ARCHAEOLOGICAL SERVICES
DURHAM UNIVERSITY

on behalf of
the Chatsworth Settlement Trustees

Paine's Mill
Chatsworth Park
Derbyshire

geophysical survey

report 3275
November 2013

Durham University

Contents

Figures

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South Road · Durham · DH1 3LE · tel 0191 334 1121 · fax 0191 334 1126
archaeological.services@durham.ac.uk · www.dur.ac.uk/archaeological.services

1. Summary

The project

1.1 This report presents the results of geophysical surveys conducted at Paine's Mill in Chatsworth Park, Derbyshire. The works comprised geomagnetic and earth resistance surveys to try to locate the former mill leet.

1.2 The works were commissioned by The Jessop Consultancy on behalf of the Chatsworth Settlement Trustees, and conducted by Archaeological Services Durham University.

Results

1.3 Although the surveys have not provided a clear indication of the location and nature of the former leet, they have detected linear and discrete anomalies consistent with sediments and disturbance in the area where the leet would have been expected, between the sluice and an extant water channel north of the mill.

1.4 Part of a former water channel may have been detected just east of the mill building.

1.5 An area of rubble or otherwise disturbed or made-ground has been detected around the mill building.

2. Project background

Location (Figure 1)

2.1 The study area comprised land adjacent to Paine's Mill in Chatsworth Park, Derbyshire (NGR mill: SK 2592 6876). Earth resistance and geomagnetic surveys were undertaken on land between the mill and the River Derwent to the east.

Objectives

2.2 The principal aim of the surveys was to determine the location of a former mill leet between the mill and the river. A secondary aim was to determine the nature and extent of any other sub-surface features of potential archaeological or historic significance.

Methods statement

2.3 The surveys have been undertaken in accordance with instructions from the client and national standards and guidance (see para. 5.1 below).

Dates

2.4 Fieldwork was undertaken on the 10th October 2013. This report was prepared for November 2013.

Personnel

2.5 Fieldwork was conducted by Nathan Thomas (Supervisor) and Rebekah Watson. Geophysical data processing and report preparation was by Duncan Hale (the Project Manager) with illustrations by Janine Watson.

Archive/OASIS

2.6 The site code is **DCH13**, for **D**erbyshire **CH**atsworth 20**13**. The survey archive will be supplied on CD to the client for deposition with the project archive in due course. Archaeological Services Durham University is registered with the **O**nline **A**cces**S** to the **I**ndex of archaeological investigation**S** project (**OASIS**). The OASIS ID number for this project is **archaeol3-163899**.

Acknowledgements

2.7 Archaeological Services is grateful to the Chatsworth Estate and The Jessop Consultancy for facilitating this research.

3. Landuse, topography and geology

3.1 The survey area comprised managed grassland on the west side of the River Derwent. The disused mill stood in the southern part of the survey area, with a few trees between it and the river. Three benches, a footpath and an inspection cover were also present within the survey area.

3.2 A sluice was present on the upstream side of the wear just north of the mill; this presumably marks the north end of the leet. A water channel heads north from the mill building before turning west. The former leet is expected to run between the sluice and the turn in the existing water channel. A linear feature is visible between those two points on aerial imagery.

3.3 To the north of the wheel house there was an opening for a bypass channel to the wheepit, which is assumed to connect with the outlet channel that flows from the wheel pit to the river; a channel outlet was also noted in the riverbank just south-east of the mill.

3.4 The land occupies a very gentle slope on the west bank of the river, at approximately 105m OD.

3.5 The underlying solid geology of the area comprises Namurian mudstone and siltstone of the Marsden Formation, overlain by Holocene alluvial deposits of gravel, sand, silt and clay.

4. Geophysical survey

Standards

4.1 The surveys and reporting were conducted in accordance with English Heritage guidelines, *Geophysical survey in archaeological field evaluation* (David, Linford & Linford 2008); the Institute for Archaeologists (IfA) *Standard and Guidance for archaeological geophysical survey* (2011); the IfA Technical Paper No.6, *The use of geophysical techniques in archaeological evaluations* (Gaffney, Gater & Ovenden 2002); and the Archaeology Data Service *Guide to Good Practice: Geophysical Data in Archaeology* (Schmidt & Ernenwein 2011).

