National Roads Authority
Archaeological Geophysical Survey Database 2001-2010: Archive Report

This report has been archived by J. Bonsall, NRA Fellow at the University of Bradford. The archive was funded by and carried out under the auspices of, the National Roads Authority Research Fellowship Programme.

Survey Event No.	**46**
Survey Name	**Site 4, Steelstown & Site 5, Bustyhill, N7 Rathcoole to Kildare County Boundary road improvement scheme, county Dublin**

This Geophysical Report should be Referenced or Acknowledged as:

Bonsall, J. and Gimson, H., 2004. Site 4, Steelstown & Site 5, Bustyhill, N7 Rathcoole to Kildare County Boundary Road Improvement Scheme, County Dublin: Archaeological Geophysical Survey. Earthsound Archaeological Geophysics. Unpublished Report No. 19. January 2004.

Detection Licence No.	03R150
Ministerial Directions No.	Not Applicable
NRA Route No.	N7
NRA Scheme Name	Naas Road to Kildare Co. Bdy.
NRA Scheme ID	SD/99/110

Survey carried out for South Dublin County Council

Survey funded by the National Roads Authority

Known problems with this report

There are no known archive issues with this report

Depositor	James Bonsall, NRA Fellowship Programme
Primary Archive held by	Dublin NRDO
Secondary Archive held by	Earthsound Archaeological Geophysics

This archive was last updated on 12/12/2011

Site 4, Steelstown & Site 5, Bustyhill

N7 Rathcoole To Kildare County Boundary

Road Improvement Scheme,

County Dublin

Archaeological Geophysical Survey

Survey undertaken on behalf of

Irish Archaeological Consultancy Limited

J. Bonsall BA (Hons) MSc PIFA
H. Gimson BA (Hons) MSc

EAG 19

12 January 2004

EARTHSOUND archaeological geophysics
2 SCARLET COURT, DROGHEDA, COUNTY LOUTH, IRELAND
WWW.EARTHSOUND.NET

Table of Contents

Summary of Results ii
Statement of Indemnity ii
1. Introduction 1
1.1 Geography, Topography & Geology 1
1.2 Archaeological Background 2
1.3 Aims & Objectives 2
2. Methodology 3
2.1 Fluxgate Gradiometer Survey 3
2.2 Magnetic Susceptibility Survey 4
2.3 Reporting, Mapping and Archiving 6
3. Results & Discussion 7
3.1 Site 4 7
3.2 Site 5 8
4. Conclusions 10
4.1 Achievement of Objectives 10
4.2 Summary of Results 10
4.3 Implications 10
4.4 Geophysical Research Value 10
4.5 Recommendations 10
4.6 Dissemination 10
5. Acknowledgements 11
6. Bibliography 11
7. Figures 12

Summary of Results

Between the 19 – 30 November 2003, a geophysical survey carried out on behalf of Irish Archaeological Consultancy Limited*, for* Kildare County Council National Roads Design Office*, was conducted within the Compulsory Purchase Order boundary of the proposed N7 Rathcoole-Kildare County Boundary Road Improvement Scheme, County Dublin. The survey was carried out at two sites on either side of the existing N7, in Steelstown (Site 4) to the south and Bustyhill (Site 5), to the north. The sites were not known to contain specific archaeological features, although a souterrain, church, graveyard, possible enclosure, tower house and field system all lie within 240 m of the sites.*

Fluxgate gradiometer surveys of the sites were conducted at a sampling resolution of 1 x 0.5 m. The data were supplemented by a topsoil magnetic susceptibility survey conducted at a sampling resolution of 5 x 5 m.

The surveys were conducted upon the Carrighill Formation geological bedrock; a calcareous greywacke siltstone and shale, which was found to have a very weak magnetic property. The survey areas were covered in recently sown winter barley. Site 4 was on the northern slopes of Windmill Hill; Site 5 was on the southern slopes of Bustyhill.

The geophysical surveys successfully identified a small number of geophysical anomalies, the majority of which were not archaeological in origin. Significant archaeological remains were discovered only in Site 5; a potentially large deposit of iron debris (or possibly a kiln) and three possible field boundaries, the latter of which were probably already known from early OS mapping. Site 4 contained no features of particular importance, except for a suspected field boundary adjacent to an extant boundary.

The geophysical survey suggests that very little cultural remains will be uncovered in Sites 4 and 5, having few archaeological implications for the Road Scheme.

Of the anomalies discussed, the potential field boundaries within Site 5 may need to be tested to recover dating evidence, although these should be simple features to assess. A circular spread of ferrous material possibly contained within a pit, also in Site 5, requires intrusive investigation to determine its exact components. The anomaly lies at E299032 N225776; the lack of associated features may make this suitable for a watching brief to be carried out during the Road Scheme construction.

Statement of Indemnity

A geophysical survey is a scientific procedure that produces observations of results, which are influenced by specific variables. The results and subsequent interpretation of the geophysical survey presented here should not be treated as an absolute representation of the underlying archaeological features, but as a hypothesis that must be proved or disproved. It is normally only possible to provide verification via intrusive means, such as trial trench excavations.

1. Introduction

Earthsound Archaeological Geophysics were commissioned by Mr. D. Nelis, Senior Archaeologist, *Irish Archaeological Consultancy Limited*, to execute geophysical surveys along the N7 Rathcoole-Kildare County Boundary Road Improvement Scheme ('the Road Scheme'), located in the townlands of Steelstown and Bustyhill, SW of Rathcoole (*Ráth Cúil*), County Dublin.

The Road Scheme is 5.5 km in length (Figure 1), the area requiring geophysical survey measured 1km in length. The geophysical surveys were requested to advise the strategy of a pre-construction centre-line and site-specific testing programme being carried out over the full length of the Road Scheme by *Irish Archaeological Consultancy Limited* (*IAC*). The surveys were conducted at two sites, identified as Sites 4 and 5.

Permissions to undertake the surveys were obtained from the *Department of the Environment, Heritage and Local Government* (Licence Number 03R150, dated 18/11/2003) and the NRA Project Archaeologist Ms. S. Desmond.

1.1 Geography, Topography & Geology

The two sites are located on either side of the existing N7, 3.7 km SW of Rathcoole (Figure 2). The Dublin-Kildare County Boundary lies at the SW edge of Site 4. The sites were defined by the Compulsory Purchase Order (C.P.O.) boundary, however the geophysical survey extended slightly beyond the C.P.O. boundary in order to fit within a regular grid matrix.

Site 4 in the townland of Steelstown, lies at *Ordnance Survey of Ireland* National Grid (ING) Reference E298814 N225204, on the south side of the N7 and on the NW slopes of Windmill Hill, between 146-156 m above Ordnance Datum (OD). The Wicklow Mountains are situated 2.5 km to the SE. Site 4 is comprised of two fields; the eastern field contains a house and walled garden in its NE corner.

Site 5 in the townland of Bustyhill, lies at ING Reference E298733 N225408, on the north side of the N7 and on the SE slopes of Bustyhill, between 139-145 m OD. Site 5 is located in one large field, which extends beyond a farm and continues as a narrow corridor, with a total length of 850m.

The bedrock geology on both sites is the Carrighill Formation, a calcareous greywacke siltstone and shale. The geology is magnetically quiet. Previous geophysical surveys on the Carrighill Formation have demonstrated an excellent contrast between the background geology, archaeological features and manuring practices, including the presence of magnetically weak plough furrows (Bonsall & Gimson 2003c). The location of the sites on the slopes of two hills suggests that colluvium will have been deposited on to the survey areas, adding a thicker covering of soil, which may mask weaker features.

1.2 Archaeological Background

The two sites were chosen for geophysical surveys to supplement a programme of trial trenching.

A Cultural Heritage study as part of the Environmental Impact Statement (South Dublin County Council 2003) carried out by *Margaret Gowen and Company Limited*, found no recorded archaeological monuments within the two survey areas. A souterrain (DU020:010) is located approximately 130 m N of Site 5, while a church, graveyard and possible enclosure (DU020:009) are located approximately 180 m N of the proposed C.P.O. boundary in Colmanstown townland, to the east of Site 5. A tower house and field system (DU020:011) are also located in Colmanstown, approximately 240m N of the C.P.O. boundary.

1.3 Aims & Objectives

The aim of the geophysical survey was to determine the nature of the archaeological resource in advance of the Road Scheme. A specific objective was to:

- Determine the presence/absence and spatial extent of archaeological features

A methodology was developed to allow two techniques to systematically investigate the sites. A detailed fluxgate gradiometer survey was carried out within the identified survey areas, a technique which has been used in commercial and research archaeological projects for many years and considered one of the most appropriate techniques for a detailed investigation of the underlying archaeology (Clarke 1996, Scollar *et al.* 1990).

A coarse sample topsoil magnetic susceptibility survey was also used to supplement the gradiometer data. This technique has been an effective and proven method of identifying potential archaeological trends in European sites. Recent geophysical investigations along the proposed N25 Waterford Bypass and N7 Naas-Kildare County Boundary Road Scheme have demonstrated the success of topsoil magnetic susceptibly as a reconnaissance prospection strategy, capable of indicating occupational, ritual, agricultural and industrial archaeological sites for further investigation (Bonsall & Gimson 2003a, 2003b, 2003c).

Where possible, the use of multiple geophysical techniques allows a greater confidence to be placed in the interpretation of detected anomalies. Their combined application for determining the geometry and construction material in addition to the lateral extension of an archaeological target can also be facilitated.

2. Methodology

The fieldwork was carried out from 19-27 November 2003 by J. Bonsall and H. Gimson of *Earthsound Archaeological Geophysics*, using a *Geoscan Research* FM36 fluxgate gradiometer. A *Bartington* MS2 Magnetic Susceptibility meter and an MS2D search loop were linked to a *Trimble* Pro-XRS Differential Global Positioning System, forming a hybrid instrument referred to in this report as an MS-DGPS.

The fluxgate gradiometer was used to investigate magnetic anomalies of potential archaeological origin. The gradiometer also provides a basemap for targeted ground proofing (via trial trenches). The MS-DGPS was used to supplement the gradiometer data.

The geophysical grids at each site were established on pre-determined co-ordinates linked to the Irish National Grid. A rectangular grid was laid out using a *Trimble* Pro-XRS Differential Global Positioning System (see Technical Appendix 2), and divided in to 30 × 30 m sub-grids.

The geophysical survey grid followed the curvilinear lines of the Compulsory Purchase Order (C.P.O.) boundary as far as feasibly possible, ensuring 100% coverage of the sites, except for inaccessible areas.

2.1 Fluxgate Gradiometer Survey

The fluxgate gradiometer survey was undertaken along lines parallel to the sub-grid edges, walking approximately SW-NE, starting in the northwest corner of each grid. Subsequent lines were surveyed in alternate directions (‘zigzag’).

Data were recorded using an FM36 at a spatial resolution of 1 m intervals between traverses and 0.5 m intervals along those lines. The instrument was positioned facing north, parallel to the Earth’s magnetic field, to allow increased geo-magnetic resolution.

