3887 Beneath the Soil from Trent to Nene: Assessment of the Performance of Geophysical Survey in the East Midlands: Archive Report

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March 2007

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Cover photograph: magnetometer survey in progress near the Roman town of *Margidunum*, Nottinghamshire. Survey by Oxford Archaeotechnics Ltd on behalf of Highways Agency. Photograph by Blaise Vyner

1 Introduction

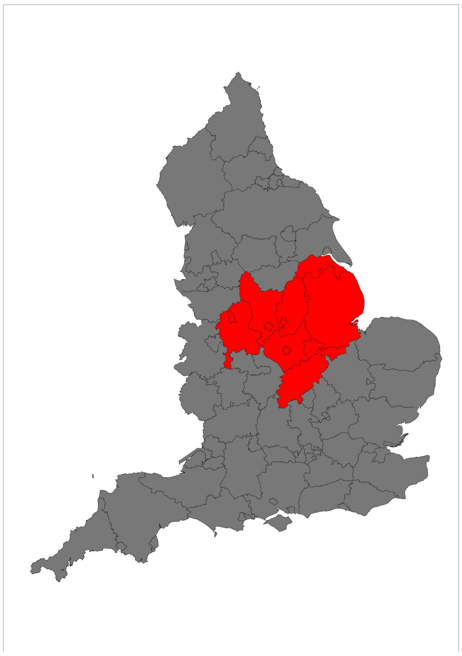


Fig.1 The study area

This project aims to investigate the effectiveness of geophysical survey as an archaeological prospecting technique in an area of the English Midlands extending between the Rivers Trent and Nene (Fig.1).

The project developed from curatorial concerns regarding the poor performance of geophysical survey in the Trent Valley, and was expanded after discussions with English Heritage to include a much larger area of the Midlands that would permit comparison between the Trent and Nene Valleys. These river valleys are two of the most productive areas for sand and gravel extraction in the UK, and it was felt that detailed analysis of the variable performance of geophysical survey in these challenging riverine environments would contribute significantly to assessments of the role of geophysics in archaeological evaluation. This significantly larger area encompasses the East Midlands Counties and Unitary Authorities of Derby City, Derbyshire, Leicester City, Leicestershire, Lincolnshire, North Lincolnshire, North-East Lincolnshire, Northamptonshire, Nottingham City, Nottinghamshire and Rutland. The East Midlands study area was extended to include Peterborough, Stoke-on-Trent and Staffordshire, thereby permitting inclusion of geophysical data obtained from the entire length of the Trent Valley and from the Nene Valley upstream of the Cambridgeshire Fens.

Analysis of the effectiveness of geophysical survey is based in this study upon analyses of geophysical reports deposited in Historic Environment Records (HERs). It is recognised that an unknown number of geophysical survey reports have not been deposited in HERs, and quite possibly that surveys deemed not to have yielded useful archaeological results may be especially underrepresented in this archive source. With these provisos, however, we would argue that the total of 2,882 survey events examined during this survey provides a sufficiently representative sample to justify general conclusions on the effectiveness of different geophysical techniques and spatial variability in their performance. In particular, with a total of 566 Trent Valley survey events recorded in HERs, there now exists a solid body of data for assessing the effectiveness of geophysical survey in this aggregates-rich environment.

2. Relevance to current ALSF Criteria

The project addresses directly the following headline objectives of the English Heritage Aggregates Levy Sustainability Fund (ALSF):

- developing the capacity to manage aggregate extraction landscapes in the future
- delivering to public and professional audiences the full benefits of knowledge gained through past work in advance of aggregates extraction
- research to enhance understanding of the scale and character of the historic environment in aggregate producing areas in order to provide the baseline information necessary for effective future management

- the archaeology of the Quaternary Period: research to characterise the resource and to develop evaluation frameworks, predictive tools and mitigation strategies

- methodological and technical development, in particular remote sensing, geophysical survey and predictive techniques and the development of mitigation strategies

- training and professional development: programmes to raise awareness, to improve the quality of historic environment work undertaken in response to aggregate extraction, and to develop and promote the uptake of best practice

- the analysis and dissemination of important data from past work undertaken in response to aggregate extraction

The focus upon ground-based geophysical techniques addresses directly an issue of crucial concern in the formulation of archaeological Schemes of Treatment in areas such as the Nene or Trent Valleys where aggregates extraction is proposed. Discussions with regional archaeological curators by the authors and by Drs Jim Williams and Neil Linford of English Heritage confirmed the substantial support for this scheme in the curatorial profession. Archaeological curators have long felt that determination of the most appropriate conditions for application of each of the key geophysical techniques should permit more effective geophysical prospection for archaeological sites, using complementary techniques, and hence should enhance significantly the process of archaeological evaluation.

3 Aims and Objectives

This project aimed to provide a database of geophysical survey reports contained in East Midlands HERs, and by analysing these to assess the effectiveness of geophysical survey in the study area as defined in Section 1.

The key objectives may be summarised as follows:

- Identify sites within the study area that have been the subject of geophysical survey and compile as a research resource a corpus of geophysical reports contained in the region's HERs.

- Compile a database and metadata, based upon HER information from the region, compatible with and transferable to the EH geophysics database (EHGSDB).

- Analyse geophysics reports contained in HERs to establish the effectiveness of geophysical survey as an archaeological prospecting method. The main focus of analysis rests upon comparisons between geophysical surveys in the contrasting geological conditions of the Nene and Trent Valleys, although fruitful comparisons may also be drawn with the results of work carried out in other areas of the East Midlands. Effectiveness has been measured by comparing the results of geophysical survey and excavation, with consideration of the variation of individual geophysical techniques over different drift and solid geologies and archaeological features. This will inform curators, geophysical contractors and archaeological consultants of appropriate geophysical methodologies that may be applied within the challenging conditions associated with aggregate extraction sites in these valley environments.

- Produce a full archive report, to be distributed to English Heritage, archaeological curators within the study area and other interested parties. The chief purpose of this is to inform curators, geophysical contractors and archaeological consultants of appropriate geophysical methodologies for use in the context of aggregate extraction sites.

- Publish a synthetic review, summarising the aims, objectives, methodology and results of the project, with recommendations for the further use of geophysical surveys.

- Publicise the results of this survey by a series of presentations to archaeological curators, staff of contracting units active in the study region, representatives of English Heritage, members of the Association of Local Government Archaeological Officers (ALGAO) and other interested parties.

4 Links with other ALSF Projects

This project is one of several recently completed and current ALSF projects incorporating assessments of the effectiveness of geophysical survey as a method for locating and investigating archaeological sites. These include a review by Terra Nova Ltd of geophysical surveys conducted in aggregates-related archaeology in north-western England (Jordan 2006; http://www.terranova.ltd.uk/ALSF%20NW%20Geophysics.doc) and, within an East Midlands context, two projects focused upon the confluence of the Trent with the Rivers Soar (Carey *et al* 2006) and Tame (*Where Rivers Meet: Landscape, Ritual, Settlement and the Archaeology of the River Gravels*: available at http://www.arch-ant.bham.ac.uk/research/ fieldwork research themes/projects/whereriversmeet/index.htm) The data collected during these projects should provide a sound basis for a wider synthesis of the effectiveness of different geophysical techniques and methodologies in a wide range of environments. In addition, comparison of the effectiveness of the methodologies employed in these projects should expedite the design of subsequent projects aimed at assessing the value of geophysical survey as a method of prospecting for archaeological sites.

5 Relationship to English Heritage Research Objectives

The project has been designed to fulfil the research priorities identified in English Heritage's *Implementation Plan for Exploring Our Past* (1998) and the *Archaeology Division Research Agenda* (1997). It fulfils most of the selection criteria in the *Implementation Plan for Exploring our Past* (2003) and in particular:

- supports *The Historic Environment: a Force for Our Future* (2001) and *Power of Place: the Future of the Historic Environment* (2000).
- supports best management of the archaeological resource
- encourages innovative approaches to data-collection, analysis and dissemination
- helps to develop and support best practice

The project contributes significantly to the Primary Goals specified in the *Archaeology Division Research Agenda,* and in particular to the goals listed under headings **A1, B4, B5** and Methodological and Technical Development **(MTD) 2**. It also addresses goals listed under the headings of **A5, A6, B2, B6, B7, C1, C4, E3, E4, E5, MTD1, MTD6, MTD9 and MTD12**. With respect to the Programmes and Sub-Programmes defined in *EoP98*, the project makes particularly important contributions to **MTD 17.1, 17.1, 17.6, 17.9 and 17.12**, and further significant contributions to **Sub-Programmes 1.3, 1.7, 2.3, 2.4, 2.5, 6.5, 7.2, 7.3, 16.2, 16.3, 16.5, 16.6 and 16.12.**

6 Methodology

Data have been collected on geophysical surveys conducted before January 2006 in the East Midlands administrative authorities of Derby City, Derbyshire, Leicester City, Leicestershire, Lincoln City, Lincolnshire, North Lincolnshire, North-East Lincolnshire, Northamptonshire, Nottingham City, Nottinghamshire and Rutland. The data collection area was extended westwards into the West Midlands to include the areas administered by Staffordshire County Council and Stoke-on-Trent City Council and eastwards to encompass Peterborough City.

The desk-based analysis commenced in March 2006 and proceeded through seven key stages.

6.1. Database Design

An appropriate database was designed by Alastair MacIntosh in consultation with English Heritage prior to the commencement of the HER visits. This represents an enhanced version of the English Heritage Geophysical Survey Database (EHGSDB), supplemented by tables aimed at assessing effectiveness and conditions.

6.2. Data Collection

The following sources were used to identify archaeological sites where geophysical surveys had been conducted:

- Historic Environment Records (HERs) housed in the offices of the following organisations:
    - Derbyshire County Council, Matlock (includes data for Derby City Council, Derbyshire and also the Peak District National Park)
    - Leicester City Council, Leicester
    - Leicestershire County Council, Leicester (includes data for Leicestershire and Rutland)
    - Lincoln City Council, Lincoln (UAD archive data)
    - Lincolnshire County Council, Lincoln
    - North Lincolnshire Council, Scunthorpe
    - Northamptonshire County Council, Northampton
    - North-East Lincolnshire Council, Grimsby
    - Nottingham City Council, Nottingham
    - Nottinghamshire County Council, Nottingham
    - Peterborough City Council, Peterborough
    - Staffordshire County Council, Stafford
    - Stoke-on-Trent City Council, Stoke-on-Trent

  Each of the above HERs was visited by Eileen Appleton to establish the likely size of the resource. Preliminary assessment of the contents of each HER suggested a total of 1393 survey reports (Knight and Pearce 2005: Appendix 1). Detailed analyses of geophysics reports later showed this to underestimate significantly the total number of geophysical surveys - due largely to the disproportionate impact upon the number of geophysical events of a small number of major pipeline schemes in which geophysics had figured prominently. The final total of geophysical survey events reached 2,882, which lengthened significantly the time required for data inputting but yielded a large database with significant scope for detailed quantitative analysis.

- The Bibliographic Database of Archaeology in the Trent Valley, completed as part of the Trent Valley GeoArchaeology 2002 ALSF research project (http://www.tvg.org.uk/; Brookes 2003). This provides a comprehensive review of all grey and published literature within a substantial portion of the proposed study area.

  The bibliographic database is available on-line via the Archaeology Data Service (http://ads.ahds.ac.uk/catalogue/specColl/trentvalley_eh_2004/index.cfm?CFID+507139&CFTOKEN=74560359).

- English Heritage Geophysical Survey Database (EHGSDB). Although the EHGSDB primarily contains records of geophysical surveys conducted either directly by English Heritage or where scheduled ancient monument consent was required, it is widely available via the internet and contains searchable information fields entirely pertinent to the current study (http://sdb2.eng-h.gov.uk). It was also proposed that all data relating to geophysics on previous sites, identified through the desktop study, be recorded on the EHGSDB as part of the project.

The process of data collection proceeded as follows:

- Sites within the study area where geophysical surveys had been carried out were identified during visits to the above HERs. Copies were located in each HER of the geophysical reports pertaining to these sites. Where permitted by the copyright holder, a photocopy of each of these reports was taken and incorporated in the report archive housed at the University of Nottingham

- Other reports in the HER containing data relevant to interpretations of the geophysical reports data were identified. Appropriate sections of these were photocopied and incorporated in the project archive.

- The Bibliographic Database of Archaeology in the Trent Valley and the EHGSDB were searched to identify geophysics reports not listed in the HER. These were listed in the database, but analysis was restricted to reports obtained from HER sources.

6.3. Compilation of Database

Data were entered into the database in parallel with and subsequent to the identification and copying of reports. Information obtained from each site includes: parish, site name, OS grid reference and other locational details, NMR/SMR numbers, bibliographic references (author, date, title of report, *etc*.), factors that may impact upon the effectiveness of geophysical survey (notably drift and solid geology, land use, weather conditions, soil moisture, cultivation state, vegetation, surface contamination, time of year, instrument type and field methodology), assessment of the effectiveness of geophysical survey by comparing the results of geophysical prospection and archaeological excavation, and a summary description of the archaeological remains. Full details of the database are recorded in Section 7.

6.4. Data analysis

The factors that may have contributed towards the variable success of the geophysical techniques employed in the Trent and Nene Valleys were assessed from data collected during surveys of, these regions. Fruitful comparisons were also drawn at this stage with the results of work carried out in other areas of the East Midlands, but the main focus of analysis rested upon comparisons between geophysical surveys in the Nene and Trent Valleys. Appropriate time was allowed during this stage of the work for consultation of associated published and grey reports, with the aim of investigating the character of the associated archaeology and factors that may have influenced the effectiveness of geophysical survey (notably soils, geology, land use, weather conditions, soil moisture, cultivation state, vegetation, contamination, time of year, instrument type and field methodology).

6.5 Presentations of results

Project presentations were made at English Heritage geophysics training days at Cambridge, Birmingham and Northampton, covering respectively the English Heritage Eastern Region, West Midlands and East Midlands, to meetings of representatives of ALGAO at Leicester and York, and to regional curators, contracting unit staff, English Heritage representatives and other interested parties at a conference organised at the British Geological Society, Keyworth, by Trent Valley GeoArchaeology,

Preliminary findings of the investigations were presented at two major international conferences: GeoArchaeology 2006, held at Exeter University in early September 2006, and the annual conference of the European Association of Archaeologists, held in Krakow, Poland, in late September 2006.

6.6. Archive report and publication

The current report has been distributed as a paper copy and as a PDF report to English Heritage, all archaeological curators within the study area and other interested parties, and as an electronic version for the ALSF and ADS websites. A review has been submitted to *Geoarchaeology, Climate Change and Sustainability*: a special volume of the Geological Society of America, edited by Professors Karl Butzer and Tony Brown, which will comprise a series of peer-reviewed papers based upon presentations to the GeoArchaeology 06 conference at Exeter University. This provides a synthesis of the full archive report, with particular emphasis upon the factors influencing the outcome of geophysical surveys and recommendations for the future use of geophysical prospecting.

6.7 Data storage and dissemination

The paper archive of geophysical reports relating to sites within the region has been deposited in the Archaeology Department of the University of Nottingham. Electronic data collected during the course of this project have been submitted to the EHGSDB to ensure that these are fully accessible for future work.

7.Geophysics Database

It was decided that the project database should be fully compatible with the English Heritage Geophysical Survey Database (EHGSDB) as this would allow additional geophysical surveys to be added to the 298 records from the study area that existed in the EHGSDB prior to the commencement of this survey (increased by *c*.970% during the course of this project to 2882 records). This was achieved by the addition of certain project-specific elements (Section 7.4) and by certain other alterations implemented to ensure that the project could be completed on time and within budget (Sections 7.1-7.3).

It should be noted that the native format of the EHGSDB is Oracle 7, while the East Midlands database is maintained in Microsoft Access. These different formats, however, have posed no problems of compatibility.

7.1. Alterations to EHGSDB Structure

Although all existing tables and fields within the EHGSDB have been retained in the project database, data have been entered to only a proportion of the total available fields during this project. All of the mandatory fields listed in the EHGSDB Data Dictionary have been completed, except where appropriate data are not recorded in the available geophysical reports. However, to ensure completion of the project on time and within budget, only those non-mandatory tables and fields incorporating date of direct relevance to the project objectives have been completed. All EHGSDB tables and fields that were used during this project are listed in Section 7.2

Several new fields were required for the purposes of this project (Section 7.4), but no alterations were made to the basic structure of the database. The new fields were accommodated instead in new tables, and were linked to the database by means of three existing fields (SURVEY_VISIT_NO; REPORT_ID; MONUMENT_ID). It is possible, therefore, to remove the new tables without compromising the other data collected during the project.

7.2 Completed EHGSDB tables and fields

The following tables and fields within the EHGSDB are viewed as critical to the current project and were completed as fully as possible for all new records:

- Survey Visit. *Survey_Visit_No, Survey_Name, County_Code, Survey_Start, Survey_End, Report_ID, NGR_100km_Square, NGR_Easting, NGR_Northing, NGR_No_East,* *NGR_No_North, Privacy_Code, Unitary_Authority, Min_East, Min_North, Max_East, Max_North.*

- Survey Technique. *Technique_No, Survey_Visit_No, Survey_Type, Method_of_Coverage, Traverse_Separation, Reading_Interval, Instrument_Type, Instrument_Make, Probe_Configuration, Probe_Spacing, Land_Use, Area_Surveyed.*
- Report. *Report_ID, Title, Report_Date, Author, Holder, URL.*
- Classification. *Class_ID, Survey_Visit_No, Monument_Type, Monument_Period, Source, Monument_ID.*
- Survey Role. All Fields.
- Survey Personnel. All Fields.
- Monument Classification. All Fields.
- Related Monument. All Fields.
- Related Drift Geology. All Fields.
- Related Solid Geology. All Fields

7.3 Unused EHGSDB tables and fields

The tables listed below are for archiving rather than analytical purposes. They contain no fields detailing the survey methodology or results, and hence have been excluded from the current project.

- Tape Archive. It is not considered that knowledge of the physical whereabouts of the Survey Data will be needed in the evaluation of its effectiveness.
- Further Comments. In order to speed completion of the East Midlands database, it is intended that those tables and fields relying on free text entry should not be completed for new entries.
- Survey Comments. As 2 above.
- Report Summary. As 2 above.
- Address. There is no scope in the project design for personal communications with clients or contractors. Therefore there should be no need to include their addresses or contact details
- Bibliographic References. Bibliographic information can be found to the required level as part of the REPORT table (section 7.2)

Within the remaining tables, several fields intended for archiving rather than analytical purposes have also been left blank:

- Classification – *Monument_Certainty; Broad_Term; Period_Precision.*
- Report – *Report_Series; Series_No; Copy_Held; Section42; Copy_Of_Licence.*
- Survey Technique – *Add_Remarks; Data_URL*
- Survey Visit – *Date_Cert; Visit_Purpose; Project_Title; EH_Job_No; AML_Survey_No; Report_Status; Primary_Archive; Data_Source; Compilation_Date; Update_Date*

7.4 Proposed new tables and fields

In order to assess the effectiveness of a given geophysical survey event, it was necessary to gather information that is not required by the EHGSDB. This information was entered into three new tables, namely Conditions, Monument Record No and Effectiveness. While it was not possible to complete all fields in all cases, each table was completed as fully as the available information would allow.

7.4.1 Effectiveness

This table provides an empirical approach to assessing the utility of geophysical methods.

- *Survey Visit Number.* A unique system number for each survey visit record. This is a linking field, to allow the new fields to be queried in conjunction with existing fields in the EHGSDB
- *Percentage Background.* The estimated percentage of background pixels to other pixels in the image.
- *Percentage Noise.* The estimated percentage of noise pixels to other pixels in the image.
- *Percentage Anomalies.* The estimated percentage of pixels in the image representing anomalies.

The above three values were estimated using percentage charts employed by the Soil Survey of England and Wales for estimating mottles, stones, nodules, etc. (Hodgson ed 1976 , fig.5). These fields are intended to give an objective measure of how effective a survey was, regardless of any interpretation carried out by the contractor.

- *Plot Type* A number of different plot types may be used for the presentation of geophysical data, such as the common greyscale plot, dot-density plots and trace plots. This field allows analysis of the effectiveness of each method.
- *Processing.* It is rare for geophysical data to be presented without some form of processing, such as filters and statistical operators. If the processing tools are described, they are listed here.
- *Raw Data.* Indicates whether or not the raw data has been supplied in the report.
- *Correlation with Excavation.* A key indicator of effectiveness. By comparing the written interpretation of a geophysical plot with the proved results of any subsequent excavation it should be possible to estimate the level of agreement between the two. This is scored as a percentage range value, in twenty percent increments.
- *Comments on Correlation.* A free text field, which allows a greater depth of information to be recorded. Reports of significant interest can be flagged here.
- *Congruence with ADS Guide to Good Practice.* This indicates the level to which the report adheres to the guide's recommendations for the provision of metadata and the production of plots. This is scored as a percentage range value, in twenty percent increments, where each increment represents one fifth of the recommendations of the ADS guide. Therefore a score of 0-20% will show that the report provides one fifth of the metadata suggested by the guide, while a report that adheres closely to the ADS Guide to Good Practice (Schmidt, 2002) in all these respects would receive a score of 80-100%.
- *Feature Numbers.* This will give the number of anomalies interpreted by the surveyor as archaeological features.
- *Percentage Investigated.* The number of interpreted features investigated by excavation, presented as a percentage of interpreted features.
- *Percentage Proved.* The number of interpreted features proved by excavation, presented as a percentage of interpreted features

7.4.2 Conditions

In order to assess the effects of various environmental conditions upon geophysical surveys, the following fields were required:

- *Survey Visit No.* A unique system number for each survey visit record This is a linking field, which allows the new fields to be queried in conjunction with existing fields in the EHGSDB
- *Month.* This allows analysis of the impact of seasonal variation on the effectiveness of geophysical techniques.
- *Weather.* Adverse weather conditions may have significant effects on personnel and equipment, and therefore on the resulting survey.
- *Soil Moisture.* It is well known that free draining soils will give different results to waterlogged soils in a resistivity survey.

- *Cultivation.* Indicates the type and depth of any ploughing or harrowing prior to the survey.
- *Vegetation.* An indication of the type of vegetation growing in the survey area.
- *Vegetation Height.* The physical height of vegetation can have an impact on the logistics of a geophysical survey, hindering the production of a consistent survey.
- *Surface Contamination.* The effects of stray metal objects or modern burning events can have strong effects on magnetometer surveys.
- *Sub-surface Contamination.* Utilities such as electricity cables can influence magnetometer surveys, and will also appear on resistivity surveys. The packing of field drains can also be magnetically enhanced, as fuel ash slag is often used. Where field drains have been ploughed out, this can be spread across a wide area.
- *Masking Deposits.* Large areas of the major river valleys have deep alluvial deposits overlying or interstratified with archaeological deposits and features. This can have a clear impact on the success or failure of geophysical techniques, especially resistivity. Other deposits which may mask archaeological remains include colluvium and wind-blown sand.
- *Masking Deposit Character.* The character of these deposits can vary significantly, from thick clay alluvium to fine silt. The different effects of each deposit type must therefore be addressed.
- *Masking Deposit Thickness* (recorded in mm).

7.4.3 Monument Record Number

This table provides details of any monument of national or local significance in the survey area

- *Survey_Visit_No.* A unique system number for each survey visit record This is a linking field, which allows the new fields to be queried in conjunction with existing fields in the EHGSDB
- *Authority*. The local or unitary authority with responsibility for the monument.
- *NMR_No*. The National Monuments Record number of any previously known archaeological remains.
- *SMR_No*. The local Sites and Monuments Record number of any previously known archaeological remains.

8. Results

We identified 1,090 geophysical reports archived in the Historic Environment Records of the study area (i.e. the English Heritage East Midlands region, with the addition of Staffordshire and the City of Peterborough). Data were analysed in two basic categories. These are 'survey projects' (defined as all those surveys described in a report, n.=1,090) and 'survey events' (in the sense of those surveys carried out per block of land; there may be a variable number of events within any project; n.=2,882). Table 1 lists the spatial distribution of survey projects and events in the study area; Figure 2 provides a graph for projects and Figure 3 for events.

