



Terra Nova

Evaluating Aggregate in North West England

The Effectiveness of Geophysical Survey in Archaeological Investigations

An Aggregates Levy Sustainability Fund Project

David Jordan, Terra Nova Ltd

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The Effectiveness of Geophysical Survey as an Archaeological Tool

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The Project

Companies quarrying aggregate are required to record archaeological remains before they are destroyed. Thus the availability of means to find buried remains before extraction is a key part of the aggregate planning process.

Some professional archaeologists have concluded that geophysics may not be an effective way to find and map remains in North-West England. If this is true then it might have a serious effect on archaeological mitigation strategies for aggregate planning in the region since there are few other ways of finding and mapping sites in areas, such as this, where pasture predominates.

This project proposes to find out whether geophysical survey is an efficient and effective way to assess archaeological remains in the North West and to suggest means by which it might be improved. It will consider the technical matters which influence the outcome of surveys by looking in detail at a selection of survey results in the light of subsequent excavation. It will also consider how the practice and administration of archaeology influences the use of and outcomes of surveys.

The project will make publicly accessible a report which will address these questions, give guidance on the use of geophysical survey in the North West and provide fuller information on surveys carried out in the region. Meetings of all concerned will be convened to allow the report to be discussed and the project will be brought to the attention of the wider public through references in popular publications.

This will be a demanding project which will consider matters of technique, attitude and policy relevant to archaeological geophysics. It will need a command of the technical and administrative issues involved, as well as a light touch when considering some sensitive professional concerns. We do not underestimate these problems but hope that all those affected by the project will offer their support to an honest and open attempt to address a significant practical problem.

Terra Nova Ltd

terra@terra.plus.com

Context

Aggregate and Archaeology in the North-West

About 13 million tonnes of aggregate is extracted in North-West England each year. About 10 million tonnes of this is crushed limestone, sandstone and igneous rocks and the remainder is sand and gravel¹. The area affected and the potential to destroy buried remains is considerable.

The distribution of extraction and of potential extraction of the various types of aggregate is uneven between the authorities of Cheshire, Greater Manchester, Merseyside, Lancashire and Cumbria. Most of the crushed-rock aggregate comes from Cumbria and Lancashire, most of the gravel and sand from Cheshire.

The North-West is unusual because it produces a much higher proportion of crushed-rock aggregate than more lowland areas. Much of this quarrying takes place on the upland margin, in areas where the density of known archaeological remains is lower and its character more ephemeral and more difficult to detect than in much of the rest of England. Complex, glacial drift soils and a predominance of pasture tend to make remains even harder to find. The techniques we most rely on to find buried remains elsewhere, especially air-photography and field-walking, are usually ineffective.

Geophysics for Archaeology in the North-West

Geophysics might therefore be the approach of choice. Local archaeologists report, however, that the results of geophysical survey have often proved disappointing and a review of its use and the potential for its improvement, on aggregate sites, is now urgently required.

The picture of geophysical survey success is bound to be uneven. The absolute performance of geophysics, and its performance relative to other approaches, will be different around hard rock quarries in the acid upland soils of Cumbria than around gravel quarries in the lowlands of Cheshire, especially since the soils overlying these Cheshire aggregate deposit do support significant areas of arable crop where Air Photography and Field Walking can be successful. If we are going to consider the archaeological role of geophysical survey in all the counties of the North-West together we must also consider these important differences.

The significance of archaeological remains in the North West is no less than in other regions. The MARS report² showed that the density of known monuments and the rate of their discovery is relatively low but it also made it clear that in areas where pasture and semi-natural environments are common, as here, sites stand the best possible chance of survival, increasing their potential significance. The MARS report also indicates that the number of sites destroyed in the North West by mineral extraction, as opposed to other risks, is the lowest in England but, when we take the low concentration of known sites into account, the proportional loss is very much higher. Moreover, professional opinion, gathered during this survey, suggests that many pre-medieval sites remain to be discovered. It is therefore possible that the current bias towards relatively recent sites is not truly representative of the resource and thus that aggregate extraction may be destroying unrecognised, earlier sites simply because they are hard to find.

¹ North West Regional Aggregates Working Party Annual Report 2002, Cheshire County Council. Figures refer to the most recent extraction statistics for 2001.

² T Darvill and A Fulton, 1995 *The Monuments at Risk Survey of England 1995*, English Heritage

Background Study

To prepare this proposal we visited most of those most affected by archaeological geophysics in the North West – surveyors, excavating units, curators and others – to ask their views and to recruit them to help in the project. Those few who we were not able to visit were contacted by telephone.

Not all agreed that there is a problem to address, or that the problem is principally technical. Everybody, however, agreed that a project to review North Western archaeological geophysics would be worthwhile and offered practical help to see it carried out. Thus a major objective of this initial project development exercise was achieved.

Surveyors were also mostly happy to see survey metadata supplied to the English Heritage and Archaeology Data Service archives, although those we asked said that they were not willing to pay for this – and there was some concern that ADS archive costs need to be met by clients or the public purse if survey results are to be made available in this way.