The instrument was set to a recording sensitivity of 0.1 nT. Prior to the beginning of the survey and after the completion of every two sub-grids, the electronic and mechanical set-up of the instrument were examined and calibrated as necessary over a common reference point. The magnetic drift from zero was not logged.

Data were collected automatically using an ST1 sample trigger while the operator walked at a constant pace along the traverse. The data were stored in an internal data logger and downloaded to a field computer using the *Geoscan Research* Geoplot v.3.00a software.

2.1.1 *Data Processing*

2.1.1.1 Preliminary Data Treatment

The data were pre-processed in Geoplot 3.00.

Spurious high intensity anomalies, commonly statistical outliers, are referred to as geophysical ‘spikes’. In magnetic data, an ‘iron spike’ is a response to a buried ferrous object, often in the topsoil. Iron spikes are generally not removed in geophysical data; although often modern in origin, they can be indicative of archaeological material.

The raw data contained some poorly matched sub-grids, caused by the internal drift of the fluxgate gradiometer and the gradual misalignment of the fluxgate sensors between calibration episodes. To compensate for this, a zero mean traverse (ZMT) function was employed. The use of ZMT alters data to adjust the mean of each traverse to zero by increasing or decreasing data as necessary. This alters the statistical properties of the data to give a uniformly bipolar background, centred around zero. Post-ZMT plots were compared with raw data to analyse the potential removal of geophysical anomalies along the line of a traverse.

2.1.1.2 Further Processing

A low pass Gaussian filter was applied, reducing the variability of the data whilst improving the visibility of weak geophysical anomalies. This also had a smoothing effect on the data.

A sine wave interpolation function was applied to provide a smooth, aesthetically pleasing image for presentation. For a given point x, the contribution of adjacent readings to the interpolated point is given by the function sinc (x) = sin $\pi x/\pi x$ (Scollar 1990). This function is used as a sliding window along each transect, resulting in an interpolated image, expanding the resolution of the data from 1 x 0.5 m, to 0.5 x 0.25 m. This function was chosen as giving a clearer interpolated image than linear interpolation or bicubic interpolation.

2.1.2 *Graphical Display*

Pre-processed, data are displayed in XY traceplot format in Figures 2 (Site 4) and 9 (Site 5). An XY traceplot presents the data logged on each traverse as a single line with each successive traverse incremented on the Y-axis to produce a stacked plot. The data were clipped at ±10 nT. The main advantage of this display option is that the full range of data can be viewed, dependent on the clip, so that the ‘shape’ of individual anomalies can be discerned and potential archaeological anomalies differentiated from iron ‘spikes’.

Processed data are displayed in greyscale plot format. The greyscale plot presents data as pixels on a linear grey shaded scale, increasing or decreasing dependent on the values of the maximum and minimum clip. The geophysical data (Figures 3 and 10) have been clipped at –1 nT (white) and +2 nT (black). Data values beyond the clip limits are shown as ‘pure’ black or white. The main advantage of this display option is that the data can be viewed as a base map.

Interpretation plots of the fluxgate gradiometer data are presented in Figures 4 (Site 4) and 11 (Site 5).

2.2 Magnetic Susceptibility Survey

A geophysical grid baseline was not established for the magnetic susceptibility survey; a Differential Global Positioning System (DGPS) data logger, a *Trimble* TSC1, displayed a graphical representation of the C.P.O. boundary as line data joined to points on the Irish National Grid, as supplied by South Dublin County Council. The graphical representation was utilised by the geophysicists to navigate along the C.P.O. boundary and collect data points at pre-determined intervals.

The topsoil volume magnetic susceptibility survey was undertaken along lines parallel to the C.P.O. boundary, walking across the width of the proposed road take.

Data were recorded at a spatial resolution of 5 m intervals between traverses and 5 m intervals along those lines. The MS2 was set to a recording sensitivity of 1 SI unit to obtain (infinite) volume specific magnetic susceptibility (Volume MS or κ). When measured in SI units, the data are expressed as 1 x 10^{-5} κ. The MS-DGPS also recorded northing and easting within the Irish National Grid to a minimum accuracy of ±0.5 m.

Prior to surveying and every 10 minutes following, the MS2 was calibrated according to the manufacturers guidelines, by 'zeroing' whilst holding the sensor approximately 3 m in the air. The positive and negative data presented in this report are the κ value of the survey area compared to the κ value of the air, being, theoretically, zero.

Data were collected and stored automatically in the TSC1 data logger by using a push button trigger on the MS2. The geophysicists walked at a constant pace along each traverse, pausing only briefly at each survey station to obtain a measurement of magnetic susceptibility. The data were downloaded to a field computer using *Trimble* Pathfinder Office 2.9 software.

2.2.1 *Data Processing*

2.2.1.1 Preliminary Data Treatment

The data were exported from Pathfinder Office 2.9 to *Microsoft* Excel. The data were analysed for temperature-induced drift, which was removed by a linear equation. The processed Excel data were gridded in x, y, z format as northing, easting and κ, using *Golden Software* Surfer 8.00.

2.2.1.2 Further Processing

A natural neighbour interpolation function was applied to the data to provide a smooth, aesthetically pleasing image for presentation.

2.2.2 *Graphical Display*

Pre-processed data are displayed in contour plot format in Figures 5 (Site 4) and 12 (Site 5). Contour plots join data of equal value by a single line, allowing trends and isolated values to be seen.

Contour plots can also be shaded to emphasise particular regions between lines. Processed data are shown in an interpolated colourscale contour plot in Figures 6 (Site 4) and 13 (Site 5). The colourscale plot presents data as pixels on a linear colour shaded scale, increasing or decreasing dependent on the values of the maximum and minimum clip. The geophysical data for Sites 4 & 5 have been clipped at 0 x 10^{-5} κ (dark green) and 60 x 10^{-5} κ (bright red). The main advantage of this display option is that the data can be viewed as a base map. A disadvantage is that the interpolation process can exaggerate isolated high or low data; to compensate for this, each survey station has been marked by a small black dot, to an accuracy of ±0.5 m, so that exaggeration between points can be visualised.

Interpretation plots of the magnetic susceptibility data are presented in Figures 7 (Site 4) and 14 (Site 5).

Archaeological maps based upon the interpretation of all the geophysical data and available mapping evidence, are presented in Figures 8 (Site 4) and 15 (Site 5).

2.3 Reporting, Mapping and Archiving

The geophysical survey and report follow the recommendations outlined in the *English Heritage Guidelines* (David 1995) as a minimum standard.

Geophysical data, figures and text are archived following the recommendations of the *Archaeology Data Service* (Schmidt 2001).

Technical information on the equipment used, data processing and methodology are given in Appendix 1. Appendix 2 details the survey geo-referencing information and Appendix 3 describes the composition and location of the archive.

3. Results & Discussion

The interpretation figures should not be looked at in isolation but in conjunction with the relevant discussion section and with the information contained in the Appendices. Features are numbered in all interpretation plots **[G1**=gradiometer anomalies, **M1**=magnetic susceptibility anomalies**]** *and are described and interpreted within the text.*

3.1 Site 4 (Interpretation Plots: Figures 4 and 7)

Site 4 is comprised of two fields, East and West, divided by a single field boundary.

Site 4 West is largely devoid of any geophysical anomalies. A single linear anomaly **[G1]** may be seen in the far W corner. It is 15 m in length, of positive magnetic strength, and may be associated with the adjacent field boundary, representing either a small ditch or gully, or an accumulation of sediment built up against the boundary. The C.P.O. boundary in this area is very narrow, which makes G1 difficult to characterise.

The magnetic susceptibility data shows a mostly weak background with a central broad area of enhancement **[M1]**. These could represent possible areas of burning or occupation, however an absence of similar features in the gradiometer data, suggests that these are probably geological features.

An ambiguous shaped anomaly may be seen in the south of Site 4 West **[G2]**. It is 5 m in length and of positive magnetism. Again the feature is difficult to characterise, however given the slope of Windmill Hill at this point, it is unlikely to represent a cultural structural foundation. G2 may simply be a geological spread of enhanced gravels or possibly colluvium gathered in the natural rilling of the hill.

Site 4 East contains two wide linear strips of weak magnetic enhancement **[G3-4]**. G3 is parallel to the present field boundary that divides Site 4 East and Site 4 West and may represent an accumulation of sediment against the boundary, or possibly the very weak remnants of an older boundary. It is 59 m in length.

G4 cuts across the site from N-S, beginning near a three-way field boundary and entrance and finishing near the present structure in the NE corner of the site. This may represent disturbed ground from a trackway or droveway, not necessarily a formal access route with a surface, but possibly just churned up by tractors and/or cattle. The alignment of G4 represents the shortest path between the farm entrance and the adjacent fields.

The magnetic susceptibility data indicates divisions between strong and weak enhancement as the hill becomes higher **[M2]**. Again, there is an absence of similar features in the gradiometer data which suggests that it may be geology or colluvium in origin. It is possible that it represents a manured field, but is inconsistent with the present field pattern.

Anomaly **[G5]** is a water pipe, which has created a strongly alternating positive and negative magnetic field. The pipe is aligned broadly N-S, probably originating from nearby structures to the N and continuing across Site 4. The pipe has been mapped to a length of 40 m. A freshly excavated test pit appears to have been dug directly over the water pipe.

A series of weakly magnetic geological anomalies **[G6]** have been discerned in the centre of Site 4 West.

3.2 **Site 5** (Interpretation Plots: Figures 11 and 14)

Site 5 is comprised of one large field, through which the C.P.O. boundary creates a wide interchange at its SW end and a long corridor at its NE end. Again, Site 5 is generally very quiet in terms of varying magnetic fields. The topography of the site includes occasional rises, probably comprised of gravels, which have a slightly enhanced magnetic strength.

A series of wooden electricity poles and metal shielding have created strong magnetic anomalies **[G7]** across the northern section of the site.

A haulage company to the SE of the road corridor had a large number of articulated containers parked adjacent to the C.P.O. boundary. These have created strong anomalies **[G8]** of alternating positive and negative magnetism.

Within the widest portion of the interchange, two water pipes can be seen of alternating positive and negative magnetism. The SE pipe **[G9]** is 112 m in length and is probably the more recent of the two, possibly a concrete pipe. The NW pipe **[G10]** is 113 m in length. The pipes intercept at the edge of the C.P.O. boundary, and probably lead to the adjacent industrial estate and across the road.

The SW corner of the site has a noticeably weak magnetic susceptibility, which probably reflects the amount of surface water contained at the base of the hill.

Three anomalies of positive magnetism may represent the relict field boundaries of Bustyhill **[G11-13]**. Modern OS mapping shows the hill being covered in regularly sized fields, similar to those of Site 4 (Windmill Hill, on the opposite side of the N7). The large field of Site 5 is the exception however, and the geophysical data corresponds well with the present alignment of parallel and perpendicular field boundaries, suggesting a former field system. The anomalies traverse the survey corridor and are of length 32-40 m, G11 is not as clear as the others and may not reflect an archaeological feature, but rather a geological one that is coincidental with the other boundaries.

