OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.

Report on geophysical surveys, June 2005, August 2005 and April 2006.

Summary

A detailed geophysical survey was conducted over a single round barrow to determine whether a suitable methodology to delimit the damaged caused by badgers, and other burrowing animal disturbance, could be proposed. The geophysical investigation was conducted in advance of the partial excavation of the barrow, during the summer of 2005, and was complemented by a magnetic survey of 4.4ha to cover other known monuments within the immediate vicinity. This report provides an initial assessment of the geophysical data in advance of the final excavation results.

Keywords Bronze Age, Earth Resistance, Geophysical Survey, Ground Penetrating Radar, Magnetometer

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.

Report on geophysical surveys, June 2005, August 2005 and April 2006.

Introduction

A group of three Early Bronze Age round barrows are found at the head of a south-facing dry valley in an area of undulating chalk downland known as Maizey Down, near the village of Ogbourne St. Andrew, Wiltshire, including a bell barrow 20m in diameter and 4m high (SAM 12206), a bowl barrow 26m in diameter and 0.75m high (SAM 12207) and a second bowl barrow (SAM 12208) with an adjacent saucer barrow 15m to the west. The mound of this latter bowl barrow is 20m in diameter and stands to a height of 1m surrounded by an infilled ditch from which material was presumably quarried during the construction of the monument. The saucer barrow has been completely levelled and is no longer visible at the ground surface. All three upstanding barrows show evidence of partial excavation in the late C19th and contain a large number of sarsen blocks (especially SAM 12207) that appear to be the result of field clearance, rather than forming an integral part of the monuments. In addition, the barrow group has also been subject to more recent damage due to burrowing animals, including active badger setts and extensive rabbit warrens.

The detailed geophysical survey was conducted over the smaller of the two bowl barrows SAM 12208, also known also as Ogbourne St. Andrew 8 (OSA8), as part of a programme of research to examine the impact of badger activity on prehistoric monuments (Cromwell *et al.* 2006). This was followed by the partial excavation of the barrow in September 2005 and a wider area magnetic survey in April 2006 to cover the other extant barrows and potentially reveal the remains of any more degraded monuments in the immediate vicinity of OSA8.

The site (NGR SU163731) lies on well drained calcareous soils of the Icknield 1 association (Soil Survey of England and Wales 1983) developed over Middle Chalk (British Geological Survey 1974). Weather conditions during the geophysical fieldwork were dry and sunny and the field was not in agricultural production, but was used occasionally as part of the neighbouring gallops. As a result, extensive vegetation had to be removed prior to the initial survey of the OSA8 barrow. Burrowing activity over the barrow presented a considerably disturbed surface that impeded data acquisition. At the time of the wider area magnetic survey (April 2006) the badger exclusion fence had already been established around the OSA8 barrow in preparation for the subsequent excavation.

Method

Following the visual location of the barrow in the field, an initial magnetic survey was conducted over a single 30m square using a Bartington Grad-601 fluxgate magnetometer to confirm the position of the barrow ditch (see note 2 of Annex 1). Readings were collected at 0.25m intervals along north-south orientated traverses separated by 1.0m. Minimal post acquisition processing was applied to the data beyond setting each traverse to a zero mean, to remove directional sensitivity and instrument drift, and the removal of spurious responses due to the presence of near-surface ferrous litter through the application of a 2m by 2m thresholding median filter (Scollar *et al.* 1990, 492). Data acquisition was hampered during the initial survey by the uneven nature of the terrain and the overgrown vegetation. The wider area magnetic survey data was also collected with Bartington Grad601 fluxgate gradiometers using an identical sample interval and similar data processing to the initial investigation of the barrow (Figure 1). Resulting traceplot and greytone images of the wider area magnetic data are presented on Figures 13, 14 and 15.

Once the precise location of the barrow had been established through the magnetic survey the Ground Penetrating Radar (GPR) survey was conducted with a Pulse Ekko PE1000 console using 225MHz, 450MHz and 900MHz centre frequency antennas. Details of the sample interval and areas covered with each antenna are given in Table 1. Attempts to estimate the velocity of the radar wavefront in the subsurface through a common mid-point (CMP) velocity analysis conducted in the field suggested an average subsurface velocity of ~0.075m/ns. This value was adopted as a reasonable average for processing the data from this site and for the estimation of depth to reflection events in the recorded profiles. Post acquisition processing involved the adjustment of time-zero to coincide with the true ground surface, removal of any low frequency transient response (dewow), noise removal and the application of a suitable gain function to enhance late arrivals.

Table1: Details of GPR sampling strategy.

Area of site (Figure 2)	***Survey type***	***Sample interval***		***Antenna centre frequency (average velocity)***	***Time window***
		Line	***Trace***		
30m x 30m	Area	0.5m	0.05m	225MHz	80ns
30m x 30m	Area	0.5m	0.01m	450MHz	80ns
15m x 20m	Area	0.25m	0.01m	450MHz	80ns
15m x 20m	Area	0.25m	0.01m	900MHz	40ns

Owing to antenna coupling of the GPR transmitter with the ground to an approximate depth of $^{\lambda}/_{2}$, very near surface reflection events should only be detectable below depths of 0.33m, 0.17m and 0.08m for centre frequencies of 225MHz, 450MHz and 900MHz respectively, assuming a common velocity of 0.075m/ns. However, the broad bandwidth of an impulse GPR signal results in a range of frequencies to either side of the centre frequency which, in practice, will record significant near-surface reflections closer to the ground surface. Such reflections are often emphasised by presenting the data as amplitude time slices. In this case, the time-slices were created from each data set, after applying a 2D-migration algorithm, by averaging data within successive 2ns (two-way travel time) windows (cf Linford 2004). Each resulting time slice, illustrated as a series of greytone images in Figures 8 to 11, represents the variation of reflection strength through successive ~0.075m intervals from the ground surface. A combined graphical summary of significant anomalies identified from the amplitude time slices is shown in Figure 12.

The earth resistance survey was conducted with a Geoscan RM15 resistivity meter using a twin-electrode array with a 0.5m mobile probe spacing. Readings were recorded at 1.0m x 1.0m sample intervals over a 30m grid (Figures 2 and 4). Plots of the raw data after the initial removal of spurious readings caused by poor probe contact are shown on Figure 6. A combined graphical summary of significant earth resistance and magnetic anomalies is shown in Figure 7.

A Trimble real-time kinematic Global Positioning System (GPS) was used to establish all of the survey grids and to collect detailed topographic data over the OSA8 barrow itself.

Results

OSA8 Round Barrow

<u>Magnetic survey</u>

The initial magnetic survey (Figures 3, 6(A) and 6(B)) confirmed the location of the barrow ditch as an almost complete, circular ditch-type anomaly [Figure 7: m1] with a diameter of ~20m. The ditch appears to be partly interrupted to the S, but this may well be due to the uneven nature of the terrain during the initial survey rather than a discontinuity in the underlying feature itself. Considerable magnetic disturbance is found over the central mound of the barrow within [m1] and may represent a combination of modern ferrous disturbance (more intense responses) and several pit-type anomalies [m2], possibly associated with C19th antiquarian activity. There is, apparently, some correlation between the pit-type magnetic and high-resistance earth resistance anomalies, although this is not sufficiently convincing to suggest any direct relationship between a positive magnetic response and an underlying sett. Such a correlation would not, necessarily, be expected from an extant air-filled void but it is possible that a (semi) collapsed sett may have accumulated sufficient higher magnetic susceptibility material to create a pit-type anomaly.

Earth resistance survey

Results from the earth resistance survey (Figures 4, 6(C-F)) confirmed the location of the barrow ditch but indicate a variable low resistance response better defined to the N [Figure7: r1]. This may well be due to the slumping of the mound material over or into the ditch on the S (down-slope) side of the monument. There is also evidence for a discontinuous, circular high-resistance anomaly [r2] running around the inner circumference of the barrow ditch. A series of high-resistance anomalies [r3-6] are found in the centre of the barrow over the mound and it seems plausible, from the observed location of apparent entrances over the surface of the mound, that these responses are caused by extant air-filled burrows. A more tentative low-resistance response [r7] may also be related to animal activity, perhaps a partially collapsed rabbit burrow.

Two groups of resistance anomalies [r8 and r9] to the S of the barrow ditch are found together with a tentative linear high resistance anomaly [r10], which may be associated with the edge of the meandering track-way passing through the saucer barrow to the W of OSA8. However, these anomalies are difficult to interpret and are more clearly resolved in the GPR data, although the group of short, linear anomalies forming [r8] and [r9] may well indicate further rabbit activity. A short, curvi-linear low resistance response [r11] is found to the NE of the barrow, beyond the limit of the ditch and may, perhaps, represent a more recent agricultural plough mark skirting the visible relief of the monument.

GPR survey

The 225MHz centre frequency antenna (Figure 8) provides the greatest depth of signal penetration, to approximately 2m below the surface, and the mound of the barrow is visible as a high amplitude reflection [Figure 12; g1] in the very near-surface data, between 0 and 18ns (0 to 0.675m). However, it is difficult to discern any internal detail due to the reduced lateral resolution of the low centre frequency antenna. The surrounding barrow ditch is far better resolved as a low amplitude reflection [g2], presumably due to the contrast between the ditch fill and the chalk bedrock, visible from between 16 and 50ns (0.6 to 1.875m) below which the response is degraded through signal attenuation. The ditch appears as a circular anomaly with a diameter of ~20m, varying in breadth with depth. At 1m below the surface [g2] is still approximately 1.5m wide, suggesting the bottom of the causative feature extends beyond the maximum depth of penetration recorded by the GPR survey.

Although [g2] describes a complete, circular response from the ditch, reflections from 28ns (1.05m) onwards show a more clearly defined anomaly to the N similar to the earth resistance data. Comparison with the 450MHz data (Figure 9) confirms this response to the barrow ditch, although the signal from the higher centre frequency data attenuates more rapidly with this anomaly fading beyond 32ns (1.2m). Both data sets show that [g2] is partially obscured to the S by a diffuse high amplitude response between 16 and 22ns (0.6 to 0.75m), possibly indicative of the material from the barrow mound slumping down-slope into the top of the surrounding ditch (see above). A second ditch-type anomaly [g3] is also recorded by both data sets meeting the barrow ditch from the SE of the survey area and appears to be associated with a high amplitude response [g4] visible between 36 and 46ns (1.35 to 1.725m). Interpretation of [g3] and [g4] is difficult as neither anomaly is fully described within the survey area. However, the depth of response from [g3] compared to the ditch surrounding the barrow suggests a shallower causative feature, perhaps a former field boundary or lynchet cut into the hill slope. There are no corresponding magnetic or earth resistance anomalies.

The GPR data also provides evidence for a sub-circular high amplitude anomaly running inside the response to the barrow ditch. This appears as both a more diffuse response [g5] distinct from the mound, for example within the 450MHz data (Figures 9 and 10) between 24 and 32ns (0.9 to 1.2m), and as a more discrete response [g6] particularly between 36 and 40ns (1.35 to 1.5m) in the high frequency 900MHz data (Figure 11). Due to the more limited extent of the high frequency survey [g6] is not fully described around the circumference of the barrow but appears to lie between the ditch and the more diffuse response [g5]. There is also some, highly tentative, evidence for a low amplitude pit-type anomaly [g7] in the centre of the mound between 36 and 42ns (1.35 to 1.575m) within the 225MHz data, partially overlain by a high amplitude reflector.

The most convincing anomalies related to animal burrowing at the site are, not surprisingly, found within the high resolution data (0.25m x 0.01m sample interval) conducted over the central area of the mound with both the 450 and 900MHz antenna (Figures 10 and 11). Of these two data sets the results from the 900MHz antenna appear to be the most useful, identifying significant reflections through a time window of approximately 30ns.

It is difficult to predict the expected GPR response from a badger sett and the anomalies within the 900MHz data appear as both high and low amplitude reflectors, suggesting the presence of both extant air-filled voids and, perhaps, some semi-collapsed burrows. The complicated nature of this response hampers the definitive interpretation of this data, but two low amplitude anomalies, [g8] and [g9] are visible from between 7 and 14ns (0.28 to 0.56m), which may suggest the location of extant setts within the barrow mound. Evidence for individual linear burrows or tunnels is more difficult to discern and is apparently represented by high amplitude responses to south [g10] and east [g11] of the two main sett anomalies and low amplitude response to the north [g12] and west [g13].

