The detection of unmarked graves: a geophysical approach

David Hunter - Hunter Geophysics

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Outline

Different geophysical techniques suitable for finding unmarked graves

Creswick Cemetery

The process of having a geophysical survey performed

Question time

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Geophysics

- the measure of the Earth's physical properties in order to detect buried objects, minerals or different soil types.
- originally developed for mining purposes.

Properties such as

Electrical resistivity or conductivity

Strength of the Earth's magnetic field (geomagnetism)

Strength of the Earth's gravitational pull

Ability of the Earth to absorb different types of light (e.g. radiowaves)

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Why use geophysics to find unmarked graves

Speed

Geophysics can cover large areas rapidly without the need for excavation. Excavation takes a great deal of time.

Reliability

Soil colour will vary naturally due to a variety of reasons, and unmarked graves may have the same-coloured soil as the surrounding soil. “Probing” with augers or star pickets may not work if the coffin has decomposed or if probing is not done at the right place.

Geophysical methods are a proven technology and the strengths and weaknesses of each technique is understood.

Why use geophysics to find unmarked graves

Respect for the deceased

In the past, cemeteries have used mechanical excavators to remove the topsoil in order to find unmarked graves by looking at the differing soil colours. Others have used augers or star pickets to find graves by feeling the picket hitting a coffin.

Geophysical methods do not require any excavation; the only thing that goes into the ground are tent pegs in order to hold survey lines in place. This means that geophysical methods are ideal when searching for culturally sensitive burials, e.g. indigenous gravesites.

Geophysics is comprehensive

Geophysical surveys not only detect unmarked graves, but also archaeological features, soil features, geology and buried pipes.

Geophysics

To be detectable, a buried object must have a property which is different to the surrounding soil.

Measurements are taken at regular intervals along the ground in a straight line (e.g. a measurement every sixty centimetres or two feet).

Once a line is complete, a new line is started at a regular interval from the first line (e.g. a line every metre).

Surveying

Geophysical data is collected by moving sensors around survey area in a ‘survey grid’.

•A survey grid consists of a series of parallel ‘survey lines’ of equal length.

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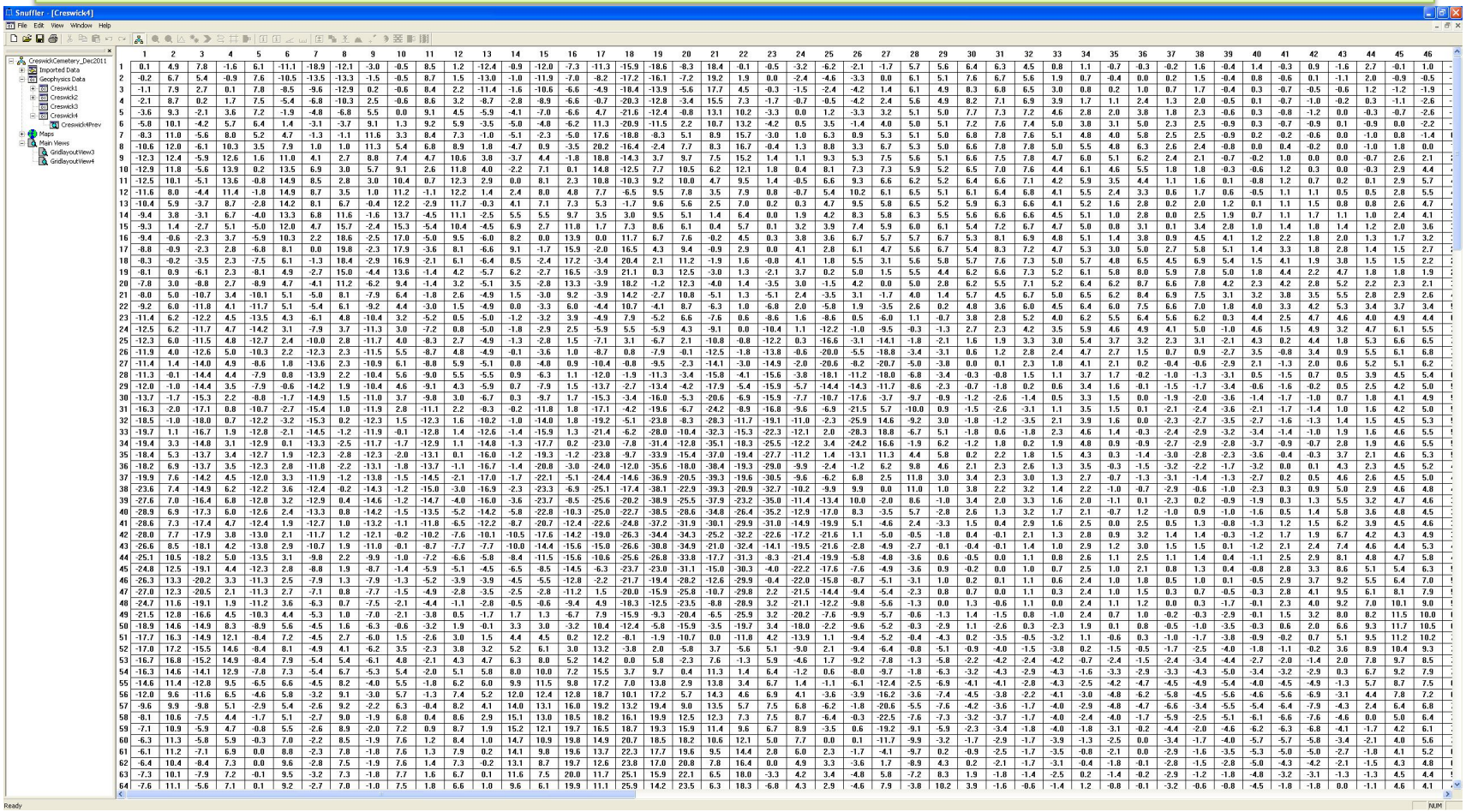
Individual readings gathered in a table



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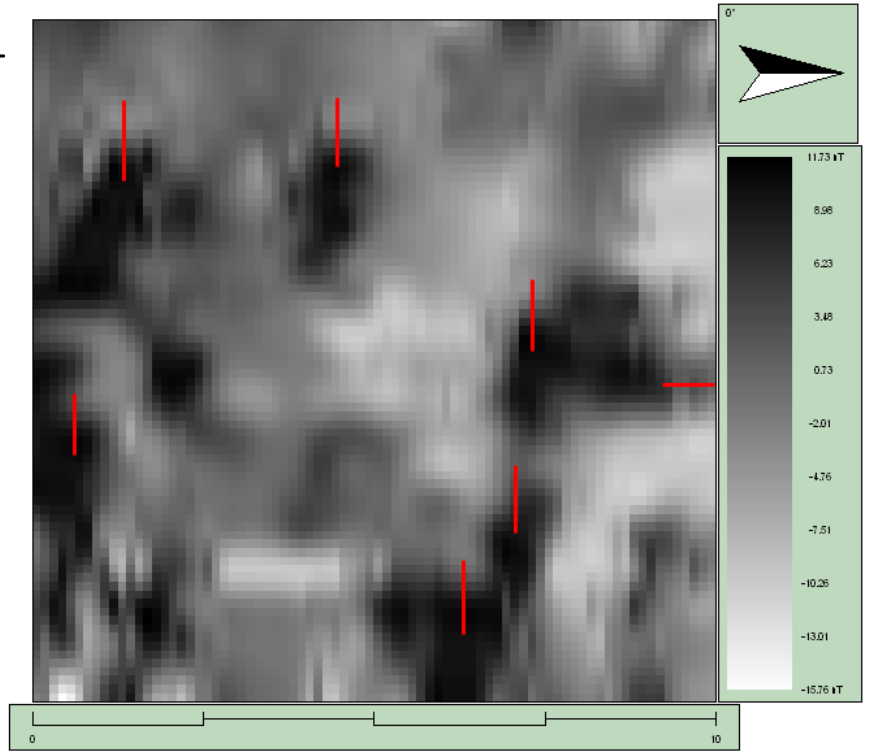
Geophysics

The collected measurements are then colour-coded, often with the highest measurement being black and the lowest being white, with other measurements in between being represented by shades of grey.

The readings are then plotted with their particular shade of grey on an “image plot”, which is a plan-view of the readings.

This is analogous to a map of buried objects.



Above: magnetometry plot showing several unmarked graves (black areas highlighted with red lines)

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Geophysical methods can detect

- Archaeological features (rubbish pits, wall foundations, buried drains, pipes, etc.)

- Geological features (such as dried-up river channels)

- Soil features (such as areas of reduced soil moisture – i.e. graves).

