PROGRAM FOUR: SALINITY MAPPING AND HAZARD ASSESSMENT PROJECT SUMMARIES - 2006- 2007

17. Project name:

CONSTRAINED PROCESSING AND INTERPRETATION OF AIRBORNE ELECTROMAGNETIC DATA IN THE DEVELOPMENT OF AN INTEGRATED LAND MANAGEMENT MODEL FOR THE ANGAS BREMER PLAINS, SA

Abbreviated title: Angas Bremer Plains AEM interpretation

Type of project Industry
Themes: Geophysical mapping and modelling in regolith terrains
Salinity systems in regolith and groundwater

Project Leader: Andrew Fitzpatrick
Start date and duration: June 2006 (12 months)

Participants: CSIRO EM, CSIRO LW

Brief project description:
Concerns by the Angas Bremer Irrigators over the future expansion and sustainable use of water resources in the Angas Bremer Plains of South Australia has driven a number of recent initiatives aimed at trying to understand the complex interaction between surface and ground water and, in particular, the effect this has on salinity of these resources and the potential for irrigation-induced salinisation of the region. Among these initiatives is the development of the Angas Bremer Integrated Systems Model (ABISM) which aims to better define strategies for a truly conjunctive approach to water management from the paddock to catchment scale. Key to the successful development of that model is the availability of good biophysical data which describe the spatial variability of salinity and water quality across the region, most particularly in the near surface (<30m). Airborne geophysics data have the potential to assist in delivering this information, but they require careful, constrained interpretation and analysis, if they are to deliver products with this information.

AEM data collected for the Angas Bremer Plains region of SA, during the South Australia – Salinity Mapping and Management Support Project (SA-SMMSP) were previously processed, with very limited constraint, to help develop a regional hydrogeological framework for the Angas Bremer Plains area. This project aims to use more detailed information on aquifer sality, depth to the saturated zone and other ground geophysical data to assist in better defining information on near surface variations in water quality and salt load. In particular we propose to use constrained methods to invert the available EM data, drawing on data available from irrigators and others. The emphasis of this study is to produce derived products that can be used directly in conceptual and analytical models for determining a water and salt mass balance for the region. To date few, if any, attempts have been made to define the appropriate protocols for the constrained processing of AEM data with a view to deriving outputs relevant to development of conjunctive water use strategies in dryland catchments. CRCLEME has unique experience in the constrained processing of AEM data and this project seeks to broaden our knowledge of how these inversion strategies can be used salinity and water use management.

Specific project objectives

1. Development and documentation of protocols for the use of constrained inversion techniques with AEM data for the derivation of biophysical products relevant to the development of conjunctive water use strategies in dryland catchments.

2. Procedures for the calculation of indicative salt loads and water quality in the unsaturated and saturated parts of the near surface respectively using constrained inversion techniques applied to AEM data.
3. Analysis of derived estimates of near surface derived salt loads and water quality against spatio-temporal data derived from irrigators.
4. Broad spatial assessment of the confidence limits for AEM derived biophysical products, based upon available ground (drillhole and ground geophysical) data

Deliverables (outputs) and expected impacts of research (outcomes):
Deliverables to Client (Adoption mechanisms)

1. A GIS compatible map/grid of the salt load in the unsaturated zone based on the constrained inversion of AEM data
2. A GIS compatible map/grid of the shallow aquifer water quality (salinity) based on the constrained inversion of AEM data.
3. A GIS compatible map of AEM confidence limits.
4. A CRCLEME report on constrained inversion processing and interpretation procedures.
5. Technology transfer workshop with BRS and CLW

A key part of the project strategy will be to work directly with BRS and CSIRO LW staff in the development of outputs that feed directly into the Angas Bremer Integrated Systems Model (ABISM).

Impacts

1. A more reliable indication of near surface salt loads and shallow aquifer water quality variations across important irrigation areas, thereby assisting in better defining groundwater management strategies and the development of a model for conjunctive water use.
2. Influence current and future irrigation developments and water allocation plans

Milestones: *(dates of significant events marking scientific progress)*

1. Agreement on strategy for the constrained inversion of AEM data and biophysical data products required in the development of analytical models with CLW and BRS (June 30, 2006)
2. Collation of constraint information for use in reprocessing of AEM data including the acquisition of additional shallow borehole induction logs (August 2006)
3. Production of a map of shallow aquifer water quality acceptable to Angas Bremer Water Management Committee (ABWMC) from the constrained inversion of AEM data (October 2006)
4. Map of near-surface soil salinity acceptable to ABWMC (October 2006)
5. Validation of constrained inversion products against available ground and borehole data (December 2007)
6. Map of AEM confidence relevant to near-surface conductivity determinations acceptable to ABWMC (December 2006)

Titles of reports

1. Constrained inversion of AEM data for improved definition of near surface salt loads in an irrigated area, SA. (February 2007)

Confidentiality requirements

Commercial-in-confidence

Project name:
SALINITY MANAGEMENT AND INDUSTRY DEVELOPMENT FROM THE BEAUFORT PALAEOCHANNEL

Abbreviated title: **Beaufort palaeochannel, WA**

Type of project Industry
Themes: Geophysical mapping and modelling in regolith terrains
Salinity systems in regolith and groundwater

Project Leader: Tim Munday
Start date and duration: June 2006 (12 months)

Participants: CSIRO EM, Golburn-Murray Water, GA

Brief project description:
The West Arthur Shire contains the remnants of an ancient palaeodrainage system now referred to as the Beaufort Palaeochannel (Waterhouse et al 1994). Existence of this palaeochannel was first mooted from two drill holes near Darlingup (CRA 1985) and Dardadine (Kinhill 1991). However it was not until 1992, that the Towerrinning section was found and later defined by the Department of Agriculture, and the existence of the Beaufort system proposed. As part of a wider program of salinity related research, electromagnetics (SALTMAP) was flown in 1997 to locate the Towerrinning section of the Beaufort palaeochannel and document its groundwater salinity. As a result a vineyard, town water supply (Duranillin) and local farm water systems have been developed. A Recovery plan for Dingo Swamp (Haddleton Nature Reserve), currently being developed by CALM, also relies on knowledge of and access to, the electromagnetics derived from this initial survey of the palaeochannel. Finally, as a result of the Kinhill project, a water supply for the Dardadine Tannery was developed, although the extent of the palaeochannel is this area is unknown. At present there is little understanding as to the sustainability of the available resource and in particular the links between the saline aquifers of adjacent areas and the available resource in the palaeochannel system.

Project Objectives:
This project seeks to accurately locate and characterise the sediments of the Dardadine palaeochannel and related up-gradient reaches of the palaeochannels of the Hillman and Beaufort Rivers, west of the Albany Highway. It proposes to use this information along with airborne electromagnetic data acquired along the stretch of the palaeochannel, processed using available constraint information to help define the a groundwater resources map. This map will then be used by the Shire and local industry development groups to focus new industries on the resource. It will have significant local and potentially regional economic and social benefits for the small town of Darkan.

Use of the information obtained may have significant salinity and related environmental benefits. If successful, it will locate the major source of groundwater responsible for extensive salinity on the Beaufort and Hillman river valleys, enable protection of biodiversity and infrastructure assets by use of pumping, and provide a source of water for new industries (especially aquaculture). The pumped water, if of a salinity less than that in the Hillman and Beaufort rivers, also offers the opportunity to maintain the permanent river pools in a much improved environmental condition than at present.

What is the new science in this project ?
The scientific challenge remains to link an understanding of the palaeochannel sedimentary system with the AEM data to develop a quantitative model for aquifer quality and stratification, which will be key to developing a water resource model. To date, no attempt has been made here or overseas, to link a detailed knowledge of regolith and sediments with airborne geophysical data for a dryland catchment, in the quantification of groundwater resources. Potentially this study could link the experience gained form ground based studies in the LEME Rural Towns Project in the development of procedures and protocols for using regolith knowledge and geophysics to help define water resources elsewhere in Australia. This work has relevance to both the mining and agricultural community.

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

Outputs
1. Definition of appropriate airborne geophysical system and survey parameters for an AEM survey,
2. Technical specifications for incorporation in survey contract
3. Management of geophysical survey contract, and quality assessment of the derived geophysical data
4. Calibrated airborne geophysical data as conductivity depth images in a GIS compatible form.
5. Report on survey outcomes and products delivered.
6. Report on Arthur river palaeochannel sedimentary system with implications for water resources
7. Technology transfer workshop to communicate the outcomes of the work to relevant stakeholders.

