**Murray Darling Basin Commission-funded projects**

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Participants: Geoscience Australia, CSIRO, ANU, AU

**Brief project description:**

Over the period March 04 to end June 2007, a number of project activities are planned to occur with co-funding from the Murray-Darling Basin Commission. It is intended that funds for the activities outlined below are used to carry out some strategic research activities, facilitate interaction with CRC CH salinity projects, and to seed-fund regionalisation of project outcomes. Four key areas of project activity are planned:

1. **Inputs to catchment management planning**
   a) LEME will carry out a ‘proof of concept’ project that will seek to assess the value-adding potential of regolith geoscience, geology and geophysics within erosional landscapes for the purposes of salinity management and catchment planning.

   Particular focus will be given to:
   - developing a technique for mapping and predicting regolith thickness in erosional landscapes that combines topographic index-based approaches (eg MRVBF) with gamma radiometrics residuals analysis, hydrogeology, regolith landscape and soils analysis;
   - demonstrating the utility of new products for mapping and prediction of salt stores in upland landscapes, particularly when linked to sub-surface salt store and regolith thickness (and hydraulic conductivity) data;
   - providing guidelines and recommendations for the acquisition of biophysical data (regolith data and ground and airborne geophysics) in erosional landscapes;
   - establishing a methodology for deriving Hydrogeomorphic Unit Maps to aid salinity management at sub-catchment scales;
   - and value-adding to existing GFS frameworks utilising pre-existing and limited additional new datasets;

   This activity will be jointly undertaken by CRC LEME and DIPNR NSW (Alan Nicholson’s Salt Action team in Central-West NSW). Project outputs will feed into a longer-term salinity management strategy within the Central-West of NSW, including assessment of recharge reduction strategies using targeted matrix farming. This project will seek broader interaction with catchment planners.

   b) Extrapolate the regolith thickness maps developed in the ‘HGU proof of concept project to the fracture rock aquifer systems in Central-West NSW (dependant on receiving appropriate additional funding from CMAs, DIPNR).

   c) Assess the applicability of the approach developed in the Stage 1 ‘HGU proof of concept’ project. This activity would review the biophysical data availability in other trial 2C catchments. Recommendations would be made on the suitability of different approaches to value-adding regolith thickness, salt store and catchment architecture studies to the other 2C Trial Catchments.


d) Carry out additional work on other 2C trial catchments. It is anticipated that this will involve a range of activity levels:
- where there is no significant pre-existing sub-surface data and no additional funding for the acquisition of new sub-surface data in trial 2C catchments, a limited assessment of the value-adding possible in these areas will be undertaken;
- where there is significant pre-existing sub-surface data and/or additional funds available for acquisition of new data, a more comprehensive value-adding exercise will be undertaken in selected 2C project areas.

e) LEME will also undertake to provide assistance to a restricted number of other active catchments in the assessment of salinity and groundwater mapping and prediction methodologies. This could be undertaken where there is on-going or planned LEME activities.

f) LEME will also assist in developing communication products on the role of geology/geophysics hydrogeology and predictive modelling based on products developed within this project.

2. **Floodplain salinisation process understanding and mapping**

a) LEME will undertake an assessment of the suitability for the cost-effective use airborne geophysics and regolith landscape understanding for salinity studies on the Murray Floodplain. Areas will be chosen for assessment based on discussions with MDBC, the Living Murray Initiative, Water for a Healthy Country, CMAs and other NRM agencies.

b) Regolith constraints on hydrograph and water table trend analysis for salinity hazard mapping remain virtually untested. Preliminary work by LEME within the Lr Balonne area suggests that knowledge of catchment geometry and materials may be equally, if not even more important in correcting hydrograph trend data, and in watertable trend forecasting. Such corrections have not been made in any hazard maps in Australia, and it is proposed to carry out semi-quantitative corrections in data-rich and data poor areas in Qld and Victoria.

c) Resolution of data for mapping water tables and mapping salinity processes in floodplain landscapes. It has been demonstrated in one sub-catchment in Victoria that the quality of DEMs can also significantly affect water table modelling (Heislers & Brewin, 2004). This issue is particularly important in floodplain landscapes. Further work is required to gauge the effects of the different resolutions of a variety of spatial data used to predict water table surfaces and trend rises. The effects of using different resolution DEMs to map water tables will be assessed by comparing outputs using LIDAR, 25m and 250m satellite DEMs, and DEMs acquired during airborne geophysics surveys in an area of the Murray Floodplain in Victoria, and the Lr Balonne floodplain in Qld.

d) Establishing the Value of Improved Spatial Information for Natural Resource Management Research organizations and NRM agencies are under increasing pressure to show the benefit of their activities. This project has been designed to develop and demonstrate strategies that will enable CRCLEME to predict and evaluate the
economic impact of one component of its research (the application of airborne geophysics and regolith geoscience in the Riverland area of South Australia).

