Historic England

Geophysics

Silchester Environs Project, Silchester Farm, Silchester, Hampshire

Neil Linford, Paul Linford and Andrew Payne

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SILCHESTER ENVIRONS PROJECT, SILCHESTER FARM, SILCHESTER, HAMPSHIRE

REPORT ON GEOPHYSICAL SURVEY, JULY 2015

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SUMMARY

Caesium magnetometer and Ground Penetrating Radar (GPR) surveys were conducted as part of the University of Reading Silchester Environs Project over a series of paddocks containing crop mark evidence for a prehistoric enclosure together with medieval or post medieval cultivation, at Silchester Farm, Silchester, Hampshire. The vehicle towed caesium magnetometer survey (2.0 ha) revealed half the circuit of a sub-rectangular enclosure containing large (~2m diameter) pit-type anomalies suggesting internal activity, and weaker linear ditches extending further to the south. A more fragmented magnetic response was encountered in the paddock to the east with some suggestion of rectilinear structures. The GPR survey (1.6 ha) targeted the medieval or post medieval cultivation ridges found in the aerial photography, which are replicated as high amplitude linear anomalies together with a wider pattern of field drainage. Some subtle ditch-type anomalies to the north, may, perhaps, represent a continuation of the activity associated with the Iron Age enclosure covered by the magnetic survey. There is also evidence for a possible quarry pit or pond, and three discrete high amplitude responses which might represent post pads for a former structure.

CONTRIBUTORS
The geophysical fieldwork was conducted by Neil Linford, Paul Linford and Andrew Payne.

ACKNOWLEDGEMENTS
The authors are grateful to the landowner for allowing access for the surveys to be conducted.

ARCHIVE LOCATION
Fort Cumberland, Portsmouth.

DATE OF SURVEY
The fieldwork was conducted between 22nd and 23rd July 2015 and the report completed on 16th May 2019. The cover image shows the vehicle towed caesium magnetometer in the field during the survey.

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INTRODUCTION

Caesium magnetometer and Ground Penetrating Radar (GPR) surveys were conducted over a series of paddocks at Silchester Farm, Silchester, Hampshire, as part of the Historic England contribution to the Silchester Environs Survey (RASMIS 7226), undertaken in partnership with the University of Reading (Barnett and Fulford 2015). This project aims to investigate the origins and early development of the Iron Age and Roman town at Calleva Atrebatum (Silchester, Hampshire), through a study of prehistoric settlement, activity and agriculture in the hinterland of the Iron Age *Calleva* to address the local context for the emergence of the *oppidum*.

The geophysical survey component of the project aims to test the magnetic and GPR response over the varying gravel, clay and chalk geologies of the Silchester area, using a vehicle towed high sensitivity caesium vapour magnetometer array together with a high sample density multichannel GPR system. It is hoped that this will complement the extensive fluxgate magnetometer and GPR coverage conducted by the University of Reading, particularly where the geophysical response has proved indistinct (Creighton and Fry 2016). Trial sites for ground based survey have been identified from aerial photography and lidar coverage within the project area (Figure 1), including the plough truncated remains of long, linear earthwork banks crossing the landscape where these survive in areas of woodland and may extend into the surrounding farmland (Linford 2015).

The paddocks at Silchester Farm contain crop mark evidence for a prehistoric enclosure, together with evidence for medieval or post medieval cultivation visible as earthworks on aerial photographs of the 1940s (AMIE Monument HOB UID 1599868). Further evidence, for what is almost certainly the same prehistoric enclosure, was discovered to the north west of the paddocks on the other side of Little London Road during an excavation prior to housing development which concluded the excavated ditches were associated with activity in the Late Iron Age to early Roman period (Taylor 2001).

The site is situated on Eocene London Clay deposits, with Lower Bagshot sand found on the higher ground to the north, over which fine loamy soils with slowly permeable subsoils of the 572j Bursledon association have developed (Geological Survey of Great Britain 1974; Soil Survey of England and Wales 1983). Four paddocks were covered with the magnetometer system, but two adjacent larger fields were under crop and could not be accessed. The paddocks were down to grazing for horses subdivided by electric fencing which caused minor interference in the magnetic measurements. GPR coverage was focused on the medieval cultivation evidence in the paddocks to the east. Weather conditions were warm and dry at the time of the survey.

METHOD

Magnetometer survey

Magnetometer data was collected along the instrument swaths shown on Figure 2 using an array of six Geometrics G862 caesium vapour sensors mounted on a non-magnetic sledge (Linford *et al.* 2015). The sledge was towed behind a low-impact All-Terrain Vehicle (ATV) which housed the power supply and data logging electronics. Five sensors were mounted 0.5m apart in a linear array transverse to the direction of travel and, vertically, ~0.36m above the ground surface. The sixth was fixed 1.0m directly above the centre of this array to act as a gradient sensor. The sensors sampled at a rate of 25Hz resulting in an along-line sample density of ~0.15m given typical ATV travel speeds of 3.5-4.0m/s. As the five non-gradient sensors were 0.5m apart, successive survey swaths were separated by approximately 2.5m to maintain a consistent traverse separation of 0.5m. Navigation and positional control were achieved using a Trimble R8 Global Navigation Satellite System (GNSS) receiver mounted on the sensor platform 1.65m in front of the central sensor and a second R8 base station receiver established using the Ordnance Survey VRS Now correction service. Sensor output and survey location were continuously monitored during acquisition to ensure data quality and minimise the risk of gaps in the coverage.

After data collection the corresponding readings from the gradient sensor were subtracted from the measurements made by the other five magnetometers to remove any transient magnetic field effects caused by the towing ATV or other nearby vehicles. The median value of each instrument traverse was then adjusted to zero by subtracting a running median value calculated over a 50m 1D window (see for instance Mauring *et al.* 2002). This operation corrects for biases added to the measurements owing to the diurnal variation of the Earth's magnetic field and any slight directional sensitivity of the sensors. The individual sensor traverses were then combined into a 2D raster grid using minimum curvature gridding. Unfortunately the GNSS antenna mount failed during the survey and the poorly secured antenna wobbled as the sledge moved causing high-frequency periodic noise in the data. This signal was isolated and removed using a 2D Discrete Wavelet Transform (DWT) based on the Symlet wavelet (Gonzalez and Woods 2002, chapter 7): soft denoising with a threshold of 0.5nT was applied to the scale 1 horizontal and vertical detail coefficients then all scale 2 horizontal detail coefficients with magnitude > 0.5nT were set to zero.

A linear greyscale image of the resulting dataset is shown superimposed over the base Ordnance Survey (OS) mapping in Figure 4 and minimally processed versions of the range truncated data (±100nT/m) are shown as a trace plot and a histogram equalised greyscale image in Figures 6 and 7.

