The London Resort Development Consent Order

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Environmental Statement
Volume 2: Appendices

Appendix 14.6 – Detailed Gradiometer Survey, 2017

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Planning Act 2008
The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009
Regulation 5(2)(a)
The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017
Regulation 12(1)

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The London Resort Company Holdings Limited

The London Resort

Environmental Statement

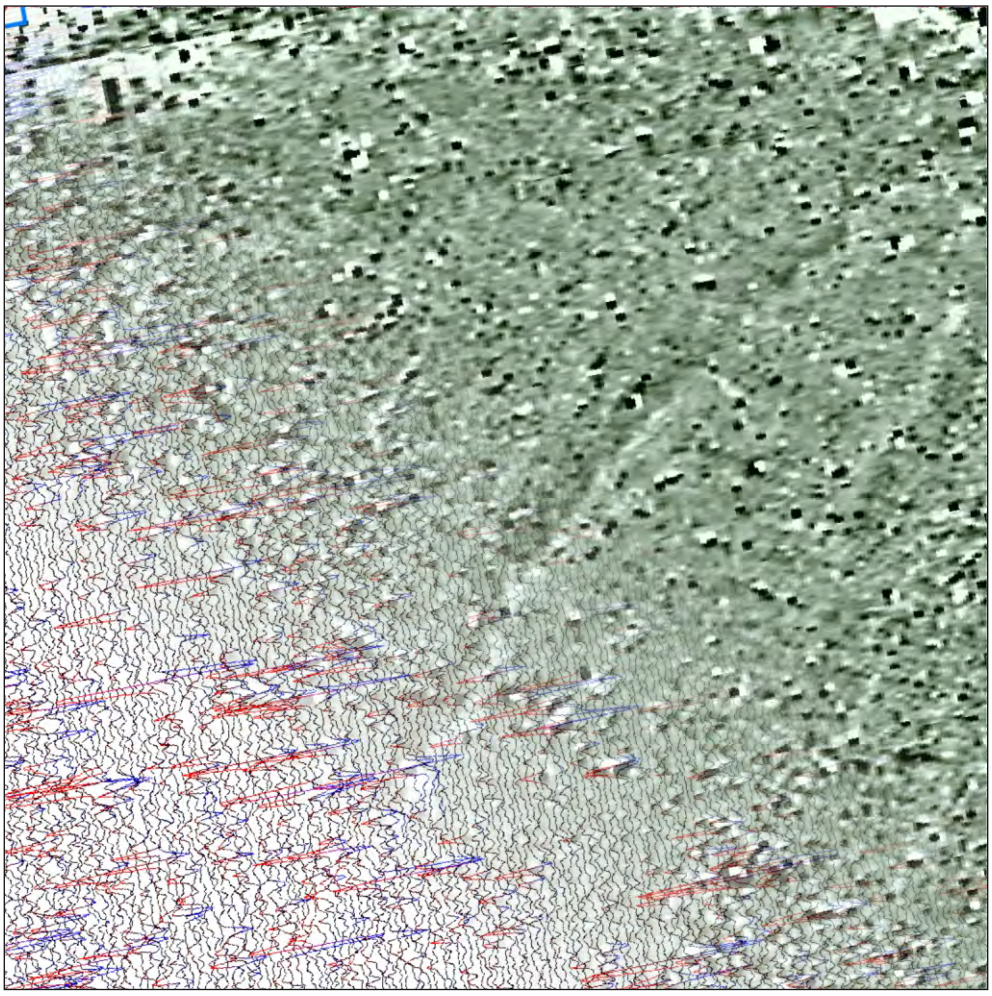
Document Reference 6.2.14.6

Appendix 14.6
London Resort
Detailed Gradiometer Survey

wessexarchaeology

London Resort, Swanscombe, Kent

Detailed Gradiometer Survey Report



Ref: 106573.02
September 2016

wessexarchaeology

London Resort, Swanscombe, Kent

Detailed Gradiometer Survey Report

Prepared for:
London Resort Company Holdings

Prepared by:
Wessex Archaeology
Portway House
Old Sarum Park
SALISBURY
Wiltshire
SP4 6EB

www.wessexarch.co.uk

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File:	R:\PROJECTS\106573_Reports\106573_ParamountGE_GJD.docx				
	E	*GJD*	*PAB*		31/07/15
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File:					
File:					
File:					

* I= Internal Draft; E= External Draft; F= Final

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Detailed Gradiometer Survey Report

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Summary

A detailed gradiometer survey was conducted over land south of Watling Street (A2), Swanscombe, Kent (centred on NGR 561400, 172500). The project was commissioned by Savills on behalf of the London Resort Company Holdings Limited, with the aim of establishing the presence, or otherwise, and nature of detectable archaeological features in support of the development of the London Resort.