Our background study confirms that there are indeed tricky, technical issues of where and how to apply geophysical survey in North-West England which need to be addressed, as our original outline suggested. We were given some specific examples, but rather more anecdotal reports, of survey “failures” where geophysical survey had not found remains later proved by excavation.

Some of the surveyors confirmed that they do not report such “failures” as often as their “successes”, for obvious professional reasons and because they feel that clients and colleagues are more interested in what works than what does not. This reticence makes it rather harder to assess the true picture of geophysical survey performance. Many of the surveyors we spoke to said that they might be willing to see their “failures” made public but were concerned that they would be criticised unfairly as a result – to their commercial disadvantage – since they believe that many of the judgements made about their work are superficial or irrational.

Technical and non-technical problems

The technical problems which determine whether archaeological remains can be detected geophysically are significant but they may be easier to resolve than those which arise because of:

- 1 the very wide range of practices and attitudes we encountered between those who design project briefs and commission surveys in different areas and organisations
- 2 the very variable way in which surveyors are trained and accredited
- 3 the lack of central support available and control imposed within what is now a substantial geophysical survey industry

We gained the strong impression, from the interviews we conducted, that these non-technical, structural issues need to be addressed and that tackling the technical issues, concerning the applied science of geophysical survey, will have much less effect if these structural issues, which are relevant to archaeological evaluation as a whole, are not tackled as well. This is not the main objective of our proposed project – but it needs to be considered and we propose to include it in our study.

The state of survey in the North West

Our discussions suggest that nobody has a clear picture of the state of geophysical survey in North West English archaeology, let alone in its application to aggregate extraction. Nor is any expert geophysicist in a position to exercise much control over practice. Thus if deficiencies were to arise in routine professional practice it is possible that they would be neither spotted nor corrected – and the strengths and expertise of surveyors goes, similarly, unremarked.

Contractors gain a limited impression of the wider picture from the tendering process, curators know about practice in their own areas but even those specialists with a central role, based in the English Heritage Centre for Archaeology, who certainly have the skills to oversee the profession, are given neither the resources nor responsibility to do so.

There have been about 150 archaeological geophysical surveys carried out in the North West of England. This is a much lower total than for most regions and, as the English Heritage survey distribution map shows³, the North West has the lowest density of completed surveys in England.

Many of these surveys have been carried out by just one company but, since they had been surveying in the region for many years, even they actually carry out very few surveys there each year. Most of the remaining surveys have been carried out by six other commercial survey companies and surveyors. There have also been a number of surveys carried out or funded by English Heritage, by University departments and by amateur groups and, though much fewer than the commercial surveys, they represent a relatively high proportion of the total when compared with other parts of England.

Survey in the North West is not commercially important to all but one or two of the archaeological geophysical contractors. Nor is it, routinely, the technique of choice for initial site assessment in any of the North West counties. It clearly has, however, been used regularly by English Heritage and its predecessors to assess protected or nationally important sites.

The methods used

A high proportion of surveys have been carried out by fluxgate magnetic gradiometry, a few by twin-electrode resistance survey and a very few by other methods. Current practice overwhelmingly favours magnetometry because it is relatively cheap and we suspect that recent advances, which double the amount of data gathered, will further increase its dominance. Our interviews left us in no doubt that most surveyors think cost is the overriding factor which determines the method used, whatever the merits of other methods. The speed of magnetometer survey, however, is also clearly important in many projects since most surveyors find themselves trying to meet very tight deadlines. Such pressures may occasionally compromise the quality and scope of the work undertaken – although this is not something that surveyors often discuss and reflects very little on the high standards that they try to uphold in often difficult professional circumstances.

A brief review of surveys suggests that an unusually high proportion of the work carried out by English Heritage, and other bodies involved in non-commercial projects in the North West, has used electrical resistance survey as the technique of choice. Commercial survey practice, however, is to use magnetometry under almost all circumstances.

³ English Heritage Website. The map is a little out of date but our findings suggest that the relative distribution of surveys is still valid.

This suggests that, where a choice can be made on the grounds of technique suitability alone, it may be different from that which is made under commercial pressures – and that this effect may be more serious to the outcome of surveys in the North West than elsewhere in England, where magnetometry may be more appropriate. We must bear in mind, however, that the purpose of most commercial and non-commercial surveys are different. Commercial surveys are principally aimed to find out if archaeology is present, and to characterise it if possible. Non-commercial surveys are usually carried out for research on sites which are already known – and this will obviously affect the choice of method and approach.

Many surveyors think that the nature of the archaeological remains and their natural context, especially the variability of the glacial drift, makes it more difficult to produce good survey results in the North West than in other areas. This supports the view that there is a “problem” with archaeological geophysics in the region.

While surveyors clearly do consider the nature of the target archaeological remains (if known) the geology, soils, hydrology and land-use in planning surveys, some told us that the low cost and high speed required of survey means that they have all-too-little time to take such matters into account – and have to choose magnetometry by default. This implies that magnetometer surveys may often be carried out, where other methods may be more appropriate, simply because of commercial pressures.

