SECTION 5

FIELD PROCEDURE

5-1 Introduction

This section gives practical instructions on how to perform area or line surveys using the RM4 with different probe configurations. You should read Section 4, which gives details on how to operate the RM4, before reading this section. The order in which the sub-sections are described below is a good guide to the recommended sequence of field procedures that you should adopt.

5-2 Safety Precautions

WARNING

Handle the pointed ends of all probes with great care, so as to avoid injury. In particular ensure that yours and other peoples feet are well clear when inserting probes into the ground. All personnel should wear suitable, stout, protective footwear when the equipment is in use. Handle the probes with care even when storing or handling the equipment away from the surveying area. Always keep the protective sleeves in place over the sharp end of the probes when they are not in use.

5-3 Planning a Survey

1 Area or Line survey

Surveys may consist of either an Area Survey, the most usual choice, or a Line Survey.

In an Area Survey the site is partitioned into a number of grids, typically 20m by 20m, which are in turn subdivided into a mesh of smaller squares, typically 1m by 1m, figure 5-1. An instrument reading is taken at the centre of each small square, giving a detailed and systematic coverage of a site. This approach is useful if it is not known in advance what features to expect, or if indeed known features are intentionally to be investigated more thoroughly.

Sometimes it is not necessary for all the detail given by an Area Survey. For example it may be that only the course of a major feature such as the ditch of an enclosure, or dyke system is required. In such cases a series of parallel traverses, separated by 2-5m with readings taken at typically 1m intervals and perpendicular to the supposed line of the feature, will generally give the information required, figure 5-1.

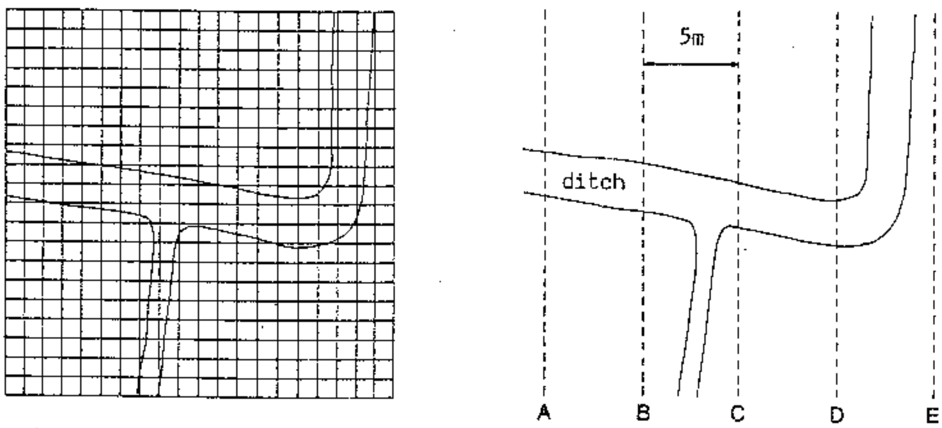


Figure 5-1. Area and Line surveys over an enclosure ditch.

Note, however, that features running parallel with the traverse lines, such as the traverse junction in the enclosure ditch, figure 5-1, may well be missed if too wide a line traverse is selected. Also the results may be open to mis-interpretation- the apparent petering out of the ditch in traverse E is in fact due to a change in direction and not its disappearance. It may well be prudent, therefore, to also do a series of traverses perpendicular to the original traverse lines so as not to miss much features.

It is recommended that an area survey be done wherever possible in preference to a line survey. The detailed information will allow a more reliable interpretion to be made and will highlight weak anomalies that would otherwise be missed with a line survey.

2 Traverse Pattern

In an area survey the ground is covered by a sequence of traverse adjacent to one another. The traverses may be either in the same direction all the time, refered to as Parallel traverses, or may reverse direction for each new traverse, referred to as Zig-Zag traverses, figures 5-2 and 5-3.

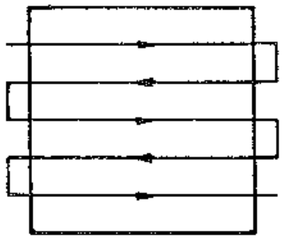


Figure 5-2. Zig-zag traverses.

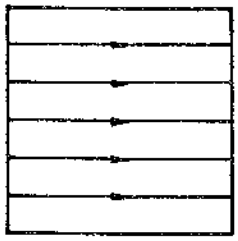


Figure 5-3. Parallel traverses.

The most usual choice of traverse method is zig-zag surveying. Zig-zag traverses eliminate the return walk back to the beginning of the next traverse and are thus more efficient than parallel surveys. Of course the probe configuration in use must not be direction dependant, otherwise a striping effect may occur, though generally most probe configurations can be used in the zig-zag mode.

An exception to this rule can sometimes occur when the Twin array is being used on sites where only very small changes in background resistance are observed. The Twin is usually thought of as being orientation independant, providing the remote probes are kept at a distance of greater than 30 times the mobile probe spacing - see section 5-6. However, in practice, there is a very small change in background reading that is dependant on the alignment of the mobile and remote probes, even at this separation. On most sites this is not noticable since the anomalies and background changes in resistance are much greater. However, on sites where only small changes in the background resistance are observed this orientation dependance becomes more apparent. In these cases, better quality data will be obtained with parallel traverses. Usually, however, good quality data will be obtained using zig-zag surveying so this is the default choice.

3 Grid size

Typical grid sizes are 10m, 20m or 30m square grids. The 20m grid is a commonly used and relatively efficient size. Whilst grids of 30m may be more efficient, requiring fewer movements of the survey guidelines over a given area (see below), 30m grids can be difficult to fit conveniently into some sites. Grids of 10m are not recommended since they involve many more grid corner pegs to be set up and much more movement of the survey guidelines. The grid can be aligned in any direction to fit in best with any boundaries or physical constrictions. Appendix F gives the diagonal dimensions of various grid sizes as an aid to defining grid right angles.

