LOST BUT NOT forgotten

A GUIDE TO METHODS OF IDENTIFYING ABORIGINAL UNMARKED GRAVES

NSW NATIONAL PARKS AND WILDLIFE SERVICE

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Cover photograph: South of Coonabarabran. Photo by Denis Byrne.

Coast Hospital Cemetery, La Perouse. Photo by Denis Byrne.

Contents

PLEASE NOTE: COST PROJECTIONS USED THROUGHOUT THIS REPORT ARE EXCLUSIVE OF GST.

Background

This guide has been prepared to assist in the identification of Aboriginal unmarked graves. The aim of this document is to assist non-specialists who are familiar with potential burial sites, but who have only limited technical expertise, to select the most appropriate technique(s) of grave identification for use in their own areas.

This guide explains how the techniques work, where they work effectively, what their limitations are, and how they may be combined for optimal results. The survey methods, outcomes, constraints and the potential costs are outlined.

Although most Aboriginal burials pre-dating European colonisation are effectively unmarked, these guidelines are specifically designed for the identification of graves from the historic period (post-1788).

The guide consists of three parts –

Section 1 An introduction to the problem of unmarked grave identification and an overview of available identification techniques.

Section 2 A review of the scope and limitations of individual techniques, including case studies relevant to the identification of unmarked graves.

Section 3 A basic guide to commissioning a specialist survey including advice for non-specialists on how to undertake background research to select the most appropriate techniques and optimise the chances of a successful survey outcome.

This report contains a number of technical terms.
Please refer to the Glossary of Terms on page 54 for plain English explanations of all terms in italics.

SECTION 1 Introduction

What are Unmarked Graves?

Unmarked graves are burial sites that are difficult to identify on the ground surface, either because they were never marked, or because the *grave markers* have decayed, been removed, or been destroyed. In many cases the original markers on the surface of Aboriginal historic period (post-1788) graves were of an impermanent nature. Some were marked by wooden crosses, others with patterns of shells or stones. As time passed these often decayed or were scattered and the exact location of the graves became less certain. Sometimes the graves of known individuals have been mapped in the past, but are not visible on the ground surface today. Other unmarked graves may be visible on the ground, but have no known records stating who was buried there, or when the burial occurred.

Common characteristics of Aboriginal unmarked graves include the following:

- They generally have no deliberately laid out border, covering or marker (e.g. headstone).
- Many occur in historic cemeteries, such as those on Aboriginal missions and reserves. Others occur in the vicinity of Aboriginal off-reserve settlements – for instance, camps on pastoral stations, along historical travelling routes, or fringe camps on the edges of towns. Some occur in pre-contact Aboriginal burial grounds.
- They are sometimes found just outside the boundaries of 'formalised' cemeteries where non-Aboriginal people were buried – the boundaries often being defined by wooden, metal, or wire fences. This resulted from municipal authorities refusing to allow Aboriginal people to be buried inside these cemeteries.
- Often, shallow depressions in the ground are found where unmarked graves exist, these depressions resulting from the subsidence of soil placed in the graves following the burial.

LEFT: This small pastoral station cemetery contains both Aboriginal and European graves (Buangor Station, Victoria).

- Sometimes ornamental bushes, such as roses, or flowering bulbs that were originally planted on or around the graves still survive after all other grave markers have disappeared.
- The unmarked graves can occur individually ('lone graves') or in groups.
- Aboriginal and non-Indigenous graves sometimes occur within the same burial ground.

During the early years of Aboriginal-European contact in NSW Aboriginal people still often cremated their dead or placed the body in a tree or in a cave or rock shelter. As people increasingly settled on Aboriginal Reserves, in fringe camps and pastoral station camps, burial in European-style graves became more common across NSW. Through the course of the 19th century Aboriginal people increasingly used wooden coffins. Though the main features of European grave-burial were adopted there were often distinctively Aboriginal features to the burials. These included the wrapping of the body in bark, the burial of personal possessions with the body, and decoration of the grave surface with shells and stones.

The techniques described in this guide are designed to detect Aboriginal burials in European-style graves. Such graves are more or less rectangular, 1 to 2 metres in length, and 0.5 to1.5 metres in depth (for an adult). Most such graves will face to the east or west.

Traditional forms of Aboriginal burial belonging to the last 217 years will be very difficult to identify using the *non-intrusive* techniques described in this guide. Archaeological investigations offer the best opportunity for the discovery of these traditional burial types, and this necessitates some form of below ground *intrusion* (e.g. *excavation*), increasing the risk of disturbance and exposure to the burial. We appreciate that many Aboriginal communities will be reluctant or unwilling to permit excavation in areas where graves are thought to be present.

Reasons for Identifying Unmarked Graves

There are several reasons for identifying unmarked graves, though probably the main one is to ensure their future protection. Realistically, this can only be achieved if their location, or approximate location, is known. Grave protection may involve fencing off the graves to avoid damage by stock, vandalism, riverbank erosion, or rabbit burrowing.

A second reason is to find vacant space within a cemetery that can be used for future burials without disturbing earlier graves. Sometimes this happens when Aboriginal people wish to be buried with their parents, grand parents, or other relatives, in an old 'mission' cemetery which has long been out of use. Vacant space in cemeteries is also sometimes wanted for the erection of monuments, buildings or paths.

Thirdly, the identification of unmarked graves is sometimes desired in order to produce an accurate plan of a cemetery. Drawing up such a plan may be preliminary to placing new commemorative markers (e.g. small plaques) on graves, or may be undertaken as part of a community history project.

What to Expect from an Unmarked Grave Survey

Before organising an unmarked grave survey it is important to understand what the final result is likely to be. There are some common misunderstandings about what the techniques can and cannot do, so it is important to be realistic about the value of the final result.

Basically there are three main groups of survey techniques:

• **surface** (topographical and botanical) • **archaeological** • **geophysical**

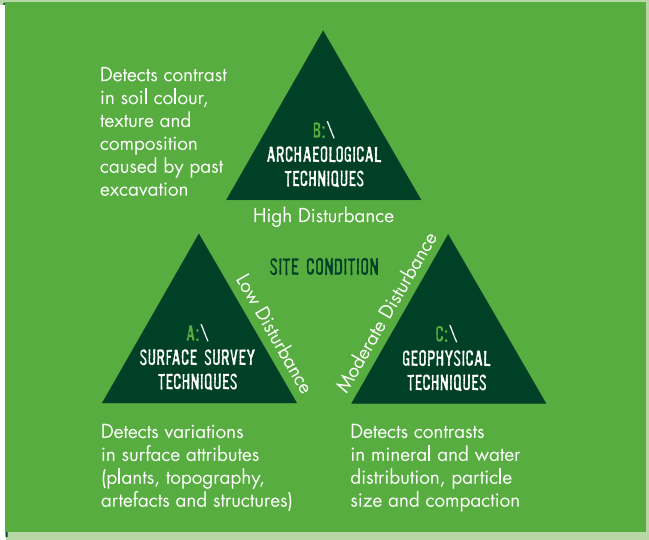
For best results it is often advisable to combine techniques so that a weakness in one is offset by a strength in another.

This diagram on the right shows which group of techniques is applicable to use in different local circumstances. These groups are coded throughout the report.

While geophysical and archaeological techniques can be of value in areas of low disturbance, the potential cost of specialist *geophysics* and the risk of disturbance through excavation makes surface survey a more appropriate option in the first instance.

Low, moderate and high disturbance:

- 'Low disturbance' describes an area which has experienced only low levels of natural disturbance or human disturbance since the time of the most recent burials.
- 'Moderate disturbance' describes an area that has received some superficial landscape alteration, such as revegetation, lawn laying or other minor obscuring of the land surface.
- 'High disturbance' describes an area that has been subject to major land surface alteration, such as through ploughing or the laying of pipelines.



A:\Surface Survey Techniques

Surface survey involves two principal techniques:

• **Topographic Survey** • **Botanical Survey**

These techniques look at differences in the form and attributes of the ground surface. They seek indications of artificial disturbance, such as mounds and depressions. They look for plant patterns and other cultural material. Such characteristics provide clues as to where the ground has been altered or disturbed in the past.

Under suitable conditions, these techniques can accurately determine the position, orientation and extent of graves by recognising where grave-fill has settled and been colonised by plants over time. In some cases 'special' plants have been deliberately planted on graves, or objects such as glass have been placed there as markers.

Often these characteristics are very minor and may only be perceptible using accurate surveying equipment.

These techniques cause no disturbance and are relatively cheap for a basic assessment. However, their effectiveness can vary considerably on a seasonal basis, and provide poor results if the ground surface has been disturbed or actively managed (e.g. in a lawn cemetery).

B:\Archaeological Techniques

Intrusive or 'archaeological' techniques involve the controlled removal of soil from the ground surface in an attempt to see where a grave has been dug into the sub-soil. This process does not generally involve disturbance to skeletal remains but

LEFT: Part of the cemetery on Norfolk Island in 1884, showing typical surface attributes of a historical cemetery: fences, paths, headstones, monuments, vegetation and grave depressions. (Source: The Australian Archives ACT Reprography Unit, Series No. CP697/96, Item 7).

RIGHT: Patches of clover mark the post stumps of a historical fenceline.

may be considered culturally inappropriate or insensitive owing to disturbance of the grave (above the level of the skeleton). It may therefore only be acceptable as a 'final check' in areas of generally high disturbance. This may involve hand excavation and/or shallow machine scraping.

These techniques cause some disturbance to the ground surface, but are relatively cheap and reliable in identifying the edges of grave 'cuts' marking the junction between the backfilled grave pits and the surrounding sub-soil or bedrock. It must be emphasised that the main purpose of these techniques is not to reveal skeletal remains, but to reveal the outline of graves above the level of the skeletal remains. There is, however, a risk that unexpectedly shallow bone can be exposed during the process.