Several of those we interviewed believed that geophysics is sometimes used simply to show that *something* has been done to assess a site – it was described by several surveyors and curators as “box ticking” – rather than to make sure that the archaeological potential of a site had been properly evaluated.

The “success” and “failure” of geophysical surveys

Assessing the outcome of surveys, as the project proposed here intends, is a complex matter and several contractors raised questions about survey “success” and “failure” asking “who decides what we mean by these terms and on what basis?”.

When we asked what surveyors and survey consumers mean by “success” and “failure” we found that their definitions depend on their own role and responsibilities.

The aims of surveys vary widely and the definition of success will vary too. To the archaeological consultant or curator success may be a matter of defining the limits of a settlement, identifying the fine details of Roman industrial activity or – perhaps most often - simply finding out if there are any remains present at all. To the aggregates quarry developer, of course, success may be finding as little archaeology as possible so that extraction is permitted with the minimum cost and delay.

We believe, on the basis of our discussions, that the only person who really should be in a position to decide if a survey has succeeded or failed is the person who specified it. It is they who know its original purpose and can judge if this has been met.

Surveys may succeed in other terms, by providing ancillary information which proves of interest later, and this information may be more significant than that originally sought. But this does not remove the need for the survey to succeed in its original purpose.

We take the view that no one definition is acceptable but that we should judge the “success” or “failure” of every project by the objectives originally set for it since this will, or should, have defined the survey approach which was used. Thus, if the project was designed to identify the limits of a known settlement, and a survey method chosen for that purpose, then success will be defined by whether it did, indeed do so correctly – as determined by later evidence, usually from excavation.

Almost all of the surveys we are considering in this project have been commissioned for planning purposes and must be judged by planning criteria, rather than research criteria. Do the survey results help us to decide a specific planning question about a development or not?

Thus a survey which was designed to decide where to build a warehouse and which maps a Roman villa in one half of a site but does not detect a Saxon settlement in the other half will have failed for most practical planning purposes because the true threat to the buried remains will have been misunderstood and further planning decisions may be incorrect, as a consequence.

Calling this outcome a failure may seem a bit harsh – after all, a good survey of a Roman villa is valuable – but the purpose of the survey was to assess a potential planning constraint. In this purpose it clearly failed if the resulting planning advice is that development should be permitted, without constraint, on the half of the site outside the villa.

This raises the further question of how we can tell if a survey achieved its purpose. How can we know if the survey's prediction of the presence or absence of remains was correct? For this we must rely on other evidence and this can usually only be gathered where excavation takes place – introducing a further bias of which we need to be aware.

A further complication is that surveys are often commissioned for several explicit and implicit purposes. It is natural to want to find, in a single volume of data, the answer to several questions such as “where are the limits to this settlement?” and “where are the principal archaeological features within it?”. This may mean that the survey methodology was designed as a compromise between two or more aims – and that success in achieving each was always a little less likely, but that this was known at the start.

It is possible, of course, that the original survey objectives were not reasonable or the approach inappropriate and these are also matters which we will have to consider. It is also important to acknowledge that success and failure are not absolute. Partial successes and partial failures are probably the norm – although perhaps outcomes are more clearly defined in planning than research terms because of the sharpness of the matters which have to be decided.

To sum up - for these reasons we will adopt the practical definition that “success” and “failure” must be judged against the original aims of those who commissioned the survey – but we will explicitly acknowledge that the way such aims are set and outcomes decided is sometimes complex and we will consider the effects of these complexities in our judgements.

A method of assessing survey success has been developed by the staff of the English Heritage Centre for Archaeology⁴. This method compares the survey results with the results of excavation, noting both what was and what was not detected of different types and ages of features.

⁴ Gill Hey and Mark Lacey, 2001 *Evaluation of archaeological decision making processes and sampling strategies* Oxford Archaeology Unit

The method has been questioned by some of those whose data was analysed for that publication and who felt that insufficient account had been taken of the constraints placed on their survey and the way its results were presented for its outcome to be judged in this way.

It seems to us that this matter also can be resolved by judging survey “success” and “failure” through the eyes of the user. Thus what matters is not whether the surveyor thinks they have a good result but whether the user finds it suitable for their purposes.

This does not, however, tell us why a survey may have failed. Nor, crucially, is it a judgement on the competence of surveyors. Those who carried out the survey may never have been drawn sufficiently into the project design to be aware of the real purposes of the survey nor put in a position to influence the methodology imposed on them. They may have been required to provide answers to complex questions without having the freedom to apply the range of techniques this would realistically require or the time needed to apply them. None of these reasons would mean that the failure is a judgement on their competence.

Method testing and Pilot surveys

All the contractors we met agreed that a widening of the terms of briefs to allow a greater range of methods and a period of trial survey to provide a better basis for project design would be worthwhile but they thought it unlikely that the immense pressure on survey time would allow this to happen.

There was a feeling that these pressures may not arise because project deadlines *need* to be tight but because developers do not plan for archaeological evaluation well enough in advance and care little for the effects of this on the outcome of the work undertaken because they think it unlikely to affect the engineering and economic matters which are their main concern.

