LONDON GATEWAY SITE X
HALSTOW MARSHES, KENT

Report on Archaeological Geophysical Survey 2012

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Introduction

This report describes a geophysical survey which has been completed as part of an archaeological field evaluation of a site on the Halstow Marshes adjacent to the Thames estuary in north Kent. The survey was undertaken for DP World in connection with the London Gateway development. The site under investigation is the proposed location of an amelioration area where new mudflats are to be created. This will require the breaching and replacement of the seawall, and ground reduction by about 0.5m.

The purpose of the survey was to test for indications of subsurface archaeological features or remains within the site, and to provide evidence which may inform later stages of the evaluation. The survey was commissioned from Bartlett Clark Consultancy, Specialists in Archaeogeophysics of Oxford, by Oxford Archaeology Ltd. Fieldwork for the survey was carried out between 29 May and 21 June 2012. Plots of the survey findings have previously been supplied to Oxford Archaeology, and are now presented for the record in this report.

The Site

The site is described in the Archaeological Desk Based Assessment (DBA) prepared and supplied to us by Oxford Archaeology [1]. This report includes information on the project background and the topography of the site, as well as an account and gazetteer of previously identified archaeological findings within a study area centred on the site. We previously included a summary of the more relevant archaeological findings as noted in the DBA in the Method Statement (prepared by BCC and submitted to OA) at the start of this project [2]. The following comments are reproduced in part from this earlier summary.

Location and topography

The evaluation area as described in the DBA amounts to c. 190ha. It is located on the alluvial floodplain of the River Thames in the parishes of Cooling and High Halstow, and centred approximately at NGR TQ 765 785. The total extent of the evaluation area is indicated by grey shading on the survey location plan (figure 1). The site is in two parts in separate ownership, as indicated by red and blue cross hatching on figure 1. It was originally proposed that the survey should cover both areas, but the south eastern area (cross hatched in blue, and amounting to about 74ha) had to be excluded from the survey

because of land access issues. The survey as undertaken was therefore restricted to the remaining (western) part of the site. The final survey coverage within this area (excluding watercourses, etc) amounted to c. 109ha.

The survey area is flat reclaimed marshland at an elevation between c. 0 to 0.5m AOD, and is now covered by improved grassland. It is subdivided by watercourses and tidal channels (as seen on figure 1). Salt Fleet crosses the centre of the site, and Hope Fleet forms the southern boundary.

Geology

The geology of the site is alluvium. This includes marine alluvium, and comprises silt and clay with beds of peat and seams of sand and gravel. The detectability of archaeological features may depend on factors including depth of burial, and the relative dates of the alluvial deposits and the archaeological layers. It is mentioned in the DBA that borehole data indicates alluvial deposits of 15 to 23m depth above chalk and sand bedrock. The alluvium results from marine transgressions and rising sea levels, and has buried a sequence of land surfaces from prehistoric to Roman periods. Surface scatters of Iron Age and Roman material have been recorded from the site, which suggests that archaeological deposits from those and subsequent periods will not necessarily be too deeply buried to be detectable. Archaeological remains from earlier periods are likely to be less substantial, and so less readily detectable, and may also be buried at greater depth within the alluvial sequence.

It is probable that the site also contains peat deposits, as were seen in a BGS cross section across the Cliffe Marshes c. 4km to the west. This indicated peat in a series of lenses each 0.5 to 1m thick in the upper 7m of soil. Peat is likely to occur in isolated patches rather than as a uniform layer across the site. It is of archaeological interest because it offers favourable conditions for organic preservation, but it is magnetically unresponsive. It is possible therefore that areas of relatively quiet magnetic response could indicate near-surface peat deposits (as could low magnetic susceptibility readings). [Evidence from BGS boreholes within the site itself is reported to indicate that the peat is mainly at a depth below 1.2m. The magnetic response if so will be determined mainly by the composition of near-surface soils above the peat.]

We noted in the Method Statement that it is sometimes the case that magnetometer surveys on reclaimed coastal marshland will detect characteristic strong and irregular magnetic anomalies. Magnetic activity of this kind was seen in some of the areas previously surveyed in connection with the London Gateway project on the north bank of the Thames. The magnetic variations may reflect the contrasting magnetic effects of silt and peat, and also variations in the depth and composition of the silt within former channels. Magnetic disturbances similar to those seen previously to the north of the river were in fact found to be widespread in the present survey, as is noted in the discussion of the findings below. These results confirm, as expected, that the greater part of the survey area, except for limited areas towards the southern boundary, was previously a salt marsh.