C:\Geophysical Techniques

Non-intrusive or 'geophysical' techniques involve detecting and measuring contrasts below the ground surface, such as where graves are dug into a hard sub-soil and backfilled with a looser material. A number of geophysical techniques developed in the mineral prospecting industry can be useful in relocating graves. These variously measure contrasts in magnetic susceptibility, electrical conductivity and soil density, producing data that can be 'plotted' to produce a sub-surface map of grave 'cuts' or fills. These techniques do not produce high resolution 'X-ray' photographs showing bodies or coffins (though effects produced, for instance, by iron nails in coffins, may make the outline of the coffins identifiable).

These techniques cause minimal sub-surface disturbance. They can be very effective at identifying individual graves provided the appropriate technique is used for the right location. If not, the results can be difficult to understand and will be of limited value.

The costs of geophysical work can be relatively high and specialist geophysical expertise is usually required to ensure that the data collection and analysis is undertaken successfully.

The History of Unmarked Grave Survey in Australia

The identification of unmarked graves using scientific methods is a comparatively recent development in Australia, though the basic principles have been in existence internationally for several decades. Geophysical methods of *archaeological prospecting* were developed during the 1950s, while the surface recognition of underground disturbance has been undertaken through aerial photography since the 1940s. Adaptations of both techniques form the mainstay of unmarked grave survey as used today.

Before the mid-1970s there were limited attempts in Australia to relocate historical graves, either Aboriginal or European, and these were conducted largely by oral history and documentary research. Attempts to identify, protect and manage burial sites have been very rare until quite recently. There have, however, been numerous documented instances of the excavation and removal of skeletal remains from graves throughout the 20th century by researchers and local people.

One early example of a grave identification and protection study was undertaken in 1976 at Nymboida, NSW by NPWS staff. A field inspection by Rosemary Buchan noted a row of three depressions, which were identified as likely grave sites. As a result, the site was declared an Aboriginal Place and protected by a fence.

In 1977, John Stanley and Graham Connah, of the University of New England, pioneered the use of geophysics in grave identification through a ground magnetic study undertaken near the Aboriginal Reserve at Forster, NSW. The study successfully demonstrated the potential of this technique in identifying unmarked graves without disturbing the ground surface.

Other geophysical methods, including *resistivity*, *ground penetrating radar* (GPR) and *ground magnetic survey*, have subsequently been used to identify unmarked graves throughout Australia and New Zealand with variable results (Table 1). It should be noted that these techniques have become substantially more sophisticated through their use in mineral prospecting and other commercial applications, though their overall use in archaeology in Australian conditions has been limited.[1]

[1] Ground penetrating radar, *electromagnetic methods*, and ground magnetics have also been used, with varying success, at other locations than those shown in this list. However, little has been published.

BELOW: Table 1: Examples of Previous Unmarked Grave Geophysical Surveys in Australasia.

TABLE 1

Location	Technique(s)	Comments	Reference
Forster Aboriginal Cemetery (NSW)	Ground magnetics	A number of probable graves sites was detected though the information was insufficient to make definite determinations.	Stanley & Connah 1977
Wybalenna Burial Ground, Flinders Island (TAS)	Resistivity	A large area of lower resistivity was located which might have been the burial ground. 15,000 readings at 0.5m spacing. Individual graves were not located though rows of small anomalies were noted in one area. Closing the spacing to 0.25 metres would have improved resolution and might have located individual graves.	Ranson & Egloff 1988
Dandenong Police Paddocks (VIC)	Resistivity	A lack of useful locational information impaired the effectiveness of the survey results.	Ranson 1990
Rotnest Island Aboriginal Cemetery (WA)	Ground Penetrating Radar	A number of generations of GPR were used to define the location of Aboriginal cemeteries on Rottnest Island. The results were qualitative and open to interpretation though in the best cases the shape of graves could be seen clearly. Other cemetery sites were also investigated during this project.	Randolph et al 1993
Taroom Aboriginal Reserve (QLD)	Ground Penetrating Radar	A number of probable graves were located. Skeletal remains could be detected in one case.	L'Oste-Brown. et al 1996

Location	Technique(s)	Comments	Reference
Parramatta, NSW	Ground Penetrating Radar	A GPR survey identified a number of probable grave sites at St Patrick's Cemetery, Parramatta, prior to commencement of a proposed road widening project. The method was able to identify sites by the GPR response and also by the shape of the features across a number of profiles.	CMP-GBG 1996
Ebenezer Mission Cemetery (VIC)	Ground Penetrating Radar	A large detailed survey was completed and areas of subsurface disturbance outlined but due to location problems and insufficient interpretation individual grave sites were not located.	McDougall et al 1997
Glenorie, NSW	Ground Penetrating Radar	A GPR survey identified a number of possible sites of the graves of convicts killed during building of the Old North Road.	CMP-GBG 1998
Oaro Urupa (NZ)	1 Ground Magnetics 2 Ground Penetrating Radar 3 Shallow Electromagnetic	Using all three methods it was possible to derive improved estimates of grave location though the results remain somewhat ambiguous.	Nobes 1999
Bowraville Aboriginal Cemetery (NSW)	Ground Magnetics	A brief test of the system was conducted on site. This was deemed a success but a larger survey was not done.	Stanley 1999
Ebenezer Mission Cemetery (VIC)	Ground Magnetics	A magnetic survey was conducted over an area including that surveyed with GPR. Individual graves could be located in most areas, but in some cases there was insufficient magnetic material in the soil for the method to work.	von Strokirch 1999

ABOVE: Table 1(cont.): Examples of Previous Unmarked Grave Geophysical Surveys in Australasia.

RIGHT: Part of Ebenezer Mission cemetery, showing a complex pattern of surface depressions, mounding and vegetation growth,including exotic flowering bulbs.

The first attempts at site mapping through an integrated investigation of vegetation patterns and other surface variation were undertaken at three post-contact Aboriginal sites in Victoria during 1991 (Lomax 1991a; 1991b; Long 1998a). In each case the study's emphasis was placed on the identification and mapping of a burial ground, though in one instance the survey coverage incorporated a wider settlement area. In each case the field recording and plotting methods were rough and ready, though the results were highly promising. As a result, the process was later repeated using accurate *digital mapping* methods at two locations (Ebenezer Mission Station and Murchison Police Paddocks) to dramatic effect (cf. Long & MacKinnon 1999).

Of these studies, the ongoing research at Ebenezer Mission Station (Brown et al 1999) is perhaps of greatest interest to the particular problems posed in unmarked grave identification.

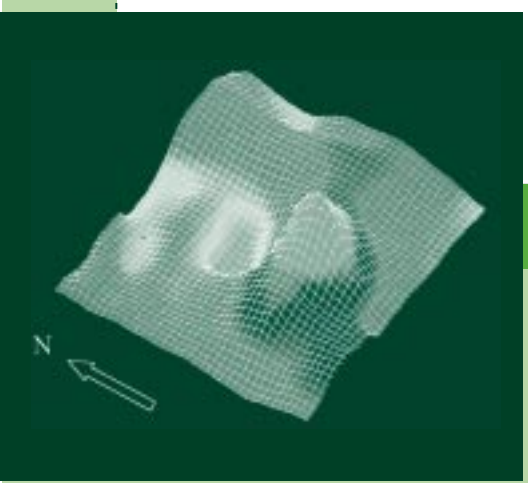
Ebenezer Mission (1860-1904) is located in a semi-arid environment on the Wimmera River in Western Victoria, near the town of Dimboola. The cemetery at Ebenezer is exceptional in that comparatively limited surface disturbance has occurred. A remarkable pattern of surface depressions and plant patterns reflect the underlying layout of graves.

This situation provided a unique opportunity to compare and contrast the results of different approaches to the identification of unmarked graves. An investigation was undertaken of the potential for plants to be grave indicators over a range of seasonal conditions. The results of a selection of geophysical investigations was directly compared with the surface remains and this allowed an assessment of the effectiveness of different geophysical techniques in relation to geological, climatic and land use variables. To date an 'exploratory' ground penetrating radar (*GPR*) survey (McDougall et al 1997), ground magnetic survey (von Strokirch 1999), and a 15 month botanical and topographic study (Long 1998b; MacKinnon 1999; Long & MacKinnon 2000) have been completed.

In New South Wales these more recent technologies have been applied more frequently in the search for the graves of convicts and early white settlers than for Aboriginal graves. Two such projects have been carried out in formerly rural, outlying districts of Sydney (CMP-CGG 1996; 1998). In each case ground penetrating radar (GPR) was successfully used to define the probable location of burial sites, using non-invasive methods.

An '*orientation survey*' using the ground magnetic technique has also been recently undertaken at the Bowraville Aboriginal settlement in north-eastern NSW (Stanley 1999). The intention of this pilot study was to determine whether the technique would be effective in determining the location and extent of a nearby burial ground featuring unmarked graves. Although no Aboriginal graves were identified in the pilot study, the technique was proven to be successful in identifying a 'simulated grave' in soil conditions identical to those in the area of the burial ground. This consisted of deliberately excavating a pit of roughly grave-like dimensions, and then running the survey equipment over the general area to see what pattern emerged from the data (see above). The results matched the predicted '*profile*' for a grave, indicating the suitability of this technique in local soils.

This trial demonstrated the advantage of undertaking a preliminary orientation survey in order to avoid the risk of disappointment through poor results.



LEFT: An isometric image of the simulated grave data from Bowraville, NSW. The light spots clearly mark the corners of the hole (Source: Stanley 1999).

SECTION 2 Description

In this section the three main groups of techniques for identifying unmarked graves are described. A basic summary of each technique is presented, followed by more detailed information on its key characteristics. A review of alternative methods and approaches is provided at the end of this section.

We emphasise the importance of undertaking a preliminary assessment with suitably qualified NPWS staff or consultants to ensure that the most appropriate methodology is chosen for your study.

A:\ SURFACE TECHNIQUES

Surface survey methods examine the land surface for clues about the location of unmarked graves and other features indicative of a burial place or cemetery, such as fence lines and pathways.

