Baldinnies Geophysical Survey

Data Report

May 2013

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Summary

As part of the Strathearn Environs and Royal Forteviot (SERF) project a geophysical survey, using both resistivity and gradiometric techniques, was conducted at Baldinnies Farm, over an area where cropmark enclosures have been recorded. The survey was undertaken between 29th April and 1st May 2013. The main aim of the survey was to help further define the archaeological features associated with the cropmarks. The detection of the archaeological features corresponding to the cropmark record was difficult due to the local geology. Despite the poor contrast between the archaeological features and the surrounding soil, the geophysical character of a large enclosure was recorded. Furthermore, the results demonstrate the importance of utilising and comparing different survey techniques.

1.0 Introduction

A geophysical survey was carried out at Baldinnies, Dunning (NO 02079 16122), 29th April and 1st May 2013 in advance of proposed excavations on this cropmark complex as part of the SERF research project. Permission for this survey was granted by Historic Scotland as this is a Scheduled Ancient Monument. This work was undertaken as part of Phase 2 of the SERF Project (see Driscoll et. al. 2010 for an overview of phase 1).

1.1 Aims

The aims of the geophysical survey were to use geophysical techniques:

- to detect and characterise any potential archaeological features in the area
- to continue to test the response of resistivity and gradiometry surveys within this landscape
- to compare the geophysical results with the aerial photographic data in order to build a more complete picture of the character of the archaeology.
- to assist in the selection of areas for archaeological investigation through excavation.

1.2 Archaeological Description & Background

The cropmarks at Baldinnies Farm have been identified as part of the group surrounding Leadketty Farm (NMRS NO01NW 21, 56). These cropmarks were initially recorded in 1970 by CUCAP, and since 1976 they have been recorded by regular flights by RCAHMS. Over the years this reconnaissance work has revealed a remarkable complex of cropmarks (see Figure 1). The main density of these cropmarks stretch across two large fields of the Leadketty and Baldinnies farms, on the south side of the Earn valley. The complex consists of a range of sites which are most likely to date to the Neolithic and Bronze Age, although some elements are probably later prehistoric and medieval. The clarity of the archaeological features within this group of cropmarks is variable which is most likely due to the depth and character of the surrounding soils and underlying palaeochannels.

In 2012 the SERF project began the second phase of archaeological campaign, which included a geophysical survey and excavation of targeted archaeological features in the field immediately to the N of Leadketty Farm (Maldonado & Brophy 2012; Brophy, Gould, Noble, Wright & Younger 2012). Here cropmarks have recorded a huge timber-defined palisaded enclosure, one of only four known in Scotland, and potentially the largest with a width east-west of c400m. The boundary of this monument is indicated by an irregular line of postholes, with the southern side of the enclosed space defined by an escarpment; a single entrance avenue runs from the NE sector of the enclosure. This monument was one of the features that were investigated as part of SERF in 2012 and is likely to date to the later Neolithic (3000-2500BC) (Noble & Brophy 2011; Brophy *et al.* 2012). Within this palisaded enclosure cropmarks have also revealed a series of enclosures, pits and pit-structures as well as some structures outwith its boundary; the chronology of these probably varies considerably. During the 2012 excavation season an early prehistoric mini-henge and a four-post structure within this area were also explored (Brophy *et al.* 2012).

The focus for the current geophysical survey is the archaeological features in the large field to the N of the timber palisade. The main feature identified through aerial photography is an unusual circular enclosure defined by a ditch with several 'gaps' or 'causeways' along its perimeter. This enclosure is about 100m in diameter, with a ditch varying in width from 2.5-4.0m. There are several circular rings and pits both within the enclosure and particularly in the SE. There is a concentration of features around the SE corner which may or may not be contemporary to the large 'causewayed' enclosure and some which are not depicted in the current transcription. This complex of features may relate to various phases of prehistoric activity. The large enclosure is thought to be a possible early Neolithic causewayed enclosure, but equally could be of later date. Other circular enclosures within this field are of unknown date and purpose, and at least one square barrow has been identified (possibly dating to the 1st millennium AD).