The site comprises arable fields located to the south of Watling Street (A2), covering an area of 6ha. The geophysical survey was undertaken on 22nd to 26th June 2015.

The anomalies identified by the detailed gradiometer survey as being of archaeological interest are primarily pit- and ditch-like features. Features identified are primarily linear ditch features with clusters of pits also evident throughout the survey area. In addition to these, anomalies interpreted as ploughing trends, areas of increased magnetic response and trends of unknown origin have also been identified.

The most substantial features identified are two large linear features that run through the middle of the dataset and have been interpreted as possible ditches flanking a trackway. The other area of substantial archaeology is on the eastern boundary where a complex of linear features may represent a form of enclosure or building. An area of increased magnetic has also been identified which may represent an area of former burning or debris and indicate an area of occupation.

London Resort, Swanscombe, Kent

Detailed Gradiometer Survey Report

Acknowledgements

This project was commissioned by Savills on behalf of London Resort Company Holdings Limited and Wessex Archaeology is grateful to them and in this regard.

The fieldwork was undertaken by Chris Hirst and Michael Keech. Genevieve Shaw processed and interpreted the geophysical data and Garreth Davey wrote the report. The geophysical work was quality controlled by Paul Baggaley. Illustrations were prepared by Garreth Davey. The project was managed on behalf of Wessex Archaeology by Mark Williams.

London Resort, Swanscombe, Kent

Detailed Gradiometer Survey Report

1 INTRODUCTION

1.1 Project background

1.1.1 Wessex Archaeology (WA) was commissioned by Savills on behalf of London Resort Company Holdings Limited to carry out a geophysical survey at land south of Watling Street (A2), Swanscombe, Kent (hereafter "the Site", centred on NGR 561400, 172500) (**Figure 1**). The survey forms part of an ongoing programme of archaeological works being undertaken in support of the development of the London Resort.

1.1.2 The aim of the geophysical survey was to establish the presence/absence, extent and character of detectable archaeological remains within the survey area.

1.1.3 This report presents a brief description of the methodology followed, the detailed survey results and the archaeological interpretation of the geophysical data.

1.2 Site location and topography

1.2.1 The Site is located 2.1km southeast of the town of Swanscombe and 7.5km southeast of Dartford, in the Dartford Borough of Kent.

1.2.2 The Site occupies an area of 6ha of agricultural land, currently utilised for silage. The Site is bounded by Watling Street (A2) to the north, Park Corner Road to the west, further agricultural land to the south and industrial units to the east.

1.2.3 The Site is on an east facing incline, sloping from 10m aOD at the north-eastern edge to approximately 33m aOD at the south-western edge.

1.3 Soils and geology

1.3.1 The solid geology comprises Sand, Silt and Clay of the Thanet Sand formation with recorded areas of Chalk from the White Chalk subgroup recorded to the northeast of the survey area. There are no recorded overlying superficial geological (BGS 2015).

1.3.2 The soils underlying the Site are likely to consist of Typical argillic brown earths of the 571g (Fyfield 4) association (SSEW SE Sheet 6 1983). Soils derived from such geological parent material have been shown to produce magnetic contrasts acceptable for the detection of archaeological remains through magnetometer survey.

1.4 Archaeological background

1.4.1 A comprehensive Archaeological Desk-Based Assessment (DBA) undertaken by Wessex Archaeology (2015) examined the potential for the survival of buried archaeological remains within the development area and a 1km Study Area. This DBA used information provided by the Kent Historic Environment Record (KHER), Essex Historic Environment Record (EHER) and the National Heritage List for England (NHLE). The following background is summarised from the DBA.

1.4.2 The Site itself is covers two Scheduled Ancient Monuments (SAMs), with another recorded in the Survey Area. There are no World Heritage Sites, Registered Parks and Gardens, Conservation Areas or Historic Battlefields identified within the Study Area and one Grade II listed building is also recorded.

