St Benet's Abbey: A geophysical investigation

Author:

David Bescoby MIfA

15th October 2014

A report produced for the Norfolk Archaeological Trust

Contents

1 Summary

A geophysical survey using magnetic and earth resistance measurements was undertaken at St Benet's Abbey, Norfolk in order to evaluate the survival of subsurface features and gain further insight into the configuration of the abbey buildings. It appears little survives below ground of the buildings immediately south of the extant remains of the church (with evidence for the extensive robbing of foundation layers). However, beneath the lower lying ground to the south foundations relating to an extensive range of buildings were detected, their orientation also suggesting the presence of an inner precinct boundary. The survival of these remains might relate to their low lying position, with waterlogging making removal of foundation levels difficult. Proximity to the river may have also contributed to their continued usefulness after the main abbey buildings were dismantled. The survey also identified further evidence of an inner precinct enclosure to the west and north of the church likely comprised of a wall and outer ditch. An adjoining enclosure to the north was identified as the possible location of a cemetery. Along the eastern margins of the site an extensive network of land drainage features were identified.

2 Introduction

The remains of St Benet's Abbey, located on a low, natural promontory or 'holm' within the lowland marshes of the Norfolk Boards, has long been an iconic and much loved landmark. Recent work by the Norfolk Archaeological Trust under the St Benet's Abbey Conservation Access and Community Project has seen the conservation of the gatehouse and windmill along with improved visitor access and information. By way of complementing these works, a 15 day geophysical investigation of surviving sub-surface remains at St Benet's was undertaken during August and September 2014, funded by the Heritage Lottery Fund. The results of the survey are described within this report.

3 Aims and Objectives

The principal aim of the current study was to investigate the area immediately south of the extant remains of the abbey church over which the cloister buildings would have once stood. In contrast to elements of the nave, choir and north transept which still survive above ground, the only discernable topographic features to the south consist of an apparently levelled platform containing two distinct shallow depressions.

In addition, the study also aimed to map the wider area of elevated ground surrounding the church, running down to the lowland margins of the site.

4 Geophysical methods

Archaeological geophysics provides a means of mapping surviving sub-surface remains, relying on contrasting geophysical properties between buried remains and their surrounding burial environment. In the current study, magnetic and electrical properties of the sub-surface have been investigated. In each case, a large number of uniform measurements are taken over a regular network of grids and plotted out as greyscale maps depicting the sub-surface and any anomalous responses that might relate to historical activity. An important point to bear in mind is that geophysical data represents palimpsest of past activity, spanning the most recent of events to those of the distant past. This accumulated layering of geophysical responses is perhaps the greatest challenge to accurate data interpretation. Both techniques employed are sensitive to sub-surface features down to a depth of ca. 1.5 metres.

Geophysical techniques were deployed in adherence to guidelines for best practice issued by English Heritage [1] and the Institute for Archaeologists (IfA) Standards and Guidance for archaeological geophysical survey (2013) [2]. Technical details of the field methods employed are provided in Appendix A. A copy of this report will be submitted to English Heritage in accordance to the licence granted under Section 42 of the Ancient Monuments and Archaeological Areas Act 1979.

4.1 Magnetic measurements

Magnetometer survey, sensitive to minute distortions in the earth's magnetic field in the presence of buried objects, provides a rapid means of mapping sub-surface features and was the main technique employed. The interaction of the earth's magnetic field with that of buried features produces a characteristic dipolar response of both positive and negative values, represented in greyscale maps as associated black and white features.

The technique is sensitive to masonry building foundations or footings constructed either from 'magnetic' materials such as fired clay brick, producing strong positive magnetic responses, or non-magnetic materials such as limestone blocks, which produce negatively trending magnetic responses, being less magnetic than the surrounding soil. Magnetometer surveys are also sensitive to archaeological features such as pits and ditches, which tend to infill with more magnetic topsoil, providing a magnetic contrast with surrounding soil. Areas of burning, burnt materials and structures relating to heating processes such as kilns and hearths all produce a strong magnetic response as heating dramatically enhances their innate magnetic properties.

4.2 Earth resistance (resistivity) measurements

The resistance of the earth to an electrical current at a particular point is measured by placing electrical probes into the ground. The presence of buried remains effects how well the surrounding soil conducts an electrical current. The technique is also sensitive to buried wall foundations or footings as these, being solid structures present a higher electrical resistance than the surrounding soil. Conversely, features such as pits and ditches generally hold more soil moisture than the surrounding soil (their infilling material being less well compacted), presenting a lower electrical resistance than the surrounding soil.

While both magnetic and earth resistance measurements detect the same kinds of buried archaeological features, they measure different geophysical properties

and are therefore complementary and in combination often provide a good deal of information concerning the physical nature of anomalous sub-surface features. Resistivity measurements are markedly slower to make compared with magnetic measurements and therefore this technique was used to elucidate results from the magnetometer survey where interpretation was unclear or ambiguous.

4.3 Geological considerations

The high ground comprising the 'holm' is formed of Quaternary sand and gravel deposits that can contribute to the overall levels of magnetic 'noise', depending on the depth of overlying soils. They also providing a comparatively free draining substrate suitable for earth resistance measurements. The lower lying margins of the site contain deeper alluvial soils and associated sedimentary deposits. However, the presence of extant remains in these areas suggests the relatively superficial burial depths of archaeological deposits.

5 Results

The results from the magnetometer survey are shown in Figure 1, covering ca. 7 ha. It can be seen that the survey was successful in detected a large number of anomalous features, particularly within the southern portion of the survey area producing an often complex picture of the sub-surface, discussed in detail in the following section.

As magnetic measurements are sensitive to noise from carried ferrous objects, mobile phones and pet collars etc., it was necessary to maintain an 8 m buffer around the much visited standing remains of the abbey church. It was possible to extend the survey area to within ca. 40 m of the site perimeter on the northern and southern edges, after which point the ground became too boggy and vegetated.

