

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

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Survey Event No. **157**

Survey Name **Derryvorrigan, M7 Portlaoise-Castletown / M8 Portlaoise-Cullahill**

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Survey funded by the National Roads Authority

Known problems with this report

There are no known archive issues with this report

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**Derryvorrigan 1, M7 Portlaoise-Castletown / M8
Portlaoise - Cullahill, Contract 2, Coolfin To Townparks
And Derrinsallagh**

Archaeological Geophysical Survey

Direction No. A015
Registration No. R44
(Testing Area 11 A015/038)

Survey undertaken on behalf of

Archaeological Consultancy Services Limited

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EAG 94
19 December 2006



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Summary of Results

On the 22 November 2006, a series of geophysical surveys funded by Archaeological Consultancy Services Limited were conducted adjacent to the compulsory purchase order boundary of the proposed M7 Portlaoise to Castletown / M8 Portlaoise to Cullahill Road Scheme, County Laois. The areas were investigated using a fluxgate gradiometer at a sampling resolution of 1 x 0.25 m.

The survey was conducted upon a bedrock geology of the Ballysteen Formation of fossiliferous dark-grey muddy limestone shale. This type of geology is magnetically quiet and caused no problem for the magnetic survey. The survey area was covered in short grass and was comprised of pastureland which was amenable for geophysical surveys.

A large number of possible pit features were identified across the site. These appear to have no direct relationship to one another and form no discernable pattern. However their presence within the survey area can be directly compared to the archaeological features revealed during the adjacent excavation where postholes, pits, limekilns, bowl furnaces, hearths and charcoal spreads were found. Many of these archaeological features could also explain the dipolar ferrous anomalies detected across the site.

A number of linear ditches were also detected within the survey area which suggest that the area has had several different field boundary alignments placed within it. A number of other possible ditches were also detected which are probably associated with the archaeological activity on the site and may compare with the linear features found during the excavation.



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 Test Trench excavations.

1. Introduction

Earthsound Archaeological Geophysics were commissioned by Ms. D. Murphy of *Archaeological Consultancy Services Limited*, to execute a geophysical survey adjacent to a defined archaeological site identified as Derryvorrigan 1, located within the proposed M7 Portlaoise to Castletown / M8 Portlaoise to Cullahill Road Scheme, County Laois.

Permissions to undertake the survey were obtained from the *Department of the Environment, Heritage and Local Government* (Licence Number A015/168 – R44). There are no Recorded Monuments present and the site is not the subject of any legal instruments under the National Monuments Act (1930-94).

The geophysical survey was requested to determine the presence/absence of unknown archaeological features associated with the results of archaeological test trenching.

1.1 Geography, Topography, Geology & Climate

The site is located in the townland of Derryvorrigan and in the parish of Aghaboe. The northwest corner of the site (Figure 1) lies at *Ordnance Survey of Ireland* Irish National Grid (ING) Reference E225445 N185902.

Derryvorrigan 1 is located in southwest County Laois. The townland is located 2 km southeast of Borris-in-Ossory off the N7 National Road, 1 km east of the R435 Regional Road, 1 km south of Sentryhill and at the foot of Knockseera Hill. It is located within Contract 2 of the proposed Motorway scheme, which extends from the townland of Coolfin to Derrinsallagh and Townparks (Chainage 0–19500).

The survey area was located in the centre of an inverted L-shaped field, one field north of a graveyard visible on the OS map. The topography of the site gently slopes to the north, lying on the lower slopes of Knockseera hill. The geophysical grid baseline was established along the C.P.O. boundary of the proposed Motorway.

The survey was conducted upon a bedrock geology of the Ballysteen Formation of fossiliferous dark-grey muddy limestone shale. This type of geology is magnetically quiet and caused no problem for the magnetic survey.

The week preceding the geophysical survey, the climatic conditions were mild and wet and this continued during fieldwork. This will not have had any adverse affect on the geophysical survey.

1.2 Archaeological Background

Archaeological excavations at Derryvorrigan 1 were completed in September 2006, by *Archaeological Consultancy Services Ltd*. The site consisted of the remains of a prehistoric settlement site, which included post-holes, pits, linear features, a limekiln, bowl furnaces, hearths and charcoal spreads.