Archaeological background

Findings listed within the DBA study area include evidence for Iron Age and Roman pottery manufacture, as well as Iron Age and later salt making. Most known pottery sites are located adjacent to navigable creeks. Any surviving remains of kilns, together with associated waster heaps, should give rise to detectable magnetic anomalies. Findings from nearby salt making sites have included pottery, tile and salt-drying briquetage, which should also be magnetically detectable.

Salt making in medieval and later periods is described in the DBA as involving the scraping of estuarine alluvium into a mound, and rinsing it to produce brine. Two such former mounds have been identified within the site, but have been levelled by modern ploughing. (Refuge mounds within the former marsh have also been ploughed out.) It is probable that debris relating to buildings used for subsequently boiling the brine, and any related briquetage deposits, will be more readily detectable than the mounds themselves.

Other features which might be visible in the survey include post-medieval ditches dug during marshland reclamation, former ponds, and debris associated with various buildings and farmsteads. The line of the original sea wall (as shown on a map of 1801) probably lies outside the northern limit of the survey area.

Survey procedure

The method used for the geophysical survey was a full recorded magnetometer survey supplemented by background magnetic susceptibility testing.

Magnetometer survey

Readings for the magnetometer survey were collected using Bartington 1m fluxgate magnetometers, and are plotted at 25cm intervals along transects 1m apart. The results of the survey are shown as grey scale plots in sections at 1:2000 scale in figures 3-7, and as graphical (x-y trace) plots in figures 8-15. [The locations of the plans are shown on the key map; figure 2.] These alternative representations allow the detected magnetic anomalies to be seen in plan and profile respectively. The x-y plots represent the readings after minimal pre-processing operations. These include adjustment for irregularities in line spacing caused by heading errors (direction sensitivity in the instrument zero setting), and truncation of extreme values. The grey scale plots show a lightly processed version after additional low pass filtering to control background noise levels.

The magnetometer responds to cut features such as ditches and pits when they are silted with topsoil, which usually has a higher magnetic susceptibility than the underlying natural subsoil. It also detects the thermoremanent magnetism of fired materials, notably baked clay structures such as kilns or hearths, and so responds preferentially to the presence of ancient settlement or industrial remains. The readings are also strongly affected by ferrous and other debris of recent origin.

Magnetic susceptibility survey

We usually supplement a magnetometer survey with background magnetic susceptibility readings, which in this case were taken at 60m intervals using a Bartington MS2 meter with a field detector loop. Susceptibility measurements can provide a broad indication of areas in which archaeological debris, and particularly burnt material associated with past human activity, has become dispersed in the soil. They are also affected by non-archaeological factors, including geology, past and present land use, and modern disturbances, and so provide evidence relating to soil and site conditions which can be of help in interpreting the magnetometer survey. The results are presented as a shaded plot inset in figure 16.

This plot shows that susceptibility values overall are relatively low, with a mean of 7 (x 10^{-5} SI). They may be depressed in part because the measurement coil gives lower readings on pasture than on bare earth, but the readings are consistent with the presence of a soil partly composed of relatively non-magnetic sand or peat. This should not inhibit the detection of industrial or structural remains (where the debris includes burnt clay), but it may mean that such features as recent or shallow ditches containing a topsoil fill could be difficult to detect.

Presentation

An interpretation of the findings is shown superimposed (for comparison) on the graphical plots (figures 8-15), and is reproduced separately to provide a summary of the findings in figures 19-22. Features as marked include the extensive magnetic activity as noted above which relates to variations in the depth or composition of silt across the former marshland. These magnetic anomalies are outlined in a light green. Various more linear features are also visible within the marshland areas. These form intersecting and branching patterns characteristic of watercourses, and are defined most clearly by negative magnetic anomalies (white in the grey scale plot). These possible former channels are indicated in the interpretation by light yellow/brown outlines.

Some of the larger former stream channels are visible in the survey plots as meandering linear features characterised by reduced magnetic activity, and an absence of the disturbed marshland magnetic response. The possible limits of these channels are indicated approximately in figures 19-22 by broken brown outlines.