4 Sample and Traverse Interval

The choice of sample and traverse interval is a compromise between resolution and speed of operation. The terms sample interval and traverse interval are defined in figure 5-4. For many applications a sample and traverse interval of 1m is acceptable figure 5-5 (a). If more resolution is required then a 0.5m sample and traverse interval may be adopted, figure 5-5 (b), but at the expense of a quadrupling of survey time. A typical situation where this might arise would be in a search for pits 1m in diameter. A 1m sample

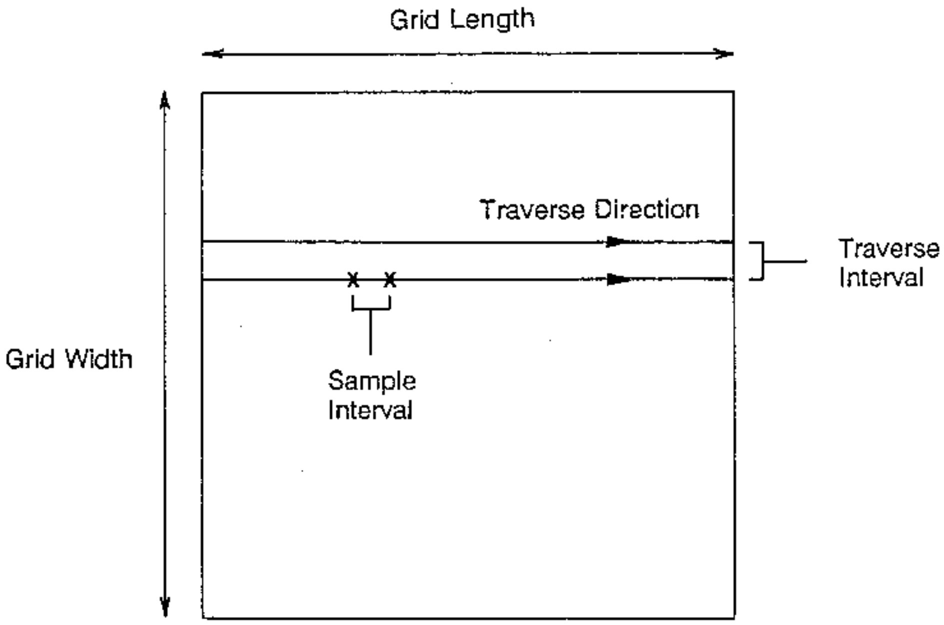


Figure 5-4. Definition of grid length, grid width, traverse interval and sample interval.

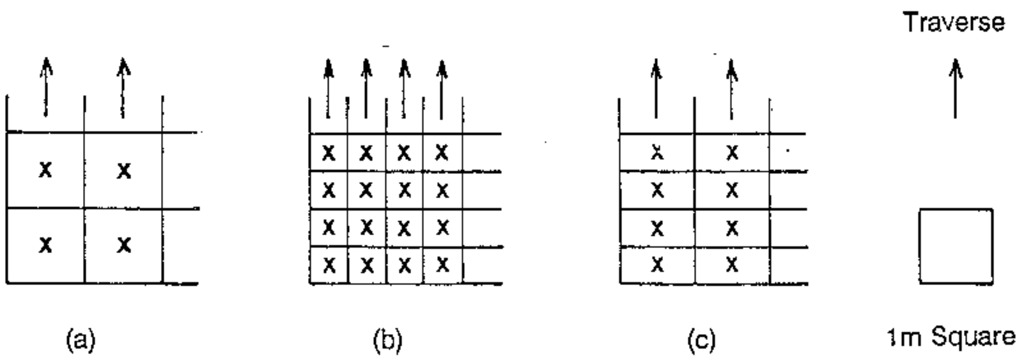


Figure 5-5. Possible data sampling patterns.

and traverse interval survey would only produce one reading directly over the pit. A 0.5m sample and traverse interval survey, on the other hand, would produce four readings over the pit allowing much greater confidence in the interpretation.

A compromise between good resolution and fast survey time is to use a traverse interval of 1m but sample interval of 0.5m, figure 5-5 (c). Clearly this process is orientation sensitive so should be used with care if looking for narrow features. It does however give more information on the profiles of features that are crossed at right angles.

A further factor to consider is that it may be desirable to survey an area greater than that occupied by the archaeological structure. This can assist greatly in the interpretation of a site where it is anticipated that complicating factors such as geology terrain, field drains, ridge and furrow etc. will also produce a response, usually fairly extensive. Indeed, once a survey is started it often becomes apparent that the archaeology also extends further than at first anticipated. Clearly the balance between resolution and time available to survey the larger area must be carefully considered before embarking on too detailed a survey.

5 Changing Grid Size, Sample and Traverse Interval

It is a good idea to never change grid size or sample or traverse interval during a survey. If you do have a site survey with mixed grid sizes, sample or traverse intervals, this will be much more complicated to manipulate when it comes to processing the data than if you stick to one standard size. Before starting the survey consider carefully if you really do need different sizes or whether you can use just one standard size. For example you may wish to complete a complex survey pattern with a few 10m grids, whilst the majority of the survey has already been done with 20m grids. It would be much more efficient from a processing point of view to stay with 20m grids and record unsurveyed parts with dummy readings - see section 5-11 for further details.

5-4 Use of Survey Guide Lines

An efficient way of doing an area survey with the Twin array (PA1 or PA5), or many other arrays configured using a PA5, is to use a set of three tapes marked at appropriate intervals - two parallel lines which are fixed and one which is moved perpendicular to the other two, shown in figure 5-6 for a 0.5m Twin array and a 10m grid. The central perpendicular line is used as a guide for either zig-zag or parallel traverses.

The first line of readings is made by traversing along one side of the perpendicular line, with the array itself positioned at a right angle to the perpendicular line. The direction of the traverse must be compatible with the software you are using - for example program GEOPLOT requires that the first traverse be in a clockwise direction, though the start position may be in any corner of the grid. For a 1m sample and traverse interval, the centre of the array is positioned adjacent to the the central perpendicular tape, at a distance of 0.5m from the 0.5m mark on the tape for a 1m mesh, so that the centre of the array coincides with the centre of each 1m cell, figure 5-7 (a). The second traverse is carried out on the other side of the line, either back down the line towards the start point (zig-zag) or in the same direction as the first traverse (parallel). The perpendicular line is then moved on two line intervals, to the 3m mark, for the next two traverses and so on (5m, 7m, and 9m marks) until the whole grid is completed.

For a 0.5m sample and traverse interval, the centre of the array is positioned at a distance of 0.75m from the 0.25m mark on the tape, so that the centre of the array coincides with the centre of each 0.5m cell, figure 5-7 (b). The second traverse is also carried out on this side of the line, either back down the line towards the start point (zig-zag) or in the same direction as the first traverse (parallel). The third and fourth traverses are carried out on the otherside of the perpendicular line. The survey guide lines may be made from nylon rope, marked with heat-shrink sleeving or bands of adhesive tape, and with loops at each end so that the line may be fixed in position. The colour coding used on the Geoscan Research guide lines, for 0.5m and 1m intervals, is detailed in Appendix F (these lines are no longer available).