1.4.3 The two SAMs recorded within the survey area comprise *Springhead Roman Town* and a *Roman Enclosure SE of Vagniacis.* These areas have been extensively recorded with Springhead being referred to as a Roman Site since at least the 18th century. Further investigations in the area of both SAMs revealed gravelled surfaces and associated finds. Geophysical surveys have also identified possible roads, buildings and further settlement evidence.

1.4.4 Springhead Roman Town has been interpreted as a Sanctuary Complex occupied between the 1st to 3rd centuries with abandonment dated to the 4th century. The complex is detailed to consist of a number of shrines and temples within a small area. Alongside the complex other buildings have been recorded. An excavated building, recorded as a bakery had three rooms, one fronted onto the metalled street surface and the other two contained ovens.

1.4.5 The area designated as Roman Enclosure SE of Vagniacis contains a walled cemetery and outer enclosure. The walled cemetery was discovered accidently by ploughing in 1801. The area contained cremation urns, glass vessels and stone tombs with lead coffins along with other burials and associated grave goods, some of which were precious metal items. A later geophysical survey identified the location of the walled cemetery and a further outer enclosure, which, as a whole form the current scheduled area.

1.4.6 The third SAM is part of the area designated as *Neolithic sites near Ebbsfleet*, approximately 750m northeast of the site. This area was excavated in the 1930s and the site gave its name to Ebbsfleet Ware pottery due to the middle Neolithic pottery assemblages discovered here.

1.4.7 The only listed building with the area is North End Farmhouse which comprises an L-shaped circa 18th century red bricked farmhouse with 19th century extensions and additions.

1.4.8 The map regression exercise indicated that the Site area has been in use as arable fields from at least the 19th century to present, however internal boundaries have changed over time and road systems have developed.

2 METHODOLOGY

2.1 Introduction

2.1.1 The detailed gradiometer survey was conducted using a Bartington Grad 601-2 dual fluxgate gradiometer system. The survey was conducted in accordance with English Heritage guidelines (English Heritage 2008).

2.1.2 The geophysical survey was undertaken by Wessex Archaeology's in-house geophysics team between the 22nd – 26th June 2015. Field conditions at the time of the survey were good, with dry conditions throughout the period of survey. An overall coverage of 6 ha was achieved.

2.2 Method

2.2.1 Individual survey grid nodes were established at 30m x 30m intervals using a Leica Viva RTK GNSS instrument, which is precise to approximately 0.02m and therefore exceeds English Heritage recommendations (2008).

2.2.2 The detailed gradiometer survey was conducted using a Bartington Grad601-2 fluxgate gradiometer instrument, which has a vertical separation of 1m between sensors. Data were collected at 0.25m intervals along transects spaced 1m apart with an effective sensitivity of 0.03nT, in accordance with English Heritage guidelines (2008). Data were collected in the zigzag method.

2.2.3 Data from the survey was subject to minimal data correction processes. These comprise a zero mean traverse function (±5nT thresholds) applied to correct for any variation between the two Bartington sensors used, and a de-step function to account for variations in traverse position due to varying ground cover and topography. These two steps were applied throughout the survey area, with no interpolation applied.

2.2.4 Further details of the geophysical and survey equipment, methods and processing are described in **Appendix 1**.

3 GEOPHYSICAL SURVEY RESULTS AND INTERPRETATION

3.1 Introduction

3.1.1 The detailed gradiometer survey has identified magnetic anomalies of archaeological interest across the Site, along with areas of increased magnetic response and a large amount of ferrous. Results are presented as a series of greyscale plots, XY plots and archaeological interpretations at a scale of 1:1500 (**Figures 2** to **4**). The data are displayed at -2nT (white) to +3nT (black) for the greyscale image and ±25nT at 25nT per cm for the XY trace plots.

3.1.2 The interpretation of the datasets highlights the presence of potential archaeological anomalies, ferrous/burnt or fired objects, and magnetic trends (**Figure 4**). Full definitions of the interpretation terms used in this report are provided in **Appendix 2**.

3.1.3 Magnetic anomalies have been identified throughout the survey area. The most substantial of these appears to be a pair of linear ditch-like features across the middle of the site, however small ditch-like linear features have also been identified in the dataset to the east and pit-like features to the west.

3.1.4 Numerous ferrous anomalies are visible throughout the dataset. These are presumed to be modern in provenance and are not referred to, unless considered relevant to the archaeological interpretation.