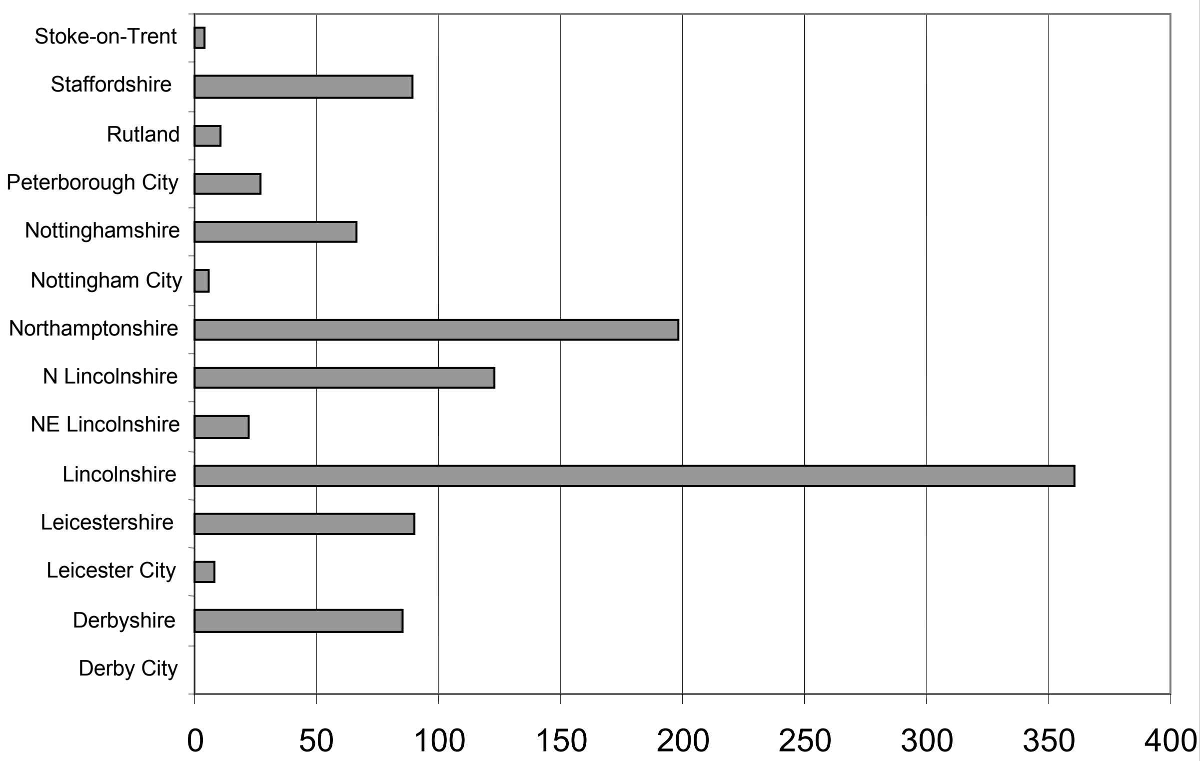
It should be noted that for the purposes of this study we have defined the Trent Valley in terms of *administrative* units, i.e. as those parishes, towns and unitary authorities which include the river valley in their territories (see Appendix 14). This definition deliberately follows that of the Trent Valley Bibliographical Database (Brookes 2002), which is available online from the Archaeological Data Service. The same criteria were used to define the Nene Valley (see Appendix 15).

It must also be stressed that geophysical research has been carried out by a wide range of bodies, including commercial contractors, research bodies and amateur groups (see Appendix 13): the standards of their work, and more crucially of reporting, are very variable. We used a number of measures to assess the quality of geophysical research and these are reported below.

Table 1. Survey Projects and Events by Authority

Authority	**N. of Survey projects**	**N. of Survey events**
Derby City	0	1
Derbyshire	85	194
Leicester City	8	13
Leicestershire	90	278
Lincolnshire	361	874
NE Lincolnshire	22	43
N Lincolnshire	123	298
Northamptonshire	198	493
Nottingham City	6	16
Nottinghamshire	66	211
Peterborough City	27	100
Rutland	11	30
Staffordshire	89	321
Stoke-on-Trent	4	10

Fig.2 Survey projects by authority



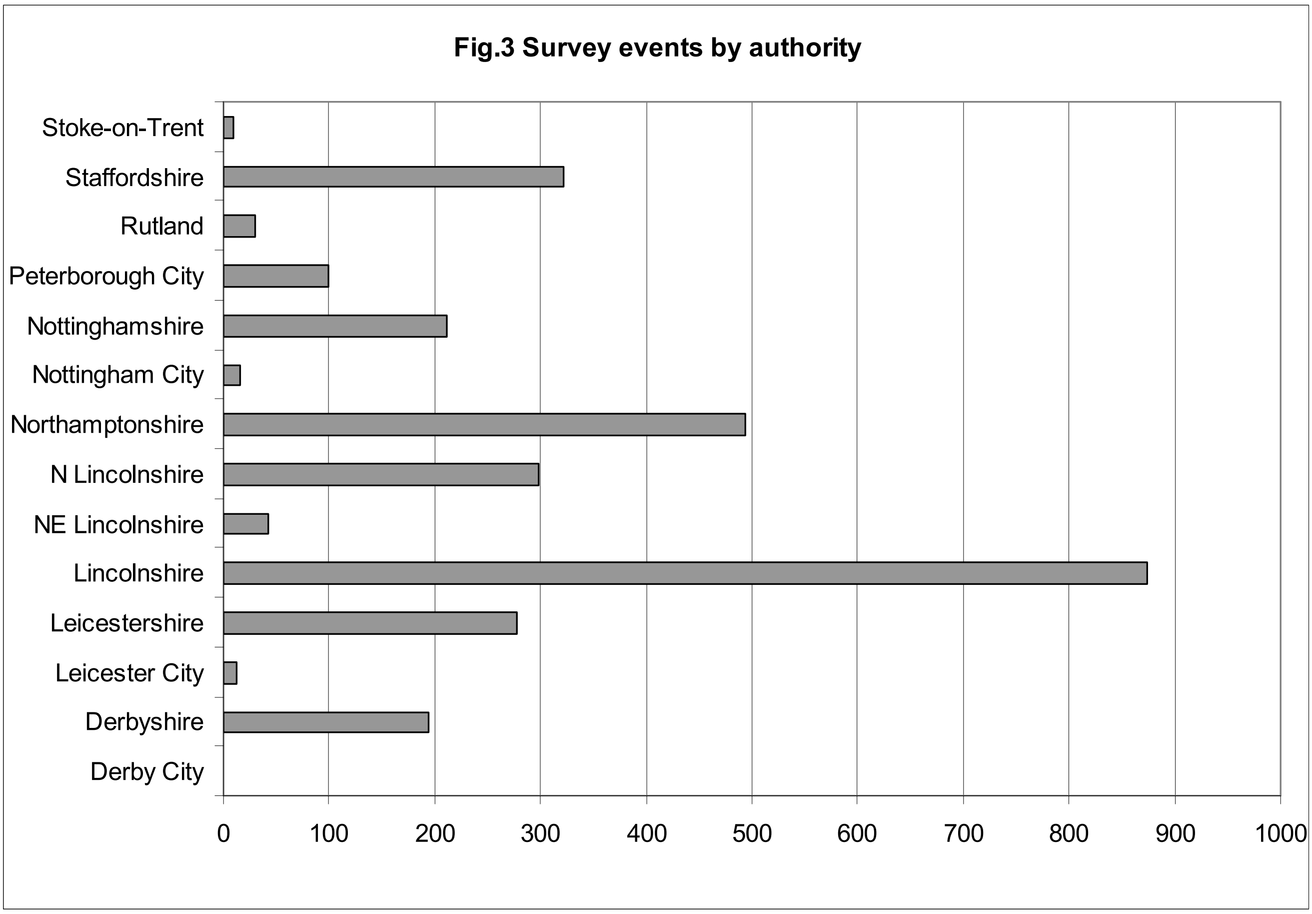


Table 1 and Figures 2 and 3 clearly indicate quite wide variability between the various shire counties and unitary authorities, but this is not just a function of the relative size of their areas, as Tables 2 and 3 and Figures 4 and 5 make clear. Data for the size of authorities is as provided by the Office of National Statistics on the following webpages:
http://www.statistics.gov.uk/geography/downloads/SAM_LAD_DEC_2004_UK.xls
http://www.statistics.gov.uk/geography/downloads/SAM_CTY_DEC_2004_EN.xls
The measure used is denoted 'AREALHECT' data and is an 'area measurement of land area only', i.e. to coastline feature boundaries (high water mark) and excluding inland water features larger than 1 km^2 (such as e.g. Rutland Water).

Although Lincolnshire is the largest county and has the most survey projects and events, it is surpassed in a simple measure of density by the Cities of Leicester, Nottingham, and Peterborough, where there is great development pressure at present, by North Lincolnshire and North East Lincolnshire, where there has been much geophysical survey activity as part of the Humber Wetlands project, and by Northamptonshire, where the River Nene largely runs. The counties of Nottinghamshire and Derbyshire, along the Trent Valley, have low densities of surveys, perhaps reflecting the lack of confidence in geophysical techniques in the area, despite development pressure, not least from aggregates quarrying. The low figures for the City of Derby may reflect the same prejudice, whilst Rutland is a largely rural county with low development pressure.

Table 2. Density of survey projects in the study area

Authority	N. of survey projects	Square kilometres	Survey projects per km^2
Derby City	0	78.03	0
Derbyshire	85	2546.71	0.033376395
Leicester City	8	73.31	0.109125631
Leicestershire	90	2082.88	0.043209402
Lincolnshire	361	5920.62	0.060973344
NE Lincolnshire	22	191.91	0.114637069
N Lincolnshire	123	846.31	0.145336815
Northamptonshire	198	2363.98	0.083757054
Nottingham City	6	74.61	0.080418175
Nottinghamshire	66	2084.77	0.031658169
Peterborough City	27	343.38	0.078630089
Rutland	11	381.51	0.028832796
Stoke-on-Trent	4	93.45	0.042803638
Staffordshire	89	2620.25	0.033966225

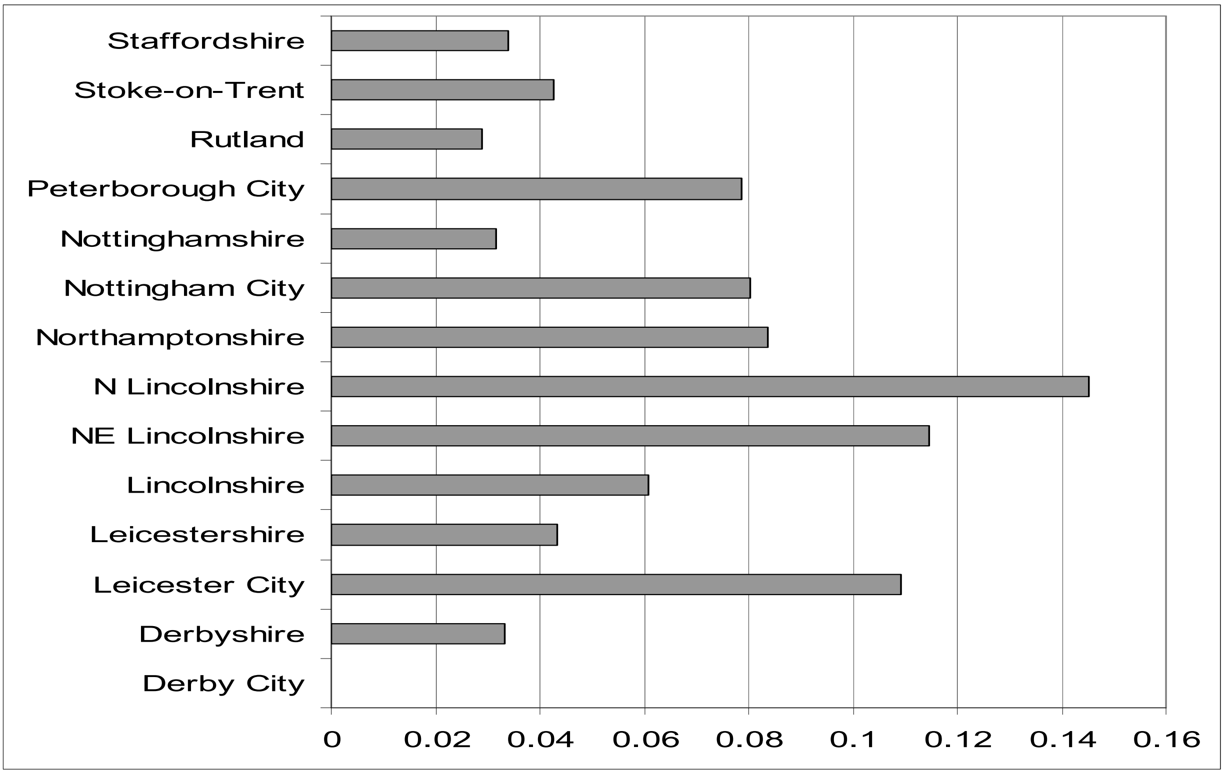


Figure 4. Survey projects per square kilometre.

Table 3. *Density of survey events in the study area*

Authority	N. of survey events	square kilometres	survey events per km^2
Derby City	1	78.03	0.012815584
Derbyshire	194	2546.71	0.073035406
Leicester City	13	73.31	0.17732915
Leicestershire	278	2082.88	0.133949147
Lincolnshire	874	5920.62	0.147619675
North East Lincs	43	191.91	0.218852587
North Lincs	298	846.31	0.352116837
Northamptonshire	493	2363.98	0.208546604
Nottingham City	16	74.61	0.214448465
Nottinghamshire	211	2084.77	0.101210205
Peterborough City	100	343.38	0.291222552
Rutland	30	381.51	0.078634898
Staffordshire	321	2620.25	0.122507394
Stoke City	10	93.45	0.107009096

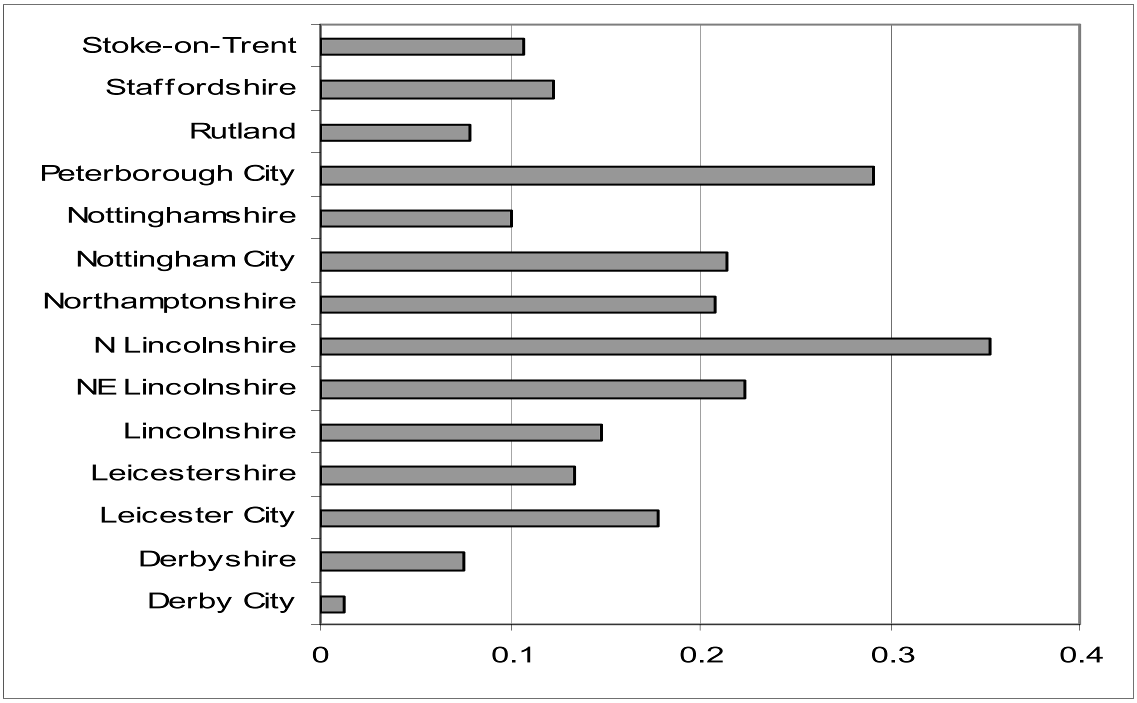


Figure 5. Survey events per square kilometre.

Table 4 and Figure 6 show the relative numbers of survey projects and events in the two river valleys and the study area.

Table 4	**Projects**	**Events**
Trent	173	566
Nene	110	290
Other	807	2026
Total	1090	2882

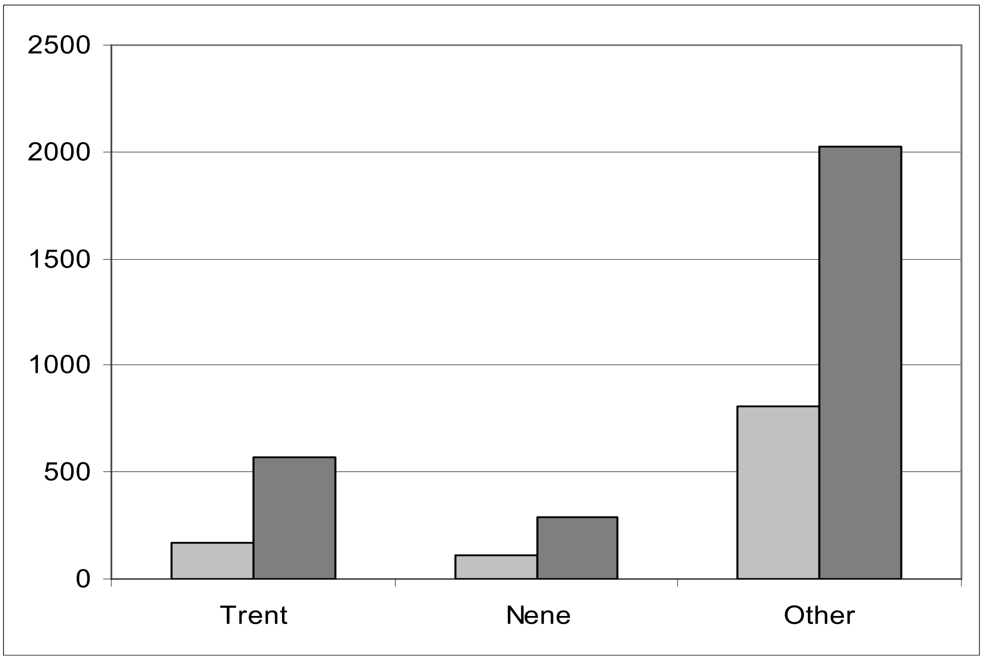


Figure 6. Relative numbers of survey projects and events in the Trent and Nene Valleys and the rest of the study area.

Figure 7 shows the temporal distribution of survey projects in the region and Figure 8 that of survey events. The pattern that emerges is of a peak of projects in the late-mid 1990s, with a recent decline. As regards events, these also seem to peak at the end of the 1990s, suggesting a growing number of large infrastructure projects with multiple survey events. The Nene (Figs 9 and 10) shows a rather different pattern, with a peak in the 1990s, followed by a drop and then a gradual increase to present for projects, with a similar pattern for survey events. However the pattern for the Trent Valley (Figs 11 and 12) is more similar to that of the study area as a whole, but with a more marked drop-off in projects in recent years; this is likely to reflect the scepticism concerning the effectiveness of geophysical techniques in the valley.

These patterns may perhaps be explained as a product of development cycles, compounded by the slowness with which reports trickle through to archaeological curators. It may also be that in an increasingly competitive contracting environment, geophysical survey is being omitted on the grounds of cost, especially where it is perceived to be ineffective, as in the Trent (cf. Fig.12).

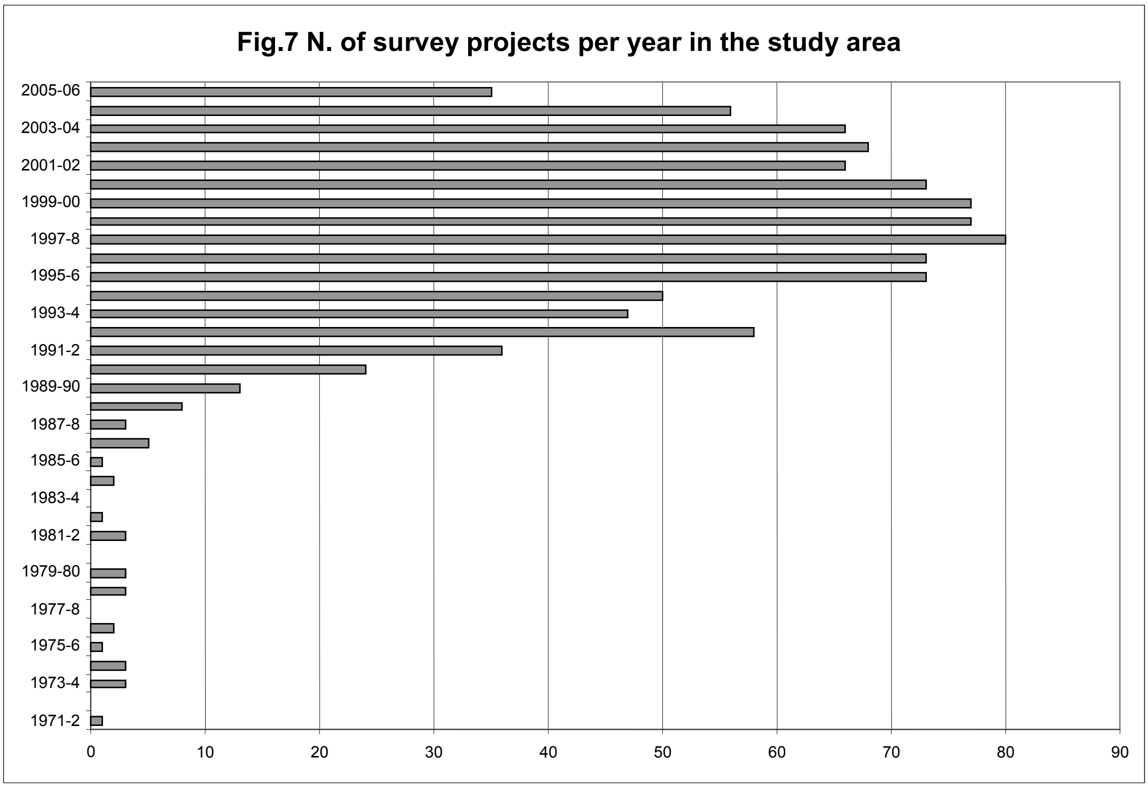


Fig.7 N. of survey projects per year in the study area
2005-06
2003-04
2001-02
1999-00
1997-8
1995-6
1993-4
1991-2
1989-90
1987-8
1985-6
1983-4
1981-2
1979-80
1977-8
1975-6
1973-4
1971-2
0
10
20
30
40
50
60
70
80
90

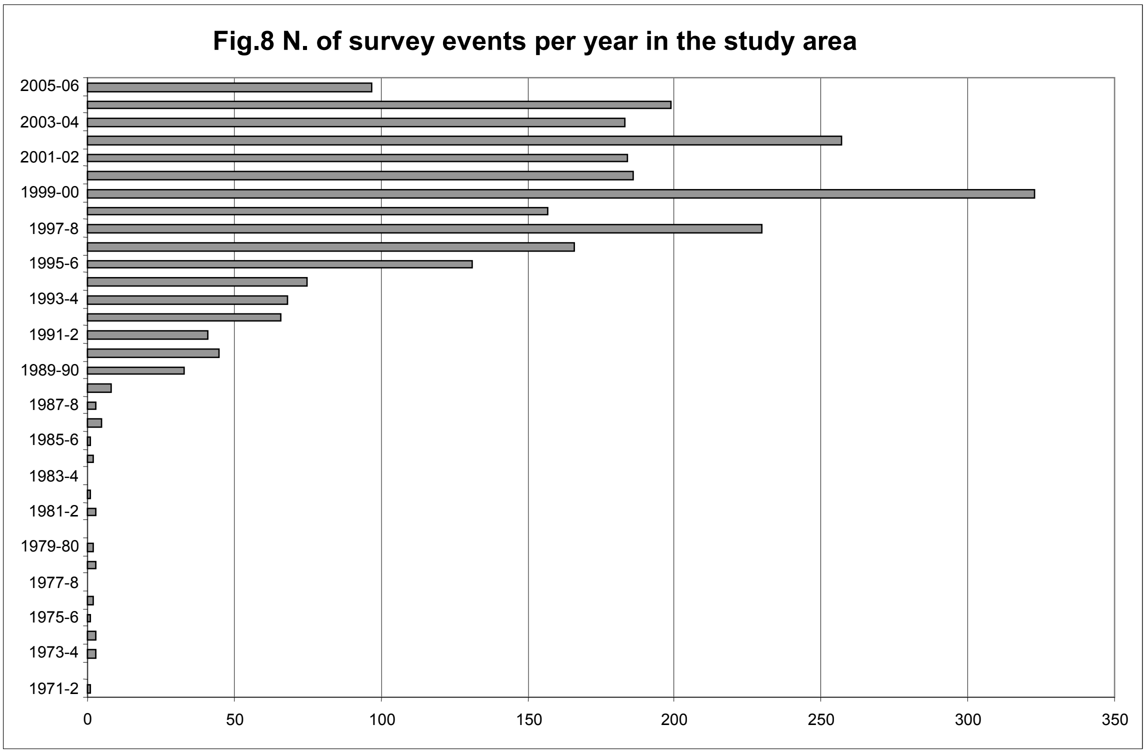


Fig.8 N. of survey events per year in the study area
2005-06
2003-04
2001-02
1999-00
1997-8
1995-6
1993-4
1991-2
1989-90
1987-8
1985-6
1983-4
1981-2
1979-80
1977-8
1975-6
1973-4
1971-2
0
50
100
150
200
250
300
350