A suggested way of using and moving the survey guide lines is to break the site into a number of strips. Orientate the two outer parallel lines so that they lie along the length of the strip. They can then be 'flipped' over for each successive grid and the perpendicular line moved progressively down the strip one traverse at a time, figure 5-8.

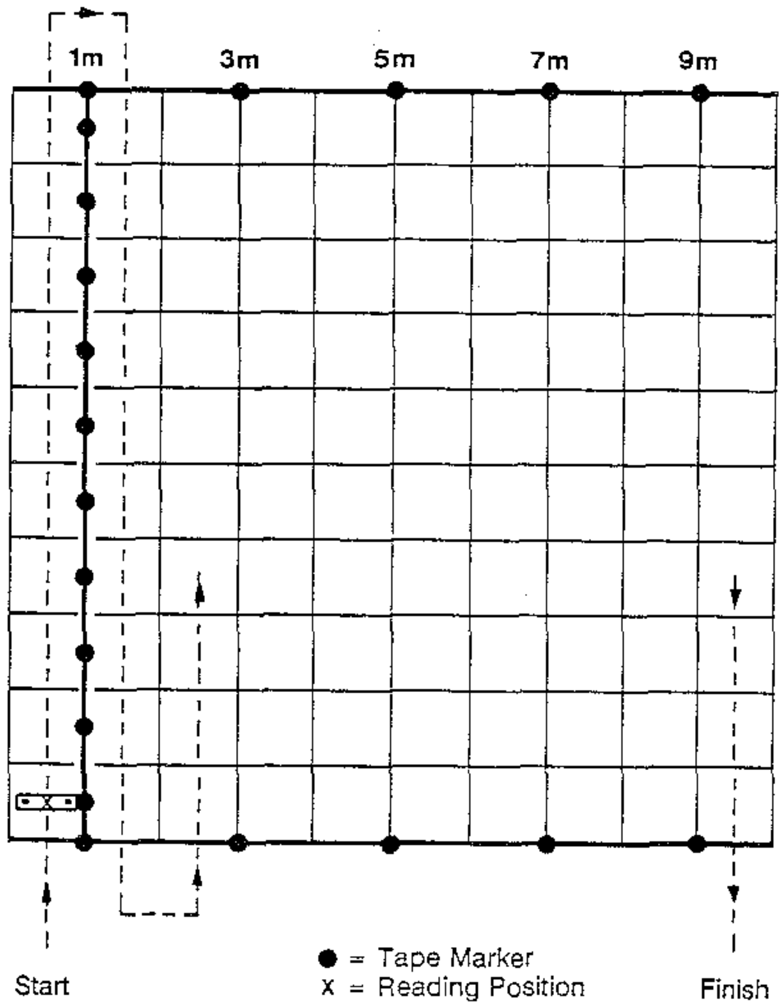
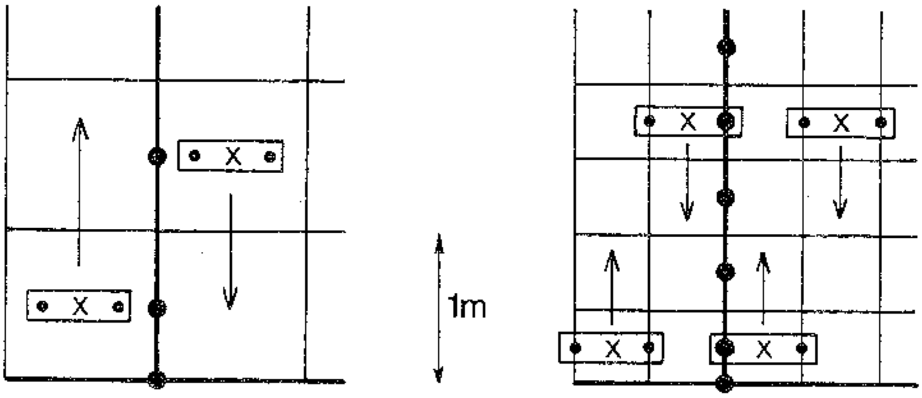


Figure 5-6. Use of survey guide lines for the Twin array and a 10m grid.



(a) 1 m sample and traverse interval (b) 0.5 m sample and traverse interval

Figure 5-7. Positioning of Twin array when using survey guide lines and zig-zag surveying.

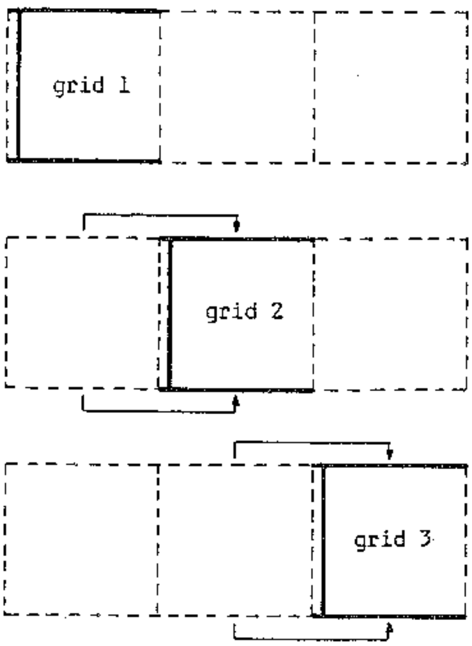


Figure 5-8. Movement of survey guide lines (and measurement tapes, section 5-5).

5-5 Use of Measurement Tapes

Survey guide lines are not directly suitable for use with arrays configured using the PA3 (configurations such as Wenner, Double-Dipole) since these arrays require very accurate placement of the probes with respect to probe separation, and the guidelines may stretch slightly - see Section 5-9(2). It is far better to use a conventional measurement tape for the central perpendicular line, though the survey guide line outer parallel pair could be used. Figure 5-9 shows a conventional measurement tape being used to set the first two measurement positions for a Wenner array. Note that if you use the PA5 configured as a 0.5m Wenner or Double-Dipole array then you CAN use survey guide-lines and there is no need to use measurement tapes.