3.1.5 It should be noted that small, weakly magnetised features may produce responses that are below the detection threshold of magnetometers. It may therefore be the case that more archaeological features may be present than have been identified through geophysical survey.

3.2 Gradiometer survey results and interpretation

3.2.1 In the centre of the site an area of +1-2nT magnetic responses form a linear feature at **4000**. These anomalies appear to represent a cut feature, likely to be a ditch. The feature is aligned northeast southwest and is approximately 145m long and 8m wide.

3.2.2 Another linear set of anomalies is evident at **4001**. This feature shares similar magnetic properties to **4000** as well as alignment and width, however only approximately 70m is evident. This is likely another substantial ditch-like feature. An area of weaker responses at the south-western extents of this feature shares its alignment and dimensions with **4000** and is likely a continuation of this, however given the difference in the magnetic properties this cannot be certain.

3.2.3 A roughly rectangular 11m x 3m anomaly at **4002** presents responses consistent with burnt or ceramic materials, however as there are no clear features related to this it is difficult to classify.

3.2.4 To the east of the field at **4003** an area of +2-3nT magnetic responses forming a linear feature is apparent. The feature is approximately 14m x 3m and may be a ditch feature, however given its fragmentation this may also be an alignment of pits.

3.2.5 Weaker positive anomalies of +1-2nT form the northeast-southwest linear at **4004**. The feature is approximately 22m x 2m and is likely a short length of a ditch feature.

3.2.6 A group of weak magnetic anomalies at **4005** appear to show another fragmented linear feature aligned approximately east west and approximately 30m x 2m. Given the fragmentation of the responses this maybe a ditch or alignment of pit-like features.

3.2.7 Extremely weak +1nT anomalies at **4006** may represent a cluster of possible pit features. The largest of these is 4m x 3m whilst the smaller is approximately 1.5m x 2m.

3.2.8 Stronger anomalies at **4007** appear to present another pit feature. This feature appears isolated, however given its proximity to the modern service **4019,** further associated features maybe masked.

3.2.9 Similar anomalies at **4008** and **4009** present clusters of similar sized pit-like features with higher +2-3nT magnetic responses.

3.2.10 A weak section of linear anomalies has been identified at **4010,** aligned northeast southwest, 14m x 2.5m. This is likely a small section of a ditch like feature, possibly damaged by the ploughing that appears to respect the same alignment.

3.2.11 A number of highly positive magnetic responses at **4011** appear to present a number of pit features in close proximity. These maybe individual pits in a confined space, however the

feature may also represent a single large pit feature with a fill of variable magnetic properties.

3.2.12 An area of +1nT responses at **4012** present responses similar to those at **4002** and may be evidence for a pit feature containing burnt or ceramic materials.

3.2.13 An elongated anomaly at **4013** exhibits magnetic properties consistent with a ditch-like feature however given its relatively small area, only 7m x 2m in size it may represent an elongated pit.

3.2.14 Highly magnetised positive magnetic anomalies at **4014** present another short elongated pit-like feature, approximately 3m x 1.5m aligned east west.

3.2.15 An area of increased magnetic responses at **4015** may represent an area of former burning or containing debris. This may indicate an area occupation given its almost rectangle formation however this area could instead represent a change in the near surface geology

3.2.16 Linear anomalies at **4016, 4017** and **4018** have been identified as likely plough lines and evidence for former agricultural activity on the site. The orientations are variable and this is likely a sign of differing techniques and variable field boundaries as are evident throughout historic mapping.

3.3 Modern Services

3.3.1 A modern service has been identified in the southwest of the survey dataset running almost east west at **4019.**

3.3.2 It should also be noted that gradiometer survey may not detect all services present on Site. This report and accompanying illustrations should not be used as the sole source for service locations and appropriate equipment (e.g. CAT and Genny) should be used to confirm the location of buried services before any trenches are opened on Site.

4 CONCLUSION

4.1.1 The detailed gradiometer survey has been successful in detecting anomalies of archaeological interest throughout the survey area. In addition to these, anomalies interpreted as ploughing trends, areas of increased magnetic response and trends of unknown origin have also been identified.