Other groups of more discontinuous anomalies (e.g. [g14] and [g15]) may also be associated with animal burrows and many of these are directly associated with the location of apparent entrances observed over the surface of the barrow at the time of the survey (Figure 12). A small number of these recorded entrances fail to correspond with any underlying geophysical response.

Wider area magnetic survey

The ditch of the saucer barrow, immediately adjacent to OSA8, appears as a positive magnetic anomaly [Figure 16; m3] interrupted by the intense response to the badger exclusion fencing [m4] erected prior to the excavation of the OSA8 barrow. Unfortunately, as no surface expression of the saucer barrow is evident, perhaps because it has been eroded by the course of a meandering track-way [m5], this monument remained unrecognised at the time the fencing was installed. The track-way [m5] continues N as a subtle magnetic anomaly generally following the course described by the OS mapping, although there is some geophysical evidence for an additional branch to the E.

The ditches of the bowl barrow (SAM 12207) to the S of OSA8 also appear as a positive magnetic anomaly [m6], but appear to be better resolved on the N (upslope facing) side of the mound. Some down-slope slumping of the mound material was recorded during the subsequent excavation of the neighbouring OSA8 barrow and this may explain the incomplete nature of [m6]. However, over OSA8 the variation in geophysical response is far more evident in the earth resistance data [Figure 7; r1] than the almost complete, circular magnetic anomaly [Figure 7; m1] suggesting another cause, such as erosion through ploughing, may be equally likely. The intense response of a ferrous pipeline [m7] also impinges upon [m6] to the W. The buried pipe appears to consist of two, differently aligned sections, perhaps originally connected to a feature such as a cattle watering trough (between the points where the pipe response is interrupted) that has now been removed. There is also evidence for a concentration of disturbed response [m8] inside the barrow ditch, possibly related to the deliberate clearance of large stone fragments and other ferrous detritus from the field that have been dumped over the mound of this monument.

The ditch of the largest of the four barrows, the bell barrow to the NW of OSA8, is also replicated as a circular magnetic anomaly [m9] and again contains an area of magnetic disturbance [m10]. A small sub-rectangular enclosure ditch [m11] abuts the NW segment of [m9], although it appears to be largely devoid of any internal anomalies. The significance and date of this enclosure are uncertain and it may simply represent a later re-use of the adjacent barrow ditch, perhaps as a stock enclosure. An alternative interpretation might be a ritual enclosure, such as the features linked to funerary practices adjacent to barrow structures at sites such as the West Cotton monument complex in the Nene valley, near Raunds, Northamptonshire (Windwell *et al.* 1990, Fig. 7).

A more tentative outline of weak linear positive responses [m12] is found to the E of [m9] and may, possibly, represent a second enclosure sharing a similar orientation to [m11]. However, it seems equally likely that [m12] is related to the magnetic disturbance due to the track-way [m5] or other fragmentary linear anomalies, such as [m13], that possibly represent lynchets or field boundaries cut into the hillside. Further weak linear anomalies [m14-

18] are found throughout the survey area, but these would appear to be related to recent track-ways and gallops rather than significant archaeological activity.

Initial comparison with the excavation data

The limit of the subsequent excavation of the OSA8 barrow is shown together with the graphical interpretation of the geophysical data sets on Figures 7 and 12. Initial analysis of the excavation results suggests that both the GPR and the earth resistance surveys have, in part, located individual animal burrows (e.g. [r7] and [g11]) and a concentration of anomalies associated with the two main badger setts (Figure 17(A) and (B)). Some of these anomalies were shown to be quite subtle, such as the GPR response [g11] to an individual rabbit burrow running from the barrow ditch to the central mound (Figure 17(C)). However, in general the network of the inter-cut badger setts and rabbit burrows within the centre of the barrow mound has produced a highly complex geophysical response. Both the GPR and the earth resistance demonstrate some correlation with the distribution of underlying animal burrows, but neither data set is wholly convincing. Distinct areas of low amplitude GPR response (e.g. [g8]) that contain no earth resistance anomalies do appear to correlate with undisturbed portions of the mound, suggesting the geophysical data may indicate parts of the monument that have survived damage from animal activity.

Correlation between the magnetic anomalies and the animal burrows is less convincing. However, the general focus of the animal disturbance has, perhaps serendipitously, been identified by this technique. The pit-type response at [m2], in the centre of the barrow mound, did correspond with the location of an antiquarian excavation pit with fragments of a disturbed sarsen setting found at the base. This feature was also detected by the GPR survey [g7] that produced a combined low amplitude response to the pit and a high amplitude reflection, perhaps from the fragments of buried stone (Figure 17(D)).

Both the earth resistance and the GPR data identify an intermittent high resistance/amplitude response ([r2] and [g6]) following the inner circumference of the barrow ditch. The course of these anomalies was partially covered by the main excavation trench, although no distinct causative feature was observed. The mound of the barrow was found to seal a ring of stake-holes, but the location and diameter of these did not match the much wider circumference of the geophysical anomalies. It is possible that the geophysical survey has responded to the differential compaction of deposits within the barrow ditch, which was found to be highly variable and no doubt relates to differential phases of infilling (V. Crosby *pers. comm.*). Perhaps more difficult to explain is the absence of any feature related to the possible lynchet or field boundary identified by the GPR survey at [g3] and [g4] approaching the barrow ditch from the SE. Whilst only the low amplitude response [g3] was coincident with the excavation trench no visible explanation for the anomaly was apparent.

The excavation across the barrow ditch suggested some slumping of material from the mound into the top of the ditch. However, it is unclear whether this accounts for the differing geophysical response to the ditch in the earth resistance and GPR due to the position of the excavation trench.

Finally, it is noted that despite a lack of direct spatial correlation between GPR anomalies and the excavated animal burrows there is a strong morphological similarity. It is possible that this is due to the tilt of the GPR antenna as it traverses the topography of the mound (Figure 18(A)). The application of appropriate topographic and tilt angle corrections to the GPR data can result in the significant lateral variation of the resulting anomalies (cf Goodman *et al.* 2006, Figure 4). Whilst the degree of topographic variation over the mound of the OSA8 barrow is comparatively slight (total variation <2m; Figure 18(B)), given the subtle physical dimensions of the animal burrows (<0.3m) even a modest translation of the GPR anomalies following a topographic and tilt correction may improve the apparent spatial correlation. A trial tilt correction algorithm following Goodman *et al.* (2006) demonstrates a potentially significant translation of the GPR anomalies that may assist with a more detailed comparison with the complete digitised excavation plans, when these become available.

Conclusions

Detailed geophysical survey over the OSA8 barrow demonstrates the difficulty in mapping anomalies related to individual features of a well established, inter-cut series of badger setts, tunnels and rabbit burrows. Both earth resistance at a standard sample resolution (1m x 1m) and detailed GPR (900MHz; 0.01m x 0.25m) survey have successfully identified a complex response associated with the location of two badger setts and individual linear anomalies due to discrete animal burrows isolated from the main activity. This suggests that both geophysical techniques may be of most use for mapping comparatively recent animal burrows in previously undamaged monuments.

All three geophysical techniques applied over the barrow have also apparently delimited the main areas of animal activity, although this was only tested against partial excavation data and could, perhaps, have been equally obtained from recording the distribution of visible burrows over the surface of the monument. Whilst GPR survey provided the most detailed image of the subsurface and uniquely provided the vertical separation of anomalies, it also produced the most demanding data set in terms of field acquisition (including a digital terrain model), data processing, visualisation and interpretation. In this regard, a combination of earth resistance and magnetic survey would be recommended where the most cost effective means of geophysical evaluation is required.

Significant archaeological information was also recovered from the geophysical survey over the barrow, including the location of a central pit associated with antiquarian investigation of the monument and the more detailed mapping of the surrounding ditch. The wider magnetic survey confirmed the location of the adjacent saucer barrow, unfortunately now bisected by the line of the badger exclusion fence, and at least one additional rectilinear enclosure abutting the anomaly due to the ring ditch of the bell barrow to the N of the survey area. Magnetic anomalies concentrated within the centre of the bell barrow also suggest a degree of interference, possibly from a combination of antiquarian excavation and damage due to more recent animal burrowing activity. The ring ditch of the second bowl barrow to the S of OSA8 was also identified as a magnetic anomaly, although this was heavily disturbed by ferrous interference.

Surveyed by:	N Linford L Martin	Date of survey:	13-16/6/2005 18/8/2005
	L Martin A Payne A Rogers (student volunteer)		3-5/4/2006
Reported by:	N Linford A Payne	Date of report:	23/1/2007

Geophysics Team,
English Heritage.

List of figures.

Figure 18 Cartoon (A) illustrating how antenna tilt may result in horizontally displaced or over-lapping GPR reflections together with (B) a greyscale image of the magnetic data draped over a digital terrain model of the barrow (exaggerated vertical axis). An uncorrected amplitude time slice (C) from the 900MHz survey (between 10 and 11ns) can be compared with (D) the same data after the application of a tilt correction algorithm following Goodman *et al.* (2006). A subtle redistribution of the GPR anomalies is evident in the corrected data under the central mound where the most significant topographic variation is found.

References

British Geological Survey 1974. Marlborough, England and Wales, Sheet 266 1:50,000 scale.

Cromwell, T, Crosby, V, Last, J and Linford, N 2006 'Badger-damaged Round Barrows Project: developing recording methods'. *English Heritage Research News*, 3, 10-13

Goodman, D, Nishimura, Y, Hongo, H and Higashi, N 2006 'Correcting for topography and the tilt of ground-penetrating radar antennae'. *Archaeological Prospection*, 13 (2), 157-161

Linford, N 2004 'From Hypocaust to Hyperbola: Ground Penetrating Radar surveys over mainly Roman remains in the U.K.' *Archaeological Prospection*, 11 (4), 237-246

Scollar, I, Tabbagh, A, Hesse, A and Herzog, I 1990 *Archaeological Prospecting and Remote Sensing*, Vol. 2, Topics in Remote Sensing, Cambridge University Press, Cambridge

Soil Survey of England and Wales 1983. Soils of England and Wales, Sheet 6, South East England 1:250000 scale.

Windwell, D, Chapman, A and Woodiwiss, J 1990. From Barrows to Bypass: Excavations at West Cotton, Raunds, Northamptonshire 1985 - 1989. Northamptonshire Archaeology Unit, Excavation Report.

Annex 1: Notes on standard procedures

1) **Earth Resistance Survey:** Each 30 metre grid square is surveyed by making repeated parallel traverses across it, all aligned parallel to one pair of the grid square's edges, and each separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metres from the nearest parallel grid square edge. Readings are taken along each traverse at 1 metre intervals, the first and last readings being 0.5 metres from the nearest grid square edge.

Unless otherwise stated the measurements are made with a Geoscan RM15 earth resistance meter incorporating a built-in data logger, using the twin electrode configuration with a 0.5 metre mobile electrode separation. As it is usually only relative changes in earth resistance that are of interest in archaeological prospecting, no attempt is made to correct these measurements for the geometry of the twin electrode array to produce an estimate of the true apparent resistivity. Thus, the readings presented in plots will be the actual values of earth resistance recorded by the meter, measured in Ohms (Ω). Where correction to apparent resistivity has been made, for comparison with other electrical prospecting techniques, the results are quoted in the units of apparent resistivity, Ohm-m (Ωm).

Measurements are recorded digitally by the RM15 meter and subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to the Centre for Archaeology using desktop workstations.

2) **Magnetometer Survey:** Each 30 metre grid square is surveyed by making repeated parallel traverses across it, all parallel to that pair of grid square edges most closely aligned with the direction of magnetic N. Each traverse is separated by a distance of 1 metre from the last; the first and last traverses being 0.5 metre from the nearest parallel grid square edge. Readings are taken along each traverse at 0.25 metre intervals, the first and last readings being 0.125 metre from the nearest grid square edge.