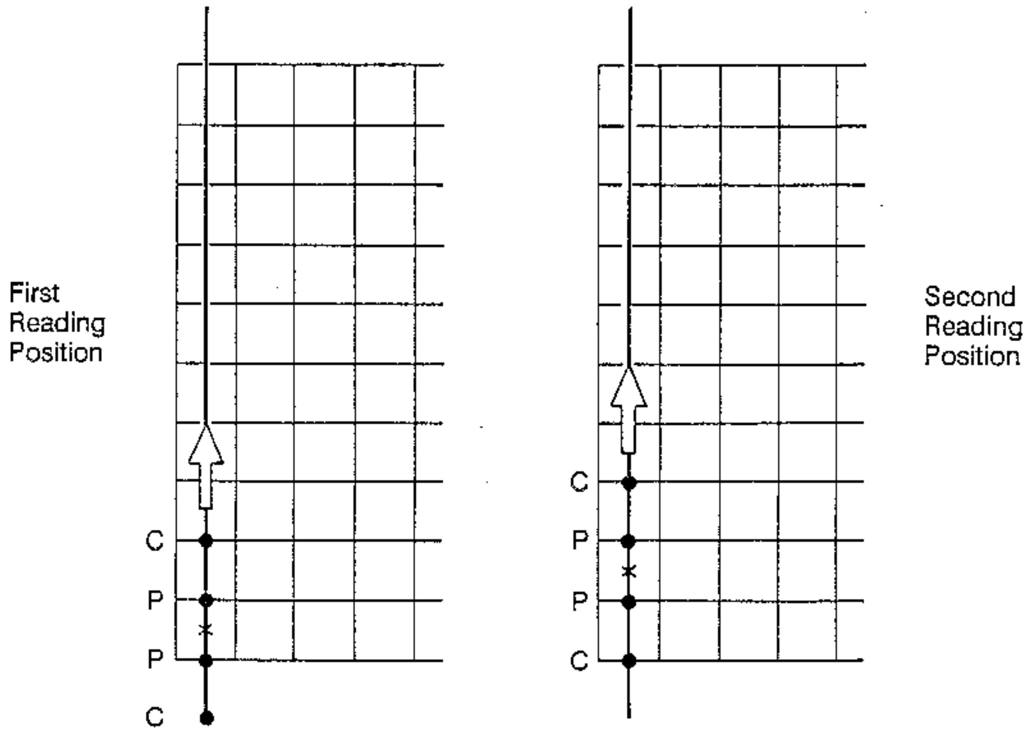


Figure 5-9. Use of a measurement tape with a Wenner array and 10m grid.

Area surveys may be carried out for the Wenner and Double-Dipole array in much the same way as for a Twin array, using zig-zag or parallel traverses. As with using survey guide lines, the direction of the first traverse must be compatible with the software you are using - for example GEOPLOT requires that the first traverse be in a clockwise direction, though the start position may be in any corner of the grid. If soil conditions are good, the holes made by the probes may be re-used by the following probes as they are stepped along.

5-6 Area surveying with a 0.5m Twin array (PA1 + PA5)

1 Introduction

Section 5-6 describes how to do an area survey with Twin arrays, mobile probe separation 0.5m. These may be configured using either the PA1 probe array (0.5m only) or by using just the centre section of the PA5 probe array. It covers all aspects of the procedure except for dealing with obstacles or areas of grids which are not to be surveyed - see section 5-11 for details concerning this. Figure 5-10 shows a 0.5m Twin array set up for area surveying. Before reading the following text, follow the instructions of section 2-3(1) or 2-4(2) and 2-4(3) for assembling the RM4 and PA1 or PA5 probe arrays for field use. It is most convenient to use survey guide lines to position the array, section 5-4.

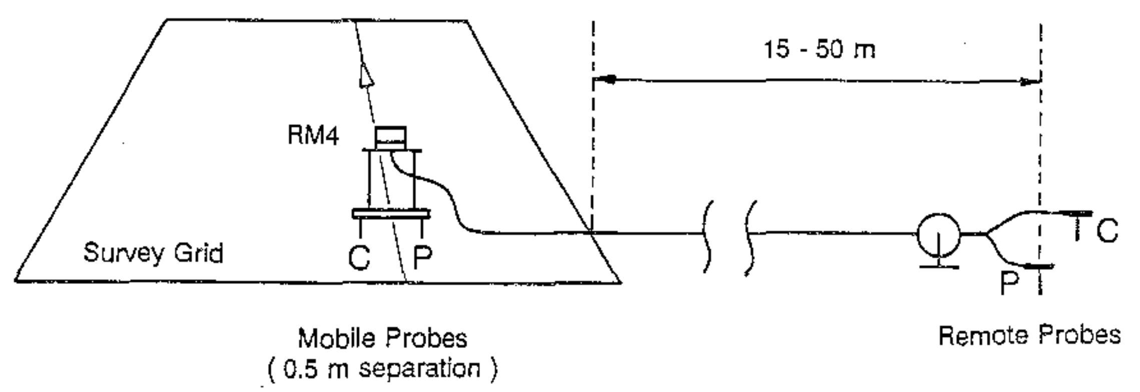


Figure 5-10. Probe Array PA1 or PA5 set out for a Twin Electrode survey.

2 Positioning the remote probes

The pair of remote probes should be positioned well away from the survey area and left fixed in position for each grid. Make sure that the cable drum is emptied completely, since the inductance of the coiled cable left on the drum could cause errors in the readings. The standard recommendation is that the remote probes must be distanced at least 30 times the spacing of the mobile probes away from the survey area, that is, at least 15m for a 0.5m Twin array. This distance ensures that the background resistance reading is essentially independant of the location of the mobile probes. If the separation is less than 15m then the background resistance will be found to vary significantly with the separation.

An easy to remember procedure for positioning the remote probes is to triangulate two 20m lines from the two corners of a 20m square and place the remote probes at their inter-section. This position will allow up to three complete 20m squares to be surveyed without moving the remote probes. If possible, insert the remote probes in ground which is not suspected of overlying archaeological features. The effect of these features will not then be superimposed on the background resistance, which makes the repositioning of the remote probes, when it is required, much faster to accomplish - see section 5-6(5).

If surveying on urban sites where the reading does not remain steady, due to severe interference from mains power earth currents, it may be possible to reduce these effects by trying different locations for the remote probes, since the interference will be most severe when the probes are directly over buried cables.

3 Remote probe separation

The background resistance reading will be found to vary markedly with the remote probe separation, but providing the probes are left fixed (or repositioned using the procedure described in section 5-6(5)) then this will have no effect on the survey, since one is looking only for changes on the background level as the mobile probes are moved. Set the remote probe spacing so that 100 % changes in the resulting background level can still be accomodated without the reading going over-range - you should **NEVER** change the range setting during a Twin electrode survey - see 5-6(8). The spacing between the remote probes is not critical and can be between 0.25m and 2m for example. A spacing of 1m is a good starting point and is sufficiently wide to make fine adjustments easily to the spacing when the remote probes have to be repositioned.

