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DELIVERING LARGE-SCALE ENVIRONMENTAL FLOWS THROUGH AN AGRICULTURAL LANDSCAPE – UPPER SOUTH EAST REGION OF SOUTH AUSTRALIA

Darren Willis, Naturallogic Australia Pty Ltd

The South East Region of South Australia is today a highly modified landscape. Broad-scale land clearing and an extensive drainage network have converted what was once a wetland dominated landscape to agricultural production on a vast scale.

As part of the region's development, extensive cross catchment drainage schemes were constructed in the South East that intercepted surface water flows and removed them from the landscape. Instead of surface waters from the Lower South East (LSE) flooding the Upper South East (USE), water has been progressively drained to the sea since the early 1900s. Conversely, a lack of coordination of drainage works left the USE prone to flooding.

A series of extensive and prolonged flooding events in the 1980's and early 1990's resulted in a significant rise in saline groundwater, the result of which was the onset of extensive tracts of dryland salinity across the landscape.

The USE Program was established as an integrated scheme, incorporating environmental and engineering sub-programs, designed to address flooding and salinity problems in the at-risk parts of the landscape, whilst at the same time providing for the conservation and enhancement of biodiversity assets across the region, with a particular focus on the delivery of environmental flows to key wetlands.

The USE Network is not simply a drainage scheme as commonly described. It's an integrated system of drains, flood-ways, natural watercourses and wetlands, through which flows of different natures can be manipulated, by a sophisticated arrangement of approximately 150 flow regulating structures, to achieve a variety of objectives.

A broad program of work has been undertaken to develop the infrastructure, knowledge-base, operating principles and decision support system to underpin the management of the USE Network. The USE Program has:

- Established extensive water resource management infrastructure to enable the manipulation of ground and surface water resources for fit-for purpose application
- Invested in the development of natural asset inventories, system-level and ecological component conceptual models to underpin ecological character descriptions and particularly to define environmental watering objectives and prescriptions for environmental flow delivery
- Invested in the development of regional water resource assessments and regional 'downscaling' of climate change scenario impact projections to underpin strategic thinking about future water resource availability and application
- Established an integrated hydrometric/water-quality/ecological-response monitoring network to provide data to underpin management planning, operational decision-making and response evaluation
- Established perpetual conservation covenants of some 12,000 ha of biodiversity assets on private lands, including a number of significant wetland systems.
- Established a sophisticated Decision Support System.

Adaptive management is a process that promotes flexible decision making that can be adjusted in the face of uncertainties, as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process.

Adaptive management also recognises the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes planned management experimentation and learning through experience.

It was recognised that such an adaptive management approach would be required to manage the USE Network into the future. Establishing an effective adaptive management framework for the USE Network required the core elements of:

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DELIVERING LARGE-SCALE ENVIRONMENTAL FLOWS THROUGH AN AGRICULTURAL LANDSCAPE – UPPER SOUTH EAST REGION OF SOUTH AUSTRALIA

Darren Willis, Naturallogic Australia Pty Ltd

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- A systematic, structured approach to management
- A comprehensive practical understanding of the natural resource system - its component elements and processes
- Realistic conceptual models of the system as a basis for exploring and defining how it works (conditions and processes); for evaluating risks, constraints (including uncertainty) and management alternatives; and for defining objectives and developing intervention strategies and evaluation systems
- Clear, practical articulation of management 'logic'- goals/ objectives, constraints, strategies, methods, performance criteria, evaluation framework
- Deliberate (scientific) testing of assumptions and predictions – and applied knowledge generation
- Well-designed monitoring and measurement of both the natural resource system and management performance
- Diligent review of learning's and application to future planning and decision-making
- Full transparency and accountability of process.

Information capture and knowledge development - Considerable work has been done to develop the systemic understanding, multi-disciplinary knowledge-base, data resources, operating principles & rules, monitoring capabilities, ICT platform and decision support system to underpin the adaptive management of the USE Network into the future.