These methods are totally ineffective where there has been extensive surface disturbance (e.g. ploughing). However, they are a fast and effective way of documenting the features of possible burial grounds and for this reason they are recommended as a part of an initial site assessment or feasibility study, to determine the potential of the site for a more detailed study. These assessments are best undertaken by an archaeologist and/or landscape architect, who would be best able to interpret and understand the processes and activities that have produced the present land surface.

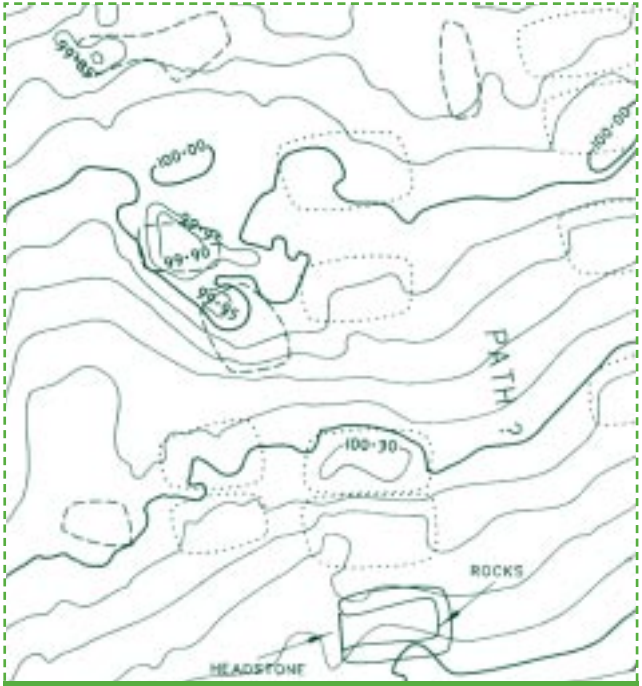
Two types of surface survey are described here:

topographic survey and *botanical survey*. Although they are described separately, these two approaches are often best integrated into a single study in order to save time and money.

\ TOPOGRAPHIC SURVEY

\ BOTANICAL SURVEY

A:\SURFACE SURVEY\TOPOGRAPHIC SURVEY



ABOVE: A micro-topographic plot, showing unmarked graves revealed as depressions and mounds contours at 5 cm intervals. At some undisturbed places, this technique has been used very effectively in defining the precise layout of historical burial grounds and other sites, some of which date back to the early Colonial period (c.1788-1850).

Topographic surveys record in detail the exact 'shape' of the ground surface – they map all the hollows, slopes, mounds etc. As well as recording the natural variations in the ground surface, such a survey will record variations resulting from human action, such as depressions resulting from the digging of graves. Significant surface features of a burial area can be very minor and hard to notice during a casual inspection. The survey equipment may be able to detect differences that cannot be seen with the naked eye.

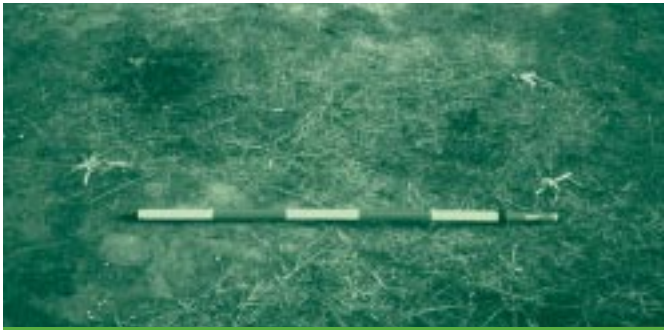
It is important to note that surface disturbance can easily destroy or obscure the minor depressions or mounds on the land surface that may indicate the presence of graves.

The technique requires detailed measurement of the land surface using precise survey equipment, such as a *differential global positioning system* (DGPS). The project team must include someone who can use this equipment effectively as well as an archaeologist, geomorphologist, or landscape architect, who can accurately read and interpret the form of the land surface.

How the method works

A very close inspection of the ground surface will help to define any obvious surface depressions and mounds in the area of interest. These can be marked on the ground with nails or stakes,

A:\SURFACE SURVEY \TOPOGRAPHIC SURVEY



ABOVE: A grave is revealed during exceptionally dry weather as a shallow depression filled with vegetation, surrounded by bare earth.

and plotted using a *differential GPS unit* or a conventional total station. Readings should be taken around the outline, in the centre, and in high/low points surrounding the feature.

This information can be used to produce a map of surface depressions and mounds, defined both by the human eye and by the computer calculation of 'contours' using recorded spot heights. Contours would be calculated at very close intervals (e.g. 1-5 cm) to best reflect the underlying topography of the site.

How it can detect burial sites

A grave will typically consist of an excavation dug into a 'hard' sub-soil and backfilled with looser material. In time, the backfill will settle and wooden objects, such as a coffin, will decay and collapse, potentially resulting in a distinct depression. Where a grave has been backfilled or refilled in more recent years, a shallow surface mound may be present.

The fill may also display other characteristics, such as differences in colour or texture. The ability of the soil in the grave to retain moisture after rainfall, or to act as a fertile bed for plants to colonise, can also provide clues to the location of a grave.

Where it won't work

Ground surfaces that have been disturbed through various forms of impact, such as stock trampling, ploughing and landscaping, will display little or no surface variation relating to historical graves. In these situations, micro-topographic survey is not recommended.

The technique is less useful in relation to small (e.g. child) graves, and may only identify the most obvious graves, rather than the total number of burials present in an area.

Where the area is covered by dense vegetation, prior to survey it may be advisable to slash to no closer than 5cm above the ground surface or wait for seasonal *dieback* to reveal more of the ground surface. It should be remembered that the presence of certain plants may hold the key to grave location. It may therefore be preferable to conduct a combined micro-topographical/botanical survey to optimise the study results.

Impact on the site

Low. A topographic survey is conducted by walking systematically across the site with a pole-mounted prism. Metal markers may be inserted in the ground to mark identified graves (Note: these should be removed before undertaking some geophysical methods, such as ground magnetic survey, as they may distort the readings).

What you get

Under the right circumstances, the technique will produce a detailed and accurate contour plan showing potential grave locations and other areas of surface disturbance.

Required specifications

This form of survey requires expertise in archaeology and digital mapping.

It is important that a series of control locations around the presumed grave site are examined to ensure that perceived surface topographic anomalies are not the result of unrelated local factors (e.g. rabbit burrows, agricultural or geological disturbance).

The recording of spot heights should be undertaken as systematically as possible (25-50 cm intervals), but allowing for breaks of slopes and high/low points. An ordered 'grid' of readings is therefore not recommended unless the topography in specific locations appears to be even.

Cost

About $2,000 to $3,000 for a *feasibility* assessment.
A large cemetery with many graves will cost around $7,000 to $10,000 to survey per hectare, depending on location. The overall costs can be reduced through a combined topographic/botanical survey

SNAPSHOT \ TOPOGRAPHIC SURVEY

BEST WHERE > Abandoned cemeteries and burial plots. Open, undisturbed ground.
POOR WHERE > Ploughed land, lawn cemeteries, areas with dense vegetation.
IMPACT LEVEL > Low.

A:\SURFACE SURVEY \BOTANICAL SURVEY

Botanical surveys record the location and density of plant species in an area in order to assist in the identification of unmarked graves. The plants may include species specifically planted on graves (e.g. flowering bulbs) or species which have found grave fill to be favourable for colonisation. In areas of low disturbance, this technique has been effective in determining the precise layout of historical sites dating back to the early post–contact period.

This technique can significantly enhance the results of a topographic survey, as seen in the photo to the right, where the existence of slight mounds becomes more obvious once the dense grass cover on them is recorded. A study of this type can help to define the precise location of graves on the ground without the need for surface excavation or expensive geophysics.

Success depends on a range of factors, including land use history, the season in which it is undertaken, and general climate in the area. A relatively undisturbed land surface containing a wide range of plant species in a region with pronounced seasons would be ideal.

How the method works:

A very close inspection of the ground surface will help to identify the location of flowering bulbs, distinct colonies of diverse plant growth and unusual densities within the distribution of a single

ABOVE: In winter, graves stand proud with a lush growth of grass at Ebenezer Mission (Victoria).

species. Depending on the type and characteristics of the species, these may mark the location of individual or close spaced graves.

These distribution patterns can be mapped using a differential GPS unit.

How it can detect burial sites

If allowed to develop naturally, without human interference, certain plant species behave in predictable ways. There are two types of plants of primary interest:

1 Exotic species planted as grave markers or as a 'flower of remembrance'. Some species, such as Harlequin Flower (*Sparaxis tricolor*), Flag Iris (*Iris x germanica*), Grape Hyacincth (*Muscari sp.*) and Peruvian Lily (*Scilla peruviana*), form colonies which do not migrate significantly over time, and as such are strong indicators of grave location.

2 Those species, both native and exotic find the rich grave backfill soil, or certain parts of the backfill (such as where the grave 'cut' and fill meet), a good place to grow in the local environment. Such plants tend to survive longest in summer and flourish in winter. Under the right circumstances an examination of the distribution of these plants can precisely define the extent and layout of graves.

ABOVE: At the end of summer, graves can still be identified by differences in grass growth. The depth of soil in a grave provides relatively moist conditions for plants to survive through the hot weather.

Where it won't work:

Ground surfaces that have been impacted by various forms of disturbance, such as heavy stock trampling, ploughing and landscaping, may display little or no botanical variation. Bulb colonies may, however, survive such disturbance, and serve to indicate the presence of burial areas and old gardens.

Seasonal factors are critical to the success of this approach. If only one inspection is affordable, a spring visit (September/ October), when plant growth is at its most vigorous, is advisable. High summer or winter may not display the same level of botanical diversity, and dormant bulbs could be very difficult to identify.