4 Remote probe insertion depth

Insertion depth for the remote probes is not crtical, since the RM4 can tolerate reasonable contact resistances without producing significant errors. However, an offset in background resistance can arise due to remote probe contact resistance and capacitive coupling of the 50m cable. This offset is normally not important for a Twin survey since one is looking only for changes in an arbitrary background level as the mobile probes are moved around. However, if remote probe contact resistance changes, eg due to a downpour of rain, then the offset and background resistance may change. Therefore, it is a good idea to keep this offset to a low level as a matter of course by inserting the remote probes as deep into the ground as possible. In very dry conditions, it is also strongly advised that the remote probes are watered-in to lower the contact resistance, wherever possible. After doing this try to cover the probes with plastic sheeting to reduce evaporation which may lead again to a change in background resistance.

5 Repositioning the remote probes

The remote probes will usually have to be repositioned during the course of a survey, because the cable length is insufficient to reach the new survey area. In order to maintain continuity of background resistance reading, the following procedure should be adopted. With the mobile frame positioned in the old survey area and the remote probes still in position, take note of the reading. Now move the remote probes to their new location, leaving the mobile probes still in position in the old survey area. Insert the remote probes at roughly the same separation as before and take note of the reading. By making slight adjustments to the remote probe separation, it will be possible to obtain exactly the same reading as before. Obtaining a consistent background reading and continuity of readings between adjacent grids, makes later processing and presentation of the data much easier. Note that merely reinserting the remote probes in a new location at exactly the same spacing as before is unlikely to produce the same reading, since localised soil resistivity conditions will be different.

6 Positioning the mobile probes

The mobile probes are inserted in the ground so that the centre of the mobile frame (the centre of the cross-beam) lies over the centre of the 1m or 0.5m cell. It is not neccessary for the probes to be accurately positioned or orientated - aim to be within +/-15 cm of the centre for a 0.5m Twin in a 1m cell, and within +/-7.5 cm of the centre for a 0.5m cell, though distances greater than this will generally not have a significant effect. This freedom of probe placement makes the Twin Electrode array fast and easy to use, so do not negate this advantage by trying to be too precise in placing the probes. If there is a stone in the way, rather than recording a DUMMY reading consider inserting the probes to one side if displacement from the centre is not too great.

7 Mobile probe insertion depth

Insertion depth for the mobile probes is not at all critical, since the RM4 can tolerate high contact resistances without producing significant errors. When the soil is reasonably moist it is usually sufficient to just use the downward momentum of the mobile frame and RM4 to push the probes into the ground - a depth of 3 to 5 cm, for example, will probably be all that is needed to produce a low contact resistance. In such situations there is no advantage in pushing the probes further into the ground - indeed, this may needlessly slow the survey down.

Even in dry conditions, it may still not be neccessary to push the probes in deeply to get consistent readings. However, if conditions are very dry, and the soil surface has dried out completely, then you may well need to insert the probes more deeply to overcome the high contact reistances at the surface. When pushing the mobile probes in deep, always apply presure to the centre of the cross beam - do **NOT** apply pressure by putting your foot on each probe in turn, since you will almost certainly bend, and may even break, the probes and their water-proof seal. (If you are using an external data logger then try to insert the potential probe fractionally before the current probe since this will aid settling of the reading before an auto-log cycle starts).

If the topsoil is a thin layer over bedrock then you may observe significant changes in the reading with increasing probe insertion depth - this is due to a rapidly changing current path geometry, not contact resistance errors. In this situation it is best to just touch the surface of the ground, or insert just sufficiently to get a reading. The current path geometry is then more likely to be the same for each reading.

8 Instrument settings

The recommended instrument settings are Filter = Rural and range 2000 ohms. In the majority of cases the normal 1 mA range should be selected, but if extremely dry conditions prevail, then the resulting high contact resistances may require the HCR mode to be used to obtain readings, though the instrument signal to noise ratio will not be as good as for the normal 1 mA range.

The Range should be selected so that changes of about 1% in the background resistance can be observed. For many sites background resistance will be greater than 100 ohms so that choosing the 2000 ohm range (which results in a resolution of 1 ohm with a current of 1 mA) will enable changes of at least 1% to be observed. If background resistance is lower than 100 ohms or "soil noise" is very low, then the 200.0 ohm range should be selected to give a resolution of 0.1 ohm with a current of 1 mA. This will give a resolution of 0.1% at 100 ohm down to 1% at 10 ohms. Background resistances below 10 ohms are rare with the Twin array, but if encountered then the 20.00 ohm range may be used. However, avoid using the 20.00 ohm range with the Twin unneccessarily, since measurement errors arising when contact resistance is high will be more appreciable than with the other range settings. On the 200.0 ohm and 20.00 ohm ranges you may need to set the Filter switch to the Urban setting to reduce interference effects, but this will double the reading settling time.

You should **NEVER** change ranges during a Twin electrode survey of a grid. This is because the combination of remote probe contact resistance and 50m cable capacitance and inductance produces an offset in the background resistance. This offset is normally not important for a Twin survey since one is looking only for changes in an arbitrary background level as the mobile probes are moved around. However, the offset, which may have a value between 0 and 100 ohms, depending on the remote probe contact resistance, and will change with range setting - this would result in a step change in the background resistance. See section 5-6 (3) on remote probe separation for advice on avoiding a change of gain or current range. If occasional over-range readings are unavoidable these should be recorded as Over-range.

9 Survey procedure

WARNING

Handle the pointed ends of all probes with great care, so as to avoid injury. In particular ensure that yours and other peoples feet are well clear when inserting probes into the ground. All personnel should wear suitable, stout, protective foortwear when the equipment is in use. Handle the probes with care even when storing or handling the equipment away from the surveying area. Always keep the protective sleeves in place over the sharp end of the probes when they are not in use.

1 Record essential details of the site as listed on the survey sheets of Appendix F, either on the sheets themselves, or if manually inputting data to GEOPLOT software, on the Input Template form. This will be of particular use when it comes to presenting and interpreting the survey at a later date. Note the location of obvious physical features and where adjacent objects, such as trees, are located since they may have an effect on the readings.