Ground Penetrating Radar survey

A 3d-radar MkIV GeoScope Continuous Wave Step-Frequency (CWSF) Ground Penetrating Radar (GPR) system was used to conduct the survey collecting data with a multi-element DXG1820 vehicle towed, ground coupled antenna array (Linford *et al.* 2010). A roving Trimble R8 Global Navigation Satellite System (GNSS) receiver, together with a second R8 base station receiver established using the Ordnance Survey VRS Now correction service, was mounted on the GPR antenna array to provide continuous positional control for the survey collected along the instrument swaths shown on Figure 3. Data were acquired at a 0.075m x 0.075m sample interval across a continuous wave step frequency range from 60MHz to 2.99GHz in 4MHz increments using a dwell time of 2ms. A single antenna element was monitored continuously to ensure data quality during acquisition together with automated processing software to produce real time amplitude time slice representations of the data as each successive instrument swath was recorded in the field (Linford 2013).

Post-acquisition processing involved conversion of the raw data to time-domain profiles (through a time window of 0 to 50ns), adjustment of time-zero to coincide with the true ground surface, background and noise removal, and the application of a suitable gain function to enhance late arrivals. Representative profiles from the GPR survey are shown on Figure 8. To aid visualisation amplitude time slices were created from the entire data set by averaging data within successive 2.4 ns (two-way travel time) windows (e.g. Linford 2004). An average sub-surface velocity of 0.147m/ns was assumed following constant velocity tests on the data, and was used as the velocity field for the time to estimated depth conversion. Each of the resulting time slices, shown as individual greyscale images, therefore represents the variation of reflection strength through successive ~0.18m intervals from the ground surface in Figures 5, 9 and 10. Further details of both the frequency and time domain algorithms developed for processing this data can be found in Sala and Linford (2012).

Due to the size of the resultant data set a semi-automated algorithm has been employed to extract the vector outline of significant anomalies shown on Figure 11. The algorithm uses edge detection to identify bound regions followed by a morphological classification based on the size and shape of the extracted anomalies. For example, the location of possible pits is made by selecting small, sub circular anomalies from the data set.

RESULTS

Magnetometer survey

A graphical summary of significant magnetic anomalies [**m1-13**] discussed in the following text superimposed on base OS map data is provided in Figure 10.

In the northwest corner of the survey a linear ditch [**m1**] describes half the circuit of a sub-rectangular enclosure containing large (~2 m diameter) pit-type anomalies [**m2**] suggesting internal activity. With peak magnitudes in the range 5-11 nT/m the response is surprisingly strong for archaeological anomalies over the underlying London Clay geology. Further evidence for what is almost certainly the same enclosure was discovered on the other side of Little London Road during an excavation prior to housing development which concluded the excavated ditches were associated with activity in the Late Iron Age to early Roman period (Taylor 2001). A number of weaker (~0.5-1 nT/m) linear ditches [**m3**] extend to the southeast, possibly linking the enclosure to a second rectangular enclosure ditch one corner of which [**m4**] is visible to the south of the adjacent paddock.

Further linear ditches [**m5-7**] on varying alignments, suggestive of distinct phases of activity, are present to the east of [**m1**], possibly associated with fragmented anomalies [**m8**] and [**m9**] on an approximate rectilinear plan suggesting structural remains, although these is no evidence for any buildings recorded on the historic mapping. Larger discrete responses, [**m10**] and [**m11**], are intensely magnetised suggesting thermoremanent or ferrous material so a modern origin cannot be discounted. However, [**m10**] is of rectangular form of approximately 4 m x 2.5 m with a peak magnitude ~60 nT/m and may represent a kiln or similar fired structure. An additional larger intense response [**m12**] may also be due to a thermoremanent source, but is located to the south east of [**m8-11**]. Further to the south, in the adjacent paddock, a group of large weakly magnetised pit-type anomalies [**m13**] suggest either geomorphology or perhaps small scale quarrying.

Ground Penetrating Radar survey

A graphical summary of the significant GPR anomalies, [**gpr1-6**] discussed in the following text, superimposed on the base OS map data, is provided in Figure 11.

Significant reflections have been recorded to ~25 ns before the signal becomes more highly attenuated. The near-surface data has responded to the local topography and most prominent drainage channels.

The GPR survey targeted cultivation ridges found in the aerial photography, which are replicated as high amplitude linear responses [**gpr1**] together with a wider network of field drainage [**gpr2**], apparently laid within low amplitude ditches possibly an east-west alignment of the agricultural pattern. One of the apparent field drains partially replicates a section of ditch from the enclosure [**m4**] found to the south and may, potentially, be of greater significance. The higher ground to the north contains some subtle ditch-type anomalies [**gpr3**], perhaps a continuation of the activity associated with the Iron Age enclosure, together with a rectilinear low amplitude response [**gpr4**]. There is also evidence for a rectilinear anomaly [**gpr5**], perhaps some form of quarry pit or pond, and three discrete high amplitude responses [**gpr6**] between 9.6 and 16.8 ns (0.71 to 1.23 m) from the surface with a diameter of approximately 1.5m which might represent post pads for a former structure here.

CONCLUSIONS

The magnetic survey has successfully identified fragmented anomalies throughout the available survey area, suggesting a wider continuation of activity associated with the Iron Age enclosure. Additional evidence for possible thermoremanent anomalies has also been revealed, together with a more tentative suggestion of structural remains and quarrying activity in the paddocks to the east. GPR coverage enhanced the aerial photographic evidence for cultivation ridges and revealed a more extensive pattern of field drainage. There is also evidence for a possible quarry pit or pond, and three discrete high amplitude responses which might represent post pads for a former structure.

LIST OF ENCLOSED FIGURES

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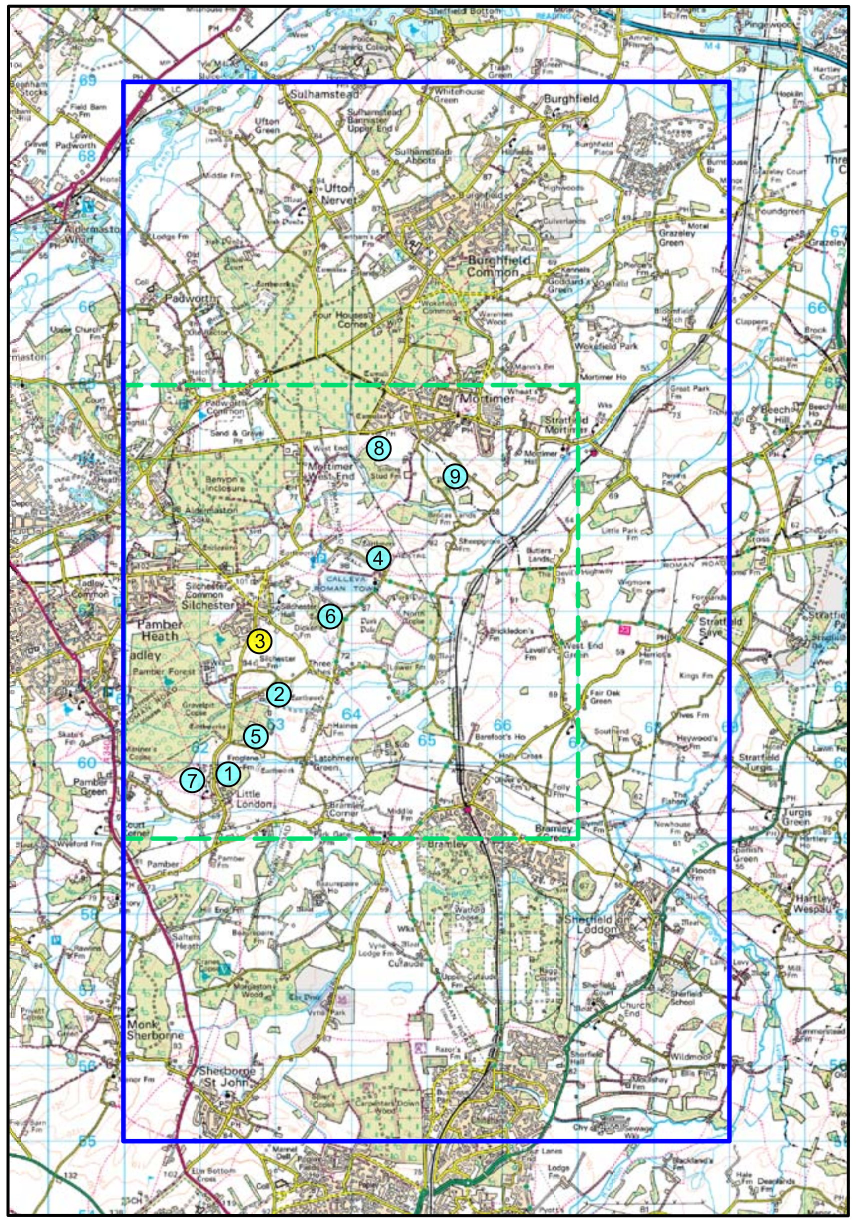
Figure 1