This work has included the development of:

- A Network systemic model and related hydrological modelling
- A very high resolution (LIDAR derived: +/- 150mm) micro-topographic digital elevation model to underpin water harvesting, flow and flood mitigation planning through this broad, flat landscape
- Wetland asset inventories, detailed ecological conceptual models and environmental flows prescriptions covering the 14 Wetland Landscape Unit types represented across the region
- A comprehensive engineering structures/capabilities inventory and flow management structure operating guidelines for all flow regulating units
- An integrated hydrometric / water quality / wetland response monitoring network, which provides critical data to underpin system modelling, resource planning, event prediction and warning, real-time operational decision-making; and to evaluate both system and management performance.
- A systemic operational management strategy, defining management purposes and functional requirements for 28 Network Management Units and 5 critical Source-water Catchments; and operating guidelines for each regulator in the Network
- A management decision support system, using a spatially interfaced, relational database platform, to inform management option scenarios, flow planning, operational decision-making and post event evaluation.

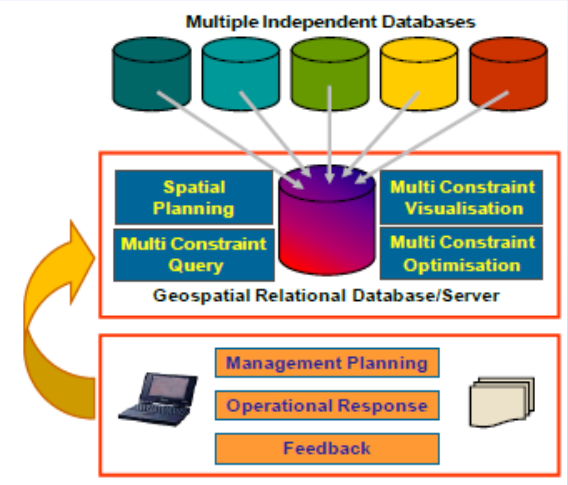
The decision support system - The product of this work is not a classic 'Plan' (a bound document which ends up sitting on a shelf), but rather an interactive geospatial/relational database that:

- Holds the collective body of knowledge relating to the landscape and the Network features - topography, ecological assets (wetlands), operating infrastructure and water resources.
- Captures relevant new meteorological, hydrological, ecological and operational data about how the landscape and the Network are functioning.
- Defines the current flow management prescriptions for catchment management units and in many cases individual wetlands or wetland complexes.
- Identifies the current operating principles and 'rules' for the network (condition-based diversion triggers for example) - from the catchment level down to the individual regulator.
- Makes this information available to decision-makers when planning the management of the Network and/or considering specific operational management decision options.
- Captures and accounts for all related management decisions and actions and supports the practical evaluation of their consequences.

These capabilities have been applied to plan, implement, monitor and evaluate progressively more complex multi-source / multi-target environmental watering events over the past six years of the Program.

The learning's from this experience are captured, evaluated and fed back into the relevant system models, management logic frameworks and operating guidelines to refine system understanding and management performance into the future.

Environmental Flows Adaptive Management DSS - High-level Concept



HYDROGEOPHYSICS: SOMETHING OLD AND SOMETHING NEW - AN OVERVIEW OF FAST-SAMPLING TEM AND NMR

Brett Ibbotson, Eco Management Services Pty Ltd

On Thursday the 28th June, attendees at the Hydrological Society technical meeting were treated to an insight into applications of hydrogeophysics by Michael Hatch from the University of Adelaide.

The presentation started with some equations that only an engineer would understand, although many would choose not to. Following this was a curious graphic illustrating the electromagnetic spectrum and the frequency range for various geophysical techniques. This graphic also included the frequency range for other random items such as brain waves, superman's heat vision and shouting car dealership commercials.

An overview of electromagnetic application to sampling was discussed which led into an explanation of Time Domain Electromagnetics (TEM). TEM represented the "something old" aspect of the talk.

Members of the Hydrological Society may remember a technical meeting last year on the Murray River salt interception scheme which used this technology to identify 'hot spots' of saline groundwater intrusion into the river. These areas were then prioritised for the salt interception scheme.