Impact on the site:

Low. There is no ground surface disturbance, though some plants may be removed for identification purposes. Nails or pegs may be left in the ground to mark potential graves.

What you get:

A map showing the distribution of significant plants in the study area and the location of potential graves, as defined by these patterns. A series of recording forms, photos and a report containing supporting information and management guidelines for significant plants should also be produced.

Required specifications:

This form of survey requires someone with a detailed knowledge of plants, both native and introduced, and their growth habits (e.g. a botanist, horticulturalist, or landscape architect).

Cost:

About $2,000-$3,000 for a *feasibility* assessment. A large cemetery with many graves will cost around $7,000 to $10,000 to survey per hectare, depending on location. The overall costs can be reduced through a combined micro-topographic/ botanical survey.

SNAPSHOT \ BOTANICAL SURVEY

BEST WHERE > Abandoned cemeteries and burial plots. Open, undisturbed ground.

POOR WHERE > Ploughed land, lawn cemeteries, and densely overgrown land.

IMPACT LEVEL > Low.

Jerzy Pawlowski, Geonics Limited is operating an EM 31-SH with a wheel-mount accessory.

B:\ ARCHAEOLOGICAL TECHNIQUES

Archaeological methods of unmarked grave identification involve the removal of a layer of soil and other materials from the surface in order to reveal the presence of deeper excavations, such as graves. Of the methods described in this guide, archaeological techniques are the most destructive. Because of its impact on the upper level of any graves that do exist in the area, archaeological excavation is not recommended except as a last resort where other methods cannot be used. Aboriginal people may be distressed by the idea of any digging in the vicinity of possible graves. These techniques, however, can be most effective in grave identification since they deal directly with graves themselves rather than with surface or geophysical indicators only.

Two approaches are described here:

Surface scraping This removes a thin layer of surface soil which might cover potential grave sites. This has a moderate to high impact on the ground surface, but is unlikely to disturb human remains since these will usually lie deeper in the ground.

Burial excavation This reveals graves through detecting the presence of skeletal remains. This technique should not be used to identify suspected burial sites but is often used, with the consent of the Aboriginal community, to recover skeletal remains where these have been exposed by erosion or earth works (e.g., pipeline construction).

These approaches must be undertaken by a qualified archaeologist, who will be able to test for and recognise differences in soil colour, texture and composition, as well as potential artefacts and human remains. Neither approach can be undertaken in NSW except under permit from NPWS. A standard requirement for such permits is consultation with and consent of the Aboriginal community, especially those who may be relatives of the deceased.

\ SURFACE SCRAPING

\ BURIAL EXCAVATION

B:\ARCHAEOLOGICAL\SURFACE SCRAPING

Surface scraping is a common technique used in Australia and overseas for the identification of archaeological objects, such as pits, postholes and hearths. It can also be used to detect graves. This is especially useful where there has already been extensive disturbance to the land surface, through either the addition or mixing of soils, making surface survey and geophysical methods either ineffective or the results unclear.

How the method works:

The grass and topsoil are removed systematically to reveal the surface of the underlying sub-soil. The method used will depend on site conditions and the potential for finding shallow skeletal remains.

If the topsoil is very thin it is best removed by hand. The choice of excavation tools then depends on the type and thickness of soil. Shovels are best for larger quantities of heavier materials, while hoes should be used for lighter, less compact materials, such as sand. Hand trowels can be used in smaller areas, but are inefficient over a large area.

Where there is a thick layer of topsoil, such as a plough soil, and where there is less risk of damaging possible skeletal remains, a mechanical excavator is more efficient, followed by a surface 'clean up' by hand. Use of a mechanical excavator may only be practicable if the machine has unrestricted access to the site. It may not be appropriate within the confines of a small cemetery.

How it can detect burial sites:

Since the 19th century Aboriginal people have tended to be buried lying on their backs in deep graves dug into the ground.

Depending on the size of the deceased person, these graves will today consist of rather big excavations (1.5-2 m in length for an adult) into the sub-soil. When the dead were buried, their graves will have been backfilled with a different soil, consisting of some plant remains, topsoil, rocks and other materials from the surface. This backfill will have a different structure, colour, texture and/or composition to the surrounding undisturbed soils. An experienced archaeologist will be able to tell the difference between the different soils.

Depending on the type of sub-soil, the outline of these pits will be visible as patches of different coloured and textured soil exposed on the surface of the scraped sub-soil. Depending on the depth of burial, any surviving bones should still be protected beneath the lower backfill. Careful records will have to be taken of the depth of excavation to minimise risk to skeletal remains.

B:\ARCHAEOLOGICAL\SURFACE SCRAPING

Where it won't work:

It is important to appreciate that many Aboriginal communities will be reluctant to allow any form of digging in a vicinity believed to contain Aboriginal graves. This reluctance stems from a fear of disturbing the remains of those buried in the graves, a disturbance that might be considered to be
a desecration of the graves.

Where it is used, this technique is less successful and slower on heavy soils (e.g. clay), rocky soils, or sites containing underground obstructions (e.g. wall footings and drains) or soils containing brick or rubble in-fill.

Impact on the site:

Moderate to high. The process involves the total removal of the ground surface. Only recommended where the ground has already been substantially altered.

What you get:

An accurate map showing the extent and position of graves, with supporting report.

Required specifications:

Appropriate permit from NPWS.
Aboriginal community consent.
It is important that a qualified archaeologist supervises this work.

Cost:

This will depend considerably on surface conditions. $2000-4000 per 1/4 hectare, at a rate of 1 hectare per 1-3 days.

SNAPSHOT \ARCHAEOLOGICAL TECHNIQUES

BEST WHERE > Can be used anywhere, but it is best to use where the surface soil is disturbed already or where the body is buried below younger layers of soil.

POOR WHERE > Surface scraping is less effective and slower in heavy (e.g. clay) or rocky soils.

IMPACT LEVEL > High. Soil will be removed, and the burial will most probably be revealed.

B:\ARCHAEOLOGICAL\BURIAL EXCAVATION

In some cases the Aboriginal community may be concerned about the place where a person is presently buried, and may wish to return the remains to a place where they can be better looked after. This is when burial excavation is the most appropriate method.

For this reason, an option has been included which outlines the process of burial removal.

In general, this technique will not be appropriate for graves from the last 217 years. Suspected Aboriginal burial sites under threat will normally be protected through a process of negotiation and mitigation measures. Burial excavation also offers opportunities for further research into the burial, if the Aboriginal community expresses an interest in such research.

How the method works:

The first stage in this process is a surface scrape to identify the borders of possible grave 'cuts' (see previous section).

Having identified the size and border of the possible burial, it is then possible to carefully remove the backfill and determine whether a body (skeletal remains) is present or not.

The Aboriginal community may wish to determine how the skeletal remains are removed from the burial site.

Impact on the site:

High. The process involves the removal of both the backfill and any skeletal remains.

This can only be undertaken with full consent of the community and by permit from NPWS.

What you get:

An absolute determination of the presence of graves and skeletal remains. A detailed archaeological report.

Required specifications:

If the community opts for a burial excavation, it is important to know as precisely as possible where the burial is located (through historical research, a surface scrape or geophysical method).

To keep disturbance to a minimum when removing skeletal remains, it is recommended that an archaeologist or physical anthropologist be engaged, as they will be better able to identify the bones, record the position of the bones, and carefully remove the remains and any other items in the grave.

C:\ GEOPHYSICAL TECHNIQUES

Remote sensing methods can be used to 'see' beneath the earth in places where there are no markings (e.g. headstones) on graves. The science of geophysics concerns itself with detecting and predicting from remote sources what is going on below the ground surface. This can range from understanding the structure of the earth's core, through earthquake prediction, to methods that can detect variations in surface soil layers.

Geophysical detection methods rely on detecting contrasts in the soil underneath the topsoil. These can be contrasts in density, conductivity, magnetic susceptibility and numerous other characteristics.

It is often necessary to dig a 'test' pit to determine the most suitable method to use on a site; however, this may be done on similar ground away from the site and without disturbing graves.

In general these methods have low impact, in that they involve very little ground disturbance. Typically, a geophysical expert will carry a lightweight instrument in lines across the site. Measurements are taken using a grid laid out by measuring tapes and small pegs, all of which are later removed. As satellite navigation technology becomes more readily available this will increasingly be used to provide accurate locations for small area surveys, but at present this type of technology can almost double the costs.

No geophysical technique will work every time, and small, isolated pits, like graves, are usually hard to find. Therefore it is strongly advised to have an experienced geophysicist check the site first and do a few soil tests. This 'orientation survey' is often critical. In some cases the geophysicist may find that no geophysical surveys will be effective at a particular location. Reasons can be the history of the land use or the nature of the different soil layers.

Since geophysical methods measure fine contrasts below ground, they can easily be disrupted by objects on the surface. For example metal objects on the site, such as cans, wire and roofing material, can seriously skew the results of the geophysical methods. If such materials are not of cultural value it is important to remove them before commencing the survey.

The techniques described in detail in this section have been proven to be the most successful for revealing unmarked graves. A selection of alternative methods is described at the end of the section.

\ GROUND MAGNETIC SURVEY

\ GROUND PENETRATING RADAR

C:\GEOPHYSICAL TECHNIQUES\GROUND MAGNETIC SURVEY

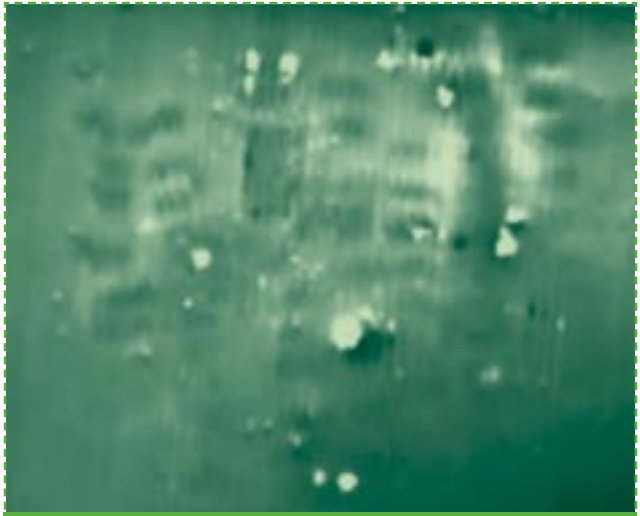
ABOVE: Headstones, rocks, or metal fences around graves and other similar objects may have strong geophysical responses that will confuse nearby readings.