These traverses are walked in so called 'zig-zag' fashion, in which the direction of travel alternates between adjacent traverses to maximise survey speed. Where possible, the magnetometer is always kept facing in the same direction, regardless of the direction of travel, to minimise heading error. However, this may be dependent on the instrument design in use.

Unless otherwise stated the measurements are made with either a Bartington *Grad601* or a Geoscan FM36 fluxgate gradiometer which incorporate two vertically aligned fluxgates, one situated either 1.0m or 0.5 metres above the other; the bottom fluxgate is carried at a height of approximately 0.2 metres above the ground surface. Both instruments incorporate a built-in data logger that records measurements digitally; these are subsequently transferred to a portable laptop computer for permanent storage and preliminary processing. Additional processing is performed on return to the Centre for Archaeology using desktop workstations.

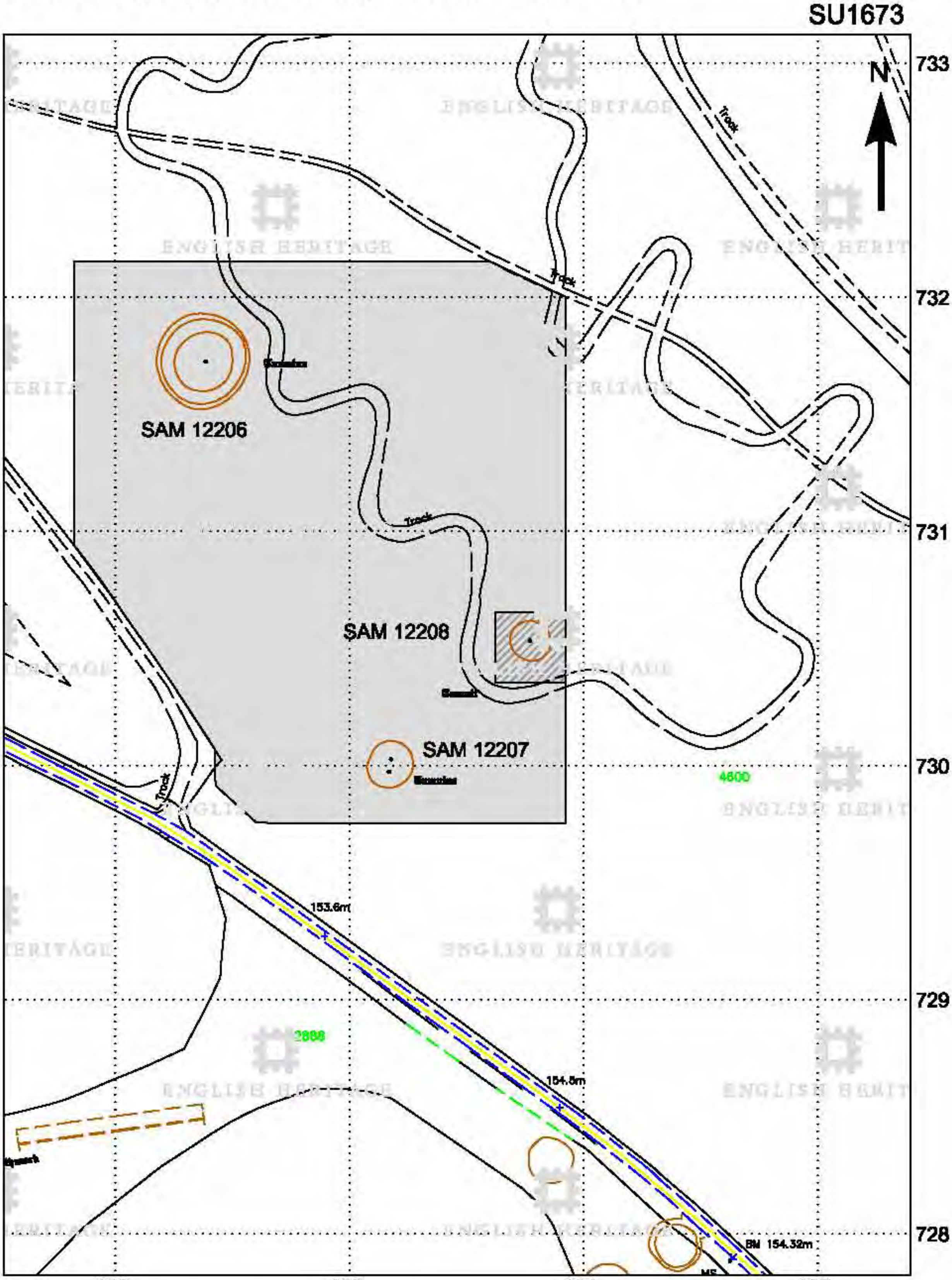
It is the opinion of the manufacturer of the Geoscan instrument that two sensors placed 0.5 metres apart cannot produce a true estimate of vertical magnetic gradient unless the bottom sensor is far removed from the ground surface. Hence, when results are presented, the difference between the field intensity measured by the top and bottom sensors is quoted in units of nano-Tesla (nT) rather than in the units of magnetic gradient, nano-Tesla per metre (nT/m).

3) **Resistivity Profiling:** This technique measures the electrical resistivity of the subsurface in a similar manner to the standard resistivity mapping method outlined in note 1. However, instead of mapping changes in the near surface resistivity over an area, it produces a vertical section, illustrating how resistivity varies with increasing depth. This is possible because the resistivity meter becomes sensitive to more deeply buried anomalies as the separation between the measurement electrodes is increased. Hence, instead of using a single, fixed electrode separation as in resistivity mapping, readings are repeated over the same point with increasing separations to investigate the resistivity at greater depths. It should be noted that the relationship between electrode separation and depth sensitivity is complex so the vertical scale quoted for the section is only approximate. Furthermore, as depth of investigation increases the size of the smallest anomaly that can be resolved also increases.

Typically a line of 25 electrodes is laid out separated by 1 or 0.5 metre intervals. The resistivity of a vertical section is measured by selecting successive four electrode subsets at increasing separations and making a resistivity measurement with each. Several different schemes may be employed to determine which electrode subsets to use, of which the Wenner and Dipole-Dipole are typical examples. A Campus Geopulse earth resistance meter, with built in multiplexer, is used to make the measurements and the Campus Imager software is used to automate reading collection and construct a resistivity section from the results.

Figure 1

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Location of geophysical survey, June 2005 - April 2006.



This map is based upon the OS map by English Heritage with the permission of Ordnance Survey on behalf of The Controller of Her Majesty's Stationery Office,
Licence Number: 100019088 2007.

Magnetic survey

GPR and earth resistance surveys

0 90m
1:2500

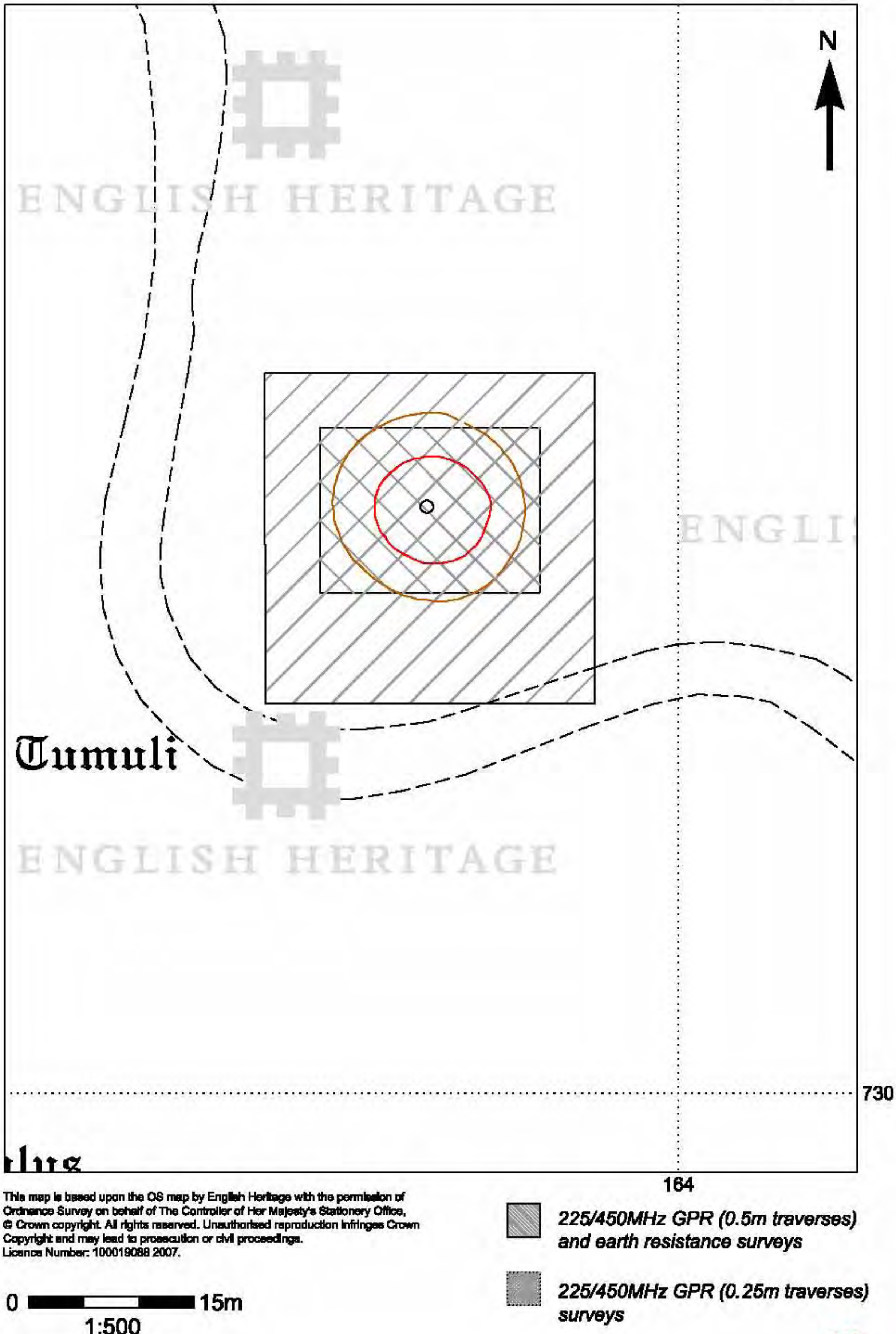
Geophysics Team 2007

ENGLISH HERITAGE

Figure 2

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Location of geophysical surveys, June and August 2005.