4.1.2 The most substantial features identified are two large linear features that run through the middle of the dataset and have been interpreted as possible ditches flanking a trackway. The other area of substantial archaeology is on the eastern boundary where a complex of linear features may represent a form of enclosure or building. An area of increased magnetic has also been identified which may represent an area of former burning or debris and indicate an area of occupation.

4.1.3 The ditch-like features at **4000** and **4002** may represent a form of land division, however given their spacing from one another and their consistent alignment, they may be ditches flanking the sides of trackway.

4.1.4 There is complex of linear features at **4003-4005**, which may be related to one another and may form small areas of enclosure. The area of increased magnetic response at **4015**

is more difficult to define. This may represent an area of former burning or containing debris.

4.1.5 Given the archaeological background of the area, it is highly likely that these features identified are of romano-british origin, however this is only a speculative date.

4.1.6 Frequent ploughing trends are visible across the Site on differing alignments. This is likely due to variable boundaries and different farming processes but these are likely to be medieval, post-medieval and modern in provenance.

5 REFERENCES

5.1 Bibliography

English Heritage, 2008.*Geophysical Survey in Archaeological Field Evaluation*. Research and Professional Service Guideline No 1, 2nd edition.

Wessex Archaeology, 2015.*Archaeological Desk-Based Assessment, London Paramount Entertainment Resort, Swancombe, Kent*. Unpublished Client Report.

5.2 Cartographic and documentary sources

Ordinance Survey

1869 Kent 6” (1:10,560)

1872 Kent 6” (1:10,560)

1882 Kent 25” (1:2500)

1896 Kent 25” (1:2500)

1898 Kent 6” (1:10,560)

1909 Kent 25” (1:2500)

1910 Kent 6” (1:10,560)

1938 Kent 6” (1:10,560)

1946 Kent 6” (1:10,560)

1953 Kent 25” (1:2500)

1962 Kent 25” (1:2500)

1962 Kent 6” (1:10,560)

Soil Survey of England and Wales, 1983.*Sheet 6, Soils of South East England*. Ordnance Survey: Southampton.

5.3 Online resources

UK Soil Observatory, http://www.ukso.org [accessed July 2015]

British Geological Survey, http://www.bgs.ac.uk [accessed July 2015]

APPENDIX 1: SURVEY EQUIPMENT AND DATA PROCESSING

Survey methods and equipment

The magnetic data for this project was acquired using a Bartington 601-2 dual magnetic gradiometer system. This instrument has two sensor assemblies fixed horizontally 1m apart allowing two traverses to be recorded simultaneously. Each sensor contains two fluxgate magnetometers arranged vertically with a 1m separation, and measures the difference between the vertical components of the total magnetic field within each sensor array. This arrangement of magnetometers suppresses any diurnal or low frequency effects.

The gradiometers have an effective resolution of 0.03nT over a ±100nT range, and measurements from each sensor are logged at intervals of 0.25m. All of the data are stored on an integrated data logger for subsequent post-processing and analysis.

Wessex Archaeology undertakes two types of magnetic surveys: scanning and detail. Both types depend upon the establishment of an accurate 20m or 30m site grid, which is achieved using a Leica Viva RTK GNSS instrument and then extended using tapes. The Leica Viva system receives corrections from a network of reference stations operated by the Ordnance Survey and Leica Geosystems, allowing positions to be determined with a precision of 0.02m in real-time and therefore exceed the level of accuracy recommended by English Heritage (2008) for geophysical surveys.

Scanning surveys consist of recording data at 0.25m intervals along transects spaced 10m apart, acquiring a minimum of 80 data points per transect. Due to the relatively coarse transect interval, scanning surveys should only be expected to detect extended regions of archaeological anomalies, when there is a greater likelihood of distinguishing such responses from the background magnetic field.

The detailed surveys consist of 20m x 20m or 30m x 30m grids, and data are collected at 0.25m intervals along traverses spaced 1m apart. These strategies give 1600 or 3600 measurements per 20m or 30m grid respectively, and are the recommended methodologies for archaeological surveys of this type (EH, 2008).

Data may be collected with a higher sample density where complex archaeological anomalies are encountered, to aid the detection and characterisation of small and ephemeral features. Data may be collected at up to 0.125m intervals along traverses spaced up to 0.25m apart, resulting in a maximum of 28800 readings per 30m grid, exceeding that recommended by English Heritage (2008) for characterisation surveys.