Right: undertaking a ground-penetrating radar survey on a concreted car park in inner Melbourne at 3am.

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How can we find an unmarked grave? Soil moisture

Subtle changes in the amount of moisture in the soil can be detected.

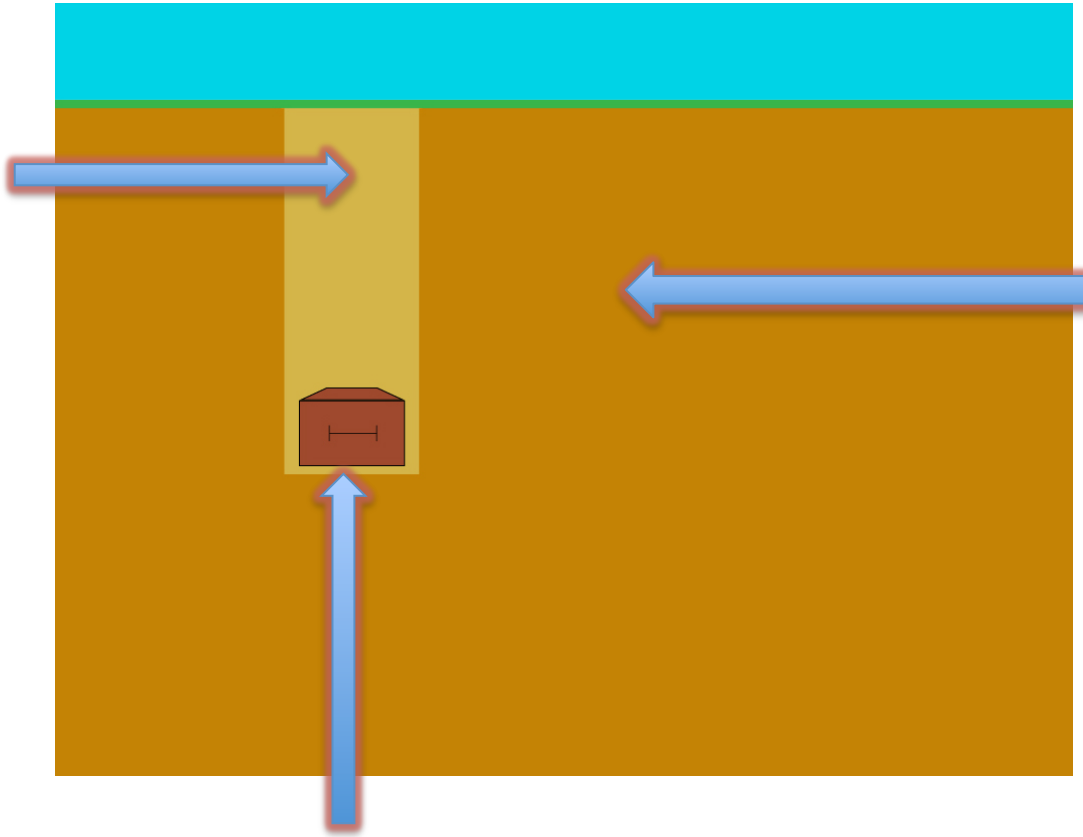
During a funeral, the soil is left out in either sun or rain, either drying or wetting the soil.

Soil is then returned to the grave after interment.

It is this change in soil moisture that is detectable using geophysical methods.

Cross-section of a grave – ideal conditions

Soil within the grave shaft has a different concentration of water than the surrounding soil



Ordinary soil surrounding grave.

Coffin

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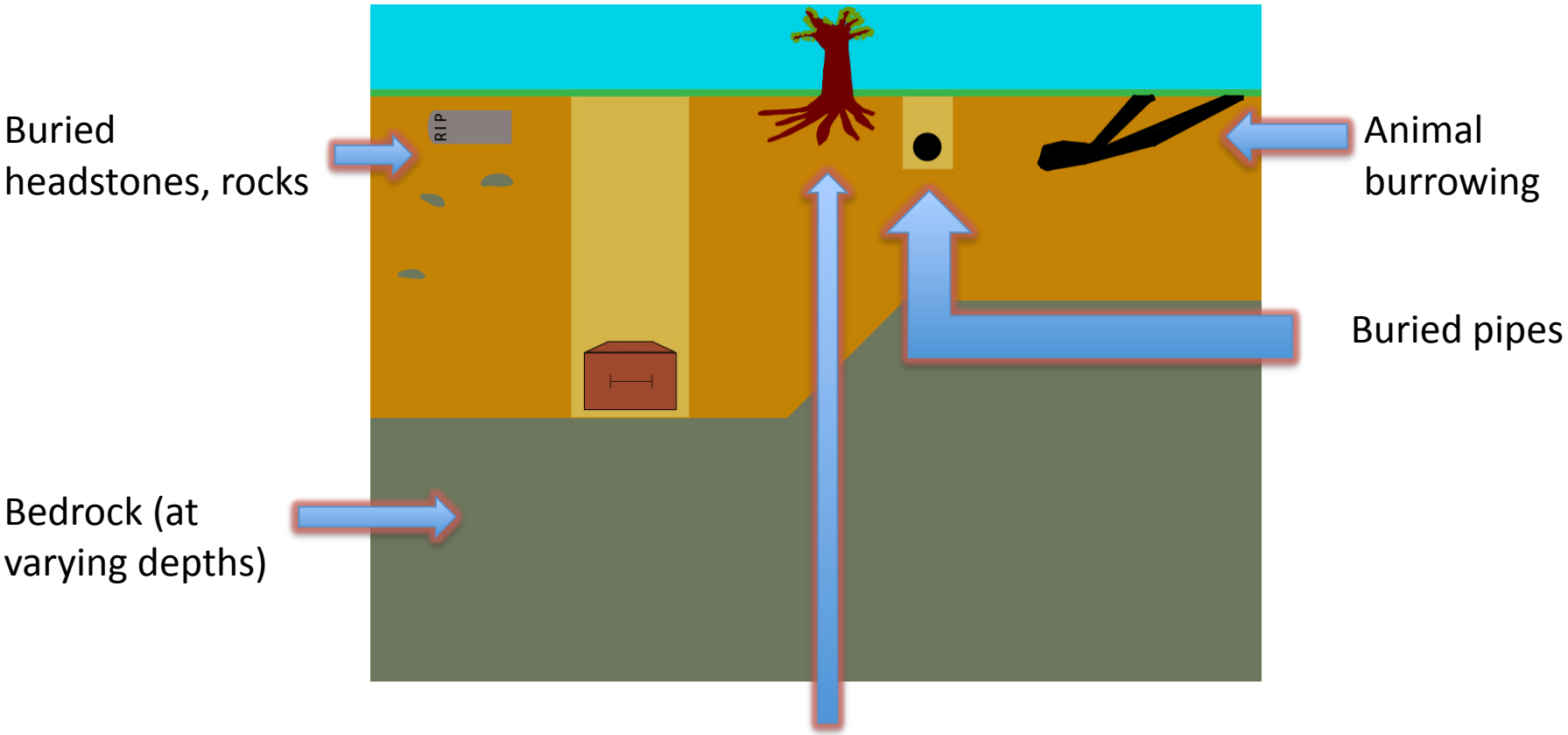
Cross-section of a grave – typical conditions