SU1673



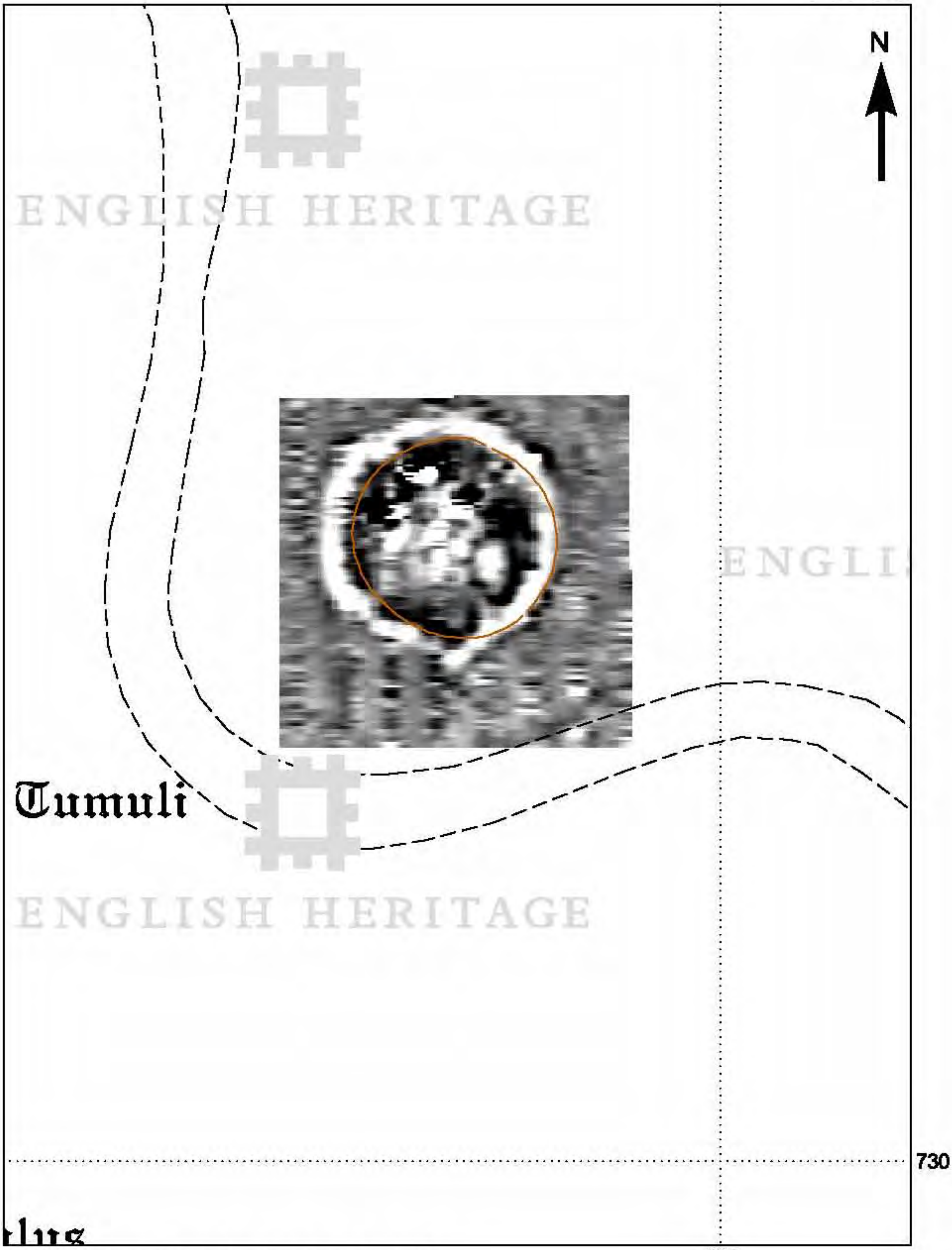
Geophysics Team 2007

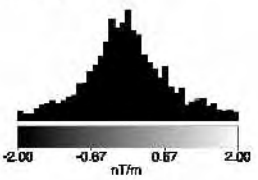
ENGLISH HERITAGE

Figure 3

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Magnetometer survey, June 2005.

SU1673





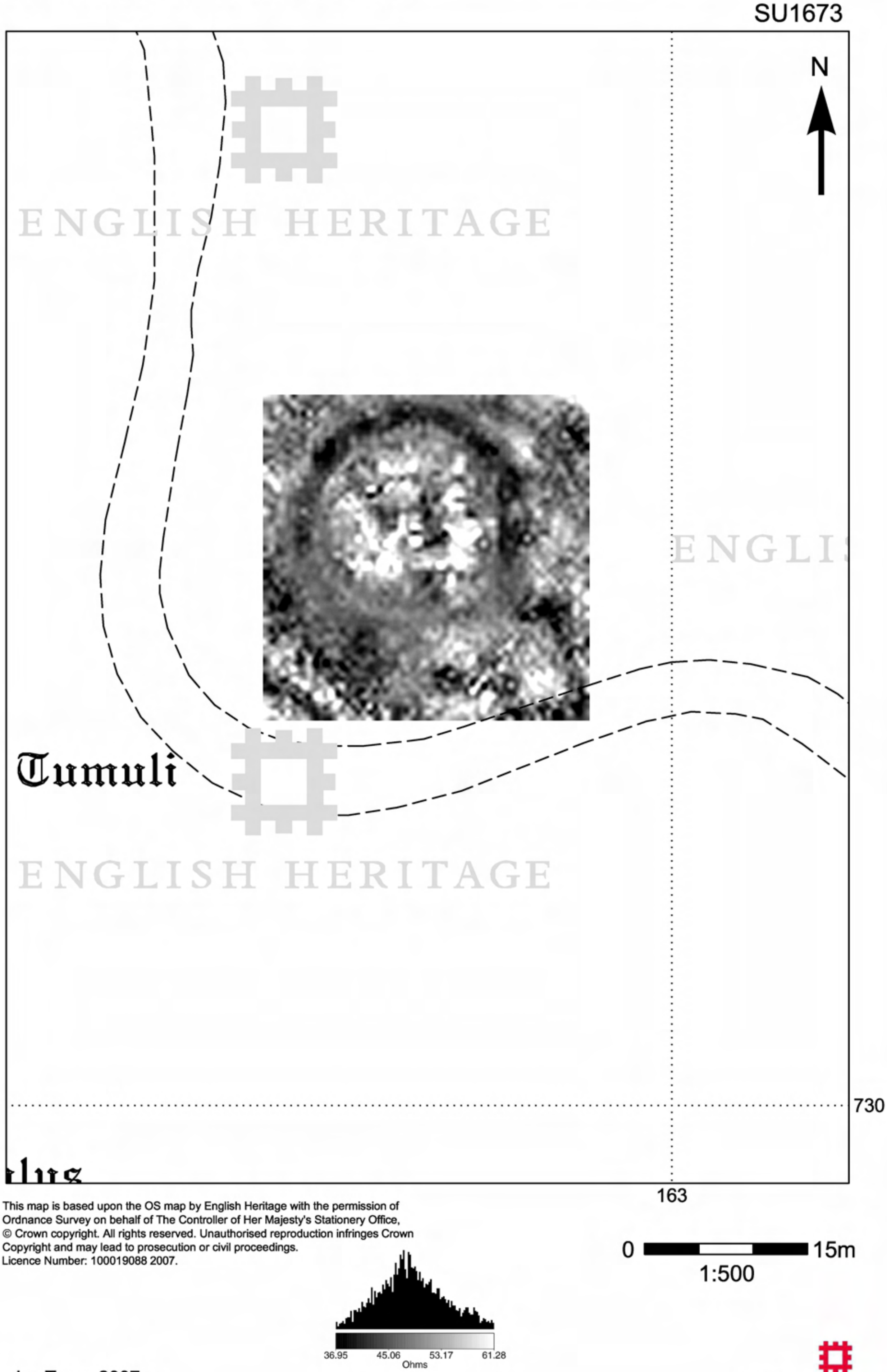
0 15m
1:500

Geophysics Team 2007

ENGLISH HERITAGE

Figure 4

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Earth resistance survey, June 2005.

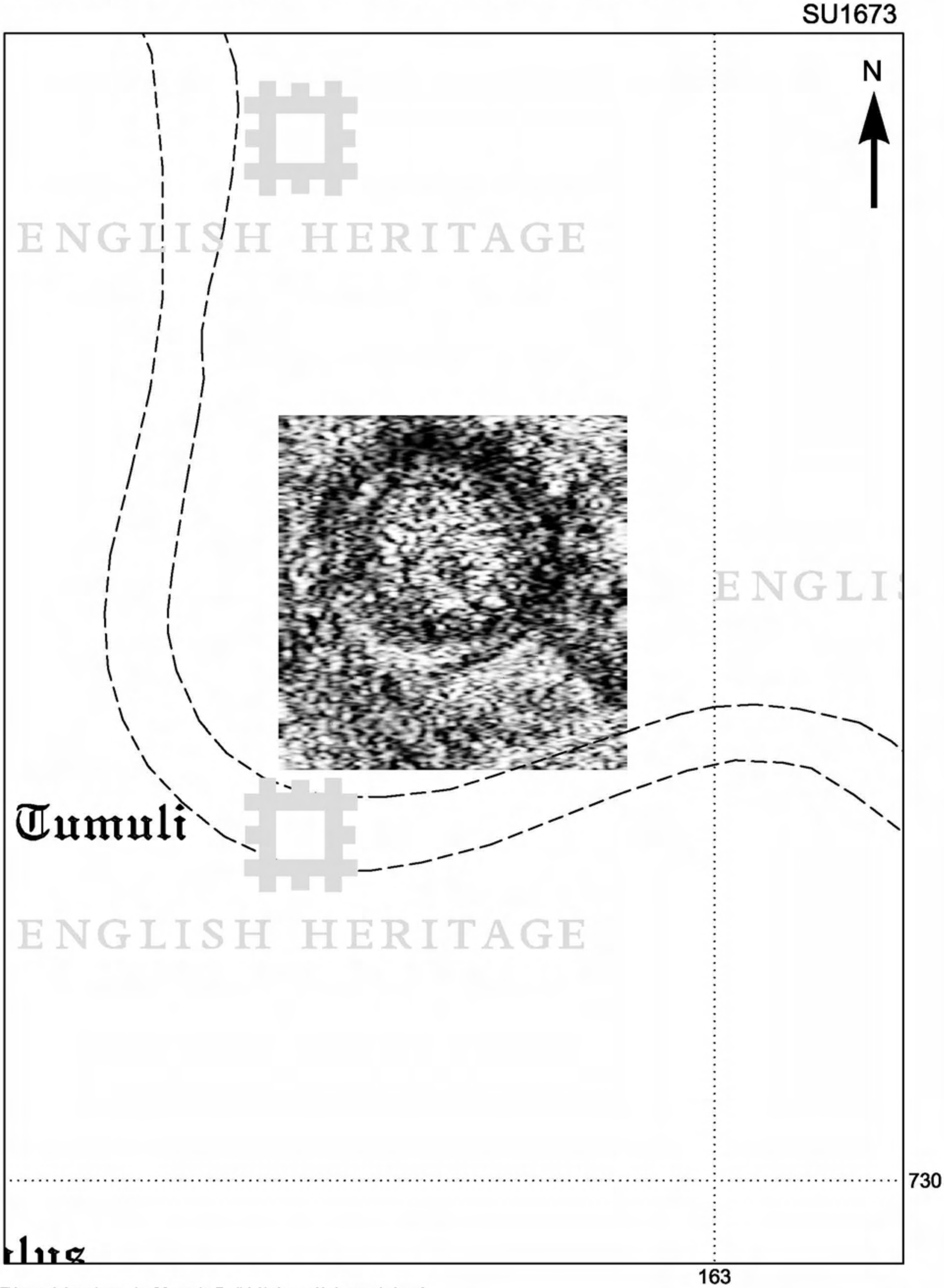


Geophysics Team 2007

ENGLISH HERITAGE

Figure 5

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
225MHz GPR survey, 18 - 20ns amplitude time slice, June 2005.