The geophysical data failed to determine the presence of any discrete features (ditches); which may be magnetically weak, or completely absent, possibly represented only by a hedgerow. The very wide enhanced spread of material suggests that the boundaries have been completely ploughed out and may require further intrusive investigation. Between the field boundaries, a dramatic change in the magnetic susceptibility data can be seen, from weak to strong enhancement **[M3 & M4]** indicating at least the different use of the fields and suggests the possibility of manuring in the strongly enhanced fields. The magnetic susceptibility data matches the existing field boundaries and the gradiometer data precisely.

In the centre of the C.P.O. boundary corridor, a single anomaly can be seen **[G14]**. It is a positive anomaly surrounded by a negative halo, circular in shape and has created an anomaly of size 11m diameter, although this is merely representative of its strong magnetic field (between –128 and +30 nT), not its spatial qualities (probably only 1-2 m). The anomaly is incredibly strong which suggests either a deeply buried ferrous object or an area of intense burning. The circular representation of G14 indicates that the shape is of equilateral proportions, e.g. a square, cube, sphere or circle *etc*., and not, for example, an elongated object. It may represent a piece of agricultural machinery, a buried steel drum or other large ferrous object. Alternatively, intensive burning could indicate the presence of a fire-pit or kiln.

The magnetic susceptibility data shows slight enhancement around this area **[M5]**, but not actually centred on the anomaly itself, which may rule out a burnt feature. The anomaly certainly requires further clarification to determine if it is modern or archaeological.

4. Conclusions

4.1 Achievement of Objectives

The geophysical surveys have successfully identified a small number of geophysical anomalies, the majority of which were not archaeological in origin. Both Sites 4 and 5 have been assessed for archaeological evidence, which appears to be largely absent from the Road Scheme.

4.2 Summary of Results

Of the two sites investigated, significant archaeological remains were discovered only in Site 5; a potentially large deposit of iron debris (possibly a kiln), two probable field boundaries and a variance in manuring practices contained therein. Site 4 contained no features of particular importance, except for a possible field boundary adjacent to an extant boundary.

4.3 Implications

The geophysical survey suggests that very little cultural remains will be uncovered in Sites 4 and 5, having few archaeological implications for the Road Scheme.

4.4 Geophysical Research Value

The use of a magnetic susceptibility meter over each of the sites as a supplement to the fluxgate gradiometer survey has been very useful. The susceptibility data has demonstrated the magnetically quiet nature of the geological background and allowed a consistent appreciation of farming practices such as manuring, which have not been detected within the gradiometer data.

4.5 Recommendations

These results should help assist a testing strategy at Sites 4 and 5. Of the anomalies discussed, the potential field boundaries of Site 5 [G11-13] may need to be tested to recover dating evidence, although these should be simple features to assess (weakly magnetic ditches or ploughed out hedgerow debris).

Anomaly G14, also in Site 5, requires intrusive investigation to determine its exact components, although it is most probably a spread of ferrous (iron) material, possibly contained within a pit. The anomaly lies at E299032 N225776 and could be pinpointed with a total station, GPS or a standard metal-detector. The lack of associated features around G14 may make this suitable for a watching brief to be carried out during the Road Scheme construction, rather than introduce a specific testing programme for a single feature.

4.6 Dissemination

The results of this survey were handed to the *Client*. *Earthsound* will ensure that copies will be forwarded to the *Department of the Environment, Heritage and Local Government* and the National Museum.

5. Acknowledgements

Project Management: James Bonsall BA (Hons) MSc PIFA

Fieldwork: James Bonsall
Heather Gimson BA (Hons) MSc

Report: James Bonsall
Graphics: Heather Gimson

Project Archaeologist: Ms. S. Desmond, *Kildare National Roads Design Office*,
Kildare County Council, Maudlins, Naas,
County Kildare

6. Bibliography

BONSALL, J. & GIMSON, H. 2003a *Killaspy Cross Road, County Kilkenny, N25 Waterford Bypass; Archaeological Geophysical Survey*, Earthsound Archaeological Geophysics, Report No. EAG-13, June 2003, unpublished report

BONSALL, J. & GIMSON, H. 2003b *Woodstown 6 East, Woodstown, N25 Waterford Bypass, County Waterford; Archaeological Geophysical Survey*, Earthsound Archaeological Geophysics, Report No. EAG-14, August 2003, unpublished report

BONSALL, J. & GIMSON, H. 2003c *Sites 14 & 48, Blackchurch Townland, Site 36, Kill West Townland & Cocoman's Land, Boherphillip Townland, N7 Naas Road Widening And Interchanges Scheme Contract No.2, County Kildare; Archaeological Geophysical Survey*, Earthsound Archaeological Geophysics, Report No. EAG-18, October 2003, unpublished report

DAVID, A. 1995 *Geophysical Survey in Archaeological Field Evaluation: Research and Professional Services Guidelines*, No. 1, English Heritage

SCHMIDT, A. 2001 *Geophysical Data in Archaeology: A Guide to Good Practice*, Archaeology Data Service, Oxford, Oxbow

The following texts are referenced in the Technical Appendix:

CLARK, A.J. 1996 *Seeing Beneath the Soil*, London, Batsford

SCOLLAR, I., TABBAGH, A., HESSE, A. AND HERZOG, I. 1990 *Archaeological Prospecting and Remote Sensing*, Cambridge, Cambridge University Press. Topics in Remote Sensing Vol. 2

WALKER, R. 2000 *Geoplot Version 3.00 for Windows, Instruction Manual, Version 1.2*, Clayton, West Yorkshire

7. Figures

Figure 1: Site Locations along the N7 Rathcoole-Kildare County Boundary Contract

Figure 2: Site 4 pre-processed fluxgate gradiometer data

Figure 3: Site 4 processed fluxgate gradiometer data

Figure 4: Site 4 fluxgate gradiometer interpretation

Figure 5: Site 4 pre-processed magnetic susceptibility data

Figure 6: Site 4 processed magnetic susceptibility data

Figure 7: Site 4 magnetic susceptibility interpretation

Figure 8: Site 4 interpreted archaeology map

Figure 9: Site 5 pre-processed fluxgate gradiometer data

Figure 10: Site 5 processed fluxgate gradiometer data

Figure 11: Site 5 fluxgate gradiometer interpretation

Figure 12: Site 5 pre-processed magnetic susceptibility data

Figure 13: Site 5 processed magnetic susceptibility data

Figure 14: Site 5 magnetic susceptibility interpretation

Figure 15: Site 5 interpreted archaeology map

Technical Appendix

Appendix 1

1. Magnetic Survey: Technical Information

1.1 Magnetic Susceptibility and Soil Magnetism

The Earth is comprised of approximately 6% iron. Via geological and pedological processes iron is present in soils and rocks as three main minerals; haematite, magnetite and maghaemite. Haematite is a very common mineral in archaeological soils and is largely responsible for most of the red colouration in the environment. Magnetite is a common mineral found in all igneous rocks, most sedimentary rocks and nearly all soils. These minerals have a weak, measurable magnetic property.

The magnetism observed in a rock is made up of remanent and induced components. In the weak magnetic field due to the earth, the induced component is proportional to the earth's field. The constant of proportionality is called the magnetic susceptibility. The susceptibility of a rock is controlled by the amount of ferrimagnetic material contained in them, their grain size, and mode of distribution.

An enhancement of ferrimagnetic minerals is responsible for the formation of magnetic anomalies in soils at archaeological sites. Magnetic Susceptibility (MS) measures how susceptible a material is to becoming magnetized. A MS survey can identify and classify different types of iron bearing materials in a safe, fast and non-destructive manner either in a laboratory or as a fieldwork component, complementing other archaeological analyses.

Anthropogenic activities can redistribute these minerals and alter others into more magnetic forms by a process of enhancement, such as burning, industrial activity, fermentation and manuring. Magnetic susceptibility enhancement of antiferromagnetic haematite in the topsoil is caused by the Le Borgne effect of domestic fires on soils and vegetational matter:

> *The burning of organic matter and the heating of non-organic matter above 200°C, allows electrons to be gained through a process of reduction, creating ferrimagnetic magnetite. As the matter cools, or in the case of organic matter, is combusted, electrons are lost through a process of re-oxidation, creating ferrimagnetic maghaemite.*

The decay of organic material associated with areas of human occupation or settlement can be identified by measuring the magnetic susceptibility of the topsoil and noting the degree of enhancement. If the enhanced material subsequently comes to fill features, such as ditches or pits, localised isolated and linear magnetic anomalies can result whose presence can be detected by a magnetometer (fluxgate gradiometer).

There are five different types of magnetic behaviour found in Magnetic Susceptibility surveys, dependent upon the sub-atomic properties of the samples:

Strongest

- *Ferromagnetism*
- *Ferrimagnetism*
- *Antiferromagnetism*
- *Antiferromagnetism*
- *Paramagnetism*
- *Diamagnetism*

Weakest

Magnetic susceptibility is a value defined by a combination of all of the above types of magnetic behaviour, so that weaker paramagnetism and diamagnetism will be masked if other, *stronger*, magnetic properties are present. For example, a topsoil magnetic susceptibility survey will introduce additional contributions from colluvial/alluvial covering or a disturbed Ap horizon (cultivation/pasturing disturbance *etc*.) that may mask an archaeologically derived response.

Magnetic anomalies are either are termed **'negative'** or **'positive'** referring to their magnetic properties relative to the bipolar background (theoretically, 'zero').

The types of response mentioned above can be divided into five main categories which are used in the graphical interpretation of the gradiometer data:

Areas of positive/negative enhancement

These responses can be quite widespread, and often caused by rubble or foundations, burning, agricultural disturbance and general occupational induced enhancement.

Linear and curvilinear anomalies

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

Isolated positive/negative anomalies

These generally represent small areas of enhancement. They may be caused by exotic geology or by in-filled archaeological pits.

Isolated Ferrous anomalies

Theses are very strong magnetic responses caused by ferrous (iron) debris, often found scattered in fields. These are usually modern in origin, although may represent archaeological material such as coffin nails.

Areas of Disturbance

These are mostly modern in origin, causing widespread magnetic interference, often masking all other magnetic features within the vicinity. These can be caused by nearby structures, metallic fences, road traffic and metallic pipelines.

1.2 Methodology

1.2.1. *Magnetic Susceptibility Survey*

The magnetic susceptibility meter displays the magnetic susceptibility value of material when they are brought within the influence of the sensor, such as the field search loop. An oscillator circuit within the *Bartington* MS2 meter generates a low alternating magnetic field. Any material brought within the influence of the field (in the case of the search loop, the field of influence is between 0cm and 18cm beneath the loop, i.e. generally the topsoil), will bring about a change in the oscillator frequency. The frequency information is returned in pulse form to the MS2, where it is converted in to a value of magnetic susceptibility, κ, in SI units.