In order to achieve this objective it is necessary to follow the effect of improved spatial information through to its final impact on the management and investment activities of natural resources managers. We propose that these ideas be tested by evaluating the increase in Net Present Value (NPV) that can be obtained by using the clay thickness results from the Riverland AEM survey undertaken by CRCLEME in the SA-SMMSMSP.

3. **In-stream processes**
Support the Living Murray Initiative. LEME is in the process of developing MOUs with CSIRO’s Water for a Healthy Country, and the eWater CRC bid consortium. One aim of these MOUs is to ensure that there is good communication between groups developing projects related to NRM initiatives in the Murray-Darling Basin and other regions. Projects are yet to be scoped with these other groups, however the intention is to ensure that projects are developed in a coordinated fashion. Projects being discussed include geomorphology/sedimentology of the floodplain and the sub-surface architecture, particularly from the perspective of gaining an improved understanding of salinity processes on the floodplain and zones material controls on surface-groundwater interaction and preferential flowpaths in the sub-surface.

4. **Salt Interception Investigations**
Assess in-river Nanotem conductivity mapping
- Nanotem in-river data is used to locate salt stores in riverbeds (already happening in Mallee zone SA and Vic). LEME co-developed and pioneered the use of on-river conductivity mapping in the River Murray. Issues remain on the calibration and operating parameters for this technology, and in interpretation. It is proposed to work with key clients and stakeholders, Zonge Engineering to validate the technology. This may be accomplished through student projects within LEME.

- There is also a perceived need to link Nanotem interpretations to local geologic and geophysics interpretation of floodplain and regional aquifers. This could only be achieved through cooperation with relevant agencies, with additional funding to ‘link’ datasets in the different parts of the landscape. A project proposal could be developed along these lines.
YEAR 1 ‘HGU Proof of Concept’ Project (March 04- END June 04)

Hydrogeomorphic Units- a sub-catchment scale framework for land use decision making (value-adding to Groundwater Flow Systems)

The existing groundwater flow systems approach is the prime catchment management decision making framework for managing salinity in Australia. It synthesises existing knowledge of the groundwater processes influencing dryland salinity to produce conceptual models of the different processes and manifestations of salinity, and a spatial representation of the distribution of different groundwater flow system types. The strength of this approach is that it enables the detailed experience and knowledge of a limited number of specialists to be translated into common and widespread usage. It identifies provinces with similar geological and geomorphological characteristics that influence the recharge, transmission and discharge of groundwater involved in dryland salinity. This allows a broad scale, qualitative perspective on the variation in processes and timescales of salinisation.

However, the major limitation of this approach has been that there has been a paucity of subsurface data with which differentiate the complexity of groundwater flow system types in this area, and that the current groundwater flow systems classification has been at too broad a scale for on-ground management decision making.

This project will demonstrate the contribution that subsurface information can make to characterising the groundwater flow characteristics of the Cowra area and improving the existing groundwater flow systems classification. It will complement work being undertaken by DIPNR to describe the deep drainage characteristics of different land management practices across the 1:100,000 Cowra map sheet, focussing on two 25x25 km² areas near Cowra and Wellington. It will provide insights into the subsurface characteristics and salt store distribution across these areas, to assist in the characterisation of more detailed hydrogeomorphic units (HGUs) for land use management decision making purposes.

Objectives

- To value-add to the usefulness of the existing groundwater flow systems approach by incorporating subsurface characterisation with hydrogeological interpretation and mapping of shallow salt store distribution;
- To provide improved surface and subsurface data to assist in the spatial delineation of hydrogeomorphic units (HGUs), at appropriate scales to management decision making;
- To describe the locations and mobilisation pathways of critical salt stores within the surface and shallow subsurface of each hydrogeomorphic unit;
- Link to existing salinity and salt export modelling, and to matrix farming trial studies for salinity and recharge management (with DIPNR).

This project links to the CRC CH ‘Project 2C’ salinity modelling framework. The aim of the 2C model is to quantify surface and groundwater contributions of salt to catchment scale salt export, and to predict the impacts of land use change on salt movement at a catchment scale. The LEME HGU project outputs aim to ......