SILCHESTER ENVIRONS PROJECT, SILCHESTER FARM, SILCHESTER, HAMPSHIRE

Location of survey

(A)



Core project area

Detailed OS mapping area (B)

0 3km

1:100000

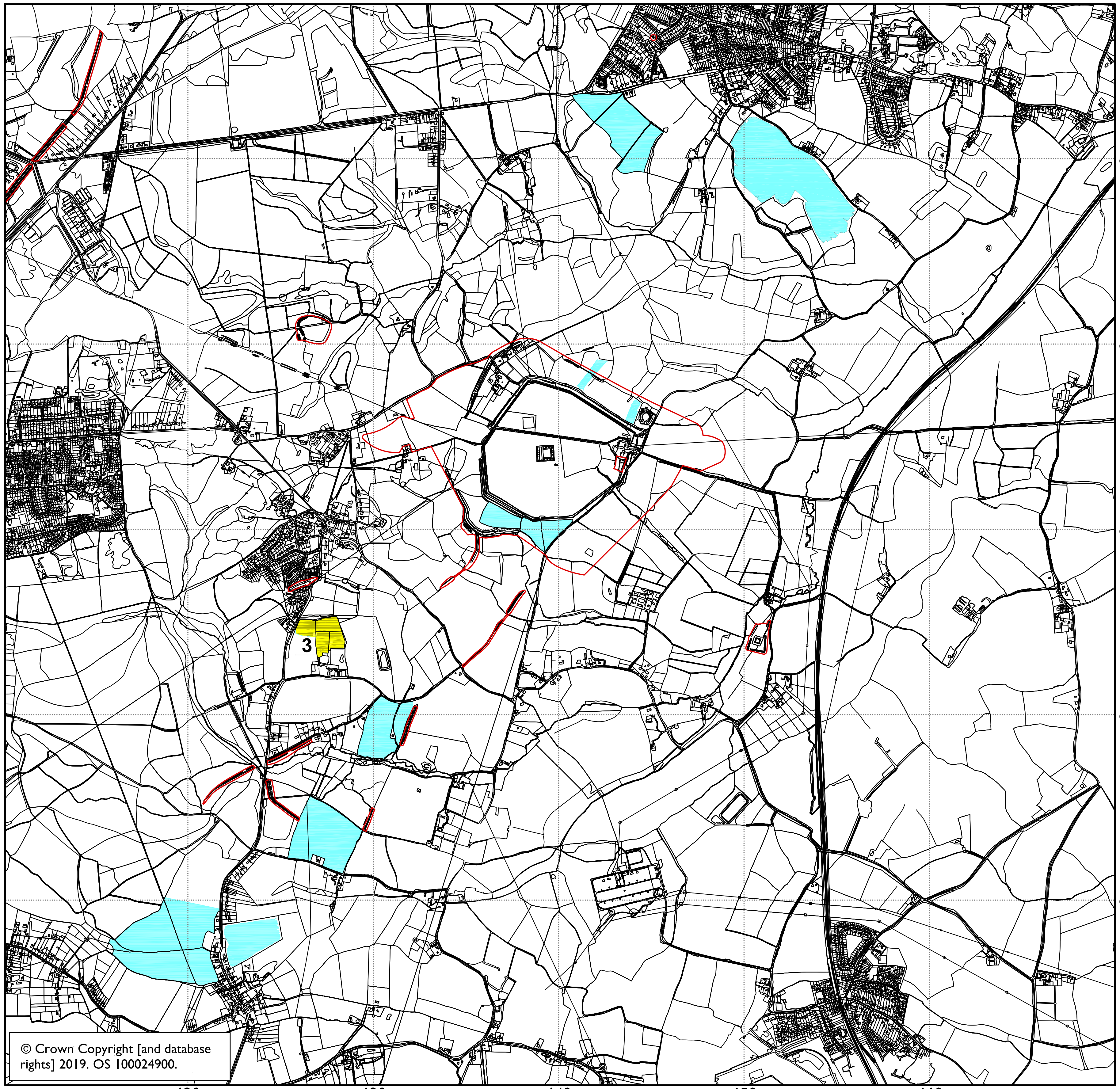
HE geophysical survey locations:

1. Little London Roman tilery
2. Woods Farm Dyke
3. Silchester Farm
4. Chitty Farm
5. Bridle's Copse
6. Rampier Copse
7. King's Hogsty Copse
8. Simms's Copse
9. Windabout Copse

(B)