2 Lay out the survey guide lines, section 5-4, and position the RM4 and mobile probes at the start of the grid, figure 5-6, - remember that the first traverse must be in the correct direction for the computer software - GEOPLOT requires a clockwise traverse. Try to arrange for the first traverse to be nearest the remote probes - this will avoid subsequent tangling of the cable with the mobile frame since you will then be working away from the remote probes.

3 Switch on, check that the RM4 range, filter and HCR mode are set correctly.

4 Record the first reading on a survey sheet similar to that shown in Appendix F. Move the probes on to the next position and record the new reading. This procedure is followed until the end of the traverse.

5 Reposition the probes at the start of the next line. The new start position obviously depends on whether parallel or zig-zag surveying is being used. Record the first reading of the next line and continue as previously.

6 Continue to survey the grid in the same manner until the last line of the grid is complete. Fill in any unsurveyed parts of a grid with dummy readings.

7 Survey additional grids in the same way, relocating the remote probes if neccessary.

5-7 Area surveying with 0.25m to 2m Twin arrays (PA5)

1 Introduction

Section 5-7 describes how to do an area survey with a 0.25m to 2m Twin array, configured using the PA5 probe kit. Before reading the following text, follow the instructions of sections 2-4(2) and 2-4(3) for assembling the RM4 and PA5 probe array for field use.

The general approach to surveying with Twin arrays larger than the standard 0.5m are very similar to that just described in the previous section 5-6, but differences are apparent when you consider the positioning of the remote probes and instrument settings. These differences are described next - for guidance on other aspects please refer to the previous section.

2 Positioning the remote probes

As mobile probe spacing increases so the distance to the remote probes must also increase. This is to ensure that the background resistance reading stays essentially independant of the location of the mobile probes, as they are moved around within the survey grid. Using the standard recommendation that this distance be at least 30 times the mobile separation, the remote probes should ideally be positioned at least 30m away for 1m mobile separation, 45m away for 1.5m mobile separation and 60m away for 2m mobile separation. Whilst it is possible to achieve this distance for a mobile separation of 1m, extra cable length is ideally required for greater mobile probe separations.

In practice you may find that using the standard cable length fully extended will give a sufficently level background resistance for mobile spacings of up to 1.5m on many sites, though the possibility remains that you may experience problems making a good match between adjacent grids. To be on the safe side the cable length should be extended beyond the standard 50m. It is strongly recommended that this is done by replacing the two 2m cables that connect the remote probes to the cable drum by two 25m cables. It is **NOT** recommended that you increase the length of the 50m cable by adding more twin core cable since this will increase cable capacitance and may lead to larger contact resistance offsets being generated in dry conditions - see 5-6(4) and 5-6(8).

It is likely that you will have to reposition the remote probes more often if working at the limit of the standard cable length. Extending the remote probe distance with the two 25m cables may help reduce this problem, depending on the mobile probe separation being used.

3 Instrument settings

Most of the recommended settings and associated limitations are very similar to those already described earlier in section 5-6(8) for the 0.5m Twin. However, there will be differences concerning the range setting. As mobile probe separation increases, so the background resistance reduces, roughly in direct proportion. Therefore you will almost certainly need to set the RM4 to the 200.0 ohm range in order to be able to resolve to 0.1 ohms. If background resistance is exceptionally low and mobile probe spacing is wide then you may need to increase resolution even further to 0.01 ohms, by using the 20.00 ohm range. Again you may need to set the Filter switch to the Urban setting to reduce interference effects.

5-8 Area surveying with 0.5m Wenner, Double-Dipole arrays (PA5)

1 Introduction

Section 5-8 describes how to do an area survey with a Wenner or Double-Dipole array, configured using the PA5 probe kit. It covers all aspects of the procedure except for dealing with obstacles or areas of grids which are not to be surveyed - see section 5-11 for details concerning this. Figure 5-11 shows a four-probe array set up for area surveying. Before reading the following text, follow the instructions of sections 2-4(2) and 2-4(5) for assembling the RM4 and PA5 Probe Array for field use.

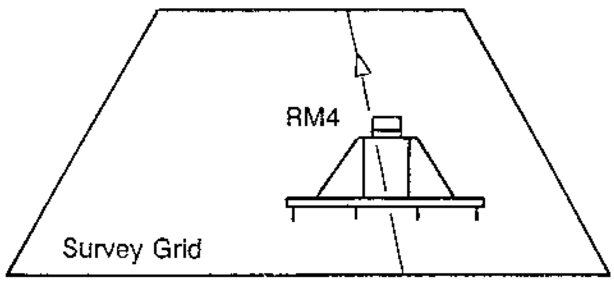


Figure 5-11. Probe Array PA5 configured for a Wenner or Double-Dipole survey.

The PA5 probe array may be configured as a 0.5m Wenner or Double Dipole array, figure 5-11. All four probes are moved together along the traverse line for each reading. The response centre for both Wenner and Double Dipole lies at the centre of the array. It is most convenient to use survey guide lines to position the array, section 5-4.

2 Positioning the PA5 probes

The PA5 probes are inserted in the ground so that the centre of the frame (the centre of the cross-beam) lies over the centre of the 1m or 0.5m cell, and the frame itself is positioned at a right angle to the perpendicular tape. It is not neccessary for the probes to be accurately positioned - aim to be within +/-15 cm of the centre in a 1m cell, and within +/-7.5 cm of the centre for a 0.5m cell, though distances greater than this will generally not have a significant effect. However, you should always try to maintain the same orientation with respect to the traverse direction, since the Wenner and Double-Dipole arrays can give an orientation dependant response over some targets. If there is a stone in the way, rather than recording a DUMMY reading consider inserting the probes to one side if displacement from the centre is not too great.

3 Probe insertion depth

Unlike the Twin array, the reading may vary with insertion depth of the probe, especially on sites with shallow, but variable overburden depth. This is due to a change in the current path geometry, not instrumentation errors. This effect can be reduced by always inserting the probes to the same, shallow depth. When the soil is reasonably moist it is usually sufficient to just use the downward momentum of the PA5 frame and RM4 to push the probes into the ground, typically a depth of 3 to 5 cm. On rough terrain you may have to increase the depth slightly to ensure good contact for all probes at the same time. Likewise, if conditions are very dry then consider increasing the insertion depth to reduce high contact resistance errors. Alternatively, try using the HCR mode - see the next section 5-8(4) for more details. As a very last resort, consider watering in the probes, though this will slow down a survey considerably and you may still observe a variability in the reading. Large variations in resistance reading for repeated runs over a sample traverse will indicate if there are likely to be problems occuring due to terrain or soil conditions.