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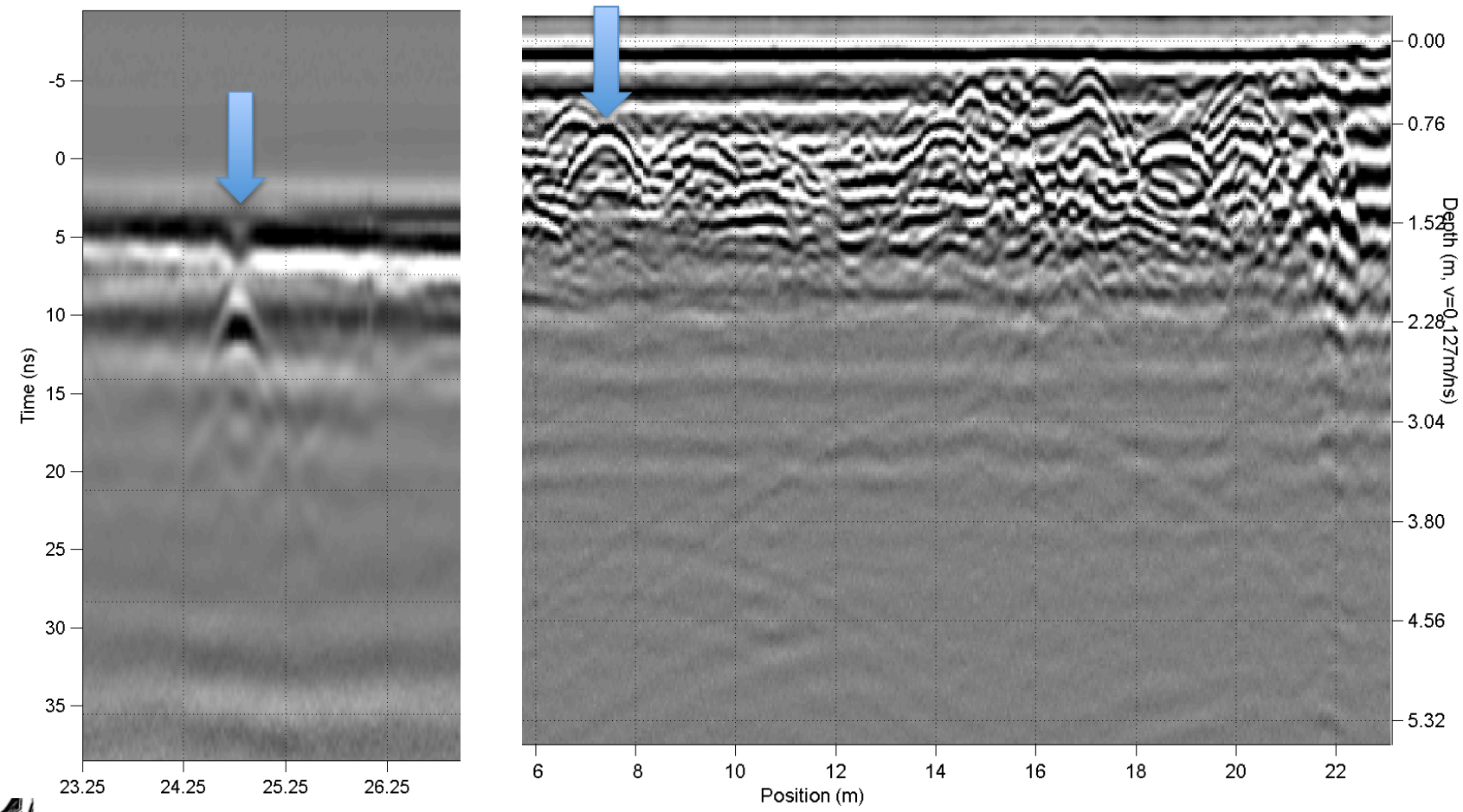
Radargram (ideal vs. complex)



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Ground-penetrating Radar (GPR)

Ground-penetrating radar sends radiowaves into the ground and records the timing of any reflections of the radiowaves.

Radiowaves are reflected by buried objects. The amplitude (strength) of the reflection is related to the electrical conductivity of the object.

- Therefore, water-logged soils or objects made of iron or copper produce weak reflections.

- Dry soils produce strong reflections.

- This allows us to find areas of varying soil moisture and, therefore, unmarked graves.

Radargrams

Above: David Hunter (right) performs a ground-penetrating radar survey while Matt (left) uses a survey-grade GPS to create a map of a cemetery.

Ground-penetrating radar data is collected in ‘survey lines’. Each line of GPR data is displayed as a ‘radargram’.

- Radargrams show the reflective surfaces of buried objects. It is not a cross-section of the ground.

- Radargrams can be complicated and require time to interpret accurately.

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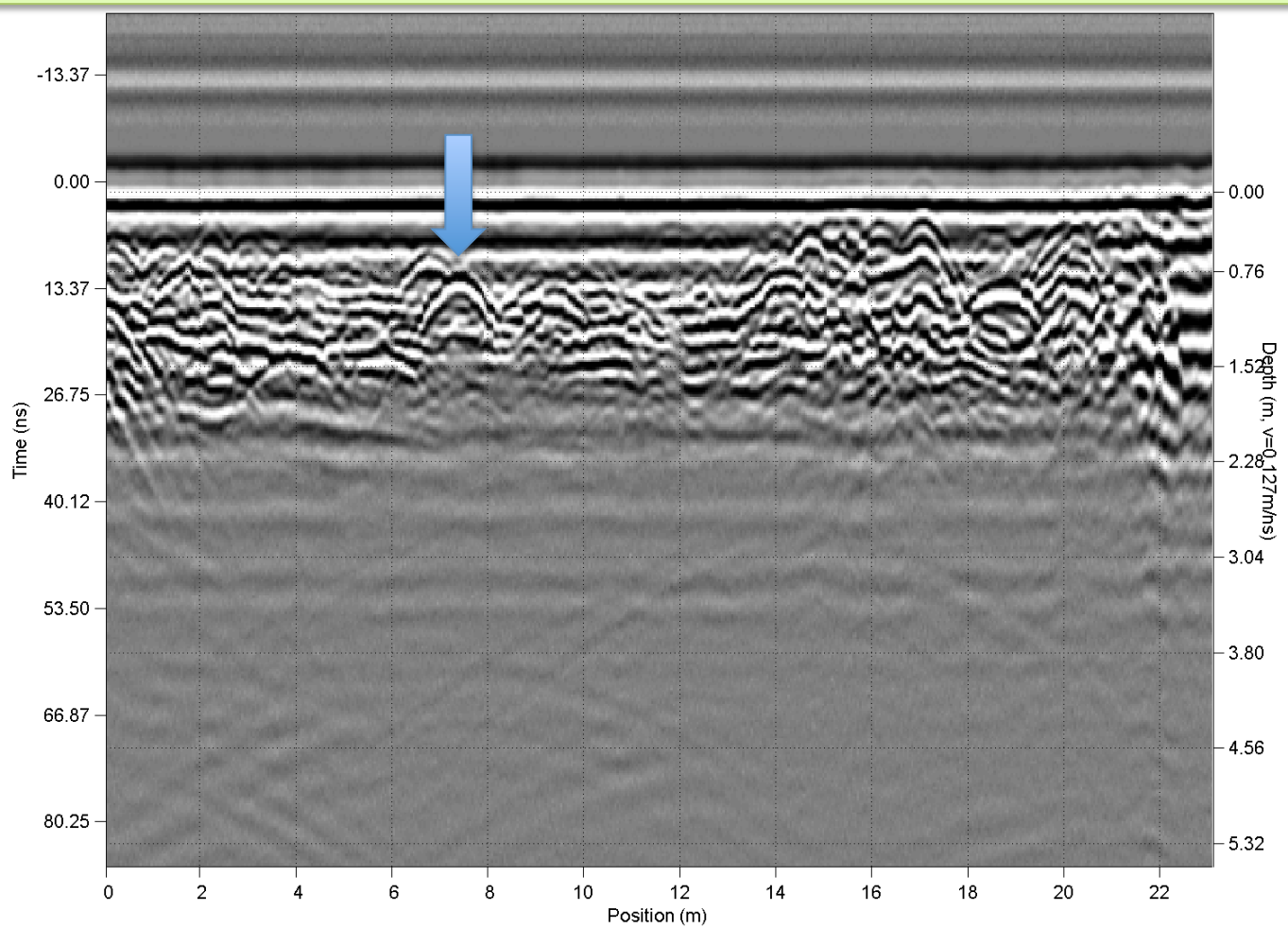
Radargram showing a grave (typical conditions)



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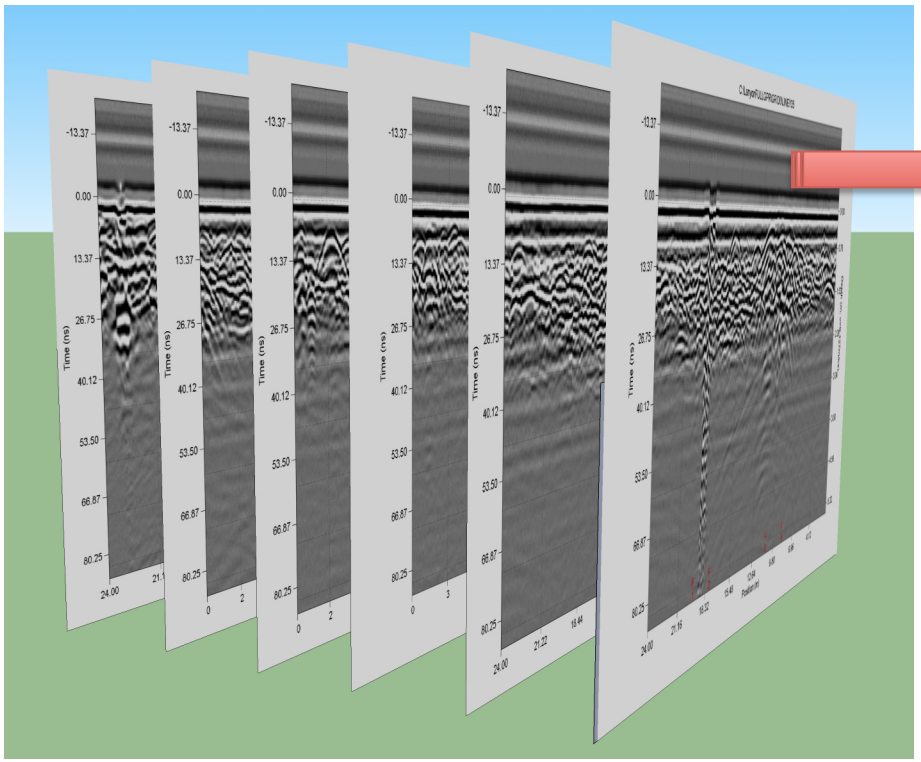
Depth slices

