10.1071/PVv2017n187p36

Environmental geophysics

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Sometimes it is not the latest and greatest, or the most fantastic, expensive and complicated geophysics that find economic viability. In the environmental market it is more often geophysics that is focused on the needs of the client that is most viable (nothing too profound there – but not always done). In our age of cheap memory, reliable GPS and the advent of the Internet of Things (IoT), 'focused' geophysics is even more important. This month I have asked Dave Allen of Groundwater Imaging (http://groundwaterimaging.com.au) to put together some of his thoughts based on his years of working as a practicing geophysicist in the environmental field, both developing instrumentation and then running surveys. Much of his work is with farmers, helping identify issues on their land, often to improve their irrigation infrastructure. In this article Dave talks about developments that he has made on the systems that he builds and runs to collect data over canals, and other watercourses. Dave also designs, builds and runs shallow-TEM systems for farm fields, wetlands, etc., and has applied the same improvement principles to these as well (worth looking at on his website).

Here is what Dave has to say:

Focused geophysics

(from the perspective of an applied environmental geophysicist)

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My experience applying electrical geophysics to the problem of imaging beneath watercourses has taught me that simple and appropriate geophysics 'sells'. Quite a few of my clients really have relatively simple questions. A very common one is: where am I losing water under my irrigation canals? This is not one of the 'deep' hydrogeological problems that I set out to solve when, many years ago, I started my PhD research on imaging groundwater salinity and groundwater-river connectivity using electrical techniques. Sure, the relatively complex data acquisitions systems that I developed were useful to research-oriented hydrogeologists studying river-groundwater connectivity but, as my consultancy developed, I saw a much wider application of simpler (but more focussed) systems to the problems that farmers and other land-users had.

The process of 'simplification' is quite challenging. The innovations that I experimented with had to make the data that I collected useful to my clients, but couldn't actually make the data collection process more expensive. Additionally, there was the problem of letting the market know about the improvements that I had made. Many of my potential clients were relatively unaware of the obvious (to all of us?) advantages of using geophysical data. Additionally, they required geophysical data sets that provide information they can interpret without a large amount of training. Obviously the geophysicist needs to interact with potential clients at an appropriate level; often the solutions that are suggested to clients may achieve results that they never thought possible.

simple and appropriate geophysics 'sells'

My work on environmental geophysics started with my Honours work in 1991 on towed array resistivity. It continued in 2002 as I started constructing waterborne geo-electric streamers as part of my PhD research. My first attempts at array construction were big, heavy, floating streamers using conventional dipole-dipole arrays that were deployed with large receiver systems and transmitter equipment that needed hundreds of volts of input and put out several amps. The transmitter system required power from not one but two truck batteries, making field logistics literally horrific. Additionally, data quality was not as good as it could be – but a start was made. I was using state-of-the-art, off-the-shelf geophysical equipment and software that were not really appropriate for the problems I was working on; ultimately it was just not marketable. Over the years 'simplification' of equipment and software has resulted in the development of systems suitable for imaging sediments under irrigation canals, drains, reservoirs and general river surveys.

Some of the refinements that I have made to improve the data collection system include:

- replacing the conventional dipole-dipole array that I used at first (based on the needs of mineral exploration) with an exponentially spaced bipole array to improve SNR and data distribution (this exponential array refers to variable spacing that uses shorter spaced receiver electrodes for electrodes collecting shallow data, and larger spacings for deeper data);

- optimising the array – with better spacing it was possible to use fewer channels to collect the same data as with the larger less optimal arrays;
- identifying and minimising noise sourced from streaming potential;
- setting up the cable so that the array is now often dragged along the watercourse bottom. This improves the resolution of the water-sediment interface and also improves thickness estimates of (what I like to call) the sludge layer.