The resistivity surveys were deployed in key areas of interest, to the south and west of the extant church buildings, covering an area of 1 ha. The results are shown Figure 2.

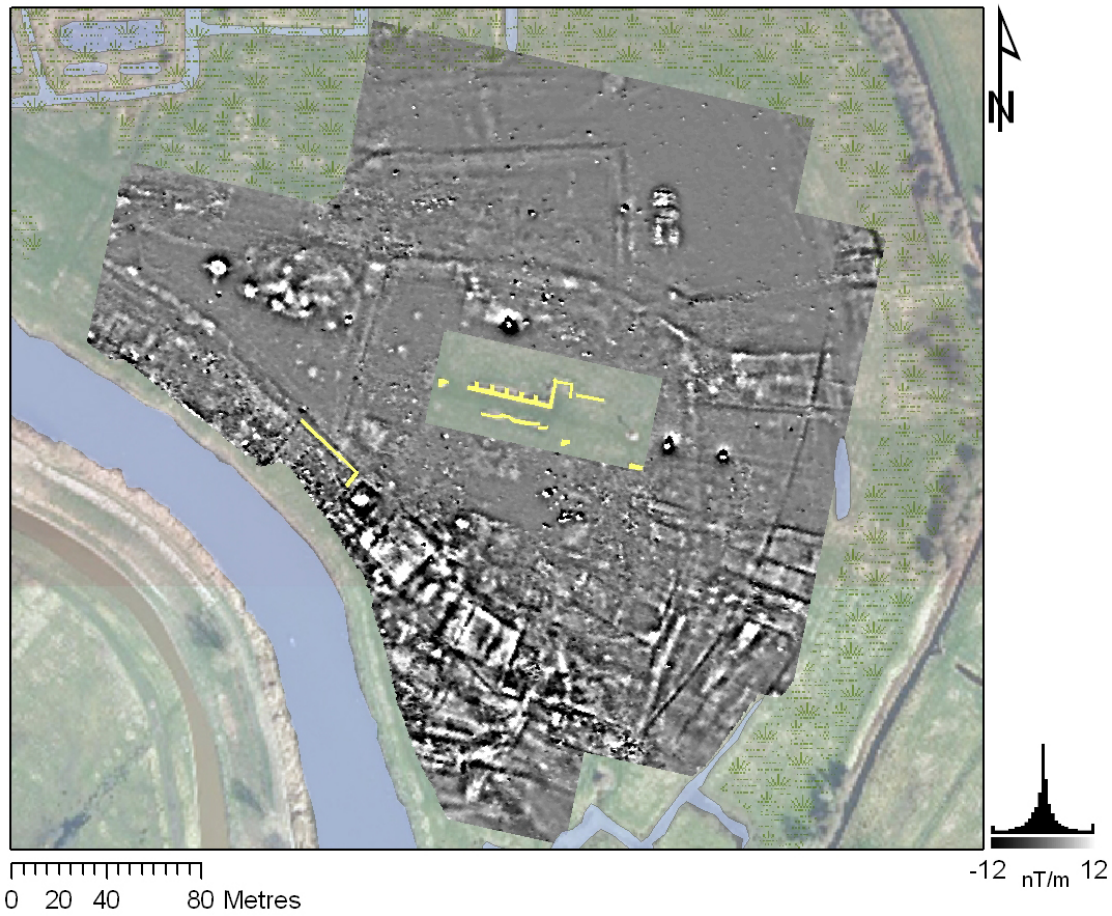

Figure 1: Magnetometer survey data. Extant remains marked in yellow.

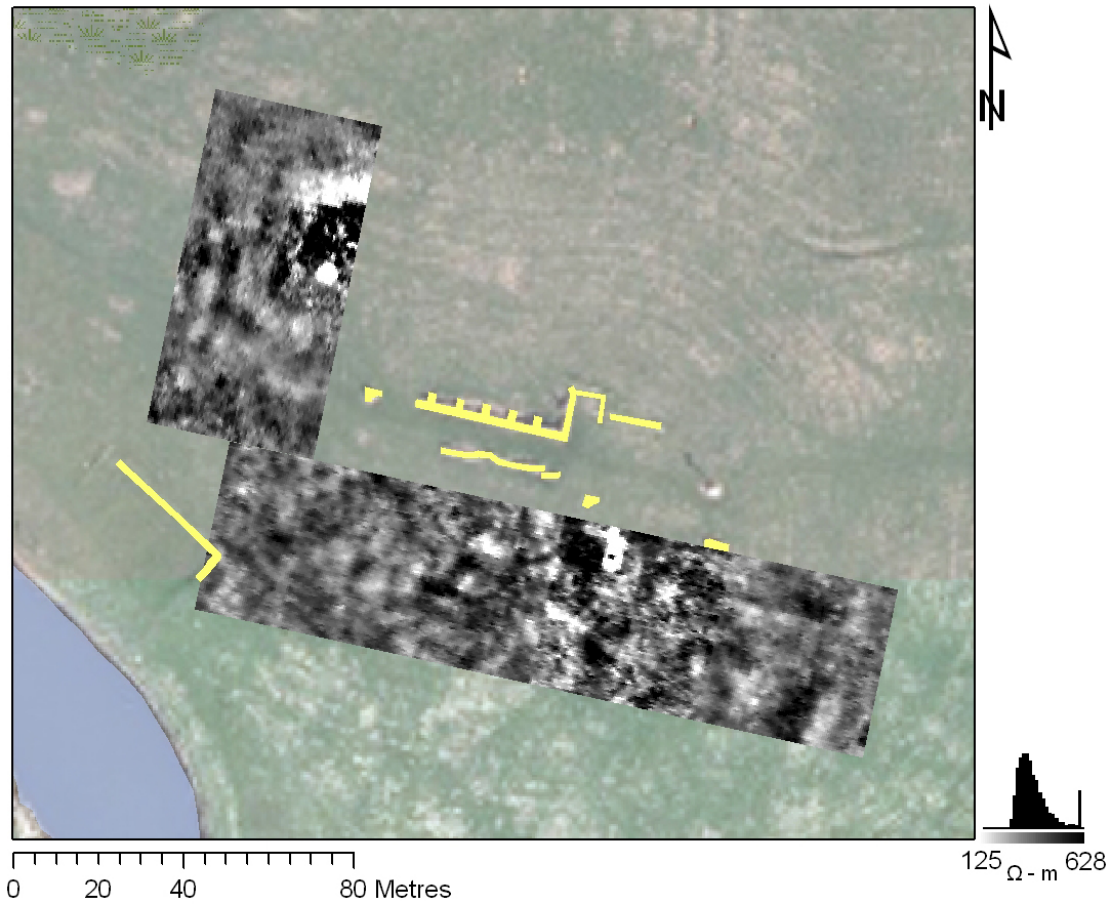

Figure 2: Resistivity survey data. Extant remains marked in yellow.