Outcomes
1. Establish the extent, quantity and quality of a extensive groundwater resource
2. Understand the interaction between existing salinity and the palaeochannel
3. Define suitability and impact of engineering and plant based salinity management options
4. Target salinity management works for key assets
5. Create potential for environmental improvements from discharging low salinity groundwaters to streams, rivers and pools of the Beaufort, Hillman and Arthur Rivers.
6. Enable the information to build new industries from otherwise damaging processes
7. Provide community benefits to a small rural community

Milestones

1. Define AEM survey objects and area – June 2006
2. Place contract for data acquisition – July 2006
3. Begin AEM data acquisition – August 2006
4. Quality assessment and control – September 2006
5. EM data delivered by contractor – October 2006
6. Acquisition of calibration/constraint data – Jan 2007
7. Constrained inversion of AEM data – for definition of aquifer water quality (GIS compatible conductivity grids delivered to project partners) – March 2007
8. Final project workshop– June 2007

Reporting
- Progress reports are required on a monthly basis.
- Technical report on AEM survey outcomes and conductivity depth images (June 2007)
- Report on Arthur River Palaeochannel sediments (June 2007)

Confidentiality requirements - None

Project name:
AUSTRALIAN GOVERNMENT COMMUNITY STREAM SAMPLING AND SALINITY MAPPING (CSS&SM) PROJECT- VICTORIAN AEM MAPPING PROJECT

Abbreviated title: BRS Victorian Salinity Mapping

Type of project Industry
Themes: Salinity mapping and Hazard Assessment

Project Leader: Ken Lawrie
Start date and duration: May 2006- end June 2008

Participants: Geoscience Australia, CSIRO L&W, DPI Vic. (and GA and CSIRO L&W outside LEME, plus BRS, private industry contractors, and CMAs).

Brief project description: The $20m Australian Government Community Stream Sampling and Salinity Mapping (CSS&SM) Project has three components. They are:

1. Stream sampling element
2. Re-analysis of AEM data that has been gathered and analysed in earlier stages of the development of the AEM technology, and
3. Gathering and interpreting new AEM data to demonstrate the effectiveness of AEM technology for salinity management in areas where high value assets are at risk.

The CSS&SM project is focused into the NAP regions of the Murray Darling Basin. The project is managed on behalf of the Australian Government by the Bureau of Resource Sciences. The Bureau of Resource Sciences is working with Geoscience Australia to deliver the project in line with the scientific and technical standards established by the Joint Academies of Science. CRC LEME is being sub-contracted to GA to deliver a specific component of the Victorian AEM mapping project.

This project will involve the provision of specific expert scientific skills to the BRS-led Program. This will be based around core P4 skills in regolith science and the interpretation of AEM datasets as part of multi-agency teams. Victorian CMAs have submitted 17 proposals, which have been reduced to proposals in 4 different landscape settings with a range of high value assets at risk of salinisation.

CRC LEME's tasks in this particular sub-project are being negotiated, but early discussions have outlined the following specific areas of science provision:

- Work with relevant agencies to compile relevant geoscience data to enable the Victorian Technical Working Group (VTWG; drawn from the Commonwealth, State, CMAs and private sector) to carry out a full evaluation of project proposals.
- Participate in VTWG discussions on project area selection.
- Compile relevant geoscience and hydrogeological data and construct a GIS of all relevant information to assist with project design and implementation
- Assist with forward modelling exercise by providing relevant regolith and hydrogeological data, including new ground data as required.

- Plan drilling activities associated with calibration of the AEM dataset, and carry out relevant scientific studies to assist with calibration of the AEM dataset.
- Carry out detailed hydrogeochemical sampling and analysis to gain an understanding of salinity dynamics.
- Provide input to hydrogeological and broader focus NRM models.
- LEME will be responsible for overall analysis and interpretation of the AEM dataset, and delivery of final products and an integrated report.

Note: GA staff will carry out all geophysical services for this project, with the exception of ground geophysical surveys which are likely to be contracted to the private sector. BRS will provide hydrogeological advice, and manage all drilling contracts. Shawn Butters will provide liaison between all agencies and the CMAs. Floodplain process understanding and models will need to be accessed from other agencies.

Deliverables (outputs) and expected impacts of research (outcomes):
To be developed in workshops and meetings by end June 06.

Milestones: *(dates of significant events marking scientific progress)*
To be developed in workshops and meetings by end June 06. However the following timelines have been established:

- Provision of data to enable assessment of project proposals by end May 2006.
- Selection of project area by July 2006.
- Acquisition of AEM data in April 2007
- Delivery of initial products by end March 2008.
- Full write-up of scientific results by end June 2008.

Confidentiality requirements
None anticipated. Note timing of release of final products will be determined in discussion with BRS.

Project name:
NEXT GENERATION CENTRAL WEST GROUNDWATER FLOW SYSTEMS

Abbreviated title: Central West NSW GFS

Type of project Industry
Themes: Salinity

Project Leader: John Wilford
Start date and duration: May 15 - end August 06

Participants: GA. Working in multi-agency team with NSW DNR and CW CMA staff.

Brief project description:
Recent work by CRC LEME in Project 4.20 (MDBC-funded projects) has generated a new series of maps and data layers that show considerable promise in adding significant value to existing groundwater flow system constructs. To date LEME has produced "Regolith Flow System" maps for Cowra-Wellington in NSW and Bet Bet in Victoria. These maps enhance the groundwater flow system maps that are already available for the MDB. However, the new LEME-MDBC products have yet to be rigorously validated, and their value for extrapolation has not been tested. As foreshadowed in the schedule for Project 4.20 (section 1b), we have now obtained funding from the Central West CMA for this validation and testing. This will place our MDBC-co-funded maps on a firm scientific basis, and allow the methodology to be transferred to other areas. It may also lead to further funding from the CW CMA to extend the concepts to other types of landscape.

This project will be carried out in partnership with the Central West CMA and NSW DNR. The project will also be used to build relationships between these agencies and LEME-MDBC. This project links considerable local knowledge of groundwater processes and management approaches through the CW CMA with LEME's strength in regolith mapping and landscape analysis. It is anticipated that this synergy will lead to both innovative and client focused products that are likely to have wider application in other regions.

This is viewed as the first phase of a larger project. However in phase 1, LEME is being contracted at this stage for five specific activities:

1. Compilation of a GIS all relevant physical science datasets over the Central West catchment (see table 1). The dataset/GIS component of the project will require a team effort from all parties, although LEME will take on the final responsibility to collate all datasets. All datasets will be provided to LEME by the clients and/or partner organisations free of charge, with the exception of the DEMs.
2. Refine and validate the regional value added GFS map over the Cowra and Wellington area. Validation will involve calibration of the map units with existing datasets (eg. salt scalds, drilling, stream ECs), expert panel discussions and field checking.

3. Acquire high resolution DEM over focused study areas. These areas are likely to be within the Cudgegong and Bell River catchments.
4. Scientific communication and technology transfer. Specifically this relates to the methodology used in generating the GFS+ products and in understanding the linkages between GFS, HGU and LMU concepts.
5. Scope additional projects in both depositional and erosional landscapes. These new initiatives will build on the methodologies established in this project. The key outcome of these new projects will be a comprehensive GFS map over the whole of the Central West catchment. This map will underpin more robust hydrological modelling and improved NRM throughout the CW CMA.

The GIS component of the project will involve all parties including LEME, CW CMA and DNR. The datasets and the primary group responsible for providing the information are listed below.

Table 1.

Datasets	**Main group responsible**
Stream EC	CW and DNR
Soil-landscape maps	CW and DNR
Soil descriptions (point and polygon)	CW and DNR
Bore holes – materials and hydrological properties	CW and DNR
DEMs – shuttle, 25m and high resolution	LEME
Gamma-ray imagery	LEME
Magnetic imagery	LEME
EM31/38 surveys	CW and DNR
Regolith maps	LEME
SPOT imagery	CW and DNR
ASTER imagery (one scene only)	LEME
LEME drill holes	LEME
Salt scalds	CW and DNR
Erosional scarps	LEME
NanoTem lines	LEME
Catchment boundaries (regional and sub catchment)	CW and DNR
Terrain themes (TWI and MRVBF)	LEME
Bedrock structures	LEME
Existing GFS	CW and DNR
Topographic contours, drainage and spot heights	LEME
New GFS for the Cowra and Wellington area	LEME
Climate surfaces	LEME
Geology coverage	LEME

Deliverables (outputs)

1. GIS of key physical datasets within the CW CMA
2. Seamless gamma-ray imagery and DEM over the CW CMA (dependent on agreement with GA for delivery of this product)
3. Delivery of a refined and validated GFS+ map for the Cowra and Wellington area.

Expected impacts of research (outcomes):

- Key impact will be new robust methodology/product to value add the existing GFS. The technique is likely to have much broader application throughout upland landscapes in Australia.
- Publications: 1. GFS+ implications for natural resource management Maps: Next generation GFS These products will initially be published as LEME reports with a journal paper (Hydrological Processes) published in the final year of LEME

Milestones: (dependant on external funding)

- Field trip (May, 2006)
- Dataset workshop with LEME GIS staff , CW CMA and DNR (May 2006)
- GIS thematic layers (June, 2006)
- 1-2 day workshop in the GA 3D theatre to explore dataset relationships and formulated specific work plans/approaches for component 3 August 2006.

Project Name:
AIRBORNE GEOPHYSICS FOR HYDROGEOLOGICAL APPLICATIONS IN THE SOUTHERN EYRE PENINSULA, SOUTH AUSTRALIA,

Abbreviated title **Eyre Peninsular II**
Commercial project

Leader: **Tim Munday**
Start - finish - duration: July 2006 – June 2007, 1 year

Brief project description:
The social and economic viability of the southern Eyre Peninsula is currently reliant on access to a sustainable groundwater resource. SA Water relies on groundwater from the Southern Basins PWA for a major component of its public reticulated water supply for the Peninsula. Determining the sustainable yield of these aquifer systems requires improved understanding of their characteristics, geometry and spatial (vertical and horizontal) variability. Presently this knowledge is limited to that obtained from scattered boreholes and a few ground geophysical traverses. Additionally, some of the aquifer systems lie within environmentally sensitive areas, with limited access preventing a better understanding of their extent and quality.