SU6159

N



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0 1500m

1:25000

3 Silchester Farm survey area

Other HE geophysical survey areas

Scheduled areas

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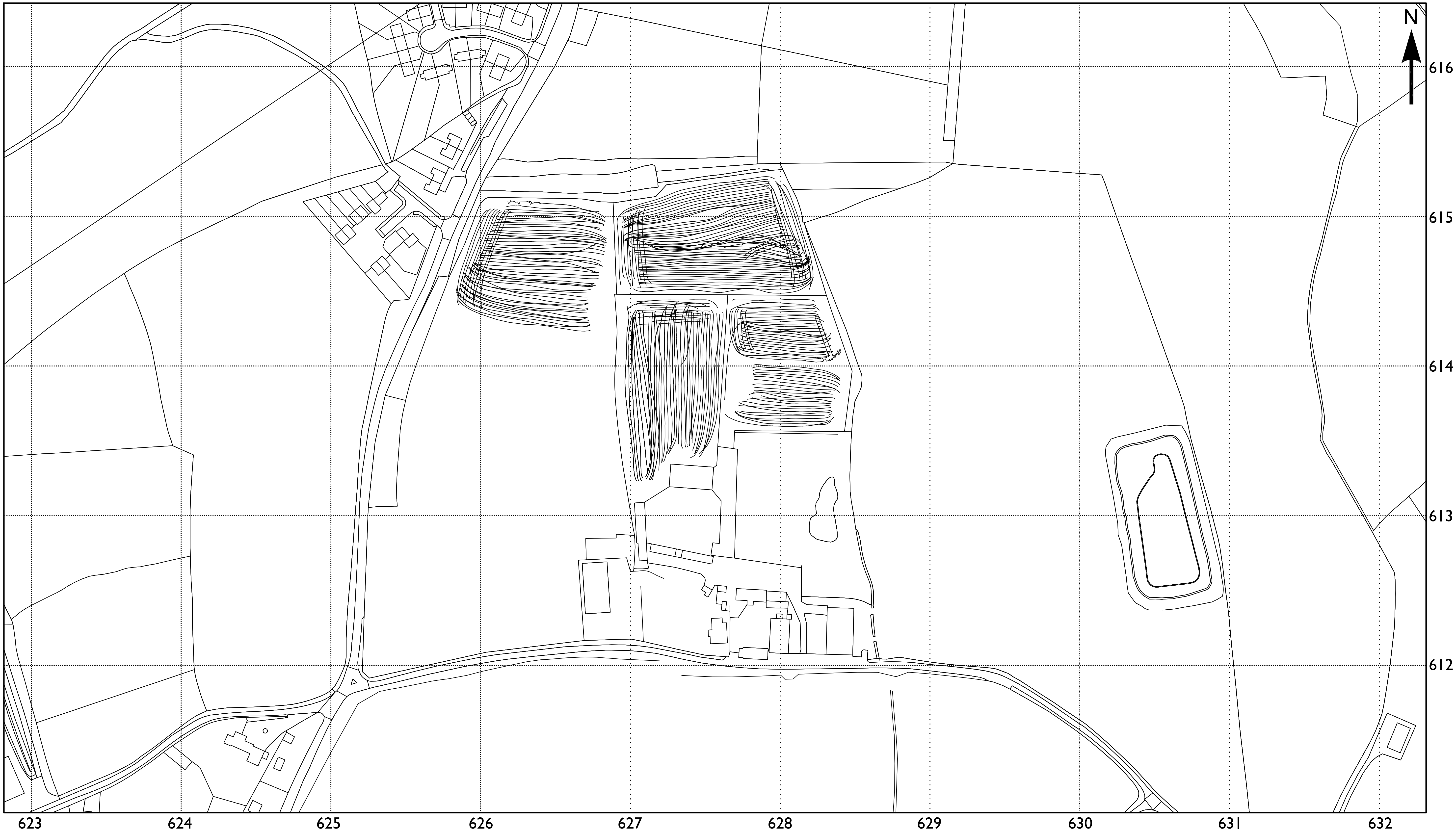
Figure 2

SILCHESTER FARM, SILCHESTER, HAMPSHIRE

Location of caesium magnetometer instrument swaths, July 2015

SU6261



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0 90m

1:2500

Caesium Magnetometer survey swaths

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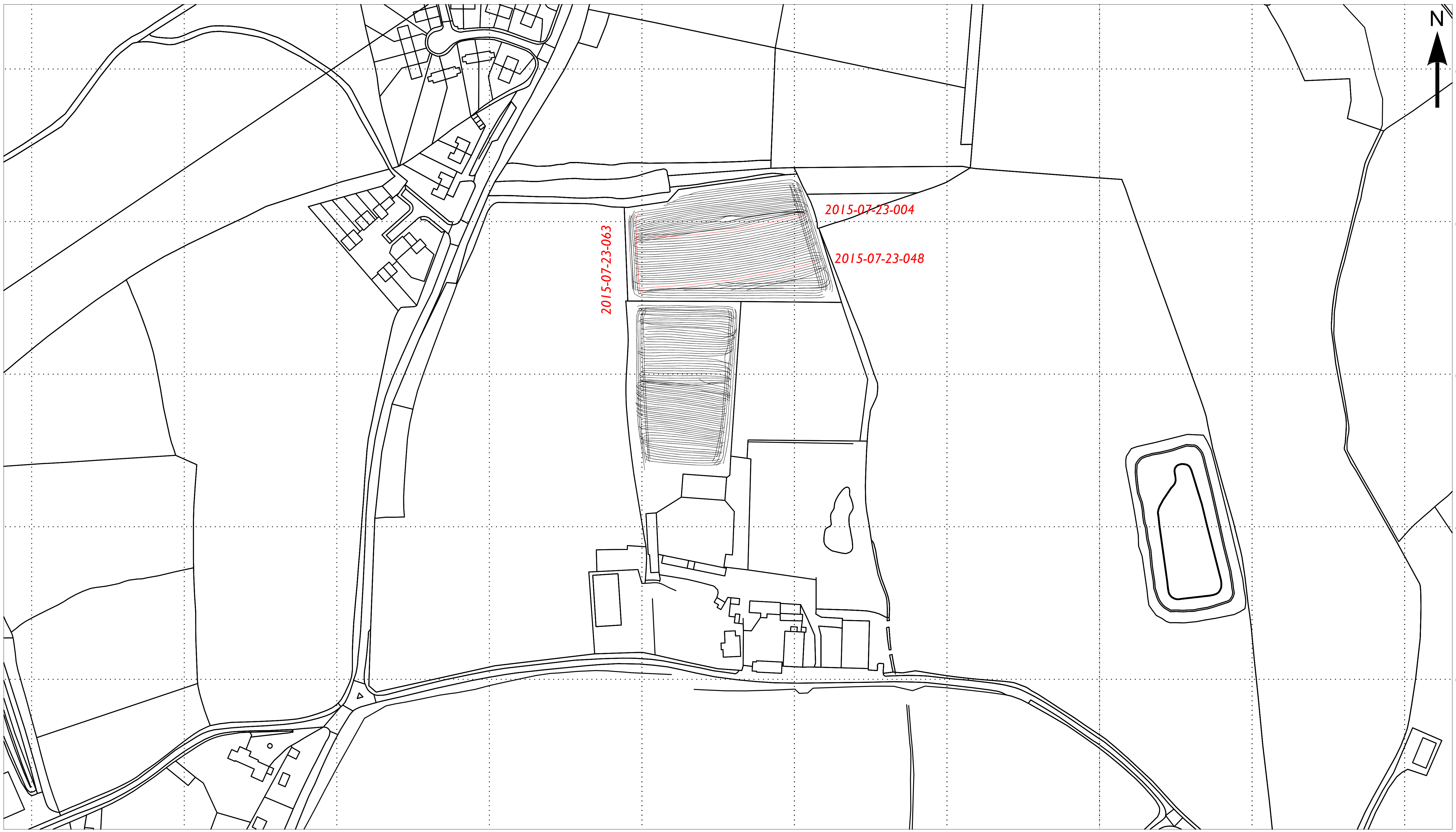
Figure 3

SILCHESTER FARM, SILCHESTER, HAMPSHIRE
Location of GPR instrument swaths, July 2015



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0 90m
1:2500

2015-07-23-004 Location of selected GPR profiles shown on Figure 8

Ground Penetrating Radar survey swaths

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Figure 4

SILCHESTER FARM, SILCHESTER, HAMPSHIRE
Location of caesium magnetometer survey, July 2015

