survey area have been numbered and are

described below with subsequent discussion in Section 4.

3.1.2 Data are considered representative of the magnetic anomalies present within the survey area. Instrument balancing has been influenced by magnetic disturbance associated with metamorphic rock formation but this has not significantly degraded the data. Naturally formed anomalies are widespread across the site due to the high level of magnetic susceptibility within the underlying geology and soil. However, the geological and pedological conditions have proved useful in creating strongly contrasting magnetic anomalies associated with anthropogenic features.

3.1.3 The list of sub-headings below attempts to define a number of separate categories that reflect the range and type of features located during the 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 referencing to the abstraction and interpretation plot. CAD layer names are included to aid reference to associated digital files (.dwg/.dxf). 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 archaeological potential AS-ABST MAG POS LINEAR ARCHAEOLOGY	Anomalies have the characteristics (mainly morphological) of a range of archaeological features such as pits, ring ditches, enclosures, etc..
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 relating to land management AS-ABST MAG BOUNDARY	Anomalies are mainly linear and may be indicative of the magnetically enhanced fill of cut features (i.e. ditches). The anomalies may be long and/or form rectilinear elements and they may relate to topographic features or be visible on early mapping. In Cornwall the removed hedge banks have distinctive characteristics of a negative linear anomaly, flanked by two positive linear anomalies.
Anomalies associated with magnetic debris AS-ABST MAG STRONG DIPOLAR	Strong discrete dipolar anomalies are responses to ferrous objects within the topsoil.
Anomalies with a natural origin AS-ABST MAG NATURAL FEATURES	Naturally formed magnetic anomalies are are caused by localised variability in the magnetic susceptibility of soils, subsoils and other drift or solid geologies. Anomalies may be amorphous, linear or curvilinear and may appear 'fluvial' or discrete; the latter are almost impossible to distinguished from pit-like anomalies with an anthropogenic origin. Fluvial, glacial and periglacial

	processes may be responsible for their formation within drift material and subsoil. Igneous and metamorphic activity can lead to anomalies within more solid geology.

Table 2: List and description of interpretation categories

3.2 List of anomalies - Area 1

Area centred on OS NGR 198540 77930, see Figures 03 – 05.

Anomalies of archaeological potential

(1) – The survey area appears to contain several positive curvilinear anomalies that are likely to relate to ring-ditches. At least one appears to have internal features, such as pits or areas of magnetic enhancement. Their diameter is between 11m and 15m wide, and it is possible that they relate to the remains of round houses.

(2) – An “L” shaped positive linear anomaly appears to reveal a cut feature with archaeological potential. The ring-ditches are situated either side of this anomaly and it appears to extend southwards into Area 2 where it becomes part of anomaly (10).

(3) – A positive linear anomaly may relate to a ditch-like feature and may be an easterly extension of anomaly (2).

(4) – An “L” shaped positive linear anomaly, located in the western part of the survey area, indicates a former ditch-like feature. The anomaly appears to be associated with (2).

Anomalies with an uncertain origin

(5) – Several discrete positive anomalies are located in the vicinity of anomalies 1-4, and may indicate pit-like responses. It is not possible to determine if these are features associated with anomalies 1-4, as due to the response to the underlying geology, similar pit-like responses across the site may relate to natural features.

(6) – The survey area contains several positive linear and curvilinear anomalies of uncertain origin. Although it is possible that they relate to cut features, the underlying geology has produced linear and discrete anomalies preventing a confident interpretation.

(7) – Negative linear anomalies that may indicate subsoil or stone of comparatively low magnetic susceptibility.

Anomalies associated with land management

(8) – The survey area contains three former field boundaries indicated by typical

double positive linear anomalies flanking a negative linear anomaly. This response is typical of a removed hedgebank and appears to relate to the remains of a wall and the flanking ditches. Only one field boundary is shown on the 1842 Tithe Map.

Anomalies with a natural origin

(9) – Variable magnetic response and broadly enhanced zones caused by the underlying geology.

3.3 List of anomalies - Area 2

Area centred on OS NGR 198550 77630, see Figures 06 – 11.

Anomalies of archaeological potential

(10) – An “L” shaped positive linear anomaly appears to form the eastern and southern sides of a rectilinear enclosure. The western part of the anomaly extends northwards into Area 1 where it can be seen to continue as anomaly (2).