Some of the detected magnetic anomalies show characteristics to be expected from features of potential archaeological significance, and there are others which on the basis of their location or context might be thought to be of archaeological interest. These are outlined in the interpretation in red. Weak magnetic anomalies of probably natural or non-archaeological origin are outlined in light brown. Probable recent or non-archaeological disturbances are indicated in darker brown and ferrous debris in blue. Magnetic disturbances along past or present farm tracks are indicated in grey.

One difficulty in classifying findings in this survey is that magnetic disturbances relating to ancient industrial activity (pottery and salt making) are not necessarily distinct from

those caused by scatters of modern debris (brick rubble, etc). Various anomaly clusters are therefore indicated by a mixture of red (for archaeology) and brown (recent) outlines to reflect this ambiguity. The classification and colouring also in some case takes account of correspondences between the survey findings and known archaeological sites. These are indicated on the plan (reproduced from the DBA) inset in figure 16.

The site has additionally been the subject of an aerial Lidar survey to record small variations in surface relief. A plot of the available Lidar results (covering the southern half of the survey area) is reproduced (with magnetometer survey areas superimposed) in figure 17. Selected survey findings have also been added for comparison in a second version of this plan (figure 18).

Survey location

The survey was located by reference to a temporary site grid which was set out and tied to national grid co-ordinates (to c. 10cm accuracy) by means of a differential GPS system (with satellite correction). OS co-ordinates of map locations can be read from the AutoCAD version of the plans which can be supplied with this report.

Results

The survey has detected extensive magnetic activity, much of which (as noted above) is characteristic of the magnetic variation commonly found on former wetland. The presence and distribution of this magnetic activity serves to distinguish drained marsh from silted palaeochannels, and so provides information relating to the landscape history of the site. Various other subsurface features and disturbances are visible in the survey. Some of these are likely to be of archaeological interest, but further investigation may be needed to determine whether others include features or debris of archaeological origin.

Fields within the survey area have been numbered in an arbitrary sequence (1-11) for identification in this report. Findings are described below by fields listed in this order.

Fields 1-2

The survey in field 1, as in neighbouring fields, has detected dense irregular magnetic anomalies representing drained and levelled former marshland. These disturbances are particularly concentrated in the eastern half of field 1, and in other fields to the north of Salt Fleet. These background disturbances (as outlined in green) are intersected by slightly more continuous linear features (shown in yellow/brown). These former channels appear to contain a fill (perhaps containing more sand or peat) which is less magnetic than the marshland silt.

The survey has also detected a number of former wide main channels. Two of these (A and B as labelled on figure 19) are visible in field 1. They extend into adjacent fields, and

link variously with Salt Fleet, and with a former western continuation of Salt Fleet (C) in field 9. The channel at A in part follows the line of a ditch or boundary shown on the 1842 tithe map (reproduced from the DBA, and included in figure 16). [Some other ditches or boundaries shown on this map are not readily identifiable in the survey, perhaps for reasons as mentioned in the note on magnetic susceptibility (above).]

Previously recorded archaeological findings from field 1 which are noted in the DBA include Iron Age and Roman pottery finds near the northern boundary (26 and 27 on map in figure 16), ponds (66 and 133), and a WWII magazine (57). The ponds do not appear to contain any distinctive fill, and there are no disturbances to indicate the magazine at its recorded position. It could perhaps be further to the east where there are strong magnetic disturbances (suggesting rubble or hardcore) next to a field entrance (D). This response could in part represent hard standing at the field entrance, but the disturbance is extensive enough perhaps to include debris from a magazine, or from a sheep fold (74).

A scatter of small magnetic anomalies (E) was detected in the vicinity of the Roman and Iron Age finds along the northern field boundary. These are most concentrated near to the existing access track (labelled F), and so could in part indicate recent rubble or debris, but burnt material from ancient pottery making or salt drying could produce a similar response. A few magnetic anomalies at E which could be interpreted as small silted pits (of possible archaeological interest) are outlined in red, but most of the disturbances are likely to represent items of burnt or ferrous debris. Two further possible pit-like features are indicated at the edge of a former channel at G, but are very isolated and do not suggest a concentration of archaeological features.

Findings in field 2 are limited to background magnetic anomalies indicating drained marsh.

Fields 3-5

The main findings in fields 3 and 4 include extensive delta-like patterns of former channels (H, J). These are again superimposed on an irregular magnetic background indicating former marsh. The channels converge on an existing drain in field 4, and on the former channel (A) in field 3. Additional former channels (K) in field 4 align in part with a ditch shown on the 1842 map.