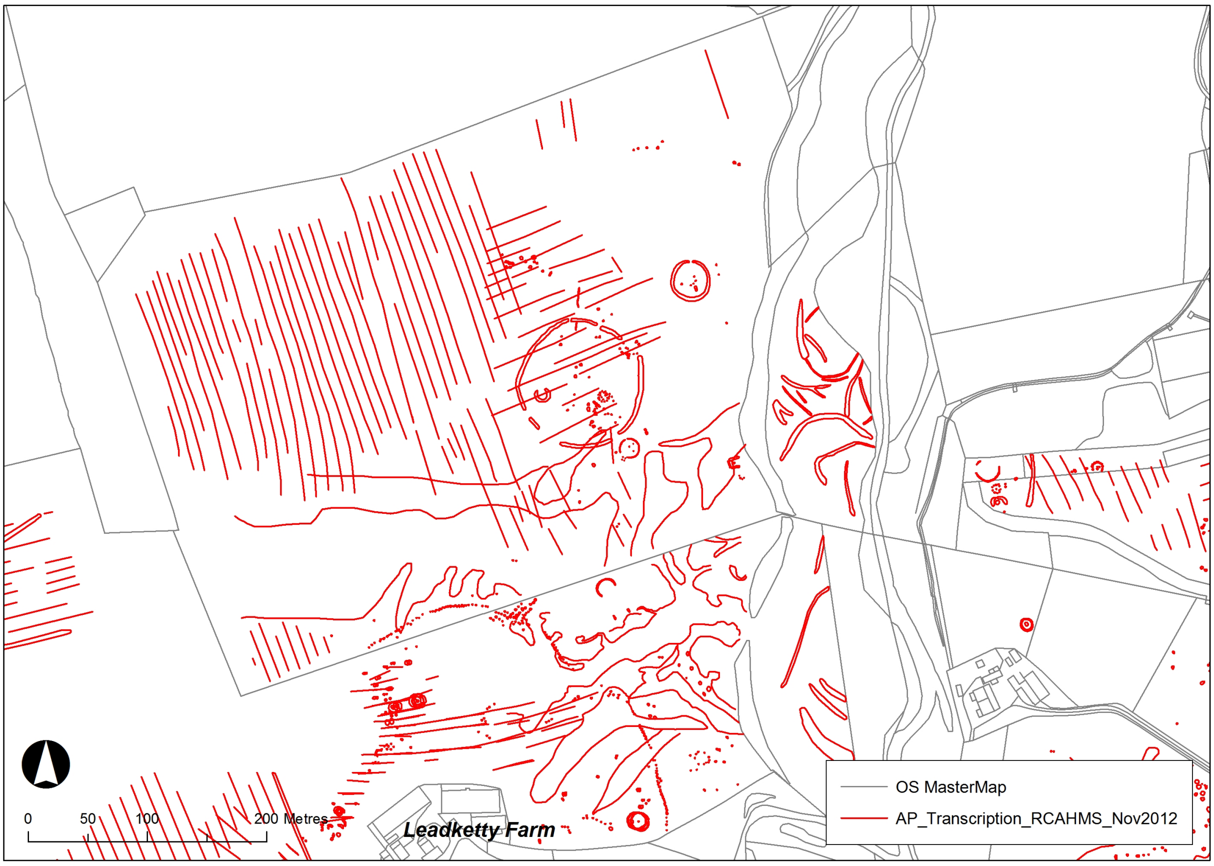

Figure 1: Transcription of the cropmarks at Leadketty and Baldinnies ©RCAHMS

1.2.1 Results of 2012 Geophysical Survey at Leadketty

In 2012 several areas were targeted for geophysical survey at Leadketty with two main objectives: to test the potential for geophysics in the cropmark area, and to help inform the excavation strategy (Maldonado & Brophy 2012). The survey mainly utilised gradiometry but resistivity was also attempted in a small area. The conclusions from this survey were that in general the Leadketty fields respond well to geophysical survey, and add more detail to the existing cropmark record (*ibid*). Although both the gradiometer and resistivity surveys did provide some geophysical detail to the archaeological features and several potential new areas of archaeological interest were recorded, the geophysical responses of the archaeological features were weak. The topography and past agricultural activities all seemed to have an impact on the results.

1.3 Geology, Topography & Vegetation

The underlying solid geology of Baldinnies is Scone Formation sandstone (BGS 1:50,000). This is overlain by Devonian till and the superficial geology consists of mixed glacial-fluvial deposits of sands, silts and gravels (BGS 1:50,000). The freely-draining gravels make this very fertile land. The survey was conducted in a recently sown agricultural field, with crops of barley only about 5cm tall. The ploughsoil has been heavily manured in more recent times as was apparent in the frequent occurrences of abraded modern glass and ceramic sherds visible on the surface.

The large causewayed enclosure at Baldinnies is situated on what appears to be a fairly level river terrace, with only very gentle undulations, above the Duncrub Burn. The enclosure lies just to the E of a low and broad hillock, which may have 'hidden' this enclosure from the W.

2.0 Methodology

2.1 Survey Methodology

Two techniques of geophysical survey were employed: gradiometry and resistivity. The gradiometry survey was conducted using a dual sensor Bartington Grad 601. Readings were recorded within 20m by 20m grids and taken every 0.25m (traverse) by 0.125m (sample). The total area surveyed by gradiometry was 21,600m^2 (*see Figure 2*).

A smaller area, over the potential excavation trench, was selected for resistivity survey. The resistivity survey was conducted using a GeoScan RM15 with 0.5m probe separation. Twenty-six 20m by 20m grids (covering an area 10,800m^2) was surveyed taking readings every 1m by 1m (*see Figure 2*).

The location of the survey grids were recorded using a Leica 407 Total Station and then georeferenced in ArcMap.

2.2 Processing Methodology

All the gradiometry survey data was downloaded using Grad 601 software and then imported into GeoPlot v3 for processing. Results were produced as grayscale images.