Ground magnetic surveys have been used for many years in the search for unmarked graves. Recent technological developments have improved data collection and data quality, making this technique one of the most effective and cost efficient in the right place.

With good ground conditions this method can detect small occurrences of disturbed ground, which makes it one of the best methods for finding grave locations.

If used effectively, the method can even show the boundaries of individual graves, as shown in the drawing below on the right.

The method does not entail any risk of disturbing the ground surface, provided the area is free from fragile grave markers or other relics.



ABOVE: Example of a magnetic 'image' of Ebenezer Mission Cemetery. The dark rectangular areas represent graves. Bright spots are small pieces of scrap metal on the surface.

There will be problems, however, if several layers of soil have been laid over the top of earlier graves, such as windblown sand or river silt. This will make it extremely difficult to reveal the underlying pattern of graves and their correct location. The technique should only be performed by a qualified geophysical expert. Before the main survey starts, the expert will carry out an orientation survey to help to decide whether this technique is suitable for the specific study area.

How the method works:

The technique relies on making exact measurements of the *magnetic field* of the earth, the same magnetic field that makes a compass needle point to the north. The earth's field is distorted by the presence of iron or magnetic minerals (usually oxides of iron) near the surface of the earth. Even very small amounts of magnetic material can cause sufficient distortion in the field for modern instruments to detect the change.

How it can detect burial sites:

Soil which has been allowed to develop undisturbed by digging or major earth moving will form in layers. These layers will contain varying amounts of fine magnetic sand. The surface layers usually contain more magnetic minerals since iron oxides are heavy and thus do not get blown or washed away.

ABOVE: A ground magnetic survey in action.

When the surface is disrupted by digging, the magnetic layers are disrupted as well. This disruption can be measured using a *magnetometer*.

Where it won't work

For this method to work, the magnetic layering in the soil needs to be undisturbed. Where the soils have been recently deposited by wind or water, or disturbed by a river, there will likely be problems with the data (because of destroyed magnetic layering).

Large amounts of other magnetic material, such as nails, cans and other metal rubbish in the survey area may disturb the measurements considerably. Fences and metal roofed buildings will also cause distortions (these, however, can usually be allowed for when metal items are as large as a roof or fence).

Impact on the site:

A ground magnetic survey is conducted by walking in a regular pattern (straight lines) across the site carrying an instrument.

What you get:

If detailed information is collected it will be possible to produce maps and images like the one in the diagram shown on page 29 and to prepare a map showing where all graves are indicated to be.

Required specifications:

It is important that enough data is collected to be able to distinguish between the shape of grave sites and other excavations such as trenches and rabbit burrows.

To get the best possible information about the shapes of graves, it is suggested that magnetic field readings be taken every 5cm along lines spaced 25cm apart. The space between these readings depends on the specific site.

Cost:

Around $3,000-10,000 per hectare depending on the site, covering about 1/2-1 hectare per day.

SNAPSHOT \ GROUND MAGNETIC SURVEY

BEST WHERE > The area is open, has little soil disturbance, and where the soil has not been recently moved by wind and water.

POOR WHERE > Excavation, ploughing, or building has gone on. Unlikely to work in sand dunes or areas next to rivers. Strongly disrupted by metal objects (fences, grave markers or litter).

IMPACT LEVEL > Low. Equipment operators walk systematically across site in straight lines.

C:\GEOPHYSICAL TECHNIQUES\GROUND PENETRATING RADAR

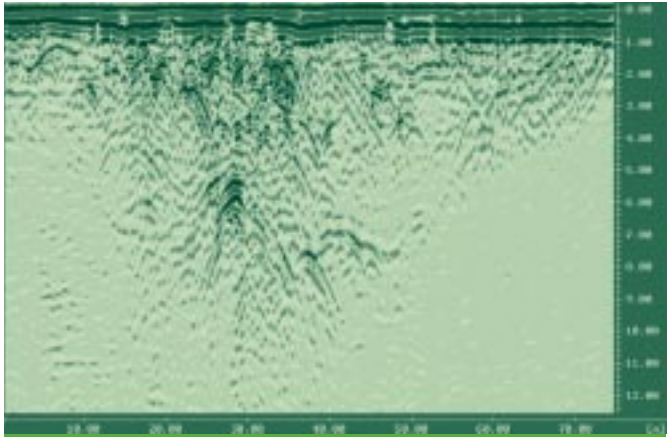
Ground penetrating radar (GPR) has been used with great success in all kinds of shallow sub-surface investigations for a range of environmental, archaeological, forensic and civil engineering purposes. As it is a relatively new technique, technology is improving steadily, providing increasingly better data, greater ease of use, and a lower cost from year to year.

The chances of finding unmarked graves by using a GPR are very good. A *radio pulse* creates *three-dimensional images*. With optimal ground conditions the method can detect signs of a skeleton or other buried objects in a grave (see image on the right).

It is a relatively expensive method to use, and, until the technique is tested more effectively with grave identification, the results can sometimes be unclear. As a result, it requires considerable skill to operate the equipment successfully and interpret the resulting data.

Only a qualified geophysical contractor should undertake a ground penetrating radar survey.

To find out whether a GPR is the right method for detecting possible unmarked graves, an orientation survey will be necessary beforehand. This should only be undertaken by a geophysical expert.



ABOVE: GPR cross-section through a grave site. The patterns in the upper part of the section show ground disturbance. The lower arcs indicate the presence of buried objects.

Bellbrook Case Study

In September and October 2001 a ground penetrating radar survey was carried out at the cemetery attached to the former Aboriginal Reserve at Bellbrook in the Macleay Valley. The investigation was carried out by Richard Yelf (Georadar Research Pty Ltd) as part of a NPWS funded project managed by Vic Buchanan, Aboriginal Sites Officer, Coffs Harbour.

The study was requested by Aboriginal elders from Bellbrook who wanted to be buried at the old cemetery but were worried that any new graves might disturb older, unmarked graves dating from about 1900 – 1930. The survey focused on two areas of the lawn-covered cemetery. The radar equipment (a GSSI SIR-10 system) sent *radio waves* 2-4 metres under the ground along transects 1 metre apart. A total of 8 adult graves and 13 child graves were detected by the survey. The location of these graves was previously unknown. The survey showed that one of the two areas investigated was almost free of graves.

How the method works:

Ground penetrating radar *(GPR)* uses radio waves to detect underground variations in soil structure and content.

GPR can be used to map any object capable of being penetrated by radio waves, just as X-rays image the internal structure of the body. A sensitive detector is used to record weak radio waves reflected from objects and other underground 'contact points', such as differences between soil layers.

Measurements must be made at many points to ensure an accurate representation of the area being examined. GPR data are transformed into an image on a computer. *Hyperbola* (arches) displayed on this image, indicate the placement and depth of objects (e.g. skeletal remains) in the survey area.

How it can detect burial sites:

When holes are dug, contrasts (or 'cuts') develop between the disturbed soil in the hole and the surrounding material, such as natural sub-soil or bedrock.

The GPR receives radio wave reflection from the edges of the hole, and can also detect differences between the naturally layered soil and the 'mixed' soil in the grave. If a coffin is present it might also generate reflections that can be picked up.

The method relies on radio waves going through (penetrating) the ground and detecting contrasts. While the presence of water in the soil can improve the quality of data collected from underground features, it may make penetration more difficult. Well developed horizontal layering is important since breaks between the layers can often be detected.

Where layering of different soils is not present, such as in sand dune areas, GPR may have improved resolution in the detection of skeletal remains or wooden coffins. To the instrument, however, these may appear to be very similar to tree roots.

Where it won't work

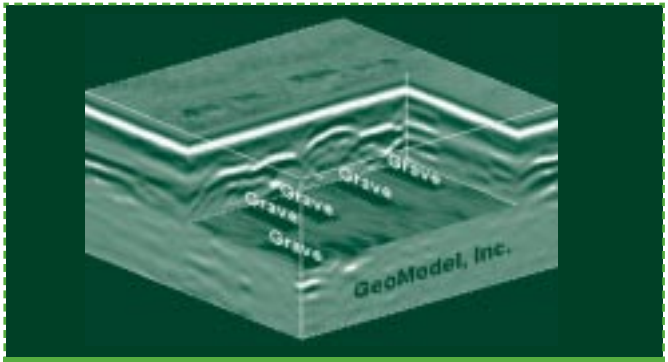
Where surface layering is not horizontal, such as in dunes or sand deposits near rivers, the method may find it difficult to

detect the contrasts caused by grave digging. Excessively wet ground can also cause problems with the data.

Because of the shape of the instrument it is difficult to collect data over areas with numerous obstructions of a natural or cultural nature.

Impact on the site:

This technique does not disturb the ground surface, providing the area is free from fragile grave markers or other relics. A GPR survey is conducted by walking systematically across the site while towing an instrument. Small plastic pegs and plastic tape may be used for location and removed afterwards.



ABOVE: Cemetery with headstones showing cut-away view of GPR data detecting grave sites.

What you get:

Data collected is presented in vertical sections like the one shown below left. Burial sites will produce arches in the data. The width of the arch relates to the width of the excavation. With additional processing it is often possible to produce images of the GPR over an area similar to the plot shown in the ground magnetic survey section.