One of our correspondents commented that pilot surveys may not be useful, in most cases, simply because you don't know what you are looking for and thus can't judge the success of techniques against each other. We only partly agree because there are cases where some features *are* known (from air-photography, for example) against which pilot survey outcomes can be compared. Elsewhere, we think, a judgement on the outcome of pilot surveys may still be made on the basis of the way in which natural or archaeological features, encountered fortuitously, have been detected – although the extrapolation from these to the wider site (and from natural or agricultural features to archaeological remains) takes considerable knowledge and experience. It is, however, a rare survey which detects neither archaeological nor natural variations in the soil.

Assessing survey against excavation results

Most of the survey contractors expressed a strong desire to be sent details of the outcomes of excavation following surveys so that they could assess and improve on their own performance. Almost all had failed to make this happen because those on whom such feedback depends – especially the main archaeological contractors who would provide the information – do not do so, despite repeated requests. Several contractors expressed considerable frustration at this and clearly believe that they are being let down by their excavating colleagues.

It was suggested that the curators and excavators could not require the small cost of this feedback from the developers funding survey because this would be a post-hoc cost, required only for the future benefit of the surveyor rather than the immediate benefit of the developer.

It is hard to believe, however, that professional scientific practice in any other field could exist without this kind of process of monitoring and learning, nor how such a lack can be justified here. Would we permit surgeons to operate or engineers to build without some process by which they can review the outcomes of their work?

Standard information

One of the geophysical contractors we interviewed suggested that it would be very helpful if they could be provided with a standard set of information at the beginning of a project and produced a standard set of information at the end so that the whole process was better defined.

We were told that there is a great deal of variation in what the commissioning parties – and especially the archaeological consultants – expect to put into and get out of a survey project. For this reason some of the variations in survey outcome are probably the result of variations in the quality of data originally provided to the surveyor rather than the methods used, the competence of the surveyor or the potential of the site. One example is historic mapping, which the archaeological consultant often possesses before a survey takes place and which can be invaluable, but is rarely provided, to the geophysical surveyor.

The views of archaeological consultants

Surveyors also reported wide variations in the attitudes of consultant archaeologists and excavators towards geophysics, even between the project managers within the major contracting units. We were told that some see it as a crucial part of the methods at their disposal, others see it as a waste of money or a distraction from the real business of digging holes. The result is that the degree to which geophysics is promoted as an evaluation approach varies widely and this may be especially significant given the dominance of relatively few, major contractors in managing archaeological projects in the region.

The consultants, naturally enough, believe their own views to be rational and reasonable but it is striking that, if this is the case, they come to such a wide range of conclusions.

The views of archaeological curators

Curators have just as wide a range of views about the role of geophysics in evaluation. Most had mixed feelings. They told us that they had experience of surveys which had largely succeeded or entirely failed in finding the majority of the remains buried in sites later tested by excavation.

Some asked “why bother to do a geophysical survey since there is going to be an evaluation excavation anyway?”.

It was suggested that the larger areas of sites – 5% and more - now being evaluated by excavation might make geophysics increasingly redundant, since some see excavation as certain and geophysics uncertain at best.

One consequence of the very limited faith some curators and consultants have in geophysical survey results is that, while some are prepared to use these results to influence the design of later evaluation trenching, many are not – even where the survey results give a great deal of detailed information. As a result much geophysical survey information is underused because it is not trusted. One might argue, alternatively, that many surveys are over-specified and that surveyors may be trying to answer more complex questions than those who specify surveys really want to ask.

Despite this, we gained the impression that most of the curators believe that geophysics should be an important tool in discharging their responsibilities, especially given the lack of alternatives. Our interviews suggested that some of the variation in survey practice is due to variations in the way in which archaeology is integrated into the planning process by different planning authorities, such as the amount which is demanded of developers before consent is granted or the amount which is incorporated into agreements for post-determination work. Such variations in planning policy make the surveyors life more difficult because they have to adjust their approach to their projects depending on the authority and individual curators concerned.

We noticed that the view which individuals and specific branches of the profession – surveyors, curators and consultants – have of themselves and their practices is often quite different from the views they have of each other. This suggested to us that there is too little opportunity for professionals to exchange views and develop cooperative relationships through which they stay in touch with each others needs and circumstances. One might hope that the IFA, CBA, ALGAO and other professional bodies might have addressed this situation but this does not seem to be the case in part, perhaps, because of the commercial pressures which keep the profession divided. The emergence of bodies representing the geophysical surveyors themselves (ISAP and within EIGG) is encouraging since it may help the profession to maintain standards and better define its role but we think that some of the problems which arise in the commissioning and use of geophysical survey could be addressed by better communication between the professionals involved.

Advice and support for setting briefs and designing survey

Curators and consultant archaeologists get advice on designing and specifying surveys from a number of sources. The English Heritage Centre for Archaeology and Archaeological Science Advisors were consulted by some, although less often than they might. Most say that they ask the contractors themselves for advice, and especially the major geophysical contractors who are seen as being particularly objective and reliable. Despite this, the contracting surveyors expressed frustration that their advice on the right approach was sought so rarely, even on projects where they were to subsequently carry out the survey.