TEM measures the resistance of the matter that it passes through; high resistance causes a fast decay in the signal voltage while material with a low resistance causes a slow decay.

In this way, two dimensional depth profiles can be created that illustrates the conductivity of different layers through the depth profile. This can be used in both soil and water profiles.

The difficultly comes in trying to determine what the different conductivity layers represent. In a water column, conductivities can be directly attributed to salinity and to a lesser extent turbidity. In a soil column this becomes more complicated since characteristics such as soil texture and porosity influence conductivity along with soil water salinity and presence.

Michael showed the various electromagnetic arrays that have been used for both land and water based measurements of TEM. He showed us that in his line of work you can get paid to go on a house boat holiday, as long as you drag a TEM array behind you. I, for one, was jealous.

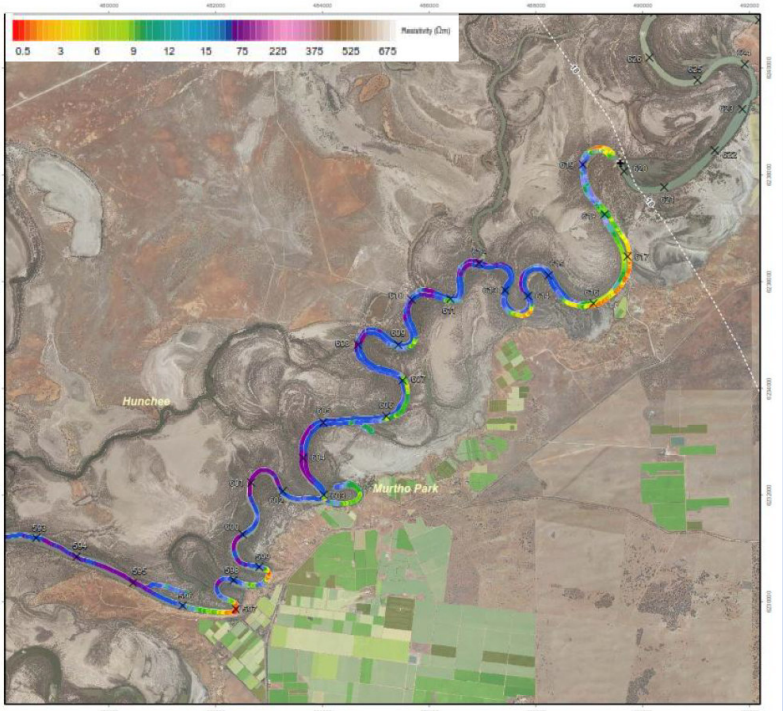
Data was presented that proved they got some work done while out on the river. Areas of high salinity were clearly identified in the colour coded scale.

There was discussion amongst the presenter and members of the audience as to the cause of the high salinities in certain sections of the river with the evidence pointing towards infiltration from adjacent irrigation areas, both past and present. (see figure below)

In summarizing the TEM applications, Michael stated that TEM is useful to provide conductivity information about the near surface. Useful readings generally start 1-2m below the surface so that, depending on configuration and ground conductivity, information on depths of 10 to 100m can be achieved. If run as a discrete station, around 40-50 stations can be sampled per day with good depth penetration. If towed behind a boat, car or other vehicle, it can take a long time to set up, but can take readings at around 5-10 kph although has less depth penetration than discrete stations.

The talk then moved on to the "something new" item which was the technology of Nuclear Magnetic Resonance (NMR). These systems take advantage of quantum physical effects that are based on the nucleus of a hydrogen atom (among other atoms).

The public perception of the word 'nuclear' has resulted in some name changes; in medicine it's called MRI-Magnetic Resonance Imaging and for geological work it's often called MRS-Magnetic Resonance Sounding or GRM-Ground Magnetic Resonance.