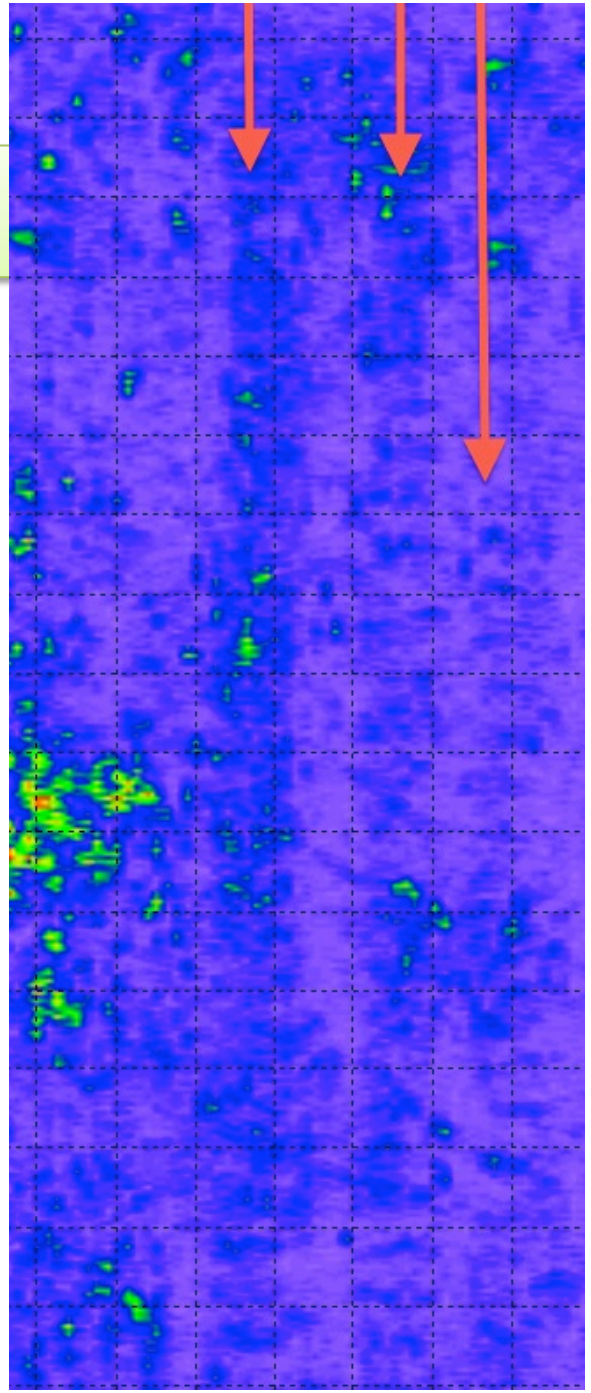
Ground-penetrating radar data can be simplified by creating depth slices.

A plan view of a survey grid may take a few hours to interpret per day of survey work (as opposed to the weeks that may be required to interpret radargrams).

Depth slices

Depth slices are made by stacking radargrams side-by-side, and then slicing the block of radargrams horizontally.





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How can we find an unmarked grave? Soil moisture

Instead of using radiowaves (GPR), the electrical resistivity of the soil can be measured directly by inserting electrodes into the ground and using a resistivity meter.

1. Electricity with known voltage is applied to the ground through electrode 1.
2. Electricity flows through the ground from electrode 1 to electrode 2.
3. The voltage is measured at electrode 2 and compared with the original voltage.

Detected variations in soil resistivity may indicate variations in soil moisture (which, in turn, may indicate the presence of a grave).

Electrical resistivity

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How can we find an unmarked grave? Electromagnetism

Electromagnetic (EM) techniques allow us to wirelessly measure the electrical conductivity (the opposite of electrical resistivity) of the soil.

It is a relatively new method being used for detecting unmarked graves.

Hunter Geophysics uses electromagnetics primarily for detecting broader features, such as dried up creeks, rows of unmarked graves, mass graves or rubbish pits.

How can we find an unmarked grave? Magnetism

Changes in the Earth's natural magnetic field can be detected. This may permit the detection of buried headstones and cremation urns.

Iron-rich materials, including volcanic rocks (basalt, granite) and metal objects can be detected.

Basalt and granite are often used for headstones.

This change in magnetism is detectable using geophysical methods.

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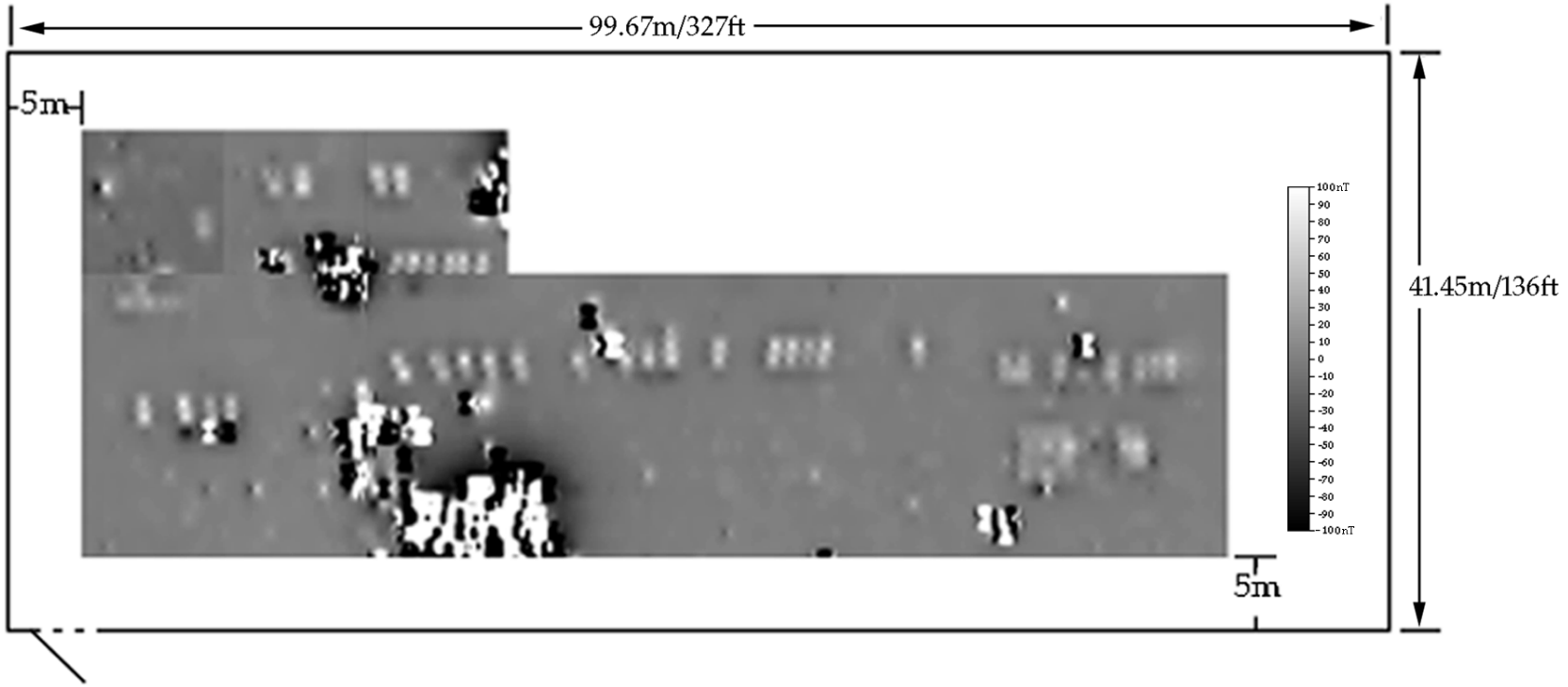
Magnetometry plot of a cemetery



Archaeological Prospectors
St. Paul's Cemetery
Geophysical Survey
Fluxgate Gradiometer Magnetometer
12/10/03
Jason Jeandron, MPhil

Image courtesy of Archaeological Prospectors: http://www.facebook.com/pages/Archaeological-Prospectors/112665468816111

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Case study – Creswick Cemetery

Hunter Geophysics performed a series of geophysical surveys at the Creswick Cemetery in 2011.