It may sometimes be the case that, while curators set broad briefs for geophysical surveys intending the surveyors to decide the best approach, the archaeological consultants who select the geophysical survey company to do the work may set a much narrower brief defined principally by cost. These are important matters because the significantly affect the way in which geophysical survey is used – and the degree to which it succeeds.

Almost everybody thinks that the English Heritage and IFA survey guidelines are valuable. They are widely, but selectively, used in the design of briefs with the result that the way that they are applied varies greatly. Some surveyors feel that they need urgently to be updated, because practice has moved on, and that some of the guidance is now questionable.

Surveying large areas

Many of those we talked to expressed particular concern about methods which should be used to prospect for remains over very large areas – tens or hundreds of hectares. There are many surveys of this kind and numbers are increasing. Most contractors are uncomfortable with unrecorded magnetic scanning and some thought it entirely unjustifiable. They continue to do it, however, because it is demanded by briefs which the surveyors feel they cannot challenge without the risk (almost the certainty) of losing the work.

Some believe that extensive magnetic susceptibility survey is a good alternative to scanning while others thought this equally questionable, especially given the limitations of the instruments available.

There is clearly a need for the matter of large area prospecting surveys to be reconsidered, for survey outcomes to be reviewed and for new guidance to be issued.

The pressures of economic development

One of the curators pointed out that the economy in their part of the North West is not as dynamic as in other parts of the country and that developments tend to be both smaller and less profitable than elsewhere, making the cost of archaeological mitigation a greater burden – and that local and national government priorities tend to apply *additional* pressure to make sure that development is not impeded. Moreover, the lack of aggregate sources in some areas adds to pressures from mineral planning officers to ensure that extraction permissions are granted.

In short, there is less money to pay for archaeological evaluation, the impact of costs on projects tends to be greater and there is more pressure to make sure that archaeologists don't get in the way of commerce than elsewhere in England.

Some of the geophysical surveyors believe that most of the pressure to keep costs low – and thus to restrict the use of geophysics – comes not from the archaeological consultants or even the developers (who may be more concerned about getting work done quickly than cheaply) but from the planning system which exerts particular pressure to keep the impact of archaeology to a minimum.

If geophysics were seen as a usefully reliable tool to evaluate sites at less cost than excavation then these factors might count in its favour – but this does not seem to be the case. They certainly add to the pressures which surveyors encounter when carrying out some surveys

The situation may be changing as a result of new patterns of development with ever larger housing schemes, in particular, drawing in more resources for evaluation and larger areas of survey. It is too early, however, to see whether geophysics has been successful in allowing a correct assessment of sites in these rather different circumstances.

Summary

Surveyors, consultants and curators agree that it seems harder to get good results out of archaeological geophysics on aggregate and potential aggregate extraction areas in the North West of England than in other regions. All want to find out more about why this is so and what can be done about it. Thus the aims of the project have received broad support and we have been offered the practical cooperation which will be vital to success.

There are, however, a range of issues, which are the result of the broader structure of archaeological mitigation in the North West, which are equally significant to the way geophysics is used and the outcomes of survey projects. These too will need to be addressed if the use of geophysics is to be improved.

We therefore propose a project which will assess the results of geophysical surveys on aggregate sites in the North West and survey attitudes towards archaeological geophysics in the region.

The Project Proposal

We propose to study the potential and limitations of geophysical survey on areas of aggregate in the North-West, in comparison with other areas and geologies, to assess the contribution it makes, and could make in future, to archaeological site evaluation and analysis.

We intend to achieve this by reviewing 30 geophysical surveys, of which at least 20 will be from areas of past, actual or potential aggregate extraction, taken from a list of all the known surveys in the region, to find out, as objectively as possible, the degree to which they have been successful or unsuccessful. This number of surveys was chosen as an appropriate balance between our need to examine a representative number against our ability to study the survey results in sufficient detail. The possible inclusion of some non-aggregate sites is required by the need to obtain a sufficiently representative sample and to contrast the outcome of surveys in aggregate areas with those elsewhere.

Our project will study the technical issues which influence the success of geophysics in the North West but it will also seek to clarify, though not address, wider structural issues of professional attitude and practice through further interviews with those involved in the North West, given the efficiency and effectiveness of those already carried out during the preparation of this project design.

We will therefore review surveys already carried out on aggregate and potential aggregate sites in the region in order to identify the factors which have most influenced the degree to which they succeeded. We intend to clarify those conditions and environments in which geophysics has succeeded and those where it has failed to meet the objectives set for it. From this we intend to identify those factors which most influence success and failure and thus to suggest ways in which techniques can be chosen more appropriately and applied more effectively to each site so that success will be more likely.

The tone of the project will be consultative and collaborative – working with those involved to develop better practice.