1.3 Aims & Objectives

The aim of the geophysical survey was to determine the extent of the archaeological resource in advance of the proposed development scheme. Specific objectives were to:

- Determine the presence or absence of the suspected archaeology
- Assessment of the spatial extent of any archaeological features

2. Methodology

The fieldwork was carried out on 22 November 2006 by J. Bonsall and I. Murin of *Earthsound Archaeological Geophysics*.

The geophysical survey was carried out using two *Geoscan Research* FM256 fluxgate gradiometers.

The survey area covered a total of 2.13 hectares. A rectangular grid was laid out using a *Trimble* Pro-XRS Differential Global Positioning System (see Technical Appendix 2), and divided in to 40 × 40 m sub-grids for the gradiometer survey.

2.1 Magnetic Gradiometer Survey

The survey was undertaken along lines parallel to the sub-grid edges, walking approximately west to east, starting in the northwest corner of each grid. Subsequent lines were surveyed in alternate directions ('zigzag').

Data were recorded using an FM256 at a spatial resolution of 1 m intervals between traverses and 0.25 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 internal 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

No further processing functions were applied due to the high quality of the data collection.

A low pass Gaussian filter was applied, reducing the variability of the data whilst improving the visibility of weak archaeological features. 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 $\text{sinc}(x) = \sin \pi x / \pi x$ (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 m x 0.25 m to 0.5 m x 0.125 m. 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).

2.1.2 Graphical Display

Pre-processed data are displayed in XY traceplot format in Figure 2. 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 have been clipped at -3 and $+3$ 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 potentially archaeological anomalies differentiated from iron 'spikes'.

Processed data are shown in Greyscale format in Figure 3. 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 in Figure 3 have been clipped at -2 (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.

An interpretation plot is presented in Figure 4.

2.2 Reporting, Mapping and Archiving

The geophysical survey and report follow the recommendations outlined in the *English Heritage Guidelines* (David 1995) and *IFA Paper No. 6* (Gaffney *et al.* 2002) as a minimum standard.

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

Field boundaries were mapped and drawn based upon data gathered by the DGPS. All figures reproduced from *Ordnance Survey Ireland* mapping are done so with permission from OSI copyright (Licence No. AR 0047306).

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 Figure 4 and are described and interpreted within the text.

3.1 Magnetic Gradiometer Survey

Figure 3 – Magnetic Gradiometer Data

Figure 4 – Magnetic Gradiometer Interpretation

In magnetic data, a dipolar anomaly or ‘iron spike’ is a response to buried ferrous objects, often in the topsoil. Iron spikes generally are not removed in geophysical data, although often modern in origin, they can be indicative of archaeological material such as kilns, hearths and furnaces revealed during archaeological excavations.

Two linear north-south trends of dipolar anomalies can be seen within the centre of the data. These comprise a linear series of individual dipolar signatures and are suggestive of relict field boundaries or possible deeply buried pipes. The western example also includes the magnetic response from a gate.

A large number of possible pit features were also detected across the survey area. These have a slightly raised magnetism associated with them that suggests possible burnt or fired debris may be contained within them. The archaeological excavation revealed the presence of limekilns, bowl furnaces, hearths, pits, postholes and charcoal spreads all of which are likely to cause these pit-type anomalies within the geophysical data. A linear row of five possible pit anomalies can be seen on the eastern edge of the survey area, suggesting a possible uniform archaeological feature.

A number of cultivation furrows were also detected across the survey area. These are aligned northwest to southeast and appear to suggest at least one phase of cultivation activity.

Anomaly [1] is a linear probable ditch feature that runs the length of the survey area. Orientated on an east-west alignment and detected for a length of 250 m it is likely that this represents a relict field boundary as it runs at right angles to the existing field boundaries in the area.

Anomaly [2] is a curvilinear possible ditch anomaly that is located on the northeastern edge of the survey area. This anomaly has a greater magnetic signature than that of anomaly 1 and probably represents archaeological activity. There are two possible pit anomalies located in the centre of this ditch anomaly.

Anomaly [3] is a diffuse area of magnetic enhancement that traverses the eastern half of the survey area. Measuring 114 m in length and approximately 10 m in width it is possibly a geological anomaly or the ploughed out remains of a relict field boundary. Some of the plough furrow anomalies appear to terminate adjacent to this area of enhancement.