Airborne geophysics, particularly airborne electromagnetics, has been touted as a technology with the potential to address some of these issues, and recent ground EM traverses in the area support this contention. SA Water have requested that CRC LEME employ its unique skill base and experience in the analysis and interpretation of AEM data to provide additional hydrogeological constraint for their groundwater modelling and water resource assessment. This project is concerned with the acquisition and processing of AEM data and the supply of information on the hydrogeology of sedimentary basins in the southern Eyre peninsula.

Scientific Deliverables (new scientific advances)
1. Development and application of appropriate AEM constrained inversion procedures for the derivation of aquifer bounding surfaces and information of groundwater quality in a sedimentary aquifer system.
2. Definition of appropriate protocols for the incorporation of AEM derived data in groundwater modelling and water resource assessment
3. Scientific paper in refereed journal.

Deliverables to Client (Adoption mechanisms)
1. Modelled constraints on spatial variations in groundwater quality and aquifer bounds
2. Report, GIS and compatible grids for 3D groundwater models

Impacts
1. Enhanced understanding of the available water resource in the region

Project name:
LANDSCAPE ANALYSIS – EXPLANATIONS OF LANDSCAPE VARIATION IN UPLAND LANDSCAPES IN THE MURRAY DARLING BASIN

Abbreviated title: Landscape Analysis MBD

Type of project: Centre
Themes: Salinity and regolith mapping

Project Leader: Colin Pain, John Wilford
Start date and duration: 1 July 2006 – 2 years

Participants: GA

Brief project description:
Projects under way in 05/06 have made it clear that different landscapes require different scales of study to provide meaningful results relating to salt movement. This project will take the understanding gained from the externally funded projects (MDBC and Central West CMA), and extend it by developing a framework for extrapolation of results from detailed studies to broad areas. This framework for the study area will be based on:

- A description of the variation of landscapes.
- A collation of work to date on landscape evolution
- An explanation of landscape evolution

The Physiographic Regions project in P1 is concerned with developing the criteria for upper level mapping related to soils and regolith in the Australian Soil Resources Information System (ASRIS). In 06/07 we have obtained more funding from ACLEP to provide more regolith information for selected physiographic regions – this will involve subdivision of physiographic regions and an assessment of the landscape scale to determine appropriate scales for detailed work. The Landscape Analysis project will use the ASRIS mapping hierarchy together with an understanding of regolith and landforms and how they have evolved to develop an understanding of the landscapes that will allow us to more confidently predict regolith distribution. Catchment Management Authorities in NSW work on a three-tiered system of land subdivisions, from large to small: Groundwater Flow Systems (GFS), Hydrogeomorphic Units (HGU), and Land Management Units (LMU). So far we have worked at GFS and HGU scales using data of relatively coarse resolution. Only one study (Bet Bet in the MDBC project) has been carried out at a LMU scale. Results to date show that at the GFS scale, descriptions may be adequate, but that explanations, and especially predictions, are not easily made. The Landscape Analysis project described here seeks to remedy this situation by providing a firm descriptive and evolutionary framework.

Outputs

- Maps of hierarchical land units for selected parts of the Murray-Darling Basin.
- A report describing geological and regolith features that indicate how landform and regolith has evolved for selected parts of the Murray-Darling Basin.

- Reports that link the mapping hierarchies to groundwater flow systems, regolith, geomorphic history, geology, salt stores etc.
- Paper, "A review of groundwater flow and regolith architecture in upland landscapes in eastern Australia", to be published in Hydrological Processes, submitted by March 2008.
- A report detailing the following will be presented to CMAs, MDBC, etc. during the second quarter of 2008.

Outcomes

- Significantly improved regional natural resource management tools;
- Demonstration of methods of extrapolation using a hierarchical mapping system.

Impacts

1. Better understanding by CMAs of the importance and scale of landform and regolith for NRM, initially the management of salinity.
2. Ability to consider whole-of-catchment management options.

Milestones: *(dates of significant events marking scientific progress)*

December 2006	preliminary report on landscape evolution in the upland areas of the MDB.
June 2007	preliminary report that assesses different approaches to modelling at different landscape scales.
December 2007	Report on regolith and bedrock models that consider catchment and salinity processes at sub-catchment scales.
March 2008	Paper submitted to international journal, and report submitted for peer review.

Confidentiality requirements None

Project Name:
Mapping salt water intrusion and salinity and groundwater systems in the Lower Burdekin Delta

Abbreviated Name **Lower Burdekin salt mapping**

Leader: Ken Lawrie and Jon Clarke

Start - finish - duration: P4 research in this area is in its 3rd year. Any new studies would have to conclude within the time of NAP-funding (June 2008).

Brief project description:

1. The Lower Burdekin Delta in North Queensland, is the oldest irrigation area in Australia, and has some of the best time-series hydrograph data to evaluate salt water intrusion, which currently lies 11km inland, often within a few metres of the surface. In this area water management involves widespread groundwater pumping and irrigation, and artificial recharge of aquifers in the coastal zone. However management is hindered by the lack of a 3D understanding of aquifers and aquicludes, and a lack of understanding of the dynamics of groundwater movement and surface-groundwater interaction. New geoscience insights are needed in these landscapes.
2. P4 research in this area is currently in its 3rd year, and is due to report its latest findings in the next 6-8 weeks. Significant technical issues have been encountered with ground EM surveys, and this is the first time that significant doubt has been cast on the ability of this technique to reliably map ground conductivities. This finding may have much broader implications.
3. Phase 3 of our research in this area will most likely include the acquisition of additional ground or airborne geophysical surveys and some additional calibration drilling as well as regolith studies of aquifer systems. Negotiations on phase 3 are not scheduled to commence until April-May 2006, upon consideration of research findings from a range of studies currently nearing completion.

Scientific Deliverables (new scientific advances)

1. Studies of aquifer characteristics have demonstrated that a new model is required to explain aquifer and connectivity. The next stage in this project would enable a new model to be developed.
2. Research in this area has found that ground and in-river EM surveys are not giving reliable data when compared to known borehole conductivity profiles. Further research is required to establish whether this is a technology issue, or due to specific ground conditions (eg transient EM and/or IP anomalies). Questions have also been raised over the suitability of inversion algorithms. This needs further research as it may have much broader implications.

Deliverables to Client (Adoption mechanisms)

1. Maps and digital data showing the extent of salinity and fresh groundwaters in the Burdekin Delta in 3D.
2. Reports detailing/explaining project findings, including a new aquifer model.
3. Knowledge transfer workshops.

Impacts

1. This project has the potential to demonstrate that new 3D maps of the aquifers, dryland salinity and salt water intrusion (based on AEM geophysical mapping

and regolith –sedimentological studies), when linked into hydrogeological models, and in a community keen to utilise new data and methods, have the potential to significantly improve water and salinity management (dryland and salt water intrusion) in complex and dynamic aquifers such as the Burdekin.

2. Links within a multi-agency project (CSIRO and QDNRM) have been flagged, and this should provide a vehicle for LEME products to be fully utilised in groundwater and NRM planning.
3. This area has also been recommended as one of 4 major field trips for the ISF08.

Project name:
MDBC-FUNDED PROJECTS

Abbreviated title: **MDBC Projects**

Type of project Industry:
Themes: Salinity and Groundwater Management

Project Leader: Overall management Ken Lawrie, with sub-project leaders John Wilford, K P Tan
Start date and duration: March 04- end June 07

Participants: Geoscience Australia, CSIRO, ANU, AU

Brief project description:
This is a three year project (March 2004-June 2007), carried out with co-investment by MDBC. Over the period March 2004 to end June 2006, a number of strategic research projects have been carried out, however specific deliverables and milestones for 2006-2007 have yet to be finalised. There are four key areas of project activity identified:

1. Catchment management

In 2004-2005, LEME has carried out a 'proof-of-concept project' to demonstrate the value that regolith geoscience (both geology and geophysics) can make to salinity management and catchment planning in erosional landscapes in the Murray-Darling Basin. A multi-scale approach was adopted, with products developed for value-adding from sub-catchment scales to national scales. The products have been termed GFS+ and HGU maps. Reports and products are going through peer review for publication in 2006-07. It is intended to workshop the products with peers and clients in the coming year.

a) Catchment extrapolation products based on the 'proof of concept' approach – termed GFS+, have been produced for an area between Cowra and Wellington in NSW. The products have been given to clients for peer review. Excellent feed-back has resulted in a new contract to further validate and extend this work in Central West CMA. This work will be carried out in 2006-07 as an allied project to be externally funded by Central-West CMA.

b) Assessments of the value that new GFS+ data layers add to existing salinity predictions have been carried out independently be CRC Salinity and DIPNR/Central West CMA. Specifically, these have included comparisons with the existing '2C Salt' and CAT3D models for the Bet Bet Catchment in Victoria, and existing GFS constructs in Central West NSW. Positive comparisons have resulted in new joint activities being planned with both organisations for 2006-07 under the auspices of this project activity. A separate agreement is to be drafted with CRC Salinity to ensure alignment of LEME-MDBC's work in this project with CRC Salinity activities. Specifically, this will enable GFS+ products to be incorporated into CAT 3D hydrogeological models, and into decision frameworks such as SIF3. This will ensure project outputs are fully tested and utilised by peer groups and a range of clients. It is likely that new studies in 2006-2007 will focus on a key catchment in Victoria and one in New South Wales.

c) Commence value-adding assessments on other catchment trials, where:
- there is limited sub-surface data and no funding for new data acquisition

- there is significant pre-existing sub-surface data and likely additional funds available for acquisition of new data.