4 Instrument settings

The recommended instrument settings are Filter = Rural and range either 2000 ohms or 200.0 ohms. In the majority of cases the normal 1 mA range should be selected, but if extremely dry conditions prevail, then the resulting high contact resistances may require the HCR mode to be used to obtain readings, though the instrument signal to noise ratio will not be as good as for the normal 1 mA range.

The Range should be selected so that changes of about 1% in the background resistance can be observed. When using the 0.5m Wenner array on many sites the background resistance will be greater than 100 ohms so that choosing the 2000 ohm range (which results in a resolution of 1 ohm with a current of 1 mA) will enable changes of at least 1% to be observed. If background resistance is lower than 100 ohms or "soil noise" is very low, then the 200.0 ohm range should be selected to give a resolution of 0.1 ohm with a current of 1 mA. This will give a resolution of 0.1% at 100 ohm down to 1% at 10 ohms. When using the 0.5m Double-Dipole array on many sites the background resistance will be less than 100 ohms so the 200.0 ohm range should be selected to give a resolution of 0.1 ohm with a current of 1 mA. This will give a resolution of 0.1% at 100 ohm down to 1% at 10 ohms. If background resistance is exceptionally low then you may need to increase resolution even further to 0.01 ohms, by using the 20.00 ohm range. You may need to use the HCR mode to help reduce contact resistance problems, especially since you now need to insert 4 probes at the same time, as opposed to the 2 probes of a Twin array.

If you are surveying in an urban situation with the 200.0 ohm or 20.00 ohm range then you may find that the reading flickers, as a result of interference by underground mains power earth currents (this may also be observed in some rural situations). If this is the case you may need to set the Filter switch to its Urban setting.

You should in general try to avoid changing the resistance range during the survey of a grid. If it becomes neccessary, because the reading is over-range, then, unlike the situation for the Twin, this is acceptable.

5 Survey procedure

WARNING

Handle the pointed ends of all probes with great care, so as to avoid injury. In particular ensure that yours and other peoples feet are well clear when inserting probes into the ground. All personnel should wear suitable, stout, protective footwear when the equipment is in use. Handle the probes with care even when storing or handling the equipment away from the surveying area. Always keep the protective sleeves in place over the sharp end of the probes when they are not in use.

1 Record essential details of the site as listed on the survey sheets of Appendix F, either on the sheets themselves, or if manually inputting data to GEOPLOT software, on the Input Template form. This will be of particular use when it comes to presenting and interpreting the survey at a later date. Note the location of obvious physical features and where adjacent objects, such as trees, are located since they may have an effect on the readings.

2 Lay out the survey guide lines, section 5-4, and position the RM4 and mobile probes at the start of the grid, figure 5-6, - remember that the first traverse must be in the correct direction for the computer software - GEOPLOT requires a clockwise traverse.

3 Switch on, check that the RM4 range, filter and HCR mode are set correctly.

4 Record the first reading on a survey sheet similar to that shown in Appendix F. Move the probes on to the next position and record the new reading. This procedure is followed until the end of the traverse.

5 Reposition the probes at the start of the next line. The new start position obviously depends on whether parallel or zig-zag surveying is being used. Record the first reading of the next line and continue as previously.

6 Continue to survey the grid in the same manner until the last line of the grid is complete. Fill in any unsurveyed parts of a grid with dummy readings.

7 Survey additional grids in the same way.

5-9 Area surveying with Wenner and Double-Dipole arrays (PA3)

1 Introduction

Section 5-7 describes how to do an area survey with a Wenner or Double-Dipole array, configured using the PA3 probe kit. It covers all aspects of the procedure except for dealing with obstacles or areas of grids which are not to be surveyed - see section 5-11 for details concerning this. Figure 5-12 shows a four-probe array set up for area surveying. Before reading the following text, follow the instructions of section 2-3(2) for assembling the RM4 and PA3 Four Probe Array for field use.

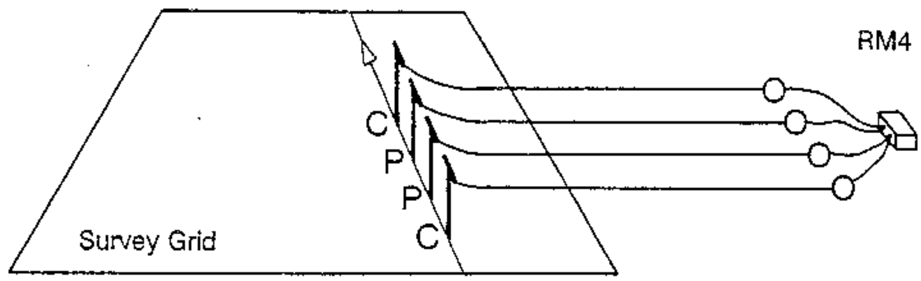


Figure 5-12. Four Probe Array PA3 set out for a Wenner array survey.

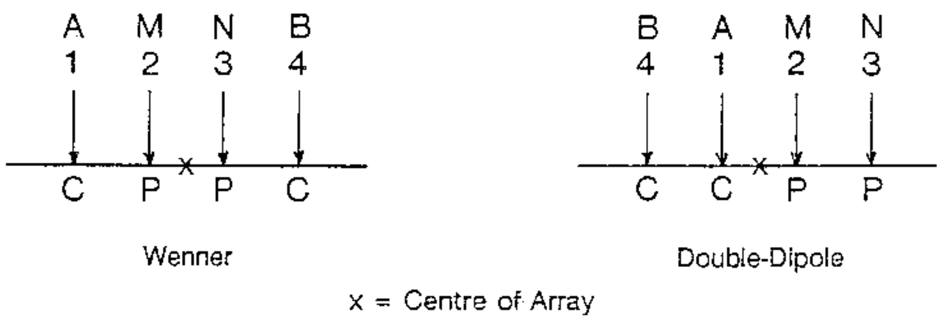


Figure 5-13. Connections for a Wenner or Double-Dipole array using the PA3 probe array.

The PA3 probe array may be configured as a Wenner, Double Dipole, or any other four probe configuration. The connections and layout of the hand-probes required to configure the Wenner and Double-Dipole arrays are shown in figure 5-13. All four probes are moved together along the traverse line for each reading, maintaining a constant separation (typically 1m) between the probes. The double dipole array may be configured using the probes in the order BAMN (4123) or MNBA (2341) with exactly the same results. The response centre for both Wenner and Double-Dipole lies at the centre of the array. It is most convenient to use measurement tapes to position the probes, section 5-5.