The project will seek to ensure that outputs from the LEME project are compatible with the 2C model.
Deliverables (outputs) and expected impacts of research (outcomes):

A. Project design phase

(i) Develop detailed process and project design

Within a workshop forum amongst selected investigators and representatives of DIPNR, agree:
(a) a scientific process for the project (KL/JW);
(b) timeframes, milestones and key responsibilities for each sub-catchment study to be undertaken (JC/KL/JW).

Output: detailed workplan for ensuing investigation(s)

B. Cowra project area, Walgoolah sub-catchment study

This phase of the project will demonstrate salt store mapping approaches in the Walgoolah sub-catchment, and develop rules to extrapolate to the broader Cowra area to produce both a salt store map and a salt mobilisation model.

(i) Relative regolith thickness mapping in Walgoolah sub-catchment

Method:
- Interpretation of radiometrics data, existing soils/regolith mapping, field investigations (JW, LR, HA)
- Identify geomorphic criteria for indicating regolith thickness (CP)

Output: Digital coverage of relative regolith thicknesses

(ii) Production of DEM

Method:
- Investigate feasibility of scanning and digitising 1:50,000 and 1:25,000 contour maps, ASTER DEM, and air photo compilation
- Select method that will enable best resolution DEM within the timeframes available and produce DEM (HA, LH, JW)

Output: Most detailed digital elevation model possible

(iii) Structural geology mapping for Walgoolah area

Method:
- Acquire all relevant data and where necessary convert to appropriate format (HA, KL).
- Identify criteria for interpreting basement depths and other critical structural features (KL, HA, JC)
- Interpret basement depths, critical structural and geomorphological features, and produce 3D regolith model (HA, LH, KL, JC, CP)

Output: 3D model of regolith thickness and critical structural features

(iv) Interpretation of shallow salt store distribution in Walgoolah sub-catchment

Method:
- Use shallow drill hole information, relative soil thickness mapping, regolith thickness mapping, stream salinity data and topographic index modelling
(other info) to develop explicit rules for predicting salt store distributions (JW, LR, JC, KL)

- Produce initial 3D model of shallow salt store distributions (LR, HA, LH, JW)
- Field validate initial model (LR, HA, LH, JW)
- Revise explicit rules for predicting salt store distributions (LR, JW, JC, KL)
- Produce final 3D model of shallow salt store distributions (LR, HA, LH, JW)

Output: Map and 3D model of shallow salt store distributions in Walgoolah sub-catchment

(v) Salt mobilisation interpretation for Walgoolah area

Method:
- Acquire available groundwater information (data and reports) (LR, DIPNR hydrogeologist, HA, LH)
- Use regolith thickness mapping, regolith-landform map, and existing groundwater level information to develop conceptual model of groundwater flow paths (JC, DIPNR hydrogeologist, HA)
- Integrate groundwater flow path model with salt store distribution to predict salt store mobilisation (JC, KL, DIPNR hydrogeologist)

Output: Description of salt mobilisation pathways and diagrammatic representation

(vi) Report preparation

Method:
- For each phase of the project, write description of methodology used and prepare relevant diagrams and maps (key person responsible for each phase)
- Collate assorted contributions into coherent report (JC)

Output: Draft report

C Wellington area study

This phase of the project will demonstrate salt store mapping approaches in the Wellington sub-catchment, and develop rules to extrapolate to the broader Cowra area to produce both a salt store map and a salt mobilisation model.

(i) Relative regolith thickness mapping in Wellington sub-catchment

Method:
- Interpretation of radiometrics data, existing soils/regolith mapping, field investigations (JW, ST, HA)
- Identify geomorphic criteria for indicating regolith thickness (CP)

Output: Digital coverage of relative regolith thicknesses

(ii) Production of DEM

Method:
- Investigate feasibility of scanning and digitising 1:50,000 and 1:25,000 contour maps, ASTER DEM, and air photo compilation
• Select method that will enable best resolution DEM within the timeframes available and produce DEM (HA, LH, JW)

Output: Most detailed digital elevation model possible

(iii) Structural geology mapping for Wellington area

Method:
• Acquire all relevant data and where necessary convert to appropriate format (HA, KL).
• Identify criteria for interpreting basement depths and other critical structural features (KL, HA, JC)
• Interpret basement depths, critical structural and geomorphological features, and produce 3D regolith model (HA, LH, KL, JC, CP)