The survey covered an area of approximately 50 x 50 metres in Compartment Six. Records indicated that 377 individuals (mainly Chinese) were buried in the area from 1858 until 1923.

The cemetery sexton's cottage was also believed to be located near Compartment Six.

Ground-penetrating radar, electrical resistivity, electrical conductivity (electromagnetics) and magnetic data were collected; old aerial photographs of the cemetery were also examined.

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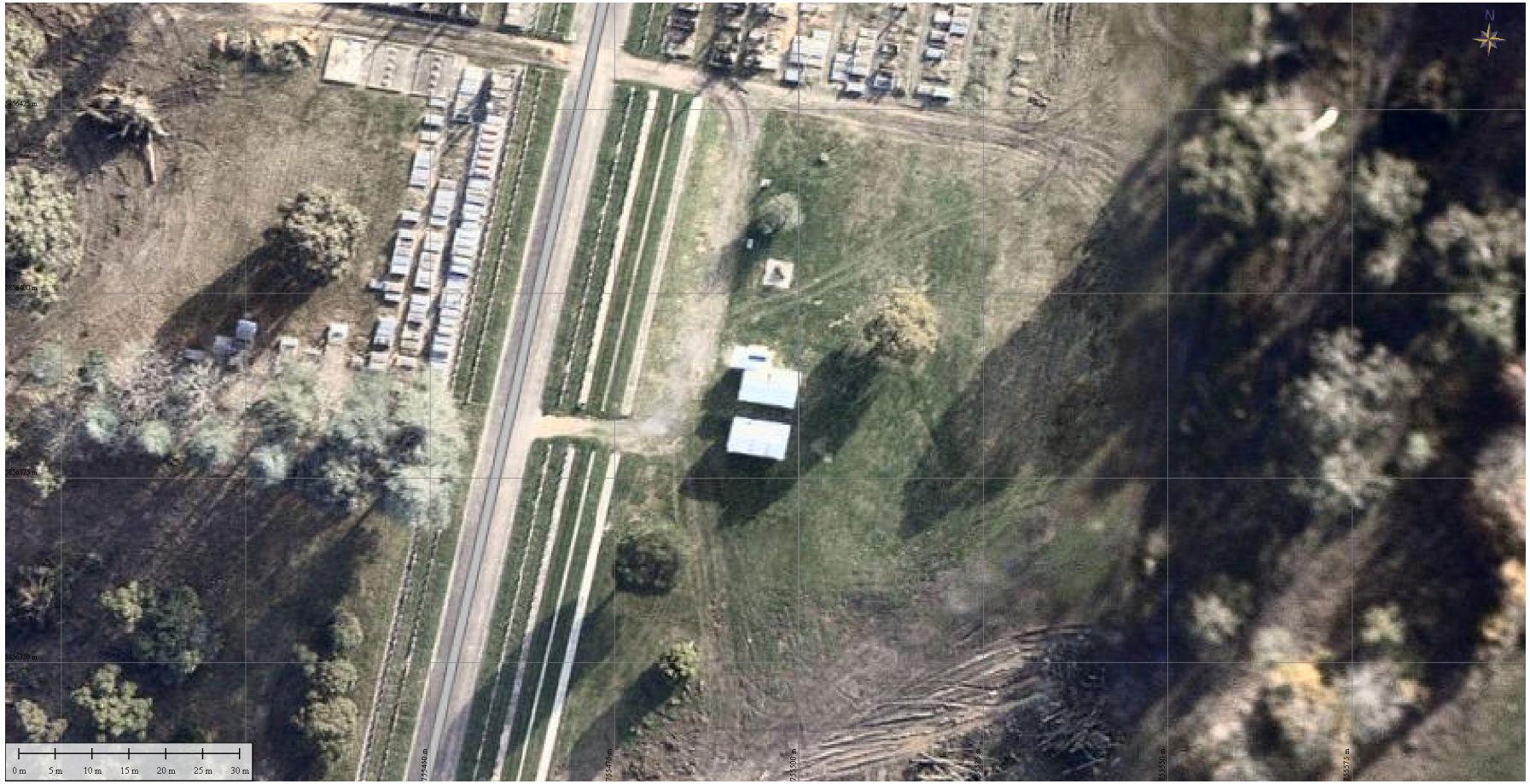
Creswick Cemetery – aerial photographs



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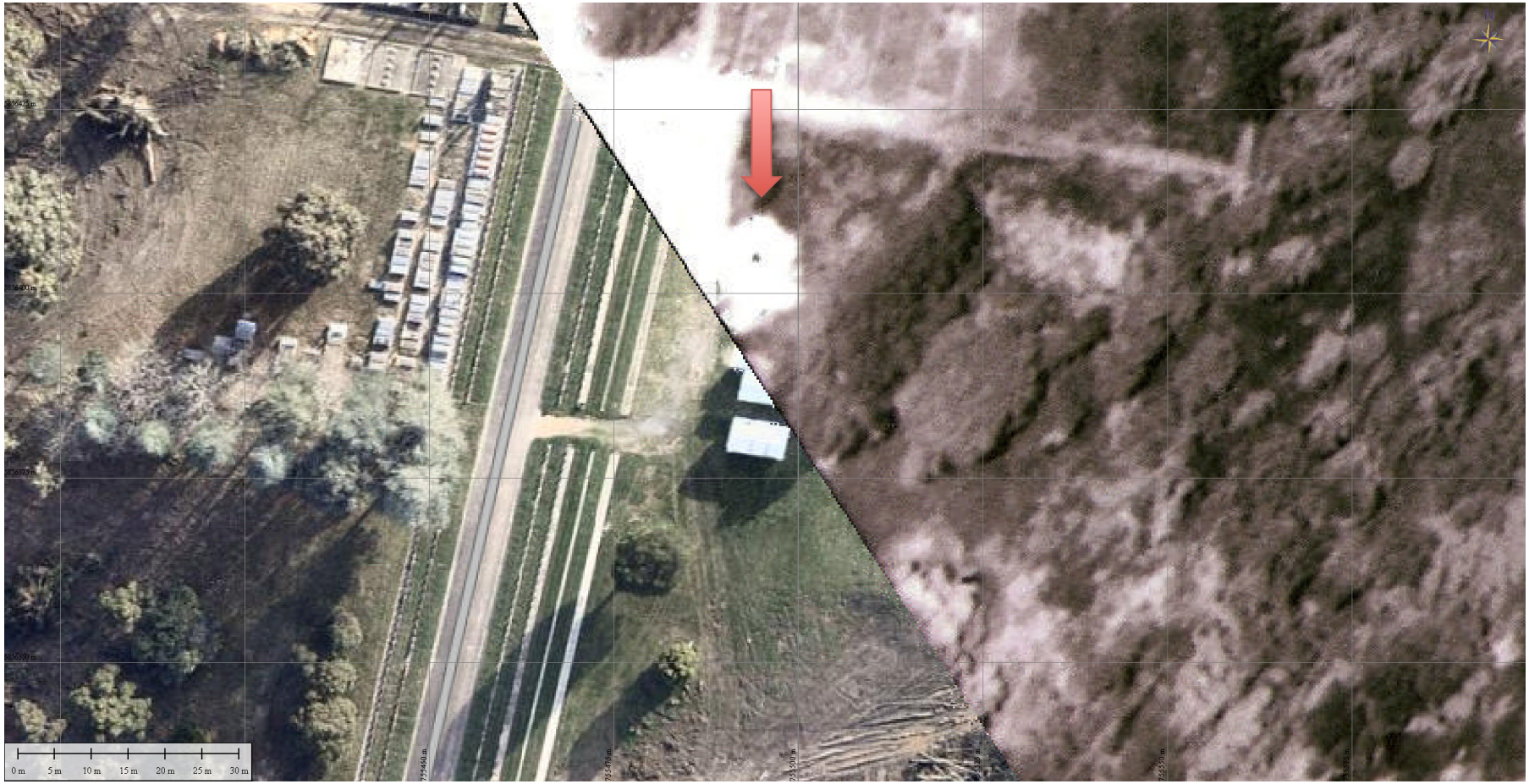
Creswick Cemetery – aerial photographs



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Case study – Creswick Cemetery – aerial photographs

Air photos of the Creswick Cemetery show the possible location of the sexton's cottage, although this could be the sun reflecting on gravel or puddles.