Required specifications:

Other objects or soil disturbances will produce similar patterns to graves. Thus collection of sufficient data is very important. At least two lines of data should be collected across each grave. As a guide, it is suggested that GPR readings should be taken every 1-10cm along lines spaced 50cm apart. A frequency of at least 500mHz should be used, or higher if shallow penetration is adequate.

Cost:

Around $6,000-13,000 per hectare, with a coverage rate of 1/4 hectare per day.

C:\GEOPHYSICAL TECHNIQUES\ELECTROMAGNETIC SURVEY

ABOVE: Parks Canada Archaeologists using Electromagnetic Survey to measure soil conductivity.

Electromagnetic (EM) surveys are used for detecting a range of magnetic sources in the ground (from huge mineral ore bodies to buried copper wires). The equipment ranges from simple metal detectors to systems that can accurately map the shape and size of buried objects.

There is a wide variety of methods available, which make it difficult to accurately describe the expected results or to estimate costs.

In general, EM survey allows us to identify differences in the ground caused by variations in ground *conductivity*. These may result from excavations or buried minerals, objects and wall footings. The effectiveness of the technique may be significantly reduced by the presence of magnetic materials, such as iron, both in mineral form and as buried or surface iron objects.

The method involves no risk of potential disturbance to the ground surface, provided the area is free from fragile grave markers or other relics.

A preliminary 'orientation survey' will be required to determine the suitability of the technique to a specific study area. This should only be undertaken by a geophysical expert.

How the method works:

An electric current passes through a wire coil at the surface, producing a magnetic field, which penetrates the earth. Where it encounters conductive material, further electric and magnetic fields are created. These can be detected again at the surface.

Simple equipment will give an indication of whether the ground is more or less conductive and perhaps give a single conductivity value for each point. More advanced equipment will be able to produce section diagrams of the ground and estimate depths.

C:\GEOPHYSICAL TECHNIQUES\ELECTROMAGNETIC SURVEY

The most recent EM equipment produces excellent data for shallow sub-surface investigations. It collects data along a line using equipment carried on a small buggy. At each station, a number of readings are collected. These provide depth related information, resulting in a vertical section on each profile. Where the EM method is suitable, this system could provide excellent results.

How it can detect burial sites:

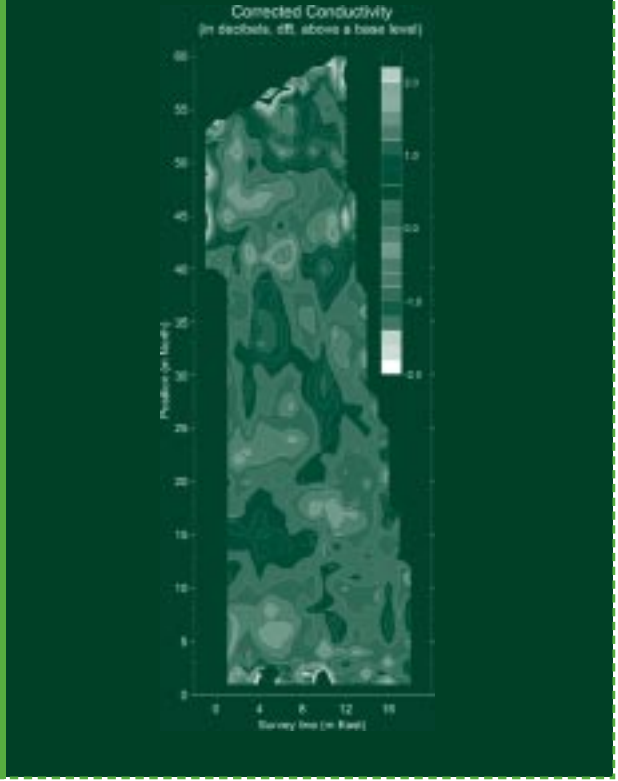
Soil which has been allowed to develop undisturbed by digging or other major earth moving will form in layers. These layers will have contrasting conductivities.

When the surface is disrupted by digging, the conductive layers are disrupted. This disruption can be measured using an EM instrument.

A burial site or other hole may also tend to be wetter or drier than the surrounding soil. This will influence the conductivity of the soil, which can be detected by the instrument.

Where it won't work:

For this method to function effectively there must be conductivity contrasts in the ground. Where soils have restricted variation and limited moisture content the method is unlikely to work successfully.



RIGHT: An EM conductivity plot showing potential grave sites as dark patches (Source: Nobes 1999).

Metal objects are of course extremely conductive and their presence will disrupt any attempt to detect subtle features related to burial sites.

Impact on the site:

None. EM surveys require one or two people to walk systematically across the site with equipment.

What you get:

If detailed information is collected it will be possible to prepare maps and images of the data and produce an interpretation map showing where all graves are believed to be located.

Required specifications:

Most EM systems take longer to collect readings than *ground magnetics* or GPR. It is important that enough data is collected to be able to accurately distinguish the shape of grave sites from other causes of *anomalous* EM readings. Economising on data collection, in order to save time and money, should be avoided.

As a guide it is suggested that EM field readings should be collected at a minimum of every 25cm along lines spaced 100cm apart. Although this will give insufficient data to accurately define graves shapes, it should detect burial sites if they show good contrast with their surroundings. A closer line spacing would be better.

Cost:

EM systems with shallow penetration are often owned by local government authorities and used for ground water studies. While these may not be ideal they can be a cost effective way of getting hold of the equipment.

A range of costs for EM surveys using geophysical contractors and modern equipment for 1-2 hectares would be $10,000-$25,000. With older equipment a cost of $5,000 might be achievable at the expense of data quality.

SNAPSHOT \ ELECTROMAGNETIC SURVEY

BEST WHERE > The site is open and the soil is damp. Clay soils are optimal.

POOR WHERE > Disrupted by utilities, such as underground pipes and cabling. Can be affected by other surface disturbance.

IMPACT LEVEL > None. Equipment operators walk carefully in straight lines across the survey area.

C:\GEOPHYSICAL TECHNIQUES\RESISTIVITY SURVEY

ABOVE: Taking readings with a resistivity receiver in rugged bushland.

Resistivity surveys were amongst the earliest geophysical methods to be developed. They have been used extensively in mineral exploration and environmental work.

These surveys rely on introducing an (electrical) current into the ground and then detecting perturbations in the ground current around the area of interest. Because they require wires to be laid out for the ground current and also for the receiver, resistivity surveys can be quite slow. Most resistivity methods require good electrical contact with the ground, making them inappropriate for use in very dry areas, such as parts of western NSW.

Variants on the resistivity method have thus been used with best effect in temperate south-eastern Australia, where ground moisture levels tend to be high.

The method involves little risk of potential disturbance to the ground surface, provided the area is free from fragile grave markers or other relics, though current must be introduced into the ground through *electrodes*, usually metal spikes.

The technique should only be performed by a qualified geophysical contractor.

A preliminary orientation survey will be required to determine the suitability of the technique to a specific study area. This should only be undertaken by a geophysical expert.

How the method works:

Electrodes are inserted in the ground and electric current pumped through them. Surface electrodes then are used to take measurements of voltage between points. Depending on the resistance of the sub-surface the voltage will vary.

How it can detect burial sites:

This method is very similar to the EM technique only it is more sensitive to resistive features. Thus it is more likely to map graves if they are more resistant than the surrounding soil. This usually occurs because they are drier.

Where it won't work

There must be some contrast between the grave pit and the surrounding soil. Ideally the grave should be significantly drier and more resistant to electric flow than its surrounds. If this is not the case the method is likely to be ineffective.

The ideal site for this method would be one where a sandy soil contains occasional damp clay layers (an alluvial environment). The digging of graves would entail disruption of the damp and relatively conductive clay layers, locally increase resistance and show as an anomaly.

Impact on the site:

The current electrodes are usually placed outside the burial site area. Sometimes small pits are dug if it is difficult to get current into the ground. However these can be placed at a considerable distance outside the target area.

Apart from the current electrodes the rest of the activity is low impact. Two operators walk across the ground measuring the response between two small metal pegs or porous ceramic pots. If the ground is damp the pegs are only inserted a few centimetres and the pots need to be placed in a shallow scrape in the soil usually made with the heel of a shoe. Typically pegs are used for small scale surveys.

What you get:

It is possible to conduct resistivity surveys that provide detailed depth information as well as a map of how ground resistivity varies across an area. However, these require extensive

coverage of both current and potential electrodes throughout the survey area. For a small project like a cemetery it would be much more cost effective to aim just for a map and hope that there is sufficient information to be able to recognise graves by shape. If adequately detailed information is collected it will be possible to prepare maps and images of a quality comparable with those from the other methods.

Required specifications:

As always, it is important that enough data is collected to be able to accurately distinguish the shape of graves.

As a guideline it is suggested that resistivity readings should be taken every 25cm along lines spaced 25cm apart. This will result in an exceptionally detailed resistivity survey.

Cost:

Around $10,000 would cover contractor and equipment costs for a small cemetery. $3,500-10,000 per hectare, at a rate of 1 hectare per 5 days.

SNAPSHOT \RESISTIVITY SURVEY

BEST WHERE > The site is open and soil is damp. Clay soils are best.

POOR WHERE > Dry surfaces. It is also inappropriate for use in built–up areas because of the presence of underground cabling. The results can also be affected by other forms of surface disturbance.

DRAWBACKS > The process is quite complex, and the results tend to be dependent on survey direction.

IMPACT LEVEL > Equipment operators walk systematically across the site with no risk of disturbance.

SECTION 3 Other methods & approaches

\OTHER METHODS AND APPROACHES

Digitally Enhanced Topographic Imaging

As well as the interpreted plots and contour maps produced during a topographic survey, it is also possible to produce a *topographic image* of the data. This can produce a black and white picture of the data (similar to the picture in the ground magnetic section). With proper digital image improvement, fine features can readily be distinguished.

This type of presentation tends to be more effective for interpretation than a contour map, as the contouring process will introduce smoothing into the data. The production of digital images should add very little additional cost to a micro -topographic report.