Output: 3D model of regolith thickness and critical structural features

(iv) Interpretation of shallow salt store distribution in Wellington sub-catchment

Method:
• Use shallow drill hole information, relative soil thickness mapping, regolith thickness mapping, stream salinity data and topographic index modelling (other info) to develop explicit rules for predicting salt store distributions (JW, ST, JC, KL)
• Produce initial 3D model of shallow salt store distributions (ST, HA, LH, JW)
• Field validate initial model (ST, HA, LH, JW)
• Revise explicit rules for predicting salt store distributions (ST, JW, JC, KL)
• Produce final 3D model of shallow salt store distributions (ST, HA, LH, JW)

Output: Map and 3D model of shallow salt store distributions in Wellington catchment

(v) Salt mobilisation interpretation for Wellington area

Method:
• Acquire available groundwater information (data and reports) (ST, DIPNR hydrogeologist, HA, LH)
• Use regolith thickness mapping, regolith-landform map, and existing groundwater level information to develop conceptual model of groundwater flow paths (JC, DIPNR hydrogeologist, HA)
• Integrate groundwater flow path model with salt store distribution to predict salt store mobilisation (JC, KL, DIPNR hydrogeologist)

Output: Description of salt mobilisation pathways and diagrammatic representation

(vi) Report preparation

Method:
• For each phase of the project, write description of methodology used and prepare relevant diagrams and maps (key person responsible for each phase)
• Collate assorted contributions into coherent report (JC)

Output: Draft report
**D. Salt mobilisation for the broader Cowra map sheet**

This phase of the project will demonstrate how the explicit rules developed in the previous more detailed sub-catchment studies can be extrapolated to the broader Cowra area to produce both a salt store map and a salt mobilisation model.

(i) Extrapolation

**Method:**
- Adapt and apply explicit rules from sub-catchment studies for use with broader Cowra map sheet datasets.
- Undertake preliminary field work to assess validity of explicit rules in the context of the broader area.
- Prepare relevant maps and written discussion of validity of methodology and recommendations for further work.

**Outputs:** Maps and discussion paper of results of extrapolation, and recommendations for further work

**E. Proof of concept report preparation**

**Method:**
Collate written contributions and maps from each phase of the project into coherent report (JC, KL and JW)

**Output:** Proof of concept report
Sub-project: Regolith constraints on hydrograph and water table trend analysis for salinity hazard mapping

**Brief project description:** *(in no more than 400 words address objectives, scope of work, knowledge to date, what is new, interactions with other projects, contribution to strategic intent.)*

Salinity hazard maps identify areas where landscape salinity might occur. Salinity hazard is derived from an understanding of areas of recharge, discharge, salt stores and groundwater flow systems. A range of salinity hazard mapping methodologies have been developed in Australia. While these include trend-based methodologies, where future areas of shallow watertables are estimated by extrapolating rates of groundwater rise from data collected in groundwater bore networks. A simple area affected and groundwater discharge function is then applied to estimate increases in groundwater discharge. Similarly, composite index salinity hazard mapping methodologies utilise spatial data including soils, topography, salt stores, climate, and conceptual groundwater flow systems data. The latter approaches are more commonly adopted in data-poor areas.

However, a common issue to all the existing salinity hazard and risk mapping approaches is the lack of spatially explicit sub-surface geoscience data. Recently it has been demonstrated that local climate and palaeo-climate data is critical in forecasting groundwater trends and hence the areas of salinity hazard (Heislers & Brewin, 2004). Preliminary work by LEME within the Lr Balonne area suggests that knowledge of catchment geometry and materials may be equally, if not even more important in correcting hydrograph trend data, and in watertable trend forecasting. Such corrections have not been made in any hazard maps in Australia, and it is proposed to carry out semi-quantitative corrections in data-rich and data poor areas in Qld and Victoria.

Similarly, it has been demonstrated in one sub-catchment in Victoria that the quality of DEMs can also significantly affect water table modelling (Heislers & Brewin, 2004). This issue is particularly important in floodplain landscapes. Further work is required to gauge the effects of the different resolutions of a variety of spatial data used to predict water table surfaces and trend rises. The effects of using different resolution DEMs to map water tables will be assessed by comparing outputs using LIDAR, 25m and 250m satellite DEMs, and DEMs acquired during airborne geophysics surveys in an area of the Murray Floodplain in Victoria, and the Lr Balonne floodplain in Qld.