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Figure 5

SILCHESTER FARM, SILCHESTER, HAMPSHIRE
GPR amplitude time slice between 12.1 and 14.6ns (0.69 to 0.82m), July 2015

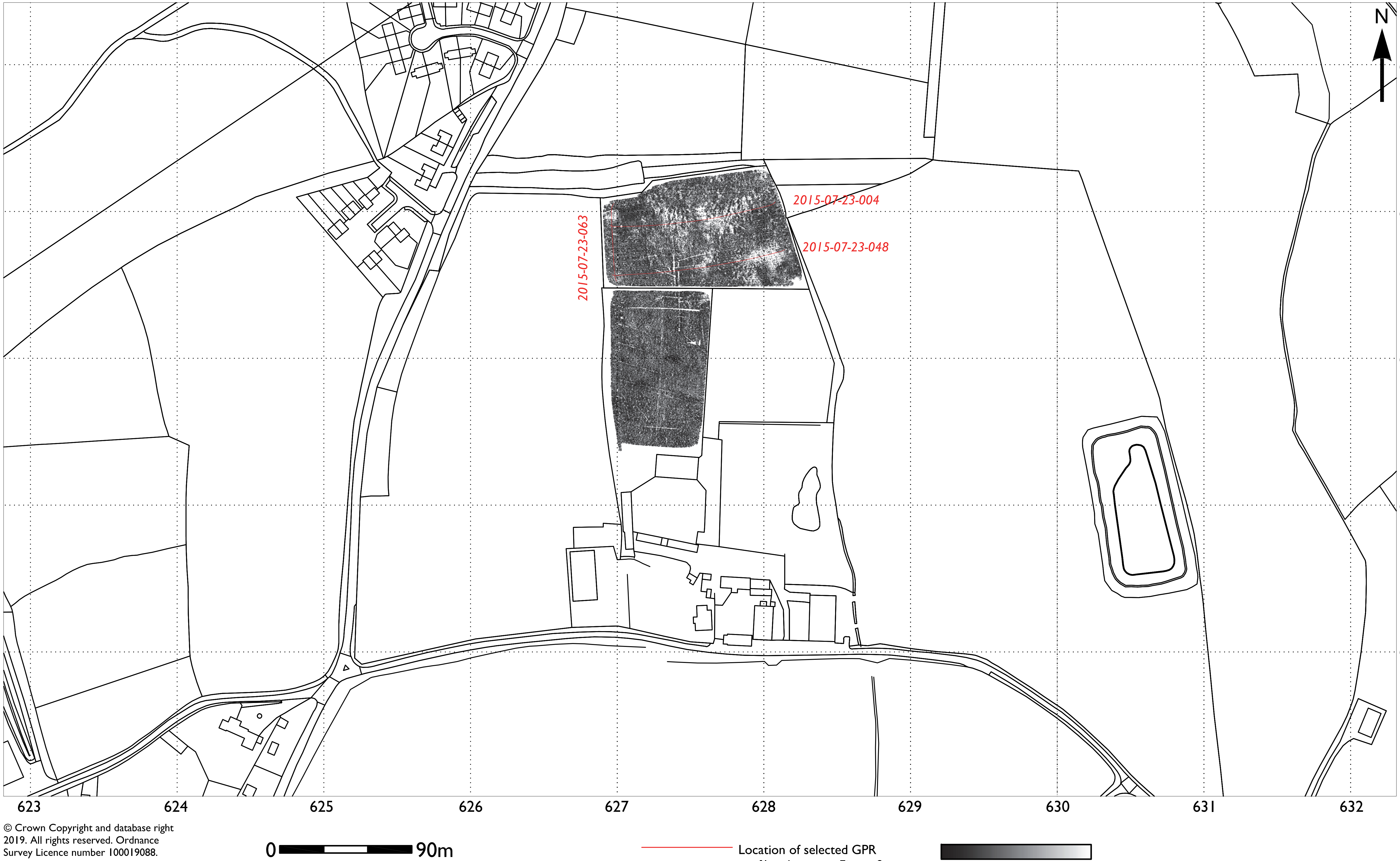

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Figure 6

SILCHESTER ENVIRONS PROJECT, SILCHESTER FARM, SILCHESTER, HAMPSHIRE