The disturbances at L in field 4 are slightly to the west of a recorded medieval salt working site (132 on DBA map), and are near to a field entrance. A further group of magnetic disturbances at M in field 5 aligns with a former track (N) in field 6, and so could be recent, but it is also suitably located next to a stream, and so it is not impossible it represents a pottery or salt working site.

Other potential archaeological features previously recorded in these fields include ponds (153 and 159) and refuge mounds (150 and 177). These do not appear to be associated with any magnetic response which is distinguishable from the marshland background.

Fields 6-7

The main finding in field 6 is a dense group of disturbances in the north of the field at N. This corresponds clearly to the location of a farmstead shown on the 1842 map (73 in DBA). The magnetic susceptibility plot also shows high readings at this location.

There is a further group of strong magnetic anomalies near to an extant drainage ditch at P in field 6. These include individual magnetic anomalies (as seen in the graphical plot; figure 10) of a strength which could indicate either large modern ferrous objects or former kilns. [It is perhaps likely there would be a greater spread of magnetic debris at an ancient industrial site than is seen here, and so it remains possible that the features are modern. It is not always clear whether strong individual magnetic anomalies could represent modern ferrous objects, or well-preserved kiln bases. Some rather ambiguous large anomalies (as at P) are therefore outlined in red.]

There are further groups of strong magnetic anomalies in the south of field 6 at Q and R. Of these, Q could be a recent ferrous object, but R is more complex. It is at the edge of the former wider Salt Fleet channel, and could perhaps indicate a pottery or salt working site. A track across the field was detected at S.

There are no clearly interpretable findings in field 7 except for strong (and perhaps recent) disturbances near to watercourses at T.

Fields 8-9

Findings in both fields include additional former channels within the marsh (e.g. U, V), and the former wider course of the Salt Fleet (C). Individual strong magnetic objects (at W, X, Y) are perhaps more likely to be modern ferrous objects than kilns.

The disturbed area at Z extends around the northern entrance to field 9, and links to the similar disturbances (D) in field 1. Each could represent mainly recent debris. A more isolated group of findings is located within a former stream channel at AA, and is of uncertain origin.

There are no previously recorded archaeological findings in these fields (other than the sheepfold 74, which may be in field 1), but the farmer told the survey team that a Spitfire crashed in this part of the site. The magnetic anomaly at BB could, if so, be of a strength to suggest a buried engine.

The greater part of fields 8 and 9 is covered by the Lidar plot. None of the features detected by the survey is clearly identifiable in the Lidar image (figs 17-18), other than the extant track at the west of field 8.

Fields 10-11

Magnetic disturbances indicating former marshland were detected in the northern part of field 10, but they are weaker and more dispersed elsewhere.

The findings include a large group of magnetic disturbances at CC in field 11. Some of these could be recent, but they also correspond well to a medieval salt working site (DBA 82). There is perhaps another smaller group of such features next to Salt Fleet at DD in field 10.

Other disturbances (EE, FF) are located near to field entrances. Bricks and rubble are visible on the ground surface in the corner of field 10 at EE. This is the site of a sheepfold (DBA 80), and corresponds to an enclosure on the 1842 map.

There are strong magnetic anomalies probably indicating large ferrous objects at GG, HH, JJ, KK. A weaker broad feature at LL could be a large silted hollow.

The Lidar plot shows curving channel-like features, some of which (in the south of field 6, and in field 10) may correspond broadly to channels seen in the survey plots, but there are no other Lidar features which can be identified in the magnetometer survey.

Conclusions

Findings from the survey include magnetic disturbances which indicate the presence of drained and reclaimed salt marsh, and of former channels and watercourses within the marsh. These include both dense branching networks of small natural channels, and a wide curving main channel. This extends the line of the existing Salt Fleet at least to the western limit of the survey area.

Other findings include a number of more localised magnetic disturbances. Some are located near former or present watercourses, as would be expected for medieval or earlier salt working or pottery making sites. It is sometimes difficult (as mentioned) to distinguish the magnetic debris associated with these activities from modern disturbances on the basis of the survey evidence alone, but some of the findings could provide targets for further investigation. These could include the magnetic activity (E) near to the iron Age and Roman findings to the north of field 1, as well as findings (M, P) near to extant ditches in fields 5 and 6. Other groups of magnetic anomalies with at least some potential to represent former pottery making or salt drying sites include D/Z in fields 1 and 9, R in field 6 and AA in field 9.