I have also worked on improving the robustness of the system, making it stronger, easier to move and less likely to break in the field. Some of these improvements are:

- the streamer is now constructed of a simpler, multi-channel (thick wire) copper conductor cable with moulded-on electrodes (much stronger and more robust than some of the network cable variations that were used originally);
- new receiver/transmitter electronics that were tested until a compact solution providing enough power for the more efficient array configuration described above was developed (Figure 1 shows the significantly smaller receiver/transmitter unit);
- instead of requiring a boat to tow the electronics and array, the new, smaller electronics package is built into a waterproof floating enclosure that can be pulled by one person using ropes from canal banks, making the entire setup easier to drag over the obstacles that are frequently found in canals. The unit can still be towed by boat where appropriate (Figure 2 shows the unit being dragged past a typical canal obstacle – a small irrigation regulator);
- a set of dedicated software and 1D inversion code was written to robustly and efficiently process the resistivity data collected by this system (1D modelling is quite fast and provides sufficient information for nearly all of the data that are collected);
- code has also been written to display, in ‘3D’ on Google Earth, imagery of the inversion results that clients could understand and geo-locate with reference to features that they are familiar with on their properties (Figure 3). Using their knowledge of the soil and other conditions on their farms, along with their own observations of canal water loss, they could interpret the geophysical data and understand what it was telling them – again integrating their own knowledge with sensible presentation of the data.

Geophysics focused on solving real world problems simply, and in a cost-effective fashion…

I am constantly trying to improve the usefulness of the data that is provided to my farming (and other) clients. For example, I am presently working on integrating (and simplifying) data collected using a commercially available full-waveform sonar to provide additional information on sediment firmness at the base of canals, information that may be useful when canal leaks are being repaired and earthmoving contractors are working in the drained canal. Geophysics focused on solving real world problems simply, and in a cost-effective fashion, is what keeps my business viable.

Figure 1. *New receiver/transmitter electronics package being towed along an irrigation canal. The electrode array is being towed along the canal bottom and is not visible.*

Figure 2. *Electronics and array being dragged through typical canal obstacle. Small regulators, like these, and other obstacles may occur every 100 m along a typical canal.*

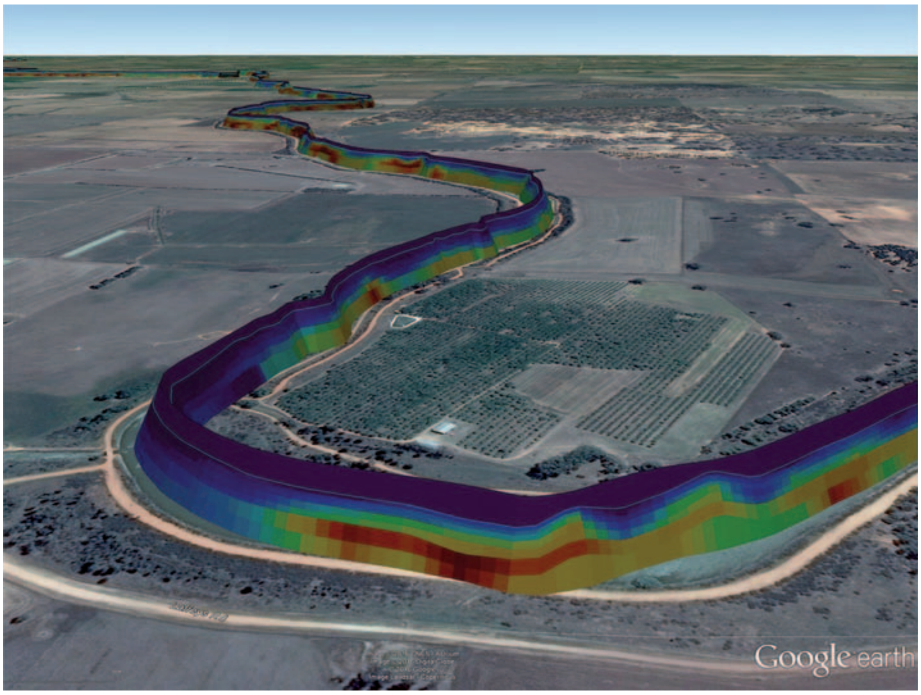

Figure 3. *Electrical resistivity projected along a canal. The aqua line represents the canal bed. Reds in the sections are conductive, while purples are resistive. Indurated bedrock, weathered eluvium, and possibly windblown sand, are inferred to be representative of the materials under this canal.*