2 Probe and cable separation

For good resolution the probe separation should be as small as possible whereas for good depth penetration the probe separation should be as large as possible. There are also practical limits as to how small the probe separation can be as explained in 5-7 (3). A good compromise for archaeological surveys is to use a probe separation of 1m. Avoid running the cables parallel to one another to prevent capacitive coupling.

3 Probe positioning

Unlike the Twin probe array, much greater care must be taken in inserting the probes at precisely the correct point on the traverse line to minimise reading errors. The problem is reduced by using as large a probe separation as possible, though resolution then decreases. A good compromise is to use a probe separation of 1m for the Wenner and Double Dipole arrays, and position the probes to within 1cm of their correct position. This will keep displacement errors below 1%. It is not practicable to decrease the probe separation much below 1m, in order to improve resolution, since displacement errors will increase considerably.

4 Probe insertion depth

The reading will vary with insertion depth of the probe, especially on sites with shallow, but variable overburden depth. This is due to a change in the current path geometry, not instrumentation errors. This effect can be reduced by using as large a probe separation as possible, though resolution then decreases. Alternatively the effect can be minimised by always inserting the probes to the same depth and by inserting to as shallow a depth as possible. However, there is a limit as to how shallow the probe insertion depth can be since high contact resistances can produce reading errors on very dry sites. A good compromise is to insert the probes to a depth of 10cm, set by the soil-stop disc. For good repeatability push the probe into the ground using a combination of leverage on the "T" piece of the hand probe and foot pressure on the nylon soil-stop. This should keep errors due to insertion depth below 0.5%. If conditions are very dry then consider increasing the insertion depth to reduce high contact resistance errors, or as a last resort, watering in of the probes, though this will slow down a survey considerably. Large variations in resistance reading for repeated runs over the traverse will indicate if there are problems occuring due to soil conditions.

5 Instrument settings

The recommended instrument settings are Filter = Rural and range either 200.0 ohms or 20.00 ohms. In the majority of cases the normal 1 mA range should be selected, but if extremely dry conditions prevail, then the resulting high contact resistances may require the HCR mode to be used to obtain readings, though the instrument signal to noise ratio will not be as good as for the normal 1 mA range.

The Range should be selected so that changes of about 1% in the background resistance can be observed. For many sites this will mean selection of the 200.0 ohm or 20.00 ohm ranges. For example if background resistance is of the order of 10 ohms the 200.0 ohm range will result in a resolution of 0.1 ohm, enabling changes of 1% to be observed. However, if background resistance is lower than 10 ohms or "soil noise" is very low, then the 20.00 ohm range should be selected, resulting in a resolution of 0.01 ohm, enabling changes of 1% to be observed right down to a background resistance of 1 ohm.

If you are surveying in an urban situation with the 200.0 ohm or 20.00 ohm range then you may find that the reading flickers, as a result of interference by underground mains power earth currents (this may also be observed in some rural situations). If this is the case you may need to set the Filter switch to its Urban setting.

You should in general try to avoid changing the resistance range during the survey of a grid. If it becomes neccessary, because the reading is over-range, then, unlike the situation for the Twin, this is acceptable.

6 Survey procedure

WARNING

Handle the pointed ends of all probes with great care, so as to avoid injury. In particular ensure that yours and other peoples feet are well clear when inserting probes into the ground. All personnel should wear suitable, stout, protective foortwear when the equipment is in use. Handle the probes with care even when storing or handling the equipment away from the surveying area. Always keep the protective sleeves in place over the sharp end of the probes when they are not in use.

1 Record essential details of the site as listed on the survey sheets of Appendix F, either on the sheets themselves, or if manually inputting data to GEOPLOT software, on the Input Template form. This will be of particular use when it comes to presenting and interpreting the survey at a later date. Note the location of obvious physical features and where adjacent objects, such as trees, are located since they may have an effect on the readings.

2 Lay out the measurement tapes, section 5-5, and position the probes at the start of the grid, figure 5-9, - remember that the first traverse must be in the correct direction for the computer software - GEOPLOT requires a clockwise traverse. Try to arrange for the first traverse to be nearest the cable drums - this will avoid subsequent tangling of the cable with the probes since you will then be working away from the cable drums.

3 Switch on, check that the RM4 range, filter and HCR mode are set correctly.

4 Record the first reading on a survey sheet similar to that shown in Appendix F. Move the probes on to the next position and record the new reading. If soil conditions are good, the holes made by the probes may be re-used by the following probes as they are stepped along. This procedure is followed until the end of the traverse.

5 Reposition the probes at the start of the next line. The new start position obviously depends on whether parallel or zig-zag surveying is being used. Record the first reading of the next line and continue as previously.

6 Continue to survey the grid in the same manner until the last line of the grid is complete. Fill in any unsurveyed parts of a grid with dummy readings.

7 Survey additional grids in the same way.

5-10 Dealing with Large Obstacles and Completing Grids

If you cannot make a measurement at a reading station because of some obstacle, such as a rock, or you encounter larger blocks of the survey area that cannot be surveyed then record these with dummy readings that can later be identified as such. For example the number 2047.5 is used as a dummy reading in other Geoscan Research equipment that has in-built facilities for logging data.

You should **ALWAYS** ensure grids consist of valid data, either real recorded data values or dummy readings, in unsurveyed parts of a grid. When you survey the last grid, remember to record any unsurveyed parts with dummy readings. This will ensure that when the data is input to a PC the software will be able to calculate sensible statistics for the grid, ignoring dummy readings for this purpose. If you do not complete unsurveyed parts with dummy readings then those parts of the grid will contain random data which will confuse the program statistics.

5-11 Doing a Line survey

The basic procedure for a line survey is much the same as described above for an Area Survey. Usually this will consist of several parallel traverses laid out perpendicular to a linear feature, in order to trace its direction. The earlier comments on choosing an appropriate sample interval still apply. In particular, remember that features may be missed that run parallel with, but in between the traverses. A series of linear traverses perpendicular to the first set of traverses should avoid such features being missed.

5-12 Avoiding Split Surveys

If you perform two adjacent surveys at the same site, with each done at different times of the year, then it is highly likely you will no longer be able to make a good match of the grids at the junction of the two surveys since the ground resistivity and contrast may well have changed. Indeed, you may find the same effect if try to extend a survey done, for example, a week earlier, but in the meantime weather conditions have changed considerably. It is therefore always advisable to try and complete a site survey in one session only, though of course this may not always be possible due to the sheer size of a site or individual circumstances.