Trace plot of minimally processed caesium magnetometer data, July 2015

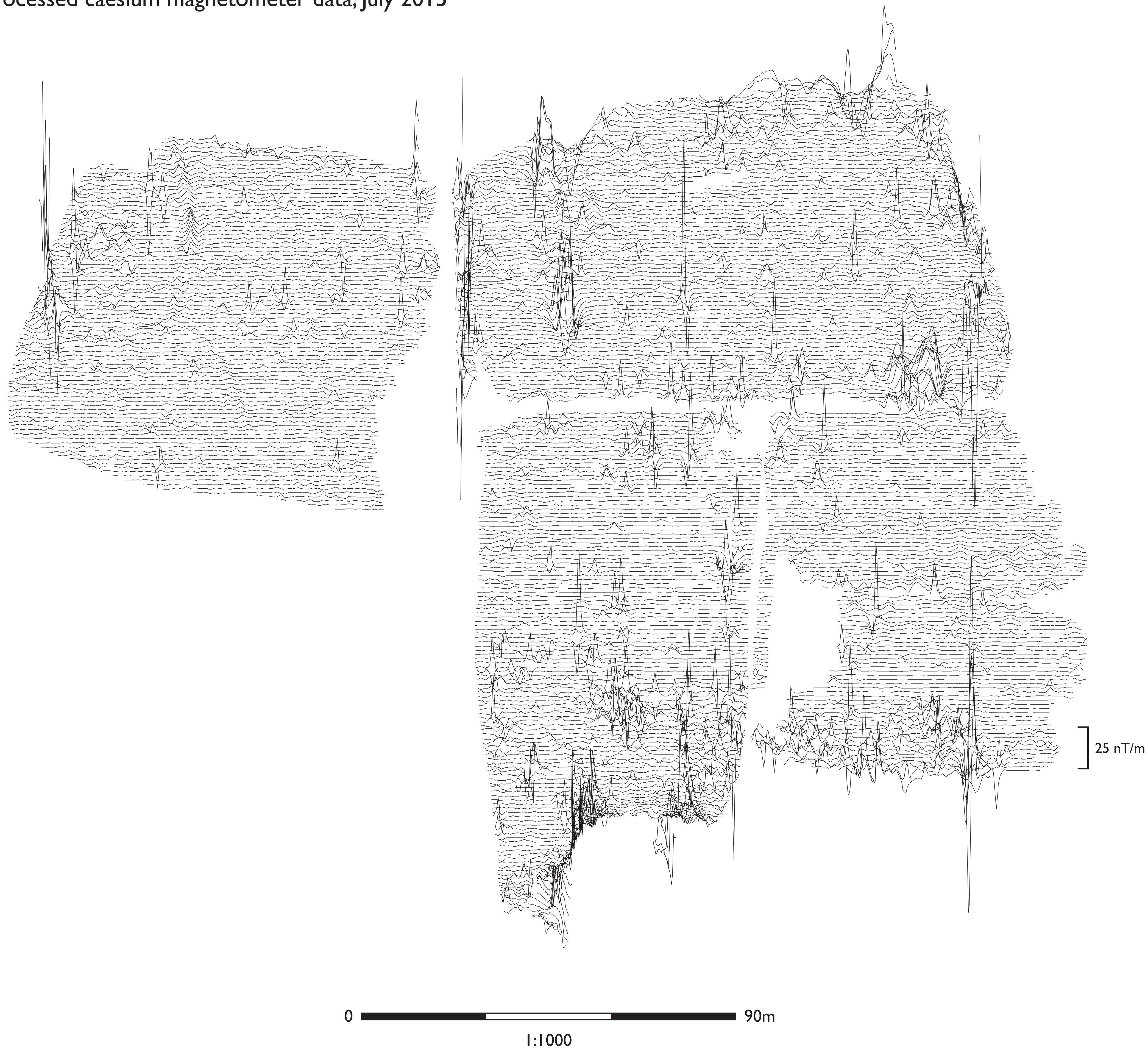

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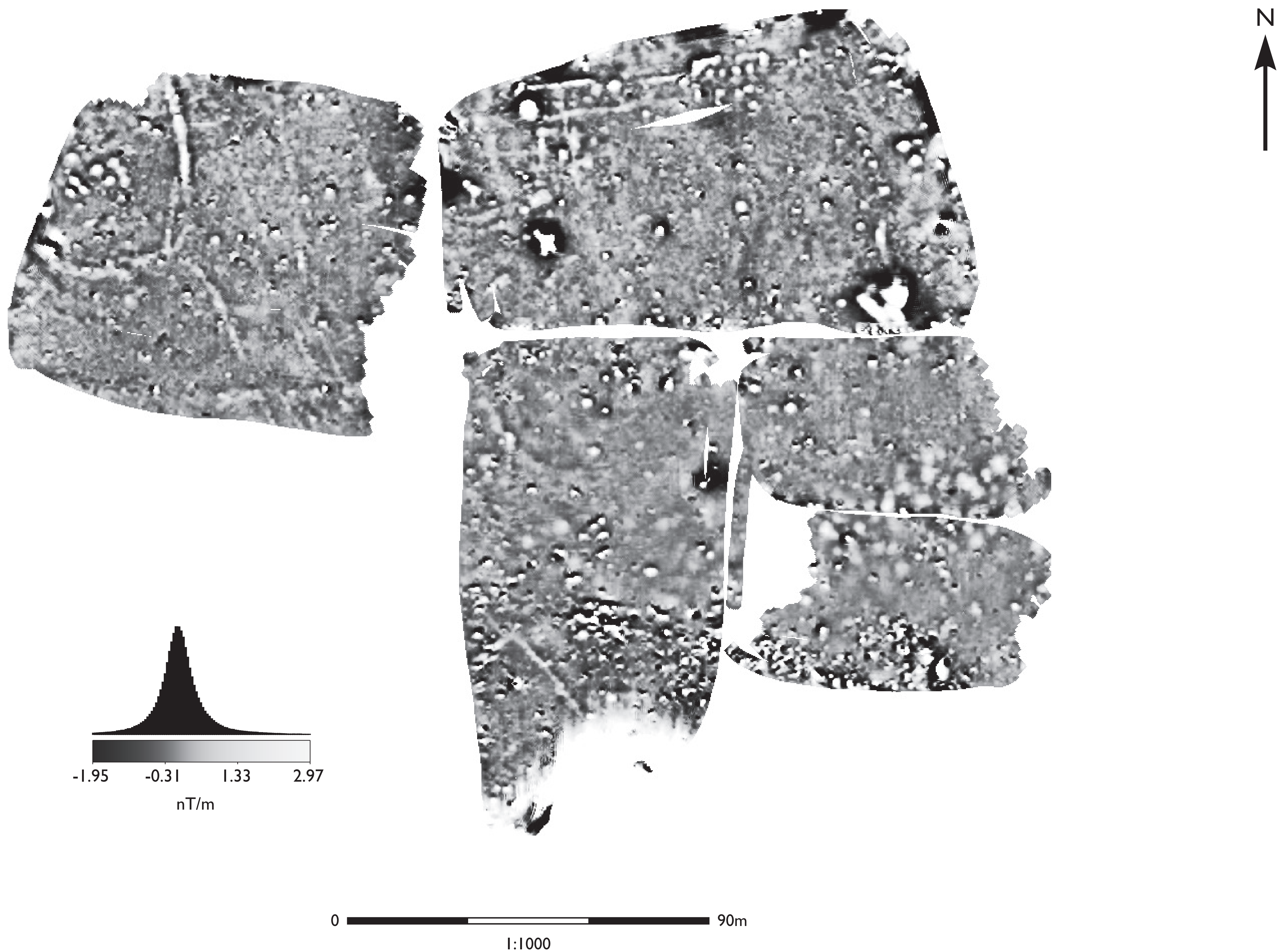
Figure 7

SILCHESTER ENVIRONS PROJECT, SILCHESTER FARM, SILCHESTER, HAMPSHIRE
Histogram normalised image of minimally processed caesium magnetometer data, July 2015