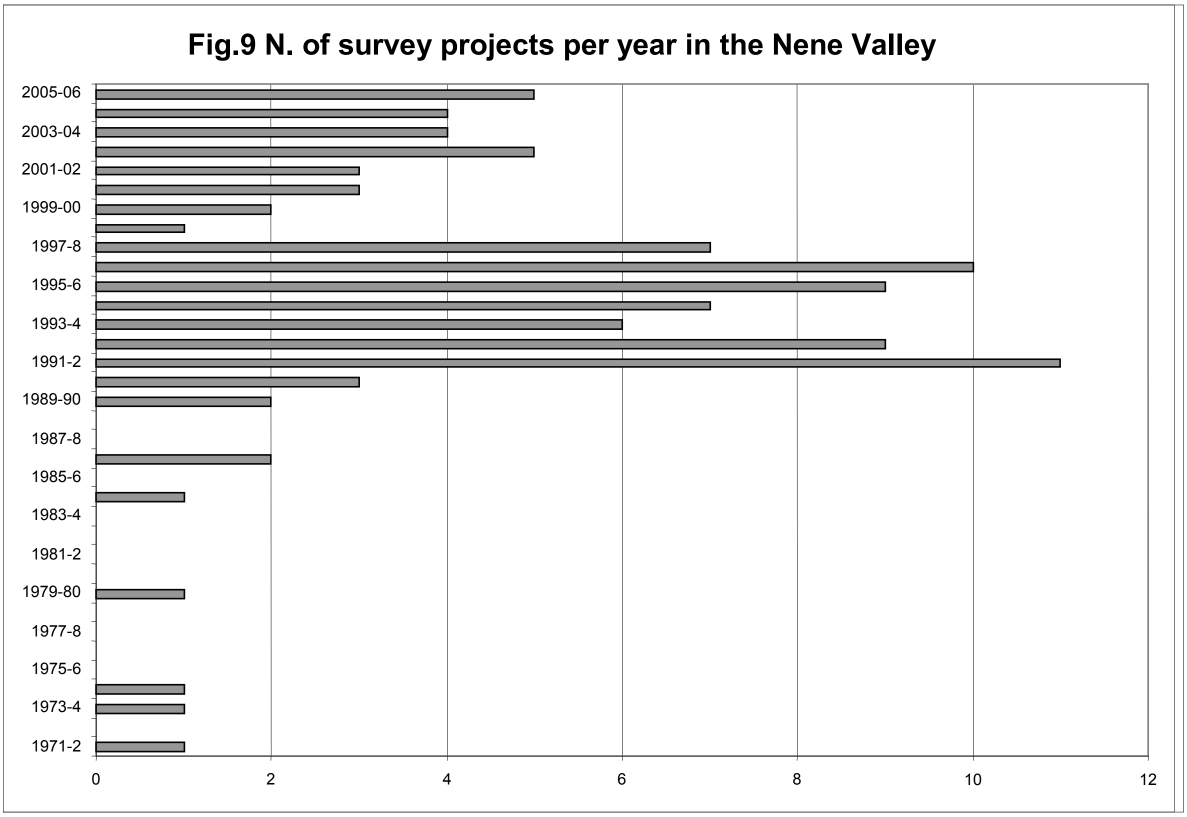


Fig.9 N. of survey projects per year in the Nene Valley
2005-06
2003-04
2001-02
1999-00
1997-8
1995-6
1993-4
1991-2
1989-90
1987-8
1985-6
1983-4
1981-2
1979-80
1977-8
1975-6
1973-4
1971-2
0
2
4
6
8
10
12

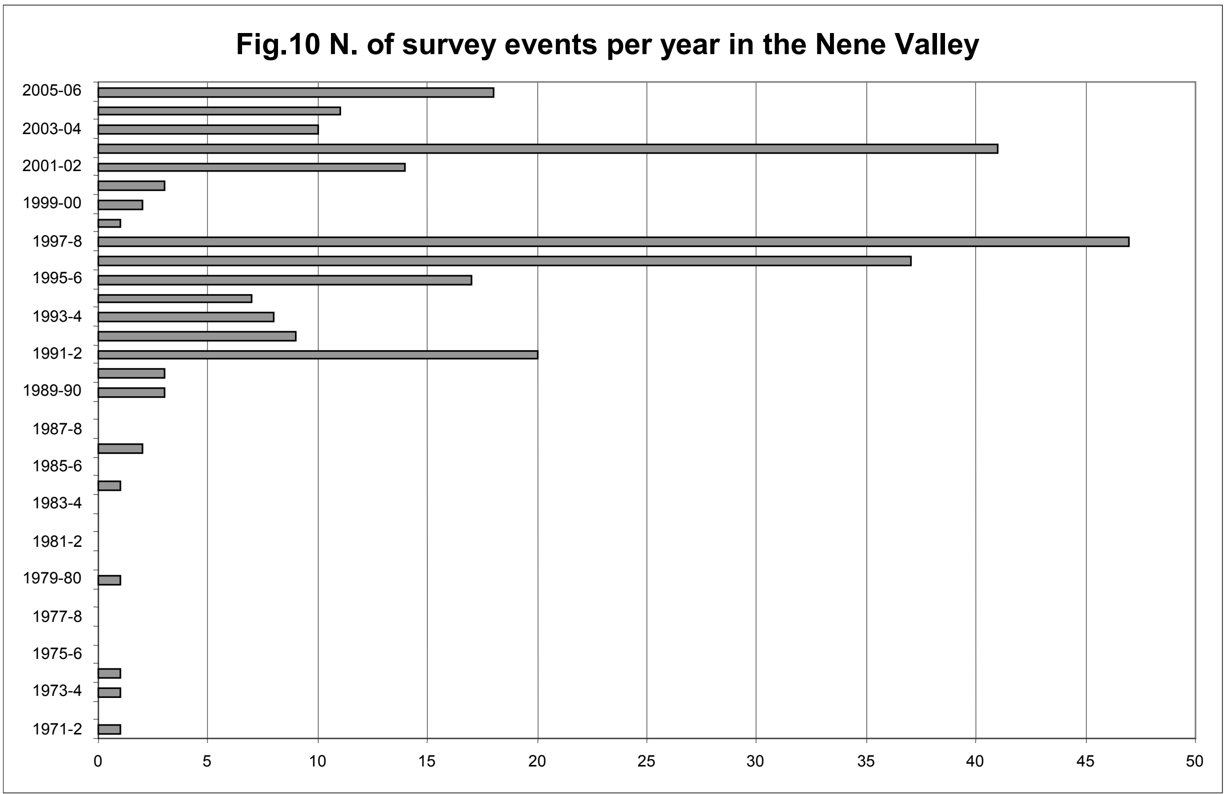
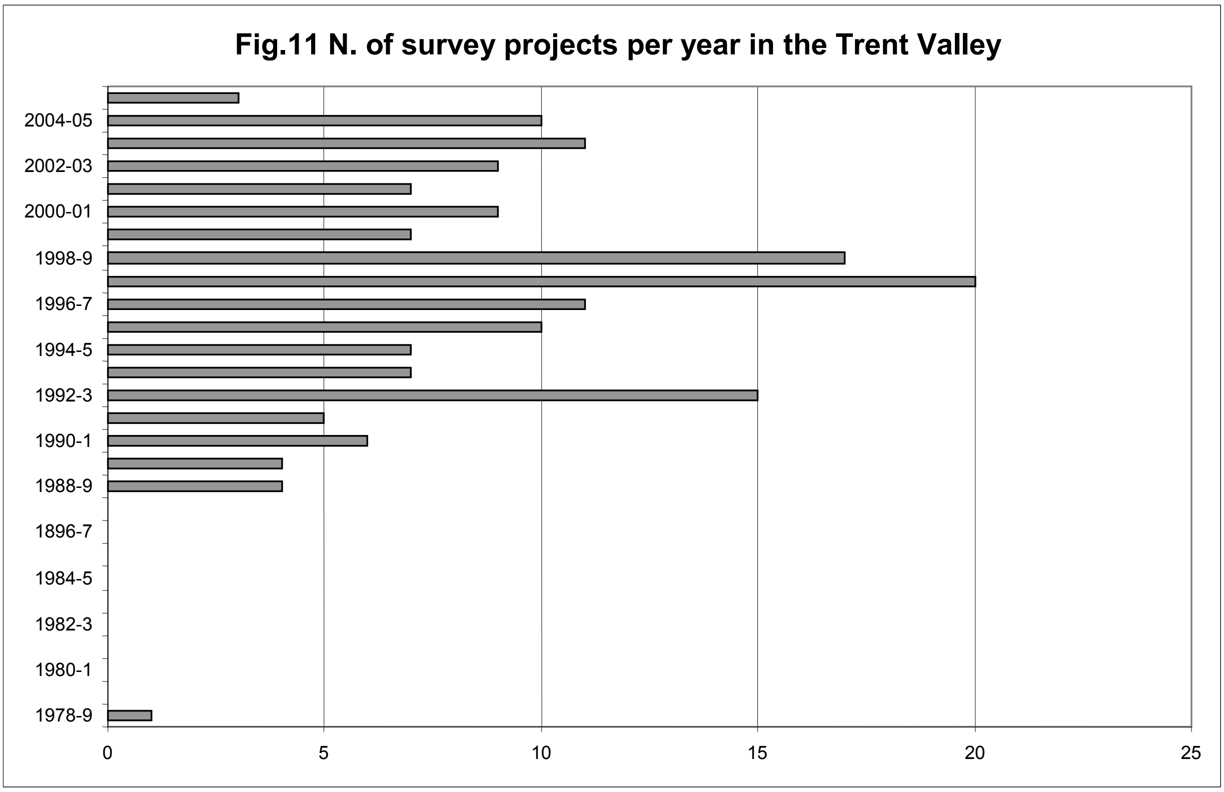
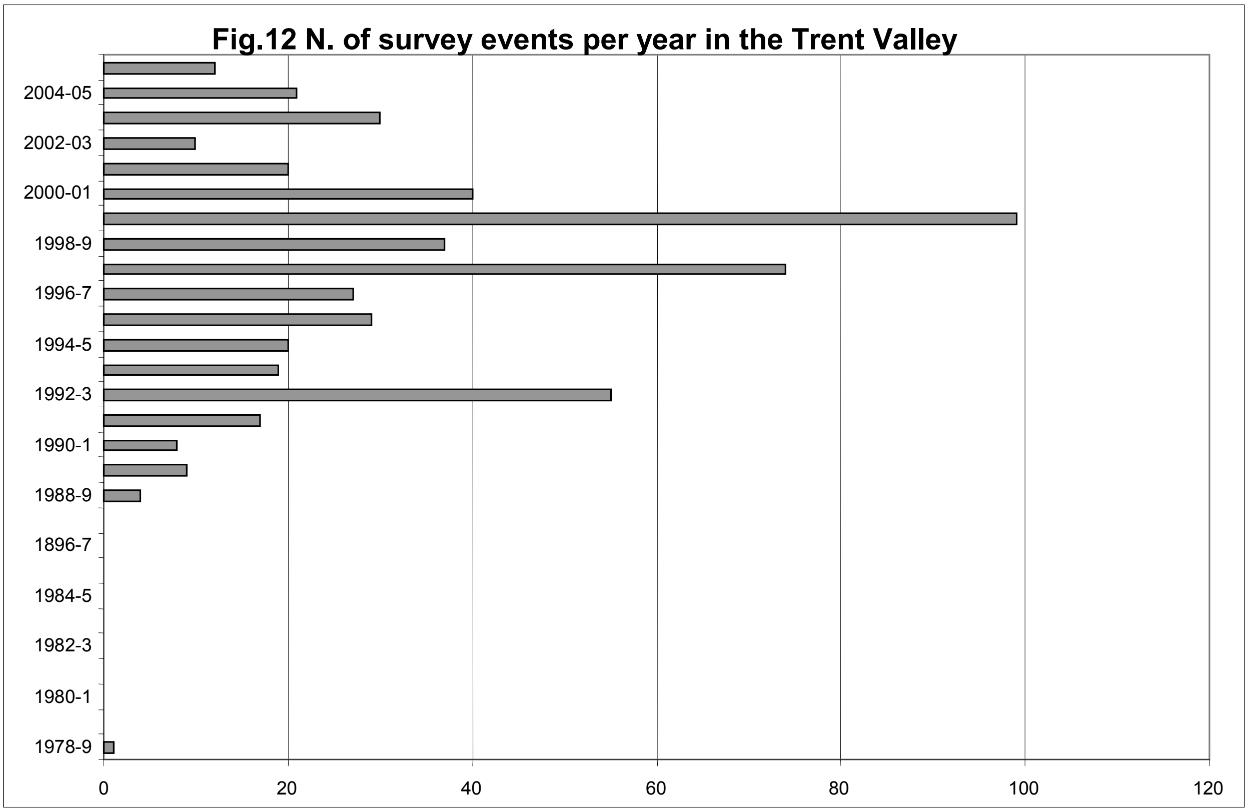


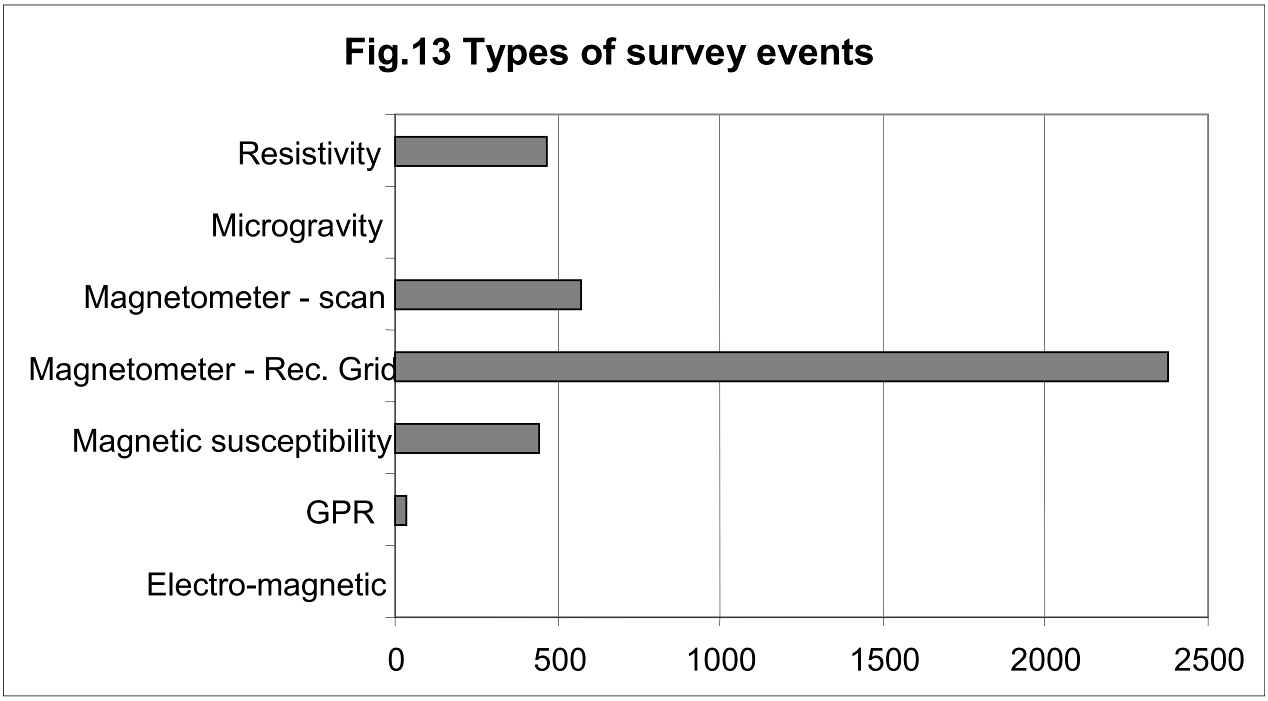
Fig.10 N. of survey events per year in the Nene Valley
2005-06
2003-04
2001-02
1999-00
1997-8
1995-6
1993-4
1991-2
1989-90
1987-8
1985-6
1983-4
1981-2
1979-80
1977-8
1975-6
1973-4
1971-2
0
5
10
15
20
25
30
35
40
45
50

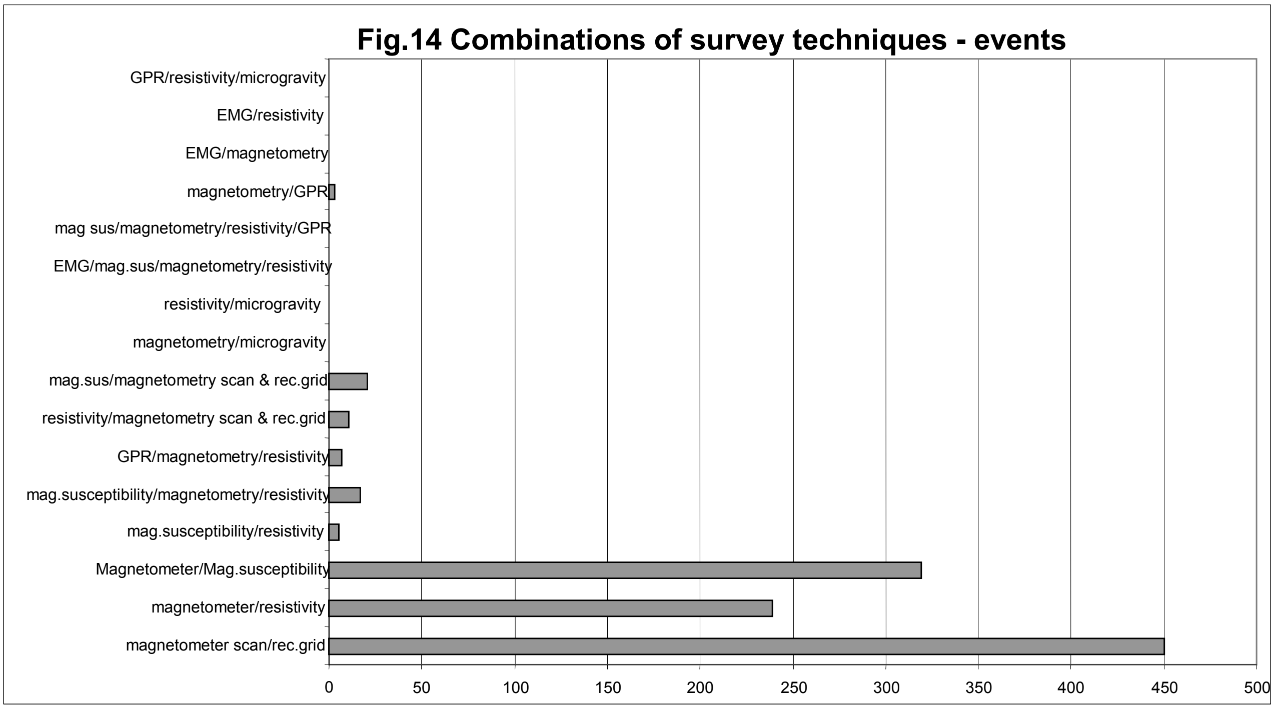




As is shown in Figure 13, magnetometry is the most commonly used survey technique, and Figure 14 shows which combinations of techniques have been used; Figure 15 shows the trend in the use of the various survey techniques, indicating a recent fall in scanning magnetometry, with recorded grid magnetometry the most commonly used technique since the late 1980s. This impression is confirmed by analysis of the percentage of events where this technique was used (Fig.16). After a peak at the end of the 1990s the use of magnetic susceptibility also appears to be in decline, though analysis of the percentage of events where this technique was used (Fig.17) shows that this trend is not significant.

It should be noted that large infrastructure projects, such as pipelines and new roads, will skew the data for 'type of survey events' as they typically consist of multiple events where the same geophysical techniques are used repeatedly.





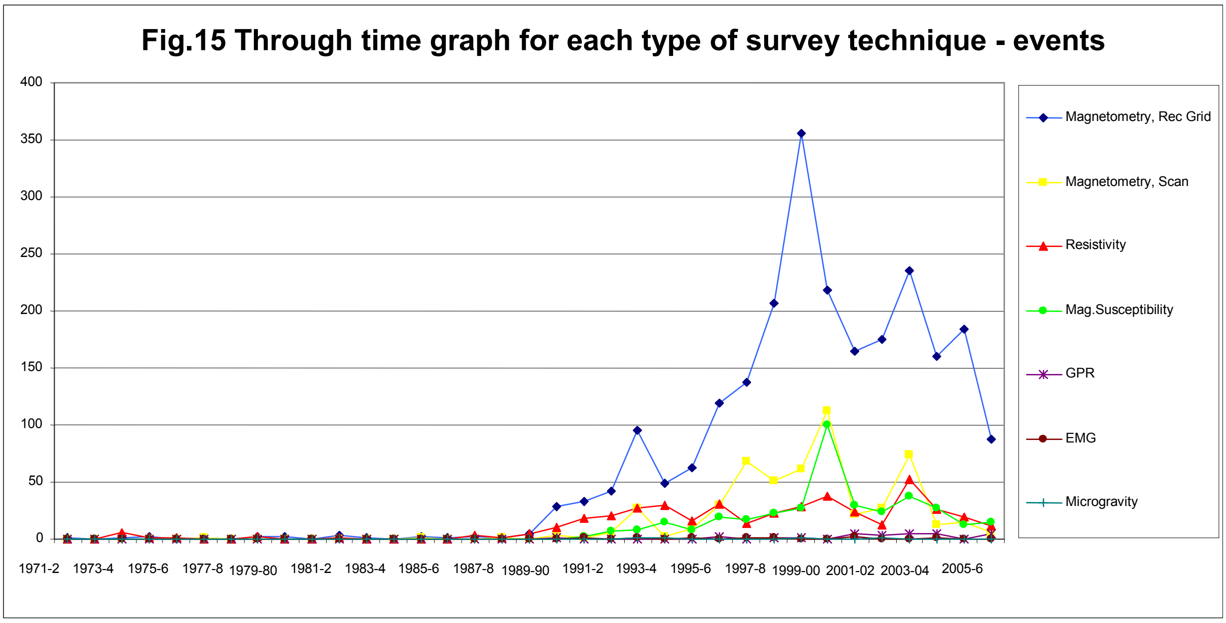


Fig.15 Through time graph for each type of survey technique - events
400
350
300
250
200
150
100
50
0
1971-2
1973-4
1975-6
1977-8
1979-80
1981-2
1983-4
1985-6
1987-8
1989-90
1991-2
1993-4
1995-6
1997-8
1999-00
2001-02
2003-04
2005-6
Magnetometry, Rec Grid
Magnetometry, Scan
Resistivity
Mag.Susceptibility
GPR
EMG
Microgravity

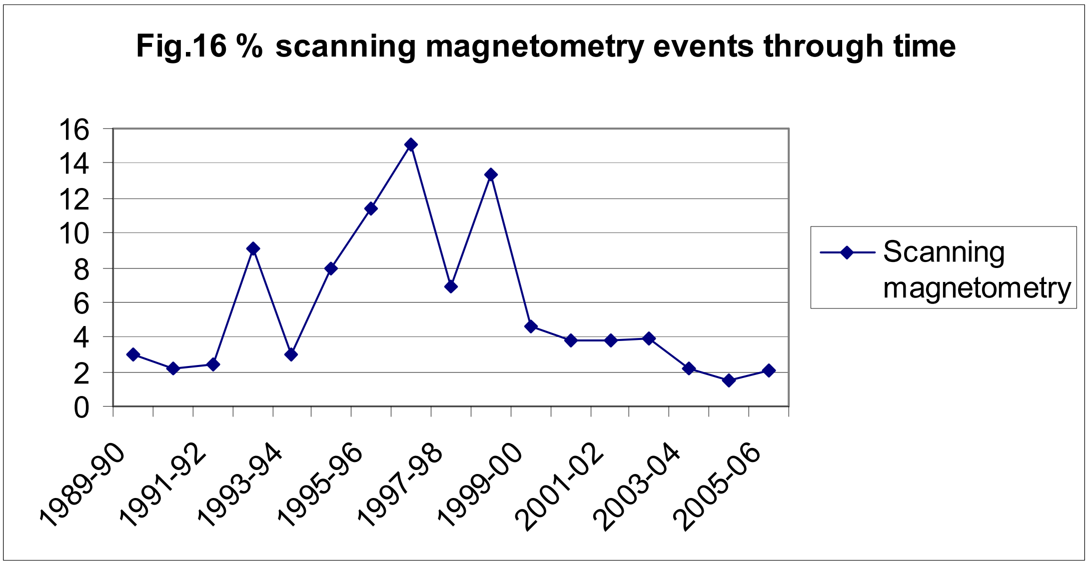


Fig.16 % scanning magnetometry events through time
16
14
12
10
8
6
4
2
0
1989-90
1991-92
1993-94
1995-96
1997-98
1999-00
2001-02
2003-04
2005-06
Scanning magnetometry

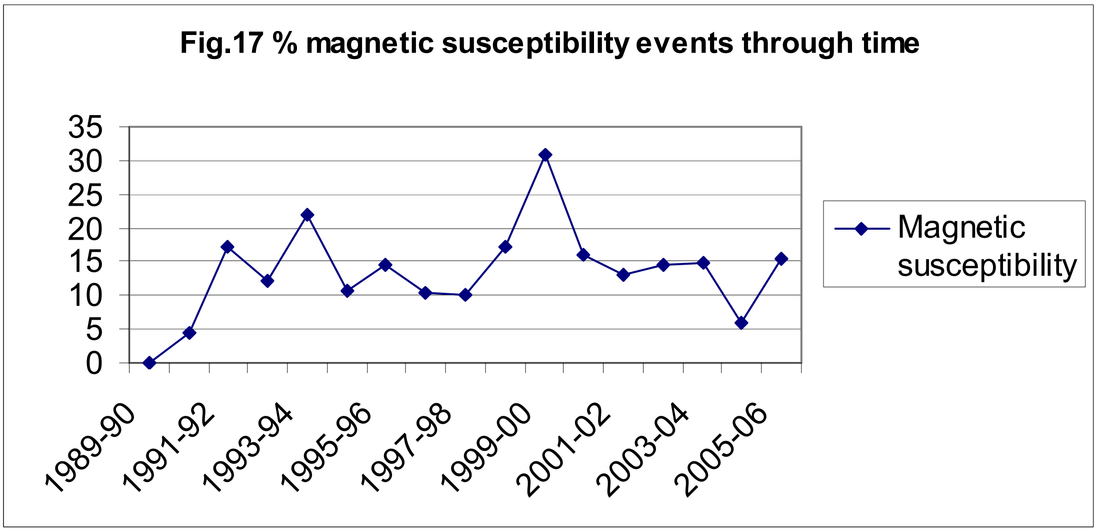


Fig.17 % magnetic susceptibility events through time
35
30
25
20
15
10
5
0
1989-90
1991-92
1993-94
1995-96
1997-98
1999-00
2001-02
2003-04
2005-06
Magnetic susceptibility

8.1 Effectiveness: correlation with the results of excavation

The first stage in assessing the effectiveness of geophysical survey in the various parts of the study area is the measurement of the extent to which the features predicted by geophysical survey have been confirmed by excavation. Figure 18 gives an assessment for the whole study area (based on 814 events), whilst Figure 19 reports the same measurement for the Trent Valley (108 events), Figure 20 for the Nene Valley (84 events) and Fig.21 for the rest of the study area (622 events). Given the larger sample size for the Trent, geophysical survey is by this measure more effective in the Nene Valley than in the Trent. It must however be stressed that there is **no** evidence to confirm the widely held view that Geophysical survey is ineffective in the Trent Valley, as Fig. 19 clearly confirms.