In order to reduce the effect of the very high magnetic readings the data was processed by setting the absolute readings to a minimum of -10nT and a maximum of +10nT. Furthermore, to compensate for the slight discrepancy between the 'balancing' of the two sensors of the Bartington Grad 601, which produced a 'striped' appearance, a 'zero mean' process was applied to all the grids. Also there was a staggered effect between the readings of individual lines due to the large number of measurements taken every metre and the difficulty of absolute consistency in the surveyor's walking pace. Therefore a 'destagger' was applied to the data.

The resistivity data was downloaded directly into GeoPlot v3 software. Occasional spurious readings were corrected by a 'despike' process. The final image was then created by applying a high pass filter in order to highlight the contrast between the low and high resistance readings.

3.0 Results

3.1 Gradiometry Survey

(*Figures 3, 4 & 5)*

Most of the archaeological features identified on the aerial photographs were not detected through the gradiometer survey. This lack of detection suggests that these features have a magnetic signature very similar to the magnetically neutral geology or that the plough soil is very deep in places and therefore masking the subtle magnetic readings of the archaeological features.

Some portions of the ditch of the large 'causewayed' enclosure produced a subtle magnetic signature. The ditch is most visible in the NW corner where it appears as a segment of slightly weak negative magnetism with edges of slightly positive magnetism. At the N end of this segment there is a slight kink in the ditch. Further to the NE, E and SE the ditch is less visible and the edges are only detectable as discontinuous bands of slightly positive lines. The ditch disappears completely in the SW corner. Considering these responses, the ditch appears to not contain highly magnetic fills (i.e. burnt material or material derived from a very different source compared to the surrounding soil).

In this SW corner of the survey area there is particularly high concentration of discrete positive anomalies. These anomalies may reflect underlying features such as pits, but most likely they may be the response of stones within a distinct glacial deposit in this area. No distinct pattern of these anomalies could be identified. In the NW corner of the survey there are several other positive anomalies, these too may be pits or stone.

Throughout the survey area there is a scatter of dipoles (anomalies with very strong positive and very strong negative readings). These dipoles are likely metallic objects found within the topsoil; however, interestingly a few of the dipoles appear to be in the line of the ditch of the large enclosure and perhaps these are deposits within the ditch fill. Another anomaly which produced a strong positive and negative magnetic response is recorded just within the ditch of the large enclosure in the SW side. This dipole may be a metallic object, but more likely an igneous stone, perhaps similar to the stone discovered at the entrance of the double enclosure at Forteviot (James 2010).

Towards the NE corner of the survey area there are parallel curvilinear bands of positive and negative magnetism. It is suggested that these relate to a palaeochannel or natural geological deposits, which are comparable to features visible on the aerial photographs. There is no change in the topography visible on the ground.

In the extreme NE corner an enclosure identified by aerial photography was surveyed; however, this feature was not detected. No clear archaeological features were noted in this area.

Plough marks are visible particularly in the N half of the survey area. The majority of the lines appear to run from the NE to SW. These are likely the remains of rig and furrow cultivation. There is a stronger line of positive magnetism parallel to these marks towards the N end of the survey area. This line matches with an old field boundary depicted on the OS 1st edition map (OS 1862). In the NE corner of the survey area there are also plough lines that also run from the NW to SE and are closer together and may be a result of more recent ploughing. The current plough marks, visible on the surface, was not reflected in the survey data.

3.2 Resistivity Survey

(*Figures 6, 7 & 8*)

Despite the coarse sampling interval of the resistivity survey (1m by 1m), the results describe the general character the large enclosure as well as the different background superficial deposits.

The ditch of the large enclosure can be traced as a discontinuous band which changes in resistance from low resistance in the SE and E side to higher resistance in the SW corner. In this SW corner the ditch appears narrower and the definition of becomes less clear. The results highlight the difference in the resistance of material within the ditch compared to the surrounding soil. The majority of the gaps in the ditch recorded by the resistivity survey most likely correspond to variations in the deposits rather than real gaps. However, there is one gap on along the SE side that may be an entrance on causeway.

In the SE corner of the survey area there is a variety of high and low resistivity readings. Although some of these form rough shapes, no clear features could be identified due to the coarse sampling strategy.

This survey does record the general background resistance of the glacial-fluvial deposits. In the SW corner there is a clear spread of low resistant material. There are also several bands of both low and higher resistance which run NE-SW in the survey area that may also reflect geological deposits.

Plough marks, about 6m apart, can be clearly seen across the whole survey area, running in a NE to SW direction. These are likely the remains of rig and furrow cultivation.

4.0 Discussion & Conclusions

The results of the geophysical demonstrate the usefulness of conducting both gradiometry and resistivity techniques to the same area. The results of these two surveys are complimentary. This is particularly notable in detection of the ditch of the large enclosure. Each survey detected different elements of the ditch. Interestingly it is the area the low background resistance where the ditch was undetectable through the gradiometry survey. Here the resistance of the ditch is high. The character of the ditch fill in this area is distinct from the rest of the ditch. Unfortunately the resistivity survey did not extend to the NW corner of the enclosure to compare the results where the ditch had the strongest magnetic signature.