Method

Part 1

We will begin the project by compiling a list of all the known surveys in the North West and selecting 60 at random. The 20 of these which have the poorest supporting information, such as air-photographs and the various kinds of mapping, will then be eliminated and 30 of the remaining 40 will be studied in detail. This will be carried out by visiting all of those who have produced the chosen archaeological surveys in the region and working with them to extract the key information for each survey about the site conditions, survey method and results.

Information on method, instrument, date, surveyor and the state of the ground will be obtained wherever possible, although the survey contractors will have absolute control over the information they make available, enabling them to restrict the wider release of anything they consider commercially sensitive. Further confidentiality will be established, where requested, by describing surveyors, clients, survey projects and sites by codes rather than giving full details – although we anticipate that this will rarely be necessary.

We will examine medium-resolution photomosaics of the area around each site to extract broad topographic, geological, soil and land-use data. We will also obtain high-resolution (0.25m) air-photographic imagery for the 1x1km square around each site to act as a map-base and give very local context detail. We will then study air-photographs which contain information about geology and soils, wherever possible (not all do), and 1:25000 scale topographic maps of the site as well as the most detailed soil and geological mapping available. Information of weather conditions and soil moisture deficit will also be obtained from meteorological records and site notes for the period of the survey. We will derive more detailed geological, land-use and soil information from these resources to provide a context for each site.

Information, plans, sections and photographs will be obtained of each site which has been subsequently excavated, even if only in part, to compare with the survey results.

The survey data itself will then be examined, using unprocessed data images on-screen wherever they are available, but making use of all helpful data and images as well. The methods of comparison will build on those of Hey and Lacey⁵ although they will consider a wider range of influences, as discussed above. We will work closely with the surveyors in reviewing their results and ask them to make their own observations on the survey outcome – although we will make it clear that we intend to reach our own independent conclusions.

The review of the survey results will have two components:

I a basic review in which we will simply assess whether the survey succeeded in the light of the objectives set for it and against the standards of other information, including subsequent excavation results. We will, in particular, assess the proportion of the archaeological features within the site, identified in excavation, which are also identifiable in the geophysical survey (whether or not they were originally identified in the survey report) except where the survey was not designed to detect buried features directly (as is the case for most soil magnetic susceptibility surveys). Each conclusion will be supported by notes which explain how it was reached. The objectives themselves will also be critically reviewed so that we can understand why geophysics was used and what was originally expected of it.

⁵ Gill Hey and Mark Lacey, 2001 *Evaluation of archaeological decision making processes and sampling strategies* Oxford Archaeology Unit

II we will also, where sufficient information is available, attempt to relate the degree of success to the site context, concentrating on those factors which are most likely to influence success for each method, including instrument, geology, soil, soil moisture, surface state (recently ploughed, flat surface grazing, rough grazing with *Molinia* tussocks...), vegetation, contamination (metal fragments, diesel spillage ...) and land-use. Thus, for magnetometry, we will concentrate on substrate lithology and mineralogy (interpreted from geological and soil mapping and from air-photography) as well as surface state and contamination. For electrical resistance survey we will concentrate on soil type, structure, moisture, vegetation and cultivation state.

We will also consider the effect of the time-of-year, and the reasons why the survey was carried out precisely then, on the survey outcome, taking into account the state of the site (crop and soil moisture in particular) and the method used. We will use this information to consider whether development constraints on when and how surveys are carried out significantly influence survey outcomes.

We note that there are classes of geophysical anomaly which do not appear to correspond to identifiable buried features, when sites are excavated. We will try to quantify the occurrence of such “ghost features”⁶, although we will not have all the information we need to reach precise conclusions about where and why they occur on sites in the North West, to supplement those already published.

Our conclusions about the influences on survey outcomes will be tested by studying the remaining 10 surveys in the North-West. We will obtain information about each survey and site and see whether the understanding of controlling influences gained from our review of the first 30 surveys will allow us to predict whether each survey is likely to have been successful in the terms originally set out for it. We will then test our predictions against the actual degree of success achieved by the survey.

We do not expect such predictions to be very precise because of the great variability between sites and the numbers of variables involved but it will be useful to test whether we have, to any degree, been able to identify the key factors in survey success. This will also allow us to assess whether the objectivity which we will attempt to achieve in reviewing survey success has, indeed been achieved.

⁶ N Linford, 2002 *Magnetic Ghosts: Mineral magnetic measurements on Roman and Anglo-Saxon graves*, EGS Nice

Outcomes

The project will be designed to deliver a range of products:

- 1 We will produce a report, on paper, CD and on website, detailing its findings concerning the success of geophysical survey in the region. This report will describe the project methodology, a brief description of the sites examined and the outcome of each survey review.
- 2 The report will give as complete a list as possible of geophysical surveys carried out in the North West region, providing a metadata summary to the EH geophysical survey database. Sites not included in the Regions SMRs will be identified by comparing survey lists from the SMR officers and from those who have carried out surveys so that the SMR officers can request the missing survey details from the surveyors.
- 3 The report will give a summary of our overall findings and discuss these in the light of our objectives. It will reach a conclusion about the degree to which archaeological geophysics is or is not successful in the North West and discuss our insights into why this is the case. The discussion will be divided into two sections:
 - 3.1 a discussion of the purely technical questions concerning the performance of geophysics in the context and for the purposes given to it. This will describe the digested results of our analysis of the factors influencing survey outcome. It will describe the correlation we found between the survey outcome and the techniques used and field conditions encountered. The analysis will not be a purely mechanical matter of cross-correlating inputs and outcomes but will make use of what we already know about the reasons for geophysical survey performance – such as the influence of soil moisture on electrical resistance contrasts. It will therefore be supported by an up-to-date review of current research in this field.