Post-processing

The magnetic data collected during the detail survey are downloaded from the Bartington system for processing and analysis using both commercial and in-house software. This software allows for both the data and the images to be processed in order to enhance the results for analysis; however, it should be noted that minimal data processing is conducted so as not to distort the anomalies.

As the scanning data are not as closely distributed as with detailed survey, they are georeferenced using the GPS information and interpolated to highlight similar anomalies in adjacent transects. Directional trends may be removed before interpolation to produce more easily understood images.

Typical data and image processing steps may include:

- Destripe – Applying a zero mean traverse in order to remove differences caused by directional effects inherent in the magnetometer;
- Destagger – Shifting each traverse longitudinally by a number of readings. This corrects for operator errors and is used to enhance linear features;
- Despike – Filtering isolated data points that exceed the mean by a specified amount to reduce the appearance of dominant anomalous readings (generally only used for earth resistance data)

Typical displays of the data used during processing and analysis:

- XY Plot – Presents the data as a trace or graph line for each traverse. Each traverse is displaced down the image to produce a stacked profile effect. This type of image is useful as it shows the full range of individual anomalies.
- Greyscale – Presents the data in plan view using a greyscale to indicate the relative strength of the signal at each measurement point. These plots can be produced in colour to highlight certain features but generally greyscale plots are used during analysis of the data.

APPENDIX 2: GEOPHYSICAL INTERPRETATION

The interpretation methodology used by Wessex Archaeology separates the anomalies into four main categories: archaeological, modern, agricultural and uncertain origin/geological.

The archaeological category is used for features when the form, nature and pattern of the anomaly are indicative of archaeological material. Further sources of information such as aerial photographs may also have been incorporated in providing the final interpretation. This category is further sub-divided into three groups, implying a decreasing level of confidence:

- Archaeology – used when there is a clear geophysical response and anthropogenic pattern.
- Probable archaeology – used for features which give a clear response but which form incomplete patterns.
- Possible archaeology – used for features which give a response but which form no discernible pattern or trend.

The modern category is used for anomalies that are presumed to be relatively modern in date:

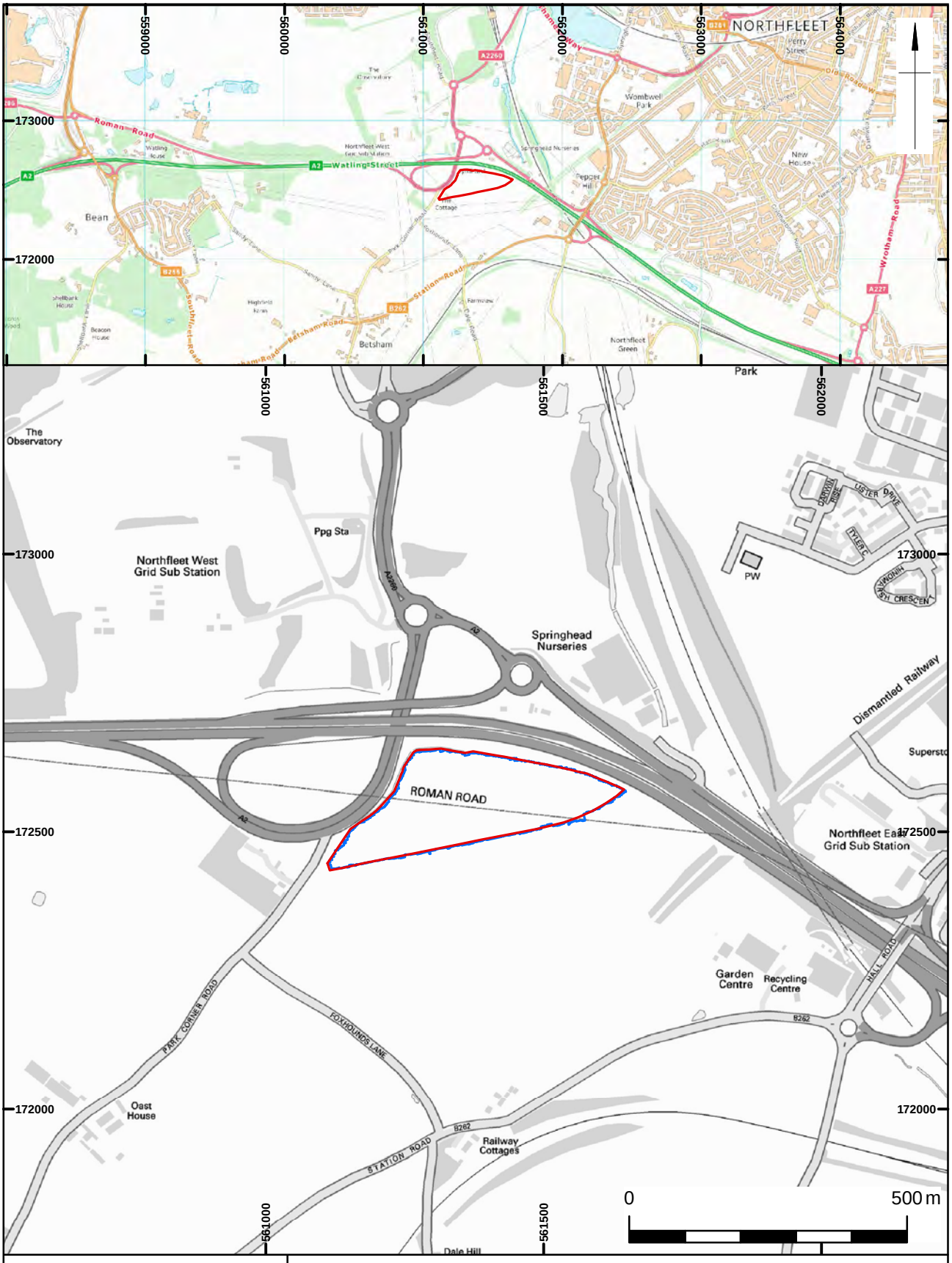
- Ferrous – used for responses caused by ferrous material. These anomalies are likely to be of modern origin.
- Modern service – used for responses considered relating to cables and pipes; most are composed of ferrous/ceramic material although services made from non-magnetic material can sometimes be observed.