A topsoil magnetic susceptibility survey assumes that the sample size is infinite, as the precise mass of each sample point cannot be calculated in the field. Calibration therefore, is best expressed in units of Volume Specific susceptibility. Repeatability of the survey is dependent upon the uniformity of the surface under investigation. Volume susceptibility is expressed as $\kappa \times 10^{-5}$ SI units.

1.2.2. *Fluxgate Gradiometer Survey*

A detailed survey requires a sample trigger to automatically take readings at predetermined points. These readings are stored in the memory of the instrument and are later dumped to computer for processing and interpretation. Detailed survey allows the visualisation of weaker anomalies that may not have been detected by magnetic scanning or magnetic susceptibility.

2. Data Processing and Presentation

The data have been presented in this report in XY traceplot and greyscale formats. In the XY traceplot the data shown is ‘raw’ with no processing occurring.

2.1 Interpolation

Interpolation can be defined as the estimation of a value between known values. The data magnetometer data displayed in this project have been interpolated using the sin *x/x* function in *Geoplot* 3.0 (Walker 1999). For a given point *x*, the contribution of adjacent readings to the interpolated point is given by the function sinc $(x) = \sin \pi x/\pi x$ (Scollar 1990.82,213). This function is used as a sliding window (similar to a 1D sliding box filter) along each transect, resulting in an interpolated image. This function was chosen as giving a clearer interpolated image than linear interpolation (which assumes a direct linear change between each point) or bicubic interpolation (taking the surrounding sixteen values into account).

The magnetic susceptibility data was not processed within *Geoplot* 3.0 but within *Surfer 8*, which uses a different system.

Gridding methods produce a regularly spaced, rectangular array of Z values from irregularly spaced XYZ data. The term "irregularly spaced" means that the points follow no particular pattern over the extent of the map, so there are many "holes" where data are missing. Gridding fills in these holes by extrapolating or interpolating Z values at those locations where no data exists.

A grid is a rectangular region comprised of evenly spaced rows and columns. The intersection of a row and column is called a grid node. Rows contain grid nodes with the same Y co-ordinate, and columns contain grid nodes with the same X co-ordinate. Gridding generates a Z value at each grid node by interpolating or extrapolating the data values. The *Kriging* gridding method produces visually appealing maps from irregularly spaced data. *Kriging* is a geostatistical gridding method that has proven useful and popular in many fields. *Kriging* attempts to express trends suggested in the data so that, for example, high points might be connected along a ridge rather than isolated by bull's-eye type contours.

Appendix 2

Survey Grid Re-location

1. Each survey grid was laid out using a *Trimble* Pro-XRS Differential Global Positioning System (DGPS), to an accuracy of ±10cm.
2. There was a good correlation between the geophysical survey data and the digital map base and it is estimated that the average 'best fit' error is lower than ±0.25m. It is important to note that local grid north (19/11/2003) varies slightly from *Ordnance Survey* north, with an annual decrease of 0.9°3'.

Appendix 3

Geophysical Archive

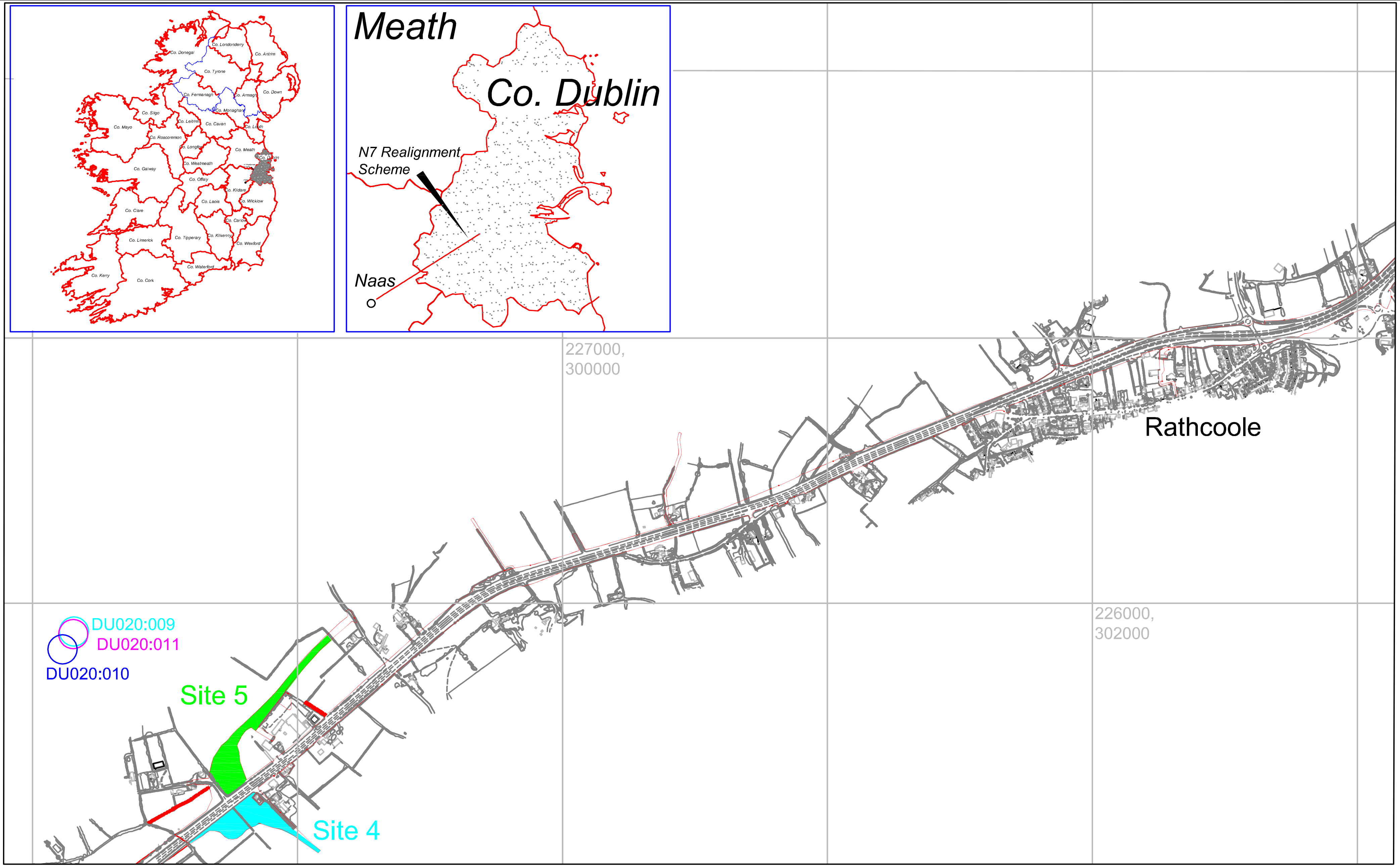
Earthsound Archaeological Geophysics takes its archiving responsibilities very seriously. Archiving is a necessary measure to maintain a complete record of past research, prevent unnecessary duplication and allow the re-use and re-interpretation of geophysical data as analytical techniques evolve.

The geophysical archive comprises:-

- an archive CD-ROM containing files of the raw data (Geoplot 3.00a, MS-Excel), report text (Word 2000 9.0), and graphics files (AutoCAD 2000).
- a hard (paper) copy of the report

At present, two copies of the archive are held by *Earthsound Archaeological Geophysics*, at separate locations to ensure preservation against accidental damage or theft. The Client, *Irish Archaeological Consultancy Limited*, holds one further copy of the archive. Additional paper copies intended for ultimate deposition with the Department of the Environment, Heritage and Local Government are in the guardianship, and are the responsibility of, *Earthsound Archaeological Geophysics*.

.



Legend

- CPO line
- Basemap
- SMR Sites

Site Location: N7, South County Dublin

Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO	Date 18/11/03	Drawing No.: 03-61/01

0m 500m 1000m

Figure No. 1 Location map

EARTHSOUND archaeological geophysics

N7 Rathcoole To Kildare County Boundary, Road Improvement Scheme, County Kildare

Figure 02: Pre-processed Fluxgate Gradiometer XY Traceplot of Site 4

EARTHSOUND archaeological geophysics

Drawing No.: 03_61/02

Legend

CPO line

Basemap

nT

-2 0 1

Site Location: N7, South County Dublin

Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO	Date 5/12/03	Drawing No.: 03-61/03

0m 50m 100m

Figure No. 3 Site 4 Fluxgate Gradiometer Data

EARTHSOUND archaeological geophysics

Legend

CPO line
Basemap

Discrete Negative Anomaly
Discrete Positive Anomaly

nT
-1 0 2

Site Location: N7, South County Dublin

Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO	Date 5/12/03	Drawing No.: 03-61/04