The largest and potentially most significant finding of this kind is the group of disturbances at CC in field 11, which corresponds to a recorded salt working site (DBA 82). There could be a smaller similar disturbance at DD in field 10.

Disturbances (N) were detected at the site of a 19th C farmstead in field 6, and others (EE) correspond to a 19th C enclosure in field 10. There is a strong magnetic anomaly (BB) near to a reported Spitfire crash site in field 9.

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The fieldwork for this project was done by F. Prince, P. Cottrell, C. Oatley, P. Heykoop and N. Paveley.

References

[1] London Gateway Site X Cultural Heritage Assessment; Oxford Archaeology South, March 2012

[2] Method Statement for Archaeological Geophysical Survey 2012. London Gateway Site X, Halstow Marshes, Kent. Document submitted to oxford Archaeology by Bartlett Clark Consultancy 21 May 2012.

London Gateway Site X: Geophysical Survey
Appendix : Inventory of Selected Findings

This list notes the more significant findings from the magnetometer survey of this site. The grading (1-4) given alongside each entry refers primarily to the reliability of the geophysical evidence, but the potential archaeological relevance of detected features is also taken into account in the definitions of grades 3 and 4.

Grade 1: Distinct magnetic anomalies of probable archaeological origin.

Grade 2: Weaker or more isolated magnetic anomalies which could in part be archaeologically significant.

Grade 3: Distinct magnetic anomalies, but probably natural, or of recent or other non-archaeological origin.

Grade 4: Weaker or more isolated magnetic anomalies of probably non-archaeological origin.

This summary list includes only selected magnetic findings, particularly those which may be of potential archaeological interest. Magnetic disturbances which may be mentioned in the text or indicated on plans are not necessarily included if they appear to be of natural or non-archaeological origin.

Field	Feature		Grade
1-2	A	Silted palaeochannel (meets Salt Fleet in field 3).	3
1	B	Silted palaeochannel: joins former western continuation of Salt Fleet (C) in field 9.	3
9	C	Wide meandering silted channel: former western continuation of Salt Fleet.	3
1	D	Disturbances near field entrance: could include debris from magazine (DBA 57) or sheep fold (DBA 74).	3
1	E	Scatter of (small, strong) magnetic anomalies. Perhaps recent, but located near IA / RB finds (DBA 26).	1-2
1, 8	F	Strong magnetic response from extant track.	3
1	G	Small pit-like magnetic anomalies.	2
3, 4	H, J	Examples of branching patterns of former (natural ?) channels through marsh.	3
4	K	Ditch-like features may correspond in part with ditch on 1842 tithe map.	2-3
4	L	Disturbances near field entrance (some distance to west of possible medieval salt-working site DBA 132).	3

5	M	Disturbances next to drainage ditch. Possibly recent, but location is suitable for pottery / salt working.	2
6	N	Magnetic disturbances at site of 19th C farmstead.	1 or 3
6	P	Strong magnetic disturbances near drain: recent, or pottery/salt working site ?	2
6	Q	Isolated strong magnetic anomalies: perhaps recent ?	3
6	R	Possible industrial (salt/pottery) debris at edge of former water course ?	1
6	S	Magnetic disturbances on line of former track.	3
7	T	Strong magnetic disturbances near two drains: recent or (very) small pottery/salt working site ?	2
8, 9	U, V	Former (natural ?) channels within marsh (as at H, J, K).	3
8, 9	W, X, Y	Isolated strong magnetic anomalies: probably modern ferrous objects (rather than kilns).	3
9	Z	Disturbances around field entrance (as at D).	3
9	AA	Scatter of magnetic debris: recent or small pottery/salt working site ?	2
9	BB	Large ferrous anomaly (in vicinity of Spitfire crash site ?)	1 or 3
11	CC	Magnetically disturbed area corresponding to medieval salt working site (DBA 82).	1
10	DD	Smaller group of disturbances perhaps similar to CC ?	1-2
10	EE, FF	Disturbances near to field entrances. (EE near to sheepfold DBA 80: bricks and rubble visible on surface.)	3
10	GG, HH, JJ, KK	Isolated strong magnetic anomalies (probably ferrous, as for W, X, Y)	3
10	LL	Broad weak anomaly: large silted pit ?	1 or 3