(11) – A further linear anomaly may represent an addition to the enclosure represented by anomaly (10).

(12) – A sub-rectangular positive anomaly is located in the southern half of the survey area (see Fig 11), with dimensions of 13m by 15m. A former Cornish Hedge appears to cross through the anomaly and has changed direction slightly within it. Medieval pottery sherds were noted on bare patches of soil in the vicinity.

Anomalies with an uncertain origin

(13) – The survey area contains several fragmented and incomplete positive curvilinear anomalies. Although it is possible that some may indicate ring-ditches with an archaeological origin, the majority are likely to have been caused by natural features.

(14) – A positive anomaly appears to form the eastern side of the enclosure, anomaly (10); however, its morphology may indicate that it is a natural feature, rather than a cut feature of anthropogenic origin.

(15) – Area 2 contains many positive and negative linear anomalies. Although a positive anomaly may indicate a cut feature, and a negative anomaly may indicate stone, subsoil etc, the majority of the anomalies cannot be confidently interpreted.

(16) – Several discrete positive anomalies have been located within the survey area, and although it is possible that they relate to cut pit-like features, it is also possible that many are natural in origin.

(17) – A weak linear response that appears to extend through anomaly (10) from the north, and a similar response can be seen to the south, possibly extending towards anomaly (12). The anomalies may indicate a trackway.

(18) – Positive and negative linear anomalies are located close to the southern edge of the survey area (see Fig 11) and to the south of a former field boundary (19). They have a similar response to a removed field boundary although they may relate to the edge of former cultivation.

Anomalies associated with land management

(19) – Area 2 contains evidence for four former Cornish Hedges that have subsequently been removed. The two most northerly were removed between 1963 and 1974, while the most southerly field boundaries had been removed some time before the 1842 Tithe Map was produced.

Anomalies with a natural origin

(20) – Along the eastern edge of the survey area is a sinuous positive anomaly. It appears to relate to a feature within the underlying geology.

3.4 List of anomalies - Area 3

Area centred on OS NGR 198355 77735, see Figures 06 – 14.

Anomalies of archaeological potential

(21) – A positive linear anomaly, oriented north-north-west to south-south-east, appears to contain a deliberate gap at its centre, where it is crossed by anomaly (28). It appears to relate to a former ditch, and it is parallel with anomaly (23) and may be associated with anomaly (22) to the north.

(22) – A positive linear anomaly, orientated orthogonally to anomaly (21) may be associated with it.

(23) – A positive linear anomaly is located parallel to, and 68m east of anomaly (21). It is possible that a north western extension of this anomaly has been located within Area 1 to the north west.

(24) – An “L” shaped weakly positive linear anomaly. It is not parallel with anomalies (21) and (23) within Area 3, but it is parallel with and 60m west of, anomaly (10) in Area 2 to the east.

Anomalies with an uncertain origin

(25) – Located east of (28) is a positive curvilinear anomaly, surrounding a

negative curvilinear anomaly, which then surrounds a discrete positive anomaly. The anomalies do not form complete rings, rather they appear as semi-circular features. Although they are uncertain in origin, they may have archaeological potential.

(26) – Several positive curvilinear and discrete anomalies have been located close to the western field boundary. A former field boundary appears to extend across these features, and although uncertain in origin, it should be considered that they may relate to ditch-like and pit-like features.

(27) – A negative anomaly in the north eastern part of the survey area forms a sub-circular feature. Although this may be a response to material with low magnetic susceptibility, such as stone or subsoil, its origin is uncertain.

(28) – A positive linear anomaly located between anomalies (21) extends towards anomaly (25). It is not possible to determine the origin of this anomaly, but it may relate to an archaeological cut feature.

(29) – Area 3 contains many positive linear, curvilinear and discrete anomalies. While it is possible that the may relate to ditch-like and pit-like features, their response is generally weak and their form incoherent, and it is not possible to confidently characterise them.

(30) – The survey area contains several positive and negative linear anomalies oriented north to south. It is not possible to determine the origin of these anomalies, although may may relate to agricultural features.

(31) – A very weak curvilinear anomaly is located in the southern half of the survey area. Although the weak response to this anomaly does not aid confident interpretation, it is possible that this relates to a cut feature such as a ring-ditch.

Anomalies associated with land management

(32) – The survey area contains evidence for three former Cornish Hedges, some of which had been removed prior to 1842, while others had gone by 1974.