A report on the availability of minerals exploration data in the MDB was completed in 2005-06. Work has commenced on additional sub-catchments, and this work will continue in 2006-07, and incorporated into the above activity in association with CRC Salinity.

d) MDBC requested that LEME would also potentially provide assistance to a number of other active catchments involved in salinity prediction and groundwater mapping. In 2005-06 an example of this was in the Chowilla Floodplain, and in 2006-2007 this is likely to be in the Sunraysia District and/or in the Murray Floodplain more generally.

e) LEME will assist in developing communication products on the roles of regolith geology, geophysics, hydrogeology and predictive modelling. This will be accomplished through LEME legacy products (detailed elsewhere) that will include GFS+ products. It is likely that a specific LEME-MDBC product on GFS+ will be developed.

2. Floodplain salinisation processes

a) LEME has been tasked with further assessing the cost-effectiveness of airborne geophysics and regolith-landscape modelling for salinity studies on the Murray Floodplain. This work will be undertaken after completion of the Murray Floodplains study.

b) The value of regolith inputs to the analysis of hydrograph and watertable trends remain was tested in studies of boreholes in Victoria in 2005-06. Further conceptual, modelling and experimental studies have been carried out in 2005-06 to determine what the 'regolith correction factors' might be in different landscape scenarios. This work has been written up as a number of conference papers, but will be further developed as a full peer-reviewed paper in 2006-07.

c) It has been demonstrated in one sub-catchment in Victoria that the quality of DEMs significantly affects water table modelling (Heislers & Brewin, 2004). It was identified that further work was required to gauge the effects of different resolutions of spatial data in predicting watertable rises. In 2005-06 work was carried out in the Corangamite Catchment to compare outputs using LIDAR, 25m and 250m satellite DEM, and DEM from airborne geophysical surveys. This work has been written up as a report, however it is the intention to apply the methodology developed out of the Corangamite study other work on DEMs being carried out in the MDB, and but will be further developed as a report and paper in a thematic volume on DEMs and landscape processes in 2006-07.

d) This activity will demonstrate the value of improved spatial information for evaluating the economic impact of some of LEME research – for example – the application of airborne geophysics and regolith geoscience in the Riverland area of South Australia. In 2005-06 LEME commissioned ACIL Tasman to assess the cost-effectiveness of airborne geophysics and regolith-landscape modelling for salinity studies on the Murray Floodplain (Riverland Project). This project highlighted a number of difficulties found in using traditional accounting procedures to value NRM projects with long timeframe outcomes. While a positive economic benefit was identified, further work in this area will most likely await the outcome of a CRC Association project being carried out to produce guidelines for valuing NRM projects in CRCs.

3. In-stream processes

This activity is based on demonstrating how geomorphology/sedimentology and sub-surface architecture studies of floodplain environments can assist with understanding salinity processes, as well as contributing to better estimates of surface-groundwater interaction and sub-surface flow paths. While studies to date have focussed on the Balonne floodplain, research in 2006-07 will focus on the Murray floodplain.

4. Salt Interception Investigations

This sub-project was established to assess the value of in-river Nanotem conductivity mapping to optimise salt interception schemes. A report was completed in 2005-06, and this work is being written up as a series of peer-reviewed papers for publication in 2006-07. Further work in this area is being carried out by two PhD students at Adelaide University.

Deliverables (outputs) and expected impacts of research (outcomes) in 2006-2007:
Some indication of the work program in 2006-07 is given above. However, specific deliverables are still being negotiated, and will be detailed after meetings and workshops during May.

Milestones: *(dates of significant events marking scientific progress)*
These will be detailed after meetings and workshops during May.

Confidentiality requirements None

Abbreviated title: **Prog 4 communications**

Type of project Centre
Themes: Salinity and applications of regolith geoscience for Natural Resource Management

Project Leader: Ken Lawrie
Start date and duration: 2006-07 financial year

Participants: GA, CSIRO DEM & L&W, ANU, CUT, AU

Brief project description:
P4 has generated many technical reports in the last 4 years, building up a wealth of materials for wider dissemination. In the last 2 years of LEME there is an opportunity to build on this foundation, with the aim of building momentum to the ISF 2008 conference that essentially coincides with the end of LEME.

The aims of this project are to communicate the outcomes of P4's salinity projects to a national and international client, stakeholder and peer base. While regolith geoscience is broadly accepted now within minerals exploration, there is still poor awareness of regolith geoscience within the broad NRM community. Specific challenges exist with convincing key peer groups of the value of regolith science for salinity management. These include hydrogeological modellers, NRM modellers, policy makers, and key client and stakeholder groups, particularly in the eastern States, that hold the purse strings for further application of our science (eg State agencies and CMAs).

This project recognises the need to communicate LEME's science within NRM to a very diverse group of peers and decision makers. This diversity requires a multi-pronged strategy, with delivery of a range of multi-media outputs. In order to demonstrate the quality and value of our science, particular attention will be given in the remaining 2 years to gaining peer acceptance in national and international forums (journals and conferences), while recognising that great strides must also be made in familiarising potential clients with our methods and products.

Particular emphasis in the last 2 years of LEME will be given to preparation of legacy products, publication of peer reviewed science publications, and knowledge transfer activities with clients. Specific deliverables will include:

(a) Work will commence on a number of key legacy products to be delivered over the final 2 years of LEME. Details of these legacy volumes are dealt with in separate project schedules. The main legacy products are:
    1. Special thematic publication in AJES volume from SA NAP projects (in final edit stages, for publication in Dec. 06).
    2. AESC 2006. Ken Lawrie is convenor of the major symposium 'Environmental and Geological Hazards and Risks to Australasia' and 3 parallel environmental symposia. LEME is a major sponsor and participant. Specific products being developed (LEME staff as editors and contributors) are:

i. A book for decision makers and the general public documenting our present understanding of the Environmental and Geological Hazards and Risks to Australasia
ii. Invited scientific papers in a special issue of a major international hazards journal
iii. Field trip guides (2 field trips).

3. International Association of Sedimentologists Special Publication on Australian Cainozoic Cratonic Basins. Jon Clarke and Colin Paine are editors of this volume, with several LEME contributors. This is planned for release to coincide with a workshop at ISF 08.
4. A special volume of case studies of the use of DEMs in environmental mapping and management. Colin Pain to edit, with contributions from several LEME staff. To be prepared in conjunction with MODSIM conference series, this will be timed for release to coincide with ISF 08.
5. Special LEME volume on Environmental Geophysics (contributions from several LEME staff, and edited by Paul Wilkes and Richard Lane). To be released at ISF08.
6. International Salinity Forum ISF 08 (31 March to 3 April 2008). Specific legacy products from P4 will include:
    i. ISF 08 peer reviewed journal volumes (writing to commence in July 06). Specific special issues of international journals will be produced for salinity mapping, salinity management, catchment characterisation, and salinity processes. LEME staff will be invited to contribute to overview papers, and submit case study results.
    ii. ISF 08 workshop materials. It is planned to run at least 2 workshops: one on the use of AEM for mapping and managing salinity (Tim Munday to organise), and a second workshop on Basins and catchment characterisation (Ken Lawrie, John Wilford and Jon Clarke to organise).
    iii. ISF 08 field trip guides. Three field trips with significant LEME input and leadership are currently planned. One will be focussed on salinity in the WA wheat belt, one on salinity in the Murray Basin, and another on salt water intrusion and salinity mitigation etc in Qld. LEME staff to contribute to all of these.
    iv. ISF 08- NAPSWQ- sponsored information session for CMAs and decision makers (invited workshop)

(b) Ken Lawrie has been appointed to an IUGS working group (GEM) on communicating environmental geoscience to decision makers. It is planned to link LEME's activities in this area to both IGC 08 and the International Year of Planet Earth (2008, although activities will span 2007-09). Materials and activities will be developed specifically to showcase LEME's contribution to an understanding of environmental issues, and will be coordinated with Ian lambert who is Australia's geoscience representative for International Year of Planet Earth. KL's attendance at international GEM meetings will be co-sponsored by GA-LEME and IUGS.