It is clear that the magnetic signature of cut features in this landscape is particularly weak and is related to what material the feature is cut into as well as the fill. This is most obviously demonstrated in the magnetic detection of the plough marks. Only a few marks running NE to SW were detected in the gradiometry survey. By contrast these marks are clearly visible throughout the resistivity survey. This suggests that the background material is quite mixed already and any features cut within this (and subsequently filled with a similar material) will not produce a strong magnetic response. However, because the material has been loosened during excavation the resistance of this material may have been altered.

In comparison with the cropmarks identified by aerial photography the results of the survey clearly shows that there is a discrepancy in the georeferencing of two datasets (see Figure 9). Nonetheless, the circuit of the large enclosure noted in the geophysical survey can be seen to roughly follow that of the cropmarks; however, the gaps in the ditch do not match. None of the other transcribed archaeological features, including an enclosure in the NE area of the survey, seem to have been clearly detected through the geophysical survey. Comparing the aerial photographs themselves, however, does show corresponding geological deposits and bands.

Recommendations for future geophysical work in this area would be to conducted more resistivity survey at a finer sampling interval. And although the gradiometry survey showed the magnetic response of the archaeological features to be weak, it is a useful comparison with other survey techniques. It may also be worthwhile to re-survey any areas that will be excavated once the topsoil is stripped to consider the affect of the plough soil on the gradiometric results.

5.0 Acknowledgements

The author would first like to thank Stuart McLaren for kindly giving us permission to conduct this survey. The survey would not have been a success without out the help of several hardworking students: Scott Morris, Joss Durnan & Diana Bastalla ably conducted the resistivity survey and Kelsey Brunasso, Jamie Barnes & Timothy Casey assisted with the gradiometry survey. Thanks to Lorraine McEwan for surveying the location of the grids. SERF is sponsored by Historic Scotland

6.0 References

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OS 1862 1st edition map 6inch to a mile.

Figure 2: Location of the geophysical survey areas overlain on Ordnance Survey mapping data