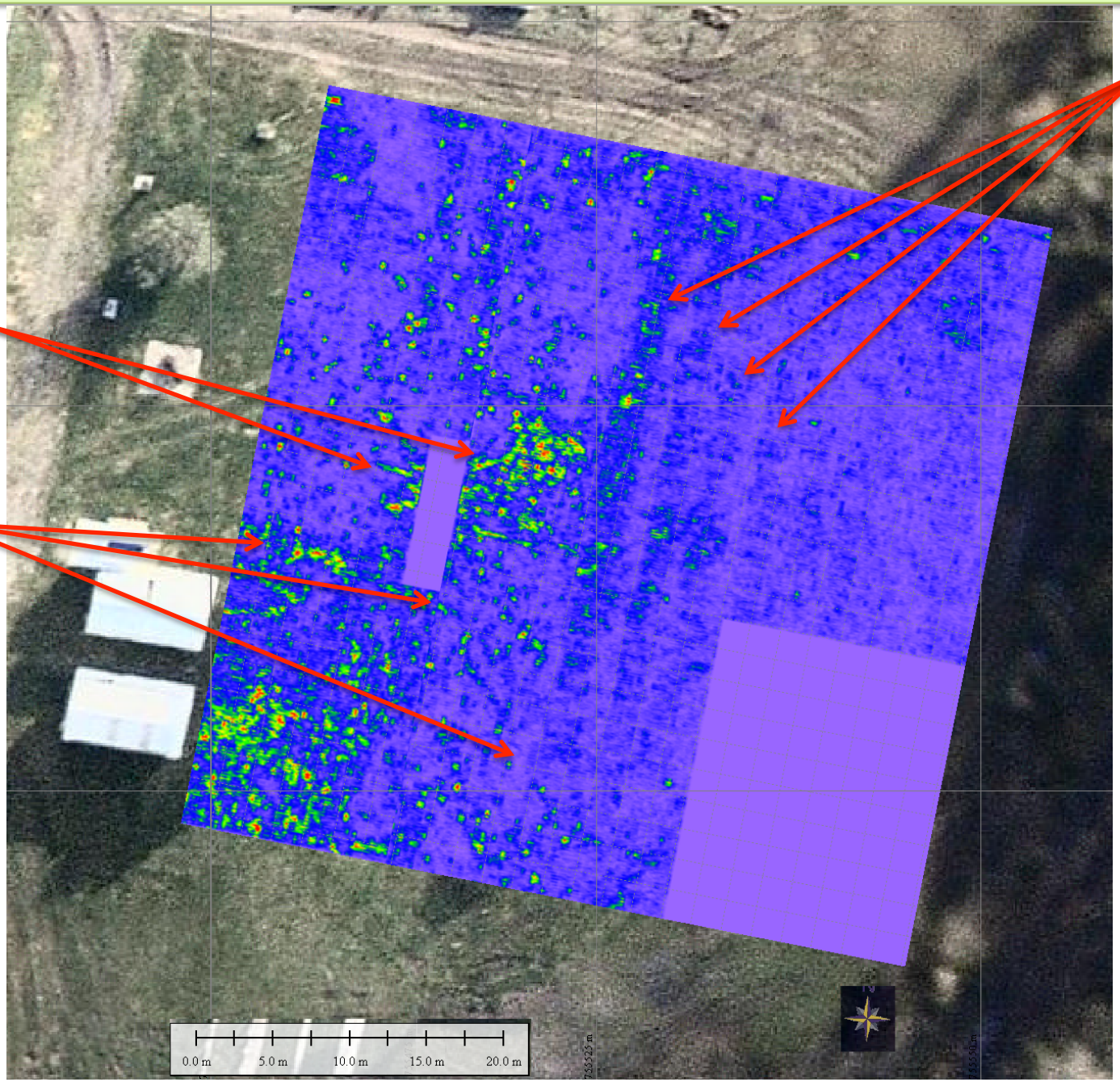
However, as it is roughly rectangular it may be the cottage.

Recent air photo show a drainage ditch leading southward (downhill) from where the cottage would have been (based on the old photograph).

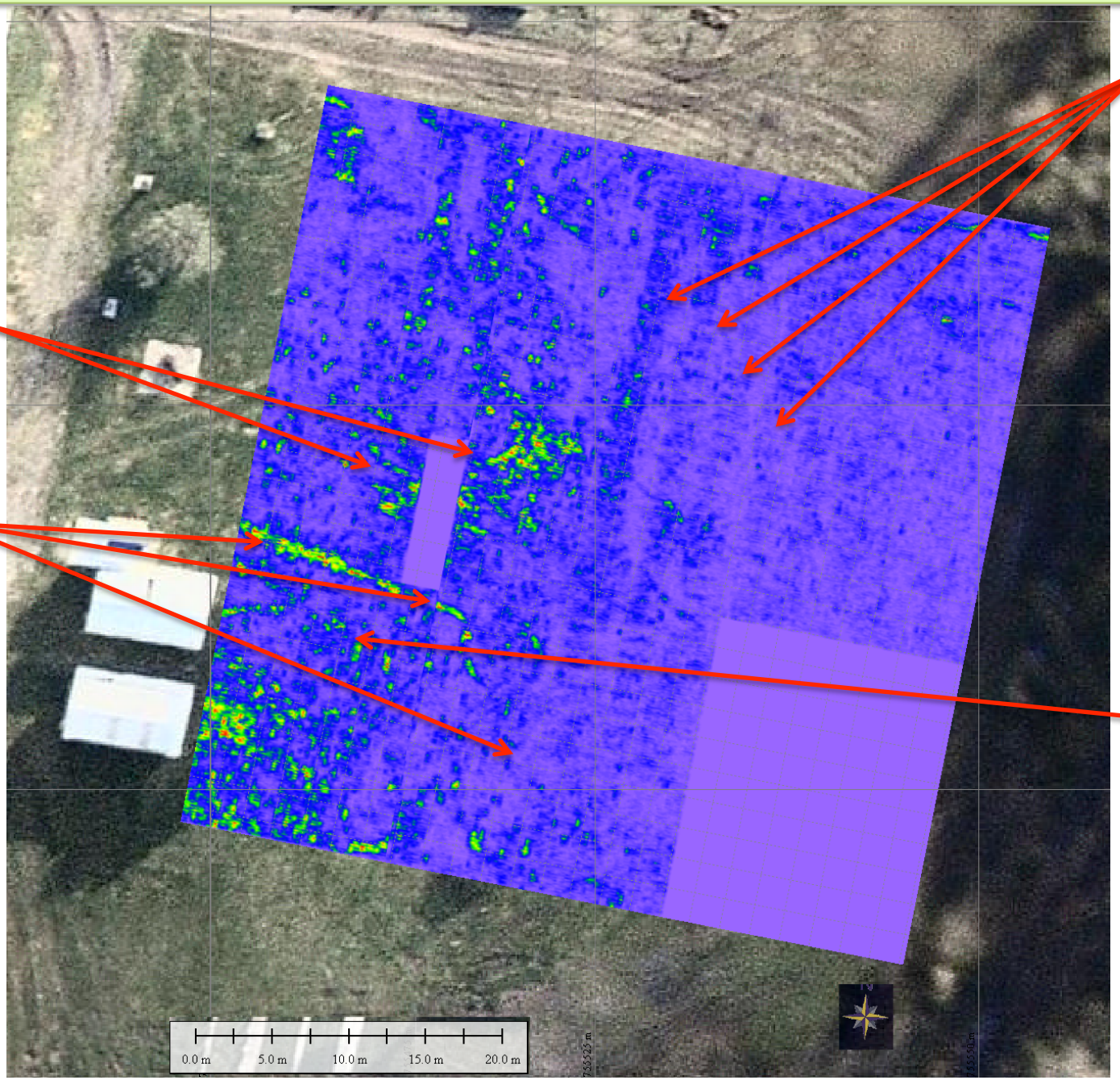
Various artefacts found at the southern end of the drainage ditch.

These artefacts may originate from rubbish pits near the cottage that were brought down the ditch by swelling of the clay soil and groundwater flow.