6 Interpretation

The following interpretation of the survey results aims to draw out the most important aspects relating to the former abbey buildings, with the main focus being on those forming the abbey cloister. Much of the interpretation is framed with reference to the published guidebook to the site [3]. In considering an interpretation of the results, it is necessary to bear in mind the known historical accounts of the abbey complex. In keeping with monastic tradition, numerous phases of construction and refurbishment followed the succession of abbots, adding the cloister (in two phases), chapter house, dormitory, refectory, eastern bell tower and later an infirmary cloister and associated chapel [3]. However, by the end of the 16th Century, most of the abbey buildings are thought to have been pulled down, dismantled for building material, while the 19th Century saw fresh excavations at the site of soil for fertiliser. It is against this background that the accumulative maps

of geophysical data have to be interpreted.

6.1 Principal abbey buildings

One of the primary aims of the study was to investigate the sub-surface survival of remains immediately to the south of the church known to have once surrounded the abbey cloister. At first glance, the magnetic measurements over this area do not appear too revealing (Figure 3). What is interesting, particularly in relation to the larger magnetic responses seen to the south, is the overall lack of well defined signals, except for the cluster of discrete, high amplitude anomalies highlighted, most likely representing ferrous debris. A particularly quiet area seems to define two adjoining rectangular areas, outlined in Figure 4. It seems possible that this magnetically quiet area reflects the position or footprint of a former range of buildings, although nothing detectable seems to remain of their corresponding footings. In this instance, the overall lack of disturbance compared with conditions outside the building footprint results from the degree of protection afforded by a floored/covered space over time, even in a derelict state. Another seemingly well defined area can also be seen immediately to the north, as a square of diffuse magnetic responses, highlighted in Figure 5. Measuring ca. 20 m across, the size and location of this area makes it tempting to identify it with the likely location of the abbey cloister. Taken together, a reasonable guess at the location of the main cloister complex can be made.

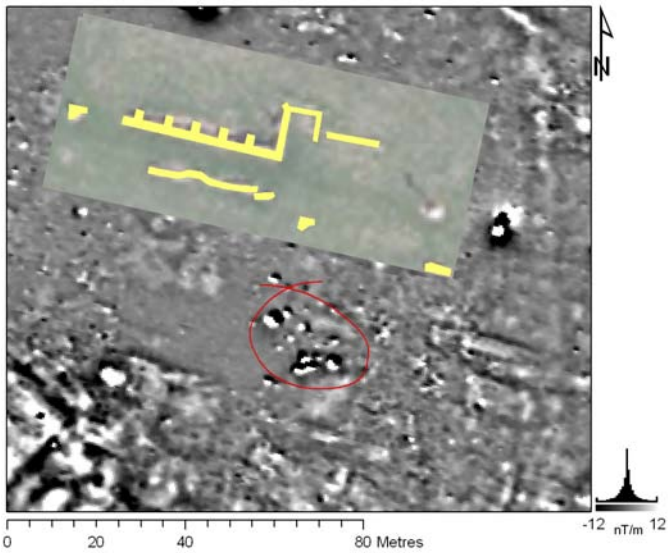

Figure 3: Magnetometer survey data south of the church. High amplitude anomalous responses highlighted.

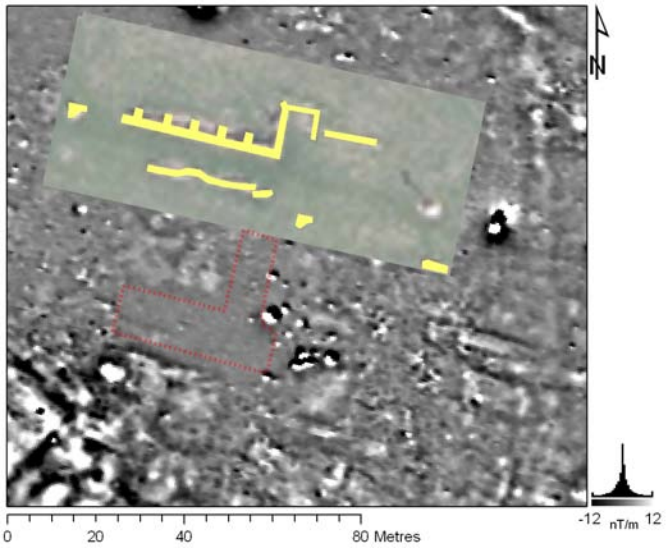

Figure 4: Magnetometer survey data south of the church. Magnetically quiet area highlighted.