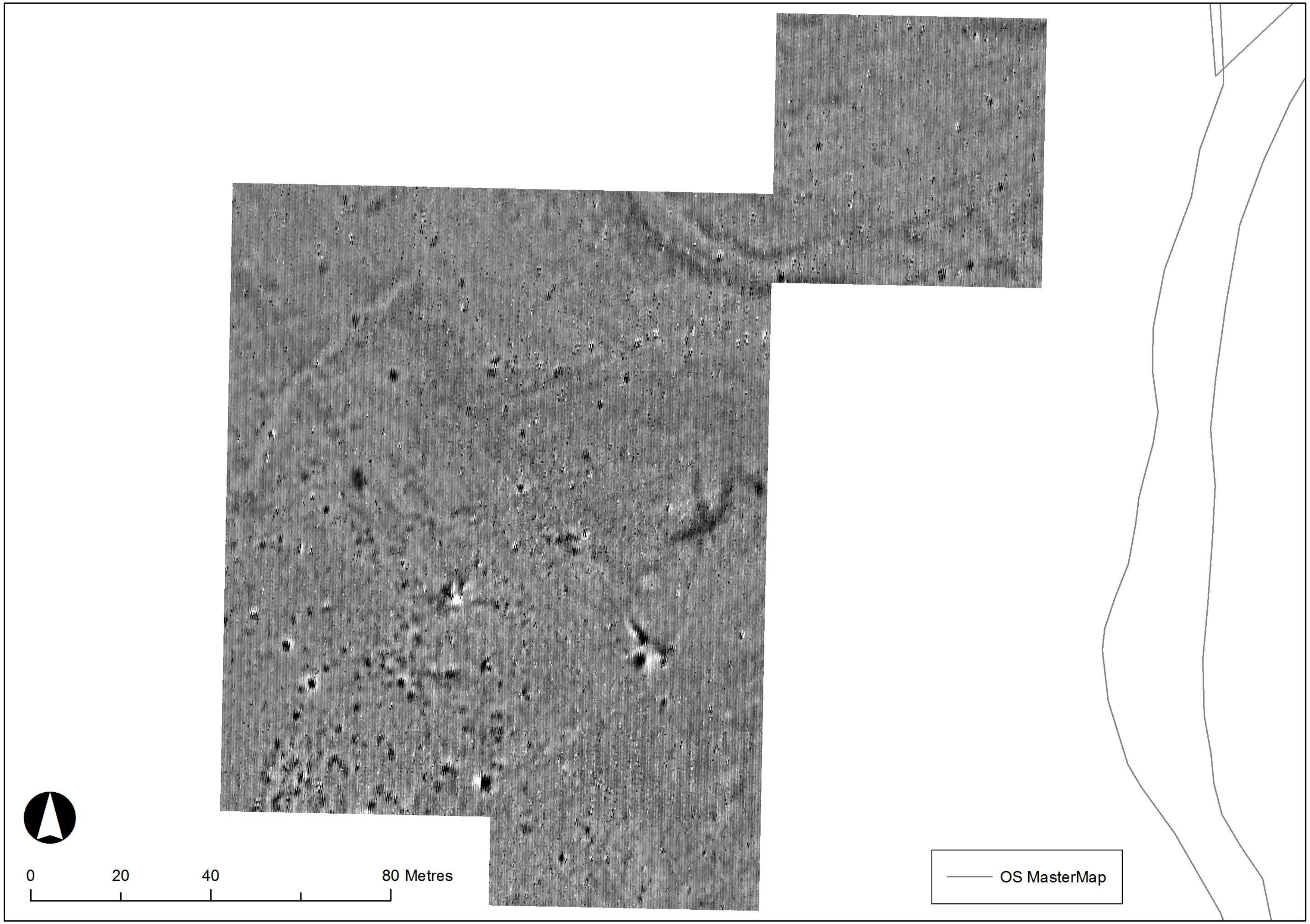

Figure 3: Raw gradiometry data

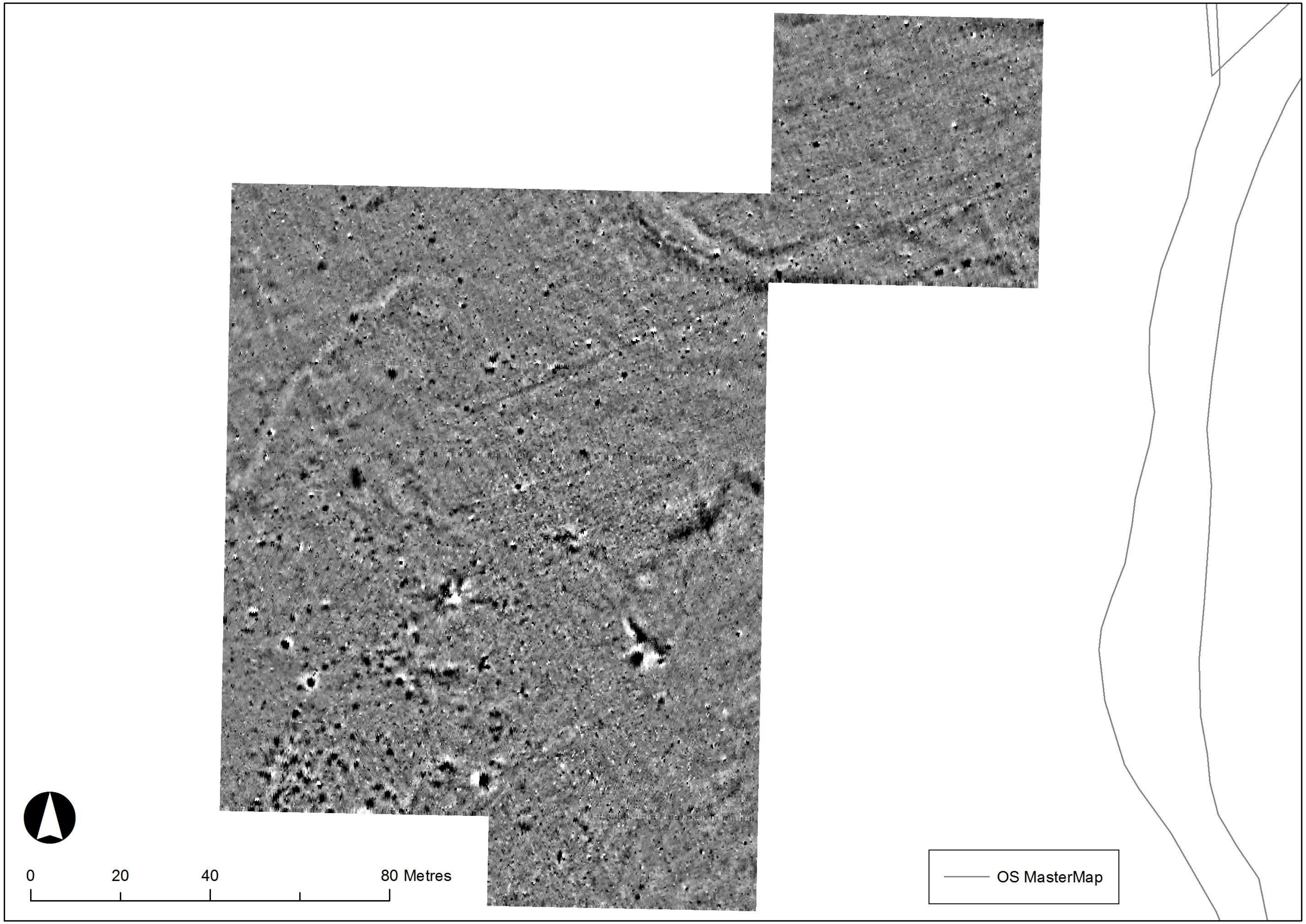

Figure 4: Processed gradiometry data