Fig.18 Study area correlation with excavation - events

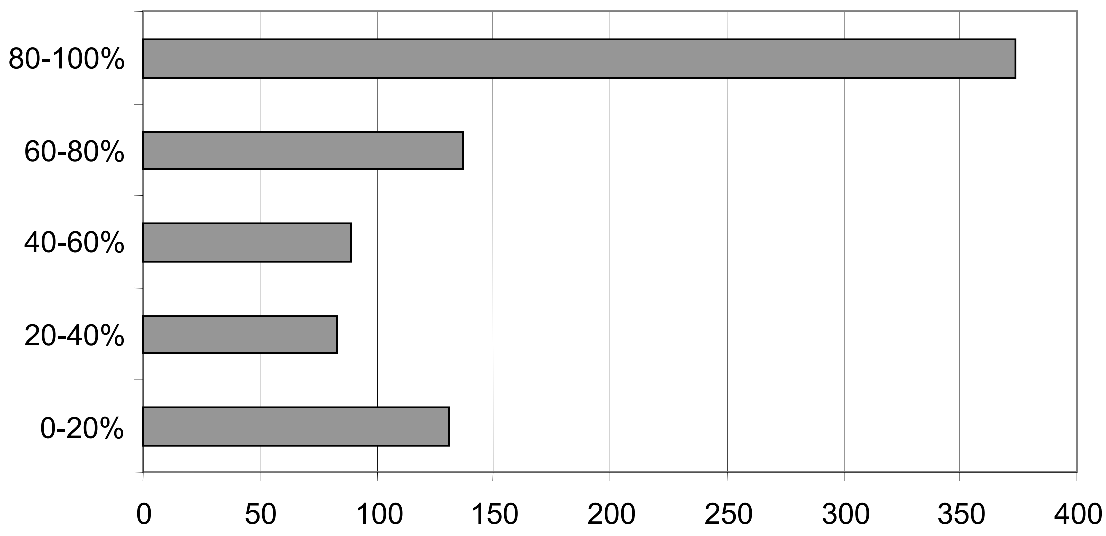


Fig.19 Trent Valley events - correlation with excavation

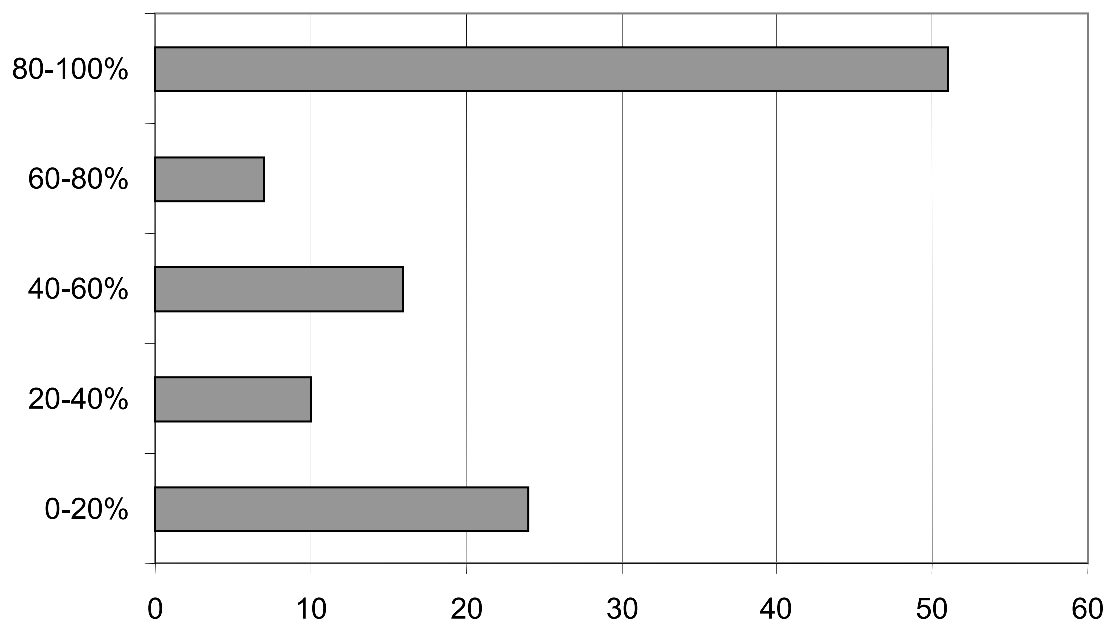
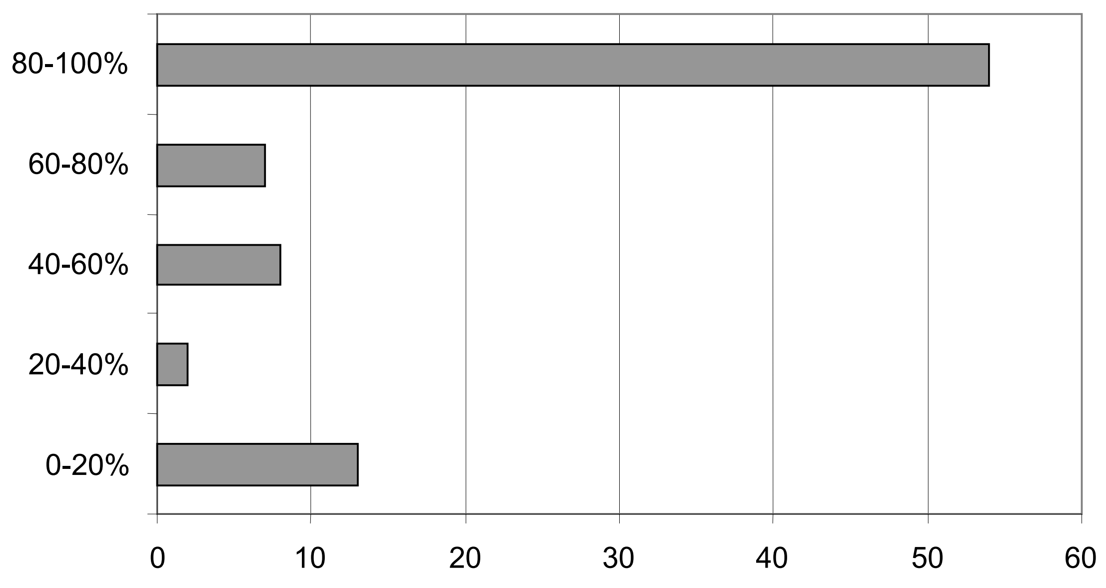
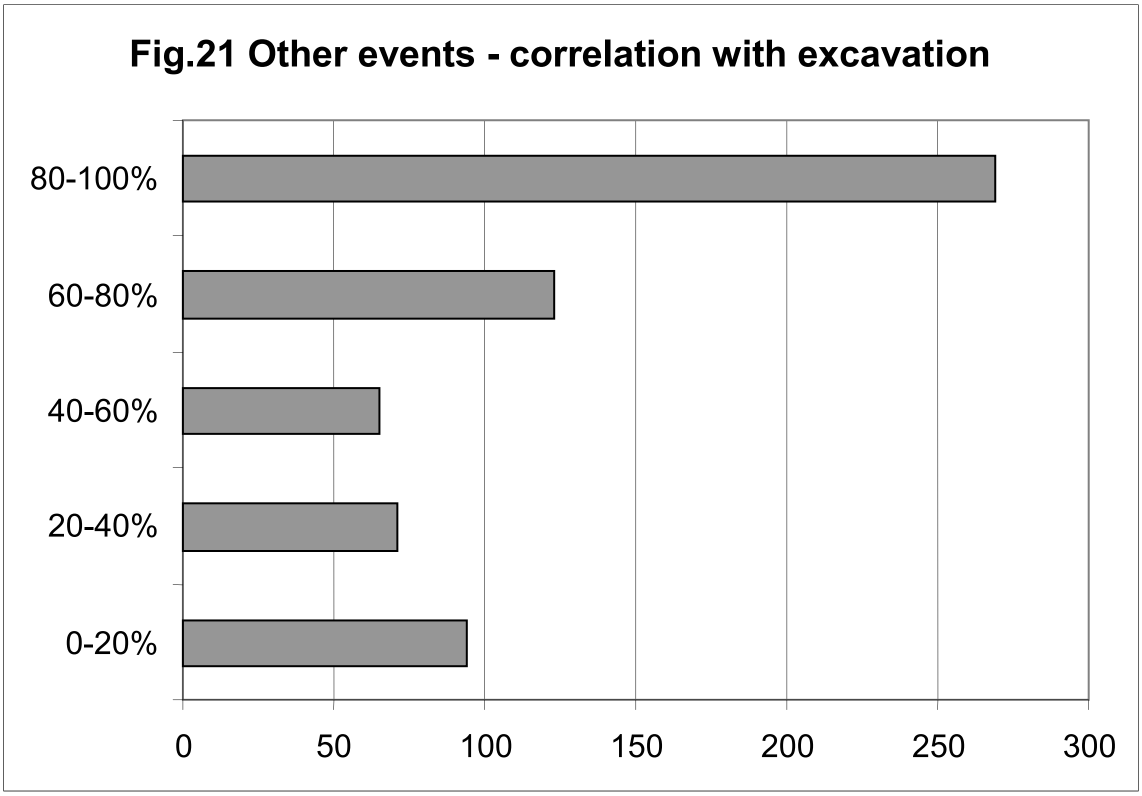


Fig.20 Nene Valley events - correlation with excavation





8.2 Effectiveness of different techniques

Figure 22 shows the relative effectiveness of the most common survey techniques in the study area as a whole – it will be noted that resistivity (n.=70) and recorded grid magnetometry (n.=348) are the most effective techniques. The pattern for the Trent Valley (Fig.23) is similar (resistivity n.13 and recorded grid magnetometry n.42), whilst the data for the Nene (Fig.24) show a generally higher percentage effectiveness, particularly as regards Ground Penetrating Radar; caution should be exercised with these figures as a result of the small sample sizes: magnetic susceptibility n.=1; recorded grid magnetometry n.=52; scan magnetometry n.=17; resistivity n.=9; GPR n.=3.

Fig.22 Study area events - highest correlation with excavation vs technique

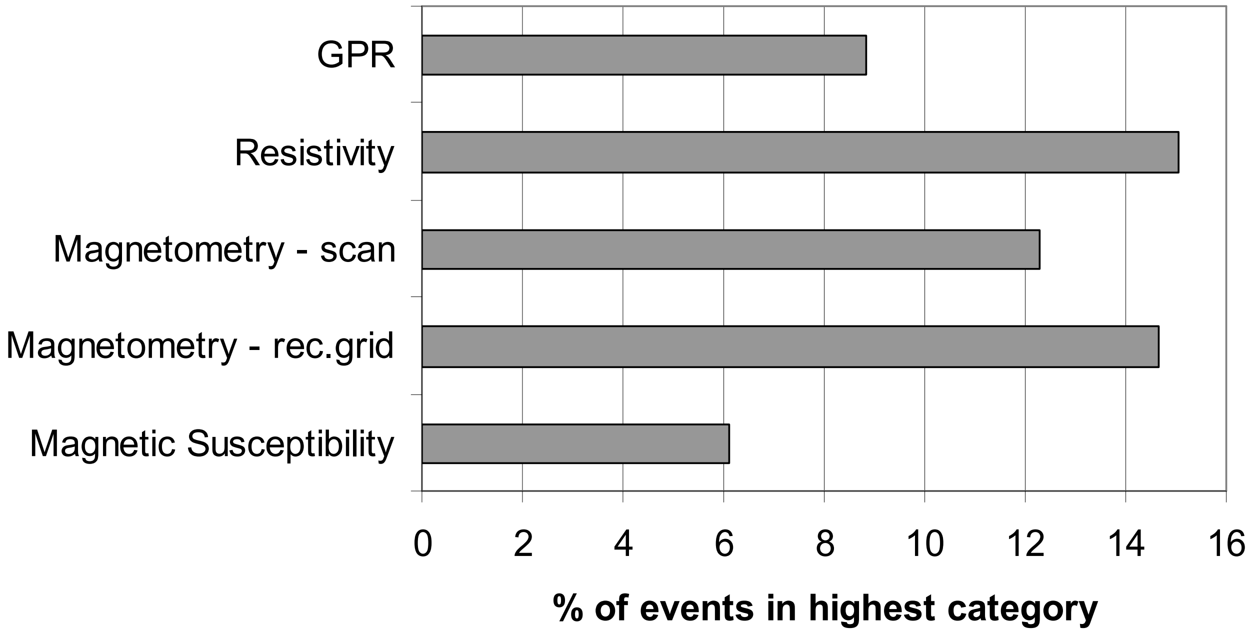
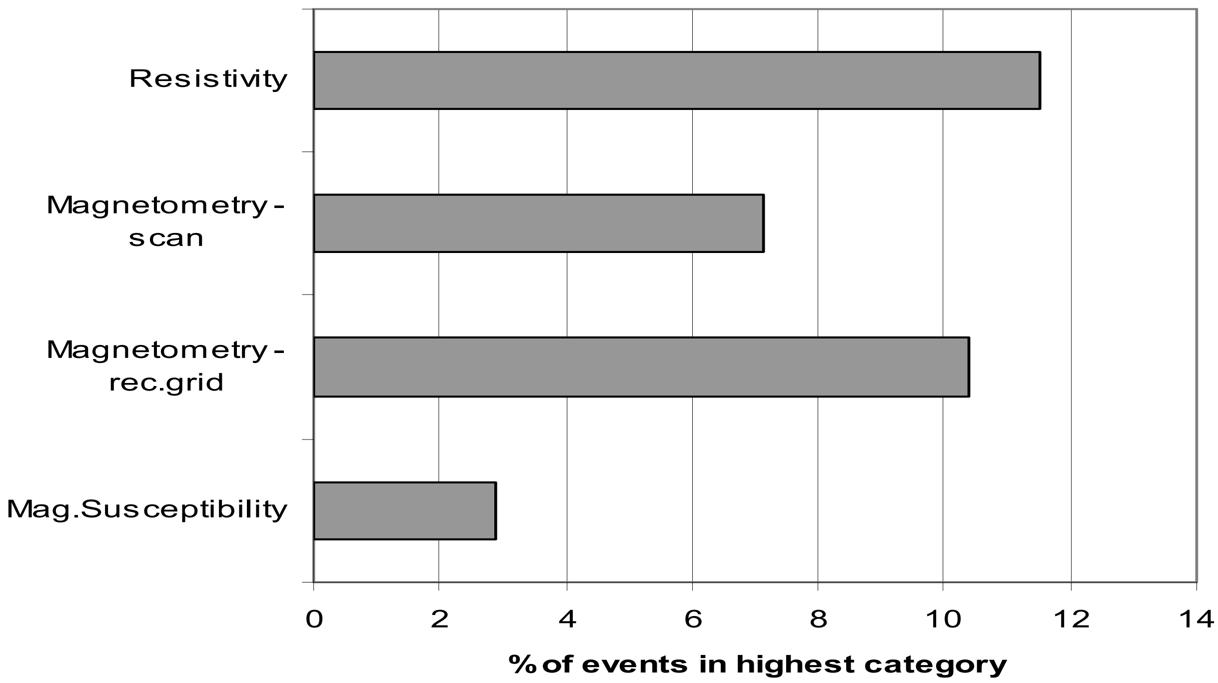
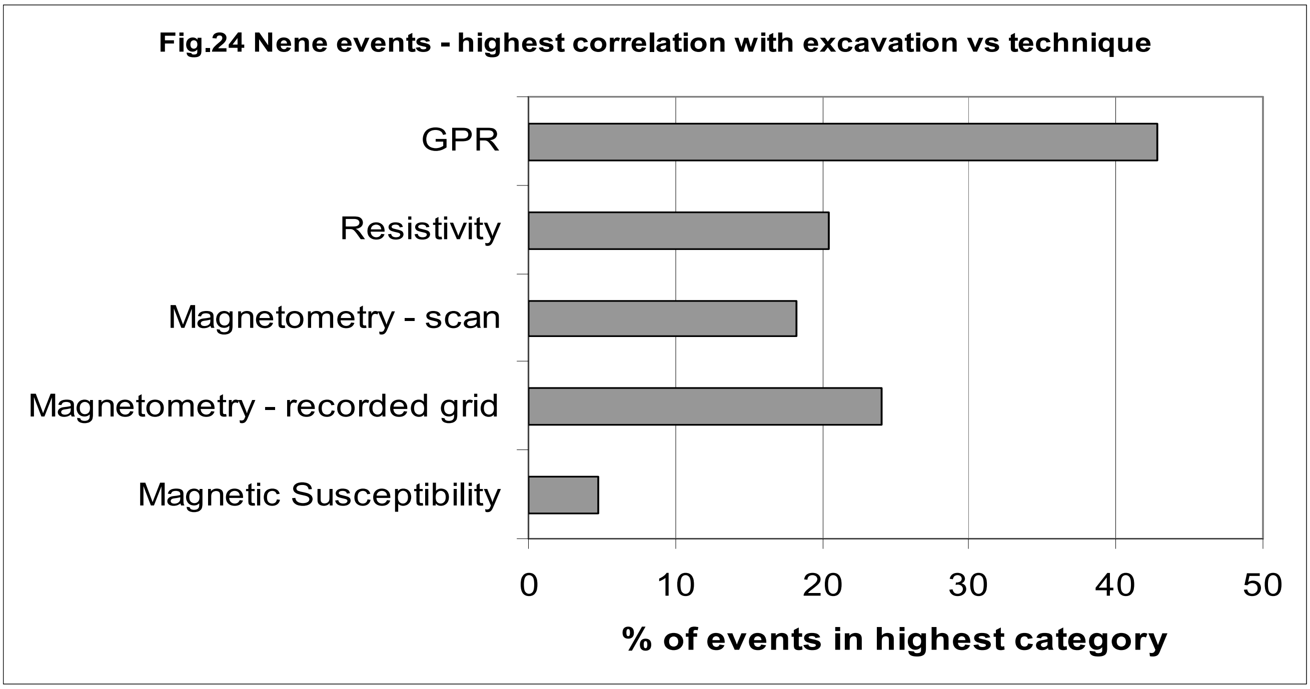


Fig.23 Trent events - highest correlation with excavation vs technique





A similar analysis can be undertaken for multiple technique events. Figure 25 shows the study area as a whole. The results are however complicated by the extremely low sample size for some technique combinations (magnetometry and resistivity n.= 32; recorded grid and scan magnetometry n.= 68; magnetometry and magnetic susceptibility n.= 18; GPR and resistivity n.=1; GPR, magnetometry and resistivity n.=1; recorded grid and scanning magnetometry and magnetic susceptibility n.=1). Unfortunately the figures for the Trent (Fig.26, total sample size = 15) and Nene (fig.27, total sample size = 21) are too low to be of any significance.

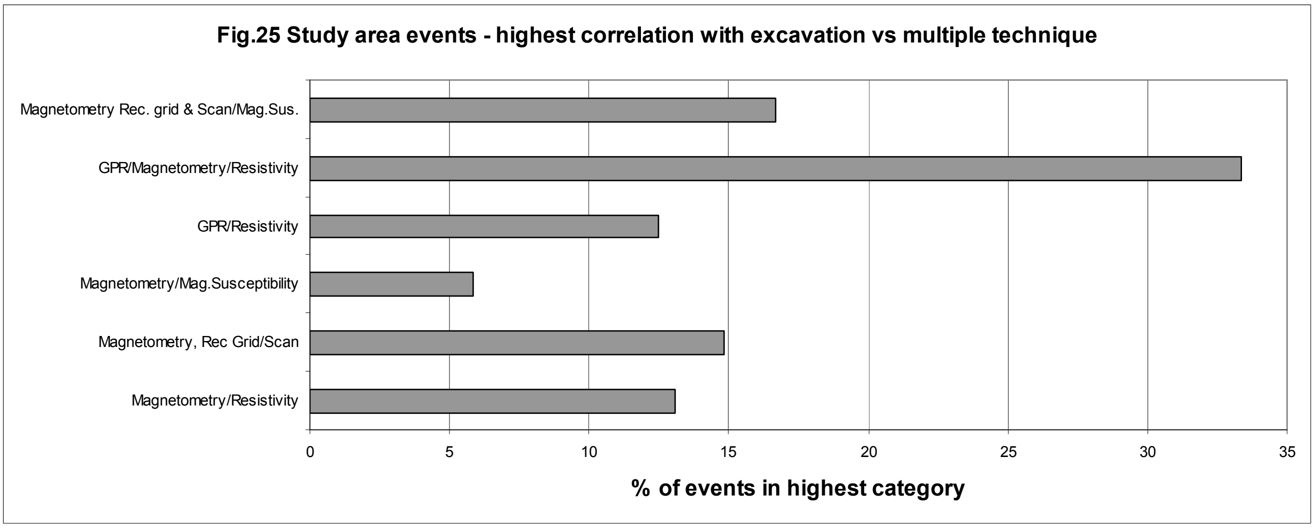


Fig.26 Trent events - top correlation with excavation vs multiple techniques

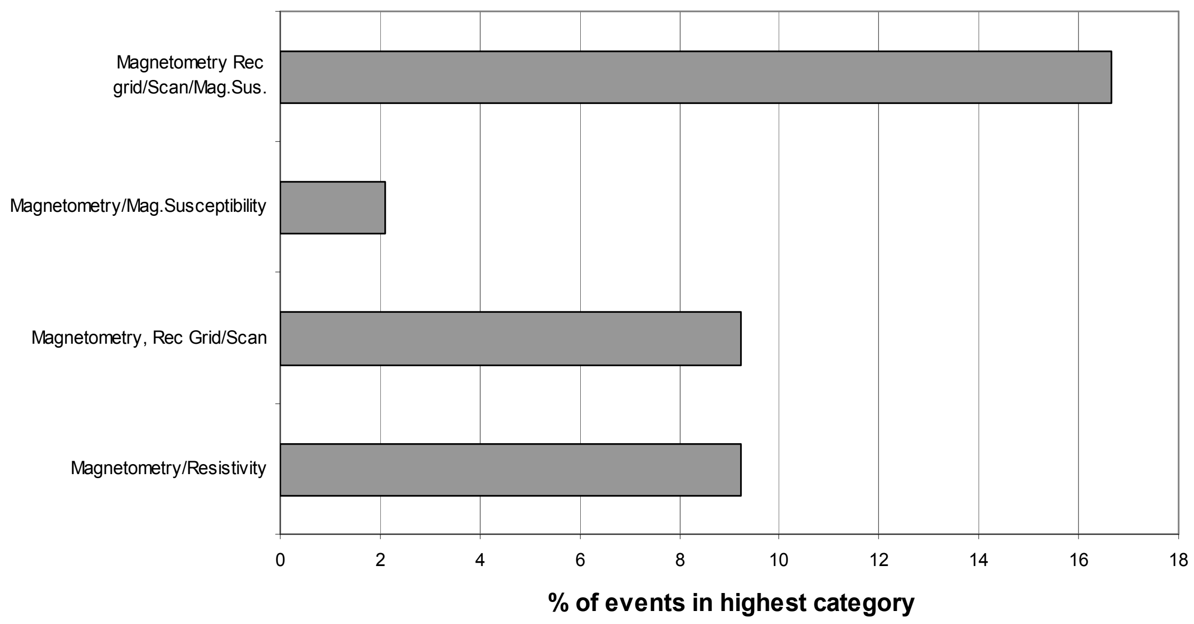
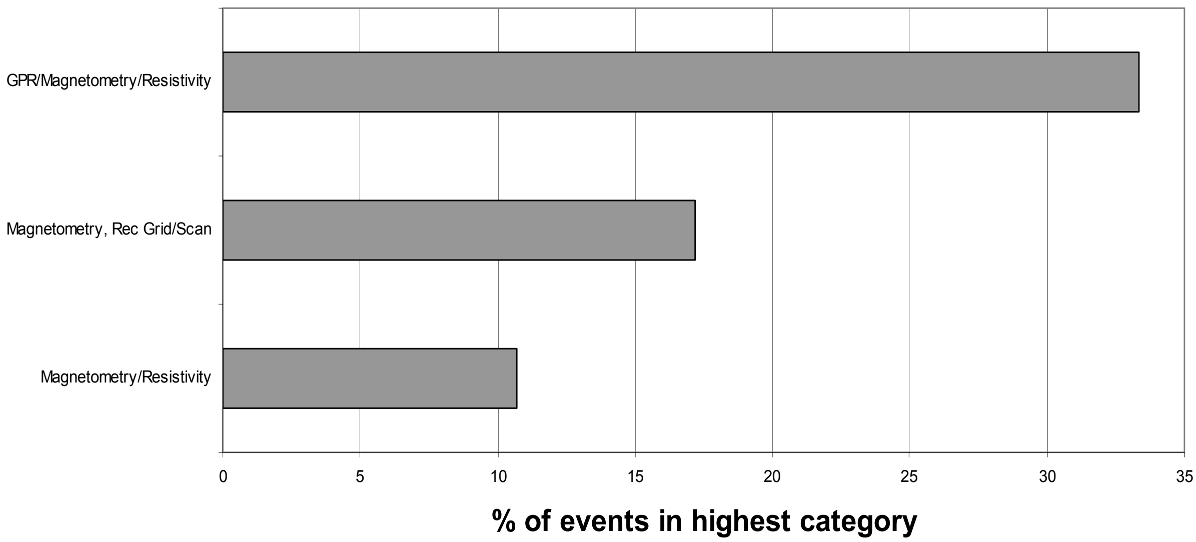
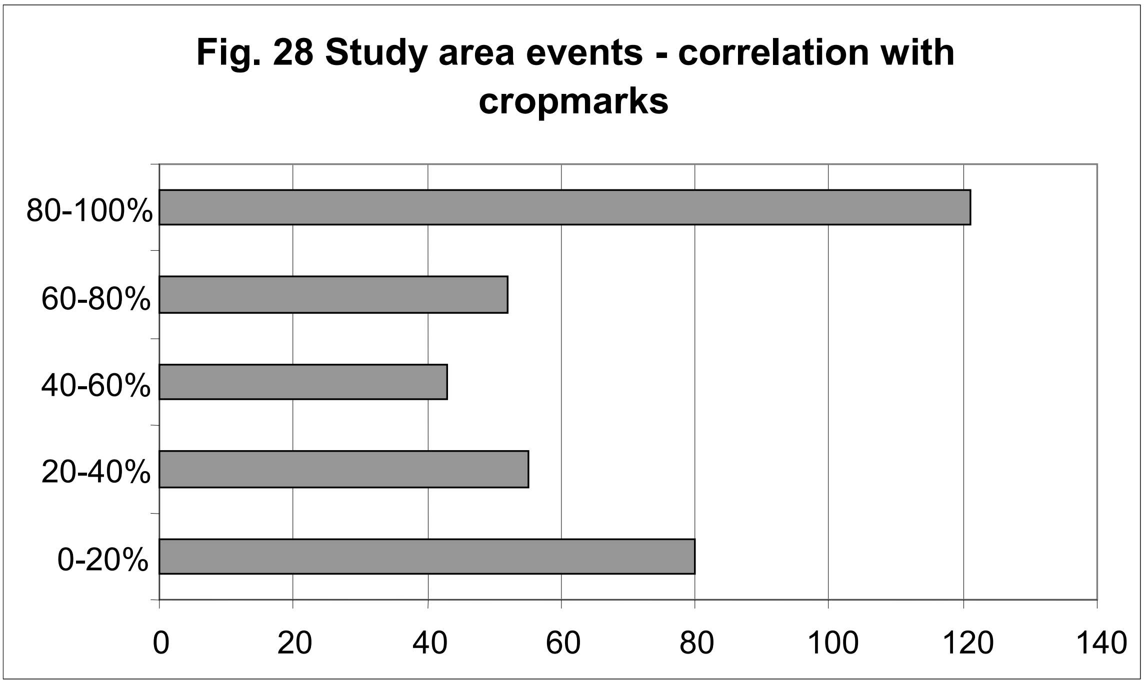