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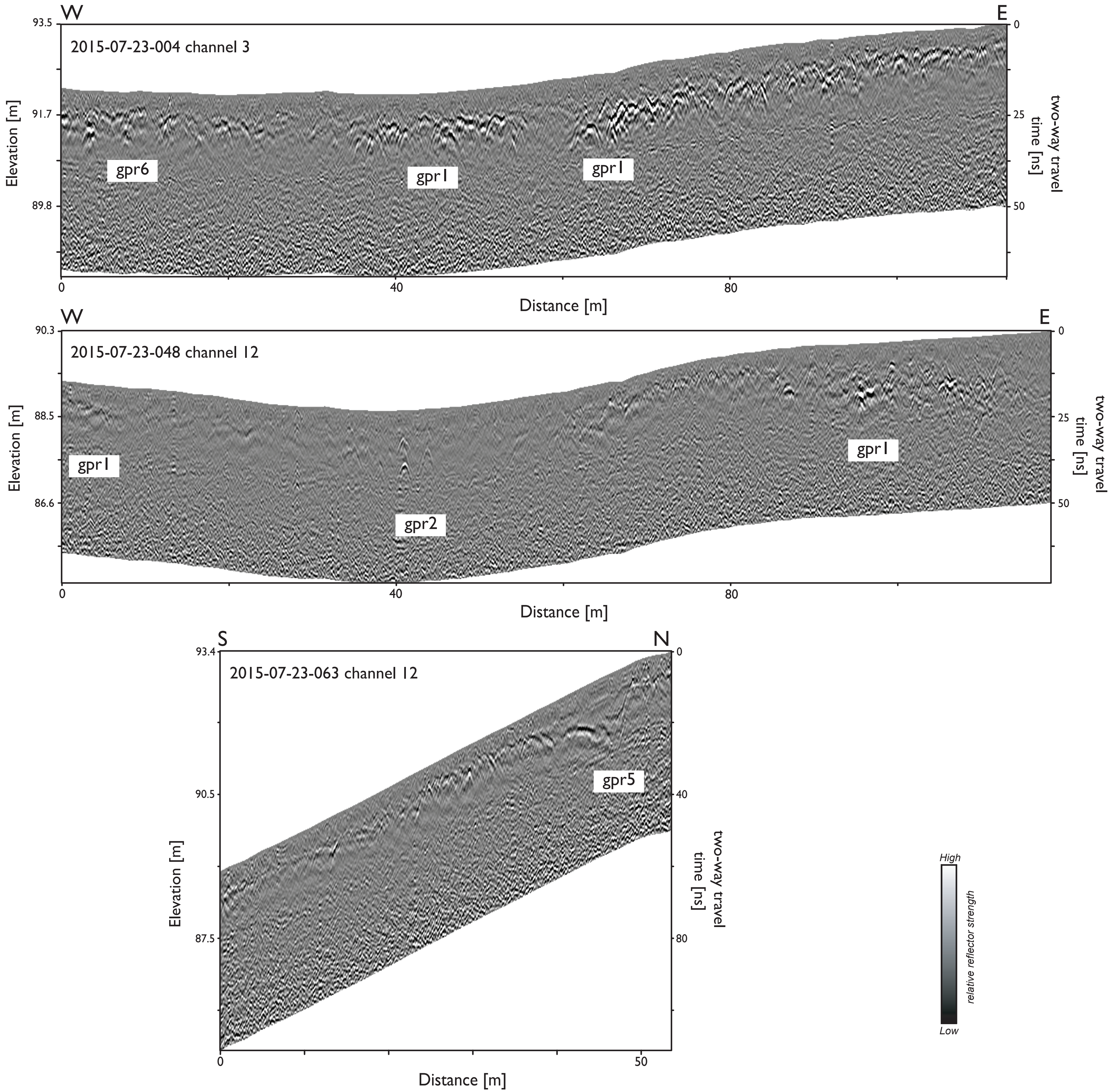
SILCHESTER ENVIRONS PROJECT, SILCHESTER FARM, SILCHESTER, HAMPSHIRE

Figure 8

Topographically corrected GPR profiles, July 2015



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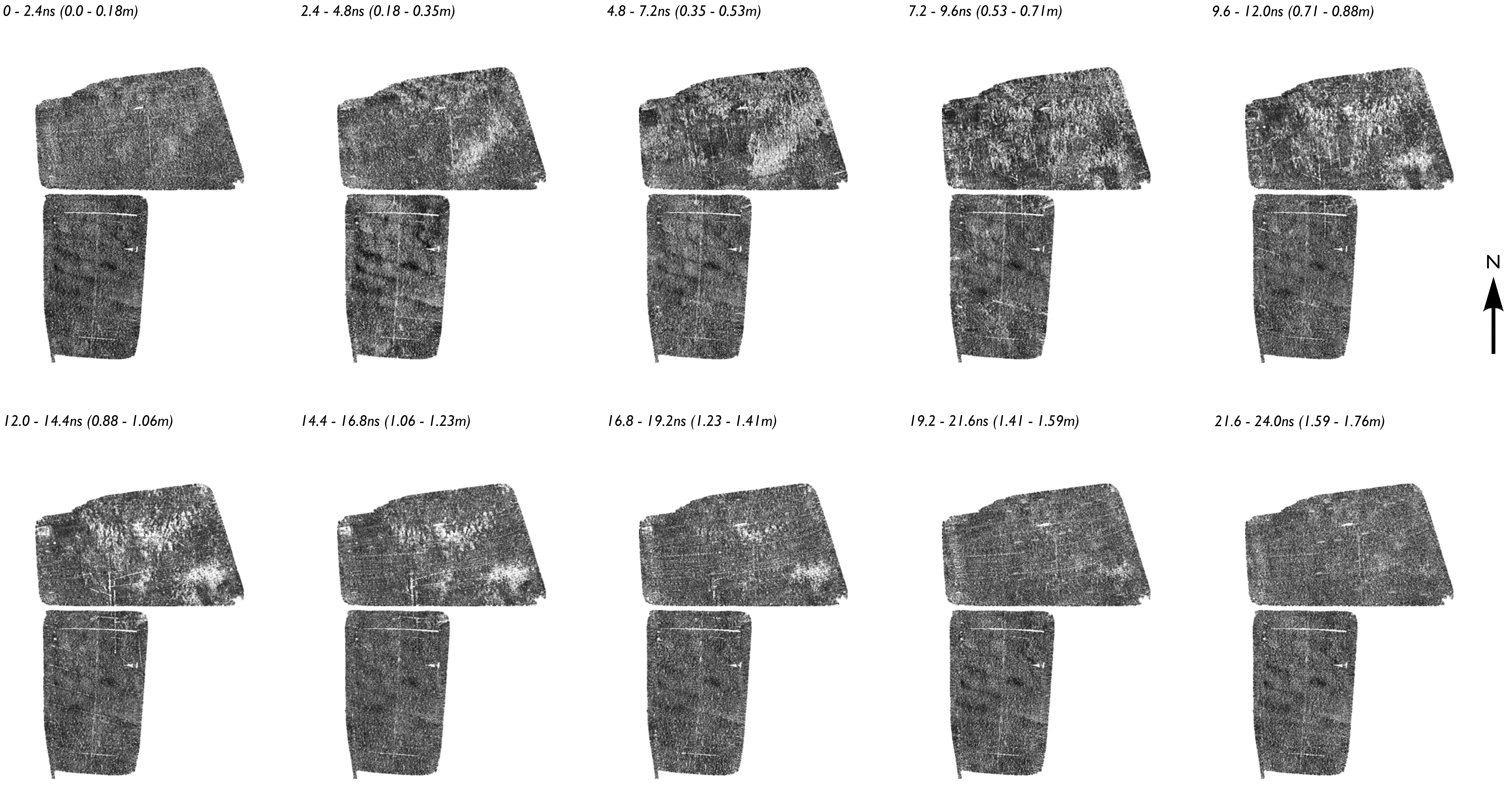
SILCHESTER ENVIRONS PROJECT, SILCHESTER FARM, SILCHESTER, HAMPSHIRE

Figure 9

GPR amplitude time slices between 0.0 and 24.0ns (0.0 - 1.76m), July 2015



Low *High*
relative reflector strength

0 90m
1:2500

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Figure 10

SILCHESTER FARM, SILCHESTER, HAMPSHIRE
Graphical summary of significant magnetic anomalies, July 2015