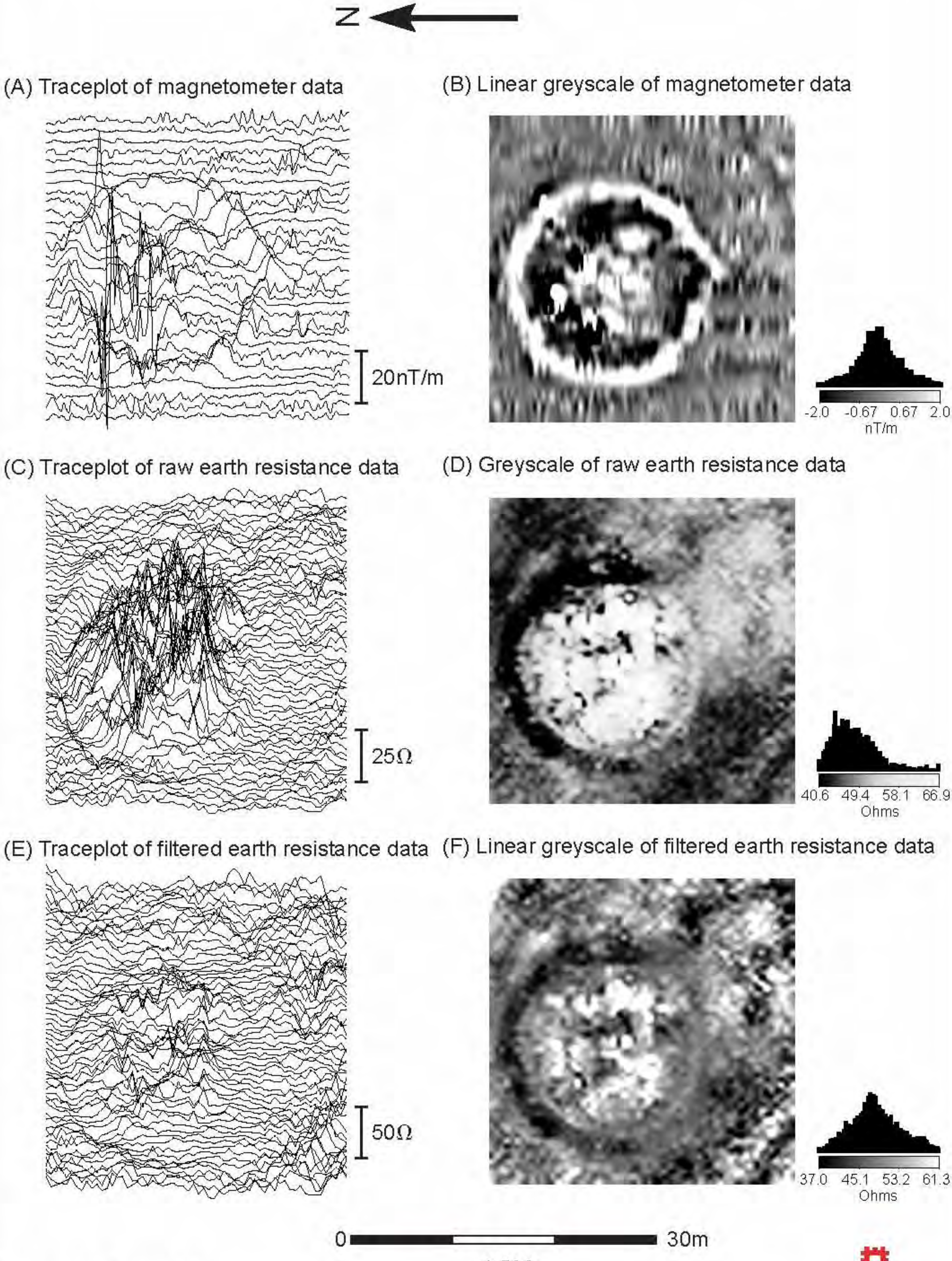
0 15m
1:500

Geophysics Team 2007

ENGLISH HERITAGE

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Magnetic and earth resistance surveys, June and August 2005

Figure 6

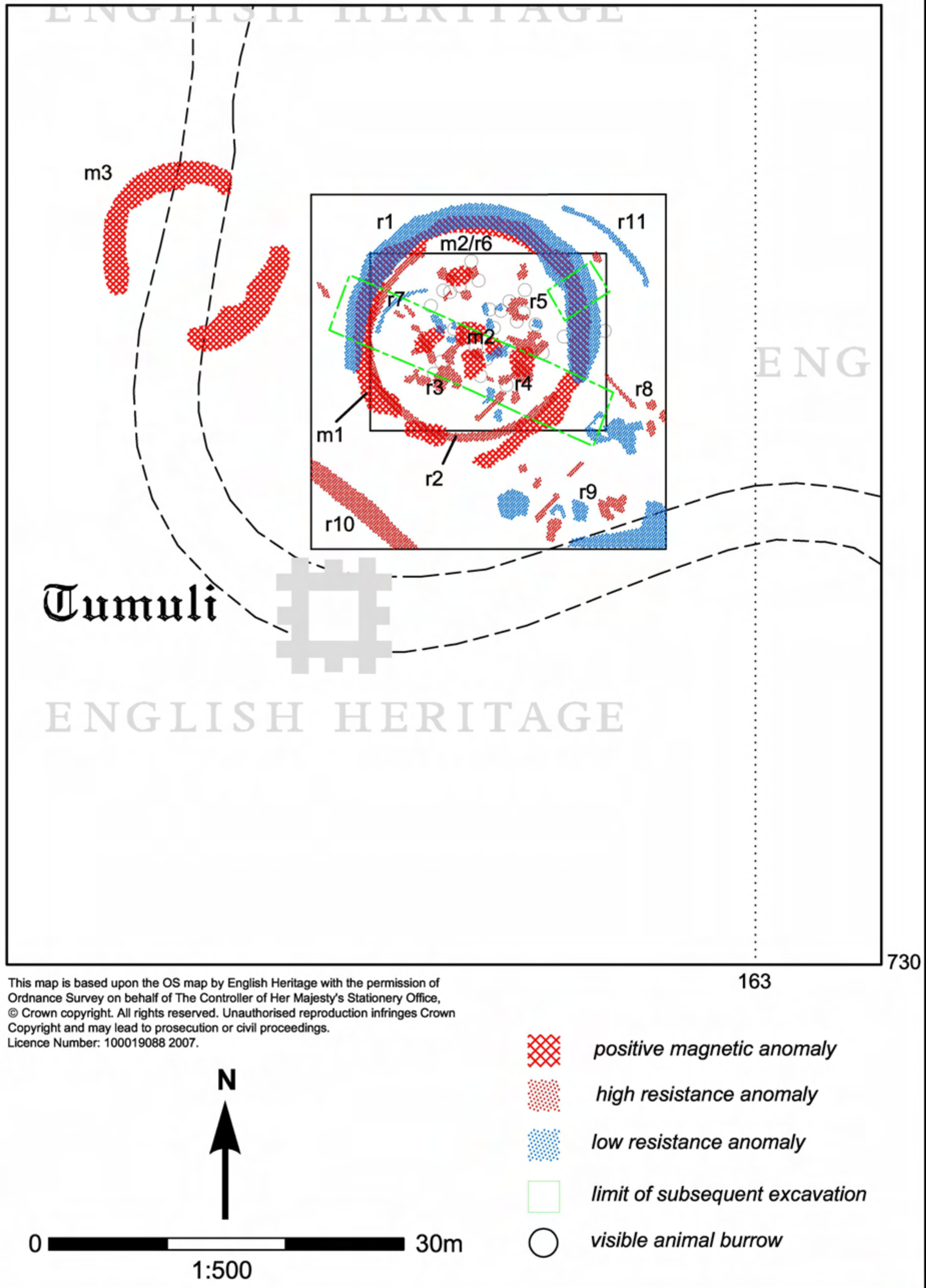


1:500

Geophysics Team 2007

ENGLISH HERITAGE

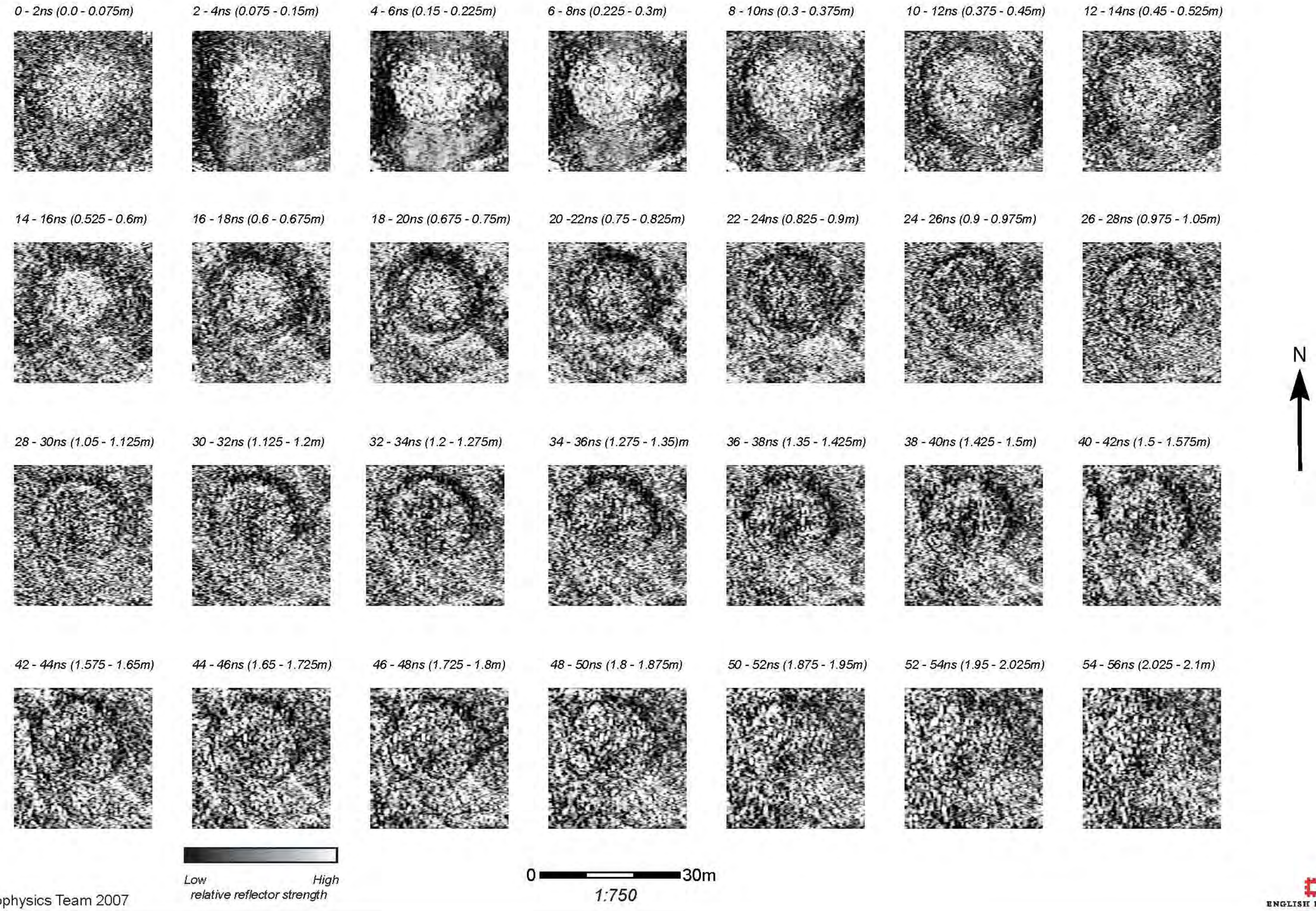
OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Summary of significant magnetic and earth resistance anomalies



Geophysics Team 2007

Figure 8

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
GPR Amplitude Time Slices 225MHz