3.5 List of anomalies - Area 4

Area centred on OS NGR 198220 77750, see Figures 12 – 14.

Anomalies with an uncertain origin

(33) – The survey area contains many weak positive linear and curvilinear anomalies. Although this type of response may indicate ditch-like features, their form and magnitude prevents confident interpretation.

(34) – Positive discrete and weak amorphous responses may indicate pit-like anomalies; however, this type of response may also relate to natural features.

4 DISCUSSION

4.1.1 The geophysical survey has located several phases of land division. There are at least two distinct layouts of ditches, indicated by a series of positive linear and rectilinear anomalies, with a later phase of construction and subsequent removal of Cornish Hedges. One series of ditches is oriented west-north-west to east-south-east and south-south-west to north-north-east, while another is west-south-west to east-north-east and north-north-west to south-south-east. These are located primarily in the northern central part of the site within Areas 1, 2 and 3. The Cornish Hedges appear to be later, with at least eleven being removed by 1974. These have a distinctive response of a negative linear flanked by two positive linear anomalies.

4.1.2 Within Area 1 in the northern part of the site, several positive curvilinear anomalies appear to relate to ring-ditches, possibly indicating prehistoric settlement. Positive linear anomalies in the vicinity indicate ditches, and although it is not possible to determine if they are contemporary this is a possibility. One removed hedgebank appears to cross a ring-ditch in one direction, and also incorporate a single linear ditch in another direction possibly indicating that Cornish Hedges are the later style of land division.

4.1.3 Area 2 contains evidence for a continuation of the cut features seen in Area 1 to the north. Positive linear anomalies appear to form two sides of a possible rectilinear enclosure. In the southern half of this survey area a sub-rectangular anomaly has been crossed by a later Cornish Hedge. It appears to form an enclosure of 15m by 12m and medieval pottery sherds were noted on patches of bare soil in the vicinity, although there may be no direct association.

4.1.4 Several positive linear anomalies, relating to ditches, have also been located within Area 3 in the western part of the site. A complex series of anomalies appears to relate to at least two phases of land division using ditches on different alignments, possibly with a subsequent phase using Cornish Hedges.

4.1.5 Area 4, located in the far west of the site contained several positive linear, curvilinear, discrete and amorphous anomalies of uncertain origin. Similar anomalies can be seen throughout the other survey areas; however, partly due to responses from the underlying geology, and the weak and fragmented natures of the anomalies, it is not possible to confidently interpret them. It is possible that some relate to cut features, such as ditches, ring-ditches and pits, although a natural origin is possible for many.

5 CONCLUSION

5.1.1 The detailed magnetometer survey located a number of geophysical anomalies with archaeological potential. Positive linear and rectilinear anomalies appear to possibly form two distinct patterns of land division, with a third phase associated with characteristic linear anomalies relating to removed Cornish Hedges.

5.1.2 Several positive curvilinear anomalies have also been located across the site, although not all can be confidently interpreted as archaeological in origin. In Area 1, forming the north eastern part of the site, a cluster of positive curvilinear anomalies relate to a group of ring-ditches which suggest prehistoric settlement.

5.1.3 Towards the southern end of the site, within Area 2, a sub-rectangular enclosure has been located. This appears to have a subsequent, and later removed, Cornish Hedge constructed over the top of it. Medieval pottery sherds were noted on bare soil within the vicinity.

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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. It has been found that clipping data to ranges between ±5nT and ±1nT often improves the appearance of features associated with archaeology. Different ranges are applied to data in order to determine the most suitable for anomaly abstraction and display.

Zero Median/Mean Traverse

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

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

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.

FFT (Fast Fourier Transform) spectral filtering

A mathematical process used to determine the frequency components of a traverse. Repetitive features, such as plough marks, produce characteristic spectral zones that can be suppressed allowing greyscale images to appear clearer.