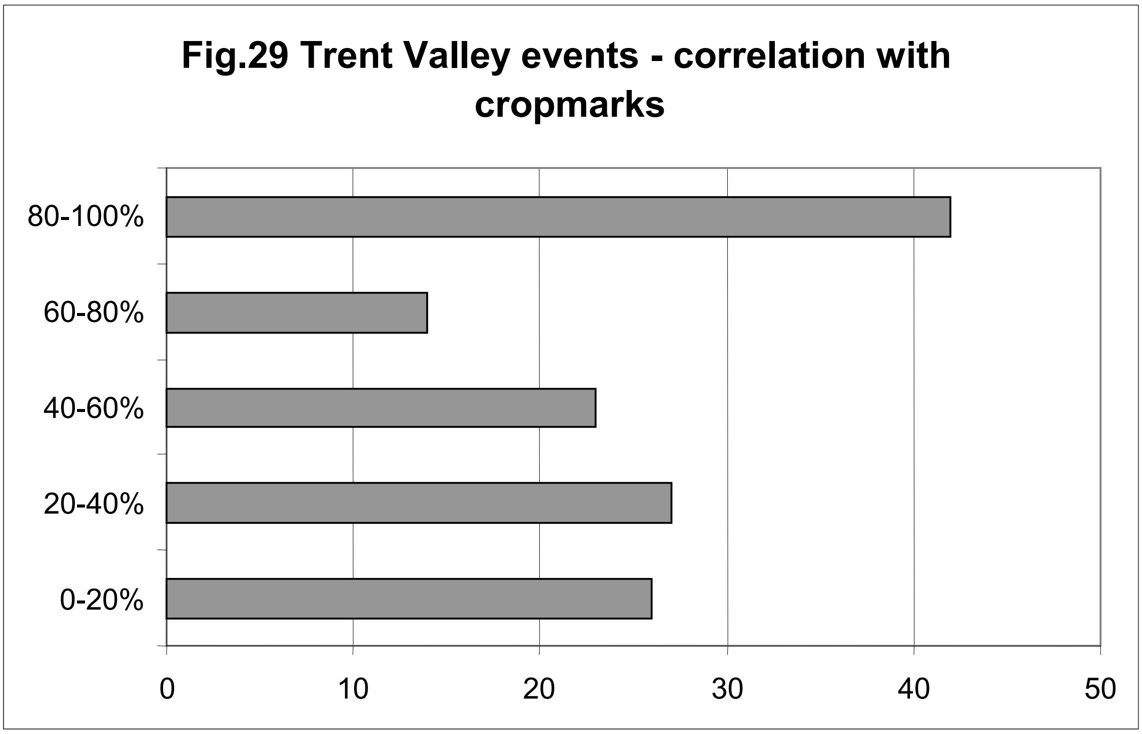
Fig.27 Nene events - highest correlation with excavation vs multiple techniques



8.3 Effectiveness: correlation with cropmark evidence

The correlation with cropmark evidence is less marked (Fig.28), and the Trent (Fig.29) data shows a similar pattern, whilst there seems to be a better correlation in the Nene valley data (Fig.30). It should be stressed that these comparisons are based on small data sets, as we were able to assess correlation with cropmarks in few cases: 351 overall, of which 132 in the Trent and 42 in the Nene. We suggest that this finding suggests that in the Trent Valley and study area as a whole geophysical survey is complementary to cropmark evidence – i.e. that each method of research detects a slightly different range of archaeological features, and that both need to be used if as full a range of buried features as possible are to be identified. It is not impossible that this finding indicates that cropmarks are in fact a less reliable predictor of archaeological features than geophysical survey, but the small size of our data set means that further verification is necessary. It should be noted that study area sites outside the Trent and Nene valleys (i.e. in areas where air photography is less successful) show even weaker correlations with cropmarks (n. = 177; Fig 31).





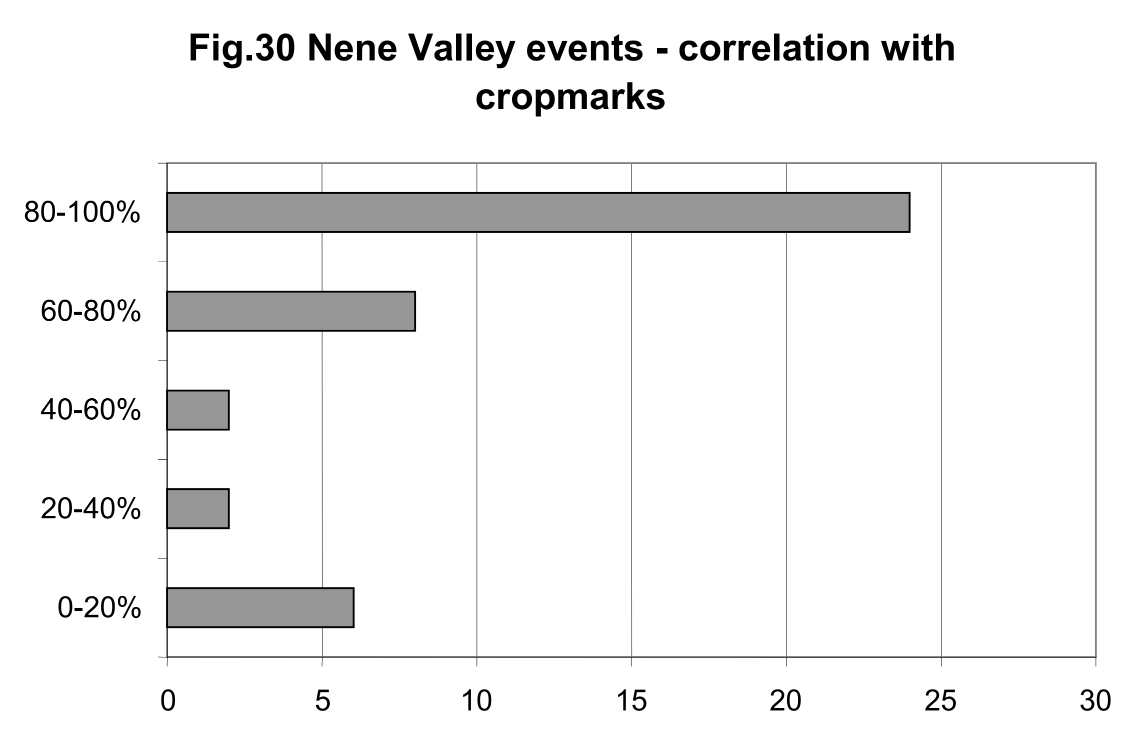


Fig.30 Nene Valley events - correlation with cropmarks

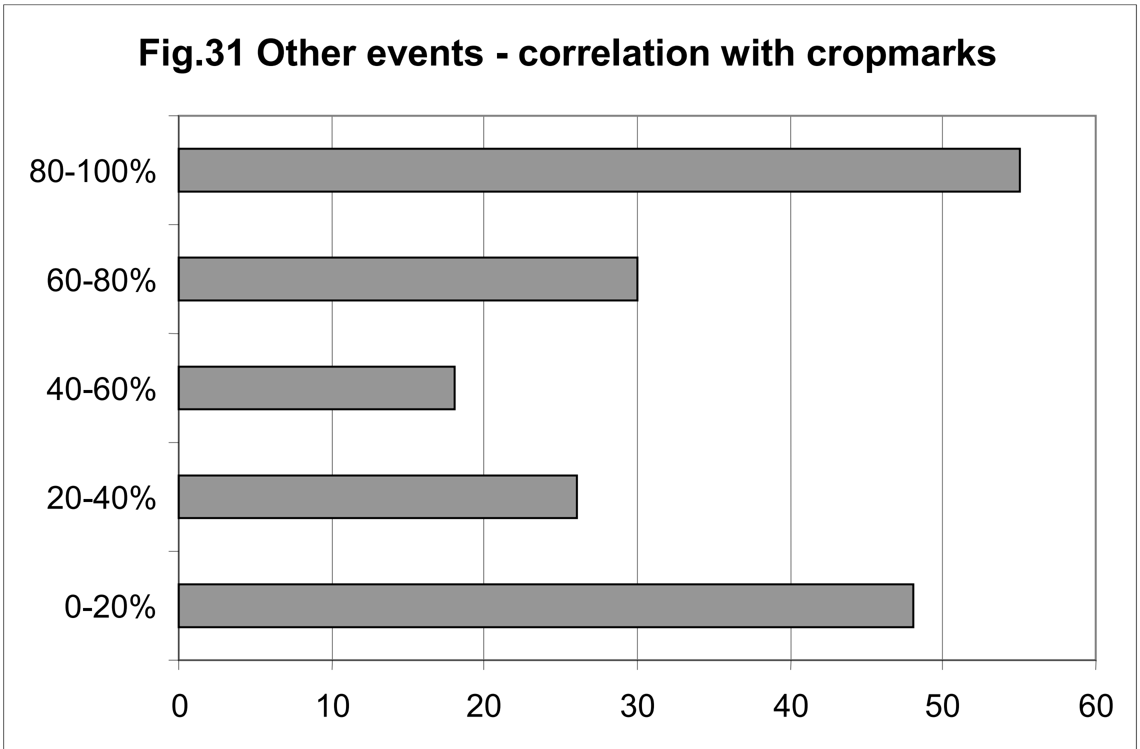
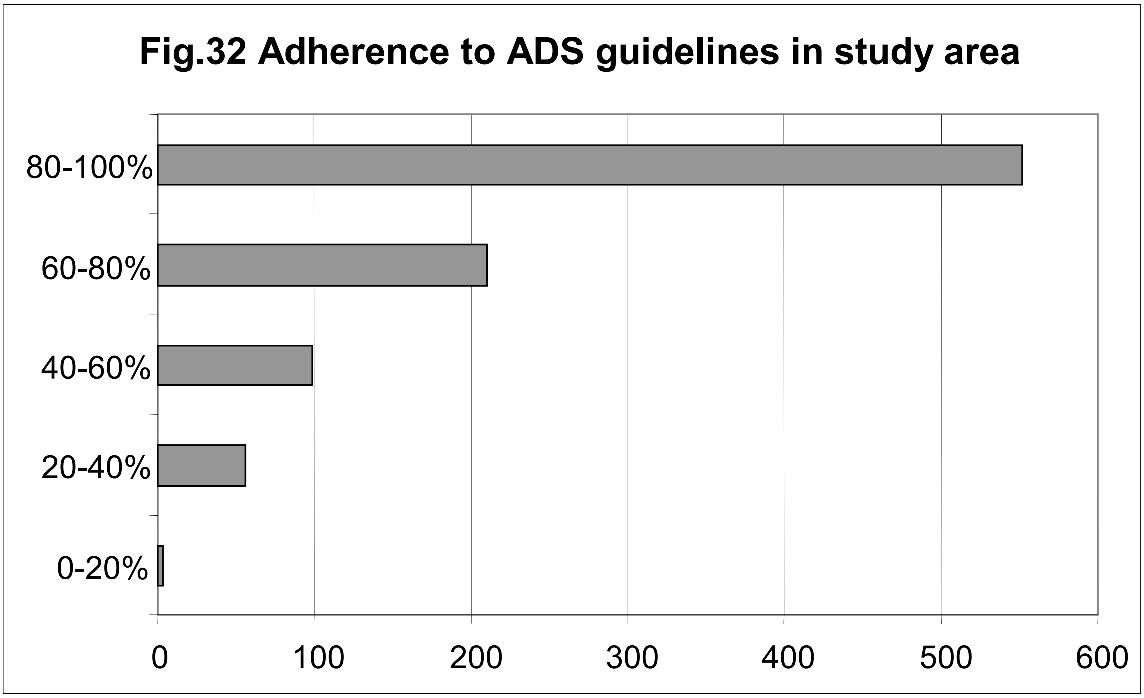
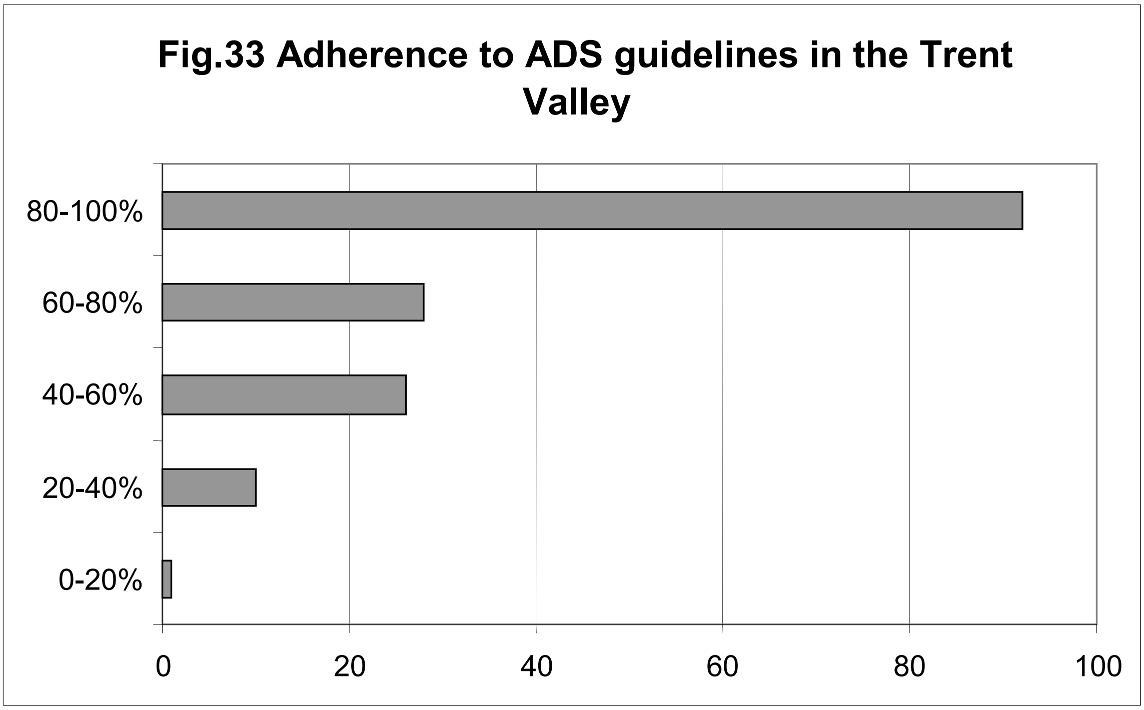


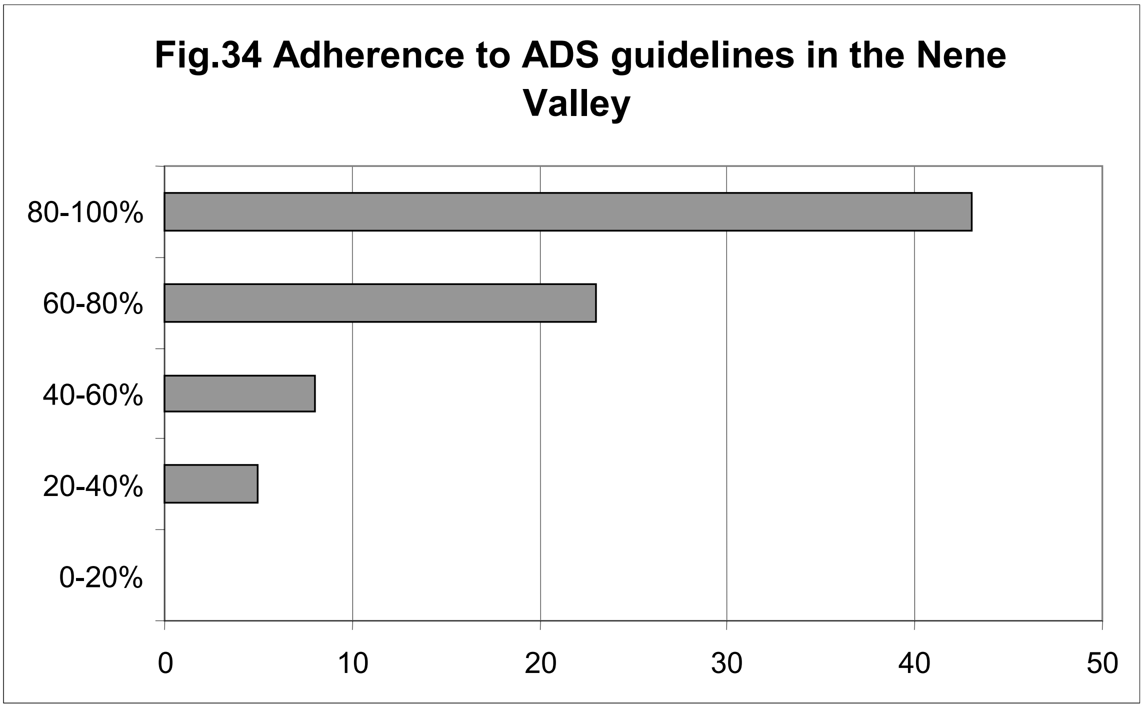
Fig.31 Other events - correlation with cropmarks

8.4 Adherence to National Guidelines

A further measure we have applied to our data is the extent to which reports by geophysics contractors adhere to the guidelines recommended by the British Archaeological Data Service (Schmidt 2002); this is because poorly documented reports tend to be less useful. As can be seen, the standard of the reports we have assessed to date is generally good, with a relatively consistent pattern across the region (Fig.32, n.=920, study area; Fig. 33, n.=157, Trent Valley; Fig. 34, n.=79, Nene Valley).

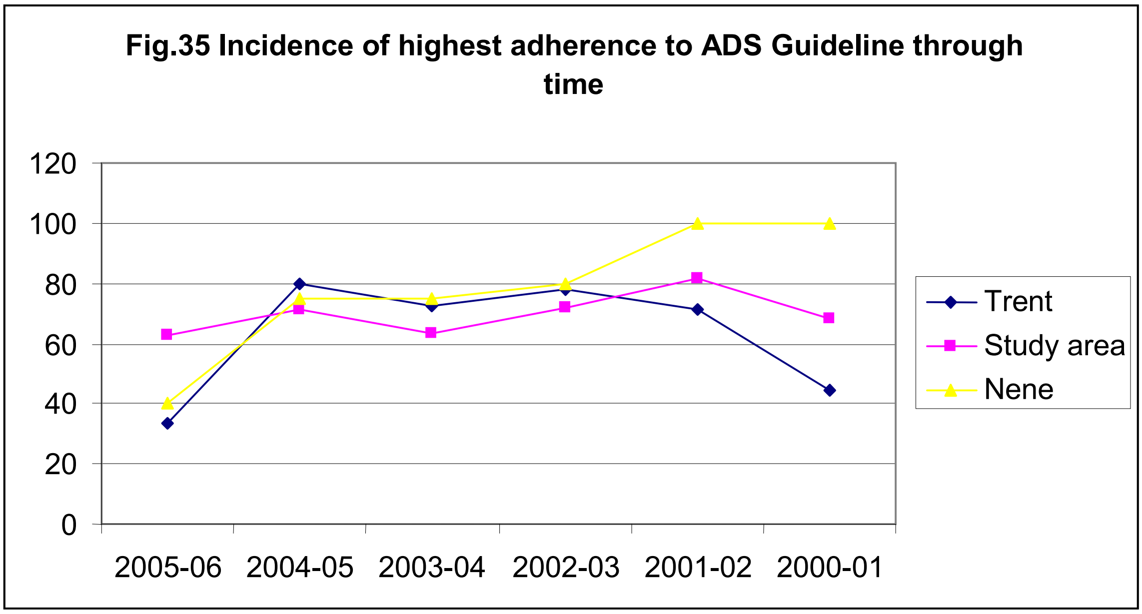






ADS guidelines were introduced in 2002. Table 5 and Figure 35 show the rate of highest (80-100%) adherence to ADS guidelines through time, for the study area as a whole and for the Trent and Nene Valleys. Although the data set is very small, this simple measure of the reporting standards of geophysical contractors, which arguably may offer a proxy for data quality, shows a worrying decline, perhaps as a result of cost-cutting in a highly competitive environment.

	Trent			**Nene**			**Study Area**		
Table 5	*80-100% adherence*	*Total n. projects*	*% rate*	*80-100% adherence*	*Total n. projects*	*% rate*	*80-100% adherence*	*Total n. projects*	*% rate*
2005-06	1	3	33	2	5	40	22	35	63
2004-05	8	10	80	3	4	75	40	56	71
2003-04	8	11	73	3	4	75	42	66	64
2002-03	7	9	78	4	5	80	49	68	72
2001-02	5	7	71	3	3	100	54	66	82
2000-01	4	9	44	3	3	100	50	73	68



There are however some reports which do not adhere to the guidelines. Table 6 shows the incidence of reports in the lowest (0-20%) class of adherence to these for the period 2000-01 to 2005-06, in the Trent and Nene Valleys and in the study area as a whole.

	Trent			**Nene**			**Study Area**		
***Table* 6**	0-20% adherence	*Total n. projects*	% rate	0-20% adherence	*Total n. projects*	% rate	0-20% adherence	*Total n. projects*	% rate
2005-06	0	3	0	0	5	0	1	35	3
2004-05	1	10	10	0	4	0	1	56	2
2003-04	0	11	0	0	4	0	2	66	3
2002-03	0	9	0	0	5	0	0	68	0
2001-02	0	7	0	0	3	0	1	66	2
2000-01	1	9	11	0	3	0	0	73	0

8.5 Sites with the highest (80-100%) correlation of geophysics results with excavation as compared with correlation with cropmark evidence

The following graphs indicate the correlation between those sites with a high (80-100%) agreement between geophysics and excavation as compared with the agreement with cropmarks: Fig.36 - study area (n.=77), Fig.37 - Trent (n.=21), Fig.38 - Nene (n.=16) and Fig.39 - other (n.=40). This correlation is high, though the sample sizes are unfortunately small. It should however be noted that it is less high in the areas outside the Trent and Nene valleys, where in the presence of less suitable soils air photography is often less successful.