Creswick Cemetery – GPR results – 20cm below surface



Creswick Cemetery – GPR results – 30cm below surface



Rows of unmarked graves

Tree roots

Drainage ditch (later re-used for a pipeline)

Well associated with cottage

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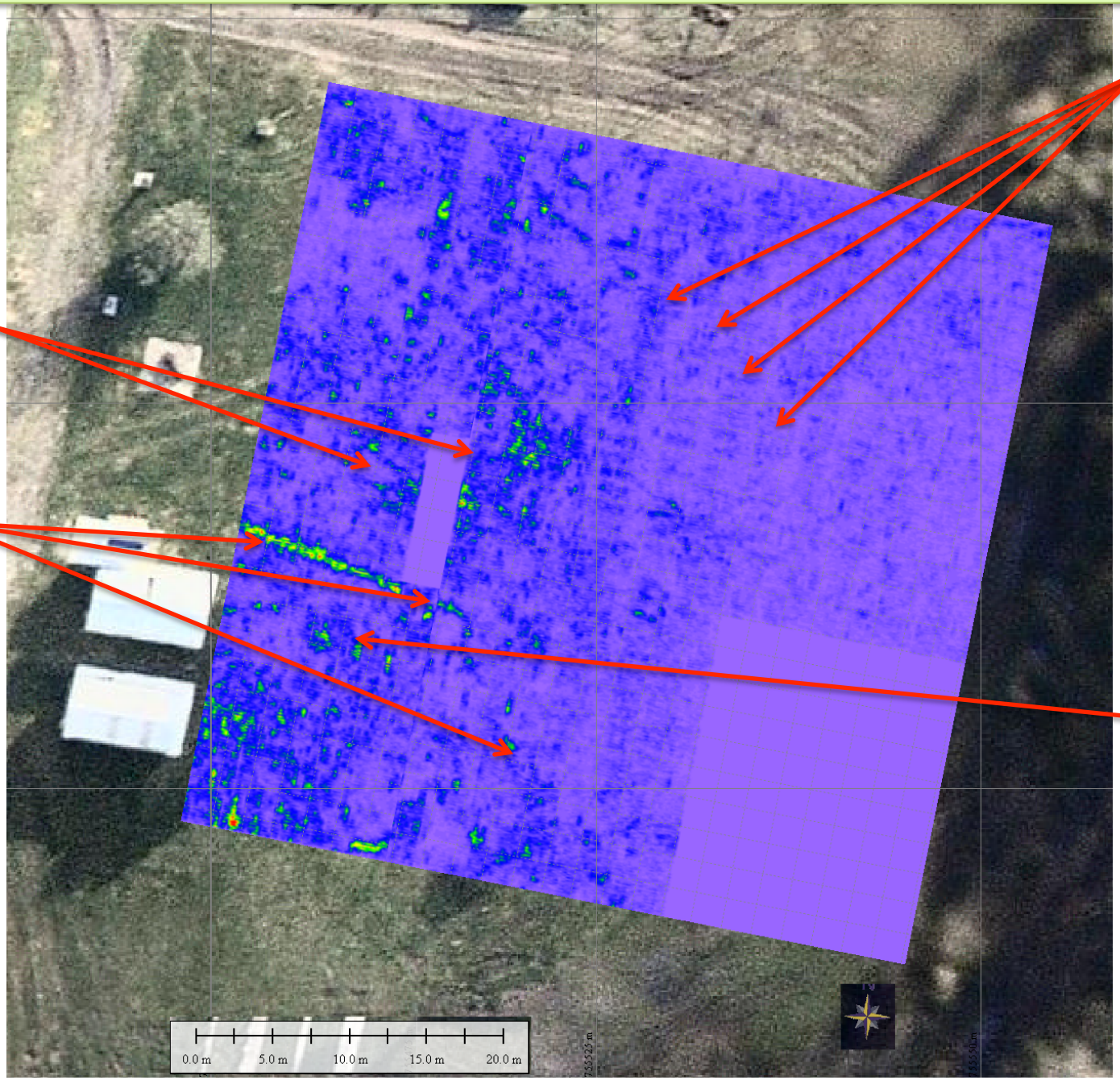
Creswick Cemetery – GPR results – 40cm below surface



Rows of unmarked graves

Tree roots

Drainage ditch (later re-used for a pipeline)

Well associated with cottage

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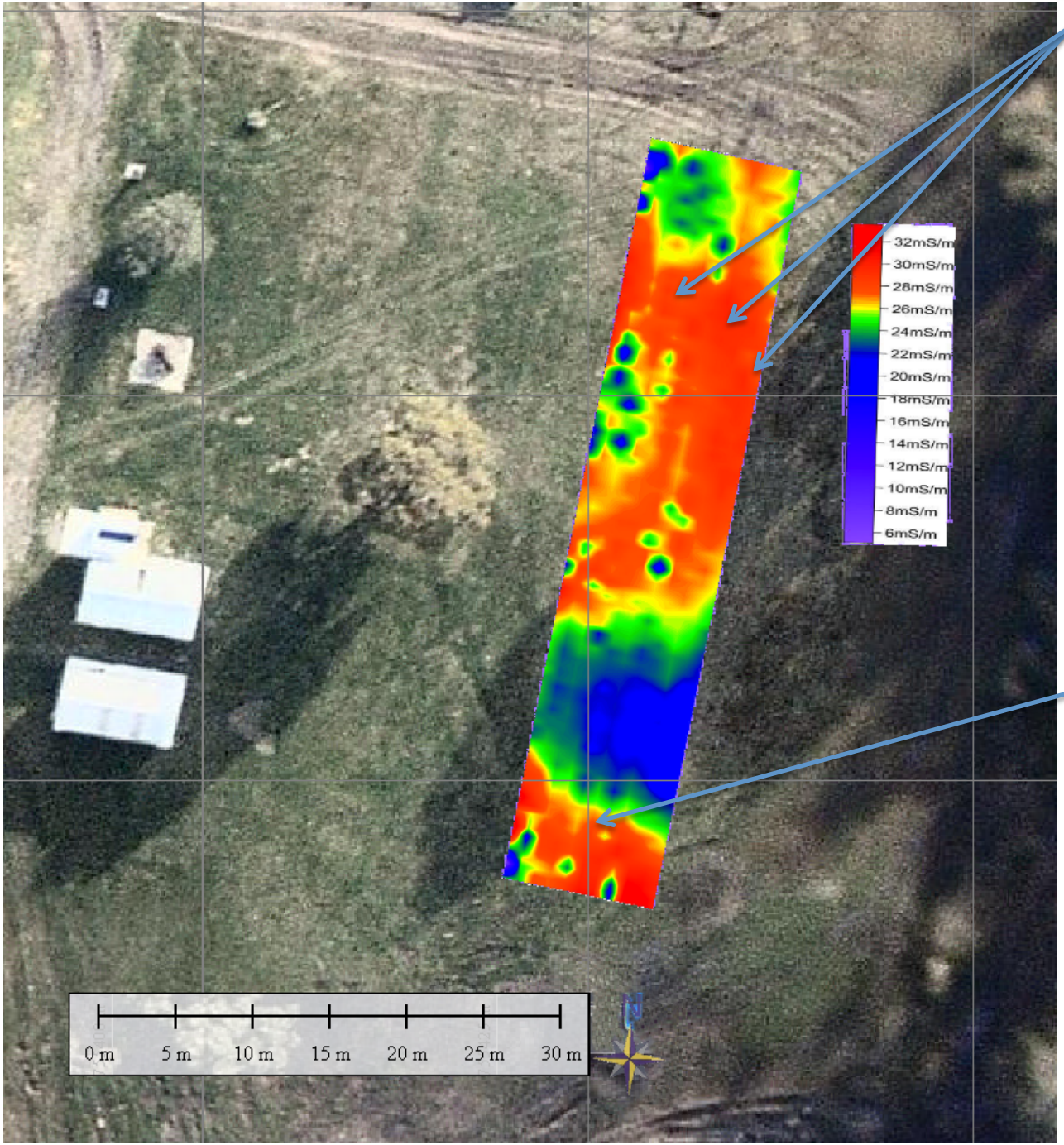
Creswick Cemetery – EM (conductivity) results



Rows of unmarked graves as shown in GPR results. The EM survey has identified the rows of unmarked graves.

The EM survey has also detected a high conductivity feature (i.e. high moisture, iron-rich) at the southern end of the drainage ditch.