Appendix C – survey and data information

Area 1 raw data

COMPOSITE
Filename: J358-mag-Area1-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 13/03/2011
Assembled by: on 13/03/2011
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 1320 x 270
Survey Size (meters): 330 m x 270 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: 3.80
Mean: -0.24
Median: -0.41
Composite Area: 8.91 ha
Surveyed Area: 4.4689 ha

Processes: 6
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 De Stagger: Grids: 34.xgd 37.xgd Mode: Both By: 1 intervals
4 De Stagger: Grids: 34.xgd Mode: Both By: 1 intervals
5 De Stagger: Grids: 52.xgd 53.xgd Mode: Both By: 1 intervals
6 De Stagger: Grids: 62.xgd Mode: Both By: 1 intervals

Source Grids: 70
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2 Col:0 Row:7 grids\71.xgd
3 Col:1 Row:5 grids\66.xgd
4 Col:1 Row:6 grids\67.xgd
5 Col:1 Row:7 grids\68.xgd
6 Col:1 Row:8 grids\69.xgd
7 Col:2 Row:2 grids\01.xgd
8 Col:2 Row:3 grids\02.xgd
9 Col:2 Row:4 grids\03.xgd
10 Col:2 Row:5 grids\62.xgd
11 Col:2 Row:6 grids\63.xgd
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17 Col:3 Row:4 grids\07.xgd
18 Col:3 Row:5 grids\58.xgd
19 Col:3 Row:6 grids\59.xgd
20 Col:3 Row:7 grids\60.xgd
21 Col:3 Row:8 grids\61.xgd
22 Col:4 Row:1 grids\08.xgd
23 Col:4 Row:2 grids\09.xgd
24 Col:4 Row:3 grids\10.xgd
25 Col:4 Row:4 grids\11.xgd
26 Col:4 Row:5 grids\54.xgd
27 Col:4 Row:6 grids\55.xgd
28 Col:4 Row:7 grids\56.xgd
29 Col:4 Row:8 grids\57.xgd
30 Col:5 Row:1 grids\12.xgd
31 Col:5 Row:2 grids\13.xgd
32 Col:5 Row:3 grids\14.xgd
33 Col:5 Row:4 grids\15.xgd
34 Col:5 Row:5 grids\50.xgd
35 Col:5 Row:6 grids\51.xgd
36 Col:5 Row:7 grids\52.xgd
37 Col:5 Row:8 grids\53.xgd
38 Col:6 Row:1 grids\16.xgd
39 Col:6 Row:2 grids\17.xgd
40 Col:6 Row:3 grids\18.xgd
41 Col:6 Row:4 grids\19.xgd
42 Col:6 Row:5 grids\46.xgd
43 Col:6 Row:6 grids\47.xgd
44 Col:6 Row:7 grids\48.xgd
45 Col:6 Row:8 grids\49.xgd
46 Col:7 Row:1 grids\20.xgd
47 Col:7 Row:2 grids\21.xgd
48 Col:7 Row:3 grids\22.xgd
49 Col:7 Row:4 grids\23.xgd
50 Col:7 Row:5 grids\42.xgd
51 Col:7 Row:6 grids\43.xgd
52 Col:7 Row:7 grids\44.xgd
53 Col:7 Row:8 grids\45.xgd
54 Col:8 Row:0 grids\25.xgd
55 Col:8 Row:1 grids\26.xgd
56 Col:8 Row:2 grids\27.xgd
57 Col:8 Row:3 grids\28.xgd
58 Col:8 Row:4 grids\29.xgd
59 Col:8 Row:5 grids\39.xgd
60 Col:8 Row:6 grids\40.xgd
61 Col:8 Row:7 grids\41.xgd
62 Col:9 Row:0 grids\30.xgd
63 Col:9 Row:1 grids\31.xgd
64 Col:9 Row:2 grids\32.xgd
65 Col:9 Row:3 grids\33.xgd
66 Col:9 Row:4 grids\34.xgd
67 Col:9 Row:5 grids\37.xgd
68 Col:9 Row:6 grids\38.xgd
69 Col:10 Row:3 grids\35.xgd
70 Col:10 Row:4 grids\36.xgd

Area 1 processed data

COMPOSITE
Filename: J358-mag-Area1-proc.xcp

Stats
Max: 5.30
Min: -5.01
Std Dev: 2.42
Mean: 0.10
Median: 0.00
Composite Area: 8.91 ha
Surveyed Area: 4.4689 ha