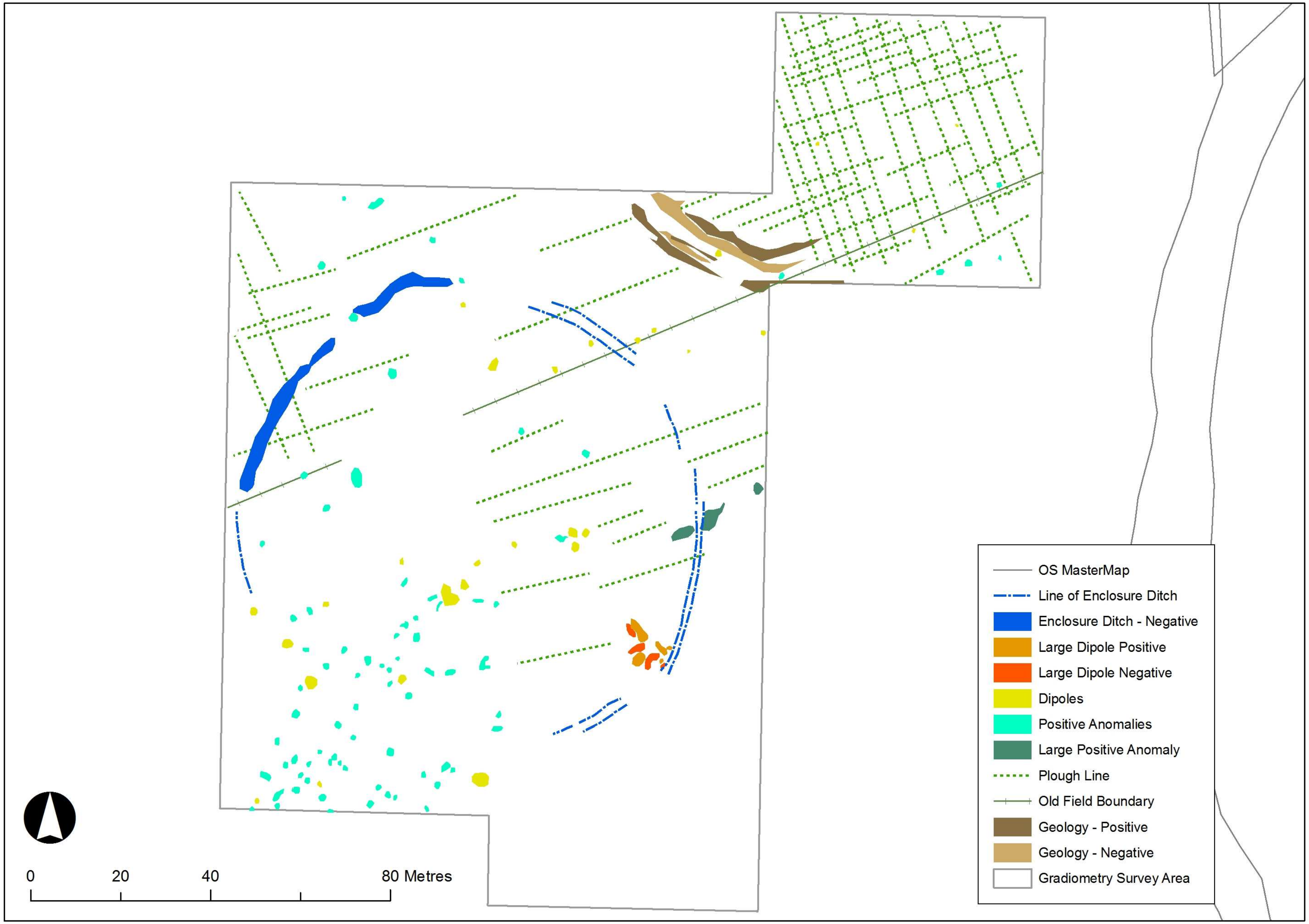

Figure 5: Interpretation of processed gradiometry data

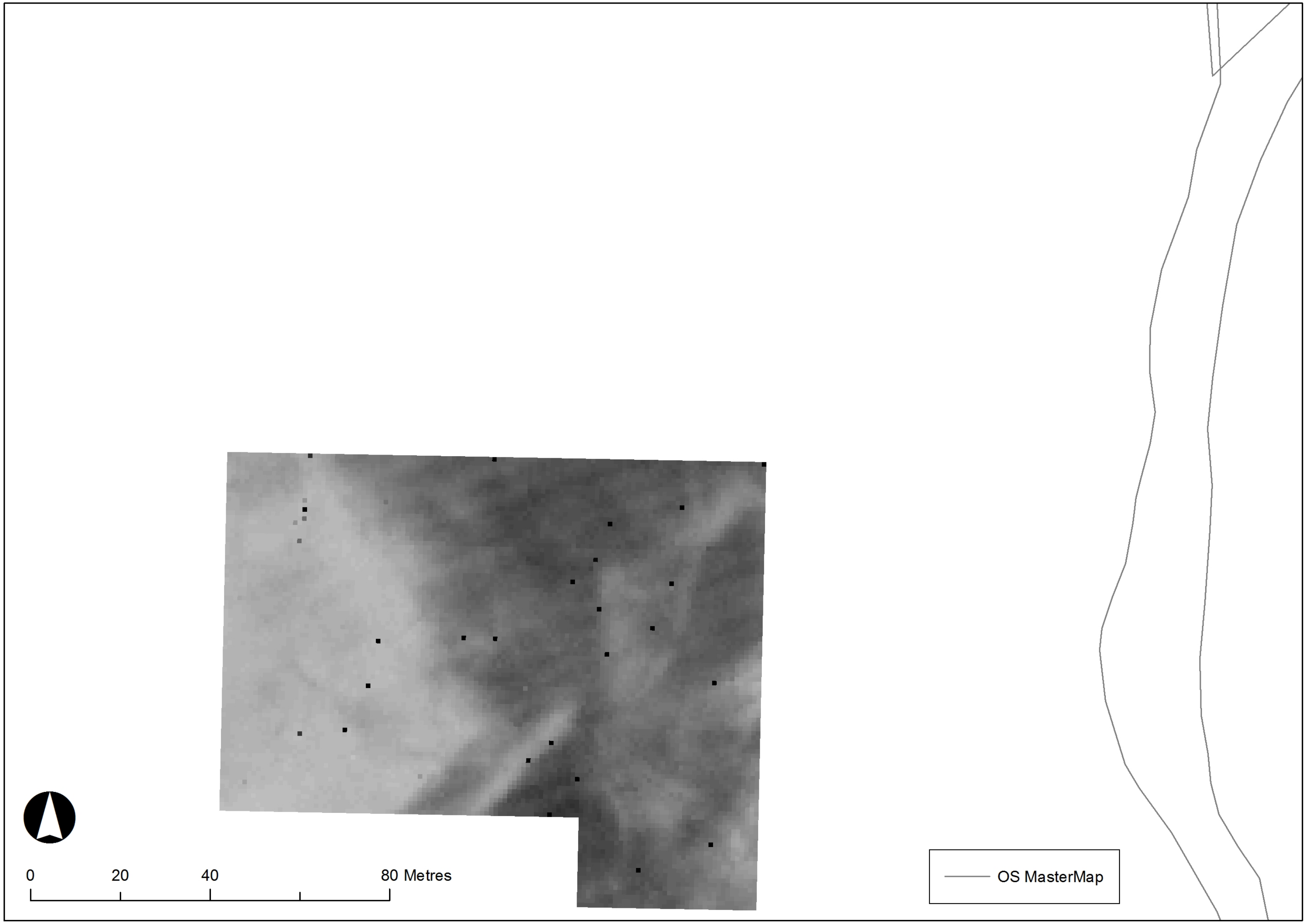