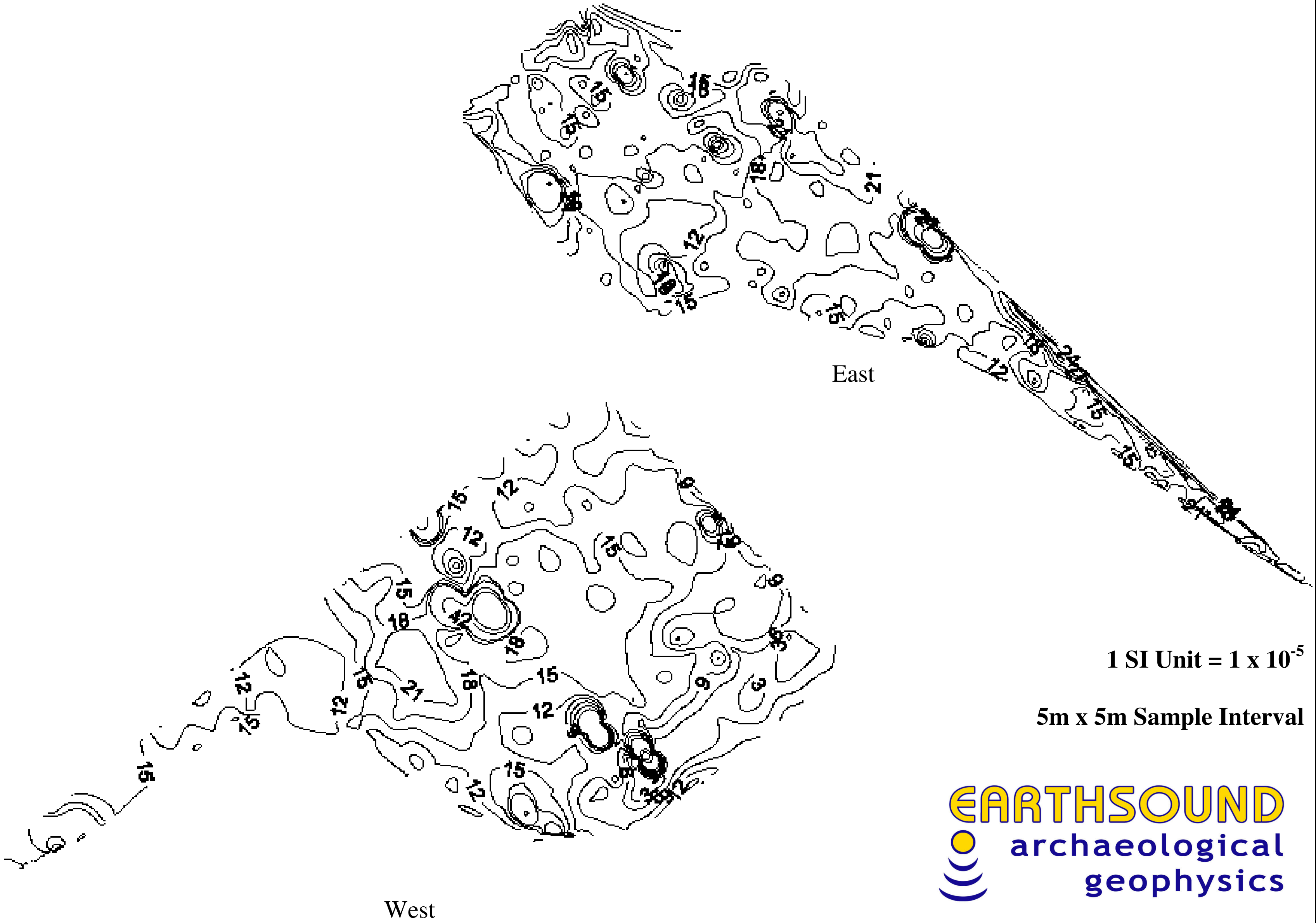
0m 50m 100m

Figure No. 4 Site 4 Fluxgate Gradiometer Interpretation

EARTHSOUND archaeological geophysics

N7 Rathcoole To Kildare County Boundary, Road Improvement Scheme, County Kildare

Figure 5: Pre-processed Magnetic Susceptibility Contour Plots of Site 4

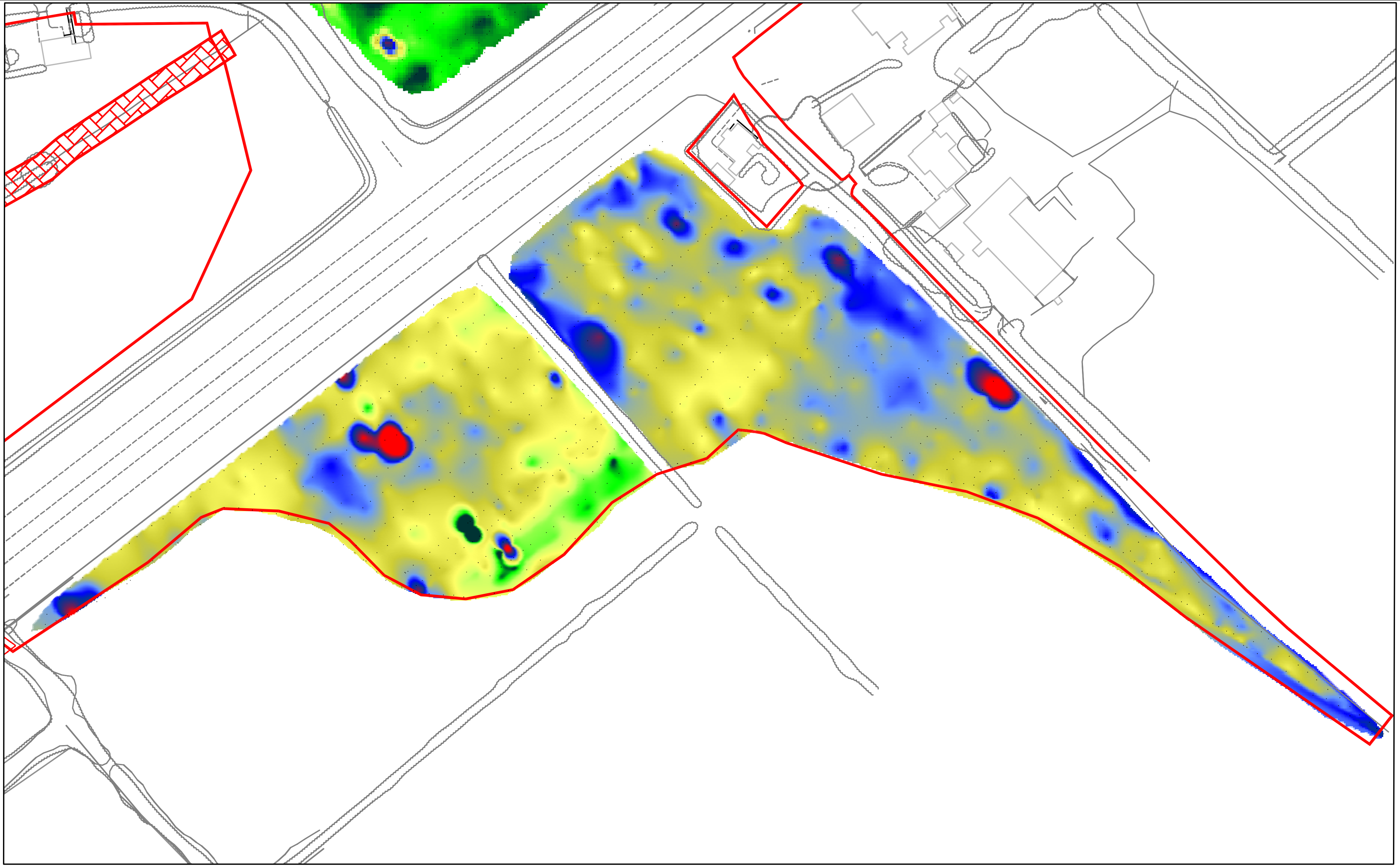


1 SI Unit = 1 x 10^{-5}

5m x 5m Sample Interval

EARTHSOUND archaeological geophysics

Drawing No.: 03_61/05



Legend

C.P.O. Boundary
Basemap
Survey Stations

x 10^{-5} K
0 20 60

Site Location: N7, South County Dublin

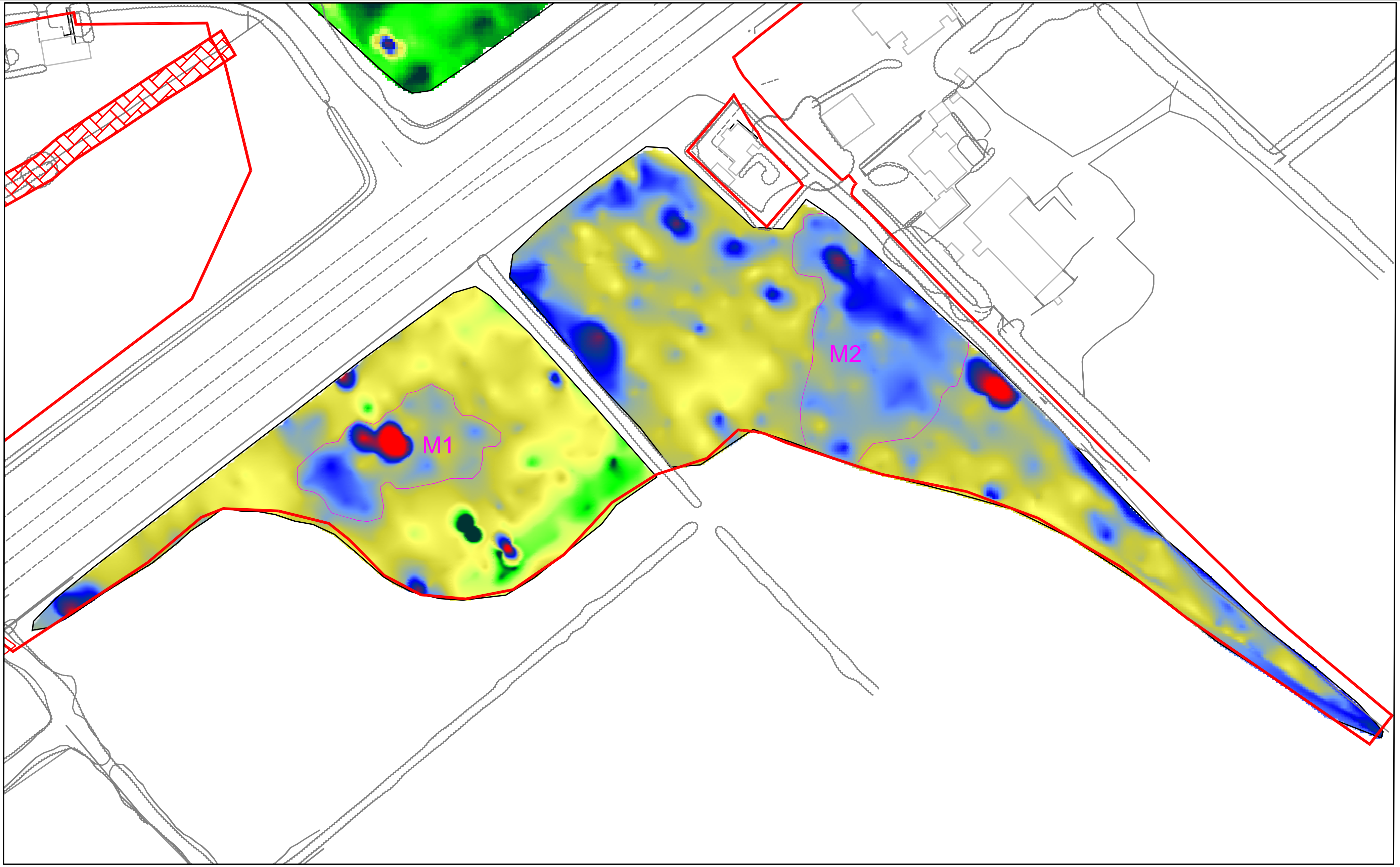
Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO	Date 5/12/03	Drawing No.: 03-61/06