Processes: 12
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 De Stagger: Grids: 34.xgd 37.xgd Mode: Both By: 1 intervals
4 De Stagger: Grids: 34.xgd Mode: Both By: 1 intervals
5 De Stagger: Grids: 52.xgd 53.xgd Mode: Both By: 1 intervals
6 De Stagger: Grids: 62.xgd Mode: Both By: 1 intervals
7 DeStripe Median Traverse: Grids: All
8 Clip from -5.00 to 5.00 nT
9 De Stagger: Grids: 51.xgd Mode: Outbound By: 1 intervals
10 De Stagger: Grids: 63.xgd Mode: Outbound By: 1 intervals
11 De Stagger: Grids: 64.xgd Mode: Outbound By: 1 intervals
12 De Stagger: Grids: 65.xgd Mode: Outbound By: 1 intervals

Area 2 raw data

COMPOSITE
Filename: J358-mag-Area2-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 15/03/2011
Assembled by: on 15/03/2011
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 1200 x 420
Survey Size (meters): 300 m x 420 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: 3.43
Mean: -0.31
Median: -0.51
Composite Area: 12.6 ha
Surveyed Area: 6.1885 ha

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

Source Grids: 90
1 Col:0 Row:0 grids\01.xgd
2 Col:0 Row:1 grids\02.xgd
3 Col:0 Row:2 grids\03.xgd
4 Col:0 Row:8 grids\54.xgd
5 Col:0 Row:9 grids\55.xgd
6 Col:1 Row:0 grids\04.xgd
7 Col:1 Row:1 grids\05.xgd
8 Col:1 Row:2 grids\06.xgd
9 Col:1 Row:3 grids\07.xgd
10 Col:1 Row:4 grids\08.xgd
11 Col:1 Row:5 grids\50.xgd
12 Col:1 Row:6 grids\51.xgd
13 Col:1 Row:7 grids\52.xgd
14 Col:1 Row:8 grids\53.xgd
15 Col:1 Row:9 grids\56.xgd
16 Col:1 Row:10 grids\57.xgd
17 Col:1 Row:11 grids\58.xgd
18 Col:2 Row:0 grids\09.xgd
19 Col:2 Row:1 grids\10.xgd
20 Col:2 Row:2 grids\11.xgd
21 Col:2 Row:3 grids\12.xgd
22 Col:2 Row:4 grids\13.xgd
23 Col:2 Row:5 grids\46.xgd
24 Col:2 Row:6 grids\47.xgd
25 Col:2 Row:7 grids\48.xgd
26 Col:2 Row:8 grids\49.xgd
27 Col:2 Row:9 grids\59.xgd
28 Col:2 Row:10 grids\60.xgd
29 Col:2 Row:11 grids\61.xgd
30 Col:3 Row:0 grids\14.xgd
31 Col:3 Row:1 grids\15.xgd
32 Col:3 Row:2 grids\16.xgd
33 Col:3 Row:3 grids\17.xgd
34 Col:3 Row:4 grids\18.xgd
35 Col:3 Row:5 grids\42.xgd
36 Col:3 Row:6 grids\43.xgd
37 Col:3 Row:7 grids\44.xgd
38 Col:3 Row:8 grids\45.xgd
39 Col:3 Row:9 grids\62.xgd
40 Col:3 Row:10 grids\63.xgd
41 Col:3 Row:11 grids\64.xgd
42 Col:3 Row:12 grids\65.xgd
43 Col:4 Row:0 grids\19.xgd
44 Col:4 Row:1 grids\20.xgd
45 Col:4 Row:2 grids\21.xgd
46 Col:4 Row:3 grids\22.xgd
47 Col:4 Row:4 grids\23.xgd
48 Col:4 Row:5 grids\38.xgd
49 Col:4 Row:6 grids\39.xgd
50 Col:4 Row:7 grids\40.xgd
51 Col:4 Row:8 grids\41.xgd
52 Col:4 Row:9 grids\66.xgd
53 Col:4 Row:10 grids\67.xgd
54 Col:4 Row:11 grids\68.xgd
55 Col:4 Row:12 grids\69.xgd
56 Col:4 Row:13 grids\90.xgd
57 Col:5 Row:0 grids\24.xgd
58 Col:5 Row:1 grids\25.xgd
59 Col:5 Row:2 grids\26.xgd
60 Col:5 Row:3 grids\27.xgd
61 Col:5 Row:4 grids\28.xgd
62 Col:5 Row:5 grids\34.xgd
63 Col:5 Row:6 grids\35.xgd
64 Col:5 Row:7 grids\36.xgd
65 Col:5 Row:8 grids\37.xgd
66 Col:5 Row:9 grids\70.xgd
67 Col:5 Row:10 grids\71.xgd
68 Col:5 Row:11 grids\72.xgd
69 Col:5 Row:12 grids\73.xgd
70 Col:5 Row:13 grids\89.xgd
71 Col:6 Row:6 grids\31.xgd
72 Col:6 Row:7 grids\32.xgd
73 Col:6 Row:8 grids\33.xgd
74 Col:6 Row:9 grids\74.xgd
75 Col:6 Row:10 grids\75.xgd
76 Col:6 Row:11 grids\76.xgd
77 Col:6 Row:12 grids\77.xgd
78 Col:6 Row:13 grids\88.xgd
79 Col:7 Row:7 grids\29.xgd
80 Col:7 Row:8 grids\30.xgd
81 Col:7 Row:9 grids\78.xgd
82 Col:7 Row:10 grids\79.xgd
83 Col:7 Row:11 grids\80.xgd
84 Col:7 Row:12 grids\81.xgd
85 Col:7 Row:13 grids\87.xgd
86 Col:8 Row:9 grids\82.xgd
87 Col:8 Row:10 grids\83.xgd
88 Col:8 Row:11 grids\84.xgd
89 Col:8 Row:12 grids\85.xgd
90 Col:8 Row:13 grids\86.xgd