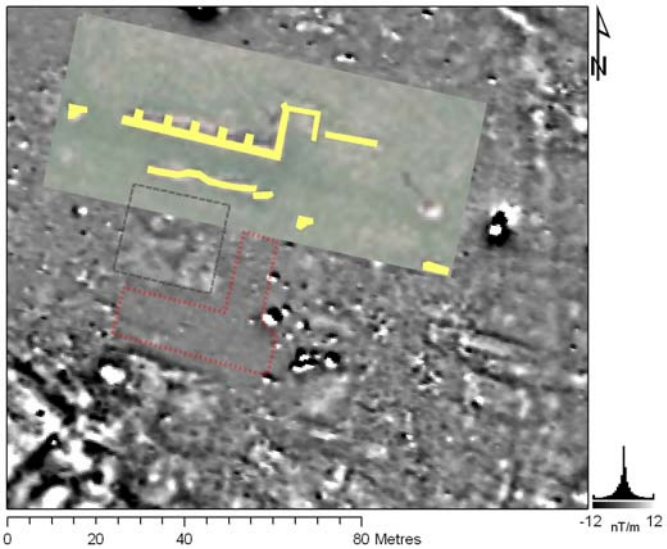

Figure 5: Magnetometer survey data south of the church. Area of 'diffuse' responses highlighted.

A closer look at magnetic map also reveals a few faint linear anomalies that conform to the same alignment as the church and features discussed above. Figure 6 shows a few such anomalies highlighted, which although weak, may indicate the surviving remnants of building foundations or footings.

To gain further information relating to surviving remains within this area, earth resistance measurements were also undertaken, the results of which are shown in

Figure 7. In contrast to the magnetometer survey, the resistivity measurements reveal greatly contrasting sub-surface conditions. This is most evident over the area highlighted, with highly contrasting values indicating a spread of building material likely to result from demolition activities. Along the northern edge of the disturbed area is a well defined sub-rectangular block of high resistance values (black) most likely to be produced by a large section of surviving masonry - see Figure 8. Perhaps the best evidence for the extent to which the foundation stone has been robbed or quarried can be seen to the east (Figure 8), where a coherent line of low resistance (light grey) anomalies indicate the positions of 'robber' trenches from which the foundation stone has been removed.

The resistivity survey also revealed a few linear high resistance anomalies potentially indicating areas where elements of foundation material do survive in situ. Some of these are indicated in Figure 9 and correlate well with those detected by the magnetometer survey.

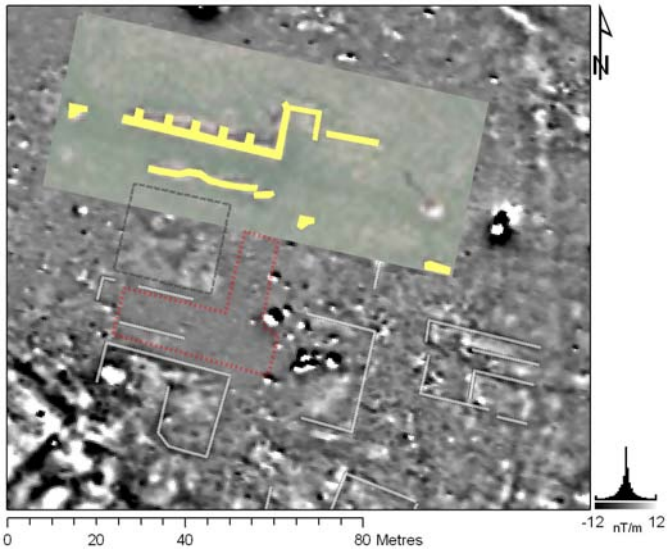

Figure 6: Magnetometer survey data south of the church showing anomalous linear responses possibly related to surviving wall foundations.

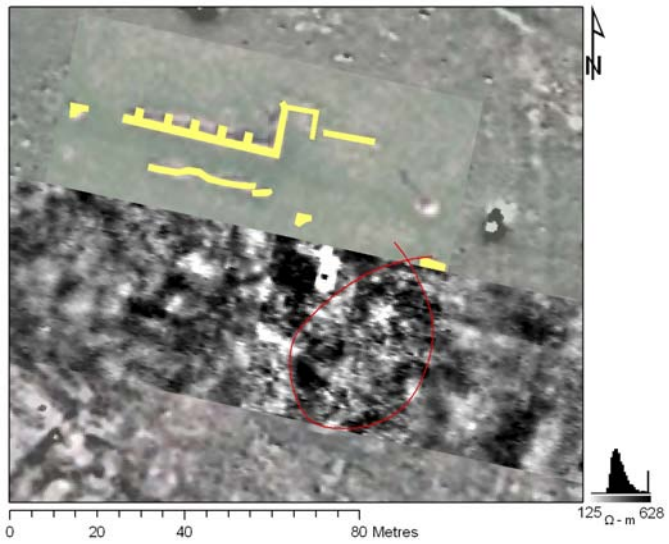

Figure 7: Resistivity survey data south of the church.

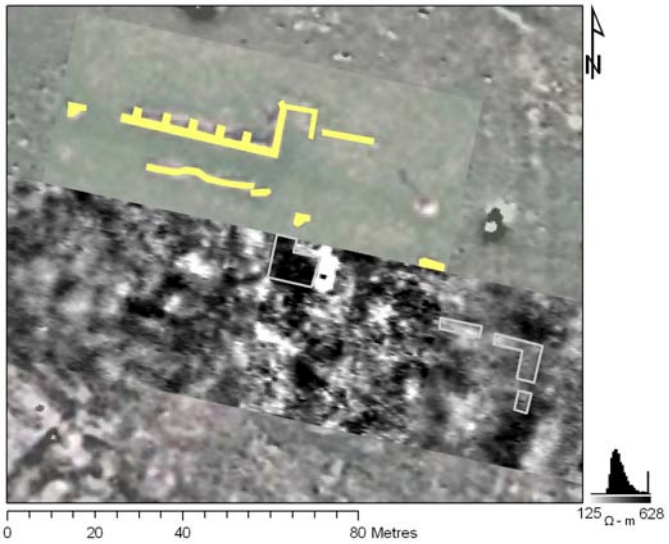

Figure 8: Resistivity survey data south of the church showing anomalous responses discussed in the text.