Anomaly [4] is a linear possible ditch feature which was detected for a length of 85 m and continues beyond the survey area in to the Motorway corridor. Orientated on the same alignment as the adjacent plough furrows it is possible that this represents a bounding feature, drainage ditch or a further plough furrow.

Anomaly [5] is a linear possible ditch feature which appears to terminate adjacent to a linear dipolar anomaly and continues beyond the survey area on a southeast direction. Detected for a length of 45 m it is probable that this represents a relict field boundary.

Anomalies [6] and [7] are two linear ditches which run (broadly parallel) for a length of 43 m and 29 m respectively. These may be associated with the archaeological remains identified in the excavation or may post date these remains.

Anomaly [8] comprises of a series of linear and curvilinear enhancement anomalies that appear to form a sub-circular probable archaeological feature measuring approximately 23 m in diameter. These anomalies appear to suggest that the feature has an enclosing possible ditch with internal linear divisions, having a separation of 3 m. It is possible that this represents some ancient cultivation activity, or possibly a series of slot-trenches.

Anomaly [9] is an area of magnetic enhancement located on the north-western edge of the survey area. Measuring 25 m by 37 m this is likely to represent archaeological activity that has probably been disturbed and spread by plough activity.

4. Conclusions

4.1 Achievement of Objectives

The geophysical survey conducted on this site has enabled a greater understanding to be gained about the archaeological activity on the site. Geophysical results have shown that the archaeological activity revealed during the excavation continues outside the CPO boundary.

4.2 Summary of Results

A large number of possible pit features were identified across the site. These appear to have no direct relationship to one another and form no discernable pattern. However their presence within the survey area can be directly compared to the archaeological features revealed during the adjacent excavation where postholes, pits, limekilns, bowl furnaces, hearths and charcoal spreads were found. Many of these archaeological features could also explain the dipolar ferrous anomalies detected across the site.

A number of linear ditches were also detected within the survey area which suggest that the area has contained several different field boundary alignments over time. A number of other possible ditches were also detected which are probably associated with the archaeological activity on the site and may compare with the linear features found during the excavation.

4.3 Dissemination

The results of this survey were submitted to *Archaeological Consultancy Services Limited*. *Earthsound* will ensure that copies will be forwarded to the *Department of the Environment, Heritage and Local Government* and the National Museum of Ireland in compliance with the Licence agreement.

5. Acknowledgements

Project Management:	James Bonsall BA (Hons) MSc PIFA
Fieldwork:	James Bonsall Igor Murin MSc
Report:	Heather Gimson BA (Hons) MSc MIAI Suzanne Eggar BSc
Graphics:	Heather Gimson

6. Bibliography

- CLARK, A.J. 1996 *Seeing Beneath the Soil*, London, Batsford
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- GAFFNEY, C., GATER, J. & OVENDEN, S. 2002 *The use of Geophysical Techniques in Archaeological Evaluations*, IFA Paper No. 6, Institute of Field Archaeologists
- SCHMIDT, A. 2001 *Geophysical Data in Archaeology: A Guide to Good Practice*, Archaeology Data Service, Oxford, Oxbow
- 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
- The following texts are referenced in the Technical Appendix:
- WALKER, R. 2000 *Geoplot Version 3.00 for Windows, Instruction Manual, Version 1.2*, Clayton, West Yorkshire

7. Figures

- Figure 1: Site Location
- Figure 2: Pre-processed magnetic gradiometer data
- Figure 3: Processed magnetic gradiometer data
- Figure 4: Magnetic gradiometer interpretation

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. MS 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 MS 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:

- *Ferromagnetism* Strongest
- *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.

1.2 Types of Magnetic Anomaly

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.

1.3 Methodology

1.3.1. *Magnetic Susceptibility Survey*

The magnetic susceptibility meter displays the MS 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 0-18cm 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 MS 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.

1.3.2. *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

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 2000).

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 $\pm 50\text{cm}$.
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 $\pm 0.25\text{m}$. It is important to note that local grid north (27/08/03) varies slightly from *Ordnance Survey* north, with an annual decrease of $0.9^{\circ}3'$.