(c) Submission of project results eg MDB uplands, Lr Balonne, Bland, Rural Towns, Chowilla, and salinity dynamics results to international journals (see list in table below)

(d) Community-based knowledge transfer workshops for salinity mapping and management (MDBC project areas, WA wheat belt, SA and Eastern Australia)
(e) Conferences participation. Specific conferences where LEME staff have been invited or wish to present in the final 2 years of LEME include:
    1. AESC 2006, 2nd-6th July in Melbourne
    2. Hydrogeophysics Workshop *31 July - 2 August 2006 Vancouver*
    3. 10th Murray-Darling Basin Groundwater Workshop, 18-20th September 2006, Canberra
    4. Joint Congress of: 9th Australasian Environmental Isotope Conference & 2nd Australasian Hydrogeology Research Conference**,**13-15 December 2006, Adelaide SA
    5. 18th World Soils Congress in Philadelphia 2006
    6. ANCID 2006, Darwin, October 06.
    7. Goldschmidt 2006, Melbourne.
    8. 20th SAGEEP Symposium on the application of geophysics to engineering and environmental problems, April 1-5, 2007, Denver, USA.
    9. ASEG 19th International Geophysical Conference and Exhibition, Perth Nov 2007
    10. MODSIM Christchurch, NZ Dec 2007
    11. ANZGG Queenstown TAS Feb 2008
    12. ISF 2008 in Adelaide, 30th March to 4th April 2008
(f) Logistic support (T/A) for organising and convening AESC 2006 and associated field trips, and ISF 2007/8. Ken Lawrie is convenor of AESC Invited Symposium, and on International Steering Committee and Technical Committee of ISF 08.
(g) Continued input to up-grade of website materials to inform on salinity and broader NRM activities. This will be undertaken largely by Greg Lawrence, but will need a number of P4 staff to prepare materials;
(h) Write contributions for the Salinity Communication newsletter 'Focus on Salt', and other relevant publications (eg client magazines and other publication media- newspapers).

Other activities such as producing on-line materials, and articles for newsletters, Focus on Salt etc, are covered in HQ costs. Sponsorship for AESC 06 ($10k) and ISF 08 ($20k) are covered in HQ budget.

Deliverables (outputs) and expected impacts of research (outcomes):
See above

Milestones: *(dates of significant events marking scientific progress)*
See above.

Confidentiality requirements Nil

Project name:
REVIEW GEOPHYSICAL DOCUMENT FOR LAND & WATER AUSTRALIA

Abbreviated title: Review David Allen Review.

Type of project Commercial
Themes: Salinity systems in regolith and groundwater

Project Leader: Paul Wilkes

Start date and duration: 24 April 2006 to 22 May 2006

Participants: CUT

Brief project description:
This project is to review and edit a document, to publication standard, for Land & Water Australia which resulted from a study tour by David Allen in 2004. The introduction to David Allen's document is reproduced here as the following paragraph.

Using the 2004 ANCID/Sustainable Irrigation Travel Fellowship, David Allen conducted an international survey of over 100 geophysical instruments applicable to irrigation problems. After attending the Symposium on Application of Geophysics to Engineering and Environmental Problems in Atlanta, Georgia, USA he visited equipment manufacturers and researchers in Canada, Denmark and Sweden. The survey of equipment details and prices is to be published on the ANCID web site. David was able to discuss with overseas manufacturers and researchers his own PhD work on electrical conductivity imaging of aquifers connected to watercourses. He got to present his work at three public gatherings and received much feedback on how it could be integrated with technical advances made by the audiences.

This review project has the following objectives.

1. To provide an introduction to David Allen's review, that contextualises geophysical methods with others (such as airborne and ground magnetics, ground penetrating radar etc.) and describes the application of these technologies to irrigation situations.

2. To improve the structure of existing text through addition of headings and other re-arrangement to improve the logical flow of the text.

3. To correct errors and, in conjunction with David Allen, clarify ambiguities in the document.

4. To add references where appropriate to other research papers, reports and books, particularly where these are available on the web.

5. To edit the report to a level where it is ready for publication (recognising that there may be additional text to be drafted).

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

Edited report suitable for publication This is an example of CRC LEME collaborating with other research groups to produce enhanced products to advance the science used in Irrigation.

Milestones and Payment Schedule:

Date	Description of milestone	Achievement criteria	Amount (Excl GST)
24/04/06	Milestone 1 Signed agreement.	On receipt of short form agreement in acceptance of these terms.	**$2,000**
15/05/06	Milestone 2 Draft review of the report received.	The report must provide sufficient detail that satisfies the objectives of the project.	**$0**
22/05/06	Milestone 3 Final review of the report and edited version of the report received.	1. Detailed report on David Allen's review noting any omissions that ought to be included for the report to be suitable for the Irrigation Insight series and incorporating feedback received from LWA. 2. Edited Word version of David Allen report.	**$6,000**
		Total	**$8,000**

Confidentiality requirements - None

Project name:
HYDROGEOLOGICAL STUDIES OF RIVER MURRAY FLOODPLAINS, RIVERLAND, SOUTH AUSTRALIA USING AIRBORNE AND GROUND GEOPHYSICAL TECHNIQUES

Abbreviated title: SA Murray Floodplains

Type of project Centre/Industry/commercial
Themes: Theme 7: Salinity systems in regolith and groundwater

Project Leader: Tim Munday
Start date and duration: August 2005 to June 2007

Participants: CSIRO EM, CSIRO LW, Geoscience Australia, SA Water, DWLBC

Brief project description:
This project focuses on analysis and interpretation of ground and airborne (AEM) geophysical data across the Chowilla SEA and Bookpurnong floodplains, informing the Chowilla Integrated Natural Resource Management Project and the Bookpurnong Floodplain Pilot Project which are funded by the NAP, MDBC, DWLBC and NHT. Floodplains of the River Murray are a potential source of salt and other contaminants to the river, due to their role in intercepting saline groundwater discharge. The roles of surface water–groundwater interactions in wetland soil and water chemistry, and the resultant biotic responses are poorly known. The connectivity of the surface and groundwater depends on regional hydrogeology and wetland geomorphology, and will also be affected by operations such as wetland wetting-and-drying cycles and groundwater interception. Regional groundwater is highly saline, anoxic and reduced, impacting wetland water quality and habitat. The knowledge gap in water interactions in wetlands, and impact of water quality on ecology and biodiversity, is a shortcoming in our ability to determine the most appropriate way of managing wetlands of the lower River Murray.

We propose to apply new geophysical techniques to derive soil-regolith and salt store maps that would help identify local recharge and discharge areas, and likely effects on river salinity. We will examine the role of electrical geophysical methods to map spatial and temporal variations of salinity linked to environmental flow management in particular test sites in the Riverland area. We believe the geophysical data, when linked to detailed ground investigations, will provide an understanding of causal links between in-river salinity, floodplain and upland aquifer characteristics, and discharge processes. This will have environmental benefits to the River and its wetlands, and salinity benefits to ecologically important floodplain areas.

The project will also re-examine existing HEM data for Pike River, Murtho and Chowill SIS areas. Combining these data with local ground information will deliver information on the Loxton-Parilla Sands aquifer which will help plan these schemes. This work will build on knowledge from the SA-SMMSP in the Bookpurnong area, which demonstrated that geophysical methods do provide detailed spatial information to assist in the prediction of irrigation impacts, the design of salt interception schemes, and protection of floodplain values in the Riverland region. These issues are central to the regional and state strategies for the River Murray and are identified as key targets in the SA MDB INRM Plan (2003).

Project Objectives

Principal objectives are:

1. To better define the hydrogeological characteristics of the principal aquifer systems in order to inform planning of floodplain and highland components of the Chowilla, Pike River and Murtho Salt Interception Schemes.
2. To determine the value of airborne geophysics in helping define and protect groundwater dependent ecosystems on the Chowilla floodplains.
3. To relate run-of-river salinity to variations in floodplain aquifer and soil characteristics
4. To map salt stores and soil variability in the Chowilla Floodplain and over Bookpurnong Floodplain Pilot Project site using new helicopter electromagnetic data processed using local constraints.
5. To develop spatial-temporal ground geophysical monitoring techniques and apply them to floodplain studies at Bookpurnong and Chowilla (through links to SA CNRM Projects 16 and 17).
6. Relate structures in soils and aquifers, as determined by geophysics and drilling, to the siting of irrigation developments, in order to better assess the time delays between changed land use and impact on river.

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

1. A CRC LEME technical report on the inversion procedures used in reprocessing existing HEM data for Pike River, Murtho and Chowilla SIS areas. This report will detail characteristics of the Loxton-Parilla aquifer interpreted from airborne EM data and geological information collected from bores. This will assist planning and development of salt interception schemes. GIS compatible grids from the inversion will be supplied to DWLBC. Results from this work will be workshopped with DWLBC.
2. CRC LEME Technical report on value of AEM for management of groundwater dependent ecosystems on salinising floodplain
3. GIS compatible maps/grids of salt stores and aquifer water quality (salinity) covering Chowilla SEA and Bookpurnong floodplain test areas as derived from the constrained inversion of HEM data. A CRCLEME Technical report will describe procedures used in the constraint and validation of HEM data. The technical report will include laboratory determination of floodplain sediment characteristics, salinity, moisture content and particle size. It will define the principal factors in determining the observed conductivity. The relationship between observed conductivities (salinity) on the floodplain and in the river will be documented. A merged AEM data set linking the southern upland area and the Chowilla floodplain will be produced in a GIS compatible form.
4. A CRC LEME Technical report with the University of Adelaide describing the ground geophysical techniques developed to understand spatio-temporal patterns and processes associated with Environmental flow management on the floodplains and the consequence of SIS implementation. This work will also be presented as a conference paper.
5. A CRC LEME/CSIRO LW Technical report on modelling the effects of spatially variable recharge to the Loxton Parilla aquifer at Bookpurnong, and the role of variable transmissivity linked to facies variations in the aquifer. This work will link upland processes with floodplain transmissivity, to determine the effect of aquifer heterogeneity on groundwater flow patters across the floodplain. It will

also determine whether additional modelling is necessary. Interim field results and progress in modelling will be reported in Progress and Annual Reports and Presentations.