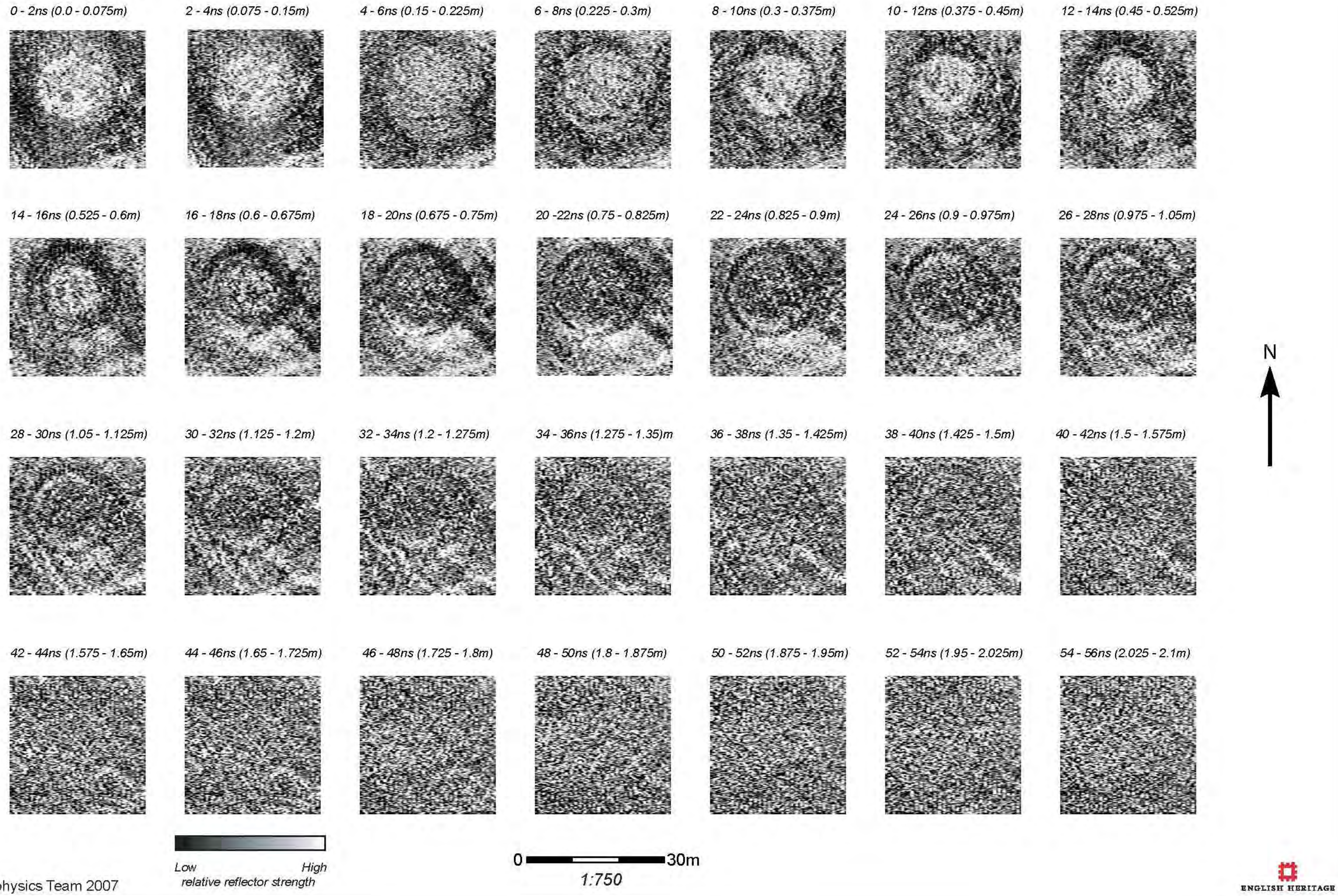


Geophysics Team 2007

ENGLISH HERITAGE

Figure 9

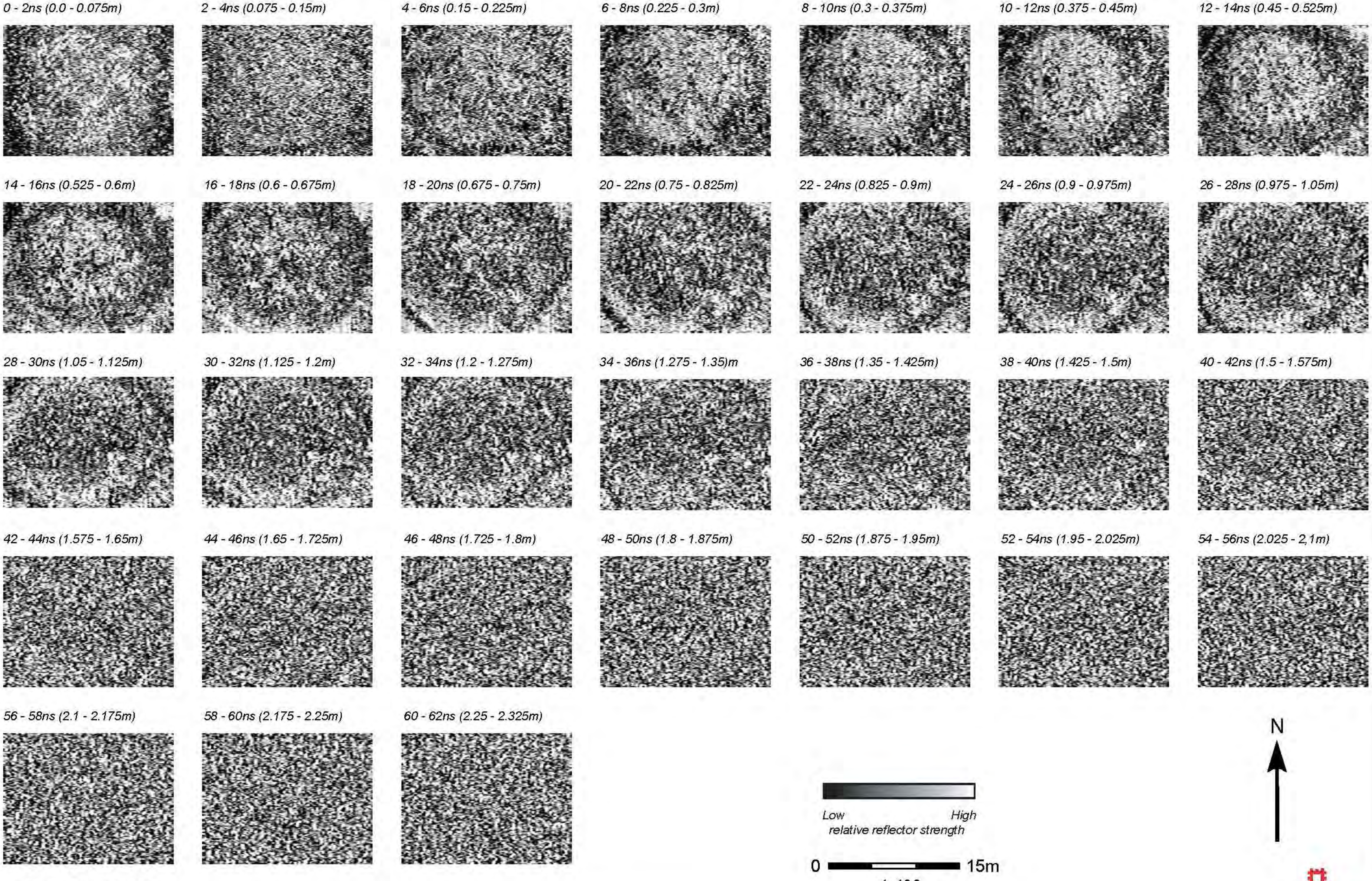
OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
GPR Amplitude Time Slices 450MHz



Geophysics Team 2007

ENGLISH HERITAGE

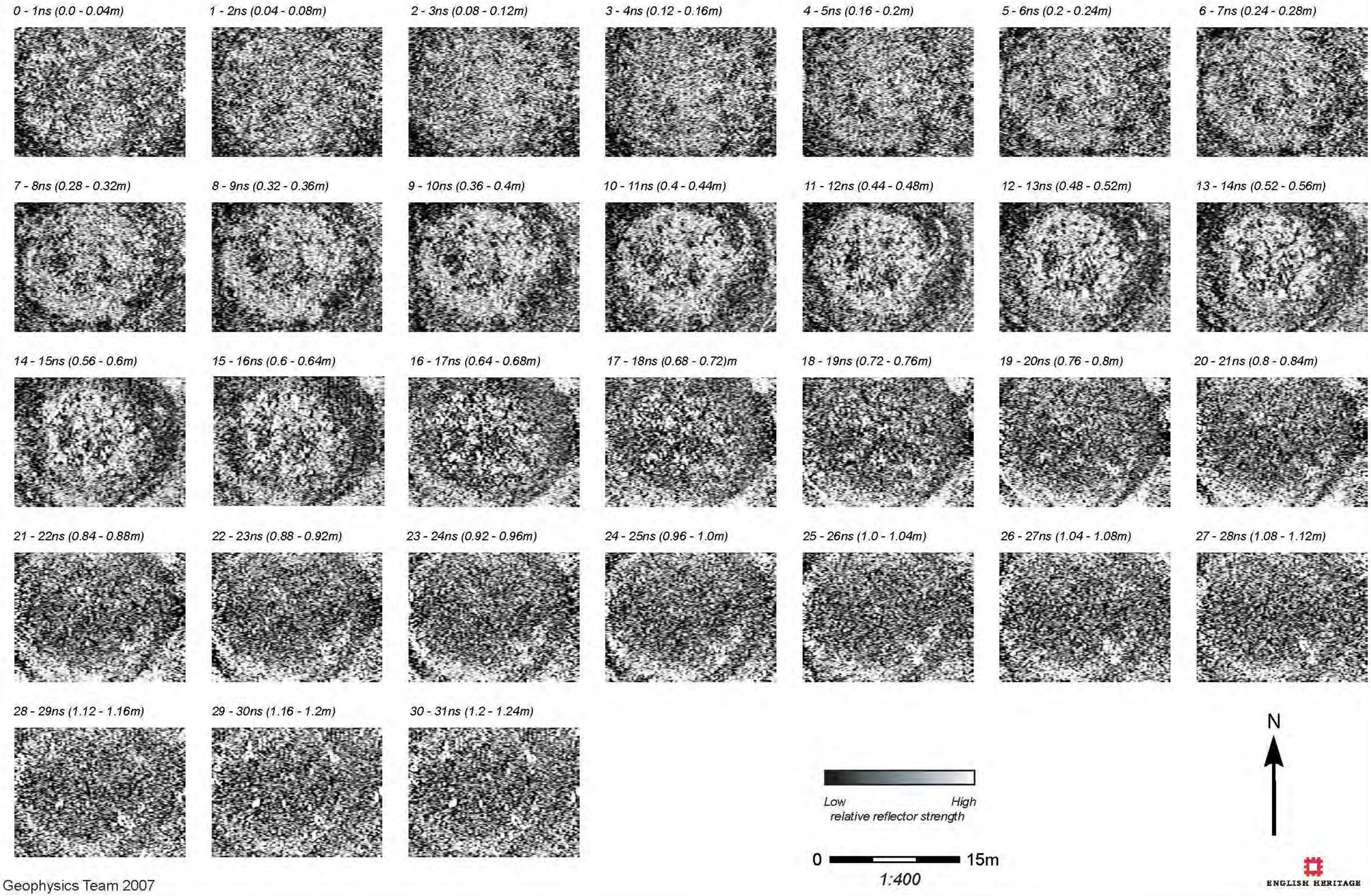
OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
GPR Amplitude Time Slices 450MHz high resolution data



Geophysics Team 2007

ENGLISH HERITAGE

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
GPR Amplitude Time Slices 900MHz high resolution data



Geophysics Team 2007

ENGLISH HERITAGE

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Summary of significant GPR anomalies