Instream NanoTEM, data shown courtesy of Peter Forward, SA Water

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HYDROGEOPHYSICS: SOMETHING OLD AND SOMETHING NEW - AN OVERVIEW OF FAST-SAMPLING TEM AND NMR

Brett Ibbotson, Eco Management Services Pty Ltd

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This technology has been used in the oil industry for some time, although on a coarser scale and as a borehole tool. It has been recognised as being potentially very useful for in situ hydrological characterisation, however, earlier applications were not successful. The current application of this technology is a new incarnation of an existing technology.

Michael did a great job of explaining the basics of NMR and the quantum physics involved. I will not attempt to repeat the feat here but would direct those interested to view Michael's slides which should be available on the Hydrological Society website shortly (www.hydsoc.org).

In essence, the protons in the hydrogen nuclei of water molecules act as little magnets. These little magnets are excited using an alternating pole electromagnet which moves them away from their resting position.

When the electromagnet is turned off, the protons move back to their original positions. The movement of the protons (little magnets) creates a small electrical current, the decay of which can be measured (similarly to TEM).

The decay, or relaxation rate, in porous media is governed by surface interactions and can be used to estimate pore size distribution and hydraulic conductivity.

NMR can be used either at the ground surface, or subterranean via a borehole. Multi-channel surface NMR is non-invasive, is cheaper than drilling and has a maximum depth resolution up to 150m.

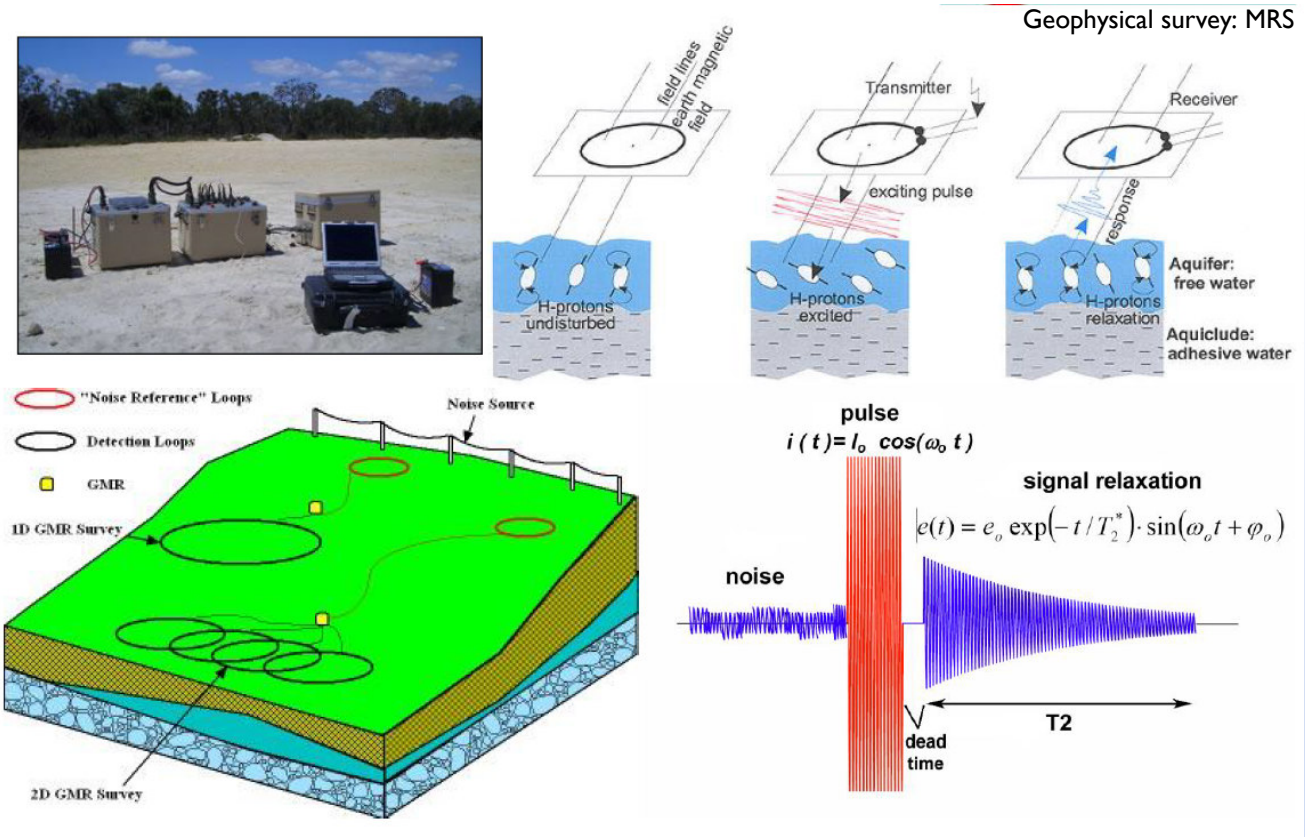
Noise reference loops are used to detect and remove background noise (eg power lines) from the NMR readings. This method is relatively time consuming and may not work in all areas as signal levels are low, so is sensitive to cultural noise.