Area 2 processed data

COMPOSITE
Filename: J358-mag-Area2-PROC.xcp

Stats
Max: 5.00
Min: -5.00
Std Dev: 2.26
Mean: 0.10
Median: 0.00
Composite Area: 12.6 ha
Surveyed Area: 6.1885 ha

Processes: 6
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -5.00 to 5.00 nT
5 De Stagger: Grids: 71.xgd Mode: Outbound By: 1 intervals
6 Clip from -5.00 to 5.00 nT

Area 3 raw data

COMPOSITE
Filename: J358-mag-Area3-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 18/03/2011
Assembled by: on 18/03/2011
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 840 x 390
Survey Size (meters): 210 m x 390 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: 2.99
Mean: -0.03
Median: -0.14
Composite Area: 8.19 ha
Surveyed Area: 3.886 ha

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

Source Grids: 61
1 Col:0 Row:0 grids\59.xgd
2 Col:0 Row:1 grids\35.xgd
3 Col:0 Row:2 grids\36.xgd
4 Col:0 Row:3 grids\37.xgd
5 Col:0 Row:4 grids\38.xgd
6 Col:0 Row:5 grids\34.xgd
7 Col:1 Row:0 grids\60.xgd
8 Col:1 Row:1 grids\39.xgd
9 Col:1 Row:2 grids\40.xgd
10 Col:1 Row:3 grids\41.xgd
11 Col:1 Row:4 grids\42.xgd
12 Col:1 Row:5 grids\32.xgd
13 Col:1 Row:6 grids\33.xgd
14 Col:2 Row:0 grids\61.xgd
15 Col:2 Row:1 grids\43.xgd
16 Col:2 Row:2 grids\44.xgd
17 Col:2 Row:3 grids\45.xgd
18 Col:2 Row:4 grids\46.xgd
19 Col:2 Row:5 grids\30.xgd
20 Col:2 Row:6 grids\31.xgd
21 Col:3 Row:1 grids\47.xgd
22 Col:3 Row:2 grids\48.xgd
23 Col:3 Row:3 grids\49.xgd
24 Col:3 Row:4 grids\50.xgd
25 Col:3 Row:5 grids\26.xgd
26 Col:3 Row:6 grids\27.xgd
27 Col:3 Row:7 grids\28.xgd
28 Col:3 Row:8 grids\29.xgd
29 Col:3 Row:10 grids\12.xgd
30 Col:3 Row:11 grids\13.xgd
31 Col:4 Row:1 grids\51.xgd
32 Col:4 Row:2 grids\52.xgd
33 Col:4 Row:3 grids\53.xgd
34 Col:4 Row:4 grids\54.xgd
35 Col:4 Row:5 grids\22.xgd
36 Col:4 Row:6 grids\23.xgd
37 Col:4 Row:7 grids\24.xgd
38 Col:4 Row:8 grids\25.xgd
39 Col:4 Row:9 grids\09.xgd
40 Col:4 Row:10 grids\10.xgd
41 Col:4 Row:11 grids\11.xgd
42 Col:5 Row:3 grids\55.xgd
43 Col:5 Row:4 grids\56.xgd
44 Col:5 Row:5 grids\18.xgd
45 Col:5 Row:6 grids\19.xgd
46 Col:5 Row:7 grids\20.xgd
47 Col:5 Row:8 grids\21.xgd
48 Col:5 Row:9 grids\06.xgd
49 Col:5 Row:10 grids\07.xgd
50 Col:5 Row:11 grids\08.xgd
51 Col:5 Row:12 grids\05.xgd
52 Col:6 Row:3 grids\57.xgd
53 Col:6 Row:4 grids\58.xgd
54 Col:6 Row:5 grids\14.xgd
55 Col:6 Row:6 grids\15.xgd
56 Col:6 Row:7 grids\16.xgd
57 Col:6 Row:8 grids\17.xgd
58 Col:6 Row:9 grids\01.xgd
59 Col:6 Row:10 grids\02.xgd
60 Col:6 Row:11 grids\03.xgd
61 Col:6 Row:12 grids\04.xgd