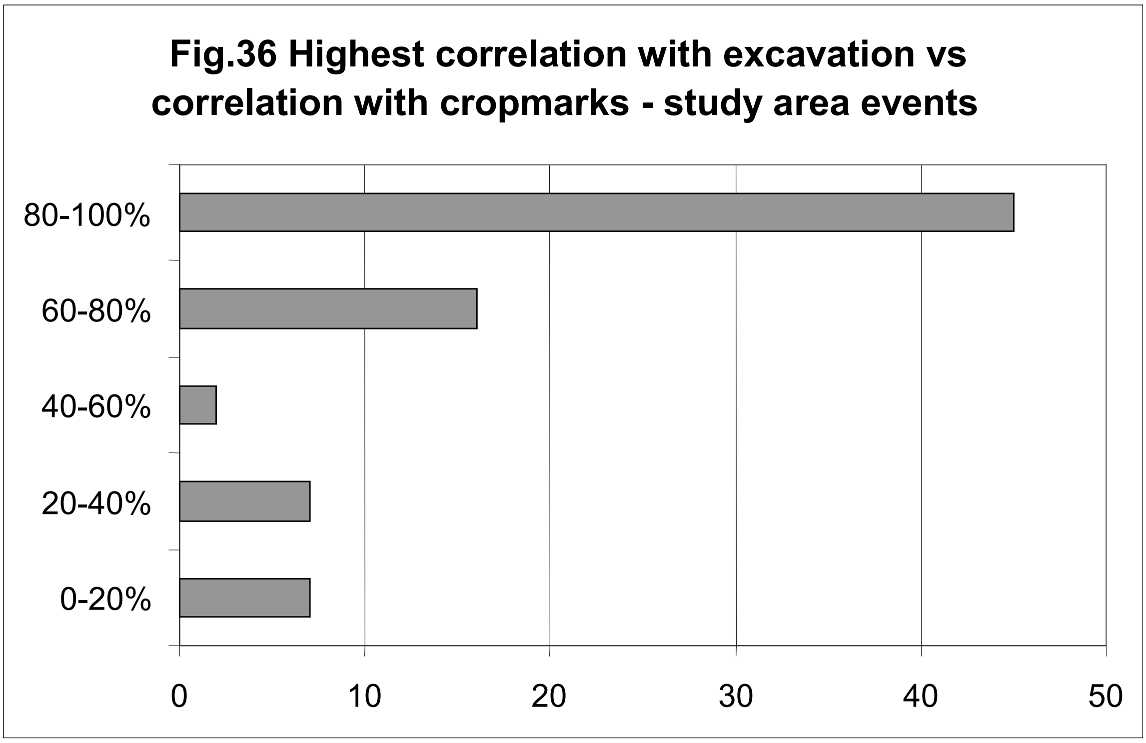


Fig.36 Highest correlation with excavation vs correlation with cropmarks - study area events
80-100%
60-80%
40-60%
20-40%
0-20%
0
10
20
30
40
50

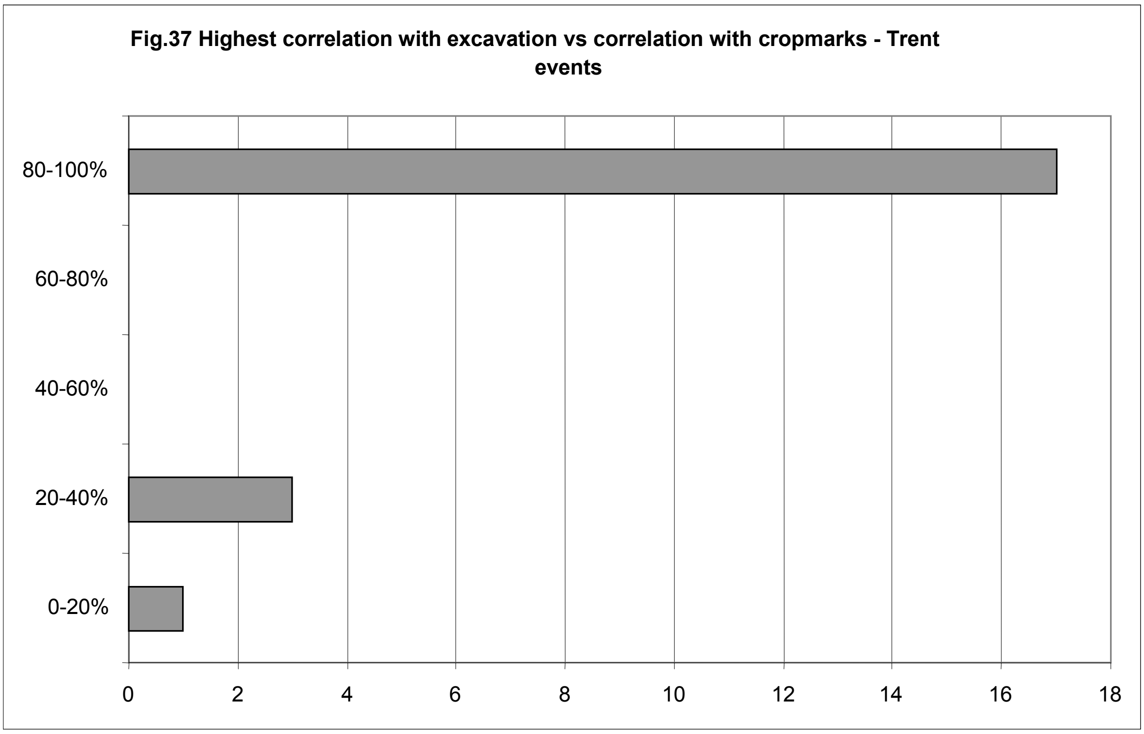


Fig.37 Highest correlation with excavation vs correlation with cropmarks - Trent events
80-100%
60-80%
40-60%
20-40%
0-20%
0
2
4
6
8
10
12
14
16
18

Fig.38 Highest correlation with excavation vs correlation with cropmarks - Nene events

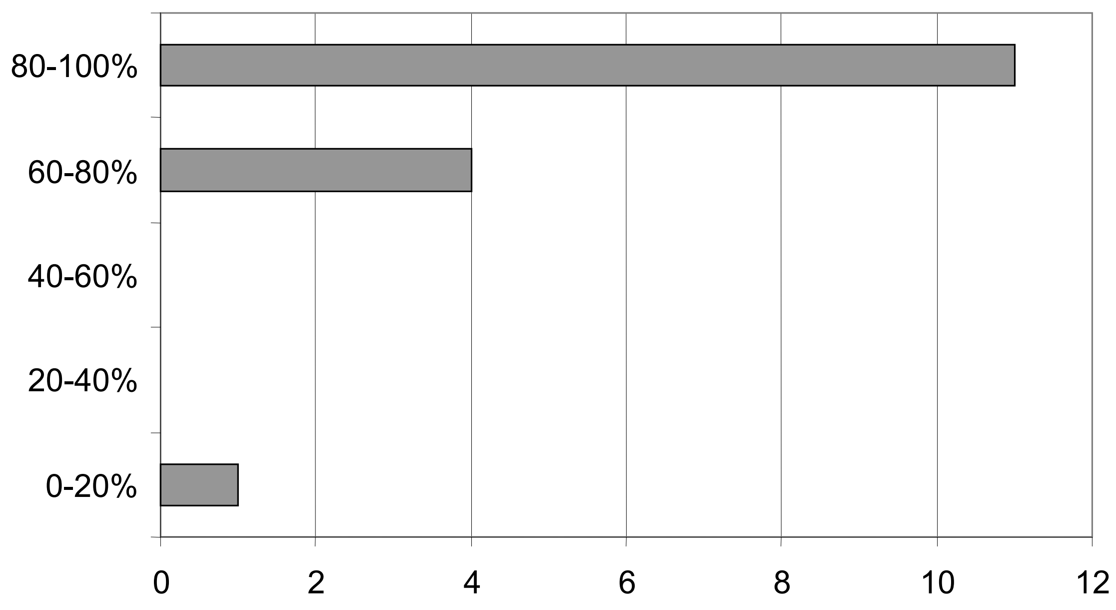
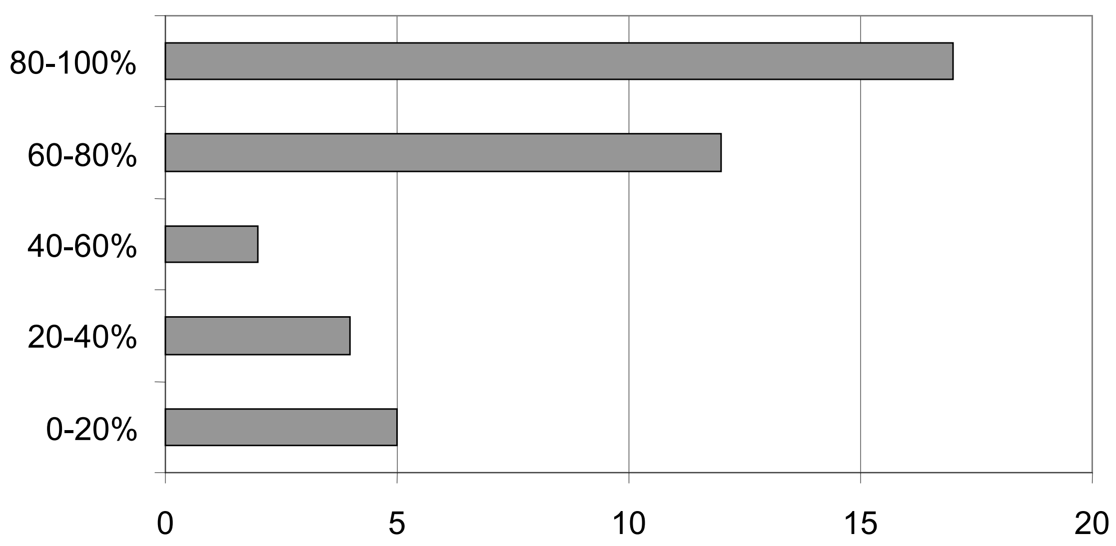


Fig.39 Highest correlation with excavation vs correlation with cropmarks - other events



8.6 Time of year

Figure 40 shows the time of year when survey events with the highest (80-100%) correlation with excavation took place (n.=335). Figure 41 is for the Trent (n.=46) and Figure 42 for the Nene (n.=47). In the study area as a whole, March and September may be seen to be the most suitable months, whilst in the Trent Valley August and September appear the most successful. The Nene data is bimodal, suggesting May and September as most suitable.

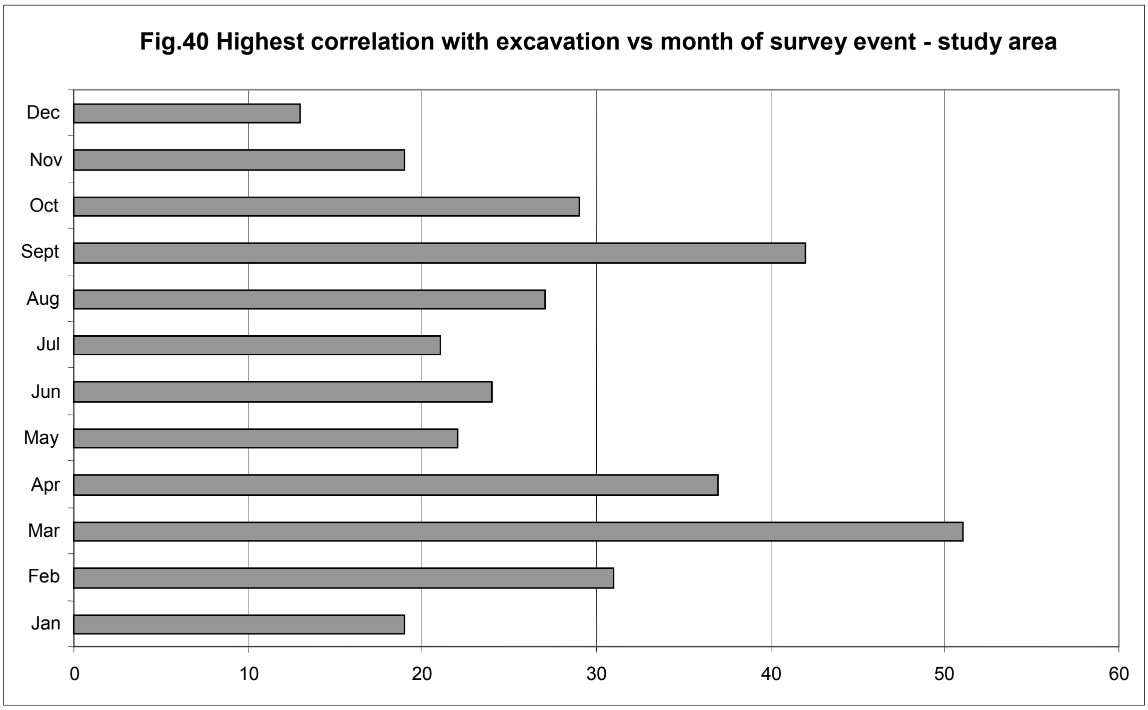


Fig.40 Highest correlation with excavation vs month of survey event - study area
Dec
Nov
Oct
Sept
Aug
Jul
Jun
May
Apr
Mar
Feb
Jan
0
10
20
30
40
50
60

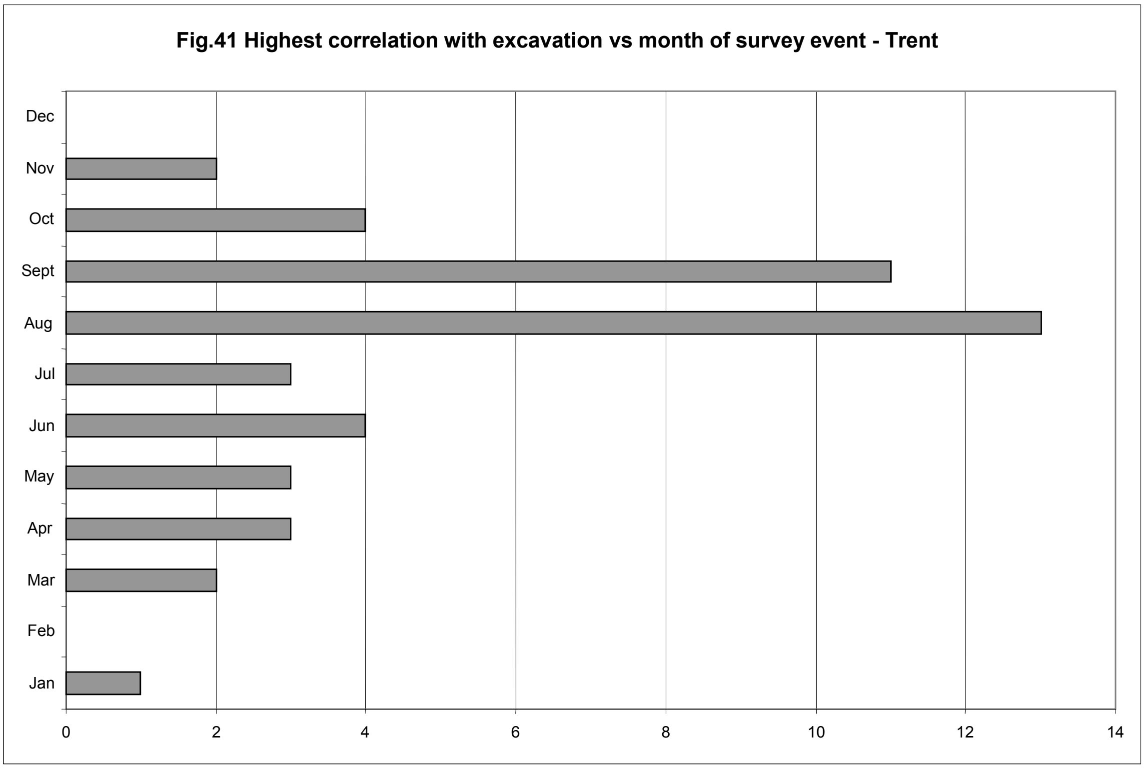
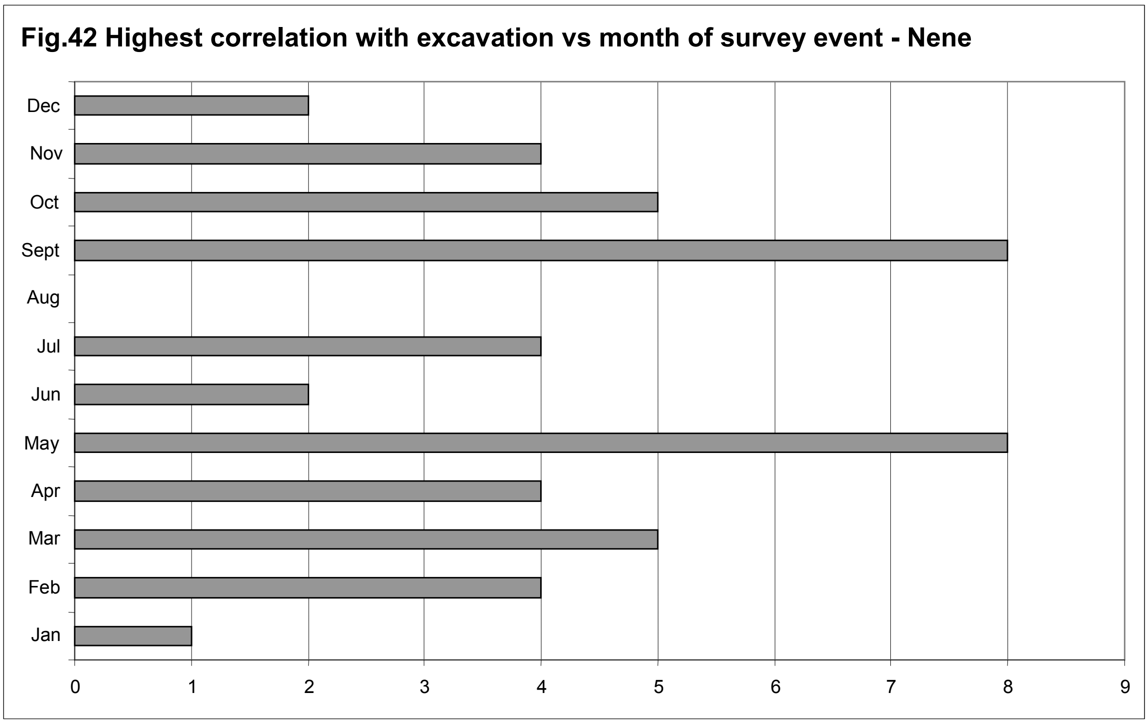


Fig.41 Highest correlation with excavation vs month of survey event - Trent
Dec
Nov
Oct
Sept
Aug
Jul
Jun
May
Apr
Mar
Feb
Jan
0
2
4
6
8
10
12
14



It is possible to explore this data and examine the success of specific survey techniques in different months. Figure 43 shows the month when recorded grid magnetometer events with the highest (80-100%) correlation with excavation took place (n.=308) and Figure 44 shows the same data for resistivity survey events (n.=75). The graph for magnetometry shows March and June-July as the months with the most highly successful events whilst that for Resistivity suggests June and to a lesser extent April and September.

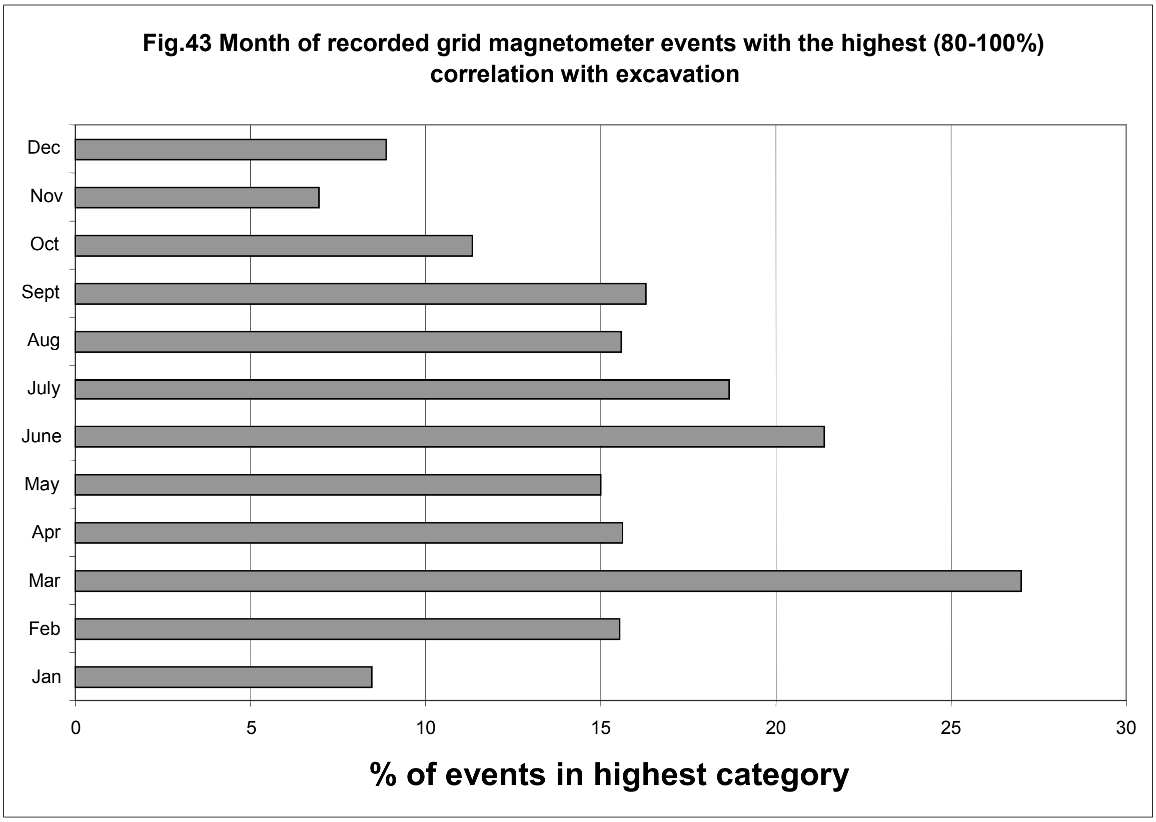
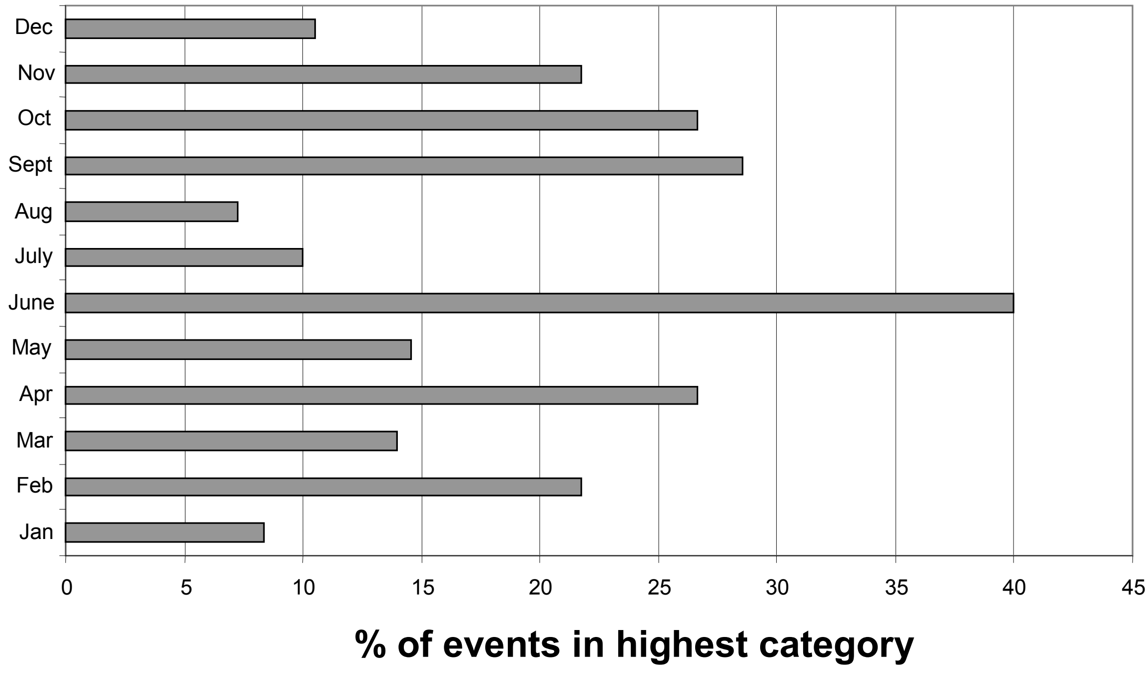


Fig.44 Month of resistivity events with the highest (80-100%) correlation with excavation



8.7 Quality of survey compared with results

We consider adherence to ADS guidelines a measure of the quality of a survey, and the following graphs show the correlation of this measure with surveys with the highest correlation with the results of excavation (80-100%). Figure 45 shows the study area as a whole, (n.=357), Figure 46 shows the Trent (n.=51) and Figure 47 shows the Nene (n.=49). All three graphs show a similar pattern, suggesting that high quality surveys do tend to give good results. Although this result may seem banal, it provides a predictive tool for the likely success rate of geophysical survey, on the basis of the contractor's adherence to national standards of reporting.