0m 50m 100m

Figure No. 6 Site 4 Magnetic Susceptibility Data

EARTHSOUND archaeological geophysics



Legend

- C.P.O. Boundary
- Basemap
- Magnetic Susceptibility Anomaly

$x\ 10^{-5}\ K$

0 20 60

Site Location: N7, South County Dublin

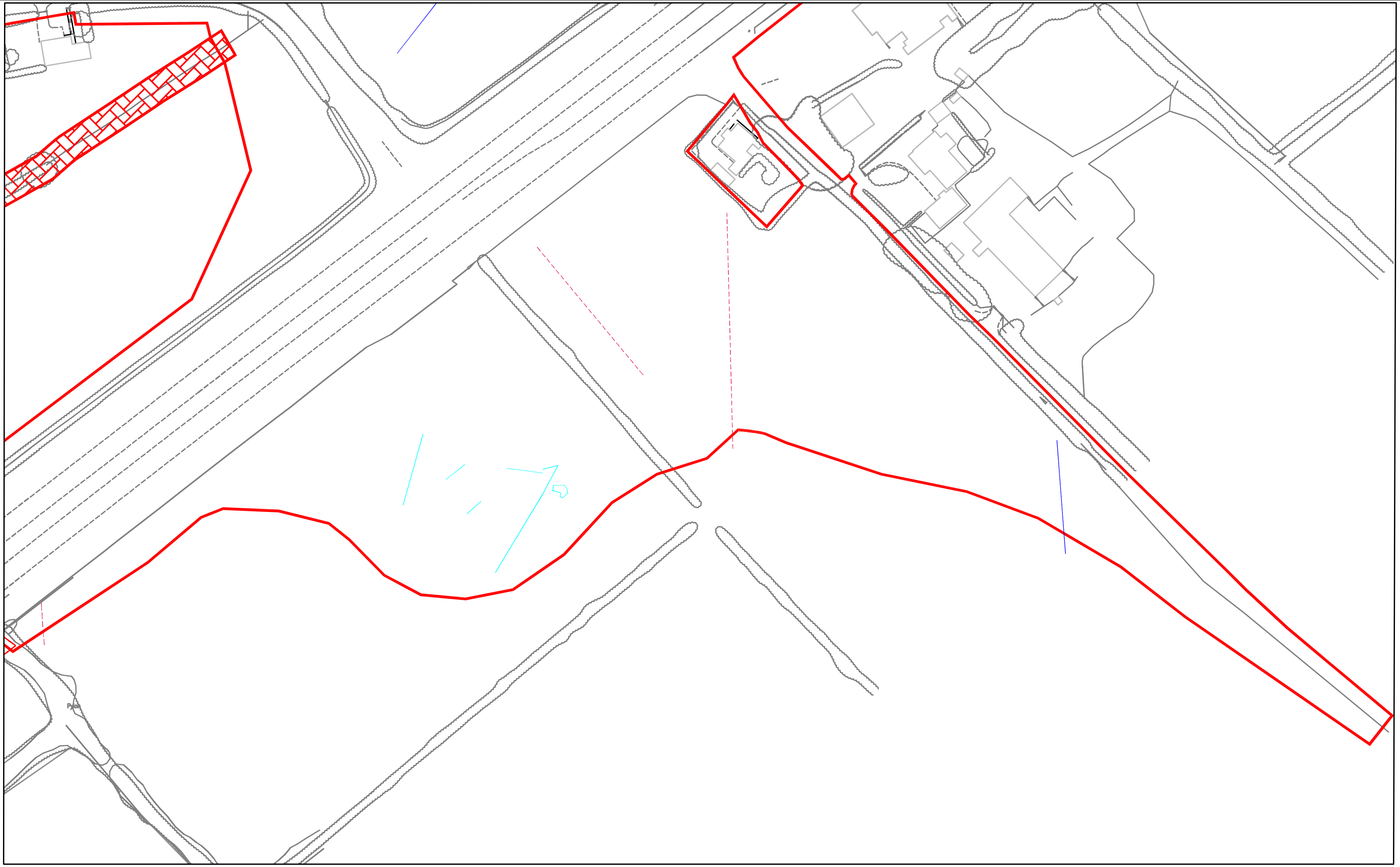
Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO | Date 5/12/03 | Drawing No.: 03-61/07

0m 50m 100m

Figure No. 7 Site 4 Magnetic Susceptibility Interpretation

EARTHSOUND archaeological geophysics



Legend

- C.P.O. Boundary
- Basemap
- Probable Archaeological Remains (ditches, pits *etc*.)
- Possible Archaeological Remains
- Waterpipe
- Probable Geology

Site Location: N7, South County Dublin

Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO	Date 6/12/03	Drawing No.: 03-61/08

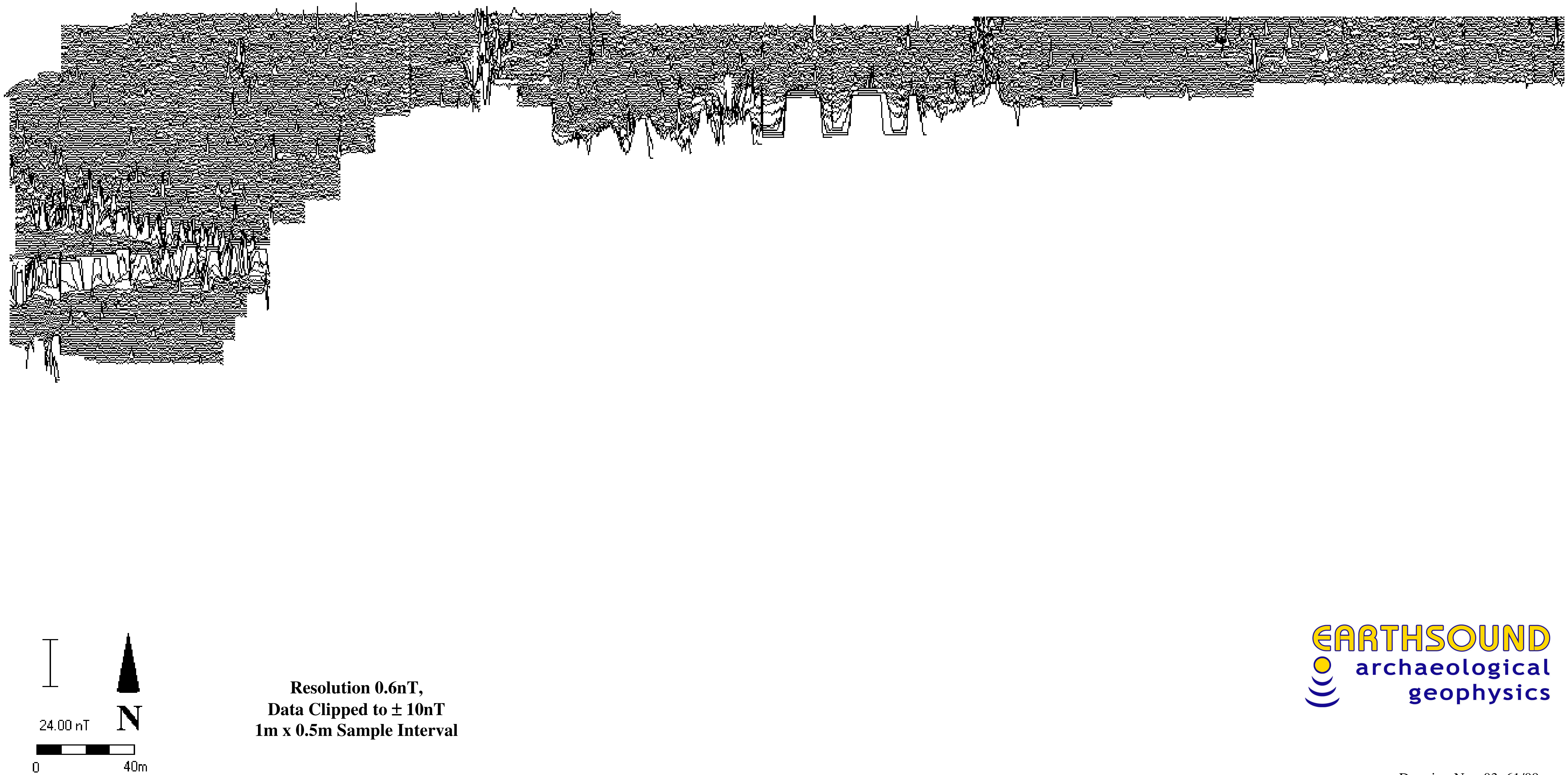
0m 50m 100m

Figure No. 8 Site 4 Interpreted Archaeology Map

EARTHSOUND archaeological geophysics

N7 Rathcoole To Kildare County Boundary, Road Improvement Scheme, County Kildare

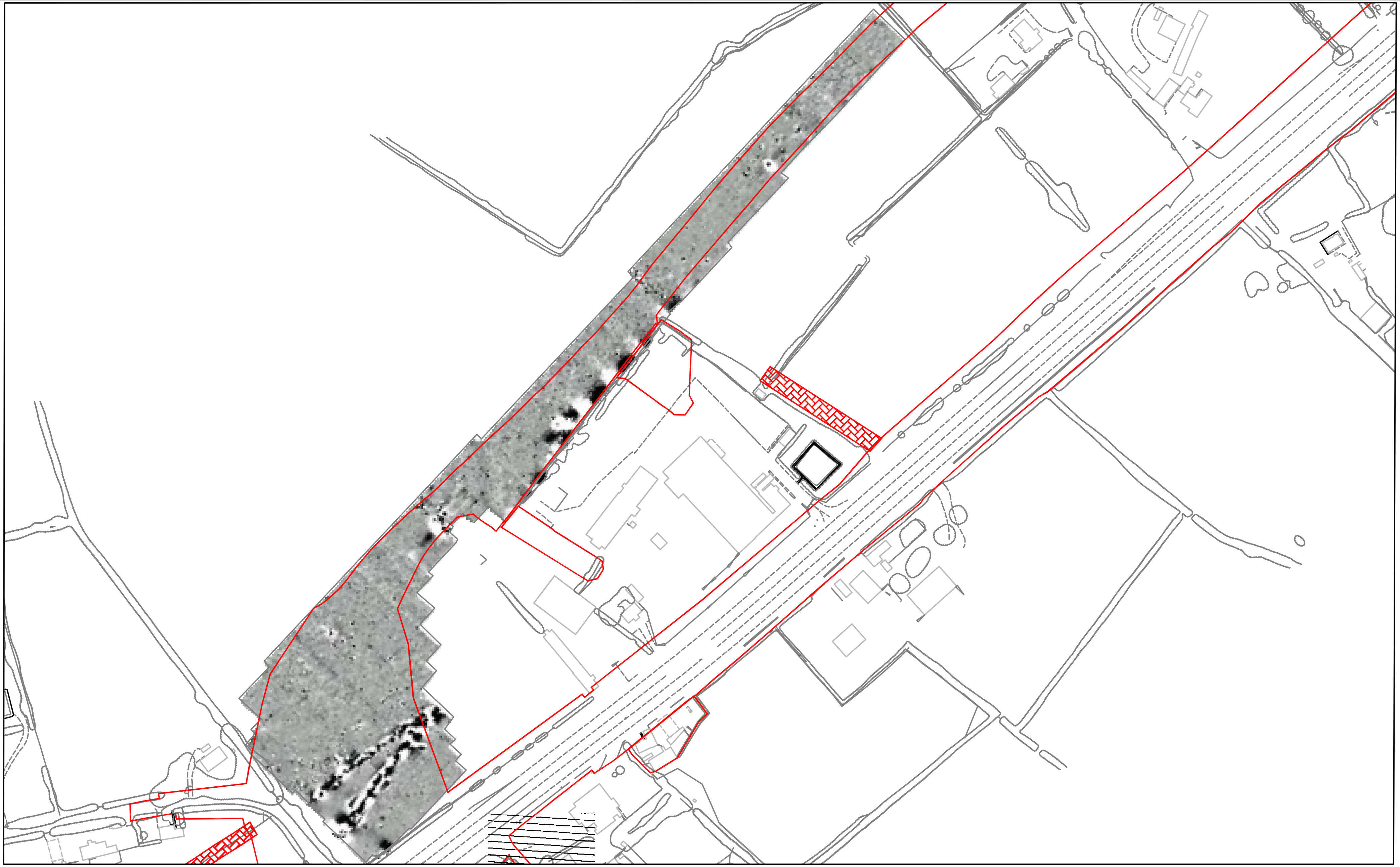
Figure 09: Pre-processed Fluxgate Gradiometer XY Traceplot of Site 5



Resolution 0.6nT,
Data Clipped to ± 10nT
1m x 0.5m Sample Interval

EARTHSOUND archaeological geophysics

Drawing No.: 03_61/09



Legend

- CPO line
- Basemap

nT

-2 0 1

Site Location: N7, South County Dublin

Client: Irish Archaeological Consultancy Ltd.