Technique selection

4.2 Geophysical survey enables the relatively rapid and non-invasive identification of sub-surface features of potential archaeological significance and can involve a suite of complementary techniques such as magnetometry, earth electrical resistance, ground-penetrating radar, electromagnetic survey and topsoil magnetic susceptibility survey. Some techniques are more suitable than others in particular situations, depending on site-specific factors including the nature of likely targets; depth of likely targets; ground conditions; proximity of buildings, fences or services and the local geology and drift.

4.3 In this instance, it was anticipated that the former mill leet associated with Paine's Mill would be present within the survey area.

4.4 Given the anticipated depth of the target and the presence of the former mill building, both geomagnetic and electrical resistance techniques were considered appropriate. Earth electrical resistance survey can be particularly useful for mapping stone and brick features. When a small electrical current is injected through the earth it encounters resistance which can be measured. Since resistance is linked to moisture content and porosity, stone and brick features will give relatively high resistance values while soil-filled features, which typically retain more moisture, will provide relatively low resistance values.

4.5 The geomagnetic technique, fluxgate gradiometry, involves the use of hand-held magnetometers to detect and record anomalies in the vertical component of the Earth's magnetic field caused by variations in soil magnetic susceptibility or permanent magnetisation; such anomalies can reflect archaeological features.

Field methods

4.6 A 20m grid was established across the survey area and related to the Ordnance Survey National Grid using a Leica GS15 global navigation satellite system (GNSS) with real-time kinematic (RTK) corrections typically providing 10mm accuracy.

4.7 Measurements of earth electrical resistance were determined using a Geoscan RM15D Advanced resistance meter and MPX15 multiplexer with a mobile twin probe separation of 0.5m. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was 0.1ohm, the sample interval was 1m and the traverse interval was 1m, thus providing 400 sample measurements per 20m grid unit.

4.8 Measurements of vertical geomagnetic field gradient were determined using a Bartington Grad601-2 dual fluxgate gradiometer. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was nominally 0.03nT, the sample interval was 0.25m and the traverse interval was 1m, thus providing 1,600 sample measurements per 20m grid unit.

4.9 Data were downloaded on site into a laptop computer for initial processing and storage and subsequently transferred to a desktop computer for processing, interpretation and archiving.

Data processing

4.10 Geoplot v.3 software was used to process the geophysical data and to produce both continuous tone greyscale images and trace plots of the raw (minimally processed) data. The greyscale images and interpretations are presented in Figures 2-4; the trace plots are provided in Figure 5. In the greyscale images, high resistance and positive magnetic anomalies are displayed as dark grey, while low resistance and negative magnetic anomalies are displayed as light grey. Palette bars relate the greyscale intensities to anomaly values in nanoTesla/ohm as appropriate.

4.11 The following basic processing functions have been applied to the resistance data:

despike	locates and suppresses spikes in data due to poor contact resistance
interpolate	increases the number of data points in a survey to match sample and traverse intervals; in this instance the data have been interpolated to 0.25m x 0.25m intervals

4.12 The following basic processing functions have been applied to the geomagnetic data:

clip	clips data to specified maximum or minimum values; to eliminate large noise spikes; also generally makes statistical calculations more realistic
zero mean traverse	sets the background mean of each traverse within a grid to zero; for removing striping effects in the traverse direction and removing grid edge discontinuities

interpolate increases the number of data points in a survey to match sample and traverse intervals; in this instance the data have been interpolated to 0.25m x 0.25m intervals

Interpretation: anomaly types

4.13 Colour-coded geophysical interpretations are provided. Two types of resistance anomaly have been distinguished in the data:

high resistance regions of anomalously high resistance, which may reflect foundations, tracks, paths and other concentrations of stone or brick rubble

low resistance regions of anomalously low resistance, which may be associated with soil-filled features such as pits and ditches