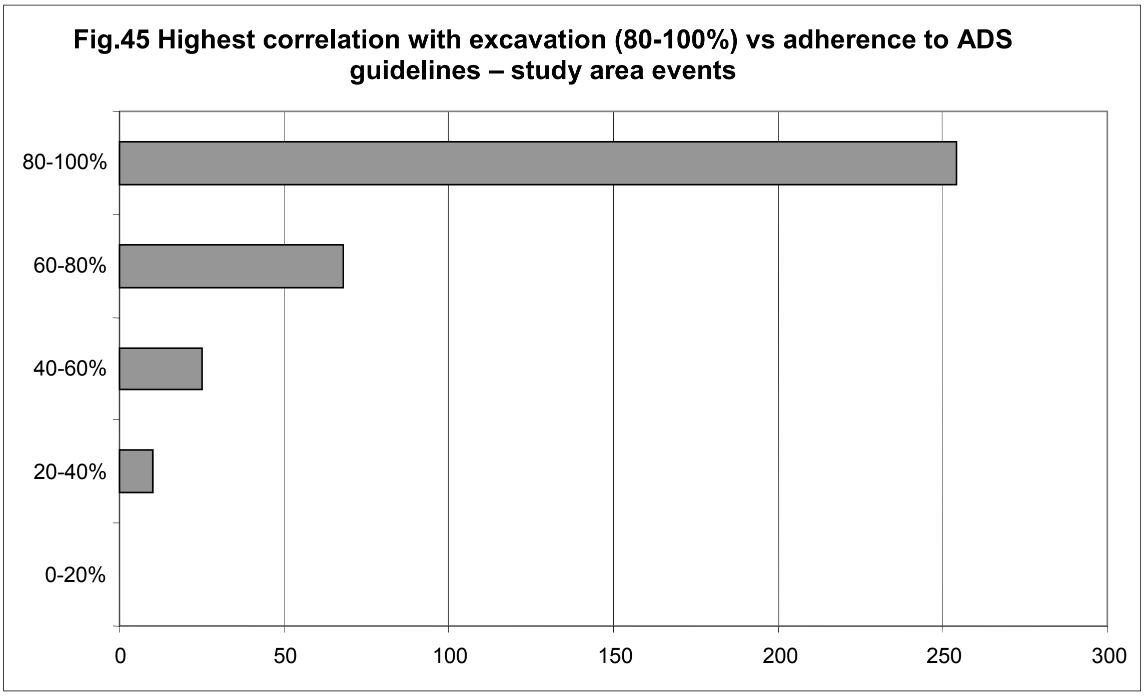


Fig.45 Highest correlation with excavation (80-100%) vs adherence to ADS guidelines – study area events
80-100%
60-80%
40-60%
20-40%
0-20%
0
50
100
150
200
250
300

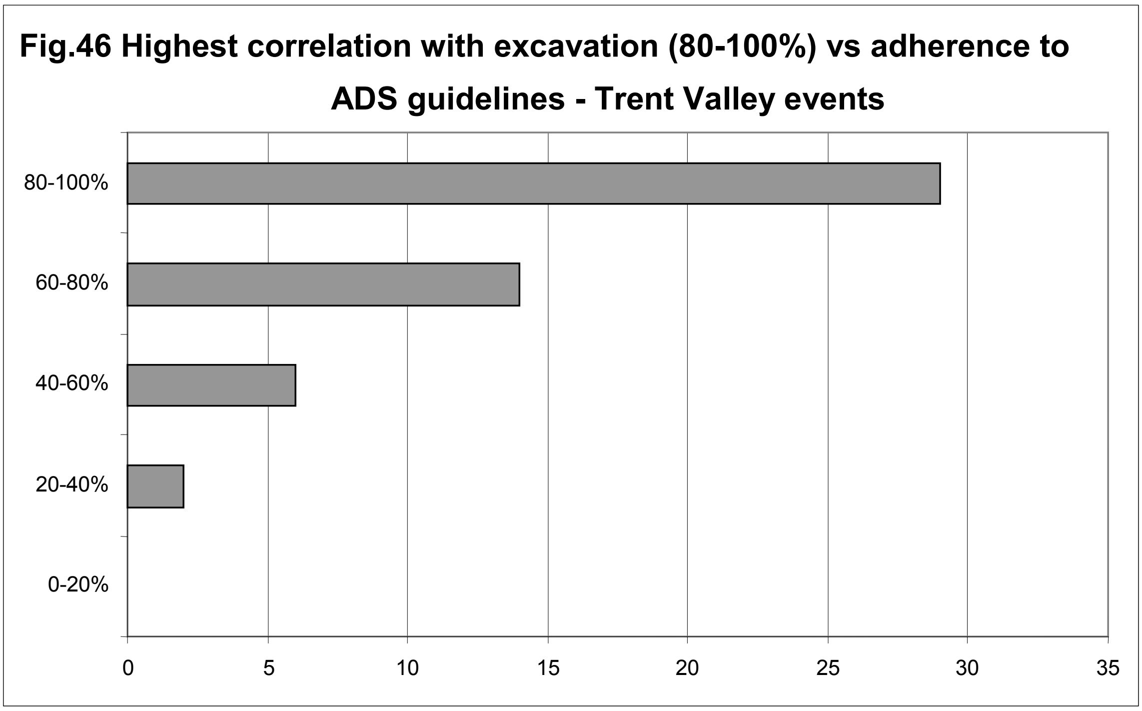
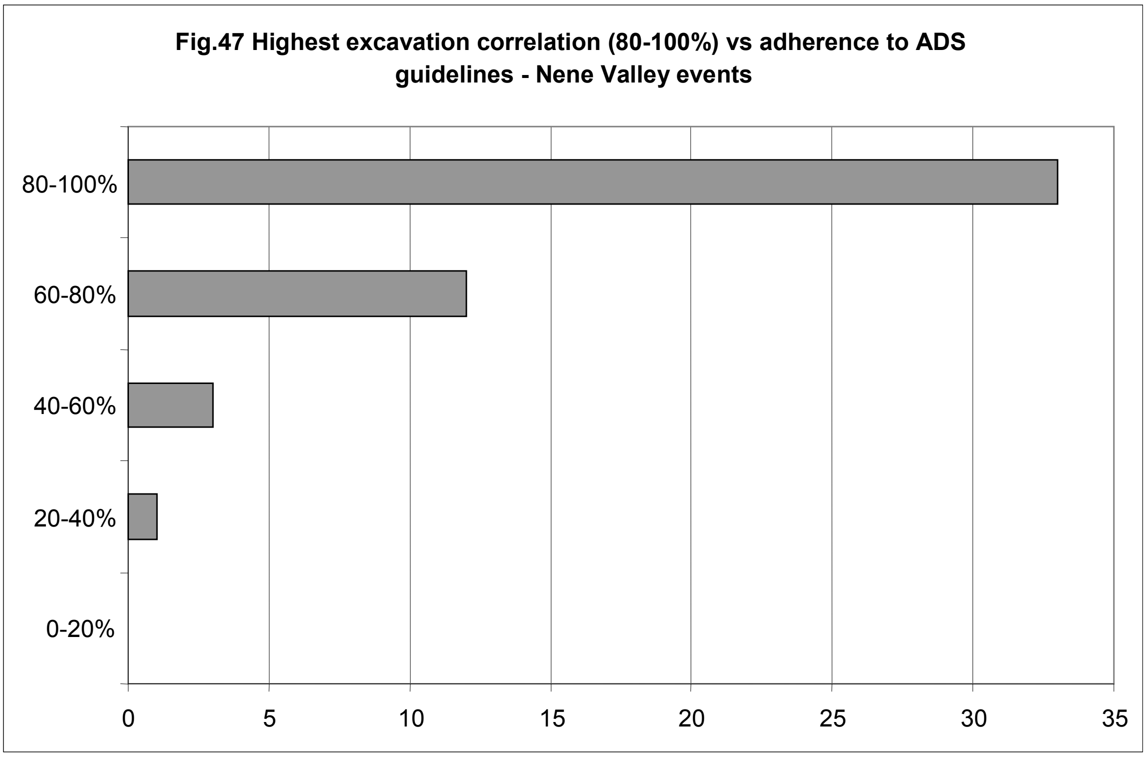
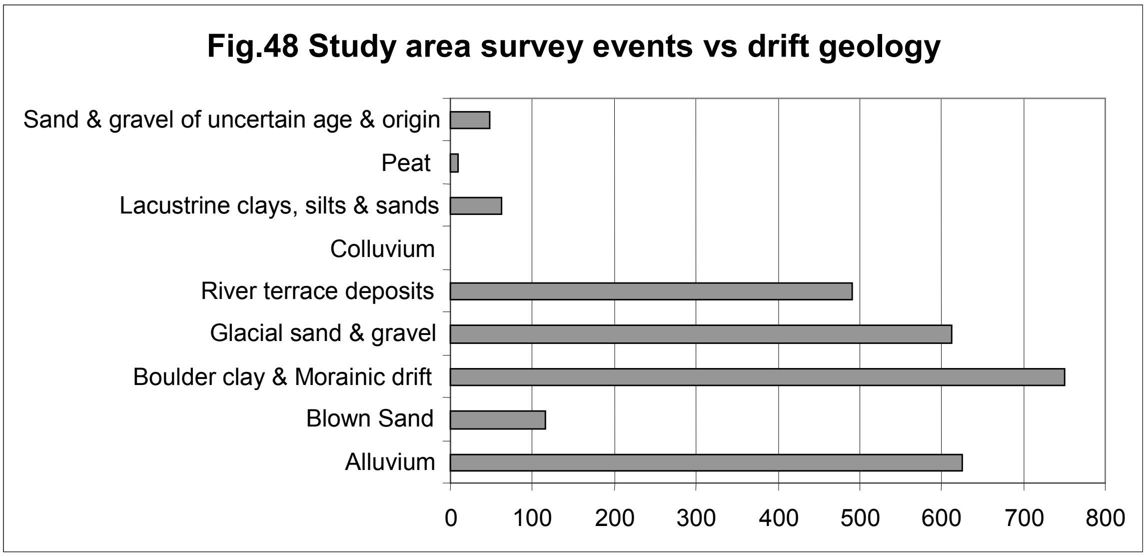


Fig.46 Highest correlation with excavation (80-100%) vs adherence to ADS guidelines - Trent Valley events
80-100%
60-80%
40-60%
20-40%
0-20%
0
5
10
15
20
25
30
35



8.8 Geology

The solid and drift geology encountered by the various survey events is reported in Figures 48-49: study area; Figures 50-51: Trent; and Figures 52-53: Nene. The graphs show differences between the two river valleys, with more alluvium in the Trent and more boulder clay and morainic drift in the Nene valley. The solid geology of the two valleys shows that they have very different underlying geologies.



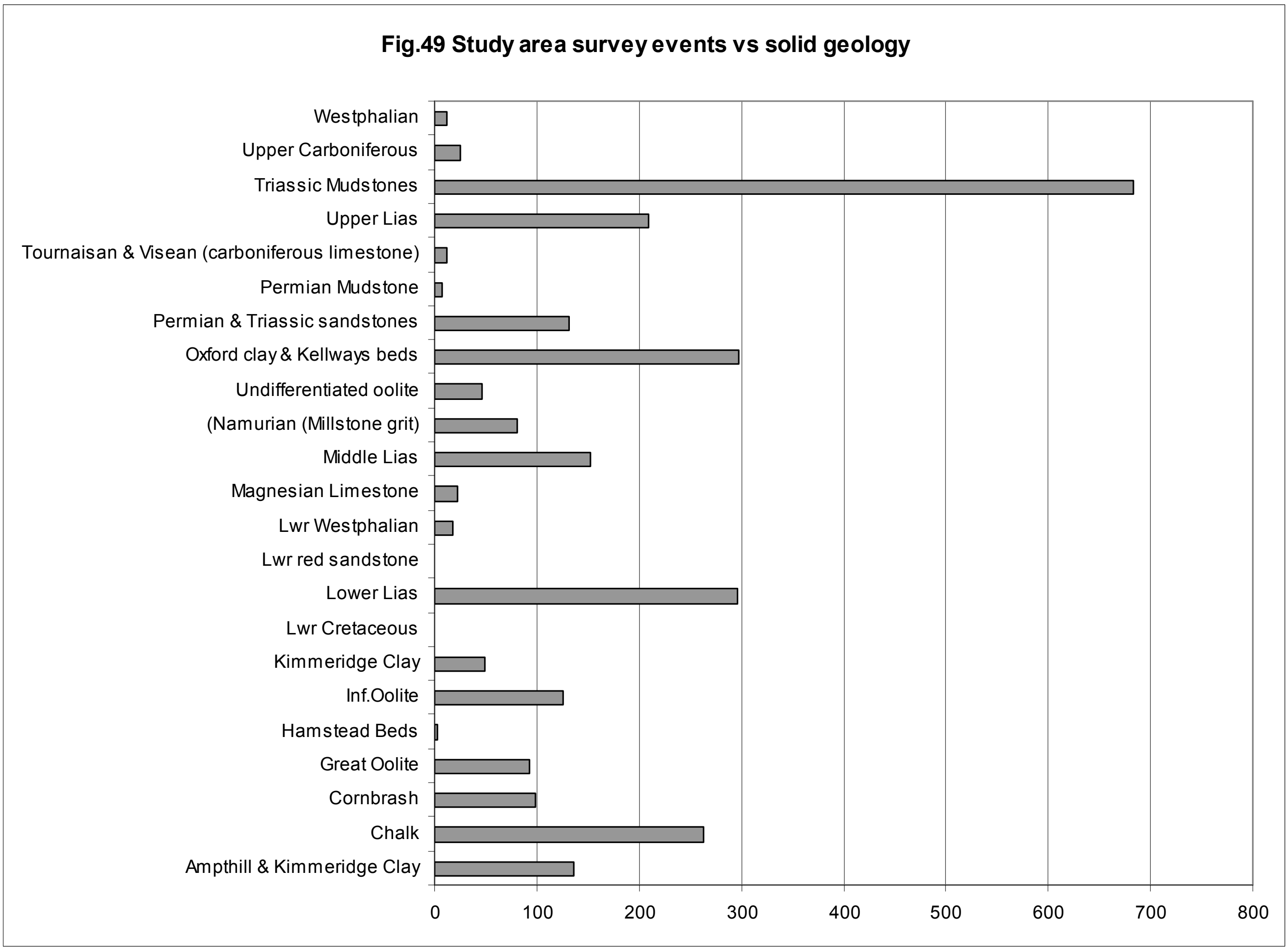


Fig.49 Study area survey events vs solid geology
Westphalian
Upper Carboniferous
Triassic Mudstones
Upper Lias
Tournaisan & Visean (carboniferous limestone)
Permian Mudstone
Permian & Triassic sandstones
Oxford clay & Kellways beds
Undifferentiated oolite
(Namurian (Millstone grit)
Middle Lias
Magnesian Limestone
Lwr Westphalian
Lwr red sandstone
Lower Lias
Lwr Cretaceous
Kimmeridge Clay
Inf.Oolite
Hamstead Beds
Great Oolite
Cornbrash
Chalk
Ampthill & Kimmeridge Clay
0
100
200
300
400
500
600
700
800

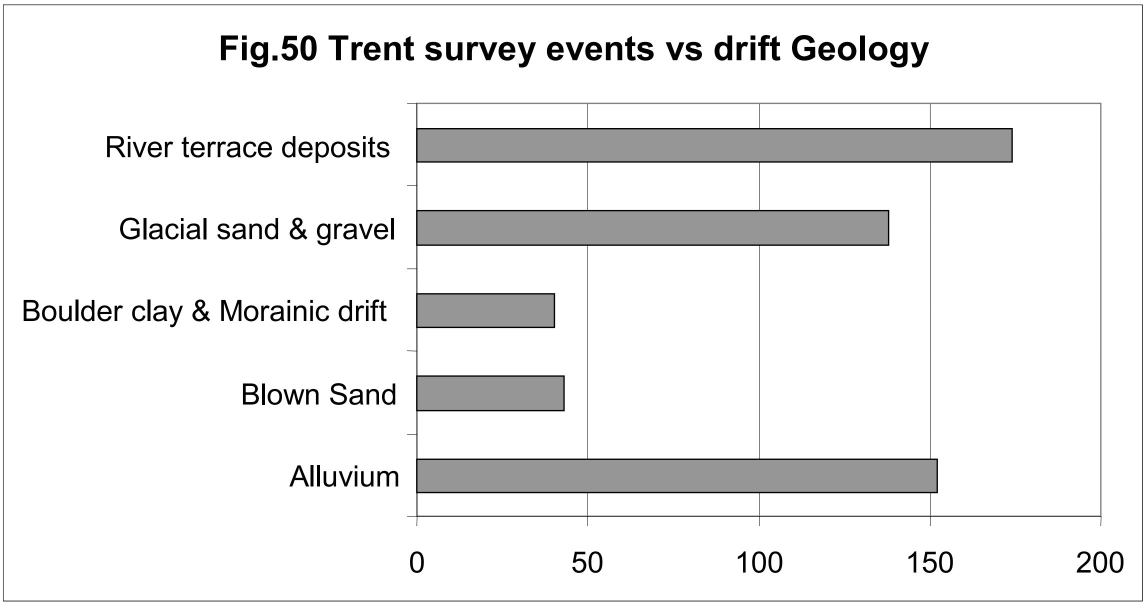


Fig.50 Trent survey events vs drift Geology
River terrace deposits
Glacial sand & gravel
Boulder clay & Morainic drift
Blown Sand
Alluvium
0
50
100
150
200

Fig.51 Trent survey events vs solid geology

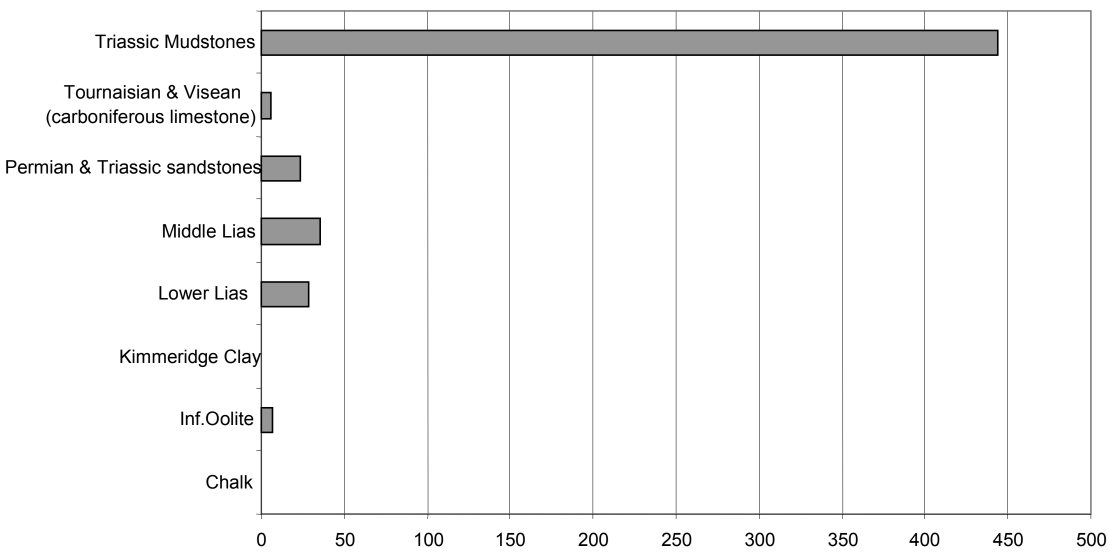
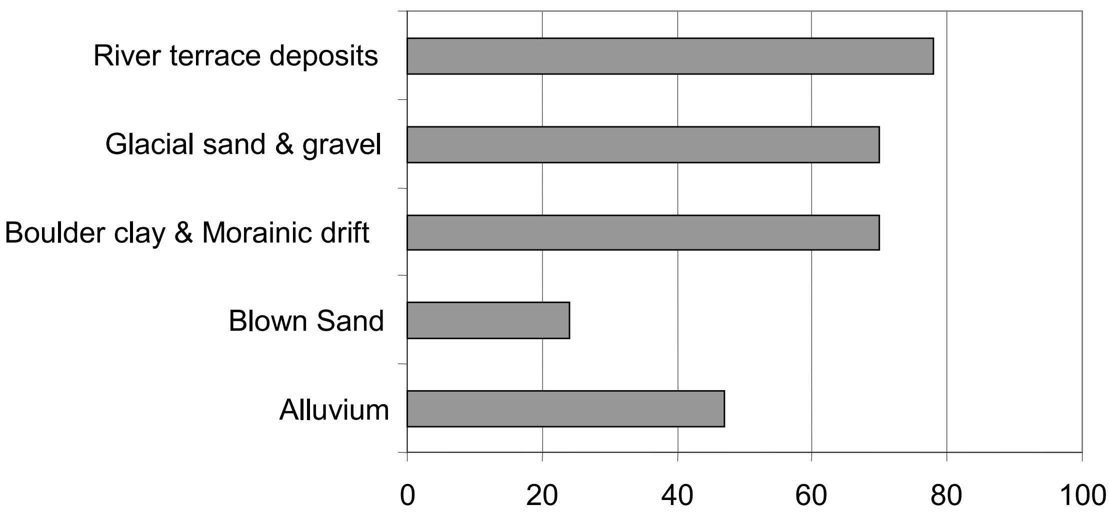
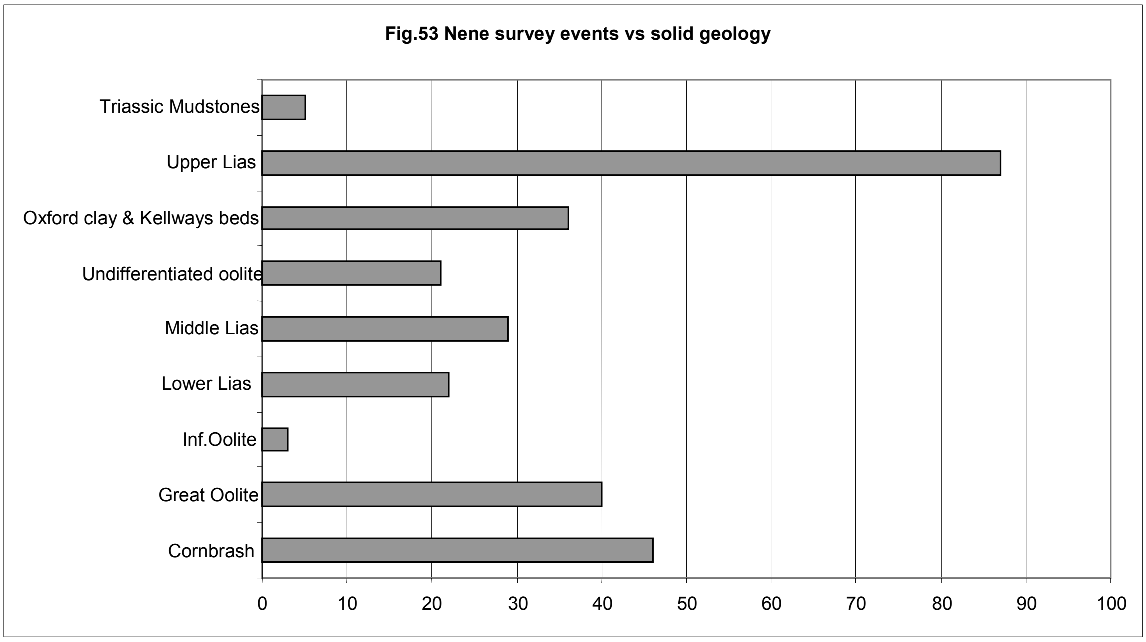


Fig.52 Nene survey events vs drift geology





The next diagrams show the various percentages of events in the study area with the highest correlation with excavation against drift geology (Fig.54) and solid geology (Fig.55).