Our initial survey has confirmed our original supposition that most archaeological geophysical survey in the region uses few methods, applied in few ways. The sites and soil types surveyed, however, vary considerably, which suggests that a wider range of geophysical techniques and field methods, designed more specifically for each case, would produce better results. We will therefore consider, on the basis of our findings, whether it will be appropriate to aim to encourage a broadening of practice, incorporating a phase of method testing into routine survey projects so that techniques can be refined as a normal part of each project.

Our initial study has also confirmed that it is unusual for geophysical surveyors and excavators to review the outcome of survey against those of excavation – although the surveyors very much wish to do so, since they agree that we would learn a lot more about how to do good surveys if review was a normal part of survey. We will therefore consider how best to promote such collaborative review as a normal and significant part of commercial practice.

It will provide example protocols by which such review could be carried out and suggest ways in which excavation data of particular value in survey analysis, such as soil magnetic susceptibility values, could be routinely gathered.

3.2 a brief discussion of the influence which attitudes and policy in the North West plays in the application and outcome of survey. This will involve a dissection of the processes by which surveys are typically brought about and the way in which the briefs by which they were commissioned influenced the survey outcomes. They will therefore, for example, consider how the pressure of time, caused by the process of project planning, may have restricted the scope for the development of survey methodology, for a particular project, and the way this might influence a survey outcome.

4 The report will describe how our conclusions about both technical and “attitude and policy” matters might lead to changes in practice. We will intend to show how, based on our findings, changes in survey practices will have specific effects on survey outcomes. We will also offer advice, after close consultation with colleagues in English Heritage, in the universities and among the geophysical contractors, about the better development of briefs, choice of methods, choice of instruments and the timing of surveys. This will pay particular attention to the variations in practice required by the differences in aggregate development, archaeology, topography, geology, hydrology and soils between the contrasting landscapes of the region – in particular between lowland Cheshire and the higher land to the north. The advice will be aimed at those responsible for setting briefs, commissioning surveys and carrying them out.

The report will be completed by a brief final chapter which will discuss the lessons learnt, consider ways in which similar reviews might be carried out in other regions, and further work built on the outcomes of this project.

5 Two open meetings will be held:

5.1 The first will be convened by the International Society for Archaeological Prospection, a recently formed body representing survey professionals, to which all those carrying out geophysical survey in the region, and other technical specialists will be invited to discuss our technical findings. The meeting will aim to promote dialogue between survey professionals.

5.2 All those involved in the mitigation of aggregate development impacts on archaeology in the region – curators, consultants, contractors and others - will be invited to the second meeting to discuss our findings on brief-setting and the role of geophysics within wider mitigation policy.

6 The results of the project will be made available to the public through a website and brought to the attention of a wide cross-section of all those with an interest in archaeology through summary publication in peer-reviewed professional journals and at conferences.

Reference will be made to the study and website in a letter to a popular publication such as Current Archaeology. The final report, incorporating the project review, will be produced on paper and in a computer based form, to be placed on an appropriate website such as that of the ALSF projects hosted by English Heritage.

Relationship to other projects

This proposed ALSF project complements two others in addressing the role and performance of geophysics in English aggregate-area archaeology. The three will, together, provide a much better response to the need for research in this field.

We conclude from our initial study that we know too little about the origins of geophysical anomalies measured above ground in the physical properties of the remains buried beneath. The result is that surveyors cannot predict confidently how best to survey sites – what techniques to use, what configuration to adopt and under what conditions to expect the best outcome – although the matter is too rarely discussed openly among professional surveyors. There are some reliable rules of thumb, derived from a mixture of realistic models and empirical observation, but there are frequent and serious exceptions to these in practice. One reason for this is the tremendous complexity and variability of archaeological features which means, for example, that precisely the same feature may appear quite differently in geophysical survey results where it is found in two different soil contexts.

We urgently need to address this gap in our knowledge by finding out more about the origins and distribution of geophysical properties in a variety of archaeological remains, relating these to the form of the anomalies detected at the surface.

This problem will be addressed, in part, by a rigorous process of comparing the results of survey with those of excavation, as this project proposes should become a routine part of commercial and research practice. Two other proposed ALSF projects will take this process further. The “Where Rivers Meet”⁷ project, having gathered a great deal of geophysical data over an important suite of sites in the Trent valley north of Birmingham, will now go on to analyse the distribution of geophysical properties in the deposits beneath and seek an explanation for these in the origins of the deposits involved. The “Trent Valley Geoarchaeology”⁸ project will undertake similar studies of survey outcomes in the Trent valley and will carry out experimental fieldwork to consider the factors influencing the survey results.