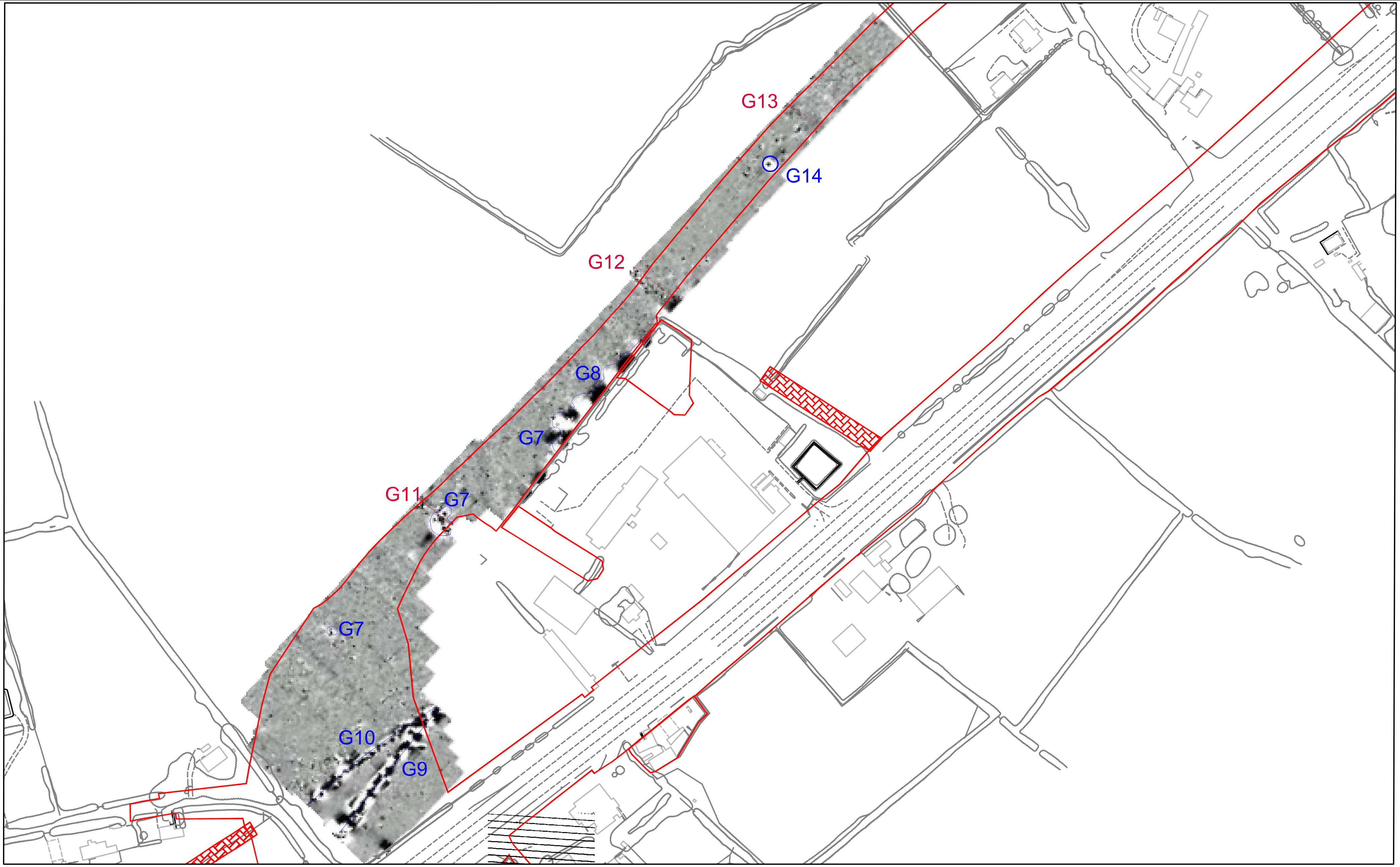
Drawing Courtesy of: Kildare NRDO	Date 5/12/03	Drawing No.: 03-61/10

Ordnance Survey Ireland Licence No. AR 0047304

0m 100m 200m

Figure No. 10 Site 5 Fluxgate Gradiometer Data

EARTHSOUND archaeological geophysics



Legend

- CPO line
- Basemap
- Discrete Negative Anomaly
- Discrete Positive Anomaly

nT

-1 0 2

Site Location: N7, South County Dublin

Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO | Date 5/12/03 | Drawing No.: 03-61/11