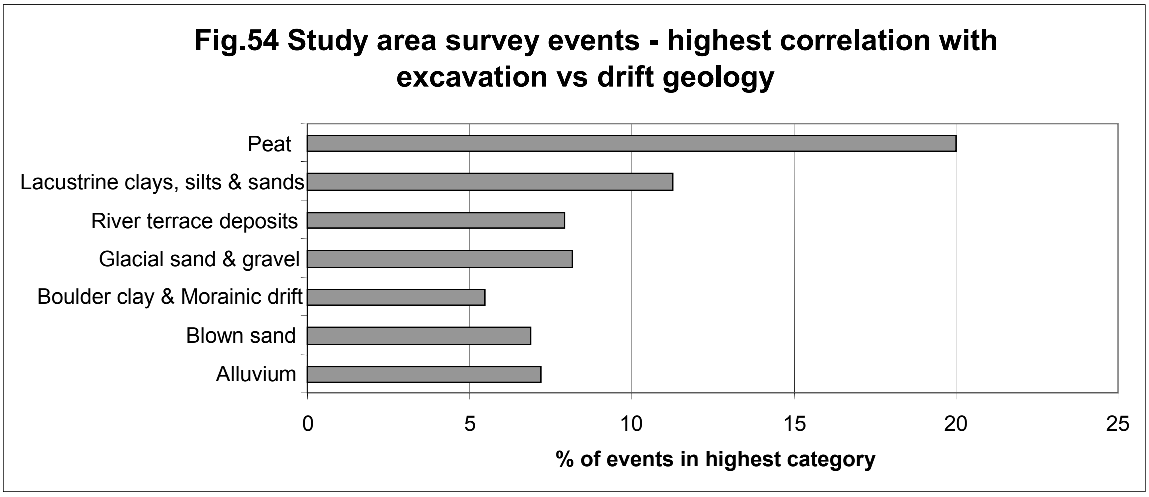
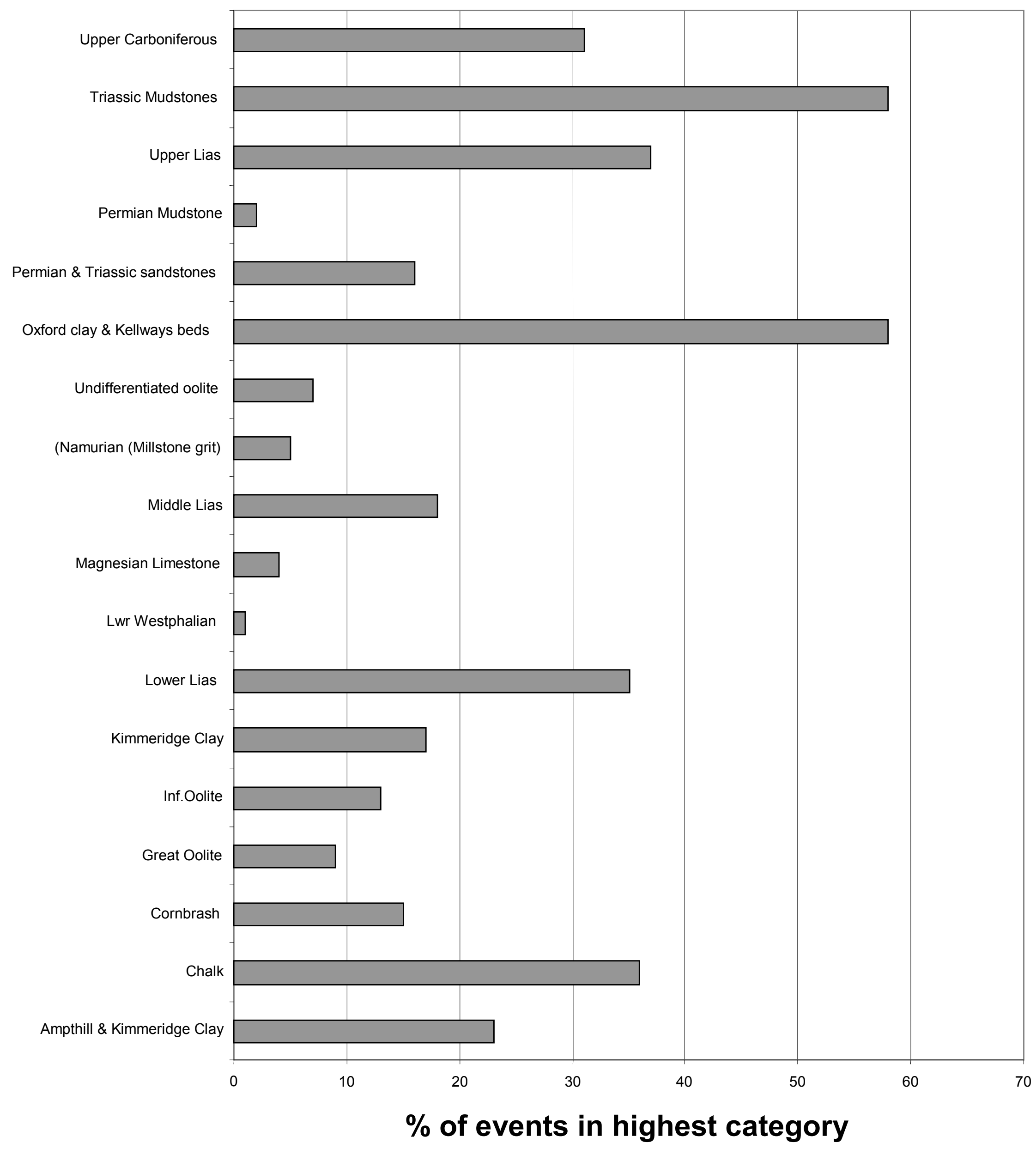
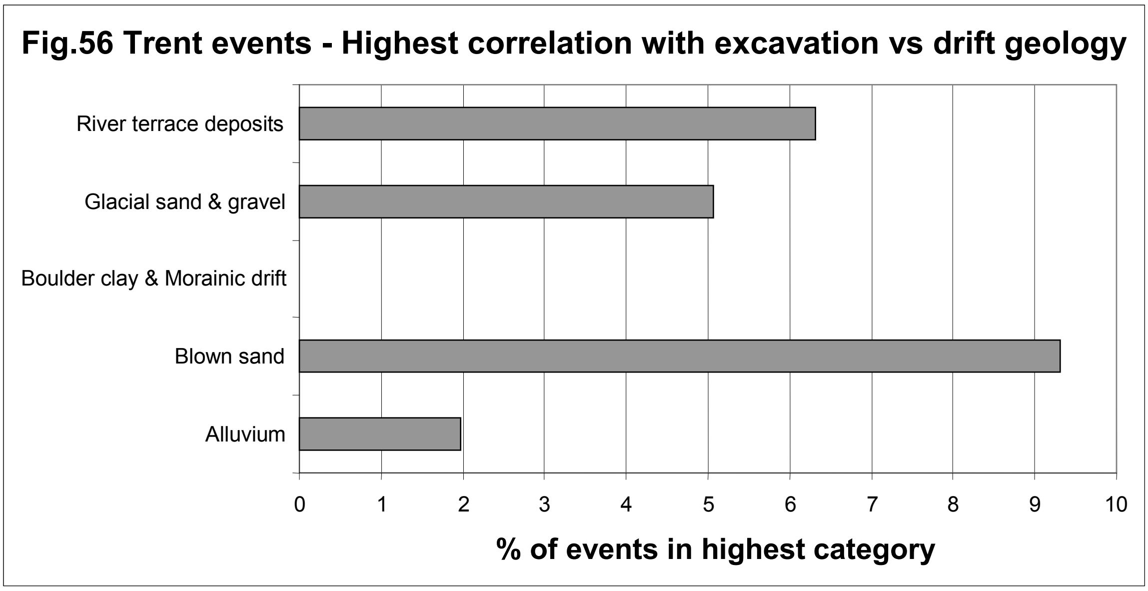
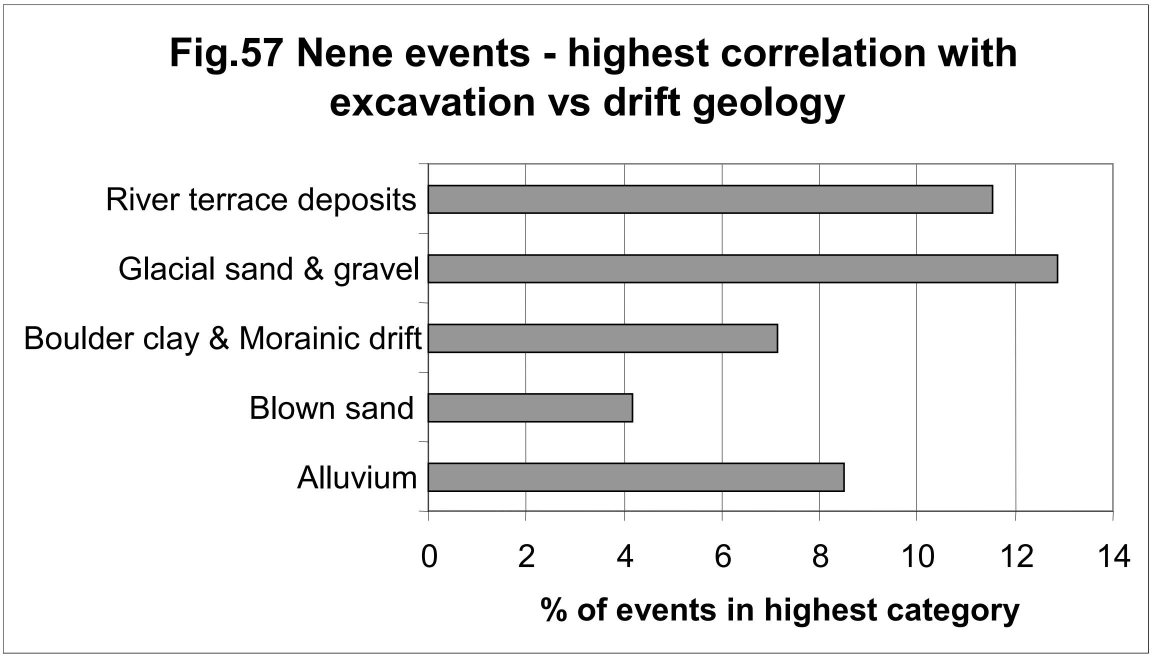


Fig.55 Study area survey events - highest correlation with excavation vs solid geology



The graphs for percentages of events with the highest correlation with excavation against drift geology in the Trent (Fig.56) and the Nene (Fig.57) Valleys are very instructive: in the Trent the boulder clays and morainic drift do not seem to be conducive to the highest category of correlation with excavation, whilst survey is more successful on them in the Nene Valley. Survey on the blown sands of the Trent seems to be much more successful than in the Nene Valley, whereas the opposite is true as regards alluvium.





Because of the difference in the underlying geology between the Trent and Nene Valleys, it is difficult to identify significant correlations in the graphs for percentages of events with the highest correlation with excavation against solid geology (Figs 58 & 59).

Fig.58 Trent events - highest correlation with excavation vs solid geology

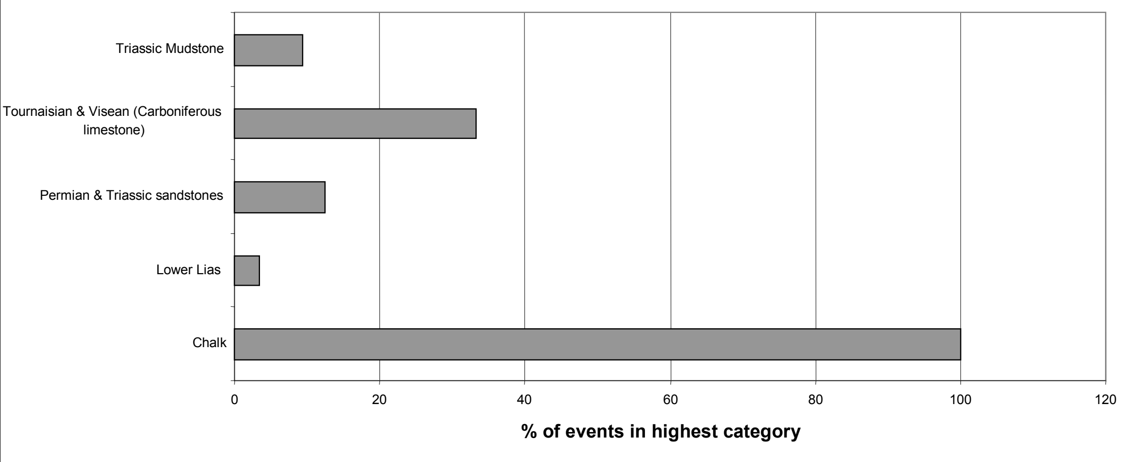
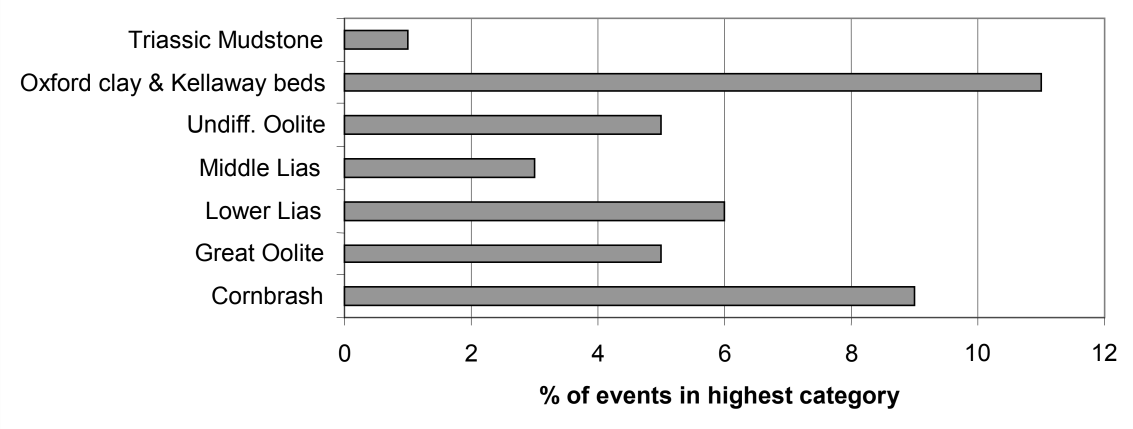


Fig.59 Nene events - highest correlation with excavation vs solid geology



9. Conclusions and Recommendations

A number of general conclusions can be drawn from the analyses presented:

- The number of geophysical surveys that have been carried out in the East Midlands is much greater than was indicated by the *The English Heritage Geophysical Survey Database* (http://sdb2.eng-h.gov.uk) or suggested by previous estimates for the Country as a whole (Gaffney and Gater 2003: 22-23, fig.3).
- There is a high correlation in both the Trent and Nene valleys between geophysical anomalies and excavation results.
- There is a less obvious correlation with cropmarks, which suggests that the information that they provide is complementary to geophysical survey for predicting archaeological features.

Recommendations

- Similar surveys should be carried out in the other regions of England in order to obtain realistic estimates of the number of geophysical surveys that have been carried out and to provide baseline data for further analysis.

- Geophysical investigation should be recommended by curators and consultants as a matter of course, and English Heritage and Archaeological Data Service guidelines should always be specified.
- Our investigation was limited by lack of data in many reports, and although we are sure that curators specify that English Heritage and Archaeological Data Service guidelines should always be followed, it is worth remarking that this does not always happen in practice. There is no doubt that better quality data would have enhanced our study, and the strong correlation between successful survey and adherence to guidelines indicates that contractors who provide high quality reports tend to be those contractors who carry out effective surveys.
- Finally we recommend that our conclusions should be verified by an experimental programme in which sites well documented by air photography (such as on river gravels) are investigated by a range of geophysical techniques and then the archaeological features predicted by the various techniques (air photography and geophysical survey) are tested by ground-truthing.

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Acknowledgements

This project was run through the University of Nottingham and managed for the University by Drs Mark Pearce (Department of Archaeology) and David Knight (Trent & Peak Archaeology) The project database was designed by Alastair MacIntosh (Department of Archaeology), with advice from Neil Linford and Manny Lopez of English Heritage. Geophysical reports and appropriate supporting data were obtained from HERs by Eileen Appleton, Alastair MacIntosh and Alison Wilson. Alison Wilson compiled the database and analysed the desk-based information. The project was monitored on behalf of English Heritage by Drs Sarah Jennings, Neil Linford and Paddy O'Hara and benefited also from discussions with Dr Jim Williams, English Heritage's scientific advisor for the East Midlands. Particular thanks must also be extended to the many staff of the HERs in study area who assisted during the collection of geophysical data, and without whom none of this would been possible.

APPENDICES

Appendix 1

Report Number -

Database Proforma – Survey Visit

Survey Visit Number	

Survey Name	

County	

Survey Start	
Survey End	

Report ID	

NGR 100KM Square	

NGR Easting	
NGR Northing	

NGR No	

Authority	

Min Easting	
Min Northing	

Max Easting	
Max Northing	

Appendix 2

Survey Visit Number -

Database Proforma – Survey Technique

Technique No	
Survey Type	
Method of Coverage	
Traverse Sep	
Reading Int	
Instrument Type	FG CM RES MS GPR SEI
Instrument Make	
Probe Configuration	TWIN DD WENNER MULTI
Probe Spacing	0.5 1 MULTI
Land Use	
Area Surveyed	

Appendix 3

Report Number –
Survey Visit Number –

Database Proforma – Classification Table

Classification ID	

Monument Type	

Monument Period	

Source	

Monument ID	

Appendix 4

Survey Visit Number -

Database Proforma – Personnel

Contractor (Role ID-)	

Client (Role ID-)	

Archaeological Unit (Role ID-)	

Appendix 5

Database Proforma – Monument Classification Table

Monument ID	

Monument Name	

RSM No	

NAR No	

SAM No	

Appendix 6

Database Proforma – Geology

Solid	

Drift	

Appendix 7

Survey Visit Number -
Technique Number -

Database Proforma – Effectiveness

Plot Type	**Greyscale Trace Dot-Density Contour Colour**
Raw Data	**Y N**

Processing	

Percentage Background	

Percentage Noise	

Percentage Anomalies	

Number of Features (Interpreted)	

Number of Features Investigated	

Number of Features Proved	

ADS Correlation	

Correlation with Excavation	

Correlation with Cropmarks	

Correlation Comments	

Area Excavated	

Appendix 8

G Survey Visit Number -

Database Proforma – Conditions

Month of Survey	**JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC**
Weather Conditions	**RAIN SUN WIND N/A**
Soil Moisture	**DRY MOIST WET STANDING N/A**
Cultivation	**PLOUGH HARROW MEADOW PASTURE DRILL N/A**
Vegetation	**SCRUB GRASS CROP NONE N/A**
Vegetation Height (mm)	
Surface Contamination	
Sub-Surface Contamination	
Masking Deposits	**ALLUVIUM COLLUVIUM LOESS**
Masking Deposit Character	**HEAVY SILT LIGHT SILT SAND**
Masking Deposit Depth (mm)	

Appendix 9

Report Number -

Database Proforma – Monument Number

Monument ID.	
Monument Name	
Local/Unitary Authority	
SMR No.	
NMR no.	

Appendix 10

GEOPHYSICAL REPORT COVERSHEET

REPORT ID	AUTHORITY
DATE COMPILED	SMR NO/ID

TITLE
AUTHOR
DATE

GP CONTRACTOR	ARCH CONTRACTOR	CLIENT ORG

SINGLE/IN OTHER* *Delete as appropriate

If in other report: Title Author Date	Related Report ID Numbers
	Survey Visit Numbers Survey Technique Numbers Monument Numbers

Appendix 11

EXCAVATION REPORT COVERSHEET

EX REPORT ID	AUTHORITY
DATE COMPILED	SMR NO/ID

TITLE AUTHOR DATE	CONTRACTOR CLIENT
	REFERS TO

REPORT ID NUMBER
MONUMENT NUMBERS

Appendix 12

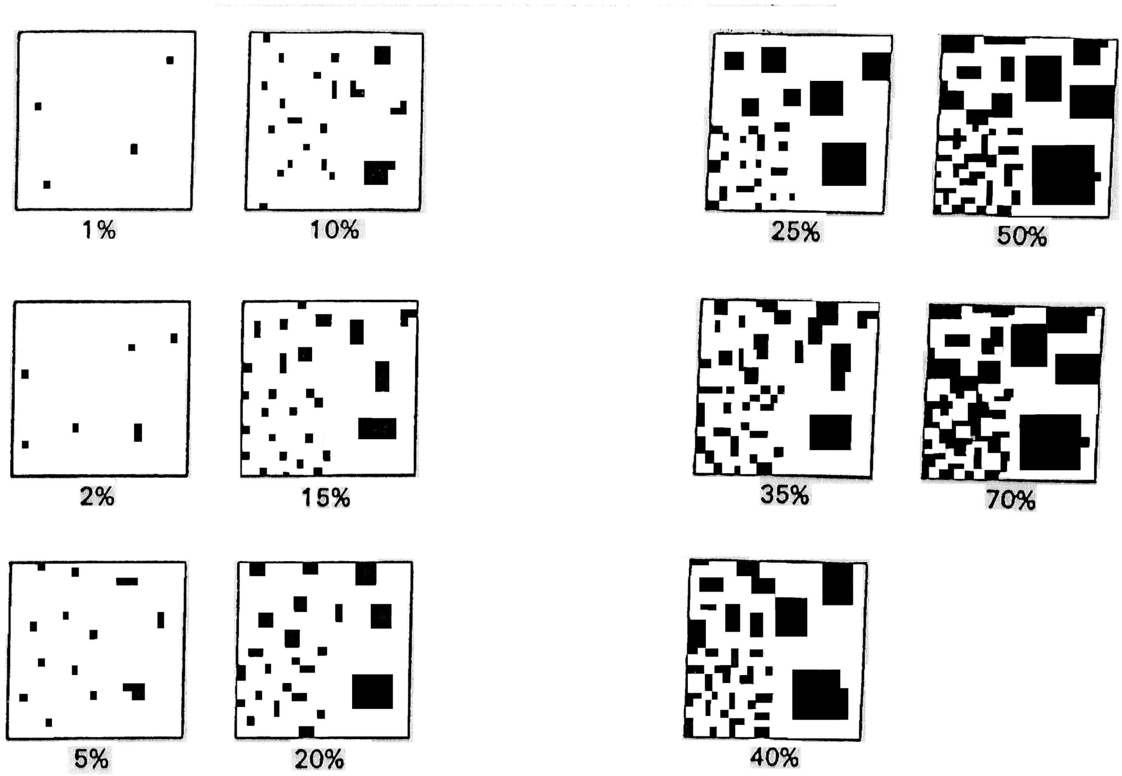

Chart for estimating percentages of pixel types in greyscale geophysics plots (after Soil Survey Handbook).

Appendix 13 – List of bodies carrying out surveys - by Authority

Derby City
Stratascan
Derbyshire
Ancient Monuments Laboratory
Arcus
Bartlett Clark Consultancy
D. Carpenter
E.G. Frost
Field Archaeology Specialists - University of York
Geophysical Surveys of Bradford (GSB Prospection)
Geoquest Associates
Ground Scan
Mike Griffiths and Associates
Northamptonshire Archaeology
Oxford Archaeotechnics
Paul Beavitt
Phoenix Consulting
S.M. Garrod
Stratascan
Trent and Peak Archaeological Trust
University of Bradford, Dept of Archaeological Science
University of Leicester Archaeological Services
University of Sheffield, Dept of Archaeology & Prehistory
Leicester City
Pre-construct Geophysics
Stratascan
University of Bradford, Dept of Archaeological Science
University of Leicester Archaeological Services
Leicestershire
Ancient Monuments Laboratory
Archaeological Surveys
Bartlett Clark Consultancy
Engineering Archaeological Services
Geophysical Surveys of Bradford (GSB Prospection)

Heritage & Resources team, Leics CC
Leicestershire Museums
Melton Fieldworkers
Northamptonshire Archaeology
Oxford Archaeotechnics
Pre-construct Geophysics
Stratascan
University of Leicester Archaeological Services
Birmingham Field Archaeology Unit
Lincolnshire
Ancient Monuments Laboratory
Archaeological Project Services Ltd
Archaeological Services, University of Durham
Bartlett Clark Consultancy
Cambrian Archaeological Projects Ltd
Centre for Archaeology
Engineering Archaeological Services
English Heritage
Field Archaeology Specialists - University of York
Geophysical Surveys of Bradford (GSB Prospection)
Geoquest Associates
Heritage Lincolnshire
Joanne Buckley (University of Sheffield)
Landscape Research Centre
Lindsey Archaeological Services
Northamptonshire Archaeology
Oxford Archaeotechnics
Pre-construct Geophysics
Stratascan
The Grantham Archaeology Group
T. Ellis
University of Leicester Archaeological Services
University of Sheffield, Dept of Archaeology & Prehistory
West Yorkshire Archaeological Services
N.E. Lincs
Bartlett Clark Consultancy
Ancient Monuments Laboratory
Geophysical Surveys of Bradford (GSB Prospection)
Geoquest Associates
Oxford Archaeotechnics
Pre-construct Geophysics
Stratascan
West Yorkshire Archaeological Services
N. Lincs
Ancient Monuments Laboratory
West Yorkshire Archaeological Services
Archaeophysica Ltd
Community Archaeology Research Project
Engineering Archaeological Services
Geophysical Surveys of Bradford (GSB Prospection)
Geoquest Associates
Humber Field Archaeology
John Samuels Archaeological Consultancy
Oxford Archaeotechnics
Pre-construct Geophysics
Stratascan
University of Sheffield, Dept of Archaeology & Prehistory
Northamptonshire
Albion Archaeology
Ancient Monuments Laboratory
Archaeological Services and Consultancy Ltd
Bartlett Clark Consultancy
A. Challands
Engineering Archaeological Services
English Heritage
Geophysical Surveys of Bradford (GSB Prospection)
Geoquest Associates
John Samuels Archaeological Consultancy
Nene Valley Research committee
Northamptonshire Archaeology
Northampton Archaeology
Northamptonshire County Council
P.D. Catherall
Stratascan
University of Bradford, Dept of Archaeological Science
West Yorkshire Archaeological Services
Nottingham City
Stratascan
Geophysical Surveys of Bradford (GSB Prospection)
Nottinghamshire
A. German
A. Morris
Arcus
A. Aspinall & S. Dockrill
British Geological Society
C.J. Brooke
C. Samson
Earth Solutions
E. Midlands Earthwork Project
Engineering Archaeological Services
Field Archaeology Specialists - University of York
Geophysical Surveys of Bradford (GSB Prospection)
Geoquest Associates
Glasgow University
Lindsey Archaeological Services
Northamptonshire Archaeology
Oxford Archaeotechnics
P. Roberts
P. Cresswell
Stratascan
Trent and Peak Archaeological Trust
University of Sheffield, Dept of Archaeology & Prehistory
West Yorkshire Archaeological Services
Peterborough City
A. Challands
Ancient Monuments Laboratory
Bartlett Clark Consultancy
Engineering Archaeological Services
Geophysical Surveys of Bradford (GSB Prospection)
Geoquest Associates

Northamptonshire Archaeology
UTSI Electronics
Rutland
Ancient Monuments Laboratory
Northamptonshire Archaeology
Pre-construct Geophysics
Stratascan
University of Leicester Archaeological Services
Staffordshire
A. Richardson
Ancient Monuments Laboratory
Archaeophysica Ltd
Bartlett Clark Consultancy
Birmingham Field Archaeology Unit
D. Leavy
Engineering Archaeological Services
Geophysical Surveys of Bradford (GSB Prospection)
Grantham Archaeology Group
Northamptonshire Archaeology
Oxford Archaeological Association
Penk Valley Archaeological Group
Stafford Borough Council, archaeology section
Staffordshire County Council
Stratascan
University of Keele
University of Leicester Archaeological Services
Stoke-on-Trent
Engineering Archaeological Services

Appendix 14. Trent Valley parishes with geophysical surveys

Alkborough
Alrewas
Aston-on-Trent
Barlaston
Barrow-upon-Trent
Barton-under-Needwood
Besthorpe
Bottesford
Burton-upon-Trent
Cannock Chase
Castle Donington
Caythorpe
Collingham
Colton
Crowle
Derby
Drakelow
Dunstall
Edingale
Elvaston
Epworth
Farndon
Findern
Flixborough
Foston
Gainsborough
Gamston
Girton
Grassthorpe
Greetwell
Hatton
Haxey
Hilton
Ingleby
Keadby
Kegworth
Langford
Laughton
Little Carlton
Lockington
Marnham
Marton
Mavesyn Ridware
Melbourne
Messingham
Newark
Newton-on-Trent
North Muskham
Ockbrook
Rampton
Scotter
Scunthorpe
Shardlow
Stafford
Stanton Lees
Staythorpe
Stoke
Sturton-le-Steeple
Swynnerton
Thonock
Torksey
Tutbury
Walton-upon-Trent
Willington
Wychnor

Appendix 15. Nene Valley parishes with geophysical surveys

Barnwell
Bozeat
Brackmills
Castor
Croughton
Duston
Earls Barton
Fotheringhay
Great Houghton
Grendon
Hardingstone
Hemington
Higham Ferrers
Irchester
Irthlingborough
Nassington
Nether Heyford
Northampton
Oundle
Paston
Peterborough
Preston Capes
Raunds
Ringstead
Rothersthorpe
Rushden
Stanground
Stanwick
Thrapston
Upper Heyford
Upton
Wadenhoe
Warmington
Wellingborough
Wollaston