Area 3 processed data

COMPOSITE
Filename: J358-mag-Area3-proc.xcp

Stats
Max: 5.00
Min: -5.00
Std Dev: 1.88
Mean: 0.08
Median: 0.00
Composite Area: 8.19 ha
Surveyed Area: 3.886 ha

Processes: 7
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -5.00 to 5.00 nT
5 De Stagger: Grids: 22.xgd Mode: Both By: 1 intervals
6 De Stagger: Grids: 53.xgd Mode: Both By: 1 intervals
7 Clip from -5.00 to 5.00 nT

Area 4 raw data

COMPOSITE
Filename: J358-mag-Area4-raw.xcp
Instrument Type: Bartington (Gradiometer)
Units: nT
Surveyed by: on 18/03/2011
Assembled by: on 18/03/2011
Direction of 1st Traverse: 90 deg
Collection Method: ZigZag
Sensors: 2 @ 1.00 m spacing.
Dummy Value: 32702

Dimensions
Composite Size (readings): 720 x 150
Survey Size (meters): 180 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: 2.32
Mean: -0.30
Median: -0.47
Composite Area: 2.7 ha
Surveyed Area: 1.0349 ha

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

Source Grids: 20
1 Col:0 Row:2 grids\19.xgd
2 Col:0 Row:3 grids\20.xgd
3 Col:1 Row:1 grids\16.xgd
4 Col:1 Row:2 grids\17.xgd
5 Col:1 Row:3 grids\18.xgd
6 Col:2 Row:0 grids\11.xgd
7 Col:2 Row:1 grids\12.xgd
8 Col:2 Row:2 grids\13.xgd
9 Col:2 Row:3 grids\14.xgd
10 Col:2 Row:4 grids\15.xgd
11 Col:3 Row:0 grids\06.xgd
12 Col:3 Row:1 grids\07.xgd
13 Col:3 Row:2 grids\08.xgd
14 Col:3 Row:3 grids\09.xgd
15 Col:3 Row:4 grids\10.xgd
16 Col:4 Row:2 grids\03.xgd
17 Col:4 Row:3 grids\04.xgd
18 Col:4 Row:4 grids\05.xgd
19 Col:5 Row:3 grids\01.xgd
20 Col:5 Row:4 grids\02.xgd

Area 4 processed data

COMPOSITE
Filename: J358-mag-Area4-proc.xcp

Stats
Max: 5.00
Min: -5.00
Std Dev: 1.61
Mean: 0.11
Median: 0.00
Composite Area: 2.7 ha
Surveyed Area: 1.0349 ha

Processes: 4
1 Base Layer
2 Clip from -30.00 to 30.00 nT
3 DeStripe Median Traverse: Grids: All
4 Clip from -5.00 to 5.00 nT

Appendix D – digital archive

Archaeological Surveys Ltd hold the primary digital archive at Castle Combe, Wiltshire (see inside cover for address). Data are backed-up onto an on-site data storage drive and at the earliest opportunity data are copied to CD ROM for storage on-site and off-site. 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). The distribution of both hardcopy report and digital data is considered the responsibility of the Client unless explicitly stated in the survey Brief, Written Scheme of Investigation or other contractual agreement.

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

- ArcheoSurveyor version 2.5.9.4 (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.

The CD ROM structure is formed from a tree of directories under the title J358 Treswarrow – CD. Directory titles include Data, Documentation, CAD and PDFs. 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).