The agricultural category is used for the following:

- Former field boundaries – used for ditch sections that correspond to the position of boundaries marked on earlier mapping.
- Agricultural ditches – used for ditch sections that are aligned parallel to existing boundaries and former field boundaries that are not considered to be of archaeological significance.
- Ridge and furrow – used for broad and diffuse linear anomalies that are considered to indicate areas of former ridge and furrow.
- Ploughing – used for well-defined narrow linear responses, usually aligned parallel to existing field boundaries.
- Drainage – used to define the course of ceramic field drains that are visible in the data as a series of repeating bipolar (black and white) responses.

The uncertain origin/geological category is used for features when the form, nature and pattern of the anomaly are not sufficient to warrant a classification as an archaeological feature. This category is further sub-divided into:

- Increased magnetic response – used for areas dominated by indistinct anomalies which may have some archaeological potential.
- Trend – used for low amplitude or indistinct linear anomalies.
- Superficial geology – used for diffuse edged spreads considered to relate to shallow geological deposits. They can be distinguished as areas of positive, negative or broad bipolar (positive and negative) anomalies.



Site Boundary

Detailed Survey Extents

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Scale:	1:40000 and 1:10000 at A4	Illustrator:	GJD
Path:	R:\PROJECTS\106573\GIS\FigsMXD\2015_07_08\Fig01.mxd		

Site location and survey extents

Figure 1

561200
561300
561400
561500
561600

172700
172600
172500
172400

+3nT
-2nT

0
100 m

Detailed Survey Extents

Site Boundary

Date:	08/07/2015	Revision Number:	0
Scale:	1:1500 at A3	Illustrator:	GJD
Path:	R:\PROJECTS\106573\GIS\FigsMXD\2015_07_08\Fig02.mxd		

Greyscale plot (west)