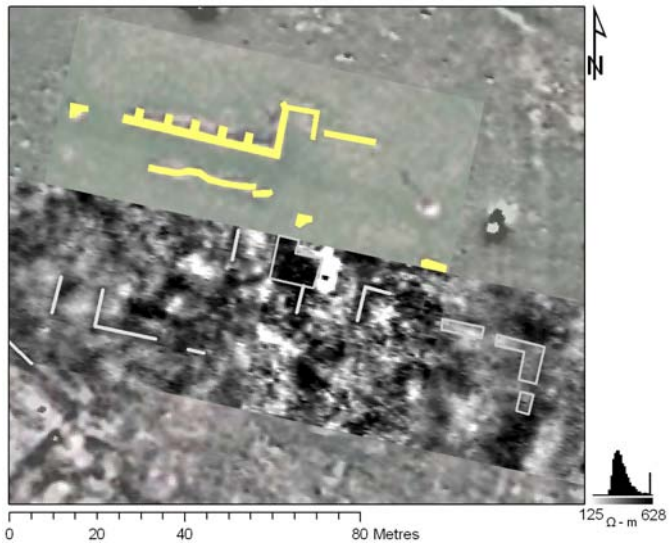

Figure 9: Resistivity survey data south of the church showing anomalous linear responses possibly related to surviving wall foundations.

Another interesting feature to emerge from the resistivity survey is an additional orientation of recorded anomalies in the western portion of the survey, highlighted in Figure 10. These appear to be orientated at ca. 45 degrees from the alignment of the church and associated remains discussed above, overlying the area postulated to have once been occupied by the cloister and southern range of buildings. It can be seen that they do in fact align with the building outline immediately to the south detected by the magnetometer survey (discussed below) and that the resistivity measurements also pick up the surviving wall foundations of this structure. One possible explanation might be the continued reuse and later expansion of this building in the late medieval period after the principal abbey buildings had been demolished. The anomalous responses themselves are quite faint and may relate to some sort of enclosed area.

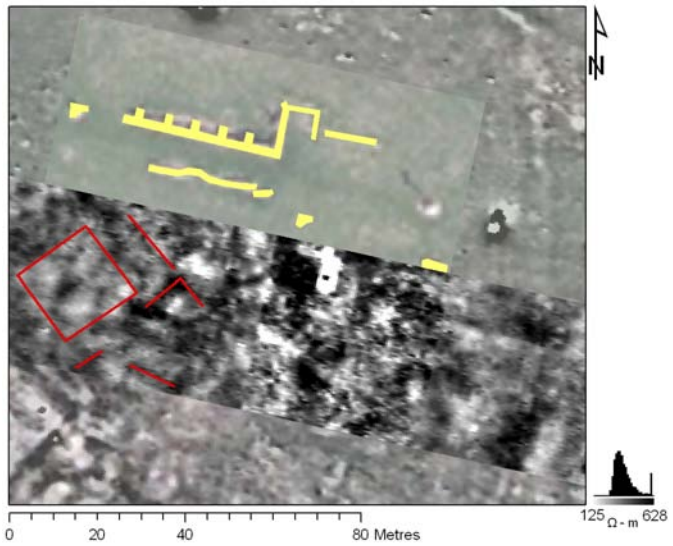

Figure 10: Resistivity survey data south of the church showing linear anomalous responses respecting an alternative alignment.

6.2 Buildings to the south of the church complex

The clearest evidence for the sub-surface survival of building remains comes from the area to the south between the church and the river, over which the magnetometer survey revealed the planform of what appears to have been an extensive complex of buildings (Figure 11). The strength and clarity of these anomalies indicates the survival of significant foundational elements. In particular, the ground plans of two, fairly large buildings can be readily picked out (marked 'B' and 'C' in Figure 12). This contrasts strongly with the situation outlined in 6.1 above and might be explained by the lower-lying position of these remains, with water logging potentially making the removal of footings more difficult. Alternatively their juxtaposition to the river may have extended their usefulness in the post-monastic use of the site.

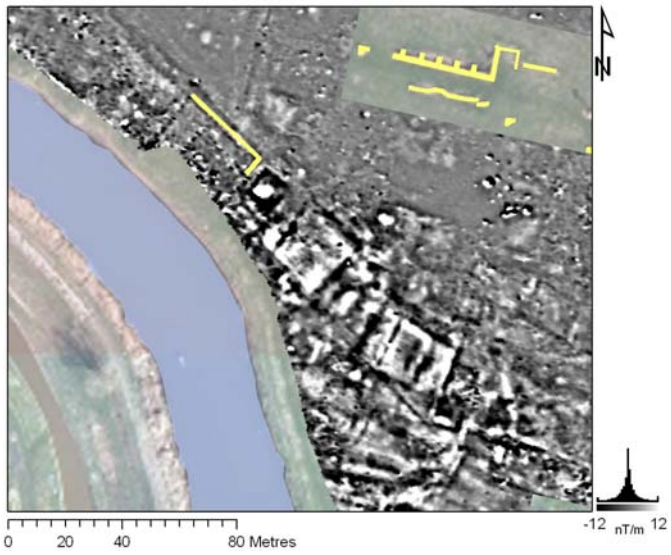

Figure 11: Magnetometer survey data showing the responses from a number of surviving building foundations in the southern portion of the study area.

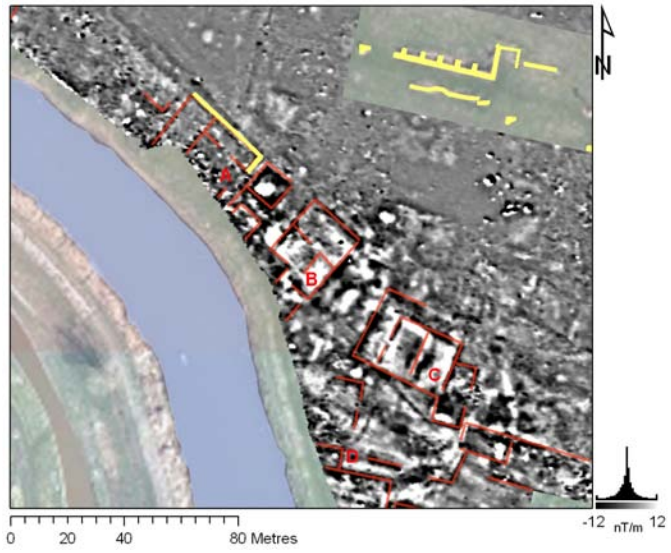

Figure 12: Interpretation showing the likely location of surviving building wall foundations of prominent structures.