Aerial Photographic Imaging

As well as ground surveys it is also possible to obtain survey data from the air. If a large area is of interest and if detailed air photos are available or are required for some other purpose then digital elevation models can be derived from a pair of air photos. To have any hope of obtaining useful data, the air photos will have to be at 1:5 000 scale or better. At this scale, local *topographic* variation of about 3cm can be resolved and grave sized features might be detectable. Normal air photo surveys are at 1:15,000 to 1:25,000. Generally, the costs of processing and photo-reproduction are small, with a pair of good quality photos for the area of interest costing in the order of $1,000.

Other Geophysical Methods

Seismic methods rely on tracing vibrations in the ground. They are extensively used in oil exploration because of the accuracy with which they can resolve deep underground features. They are not usually effective in work near the surface and tend to be expensive for collecting and processing data. GPR normally replaces the seismic methods for shallow sub-surface imaging.

The **self potential method** relies on measuring naturally occurring electric currents in the ground. While in some cases there might be current variation due to changes in ground water conditions, one would not generally expect noticeable variations over old grave sites. Self potential surveys require only wire, two electrodes and a *volt meter*. The method is cheap but the results are difficult to interpret.

Radiometric techniques detect the presence of elements which have naturally occurring radioactive isotopes. The most common of these is potassium. Where there are marked variations in potassium between soil layers, as can occur in soils over granites, it might be

possible to detect changes produced by digging. In general, however, these changes would be difficult to resolve with existing equipment.

Electrokinetic surveying (EKS), is a recently developed method for measuring *ground permeability*. Digging will disrupt permeability if the excavation is in wet ground. As graves do not tend to penetrate the water table, the method is likely to be unsuccessful unless the circumstances are exceptional.

Gravity measurements can be used to resolve subtle differences in density beneath the surface. Very detailed measurements of the gravitational field have been used to successfully detect underground cavities. In older grave sites there are unlikely to be any cavities remaining. Where there are well developed layers of contrasting *density*, *gravity surveys* might effectively determine evidence of burial sites. However, gravity surveys tend to be slow and thus relatively expensive.

More details on these methods are found in the glossary.

A ground magnetic survey in action.

SECTION 4 Guidelines for Commissioning Investigators

\GUIDELINES FOR COMMISSIONING INVESTIGATORS

This section is intended to assist groups or individuals who have an interest in finding or better defining Aboriginal graves and burial areas from the last 217 years. This will include members of Aboriginal communities, Aboriginal community heritage staff, and NPWS staff. The steps outlined below will guide people to make informed decisions about the best approach to take and enable them to provide the right information for a professional contractor to undertake the study effectively.

It is important to bear in mind that these studies are a high-cost activity, and each technique depends on a particular set of circumstances in order to provide value for money.

In every case the preferred approach is to commission, at the outset, an orientation survey or *preliminary site inspection* to establish the best research methodology for the specific location. Without this it would easily be possible to commission an expensive but inappropriate geophysical study, when a cheaper and more effective technique was available.

Aboriginal communities and individuals are encouraged to liaise closely with NPWS regional cultural heritage staff throughout this process to benefit from their expertise and field experience.

The individual tasks are divided into things that you can do yourself and things that require professional assistance. Many of these tasks could be undertaken by a community member, NPWS staff member, or an independent consultant.

Things you can do

There are three main steps you should take before commissioning a professional study.

Step 1: Community Discussion

Talk with community members to find out where known Aboriginal post-contact burials are located. There may be a wealth of information held within the community that is not commonly discussed, which may provide clues about the location, date and details of unmarked graves, whether as lone graves, in rural cemeteries, or informal burial plots.

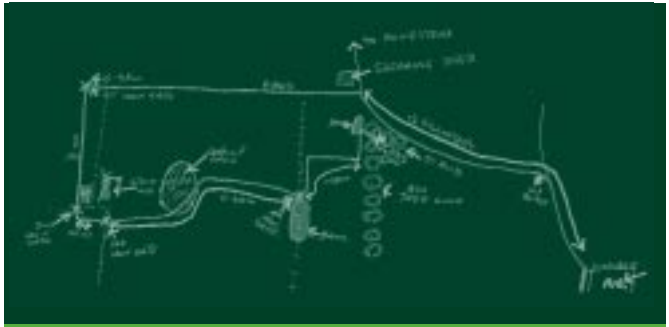
For information on known post-contact Aboriginal burials and cemeteries in NSW, contact:
Information Services Unit, Cultural Heritage Division,
NSW National Parks and Wildlife Service,
43 Bridge Street,
PO Box 1967, Hurstville NSW 2220
Tel (02) 9585 6471, (02) 9585 6470 Fax (02) 9585 6094

It is important to talk widely with the whole local Aboriginal community to ensure that all views have been considered in deciding whether it is appropriate to search for these graves, what techniques should be used to look for the graves, and how they should be managed after their discovery. Effective community consultation could help narrow the scope of the study area, save time and money, and significantly improve the chances of successfully relocating the graves.

This dialogue with the community should continue throughout the time it takes you to investigate the graves.

Step 2: Site Identification

When you have identified a possible Aboriginal burial place and have consent from the wider community and/or descendants to investigate its location, the next step is to find and closely define the place thought to contain graves. Visit the place and make your own assessment. Can you see grave markers (e.g. wooden crosses or the remains of these) or other features relating to a historic burial ground, such as fencelines or paths? Can you see mounds or depressions? Can you see unusual plants, such as exotic bulb species? Does the place match descriptions in documents or recollections by elders?



ABOVE: Sketch plan of the environs of an Aboriginal cemetery in Western NSW by NPWS Aboriginal Sites Officer, Sabu Dunn, 1982.

When you are certain that you have found the right place, you can help the experts help you by providing as much information about the site location as possible. The more information you can supply, the better the chances of the project being a success and reducing the need for others to do research for you. Things you should include in your preliminary assessment:

- Draw a sketch plan of the place, showing the main features, such as trees, fencelines, grave indicators, other cultural features and the approximate distance and direction between them, and a map showing how to get there.

- Describe what the site is currently used for?
- Find out who owns the land, and what they know about the place. Remember that if the place is on private land, the owner's permission will be needed to visit the site and conduct any investigation. If you encounter problems it would be best to speak to regional NPWS staff.
- It is important to calculate the size of the area potentially containing graves, so that the area of interest can be narrowed down as much as possible. Some of the techniques outlined in this book are expensive and slow to perform. Cost savings can be made by reducing the potential area of coverage.
- If you can, calculate an accurate AMG (Australian Map Grid) coordinate for the site using a best scale topographic map (1:100,000, 1:50,000 or 1: 25,000) or GPS (Global Positioning System). Remember that some commercially available GPS's may not be able to give the pinpoint accuracy required for this type of work.

Step 3: Background Research

When the potential burial location has been defined, try to find out as much as you can about the place. This information could form a site 'record' to assist you and potential contractors determine the appropriate approach and its potential costs. Local knowledge is very important here, as maps and other records are often not of sufficient detail.

These include:

- *The Geology of the Site* – Is the sub-soil stony, sandy or clayey? You might be able to find this out from maps or by talking to local people who have farmed the land. In the case of a cemetery, you may be able to talk to people who have dug the graves.
- *The History of the Burials* – How many people were buried? When, how and where were they buried? Who were the people buried? Are there any particular stories about these people, or the circumstance in which they died? You may be able to find out about this through talking with local people or by consulting books and historical documents.

- *The History of Site Landuse* – Other than burials, what else has the site been used for, both before and after the burials took place? It is very important to have this information when deciding which technique or combination of techniques to use. Again, you will need to visit the site, talk to local people and examine historical records. Try to get hold of old aerial photographs of the site – these could date back to the 1940s and may show things not visible today, possibly including graves.

Step 4: Decide the Best Approach

When you have researched the site as much as you are able, talk to the community again and find out what their views are on investigating the site further. In deciding which direction to go, you will probably need to speak to NPWS staff or other professionals for advice.

Things to bear in mind include:

- What results you want to see at the end of the project, and how you will make use of them. For instance, will the community want to protect the burial area by fencing?
  Do you want to find a vacant area in a cemetery to use for more burials?
- Have realistic expectations about what the technique will produce for you. Speak to a range of contractors about your project before making a final decision.
- How much funding you have available for the investigation.
- In some case, a combination of two complimentary techniques has a greater chance of producing effective results than a single technique.
- Obtain the views and opinions of the landowner, and whether they will agree to the investigation.
- Consult the NSW legislation for the protection and management of post-contact burials and cemeteries (NPWS staff can assist with this). This includes the National Parks and Wildlife Act 1974, the Heritage Act 1977 (amended 1998), the Coroners Act 1980 and the Public Health Act 1991 (see the NPWS website: www.nationalparks.nsw.gov.au). To summarise, areas thought to contain exclusively Aboriginal burials are covered by the NPW Act 1974, while areas containing both Aboriginal and non-Aboriginal graves are covered by the Heritage Act 1977. For more information about how these acts can effect your proposed methodology, seek advice from NPWS.

Step 5: Secure Funding and Appoint a Contractor

Before formally commissioning an investigation it is important to undertake the following:

- Ensure that you have adequate funding to complete the investigation. It is preferable to budget for two different techniques to maximise the chances of a successful result. Determine the size of the study area in hectares and use the cost scales for each technique to determine the amount required (See Schedule 1, at the end of this book).
- There are several potential funding sources for research of this nature. Contact the Cultural Heritage Division staff at your local NPWS office for advice.
- Ask NPWS for assistance in writing a project brief and contract for you to ensure that you get what you expect out of the project.
- If there is any doubt about which technique to use, a low cost pilot study may help determine the best direction before committing to a full study.

NPWS regional staff will be glad to advise or assist at any step in this process.