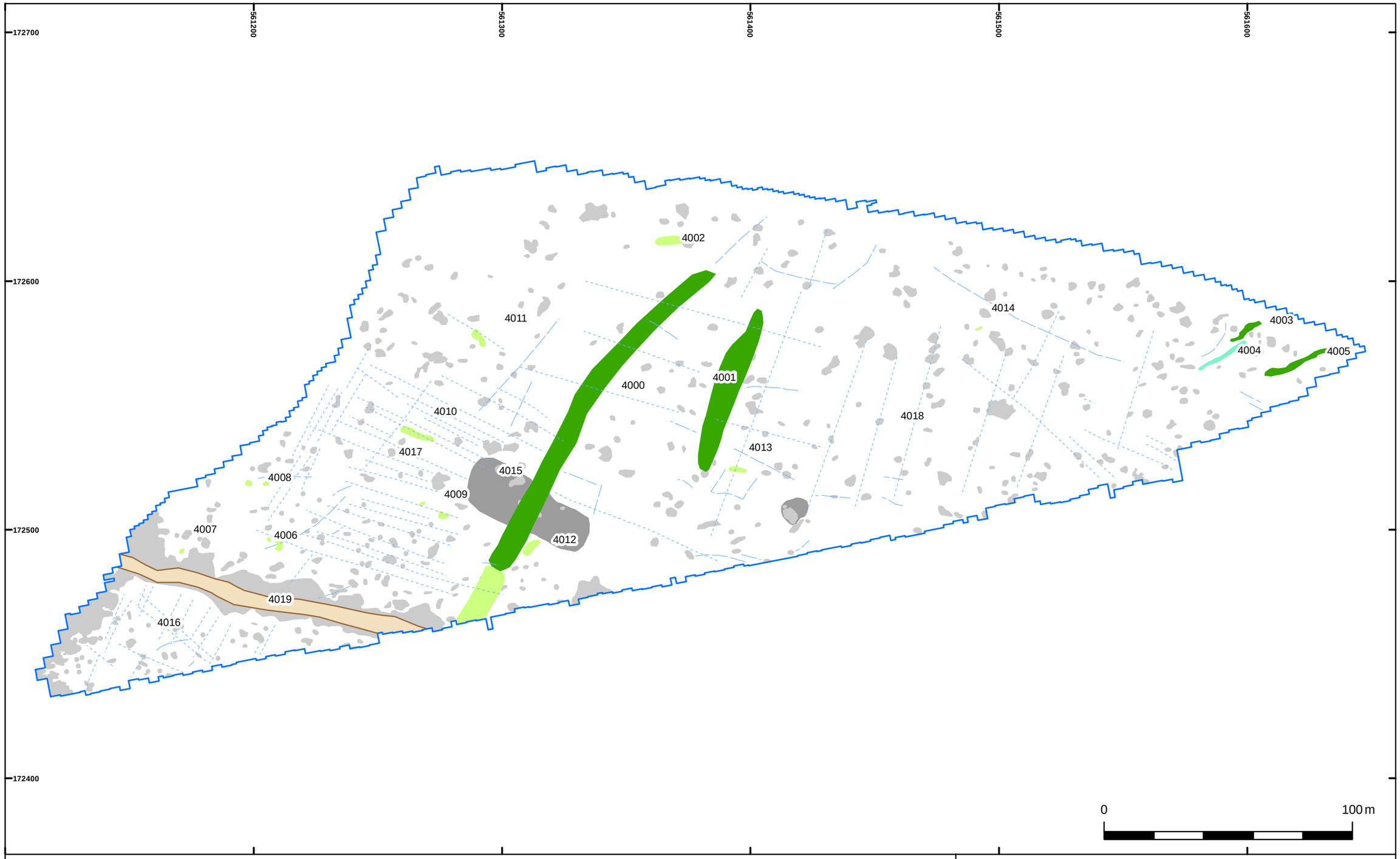
Figure 2

561200
561300
561400
561500
561600
172700
172600
172500
172400
+25nT
-25nT
0
100 m
Site Boundary
Detailed Survey Extents

Date:	08/07/2015	Revision Number:	0
Scale:	1:1500 at A3	Illustrator:	GJD
Path:	R:\PROJECTS\106573\GIS\FigsMXD\2015_07_08\Fig03.mxd		

XY Trace plot (west)

Figure 3



Detailed Survey Extents
Ploughing
Trend
Archaeology
Probable Archaeology
Possible Archaeology
Modern Service
Ferrous
Increased Magnetic Response

Date:	08/07/2015	Revision Number:	0
Scale:	1:1500 at A3	Illustrator:	GJD
Path:	R:\PROJECTS\106573\GIS\FigsMXD\2015_07_08\Fig04.mxd		

Archaeological Interpretation (west)

Figure 4

Wessex Archaeology Ltd registered office Portway House, Old Sarum Park, Salisbury, Wiltshire SP4 6EB
Tel: 01722 326867 Fax: 01722 337562 info@wessexarch.co.uk www.wessexarch.co.uk

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