**Deliverables (outputs) and expected impacts of research (outcomes):**

- It is intended to organise a national workshop on salinity hazard and risk mapping methodologies, to provide a more consistent national approach to mapping methodologies;
- A report will be produced summarising work on regolith constraints on hydrograph interpretation for water table rise predictions and the DEM scaling effects for water table mapping and salinity hazard predictions.
Sub-project: Establishing the Value of Improved Spatial Information for Natural Resource Management

Brief project description:
Research organizations and NRM agencies are under increasing pressure to show the benefit of their activities. This project has been designed to develop and demonstrate strategies that will enable CRCLEME to predict and evaluate the economic impact of one component of its research (the application of airborne geophysics and regolith geoscience in the Riverland area of South Australia).

In order to achieve this objective it is necessary to follow the effect of improved spatial information through to its final impact on the management and investment activities of natural resources managers. We propose that these ideas be tested by evaluating the increase in Net Present Value (NPV) that can be obtained by using the clay thickness results from the Riverland AEM survey undertaken by CRCLEME in the SA-SMMSP.

The Concept
The mapping of the Blanchetown Clay in the Riverland was justified on the basis of its potential to contribute to the design of management practices that can minimize the recharge of the saline groundwater and thus salt inflows to the River Murray.

It was argued that locations where Blanchetown Clay is thicker are places where the groundwater will be recharged more slowly and thus are more suitable for irrigation or continuing dryland agriculture practices that are likely to produce increased drainage. Conversely, areas where the clay is absent are logical places where recharge reduction strategies (such as revegetation) should be implemented. The inherent assumption is that a more accurate knowledge of the distribution and thickness of the clay will enable a more accurate placement of investments, either for protecting the River Murray or for more cost effective agriculture.

This assumption needs to be tested for all the possible applications of the clay distribution information we have generated. Some, but perhaps not all, of the potential applications of the data are:

a) Improved estimates of the long-term salinity in the Murray. This is probably the weakest argument for better spatial information because the estimate will only be substantially improved if the survey results show that average amount of clay in the survey area is substantially different from older information derived from existing drilling.

b) Improved location of plantings for recharge reduction. Given finite funding for this activity, the accurate placement of plantings will achieve that greatest possible reduction in recharge and consequent impact on river salinity in the future.

c) Improved selection of sites for future irrigation. This should have potential benefit for regulators who will be able to assess the consequence of proposed irrigation development with greater confidence. It should also enable potential investors to select sites more cost effectively.

d) Improved design of Salt Interception Schemes (SIS). At Loxton, it appears that the improved understanding of strand-line locations provided by the geophysics is assisting in the selection of higher permeability zones that are important for bore-field design. Similar results may be obtained for proposed SIS schemes along the river, such as at Murtho and Pike.

e) Improved selection of disposal sites for water from SIS.
For each of these applications an evaluation of the benefits of high-resolution information will involve documenting and quantifying the management and investment processes illustrated below.

The above processes will be simulated for both the spatial data options to assess the value of the higher resolution data. SIMPACT (which models both unsaturated and saturated zone processes for use in land use / irrigation planning) will be used to determine where and whether benefits arise from modified recharge to the groundwater. The model makes direct use of data on the distribution of Blanchetown Clay, and can give spatial information on recharge and the salinity impacts of irrigation trading, allowing us to quantify, in terms of NVP, the resulting EC changes in the River Murray.

**The Feasibility Study**

We propose a staged approach to achieve these objectives, in co-operation with staff in CSIRO Land and Water and the South Australian Government – the Departments of Land Water and Biodiversity Conservation, and Environment and Heritage. In the initial instance we need to determine:

- The extent to which the availability of the higher resolution information will (or could) change investment practices.
- The absolute and relative contribution that variability the thickness of the Blanchetown Clay makes to total recharge.

This will then be followed by modelling various scenarios using SIMPACT in collaboration with the State agencies and CSIRO L&W’s Policy and Economics Research Unit. As an initial step in progressing this analysis we propose that LEME support a series of meetings with key individuals in South Australia to develop the scope and strategy that would best deliver on the project objectives.

**Deliverables (outputs) and expected impacts of research (outcomes):**

This proposal outlines the concepts behind the project and suggests that LEME support some meetings and a small feasibility study that will enable us to understand the full ramifications and practicality of the proposed project.
Outputs
• A report on feasibility and scope of a project for evaluating the increase in Net Present Value (NPV) that can be obtained by using the clay thickness results from the Riverland AEM survey

Outcomes
• If successful, this project will result in the development and demonstration of strategies that will enable CRCLEME to predict and evaluate the economic impact of its research.