6.3 St Benet's House/The Chequers Pub

A stretch of extant wall at the site of St Benet's House (labelled 'A' in Figure 12) lines up well with the plan present on the 1st Edition Ordnance Survey Map, forming a portion of the northernmost wall (see Figure 13). Magnetic anomalies identified as wall foundations over this area also line up well with the former

building, showing some of the internal dividing walls. The 6-inch to the mile series of maps were completed for Norfolk by 1886, perhaps indicating the general extent of St Benet's House at that time, prior to the recorded fire of 1891. The magnetometer survey data indicate a further range of buildings in close proximity and on the same alignment to the southeast, which may have once been associated with this building. Particularly intriguing is the adjacent small square building measuring 10 x 10 m (see Figures 11 and 12). The contrasting clarity with which surviving foundations (black) are seen against a highly magnetic (white) interior are suggestive of burning and it is possible that this structure was part of the late medieval building destroyed by fire.

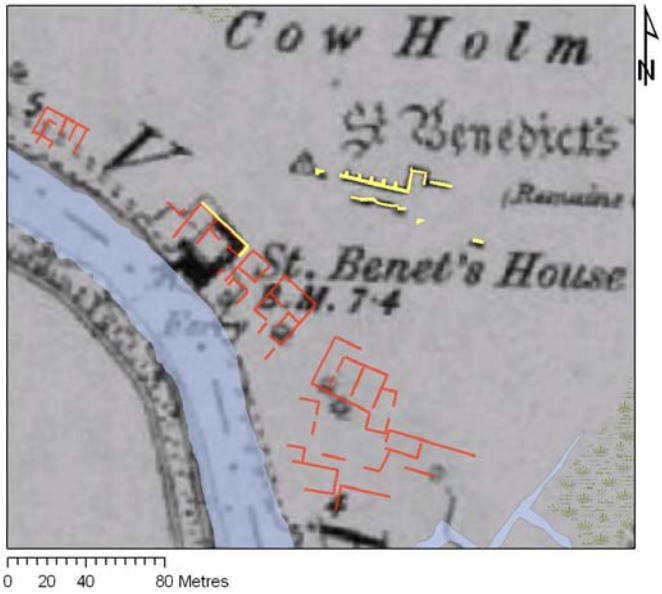

Figure 13: 1st edition Ordnance Survey map showing the location of St Benet's House and correlation with extant wall remains and surviving foundation detected by the magnetometer survey.

6.4 Buildings 'B', 'C' and 'D'

Dating these apparently unrobbed structural remains is difficult, although some clues might lie in their apparent orientation. Building 'B' represents a the remains of a significant structure, measuring 43 m x 25 m, with a number of internal walls being well defined. It can be seen that its alignment differs slightly from the river fronting St Benet's House, which might reflect its relationship to the position of a inner enclosing precinct wall and suggest its earliest phases are contemporaneous with the abbey. This interpretation is strengthened by a further small change in alignment of the slightly smaller, adjoining Building 'C'. The smaller range of

buildings extending to the southeast further suggests that originally this range of buildings followed the alignment of an inner abbey precinct (see 6.5 below) and were not wholly of a later phase of construction.

A less coherent group of anomalies consistent with surviving wall foundations can be seen further south and appear to follow a different alignment (labelled 'D' in Figure 12), placing them roughly perpendicular to the river. These are associated with extant remains adjacent to a possible jetty on the waterfront, mentioned in Pestell (2008) [3] – see Figure 1 'G' therein. The poorly defined nature of the magnetic anomalies recorded suggests these riverside buildings underwent extensive phases of redevelopment or alternatively that their proximity to the jetty made for their easy removal.

6.5 The inner abbey precinct

The magnetometer survey indicates the presence of a number of enclosing features which appear to encircle the abbey church which, along with the alignment of buildings discussed above, might be interpreted as defining a inner abbey precinct (Figure 14). The magnetic anomalies present suggest the surviving remains of a small enclosing wall with an outer ditch. Some traces of the ditch can be discerned as a depression in the sloping grassland to the north of the church. The sub-surface survival of the wall footings seems intermittent. It is difficult to know whether this inner enclosure represents the original extent of an early abbey precinct predating the extensive outer precinct wall constructed in the 14th Century, or instead was constructed to demark the 'inner court' of the abbey, or both.

To the west of the church the enclosing ditch does not appear to be present. Instead there appears to be a space in front of the wall ca. 8 m wide, in front of which may have existed a further section of wall (see Figure 15). There appears to be a well defined gap in the wall forming an entrance into the precinct which aligns with the east–west axis of the church. Some of the features here are elucidated somewhat by the earth resistance data (Figure 16), which indicate the lines of the two parallel walls as high resistance linear features with a short perpendicular wall to the north, connecting the two. To the south of the entrance, the outer wall appears to run at an angle towards the supposed southwest corner of the precinct boundary (Figure 14). Outside the precinct a diffuse spread of high amplitude magnetic anomalies were recorded which may relate to some form of industrial activity likely to post-date the life of the abbey, or even relate to its destruction. The resistivity data also indicate some interesting anomalies in the northwest corner of the enclosed area consisting of a well delineated area of high

resistance (Figure 16). There are no obvious magnetic anomalies corresponding to this feature, although there are faint traces of a linear feature running along the inside of the northern boundary wall and it is possible the area of high resistance represents some kind of compacted surface.

Figure 14: Interpretation of magnetic anomalies potentially representing an inner wall (black) and outer ditch (brown), forming an inner precinct.