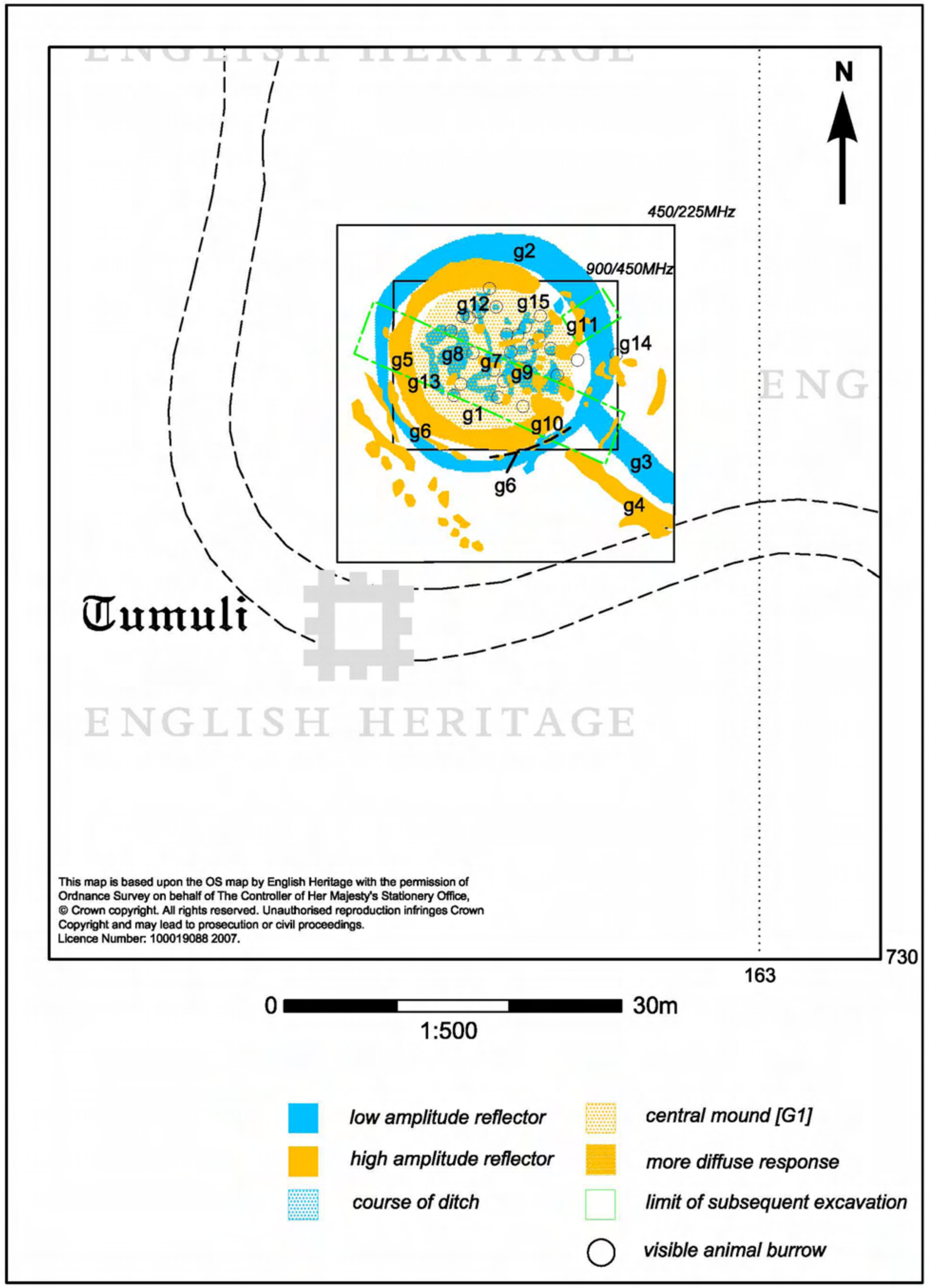
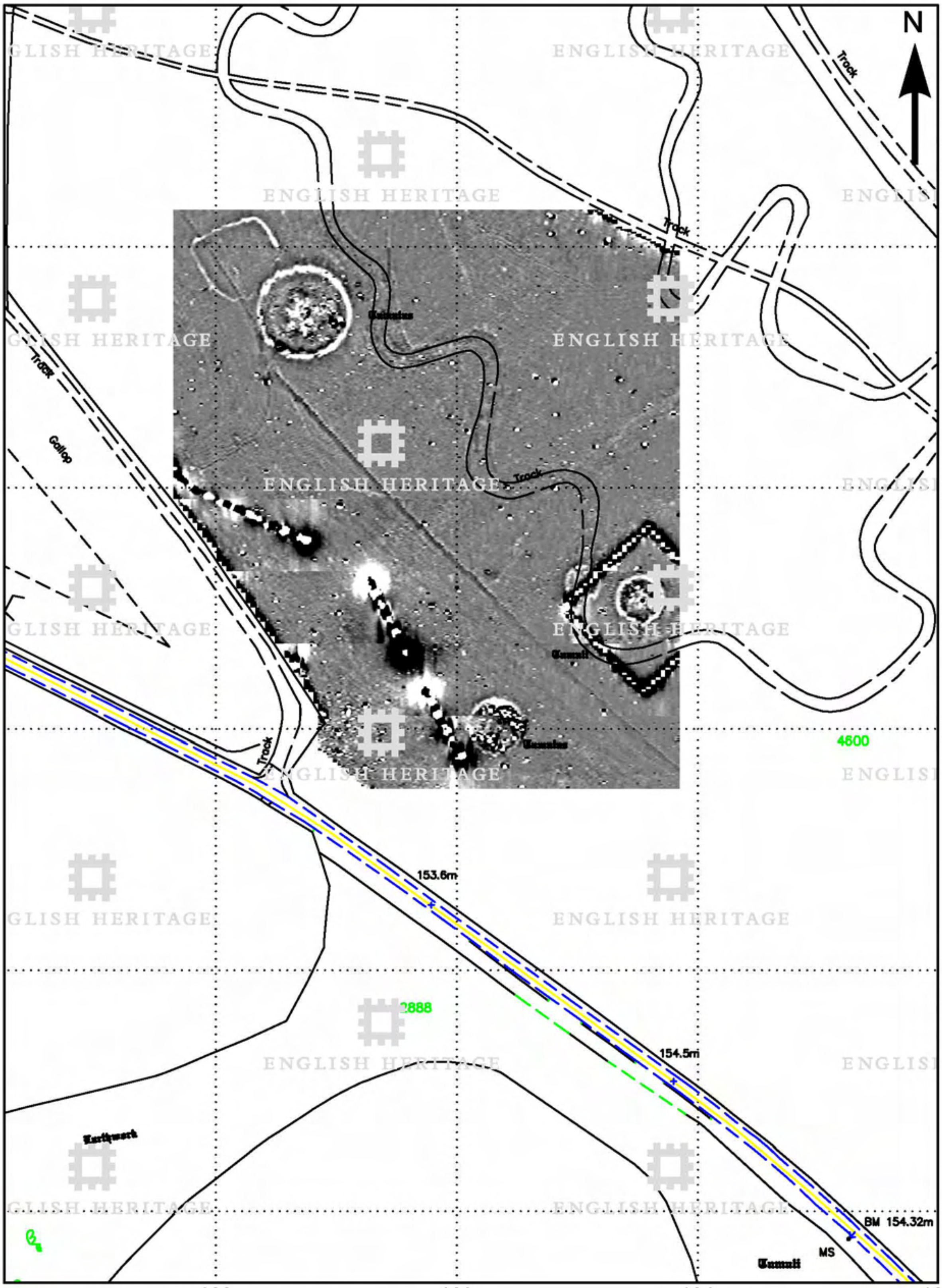


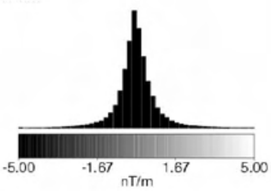
Figure 13

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Location of magnetic surveys, June 2005 and April 2006.

SU1673



0 90m
1:2500

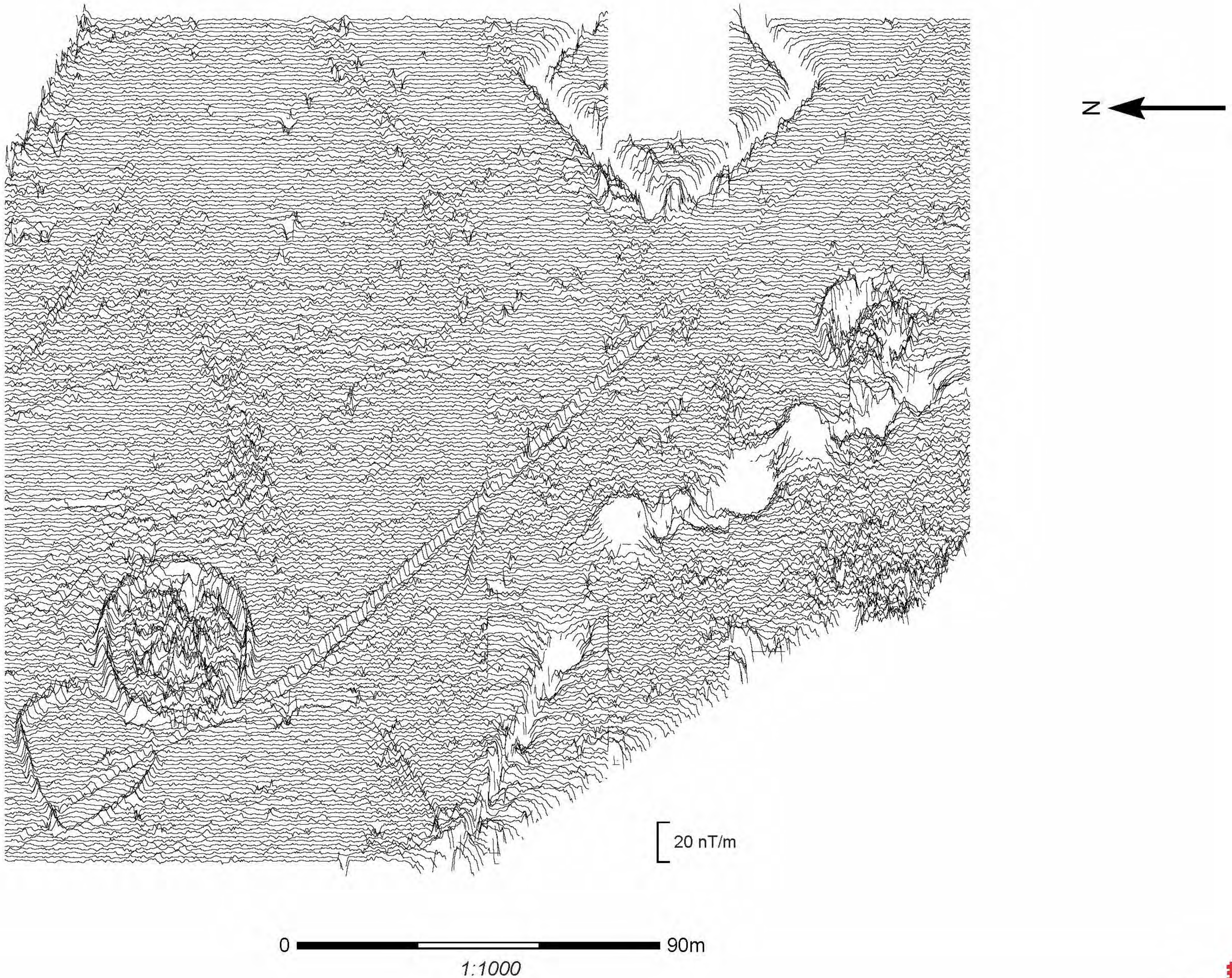


Geophysics Team 2007

ENGLISH HERITAGE

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Trace plot of the wider area magnetic data (despiked and truncated to +/- 7.5nT/m)

Figure 14

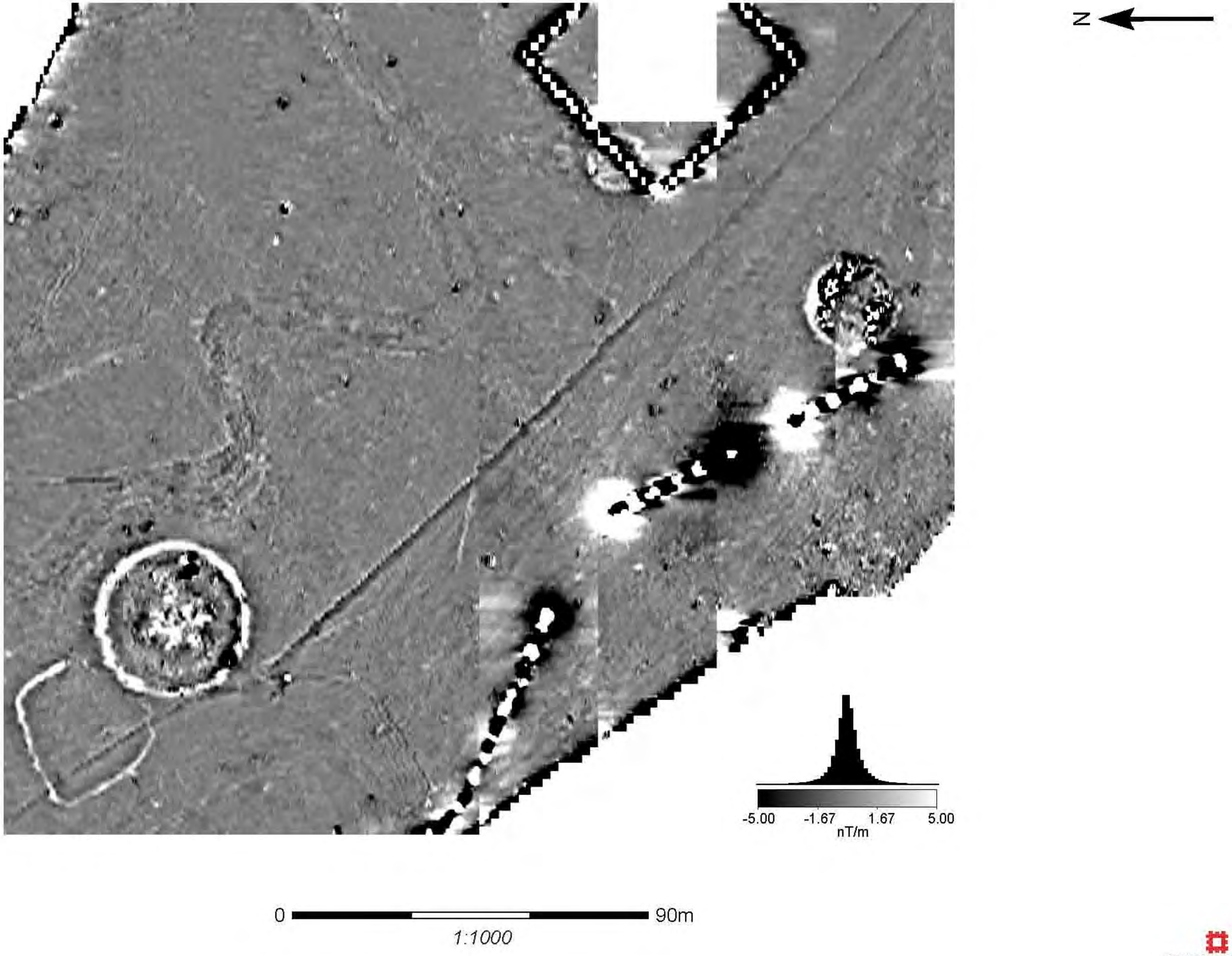


Geophysics Team 2007

ENGLISH HERITAGE

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Greytone image of wider area magnetic data