Outcomes

The project addresses key strategies and actions defined as "Essential" in the River Murray Salinity Strategy, the Dryland Salinity Strategy, and the River Murray Catchment Water Management Plans. Additional airborne geophysics in the River Murray floodplain will be a critical bridging link between land characteristics and groundwater processes in upland and floodplain regions. These data will promote an understanding of causal links between in-river salinity and floodplain and upland aquifer characteristics and discharge processes. The outcomes will influence the location and effectiveness of SIS and affect policy irrigation development and salinity credits.

Key outcomes for the project are:

1. The provision of baseline data on the spatial distribution of near surface salt stores and materials in the floodplain and their relationship with in-river salinity. Project outputs will assist in the maintenance and development of enhanced environmental values for the Chowilla floodplain and river through a mix of management strategies
2. Determining the value of airborne geophysics for informing the management of other floodplains areas in the Murray Basin
3. Cost effective and efficient SIS design and development
4. Better informed policy on irrigation development and water use efficiency
5. The development of an internal (SA Govt Department) capacity to use airborne geophysical data linked to on-ground investigations in hydrogeological applications.

Milestones: *(dates of significant events marking scientific progress)*

Mile stone No.	Milestone	Responsibility	Objectives Addressed	Deliverables (outputs) Addressed	Mile-stone Date
2006/07					
1	Ground calibration site measurements for Chowilla HEM validation and calibration	CRC LEME/ DWLBC	3	3	July 06
2	Report to the Project Steering committee and CNRM and MDB INRMG Boards (Jun 06)	CRC LEME/CSIRO LW	1,2,3,4,& 5	1,2,3,4 & 5	July 06
3	Report on Revised interpretation of Pike River and Murtho HEM data	CRCLEME	1	1	August 06
4	Field visit and water sampling for drainage study at Bookpurnong Irrigation area.	CRC LEME /CSIRO LW	6	5	Dec 06
5	Field visits looking at Bookpurnong study sites and effect of SIS and flooding on geophysical responses	CRC LEME/Univ Adelaide/ CSIRO LW/DWLBC	3 & 4	2, 3, 4 & 5	Mar-07

6	Field investigations at Chowilla – drilling and sampling for validation of HEM data and link with in river salinity	CRC LEME/ DWLBC	2,3 & 4	2, 3 & 4	Mar-07
7	Report on value of AEM for management of groundwater dependent ecosystems in floodplain settings	CRC LEME/ CSIRO LW	2	2	June 07
8	Report/workshop/presentation of final project outcomes to CNRM and MDB INRMG Boards (excluding drainage study)	CRC LEME/Univ Adelaide/CSIRO LW	1,2,3,4,& 5	1,2,3 & 4	Jun-07
9	Report on drainage study at Bookpurnong, and HEM interpretation at Chowilla. Paper on Bookpurnong floodplain study.	CRC LEME/ Univ Adelaide/ CSIRO LW	6	5	Aug-07

Titles of proposed publications and journals where the papers will be submitted

1. Combining Air, Ground and 'In River' Electromagnetics in the Definition of Spatial Patterns of Groundwater Induced Salt Accumulation (Journal of Environmental and Engineering Geophysics)
2. The application of airborne geophysics as an aid to better understanding River Murray - groundwater interactions – examples from the Chowilla Floodplains, South Australia (J Hydrology)

Titles of reports

2. Constrained inversion of HEM data for informing the development of the Pike River and Murtho SIS (August 2006)
3. AEM for management of groundwater dependent ecosystems on salinising floodplain (June 2007)
4. The application of ground geophysical techniques for understanding spatio-temporal patterns and processes associated with environmental flow management on the Murray floodplains, SA (June 2007)
5. Modelling the effects of spatially variable recharge to the Loxton Parilla aquifer at Bookpurnong, and the role of variable transmissivity linked to facies variations in the aquifer. (August 2007)

Confidentiality requirements Reports will be delivered to the SA CNRM and MDB INRMG Boards whereon their publication will be unrestricted.

Project name:
THE DYNAMICS OF SALINITY IN AUSTRALIA: ORIGINS, MOBILISATION AND TRANSPORT OF SALT IN THE AUSTRALIAN REGOLITH AND RESPONSE TIMES RELATING TO SALINITY.

Abbreviated title: **Salinity Dynamics**

Type of project **Centre**

Themes: 1. Understanding regolith processes
3. Acid and alkaline soils
5. Making geochemistry more effective
7. Salinity systems in regolith and groundwater
9. Environmental geochemistry and the regolith

Project Leader: **Richard Cresswell**
Start date and duration: 1 July 2005 to end December 2007

Participants: CSIRO Land & Water, Geoscience Australia, ANU

Brief project description:
This project investigates the physical, chemical and environmental factors influencing salt mobilisation in an Australian regolith context.

- Integration of salt mobilisation understanding into a broad landscape and climatic context.

This project aims to determine quantitative parameters that address system response times in salinity-prone environments. The following specific questions will be addressed by the project:

- What is the origin of the salt?

This question will be addressed on 3 fronts: isotopic studies (Lenahan, Cresswell); rainfall chemistry studies (Cresswell, Dighton) and through chemical modelling in the unsaturated zone (Rassam, Cresswell).

- How does saline water and salt interact with regolith materials?

This will be addressed through geochemical modelling (Rassam); lysimeter experiments (Rassam, Cresswell) and chemical equilibrium, determined through CEC and XRD analysis (Tan, Rassam)

- How and how fast is it mobilized?

Basic hydraulic properties of regolith materials will be determined through field pump tests and laboratory analysis (porosimetry, x-ray tomography, permeability test, etc) on samples collected from drill cores (Tan, Turner, Cresswell, Gilfedder, Dighton). Isotopic studies will help elucidate timeframes for mobilisation and components of the mass balance equations (Cresswell).

- Where and at what rate is it transported?

Landscape analysis, hydrology and hydrogeology models will be used to characterise different terrains and model the 3D spatial variability in salinity mobilisation using

the parameters determined in 3)(Cox, Davies, Gilfedder, Stenson, Cresswell, Gibson, Tan). Climate as a driver will be examined in well-characterised catchments and the effects of land-use change evaluated (Cresswell, Davies, Stenson).

To date, salinity parameters have been largely semi-quantitative. Working constructs, such as groundwater flow systems provide a targeting approach for more detailed studies, but generally involve poor integration of sub-surface regolith constraints. The continuing *MDBC-funded* project is attempting to redress this issue, but requires quantification of parameters such as hydraulic conductivity, transmissivity, permeability, specific yield and porosity that are specific to regolith materials, particularly where these materials act as groundwater hosts. This information is required at micro- macro- and regional scales.

Water transport properties for the regolith are vital components of transport models, and require detailed quantification. The interaction and ionic exchange of salts, particularly at high salinities, is also critical when deducing potential end-of-valley salt loads and correlating standard electrical conductivity measurements to actual salt impact. Hydrochemical studies aimed at elucidating the transport of salts within, and through, the regolith, are also fundamental to this project. This also links to projects under Programs 1, 2 and 3.

Climate trend analysis will be integral to the development of salinity risk maps (e.g. through 2Csalt) and will, therefore, come under the scope of this project.

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

Scientific Deliverables (new scientific advances)

1. Rainfall chemistry evaluated and assessed for salt accession (**Oct-06**)
2. Geochemical modelling incorporated into a groundwater flow systems framework (**Dec-06**).
3. Integrated look-up tables of hydrogeological parameters pertinent to groundwater modelling in regolith dominated environments (**Jun-07**).
4. Salinisation response times determined through a combination of geochemical and isotopic tracers and modelling (**Jun-07**).
5. Report documenting salinity mitigation products in Qld catchments (eg Hodgsons Creek) (June 07)
6. An assessment of salinity dynamics and processes in MDBC project areas (June 07)

Deliverables to Client (Adoption mechanisms)

1. 3D hydrogeological and hydrogeochemical frameworks for modelling of key NRM areas (**Jun-07**).
2. Rainfall/hydrograph analysis tool (**Jun-07**).
3. Integrated look-up tables of hydrogeological parameters pertinent to groundwater modelling in regolith dominated environments (**Dec-07**).