For downhole NMR a borehole probe (the 'Javelin') is lowered down a borehole. This tool is sensitive in a narrow cylindrical zone around the tool that is intended to be outside of the area disturbed by borehole construction.

This gives improved estimation of porosity and permeability in the undisturbed formation, and is not affected by drilling mud and hole fill. Downhole NMR is not overly affected by cultural noise, however, it is also relatively time consuming and gives very localised information.

In summary, NMR is good for targeting groundwater. It is able to get bulk estimates of aquifer properties, including porosity and permeability (improved with calibration). NMR can be run from the surface or as a borehole tool.

The Hydrological Society would like to thank Michael Hatch for his presentation and looks forward to hearing about further developments in his research area in the future.



UPCOMING EVENTS

The Hydrology and Water Resources Symposium (HWRS) 2012 is Australia's largest symposium devoted to hydrology, water engineering and related areas in water resources management.

The Symposium has a long history as Australia's pre-eminent event in hydrological research and provides a forum to discuss emergent and innovative approaches for practicing engineers and scientists.

HWRS 2012 will bring together a large audience of academics, government officials and industry practitioners. Symposium highlights will include presentations from various researchers working on the 21 Australian Rainfall and Runoff Revision Projects, and keynote presentations from some of the world's leading experts in hydrology and water resources.

We look forward to seeing you there!

HWRS 2012 Committee

CSIRO LAND & WATER
www.csiro.au

Dear Colleagues,

We are pleased to invite you to attend an intensive training course on uncertainty modeling in water resource, ecosystem and landscape management using the Markov Chain Monte Carlo based DREAM (Differential Evolution Adaptive Metropolis) simulator. Methods such as DREAM permit proper accounting of all sources of simulation error, including parameter, model structural and forcing data uncertainty. The method implements a novel adaptive Markov Chain Monte Carlo (MCMC) algorithm for efficiently estimating the posterior probability density function of parameters within a Bayesian framework.

The course is mainly intended for MSc. and PhD. students, researchers and practicing professionals wishing to expand their knowledge on model-data synthesis methods and uncertainty quantification. Course highlights include the latest developments in model-data synthesis using the DREAM software package. Particular emphasis is placed on Bayesian inference, posterior inference, and explicit treatment of all sources of error. The applications we envisage during this training course are at the interface of several disciplines including hydrogeology, soil hydrology, soil carbon and nutrient cycling, and agro-meteorology. The course introduces participants to state-of-the-art optimisation, posterior sampling, data assimilation and model averaging methods and packages for quantification of predictive uncertainty.

Computer exercises in the afternoon are used to illustrate the theory and concepts that have been introduced and discussed during the morning sessions. The course is specifically designed so that participants can easily use the DREAM package and ideas in their own research and work. The DREAM package and its derivatives are distributed free of charge to course participants.