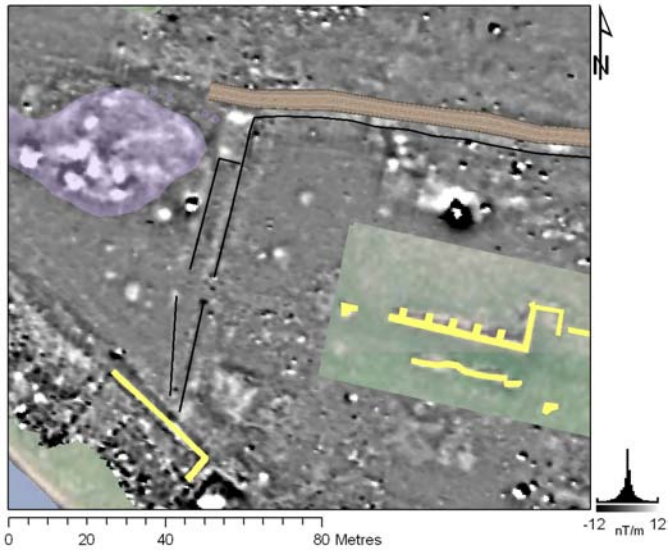

Figure 15: Interpretation of magnetic anomalies along the western section of the proposed inner precinct showing surviving wall foundations (black) and an area of high amplitude responses outside the precinct wall (purple shading).

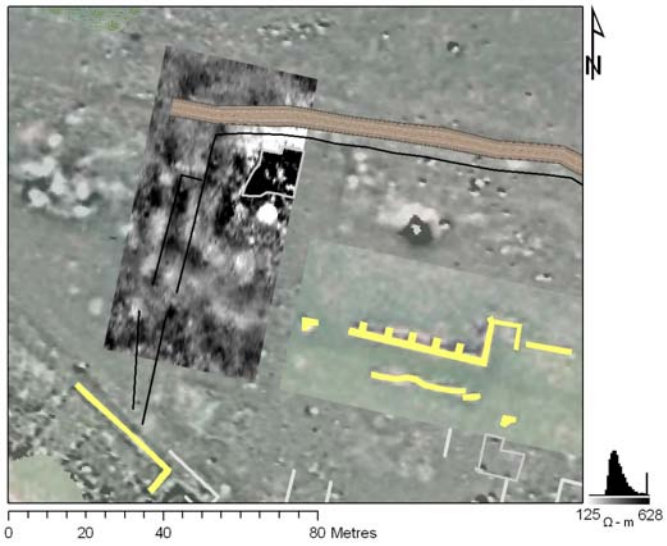

Figure 16: Interpretation of restivity measurements showing possible surviving wall foundations and structural elements inside the inner precinct (grey outline).

6.6 Cemetery

To the north of the inner precinct enclosure, the magnetic survey revealed an adjoining sub-rectangular enclosure of seemingly similar construction consisting of remnants of an inner wall and an outer ditch (Figure 17). Within the enclosed area, a fairly complex pattern of small, diffuse magnetic anomalies can be seen, indicating an area of low-level activity and disturbance. This contrasts with the areas surveyed immediately outside the enclosure, which apart from the strong collection of anomalies to the east (see below), are magnetically very quiet. It is postulated that this area might represent the remains of one of a number of cemeteries likely to have existed at the abbey. At Peterborough a lay cemetery is similarly located to the north of the cathedral building [4]. The location of individual graves are very difficult to detect geophysically, as the rapid backfilling of graves leaves little in the way of contrasting geophysical properties.

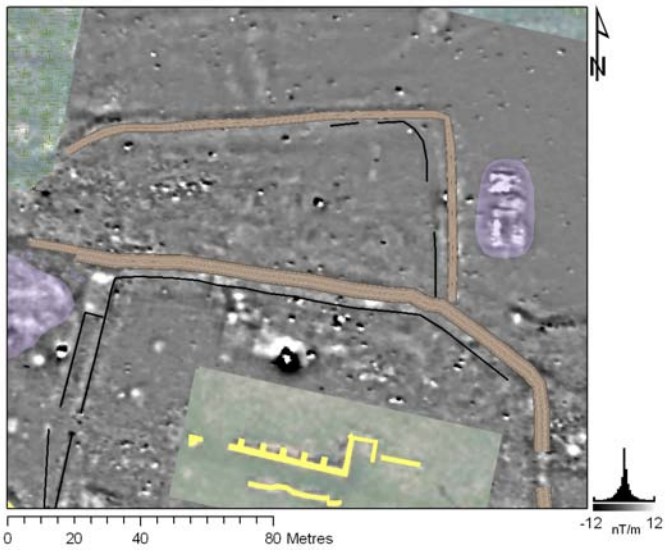

Figure 17: Interpretation of magnetometry measurements showing possible surviving elements of an enclosing wall and outer ditch in keeping with a monastic cemetery enclosure. Grouping of magnetic anomalies to the east (purple shading) interpreted as a possible rabbit warren.

To the east, outside the enclosed area in an otherwise magnetically quiet area are a series of strong anomalies forming a well delineated area orientated N-S and measuring ca. 20 m x 10 m across (see Figure 17). On the ground there is a slight topical rise over this area and it is suggested that it might relate to the remains of a rabbit warren. Ecclesiastical warrens were common in the middle ages, such as the Elmswell warren in Suffolk which supplied the abbot of St Edmunds and his retinue [5].

6.7 Land drainage

Along the southeastern margins of the study area, outside the proposed inner precinct, a network of strong linear features were recorded (Figure 18). The amplitude of these anomalies suggests they might relate to brick lined culverts forming a network of drainage channels. A long, curved collecting channel runs from the bottom of the survey area in a NNE direction and seems to connect to several radiating channels. It is hard to know whether these works are contemporary with the abbey or relate to some later programme to drain the low lying land, perhaps associated with the earlier drainage mill, located in the southernmost corner of the site. A possible clue might be in what appears to be an area of robbed out building foundations east of the church buildings, apparently cut by the collect-

ing drain (Figure 19). The weak and somewhat diffuse positively trending linear anomalies are often synonymous with robber trenching (cf. evidence for robber trenching revealed in the resistivity data in 6.1 above).