4.14 Two types of geomagnetic anomaly have been distinguished in the data:

positive magnetic regions of anomalously high or positive magnetic field gradient, which may be associated with high magnetic susceptibility soil-filled structures such as pits and ditches

dipolar magnetic paired positive-negative magnetic anomalies, which typically reflect ferrous or fired materials (including fences and service pipes) and/or fired structures such as kilns or hearths

Interpretation: features

4.15 A colour-coded archaeological interpretation plan is provided.

4.16 A concentration of small, intense dipolar magnetic anomalies has been detected around the disused mill. These anomalies almost certainly reflect building rubble and other ferrous/fired materials. Following damage after a fallen tree, the mill was partially demolished and the external ground levels appear to have been re-landscaped (Jessop, pers.comm.).

4.17 A scatter of similar, discrete anomalies has been detected across the survey, which almost certainly reflects occasional items of near-surface ferrous and/or fired debris, such as horseshoes and brick fragments, for example, which in most cases have little or no archaeological significance.

4.18 Other relatively large dipolar magnetic anomalies correspond to the sluice gate in the north and the outlet in the south, and an inspection cover east of the mill.

4.19 Some very weak linear positive magnetic and discrete dipolar magnetic anomalies detected in the north of the survey area could reflect sediments and other materials within the course of the former mill leet. The anomalies are broadly aligned between the sluice and the existing water channel to the north of the mill, where the leet might be expected. The anomalies do not appear to reflect a brick or stone-lined channel.

4.20 Two rectilinear positive magnetic anomalies detected in the central part of the survey could reflect soil-filled ditches or gullies, or perhaps trenches for robbed-out wall footings.

4.21 Three sub-circular areas of high electrical resistance have been detected around the three trees present east of the mill. The anomalies reflect the relatively dry ground conditions associated with the water uptake of the tree roots.

4.22 A band of relatively low resistance was also detected, parallel to the eastern face of the mill. This anomaly reflects relatively moist ground and could reflect a former water channel, probably associated with the mill.

4.23 A short high resistance anomaly detected just north of an inspection cover may reflect part of the service associated with that cover.

5. Conclusions

5.1 Geomagnetic and earth resistance surveys have been undertaken at Paine's Mill on the Chatsworth estate in Derbyshire.

5.2 Although the surveys have not provided a clear indication of the location and nature of the former leet, they have detected linear and discrete anomalies consistent with sediments and disturbance in the area where the leet would have been expected, between the sluice and an extant water channel north of the mill.

5.3 Part of a former water channel may have been detected just east of the mill building.

5.4 An area of rubble or otherwise disturbed or made-ground has been detected around the mill building.

6. Sources

David, A, Linford, N, & Linford, P, 2008 *Geophysical Survey in Archaeological Field Evaluation*. English Heritage

Gaffney, C, Gater, J, & Ovenden, S, 2002 *The use of geophysical techniques in archaeological evaluations*. Technical Paper **6**, Institute of Field Archaeologists

IfA 2011 *Standard and Guidance for archaeological geophysical survey*. Institute for Archaeologists

Schmidt, A, & Ernenwein, E, 2011 *Guide to Good Practice: Geophysical Data in Archaeology*. Archaeology Data Service

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geophysical survey
report 3275