Appendix 3

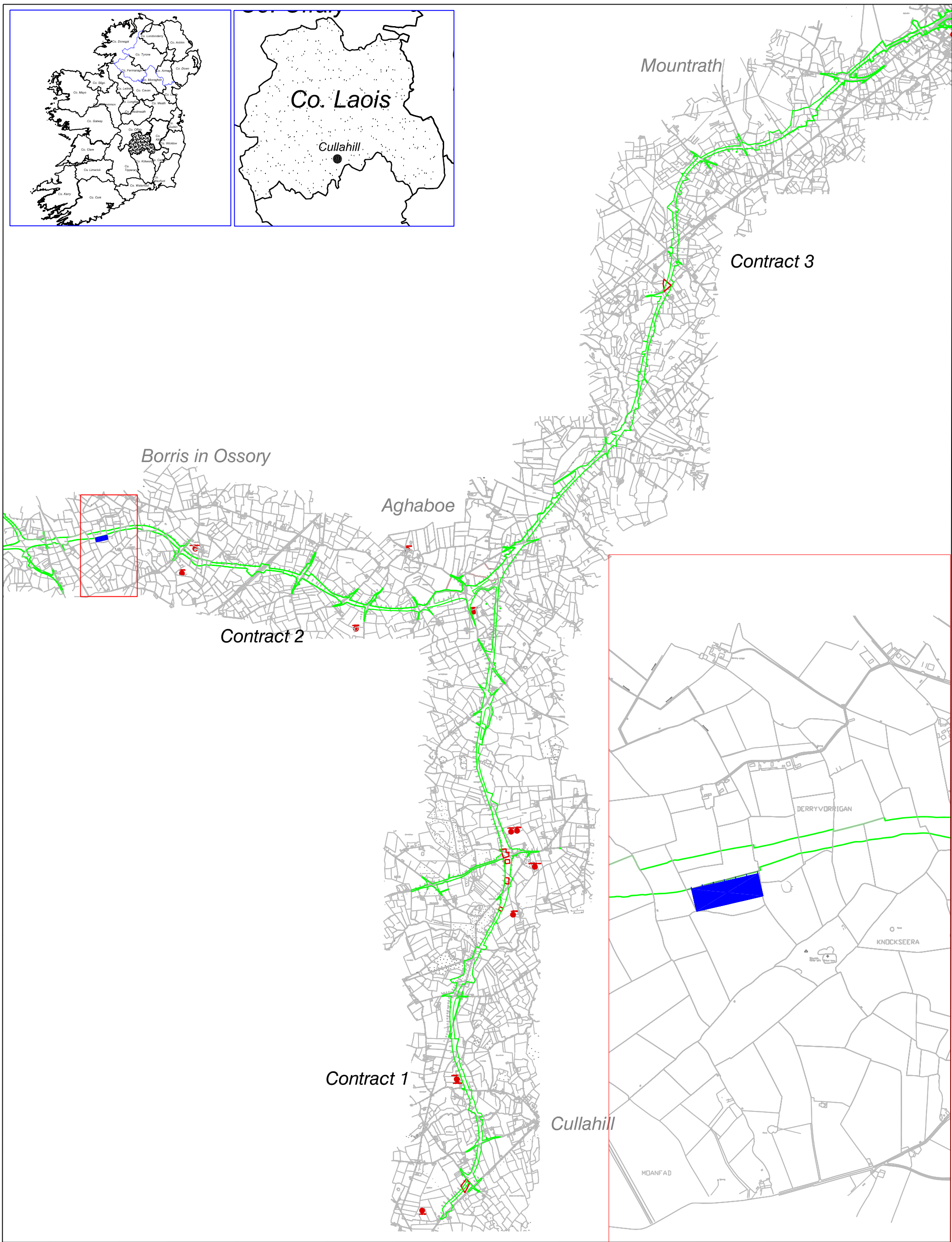
Geophysical Archive

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:-

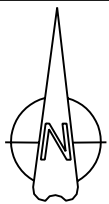
- an archive CD-ROM containing files of the raw data (Geoplot 3.00a, MS-Excel), report text (Word 2000 9.0), and graphics files (AutoCAD 2000).
- a hard (paper) copy of the report

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, *Archaeological Consultancy Services Limited* Archaeological Consultancy Services 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
- RMP Sites
- Geophysical survey area