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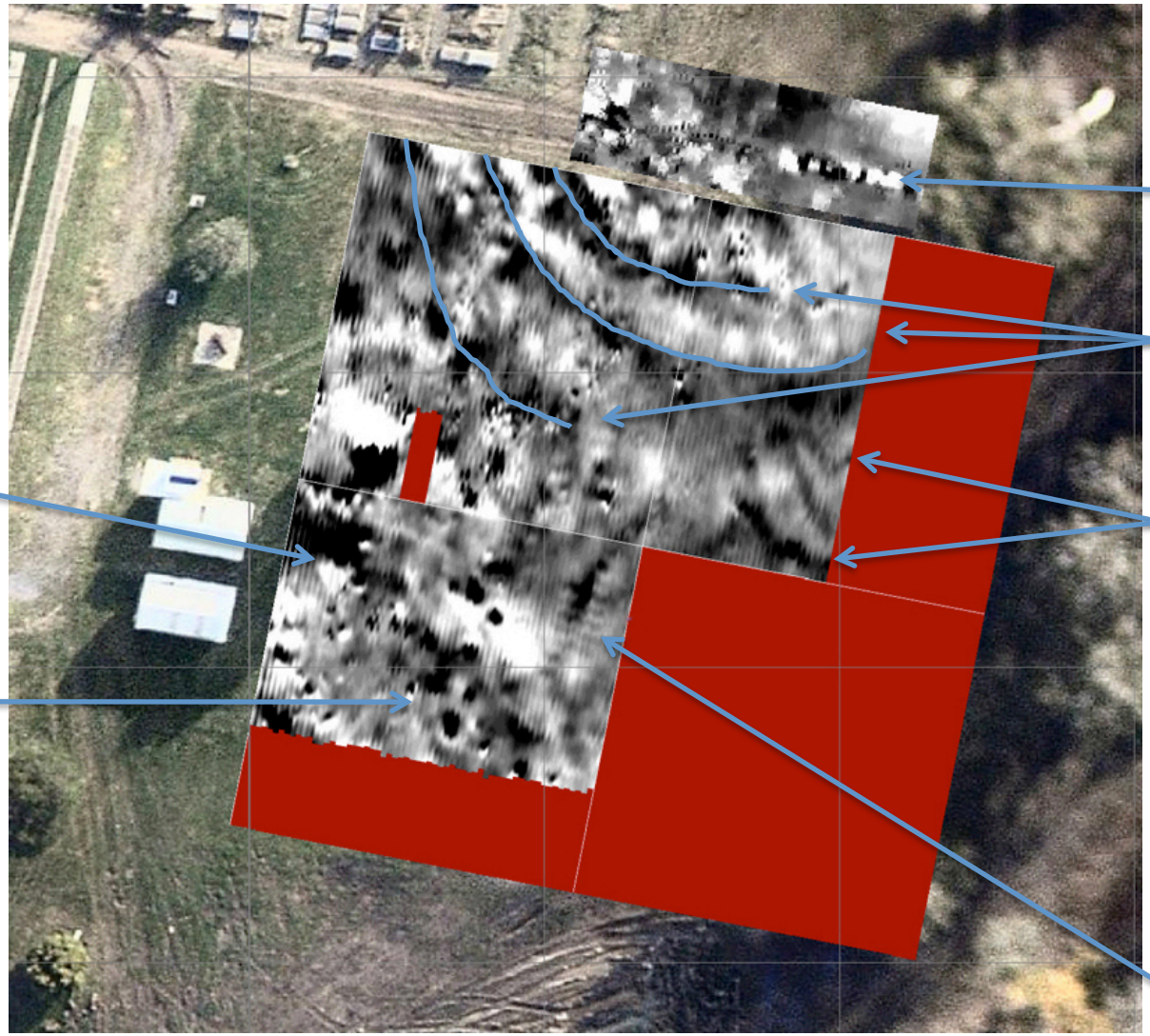
Creswick Cemetery – magnetometry results



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Creswick Cemetery – summary of results

- Four rows of unmarked graves were found.

- The possible location of the remains of the sexton's cottage has been determined.

- A well and drainage system has been located.

- Large collection of artefacts found to the south of the area has been explained.

- Two rows of buried headstones were detected.

- Old creeks have been found.

- A possible second structure has been found with magnetometry.

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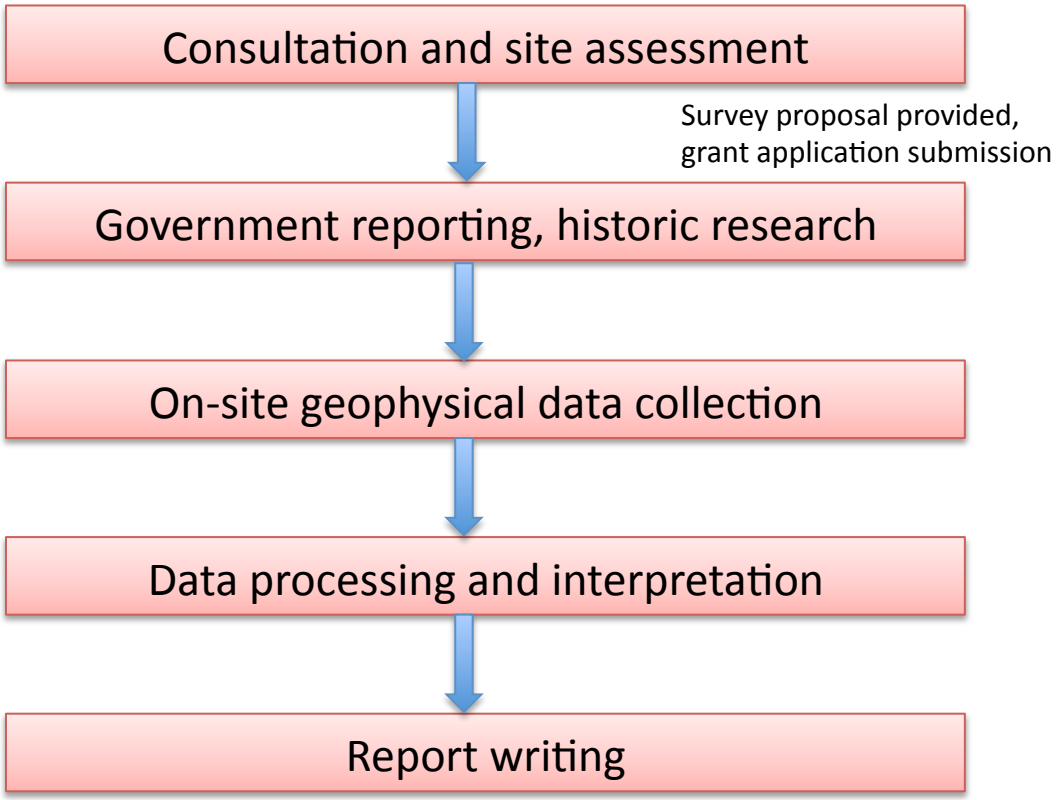
What is the process?



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What is the process?

Consultation and site assessment

When Hunter Geophysics visits the cemetery, we consult with the Trust and discuss the areas that are to be surveyed for unmarked graves.

We also

- Determine the most appropriate geophysical method to use during a survey,
- Locate government survey marks in the surrounding area,
- Mark out the areas to survey using survey-grade GPS,
- Assess OH&S risks and logistical requirements,
- Determine the amount of time required to perform the survey,
- Take soil samples,
- Assess any other matters that may be relevant to the cemetery.

Allows us to provide a more accurate and cost effective quotation.

What is the process?

Government reporting, historic research

Hunter Geophysics must report proposed surveys to Heritage Victoria under the *Heritage Act* (1995).

Heritage Victoria requires that we undertake historic research into the cemetery, preferably prior to performing a geophysical survey.

Information about the cemetery's history provides us with details that can assist in the interpretation of geophysical data.

> For example, if old records state that a particular individual was buried immediately next to a house, and we find wall foundations with an unmarked grave next to the foundations, we will be able to identify the individual.

Undertaking this research ensures that geophysical data is interpreted correctly.

What is the process?

The geophysical survey itself

Hunter Geophysics spends a period of time at the cemetery collecting readings. The time taken depends on the size of the area and the number of obstacles within the area.

Each cemetery is unique and our assessment helps determine the required duration of on-site survey work.

Data processing and interpretation

Following on-site work, data are entered into a computer and sent through a variety of filters to ensure that they are of the highest quality. The data are then plotted onto a map of the survey area and interpreted.

Report writing

Finally, Hunter Geophysics writes a report detailing the findings of the survey, which is then sent to the cemetery and to Heritage Victoria.

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Geophysics is reliable

Geophysics is comprehensive

Respectful of the deceased

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What is the next step?

Contact us if you would like to proceed

Ask me for a business card

Phone 03 9913 2259

Email contact@huntergeophysics.com

Website www.huntergeophysics.com

Read the report written for the Creswick Cemetery at www.huntergeophysics.com/archive