This proposed project will hold a number of meetings with the staff of the other two projects in order to exchange ideas and observations both during and at the end of their work. Other, similar opportunities to work with other research bodies and project teams will be sought.

Data Sources and Map Bases

Obtaining the right mapping and map licences of sufficient duration is often a problem for a project of this kind. The costs of electronic map formats, in particular, can be very high because of the need to pay repeated annual licenses, and copyright restrictions can be onerous.

The map and AP data listed below has been chosen carefully to give us all the information we need, keeping costs to a minimum and avoiding repeat license payments and restrictive copyright conditions. To do this we will use digital, map-correct APs, which require no further licenses, as our map-base and paper maps, where electronic data would require annual licences,. We will also make full use of the extensive data sets which Terra Nova Ltd already owns. NMRC has agreed to carry out AP searches for our 40 sites, to pull the required photographs from their shelves for us to examine and to make selected prints, at no cost to the project.

⁷ www.arch-ant.bham.ac.uk/whereriversmeet/index.htm

⁸ www.tvg.org.uk

The project will make use of topography (as Digital Terrain Models – DTMs and contours on paper maps), air-photographs (as digital images and prints), soil maps (on paper) and geological maps (as digital images of solid, drift and linear detail). It will also make use of precipitation and other weather data as well as model-derived Soil Moisture Deficit statistics. These datasets will be obtained from a number of sources.

Terra Nova Ltd already owns medium-resolution (1-2m pixel) geo-correct AP and DTM coverage for the whole of England and Wales which will be available to the project for analysis of site hydrology and land-use. Map detail will not be bought but be derived, where necessary, from georectified AP coverage, from Getmapping PLC, which has the advantage of lower cost than electronic mapping and a permanent license as well as providing more precise and much fuller detail than the maps. Thus the geo-correct APs will form the map base for the project.

Air-photographs will be listed, recovered and studied at NMRC, Swindon, and detail transcribed by hand to the vertical AP map-base. Selected photographic prints will be provided by NMRC. We will need, however, to give them sufficient notice of the sites in question and to stagger access to the photographs to fit this large request into their workload.

Geological data will be obtained from paper solid and drift 1:50000 geology maps since this is significantly cheaper than digital data for the areas to be covered. We will obtain soil data from the very few detailed soil maps for the areas of interest, which we will buy, and from the regional soil maps, which Terra Nova Ltd already owns and can make available to the project. Further soil and geological mapping will be generated from existing maps and air-photographs during the project.

Weather, including precipitation, data will be obtained from the Meteorological Office using their monitoring grid reports. Local soil moisture conditions will be provided, where required, from these data using an adaptation of the Penman-Monteith equation⁹¹⁰ through the Met Office MORECS model.

⁹ Alessandro Gimona and Richard Birnie, 2002, *Spatio-temporal modelling of broad scale heterogeneity in soil moisture content* Landscape Ecology **17**(1): 27-41

¹⁰ M Hough, S Palmer, A Weir, M Lee, I Barrie **1995** *The Meteorological Office Rainfall And Evaporation Calculation System: MORECS Version 2.0* Meteorological Office, Bracknell

Management and staff

This project will be carried out and managed by David Jordan with the support of other Terra Nova Ltd staff, who will usually be geoarchaeologists qualified to MSc or above. It will receive advice from a group of seven professionals including representatives of English Heritage (Neil Linford and Susan Stallibrass), the local authority curators (Mark Leah), the universities (Armin Schmidt), the archaeological consultants (Emily Mercer) and the geophysical surveyors (Chris Gaffney and Ann Roseveare). This group will be consulted at the beginning of the project, to help set direction, kept abreast of progress throughout the project and met with individually, at least once, to discuss outcomes.

Timetable

This project will run over two years from October 2004, with a final review report and meeting of the guidance committee in October 2006.

Meeting English Heritage research goals

This project is designed to help the archaeologists of North West England carry out their professional duties more effectively. It is also designed to meet English Heritage research priorities as identified in the EoP98 Implementation Plan and Archaeology Research Agenda. It can reasonably claim to meet most of the EoP98 Selection Criteria and make contributions, in varying degrees, to all the five Primary Goals of the Archaeology Research Agenda.

Our aims match very closely those stated under several headings – especially A1, B4, B5 and MTD 2 and make a significant contribution to goals under headings A5, A6, B2, B6, C1, C4, D4, D7, E3, E4, E5 and MTD 1, 6, 9 and 12.

Our aims support those stated in *Power of Place* and *Force for our Future*. They also make cost-effective use of existing data to reach new conclusions thus efficiently adding value to work already undertaken.

Acknowledgements

This project design was drawn up after many discussions with the curatorial staff of local authorities in the North West, mineral planners, project staff in the excavating units, geophysical surveyors and others. We are very grateful for the time and experience that they so freely offered and we hope that the outcome will help meet everyone's desire to see better professional practice.

David Jordan MSc MIFA FGS

18 October 2004