Deliverables (Outputs):

1. Journal papers, Technical Reports and Open File Reports (***see list below***)
2. Papers presented at National and International Conferences (***see table below***)
3. Communication of results through conferences, workshops and literature

Expected impacts (Outcomes):

4. Improved understanding and assessment of salinity risks and response.
5. Consolidation of research on the age, origins, distribution and mobilisation of salts in the Australian regolith.
6. Integration of chemical processes into salinity delivery mechanisms.
7. Adoption of outputs from airborne geophysics and regolith characterisation projects into salinity management procedures and modelling exercises
8. Establishment of hydrogeological dynamics (response times of a system) to changes in land-use and/or climate change
9. Demonstration of the relevance of regolith and geophysical information to decision support systems for land management of salinity

Milestones: *(dates of significant events marking scientific progress)*

Quarterly reports from Project Leader to Program 4 Leader and Board
Annual Report of Activities
Major milestones are:

Review of salinity in Australia – **Dec 2006** (Open File Report)
Chemistry of salinity – **Jun 2007** (OFR)
Rainfall: hydrograph analysis tool developed – **Jun 2007** (OFR)
Integrated look-up tables for salinity modelling - **Jun 2008** (OFR)

Projected Publications and Legacy Products

Legacy:

1. Salt in the Australian Landscape: Sources, Stores and Mobilisation
   (Cresswell with Glen Walker, Ray Evans, Andrew Herczeg) – **paper to AESC Salinity volume 2006**
2. The Chemistry of Salinity
   (Cresswell, Kirste and others) – **paper to ISF 2008 Legacy Volume**
3. Hydraulic Parameters of the Regolith
   (Cresswell, Tan, Cox, Kirste and others) – **paper to ISF 2008 Legacy Volume**
4. *Salinity Dynamics: Response times in the Australian context*
   (Cresswell, Gilfedder, Stenson, Rassam, Dighton, Cox, Barton with others) – **paper to ISF 2008 Legacy Volume**

Proposed publications (plus more to follow, particularly from Graduate students):

N.B. Also, a series of publications from the SA-SMMSP, currently under review to AJES

1. Groundwater and Salinity in the Goondoola Basin, Queensland
   (Cresswell and Dighton with Andrew Biggs, Mark Silburn, Ralph DeVoil) – in prep AJSR
2. Chloride and ^{36}Cl across Australia
   (Cresswell with Keith Fifield, Allan Chivas) – in prep GCA
3. Matching Deep Drainage to Rainfall and Groundwater Hydrographs
   (Cresswell and Rassam with Mark Silburn, Jo Owens, Peter Barker) - in prep
4. Base flow for the Fitzroy Basin
   (Cresswell with Mark Silburn, Vivienne McNeill)
5. Catchment-scale Modelling of Salt Mobility in Hodgson Creek, Queensland
   (Gilfedder, Stenson, Cresswell and Dighton with Mark Silburn, Jo Owens, Ralph DeVoil) – in prep

6. Modelling salinity: a review of models incorporating salt mobilisation and re-distribution
   (Gilfedder, Rassam, Cresswell)
7. Deep drainage processes and salt mobility
   (Rassam with Jenny Foley, Mark Silburn)
8. Salt mobility in the Fitzroy Basin, Queensland
   (Cresswell and Gilfedder with Bruce Pearce, Lucy Reading, Mark Silburn)
9. Hydrogeology of a weathered basalt terrain: Corangamite, Victoria
   (Cox, Davies and Dighton with Chris Smitt, Peter Dahlhaus)
10. Salt store and mobilisation in the Regolith: Controls from the Physical Attributes of the Regolith
    (Tan and Cresswell) – to ISF 2008
11. Dryland Salinity in Australia: A World Comparison
    (Cresswell and others) – *to ISF 2008*

Confidentiality requirements. Some proprietary requirements for CMAs and State Agencies. Short term Commercial-in-Confidence issues with CMAs and INRM groups.

Project name: **Southern River - extension to project**

Abbreviated title: **Southern River**

Type of project Commercial + Centre

Program: 4

Themes: Salinity systems in regolith and groundwater

Project Leader: Paul Wilkes

Start date and duration: June 2006 to 30 September 2006

Participants: CUT

Brief project description:
This extension to an existing project includes borehole logging and further analysis of GPR data which has been acquired by Baigent Geoscience under sub contract to CRC LEME. The extension is subject to agreement with client.

The following is the original project description

This project is collaborative with and funded by Water for a Healthy Country. (WFHC)

WFHC requires a geophysical survey to be carried out n the Southern River area, starting with the Brookdale redevelopment area in SE Perth.. The area is about 1500 ha, and is characterised by shallow groundwater, high clay content of substrata and locally saline groundwater. The main objectives of the survey are

1. To identify the boundaries of the local geological units (Guildford clays, Bassendean sands and some members of the Leederville Formation, which is reasonably shallow at the site, 50-60m).

2. To define spatial dimensions of the Superficial aquifer delineating the area with the potentially greater yields to support a local (domestic) non-potable water supply scheme.

3. To define areas of potential connectivity between the Superficial and Leederville aquifers, which may control deep drainage.

4. To delineate the area of the saline groundwater occurrence.

Deliverables (outputs) and expected impacts of research (outcomes):
Methodology for a near-urban environment
Processed and interpreted datasets
Project report
Updated report

Milestones: *(dates of significant events marking scientific progress)*
Completion of processing and interpretation report. This is due at end June 2005 provided weather permits completion of fieldwork in due time. Weather and permissions delayed fieldwork by many months.
Final report expected by end September 2006. Two previous reports have already been submitted.

Confidentiality requirements
No special requirements

Project name:
THE APPLICATION OF AIRBORNE ELECTROMAGNETIC DATA IN THE MAINTENANCE AND DEVELOPMENT OF ENHANCED ENVIRONMENTAL VALUES FOR THE MURRAY FLOODPLAIN AND RIVER – SUNRAYSIA, VICTORIA: PHASE 1

Abbreviated title: **Sunraysia**

Type of project **Industry**
Themes: *6. Geophysical mapping and modelling in regolith terrains*
7. Salinity systems in regolith and groundwater

Project Leader: Tim Munday
Start date and duration: June 2006 (12 months)

Participants: CSIRO EM, Golburn-Murray Water, GA

Brief project description:
The Mallee Murray irrigation region supports a nationally significant citrus, vegetable production and horticulture industry. This industry is dependent upon the Murray River supplying water for irrigation, household use, livestock consumption, and industrial water use - accounting for nearly half the total water use across the Mallee. Salinisation of the Murray River is a significant threat to the sustainability of the irrigation resource for this region. Natural inflows of highly saline groundwater to the River Murray have been exacerbated by irrigation development and adjacent clearing of dryland within the vicinity of the river. Future irrigation development and the delayed impacts of land clearing in the dryland farming area will continue to increase these inflows into the future. The principle asset at risk is the Murray River, that supplies potable and irrigation water to the immediate region and downstream. Salt-interception schemes are an important feature to protect water quality. However, key to their development and effectiveness is information on the:

1. The spatial and temporal distribution of sub-surface saline inflows into the Murray River and their relationship with land use change
2. Salt build up in the Mallee floodplain which presents a significant risk to River Murray salinity
3. The recognition of high and low irrigation impact zones
4. The appropriate location for salt interception high yielding production bores.

It is expected that significant 'green-field' developments will continue to occur into at least the medium–term adding further pressure to the supply of water and the protection of river and floodplain values.

Geophysical methods have the capacity to provide detailed spatial information to assist in the prediction of the impact of current and future irrigation developments, the design of salt interception schemes and protection of floodplain values. These issues are central to the regional and state strategies for the River Murray. The project has been initiated by the Sunraysia Salt Interception Integration and Optimisation Steering Committee and Project Board (MDB Ministerial Council Endorsed with MDBC approved work plan) in support of two of their high priority projects - A Sunraysia Regional Disposal Strategy (MDBC Funded) and the Refurbishment Planning for the ageing and underperforming Mildura-Merbein Salt Interception scheme (G-MW/MDBC co-funded). Project outputs will assist in the maintenance and development of enhanced environmental values for the floodplain and river through a mix of management strategies.

Specific project objectives
This project will focus on using a combination of airborne geophysics, particularly electromagnetic for understanding floodplain processes for MM SIS refurbishment planning and in support of the CMA floodplain salt storage project - Kings Billabong site. Specifically it will provide baseline data on the distribution of near surface salt stores and materials in the floodplain and their relationship with in-river salinity, as part of a strategy to refurbish the MM SIS. In this instance the appropriate siting of bores will be critical to achieving interception so a key objective will be to identify floodplain features that may influence the effectiveness of this scheme. In the case of the Mallee CMA (Kings Billabong) area, the goal is to provide baseline information in the development of a 5 yr Floodplain salt storage project. The project will focus on the use of local constraint information to invert the AEM data to provide spatial information on groundwater salinity and salt loads in the unsaturated zone.

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

1. Definition of appropriate airborne geophysical system and survey parameters for an AEM survey,
2. Technical specifications for incorporation in survey contract
3. Management of geophysical survey contract, and quality assessment of the derived geophysical data
4. Calibrated airborne geophysical data as conductivity depth images in a GIS compatible form.
5. Report on survey outcomes and products delivered.
6. A report on the constrained inversion of HEM data, the procedure used, limitations of derived products (supplied in a GIS compatible format).
7. Technology transfer workshop at GW-W to communicate the outcomes of the work to relevant stakeholders.

Outcomes

1. Provision of baseline information on near surface salt stores and materials in the floodplain and their relationship with in-river salinity. Project outputs will assist in the maintenance and development of enhanced environmental values for the floodplain and river through a mix of management strategies.
2. The development of a local capacity to use airborne geophysical data linked to on-ground investigations in hydrogeological applications.