When to get Professional Assistance

There are some aspects of this process where you will probably need to get professional advice from either NPWS or an independent consultant. These include:

- Detailed historical research into the burials.
- A site inspection to get a professional appraisal before committing funds to a study.
- An orientation study to check the suitability of the site for a particular geophysical technique. It may be best to get someone with expertise in a broad range of techniques to undertake this.

Remember, all the techniques described in this guide are highly specialised in nature and it is important to ensure that any advice you receive comes from a qualified source, preferably someone with demonstrated experience in successfully undertaking work of a similar nature.

BELOW: Schedule 1: Approximate costs for Geophysical Survey.

Survey method	Survey Cost (excluding travel to and from site)	Rate of Coverage	Processing and Reporting costs	Comments
Orientation Survey	$300 - $600 per day depending on the instruments required	N/A	Included	In order to maximise the chance of getting effective results, an orientation survey is valuable.
Ground Magnetic	$1000 -$2000 per day. Can be less in easy situations	1/2 to 1 hectare per day depending on terrain (more if easy and less if difficult	$1000 - $5000 depending on detail and quality required	This assumes that multiple readings can be taken at once
Electro-magnetic (EM)	$1000 - $2000 per day	Very variable depending on data quality required	$2000 - $10000 depending on method and amount of processing	Price and coverage depends very much on the quality of data required
Ground Penetrating Radar (GPR)	$1000 - $2000 per day	1/4 hectare per day with good conditions	$2000 - $5000	Dependent on ground surface
Resistivity	$500 - $1000 per day	1/5 hectare per day maximum	$1000 - $5000	Can be more expensive if more detail required
Combination Magnetic and EM	$1500 -$3000 per day	Slightly less than magnetic alone since wires have to be laid out.	$1000 - $5000 depending on detail and quality required	

A ground penetrating radar in action at the Bellbrook Cemetery in Northern NSW, 2001.

SECTION 5 Glossary & Further Reading

\GLOSSARY

Anomalous

Unexpected local variations are referred to as anomalies. An anomalous response is one which differs from the expected smooth pattern of response.

Archaeological prospecting

The use of geophysical methods for the identification of subsurface archaeological features. These methods do not involve disturbance to the ground surface.

Botanical survey

A study undertaken by a botanist or horticulturalist concerned with the range and distribution of plant species in a given area.

Burial

In colonial Australia most burials were undertaken in the Christian tradition of extended, supine inhumation, where the body is placed on its back with the legs stretched out and the arms by its side. Traditional Aboriginal burial practice had many forms of expression, including flexed inhumation, where the body is placed in a crouched position.

Cemetery

A place where multiple burials are found. Individual graves outside the boundaries of defined cemeteries are termed lone graves.

Civil engineering

Civil engineering is the branch of industry related to construction of roads, reservoirs and buildings.

Conductivity

All matter will conduct electricity to varying degrees. The earth is generally a poor conductor of electricity, however the presence of metal or salty ground water may improve this conductivity.

Density

A measure of compactness of a substance. The density of rocks and soil can vary considerably. A light soil may have a density of 1.5 grams per cubic centimetre (g/cc), whereas a solid heavy rock may have a density of 3 g/cc.

Dieback

The range, distribution and vigour of plant species can vary significantly on a seasonal basis. In periods of low rainfall, plants will naturally 'dieback'.

Differential global positioning system (DGPS)

A non-differential GPS (Global Positioning System) is a system that uses radio signals from satellites to show your exact position on the earth on a special piece of equipment. A differential system takes this information and compares it with results from another GPS system in a known location. By adjusting the results from a mobile GPS to remove the effects of local variations a much more accurate location can be obtained. The best systems are only a few centimetres away from the actual position though commonly available DGPS systems are exact to around 1 metre.

Differential GPS unit

A GPS with a link (usually by radio or microwave) to a fixed GPS base station is referred to as a Differential GPS (DGPS).

Digital mapping

Survey instruments collect information systematically across an area (instead of drawing a map by hand) and digital maps of this information can be plotted.

Electrical conductivity

See entry for *conductivity*. The degree to which a given material allows the movement of electricity.

Electrodes

Electrodes are used to transmit or detect electric current in a given material.

Electrokinetic surveying (EKS)

EKS is a recently developed method for measuring ground permeability. It detects small currents that are set off in water filled ground when the ground is vibrated (by a hammer or explosives).

Electromagnetic

Electromagnetic (EM) systems measure the conductivity of the ground. The measurements are taken by an instrument at the surface and give an indication of conductivity below the surface.

Electromagnetic conductivity

Conductivity as measured by EM systems is not the true conductivity of the ground at depth, but represents an average of conductivity at the sample point.

Electromagnetic methods

There are many varieties of electromagnetic equipment available. Some are designed for measuring conductivity hundreds of metres below the surface whereas others concentrate in the top few metres. Currently Monash University is producing a very effective shallow penetration system suitable for grave site investigation.

\GLOSSARY

Excavation

To unearth or 'dig out' (buried objects) methodically in an attempt to discover information about the past. This can be done either mechanically or by using hand tools. It is an intrusive technique, as it involves disturbance to the ground surface and the removal of the underlying soil structure and the objects it may contain.

Feasibility study

See *orientation survey*.

Forensic

Forensic science is the study of evidence at crime scenes, utilising a wide range of methods from many fields of research.

Geophysical signatures

A geophysicist will expect to see a particular pattern (usually on a computer printout or plot) using a geophysical technique in a certain location. This expected pattern is called the geophysical signature of the feature/location.

Geophysics

Geophysics predicts the structure of the subsurface using data which can be measured at the surface.

GM survey

Ground magnetic survey. See *Magnetic survey*.

Grave marker

Any form of marker used to mark or commemorate a grave, including stone slabs, headstones, fences, crosses or other materials, such as gravel, broken glass, and plants.

Gravity measurements

Gravity surveys show variations in the density of materials under the ground. These variations can be due to different rock types, variations in soil thickness or the presence of underground caves or due to buried tanks, soil disturbance or ground fill.

Magnetic surveys

Magnetic surveys are used to measure local variations in the natural magnetic field of the earth.

Ground magnetics

See *magnetic surveys*. Ground magnetic surveys are those taken by collecting data on the surface.

Ground Penetrating Radar

Ground Penetrating Radar (GPR). See *radio waves* and *radio pulse*.

Ground permeability

Ground permeability refers to the ease with which water flows through the ground.

Hyperbola

A hyperbola is a rounded V shaped mathematical curve. GPR systems generate hyperbolae where the radar signal meets an object of different dielectric character.

Initial site assessment

See *orientation survey*. In many cases a geophysicist checks the area where the survey will be undertaken to check for features (such as surface water, buildings, electric fences, sand dunes or land fill) that may be problematic for a particular technique.

Magnetic field

The earth acts as a giant magnet, generating a huge magnetic field flowing from one pole to the other.

Magnetic response

The measured strength and/or direction of the magnetic field at a point is sometimes called the magnetic response. The measured magnetic response of an object becomes weaker with distance.

Magnetic susceptibility

The earth's magnetic field flows through all materials. When objects that contain iron or iron oxide act as magnets in a magnetic field, this is called magnetic susceptibility.

Magnetometer

An instrument for measuring the intensity of magnetic forces.

Orientation survey

A geophysicist usually undertakes an orientation survey on-site that allows him to decide what the most appropriate geophysical method is for the given location and its specific characteristics.

Profile

A line of measurements taken as points along the ground are referred to as a 'profile' or 'traverse'. With most methods it is easier and more effective to collect data at points along a line rather than collecting information randomly.

\GLOSSARY

Radio pulse

GPR (ground penetrating radar) systems generate radio waves like a normal radio transmitter, though in specific frequencies. Penetrating depth and the size of objects detected is related to the frequency used. The term *radio pulse* relates to seismic methods which require a burst or pulse of vibration energy. A GPR detects radio signals as they are reflected from objects in the ground.

Radio waves

The GPR system emits a signal at a specific frequency (or wavelength) in the radio part of the spectrum.

Radiometric techniques

Radiometric methods detect the presence of elements which have naturally occurring radioactive isotopes (Potassium, Uranium and Thorium).

Remote sensing

Geophysical methods detect responses from materials at a distance. Remote sensing generally refers to data collected from satellites rather than other geophysical methods.

Repatriation

The act of returning the remains of a person to their place of origin or home. This may be undertaken at the request of relatives where a burial has occurred in a distant or inappropriate location or where a person's remains have been placed in a museum collection.

Resistivity

Unlike EM systems which measure the conductivity of the ground, resistivity systems measure the opposite characteristic, the electrical resistance.

Satellite navigation

GPS systems use satellites to determine location. They can also be used to navigate between two locations.

Seismic methods

Seismology is the branch of geology concerned with the study of earthquakes. Seismic methods rely on tracing vibrations in the ground. The ground is hit with a hammer, a shotgun blast or an explosive charge. This generates a vibration pulse that travels away from the source. When this pulse encounters a hard object, some of the vibration reflects back or is deflected and this will be detected by a receiver.

Self potential method

The self potential or spontaneous potential (SP) method relies on measuring naturally occurring electric currents in the ground. Generally SP works best at locating larger disturbances than grave sites since a small hole is unlikely to have much impact on overall ground currents.

Simulated grave

Refers to a computer generated model featuring the natural geophysical properties of the ground in a particular location and simulating the alterations to these caused by a subsurface feature, such as a grave, for comparison with actual field results.

Soil density

See *Density*.

Three–dimensional images

Computers can generate complex pictures of elevation data to allow us to view the information as if we were looking from any point in space.

Topographic image

Topographic images are like 3D images but are seen from above with a shading to make it look as if the sun is illuminating the topography from one side.

Topographic survey

A survey recording relative heights across a land surface, defining the scale and extent of slopes, mounds and depressions. This will result in a contour plan or topographic image.

Volt meter

A volt meter is a simple device for measuring voltage (electric potential). Any one who works with electrical circuits has them. Geophysicists use them for SP (see self potential method above) surveys.

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