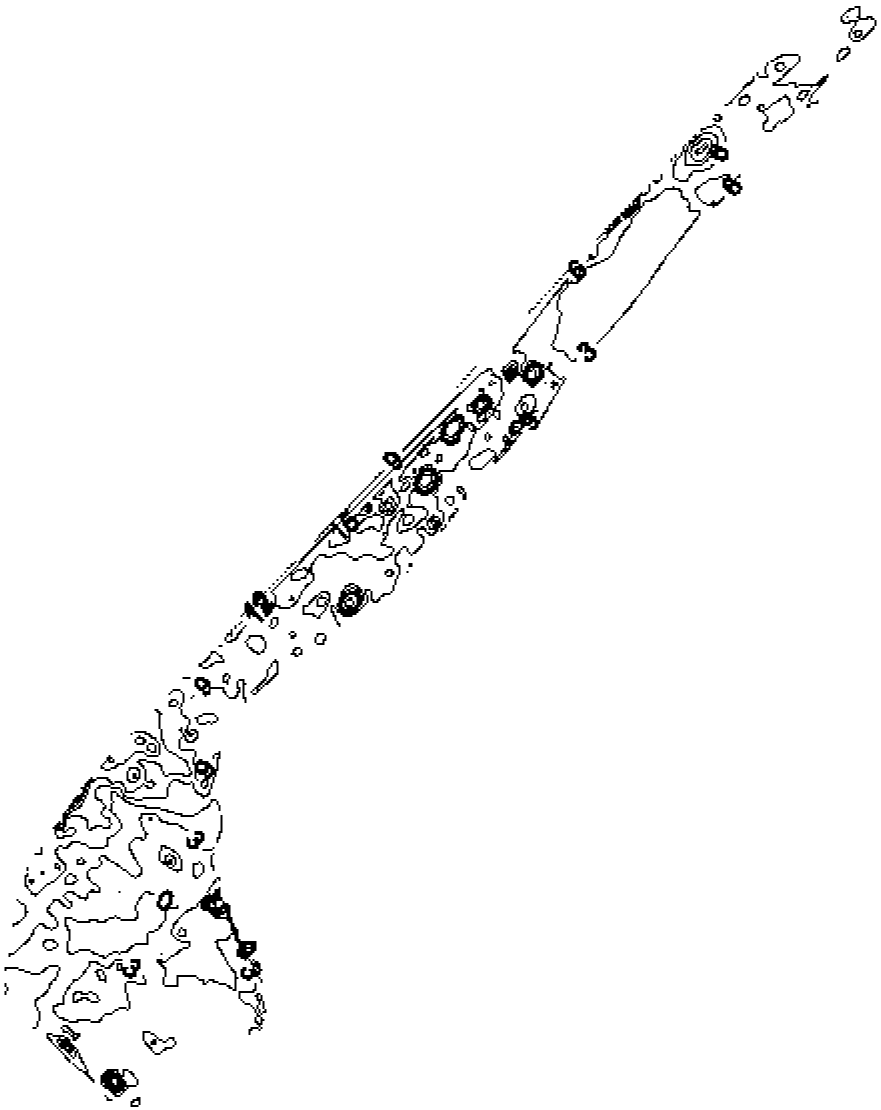
0m 100m 200m

Figure No. 11 Site 5 Fluxgate Gradiometer Interpretation

EARTHSOUND archaeological geophysics

N7 Rathcoole To Kildare County Boundary, Road Improvement Scheme, County Kildare

Figure 12: Pre-processed Magnetic Susceptibility Contour Plots of Site 5

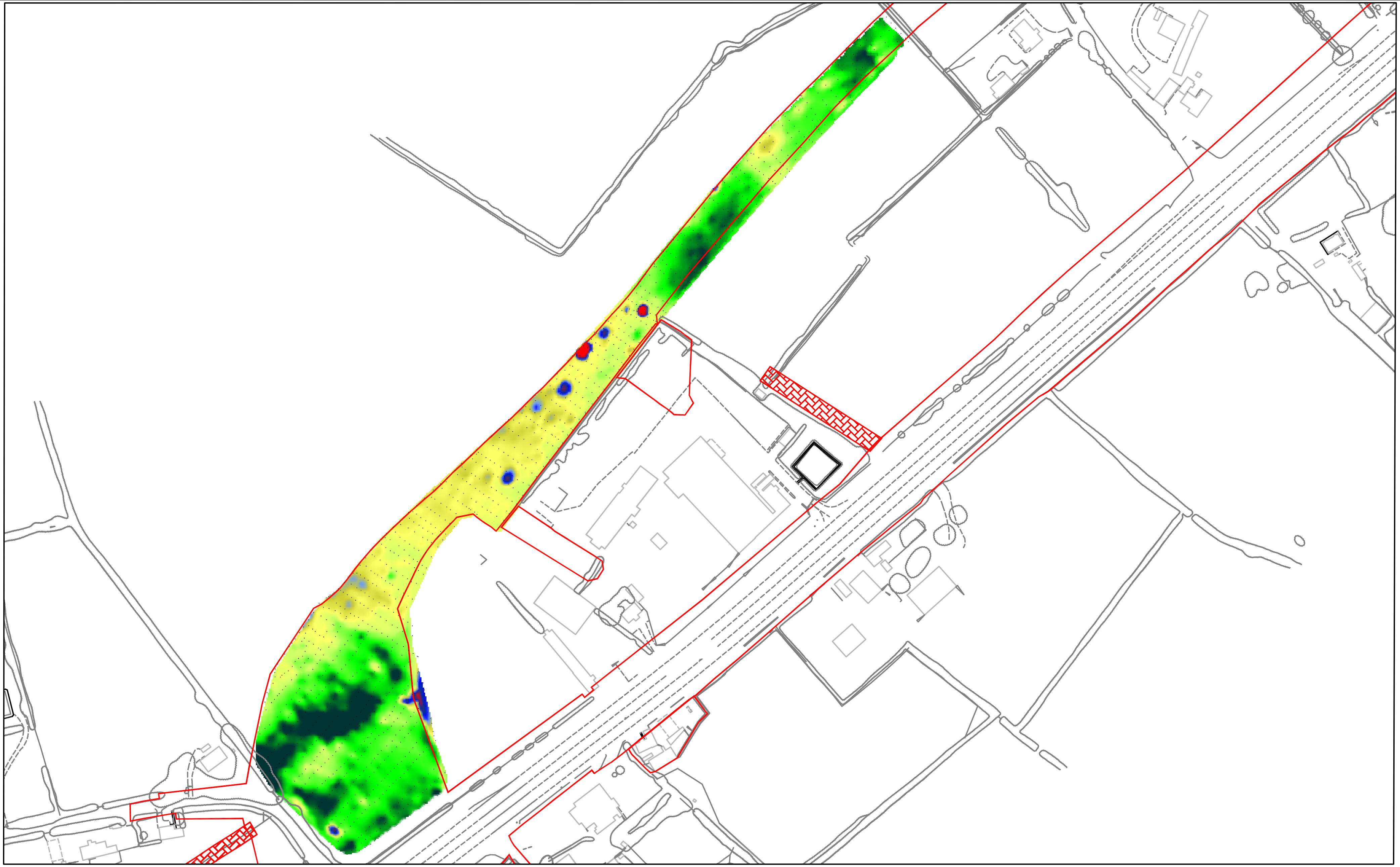


1 SI Unit = 1 x 10^{-5}

5m x 5m Sample Interval

Drawing No.: 03_61/12

EARTHSOUND archaeological geophysics



Site Location: N7, South County Dublin		
Client: Irish Archaeological Consultancy Ltd.		
Drawing Courtesy of: Kildare NRDO	Date 5/12/03	Drawing No.: 03-61/13

Figure No. 13 Site 5 Magnetic Susceptibility Data

Legend

C.P.O. Boundary

Basemap

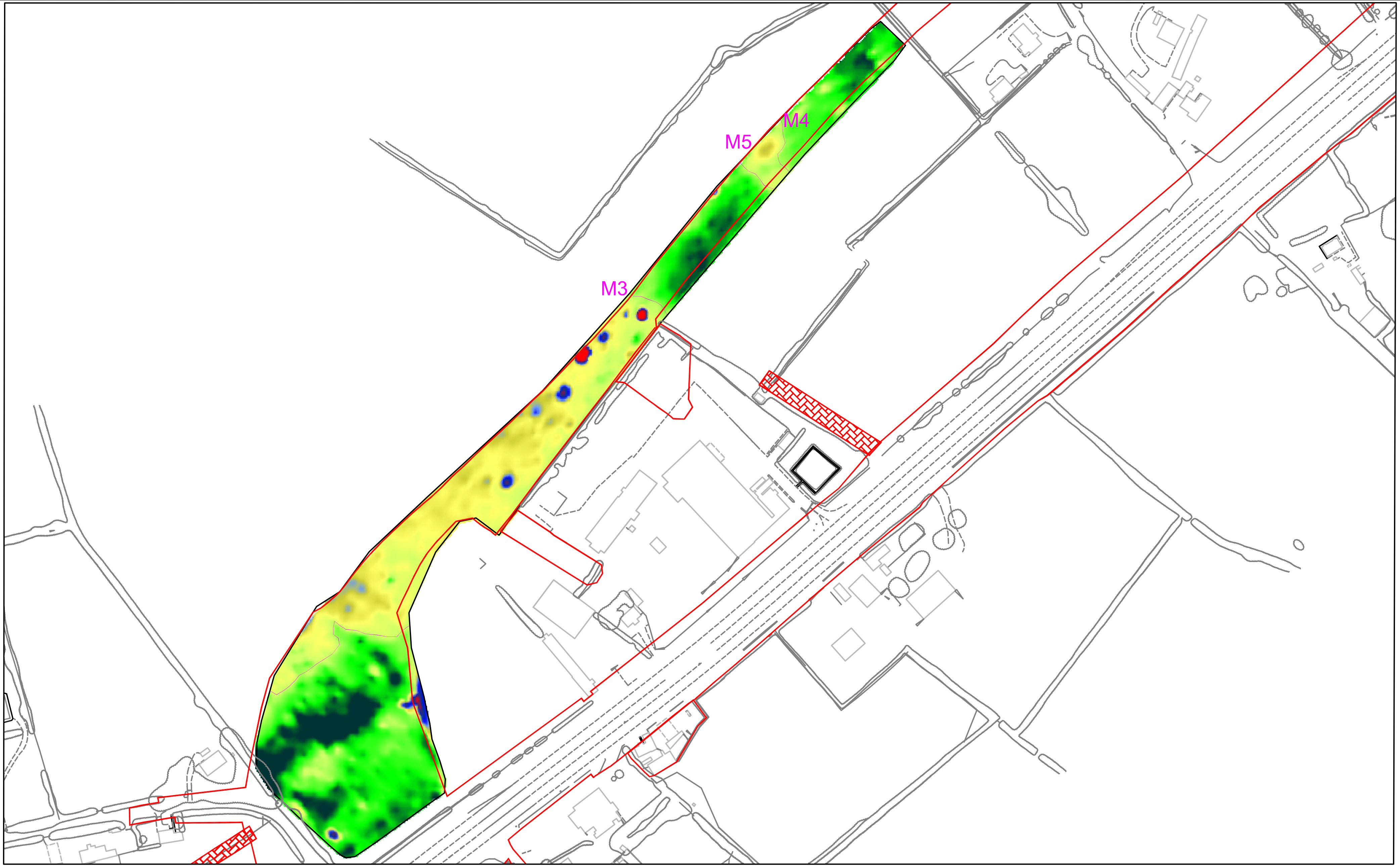
Survey Stations

x 10^{-5} K

0 20 60

0m 100m 200m

EARTHSOUND archaeological geophysics



Legend

- C.P.O. Boundary
- Basemap
- Magnetic Susceptibility Anomaly

x 10^{-5} K

0 20 60

Site Location: N7, South County Dublin

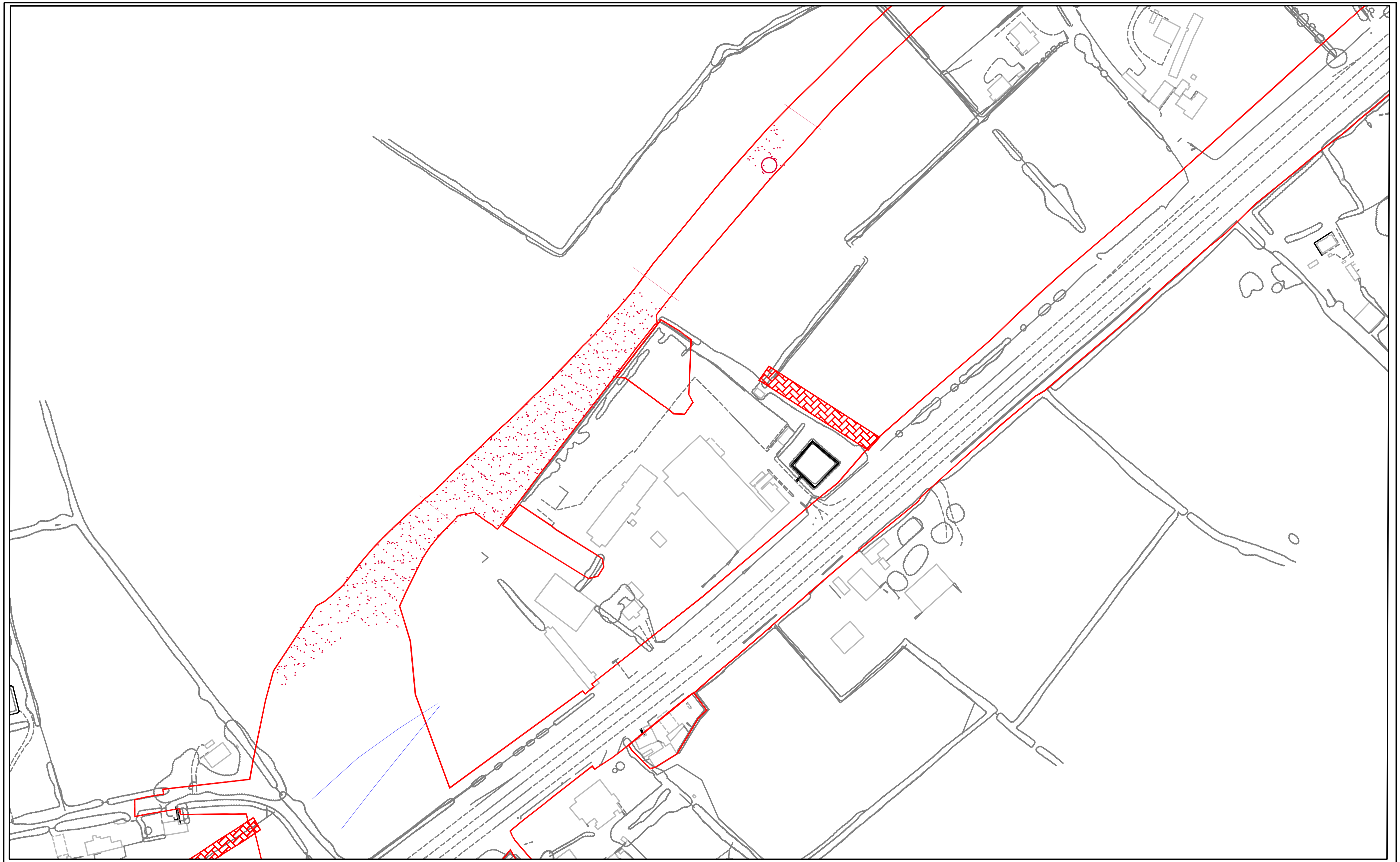
Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO	Date 5/12/03	Drawing No.: 03-61/14

0m 100m 200m

Figure No. 14 Site 5 Magnetic Susceptibility Interpretation

EARTHSOUND archaeological geophysics



Legend

- C.P.O. Boundary
- Basemap
- Probable Archaeological Remains (ditches, pits *etc.*)
- Possible Archaeological Remains
- Archaeological Enhancement (Manured Field)
- Waterpipe

Site Location: N7, South County Dublin

Client: Irish Archaeological Consultancy Ltd.

Drawing Courtesy of: Kildare NRDO	Date 6/12/03	Drawing No.: 03-61/15

0m 100m 200m

Figure No. 15 Site 5 Interpreted Archaeology Map

EARTHSOUND archaeological geophysics