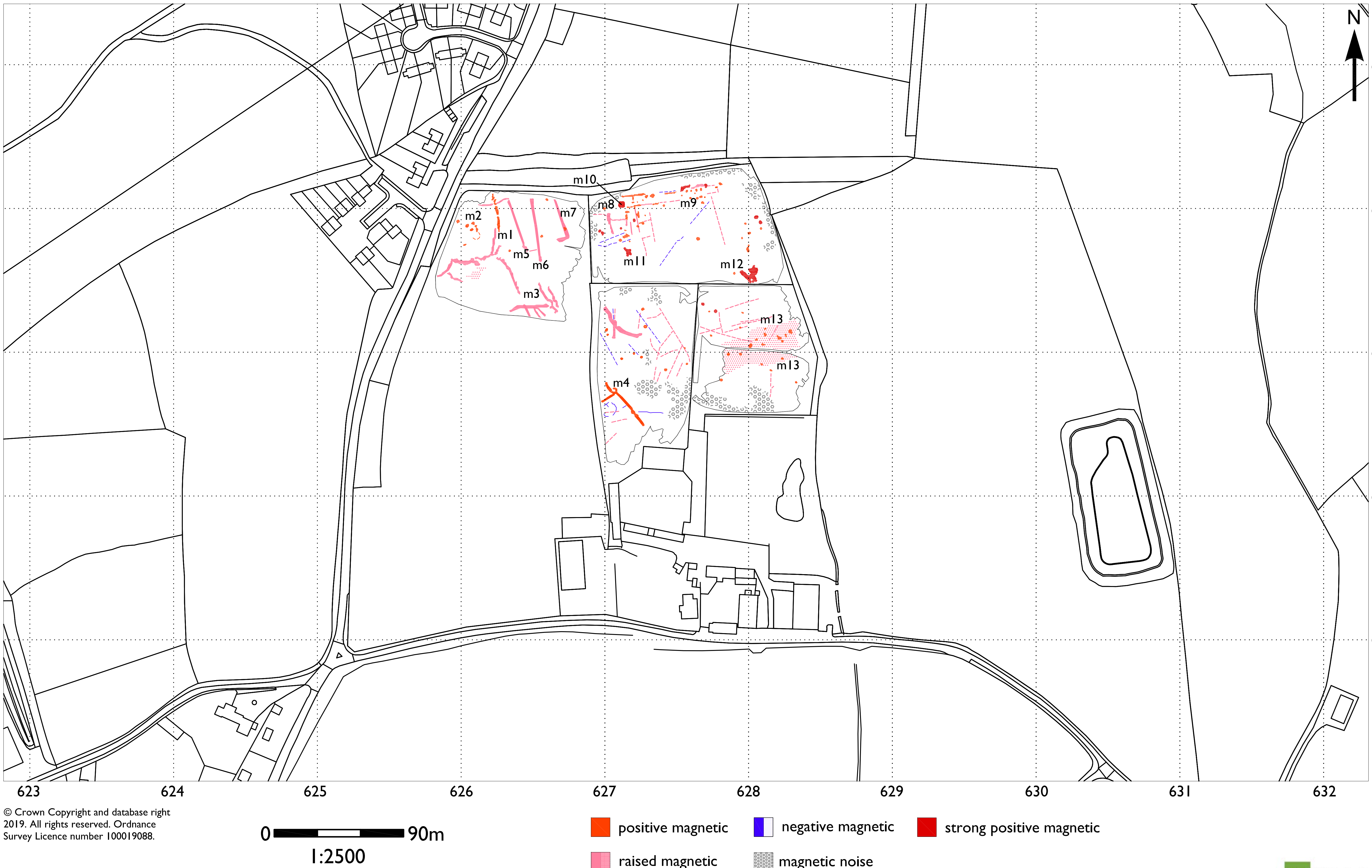

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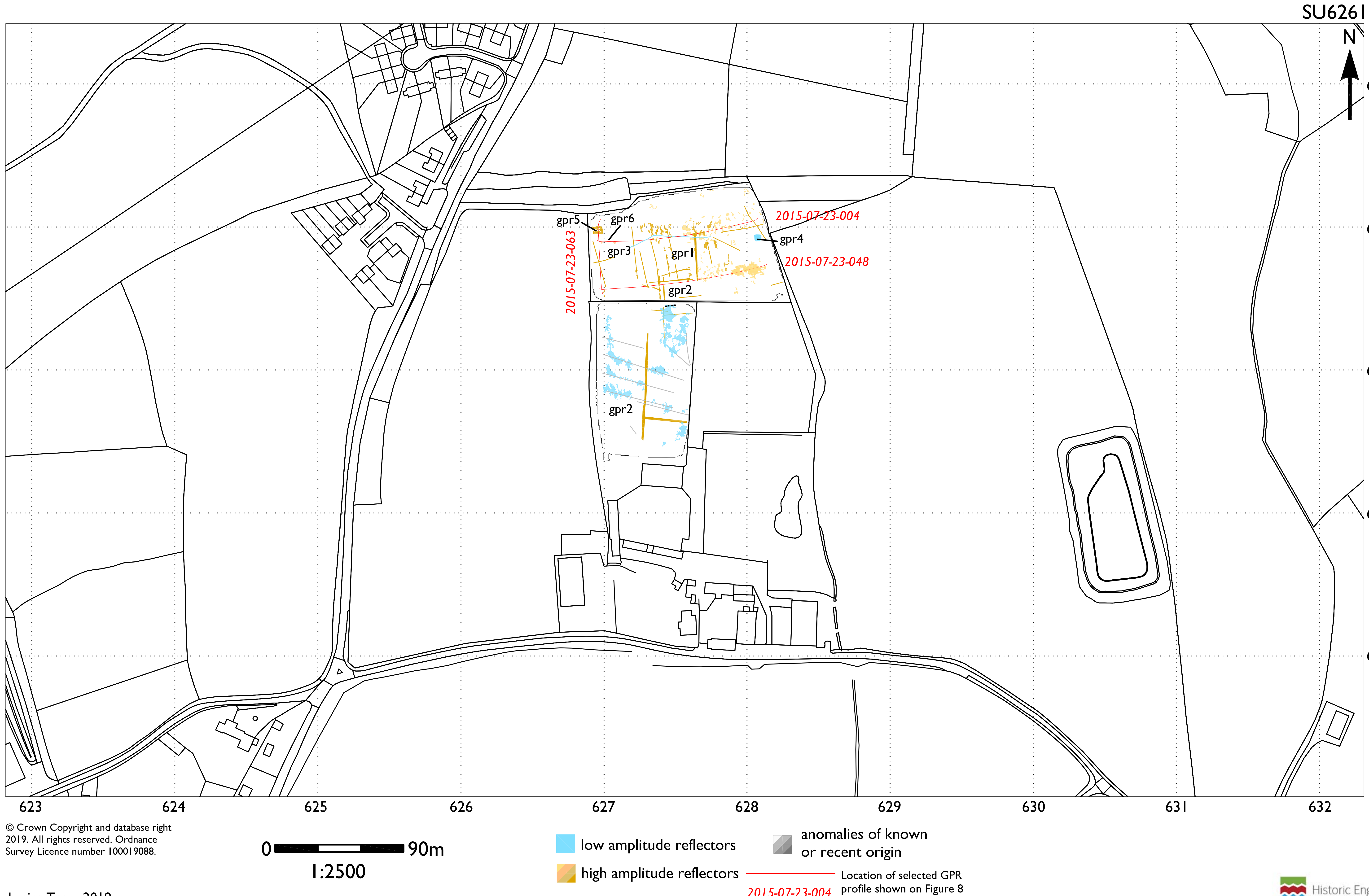
Figure 11

SILCHESTER FARM, SILCHESTER, HAMPSHIRE
Graphical summary of significant GPR anomalies, July 2015



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