Figure 18: Interpretation of magnetometer survey data showing possible surviving elements of a network of drainage culverts and ditches.

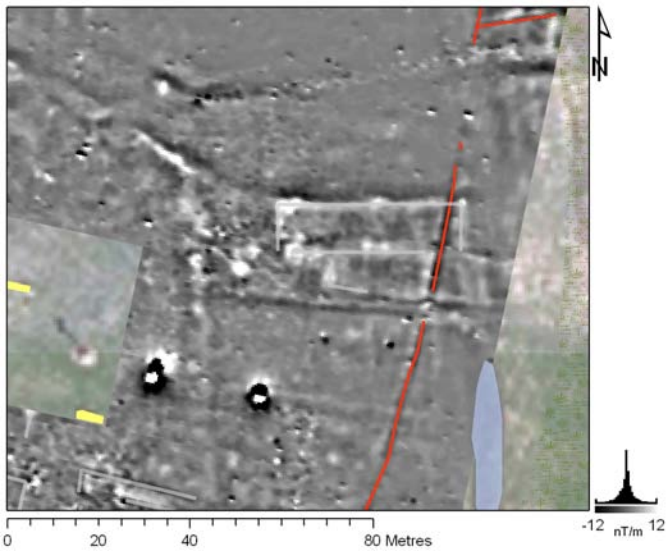

Figure 19: Interpretation of magnetometer survey data showing possible foundations of a large building, cut by the construction of a later drainage culvert.

7 Conclusions

The geophysical survey of St Benet's Abbey has proved effective in mapping surviving sub-surface elements relating to the former layout of the abbey and later activity on the site. From the interpretations discussed above, the following conclusions might be drawn:

- Little survives of the principal range of buildings connected to the south of the church. The survey indicated a few surviving wall elements as well as signs of surviving robber trenches used to remove foundation stone. Magnetic 'shadows' may indicate the location of the main cloister and attendant buildings to the east and south, although together these anomalous features are not sufficient to allow a meaningful reconstruction of the cloister buildings.
- Further south towards the river, a complex network of building foundations appear to survive largely in tact, representing the remains of a substantial range of buildings postulated to sit along the southern boundary of an inner abbey precinct and some may pertain to the Bishop's residence. The survival and continued use of these buildings is known to extend into the post–medieval period (St Benet's House), and others in the complex might well have continued in use after the demolition of the abbey. Results from the southernmost area of the survey along the river frontage indicate an intensity of use that most likely continued after the abbey ceased to exist.
- An inner abbey precinct, consisting of sections of surviving wall foundations and an outer ditch appears to have enclosed the church and main abbey buildings – an area of ca. 2.3 ha and may represent the original abbey precinct predating the construction of the more extensive 14th Century precinct wall. A well defined area to the north, also enclosed by a ditch and possible wall may represent one of the abbey cemeteries.
- Along the eastern margins of the survey area, a fairly complex network of drainage features indicates the extent to which the lowland areas surrounding the holm were managed. Dating of these features is difficult, although it is likely some of these are contemporary with the abbey.

8 Acknowledgements

The project was made possible by a grant from the Heritage Lottery Fund. I would like to acknowledge the help and keen support of Caroline Davison, Director of the

Norfolk Archaeological Trust as well as the energy and enthusiasm for the project shown by the Trust's former Director, Peter Wade-Martins. I would also like to thank Alison Ritchie of Ludham Hall Farm, for her kind logistical support.

References

[1] David, A., Linford, N. and Linford, P. (2008). *Geophysical Survey in Archaeological Field Evaluation.* Swindon: English Heritage Publishing.

[2] IfA (2013) Standards and guidence for archaeological survey. Available online at `http://www.archaeologists.net/codes/ifa.html`

[3] Pestell, T. (2008) *St Benet's Abbey. A guide and history.* Norwich: Norfolk Archaeological Trust.

[4] Britton, J. (1828). *The history and antiquities of the abbey and the cathedral church of Peterborough.* London: Longman, Rees, Orme, Brown & Green.

[5] Bailey, M. (1988). The rabbit and the medieval East Anglian economy. *The Agricultural History Review* 36, 1–20.

A Field methods

A 40 x 40 m grid was established across the survey area orientated NNE and aligned with the extant remains of the abbey church. The position of the grid was then recorded in each of the four corners using a Topcon HyperPro Global Navigation Satellite System (GNSS) with real-time kinematic (RTK) corrections typically providing 10 mm accuracy.

A.1 Magnetometer survey

Measurements of vertical geomagnetic field gradient were determined using a Bartington Grad601 fluxgate gradiometer with an instrument sensitivity of ca. 0.03 nT/m. A zig-zag traverse scheme was employed and data were logged in 40 m grid units. The measurement sample interval was 0.25m along each travers and the traverse interval was 0.5 m, thus providing 12,800 measurements per 40m grid square.

A.2 Earth resistance survey

Measurements of earth electrical resistance were determined using a Geoscan RM15 resistance meter with a mobile twin-probe configuration. Probe separation was 0.5m. A zig-zag traverse scheme was employed and data were logged in 20m grid units. The instrument sensitivity was 0.1 ohms. The sample interval along each traverse was 0.5 m and the traverse interval was 1m, thus providing 800 sample measurements per 20m grid unit.

A.3 Data processing

Data processing was undertaken using the author's own software. The following data processing routines were applied:

- Magnetic measurements: Zero mean traverse, to remove striping caused by instrument heading errors; Gaussian low-pass filter; Polynomial interpolation of traverse (X-axis) data to 0.25 m.
- Resistivity measurements: Zero mean grid, removing differences in measured background resistance; High-pass filtering; Polynomial interpolation of traverse (X-axis) data to 0.5 m.

A.4 Data Visualisation

Geophysical data were analysed using a Geographic Information System (GIS) database (ERSI ArchMap 9). The basemap is a natural colour Quickbird II satellite image ©Digital Globe 2013. The 1st edition OS map data is ©Crown Copyright 2011.