Figure 1: Site location

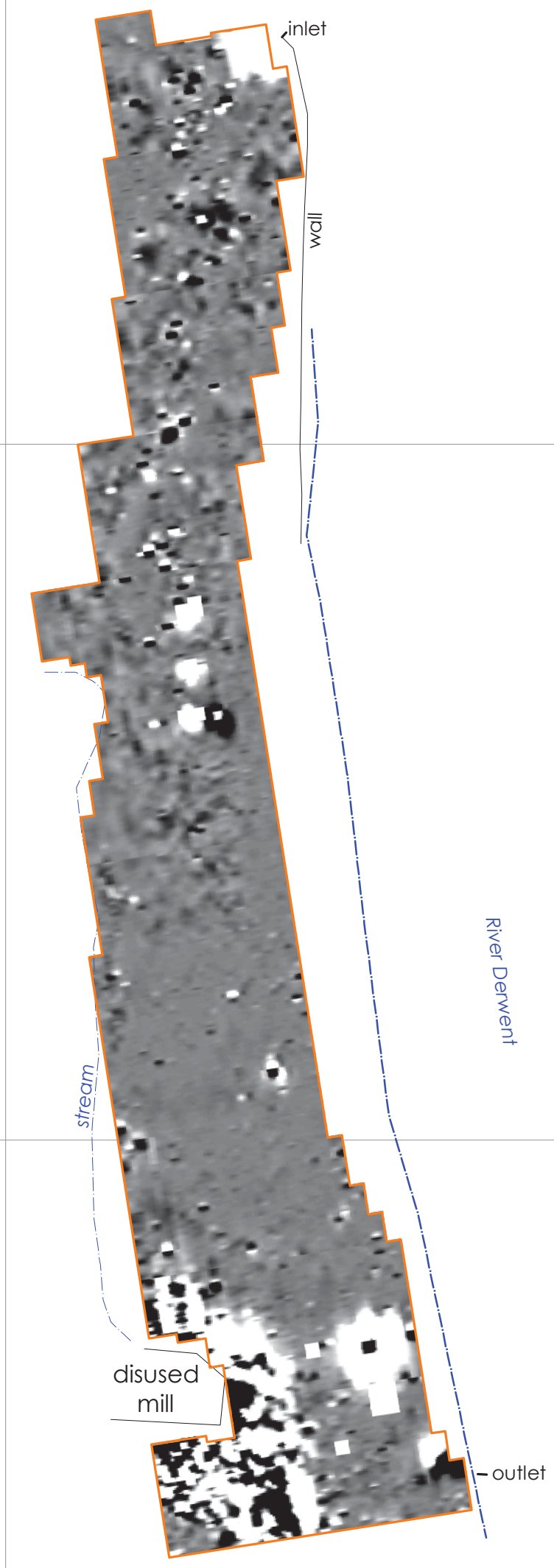
magnetic survey

-5 nT 5

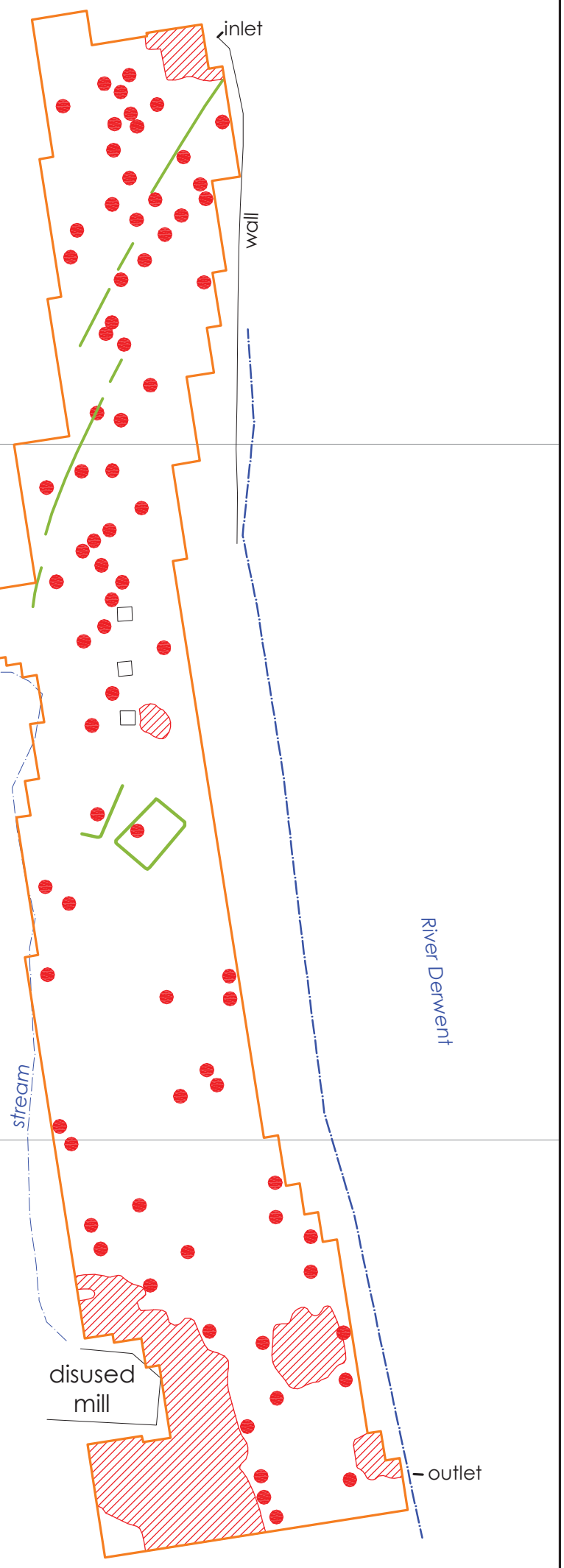
dipolar magnetic anomaly (B)