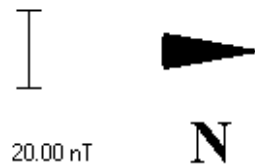
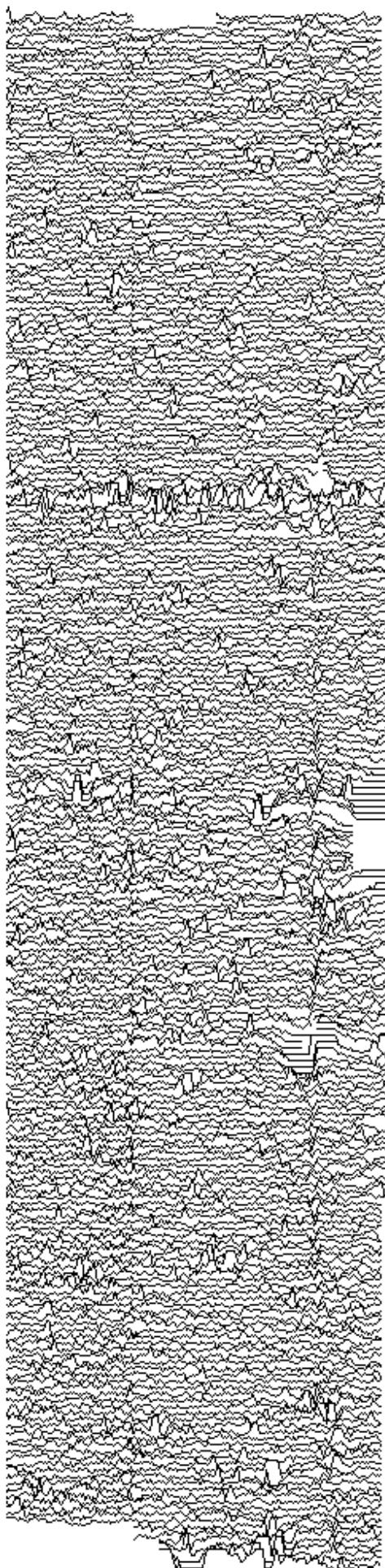
Site Location: Bushfield, Contract 2, M7 / M8, County Laois
Client: Archaeological Consultancy Services Ltd.
Drawing Courtesy of: LCC
Date: 08/12/06
Drawing No.: 06-35/01
Ordnance Survey Ireland Licence No. AR 0047306
Copyright Ordnance Survey Ireland Government of Ireland
0m 2000m 4000m