Milestones

1. Define AEM survey objects and area – June 2006
2. Place contract for data acquisition – July 2006
3. Begin AEM data acquisition – August 2006
4. Quality assessment and control – September 2006
5. HEM data delivered by contractor – October 2006
6. Survey report - November 2006
7. GIS compatible conductivity grids delivered to project partners – December 2006
8. Collation of local constraint data and inversion of EM data – March 2007
9. Report on Constrained inversion of HEM data and supply of derived products in GIS compatible form – June 2007

Reporting
Progress reports are required on a monthly basis.

1. Technical report on AEM survey outcomes and conductivity depth images (Nov 2006)
2. Constrained inversion of EM data – Sunraysia (June 2007)

Confidentiality requirements None

Project name:
WA RURAL TOWNS

Abbreviated title: **WA Rural Towns**

Type of project Commercial + Centre
Themes: Salinity systems in regolith and groundwater

Project Leader: Paul Wilkes
Start date and duration: April 2004 to June 2007

Participants: CUT plus external agencies

Brief project description:
This is a continuing project which began in 2004, and is due to run to mid 2007.

Urban salinity has a significant impact on 38 rural towns in WA. The Rural Towns – Liquid Assets project, contributes to effective salinity control and shows how locally sourced saline groundwater may be treated and turned into a resource. This 3 yr project is working on 16 of the most salt affected towns. Katanning was originally in the list of 16 towns and some work was done on Katanning before it left the project. Hence by the time the project is completed we will have worked on 17 towns.

CRC LEME is a partner in the overall project with Curtin University of Technology, CSIRO including Water for a Healthy Country, Department of Agriculture WA, WA Chemistry Centre and UWA, Water Corporation and the 16 Shires. CRC LEME / CUT is a member of the Water Resources Group which meets regularly to plan and execute this part of the project. CRC LEME is also represented by PGW on the overall Steering Committee which oversees the whole project.

CRC LEME contributes basic regolith information and an understanding of the geology and hydrogeology of the towns and the related catchments.. Geophysical surveys and existing datasets are being used to provide regolith information including regolith thickness and geological structures which affect the regolith and salt distribution within the regolith. New challenges include working effectively in urban built environments with powerlines, people and vehicles.

New science includes :

1. Working out innovative ways of providing solutions to geological and hydrogeologcial questions in each of the project towns.
2. The use of 3D geological / geophysical modelling using state of the art Geomodeller software which originated in BRGM, France and is now being further developed by Intrepid Geophysics in Australia
3. The use of seismic reflection and refraction techniques in urban settings. This uses the latest equipment from the US and new techniques developed by Curtin Exploration Geophysics. Surveys have been carried out in 2005-2006 in Moora and Dowerin.
4. Developing linkages between geophysics and hydrogeological modelling.
5. New techniques for acquiring transient EM data.

Some surveys are sub-contracted to commercial groups with CRC LEME providing specification and management of these surveys. Date processing and interpretation are done by CRC LEME staff and students..

All operating costs for this project are externally funded. Opportunities are created for student involvement. The project includes technology transfer and communication both to other project scientists and to the local communities in the towns where we are operating.

Deliverables (outputs) and expected impacts of research (outcomes):
Methodology on how to provide cost effective regolith geoscience information to meet the overall objectives of the Rural Towns – Liquid Assets project. This includes research results and case histories on how to apply geophysical methods in urban environments and how this contributes to a multi-disciplinary, multi-facetted project.

Maps, reports, datasets and interpretations are delivered as project outputs.

Papers are being written and presented at conferences to describe the new science being done in this project. A poster was presented at SAGEEP, Seattle in April 2006. and a related paper was included in the proceedings. A paper on this project will be presented at AESC 2006 in Melbourne in July 2006.
Articles have also been written for inclusion in Focus on Salt and the RTLA newsletters.

Milestones: *(dates of significant events marking scientific progress)*

As shown in the accompanying payment schedule which is reproduced from the draft project agreement.

Quarter commencing	**Expected payment**	**Milestone achieved or output delivered**
1 April 2004	$60,000	On signature of the Agreement by both parties
1 July 2004	$30,000	On completion of the first Pilot study. Data sets and report delivered.
2 Sept 2004	$26,973	On completion of Katanning Project
1 October 2004	$30,000	On completion of the second and third Pilot town studies. Data sets and reports delivered.
1 January 2005	$30,000	On completion of the fourth Pilot town study. Methodology finalised and ready to apply to Priority towns. Data sets and reports delivered.
1 April 2005	$30,000	On completion of four of 12 Priority town studies. Data sets and reports delivered.
1 July 2005	$30,000	On completion of eight of 12 Priority town studies. Data sets and reports delivered.
1 October 2005	$30,000	On completion of 12 of 12 Priority town studies. Data sets and reports delivered.
1 January 2006	$60,000	On production of a final report and financial statement.
TOTAL	**$326,973**	

Deliverables have changed as the project has evolved. By April 2006 geophysical work has been carried out on Dowerin, Katanning, Lake Grace, Merredin, Moora, Nyabing, Wagin, Woodanilling. Work is planned for the remaining 9 towns between April 2006 and June 2007..

$ 176,973 plus GST was received in 2004-2005. $ 120 K will be received in 2005 – 2006 and the balance of $ 30 K in 2006 – 2007. The balance of funds unspent by end June 2006 will be carried over into 2006- 2007.

Confidentiality requirements

The following is an extract from the Project Agreement between CRC LEME and WA Department of Agriculture (managers of Rural Towns – Liquid Assets project)

The CRC LEME shall treat as confidential all information disclosed to the CRC LEME, made known to the CRC LEME or developed by the CRC LEME during the course of or for the purposes of the Services ("the confidential information").

Without limiting the generality of the preceding sub-clause, the confidential information includes computer programs, client lists, the Department of Agriculture's methods of operation and details of clientele and potential clientele of the Department of Agriculture.

Immediately upon the completion of the Services and the termination of the General Agreement, the CRC shall deliver to the Department of Agriculture all documents, electronic datasets, files and materials relating in anyway to the confidential information which are then in the CRC LEME's possession.

Abbreviated title: **Yarra Yarra**

Type of project Commercial + Centre

Program: 4

Themes: Salinity systems in regolith and groundwater

Project Leader: Paul Wilkes

Start date and duration: May 2004 to end October 2006

Participants: CUT in collaboration with WA Agriculture and the Yarra Yarra Catchment Management Group.

Brief project description:

This is a continuation of a project which began in 2004 – 2005.

This project is a sub-project within the NAP/ NHT funded larger project entitled "Feasibility study into establishing Yarra Yarra as a pilot demonstration project to demonstrate Catchment Governance and planning concepts ' This overall project will identify best practice governance and design criteria for a sustainable regional drainage system. It will provide seed funding to establish a working model of the combined initiatives to enable effective evaluation by the community. A second parallel project has also been funded " A coordinated approach to dissemination and collection of NRM data in the Yarra Yarra sub-region."

This sub project is to produce soil maps from airborne geophysical datasets and digital elevation data – from the WA Land Monitor program and also from low level geophysical surveys. GA has released a composite airborne geophysical dataset for the Burakin area of WA in late February 2004. This combines newly acquired data flown for GA in 2003 with some existing company datasets. The study area – the Yarra Yarra catchment and surrounds is located within the Ninghan, Bencubbin, Kellerberrin, Moora and Perth 1;250 000 map sheets.

The project builds on the experience gained at Elashgin (within Kellerberrin map sheet) in 2001. This area of very detailed airborne geophysics (20 metre flying height and 25 metre line spacing) has become a test area for soil mapping using a variety of techniques which include airborne and ground geophysics, conventional soil mapping, and very recently hymap.

In the Yarra Yarra catchment we are establishing a robust methodology for soil mapping from airborne geophysics and digital elevation data with the associated field checking and analysis. The work is done in conjunction with WA Agriculture and engages strongly with the Yarra Yarra Catchment Management Group. The group has produced some of their own soil maps by conventional methods and some of the area mapped by them will be compared with the new maps.

An extension to the original project is to do work on up to 6 transects across the catchment to study possible linkage between surface drainage and underlying aquifers. Fieldwork for this extension to the project will be done in 2005 and 2006.

Deliverables (outputs) and expected impacts of research (outcomes):
Outputs will include an established methodology for producing efficiently soil maps from airborne geophysical datasets and digital elevation data.

Soil maps will be produced for and with the Yarra Yarra Catchment Management Group.

This project will impact on decisions to be made on locating a regional drainage system and also feed into the second externally funded project on best use of NRM data for catchment management purposes.

Report of drainage aspects of up to 6 transects across the catchment

Milestones: *(dates of significant events marking scientific progress)*

Preliminary images of the radiometric, magnetic and DEM data were produced in June 2004 for use in planning meetings fro the project.

Soil sites were sampled by DAWA in late 2004

Soil maps and report are to be delivered by end August 2006.

Fieldwork on drainage transects will be done in mid 2005 and mid 2006
Report on drainage transects to be delivered by end October 2006.

Confidentiality requirements

No special requirements**.**