Professor Jasper Vrugt from the University of California at Irvine will be our main instructor. Jasper developed the DREAM simulator and other new computational methods that better analyse the discrepancies between model predictions and corresponding observations, and provide feedback to users about the errors in the model, input (forcing/boundary conditions) data, and other variables such as model parameters. Jasper was recently awarded CSIRO's Sir Frederick McMaster Visiting Fellowship.

The course will be organised from 24-28 September 2012 at Flinders University (Faculty of Science and Engineering).

We look forward to meeting you at this exciting training course. Registration is on a first come, first served basis as seating is limited.

Further information is available at www.csiro.au/DREAM. For registration and inquiries please contact Marcia Sanderson.

Best regards,

Dr. Dirk Mallants
Research Program Leader Groundwater Hydrology
CSIRO Land and Water

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MEDIA WATCH

Ocean renewable energy
CSIRO modelling predicts that wave energy could play a large part in Australia's future energy mix. Ocean energy extraction is an emerging technology and research is required on the nature of the resource, technology, performance and understanding the wider impacts.
http://www.csiro.au/en/Organisation-Structure/Flagships/Energy-Transformed-Flagship/Ocean-renewable-energy.aspx

Proposed amendments to the water market and charge rules
Amendments are proposed to the Water Market Rules 2009 and the Water Charge (Termination Fees) Rules 2009 to address technical issues that arose during implementation. The amendments provide clarity for irrigation infrastructure operators and irrigators in the Murray-Darling Basin about how the rules operate.
http://www.environment.gov.au/water/australia/water-act/notice-amend-market-charge-rules-2012.html

Understanding the 2010-12 La Niña events - new publication released
A new publication illustrating the significance of the recent 2010-2011 and 2011-2012 La Niña events and their impact on Australia's climate has been released by the Bureau of Meteorology.
http://www.bom.gov.au/announcements/media_releases/ho/20120719.shtml

Bureau of Meteorology review final report
The Review of the Bureau of Meteorology's capacity to respond to future extreme weather and natural disaster events and to provide seasonal forecasting services has been released.
http://www.environment.gov.au/about/bom/index.html

Water efficiency labelling and standards scheme enhanced
The national Water Efficiency Labelling and Standards (WELS) Scheme has been strengthened with the passage through Parliament recently of the Water Efficiency Labelling and Standards Amendment (Scheme Enhancements) Bill 2012
http://www.environment.gov.au/minister/farrell/2012/mr20120628.html

Funding for study into South Australian irrigation industry
The Gillard Government will provide up to $1.2 million to explore new proposals to improve irrigation efficiency in South Australia.
http://www.environment.gov.au/minister/burke/2012/mr20120718.html

The Great Barrier Reef World Heritage Area - UNESCO State of Conservation report
The UNESCO World Heritage Centre has released documents for the upcoming meeting of the World Heritage Committee (to take place 24 June - 6 July 2012) relating to the Great Barrier Reef World Heritage Area.
http://www.environment.gov.au/heritage/places/world/great-barrier-reef/whc-concerns.html#unesco

Final Commonwealth Marine Reserves Network Proposal
Comment invited on Final Commonwealth Marine Reserves Network Proposal. Comments close 10 September 2012.
http://www.environment.gov.au/coasts/mbp/reserves/index.html

CSIRO signs landmark agreement with US NOAA on marine and climate research
CSIRO and the United States' National Oceanic and Atmospheric Administration (NOAA) today signed a series of agreements that bring together the scientific capabilities of two global leaders in marine and atmospheric research.
http://www.csiro.au/Portals/Media/NOAA-Agreement-MarineClimateResearch.aspx

New discovery of how carbon is stored in the Southern Ocean
A team of British and Australian scientists has discovered how carbon is drawn down from the surface of the Southern Ocean to the deep waters beneath.
http://www.csiro.au/Portals/Media/How-carbon-is-stored-in-the-Southern-Ocean.aspx

SA still suffering legacy of over-allocation
South Australia is still suffering the consequences of decades of upstream over-allocation from the River Murray which was exacerbated by the recent severe drought
http://www.ministers.sa.gov.au/images/news_releases/12_07Jul/walker_flat.pdf