Figure No. 1 Location map

EARTHSOUND
archaeological
geophysics

Derryvorrigan 1, Contract 2, M7 / M8, County Laois

Figure 2: Pre-processed Fluxgate Gradiometer XY Traceplot



0  20m

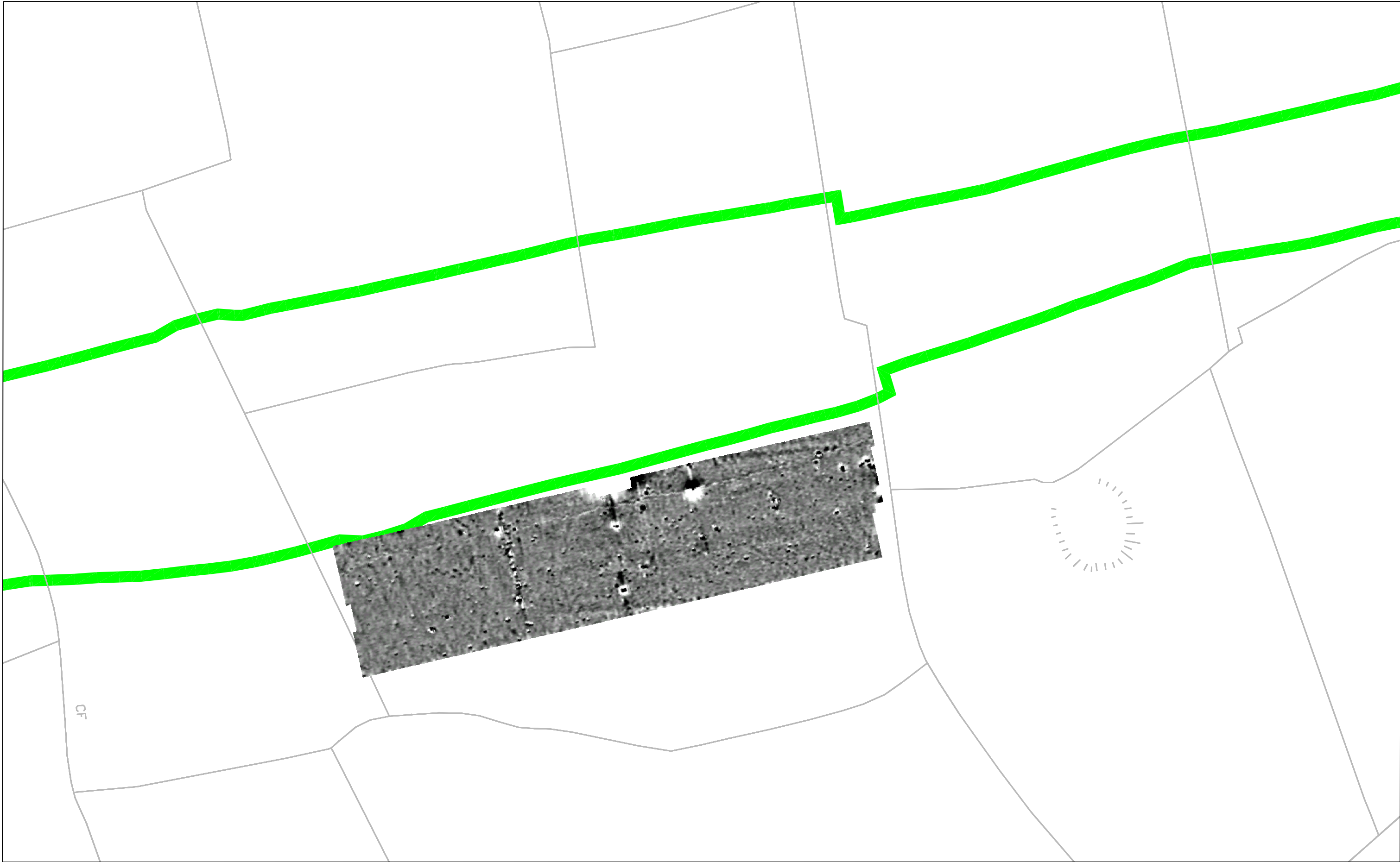
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Data Clipped to ± 3 nT,

1m x 0.25m Sample Interval

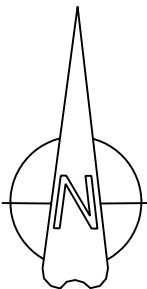
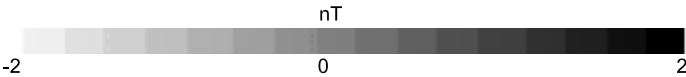
EARTHSOUND
 **archaeological
geophysics**

Drawing No.: 06_35/02



Legend

- Fieldboundary
- Archaeological remains



Site Location: Derrinsallgh 3, Contract 2, M7 / M8, County Laois

Client: Archaeological Consultancy Services Ltd.

Drawing Courtesy of:LCC

Date 13/12/06

Drawing No.: 06-35/03

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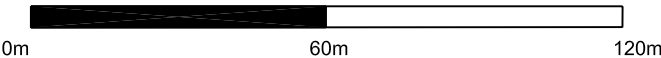


Figure No. 3 Magnetic Gradiometer data





<p>Legend</p> <ul style="list-style-type: none"> CPO line Basemap Survey area Possible pit Possible Ditch Positive Magnetic Enhancement Dipolar Anomaly (ferrous remains) 		<p>Site Location: Derrinsallgh 3, Contract 2, M7 / M8, County Laois</p> <p>Client: Archaeological Consultancy Services Ltd.</p> <p>Drawing Courtesy of: LCC</p> <p>Date 15/12/06 Drawing No.: 06-35/04</p> <p>Ordnance Survey Ireland Licence No. AR 0047306 Copyright Ordnance Survey Ireland Government of Ireland</p> <p>0m 60m 120m</p>	<p>Figure No. 4 Magnetic Gradiometer interpretation</p> <p>EARTHSOUND archaeological geophysics</p>
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