positive magnetic anomaly (B)

A



B



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0 40m
scale 1:800 for A3 plot

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Chatsworth Park
Derbyshire

geophysical survey
report 3275

Figure 2: Geomagnetic survey and geophysical interpretation

resistance survey

magnetic survey

20 ohm 50

high resistance anomaly (B)

low resistance anomaly (B)

A

B

inlet

wall

River Derwent

stream

disused mill

outlet

689

688

259

0 40m

scale 1:800 for A3 plot

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Paine's Mill
Chatsworth Park
Derbyshire

geophysical survey
report 3275

Figure 3: Resistance survey and geophysical interpretation

magnetic survey

resistance survey

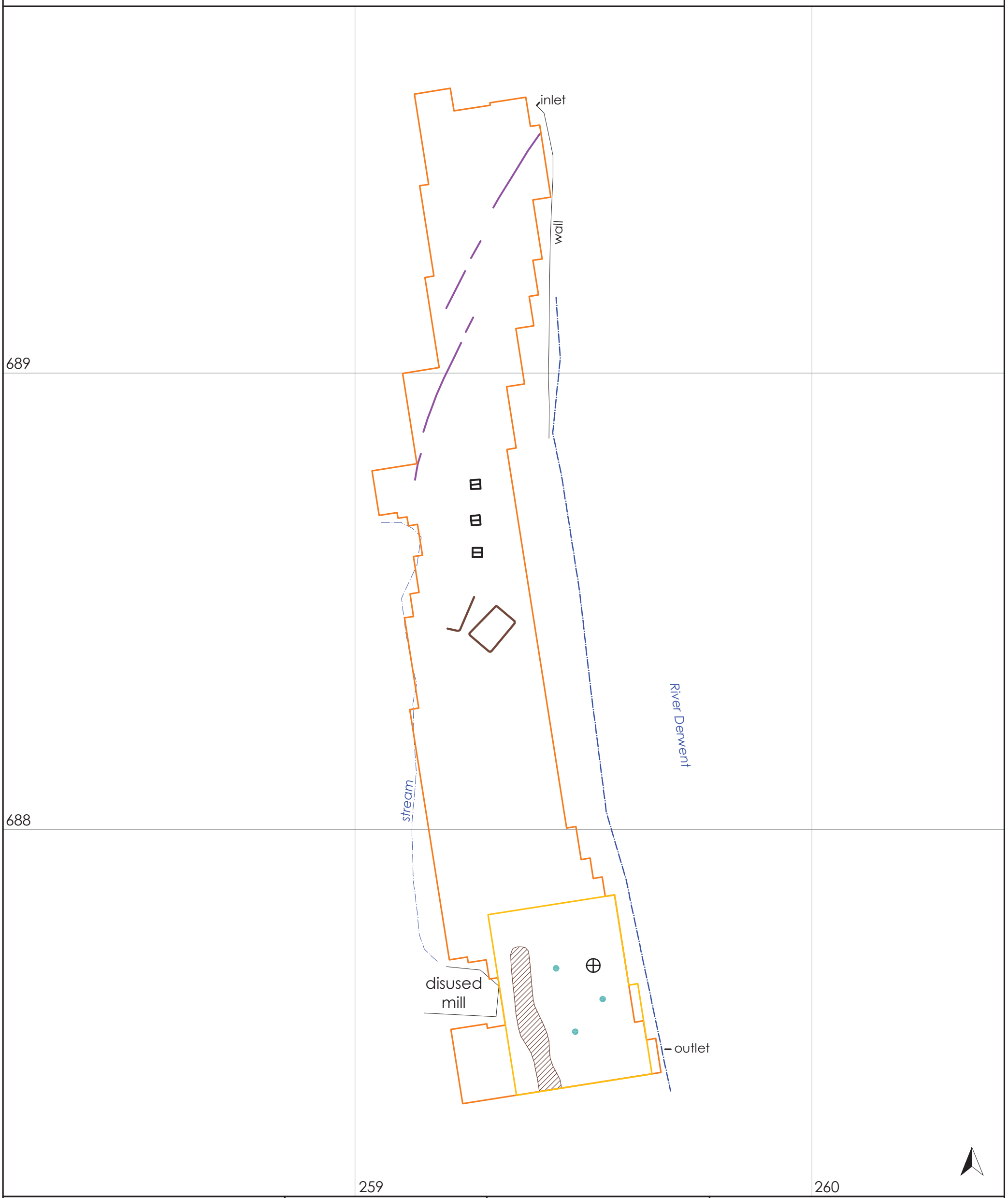
possible soil-filled ditch / trench

tree

possible mill leat

inspection cover

bench



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0 40m
scale 1:800 for A3 plot

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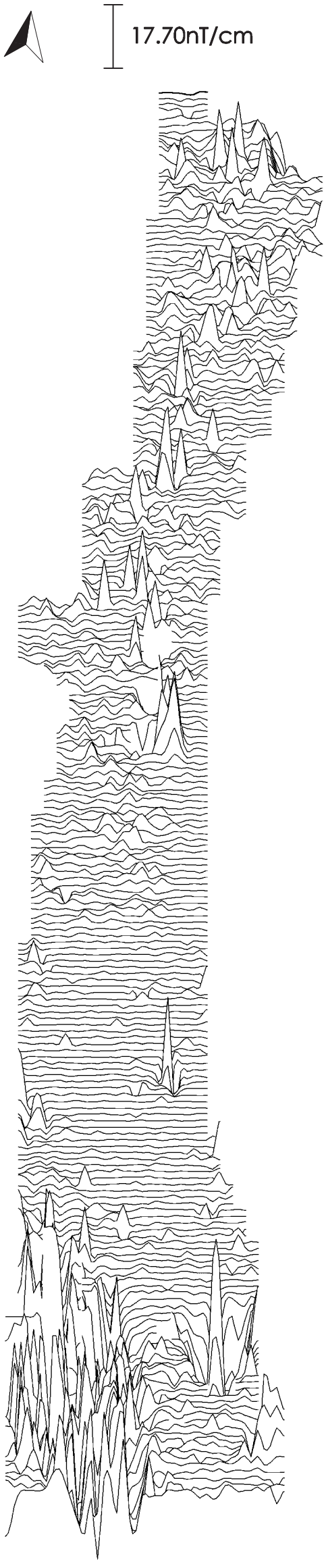
Chatsworth Park
Derbyshire

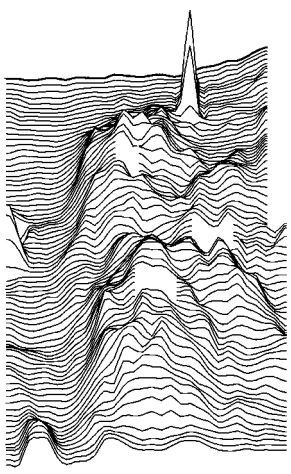
geophysical survey
report 3275

Figure 4: Archaeological interpretation

Geomagnetic survey



Resistance survey



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0 40m
scale 1:800 for A3 plot

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Chatsworth Park
Derbyshire

geophysical survey
report 3275

Figure 5: Trace plots of geomagnetic and resistance data