Figure 6: Raw resistivity data

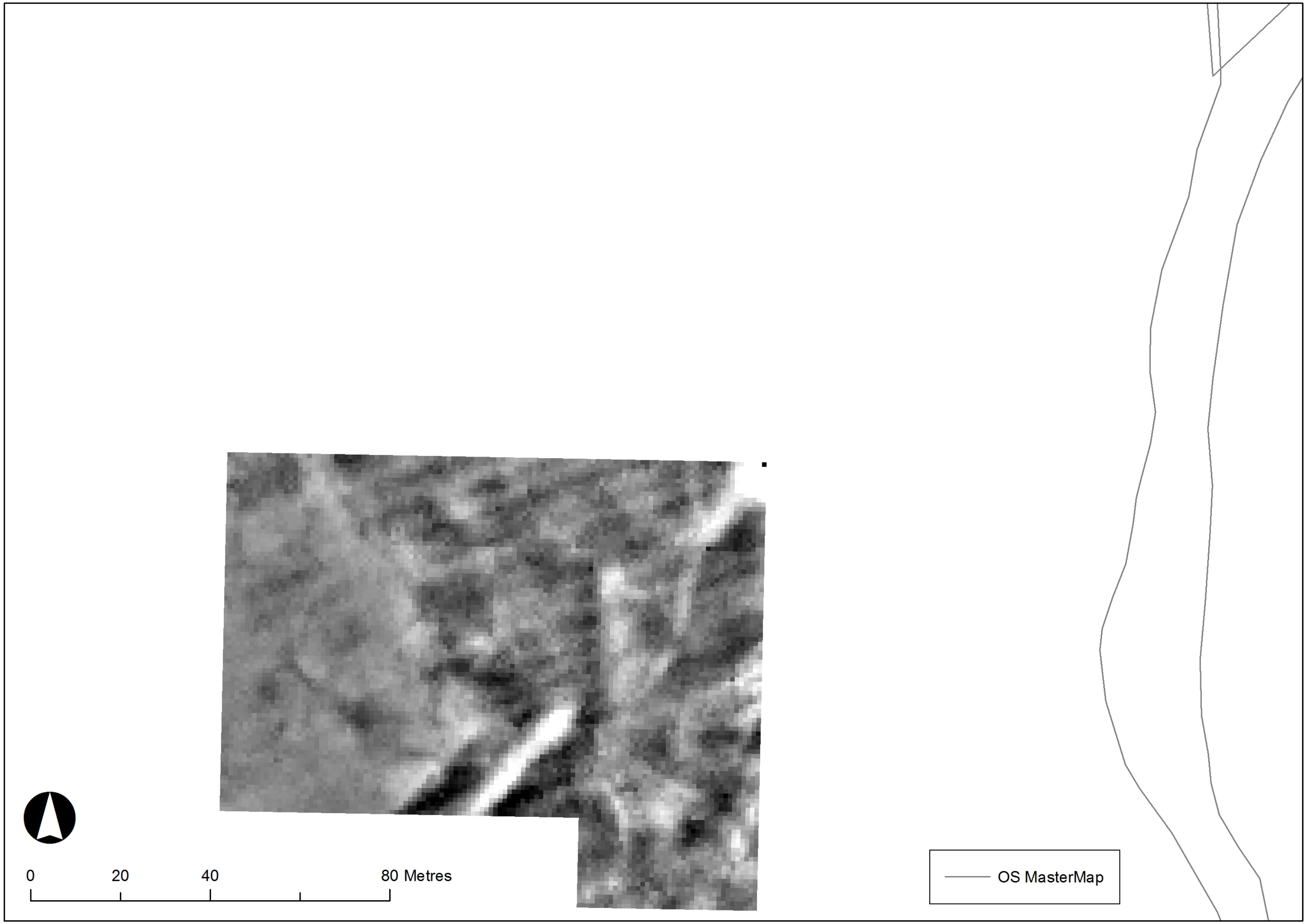

Figure 7: Processed resistivity data

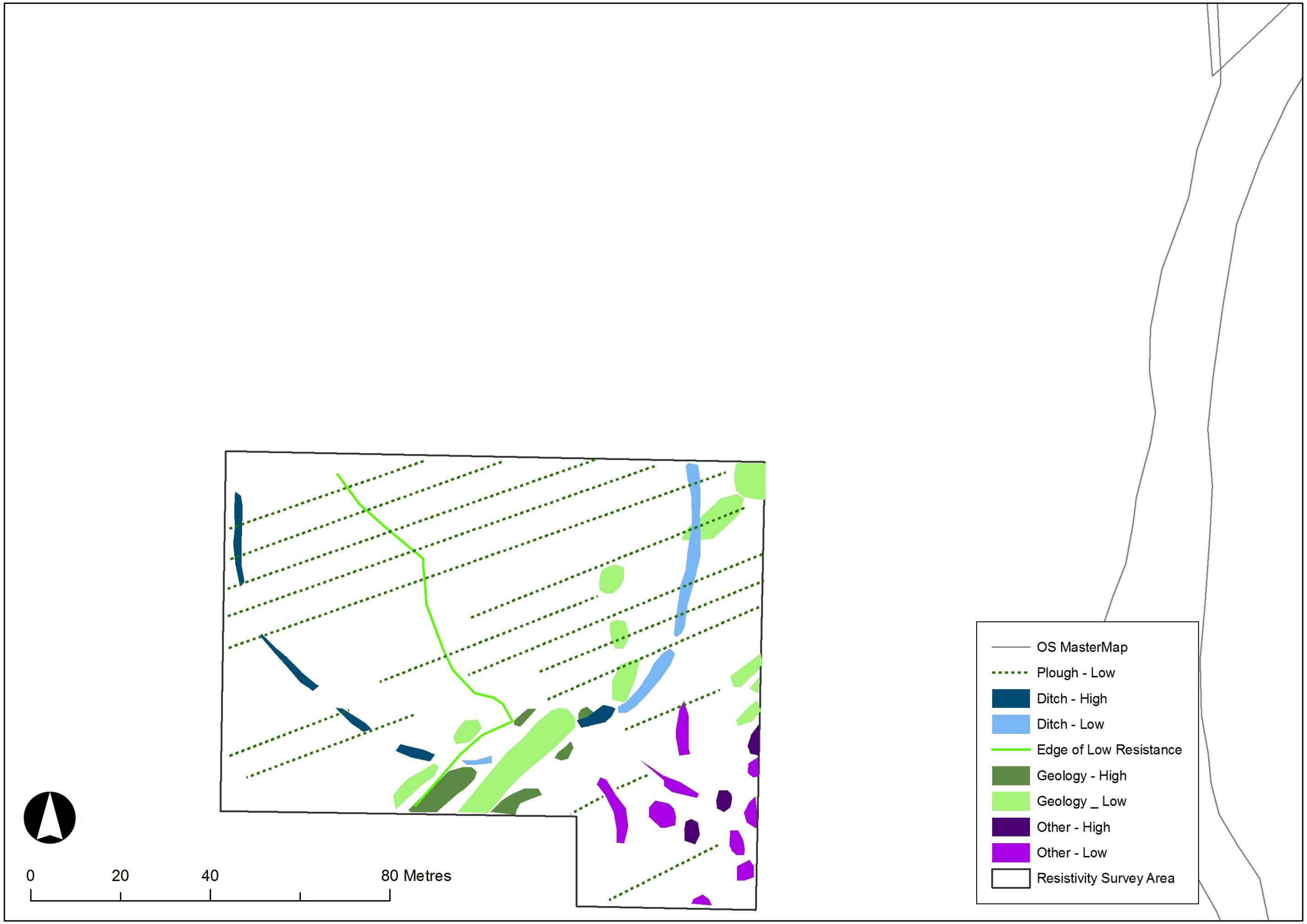

Figure 8: Interpretation of resistivity data

Figure 9: Interpretation of gradiometry and resistivity data overlain with aerial photographic transcription (RCAHMS)