Figure 15



Geophysics Team 2007

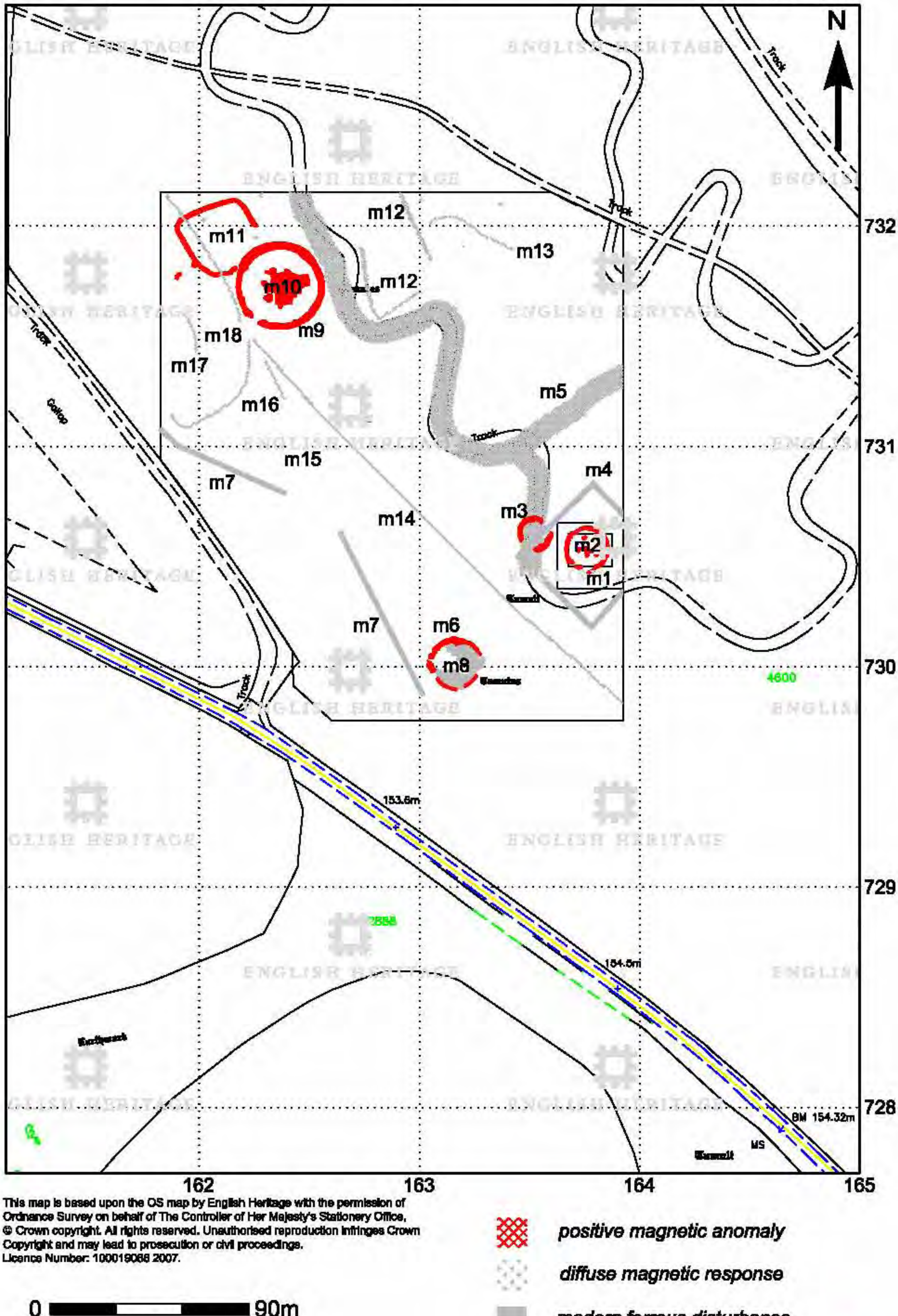
ENGLISH HERITAGE

Figure 16

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.

Summary of significant magnetic anomalies, April 2006

SU1673

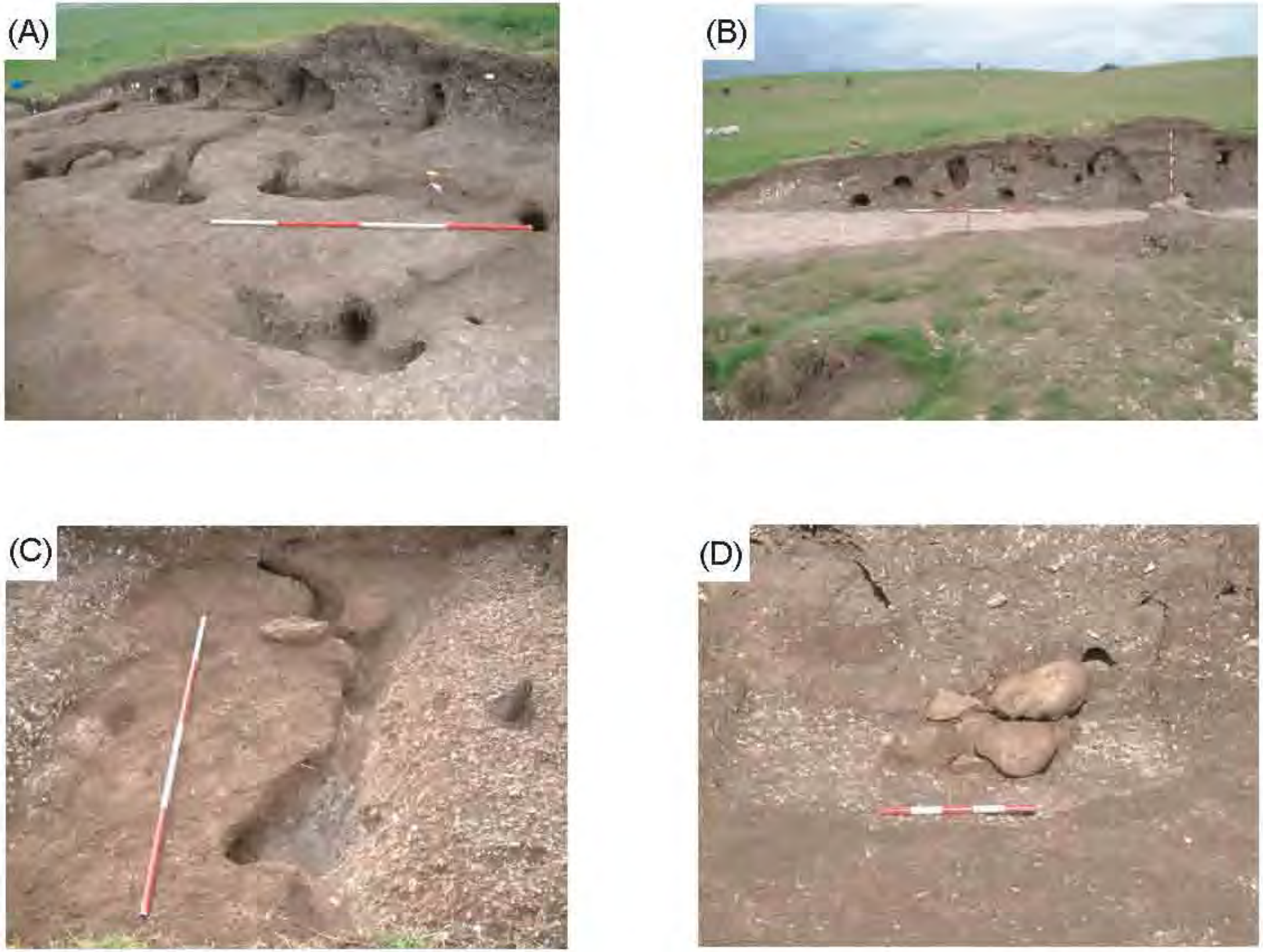


Geophysics Team 2007

ENGLISH HERITAGE

OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Excavation photographs, September 2005

Figure 17



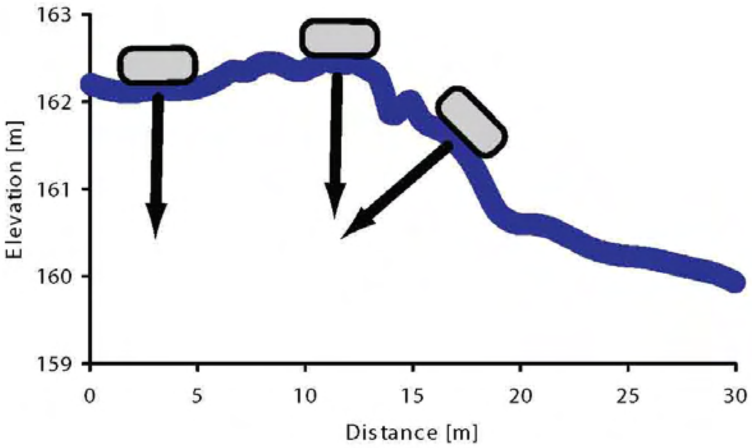
Geophysics Team 2007

ENGLISH HERITAGE

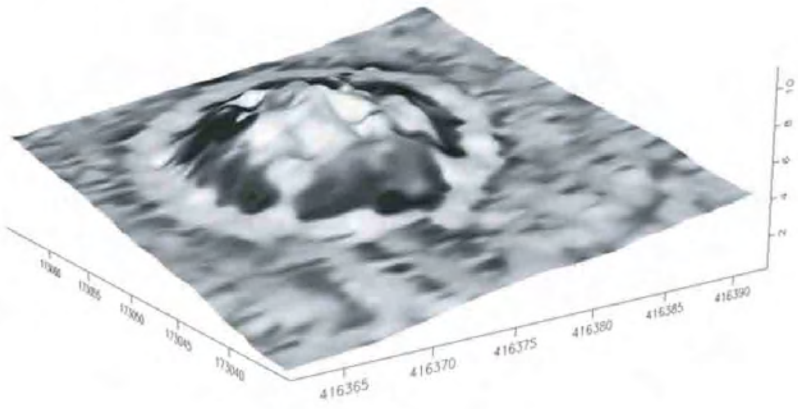
OGBOURNE ST. ANDREW 8, BARBURY CASTLE ESTATE, Wilts.
Topographic and tilt corrected GPR data

Figure 18

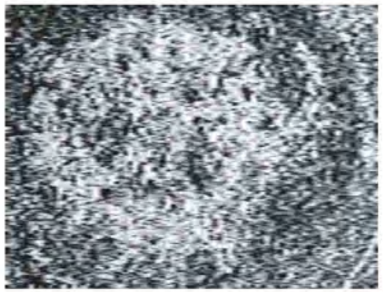
(A)



(B)



(C)



N

(D)

Low *High*
relative reflector strength

0 15m
1:400

Geophysics Team 2007

ENGLISH HERITAGE